Planning Board

Town of Truro

24 Town Hall Road
Truro, MA 02666
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Date: December 19, 2019
To: Truro Zoning Board of Appeals
From: Truro Planning Board
Re: Cloverleaf Truro Rental Housing Comprehensive Permit Application

The Truro Planning Board (hereafter "Board") offered initial comments to the Truro Zoning Board of Appeals (hereafter "ZBA") on December 12, 2019. The Board met again on December 17, 2019 to review the Comprehensive Permit application for the Cloverleaf Truro Rental Housing project proposed by Community Housing Resource, Inc. and offers these further comments. The Board will likely submit additional comments later in the review process.

The Board thanks the ZBA for its consideration of these comments.

The Board suggests that the ZBA verify that abutters to the project were properly noticed. The Board has concerns based on discussions with local residents and a review of the abutters list included in the application.

The Board suggests that the ZBA request direct comment from the Provincetown Water and Sewer Department as to whether the project would negatively impact water pressure in the surrounding area, including, but not limited to if multiple fire events were to occur at the same time in different parts of North Truro.

The Board fully supports the ZBA's request to hire a qualified engineering firm to assess any impacts from the proposed septic system. The Board echoes that such a review includes a hydrogeologic evaluation of groundwater at the site to determine the potential flow of effluent.

In the case of *Reynolds v. Stow Zoning Board of Appeals*, the Massachusetts Supreme Judicial Court held that projects permitted under MGL Ch. 40B cannot negatively impact neighboring private wells regardless of whether a project meets state regulations. The ZBA should consider this decision during its review of this project.

Downgradient wells show high levels of nitrogen that are of significant concern to the Board and may already pose serious health concerns. A 2014 report prepared for the Town by the firm Weston & Sampson showed high levels of nitrogen in groundwater proximate to the project site itself as well as throughout the Pond Village area. The project as currently proposed is highly likely to further degrade water quality in these areas. The 2014 report is attached hereto.

The Board also requests that information be provided as to how a prolonged drought could effect the quality of groundwater and the movement of effluent from the site.

The Board suggests that the ZBA explore contracting with the Horsley Witten Group to conduct this analysis. This firm has significant experience working on these issues, including a significant amount of work on Cape Cod, and is very highly regarded.

Last, the Board suggests the ZBA seek comment from the Town's Conservation Commission. As stormwater from Highland Road is directly discharged to Pilgrim Pond, the Conservation Commission may offer useful comments related to impacts on that impaired water body. Any comments provided should be forwarded to the peer review consultant for consideration.

Anne Greenbaum, Chair

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report

Integrated Water Resources Management Plan, Phase I

Town of Truro
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October 2014

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Executive Summary

This Integrated Water Resource Management Plan (IWRMP) represents the first phase of Truro's approach to the long-term management of surface water and groundwater resources in Truro. Wholesale modifications to existing infrastructure are not recommended and instead, Truro will benefit from a diligent, incremental process to improve stormwater and wastewater management, employ innovative nutrient removal technologies and continue monitoring of general water quality and specific areas of concern. Extensive mapping efforts have been undertaken to estimate potential impacts from land uses, wastewater sources, and stormwater. A nutrient load model created under this study indicates that most areas within Truro do not have sufficient density of development to be a cause for concern. However, the ongoing water well sampling program and the nutrient modeling indicate that future efforts are necessary to address concerns for certain discrete areas or lots within Truro. These include the Beach Point area with respect to wastewater management options and potential stormwater impacts to East Harbor, Route 6 stormwater drainage and impact due to road salt. Continued diligence with respect to Title 5 wastewater disposal fields, and continuance of the volunteer private well monitoring program are recommended. Aquifer monitoring of groundwater levels and water quality in select areas and in observation wells around the existing municipal supply wells is recommended. Long-term water supply strategies include identifying ways to secure and protect favorable groundwater supply development sites for future use by Truro, or to work towards an interconnection with a source of supply in the Chequesset lens. Most importantly, this first phase of the IWRMP process indicates that Truro, through incremental improvements in stormwater and wastewater management can control impacts of nutrient loads and should not have to fund huge infrastructure projects proposed elsewhere on Cape Cod. Continued diligence and a commitment to advances in residential and commercial land use practices should provide a sustainable future.

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1. Introduction

With increased pressures and long-term impacts of land use patterns on water quality and water quantity, most Massachusetts towns have initiated integrated studies to address infrastructure needs, management methods, and development impacts to water resources. Integrated Water Resource Management Plans have evolved from earlier comprehensive wastewater planning effort to include both water resources (surface and groundwater) and stormwater. The states IWRMP guidance seeks to have towns look at these topics with a holistic approach that is protective of both human health and the environment. Concurrent with those goals, infrastructure management and local controls (regulations, by-laws, etc.) must allow for satisfactory economic development and adequate aesthetic benefits related to recreation and resource enjoyment.

Truro, like many Cape Cod communities is seeking to understand both current and potential future impacts to water resources and undertake a sensible and cost-effective approach to management. Maintaining the rural characteristics and natural beauty of Truro is of primary importance. Managing impacts due to summer population increases while not placing undue burden on year round residence is also important. While economic cycles may cause changes in the rate of development, future increases in population, tourist visits, and ageing infrastructure will most likely have increased water demand, additional wastewater management needs and increasing impervious cover dictating stormwater infrastructure improvements.

The surface water and ground water resources of Truro represent valuable assets that require protection and strategic management efforts. Although approaches to each resource classification are often separated, on Cape Cod they are inextricably related. This section focuses heavily on discussions of water resources as it relates to drinking water supplies and to some extent surface water resources. As both private and public drinking water supplies came from ground water wells, much attention is given to aquifer withdrawals and threats to groundwater quality. Subsequent sections also deal with threats to water quality and focus primarily on infrastructure related impacts and strategies for modification of these impacts.

One of the Outer Cape's greatest assets is the groundwater lenses that are capable of providing potable water resources. With the recent development of the North Union Field Wells, the municipal system feeding parts of Truro and most of Provincetown no longer requires the use of the North Truro Air Force Base Wells. While a large step forward in being self-reliant, all the current sources of municipal drinking water are present in the North Pamet Lens area. This section details their development but also suggests that future supplies, and true redundancy for the system dictates long term development of the Chequesset lens or interconnections with a system that affords a separate withdrawal. Later sections deal with stormwater and wastewater impacts to ground water quality and strategies that will protect individual domestic supplies.

Setting

The Lower Cape is underlain by glacial deposits which dictate its topography, natural setting, and resultant surface and groundwater interactions.

Regional and Local Hydrogeologic Setting

The following sections describe the geologic and hydrologic conditions for lower Cape Cod and the NUF well field. This information aided in developing the site conceptual model that formed the basis for the numerical groundwater model used in the recommended yield and Zone II analysis. Analysis of the date collected from the aquifer testing program provided key parameter values for the approvable yield and Zone II modeling analyses.

Hydrogeology of Lower Cape Cod

The glacial sediments were deposited by glacial lakes and glacial melt-water processes that left a variety of deposits ranging from layers of low permeability clay to coarse sand and gravel materials (Oldale and Barlow 1986: Oldale 1992). Much of the aquifer deposits in Lower Cape Cod are stratified outwash deposits, some of which extend to bedrock in many areas or are underlain by glacial lake deposits in other areas (Foster and Poppe 2003). The outwash deposits are represented by the Wellfleet Palin deposits (oldest), followed by the increasingly younger Truro Plain and Eastham Plain deposits (Oldale and Barlow 1986).

The groundwater flow system that occurs in the glacial sediments of Lower Cape Cod consists of 1) freshwater lenses where recharge occurs, 2) surface water bodies such as streams and ponds where recharge and discharge occurs, and 3) shoreline and nearshore areas where

discharge occurs.

Freshwater contained in Lower Cape Cod sediments is underlain by saltwater (Masterson 2004). Freshwater in the aquifer and surface water bodies is entirely from precipitation that provides recharge. The saltwater beneath is from intrusion of seawater from the Atlantic Ocean and Cape Cod Bay and is denser and heavier than the freshwater. The system of groundwater flow on Lower Cape Cod is the result of groundwater mounds that form along the central axis of Lower Cape Cod. Groundwater flows outwards toward the coastlines (eastward and westward) and toward bisecting rivers or ponds such as Pamet Harbor and the Pamet River or East Harbor.

The aquifers are called freshwater lenses because lens-shaped mounds of freshwater overlies denser saltwater that occurs at depth. The zone between overlying freshwater and underlying saltwater is called the freshwater/saltwater transition zone (Masterson 2004; Bear and Cheng 2010). Another term commonly used to describe the boundary between fresh and saltwater is the saltwater interface (SWI). The approximate center of the lens is where the freshwater thickness is greatest.

Recharge from precipitation on Lower Cape Cod has been estimated to be approximately 45 to 55 percent of annual rainfall based on an average annual precipitation rate of between 40 to42 inches/hear (LeBlanc et al. 1986: Masterson et al. 1998), which yields a recharge rate between 18 to 23 inches/year. Recharge at ponds is reportedly less (14 inches/year) because evaporation rates are higher for surface water bodies than for land surface (Masterson 2004). Streams or ponds occur in low areas or depressions in the ground surface that are low enough to intersect the water table (Masterson 2004). When the water table is higher than the stream or pond level, the ponds receive groundwater discharge (Masterson 2004). When the water table drops below these depressions, the streams and ponds will go dry (Sobczak et l. 2003). Therefore, surface water runoff does not contribute a sufficient amount of water to maintain stream and pond levels. Major surface freshwater features in the Truro area of Lower Cape Cod include the Pamet and Little Pamet Rivers.

The coastal areas of Truro form the outer boundaries of the freshwater lens and are dominated by beach, lagoonal, and estuarine environments (Oldale 1992). Near the shorelines, shallow

groundwater may be fresh, brackish, or saline, depending upon the interaction between the nearshore environment and the influx of fresh groundwater and/or surface water (Barlow 2003). Groundwater discharge occurs in these areas (Masterson 2004).

Land use Patterns

Land use patterns were studied extensively in 2008 under a Cape Cod commission evaluation by Scott Michaud. Land use patterns are continuously updated by the Massachusetts Geographic Information System. In addition, several studies have identified potential future development through partial and full build-out of areas outside of the National Seashore.

In general, the National Seashore represents approximately 67% of Truro and is the major land use feature. In addition to commercial interests along Route 6 and 6A, Truro has several distinct commercial areas. These include:

- Beach Point Limited Business District
- Route 6A North Truro Limited Business District
- An Affordable Housing District
- Route 6 General Business District
- Truro Center Business District

The remaining areas of Truro are residential with some agricultural areas. Other than power, and telecommunications infrastructure, supporting these areas can be divided into the categories related to water, wastewater and stormwater. Each of these topical areas and the characterization of their impacts on water resources are addressed in subsequent sections.

Goals of the IWRMP

The IWRMP was initiated to understand the cumulative effects of nutrient loading on groundwater quality and surface water resources. With this basic understanding, impacts to wells, ponds, rivers and estuaries can be understood. When combined with long-term water withdrawal strategies a plan for protecting drinking water supplies can be developed. Thus, subsequent sections detail the extensive GIS mapping protocols and the land use evaluation which led to the development of a nutrient load model which was then compared to ongoing nitrogen sampling efforts.

By combining nutrient loads from stormwater, wastewater and land use activities (e.g. fertilization and agriculture) current nutrient loads could be compared to future build out. This

analysis is described in Section 6.

Conclusion and recommendations are provided in Section y. Based on multiple working sessions with the Truro Water Resources Oversight Committee a rational approach to incremental change and methods to address data gaps was developed. The overarching goal of sustainable water resource stewardship for Truro is well served by the committee and their commitment to a long-term plan.

2. Water Resources

The water resources of Truro are dominated by groundwater flow and movement within aquifer deposits. Like many island systems the outer Cape Cod area has a series of fresh water lenses. These lenses have been studied extensively by the USGS, Cape Cod Commission, private consultants and municipal entities. On the outer Cape, the three dominant fresh water lenses include: The Pilgrim lens predominantly in Provincetown, the Pamet lens (between Pilgrim Lake and the Pamet River), and the Chequesset lens south of the Pamet River and extending into Wellfleet. Each of these lenses is shown with relative groundwater elevations in Figure 2-1.

Each freshwater lens essentially sits as a dome or eye (in cross-section) above a sea water interface. Due to density differences the interface exists at significant depths below the ground surface throughout much of the central axis of the outer Cape while shallowing towards sea level along the coast lines. It is the freshwater lens that supplies all of the drinking water supplies on the outer Cape including municipal, public and private wells. Municipal wells have been established by Provincetown in several locations in the Pamet lens. Small public water systems do exist within Truro but these systems are relatively small and serve transient populations (e.g. hotels, public buildings, etc.). Private Wells are geographically dispersed across Truro and provide the majority of the supplies for residential systems in Truro. Some added history and discussion is provided below.

Ground Water Resources

Historically groundwater development in the outer Cape was most dramatically influenced by an act of the legislature in 1952 (Chapter 439). This act established a southern well field boundary for Provincetown wells in the Pamet lens in Truro. This act allowed the development of several large municipal wellfields including:

- Knowles Crossing (PWS 4242000-02G)
- Paul D. Daley Wellfield (PWS-4262000-03G)
  also known as South Hollow

Additionally, the former North Truro Air Force base installed wells to provide for base activities.

Of these wells, Well #5 has been used to supply water to Provincetown as both an emergency source and supplemental source under an extended agreement with the National Seashore. This well, noted as NTAFB Well #5 is listed as source #4242000-05G in the MADEP database.

Water withdrawals from these three major groundwater well or wellfields were original registered for a withdrawal volume of 0.85 MGD (Annual withdrawal of 311.62 MGD) in 1998. The registration renewal was granted in 2008 for these supplies and is provided in Appendix A.

Concurrent with MADEP actions to renew the registration statement, the National Park Service, who had inherited ownership of the Air Force Base Well #5, indicated to Provincetown that long term usage of National Park assets for local municipal benefit was inconsistent with federal policy. Thus, the annual renewal of a Special Use Permit could not be sustained and Provincetown must seek alternate sources of supply. Long-term studies and efforts to identify, test and seek approval for a replacement groundwater source were underway for Provincetown. These efforts are described below relative to the "North Union Field" groundwater source.

North Union Field

The North Union Field (NUF) well location was initially identified by both the USGS and the Cape Cod Commission prior to 2003. The USGS study (Masterson, J.P. 2004) indicated that both the NUF site and the Cape Cod Commission site (CCC-5) could potentially yield viable quantities of water for a municipal system. Provincetown elected in 2003 to undergo a subsurface investigation program primarily focused on the NUF site. In general the proximity to the current water distribution system and the possibility of land acquisition for prolective radii made this site more favorable. A number of studies were undertaken including:

- Water Supply Investigations at North Union Field, Truro; June 1, 2004 (Environmental Partners Group)
- Water Supply Investigations at North Union Field, Truro: soil borings, monitoring wells, installations, aquifer pump test and computer modeling of water withdrawals; February 11, 2005 (Environmental Partners Group)
- North Union Field: Installation and testing of four new wells to support site development and aquifer testing work plan; June 2005 (Environmental Partners Group)
- New Water Supply Activities for North Union Field: final summary report – installation and testing of monitoring well 8; December 2005 (Environmental Partners Group)

These efforts were deemed necessary to characterize the site geology, provide initial characterization of water quality, apply for approval of a pumping test plan with MADEP and to evaluate the potential for salt water intrusion should large groundwater withdrawals be made at the site. This initial testing indicated that the fresh water lens (Pamet Lens) is approximately 275 ft. thick and exists at approximately 115 feet below grade at the site. The aquifer itself has numerous intermittent silt and clay layers that create a highly variable subsurface with large differences in vertical versus horizontal anisotropy. This intermittent layering therefore required extensive testing and analysis to determine a safe sustained yield, a proper protection area, and a long-term strategy for aquifer monitoring and well operation.

Aquifer Testing Results

Two test production wells TPW-1 and TPW-2 were installed and long-term constant rate pumping tests were completed in the summer of 2007. Aquifer water levels were monitored in a series of monitoring wells. Monitoring wells and water level elevation data are shown in Table 1.

The 10 day pumping tests were conducted on each test production well at rates of approximately 1 MGD (rates varied slightly between 694 and 718 gpm). Although these instantaneous rates indicate good well performance, long-term yield is dependent on rainfall recharge to the capture area and the potential up-coming or salt water intrusion from brackish zones below the Pamet lens. Aquifer modeling using SEAWAT (GUO and Langevin, 2002) created a three dimensional simulation of aquifer response. The model is capable of predicting movement of water of different density (i.e. dissolved salt or seawater). Simply put, as the core of depression from pumping a well induces flow up to the production well, concurrent up coning or inverse cone of salt laden groundwater occurs. An extensive discussion of model calibration, model dimensions and predictive model scenarios was submitted to MADEP under the source approval process. The report entitled "North Union Field Water Supply DEP Pumping Test Report (BRPWS-19) estimated that an approvable yield of 734,000 gpd from a single well or as a combined rate from both wells (e.g. both wells pumping at half the total rate).

Due to the variability of the subsurface deposits, and the potential for model inaccuracies, long-term monitoring of the wells was implemented in both the shallow, middle and deeper zones within the aquifer. In addition to the monitoring program an operational agreement was

instituted whereby Provincetown Water should commit to pumping NUF wells at a significantly lower rate for a number of years as current water system demand does not warrant excessive withdrawals and seasonal population fluctuations require extra source capacity in the summer months. This demand analysis is discussed in sections below. This monitoring program will be invaluable to monitor salt water upconing and avoid extensive damage to the aquifer through salt water intrusion. Results of the monitoring program are to be shared with both MADEP and Truro through its Board of Health and Water Resources Oversight Committee.

Water Assets and Aquifer Yield

The major municipal wells discussed previously, supply all of the water to the Provincetown system. This system also serves some 600 connections in Truro for primarily commercial customers long Rte. 6. System use and overall demand is reported annually in Annual Statistical Reports submitted to MADEP. Additionally, population increases and future demand projections (including commercial and industrial use) are undertaken by the Department of Conservation and Recreation and are intended to manage municipal withdrawals under the Water Management Act. Historic pumping withdrawals from 2001-2010 are shown in Table 2. Eventual use of the NUF wells is intended to replace the use of the NTAFB wells and to allow a decrease in withdrawals from South Hollow. The NUF wells are not intended to increase total permitted withdrawal capacity for the entire system. The NUF wells do however provide a reliable back up to help meet overall system demands should problems occur at South Hollow like historic events have shown (e.g. accidental spills or releases of oil or hazardous materials). Thus, the wise management or balanced withdrawals from all three sources should be protective of the aquifer or Pamet lens, avoid any long-term impacts from upconing or saltwater intrusion, and provide for slight increases in population growth. It is anticipated that with the application of proper system maintenance and conservation practices total demand should not rise significantly over the next 10 years in both Truro and Provincetown.

Transient and Non-Transient Community Supplies

In addition to the large municipal wells a total of approximately 31 smaller community supplies exist within Truro. These wells by definition serve more than 25 people 90 days per year. Their locations are shown on Figure 2-2. Many of these wells are linked to commercial establishments such as hotels and restaurants or public buildings. In addition to their well systems these facilities generally return flows to the aquifer through on-site wastewater

disposal. Thus, there net consumptive use from the groundwater system is significantly less than one might anticipate with return flows generally ranging from 60 to 85% of the pumped volume. Interim well head protection radii are required to reduce threats to water quality however, same well systems may be influenced by nutrients and other water quality problems associated with on-site septic systems. Currently both transient and non-transient community systems have reporting requirements to MADEP and the Truro Board of Health (BOH) (something here on participation % for the nitrate sampling program)

Residential Supplies

The majority of the homes in Truro are supplied by private wells located within their property boundaries. Current Bolt rules regulate the installation, sampling and operation of these wells. Truro has instituted one of Cape Cod's most extensive voluntary water quality sampling programs for private wells on Cape Cod. Results of this program are discussed in Chapter 6 – Water Quality.

Like the small community systems, residential systems return flow to the aquiver through on-site disposal systems. Year round residences could be expected to return upwards of 85% of their flow with the balance being lost to consumptive uses. Seasonal homes may experience slightly lower return percentages due to an increase in non-essential uses such as outdoor watering, car washing, etc. In general however, the lack of development density, no significant or rapid changes to developed land and the benefit of on-site return flows has resulted in a relative balance to the hydrologic cycle in Truro. Water resources including lakes, ponds, rivers and coastal embayment's do not exhibit signs of stress due to flow impairments or lack of return flows due to residential well use. Both short and long-term water quality issues are addressed in Section 6.

Flow Based Aquifer Management Strategies

Over withdrawal from the Pamet lens and to some extent the Pilgrim and Chequesset lenses, are concerns primarily related to the operation of large withdrawals. Through the WROC and the installation of 2 board members on the Provincetown Water Commission, Wise and safe monitoring of the major sources of supply should be accomplished. Long-term goals for the municipal system should include:

- Proper operation and maintenance of the wells
- Replacement or expansion of any of the wellfields only after careful consideration of aquifer impacts and generally only when needed to replace failing wells
- Proper and continued aquifer monitoring for water level elevation and water quality to avoid impacts from upconing or saltwater intrusion
- Continued exploration of an alternate source in the Chequesset lens to provide redundancy and potential future capacity
- Wise stewardship of land use practices, waste management and potential water quality concerns from stormwater

These last issues are discussed in greater detail in Sections 3, Stormwater; and Section 4, Wastewater. Long-term water quality issues and nutrient load issues are discussed in Sections 5 and 6 respectively.

