Preliminary Analysis of Proposed CAFO in the Flower Creek Watershed

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January 10, 2018

General Site Characteristics

The proposed swine CAFO, located at 9105 S. 56th Ave, Montague, MI, is located within the Flower Creek Watershed (**Figure 1**), which is a designated a Hydrologic Unit Code (HUC) 12 watershed, #040601011007. This watershed has a drainage area of 85.5 km^2 (~33 mi^2), and drains directly to Lake Michigan.

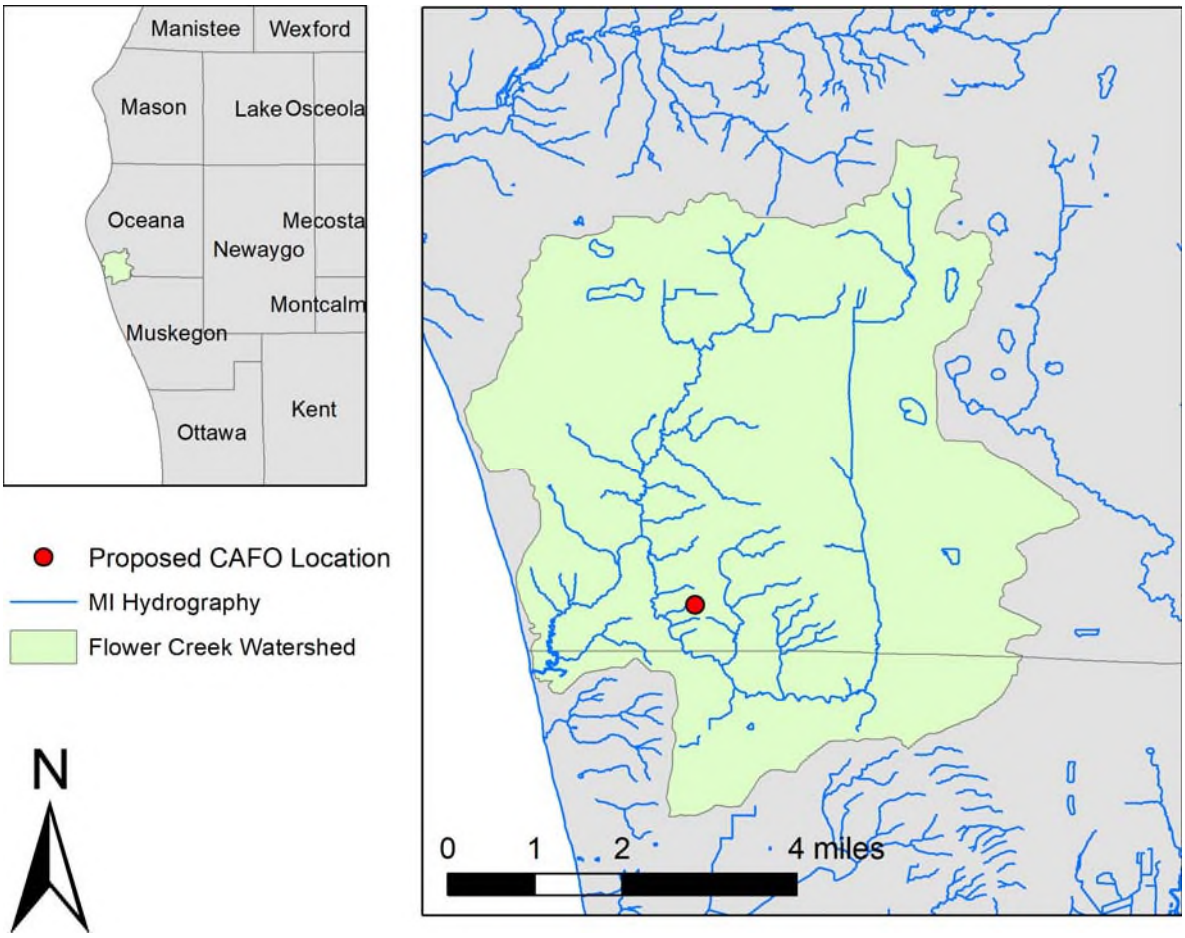

Figure 1. *Location of the proposed CAFO within the Flower Creek Watershed. The map at the top left locates the watershed within Oceana and Muskegon counties.*

The proposed CAFO is located along the southern branch of Flower Creek, and is proposed to have direct access from Flower Rd (**Figure 2**).

