Watershed Management Plan for the Dorothea Watershed

St. Thomas, USVI

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U.S. Virgin Islands Dept. of Planning and Natural Resources

Office of Disaster Recovery — U.S. Virgin Islands — Building a Legacy of Resilience

Watershed Consulting

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List of Acronyms

APR	Area of Protection or Restoration
APC	Areas of Particular Concern
AU	Assessment Unit
BMP	Best Management Practice
CN	Curve Number
CWA	Federal Clean Water Act
CWP	Center for Watershed Protection, Inc.
DEM	Digital Elevation Model
DPNR	Department of Planning and Natural Resources
DPW	USVI Department of Public Works
DSM	Digital Surface Model
EPA	Environmental Protection Agency
FEMA	Federal Emergency Management Agency
GIS	Geographic Information System(s)
GSI	Green Stormwater Infrastructure
HMGP	Hazard Mitigation Grant Program
HUC	Hydrologic Unit Code
HSG	Hydrologic Soil Group
H&H	Hydrologic & Hydraulic
LID	Low Impact Development
MS4	Municipal Separate Storm Sewer System
MGD	Million Gallons per Day
nDSM	Normalized Digital Surface Model
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
NRCS	National Resource Conservation Service
NWI	National Wetlands Inventory
OSDS	On-Site Disposal Systems
PAD-US	U.S. Geological Survey's Protected Areas Database
USGS	United States Geological Survey

USVI (or VI)	United States Virgin Islands
UVI	University of the Virgin Islands
SCS	Soil Conservation Service
SSO	Sanitary Sewer Overflow
STP	Sewage Treatment Plants
TMDL	Total Maximum Daily Load
TN	Total Nitrogen
TP	Total Phosphorus
TPDES	Territorial Pollutant Discharge Elimination System
TSS	Total Suspended Solids
VIWMA	Virgin Islands Waste Management Authority
WAPA	USVI Water and Power Authority
WMP	Watershed Management Plan
WTM	Watershed Treatment Model

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1 Executive Summary

The United States Virgin Islands Department of Planning and Natural Resources (USVI DPNR) obtained grant funding in 2019 through the Federal Emergency Management Authority Hazard Mitigation Grant Program (FEMA HMGP) to develop comprehensive Watershed Management Plans (WMPs) for eight high priority watersheds of concern, three on St. Thomas and five on St. Croix. An additional priority watershed on St. Thomas, Dorothea, was added at a later date.

This watershed management plan (WMP) summarizes watershed-specific assessments and provides recommendations and design details to reduce flooding and improve water quality and resiliency for the Dorothea watershed. The three watersheds previously initially assessed on St. Thomas include Bolongo Bay, Cyril E. King Airport, and St. Thomas Harbor (Figure 1). The concurrent study on St. Croix includes the watersheds of Bethlehem, Diamond, Hovensa, Long Point Bay, and Salt River Bay. These plans are available through DPNR.

This plan is intended to guide actions to:

1. Remedy current water quality issues,
2. Inform future development and improvement projects, and
3. Increase resiliency for existing and future land, water, and climate conditions.

Figure 1. The four study watersheds on St. Thomas are outlined in red.

This WMP provides a detailed summary of existing regulations, policies, and programs related to water quality on St. Thomas. This is paired with a watershed-specific characterization that includes geology, hydrology, habitat, ecology, and demographics. To fully understand current watershed conditions, several datasets were developed or refined. Existing watershed boundaries and mapped guts were revised to better reflect drainage patterns. Stormwater infrastructure and existing stormwater best management practices were mapped and now reflect the most comprehensive dataset for the watershed. A detailed land cover dataset was developed utilizing high-resolution imagery from 2019. To identify areas of development change since the 2019 imagery was collected, an unmanned aircraft system (UAS) was flown over key areas in March 2023 to capture these areas and update the land cover dataset. This information was then used to predict potential future development through 2100. Within the Dorothea watershed, a series of visual gut observations were completed using remote cameras to visually monitor water quality and response to storm events.

The WMP also details the drivers of declining water quality and increasing flooding including a lack of stormwater best management practices (BMPs), unmaintained or absent stormwater infrastructure, unstable slopes, poorly planned development, failing wastewater infrastructure, solid waste management, and climate change influenced changes in rainfall patterns. Other issues of concern are also summarized including point source pollution, mangrove health, coral health, and air pollution.

A critical component in the development of this plan was community outreach and community and stakeholder input. A project website was developed so that easy to understand information, meeting invitations, and project deliverables could be shared. Two public outreach meetings were completed at pivotal stages of the development of this plan to inform and solicit feedback on areas of concern, utilizing critical local knowledge. As this WMP and other water quality driven efforts in the USVI span many years, it is important that the next generation take on the mantle of environmental stewardship. As such, a curriculum for watershed educators was developed for educators to use to share this important understanding with their students. An in-person field-based training for a group of educators was completed in 2023.

To improve water quality, reduce flooding, and improve resilience, a suite of recommendations was presented. A key component of the recommendations involved the identification, field and desktop assessment, water quality and hydrologic modeling, and ranking of stormwater BMPs. Preliminary (30%) engineering designs were advanced for two priority projects in the watershed and cost estimates were provided so that funding can be sought for final design and implementation. Other recommendations include changes to policies regarding solid waste management, watershed planning, site design, and stewardship. As this plan is meant to be actionable, financial and technical assistance needs, proposed timelines, and preliminary costs are also provided.

2 Project Overview

2.1 INTRODUCTION

The United States Virgin Islands Department of Planning and Natural Resources (USVI DPNR) obtained grant funding in 2019 through the Federal Emergency Management Authority Hazard Mitigation Grant Program (FEMA HMGP) to develop comprehensive Watershed Management Plans (WMPs) for:

- Three (3) high priority watersheds of concern on St. Thomas.
- Five (5) high priority watersheds of concern on St. Croix.

Additional grant funds were then acquired by DPNR to complete the WMP for the priority watershed of Dorothea on St. Thomas (Figure 2). This watershed includes primarily residential development with several areas of interest.

The high priority study watersheds were selected based on their importance to Virgin Islanders as places where the negative impacts of development have led to decreasing water quality and increased flood risk or are areas at risk for these impacts (Figure 3). As the Dorothea watershed still contains large stretches of undeveloped vegetated areas, it is important to mitigate existing issues and prevent future impacts to water quality. Prevention of water quality issues has been shown to be more effective and less expensive

Figure 2. The Dorothea study watershed (outlined in red) is located on the northern coast of St. Thomas.

than remediating existing issues. The recommendations of this report will equip the Virgin Islands with the means to reduce consequences of climate change as the region is expected to experience more intense rainfall events with long stretches of drought. The goal of this WMP is to summarize watershed-specific issues, propose attainable solutions to improve water quality and reduce flooding, outline the technical and financial resources required to do so, and create a proposed implementation timeline. This plan will be used to inform local agencies and institutions on site-specific options for flood reduction, stormwater management, and water reuse as well as larger programmatic changes that would improve water quality and resiliency.

Figure 3. The Dorothea watershed, while less developed than some other more populated watersheds on St. Thomas, has suffered water quality issues and alteration of natural drainage patterns.

2.2 BACKGROUND

2.2.1 Watersheds and Guts

A watershed is an area of land where rainfall drains to a common body of water such as a bay or harbor. There are 15 primary watersheds on St. Thomas, separated from each other by the crests of hills, ridgelines, and constructed infrastructure that guide the movement of water across the land (Figure 4). Each of these watersheds is made up of smaller drainage systems called subwatersheds that are also determined by topography and water flow.

A healthy watershed is one that conserves and cleans water, maintains aquatic ecosystems, supports healthy soils, and provides habitat for wildlife and plants. One of the most critical processes in maintaining

Figure 4. Watersheds of St. Thomas.

healthy watersheds is infiltration, that is, the process by which water absorbed into the ground. This process provides many benefits, from recharging groundwater reservoirs to acting as a natural filtration system and removing pollutants. When the rate of rainfall exceeds the rate of infiltration, stormwater runoff is produced. This happens more readily and with smaller rainfall amounts when rain falls on impervious surfaces such as parking lots, roofs, roads, and driveways that do not allow water to soak into the ground (Figure 5). In its wake, stormwater runoff can scour the landscape, causing erosion and flooding that can damage local ecosystems and communities alike. This becomes more likely as native vegetation, which stabilizes and protects the native soil, is removed. As stormwater moves across the land, it can pick up harmful pollutants like trash, chemicals, nutrients, and excessive sediment before inevitably depositing these pollutants into St. Thomas's harbors and bays.

Figure 5. Runoff from impervious surfaces such as roads contributes to flooding and water quality problems.

The dominant water conveyance system within the watersheds of St. Thomas are guts and these waterways can also transport sediment and pollutants (Platenberg, 2006). A gut (sometimes spelled "ghut") is a stream with a reasonably well-defined channel (Figure 6). The guts of St. Thomas are ephemeral, flowing only when there has been enough rain for the accumulation of water within the defined gut channel. Historically, there were many guts that flowed year-round, fed by the groundwater reserves of the island. As recently as 1950, it was reported that a gut in Charlotte Amalie ran year-round (Moonlenaar & Paiewonsky, 2005). Now, guts primarily only flow following storm events, and this ephemeral nature has impacted the public perception of guts as only being useful as stormwater conveyances and not as a functional amenity of the island (Gardner et al., 2008). However, sections of the Dorothea Gut do often have pooled water, even in dry periods.

Guts provide a variety of critical ecosystem services to St. Thomas. They provide habitats to many rare flora and fauna, are sources of food and recreational opportunities to members of the community, and provide fresh water for agricultural, industrial, and domestic purposes (Gardner et al., 2008). While other types of wetlands are present on St. Thomas and serve vital functions, the absence of large freshwater resources means that guts form the basis for watershed management in the territory (USVI DPNR, 2020).

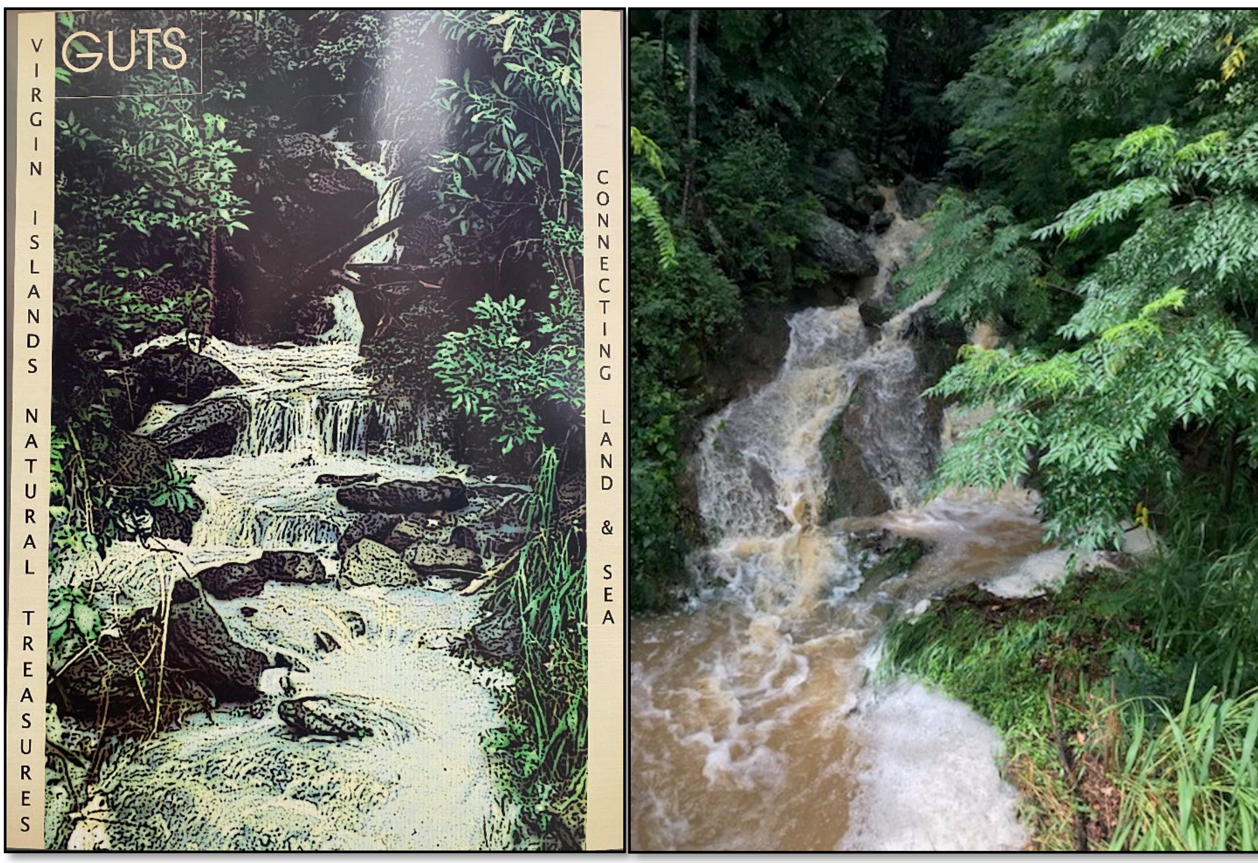


Figure 6. Illustration of a gut by the University of the Virgin Islands, Cooperative Extension Service (left) and picture of gut (right).

2.2.2 Watershed Management Planning

When Hurricane Irma hit the Virgin Islands in September of 2017, the impacts were devastating. High winds and flooding catastrophically damaged infrastructure across St. Thomas including homes, schools, hospitals, roads, and private businesses. Many residents were left with limited access to food, water, or electricity (Cox et al., 2019). The significant flooding also led to surges in nutrients and sediment entering the coastal ecosystems, causing serious damage to the coral reef communities (Hernández et al., 2020).

Events like these underline the need for proper watershed management, which is vital to maintaining healthy watersheds. There are many management practices that a community can employ to address stormwater runoff and prevent pollution at its source. Public education and outreach can be used to communicate the importance of responsible landscaping and proper use and storage of toxic household materials. Land use controls and/or incentives can be used to manage the development of impervious surfaces. Best management practices (BMPs) such as low impact development (LID) and green stormwater infrastructure (GSI) can be designed to clean and store stormwater.

At the heart of watershed management is the underlying philosophy that everything is interconnected. Every component of a watershed is interrelated and interdependent, bound together by the same shared water system. A successful watershed management framework supports partnerships and uses sound multi-disciplinary science to identify and complete well-planned, connected actions to achieve results.

In developing this WMP, the guidelines established in the U.S. Environmental Protection Agency's (EPA) *Handbook for Developing Watershed Plans to Restore and Protect our Waters* (the Handbook) were followed (U.S. EPA, 2008). The Handbook details a six-step process for watershed planning as outlined in Figure 7. The contents of this WMP are the product of Steps 1-4, that is, build partnerships (Step 1), characterize the watershed (Step 2), set goals and identify solutions (Step 3), and design an implementation program (Step 4). Recommendations for implementation of the WMP (Step 5) and measurement of progress and making adjustments as progress is made (Step 6) are also provided within this WMP. It is important to note that the process of watershed management is dynamic and iterative. As more information is collected and lessons are learned, the implementation program should be reassessed, refined, and modified accordingly.

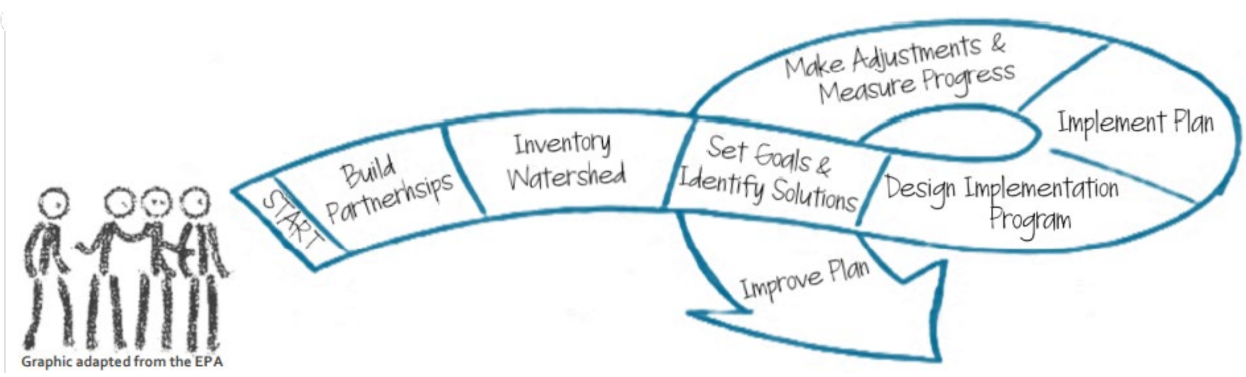


Figure 7. Conceptual drawing of the WMP and implementation process.

One key component of this process is its incorporation of the nine minimum elements from the Clean Water Act section 319 Nonpoint Source Program's funding guidelines. Each of these elements are embedded within the six-step process for watershed planning as shown in Figure 7. The nine elements are designated by the EPA as the most critical for an effective watershed planning process and are generally required for watershed projects funded under section 319. The nine elements, included in EPA's *Handbook for Developing Watershed Plans to Restore and Protect Our Waters* (2008), are:

1. Identify causes and sources of pollution
2. Estimate load reductions expected
3. Describe management measures and targeted critical areas
4. Estimate technical and financial assistance needed
5. Develop an information and education component
6. Develop a project schedule
7. Describe interim, measurable milestones
8. Identify indicators to measure progress
9. Develop a monitoring component

2.3 COMMUNITY OUTREACH

An essential component in the creation of this WMP is following the principles of community-driven development. Broad public education and engagement in the planning process is essential to the success of watershed management. This requires deliberate efforts to develop public participation in a shared analysis of both the problems and solutions for a given watershed. Communities most vulnerable to the effects of flooding and degraded water quality have relevant direct experience and can provide first-hand accounts and information not typically available by other means of investigation. It is also these same communities that are likely to be the most directly affected by the outcomes of the WMP. The more residents that are engaged in their own community solutions, the more effective those solutions will be.

In the development of this WMP, a variety of mediums were utilized for the purposes of community outreach and engagement. This included virtual meetings, site visits, social media engagement, short educational videos, and development and piloting a teaching curriculum. One key component of community outreach was the development of a project website designed using the ESRI Story Map platform (Figure 8). The purpose of the Story Map is to provide a comprehensive resource for DPNR, partners, and community members to learn about the project, provide input, and access updates on project events and deliverables. One of the primary features of the Story Map is a tab that allows the public to submit reports of flooding or other water quality issues in a geographic format. This feature enables citizens to engage with the project continuously and to act as citizen scientists.

A link to the Story Map is provided here: Visioning Story Map. It can also be accessed and promoted via tinyurl.com/StormwaterUSVI.

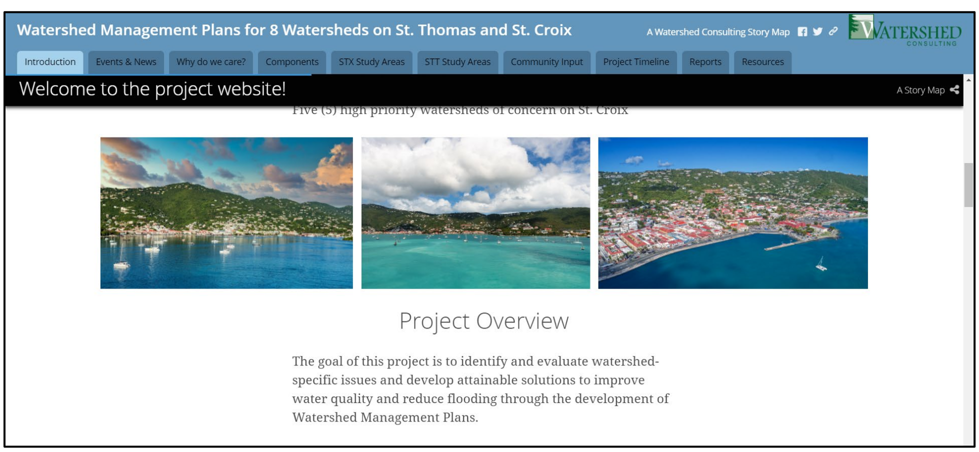


Figure 8. A screenshot from the Project Overview section of the WMP Story Map.

2.3.1 Public Outreach

Community members were informed of upcoming events and to increase general awareness of the project. Outreach was completed through the DPNR and project website, DPNR social media posts, and on the project's Facebook page. The project piqued the interest of local news organizations, resulting in article titled *Dorothea Watershed Study Underway; Community Input Sought* published by The St. Thomas Source.

2.3.2 Community Meetings

To engage with the local community of the Dorothea watershed, two virtual public meetings were held (Figure 9) in addition to conversations and site visits with individual stakeholders.

The first meeting was held in April 2023 and focused on characteristics of the watershed, infrastructure mapping, common stormwater management issues and their consequences, and types BMPs that can be implemented. A second meeting was held in September 2023 and included progress to date on the project, issues identified, and proposed solutions. A discussion with community members was facilitated after each meeting. Stakeholders were encouraged to reach out individually to the project team following these meetings to discuss specific concerns and areas of interest.

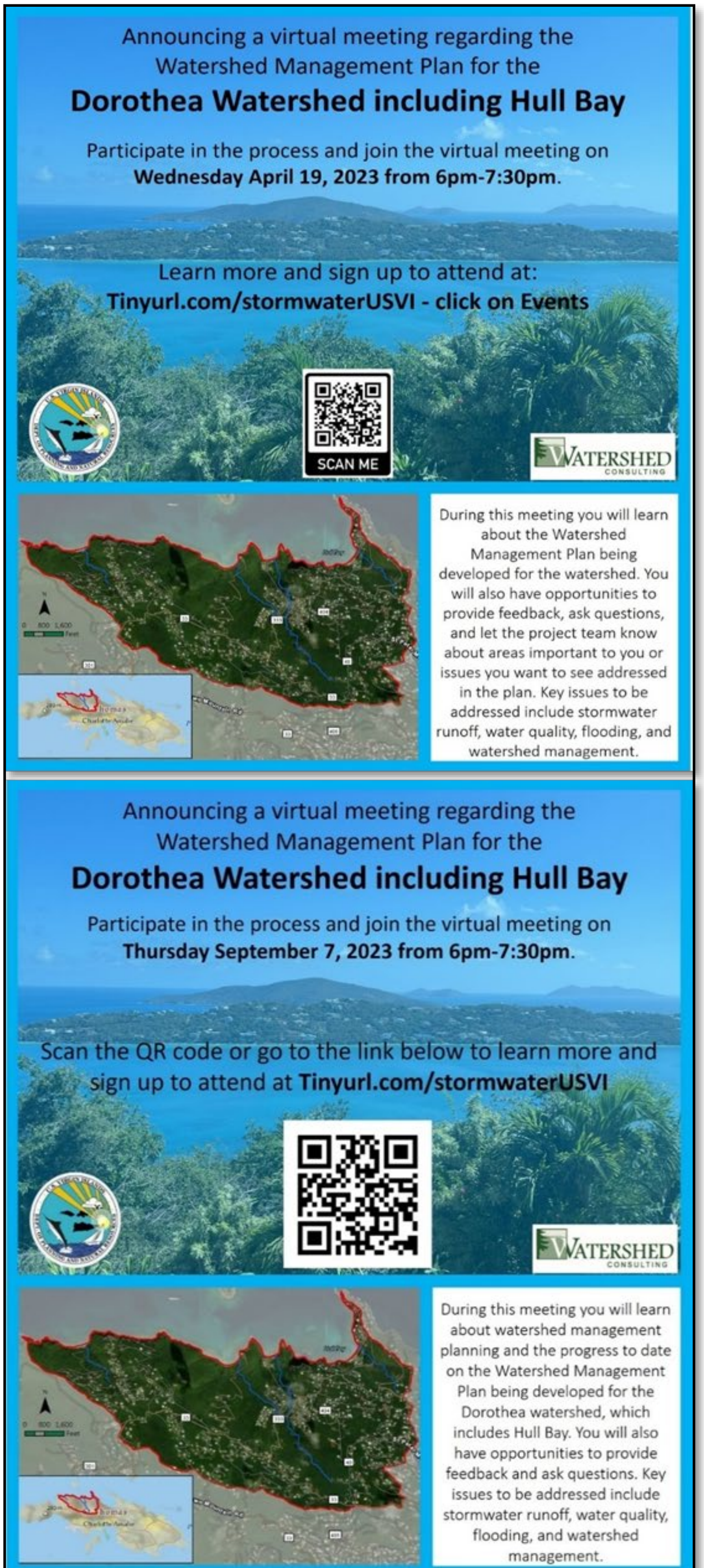


Figure 9. Two virtual meetings were held for the Dorothea watershed.

2.3.3 Site Visits

Property damage, sediment transport, and damage to roadways caused by flooding and erosion were the most prevalent concerns brought up by community members. In response to many of those who contacted the project team or our partners about site specific issues, representatives from our team conducted site visits to assess the damage or issues, meet with community members in-person, and develop proposed solutions.

Often a relatively recent infrastructure development was cited as the source of erosion and sediment transport (Figure 10). This highlights the need for careful planning that considers stormwater management in any type of development.

Figure 10. Photo of road erosion related to new development in the Dorothea watershed.

Figure 11. Field staff investigated potential water quality issues in the watershed.

Field staff assessed potential sources of water quality degradation, opportunities for management, and other issues such as contamination due to wastewater leaks (Figure 11) or solid waste management. These observations were documented for further assessment.

2.3.4 Short Educational Videos

A series of three short educational videos were developed as a part of the larger WMP project. The purpose in the development of these videos was to provide DPNR with educational outreach content that they could share on their social media and with local stakeholders.

Educational Video #1: An Introduction to Watersheds

> This video provides an introduction to watersheds. The video introduces viewers to the fundamentals of watershed science, providing them with the knowledge to identify the basics of what constitutes a healthy watershed, and what potential threats may compromise that health. The video goes on to describe watershed management as a practice, why it is important and what that means for residents of a watershed. The narrator in this video is Olasee Davis, an assistant professor in the Natural Resources Program at the University of the Virgin Islands (UVI).

Educational Video #2: Threats to Watersheds and Potential Solutions

> The second educational video dives a little deeper into the threats that watersheds in the Virgin Islands face and management strategies that can be used to address them. It provides an introduction to the specific water quality constituents (i.e., nutrients, sediment and bacteria) that

threaten human and environmental health. This was followed by an introduction to hydrologic dynamics, specifically the methods of water movement including infiltration, interception, storage, and transport and how land use plays an influential role in these dynamics. The video summarizes common stormwater best management practices and explains how these practices utilize hydrologic dynamics to address pollutants of concern.

Educational Video #3: Community Action

The last video of the educational series focused on community action. Specifically, how local residents and businesses can engage in reducing contamination and improving the overall health of USVI watersheds. The primary premise of this video is that watershed protection is everyone's responsibility and there are impactful ways that individuals can contribute to improved watershed management. The first subject of focus is vegetation, emphasizing the value of utilizing vegetation to minimize erosion and reducing fertilizer and pesticide use to minimize nutrient pollution. This is followed by a discussion of hazardous chemicals and solid waste, and how residents can properly dispose of them. Next, the video describes the value in building a rain garden and keeping new structures out of flood zones. The video ends with a discussion of community action groups and local clean ups where community members can volunteer and get involved.

2.3.5 Educational Outreach

2.3.5.1 Curriculum Development

A field-based lesson plan was developed to be used by educators in the Virgin Islands to document existing conditions of a gut and to better familiarize students with their environment. The activities developed were designed to be fairly simple and to be completed by a group of students in approximately half a day. High school aged students were the target audience, although the exercises could be adapted for younger students.

2.3.5.2 Training Session

On March 21, 2023, an in-person training session for a group of educators, interested professionals, and local stakeholders was held near the Dorothea gut outlet. The field-based session began with an overview of the materials, the exercises, and the itinerary for the training session (Figure 12). Following this introduction, the group walked to the Dorothea gut outlet. The group went through each of the activities and a demonstration was provided (Figure 13).

The group had discussions about the important topics and concepts to introduce to students. A series of questions were also discussed that could be posed to students to guide and engage them through the series of exercises. These questions were developed to help students to work out key concepts independently and ask their own questions.

Following the field demonstration and training, the group returned to the vehicles and completed a driving tour of the watershed. The cars following the lead car were provided with walkie talkies so that key features could be pointed out. The driving tour focused on the Ridge to Reef concept, which is important as it provides a local and visual example of the importance of considering the entire watershed to understand impacts to water quality. The group stopped at a gut crossing to assess the condition of the gut at this location in the watershed with a focus on water clarity and quality. The second stop included a small neighborhood-scale wastewater treatment plant (Figure 13). Discussions regarding water quality and waste management were held at these locations. The developed educational materials and an explanatory memo are provided in Appendix C.

Figure 12. An overview of the materials and training itinerary was provided.

Figure 13. Each of the activities was discussed with the group to ensure that they would be able to present the materials to students (upper). The group also visited a gut crossing (lower left) and a neighborhood wastewater treatment plant (lower right).

2.4 Existing Regulations, Policies & Programs

Existing regulations, policies, and programs related to water quality have a profound impact on the success of current and future watershed planning efforts. Strong regulations and programs provide a solid base for watershed planning efforts and can establish potential sources of funding for staffing and training. As part of the larger WMP project, an evaluation of current codes and a survey of staff to better understand current challenges for staff and where code language may be adjusted to enhance water quality and protect natural resources was conducted. The complete methods and findings from the evaluation are documented in the U.S. Virgin Island Regulatory Review Report found in Appendix A. A summary of this information targeted at DPNR staff is also provided in Appendix A.

2.4.1 Current Policies & Legal Framework

In the USVI, both federal and local policies and procedures are in place for environmental protection. The USVI government implements or enforces the following federally mandated environmental programs:

- Clean Water Act (CWA)
    - Ambient Water Quality Monitoring
    - Section 319 Nonpoint Source Pollution
    - Section 402 Territorial Pollutant Discharge Elimination System (TPDES)
    - Beaches Environmental Assessment and Coastal Health (BEACH) Act
- Safe Drinking Water Act (SDWA)
- Clean Air Act (CAA)
    - Air Pollution Prevention and Control
    - Title V Operating Permits
    - New Source Performance Standards
    - Risk Management Program (RMP)
    - Section 112 Air Toxics, including National Emission Standards for Hazardous Air Pollutants
- Energy Policy Act of 2005

The Virgin Islands Code currently contains the policies for water resources management and watershed planning in the USVI. The 2019 Code includes measures to ensure that some level of protection is provided for available water resources since development activities on land can result in direct impacts on coastal waters and marine resources due to the islands physiography. The USVI has several watershed protection codes in place (i.e., buffers, erosion, and sediment control) but are still experiencing negative water quality impacts. The surveys conducted through this regulatory audit and needs/capabilities assessment helped to identify how implementation of the codes could be improved. The regulatory review (see Appendix A, report Table 1) highlights the sections of the Virgin Islands Code that have direct influence on water resources and watershed planning efforts.

2.4.2 USVI Regulatory Agencies

The institutions with regulatory responsibilities related to watershed management and planning in the USVI are as follows:

2.4.2.1 Department of Planning & Natural Resources (DPNR)

The Department of Planning and Natural Resources (DPNR) was established in 1987 and serves as the agency responsible for the administration and enforcement of all laws pertaining to the preservation and conservation of fish and wildlife, trees and vegetation, coastal zones, cultural and historical resources, water resources, and other environmental concerns. Prior to 1987 the agency was known as the Department of Conservation and Cultural Affairs. The responsibilities of the DPNR include oversight and compliance for land subdivision, development and building permits, code enforcement, earth change permits, zoning administration in the coastal zone, boat registration, and mooring and anchoring of vessels within territorial waters. DPNR is comprised of ten primary operating divisions, each with its own regulatory mandate. The divisions with responsibilities relevant to watershed management can be found in Appendix A's regulatory review.

2.4.2.2 VI Department of Agriculture (VIDA)

The Virgin Islands Department of Agriculture (VIDA) is responsible for soil conservation practices on agricultural lands including maintaining buffer zones along guts. VIDA exercises its authority for earth change activities conducted on sites over which they have authority They also support the activities of the Virgin Islands Conservation District (VICD) to provide for the conservation and development of the soil, water, and other natural resources of the Virgin Islands.

2.4.2.3 Department of Public Works (DPW)

The Department of Public Works (DPW) routinely impacts watershed health and planning efforts through several program areas including:

1. Infrastructure Maintenance: DPW is mandated to plan, construct and maintain public roads, highways, storm drainage systems, buildings, transportation systems, parking facilities, and cemeteries.
2. Gut Cleaning Program: DPW operates a program to clean guts to avoid nuisance flooding especially during the hurricane season. Guts are cleared and maintained in accordance with the guidelines stipulated by the DPNR and may involve bushing the sides of the guts and removal of solid waste. DPW has also partnered with the Waste Management Authority (WMA) to address guts that have been affected by sewage.
3. Flood Mitigation: DPW undertakes flood mitigation work for roads, as well as general flood mitigation for properties in floodplains. Examples include the Smith Bay Road stormwater mitigation project[1] and the St. Andrews Flood Mitigation Project[2].

2.4.2.4 Waste Management Authority (WMA)

This agency provides waste collection, treatment, and disposal services to protect public health and preserve the environment of the USVI. They regulate the landfills, convenience centers, and bin locations where solid waste is collected. The agency is also responsible for the public sewer system and addressing sanitary sewer overflows (SSOs) and combined sewer overflows (CSOs).

[1] https://www.usviodr.com/dpw-receives-award-to-address-chronic-flooding-in-smith-bay/
[2] https://www.fema.gov/case-study/successful-storm-sewer-system-improvement

2.4.2.5 Water and Power Authority (WAPA)

This agency produces and distributes electricity and drinking water to residential and commercial customers in the territory. This includes the islands' wells that may be impacted by pollutants from runoff. The DPNR DEP's groundwater program also has a role in in drinking water through their public water systems supervision program that regulates well management and new well drilling.

2.4.3 Coastal Zone Management Tier Structure

The entirety of the USVI is in the coastal zone because they are small islands. For planning and permitting considerations, the coastal zone is divided into two tiers: Tier 1 and Tier 2. Tier 1 extends landward from the outer limit of the territorial sea, including all offshore islands and bays, to distances inland as specified in an approved map that was first developed in 1979 (NOAA, 2018). Figure 14 shows the extent of the Tier 1 areas for St. Thomas as provided by the Coastal Zone Management (CZM) program. Tier 2 includes the remainder of the USVI - interior portions of the Islands of St. Thomas, St. John, and St. Croix, including all watersheds and adjacent land areas not included in Tier 1.

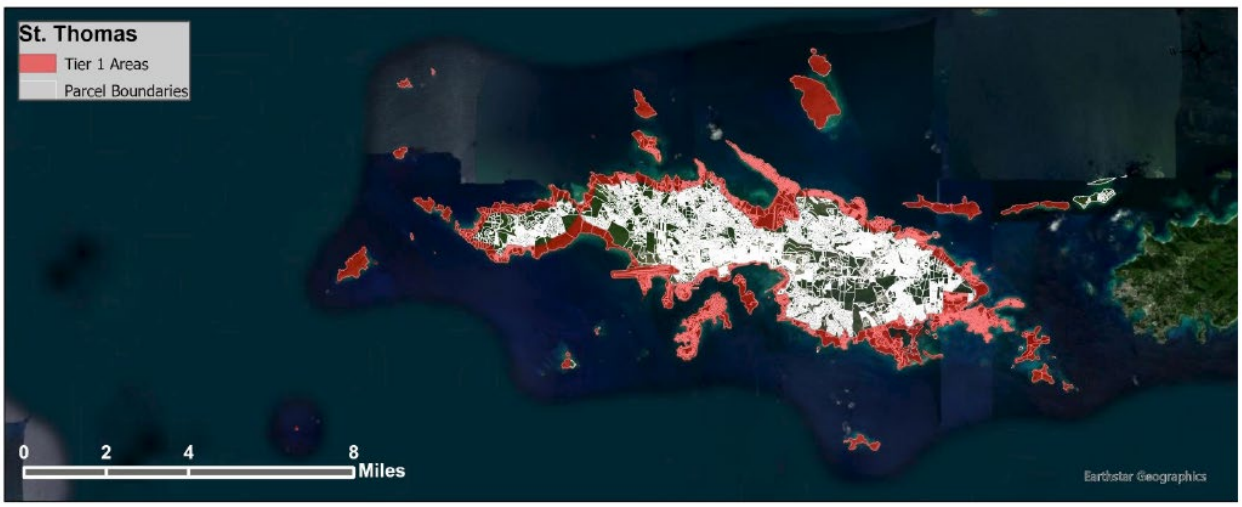


Figure 14. CZM Tier 1 areas (courtesy of CZM).

Areas designated as Tier 1 have a more stringent permitting process than those in Tier 2. Permits for development can be for either minor activities or major activities and permitting development responsibilities are assigned based on the activity type. The DPNR Commissioner issues permits for all minor activities. A Coastal Zone Management Commission committee for each of the three major islands issues all permits for major activities within Tier 1. A more comprehensive coastal zone permit process is focused only on proposals in Tier 1, and Section 906 of the VICZMA is focused on specific policies applicable to the tier. Major construction permit applications for Tier 1 projects are reviewed by CZM staff who then issue a report with recommendations that trigger a public hearing process. After the public hearing, the project must be approved by the local Coastal Zone Management Commission committee for the specific island, and then by the USVI legislature and the governor.

Tier 2 permit applications have fewer requirements for applicants during the DPNR review process and are handled entirely by DPNR. The Division of Building Permits issues permits for activities under the Earth Change law, while the Division of Planning issues zoning and subdivision permits. No public hearing is currently required for Tier 2 projects unless a zoning change is required. Although development projects in Tier 2 are required to be consistent with the goals of the VICZMA and reviewed by the relevant authorities, compliance monitoring and enforcement by DPNR personnel is typically limited to permitted activities within Tier 1 only.

2.4.4 Survey

DPNR staff were surveyed to identify programmatic strengths and gaps in watershed protection strategies. The review used multiple online survey tools to best understand current practices and procedures and to allow staff an opportunity to weigh in on programmatic issues they encounter while performing their jobs. The review was conducted to document current conditions, not as a critique of past management efforts.

The results of the surveys informed the watershed plan recommendations and were instrumental in developing optimum management standards and strategies to reduce the impacts of urbanization and new development. Understanding the current state of development strategies and practices allows for an assessment of strengths and weaknesses, guides future watershed planning strategies, and highlights changes and additions to current codes that help design effective watershed plans and protect important water resources. A total of four surveys were completed by DPNR and WMA staff. They included:

1. **Eight Tools of Watershed Protection Audit**
   This audit tool, developed by CWP, identifies programmatic strengths and gaps in watershed protection strategies and helps inform watershed planning recommendations.
2. **Needs and Capabilities Assessment**
   The Needs and Capabilities Assessment explores programmatic needs and existing capacity pertaining to the process of plan reviews and inspection of stormwater Best Management Practices (BMPs).
3. **Future Land Use Questions**
   These questions were designed to obtain more information on future watershed development. It was intended to answer questions about planned future projects and the protections provided to certain land uses and physical topographies to reduce the impact of development.
4. **Better Site Design Questions for WMA**
   Other agencies outside of DPNR also have programs or practices that influence watershed protection planning. A set of questions was provided to WMA staff to provide their insight into how their current practices influence watershed resources.

The links to three of the surveys were provided to DPNR staff in early May 2021 and respondents were given several weeks to provide input. Some tools had better response rates than others, and some questions received no response since the preceding question was answered with a no or a response that that meant there was no additional information. The Needs and Capabilities Assessment had four responses (compared to eight responses to the Eight Tools Audit survey), but the responses did provide additional input from staff on the development review process. Appendix A includes the results of the assessment. There was no response to the Post-Construction Management questions, which may indicate that post construction inspection and maintenance may be a tool that should be adopted in the future.

3 Dorothea Watershed

3.1 Watershed Introduction

Dorothea is a 2.63 sq. mile watershed located on the northern coast of St. Thomas (Figure 15). The watershed has a population of 3,881 based on 2020 U.S. Census data, a majority of which are minorities. The watershed contains 2.9 miles of mapped guts and 4.2 miles of shoreline. It includes 5.6 acres of wetlands, consisting of roughly 2.2 acres of freshwater forested/shrub wetland, 2 acres of estuarine and marine wetlands, and 1.4 acres of freshwater ponds.

The dominant Hydrologic Soil Group (HSG) is HSG-B soils that have a moderate rate of infiltration and runoff potential. The total impervious cover of the watershed is approximately 10%, and the watershed has 78% tree canopy cover. The primary zoning categories are low-density residential (90%) with small areas of transportation, agricultural, and business zoned areas. Housing development in the watershed primarily occurred during the 2010s and 1960s. Data from the U.S. Virgin Islands Department of Planning and Natural Resources (DPNR) ambient and beach water quality monitoring programs categorizes assessment units as Class B, with impairments for dissolved oxygen and pH. See Appendix B for the complete watershed characterization.

Figure 15. Overview map of the watershed.

3.2 Physical & Natural Features

3.2.1 Soils & Topography

3.2.1.1 Soils

When rain falls over land, a portion runs into guts, the ocean, and the stormwater system while the remaining infiltrates into the soil or evaporates into the atmosphere. The hydrologic soil group (HSG) is a soil property that represents the rate at which water infiltrates into a type of soil. Soils are classified into seven soil groups, including four HSGs (A, B, C, and D) based on the soil's infiltration capacity, and three "dual classifications" (A/D, B/D, and C/D) where a soil's infiltration capacity is influenced by a perched water table (Table 1). Data was obtained from the USVI Department of Planning and Natural Resources (DPNR) soil boundaries and the gridded National Soil Survey Geographic Database (gNATSGO), which is developed and maintained by the U.S. Department of Agriculture's Natural Resource Conservation Service (USDA NRCS).

