TECHNICAL MEMORANDUM | LAKE AUBURN MODEL

TO: Eric Cousens, City of Auburn, Maine

FROM: Laura Diemer, FB Environmental Associates

SUBJECT: Memorandum on Modeling 2022 Proposed Ordinance Changes

DATE: August 1, 2022

CC: Forrest Bell & Maggie Kelly, FB Environmental Associates

The City of Auburn requested FB Environmental Associates (FBE) to evaluate proposed ordinance changes for their potential effects on land use and development in the Lake Auburn watershed and associated impacts to lake water quality. The purpose of this memorandum is to 1) summarize the proposed ordinance changes that the City of Auburn deliberated in May 2022 and 2) describe the modeling work that was completed which simulated the impact that the proposed ordinances changes will have on land use and development in the watershed and subsequent lake water quality.

BACKGROUND

This work follows up on a comprehensive analysis that FBE, along with Horsley Witten Group and Dr. Adam Daigneault of the University of Maine, conducted for the City of Auburn in 2021. For that analysis and subsequent report, FBE ran a buildout analysis and a coupled watershed-lake model that estimated phosphorus loading from the watershed to Lake Auburn and subsequent in-lake water quality conditions. The calibrated baseline watershed-lake model was run for several future scenarios that simulated in-lake water quality conditions under different watershed development conditions. With the calibrated baseline watershed-lake model, additional future scenarios can be run based on changes to the underlying model inputs and/or assumptions.

PROPOSED REGULATORY CHANGES & MODELING APPROACH

The proposed ordinance changes that FBE were given to consider are in Section 60-952 (the Lake Auburn Watershed District Overlay) and Section 60-1066 (the Phosphorus Control Ordinance). The ordinance changes with implications for the modeling effort are described in Table 1.

For carrying out the model run, the first step was to update the buildout analysis to account for the new ordinances. A buildout analysis uses existing or in this case proposed ordinances, existing natural features, and other development constraints to estimate the number and location of new buildings possible under the simulated zoning. Once the buildout analysis was complete, the results were input to the watershed-lake model. FBE started with the "Business As Usual + LID" model scenario and made adjustments to the new model run to account for the proposed ordinance changes, which included changing the number of projected new buildings (for Auburn only) and agricultural land area within the 100 ft buffer of surface waters[1] (refer to Table 1).

[1] Note for future model runs: with the anticipated decline in existing agricultural land area in the watershed, these agricultural lands were assumed to likely be replaced by new development; however, there were instances where the anticipated increase in development was less than the anticipated decline in agricultural lands which were then assumed to lay fallow and regenerate into forest. Overall, the new model run estimated up to 39 acres of regenerated forest by 2100. It may be more practical to convert these agricultural lands to open land rather than forest in the model unless the agricultural lands are managed and protected as forested land. Open land has a slightly higher phosphorus export compared to forested land, so this change in assumption would minorly increase the total phosphorus load estimate.

Table 1. Summary of existing ordinances and their proposed changes, along with a description of the modeling approach to account for these proposed ordinance changes.

