Deer and Pokegama Lakes Stream Phosphorus Reduction: Stream Geomorphology Report

PREPARED FOR

Itasca Soil and Water Conservation District

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"Managing natural resources through technical assistance and education."

Itasca County Soil and Water Conservation District

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Front Cover:

Clockwise from left, headwaters tributary of Smith Creek (Brook Trout stream); bog and alder swamp flow through wetland common to the region; open, flow through wetland; measuring depth in a typical woodland stream within the study area.

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SUMMARY OF FINDINGS AND RECOMMENDATIONS

An assessment of subwatersheds draining to Deer (31-0719) and Pokegama (31-0532) Lakes, Itasca County, MN, was made to identify locations and extent of sediment and nutrient export affecting water quality in the region. Historical data suggests that water quality in these lakes is gradually declining given increasing phosphorus levels. A 2013 study (*Deer-Pokegama Clean Water Partnership Diagnostic Study*) identified 16 subwatersheds containing excess amounts of phosphorus (7 draining to Deer Lake and 9 draining to Pokegama). This study presented the following findings important to lakes in the region of Pokegama and Deer:

(1) Precipitation is an important source of nutrients and likely other chemicals, and
(2) The lakes both have inordinately high rates of oxygen depletion in the hypoliminion.

In addition, the previous study indicated areas around Pokegama and Deer Lakes where further assessment be made and proposed that:
(1) A more detailed and controlled groundwater monitoring network be established and tracked
(2) Streams that are contributing excess phosphorus (e.g., out of compliance with Minnesota draft standards) be carefully examined and remediated
(3) The causes of extreme deep water oxygen consumption be analyzed and experimentally managed
(4) The two lakes be monitored continuously to act as bell-weathers of regional change
(5) Road drainage modification be sought to alleviate high nutrient inputs
(6) The Mississippi River backflow be decreased if possible, and
(7) A septic system improvement and education program be implemented.

In 2016, an Enbridge funded *Eco-footprint Grant Agreement* to fund implementation of specific recommendations, within the 2013 study, was granted. This *Deer and Pokegama Lakes Stream Phosphorus Reduction: Stream Geomorphology Report* presents methods, results and implementation recommendations from a detailed geomorphic study of the 16 subwatersheds and respective streams suggested as potentially significant sources of nutrients within the 2013 study.

The geomorphological assessment used a tiered, top-down approach to identify potential drivers of sediment mobilization, transport, and fate from the landscape to the stream to its outfall to the lake. The analysis started with an assessment for sediment and stability consequences to identify subwatersheds and specific reaches most at risk of degradation and nutrient export. A Level-1 stream reach delineation and classification considering the landscape geomorphology (valley cross section and type, depositional patterns, etc.) and remotely-estimated values of entrenchment, width-to-depth ratio, sinuosity, slope and bed materials was made. This was followed by a historical review of landscape activities that have potentially affected sediment supply and channel stability relative to stream reach types. Land uses were correlated to published influences on stream channels and sediment supply.

For subwatersheds/stream reaches most likely to be affected by drivers of sediment supply and bank and/or bed erosion, a more detailed, in-field assessment was made. The NRCS Stream Visual Assessment

Protocol (version 2), was used to determine scores relative to channel condition, hydrologic alteration, riparian zone, bank stability, nutrient enrichment, barriers to fish movement, and invertebrate habitat. The combined score provided a comprehensive condition of overall ecological health, as well as variables affecting nutrient transport to the lakes. The stability of each visited reach's upper banks, lower banks and bed was assessed via 15 metrics to produce a more detailed assessment of channel stability incorporating scores relative to channel evolutionary stage. Lastly, channel cross section morphological and bed composition was recorded to inform a modified Level-2 classification. This information was used to update classifications of unvisited streams with similar channel, valley and depositional patterns as well as to assist in estimation of flow rates and shear forces used in channel restoration design.

The results of the rapid and detailed assessment allowed for a condition assessment, as well as recommendations for management of sediment and nutrient export.

Results of this geomorphic assessment suggest that Lake Pokegama's subwatersheds and associated streams would provide greater opportunity to address watershed drivers of sediment and nutrient export, as well as channel instability, than Deer Lake. However, though the 2013 study identified streams with excessive nutrient export, little evidence of current channel sediment transport processes exist that are likely candidates for excessive nutrient export to Pokegama Lake. In some cases, streams were ephemeral, with no flows observed at the time of the study as well as with a lack of defined channel. In most cases, subwatersheds, though certainly altered from natural conditions to variable degrees, have either not been modified to the extent needed to destabilize channels or have not been altered within the past 20-30 years, thereby allowing channels to re-stabilize. There is, however, evidence of some current land use effects and the presence of backwater and wetlands, some within peat areas, that likely contribute to sediment and nutrient transport to downstream reaches and to Lake Pokegama. Limited stream channel related projects were identified for remediation for Pokegama in this study.

Deer Lake is reported as having a water budget strongly influenced by ground water, and this assessment concurs with observation of very limited perennial stream flow from its identified subwatersheds of concern. Deer Lake's watershed is significantly less altered than Pokegama's, with fewer roads, developments or silviculture. No landscape or stream channel related projects were identified for remediation in this assessment. Similar to Pokegama's watershed, Deer Lake's drainages contain several wetlands with apparently intermittent flow of sediment and nutrients.

In both cases, evidence from this assessment's identification of very limited stream destabilization related sources of nutrients affirms the 2013 suggestion that other sources are important to the nutrient budgets of each lake. The results of this study, however, do not suggest stream bank or bed erosion as a significant source of nutrients. Though not studied further here, it is likely that wetlands, limited agriculture, road runoff and ground water are the conduits of nutrient export to streams. It is also quite possible that historic deposition of sediment and nutrients into wetlands and smaller lakes midway up subwatersheds has created legacy nutrient sources for export to Lake Pokegama. Lastly, it is also possible that aging or non-compliant subsurface sewage treatment systems may be leeching nutrients to groundwater or directly to stream valleys or channels. It is important to note that this analysis only investigated landscape and fluvial geomorphic systems and did not monitor surface water, lake or wetland benthic sediments or compliance, or export of nutrients from septic systems. In 2016 and 2017, as part of the Eco Foot Print Grant, Itasca SWCD monitored surface waters for Total Phosphorus and Chlorophyl-A.

RECOMMENDED PROTECTION STRATEGIES

1. It is recommended that an analysis of septic system compliance and function be made in tandem with implementation of an educational-outreach program.
2. It is recommended that cities consider adoption of stormwater ordinance language within the Minimum Impact Design Standards Community Assistance Package developed by the Minnesota Pollution Control Agency (MPCA-MIDS).
3. It is recommended that Itasca County considers adoption of land use conservation zoning overlays related to future development.
4. It is recommended that Itasca SWCD considers using select reaches from this study as stable reference sites to be used in evaluation of departure from "normal" on future stream studies in the region as well as for estimating the magnitude of stream impacts in similarly classified streams.
5. It is recommended that first order headwaters are preserved or only very selectively harvested to maintain channel equilibrium downstream.
6. It is recommended that upstream lakes within historic logging areas be studied to understand nutrient export.
7. Reaches within logged lands present a unique opportunity to establish monitoring and further historical review (desktop and in-field) to develop a case study for the conservation effectiveness of modern forestry as compared to historical practices. Results can inform UPM Blandin Paper on the effectiveness of their conservation BMP selection and implementation.

RESTORATION STRATEGIES

1. Pokegama's subwatershed P2 drains a commercial district along the east side of highway 169 via a ditch with occasional rip-rap. It is recommended that the SWCD consider installation of ditch checks to allow for sediments in stormwater runoff to settle within the ditch or be filtered. The drainage area leading to the ditch is not expansive, though does generate sediment and associated pollutants from impervious surfaces to the lake.
2. It is recommended that Itasca SWCD consider working with the landowner of the agricultural lands located in subwatershed P3 on implementation of NRCS agricultural BMPs, as well as potentially dredging the farm pond. Conversion of woodland cover to agricultural land use has likely increased sediment/nutrient export to the pond causing the pond to become a source of nutrient export to Lake Pokegama. Dredging of the pond will require a feasibility study to determine the cost/benefit accurately.
3. It is recommended that Itasca SWCD considers analyzing benthic sediment deposition in Smith Lake for sedimentation depth, age and phosphorus composition and likely behavior relative to internal loading. The lake is positioned at the bottom of major stream network running through

historically heavy forestry activities, and there is a possibility of legacy nutrient deposition in the lake acting as a nutrient source to Lake Pokegama. Benthic sediment sampling, water sampling, lab fees and development of a moderate watershed and lake response model (e.g., Bathtub) are required for this investigation.

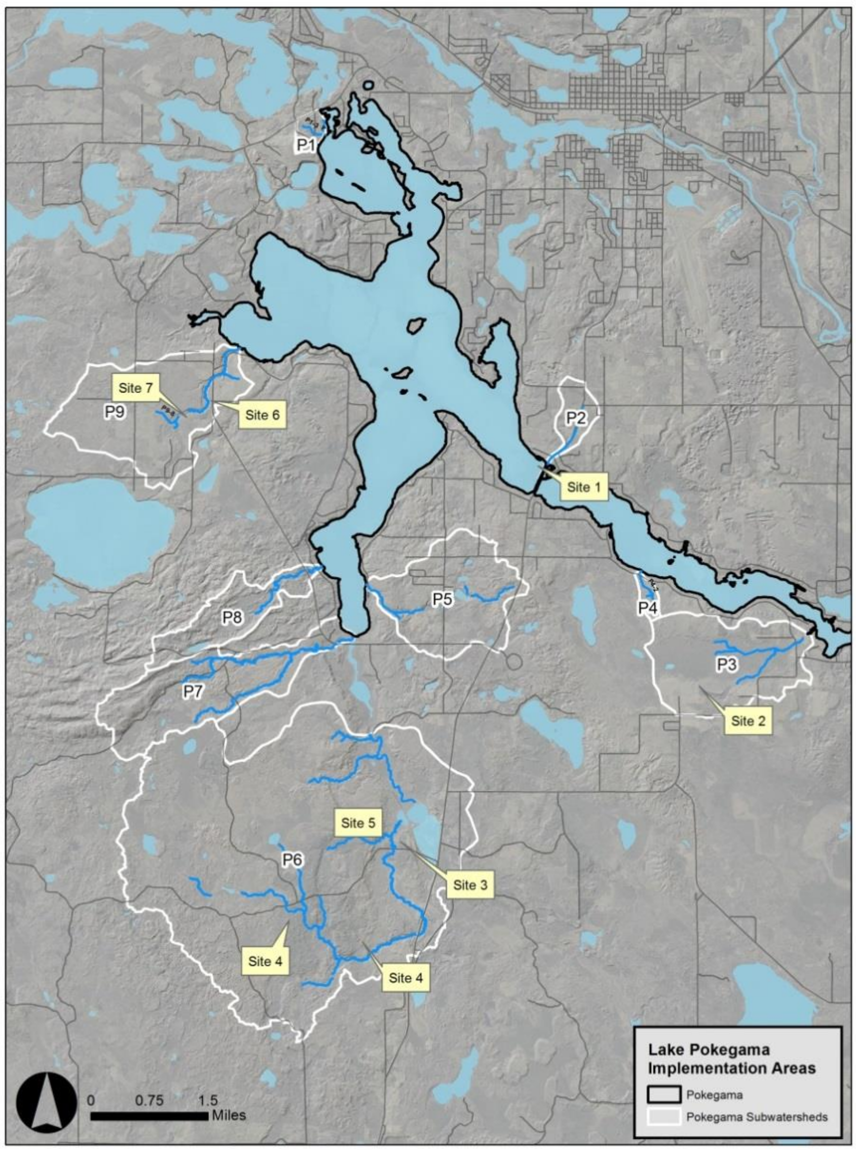
4. Smith Creek, within Pokegama subwatershed 6, is a State-listed Trout Stream. Several Brook trout were observed in the field assessment, all the way up to the headwaters of tributaries. This stream network flows through historically and currently forested land owned by the UPM Blandin Paper company. Though current forestry practices appear to have minimal effect on stream hydrology and fish habitat, there is evidence (P6.11, 12, and 13) of channel impacts from historical practices approximately 25-30 years ago. These impacts are slowly healing, but observations of instream fish habitat, though not explicitly studied in this project, suggest diversity and continuity is still impacted and likely linked to historical logging prior to current forestry standards. Simple Brook Trout habitat improvements are an option in many reaches.
5. It is recommended that Itasca SWCD consider installation of a toe-wood bioengineered bank treatment along Smith Creek, upstream from Smith Lake and immediately downstream of the new bridge built circa 2013 (P6.5). This listed Trout stream was the site of a bridge blow-out during excessively heavy storms in 2012-2013, further causing the downstream bank to destabilize. The bank is actively eroding, causing downstream deposition of sands and gravels, forming bars that push flows to outer banks and thereby, increasing the risk of accelerated or new bank erosion and sediment/nutrient export along downstream sections.
6. Active clear cutting was observed on Pokegama's P9.4 reach, on private land during field assessment to the wetland edge. During the site investigation there were cattle grazing on the same property above the stream valley. It is unknown if the cutting was within jurisdictional wetland or whether the intent of the cutting was for cattle access to the stream. In any case, this reach is aggrading its stream bed given altered upstream hydrology from a very large beaver dam along P6.5, P6.6, and P6.7. It is expected that this accumulation of sediment and subsequent channel instability will increase given the removal of tree canopy. If, in fact, grazing occurs in the channel, the stream channel will cease to exist and the area will convert to open mud flats with significantly increased export of sediment, nutrients and fecal bacteria. It is recommended that discussions are made between the owner of the property and the SWCD to ascertain the intent for land use in the newly cut area and to formulate a management plan.

