Addressing Phosphorus and Sediment in the Genesee River Basin: A Synopsis of Existing Reports to meet EPA's Nine Elements of a Watershed Plan

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Contents

Background

The U.S. EPA has identified nine minimum elements that should be contained within a watershed plan (EPA, 2008). The Genesee River basin is well studied and numerous reports exist which collectively address all of the elements. This document serves to bring all of the elements together under one umbrella to serve as the comprehensive watershed plan to address phosphorus and sediment in the Genesee River basin. Summary information and conclusions have been provided for each of the minimum elements. Specific details of the analyses can be found in the original reports, to which references have been included.

Introduction

The Genesee River originates in Pennsylvania and then flows north across New York to Rochester where it meets Lake Ontario. Nutrient and sediment driven impacts are observed throughout the watershed and the Rochester embayment of Lake Ontario. The Genesee River is also the second largest tributary loading of phosphorus to Lake Ontario. With a watershed area of 2490 square miles, management practices are needed in all of the major subbasins (Figure 1) to

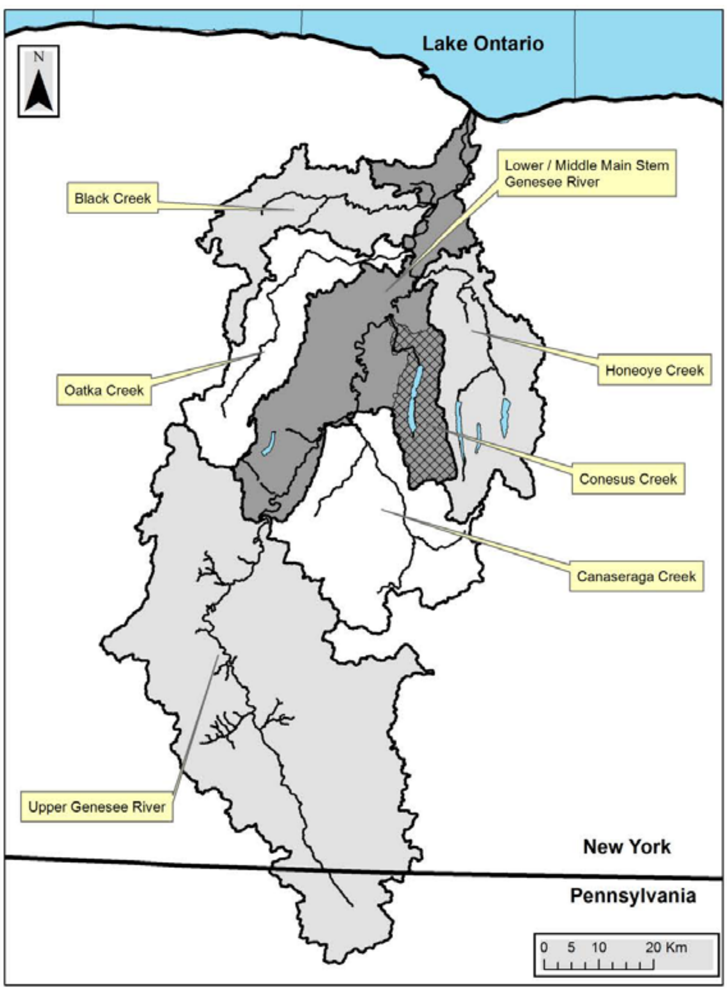

Figure 1: Major subbasins within the Genesee River watershed (Makarewicz J. C., et al., 2013)

address these problems. This nine element watershed plan serves to identify and prioritize the areas of the watershed where efforts should initially be focused.

This is intended to be a living document, with revisions made as implementation progresses, as local water quality problems are addressed, as new priorities arise and as additional information becomes available. Revisions are envisioned as watershed plans at smaller scales are developed. These plans are better able to identify, prioritize and address local water quality impairments. As such, they should be incorporated into this framework so long as they are consistent with the overarching goals of this document of reducing phosphorus and sediment loads within the Genesee River basin.

The Genesee/Finger Lakes Regional Planning Council is currently finalizing such plans for Black and Oatka Creeks, with completion expected by the end of 2014. Components of these plans have already been reviewed and deemed consistent with the goals of this watershed plan. Upon completion those reports will, therefore, be incorporated into this framework. The recommendations and prioritizations found within those reports should be given equal consideration when determining future actions. As additional local watershed plans are developed and determined consistent they too shall become part of this framework and given equal consideration.

I. Identification of causes of impairments and pollutant sources

The 2012 New York State 303(d) list identifies impaired waterbodies within New York State and includes both the cause and source(s) (NYSDEC, 2013). Impairments relevant to phosphorus and sediment for the Genesee River basin are listed in Table 1. Additional information on each waterbody can be found in the NYS 303(d) list and in the Genesee River Waterbody Inventory and Priority Waterbodies List (NYSDEC, 2003) .

The Makarewicz research group at The SUNY College at Brockport produced a series of reports which characterized the loads and sources of phosphorus and sediment for the entire Genesee River basin (Makarewicz J. C., et al., 2013) (Makarewicz J. C., Lewis, Snyder, & Smith, 2013) (Makarewicz, Lewis, & Snyder, 2013) (Winslow, Makarewicz, & Lewis, 2013) (Rea, Makarewicz, & Lewis, 2013) (Pettenski, Makarewicz, & Lewis, 2013). Those projects were built upon flow measurements and an intensive water quality sampling and analysis program over several years. Calibrated SWAT models were developed using those data. Those models were then utilized to further identify and allocate sources of sediment and phosphorus and estimate potential load reductions from various management practice scenarios. The reports estimated that the current sediment load to Lake Ontario from the Genesee River is 8.5×10^{8} lb/yr. The reports estimate the phosphorus load to Lake Ontario to be 909,417 lb/yr. Hayhurst et al. (2010) estimated the 2003-2008 average phosphorus load to be 968,000 lb/yr.