Category	Existing Ordinance	Proposed Ordinance	*Model*: Modeling Approach
Agricultural Buffer Strips	In Section 60-952 (c), for tilled agricultural lands adjoining the lake or its perennial tributary streams, the width of untilled agricultural buffer strips is 50 feet.	The proposed ordinance changes the setback to 100 feet.	*Watershed-Lake Model:* FBE found the intersection of agricultural land use and a 100 ft buffer from Lake Auburn and its ponds and perennial tributaries (within the City of Auburn) and manually changed any agriculturally classified land use as open land, assuming that property owners will be required to reforest or lay fallow tilled fields within 100 ft of those surface waters. FBE identified 0.82 hectares (2.01 acres) and 2.26 hectares (5.58 acres) of agricultural land use within a 50 ft and 100 ft buffer, respectively, from Lake Auburn and its ponds and perennial tributaries (within the City of Auburn) (Table 2). Note that this desktop analysis was performed at a coarse scale, and some of these agricultural areas may be outside of the buffer zone if measured in the field. **Converting the 2.26 hectares (5.58 acres) of agricultural land use to open land for this new model run includes the 0.82 hectares (2.03 acres) of agricultural land within the existing 50 ft buffer restriction and posed as a minor limitation to directly comparing the results between the model runs since the "Business As Usual" model scenario considered some agricultural land within the 50 ft buffer despite existing regulations.**
Subsurface Disposal Systems (Septic Systems)	Section 60-952 (f) (1) currently prohibits the siting of systems where there is less than 36 inches of vertical separation from the bottom of the organic horizon and the nearest "limiting factor" (bedrock, seasonal water table, occluding layer of clay or other mineral that would prevent drainage). This vertical separation must be achieved by previously in-situ soils or sediments, disallowing the use of fill materials.	The proposed change allows for siting of septic systems where there is 12 inches of in-situ vertical separation between the bottom of the disposal field and the limiting factor, a standard that is consistent with the State of Maine Subsurface Wastewater Disposal Rules 10-144 Chapter 241 (a.k.a., Chapter 241). In addition, the revised section would allow the use of suitable fill materials to achieve a total of 36 inches of vertical separation, which is retained from the old rules.	*Buildout Analysis*: Using county-level NRCS soil series data, we updated the development constraints input to show areas with restrictive layers within 12" of the surface (compared to 36" originally).
	Section 60-952 (f) (2) currently prohibits the siting of septic systems within 300 feet of the high-water line where soils are described as deep, loose, and sandy containing 70 percent sand.	The proposed change prohibits the siting of septic systems within 400 feet of the high-water line where soils are profiled as gravel outwash or stratified drift as shown in Table 4D (profiles 5, 6, and some of 11) of Chapter 241.	*Buildout Analysis*: We expanded the target area from 300 to 400 ft around Lake Auburn and its ponds and tributaries. FBE roughly matched soil series (from county-level NRCS data) in the watershed to 5, 6, and 11 soil profiles in Table 4D of Chapter 241. However, the soil profiles in Table 4D are broadly applicable to several soil series under different environmental conditions and likely do not reflect true parcel-by-parcel variability in septic system siting restrictions. FBE's approach of excluding only those soil series that are definitively not 5, 6, and 11 soil profile types is conservative for development potential, showing nearly the entire 400 ft buffer as restricted from development. Practical field application of the Table 4D rules would likely be less restrictive, but there is no way of knowing the extent of the difference without field evaluations by a Licensed Site Evaluator. FBE confirmed this limitation with Daniel Locke, a Professional Geologist and Licensed Site Evaluator with the Maine Geological Survey. **Thus, the buildout analysis results for the new model run likely underestimated new building potential. There were 23 projected new buildings identified within the 300 ft buffer under the "Business As Usual" model scenario that the new scenario run using the Table 4D soil profiles excluded and therefore potentially underestimated development along the shoreline.**
Zoning Change	Approximately 1,038 acres are proposed to be rezoned from Rural Residential to Low-Density Country Residential. If carried out, this change will result in minimum three-acre lots where previously the minimum lot size was one acre.		*Buildout Analysis*: We rezoned Rural Residential to Low-Density Country Residential in the Auburn portion of the watershed so that the minimum lot size increased from 1 to 3 acres.