   Removal of the beaver dam along P9.6 (omitted on maps given its conversion to a pond) would be necessary to restore channel hydraulics within lower reaches. Semi-annual Beaver would be necessary to maintain channel flow in subsequent years. It is also possible that nutrient dynamics related to ponding may contribute to seasonal pulses of dissolved phosphorus and organics as the pond converts to wetland through time, increasing the overall nutrient discharge from the watershed to Lake Pokegama. The challenge of removing the dam and semi-annual beaver trapping is access. Though access can be made by walking the channel upstream from Sugar Hill Road, it is not recommended. The site may be accessed via private land, with permission, from a field accessed off North Sugar Lake Trail. Though Beaver damming is a natural part of the forest and stream ecosystem, control would restore this reach and channel hydraulics and, possibly, reduce nutrient export to Lake Pokegama.

Implementation Opportunities within Lake Pokegama Watershed

ID	Receiving Waterbody	Subwatershed and Reach	Action	Opinion of Probable Cost for Implementation
1	Pokegama	P2	3 Ditch checks along Highway 169 (east side)	$10,000 - $15,000
2	Pokegama	P3	Agricultural BMPs Pond Dredging Feasibility Study	Variable by Practice $15,000 - $20,000
3	Pokegama	P6	Smith Lake Nutrient Budget	$15,000 - $17,500
4	Pokegama	P6	Smith Creek Trout Habitat Improvements	Variable
5	Pokegama	P6.5	Bank Stabilization and Habitat	$25,000 - $30,000
6	Pokegama	P9.4	Management Plan	SWCD staff time
7	Pokegama	P9.6	Beaver control and dam removal	$1,500

Beaver Dam removal can be achieved by contracting with the Department of Agriculture Wildlife Services in Grand Rapids (John Hart, 218.327.3350). $500 per dynamite application ($200 for additional removals during same day). Trapping costs range from $400 - $1000).



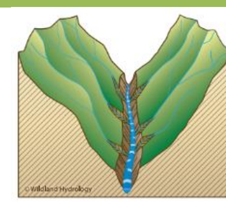
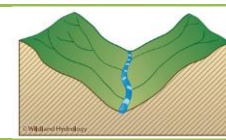
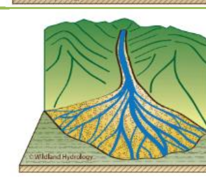
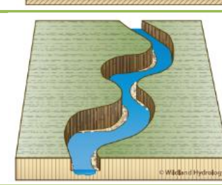
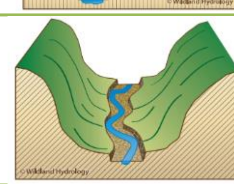
APPENDIX 1: METHODS

Desktop Analysis

Topography, landscape geomorphology and valley types

The landscape drives channel form. To a great extent, a stream's behavior is driven by slope, parent material it flows through and the type of valley it is contained within. As part of the desktop analysis, slope and valley types were reviewed (Table 1) to help understand the degree of lateral confinement imposed on overbank flows. Given that each valley type yields specific channel types, this information was used not only used as part of the classification criteria, but also for diagnosis of potential channel instability and evolutionary stage (Table 2). Digital elevation models (DEM) were used within GIS to assist in the definition of valley types (MNTOPO). The ERSI 3D Analyst toolset was used to create cross sections for reaches to make remote measurements of valley width and to define its shape. The DEM was formatted with hillshade relief to assist in visual interpretation of valleys from the aerial perspective.

Table 1. Valley types used for geomorphic characterization (Rosgen, 1996)

Valley Type	Summary Description of Valley Types	
I	Steep. Confined. "V" notched canyons, rejuvenated sideslopes	
II	Moderately steep, gentle-sloping side slopes often in colluvial valleys	
III	Alluvial fans and debris cones	
IV	Gentle gradient canyons, gorges and confined alluvial and bedrock-controlled valleys	
V	Moderately steep, "U" shaped glacial-trough valleys	

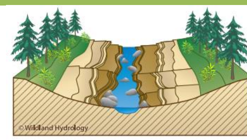
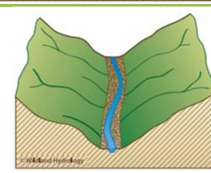
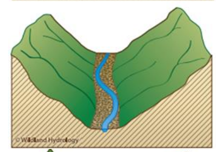
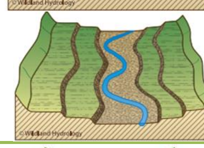
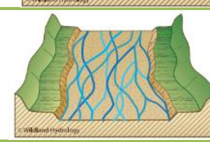
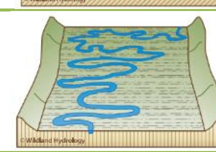
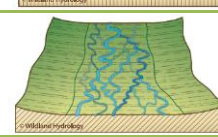
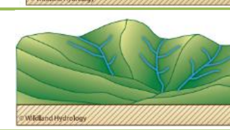
Valley Type	Summary Description of Valley Types	
VI	Moderately steep, fault, joint, or bedrock (structural) controlled valleys	
VII	Steep, fluvial dissected, high-drainage density alluvial slopes	
VIII	Wide, gentle valley slope with well-developed floodplain adjacent to river and/or glacial terraces – alluvial valley fills	  
IX	Broad, moderate to gentle slopes, associated with glacial outwash and/or eolian sand dunes	
X	Very broad and gentle valley slope, associated with glacio- and non-glacio-lacustrine deposits	
XI	Deltas	
XII	Eolian Loess or Sand Dunes	

Table 2. Valley-stream type associations (Rosgen, 1996)

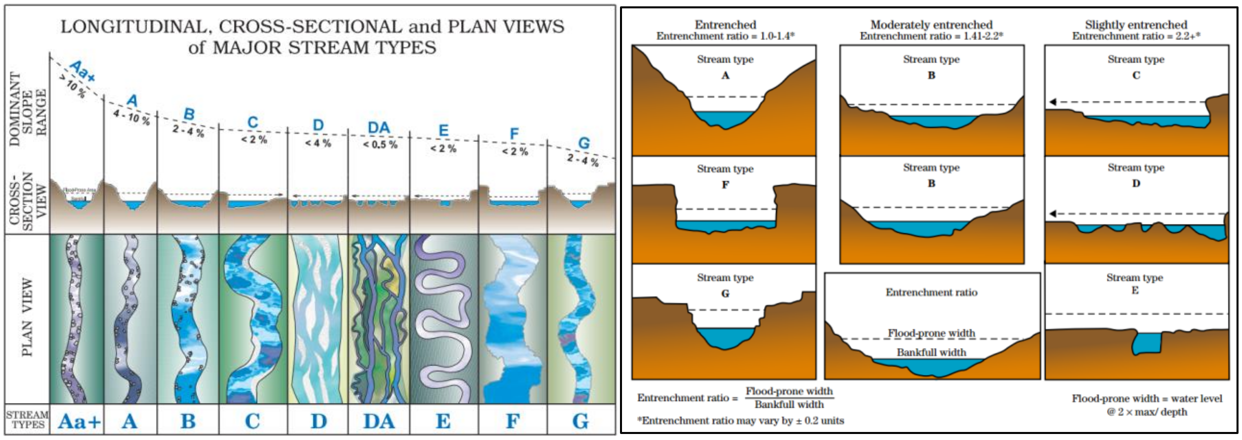
Valley Type	Common stream types	Less common stream types	Unstable stream types
I	A, G		
II	B	G	G, F
III	A, B, G, D		
IV	F	C	
V	C, D,G		
VI	B	C, F	G, F
VII	A, G		
VIII	C, E	D, F, G	
IX	C, D		
X	C, E, DA	G, F	G, F
XI	DA, D	C, E	

The region's overall geomorphology was used in conjunction with valley type definition to better understand expected fluvial geomorphology. The Geomorphology of Minnesota data set was used to define the historic phase of landscape formation, overall topographic features and associated sediment types for each stream network (MN Geospatial Commons).

Stream classification and sensitivity to watershed alteration

Stream segments were broken into discrete reaches given their proximal relationship to valley type and contiguous geometric and slope characteristics. This provided the means of classifying streams in order to describe their physical characteristics as well as to understand their potential sensitivity and likely response to watershed alteration (i.e., changes in hydrology and sediment supply) from a historic, current and future perspective. A Level 1 Rosgen classification (Rosgen, 1996; Figure 1) was performed using commonly available GIS and aerial imagery data sets from the MN Geospatial Commons, MNTOPO and Google Earth. National Hydrologic Dataset stream center lines were manually corrected using high resolution aerial imagery enabling more accurate measurements of sinuosity and slope. Entrenchment ratios were estimated using the DEM and ArcGIS 3D Analysts toolset assuming a 1.5 foot bankfull depth (BFD) for first order streams, a 2.0 foot BFD for second and a 3.0 foot BFD for third order or greater streams. Bankfull width-to-depth ratios were estimated in the same fashion. Channel materials were estimated from sediment association data in the Geomorphology of Minnesota as well as NRCS Soils data sets available on the MN Geospatial Commons website. A Level 2 stream classification was made via in-field verification of 21 reaches. Information from these was used for validation and correction of Level 1 classifications for un-visited reaches.

Figure 1. Rosgen stream types (classification is made via several additional metrics not illustrated here; Rosgen 1994, 1996)



Level 2 classification allowed for predicted stream sensitivity to disturbance, recovery potential, relative sediment supply, erosion potential and vegetation controlling influence (Table 3; Rosgen 1994, 1996).

Table 3. Select examples of broad-level, generalized interpretations by stream type (Rosgen 1994, 1996)

Stream Type	Sensitivity to disturbance	Recovery potential	Sediment supply	Streambank erosion potential	Vegetation controlling influence
A3	Very high	Very poor	Very high	Very high	Negligible
C5	Very high	Fair	Very high	Very high	Very high
E5	Very high	Good	Moderate	High	Very high
G4	Extreme	Very poor	Very high	Very high	High

Land use impacts on stream channels and sediment supply

Each subwatershed was reviewed via historic aerial imagery to develop an understanding of when, what kind and to what extent landscape alteration activities have occurred in relation to the stream networks they drain to. Alterations in the physical landscape predictably impact hydrologic, hydraulic, vegetative community and other features that in turn, drive sediment delivery to channels as well as erosional processes within channels (Rosgen 2006; Table 4). Each of 14 possible land uses and impacts was recorded for each subwatershed. Imagery from 1991, 2003, 2004, 2006, 2008, 2009, 2011 and 2013 from Google Earth was used for this review.

Table 4. Select examples of direct (D) and indirect (I) potential influences of land use variables on stream channels and sediment supply (reduced from Rosgen, 2006; additional land use drivers were considered in the analysis).

LAND USES	VARIABLES INFLUENCED											
	(1) Streamflow changes (magnitudes/timing)	(2) Riparian vegetation change (composition/density)	(3) Surface disturbance (% bare ground/compaction)	(4) Surface/sub-surface slope hydrology	(5) Direct channel impacts that destabilize channel	(6) Clear water discharge	(7) Loss of stream buffers, surface filters, ground cover	(8) Altered dimension, pattern and profile	(9) Excess sediment deposition/supply (all sources)	(10) Large woody debris in channel	(11) Stream power change (energy distribution)	(12) Floodplain encroachment, channel confinement (lateral confinement)
Urban Development	D	D	D	D	D	D	D	D	I	D	D	D
Silvicultural	D	D	D	D	D		D	I	D	D	I	D
Agricultural	D	D	D	D	D		D	D	D	D	D	D
Channelization	D	D		D	D		D	D	D	D	D	D

Potential erosional and streamflow process impacts

Each subwatershed was further evaluated within the aerial imagery record in light of the results of the land uses and impacts review to identify potential erosional process impacts to stream channels given their correlation (Rosgen 2006; Table 5). Guidance from the *Watershed Assessment of River Stability and Sediment Supply* (WARSSS; Rosgen, 2006) was used for this review to identify subwatersheds for field review. Surface erosion was evaluated in consideration of soil and geomorphology data in conjunction with the DEM (slopes) and aerial imagery. Attention was paid to locating surface erosion on steep, dissected slopes, unstable soils at lower slope positions adjacent to drainage ways, location of skid or off highway vehicle trails relative to position on slope, and surface disturbance on rill-dominated slopes.

Potential for mass erosion was reviewed by:

- Looking for evidence of slumping or mass slides within the past 10 years
- If slides were located on slopes conducive to rapid sediment export and low stability
- If a high percentage of vegetative clearing occurred on landslide-prone terrain
- If slide activity was located adjacent to drainage ways
- If any slump/slide was potentially caused by roadways

A review for processes related to streamflow changes was reviewed by:

- Land cover (urban or rural)
- Stream order
- Stream classification
- Time-trend of vegetative cover
- Diversions or depletions to historic flows
- Location of roadways within the stream networks

Direct impacts to streambanks and channels were assessed considering:

- Possible stream dimension
- Pattern and profile alteration through time
- Evidence of riparian vegetation alteration from woody to grass/forb communities

Table 5. Direct (D) and indirect (I) relation of stream and channel variables from Table 4 to erosional processes (Rosgen, 2006)

	POTENTIAL EROSIONAL PROCESS IMPACTS								
VARIABLES INFLUENCED	**Surface erosion**	**Mass erosion**	**Gully erosion**	**Streambank erosion**	**Channel enlargement**	**Aggradation**	**Degradation**	**Channel incision**	**Sediment delivery efficiency**
(1) Streamflow changes (magnitudes/timing)		I	D	D	D	D	D	D	I
(2) Riparian vegetation change (composition/density)			D	D	D	D	D	D	I
(3) Surface disturbance (% bare ground/compaction)	D	I	D	I	I	I	I	I	D
(4) Surface/sub-surface slope hydrology	D	D	D	I	I	I	I	I	D
(5) Direct channel impacts that destabilize channel			D	D	D	D	D	D	I
(6) Clear water discharge			D	D	D	I	D	D	
(7) Loss of stream buffers, surface filters, ground cover	D		I						D
(8) Altered dimension, pattern and profile				D	D	D	D	D	
(9) Excess sediment deposition/supply (all sources)				D	D	D	D	D	
(10) Large woody debris in channel		D	D	D	D	D	D	D	
(11) Stream power change (energy distribution)			D	D	D	D	D	D	
(12) Floodplain encroachment, channel confinement		I	I	D	D	D		I	D

Stream Crossings and Culverts

Each subwatershed was reviewed for the presence, position and density of stream crossings to evaluate the potential effects on channel confinement. Culverts and bridges tend to confine channels, change local stream power and alter channel dimension. These in turn, directly affect the immediate reach's streambank erosion rates, channel enlargement risk, degradation of the streambed and incision of the stream channel. This can lead to downstream bed aggradation of eroded bank soils and channel enlargement through a process in which deposited soils redirect stream flows to the banks, increasing scour and bank migration rates.

