When it comes to water supply, most of the USVI relies on rainwater collected in cisterns for household needs and on bottled water for drinking. Some hotels and communities run small systems for turning seawater into freshwater. About 25 percent of the Territory’s residents living on St. Croix, St. John, and St. Thomas are connected to the central water supply system that is run by the Water and Power Authority (WAPA). The system is fed by reverse osmosis plants on St. Croix and St. Thomas; it also includes tanks for storing the water and pumping stations for delivering it to customers through a network of pipes. The system’s desalination plants are less than a decade old, but much of the distribution system is far older—with some pipes dating back to the 1940s—and therefore prone to leaks and easily damaged, including during hurricanes.

Hurricanes Irma and Maria affected all parts of the water supply system to different extents. The reverse osmosis plants lost power and were not working for two days on St. Croix and 10 days on St. Thomas. Storage tanks and pumping stations were damaged or even—in the case of one pumping station—completely destroyed. Distribution pipes throughout the Territory were damaged by uprooted trees and utility poles. While the system never fully shut down, many customers experienced unpredictable supply interruptions, and it took WAPA a month to restore the system on all primary islands to its normal functioning.

In the future, stronger (although not necessarily more frequent) storms will threaten all of the system’s components, including reverse osmosis (RO) facilities, storage tanks, pump stations, and distribution pipes. Higher average temperatures and possible longer dry spells may also drive up water demand.

Facing future climate risks will require hardening all components of the existing system (including rehabilitating old distribution pipes), expanding the system to serve isolated communities and to strengthen service on the western end of St. Croix, and better preparing for future hurricanes through installing backup generators at major facilities, educating the public, and developing a water rationing plan.

### HOW THE WATER SYSTEM WORKS

The US Virgin Islands has little naturally occurring water. The majority of the islands’ population uses cisterns to collect rainwater for general use and purchases bottled water for drinking. About a quarter of the population also has access to the water supply system that is run by WAPA. This system produces freshwater at reverse osmosis plants on St. Croix and St. Thomas through desalinating seawater and then distributes it through a network of storage tanks, pump stations, and pipelines. Some residents are also served by third-party water hauler trucks (see map: WAPA’s water system).

### WAPA water production

WAPA produces potable water for the Territory at a rate of around 6 million gallons per day (MGD), supplying around 13,000 customers on St. John, St. Thomas, and St. Croix.

Water is first produced at RO plants on St. Croix and St. Thomas that make potable water out of seawater. On St. Croix, the two plants at the Richmond Power Plant can produce 3.6 MGD. On St. Thomas, the plant at Randolph Harley Power Plant can produce 2.3 MGD, with a maximum capacity of 3 MGD (see table: WAPA water infrastructure). All of the plants are owned and operated by Seven Seas Water, a private for-profit company established in the USVI in 1996.

<table>
<thead>
<tr>
<th>WAPA water infrastructure</th>
<th>St. Croix</th>
<th>St. Thomas-St. John</th>
</tr>
</thead>
<tbody>
<tr>
<td>Storage tanks</td>
<td>7</td>
<td>7</td>
</tr>
<tr>
<td>Storage capacity</td>
<td>20 MG</td>
<td>35 MG</td>
</tr>
<tr>
<td>Water mains</td>
<td>190 miles</td>
<td>420 miles</td>
</tr>
<tr>
<td>Reverse osmosis plants</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Reverse osmosis production</td>
<td>3.6 MGD</td>
<td>2.3–3 MGD</td>
</tr>
</tbody>
</table>

1 The RO plants replaced an older and much less energy efficient process called multi–effect distillation (MED), which used heat and vacuum to boil the water and leave the salt behind, requiring four times as much energy.
Once Seven Seas produces the water, WAPA treats it again and then sends it to storage tanks, of which there are seven in each system, with a total capacity of 20 MG (five and a half days of maximum production) on St. Croix and 35 MG (10-15 days of maximum production) on St. Thomas.

From the tanks, pump stations move water into the mains that deliver the water to customers. The mains are old and fragile: many of the pipes are old ductile iron types installed as far back as the 1940s. As a result, leaks are a major problem: on St. Croix, approximately 30 percent of water is lost in the distribution system, and on St. Thomas, approximately 10 percent. Customer coverage is limited, too: on St. Thomas only 45 percent of the island has potable water service, and the system has not yet been expanded to provide service to the western and northern parts of the island. On St. Croix, the system primarily serves Frederiksted and Christiansted. On St. John, which receives its water from St. Thomas via a reinforced underwater distribution pipe, the water system serves only Cruz Bay.