Category	Existing Ordinance	Proposed Ordinance	*Model*: Modeling Approach
	Auburn's Chapter 60 – Zoning, Article IV. – District Regulations, Division 2 – Agriculture and Resource Protection District use regulations provide restrictive standards for new development and are only approved on a case-by-case basis.	No change.	*Buildout Analysis*: We removed new development in the Agriculture and Resource Protection Zone. **The original "Business As Usual" model scenario showed 74 projected new buildings in the Agriculture and Resource Protection Zone, which posed as a limitation to directly comparing the results between the model runs.**
Phosphorus Control Plans	Section 60-1066 (1) concerns the applicability of the ordinance, with any new building or structure of 575 square feet of ground floor area requiring the creation of a Phosphorus Control Plan – essentially a detailed stormwater management plan that includes estimated phosphorus loading calculations.	The proposed change requires any new building of 200 square feet of ground floor area to develop a Phosphorus Control Plan, making the applicability much broader.	*Watershed-Lake Model:* For the broader application of Phosphorus Control Plan requirements on new development in the watershed, we will want to consider the fact that the change from 575 square feet to 200 square feet would largely only extend phosphorus controls to accessory buildings or additions since primary dwellings are already required to submit a Phosphorus Control Plan. In addition, the "Business As Usual" model scenario did not account for low impact development (LID) standards that would be implemented as a result of a Phosphorus Control Plan, so we recommend comparing the new model run results to the "Business As Usual + LID" model scenario. According to the Phosphorus Control Ordinance, the per-acre phosphorus allocation for new development in the Lake Auburn watershed is 0.047 lbs. per acre (0.060 lbs. per acre when including background levels) which would amount to 0.180 lbs. per year on a 3-acre lot. The phosphorus export for low density residential development assumed in the model is roughly 0.652 lbs. per acre. Applying LID adjustments (30% less impact area, 70% reduced phosphorus export) lowers the phosphorus export for low density residential development to roughly 0.121 lbs. per acre which would amount to 0.170 lbs. per year on a 3-acre lot with 1 acre of developed area and 2 acres of forest land. Despite the model appearing to meet the allowable phosphorus allocation per built lot, it is important to note that these are rough average estimates since the model adjusts the phosphorus export from any given parcel of land based on accumulation and runoff with dry and wet spells. There may be times when the phosphorus export is lower than the allowable phosphorus allocation and other times when it is higher. **Note**: The City of Auburn uses 450-ft-deep "residential strips" to effectively limit the construction of new roads in rural areas, most especially in the Lake Auburn watershed. Therefore, our assumption that each new building will slightly increase the amount of roadway in the area may not be applicable at least in the Auburn portion of the watershed. In addition, most new built lots in the watershed are less than one-half acre of developed area as opposed to the model assumption of one-acre (which was based on the average existing developed area per existing building in the watershed). Adjusting these model assumptions should be considered in a future model run but will likely have a negligible impact to the total phosphorus load and in-lake total phosphorus concentration.

Table 2. Agricultural land cover by sub-basin within a 50 ft and 100 ft buffer from Lake Auburn and its ponds and perennial tributaries (within the City of Auburn).

Basin Name	Land Cover	50 ft Buffer		100 ft Buffer	
		Area (hectares)	Area (Acres)	Area (hectares)	Area (Acres)
Townsend Brook	Cropland	0.01	0.02	0.01	0.02
Townsend Brook	Hay/Pasture	0.77	1.89	1.94	4.78
West Auburn Rd-Youngs Corner-Gracelawn-Summer St	Cropland	0.04	0.10	0.31	0.78
	Total	**0.82**	**2.01**	**2.26**	**5.58**

NEW MODEL RUN RESULTS

Results of the buildout analysis incorporating the 2022 ordinance changes compared to the original baseline buildout analysis are provided in Tables 3 and 4 and shown in Figures 1-3. The ordinance changes only impacted the Auburn portion of the watershed, reducing the total buildable area by 955 acres and the number of projected new buildings by 155. However, these results reflect adjustments made to the buildout assumptions that more accurately apply existing ordinances. For example, new development in the Agriculture and Resource Protection zone was removed which accounted for 928 acres of buildable area and 74 projected new buildings. In addition, there were 23 projected new buildings identified within the 300 ft buffer under the original baseline buildout that the ordinance changes conservatively excluded due to the limitations of using the Table 4D soil profiles. Accounting for these adjustments, the ordinance changes directly reduced the total buildable area by 27 acres and the number of projected new buildings by 58. This indicates that the expansion of buildable area with the lifting of the septic system siting restriction (changing from 36" to 12" to limiting factor) was effectively offset by the reduction of buildable area with the rezoning of Rural Residential to Low Density Country Residential (changing from 1-acre to 3-acre minimum lot size).

