memo

Project Name |	Weise Property Park Master Plan	**Date** |	3/5/2021
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Regarding |	Water Quality and Discharge (Runoff) Comparison		

1. BACKGROUND

Sherburne County is developing a master plan to obtain funding for a future park. The 430-acre potential park property features over a mile of shoreline along Elk Lake (Figure 1). When evaluating the benefits that the park may bring to the County, it is critically important to evaluate what role the park could play in terms of reducing stormwater runoff and total phosphorus delivery to Big Elk (Elk) Lake. Elk Lake is listed by the Minnesota Pollution Control Agency (MPCA) as impaired for Aquatic Recreation, meaning the lake is not supporting designated uses such as fishing, swimming, and water sports. The specific reason is excessive nutrients, primarily total phosphorus. Elk Lake is considered a shallow lake with a numeric target of 60 µg/L total phosphorus concentration.

Master Planning for Potential Future County Park | Property Basemap

** The property is still privately owned and not accessible to the public **

SHERBURNE COUNTY

Figure 1.Proposed Park Location

1.1. 2014 TMDL Study

Data and modeling from the 2014 Elk River Watershed Association Total Maximum Daily Load (TMDL) Study indicated that a 62% phosphorus load reduction to Elk Lake is required to meet the 60 ug/L total phosphorus concentration (Table 1). Section 8.3.2 of the 2014 TMDL study identified priority load management strategies for Elk Lake. Because the lake is sensitive to mid to late summer watershed loads, the plan suggests focusing on reducing loads from agricultural lands in high priority areas like the proposed park location, which is directly adjacent to Elk Lake.

Table 1. Elk Lake average year phosphorus and load reductions – Source: 2014 TMDL Table 8.3

	Pounds of Phosphorus/ year			
Category	Existing	Goal	Reduction	Reduction (%)
Direct Watershed	95	22	73	77%
Tributaries	15,438	3,551	11,887	77%
SSTS	529	0	529	100%
Atmospheric & Groudnwater	402	402	0	0%
Internal	3,613	3,613	0	0%
Total	20,077	7,587	12,490	62%

1.2. Mississippi River St. Cloud Watershed HSPF Model

Elk Lake is part of the Mississippi River – St. Cloud HUC-8 Watershed. In 2015, the MPCA finalized a Hydrologic Simulation Program FORTRAN (HSPF) model for the Mississippi River – St. Cloud Watershed. HSPF models simulate hydrology and water quality parameters on a watershed basis and can be used to evaluate the potential benefits to water quality resulting from a land use change (e.g., conversion of cropland to parkland).

The tributaries to Elk Lake (Elk River, Lily Creek, and Unnamed Creek) and their corresponding sub-watersheds (Basins) are already broken out as distinct subwatersheds in the existing HSPF model (Figure 2). EOR extracted the Basin Source Load Rate from each different land use category in the HSPF Basins that directly drain to Elk Lake. The Basin Source Load Rate is the sum of the constituent (e.g., total phosphorus yield) at the outlet of each HSPF Basin aggregated by source (e.g., cropland) and divided by area in acres to get the total local yield per acre coming from each unique combination of source within a given HSPF basin (Table 2 and Table 3).

Table 2. Mississippi River - St. Cloud HSPF Model – Total, Total Phosphorus (lbs/acre/year)

Miss. R. - St.Cloud HSPF Model Results - Total Total Phosphorus (lbs/acre/year) Basin Source Load Rate													
	Developed EIA, (Impervious)	Developed (Pervious)	Forest Deciduous AB	Forest Deciduous CD	Forest Conifer AB	Forest Conifer CD	Grassland	Pasture AB	Pasture CD	Wetland	Forest Young AB	Cropland	Feedlot
A510	0.35	0.09	0.04	0.04	0.03	0.03	0.07	0.00	0.00	0.06	0.05	0.43	0.85
A517	0.35	0.09	0.04	0.04	0.03	0.00	0.07	0.00	0.00	0.06	0.00	0.43	0.00
A591	0.35	0.09	0.04	0.04	0.03	0.03	0.07	0.14	0.00	0.06	0.00	0.43	
A620	0.35	0.09	0.04	0.04	0.03	0.03	0.07	0.00	0.00	0.06	0.00	0.43	0.00
Average	**0.35**	**0.09**	**0.04**	**0.04**	**0.03**	**0.02**	**0.07**	**0.04**	**0.00**	**0.06**	**0.01**	**0.43**	**0.28**

