

Septic-to-Sewer Conversion Technology Optimization

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ABSTRACT

Aging septic tank systems used for the treatment of residential/commercial wastewater were determined to leak and negatively impact groundwater and nearshore water bodies by releasing nitrogen and phosphorus into the environment. To reduce these impacts, the State of Florida enacted the “Clean Waterways Act”. In response to this bill and community outcry to clean the Indian River Lagoon, Brevard County passed a referendum to fund the Save Our Indian River Lagoon Program which includes the elimination of septic tanks located in areas adjacent to the lagoon. This paper focuses on the technology selection and design optimization to be used for the elimination of septic systems and conveyance of wastewater to existing wastewater treatment facilities in three areas adjacent to the Indian River Lagoon, and the selection of the best collection system technology.

KEYWORDS

Collection systems, septic-to-sewer, septic, wastewater

INTRODUCTION

For more than a century, septic systems have been used to collect and treat solid organic waste. However, this method of sewage disposal has come with an environmental price. Septic systems installed in the seasonal high groundwater table, hydraulically conductive soils, and/or not maintained on a routine basis can contaminate groundwater, tributaries, and nearby coastal waters which eventually leads to public health issues. Publications, from the University of Florida and Florida Atlantic University, have documented how septic systems negatively impact not only our drinking water but the quality of our ecosystem and aquatic life.

Water quality monitoring for fecal indicator bacteria (fecal coliform and enterococci) are typically performed for the purpose of providing an indicator of water quality. These bacteria are influenced by specific factors such as geomorphology as well as regional factors such as wastewater infrastructure projects which can have a significant impact in coastal waters. Regional studies using water quality monitoring have demonstrated a significant improvement in coastal water quality following the implementation of large-scale septic-to-sewer programs.

Many Florida coastal communities are quickly recognizing the detrimental impacts that septic systems have on water quality and marine life habitat, commercial fisheries, property values, and tourism. As a result, many new septic-to-sewer programs are being implemented throughout Florida coastal communities. Some such programs within Florida include the septic to sewer programs constructed and in operation for the Village of Islamorada, Sarasota County, and Marathon Key.

The focus of this paper is on the technology selection to optimize the septic-to-sewer conversions as part of the Save Our Indian River Lagoon (SOIRL) Program in Brevard County, FL.

BACKGROUND

The Indian River Lagoon (IRL) system spans 156 miles of Florida's eastern coastline and in April 1990 was designated by the US Environmental Protection Agency as "an estuary of national significance" resulting in the inclusion of the lagoon in the National Estuary Program. The largest portion (71%) of the IRL is located within Brevard County and provides jobs, housing and industry to Florida residents, plus recreational and tourism opportunities to visitors. However, the delicate ecosystem of the IRL in Brevard County has been disturbed as development has led to harmful levels of nutrients entering the lagoon from poorly maintained septic systems, stormwater runoff (urban and agricultural areas), wastewater treatment facility discharges, and excess fertilizer applications. Since the 1990s, collective restoration efforts have been made by regional municipal treatment facilities, educational institutions, and federal, state, and local governments to improve water quality.

In 2016, the SOIRL Program was created with the ½ cent sales tax that Brevard County residents voted to impose on themselves. The program is designed to address excess nitrogen and phosphorus pollution to the IRL through various projects to reduce pollution inputs, remove legacy loads of pollution, and restore natural filtration systems. It is estimated that the plan will raise up to \$586 million in revenue over 10 years to fund projects that will reduce or remove over 1.3 million pounds of excess nitrogen and 106 thousand pounds of phosphorus annually from the Indian River Lagoon.

With efforts from the SOIRL program, improvements to water quality have been set into motion to improve the health, productivity, aesthetic appeal, and economic value of the lagoon in this coastal environment. Based on an economic evaluation of the IRL system, Brevard County determined an approximate \$2 billion in benefits from restoration and an estimated \$4 billion in damages of the IRL if not restored in the next decade. The expected benefits and present value include tourism and recreation growth (\$997M), property value growth (\$852M), rebirth of commercial fishing (\$159M), and improved quality of life and health of residents and tourists (not quantified). As of February 2024, approximately \$320M in prioritized projects are underway out of a \$586M designated project budget. These projects will have removed more than 987,000 pounds of total nitrogen (75% of goal) and more than 73,000 pounds of total phosphorus (68% of goal) from the IRL.

A principal effort associated with the SOIRL Program is the conversion of hundreds of existing residential septic systems to either gravity, low-pressure, or vacuum sewer systems. Septic-to-

sewer projects account for approximately \$130M of the total project cost based on the 2023 SOIRL Plan update. This paper outlines the process of selecting and optimizing collection system technologies for converting septic systems in ten wastewater service areas adjacent to the IRL. Three alternative collection technologies are identified and evaluated by examining, prioritizing, and assigning weighted scoring values to the technical criteria used in the selection process of a collection technology for each service area.

PROJECT AREA DESCRIPTION

The project area consisted of ten (10) areas served by septic systems in Brevard County, Florida within the developed regions of North Brevard, South Merritt Island, and Little Hollywood as illustrated in Figure 1. A total of 2,261 parcels are in these service areas.

North Brevard

The North Brevard region consists of 4 service areas ranging in size from 147 parcels to 358 parcels. Table 1 provides a breakdown of the residential, commercial, and vacant parcels located in the region.