Subsurface Sewage Treatment Systems (septic systems)

Each watershed was reviewed for proximity of septic systems to stream channels to identify risk of stream migration impacts, as well as a relative surrogate for risks associated with septic leeching into ground and surface waters. Reaches were reviewed for the density of septic systems adjacent to the channel as a potential threat to surface water if a channel migrated laterally into it. Similarly, risk of nutrient transmittal from either failing or otherwise non-compliant systems was evaluated relative to proximity to the channels solely on the assumption that the closer the system is to the channel, the greater the possibility of contamination. It is important to note that no determination of septic system functioning, compliance or nutrient transmittal to ground water or streams was made in this study.

Minnesota Chapter 7080 describes rules for subsurface sewage treatment systems as "…must be protective of groundwater. A system that is not protective is considered a system failing to protect groundwater. At a minimum, a system that is failing to protect groundwater is a system that is a seepage pit, cesspool, drywell, leaching pit, or other pit; a system with less than the required vertical separation distance…built after March 31, 1996, or in an SWF area…before April 1, 1996, in areas that are not SWF areas as defined under part 7080.1100, subpart 84, must have at least two feet of vertical separation…"

Channel Evolution

Each subwatershed was reviewed through historic aerial photography for signs of possible evolutionary shifts in channel type. (Field investigation of the river valley, floodplain, relative tree age, channel, banks and stream bed assisted in finalizing this assessment.) Streams naturally erode steep topography, transport sediment through mid-watershed reaches and deposit sediments in reaches low in the watershed and within lakes. Watershed alterations and changes in precipitation frequency, duration and intensity can dramatically accelerate this process. This accelerated process affects the total load of sediment and nutrients delivered downstream and to the lake. This process can also put infrastructure at risk, such as roadways, bridges, buildings, utilities and septic drain fields, among others. When natural channels can accommodate periodic episodes of these changes to flow and watershed sediment supplies without significantly changing their characteristic channel types they are considered to be in equilibrium (in balance, or stable) with their watershed. When the resistive features within a channel and its floodplain are stressed with too high, frequent and/or long periods of increased flow, and/or sediment beyond some critical threshold, it will begin to change its pattern, longitudinal profile and cross sectional characteristics. This describes a destabilized system (disequilibrium) that needs to find new equilibrium at some point in the future, via a series of channel type modifications that can accommodate the new inputs. Both Schumm (1984) and Rosgen (1996) provide predictions of typical channel evolutionary successions that were considered when the previous desktop reviews suggested the potential for disequilibrium.

Field Analysis

A field assessment was made of select streams within the study area to serve two purposes: (1) to verify assumptions and desktop interpretations, and (2) to collect reach-specific information related to their overall health and stability. Subwatersheds that showed strong indication of potential for landscape and channel erosional processes were visited in the field for verification and a more detailed condition analysis. Not every reach was visited for this analysis, as field resource allocation was prioritized using the results from the desktop analysis. Inferences on the stream conditions for unvisited reaches were made by referencing results of visited streams based on similar classification, valley watershed characteristics.

Rapid condition analysis

The NRCS *National Biology Handbook: Subpart B – Conservation Planning, Part 614, Stream Visual Assessment Protocol, Version 2* (SVAP; NRCS, 2009) was used for the first of two in-field assessments of reaches. This assessment provides a basic level of stream health evaluation. This protocol provides an assessment based primarily on physical and chemical conditions within the assessment area. Individual metrics were scored to help identify clues to degradation. The summed score provided a means of describing the overall reach condition, while individual metric results help guide management strategies. This process not only provides a more complete picture of stream health and stability but also provides rapid redundancy in evaluation, enhancing the confidence in final assessments of channel stability and extent of sediment and nutrient sourcing to the lakes.

The following assessment categories were evaluated in this study:

Channel Condition - Often, development of a subwatershed results in changes to stream meandering pattern and flow. These changes may affect the way a stream naturally does its work, potentially altering the transport of sediment and the development and maintenance of habitat for fish, aquatic insects, and aquatic plants. Some modifications to stream channels have more impact on stream health than others. For example, channelization and dams affect a stream more than the presence of pilings or other supports for road crossings. Reaches were scored based on evidence of varying degrees of modification to channel conditions such as presence of dikes or structures, excessive downcutting or lateral cutting, past channel regrading, presence and amount of rip-rap or channelized (straightened) sections, excessive aggradation or altered valley to a higher degree of flood confinement.

Hydrologic Condition – Bankfull flows and flooding are important to maintaining channel shape and function (e.g., sediment transport) and maintaining physical habitat. High flows scour fine sediment to keep gravel areas clean for fish and other aquatic organisms. These flows also redistribute larger sediment, such as gravel, cobbles, and boulders, as well as large woody debris, to form pool and riffle habitat important to stream biota. The river channel and flood plain exist in dynamic equilibrium, having evolved in the present climatic regime and geomorphic setting. The relationship of water and sediment is the basis for the dynamic equilibrium that maintains the form and function of the river channel. Any change in the subwatershed or channel flow regime alters this balance and stress is placed on the system, causing a shift into a new stream form (or Classification). Reaches were scored based on evidence of varying degrees of frequency of flooding, presence of dams or dikes, water withdrawal (if present), effect on low flow-habitat access/availability relationships, and degree of channel incision (channel confinement).

Riparian Zone – This element refers to the width of the natural vegetation zone from the edge of the active channel out onto the flood plain. For this metric, the word “natural” means plant communities with (1) all appropriate structural components and, (2) species native to the site or introduced species that function similar to native species at reference sites. A healthy riparian vegetation zone is one of the most important elements for a healthy stream ecosystem. The quality of the riparian zone increases with the width and the complexity of the woody vegetation within it. Riparian zones serve many functions ranging from runoff filtration (sediment/nutrient capture), erosion control, bank stability, floodplain and in-channel habitat structure, channel shading, large woody debris sources to the stream for pool formation, microinvertebrate substrate, fish cover, forced pool creation, bed stabilization, organic material, etc. Reaches were scored based on evidence of varying degrees of the width of the riparian vegetation, its filtering capacity and extent of vegetative regeneration.

Bank Stability – This element provided an initial, rapid assessment of the potential for detachment of soil from the upper and lower stream banks and its movement into the stream. (The following analysis, Pfankuch Stream Stability, goes into greater detail.) These sediments carry nutrients (e.g., phosphorus) downstream. Some bank erosion is normal in a healthy stream. Excessive bank erosion occurs where riparian zones are degraded or where the stream is unstable because of changes in subwatershed hydrology, sediment load, or isolation from the flood plain. High and steep banks are more susceptible to erosion or collapse. All outside bends of streams erode, so even a stable stream may have 50 percent of its banks bare and eroding. A healthy riparian corridor with a vegetated flood plain contributes to bank stability. The roots of perennial grasses or woody vegetation typically extend to the baseflow elevation of water in streams that have bank heights of 6 feet or less. The root masses help hold the bank soils together and physically protect the bank from scour during bankfull and flooding events. Vegetation seldom becomes established below the elevation of the bankfull surface because of the frequency of inundation and the unstable bottom conditions as the stream moves its bedload. Reaches were scored based on evidence of varying degrees of bank height relative to bankfull, root density, outside bend erosion extent, abundance of overhanging root mass and fallen trees and presence of actively eroding inside bends.

Nutrient Enrichment - Nutrient enrichment is often reflected by the types and amounts of aquatic vegetation in the water. High levels of nutrients (e.g., phosphorus) promote an overabundance of algae and floating and rooted macrophytes. The presence of some aquatic vegetation is normal in streams. Algae and macrophytes provide habitat and food for all stream animals. However, an excessive amount of aquatic vegetation is not beneficial to most stream life and may suggest excessive nutrient export to lakes. Plant respiration and decomposition of dead vegetation consume dissolved oxygen in the water. Lack of dissolved oxygen creates stress for all aquatic organisms and can cause fish kills. Reaches were scored based on evidence of varying degrees of water clarity and color, aquatic plant diversity and algal abundance.

Barriers to Fish Movement – Although not critical to nutrient export from streams to the lakes within this study, given the presence of listed trout streams in the area and relatively healthy watersheds compared to the southern half of the State, it was decided to record the presence of any fish barriers discovered during field work. Barriers that block the movement of fish or other aquatic organisms, such as fresh water mussels, must be considered as part of the overall stream assessment. If sufficiently high, these barriers may prevent the movement or migration of fish, deny access to important breeding and foraging habitats, and isolate populations of fish and other aquatic animals. Reaches were scored based on evidence of varying degrees of seasonal water withdrawal effect on access to, or quality of, in-stream habitat units and the presence of drop structures, culverts, dams or diversions.

Invertebrate Habitat – Invertebrate habitat abundance and quality can serve as surrogate to water quality and bed stability. Stable substrate is important for insect/invertebrate colonization. Substrate refers to the stream bottom, woody debris, or other surfaces on which invertebrates can live. Optimal conditions include a variety of substrate types within a relatively small area of the stream. Stream and substrate stability are also important. High stream velocities, high sediment loads, and frequent flooding may cause substrate instability even if substrate is present. Reaches were scored based on evidence of varying degrees of the number of habitats available, habitat developmental stage and substrate disturbance or deposition.

Pfankuch stream stability

The second assessment performed at each visited reach used a relative channel stability ranking developed by Pfankuch (1975; Table 6) for the U.S. Forest Service in the central and western US states, which Rosgen modified for consideration within his channel categorization structure. In this field-based ranking system, channel features of the upper banks, lower banks, and bottom are assessed for a variety of metrics with individual condition results ranging from excellent to poor. Once the condition of each category is determined, its rank is tallied to arrive at a summative index value, which is evaluated based on Level 2 channel type. This allows for determination of the channel stability ranking as good, fair, or poor. A lower index value indicates higher stability and low sensitivity to disturbance. A higher index value indicates lower stability and higher sensitivity to disturbance. Results are adjusted in consideration of the expected stable channel form that the reach in question is evolving into. In the case of streams within equilibrium ("stable"), this would mean the current classification.

Table 6. Pfankuch evaluation metrics for upper and lower banks and channel bottom (Pfankuch, 1975; ranking guidance omitted)

Location	Key	Category
Upper banks	1	Landform slope
	2	Mass erosion
	3	Debris jam potential
	4	Vegetative bank protection
Lower banks	5	Channel capacity
	6	Bank rock content
	7	Obstructions to flow
	8	Cutting
	9	Deposition
Bottom	10	Rock angularity
	11	Brightness
	12	Consolidation of particles
	13	Bottom size distribution
	14	Scouring and deposition
	15	Aquatic vegetation

APPENDIX 2: RESULTS AND DISCUSSION

Pokegama Study Area

Landscape and channel variables affect dynamic equilibrium within the Lake Pokegama tributaries. Topography affects watershed runoff rates as well as channel gradient. Pokegama subwatersheds 1, 2, and 5-9 provide the greatest topographic relief on their streams, while subwatersheds 3 and 4 are relatively low gradient (Figure 2). Greater topographic relief yields higher gradient stream channels, as well as the potential for greater runoff volumes and rate and sediment transport to the channel. Over the span of a channel's evolution, there is tendency for a reduction in channel gradient. Therefore, there is a propensity for stream systems in these landscapes to exist in either a dynamic equilibrium at a certain gradient and cross section, or to be actively down-cutting their beds, becoming incised, leading to bank failures and migration. In the case of the latter potential, more sediment leaves the system than is received. Conversely, lesser topographic relief yields lower gradient streams and the potential for lesser runoff volumes and rate, as well as sediment transport to the channel. Over the lifespan of these channel's evolution, sediment is typically collected and settled in the bed, forcing the channel width to expand and its course to meander until an equilibrium state with the watershed is reached.

The landscape's geomorphology affects a stream's cross section and sediment balance. Geomorphology can affect a stream channel's resistance to hydraulic scour, in turn affecting in-channel sediment mobilization and migration downstream. Pokegama subwatersheds P1, P2, and P5 through P9 exist in predominantly Supraglacial Drift Complexes, while subwatersheds 3 and 4 lay within Undifferentiated and Peat landscapes (Figure 3). Subwatersheds P6 and P7 have portions of Till Plain as well. These geomorphic features affect the degree of confinement imposed on the stream (flood plain extent) and also the material the stream is working against. Supraglacial Drift landscape features are formed from lateral and medial moraines and from flow of supraglacial material at the terminal end of glaciers. Well-drained silty glaciolacustrine deposits over loamy till, and sandy and silty glaciolacustrine deposits over sandy and gravelly outwash dominate in Pokegama supraglacial drift complex areas. In higher gradient reaches within this complex, the more erodible silt-dominated top soils uncover sand, gravel and cobble beds depending on stream gradient and drainage area size and land cover. Till Plain landscape features are comprised of extensive flat plains of glacial till formed from detached sheets of the main body of a glacier that melted in place depositing the sediments it carried. Interspersed in the plain are gentle rolling hills and ground moraines, formed when the till melts out of the glacier in irregular heaps. Soils within the Pokegama watershed are similar to the adjacent Supraglacial Drift. The confinement of these landscapes on its stream channels reduces the width of the available floodplain that otherwise serves to spread out overbank flows, thereby reducing the magnitude of hydraulic force (scouring potential). Observations were made of varying degrees of confinement, with greater confinement overall within Supraglacial Drift areas. In areas with less confinement and low gradient valleys, wetlands have formed. These serve as sediment sinks but do have the potential to export nutrients during heavier flow in the form of suspended and dissolved forms. Peat landscape features in the area are comprised of heavily organic-dominant sediments deposited in valley floors, with groundwater connectivity, below the steeper topography of Supraglacial and Till Plain complexes. These channels were observed to have very broad flood plains with little to no confinement of the stream flow to the immediate channel. No excessive hydraulic scour was expected or observed, given this fact. It is likely that these systems store sediment given their position in the stream network and as such, maintain sedimentation processes with occasional export during heavier flow events. Though the Peat landforms and their channels act as a sink for sediment, they conversely serve as a nutrient supply exporting both suspended and dissolved nutrients to the lake.