Surface Water Resources

Surface water systems are predominantly supported by ground water base flow. While overland runoff does contribute flow to rivers and smaller drainage systems within Truro, groundwater infiltration rates are high due to the sandy soils that predominate in Truro. The major drainage in southern Truro is represented by the Pamet River. This resource is both an aesthetic treasure and a recreational feature for Truro and its visitors. Further towards Wellfleet, the Herring brook and supporting minor drainage systems are a major contributor to Wellfleet bay. In addition to these significant drainage systems, Truro is populated with ponds, predominantly within the boundaries of the National seashore, but also scattered throughout Truro. The largest of these is East Harbor, a former embayment which has been somewhat isolated from saltwater interactions due to the construction of Rte. 6 and 6A. The Pamet River, Herring Brook and East Harbor are discussed below with respect to resource management and infrastructure impacts

Pamet River

Although the Pamet River has been the recent subject of much attention due to a catastrophic breach near Ballston Beach in March 2013. This type of periodic breach can inundate the entire vally with seawater. Long-term remedies and the relative frequency of these events under climate change scenarios are being investigated. However, the IWRMP goals are to evaluate infrastructure impacts and modify current practices if water quality and flow improvements are necessary.

Two areas of concern are related to stormwater discharge and wastewater impacts to groundwater baseflow. In general groundwater/nutrient load modeling does not suggest that

nitrogen impairments are being caused by septic systems. Some localized problems may exist however the river is predominantly underlain by organic rich sediments where Nitrogen uptake generally occurs. Modeled groundwater concentrations remain low throughout this area suggesting monitoring as an essential part of a long term strategy. Total loads discharged to the Pamet Harbor may be a longer term cause for concern and warrant future monitoring. Stormwater runoff may carry more serious water quality threats for both nitrogen and bacteria. Best management practices for controlling both stormwater systems through infiltration and land use applications is warranted. Stormwater measures are discussed in Section 3.

Herring River

The Herring River project deserves some mention as it relates to the overall IWRMP project. Essentially, this project has studied and developed an implementation plan to replace the Chequesset Neck Dike with a bridge and flow control structure. The result will be increased tidal flows to reestablish salt marsh habitat. While the overall project impacts Wellfleet, several benefits may be realized relative to groundwater quality within this area (including portions of Truro). Essentially, years of hydraulic separation from tidal influences have potentially increased oxygen levels and essentially dried out low lying peat or swamp deposits. When anaerobic (underwater), these deposits are home for nitrogen digesting bacteria. The plan to reestablish brackish saltmarsh deposits may improve nitrogen uptake. An adaptive management plan is in place to monitor and assess the impacts over a 5 year period as the bridge and gate structure is installed and operated. Truro may wish to support Wellfleet in monitoring and evaluating any water quality improvements in the region but the changes are, at this time, presumed to be minimal and do not alter the wastewater or stormwater management suggestions.

Ponds of Truro

A number of unique Kettle ponds exist within Truro. In addition, Pilgrim Lake or East Harbor represents a significant water body just north of Moon Pond. Other major ponds fall within the National Seashore with the notable exceptions being Village Pond and the Great Swamp. Total land area of all ponds combined is approximately 35 square miles or 140 acres (www.capecodgroundwater.org/ponds/Truroponds).

Within the National Seashore, land use management and infrastructure practices are predominantly outside the jurisdiction or influence of the Town of Truro. Continued monitoring of

other ponds in Truro is warranted, however data to date indicates significant changes to pond ecology due to anthropogenic influences is not occurring. This may not be the case for East Harbor which has seen significant algal blooms, odor problems and increasing eutrophication over the last two decades. Notwithstanding studies and efforts to modify the current lack of a hydraulic connection with saltwater systems, the potential impacts of nutrient loading from stormwater sources and wastewater inputs needs to be better understood at East Harbor. Groundwater flow patterns, seasonal fluctuations and tidal influences on groundwater movement are recommended for Phase II efforts of the IWRMP.

Bibliography

Delineation of Contributing Areas to Selected Public-Supply Wells, Western Cape Cod, Massachusetts. Masterson, J.P, Walter, D.A., Leblanc, Denis R. U.S. Geological Survey Water-Resources Investigation Report 98-4237, 1998.

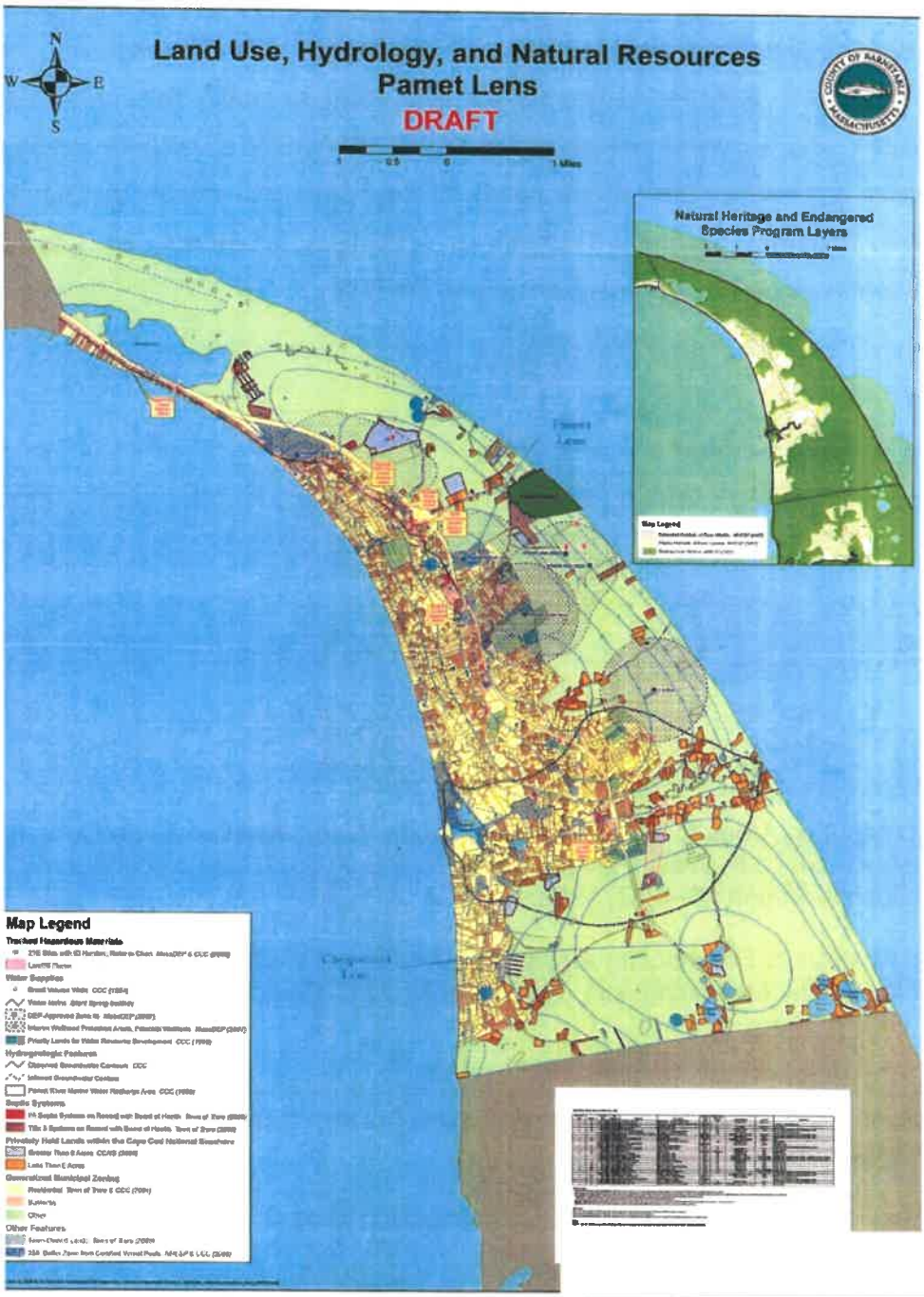
Particle-Tracking Analysis of Contributing Areas of Public-Supply Wells in Simple and Complex Flow Systems, Cape Code, Massachusetts. Barlow, P.M., U.S. Geological Survey, OFR 93-159.

Simulation of Groundwater Flow at Beach Point Cape Cod, Massachusetts. Cape Cod National Seashore Draft Publication. Natural Resources Program Center, National Park Service, U.S. Department of the Interior, 2008.

Sustainability of Ground-Water Resources, U.S. Geological Survey Circular 1186

Utilization of Numerical Groundwater Models for Water Resource Management. Bachmat, Y., Andrews, B., Holtz, D., Sebastian, S. U.S. Environmental Protection Agency, EPA-600/8-78-012, June 1978.

Water Resources of Massachusetts. Simcox, A. U.S. Geological Survey Water-Resources Investigations Report 90-4144, 199



Map created June 18, 2008 by the Cape Cod Commission's GIS Department

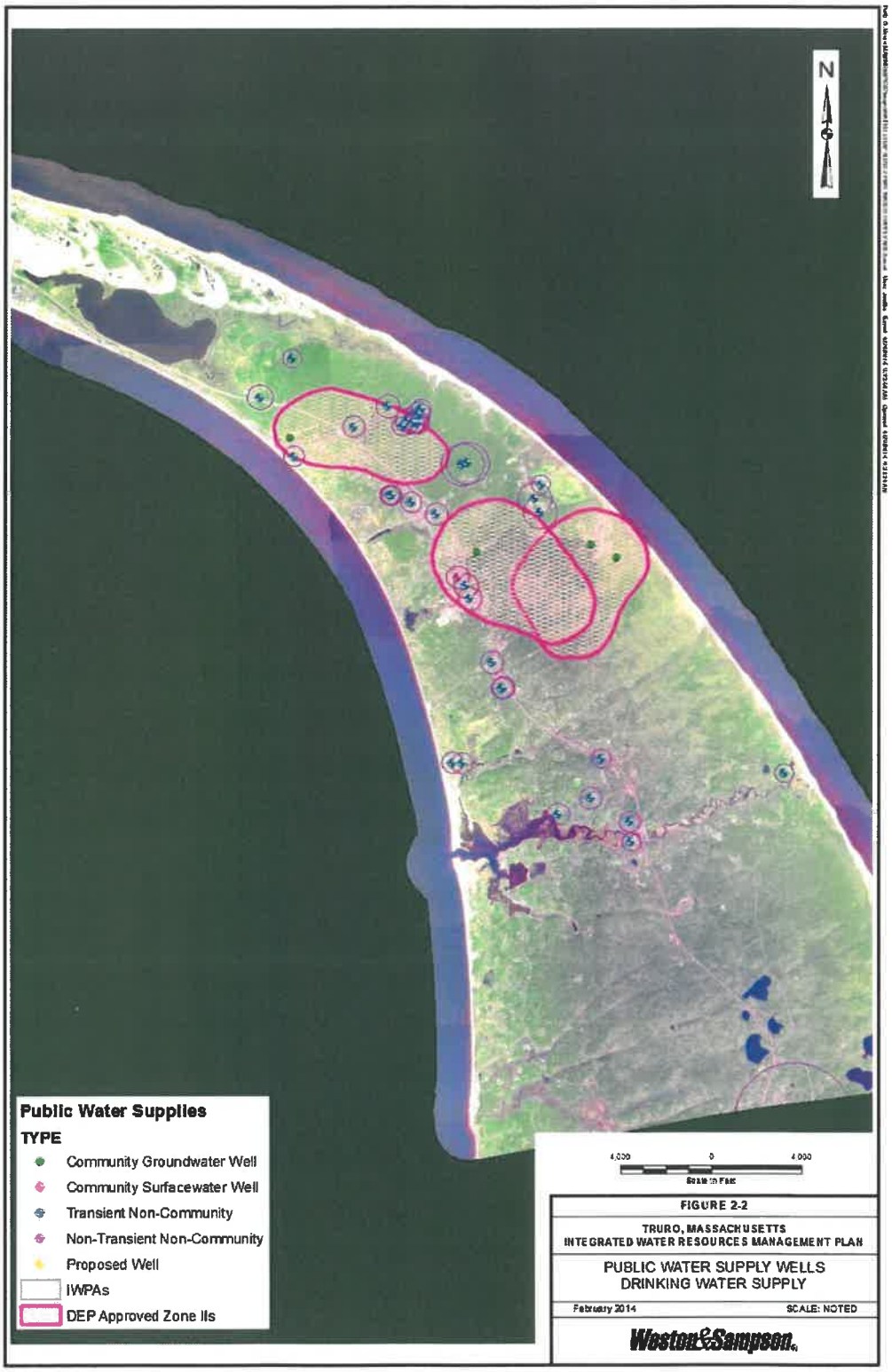
FIGURE 2-1

TRURO, MASSACHUSETTS
INTEGRATED WATER RESOURCES MANAGEMENT PLAN

ESTIMATED GROUNDWATER ELEVATIONS

MAY 2014 SCALE NOTED

Weston&Sampson


N
Public Water Supplies
TYPE
Community Groundwater Well
Community Surfacewater Well
Transient Non-Community
Non-Transient Non-Community
Proposed Well
IWPAs
DEP Approved Zone IIs
4,000
0
4,000
FIGURE 2-2
TRURO, MASSACHUSETTS
INTEGRATED WATER RESOURCES MANAGEMENT PLAN
PUBLIC WATER SUPPLY WELLS
DRINKING WATER SUPPLY
February 2014
SCALE: NOTED
Weston&Sampson

3. Stormwater

3.0 Introduction

Stormwater management in Truro was reviewed with respect to impacts to nutrient loads and general improvements to Water Quality. In general, the permeable deposits within Truro readily allow infiltration next to most impervious surfaces. The exceptions include highway runoff from Route 6 and potential direct discharges near ocean front properties or areas along the Pamet River. In addition, storm drains and runoff impacts to Pilgrim Lake require further analysis to quantify impacts to this valuable water body. Most direct discharges are of greater concern for turbidity and bacteriological sources.

In general, water quality concerns on Cape Cod have focused on Nitrogen and Phosphorus. Nitrogen being the primary focus for impacts to embayments and resulting loss in eel grass densities has therefore been the focus for most IWRMP work. Effects on eel grass are generally used as an indicator or surrogate evaluation tool for water quality impacts due to elevated nitrogen levels. Loss of density in eel grass beds has been shown to have subsequent impacts on a variety of species dependent on eel grass habitat. Nitrogen sources are varied but can be found in stormwater, wastewater and through direct deposition from the atmosphere or land use practices.

Ensuring that precipitation enters the ground where it falls (direct infiltration) is a critical component of improving stormwater management. The largest inhibitor of direct infiltration is impervious surfaces and therefore, the most important factor in minimizing the amount of stormwater is by reducing impervious surfaces or treating stormwater from impervious surfaces. The amount of existing impervious surface varies by community, but all communities must work diligently to minimize the amount of newly constructed impervious surface, and even reduce that already existing, through proper regulation of growth and development. This is particularly true for critical recharge zones within Truro. Recharge zones based on ground water flow patterns are shown in Figure 3-2. Essentially, Truro can be divided into nineteen (19) zones effecting wells, rivers, lakes or direct discharge to the ocean.

The Massachusetts Department of Environmental Protection (MADEP) regulates stormwater. The MADEP established an official Stormwater Policy and used the authority of Wetlands Protection Act to implement stormwater standards and develop a comprehensive Stormwater Handbook to offer detailed guidance. The MADEP Stormwater Standards apply to all development and redevelopment projects falling under jurisdiction the Wetlands Protection Act; however, many Massachusetts communities have chosen to use local regulatory mechanisms to apply the MADEP Stormwater Standards to projects outside the Wetlands jurisdiction. Other communities have chosen to enact their own standards.

a. EXISTING STORMWATER ISSUES

EPA defines nonpoint source pollution as pollution that is generally the result of land runoff, precipitation, atmospheric deposition, drainage, seepage or hydrologic modification. In general, the term "nonpoint source" is defined to mean any source of water pollution (stormwater, wastewater, etc.) that does not meet the legal definition of "point source" in Section 502(14) of the Clean Water Act. The definition for a point source states:

> "Point source" means any discernible, confined and discrete conveyance, including but not limited to any pipe, ditch, channel, tunnel, conduit, well, discrete fissure, container, rolling stock, concentrated animal feeding operation, or vessel or other floating craft, from which pollutants are or may be discharged. This term does not include agricultural storm water discharges and return flows from irrigated agriculture.

i. Point Sources of Pollution in Truro

In the Town of Truro most point sources of pollution of Stormwater come from existing stormwater infrastructure. Since most of the impervious pavement and roadway infrastructure uses "country drainage" there is not a tremendous amount of point sources within Truro. The term country drainage implies the lack of stormwater collection and conveyance systems. Instead runoff flows by sheet flow across pavement surfaces to low points along parking lots and roadways where it infiltrates into sandy or partially vegetated areas. This is typical of Cape Cod development. The point sources that do exist within Truro are generally located predominantly around the heavily trafficked or impervious areas associated with Route 6 and associated parking, industrial and commercial settings. Point

sources are evident from MassDOT drawings along Route 6 and in particular along Pilgrim Lake.

ii. Non-Point Sources of Pollution in Truro

Non-point sources are a much larger contributor to Stormwater pollution within Truro. As stated above most stormwater is allowed to drain as "country drainage" and therefore no point of discharge is ever created.

b. WORK CONDUCTED

The work conducted for this project included an initial desk-top stormwater recharge siting analysis. The analysis considered various criteria throughout all of Truro. The analysis of these criteria was undertaken in Geographical Information Systems (GIS) software, with results presented in electronic mapping format. A field investigation was then conducted to field verify certain criteria that was initially mapped in GIS. The initial GIS maps were then updated with field-verified data. Stormwater recharge areas were then identified and stormwater runoff volumes were calculated. Based on these volumes as well as several other factors nutrient loads were calculated for each recharge area. Following the siting analysis the Town bylaws were reviewed and the information was used to determine possible future bylaw modifications to improve conditions in town. Each of these efforts are discussed if further detail, below.

i. Identification of Stormwater Recharge Areas

Utilizing the USGS study, "Ground-Water Recharge Areas and Travel times to Pumped Wells, Ponds, Streams, and Coastal Water Bodies, Cape Cod, Massachusetts" we identified nineteen (19) separate recharge areas within the Town of Truro to be used as part of this study. These recharge areas will be used throughout the course of the study to calculate nutrient loads expected within each recharge area. In this section, nutrient loads generated from stormwater practices within each recharge area were calculated utilizing a GIS based stormwater analysis, field verification, and identification and location of stormwater infrastructure.

ii. GIS Based Stormwater Analysis

To aid in the quantification of nutrient loads within each stormwater recharge are in Truro, a town-wide site-screening analysis at the desk-top level was conducted for stormwater capture areas in GIS. This effort entailed a large-scale analysis of the entire town,

considering several variables that are influential in properly locating recharge areas and nutrient loads associated with each recharge area, including evaluation of topographical maps, hydrogeologic information, land use patterns, stormwater structures and impervious areas. The goal was to consider a large area (the Town of Truro) and conclude where the stormwater capture areas were contributing high nutrient loads to either groundwater or surface water receptors. To represent these data on a large-scale, town basis, the Town of Truro was divided into 44 rectangles which include most of the developed areas and impervious surfaces (see Figure 3-1). Within each rectangle the following criteria was evaluated:

iii. Parcel Mapping

Utilizing existing Assessor's information, parcel mapping for the 44 rectangles was developed so that each parcel could be identified as a separate unit. Each parcel could then be evaluated for land use patterns, fertilizer application and impervious areas.

iv. Land Use Patterns

1. Undeveloped Land, Pervious Surfaces

These areas typically are open space and are shown as permeable, sandy areas without vegetative cover or cultural features such as roads or buildings. Open area for each recharge zone was mapped and calculated in GIS using 2005 MassGIS Land Use data.

- Open land
- Salt water sandy beach
- Mining

2. Vegetated Cover

Land use patterns on a parcel by parcel basis were evaluated. Land use data from the State (MassGIS) was used to create a vegetative cover area. There are many different land use descriptors in the land use database. The land use descriptors selected to represent vegetative cover area included the following:

- Forest
- Brushland
- Forested wetland

- Non-forested wetland
- Salt water wetlands
- Cranberry bogs
- Orchards
- Nursery
- Cropland
- Pasture
- Cemetery
- Golf course
- Transitional land (i.e. buffer areas between parcels)

These land use types were combined to create one vegetative cover area for Truro. The vegetative cover area was calculated for each parcel and then in turn for each recharge zone.

3. Fertilized Lawn

A subset of the Vegetated Cover map was residential and commercial lawn areas. These were identified using aerial photography to identify vegetated cover areas that were not forested but were open lawn areas. An assessment of the aerial photography and condition of the lawn gave indications on whether fertilizer was being applied to the lawn areas.

v. Impervious Areas

Using the MassGIS Infrared data from 2005, our GIS department compared the 2005 data against aerial images from 2008. We then added new houses and roads to the impervious surface layer and deleted areas that were obviously permeable (e.g. sand and gravel pits, beach paths, etc.). A new impervious layer was developed to be used through the course of this project. Utilizing aerial photography it was estimated that 90% of the impervious area in Truro was pavement and 10% was roof.

vi. Existing Stormwater infrastructure

Using the MassGIS data, aerial photography and paper maps collected from MassDOT existing stormwater infrastructure was mapped within each recharge area. This data was utilized to help understand whether stormwater flows from one recharge area to another and the eventual end-pipe location of stormwater systems.

