Province Lake Watershed Build-Out Analysis:

Effingham and Wakefield, New Hampshire & Parsonsfield, Maine

March 2014

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Prepared by FB Environmental Associates, Inc.

in cooperation with the Province Lake Association, the Acton Wakefield Watersheds Alliance, and the New Hampshire Department of Environmental Services.

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Cover photo: Province Lake (Source: FBE)

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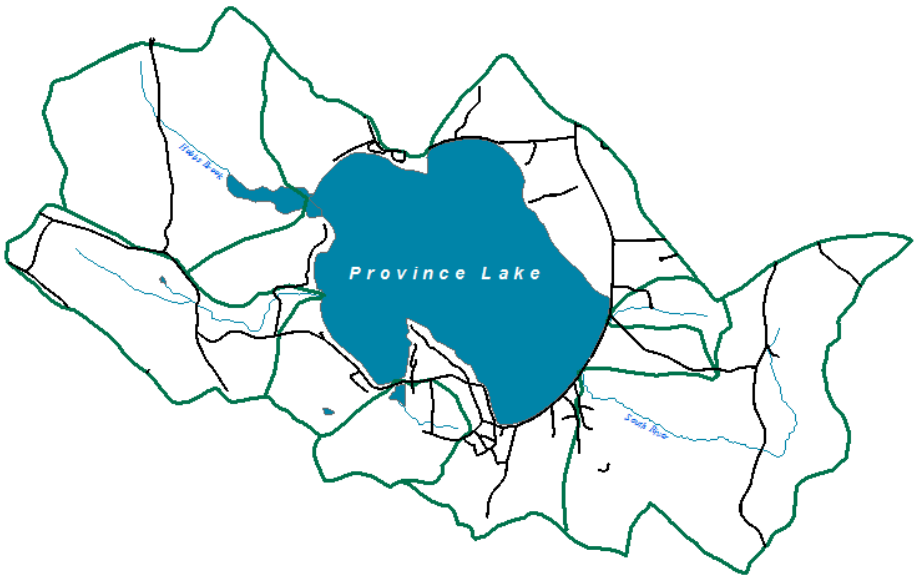

The Province Lake Watershed

1.0 INTRODUCTION

FB Environmental (FBE) performed a build-out analysis for the Province Lake watershed, located on the border of southwestern Maine and east-central New Hampshire. Province Lake has a small watershed (3,904 acres) relative to the lake's surface area (967 acres). Effingham, NH contains the largest portion of the watershed (1,738 acres), followed by Parsonsfield, ME (1,183 acres), Wakefield, NH (670 acres), Newfield, ME (152 acres) and Ossipee, NH (161 acres) (Figure 1). The northwest portion of the watershed includes a large wetland area, and Province Lake's primary inflow, Hobbs Brook. The lake's primary outflow is the South River at its north end, where it flows north to the Ossipee River, a tributary of the Saco River. Several other tributaries flow into Province Lake including the South River on the southeast side of the lake, several unnamed tributaries near Bonnyman Road in Effingham, the Island Inlet in Wakefield, and at the golf course in Parsonsfield.

The build-out analysis was performed for the three towns that make up the majority of the watershed (Effingham, Parsonsfield, and Wakefield). The results of the analysis provide estimates of the number of potential lots and the number of new units the watershed towns may see developed at some point in the future. "Full build-out" refers to the time and circumstances whereby, based on a set of restrictions (e.g. environmental constraints and current zoning), no more building growth may occur, or the point at which lots have been subdivided to the minimum size allowed and there is no more "developable" land.

Performing a build-out analysis shows a locality what land is available for development, how much development can occur, and at what densities. Municipalities can use the analysis as a tool for planning development patterns into the future. The build-out analysis is also a valuable tool to help model potential impacts from future development on water and other natural resources, and can be used to help set water quality goals for both impaired and high quality waters. The build-out analysis for the Province Lake watershed was conducted using ESRI ArcGIS version 10.0 and CommunityViz version 4.3.

1.1 CommunityViz Software

CommunityViz is a GIS-based decision-support tool designed to help planners and resource managers visualize, analyze, and communicate about important land-use decisions. While there are many components to CommunityViz, for the purposes of this study two tools were utilized: The 'Build-out Wizard' was used to calculate the development capacity of the watershed land (numerically and spatially), and the 'Time Scope Analysis' tool was used to visualize how development could occur over time.