Roads and their stream crossings can have a direct impact on streams, their channels and sediment and nutrient transport. In the storms of 2012-2013, at least three road crossings were destroyed and subsequently repaired. Twenty-four road crossings were visited across each subwatershed within the Pokegama Lake watershed (Figure 4). Upstream and downstream indicators of culvert-induced influences were inspected including bank failure, bed aggradation (sedimentation), bed degradation (down cutting) and culvert end running (erosion around the culvert). No obvious influences on culverts were noted in the field. Considering this and the apparent resilience to the 2012-2013 storm flows, it is likely culverts and crossings within the watershed are capable of passing flows at a rate suitable for Pokegama's channels.

Subsurface sewage treatment systems (SSTS) were mapped for the Pokegama watershed to investigate relative proximity to stream channels (Figure 5). No attempt was made to validate the County's spatial data accuracy for the exact position within the landscape. Subwatershed P3 has two SSTS close to the stream channel, though the channel itself appears stable and no immediate risk of meander migration into the SSTS is prevalent under the climatic conditions experienced to-date. Similarly, P5 has several (6 to 10) SSTS that may be close to the upper portion of the subwatershed's area and the channel is stable and does not drain to Lake Pokegama (this subwatershed is hydrologically non-contributing). Subwatershed P6 has two SSTS at the midpoint of its drainage area and 2 proximal to a tributary near its outlet to the wetlands along the south shore of the Lake. It is unlikely that the SSTS in the midpoint of the subwatershed (along Highway 169) are at risk of being encroached on. The tributary nearest the subwatershed's outlet were unable to be visited due to access limitations (private property). Subwatershed P9 has five SSTS near its channel. The upper channel SSTS is located at the channels origination and is at very low risk of channel migration. The lower SSTS are located along a channel undergoing aggradation and should be considered moderately at risk depending upon their actual distance from the channel. The channel in the lower P9 subwatershed does not appear to be undergoing significant bank migration but should be monitored through time.

The second risk associated with SSTS proximity to channels is related to ground water conveyance of SSTS infiltrate and associate nutrients. It was beyond the scope of this study to evaluate this risk thoroughly, though it is recommended that an evaluation of SSTS compliance to modern State Standards is recommended. The evaluation can identify non-compliance sites to identify locations within the channels for water quality monitoring for indicators of SSTS contributions to streamflow and water quality degradation. This will be important in perennial ground water reaches.

Current streams morphology was characterized with the Rosgen Classification System (Rosgen 1996) to aid in understanding of stability within a given valley type, susceptibility to watershed alteration, and their positon within channel evolution characterize their classes and evolutionary stage (Figure 6). Evolutionary stages help the assessment determine a channel's deviation from equilibrium and predict the subsequent stages to expect until equilibrium is regained. Very few disequilibrium stages were identified within this assessment. Some notable exceptions were identified, however. Subwatershed P6 provided evidence of channel evolution as induced from logging practices 15-30 years ago. In this subwatershed's headwaters (first and some second order reaches), floodplains and banks were harvested causing an influx of sediment and runoff. The headwater channels were likely similar in morphology to what was observed in un-logged areas (or areas logged greater than 20-30 years ago), but adjusted their alignment and cross sectional dimensions as the result. Sediment export to Smith Lake was likely very high during this period of time and the years preceding it. Sediments carrying nutrients have likely accumulated within the lake, where at least twice a year, anoxic conditions and lake turnover cause nutrient export to Lake Pokegama. (No evaluation of in-lake nutrient dynamics was made during this study.) This assessment suggests that the average stream recovery time related to a change in forestry practices in the Till Plain region of the watershed is 20-30 years. Currently, these streams, though not completely recovered back to their stable channel form, are nearly back to their stable dimensions. Fish habitat is still in recovery mode, as the channels are currently shallower and wider than what would be considered the stable channel form. These reaches' evolution to stable form, upstream of Smith Lake, could be accelerated via simple bank treatments to narrow the channel cross section and to provide bank cover for its Brook Trout populations. This narrowing would help scour sediments, exposing additional spawning reds (beds) as well.

Also within P6 is an actively eroding reach south of the Smith Lake Road bridge; the scene of a bridge blow-out in the 2012-2013 storms. An extensive lateral and mid-channel gravel bar has formed downstream of the bridge, pushing the flows to the outer banks. This has increased toe scouring and subsequent sloughing of banks resulting in tall vertical banks and export of sediments downstream that may be putting additional banks at risk of accelerated erosion and habitat loss. It is recommended that simple toe-wood and cedar tree revetments be installed on the first, possibly the second bend downstream of the bridge. The gravel bar and sands deposited in this reach can be excavated and placed in these bank treatments to help reform a channel cross section using stable reaches reference dimensional ratios in the area.

Land use, erosional processes and streamflow changes were assessed to identify potential stream impacts in this study (Figure 7; Figure 8). Stable stream channels were strongly correlated to natural, stable upstream drainage areas. In areas with minimal landscape alteration, streams remained stable and resilient to previous extreme climatic events. The extreme rainfall events of 2012-2013 caused a shift in stream alignment and cross sectional geometry of the highly susceptible Type A channel within P8, though it regained stability within 3 years to the state it is in today. This channel is an example of the resilience of streams to episodic climate events within natural watersheds and should serve as a reference site for similar stream-valley types in the region that are currently or have in the past experienced land cover or hydrologic modifications. Hydrologic modifications to the mid-to-upper watershed in P9, however, illustrate how reductions in flow cause sediment build up, bank failure and channel evolution. This modification is driven by an extensive beaver dam that has led to a radical shift in storage and flow rates in the reach immediately east of Sugar Hill Road. The stream has become shallow and widened from Sugar Hill Road to Moose Point Road, resembling how the Second order streams of subwatershed P6 likely appeared 20 years ago when logging occurred within the riparian zone. It is not recommended that beaver control be executed at this time, as access to the dam area is difficult and it will require yearly trapping. Reshaping the impacted stream reach east of Sugar Hill Road is also not recommended at this time, though a riparian management plan should be considered. The riparian forest was being logged during this evaluation and active grazing was observed above the channel valley. Removal of riparian forest and grazing (if it occurs) rapidly destroys stream banks. In this particular case, this channel is very small and runs through a scub-shrub bog with highly sensitive soils incapable of any cattle or machinery traffic. Sediment and nutrient export will result from the loss of riparian cover and root structure if improperly managed in the immediate future.

A rapid condition assessment was made for reaches identified as most susceptible to impairments as the result of the desktop analysis (Table 7; Figure 9). This analysis estimated the current ecological health of the reaches using several metrics as a means of assisting in determination of stability, nutrient export and as ability to support for macroinvertebrates and fish. Possible scores were poor, fair, good or excellent. Results ranged from fair to excellent with six reaches being fair, seven being good, and five being excellent. One reach was a roadway drainage swale and, in as such, was not scored for ecological health. Unvisited reaches are expected to score predominantly good to excellent. This condition assessment should be considered a preliminary assessment of impairments similar to, but not as extensive as, the Minnesota Pollution Control Agency's (MPCA) monitoring efforts for determination of impaired waters during the Stressor Identification phase of Watershed Restoration and Protection (WRAPS) planning.

A stream stability assessment was performed for reaches requiring a field assessment was identified in the desktop analysis (Table 7;Figure 10). The assessment summed scores relative to upper and lower banks and the streambed to provide indication of overall channel stability. Four reaches were not assessed for stability given access limitations (P3 and 4), the channel was non-contributing/un-defined (P5) or was a roadway ditch (P2). Possible ratings included unstable, moderately unstable or stable. One reach was considered unstable, five were moderately unstable and nine were stable. Unvisited reaches are expected to score predominantly as stable.

Table 7. Lake Pokegama results for field assessed reaches (reaches not represented were not identified in the desktop analysis for the need for field review)

Watershed.Reach	Rapid Assessment Rating	Stability Assessment
P2	Stable Ditch[1]	NA
P3	Fair-Good[2]	NA
P4	Fair-Good[2]	NA[3]
P5[4]	NA	NA
P6.5	Good-Excellent	Moderately Unstable
P6.6	Excellent	Stable
P6.12	Good	Moderately Unstable
P6.13	Fair	Stable
P6.27	Excellent	Stable
P6.28	Excellent	Stable

P6.36	Excellent	Stable
P7.7	Excellent	Stable
P8.1	Fair	Moderately Unstable
P8.2	Good	Moderately Unstable
P9.2	Good	Moderately Unstable
P9.3	Fair	Unstable
P9.4	Fair	Poor
P9.5	Good	Stable
P9.8	Good	Stable
P9.9	Good	Stable

[1]Ditch appeared stable. Rapid Assessment of ecological health not performed.
[2]Private land access not obtained. View from road and aerial photography suggest Fair to Good rating.
[3]Aerial photography and watershed assessment suggest stable channel form.
[4]Non-contributing subwatershed

Figure 2. Topography of the Lake Pokegama watershed

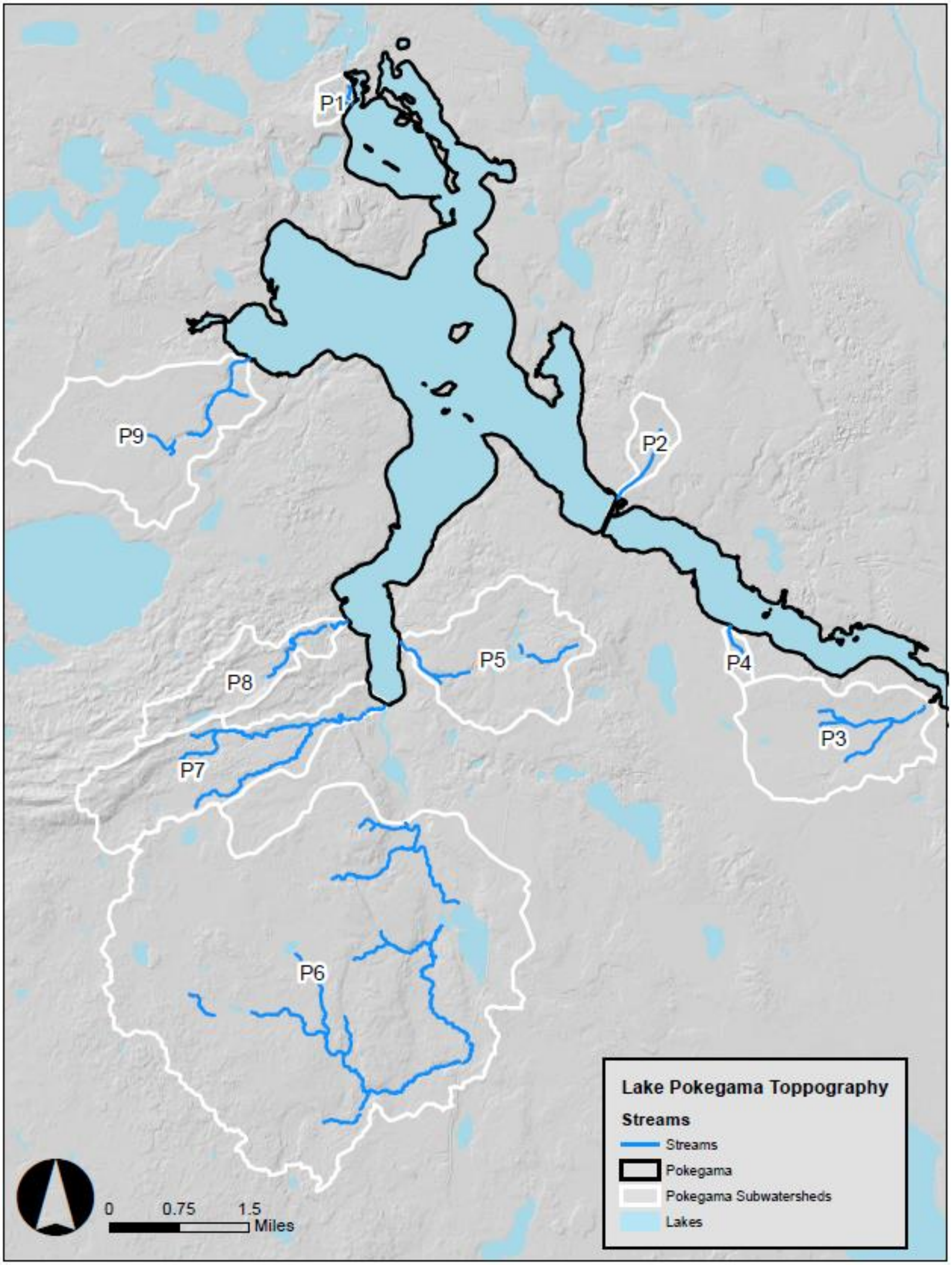


Figure 3. Landscape geomorphology of the Lake Pokegama watershed.