To increase accuracy of this desktop analysis, field verification was conducted. This effort is described in further detail, below.

c. *FIELD INVESTIGATION/MAP UPDATES*

Weston & Sampson personnel conducted field verification efforts to verify stormwater infrastructure and land use patterns within the Town of Truro. Key sites noted in the initial recharge siting analysis were visited and inspected for any impervious area and land use mapping discrepancies, stormwater infrastructure outfall identification, and local hydrology and stormwater system catchment areas. The GIS mapping updates were able to be conducted real time, in the field, using Weston & Sampson's iDataCollect technology.

The iDataCollect technology is specifically designed to eliminate paper forms historically used to conduct routine inspections or mapping updates. Utilizing a hand-held device (in this case, an iPad), Weston & Sampson was able to collect data electronically and download that data automatically through web-based programming and reporting. This system is extremely efficient since it eliminates printing and managing paper work, interpretation of hand-writing and redundant data entry. It also facilitates data handling, storage, and reporting.

With the iPad in hand, Weston & Sampson personnel were able to easily navigate from site-to-site. Previously made GIS maps were viewed on the iPad and compared to what was noted in the field. Any needed mapping updates were able to be made while at the site. The most notable changes in impervious area were sand parking lots/dirt roads that were mapped as impervious areas in MassGIS. These areas were removed from total impervious area calculations.

After the initial field effort was completed it was determined that, while the field work increases accuracy, the effect on the total nitrogen load in any given sub-basin is comparatively small. This is due to the high level of accuracy obtained from aerial photos as well as the minimal impact of stormwater on actual nutrient loads generated from stormwater in the Town of Truro. Future field efforts were eliminated.

Each site was also investigated to confirm outfall locations and local hydrology. Consideration of outfall condition, topography, degree of soil saturation, vegetative cover and possible use of fertilizer were documented at each location. Distance to surface water resources and local channelization were also noted.

d. COMPARISON TO EMPIRICAL GROUND WATER SAMPLING

Although nitrogen concentrations can be modeled, empirical ground water sampling data is often used to compare and contrast predicted concentrations from the model. Nitrogen sampling data from domestic wells was compared and plotted against modeled concentrations. Lots revealing > 5ppm (mg/l) of nitrogen are shown on Figure 3-2.

Sampling data suggests that over the sample period (2007-2009) over 1181 lots have been sampled with 45 showing concentrations above 5 ppm and 2 lots revealing concentrations above 10 ppm. Concentrations above 5 represent action levels for public drinking water supplies while concentrations above 10 exceed safe drinking water standards. Although, individual sample results require verification through sampling, the results suggest a variety of actions and management approaches are warranted.

e. NUTRIENT/POLLUTANT LOAD CALCULATION, STORMWATER

The analysis included area calculations of natural, impervious, and open areas conducted as part of the MassGIS study. Figure 3-3 shows a representation of these mapped areas. Nitrogen loading rates for each land use type were then applied to calculate annual nitrogen loading for each land use condition within specific recharge zones. The loading rates are consistent with land use values used by the Buzzards Bay National Estuaries Program nitrogen loading studies (http://www.buzzardsbay.org/bbpnitro.htm).

Table 1, below, provides a summary of annual nitrogen loading from direct infiltration or runoff anticipated in each recharge zone. The Recharge Zone IDs in the table have been provided on Figure 3-2 for reference purposes. Although stormwater and wastewater loads are discussed in Sections 3 and 4 respectively, a brief description of the nitrogen loads is provided below:

Impervious Surface

Utilizing aerial photography it was estimated that 90% of the impervious area was pavement and 10% was roof. A nitrogen loading rate of 13.5 pounds/acre/year was used for pavement loading and 6.76 pounds/acre/year was used for roof loading.

Vegetative Cover

A nitrogen loading rate (0.45 pounds/acre/year) was applied to each recharge zone to calculate annual nitrogen loading for vegetative cover.

In lawn areas a loading rate of 1.08 pounds/5000sf/year was applied to each recharge zone to calculate annual nitrogen loading from the addition of fertilizers applied to lawn areas.

Open Area

A nitrogen loading rate of 9.73 pounds/acre/year was used for open area loading.

Again, all loading rates are consistent with land use values used by the Buzzards Bay National Estuaries Program nitrogen loading studies (http://www.buzzardsbay.org/bbpnitro.htm).

Table 1:

Nitrogen Loads Generated by Stormwater [1]

		Annual Nitrogen Load (lbs)				
Recharge Zone ID	**Acreage**	**Impervious**	**Vegetation**	**Open Land**	**Lawn**	**Total**
1	962	265	127	3,377	0	**3,769**
2	0	0	0	0	0	**0**
3 (Atlantic)	4,631	1,720	1,571	9,773	2	**13,065**
4	338	73	128	441	0	**642**
5	203	34	62	0	0	**96**
6	415	520	113	1,192	12	**1,838**
7	3,294	1,764	1,382	181	33	**3,361**
8	5	0	0	43	0	**43**
9	34	0	6	196	0	**202**
10	320	493	117	171	19	**799**
11	1,380	1,907	525	487	122	**3,041**
12	645	1,397	211	579	55	**2,242**
13	150	265	38	351	12	**666**
14	268	601	87	214	42	**943**
15	334	587	128	2	29	**747**
16	158	405	53	28	30	**516**
17	128	89	54	0	0	**144**
18	52	30	20	17	0	**67**
19	779	1,861	210	1,501	75	**3,648**
Total less Atlantic		**10,292**	**3,263**	**8,779**	**431**	**22,765**
Total for All Truro		**12,013**	**4,834**	**18,552**	**433**	**35,831**

[1] Note: Stormwater is used to represent both runoff and direct infiltration from precipitation.

All recharge zones from Table 1 are shown in Figure 3-2. Recharge Zone #3 is an area which discharges to the open Atlantic Ocean side. This area is characterized as having expansive areas which are not vegetated (e.g. beach front, etc.). The effective nitrogen load from direct atmospheric deposition is quite high. There is also a large impervious area in Recharge Zone #3 associated with the former Air Force base, now the Highland Center, which has a corresponding high nitrogen load. The amount of open land and impervious

area results in a total load of 13,065 lbs/year, or almost 37% of Truro's total annual nitrogen load for this analysis. This high value is also a reflection of the excessive size for Recharge Zone #3. The remaining areas provide a total of 22,766 lbs/year generated by Stormwater. This load is divided into numerous smaller recharge areas.

f. CRITICAL AREAS

Nutrient removal and water quality improvements could be realized in a variety of targeted areas but changes to current systems would not likely dramatically affect the nitrogen or nutrient concentrations. Instead Truro's long-term focus should be on developing BMP's for critical areas of concern in Town including, Route 6 stormwater discharges in areas adjacent to Pilgrim Lake (East Harbor), the Pamet River and the Wellfields.

i. Pilgrim Lake (East Harbor)

Pilgrim Lake is experiencing eutrophication due to increased nutrient loads. Increased nutrient loads can be caused by a number of factors, including human induced eutrophication, which is usually the result of introducing fertilizers or sewage to an environment. This introduction causes an increase of nutrients such as phosphates and nitrates. Eutrophication can also occur naturally in a water body that has accumulated nutrients over time and that has no ability to flush those nutrients from its system (depositional environments).

Based on the location of Pilgrim Lake, fertilizers and sewage most likely are not an issue, as most residences in the area are on private septic systems and the homes do not exhibit a high rate of fertilizer use (no large lawn areas). However, based on MassDOT records the majority of the Stormwater Drainage from Route 6 drains directly to Pilgrim Lake. This stormwater could carry any number of nutrients and other contaminants that could be posing a threat to Pilgrim Lake.

Pilgrim Lake is most likely a depositional environment, which is causing the eutrophication problem. However, more research should be done to determine if Route 6 drainage is compounding the problem and whether stormwater can be handled in a more environmental way. This could include sampling of the Route 6 outfalls to see what nutrients are entering Pilgrim Lake and working with MassDOT to improve stormwater structures along all of Route 6.

A more long term solution may be to improve the opening from Pilgrim Lake to Cape Cod Bay in order to flush some of the nutrients from the system and make Pilgrim Lake less of a depositional environment. Again, an in depth feasibility study of this option would be required in order to make this a viable option.

ii. Pamet River

The Pamet River drainage basin receives almost 2/3's of its nutrient load from impervious areas. The majority of this impervious area is located west of Route 6 and is made up of residential areas. Stormwater from this impervious area in this basin either infiltrates into the ground routed as sheet flow and "country drainage" or is discharged directly to the Pamet River. During large storm events, once the soils are saturated, stormwater can run overland, rather than infiltrating, directly discharging to nearby water bodies. If this occurs in this basin it would cause even more water to run into the Pamet during large storm events.

Further mapping is needed in this area to confirm drainage patterns of all impervious areas. Furthermore, wet weather stormwater sampling/monitoring should be conducted to confirm the amounts of stormwater entering into the Pamet during large storm events.

If this stormwater can be managed and treated, especially in areas identified to be large contributors during storm events, then potential improvements can be realized within the Pamet River.

iii. South Hollow/North Union Wellfield

South Hollow Wellfield has long had issues associated with road salt. This most likely comes from treatments applied to Route 6 by MassDOT. The Town should consider working with both MassDOT and the Town of Provincetown to reduce salting of the roads in and around South Hollow Wellfield. This could include using Calcium Chloride on Route 6 in this area.

North Union wellfield water supply currently does not exhibit impacts associated with road salt. The Zone II for this wellfield does not extend to Route 6 and therefore salt

from that roadway should not impact these wells. However, several residential developments are located within the Zone II. The roadways in these areas should be treated with road salt alternatives and long-term monitoring should be conducted to monitor for potential future impacts.

g. BYLAW REVIEW

In an effort to understand Truro's ability to regulate stormwater and recharge, Weston & Sampson reviewed a variety of Truro's regulatory mechanisms. The following bylaws and regulations were reviewed:

- General Bylaws (2010),
- Zoning Bylaws (2009, 2013 – including proposed amendments to parking and site plan requirements),
- Conservation Bylaw (2010),
- Conservation Commission Rules of Procedure (2010),
- Conservation: Erosion Control Regulations (2012), and
- Sub-Division Regulations (2011)

The Town of Truro does not have a separate Stormwater Bylaw and associated Stormwater Regulations. Furthermore, it appears that stormwater is only minimally regulated in the above-mentioned mechanisms, and only the MADEP Wetlands Protection Act is used to control stormwater in the Town of Truro.

Stormwater bylaws can reduce confusion from overlapping and potentially conflicting regulations and create a single set of standards to regulate stormwater discharges. Stormwater bylaws can also be used to promote environmentally sensitive development such as Low Impact Development (LID) techniques that both filter stormwater and promote local ground water recharge. Stormwater bylaws define the administration and enforcement of the six minimum control measures, including:

1. Public education and outreach
2. Public participation/ involvement

3. Illicit discharge detection and elimination
4. Construction site runoff controls
5. Post-Construction runoff control
6. Pollution prevention and good housekeeping

h. CONCLUSIONS/ IMPLEMENTATION STRATEGIES

Potential Bylaw Revisions

Since no Stormwater Bylaw exists no revisions are applicable. However, to better handle stormwater runoff and impose more stringent regulations above and beyond State requirements concerning stormwater, a Stormwater Bylaw and associated Stormwater Regulations could be created. A sample stormwater bylaw is provided in Appendix B.

Public Outreach/Education

In order to improve stormwater issues within Town, a public outreach program should be developed to make the population aware of the issue. In addition, as part of their education, several low cost mitigation options should be developed and presented to the local residents. These options could be anything from the implementation of rain gardens, to cisterns, to rain barrels that could be utilized by each resident to improve stormwater on a parcel-by-parcel level. By education the people, relationships and alliances to improve stormwater can be developed between the municipality and their residents.

Potential Stormwater Best Management Practices (BMP) Improvement Locations

The Town should also consider developing Conceptual BMP's for 10 most practical/critical stormwater systems in Town. This would include BMP's along Route 6 as well as improvements to existing BMP's in the critical areas of concern identified in Section 3.6 of this section.

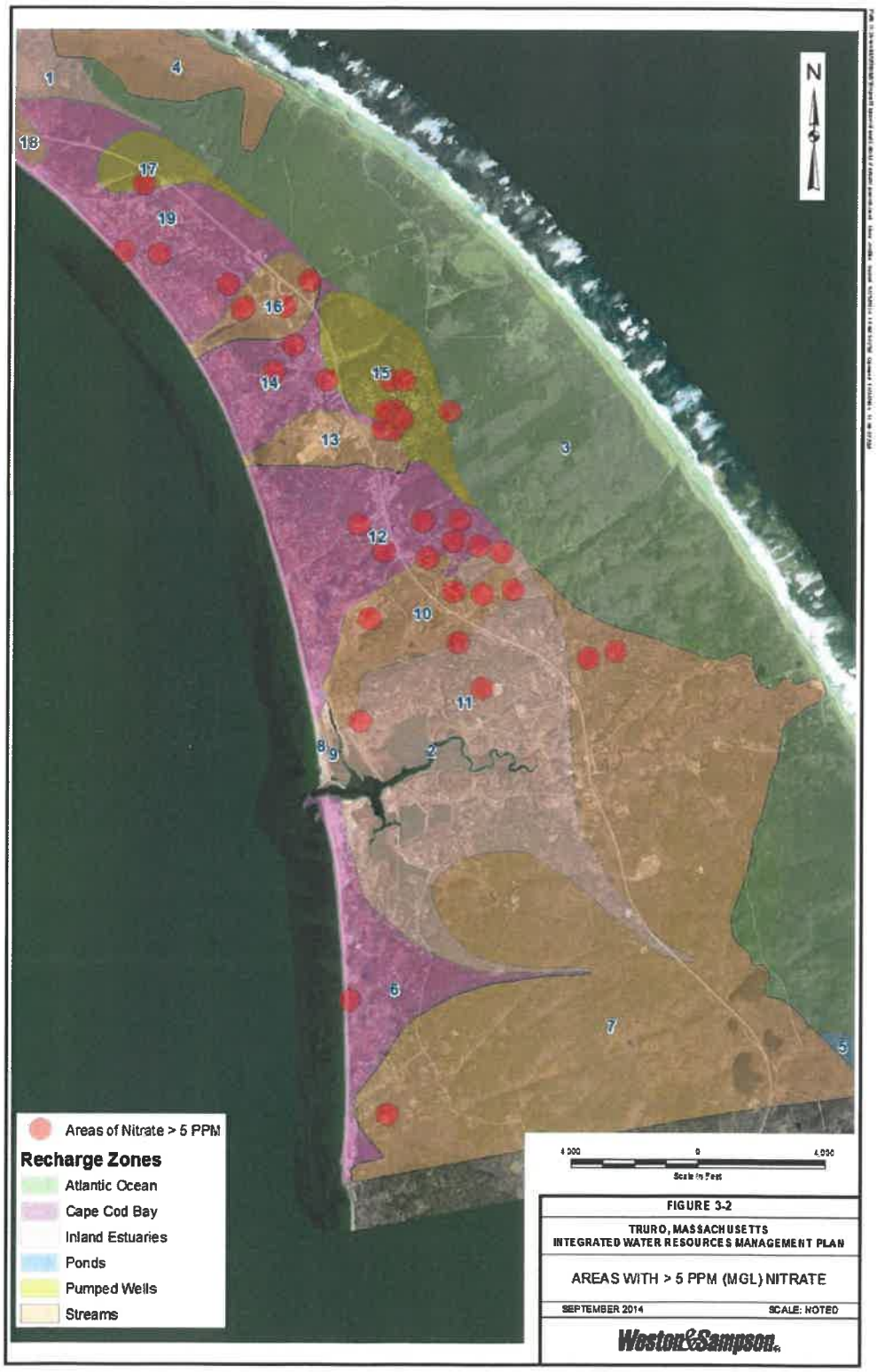
Evaluate and create preliminary designs of infrastructure modifications for Route 6 drainage systems. Although Route 6 is maintained by MassDOT, by creating preliminary designs for them, the Town can request that MassDOT incorporate new and improved stormwater infrastructure projects the next time they maintain Route 6. A meeting with MassDOT officials to discuss the possibility of improving infrastructure conditions and teaming with them to improve the existing stormwater along the Route 6 corridor is paramount.

Other Municipal Practices/Mitigation Strategies

Develop, locate and install monitoring/protection wells at key locations in Truro. Wells should be located in areas of concern as identified in this section. These wells should be located between existing stormwater problems and important groundwater and surface water resources. A proposed monitoring plan with well locations should be developed and implemented as part of Phase II.

The Town should also consider conducting detailed assessments of land use practices in areas where the sample results have exceeded 5mg/L (Figure 3-2). By identifying what is causing these elevated loading rates the Town may be able to implement some corrections to reduce the loading at these parcels. .


N
Grid
4,000
0
4,000
Scale in Feet
FIGURE 3-1
TRURO, MASSACHUSETTS
INTEGRATED WATER RESOURCES MANAGEMENT PLAN
GRID INDEX
February 2014
SCALE: NOTED
Weston&Sampson


N
1
4
18
17
19
16
14
15
13
3
12
10
11
8
9
2
6
7
5
Areas of Nitrate > 5 PPM
Recharge Zones
Atlantic Ocean
Cape Cod Bay
Inland Estuaries
Ponds
Pumped Wells
Streams
4,000
0
4,000
Scale in Feet
FIGURE 3-2
TRURO, MASSACHUSETTS
INTEGRATED WATER RESOURCES MANAGEMENT PLAN
AREAS WITH > 5 PPM (MGL) NITRATE
SEPTEMBER 2014
SCALE: NOTED
Weston&Sampson


N
Impervious Cover
Lawn Fertilized
Vegetative Cover
Pervious Cover
4,000
0
4,000
Scale in Feet
FIGURE 3-3
TRURO, MASSACHUSETTS
INTEGRATED WATER RESOURCES MANAGEMENT PLAN
COVER AREA
February 2014
SCALE: NOTED
Weston&Sampson

4. Wastewater

Wastewater Management in Truro is predominantly a residential systems issue. These systems are regulated under the state Code of Massachusetts Regulations (310 CMR 5.15) otherwise known as Title 5. Locally, the Board of Health rules and regulations govern subsurface disposal systems and the discharge of wastewater. Systems above a capacity of 10,000 GPD are required to obtain a Ground Water Discharge Permit (BRP WS-79, 85) and apply treatment technologies that limit the impacts to receptors and generally maintain groundwater quality at less than 10 ppb of Nitrogen (measured as Nitrate) at a property boundary. Although some inconsistency exists with this criteria and the drinking water action level of 5 ppb, most large systems in recent years have been achieving discharge concentrations between 4 and 7 ppb.

HISTORY

Wastewater disposal systems have improved significantly since the advent of Title 5 and with the review and regulatory conformance oversight undertaken by the Board of Health and current agent Pat Pajaron. The Title 5 requirement to disclose failed systems and excessive pump outs has led to more timely repairs and retrofits or replacements. Additionally, inspections and certifications for a properly operating system during property transactions and inspections filed when a permit is necessary for increased living space has led to both better tracking and record keeping, and a clear point of leverage for enforcement actions. Economically, the costs of septic system improvements conducted at the time of real-estate sale have alleviated some of the financial burdens particularly with rising real estate prices. However, even with this economic advantage, system repairs, replacements or upgrades have not typically included the installation of innovative technologies for nitrogen removal.

Current local regulations require a setback distance of 100 feet between a private well and on-site subsurface disposal systems (septic). Lots that had pre-existing systems and wells are generally "grandfathered" and exempt from this requirement. Although long held to be an acceptable separation distance to be protective of human health, permeable sand deposits and other subsurface conditions (e.g. shallow water table, dug wells etc.) can result in insufficient filtration or adequate biological activity to provide degradation of nutrients.

The town recognizing the predominant reliance on private well systems for both residential and commercial sites embarked on a voluntary sampling program. This program while somewhat unique has met with overwhelming success and has provided data that is not readily available in most Massachusetts communities even on Cape Cod with its sole source aquifers and fresh water lenses. The results of this sampling are discussed below.

Current system records maintained by the Health department provide accurate locations and designs for the majority of the systems. Flow and design capacity is based on the number of bedrooms for the serviced housing unit. Although the summer influx of visitors and the transient population at Hotels and Inns causes difficulty in quantifying wastewater loads in any given area, nutrient loads are quantified and located as accurately as possible and are discussed in Section 5. Currently, Massachusetts Geographic Information Systems lists no currently active Groundwater Discharge Permits (flows above 10,000 gpd) within Truro. Similarly, surface water discharges for wastewater regulated under the National Pollution Discharge Elimination System (NPDES) Program are not listed for the Town of Truro or the National Seashore.

NITRATE SAMPLING PROGRAM

The initiation of a water quality sampling program in 2007 was a progressive move by concerned citizens. The program generally initiated through the Water Resources Oversight Committee was modeled after a program already being undertaken in Eastham. The program was designed to sample one-third of the private wells in Truro in every calendar year. The program is voluntary and response is neither mandatory nor punitive. Sample results above the safe drinking water level of 10mg/L (ppm) are asked to retest immediately. Sampling efforts have met with a high rate of response which has helped to establish baseline data throughout the town.

Although many variables may impact the results of Nitrate or Nitrogen in well water samples, the variable conditions do not negate the value of this data. Well depth, method of construction and duration of pumping period may effect concentrations. Sampling methods and sample location within a domestic system may also cause variation. Without discounting these factors, the sample results for each year are discussed below.

