# Lake County Wastewater and OSTDS Remediation Plan

UPPER OCKLAWAHA RIVER BASIN BMAP

WEKIVA RIVER, ROCK SPRINGS RUN, LITTLE WEKIVA CANAL BMAP

SILVER SPRINGS AND RIVER BMAP



LAKE COUNTY, FL

REAL FLORIDA · REAL CLOSE

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In 2022, the Lake County Board of County Commissioners (Board) established a program to assist residents in converting their existing septic systems to a Distributed Wastewater Treatment System (DWTS). The Lake County DWTS consists of multiple, individual Distributed Wastewater Treatment Units (DWTU), each of which are owned by the County and under the continuous supervision of licensed wastewater operators. The Lake County DWTS and all individual DWTUs are subject to the regulatory authority of the Florida Department of Environmental Protection (FDEP). In the establishment of this program, the Board created Florida's first DWTS-based program to retrofit existing septic tanks in impaired watersheds, countywide.

On December 20, 2022, the Board approved Article V, Chapter 21, Lake County Code, establishing *Distributed Wastewater Treatment System Assessment Procedures* (Exhibit A) for the installation and maintenance of the Lake County DWTS through a Municipal Services Benefit Unit (MSBU). Residents or businesses interested in converting their septic system to the Lake County DWTS can apply to join the MSBU, and their annual MSBU assessments fund the ongoing costs of operating and maintaining their DWTU equipment. The Lake County DWTS-MSBU forms the financial backbone of a comprehensive program to reduce the number of existing septic systems in the impaired watersheds of unincorporated Lake County.

On January 24, 2023, the Board approved a grant agreement with the FDEP to provide $1 million for costs associated with the removal of septic tanks and installation of DWTUs. The FDEP grant requires a 50% non-state match, and the Board set aside $1 million of American Rescue Act Funds (ARPA) for this purpose. In total, the $2 million in funding currently available is estimated to eliminate between 100 and 130 septic tanks in BMAP areas across the County. On the same date, the Board approved a contract with OnSyte Performance, LLC (OnSyte) to provide turnkey installations and licensed wastewater operations of the DWTS to support the County program.

On July 11, 2023, after several interested residents expressed a desire to participate, the Board formally established the DWTS MSBU in Ordinance No. 2023-43 (Exhibit B) and authorized the start of the program. OnSyte subsequently notified the FDEP of the first installations on July 20, and the program is already removing septic tanks. The County projects the first phase of the program will remove between 100 and 130 septic tanks by the end of March 2024. The County has a pending grant application to request additional funding ($6 million from FDEP and $2 million matching from Lake County, Total $8 million) from the FDEP Water Quality Improvement Grant to expand its program to remove another 500-1,000 septic tanks over the next 2 years.

## I. Wastewater Treatment Plan Components

1. **Facility Capacity**. The existing Lake County DWTS permit (FLAB07156) authorizes up to 0.020 MGD, which is adequate capacity for approximately 130-150 residential DWTUs. In early 2024, OnSyte and Lake County will seek

an expansion of the DWTS permit to 0.12 MGD, which is adequate capacity for approximately 600-750 residential DWTUs.

2. **Nutrient Effluent Limits**. The Lake County DWTS permit contains reporting requirements for TN and TP.
3. **Estimated Nutrient Loads**. Based on years of continuous operation, testing and verification by FDEP in the City of Apopka Septic-to-DWTS Program, residential DWTUs have been shown to remove in excess of 80% TN prior to discharge to a subsurface absorption field (drainfield). The 2021 Lapointe Study (Exhibit C) supports an additional 10% TN removal efficiency in the drainfield, resulting in a total of 90% TN removal for each septic tank removed. <u>For the Silver and Wekiwa BMAPs, the TN reduction per DWTU conversion will be based on the recharge area as follows</u>:

| County | Persons Per Household | Load Per Person | Medium Recharge Rate |
|---|---|---|---|
| **Lake** | **2.55** | **9.012** | **0.5** |

**Calculation Table**

| Recharge Category | Conventional OSTDS Load to GW (lb-N/yr/tank) | Improvement to GW (lb-N/yr/tank) |
|---|---|---|
| | | **DWTU** |
| Nitrogen Input | 22.98 | |
| Attenuation | 11.5 | |
| Low Recharge | 1.1 | **0.9** |
| Medium Recharge | 5.7 | **4.6** |
| High Recharge | 10.3 | **8.3** |

The Ocklawaha BMAP is based on TP reduction, which requires a different analysis. For this program, the TP reduction credit will be limited to conversions within 200 meters of an impaired lake or tributary within the Ocklawaha BMAP area. The TP reduction per septic tank removed will be based on the reduction allocated to septic-to-sewer conversions in the Wekiva Basin (surface water) BMAP[1], adjusted to match the TP removal efficiency from the Lapointe Study. For the Ocklawaha BMAP, the TP reduction per DWTU conversion will be 2.49 lb-TP/yr.

4. **Capacity Analysis**. The DWTS permit contemplates expansion as the number of DWTUs increases with the program. The projected capacity analysis over the next 10 years is shown in Table 1:



[1] <u>TP reduction per septic tank conversion is 2.5 lb/yr within 200m of receiving waterbody</u> [Final BMAP: Wekiva River, Rock Springs Run, and Little Wekiva Canal, October 2015. Table B.12.]

**Table 1: Lake County BMAP Plan – Capacity Analysis by Program Year**

| | 2023 | 2024 | 2025 | 2026 | 2027 | 2028 | 2029 | 2030 | 2031 | 2032 | 2033 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Projected septic tank replacements | 100 | 600 | 1100 | 2100 | 3100 | 4100 | 5100 | 6100 | 7100 | 8100 | 9100 |
| Required DWTS Capacity (MGD) | 0.02 | 0.12 | 0.22 | 0.42 | 0.62 | 0.82 | 1.02 | 1.22 | 1.42 | 1.62 | 1.82 |

5. **Facility Expansion and Estimated Costs**. The DWTS program is capable of expanding as needed to achieve the County's BMAP requirements. Based on the projected growth of the program, the County will achieve its BMAP objectives within 9-10 years, at an estimated cost of $162M (present value). This amount is currently unfunded by the County and would require additional funding from state and/or federal agencies to implement.
6. **Projected Timeline**. The projected timeline for the expansion of the Lake County DWTS program is shown in Table 1.

## II. OSTDS Remediation Plan Components

7. **OSTDS Inventory**. The inventory of existing OSTDS inside the BMAP boundaries within unincorporated Lake County is shown in Table 2.

**Table 2: OSTDS Inventory, Unincorporated Lake County**

| | Silver BMAP | Wekiwa BMAP | Ocklawaha BMAP |
|---|---|---|---|
| Existing OSTDS | 3,948 | 11,984 | 31,998 |
| High Recharge | 3,276 | 8,297 | 14,329 |
| Medium Recharge | 423 | 2,275 | 8,162 |
| Low Recharge | 249 | 1,412 | 9,507 |
| < 200m | ------------------- | ------------------- | 8,087 |

8. **OSTDS Estimated Growth**. For new development on individual parcels smaller than one acre, the County intends to require connection to its DWTS Program or an advanced nutrient removal (NSF 245) septic system. On lots larger than one acre, additional growth of OSTDS is projected. In order to estimate the rate of growth, the County reviewed the OSTDS permitting records. In the last complete year of records (2020), 731 permits were issued for new OSTDS in the county. In the last 30 days, 46 permits were issued for new OSTDS in the county, which is an annual rate of about 550 per year. Using this information, low, medium and high projections were developed, and the resulting projected annual growth of OSTDS in each BMAP and outside of BMAP boundaries is shown in Table 3.

| Table 3: OSTDS Projected Growth | | | | |
|---|---|---|---|---|
| | Silver BMAP | Wekiwa BMAP | Ocklawaha BMAP | Outside BMAPs |
| Existing OSTDS | 3,948 | 11,984 | 31,998 | 18,669 |
| Undeveloped lots | 1,871 | 14,275 | 7,310 | 16,412 |
| < 1 acre (DWTU only) | 950 | 6,435 | 3,411 | 10,285 |
| > 1 acre | 921 | 7,840 | 3,899 | 6,127 |
| Projected OSTDS/yr | | | | |
| Low @ 500/yr | 4 | 37 | 18 | 29 |
| Medium @ 625/yr | 5 | 46 | 23 | 36 |
| High @750/yr | 6 | 55 | 27 | 43 |
| TN Loading (lb) | 102 | 872 | 434 | 681 |

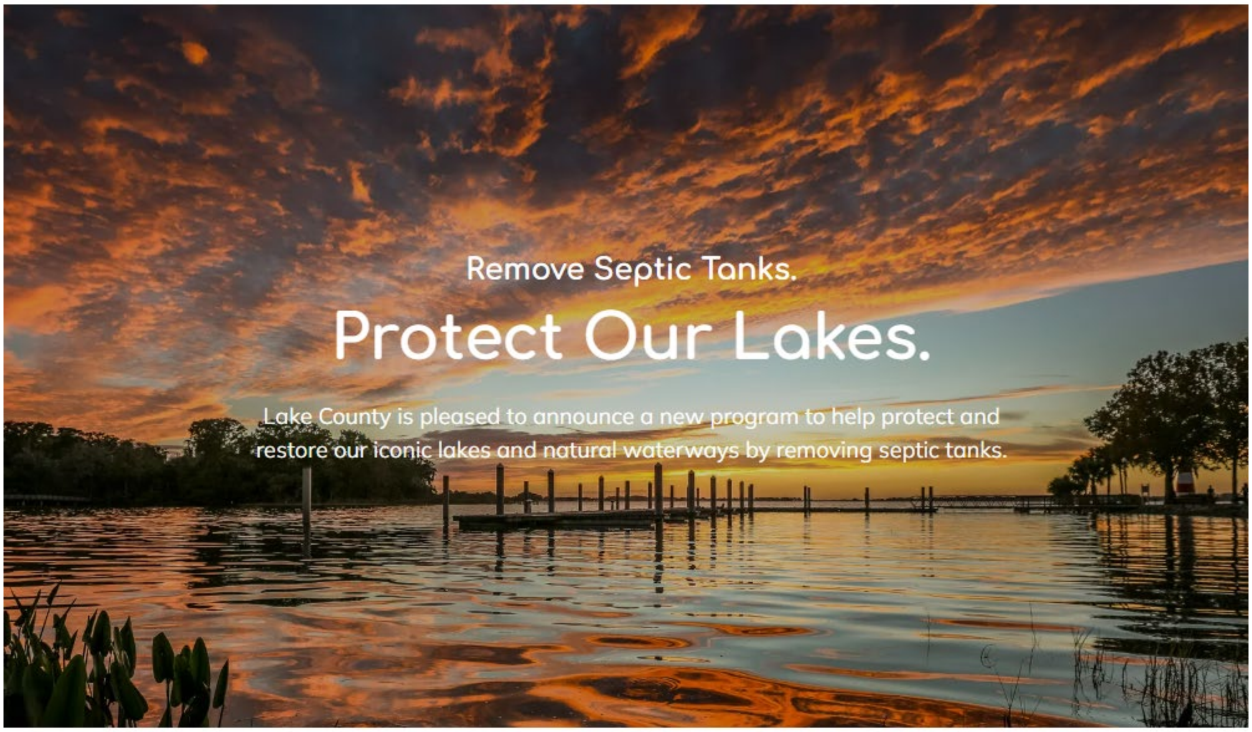
9. **OSTDS Connection to DWTS.** Exhibit D shows the projected conversions of conventional septic tanks to DWTUs over 10 years.
10. **OSTDS to DWTS Milestones**. Exhibit D shows the conversion milestones to achieve the TN and TP reductions each BMAP.
11. **OSTDS to DWTS Estimated Costs**. The total estimated cost of the program is approximately $188M (present value). The total estimated costs to achieve the interim conversion milestones are also shown in Exhibit D.
12. **OSTDS to ENR-OSTDS.** As the entirety of Lake County is accessible with its DWTS program, no projected costs are associated with this activity.
13. **OSTDS to ENR-OSTDS Estimated Costs.** None.
14. **Other Projects**. None.

## III. Conclusion

To support its septic tank elimination goals and the nutrient reduction requirements of the three BMAP areas, the County established an innovative Septic to DWTS Conversion Program. The County is promoting its program through a dedicated website, electronic and written communication, traditional and social media, and public meetings. The grant-supported septic tank conversion program is currently being offered to property owners inside unincorporated Lake County on a voluntary basis. Once eligibility is confirmed and the property owner has signed up, the septic tank abandonment and DWTU installation takes place in less than 30 days. The website is shown on the following page.

