Natural Resources

Contents

Overview

The U.S. Virgin Islands is made up of a variety of ecosystems, from subtropical forests to sandy beaches. Freshwater ponds and guts dot the landscape, supporting unique flora and fauna which have adapted to these ecosystems. The coasts of the U.S. Virgin Islands are fringed with biologically diverse mangrove systems, home to resident and migratory birds. Mangrove forests are connected to seagrass beds and coral reefs and are the nurseries for countless fish and invertebrates that eventually mature and thrive in the adjacent habitats. The islands' unique resources define the Territory as an ecologically rich and biodiverse region, but land and water resources in the U.S. Virgin Islands are finite. The health of these different resource types are intrinsically linked to one another. Excessive development on upland resources, for example, can lead to increased sedimentation which degrades water quality downstream, harming aquatic ecosystems. It will be important to think holistically about the future of these natural resource areas to ensure that the region develops sustainably. Ultimately, decisions made regarding the use and protection of natural resources will define the future of the region.

Land Features

Topography

The topography of the U.S. Virgin Islands has played a major role in determining the extent of where and how development can occur in the Territory.

The U.S. Virgin Islands are part of the Greater Antilles, an extension of the central fault-block mountain ranges of Puerto Rico. Volcanic mountains dominate the topography on St. John and St. Thomas, and steep slopes are characteristic of the two islands (U.S. Department of Agriculture, 2000). During the Pleistocene, St. Thomas, St. John, their satellite cays, the British Virgin Islands, and Puerto Rico (but not St. Croix) were connected as a single land mass approximately twice the area of Puerto Rico today. Rising water levels separated the islands into the archipelago of the Puerto Rico Bank around 8,000 years ago. For this reason, the mountains on St. Croix are less rugged than those on St. John and St. Thomas, a reflection of the different geologic history of the region (Platenberg and Boulon, 2006). On St. John, approximately 80% of the land surface exceeds a slope of 35 degrees. On St. Croix, roughly 50% of the land surface exceeds a slope of 25 degrees. On St. Thomas, more than 70% of the land surface has a slope that exceeds 35 degrees (DPNR and USDA NRCS, 1998). The steep, rugged mountains on St. Croix are confined to the north, with broad alluvial plains underlain with marine sediments derived from ancient coral reefs to the south. The northern mountainous areas of St. Croix contain narrow, steep-sided valleys with rocky outcroppings (Renken et al., 2002). The highest peak of St. John is Bordeaux Mountain with an elevation of 1,297 feet, the highest peak of St. Thomas is Crown Mountain with an elevation of 1,556 feet, and the

St. Thomas coastline (Pixabay).

highest point of St. Croix is Mount Eagle with an elevation of 1,088 feet (U.S. Department of Agriculture, 2000).

Geology

The geologic features of the U.S. Virgin Islands define the topography, hydrology, and soils of the Territory, directly determining the viability of areas for development.

The U.S. Virgin Islands are primarily comprised of metamorphosed igneous and sedimentary rocks with deposits of limestone and alluvium. They were formed by folding, uplift, and weathering events over millions of years (Thomas and Devine, 2005). The geology of the U.S. Virgin Islands is a major factor influencing the hydrology and forest cover of the islands. Steep slopes and impermeable bed rock make the USVI prone to flash flooding as rain can travel from mountain tops to the sea in a single day (Adams and Hefner, n.d.).

Trunk Bay in St. John (Cyrus Crossan/Unsplash).

On St. Thomas, the main geologic formation is the Louisenhoj formation (Lower Cretaceous). The rocks that make up this formation are volcanic breccia, tuff, and conglomerate from the Upper Cretaceous period. There are also pockets of Alluvium (Holocene), which is primarily gravel and sand and the Tutu Formation (Lower Cretaceous), which is volcanic wacke (Alminas et al., 1994). St. John's visible geologic history ranges from Lower Cretaceous submarine volcanic eruptions to modern-day surface deposits which make up the island's beaches and alluvial plains. Most of St. John is composed of volcanic rocks (*e.g.,* basalt and andesite) or sedimentary material derived from these rocks. Calcareous rocks and chert are also present in small amounts on St. John, and stratified rocks, except for recent deposits, are Cretaceous age. Dikes, sills, and batholiths of Tertiary age have intruded these rocks as well (Rankin, 2002). St. Croix is underlain by strongly folded Upper Cretaceous rocks which have experienced low-grade regional metamorphism, gently folded unmetamorphosed Tertiary sedimentary rocks, and igneous intrusions with contact- metamorphic aureoles of Late Cretaceous or Early Tertiary age (Whetten, 1966).

Soils

Already a finite resource in the U.S. Virgin Islands, development on soils that have drainage issues can lead to increased runoff pollution which impacts the health of neighboring ecosystems.

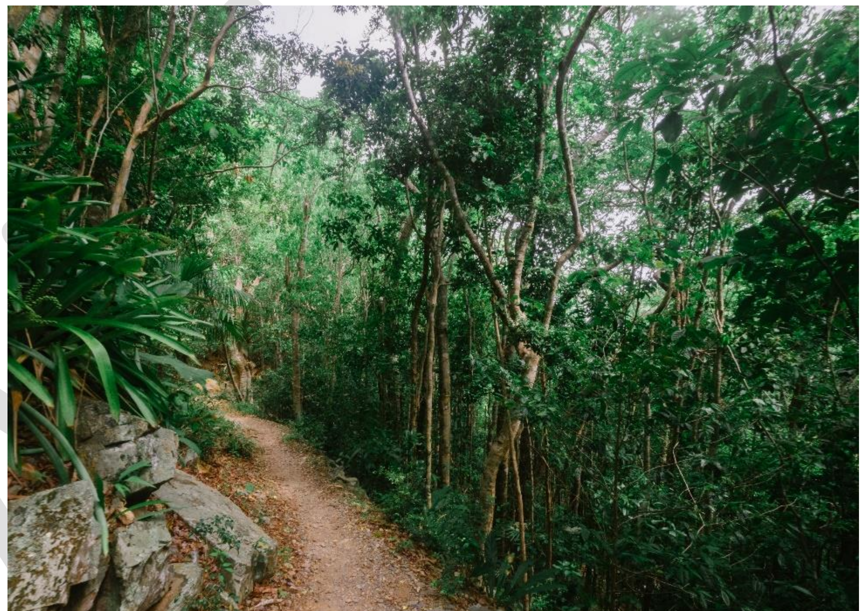
The majority of soil layers in the U.S. Virgin Islands are thin and highly erodible, making them a particularly critical resource to protect. Of the five U.S. Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS) Soil Survey Geographic Database (SSURGO) soil orders currently recognized in the U.S. Virgin Islands, Inceptisols cover 24.9%, Mollisols cover 63.6%, Alfisols cover 4.7%, Vertisols cover 3.1%, and Entisols cover 3.7% of the total land area across all the islands (González et al., 2020). The U.S. Virgin Islands are dominated by rock fragments, fine-grained sediments, and caliche soils that are held together by mineral particles. The major component of soils in the U.S. Virgin Islands is clay. The colloidal nature of the clays inhibits them from settling promptly, resulting in significant sediment runoff into coastal waters (DPNR and USDA NRCS, 1998). These soils have generally poor drainage, creating problems for crop production as well. Soils suitable for infiltration have lower rates of runoff during precipitation events, meaning they are less susceptible to cause sedimentation issues in nearby surface waterbodies (DPNR and USDA NRCS, 1998).

U.S. Virgin Islands Victory soil profile (NRCS).

The NRCS has classified soils in the U.S. Virgin Islands by four hydrologic soil groups which are denoted by the letters A, B, C, and D, which refer to the runoff potential of the soil. A soils have the lowest runoff potential and D soils have the highest runoff potential. Approximately two-thirds of the U.S. Virgin Islands has D soils and only approximately 10% has an A or B designation (DPNR and USDA NRCS, 1998). Most of the soils in St. John are either Hydrologic Soil Group (HSG) A, B, or D. HSG A and B soils are typically suitable for infiltration, while HSB D soils are not (NRCS, 2006). St. John has one dominant soil association, Cramer-Isaac. The surface soil zone is usually thin, particularly on mountain slopes, and comprised of silt and clay particles (Graves, 1996). Soils are thicker in valley areas on St. John and in all locations covered by the weathered rock zone (Cosner, 1972). The majority of soils in St. Thomas are either HSG B or D, which are not likely good for infiltration. Pockets of HSG B soils exist in the flatter alluvial valleys and along the coast. A majority of soils in St. Thomas are a combination of 2 different kinds over varying slopes: Dorothea-Susannaberg complex and Fredriksdal-Susannaberg complex. Fredriksdal-Susannaberg complex soils have 40 to 60 percent slopes that are extremely stony. Dorothea-Susannaberg complex is also present on St. Thomas with 40 to 90 percent slopes that are extremely stony. Based on NRCS soil classifications, most of the land on St. Thomas is highly erodible (NRCS, 2006). The soils on the hilltops and side slopes in St. Croix are generally shallow, well drained loams. Most of the soils in St. Croix are classified as Southgate-Victory-Cramer. Most of these areas are classified as HSG B soils, which are suitable for infiltration. Victory soils are formed from weathered bedrock, have a low to medium fertility, and can be slightly acidic. Weathered friable bedrock material is commonly observed at road cuts, summits, and other areas of exposure. Victory soils are unsuitable for crop cultivation and therefore, these areas are typically used as rangeland, pasture, or residential development. According to the USDA Soil Survey, the majority of the soils in the coastal plains areas on St. Croix are classified as Glynn-Hogensborg (NRCS, 2006).

Terrestrial Resources

The U.S. Virgin Islands has an abundance of unique terrestrial resources that define the U.S. Virgin Islands. Collectively, these resources provide significant ecological habitats, provide benefits to humans such as shade and carbon sequestration benefits, and more, as described in more detail in the following sections. All of these resources are connected to one another and are subject to threats from many sources.



U.S. Virgin Islands forest (Cyrus Crossan/Unsplash).

It is important to note that the U.S. Virgin Islands has unique protections in place to protect many important terrestrial resources. The U.S. Virgin Islands has designated territorial government protections for several wildlife sanctuaries, territorial parks, and marine reserves (DFW and NOAA, n.d.). In addition, the U.S. Virgin Islands is home to a number of federally protected parks and national monuments, including properties overseen by the National Park Service and the U.S. Fish and Wildlife, in addition to conservation lands that are protected by non-profit organizations such as The Nature Conservancy. Designating Areas of Particular Concern (APC) is another tool the U.S. Virgin Islands has for land and water use protection. APCs are geographical areas that are environmentally sensitive or provide significant environmental value. There are special requirements and considerations for any development that occurs within an APC, and some APCs are protected from development altogether (Pittman, 2014).

Offshore Cays

Because of their relatively small area and typically unique species assemblages, cays are particularly vulnerable habitats, making it imperative that long-range land and water use plans ensure the protection and progressive management of offshore cays.

The offshore cays around the three main islands of St. Croix, St. John, and St. Thomas are for the most part uninhabited and in part because of their isolation, they provide habitat for many endangered, at-risk, and threatened species including many resident and migratory species of endemic reptiles, seabirds, shorebirds, and plants (Murry et al., 2019). More than 50 islands and cays dot the perimeter of the U.S. Virgin Islands, in total comprising approximately 3% of the land area of the U.S. Virgin Islands (Platenberg and Boulon, 2006). The cays are critical to the ecology of the U.S. Virgin Islands, often providing habitats that would not otherwise be found on the three main islands. For example, the cays provide habitat for the endangered St. Croix ground lizard, sea turtles, and spawning habitat for coral reef organisms. The cays also provide particularly important habitat for native bird species, providing prime nesting habitat for approximately 99% of the islands' seabird populations. Major U.S. Virgin Islands seabird nesting areas are found on 25 of the most remote cays off St. Thomas and St. John (DFW and NOAA, n.d.). In addition to their ecological importance, offshore cays also have social, economic, and cultural value. Their position on the coast can dissipate wave and storm energy, reducing impacts to coastal communities on nearby islands. In addition, the ecosystems associated with offshore cays also provide nursery habitats for commercially important fish and invertebrates that support local artisanal and recreational fisheries (Murry et al., 2019).

Offshore cays near St. John (Robert English/Flickr).

Conditions and Threats

Invasive species are one of the major threats to offshore cays, including invasive plants that alter habitat conditions and invasive mammals. Goats severely degrade vegetative communities through grazing, as do rats to a lesser degree. Exotic mongoose prey on a wide range of native animals with severe impacts. Recreational and commercial uses by humans, as well as marine debris and harmful algal blooms, also pose a significant threat to the offshore cay habitats and native species. In addition, cays are threatened by the impacts of climate change including drought, rising sea levels, and more intense and frequent storms (Murry et al., 2019).

