SEPTIC SYSTEMS VULNERABLE TO SEA LEVEL RISE

November 2018

Final Report in support of Resolution No. R-911-16

This report was developed collaboratively by the
Miami-Dade County Department of Regulatory & Economic Resources
Miami-Dade County Water and Sewer Department &
Florida Department of Health in Miami-Dade County (Dr. Samir Elmir)

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Figure 1: King Tide flooding in a neighborhood served by septic tanks

Executive summary

Wastewater in Miami-Dade County is generated by domestic and non-domestic sources. Domestic wastewater includes residential (such as single family residences and apartment buildings) and commercial sources (such as office buildings and restaurants). Domestic sources primarily originate from water use associated with bathrooms (sinks, toilets, and showers), laundries (washing machines and sinks), kitchens (sinks and garbage disposals), and general cleaning (mop sinks). Non-domestic sources include industrial, manufacturing, and institutional facilities.

In Miami-Dade County, wastewater is handled under two broad categories: (1) onsite (decentralized) systems and (2) regional (centralized) systems. Onsite systems include septic systems and are used where centralized systems are not available. Centralized systems include private and public pipes, manholes and pumps which move (convey) wastewater from buildings to locations where treatment and disposal occurs. There are approximately 105,000 parcels served by septic tanks, approximately 100,000 of which are within the Urban Development Boundary (UDB). The centralized system is referred to as the Wastewater System and includes the collection and transmission systems and treatment plants.

This report provides an overview of how septic systems may be impacted by current and future water levels. A separate report, completed pursuant to Resolution No. R-908-16, assesses how sea level rise may affect sanitary sewer and stormwater systems.

Septic systems treat wastewater from individual properties. The wastewater from kitchens, bathrooms, and other sources is partially treated as the wastewater flows through a septic tank and subsequently a drainfield, where the clarified liquid is further treated by the unsaturated soil. Thus, by design, the drainfield must be above the groundwater table and remain unsaturated to function effectively. Consequently, septic systems are highly vulnerable to rising groundwater levels. In fact, rising sea levels are already affecting septic systems in certain areas and these impacts are expected to increase over time.

Since 1994, sea levels have risen four inches and are expected to increase an additional two to six inches by 2030. This has, in turn, led to higher groundwater levels in certain areas. The County, in collaboration with the U.S. Geological Survey, has identified how sea level rise will increase groundwater levels over the longer term. During times of elevated groundwater levels, septic systems cannot function as designed. Improperly functioning septic systems can pose an immediate public health risk. There are also many financial and environmental risks, including contamination of the freshwater aquifer, which is the community's sole source of potable water.

Rising sea and groundwater levels will impact the lowest lying areas first; however, these vulnerable areas are scattered across the County and are not confined to the coast. In some low-lying areas, the groundwater levels are already just a few feet below the surface. The following report identifies areas where groundwater levels are currently so close to the surface that the existing septic systems are likely compromised and may no longer be providing adequate treatment at least part of the year. The report also specifically identifies areas where those risks are most severe and systems are vulnerable to complete failure or are compromised during the average rainy season conditions each year, not just during particularly wet years or storms. In addition to this initial analysis of areas that are most at risk today due to current water levels, this study also identifies areas that are expected to be impacted by 2030 and 2040.

Within the next 25 years, the County can expect the number of residential systems that may be periodically compromised during storms or wet years to significantly increase from approximately 56% today (58,349 parcels) to more than 64% by 2040 (67,234 parcels). The highest risk areas are those where parcels are compromised under average conditions as these are vulnerable a significant portion of the year. While sea level rise will increase the number of affected properties, there are already almost 1,000 properties likely failing under current conditions. Of these highest risk properties, the vast majority (88%) are located in unincorporated Miami-Dade County.

This report includes potential approaches to limit this vulnerability through infrastructure improvements and policy changes. Finally, the report includes cost estimates from previous studies that examined extending sewer service and potential funding mechanisms. Subsequent work will be needed to identify the appropriate mechanisms for local governments and property owners to manage the potential costs associated with these impacts and improvements.

Supporting resolution

On October 5, 2016, the Board of County Commissioners (Board) passed Resolution No. R-911-16, which directs the Mayor or Mayor's designee,

> "to study and assess how sea level rise may affect septic systems in Miami-Dade County, and to prepare a report. The report shall, at a minimum, identify: (1) how septic systems may be affected by sea level rise; (2) the potential risks involved; (3) areas of the County that could be most impacted; (4) recommendations on how best to eliminate the vulnerability of septic systems to sea level rise; and (5) recommendations as to any further legislative or administrative action that may be necessary to address the vulnerabilities and problems identified, including, but not limited to, seeking funding from the state for purposes of carrying out the objectives of this item."

In response to this Resolution, this report provides an overview of how septic systems may be impacted by current and future water levels, outlines how rising sea levels may already be affecting septic systems in certain areas, describes which areas will be impacted in the future, and provides recommendations for how to address these issues.

Much of Miami-Dade County is already vulnerable to flooding. Even in the urban core, there are areas where today's water levels are compromising the effectiveness of existing septic systems. Several municipalities are also exploring similar issues related to septic tanks; however, this report will focus primarily on the efforts led by the County.

Background, previous reports and initiatives to extend sewer services

This report builds on several previous studies that identified areas without wastewater service and provided recommendations on how to incrementally extend services. All of the studies described below were completed by the Miami-Dade Water and Sewer Department (WASD) and provide useful guidance on how to phase and fund sewer extensions. It is important to note that the studies have varying scopes in terms of property types (residential vs. commercial), service areas, and upstream and downstream cost components that should be considered when comparing outcomes. Some of the following studies to connect commercial and industrial properties to the County's wastewater treatment system informed the existing Building Better Communities General Obligation Bond Program Project No. 17 - "Countywide Water and Sewer System Enhancements," which funds the connection of ten projects based on a prioritization methodology. A preliminary analysis conducted in 2013 by WASD estimated a cost of $2.3 Billion to connect residential properties. This was followed by a more detailed study in 2016, which included the cost of infrastructure to support the additional service, such as force mains and pump stations, and estimated the cost to connect pockets of residential properties (approximetaly 83,000 septic systems) at $3.3 Billion. A summary of the studies and analysis are provided below.

MIAMI-DADE GREEN TECHNOLOGY CORRIDOR WATER AND SEWER STUDY

This study, completed in April 2012, examined the water and sewer infrastructure needs of the commercial and industrial areas inside the "Miami-Dade Green Technology Corridor." The Corridor was established in March 2011 via Board Resolution No. R-197-11 to help focus economic development and marketing efforts around companies and entrepreneurs that deal with renewable energy, energy efficiency, and other environmentally beneficial technologies. The Corridor is located in the unincorporated area bounded by Northwest 127th Street to the North, Northwest 27th Avenue to the East, Northwest 37th Avenue to the West, and the Miami River to the South. The report identified water and sewer infrastructure deficiencies in that area and recommended a phasing plan to bring services there. The evaluation indicated that improvements were required including extending gravity sewers and increasing the capacity of existing pump stations. New infrastructure was proposed for a significant portion of the area without sewer services.

The project cost for the sewer infrastructure to serve all commercial and industrial properties inside the Corridor was estimated to be $31 million. Several projects have transitioned to design and construction and all Corridor projects are expected to be complete prior to 2022. These projects are funded by the Building Better Communities General Obligation Bond funds designated for funding extensions of sewer systems to commercial and industrial corridors. through Resolution No. R-537-14.

COST ESTIMATE TO CONNECT RESIDENTIAL AND COMMERCIAL PROPERTIES TO THE COUNTY'S WATER AND SEWER SYSTEM

In April of 2013, WASD issued an estimate of the costs to extend water and sewer infrastructure to various residential and commercial properties within its service area that are not connected to WASD's water and sewer systems. This report estimated that there were approximately 90,000 properties without sewer infrastructure within the County boundaries. More than 60,000 of those properties are within unincorporated Miami-Dade County.

The report estimated the costs for providing needed sewer infrastructure would be approximately $2.3 billion. The costs to provide sewer infrastructure to just the 3,000 commercial properties lacking service was estimated to be approximately $230 million.

SEWER SERVICE TO COMMERCIAL PROPERTIES IN MIAMI-DADE COUNTY

This study, completed in January 2014, developed a plan, including planning-level cost estimates and project schedules, to extend sewer infrastructure to commercial and industrial properties within WASD's service area. This report was developed to comply with the requirements of Resolution No. R-597-13, which directed the Mayor to provide a plan to extend sewer service to commercial areas and industrial areas.

The study identified 29 potential projects with an estimated cost of approximately $284 million, of which local infrastructure costs were estimated at approximately $233 million.

IDENTIFICATION, COST ESTIMATES, AND FUNDING OPTIONS FOR RESIDENTIAL POCKETS WITHOUT WATER AND/OR SEWER SERVICES

Published in December 2016, this report identified "doughnut" neighborhoods that do not have County nor municipal water and/or sewer service and are within a certain proximity of wastewater infrastructure. This report, developed in response to Resolution No. R-517-16 indicated there are more than 83,000 septic systems within unserved areas and surrounded by the existing regional wastewater system.

The estimated cost to connect the residential pockets within WASD's service area to the regional wastewater system was approximately $3.3 billion.

GOB COMMERCIAL CORRIDOR SEWER PROGRAM

Resolution No. R-537-14 approved the allocation of $126 million from the Building Better Communities General Obligation Bond Program Project No. 17 - "Countywide Water and Sewer System Enhancements" to fund extension of sewer system to developed commercial and industrial corridors of the County. The Research Section of the Regulatory and Economic Resources Department's (RER) Planning Division then developed a methodology to evaluate and rank the 29 projects proposed in the *Sewer Service to Commercial Properties* study developed pursuant to Resolution No. R-597-13. Each of these projects were ranked based on a variety of considerations including planning, environmental, special economic areas, land use, current business environment, and existing socio-economic condition. A description of the full methodology is included in Appendix 1. Ten projects were identified for completion with the available funding (Table 1).

Table 1: GOB commercial corridor sewer program projects

Rank	Project Name	Description[1]
1	Green Technology Corridor	Approximately area bound by 37th Ave and 27th Ave, NW 22th Street to NW 106nd Street
2	D2-D	NW 7th Ave. from NW 135th Street to NW 159th Street
3	D2-A	Various discontinuous areas along NW 27th Avenue from NW 135th Street to 81st Terrace, NW 74th Street to NW 68th Street, and NW 32nd Street to NW 20th Street.
4	D2-C	NW 22nd Ave. from NW 79th Street to 97th Street
5	D2-B	NW 79th Street from NW 27th Ave. to Miami Ave.
6	D7-A	South Dixie Hwy. from Franklin Avenue to SW 117 Street.
7	D9-A	South Dixie Hwy. (west) from SW 168th Street to SW 224th Street with extensions North to Lincoln Blvd. and West to 142nd Avenue
8	D8-A	Various discontinuous areas along South Dixie Hwy. (east) from SW 141st Street 304th Street
9	D3-A	NE 2nd Ave. from NE 91st Street to NE 119th Street
10	D10-A	SW 40th St. from SW 84th Ave. to SW 112 Ave.
1.	Project descriptions noted are illustrative of areas to be served. Please refer to attached figure indicating the geographical boundaries of each sewer corridor project. For more detailed information refer to Basis of Design Reports for each project.	

WASD has commissioned and completed Basis of Design Reports (BODRs) for the projects and is proceeding with detailed design and subsequent construction. Throughout the design and construction process, better information will become available regarding the anticipated cost of the respective corridor projects and a final determination made regarding projects to be completed with the allocated funding.

How could sea level rise affect septic systems?

Historic sea level rise

Sea levels have risen several inches since the incorporation of Miami in 1896. Over the past two decades, measurements at the Virginia Key tide gauge have indicated an increase of more than four inches in average sea levels since 1994.[1] These changes have in turn led to higher groundwater levels in portions of the County. Elevated groundwater can compromise certain underground infrastructure such as septic systems and french drains that rely upon unsaturated soils in order to function properly.

Projected future sea level rise

For planning purposes, Miami-Dade County relies upon the "Unified Sea Level Rise Projection for Southeast Florida," developed by the South Florida Regional Climate Change Compact(Figure 2).[2] The projection, which was updated in 2015 by a panel of scientists to reflect the best available data, indicates that mean sea levels could be between six to ten inches higher than 1992 levels by 2030. As mentioned, four inches of rise has already been observed in Miami since 1994. By 2060 the regional sea level rise projections suggest that planning for an additional 10 to 26 inches will be needed.[3]

Figure 2: Unified sea level rise projection for Southeast Florida

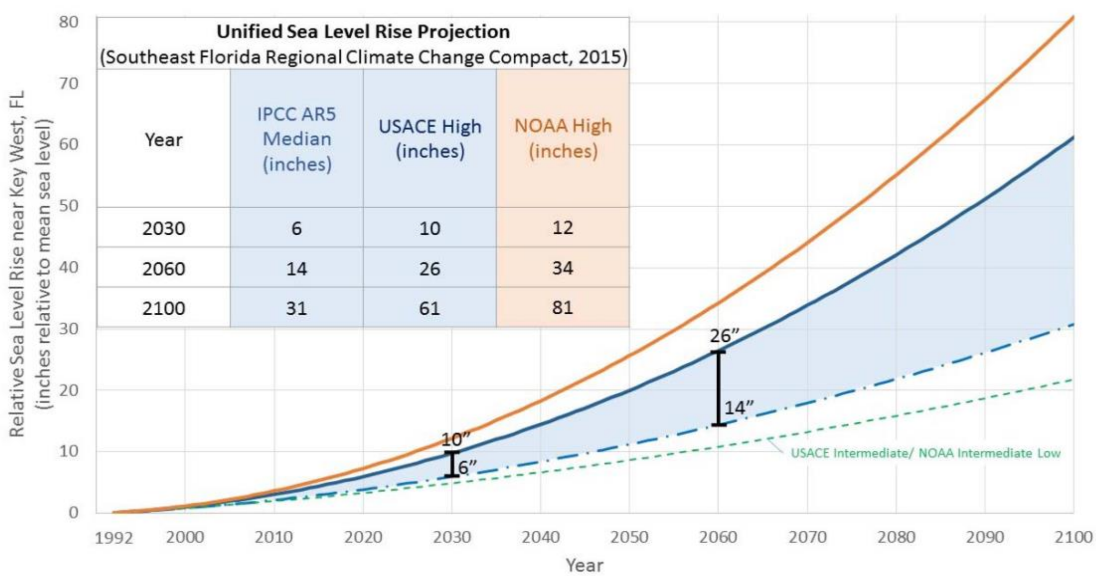


Figure 1: Unified Sea Level Rise Projection. These projections are referenced to mean sea level at the Key West tide gauge. The projection includes three global curves adapted for regional application: the median of the IPCC AR5 RCP8.5 scenario as the lowest boundary (blue dashed curve), the USACE High curve as the upper boundary for the short term for use until 2060 (solid blue line), and the NOAA High curve as the uppermost boundary for medium and long term use (orange solid curve). The incorporated table lists the projection values at years 2030, 2060 and 2100. The USACE Intermediate or NOAA Intermediate Low curve is displayed on the figure for reference (green dashed curve). This scenario would require significant reductions in greenhouse gas emissions in order to be plausible and does not reflect current emissions trends.

Source: Southeast Florida Regional Climate Change Compact

[1] This increase is based on the calculated increase in monthly mean sea levels measured at the Virginia Key tide gauge from 1994 through September 2017. Raw data are available from the National Ocean and Atmospheric Administration at https://tidesandcurrents.noaa.gov/stationhome.html?id=8723214

[2] Southeast Florida Regional Climate Change Compact Sea Level Rise Work Group (Compact) October 2015. *Unified Sea Level Rise Projection For Southeast Florida*. A document prepared for the Southeast Florida Regional Climate Change Compact Steering Committee

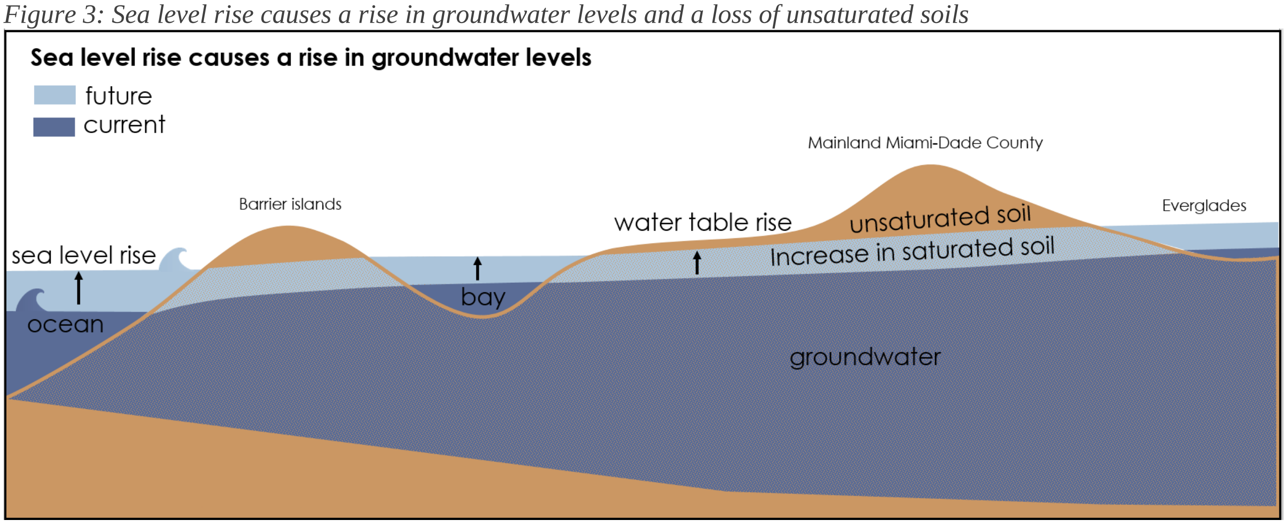
[3] These changes are all relative to the baseline year 1992.

Rising groundwater levels

Higher sea levels raise groundwater levels, and higher groundwater levels have been observed in coastal parts of the County.[4] The County, in collaboration with the U.S. Geological Survey, has recognized that rising sea levels will continue to increase groundwater levels in certain areas.[5] Many areas will experience groundwater levels within half a foot of the surface more than 25% of the year by 2040. For other areas, groundwater levels are expected to be within half a foot of the surface more than 75% of the year. In these places, it will be very difficult for septic systems to function properly unless they are elevated. Similarly other infrastructure that relies on unsaturated soils, such as french drains, will also be compromised in these regions. The coupled surface water/ groundwater model that was used to develop these estimates is described in more detail in the following section and was used to support this analysis of septic systems.

As the groundwater rises, the unsaturated zone (or thickness of unsaturated soils) is reduced (Figure 3). One important consequence of this shrinking unsaturated zone is the loss of the storage capacity in the soil that typically helps alleviate flooding after rain events.

Figure 3: Sea level rise causes a rise in groundwater levels and a loss of unsaturated soils



A reduction in the unsaturated zone can also be a problem for septic systems which rely upon the unsaturated soils underlying the drainfield to store and treat wastewater and reduce nutrients and pathogens emerging from properties (Figure 4). As groundwater levels rise and the area of unsaturated soil decreases, there is an increased risk of pollution or system failure, described in detail in the next section. **Septic systems were not designed with the assumption that groundwater levels would rise gradually over time** and as a result many are not functioning as they were originally designed. It should be noted that many septic tank drainfields include porous limestone bedrock versus soil substrates, which also may influence effluent quality.