Home Forms Sign Up Today
Technology Deep Dive

CONTACT US




For eligible homeowners, limited funding (first 130 homeowners) is available to remove septic tanks and convert homeowners to Lake County's Distributed Wastewater Treatment System. This program will provide distributed wastewater treatment units that reduce pollution beyond the reach of traditional sewer systems.

### Lake County Customer Application

Download Form

### DWTS System Checklist

Download Form

### Utility Easement Form

Download Form

### Tax Assessment for DWTS

Download Form

### Sewer Notification

Download Form

The Lake County septic to DWTS Program is designed to achieve the County's BMAP requirements to eliminate septic tanks in unincorporated areas out of reach of municipal wastewater treatment facilities and their collection systems. The Lake County DWTS and all individual DWTUs will be owned by the County, which allows access to grant funding and provides efficient grant and program administration. The creation of an MSBU ensures adequate funding for the long-term maintenance and repairs of all treatment equipment. Licensed operators oversee the DWTS system operation, and monthly sampling and certified laboratory testing are performed under the regulatory oversight of FDEP. With such a program in place, the assurance of long-term nutrient removal goals is extremely high in a DWTS-based, septic-to-sewer program (comparable to conventional septic-to-sewer projects). This type of program requires no established utility or up-front capital to start, is efficient to implement, and is extremely scalable due to the DWTS permit allowing septic tank replacements anywhere in the County's jurisdiction. This enables the program to proceed very quickly, accommodating hundreds and ultimately thousands of septic tank conversions under a single DWTS permit.

Lake County is appreciative of the Department's support throughout this process, and the entire staff are eager to hear from the Department on this Lake County Wastewater and OSTDS Remediation Plan. Please direct any questions or comments to Jeff Earhart, P.E. at jeff.earhart@lakecountyfl.gov or 352-253-6009. Thank you.

# Exhibit A

## *Distributed Wastewater Treatment System Assessment Procedures*

## Article V, Chapter 21, Lake County Code

# EXHIBIT A

## ARTICLE V. - DISTRIBUTED WASTEWATER TREATMENT SYSTEM ASSESSMENT PROCEDURES

### Sec. 21-55. - Power and authority.

(a) The board of county commissioners may provide for the installation and maintenance of distributed wastewater treatment systems in the unincorporated area of the county and may assess against the property to be improved the cost of installation and/or maintenance, or any portion thereof, and to pay as a county charge any of the costs which are not assessed.

(b) At its option, the board of county commissioners may impose assessments within an area and establish municipal service taxing or benefit units to fund costs and services of improvements. Notwithstanding any petition process set forth in this article, the board shall retain the authority to establish improvement areas without a landowner petition and the board shall not be legally bound by the result of the petition process.

(c) The County Manager or designee shall have responsibility for the administration, coordination, permitting, bidding, inspecting, and record keeping activities associated with any assessment program and resulting projects.

(d) All properties owned by federal, state and local governments are exempt from assessments imposed under this article.

(Ord. No. 2022-58, § 2, 12-20-22)

### Sec. 21-56. - Municipal Service Taxing (MSTU) or Benefit Unit (MSBU).

(a) As provided for in Section 125.01(q), Florida Statutes, the board of county commissioners may establish, merge or abolish municipal service taxing units (MSTU) or benefit units (MSBU) in accordance with the procedures set forth in this article and as provided in Florida law to include property within the unincorporated area of the county in order to fund an improvement project that benefits public health, safety or welfare. Property owners requesting the installation, and subsequent maintenance, of a distributed wastewater treatment system by the establishment of a municipal service taxing or benefit unit must petition the County. Petitions in support of the MSTU or MSBU area must be received from at least fifty-five percent (55%) of the property owners within the proposed unit boundaries. Individual property owners may also submit a petition. Verification will be accomplished by comparing the petitions with the existing tax rolls.

(b) The County Manager or designee will estimate the overall cost of the installation and maintenance of the distributed wastewater treatment system and provide the estimate to the property owners if requested.

(c)

After receipt and verification of the results of the petition process, the County Manager or designee will present the project, estimated project cost, and estimated assessments to the board of county commissioners for the board's consideration. Assessments in the MSTU or MSBU area will be based on costs to provide the installation and maintenance of the system, number of properties within the unit boundaries, and taxing or benefit unit allocated to each participating property. Assessments may be based on the number of lots, home sites, front footage, acreage, or other equitable measures within the MSTU or MSBU area. There will be no funding participation by the board of county commissioners unless the board otherwise agrees pursuant to a majority vote.

(d) The board of county commissioners shall be the governing body of the MSTU or MSBU and upon adoption of an initial resolution, the assessments must be levied and collected pursuant to Chapter 197 and Chapter 200, Florida Statutes, including Section 197.3632, Florida Statutes. The MSTU or MSBU shall remain in effect for so long as the distributed wastewater treatment system remains functional and in place. Any request for change in amount of assessment, boundary or purpose will be presented to the board at a public hearing for consideration. A MSTU or MSBU can only be dissolved (1) if the property connects to a municipal or other public wastewater system, or (2) the board determines dissolution benefits the public health, safety or welfare.

(Ord. No. 2022-58, § 2, 12-20-22)

Sec. 21-57. - Preliminary resolution to declare a MSBU.

(a) When the board decides to establish a MSBU for system installation and/or maintenance, the board shall so declare by resolution stating the nature of the proposed improvements, designating the property to be improved, the parcels to be benefited, and the portion of the cost to be paid by the assessment. The resolution shall also designate the lands upon which the assessments shall be levied and shall also state the total estimated cost of the improvement.

(b) The resolution adopted pursuant to subsection (a) shall be recorded in the public records of the county immediately after its adoption.

(c) The board of county commissioners shall cause to be published [a] notice as required under Section 197.3632, Florida Statutes.

(d) At the time designated in the notice or to which an adjournment may be taken, the board of county commissioners shall receive any objections of interested persons and may then or thereafter adopt such resolution with such amendments, if any, as may be desired by the board and which do not change the location of the improvement or increase the probable cost thereof.

(e) The project(s) shall not commence until the initial resolution is recorded in the public records of Lake County, Florida, and the assessment will be placed on the next available tax bill, and each subsequent tax bill so long as the system remains functional and in place, unless the board of county commissioners otherwise terminates the assessment.

(Ord. No. 2022-58, § 2, 12-20-22; Ord. No. 2023-30, § 4, 5-9-23)

Sec. 21-58. - Assessment roll.

(a) For each year that the MSBU remains in place, the board of county commissioners shall cause to be prepared an assessment roll containing property descriptions and assessments of cost against each lot or parcel of land within the MSBU. Upon completion of the assessment roll, the board shall cause to be published a notice stating that the assessment roll has been completed, is on file in the office of the board, is open to public inspection and, that at a regular meeting of the board on a certain day and hour, the board will hear objections of all interested persons to the proposed assessments contained in the assessment roll. The notice shall further state in brief and general terms, a description of the purpose of the assessment with the location thereof. On or after the hearing provided for in this section, the board shall either annul, sustain, or modify, in whole or in part, the assessment indicated on the assessment roll either by confirming the assessment against any or all lots or parcels described therein, or by canceling, increasing, or reducing the same but shall not confirm any assessment in excess of the special benefit to the property assessed. Immediately after the determination of assessments as hereinbefore provided, the assessment roll shall be final and conclusive unless proper steps shall be taken in a court of competent jurisdiction to secure relief as provided for by law. The notices required herein shall be provided in accordance with Section 197.3632, Florida Statutes.

(b) The final assessment roll shall be recorded in the public records of the county immediately after adoption.

(Ord. No. 2022-58, § 2, 12-20-22; Ord. No. 2023-30, § 5, 5-9-23)

Sec. 21-59. - Priority of lien.

All assessments for any improvements made under the provisions of this article shall constitute liens upon the property assessed from the date of the recording of the final assessment roll and shall be of the same nature and to the same extent as liens for general county taxes. No sale of any property for general county taxes or for an installment or installments of any such assessment and no perfecting of title under any such sale shall divest the lien of any installment of such assessment not due at the time of the sale. Collection of such assessments with such interest and penalties, costs and attorneys' fees, may be made by the county or lending institution by proceedings in a court of equity to foreclose the lien of the assessment as a lien for mortgages is, or may be foreclosed under the laws of the state. It shall be lawful to join in any bill for foreclosure any one (1) or more lots or parcels of land, by whomsoever owned, if assessed for the same improvement; provided that failure to pay any installment of principal or interest on any assessment within thirty (30) days of the date when such installment shall become due shall without notice or other proceedings, cause all installments of principal remaining unpaid to be forthwith due and payable with interest due thereon at date of default and further interest as herein provided; but if before the sale of the property for delinquent assessments, the amount of such delinquency shall be paid with all penalties, interest costs and attorneys' fees, further installments of the principal shall cease to become so due and payable, and shall be due and payable at the times at which the same would be due if no such default had occurred.

(Ord. No. 2022-58, § 2, 12-20-22)

Sec. 21-60. - Method of collection.

(a) If an MSBU is to be imposed by the board, the duties of the property appraiser and tax collector under the Uniform Assessment Collection Act, Section 197.3632, Florida Statutes, are ministerial.

(b) MSBU assessments to be imposed pursuant to this article will constitute a non-ad valorem assessment within the meaning and intent of the Uniform Assessment Collection Act. The county shall comply with the procedures set forth in the Uniform Assessment Collection Act, Section 197.3632, Florida Statutes, as amended.

(c) MSTU assessments are considered ad valorem taxes and the duties of the property appraiser and tax collector shall be the same as for any other ad valorem levy.

(Ord. No. 2022-58, § 2, 12-20-22)

Sec. 21-61. - Bonds—Generally.

(a) The board of county commissioners shall have the power and it is hereby authorized to provide by resolution from time to time for the issuance of bonds for the purpose of paying all or a part of the cost of any one (1) or more improvements authorized by this article or any combination of improvements as a single improvement. The principal and interest of the bonds shall be payable from the assessments levied against the property and any other funds legally available for payment that are pledged or made available for such payment pursuant to the authorization resolution. The bonds of each issue shall be dated, shall bear interest at such rate or rates not to exceed the provisions of Section 215.84(3), Florida Statutes, and shall mature at such time or times not exceeding thirty (30) years from their date or dates as may be determined by the board and may be made redeemable before maturity at the option of the county at such price or prices and under such terms and conditions as may be determined by the board prior to the issuance of the bonds. The board may add a component to the interest rate charged to recompense the county for administrative costs associated with establishing or maintaining the assessment program. The board shall determine the form of the bonds, the manner of executing the bonds and coupons and shall fix the denomination or denominations of the bonds and the place or places of payment of the principal and interest which may be at any bank or trust company within the state. In case any officer whose signature or a facsimile signature shall appear on any bonds or coupons shall cease to be such officer before the delivery of the bonds, this signature or facsimile shall nevertheless be valid and sufficient for all purposes the same as if the officer had remained in office until delivery. All bonds issued under the provisions of this article shall have and are hereby declared to be and to have all of the qualities and incidents of negotiable instruments under the laws of the state. Provision may be made for the registration of any of the bonds in the name of the owner as to the principal alone and also as to both principal and interest. The bonds may be issued without regard to any limitation on indebtedness prescribed by any law and shall not be included in the amount of bonds which the county may be authorized to issue under any statute. The board shall sell the bonds by competitive sale unless it first determines that a negotiated sale best serves the interest of the county. The board may sell the bonds at such interest rate or rates limited only by applicable law, and for such price as it may determine to be for the best interests of the county. The board may also provide for the replacement of any bonds which shall become mutilated or be destroyed or lost. Bonds may be issued without any other proceedings or the happening of any other conditions or things than those proceedings, conditions or things which are specifically required by this article.

(b) The proceeds of bonds shall be used solely for the payment of the cost of the improvement, costs of issuing the bond, capitalizing interest, funding reserves or any other lawful purpose, and shall be disbursed in such manner and under such restrictions, if any, as the board may provide. If the proceeds of the bonds by error of estimates or otherwise shall be less than the cost of the improvement, the board of county commissioners may pay the deficit from any other county revenues or funds legally available for the purpose. If the proceeds of bonds issued for any improvement shall exceed the cost of the improvement, the surplus may be paid into the fund provided for the payment of principal and interest on the bonds or for any lawful purpose.

(c) In the event that the county has constructed an improvement under the terms of this article, and to pay the cost of that improvement has issued bonds payable from the funds provided for herein, and in the event the county desires to construct additions, extensions or betterments to the initial improvement or to construct an additional improvement and to combine the additional improvement with the initial improvement and to refund the outstanding bonds, the county may provide for the issuance of a single issue of bonds under the provisions of this article or for the combined purposes:

(1) Of refunding bonds then outstanding.