Year 2007 - 2008

Sample bottles were directly distributed to 889 residences in 2007. Approximately 90% of these residences were in the Pamet River area. Randomly selected residences in North Truro, Pond Village and Beach Point constitute the remaining 10%. Approximately 50% of the sample containers (442) were returned for laboratory analysis. Only 10 sample results indicated concentrations between 5 and 10 ppm. No sample results revealed concentrations above 10. A calculated average concentration for all samples was 0.92 ppm. Sample results in groundwater at a level of 1.0 or less are extremely common throughout Southeastern MA. No discernible pattern or clustering of the results between 5 and 10 ppm could be suggested. Instead results appeared scattered or random over the subject population.

Year 2008-2009

In 2008, 750 residences received sample bottles. Most of these residences were in North Truro. A 47% return rate resulted in 353 samples submitted for laboratory analysis. Reported data summarized in March 2009 indicated only 1 sample above 10 ppm. All of the 17 samples that revealed concentrations between 5 and 10 ppm were targeted for retesting in 2009. Data sets again showed a fairly random result; however, certain areas in North Truro may be influenced by lawn fertilization and/or the proximity of multiple residential systems.

Year 2009-2010

Sample bottles were distributed to the remaining homes in Truro. Sample participation rates were extremely high with 1181 samples taken over the three years (51% return rate). The average concentration over all samples was 1.11mg/L (ppm). Only 2 samples exceeded the 10 mg/L standard while 45 samples indicated concentrations between 5 and 10 ppm. Table 1 below shows the results over the three years with respect to assessor's maps within town. Figure 4-1 shows sample locations above 5.

Table 1:

North of Pond Village (Maps 2 -35):

- 123 samples
- Average concentration = 1.23 mg/L
- 2.4% of samples at 5 mg/L or higher

- **Pond Village/Shearwater** (Maps 36, 38, and 39):
- 169 samples
- Average concentration = 1.5 mg/L
- 5.9% of samples at 5 mg/L or higher

South of Shearwater to North of Pamet River (Maps 37, 40, 41, 42, 43, 44)

- 318 samples
- Average concentration = 1.34 mg/L
- 5% of samples at 5 mg/L or higher

Pamet River Valley (Maps 45-51):

- 391 samples
- Average concentration = 0.99 mg/L
- 3.6% of samples at 5 mg/L or higher

South Truro (Maps 52-64):

- 179 samples
- Average concentration = 0.51 mg/L
- 1.1% of samples at 5 mg/L or higher

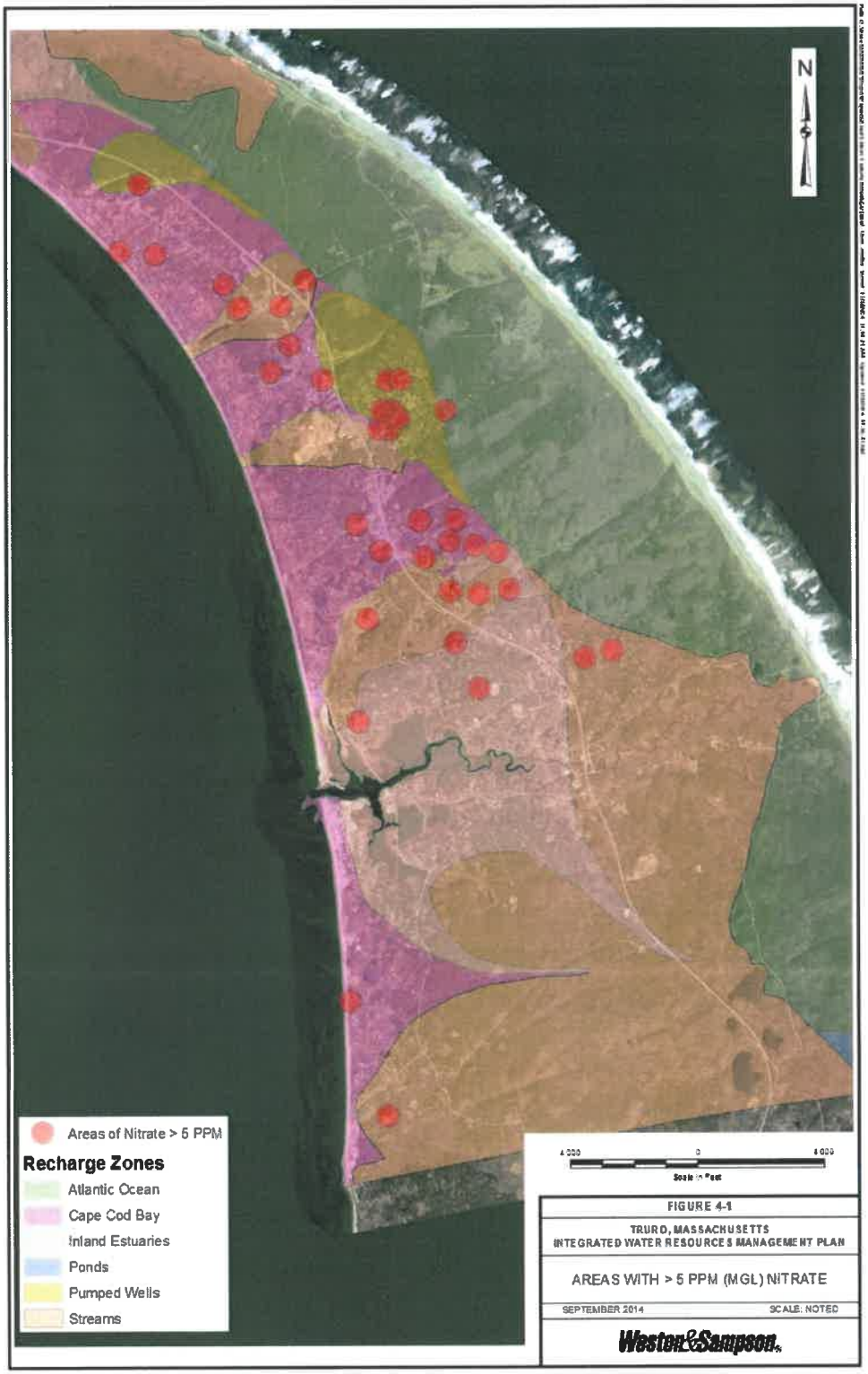
In general, sample results indicate few problems within the Pamet River. Although the participation rate of 51% was extremely high for a volunteer program, absolute conclusions cannot be established from the data. Figure 4-2 compares the locations of sample sites above 5 with respect to modeled nitrate concentrations from Section 5. In general, densely developed areas tend to have higher predicted concentrations in the model and also a greater occurrence of elevated nitrate results in the sampling program. Continued use of this program is

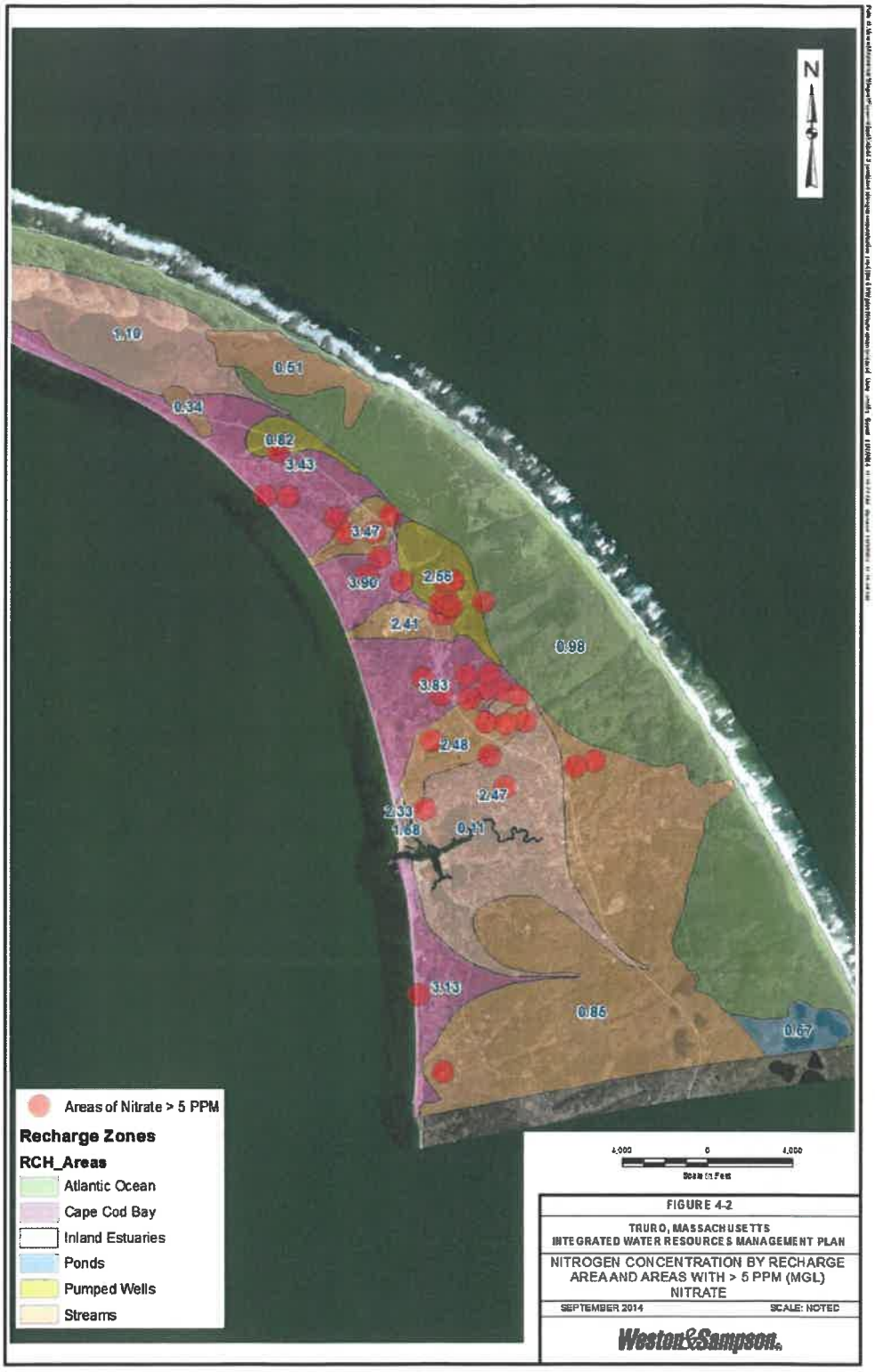
recommended to provide insight into elevated concentrations and to attempt to ensure sample results from all drinking water sources.

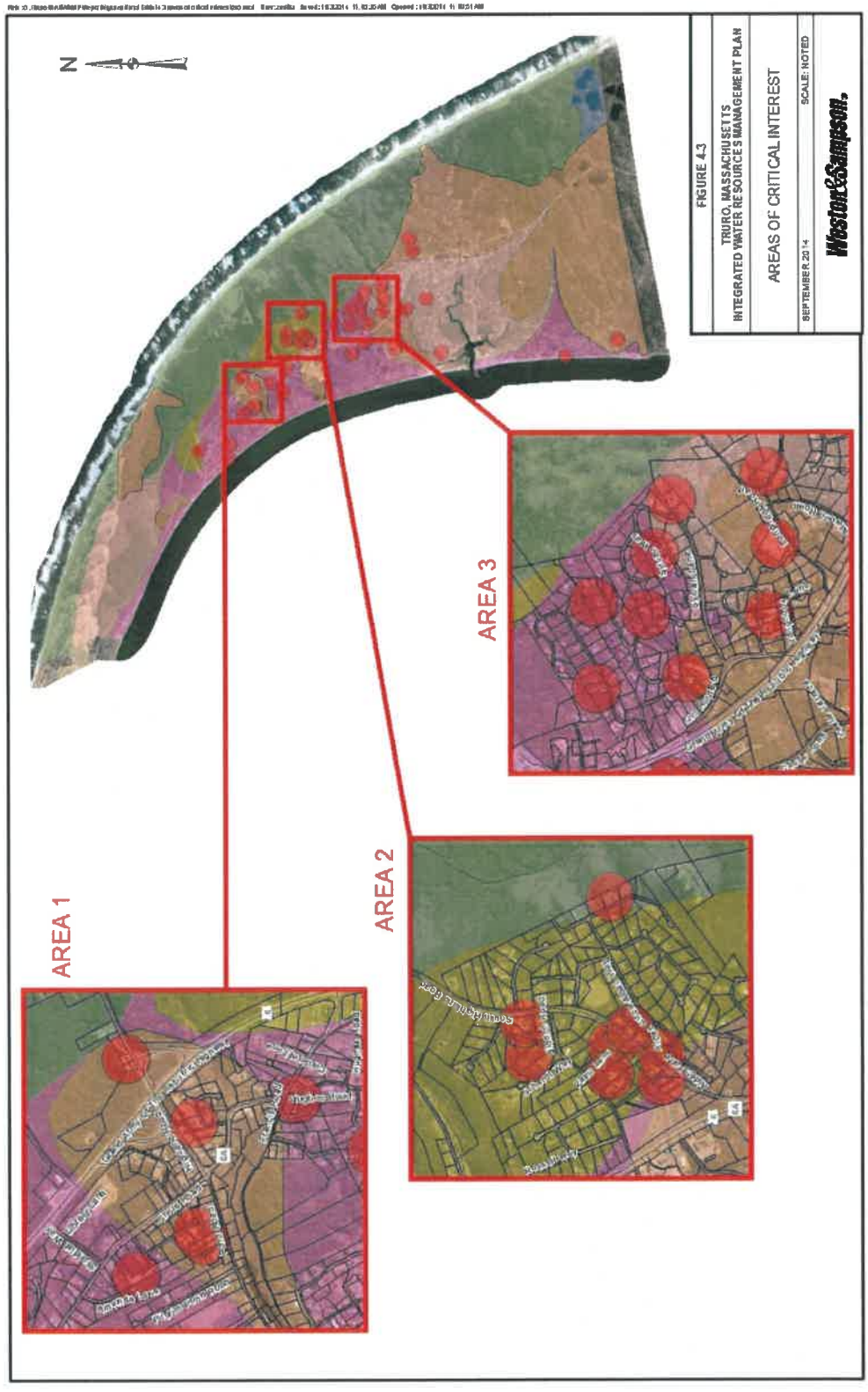
Further work is necessary in densely developed areas and within the general locale of elevated concentrations. Detailed field surveys should be undertaken and setback distances from septic systems to well sites should be evaluated for abutters and landowners who fall within a set radius or catchment/drainage area near the elevated concentrations. In addition, public education and outreach regarding proper septic system maintenance and operation should be targeted for both areas with nitrate concentrations approaching or exceeding 5 ppm. This is particularly true in areas with predicted or theoretical modeled concentrations that are 2 to 3 times the average nitrate level, found in Truro. Ongoing efforts in Phase II of the IWRMP should both investigate and address these areas in Truro. These areas are shown in Figure 4-3

SEWERS

Although no municipal sewer collection systems or significant private collection systems exist in Truro, some potential opportunities exist to realize the benefit of collection and advanced treatment. Of significant note is the primarily commercial zone along Beach Point where the influx of summer visitors creates significant increases in nitrogen loads. Currently a sewer line for the Provincetown system was extended towards the Truro town line. This line is reportedly 6 inches in diameter but its overall flow capacity and current utilization in Provincetown is not well known. Further work is necessary to evaluate the possible impacts of a connection for the Beach Point area. Similarly this alternative must be balanced against localized collection and treatment, individual upgrades, and a no-action alternative. The costs and preliminary engineering analysis are recommended as part of the second phase for the IWRMP.


N
Areas of Nitrate > 5 PPM
Recharge Zones
Atlantic Ocean
Cape Cod Bay
Inland Estuaries
Ponds
Pumped Wells
Streams
4,000
0
4,000
Scale in Feet
FIGURE 4-1
TRURO, MASSACHUSETTS
INTEGRATED WATER RESOURCES MANAGEMENT PLAN
AREAS WITH > 5 PPM (MGL) NITRATE
SEPTEMBER 2014
SCALE: NOTED
Weston&Sampson


N
1.10
0.51
0.34
0.82
3.43
3.47
3.90
2.56
2.41
0.98
3.83
2.48
2.47
2.33
1.68
0.11
3.13
0.85
0.67
Areas of Nitrate > 5 PPM
Recharge Zones
RCH_Areas
Atlantic Ocean
Cape Cod Bay
Inland Estuaries
Ponds
Pumped Wells
Streams
4,000
0
4,000
Scale in Feet
FIGURE 4-2
TRURO, MASSACHUSETTS
INTEGRATED WATER RESOURCES MANAGEMENT PLAN
NITROGEN CONCENTRATION BY RECHARGE AREA AND AREAS WITH > 5 PPM (MGL) NITRATE
SEPTEMBER 2014
SCALE: NOTED
Weston&Sampson


N
AREA 1
AREA 2
AREA 3
FIGURE 4.3
TRURO, MASSACHUSETTS
INTEGRATED WATER RESOURCES MANAGEMENT PLAN
AREAS OF CRITICAL INTEREST
SEPTEMBER 2014
SCALE: NOTED
Weston&Sampson.

5. Nutrient Loading

Introduction

To describe the process and criteria used to assess nutrient loads within Truro, a step-by-step description of what was done will be provided, followed by an in-depth description of each criterion used, its importance in relation to nutrient loading, the source of information for the parameter, and matrix values assigned to each criterion.

Load Calculation Process

A town-wide site nutrient loading analysis was conducted at a desk-top level to rank areas in Truro according to potential nutrient loading threats. When evaluating causes of nutrient loading three major categories are evaluated: land use patterns, stormwater inputs, and wastewater inputs. All three are sources of nutrients in any environment and the way they are handled or managed can add or reduce nutrients into sensitive and critical areas. The analysis of these criteria was undertaken in Geographical Information Systems (GIS) software, with results presented in electronic mapping format. The field investigation was then conducted to field verify certain criteria that was initially mapped in GIS. The initial GIS maps were then updated with field-verified data.

To represent these data on a large-scale, town basis, the entire town of Truro (developed portions) was segregated into forty-four rectangles. Within each rectangle, existing parcel mapping was used to track and isolate each parcel. Land use patterns were then evaluated on a parcel by parcel basis, including open space, vegetated cover (forested), impervious areas, lawn areas (fertilized and un-fertilized), and developed areas (residences and other structures).

Once identified through the land use analysis the impervious area was used to generate stormwater loading rates based on the amount of stormwater generated from each acre of impervious area. Lawn areas were also used to calculate additional loads that would be generated through the use of fertilizers and other lawn care additives. Finally, wastewater loading rates were generated from both GIS data analysis (aerial photography) which identified structures and also a search of the local Board of Health data to locate septic facilities. Since the majority of Truro is on private septic tanks most residential units and commercial business have septic tanks located within their parcel boundary. This made locating and estimating

loading rates for each parcel possible. The process of estimating loading rates by criteria within land use patterns, stormwater inputs and wastewater inputs is described in more detail below.

Once loading rates were estimated for each of the forty-four blocks, on a parcel by parcel basis, the entire town of Truro was overlayed with ground water recharge areas that were generated from the USGS study "Ground-Water Recharge Areas and Travel times to Pumped Wells, Ponds, Streams, and Coastal Water Bodies, Cape Cod, Massachusetts" (2004). The study identified nineteen (19) separate recharge areas within the Town of Truro. This allowed for the calculation of loading rates for not only parcels but for entire recharge areas.

Evaluation of Land-Use Patterns:

Utilizing existing Assessor's information, parcel mapping for the 44 rectangles was developed so that each parcel could be identified as a separate unit. Each parcel could then be evaluated for land use patterns, fertilizer application and impervious areas.

- Land Use Patterns
    - Open Space
        - These areas are shown as permeable, sandy areas without vegetative cover or cultural features such as roads or buildings. Open area for each recharge zone was mapped and calculated in GIS using 2005 MassGIS Land Use data.
            - This layer contains areas including, open water bodies, sandy beaches, mining (gravel excavation) areas, etc.
    - Vegetated Cover
        - Land use data from the State (MassGIS) was used to create a vegetative cover area. There are many different land use descriptors in the land use database. The land use descriptors selected to represent vegetative cover area included the following:
            - Forest, Brushland, Forested wetland, Non-forested wetland, Salt water wetlands, Cranberry bogs, Orchards, Nursery, Cropland, Pasture, Cemetery, Golf course, and Transitional land.
        - These land use types were combined to create one vegetative cover area for Truro. The vegetative cover area was calculated for each parcel and then in turn for each recharge zone.

- Lawn Areas (Fertilized/Un-Fertilized)
  - A subset of the Vegetated Cover map was residential and commercial lawn areas. These were identified using aerial photography to identify vegetated cover areas that were not forested. An assessment of the aerial photography and condition of the lawn gave indications on whether fertilizer was being applied to the lawn areas.
    - All "potentially" fertilized lawns were then field verified to confirm accuracy.
- Impervious Areas
  - Using the MassGIS Infrared data from 2005, GIS personnel compared the 2005 data against aerial images from 2008. New houses and roads were then added to the impervious surface layer and areas that were obviously permeable (e.g. sand and gravel pits, beach paths, etc.) were removed from the layer. A new impervious layer was developed to be used through the course of this project. It was assumed that 90% of the impervious area was pavement and 10% was roof.
- Developed Areas/Structures
  - Using MassGIS aerial photography all residential units and commercial properties were identified.

Evaluation of Stormwater Inputs:

Nutrient loads generated from stormwater practices within each recharge area were calculated utilizing a GIS based stormwater analysis, field verification, and identification and location of stormwater infrastructure.