Table 3. Mississippi River - St. Cloud HSPF Model – Total Discharge (Acre-Feet/acre/year)

Miss. R. - St.Cloud HSPF Model Results - Basin Source Load Yield (Acre-feet/acre/year)													
	Developed EIA, (Impervious)	Developed (Pervious)	Forest Deciduous AB	Forest Deciduous CD	Forest Conifer AB	Forest Conifer CD	Grassland	Pasture AB	Pasture CD	Wetland	Forest Young AB	Cropland	Feedlot
A510	1.76	0.56	0.30	0.30	0.23	0.24	0.50	-----	-----	0.50	0.40	0.54	0.74
A517	1.76	0.56	0.30	0.30	0.23	-----	0.50	-----	-----	0.50	-----	0.54	0.00
A591	1.76	0.56	0.30	0.30	0.23	0.24	0.50	0.63	-----	0.50	-----	0.54	0.00
A620	1.76	0.56	0.30	0.30	0.23	0.24	0.50	-----	-----	0.50	-----	0.54	0.00
Average	**1.76**	**0.56**	**0.30**	**0.30**	**0.23**	**0.24**	**0.50**	**0.63**	**N/A**	**0.50**	**0.40**	**0.54**	**0.19**

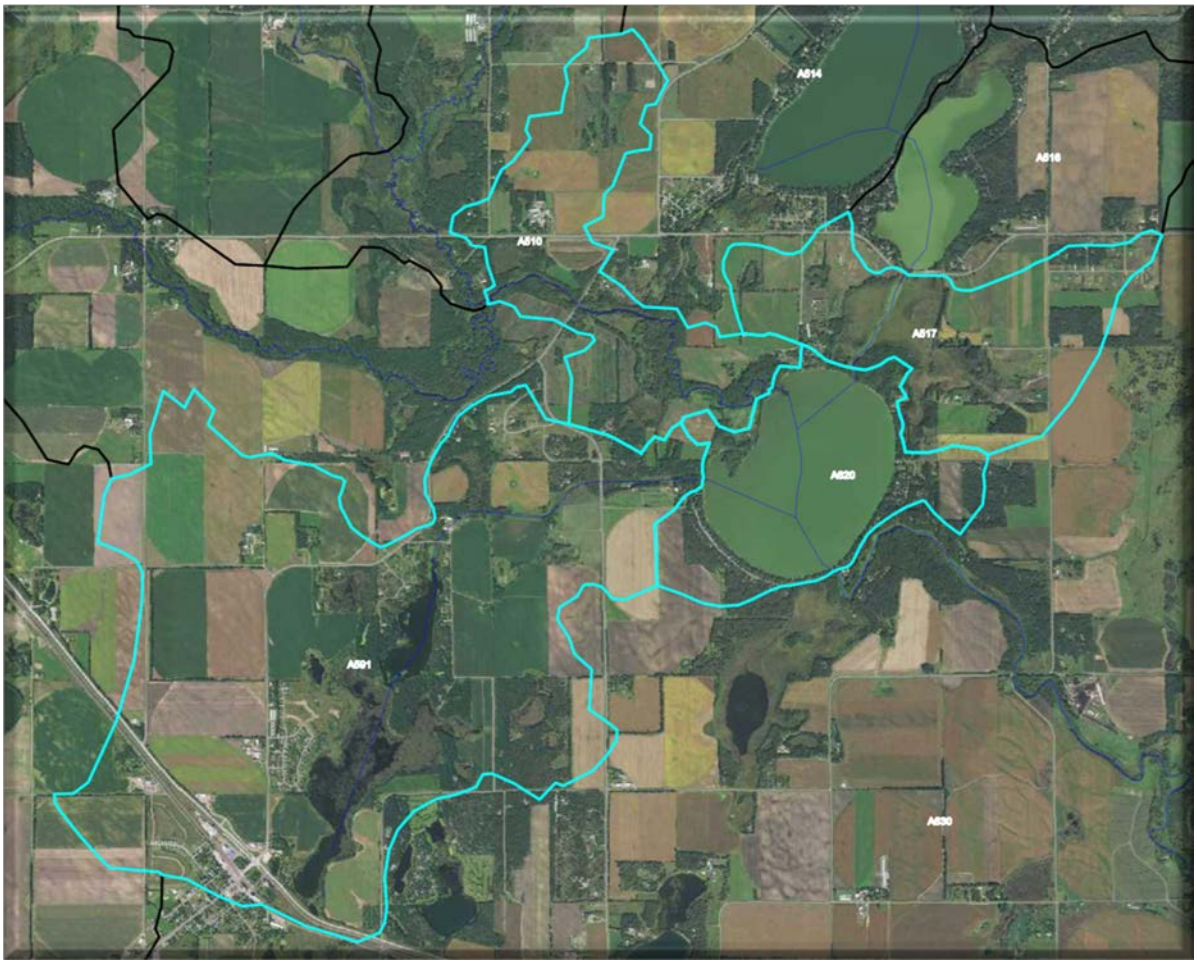

Figure 2. Contributing HSPF Model Basins to Elk Lake

2. HSPF MODEL ANALYSIS

2.1. Existing vs. Proposed Loading Rates

EOR extracted total phosphorus (TP) loading and discharge (runoff) information on a per-acre basis for each land use present as shown in Table 2 and Table 3. From this information, EOR was able to determine an average per acre TP loading and discharge rate for the existing conditions (cropland, developed, forest, grassland), proposed parkland conditions, a potential 0.5-acre residential development, and a 0.25-acre residential development scenario (Table 4).

2.1.1. Future Land Use Assumptions

Parkland