Table 1. Overview of Hydrologic Soil Groups (HSG)[1].

Hydrologic Soil Group (HSG)	Description
HSG-A	HSG-A soils consist of deep, well-drained sands or gravelly sands with high infiltration and low runoff rates.
HSG-B	HSG-B soils consist of deep, well-drained soils with a moderately fine to moderately coarse texture and a moderate rate of infiltration and runoff.
HSG-C	HSG-C consists of soils with a layer that impedes the downward movement of water or fine-textured soils and a slow rate of infiltration.
HSG-D	HSG-D consists of soils with a very slow infiltration rate and high runoff potential. This group is composed of clays that have a high shrink-swell potential, soils with a high-water table, soils that have a clay pan or clay layer at or near the surface, and soils that are shallow over nearly impervious material.
HSG-A/D	HSG-A/D soils naturally have a very slow infiltration rate due to a high-water table, but they will have high infiltration and low runoff rates if drained.
HSG-B/D	HSG-B/D soils naturally have a very slow infiltration rate due to a high-water table, but they will have a moderate rate of infiltration and runoff if drained.
HSG-C/D	HSG-C/D soils naturally have a very slow infiltration rate due to a high-water table, but they will have a slow rate of infiltration if drained.
No HSG Assigned[2]	Data not available in gNATSGO.

Hydrologic Soil Group (HSG)	Description
[1] Source: NRCS, 2007 https://directives.sc.egov.usda.gov/OpenNonWebContent.aspx?content=17757.wba	
[2] Indicates HSG data was not available within a particular soil boundary.	

Figure 16 shows the distribution of HSG classes within the watershed and Table 2 provides a breakdown of the acres and percentages. The watershed consists predominantly of moderately well-draining soils, with 91.7% HSG-B soils. There is a small percentage (5.2%) of low infiltration HSG-D soils along the shoreline. By the mouth of each gut, well-draining HSG-A soils and slow-draining HSG-A/D can be found. As shown in Table 2, the percentage of total area attributed to HSG classes amounts to 99.7% of the watershed. The final 0.3% can be attributed to surface water in the watershed.

Table 2. Hydrologic Soil Groups (HSG) in the watershed.

Hydrologic Soil Group (HSG)	Area in Watershed (acres)	Percentage of Total Area (%)
A	30.0	1.8%
B	1,545.3	91.7%
C	0	0%
D	87.3	5.2%
A/D	15.8	0.94%
C/D	2.0	0.12%
No HSG Assigned	5.2	0.31
Total	1,680.4	99.7%

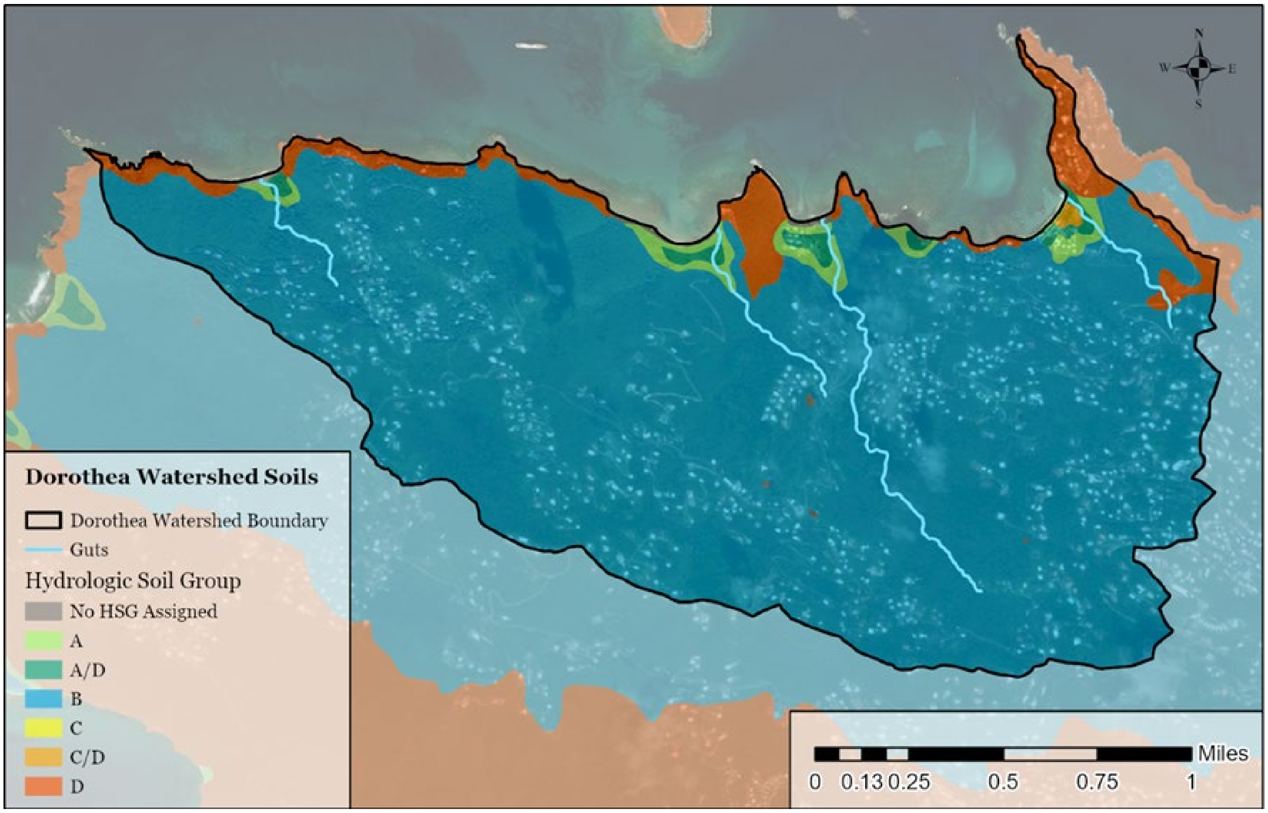


Figure 16. Hydrologic Soil Groups (HSG) in the watershed.

3.2.1.2 Topography

Development on steep slopes is highly susceptible to erosion that carries sediment to nearby waterways and ultimately local bays. In excess, sediment has harmful impacts on aquatic ecosystems, including but not limited to 1) reduced light penetration, which inhibits coral and seagrass growth, 2) clogging of gills and filters in fish and shellfish, and 3) decline of commercial and recreation fishing success (Schueler, 1987). Sediment deposition in coastal waters smothers seagrass beds and coral reefs, increases sedimentation of channels and harbors (requiring more frequent dredging), changes bottom composition, and leads to loss of use for recreational purposes like swimming and snorkeling (U.S. EPA, 1993). To date, there is no steep slope ordinance in the USVI to limit development on steep slopes and ensure adequate soil and erosion control practices are used.

Soil surveys produced by the U.S. Department of Agriculture categorize soil types, in part, based on typical slope ranges shown in Table 3 below. These ranges, along with a slope data layer developed for this project using 2018 topographical data, were used to summarize slopes in the watershed (summarized in Table 3 and displayed on Figure 17). Slopes in the watershed are predominantly between 11-25%. Figure 17 shows that the greatest slopes are in the southern portion of the watershed associated with the watershed boundary, guts, and forested areas. The soils associated with the steeper slopes have moderate runoff potential. During a rain event, the runoff flows down these slopes to the floodplains below, potentially resulting in flooding or issues related to high stormwater runoff such as erosion. Figure 21 below shows the locations of floodplains in the Dorothea watershed.

Figure 17 shows the location of the developed areas in relation to the slope percentages. Development areas, based on data from 2020, were defined as areas containing greater than 20% impervious cover.

There are approximately 363 acres of developed area in the watershed, which equates to 21.5% of the total watershed area. Most development has occurred in the eastern and central areas of the watershed. However, there is also some low-density residential development located along the steeper slopes in the southwestern and southeastern portions of the watershed.

Table 3. Slope percentages in the Dorothea watershed.

Slope Percentage	Area in Watershed (acres)	Percentage of Total Area (%)
0% - 10%	303.4	18.0%
11% - 18%	380.9	22.6%
19% -25%	468.6	27.8%
26% - 33%	308.5	18.3%
34% - 43%	160.1	9.5%
> 44%	64.1	13.8%
Total	1,685.6	100%

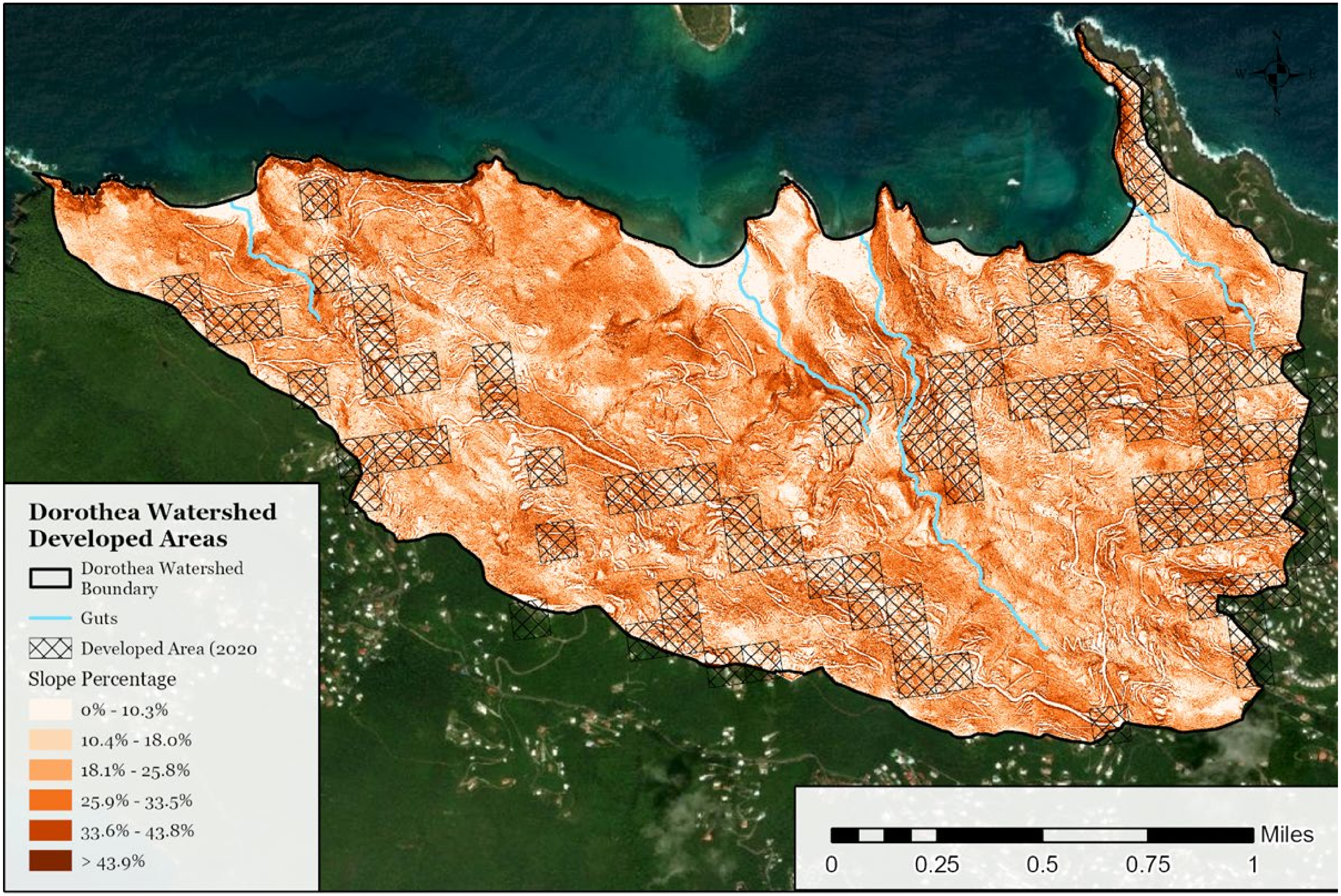


Figure 17 . Developed areas and slope percentages in the watershed.

3.2.2 Hydrology

3.2.2.1 Rainfall

Rainfall in the watershed is primarily dominated by weather systems that arrive from the east in the summer and from the northwest in winter. The average annual rainfall on St. Thomas is approximately 38 inches. Most of this rainfall comes during the wettest months, typically between September and November. The driest months on the island are generally February to March. Rainfall patterns vary significantly from year to year, with above average precipitation and flooding one year and drought or near-drought conditions the following year (RMSI Private Limited, 2021).

3.2.2.2 Surface Water Features

Within the watershed, there are 2.9 miles of guts, 1.4 acres of freshwater ponds, and 4.2 miles of shoreline (Figure 18). Surface water data were obtained from USVI DPNR and from the National Wetlands Inventory (NWI) dataset.

The guts of St. Thomas currently flow only after heavy rainfall or during the rainy season. In the 18th and 19th centuries, guts served as the primary drinking water source on St. Thomas; they also served as a drinking water source to a limited degree in the 20th century through the 1960s but are no longer used for drinking water (Gardner et al., 2008). Guts were and are also used for hunting, freshwater fishing, bathing, and hiking (Gardner et al., 2008).

Guts with permanent pools of freshwater can serve as habitat for rare species of aquatic animals (e.g., Mountain Mullet and American Eel), and the Dorothea Gut is a prime example of this as it generally has a significant pool of water outside of rain events. In addition, guts form corridors that facilitate the movement of wildlife species (Gardner et al., 2008). Over time, increased development led to their degradation as they were seen as dumping grounds. Today, they are still used as a source of freshwater for agriculture and to recharge groundwater. Due to the ephemeral nature of guts, the water quality monitoring programs in the U.S. Virgin Islands focus on coastal waters and beaches, so information concerning water quality in guts is sparse.

There are four main guts of interest in the Dorothea watershed. The guts range in length, with the longest being 1.3 miles and the others ranging between 0.4 and 0.6 miles. The longest gut begins in a heavily vegetated area on the southern end of the watershed prior to passing through a residential area and discharging into Dorothea Bay.

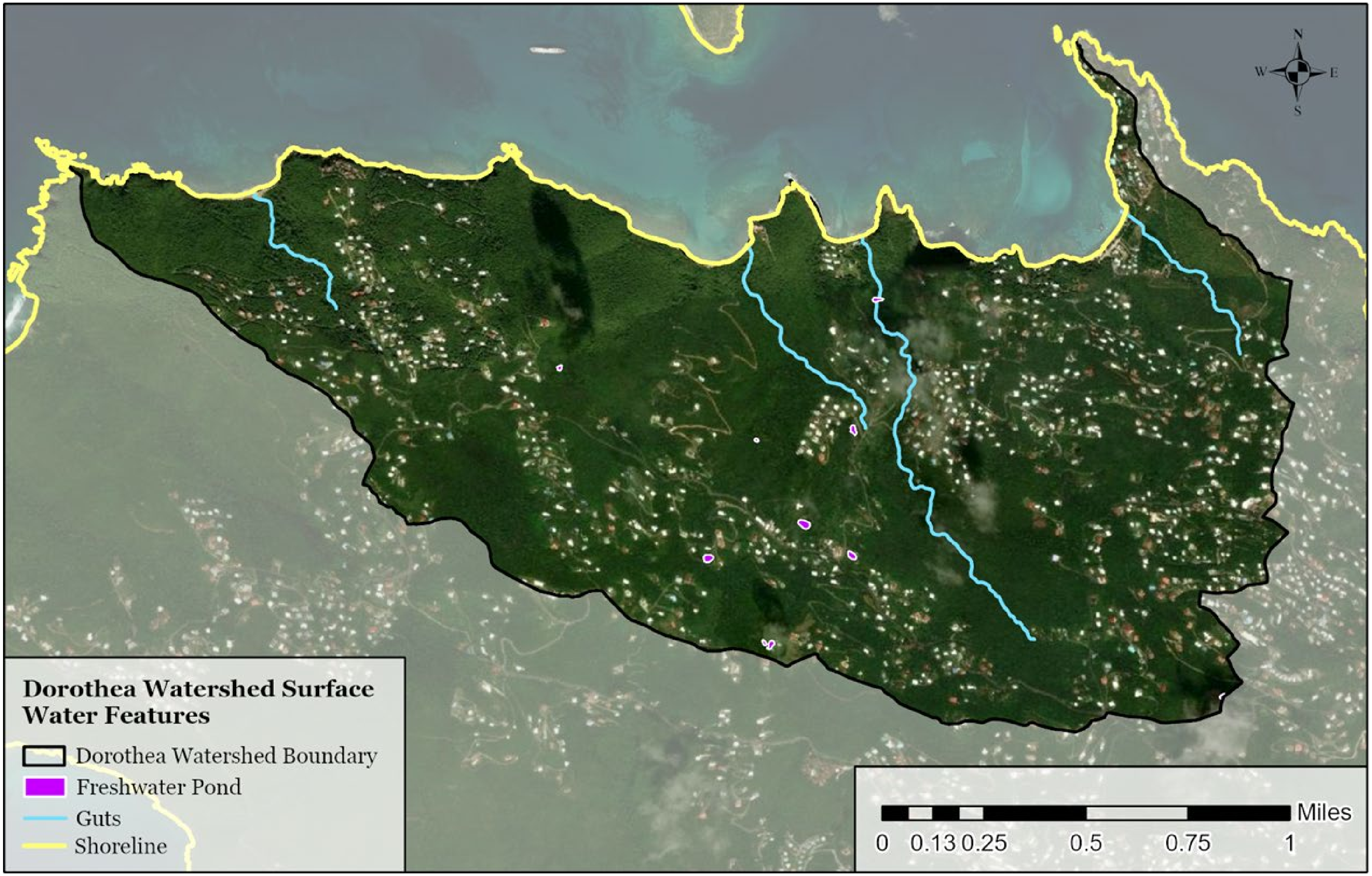


Figure 18. Surface water features in the watershed.

3.2.2.3 Riparian Zones

Existing land cover was summarized within a 25-foot buffer surrounding the guts in the watershed. These buffers are commonly referred to as riparian zones, transitional areas occurring between guts and the neighboring land. Riparian zones are characterized by distinctive hydrology, soil, and biotic conditions, and while they are often proportionally a small component of a watershed, they play a significant role in ecosystem process and local fauna composition (Heartsill-Scalley, 2021).

In the Dorothea watershed, 93% of the existing land-cover within the riparian buffer zone is composed of tree canopy. This is higher than what is observed in surrounding watersheds due to the high percentage of forested land and lack of development throughout the watershed. In addition, it is noteworthy that 0.53% of the riparian buffer zone consists of impervious cover (buildings, roads, and other paved areas), indicating a lack of development directly along the guts, which should be lauded and preserved (Figure *19*).

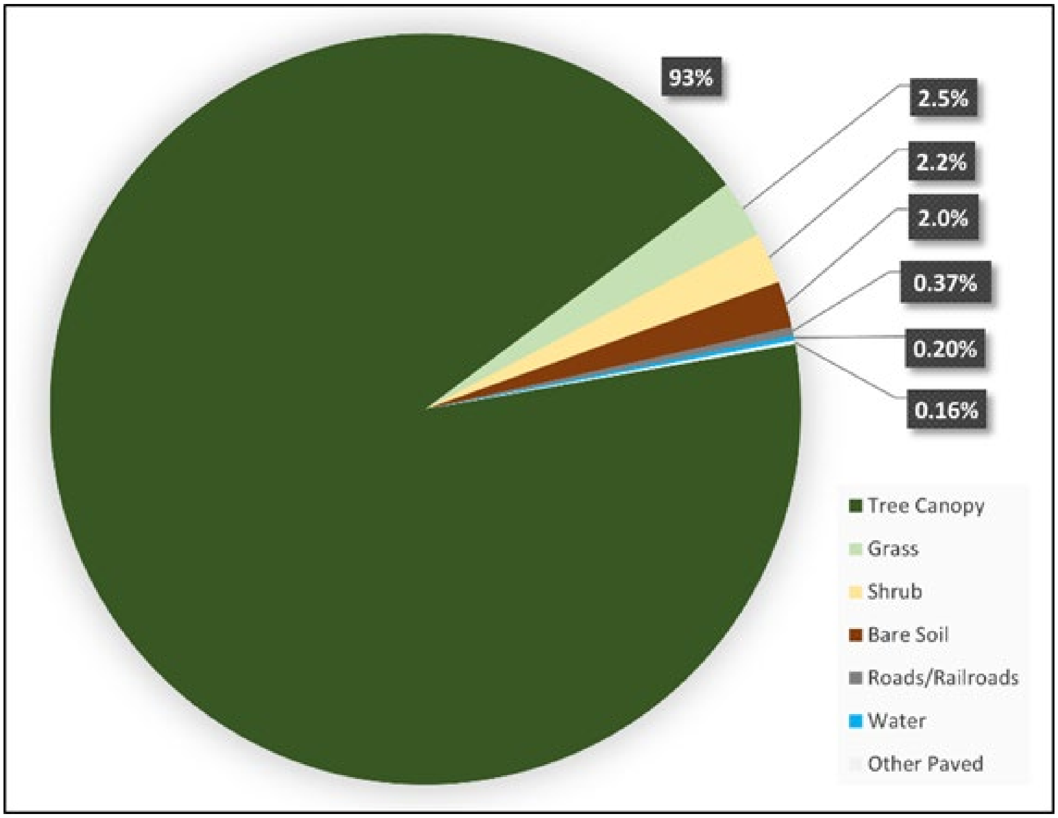


Figure 19. Existing land cover within a 25-foot buffer of guts in the watershed.

3.2.2.4 Wetlands

According to the National Wetlands Inventory (NWI), there are a total of 5.6 acres of wetlands within the Dorothea watershed (Table 4). This is broken down into 2.2 acres of freshwater forested/shrub wetland, 2 acres of estuarine and marine wetland, and 1.4 acres of freshwater ponds. There are no fresh water emergent wetlands or lacustrine wetlands.

Table 4. Summary of wetland types in the Dorothea watershed.

Wetland Type	Area in Watershed (Acres)
Estuarine and Marine Wetland	2.0
Freshwater Forested/Shrub Wetland	2.2
Freshwater Pond	1.4
Total	*5.6*

3.2.2.5 Freshwater Resources

Fresh water is a scarce resource in the U.S. Virgin Islands. Water is supplied to housing units through a combination of cisterns, water deliveries, wells, public water sources, and purchased bottled water. Figure 20 shows the percentage of residences with a cistern by estate based on 2020 U.S. Census data. The public water supply is provided by the USVI Water and Power Authority (WAPA), which operates the desalination plant, Randolph Harley, that can produce 2.3 million gallons per day of potable water using energy efficient reverse osmosis. The WAPA pipe distribution system serves 45% of the island but has not yet been expanded to provide service to the western and northern parts of the island. The water main pipes that deliver water to residents are old and fragile ductile iron types installed as far back as the 1940s. This has resulted in leaks in the system with approximately 10 percent of water lost in the distribution system on St. Thomas (USVI Hurricane Recovery and Resilience Task Force, 2018).

Most of the island's population uses cisterns to collect rainwater for general use and purchases supplementary water for drinking. The USVI Code Title 29 Chapter 5 requires that all buildings except commercial development dwellings and single unit apartments already connected to potable water systems be constructed with a self-sustaining water system such as a cistern or water collection system (USVI, 2019). This includes a requirement to have a certain minimum usable capacity of gallons per square foot of roof area based on building type. Bottled water is from either WAPA or well water that is re-filtered, bottled, and certified by the Department of Health. Many hotels and condominiums in the USVI use small reverse osmosis units to produce their own water (USVI Hurricane Recovery and Resilience Task Force, 2018). Private water haulers also purchase potable water from WAPA, and several have built their own reverse osmosis production system (Alderson et al., 2018).

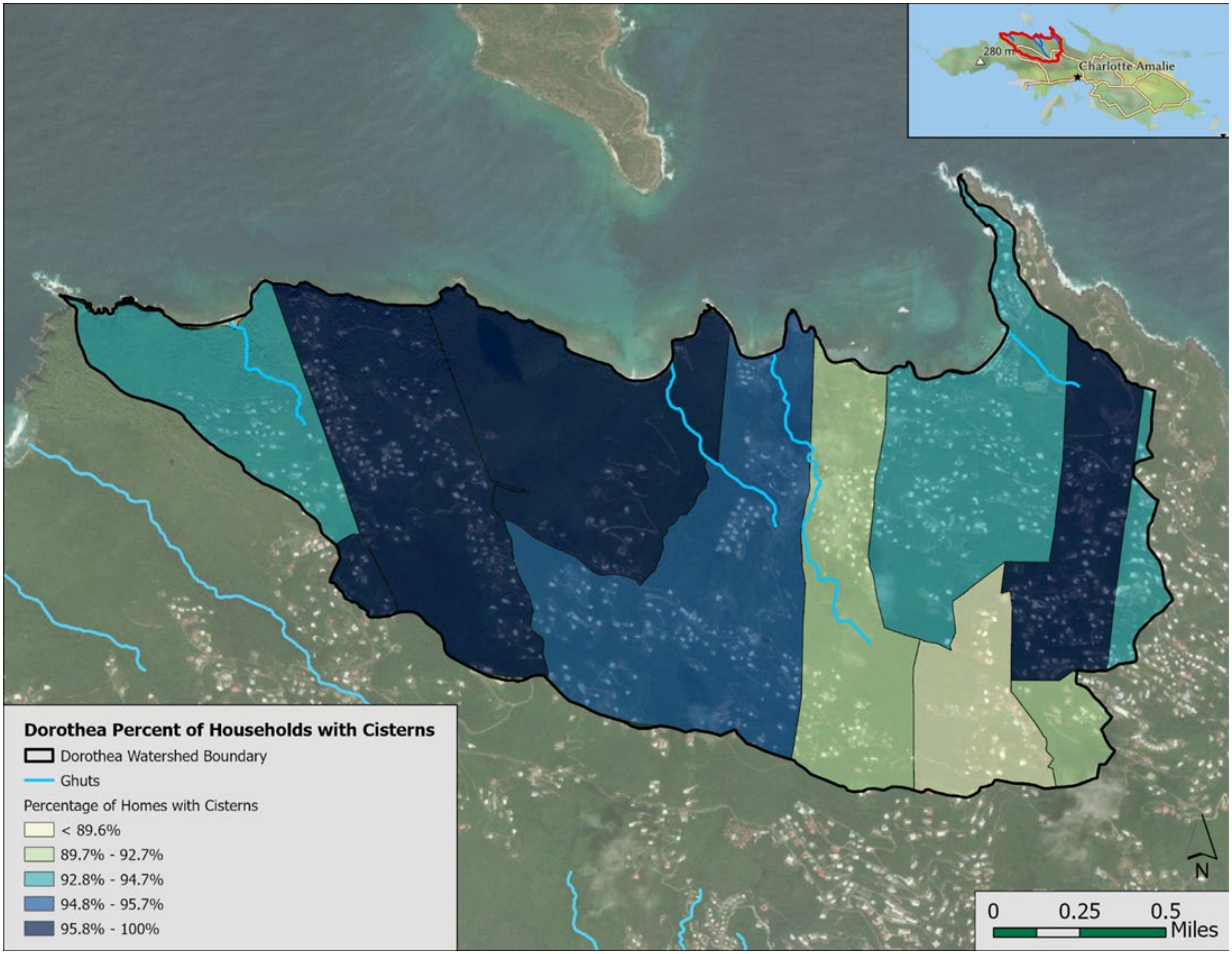


Figure 20. Cistern use by household, summarized be estate in the Dorothea watershed (Source: 2020 U.S. Census data).

3.2.2.6 Flood Zones

Flood zones in the USVI are characterized by the impact associated with the 100-year and 500-year flood events (Table 5). As indicated in Table 5, most of the mapped flood zone is in the "A" zone located on the northern portion of the watershed, often surrounding the guts. Several "AE", "VE", and "X" areas exist along the coast (Figure 21).

Table 5. Flood zone types and areas in the watershed.

Flood Zone	Definition*		Area in Watershed (acres)
A	Areas subject to inundation by the 1-percent-annual-chance (100-year) flood event where no hydraulic analyses have been performed.		11.54
AE	Areas subject to inundation by the 1-percent-annual-chance (100-year) flood event where hydraulic analyses have been performed.		11.8
AO	Areas subject to inundation by the 1-percent-annual-chance (100-year) shallow flooding where average depths are between one and three feet.		0
VE	Areas subject to inundation by the 1-percent-annual-chance (100-year) food event with additional hazards due to storm-induced velocity wave action.		20.9
X	An area of minimal to moderate flood hazard that is outside of the Special Flood Hazard Area and either 1) between the limits of the base flood and the 0.2-percent-annual chance (500-year) flood, or 2) above the elevation of the 0.2-percent-annual-chance (or 500-year) flood.		0.6
*Definitions adapted from https://floodpartners.com/flood-zones/		Total:	148.7

Figure 21. Flood zones in the Dorothea watershed.

3.2.3 Habitat & Ecology

St. Thomas is home to many species of protected and endangered plants, birds, fish, reptiles, mammals, and coral. The U.S. Endangered Species Act of 1973 provides for the conservation of endangered or threatened species and all or portions of their required habitats and ecosystems. A species is considered ‘endangered’ if it is likely to become extinct in a significant portion of its range. A species is considered ‘threatened’ if it is likely to become endangered in the near future (UVI, 2009).

Coral reefs consist of a community of coral polyps that form some of the most diverse ecosystems and provide habitat for at least 25% of all marine species (UVI, 2009). Global stressors to the reefs include ocean warming and other impacts related to climate change. Local threats include pollutants associated with runoff from development, unsustainable land use and fishing pressure, physical damage from anchors, boat groundings, and marine debris. Strategic priorities for coral reef management are documented in Rothenberger & Henderson (2019).

Coral reefs are important to the USVI economy; they provide food, jobs, recreation, and culture, as reef products are incorporated in streets and buildings. Corals also provide a natural defense to coastal property and protect the islands from hurricane-induced flooding, providing an estimated $47 million dollars in annual flood protection benefits (Rothenberger & Henderson, 2019). They help support recreation, as they contribute to swimmable and aesthetic bays and beaches as well as diving locations for tourists.

According to the U.S. Fish and Wildlife Service’s spatial datasets, the Dorothea watershed does not contain critical habitat for rare, threatened, or endangered species. No spatial datasets for wildlife corridors, Areas of Protection or Restoration (APR), or coral reef management locations were available for the island of St. Thomas. These areas may exist on the island, but data was unable to be obtained to summarize as part of this report.

Protected areas on St. Thomas are available from the U.S. Geological Survey’s (USGS) Protected Areas Database (PAD-US). The PAD-US is a national inventory of protected areas including areas dedicated to the preservation of biological diversity, and other natural uses—such as recreational or cultural uses, including extraction—managed for these purposes through legal or other effective means (GreenInfo Network, 2016). Based on USGS PAD-US data, there are no significant protected areas within the Dorothea watershed, with the exception of a protected area on the southwest side that has about 0.20 acres of overlap. Protected areas and mangroves surrounding the watershed (data provided by USVI DPNR) are displayed on Figure 22.

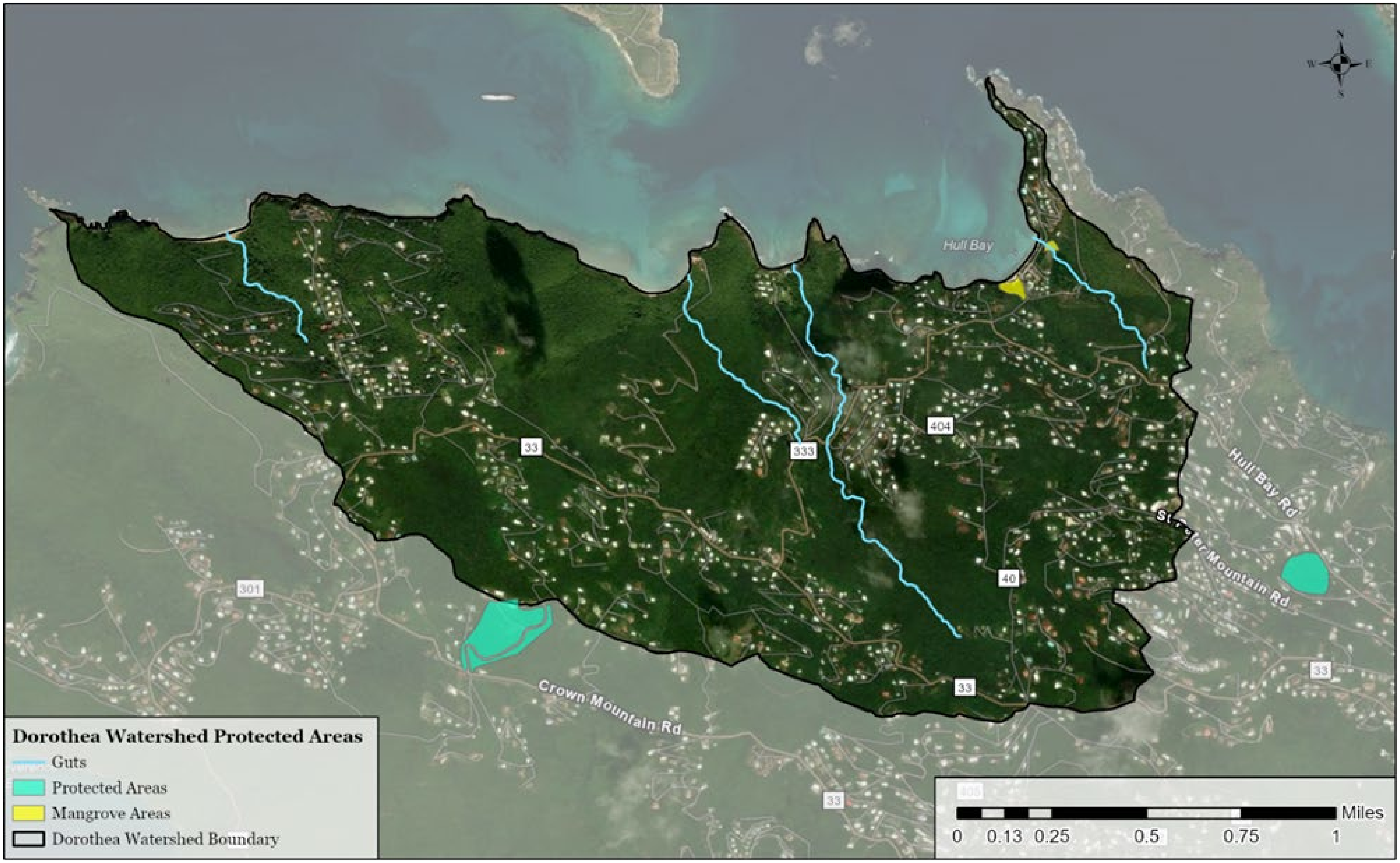


Figure 22. Protected areas and mangroves within and surrounding the watershed.

3.3 Population Characteristics & Land Cover

3.3.1 Watershed Demographics

Various demographics were summarized for the watershed utilizing 2020 U.S. Census data. Data was obtained from the U.S. Census Bureau's Virgin Islands webpage and summarized by USVI estate boundaries. Estates that intersected watershed boundaries were summarized according to the proportion of each estate within the watershed. In most cases, the westernmost estate did not have any data available. The demographic data categories include:

- Total Population
    - Total number of people of any age.
    - This value was adjusted to account for the proportion of the estate that is contained within the study watershed.
- Percent Minority
    - Percentage of population with a racial status other than white alone and/or non-Hispanic or Latino (i.e., all people other than non-Hispanic-or-Latino, white-alone individuals). The minority population in the USVI is primarily African American and West Indian.
- Percent Linguistically Isolated
    - Percentage of population over 5 years old who speak a language other than English and who speak English less than "very well"
- Percentage of occupied households with no vehicles

Figure 23 below illustrates the population density of the estates in the Dorothea watershed. Populations are shown in people per square mile. The most densely populated areas are located across the south-central and eastern portion of the watershed corresponding to primarily low-density residential development.

Figures below illustrate (Figure 24) the percent minority of the population of each estate, (Figure 25) the percent of the population in each estate that is linguistically isolated, and (Figure 26) the percentage of occupied households with zero vehicles by estates. Note that estates with gray fill do not have any data according to the 2020 Census data, and therefore have no associated metrics.

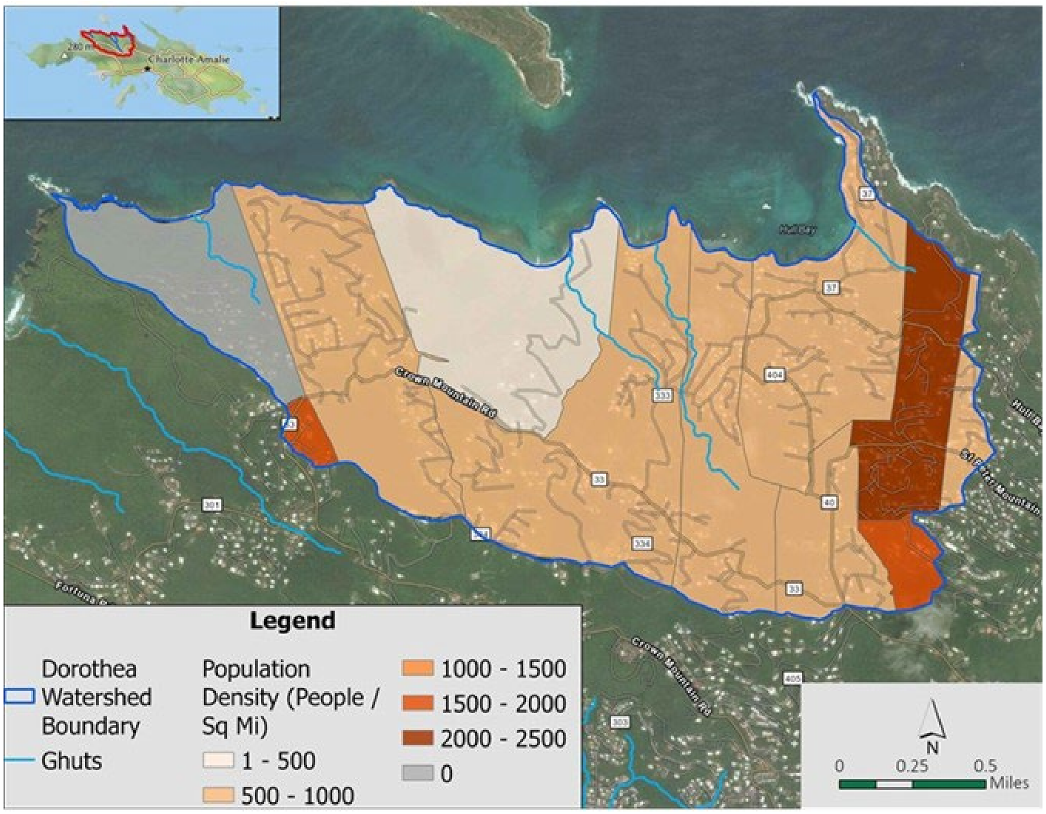


Figure 23. Population density (people per square mile) by estate within the watershed (source: 2020 U.S. Census).

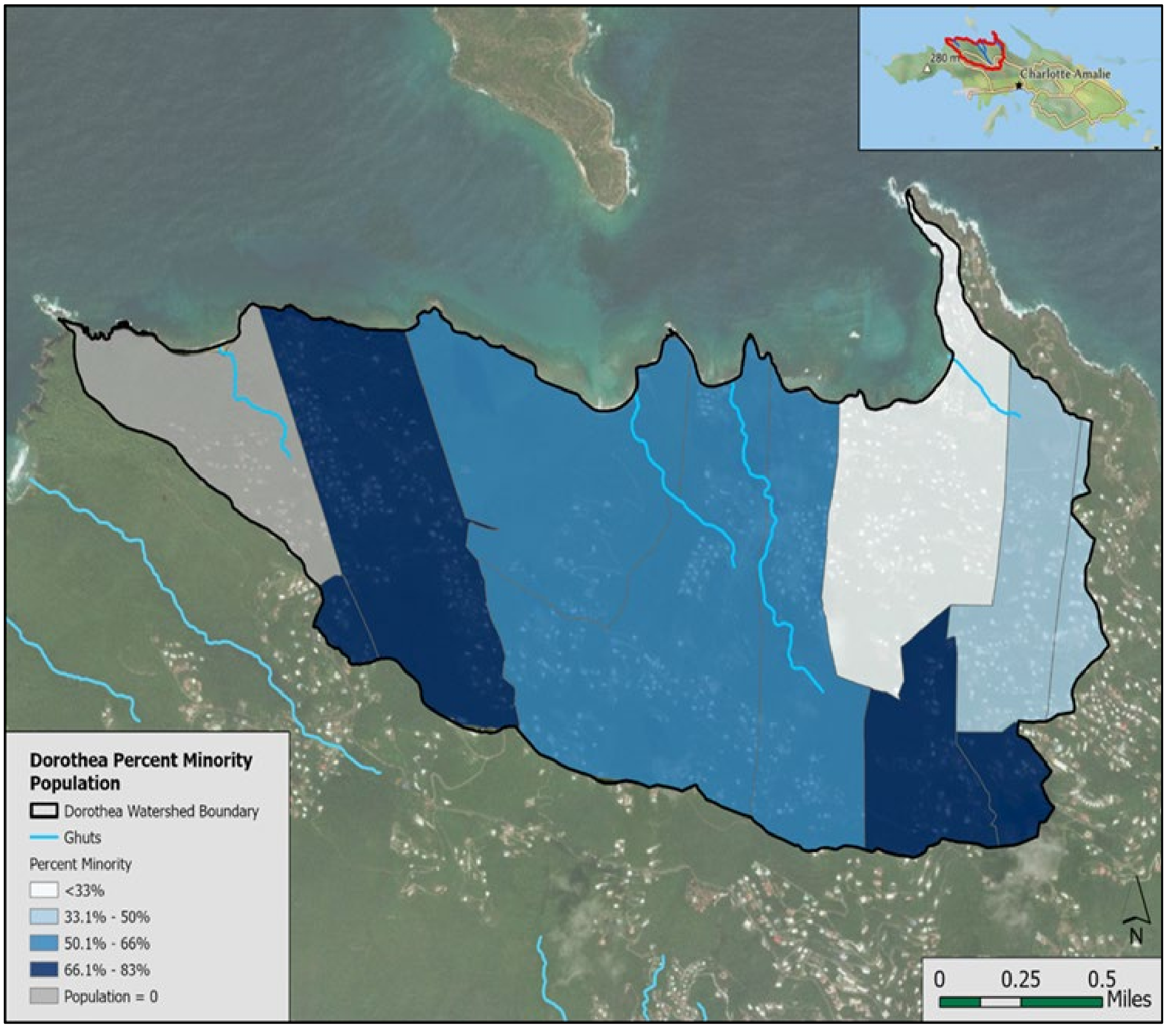


Figure 24. Percent minority population by estate within the watershed (source: 2020 U.S. Census).