- Utilizing the Impervious Area layer
  - By utilizing the impervious area layer that was generated during the land use patterns analysis, loading rates were generated for stormwater runoff from impervious areas. A detailed discussion of stormwater inputs is provided in Section 3.
- Existing Stormwater infrastructure
  - Using the MassGIS data, aerial photography and paper maps collected from MassDOT existing stormwater infrastructure was mapped within each recharge

area. This data was utilized to help understand whether stormwater flows from one recharge area to another and the eventual end-pipe location of stormwater systems.

Evaluation of Wastewater Inputs:

Nutrient loads generated from wastewater practices within each recharge area were calculated utilizing a GIS based developed area/structure layers, field verification, and a review of documentation at the board of Health.

- Utilizing the Developed Area layer
    - By utilizing the developed area layer that was generated during the land use patterns analysis, loading rates of nitrogen were generated for wastewater from septic tanks. Since the majority of Truro is on septic systems it was assumed that all parcels containing structures maintained an operational septic tank/field. In total load adjustments were made for intensive summer use (see build out analysis)
    - Based on current demographics in Truro it was assumed that on average each tank was servicing a house with 3 bedrooms, which would generate 450 gallons/day of wastewater to the septic field
    - A loading rate of 26.23 mg/L of nitrogen was used for residential septic systems for the entire Town. This loading rate is consistent with current MassDEP assumptions for working septic systems. Additionally, this loading rate is consistent with values used in the Massachusetts Estuaries Program and ongoing studies for Cape Cod.
- Board of Health Review
    - Documentation from the Board of Health was used to determine the accuracy of the assumptions and the location of the septic fields. This was of primary concern when the parcel was located on one of the recharge area divides. The load from that septic field would need to be placed in the proper recharge area to be accurate.
- Field Verification
    - As part of the field verification effort, homes and septic fields on drainage area divides were investigated for accuracy.

Field Verification Efforts:

On July 9th -10th 2012, Weston & Sampson personnel used field verification techniques to verify data obtained for the Nitrogen loading model, in Truro, MA. Identification of which houses in Truro were currently using fertilizers on their lawns was the primary goal; however stormwater infrastructure and septic system identification was also evaluated. Correctly identifying the total Nitrogen load in each basin is important as this will allow the town to prioritize which areas needed the most remediation.

As mentioned above the town was sectioned into a total of 19 recharge basins which depicted where the Nitrogen would flow. By looking at locations of septic tanks, land use patterns, and areas of fertilized lawn, in the field the model could be updated. Data was collected in real time and uploaded to the model from the field. For this task, software was created by the GIS team on ArcGIS that took aerial maps of Truro, and broke the town up into 44 rectangles, which made it easier to keep track of what land was confirmed in the field. The map was layered with a polygon drawing tool, so the lawns could be outlined, and the area of the lawn could be calculated. Once these were located and traced, infrared photos could be layered in the software to help determine which of these lawns were potentially fertilized. When a lawn was toggled as "fertilized" it changed the total square footage of fertilized lawn in the model, so the Nitrogen load was adjusted accordingly.

The GIS team used an ArcGIS application and uploaded the Truro maps into the application on an iPad. This allowed for the same interface on the iPad, in the field, that was on the computers, in the office. With this technology, real-time changes to the Truro maps made in the field would directly alter the nutrient loading model. This allowed for a more accurately informed model.

6. Build-Out Analysis

CHARACTERIZING

The long-term growth of many towns in Massachusetts presents a series of challenges for planners, scientists, infrastructure engineers and local or state regulators. In addition, townspeople themselves often differ significantly with respect to goals and actions. The intent of this section is to identify or bracket the potential range of impacts associated with nutrient loads which occur under different build out scenarios.

BACKGROUND

Much of the character and land use management goals or guidance for Truro are outlined in the Local Comprehensive Plan and in the Open Space and Recreation Plan. The intent of both plans are then mirrored, to some extent in Section 40.6 of the Zoning Bylaw – Growth Management. This bylaw restricts new single family dwelling permits to 40 units per year and 6 units per month. The zoning bylaw expires in 2016. The Local Comprehensive Plan was originally initiated in 1990, and updated in 2000-2002, with the current plan intended to cover from 2005-2010. Given the extensive work and the evolution of these efforts, it is assumed that goals and direction for Truro enunciated in this plan carry forward to the present. Similarly the Open Space Plan and Recreation Plan is listed as covering an extended period from 2009 to 2014, although current efforts are intended to be consistent with its goals, which extend beyond the 2014 end date. This report does not discuss or incorporate the modified Open Space Plan developed in 2014. Instead ongoing IWRMP phases will address the potential impacts or results anticipated from the revised Open Space Plan.

Essentially, the local Comprehensive Plan and the Open Spaces and Recreation Plan, emphasize the rural nature of Truro as being one of its key assets or treasures. Growth is shown to be fairly low in terms of actual numbers of development or total population change, even though the percentage growth is actually fairly high. Population demographics may be changing with fewer younger children from 1990 to present and an increasing population over 65. An increasing second home population and a large summer influx of part-time residents

and visitors is assumed for this sought after summer community. It is estimated that over half of the approximately 1,800 dwelling units are seasonal homes. Additionally, commercial activity located along Route 6 is heavily dependent on summer "day trippers" and short-term visitors.

Although a rural designation can denote a number of characteristics for Truro, relative to development, it reflects a desire to minimize commercial development, support local trades' people and home occupations, minimize large scale development, residential development complexes, and continues at its current pace of residential development. It is under this general intent that the build out analysis was framed.

OVERVIEW

The time frame was restricted to a 10-year build-out analysis for nutrient loading purposes. The 10-year time frame was essentially chosen due to the relatively recent data sets available from the 2010 census and its comparison to 1990 and 2000 data. The analysis included nutrient loading using nitrogen as a key essential component of the challenges faced by most Cape Cod communities. Loads were computed based on estimated commercial, agricultural, and residential use. The different 10-year build-out scenarios included low (13% increase in existing conditions), moderate (50% of full build-out) and full build-out (100% build-out) conditions. Table 1, below, provides a summary of nitrogen loading based on these three scenarios broken down for commercial, agricultural and residential use.

Table 1. Nitrogen Loading Summary (10-Year Build-Out)

	Commercial	Agricultural	Residential
Total existing (2010) N load (lbs/yr)	2,289	398	46,126
Total low buildout N load[1] (lbs/yr)	2,340	439	48,895
Total medium buildout N load[2] (lbs/yr)	2,486	557	56,775
Total full buildout N load[3] (lbs/yr)	2,683	716	67,423

1. Assumed to be existing conditions PLUS 13% (which is the average % change per 10 year period in population from 1990 - 2010) of the difference between existing and full buildout
2. Assumed to be existing conditions PLUS 50% of the difference between existing and full buildout
3. Maximizing lot buildout potential (Commercial and agricultural individual lot information provided by Town of Truro. Residential information obtained through 2010 Census Data and Town web-site)

% change from existing to full build-out conditions	17.2	80.0	46.2
additional pounds N loading from existing to full build-out	394	318	21,297

The following is a description of work conducted and results of the build-out analysis. Each land use and associated build-out assumption is listed.

Commercial Use

The analysis for commercial properties concentrated on lots in the General Business District of Truro based on data up until 2013. Existing commercial conditions were calculated using lot-specific information from Town records, including existing number of bedrooms, number of employees, area of building footprint, and lot area (see Table 2, below).

Table 2. Rte 6 - General business District
10-Year Buildout Scenarios - N-loading

	Map	Parcel	#	Street	Sq. Ft.	Existing # of BR	Full Buildout # of BR	CI Code	Notes	existing flow (gpd)	g
1	39	155	6	Shore Road	114563	56	56	102	Condos – 28 Units – Maxed out Assume 2 BR/condo	6160	
2	39	159	4	Shore Road	16553			924	Comm. Of Mass.		
3	39	320	10-A	Peters Pond Road	14810	0	3	132	Land Locked – Could be combined w/adj parcel(s) for add BR or expansions (assume 3 BR home)	0	
4	39	158	9	Peters Pond Road	39640	2	3	101	1 additional BR allowed. Although GB zoned, difficult to use as commercial	220	
5	39	162	10	Peters Pond Road	24394	2	2	101	No additional BR. Although GB zoned, difficult to use as commercial	220	
6	39	234	2	Shore Road	47480			316	Atlantic Spice Co. Room for expansion of warehouse/retail space. Existing = 6 employees, full buildout = 12 employees w/out cafeteria	90	
7	39	163	364	Rt 6	131987	32	32	301	Cape View Motel – 32 units. No additional BR. Possible change of use (assume 1 BR/unit)	3520	
8	39	166	1	Noon Heights Road	192970		19	325	2 retail bldg, 1 garage/storage, Crane/Earth Business – 19 BR pos, chg of use or exp (assume existing 20,000 sf retail bldg, 4 people at storage/earth business)	1060	
9	39	164	1	Sand Pit Road	180774			316	Com Site, Garage,earth moving business, split zone – current use as use – Req CCC (existing = 5 employees, full = 10 employees)	75	
10	39	167	352	Rt 6	152460			316	4 Commercial Bldgs – Multi-Use, many restrictions (existing = 20,000 sq ft office)	1500	
11	39	168	350	Rt 6	43996		4	341	Bank – 4 Br allowed (existing = 6 employees)	90	
12	39	169	346	Rt 6	75794		7	316	2 bldgs – office and mini-storage – 7 BR allowed (existing = 20,000 sq ft offices)	1500	
13	39	302	5	Parker Drive	42689	4	4	101	No additional BR. Although split R/GB zoned, unlikely to change	440	
14	39	172	344	Rt 6	176505	1	2	935	Public Safety Facility & Cell Tower – could see additional bunk space.	110	
15	39	323	340	Rt 6	117307	0	11	930	Vacant Town Property – Up to 11 BR – potential housing and/or rec use	0	
16	39	175	1	Fisherman Road	64469	6	6	101	No additional BR – Could have mixed use (full = add 2 person business)	660	
17	42	74	5	Fisherman Road	43560	3	3	101	No additional BR – Could have mixed use – depending on Deed Restrictions(full = add 2 person business)	330	
18	42	94	6	Fisherman Road	33977	3	3	101	No additional BR – Could have mixed use – depending on Deed Restrictions(full = add 2 person business)	330	
19	42	95	332	Rt 6	42244		4	340	Office Building – Could have 4 BR – potential mixed use (existing = 15,000 sf office)	1125	
20	42	262	1	Bayside Hills Road	33977	3	3	101	No additional BR – Could have mixed use – depending on Deed Restrictions (full = add 2 person business)	330	
21	42	263	3	Bayside Hills Road	33977	3	3	101	No additional BR – Could have mixed use – depending on Deed Restrictions (full = add 2 person business)	330	
22	42	264	5	Bayside Hills Road	33977	6	6	101	No additional BR – Could have mixed use – depending on Deed Restrictions (full = add 2 person business)	660	
									No additional BR – Could have mixed use –		

37	42	182	1	Cabral Farm Road	59677	2	6	310	SFR & Mini-Storage – 4 additional BR – Possible Expansion	220	1
38	42	185	302	Rt 6	48352			316	Mini-Storage – Appears Maxed Out (assume 2 employees)	30	
39	42	293	6	Cabral Farm Road	48787	2	4	101	2 Additional BR – Unlikely to change use	220	1
40	42	186	300	Rt 6	72745			325	Farm Stand, Liq Store, Hair Salon, Box Lunch, R.E., Fish Mrkt – 7 BR? Water Issues (existing = 20 employees, full = 30 employees)	300	
41	43	57	298	Rt 6	49876		5	390	Vacant Commercial Property – 4 or 5 BR possible – Variety of Uses Possible	0	
42	42	187	7	Anderson Way	23958	2	2	101	Unlikely change of use	220	1
43	43	46	5	Anderson Way	16117	1	1	101	Unlikely change of use	110	
44	43	47	3	Anderson Way	26136	1	2	101	1 additional BR – Unlikely change of use	110	
45	43	48	126	Castle Road	40066	6	6	301	3 Unit Motel – Castle Sea Scent Pines – No additional BR – Change of Use?	660	4
46	43	116	296	Rt 6	43996	36	36	301	36 Unit Motel – Truro Motor Inn - No additional BR – Change of Use?	3960	28
47	43	49	124	Castle Road	33968	8	8	301	4 Unit Motel – Castle Pines Motel(?) - No additional BR – Change of Use?	880	6

	existing flow (gpd)	existing loadir (lbs/yea
Total	31,790	2
% change in N loading at full buildout	17.2	

State Land Use Codes:

101 – One Family
102 – Condo
130 – Developable Land
132 – Undevelopable Land
301 – Motel
310 – Oil Storage
316 – Commercial Storage
325 – Small Retail
326 – Restaurant/Bar
340 – General Office
341 – Bank
343 - Commercial Condo
390 – Developable Land/Commercial
924 – Mass Highway
930 – Vacant, Selectmen or City Council
935 – Municipal Public Safety

Total existing N load (lbs/yr)	2,289
Total low buildout N load[2] (lbs/yr)	2,340
Total medium buildout N load[3] (lbs/yr)	2,486
Total full buildout N load (lbs/yr)	2,683

BR -Bedroom – Assumes Title 5
Development Potential
comments by MFH in BLUE

1. Loading (lbs N/year) = FLOW (gpd)*23.63 mg/L * 3.785 L/gal * 0.0000022 lbs/mg * 365 days/year
2. Low buildout = 13%increase every 10 years, based on 1990 - 2010 Truro population Census data
3. Medium buildout = half the full buildout conditions

Existing wastewater flow conditions were calculated using allowable flow rates for Title 5 systems as provided by the State in 310 CMR 15.203 based on type of establishment at the lot. Once flow rates were assigned to each parcel, a nitrogen loading rate of 23.63 mg/L for wastewater flow was used to calculate existing annual nitrogen loading per year per parcel for parcels with number of bedrooms associated with it. 110 gallons per day per bedroom was the assumed wastewater flow. This loading rate of 23.63 mg/L for wastewater flow is comparable to the loading rate used by the Buzzards Bay National Estuaries Program nitrogen loading studies (web site http://www.buzzardsbay.org/bbpnitro.htm).

Besides wastewater flow/nutrient loading associated with number of bedrooms on a lot, wastewater flows were, in addition, calculated using number of employees, square footage of retail/office building and/or number of garage bays. Flows for these scenarios were calculated using allowable flow rates for Title 5 systems as provided by the State in 310 CMR 15.203. These flows included 15 gallons per day per employee, 75 gallons per day for every 1,000 square feet of office building, 50 gallons per day for every 1,000 square feet of retail store, and 150 gallons per day per garage bay.

Once existing nutrient loading conditions were established, loading under low, moderate and full build-out scenarios were then calculated. The low build-out was linked to recent historical year-round residence population change in Truro. According to recent US Census data, the year-round population in Truro increased by 13% every 10 years from 1990 – 2010. Loading under low build-out conditions were similarly adjusted. It was assumed that in 10 years, year-round population would increase by 13%, as would nutrient loading.

The moderate build-out scenario was assumed to be 50% of the full build-out scenario. The full build-out scenario maximized build-out potential per lot based on lot specific conditions, including lot size and septic system design. Total maximum number of bedrooms, employees, and/or area of office space was calculated for each parcel. Wastewater flow was estimated at each parcel using allowable flow rates for Title 5 systems, dependent on type of establishment.

Agricultural Use

The agricultural use loading analysis concentrated on lots identified by Town records as being, or possible being, used for agricultural or home gardening use. Although agricultural practices vary in terms of net nitrogen impacts, a nitrogen loading rate of 9.1 pounds per acre was

applied to the area being used for agricultural purposes. The National Estuaries Program lists cranberry bogs as having a loading rate of 6.1 lbs./acre/year. However, general use of 9.1 lbs./acre/year provides a more conservative, all-encompassing value. This loading rate is the same as the loading rate used by the Buzzards Bay National Estuaries Program nitrogen loading studies.

According to the USDA's 2002 census of Agriculture, 46.4% of land designated as farmland is actually used as cropland. As such, existing loading conditions assumed that 50% of each agricultural parcel was being used for to grow crops. As with the commercial use loading analysis, loading under low build-out conditions assumed a 13% increase in loading over a ten-year period, while moderate build-out was 50% of full build-out conditions.

Because 100% agricultural use is not realistic (lots also contain houses, barns roads and other areas that cannot be used as crop land), full build-out conditions assumed that 90% of the lot area was used for agricultural purposes. Additionally, for full build-out conditions, aerial photography was used to analyze smaller lots (less than one acre in size) to ascertain if 90% agricultural use is realistic. If 90% agricultural use on these smaller lots was not realistic, the open area was calculated in GIS and used as the full build-out area for that lot.

Table 3 provides a summary of Agricultural Use loading.

Table 3. Existing and Possible Agricultural Lots

Map	Parcel	#	Street	acre	N loading rate (lbs/acre)	Existing N loading[1] (lbs/year)	Full buildout N loading (lbs/yr)
45	126	16	Perry Road	33.8	9.1	153.9	277.1
45	136	14	Perry Road	2.9	9.1	13.0	23.4
45	131	23	Perry Road	10.0	9.1	45.5	81.9
45	133	18	Perry Road	5.0	9.1	22.9	41.2
45	142	22	Perry Road	0.3	9.1	1.3	2.3
39	137	11	Shore Road	3.1	9.1	14.1	25.4
51	55	68	South Pamet Road	3.3	9.1	15.1	27.1
51	56	63	South Pamet Road	2.9	9.1	13.3	24.0
43	113	10	Pomp Lot Road	0.9	9.1	4.0	7.2
43	114	5	Pomp Lot Road	0.8	9.1	3.7	6.7
46	138	6	Pomp Lot Road	1.2	9.1	5.4	9.7
46	139	12	Long Nook Road	2.9	9.1	13.1	23.5
46	140	11	Long Nook Road	1.3	9.1	5.7	10.3

POSSIBLE OTHER PARCELS FOR AGRICULTURE/HOME GARDENERS

Map	Parcel	#	Street	acre			
39	190	1	Friendship Way	1.0	9.1	4.6	8.2
50	184	2	Hatch Road	0.0	9.1	0.0	0.0
54	92	33	Holsberry Road	8.8	9.1	40.0	72.1
54	93	41	Holsberry Road	3.0	9.1	13.7	24.6
50	283	11	Hatch Road	1.3	9.1	5.9	10.6
50	191	7	Hatch Road	1.2	9.1	5.5	9.8
50	270	1	River View Road	1.4	9.1	6.3	11.4
50	35	45	Depot Road	1.3	9.1	5.8	10.5
45	112	5	First Light Lane	1.2	9.1	5.3	9.5

Total existing N load[1] (lbs/yr)	398.0
Total low buildout N load[2] (lbs/yr)	439.4
Total medium buildout N load[3] (lbs/yr)	557.1
Total full buildout N load (lbs/yr)	716.3

1. Existing conditions assumed 50% of lot being used for agricultural purposes.
2. Low buildout = 13%increase every 10 years, based on 1990 - 2010 Truro population Census data
3. Medium buildout = 50% full buildout conditions
4. Full build-out = 90% lot area

Residential Use

Because of the vast difference in population in Truro throughout the year, residential nutrient loading was calculated using population estimates during the tourist and non-tourist months of the year. The tourist season was assumed to be June through August. The tourist season

population was estimated to be 25,000 persons (Local Comprehensive Plan). The non-tourist season was assumed to be January – May and September – December, with a population estimated to be 2,003 people (2010 US Census data). The existing nutrient loading rate from residential use was then calculated using the nitrogen loading rate of 5.95 pounds per person per year, which is the loading rate per person used in the Buzzards Bay Project's Nitrogen Loading Model. For the total annual load, 25% of annual load during tourist season 25,000 people * 5.95 pounds/person/year * 0.25) was added to 75% of the annual load during non-tourist season (2,003 * 5.95 pounds/person/year * 0.75).

As with the commercial use loading analysis, loading under low build-out conditions assumed a 13% increase in loading over a ten-year period, while moderate build-out was 50% of full build-out conditions.

Residential full build-out conditions were estimated using the number of developable lots in Truro according to the Truro assessor's database information. A thorough review of developable parcels was conducted by the planning department. A summary table is provided below (Table 4).

Table 4. Residential N loading (10-year build-out scenarios).

		N Loading rate[1] (lbs/person/year)	Existing Population	Existing N load (lbs/year)	Full Buildout Population[4]	Full build-out N load (lbs/year)
Population (June - August)[2]		5.95	25,000	37,188	33,862	55,316
Population (Jan - May, Sept - Dec)[3]		5.95	2,003	8,938	2,713	12,107
			Total	**46,126**		**67,423**

Total existing N load (lbs/yr)	46,126
Total low buildout N load[5] (lbs/yr)	48,894.5
Total medium buildout N load[6] (lbs/yr)	56,774.5
Total full buildout N load (lbs/yr)	67,423

Notes:
1. from Buzzards Bay Project's Nitrogen Loading Model
2. from 2005 Truro Local Comprehensive Plan
3. from 2010 Truro Census data
4. per assessors database, 350 developable lots, average household size is 2.03 people/house (2010 Census), year-round full buildout = 710 additional people, buildout year-round population.
   Seasonal buildout population is the existing seasonal/year-round population ration multiplied by full
5. Low buildout = 13%increase every 10 years, based on 1990 - 2010 Truro population Census data
6. Medium buildout = half the full buildout conditions

Although commercial and some minor development for water services along Route 6 was undertaken in 2003. This latest evaluation provides a different and more up to date view of the potential stress on land areas throughout Truro. The average household size in Truro (2.03 people per house per 2010 Truro Census data) was then applied to each developable lot to determine total number of additional year-round population that would be added to Truro should all lots be developed. The seasonal population was also calculated using the existing seasonal to non-seasonal population ratio in Truro. The nitrogen loading rate of 5.95 pounds per person per year was then applied to the full build-out population to determine residential full build-out loading.