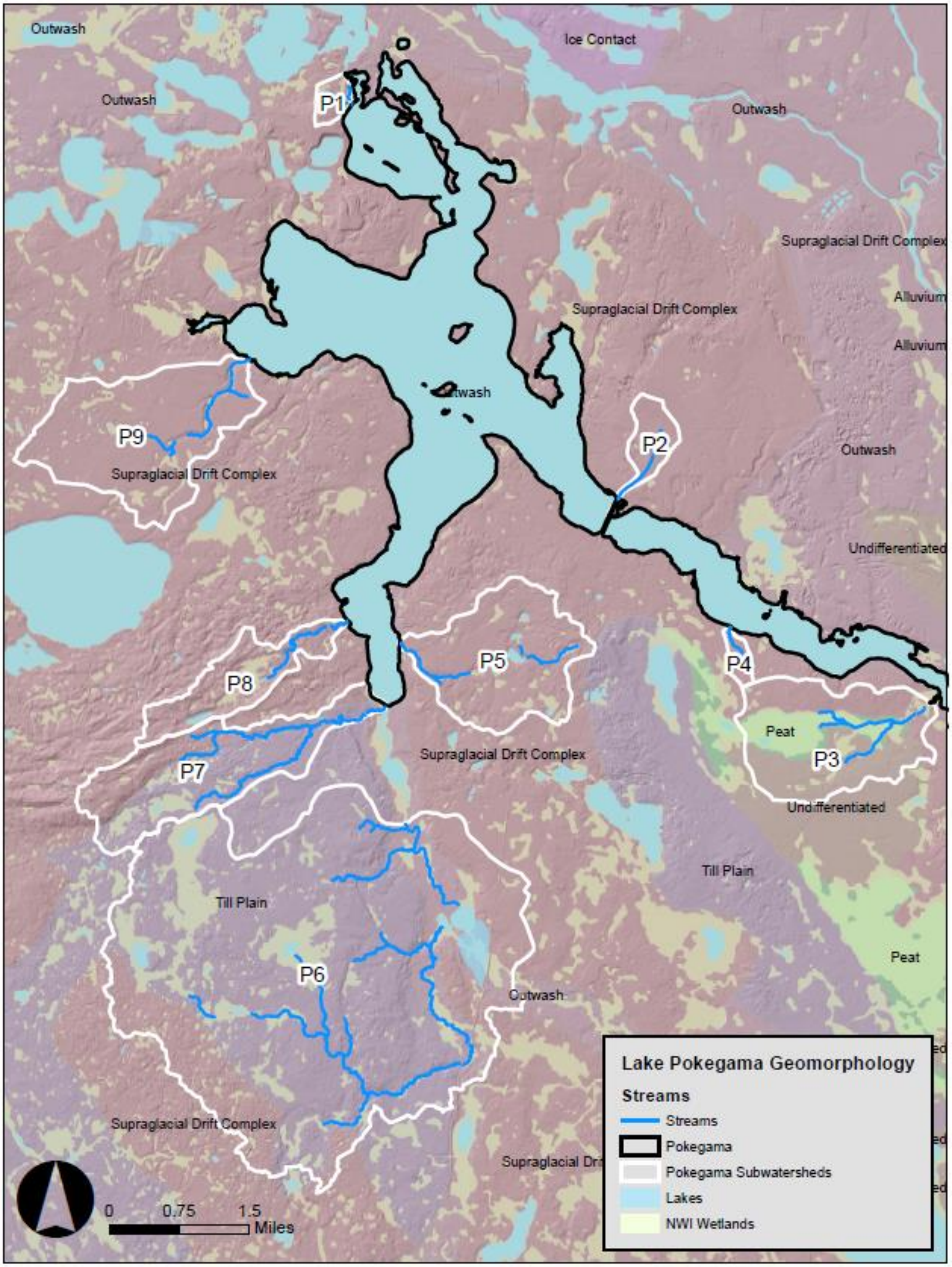


Figure 4. Roads and stream crossings in the Lake Pokegama watershed.

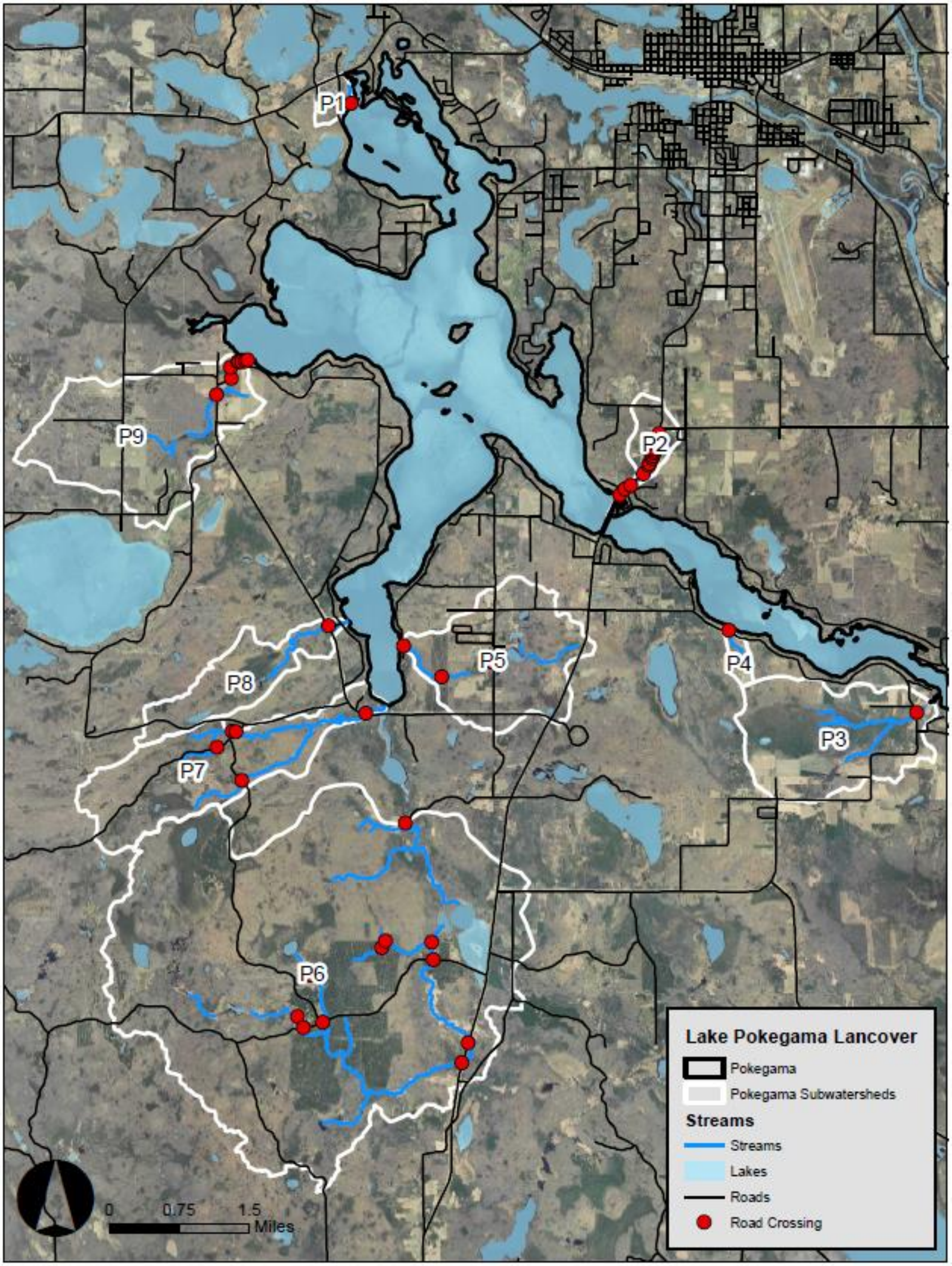


Figure 5. Subsurface sanitary drain fields in the Lake Pokegama watershed.

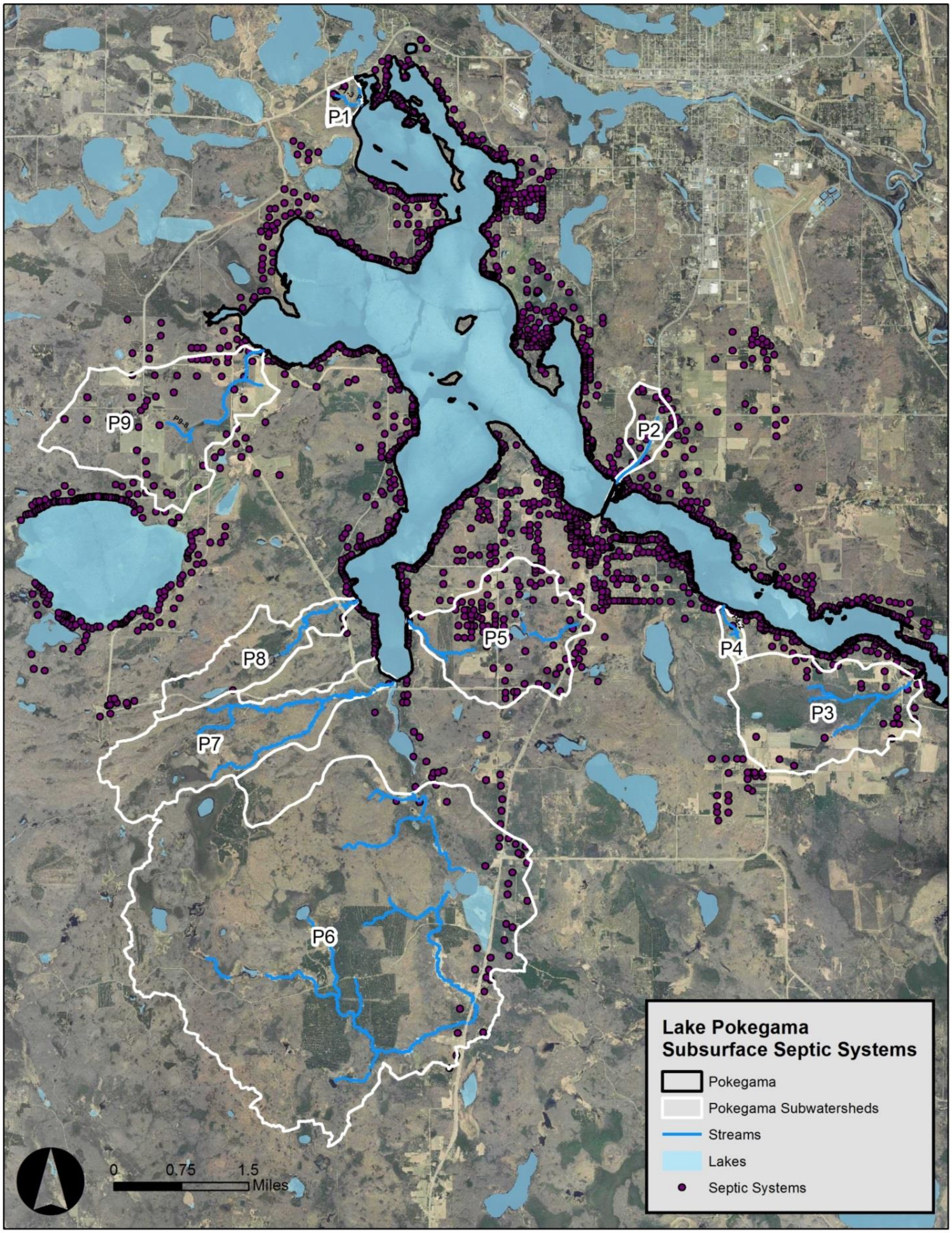


Figure 6. Rosgen stream classes of reaches within the Lake Pokegama watershed.

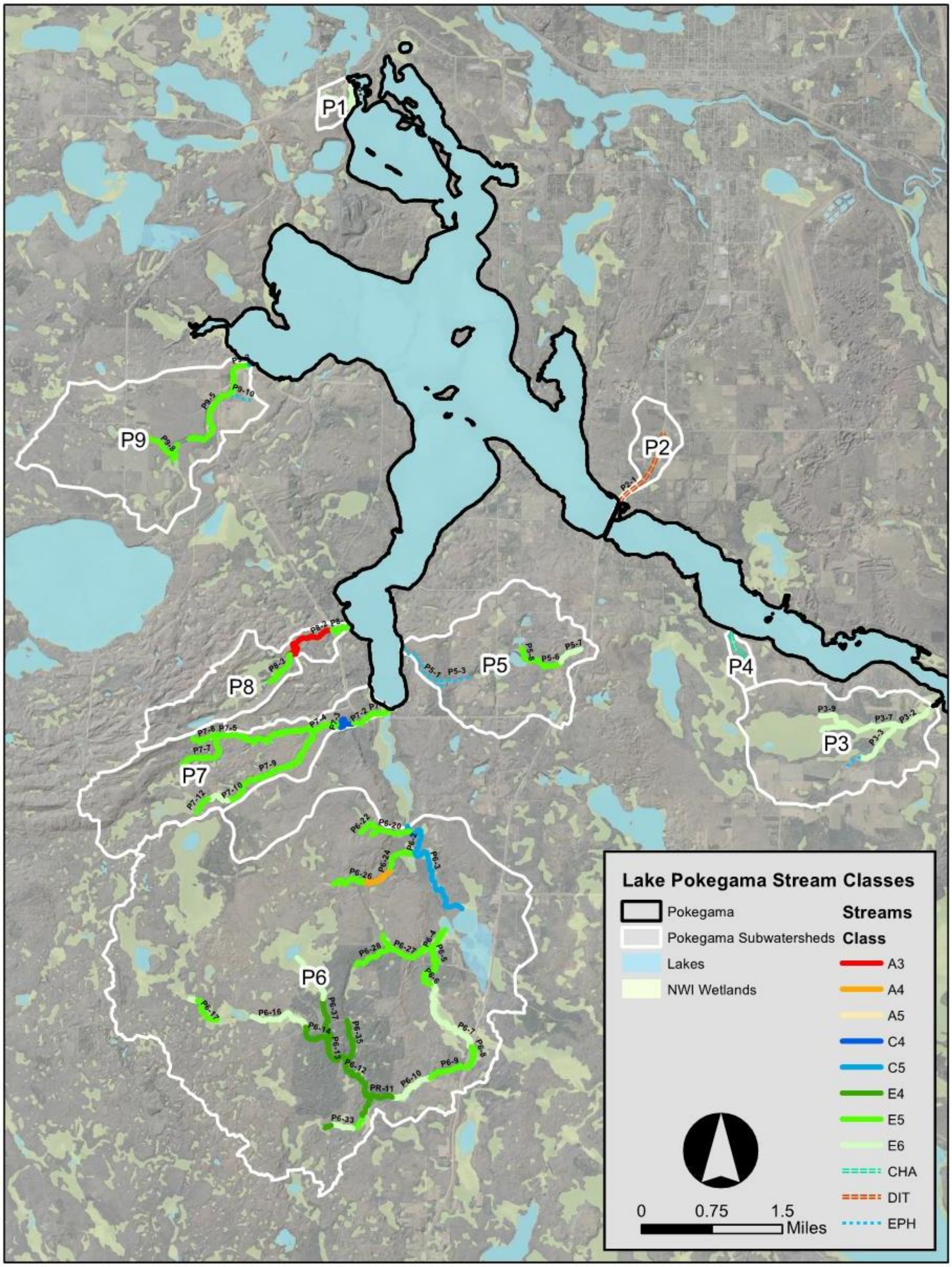


Figure 7. Land use and impacts within the Lake Pokegama watershed.