Table 1. North Brevard Service Area Designations

Service Area	Residential Parcels	Commercial Parcels	Vacant Parcels	Total Parcels
Cocoa - Zone C	300	26	32	358
North Merritt – Zone E	205	1	3	209
Sharpes - Zone A	208	22	27	257
Sharpes - Zone B	145	1	1	147
Total	858	50	63	971

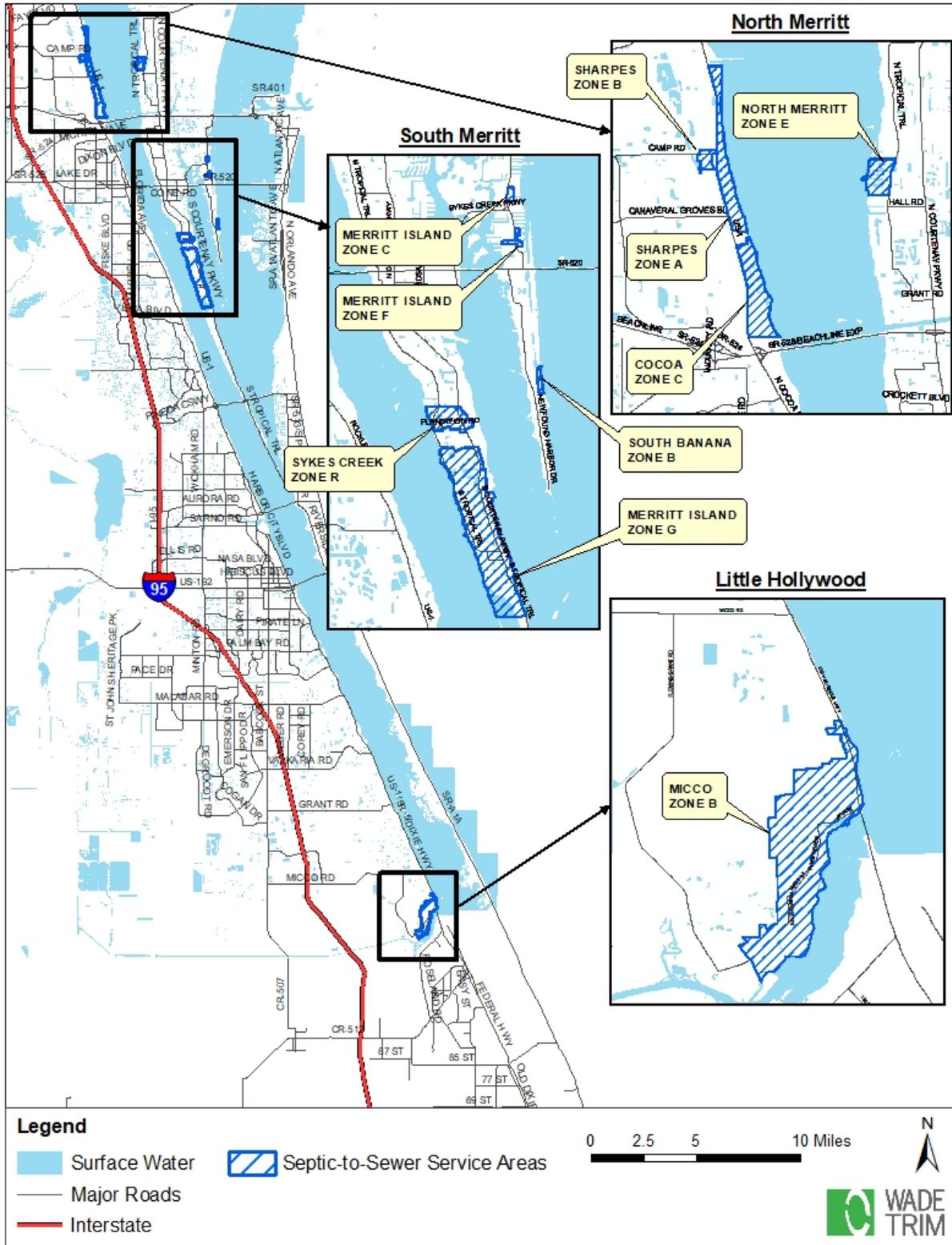


Figure 1. Project Location Map

Figure 2. North Brevard Service Area illustrates the location of each individual service area and their dedicated land use in North Brevard. Land use consists of 88% single and multi-family residential with 5% commercial development. Vacant parcels account for approximately 6 percent of undeveloped land in the project area. Most residential parcels are less than 1/2-acre in size (72 percent) with the remaining parcels great than 1/2-acre in size.