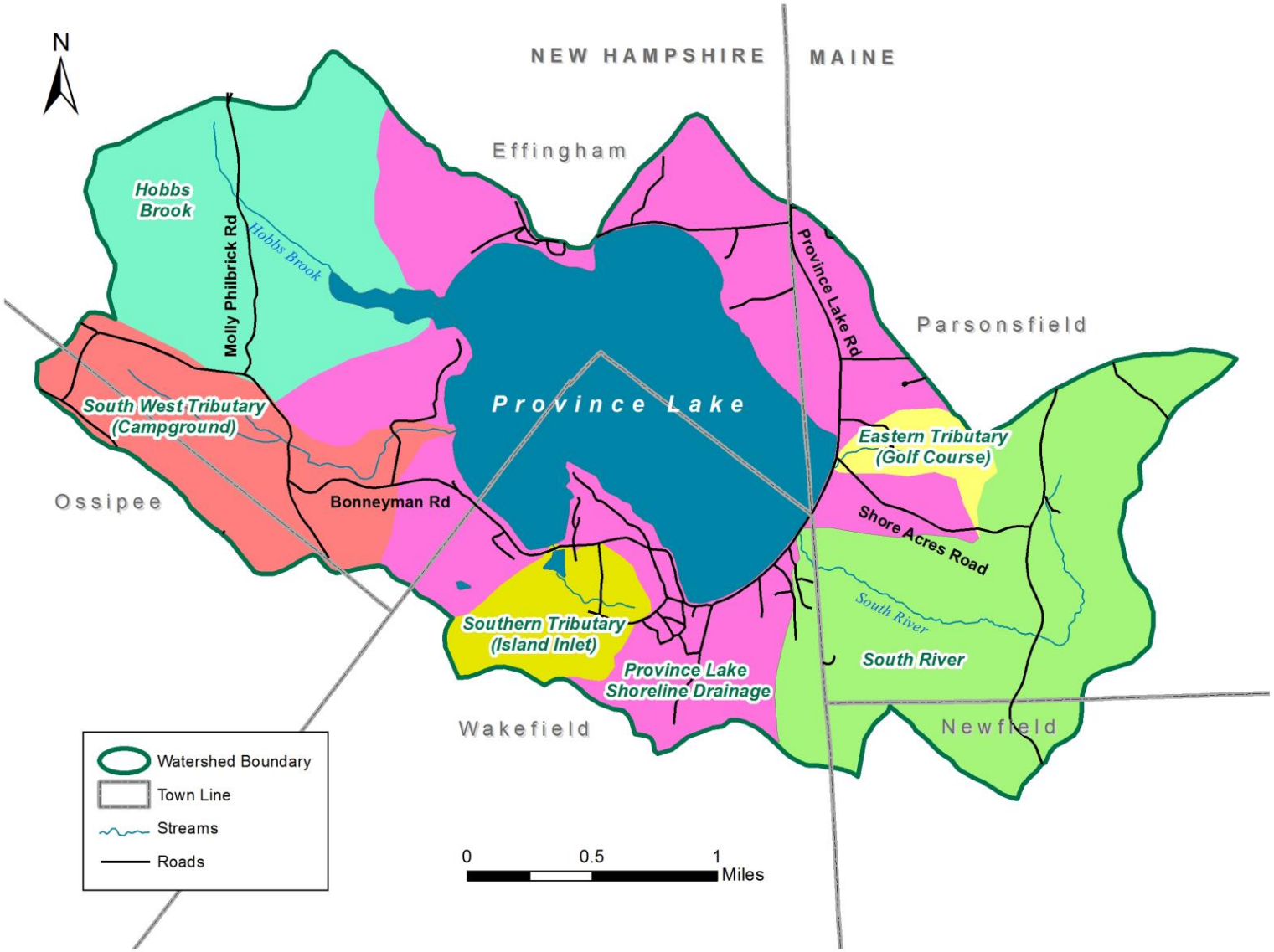

Figure 1. Province Lake subwatersheds.

Using these tools, this study explores several basic questions about the future of the Province Lake watershed:

- How much 'developable land' is there in the watershed?
- How much new development can theoretically occur in the watershed, based on current zoning and other constraints? (*Build-out Analysis*)
- At its current growth rate, how will the watershed's appearance potentially change over time? (*Time Scope Analysis*)

2.0 METHODS

The Province Lake watershed build-out analysis was performed according to the general steps outlined below:

1. Collect information on existing conditions in the watershed: existing buildings, zoning, and growth rates for Effingham, Parsonsfield, and Wakefield.[1]
2. Collect GIS data and development constraints layers.[2]
3. Based on constraints layers, determine where development may occur.
4. Analyze watershed build-out potential using the Build-out Wizard.
5. Determine potential future development patterns using the Time scope Analysis tool.
6. Present results in tables and maps.

2.1 Existing Buildings

The location and number of existing buildings in the Province Lake watershed was determined using high-resolution digital orthophotographs produced from aerial photos collected in Southern New Hampshire in the spring of 2010. The data was accessed through New Hampshire's Statewide Geographic Information System Clearinghouse, NH GRANIT website. Using these images, a new GIS layer for the watershed was created, with a point representing each existing building in Effingham (189 buildings), Parsonsfield (65 buildings), and Wakefield (176 buildings). Orthophotos from NH GRANIT were crosschecked using Google Earth and Bing Maps.

2.2 Zoning

Crucial to a build-out analysis is the feasibility of modeling zoning requirements. Certain zoning requirements are too site-specific to be able to incorporate into the analysis. With that in mind, this analysis made use of the following caveats in the determination of build-out zoning restrictions:

- Future lots will be made the smallest size allowable for the zoning district, taking into account minimum lot size and minimum buildable area.

[1] Parcel and zoning GIS layers for Effingham and Wakefield were obtained from the towns. Parcel and zoning GIS layers for Parsonsfield were obtained from the Southern Maine Regional Planning Commission.

[2] Development constraints GIS layers for Effingham and Wakefield were obtained from the State's online GIS clearinghouse (NH GRANIT). Development constraints GIS layers for Parsonsfield were obtained from the Maine Office of GIS (MEGIS).

- Potential unit types (e.g., house, garage) are not specified.
- Road and shoreland frontage requirements are not specified.

Zoning information used in the build-out analysis represent restrictions that apply in the sections of each town that fall within the watershed boundary (Table 1). In addition to the zoning restrictions listed below, each watershed town also follows the minimum Shoreland Zoning restrictions required in New Hampshire.

Table 1. Effingham, Parsonsfield, and Wakefield zoning restrictions for areas within the Province Lake watershed.

Zone	Building Setbacks	Road Setbacks	Min. Lot Size	Lot Coverage	Building Size Restrictions
Effingham					
Rural/Agricultural	side - 30 ft. rear - 50 ft.	50 ft.	2 ac	N/A	Max. Height – 35 Ft.
Province Lake District	side - 20 ft. rear - 30 ft.	30 ft.	2 ac	N/A	Max. Height – 35 ft.
Parsonsfield					
Rural Residential	side - 25 ft. rear - 50 ft.	75 ft.	2 ac	30%	Max. Height – 35 ft. Max. Size – 15,000 sq. ft.
Forest and Farm	side - 25 ft. rear - 50 ft.	75 ft.	3 ac	20%	Max. Height – 35 ft. Max. Size – 15,000 sq. ft.
Shoreland	side - 25 ft. rear - 50 ft.	75 ft.	0.92 ac	20%	Max. Height – 35 ft. Max. Size – 15,000 sq. ft.
Wakefield					
Residential II (Shorefront)	side - 20 ft. rear - 10 ft.	20 ft.	1 ac	N/A	Max. Height – 35 ft.
Agricultural	side - 20 ft. rear - 15 ft.	50 ft.	5 ac	N/A	Max. Height – 35 ft.

2.3 Population Growth Rates

According to the US Census Bureau, the towns within the Province Lake watershed have experienced steady population growth since the middle part of the last century. The populations of the three towns combined have grown from 2,421 people in 1960 to 8,441 people in 2010–a 249% increase. The average annual growth rate of the three towns during this period is 2.49% (Table 2). This annual growth estimate was used in the TimeScope Analysis.

Table 2. Effingham, Parsonsfield, and Wakefield population estimates, 1960–2010.

Town	1960	1970	1980	1990	2000	2010	Numeric Change 1960–2010	Percent Change 1960–2010	Average Annual Growth Rate
Effingham, NH	329	360	599	941	1,273	1,465	1,136	345%	3.45%
Wakefield, NH	1,223	1,420	2,237	3,057	4,252	5,078	3,855	315%	3.15%
Parsonsfield, ME	869	971	1,089	1,472	1,584	1,898	1,029	118%	1.18%
Combined	**2,421**	**2,751**	**3,925**	**5,470**	**7,109**	**8,441**	**6,020**	**249%**	**2.49%**

2.4 Development Constraints

Constraints to development in a build-out analysis are those areas that are considered undevelopable, or areas where no future buildings may be built. To determine where development may occur in the watershed, build-out calculations deduct land due to physical constraints to development including environmental restrictions (e.g. soils, slopes, wetlands), zoning restrictions (e.g. shoreland zoning, street Right-of-Ways (ROWs), building setbacks), and practical design considerations (e.g. lot layout inefficiencies). Existing buildings may also reduce the available capacity for new development.