(2) Of constructing additions, extensions or betterments or constructing additional improvements and the principal of and the interest on the bonds shall be payable from the funds pledged therefore as provided herein.

(d) The resolution providing for the issuance of the bonds may also contain such limitations upon the issuance of additional bonds as the board of county commissioners may deem proper and additional bonds shall be issued under such restrictions and limitations as may be prescribed by resolution. All monies received from any bonds issued and sold under the provisions of this article shall be applied in accordance with the provisions hereof and of the resolution authorizing the issuance of the bonds.

(Ord. No. 2022-58, § 2, 12-20-22)

Sec. 21-62. - Same—Pledge of assessments.

(a) The county shall pledge the assessments provided for by this article as security for the payment of the principal of and interest on any bonds issued under the terms of this article or for a reserve for such debt service.

(b) The pledge of assessments shall be a valid and legal binding contract between the county and the holders of the bonds and the county shall be obligated to continue to receive and apply the assessments in accordance with the proceedings which authorize the issuance of the bonds for which the assessments are pledged as security as long as any of the bonds are outstanding and unpaid.

(Ord. No. 2022-58, § 2, 12-20-22)

Sec. 21-63. - Same—Neither credit nor taxing power pledged.

(a) Bonds issued under the provisions of this article shall not constitute a debt of the county or a pledge of the faith and credit of the county but shall be payable solely from assessments levied against the property benefitting from the improvement, and from any other revenues described in the authorizing resolution. All bonds shall contain a statement on their face to the effect that the county is not obligated to pay the principal or the interest thereon except from the funds provided for in this article and that the faith and credit of the county are not pledged to the payment of the principal or interest of the bonds.

(b) The issuance of bonds under the provisions of this article shall not directly or indirectly or contingently obligate the county to levy or to pledge any form of ad valorem taxation upon real property. No holder of any bond shall have the right to compel any exercise by the county of the ad valorem taxing power to pay any bonds or the interest thereon or to enforce payment of the bonds or the interest thereon against any property of the county. The bonds shall not constitute a charge, lien or encumbrances, legal or equitable upon any property of the county except those funds pledged for the payment of the bonds.

(Ord. No. 2022-58, § 2, 12-20-22)

Sec. 21-64. - Refunding bonds.

(a) The county is hereby authorized to provide by resolution for the issuance of refunding bonds for the purpose of refunding any bonds then outstanding and issued under the provisions of this article for the purpose of financing or refinancing all or a part of the cost of improvements provided for in this article. The county is further authorized to provide by resolution for the issuance of bonds for the combined purpose of:

(1) Paying the cost of constructing an additional improvement or improvements; and

(2) Refunding bonds of the county which shall previously have been issued for financing or refinancing improvements provided for by this article and shall then be outstanding.

(b) The issuance of such refunding bonds, the maturities and other details thereof, the rights of the holders thereof and the duties of the board of county commissioners and of the county in respect to refunding bonds shall be governed by the provisions of this article insofar as those provisions may be applicable.

(c) If outstanding bonds to be refunded are not redeemable, or immediately redeemable, the board of county commissioners shall have the power to invest the proceeds of refunding bonds in direct obligations of the United States of America or in time deposit of banks or trust companies represented by certificates of deposit secured by direct obligations of the United States of America until the maturity date thereof or the first date upon which the outstanding bonds are redeemable prior to maturity.

(Ord. No. 2022-58, § 2, 12-20-22)

Sec. 21-65. - Additional security.

The county may additionally pledge or otherwise provide for the payment of the principal of and interest on any bonds issued under the provisions of this article any funds of the county legally available for the purpose.

(Ord. No. 2022-58, § 2, 12-20-22)

Sec. 21-66. - Trust funds.

All monies received pursuant to the authority of this article whether as proceeds from the sale of bonds or otherwise, shall be deemed to be trust funds to be held and applied solely as provided for in this article. The board of county commissioners may, in a resolution authorizing the issuance of bonds, provide for the payment of the proceeds of the sale of the bonds to any officer or to any agency, bank or trust company which shall act as trustee of the funds and hold and apply the funds to the purposes of this article subject to such regulations as this article and the resolution may provide.

(Ord. No. 2022-58, § 2, 12-20-22)

Sec. 21-67. - Remedies of bondholders.

Any holder of bonds issued under the provisions of this article except to the extent the rights herein given may be restricted by resolution passed before the issuance of the bonds, may by suit, action, mandamus or other proceedings, protect and enforce any and all rights under the laws of this state or granted by this article or resolution and may enforce and compel the performance of all duties required by this article or resolution to be performed by the county or the board of county commissioners or by any officer thereof.

(Ord. No. 2022-58, § 2, 12-20-22)

# Exhibit B

## Distributed Wastewater Treatment System Municipal Service Benefit Unit

## Ordinance No. 2023-43

# EXHIBIT B

**Summary of Ordinance**

The purpose of this Ordinance is to establish a Municipal Services Benefit Unit (MSBU) for unincorporated residents that participate in the Distributed Wastewater Treatment System Program. The MSBU would only be levied against property owners that agree to participate in the Program and who convert their existing septic systems to a distributed wastewater treatment system.

Changes are shown as follows: ~~Strikethrough~~ for deletions and Underline for additions to existing Code sections. The notation "* * *" shall mean that all preceding or subsequent text remains unchanged (excluding any renumbering or relettering that might be needed).

**ORDINANCE NO. 2023-43**

**AN ORDINANCE OF THE BOARD OF COUNTY COMMISSIONERS OF LAKE COUNTY, FLORIDA; ESTABLISHING THE DISTRIBUTED WASTEWATER TREATMENT SYSTEM MUNICIPAL SERVICES BENEFIT UNIT (MSBU); PROVIDING THE BOARD OF COUNTY COMMISSIONERS WITH THE AUTHORITY TO LEVY AND COLLECT SPECIAL ASSESSMENTS AND SERVICE CHARGES WITHIN THE MSBU FOR PARTICIPATING RESIDENTS; AMENDING SECTION 20-1, LAKE COUNTY CODE, TO ADOPT THIS ORDINANCE BY REFERENCE; PROVIDING FOR SEVERABILITY; PROVIDING FOR INCLUSION IN THE CODE; PROVIDING FOR FILING WITH THE DEPARTMENT OF STATE; AND PROVIDING FOR AN EFFECTIVE DATE.**

**WHEREAS,** Section 125.01, Florida Statutes, grants the Lake County Board of County Commissioners, hereinafter the "Board", all powers necessary to carry on County government; and

**WHEREAS,** specifically, Section 125.01(1)(q), Florida Statutes, grants the Board the power to establish municipal services benefit units for any part or all the unincorporated area of Lake County, within which may be provided benefits such as waste and sewage collection and disposal; and

**WHEREAS,** on December 20, 2022, the Board adopted Ordinance 2022-58, which established Article V, Chapter 21, Lake County Code, entitled *Distributed Wastewater Treatment System Assessment Procedures*, which created the process for installation and maintenance of Distributed Wastewater Treatment Systems and a method by which to assess the costs to residents; and

**WHEREAS,** on January 24, 2023, the Board accepted the award of a Florida Department of Environmental Protection grant for a Septic to Sewer Conversion Program and entered into an agreement with Onsyte Performance, LLC to install the distributed wastewater treatment systems for interested residents within the geographic boundaries of Lake County; and

**WHEREAS,** Onsyte Performance, LLC, holds the proper permits from the Florida Department of Environmental Protection (Permit No. FLAB07156) to install, operate and maintain distributed wastewater treatment systems; and

**WHEREAS,** several interested residents have expressed a desire to participate in the Distributed Wastewater Treatment System (DWTS) Program; and

**WHEREAS,** the Board finds that establishing a municipal services benefit unit to provide a mechanism for interested residents to pay for services associated with the installation of a DWTS in is the best interests of and serves the health, safety, and general welfare of the residents of Lake County, Florida.

**NOW, THEREFORE, BE IT ORDAINED** by the Board of County Commissioners of Lake County, Florida as follows:

**Section 1.** **Legal Findings of Fact.** The foregoing recitals are hereby adopted as legislative findings of the Board of County Commissioners and are ratified and confirmed as being true and correct and are hereby made a specific part of this Ordinance upon adoption hereof.

**Section 2.** **Establishment.** A municipal services benefit unit to be known as the "Distributed Wastewater Treatment System Municipal Services Benefit Unit" is hereby established in the unincorporated area of Lake County, Florida.

**Section 3.** **Purpose.** The purpose of the Distributed Wastewater Treatment System Municipal Services Benefit Unit is to provide a mechanism to levy an annual fee to cover the costs of operating a Distributed Wastewater Treatment System on participating properties located in the unincorporated areas of Lake County, Florida.

**Section 4.** **Governing Body and Authority.** The Board of County Commissioners of Lake County, Florida, shall be the governing body of the Distributed Wastewater Treatment System Municipal Services Benefit Unit and is hereby authorized to:

(1) Levy and collect special assessments, pursuant to the provisions of Section 197.3632, Florida Statutes, as amended from time to time, on participating real properties within the Distributed Wastewater Treatment System Municipal Services Benefit Unit, the portion of the unincorporated area of Lake County, Florida, described in **Exhibit "A"**, to fund the services associated with installation, operation and maintenance of a distributed wastewater treatment system; and

(2) Enter into binding contracts to install, operate, and maintain a distributed wastewater treatment system within the Distributed Wastewater Treatment System

(13) Ordinance No. 1991-11 (Greater Groves Municipal Service Benefit Unit).

(14) Ordinance No. 1991-15 (Deer Island Community Development District).

(15) Ordinance No. 1991-16 (Country Greens Community Development District).

(16) Ordinance No. 1991-19 (Imperial Terrace West Municipal Taxing Unit).

(17) Ordinance No. 2000-35 (County-Wide Municipal Service Taxing Unit)

(18) Ordinance No. 2006-115 (Municipal Services Taxing Unit).

(19) Ordinance No. 2008-20 (Country Green Community Development District).

(20) Ordinance No. 2017-7 (Sylvan Shores Municipal Service Benefit Unit).

(21) Ordinance No. 2020-59 (Inclusion of the City of Mascotte into the Fire MSTU/Assessment).

(22) Ordinance No. 2020-60 (Inclusion of the Hawthorne at Leesburg and Sago Palm at Hawthorne Communities into the Fire MSTU/Assessment).

(23) Ordinance No. 2020-66 (Challenger Drive and Lenze Drive Municipal Service Benefit Unit).

(24) Ordinance No. 2020-74 (Inclusion of the City of Fruitland Park into the Fire MSTU/Assessment).

(25) Ordinance No. 2022-15 (Inclusion of the Town of Montverde into the Fire MSTU/Assessment).

(26) Ordinance No. 2022-53 (Establishment of the Wellness Way Transportation Network Municipal Services Taxing Unit).

<u>(27) Ordinance No. 2023-__ (Establishing the Distributed Wastewater Treatment System Municipal Services Benefit Unit).</u>

**Section 7.** **<u>Severability.</u>** If any section, sentence, clause, or phrase or word of this Ordinance is for any reason held or declared to be invalid, unconstitutional, inoperative or void by any court of competent jurisdiction, then said holding shall in no way affect the validity of the remaining portion of this Ordinance; and it shall be construed to have been the Commissioners' intent to pass this Ordinance without such unconstitutional, invalid or inoperative part therein; and the remainder of this Ordinance, after the exclusion of such part or parts shall be deemed and held to be valid, as if such parts had not been included herein; or if this Ordinance or any provisions thereof shall be held inapplicable to any person, groups of persons, property, kind of property, circumstances or set of circumstances, such holding shall not affect the applicability thereof to any other person, property or circumstances.

**Section 8.** **<u>Inclusion in the Code.</u>** It is the intent of the Board of County Commissioners that the provisions of this Ordinance shall become and be made a part of the Lake County Code and that the sections of this Ordinance may be renumbered or relettered and the word

Municipal Services Benefit Unit as may be desired by the Board of County Commissioners of Lake County, Florida; and

(3) Borrow and expend money, and issue bonds, revenue certificates and other obligations of indebtedness and to exercise any and all powers granted by general or special law; and

(4) Impose service charges within the Distributed Wastewater Treatment System Municipal Services Benefit Unit described as "all participating properties within the unincorporated area of Lake County, Florida, in order to fund the installation, operation and maintenance of a distributed wastewater system pursuant to Section 125.01(1)(q), Florida Statutes.