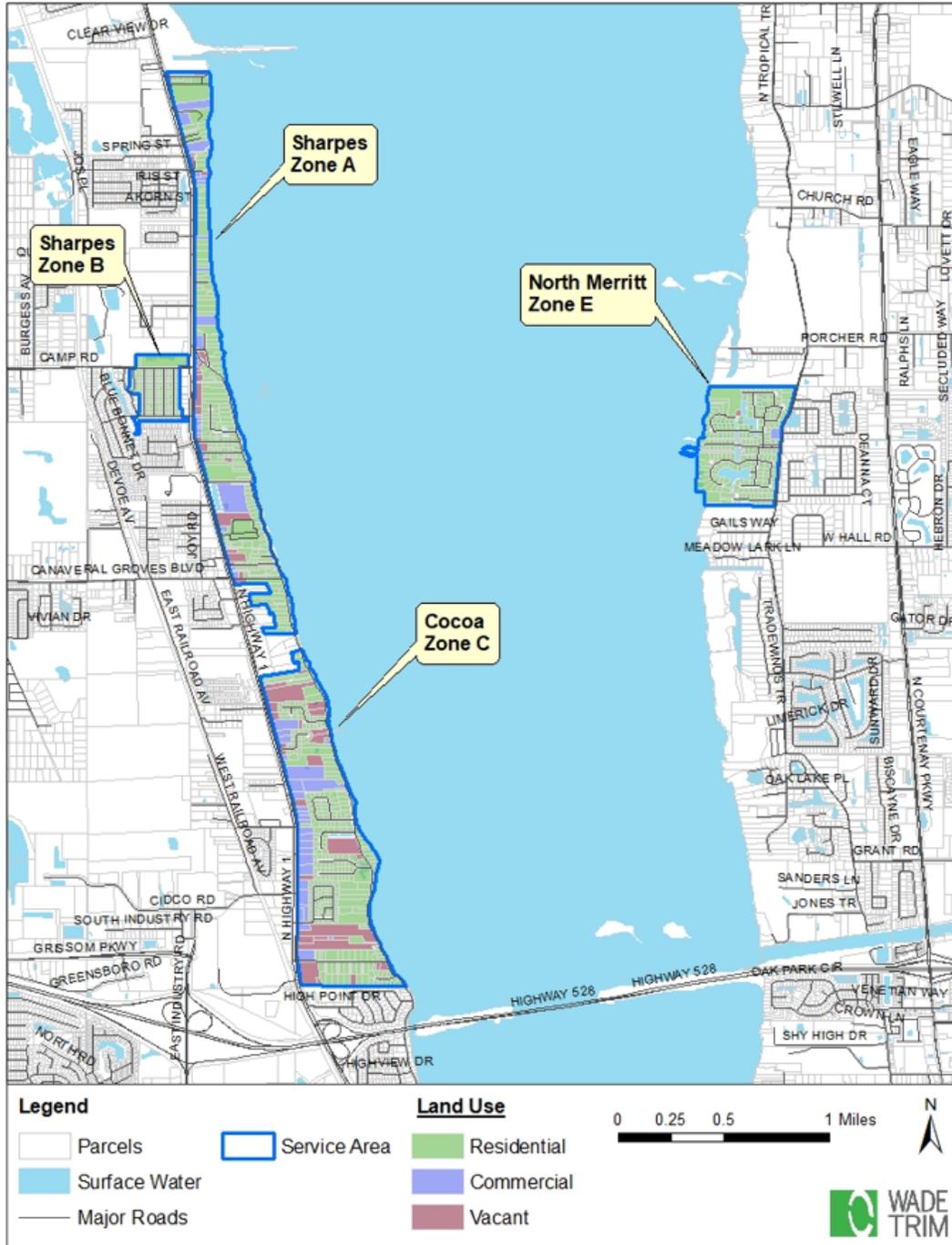


Figure 2. North Brevard Service Area

South Merritt Island

The South Merritt Island region consists of 5 service areas ranging in size from 43 to 1,272 parcels (the largest area, Zone G, is subject to change based on on-going analysis). These service areas are located on Merritt Island, bounded by the Indian River on the west and Sykes Creek and the Banana River to the east, all part of the IRL. Table 2 provides a breakdown of the residential, commercial, and vacant parcels located in the region.

Table 2. South Merritt Island Service Area Designations

Service Area	Residential Parcels	Commercial Parcels	Vacant Parcels	Total Parcels
Merritt Island – Zone C	43	0	0	43
Merritt Island – Zone F	79	1	0	80
Merritt Island – Zone G	1,222	4	55	1,281
South Banana – Zone B	49	0	0	49
Sykes Creek – Zone R	197	0	8	205
Total	1,590	5	63	1,658

Figure 3 and Figure 4 illustrates the location of each individual service area and their dedicated land use in South Merritt Island. Land use consists of 96% single and multi-family residential and less than 1% commercial development. Vacant parcels account for approximately 3 percent of undeveloped land in the project area. Most residential parcels are less than ½-acre in size (74 percent) with remaining parcels greater than ½-acre in size.

Little Hollywood

The Little Hollywood service area is in southern Brevard County. The service area is bordered on the east by the Indian River, the south by the Saint Sebastian River, the west by wetlands and undeveloped land, and the north by developments in Micco, Snug Harbor Village and Barefoot Bay.

Table 3. Little Hollywood Service Area Designations

Service Area	Residential Parcels	Commercial Parcels	Vacant Parcels	Total Parcels
Little Hollywood	700	17	35	752

Figure 5 illustrates the location of the individual service area and its dedicated land use in Little Hollywood. Land use consists of 93% single and multi-family residential and 2% commercial development. Vacant parcels account for approximately 5% of undeveloped land in the project area. Approximately 66% of the service area is comprised of residential parcels ½-acre or

smaller in size, 2 percent are parcels greater than 1/2-acre and smaller than 1 acre in size with the remaining parcels greater than 1 acre in size.