The work by Makarewicz et al. estimated the phosphorus loads attributable to different source sectors based upon their modeling results (Makarewicz J. C., et al., 2013). Using the percentages reported in that report, estimated loads from each source sector were calculated (Table 2). There are small discrepancies between measured and modeled loads reported in the various documents cited above. Additionally, while not discussed herein, losses of sediment and phosphorus were estimated by the models within some river reaches such that estimated upstream loads may

Table 1: Impaired waterbodies in the Genesee River basin (NYSDEC, 2013). Only impairments relevant to nutrients or silt/sediment are included.

Watershed Index No.	Waterbody Name	Cause/Pollutant	Source
Ont 117 (portion 1)	Genesee River, Lower, Main Stem	Phosphorus Silt/Sediment	Various, multiple
Ont 117 (portion 2)	Genesee River, Middle, Main Stem	Oxygen Demand Phosphorus	Agriculture
Ont 117-19	Black Creek, Lower Black Creek, Upper	Phosphorus	Agriculture Municipal
Ont 117-19-4	Mill Creek/ Blue Pont Outlet and tribs	Phosphorus	Agriculture
Ont 117-25-7-4-P2a	LeRoy Reservoir	Phosphorus	Agriculture
Ont 117-27-P57	Honeoye Lake	Phosphorus Oxygen Demand	Unknown
Ont 117-40-P67	Conesus Lake	Phosphorus Oxygen Demand	Agriculture
Ont 117-42	Christie Creek and tribs	Phosphorus	Agriculture
Ont 117-66-8-2	Bradner Creek and tribs	Phosphorus	Agriculture
Ont 117-27-34	Hemlock Lake Outlet and minor tribs	Phosphorus Pathogens	Onsite Waste Treatment Systems
Ont 117-19-30	Bigelow Creek and tribs	Phosphorus	Agriculture
Ont 117-27-13	Unnamed Trib to Honeoye Creek and tribs	Nutrients	Agriculture
Ont 117-57	Jaycox Creek and tribs	Phosphorus Silt/Sediment	Agriculture
One 117-66-22	Mill Creek and minor tribs	Silt/Sediment	Stream bank erosion

sometimes be greater than loads estimated at downstream locations. Loads reported here should be considered order of magnitude estimates rather than absolute values, but are deemed sufficiently accurate for the purpose of this plan.

Priority watersheds in the lower/middle Genesee River basin

The lower/middle Genesee River Basin received inputs from all of the other subwatersheds identified in Figure 1. Exclusive of the other subwatersheds, the lower/middle basin contributes approximately 97,734 lb/yr of phosphorus, or just over 10% of the total load from the entire watershed. The lower/middle Genesee River basin was not considered separately in the modeling conducted by Makarewicz et al. (2013), but rather was incorporated as part of the model of the entire Genesee River basin.

The USGS Sparrow model (Robertson & Saad, 2011), PWL (NYSDEC, 2003) and 303(d) (NYSDEC, 2013) list were used to identify high priority watersheds within the lower/middle basin. These were selected based upon estimated high phosphorus load contributions and demonstrated nutrient impacts. High priority watersheds within the lower/middle Genesee River basin are indicated in Table 3.

Table 2: Estimated source sector loads for the entire Genesee River basin as estimated by Makarewicz et al. (2013).

Land Use/Activity	Percent of predicted load	Estimated phosphorus load (lb/yr)	Estimated sediment (TSS) load (lb/yr)
Agricultural crops	28.3	257,365	
Tile drainage	5.3	48,199	
Farm animals (CAFO only)	8.8	80,029	
Stream bank erosion	5.0	45,471	
Wetlands	0.3	27,283	
Groundwater	29.3	266,459	
Forest	5.4	49,109	
Urban Runoff	1.9	17,279	
Rochester storm sewer*		5,020	1.3×10^6
Rochester CSO*		3,382	0.8×10^6
Point sources	11.5	104,583**	
Septic systems	4.2	38,196	
Total	100	909,417	8.5×10^8

*The Makarewicz research group produced an additional model of the sewer contributions from the city of Rochester (Dressel, 2014). The estimated loads are included here as a subset of the urban runoff loads from the greater Genesee River model (Makarewicz J. C., et al., 2013).
**Point source contributions were estimated based upon limited available data. Additional data from facility Discharge Monitoring Reports indicate the current contribution of phosphorus to the Genesee River from wastewater treatment plants is approximately 79,300 lb/yr.

Table 3: High priority watersheds in the lower/middle Genesee River watershed. See Appendix A for the entire Genesee River basin list and for a map of HUC12 locations.

Subwatershed	Watershed Index Number	HUC12
Genesee River, lower	Ont 117 (portion 1)	041300030704
Jaycox Creek	Ont 117-57	041300030502
Genesee River, middle	Ont 117 (portion 2)	041300030703
Beards Creek	Ont 117-60	041300030501
Conesus Creek	Ont 117-40	041300030103
Conesus Lake	Ont 117-40-P67	041300030102
Conesus Lake tributaries	Ont 117-40-P67-	041300030101 041300030102

The Conesus Lake Watershed Management Plan (CLWMPP, 2003) identifies a number of high priority subwatersheds within the Conesus Lake watershed. These are included in Table 3 as part of the Conesus Lake tributaries and associated HUC12s. The high priority subwatersheds identified in the Plan include: Northwest Creeks, North Gully, Long Point Gully, Sand Point, No Name Creek Cottonwood and Central subwatersheds. Moderate and Low priority subwatersheds are also identified in the Plan and are shown in Maps 4-1 and 4-2 in that report. Areas of stream bank and ditch erosion are also indicated within the Plan in Maps 5-1 and 5-2, respectively.

The Makarewicz research group also applied the Storm Water Management Model (SWMM) to the lower Genesee to determine the impact from the barge canal, storm sewers and combined sewer overflows (Dressel, 2014). Contributions from combined sewer overflows were estimated to be 3,382 lb/yr and 784,555 lb/yr for phosphorus and total suspended solids, respectively. Separate storm sewers were estimated to contribute 5,020 lb/yr of phosphorus and 1,379,405 lb/yr of total suspended solids. The model identified the Merrill, Irondequoit, Kendrick and Elmwood sewersheds as the greatest contributors of phosphorus and sediment.