**Section 5.** **Legislative Findings.** The levy of special assessments within the Distributed Wastewater Treatment System Municipal Services Benefit Unit shall benefit the participating property owners within the Distributed Wastewater Treatment System Municipal Services Benefit Unit as the use of a distributed wastewater treatment system improves water quality, enhances the quality of life, and improves the environment.

**Section 6.** **Amendment.** Section 20-1, Lake County Code, entitled *Ordinances adopted by reference,* shall be amended to read as follows:

**Sec. 20-1. Ordinances adopted by reference.**

The following ordinances, as amended are adopted by reference as if set out in full in this Code:

(1) Ordinance No. 1979-8 (Pasco Fire Control District).

(2) Ordinance No. 1980-1 (Plymouth Fire Control District).

(3) Ordinance No. 1980-2 (Paisley Fire Control District).

(4) Ordinance No. 1980-3 (Northwest Lake County Fire Control District).

(5) Ordinance No. 1980-4 (Bassville Fire Control District).

(6) Ordinance No. 1980-5 (South Lake Fire Control District).

(7) Ordinance No. 1985-13 (Lake County Municipal Taxing Unit for Fire Protection).

(8) Ordinance No. 1989-5 (Indian Lakes Municipal Service Taxing Unit).

(9) Ordinance No. 1990-25 (Lake County Municipal Service Taxing Unit for Unincorporated Lake County).

(10) Ordinance No. 1990-26 (Lake County Municipal Service Taxing Unit for Waste Collection and Disposal).

(11) Ordinance No. 1990-27 (Lake County Municipal Service Taxing Unit for Water and Wastewater Services).

(12) Ordinance No. 1990-28 (Greater Hills Municipal Service Taxing Unit).

"ordinance" may be changed to "section," "article," or such other appropriate word or phrase in order to accomplish such intentions.

**Section 9.** **Filing with the Department of State.** The Clerk shall be and is hereby directed forthwith to send an electronic copy of this Ordinance to the Secretary of State for the State of Florida in accordance with Section 125.66, Florida Statutes.

**Section 10.** **Effective Date.** This Ordinance shall become effective as provided for by law.

Enacted this ________ day of ___________________, 2023.

Filed with the Secretary of State ______________________, 2023.

| | |
|---|---|
| ATTEST: | BOARD OF COUNTY COMMISSIONERS<br>LAKE COUNTY, FLORIDA |
| ______________________________ | ______________________________ |
| Gary J. Cooney, Clerk of the<br>Board of County Commissioners<br>of Lake County, Florida | Kirby Smith, Chairman<br><br>This _____ day of _________________, 2023. |

Approved as to form and legality:

______________________________
Melanie Marsh, County Attorney

LAKE
COUNTY, FL
REAL FLORIDA · REAL CLOSE

# ECONOMIC IMPACT STATEMENT

**Contact Information**

| | | | |
|---|---|---|---|
| Date: | June 27, 2023 | Contact Name: | Jeff Earhart |
| Dept./Division: | Public Works | Contact Phone: | 352-253-6009 |
| | | | |

**Ordinance Information**

**Describe the Ordinance:**

The purpose of this Ordinance is to establish a Municipal Services Benefit Unit (MSBU) for unincorporated residents that participate in the Distributed Wastewater Treatment System Program. The MSBU would only be levied against property owners that agree to participate in the Program and who convert their existing septic systems to a distributed wastewater treatment system.

**Describe the direct economic impact of the ordinance upon the operation of the County:**

An MSBU coordinator will need to be hired to manage this program and other newly created MSBU programs. The program will require staff resources from Public Works, Budget and Finance staff to support the MSBU program.

**Describe the direct economic impact of the ordinance upon the property owner/taxpayers/citizens who are expected to be affected:**

Each residential property that participates in the Distributed Wastewater Treatment Program will be charged $660 per year to cover the operation and maintenance of the system. The fee will increase three (3%) percent or the consumer price index (CPI) percentage per year, whichever is greater. The fee will be included on the residential tax bill.

**Identify any potential indirect economic impacts, positive or negative which might occur as a result of the ordinance:**

The treatment units are expected to decrease the amount of nitrogen that would have been discharged from typical septic tanks, and ultimately improve water quality in adjacent lakes.

# Exhibit C

## 2021 Lapointe Study (2021)

EXHIBIT C

# Assessment of an OnSyte Performance Distributed Wastewater Treatment Unit on Groundwater Quality in Lake Hamilton, FL


Brian Lapointe, Ph.D. & Rachel Brewton, M.S.

December 17, 2021

HARBOR BRANCH

FLORIDA ATLANTIC UNIVERSITY®

Ocean Science for a Better World®

5600 US 1 N.
Fort Pierce, FL 34946

# Executive Summary

Globally, wastewater management is a critical issue because excess nutrients from wastewater can contribute to eutrophication, as well as the formation and maintenance of harmful algal blooms (HABs). For many communities in Florida, the importance of this issue is heightened by the proximity to sensitive ecosystems, such as coral reefs in the Florida Keys, estuaries like the Indian River Lagoon and Caloosahatchee River Estuary, and freshwater springs found throughout central Florida. All of these ecosystems support threatened and/or endangered species, so improving and maintaining water quality by upgrading wastewater management in these areas is paramount. Further, minimizing wastewater pollutants in groundwater is important to human health as effluent could contaminate drinking water wells or adjacent surface waters. The installation of Distributed Wastewater Treatment Units (DWTU), such as the one manufactured by OnSyte Performance, LLC (OnSyte), may offer an alternative in some locations to septic-to-sewer conversions or the use of centralized sewer infrastructure.

In this study, commissioned by the Florida Department of Environmental Protection (FDEP), the performance of a DWTU was tested at 1045 West Main St., Lake Hamilton, FL (Permit Number FLAB07110, issued April 27, 2020). The study followed the recent construction of a single-family residence and installation of a new DWTU with a subsurface absorption field. Prior to 2020, the property was vacant and there are indications of agricultural land use. A monitoring well was installed immediately downgradient (within 10’) of the DWTU absorption field to establish baseline groundwater conditions prior to occupation of the residence and to monitor changes occurring during the study. The residence was occupied on December 1, 2020, after which groundwater, DWTU influent, and effluent samples were collected for approximately ten months.

The OnSyte DWTU is an activated-sludge sequencing batch reactor (SBR) that isolates and treats a “batch” of wastewater in a series of automated steps, including aeration, mixing and clarification, in the presence of activated sludge and denitrifying bacteria. A computer controls the treatment process and allows remote operation and control by licensed wastewater operators using a cloud-based operating system (SCADA). During the “unit conditioning” phase of the study, the DWTU began operation “dry” without seeding with activated sludge, and the DWTU’s internal recycling (“multi-pass”) program was initially disabled to prevent the dilution of the influent. The DWTU was made “fully operational” on March 10, 2021 when the multi-pass feature was activated in the treatment program. With multi-pass, approximately 65% of the treated wastewater from each treatment “batch” is pumped back to the first chamber, diluting the incoming wastewater and receiving additional treatment. The residence was vacated on June 30, 2021 and reoccupied in mid-August, 2021.

From the initiation of the fully operational phase until the house was vacated, there were substantial differences between the wastewater influent and effluent as a result of the

DWTU treatment process. In the DWTU, many water quality parameters significantly decreased from influent to effluent, including ammonia ($NH_3$; 97%), total Kjeldahl nitrogen (TKN; 95%), total nitrogen (TN; 88%), the TN:TP ratio (84%), carbonaceous biochemical oxygen demand (CBOD; 96%), and total suspended solids (TSS; 96%). Decreased concentrations of total phosphorus (TP; 38%) and fecal coliforms (92%) were also observed between the influent and effluent, but the change was not significant. Conversely, nitrate + nitrite ($NO_x$) concentrations increased significantly from the influent to the effluent (3,071%), due to the nitrification of $NH_3$.

Changes in groundwater nutrient concentrations were observed in the downgradient monitoring well following occupation of the residence. Significant increases were observed from the baseline to the conditioning phase for groundwater concentrations of $NH_3$, $NO_X$, and TN. For example, during the unit conditioning phase, the groundwater TN concentration increased from the baseline average of 2.36 ± 0.34 to a maximum of 54.6 mg/L on March 25, 2021. Once the unit was fully operational, groundwater $NH_3$ concentrations significantly decreased. Groundwater $NO_X$ and TN concentrations also substantially decreased, though the change was not significant. In particular, TN declined to 7.0 mg/L at the end of the fully operational phase.

The study demonstrated that the OnSyte DWTU was effective at improving quality of wastewater effluent, especially for TN, which suggests these systems may offer an alternative treatment method in locations where adjacent surface waters are sensitive to nitrogen (N) enrichment. The performance of the DWTU could still be further studied or improved by additional treatment options (e.g., polishing filters) to remove TP. Additionally, longer-term studies examining variable conditions would also allow for a better understanding of the DWTU’s functionality under a wider range of conditions. Nonetheless, the performance of the OnSyte DWTU was particularly impressive in this study because of the very high N loading (118 ± 4.7 mg/L), which is above the average for households that ranges from 35 – 100 mg/L. Decreasing the wastewater nutrient load to groundwater throughout Florida will be an important step to decreasing negative environmental impacts, such as eutrophication and HABs. Lastly, this technology may help to minimize human health impacts of wastewater contamination of groundwater and surface water.

# Contents



# List of Figures



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## Acronyms and Formulas used in Text

| | |
|---|---|
| AL | Ackuritelabs, Inc. |
| AEL | Advanced Environmental Laboratories, Inc. |
| ANOVA | analysis of variance |
| CBOD | carbonaceous biochemical oxygen demand |
| DWT | Distributed Wastewater Treatment |
| DWTS | Distributed Wastewater Treatment System |
| DWTU | Distributed Wastewater Treatment Unit |
| FDEP | Florida Department of Environmental Protection |
| HAB | harmful algal bloom |
| HBOI-FAU | Harbor Branch Oceanographic Institute-Florida Atlantic University |
| MDL | method detection limit |
| mg/L | milligrams per liter |
| $NH_3$ | ammonia |
| $NO_x$ | nitrate + nitrite |
| $NO_2^-$ | nitrite |
| $NO_3^-$ | nitrate |
| OnSyte | OnSyte Performance, LLC |
| Pace | Pace Analytical Services, LLC |
| SBR | sequencing batch reactor |
| SE | standard error |
| SM | standard method |
| TN | total nitrogen |
| TP | total phosphorus |
| TN:TP | total nitrogen to total phosphorus ratio |
| TKN | total Kjeldahl nitrogen |
| TSS | total suspended solids |

# 1. Introduction

Wastewater management is a globally important issue because inadequately treated domestic wastewater can have negative impacts when released into the environment. For example, increased nutrient loading from wastewater can promote harmful algal blooms (HABs) and eutrophication (Anderson et al., 2002; Anderson, 2009; Nixon, 2009; Lapointe et al., 2015; Lapointe et al., 2017; Paerl et al., 2018). Further, wastewater can increase fecal pollution and pathogen loading to surface waters (Lipp et al., 2001a), especially during times of increased precipitation (Lipp et al., 2001b). Thus, it is critically important to reduce or eliminate domestic wastewater flows into the environment.

In Florida, septic systems are widely used for on-site wastewater management, as regulated by Florida Administrative Code 64E-6.002. However, many locations are not appropriate for this method due to sandy, karstic, or porous soils, often with seasonally high water tables and high population densities (Bicki et al., 1984; Bicki & Brown, 1990, 1991; Lapointe et al., 2017; Herren et al., 2021). As such, septic systems often contaminate groundwater and surface waters in Florida with excessive nutrients and bacteria (Lapointe et al., 1990; Aravena et al., 1993; Lapointe & Krupa, 1995; Corbett et al., 2002; Lapointe et al., 2015; Lapointe et al., 2017; Lapointe et al., 2020; Herren et al., 2021). This contamination is a critical issue because there are many sensitive aquatic habitats throughout Florida, including coral reefs in the Florida Keys and Southeast Florida, estuaries such as the Indian River Lagoon and the Caloosahatchee River Estuary, and freshwater springs. All these ecosystems support threatened and/or endangered species, so improving and maintaining water quality by improving wastewater management in these areas is paramount.