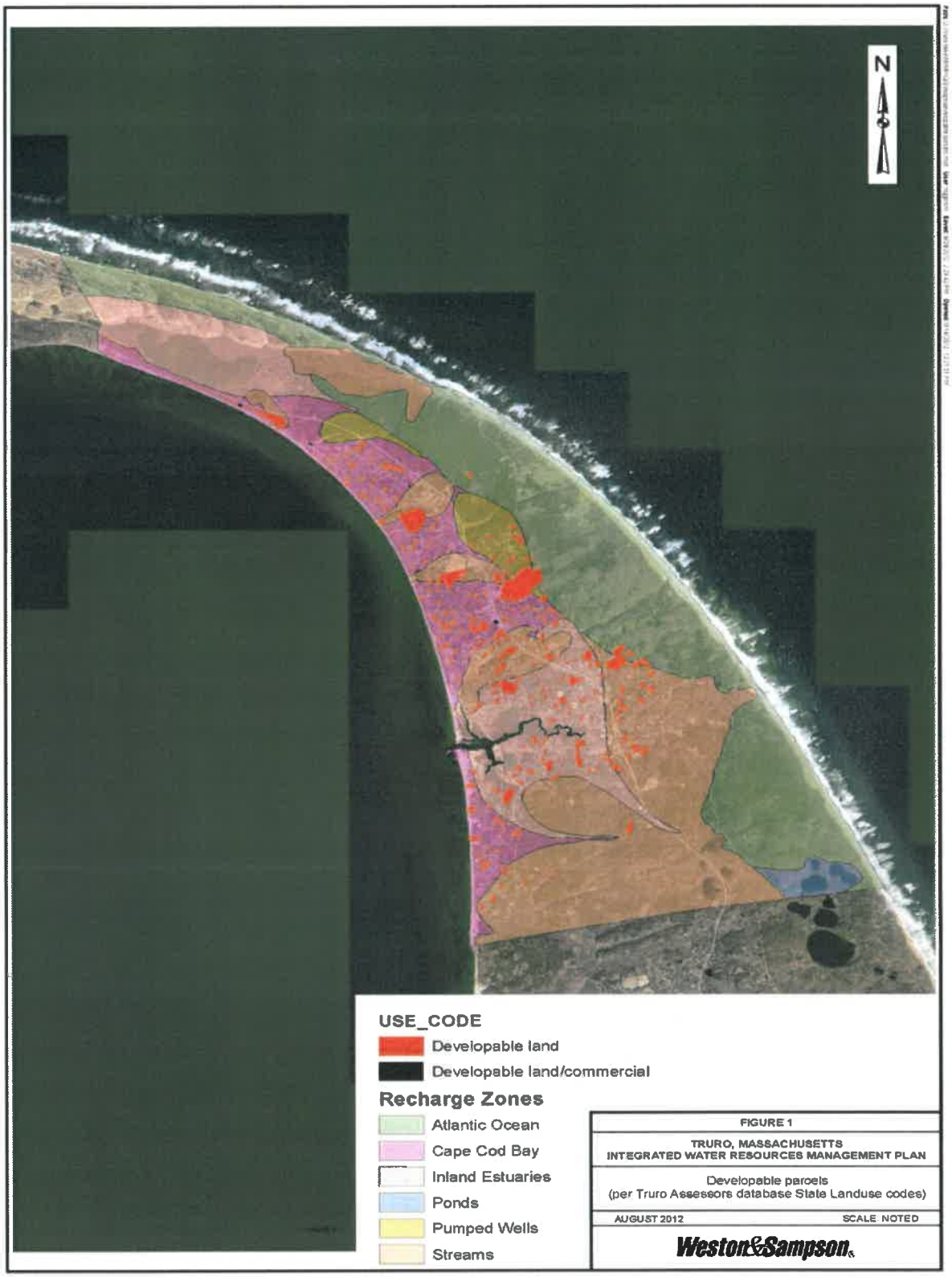
RESULTS

Summary tables of nutrient loading associated with commercial, agricultural and residential use, under low, moderate and full build-out conditions, are attached.

When examining the increase in nitrogen loading from existing to full-build-out conditions, it should be noted that the increase in nitrogen load associated with residential use (approximately 15,000 pounds/year) far exceeds the increase in nitrogen load associated with commercial and agricultural use (approximately 400 and 320 pounds/year).

In all, an estimated 15,750 pounds of nitrogen could be entering the system on an annual basis in 10 years under full build-out conditions. Because the residential use is the major parameter driving this increase in time, the areas, or recharge basins, where the developable lots are located should be targeted for future nitrogen management practices. Please refer to Figure 1, below, which shows developable lots in Truro.

In general, some 349 – 350 potentially developable or currently undeveloped parcels existed in Truro at the time of this screening. Of these, site constraints, relative to a variety of factors, led to the classification of parcels with regard to successful development. In many instances size or frontage was a limiting factor. Balancing that, some lots were identified as having the potential for subdivision. Wetlands issues were noted in several areas as well as the need to meet septic system siting or placement criteria. Other parcels were identified as having the potential for development only if new road construction were undertaken. Figure 1 provides a graphic representation of the distribution of these lots throughout Truro.


N
USE_CODE
Developable land
Developable land/commercial
Recharge Zones
Atlantic Ocean
Cape Cod Bay
Inland Estuaries
Ponds
Pumped Wells
Streams
FIGURE 1
TRURO, MASSACHUSETTS
INTEGRATED WATER RESOURCES MANAGEMENT PLAN
Developable parcels
(per Truro Assessors database State Landuse codes)
AUGUST 2012
SCALE: NOTED
Weston&Sampson

Although some subjectivity regarding land constraints is implied in this analysis, additionally engineered solutions for septic systems and private well placements may be possible. However, the general results are as follows.

Full build out of undeveloped lots would likely include the removal of 50 lots of the approximately 350 available (see Table 5). Of the remaining 300 lots, 17 lots appear to be available for subdivision. The subdivision potential includes only 3 parcels where greater than 3 housing lots could be segmented on the property. A total of 8 parcels could be subdivided into 2 housing lots and 3 parcels could be divided into 3 housing lots. 4 additional parcels would require road construction. In sum, the potential for extensive subdivision and large scale development is unlikely and certainly not consistent with the Local Comprehensive Plan and the ideals described in the Open Space and Recreation Plan. Examples of Subdivision Plans are also attached.

Truro - IWRMP

Developable Parcels in Truro as shown on the "Developable Parcels" map

KEY		
Questionable Development	Subdividable	Not Buildable
Couldn't find - General Comment	New Single Family Dwelling	Requires Road Construction

MAP PARCEL ID	SITE ADDRESS	CITY	ZIP	BOOK #	PAGE #	COMMENTS
001-000-003-000	679 SHORE RD	Truro	02666	1323	318+	
002-000-002-000	647 SHORE RD	Truro	02666	3078	093	Questionable - contains only 0.18 ac
003-000-004-000	607 SHORE RD	Truro	02666	3227	344+	
005-000-003-000	583 SHORE RD	Truro	02666	7975	236	Questionable - contains only 0.146 ac
005-000-004-000	579 SHORE RD	Truro	02666	7989	160	Questionable - contains only 0.144 ac
008-000-001-000	481A SHORE RD	Truro	02666	3147	20+	
008-000-009-000	463 SHORE RD	Truro	02666	12869	215+	
008-000-015-000	449 SHORE RD	Truro	02666	8148	247	Questionable - contains only 0.22 ac
008-000-018-000	439 SHORE RD	Truro	02666	22328	55+	Questionable - contains only 0.190 ac
010-000-001-000	413A SHORE RD	Truro	02666	8982	120+	
010-000-008-000	375A SHORE RD	Truro	02666	2969	159	
010-000-009-000	383 SHORE RD	Truro	02666	7983	054	Questionable - contains only 0.15 ac
010-000-017-000	355 SHORE RD	Truro	02666	N/A	N/A	Questionalbe - part of White Pond Village Development (either parking or septic
013-000-002-000	337 SHORE RD	Truro	02666	N/A	N/A	Questionalbe - part of White Pond Village Development (either parking or septic
013-000-013-000	299A SHORE RD	Truro	02666	933	473+	Possibly subdividable - 10.14 acres, wetlands and shape issues
017-000-002-000	261 SHORE RD	Truro	02666	19927	183+	Questionable - contains only 0.21 ac
017-000-004-000	239 SHORE RD	Truro	02666	19927	183+	Conservation Restriction
017-000-006-000	231 SHORE RD	Truro	02666	23182	149	Questionable - Appears to be frontage issue
017-000-012-000	270 SHORE RD	Truro	02666	19927	183+	Questionable - contains only .23 ac.
017-000-013-000	266 SHORE RD	Truro	02666	14767	294+	Questionable - contains only .22 ac
017-000-015-000	250 SHORE RD	Truro	02666	19927	183+	Could not find
021-000-011-000	147 SHORE RD	Truro	02666	4778	168	
024-000-013-000	4 SAMS WAY	Truro	02666	18296	74	
024-000-023-000	2 WHALE WATCH DR	Truro	02666	6618	174+	
024-000-028-000	1 WHALE WATCH DR	Truro	02666	6618	174+	Single Family Dwelling
024-000-029-000	3 WHALE WATCH DR	Truro	02666	N/A	N/A	Single Family Dwelling
024-000-032-000	12 WHALE WATCH DR	Truro	02666	N/A	N/A	
032-000-033-000	13 ARROWHEAD RD	Truro	02666	12516	204	
032-000-034-000	15 ARROWHEAD RD	Truro	02666	12516	204	Commercial Warehouse
032-000-035-000	123 SHORE RD	Truro	02666	N/A	N/A	Possibly subdividable - 2 Lot total
032-000-036-000	119 SHORE RD	Truro	02666	N/A	N/A	
035-000-014-000	32 KNOWLES HGTS RD	Truro	02666	N/A	N/A	
035-000-020-000	34 KNOWLES HGTS RD	Truro	02666	1383	209	Questionable - appears the it might be merged (for zoning purposes) w/#36 Know
035-000-026-000	45 KNOWLES HGTS RD	Truro	02666	N/A	N/A	

MAP PARCEL ID	SITE ADDRESS	CITY	ZIP	BOOK #	PAGE #	COMMENTS
035-000-088-000	38 TWINE FIELD RD	Truro	02666	21941	293+	
035-000-091-000	17 PILGRIMS PATH	Truro	02666	N/A	N/A	
035-000-095-000	22 PILGRIMS PATH	Truro	02666	N/A	N/A	
035-000-100-000	13 PILGRIMS PATH	Truro	02666	N/A	N/A	
035-000-106-000	17 TWINE FIELD RD	Truro	02666	N/A	N/A	
035-000-114-000	13 TWINE FIELD RD	Truro	02666	N/A	N/A	
035-000-141-000	8 FLORENCE WAY	Truro	02666	4158	098	
036-000-031-000	25 TWINE FIELD RD	Truro	02666	N/A	N/A	
036-000-038-000	7 PILGRIM POND RD	Truro	02666	8237	127	
036-000-040-000	12 POND VILLAGE AVE	Truro	02666	4059	322	
036-000-071-000	67 SHORE RD	Truro	02666	3540	337	
036-000-122-000	8 POND RD	Truro	02666	767	33	Mostly Wetland
036-000-173-000	44 HIGHLAND RD	Truro	02666	18642	296	Part of Camp Grounds - lot area needed for septic calculations
036-000-197-000	6 POND VILLAGE AVE	Truro	02666	4762	346	
036-000-198-000	4 POND VILLAGE AVE	Truro	02666	4762	346	
036-000-203-000	444 RT 6	Truro	02666	21221	212	
036-000-209-000	3 PILGRIM POND RD	Truro	02666	8237	126	
036-000-219-000	1 LAMBROU LN	Truro	02666	13349	271	
036-000-228-000	2 YELLOW BRICK RD	Truro	02666	22463	127	Single Family Dwelling
036-000-229-000	4 YELLOW BRICK RD	Truro	02666	22463	127	Single Family Dwelling
036-000-230-000	6 YELLOW BRICK RD	Truro	02666	22463	127	Single Family Dwelling
036-000-231-000	8 YELLOW BRICK RD	Truro	02666	22463	127	Single Family Dwelling
036-000-232-000	10 YELLOW BRICK RD	Truro	02666	22463	127	Single Family Dwelling
036-000-233-000	12 YELLOW BRICK RD	Truro	02666	22463	127	Single Family Dwelling
036-000-234-000	14 YELLOW BRICK RD	Truro	02666	22463	127	
036-000-235-000	13 YELLOW BRICK RD	Truro	02666	22463	127	Single Family Dwelling
036-000-236-000	5 YELLOW BRICK RD	Truro	02666	22463	127	Single Family Dwelling
036-000-237-000	1 YELLOW BRICK RD	Truro	02666	22463	127	Single Family Dwelling
039-000-004-000	3 BAY VIEW RD	Truro	02666	11699	035	Questionable - may have frontage issues
039-000-010-000	34 POND RD	Truro	02666	11699	035	
039-000-027-000	6A BAY VIEW PATH	Truro	02666	N/A	N/A	No frontage, part of #6 Bay View Path
039-000-058-000	30 BAY VIEW RD	Truro	02666	2468	313	
039-000-060-000	32 BAY VIEW RD	Truro	02666	12017	262	
039-000-063-000	22 PRIEST RD	Truro	02666	1449	812	
039-000-069-000	28A PRIEST RD	Truro	02666	21557	334	Questionable - contains only 0.23 ac
039-000-075-000	4J BAY VIEW RD	Truro	02666	7513	161	Could not find - #4 Bay view Road is Wetland
039-000-076-000	4I BAY VIEW RD	Truro	02666	6206	42+	Could not find - #4 Bay view Road is Wetland
039-000-077-000	4H BAY VIEW RD	Truro	02666	7572	048	Could not find - #4 Bay view Road is Wetland
039-000-078-000	7 SAGE RIDGE RD	Truro	02666	8582	297+	
039-000-088-000	19 PRIEST RD	Truro	02666	1602	247	

MAP PARCEL ID	SITE ADDRESS	CITY	ZIP	BOOK #	PAGE #	COMMENTS
039-000-241-000	5 KESTREL LN	Truro	02666	N/A	N/A	
039-000-255-000	14 CORMORANT RD	Truro	02666	N/A	N/A	
039-000-287-000	9 SAWYER GROVE RD	Truro	02666	11292	004	
039-000-289-000	5 SAWYER GROVE RD	Truro	02666	11259	227	
039-000-305-000	20 PRIEST RD	Truro	02666	7781	146	Questionable - may have frontage issues
039-000-307-000	17 NOONS DR	Truro	02666	16292	288	
039-000-313-000	6 SCHARDT WAY	Truro	02666	20200	207+	
039-000-318-000	5 RUSSELL WAY	Truro	02666	10710	289	
039-000-322-000	6 HUTCHINGS LN	Truro	02666	7572	048	
040-000-051-000	9 ALDEN CIR	Truro	02666	18848	117	
040-000-065-000	8 HOPKINS WAY	Truro	02666	N/A	N/A	Single Family Dwelling
040-000-080-000	26 HOPKINS WAY	Truro	02666	N/A	N/A	
040-000-088-000	30 HOPKINS WAY	Truro	02666	N/A	N/A	
040-000-121-000	14 NO UNION FIELD RD	Truro	02666	12550	075	
040-000-128-000	43 SO HIGHLAND RD	Truro	02666	23076	349	Single Family Dwelling
040-000-134-000	8 ANDREW WAY	Truro	02666	12008	019	
040-000-135-000	10 ANDREW WAY	Truro	02666	12008	019	
040-000-136-000	12 ANDREW WAY	Truro	02666	12008	019	
040-000-137-000	14 ANDREW WAY	Truro	02666	12008	019	
040-000-142-000	2 LEEWARD PASSAGE	Truro	02666	12801	054	
040-000-143-000	4 LEEWARD PASSAGE	Truro	02666	12801	054	
040-000-145-000	8 LEEWARD PASSAGE	Truro	02666	14008	301	Single Family Dwelling
040-000-152-000	6 FRIENDSHIP WAY	Truro	02666	18894	186	
040-000-159-000	10 FAIR WINDS PASSAGE	Truro	02666	18533	79+	
040-000-160-000	12 FAIR WINDS PASSAGE	Truro	02666	18533	79+	
040-000-161-000	7 FAIR WINDS PASSAGE	Truro	02666	20072	41	
040-000-162-000	5 FAIR WINDS PASSAGE	Truro	02666	18533	79+	
040-000-163-000	3 FAIR WINDS PASSAGE	Truro	02666	18533	79+	
042-000-006-000	7 CHICKADEE LN	Truro	02666	10486	139	
042-000-011-000	6 CRESTVIEW CIR	Truro	02666	10437	070	
042-000-024-000	4 CHICKADEE LN	Truro	02666	12562	124	
042-000-029-000	25 PARKER DR	Truro	02666	12656	198	
042-000-030-000	29 NOONS DR	Truro	02666	4402	073	
042-000-039-000	21 CRESTVIEW CIR	Truro	02666	22820	190	Single Family Dwelling
042-000-079-000	34 FISHERMANS RD	Truro	02666	N/A	N/A	
042-000-112-000	5 BAYBERRY RD	Truro	02666	N/A	N/A	
042-000-130-000	8 BAYBERRY RD	Truro	02666	N/A	N/A	
042-000-133-000	30 HART RD	Truro	02666	13912	349	
042-000-139-000	12 HART RD	Truro	02666	11979	255	
042-000-157-000	16 QUAIL HILL RD	Truro	02666	N/A	N/A	

MAP PARCEL ID	SITE ADDRESS	CITY	ZIP	BOOK #	PAGE #	COMMENTS
042-000-225-000	8 LAWRENCE WAY	Truro	02666	11158	87	
042-000-243-000	4 SUNSET LN	Truro	02666	N/A	N/A	
042-000-244-000	32 GREAT HOLLOW RD	Truro	02666	N/A	N/A	
042-000-251-000	23 HART RD	Truro	02666	17310	295	
042-000-252-000	4 HILLTOP LN	Truro	02666	11064	055	
042-000-261-000	36 CORMORANT RD	Truro	02666	N/A	N/A	
042-000-270-000	~~2 BAYSIDE END~~ **6 Bayside Hill Rd**	Truro	02666	10867	204	Address Change
042-000-280-000	12 MARSH HAWK TRACE	Truro	02666	18675	262	
042-000-283-000	14 GREAT HOLLOW RD	Truro	02666	7618	050	
042-000-285-000	3 MARSH HAWK TRACE	Truro	02666	21327	262	
042-000-286-000	5 MARSH HAWK TRACE	Truro	02666	10539	227+	
042-000-288-000	3 BEARBERRY LN	Truro	02666	13912	347+	
042-000-292-000	2 BEARBERRY LN	Truro	02666	N/A	N/A	
042-000-298-000	3 QUAIL WAY	Truro	02666	N/A	N/A	
042-000-299-000	1 KILL DEVIL RD	Truro	02666	19002	123	
042-000-301-000	14 FIRST LIGHT LN	Truro	02666	22537	66	Single Family Dwelling
042-000-305-000	1 SKY VIEW DR	Truro	02666	23278	97	
043-000-002-000	10A WALSH WAY	Truro	02666	15998	325+	
043-000-007-000	309 RT 6	Truro	02666	2263	116+	
043-000-009-000	8 WALSH WAY	Truro	02666	2263	116+	Possibly subdividable - 2 Lot total
043-000-018-000	12 QUAIL RIDGE RD	Truro	02666	12553	312	
043-000-037-000	19 QUAIL RIDGE RD	Truro	02666	2807	221	
043-000-039-000	23 QUAIL RIDGE RD	Truro	02666	3167	274+	
043-000-045-000	2 QUAIL RIDGE EXT	Truro	02666	11684	076	Single Family Dwelling
043-000-057-000	298 RT 6	Truro	02666	9258	325	
043-000-063-000	45 SYLVAN LN	Truro	02666	1508	451	
043-000-066-000	37 SYLVAN LN	Truro	02666	13085	332	
043-000-069-000	34 SYLVAN LN	Truro	02666	2289	216	
043-000-075-000	31 SYLVAN LN	Truro	02666	20479	105	Questionable -prossible frontage issue
043-000-078-000	14 WHITMANVILLE RD	Truro	02666	5122	022	Questionable - contains only 0.20 ac
043-000-095-000	22 SYLVAN LN	Truro	02666	1515	476	
043-000-096-000	4 SYLVIAS WAY	Truro	02666	6662	218	Single Family Dwelling
043-000-105-000	7 TURNBUCKLE WAY	Truro	02666	22612	285	
043-000-138-000	8 OVERLOOK DR	Truro	02666	5106	086	
043-000-165-000	7 WHITMANVILLE RD	Truro	02666	7368	121	
043-000-173-000	18 MORRIS AVE	Truro	02666	11026	064	
043-000-181-000	6 NELSON DR	Truro	02666	20479	105	Questionable - possible frontage issue
043-000-183-000	5 QUAIL RIDGE RD	Truro	02666	9316	283	
043-000-184-000	2 STORY BOOK LN	Truro	02666	20018	302	
043-000-186-000	27 WHITMANVILLE RD	Truro	02666	20018	302	