Priority watersheds in the upper Genesee River basin

The upper Genesee River basin encompasses 985 square miles. Land use with the upper Genesee River basin is primarily forest (57%) and agricultural (35%) while range/grassland (4%), residential (3%) and wetlands (1%) are minor contributors. The study of the upper Genesee River basin found that approximately 60% of the total phosphorus load can be attributed to anthropogenic sources (Makarewicz J. C., Lewis, Snyder, & Smith, 2013). Of the total 507,234 lb/yr load of phosphorus estimated for the upper Genesee Basin, agriculture is the single greatest source. Crops account an estimated 45% of the total load and farm animals (CAFO) account for an additional 10% of the total load. The estimated sediment load from the upper Genesee River basin is 9.3×10^8 lb/yr.

Identification of the highest priority HUC12s began with the corresponding areas of the watershed found by Makarewicz J. C., Lewis, Snyder, & Smith (2013) to contribute the greatest amount of phosphorus for the watershed. Additional priority HUC12s may also be identified based upon other information or reports. The highest priority watersheds within the upper Genesee River watershed are indicated in Table 4. Additional high priority watersheds are identified in Figure 27 of Makarewicz J. C., Lewis, Snyder, & Smith (2013).

Stream bank erosion is a serious problem from Caneadea to Fillmore (3.3 mi) and Belmont to Angelica (2.6 mi) along the main stem. Tributaries with observed eroded stream banks were Phillips Creek (1.0 mi), Cold Creek (0.7 mi), Van Campen Creek (1.3 mi) and Angelica Creek (0.7 mi). Additional details and specific site locations are identified in Tables 12 – 16 of Makarewicz J. C., Lewis, Snyder, & Smith (2013), with Tables 15 and 16 identifying high priority sites.

Makarewicz J. C., Lewis, Snyder, & Smith (2013) indicated that, at the time of their study, there were 17 concentrated animal feeding operations (CAFOs) in the upper Genesee River Basin. The model results from that study indicate the CAFOs contribute approximately 10% of the total phosphorus load within the basin, primarily through the spreading of manure on fields for fertilizer.

Table 4: High priority watersheds in the upper Genesee River watershed based upon phosphorus load. See Appendix A for the entire Genesee River basin list and for a map of HUC12 locations.

Subwatershed	Watershed Index Number	HUC12
Brimmer Brook	Ont 117-180	041300020503
Black Creek	Ont 117-148	041300020601
Black Creek	Ont 117-155-9	041300020401
Caneadea Creek	Ont 117-136	041300020603 041300020604
Cold Creek	Ont 117-118	041300020801
East Koy Creek	Ont 117-104-3	041300020703 041300020705

Table 5: High priority watersheds in the Honeoye Creek basin based upon phosphorus loads. See Appendix A for the entire Genesee River basin list and for a map of HUC12 locations.

Subwatershed	Watershed Index Number	HUC12
Springwater Creek	Ont 117-27-34-P44-7	041300030203
Honeoye Creek, Upper	Ont 117-27	041300030205 041300030301 041300030206
Hemlock Lake Outlet	117-27-34	041300030204

Priority watersheds in the Honeoye Creek basin

The Honeoye Creek watershed encompasses 267 square miles, which is dominated by agricultural (43%) and forested (39%) lands. Range/grassland, residential and water/wetlands make up majority of the remaining land at roughly 6% each. Of the 28,135 lb of phosphorus load estimated from the watershed each year, it was estimated that 71.5% was from anthropogenic sources (Makarewicz, Lewis, & Snyder, 2013). Agriculture, wastewater treatment plants and natural sources were identified as the primary sources, with each estimated to contribute roughly one-third of the total load. The total annual sediment load was estimated to be 1.3×10^7 lb/yr.

Identification of the highest priority HUC12s began with the corresponding areas of the watershed found by Makarewicz, Lewis & Snyder (2013) to contribute the greatest amount of phosphorus for the watershed. In addition, the Hemlock Lake Outlet is identified as a high priority due to the use impairments (Table 1) and the inclusion as a high priority watershed in the Genesee River Basin Action Strategy (GFLRPC, 2004). The highest priority watersheds within the Honeoye Creek basin are indicated in Table 5. Additional high priority watersheds are identified in Figure 22 of Makarewicz, Lewis & Snyder (2013).

Priority watersheds in the Canaseraga Creek basin

The Canaseraga Creek basin encompasses an area of 342 square miles. The dominant land uses are agriculture (46.8%) and forest (44.4%). Urban and range/grass lands are minor contributors at 5.7% and 3.0%, respectively. The estimated annual phosphorus load is 124,261 lb/yr and the estimated annual sediment load is 1.56×10^8 lb/yr (Rea, Makarewicz, & Lewis, 2013).

Identification of the highest priority HUC12s began with the corresponding areas of the watershed found by Rea, Makarewicz, & Lewis (2013) to contribute the greatest amount of phosphorus for the watershed. Additional priority HUC12s may also be identified based upon other information or reports. The highest priority HUC12s in the Canaseraga Creek basin are indicated in Table 6. Additional high priority watersheds are identified in Figure 79 of Rea, Makarewicz, & Lewis (2013).

Stream bank erosion in the Groveland Flats area has been identified as a significant contributor of sediments to the basin (Rea, Makarewicz, & Lewis, 2013) (GFLRPC, 2004). Stream bank erosion is also suspected within the Mill Creek watershed.

Table 6: High priority watersheds in the Canaseraga Creek basin based upon phosphorus loads. See Appendix A for the entire Genesee River basin list and for a map of HUC12 locations.

Subwatershed	Watershed Index Number	HUC12
Bradner Creek	Ont 117-66-8-2	041300020906
Keshequa Creek, Upper	Ont 117-66-3	041300020909
Keshequa Creek, Middle	Ont 117-66-3	041300020910
Buck Run Creek	Ont 117-66-1 -1	041300020911
Twomile Creek	Ont 117-66-8-3	041300020907
State/West Ditch	Ont 117-66-8	041300020907

Priority watersheds in the Black Creek basin

The Black Creek watershed encompasses an area of 202 square miles. Agriculture is the dominant land use (62.5%) with wetlands (14.3%), forested lands (12.8%) and urban lands (10.0%) accounting for the remaining significant land uses (GFLRPC, 2012). Modeling by Winslow, Makarewicz, & Lewis (2013) estimated the total phosphorus load for Black Creek to be 36,376 lb/yr and the sediment load to be 1.8×10^7 lb/yr.