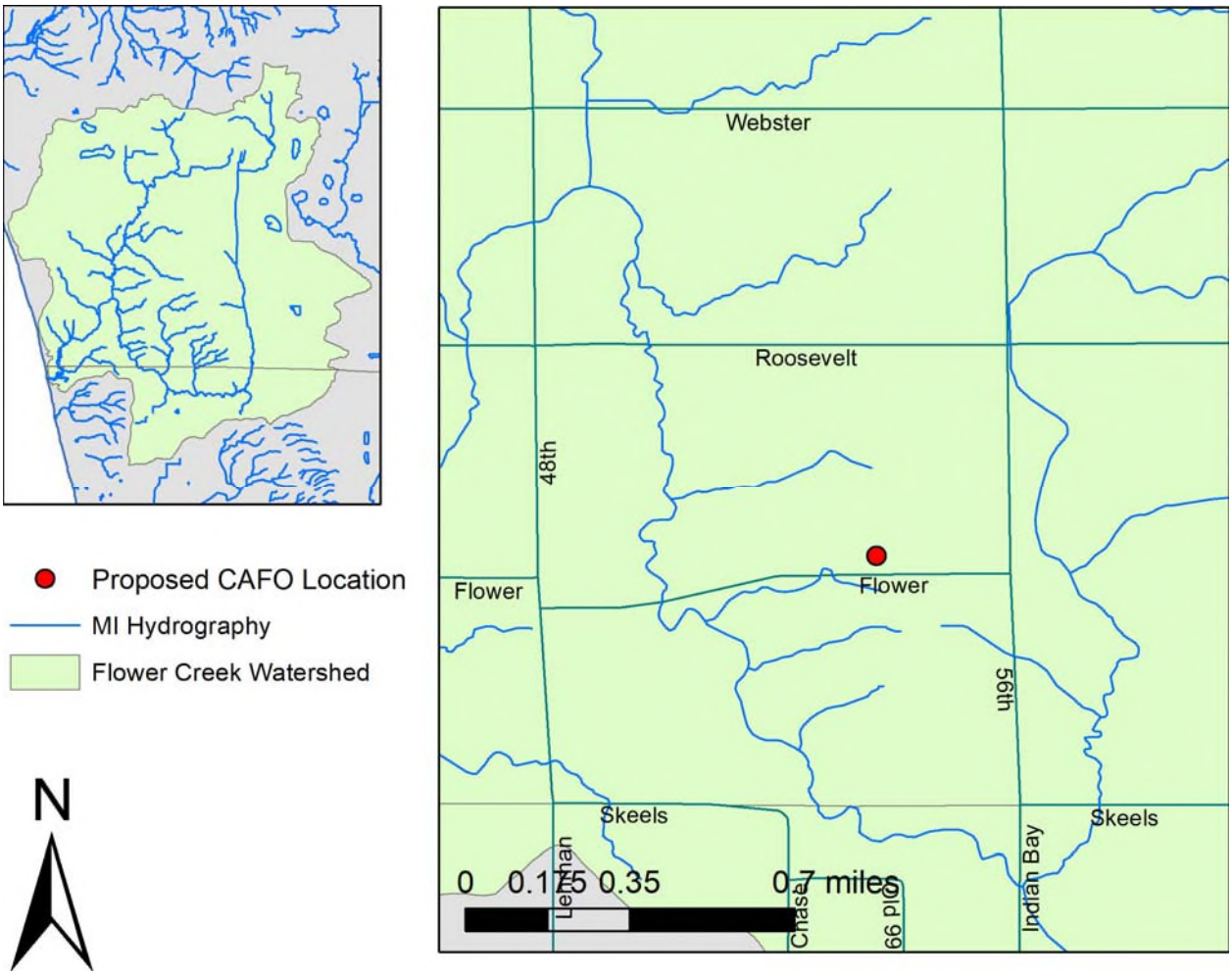

***Figure 2**. Location of the CAFO along Flower Rd., along the southern branch of Flower Creek.*

The proposed CAFO will house up to 4,000 swine for roughly 120 days at a time, and proposes to distribute its manure to neighboring farms. Due to the weight and transport expense involved with the liquid-heavy swine manure, much of this distribution is likely to happen to farms within a 1-2 mile radius. No specific information was available on the exact locations of farms that would be contracted. In some cases, manure distribution may require longer transport distances. In most cases, literature supports a distribution radius of generally less

than 5 miles. These three distances are shown as ring buffers on **Figure 3**, centered on the proposed CAFO location.