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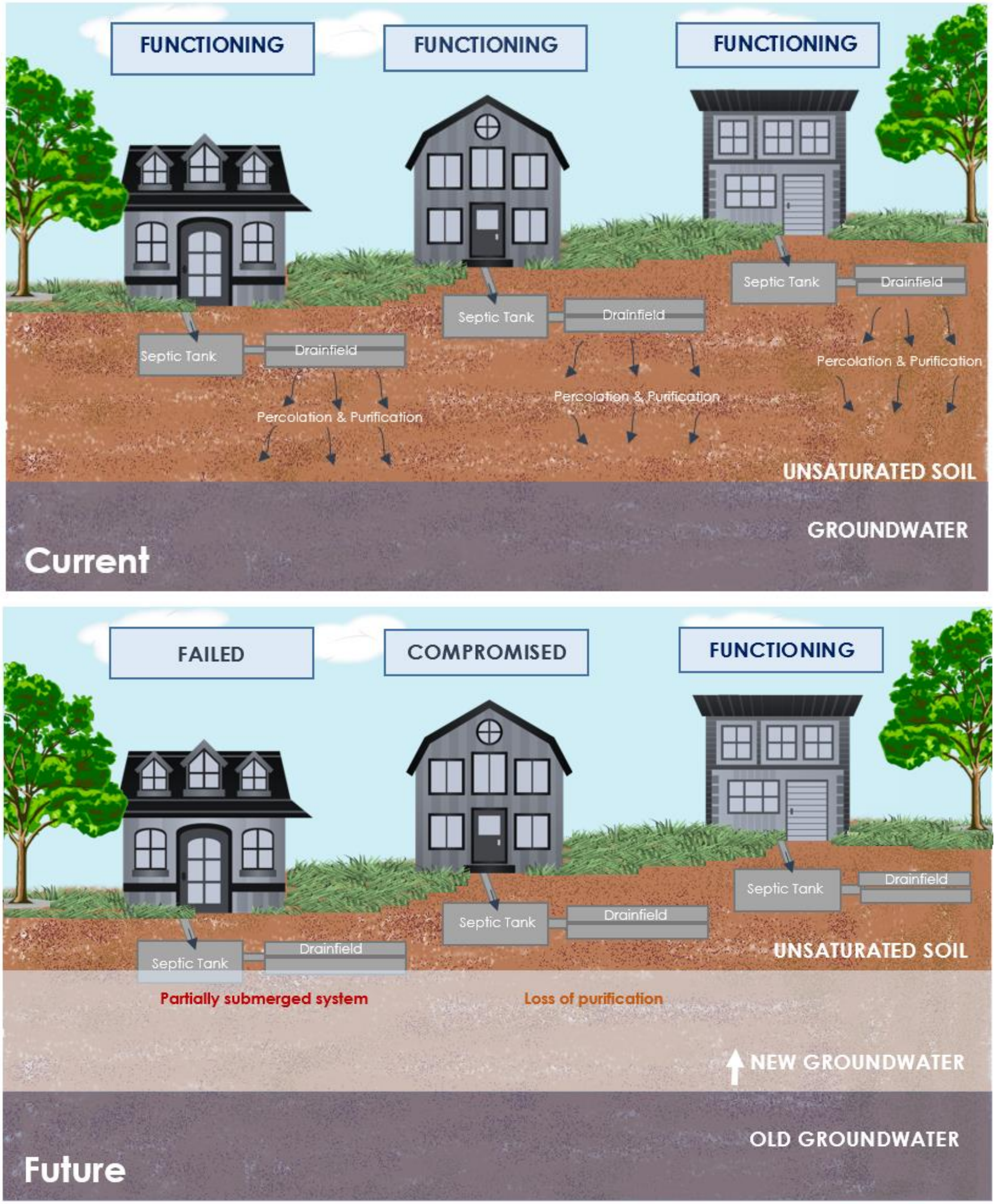
[4] Prinos, S.T., and Dixon, J.F., 2016, Data, Statistics, and Geographic Information System Files, Pertaining to Mapping of Water Levels in the Biscayne Aquifer, Water Conservation Areas, and Everglades National Park, Miami-Dade County, Florida, 2000-2009 - Scientific data associated with USGS SIR 2015-5005: U.S. Geological Survey Data Release, http://dx.doi.org/10.5066/F7M61H9W.

[5] Hughes, Joseph D., and White, Jeremy T., 2014, Hydrologic conditions in urban Miami-Dade County, Florida, and the effect of groundwater pumpage and increased sea level on canal leakage and regional groundwater flow: Scientific Investigations Report. http://pubs.usgs.gov/sir/2014/5162

Figure 4: How rising groundwater can compromise septic systems



How do elevated water levels compromise septic systems?

Septic systems treat and dispose wastewater from individual properties. The wastewater from kitchens, bathrooms, laundries, and other sources is gradually treated by allowing the wastewater to pass through the septic tank and, subsequently, the drainfield. The process is continuous; every drop of wastewater that enters the septic tank displaces a drop of wastewater already in the tank to the drainfield. In the septic tank, heavy solids settle to the bottom and light solids and liquids (e.g., oils and greases) float to the top of the tank. These solids and liquids are trapped in the tank itself and undergo limited treatment. Therefore, the septic tanks need to be periodically cleaned by removing the entire contents (liquids and solids) of the tank. The liquid waste that exits the septic tank flows inside drain pipes to the drainfield where the liquid gradually flows vertically down through the soil to the water table. To achieve removal of pathogens (bacteria and viruses) and other organic and inorganic pollutants, this vertical flow must be achieved under unsaturated flow conditions. Unsaturated flow conditions allow for aerobic conditions in the soil matrix and the air filled soil voids slows the vertical flow which maximizes the treatment time. Unsaturated conditions provide for wastewater treatment by adsorption, absorption, aeration, filtration, and biochemical reactions.

To achieve unsaturated flow conditions, a minimum vertical separation must be maintained between the bottom surface of the drainfield and the wet season high water table year round. The Environmental Protection Agency's Design Manual, Onsite Wastewater Treatment and Disposal Systems (EPA 625/1-80-012), recommends a minimum separation between the bottom surface of the drainfield and the wet season high water table of 24 to 48 inches. The minimum separation required by the Florida Department of Health (FDOH) is 24 inches (Chapter 64E-6, Florida Administrative Code). Furthermore, the FDOH defines the wet season water table as the highest water table elevation determined, based on a site specific soil survey and soil-based features (e.g., redoximorphic features). This water table elevation is typically higher than the physical measurement of the water table in a bore or well.

Septic systems can fail in two ways. First, there can be a hydraulic failure which is relatively easy to detect. A *hydraulic failure* typically manifests as wastewater surfacing on the ground or a backup in plumbing which is often immediately noticeable. In contrast, the other type of failure, a *treatment failure*, may be more difficult to notice. These can go undetected for years. With a treatment failure the plumbing may be functioning just fine; however, the wastewater may move relatively unimpeded to ground and surface waters in a saturated manner. Because the vertical section of soil between the bottom surface of the drainfield is saturated, wastewater moves through the soil faster, reducing treatment time. Because aerobic conditions are not achievable under saturated flow conditions and treatment time is reduced, wastewater entering groundwater is not being adequately treated increasing the risk of contamination and risk of human health impacts.

Because much of the treatment of wastewater relies upon the unsaturated soil below the drainfield, treatment and disposal are less effective as more of the soil becomes permanently saturated with rising groundwater resulting from sea level rise. A higher groundwater table reduces the volume of soil available to treat and dispose of the wastewater which increases the likelihood of failure and contamination. The volume of unsaturated soil underneath the drainfield impacts the septic system's ability to efficiently remove pollutants.

According to Dr. Samir Elmir from the Florida Department of Health:

"The volume of unsaturated soil underneath the drainfield impacts the [septic system's] ability to efficiently remove pollutants. It has been shown that aeration of effluent in the unsaturated soil is important in achieving decomposition of organic particles and compounds, in effectively removing phosphorus, in facilitating nitrification that serves as the basis for denitrification to remove nitrogen, and in decreasing bacteria and viruses.[6] In addition, effluent moves more slowly in unsaturated soil than in saturated soil, and, therefore, experiences a longer treatment time and a better opportunity for many pollutants to be removed.[7] Studies conducted in Florida show that the concentrations of various contaminants from the septic tank decrease considerably with the increase of the depth of unsaturated soil.[8] Bacteria and viruses from wastewater treated by septic systems travel considerable distances in saturated soil and cause groundwater pollution.[9]"

In many areas, the distance between the surface and the groundwater table is very small, and further rise in groundwater levels can result in hydraulic failure and cause the drainfield to be flooded, especially during the wet season. As Dr. Elmir notes, "a compromised treatment function may result in the relatively unimpeded movement of wastewater contaminants to ground and surface waters." Reduced treatment can cause contamination, in the form of disease-causing pathogens, excess nutrients, and chemical contaminants that may pose a potential risk to both human and environmental health. For example, insufficient treatment can result in nutrient pollution, in the form of nitrate and ammonia, which can have significant financial, health, and environmental impacts. Elevated levels of these pollutants may require additional treatment of groundwater, increasing the cost of providing safe potable water. If left untreated, nitrate and ammonia can degrade surface waters.[10] Insufficient treatment may also increase the persistence of bacterial, viral, and protozoan pathogens in the environment from wastewater that may contaminate groundwater, terrestrial runoff, and coastal environmental waters (including recreational waters), thereby putting both the public and ecosystems at increased risk from exposure to this under-treated wastewater.
A typical section of a drainfield before and after groundwater rise is shown in Figure 4. A similar figure, Figure 5 shows how the required minimum distance between the bottom surface of the drainfield and the wet season high water table has changed over time. The current standard of 24 inches of separation is significantly stronger than the older regulations which only required a separation of 12 inches.[11] Because of the relative weakness of previous standards, neighborhoods that were developed earlier are more vulnerable to rising groundwater. This risk is compounded by the fact that many of the older neighborhoods within unincorporated Miami- Dade County and the Urban Development Boundary that have not been substantially redeveloped are also, often areas of more

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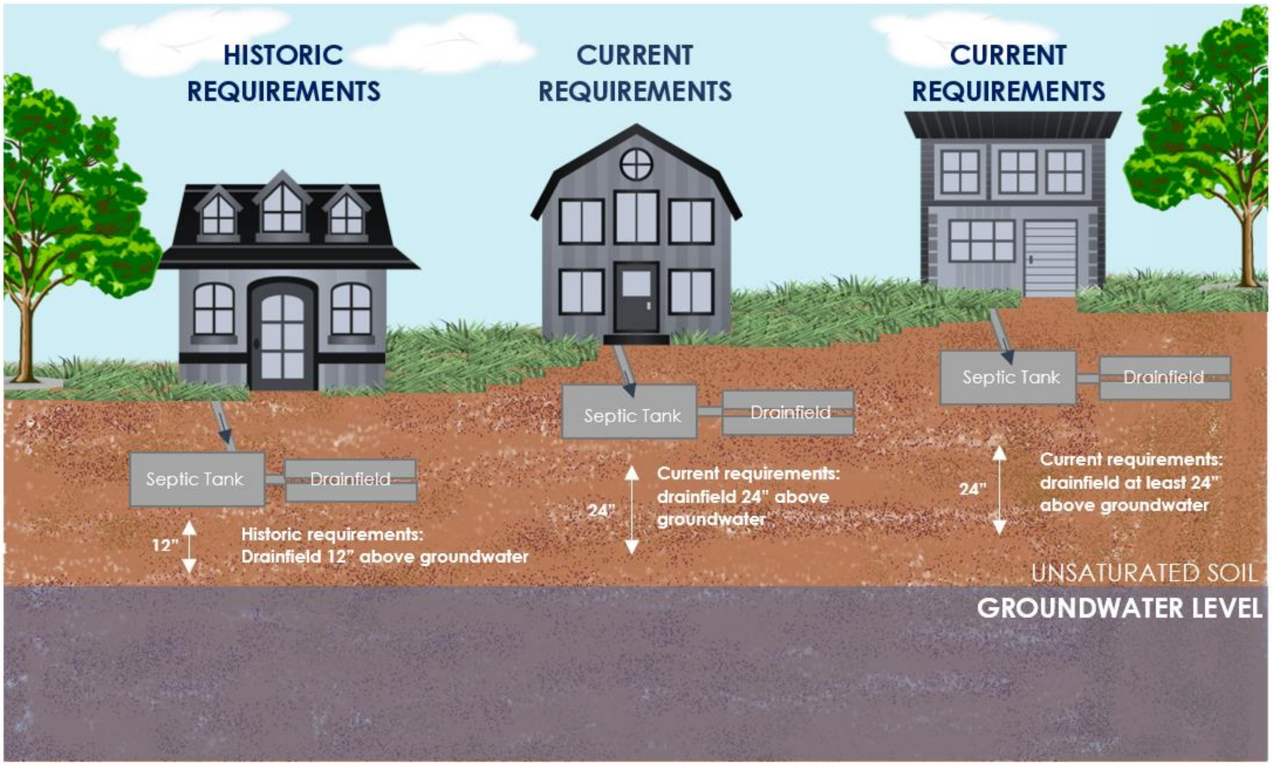
[6] Bicki, T. J., R. B. Brown, M. E. Collins, R. S. Mansell, and D. F. Rothwell. 1984. Impact of On-Site Sewage Disposal Systems on Surface and Ground Water Quality. Report to Florida Department of Health and Rehabilitative Services under Contract number LC170.
[7] Bicki, T. J. and R. B. Brown. 1990. On-Site Sewage Disposal – The Importance of the Wet Season Water Table. Journal of Environmental Health 52(5): 277-279
[8] Anderson, D. L., A. L. Lewis, and K. M. Sherman. 1990. Unsaturated Zone Monitoring Below Subsurface Wastewater Systems Serving Individual Homes in Florida. IN: Proceedings of the National Environmental Health Association's Fifth Annual Midyear conference "Drinking Water and Groundwater Protection". Pp. 413- 438; Ayres Associates. 1989 Onsite Sewage Disposal System Research in Florida – Performance Monitoring and Ground Water Quality Impacts of OSDSs in Subdivision Developments. Prepared for Florida Department of Health and Rehabilitative Services, Tallahassee, Florida.; Otis, R. J. 2007. Estimates of Nitrogen Loadings to Groundwater from Onsite Wastewater Treatment Systems in the Wekiva Study Area. Task 2 Report Wekiva Onsite Nitrogen Contribution Study
[9] Hain, K.E., and R.T. Obrien. 1979. The survival of enteric viruses in Septic tanks and septic tank drainfields. Water Resources Res. Inst. Rept. No. 108, New Mexico Water Resources Res. Inst., New Mexico State Univ., las Cruces, New Mexico.; Viraraghavan, T. 1978. Travel of microorganisms from a septic tile. Water, Air, and Soil Poll. 9:355-362
[10] "The Effects: Human Health." *EPA*, Environmental Protection Agency, 10 Mar. 2017, www.epa.gov/nutrientpollution/effects-human-health.
[11] More information about existing regulations can be found in Appendix 1.

affordable housing and more moderate income residents. Therefore, it is important to consider the broader socio-economic conditions when evaluating projects to reduce these risks.

Figure 5: Historic and current requirements for septic system clearance above groundwater levels



What are the risks associated with failed septic systems?
Improperly functioning septic systems can cause several problems. Most importantly, partial or complete failure of these systems can pose an immediate public health risk. There are also many environmental risks including contamination of the freshwater aquifer which the community depends upon for its drinking water and the coastal waters that provide for recreation, tourism, and ecological value. Finally, failures can compromise the usability of certain structures.

Public health and environmental concerns

According to Dr. Samir Elmir, "shigellosis, salmonella, hepatitis A, viral gastroenteritis and other human viral diseases are shed in human waste in extremely high numbers (order of millions) in waste discharged from both ill and healthy people." In addition, Dr. Elmir notes that, "Some of the pathogenic human organisms can survive harsh and various environmental conditions (extreme temperatures, various soil moisture conditions, rainfall, salinity, etc.) for a long time from one day to a couple of years." Water from the septic systems across the County are constantly recharging the Biscayne Aquifer, which is the main source of the County's drinking water. The public health risks are of particular concern for those properties that are served by both a septic system and well water, whose shallow withdrawals present a higher level of concern of contamination. Exposure to contaminants can result from drinking water or through contact with surface waters.

The U.S. Environmental Protection Agency (USEPA) has noted in previous studies that "Septic systems are a significant source of groundwater contamination leading to waterborne disease outbreaks and other adverse health effects."[12] According to the same resource, septic systems present a higher risk in certain areas. The Agency notes that:

> "Areas with high water tables and shallow impermeable layers should be avoided because there is insufficient unsaturated soil thickness to ensure sufficient treatment. Soil permeability must be adequate to ensure proper treatment of septic system effluent… If permeability is too high, the effluent may reach groundwater before it is adequately treated. As a result, alternative systems may be necessary in karst areas."

This report and another report from the Florida Department of Health also include more detailed information on other studies which have demonstrated the migration of viruses from septic tanks to coastal waters in the Keys, Sarasota, and Charlotte Harbor.[13]

Compromised systems can lead to water quality impacts and secondary impacts from excess nutrients and chemical contaminants from bathrooms, kitchen drains, and laundry units. Pollutants can include household chemicals such as solvents, drain cleaners, oils, paint, pharmaceuticals, and pesticides. Additionally, pollutants can include anthropogenic nutrients, in the form of nitrogen (e.g., nitrate, ammonia) and phosphorus. When properly sited, designed, constructed, maintained, and operated, septic systems are expected to provide an acceptable level of treatment and disposal of domestic sewage. That is, a well-functioning septic system, where the bottom of the drainfield is at least 24-inches above the wet season high water table, is expected to minimize groundwater and surface water impacts based on the separation of groundwater from the functioning drainfield.

Groundwater pollutants have the potential to migrate to private and public water wells, lakes, canals, and coastal and bay water ecosystems given the highly transmissive nature of the Biscayne Aquifer. Eutrophication, an increase in the rate of supply of organic matter to an ecosystem, caused by anthropogenic nutrient inputs, can result in the overstimulation of plant growth, including the proliferation of harmful "algal blooms" and "dead zones" in coastal marine ecosystems.[14] "Dead zones" are caused when blooms of algae die and sink to the sediment floor where the subsequent process of decomposition draws nearly all the oxygen out of the water column creating a "dead zone" and threatening the adjacent fish and crustacean populations. The National Oceanic and Atmospheric Administration (NOAA) has recently designated Biscayne Bay as one of their new Habitat Focus Areas based in part on concerns of declining water quality in Biscayne Bay including elevated levels of nutrients that can trigger algal blooms and seagrass dieoffs. The Division of Environmental Resources Management's (DERM) monitoring has documented a benthic algal bloom that has caused a seagrass die-off in Biscayne Bay near areas of high septic tank concentration, such as Coral Gables. In some basins of Biscayne Bay, chlorophyll 'a', which is an indicator of plankton in the water column, has been increasing. This is a potential indication that water quality in Biscayne Bay is being impacted to the point where nutrient inputs may be shifting the ecosystem from a clear water/low nutrient seagrass dominated system to a more turbid/elevated nutrient system dominated by algae which would be an expected result of eutrophication.

12 https://www.epa.gov/sites/production/files/2015-06/documents/2006_08_28_sourcewater_pubs_septic.pdf
13 http://www.floridahealth.gov/environmental-health/onsite-sewage/research/_documents/research-reports/_documents/seasonally-inundated-report.pdf
14 Definition of eutrophication put forward by Nixon. See: Nixon, S., "Coastal marine eutrophication: A definition, social causes, and future concerns". Ophelia, 41, 1 (1995) http://www.tandfonline.com/doi/abs/10.1080/00785236.1995.10422044>

Several waterways in the County are not currently meeting existing state water quality standards. Fecal coliforms and fecal enterococci are groups of bacteria found in the feces of warm-blooded animals such as people, livestock, pets, and wildlife.[15] The amount of fecal coliforms or fecal enterococci in a waterway can increase with the amount of human sewage waste and/or animal manure. While the relationship between compromised septic systems and impaired waterbodies has not yet been studied, there is a need to analyze the extent to which compromised systems are a contributor to watersheds with elevated levels of fecal coliform. It should be noted that septic tanks are not the only source of nutrients to the Bay since leaks in the sewage collection and transmission system, in addition to stormwater runoff to surface water, may also contribute nutrients to the surrounding groundwaters and the Bay. Additional sampling and analysis is needed to understand and quantify the contributions from the various sources.

The presence of enteric bacteria is an indication of fecal pollution, which may come from stormwater runoff, pets, wildlife, human sewage, or flushing of urban infrastructure and contaminated soils. If these fecal bacteria are present in high concentrations in recreational waters or floodwaters and are ingested while swimming or enter the skin through an open wound, they may cause human disease, infections or rashes. The populations most at risk are the elderly, children, individuals who may be immunocompromised, and individuals with open wounds or sores who swim in contaminated waters or are exposed to these floodwaters. The risk of exposure to the public can be substantially reduced by limiting exposure to contaminated surface waters and floodwater or if that is not avoidable, then by good hygiene practices such as hand-washing and showering after exposure.

During a single King Tide event in November 2016, measurements of fecal enterococci and genetic measurements of human-host-specific fecal bacteria indicated high levels of bacterial contamination in the floodwaters. These measurements were collected as part of an on-going joint pilot survey by the NOAA, Florida International University, University of Miami, and NOVA Southeastern University. These researchers have conducted initial measurements of nutrient and microbial contaminants in urban tidal floodwaters.[16] One location of concern is near the Little River (close to the Little River Pocket Park). At that location, they measured live fecal enterococci in the floodwaters at levels between 3,700 and 5,200 colony forming units (cfu)/100mL.[17] In the opinion of the researchers, these levels present potential risks to public health.[18] The USEPA recommends enterococci levels below a geomean of 30 or 35 enterococci CFU per 100mL for both marine and

[15] "Fecal coliforms" are a broad group of rod-shaped intestinal bacteria with thin cell walls (i.e. "Gram negative") that have been used for many decades as fecal indicator bacteria. *Escherichia coli* (*E. coli*) is a specific species of this group that is the most commonly used fecal coliform indicator today. "Fecal enterococci" are a different group of thick cell walled (i.e. "Gram positive") spherical-shaped intestinal bacteria that have been widely used as a marine water quality indicator since the 1980's. Enterococci are considered by US EPA to be better fecal indicator bacteria than fecal coliforms in marine and brackish environments. Both bacterial groups are still used as water quality indicators for regulatory water quality criteria.