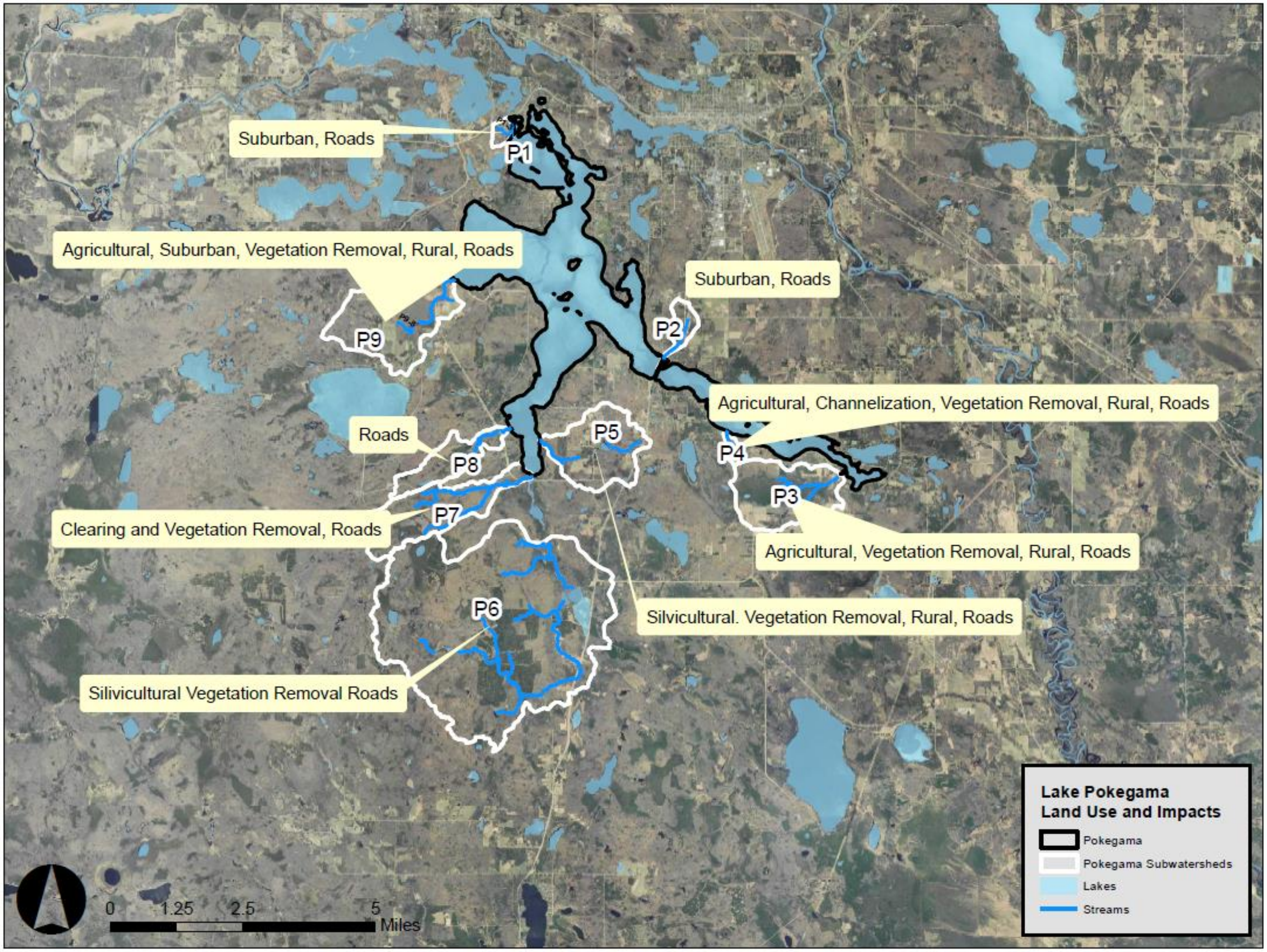


Figure 8. Erosional and streamflow processes within the Lake Pokegama watershed.

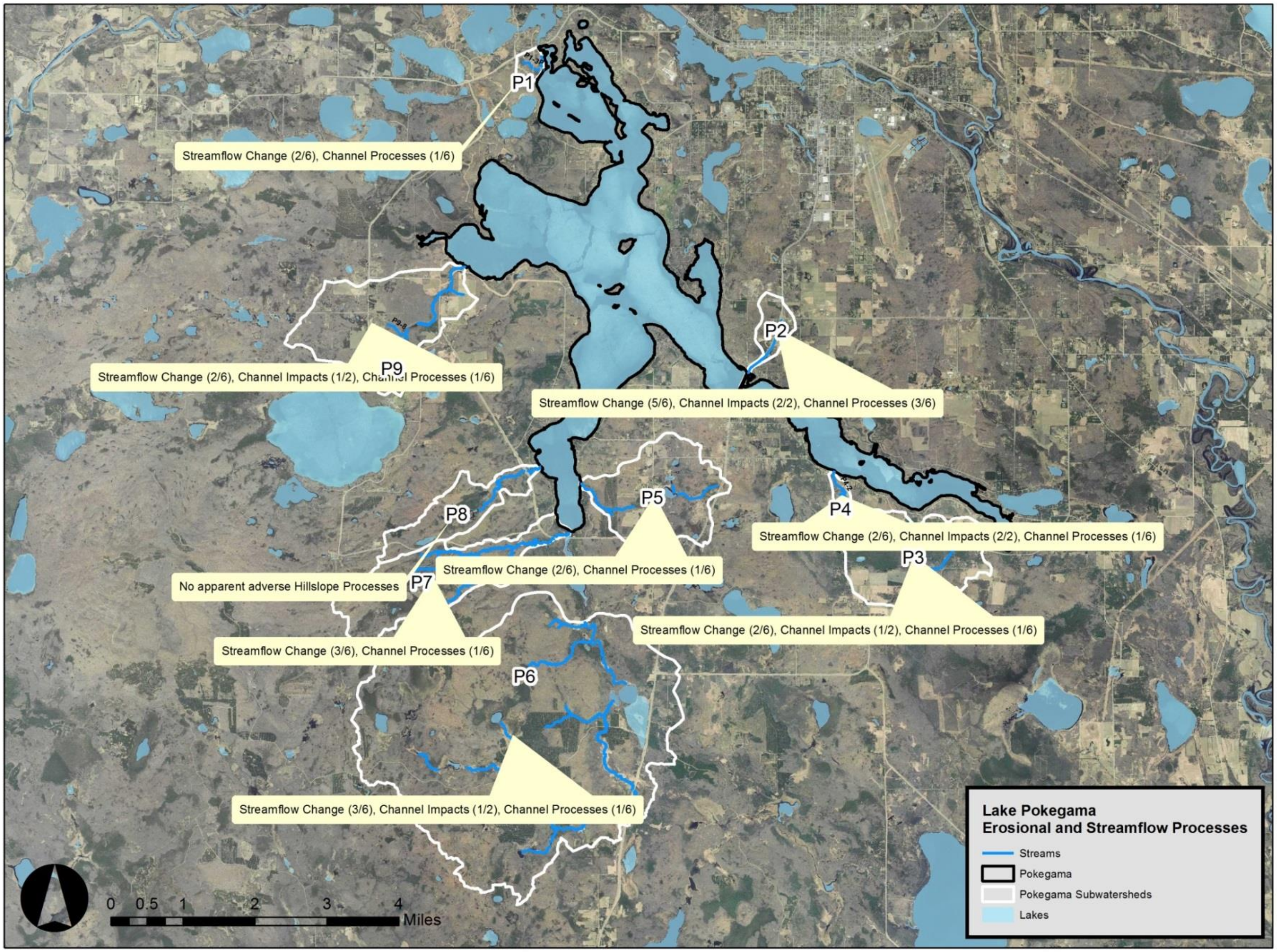


Figure 9. Rapid condition assessment results for reaches within the Lake Pokegama watershed.

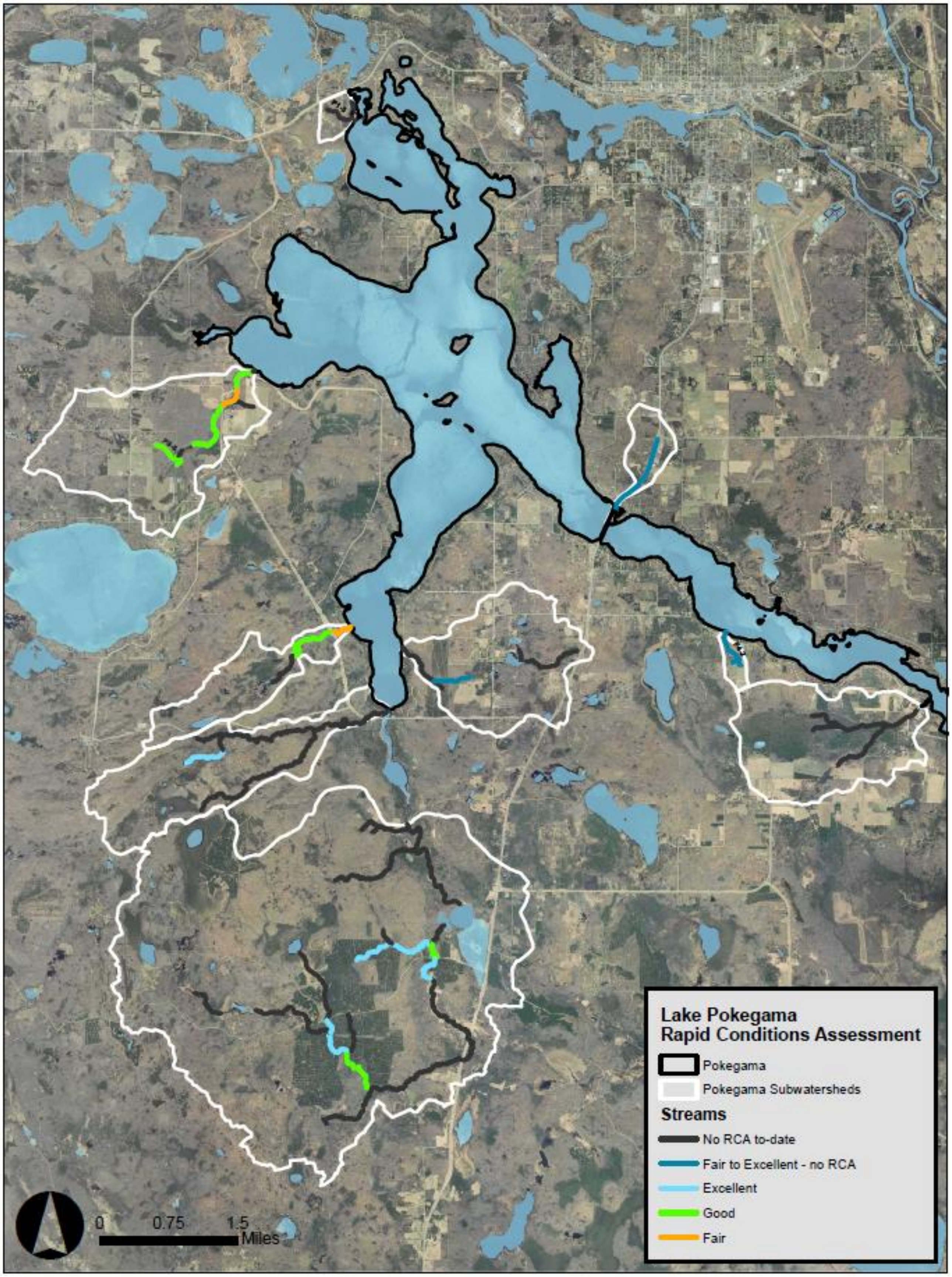
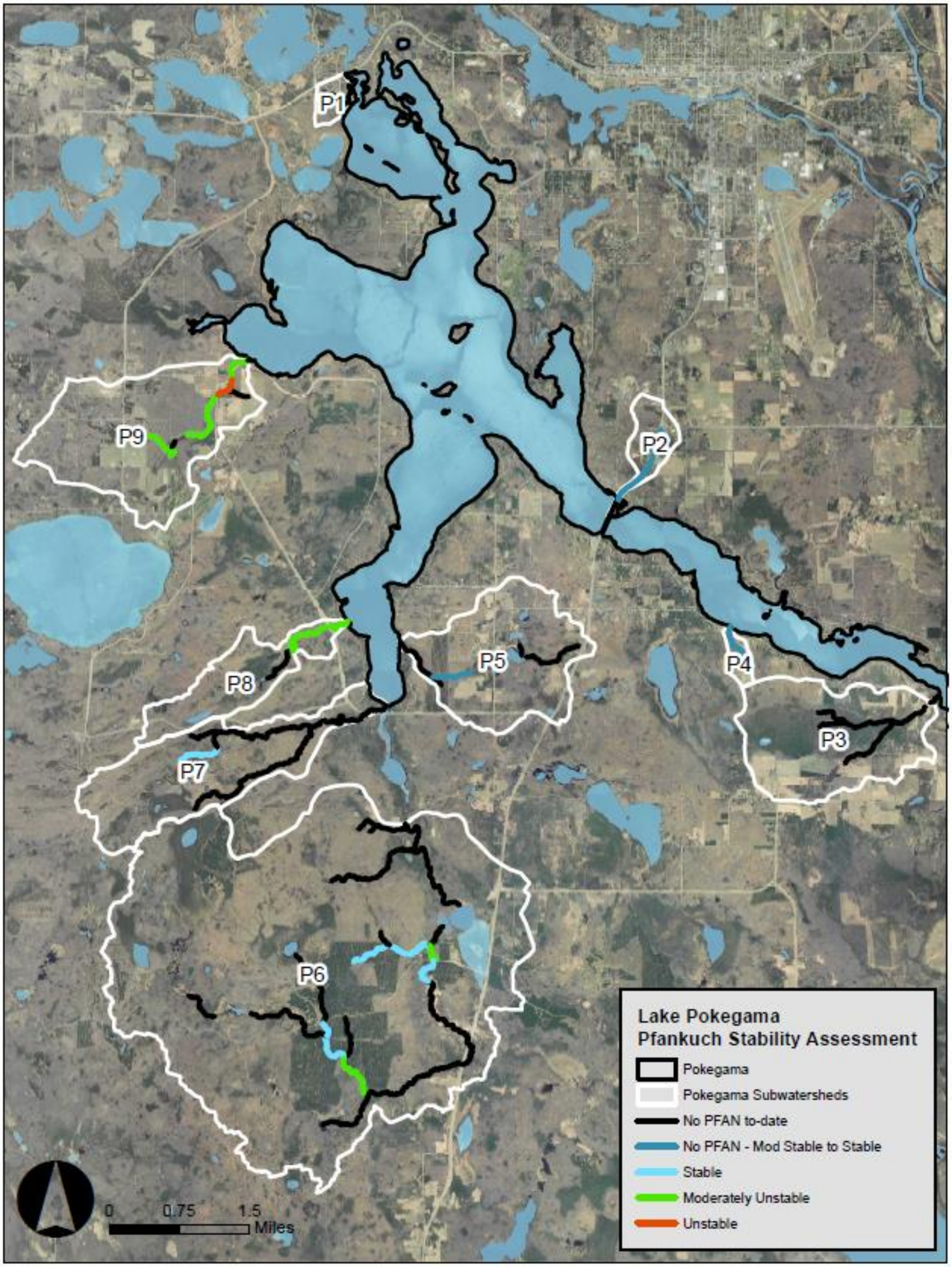