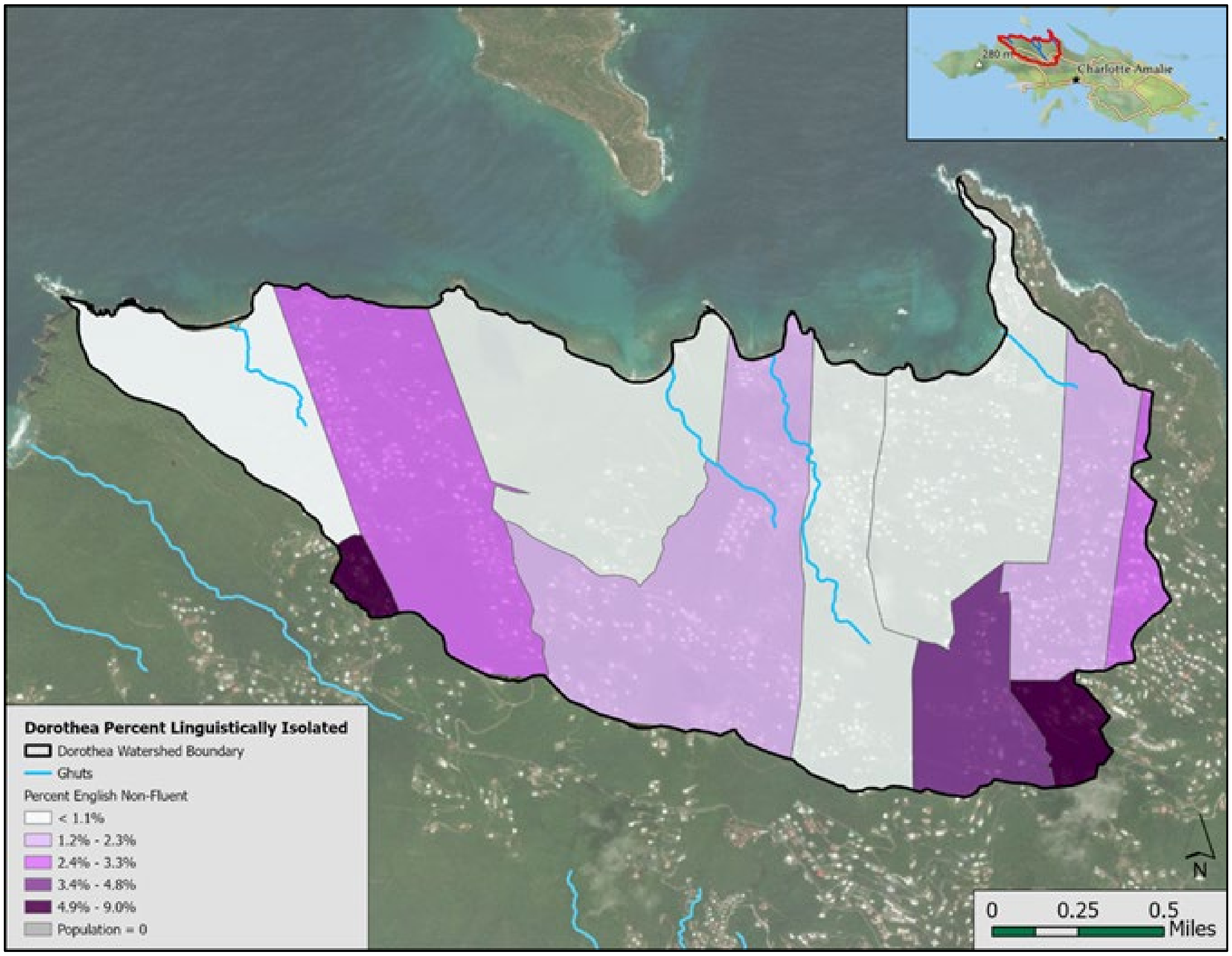


Figure 25. Percent linguistically isolated by estate within the watershed (source: 2020 U.S. Census).

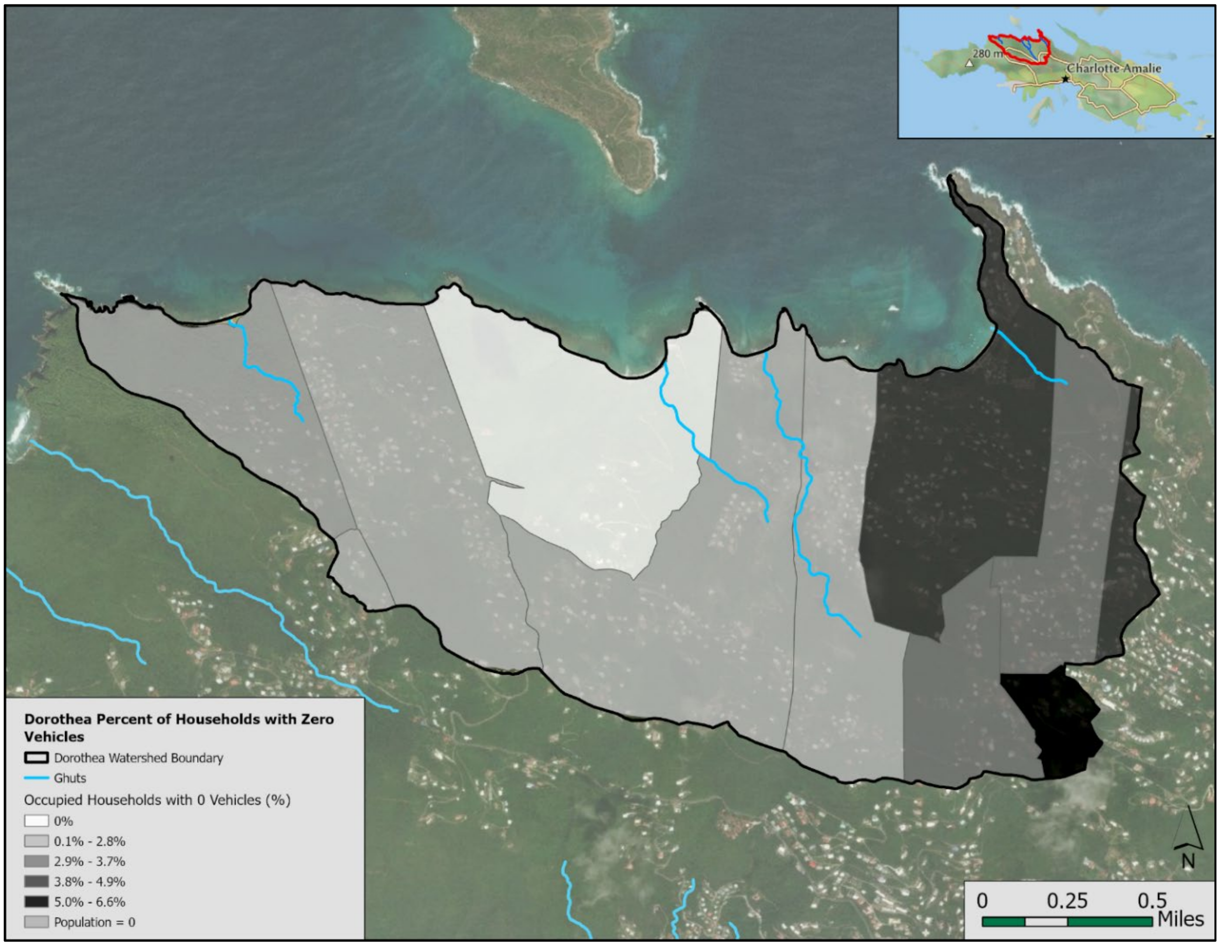


Figure 26. Percent of households with zero vehicles by estate within the watershed (source: 2020 U.S. Census).

3.3.2 Land Cover Mapping

Land cover was mapped from high-resolution, remotely sensed data yielding the most complete, precise, and accurate mapping ever carried out for the USVI. The primary source data sets used consisted of aerial imagery obtained through the Hexagon imagery program and publicly available LiDAR sourced from NOAA Digital Coast. The aerial imagery, collected in 2019, has a spatial resolution of 15 cm with spectral coverage in the blue, green, red, and near-infrared portions of the electromagnetic spectrum. The LiDAR data, which was collected in 2018 using a discrete return sensor, had a point spacing that exceeded 90 points per square meter in some locations. Supplementing these remotely sensed data sets were vector layers representing roads and hydrologic features.

The imagery data were processed to create seamless mosaics for the island. The LiDAR was processed to create normalized and classified point clouds in addition to raster surface models. The surface models consisted of a Digital Elevation Model (DEM), Digital Surface Model (DSM), and a Normalized Digital Surface Model (nDSM). The DEM was derived from the LiDAR ground classified points, with each pixel value representing the ground surface topographic elevation relative to sea level. The DSM was derived from the LiDAR first returns, with each pixel representing the height of features relative to sea level. The nDSM was obtained by subtracting the DEM from the DSM, yielding a model in which each pixel represented the height above ground. All raster surface models were produced at a resolution of 0.5 meters. Some editing was performed on the vector data sets to improve their consistency and quality prior to incorporating them into the land cover mapping.

Land cover feature extraction was carried out using a semi-automated process at a resolution of 0.5 meters. The automated part of the mapping centered on an object-based feature extraction approach that incorporated the imagery, LiDAR point clouds, LiDAR surface models, and supporting vector data sets to map land cover features using a combination of artificial intelligence and expert systems. The output from the automated workflow was then manually reviewed by technicians at a scale of 1:1000 to correct visible errors. The final landcover data set contained eight classes: 1) bare soil, 2) buildings, 3) grass/herbaceous vegetation, 4) other paved/impervious surfaces, 5) roads, 6) shrubs, 7) tree canopy, and 8) water. The height threshold for tree canopy was 2 meters. See Figure 27 below for an example of the imagery, nDSM, and land cover classifications for an example area on St. Thomas (not within the Dorothea watershed).

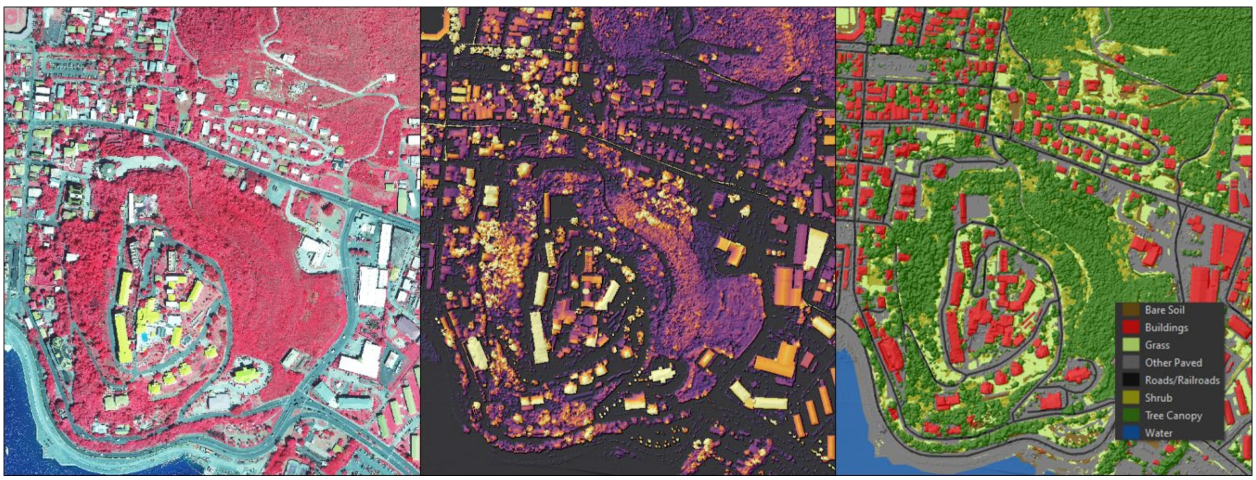


Figure 27. Imagery displayed as color infrared (left), LiDAR nDSM (center), and resulting land cover (right) on an example area in St. Thomas.

The existing land cover in the Dorothea watershed is predominantly tree canopy (77.7%), grass shrub (5.9%), and grass (4.4%). Figure 28 and Table 6 present the existing land cover within the watershed.

Total impervious cover is approximately 10.1%, placing the watershed in the "Impacted" category, based on the Impervious Cover Model. According to this classification system, "Impacted" watersheds have between 10% and 25% impervious cover. Within this range, the stream quality tends to be fair, but the overall stream health begins to decline (Schueler et al., 2009). However, with recent development and construction, the total impervious within the Dorothea watershed will likely increase in the near future. Land cover data can be found in Appendix D.

Table 6. Existing land cover in the watershed.

Land Cover Category	Area in Watershed (acres)	Percentage of Total Area
Bare Soil	27.0	1.6%
Buildings	52.3	3.1%
Grass	74.2	4.4%
Other Paved	72.5	4.3%
Roads	45.5	2.7%
Shrub	99.5	5.9%
Tree Canopy	1,309.7	77.7%
Water	5.1	0.3%
Total	*1,685.6*	*100%*

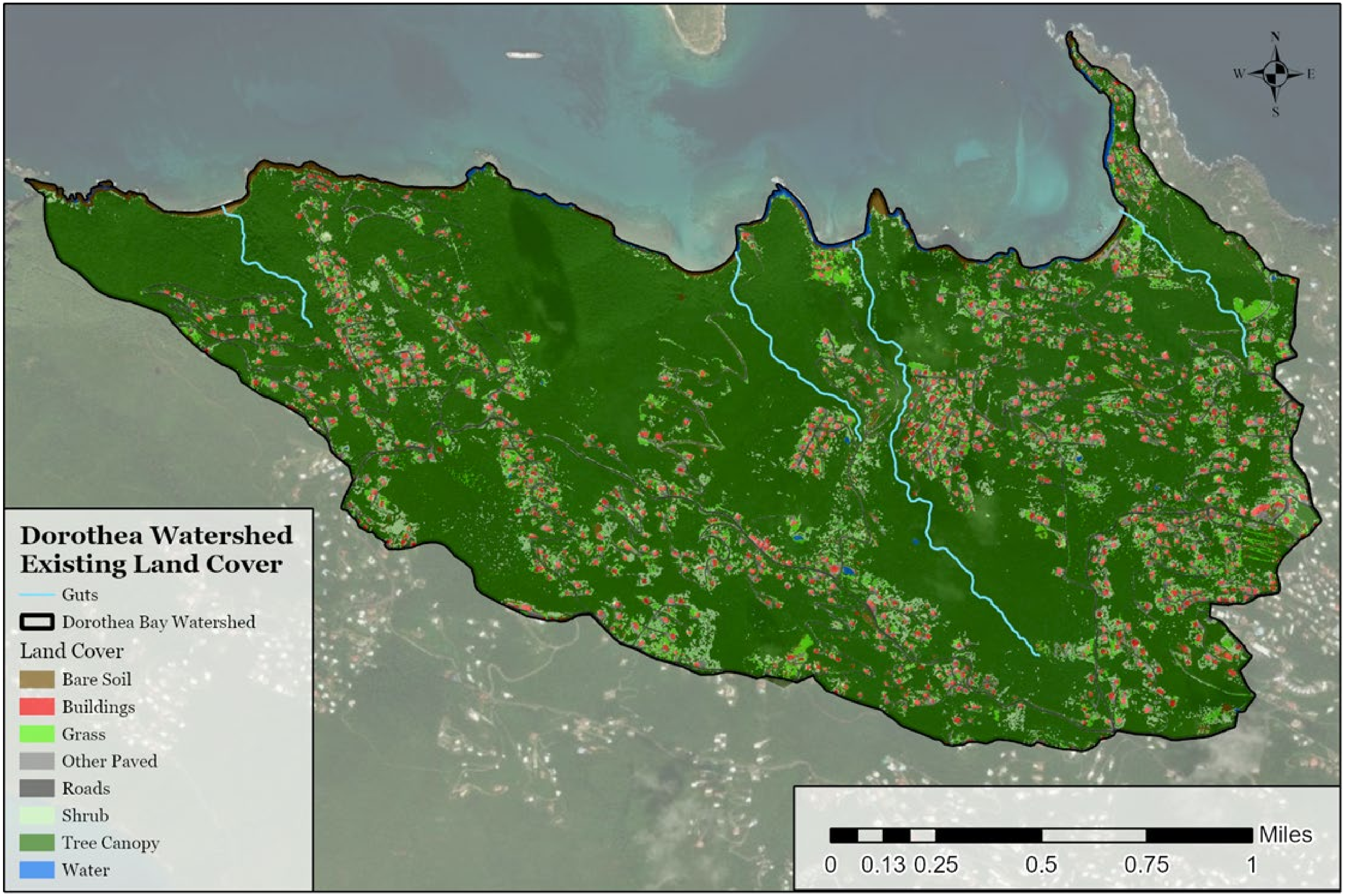


Figure 28. Existing land cover in the watershed.

3.3.3 Zoning

The USVI Zoning Code defines how property in specific zones can be used. The document details whether specific geographic zones are acceptable for residential, commercial, or industrial purposes. Zoning codes may regulate lot size, placement, density, setbacks, acceptable uses, and the height of structures. The U.S. Virgin Islands have 18 distinct zoning districts: two agricultural districts, five residential districts, four business districts, one commercial district, two industrial districts, two waterfront districts, one public district, and one special district.

Zoning information is available for the USVI as part of a parcel layer that contains the current, previous, and proposed zoning districts. However, the zoning districts in the spatial dataset do not match those in DPNR's "Virgin Islands Zoning District Requirements" document, which can be found on their website.

The zoning districts in the spatial dataset were revised to represent land use categories that are: 1) more meaningful from a planning sense, and 2) more consistent with the Watershed Treatment Model, which will be used in later phases of plan development for the watershed. In general, the zoning districts were categorized based on the use category (e.g., all agricultural zones characterized as "Agricultural"). Residential zoning districts were subdivided based on their densities, with "Waterfront Pleasure" classified as Low Density Residential due to the zoning density being the same as the Low-Density Residential category. Figure 29 illustrates the breakdown of the revised zoning districts throughout the parcels in the watershed. Most of the watershed is characterized as low-density residential (95.2%), agricultural (2.7%), and transportation (1.0%).

It is important to note that neither the revised zoning districts, nor the original zoning districts on which they are based, are necessarily reflective of all uses occurring in the parcel. Original zoning districts appear to be designated based on the parcel's majority use. As such, a parcel may contain areas that do not match its overall zoning district. Zoning districts defined as "Other" refer to zoning districts that were originally blank, or defined as "PAD", "S Special" or "NL".

The pie charts in Figure 30 below summarizes the relationship between existing land cover and area of the revised zoning districts in the watershed. Most of the land-use in residential development zoning areas is green space, most notably in low-density developments and to a lesser degree in medium and high-density developments. Business zoning areas also show to be predominated by green space, roughly as much so as medium-density developments. Industrial, commercial, and public zoning areas in contrast are dominated by impervious surfaces. Land cover mapping and predicted future land cover can be found in Sections 3.3.2 and 3.3.5 respectively as well as Appendix D.

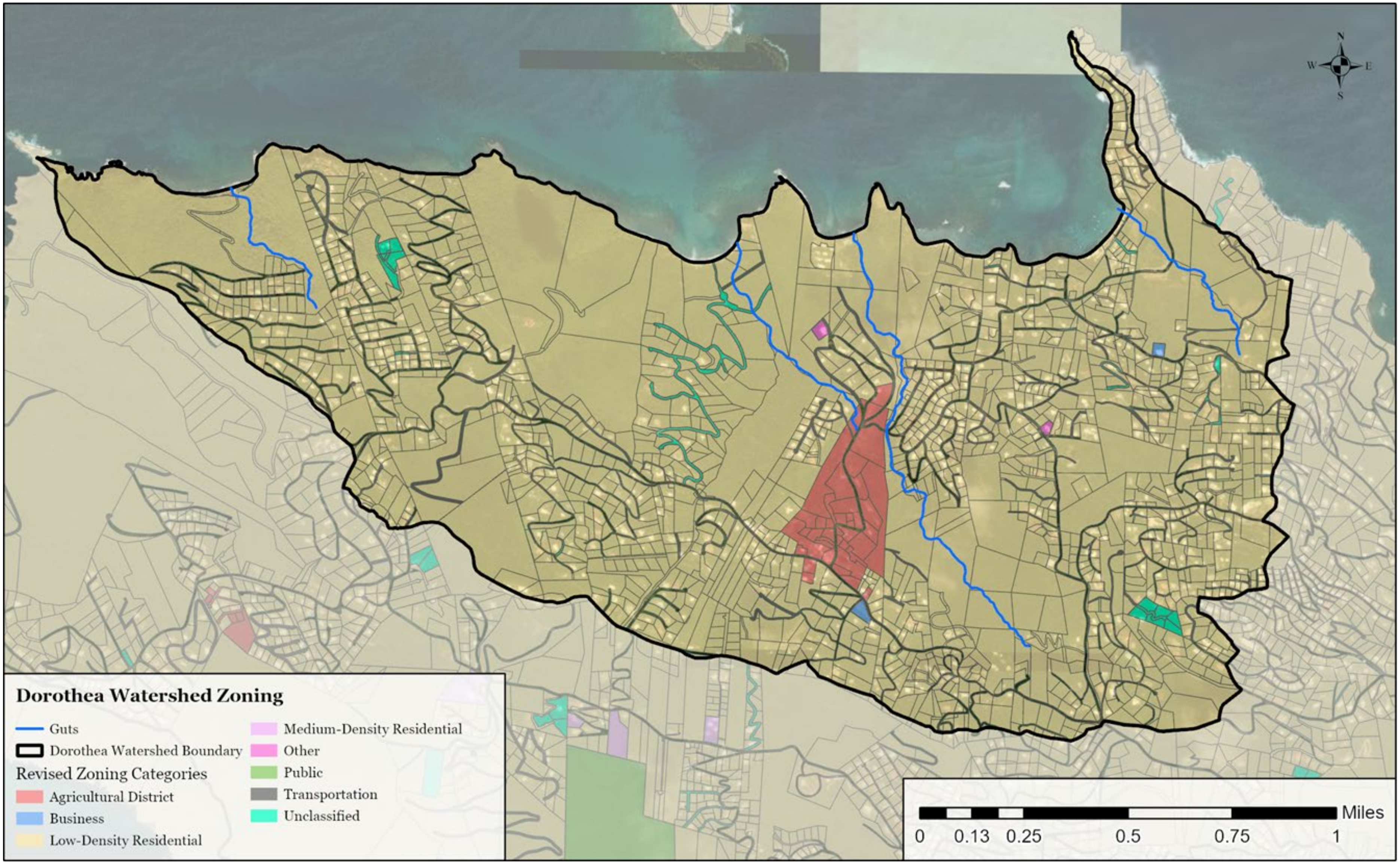


Figure 29. Revised zoning districts within the watershed.

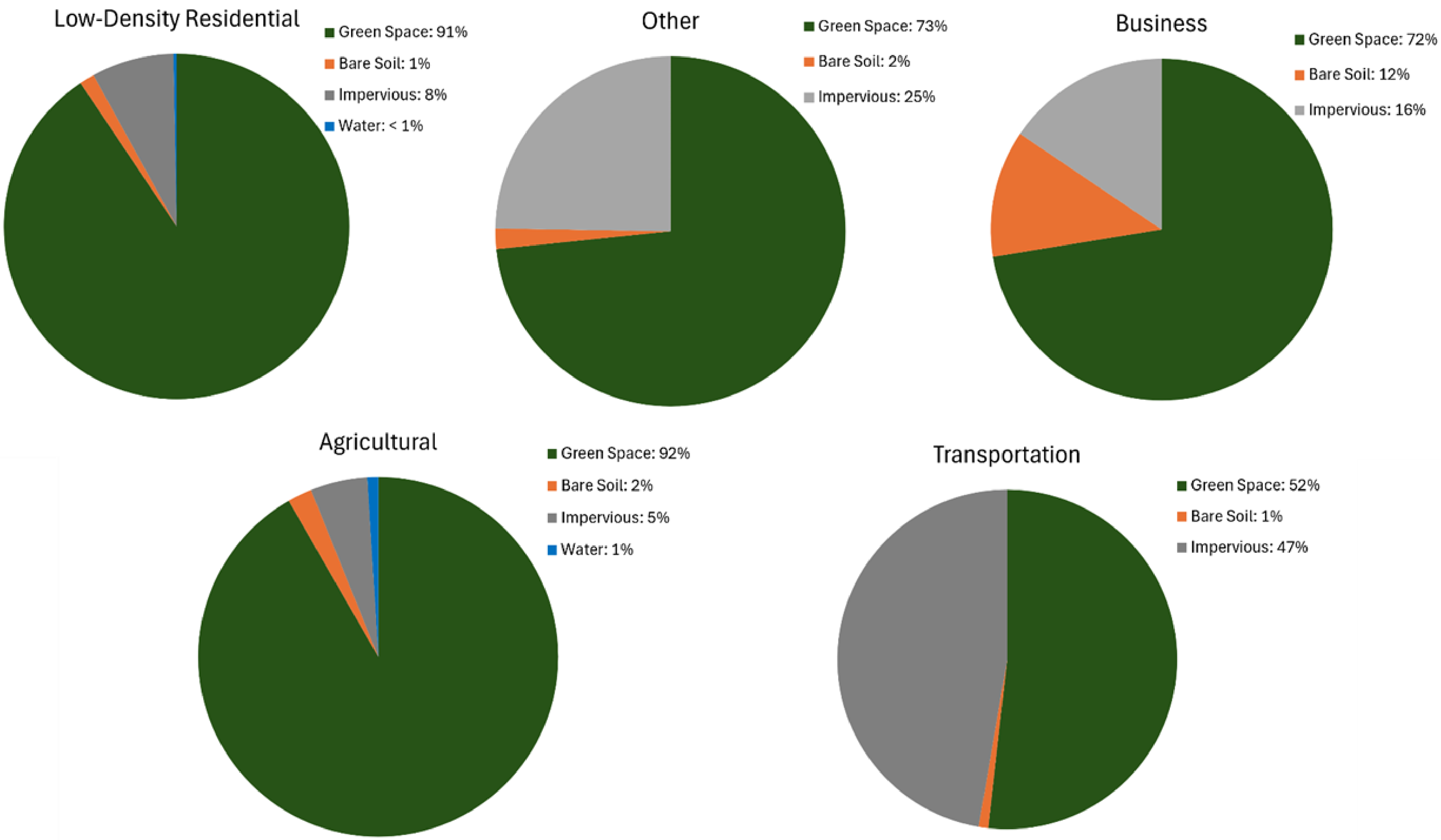


Figure 30. Land cover in revised zoning districts in the watershed.

3.3.4 Housing Development Age

Median decade of housing unit development by estate in the watershed was identified by the 2020 U.S. Census data. As shown in Figure 31, the predominant decades housing units were constructed in the Dorothea watershed were the 1960s and 2010s.

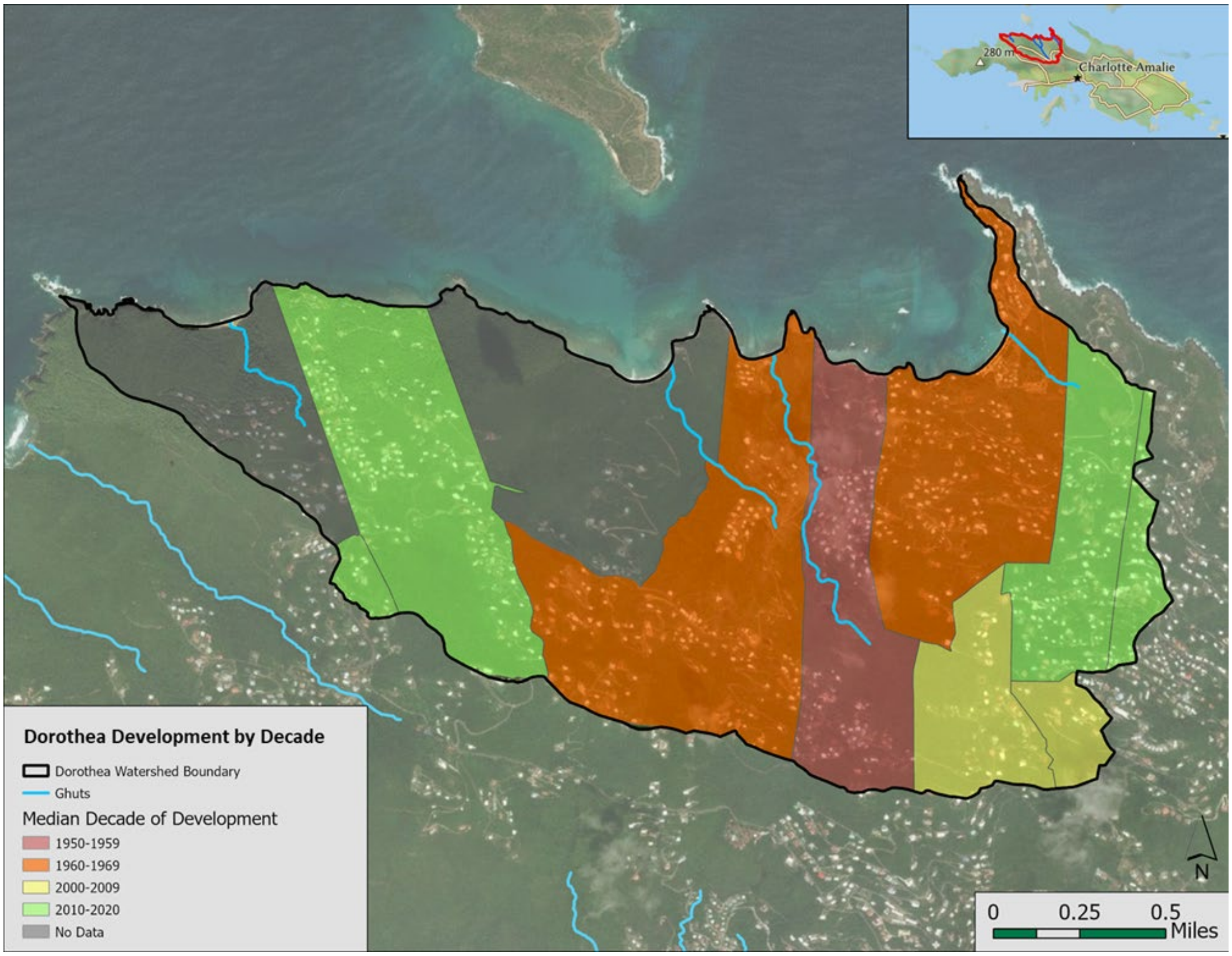


Figure 31. Median decade of housing unit development by estate (Source: 2020 U.S. Census data).

3.3.5 Predicted Future Land Cover

Future land cover scenarios for 2030, 2050, 2080, and 2100 were developed based upon 2020 land cover data and predicted development based on past trends within the watershed to assess the impacts of this growth. Feature engineering was employed to predict where this future development will occur based on observed development patterns.

First, an equally sized grid overlaying the watershed area was created. Each grid cell represents 5 acres. Then, the area of each land cover class for the years 2003 and 2012 within each grid cell was calculated. Data was obtained from the NOAA Coastal Change Analysis Program. Land cover classes were generalized into the following classes: impervious cover, bare soil, forested, grass, water, or forested / grass combination. Note that the land cover within the entirety of edge cells was calculated and a percentage of each land cover class was calculated irrespective of the watershed boundary. This information was used to proportionally adjust edge grid cells so as not to over or under weight the development within these grid cells due to their location in comparison to the watershed boundary. For example, one house could fall within the 10% of a grid cell that is within the watershed boundary. If taken directly from this data, the impervious percentage may be 90%. However, when considering the entirety of the grid cell's development, the impervious may be only 15%. As such, this proportional approach was used for all grid cells that crossed the border of the watershed.

The percent change in impervious cover from 2003 to 2012 land cover data were calculated for each grid cell. Grid cells with ≥20% impervious cover were then classified as "developed". The relationship between percent impervious cover between 2003 and 2012 (considered to be approximately 10 years of change) was determined and a linear relationship defined (R2=0.9525). The trendline explains a significant amount of variability in the change in impervious cover over this time period. As such, the relationship was then applied to the 2012 data in iterative 10-year increments to predict change in impervious cover for 2030, 2050 (Figure 33), 2080, and 2100 (Figure 34). The developed areas in 2003 and 2012 can be found in Figure 32.

Future land cover grids were classified as "developed" if the predicted impervious cover equaled or exceeded 20% impervious. The average percent reduction in forested and forest / grass combination land cover classes was utilized to adjust their respective land cover classes for the 2030, 2050, 2080, and 2100 datasets. For example, if the predicted impervious increase in a grid cell was 2%, that 2% must be removed from another land cover class. Of that 2%, 97% was removed from forested land cover and 3% was removed from forest / grass combination land cover to reflect observed conversion of pervious land cover classes to impervious.

Overall, the predicted development pattern generally includes infill development in areas where existing development is already present. It is predicted that impervious cover will steadily increase over time with a corresponding reduction in forested (97% of reductions) and forest / grass combination (3% of reductions) land cover classes. This data will be used in future modeling tasks to determine the water quality and hydrology impacts of this increased development. The modeled impervious cover was predicted to increase over each of the future landcover scenarios (Figure 35). Land cover estimates over time are provided in Table 7. See Appendix D for more information.

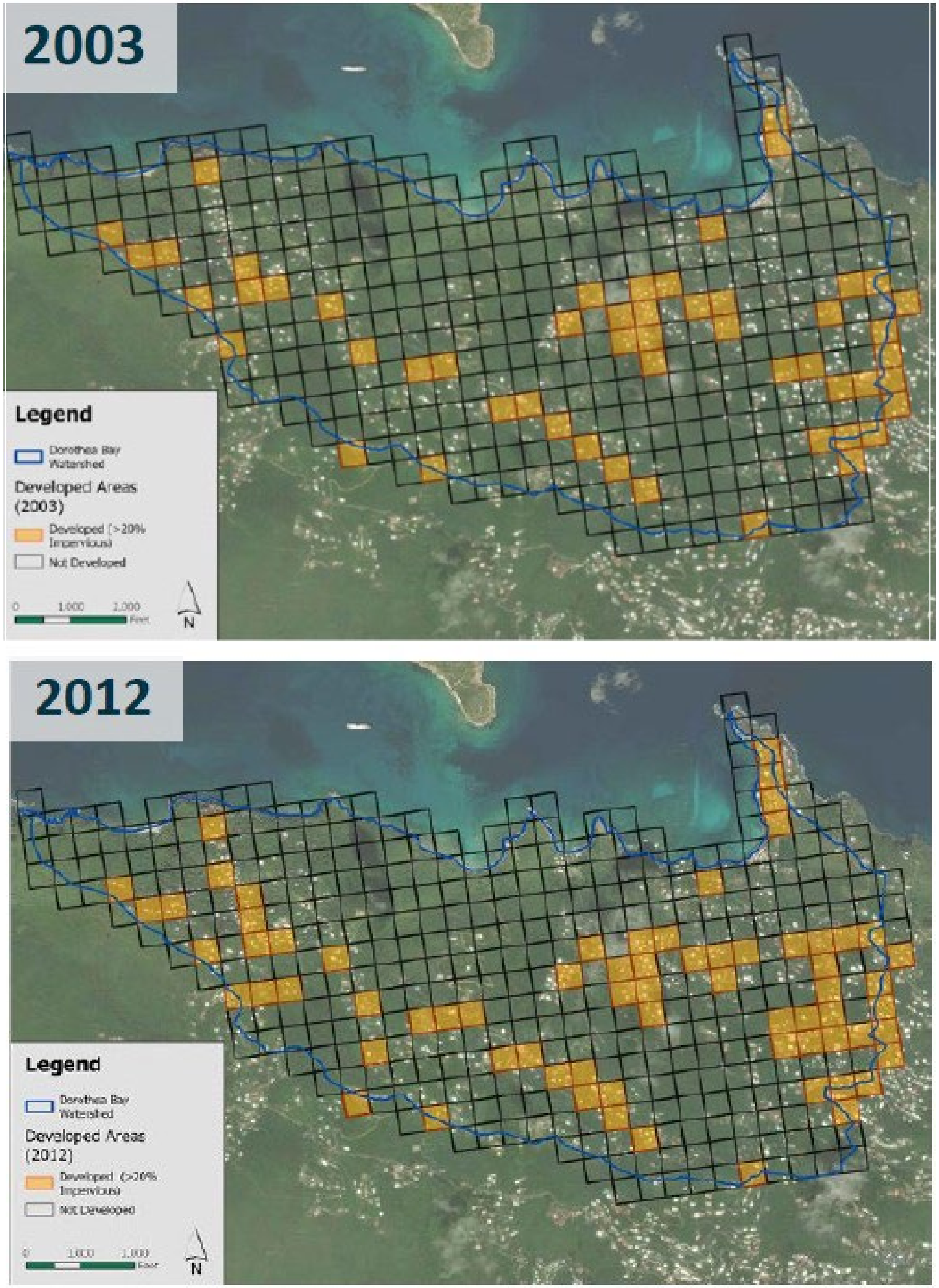
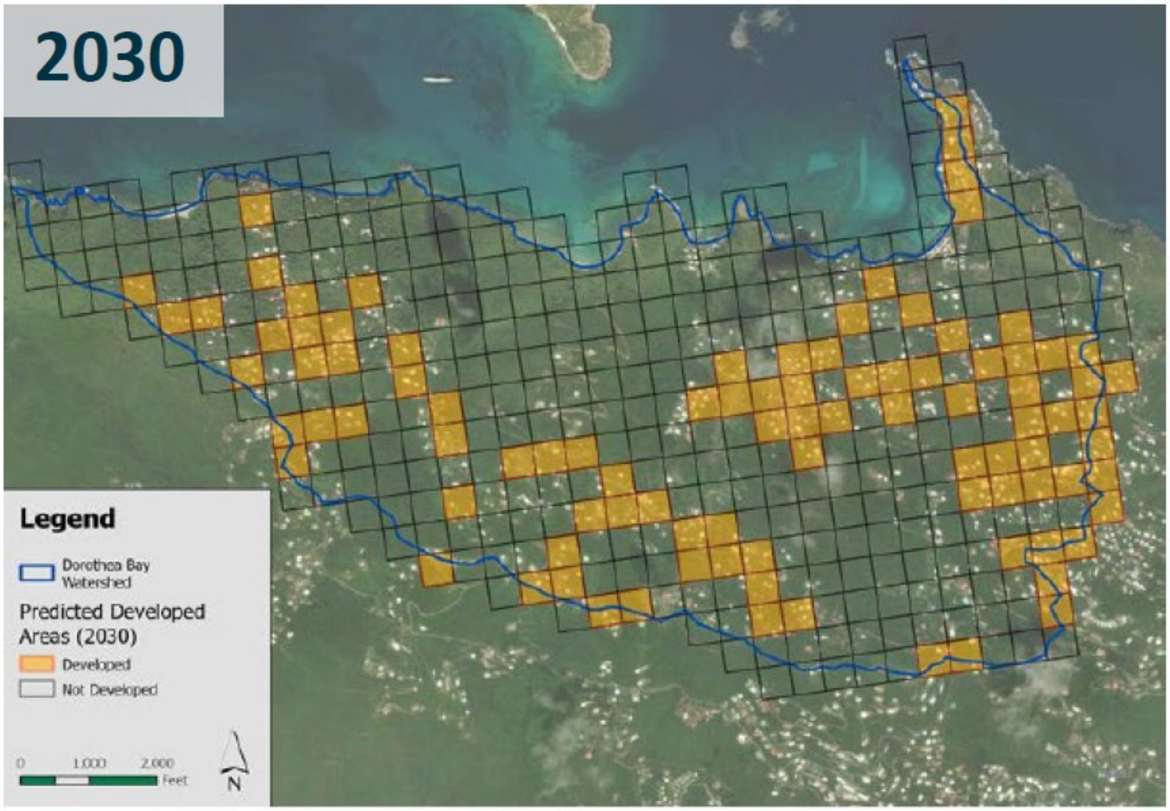


Figure 32. Existing development (>20% impervious), displayed in orange for 2003 (upper) and 2012 (lower).