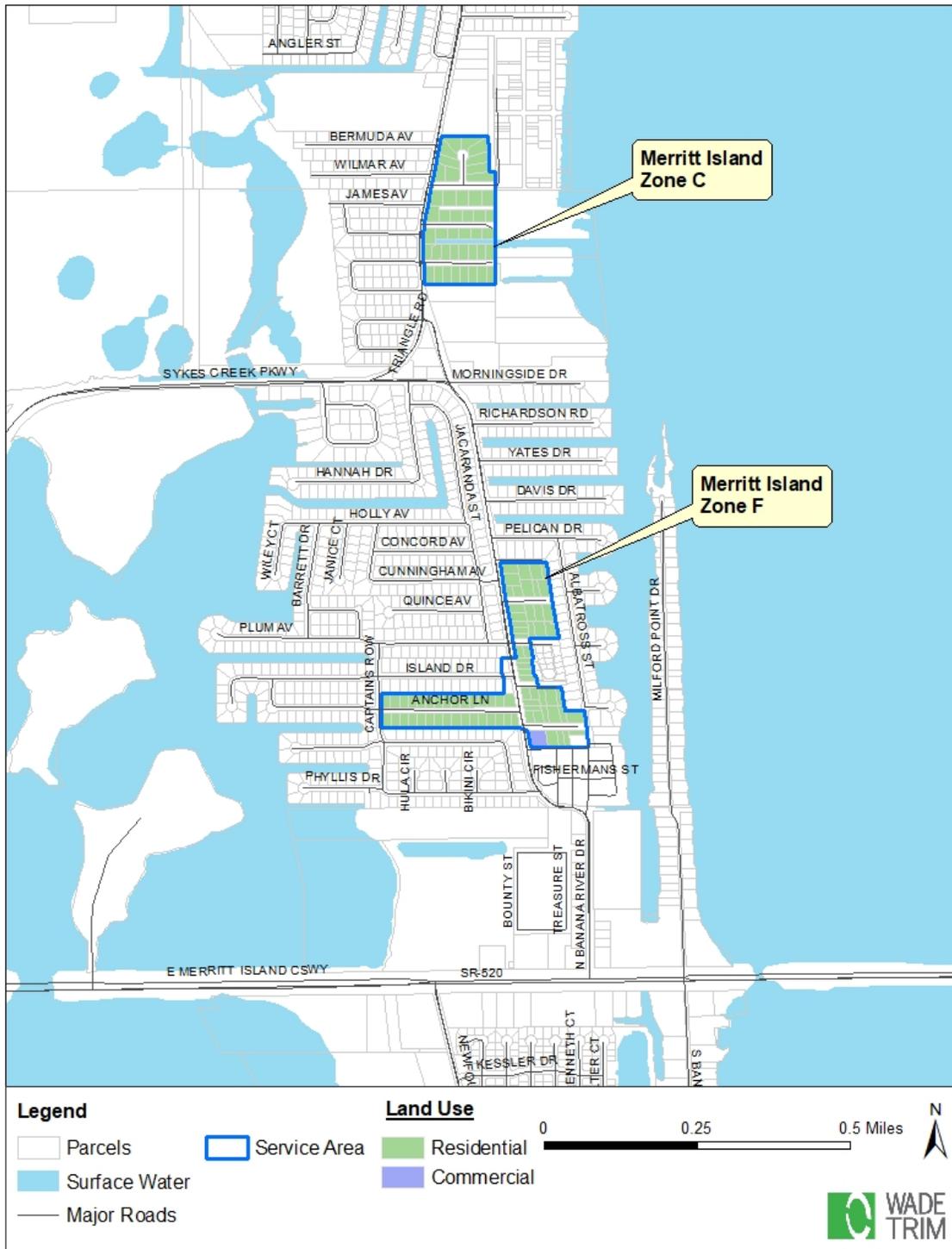


Figure 3. South Merritt Island Service Area North of SR-520

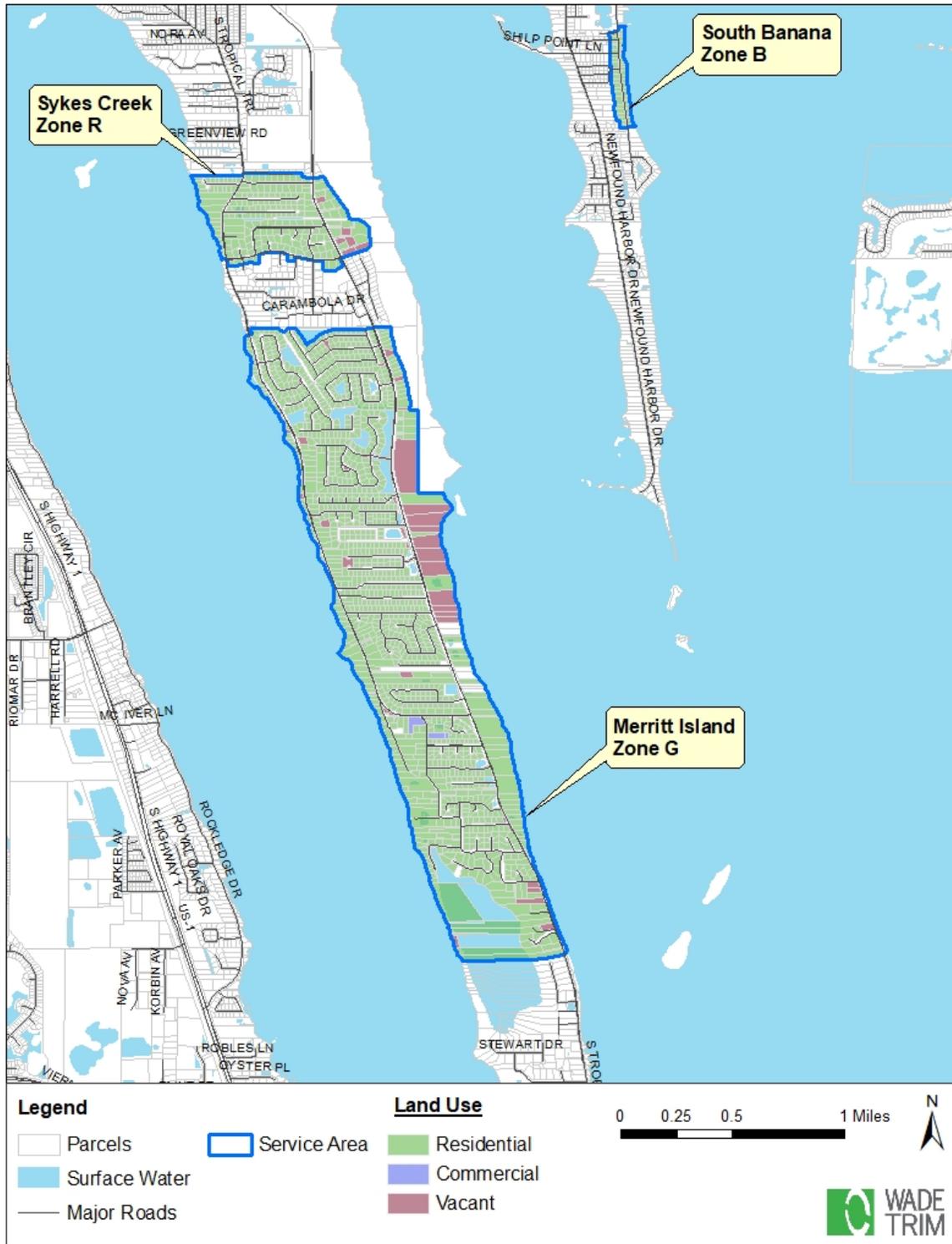


Figure 4. South Merritt Island Service Area South of SR-520

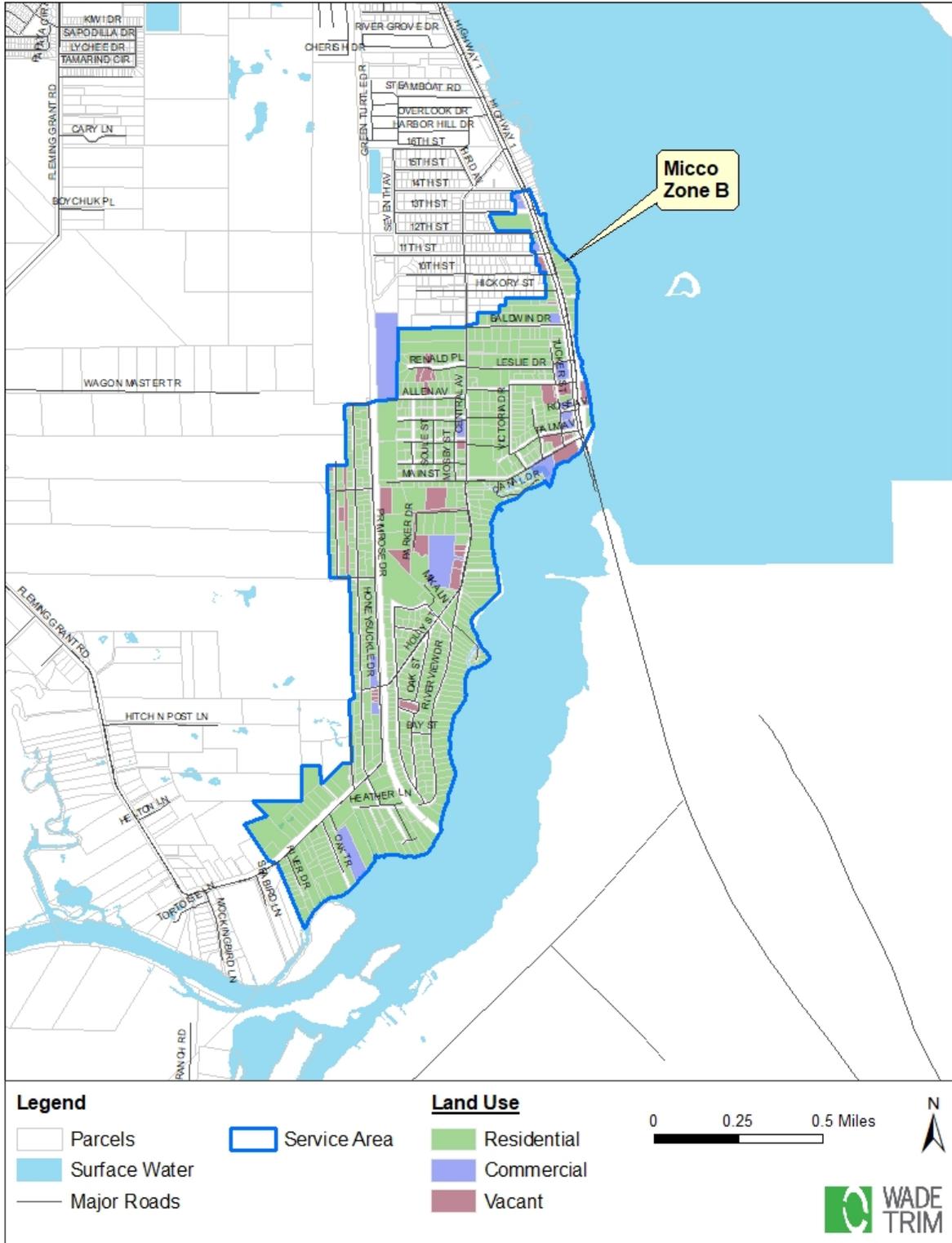


Figure 5. Little Hollywood Service Area

METHODOLOGY

Collection System Technologies Considered

Determining the optimal method for providing a sewer system to each of the service areas requires an analysis of alternative collection system technologies and their applicability to the individual service areas. Determining which type of collection system is most beneficial to a community is usually decided upon using factors that include geographical location, parcel density, environmental features, available land, capital costs, and constructability. This section summarizes the gravity and vacuum sewer system technologies that were considered for the Project.