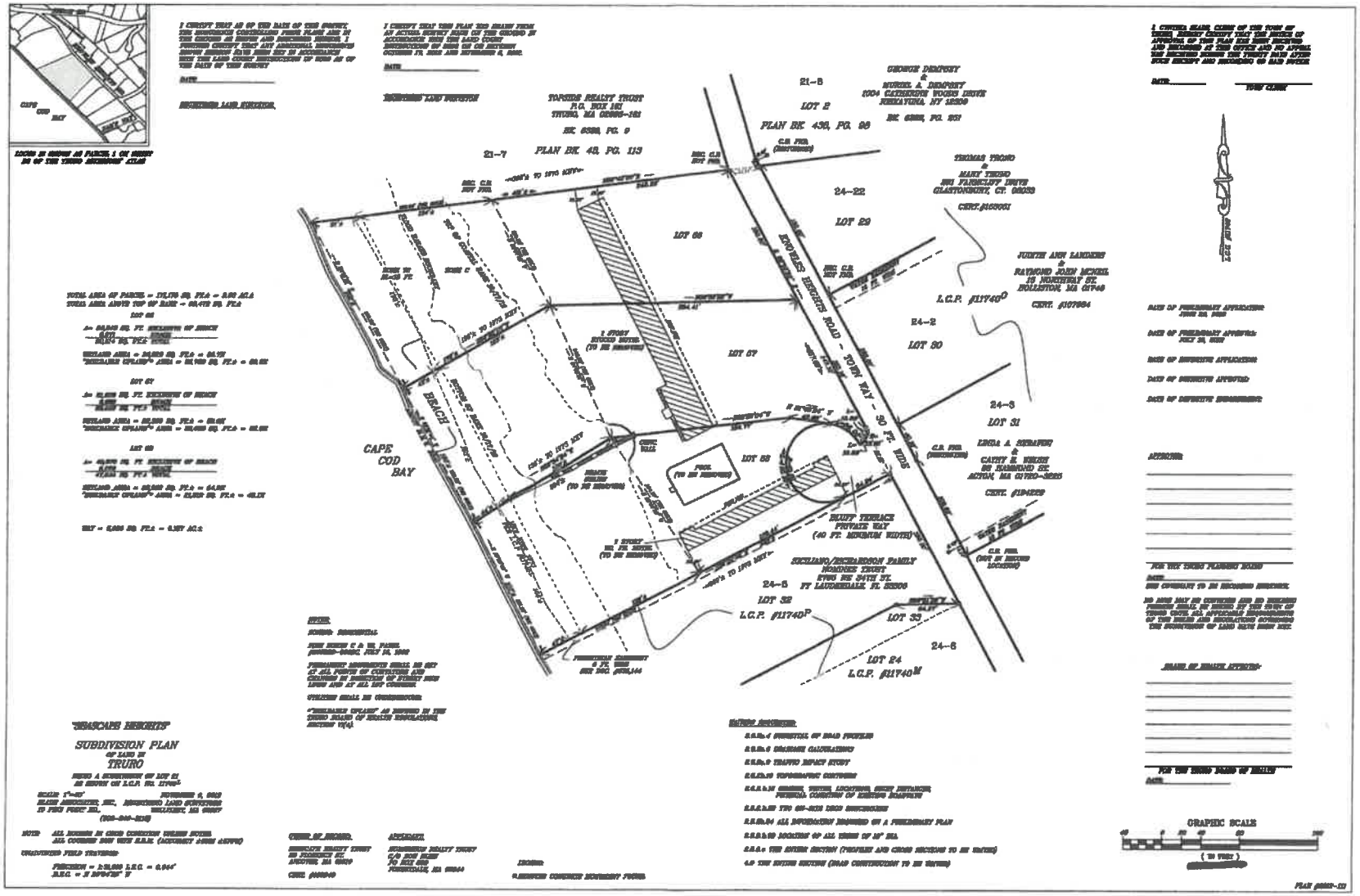
MAP PARCEL ID	SITE ADDRESS	CITY	ZIP	BOOK #	PAGE #	COMMENTS
043-000-201-000	7 SANDY LN	Truro	02666	13034	172+	
043-000-207-000	23 WHITMANVILLE RD	Truro	02666	17206	320	
043-000-211-000	4 LILY LN	Truro	02666	N/A	N/A	
043-000-212-000	2 LILY LN	Truro	02666	N/A	N/A	
043-000-213-000	1 LILY LN	Truro	02666	N/A	N/A	
043-000-215-000	5 LILY LN	Truro	02666	N/A	N/A	
043-000-216-000	7 LILY LN	Truro	02666	N/A	N/A	
043-000-217-000	10 LILY LN	Truro	02666	N/A	N/A	Single Family Dwelling
043-000-218-000	8 LILY LN	Truro	02666	N/A	N/A	Single Family Dwelling
043-000-219-000	6 LILY LN	Truro	02666	N/A	N/A	
045-000-001-000	5 OLD COLONY WAY	Truro	02666	23324	29+	
045-000-015-000	19 CORN HILL LNDG	Truro	02666	12397	109	
045-000-020-000	18 CORN HILL LNDG	Truro	02666	3249	252	
045-000-037-000	57 CORN HILL RD	Truro	02666	22894	236	Single Family Dwelling
045-000-063-000	21 RESOLUTION RD	Truro	02666	3708	254	
045-000-077-000	8 CORN HILL RD	Truro	02666	11988	018	
045-000-081-000	3 OUTWATER LN	Truro	02666	N/A	N/A	Would require road construction
045-000-100-000	14 TOMS HILL PATH	Truro	02666	N/A	N/A	
045-000-104-000	10 OLD COLONY WAY	Truro	02666	10886	136	
045-000-111-000	4 HARDINGS WAY	Truro	02666	6086	053	
045-000-113-000	3 PERRY RD	Truro	02666	12755	025	
045-000-128-000	10 FIRST LIGHT LN	Truro	02666	15620	133	
045-000-134-000	17 HARDINGS WAY	Truro	02666	10569	200+	Single Family Dwelling - Lot divided into 2 parcels - this is now parcel 141, other p
046-000-019-000	10 RESOLUTION RD	Truro	02666	1531	279	
046-000-026-000	3 JOSEPHS RD	Truro	02666	3366	346	
046-000-027-000	3 JEANS WAY	Truro	02666	7482	294	
046-000-053-000	3 LITTLE PAMET WAY	Truro	02666	14565	087	
046-000-062-000	69 CASTLE RD	Truro	02666	6905	214	
046-000-068-000	11 RYANS WAY	Truro	02666	23270	205	Single Family Dwelling
046-000-070-000	70 CASTLE RD	Truro	02666	N/A	N/A	Possible subdivision - 13.04 ac - 15 lots?
046-000-087-000	15 RYANS WAY	Truro	02666	14017	145	
046-000-088-000	8 RYANS WAY	Truro	02666	12280	065+	
046-000-090-000	3 GRACE WAY	Truro	02666	13849	111	
046-000-091-000	1 TRYWORKS RD	Truro	02666	6631	244	
046-000-105-000	~~57 CASTLE RD~~ 5 Souza Way	Truro	02666	23321	114+	Single Family Dwelling
046-000-111-000	2 HOOKERS WAY	Truro	02666	20482	140	
046-000-117-000	2 RYANS WAY	Truro	02666	20482	140	
046-000-130-000	10 TRYWORKS RD	Truro	02666	1373	1122	
046-000-142-000	6 LONGNOOK LN	Truro	02666	1708	106	
046-000-147-000	4 ROMPS LOT RD	Truro	02666	22280	210	No Access & other issues

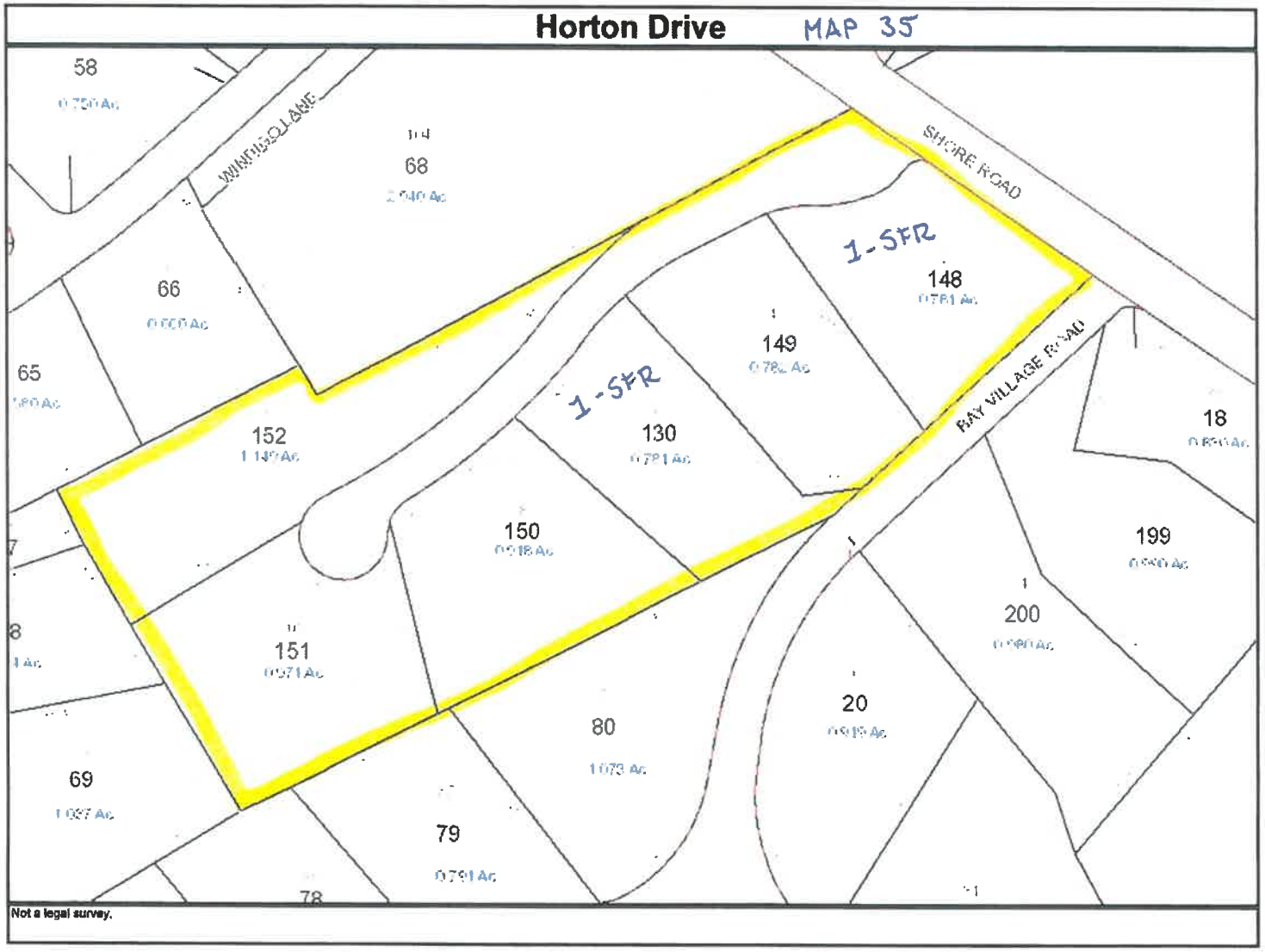
MAP PARCEL ID	SITE ADDRESS	CITY	ZIP	BOOK #	PAGE #	COMMENTS
046-000-187-000	3 FIRST DISCOVERY RD	Truro	02666	13163	076	
046-000-213-000	9 BLACKFISH RD	Truro	02666	13439	098	
046-000-215-000	222 RT 6	Truro	02666	22045	219	Truro Conservation Trust
046-000-254-000	22 MEETINGHOUSE RD	Truro	02666	7896	303	
046-000-255-000	24 MEETINGHOUSE RD	Truro	02666	11015	128	
046-000-263-000	13 BRIDGE RD	Truro	02666	3341	291	
046-000-268-000	23 TOWN HALL RD	Truro	02666	12323	242	
046-000-271-000	13 TOWN HALL RD	Truro	02666	10003	079	
046-000-315-000	5 HELENS WAY	Truro	02666	15344	105+	
046-000-327-000	10 GLACIER DR	Truro	02666	9917	031	
046-000-332-000	4 WARREN PL	Truro	02666	6955	190	
046-000-333-000	13 TOMS HILL RD	Truro	02666	9574	345	Questionable - frontage issue
046-000-336-000	41 TRURO CENTER RD	Truro	02666	8429	008	
046-000-337-000	202 RT 6	Truro	02666	21828	337	
046-000-361-000	102 CASTLE RD	Truro	02666	9029	193	Possible subdivision - 2.116 ac - 2 Lots
046-000-363-000	92 CASTLE RD	Truro	02666	11230	072	Possible subdivision - 2.78 ac - 3 Lots?
046-000-365-000	3 LEFT HANDED RD	Truro	02666	6539	092	
046-000-367-000	6 LONGNOOK DR	Truro	02666	22564	149	
046-000-372-000	4 ATWOOD RD	Truro	02666	14568	254	Possible subdivision - 2 Lots
046-000-381-000	4 MARSH LN	Truro	02666	17996	088	
046-000-382-000	49 CASTLE RD	Truro	02666	22541	37+	Conservation Restriction
046-000-383-000	1 TILLIE WAY	Truro	02666	11215	014	Single Family Dwelling
046-000-384-000	99 CASTLE RD	Truro	02666	N/A	N/A	
046-000-385-000	101 CASTLE RD	Truro	02666	N/A	N/A	This was subdivided into 3 lots - SEE BELOW
047-000-006-000	67 OLD KINGS HWY	Truro	02666	13445	315	
047-000-020-000	54A OLD KINGS HWY	Truro	02666	14103	132	Not Buildable
047-000-021-000	32 UNION FIELD RD	Truro	02666	20865	248	Possible subdivision - 2 Lots
047-000-047-000	33 UNION FIELD RD	Truro	02666	N/A	N/A	
047-000-057-000	2 DEER PATH	Truro	02666	N/A	N/A	Questionable - appears that it might be merged (for zoning purposes) w/#4 Deer
047-000-073-000	9 UNION FIELD RD	Truro	02666	N/A	N/A	
047-000-074-000	16 CRANBERRY LN	Truro	02666	7033	170	
047-000-080-000	9 RABBIT HILL RD	Truro	02666	N/A	N/A	
047-000-084-000	4 BLUEBERRY LN	Truro	02666	3444	229	
047-000-087-000	6 BLUEBERRY LN	Truro	02666	3811	144	
047-000-091-000	11 SWALE WAY	Truro	02666	N/A	N/A	
047-000-092-000	12 SWALE WAY	Truro	02666	N/A	N/A	
047-000-099-000	8 AVERY HILL WAY	Truro	02666	N/A	N/A	
047-000-106-000	1 HUCKLEBERRY LN	Truro	02666	1498	1167	
047-000-110-000	17 AVERY WAY	Truro	02666	N/A	N/A	
047-000-114-000	4 DYER RD	Truro	02666	1510	931+	

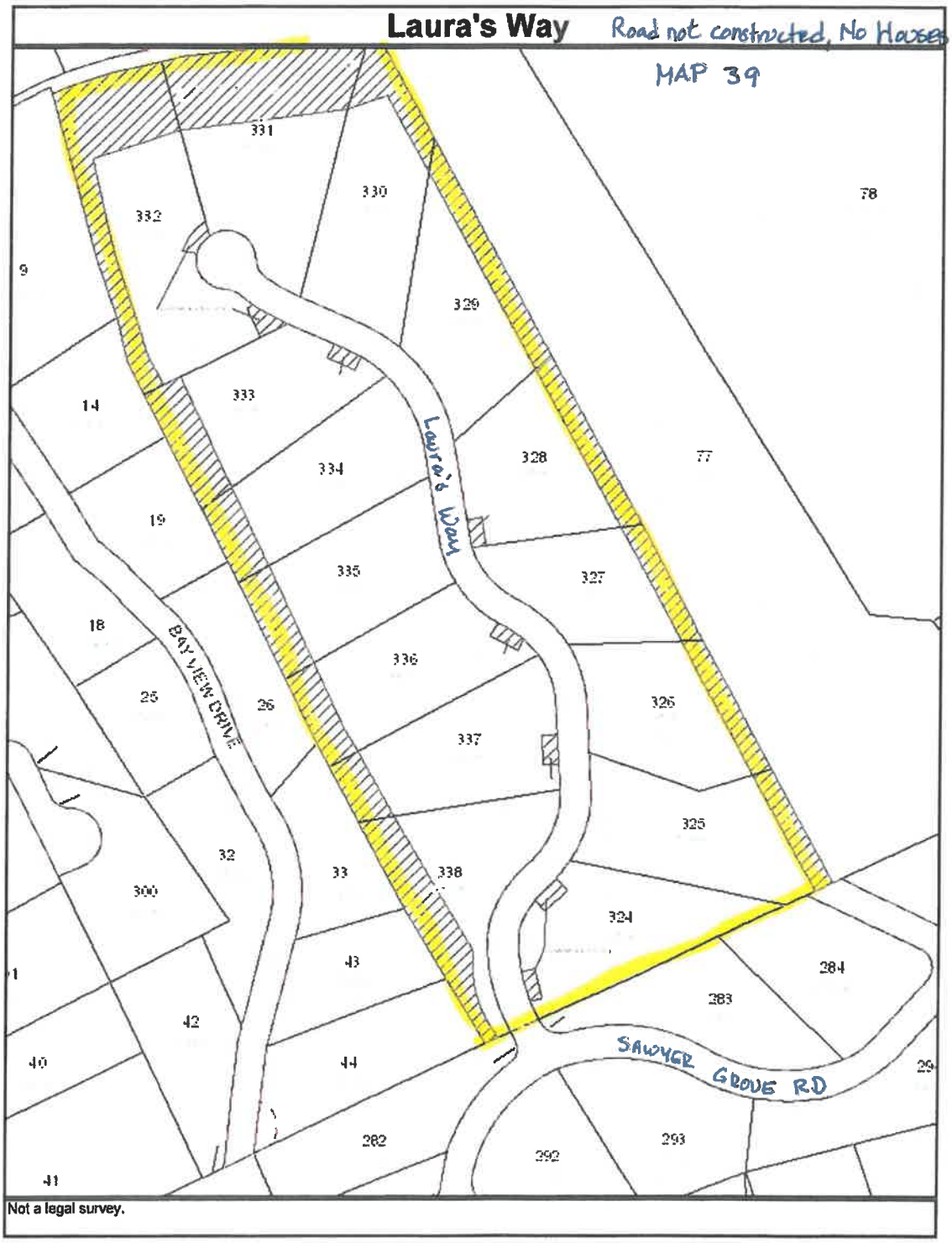
MAP PARCEL ID	SITE ADDRESS	CITY	ZIP	BOOK #	PAGE #	COMMENTS
049-000-006-000	17 TOMS HILL PATH	Truro	02666	N/A	N/A	Questionable - appears that it might be merged (for zoning purposes) w/#15 Tom
049-000-036-000	14 GREAT HILLS RD	Truro	02666	10471	048	Possible Subdivision - 2 Lots
050-000-085-000	6 SECOR LN	Truro	02666	21397	327+	
050-000-106-000	10 OLD COUNTY RD	Truro	02666	21024	107	Conservation Restriction
050-000-116-000	5 HOLSBERY RD	Truro	02666	4527	031	Single Family Dwelling
050-000-117-000	24 DEPOT RD	Truro	02666	12553	072	
050-000-129-000	15 CASTLE RD	Truro	02666	13016	292	
050-000-154-000	10 SLADE HILL RD	Truro	02666	19026	66	No Frontage
050-000-159-000	3A MARSHALL LN	Truro	02666	N/A	N/A	Questionable - appears that it might be merged (for zoning purposes) w/#3 Mars
050-000-164-000	14 OLD COUNTY RD	Truro	02666	21024	107+	Possible Subdivision - 3 Lots
050-000-165-000	17 DEPOT RD	Truro	02666	10582	159	Possible subdivision - 2 Lots
050-000-172-000	21 DEPOT RD	Truro	02666	N/A	N/A	
050-000-201-000	19 OLD BRIDGE RD	Truro	02666	N/A	N/A	No Actual Frontage
050-000-231-000	29 BRIDGE RD	Truro	02666	12952	190	
050-000-232-000	23 OLD BRIDGE RD	Truro	02666	22299	182	No Actual Frontage
050-000-235-000	9 CASTLE RD	Truro	02666	19868	270	
050-000-238-000	13 OLD COUNTY RD	Truro	02666	20101	1	
050-000-240-000	14 OLD BRIDGE RD	Truro	02666	10627	204	Single Family Dwelling
050-000-245-000	57 DEPOT RD	Truro	02666	21491	74	
050-000-252-000	5 CASTLE HILL LN	Truro	02666	N/A	N/A	Questionable - frontage issue
050-000-267-000	6 RIVER VIEW RD	Truro	02666	20838	215	
050-000-270-000	1 RIVER VIEW RD	Truro	02666	21005	136	
050-000-271-000	4 BAKER LN	Truro	02666	9977	201	
050-000-283-000	11 HATCH RD	Truro	02666	10593	130	
050-000-284-000	6 HATCH RD	Truro	02666	N/A	N/A	
050-000-290-000	23 OLD COUNTY RD	Truro	02666	20579	228+	Single Family Dwelling
050-000-292-000	9 OLD COUNTY RD	Truro	02666	19727	3+	Single Family Dwelling
051-000-002-000	12 NO PAMET RD	Truro	02666	N/A	N/A	
051-000-003-000	14 NO PAMET RD	Truro	02666	N/A	N/A	
051-000-023-000	9 SO PAMET RD	Truro	02666	1493	059	Possible subdivision - 2 Lots
051-000-033-000	143 RT 6	Truro	02666	11950	005	
051-000-066-000	181 RT 6	Truro	02666	N/A	N/A	
051-000-071-000	8 OLD PAMET RD	Truro	02666	N/A	N/A	Questionable - Access Issues
051-000-079-000	3 KEEZER CT	Truro	02666	N/A	N/A	Road would need to be built
051-000-080-000	18 HATCH RD	Truro	02666	N/A	N/A	Questionable - Access and Frontage Issues
051-000-085-000	10 HATCH RD	Truro	02666	N/A	N/A	
051-000-086-000	12 HATCH RD	Truro	02666	N/A	N/A	
051-000-088-000	6 EDGEWOOD WAY	Truro	02666	6126	259+	Road would need to be built
051-000-089-000	8 EDGEWOOD WAY	Truro	02666	6126	259+	Road would need to be built
051-000-090-000	10 EDGEWOOD WAY	Truro	02666	6126	259+	Road would need to be built