Rainwater cisterns

Approximately 95 percent of the Territory’s residents collect rainwater and store it in cisterns attached to their homes or businesses. These cisterns function as manmade wells, are privately owned and operated, and vary widely in capacity. Cisterns are generally one of two types: concrete holding tanks lined in waterproof coating and placed underground or plastic tanks located either above ground or buried. Rainwater is generally collected from a rooftop drainage system, which routes the water down to the cistern from which electric pumps send the water into plumbing systems. Cisterns commonly provide all running water for homes, including toilets, sinks, dishwashers, washing machines, and showers, but are generally not used for drinking water. In the event of a drought (or leak in the cistern tank), residents purchase water from WAPA to refill cisterns. Private water haulers deliver WAPA water in large tanker trucks and pump it into customers' cisterns; typically, customers pay the third-party water haulers both for the water and delivery, and the water haulers purchase the water directly from WAPA.

Cisterns are subject to contamination because they are generally not sealed and thus exposed to the environment. Rooftop intake drains are usually
covered with a mesh screen to keep out larger animals and debris, but mosquitoes and frogs are frequent unwlited cistern residents. It is common practice throughout the Territory to treat cistern water with a cup or two of chlorine bleach to kill any animals, insects, or pathogens. This bleach treatment is in line with CDC guidelines for the safe treatment of collected rainwater. More advanced treatment systems can effectively treat cistern water to produce clean, potable water, but these are typically expensive and thus less common; these include UV treatment and a variety of filtration systems.

**Bottled water**

Most Virgin Islanders rely on bottled water purchased in stores for their drinking water. On St. Croix and St. Thomas, WAPA or well water is re-filtered and bottled, and certified by the Department of Health (VIDOH) for use. The use of bottled water in small bottles and jugs contributes to the Territory’s plastic waste problem.

**Privately owned “small systems”**

Because WAPA does not provide potable water in all areas, between 50 and 80 percent of the hotels and condominiums in the USVI produce their own water, usually by using small reverse osmosis units.

**Regulation**

Three main bodies regulate water in the USVI: the Department of Planning and Natural Resources (DPNR), Public Service Commission (PSC), and the Department of Health (VIDOH).

DPNR and PSC regulate WAPA—the former on water quality, the latter on rates. DPNR’s regulation under the federal Safe Drinking Water Act, which DPNR enforces on behalf of the Environmental Protection Agency (EPA), requires WAPA to collect daily water samples from all parts of its system and to send them to its EPA-certified lab to ensure that the levels of turbidity (cloudiness or haziness of the water), pH (acidity), E. coli, and other contaminants fall within regulated ranges. PSC’s regulation sets WAPA’s rates. The PSC also represents WAPA’s consumers in any issues related to rates and terms of service.

VIDOH regulates bottled water resellers. It issues their permits and has the right to inspect their premises and either issue fines or retract permits if it finds any violations.

Finally, DPNR also regulates cisterns, water haulers, and well providers. At present, there is no system in place for cistern testing and inspection.

**Funding, planning, and budgeting**

The majority of WAPA’s water budget comes from federal grants: the EPA provides 95 percent of WAPA’s system maintenance and rehabilitation funding based on a needs survey that the agency conducts every four years. WAPA does not rely on residential service revenue to any meaningful extent, as service fees are insufficient to support, maintain, and operate the system—let alone expand it.

WAPA has both a capital plan and a 20-year strategy plan that is about 25 percent accomplished. Capital projects are roughly 25 years behind schedule primarily due to funding issues: among other constraints, WAPA had no capital market access for the last 10 years. WAPA’s deteriorating cash position has been a problem, too: when the authority contracts with vendors that require upfront payment, payment issues lead to project delays.