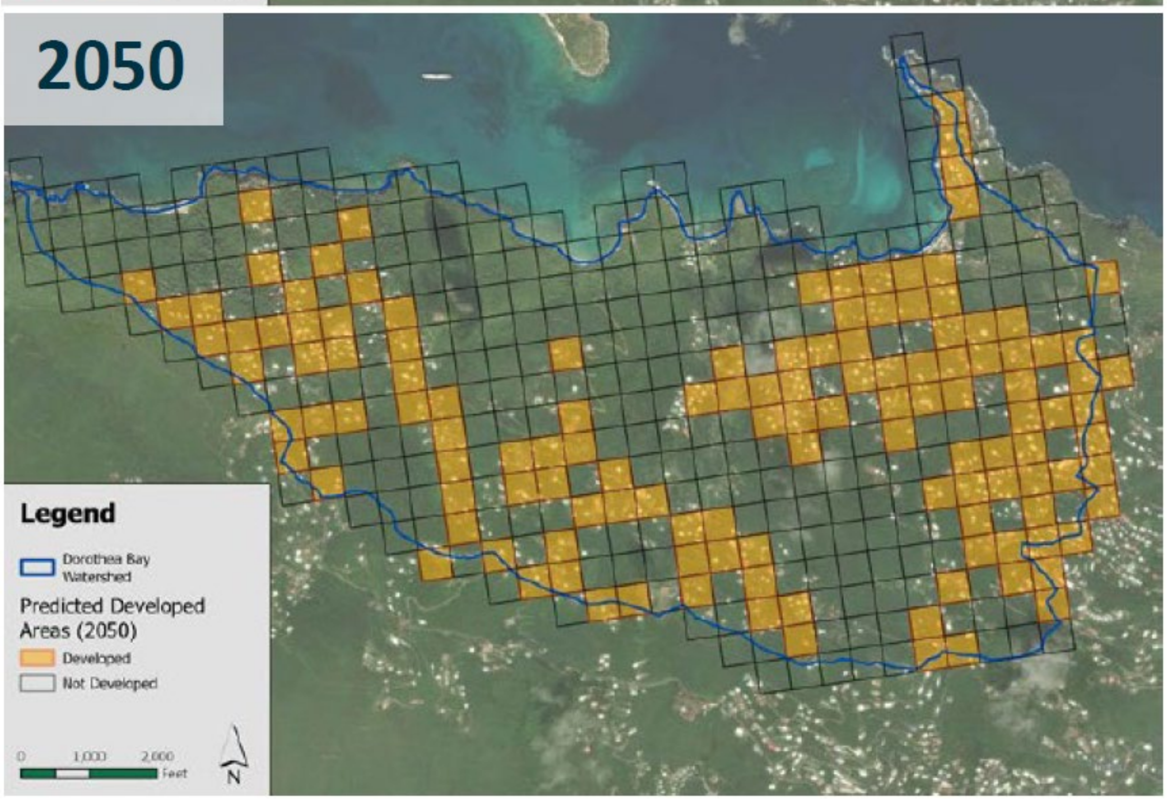


Figure 33. Predicted areas at potential risk for development in by 2030 (upper) and 2050 (lower) are shown in orange.

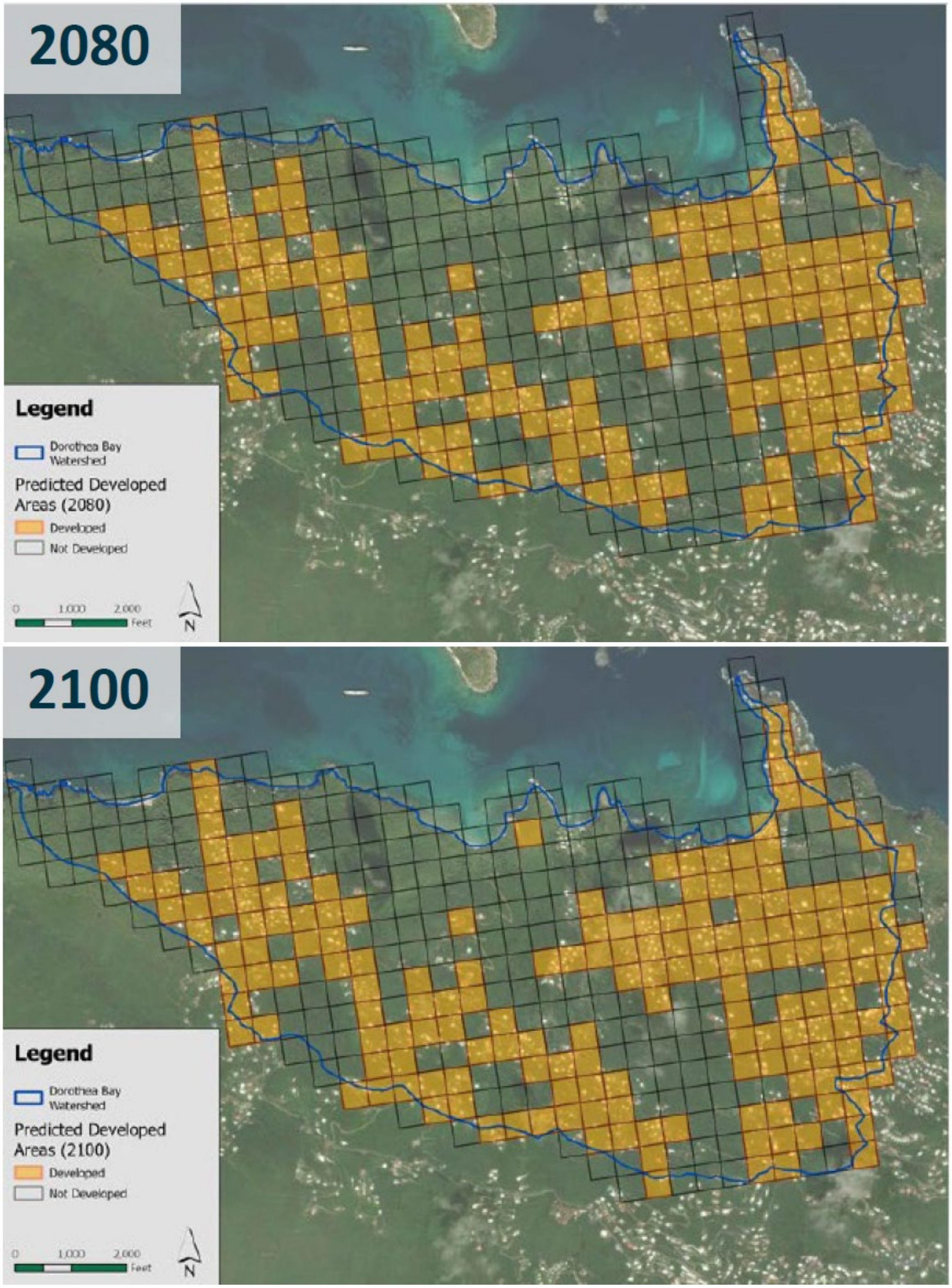


Figure 34. Predicted areas at potential risk for development in by 2080 (upper) and 2100 (lower) are shown in orange.

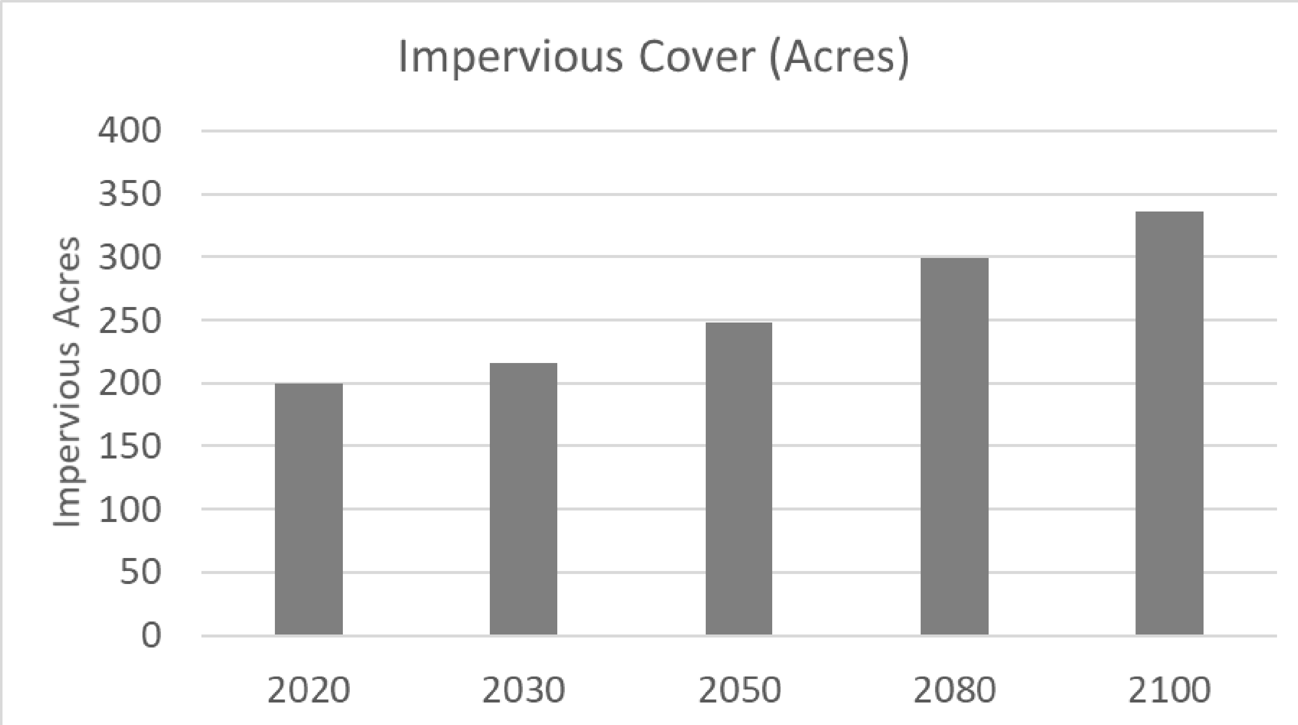


Figure 35. Impervious cover is predicted to increase over time

.

Table 7. Predicted land cover change over time.

Year	Impervious (Acres)	Woods (Acres)	Woods/Grass (Acres)	Grass (Acres)	Water (Acres)	Bare Soil (Acres)
2020	199.7	1217.3	166.5	53.0	27.3	16.1
2030	215.3	1202.1	166.1	53.0	27.3	16.1
2050	247.7	1170.6	165.2	53.0	27.3	16.1
2080	299.0	1126.2	163.8	53.0	27.3	16.1
2100	335.2	1085.4	162.8	53.0	27.3	16.1

3.4 Problem Definitions

3.4.1 Impaired Waterbodies

USVI DPNR is responsible for implementing and enforcing territorial water quality standards and pollution control laws under the federal Clean Water Act. To meets these goals, DPNR administers two water quality monitoring programs, the coastal water quality monitoring program and the beach water quality program. The coastal water quality monitoring program is the primary mechanism for monitoring the U.S. Virgin Islands coastal water quality. In this program, delineated waterbodies referred to as assessment units (AUs) are sampled for a variety of water quality indicators on a quarterly basis. In the beach water quality monitoring program, designated beaches throughout the territory are sampled for water quality indicators on a weekly basis. Due to the ephemeral nature of guts, water quality monitoring programs focus on coastal waters and beaches. Data collected by these programs is used to protect public health and provide notification of beach closures. The data also determines effluent permit limits and develops waterbody impairment listings for the 303(d) list. This list is used to establish priorities for the implementation of water quality improvement measures including the development of TMDLs.

According to the current U.S. Virgin Islands water quality standards, the waters of the U.S. Virgin Islands exist in one of four classes: I, A, B, and C. Standards as defined in the 2020 Integrated Water Quality Monitoring and Assessment Report can be found in Table 8.

- Class I waters include either inland surface waters or inland groundwaters are therefore excluded from the water quality monitoring program at this time.
- Class A waters (or Outstanding National Resource Waters) are marine and coastal water with exceptional recreational, environmental, or ecological significance to be preserved. They are designated for maintenance and propagation of desirable species of aquatic life (including threatened, endangered, and indigenous species), for primary contact recreation, and for use as potable water sources.
- Class B waters encompass all marine and coastal waters not classified as Class A or Class C. As with Class A waters, they are designated for maintenance and propagation of desirable species of aquatic life, for primary contact recreation, and for use as potable water sources.
- Class C waters are those waters which are located in industrial harbors and ports. They have less stringent water quality standards for certain parameters and are designated for the maintenance and propagation of desirable species of aquatic life, primary contact recreation, industrial water supplies, shipping, navigation, and for use as potable water sources for those waters being used currently or that could be used in the future as potable water sources.

Table 8. Water quality and assessment criteria (USVI DPNR, 2020).

Parameter	Source Data Type	Assessment Method
Enterococcus	Ambient, Beach	The 30-day geometric mean for enterococcus shall not exceed 30 colony-forming units/100 mL and no more than 10 percent of the samples collected in the same 30 days shall exceed 110 colony-forming units/100 mL.
Turbidity	Ambient, Beach	A maximum nephelometric turbidity unit reading of three (3) shall be permissible, and secchi disk reading of minimum of 1 meter.
Clarity	Ambient, Beach	***For areas where coral reef ecosystems are located**, a maximum nephelometric turbidity unit reading of one (1) shall be permissible, and secchi disk reading of minimum of 1 meter.
Total Phosphorus	Ambient	Shall not exceed 50 µg/l
pH	Ambient	Class A, B: Range shall not be outside 7.0 to 8.3 standard units Class C: Range shall not be outside 6.7 to 8.5 standard units
Dissolved Oxygen	Ambient	Class A, B: Shall be no less than 5.5 mg/L Class C: Shall be no less than 5.0 mg/L
Temperature	Ambient	Shall not exceed 32 degrees Celsius at any time, nor as a result of waste discharge to be greater than 1.0°C above natural conditions. ***For areas where coral reef ecosystems are located**, shall not exceed 25-29°C at any time, nor as a result of waste discharge to be greater than 1.0°C above natural.

*Areas that contain coral reef ecosystems are determined based on Benthic Habitat Mapping in Puerto Rico and the U.S. Virgin Islands (NCCOS, 2002)

The assessment units (AUs) are classified as Class B, with impairments for Dissolved Oxygen, pH, Turbidity (Figure 36; Table 9). The Class B classification allows for 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.

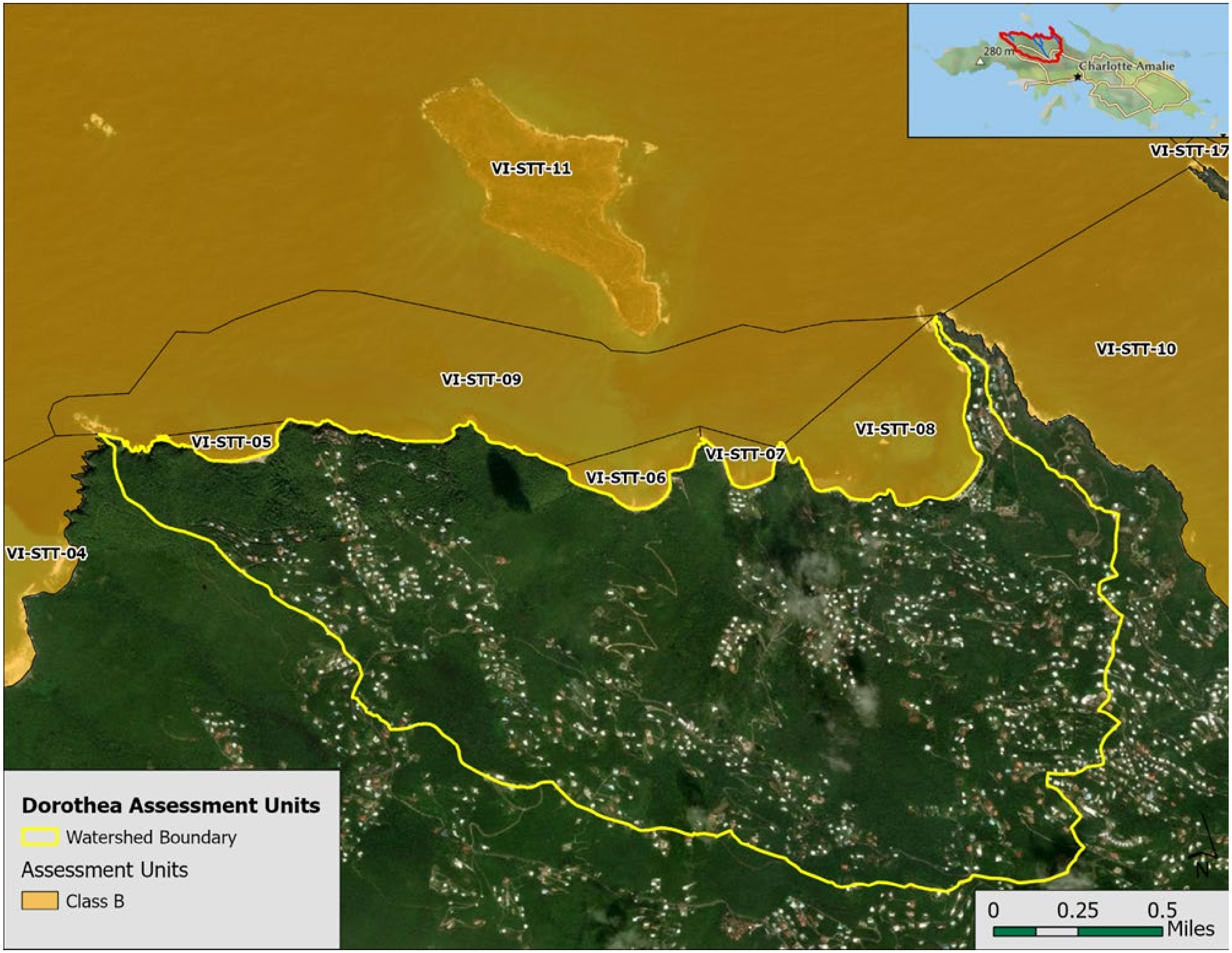


Figure 36. Assessment units in the watershed.

Table 9. Assessment units (AUs) with 303(d) listing in the watershed (USVI DPNR, 2020).

AU ID	AU Name	Associated Monitoring Stations	Priority	Class	Impairment	Years Impaired
VI-STT-04	Santa Maria	STT-11	Low	B	Dissolved Oxygen, pH, Turbidity	2010, 2016, 2020
VI-STT-05	Caret Bay	STT-12	Low	B	Dissolved Oxygen, pH	Prior to 2010, 2016, 2018
VI-STT-06	Neltjeberg Bay					
VI-STT-07	Dorothea				Dissolved Oxygen, pH	
VI-STT-08	Hull Bay	STT-14, VI616865	Low	B	Dissolved Oxygen, pH	2018, 2020
VI-STT-09	Dorothea Bay subwatershed, off					
VI-STT-11	Northwest St. Thomas HUC 14, off					

3.4.2 Stormwater

3.4.2.1 Lack of Management Practices

Stormwater BMPs improve water quality of stormwater runoff both by removing pollutants through filtering or settling and by controlling both the volume and rate of flow of runoff entering guts and coastal waters. As detailed in Section 3.5.2, the watershed has one existing stormwater practice that has a drainage area of 3.4 acre. This leaves the majority of the watershed presently untreated.

As land development continues in the USVI, stormwater management practices will play an important role in reducing flooding and improving water quality by infiltrating a greater amount of water into the groundwater and detaining stormwater to reduce peak discharge rates, more nearly approximating pre-developed hydrology.

3.4.2.2 Deteriorated & Absent Stormwater Conveyance

Failure to manage stormwater runoff from roads, most notably unpaved roads, is one of the primary land-based sources of pollution in the USVI (U.S. Virgin Islands, 2020). There are approximately 34 miles of roads in the watershed. To minimize surface water contamination and reduce flooding, roadway stormwater infrastructure such as culverts, swales, and surface crossings are utilized to intercept flows and convey water. Many of the roads of St. Thomas either do not have adequate infrastructure or the existing infrastructure is not functioning properly (i.e., clogged or damaged). This can result in ponding and flooding within and along the roadway and can result in erosion in other areas due to the increased stormwater volume and velocity (Figure 37). This presents both a public safety hazard and maintenance burden.

Figure 37. Road erosion (left) and undermined slope due to unmanaged stormwater (right).

Many of the stormwater drainage structures observed in the watershed needed maintenance (Figure 38). Some structures needed structural repairs while many were obstructed and/or plugged with sediment, debris, and trash. There is a need for a structured program that ensures routine and post-storm event maintenance, as local property owners often indicated that maintenance was an issue. Regularly scheduled maintenance would help alleviate some of the localized flooding problems by removing obstructions from the guts and roadway swales.

Figure 38. Roadway and drainage structures in need of maintenance were observed within the watershed.

One way of assessing adequate drainage infrastructure in the watershed is to determine how far road segments are from drainage structures. Of the 34 miles of roads in the watershed, only 12.2 miles (36%) are within 50 feet of a drainage structure (Figure 39). This indicates that in these locations, stormwater must travel overland for long distances prior to accessing a drainage relief structure, often resulting in large volumes of concentrated stormwater flow.

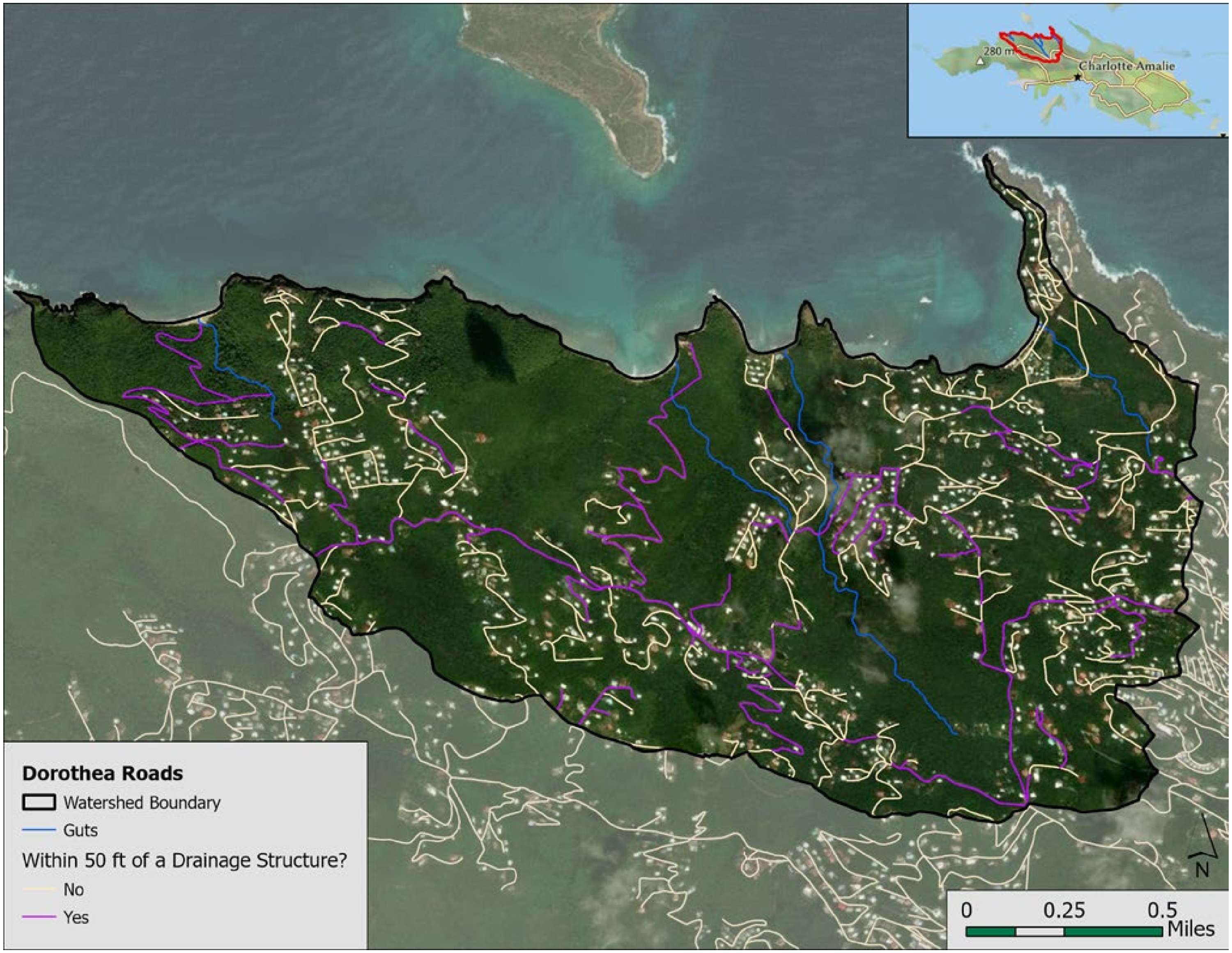


Figure 39. Roads in the watershed and a classification of distance to nearest drainage structure.

3.4.3 Wastewater

Improperly managed or treated wastewater including leaking, broken, or disconnected wastewater and septic system pipes pose a significant threat to the watershed. In the watershed, wastewater pipes are often outdated and infrequently maintained. Consequently, illicit discharges from leaking, broken, or disconnected sewer or damaged or malfunctioning septic systems may run-off into the region's stormwater system, leading to increased pollution and contamination. Wastewater can pose human health risks and contains high bacteria and nutrient loads.

Wastewater treatment for the USVI is provided by either wastewater treatment systems (Figure 41) or by private on-site disposal (septic) systems (OSDS). Septic system use can be constrained by a number of factors, including poor suitability of soils for conventional systems. A study of OSDS applicability in the Virgin Islands found that much of land area in the USVI is unsuitable for septic soil absorption systems, including conventional and some alternatives (The Cadmus Group, 2011). As such, leaking septic systems are an issue of concern for the entire USVI. Proper inspection and maintenance of OSDS are critical to ensure effectiveness and to verify that systems are not damaged and leaking.

The current sewer system in the USVI consists of eight wastewater treatment plants, 31 pump stations, and hundreds of miles of buried wastewater lines. More than 4.5 million gallons of wastewater are collected daily (VIWMA, n.d.). Of the eight plants run by the agency, five are on St. Thomas, one is located on St. Croix, and the remaining two are on St. John. The sewer system includes combined sewer where wastewater and rainwater are collected. Since many of the wastewater lines are located along the intermittent waterways (guts) that carry stormwater runoff, they may be subject to possible sanitary sewer overflows (SSOs) that can result in untreated sewage being introduced into stormwater flows. No data for SSOs is currently available at the time of this report development.

Possible illicit discharges due to failing or misconnected infrastructure was a major issue identified by field crews. Illicit discharges can contribute both pollutants and bacteria to surface waters and the storm drain system through leaking pipes, illegal connections, and unexpected overflows during storm events and pose a public health risk. Field crews observed wastewater contamination to a gut in the Dorothea watershed lines during field visits, suggesting that illicit discharges may be a significant issue in the islands (Figure 40).

Figure 40. Suspected illicit discharge in gut.

Figure 41. Brassview neighborhood wastewater treatment system within the Dorothea watershed.

3.4.4 Solid Waste Management

The Virgin Islands Waste Management Authority (VIWMA) is responsible for all waste disposal in the territory. The organization has made efforts to start and sustain various recycling and composting efforts, but the organization is historically underfunded and markets for recycled materials are difficult to access.

The USVI has one unlined landfill on the island of St. Thomas, the Bovoni Landfill, that accepts residential, commercial, and industrial waste. This landfill is near capacity and has been operating under EPA consent decrees since 2012 and 2013 for various violations including leaching of toxic waste into the nearby mangrove (Culbertson et al., 2020). Most residents bring their solid waste to collection bins at roadside locations, to staffed convenience centers, or directly to the landfill. In addition, VIWMA also provides some residential collection services, either directly or through contracts with permitted service providers. Businesses directly contract waste removal with permitted waste haulers.

3.4.4.1 Improper Waste Disposal

It was observed during site visits that solid waste such as trash and debris is often found alongside roadways and abundant at dumpster sites around waste bins. This is most often caused by improper household waste disposal (Figure 42). Signs directing the proper disposal of waste are regularly posted throughout the island but are often ignored. Dumpster sites often overflow with waste, leading to a significant amount of garbage accumulating adjacent to the dumpsters. The main bin site for Dorothea is adjacent to a gut, and there is significant trash accumulated in the gut, potentially leaching contaminants and transporting floatable debris downstream (Figure 42).

Improper solid waste management presents risks to public and environmental health and reduces aesthetics. It can increase the risk of disease, water and air pollution, leachate, trash odors, and scavenger animals. When improperly contained and managed, trash, especially plastic waste, can also become floatable debris, an issue of international concern. Trash can also enter and clog stormwater systems, limiting the infrastructure's functionality within the watershed and causing localized flooding.

Figure 42. Examples of illegal dumping adjacent to dumpsters and a posted no dumping sign.

3.4.4.2 Hazardous Waste

Hazardous waste is directly harmful to human health and the environment. Household hazardous waste may include cleaning supplies, furniture polish, fertilizers, motor oil, paint supplies, nail polish remover, lighter fluid, and other chemicals. Boat repair and automobile shops may use hazardous waste such as grease and gasoline that are toxic. Improper handling and storage of these wastes can pose a significant risk to human health and wildlife habitat. A complete inventory of solid or hazardous waste issues was not completed as a part of this WMP, but it remains a potential issue of concern.

3.4.4.3 Damaged & Abandoned Vehicles

In the USVI, there is an abundance of abandoned vehicles. Although this is not a major observed issue in the Dorothea watershed, it is important that it does not become an issue in the watershed. Options for disposing of these vehicles are limited and require both time and, in some cases, a fee to hire a tow truck to transport the vehicle for disposal. Vehicles can be brought to the Bovoni Landfill on St. Thomas for free disposal Monday through Saturday (as of January 2022). The Office of the Administrator launched an Abandoned Vehicle Taskforce in 2019 to mark and dispose of abandoned vehicles and as of May 2019, approximately 175 abandoned vehicles were removed on St. Thomas. Although abandoned vehicles are subject to a minimum $1,000 fine (Figure 43), these fines are rarely enforced.

During field visits, an accident was observed outside of the Dorothea watershed where potentially hazardous fluids were leaking from a damaged vehicle (Figure 43). Although emergency services were on the scene of the accident, no spill response measures were applied to these leaking fluids. The fluids were draining towards stormwater infrastructure that is directly connected to the ocean.

Figure 43. Warning sign regarding a fine for abandoned vehicles (left) and vehicle damaged in an accident with fluids spilling on the ground (right).

3.4.5 Other Issues of Concern

3.4.5.1 Sea Level Rise

Climate change influenced sea level rise is an issue of concern for the USVI. Due to the melting of polar ice caps and thermal expansion of ocean waters, sea level rise poses a significant risk to the island in the form of shoreland erosion, infrastructure degradation, and the contamination of groundwater aquifers, wetlands, and estuaries.

Data provided by the Sea Level Rise and Coastal Flood Hazard Scenarios and Tools Interagency Task Force suggests that sea level rise proximal to St. Thomas will be between approximately 3.38 ft by 2100, with a high estimate of 6.79 ft and a low estimate of 1.21 ft depending on the modeled scenario (Sweet et al., 2022). This is of notable concern as many of the critical harbors and bays surrounding St. Thomas are within a few feet of sea level. Interactive sea level rise projection maps can be found at: https://sealevel.nasa.gov/task-force-scenario-tool.

Figure 44. Coastal erosion due to sea level rise threatens stability of homes near the coast (note photo is from another area on St. Thomas and not within the Dorothea watershed).

3.4.5.2 Mangrove Health

Mangroves provide important coastal protection from storm surges, store and filter stormwater, and provide wildlife habitat (Figure 45). Mangroves are threatened by development pressures, pollution especially from marine debris and from polluted stormwater, and climate change impacts including sea level rise.

Figure 45. Mangroves provide critical habitats and hydrologic functions to the islands of USVI.

3.4.5.3 Coral Health

Coral reefs provide coastal protection from storm surges and damage, aquatic habitat for critical local food sources and biodiversity, and economic contributions as a draw for tourism and recreation. On an economic scale, the total value of the USVI coral reefs is an estimated $187 million (Brander & Van Beukering, 2013). The island's coral reefs are at risk due to climate change driven temperature increases, increased hurricane storm intensity, ocean acidification, bleaching, reduction in reef predators and herbivores, pollution from human activity, and increased sedimentation from land-based sources of pollution including development. Stony coral tissue loss disease (SCTLD) is another threat to coral reefs, and this often-fatal disease has been detected in the USVI.

3.4.5.4 Air Pollution

Although air quality in the USVI is generally good, air quality can be degraded by Saharan dust events, industrial pollutants, and vehicle emissions. Dust from storms occurring in Africa can be transported by prevailing winds from the North African desert over the Atlantic Ocean and to the USVI. These dust events can cause issues for people with respiratory conditions (Platenburg, 2018). The USVI is heavily reliant on passenger vehicles and public transportation is not well utilized. As such, vehicle emissions are especially concentrated in the urban areas that can cause reductions in air quality (Shirley et al., 2012).

3.4.5.5 Sargassum

Since 2011, sargassum seaweed has periodically washed ashore in large quantities. Prior to this time, only small amounts of the seaweed would wash ashore. As it decomposes near shore, it can kill seagrass through shading and deoxygenation, prevent turtle nesting, and smother coral. Sargassum also creates hydrogen sulfide, a foul smelling and toxic gas that can irritate lungs and eyes. It also poses a significant economic issue for the region both in a reduction in tourism and in the cost to remove and dispose of the seaweed as it washes up on beaches.

3.4.5.6 Marinas and Boats

Marinas can be a source of pollutants due to dumping from boats or leaking pumping stations. This direct discharge of fuel or sewage can result in bacteria and toxic pollutants in near shore waters that can affect important coastal habitat. There are not currently any marinas present within the Dorothea watershed, but recreational boats are often operated near the shoreline and can also result in contamination.

3.5 Data Collection

3.5.1 Stormwater Infrastructure Mapping

Accurately mapping the existing stormwater infrastructure is critical to understanding the connectedness of these systems to plan for future stormwater upgrades to improve resiliency. Stormwater best management practices (BMPs) improve water quality both by removing pollutants through filtration, infiltration, or settling, and by reducing the volume and velocity of runoff entering guts and coastal waters. As land development continues in the USVI and precipitation patterns are impacted by climate change, stormwater management practices will play an even more important role in reducing flooding, protecting water quality and marine ecosystem health, reducing peak discharge rates, and more nearly approximating the hydrology of undeveloped lands.

An inventory of stormwater infrastructure including features like catchbasins, paved swales, grass swales, ditches, and culverts was conducted and evaluated as part of field investigations for this Plan (Figure 46). Prior to this, very limited digitized stormwater infrastructure data existed for St. Thomas. No publicly available centralized GIS repository of stormwater infrastructure currently exists for the territory. This lack of infrastructure data presents several of challenges to watershed planners. Without knowing what stormwater infrastructure is present, determining hydraulic flow paths through watersheds can often be unclear, in turn making it difficult to accurately delineate contributing drainage areas of existing or proposed stormwater treatment practices. Furthermore, a lack of data on the condition and effectiveness of existing infrastructure makes planning for regular maintenance, repairs, or upgrades inefficient.

Figure 46. Examples of stormwater infrastructure. A trench drain (left) and a culvert (right).

The infrastructure mapping effort for this Plan was split into field and desktop phases (Figure 47). Field data was collected with handheld GNSS equipment (primarily a Trimble TSC7) using the mobile data collection app ArcGIS Collector. Field data was collected in March 2023. Photo documentation was collected of each feature. The desktop mapping stage focused on quality control and completeness of the map data. Pipe connections were drawn where field notes described, cross culverts were completed with inlet/outlet pairs, and additional infrastructure visible from photo, imagery, or LiDAR topography was added.

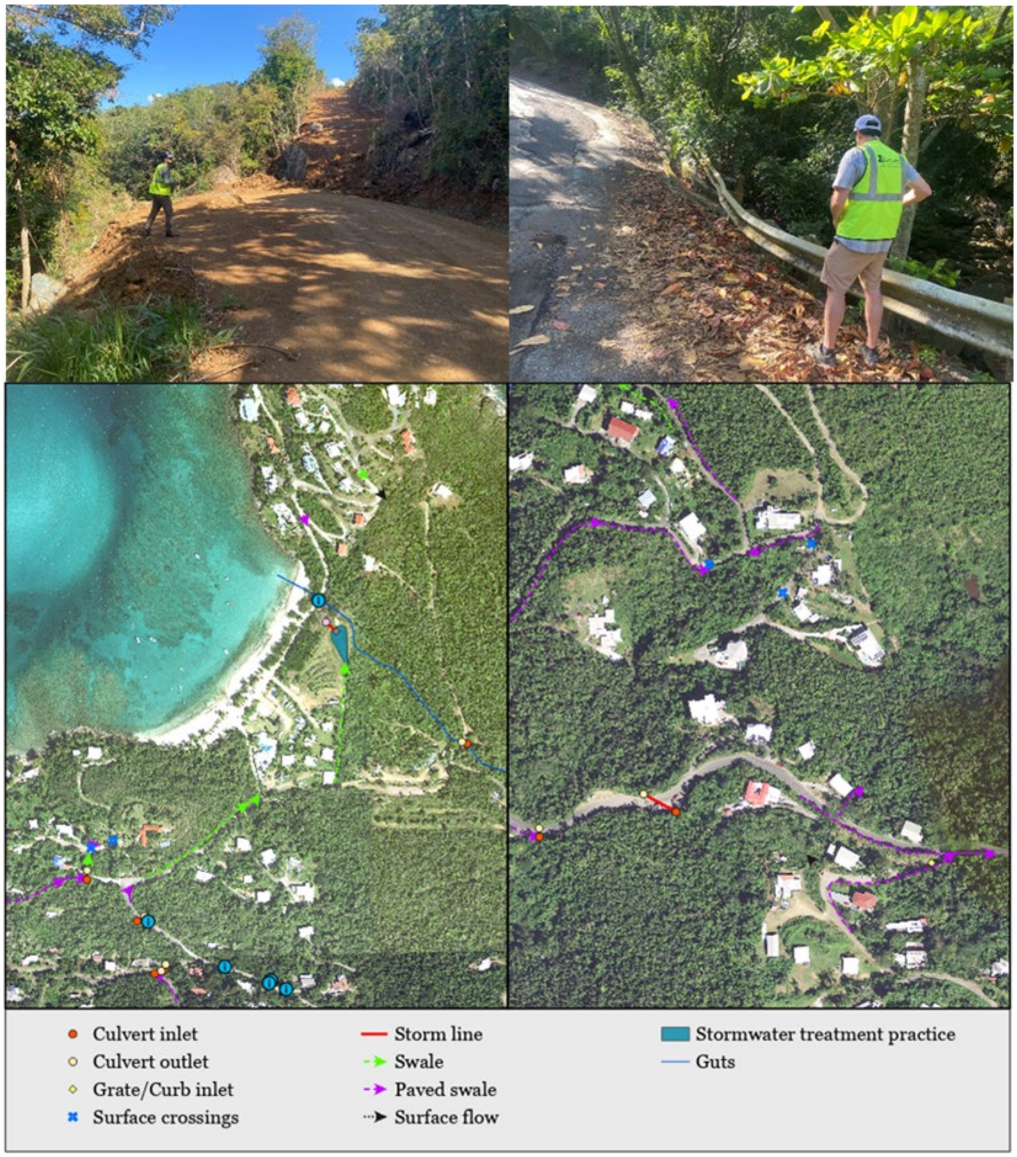


Figure 47. Inspection of existing stormwater infrastructure during field assessments (above) and an example of the maps produced (below).

This dataset is the most complete and accurate mapping of the stormwater infrastructure within the watershed. However, no mapping of this scale can capture all infrastructure. There are many private areas that were unable to be accessed in the field. It is also expected that there is some infrastructure that has become buried with sediment over time and is unable to be identified. Additionally, as-built plans were unavailable for much of St. Thomas, so in areas where field investigations were unable to be completed or where pipe connections were unclear, this data was unable to be captured. Additional steps to clarify connections or identify additional infrastructure such as feeding cameras through the stormlines or

In total, 274 points, 346 lines, and 3 polygon features were mapped within the watershed for a total of 623 features. The largest numbers of infrastructure types collected were catchbasins, culvert inlets, storm lines, and culvert outlets. A breakdown of the number of features identified by infrastructure type are included in Table 10 below. See Appendix E for more information.

Table 10. Summary of infrastructure data collected by type in the watershed.

Feature Type	Infrastructure Type	Quantity
Point Features	Culvert outlet	91
	Culvert inlet	75
	Information point	37
	Surface crossings	26
	Catchbasin	22
	Stormwater manhole	8
	Drop inlet	6
	Grate curb inlet	4
	Outfall	2
	Dry well	1
	Water bar	1
	Yard drain	1
Line Features	Paved swale	198
	Storm line	92
	Swale	32
	Surface flow	19
	Trench drain	4
	Storm tunnel	1
Polygon Features	Stormwater features	3
	Total	**623**

3.5.2 Existing Stormwater BMPs

Stormwater best management practices (BMPs) improve water quality both by removing pollutants through filtration, infiltration, or settling, and by reducing the volume and velocity of runoff entering guts and coastal waters. As land development continues in the USVI and precipitation patterns are impacted by climate change, stormwater management practices will play an even more important role in reducing flooding, protecting water quality and marine ecosystem health, reducing peak discharge rates, and more nearly approximating the hydrology of undeveloped lands.