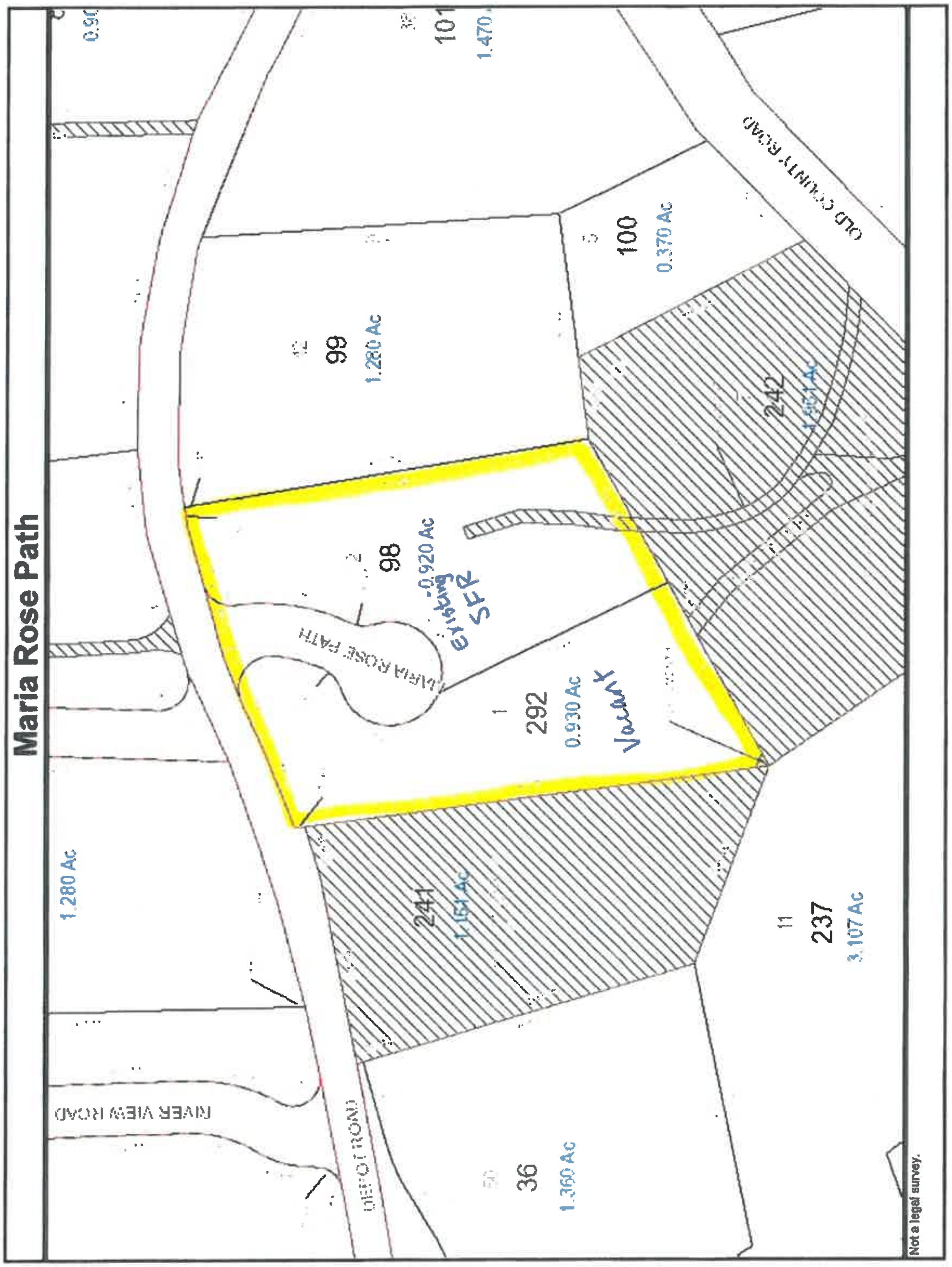
MAP PARCEL ID	SITE ADDRESS	CITY	ZIP	BOOK #	PAGE #	COMMENTS
053-000-083-000	6 BENSON RD	Truro	02666	7126	033	
053-000-094-000	3 PETERSSON WAY	Truro	02666	7396	232	Currently no access - road would have to be built
054-000-006-000	4 PHATS VALLEY RD	Truro	02666	7626	112	Currently no access - road would have to be built
054-000-010-000	12 PHATS VALLEY RD	Truro	02666	7791	086	Currently no access - road would have to be built
054-000-012-000	5 FISHER HILL WAY	Truro	02666	18953	155	Currently no access - road would have to be built
054-000-016-000	6 FISHER HILL WAY	Truro	02666	18953	159	Currently no access - road would have to be built
054-000-037-000	5 STEPHENS WAY	Truro	02666	16418	16	Questionable - Access and Frontage Issues
054-000-046-000	11 STEPHENS WAY	Truro	02666	3492	317	Single Family Dwelling
054-000-068-000	1 MILL POND RD	Truro	02666	17860	326	
054-000-083-000	77 OLD COUNTY RD	Truro	02666	N/A	N/A	
054-000-084-000	4A RICH RD	Truro	02666	N/A	N/A	Could not find
054-000-085-000	79 OLD COUNTY RD	Truro	02666	N/A	N/A	
054-000-086-000	5A COOPER RD	Truro	02666	N/A	N/A	Could not find
054-000-087-000	81 OLD COUNTY RD	Truro	02666	N/A	N/A	
054-000-099-000	3 SKYLAR LN	Truro	02666	12534	259	Questionable - Access Issues
054-000-101-000	15 HOLSBERY RD	Truro	02666	10215	261	
054-000-107-000	5 ROSE HILL LN	Truro	02666	15288	311	Currently no access - road would have to be built
054-000-108-000	7 ROSE HILL LN	Truro	02666	15288	311	Currently no access - road would have to be built
054-000-115-000	12 SALT MARSH LN	Truro	02666	19401	323	Questionable - Access Issues
054-000-119-000	9 MILL POND RD	Truro	02666	N/A	N/A	
055-000-020-000	20 PRINCE VALLEY RD	Truro	02666	22540	60	Single Family Dwelling
058-000-001-000	37 STEPHENS WAY	Truro	02666	10986	185	Questionable - Access and Frontage Issues
058-000-006-000	22 COOPER RD	Truro	02666	13294	219	Questionable - Access Issues
058-000-015-000	38 SANDPIPER RD	Truro	02666	N/A	N/A	
058-000-021-000	23 SANDPIPER RD	Truro	02666	N/A	N/A	
058-000-033-000	24 SANDPIPER RD	Truro	02666	N/A	N/A	
058-000-034-000	22 SANDPIPER RD	Truro	02666	N/A	N/A	Frontage is wetlands - access issues
058-000-035-000	20 SANDPIPER RD	Truro	02666	N/A	N/A	
058-000-062-000	22 RYDER BEACH RD	Truro	02666	N/A	N/A	
058-000-069-000	17 SANDPIPER RD	Truro	02666	N/A	N/A	Single Family Dwelling
058-000-071-000	26 SANDPIPER RD	Truro	02666	N/A	N/A	
059-000-017-000	8 COOPER CIR	Truro	02666	17766	267	Questionalbe - Access Issues
059-000-040-000	3 MARC LN	Truro	02666	N/A	N/A	
059-000-042-000	1 SANDPIPER RD	Truro	02666	N/A	N/A	
059-000-044-000	9 QUANSET RD	Truro	02666	N/A	N/A	
059-000-081-000	92 PRINCE VALLEY RD	Truro	02666	3137	168	
059-000-091-000	126 OLD COUNTY RD	Truro	02666	19439	135	
059-000-093-000	5 MARC LN	Truro	02666	N/A	N/A	
059-000-097-000	1 SPYGLASS HILL RD	Truro	02666	N/A	N/A	
063-000-004-000	24 RYDER BEACH RD	Truro	02666	13233	084	Merged with# 2 Ryder Beach Way

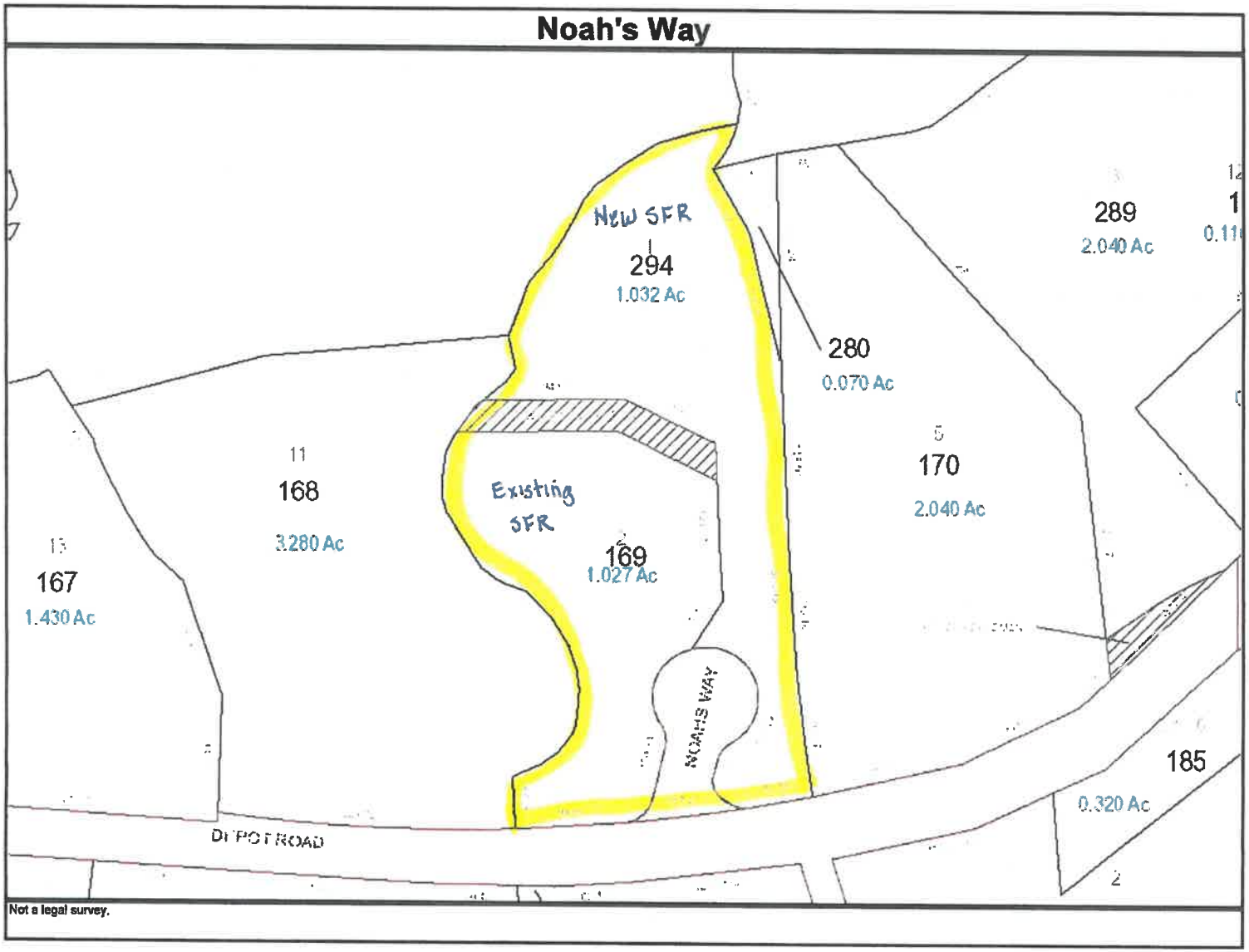
MAP PARCEL ID	SITE ADDRESS	CITY	ZIP	BOOK #	PAGE #	COMMENTS
NEW SUBDIVISIONS:						
050-000-169-000	NOAHS WAY	Truro	02666			Two Lot Subdivision off Depot Road - Both lots contain a Single Family Dwelling -
						the previous map and parcel. New Map/Parcels are #1 - 50/294, #2 - 50/169
041-000-001-000	OBBO DRIVE	Truro	02666			Five Lot Subdivision off Old Colony Way - was a cottage colony - Refer to Map (W
050-000-098-000	MARIA ROSE PATH	Truro	02666			Two Lot Subdivision off Depot Road - #2 contain a Single Family Dwelling (SFR) 50
039-000-	LAURA'S WAY	Truro	02666			15 Lot Subdivision off Sawyer Grove Road (in between #17 & #23) Road not built,
035-000-	HORTON DRIVE	Truro	02666			6 Lot Subdivision, was a cottage colony on two lots. SFR on #2 - 35/148 & SFR on
023-000-001-000	BLUFF TERRACE	Truro	02666			3 Lot Subdivision, was a 23-Unit Motel. Will now be three residential lots for 1 SF
046-000-385-000	CAPT. WILLIAMS WAY	Truro	02666			3 Lot Subdivision off Castle Road, plus an extra lot (46/384) - New SFR on #1 Capt

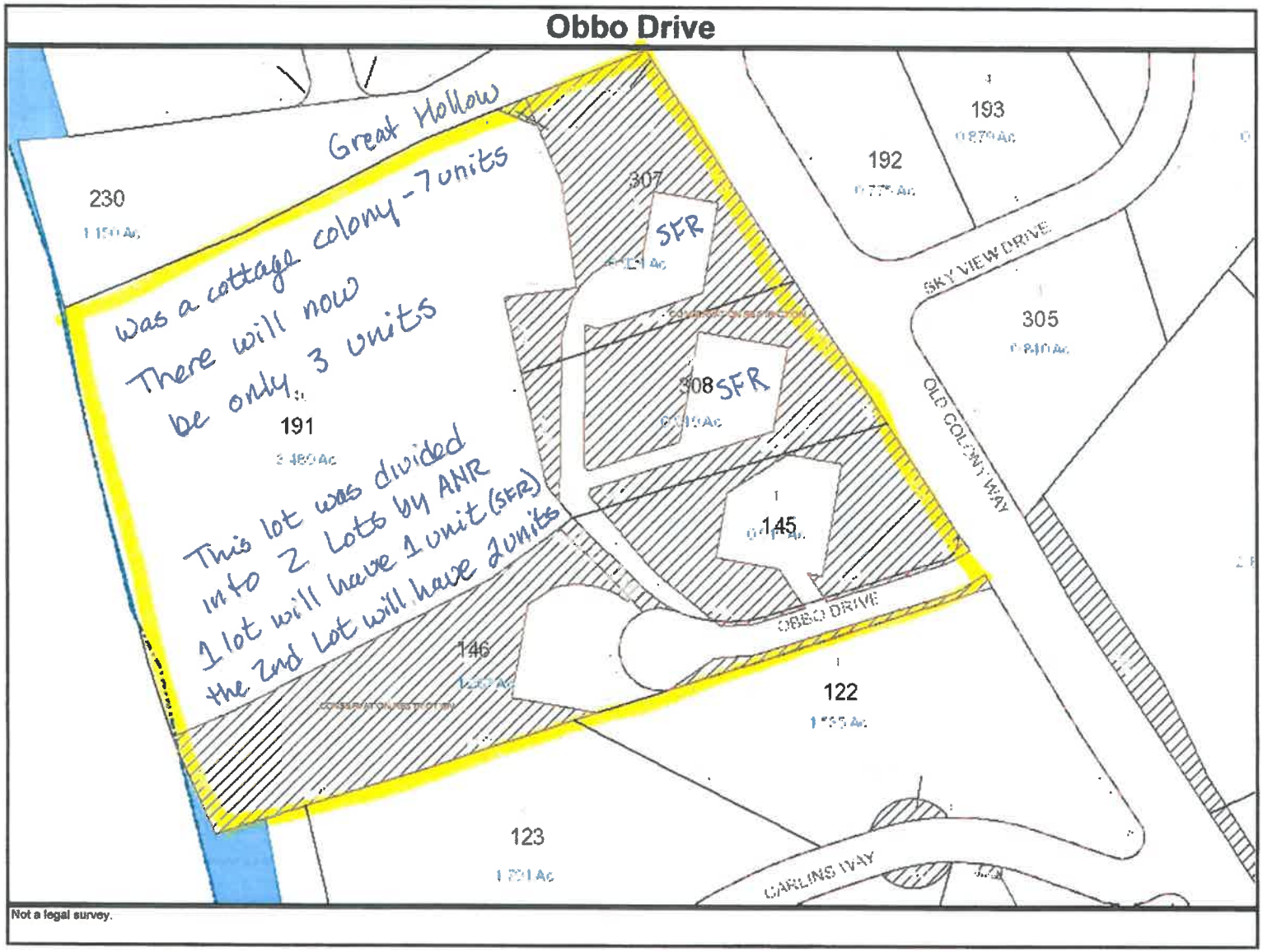





Laura's Way
Road not constructed, No Houses
MAP 39
331
330
332
78
9
329
14
333
Laura's Way
328
77
334
19
335
327
18
BAY VIEW DRIVE
336
326
25
26
337
325
32
33
338
300
324
43
284
1
283
42
SAWYER GROVE RD
40
44
29
282
293
292
41
Not a legal survey.


Maria Rose Path
1.280 Ac
RIVER VIEW ROAD
DEPOT ROAD
36
1.360 Ac
241
11
237
3.107 Ac
292
0.930 Ac
Vacant
98
0.920 Ac
Existing SFR
MARIA ROSE PATH
99
1.280 Ac
100
0.370 Ac
242
OLD COUNTY ROAD
101
1.470
Not a legal survey.





7. Conclusions and Recommendations

In the face of increasingly strict environmental regulations and controls, Truro has taken a significant step towards understanding the existing infrastructure issues for water, wastewater and stormwater. Efforts by the State, Cape Cod Commission, and Federal Regulators (e.g. establishment of Total Maximum Daily Loads (TMDL's) etc.) to reduce water quality impairments in groundwater, surface waters and estuarine environments will undoubtedly have economic, social, and environmental impacts throughout Cape Cod. Truro, with its rural nature and disperse housing and commercial densities should not become complacent. Although extended infrastructure such as regional sewering, is not necessary, ongoing efforts to ward against declining groundwater quality is important. Ageing housing stock and a gradual increase in development makes Truro an ideal candidate for the introduction of strong management practices and the use or employment of innovative technologies to reduce pollutant loads from residential and commercial properties. Consistent with this incremental improvement strategy, Truro should embark on the location and preservation of its next large public water supply source to allow for future supply and additional resiliency of municipal water supply systems for future generations.

Long term Water Resource Management goals should be attainable for Truro in an economically and socially acceptable way. In addition actions and implemented programs must comply with future regulatory controls. Data collected in this first phase of that effort indicate several specific results.

1. The sampling data and nutrient loading models indicate that excessive water quality impacts or risks to human health and ecology are not evident. Instead, sampling programs indicate that further detailed evaluations in areas with elevated nitrate sampling results should help ascertain whether land use practices, septic system conditions, or simply well construction and hydrogeologic conditions have resulted in localized impacts to groundwater quality. In essence, Truro is fortunate in that the need to create extended municipal infrastructure is not necessary.
2. With the exception of the Beach Point area and East Harbor, development impacts are generally dispersed. This area requires further evaluation regarding potential solutions and assessment of impacts to groundwater and surface waters. Although the possible solutions are diverse, consideration must be given to the potential connection to

Provincetown and the identification of nutrient loads to East Harbor (stormwater or wastewater induced).

3. Collaboration with Mass highway to manage and treat stormwater runoff along with bylaw modification and adoption of LID techniques through the planning board review process should lead towards acceptable long-term stormwater management within Truro.
4. Finally, careful monitoring, communication, and data management efforts around each of the public water supply wells should allow sufficient protection and significant lead times to mitigate any impacts to groundwater quality indicated by trends of increasing impacts from contaminates of concern.

These general conclusions lead to the implementation of several actions. First, a specific investigation of engineering alternatives for wastewater and stormwater management in the Beach Point and East Harbor area should be undertaken in a second phase effort. Further, in areas of dense development or high nitrogen loading, Truro should evaluate site specific conditions which may lead to the adoption of management efforts within designated "districts" or zones. This does not mean that utilities for stormwater or wastewater are necessary, only that designated areas may be designed where multiple methods of water resource protection may be implemented relative to land use practices, drainage or stormwater improvements, and wastewater management techniques.

A public education and outreach program regarding best management practices for septic system maintenance and repair, and long-term methods to emphasize use of advanced septic system technology for nitrogen removal should be implemented. An emphasis should be made to educate developers, homeowners undertaking new construction, existing homeowners particularly within Zone II areas or near water bodies.