Results of the watershed-lake model are provided in Table 5. The new model run reflecting the 2022 ordinance changes and other adjustments resulted in a predicted total phosphorus load of 937 kg/yr and an in-lake total phosphorus concentration of 9.3 ppb. Compared to the "Business As Usual + LID" model scenario, the ordinance changes and other adjustments reduced the total phosphorus load by 6 kg/yr and the in-lake total phosphorus concentration by 0.1 ppb. Although a small change, the reduction entered a new tier or probability bracket for bloom risk, lowering it slightly from 40% to 30-40% with taste/odor complaints still possible but slightly less likely and filtration waiver violation remaining a low risk.

To meet the goal of 900 kg/yr total phosphorus load and 9.0 ppb in-lake total phosphorus concentration in the future at full buildout, additional changes to development strategies that limit total phosphorus export will be needed. While the City of Auburn has taken valuable action to put phosphorus controls in place on new development, the goal cannot be ultimately met without the cooperation of headwater towns to implement similar development strategies controlling phosphorus in the watershed.

Table 3. Amount of total and buildable land by town and zone in the Lake Auburn watershed. Results of the new model run incorporating the 2022 ordinance changes are compared to the original baseline buildout analysis. Note: the total area for the City of Auburn's zones, Low Density Country Residential and Rural Residential, are split between two values to show that Rural Residential was rezoned to Low Density Country Residential as part of the new model run incorporating the 2022 ordinance changes; the first value represents conditions under the original baseline buildout, and the second value represents conditions under the 2022 ordinance changes baseline buildout.

Zone	Total Area (acres)*	Original Baseline Buildout		2022 Ordinance Changes Baseline Buildout	
		Buildable Area (Acres)	Percent Buildable Area	Buildable Area (Acres)	Percent Buildable Area
Auburn					
Agriculture and Resource Protection	4,501	928	21%	0	0%
General Business	1	0	0%	0	0%
Low Density Country Residential	298 / 1,170	56	19%	322	28%
Neighborhood Business	2	0	0%	0	0%
Rural Residential	873 / 0	292	33%	0	0%
Suburban Residential	371	5	1%	5	1%
Buckfield					
General Development	155	154	100%	154	100%
Hebron					
General Development	175	83	47%	83	47%
Minot					
Rural District	843	414	49%	414	49%
Turner					
Commercial	19	11	58%	11	58%
General Residential I	94	59	63%	58	62%
General Residential II	219	99	45%	99	45%
Rural I	1,252	914	73%	914	73%
Rural II	634	527	83%	527	83%
Resource Protection	266	38	14%	38	14%
Shoreland Protection	110	30	27%	30	27%
Total	**9,811**	**3,610**	**37%**	**2,655**	**27%**

Table 4. Number of existing, projected, and total buildings by town and zone in the Lake Auburn watershed. Results of the new model run incorporating the 2022 ordinance changes are compared to the original baseline buildout analysis. Note: the number of existing buildings for the City of Auburn's zones, Low Density Country Residential and Rural Residential, are split between two values to show that Rural Residential was rezoned to Low Density Country Residential as part of the new model run incorporating the 2022 ordinance changes; the first value represents conditions under the original baseline buildout, and the second value represents conditions under the 2022 ordinance changes baseline buildout.

Zone	No. Existing Buildings	Original Baseline Buildout			2022 Ordinance Changes Baseline Buildout		
		No. Proj. Buildings	Total No. Buildings	Percent Increase	No. Proj. Buildings	Total No. Buildings	Percent Increase
Auburn							
Agriculture and Resource Protection	77	74	151	96	0	77	0
General Business	2	0	2	0	0	2	0
Low Density Country Residential	47 / 265	16	63	34	79	344	30
Rural Residential	218 / 0	143	361	66	0	0	0
Suburban Residential	75	6	81	8	6	81	8
Buckfield							
General Development	2	106	108	5,300	106	108	5,300
Hebron							
General Development	13	17	30	131	17	30	131
Minot							
Rural District	49	99	148	202	99	148	202
Turner							
Commercial	6	7	13	117	7	13	117
General Residential I	15	40	55	267	40	55	267
General Residential II	50	29	79	58	29	79	58
Rural I[2]	66	311	377	471	310	376	470
Rural II	14	61	75	436	61	75	436
Resource Protection	21	15	36	71	15	36	71
Shoreland Protection	23	14	37	61	14	37	61
Total	**678**	**938**	**1616**	**138**	**783**	**1,461**	**115**

[2] The original baseline buildout from May 2021 predicted 311 buildings. There were no changes to development constraints in Turner, so this difference is likely due to small differences in how the buildings were randomly placed by the model.