Below is a list of GIS data used to model development constraints in the Province Lake watershed:

1) Conserved Land
2) Steep slopes (*>25%*)
3) Wetlands appearing on National Wetlands Inventory (NWI) maps
4) Existing buildings
5) Hydric soils
6) Effingham and Wakefield only: 100-year floodplain as designated on the Federal Emergency Management Agency's (FEMA) Flood Insurance Rate Maps or Flood Hazard Boundary Maps. The 100-year floodplain is not yet available for Parsonsfield.

The development constraints considered above do not represent the full range of possible restrictions of resources that may be found in the field. For example, rare and endangered species may be present in a given area but are not considered because data about their specific locations are not available.

2.5 Build-out Assumptions

To determine how many units (buildings) can be built on the available buildable land in the watershed, various density and other design factors are considered, based on the zoning requirements for each town. Any build-out analysis requires simplifying assumptions. Below is a list of assumptions used in the build-out analysis, based on zoning requirements in Effingham, Parsonsfield, and Wakefield. These assumptions are an important component of the model because it facilitates prediction of whether development can occur on a given lot given the types of standards for development in a given town. For example, zoning districts with large

minimum lot sizes (e.g. 5 acres, Residential/Agricultural) will result in different a development pattern in the future compared to a zoning district with smaller minimum lot sizes (e.g. 1 acre, Residential).

- **Building setbacks** were estimated based on the average front and rear setbacks specified in each town's zoning ordinances (Table 1). Setbacks are measured from building center points in CommunityViz. To account for this, building footprints need to be estimated to avoid building overlap. The dimensions of the minimum building footprint were estimated to be 30 feet x 30 feet. This number was then was added to the average front/rear setback for each zone to estimate the "Minimum Separation Distance" used in CommunityViz.
- **Minimum lot size requirements** used were based on requirements for each zone (Table 1).
- **Efficiency factors** adjust density values to account for common density losses. Lot efficiency refers to the amount of land on a parcel that is available for construction after addressing such considerations as drainage facilities, parcel contiguity, ROWs, setbacks, and conservation restrictions. They are entered as a percentage, where 100% means complete efficiency (no density lost), and 0% means no buildings will be estimated for that land use. In the Province Lake Watershed build-out, a composite 80% efficiency factor was used for all zones, based on recommendations in the CommunityViz manual (Placeways, LLC, 2007). This efficiency factor was also used in a previous build-out analysis for the Great East Lake Watershed, part of which is in the town of Wakefield.

3.0 BUILD-OUT RESULTS

3.1 Buildable area

An estimated 2,347 acres (65%) of the area within the Province Lake Watershed is developable (Table 3). More than half of the total land in all six subwatersheds is buildable. That is, the amount of buildable area exceeds the unbuildable area in all the subwatersheds. The amount of buildable land in each subwatershed ranges from 77% (South West Tributary) to 59% (South River) (Figure 2, Figure 3). There are seven zoning districts within the three towns in the Province Lake Watershed. The rural and agricultural zones within the three towns contain the greatest amount of developable area (Figure 4).

Table 3. Buildable area by subwatershed.

Watershed	Total Area (acres)	Buildable Area (acres)	Percent Buildable Area
Province Lake Direct Drainage	1,312	867	66
South River*	880	516	59
Hobbs Brook	773	504	65
South West Tributary*	336	260	77
Southern Tributary	198	134	68
Eastern Tributary	92	66	72
Totals	***3,591***	***2,347***	***65***

**Numbers presented for the South West Tributary and South River exclude 161 and 152 acres in Ossipee and Newfield, respectively.*

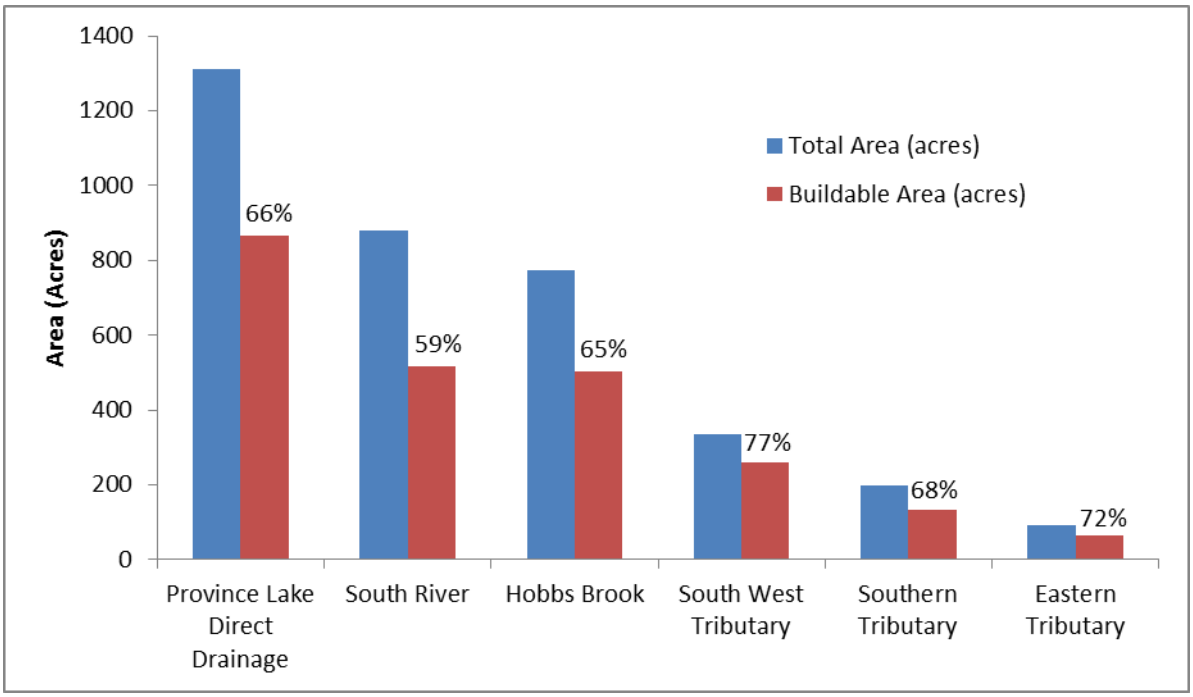

Figure 2. Total area vs. total buildable area by subwatershed. Values presented for the South West Tributary and South River exclude 161 and 152 acres in the towns of Ossipee and Newfield, respectively.