Understanding where current BMPs exist is critical to properly allocate stormwater resources across the watershed. For example, if a neighborhood or region within a watershed is already being treated by a current BMP practice, a new BMP may be better served elsewhere within the watershed. The existing

BMPs will also play a significant role in the hydrologic and water quality modeling completed for this project since these BMPs reduce pollutants and stormwater volume and velocity entering guts and coastal regions. BMPs were previously scarcely mapped, and BMP locations were generally unknown.

One existing BMP, a stormwater basin, was identified near Hull Bay (Figure 48). The existing BMP was identified using a combination of field observations, Hexagon imagery, and LiDAR topography data. This identification process focused on the identification of structural BMPs, such as infiltration basins, treatment wetlands, and wet ponds. Non-structural practices, such as disconnections to filter strips and vegetated buffers as well as reforestation efforts could not be feasibly identified. It is possible that some existing BMPs remain unidentified due to a lack of access to private property, lack of comprehensive site plans, or their small size rendering them undetectable in the available data sources.

The drainage area for the existing BMP was delineated utilizing one-foot contours derived from LiDAR elevation data and mapped infrastructure. The drainage area includes 3.4 acres. The majority of the watershed is presently untreated, further highlighting the need for watershed-scale planning.

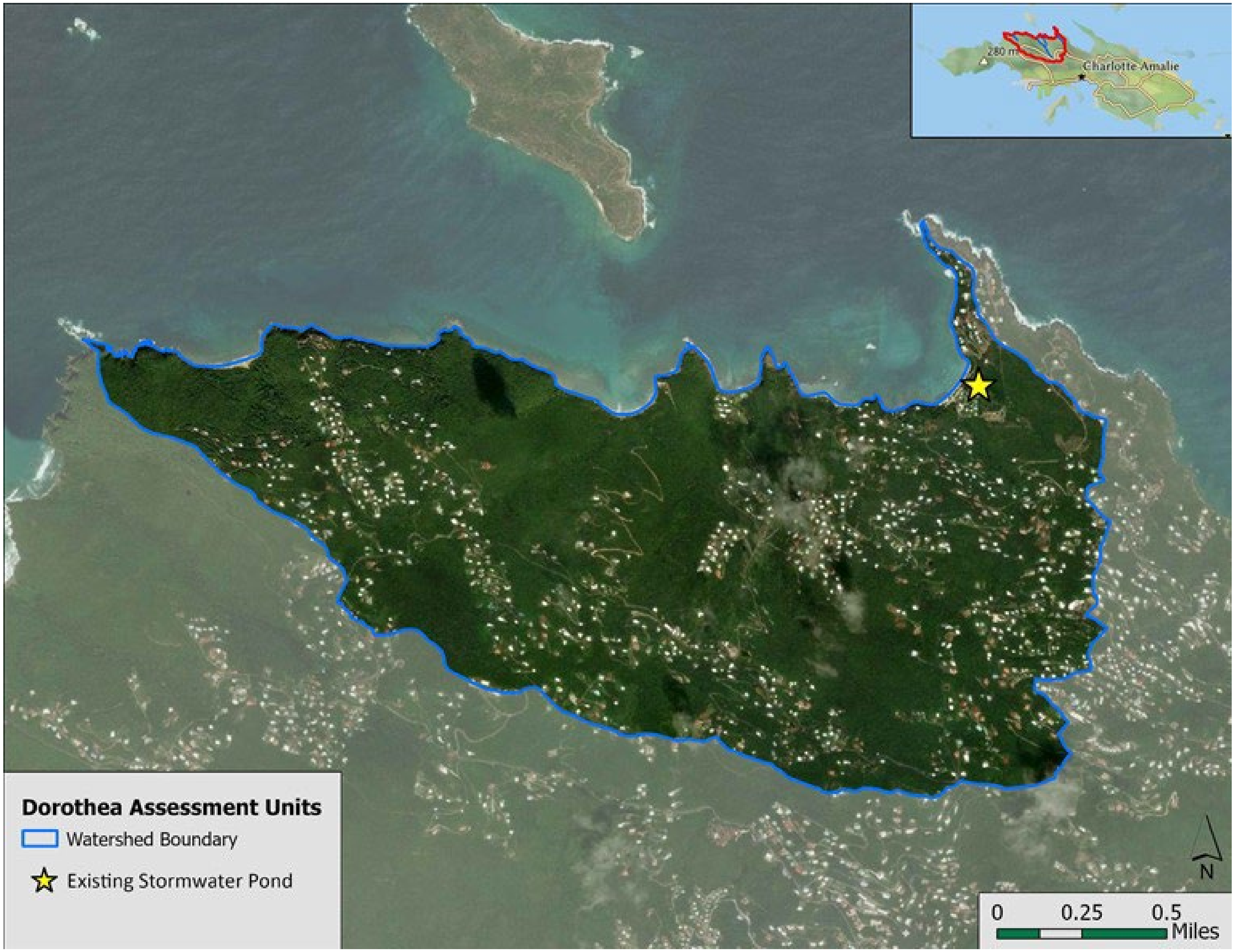


Figure 48. Existing stormwater BMP identified within the watershed.

Figure 49. Existing stormwater basin in the Dorothea watershed.

3.5.3 Updates to Existing Data

DPNR-provided watershed boundaries and FEMA-provided gut layers for the watershed was revised utilizing newly available data including LiDAR-derived elevation data (USGS, 2018), Hexagon imagery (0.15m, 2019), and stormwater infrastructure mapped as a part of this project. Mapped infrastructure such as surface crossings, culverts, and stormwater pipes as well as assumed flow confinement from roadways and buildings were also considered during drainage area delineation. This new data allowed for a better understanding of topography and drainage patterns including the impacts of previously unmapped stormwater infrastructure. For the Dorothea watershed, the updates to the watershed boundary resulted in a net watershed area change of 6.96 acres.

3.5.4 UAS Data Collection

Land cover data (see Section 3.3.2) was created using 2019 Hexagon imagery as the primary source. However, as development is ongoing, there is the potential for significant land cover changes that could impact stormwater flows including the construction of new residential developments or clearing of forested areas. To understand potential development changes, an unmanned aircraft system (UAS) was flow over key areas in March 2023 to capture up to date very high-resolution imagery (≤5 cm). The areas of suspected change were identified based on information regarding current and recent known development and shared with DPNR. A fixed wing WingtraOne Gen II UAS was utilized (Figure 50). The collected data was used to assess the level of development change in the watershed and update the land cover data used to model the selected stormwater management practice concept designs (see Section 3.7.4). In this watershed, data was collected for approximately 22 acres.

Figure 50. WingtraOne Gen II UAS utilized to collect data in the study watersheds.

3.6 Water Quality Monitoring of Guts

3.6.1 Monitoring Overview

Efficient management and monitoring of natural resources requires informative data derived from areas of interest. The guts of St. Thomas are the primary source and conveyance system of fresh water on the island. Likewise, they are also the main conduit through which chemical pollutants and sediment from the watersheds of St. Thomas reach the ocean (Platenburg, 2006). Despite their importance, the guts of St. Thomas have not been monitored with consistency and their terrestrial sources of pollutants are not well understood. The guts on the island are ephemeral, only flowing following rainfall, and this makes sampling of the guts very challenging. This study represents the most widespread and comprehensive sampling of guts in the USVI. This monitoring effort also serves as a pilot project and the lessons learned during this effort can be used to guide future monitoring and can also be used to identify pollutant sources and guide efforts to improve water quality.

In this study, visual monitoring was completed utilizing time lapse photographs taken by game cameras in four key locations within the watershed (Figure 51). Photos were taken every hour and assessed visually to determine gut response to rainfall, water clarity, and wildlife habitat. The cameras were deployed from March to September 2023. Unfortunately, one of the cameras (in the Neltjeberg area) was removed from the monitoring location. A new camera was reinstalled in this location, but this camera was also removed by unknown parties. The cameras were locked into place with cable locks, but this did not prevent the removal of the camera.

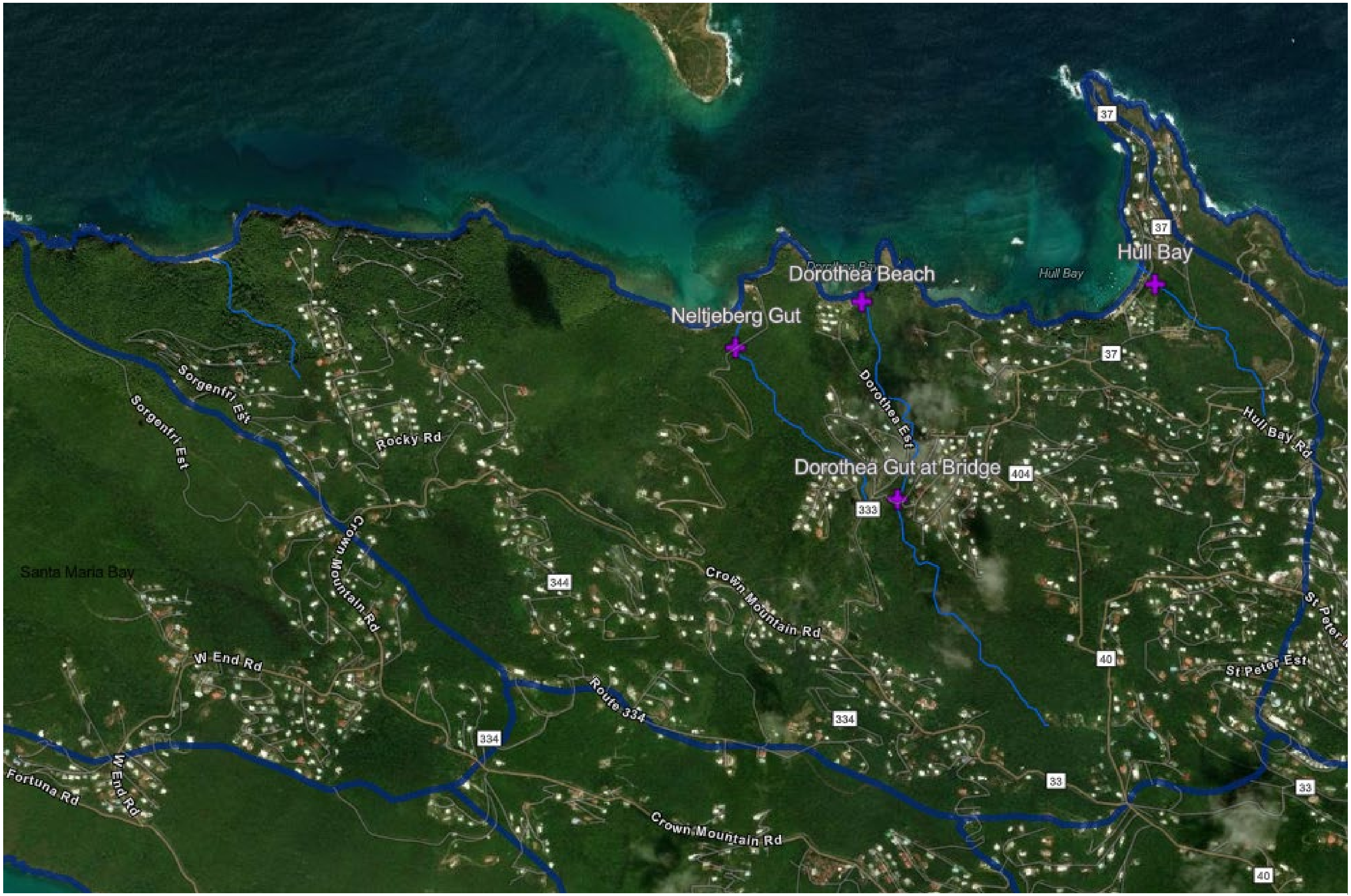


Figure 51. Visual monitoring locations are shown with purple crosses within the watershed.

3.6.1.1 Hull Bay

The camera at Hull Bay was placed adjacent to Tropaco Point Rd. This location was selected to monitor the health of the mangroves in this area, which has been disconnected from the ocean via a concrete road without a culvert or other water passage. This area did not have any ponding water throughout the monitoring period despite several storm events that produced responses in the Dorothea gut (Figure 52). This is likely in part due to the large stormwater basin that collects a significant amount of stormwater runoff in this area.

Figure 52. The Hull Bay monitoring location was consistently dry following storm events during the monitoring period.

3.6.1.2 Dorothea Beach

The Dorothea Beach monitoring location had a consistent pool of water throughout the monitoring period. The water level increased in response to rain events. Wildlife including birds were regular visitors to the area (Figure 53). Even following rain events, the water did not appear turbid, indicating that the surface runoff that reaches the gut is generally not heavily sediment laden (Figure 54). This is an important finding, and this gut should be regularly monitored, particularly following storm events, to ensure that the gut does not become turbid over time as development occurs in the watershed.

Figure 53. Wildlife, including the wading bird seen in the above photo, was regularly observed at the Dorothea Beach gut.

Figure 54. Over the monitoring period, water in the gut had high clarity and low turbidity.

3.6.1.3 Dorothea Gut at Bridge

The camera located at the Dorothea Gut Bridge along North Resolution had several issues, highlighting the need for carefully selected camera locations, preferably a high location to prevent tampering. The camera was placed behind some fairly dense vegetation in an attempt to prevent passersby from noticing the camera and removing it, but the camera was unfortunately obscured by large leaves and thus the gut was not visible at times. The water clarity was difficult to detect, but ponding water was frequently observed in the gut (Figure 55).

Figure 55. The Dorothea gut was frequently observed to have ponding water.

3.6.1.4 Neltjeberg Gut

Unfortunately, the two camera that were stationed at the Neltjeberg monitoring location were removed by unknown parties. As such, no data is available for this site.

3.7 Identification and Ranking of Stormwater BMPs

3.7.1 Best Management Practices

3.7.1.1 Desktop Assessment

A desktop assessment was completed to identify sites for potential stormwater management and flooding mitigation best management practices (BMPs). This process involved a thorough review of GIS resources and associated attribute data. Data included, but was not limited to, stormwater infrastructure data collected during this project, soils classifications, parcel data, topography, and guts. Assessments also considered areas of concern identified by project stakeholders and collected during and following public meeting input. This data was used to identify and map areas of water quality and flooding concern as well as areas where opportunities for potential BMP implementation were located. A point location was created for each of the 37 identified sites or areas for assessment in the field (Figure 56).

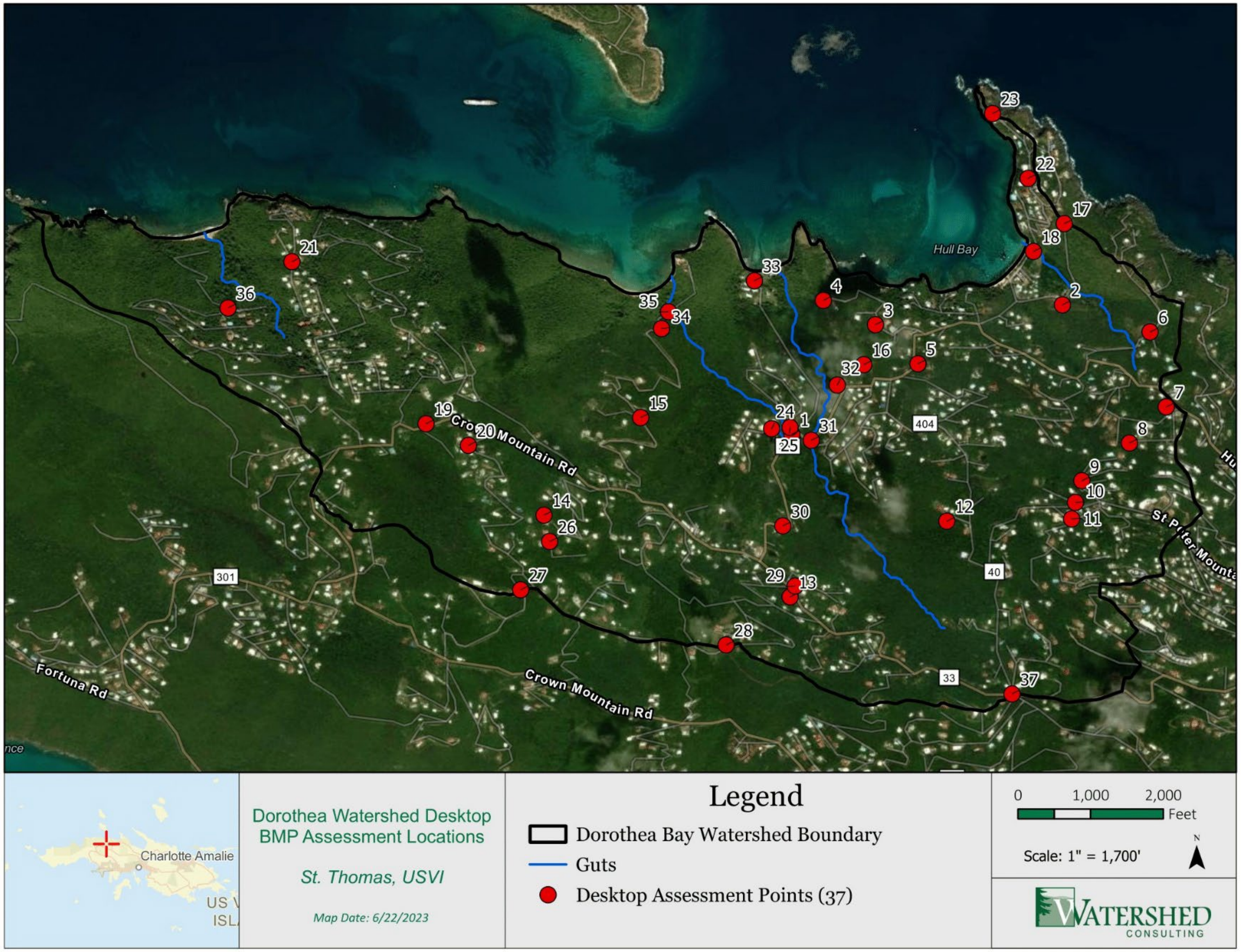


Figure 56. Overview map of desktop identified potential BMP.

3.7.1.2 Field Assessments

Targeted field assessments were completed in March 2023 and were focused on BMP assessment (Figure 57). These areas were prioritized prior to field work to further focus these efforts. In order to maximize efficiency in the field and better understand site-specific conditions, digital base maps were created. The maps show guts, watersheds, and parcel boundaries. This information was used in the field to assess potential feasibility issues for proposed practices and to better identify preliminary BMP locations. The base layers were pre-loaded into a project-specific mobile app that was customized for this project using the Fulcrum platform (Figure 57). The app was also pre-loaded with the point locations identified during the desktop assessment. These points allowed for easy site location and data collection in the field.

In total 176 locations were assessed and documented in the field. These are shown in Figure 58 below in green. While each of these locations do not indicate a recommended BMP, each site had a feature of interest. For example, the Neltjeberg area includes an unpaved road that would benefit from multiple small practices such as sediment traps, grading, and stabilization of roadside conveyances. Each of these areas was documented and this represents 39 point locations.

At each site, the customized mobile data collection app was used to collect information including site suitability, photographic documentation, proposed BMP practice, hydrologic connectivity, operations and maintenance issues, follow-up notes, and other pertinent data. All collected data was securely uploaded to the Cloud for later use (Figure 57).

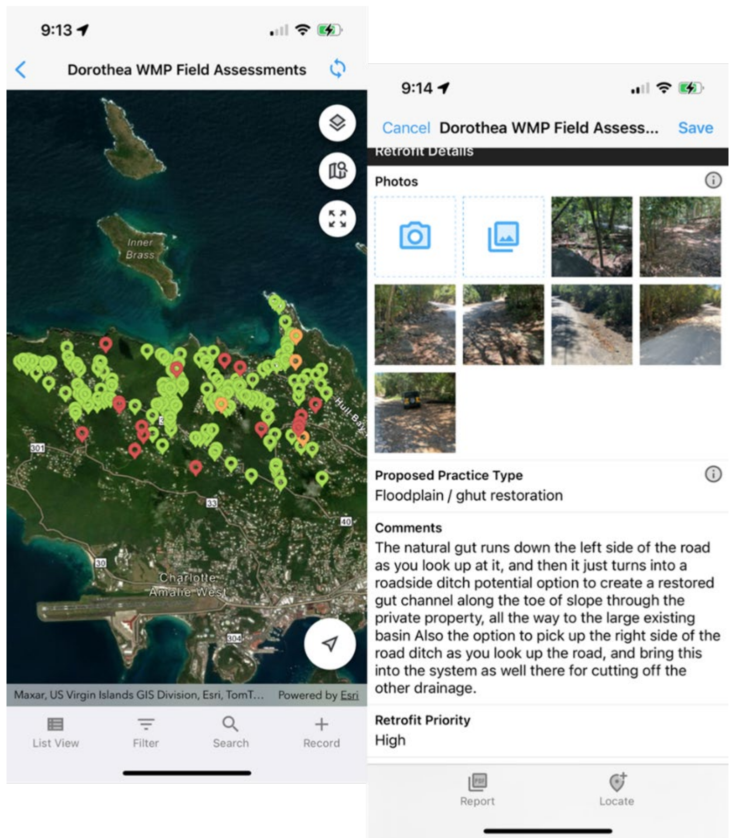


Figure 57. Fulcrum app interface used for field assessments.

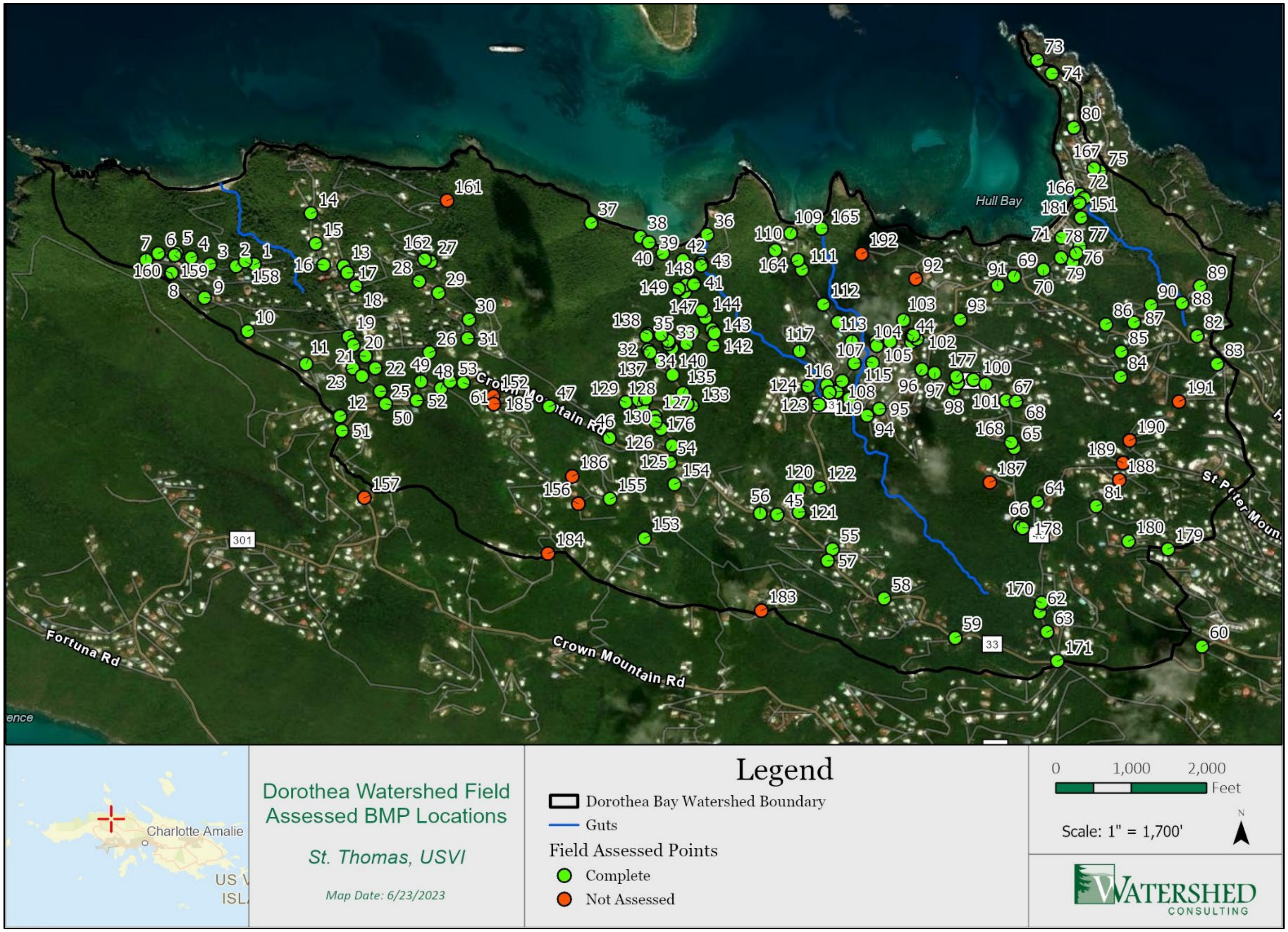


Figure 58. Overview of map of potential BMP locations and if they were assessed in the field (green) or not assessed (red).

3.7.2 Preliminary Ranking of BMP Project Sites

To help determine which practices would be most effective and feasible, a preliminary prioritization process was applied to the list of potential sites. The goal of this preliminary ranking was to assess each identified project site for its associated benefits and feasibility issues and narrow down a large list of projects to a more manageable list of 5 projects that will be impactful in terms of water quality benefits and quantity. This process is important because both time and resources are limited and can only be allocated to a limited number of practices at one time. Once the feasible top 5 projects are implemented, the next highest ranked projects should be further assessed and moved forward to additional design and eventually implementation.

As a result of the desktop and field assessments, a total of 135 sites for potential stormwater best management practices (BMPs) were identified in the watershed. BMPs identified in the Neltjeberg area were combined into one comprehensive location as it was selected for a conceptual design and later refined. The preliminary ranking considered the following factors, scoring on qualitative scales:

1) **Impervious cover managed:** If a large percentage of the estimated drainage area was impervious surface, a “High” rank was applied. Some small practices, for example parking lot treatment systems, may have had a small *total* area of impervious cover within their drainage areas but received a “High” rank as the impervious cover represented a high percentage of the drainage area.
2) **Drainage area size:** Practices that would treat large areas, relative to the other proposed practices within the watershed, received “High” scores. This included practices that would treat guts directly as guts often drain larger areas.
3) **Priority:** Ranking for this metric considered professional judgement of project priority considering nearby land use and existing known water quality issues (for example, documented turbid runoff or road erosion). Nearby higher-density developed land uses were generally considered to pose greater water quality risks than lower density development. If an area lacked existing stormwater treatment features, the potential water quality benefits were considered greater than if the proposed practice would retrofit or supplement existing stormwater features.
4) **Potential for flood mitigation:** If the proposed practice would help store and slow a large quantity of runoff during storm events, a “High” score was assigned. Practices located upstream of high-density development areas were generally considered to have higher potential flood mitigation benefit as they directly impacted the communities downstream.
5) **Difficulty of design/construction:** The available space, scale of project, and density of surrounding development were all considered for this metric. Proposed BMPs that would require potentially complicated overflow and routing systems to tie with existing infrastructure were considered higher difficulty and thus scored lower. These types of complications were often linked to concerns with construction access, land ownership, topography, and other similar limiting factors.
6) **Site of particular concern?:** This metric was either “Yes” or “No”. If a site had documented water quality, erosion, or flooding concerns based on local knowledge or field investigation, it was marked “Yes”.

Table 11. BMP preliminary ranking metric scores.

Metric	Ranking Option	Scores
Impervious cover managed	Low	1
	Medium	3
	High	5
Drainage area size	Small	1
	Medium	3
	Large	5
Priority	Low	1
	Medium	3
	High	5
Potential flood mitigation	Low	1
	Medium	3
	High	5
Difficulty of design/construction	Low	5
	Medium	3
	Complex	1
Site of particular concern?	No	0
	Yes	5

The sum of the numeric qualitative rankings represented each BMP's preliminary prioritization score. A maximum score of 30 was possible for each assessed BMP, and the closer to that score, the higher the rank (Table 11). The scores and project descriptions can be found in Table 12. The top 5 ranked sites are spatially distributed across the watershed, covering a total drainage area of 290 acres, (17% of the watershed area; Figure 59). Consequently, the selected BMPs project sites treat a variety of regions and neighborhoods throughout watershed. The ranking determined that these sites are capable of treating a large amount of impervious surface, improving water quality, and reducing flood potential within the watershed. Additionally, the chosen BMP locations have minimal known barriers to implementation.

The 5 highest ranking projects were advanced to the next round of prioritization, the final ranking. Complete preliminary ranking information and the point locations of these projects are included in Appendix F.

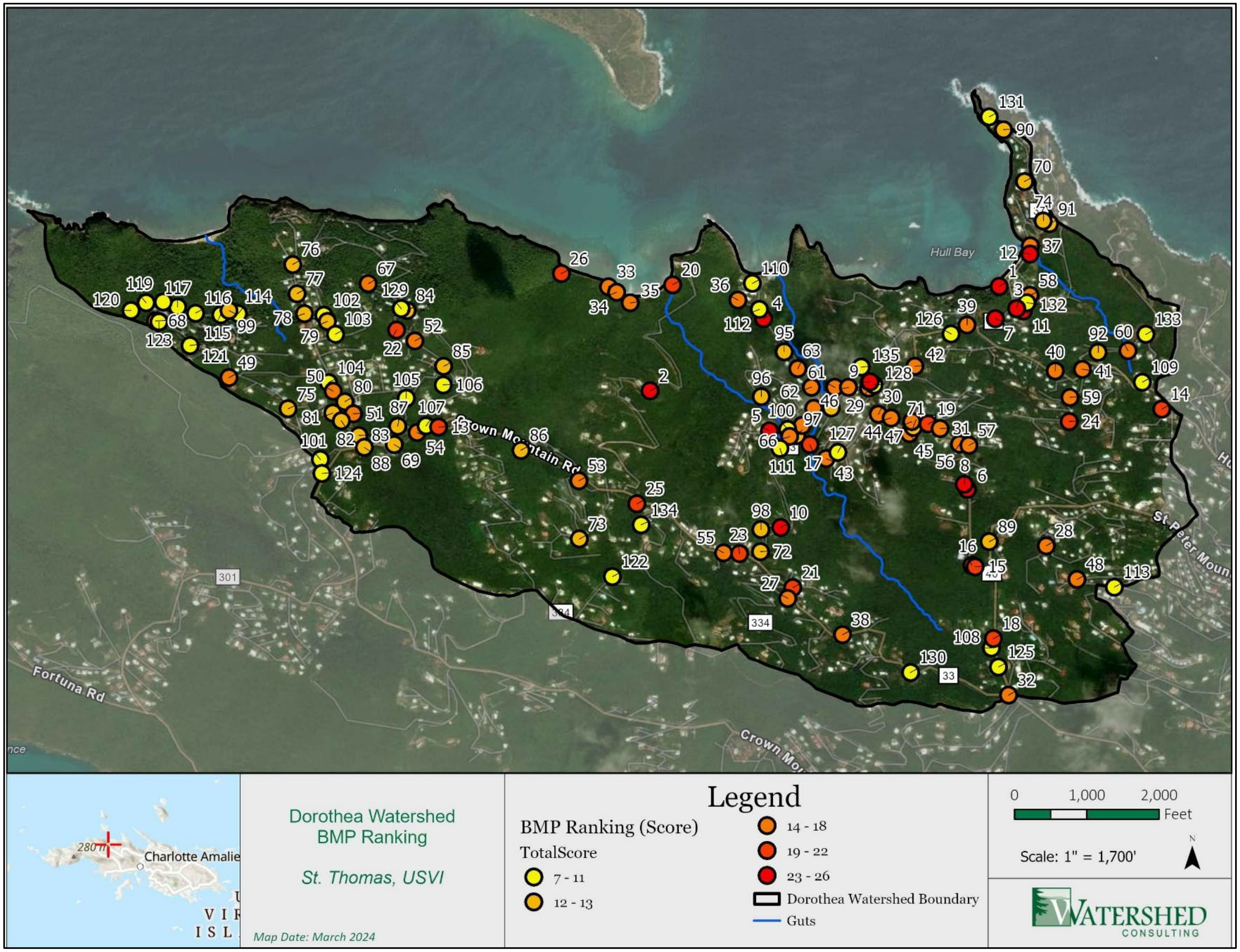


Figure 59. Map of proposed BMP points and preliminary ranking results. Higher ranked projects are shown with darker red colors.

Table 12. Summary table of preliminary BMP ranking results.

ID & Rank	BMP Type	Description	Final Score
1*	Improve parking, Stabilization, Surface Feature, manage drainage from along road	Stabilize parking area with pervious pavers; increase vegetated buffer along beach; redirect water down access drive in stabilized conveyance, direct drainage to bioretention	26
2*	Sediment traps, road grading, stabilization, cross-drainage	Multiple road improvements	26
3*	Floodplain / ghut restoration	Natural gut runs down left side of road and then turns into a ditch. Potential to create a restored gut channel along the toe of slope through the private property, all the way to the large existing basin. Option to pick up the right side of the road too	26
4*	Large surface feature to manage significant drainage	If cross drainage is installed for the road above, this would be a small project. However, if that cross drainage does not happen, this would be an excellent spot for a large basin.	24
5*	Surface feature	Great opportunity to collect road runoff and divert into basin	24
6	Cross drainage / infrastructure	Add curb cuts on either side of the road to diffuse drainage to stabilized areas	24
7	Cross drainage / infrastructure	Cross drainage to reconnect water to the gut and off the road	24
8	Cross drainage / infrastructure	Add curb cuts on either side of the road to diffuse drainage to stabilized areas	24
9	Surface feature	Sediment trap on either side of culvert; Culvert has significant erosion on the downslope side. Upslope side has ditch, erosion and long ditch with no stabilization. Stabilize ditches, add check dams.	24
10	Surface feature	Great opportunity to collect road runoff and divert into basin. Assess neighborhood; gut runs to east of this area	24
11	Floodplain / ghut restoration; Surface feature	Potential for a large gut restoration / floodplain access / surface basin in undeveloped lot that appears to be for sale.	24
12	Cross drainage	Road blocks drainage. Mangrove health appears decreased; install cross drainage or elevate roadway. Damage (undercutting) noted along roadway.	24
13	Waste management	Dumpsters are in a gut drainage; relocate or elevate dumpsters and improve solid waste management. Clean trash out of gut.	22
14	Stabilization, Surface Feature, Subsurface Feature	Stabilize slope; capture drainage from impervious in surface or subsurface BMP prior to flowing down hill	22

ID & Rank	BMP Type	Description	Final Score
15	Cross drainage / infrastructure; surface feature	Elevate road or add culverts, sand filter berm. Add turnouts on low side of road to stable areas.	22
16	Cross drainage / infrastructure; surface feature	Small area for a sediment trap; add turnouts and disconnections where possible down slope for long ditch run	22
17	Surface feature; Illicit discharge	Formalize sediment trap. Locate source of strongly suspected illicit discharge and repair.	22
18	Surface feature	Convergence of significant drainage; stabilize slopes, add surface feature / gabions	22
19	Cross drainage / infrastructure	Potential for sediment traps and turnouts and increased cross drainage to break up long flow paths; ensure drainage would not impact houses downhill of location	21
20	Gut protection	Ensure that gut is protected from development and maintains a robust vegetated buffer.	21
21	Surface feature	Gas station, concentrated impervious that could be managed via surface features such as bioretentions	20
22	Surface feature	Install sediment trap	20
23	Surface feature	Install some drainage down the road and then a splitter to an underground system for the department of agriculture locate the cistern on their property, possibly underground or in a surface tank sense the surface as well below the road	20
24	Stabilization, Surface Feature, Subsurface Feature	Significant erosion that should be stabilized. Sediment trap at a minimum, but more likely subsurface BMP due to space constraints.	20
25	Surface feature	Good spot for a surface feature on the uphill side of the road at the gut. The downhill side of the road also has a nice flat space. However, there's evidence of some types of infrastructure here, possibly wastewater station.	19
26	Gut protection	Gut drainage (unmapped), primarily undeveloped area. The gut is fairly stable although there appears to be some erosion further up that cannot be accessed. Medium gut erosion. Ensure robust vegetated buffer is maintained.	19
27	Stabilization	Potentially eroding slope / bare soil, ensure erosion control associated with new construction; manage in surface basin prior to discharge from site	18
28	Cross drainage / infrastructure; surface feature	Add sediment trap, cross drainage, and disconnections. Red colored runoff observed from this area.	18

ID & Rank	BMP Type	Description	Final Score
29	Surface feature	Great opportunity to collect upper road by installing new cross drain to surface level, spreader, or bioretention and then discharge to gut. Alternative could be to collect upper road and bring to gut above the culvert crossing, but the space is limited	17
30	Surface feature	Could potentially bring water down hills from both side into small vegetated, gut area and create a basin	17
31	Cross drainage / infrastructure	Potential for sediment traps and turnouts and increased cross drainage to break up long flow paths; ensure drainage would not impact houses downhill of location	17
32	Surface feature / Subsurface area	Potential to install infrastructure to surface or subsurface BMP	17
33	Surface feature	Stabilize area; potential to combine with project to the east of this location in a combined feature.	17
34	Surface feature	Outlet of a smaller gut here no real base material; just an erosional feature which could be stabilized	17
35	Surface feature	Convergence of two ghut outlets; stabilize and capture sediment in trap; bare unvegetated area noted to south of this location that should be stabilized and vegetated	17
36	Surface feature	The gut comes down from the woods to the road here there a spot for a basin; remove loose piled material near gut and ensure it is stabilized. Alternatively, add gabions in channel.	17
37	Surface feature	Potential for small sediment trap, however, space is constrained (telephone pole and close to the mangroves)	16
38	Surface feature	Room for small sediment trap	15
39	Subsurface feature	Add gabions in gut; manage road drainage but as there is no space for a surface feature, add subsurface practice under the road.	15
40	Stabilization, Subsurface feature	Large outfall but no space for surface feature, however, could do sub surface feature under the parking lot and then gabion dams or check dams at head of gut	15
41	Turnout	Potential to add turnouts to disconnect long flow path down road.	15
42	Stabilization; surface feature	Ensure sediment is not leaving the site of new construction; install surface sediment trap to capture drainage from site	15
43	Surface feature	Good spot for a bioretention. Area potential for a subsurface option	15

ID & Rank	BMP Type	Description	Final Score
44	Cross drainage / infrastructure; surface feature	Potential to install some small distributed sediment traps and a few areas where turnouts are possible but residences downhill may limit this option	15
45	Surface feature	Good spot for a sediment trap; ensure drainage would not impact houses downhill of location	15
46	Cross drainage / infrastructure	Disconnect drainage to stable vegetated area to break up flow path	15
47	Cross drainage / infrastructure	Potential for sediment traps and turnouts and increased cross drainage to break up long flow paths; ensure drainage would not impact houses downhill of location	15
48	Surface feature, cross drainage / infrastructure	Potential to create sediment trap to east to capture large impervious residential area; add stabilized turnouts to north	15
49	Surface feature	Small room next to the power pole for a sediment trap	15
50	Cross drainage / infrastructure, vegetated buffer	Add cross drainage to break up flow paths; plant vegetated buffer	15
51	Surface feature	Room for sediment trap on the downstream side of the road	15
52	Surface feature; stabilization	Stabilize area to prevent erosion and install sediment trap	15
53	Surface feature	Potential practice on inlet side of the culvert for a sediment trap. The gutter above the road appears to go under the site. Potentially buried?	15
54	Surface feature	Space for a small sediment trap at the entrance, but also at the outlet of the culvert the outlet is relatively flat, so could make a nice sediment trap	15
55	Surface feature	Not much room, but could potentially do a small sediment trap at the inlet to the culvert	15
56	Surface feature	Small sediment trap; add check dams / stone to ditch to stabilize and slow drainage	15
57	Stabilization	Stabilize ditch at bottom of slope with stone and add check dams	15
58	Surface feature	Install surface basin to manage drainage from impervious.	15
59	Surface feature	Potential for sediment trap	15
60	Paving, Surface Feature	Potential to pave section of steep road that drains toward gut, add cross drainage / water bars, direct flows to stable turnouts / sediment traps	15

ID & Rank	BMP Type	Description	Final Score
61	Subsurface feature; Surface feature; Stabilization	Manage drainage from elevated roadway; potential for practice closer to gut. Stabilize erosion northwest of this location.	15
62	Cross drainage / infrastructure	Install cross drainage to direct road drainage to gut to E.	15
63	Cross drainage / infrastructure	Install cross drainage to direct road drainage to gut to E.	15
64	Cross drainage / infrastructure	Install cross drainage to direct road drainage to gut to E.	15
65	Cross drainage / infrastructure	Install cross drainage to direct road drainage to gut to E.	15
66	Surface feature; sold waste cleanup	Could collect drainage from road with "Fountain" sign in this location; clean up dumped trash	15
67	Stabilization; sediment trap	Significant roadside erosion that needs to be stabilized; capture and manage sediment	15
68	Surface feature	Excellent spot for a sediment trap	15
69	Surface feature	Small pull off from road that could be used for a sediment trap	13
70	Surface feature; Stabilization	Small turnout or trap possible. Ensure sediment does not leave site of new construction.	13
71	Cross drainage / infrastructure	Good spot for a sediment traps and turnouts; ensure drainage would not impact houses downhill of location	13
72	Surface feature	Use yellow striped space for bioretention	13
73	Cross drainage / Infrastructure	Add cross drainage. Improve turnouts. Ensure area is stabilized.	13
74	Surface feature	Good spot for sediment trap or stabilized ditch with check dams on the inside bend of the road	13
75	Cross drainage / infrastructure	Install cross drainage to break up flow path and reduce erosive potential	13
76	Stabilization; surface feature	Ensure that new construction site is stable; install sediment trap(s) to capture drainage from driveway and manage	13
77	Cross drainage / infrastructure	Add cross drainage to break up flow paths.	13
78	Cross drainage / infrastructure	Add cross drainage to break up flow paths.	13
79	Cross drainage / infrastructure	Add cross drainage to break up flow paths.	13
80	Cross drainage / infrastructure	Add cross drainage to break up flow paths.	13

