TETRA TECH

MEMO

To:	Matthew T. Mitts, P.E.
Cc:	Robert J. Bolton, P.E.
From:	Matt Shelton
Date:	October 28, 2019
Subject:	Calibration for Ammonia and Update to the Live Oak STEP Basin ArcNLET Model

The City of Vero Beach (City) has begun collection of groundwater and nitrogen concentration samples at three monitoring wells in the Live Oak Septic Tank Effluent Pumping (STEP) basin. To date four quarterly samples were collected at these wells. A refined ArcGIS-Based Nitrate Load Estimation Toolkit (ArcNLET) model was developed for the area to take advantage of these measurements. Table 1-1 summarizes the sampling results. Both Nitrite/Nitrate and Ammonia were simulated with the refined model. Below is a description of the model's set-up, calibration and results.

A total of 317 septic tanks are located in and around the Live Oak STEP Basin. An additional 30 STEP-converted septic tanks were used to estimate nitrogen load reductions. The locations of these septic tanks are shown on Figure 1-1.

The City of Vero Beach provided Tetra Tech with a detailed, 1.5 feet x 1.5 feet Digital Elevation Model (DEM) coverage of the City. This dataset was projected to the NAD83 UTM17N Meter projection with a resolution of 5-meter x 5 meter. The elevation values were converted from feet. to meter. A 5-meter x 5-meter DEM was chosen to preserve more detail for the smaller modeling area. This dataset was used to calibrate the groundwater particle tracking part of the refined ArcNLET model. A smoothing factor of 160 was used in the calibrated model. Results or the hydrological calibration are shown in Figure 1-2 and the refined groundwater particle paths on Figure 1-3.

The vadose zone model (VZMOD) utility of ArcNLET was used to estimate the initial concentrations of nitrite/nitrate and ammonia at the water table for each septic tank. Resulting concentrations are summarized in Table 1-2. These concentrations vary by septic tank but are generally about 12 mg/L for NO_x, and 28 mg/L for NH_4. Higher ammonia concentrations are due to the proximity of the water table to the septic drain fields, and lack of time for completion of the nitrification process.

After the VZMOD simulation, ArcNLET nitrogen transport model was calibrated by trial and error while attempting to match the model as closely as possible to the measured values. The calibrated parameters are summarized in Table 1-2. The resulting concentrations of ammonia and nitrite/nitrate and their comparison to measured values are shown in Figures 1-4 and 1-5. The concentration plumes are shown in Figures 1-6 and 1-7. The model performs well at simulation concentrations at MW-1 and MW-2, but underestimates both the ammonia and nitrite/nitrate concentration at MW-2. A reason for this behavior can be seen on the particle path figure (Figure 1-3) – there is only one septic tank particle paths running close to the monitoring well, and the concentrations of ammonia and nitrite/nitrate is low by the time the path nears the well. This could be attributed by a discrepancy in the shape of the water table as compared to the smoothed DEM. We can see the group of septic tanks just to the north of MW-2 is generally flowing southeast, possibly the actual paths flow further south. Additionally, the measured concentrations might be attributed to another source of nitrogen, background concentrations, or a leaking sewer line.

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The updated summary of surface water nitrogen load estimates for the Live Oak basin is shown in Table 1-3. The model estimated the 317 septic tanks contribute a load of 1,953.34 pounds of ammonia and 1,054.43 pounds of nitrite/nitrate per year to the surface waterbodies. Approximately 99% of this load is directed to the Indian River Lagoon (Waterbody ID 154). The average nitrogen load per septic tank is 9.49 pounds per year.

In order to estimate the nitrogen removal due to conversion of septic systems to STEP, an additional run of the ArcNLET model was set-up using all 347 (active and converted) septic systems. The model shows that the conversion of 30 septic systems to STEP reduced the nitrogen load by 293.49 pounds per year, or 8.89% of the load. The summary of the loads and removals are shown in Table 1-4. Simulated ammonia and nitrite/nitrate plumes from all septic systems is shown on Figures 1-8 and 1-9.