Identification of the highest priority HUC12s began with the corresponding areas of the watershed found by Winslow, Makarewicz, & Lewis (2013) to contribute the greatest amount of phosphorus for the watershed. The Draft Upper Black Creek and Bigelow Creek TMDL also identified the Upper Black Creek above Bigelow Creek as a priority area (NYSDEC, 2014). The highest priority HUC12s within the Black Creek basin are indicated in Table 7. Additional high priority watersheds are identified in Figure 67 of Winslow, Makarewicz, & Lewis (2013). Additional priority HUC12s may also be identified based upon other information or reports.

Areas of significant stream bank erosion in the Lower Black Creek watershed were noted in Figure 26 of Winslow, Makarewicz, & Lewis (2013). Of the 3.2 miles of stream bank surveyed, 32% showed signs of erosion. Within the Draft Black Creek TMDL, one site (lat: 42.9244, long: -78.1178) also exhibited significant stream bank erosion (NYSDEC, 2014). The Genesee River Basin Action Strategy also identified stream bank erosion as a known major source of pollution within all reaches of Black Creek (GFLRPC, 2004). An inventory of identified sites of erosion within the Black Creek watershed are also included and prioritized in a report by the Genesee/Finger Lakes Regional Planning Council (GFLRPC, 2005).

Priority watersheds in the Oatka Creek basin

The Oatka Creek watershed has a drainage area of 215 square miles. Agriculture is the primary land use within the basin, accounting for 73.8% of the total area. Forest is the other dominant land use within the basin (21.6%). Additional minor contributions are from urban (2.7%) and

Table 7: High priority watersheds in the Black Creek basin based upon phosphorus loads. See Appendix A for the entire Genesee River basin list and for a map of HUC12 locations.

Subwatershed	Watershed Index Number	HUC12
Spring Creek	Ont 117-19-28	041300030601
Bigelow Creek	Ont 117-19-30	041300030602
Black Creek, Upper	Ont 117-19	041300030602

Table 8: High priority watersheds in the Oatka Creek basin based upon phosphorus loads. See Appendix A for the entire Genesee River basin list and for a map of HUC12 locations.

Subwatershed	Watershed Index Number	HUC12
Oatka Creek, Upper	Ont 117-25	041300030401
Pearl Creek	Ont 117-25-20	041300030402
Oatka Creek, Middle	Ont 117-25	041300030403
Oatka Creek, Middle	Ont 117-25	041300030405

wetlands (0.8%). Modeling by Pettenski, Makarewicz, & Lewis (2013) estimated an annual phosphorus load of 33,109 lb/yr and an annual sediment load of 1.1×10^7 lb/yr.

Identification of the highest priority HUC12s began with the corresponding areas of the watershed found by Pettenski, Makarewicz, & Lewis (2013) to contribute the greatest amount of phosphorus for the watershed. Additional priority HUC12s may also be identified based upon other information or reports. The highest priority watersheds within the Oatka Creek basin are indicated in Table 8. Additional high priority watersheds are identified in Figure 59 of Pettenski, Makarewicz, & Lewis (2013).

Sites of significant stream bank erosion were identified on the main stem of Upper Oatka Creek (HUC12: 041300030401). Of the 2.5 mi. segment surveyed, 27.3% was found to be experiencing erosion. Agricultural activities in the Pearl Creek subwatershed (HUC12: 041300030402) were identified as the probable source of elevated sediment loads (Pettenski, Makarewicz, & Lewis, 2013). The Genesee River Basin Action Strategy also identifies stream bank erosion and agriculture as known major sources of pollution throughout the Oatka Creek watershed (GFLRPC, 2004). An inventory of identified sites of erosion within the Oatka Creek watershed are also included and prioritized in a report by the Genesee/Finger Lakes Regional Planning Council (GFLRPC, 2005).

Point sources within the Genesee River basin

There are 37 permitted point sources which have been identified as discharging significant amounts of phosphorus, 30 of which are publicly owned treatment works (POTWs). Based upon Discharge Monitoring Report data analyzed by NYSDEC, combined, these facilities discharge approximately 79,300 lb/yr of phosphorus, or about 8.7% of the total Genesee River phosphorus load. If all of these facilities were required to meet a 1.0 mg/L phosphorus limit the amount of phosphorus discharged from these point sources would be reduced by 38,600 lb/yr, or nearly 50%. A reduction of 22,900 lb/yr could be realized if seven facilities were required to meet the 1.0 mg/L limit. Those facilities (Table 9) should therefore be the priority for phosphorus reductions from point sources. Identification of these facilities within this watershed plan is done only as a suggestion of where it may be cost effective to pursue reductions from this source sector. Inclusion here in no way indicates a requirement.

It is generally possible to meet a 1.0 mg/L total phosphorus limit in POTW effluent using chemical addition, such as alum or ferric chloride. Chemical addition can typically be incorporated without substantial investment of capital, making it cost effective in terms of dollars per pound of phosphorus removed. Treatment below this level often requires additional facilities

Table 9: High priority SPDES discharges for phosphorus reductions

Facility	SPDES
Avon (V) STP	NY0024449
Conesus Lake SD Lakeville STP	NY0032328
Geneseo (V) STP	NY0030635
LeRoy (V) STP	NY0030546
Warsaw STP	NY0021504
Perry (V) STP	NY0022985
Mt. Morris (V) STP	NY0030741

or equipment making further reductions from this source sector much less cost effective. Treatment to achieve concentrations below 1.0 mg/L is only recommended at this time if needed to improve local water quality.

II. Load reductions expected from management measures

The estimated load reductions expected from the implementation of management measures found in this section come from the work completed by the Makarewicz research group (Makarewicz, Lewis, & Snyder, 2013) (Makarewicz J. C., et al., 2013) (Makarewicz J. C., Lewis, Snyder, & Smith, 2013) (Pettenski, Makarewicz, & Lewis, 2013) (Rea, Makarewicz, & Lewis, 2013) (Winslow, Makarewicz, & Lewis, 2013) (Dressel, 2014). The SWAT and SWMM models developed by the group could be used to identify the most efficient use of management measures by specific area as well as estimate the percent reduction of phosphorus and sediment.