Alternative methods can be used to treat wastewater on site. For example, Distributed Wastewater Treatment (DWT) represents new technology for wastewater management. One type of DWT is manufactured by OnSyte Performance, LLC (OnSyte). An OnSyte DWT unit (DWTU; **Figure 1a**) is similar in size to a septic tank, but is designed for domestic wastewater “on-site” treatment. The OnSyte DWTU is an activated-sludge sequencing batch reactor (SBR) that isolates and treats a “batch” of wastewater in a series of automated steps, including aeration, mixing and clarification, in the presence of activated sludge and denitrifying bacteria. A computer controls the treatment process and allows for remote operation and control by licensed wastewater operators using a cloud-based operating system (SCADA). OnSyte DWTUs are monitored and operated remotely by licensed wastewater operators, and the entire DWT system (DWTS) is regulated by the Florida Department of Environmental Protection (FDEP) at the utility level. If a DWTU fails, technicians are immediately notified and the problem repaired. The DWT treatment process is similar to a municipal treatment plant, utilizing a three-chambered, suspended-growth, activated-sludge, sequencing batch reactor with biological nitrogen removal (**Figure 1b**). With computer-controlled internal recycling using the OnSyte “multi-pass” feature, a variable fraction (averages 65% for a typical single-family home) of the treated wastewater from each treatment "batch" is pumped back to the first chamber, diluting the incoming wastewater and receiving additional treatment. The effluent it produces is treated to a level equivalent to basic municipal wastewater treatment, and the use of a properly functioning drainfield can result in even more denitrification before entering the groundwater.

This study was designed through a research agreement between Harbor Branch Oceanographic Institute-Florida Atlantic University (HBOI-FAU), OnSyte, and FDEP to test the in situ performance of an OnSyte DWTU in the Town of Lake Hamilton located in central Florida. The goal of this study was to assess changes in wastewater effluent attributable to the DWTU and to monitor downgradient groundwater for associated changes.

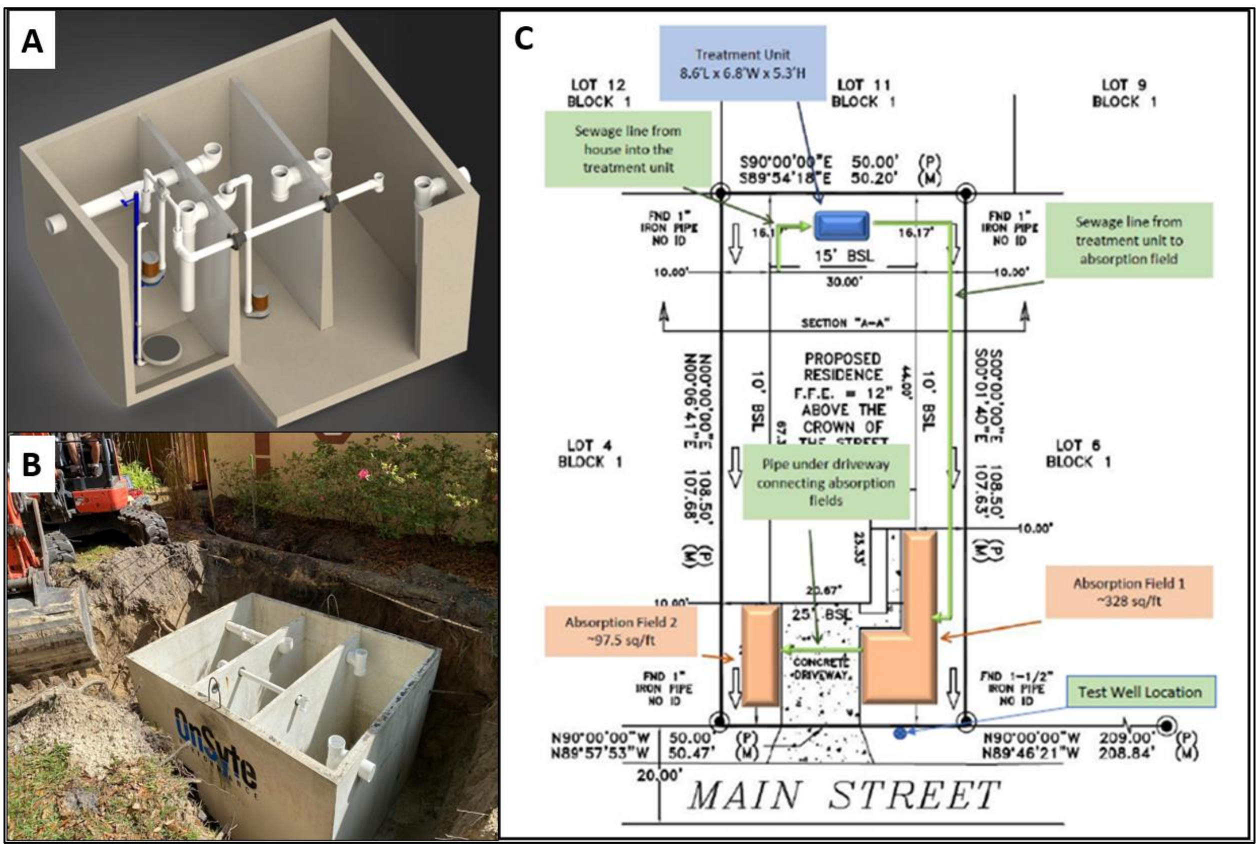


Figure 1. The three-chambered OnSyte Performance, LLC, Distributed Wastewater Treatment Unit (DWTU), shown as A) a DWTU schematic and B) photograph of DWTU during installation, also showing C) a schematic of the test site DWTU installation.

# 2. Materials and Methods

## 2.1 Study Site and Well Installation

The DWTU study site was located at 1045 West Main Street, Lake Hamilton, FL (Permit Number FLAB07110, issued April 27, 2020; **Figure 1B, 1C and 2A**). Before the construction of a single-family residence with a new DWTU and subsurface absorption field, the property was vacant and there are indications of agricultural use prior to 2000. A location in the public right of way on the north side of West Main St. that was less than 10‘ downgradient from the subsurface absorption field was selected for installation of a groundwater monitoring well (**Figure 1C and 2A, 2B**). The monitoring well was located away from external groundwater quality influences, such as nearby septic systems. The groundwater flow was in a southerly direction, towards a depressional wetland **(Figure 2B**).


Figure 2. Study site in Lake Hamilton, FL, showing A) aerial imagery of the residence where the Distributed Wastewater Treatment Unit (DWTU) and groundwater monitoring well were installed in Lake Hamilton, FL and B) groundwater flow at the study site.

At this location, a single groundwater monitoring well with a depth of ~12’ was installed using an auger on 09/21/2021. The well installation report classified the sediment at the site to be fine-grained sand and the well was constructed to the following specifications:

a) 2-in diameter Schedule 40 PVC monitoring well casing set in an 8-in borehole;
b) Casing began at 2’;
c) Silica sand (gradation 20/30) filter pack was placed around the screen from the bottom of the borehole to approximately 1’ above the screen;
d) 1’ fine sand seal was placed above the sand filter pack;
e) Well was sealed from the top of sand to ground surface with neat cement or bentonite/cement grout; and
f) Wellhead was placed in flush mounted wellhead cover with a locking well cap.

## 2.2 Study Timeline

"Baseline monitoring" of existing groundwater conditions began on October 9, 2020, prior to the occupation of the home. The residence was occupied on December 1, 2020. The DWTU began operation "dry" without seeding with activated sludge and the multi-pass program was initially disabled to prevent the dilution of the influent for testing purposes during the "unit conditioning" phase. The DWTU was made "fully operational" when the multi-pass was activated in the treatment program on March 10, 2021. During the fully operational phase, wastewater influent was diluted with recycled wastewater and the effluent received additional treatment (see Introduction). The DWTU remained fully operational until the residence was vacated on June 30, 2021. After the occupants vacated the residence, groundwater was monitored in July 2021 to assess performance with "no input". The residence was reoccupied by a different family in early August 2021, after which monitoring continued until October 7, 2021 to assess the capacity of the DWTU to function after a 40 day dormant period with no wastewater inputs.

## 2.3 Water Collection and Laboratory Analyses

Groundwater samples were collected by Pace Analytical Services, LLC, (Pace) staff with a peristaltic pump following FDEP groundwater sampling protocols and delivered to Pace, Oldsmar, FL or Tampa, FL (bacteria only) for analyses. Samples of wastewater influent and DWTU effluent were collected by OnSyte staff and sent to either Ackuritelabs, Inc. (AL), 3345 North Monroe St., Tallahassee, FL 32303 or Advanced Environmental Laboratories, Inc., (AEL) 380 North Lake Blvd., Suite 1048 Altamonte Springs, FL 32701 for the initial conditioning and fully operational phases. From after the first residents vacated the home on June 30, 2021 until the end of the study on October 7, 20201, influent and effluent samples were collected and analyzed by OnSyte staff using a Hach DR3900 Spectrophotometer.

At Pace, AL, and AEL, samples were analyzed following standards methods approved by National Environmental Laboratories Accreditation Conference (NELAC). Wet chemistry methods included ammonia ($NH_3$; EPA 350.1), nitrate ($NO_3^-$) + nitrite ($NO_2^-$= $NO_x$; SM 4500), total Kjeldahl Nitrogen (TKN; EPA 351.2), total phosphorus (TP; EPA 365.4), total suspended solids (TSS; SM 2540D), pH (SM 4500H+B), and carbonaceous BOD (CBOD; SM 5210B). Microbiology methods included fecal coliforms (SM 9222D). Method detection limits (MDLs) at Pace were 0.035 mg/L for $NH_3$, 0.025 mg/L for $NO_x$, 0.086 mg/L for TKN, 0.050 mg/L for TP, and 1.0 MPN/100mL for fecal coliforms. Method detection limits (MDLs) at AL were 0.066 mg/L for $NH_3$, 0.007 mg/L for $NO_{3-}$, 0.004 mg/L for $NO_{2-}$, 0.069 mg/L for TKN, 0.008 mg/L for TP, 2.0 mg/L for TSS, 0.1 for pH, 2.0 for CBOD, and 2.0 MPN/100mL for fecal coliforms; while $NO_x$ was calculated. Method detection limits (MDLs) at AEL were variable, but within range of the other laboratories. For the OnSyte tested samples at the end of the study period, the following Hach test kits were used: Ammonia TNT 832 (MDL 2 – 47 mg/L), Nitrate TNT 836 (MDL 5 – 35 mg/L), and Nitrite TNT 839 (MDL 0.015 – 0.600 mg/L).

## 2.4 Data Handling and Statistical Analyses

DWTU data were categorized by the study phases described in section 2.2 for statistical analyses with slight differences between groupings for the DWTU and groundwater. For the DWTU analyses, the "Unit Conditioning" phase (Cond) occurred from December 30, 2020 to March 10, 2021 and the DWTU was "Fully Operational" (FO) from March 17 to June 30, 2021.

For groundwater, due to a lag between initial loading and observed effects, TN concentrations were used as indicators of change and the following timeframes were used to statistically assess groundwater impacts. "Baseline monitoring" (BL) occurred from October 9 to January 21, 2020, the "Unit Conditioning" phase (Cond) occurred from January 28, 2020 to April 1, 2021, and the "Fully Operational" (FO) phase spanned April 15 to June 30, 2021. For groundwater analyses, the residence was considered vacated June 30 to September 3, 2021 (Vac) and reoccupied (ReOc) on September 16, 2021.

At HBOI-FAU, calculations were performed to determine concentrations of total nitrogen (TN = TKN + $NO_x$) and the molar ratio of TN to TP (TN:TP). All of the parameters were assessed by water type (groundwater, wastewater influent, and DWTU effluent) and study phase (baseline, DWTU conditioning, DWTU fully operational, residence vacated, and residence reoccupied). DWTU data for the vacated and the reoccupied phase were not statistically assessed, due to a change in the analytical methods (see section 2.3). Data were assessed for analysis of variance (ANOVA) assumptions. As assumptions were not met, characteristics of influent and effluent during the fully operational phase and groundwater for all phases were compared with a Kruskal-Wallis test (groups of three) or a Mann-Whitney U-test (groups of two) with significant differences considered at $p < 0.05$. Significant comparisons for groups of three were followed by Dunn's test with a Bonferroni correction. Statistical analyses were conducted in SPSS v. 28.0 and figures were produced in Prism v. 9. Data are presented as single values or means with standard error (± S.E.).