Gravity Sewers

Gravity sewers consist of a minimum pipe diameter of 8-inch and pump stations that convey wastewater from residential neighborhoods and businesses to a force main that delivers flow to a regional wastewater treatment plant facility. Sewers are designed and constructed with minimum slope requirements to achieve a minimum and maximum velocity of 2 and 7 feet per second (fps), respectively when flowing full. Flow through the piping network is accomplished by gravity with the assistance of local and regional pump stations for transporting flows. Gravity sewers range typically in depth from 3-feet to 20-feet below grade. Lift stations are comprised of wet wells, pumps, motors, controls, and power for the purpose of transferring wastewater from one lift station to the next. Manholes, spaced up to 400 feet apart, are required at pipe intersections, where changes in pipe direction occur, and where changes in pipe slope occur.

Vacuum Sewers

Vacuum sewer systems typically consist of smaller diameter collection mains installed at shallower depths than conventional gravity sewers. Vacuum sewers can be installed in a relatively shallow trench that collects and conveys wastewater “uphill” by a saw-toothed configured pressurized vacuum system whereby wastewater is collected at vacuum pump stations and then pumped to a nearby wastewater treatment plant for treatment and disposal. Using vacuum sewer technology has been considered beneficial for the unsewered coastal communities since these systems do not experience any inflow and infiltration. Vacuum sewers use differential pressure to move sewage in a wastewater collection system. A vacuum sewer system uses a normally closed vacuum valve at each entry point into the system which seals the mains to maintain a vacuum. The interface valves, located in the upper portion of a valve pit, open when a predetermined amount of sewage enters the collecting sump, located in the lower portion of the valve pit. The differential pressure between the atmosphere and the vacuum provides the driving force that propels sewage to the vacuum pump station where sewage is transferred to a wastewater force main and conveyed to the treatment plant facility. The vacuum pump station is the major component of a vacuum sewer system; the pump station serves as the primary transfer facility between the central collection point for the vacuum sewers and a pressurized transmission main leading directly (or indirectly) to the wastewater treatment

facility. The vacuum pump station is similar to a gravity lift station which has a wet well and two sewage pumps; however, the vacuum pump station also utilizes two or more vacuum pumps which are needed for transporting sewage within the vacuum mains of the collection system. In residential communities, a single vacuum pump station can replace up to seven conventional lift stations.

Low-Pressure Sewers

A low-pressure sewer system (LPSS) is a method of wastewater collection designed to transport sewage from homes and businesses using a network of small-diameter pipes, typically 1½-inches to 4-inches in diameter buried 3 to 4-feet below grade. Unlike traditional gravity sewer systems, which rely on a slope to move sewage, LPSS uses individual grinder pumps at each connection point to push the sewage through the pipes. These grinder pumps, typically 1-hp in size, are installed in a tank buried on each property, where the sewage is collection, ground into a fine slurry, and pumped into the sewer network under low pressure. This system is especially advantageous in areas with deep or low-lying residential parcels, where the groundwater level is high, or the soil conditions are not suitable for traditional sewer systems. The low-pressure system's small-diameter pipes also reduce the cost and disruption of installation when compared to a gravity sewer.

Technology Criteria Evaluation

An evaluation of gravity and vacuum sewer system technologies was completed for each of the ten (10) wastewater service areas. Evaluations were conducted, considering four criteria: cost effectiveness, constructability, existing infrastructure, and land availability. Descriptions of each criterion are provided below.

Low-pressure sewer systems were initially compared against gravity and vacuum sewer system technologies and found to be less preferred in all cases except when the other technologies were cost-prohibitive or infeasible due to constructability. For this reason, low-pressure systems were considered only on an “as-needed” basis and are not included in the technology evaluations. Nonetheless, low pressure is being considered for specific parcels where gravity or vacuum sewer collection systems are not possible.

Cost Effectiveness

Table 4 presents a comparison of the cost-effectiveness between gravity and vacuum sewer systems.

Table 4. Cost Effectiveness Comparison of Gravity and Vacuum Sewers

Cost	< 50 Connections	100 -150 Connections	> 200 Connections
Capital Cost	Gravity	Gravity	Vacuum
Annual O&M	Gravity	Gravity unless multiple lift stations are required	Vacuum
Life Cycle Costs	Gravity	Gravity or Vacuum	Vacuum

Previous septic-to-sewer programs in Florida such as the Sarasota County, Florida Keys, and Hillsborough County septic-to-sewer programs have demonstrated that vacuum sewers systems are lower in capital costs when compared with traditional gravity sewer systems when serving 200 homes or more in a single service area. Gravity sewer systems are typically more cost effective when serving 50 to 200 residences; however, low pressure or vacuum sewers may be more advantageous when constructability is more difficult as this can drive up the cost of a gravity system. Capital costs for serving less than 50 connections favor gravity sewers. Similarly, annual operation and maintenance (O&M) costs favor vacuum sewers when serving more than 200 connections in a single service area. O&M costs for 50 to 200 connections generally favor gravity sewers.