**IMPACT OF THE HURRICANES**

Hurricanes Irma and Maria affected nearly all water facilities across the Territory to some extent. Both the public infrastructure and private facilities suffered storm and flood damage, and the extended commercial power outages also impacted the production, delivery, and availability of potable water. The initial response focused on plugging pipeline and tank leaks, as well as getting the service stations for water haulers back up and running. Water quality sampling restarted three days after the storms, and WAPA put its emergency water-monitoring plan into effect at each island’s lab. Roadways blocked by storm debris and downed power and communications lines delayed WAPA’s response and damage assessments across the Territory for the first couple of weeks after the storms. Full restoration of the system was accomplished within a month.

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2 According to the EPA, “The Safe Drinking Water Act (SDWA) is the federal law that protects public drinking water supplies throughout the nation. Under the SDWA, EPA sets standards for drinking water quality and with its partners implements various technical and financial programs to ensure drinking water safety.”
Water production

Reverse osmosis plants need electricity to operate, and because the hurricanes led to Territory-wide power outages, potable water production was halted on both islands. On St. Thomas, poor water quality resulting from stormwater runoff into Crown Bay from which WAPA pumps water for desalination was another constraint. The water system ran on reserves in storage tanks until water production was restarted 48 hours after Hurricane Maria on St. Croix and 10 days after Hurricane Irma on St. Thomas.

Storage tanks

On St. Croix, there were problems with tank damage as well as with topping tanks off before the storms. WAPA’s hurricane plan requires the topping off because full tanks are not only essential for post-storm recovery but also weather storms better. However, pumping issues and necessary repairs to the 5 MG Mountain Tank that serves the western end of St. Croix’s distribution meant that St. Croix tanks were at roughly 75 percent capacity when Hurricane Irma hit and at 50 percent when Hurricane Maria hit. After Hurricane Maria, the 5 MG Mountain Tank, 5 MG Kingshill Tank, and 2 MG Mon Bijou Tank were emptied to make repairs. Post-hurricane mechanical failures at two of the main pump stations made it impossible to fill these three tanks, leaving the St. Croix system operating at 50 percent capacity for months after the storms. Storm debris also hindered access to the tanks, and, while most were cleared within the first few days after the hurricanes passed, debris limited access to one tank for nearly four months.

On St. Thomas, all of the storage tanks suffered some damage during the hurricanes. One of the tanks serving the Altona community lost its roof, but was still in service for a month after the storm. Another suffered weatherhead (overhead power line connection point) damage, leaving it without utility power. Yet another (Tank 3) was damaged and taken out of service in October 2017 due to a water quality issue and remained offline as of June 2018. All St. Thomas tanks had been filled prior to Hurricane Irma’s landfall.

Pump stations

On St. Croix, Hurricane Irma did not cause any major systems damage, but the Concordia pump station was impacted and down for six to eight days. Hurricane Maria, however, caused significant damage throughout the system—especially due to its impact on power supply. The Richmond pump station—the main one on St. Croix—was the only St. Croix station not to lose power because underground power lines serve it. None of the other pump stations had backup generators though; nor did WAPA have agreements in place with contractors to purchase generators to supply emergency power. Even with electricity at the system’s center, the Richmond station could not distribute water through the system to the other stations, which need power to pump water from the tanks to their gravity feeds.

On St. Thomas, the main pump station at Sarah Hill went offline during Hurricane Irma when its generator tripped. Storm conditions made it too dangerous to attempt to reset it during the storm—and, unlike on St. Croix, the water stored in St. Thomas tanks is not chlorinated until it leaves the tanks, so once the generator trips, WAPA cannot maintain chlorination and must shut down the system after four hours. As a result, the Sarah Hill system was shut down from 11 p.m. on September 6 until it could be restarted around 6 a.m. on September 7. Several WAPA staff weathered the storm at the Sarah Hill facilities, enabling a quick restart to the system once it was safe for personnel to move about. On the east end of the island, underground power lines serve Donoe Pump Station, which feeds the Donoe Tank and the underwater...
pipeline to St. John—so power to that station was restored quickly. Elsewhere on the island, every other pump station suffered some form of physical damage, and the Sototown station was completely destroyed. The stations also suffered from power outages as they were not equipped with backup generators.

Distribution system

On all of the main islands that the water system serves, the hurricanes’ strong winds and torrential rain ripped trees and utility poles out of the ground, damaging the underground pipelines and creating many leaks. Soil erosion and caved streets damaged pipelines as well. In some instances, lines were severed completely, so pipes were sending water back into the sea. The pipelines on the western end of St. Croix suffered a particularly high number of leaks related to the storm.