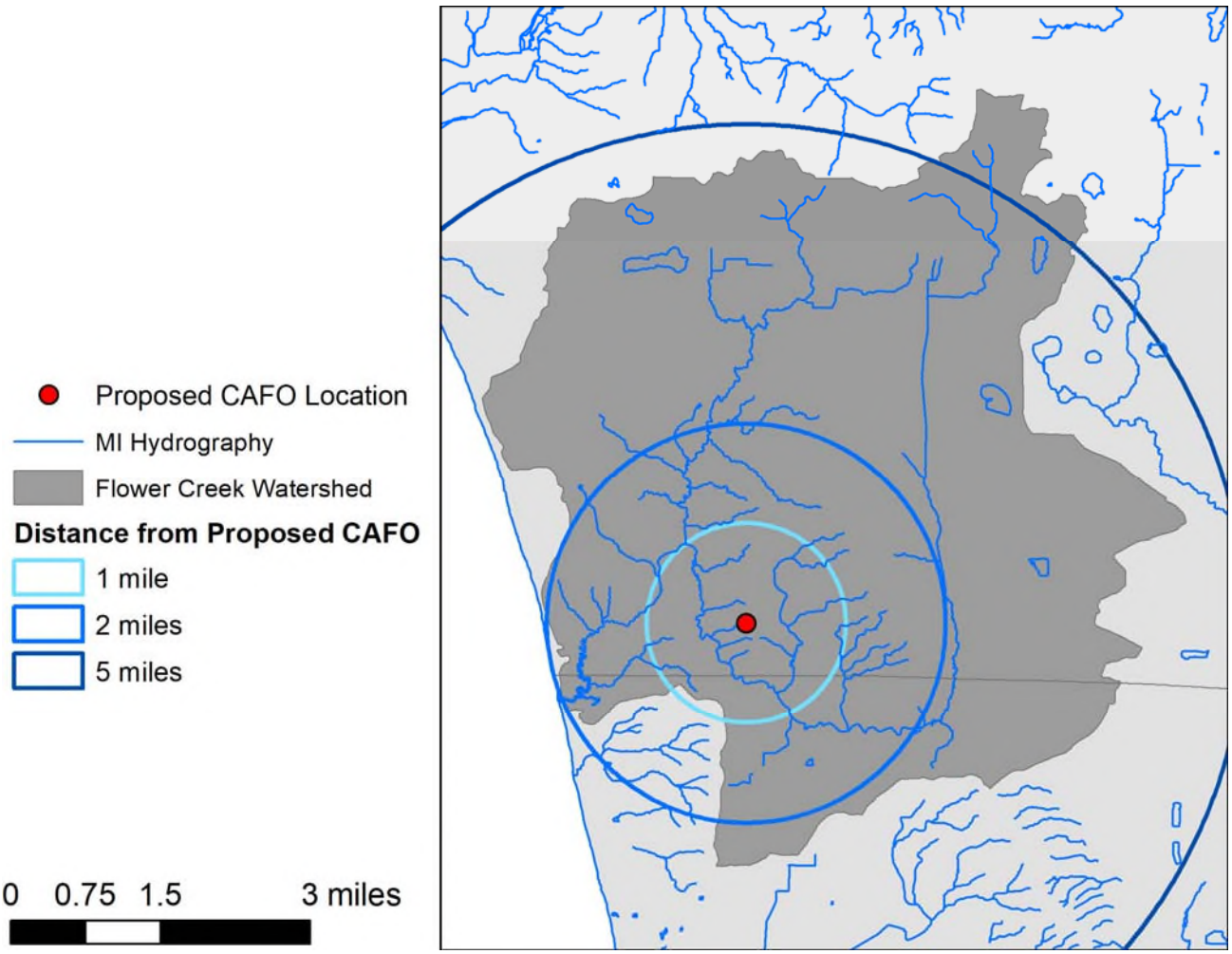

***Figure 3**. Map of the proposed CAFO location surrounded by ring buffers of 1, 2, and 5 mile radii.*

Surrounding the proposed CAFO site, the land cover/land use is predominantly agricultural, grasslands, and bare lands, consistent with a mixed row/field/pasture agricultural landscape (**Figure 4**).