[16] Live enterococci was measured by the standard EPA method 1600, while genetic markers specific for human-associated Bacteroidales and dog-associated Bacteroidales bacteria were measured by real-time PCR using genetic assays developed and validated by the USEPA and NOAA.

[17] They also measured human-specific fecal Baceroidales genetic marker between 588-781 GE/100 mL. Dog Baceroidales were measured between 1,227-2,324 TSC/ 100 mL.

[18] As of January 2016, the Florida Department of Health has adopted new water quality criteria for use in the Healthy Beaches Program. These criteria reflect the most current, 2012 Recreational Water Quality Criteria, recommendations and water quality grant requirements put forth by the United States Environmental Protection Agency. Recreational waters in Florida are rated on a geomean as: Good: 0-35 Enterococci CFU per 100 ml of marine water, Moderate: 36-70 Enterococci CFU per 100 ml of marine water; Poor (unsatisfactory): 71 or greater Enterococci CFU per 100 ml of marine water.

fresh water to maintain a bather illness rate below key thresholds.[19] The table below (Table 2) shows values highlighted in yellow from the Little River area that the researchers consider substantially elevated above expected backgrounds that might pose a public health risk.[20] The levels of fecal bacterial contamination in many of the samples from these floodwaters are orders of magnitude above recreational water quality criteria or expected background levels.

Table 2: Bacterial water quality measurements taken by NOAA during the October 2016 King Tide flooding near the Little River Pocket Park

sample ID#	**viable (live) enterococci** cfu/100mL	**qPCR Total Enterococci** by EPA Entero1 GE / 100mL	**qPCR Human Bacteroidales** by BacHum-UCD GE / 100 mL	**qPCR Human Bacteroidales** by EPA HF-183 GE / 100mL	**qPCR DOG Bacteroidales** by DogBact TSC / 100mL
Miami Shorecrest – Little River Pocket Park – at canal:					
SCC-1 (08:40am)	5,200	8,380	625	618	1,227
SCC-2 (11:31am)	4,100	4,613	781	699	2,019
SCC-3 (14:00pm)	3,700	4,096	588	602	2,324
Miami Shorecrest – Little River Pocket Park - street flooding at storm drain manhole by street at opposite end of park (other side of park from canal):					
SCS-1 (08:25am)	7900	10,282	577	553	2,517
SCS-2 (11:27am)	1500	7,391	433	461	2,920
SCS-3 (13:45pm)	>30,000	117,260	619	597	3,114

Yellow highlight with red text = in exceedance of Florida regulatory criteria for recreational waters
Yellow highlight with black text= High – (no regulatory standards yet for these markers, but target abundance is substantially above background and may represent a potential public health risk).

Source: NOAA For more information, please contact Dr. Christopher Sinigalliano, Principal Investigator of the NOAA-AOML Environmental Microbiology Lab, email: Christopher.Sinigalliano@noaa.gov,

Level of service concerns

In addition to the very serious health and environmental concerns noted above, improperly functioning septic systems can also greatly limit the usability of a structure and be an inconvenience to the property owner or tenant. Any interruption in service can have an immediate impact on quality of life. In the event of a complete failure, these problems may require substantial investment in repairs or affect property values.

[19] The latest update for the EPA 2012 criteria has two different criteria thresholds of enterococci geomean for two optional levels of illness rate protection that States can adopt: Option 1: Geomean of 35 cfu/100mL for illness rate of less than 36 per 1000 bathers; Option 2: Geomean of 30 cfu/100mL for illness rate of less than 32 per 1000 bathers. States can choose their desired level of protection but should at least conform to the GM 35cfu/100mL standard. For more details see table 4, page 43 & table 6 page 46 of the US EPA 2012 RWQC. Additionally, there are currently no promulgated regulatory criteria for exposure thresholds of Microbial Source Tracking human-specific or dog-specific fecal Bacteroidales markers . USEPA recommended criteria for enterococci by qPCR assay is less than 470 GE/100mL (US EPA 2012 Recreational Water Quality Criteria, USEPA Office of Water document 820-F-12-058).

[20] Chris Sinigalliano, National Oceanic and Atmospheric Administration, personal communication.

Figure 6: A King Tide in 2016 in a neighborhood served by septic tanks

Which areas could be most impacted?
Rising sea and groundwater levels will impact the lowest lying areas before higher ground; however, these vulnerable areas are not confined to the coast and are scattered across the County. There are many other inland areas near water bodies in the southern and western parts of the County that will be affected because the water table can be within 24 inches of the surface and impact the functionality of septic systems.

The following section describes the approach that was used to identify vulnerable areas. This analysis is meant to identify areas which are likely to be vulnerable due to very high groundwater levels. This study has not determined that the following areas are currently compromised or will be compromised, but has instead identified parcels that could potentially be compromised. It should be noted that there may be various site-specific factors that make a system less vulnerable, such as using a mounded system. Conversely, there may also be local conditions that make a system more vulnerable such as a lack of adequate maintenance or poor soil conditions.

Methodology to identify vulnerable areas

This study began with an analysis of areas that are currently at the highest risk due to historic water levels. Itthen explored areas that are expected to be impacted by 2030 and 2040 with higher sea and groundwater levels. The analysis of currently vulnerable areas is shown below as the "base case scenario." Future vulnerabilities due to sea level rise are shown as the "sea-level scenarios" (Table 3).

Table 3: Description of modeled scenarios

	Base-Case Scenario	Sea-Level Scenarios
Description	Represents areas that may already be impacted by current water levels	Represents areas vulnerable due to anticipated sea level rise and groundwater rise
Water Level Data	Historical data from Virginia Key tide gauge	Representative of a National Research Council curve III increase (National Research Council, 1987) (Figure 8). This represents an increase of approximately 15 inches from 2011 through 2040.

To identify areas where septic tanks may already be impacted by current water levels and areas that could be impacted by future water levels this study relied on the following data sources and assumptions (Table 4).

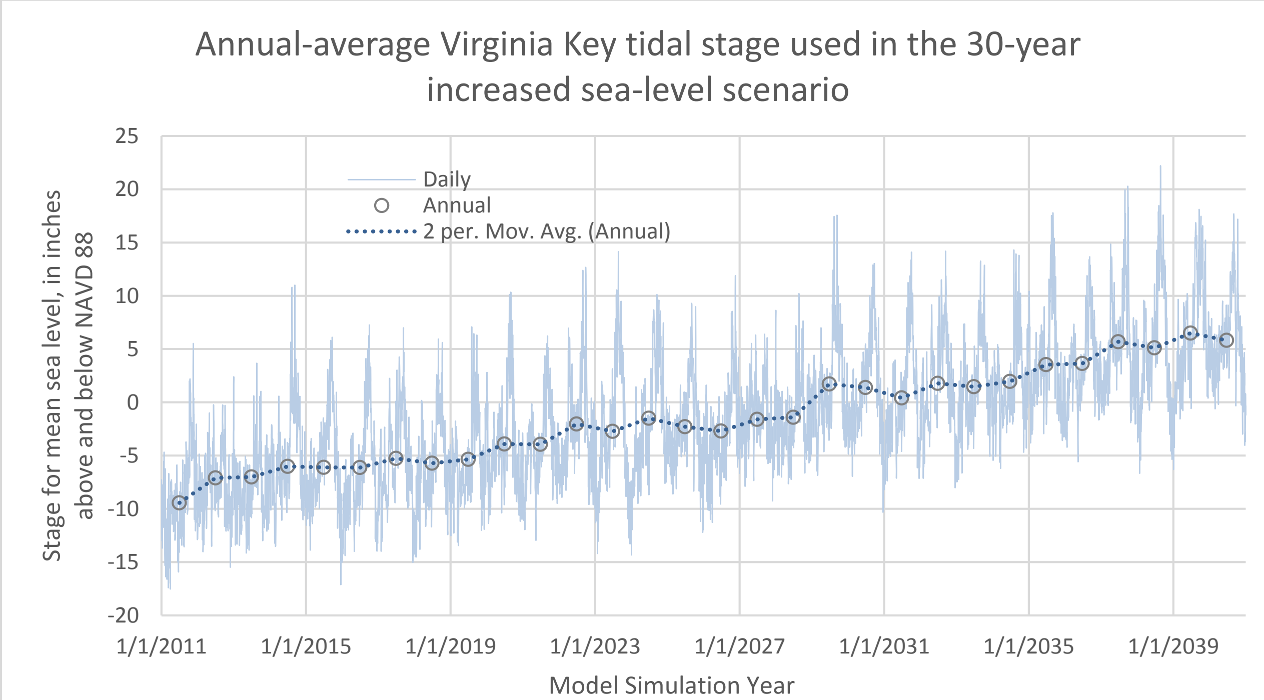
Table 4: Description of data sources

Data Source	Description
Land surface elevation	5-foot Digital Elevation Model derived from 2015 LiDAR (source: Miami-Dade County)
Groundwater levels	Derived from the U.S. Geological Survey's Surface Groundwater Model. Based on USGS model "Increased Sea Level" scenario (Hughes and White, v.1.2, 2016). This assessment used a 30-year simulation period from 2011-2040 and used daily time steps. Precipitation was based on repeating climate conditions from 1996-2010 and assumed that groundwater pumpage was conducted with the allocation projected to year 2033 and the regional canal system operations able to maintain the minimum flows and levels (MFL's) as designed. (Miami-Dade Consolidated PWS Water Use Permit; currently active and issued on 2015).

Sea level rise	Consistent with the "Unified Sea Level Rise Projection for South Florida"[21] this study assumed mean sea level increased 15.26 inches from an annual average stage of –9.43 in 2011 to 5.82 inches NAVD 88 at the end of the 30-year scenario simulation period (Figure 8). A sea-level change was applied to average daily predictive tides, which were calculated as a function of predicted and observed average daily tide, for the 15-year period from 1996-2010 and used twice in a repeating pattern to define the entire 30-year scenario simulation period. This assumes that historic interannual variability will repeat over the next several decades. Note that the annual average stage as documented in Hughes and White (2016) was corrected (4.37 inches upward) to match the sea levels observed during 2011-2016. Throughout the subsequent time period (2017-2040) sea levels were increased according to the NRC curve starting with a corrected initial value for 2017.
Areas assumed to have septic systems:	Parcels without sewer service in Miami-Dade. This is inclusive of residential and non-residential properties, properties within and outside the Urban Development Boundary. This figure did not include properties that had abutting sewer but were not connected and excluded vacant land. (source: 2016 Tetra Tech study)
Precipitation	Precipitation was based on repeating observed climate conditions from 1996-2010 in both scenarios. These conditions were repeated twice to cover the full time period being studied (2011-2040). The observed conditions included a significant flood event which was replicated in the simulation in 2015 and 2030.
Regional System Operations	The operation of the regional system will significantly influence groundwater levels.

[21] Southeast Florida Regional Climate Change Compact Sea Level Rise Work Group (Compact) October 2015. Unified Sea Level Rise Projection For Southeast Florida. A document prepared for the Southeast Florida Regional Climate Change Compact Steering Committee

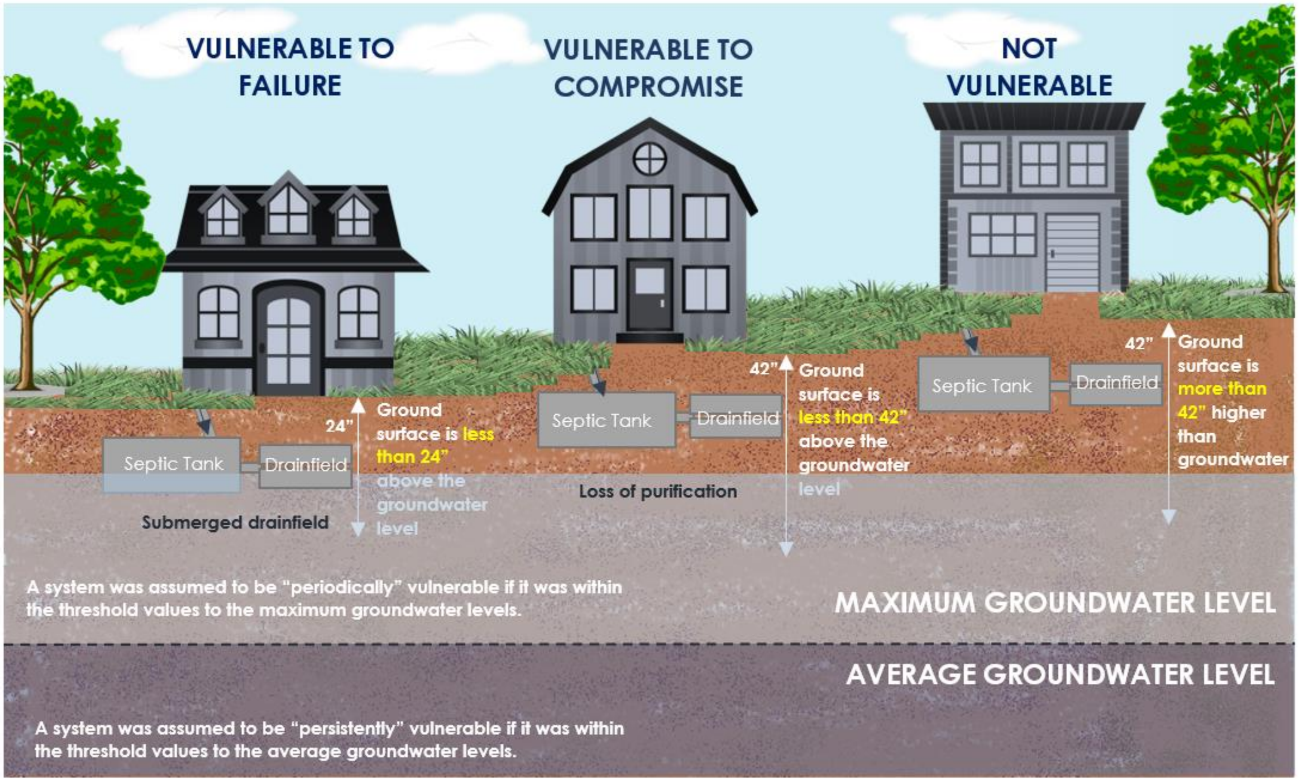
Figure 7: Calculated annual average Virginia Key tidal stage used in the 30-year increased sea level scenario (after Hughes and White, v.1.2, 2016)



To identify vulnerable areas this study relied on the following assumptions:

- A septic system was assumed to be vulnerable to compromise if the average wet season groundwater elevations were within 42 inches of the ground surface elevation (Figure 9). This assumes that the average bottom of drainfield is 18 to 24 inches below ground surface and the required minimum distance between the bottom of the drainfield and the water table elevation – to establish aerobic soils and unsaturated flow and thereby promote water quality treatment - at the wettest season of the year is 24 inches (Section 64E-6.006(2), FAC). Therefore, an average wet season groundwater elevation within 42 inches of ground surface will result in approximately 18 to 24 inches between the bottom of the drainfield and the water table elevation and less than 18 to 24 inches for the wettest season water table elevation. At these separations, water quality may be compromised.
- A septic system was assumed to be vulnerable to failure if the average wet season groundwater elevations were within 24 inches of the ground surface elevation (Figure 9). As noted above, assuming that the average bottom of the drainfield is at 18 to 24 inches below grade, an average wet season elevation within 24 inches of the ground would result in 6 inches to no separation for water quality treatment (i.e., direct groundwater discharge) and potential hydraulic failure at the wettest season water table.
- If a parcel was affected by high groundwater levels then the septic system within that parcel was also assumed to be vulnerable.
- Groundwater levels were determined for each model cell during the time period simulated (2011-2040).

Figure 8: Assumptions regarding vulnerability thresholds used in this report



Findings

Areas currently vulnerable

In some low-lying areas of the County, the groundwater levels are just a few feet below the surface. The following figure shows areas where those groundwater levels are so close to the surface that the septic systems are vulnerable to compromise and may no longer be providing adequate treatment at least part of the year or during rain storm events (Figure 9). The following map shows areas where those risks are more severe (Figure 10) and the septic systems are vulnerable to failure. The next figure (Figure 11) shows areas that are more concerning as the systems are likely compromised during average conditions. Figure 12 shows the areas that should be considered the highest concern from a public health and environmental perspective because they represent areas where water levels are elevated throughout the year. These areas have groundwater levels close enough to the surface (within 24") that they are likely causing septic systems to be persistently failing. These maps and the following tables show areas that may be vulnerable; however, site-specific conditions may reduce or increase the total number of vulnerable systems.

Areas vulnerable due to anticipated sea level rise

As sea level, and consequently groundwater, rise, the number of parcels affected predictably increases. The following figures highlight areas where septic systems could be compromised by 2030 (Figure 13) and 2040 (Figure 14). Those parcels shown in red and orange are potentially at risk. The impacts of sea level rise and related groundwater rise will predictably increase the number of legacy systems that are vulnerable to periodic or persistent impacts. Those areas that are not vulnerable today, but are expected to become vulnerable due to sea level rise between today and 2040, are shown in Figure 15.

Figure 9: Areas currently vulnerable to periodic compromise (maximum groundwater levels are within 42" of surface 2011-2017)

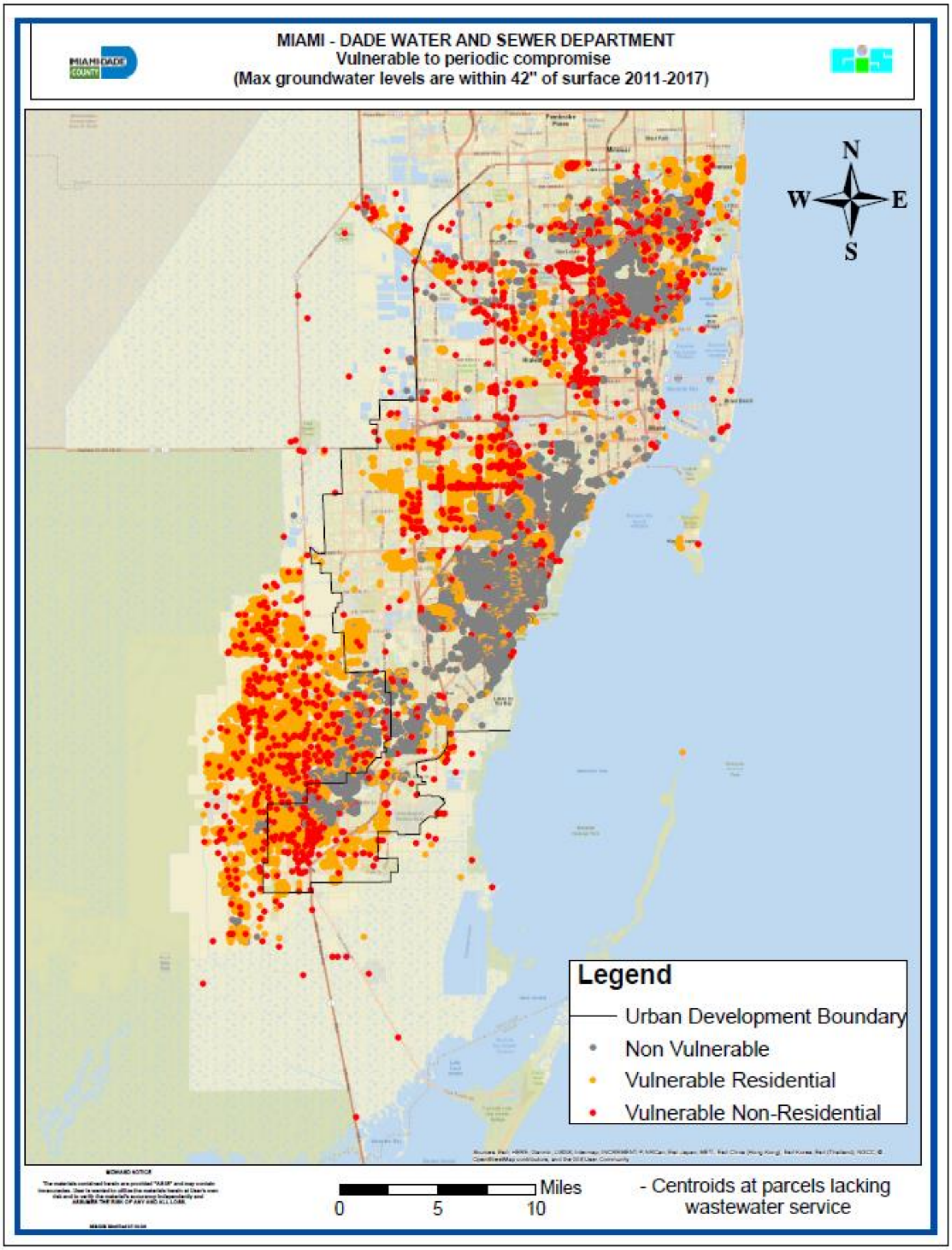


Figure 10: Areas currently vulnerable to periodic failure (maximum groundwater levels within 24" of surface 2011-2017)