# 3. Results

## 3.1 Distributed Wastewater Treatment Unit Performance

Nitrogen in the DWTU influent was dominated by $NH_3$, which comprised 63 – 75% of the TN. During the fully operational phase, the DWTU significantly (Mann-Whitney U test, $p = 0.002$) reduced $NH_3$ concentrations 97% from influent to effluent (**Table 1**). Wastewater influent $NH_3$ concentrations were slightly higher in the conditioning phase (95.3 ± 6.6 mg/L) than in the fully operational phase (73.7 ± 4.0 mg/L) during which they were diluted with recycled wastewater (**Figure 3a**). Effluent from the DWTU had the highest $NH_3$ concentrations during the conditioning phase (46.8 ± 8.7 mg/L), which decreased sharply when the unit became fully operational (2.19 ± 2.1 mg/L). When the residence was reoccupied, influent had elevated $NH_3$ concentrations (40.1 ± 5.7 mg/L). Effluent during the reoccupied phase had $NH_3$ concentrations that were initially elevated (26.4 mg/L) and then sharply decreased to < 2 mg/L.

As a result of the bacterial nitrification of $NH_3$ to $NO_x$, the DWTU significantly (Mann-Whitney U test, $p < 0.001$) increased $NO_x$ concentrations 3,071% from influent to effluent (**Table 1**). Wastewater influent $NO_x$ concentrations were lower in the DWTU conditioning phase (0.16 ± 0.5 mg/L) than in the fully operational phase (0.28 ± 0.02 mg/L; **Figure 3b**). Effluent from the DWTU had the highest $NO_x$ concentrations during the conditioning phase (14.2 ± 4.5 mg/L), which decreased when the unit became fully operational (8.91 ± 0.91 mg/L). When the residence was reoccupied, influent had moderate NOx concentrations (4.20 ± 2.5 mg/L) and $NO_x$ concentrations in effluent remained < 10 mg/L (9.46 ± 1.5 mg/L).

Similar to $NH_3$, the DWTU significantly (Mann-Whitney U test, $p = 0.017$) reduced TKN concentrations 95% from influent to effluent (**Table 1**). Wastewater influent TKN concentrations were slightly higher in the DWTU conditioning phase (127.4 ± 9.5 mg/L) than in the fully operational phase (117.5 ± 4.7 mg/L; **Figure 3c**). Effluent from the DWTU had the highest TKN concentrations during the conditioning phase (55.5 ± 11 mg/L), which decreased sharply when the unit became fully operational (5.34 ± 2.1 mg/L).

The DWTU significantly (Mann-Whitney U test, $p < 0.001$) reduced TN concentrations 88% from influent to effluent (**Table 1**). Wastewater influent TN concentrations were slightly higher in the DWTU conditioning phase (127.4 ± 9.5 mg/L) than in the fully operational phase (118.0 ± 4.7 mg/L; **Figure 3d**). Effluent from the DWTU had the highest TN concentrations during the conditioning phase (69.6 ± 10.4 mg/L), which decreased sharply when the unit became fully operational (14.2 ± 2.0 mg/L). For example, during the fully operational phase, effluent TN concentrations quickly dropped from 65.7 mg/L on March 10 to 36.0 mg/L on March 17 to 10.0 mg/L on March 30 (**Figure 3d**).

During the fully operational phase, the DWTU (Mann-Whitney U test, $p = 0.068$) reduced TP concentrations 38% from influent to effluent, though this was not statistically significant (**Table 1**). Wastewater influent TP concentrations were lower in the DWTU conditioning phase (14.3 ± 1.4 mg/L) than in the fully operational phase (19.4 ± 1.1 mg/L; **Figure 3e**). Effluent from the DWTU had the highest TP concentrations during the conditioning phase (11.6 ± 0.66 mg/L), which remained similar when the unit became fully operational (12.1 ± 0.75 mg/L).

Because of greater removal of N than P, the DWTU significantly (Mann-Whitney U test, $p < 0.001$) reduced molar TN:TP 84% from influent to effluent (**Table 1**). Wastewater influent TN:TP was slightly higher in the DWTU conditioning phase (20.13 ± 1.1) than in the fully operational phase (14.2 ± 0.64; **Figure 3f**). The TN:TP in effluent from the DWTU was highest during the conditioning phase (13.5 ± 1.9) and decreased when the unit became fully operational (2.32 ± 0.14).

The DWTU significantly (Mann-Whitney U test, $p < 0.001$) reduced fecal coliform concentrations 92% from influent to effluent (**Table 1**). Wastewater influent fecal coliform concentrations were lower in the DWTU conditioning phase (4,829 ± 1,395 CFU/100mL) than in the fully operational phase (45,139 ± 16,984 CFU/100mL; **Figure 3g**). Effluent from the DWTU had the lower fecal coliform concentrations during the conditioning phase (2,433 ± 840 CFU/100mL), than in the fully operational phase (3,775 ± 1,782 CFU/100mL), however the percent removal during the fully operational phase (92%; Table 1) was higher than in the conditioning phase (50%).

The DWTU significantly (Mann-Whitney U test, $p < 0.001$) reduced CBOD concentrations 96% from influent to effluent (**Table 1**). Wastewater influent CBOD concentrations were higher in the DWTU conditioning phase (95.3 ± 6.6 mg/L) than in the fully operational phase (410.8 ± 35.5 mg/L; **Figure 3h**). Effluent from the DWTU had the highest CBOD concentrations during the conditioning phase (39.7 ± 9.2 mg/L), which decreased sharply when the unit became fully operational (5.02 ± 0.67 mg/L).

The DWTU significantly (Mann-Whitney U test, $p < 0.001$) reduced TSS concentrations 96% from influent to effluent (**Table 1**). Wastewater influent TSS concentrations were higher in the DWTU conditioning phase (1,505 ± 303 mg/L) than in the fully operational phase (304 ± 68 mg/L; **Figure 3i**). Effluent from the DWTU had the highest TSS concentrations during the conditioning phase (50.0 ± 16 mg/L), which decreased sharply when the unit became fully operational (11.2 ± 1.6 mg/L). When the residence was reoccupied, influent had elevated TSS (190 ± 40 mg/L) concentrations. Effluent TSS concentrations were also initially elevated (47 mg/L), but then decreased to ~6.1 mg/L.

During the fully operational phase, the DWTU slightly reduced pH 2% from influent to effluent (Mann-Whitney U test, $p < 0.001$; **Table 1**). Wastewater influent pH was lower in the DWTU conditioning phase (7.05 ± 0.2) than in the fully operational phase (7.13 ± 0.1; **Figure 3j**). Effluent from the DWTU was highest in pH during the conditioning phase (7.27 ± 0.3), which decreased when the unit became fully operational (6.98 ± 0.1).

Figure 3. Water quality parameters observed in wastewater influent (influent), an OnSyte Distributed Wastewater Treatment Unit (DWTU) effluent (effluent), and a downgradient groundwater monitoring well (GWMW) from October 9, 2020 through June 20, 2021, including a) ammonia ($NH_3$), b) nitrate + nitrite ($NO_x$), c) total Kjeldahl nitrogen (TKN), d) total nitrogen (TN), e) total phosphorus (TP), f) the ratio of TN:TP, g) fecal coliforms, h) carbonaceous biochemical oxygen demand (CBOD), i) total suspended solids (TSS), and j) pH. Baseline groundwater monitoring occurred from October 9 to November 30, 2020, the "Unit Conditioning" phase occurred from December 1, 2020 to March 10, 2021, and the DWTU was "Fully Operational" from March 17 to June 30, 2021. Residence occupancy (December 1, 2020) and vacated (June 30, 2021) dates are indicated by black dotted lines, while the date the internal recycling feature was activated in the treatment program (March 10, 2021) is indicated by an orange dashed line.

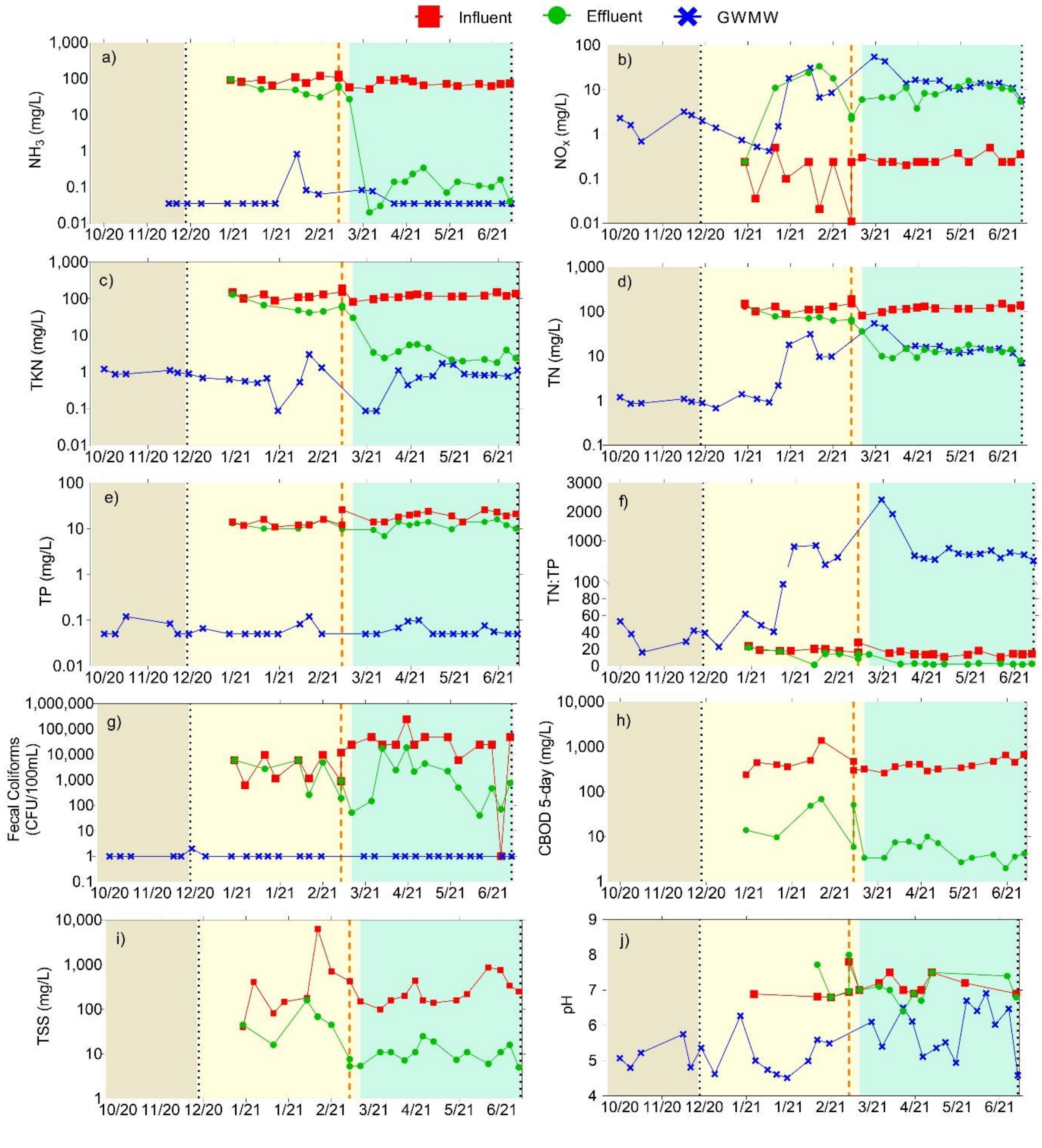

Table 1. Parameters of wastewater influent and effluent samples collected during a fully operational phase of the OnSyte Distributed Wastewater Treatment Unit (DWTU) that spanned from March 17 to June 30, 2021; showing mean ± standard error, the percent difference between influent and effluent, number of samples (n), and Mann Whitney U test p values for the comparison of influent and effluent with significant differences considered at $p < 0.05$.

| Water Quality Parameter | Wastewater Influent | DWTU Effluent | Percent Difference | n | Mann Whitney U Test p value |
|---|---|---|---|---|---|
| Ammonia (mg/L) | 73.69 ± 4.0 | 2.19 ± 2.1 | -97 | 13 | 0.002 |
| Nitrate + Nitrite (mg/L) | 0.28 ± 0.02 | 8.91 ± 0.9 | +3,071 | 13 | <0.001 |
| Total Kjeldahl Nitrogen (mg/L) | 117.5 ± 4.7 | 5.34 ± 2.1 | -95 | 13 | 0.017 |
| Total Nitrogen (mg/L) | 118.0 ± 4.7 | 14.2 ± 2.0 | -88 | 13 | <0.001 |
| Total Phosphorus (mg/L) | 19.42 ± 1.1 | 12.1 ± 0.75 | -38 | 13 | 0.068 |
| TN:TP | 14.2 ± 0.64 | 2.32 ± 0.14 | -84 | 13 | 0.030 |
| Fecal Coliforms (CFU/100mL) | 45,138 ± 16,984 | 3,775 ± 1,782 | -92 | 13 | 0.079 |
| Carbonaceous Biochemical Oxygen Demand (mg/L) | 410.8 ± 35.5 | 5.02 ± 0.67 | -96 | 13 | <0.001 |
| Total Suspended Solids (mg/L) | 304 ± 68 | 11.2 ± 1.6 | -96 | 13 | <0.001 |
| Field pH | 7.13 ± 0.1 | 6.98 ± 0.1 | -2 | 11 | 1.000 |

## 3.2 Groundwater

Concentrations of $NH_3$ in groundwater decreased significantly after a significant increase during the unit conditioning phase (Kruskal-Wallis test, $p < 0.001$; **Table 2**). Baseline $NH_3$ concentrations in the groundwater were at the MDL of 0.035 mg/L (**Figure 3a**). During unit conditioning, the groundwater $NH_3$ concentration increased (0.193 ± 0.13 mg/L), peaking at 0.82 mg/L on February 11, 2021. After the DWTU was made fully operational, groundwater $NH_3$ concentrations decreased back to below MDL by April 15, 2021, where they remained for the duration of the study period.