Estimated load reductions from implementation of the identified management measures in each of the sub-watersheds are shown in Tables 10- 15. Note that the load reductions are based upon implementation of the measures throughout the entire Genesee River watershed. Successful management of the watershed will likely incorporate multiple management measures throughout the watershed such that one hundred percent implementation of a given management measure is not necessary.

Table 10: Phosphorus and sediment load reductions associated with different management measures implemented throughout the entire Genesee River basin (Makarewicz J. C., et al., 2013).

Management measure	Phosphorus reduction (lb/yr)	TSS reduction (lb/yr)
Grassed waterway	212,801	-
Stream bank stabilization	-	243,291,755
Buffer strips	105,491	4,223,815
Contouring	75,481	-
Terracing	130,045	-
Cover crops	163,694	-

Table 11: Phosphorus and sediment load reductions associated with different management measures in the upper Genesee River basin (Makarewicz J. C., Lewis, Snyder, & Smith, 2013).

Management measure	Phosphorus reduction (lb/yr)	TSS reduction (lb/yr)
Grassed waterway	264,554	38,140
Stream bank stabilization	5,070	141,757
Buffer strips	118,168	12,125
Contouring	87,523	3,968
Terracing	162,701	6,393
Cover crops	135,805	12,125

Table 12: Phosphorus and sediment load reductions associated with different management measures in the Honeoye Creek basin (Makarewicz, Lewis, & Snyder, 2013).

Management measure	Phosphorus reduction (lb/yr)	TSS reduction (lb/yr)
Grassed waterway	8,466	165,347
Buffer strips	3,142	196,211
Terracing	4,352	123,459
Cover crops	5,549	143,300

Table 13: Phosphorus and sediment load reductions associated with different management measures in the Canaseraga Creek basin (Rea, Makarewicz, & Lewis, 2013).

Management measure	Phosphorus reduction (lb/yr)	TSS reduction (lb/yr)
Stream bank stabilization	5,759	77,241,099
Grassed waterways	58,632	7,036,133
Cover crops	40,833	8,443,359
Contouring	39,393	3,752,604
Strip cropping	36,645	2,970,812

Table 14: Phosphorus and sediment load reductions associated with different management measures in the Black Creek basin (Winslow, Makarewicz, & Lewis, 2013).

Management measure	Phosphorus reduction (lb/yr)	TSS reduction (lb/yr)
Buffer strips	6,120	5,159,141
Stream bank stabilization	1,356	12,978,727
Conservation tillage	5,772	5,611,401
Grassed waterways	9,255	7,629,501

Table 15: Phosphorus and sediment load reductions associated with different management measures in the Oatka Creek basin (Pettenski, Makarewicz, & Lewis, 2013).

Management measure	Phosphorus reduction (lb/yr)	TSS reduction (lb/yr)
Grassed waterways	5366	-
Stream bank stabilization	-	9764
Buffer strips	2486	231
Terracing	2628	-

III. Nonpoint source management measures

For all of the Genesee River watershed, high priority sub-watersheds for implementation are identified in Section I. Specific recommendations for management measures for each watershed are indicated below based upon cost per pound removal rates. Cost is, however, only one metric upon which the selection of management measures must be based. Even more important is willingness of the landowner to implement a given BMP. As such, additional management measures in addition to those specifically listed below should be considered consistent with this watershed plan. Any management measures which reduce phosphorus or sediment loads to the Genesee River and its tribtaries will help attain the load reductions sought herein. Additional agricultural measures may include, but are not limited to: hydroseeding, cover crops, silage leachate management, animal waste storage, no till, nutrient management and manure storage facilities.

Within the more developed landscape, green infrastructure (GI) projects which reduce sediment or phosphorus loads to the Genesee River or its tributaries are consistent with this watershed plan. Projects may include, but are not limited to: stormwater ponds, stream bank repairs, buffer enhancements, and other GI practices aimed at increasing infiltration and restoring natural hydrology. For both the agricultural and developed land sectors, additional guidance on management measure design and specifications can be found in the Management Practices Design Catalogue (NYSDEC, n.d.), the Stormwater Management Design Manual (NYSDEC, 2010) and the NRCS National Conservation Practice Standards (NRCS, n.d.).

There is substantial need to implement practices which will reduce existing sources of loading. At the same time, it is also important to prevent new sources from being created. Land use regulation at the local scale can help achieve this goal. This could include local requirements for percolation testing prior to septic system installation, the adoption of stream buffers or riparian setbacks for new development, and stormwater management and erosion control laws. Any local controls or laws which will reduce phosphrous and sediment loads from new development or redevelopment should be considered part of larger approach to nonpoint source management.

While the focus of this watershed plan is upon the reduction of phosphorus and sediment to the Genesee River, the Rochester embayment and Lake Ontario it is also worth noting that implementation of management measures may also reduce the amounts of other pollutants (e.g. pathogens, nitrogen and metals) delivered to these waterbodies. Similarly, management measures meant to reduce loads of other pollutants may also reduce loads of phosphorus and sediments. These ancillary benefits should be recognized as well.

Lower/middle Genesee River Basin
The agricultural nonpoint management measures recommended for the lower/middle Genesee River basin by Makarewicz et al. (2013) are the same as for the entire basin: grassed waterways, buffer strips and conservation tillage. Grassed waterways, however, were identified as the single most effective management measure.

Within the Conesus Lake watershed additional nonpoint source management measures have been identified (CLWMPP, 2003). In addition to those indicated above, the Conesus Lake Watershed

Management Plan (CLWMP) recommends comprehensive nutrient management plans, strip cropping and other erosion control practices, managed intensive grazing and stream fencing. The CLWMP also suggests management measures to address other stressors to the Lake including development, stormwater, roadways, and recreation. Stream bank and ditch erosion controls were also recommended.

The Stormwater Coalition of Monroe County has finalized a Draft Stormwater Assessment and Action Plan for Little Black Creek (SCMC, 2011), a direct tributary to the Genesee River. The Plan identifies and prioritizes a number of stormwater management measures aimed at reducing the sediment and phosphorus loads from the watershed into the Genesee River. The referenced report should be consulted for project identification, prioritization and location.