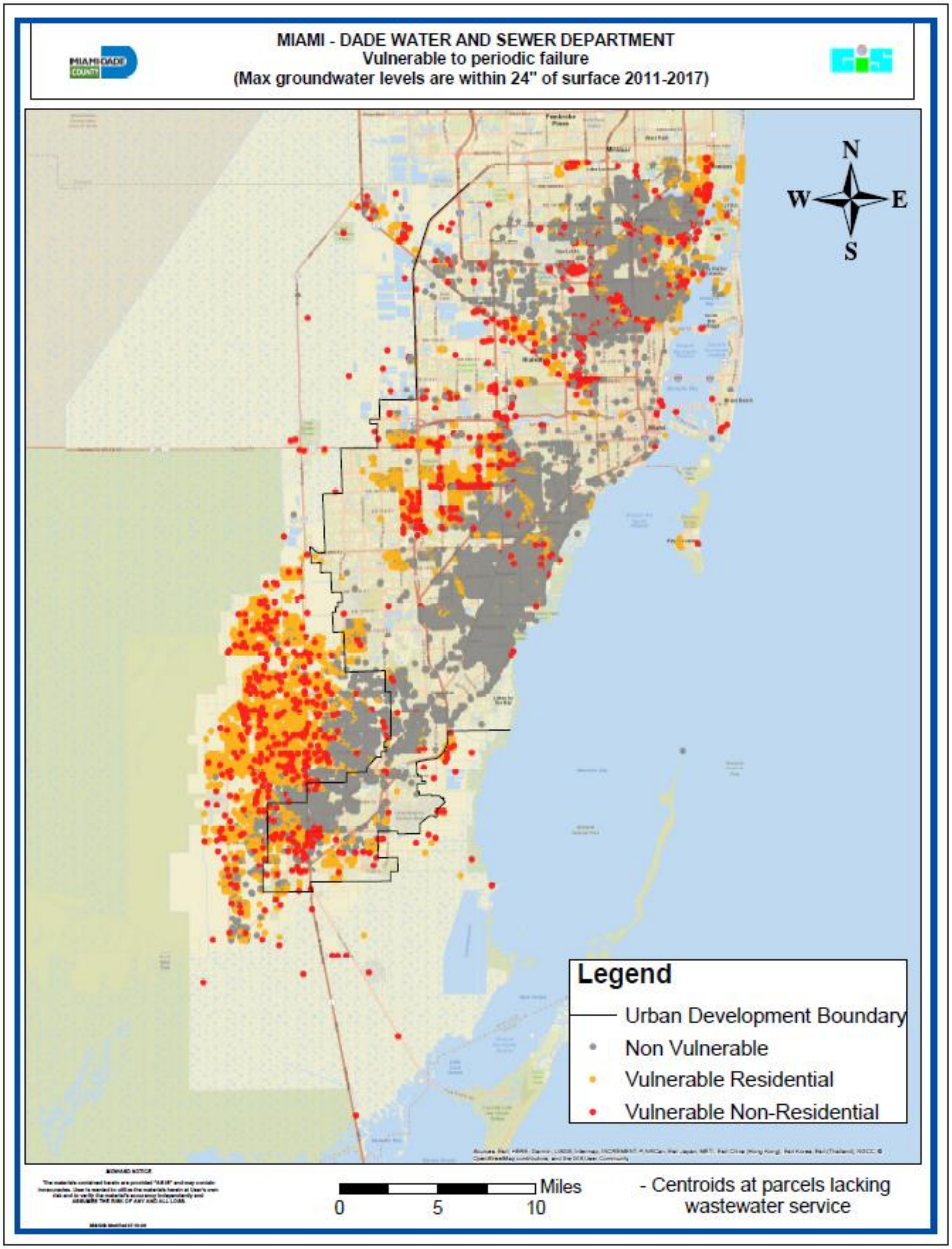


Figure 11: Areas currently vulnerable to persistent compromise (average groundwater levels are within 42" of surface 2011-2017)

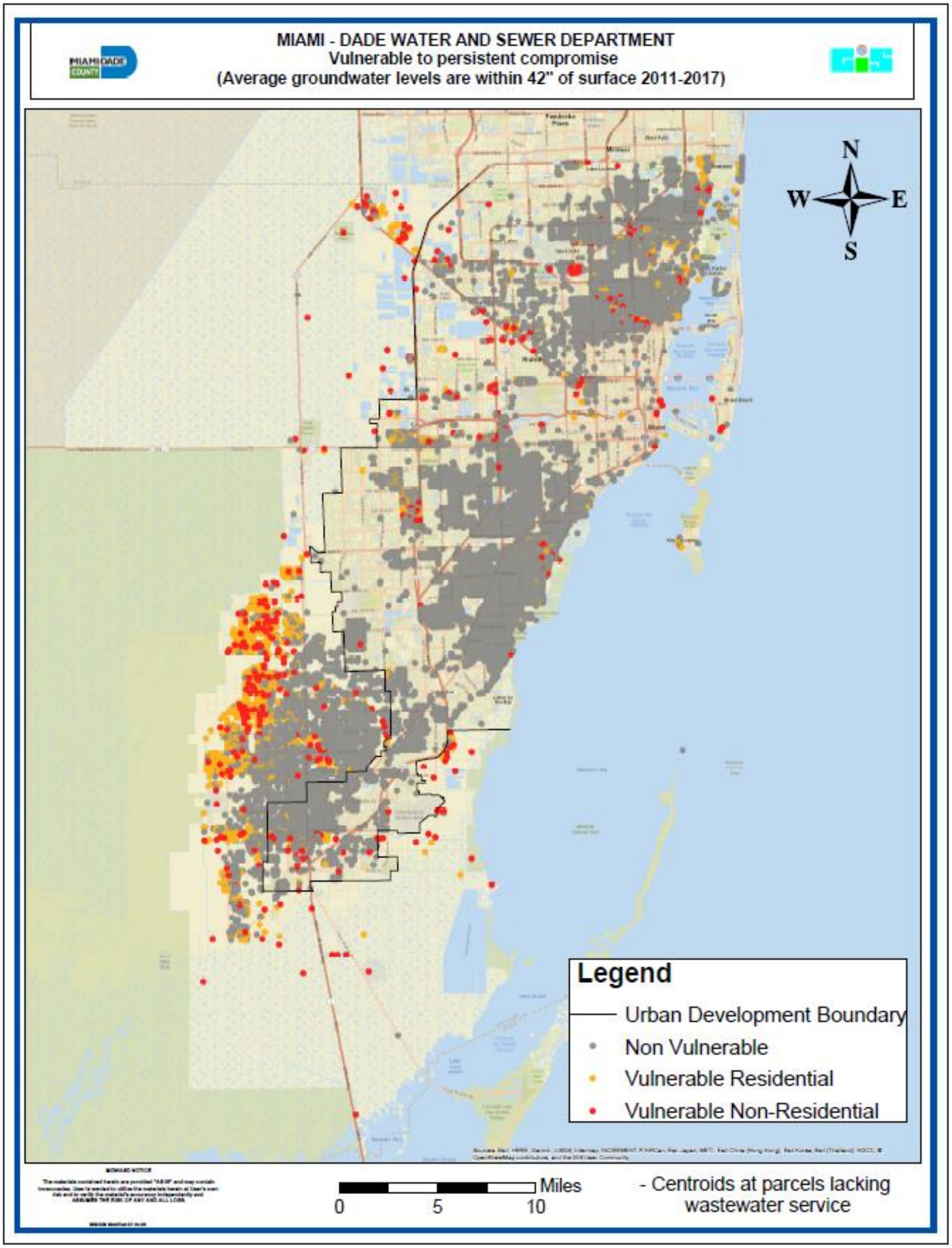


Figure 12: Areas currently vulnerable to persistent failure (average groundwater levels are within 24" of surface 2011-2017)

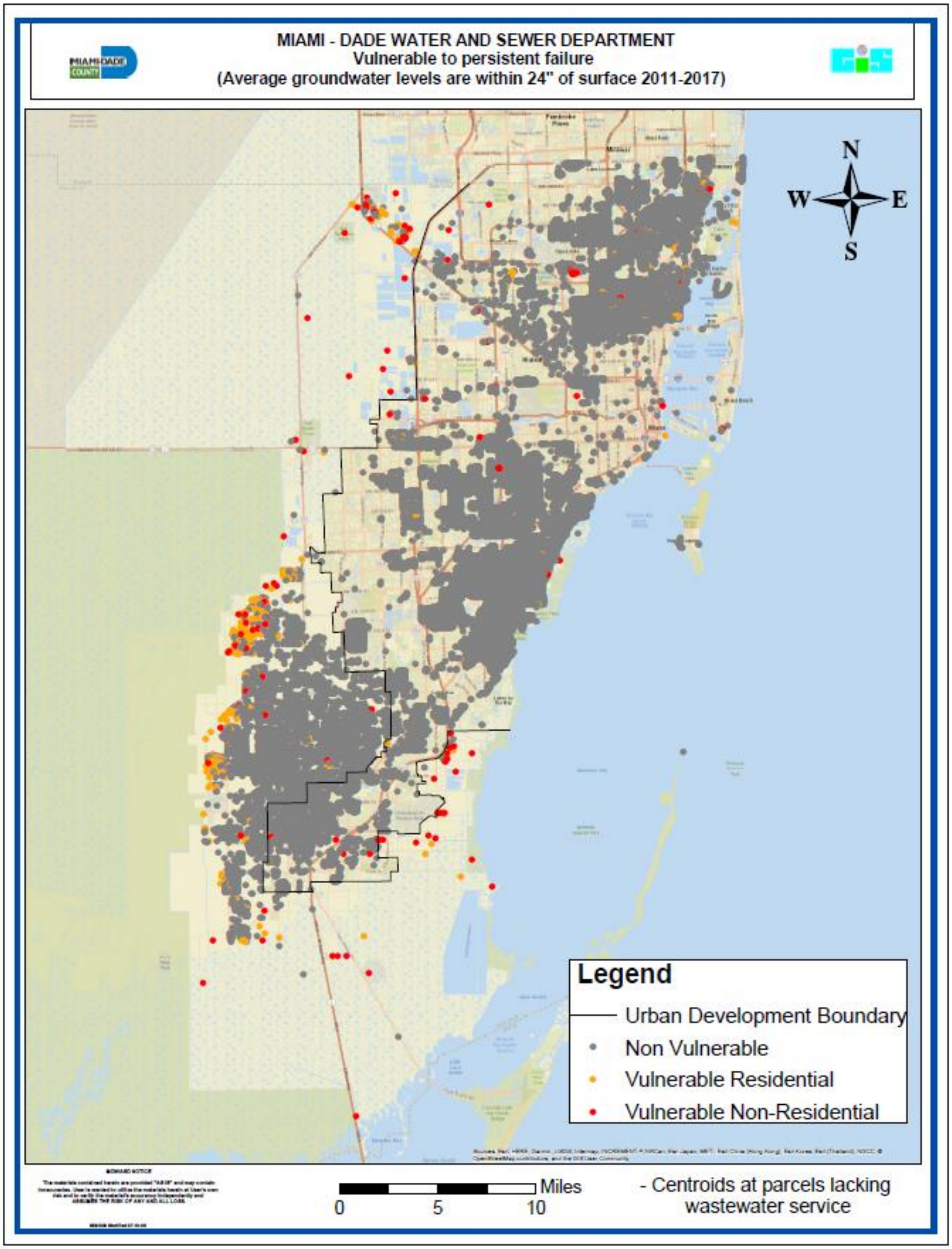


Figure 13: Areas vulnerable to periodic compromise by 2030 (maximum groundwater levels within 42" of surface)

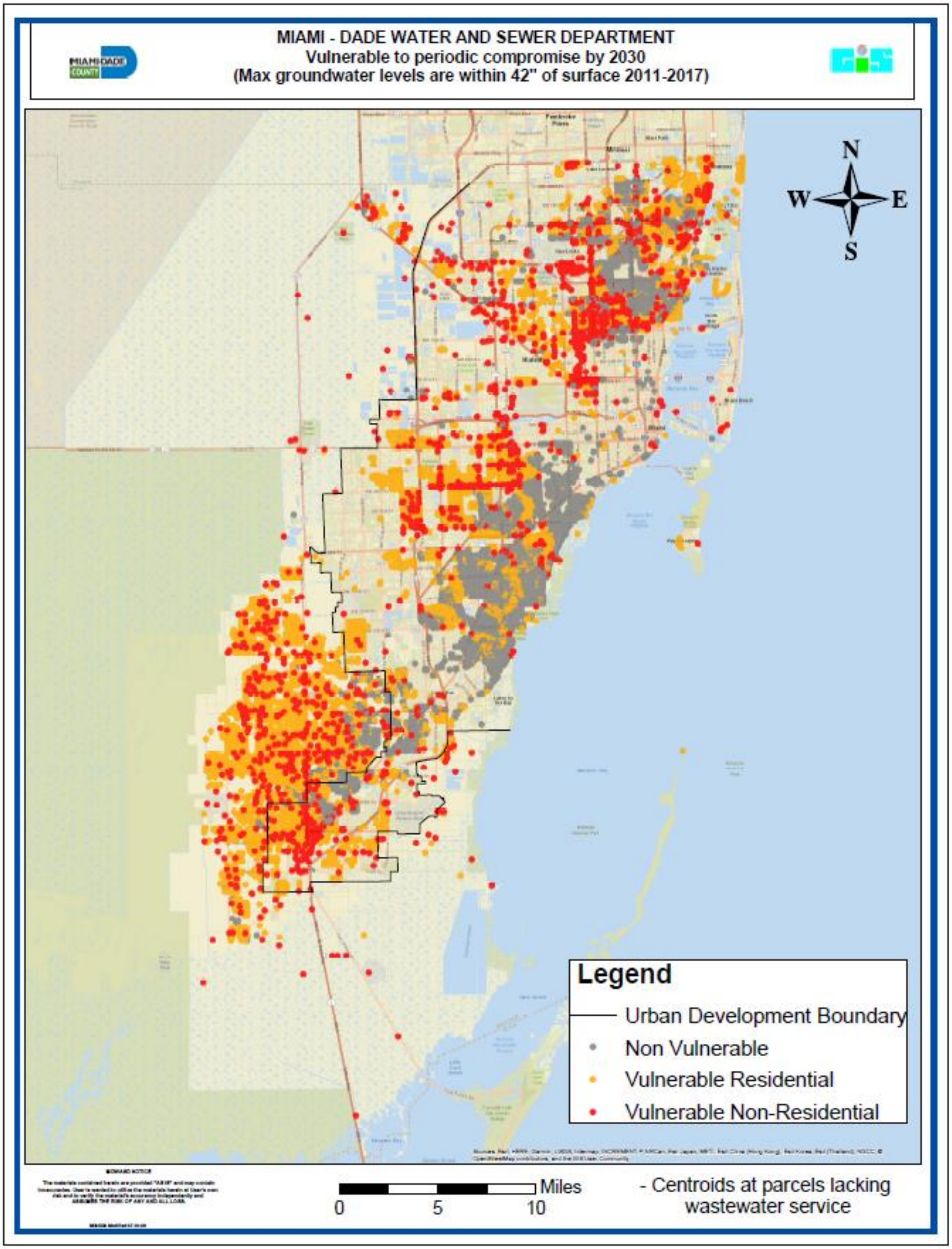


Figure 14: Areas vulnerable to periodic compromise by 2040 (maximum groundwater levels are within 42" of surface)

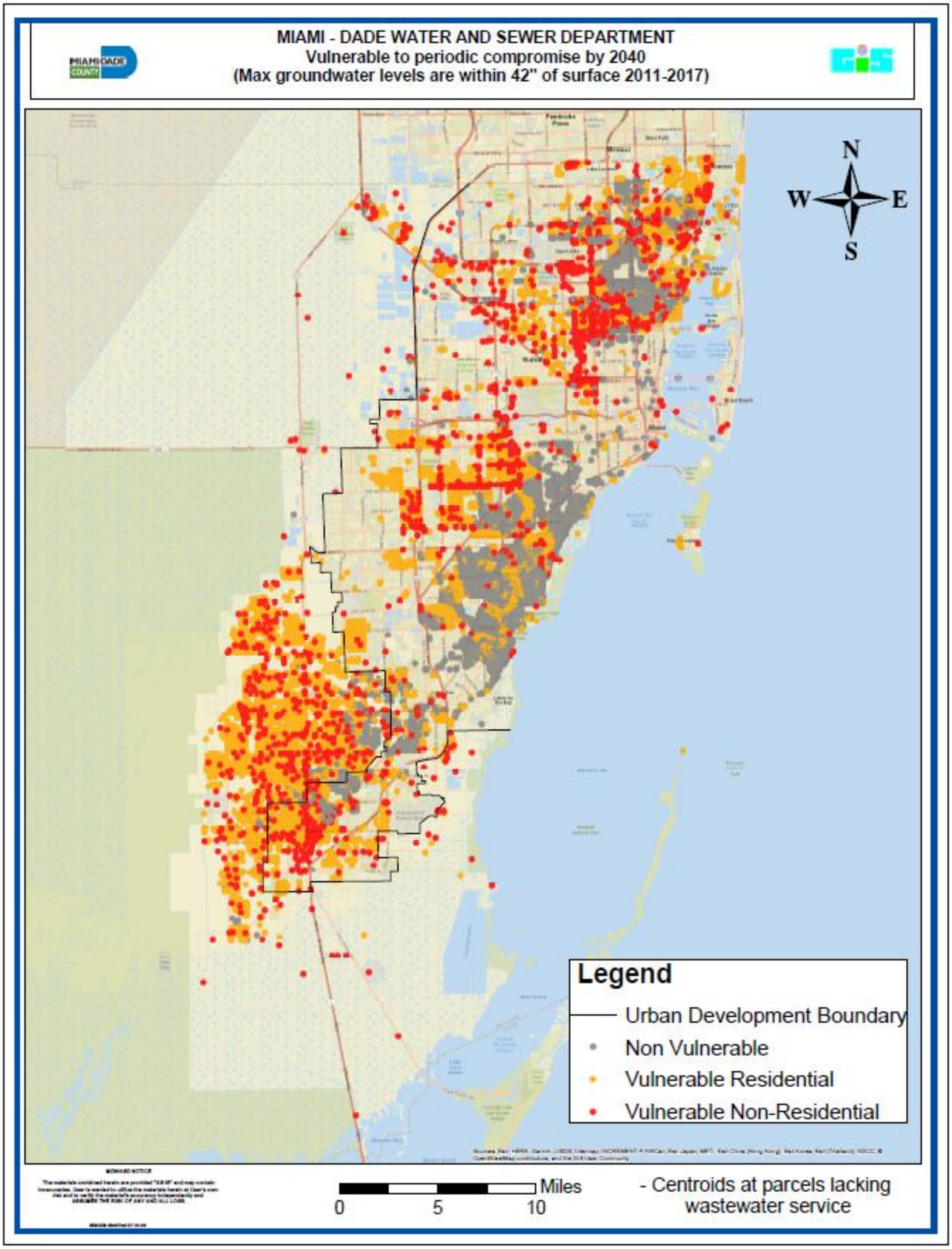
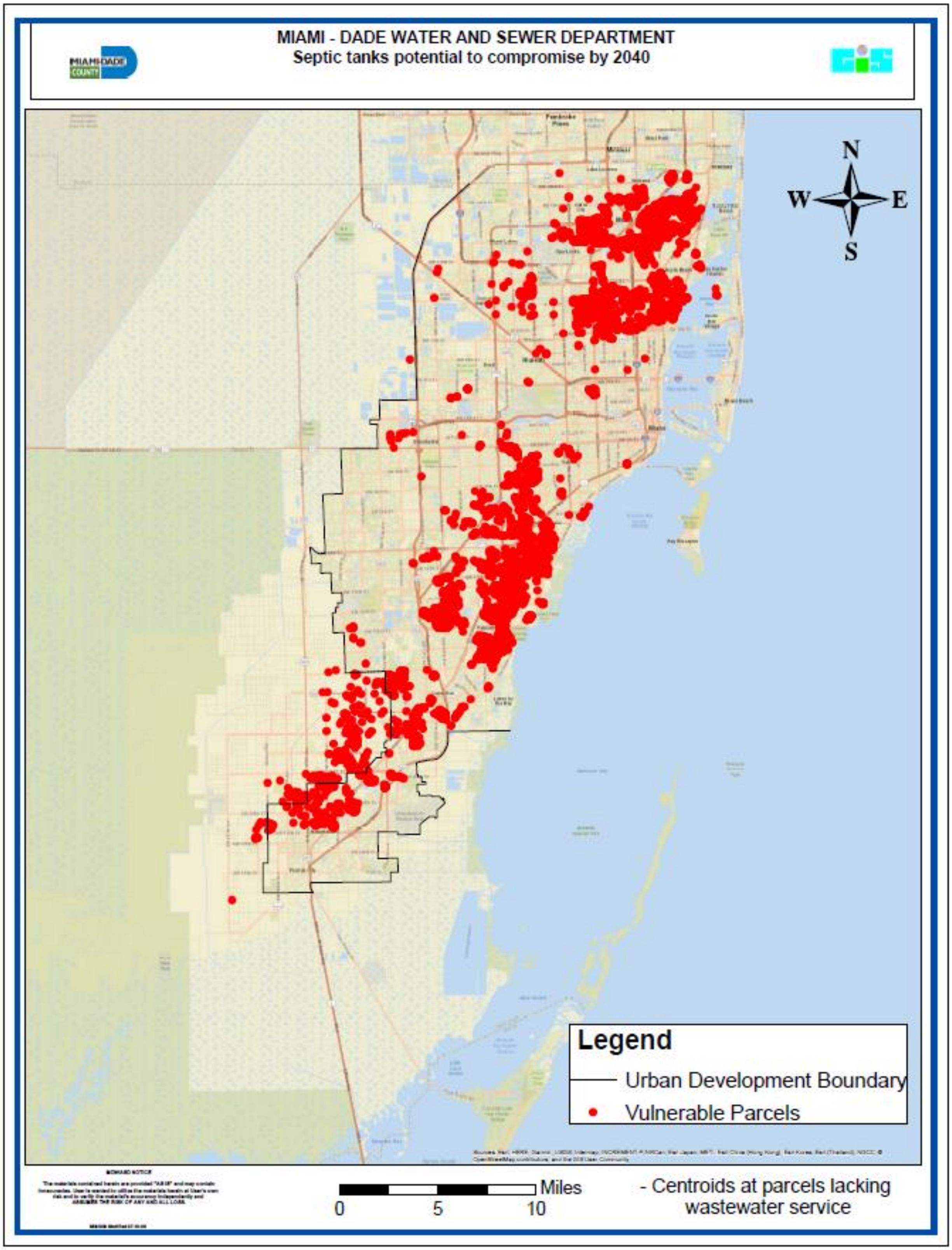