Figure 1-1 Overview of the Refined Model Area

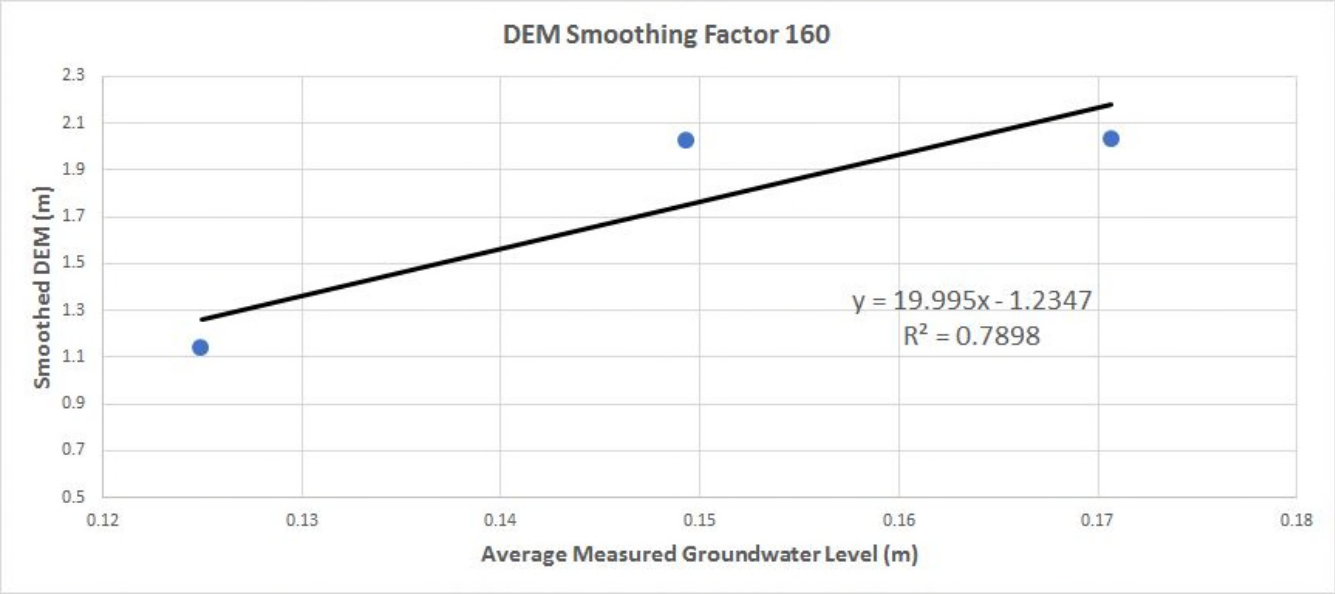

Figure 1-2 Smoothed DEM Relationship with the Measured Water Level

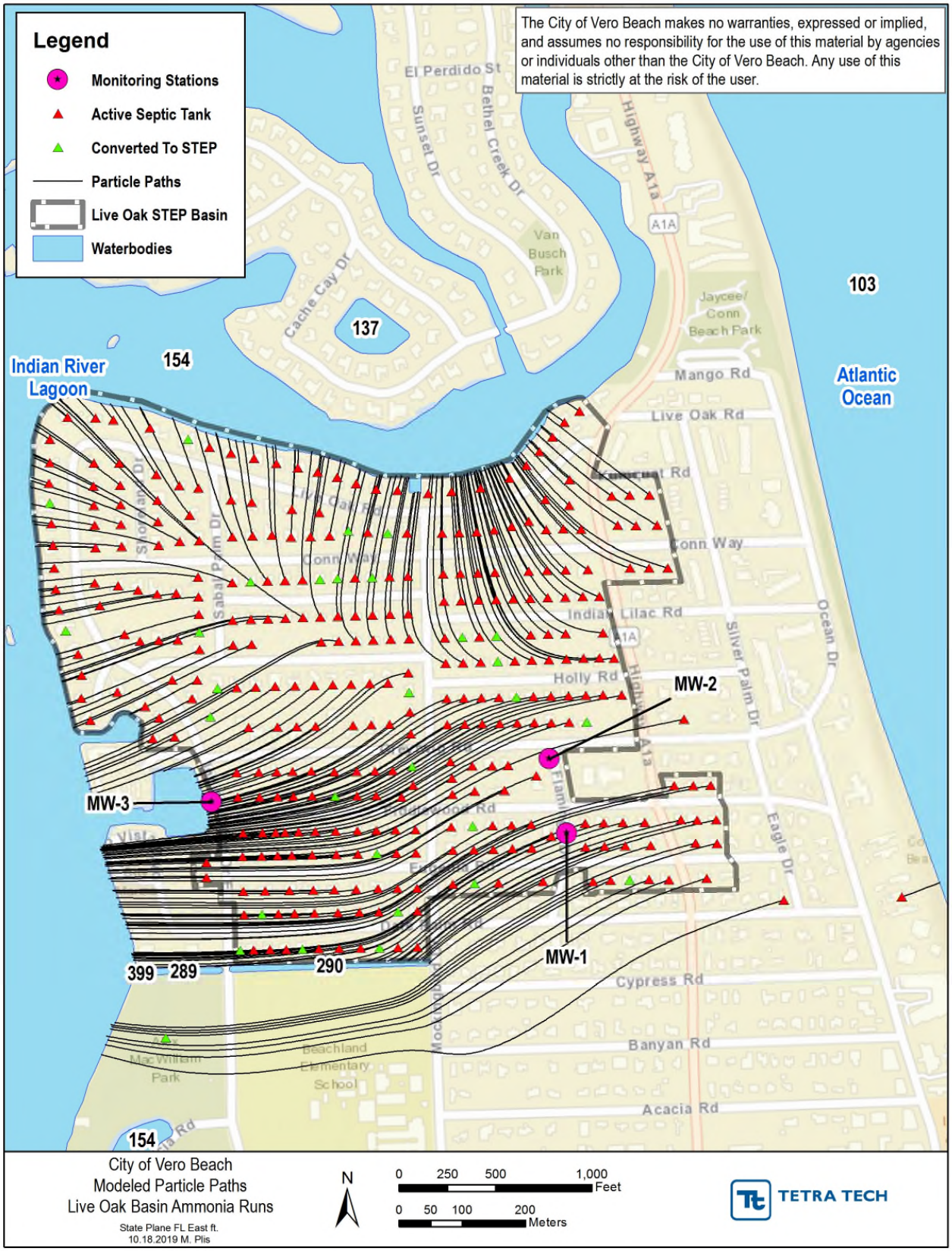

Figure 1-3 Refined Modeled Particle Paths

Table 1-1 Measured Ammonia and NOx Values

Station	Water Elevation	Min NH4	Average NH4	Max NH4	Min NO2/3	Average NO2/3	Max NO2/3
MW-1	0.49	0.18	0.23	0.26	< 0.03	1.10	4.30
MW-2	0.56	0.18	0.24	0.34	< 0.03	2.50	9.90
MW-3	0.41	0.25	0.79	1.30	< 0.03	2.38	9.40

Table 1-2 Initial and Calibrated ArcNLET Parameter Values

Parameter	Initial Value	Calibrated Value
Smoothing Factor	100	160
Source Plane NO3 Concentration (mg/L)	40	~12 (Varies)
Source Plane NH4 Concentration (mg/L)	N/A	~28 (Varies)
Longitudinal Dispersivity (m)	10	10
Horizontal Transverse Dispersivity (m)	1	2
First-Order Decay Coefficient of Denitrification	0.00055	0.005
Coefficient of Nitrification	N/A	0.00078