Table 5. Baseline and select scenario model results for total phosphorus (TP) load (kg/yr) and in-lake TP concentration (ppb), along with gross estimates for water quality risks related to drinking water and recreation in Lake Auburn. The new model run is highlighted in gray.

SCENARIO	YEAR	TP LOAD (KG/YR)	TP (PPB) - AVG	TP (PPB) - MIN	TP (PPB) - MAX	Bloom Risk	Taste/Odor	Filtration Waiver Violation Risk	Filtration Plant Needed?
Baseline or "Existing Conditions"	2018	1,114	10.9	9.2	14.4	40%	Complaints	None	No, borderline for taste/odor
Baseline + Alum Treatment	2020	842	8.3	6.6	11.8	10%	Likely Few Complaints	Likely None	No
Baseline + Alum Treatment + Climate Change (RCP 4.5) + Future "Business As Usual" Buildout (No Code Changes)	2100	957	9.5	7.8	13.0	40%	Complaints Likely	Low Risk	Likely no, but borderline for taste/odor
Baseline + Alum Treatment + Climate Change (RCP 4.5) + Future "Business As Usual" Buildout (No Code Changes) + Low Impact Development Standards	2100	943	9.4	7.7	12.9	40%	Complaints Likely	Low Risk	Likely no, but borderline for taste/odor
Baseline + Alum Treatment + Climate Change (RCP 4.5) + Future "Business As Usual + 2022 Ordinance Changes" Buildout (Code Changes) + Low Impact Development Standards	2100	937	9.3	7.6	12.8	30-40%	Complaints Possible	Low Risk	Likely no, but potentially for taste/odor
Lake Auburn Water Quality Goal Recommendation	2100	900	9.0			10-20%	Few Complaints	Low	No