Figure 15: The areas where septic systems are not currently vulnerable but may become compromised due to sea level rise expected from today to 2040



By 2040, the County can expect a significant increase in the number of periodically compromised septic systems from approximately 58,000 residential parcels today to more than 67,000 by 2040 (Tables 5 & 6). Additionally, more than 2,400 non-residential properties are potentially compromised today and that number will increase to approximately 2,700 by 2040. Of greater concern are the parcels where the system is vulnerable to persistent failure. This initial study indicated that approximately 800 residential properties and 130 non-residential properties are currently vulnerable to persistent failure (Tables 5 & 6). These systems that are impacted by today's average groundwater levels pose a much greater risk to public health and the environment since they are vulnerable a significant portion of the year. The majority of these vulnerable parcels are found within unincorporated Miami-Dade County (748 parcels) with only a small number (83) falling within municipal boundaries.

Looking more broadly at systems that may be periodically compromised during storms or wet years, the majority again fall within unincorporated Miami-Dade County (42,064 residential and 1,757 non-residential parcels). Of the total number of vulnerable properties, more than 92% are within the Urban Development Boundary. The following Tables 7 & 8 provide a summary of the impacted areas.

Table 5: Residential parcels impacted within and outside of the Urban Development Boundary (UDB)

Number of residential parcels on septic meeting the vulnerability thresholds:							
		Base-Case Scenario				Sea-Level Scenario	
		Persistent groundwater levels in average conditions		Periodic groundwater levels during 100-year storm or wet years		Periodic groundwater levels during 100-year storm or wet years	
	Parcels with septic systems[1]	Vulnerable to failure[2]	Vulnerable to compromise[3]	Vulnerable to failure[4]	Vulnerable to compromise[5]	Vulnerable to compromise by 2030[6]	Vulnerable to compromise by 2040[7]
Within UDB	99855	523	4511	27013	53998	62521	62677
Outside UDB	4916	308	1354	3743	4351	4556	4557
Total	**104771**	**831**	**5865**	**30756**	**58349**	**67077**	**67234**

[1] Total number of septic systems includes both vulnerable and non-vulnerable systems
[2] Average groundwater is within 24" of surface (current conditions)
[3] Average groundwater is within 42" of surface (current conditions)
[4] Maximum groundwater is within 24" of surface (current conditions)
[5] Maximum groundwater is within 42" of surface (current conditions)
[6] Maximum groundwater is within 42" of surface by 2030
[7] Maximum groundwater within 42" of surface by 2040

Table 6: Non-residential parcels impacted within and outside of the Urban Development Boundary (UDB)

Number of non-residential parcels on septic meeting the vulnerability thresholds:							
		Base-Case Scenario				Sea-Level Scenario	
		Persistent groundwater levels in average conditions		Periodic groundwater levels during 100-year storm or wet years		Periodic groundwater levels during 100-year storm or wet years	
	Parcels with septic systems[1]	Vulnerable to persistent failure[2]	Vulnerable to persistent compromise[3]	Vulnerable to periodic failure[4]	Vulnerable to periodic compromise[5]	Vulnerable to periodic compromise by 2030[6]	Vulnerable to periodic compromise by 2040[7]
Within UDB	3326	51	284	1091	2024	2271	2274
Outside UDB	498	85	223	390	442	468	468
Total	**3824***	**136**	**507**	**1481**	**2466**	**2739**	**2742**

[1] Total number of septic systems includes both vulnerable and non-vulnerable systems
[2] Average groundwater is within 24" of surface (current conditions)
[3] Average groundwater is within 42" of surface (current conditions)
[4] Maximum groundwater is within 24" of surface (current conditions)
[5] Maximum groundwater is within 42" of surface (current conditions)
[6] Maximum groundwater is within 42" of surface by 2030
[7] Maximum groundwater within 42" of surface by 2040
* The total number of parcels is 3861. But, a total of 3824 are within active model area

Table 7: Number of residential parcels impacted, by municipality

Number of residential parcels on septic meeting the vulnerability thresholds:							
		Base-Case Scenario				Sea-Level Scenario	
MUNICIPALITY	Parcels with septic systems[1]	Vulnerable to persistent failure[2]	Vulnerable to persistent compromise [3]	Vulnerable to periodic failure[4]	Vulnerable to periodic compromise [5]	Vulnerable to periodic compromise by 2030[6]	Vulnerable to periodic compromise by 2040[7]
AVENTURA	54	1	5	54	54	54	54
BISCAYNE PARK	854	0	21	357	607	672	708
CORAL GABLES	2930	4	22	75	195	256	260
CUTLER BAY	228	1	1	1	18	31	31
DORAL	329	9	93	166	303	321	321
EL PORTAL	754	9	94	164	365	462	462
FLORIDA CITY	0	0	0	0	0	0	0
GOLDEN BEACH	65	3	9	65	65	65	65
HIALEAH	689	18	71	287	611	649	649
HIALEAH GARDENS	124	5	22	53	119	121	121
HOMESTEAD	2305	4	163	1528	2275	2301	2302
INDIAN CREEK VILLAGE	30	0	1	22	26	30	30
KEY BISCAYNE	14	0	4	13	14	14	14
MIAMI	1603	5	23	75	156	177	177
MIAMI GARDENS	6708	0	125	1328	3761	4515	4515
MIAMI LAKES	10	0	1	5	7	8	8
MIAMI SHORES	3123	10	64	211	578	864	888
NORTH MIAMI	199	5	78	146	176	184	188
NORTH MIAMI BEACH	5265	0	4	665	2780	3751	3751
OPA-LOCKA	0	0	0	0	0	0	0
PALMETTO BAY	5757	2	18	52	893	1753	1753
PINECREST	5088	5	23	175	926	1797	1808
SOUTH MIAMI	2101	0	27	694	1203	1324	1324
SWEETWATER	672	0	244	669	672	672	672
VIRGINIA GARDENS	477	0	62	370	475	477	477
MIAMI SPRINGS	1	0	0	1	1	1	1
SUNNY ISLES BEACH	5	2	3	5	5	5	5
UNINCORPORATED	65386	748	4687	23575	42064	46573	46650
TOTAL	**104771**	**831**	**5865**	**30756**	**58349**	**67077**	**67234**

[1] Total number of septic systems includes both vulnerable and non-vulnerable systems
[2] Average groundwater is within 24" of surface (current conditions)
[3] Average groundwater is within 42" of surface (current conditions)
[4] Maximum groundwater is within 24" of surface (current conditions)
[5] Maximum groundwater is within 42" of surface (current conditions)
[6] Maximum groundwater is within 42" of surface by 2030
[7] Maximum groundwater within 42" of surface by 2040

Table 8: Number of non-residential parcels impacted, by municipality

Number of non-residential parcels on septic meeting the vulnerability thresholds:							
		Base-Case Scenario				Sea-Level Scenario	
MUNICIPALITY	Parcels with septic systems[1]	Vulnerable to persistent failure[2]	Vulnerable to persistent compromise[3]	Vulnerable to periodic failure[4]	Vulnerable to periodic compromise[5]	Vulnerable to periodic compromise by 2030[6]	Vulnerable to periodic compromise by 2040[7]
AVENTURA	10	1	1	10	10	10	10
BISCAYNE PARK	4	0	0	1	1	3	3
CORAL GABLES	112	2	4	6	15	17	17
CUTLER BAY	11	0	0	0	2	2	2
DORAL	44	7	28	35	41	41	41
EL PORTAL	9	0	0	2	5	7	7
FLORIDA CITY	18	0	7	14	18	18	18
GOLDEN BEACH	0	0	0	0	0	0	0
HIALEAH	120	2	12	47	101	112	112
HIALEAH GARDENS	19	0	3	5	10	11	11
HOMESTEAD	118	6	19	74	113	115	115
INDIAN CREEK VILLAGE	0	0	0	0	0	0	0
KEY BISCAYNE	1	0	0	1	1	1	1
MIAMI	49	2	13	15	22	23	23
MIAMI GARDENS	237	0	9	47	109	134	134
MIAMI LAKES	7	0	0	0	3	4	4
MIAMI SHORES	42	0	0	2	11	18	18
NORTH MIAMI	39	0	0	7	13	16	16
NORTH MIAMI BEACH	109	0	1	25	65	78	78
OPA-LOCKA	101	10	23	48	98	99	99
PALMETTO BAY	53	0	1	2	5	5	5
PINECREST	44	1	2	8	9	12	12
SOUTH MIAMI	40	0	1	3	8	12	12
SWEETWATER	21	0	5	21	21	21	21
VIRGINIA GARDENS	4	0	0	3	4	4	4
NORTH BAY VILLAGE	2	0	0	2	2	2	2
WEST MIAMI	2	0	0	0	2	2	2
MIAMI BEACH	7	2	5	6	7	7	7
MEDLEY	13	3	6	11	13	13	13
UNINCORPORATED	2588	100	367	1086	1757	1952	1955
TOTAL	**3824***	**136**	**507**	**1481**	**2466**	**2739**	**2742**

[1] Total number of septic systems includes both vulnerable and non-vulnerable systems
[2] Average groundwater is within 24" of surface (current conditions)
[3] Average groundwater is within 42" of surface (current conditions)
[4] Maximum groundwater is within 24" of surface (current conditions)
[5] Maximum groundwater is within 42" of surface (current conditions)
[6] Maximum groundwater is within 42" of surface by 2030
[7] Maximum groundwater within 42" of surface by 2040
* The total number of parcels is 3861. But, a total of 3824 are within active model area

Because groundwater levels change seasonally and respond to precipitation levels and storm events, these risks will vary temporally. As shown in the Figures 17 and 18, the highest risk areas will have compromised systems more than 90% of the time under average groundwater conditions (shown in the darkest blue). This means that the groundwater is expected to encroach within 42 inches of drainfields, therefore falling under the required separation from the groundwater table needed for adequate treatment of waste. These figures show current risk and long-term risk (2040). Other areas (shown in light blue) will experience periodic failure during heavy storms or wet years. From a public health perspective, failure for even a few days a year can present a significant risk. However, where those risks persist for several weeks each year there is a very significant risk of exposure to increased groundwater or surface water pollution. These persistently impacted systems will pose the greatest risk to public health and the environment. Moving forward, it will be important to address these persistently impacted systems to reduce the risks they pose to both drinking water and surface waters. Given the number of parcels that are likely impacted under existing conditions, it would be prudent to begin planning adaptation measures. This is particularly important in urban areas where there is a clustering of compromised systems in densely-populated areas.

Figure 16: Percent of time the septic systems are potentially compromised in the near-term (2020)

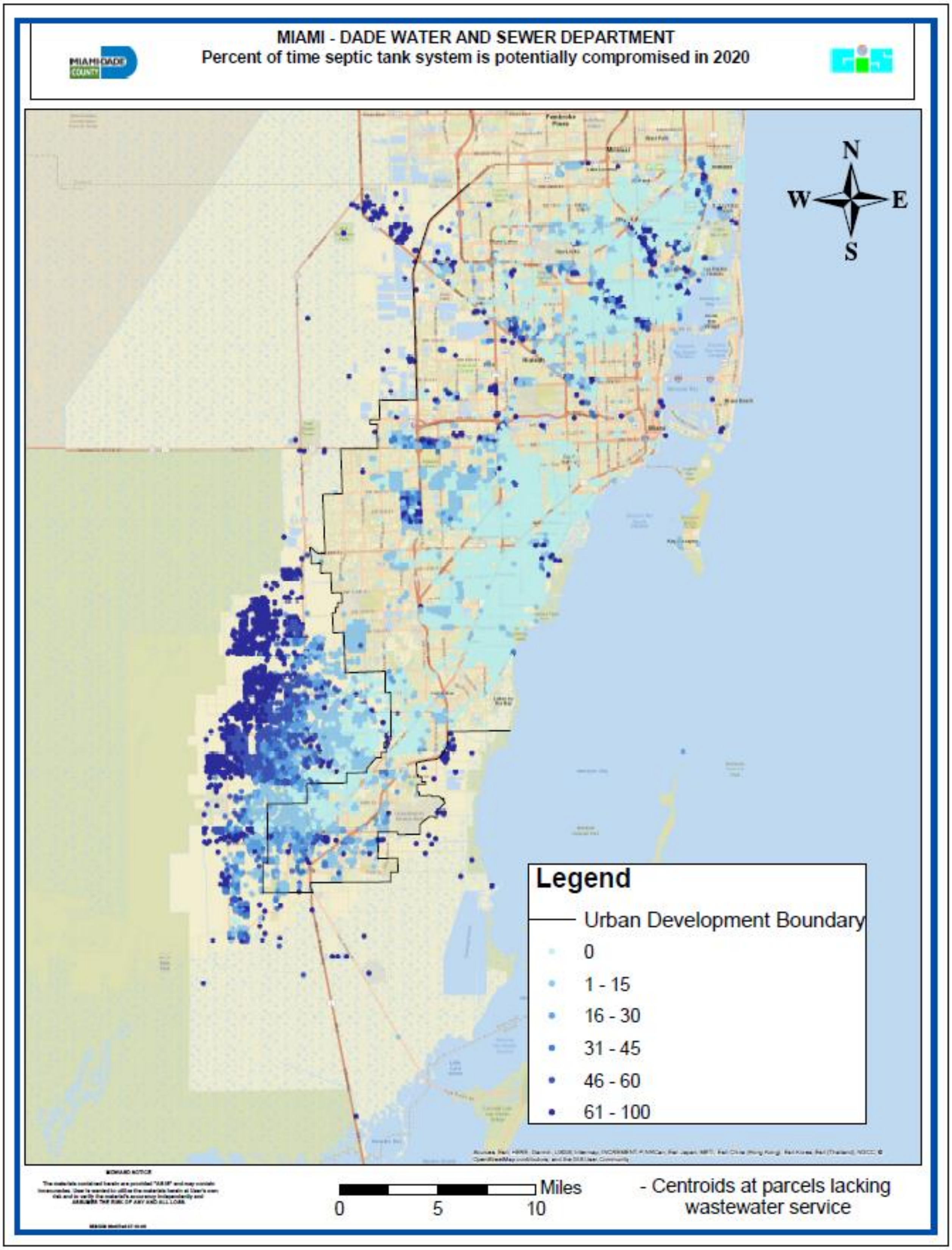
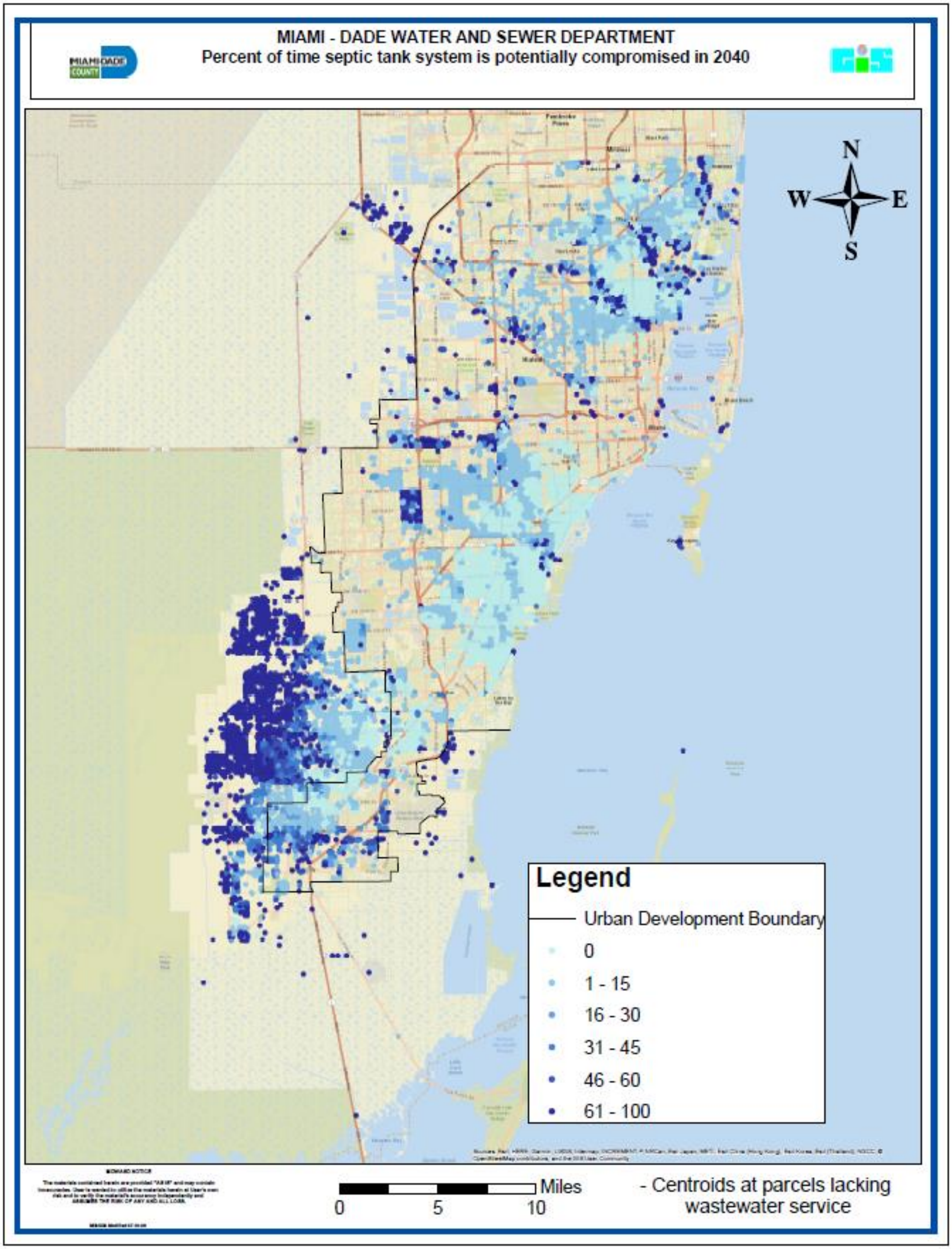


Figure 17: Percent of time septic systems are potentially compromised in 2040



Recommendations on how best to reduce the vulnerability of septic tanks to sea level rise

In order to reduce the vulnerability of exposed septic systems, it is necessary to address both the existing systems and policies governing the installation of new systems. In some areas, it will be most effective to extend sewer services. The following section describes how previous efforts have prioritized similar infrastructure extensions and provides a recommended approach for consideration.