Management

All 33 territorially owned offshore cays have been designated as wildlife sanctuaries to protect the unique habitats that these islands provide. The V.I. Department of Planning and Natural Resources' (DPNR) Division of Fish and Wildlife (DFW) is responsible for overseeing the management and protection of the territorially owned offshore cays. There are also several cays that are under federal government ownership and protection by the U.S. Fish and Wildlife Service and the National Park Service. There are also a number of privately owned cays under threat of development (DFW and NOAA, n.d.).

Forests

Development has fragmented large areas of forests in the U.S. Virgin Islands, resulting in significant impacts to wetlands and inshore marine habitats.

Forests are the largest habitat across the three main islands. Forests primarily fall into two main categories in the territory, dry subtropical forest and subtropical moist forest, with the latter primarily located at higher elevations and along riparian corridors (Platenberg and Valiulis, 2018). Up to 16 terrestrial mammal species, 8 amphibian species (including the endangered and endemic St. Croix ground lizard and Virgin Islands tree boa), and 99 bird species are associated with forest habitats in the U.S. Virgin Islands and as many as 1,769 insect species have been documented on the islands (McGinley et al., 2017). Additionally, 13 plant and 22 animal species native to the U.S. Virgin Islands are on the International Union for Conservation of Nature's (IUCN) Red List (IUCN, 2015)[1]. In addition to providing critical habitat, forests also help to sequester carbon which mitigates the effects of climate change, provide shade from canopy which mitigates heat, stabilize soil, and filter stormwater. Historically, forest coverage across all three islands has fluctuated depending on the extent and type of development that has taken place. Today, St. John is approximately 81% forested (Marcano-Vega and Williamson, 2017). St. Croix is approximately 56% forested, with most of these forests centered on the northwestern end of island. St. Thomas is approximately 44% forested (Brandeis and Turner, 2013; Marcano-Vega and Williamson, 2017). Hurricanes Irma and Maria caused widespread damage to forests in 2017 (Platenberg and Valiulis, 2018).

St. Thomas forest landscape (Pixabay).

[1] The IUCN Red List is an indicator of the health of the world's biodiversity. It provides information about range, population size, habitat and ecology, use and/or trade, threats, and conservation actions that can help inform necessary conservation decisions.

Conditions and Threats

Recent commercial and residential development has fragmented large areas of forests in the U.S. Virgin Islands, resulting in increased soil erosion, sedimentation, surface temperatures, and the eutrophication of wetlands and inshore marine habitats (Ramos-Scharrón and MacDonald, 2005; Ramos-Scharrón and MacDonald, 2007; Chakroff, 2010; Stein et. al, 2014). In the past decade, young secondary forests have been increasingly cleared for the expansion of urban areas, dispersed housing developments, and expansion of tourism-related infrastructure such as resorts and golf courses (Brandeis and Oswalt, 2007). For example, between 1994 and 2004, 11% of St. Croix's subtropical dry forest was lost, while St. Thomas lost 13% of its subtropical dry forest (Brandeis and Oswalt, 2007). The effects of habitat fragmentation on wildlife in forests include decreased carrying capacity for wildlife populations and decreased dispersal and gene flow among fragmented populations. Contiguous forest (large swathes of forest that are close though not always adjacent to other forests) and transitional forest (areas that are shifting to forest from agricultural or other uses) are most threatened by conversions to development (Chakroff, 2010). Most of the U.S. Virgin Islands forests are privately owned, a concern for future development potential in some cases (Kennaway et. al, 2008). Loss of forest cover also curtails the ecosystem services that these resources provide, such as flood and erosion control, and carbon sequestration (Chakroff, 2010). Invasive species pose another significant threat to forest ecosystems in the U.S. Virgin Islands. Historically, the U.S. Virgin Islands has also experienced losses and declines in biodiversity due to invasives (Division of Fish and Wildlife, 2016). Invasive species are identified as the second leading cause of biodiversity loss in the U.S. Virgin Islands (The Nature Conservancy, 2003). The U.S. Forest Service found tan tan (*Leucaena leucocephala*), an invasive woody plant, to be the single most common plant in the U.S. Virgin Islands (Daley et al., 2012). The effective management of invasives will be critical to ensuring the health of forest ecosystems in the U.S. Virgin Islands. Climate change is another threat to forests, changing weather patterns, resulting in longer dry seasons, wildfires, and severe rainfall events, such as hurricanes and tropical storms, that decimate trees and wash away soils (Platenberg and Valiulis, 2018).

St. Thomas tropical vista (Silver Voyager/FreeImagesLive).

Management

The V.I. Department of Agriculture (VIDA) Division of Forestry is tasked with the protection and management of forested lands and administers several programs to enhance forest resources

(Platenberg and Valiulis, 2018). In addition, forests in federally protected areas (National Park Service and U.S. Fish and Wildlife Service) are managed by these agencies. It is important to note that a significant portion of forested land is privately owned and not managed for forest activities (Chakroff, 2010).

Shrublands and Grasslands

Development has fragmented large areas of shrublands and grasslands, resulting in significant impacts for local flora and fauna.

Shrublands and grasslands are low, bushy habitats of grasses, shrubs, cacti, and other low-lying plant species found in environments that are stressed from extreme conditions, such as strong winds, or areas that have been disturbed by agriculture or land use changes. Shrublands and grasslands are often viewed as a transitional ecosystem as land becomes reforested or as conditions dry out (Platenberg and Valiulis, 2018). Shrublands and grasslands provide a range of ecological services, including wildlife habitat, such as cover for ground nesting birds, and mature plant communities (Lugo and Helmer, 2004). Shrublands and grasslands also control erosion which is critical during major storm events when precipitation levels are extreme (Platenberg and Valiulis, 2018). Shrublands and grasslands are fairly uncommon on the more heavily forested and steeply sloped St. Thomas and St. John, but they are dominant habitats on cays and previously disturbed sites on these islands. Shrublands and grasslands are more abundant on St. Croix, which has an extensive agricultural history. Within the entire territory, these habitats comprise approximately 34.12% of all habitat types (Gould et al., 2013).

Shrublands and grasslands near the Great Pond in St. Croix (Horsley Witten Group).

Conditions and Threats

Development has fragmented large areas of shrublands and grasslands, resulting in increased surface temperatures, soil erosion, sedimentation, and eutrophication of wetlands and inshore marine habitats. The effects of habitat fragmentation on wildlife include decreased carrying capacity for wildlife populations and decreased dispersal and gene flow among fragmented populations. Wildfires, primarily on St. Croix, pose another increasing threat to these ecosystems under drought conditions, which are becoming more frequent and prolonged with climate change. The introduction of exotic plant species poses another threat to native grasslands and shrublands, altering habitat composition and impacting the wildlife that call these ecosystems home (Platenberg and Valiulis, 2018).

Management

The V.I. Department of Planning and Natural Resources (DPNR), and in particular the Division of Fisheries and Wildlife (DFW), is responsible for overseeing vegetative management actions which impact shrublands and grasslands (Platenberg and Valiulis, 2018).

Freshwater Ponds

Due to steep topography and shallow soils, most of the freshwater ponds that exist in the U.S. Virgin Islands are manmade and highly susceptible to pollution from stormwater runoff and sedimentation from development.

A private pond in Bordeaux in St. Thomas (Royce Cheque of Green Ridge Guava Berry Farm).

St. Croix has the largest number of ponds of the islands, approximately 130 in total (Conservation Data Center, 2010). Many of the ponds in the territory were created for agricultural purposes using dams and impoundments. Today, many farms use these ponds as their primary source of water for irrigation and livestock. Some native (five bat species) and non-native mammals (deer, mongoose) use the ponds as sources of freshwater. Many indigenous and migratory waterbirds use freshwater ponds as habitats (Platenberg and Valiulis, 2018).

Conditions and Threats

One of the largest threats to the health of freshwater ponds is invasive species, primarily fish and plant species. Freshwater ponds are also threatened by water pollution, primarily from stormwater runoff and sedimentation (Platenberg and Valiulis, 2018). With climate change, the U.S. Virgin Islands is expected to become drier and experience more droughts, leading to a reduction in the water levels for many of these freshwater ponds (Gould et al., 2018).

Management

Agricultural ponds are managed and maintained by local farmers in conjunction with the V.I. Department of Agriculture (VIDA). Volunteer groups will occasionally clear invasive vegetation from ponds, although there are no formal management policies in place for these systems (Platenberg and Valiulis, 2018).

Watercourses (Guts)

There are no longer any perennial streams in the U.S. Virgin Islands, a recent loss that has been linked to development pressures on already strained resources.

Watercourses, known in the U.S. Virgin Islands as "guts," are defined natural channels formed by the steady flow of rain and stormwater over rock over an extended period of time. Guts are a strong defining characteristic of St. Thomas and St. John in particular (Gardner, 2008; Gardner et al., 2008).

Most guts only contain flowing water after rain events. Furthermore, many of the guts on the islands connect vegetated upland and marine systems since they drain from hills directly towards the ocean (Gardner et al., 2008). Vegetated guts can form "habitat corridors" that species may use for migration in urban areas. Guts provide nursery and nesting areas, are used for foraging, and are important watering holes and migration corridors (Gardner et al., 2008). Some guts have permanent freshwater pools that are home to a variety of aquatic species such as native freshwater shrimp. Furthermore, the forests associated with guts prevent soil erosion and the sedimentation of downstream habitats such as mangroves and coral reefs (Platenberg and Valiulis, 2018). Guts also mitigate the potential for flooding by quickly draining water that would otherwise flood adjacent lands (Gardner et al., 2008).

Conditions and Threats

Many of the guts in the U.S. Virgin Islands have been degraded and disrupted over the last few decades. Many guts were paved over in the past to abate flooding events and many today are completely covered by filled land or roadways, leading to increased water pollution and flooding from stormwater runoff over these impervious surfaces. Other threats to guts include climate change which has led to droughts and extreme rainfall events, changed drainage patterns via development, bacterial and nutrient contamination, improper solid waste disposal, sewage disposal, and agricultural waste disposal (Gardner et al., 2008). Downed and defoliated gut vegetation has increased the amount of direct sunlight exposure, causing water temperatures to rise in the immediate aftermath of storms and promoting algal growth in guts (Platenberg and Valiulis, 2018).

Reef Bay Trail gut in the Virgin Islands National Park in St. John (Daveynin/Flickr).

Management

The V.I. Department of Planning and Natural Resources (DPNR), and in particular the Division of Environmental Protection (DEP), are primarily responsible for the development and enforcement of regulations associated with guts (DEP, 2012). The V.I. Department of Agriculture (VIDA) is responsible for soil conservation practices on land under agriculture and, based on the Virgin Islands Code, maintaining buffer zones along guts. In addition, as mandated by the U.S. Virgin Islands Code, the V.I. Department of Public Works (DPW) engages with gut management through road development programs, gut cleaning programs, and flood mitigation projects for roads and properties in floodplains (Gardner et al., 2008).

Groundwater

Due in part to geologic composition and increasing development pressures over the last century, groundwater in the U.S. Virgin Islands is a scarce resource, directly impacting water supplies and endangering historic and evolutionarily co-evolved relationships in ecosystems across all of the islands.

In the U.S. Virgin Islands, groundwater is primarily present in three types of aquifers, typically under water table or semi-confined conditions: (1) carbonate rock system in St. Croix, known as the Kingshill aquifer system; (2) fractured volcanic bedrock; and (3) bedrock and alluvial deposits (DEP, 2012).

Kingshill Aquifer

The Kingshill aquifer is the largest and most productive aquifer in the U.S. Virgin Islands. The aquifer has an area of 25 square miles and accounts for approximately 67% of all groundwater withdrawals in St. Croix. Most of the groundwater exists at relatively shallow depths in unconsolidated alluvial sediments or in shallow limestone deposits. Depth to groundwater ranges from five to sixty feet below the surface. Well yields range from five to eighty gallons per minute (gpm). There are over 325 wells within the aquifer boundary, and it is estimated that the total production of the aquifer is 2.21 million gallons per day (gpd) and it is estimated that the aquifer can safely supply up to 2.5 million gpd (DEP, 2012).

Fractured Volcanic Bedrock Aquifers

Fractured volcanic bedrock aquifers are primarily located in the Tutu Valley and Sugar Estate areas of St. Thomas and in the Estate Adrian area on St. John. The Tutu aquifer in St. Thomas has the highest potential yield of any aquifer on the island, estimated at approximately 300,000 gallons per day. This aquifer is comprised of preferentially fractured bedrock overlain by unconsolidated alluvial material ranging from a few feet to tens of feet thick. Groundwater is held principally within the fractures in this bedrock with lesser amounts held in the upper weathered saphrolite and overlying unconsolidated deposits. The degree of saturation of the upper portions of the aquifer is dependent upon the intensity of pumping in the area and the overall climatic conditions (DEP, 2008).