Figure 10. Pfankuch stream stability condition results for reaches within the Lake Pokegama watershed.



Deer Study Area

Deer Lake's watershed remains relatively unchanged over the extent of the historic aerial photographic record. As discussed in the *Deer-Pokegama Clean Water Partnership Diagnostic Study*, the major source of water to the lake is via groundwater flow with a smaller contribution from surface water runoff. Though it is likely some logging has occurred in this watershed through time, no lasting effects on channels or the forest stands is apparent.

Supraglacial Drift Complexes of rolling topography dominate the watershed of Deer Lake, most notably on the southwest and northeast quadrants (Figure 11; Figure 12). This landform is highly pocketed, creating a matrix of wetlands and infiltration zones surficially-disconnected from the lake. Subwatersheds D2, 3, 4, 5 and 6 are all located in this landscape. Subwatersheds are also located within the Supraglacial Drift Complex but in flat areas with potential for more surface water connection to the Lake. At the time of the field work, fall 2017, no actively flowing channels were observed in any of the subwatersheds of Deer Lake.

In stark contrast to Pokegama's watershed, Deer Lake's watershed has only eight road crossings (Figure 13). Seven of these were observed in the field, each apparently with capacity to adequately flows without causing excessive erosion points. Total road density within the subwatersheds of Deer Lake are also far smaller than Pokegama suggesting less influence of road-surface transport of sediments than in Pokegama.

Deer Lake is similar to Pokegama in that many of its subsurface sewage treatment systems are located near the shoreline in hilly topography (Figure 14). Subsurface sewage treatment systems (SSTS) were mapped for the Pokegama watershed to investigate relative proximity to stream channels. No attempt was made to validate the County's spatial data accuracy for the exact position within the landscape. Very few SSTS appear close to the stream channels associated with the subwatersheds of concern visited in this study and are therefore not at risk to stream encroachment. As mentioned for Pokegama, the second risk associated with SSTS proximity to channels is related to ground water conveyance of SSTS infiltrate and associate nutrients. It was beyond the scope of this study to evaluate this risk thoroughly, though it is recommended that an evaluation of SSTS compliance to modern State Standards is recommended.

Deer Lake's subwatershed is comprised of relatively in-tact forest and rural development with no current logging or obvious clearing that may adversely influence water quality within streams and the Lake (Figure 16; Figure 17).

Deer Lake water quality would appear to be marginally influenced by surface water runoff given the lack of perennial flows, predominantly natural watershed and highly pocketed topography with many non-contributing areas to the lake. When streams do flow, it is likely that a pulse of nutrients and suspended sediment leaves wetlands and the forest floors, transporting to intermittent channels connected to the Lake.

Figure 11. Topography of the Deer Lake watershed

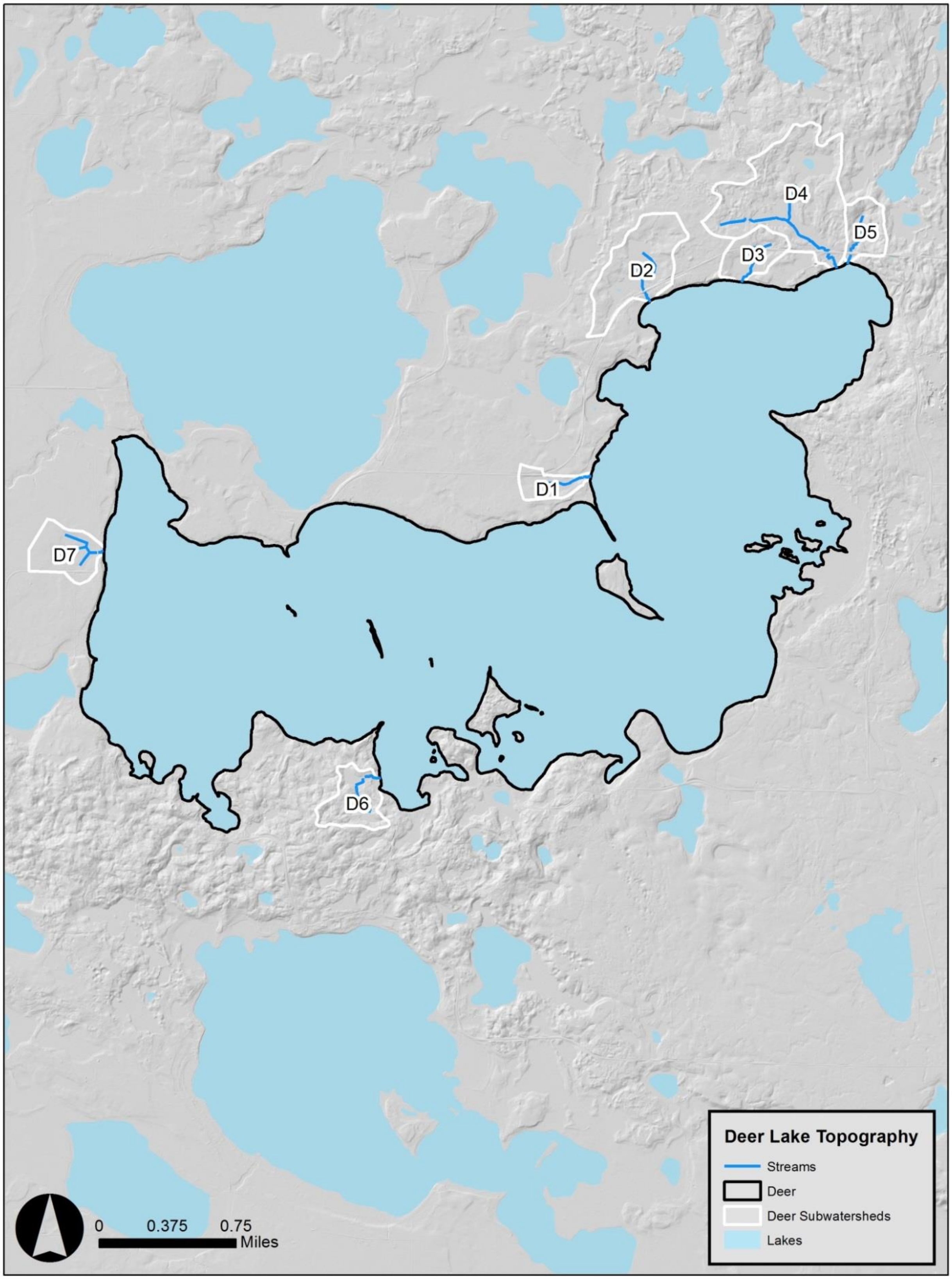


Figure 12. Landscape geomorphology of the Deer Lake watershed.

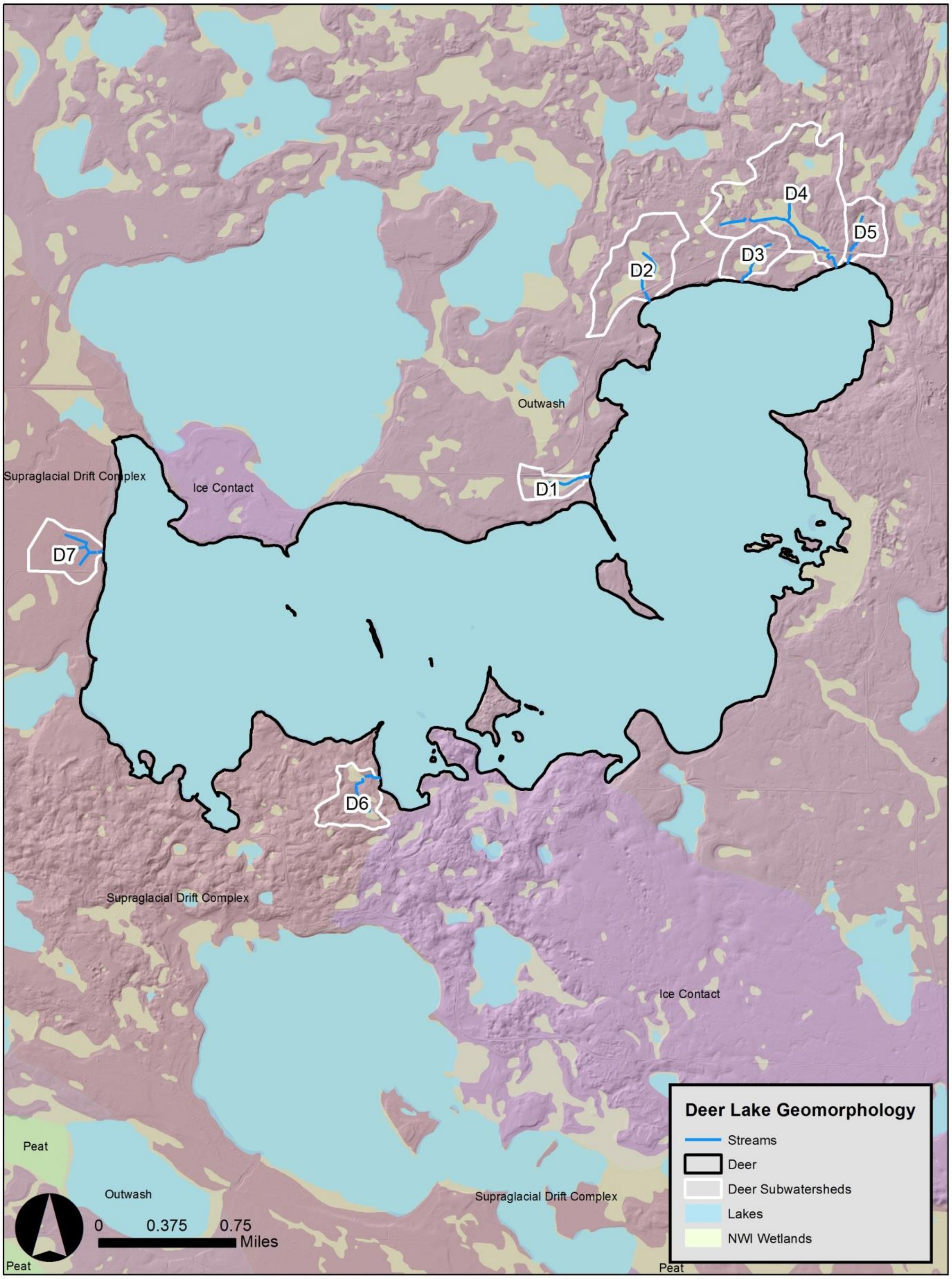


Figure 13. Roads and stream crossings in the Deer Lake watershed.