Once the DWTU was fully operational, concentrations of $NO_x$ decreased in groundwater, following a significant increase from the baseline during unit conditioning (Kruskal-Wallis test, $p < 0.001$; **Table 2**). Baseline $NO_x$ concentrations in the groundwater were 1.55 ± 0.28 mg/L (**Figure 3b**). While the DWTU was conditioning, the groundwater $NO_x$ concentration increased to 27.0 ± 7.9 mg/L. Groundwater $NO_x$ peaked on March 25, 2021 at 54.5 mg/L and then rapidly declined during the fully operational phase (12.2 ± 0.96 mg/L) to a low of 5.9 mg/L on July 30, 2021. $NO_x$ decreased to baseline levels (0.35 ± 0.24 mg/L) when the home was vacated and then increased again when reoccupied (9.90 mg/L).

Groundwater TKN did not vary significantly over the study (Kruskal-Wallis, $p = 0.059$), however continual increases were observed (**Table 2**). Baseline TKN concentrations in the groundwater were 0.81 ± 0.07 mg/L (**Figure 3c**). While the DWTU was conditioning, the groundwater TKN concentration increased slightly (0.85 ± 0.47 mg/L). Groundwater TKN concentrations continued to increase after the DWTU was made fully operational (0.97 ± 0.10 mg/L) and when the residence was vacated (1.30 ± 0.13 mg/L), peaking upon residence reoccupation (2.10 mg/L).

Concentrations of TN in groundwater, decreased when the DWTU became fully operational, which followed a significant increase from the baseline during unit conditioning (Kruskal-Wallis test, $p < 0.001$; **Table 2**). Baseline TN concentrations in the groundwater were 2.36 ± 0.34 mg/L (**Figure 3d**). After occupation of the home while the DWTU was conditioning, groundwater TN concentration increased to 27.8 ± 7.6 mg/L. TN concentrations peaked (54.5 mg/L) on March 25, 2021, after which they declined during the fully operational phase (13.2 ± 0.91 mg/L), achieving < 7.0 mg/L on June 30, 2021. After the residence was vacated, groundwater TN concentrations were similar to the baseline (1.65 ± 0.23 mg/L) and then increased again when the residence was reoccupied (12.0 mg/L).

The groundwater had relatively low concentrations of TP throughout the study, which significantly increased when the residence was vacated (Kruskal-Wallis test, $p = 0.002$; **Table 2**). Baseline TP concentrations in the groundwater were 0.061 ± 0.007 mg/L (**Figure 3e**). While the DWTU was conditioning, the groundwater TP concentration increased slightly (0.067 ± 0.012 mg/L). Groundwater TP concentrations peaked at 0.100 mg/L on April 28, 2021, after which they declined back to baseline concentrations of 0.05 mg/L by May 7, 2021. Therefore, during the fully operational phase, groundwater TP concentrations (0.061 ± 0.005 mg/L) were similar to the baseline. Interestingly, groundwater TP concentrations peaked again when the residence was vacated (0.29 ± 0.058 mg/L) and then decreased when the residence was reoccupied (0.100 mg/L).

Groundwater molar TN:TP were variable throughout the study (Kruskal-Wallis test, $p < 0.001$; **Table 2**). Baseline TN:TP in the groundwater were relatively low (44.5 ± 6.6). While the DWTU was conditioning, the groundwater TN:TP concentration significantly increased to very high values of 1,099 ± 359 (**Figure 3f**). Groundwater TN:TP peaked at 2,415 on March 25, 2021, after which it declined during the fully operational phase, but remained high (494 ± 37). When the residence was vacated, groundwater TN:TP significantly decreased (16.6 ± 6.9), and then increased again when the residence was reoccupied (266).

Low concentrations of fecal coliforms in groundwater followed occupation of the residence and operation of the DWTU, and did not vary significantly throughout the study (Kruskal-Wallis test, $p = 0.568$; **Table 2**). Baseline fecal coliform concentrations in the groundwater were 1.09 ± 0.09 CFU/100mL (**Figure 3g**). Groundwater fecal coliform concentrations remained low, while the DWTU was conditioning (1.00 CFU/100mL), during the fully functional phase (0.92 ± 0.08 CFU/100mL), when the residence was vacated (1.00 CFU/100mL), and reoccupied (1.00 CFU/100mL).

Increased pH concentrations in groundwater followed operation of the DWTU, but the difference was not significant (Kruskal-Wallis test, $p = 0.076$; **Table 2**). Baseline pH in the groundwater from November 20 to December 2, 2020 was 5.11 ± 0.16 (**Figure 3h**). While the DWTU was conditioning, the groundwater pH concentration was similar (5.35 ± 0.22). Once the DWTU was made fully operational, groundwater pH concentrations increased slightly (5.79 ± 0.23). Groundwater pH remained similar when the residence was vacated (5.64 ± 0.13) and then increased when the home was reoccupied (6.95).

Groundwater turbidity was significantly variable throughout the study (Kruskal-Wallis test, $p < 0.001$; **Table 2**). Baseline turbidity in the monitoring well was 29.3 ± 6.1 NTU. During the conditioning phase, groundwater turbidity decreased to 20.6 ± 8.0 NTU and once the DWTU was made fully operational, a further decrease to 5.34 ± 1.1 NTU was observed. When the home was vacated, turbidity increased significantly (176 ± 33 NTU) and then decreased when reoccupied (17.8 NTU).

Figure 4. Groundwater parameters observed in a downgradient monitoring well by study phase from October 9, 2020 through June 20, 2021, including a) ammonia ($NH_3$), b) nitrate + nitrite ($NO_x$), c) total Kjeldahl nitrogen (TKN),d) total nitrogen (TN), e) total phosphorus (TP), f) the ratio of TN:TP, g) fecal coliforms, and h) pH. Due to a lag between loading and groundwater effects the following timeframes were used. “Baseline” (BL) groundwater monitoring occurred from October 9 to January 21, 2020, the “Unit Conditioning” phase (Cond) occurred from January 28, 2020 to April 1, 2021, and the DWTU was “Fully Operational” (FO) from April 15 to June 30, 2021. The residence was vacated June 30 to September 3, 2021 (Vac) and reoccupied (ReOc) on September 16, 2021. Significant differences ($p < 0.05$) between study phases determined though Kruskal-Wallace tests followed by Dunn’s test with a Bonferroni correction are represented by uppercase letters, while “N/S” represents a non-significant comparison.

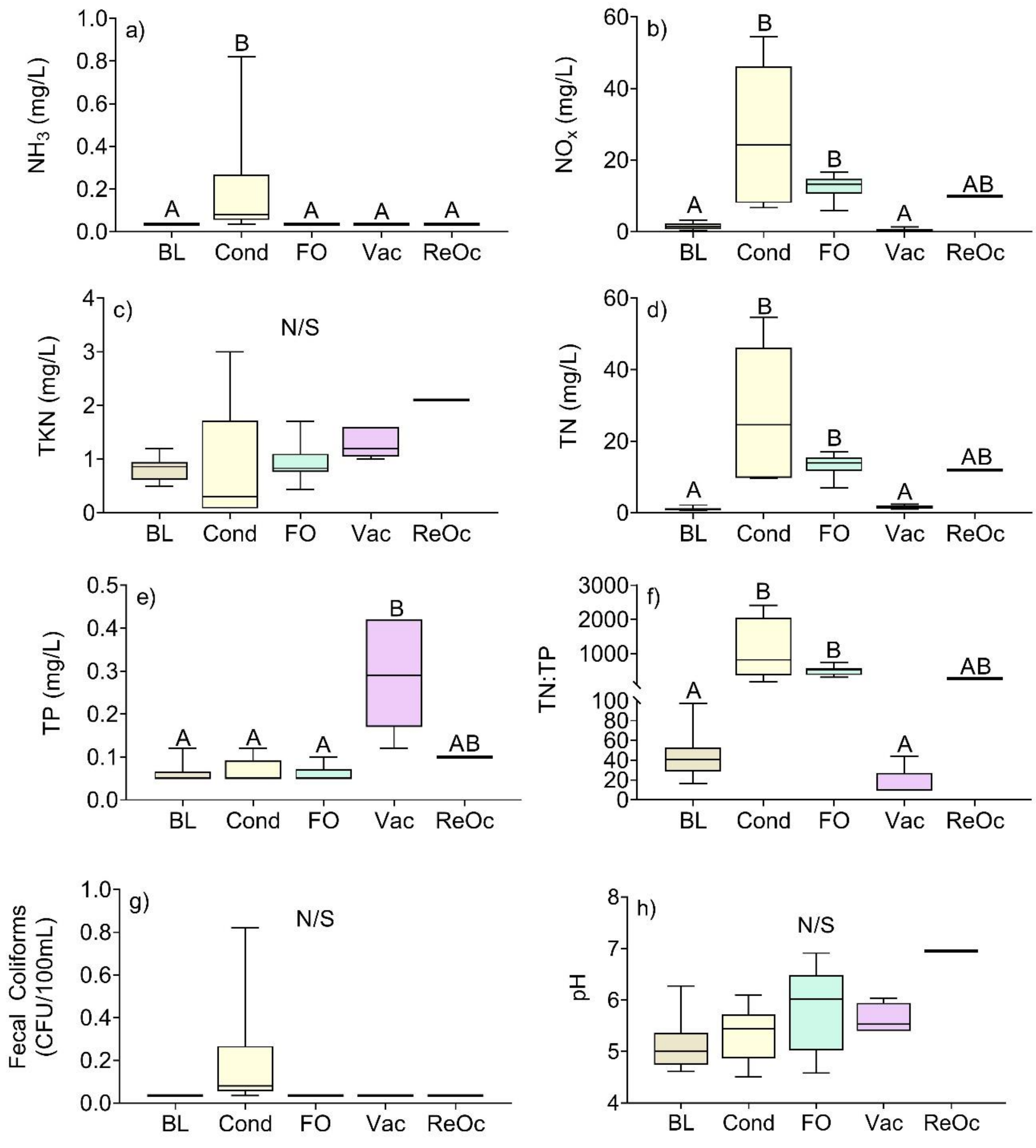

Table 2. Parameters of groundwater samples collected from a downgradient monitoring well in the Town of Lake Hamilton, FL by study phase. Due to a lag between loading and groundwater effects the following timeframes were used. “Baseline” groundwater monitoring occurred from October 9, 2021 to January 21, 2020, the “Unit Conditioning” phase occurred from January 28, 2020 to April 1, 2021, and the DWTU was “Fully Operational” from April 15, 2021 to June 30, 2021. The residence was vacated June 30 to September 3, 2021 and reoccupied on September 16, 2021. Also shown are p values from Kruskal-Wallace tests of study phases with significance considered at $p < 0.05$.

| Water Quality Parameter | Baseline (n = 5) | Unit Conditioning (n = 10) | Fully Operational (n = 15) | Vacated (n = 5) | Reoccupied (n = 1) | Kruskal-Wallis Test p value |
|---|---|---|---|---|---|---|
| Ammonia (mg/L) | 0.035 ± <0.001 | 0.193 ± 0.13 | 0.035 ± < 0.001 | 0.035 ± < 0.001 | 0.035 | <0.001 |
| Nitrate + Nitrite (mg/L) | 1.55 ± 0.28 | 27.0 ± 7.9 | 12.2 ± 0.96 | 0.35 ± 0.24 | 9.90 | <0.001 |
| Total Kjeldahl Nitrogen (mg/L) | 0.81 ± 0.07 | 0.85 ± 0.47 | 0.97 ± 0.10 | 1.30 ± 0.13 | 2.10 | 0.059 |
| Total Nitrogen (mg/L) | 2.36 ± 0.34 | 27.8 ± 7.6 | 13.2 ± 0.91 | 1.65 ± 0.23 | 12.0 | <0.001 |
| Total Phosphorus (mg/L) | 0.061 ± 0.007 | 0.067 ± 0.012 | 0.061 ± 0.005 | 0.29 ± 0.058 | 0.10 | 0.002 |
| TN:TP | 44.5 ± 6.6 | 1,099 ± 359 | 494 ± 37 | 16.6 ± 6.9 | 266 | <0.001 |
| Fecal Coliforms (CFU/100mL) | 1.09 ± 0.09 | 1.00 ± 0 | 0.92 ± 0.08 | 1.00 ± 0 | 1.00 | 0.568 |
| Field pH | 5.11 ± 0.16 | 5.35 ± 0.22 | 5.79 ± 0.23 | 5.64 ± 0.13 | 6.95 | 0.076 |
| Turbidity | 29.3 ± 6.1 | 20.6 ± 8.0 | 5.34 ± 1.1 | 176 ± 33 | 17.8 | <0.001 |

# 4. Discussion

This study demonstrated that the OnSyte DWTU was highly effective at treating wastewater and protecting the ambient groundwater at a central Florida test site. This was evidenced by a high level of contaminant removal, especially N, from the wastewater stream and relatively minimal effects observed in the immediately downgradient groundwater monitoring well once the DWTU was fully operational. Considered together, these data support that the OnSyte DWTS may be an effective method for improving water quality in areas currently serviced by conventional septic systems or for new construction, especially near sensitive water bodies or in karst regions with vulnerable aquifer conditions.