Bedrock and Alluvial Deposit Aquifers

Bedrock and alluvial deposit aquifers, primarily located in the La Grange area of St. Croix, the Long Bay area of St. Thomas and the Coral Bay area of St. John, are at the base of the watersheds adjacent to the sea on all the islands. Groundwater is found in the interstitial spaces within the alluvium and in fractures in the underlying bedrock (DEP, 2008).

Conditions and Threats

Groundwater in the U.S. Virgin Islands is highly mineralized, often containing total dissolved solids (TDS) in excess of 1,000 parts per million (ppm) (DEP, 2008). Groundwater management issues in the U.S. Virgin Islands include over pumping of coastal aquifers, saltwater encroachment, and contamination from prior development, including Superfund sites. Additional sources of groundwater contamination include failing underground storage tanks, leaking sewer lines, and improper storage and disposal of chemicals (DEP, 2008).

Management

The U.S. Virgin Islands Department of Planning and Natural Resources (DPNR), and in particular the Division of Environmental Protection (DEP), are primarily responsible for the development and enforcement of regulations associated with groundwater. Additional responsibilities include managing databases for wells and well related permits, mapping of groundwater supply well locations, and delineating of wellhead protection areas (DEP, 2012).

Marine Resources

The U.S. Virgin Islands has an abundance of special marine resources that shape both land and water. Collectively, these resources provide tremendous habitats, protect the land from storms, filter out pollutants, and so much more, as described in more detail in the following sections. All these resources are connected to one another and are subject to threats both from the land and water sides.

It is important to note that the U.S. Virgin Islands has protections in place to protect significant marine natural resources. To better conserve and enforce jurisdiction by the federal and state departments to protect marine resources, marine protected areas (MPA) have been established across the islands. MPAs are defined as areas that have been reserved by federal, state, territorial, tribal, or local laws or regulations to provide lasting protection for part or all of the natural and cultural resources therein. There are now over 30 MPAs in the USVI. Approximately 12% of U.S. Virgin Islands waters (federal and territorial) and 35% of USVI coastal sea (up to 3 nautical miles offshore) are designated as MPAs. These include MPA's overseen by the Government of the Virgin Islands, federally managed MPAs, and two co-managed MPAs. MPAs include national parks, national monuments, federal fishery closures (both seasonal and year-round), areas of particular concern, territorial marine parks, marine reserves, and wildlife sanctuaries. MPAs have a wide range of objectives that focus on managing human uses. Some MPAs have enforcement and boundaries that are physically marked while others do not. Some MPAs include terrestrial land while others are solely marine focused. A wide range of fishing regulations exist across MPAs of the USVI, with most management units offering some opportunities for commercial and recreational fishing. Several no-take MPAs also exist, each with varying levels of enforcement and compliance. In addition, not all MPAs are managed through formal management plans (Pittman et al., 2014).

Coral reef off of St. Croix (NOAA).

Marine Waters

Poor land management practices from development have led to increased runoff and water contamination, contributing to pollution in coastal waters. With climate change warming waters and increasing acidification, marine waters in the U.S. Virgin Islands are challenged by a number of factors.

The U.S. Virgin Islands marine waters contains a unique mix of shallow shelf area penetrated by deep water channels, creating three distinct marine ecosystems: coastal and shallow shelf, pelagic, and deep water. The coastal and shallow shelf ecosystems contain submerged banks which support coral reefs, seagrass, and mangroves. Each of these resources is discussed in greater detail in the following sections. Pelagic ecosystems in the U.S. Virgin Islands extend to a depth of approximately 1,500 meters and sustain a variety of marine life. Pelagic species such as dolphin, flying fish, billfish, tuna, jacks, mackerel, sharks, rays, whalesharks, and whales are present in this ecosystem. The deep water ecosystems of the U.S. Virgin Islands include waters at depths greater than 1,500 meters and include the ocean floors of submarine canyons. This ecosystem is inhabited by fish adapted to water in the open ocean, and is characterized by relatively low levels of nutrients and primary productivity, and patchy distributions of plants and animals (NPS, 2012).

Conditions and Threats

According to the 2020 USVI Integrated Water Quality Monitoring & Assessment Report, most of the assessed coastal waters in St. Croix, St. John, and St. Thomas fall into Class B, with a few falling into Class A or C. Class B waters allow "minimal changes in structure of the biotic community and minimal changes in ecosystem function. Virtually all native taxa are maintained with some changes in biomass and/or abundance; ecosystem functions are fully maintained within the range of natural variability." The Report identifies 158 instances where pollutants are causing designated use impairments, with the most frequent causes of impairment including turbidity, enterococcus, pH, and dissolved oxygen (DEP, 2020). Increases in point and non-point source discharges have caused coastal water quality issues in the U.S. Virgin Islands. Wastewater pollution, including from sewage treatment facilities and septic systems, has led to contamination issues in coastal waters. Sewer mains have failed in the past, resulting in raw sewage bypasses at times. Increased runoff from sedimentation from upland development also impacts the health of marine waters (Catanzaro et al., n.d.). Damage from human activities such as anchoring damage, removal of species, over harvesting, illegal fishing, introduction of invasive species and ship groundings also pose risks to the resources in marine waters. In addition, climate change continues to threaten marine resources in the U.S. Virgin Islands, as warming waters have resulted in significant alterations to ocean habitats (DFW, 2005).

Management

There are several entities responsible for managing the health of marine waters in the U.S. Virgin Islands. The V.I. Department of Planning and Natural Resource (DPNR) Division of Environmental Protection's (DEP) is responsible for the ambient coastal water quality monitoring program and beach water quality monitoring program which are utilized collectively to assess coastal waters in the U.S. Virgin Islands. The DPNR Division of Coastal Zone Management (CZM) manages a variety of programs covering planning, permitting, and the management and protection of natural resources in the CZM area (Tier 1). The DPNR Division of Fish and Wildlife (DFW) preserves, protects, restores, and manages the fish and wildlife resources of the Virgin Islands for ecological conservation and sustainable use by the community. In addition to these territorial agencies, several marine areas are also protected federally by the National Park Service and U.S. Fish and Wildlife (DFW, 2005).

Hawksnest Bay in St. John (Reinhard Link/Flickr).

Beaches and Rocky Shorelines

Coastal areas in the U.S. Virgin Islands are particularly threatened by development, which coupled with climate change, has severely disrupted local ecosystems.

Beaches and rocky shorelines make up a considerable percentage of the U.S. Virgin Islands. St. Croix has 70 miles of shoreline, St. John has 50 miles of shoreline, and St. Thomas has 53 miles of shoreline. Across the islands, sandy beaches comprise approximately 21% or 50 miles of the total shoreline (Dammann and Nellis, 1992). There are three types of beaches in the U.S. Virgin Islands: coralline (primarily composed of coral skeleton), gravel (primarily composed of minerals or rocks), and sand (primarily composed of shell fragments, algal plates, and urchin fragments). The remaining coastline is primarily composed of rocky shorelines and mangrove forests. The rocky shorelines primarily consist of cliffs and are poorly vegetated. Coastal vegetation typically includes salt and wind tolerant plants and trees, such as inkberry (*Scaevola plumeiri)* and marble trees (*Cassine xylocarpa).* Beaches, dunes, and rocky shorelines provide habitat for a wide range of species, including shorebirds. Sandy beaches also offer nesting areas for species such as sea turtles and Least Terns. In addition to supporting wildlife, beaches and rocky shorelines also buffer coastal areas from extreme storms and supporting coastal plant communities stabilize dunes and protect the shoreline from erosion (Platenberg and Valiulis, 2018).

Conditions and Threats

Coastal areas in the U.S. Virgin Islands are particularly threatened by development as the construction of structures, buildings, roads, and parking lots along beaches and shorelines can affect the movement of beach sediments, which can sometimes lead to erosion or accretion. Development along the shoreline can lead to light pollution, confusing nesting female turtles, including endangered and migratory species. Beach nourishment can impact water quality and sea turtle nesting habitats. Human impacts from bonfires, littering, and driving on beaches can destroy habitats for coastal wildlife. Climate change also poses a considerable threat to beaches and rocky shorelines. Increased erosion of beaches from more severe and frequent extreme storms, in addition to sea level rise and storm surges, is reshaping the coastline of the U.S. Virgin Islands (Platenberg and Valiulis, 2018).

Brown Pelican flies over the shoreline in St. Thomas (Karl Callwood/Unsplash).

Management

Within the U.S. Virgin Islands, protection of the shoreline comes under the jurisdiction of the Division of Coastal Zone Management (CZM) within the V.I. Department of Planning and Natural Resources (DPNR). CZM is responsible for promoting development and growth within the coastal zone, as well as ensuring adequate protection for natural resources while maintaining recreational opportunities (Platenberg and Valiulis, 2018).

Salt Ponds and Salt Flats

Issues with sedimentation and encroachment have led to a decline in water quality and sediment retention capabilities in salt ponds and salt flats.

Great Pond in St. Croix (Horsley Witten Group).

Salt ponds are small coastal bodies of saltwater that form intertidal basins with a limited, but regular connection to the ocean. Salt ponds are the predominant wetland systems of the U.S. Virgin Islands, comprising approximately 2,145 acres across all three islands (USDA, 2007). There are over 60 salt ponds in the U.S. Virgin Islands (Rennis et al., 2006). Salt flats differ from salt ponds in that they have a more limited connection to the ocean and are generally only inundated with water during high tides or when filled with stormwater runoff after heavy rainfall. Salt flats comprise approximately 1,841 acres across all three islands (USDA, 2007). Many salt ponds and salt flats in the territory have mangroves and other salt tolerant plants growing near or around them (Division of Fish and Wildlife, 2005; Platenberg and Valiulis, 2018). The ecosystems typically support a variety of wildlife, including resident and migratory birds (Division of Fish and Wildlife, 2005). Salt ponds and salt flats prevent marine sedimentation by trapping runoff and pollutants, protecting coral reef and seagrass beds (Rennis, 2006). Salt ponds help to alleviate coastal flooding by absorbing the impacts of oncoming waves and storing water from rainfall and storm surge events that would otherwise exacerbate flooding, and also have significant cultural value in the U.S. Virgin Islands (DFW, 2005). Historically, salt ponds were important for subsistence and recreational fishing, and people would visit salt ponds to collect mangrove roots and branches to design fish traps (Platenberg and Valiulis, 2018). Salt harvesting was also a common practice in the hypersaline ponds of the U.S . Virgin Islands and this practice still occurs at Salt Pond in St. John (Platenberg, 2006).

Conditions and Threats

Salt ponds are impacted by saltwater intrusion due to storm surges during major storm events like hurricanes. Most of the salt ponds and salt flats on the islands are still recovering from Hurricanes Irma and Maria which caused major storm surges. These events introduce pollution from stormwater runoff and debris into these ponds, severely damaging neighboring mangroves (Platenberg and Valiulis, 2018). Issues with sedimentation, encroachment, and rising sea levels have led to a decline in water quality and sediment retention capabilities in salt ponds and salt flats (Rennis et al., 2006; Platenberg and Valiulis, 2018).

Management

Salt ponds and salt flats are managed by the V.I. Department of Planning and Natural Resources (DPNR), in particular the Division of Coastal Management (CZM). In addition, the Division of Fish and Wildlife

(DFW) is mandated to protect coastal and migratory birds and the habitats they live in (Platenberg and Valiulis, 2018).

Mangroves

The continued encroachment and degradation of mangroves from development has led to negative impacts across several ecosystems.

Three species of mangroves are present in the U.S. Virgin Islands: the Red Mangrove (*Rhizophora mangle*), Black Mangrove (*Avicenia germinans*), and the White Mangrove (*Laguncularia racemosa*), as well as the transitional species of buttonwood mangrove (*Conocarpus erectus*). All three islands are home to critical mangrove areas and mangroves comprise approximately 1,265 acres across the islands (USDA, 2007). However, more recent studies of mangrove health suggest that mangroves may now cover more than this area.

The St. Thomas East End Reserve connects management for several wildlife and marine reserves and enables the protection of the largest remaining mangrove tract in St. Thomas. St. Croix currently is home to the largest wetland areas dominated by mangroves. Mangroves serve an important role as nurseries to many juvenile fish and bird species which have recreational and commercial importance (Platenberg, 2006). Mangroves help to sequester carbon, reducing the impacts of greenhouse gas emissions, and also trap and stabilize sediment between their roots, helping to prevent coastal erosion (Mcleod et al., 2011). In addition, mangroves protect low-lying inland areas by acting as a buffer from storm surges (Granek and Ruttenberg, 2008). Mangroves also help maintain surrounding water quality by trapping oncoming runoff and removing harmful pollutants from the water and soil (Mcleod et al., 2011).

Conditions and Threats

The continued encroachment and degradation of mangroves due to development is a major concern. In particular, encroachment weakens the ability of mangroves to survive large storm events, specifically hurricanes. The ecological services mangroves provide will only continue to degrade if encroachment persists and climate change continues to bring extreme storm events that are more frequent and more intense. Mangroves may also be threatened by the introduction of invasive species and may be susceptible to degradation from leaking septic tanks and sedimentation from upland areas (Platenberg and Valiulis, 2018). The loss of mangrove habitats in the U.S. Virgin

Mangrove forest in Salt River Bay in St. Croix (Horsley Witten Group).