ID & Rank	BMP Type	Description	Final Score
81	Cross drainage / infrastructure	Add cross drainage to break up flow paths.	13
82	Cross drainage / infrastructure	Add cross drainage to break up flow paths.	13
83	Surface feature	Install sediment trap	13
84	Surface feature	Direct road drainage along driveway, and then over a long level spreader	13
85	Surface feature	Stabilize gut; add gabions	13
86	Surface feature	Good spot for a sediment trap on the uphill side of the road. There's already a very deep sump at the culvert inlet. The outlet is very steep so there would be no room to do a sediment trap on the outside.	13
87	Surface feature	Room for a small trap in the pull off - could take the inside ditch and bring it across the road	13
88	Surface feature / Subsurface feature	There could be an opportunity to enhance the cistern making it larger to capture more rainwater	13
89	Surface feature	Small area for a sediment trap at the bottom of the driveway. Runoff exits onto the main road.	13
90	Surface feature	Runoff from the road is causing erosion over the edge down to the ocean, not much room, but possibility for an armored shoulder and level spreader along the edge of the road	13
91	Surface feature	Good spot for small sediment trap	13
92	Surface feature	Space for a small sediment trap at bottom of hill; add cross drainage / water bars	13
93	Surface feature	Great spot for a retrofit but tight space dropped off steeply to cut; stabilize drainage; step pools or level spreader with sediment trap possible	13
94	Cross drainage / infrastructure; surface feature	Disconnect drainage to stable vegetated area to W toward gut to break up flow path; add sediment traps as possible given space	13
95	Cross drainage / infrastructure	Install cross drainage and turnouts to direct road drainage to gut to NE.	13
96	Surface feature	Good spot for a sediment trap for upper Road	13
97	Cross drainage / infrastructure; Surface feature	The gut comes down from the woods to the road, possible spot for basin. Potential for additional cross drainage.	13
98	Subsurface feature	Possible for small cistern. Lots of agriculture below could be spot for collecting upper rd. to disconnect it	13

ID & Rank	BMP Type	Description	Final Score
99	Surface feature	Install additional cross drainage to interrupt concentrated flow paths; direct drainage to sediment trap	13
100	Cross drainage / infrastructure, Paving	Roads in this neighborhood are generally unpaved and rough, and could use stabilization in Cross drains	11
101	Surface feature	Small amount of room for a small trap and/or check dams down the inside of the swale to the gut	11
102	Surface feature	Install sediment trap to capture drainage from road / driveways	11
103	Surface feature	Land drops off steeply, but a long skinny sediment trap could be made along the driveway	11
104	Stabilization	Stabilize area to prevent erosion	11
105	Surface feature	Install sediment trap	11
106	Surface feature	Install sediment trap	11
107	Stabilization; materials storage	Material stockpile area with improper stabilization; relocate materials or stabilize area	11
108	Surface feature	Small sediment trap possible	11
109	Surface feature	Small turn out or sediment trap possible however, this area is used for parking as well so space may be restricted	11
110	Vegetated buffer	Potential to increase vegetated buffer along beach, but the area is fairly stable and flat. Recommend allowing grass to grow longer and raise mower blade.	11
111	Surface feature	Opportunity to collect road runoff and manage in sediment trap	11
112	Surface feature	Install sediment trap	11
113	Stabilization; surface feature	Ensure that sediment is not leaving construction site; construct sediment traps for driveway drainage	11
114	Cross drainage / infrastructure	Install additional cross drainage to interrupt concentrated flow paths	11
115	Cross drainage / infrastructure	Install additional cross drainage to interrupt concentrated flow paths	11
116	Cross drainage / infrastructure	Install additional cross drainage to interrupt concentrated flow paths	11
117	Cross drainage / infrastructure	Install additional cross drainage to interrupt concentrated flow paths	11
118	Cross drainage / infrastructure	Install additional cross drainage to interrupt concentrated flow paths	11

ID & Rank	BMP Type	Description	Final Score
119	Cross drainage / infrastructure	Install additional cross drainage to interrupt concentrated flow paths	11
120	Surface feature	Excellent sediment trap area	11
121	Surface feature	Add sediment trap and stabilize backslope	11
122	Surface feature	Formalize sediment trap.	11
123	Surface feature	Install sediment trap	11
124	Surface feature	Small amount of room for a small sediment trap	9
125	Cross drainage / infrastructure	Add cross drainage to disconnect concentrated flow paths	9
126	Surface feature; vegetation	Potential to manage driveway drainage in small sediment trap; Keep out sign observed at end of driveway with poorly installed fence in place; appears that ongoing construction is occurring, which should be stabilized so no sediment is leaving property	9
127	Surface feature	Very tight and steep, potential for some check dams or a very small sediment trap.	9
128	Surface feature	Great spot for a retrofit, but tight space dropped off steeply to cut	9
129	Road improvements	Road is sunken; needs infrastructure and additional fill; add sediment trap / check dams	9
130	Surface feature	Small sediment trap possible at inlet and outlet of culvert	9
131	Surface feature	Potential for a small bioretention but generally the site is stable	9
132	Gut Stabilization	Gut channel drains to this location; potential to add gabions to slow flows.	9
133	Surface Feature; Stabilization	Access wasn't possible for entire area, but adding disconnection practices and sediment traps are recommended. Ensure steep slopes are stable.	9
134	Surface feature	Install sediment trap	9
135	Surface feature	Good spot for a sediment trap in the turnaround for the house; private site	7
	*Top 5 site		

3.7.3 Final BMP Ranking

3.7.3.1 Methods & Materials

Once the 5 highest ranking proposed BMPs were determined, a more comprehensive rating methodology was utilized to establish a final ranking of the top 5 BMPs. The ranking is designed to account for the highest priorities that should be pursued for concept and final design implementation described in Table 13 below. The ranking accounts for nine factors, including both qualitative and quantitative metrics.

Quantitative factors were scored on a range of one to five with higher values receiving higher scores. Scores associated with pollutant load reductions and hydrologic properties were based on the water quality modeling and hydrologic and hydraulic modeling described in the following sections.

There are three qualitative categories: feasibility concerns, ancillary benefits, and expert opinion. Each of these categories have a unique scoring and classification system individualized to each qualitative variable being scored. All scores were summed, yielding a final score for each BMP. The BMPs were then ranked from highest score (rank 1) to lowest score (rank 5).

Table 13. Metrics included in the final ranking and their respective score ranges.

Metric	Description	Scoring
Impervious Surfaces	The total area of impervious surface in each identified Drainage Area (m^2)	Given a score 1-5 with higher values receiving higher scores.
Flooding Severity	The percentage of 100-year floodplain zones as defined by FEMA within each drainage area	Given a score 1-5 with higher values receiving higher scores.
Total Nitrogen	Total Nitrogen (TN)	Given a score 1-5 with higher values receiving higher scores.
Total Phosphorus	Total Phosphorous (TP)	Given a score 1-5 with higher values receiving higher scores.
Total Suspended Solids	Total Suspended Solids (TSS)	Given a score 1-5 with higher values receiving higher scores.
Water Quality Volume	The water quality volume the bmp would be sized to manage (ft^3)	Given a score 1-5 with higher values receiving higher scores.
Feasibility Concerns?	What is the magnitude of feasibility concerns in putting a BMP at the location? BMP feasibility concerns may include, but are not limited to ownership, space, high cost, lack of public support, etc.	Ranked from 0-30: 0 – High Concern 15 – Moderate Concern 30 – Minimal Concern
Ancillary Benefits	Any significant benefits of BMP outside of metrics in ranking? Benefits may include aesthetics, educational, healthy vegetation, etc.	Ranked from 1-5: 1 – None 3 – Some 5 - Many
Expert Opinion	How highly regarded is the site by experts in the field?	Ranked from 0-30: 0 – Recommended 15 – Recommended Moderately 30 – Recommended Highly

3.7.3.2 Final Ranking Results

The final ranking of BMP project sites can be found below in Table 14. Scores of the top 5 BMPs ranged from 46 to 83 with Neltjeberg being the highest ranked project. Figure 60 displays the spatial distribution of the Top 5 BMPs and their associated drainage areas. The top two ranked BMPs, Neltjeberg and Hull Bay Beach, were selected for additional design and the development of 30% concept plans. The BMP ranking table can be found in Appendix F.

Table 14. Final ranking table for the Top 5 recommended BMPs in the watershed.

BMP Name	BMP ID	BMP Type	Drainage Area (Acres)	Impervious Area (Acres)	Water Quality Volume (ft^3)	Total Nitrogen Removed (lb./year)	Total Phosphorus Removed (lb./year)	Total Suspended Solids Removed (lb./year)	Total Score	Final Rank
Neltjeberg	2	Road Imrovements (Filters)	28.5	3.38	13,315.20	32.5	7.5	1,500	83	1
Hull Bay Beach	1	Bioretention	2.2	0.37	1,429.50	5.9	0.9	100	73	2
Hull Bay Gut Basin	3	Basin	136.1	26.62	103,048.90	223.5	66.1	11,000	61	3
Dorothea Pond Retrofit	5	Basin	102.5	14.84	57,427.80	124.6	37	6,100	52	4
Dorothea Basin	4	Basin	17.3	2.46	9,383.00	20.4	6.1	1,000	46	5

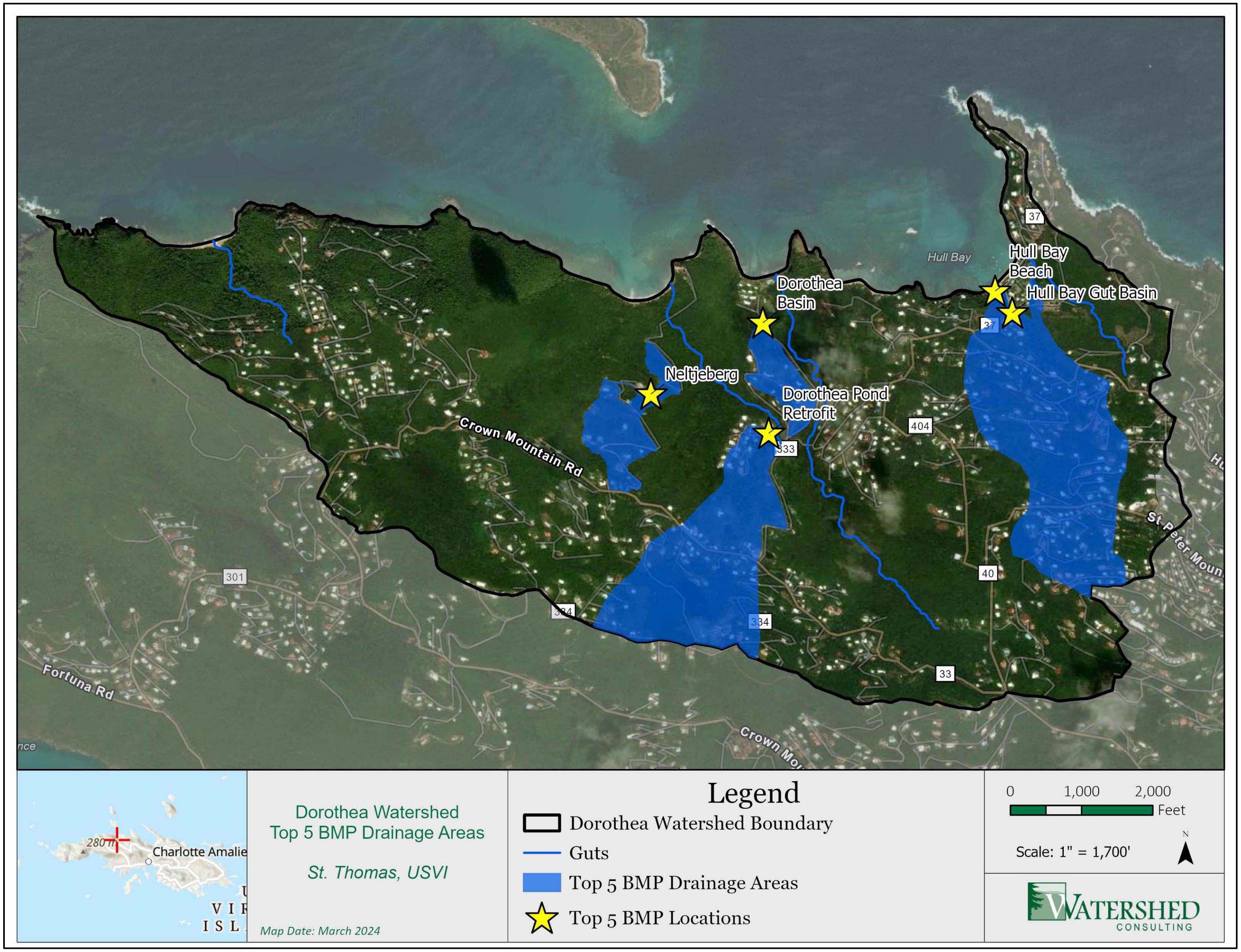


Figure 60. Top 5 high priority BMPs and their associated drainage area.

3.7.4 30% Design Sites

3.7.4.1 Hull Bay Beach

This 30% design includes a new stabilized swale to direct drainage along road and to a new bioretention basin and improved vegetated filters between parking area and beach. The bioretention manages approximately 2.2 previously unmanaged acres. This project is designed to be able to be easily incorporated into the existing design for the site that includes parking lot improvements and the redesign of the boat ramp. It can also be implemented if this proposed design is not constructed. The stormwater improvements are designed to slow and filter stormwater, reduce flooding and ponding on the access road to the beach parking lot, improve water quality, and improve conveyance of stormwater (Figure 61).

The complete 30% design plans and cost estimate can be found in Appendix I. A map showing the design components for these proposed improvements can be found below in Figure 62.

Figure 61. Stormwater improvements along the parking lot edge (above) access drive (below) to Hull Bay Beach are proposed.

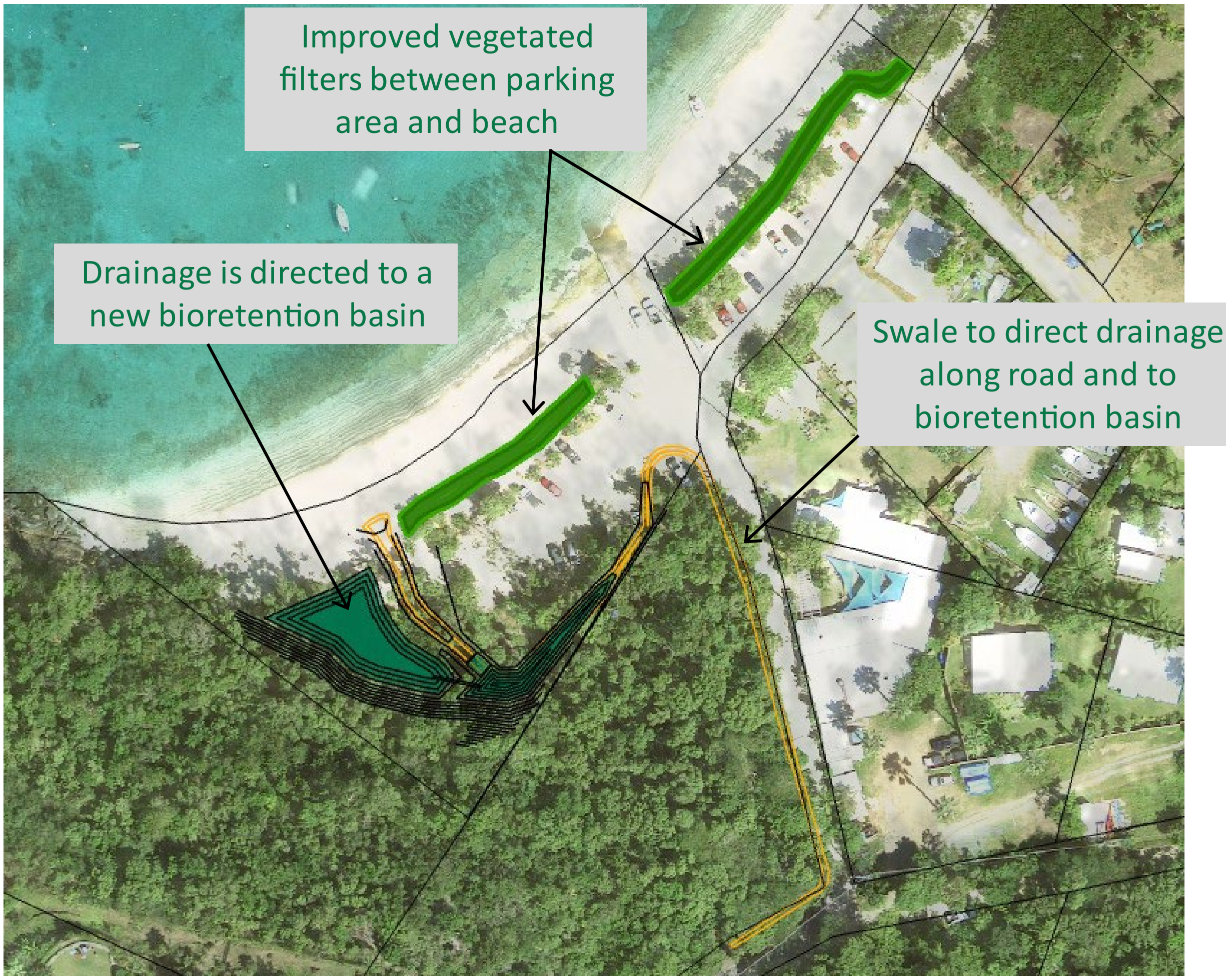
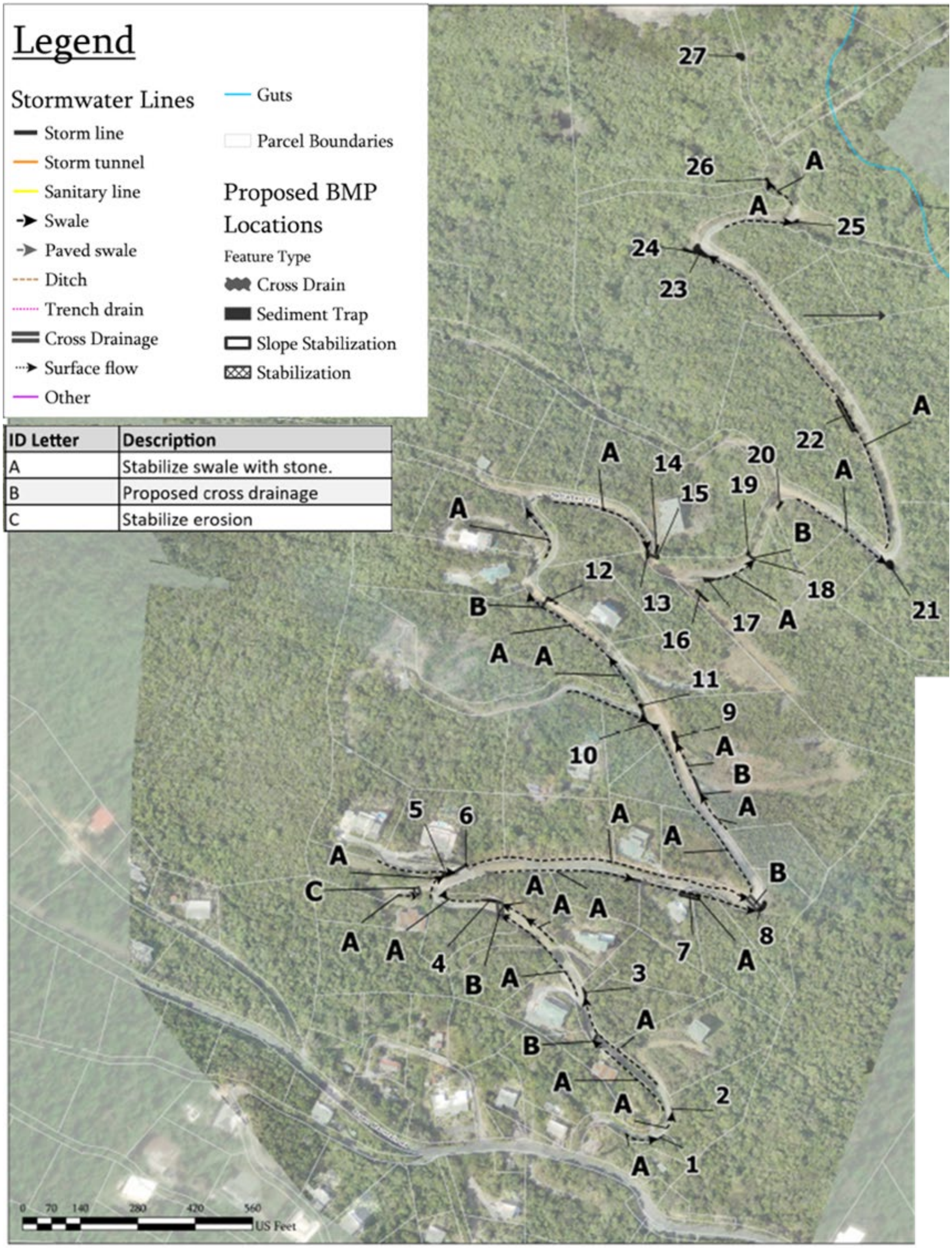


Figure 62. Conceptual design components for Hull Bay Beach.

3.7.4.2 Neltjeberg Stormwater Improvements

This 30% design a series of improvements along the unpaved Neltjeberg Estate road. This road has significant drainage issues and has experienced recent residential development without proper erosion and construction stabilization practices (Figure 63). The proposed improvements include grading, stabilization of stormwater swales, additional cross drainage, and sediment traps. The complete 30% design plans and cost estimate can be found in Appendix I. A map of the drainage area for this proposed system can be found below in Figure 64. The list of proposed practices labeled on the overview map is included in Table 15.

Figure 63. Stormwater runs down the road in many locations (upper) and new construction has not followed proper sediment and erosion control practices (lower).



ID Letter	Description
A	Stabilize swale with stone.
B	Proposed cross drainage
C	Stabilize erosion

Figure 64. Improvements are proposed along the unpaved road improve water quality and stormwater conveyance.

Table 15 . Proposed features for the Neltjeberg stormwater improvements. ID numbers correspond to the overview map of the proposed practices above.

Feature Type	Description	ID Number
Sediment Trap	Sediment trap along outside edge of turn just uphill from power pole.	1
Sediment Trap	Small sediment trap along outside edge of turn.	2
Sediment Trap	New sediment trap to overflow to E in level spreader.	3
Sediment Trap	Proposed sediment trap with level spreader overflow to NE.	4
Sediment Trap	New sediment trap for swales from west and south to discharge to existing culvert under driveways; stabilize outflow from culvert to north.	5
Stabilization	Stabilize culvert outlet.	6
Slope Stabilization	Stabilize eroding slope.	7
Sediment Trap	Install new sediment trap. Level spreader overflow to SE.	8
Sediment Trap	Proposed sediment trap with level spreader overflow to east	9
Sediment Trap	Sediment trap prior to culvert; direct both swales to trap. Culvert erosion noted.	10
Stabilization	Stabilize culvert outlet with stone	11
Sediment Trap	Sediment trap, some erosion; level spreader overflow to north.	12
Sediment Trap	Install sediment trap	13
Slope Stabilization	Stabilize slope along driveway / road.	14
Stabilization	Stabilize culvert outlet	15
Stabilization	Stabilize new construction driveway	16
Sediment Trap	Construct sediment trap at base of new driveway	17
Cross Drain	Stabilize prior to new cross drainage	18
Stabilization	Stabilize culvert / surface crossing outlet.	19
Slope Stabilization	Stabilize eroding slope	20
Sediment Trap	Sediment trap, stone stabilization; active erosion present; overflow via level spreader	21
Slope Stabilization	Backslope needs stabilization along this section	22
Sediment Trap	Proposed sediment trap; overflow via level spreader to gut.	23
Stabilization	Stabilize drainage into gut channel, which is eroded.	24
Sediment Trap	Proposed sediment trap; overflow via sediment trap.	25
Sediment Trap	New sediment trap with overflow via level spreader.	26
Sediment Trap	Sediment trap for parking area for beach; grading improvements needed to direct water to basin.	27

3.8 Watershed Modeling

3.8.1 Modeling Overview

Water quality and hydrologic and hydraulic (H&H) modeling were completed to meet several objectives. Limited technical information regarding modeling methodologies is included in this section to improve readability and allow for more discussion of modeling results. Complete modeling methodology and complete modeling results are included as Appendix G and H.

Watershed scale and individual BMP scale modeling was completed to assess four primary scenarios:

1. <u>Existing watershed conditions</u>: Assess watershed-scale water quality and hydrology taking the existing BMP into account.
2. <u>Existing watershed conditions with future development</u>: Assess watershed-scale water quality and hydrology taking existing BMPs into account through future predicted land cover scenarios in the years 2030, 2050, 2080, and 2100.
3. <u>Proposed watershed conditions:</u> Assess watershed-scale water quality and hydrology taking the existing BMP into account and the proposed Top 5 ranked BMPs.
4. <u>Proposed watershed conditions with future development:</u> Assess watershed-scale water quality and hydrology taking the existing BMP into account and the proposed Top 5 ranked BMPs through future predicted land cover scenarios (2030, 2050, 2080, and 2100).

Water quality modeling was completed using the Watershed Treatment Model (WTM), a spreadsheet-based tool developed by the Center for Watershed Protection that calculates total nitrogen (TN), total phosphorus (TP), and total suspended solid (TSS) loads based on several drainage area sources including land use, soil type, sewage use and disposal, and stream channel erosion and nutrient concentration.

Hydrologic and hydraulic (H&H) modeling was completed using HydroCAD, a software most commonly used to model stormwater runoff and design stormwater management systems. Models were developed in HydroCAD to estimate peak flow rates and model volumes, as well as to assess the peak flow rate reduction benefits of existing and proposed BMPs.

Peak flow is measured in cubic feet per second (cfs) and is indicative of how quickly water flows through a watershed. High peak flows are problematic because they exacerbate erosion and flooding as stormwater flows in fast-moving, concentrated channels down a slope. Generally, watersheds or drainage areas with a high peak flow are likely to have had land cover and/or land use changes occur, altering the natural state. Land cover is a key determinant of peak flow, although underlying soil conditions, topography, and drainage area also can play significant roles. The implementation of stormwater BMPs can reduce and delay the timing of the peak flow, which more closely mimics an undeveloped watershed (Figure 65).

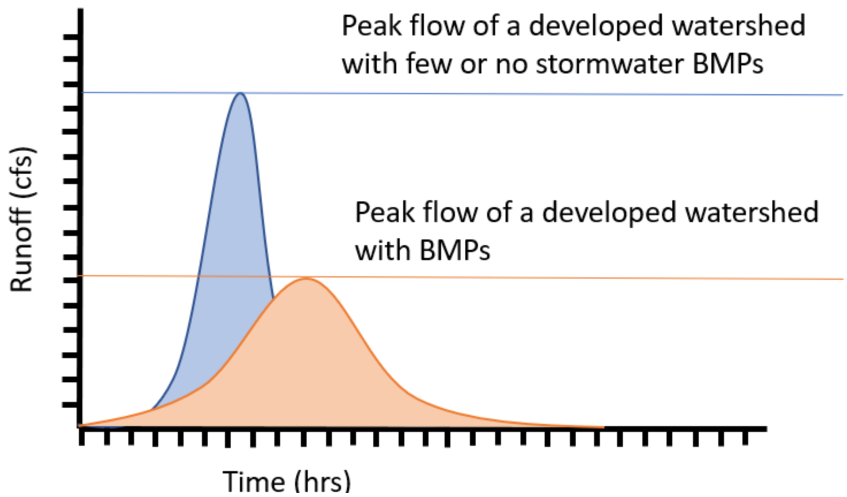


Figure 65. Illustrative hydrographs demonstrating the peak flow reduction value of implementing BMPs.

Data and information inputs to the H&H models were:

- Drainage areas for existing and proposed best management practices (source: delineated in GIS utilizing topography, imagery, mapped stormwater infrastructure, and limited field verification),
- Time of concentration, defined as the time required for a drop of water to travel from the most hydrologically remote place in a drainage area to the point of collection (source: digitized in GIS as the longest flow length),
- Hydrologic soil group (HSG) (source: National Resource Conservation Service (NRCS) soil data),
- Existing and future land use (source: developed for this project as described in Sections 3.3.2 and 3.3.5), and
- Rainfall depth and distribution (source: NOAA Atlas 14 Point Precipitation Frequency Estimates, and a Type II storm distribution is used in accordance with the Soil Conservation Service (SCS) 24-hour Rainfall Distribution).

Additional details about HydroCAD modeling methodologies can be found in Appendix G.

3.8.2 Existing Conditions

3.8.2.1 Hydrologic Modeling Results of Existing Conditions

Existing conditions were imported into HydroCAD including the one existing BMP identified during this project. The SCS TR-20 runoff method (most commonly used in this type of HydroCAD assessment) was used to generate a total runoff hydrograph for the watershed and the BMP drainage area. Runoff volume was calculated separately for each combination of land cover and soil type, known as a curve number (CN). The runoff was then summed to calculate the total runoff from each drainage area node. This approach preserves the runoff volume from each subarea within the drainage area node and thus is called the flow-weighted or "Weighted-Q" method.

To determine the hydrologic impact of the existing BMP in the watershed, the model was run with and without the existing BMPs. During the 1-year storm event, peak flow was 363.32 cfs in both scenarios. This is likely due to the large watershed size and relatively small basin size.

3.8.2.2 Water Quality Modeling Results of Existing Conditions

Existing pollutant loads, summarized by major land use categories, are presented in Table 16. In this watershed, urban land has the highest estimated loads for TN and TP. TSS loads were predominantly caused by channel erosion, which was estimated from the length of guts in the watershed. The estimated contribution from all sewage sources—sanitary sewer overflows (SSOs), illicit discharges, and septic systems—represented the majority of the fecal coliform loading. Note: these results are based on estimates based on limited information for wastewater discharges.

Table 16. Existing pollutant loads to surface waters in the watershed.

Land Use	TN (lbs./year)	TP (lbs./year)	TSS (lbs./year)	Fecal Coliform (billion/year)
Urban Land	5,322	845	123,059	228,923
Channel Erosion	1,266	506	1,012,440	0
Forest	2,323	186	92,932	11,152
Onsite Sewage	1,729	288	11,527	24,525
SSOs and Illicit Discharges	179	30	1,197	135,814
Total	**8,496**	**1,669**	**1,148,222**	**389,263**

3.8.2.3 Hydrologic Modeling - Existing Conditions with Future Development

Over time, as projected impervious cover increases and green space decreases, the watershed-scale peak flow also increases. This trend can be observed in Figure 66 below.

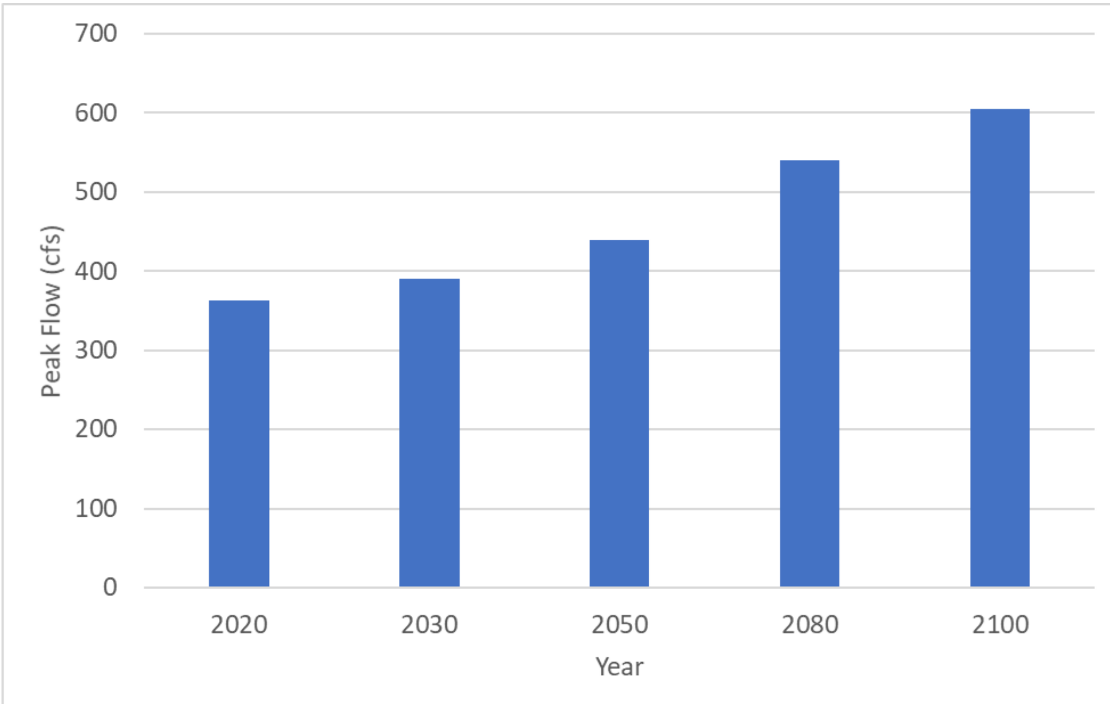


Figure 66. Relationship between watershed scale peak flow (blue) and the predicted land cover change over time.

3.8.2.4 Water Quality Modeling Results of Existing Conditions with Future Development

The water quality modeling results for the projected future land cover mirror the results observed in the hydrologic modeling (Figure 66). Over time, as impervious cover increases and green space decreases, each of the four pollutants of concern that were modeled increase (Figure 67).

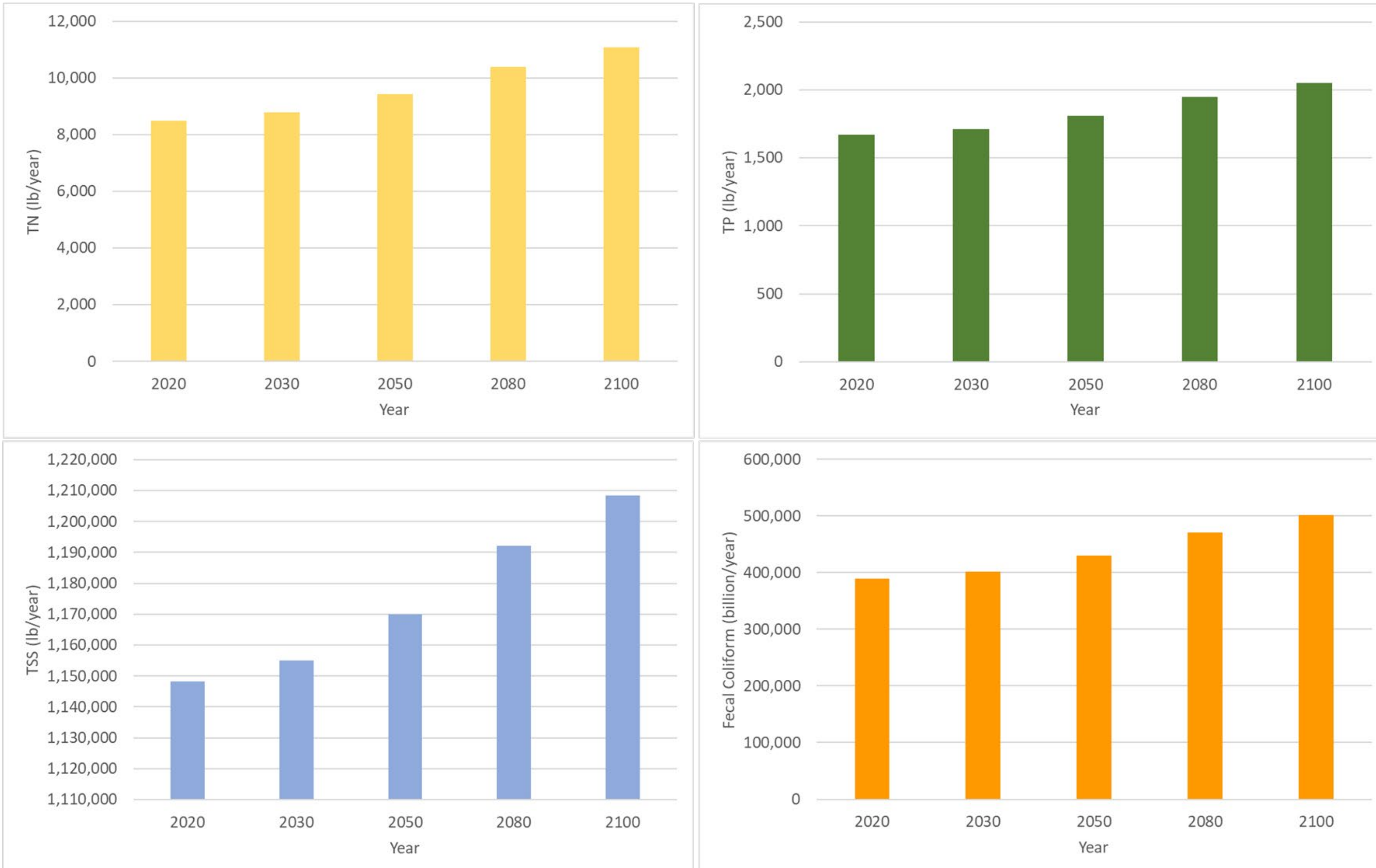


Figure 67. Relationship between watershed-scale pollutant loading for TN (yellow), TSS (blue), TP (green), and Fecal Coliform (orange) over time.

3.8.3 Top 5 Proposed BMPs

The top 5 proposed BMPs identified in Section 3.7.3 were modeled to ensure that they are adequately sized and to assess their impact on watershed-scale peak flow and water quality. Drainage areas for each of these 5 BMPs were delineated and BMPs were designed to maximize peak discharge reduction given available space, improve water quality, reduce downstream flooding impacts, and build resiliency to flooding. A summary of the model results of proposed BMPs can be found in Table 17. The location of the top 5 BMPs can be found in Figure 60.

Table 17. Modeled Top 5 proposed BMPs.

BMP Name	BMP ID	BMP Type	Drainage Area (Acres)	Impervious Area (Acres)	Water Quality Volume (ft^3)	Total Nitrogen Removed (lb./year)	Total Phosphorus Removed (lb./year)	Total Suspended Solids Removed (lb./year)
Neltjeberg	2	Road Imrovements (Filters)	28.5	3.38	13,315.20	32.5	7.5	1,500
Hull Bay Beach	1	Bioretention	2.2	0.37	1,429.50	5.9	0.9	100
Hull Bay Gut Basin	3	Basin	136.1	26.62	103,048.90	223.5	66.1	11,000
Dorothea Pond Retrofit	5	Basin	102.5	14.84	57,427.80	124.6	37	6,100
Dorothea Basin	4	Basin	17.3	2.46	9,383.00	20.4	6.1	1,000

3.8.3.1 Hydrologic Modeling Results of Proposed BMPs

Using current land-use conditions, it was determined that the 5 proposed BMPs reduced the modeled peak flow by 4.1% at watershed outlet during the 1-year storm event, from 363 cfs to 348 cfs (Figure 68). This is a substantial reduction in peak flow and would likely lead to significant reductions in erosion, sedimentation, and flooding.

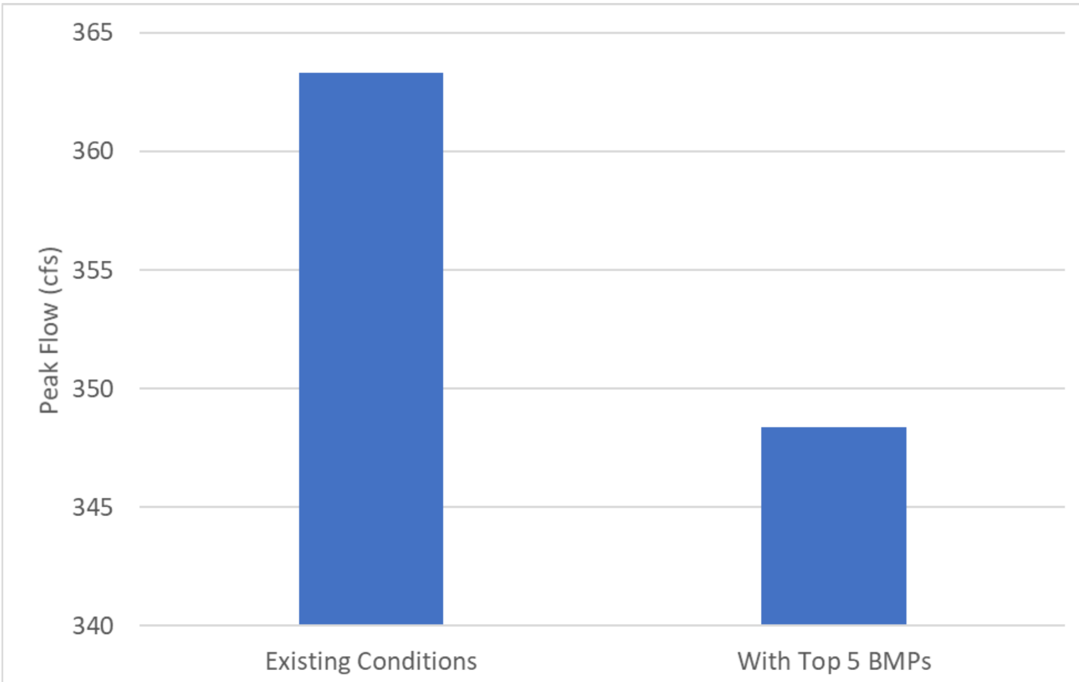


Figure 68. Peak flow was reduced at the watershed outlet from 363 cfs with existing BMPs to 348 cfs with addition of the Top 5 proposed BMPs.