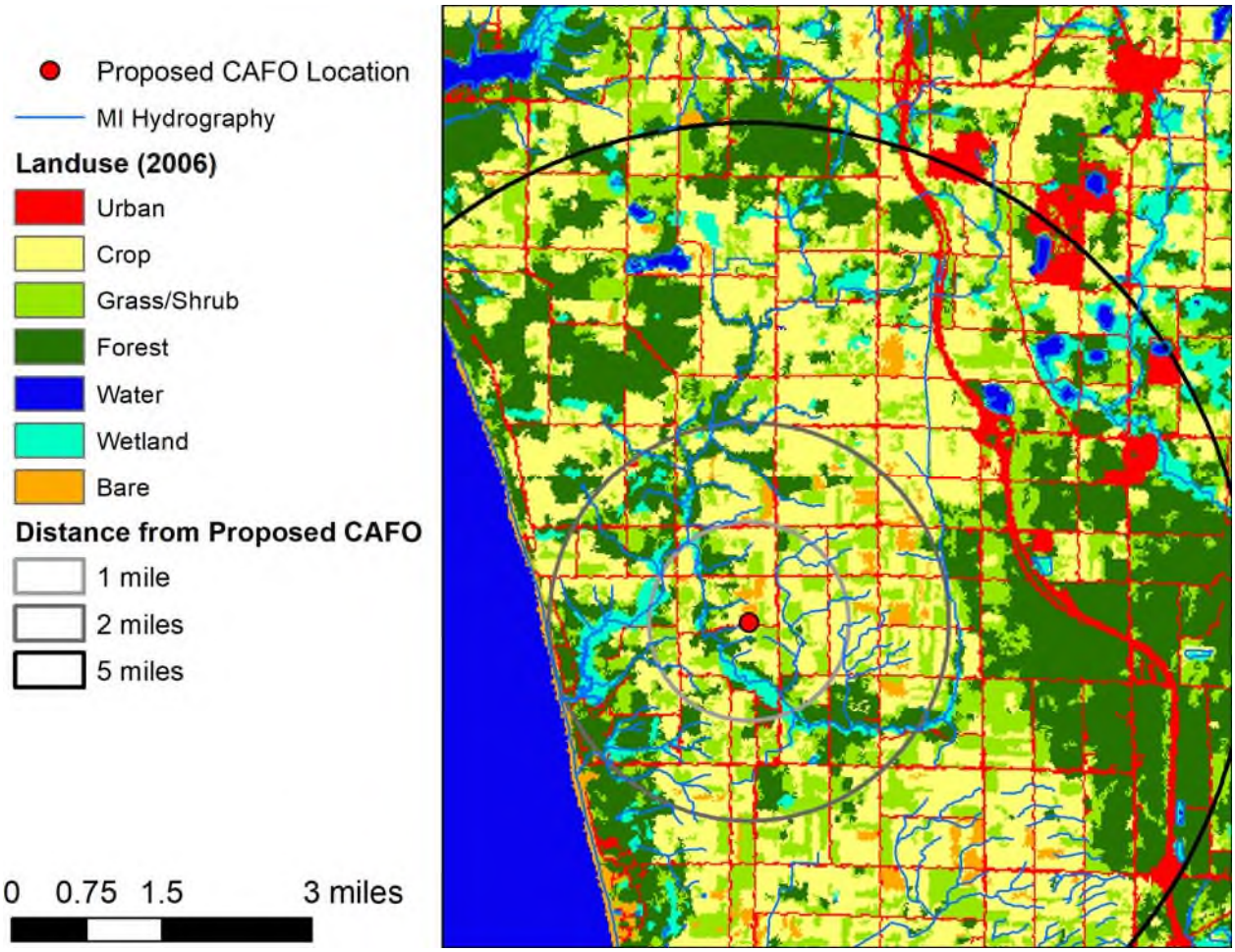

***Figure 4**. Land use characteristics surrounding the proposed CAFO site, overlain with the 1, 2, and 5 mile ring buffers. These are classified by the 2006 National Land Cover Dataset (NLCD), and aggregated into the Anderson Level-I classes shown here.*

The soils in the watershed are mostly sandy, with the exception of a wide band of clay-rich soils north and east of the site, along the east side of Flower Creek and its tributaries (**Figures 5 and 6**). Soils within the 1 and 2 mile buffers are approximately equal mixtures of high sand and high clay soils (low sand), while most of the soils within the 5 mile ring are sandier in texture. Soils with low sand content are more likely to cause overland flow runoff which would thus have higher likelihoods of Phosphorous transport to the surface water bodies such as Flower Creek. In contrast, Nitrogen is readily transported through high sand content soils such as those just to the East of the proposed site.