Parkland TP loading and discharge rates were determined using the average TP loading rate per acre from parkland-like land uses in the direct drainage area to Elk Lake. Existing parkland-like land uses in the direct drainage area include grasslands, deciduous forest, conifer forest, and young forest. The vegetation composition of the proposed park would consist of an oak-savanna with approximately 30% tree cover (deciduous trees) and 70% grassland cover. Existing, non-cropland land uses would remain as is, and are not subject to change. The only land that would change under a future parkland scenario would be the existing cropland areas.

Residential Development

Figure 9.56 of Sherburne County's Comprehensive Land use Plan for 2010 – 2030 shows the future planned land use around Elk Lake as being zoned agricultural (A-2). The A-2 Zoning District requires larger residential lots (>2.5 acres). This area could be rezoned through a conditional use permit to a Residential Planned Unit Development (R-PUD). R-PUD must be a minimum of 30-acres in size, and require a rezoning to an R-PUD Overlay District A or B. A Conditional Use Permit (CUP) is required for the R-PUD, and they must be approved by the Town Board and County Board. The intent when the R-PUD ordinance was written was for town boards to identify conservation corridors (R-PUD Overlay District B) where R-PUDs with open space would be encouraged resulting in contiguous open space corridors. There are two different types of R-PUD's in Sherburne County:

(A) requires a minimum lot size of **1.5-acres** with each lot using an individual septic system, and requires no open space; and

(B) requires a minimum lot size of **½-acre** with each lot using a common septic system, and requires that **at least half the development** be conserved as open space.