Table 1-3 Estimated Nitrogen Loading to Groundwater and Surface Waterbodies from 317 Septic Systems Located in the Live Oak Area

	Ammonia	NOx	Total
Loading to groundwater (kg/day)	4.51	2.53	7.03
Loading to Surface Waterbodies (kg/day)	2.43	1.31	3.74
Loading to Surface Waterbodies (lb/year)	1,953.34	1,054.43	3,007.77
Percentage of Loading to Waterbodies (%)	64.94%	35.06%	100.00%
Loading to Surface Waterbodies per Septic Tank (lb/year)	6.16	3.33	9.49
Percentage of Nitrogen Removal in Groundwater (%)	46.12%	48.15%	46.85%

Table 1-4 Estimated Reduction of Nitrogen Loading with STEP Conversion

	Ammonia	NOx	Total
Active Septic Loading to Surface Waterbodies (lb/year)	1,953.34	1,054.43	3,007.77
All Septic Loading to Surface Waterbodies (lb/year)	2,147.74	1,153.52	3,301.25
STEP Conversion Reduction of Loads (lb/year)	194.40	99.09	293.49
STEP Conversion Reduction of Loads per Septic Tank (lb/year)	6.48	0.34	6.82
Current Percentage of Nitrogen Reduction due to STEP Conversion	9.05%	8.59%	8.89%