Previous initiatives to extend sewer services

WASD has historically worked collaboratively with other entities, particularly the County's Planning Division, to develop a methodology to prioritize projects. One useful precedent is the approach used in 2013 to prioritize extension of service to key commercial corridors.

On July 2, 2013, the Board approved Resolution No. R-597-13, which directed WASD to develop a plan to extend sewer service to commercial and industrial areas. A study was commissioned to identify these areas near transportation corridors lacking sewers. The intent was to maximize economic development and job creation and to protect the County's water supply. The final study identified 29 potential improvement projects.

The Research Section of RER Planning Division then developed a methodology to evaluate and rank the proposed projects in a consistent, objective and comprehensive manner. The ranking was based on a set of priorities grouped into the following categories:

1. Planning considerations
2. Environmental considerations
3. Special economic areas
4. Land use considerations
5. Current business environment
6. Existing socio-economic condition

Each of these categories included a number of variables that were weighted to compute a final composite ranking. This ranking was used to select projects up to the funding constraint. A description of the full methodology is included in Appendix 1.

With facility modifications, a similar approach is recommended as the foundation for prioritizing new projects to address the risks of sea level and groundwater rise and associated compromised septic systems. The prioritization method could be adjusted to give more weight to environmental concerns and tailored to closely reflect the relevant policies outlined in the Comprehensive Development Master Plan (CDMP). The following sections describe the most relevant policies and then describe a potential new prioritization method.

Existing policies

The CDMP) outlines a number of policies that are relevant to prioritizing the extension of sewer services. These policies are included in their entirety in Appendix 3, but the most relevant policies are summarized here.

Within the Water, Sewer, and Solid Waste element of the CDMP there are a number of relevant policies including:

WS-3A. Public facility improvements will be evaluated for funding in accordance with the following general criteria:

1) Improvements necessary to **protect the health, safety, and environmental integrity** of the community, consistent with the policies of this Plan and applicable federal, state, and County regulatory requirements.
2) Improvements necessary to meet any deficiencies that may exist in capacity or in performance. These include the retrofit of deteriorating facilities which fail or threaten to fail to meet health, safety, or environmental standards.
3) Improvements extending service to previously unserved developed areas within the Urban Development Boundary.

…

7) In providing for improvements to the sanitary sewer collection system, the following additional criteria shall also be considered:
   (a) Location within a **public water supply** wellfield protection zone.
   (b) Potential for the disposal of waste other than domestic waste.
   (c) Designation on the Land Use Plan map for a use more intense than estate density residential.
   (d) Potential for impacts on existing private wells.
   (e) Location within areas of **low land elevation** in conjunction with high water table.
   (f) Locations with **poor soil conditions**.
   (g) Proximity to existing sewer mains.

WS-4D. Anywhere that the use of existing private wells, interim wastewater treatment plants, or **septic tanks pose a threat to the public health or the environmental integrity** of Miami-Dade County, the County shall assert its authority to create a Special Taxing District to finance connections to the public water supply or to the public sewer system.

WS-4G. It is the policy of the County to mandate the connection of existing developments to the regional wastewater system upon extension of the wastewater collection system proximate to said developments. However, the County shall not require connections to be made in areas with gravity systems that are surcharged at any time of the day, for more than 30 days per year. Connections will not be required if the system is subject to overflows, discharge or exfiltration of sewage at any time during the year under any storm event of five years or less.

WS-4H. Miami-Dade County shall coordinate with municipalities and the State of Florida to monitor existing **septic tanks that are currently at risk of malfunctioning due to high groundwater levels or flooding** and shall develop and **implement programs to abandon these systems and/or connect users to the public sewer system**. The County shall also coordinate to identify which systems will be adversely **impacted by projected sea level rise** and additional storm surge associated with climate change and shall **plan to target those systems** to protect public health, natural resources, and the region's tourism industry.

These policies provide clear guidance on extending sewer services to areas of the County where there is a threat to public health or the environment. Given the potential public health implications of such failures, it is recommended that the County begin a process to prioritize the extension of sewer services to these areas that are within the Urban Development Boundary.

Given the fundamental influences of infrastructure and service availability on land markets and development activities, the Comprehensive Development Master Plan has provided that the UDB serve as an envelope within which public expenditures for urban infrastructure will be confined since its inception. In this regard, the UDB serves as an urban services boundary in addition to a land use boundary. To that end, CDMP Policy WS-1H states that "New water supply or wastewater collection lines should not be extended to provide service to land within areas designated Agriculture, Open Land, or Environmental Protection on the Land Use Plan map. New water or wastewater lines to serve land within these areas should be approved or required only where the absence of the facility would result in an imminent threat to public health or safety." Public health and safety determinations are made in accordance with Chapter 24 of the Code of Miami-Dade County. Pursuant to CDMP Policy WS-4C, septic tanks may be permitted outside of the UDB where connection to the public sewer system is not feasible.

Recommended approach

To ultimately address the vulnerability of compromised or failed septic systems it is necessary to extend sanitary sewer service to certain areas in order to protect public and environmental health. As with previous extensions of service, and any significant infrastructure improvement, these extensions will need to be phased and addressed incrementally.

One approach to prioritize extensions of services is to adapt the methodology used in 2013 (Appendix 3) and modify the criteria and weighting to place additional emphasis on public health concerns, environmental concerns, and the most relevant policies in the CDMP. This report puts forth a proposed methodology for the Board's consideration presented in Table 9.

This methodology could be used to prioritize sewer extensions to address areas vulnerable to sea level and groundwater rise. The proposed approach gives the greatest weight to environmental considerations. This includes areas with elevated groundwater levels, areas reliant on well water, wellfield protection areas, areas near waterbodies, areas with non-conforming permits or within contaminated basins. The ranking also gives substantial weight to planning considerations which would direct improvements to areas best suited for future development such as zoned urban centers, urban infill areas, and areas adjacent to the SMART corridors. The proposed ranking criteria also give weight to commercial and industrial areas without sewer service, special economic areas, and existing socio-economic conditions. This approach would give the greatest weight to areas that currently present the greatest environmental and public health risks due to existing groundwater conditions. This approach treats all areas within WASD's existing service area equally including areas within municipalities. However, as noted previously the vast majority of existing septic systems are found within the Unincorporated Municipal Service Area (UMSA).

In areas where sewer extension is not desirable or feasible, there are other technical interventions such as replacing existing systems with mounded systems; however, there may be potential complications with such an approach or tradeoffs in terms of increased maintenance. These solutions are less preferable to connecting to the sanitary sewer system within the Urban Development Boundary.

To better inform the prioritization, data collection and analysis should be conducted for a subset of parcels with systems that are expected to be failing under current conditions. This will provide a better understanding of actual groundwater levels and the distribution of nutrients and other pollutants in a variety of onsite conditions, including some of the sub-conditions in the proposed ranking criteria, such as "near an open body of water."

In addition to analyzing parcels with systems that are expected to be failing under current conditions, there is an overarching need for a comprehensive understanding of the various sources and quantities of nutrients and other pollutants that are impacting the health of our groundwater, natural systems and public health. There is a need for a comprehensive water quality and geology data collection network that would inform the type of analysis called for in this report and aid natural systems management and infrastructure planning and programming. Existing sampling programs should be evaluated to identify modifications to collection sites and identify gaps to better characterize and monitor sources, destinations, and impacts of pollutants and nutrients that enter canals, groundwater, lakes, Biscayne Bay and coastal waterways.

Table 9: Proposed ranking criteria to address septic systems affected by sea level rise

Proposed Ranking Criteria to Address Septic Systems Affected by Sea Level Rise																	
	Planning considerations				Environmental considerations							Land use	Special economic areas			Socio-economic conditions	
Proposed weighting	900				1500							100	200			200	
	400	200	200	100	600	300	300	100	100	100	100	100	100	50	50	100	100
Sub-criteria	Inside the Urban Development Boundary	Within a half-mile of the SMART corridors	Zoned Urban Centers	Inside urban infill area	Area lacking adequate soils (due to elevated groundwater table)	Area currently lacking water service	Wellfield protections area	Total non-conforming DERM permits	Within a priority contaminated basin	Near an open body of water	Outside the Coastal High Hazard Area & FEMA V Zone	Commercial, industrial without sewer service (acres)	Community Redevelopment Area	Enterprise Zone	Targeted Urban Areas	Individual poverty rate	Median household income

Recommended Policy Changes

There are several potential changes to existing policy which could help reduce the vulnerability of septic tanks to compromise or failure due to flooding and rising groundwater related to sea level rise. Broadly speaking, there are steps that can be taken to reduce the number of new septic systems that are installed in vulnerable areas and steps that can be taken to reduce the risks posed by the systems that are already installed in vulnerable areas. The following section describes potential policy measures that could reduce the risks to public health and the environment; however, some of these concepts would require further study by the relevant department prior to implementation.

Reducing the environmental and public health risks of existing systems in vulnerable areas

SEWER EXTENSION

As mentioned previously, the most effective way to address the long-term risks associated with rising groundwater levels will be to connect existing structures within the UDB to the sanitary sewer system. Given both the public and private costs associated with the expansion of infrastructure, these improvements should be phased-in over time. One method of systematically and comprehensively assessing which areas should be the highest priority is included in this report.

TECHNICAL SOLUTIONS

In areas where traditional sewer extension is not possible or feasible other technical solutions can be explored. It may be possible to upgrade existing systems by elevating and creating "mounded" systems. It should be noted that when property owners fail to adequately maintain their septic systems there can still be impacts to freshwater resources and the environment, even when they are elevated an adequate distance above the groundwater table. This solution is less appropriate in areas vulnerable to other flooding risks (such as storm surges) and in densely-populated areas. Mound systems require dosing pumps to lift sewage to the mound. This creates a further vulnerability associated with pump failure and power loss, because, if a pump fails the entire system fails. Similarly, when the power fails the septic system fails unless emergency power is available. Therefore, mounded systems require greater maintenance to assure system operation. Other technologically feasible alternatives may be available and should be further explored, including alternative sewer systems (low pressure, septic tank effluent pumping (STEP)) and advanced decentralized treatment systems using Industrial Internet of Things (IIoT) centralized control and monitoring.

REDUCING VULNERABILITY THROUGH DRAINAGE IMPROVEMENTS

Groundwater levels are influenced by regional water management practices and local drainage practices. Additional analysis is needed of how these practices could be modified to reduce the impact of rising groundwater on vulnerable septic tank infrastructure. This information could inform decisions on improvements for the secondary and tertiary systems under County ownership/maintenance/operations. It should be noted that groundwater levels in coastal areas are outside of the regional water management area and are less influenced by regional conveyance practices.

Reducing the number of new septic systems installed in vulnerable areas

The following policy recommendations individually provide paths to reducing the number of new septic systems installed in vulnerable areas. These policies are complimentary, creating a path to no net increase in the number of septic systems in the County when implemented collectively:

MASTERPLAN FOR SERVICE EXPANSION

Review WASD rules, regulations, and policies to promote connections by gravity in lieu of force mains,. The existing force mains (transmission systems) should be used to promote gravity systems and not serve as primary points of connections for individual parcels or projects. The preferred method of connection is by gravity; however, this is not always possible in practice. One means of reducing this barrier is by completing a masterplan for the extension of the sewer system where expansion is desired (for example in urban centers). This could reduce the cost of expanding the infrastructure required for development. There could also be opportunities for WASD to use a cost-share model with developers to expedite certain infrastructure improvements. In order to enable these kinds of changes, it may be necessary to review the current bond ordinances which govern how WASD can expend funds for service expansions. WASD should review whether it would be advantageous to develop a masterplan for sewer service expansion in key areas and whether any changes to the current funding mechanisms for service expansions would be beneficial. Other utilities and municipalities should also pursue similar planning efforts.

REGIONAL AND SUBREGIONAL PUMP STATIONS

Review WASD rules, regulations and policies regarding regional pump stations. Where only force mains are available for connection, consider whether it would be advisable to allow "sub-regional" pump stations, "phased" regional pump stations, or more equitable cost sharing of Regional Pump Stations (e.g., using a taxing district model). In some infill areas there can be technical barriers to installing a regional pump station (for example, where it would be oversized or would overburden the developer). In such instances there may be benefits to allowing the installation of smaller "subregional" pump stations; however, these considerations would need to be balanced against the increased operations and maintenance costs and additional staff time required to manage a greater number of pump stations. In "phased" regional pump stations, a developer would be responsible for the collection system that would serve their project and sizing the pump station, excluding the wet well, to serve only their project. As other developers request to connect, they would be responsible for upgrading the capacity and controls of the pump station.

FEASIBLE DISTANCE

Review RER-DERM rules, regulations and policies regarding "Feasible Distance" for areas vulnerable to flooding associated with sea level rise. Revise Chapters 24-43.1 and 24-42.2 of County Code to include criteria and requirements so that the feasible distance evaluation includes variables related to unsaturated depth, flooding, and sea level rise. Under current regulations properties are required to connect to the sanitary sewer system when they are within a "feasible distance" to the existing system. Currently, this distance is calculated based on an algebraic formula with the critical variable being gross building area; however, there may be more appropriate methods to reduce risks in low-lying vulnerable areas. RER-DERM should review the existing "feasible distance" requirements and determine if they are adequately protecting public and environmental health.

VARIANCES

Review RER-DERM rules, regulations and policies regarding variances for use of septic systems when connection to the public sewer is required (e.g., "feasible distance"). Under current regulations there are a number of conditions where a variance could be granted to allow the use of a septic system; however, in these instances where additional septic systems are installed there is still the potential for future overall impacts to the County's freshwater resources and the environment related to sea level rise that are not directly considered. RER-DERM should work with WASD to review options to mitigate these unavoidable impacts. One means of achieving this could be by revising Chapter 24 to require that variances granted to allow certain development projects to utilize septic system, include the requirement to offset overall sewage flows by connecting other parcels in vulnerable areas to the County's wastewater treatment system. That is, approval of new projects on septic system would require that a proportional (based on mass loading and vulnerability) number of septic systems in low-lying areas impacted by flooding and rising sea and groundwater levels, that pose an increased risk to public health, be connected to public sewer. The offset would not be the basis for granting a variance, but instead would be a requirement if the variance is justified.

SETBACKS

Review RER-DERM rules, regulations and policies regarding whether existing requirements for setbacks from waterbodies are adequate. Under current regulations, septic systems are required to be set back from surface waters. These requirements are dictated by Florida Administrative Code (Chapter 64E-6). RER-DERM should review whether these existing requirements are adequate to protect public health, fresh water resources, environmental health, and tourism in Miami-Dade County. This may be particularly important in watersheds that are already impaired relative to fecal coliform and nutrient levels. The department should also review whether a setback from drainage systems, , will help protect environmental and public health.

REQUIREMENTS TO CONNECT

Review RER-DERM rules, regulations and policies regarding the existing requirements for the size of a subdivision required to connect to the sanitary sewer. Under current regulations, it is possible for developers of larger subdivisions to circumvent the requirements to connect to the sanitary sewer system. This has been achieved by breaking the project into smaller sections so that each section falls below the required threshold. RER-DERM should evaluate alternative criteria for determining connection requirements for large development projects that do not encourage phasing such projects to avoid connection to the wastewater treatment system.

REVIEW DESIGN STANDARDS

Under current regulations, new septic systems are required to be a certain distance above the groundwater level. When it is not feasible to determine the groundwater level on site, engineers refer to maps of groundwater levels. The County recently worked with the U.S. Geologic Survey to remap local groundwater levels. Those maps were published in 2016 and should be the required reference, rather than older out-of-date maps which do not adequately capture how conditions have changed. Moving forward RER-DERM should consider using the projected groundwater levels used in this report and by WASD for future planning. Broward County is already using projected groundwater levels for permitting to ensure that newly constructed infrastructure will function over the full lifetime of the asset. Miami-Dade County could pursue a similar path and include these maps in the CDMP. Similarly RER-DERM should explore whether a minimum horizontal or vertical distance from drainage systems should be considered.

REGULAR REVIEW OF POLICY IMPLIMENTATION

The County should regularly review these and other relevant policies to ensure that the County is making consistent progress toward the goal of reducing any risks to public health and the environment created by compromised septic systems.

Potential funding sources

The following section identifies possible funding sources and financing alternatives to support the extension of sewer service. The CDMP also provides guidance on potential sources noting in Policy WS-4D that, "Anywhere that the use of existing … septic tanks pose a threat to the public health or the environmental integrity of Miami-Dade County, the County shall assert its authority to create a Special Taxing District to finance connections to the public water supply or to the public sewer system." Additionally, for commercial areas, the CDMP policy CON-2D notes that "Sewer Improvement Special Taxing Districts shall be established for all industrial and potentially hazardous commercial areas within the Urban Development Boundary." When considering any of the following funding or financing mechanisms it is important to consider the impact on low and moderate income communities as well as the overall impact on housing costs.

The Water and Sewer Department's existing procedures for financing wastewater projects

The procedures for financing wastewater projects are described in the Department's Implementing Order (IO) No. 10-8 and are governed by WASD's Bond Ordinance. All project financing is closely associated with the concept of recovering all costs of new service from the new customers. Decisions about financing must be consistent with County Ordinance 93-134, Section 613, which is part of the Department's bond ordinance known as "No Free Service." This Section prohibits providing free services or preferential charges to any customer. Before utilizing any of the following financing alternatives, it is recommended that the appropriate legal authority assess the impact the "No Free Service" section of the Ordinance may have on any new funding mechanism.

Financing procedures are different for wastewater collection facilities and wastewater transmission *facilities*. Wastewater collection facilities (generally referred to as local facilities) are defined as those lines and pump stations that are needed to provide service only to retail customers. Wastewater transmission facilities (often referred to as regional facilities) are those pump stations and lines that are needed to serve all customers, both retail and wholesale.[22]

Financing collection facilities

The essential procedures that apply to new sewer service, both existing or new developments, is outlined in IO-10-8, Section 3.02(3). This rule stipulates that the customer is responsible for the expense of installing any new laterals or collection lines needed to provide wastewater service. For new developments, the collection lines are generally installed by the developer and turned over to the Department when the development is complete. For existing developments the rule requires new customers fund the cost of the new collection facilities. This can be done either by creating a Special Taxing District or establishing fees and charges which allow the Department to recover the costs of installing the collection system.

[22] Details concerning the classification of lines and pump stations were spelled out in a May 6, 2009, analysis conducted as part of a cost allocation analysis for setting wholesale customer rates. That analysis defined wastewater transmission and collection facilities as follows: "The Water and Sewer Department's definition of wastewater transmission facilities is all interceptor lines and all pump stations and force mains receiving wastewater flows that are pumped from wastewater collection systems. Transmission force mains convey wastewater that has been collected and pumped from more than one collection basin. Pump stations and lines that connect to these facilities are classified as wastewater collection." The minimum size of a force main for purposes of defining regional facilities was listed at 8-inches.

Based on the Department's regulations, new customers are required to directly fund the local (collection) costs and to reimburse the Department for the cost of installing wastewater collection lines and pump stations. Customers are also billed connection charges for the new user's impact to regional infrastructure and wastewater treatment plant capacity, as well as for ongoing wastewater service based on their metered water use.

GENERAL OBLIGATION BONDS

The County has funded Department improvements, including local collection systems for new customers, with general obligation bond proceeds and could do so to finance these sewer collection facilities. Funding for the local collection system component of the project from general obligation bonds would provide the greatest relief to property owners. Assignment of available general obligation bond funds for this purpose would require approval by the Board of County Commissioners.

REVENUE BONDS ISSUED BY THE DEPARTMENT

The Department routinely issues revenue bonds to finance capital improvements to the water and wastewater systems. The proceeds from these bonds are generally used to fund projects intended to improve the existing system which will benefit all or a large number of customers, both retail and wholesale. The bonds are amortized through payments made by utility customers through water and sewer rates. While revenue bond proceeds have routinely been allocated to fund wastewater transmission facilities, they historically have not been used to provide funding for local collection systems to service new customers due to provisions of the bond ordinance. The use of Department funds for the extension of local collection systems must be reimbursed to the Department through a Special Taxing District, fees, and charges paid by the customers benefiting, or from other non-departmental revenues.