Islands has resulted in a decline in nearshore water quality as greater quantities of sediments and pollutants have entered the sea. This has affected seagrass beds and coral reefs through reduced levels of sunlight penetration and increased stress from chronic sedimentation. Coral reefs have also suffered from a decline in balanced fish populations as nursery habitats have been destroyed (DEP, 2008).

Management

The V.I. Department of Planning and Natural Resources (DPNR) is responsible for monitoring wetlands to ensure that unpermitted activities are not taking place and that authorized activities are in full compliance with permit requirements. DPNR also comments on federal permit applications to ensure consistency with the Coastal Zone Management Plan (Platenberg and Valiulis, 2018). The Division of Fish and Wildlife (DFW) is currently involved in a territory wide analysis of the condition of all major mangrove forests and is conducting surveys of the bird populations within them. A product of this project is the creation of a mitigation bank of mangrove restoration projects.

Seagrass Beds

Native seagrass beds in the U.S. Virgin Islands are in decline for many reasons, tied directly or indirectly to human activities.

Seagrass beds in the U.S. Virgin Islands are found in shallow bays with calm waters. Three species of native seagrasses are most commonly found in the territory: shoal-grass (*Halodule wrightii*), manatee-grass (*Syringodium filiforme*), and turtle-grass (*Thalassia testudinum*). Small turtle grass (*Halophilia decipiens)*, though not as common, is also a native seagrass species that is present in the U.S. Virgin Islands. There are approximately 20,669 acres of seagrasses across all three islands (NOAA, 2001). Seagrasses filter suspended sediment and nutrients from coastal waters, increasing light availability for other benthic plants and coral reefs (Short et al., 1996). Seagrasses can also dampen wave actions, protecting marine communities and reducing erosion rates by stabilizing sand and marine sediment (Björk et al., 2008). Seagrass beds support a variety of small fishes and invertebrates, in addition to providing feeding grounds for green sea turtles, stingrays, conch, and other species. Seagrasses also provide habitat, protection from predators, and essential nursery areas to commercial and recreational fishery species (Bologna, 2014).

Conditions and Threats

Native seagrass beds in the U.S. Virgin Islands are in decline for many reasons, primarily from improper boat anchoring, sedimentation from erosion, and declining water quality from stormwater runoff. Additional threats include dredging and filling projects and unsustainable fishing practices (Duffy, 2006). Unregulated development of upland and coastal areas has resulted in increased sedimentation rates and the introduction of pollutants

NOAA surveys evaluate seagrass beds post Hurricane Maria (NOAA).

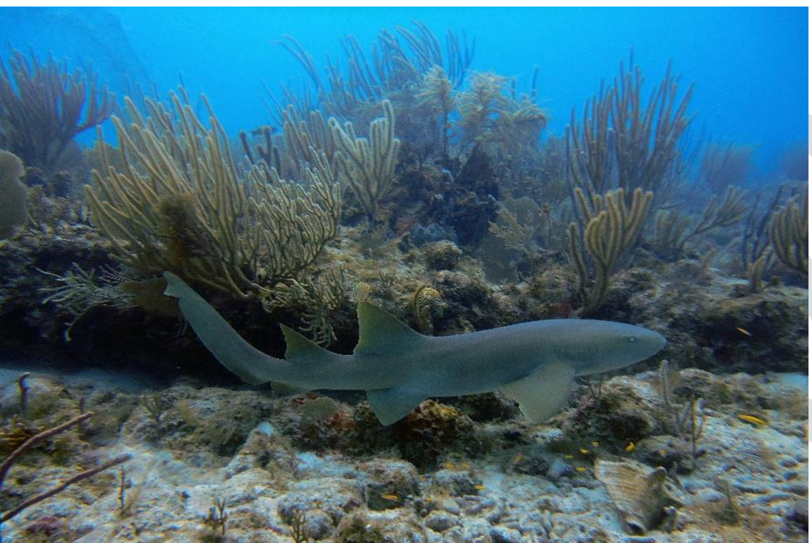
that have degraded water quality, harming sea grass beds (Orth et al., 2006). Failing septic tanks in upland areas have led to significant nutrient overloading of coastal waters, particularly in the bays around St. Thomas and St. Croix. Seagrasses are also affected by hurricanes, which cause extensive seagrass detachment (Cruz-Palacios and Van Tussenbroek, 2005). Invasive seagrasses have become more present in recent years, in particular *Halophila stipulacea*, overtaking native species and filling sandy areas (Willete et al., 2012).

Management

In the U.S. Virgin Islands, the Department of the Interior, Department of Commerce and the Virgin Islands territorial government all have jurisdiction over submerged lands. Seagrass beds are protected under a variety of management entities and with a range of objectives that focus on managing human use. For example, the National Park Service monitors seagrasses at Buck Island (St. Croix) and around St. John (Platenberg and Valiulis, 2018).

Coral Reefs

Coral reefs have been significantly impacted by overdevelopment in upland areas as well as along the coastline, threatening the stability of these habitats.



A nurse shark swims alongside coral reef in St. Thomas (Karl Callwood/Unsplash).

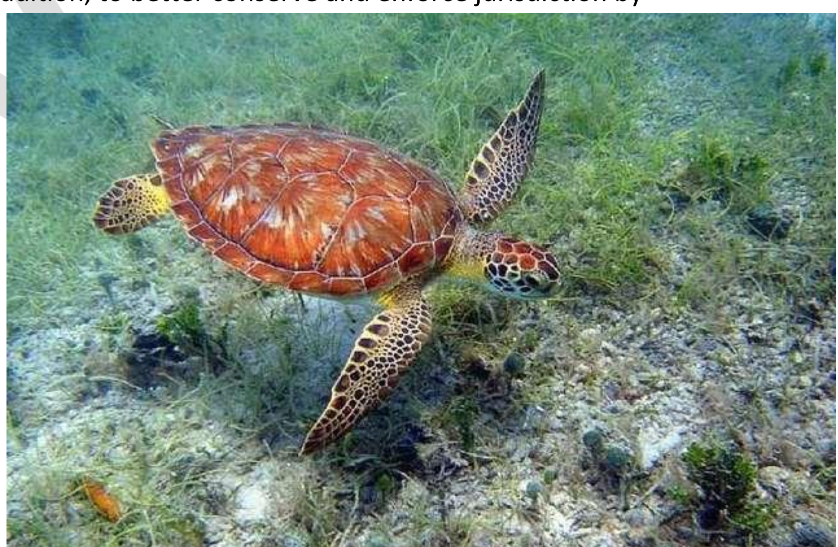
Coral reefs are intricate underwater structures formed by coral polyps, which grow hard skeletons of calcium carbonate. Coral reefs are found around St. Croix, St. John, and St. Thomas, as well as most offshore cays. There are approximately 14,197 acres of coral reef across the three islands (NOAA, 2001). Reef structures include fringing reefs, patch reefs, spur and groove reefs, barrier reefs, shelf reefs, submerged shelf reefs, and mesophotic reefs. The most extensive coral reef systems in the Territory surround St. Croix. Coral growth occurs along a significant portion of the insular shelf with a well-developed barrier reef on the eastern end, and deep coral walls on the north shore of the island. The National Oceanic and Atmospheric Administration (NOAA) estimated that existing coral reef hardbottom in the U.S. Virgin Islands was 185.8 miles^2 (NOAA, 2009). There are at least 40 different species of coral living in the U.S. Virgin Islands, mostly comprised of scleractinian corals and Millepora species (Pittman et al., 2014). Besides a variety of coral species, many different species of fish, algae, seagrass, marine invertebrates, and other marine organisms can be found living in and around reef systems (Platenberg and Valiulis, 2018). Coral reefs support commercial and local fishermen, producing a variety of economically important species such as grouper, spiny lobster, and snapper (Ennis et al., 2019). Coral reefs are also a significant part of the territory's tourism economy. The total economic value for coral reef ecosystems in the U.S. Virgin Islands is estimated at $187 million per year (DEP, 2020). In addition to supporting the economy, coral reefs protect the islands by reducing oncoming wave energy, which reduces coastal erosion and the effects of storm surges (Taylor et al., 2009). One study estimated that intact coral reefs provide the U.S. Virgin Islands with $47 million in annual flood protection benefits in the form of avoided damages to property and economic activities (Storlazzi et al., 2019).

Conditions and Threats

Corals are vulnerable to a wide range of threats, including increased ocean temperatures, ocean acidification, sedimentation from land uses, increasingly frequent damage from severe storms, and other lesser understood stressors, including sunscreens. Although the exact relationship is not fully understood, these stressors combine to cause massive coral bleaching events. Many of the coral reefs in the territory were significantly reduced by coral bleaching events in 2005, 2010, 2012, and 2019. In 2005, an estimated 50% of coral bleached and died and 90% of coral communities were negatively impacted (Clark et al., 2009). Due to the islands' steep hillsides and frequent heavy rainfall, the proximity of shallow coral reefs to the shore proves challenging for stormwater runoff. Other factors that affect the territory's coral reefs include hurricanes, invasive species such as lionfish, overfishing, and climate change (Jackson et al., 2014). Coral reefs in the territory, like the majority of the Caribbean region, have experienced significant die-offs in the last few decades. NOAA's 2020 status report for corals in the USVI declared that they are in "fair condition" but have experienced substantial losses over the past several years (NOAA, 2020). Areas with particularly strong rates of decline have included Yawzi in St. John, Buck Island in St. Croix, Mennebeck in St. John, Newfound in St. John, Lang Bank in St. Croix, and Tektite in St. John (Catanzaro et al., n.d.).

Management

In the U.S. Virgin Islands, the Department of the Interior, Department of Commerce, and the Virgin Islands territorial government all have jurisdiction over submerged lands. Coral reefs are protected under a variety of management entities and with a range of objectives that focus on managing human use. For example, the Division of Fish and Wildlife (DFW) works with the NOAA Fisheries Office to oversee the Coral Reef Conservation Program. In addition, to better conserve and enforce jurisdiction by the federal and state departments, marine protected areas (MPA) and reserves have been established in the U.S. Virgin Islands. As discussed previously, MPAs limit human-based activities to prevent physical destruction and provide refuge to marine life. There are now over 30 MPAs in the USVI. Since their establishment, protected areas with coral reefs such as the St. Thomas East End Reserves (STEER), St. Croix East End Marine Park (EEMP), Virgin Islands Coral Reef National Monument, Virgin Islands National Park, and Buck Island Reef National Monument have shown a reduction in reef degradation (Pittman et al., 2014).



A green sea turtle glides over coral reef in St. John (National Parks Gallery).

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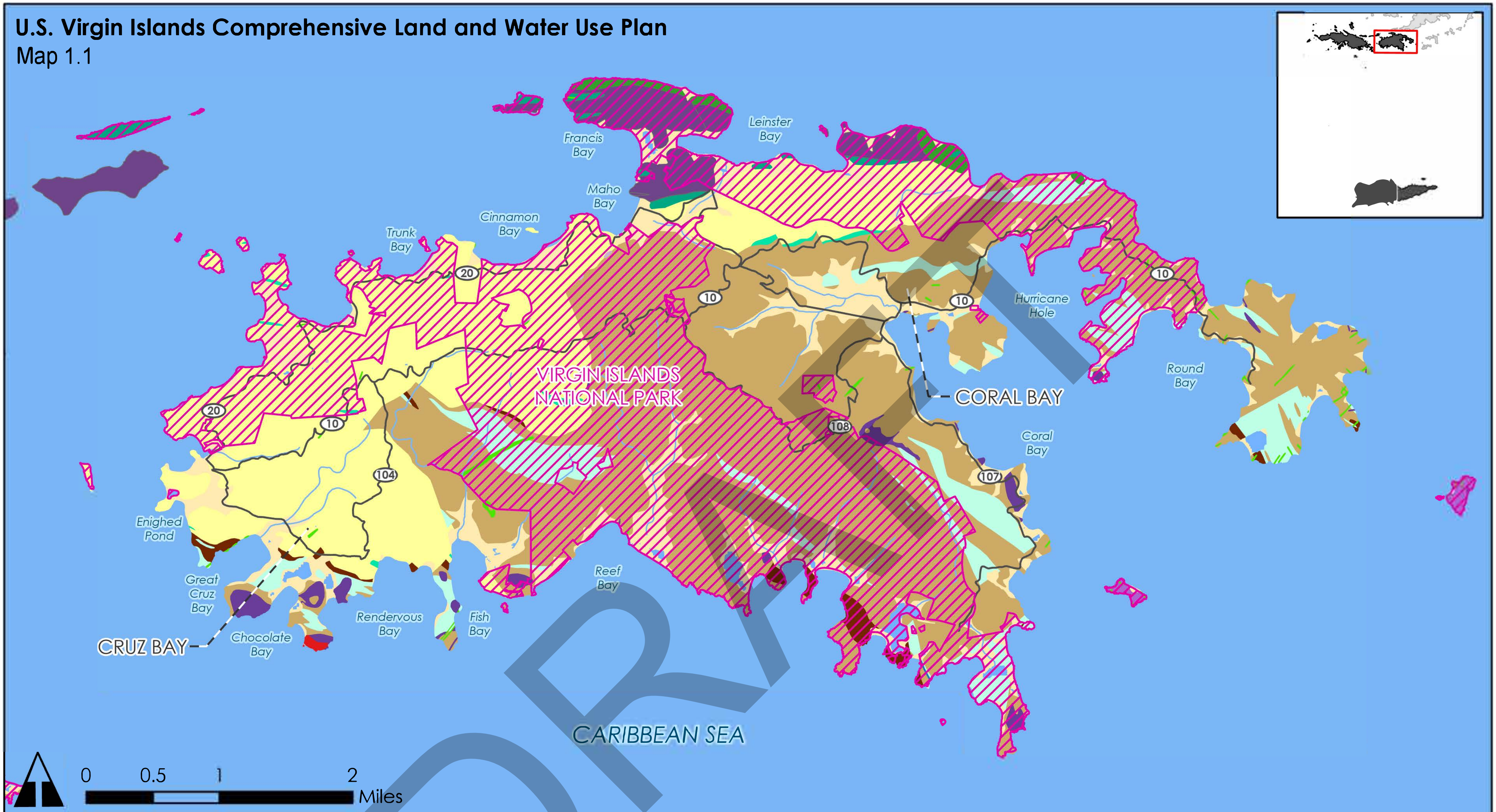