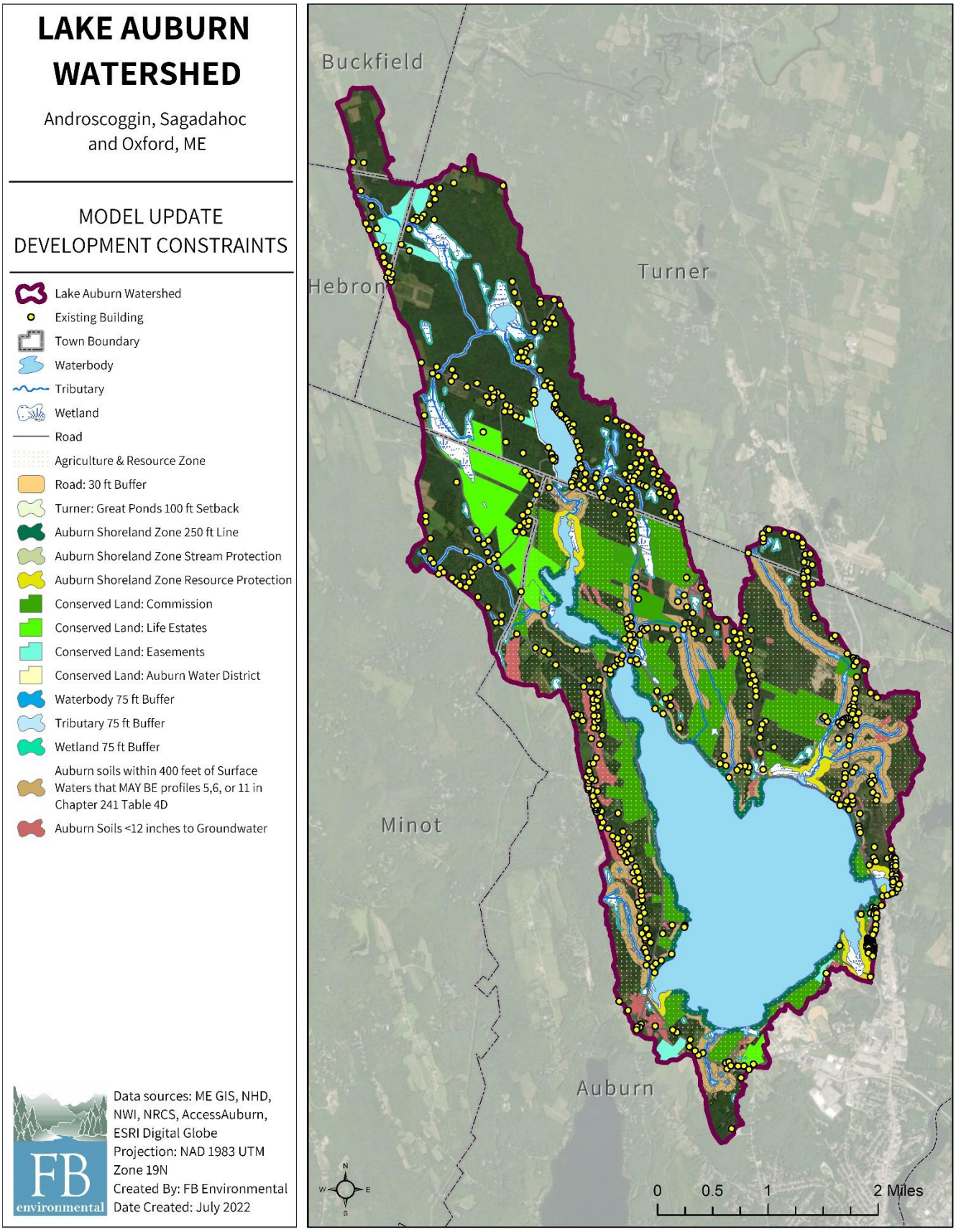

Figure 1. Development constraints in the Lake Auburn watershed for the 2022 ordinance changes baseline buildout analysis.