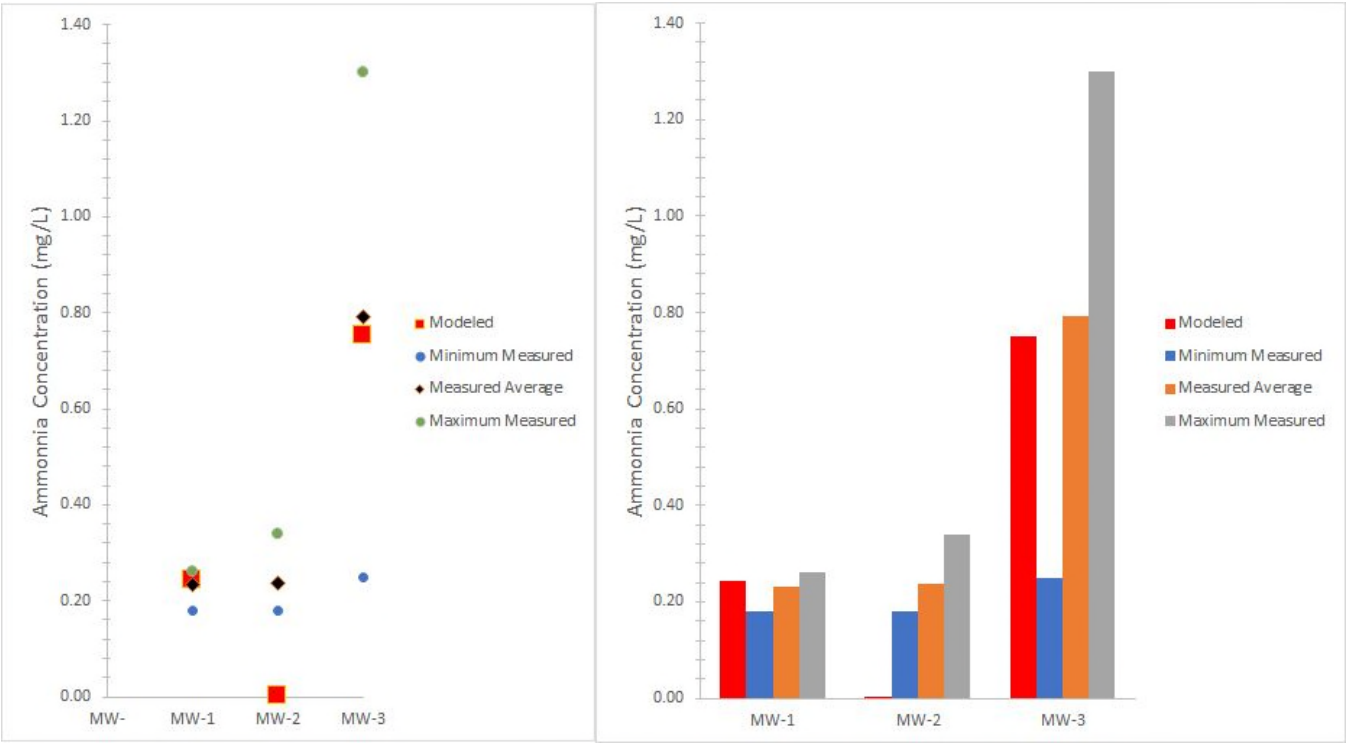

Figure 1-4 Modeled and Measured Ammonia Values

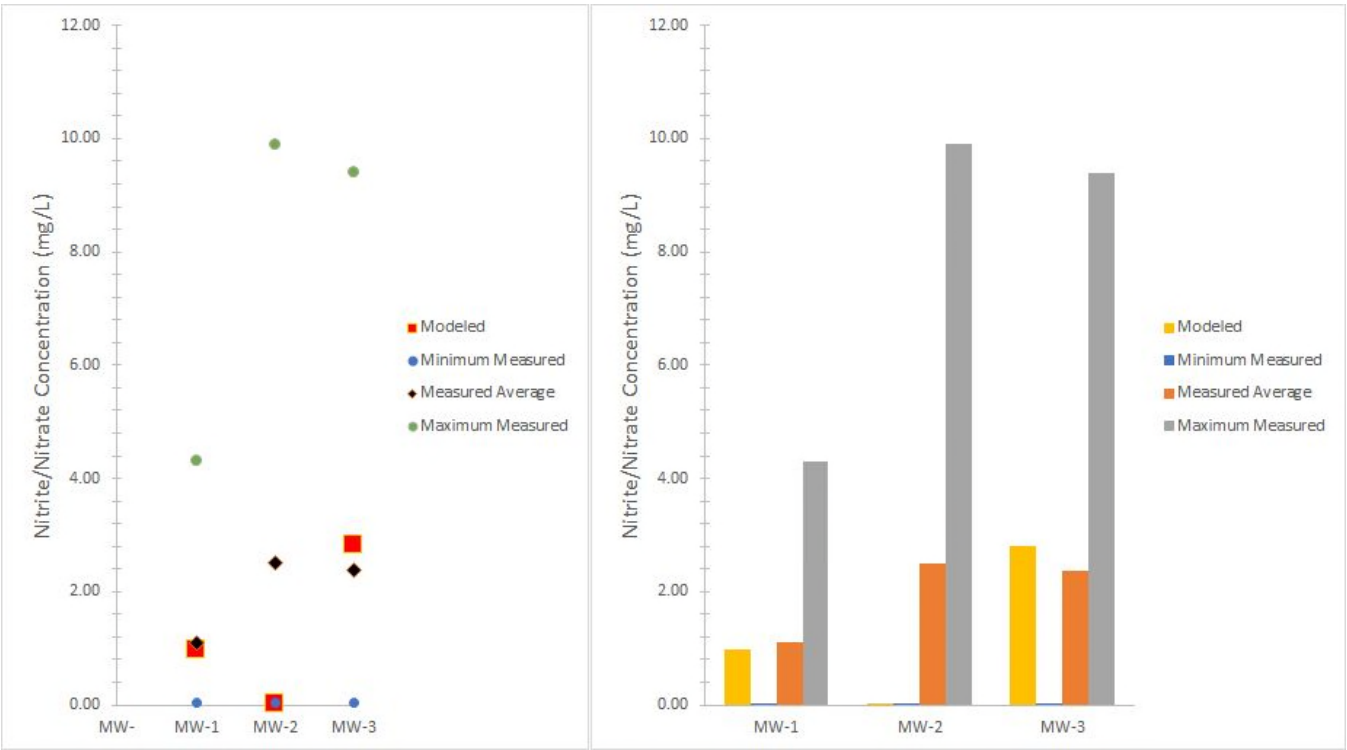