Upper Genesee River Basin

The recommended nonpoint source management measures in Makarewicz J. C., Lewis, Snyder, & Smith (2013) are grassed waterways and streambank stabilization. Other identified management measures which may result in substantial amounts of sediment and phosphorus load reductions include buffer strips, contouring, terracing and cover crops. Critical areas include those areas where crops are grown up to the stream edge without any sort of buffer. Tables 15 and 16 of Makarewicz J. C., Lewis, Snyder, & Smith (2013) identify several such locations.

Honeoye Creek Basin

Cover crops, strip cropping, buffer strips and grassed waterways were all identified in Makarewicz, Lewis, & Snyder (2013) as potential management measures.

For the Hemlock Lake Outlet management of the septic system load is needed. While a robust inspection and repair program may be sufficient, it is recommended that the feasibility of connecting the area to a municipal wastewater treatment plant be explored (GFLRPC, 2004).

Canaseraga Creek Basin

Grassed waterways were identified as the most efficient management measure for control of phosphorus while stream bank stabilization was identified for sediment control (Rea, Makarewicz, & Lewis, 2013). Terracing, cover crops and contouring were also identified as potentially effective management measures.

Black Creek Basin

Buffer strips and grassed waterways were identified as the most efficient management measures for the control of phosphorus. Stream bank stabilization was found to be the most efficient management measure for reducing the sediment load (Winslow, Makarewicz, & Lewis, 2013). The Draft Upper Black Creek TMDL also indicated that the establishment of riparian buffers, particularly along the upper reaches of the watershed would help reduce phosphorus and improve macroinvertebrate community health (NYSDEC, 2014).

Oatka Creek Basin

Grassed waterways, buffer strips and cover crops were identified as the most efficient management measures for control of phosphorus within the Oatka Creek watershed. Pettenski, Makarewicz, & Lewis (2013) also indicated particular attention should be paid to the Pearl Creek subwatershed and the White Creek subwatershed (Ont 117-25-12).

IV. Technical and financial assistance

Implementation of this plan relies almost entirely upon voluntary implementation of best management practices on agricultural lands. The Great Lakes Restoration Initiative, Water Quality Improvement Project Program and the Resource Conservation Partnership Program are all potential sources of funding.

In those instances where septic systems have been identified as a source of pollution the Clean Water State Revolving Fund and the NYSDEC/NYSEFC Engineering Planning Grants are also potential sources of funding.

Estimates of cost per unit for different management practices are listed in Table 16. Cost and efficiency information were based off data found in the CAST program of the Chesapeake Bay Program (Devereux & Rigelman, 2014). Costs estimates are intended to provide order of magnitude estimates only to aid in the planning process. Values have been annualized over the lifespan of the management measure based upon a 5% interest rate.

There are roughly 5048 miles of streams and rivers in the Genesee River basin. Implementation of 35 foot buffer strips along both sides of the entire length would cost approximately $6.2 million. Stream bank stabilization, while modeled as implemented basin wide, is likely only applicable to a portion of banks within the watershed. In some watersheds, 30% of stream banks showed signs of erosion (Makarewicz J. C., Lewis, Snyder, & Smith, 2013). For the purpose of this cost estimate, for the entire Genesee River basin, an estimate of 10% of all river miles are assumed to need stabilization. Stream bank stabilization is estimated to cost approximately $37 million. Implementation of these management measures as indicated would provide enough phosphorus reduction to attain that goal and would come close to attaining the sediment reduction goal. Attainment of the buffer strip and stream bank stabilization goals outlined in this watershed plan could therefore be estimated to cost on the order of $43 million, noting that this is an annualized cost over the life of these projects.

It is unlikely that only these management measures will be installed. While these scenarios can be used for cost estimates, a more realistic implementation will utilize whichever management measures are effective and acceptable for the conditions which exist in the field. Decision of the best management measures to install should be made by the land owner and experienced technical staff.

Load reductions from point sources may also be a cost effective means to attain modest phosphorus reductions. Chemical addition to all of the seven point sources indicated in Table 9 could perhaps be achieved at an annualized cost of $100,000 to $200,000 assuming no substantial capital upgrades are needed. These costs include both an initial investment and ongoing chemical costs. Implementation could be expedited if finances could be provided to help

Table 16: Estimates of cost to install management measures on agricultural land and the phosphorus and sediment load reductions estimated for basin wide implementation. Costs are annualized over the expected life of the project.

Management Measure	Lifespan (yr)	Measurement Unit	Annual Cost ($/unit)	Annual Phosphorus Cost ($/lb)	Annual Sediment Cost ($/lb)
Nutrient Management Plan	3	Acre	3.90	31	-
Barnyard Runoff Control	15	Acre	567	45	2.39
Prescribed Grazing	3	Acre	13	82	0.24
Stream Restoration	20	Feet	60	91	0.13
Septic Connection	25	System	527	99	-
Land Retirement	10	Acre	169	113	0.25
Grass Buffers	10	Acre	147	144	0.28
Forrest Buffers	75	Acre	231	156	0.30
Tree Planting	75	Acre	70	187	0.22
Septic Pumping	3	System	88	338	-
Intensive Rotational Grazing	3	Acre	74	456	1.34
Cover Crops	1	Acre	73	530	0.95
Wet Ponds	50	Acre	352	667	0.72
Stream Fencing	10	Acre	5307	843	2.22
Wetland Restoration	15	Acre	544	1034	2.06
Bioswale	50	Acre	922	1049	1.41
Bioretention/Raingarden	25	Acre	1127	1132	1.53
Dry Pond	50	Acre	365	1556	0.74
Stormwater Retrofit	10	Acre	1545	4263	2.71
Street Sweeping	20	Acre	916	15120	5.18
Permeable Pavement	20	Acre	14220	15172	20
Dirt Road Erosion and Sediment Control	20	Feet	0.83	-	0.35

offset some of the costs. Identification of these projects as a priority for grant and loan funding could help in the funding application process.