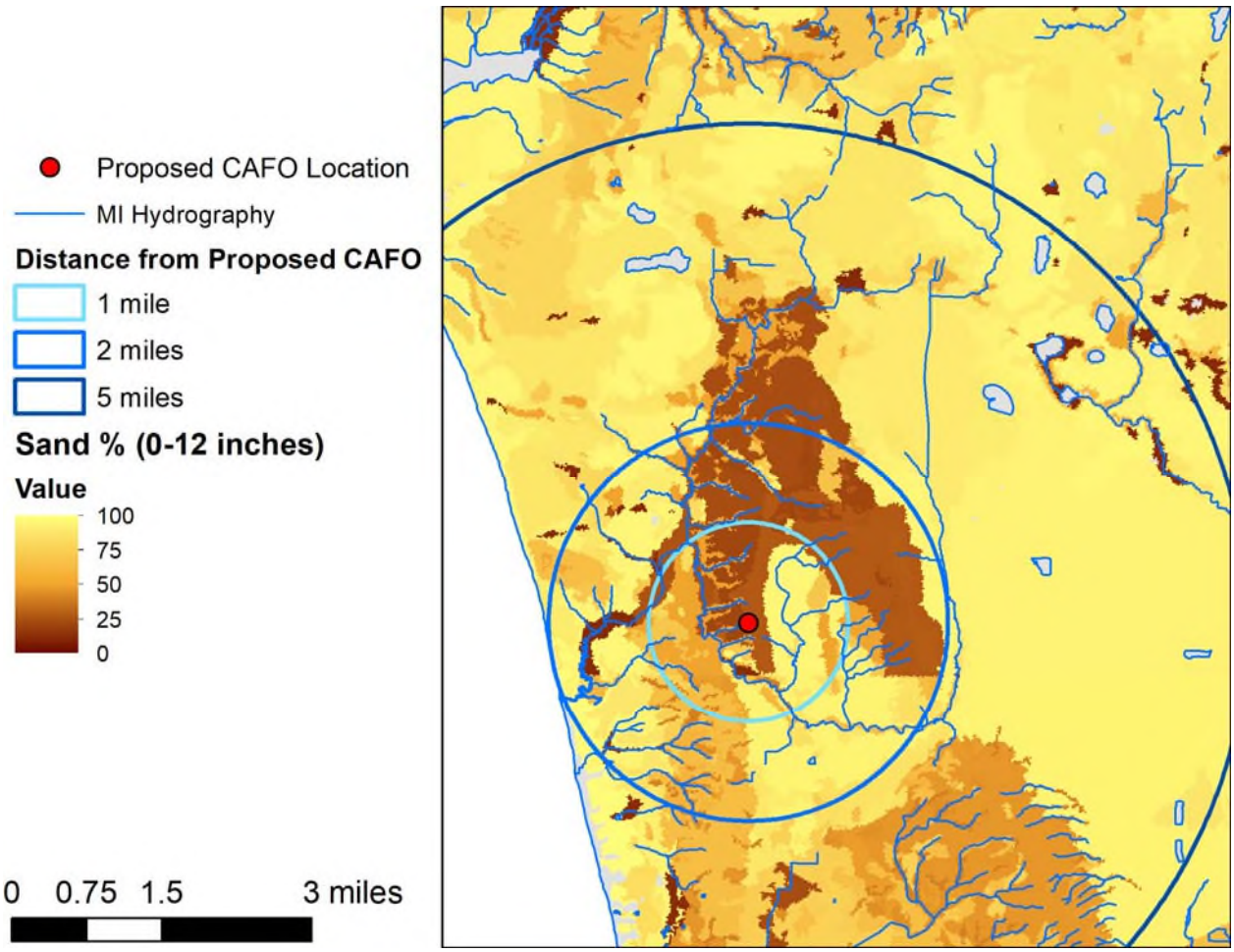

Figure 5. *Sand soil percentage in the top 12 inches of soil, identified from the National Resource Conservation Service's (NRCS) Soil Survey Geographic (SSURGO) database.*

Generally, soils below historical plowed depth (~12 inches) are somewhat more clay rich than the shallower soils (**Figure 6**).

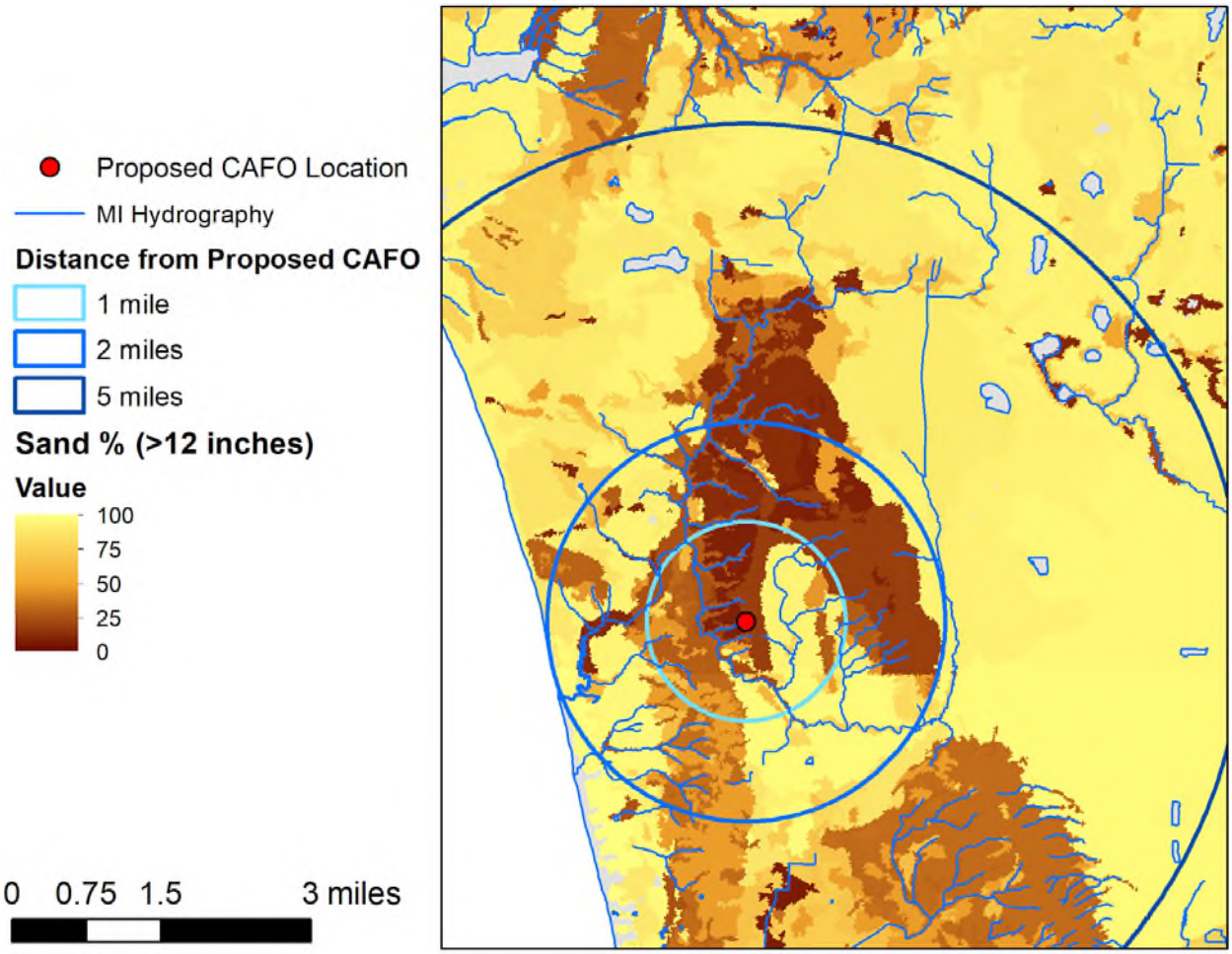

***Figure 6**. Sand soil percentage in the soils below 12 inches (generally classified down to ~6 feet).*

The land in proximity to Flower Creek tends to have higher slopes, in many cases greater than 5% (**Figure 7**). The proposed CAFO site is in such a location. Generally, east of the site the land slopes more gradually, typically less than 2%, while west of the site slopes are much higher. There are significant areas of both high clay content (Figures 5 and 6) and high slopes (Figure 7) north of the proposed CAFO. These areas would tend to have higher runoff and Phosphorous transport potential than sandier, flatter areas elsewhere. Precise details about manure distribution plan are not publically available to specifically evaluate the runoff potential of this plan.