Legend

- Surface Water Bodies
- Guts
- Major Roads
- Protected Areas (Federal, VI Government, VI Civil Society, NGO)

Geologic Features

- Basalt and basaltic andesite
- Chert
- Diorite and tonalite
- Gabbro
- Gabbronorite, norite, and diorite
- Hypabyssal dikes and intrusions
- Hypabyssal rocks and keratophyre porphyry
- Intermediate and silicic pyroclastic rocks
- Keratophyre
- Mafic volcanic rocks
- Marble and greenschist
- Surficial deposits, undifferentiated
- Trondhjemite and keratophyre
- Tutu Formation
- Water Island Formation, volcanic-clast wacke

Geologic Features - St. John

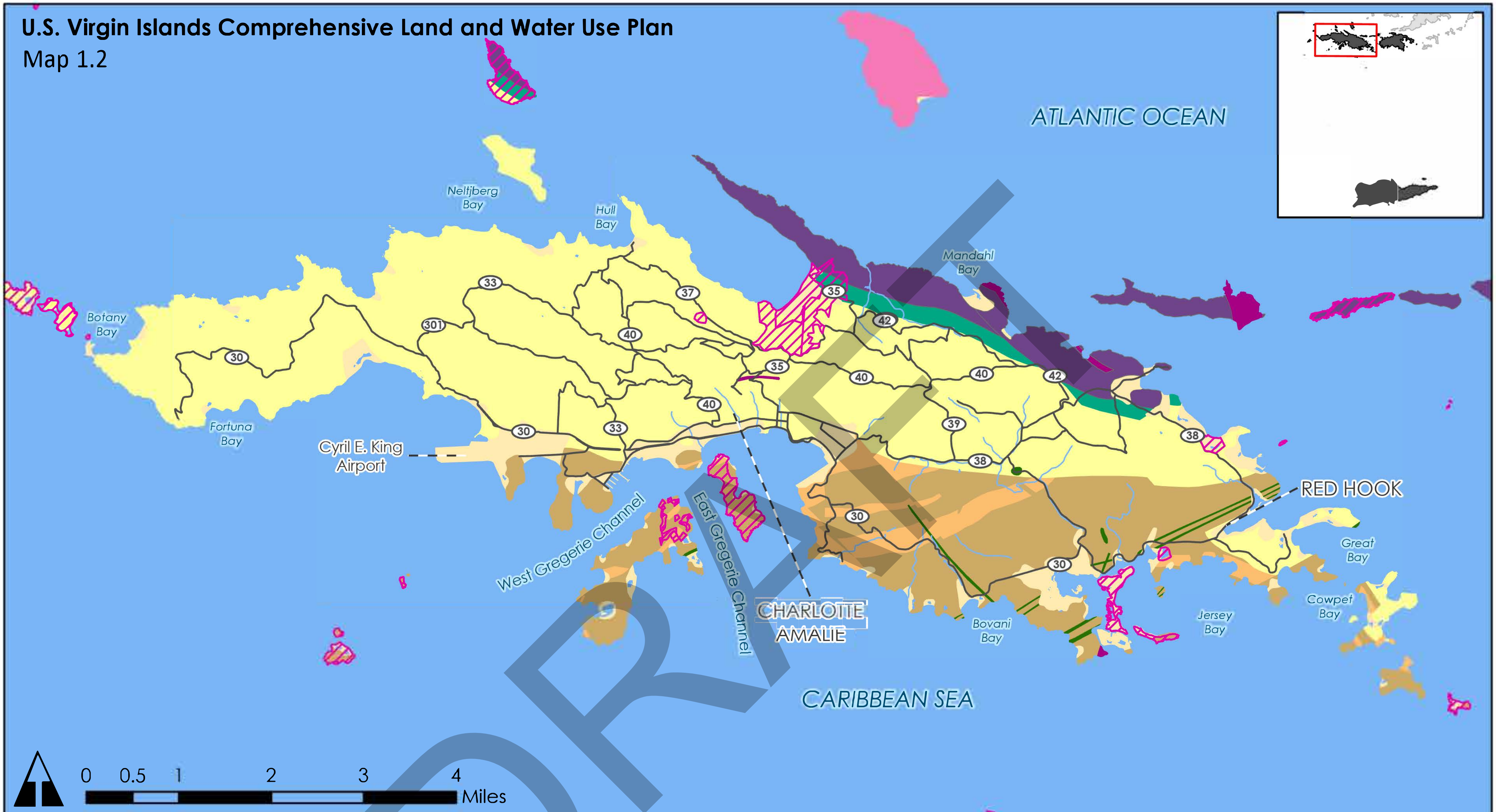
Date: 4/24/2023

Source: U.S. Census Bureau, OCHA Centre for Humanitarian Data, NOAA Office for Coastal Management, USDA Forest Service

Note: This map is for informational purposes only and is not suitable for legal, engineering, or surveying purposes.

U.S. Virgin Islands Comprehensive Land and Water Use Plan

Map 1.2



Legend

- Surface Water Bodies
- Guts
- Major Roads
- Protected Areas (Federal, VI Government, VI Civil Society, NGO)

Geologic Features

- Granodiorite and quartz monzonite
- Intermediate and silicic pyroclastic rocks
- Keratophyre
- Marble and greenschist
- Pyroclastic rocks
- Quartz diorite and diorite
- Spilitic basalt
- Surficial deposits, undifferentiated
- Tutu Formation

Geologic Features - St. Thomas

Date: 4/24/2023

Source: U.S. Census Bureau, OCHA Centre for Humanitarian Data, NOAA Office for Coastal Management, USDA Forest Service

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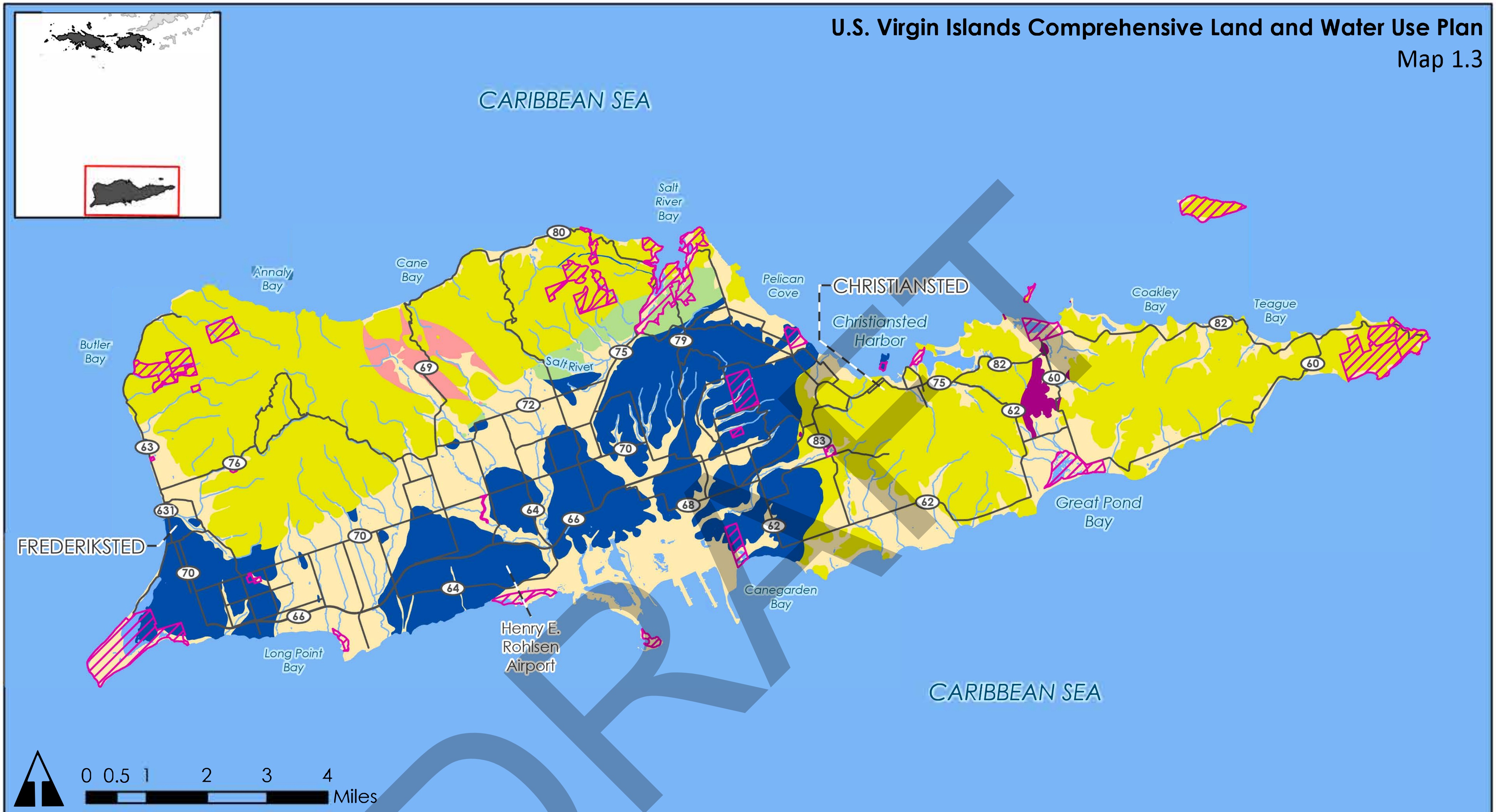


Legend

- Surface Water Bodies
- Guts
- Major Roads
- Protected Areas (Federal, VI Government, VI Civil Society, NGO)

Geologic Features

- Clastic rocks including conglomerate
- Fountain Gabbro
- Limestone and limestone conglomerate
- Limestone, marl, and calcarenite
- Quartz diorite and diorite
- Surficial deposits, undifferentiated
- Volcaniclastic sandstone and mudstone