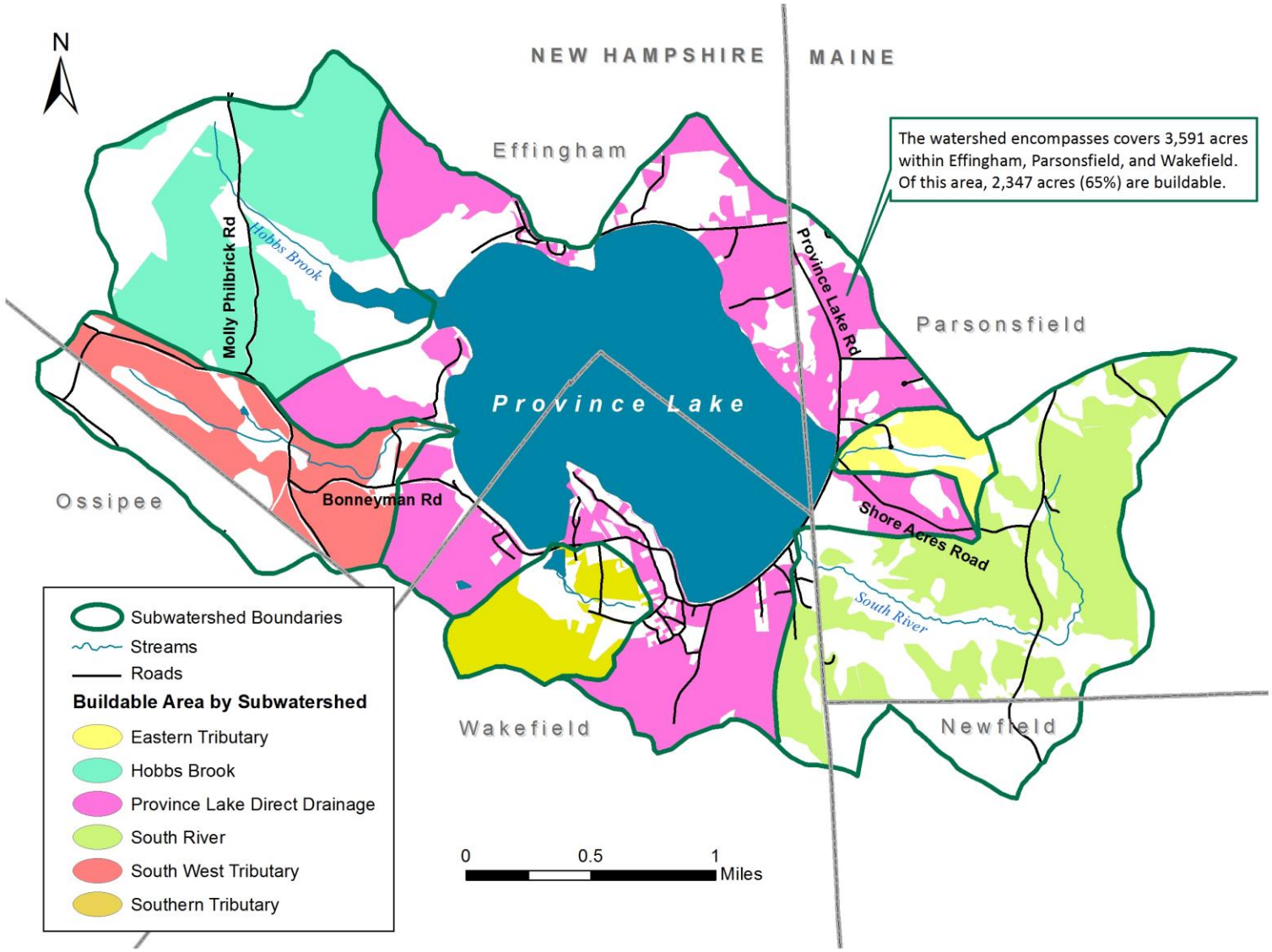

Figure 3. Buildable area by subwatershed.

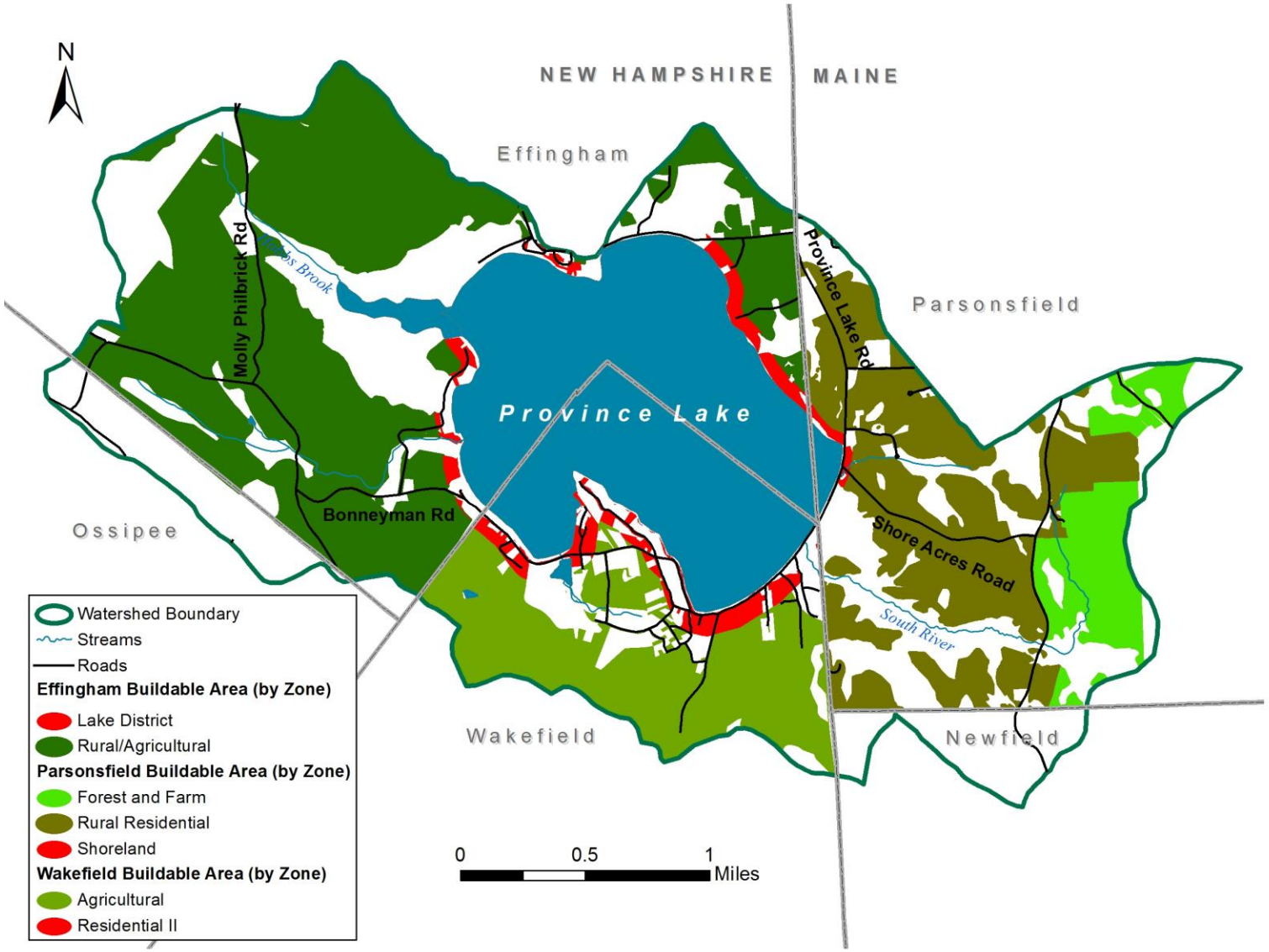

Figure 4. Buildable area by zone.