Service impact

On St. Croix, facilities have chlorinated tanks, so the water in the tanks was usable immediately following the storms even with power outages, but intermittent water service and distribution issues led to a boil-water advisory for several months. Districts at the highest elevations were most likely to be without service, with the system struggling to support any pumps requiring above 80 psi. While the number of people affected overall is difficult to calculate, service was disrupted to nine of St. Croix’s 13 districts. Hanging power lines and impassable roads hindered water haulers and WAPA personnel alike for the first two weeks following the storms. In one instance, FEMA requested water, but water trucks could not safely reach FEMA personnel. The water needs of the large cruise ship housing response workers docked in St. Croix’s Frederiksted posed a strain on the system, too: Frederiksted pier is at the lowest elevation point and is served by the 5 MG Mountain Tank (which was empty for repairs) under normal operations, and Mountain Tank is fed, in turn, by Kingshill Tank. Because of the low tank levels and the empty Mountain Tank, once the ship started taking water, there was no other water in the system. Pumping water to the ship hindered the effort to fill Kingshill, leaving the residents on the western side of St. Croix with intermittent low pressure or no service for approximately two weeks after Hurricane Maria.

On St. Thomas, nearly all the pump stations faced a lack of power—but because the tanks had been topped off before the storms they were able to keep the system running until the pump stations were back online, at least for those customers that could be supplied with gravity feeds. Many customers also experienced interruptions that were related to service line leaks from uprooted trees and debris removal.

On St. John, the water facilities did not suffer much damage, and an emergency generator kept the systems online. The biggest issue for St. John was the lack of communication as a result of the island-wide communications and power outages. Because the commercial inter-island ferry service was not yet operating in the days after Hurricane Irma, WAPA personnel had to rely on federal assets to access the island. Despite the significant damage to St. John overall, the island still had water service during the storms.

On all main islands, response to storm damage was hindered by the absence of staff members who were dealing with the storms’ effects on their personal lives and homes, as well as by debris blocking roadways. The full restoration of the system in both districts was accomplished within a month of the storms.

Impact on rainwater cisterns, wells, and small RO systems

Storm damage to home and business roofs and gutters left many cisterns unable to collect rainwater and unprotected from contamination caused by debris and storm surge water. The commercial power outage also meant most cistern pumps did not have power, so residents did not have running water, but could access collected cistern water by hand dipping with buckets. Where residents and businesses relied on wells, lack of electricity halted access unless backup generators were available. Where—as in some hotels—small reverse osmosis systems were installed, storm water runoff into the bays interrupted water production, and storm damage to facilities and power outages caused problems as well.

Impact on bottled water

Most residents rely on bottled water for drinking; bottled water was in high demand following both hurricanes. Residents had difficulty accessing bottled water as a result of short curfew windows, lack of electricity (which meant no credit or debit card transactions), and lack of access to cash (because banks could not process transactions).
FUTURE CHALLENGES RESULTING FROM CLIMATE CHANGE

Future climate challenges to the US Virgin Islands include stronger and potentially more frequent hurricanes, as well as rising sea levels, higher temperatures, and decreased rainfall. All of these pose some threat to the potable water infrastructure of the USVI: hurricane winds, rainfall, and storm surge—as well as rising sea levels—represent a significant threat to infrastructure and service continuity, while higher temperatures and decreased rainfall pose moderate threats to water production and storage.

Hurricane winds, rainfall, and storm surge

Winds can destroy water infrastructure located anywhere in the Territory: in the 2017 hurricanes, at least one pump station was destroyed completely. Rains—together with wind—can damage roads and uproot trees, damaging water mains. Finally, storm surge presents a risk to facilities located near the coast: flooding can damage reverse osmosis plants and compromise electrical infrastructure in storage tanks and pump stations. It can also contaminate non-chlorinated tank water.

Rising sea levels

Rising sea levels do not pose a major threat for the system by themselves, at least at the levels predicted by the 2050s—but they do have the potential to worsen the effects of storm surge and threaten low-lying infrastructure that would not have been threatened before.

Increases in temperature

Increases in average temperature will increase potable water demand across the Territory. Additionally, higher average temperatures will increase the amount of stored water lost to evaporation both for WAPA and private residents.