Figure 1-5 Modeled and Measured Nitrite/Nitrate Values

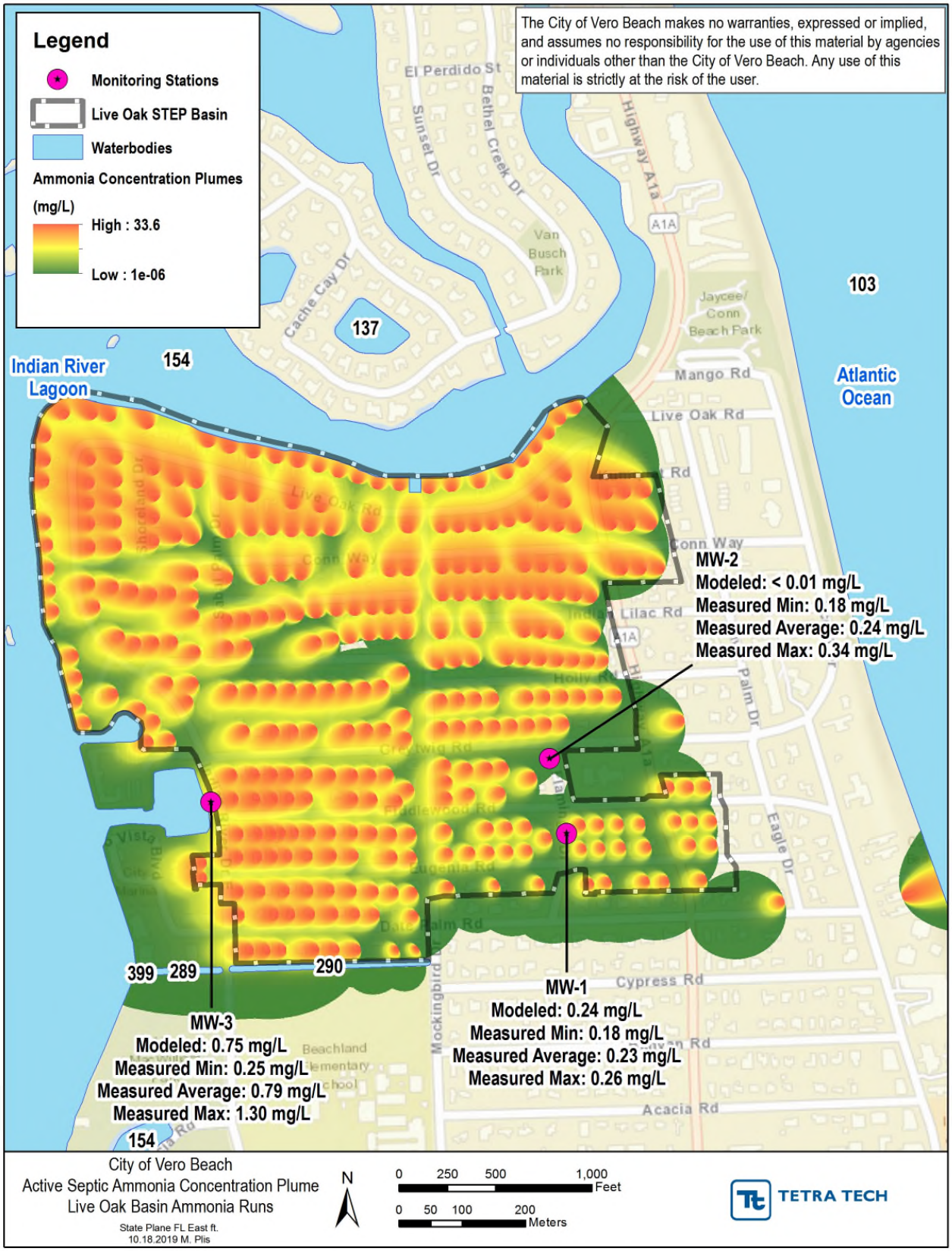

Figure 1-6 Modeled Ammonia Concentration Plumes (Active Septic)