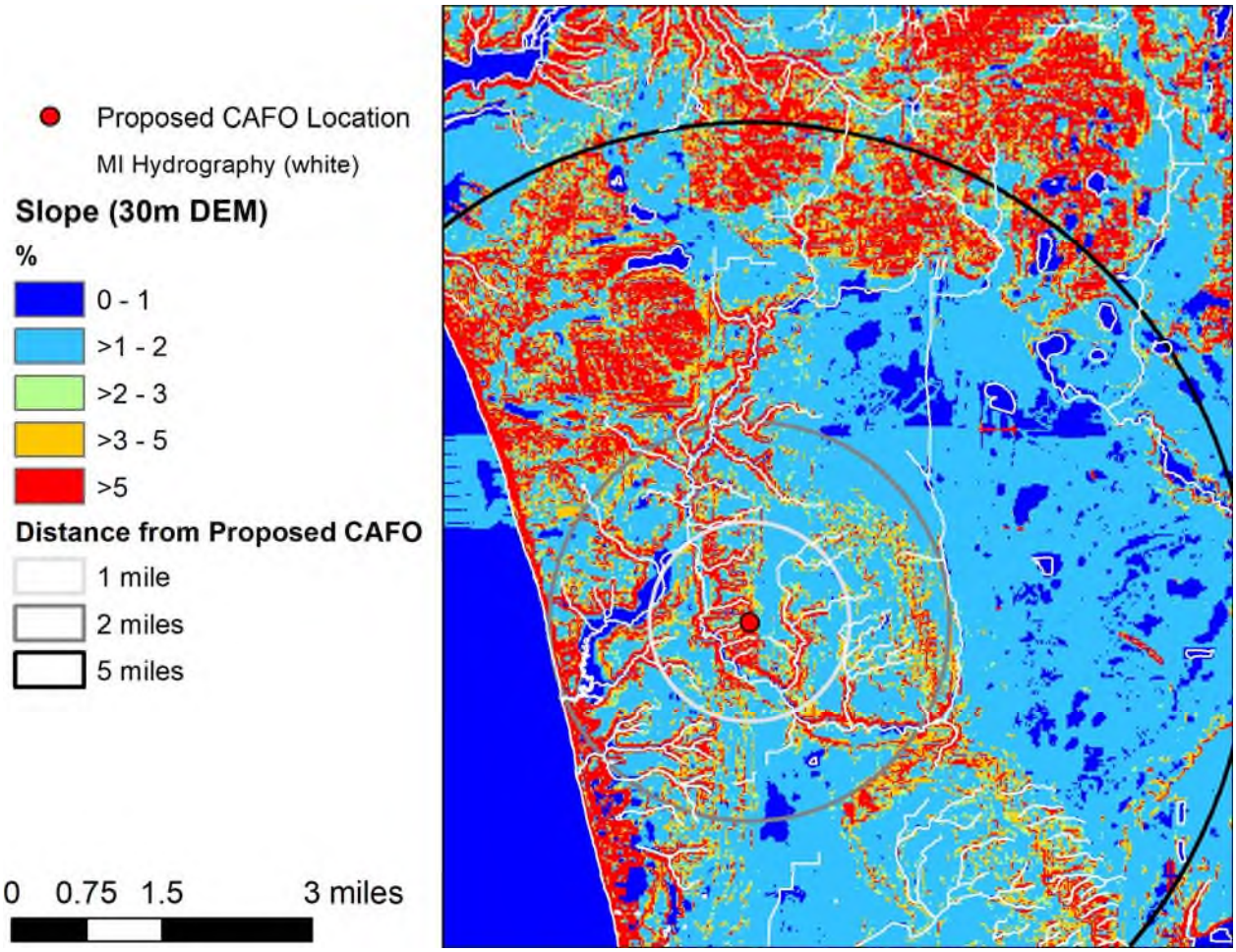

***Figure 7**. Surface slopes surrounding the proposed CAFO site, calculated from the 1 arc-second Digital Elevation Model (DEM) from the National Elevation Dataset (NED).*

Depths to groundwater were calculated from an interpolated map of water table elevations generated from drinking water well logs and surface water features (**Figure 8**). This map shows that the water table is generally 5-10+ meters deep, except for areas of high clay content, or areas immediately adjacent to Flower Creek or other surface water features. Preventing groundwater contamination in areas with shallow water tables is important.