Constructability

The constructability of a gravity and vacuum sewer systems is impacted by the size of pipe required and associated pipeline trench size, groundwater elevation, soil conditions, and parcel size.

Typically, the construction of gravity sewers in Florida is limited to new development given the limited amount of green space that can be used for trench excavation and dewatering. Trench depths for gravity sewer construction in Florida typically range from 3 to 20 feet with a maximum width of 1-foot on each side of the pipe. Research of available USGS groundwater data in each of the project service areas indicated that the highest groundwater table exists for those residential properties located in the Merritt Island service area. Groundwater in this region ranges anywhere from 6 to 12-feet below the ground surface depending on tidal conditions.

The construction of vacuum sewers requires a shallow trench, typically less than 5-feet, and requires little or no dewatering. These factors become vitally important when a septic-to-sewer project is being considered in a built-out neighborhood and in areas with a shallow groundwater table such as Merritt Island.

Past septic-to-sewer projects have shown that parcel size typically dictates the type of collection system best suited for the service area. Generally, parcels which are ½-acre or smaller in size are most cost-effectively served with either gravity sewer or a vacuum sewer system provided that a gravity service lateral can connect with the gravity or vacuum main located in the right-of-way. Larger parcels, deep lots, and/or those lower in elevation result in the infeasibility of a gravity

service lateral by which a pump is required to convey sewage to the collection system. In these cases, a low-pressure system is typically more cost-effective.

Existing Infrastructure

For each service area being evaluated, infrastructure maps were generated using GIS attribute file data to generate maps that identified force mains, lift stations, and wastewater treatment facilities. Wastewater connection points were confirmed using hydraulic modeling.

The cost to convey sewage from the septic-to-sewer service area to the existing infrastructure via a force main typically does not vary based on technology; however, tying into an existing sewer system without the use of an additional lift station or vacuum pump station is more cost-effective where possible.

Land Availability and Parcel Size

The availability of land is also a key factor when determining what type of collection system can be utilized for a residential service area. Regardless of whether a gravity or vacuum collection system was selected, a minimum 1/3-acre of land was a determining factor for the construction of a vacuum pump station or a master lift station in a gravity collection system. Individual lift stations used with gravity systems can be constructed on smaller land parcels; however, several lift station parcels are required when serving a residential service area that extends more than a mile in length. The identification of available properties needed for locating a master lift or a vacuum pump station site in each service area was accomplished using the Brevard County Property Appraiser database. Priority was given to County-owned and vacant parcels followed by government owned, school, and church property.

Technology Selection and Implementation

The optimal collection system technology for each service area was determined as gravity (G), or vacuum (V) by assigning a weight to each selection technology criteria, scoring the criteria, and summing the overall score as shown in Table 5. The technology selection process resulted in the selection of vacuum sewers for six of the larger service areas and gravity sewers for the remaining four.

Table 5. Technology Scoring for Residential Septic-to-Sewer Service Areas

Service Area	Cost Effectiveness (Weight=4)	Constructability (Weight=3)	Existing Infrastructure (Weight=2)	Parcel Size (Weight=1)	Score		Highest Score
					Vac	Gravity	
NORTH BREVARD							
Cocoa Zone C	G	V	V	V	6	4	Vacuum
N Merritt Zone E	V	V	V	V	10	0	Vacuum
Sharpes Zone A	V	V	V	V	10	0	Vacuum
Sharpes Zone B	G	V	G	V	4	6	Gravity
SOUTH MERRITT ISLAND							
Merritt Zone C	G	G	G	V	1	9	Gravity
N Merritt Zone F	G	G	G	V	1	9	Gravity
Merritt Zone G	V	V	V	V	10	0	Vacuum
S Banana Zone B	V	G	G	G	4	6	Gravity
Sykes Ck Zone R	V	V	G	G	7	3	Vacuum
LITTLE HOLLYWOOD							
Micco Zone B	V	V	V	V	10	0	Vacuum

RESULTS

Challenges Encountered and Lessons Learned

Throughout the design phase of the Brevard County septic-to-sewer program, County staff and the project design teams encountered challenges. A description of these challenges and lessons learned is provided below.

As-builts

Challenge: As-built records were non-existent or found to be inaccurate where needed in some locations.

Issue: Where non-existent, additional time and effort was required to verify the existing infrastructure via underground utility surveys, staff interviews, and additional records searches. Where as-built records were available but found to be inaccurate, concerns were raised regarding the integrity of other as-builts, errors in design, and the improper integration with existing infrastructure, compromising the overall effectiveness and longevity of the project. In these cases, like where as-builts were non-existent, additional time and effort was required to confirm verify the existing infrastructure. Each of these cases ultimately resulted in delays in the septic-to-sewer design which were not originally accounted for in the design schedule and changes to the design plans as additional information became available.

Lesson Learned: The available information should have been determined at the beginning of the design project and accounted for to provide a more accurate design schedule.

Surveying

Challenge: With multiple infrastructure projects occurring simultaneously throughout the State, contracting resources such as surveyors can become competitive and result in design delays project schedule impacts.