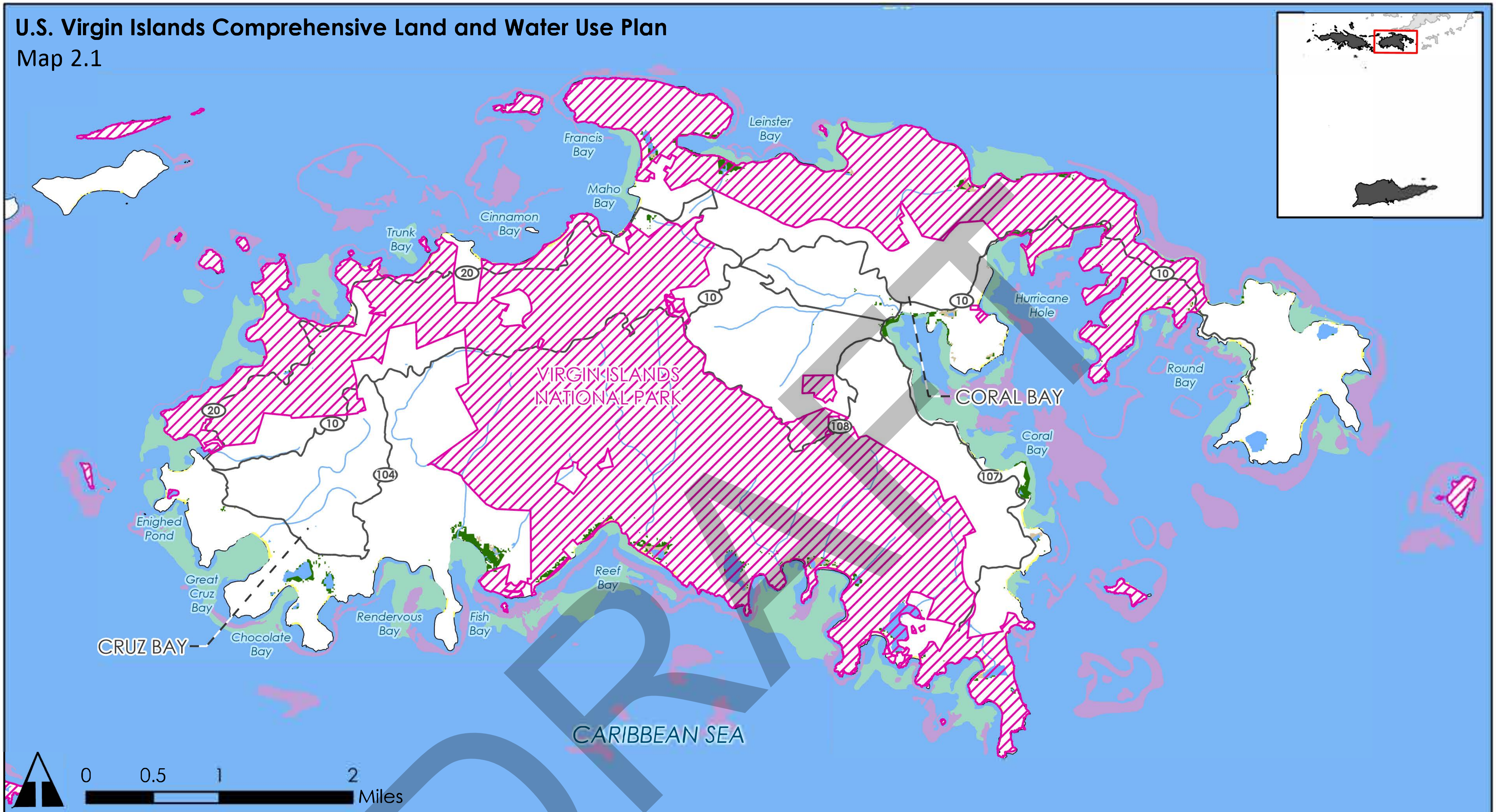
Geologic Features - St. Croix

Date: 4/24/2023

Source: U.S. Census Bureau, OCHA Centre for Humanitarian Data, NOAA Office for Coastal Management, USDA Forest Service

Note: This map is for informational purposes only and is not suitable for legal, engineering, or surveying purposes.

U.S. Virgin Islands Comprehensive Land and Water Use Plan
Map 2.1



Legend

- Surface Water Bodies
- Guts
- Major Roads

Resource Type

- Beaches
- Coral Reef
- Mangroves
- Salt Flats
- Seagrass Bed
- Protected Areas (Federal, VI Government, VI Civil Society, NGO)

Marine Resources - St. John

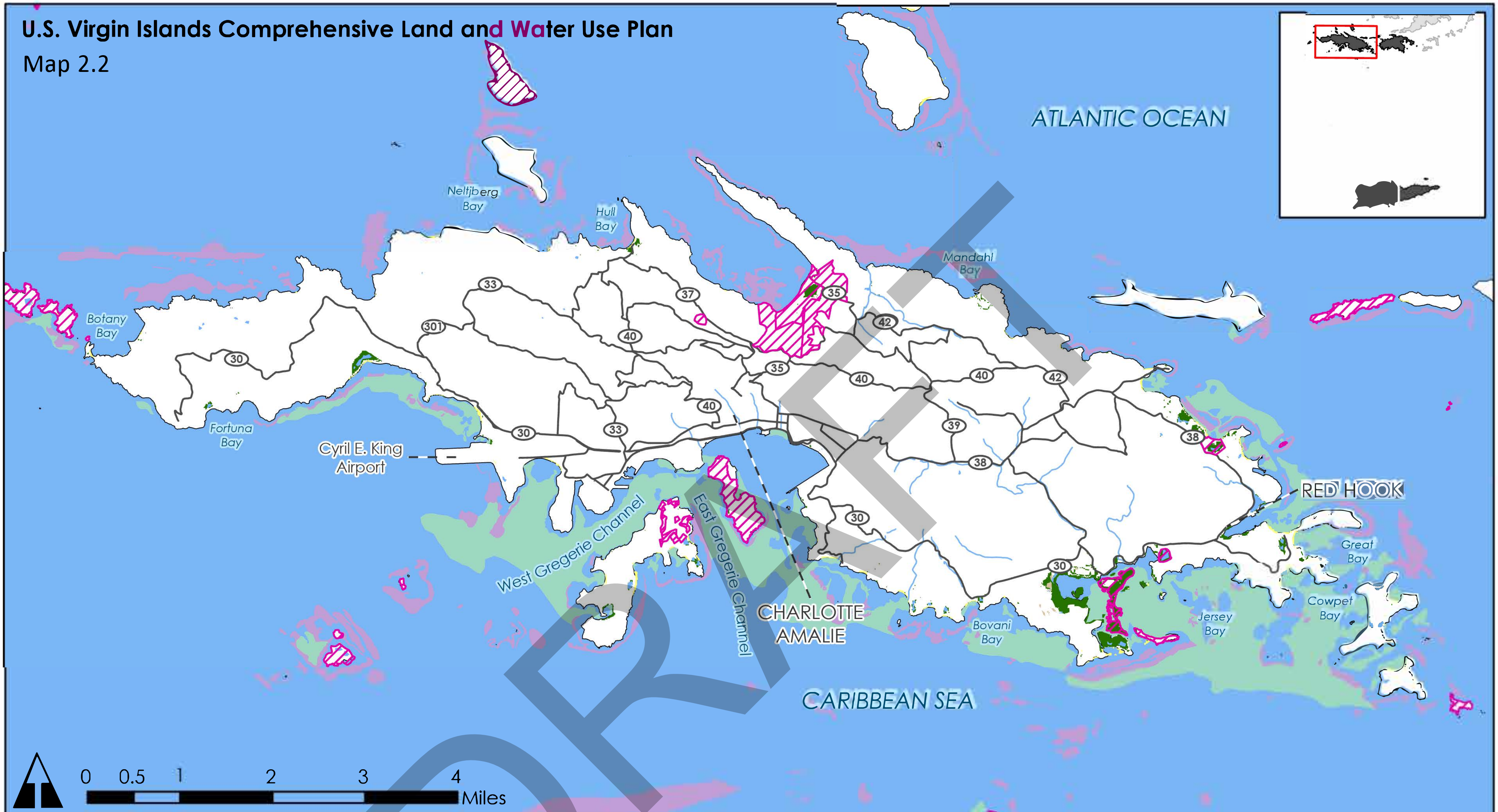
Date: 4/24/2023

Source: U.S. Census Bureau, OCHA Centre for Humanitarian Data, NOAA Office for Coastal Management, USDA Forest Service

Note: This map is for informational purposes only and is not suitable for legal, engineering, or surveying purposes.

U.S. Virgin Islands Comprehensive Land and Water Use Plan

Map 2.2



Legend

- Surface Water Bodies
- Guts
- Major Roads

Resource Type

- Beaches
- Coral Reef
- Mangroves
- Salt Flats
- Seagrass Bed
- Protected Areas (Federal, VI Government, VI Civil Society, NGO)

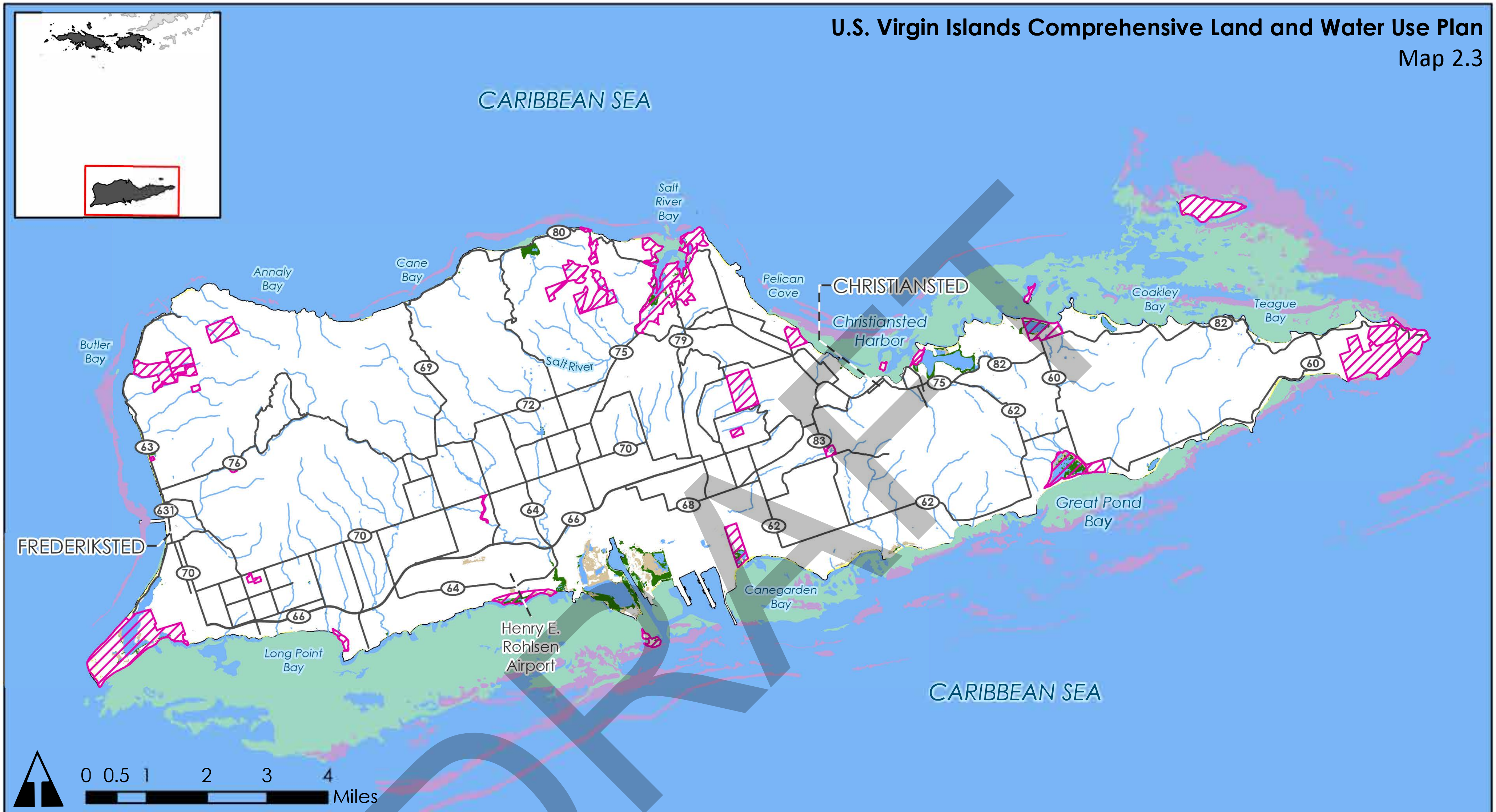
Marine Resources - St. Thomas

Date: 4/24/2023

Source: U.S. Census Bureau, OCHA Centre for Humanitarian Data, NOAA Office for Coastal Management, USDA Forest Service

Note: This map is for informational purposes only and is not suitable for legal, engineering, or surveying purposes.