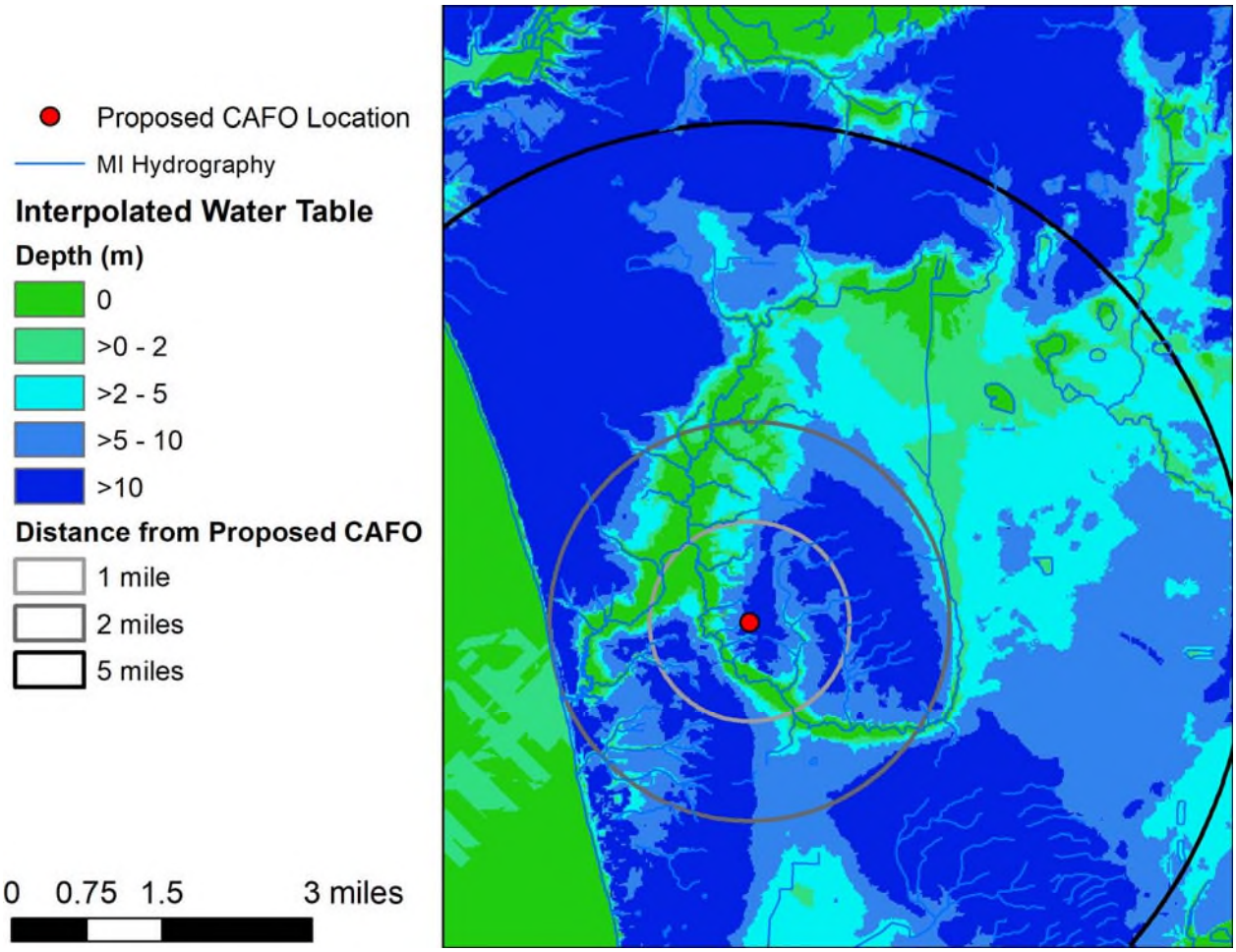

***Figure 8**. Map of depth to groundwater surrounding the proposed CAFO site. calculated from an interpolated map of water table elevations.*

Nutrient Applications in Flower Creek

Here we compare the reported annual generated loads of P and N to those estimated by our Spatially Explicit Nutrient Source map (SENSmap) product, aggregated at the HUC12 basin level. The estimated loads are as kg of P and N applied to the landscape.

The proportions of total N and P loads from each source type are both shown in Figure 9 for the period prior to the proposed CAFO.