3.8.3.2 Water Quality Modeling Results of Proposed BMPs

The pollutant load reductions from the Top 5 BMPs proposed in the watershed can be found in Table 18. The proposed practices are effective at reducing pollutants associated with sediment and erosion (TN, TP, and TSS), however are not effective at treating pollution associated with wastewater (Fecal Coliform). Collectively, the 5 proposed BMPs are estimated to remove 407 lbs. of TN, 118 lbs. of TP, and 19,700 lbs. of TSS annually. The model showed no reductions in Fecal Coliform loading. It is important to note that of the pollutants in the WTM, fecal coliform is the most difficult to characterize. Research has shown that stormwater treatment practices such as those proposed can be effective at treating fecal coliform from surface water, so it is feasible that this potential reduction was not captured in the model (Mallin, 2016).

Table 18. Estimated water quality benefits of each proposed retrofit.

Proposed BMP Practice	TN (lbs./year)	TP (lbs./year)	TSS (lbs./year)
Neltjeberg	32.5	7.5	1,500
Hull Bay Beach	5.9	0.9	100
Hull Bay Gut Basin	223.5	66.1	11,000
Dorothea Pond Retrofit	124.6	37	6,100
Dorothea Basin	20.4	6.1	1,000
Total	***406.9***	***117.6***	***19,700***

As noted above, the WTM includes several different sources of pollutant loading for the watershed as a whole, including:

- Surface Runoff (Urban, Rural, and Forest),
- Onsite Sewage,
- SSOs and Illicit Discharges, and
- Channel Erosion,

The proposed BMPs account for reductions to the Surface Runoff (Urban, Rural, and Forest) category exclusively. The 5 BMPs reduce Surface Runoff associated TN loads by 4.8%, TP loads by 7%, and TSS loads by 1.7% annually. The watershed-scale pollutant loads including all modeled sources are summarized in Table 19 below.

Table 19. Estimated pollutant loads in the watershed for the existing conditions and with reductions associated with the Top 5 proposed BMPs.

Time Frame	TN (lbs./year)	TP (lbs./year)	TSS (lbs./year)	Fecal Coliform (billion/year)
Existing Conditions	8,496	1,669	1,148,222	389,263
Existing Conditions with Top 5 Proposed BMPs	8,089	1,552	1,128,522	389,263
Difference Between Existing and Proposed Conditions	*406.9*	*117.6*	*19,700*	0

3.8.4 Proposed Conditions with Future Development

The hydrologic and water quality benefits of the proposed Top 5 BMPs were then assessed in comparison to the future land cover predictions for the watershed.

3.8.4.1 Hydrologic Modeling Results of Proposed Conditions with Future Development

With the combination of proposed BMPs and forecasted new development in the watershed, peak flow is anticipated to increase between 2030 and 2100 (Figure 69). This highlights the importance of BMP implementation in the watershed, with present conditions and in the future as new development occurs.

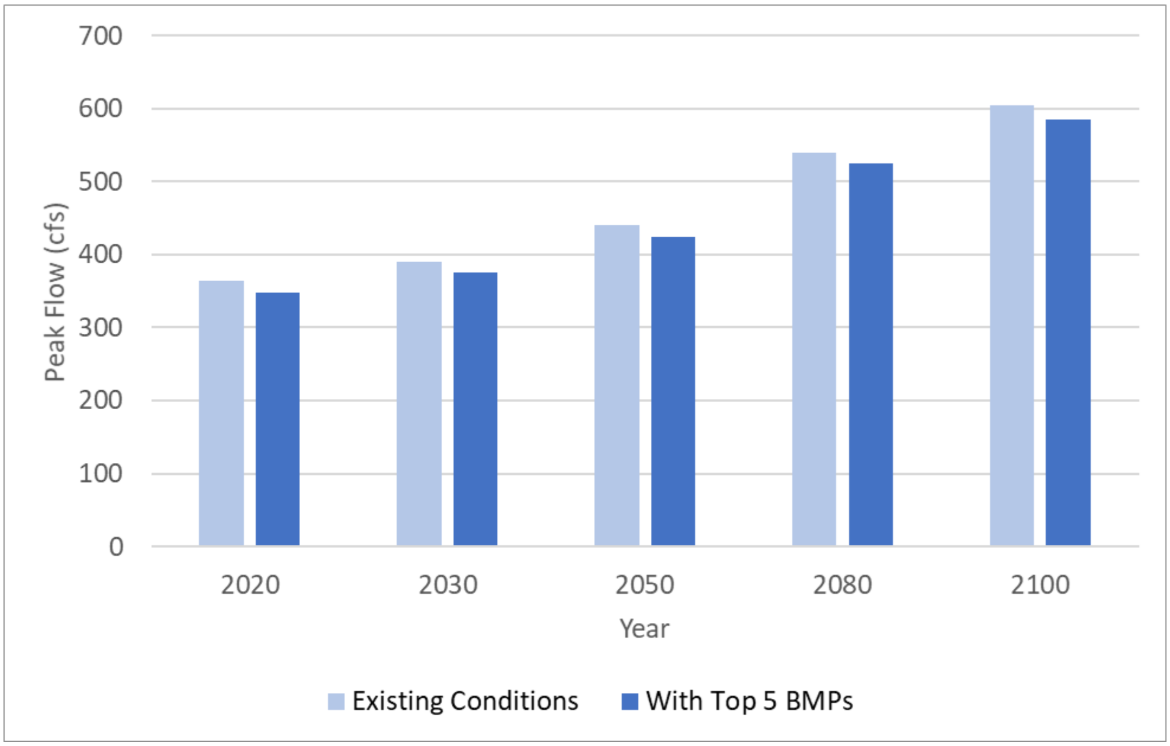


Figure 69. Relationship between watershed peak flow for the existing conditions (light blue) and proposed conditions (dark blue), which includes the implementation of the Top 5 BMPs over time.

3.8.4.2 Water Quality Modeling Results of Proposed Conditions with Future Development

The predicted future development in the watershed results in increased pollutant loads between 2030 and 2100 (Figure 70). The increase in development is well correlated to increased pollutant loads. The pollutant load reductions associated with implementation of the Top 5 BMPs reduces these loads. However, over time and with increased development, the benefits of these BMPs are diminished. This highlights the need for continued efforts to mitigate the impacts of development so that watershed conditions improve over time.

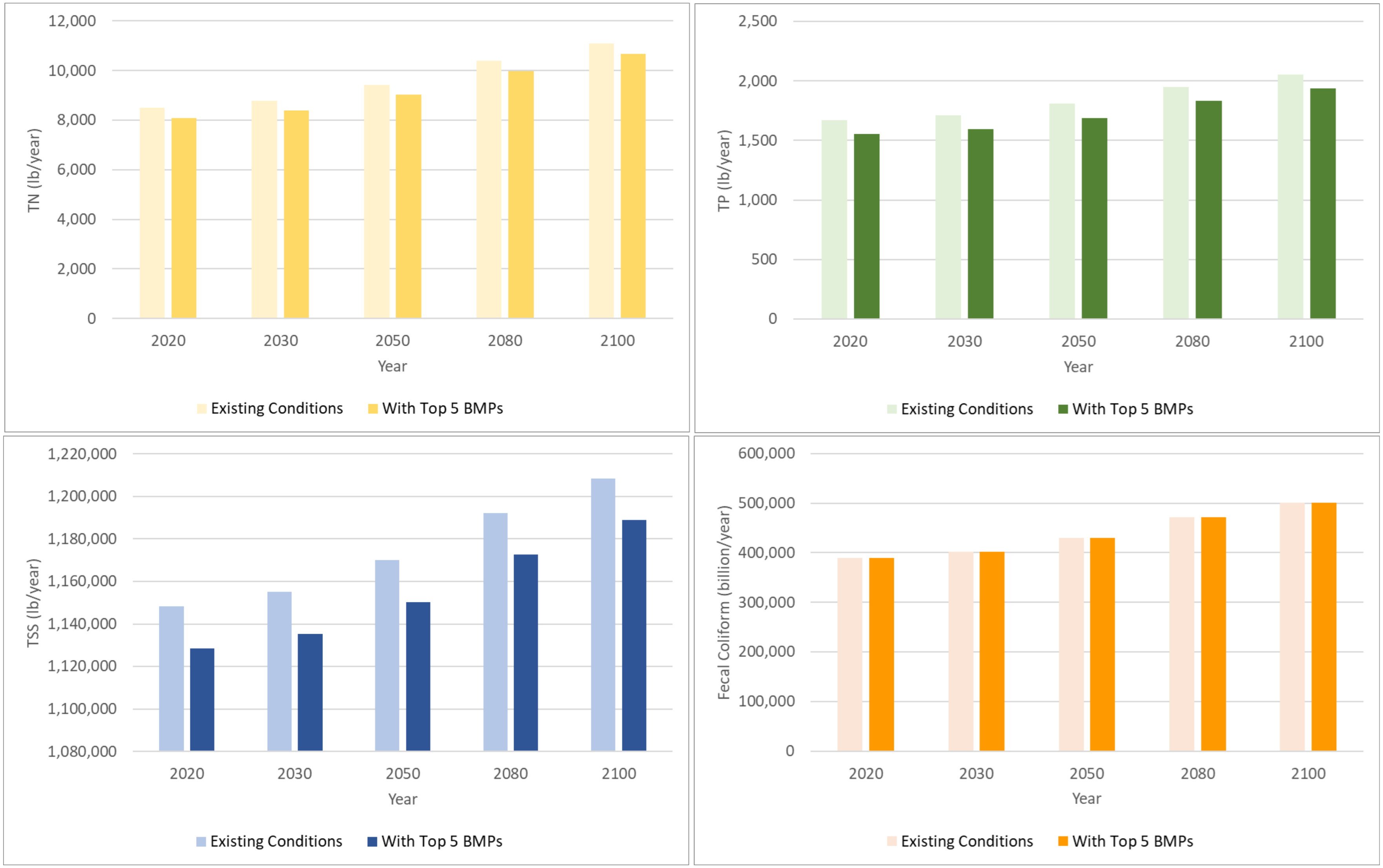
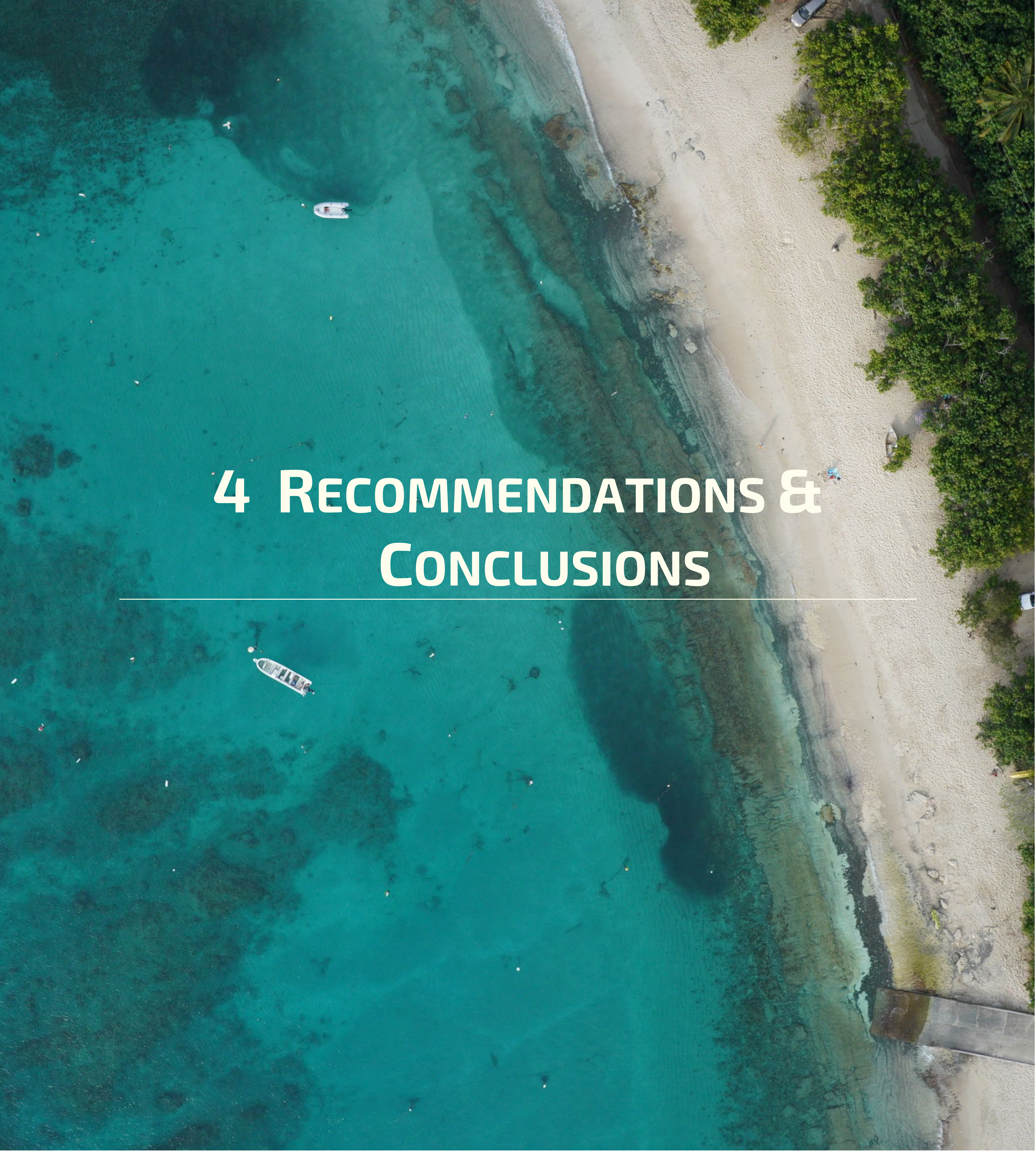


Figure 70. Relationship over time between watershed scale pollutant loading for the existing conditions (lighter colors) and proposed conditions (darker colors), which includes the implementation of the Top 5 BMPs. Loading is shown for TN (yellow), TSS (blue), TP (green), and Fecal Coliform (orange).

4 RECOMMENDATIONS & CONCLUSIONS



4.1 PROPOSED MANAGEMENT MEASURES

A variety of proposed management measures and specific actions were identified during the development of this Watershed Management Plan. Some of the measures are proposed at an island scale while others apply to the specific watershed. Recommendations were derived from the watershed specific modeling, field assessments, water quality monitoring, community outreach, review of existing research, and discussions with DPNR, DPW, and WMA. Additionally, the “Eight Tools of Watershed Protection” was used by the project team to evaluate the current state of watershed management in the USVI. This audit tool, developed by CWP, identified programmatic strengths and gaps in watershed protection strategies and helped to inform the following watershed planning recommendations.

The recommendations detailed below are categorized as recommendations for:

1. Stormwater Management and Non-Stormwater Discharges
2. Watershed Planning
3. Land Use Planning and Resource Protection
4. Site Design Guidelines
5. Solid Waste Management
6. Future Research
7. Watershed Stewardship

4.1.1 Stormwater Management and Non-Stormwater Discharges

4.1.1.1 Stormwater Management Standards and Regulations

USVI is not currently regulated by the US EPA under the NPDES Phase II permit for municipal separate storm and sewer systems (MS4 program); however, EPA authorized the USVI TPDES program in 1976. **Organization of the TPDES program around the basic NPDES MS4 six minimum measures for stormwater management** is recommended to incorporate basic elements of a stormwater management program that are missing in USVI, including post-construction, pollution prevention and good housekeeping, and illicit discharge detection and elimination (IDDE).

Post-construction stormwater standards, including inspection and maintenance; are critical in preventing future issues. It is recommended that the US Virgin Islands Environmental Protection Handbook 2022 Update – A Guide to Stormwater Management Standards and Control Measures is utilized and incorporated into specific design criteria, maintenance requirements, and typical plan details necessary for best management practices to meet stormwater standards (USVI, 2020). The updated manual should **incorporate green infrastructure (GI) techniques** to reduce stormwater runoff to the maximum extent practicable such that there is little to no discharge from the 1-year, 24-hour storm. It is recommended that this manual be adopted and promoted.

It is also recommended that USVI **develop a post-construction stormwater management program with inspection and maintenance checklists and adopt a post-construction stormwater management ordinance for new and redevelopment**. Specific references to help develop these standards include:

- Managing Stormwater in Your Community: A Guide for Building an Effective Post-Construction Program and the Appendices with Model Post Construction Ordinance
- Maryland Model Stormwater Management Ordinance

4.1.1.2 Erosion & Sediment Control (ESC)

In the USVI, erosion and sediment control (ESC) is required for all sites (12 V.I.C. § 533, Earth Change Plans) "[b]efore any real property is cleared, graded, filled or otherwise disturbed for any purpose or use." An earth change permit is provided upon approval of an earth change plan detailing the erosion and sediment control for a development site. A building permit or other permits will not be received until an earth change permit is obtained. It is recommended that requirements be amended to **require limits of disturbance to be shown on construction plans and physically marked at the site**. Limits of disturbance for existing trees should include the critical root zone also known as the drip line.

Construction sites are inspected for compliance with erosion and sediment control requirements by third party inspectors on a weekly basis. The inspectors have national certification – Stormwater Pollution Prevent Plan (SWPPP) Inspector or similar or Professional Engineer (P.E.) or similar. There are erosion and sediment control enforcement mechanisms in place (e.g., fines, stop work orders, etc.). However, several construction sites were observed during field assessments where erosion control measures such as silt fences were not installed or not properly installed. This is an issue of concern as these unstable construction areas, even if temporary, can contribute significant sediment loads to surface waters if not properly managed. It should be determined whether these noncompliant sites were either:

- Not inspected,
- Were inspected but no compliance issues were recorded indicating a misunderstanding of ESC standards by inspectors, or
- ESC noncompliance was noted by inspectors and was not fixed on site.
    - If following initial observations of noncompliance, the site was still not meeting ESC standards this could indicate that either the site was not reinspected to ensure compliance or enforcement mechanisms were levied but did not result in ESC compliance.

It is recommended that a **review of noncompliant construction sites be completed** to determine the reasons for ESC violations and determine the appropriate steps that need to be taken to address these violations. This could include formal training for inspectors, training for contractors, increased enforcement of fines or stop work orders, increased frequency of inspection, or other measures as determined by this assessment.

The 2022 Virgin Islands Environmental Protection Handbook was recently updated, and it should be consulted to illustrate proper stormwater practice design, installation, and maintenance procedures, as well as construction phase stormwater practices that reduce runoff volumes and prevent or decrease the discharge of pollutants in stormwater.

4.1.1.3 Demonstration Projects

The **implementation of GI demonstration projects on public properties** is also recommended. Demonstration of GI (green infrastructure) practices should be promoted during restoration activities that address drainage improvements to existing conditions, including public projects such as road repairs, facility renovations, and other capital improvements. Parks, schools, and other public spaces should also be inventoried and opportunities for GI identified.

One opportunity is to publicly showcase GI stormwater practices installed at the 64 West Center located on UVI's St. Croix campus. The stormwater practices at this facility include permeable pavements, vegetated bio-swales, and underground detention storage (Rain TanksTM) for landscape irrigation and to supplement water supplies for water closets, urinals, and cooling towers.

In addition to the water quality benefits of these practices, **educational materials and signs should be distributed and installed** in conjunction with these demonstration projects, particularly in areas with many visitors such as the Hull Bay Beach. Increasing the public's understanding of the importance of managing land-based sources of pollution can encourage support of additional and larger stormwater BMPs or more distributed residential practices, some of which could be located on private property with participating private landowners. It can also encourage the adoption and construction of smaller scale residential stormwater BMPs.

4.1.1.4 Implementation of Identified BMPs

One of the outcomes of this plan was the identification of stormwater and flooding BMPs including 5 high priority sites within the watershed. From the 5 high priority sites, 30% concept design plans were developed for two priority ranked sites. These concept design plans can be found in Appendix I.

To address the water quality and flooding problems derived from stormwater, the **final design and implementation of the two 30% conceptual designs should be a high priority**. Also of importance, **further design development and implementation should be pursued for the remaining three high priority potential BMP sites per watershed**. A map and tabulated summary of the 5 high priority sites can be found in the Appendix F and earlier sections of this report. The full list of identified BMPs should also be further investigated in the long term, beginning with the higher ranked or easier to implement ("low hanging fruit") practices.

4.1.1.5 Illicit Discharge & Wastewater Management

The USVI does not currently have an Illicit Discharge Detection and Elimination (IDDE) program. Dry-weather flows discharging from storm drainage systems can contribute significant pollutant loadings to receiving waters. Illicit dry weather flows originate from many sources. The most important sources typically include sanitary wastewater or industrial and commercial pollutant entries, failing septic tank systems, and vehicle maintenance activities. It is recommended that the **USVI adopt an IDDE ordinance and develop an effective IDDE program**. Technical guidance to assist in the creation of such a program can be found in Illicit Discharge Detection and Elimination: A Guidance Manual for Program Development and Technical Assessments (Brown et al., 2004).

4.1.2 Watershed Planning

Watershed planning involves critically analyzing the degree and location of future development and associated impervious cover to best account for changes in land use and its effect on water resources. Consequently, watershed planning ranks as perhaps the single most important watershed protection tool. One of the goals of watershed planning is to **shift development toward areas that can better support a particular type of land use and/or density**. The goal of watershed planning is to apply land use planning techniques to **redirect development, preserve sensitive areas, and maintain or reduce the impervious cover** within a given watershed.

4.1.2.1 Comprehensive Water and Land Use Plan

A primary recommendation to is to adopt an updated comprehensive water and land use plan. A proposed comprehensive planning effort for land and water resources was started in 2004 but never adopted. A new Comprehensive Land and Water Use Plan is currently in development.

Associated with the plan adoption are two additional recommendations. First, **ensure that the proposed Comprehensive Land and Water Use Plan accounts for impacts of future land use on water resources,** including identifying land use planning techniques that promote land development patterns **that reduce overall impervious cover**, and limit the scale of development and land disturbance in the most sensitive or high-quality watersheds. Second, **ensure that current zoning is evaluated and revised to be consistent with overall plan goals**.

4.1.2.2 Planning Tools and Conservation Easements

Another recommendation is to **assess a larger suite of land use planning tools** to see if additional techniques may be appropriate**.** Currently DPNR does permit conservation easements and land acquisition programs as techniques to manage land use and impervious cover, but does not actively facilitate, support, or encourage them. We recommend that DPNR consider **promoting the use of easements** by gathering informational materials together for applicants and providing these materials and training to DPNR review staff on how to inform and facilitate this existing policy opportunity. In addition, there are other tools such as promoting infill/redevelopment, transfer of development rights (TDRs), and overlay zoning that may also provide additional protections.

4.1.2.3 Zoning and Subdivision Code Revisions

Another recommendation is to **revise the Zoning and Subdivision Code**, which currently has an exemption for subdivisions creating less than four lots so that they do not come to DPNR for review. There is also a policy of "family subdivisions" not being required to pave their roads. This means that development can occur with little or no erosion and sediment controls in place, and that the road system can act as both a source of sediment and a conduit for stormwater runoff. A thorough review of the Code may reveal other specific code changes that could ensure that most developments are required to meet minimum standards.

4.1.2.4 Coastal Zone Tier Revisions

The management of major developments in the coastal zone uses a tiered system as was discussed in previously. It has been suggested that a **shift from the two-tier system to a watershed approach** will make plan reviews more thorough and provide more protections to upland sites currently considered Tier 2. While removing the boundary between Tiers 1 and 2 would provide a more comprehensive review process for permit applications for major developments, it would also have a major impact on the review process and require additional permit staff.

Since this change would require revamping the current process and coordination through several departments, a stepped process may work best. Potential steps in the process include:

1. Adopt a comprehensive plan to address water resources.
2. Revise the current Earth Change law to provide additional protections and stringent application conditions to areas near guts and on steep slopes in the Tier 2 zone, similar to the more stringent Tier 1.
3. Increase plan review fees and fines to fund additional staffing and required training.
4. Identify some sample development projects in the Tier 2 zone that can be test subjects for a more extensive review similar to Tier 1 projects. These pilot projects could be selected by some combination of project size and distance from or impact on significant environmental resources.
5. Redefine coastal setback limits in the codes and comprehensive plan.

4.1.3 Land Use Planning and Resource Protection

The green spaces, guts, wetlands, and coastal buffers of St. Thomas provide critical hydrologic functions, offer unique habitats, and support human and environmental health. **Conserving and restoring** these spaces are of the utmost importance when it comes to maintaining and improving the health of the watersheds of St. Thomas.

Land conservation as a watershed protection tool involves **making careful choices about the mix of natural habitats and cultural areas that must be conserved** to sustain the integrity of its aquatic and terrestrial ecosystems while maintaining desired human uses. The land conservation areas to protect can include:

- **Critical habitats** for plant and animal communities including mangroves,
- **Aquatic corridors** along streams and shorelines,
- **Hydrologic reserve areas** that sustain a stream's hydrologic regime,
- **Water hazards** that pose a risk of potential pollution spills,
- **Cultural and historical areas** that are important to a sense of place.

The USVI currently uses multiple land conservation tools to protect valued resources. These include participating in the National Flood Insurance Program and mapping their floodplains, as well as having code language (29 V.I.C. § 280-288 and 29 V.I.C. § 950 – 964) to preserve cultural or historical areas.

4.1.3.1 Agriculture Preservation

Future food security needs should be protected by **more actively encouraging agriculture preservation**. The Virginia Office of Farmland Preservation has developed tools that provide examples of methods for agricultural preservation, including agricultural and forest districts that protect working farm and forestland, and land use assessment based on current use value of a property and not at its fair market value when determining local property taxes.

4.1.3.2 Develop a Steep Slope Ordinance

Steep slopes are not currently protected in the USVI, but when these areas are disturbed and developed, they can become major sources of land-based sources of pollution. These areas are already of interest for DPNR. We recommend the **adoption of steep slope legislation to protect hilltops and prevent erosion**, potentially with varying levels of requirements based on slope percentage. Some communities regulate slopes starting at 15%, which ties in with U.S. Department of Agriculture soil survey slope classifications. Others start at 25%, another soil survey threshold and a clear benchmark for land-use limitations. While the development of this ordinance would require a thorough literature review to determine appropriate standards, specific guidance, and examples to help the USVI with development of steep slope regulations include:

- WeConservePA Steep Slope Guide
- Example steep slope regulations in Appendix B from Town of Boone, North Carolina Unified Development Ordinance that separates slopes based on conditions
- Peoria, Arizona steep slopes zoning overlay district
- Verona, NY Steep Slope Ordinance
- Vancouver, Canada Slope Hazard Development Permit Area

4.1.3.3 Forest Conservation and Tree Removal Fee

Trees are important for soil stabilization, reducing stormwater runoff, reducing climate change, shade, aesthetics, and wildlife habitat. Forest conservation is encouraged (12 V.I.C. § 133) in the Community and Heritage Tree Law of the Virgin Islands. The Virgin Islands Tree Board is charged with a mission to protect, manage, remove, and establish trees on public property within the Virgin Islands. It was noted that several parcels of land that were purchased through federal funds from the Forestry Service program have strict mandates and guidelines for conservation:

- No heritage tree may be pruned, removed, or damaged in any way unless an Urban Forester, a designated arborist, or the Territorial Forester determines that there is an overriding need for public improvements, or a severe hardship exists for reasonable use of a site.
- Any person or entity that violates any provision of this chapter by causing, contributing to, or permitting the injury of, removal, or destruction of a public tree, shrub or a heritage tree is subject to a civil penalty of not less than $100, but not more than $500 for each violation.

To discourage removal of trees, **a fee for proposed tree removal could be implemented** during the application process for a tree removal permit. This fee could act as a source of funding for the permit review office for additional staffing or as funding for heritage tree conservation. The USVI should also consider **adopting a tree ordinance and permit requirements for private lands**. This ordinance can include measures such as requiring a percentage of a site to be maintained as trees and directing that those trees be located near guts to provide channel protection. This would also help with protecting development from happening near or on top of guts. Example ordinances include:

- City of Charlotte, North Carolina tree ordinance
- Key West, Florida Tree Protection Ordinance
- Gulf Breeze, Florida Tree Protection Ordinance

4.1.3.4 Tree Canopy Goal

The VI Tree Board should also consider **developing a tree canopy goal** using the land cover dataset developed under this WMP and evaluating the current tree canopy extent. The future land cover dataset could be used to determine the estimated tree canopy loss based on previous development patterns. Opportunities can then be analyzed to reduce or limit future tree canopy loss and increase the current canopy level (i.e., plantings in gut buffers, public parks, etc.) to help achieve the tree canopy goal. Tree canopy is also an important part of addressing climate change.

4.1.3.5 Undeveloped Land Protection in Headwaters

It is highly recommended that the USVI implement a program to **preserve the undeveloped land within the gut headwaters and riparian zones**. Using the land cover dataset developed for this WMP, maps displaying developed and undeveloped land cover were developed to guide these protection efforts (Figure 71). Protection measures could include conservation easements, purchase of undeveloped areas along gut headwaters, or zoning restrictions.

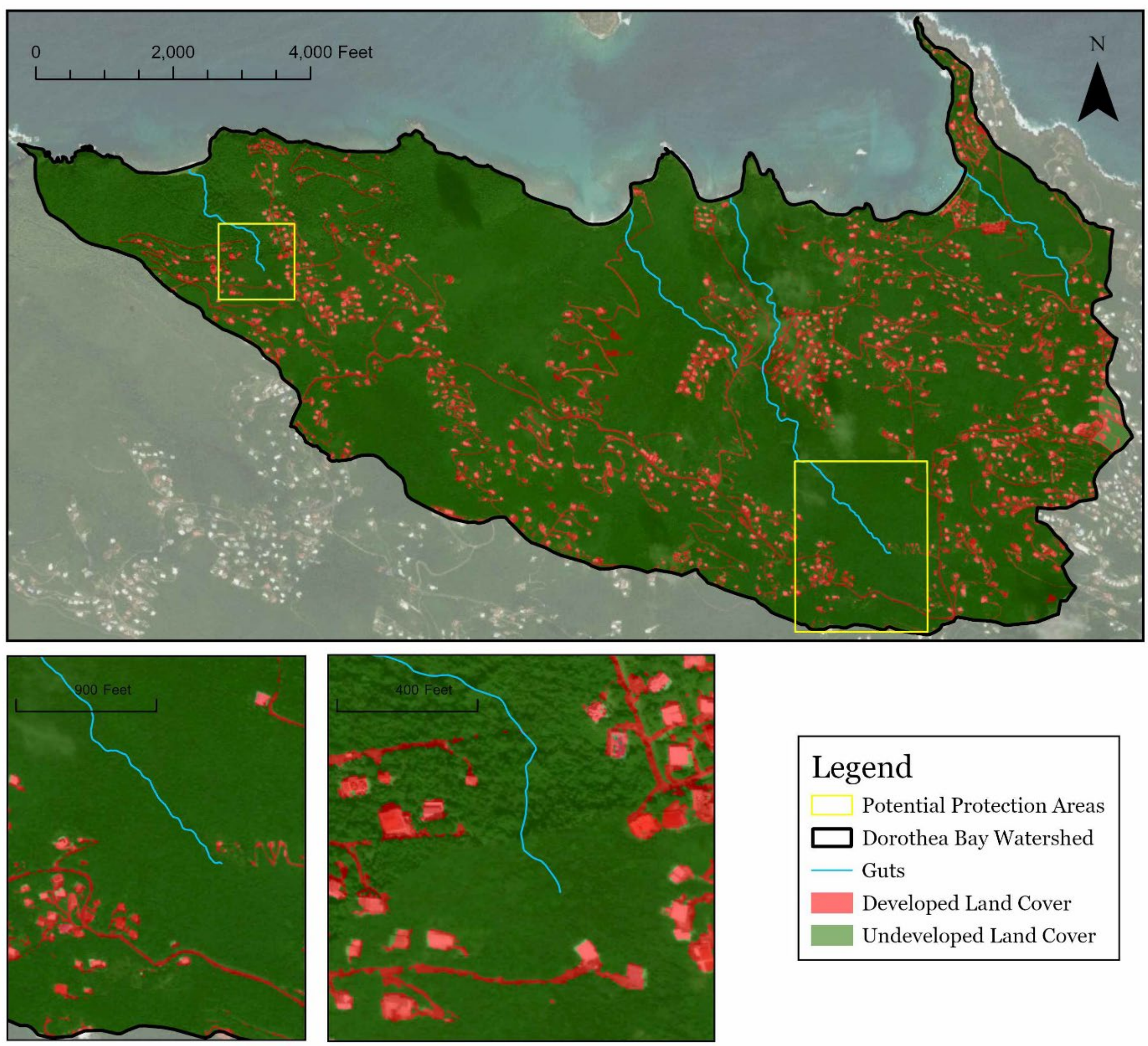


Figure 71. Potential gut headwater protection areas in the watershed.

4.1.3.6 Gut Channel and Buffer Zone Protection

Guts in the USVI act as the conveyance system for most stormwater runoff and deserve special protection including riparian buffers. There are protections for guts and drainage channels (29 V.I.C. § 226) in the code. However, it is unclear how strictly this is enforced or how often variances are granted to this requirement. Field observations have found that development may be occurring overtop some guts. It is recommended that **gut locations and potential impacts be reviewed during the permit review process** and then during the construction inspection phase to afford the necessary protections to these channels.

A buffer can be placed along a gut, shoreline, or wetland to physically protect a channel from future disturbance or encroachment. For guts, a network of buffers will act as a right-of-way during floods and sustain the integrity of gut ecosystems and habitats. Buffers can also filter pollutants traveling in stormwater or groundwater and provide wildlife habitat and recreation. Current code language does not allow clearing or construction within 25 feet of the edge or 30 feet of the center of natural watercourses (12 V.I.C. § 123). A natural watercourse is defined as any gut with a reasonably well-defined channel and includes guts with a permanent flow and those that result from the accumulation of water after rainfall, and which regularly flow through channels formed by the force of the water. However, this protection should **be expanded to a minimum of 50 feet for all guts, and 100 feet for guts where rare, threatened, or endangered species exist**. Exceptional circumstances will include areas with steep slopes or valued wetlands that require additional protections.

The DPNR should promote a **zoned buffer system** that will allow for some uses while supporting channel protection. One proposal would be a system with 30 feet of "natural vegetation" adjacent to the protected water requirements (as is currently in the codes) with an outer additional 20 feet where a greater range of impacts are allowed. The allowable uses might include septic fields (assuming they are vegetated), pathways with permeable surfaces, or other low impact activities. The publication "Better Site Design" (CWP, 1998) provides an example of a three-zone buffer system and suggested allowable uses in the buffer zones.

The development of a **gut restoration program** should also be a high priority and include riparian buffer assessment and reforestation to ensure buffers are vegetated primarily with high quality native vegetation instead of possible invasive species. The program should identify and prioritize the list of guts for restoration based on the larger overall watershed plan to ensure that the most impacted channels are addressed first.

4.1.4 Site Design Guidelines

4.1.4.1 Better Site Designs

The Better Site Design (BSD) development code review identified street widths, rights-of-way, and parking lot ratios as meeting BSD standards. These are areas of development that together help **reduce the creation of impervious cover**. Within the right of way, placing utilities under the pavement allows for the opportunity for stormwater treatment using bioretention or other green stormwater infrastructure. This area can also be planted with large trees to provide shade, capture rainfall, and generally beautify and improve neighborhoods. The Unpaved Roads Manual for Caribbean and Pacific Islands is a helpful resource to consult, especially in the Dorothea watershed where there are many unpaved roads.

The review identified other opportunities in the development code to minimize impervious cover in requirements for parking lots and driveways. USVI parking ratios meet better site design standards while other aspects of parking need improvement. **Shared parking** is allowed as a practice in the USVI and is a strategy that reduces the number of parking spaces needed by allowing a parking facility to serve multiple users or destinations. This practice should be encouraged by providing a model shared parking agreement and allowing for reduced parking requirements.

To reduce the creation of impervious cover in parking lots consider **allowing a percentage of commercial parking spaces for compact cars, which could also accommodate most Jeeps**, which are very popular on the island. Compact stalls create up to 30% less impervious cover than standard stalls so can be an important strategy for reducing impervious cover in large parking lots (CWP, 2017). Also, consider designating spillover parking areas for larger parking lots and promoting the use of alternative paving materials in these areas such as permeable pavement or pavers. The University of the Virgin Island's St. Croix campus at the 64 West Center is a local example of the use of **permeable pavements**. In addition, the standard parking space stall width should be reduced to nine feet or less. **Landscaping requirements** should be considered for parking lots that can manage stormwater in best management practices while increasing aesthetics and providing shade. Some options include: bioretention, bio swales, perimeter sand filters, filter strips, and structural soils with trees.

The analysis revealed several opportunities for code revisions regarding driveways. Consider allowing for the use of **alternative driveway surfaces, two-track design, and shared driveways** that connect two or more homes together. A two-track driveway has two strips of paving corresponding to wheel tracks with a vegetated area in between. In addition, the minimum width for a one-lane driveway should be defined in the code. Another recommendation to consider in residential areas is to allow parking lanes to also serve as traffic lanes in higher density developments. Also, in residential areas consider allowing the use of **alternate pedestrian networks** (e.g., paved trails through common areas, walkways and bike trails connecting streets) to be substituted for sidewalks.

The USVI allows for the creation of open space developments and does not require extra steps for development review. Consider allowing for **flexible site design criteria for development that utilize open space or cluster design options**. This will allow for a more unified open space rather than leftover bits of unusable property. One of the goals of open space development is to protect natural lands. Regulatory changes to consider meeting this goal include **requiring a percentage of open space to be left in its natural condition, consolidating into larger units, and defining allowable and unallowable uses** in the open space.

4.1.5 Solid Waste Management

Illegal dumping and trash were identified as a major environmental concern. Trash and debris are abundant alongside roadways and dumpster sites, most often caused by improper household waste disposal. Although bins are provided for waste disposal, they are sometimes located in areas where runoff from leaky dumpsters drains to the guts and can reach sensitive mangrove areas. The main dumpster site in the Dorothea watershed borders a gut, and there is a significant amount of trash that has accumulated in the gut as it has overflowed from the dumpsters.

4.1.5.1 Reduce Waste and Encourage Reuse

The most important and impactful strategy to reduce the negative impacts of solid waste is to have residents and visitors complete a lifestyle change where a **focus on reducing waste and reusing items** is the new normal. A territory wide campaign to emphasize reuse and source reduction to reduce reliance on disposal infrastructure for solid waste is critical. Options for reuse and composting are not readily available in USVI, forcing residents to put these items into the waste stream. Strategies for reducing waste include:

- **Develop an incentive program and/ or an ordinance to prevent the use of Styrofoam and plastic single use food and beverage packaging for “to go” items,**
- **Encourage residents to select products with minimal packaging, utilize reusable bags, decline plastic straws, and use refillable water bottles,**
- **Install public water refill stations in public areas,**
- **Encourage and provide educational materials on how to compost food scraps at a residential scale,**
- **Explore the feasibility of encouraging and / or incentivizing a commercial or other large scale composting facility where food scraps could be collected and processed,**
- **Sponsor or encourage repair and repurposing of items that would otherwise enter the waste stream, and**

- **Publicize the Caribbean Green Technology Center's Trash to Treasure Guide and other similar reuse guides.**

4.1.5.2 Expand Recycling Program

Another option for removing items from the waste stream involves **expanding the recycling program.** In the USVI, approximately 35% of waste is organic, 21% is paper, 13% is plastic, 11% is classified as "other" (contaminants and hazardous waste), 11% is textiles, 4% is glass, 4% is metals, and 1% is electronics.

There are funds to **begin a sustainable waste diversion and materials management program** to help reduce waste and divert waste from the Bovoni Landfill on St. Thomas and Anguilla Landfill on St. Croix to the Susannaberg Transfer Station. Through the Department of Planning and Natural Resources, VIWMA has been awarded a Solid Waste Supplemental Grant. Waste types to be diverted include green waste, scrap metal, tires and construction, and demolition debris. It will also provide the much-needed equipment to divert the waste stream from the landfill (VIWMA, 2021).

4.1.5.3 Improve Waste Bin Sites

It is recommended **that waste bin sites are evaluated for waste and stormwater runoff management**. The waste bin sites are operated by the Virgin Islands Waste Management Authority (VIWMA). Each waste bin site should be evaluated for site specific issues. Additionally, designs for covered bin areas should be explored as stormwater flowing through the full waste bins and draining to surface waters can contain a number of pollutants. If used motor and cooking oil are to be accepted at a bin site, a leak proof and approved container should be supplied.