Changes in precipitation

Longer dry spells can create problems for residents relying on water cisterns and increase demand for water production at RO plants as well as for the services of water delivery trucks that will have to supply residents who run out of water.

INITIATIVES FOR INCREASING RESILIENCE IN WATER

Preparing for future climate risks to the Territory’s water supply will require hardening the existing system’s infrastructure, expanding the system to better serve some of the existing communities and to include new ones, and better preparing for the inevitable disruption that future storms will bring.

HARDEN THE EXISTING SYSTEM

The first set of initiatives will harden the system that now exists, focusing on rehabilitating aging pipes in the distribution system, hardening all other water system components, and setting up a testing program for private cisterns in the Territory.

Initiative 1

Harden and rehabilitate the existing distribution system

The majority of the water distribution system in the USVI is old ductile iron pipe installed as far back as the 1940s. These pipes have reached the end of their useful lives: the lines are fragile and, during and after the hurricanes, they were easily damaged by uprooted trees and water hammer effect when water pressure returned to empty pipelines.

WAPA will rehabilitate the existing problem areas using federal funds through a combination of pipe replacement and pipe inspection and repair to
fix high rates of leakage. WAPA will also inspect and assess the distribution network to ensure that pipelines are minimally threatened by trees, roads, and other infrastructure failure, as well as work with the Department of Public Works to ensure that water mains running under and alongside roads are securely installed. Finally, the utility will complete a Supervisory Control and Data Acquisition (SCADA) system to better control and monitor the distribution system.

Initiative 2

Harden and rehabilitate pump stations, storage tanks, and administrative buildings

During the 2017 hurricanes, pump stations, storage tanks, and administrative buildings proved vulnerable to physical damage and—in the case of one pump station on St. Thomas—complete destruction. To protect the pump stations and administrative buildings, WAPA, working with DPNR, will ensure that all pump stations and buildings are built or upgraded to highest hurricane codes. To protect the storage tanks, the utility will construct wind girders and seismic zone fittings to stiffen and strengthen them. WAPA will also perform rehabilitation structural work on the Recovery Tank on St. Croix, which had not been rehabilitated in more than 20 years.

Initiative 3

Develop a cistern testing program

DPNR has the authority to test private water storage cisterns in the Territory—but the department has so far not undertaken any large-scale testing. This makes it more likely that some cisterns will fail in future natural disasters, straining the WAPA system and increasing the demand for emergency water distribution. Considering the number of cisterns in the Territory and DPNR's resources, conducting a test of all cisterns in the Territory may not be feasible—but developing a program to test at least some cisterns is certainly possible, whether those would be cisterns in remote or low-income areas, cisterns above a certain size, cisterns of a particular type, or some combination of these or other criteria. DPNR, working with the Governor’s Office, will develop a cistern testing program that will strike a balance between the department’s capacities and the need for cistern oversight. On St. John, a local nonprofit called Love City Strong will be setting up free testing for low- and moderate-income (LMI) residents and affordable testing for all others.

EXPAND THE SYSTEM

Expanding the system will include better serving communities that the system serves now and adding new communities to it—as well as updating planning documents to better prepare for future demand.

Initiative 4

Expand the water system to serve isolated communities

After the hurricanes, water supply systems in some hotels and condominiums failed because of physical damage to water equipment, lack of power, or both. Water to those users had to be hauled by truck, which was extremely difficult with roads blocked by debris. To address the issue, WAPA is considering several projects to extend the distribution system on all three primary islands that the water system serves. The total funding request to support these projects adds up to $88.7 million; which projects will ultimately get built will depend on the USVI Government’s decisions about allocating FEMA's hazard mitigation funds that would fund these projects (see table: Proposed water distribution system expansion projects).

Initiative 5

Strengthen water infrastructure on the west end of St. Croix

On St. Croix, the west end of the island is supplied by the Kingshill Tank, which gravity feeds to Frederiksted. The tank went empty immediately after Hurricane Maria, so it was difficult to fill the tank and maintain needed water for customers in the west end of the island. WAPA will, subject to availability of funding, construct a main transmission line from Richmond Pump Station to Frederiksted in addition to connecting the north shore transmission to mid-island and western distribution. This would provide a duplicate means of getting water to the west end while creating loops in the system that would increase efficiencies. The authority will also add a 5 MG storage tank to feed Frederiksted in the event of a disaster.
Initiative 6
Develop a new distribution master plan

WAPA’s distribution master plan is a long-term planning document that outlines projects that need to be completed to address the system’s future growth. The current plan is 31 years old and does not adequately address the system’s needs. WAPA will develop a new distribution master plan.