EOR modeled a future residential development scenario by assuming approximately 10% of a future development (½ - acre parcels) would be impervious surfaces (houses, garage, sidewalks, driveways) and 90% would be developed, but pervious (lawns, open spaces). This assumption is based on an average impervious footprint of 4,000 square feet on a 0.25 acre lot, and also takes into consideration that at least half the development would be conserved as open space in accordance with the County's zoning ordinance for R-PUD Overlay District B.

Lakeshore Development

Lakeshore homes with potentially manicured lawns, impervious areas, and private septic systems located immediately adjacent to the lake represent a direct source of nutrients to the lake. As such, EOR modeled a future lakeshore development scenario by assuming approximately 40% of a future lakeshore development would be comprised of developed, impervious surfaces (houses, garage, sidewalks, driveways) and 60% would be developed, but pervious (lawns, open spaces).

Table 4. HSPF Model Basin Source Load Rates Existing vs. Proposed

Land Use	Runoff Estimate (Acre-Feet/Acre/Year)	Total Phosphorus Yield Estimate (Pounds/Acre/Year)
Existing: Cropland	0.54	0.43
Existing: Lakeshore Forest/Grassland/Rural Residence	0.46	0.07
Proposed: Residential Development (0.5-Acre Lots)	0.68	0.12
Proposed: Parkland Mosaic	0.44	0.06
Proposed: Lakeshore Residential Development (0.25-Acre Lots)	1.04	0.19

3. RESULTS

3.1. Export Coefficient Comparison

EOR extracted export coefficients for discharge (runoff) and total phosphorus for existing (cropland) and proposed (parkland, residential development) conditions as shown in Table 5. Model results indicate that the proposed conversion to parkland land uses would have the greatest water quality benefit to Elk Lake. However, the proposed development would also result in a reduction of phosphorus to Elk Lake so long as the development consisted of larger (0.5-acre lots) with dedicated open spaces. The modeled export coefficients aligned with literature values (Figure 3).

Table 5. HSPF Model Results.

Scenario	Land Use	Discharge Estimate (Acre-Feet /Year)	Discharge Difference (Acre-Feet/year)	Total Phosphorus Yield (lbs/Year)	Total Phosphorus Yield Difference (Pounds/Year)
Convert 1 Acre of Existing Cropland to Parkland	Cropland	0.54	Reduce runoff by 0.10 acre-feet/year for each acre of cropland that gets converted to parkland	0.43	Reduce phosphorus yields by 0.37 lbs/year for each acre that gets converted from cropland to parkland
	Parkland	0.44		0.06	
1 Acre of Residential Development (0.5 Acre Parcels) to Parkland	Residential Development	0.68*	Reduce runoff by 0.24 acre-feet/year for each acre that gets converted to parkland rather than converted to residential development	0.12*	Reduce phosphorus yields by 0.06lbs/year for each acre that gets converted to parkland rather than residential development
	Parkland	0.44		0.06	
1 Acre of Lakeshore Development (0.25 Acre parcels) to Parkland	Lakeshore Development	1.04*	Reduce runoff by 0.60 acre-feet/year for each acre that gets converted to parkland rather than converted to residential development	0.19*	Reduce phosphorus yields by 0.13 lbs/year for each acre that gets converted to parkland rather than lakeshore development
	Parkland	0.44		0.06	
Convert 1 Acre of Existing Cropland to Residential Development (0.5 Acre Lots)	Cropland	0.54	Increase in runoff of 0.14 acre-feet/year for each acre of cropland that gets converted to residential development (0.5 acre lots)	0.43	Reduce phosphorus yields by 0.31 lbs/year for each acre that gets converted from cropland to residential development (0.5 acre lots)
	Residential Development	0.68*		0.12*	

***The discharge (runoff) and phosphorus yields presented for future residential development scenarios reflect the assumption that no quantity/quality standards or stormwater best management devices (e.g., tree trench, infiltration basin) would be applied in future developments. Therefore, the reported benefits of converting to parkland vs. a residential development would be the maximum possible, and the benefit of converting cropland to residential would be the minimum possible as properly sited stormwater best management practices could significantly reduce loading from a future development.**