U.S. Virgin Islands Comprehensive Land and Water Use Plan
Map 2.3



Legend

- Surface Water Bodies
- Guts
- Major Roads

Resource Type

- Beaches
- Coral Reef
- Mangroves
- Salt Flats
- Seagrass Bed
- Protected Areas (Federal, VI Government, VI Civil Society, NGO)

Marine Resources - St. Croix

Date: 4/24/2023

Source: U.S. Census Bureau, OCHA Centre for Humanitarian Data, NOAA Office for Coastal Management, USDA Forest Service

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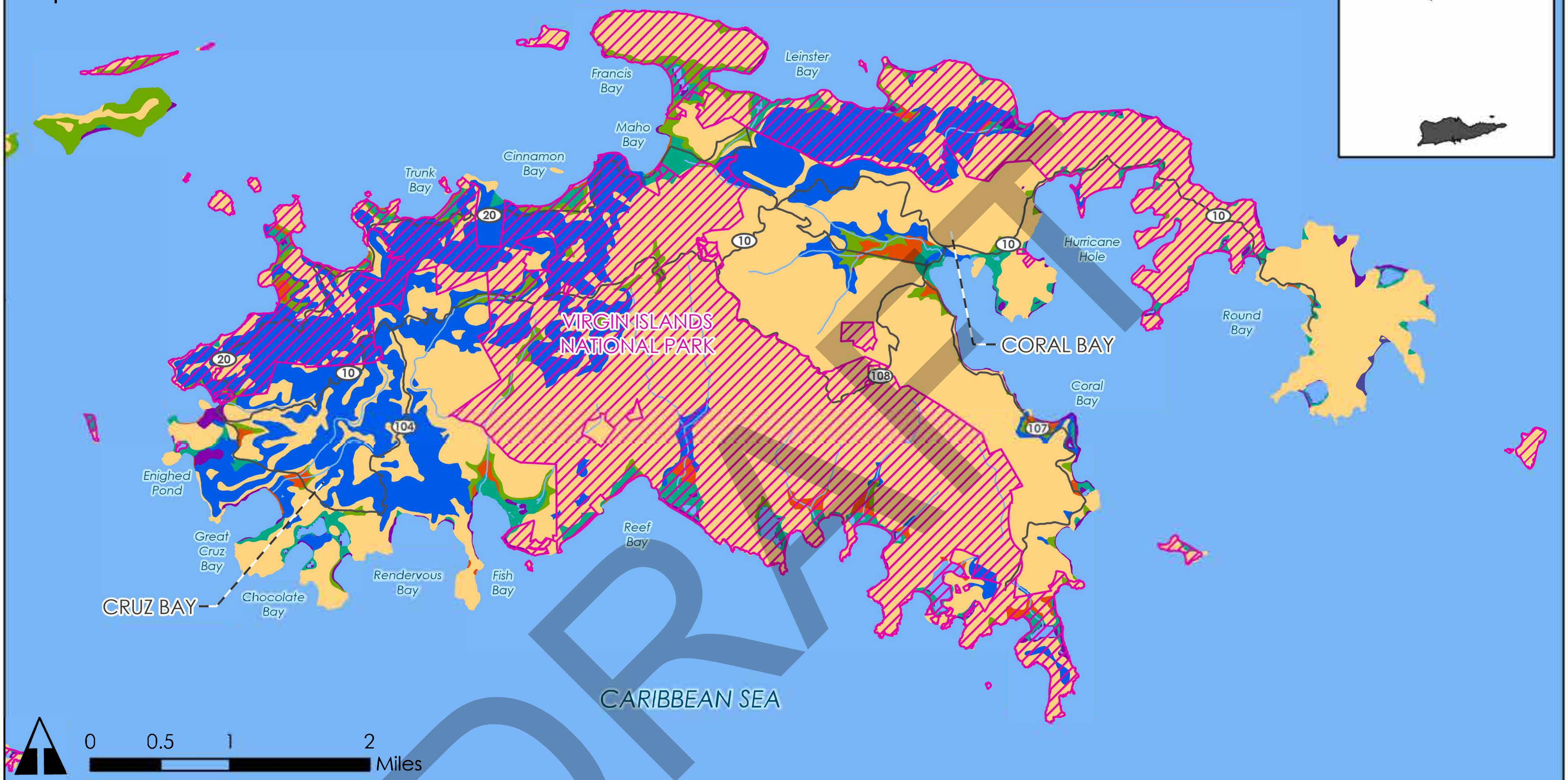
U.S. Virgin Islands Comprehensive Land and Water Use Plan

Map 3.1



Legend

Surface Water Bodies

Guts

Major Roads

Hydrologic Soil Group

- A
- A/D
- B
- C
- D
- Other

Protected Areas (Federal, VI Government, VI Civil Society, NGO)

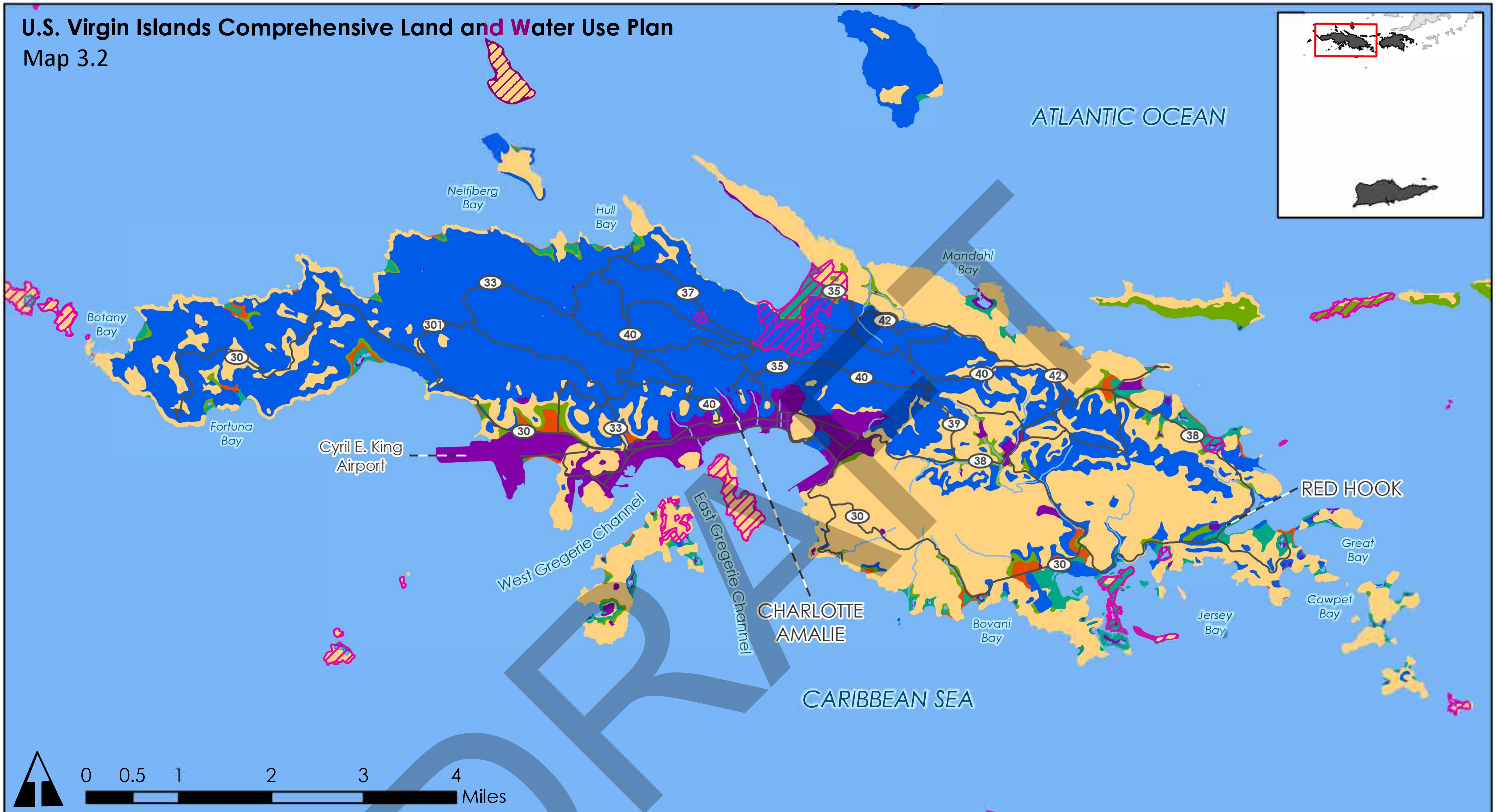
Soils - St. John

Date: 4/24/2023

Source: U.S. Census Bureau, OCHA Centre for Humanitarian Data, NOAA Office for Coastal Management, USDA Forest Service

Note: This map is for informational purposes only and is not suitable for legal, engineering, or surveying purposes.

U.S. Virgin Islands Comprehensive Land and Water Use Plan
Map 3.2



Legend

Surface Water Bodies

Guts

Major Roads

Hydrologic Soil Group

- A
- A/D
- B
- C
- D
- Other

Protected Areas (Federal, VI Government, VI Civil Society, NGO)

Soils - St. Thomas

Date: 4/24/2023

Source: U.S. Census Bureau, OCHA Centre for Humanitarian Data, NOAA Office for Coastal Management, USDA Forest Service

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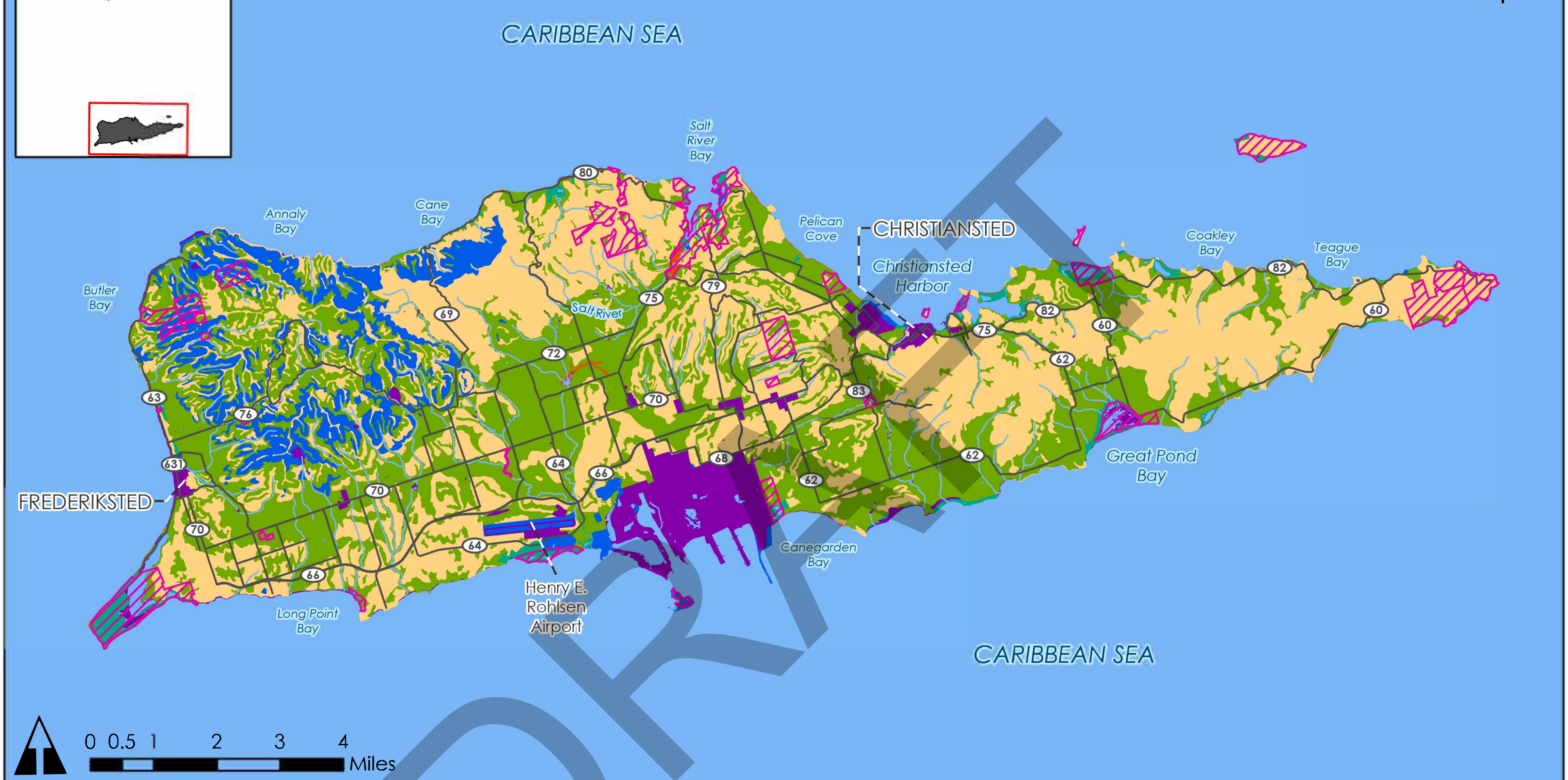
U.S. Virgin Islands Comprehensive Land and Water Use Plan

Map 3.3



Legend

Surface Water Bodies

Guts

Major Roads

Hydrologic Soil Group

- A
- A/D
- B
- C
- D
- Other

Protected Areas (Federal, VI Government, VI Civil Society, NGO)