V. Information and education

The Water Assessments by Volunteer Evaluators (WAVE) program is a citizen-based water quality assessment program developed by the NYSDEC. The purpose of the program is to enable citizen scientists to collect biological data for assessment of water quality on wadeable streams in New York State. Volunteers collect macroinvertebrates from wadeable streams which are then submitted to NYSDEC for identification. The program enables citizens to be part of the water quality evaluation process and contains both training and informational components. While the program does not measure sediment or phosphorus directly, the results can be used to identify those waters which may be impacted by these pollutants or to identify those waters which show no signs of water quality impacts.

The Genesee/Finger Lakes Regional Planning Council (G/FLRPC) works to identify, define, and inform its member counties of issues and opportunities critical to the physical, economic, and social health of the region. The G/FLRPC includes member counties which make up the middle and lower portions of the Genesee River. Program areas include regional, local and water resources planning. G/FLRPC is currently working to complete watershed management plans for the Black and Oatka Creek watersheds. The Southern Tier West and Southern Tier Central Regional Planning and Development Boards facilitate similar activities in Allegany and Steuben Counties, respectively.

The Water Education Collaborative (WEC) was formed in 2001 in response to a need for public education on what people can do to make a difference in local water quality issues. In 2007 the WEC set out to develop an awareness campaign to educate the residents of the Genesee Regional Watershed of Lake Ontario about the impact they can have on the water quality in area. WEC plans, coordinates and facilitates Water Quality Education Programs and serves as a clearing house for water education programming.

Genesee River Wilds project seeks to establish riparian buffers, parks and trails along the length of the Genesee River from the headwaters in Pennsylvania to the southern boundary of Letchworth State Park in New York. The project seeks to engage a comprehensive range of stakeholders and funding sources to create a large and attractive resource for conservation, recreation and tourism.

The Center for Environmental Initiatives (CEI) is a nonprofit organization working for environmental protection and enhanced quality of life in the Greater Rochester and Finger Lakes region through education, collaboration and informed action. Through their Genesee River Watch initiative, CEI is working to develop partnerships, promote public interest and attract project funding to the Genesee River basin to improve water quality. In February 2014 CEI brought together stakeholders from throughout the entire Genesee River basin to discuss the water quality problems facing the river and to identify potential projects that will help address those problems. CEI plants to continue to regularly hold these Genesee River Basin Summits.

A major component of this watershed plan is implementation of best management practices on agricultural land. The Soil and Water Conservation Districts play a critical role in the outreach and coordination with the agricultural community. They may also hold educational events which introduce farmers to and highlight the benefits of management measures.

VI. Implementation schedule

At 2,490 square miles, the Genesee River basin is an extensive land area to assess and implement management measures upon. As such, the initial focus should be upon those watersheds identified as high priority herein, and in the referenced supporting documents. Even so, implementation progress is most likely to be dependent upon available funding. Any implementation schedule must take into account this dependency. Significant delays in securing sufficient funding will necessitate an extension of the implementation schedule.

Given these considerations, the following timeframes are established for implementation of management measures, to the greatest extent practical, within the identified watersheds:

- High priority watersheds – 10 years from plan date
- Medium priority watersheds – 15 years from plan date
- Low priority watersheds 25 – years from plan date

VII. Milestones

Milestones can be measured in terms of the miles or acres of management measures installed. Within each of the high, medium and low priority watersheds, implementation should be assessed at the 5, 13 and 20 year marks from plan date, respectively, with the goal of having 60% of the needed practices on the ground at the respective assessment points. Assessments should be made at the HUC12 level and aggregated up to the entire basin. Measurements of implementation may include:

- Miles of stream banks stabilized
- Miles of buffer strips
- Acres of cover crops
- Acres of contouring
- Acres of conservation tillage
- Miles of grassed waterways

VIII. Assessment criteria

Most of this watershed plan has focused on identifying and reducing loads of total phosphorus and sediment. However, the phosphorus assessment criteria that is applicable to the Genesee River basin as a whole is for the soluble reactive phosphorus (SRP) load delivered to Lake Ontario. An assessment criteria aimed at a reduction from the annual baseline SRP loading of 187,400 lb to the target loading of 178,600 lb as identified in the GLRI Action Plan (Great Lakes Restoration Initiative, 2010) is adopted for this watershed plan.

Sediment concentration criteria for the Genesee River where it enters Lake Ontario have been established as part of the Rochester Embayment Remedial Action Plan (MCDPD, 2002). The criteria, which are adopted here for the purpose of this watershed plan, are that "suspended sediment concentration (SSC) in the Genesee River remain less than 30 mg/L for at least 80% of a year, and exceed 200 mg/L for no more than 5 events with a combined duration of not greater than 20 days, as determined by a 5 year average."

Meeting the criteria above should be determined based upon measurements of SRP and suspended sediment concentrations in the Genesee River at Rochester. However, for planning purposes, the above criteria can be converted into approximate values for annual total phosphorus and total suspended solids loads. The modeling results from Makarewicz et al. (2013) indicate the total phosphorus load at Charlotte is approximately 11.2% SRP. If it is assumed that management measures reduce total phosphorus and SRP equally, the above SRP reduction can be achieved by a total phosphorus reduction of 79,000 lb/yr, or approximately 8% of the current total phosphorus load.

For the purpose of this approximation, if an equivalency between TSS and SSC is assumed, the SSC criteria can be approximated as achieving an annual TSS load of 5×10^8 lb/yr, a reduction of 3.4×10^8 lb/yr, or about 40% of the annual load. This estimate is, however, conservative as it assumes no days when SSC exceeds 200 mg/L.

IX. Monitoring

The Genesee River is monitored regularly via a number of programs. The NYSDEC Rotating Intensive Basin Studies (RIBS) program has sampled the Genesee River in Rochester approximately 6 times per year for the last 13 years. Water quality parameters measured include phosphorus and sediment. On a rotating five year schedule the RIBS program conducts focused monitoring of different watersheds across the state. These efforts collect samples across the entire watershed, with the Genesee River basin being sampled as part of the 2014 cycle.

The USGS conducts regular monitoring of the Genesee River in Rochester as well. Samples are collected every six weeks and includes both phosphorus and sediment.

The USGS and NYSDEC are collaborating on sampling at select major tributaries within the basin. There is interest in continuing this sampling beyond the current two year scope.