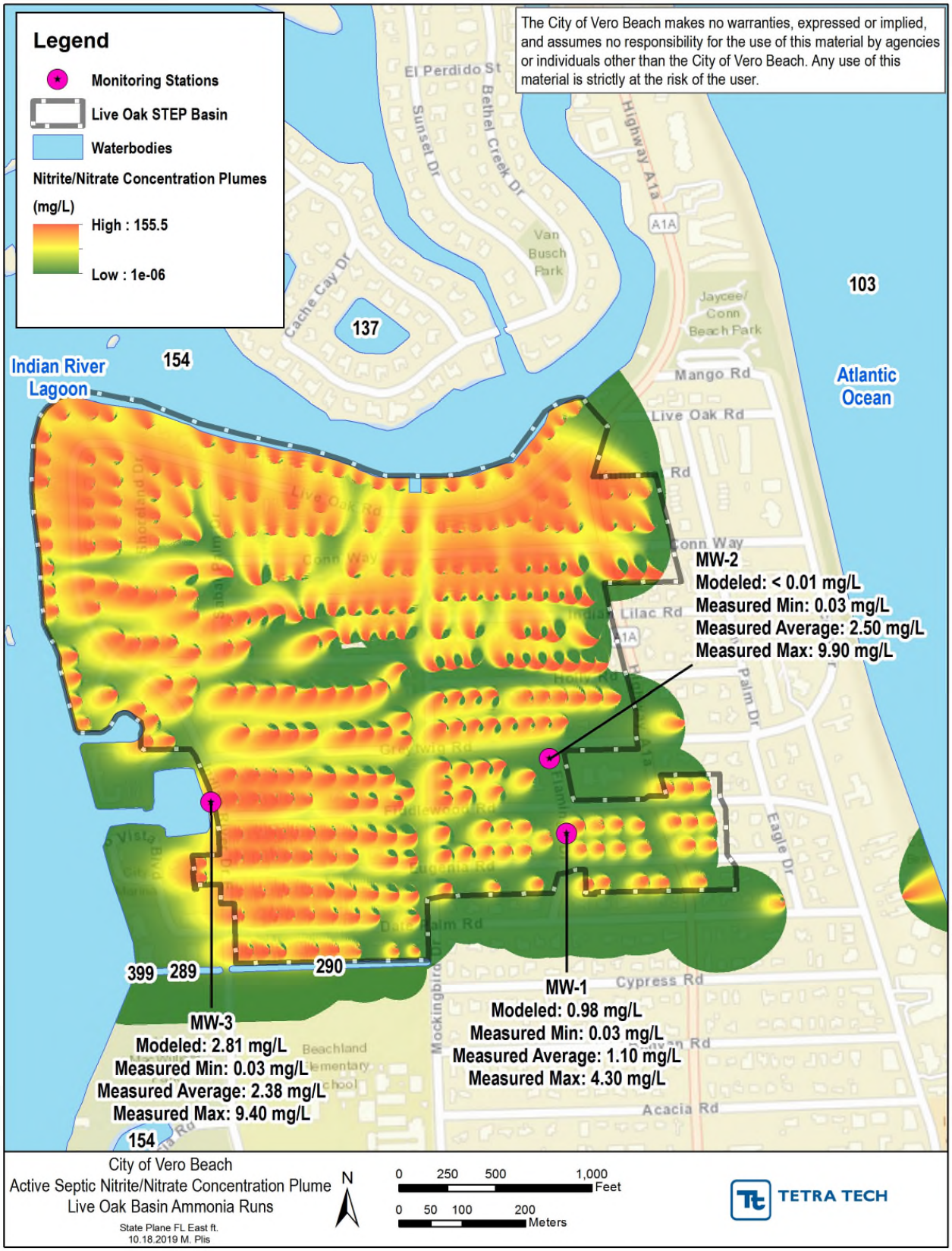

Figure 1-7 Modeled NOx Concentration Plumes (Active Septic)