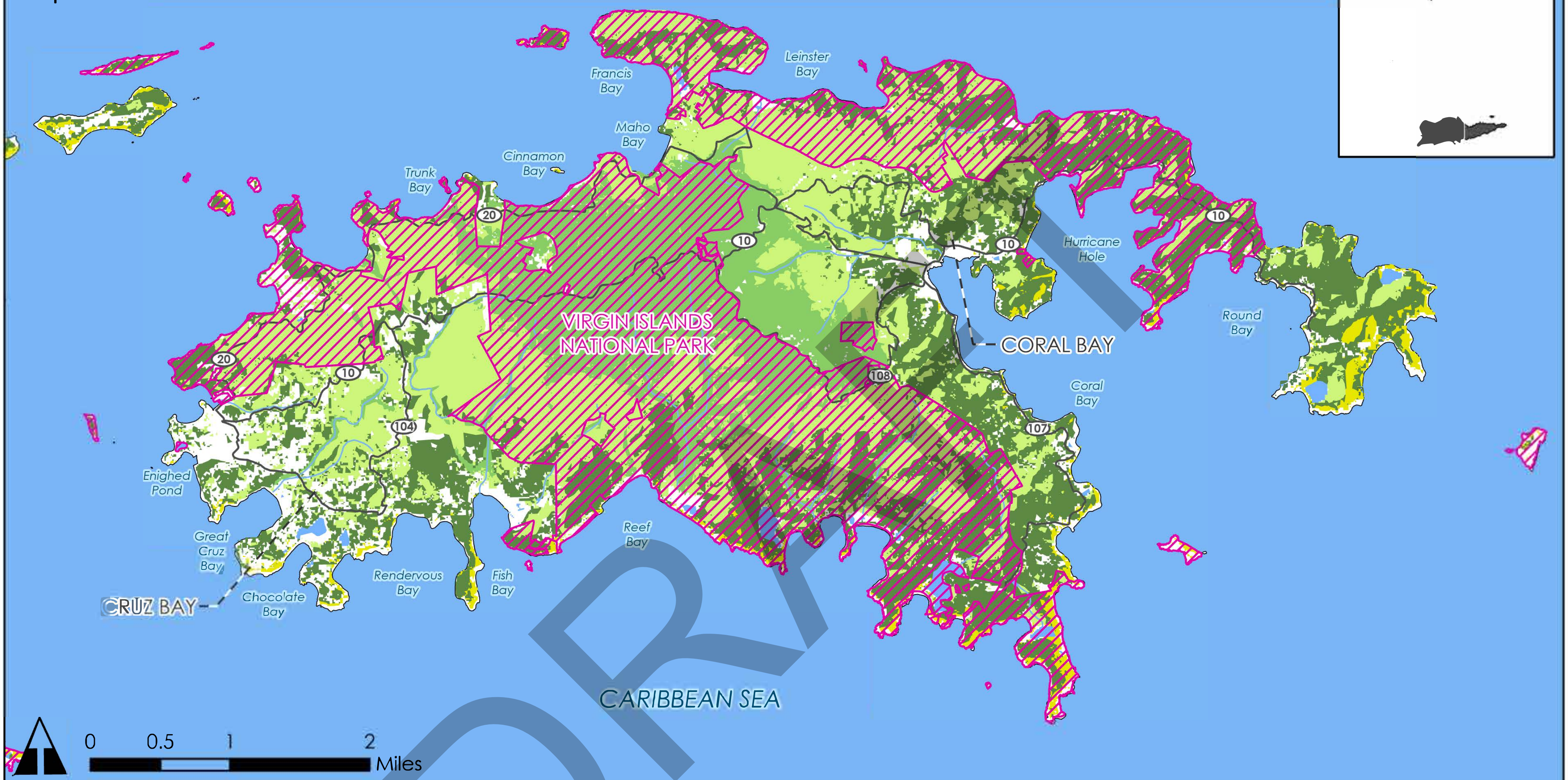
Soils - St. Croix

Date: 4/24/2023

Source: U.S. Census Bureau, OCHA Centre for Humanitarian Data, NOAA Office for Coastal Management, USDA Forest Service

Note: This map is for informational purposes only and is not suitable for legal, engineering, or surveying purposes.

U.S. Virgin Islands Comprehensive Land and Water Use Plan
Map 4.1



Legend

Surface Water Bodies
Guts
Major Roads

Resource Type

Shrubland
Deciduous Forest
Evergreen Forest
Mixed Forest
Protected Areas (Federal, VI Government, VI Civil Society, NGO)

Terrestrial Resources - St. John

Date: 4/24/2023

Source: U.S. Census Bureau, OCHA Centre for Humanitarian Data, NOAA Office for Coastal Management, USDA Forest Service

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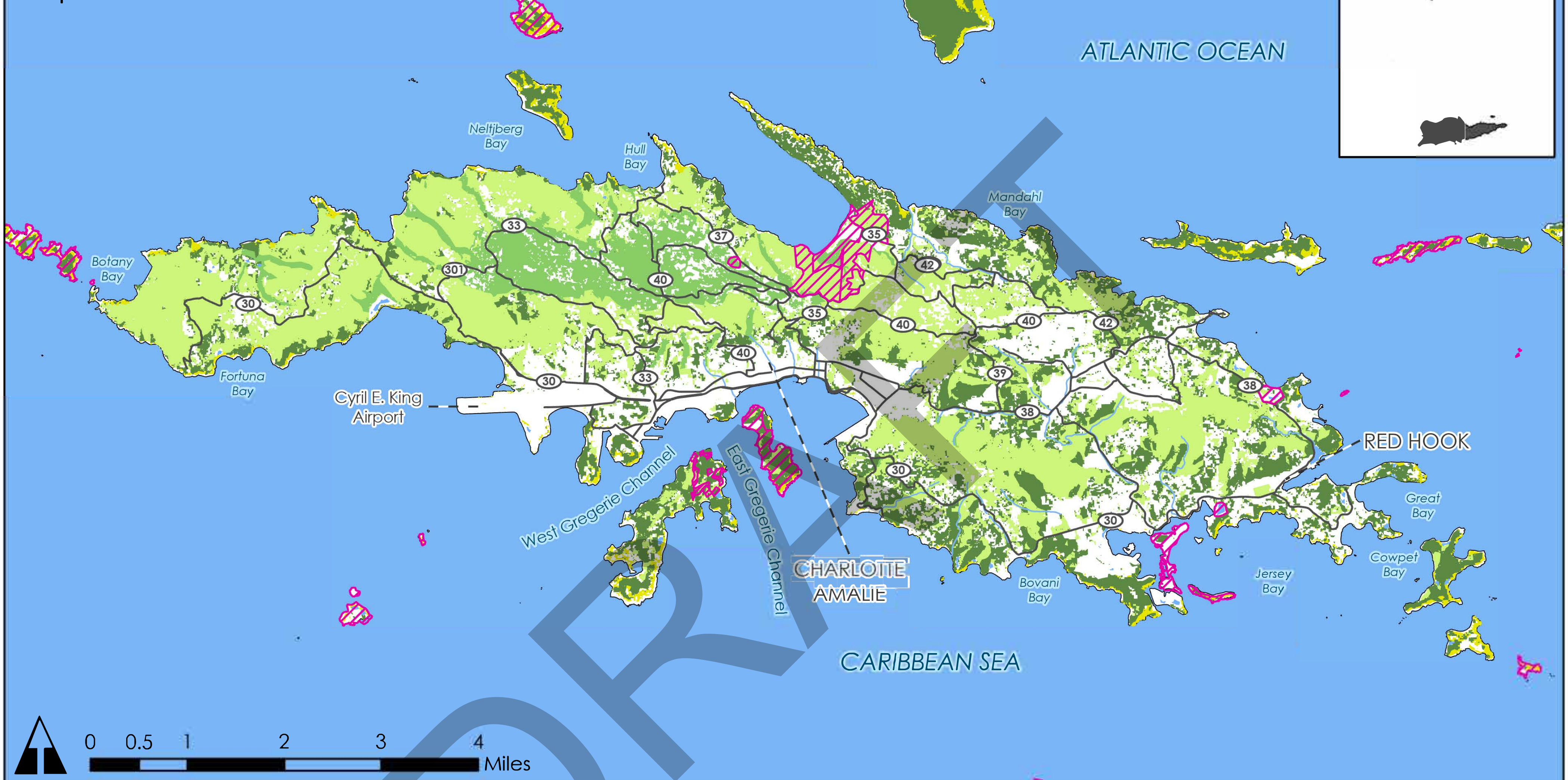
U.S. Virgin Islands Comprehensive Land and Water Use Plan

Map 4.2



Legend

- Surface Water Bodies
- Guts
- Major Roads

Resource Type

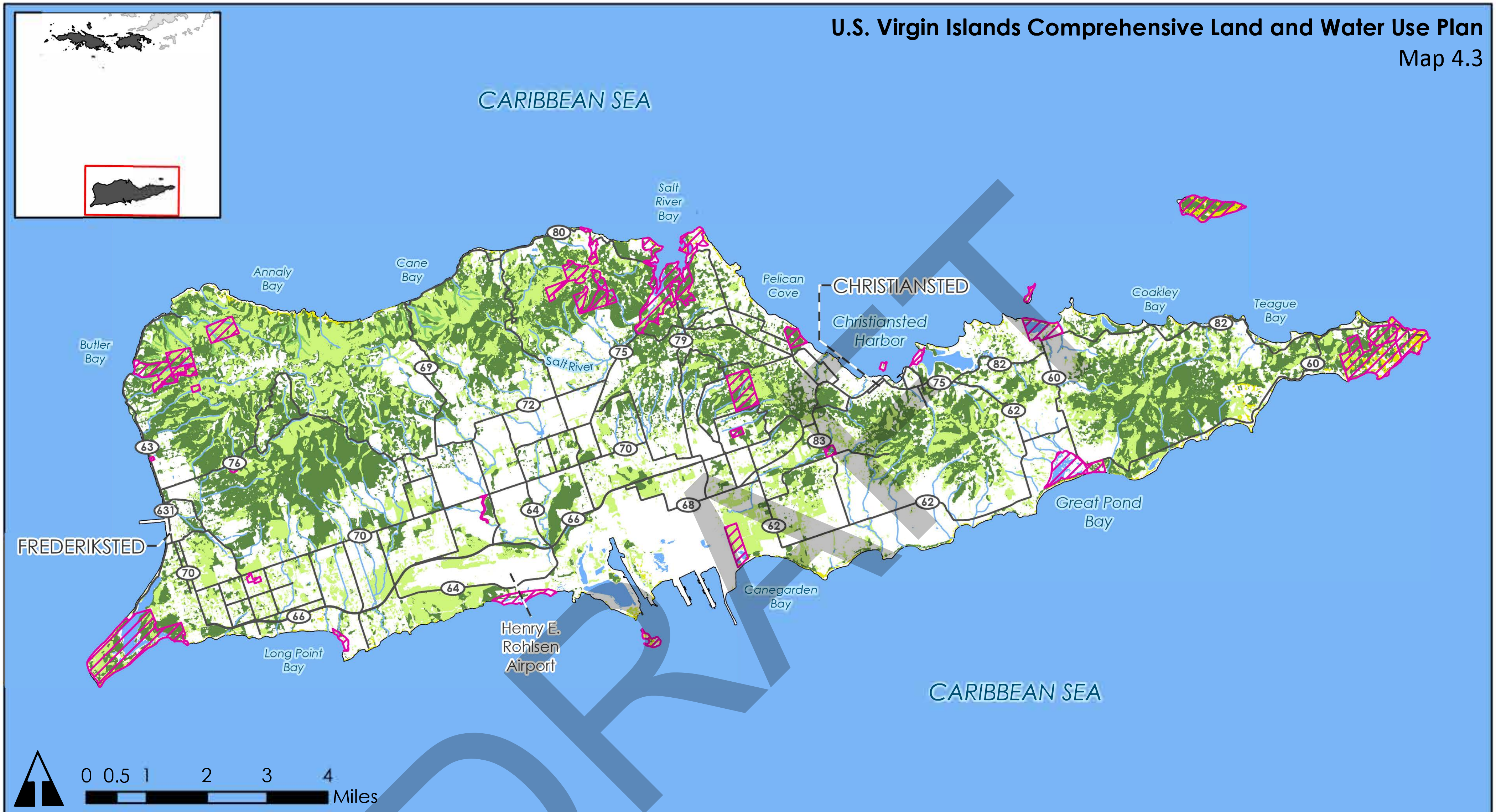
- Shrubland
- Deciduous Forest
- Evergreen Forest
- Mixed Forest
- Protected Areas (Federal, VI Government, VI Civil Society, NGO)

Terrestrial Resources - St. Thomas

Date: 4/24/2023

Source: U.S. Census Bureau, OCHA Centre for Humanitarian Data, NOAA Office for Coastal Management, USDA Forest Service

Note: This map is for informational purposes only and is not suitable for legal, engineering, or surveying purposes.



Legend

- Surface Water Bodies
- Guts
- Major Roads

Resource Type

- Shrubland
- Deciduous Forest
- Evergreen Forest
- Mixed Forest
- Protected Areas (Federal, VI Government, VI Civil Society, NGO)

Terrestrial Resources - St. Croix

U.S. VIRGIN ISLANDS DEPT. OF PLANNING AND NATURAL RESOURCES

Horsley Witten Group

Date: 4/24/2023

Source: U.S. Census Bureau, OCHA Centre for Humanitarian Data, NOAA Office for Coastal Management, USDA Forest Service

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