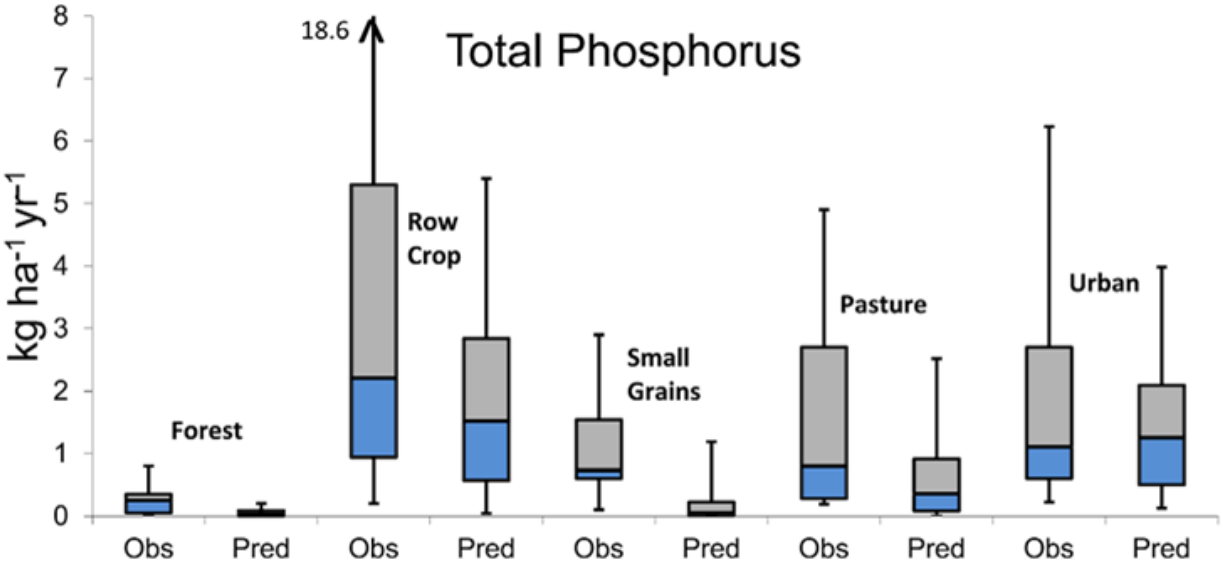

Figure 3. Total phosphorus export coefficient ranges. Source - Adapted from Beaulac and Reckhow (1982).

3.2. Convertible Lands - Subject to Change

In lieu of a formal wetland delineation, EOR assumed areas mapped as wetland in the National Wetland Inventory are not likely to be converted from their existing land use classification. By contrast, the most probable areas to be converted are the existing cropland areas (Figure 4). EOR identified a combined area of cropland that is most likely to be converted to either parkland or a future residential development of 162.7 acres. It should be noted that several cultural resources were identified near Elk Lake. These resources and/or other yet undiscovered cultural resources may further preclude residential development.

3.2.1. Lakeshore Development

A lakeshore development consisting of 0.25-acre lots is not consistent with Sherburne County's comprehensive plan and would not be permitted under existing zoning ordinances. Furthermore, much of the nearshore area is mapped as wetlands and/or is heavily forested. A lakeshore development would require purchasing and subdividing existing parcels along the lake. Last, some of the lakeshore areas are already partially developed with rural residences.

If a proposed lakeshore development was permitted, failing septic systems represent a potentially significant source of nutrients to Elk Lake. Loads from failing septic systems were included in the HSPF model as constant and are based on local information and literature values. The model assumes an average of 2.5 persons within each residence and each person within the residence was assumed to discharge 50 gallons per day (MPCA, 2004). Nutrient concentrations for phosphate (20 mg/L) were based on values presented in the Minnesota River Basin Turbidity TMDL and Lake Pepin Excessive Nutrient TMDL Tetra Tech (2002, 2009). This equates to an average TP load contribution of approximately 7.6 pounds per year for each household with a failing septic system.