During the fully operational phase, most of the parameters assessed in this study significantly decreased between the wastewater influent and the DWTU effluent. Additionally, effluent concentrations were also lower due to dilution with recycled wastewater during this phase. In particular, $NH_3$, TKN, CBOD, and TSS all decreased by over 90%. Fecal coliforms also decreased by 92% between the influent and effluent, but the change was not significant. However, $NO_x$ increased significantly from the influent to the effluent as a result of the bacterial nitrification of $NH_3$ to $NO_x$. Through biological nitrogen removal (denitrification), the DWTU converted most of the $NO_x$ to inert $N_2$ gas, which is evidenced by the effluent $NO_x$ averaging 8.91 mg/L, a value lower than the USEPA standard for drinking water (10 mg/L). The overall removal of TN by the DWTU averaged 88%, much greater than the 10% removal by conventional septic tanks through accumulation of sludge at the bottom of the tank (Bicki et al., 1984). This TN removal is impressive considering that the average influent TN of the DWTU was 118 mg/L, a very high value well above the reported range for TN in raw wastewater effluent (Bicki et al., 1984).

Compared to TN, TP removal by the DWTU was relatively low, averaging 38%. The TP concentration of conventional septic tank effluent ranges 11– 31 mg/L with a median of 16 mg/L (Bicki et al., 1984). In this study, the TP of the DWTU effluent averaged 12.1 mg/L, indicating that the DWTU still performed 25% better than a conventional septic tank. This difference in TN versus TP uptake is reflected in the decrease in TN:TP between the DWTU influent (14.2) and effluent (2.32). However, additional TP removal should occur via percolation through the soils of the absorption bed. Although wastewater TN comprised of $NO_x$ is highly mobile in soils and groundwater, this is not the case for TP. A significant amount of TP can be retained or immobilized in soil systems by the mechanisms of adsorption, chemisorption, precipitation, and biological uptake (Bicki et al., 1984).

The downgradient groundwater monitoring well, which was very close to the absorption field (less than 10’), allowed for assessment of environmental impacts of the DWTU and showed a decreased amount of reactive N entering the groundwater once the unit was fully operational. This is evidenced by below detection concentrations of $NH_3$. The maximum groundwater $NH_3$ concentration observed in this study during the fully operational phase (0.035 mg/L) is in stark contrast to the higher concentrations of groundwater $NH_3$ that have been observed in other parts of Florida near septic systems, including the Florida Keys (up to 38.5 mg/L)(Lapointe et al., 1990), Jupiter (up to 17.9 mg/L) (Lapointe & Krupa, 1995), Martin County (up to 50 mg/L) (Lapointe et al., 2017), and North Fort Myers (up to 15.3 mg/L) (Lapointe et al., 2020). The decreased $NH_3$ loading has significant environmental implications as many HABs preferentially uptake these forms of N (Glibert et al., 2016; Kramer et al., 2018; Hampel et al., 2019).

Groundwater $NO_x$ concentrations also decreased when the DWTU was fully operational. By the last sampling date of the fully operational phase (June 30, 2021), which averaged 12.2 mg/L, groundwater $NO_x$ concentrations were 5.9 mg/L. Similar to $NH_3$, high groundwater $NO_x$ concentrations downgradient of septic systems have been observed in other locations in Florida, such as in Tampa (up to 56 mg/L) (Bicki et al., 1984), the Florida Keys up to 38.5 mg/L) (Lapointe et al., 1990), and Jupiter (up to 21.5 mg/L) (Lapointe & Krupa, 1995). While the DWTU in this study generally performed better at $NO_x$ removal than what has been observed downgradient from septic systems, to meet regulatory requirements and attain levels that are protective of the environmental and human health, some improvement could be achieved through additional chemical filters or advanced performance absorptions beds (e.g., using “Bold & Gold”). However, given the very close location of the monitoring well to the absorption field (~5 – 10’), there was likely very little dilution of the DWTU effluent by groundwater before reaching the monitoring well. The slight increase in $NO_x$ concentrations observed between the effluent and the groundwater monitoring well may be a result of the effluent pooling and concentrating. In this study, the increased $NO_x$ concentrations observed in the effluent and groundwater is also a function of the very high influent TN.

Reductions in groundwater TN concentrations were also evident when the DWTU was fully operational. Importantly, groundwater TN concentrations achieved the Monroe County Onsite Wastewater Nutrient Reduction System (OWNRS) goal of < 10/mg/L by the last sampling date of the fully operational phase (7.0 mg/L). Unfortunately, after this, the residence was vacated, so it was not possible to assess the continued performance of the fully operational system. Influent TN concentrations at this study site were unusually high (118 mg/L), so the ability of the DWTU to minimize groundwater effects at these levels was particularly impressive. A longer study period with the residence occupied and the DWTU fully operational would provide greater insight into the longer-term effectiveness and N removal capacity.

During this study, the test residence was vacated for approximately six weeks after the DWTU had been fully operational for over three months, which provided an opportunity to assess the performance during a period with no inputs. Once the residence was reoccupied and the treatment process restarted, we observed similar efficiency in removal of nutrients. This suggests the OnSyte DWTU will remain functional during use if the residents of the home are away for an extended period of time. More testing could be done to assess longer durations of non-use to replicate what would occur in DWTUs installed in seasonally occupied residences (e.g., “Florida snowbirds”).

This study provided an initial assessment of the OnSyte DWTU’s in situ performance, but was not comprehensive. Future research should have more replication and examine multiple units operating separately or as part of a DWTS. Additionally, studies could be conducted in varied soil and water table conditions. For example, in Florida it would be important to understand how the DWTU functions in locations with seasonal high water tables, particularly as coastal communities work to mitigate the impacts of climate change and sea level rise. Similarly, it would be useful to assess the impacts of seasonal rainfall on the performance of the DWTU. Finally, longer-term studies to assess the continued performance of a DWTU at both occupied and seasonally occupied homes would also be useful.

Though some issues were not resolved in this study, such as the limited TP removal capacity, the performance of the OnSyte DWTU for TN removal suggests that this technology offers an alternative method to septic to sewer conversions for improving water quality in areas with conventional septic systems. These systems could be especially effective in sensitive areas where advanced wastewater treatment has been mandated or is needed, such as the Florida Keys, Indian River Lagoon, Caloosahatchee River Estuary, St. John’s River, and near spring ecosystems. In-line chemical filters or upgraded absorption fields that can help further denitrify $NO_x$ and provide additional removal capacity for TP could further improve the overall DWTU performance. Florida has a multitude of sensitive aquatic habitats, such as coral reefs, estuaries, and spring systems, and DWTSs may provide the technology to protect these areas from excessive nutrient and bacterial pollution. The OnSyte DWTU may offer a cost effective alternative to the expansion of underground municipal sewage collection systems, which account for

~ 80% of the capital costs of municipal wastewater collection and treatment systems. This is especially timely for municipalities currently examining options for expanding wastewater infrastructure, such as Jacksonville, Lee County, the Treasure Coast, and the Space Coast.

## 5. Acknowledgements

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# Exhibit D

## Lake County Septic to DWTS Program Projections

| | 2023 | 2024 | 2025 | 2026 | 2027 | 2028 | 2029 | 2030 | 2031 | 2032 | 2033 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Modeled conversions to achieve BMAPs | 900 | 1800 | 2700 | 3600 | 4500 | 5400 | 6300 | 7200 | 8100 | 9000 | 9900 |
| Projected target tank removals | 100 | 600 | 1100 | 2100 | 3100 | 4100 | 5100 | 6100 | 7100 | 8100 | 9100 |
| Projected TN removed (lbs/yr) | 830 | 4980 | 9130 | 17430 | 25730 | 34030 | 42330 | 50630 | 58930 | 67230 | 75530 |
| Projected TP removed (lbs/yr) | 250 | 1500 | 2750 | 5250 | 7750 | 10250 | 12750 | 15250 | 17750 | 20250 | 22750 |
| Projected TN vs. goal | 4% | 16% | 22% | 38% | 51% | 63% | 74% | 84% | 93% | 101% | 108% |
| Projected TP vs. goal | 21% | 43% | 64% | 85% | 107% | 128% | 149% | 171% | 192% | 213% | 235% |
| Projected total cost (in millions) | $2 | $10 | $10 | $20 | $20 | $20 | $20 | $20 | $20 | $20 | $20 |

## Silver BMAP Projections

| | 2023 | 2024 | 2025 | 2026 | 2027 | 2028 | 2029 | 2030 | 2031 | 2032 | 2033 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Target Load reduction (lb-TN/yr) | 8880 | 11248 | 13616 | 15984 | 18352 | 20720 | 22496 | 24272 | 26048 | 27824 | 29600 |
| Number of target tank removals | 1070 | 1355 | 1640 | 1926 | 2211 | 2496 | 2710 | 2924 | 3138 | 3352 | 3566 |
| Projected replacements | 300 | 600 | 900 | 1200 | 1500 | 1800 | 2100 | 2400 | 2700 | 3000 | 3300 |
| % of total universe | 9% | 18% | 27% | 37% | 46% | 55% | 64% | 73% | 82% | 92% | 101% |
| % of BMAP goal | 8% | 17% | 25% | 34% | 42% | 50% | 59% | 67% | 76% | 84% | 93% |

## Wekiwa BMAP Projections

| | 2023 | 2024 | 2025 | 2026 | 2027 | 2028 | 2029 | 2030 | 2031 | 2032 | 2033 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Target Load reduction (lb-TN/yr) | 10798 | 19796 | 28794 | 30234 | 31674 | 33113 | 34553 | 35993 | 37432 | 38872 | 40312 |
| Number of target tank removals | 1301 | 2385 | 3469 | 3643 | 3816 | 3990 | 4163 | 4336 | 4510 | 4683 | 4857 |
| Projected replacements | 550 | 1100 | 1650 | 2200 | 2750 | 3300 | 3850 | 4400 | 4950 | 5500 | 6050 |
| % of total universe | 7% | 13% | 20% | 27% | 33% | 40% | 46% | 53% | 60% | 66% | 73% |
| % of BMAP goal | 13% | 25% | 38% | 51% | 63% | 76% | 89% | 101% | 114% | 127% | 140% |

## Ocklawaha BMAP Projections

| | 2023 | 2024 | 2025 | 2026 | 2027 | 2028 | 2029 | 2030 | 2031 | 2032 | 2033 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Target Load reduction (lb-TN/yr) | 25 | 137 | 249 | 362 | 586 | 810 | 1035 | 1259 | 1484 | 1708 | 1932 |
| Number of target tank removals | 15 | 59 | 103 | 147 | 234 | 322 | 410 | 498 | 585 | 673 | 761 |
| Projected replacements | 50 | 100 | 150 | 200 | 250 | 300 | 350 | 400 | 450 | 500 | 550 |
| % of total universe | 1% | 1% | 2% | 2% | 3% | 4% | 4% | 5% | 6% | 6% | 7% |
| % of BMAP goal | 21% | 43% | 64% | 85% | 107% | 128% | 149% | 171% | 192% | 213% | 235% |