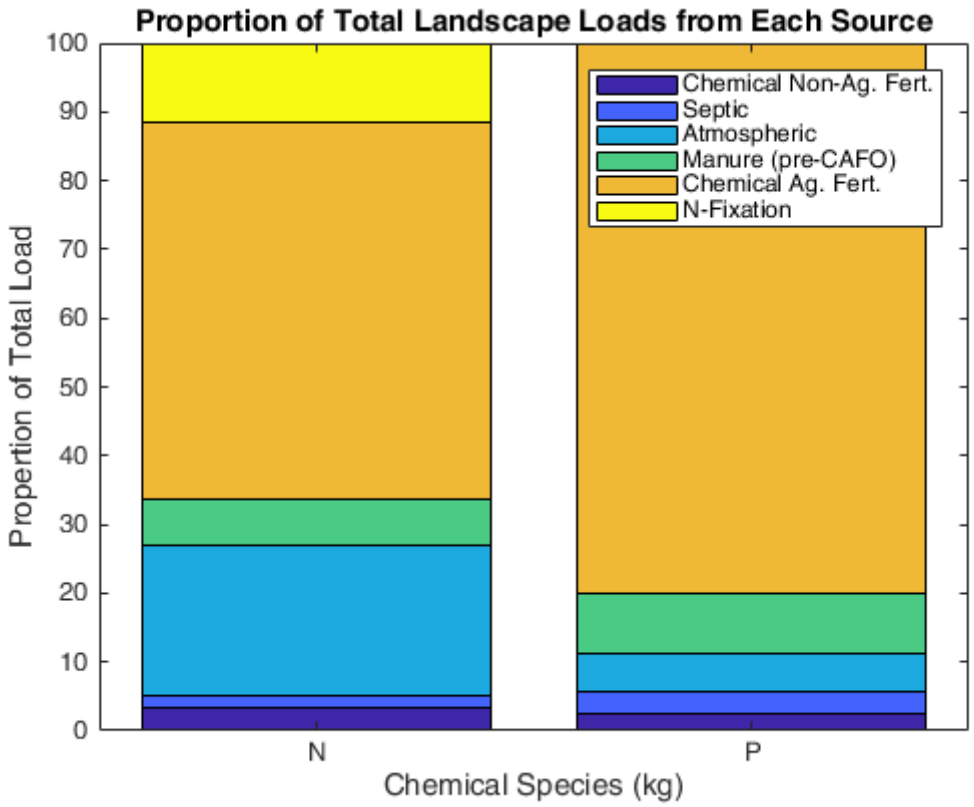

***Figure 9**. Proportion of Landscape Nutrient loads from different sources for the Flower Creek watershed prior to the proposed CAFO.*

Next, we compare the total estimated loads (pre-CAFO) to those reported by the CAFO application. These are: N - 97,786 lb (44,354 kg) and P - 41,248 lb P2O5 (23,239 lb P, 10,541 kg P).

Were the manure to be generated by the proposed CAFO distributed within the HUC12 watershed of Flower Creek, it would represent an increase of total N landscape loads by 11%, and P loads by 21%. In terms of manure loads alone, the proposed CAFO would increase manure N loads by 166%, and manure P loads by 243% over estimated current loads. The plot below (**Figure 10**) shows how the CAFO would cause a significant shift in the proportions of nutrient loads relative to **Figure 9**.

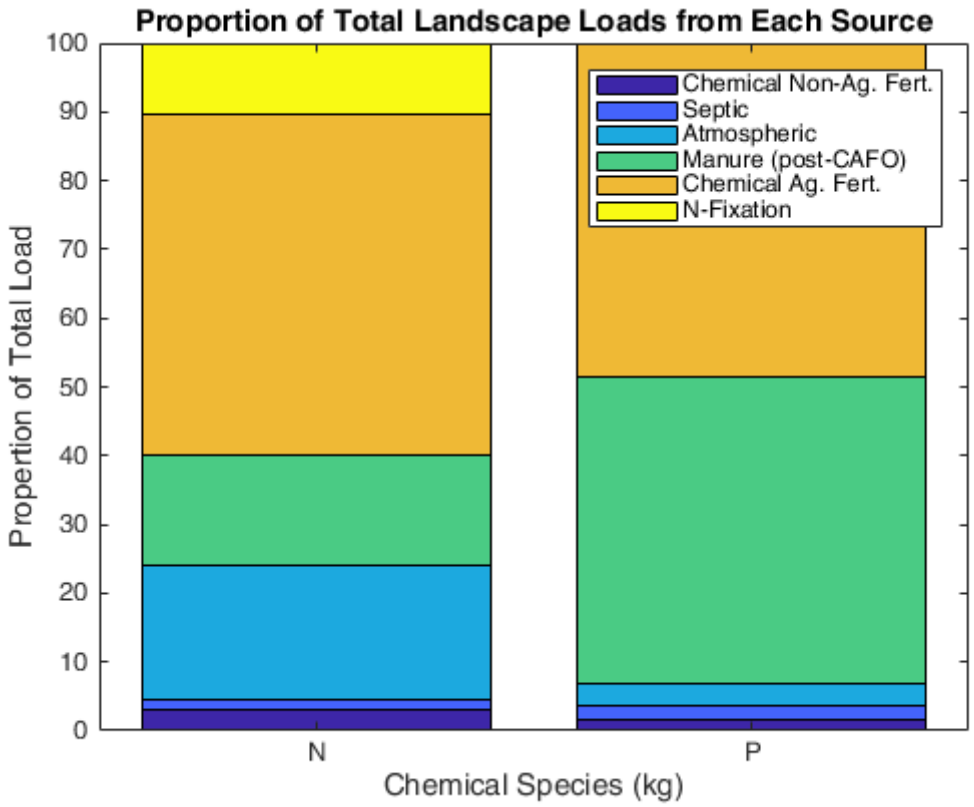

***Figure 10**. Proportion of Landscape Nutrient loads from different sources for the Flower Creek watershed including the proposed CAFO.*

Finally, comparing the Flower Creek HUC12 to all HUC12 watersheds in the US Great Lakes Basin, we find that, the Flower Creek HUC12 is approximately at the 68th percentile for both N and P loads. Were the proposed CAFO to be permitted, provided it operates according to its Nutrient Management Plan, this would move Flower Creek to one of the highest nutrient load watersheds (the 71st percentile in terms of total N load to the landscape, and 84th for total P). This would make it one of the most nutrient-rich HUC12 watersheds in the US Great Lakes Basin. In particular, the increase in P loads would present an additional burden for the watershed, and could potentially increase eutrophication and nuisance algal blooms--both of which are associated with high P loads in this region.