RATE SURCHARGE

The Department could recover the high cost of the wastewater collection improvements by imposing a surcharge on the new customers. The Department has implemented such a program, but only with the acquisition of utility systems, most recently Miami Springs. However, if sales of water and wastewater were lower than expected, the Department would be at risk of failing to fully recover the anticipated revenue. Because of this risk, a rate surcharge may be less attractive compared to forming a Special Taxing District, which would not share this same risk. A variation of the rate surcharge is the Basin Fee. This is a per-gallon of capacity charge that is added to the regular connection charge to support the expansion of the local collection system. This was recently used to increase the capacity of the collection system in several areas that are redeveloping and intensifying their uses.

SPECIAL TAXING DISTRICT

Funding and financing could be provided through a Special Taxing District. Under this method, the Department would fund the improvements with bond proceeds and recover the debt service through a recurring tax on the project's beneficiaries, the new customers. The impact to each customer would vary according to how much of the total project cost was financed in this way, the size or frontage of the parcels comprising the Special Taxing District, and the interest rate and duration of the bonds. However, the costs could be substantial based on the high cost of the collection and transmission system improvements. Additionally, per Chapter 18 of the Miami-Dade County Code, the Special Taxing District can be established by either a petition of 100% of the property owners in the district, a vote of the majority of the resident property-owners, or through Board ordinance.

TAX INCREMENT FINANCING

Tax Increment Financing (TIF) is used mainly to provide broad assistance to blighted areas through Community Redevelopment Agencies (CRA). Bonds are sold to make improvements to a designated TIF area, and the bonds are repaid from the increased property value and corresponding property tax revenues that result in part from the improvements. Because of the very high costs associated with bringing sewers to these areas, it appears unlikely that the increases in property values due to the sewers would be sufficient to recover the cost of the sewers within a reasonable time period. Presumably, separate financing districts would be needed for each project, and the process of qualifying and establishing these districts could be time-consuming. This financing alternative does not appear to be practical or applicable to this project.

Financing transmission facilities

For wastewater transmission facilities (part of the regional system), the procedures stipulated in Section 3.04 of IO 10-8 dictate that the Department may require the developer, or customer, to provide main, or transmission lines, or the Department may recover its investment in these facilities through connection fees. These fees are based on the average day gallons of wastewater expected to be produced by each new customer.[23] By collecting this connection charge from each new customer, it is presumed that the Department will be able to provide the necessary wastewater transmission and treatment facilities needed to serve an average new customer; however, the Department's actual cost of transmission facilities varies considerably from one part of the County to another. This section of the Implementing Order also stipulates that the extension of transmission facilities may be paid for through a Special Taxing District. The use of a Special Taxing District has rarely been used by WASD, but it is widely used in the County for other purposes. In general, establishing a Special Taxing District requires the concurrence of a majority of the property owners within the district.

The Department's current methods for recovering and financing wastewater transmission facilities include the methods described above as well as two others:

CONNECTION CHARGES

For new wastewater customers, WASD has established connection charges of $5.60 per gallon of expected average day water use. Connection charges are deposited into the Department's Plant Expansion Fund and can be used to support capacity improvements to the regional wastewater transmission system. Therefore to the extent that Plant Expansion Funds are available, the regional system costs can be funded in that way.

[23] These fees are currently $5.60 per average day gallon of wastewater.

CONNECTION SURCHARGE

The Department could alternatively impose a connection surcharge on each new customer as a condition of connection. This would help to recover system expansion costs for some or all of the regional and local collection systems. To recover the full cost of the transmission facilities not covered by standard connection charges; the typical new customer would be assessed approximately $15,000.

Other potential funding sources and grants

Other funding sources were reviewed for extending sewer service to areas currently experiencing septic system failures and to areas expected to be impacted by future sea level rise. One potential funding source could include establishing a new bondable revenue stream similar to the existing Utility Service Fee. The existing Utility Service Fee was established to provide environmental services and benefits, and is collected from existing utility customers, through their quarterly water and sewer bills. The fee supports groundwater protection efforts managed by the Regulatory and Economic Resources Department and landfill leachate remediation activities by the Solid Waste Department. This model could be explored to fund the extension of sanitary sewers to areas that are currently unserved, with the intent of reducing health exposures and environmental impacts to groundwater, stormwater, and surface waters attributable to failing septic systems. This funding source should be further evaluated to assess the potential bondable capacity and whether it should only include water and sewer utility customers or be expanded to include properties served by septic systems - those most vulnerable to sea level rise.

Grant funds are a potential funding source that has been used effectively by smaller utilities to expand collection systems and upgrade existing infrastructure. While grant funds cannot be relied upon to support major infrastructure projects, there may be opportunities to occasionally leverage grant funds and other sources to support individual projects on a smaller scale. Grant funding could be particularly attractive to help reduce the burden on property owners. The following are a list of resources that could be used to help explore other funding options to support sewer extensions, but is not an exhaustive list.

U.S. ENVIRONMENTAL PROTECTION AGENCY CLEAN WATER STATE REVOLVING FUND

This fund supports water quality protection projects for wastewater treatment, control of nonpoint sources of pollution, decentralized wastewater treatment, and watershed and estuary management through low-interest loans to a variety of borrowers.

U.S. ENVIRONMENTAL PROTECTION AGENCY NONPOINT SOURCE SECTION 319 GRANTS

Under Section 319 of the Clean Water Act, the agency provides grants to states to control nonpoint sources of pollution, such as agricultural runoff and malfunctioning onsite septic systems. Grants may be used to construct, upgrade, or repair onsite systems.

U.S. DEPARTMENT OF AGRICULTURE, RURAL DEVELOPMENT

Funding covers repair and maintenance of onsite systems.

U.S. DEPARTMENT OF HOUSING AND URBAN DEVELOPMENT

The department provides funds to states through Community Development Block Grants (CDBG). The grants fund various projects, including rehabilitation of residential and nonresidential structures, construction of public facilities, and improvement of water and sewer facilities.

U.S. ECONOMIC DEVELOPMENT ADMINISTRATION

The Administration manages various funding programs to promote collaborative regional innovation, public/private partnerships, national strategic priorities, global competitiveness, and environmentally sustainable development.

CATALOG OF FEDERAL FUNDING SOURCES FOR WATERSHED PROTECTION

A searchable database of financial assistance sources (grants, loans, cost-sharing) available to fund a variety of watershed protection projects is available online at https://ofmpub.epa.gov/apex/watershedfunding/f?p=fedfund:1.

U.S. ENVIRONMENTAL PROTECTION AGENCY ENVIRONMENTAL FINANCE CENTER NETWORK

EPA grant funding started 10 university-based environmental finance centers, the Environmental Finance Center Network, workS together with the public and private sectors to fund environmental programs.

Other funding models should be explored. The Utility Service Fee is an example of a funding source established to provide environmental services and benefits, and is collected from utility customers, through their quarterly water and sewer bills. The fee supports groundwater protection efforts managed by the Regulatory and Economic Resources Department and landfill leachate remediation activities by the Solid Waste Department. This model could be explored to develop a fee that would create a bondable revenue stream, to fund the extension of sanitary sewers to areas that are currently unserved, with the intent of reducing public health exposures and environmental impacts (groundwater, storm water, and surface water) attributable to failing septic systems.

Summary of funding sources and grants

Using currently available financing methods, WASD's alternatives for financing the projects contemplated in this report are limited to the use of general obligation bonds and/or revenue bonds, the collection of the costs for wastewater collection lines from the new customers, collection of the Department's standard connection charges from new customers, establishment of Special Taxing Districts, and tax increment financing. Tax increment financing does not appear to be a promising source of revenue, though such an approach might be applicable in some project areas. The availability of grant funds and State Revolving Loan Funds could be helpful in delivering these projects, but it is not possible to anticipate such availability now.

Due to the absence of the economies of scale achieved with new developments, the aggregate cost of providing these service extensions is very high on a per gallon or per customer basis. Recognizing these high costs, exploring alternative designs and technologies, and/or construction methods could possibly lower the costs of these projects. Some of the individual projects can be expected to be substantially more cost-effective than others by virtue of their proximity to existing wastewater transmission lines or a larger concentration of new customers or near-term development potential.

Selecting the more cost-effective projects for early implementation would facilitate financing as well as reduce the Department's financial burden. Based on these factors, it is recommended that the Department develop projects and identify those that could be cost-effectively implemented or have a higher priority in an early time frame. Cost-effective areas requiring only new collection facilities may be funded through a combination of direct payment by new customers to partially fund the cost of collection facilities, connection charges, a rate surcharge or Special Taxing District, and currently available general obligation bond proceeds. Other economically attractive projects may be funded using these same methods, as well as by newly issued general obligation bonds or Department-issued revenue bonds. Inasmuch as the use of Department-issued revenue bonds to fund new wastewater collection facilities would be a departure from established Department practices, it is important for the County to obtain a clear legal opinion on the use of this funding method. Conclusion and next steps

Sea levels and groundwater levels have already risen in the County and are expected to continue to rise for the next century. As a consequence, underground infrastructure such as septic systems may be compromised in low lying areas. In order to properly treat wastewater, typical septic systems are designed to be sited in unsaturated soils a specified distance above the groundwater. Historic regulations regarding septic system construction were not as strict as today's standards. Furthermore, these systems were also not designed or permitted with any assumption that groundwater levels would rise gradually overtime. However, sea levels have risen more than four inches since 1994 and in many areas groundwater levels have also risen. As a result many systems are not functioning as they were originally designed and wastewater is not being adequately treated.

As detailed in this report, more than 58,000 septic systems may be vulnerable to periodic compromise under current conditions during storm events. Even within the Urban Development Boundary there are a number of systems (4,511) that are vulnerable to compromise a significant portion of the year. The majority (79%) of the persistently compromised systems are found within unincorporated Miami-Dade County. As sea levels and groundwater levels rise, the number of systems presenting a possible risk to public health and the environment predictably increases. These challenges are not constrained to the coastal areas but are found throughout the low-lying areas of the County.

This report has provided a proposed methodology to prioritize the extension of sewer services to vulnerable areas for consideration by the Board of County Commissioners. Given the potential public health and environmental implications of septic systems within the identified areas of concern, it is recommended that the County begin an expedited process to prioritize the extension of sewer services to vulnerable areas based on an analysis of parcels that represent failing conditions.

Additionally, several policy changes have been suggested to reduce the installation of additional systems in vulnerable areas. These include exploring developing a masterplan for service expansion, reviewing criteria for regional pump stations, 'feasible distance' requirements, variances, setbacks from waterways, and using current groundwater data for improved design standards.

There are several potential funding mechanisms, though further effort should be dedicated to consideration of how to reduce the up-front cost to property owners connecting to the sanitary sewer system. This is particularly important given that many of the older neighborhoods within UMSA and the UDB that have not been substantially redeveloped are often areas of more affordable housing and more moderate-income residents. It is therefore important to consider the broader socio-economic conditions when evaluating projects to reduce these risks. While certain areas are more vulnerable, the entire community will benefit from proactively addressing these issues and reducing any risks to our aquifer, surface waters, and public health.

Appendix 1: Existing regulations governing septic systems

The Department of Health regulates the construction, modification, and operation of all septic tanks. A person may not construct, repair, modify, abandon or operate an onsite sewage treatment and disposal system (OSTDS) without first obtaining a permit approved by the Miami-Dade County Health Department.

The OSTDS program is responsible for performing application reviews, conducting site evaluations, issuing permits, and for conducting inspections and complaint investigations associated with the construction, installation, repairs, and abandonment of an onsite sewage treatment and disposal system for domestic sewage flow less than 10,000 gallons per day and commercial sewage waste not exceeding 5,000 gallons per day.

The Miami-Dade County Health Department ensures that all systems regulated by the Department are sized, designed, constructed, repaired, modified, and maintained properly in order to prevent groundwater contamination, surface water contamination, and to preserve the public health. The Health Department also permits and inspects all waste haulers, portable toilets companies, and septic tank manufacturers.

The Health Department created a good partnership with the Miami-Dade County Building Department and all municipalities in Miami-Dade County to ensure that no building permit is issued where the property is to be served by a septic tank system until a permit is obtained with the Health Department. In addition, a certificate of occupancy is not issued until there is evidence that the system has received final construction approval from the Health Department. Where a project does not meet Health Department requirements, the applicant has the rights to apply for a variance. Additional information about the existing regulations can be found on the Health Department's website: http://miamidade.floridahealth.gov/programs-and-services/environmental-health/onsite-sewage-disposal/index.html.

Appendix 2: Florida Department of Health's Contribution by Dr. Samir Elmir

Rising Water Table Impacts on Onsite Sewage Treatment and Disposal Systems

Florida Department of Health
Division of Disease Control and Health Protection Bureau of Environmental Health
Onsite Sewage Programs
June 5, 2017

Background

In Southeast Florida, Miami-Dade County commissioned a report (i.e., Septic Tanks Vulnerable to Sea Level Rise, Final Report for Resolution R-911-16), expected to be completed by August, 2017, outlining how rising sea levels may impact certain areas in the county. The report discusses impacts from sea level rise to vulnerable underground structures such as surface water drainage and onsite sewage treatment and disposal systems (OSTDS), as well as the potential impacts to ground, surface water and public health.

Sea level rise may result in landward flooding events and in rising groundwater tables that may impact existing OSTDS, particularly in low-lying areas. Flooding and higher water tables compromise an OSTDS's ability to dispose of treated effluent (i.e., hydraulic function) and diminish the system's ability to remove contaminants typically found in wastewater (i.e., treatment function). In the former case, compromised hydraulic function may result in wastewater surfacing onto the ground or backing into structures. In the latter case, a compromised treatment function may result in the relatively unimpeded movement of wastewater contaminants to ground and surface waters.

Impacts to OSTDS

Beyond the obvious impacts of flooding events, the volume of unsaturated soil underneath the drainfield impacts the OSTDS's ability to efficiently remove pollutants. It has been shown that aeration of effluent in the unsaturated soil is important in achieving decomposition of organic particles and compounds, in effectively removing phosphorus, in facilitating nitrification that serves as the basis for denitrification to remove nitrogen, and in decreasing bacteria and viruses (Bicki, et al. 1984). In addition, septic tank effluent moves more slowly in unsaturated soil than in saturated soil, and, therefore, experiences longer treatment time and better opportunity for many pollutants to be removed (Bicki and Brown, 1990). Studies conducted in Florida show that the concentrations of various contaminants from the septic tank decrease considerably with the increase of the depth of unsaturated soil (Anderson, et al. 1990, Ayres and Associates, 1989, and Otis 2007). Bacteria and viruses from wastewater treated by OSTDS's travel considerable distances in saturated soil and cause groundwater pollution (Hain and O'Brien, 1979, Viraraghavan, 1978). The possible rise of the water table, due to the sea level rise, can reduce the unsaturated zone below the drainfield, and negatively impact the OSTDS pollutant removal efficiency. In areas where the existing water table separation is already low, further elevation of the groundwater table may result in hydraulic failure of the OSTDS and cause the drainfield to be flooded, especially during the wet season.

Another factor to consider in the southeast area of the state, is that a cavernous and vugular limestone aquifer (i.e., Biscayne Aquifer) underlies the area. This type of aquifer has high hydraulic conductivity and groundwater seepages rates can be much higher (up to 670 ft/yr), as compared to the seepage rates that may be observed in the central Florida area (typically well below 25 ft/yr). The faster movement of groundwater could result in wider spread of pollutants in groundwater, if pollutants are not properly removed by the onsite sewage systems (Ayres Associates, 1989).

To ensure the proper hydraulic function and the pollutant removal efficiency from OSTDS, Florida Administrative Code (F. A. C.) Chapter 64E-6, requires at least 24 inches of separation between the bottom of the OSTDS drainfield and the seasonal high water table for all *new* construction. In cases where *modifications* to a structure will result in increased wastewater flows, the water table separation, at a minimum, is required to meet a 12-inch separation, or the existing separation (if it is greater than 12 inches). For *repair* of systems serving domestic or commercial structures constructed in different time periods, the required water table separations vary. If the original system was initially permitted and constructed before December 31, 1982, the water table separation ranges from a 6 to 12 inches and on or after January 1, 1983 the water table separation becomes 24 inches (see Rule 64E-6.015, F.A.C.).

Recommendations

The United States Department of Agriculture Natural Resources Conservation Service should be consulted regarding soil and soil-water related consequences caused by any rise in sea level.

Strategies to address impacts of groundwater rise due to sea level changes on OSTDS, where appropriate, should include septic to sewer conversions, elevated or mounded OSTDS drainfields, or fill to overcome lower land elevations. Due to the historical regulatory changes to water table separation requirements, areas with OSTDS constructed before 1983 may be more sensitive to the groundwater rise and should be considered a priority.

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Appendix 3: Project ranking methodology used previously to prioritize commercial corridors

The excerpt below is drawn from the 2014 report outlining the County's approach to prioritizing sewer extension to certain commercial corridors lacking sewer services.

Proposed Sewer Projects Methodology

In order to make a recommendation on the prioritization of proposed sewer installation projects around the County a wealth of information about the proposed areas and projects was combined into one final ranking, titled "Priorities Rank."

The Priorities Rank seeks to order the projects according to a blend of current realities and planning objectives. The Priorities Rank is a composite rank derived from six broad "Priority Areas." These areas are: Planning Considerations, Environmental Considerations, Special Economic Areas, Current Business Environment and Existing Socio-Economic Conditions. The points each project received in each category as well as the total points resulting from adding the points from every category by project and associated rank is shown in Table B1.

The points assigned to each of the "Priority Areas" reflect the stated intent of the Ordinance passed by the Board of County Commissioners on July 2, 2013, together with the professional judgment of staff. The total points assigned to each Priority Area were as follows:

1.	Current Business Environment	720
2.	Existing Socio-economic Conditions	600
3.	Environmental Considerations	600
4.	Land Use Considerations	350
5.	Special Economic Areas	250
6.	Planning Considerations	250
	Total:	2,770

As previously mentioned, the stated intent as reflected in the Board's resolution is to promote economic development and job creation specifically in distressed areas. For this reason, it was decided to give the "**Current Business Environment Priority Area**" the highest number of points. Variables contained in this category are: Average sales per business (70 points), Number of commercial properties (250 points), Number of Employees (200 points), Commercial/Industrial Buildings built since 2000 (100 points), and Median Age of Properties (100 points). The variables included measuring the economic vibrancy of the corridors. Areas ranked high in this category provide the greatest potential for an increase in business and job creation.

The next two priority areas (**"Existing Socio-Economic Conditions"** and **"Environmental Considerations"**) were each allotted 600 points. In the case of **"Existing Socio-Economic Conditions"**, the decision was made to include those variables that would provide a measurement of distress in the area, specifically poverty and unemployment. The variables included in this priority area, in order of points allotted, were: Individual poverty rate (200 points), Unemployment (150 points), Median Household Income (150 points), and Home Ownership rate (100 points).

The third major priority area is **"Environmental Considerations."** A total of 600 points were allotted to this priority area. It is of utmost importance not only for the economic well-being of the County, but also for the general welfare of its citizens that our environment be protected. The two variables included in this category are: Non-Conforming DERM permits (400 points), and Wellfield Protection Areas (200 points). The presence of non-conforming permits is an important indication of the need for sewers as they are issued to those businesses that lack sewers for the disposal of waste. The second variable Wellfield Protection Areas indicates whether the parcel lies within the cone of existing wellfields. The construction of sewers will eliminate any potential contamination of our water supply.

The next three priority areas included in our analysis: **"Land Use Considerations"** (350 points); **"Special Economic Areas"** (250 points); and **"Planning Considerations"** (250 points) complement the main three priority areas. In total they consist of a maximum of 850 points, approximately 31% percent of the total points awarded.

The first of these additional priority areas **"Land Use Considerations"** (350 points), addresses the existing zoning (110 points), vacant land (100 points), and the average (80 points) and median size of parcels (60 points). These variables provide a gauge as to the potential for development, a factor that should be considered when addressing the potential construction of sewers.

The next priority area is **"Special Economic Areas"** (250 points). The variables included are: the location in an Enterprise Zone (90 points), Community Redevelopment Areas (70 points), Targeted Urban Areas (90 points). All three of these variables represent existing programs designed to encourage economic development. As such, the improvement of infrastructure, in this specific case, sewers will be an added incentive for job creation, retention and expansion of business in these areas.

The last, priority area included in our ranking analysis is **"Planning Considerations"** (250 points). This category reflects long-standing policies that have been part of our Comprehensive Development Master Plan. They encourage infill-development, and the redevelopment of Urban-Centers to prevent sprawl and promote smart growth. The variables under consideration in this priority area are: location in Urban Centers (125 points), and the Urban Infill Area (125 points).

When taken as a whole, in our professional judgment, these priority areas address the need and concerns as expressed by the Board of County Commissioners and provide a replicable objective methodology for the ranking of the proposed sewer projects.