Monroe County has also conducts monitoring on Black, Honeoye and Oatka Creeks for nearly ten years. The Lower Genesee River is also sampled weekly. Parameters include total phosphorus, soluble reactive phosphorus and total suspended solids.

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Appendix A. Highest priority HUC12

The highest priority HUC12s identified herein for each subwatershed are included below and the counties associated with each HUC12 also indicated. A map showing the HUC12s are in Figure 2. Note that only the highest priority HUC12s are included here. The reports referenced herein should be consulted to identify additional high, medium and low priority HUC12s within the Genesee River basin as well.

HUC12	Watershed Name	County	County	County
041300020401	Black Creek	Allegany		
041300020503	Brimmer Brook	Allegany		
041300020601	Black Creek	Allegany		
041300020603	Caneadea Creek	Allegany	Cattaraugus	
041300020604	Caneadea Creek	Allegany		
041300020801	Cold Creek	Allegany	Wyoming	
041300030403	Oatka Creek	Genesee	Wyoming	
041300030405	Oatka Creek	Genesee	Monroe	
041300030601	Spring Creek	Genesee		
041300030602	Black Creek	Genesee	Wyoming	
041300020906	Bradner Creek	Livingston		
041300020907	Twomile Creek	Livingston		
041300020909	Keshequa Creek	Livingston	Allegany	
041300020910	Keshequa Creek	Livingston		
041300020911	Buck Run Creek	Livingston		
041300030101	Coneusus Lake	Livingston		
041300030102	Conesus Lake	Livingston		
041300030103	Conesus Creek	Livingston		
041300030203	Springwater Creek	Livingston	Ontario	
041300030204	Hemlock Lake Outlet	Livingston	Ontario	
041300030301	Honeoye Creek	Livingston	Monroe	Ontario
041300030501	Beards Creek	Livingston	Wyoming	
041300030502	Jaycox Creek	Livingston		
041300030703	Genesee River	Monroe		
041300030704	Lower Genesee	Monroe		
041300030205	Honeoye Creek	Ontario		
041300030206	Honeoye Creek	Ontario	Livingston	
041300020703	East Koy Creek	Wyoming		
041300020705	East Koy Creek	Wyoming	Allegany	
041300030401	Oatka Creek	Wyoming		
041300030402	Pearl Creek	Wyoming	Genesee	

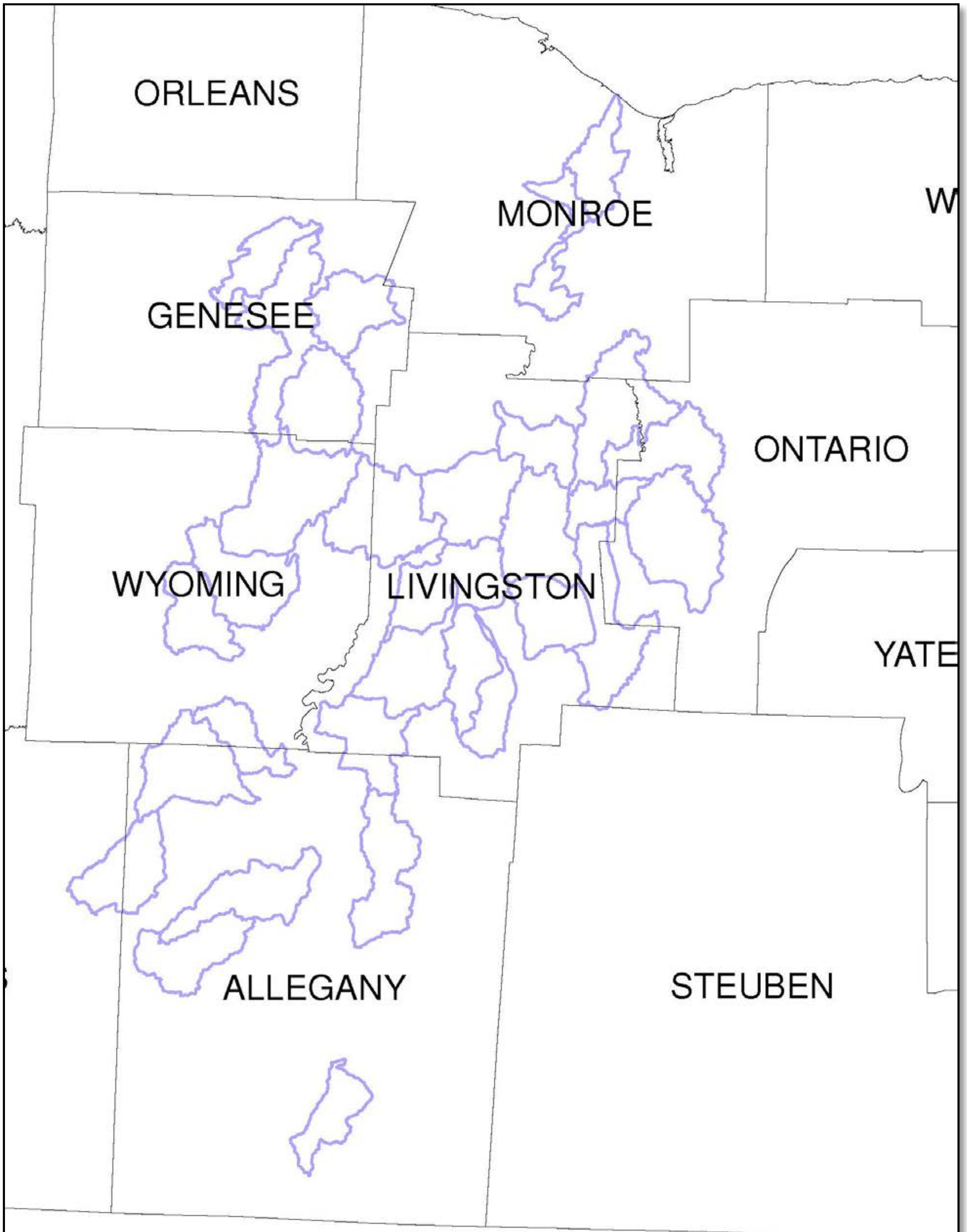

Figure 2: Highest priority HUC12s within the Genesee River basin