3.2 TimeScope Analysis

The TimeScope analysis estimates are based on a projected per-year population growth rate of 2.49% for the entire watershed (see section 2.3). This information is based on currently available projections, but long-term growth rates may vary. At the current growth rate, full build-out is expected to occur by 2060. Note that results for the period representing one-half the time to full build-out (2036) are also presented in Table 4.

The number of build-out units within the watershed is projected to increase by 886 units from 430 units in 2013 to 1,316 units in 2060 (Tables 4 and 5, Figures 4, 5, and 6). (The analysis assumes that development will occur on parcels closest to existing roads first.) New building units are projected to occur within all subwatersheds, with the Hobbs Brook subwatershed experiencing the largest percent increase in new buildings (1,727%), and Province Lake's direct subwatershed experiencing the lowest percent increase in new buildings (126%) (Table 4). All zoning districts will experience growth as well, with the greatest percent increase of new buildings occurring in Parsonsfield's Forest and Farm District. Effingham's Province Lake District is predicted to have the lowest percent increase in new buildings (Table 5).

Table 4. Build-out results by subwatershed.

Subwatershed	Existing Units 2013	Build-Out Units 2036	Build-Out Units 2060
Direct Drainage	311	531	703
Hobbs Brook	11	31	201
South River	35	64	187
South West Tributary	47	78	137
Southern Tributary	23	37	58
Eastern Tributary	3	11	30
Totals	***430***	***752***	***1316***

Table 5. Build-out results by zone.

Zone	Existing Units 2013	Build-Out Units 2036*	Build-Out Units 2060*
Effingham			
Rural/Agricultural	90	178	498
Province Lake District	99	124	131
Parsonsfield			
Rural Residential	60	116	240
Forest and Farm	3	10	55
Shoreland	2	6	7
Wakefield			
Agricultural	78	143	206
Residential II (Shorefront)	98	175	179
Totals	***430***	***752***	***1,316***

** Number includes existing building units plus projected build-out units.*

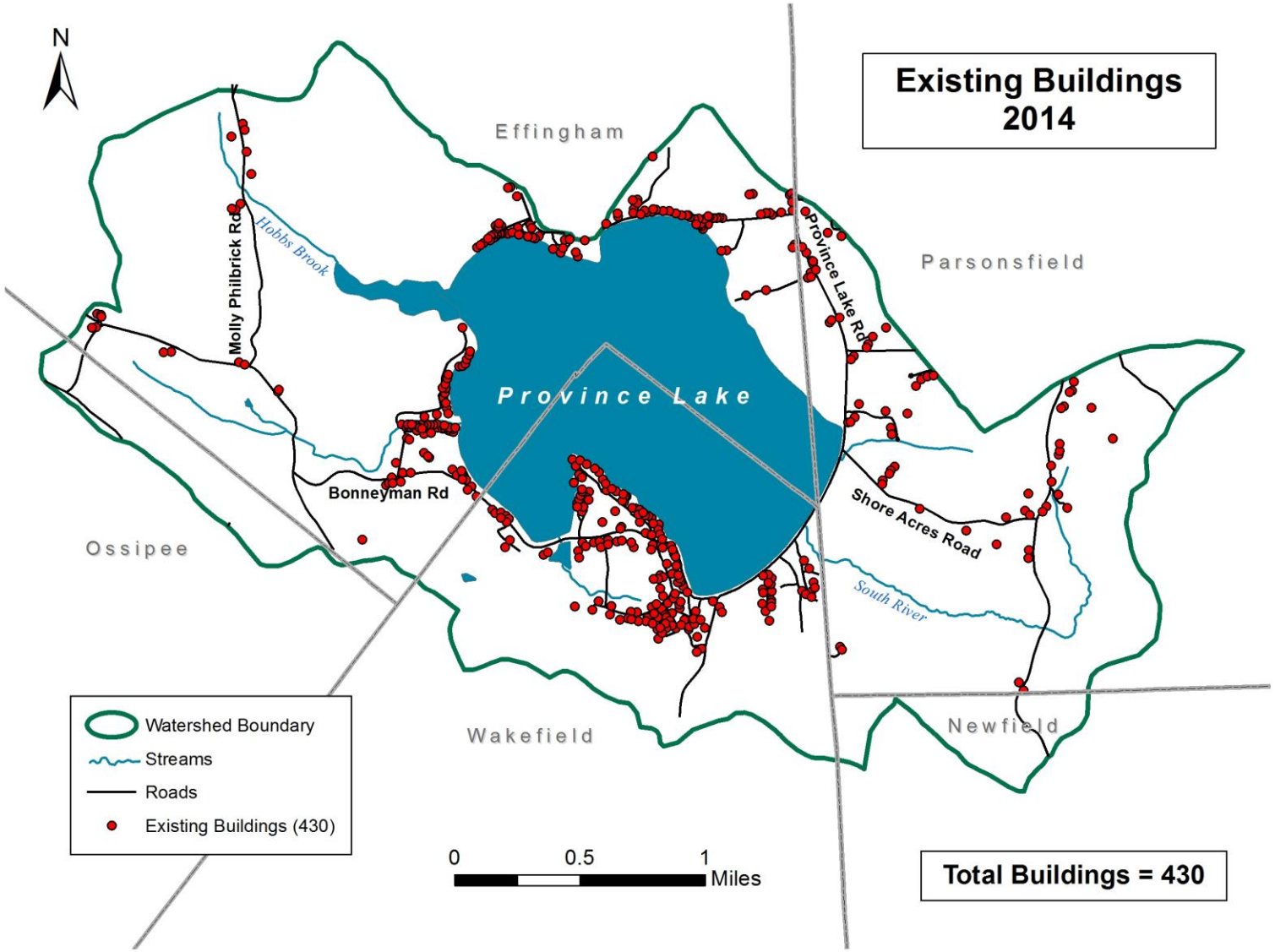

Figure 5. Existing buildings in the Province Lake watershed.