4.1.5.4 Increase Enforcement of Illegal Dumping

Per Title 19: Health, Chapter 56 § 1563, illegal dumping is subject to a fine of $1,000 and/or imprisonment. The items that are not accepted at bin sites should be brought to the most conveniently located landfill where they can be disposed of, often without a fee (depending on the item). However, illegal dumping, particularly at bin sites and along roadways, is widespread. This illegal dumping introduces hazardous and often toxic materials and other pollutants into the environment, decreases aesthetic value, and encourages additional illegal dumping. It is recommended **that enforcement of penalties for illegal dumping be enforced whenever possible. Monitoring of bin locations is also recommended via video surveillance.**

4.1.5.5 Increase Education about Proper Disposal

Accessing up to date information regarding proper disposal of items outside of normal household trash can be challenging. It is recommended that **a simple web page be developed** instructing residents how and where to dispose of items such as tires, batteries, used motor oil, used cooking oil, junk vehicles, appliances, and other waste. The site should be prominent, easy to locate, and easy to navigate. Hours of operation and fees should be clearly stated in these materials. Currently, the VIWMA website has outdated and incomplete information. Pertinent details can be difficult to locate and those that are available online often contradict. This information should also be **publicized on social media and via community groups and other community platforms**. This recommendation may also help reduce illegal dumping.

4.1.5.6 Mitigate Existing Solid Waste and Hazardous Sites

A number of solid waste management sites for future mitigation were observed including a suspected illicit discharge at the Dorothea gut bridge along North Resolution (Figure 40) and odors from leaking septic systems. Residents also noted concerns about discharges from the Brassview wastewater treatment system (Figure 41). It should be noted that this list of sites is not exhaustive, and this information was collected only if observed during the course of other targeted field investigations. Any other hazardous or solid waste issues should be corrected as they are identified, potentially through an illicit discharge study.

4.1.6 Research Topics

4.1.6.1 Recycling Market Study

The Green Technology Center conducted a market analysis of the waste, and it is estimated that the possible revenue stream from recycling is $6 million, with aluminum cans, plastic bottles, and cardboard being the most potentially profitable waste (Penn, 2021). A **study should be completed to assess recycling markets, existing recycling options, and determine the most feasible expansions to the recycling program** for the USVI.

4.1.6.2 Coastline Recession Mapping

Multidate high resolution aerial imagery including UAS-collected data and historic imagery could be utilized along the coastline to **accurately map areas of coastal erosion**. These areas could then be targeted for stabilization efforts including the identification of additional stormwater BMPs, the prioritization of currently proposed stormwater BMPs, the planting of coastal vegetation, or the stabilization of eroding slopes.

4.1.6.3 Sargassum Mitigation

Influxes of sargassum seaweed has been a recent ongoing issue negatively impacting coastal ecosystems, air quality, and the tourism industry. Removal by heavy equipment can cause compaction, remove coastal sand, exacerbate erosion, and impact native wildlife such as disturbing turtle nesting areas. The problem continues after the sargassum has been removed because it must be safely disposed of to prevent contamination from leachate.

Unfortunately, solutions to reduce sargassum accumulation, remove the seaweed without damaging beaches and harming wildlife, and process the collected materials are not well understood. As these unprecedented influxes likely stem from increased temperatures related to climate change and increased nutrient loads from the Amazon River as land is cleared for agricultural purposes (Wang et al., 2019), wholistic solutions to reduce the sargassum influx would require global cooperation. It is recommended that the USVI **participate in these global actions** to the extent possible and continue to **participate in and review research** related to sargassum management and take science-based actions to manage the influx while protecting wildlife. Additionally, **research related to safely disposing of sargassum** and the **potential use of the seaweed** for biofuel, fertilizer, building materials, or for other applications should be continued.

4.1.7 Watershed Stewardship Programs

4.1.7.1 Expand Targeted Residential and Commercial Campaigns

Several education and outreach programs are currently targeted to residents and the commercial and industrial sectors. However, **additional education and outreach could be expanded in terms of the scope of messages, frequency of publications, and media type** (i.e., social media posts, Story Maps, signs, workshops, handouts including the Visioning Document developed in concert with this WMP, and others). Topics of importance include but are not limited to:

- Recycling
- Reuse
- Waste reduction including reusable items like straws, water bottles, shopping bags, and others
- Proper waste disposal including hazardous materials, appliances, vehicles, tires, and others
- Stabilize exposed soils and install homeowner and small business owner scale stormwater BMPs
- Vegetation protection

- Gut importance and protection

Many of these recommendations are detailed in the **Visioning Document and Story Map** as well as the **short educational videos** that were produced to accompany this project. These materials should be used to **advance and inform these campaigns**.

4.1.7.2 Develop Targeted Educational Campaigns

In addition to residential and commercial outreach, **targeted campaigns should also be conducted to inform and educate the judiciary and other key decision makers to build awareness for the need to enforce existing regulations and promulgate new ones**. In addition, the **tourism industry should be engaged to increase stewardship of coastal areas where hotels, marinas, and restaurants are located**.

4.1.7.3 Develop Stewardship Programs

A lack of gut stewardship programs and pet waste management were concerns identified from the surveys distributed to DPNR staff. It is recommended that **water stewardship programs be developed in coordination with existing community groups** such as the Coral Bay Community Council, St. Croix Environmental Association, and Virgin Islands Conservation Society. Another resource could be the University of Vermont Volunteer Water Monitoring Network, which developed a guide for developing volunteer water monitoring programs. The Anne Arundel Watershed Stewards Academy builds capacity in Anne Arundel County, Maryland by training Master Watershed Stewards to help neighbors reduce pollution in our local creeks and rivers. These and other resources can help direct the development of similar programs in the USVI.

4.1.7.4 Develop Homeowner's Guide to Stormwater Management

In order to encourage adoption of best practices at a residential scale, it is recommended that **a homeowner and small business owner focused manual is developed to guide design and implementation of these stormwater management practices**. This guide can serve as a companion to revisions of the Environmental Protection Handbook currently underway. Examples include Vegetation for Erosion Control – A Manual for Residents published by the Coral Bay Community Council, the Homeowner Guide for a More Bay-Friendly Property from the Chesapeake Stormwater Network, and the Vermont Guide to Stormwater Management for Homeowners and Small Businesses published by the Vermont Department of Environmental Conservation.

4.1.7.5 Provide Technical and Financial Assistance to Homeowners

A **homeowner BMP cost-share program could be implemented to provide property owners financial and technical assistance in implementing stormwater BMPs** for improving water quality and reducing the amount of stormwater runoff. If for example, a stormwater utility fee program is developed (see funding mechanisms below), the BMPs developed from the cost-share program could help property owners receive a credit or reduction of their stormwater fee.

4.2 FINANCIAL AND TECHNICAL ASSISTANCE NEEDS, TIMELINE, AND COSTS

The tables below summarize the recommendations outlined in the previous section and identify potential technical assistance and financial needs for each recommendation. The tables also include a column for the potential lead agency in implementing the recommendation from five DPNR operating divisions and three departments that have responsibilities relevant to watershed management. These include:

- Division of Coastal Zone Management (CZM)
- Division of Comprehensive and Coastal Zone Planning (CCZP)
- Division of Environmental Protection (DEP)
- Division of Fish and Wildlife (DFW)
- Division of Building Permits (DBP)
- Department of Public Works (DPW)
- Department of Agriculture (DA)
- Waste Management Authority (WMA)

An implementation timeline by year is included. It is assumed that many of these actions will be ongoing over time and thus span the entire five-year timeline and may continue into the future.

A relative cost (low = $, medium = $$, and high = $$$) was assigned for each action. These costs are based on prior projects and general knowledge as true costs are not obtainable due to the ongoing and preliminary planning level stage of these tasks.

4.2.1 Stormwater Management and Non-Stormwater Discharges

Table 20. Stormwater Management and Non-Stormwater Discharges: Technical Assistance and Financial Needs summary table.

Action	Lead	Implementation Year					Relative Cost	Technical Assistance
		Year 1	Year 2	Year 3	Year 4	Year 5		
Solution 1: Internal Operations Changes								
Complete the USVI Stormwater Standards and Design Manual and incorporate green infrastructure techniques.	DPNR DEP						$$	Staff will be required to develop and review the final product.
								Example designs for stormwater BMPs will need to be developed and reviewed by a professional engineer.
								Training will be necessary for contractors who install stormwater practices to ensure they understand the new standards and design procedures.
Finalize and adopt the revised Environmental Handbook.	DPNR DEP						$$	Staff will be required to develop and review the final product.
								The Handbook will need to be distributed to contractors and a final determination on adopting the handbook as a required guidance document will be needed.
Adopt an IDDE ordinance and develop an effective IDDE program.	DPNR DEP						$$$	A legal expert may be necessary to draft the language of the ordinance and ensure the regulatory authority necessary.
								Consultant to develop a guide or SOP for conducting IDDE in USVI.
								Training for multiple staff will be required to learn IDDE field testing procedures and remediation measures.
								Staff will need to complete a baseline survey of existing sewer infrastructure to identify any CSO/SSO problem areas and illegal discharges.
								A staff member or consultant would be required to develop and maintain a database to track discharges and enforcement decisions to ensure compliance.
								Test kits and other equipment will need to be purchased for field evaluations.
Solution 2: Policy/Program Changes								
Organize the TPDES program around the basic NPDES MS4 six minimum measures.	DPNR DEP						$$	A qualified consultant would be required to develop the organizational structure.
								Reassignment and training of staff will be necessary to realign programs with minimum measures.

Action	Lead	Implementation Year					Relative Cost	Technical Assistance
		Year 1	Year 2	Year 3	Year 4	Year 5		
Require limits of disturbance to be shown on construction plans and physically marked at the site.	DPNR CCZP						$	A qualified DPNR staff member will need to review site plans to ensure compliance. An alteration of the Earth Change code will need to be enacted to make this a regulation.
Implement green infrastructure demonstration projects.	DPW						$$$	Staff would be required to catalog the type of practice, maintenance schedule, and what equipment is required to maintain the practice (i.e., hand tools or heavy equipment). Staff would be required to write grant applications or reallocate DPNR's existing funding. Staff time for outreach and education task to target the public and contractors who would be putting the practices.
Solution 3: Structural Improvements								
Final design and implementation of two highest priority BMPs.	DPNR						$$$	Staff will be required to manage the development of the final 100% design documents for the construction of project. Contractors with the required equipment, materials, and training to design and install the priority BMPs as needed.
Further design development and implementation of the remaining three high priority BMPs.	DPNR						$$$	Staff will be required to develop or commission the preliminary 30% design documents for the construction of project Staff will be required to develop or commission the final 100% design documents for the construction of project Contractors with the required equipment, materials, and training to design and install the priority BMPs as needed.

4.2.2 Watershed Planning

Table 21. Watershed Planning: Technical Assistance and Financial Needs summary table.

Action	Lead	Implementation Year					Relative Cost	Technical Assistance
		Year 1	Year 2	Year 3	Year 4	Year 5		
Solution 1: Internal Operations Changes								
Shift from the two-tier management system in the coastal zone to a watershed approach.	DPNR CCM	■	■	■	■		$$$	Hire additional permit staff for potential increase in workload. Development of a guidance document for staff detailing the watershed approach and the changes to current procedures Training for staff on how the watershed approach differs from the tier system and how to address properties that may straddle watershed boundaries.
Adopt the updated Comprehensive Land and Water Use Plan and ensure that it accounts for impacts of future land use on water resources.	DPNR DEP	■	■	■			$$$	Staff will be required to develop and review the final product. Staff will need to guide the plan through the legislative adoption process. Legal expertise will be needed to address any possible conflicts with other codes or policies.
Confirm that current zoning is evaluated and revised to be consistent with the overall Comprehensive Land and Water Use Plan goals.	DPNR CCZP			■	■	■	$	Internal staff review time will be needed to compare current zoning to any proposed changes. Staff time may be required for public hearings as needed to make changes to zoning categories. Legal expertise will be needed to address any possible conflicts with other codes or policies.
Solution 2: Policy/Program Changes								
Review a larger suite of land use planning tools to see if additional techniques may be appropriate.	DPNR CCZP	■	■				$$	Internal staff review time will be needed to identify potential land use tools. Legal expertise will be needed to address any possible conflicts with other codes or policies.
Promote the use of conservation easements.	DPNR CCZP		■	■			$$	Gather informational materials together for applicants and provide these materials. Train DPNR review staff on how to inform and facilitate easements.
Revise the Zoning and Subdivision Code regarding small subdivisions	DPNR CCZP		■	■	■		$$$	Legal expertise will be needed to address any possible conflicts with other codes or policies.

4.2.3 Land Use Planning and Resource Protection

Table 22. Land Use Planning and Resource Protection: Technical Assistance and Financial Needs summary table.

Action	Lead	Implementation Year					Relative Cost	Technical Assistance
		Year 1	Year 2	Year 3	Year 4	Year 5		
Solution 1: Internal Operations Changes								
Adopt steep slope legislation to protect hilltops and prevent sediment erosion.	DPNR CCZP						$$$	Staff will need to review example steep slope legislation and draft ordinance language.
								The proposed legislation will need to be reviewed to address any possible legal conflicts with other codes or policies.
Adopt a tree ordinance and permit requirements for private lands.	DPNR DBP						$$	The proposed legislation will need to be reviewed to address any possible legal conflicts with other codes or policies.
								Staff will need to review examples of ordinance language and draft final ordinance language.
								Training will be required for staff and materials distributed to the public about the new legislation.
Implement a fee for proposed tree removal.	DPNR CCZP						$$	A fee schedule and tracking system for tree removal permit applications will need to be developed.
								Potential waivers/exemptions will need to be established by staff.
								Staff would be needed to implement the fee after tree ordinance is adopted.
Develop a tree canopy goal.	DPNR CCZP						$	Staff will need to review existing and projected future canopy coverage.
								Planting plans will need to be developed to increase tree canopy in areas where it is lacking.
Review gut locations and impacts during the permit review process and then during the construction inspection phase to afford the necessary protections to these channels.	DPNR DEP						$	Training for staff on review process and necessary protections for guts.
								Accurate mapping of gut locations and existing development will be needed.

Action	Lead	Implementation Year					Relative Cost	Technical Assistance
		Year 1	Year 2	Year 3	Year 4	Year 5		
Solution 2: Policy/Program Changes								
Expand buffer requirements to a minimum of 50 feet for all guts and 100 feet for guts where rare, threatened, or endangered (RTE) species exist.	DPNR DEP						$	Staff time to review information to identify areas with RTE species. A decision will need to be made about existing locations that do not meet new requirements and how to deal with those situations. Legal expertise may be required if a challenge to increases in required buffer widths is expected.
Promote a zoned buffer system.	DPNR DEP						$	There will be a staff time cost for any code change work. Educational materials will be necessary, highlighting the change and allowed uses of the buffer system.
Create a gut restoration program.	DPNR DEP						$$	Staff or consultant for gut corridor assessments and development of appropriate restoration strategies. Equipment needs will include machinery for gut modification, materials for stream restoration structures, invasive species removal and stock of native species for buffer planting. Staff time and funding for education of contractors who would conduct gut restoration projects. Staff time to update the Stormwater Standards and Design Manual?
Create a program to preserve the undeveloped land within the gut headwaters.	DPNR DEP						$$	Staff time will be required to identify areas, contact landowners, and identify applicable properties where conservation easements could be applied. For some parcels, funding and legal guidance will be needed for the purchase of undeveloped areas along gut headwaters so they can be preserved. Staff time would be needed to monitor and administer program.
Actively encourage agriculture preservation.	DA						$	Gather informational materials on preservation options for applicants and provide these materials. Staff time to provide support for those interested in preserving their agricultural properties.

4.2.4 Site Design Guidelines

Table 23. Site Design Guidelines: Technical Assistance and Financial Needs summary table.

Action	Lead	Implementation Year					Relative Cost	Technical Assistance
		Year 1	Year 2	Year 3	Year 4	Year 5		
Solution 1: Internal Operations Changes								
Provide a model shared parking agreement.	DPNR CCZP						$	Staff will need time and funding to review examples of shared parking agreements and prepare and print handouts to further educate participants.
Allow for reduced parking requirements.	DPNR CCZP						$$	Staff will need time for code review of current parking requirements and analysis of impact of reduced parking requirements. Time for staff with legal expertise for necessary legal changes to update codes.
Allow a percent of commercial parking spaces for compact cars.	DPNR CCZP						$$	Staff time and funding for code change related costs.
Designate spillover parking areas for larger parking lots.	DPNR CCZP						$$	Staff time and funding for code change related costs. Time to conduct and analysis of possible spillover parking areas.
Develop landscaping requirements for parking lots.	DPNR CCZP						$	Staff time and funding for code change related costs. Development of landscaping standards for parking lots.
Enact code revisions regarding driveways allowing for the use of alternative driveway surfaces, two-track design, and shared driveways.	DPNR CCZP						$	Staff will need time for code review, training on alternative driveway options, and code revisions.
Promote the use of alternative paving materials.	DPNR CCZP						$	Contractors with the required equipment, materials, and training to install alternative paving materials are needed. Development of outreach and education materials including locations for demonstration sites.
Solution 2: Policy/Program Changes								
Place utilities under the roadways.	DPW						$	Staff time to train contractors. Funding for changes to codes and design manual. Need to make decision on how to retroactively address any exiting utilities and track so that when improvements are made to roadway the utilities are placed correctly.

Action	Lead	Implementation Year					Relative Cost	Technical Assistance
		Year 1	Year 2	Year 3	Year 4	Year 5		
Plant ROW with large trees.	DPW						$	Staff time to conduct assessment to identify potential tree planting areas.
								Staff time or funding for contractors for tree planting and maintenance.
Reduce the standard parking space stall width to nine feet or less.	DPNR CCZP						$	Staff time and funding for code change related costs.
Allow parking lanes to also serve as traffic lanes in higher density developments.	DPNR CCZP						$	Staff time and funding for code change related costs.
								Conduct traffic analysis to identify any potential impacts in any areas where conflicts may arise.
								Staff time for changing the lane structure.
								Education/outreach to the public on the changes.
Allow the use of alternate pedestrian networks in residential areas.	DPNR CCZP						$	Staff time and funding for code change related costs.
Approve flexible site design criteria for developments that utilize open space or cluster design options.	DPNR CCZP						$	Staff time and funding for code change related costs.

4.2.5 Solid Waste Management

Table 24. Solid Waste Management: Technical Assistance and Financial Needs summary table.

Action	Lead	Implementation Year					Relative Cost	Technical Assistance
		Year 1	Year 2	Year 3	Year 4	Year 5		
Solution 1: Policy/Program Changes								
Develop an incentive program and/ or an ordinance to prevent the use of Styrofoam and plastic single use food and beverage packaging for "to go" items.	WMA						$	Staff time and funding for code change related costs. Staff time for education/outreach to the public on the changes.
Expand the recycling program. Encourage residents to select products with minimal packaging, utilize reusable bags, decline plastic straws, and use refillable water bottles.	WMA						$	Staff time and funding for program development related costs including using the results of the recommended research on recycling markets and options. Staff time for education/outreach to the public on the recommendations.
Install public water refill stations in public areas.	DPW						$	Staff time and funding for implementation and to interface with private commercial business owners to install water stations on their properties.
Encourage and provide educational materials on how to compost food scraps at a residential scale.	WMA						$	Staff time to develop and distribute education and outreach to the public on the recommendations.
Explore the feasibility of encouraging and / or incentivizing a commercial or other large scale composting facility where food scraps could be collected and processed.	WMA						$	Staff will need time and funding to host workshops, find a meeting location, prepare a presentation, and prepare and print handouts to further educate participants. Funding for compost bins may be required if the program elects to distribute bins to workshop attendees.
Sponsor or encourage repair and repurposing of items that would otherwise enter the waste stream.	WMA						$	Education/outreach to the public on how to repair and repurpose items. Funding for repair or provide location for a community repair recurring event so community member can meet and fix items.
Publicize the Caribbean Green Technology Center's Trash to Treasure Guide and other similar reuse guides.	WMA						$	Staff time will be need for education and outreach to the public on reuse guides as they are released.
Evaluate waste bin locations and runoff management.	WMA						$	This process would require staff time to complete a survey or study of current locations and alternative dumpster sites. Educational materials would need to be developed such as signage to indicate any new dumpster locations. In cases where relocation is not possible, design and installation of stormwater BMPs may be necessary to prevent pollution from runoff.

Action	Lead	Implementation Year					Relative Cost	Technical Assistance
		Year 1	Year 2	Year 3	Year 4	Year 5		
Increase enforcement of illegal dumping and install monitoring network.	DPNR						$$	Additional staff time will be required to pursue enforcement of illegal dumping. Staff time to install and monitor monitoring equipment and funding to purchase and maintain equipment.
Mitigate known solid waste and hazardous sites.	WMA						$$	Inspection and evaluation of identified solid waste discharge sites. Develop plans and strategies to remediate known sites and identify other existing sites.

4.2.6 Research Topics

Table 25. Research Topics: Technical Assistance and Financial Needs summary table.

Action	Lead	Implementation Year					Relative Cost	Technical Assistance
		Year 1	Year 2	Year 3	Year 4	Year 5		
Conduct a recycling market study.	DPNR						$$	Create collaboration with researchers, most likely with UVI to initiate and complete study.
								Determine funding sources for study, potentially NSF grants.
Conduct a coastline recession mapping study.	DPNR						$$	Create collaboration with researchers, most likely with UVI to initiate and complete study.
								Determine funding sources for study, potentially NSF grants.
								Budget for equipment and assessment costs.
Conduct a sargassum mitigation study	DPNR						$$	Create collaboration with researchers, most likely with UVI to initiate and complete study.
								Determine funding sources for study, potentially NSF grants.
								Budget for equipment and assessment costs.

4.2.7 Watershed Stewardship Programs

Table 26. Watershed Stewardship Programs: Technical Assistance and Financial Needs summary table.

Action	Lead	Implementation Year					Relative Cost	Technical Assistance
		Year 1	Year 2	Year 3	Year 4	Year 5		
Solution 1: Internal Operations Changes								
Inform and educate the judiciary and other key decision makers to build awareness for the need to enforce existing regulations and promulgate new ones.	DPNR DEP						$$	Staff will need time and funding to schedule visits or find a meeting location, prepare a presentation, and prepare and print handouts to further educate participants.
Engage the tourism industry in watershed protection education.	DPNR DEP						$$	Staff will need time and funding to schedule visits or find a meeting location, prepare a presentation, and prepare and print handouts to further educate participants.
Develop gut stewardship and pet waste management programs.	DPNR DEP						$$	Potential to reduce cost for program management by partnering with an existing nonprofit organization to promote the program(s). Funding will be necessary to install dog waste stations at public parks and gathering areas. Staff time will be necessary to maintain waste stations, staff gut cleanup events, and answer questions from the community.
Solution 2: Policy/Program Changes								
Develop a stormwater guide for homeowners.	DPNR DEP						$$	DPNR staff or consultant will need to modify an existing example guide and then reproduce and distribute guide. Staff time will be required for education and outreach events for the public.
Create a homeowner BMP cost-share program.	DPNR DEP						$$	Funding will need to be identified to assist in cost share. Equipment may need to be purchased based on the BMP proposed. Staff time for education and answering homeowner questions or hiring of a consultant. Staff for tracking implementation and management of program
Distribute the Vegetation for Erosion Control – A Manual for Residents.	DPNR DEP						$	DPNR will need funding to update (as necessary), reproduce, and distribute the existing manual from Coral Bay Community Council. Staff time for education and outreach events for the public.

4.3 Implementation Strategy

4.3.1 Funding Mechanisms

Funding is a major factor in the implementation of the identified regulatory recommendations and capacity building. Local governments typically fund the departments and activities such as stormwater programs through a combination of general funds, federal grants and loans, fees/fines/penalties, or a dedicated funding source (user fees). The expectation is that the private sector will help to pay for environmental protection efforts including the proper management of stormwater generated by development and redevelopment activities or provide money to mitigate impacts by supporting offsite stormwater management activities and restoration efforts.

4.3.1.1 USVI Ordinances

There are a number of potential funding sources for watershed restoration efforts already in the current USVI codes. While some are already being used to fund programs, it appears that the language in the code provides enough latitude that funds could be used for watershed planning and protection measures with some creative thinking.

Table 27 highlights places in the Code that employ enforcement measures in the form of fines that could also potentially be used for watershed implementation. The fines (Table 28) can help to ensure compliance with the code and discourage violation of enacted policies.

One thing that was noted by staff is that some of the fines and fees associated with certain programs may be outdated and undervalued. It would be wise to **review the current fee structure and make adjustments** to better reflect the actual cost for conducting plan reviews and other programs to determine if additional funds can be created to assist in staffing and equipment issues. Another note is that some of the funds have maximum caps that require additional funds be moved to the general fund once the threshold has been reached. A review of those thresholds to increase them and provide more funding to programs that support the goals the fund was originally created to accomplish is recommended.

Table 27. Current Funding Mechanisms Related to Watershed Planning.	
Code	**Funding Description**
12 V.I.C.§ 81a. Fish and Game Fund Chapter 1 Wildlife. Subchapter VI Wildlife Restoration	The proceeds from all firearms licenses, all excise taxes on firearms, parts and ammunition, all fines imposed by the courts for violation of the fish, game or conservation laws, and all monies obtained as described in Chapter 9A, Section 314 of this title, shall be covered into a special fund in the Treasury of the United States Virgin Islands to be designated as the "Fish and Game Fund". However, if the balance in the Fish and Game Fund equals $250,000, all monies which would otherwise be covered into such Fund shall be deposited in the General Fund.
12 V.I.C § 81d. Fish and Wildlife Restoration Trust Fund Chapter 1 Wildlife. Subchapter VI Wildlife Restoration	(1) The funds in the Trust under this section may be used exclusively for fish restoration and management projects pursuant to 12 V.I.C. § 81c.
12 V.I.C. § 711. Virgin Islands Coastal Protection Fund	(1) The Virgin Islands Coastal Protection Fund is established to be used by the Department as a revolving fund for carrying out the purposes of this chapter. The fund shall be limited to the sum of one million ($1,000,000) dollars. To this fund shall be credited all license fees, penalties and other fees and charges related to this chapter, including administrative expenses, and costs of removal of discharges of pollution.
33 V.I.C. § 33. Acquisition of certain lands, expenditures Chapter 2A. Territorial Park Trust Fund	The Board may authorize expenditures from the Fund for the following purposes: (1) to acquire lands that represent the ecological diversity of the Virgin Islands, including natural features such as rivers, coastal, and geologic systems and other natural areas; (2) to provide for the preservation and conservation of land for recreational, scientific, educational, cultural, and aesthetic purposes; and (3) to acquire additional lands for parks, trails, aesthetic forests, fish and wildlife management areas, scenic rivers, and natural areas for the use and enjoyment of the public.
33 V.I.C. § 3004. Land Bank Fund Subtitle 3 Finance > Chapter 111. Government Fund	Monies pertaining to the Land Bank Fund shall be available for purchases, authorized by law, of real property (including improvements thereon) for purposes of public housing, outdoor recreation, conservation, or any other public uses or purposes.

Table 28. Current Fines in USVI Code that Could Fund Watershed Planning.

Code	Fine Description
12 V.I.C.§ 107. Penalties Chapter 2. Protection of Indigenous, Endangered and Threatened Fish, Wildlife and Plants	Any person violating any provision of this chapter shall, upon conviction thereof, be subject to a fine of not less than $100, and not more than $10,000.
12 V.I.C.§ 125. Penalties for violation Chapter 3. Trees and Vegetation Adjacent to Watercourses	Whoever violates any provision of this chapter shall be fined not more than $100 or imprisoned not more than 180 days, or both.
12 V.I.C.§ 145. Penalties Chapter 3A. Community and Heritage Tree Law	(a) Any person or entity that violates any provision of this chapter by causing, contributing to, or permitting the injury of, removal, or destruction of a public tree, shrub or a heritage tree is subject to a civil penalty of not less than $100, but not more than $500 for each violation.
12 V.I.C.§ 164. Penalties Chapter 5. Water Resources Conservation	(a) Any person who willfully violates any of the provisions of this chapter or of the rules and regulations promulgated pursuant thereto shall be fined not more than $500 or imprisoned for not more than 6 months, or both.
12 V.I.C § 536. Inspections and enforcement Chapter 13. Environmental Protection	(b) Any person who fails to secure an Earth Change Permit under section 534 of this title, fails to pay the Earth Change Permit fee, or violates any provision of an Earth Change Permit shall be subject to a civil penalty of $200 per day per violation.
12 V.I.C.§ 538. Violations Chapter 13. Environmental Protection	(a) Any violation of this chapter shall be deemed a misdemeanor, and the person, partnership, or corporation who is found guilty of such violation shall be subject to a fine not exceeding $5,000- or one-year's imprisonment for each and every violation.
12 V.I.C § 913. Enforcement, penalties, and judicial review Chapter 21. Virgin Islands Coastal Zone Management	(3) In addition to any other penalties provided by law, any person who intentionally and knowingly performs any development in violation of this chapter shall be subject to a civil fine of not less than one thousand dollars nor more than ten thousand dollars per day for each day during which such violation occurs.
29 V.I.C. § 296. Fees and fines for building permits Chapter 5 Building Code Subchapter II. Permits, Appeals, and Fees	(b) Fees are payable at the Department of Planning and Natural Resources as follows: (1) A nonrefundable deposit of $40/commercial and $20/residential at the time of filing the application for all permits. (d) The fee for a permit authorizing the demolition of any building or structure or appurtenances connected or attached to such building or structure shall be $50/residential and $100/commercial or two cents per square foot for residential properties and five cents per square foot for commercial properties, whichever is greater. If, however, the demolition of the structure is included as part of the permitted construction phase, then the fee shall be calculated per square-footage cost and added to the building permit fee.

Table 28. Current Fines in USVI Code that Could Fund Watershed Planning.	
Code	**Fine Description**
	(e) The fee for a Certificate of Use and Occupancy shall be $50 for residential premises and $100 for commercial premises. (f) The fee for a permit authorizing the placing, erecting, construction, or affixing of any sign to any post, fence, building, or structure for out-of-doors advertising shall be $50. (g) Any person who fails to secure a permit or certificate under this chapter or regulation, fails to pay the permit or certificate fee, or violates any provision of any permit or certificate issued under this chapter or regulation shall be subject to a civil penalty of $1500 per day per violation
12 V.I.C § 913. Enforcement, penalties and judicial review Chapter 21. Virgin Islands Coastal Zone Management	1) Any person who violates any provision of this chapter, or any regulation or order issued hereunder, shall be subject to a civil fine of not to exceed ten thousand ($10,000) dollars.

4.3.1.2 Grant Funding Sources

Federal grants provide additional funding sources. Table 29 below provides a summary of grant funding opportunities.

Table 29. Grant program funding sources.	
Program	**Description**
Coastal Zone Management Act Section 309 Grants	Improvements to state and territory coastal management programs are encouraged through this program. The focus is on nine enhancement areas: wetlands, coastal hazards, public access, marine debris, cumulative and secondary impacts, special area management plans, ocean and Great Lakes resources, energy and government facility siting, and aquaculture. The program was established in 1990 under Section 309 of the Coastal Zone Management Act. Every five years, states and territories review their programs to identify priority needs and opportunities for improvement. The programs then work with NOAA to develop multi-year improvement strategies that focus on one or more of the priority enhancement goals. https://coast.noaa.gov/czm/enhancement/
NFWF Coastal Resilience Fund	The NFWF National Coastal Resilience Fund restores, increases and strengthens natural infrastructure — the landscapes that help absorb the impacts of storms and floods — to protect coastal communities while also enhancing habitats for fish and wildlife. In partnership with NOAA. Shell Oil Company, TransRe, and beginning in 2020, the U.S. Environmental Protection Agency and AT&T, NFWF invests in projects that plan for, design, build, and monitor the restoration or expansion of natural features such as coastal marshes and wetlands, dune and beach systems, oyster and coral reefs, forests, coastal rivers, and barrier islands that minimize the impacts of storms and other naturally occurring events on nearby communities. https://www.nfwf.org/programs/national-coastal-resilience-fund?activeTab=tab-3
US Housing and Urban Development	Community Development Block Grant (CDBG). This funding can be used for projects under the Infrastructure Repair and Resiliency Program to address issues with solid waste.

4.3.1.3 Additional Potential Funding Mechanisms

Additional potential funding mechanisms that could be considered for implementation in the USVI are provided in Table 30 below.

Table 30. Additional potential funding mechanisms.

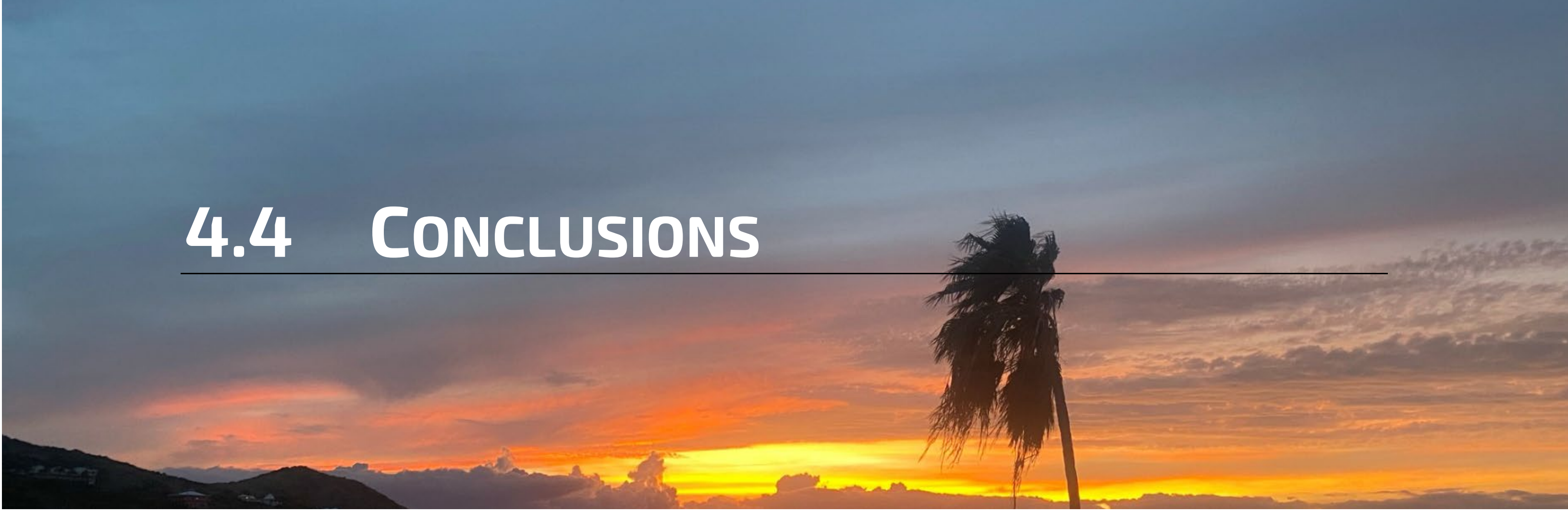
Funding Mechanism	Description
Public Works Hazard Mitigation and Infrastructure Improvement Funds	Ability to incorporate stormwater infrastructure upgrade projects. Can interview Peter from public works to discuss specifics of the program.
Fee-in-lieu Programs	For sites where stormwater management or impervious cover waivers are proposed, a fee-in-lieu program could be used to fund environmental protection efforts.
Stormwater Utility Fee	Similar to a water or sewer fee, a stormwater fee is a recurring user fee charged to property owners by a stormwater utility for the service of managing the stormwater runoff and associated pollutants coming from their property. The fee is calculated based on the demands a property places on the drainage system and is administered separately from general tax fund, ensuring sustainable and adequate funding for these public services.
Tourism Revenue Sources	Work with the Department of Tourism to identify tourism related revenues to conserve and enhance the natural resources that are the foundation of a long-term, robust, and resilient tourism and recreation economy for the Virgin Islands. https://coast.noaa.gov/data/czm/media/usvi-cmp.pdf

4.3.2 Monitoring Program

During the development of this WMP, visual monitoring of key guts was completed. Several important conclusions were drawn from this initial monitoring. These include:

- Monitoring ephemeral guts is challenging given the variable rainfall patterns and recent history of drought and low antecedent moisture conditions.
- Cameras must be installed in hard to reach places with sturdy locks and ideally camouflaged to prevent tampering.
- Time lapse cameras proved to be an efficient, inexpensive, and simple way to monitor water clarity and response to storm events. This documentation can be continued over time to assess changes in gut health and help to locate new sources of pollution (i.e., if turbidity increases following a new construction in the watershed, that new construction should be investigated).

As a next step in this baseline data collection, it is recommended that **monitoring be completed at other key locations in the watershed and continued in the current locations**. Monitoring should be carried out over a longer time span with a focus on the rainy season. Water quality sampling could also be a good next step to document existing conditions.



4.4 CONCLUSIONS

This Watershed Management Plan is a comprehensive document meant to document watershed-specific conditions related to water quality, flood risk, and resiliency. A monitoring and modeling component helped to highlight the importance of land-based sources of pollution within the watershed. A review of current policies and procedures provided insight into the current mechanisms for addressing these pollutants and enforcing the aforementioned policies. This allowed the project team to develop a list of actionable, achievable, and informed recommendations to improve water quality, reduce flooding, and increase resiliency in our changing climate.

Each watershed is an interconnected, complex, and unique area. One of the most important conclusions from this watershed management planning approach is that the entire watershed, from ridge to reef, needs to be considered. However, as conditions change over time and many of the provided recommendations are implemented, new challenges and opportunities will become more prominent. Additionally, many of these recommendations are complex and expensive and will take many years to properly implement. As such, **this Watershed Management Plan should be reassessed and updated on a five-year timeline**.

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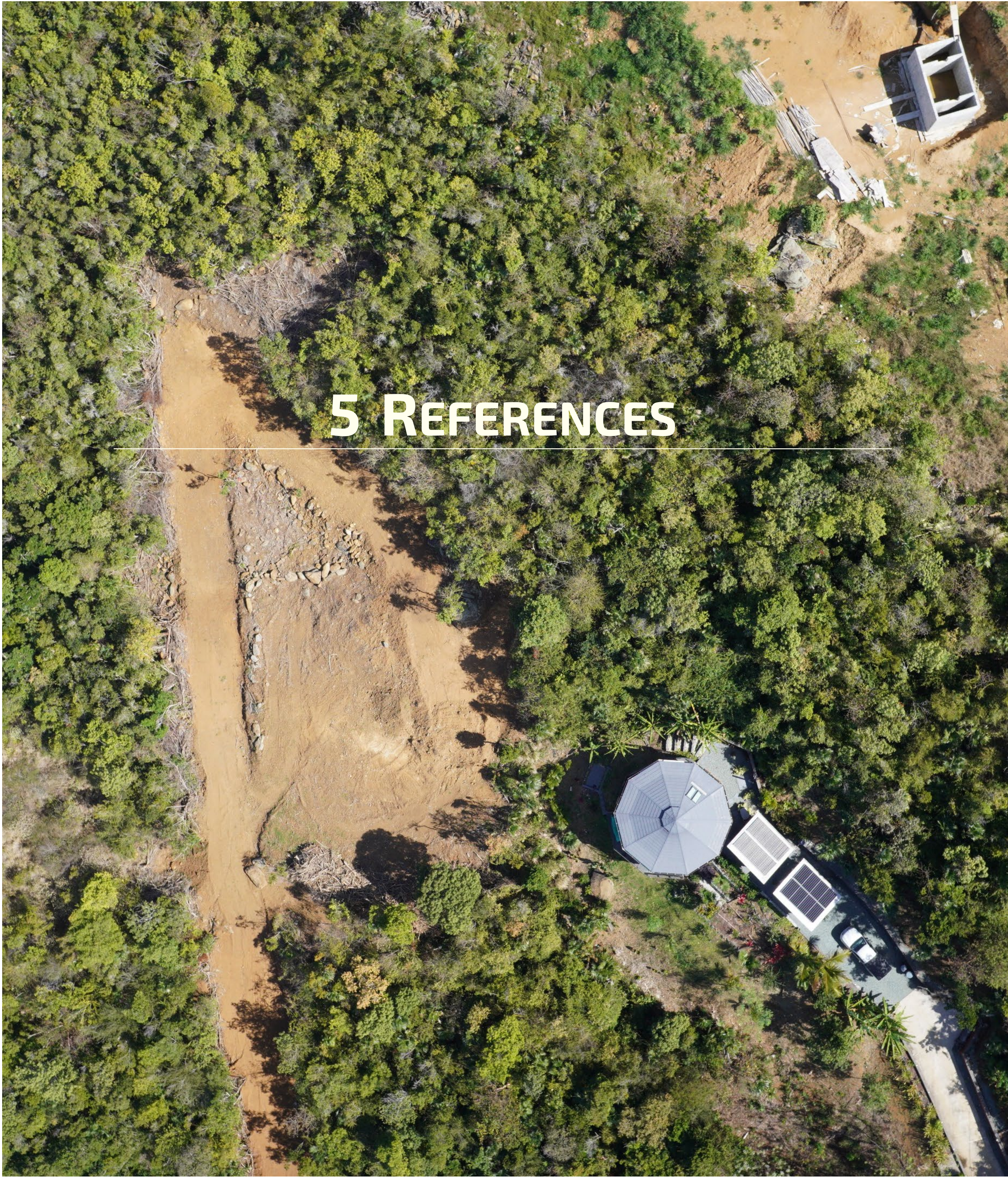

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