Assuming an average parcel size of 0.25 acres and accounting for roads and other public spaces, approximately 60 residences could notionally fit within the delineated 19.4-acre lakeshore area. A 2017 MPCA study found that on average, approximately 20% of the individual septic treatment systems in the State are failing. However, given that these residences would largely be new construction, the failure rate would likely be 5% or less. The additional TP load generated from failing septic systems in 5% of constructed residences within the proposed lakeshore development would be approximately 23 pounds per year. This source of phosphorus would be alleviated if the proposed lakeshore development were connected to City sewer.

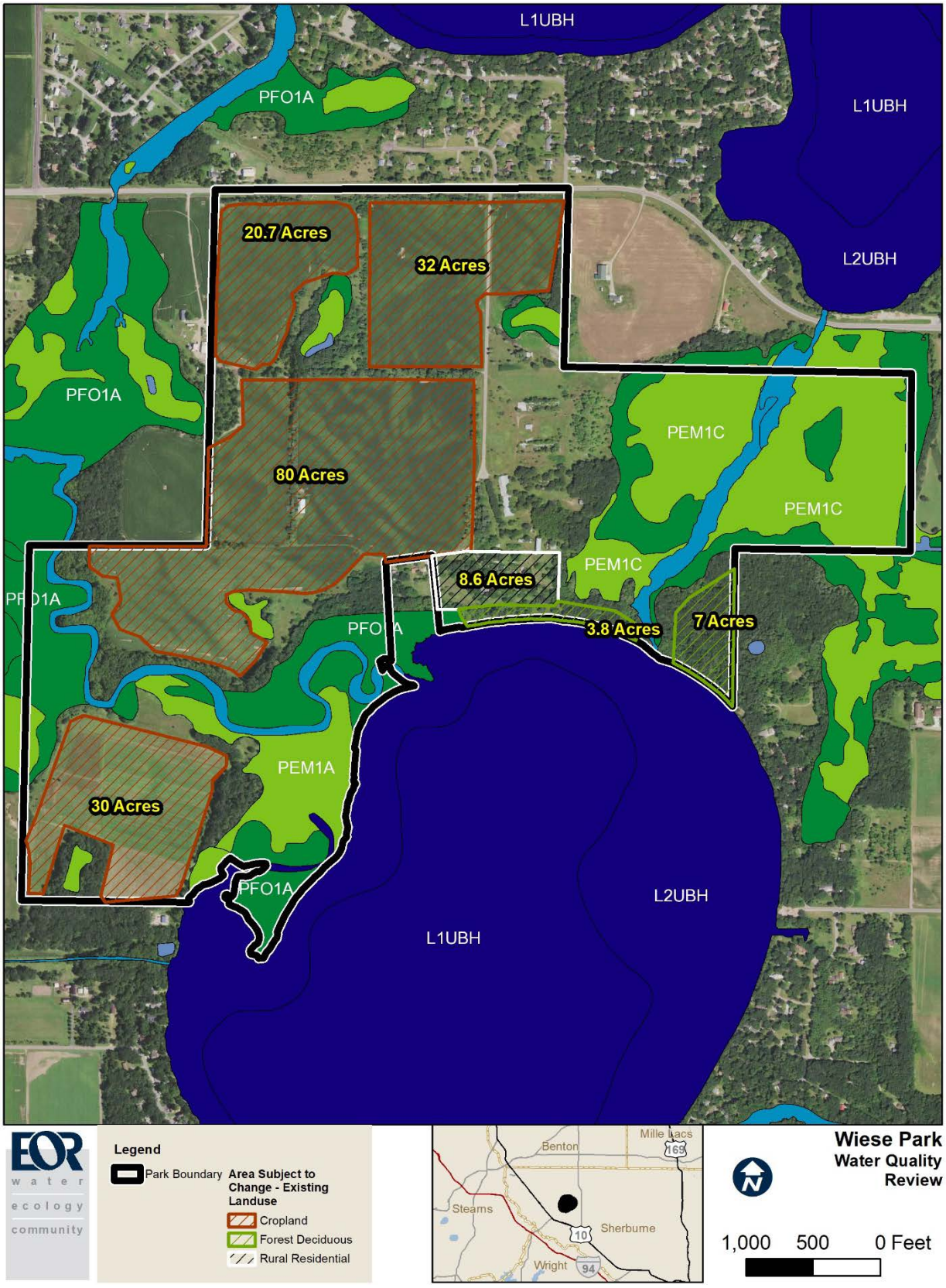

Figure 4. Future Land use Subject to Change.

3.3. Potential Benefits/Impacts to Elk Lake

3.3.1. Scenario 1

The 162.7-acre cropland area is converted from cropland to parkland.

Potential Benefits:

- ✓ A **reduction** of runoff to Elk Lake of 16.3 Acre-feet/year.
- ✓ A **reduction** of total phosphorus (TP) loading to Elk Lake of 60.2 pounds/year.

3.3.2. Scenario 2

The 162.7-acre cropland area is converted to parkland rather than a 0.5-acre residential development.

Potential Benefits:

- ✓ A **reduction** of runoff to Elk Lake of 39.1 Acre-feet/year.
- ✓ A **reduction** of TP loading to Elk Lake of 9.8 pounds/year.

3.3.3. Scenario 3

The 162.7-acre cropland area is converted from cropland to a 0.5-acre residential development.

Potential Benefits/Impacts:

- ✓ An **increase** of runoff to Elk Lake of 22.8 Acre-feet/year.
- ✓ A **reduction** of TP loading to Elk Lake of 50.4 pounds/year.

3.3.4. Scenario 4

The 19.4-acre lakeshore area is converted to parkland rather than converting to a 0.25-acre lakeshore development.

Potential Benefits:

- ✓ A **reduction** of runoff to Elk Lake of 11.6 Acre-feet/year.
- ✓ A **reduction** of TP loading to Elk Lake of 2.5 pounds/year

4. DISCUSSION