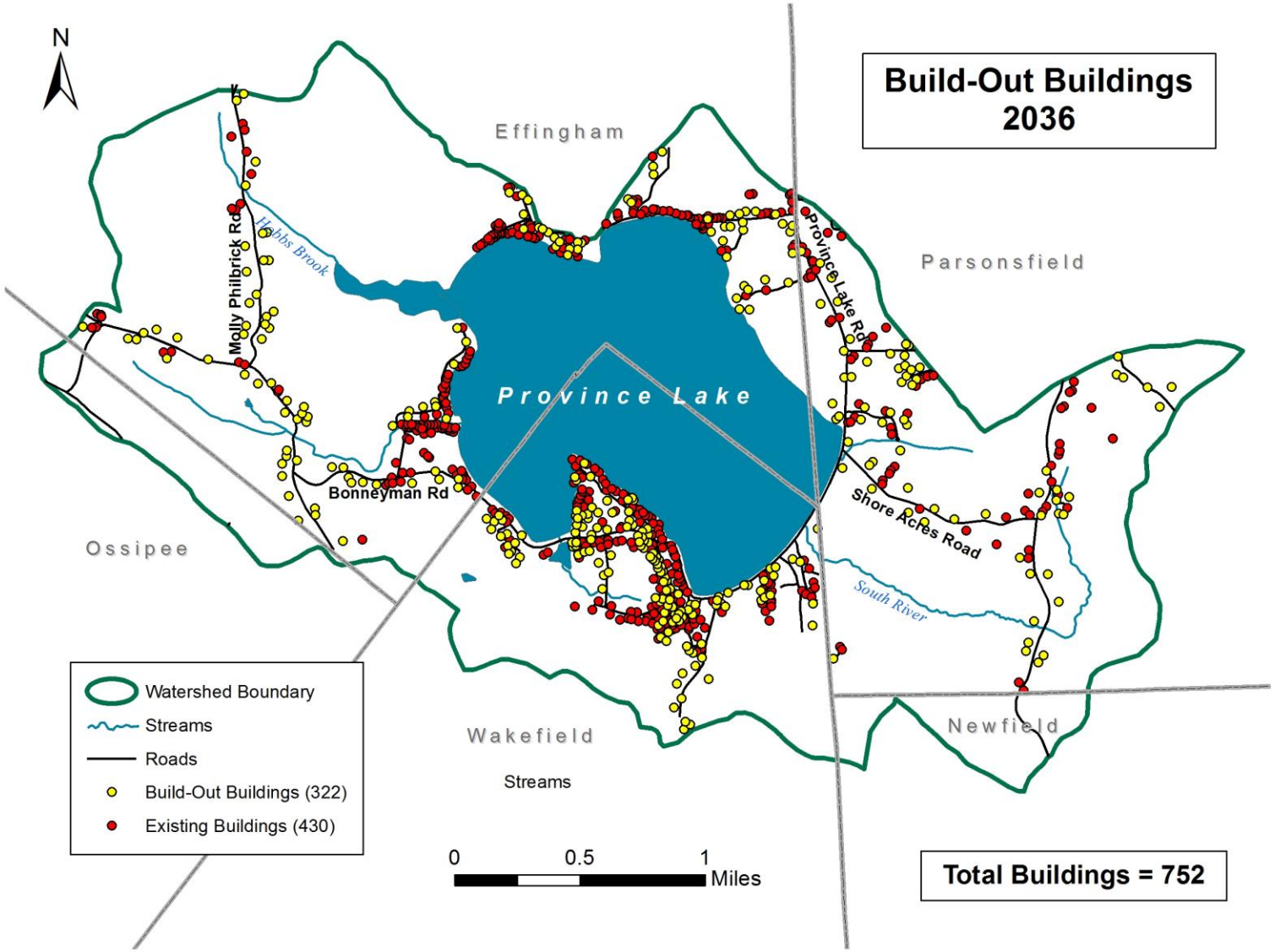

Figure 6. Projected build-out buildings in the Province Lake watershed in the year 2036.

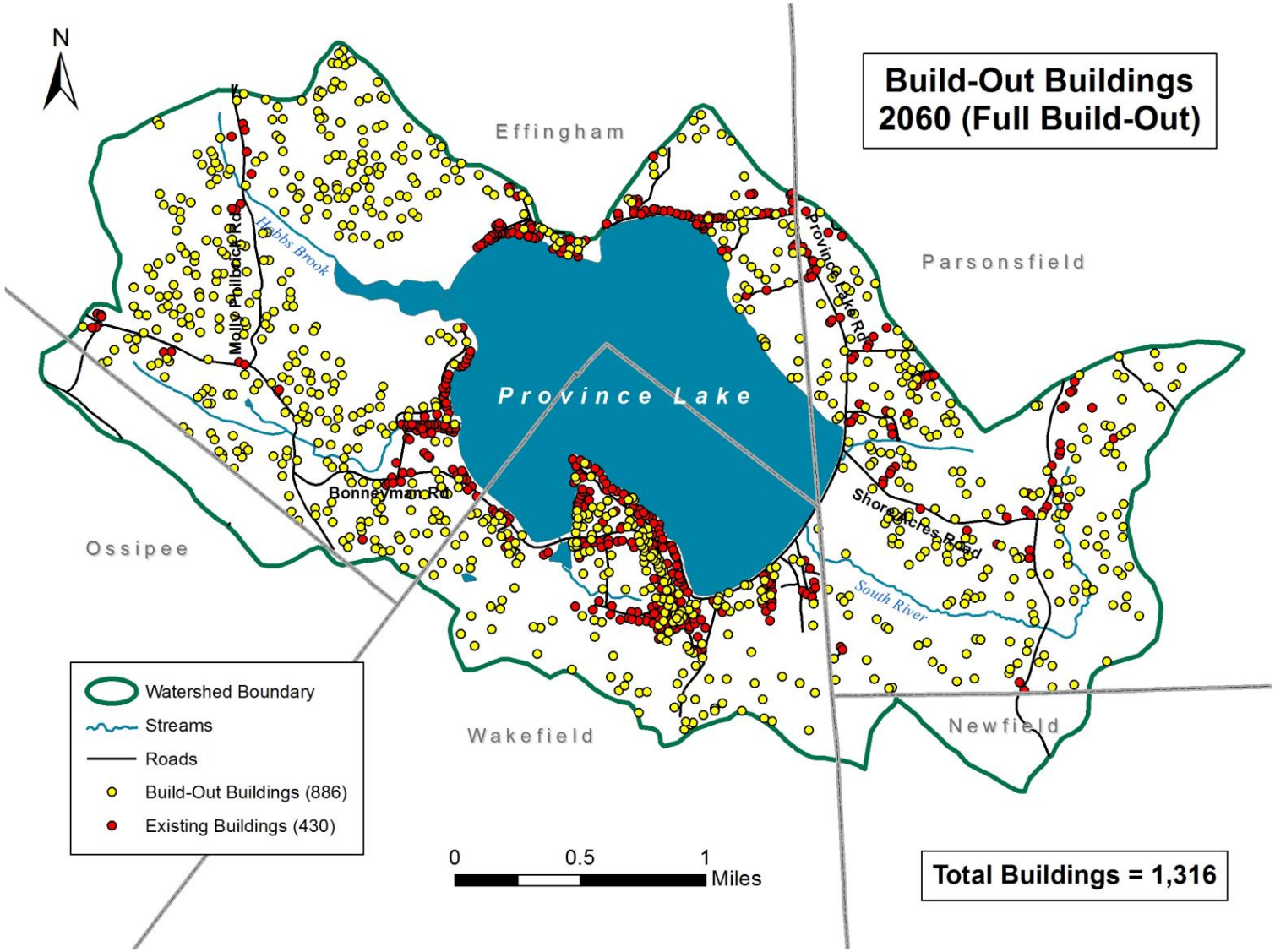

Figure 7. Projected build-out buildings in the Province Lake watershed in the year 2060 (full build-out).