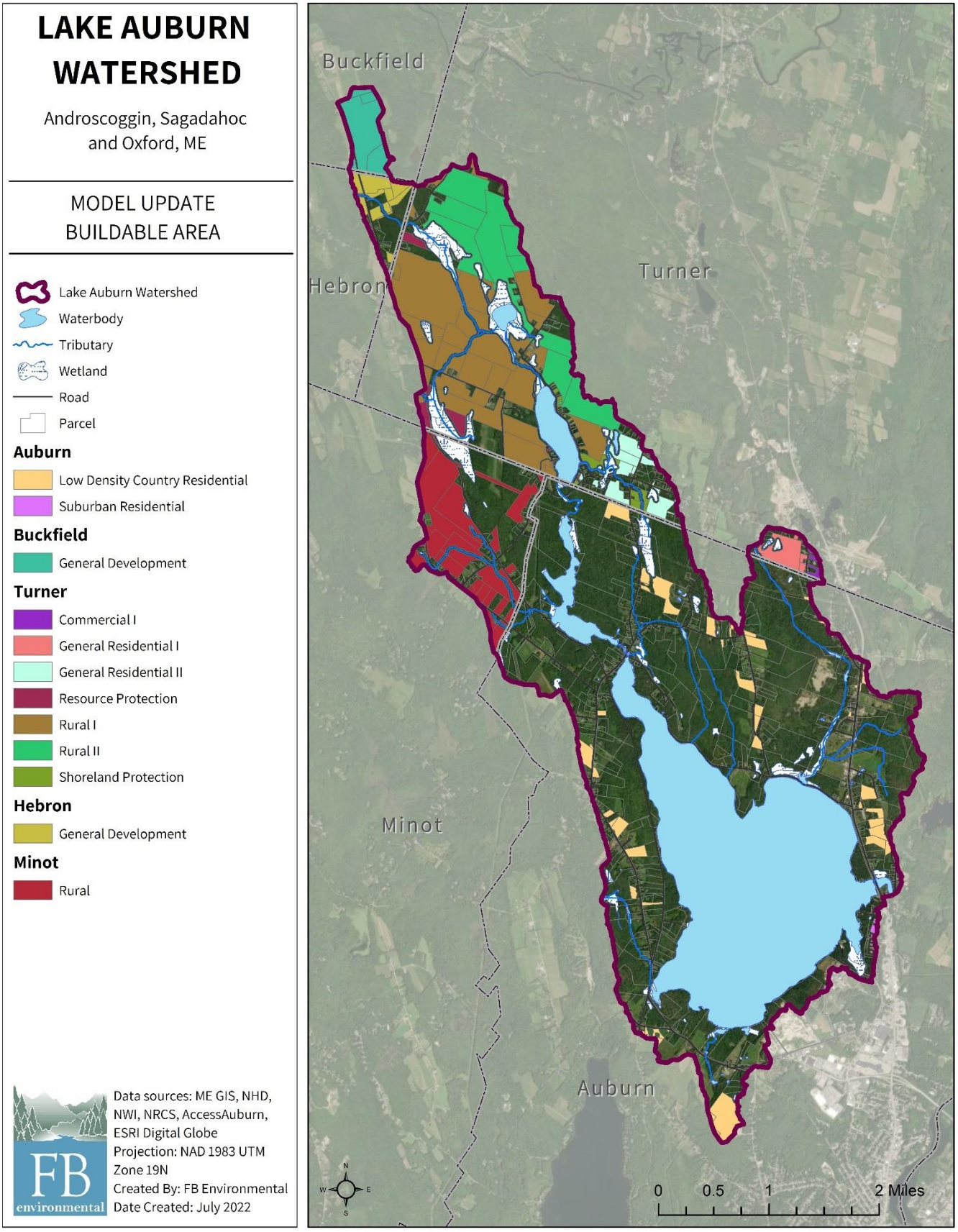

Figure 2. Buildable area in the Lake Auburn watershed for the 2022 ordinance changes baseline buildout analysis.