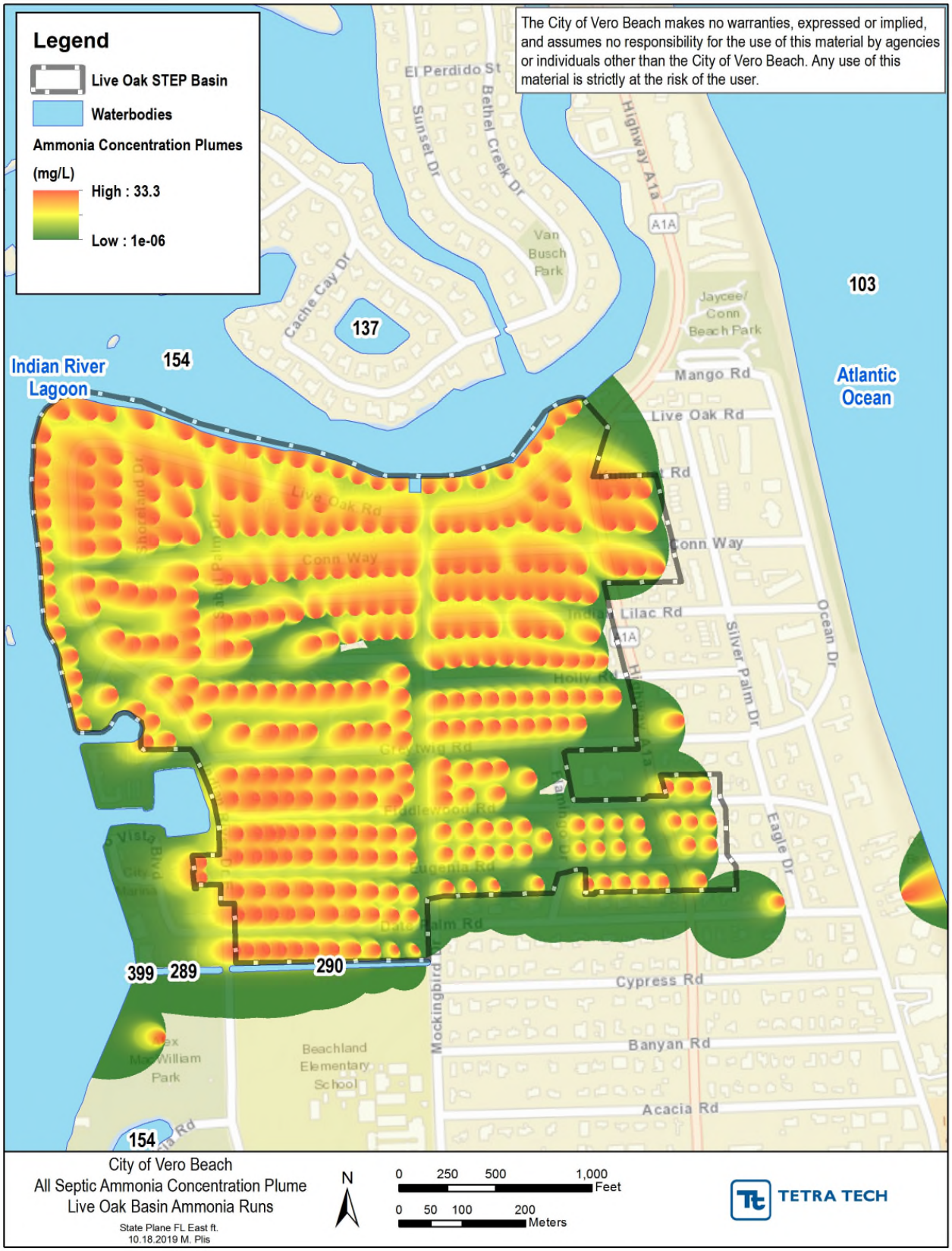

Figure 1-8 Modeled Ammonia Concentration Plumes (All Septic)