4.0 PHOSPHORUS IN THE PROVINCE LAKE WATERSHED

4.1 Build-Out Phosphorus Load Estimate

An increase in watershed development could lead to more phosphorus (P) entering Province Lake from the surrounding watershed each year. Phosphorus serves to "fertilize" the lake and decreases water clarity. Excess phosphorus can also harm fish habitat and lead to nuisance and/or toxic algae blooms. The Lake Loading Response Model (LLRM) was used to estimate the additional annual phosphorus load that could result from build-out in the Province Lake watershed. For planning purposes, phosphorus load analyses were conducted for two scenarios:

1. The first analysis estimates phosphorus loads at an intermediate build-out phase in the year 2036. An additional 322 new buildings are estimated to be built in the watershed, making the total number of watershed buildings 752 in the year 2036.

2. The second analysis estimates phosphorus loads at full build-out. At full build-out, there would be an estimated 886 additional buildings in the watershed. The total number of buildings in the watershed at full build-out is estimated to be 1,316.

Below is a description of the methods used to calculate future P loading to Province Lake at both intermediate (year 2036) and full build-out points.

Step 1: Estimating future changes in land uses in the Province Lake watershed: CommunityViz software utilized model inputs such as population growth rates, zoning, wetlands, conservation lands, and other restraints to construction, and generated a projected number of new buildings in the future. The new building count was generated for each basin in the watershed for the year 2036 and full build-out, which was projected in 2060.

Step 2: Calculating developed land coverage after intermediate and full build-out projections: Each new building was considered to generate new residential and road land uses. Specifically, the value of 0.2 ha of low-density developed land (Urban3) was assigned for each building. This figure is approximately the same as the 0.15 ha of low density and 0.02 ha of medium density developed land per house that exists currently in the watershed. In addition, 0.1 ha of roads (Urban5) were assigned to each building, which is the current ratio of roads to buildings in the watershed.

Step 3: Incorporating land use changes and septic system loading into LLRM for P loading predictions: The new developed land uses were added into the LLRM, and a corresponding area of undeveloped land (first hayfield, then forest) was removed for both intermediate build-out in year 2036 and full build-out in year 2060. In addition to land use changes, one new septic system serving two people was entered into the model per new building. Existing septic systems P loading was left unchanged. Some existing septic systems will likely

deteriorate with age, but given the high number of outhouses and cesspools in the Province Lake watershed now, many systems are expected to be upgraded or replaced in future years. Based on the new land use profiles and number of new septic systems, the model estimated TP concentration in Province Lake in years 2036 and 2060.

4.2 Phosphorus Loading Predicted Under Build-out Conditions

The phosphorus-loading model and the empirical water quality data indicate an in-lake total phosphorus concentration of 14.3 ppb in Province Lake under current conditions. The total mass load is 478 kg P. In 2036, the in-lake TP concentration is expected to rise to 18.4 ppb, an increase of 29% compared to current conditions (as modeled), and overall mass load is estimated to rise to 627 kg P. In 2060 at full build-out, the TP concentration is expected to rise to 24.5 ppb, an increase of 71% over current conditions, with a load of 837 kg P. The unnamed southern tributary basin (at Island Inlet) and the lake shoreline area show the highest percent increase in the intermediate term, while Hobbs Brook basin eventually shows the largest percent increase at full build-out. The direct shoreline drainage area remains the largest source of phosphorus under current and future scenarios.

Septic system loading is estimated to grow from 17% of phosphorus load currently to 28% under full build-out. Future loading from septic systems can be greatly reduced by ensuring that all new systems are well separated from the lake, streams, and wetlands horizontal setbacks, and well separated vertically above the seasonally high groundwater table in suitable soil. When properly located, designed, installed, and maintained, septic systems are very effective at reducing phosphorus loading.

Detailed results by source category and watershed are presented in Table 6 and Table 7. Projected increases in the phosphorus load and in-lake phosphorus concentration in Province Lake over time is shown graphically in Figure 8 and Figure 9, respectively.

Table 6. Phosphorus loading by subwatershed in build-out scenarios.

		Subwatershed						
		Eastern Tributary	Hobbs Brook	Direct Drainage	South River	South West Tributary	Southern Tributary	Septic Systems
2013	kg/year	16	41	158	54	36	10	81
2036	kg/year	18	45	216	57	42	13	154
	% Increase*	13%	10%	37%	6%	17%	30%	90%
2060 (Full Build-Out)	kg/year	22	82	258	82	56	18	237
	% Increase*	38%	100%	63%	52%	56%	80%	193%

** Increase from 2013.*

Table 7. Phosphorus loading by source category and in-lake P loading in build-out scenarios.

	Source Category					Province Lake	
	Atmospheric	Internal Loading	Waterfowl	Septic Systems	Watershed*	Total TP Load	In-Lake TP Concentration
	kg/year	*kg/year*	*kg/year*	*kg/year*	*kg/year*	*kg/year*	*ppb*
2013	78	0	3.5	81	315	478	14.3
2036	78	0	3.5	154	391	627	18.4
2060 (Full Build-Out)	78	0	3.5	237	518	837	24.5

**Accounts for attenuation factor, so watershed loads are slightly lower than sum of basin loads.*

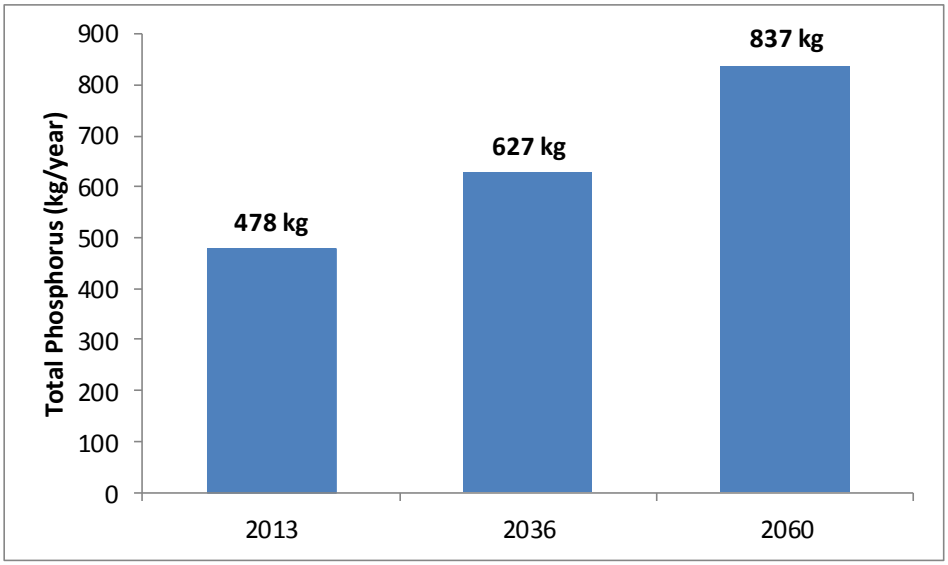

Figure 8. Estimated existing and future phosphorus loads in Province Lake.