Results from a 2014 TMDL study of Elk Lake identified the need for significant reductions in TP loading. A review of land use export coefficients from an existing HSPF model of the immediate drainage area to Elk Lake suggest cropland is the most significant contributor of total phosphorus to Elk Lake. Because Elk Lake has a very large upstream drainage area and is particularly sensitive to mid to late summer watershed loads, the TMDL Implementation Plan recommended focusing on reducing loads from cropland located in high priority areas near the lake, fundamentally like the proposed park location.

Given the park will be located immediately adjacent to Elk Lake; the results presented may underestimate the amount of nutrients and runoff that could be prevented from entering the lake following a conversion from cropland to parkland. Results presented are only meant to bracket the discussion with regards to potential water quality benefits and are only based on a comparison of export coefficients.

The discharge (runoff) and phosphorus yields presented for future residential development scenarios reflect the assumption that no quantity/quality standards or stormwater best management devices (e.g., tree trench, infiltration basin) are currently being applied as part of the future residential development scenarios. Therefore, the reported benefits of converting to parkland versus a residential development represent the "maximum" possible, and the benefit of converting cropland to residential would be the "minimum" possible. Properly sited stormwater best management practices could significantly reduce loading from a future residential development. In the same vein, a future park could implement best management practices (shoreline restorations, rain gardens, iron-enhanced sand filters) designed to enhance water quality that could provide additional reductions.

Elk Lake is a flow-through waterbody with a very short residence time, and large upstream drainage area. The TMDL identified a TP load reduction of 12,490 pounds to meet the 60 ug/L shallow lake standard. Therefore, the results presented must be viewed in the proper context when evaluating the magnitude of TP loading currently entering the Lake.