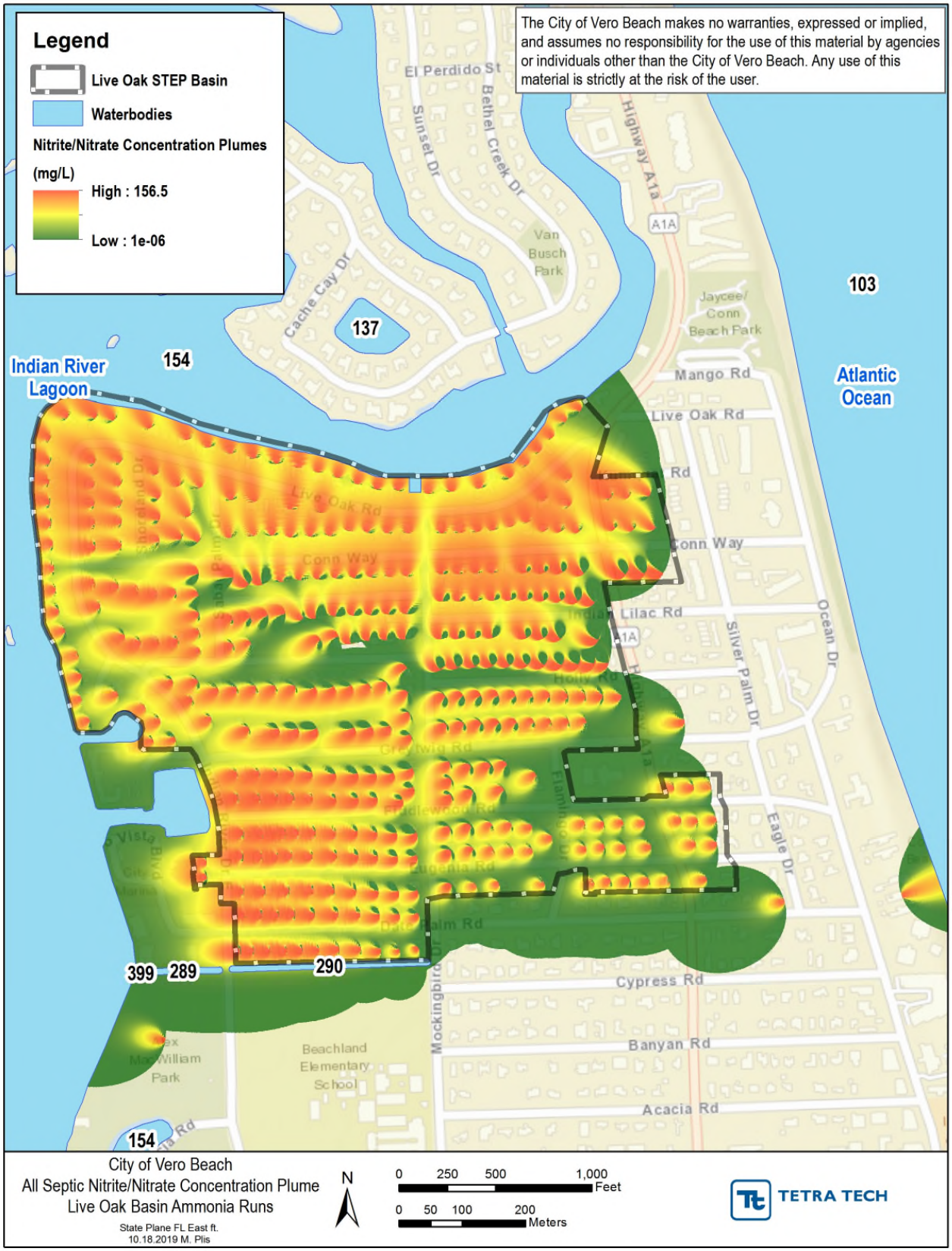

Figure 1-9 Modeled NOx Concentration Plumes (All Septic)