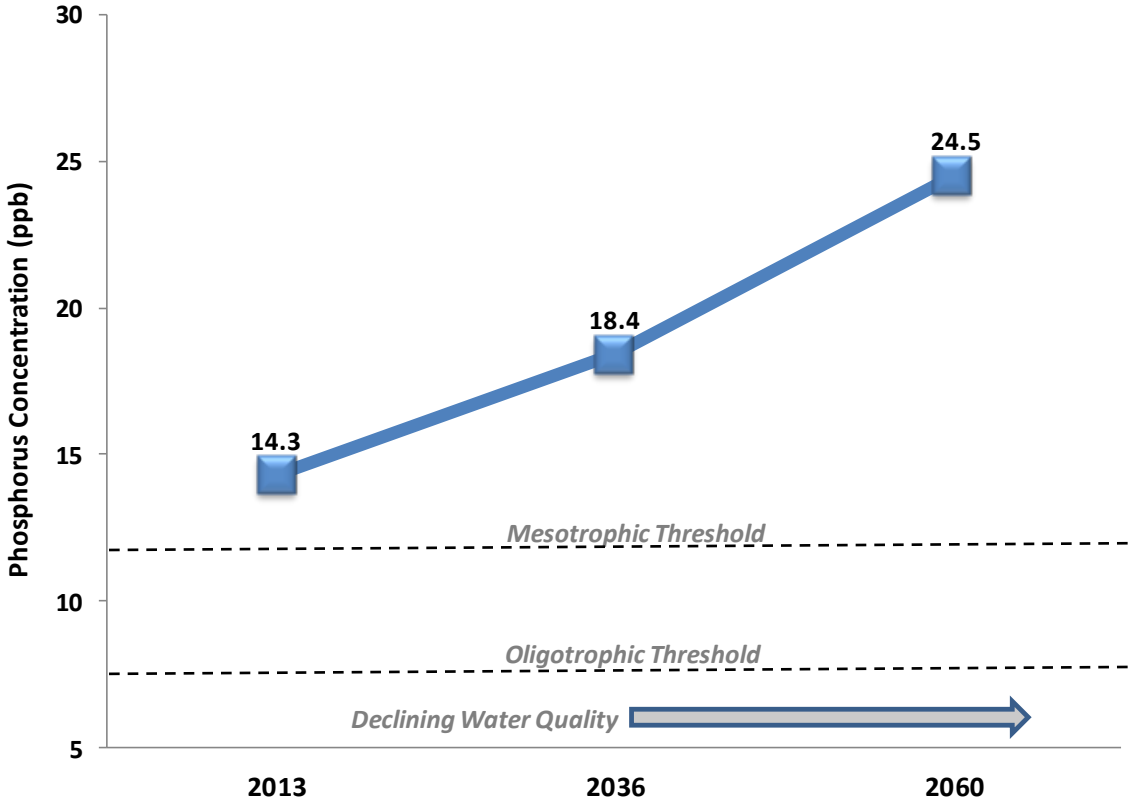

Figure 9. Estimated existing and future phosphorus concentrations in Province Lake.

5.0 SUMMARY AND RECOMMENDATIONS

The build-out analysis for the Province Lake watershed provides estimates about the potential for new residential development, including the number of new buildings (Table 4) and the amount of land area that could be developed in the watershed based on current zoning standards (Figure 4). The build-out also presents information about where the development is expected to occur (Figures 5, 6, and 7), and how total phosphorus exported from the watershed is expected to increase in Province Lake as a result of this development (Tables 6 and 7, Figures 8 and 9). The build-out analysis provides a full build-out scenario based on current zoning standards, and should be viewed as an estimate only. It should be treated as a useful planning tool that can be utilized to guide future development activities in the watershed as well as to target specific areas for conservation.

The area adjacent to the shoreline of Province Lake contains the greatest amount of existing development (Figure 5). The build-out analysis estimates that the land area encompassing the Province Lake Direct Drainage, South River, and Hobbs Brook watersheds have the greatest potential for new development (Figure 2). For the entire watershed, the analysis estimates that 886 new buildings could be added by the year 2060,

affecting 2,347 acres of buildable land remaining in the watershed (Figure 7). Note that the build-out projections show buildings on the Province Lake Country Club Golf Course. These buildings were not removed from the build-out projections as land uses may change over time, and open spaces (such as golf courses) may be desirable locations for developers to build due to the already cleared land and picturesque lake views.

Future development will increase the amount of runoff that drains to Province Lake and its tributaries, and result in greater amounts of phosphorus entering the lake. Under the full build-out scenario, phosphorus loading to Province Lake is estimated to increase by 75%, from 478 kg/year currently to 837 kg/year in 2060. Significant increases in phosphorus loading, as predicted in the build-out, can result in dire consequences for sensitive lake systems that by nature are phosphorus-limited. Any new increases in phosphorus in a lake can "tip the scales" of nature to favor increased algal growth, resulting in decreased water clarity, increased algae production and algal blooms, and increased presence of other aquatic plant growth in the shore zone, including undesirable invasive plants. Since Province Lake is already considered at the "tipping point", and is in need of phosphorus reductions, as evidenced by the higher frequency of cyanobacteria blooms since 2010, any new phosphorus added to the lake will only make conditions worse.

The build-out also predicts where the most development will occur by zoning district (Figure 4). In Effingham, the Rural/Agricultural zone is expected to have the largest increase in new development as well as the Forest and Farm zone for Parsonsfield, and the Agricultural zone in Wakefield (Table 5). Development standards that result in no net increase of stormwater should be considered for all new development, including low impact development (LID), which utilizes smart site design principles to capture and treat polluted runoff from rooftops, driveways and other impervious surfaces so that they don't end up in nearby streams and lakes. Similarly, phosphorus control standards which require the installation of best management practices (BMPs), including LID, could be adopted to limit the amount of phosphorus allowed to be exported from an individual property. Other tools such as conservation or cluster subdivisions (such as Effingham's Open Space Conservation Subdivisions) should also be encouraged in order to protect open space, wildlife habitat, water quality, and to discourage sprawl. All towns should consider improving shoreland zoning standards for future development within the shoreland zone of Province Lake due to the fact that the direct shoreline area contains the greatest estimated phosphorus load under both current and future development conditions.

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