PREPARE FOR HURRICANES

Regardless of the degree of preparation and hardening, future strong storms will cause at least some disruption—including to the Territory’s power system. The purpose of these initiatives is to reduce the impact of those disruptions.

Initiative 7
Install backup generators at all major pump stations

After the 2017 hurricanes, WAPA could not produce and distribute water at its full capacity because of the widespread power outages. Even when the main pump stations had power, many distribution pumps did not. WAPA will install, at all major pump stations, backup generators designed to withstand long runtimes and installed to automatically turn on during power outages. On St. Thomas-St. John, the pump stations include: Donoe, Contant Knolls, Jail/Tank 2, Bergs Home, Altona, Savan, Vester Gade, Roberts Pump, Lindbergh Bay, Estate Thomas, Havensight, Standpipe, and Sototown. On St. Croix, the stations include: Richmond, Contentment, Concordia, and Mt. Welcome.

Initiative 8
Develop a water safety public education program

After storms, residents might need to use water in ways that they are not used to—for example, by boiling water from WAPA’s supply and by adding more bleach than usual to their cisterns. However, not all residents may know exactly what they are supposed to do and when. WAPA will work with DPNR and, when possible, local nonprofits to develop a public education program to explain to USVI residents what they need to do before and after storms to keep their water supply safe.

Proposed water distribution system expansion projects

<table>
<thead>
<tr>
<th>Priority</th>
<th>Project</th>
<th>Cost in millions</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>Nazareth Waterline extension (St. Thomas)</td>
<td>$4.7</td>
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<tr>
<td>2</td>
<td>Bolongo Waterline extension (St. Thomas)</td>
<td>$3.4</td>
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<td>3</td>
<td>East End 16 inch expansion (St. Croix)</td>
<td>$1.7</td>
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<tr>
<td>4</td>
<td>Raphune Hill bypass (St. Thomas)</td>
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<tr>
<td>5</td>
<td>Lovenland WL extension (St. Thomas)</td>
<td>$12.5</td>
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<td>6</td>
<td>Fortuna (New Road Route) WL extension (St. Thomas)</td>
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<td>7</td>
<td>Pond Bay Line extension (St. John)</td>
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<tr>
<td></td>
<td>Total</td>
<td>$88.8</td>
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Initiative 9

**Develop a water rationing plan**

WAPA does not currently have a water rationing plan. After the 2017 hurricanes, when water supply was constrained, the absence of such a plan meant that for many communities having or not having water was a matter of chance. WAPA will work with VITEMA to develop a water rationing plan that will include the isolation of major valves to ensure communities are fed from assigned tanks at various times during the day in order to conserve water. The plan will also include a communication component to make sure that, after a major storm, communities are aware of when they can expect water to flow.

Initiative 10

**Develop a 72-hour pre-landfall playbook**

Before a storm arrives, WAPA can take standard precautions to ensure maximum resilience afterwards. During the hurricane season, water distribution already operates with all tanks at 80 percent capacity, with the ability to increase capacity to ensure all tanks are topped off 72 hours before a landfall. Additional measures can include ensuring that all backup generators are topped off and functioning as well as pre-landfall inspections of tanks and pump stations. WAPA, working with VITEMA, will develop a 72-hour pre-landfall playbook and integrate the steps in it into VITEMA’s WebEOC platform. VITEMA will be responsible for ensuring the steps in the playbook are followed.

Initiative 11

**Form water sharing partnerships with private facilities**

Seven Seas’ RO facilities are by far the largest in the Territory, but they are not the only ones. In the event of future damage either to the facilities or to the distribution networks that they feed, it would be helpful to have additional water supply options—especially in the more remote communities. WAPA will contact private facilities with reverse osmosis systems (hotels and resorts) to discuss forming voluntary partnerships to share water during emergencies, including potentially serving as distribution points for water haulers and residents.