TABLE B1 - Priorities Rank by Components

Corridor	Categories (Maximum Points)							
	PLANNING CONSIDERATIONS (250)	**ENVIRONMENTAL CONSIDERATIONS** (600)	**SPECIAL ECONOMIC AREAS** (250)	**LAND USE CONSIDERATIONS** (350)	**CURRENT BUSINESS ENVIRONMENT** (720)	**EXISTING SOCIO EXISTING SOCIO CONDITIONS** (600)	**TOTAL POINTS** (2770)	**RANK**
D1-A	125	243	90	117	353	316	124	18
D1-B	125	129	250	200	240	316	126	17
D2-A	250	371	250	23	527	546	217	3
D2-B	250	271	250	15	379	546	185	5
D2-C	250	300	250	16	395	546	190	4
D2-D	250	329	250	25	586	546	221	2
D2-E	125	129	70	13	387	546	139	16
GreenTech	250	600	250	286	634	546	2567	1
D3-A	125	300	0	14	407	600	157	-
D3-B	125	186	0	16	329	600	140	14
D4-A	250	143	70	18	604	213	145	13
D4-B	125	329	70	12	335	213	119	20
D6-A	125	357	0	97	494	427	150	11
D6-B	125	329	0	12	403	427	140	15
D6-C	125	129	0	12	85	427	891	24
D7-A	250	529	160	20	567	104	181	6
D7-B	125	343	0	12	545	104	124	19
D7-C	0	371	0	14	190	104	814	27
D8-A	125	414	180	24	489	171	162	8
D9-A	125	371	250	25	344	352	169	7
D10-A	0	586	0	20	555	196	154	10
D10-B	0	329	0	26	203	196	991	23
D10-C	0	271	0	12	280	196	872	26
D10-D	0	329	0	15	203	196	881	25
D12-A	125	443	0	26	374	263	147	12
D12-B	0	214	0	23	466	263	117	21
D12-C	0	129	0	32	309	263	102	22
D12-D	0	129	0	14	227	263	761	28

The top 10 ranked projects are highlighted.

Appendix 4: Comprehensive Development Master Plan policies related to sewer extensions

The following are the most relevant policies in the Comprehensive Development Master Plan which speak to the County's priorities regarding extending sewer services.

Water, sewer and solid waste element

WS-2E. Miami-Dade County shall continue and expand its current practice of installing oversize water and sewer mains and associated facilities in anticipation of future needs consistent with Land Use Element policies which affect the timing, staging, and location of future development, and shall require developers dedicating such facilities to the County to conform with this policy. All applications and proposed agreements for water and/or sewer extensions submitted to the Water and Sewer Department that are inside of and within 330 feet of the Urban Development Boundary and that may involve the installation of oversized water or sewer mains shall be subject to additional review by a designated water and sewer review committee. The installation of oversized water and sewer mains will be consistent with engineering requirements to protect the public health and safety of the area residents and Land Use Element policies.

WS-3A. Public facility improvements will be evaluated for funding in accordance with the following general criteria:

1) Improvements necessary to protect the health, safety, and environmental integrity of the community, consistent with the policies of this Plan and applicable federal, state, and County regulatory requirements.
2) Improvements necessary to meet any deficiencies that may exist in capacity or in performance. These include the retrofit of deteriorating facilities which fail or threaten to fail to meet health, safety, or environmental standards.
3) Improvements extending service to previously unserved developed areas within the Urban Development Boundary.
4) Improvements identified in adopted functional plans and addressing system details that are beyond the scope of the comprehensive plan for wastewater and potable water facilities, and that are consistent with the goals, objectives, and policies of the comprehensive plan.
5) Cost-effective improvements to expand capacity, maximize operational efficiency, and increase productivity.
6) * * *
7) In providing for improvements to the sanitary sewer collection system, the following additional criteria shall also be considered:
   (a) Location within a public water supply wellfield protection zone.
   (b) Potential for the disposal of waste other than domestic waste.
   (c) Designation on the Land Use Plan map for a use more intense than estate density residential.
   (d) Potential for impacts on existing private wells.
   (e) Location within areas of low land elevation in conjunction with high water table.
   (f) Locations with poor soil conditions.
   (g) Proximity to existing sewer mains.

WS-4B. Interim wastewater treatment plants within the Urban Development Boundary shall continue to be phased out as sewer service becomes available, with highest priority given to phasing out existing industrial wastewater plants in accord with regulations and procedures established by the Board of County Commissioners. The Division of Environmental Resources Management shall use its administrative, enforcement, and permitting authority to implement these regulations.

WS-4D. Anywhere that the use of existing private wells, interim wastewater treatment plants, or septic tanks pose a threat to the public health or the environmental integrity of Miami-Dade County, the County shall assert its authority to create a Special Taxing District to finance connections to the public water supply or to the public sewer system.

WS-4G. It is the policy of the County to mandate the connection of existing developments to the regional wastewater system upon extension of the wastewater collection system proximate to said developments. However, the County shall not require connections to be made in areas with gravity systems that are surcharged at any time of the day, for more than 30 days per year. Connections will not be required if the system is subject to overflows, discharge or exfiltration of sewage at any time during the year under any storm event of five years or less.

WS-4H. Miami-Dade County shall coordinate with municipalities and the State of Florida to monitor existing septic tanks that are currently at risk of malfunctioning due to high groundwater levels or flooding and shall develop and implement programs to abandon these systems and/or connect users to the public sewer system. The County shall also coordinate to identify which systems will be adversely impacted by projected sea level rise and additional storm surge associated with climate change and shall plan to target those systems to protect public health, natural resources, and the region's tourism industry.

Land use element

LU-2B. Priority in the provision of services and facilities and the allocation of financial resources for services and facilities in Miami-Dade County shall be given first to serve the area within the Urban Infill Area and Transportation Concurrency Exception Areas. Second priority shall be given to serve the area between the Urban Infill Area and the Urban Development Boundary. And third priority shall support the staged development of the Urban Expansion Area (UEA). Urban services and facilities which support or encourage urban development in Agriculture and Open Land areas shall be avoided, except for those improvements necessary to protect public health and safety and which service the localized needs of these non-urban areas. Areas designated Environmental Protection shall be particularly avoided.

LU-2D. Miami-Dade County agencies shall continue and, where possible, improve their efforts to coordinate projects to construct or repair infrastructure such as roadways and utilities in order to minimize the disruption and inconvenience caused by such construction activities.

LU-3E. By 2017, Miami-Dade County shall initiate an analysis on climate change and its impacts on the built environment addressing development standards and regulations related to investments in infrastructure, development/redevelopment and public facilities in hazard prone areas. The analysis shall consider and build on pertinent information, analysis and recommendations of the Regional Climate Change Action Plan for the Southeast Florida Regional Climate Change Compact Counties, and will include the following elements:

a) an evaluation of property rights issues and municipal jurisdiction associated with the avoidance of areas at risk for climate hazards including sea level rise;
b) an evaluation of the current land supply-demand methodology to consider and address, as appropriate, the risk associated with infrastructure investments in flood prone areas; and
c) an evaluation of the CDMP long-term time horizon in relation to addressing projected long-range climate change impacts.

Recommendations from the analysis shall address appropriate changes to land use designations and zoning of impacted properties, and development standards, among other relevant considerations.

LU-3I. Miami-Dade County shall make the practice of adapting the built environment to the impacts of climate change an integral component of all planning processes, including but not limited to comprehensive planning, infrastructure planning, building and life safety codes, emergency management and development regulations, stormwater management, and water resources management.

LU-10A. Miami-Dade County shall facilitate contiguous urban development, infill, redevelopment of substandard or underdeveloped urban areas, moderate to high intensity activity centers, mass transit supportive development, and mixed-use projects to promote energy conservation. To facilitate and promote such development Miami-Dade County shall orient its public facilities and infrastructure planning efforts to minimize and reduce deficiencies and establish the service capacities needed to support such development.

Conservation element

CON-2D. Sewer Improvement Special Taxing Districts shall be established for all industrial and potentially hazardous commercial areas within the Urban Development Boundary.

Coastal management element

Objective CM-9. Miami-Dade County shall continue to orient its planning, regulatory, and service programs to direct future population concentrations away from the Coastal High Hazard Area (CHHA) and FEMA "V" Zone. Infrastructure shall be available to serve the existing development and redevelopment proposed in the Land Use Element and population in the CHHA, but shall not be built, expanded, or oversized to promote increased population in the coastal high-risk area.

CM-9F. Public expenditures that subsidize new or expanded infrastructure that would encourage additional population growth in the Coastal High Hazard Areas shall be prohibited. New public facilities shall not be built in the Coastal High Hazard Area, unless they are necessary to protect the health and safety of the existing population or for the following exceptions: public parks, beach or shoreline access; resource protection or restoration; marinas or Ports; or roadways, causeways and bridges necessary to maintain or improve hurricane evacuation times. Potable water and sanitary sewer facilities shall not be oversized to subsidize additional development in the Coastal High Hazard Area.

CM-9H. Rise in sea level projected by the federal government, and refined by the Southeast Florida Regional Climate Change Compact, shall be taken into consideration in all future decisions regarding the design, location, and development of infrastructure and public facilities in the County.

Economic element

ECO-4C. Miami-Dade County will program infrastructure improvements in municipalities taking into account their socio-economic development priorities and overall County priorities.

ECO-4D. Infrastructure prioritization should consider needs of existing and target industries in industrial areas that do or can support these industries, especially along trade corridors and around trade hubs.

Capital improvements element (interpretive text)

Improvements to the water and sewer systems are based on the following general criteria:

1. Improvements, which are necessary to protect the health, safety and environmental integrity of the community, and meet federal, State, and local regulatory requirements.
2. Improvements, which are necessary to meet existing deficiencies in capacity or in performance. These include the retrofit of deteriorating facilities, which fail or threaten to fail to meet health, safety or environmental standards.
3. Improvements which extend service to previously unserved developed areas.
4. Improvements which have been identified in adopted functional plans and address system details which are beyond the scope of the comprehensive plan for wastewater facilities and potable water facilities and are consistent with the goals, objectives and policies of the comprehensive plan.
5. Cost-effective improvements to expand capacity, maximize operational efficiency, and increase productivity.

In providing for improvements to the sanitary sewer collection system, the following additional criteria are also taken into account:

1. Location within a public water supply wellfield protection zone.
2. Potential for the disposal of wastes other than domestic waste.
3. Designation on the Future Land Use Plan map for a use more intense than estate density residential.
4. Potential for impacts on existing private wells.
5. Areas with low land elevation in conjunction with high water table.
6. Soil conditions.
7. Proximity to open bodies of water.
8. Proximity to existing sewer mains.

CIE-2A. Public funds will not be used to subsidize increased overall density or intensity of urban development in coastal high hazard areas. However, public beach, shoreline access, resource restoration, port facilities or similar projects may be constructed.

CIE-2B. Replacement of infrastructure in coastal high hazard areas will be at or below existing service capacity except where such replacement will improve hurricane evacuation time, mitigate storm damage, or meet regulatory requirements.

Appendix 5: State and County policies related to the Coastal High Hazard Areas

State law governing Coastal High Hazard Areas

163.3178(2)(h), Florida Statutes - Designation of coastal high-hazard areas and the criteria for mitigation for a comprehensive plan amendment in a coastal high-hazard area as defined in subsection (8). The coastal high-hazard area is the area below the elevation of the category 1 storm surge line as established by a Sea, Lake, and Overland Surges from Hurricanes (SLOSH) computerized storm surge model. Application of mitigation and the application of development and redevelopment policies, pursuant to s. 380.27(2), and any rules adopted thereunder, shall be at the discretion of local government.

380.27 Coastal infrastructure policy.—
(1) No state funds shall be used for the purpose of constructing bridges or causeways to coastal barrier islands, as defined in s. 161.54(2), which are not accessible by bridges or causeways on October 1, 1985.
(2) After a local government has an approved coastal management element pursuant to s. 163.3178, no state funds which are unobligated at the time the element is approved shall be expended for the purpose of planning, designing, excavating for, preparing foundations for, or constructing projects which increase the capacity of infrastructure unless such expenditure is consistent with the approved coastal management element.
History.—s. 38, ch. 85-55; s. 38, ch. 95-196.

(8)(a) A proposed comprehensive plan amendment shall be found in compliance with state coastal high-hazard provisions if:

1. The adopted level of service for out-of-county hurricane evacuation is maintained for a category 5 storm event as measured on the Saffir-Simpson scale; or
2. A 12-hour evacuation time to shelter is maintained for a category 5 storm event as measured on the Saffir-Simpson scale and shelter space reasonably expected to accommodate the residents of the development contemplated by a proposed comprehensive plan amendment is available; or
3. Appropriate mitigation is provided that will satisfy subparagraph 1. or subparagraph 2. Appropriate mitigation shall include, without limitation, payment of money, contribution of land, and construction of hurricane shelters and transportation facilities. Required mitigation may not exceed the amount required for a developer to accommodate impacts reasonably attributable to development. A local government and a developer shall enter into a binding agreement to memorialize the mitigation plan.

(b) For those local governments that have not established a level of service for out-of-county hurricane evacuation by July 1, 2008, by following the process in paragraph (a), the level of service shall be no greater than 16 hours for a category 5 storm event as measured on the Saffir-Simpson scale.
(c) This subsection shall become effective immediately and shall apply to all local governments. No later than July 1, 2008, local governments shall amend their future land use map and coastal management element to include the new definition of coastal high-hazard area and to depict the coastal high-hazard area on the future land use map.

County policies related to the Coastal High Hazard Areas

Objective CM-9. Miami-Dade County shall continue to orient its planning, regulatory, and service programs to direct future population concentrations away from the Coastal High Hazard Area (CHHA) and FEMA "V" Zone. Infrastructure shall be available to serve the existing development and

redevelopment proposed in the Land Use Element and population in the CHHA, but shall not be built, expanded, or oversized to promote increased population in the coastal high-risk area.
Policies

CM-9A. Development and redevelopment activities in the Coastal High Hazard Area (CHHA), Hurricane Evacuation Zone A, and the Hurricane Vulnerability Zone1 Hurricane Zone B shall be limited to those land uses that have acceptable risks to life and property. The basis for determining permitted activities shall include federal, State, and local laws, the pre-disaster study and analysis of the acceptability of various land uses reported in the County's Comprehensive Emergency Management Plan required by

Policy CM-10A, when approved, and the following guidelines:

i. Discourage development on the CHHA, including the barrier islands and shoreline areas susceptible to destructive storm surge;
ii. Direct new development and redevelopment to high ground along the Atlantic Coastal Ridge and inland environmentally suitable lands;
iii. Maintain, or reduce where possible, densities and intensities of new urban development and redevelopment within Hurricane Evacuation Zone A to that of surrounding existing development and zoning;
iv. Prohibit construction of new mobile home parks and critical facilities in Hurricane Evacuation Zone A;
v. Prohibit Land Use Plan map amendments or rezoning actions that would increase allowable residential density in the FEMA "V" Zone, the CHHA or on land seaward of the Coastal Construction Control Line (CCCL) established pursuant to Chapter 161, F.S.; and,
vi. Continue to closely monitor new development and redevelopment in areas subject to coastal flooding to implement requirements of the federal flood insurance program.

CM-9B. Land use amendments to the Comprehensive Development Master Plan shall not be approved in Coastal High Hazard Areas if they would decrease Levels of Service on roadways below the LOS standards established in the Transportation Element.

CM-9C. Miami-Dade County shall consider undeveloped land in areas most vulnerable to destructive storm surges for public or private recreational uses and open space, including restoration of coastal natural areas.

CM-9D. New facilities which must function during a hurricane, such as hospitals, nursing homes, blood banks, police and fire stations, electrical power generating plants, communication facilities and emergency command centers shall not be permitted in the Coastal High Hazard Area and when practical, shall not be located in the Hurricane Vulnerability Zone.

CM-9E. The construction or operation of new non-water dependent industrial or business facilities that would generate, use or handle more than 50 gallons of hazardous wastes or materials per year shall be prohibited in the Coastal High Hazard Area. Miami-Dade County shall seek funding to wind- and flood-harden existing public facilities of this type.

CM-9F. Public expenditures that subsidize new or expanded infrastructure that would encourage additional population growth in the Coastal High Hazard Areas shall be prohibited. New public facilities shall not be built in the Coastal High Hazard Area, unless they are necessary to protect the health and safety of the existing population or for the following exceptions: public parks, beach or shoreline access; resource protection or restoration; marinas or Ports; or roadways, causeways and bridges necessary to maintain or improve hurricane evacuation times. Potable water and sanitary sewer facilities shall not be oversized to subsidize additional development in the Coastal High Hazard Area.

CM-9G. Miami-Dade County shall utilize its Geographic Information System and other forms of mapping of public buildings and infrastructure within the Coastal High Hazard Area and Hurricane Vulnerability Zone to facilitate and expedite pre- and post-disaster decision-making.

CM-9H. Rise in sea level projected by the federal government, and refined by the Southeast Florida Regional Climate Change Compact, shall be taken into consideration in all future decisions regarding the design, location, and development of infrastructure and public facilities in the County.

Appendix 6: Methodology used to identify non-residential areas with septic systems

The memo below describes the approach used by Tetra Tech to identify non-residential properties lacking sewers. A similar approach was used by Tetra Tech to identify residential parcels in a previous study.

MEMORANDUM

To: Maria A. Valdes, CSM, LEED® GA

Chief of the Comprehensive Planning and Water Supply Certification Section Miami-Dade Water and Sewer Department

From: Diana M. Santander, P.E.

Sr. Project Manager Tetra Tech

Date: August 23, 2017

Subject: GIS Information for Non-Residential Properties Lacking Sewer

INTRODUCTION

Tetra Tech has been requested to provide GIS services to the Miami-Dade County Water and Sewer Department (WASD) to identify non-residential areas within the County lacking sewer service. These services have been provided as part of Tetra Tech's Task Authorization 12, Sub-Task 7.

Sewer service in Miami-Dade County is provided by various utilities including WASD. However, several areas throughout the County are currently lacking service and they do not have the ability to connect to WASD's or municipal wastewater collection and transmission systems. These areas are generally served by septic tanks installed at each individual property.

Tetra Tech obtained GIS information from WASD including the Customer Information System (CIS), gravity and pressure systems layouts. In addition, the sewer network shapefiles prepared by other utilities and submitted to the Miami-Dade County Department of Regulatory and Economic Resources (RER) as part of their requirements for compliance with the Consent Decree were obtained for this evaluation. Information was obtained from the following utilities: Miami Beach, Coral Gables, Hialeah, North Miami, North Miami Beach, Opa-Locka, Homestead, Bal Harbour Village, Bay Habour Islands, Surfside, West Miami, Florida City, Medley, North Bay Village, Hialeah Gardens, Miami International Airport, and SFL.

The purpose of this GIS exercise it to identify the non-residential parcels lacking sewer service and the residential agricultural properties. This information will be subsequently used by WASD for other purposes.

METHODOLOGY

The methodology that was used to identify unserved non-residential parcels within and outside the

UDB is as follows:

1. Obtained GIS service layers from WASD and other sewer providers serving properties.
2. Utilized Environmental Systems Research Institute (Esri) ArcMap 10.4 to overlay shapefiles representing existing land use, parcel limits, streets, and sewer infrastructure within the County.
3. Classified parcels as non-residential according to their existing land use, zoning, and Property Appraiser information.
4. Identified as not served parcels that did not have a sewer account in the WASD CIS layer or that are not located within a 37.5 foot buffer from existing gravity sewer mains.
5. Used sewer network shapefiles prepared by the other utilities and submitted to RER for parcels within service areas other than WASD to determine whether or not sewer service was provided. Unlike WASD, the information provided by the other utilities did not have CIS layers. Therefore, only sewer lateral and gravity main information was used to determine whether or not sewer service was available to the properties. The 37.5 foot buffer was also applied to these systems.
6. Removed parcels identified via the Primary Land Use Code as bodies of water, rights-of-way, and easements.
7. Removed vacant parcels from those preliminarily identified as requiring service, assuming that the developer would have to extend the existing sewer system to obtain service.
8. Removed Agricultural and Utility parcels if they did not have a structure.
9. Removed parcels with identified private pump stations on the WASD sewer node shapefile. Additional parcels were also removed that had WASD force mains within the parcel and confirmed to be served by private pump stations.
10. Visual analysis was used for the remaining parcels to determined service to parcels beyond the 37.5 foot buffer of the existing gravity sewer infrastructure.
11. Created a new layer identified as NonResidential_Parcel_wo_Sewer containing the remaining parcels.

FINDINGS

The total amount of non-residential parcels determined to be not served based on the available information was 3,861. The total of residential agricultural properties was 67. As mentioned in the methodology, this number does not include parcels identified via the Primary Land Use Code as bodies of water, rights-of-way, easements, agricultural without structures and utilities without structures.

Tetra Tech
6303 Blue Lagoon Drive, Suite 305, Miami, FL 33126
Tel 305.908.1420 Fax 305.264.1805 tetratech.com