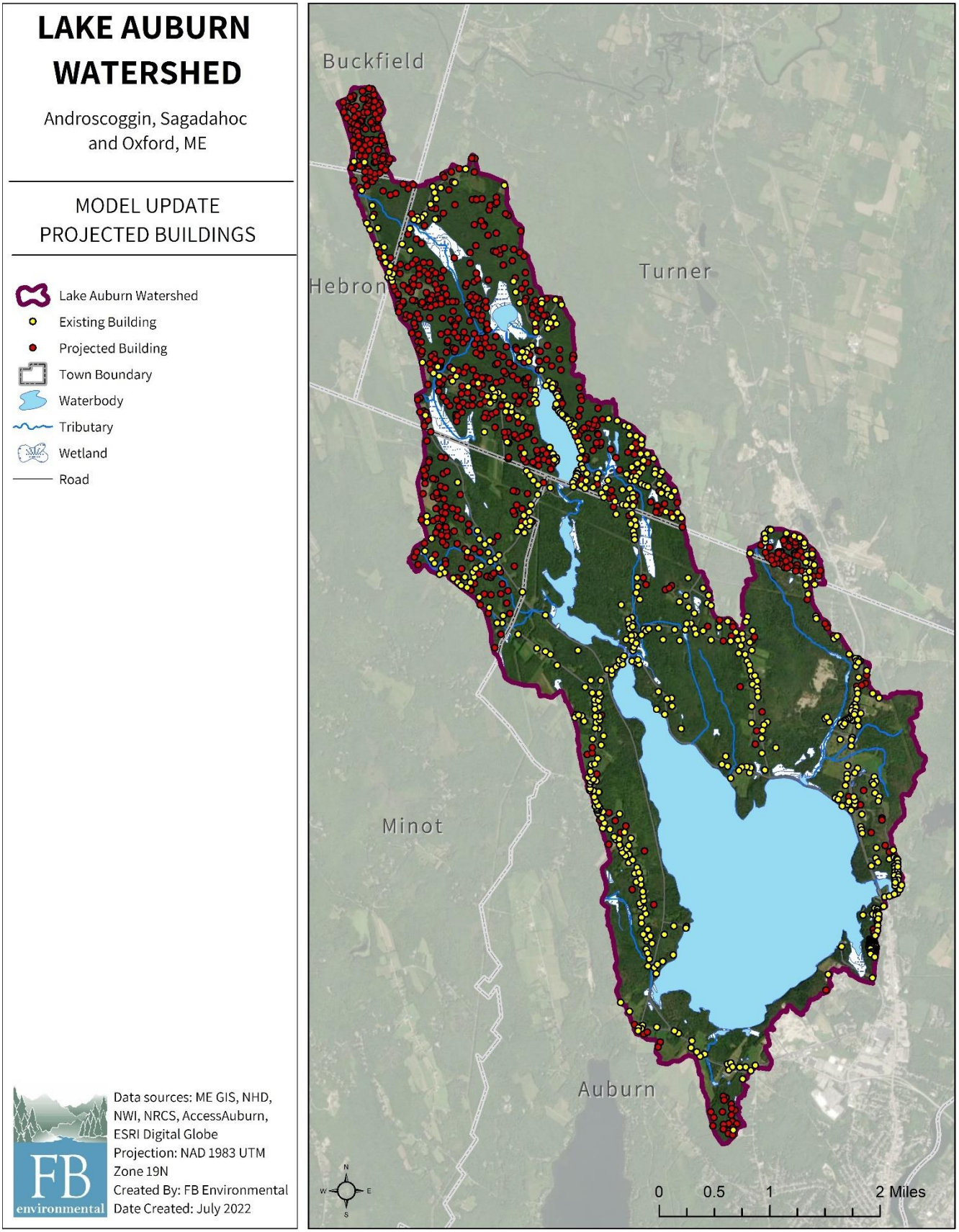

Figure 3. Existing and projected buildings in the Lake Auburn watershed for the 2022 ordinance changes baseline buildout analysis.

FUTURE SCENARIO CONSIDERATIONS

Considering additional nutrient attenuation by improved septic systems in the watershed. The City of Auburn will be requiring the use of diversion ditches and curtain drains for all septic system siting conditions. Diversion ditches and curtain drains divert surface and ground water away from leachfields to optimize the performance of septic systems, including their nutrient reduction potential (note: conventional septic systems are only designed for pathogen not nutrient removal; any nutrient removal is a byproduct of the design and is only optimized when an adequate biomat is established and maintained over time; the City of Auburn could consider requiring the installation of advanced treatment systems that directly target and reduce nutrients in sensitive environmental areas). The model already assumes that 90% of phosphorus in effluent is treated by an optimally functioning system and native soil. Additional research would be required to determine the validity of applying an adjustment factor to the phosphorus attenuation factor assumed for septic systems in the model. Even if an adjustment factor was justified in the literature, the change would likely be small and within the margin of uncertainty in the model. At the City's request, FBE could also make all existing and projected septic systems "new"[3] in the model to determine the possible improvement to in-lake water quality from upgrading all septic systems in the Auburn portion of the watershed (note: this would only be for shoreline septic systems; watershed septic systems are inherent to the land use export coefficients and would require additional research and consideration to tease out).

Including nitrogen modeling for Lake Auburn. The model can also predict nitrogen load and in-lake nitrogen concentrations, but additional work would be required to calibrate the model for nitrogen.

Strategizing how to achieve the target 900 kg/yr phosphorus load to Lake Auburn. The 2021 modeling effort set a target phosphorus load of 900 kg/yr for Lake Auburn to maintain good water quality and its filtration waiver. Model simulations for various circumstances would need to be played out to come up with one or more strategies for achieving the target load.

[3] Currently, the shoreline septic system load is a coarse estimate that splits the systems into "old" (>25 yrs) and "new" (<25 yrs) with a difference of 20% attenuation and 10% attenuation assumed for phosphorus, respectively. New systems are added to the model and split between the two age groups based on a similar ratio as existing old/new systems. This is because the model is projecting out to the end of the century - a system that is installed today will become "old" in 25 years and would likely be replaced a few times by the end of the century and alternate between those two age groups. A more nuanced analysis would take more research and discussion.