Issue: Delays in surveying can prolong the septic-to-sewer design phase and significantly impact project timelines and execution. Various surveyor contributions such as the initial topographic survey, obtaining easements, sketch & description preparations, and subsurface utility explorations can be time-consuming and requires ample notification for surveyors to properly schedule field crews and prepare submittal documents.

Lesson Learned: Upon learning of an upcoming project, notify multiple surveyors and inquire on their availability and current ongoing projects. Provide approximate project NTP and schedule durations. Upon identifying preferred candidates, obtain commitments from surveyor upper management.

Land Acquisition

Challenge: The choice of septic to sewer conversion technology determines the parcel size needed for land to establish pump station locations. Acquiring the necessary land can be a time-consuming endeavor.

Issue: The initial phase of the land acquisition process involves pinpointing parcels that meet the required dimensions for either a vacuum pump station or a gravity sewer lift station. Should suitable parcels be unavailable, it becomes necessary for the municipality to engage in discussions with property owners to secure a parcel that satisfies the requisite size specifications. This phase can extend from approximately six months to a year, thereby affecting the design timeline.

Lesson Learned: When the timeline of the project permits, the preliminary stage of a septic to sewer conversion should encompass an exploratory task. This involves conceptually ascertaining the quantity of parcels, projected flow rates, the technology for the collection system, and identifying at least five parcels that fulfill both size and geographical criteria. Given the potential delays inherent in the land acquisition phase, it is advisable to begin negotiations before embarking on any data gathering activities, such as surveying or geotechnical assessments.

Power Upgrades

Challenge: Delays by the power company in delivering electrical upgrades.

Issue: Pump stations for septic to sewer conversions are typically situated in residential areas, which usually have access to single-phase, 120V power. However, when a three-phase, 480V power supply is the preferred option for a pump station, power companies must undertake the installation of extra transformers, power poles, conduits, and more. Given the extensive portfolio of projects managed by power companies, scheduling these installations can be significantly delayed, potentially postponing the initiation of construction activities.

Lesson Learned: Early identification of power infrastructure deficiencies, and proactive coordination with the local power company are essential to mitigate delays and ensure the successful implementation of septic-to-sewer projects.

Private Roads

Challenge: The absence of comprehensive public records or utility maps detailing private roads maintained by individual landowners or homeowners' associations creates uncertainty about the roads' precise locations, dimensions, and ownership.

Issue: This lack of clarity hampers route planning for utility installations, as the infrastructure may need to cross these private roads or require access easements adjacent to them. Without accurate data on the existence and specifics of these roads, utility projects can encounter unexpected hurdles. These might include legal disputes with property owners over the rights to access these roads or construction difficulties that were not anticipated in the planning phase.

Lesson Learned: The key takeaway is the critical importance of identifying all private roads within the project's designated service area before finalizing the design. This proactive step is necessary to mitigate potential legal and construction-related issues. It underscores the need for thorough research and engagement with property owners or homeowners' associations early in the project planning process to gather essential information about private roads. By doing so, project planners can avoid costly delays, ensure smoother implementation, and enhance the project's likelihood of success.

Septic Tank Locations

Challenge: In executing a septic to sewer conversion within a developed service area, the challenge lies in minimizing the disruption and cost to the community. This entails limiting the extent of driveway repairs and reducing the length of laterals on private property. A critical piece

of information for achieving this goal is the location of existing septic tanks, which is not readily available and can be challenging for surveyors to pinpoint.

Issue: The difficulty in accessing the location of septic tanks complicates the planning and implementation of the sewer system. Without this information, determining the optimal placement for private laterals to connect homes to the new sewer lines becomes a guessing game. This uncertainty can lead to unnecessary excavation, increased costs for homeowners, and unnecessary repairs to driveways, all of which can cause discontent in the community and hinder the project's progress.

Lesson Learned: The lesson learned here is the importance of proactively collecting detailed information on septic tank locations to inform the planning process. By mailing site surveys to property owners, the design team was able to obtain the necessary data to guide the installation of private laterals efficiently. This strategy helps to ensure that the laterals are installed on the same side as the existing septic tanks, minimizing the need for extensive excavation and driveway repairs.

Escalating Costs

Challenge: Utility Improvement projects are grappling with the substantial challenges brought on by the cost escalation of manufacturing and construction goods, a direct consequence of the pandemic. This inflation has particularly impacted municipal civil projects. The disruptions in supply chains during the pandemic have resulted in shortages and heightened prices for key construction materials like steel, lumber, and concrete. These disruptions challenge the ability to manage project budgets and adhere to timelines effectively.

Issue: The rapid increase in construction costs may result in municipalities discovering that their original construction budgets are insufficient to cover the planned expenses, putting the feasibility of completing the project at risk. The fluctuating costs and availability of materials necessitate continuous revisions to project plans, which could affect the initially intended scope, quality, or completion timeline of projects.

Lesson Learned: The need for flexibility and forward planning when facing unanticipated hurdles was key to overcoming this challenge. The project team revised the boundaries of the service area, implementing a phased approach that prioritized areas with the highest potential for nitrogen reduction. Alternative collection system technologies were also evaluated as needed. This strategy ensured that priority areas were constructed first with the available construction funding. Collection service to remaining parcels would be provided service in a future phase, providing the municipality with the opportunity to obtain the necessary additional funding.

REFERENCES

Save Our Indian River Lagoon Project Plan Update. Prepared by Tetra Tech and Closewaters, LLC. February 2024.