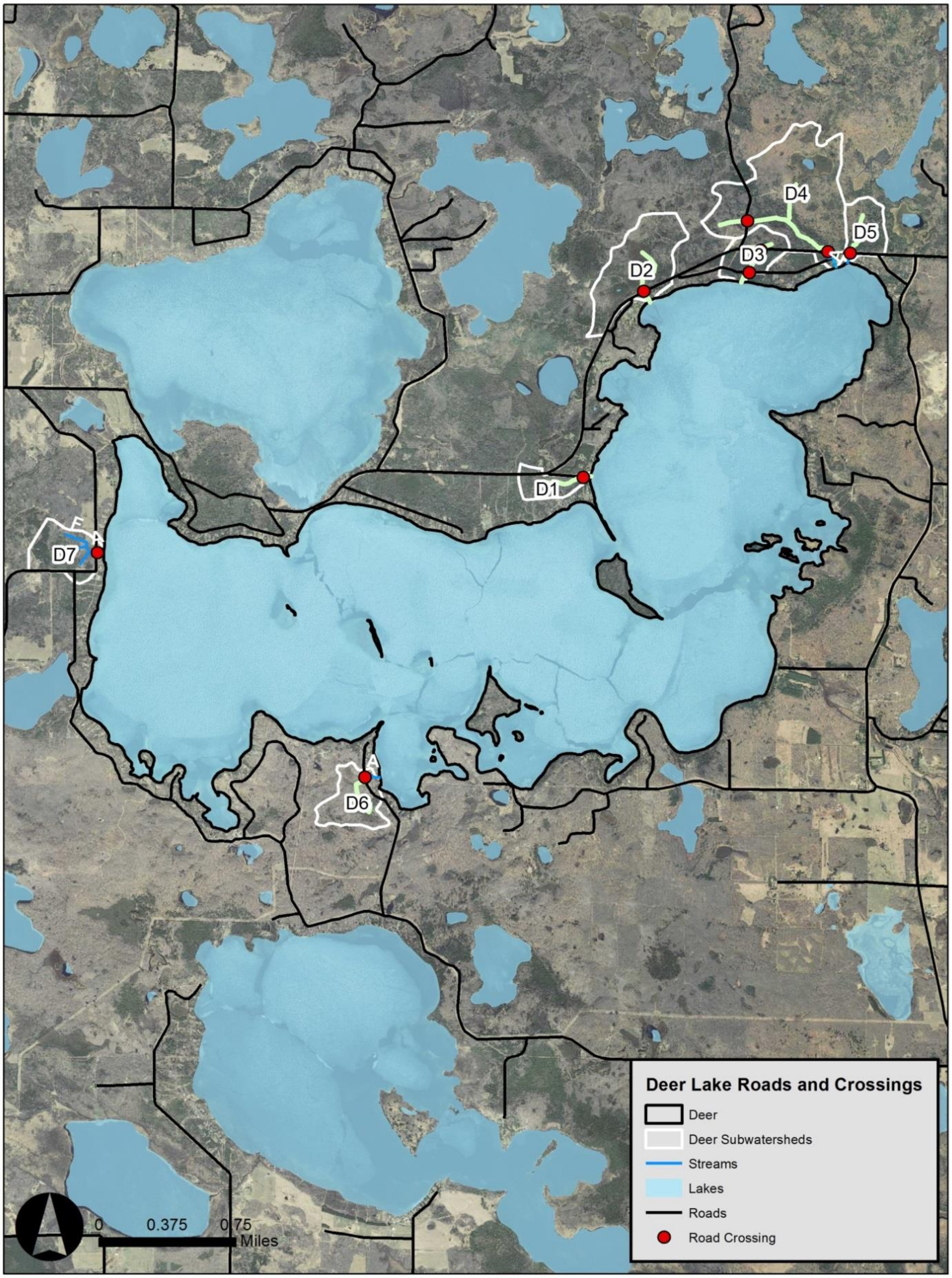


Figure 14. Deer Lake Subsurface Sewage Treatment Systems

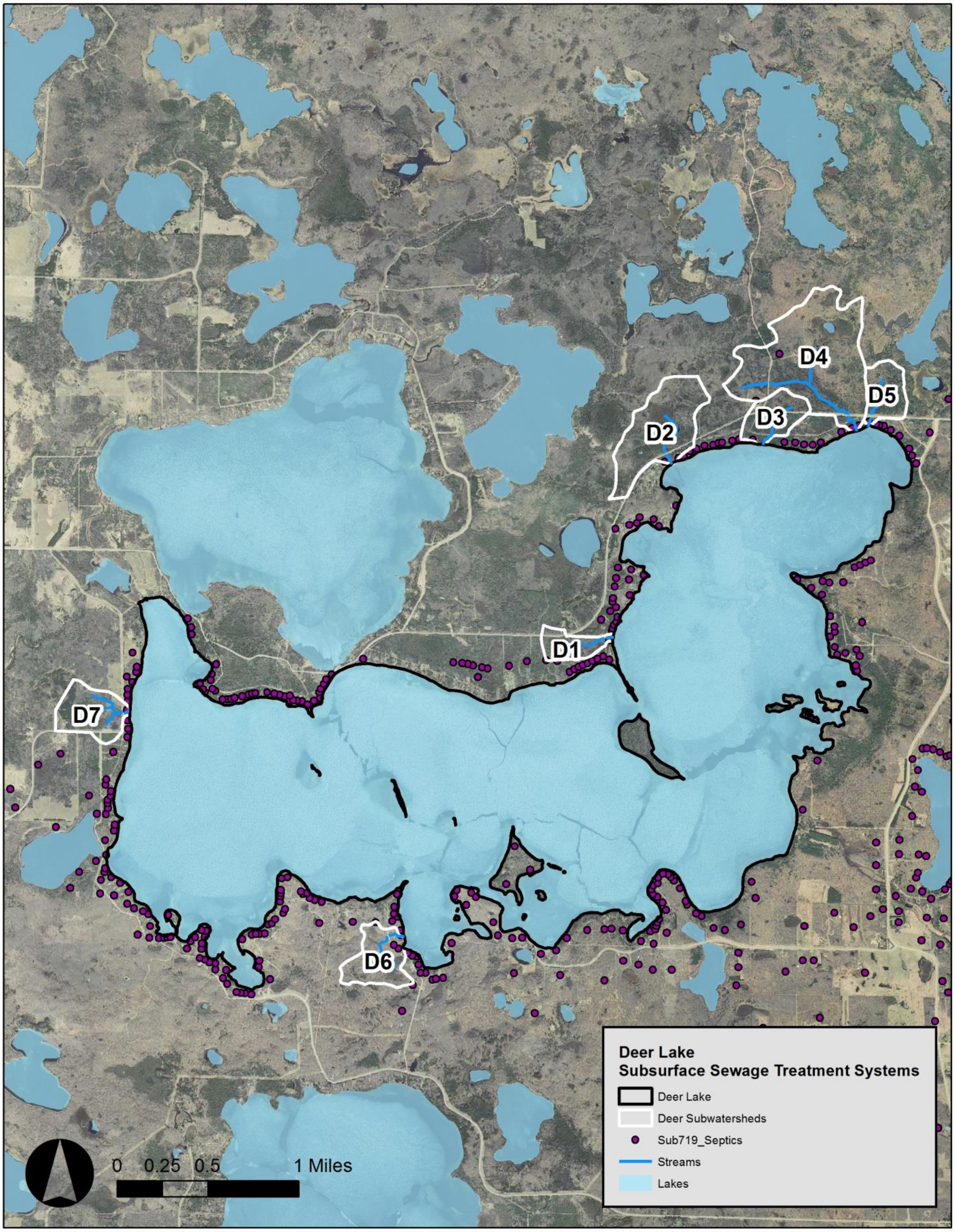


Figure 15. Rosgen stream classes of reaches within the Deer Lake watershed.

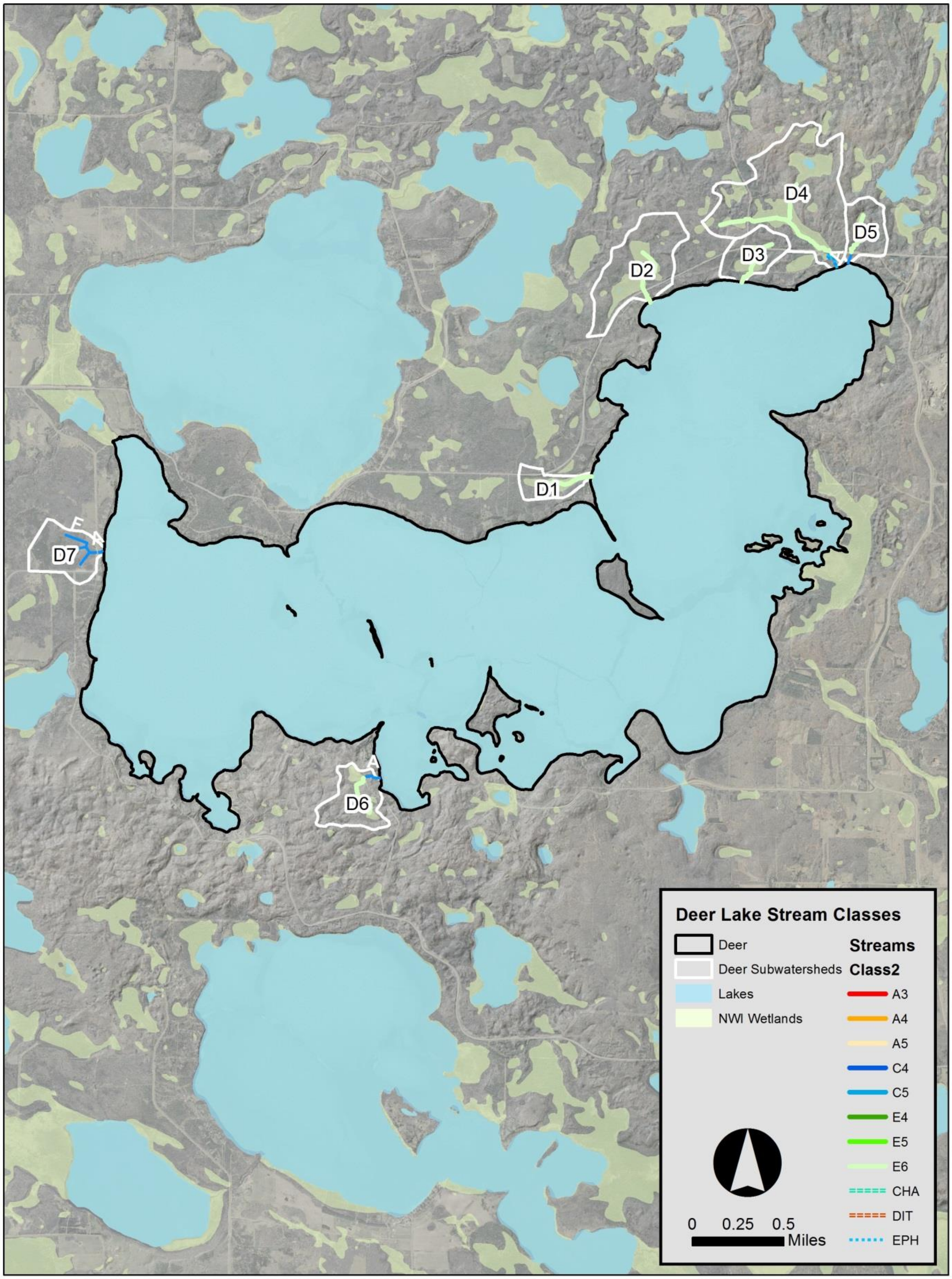


Figure 16. Land use and impacts within the Deer Lake watershed.

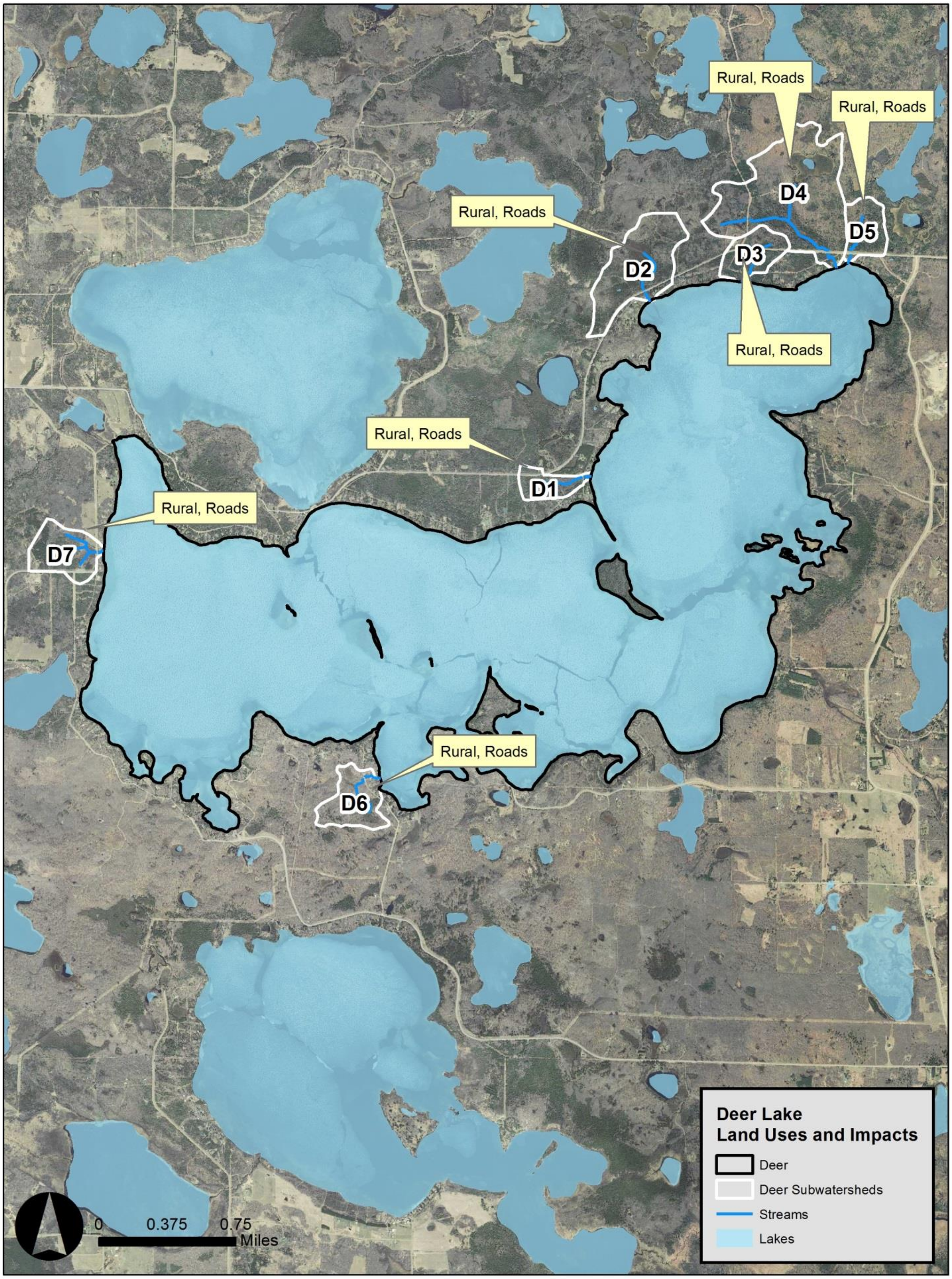
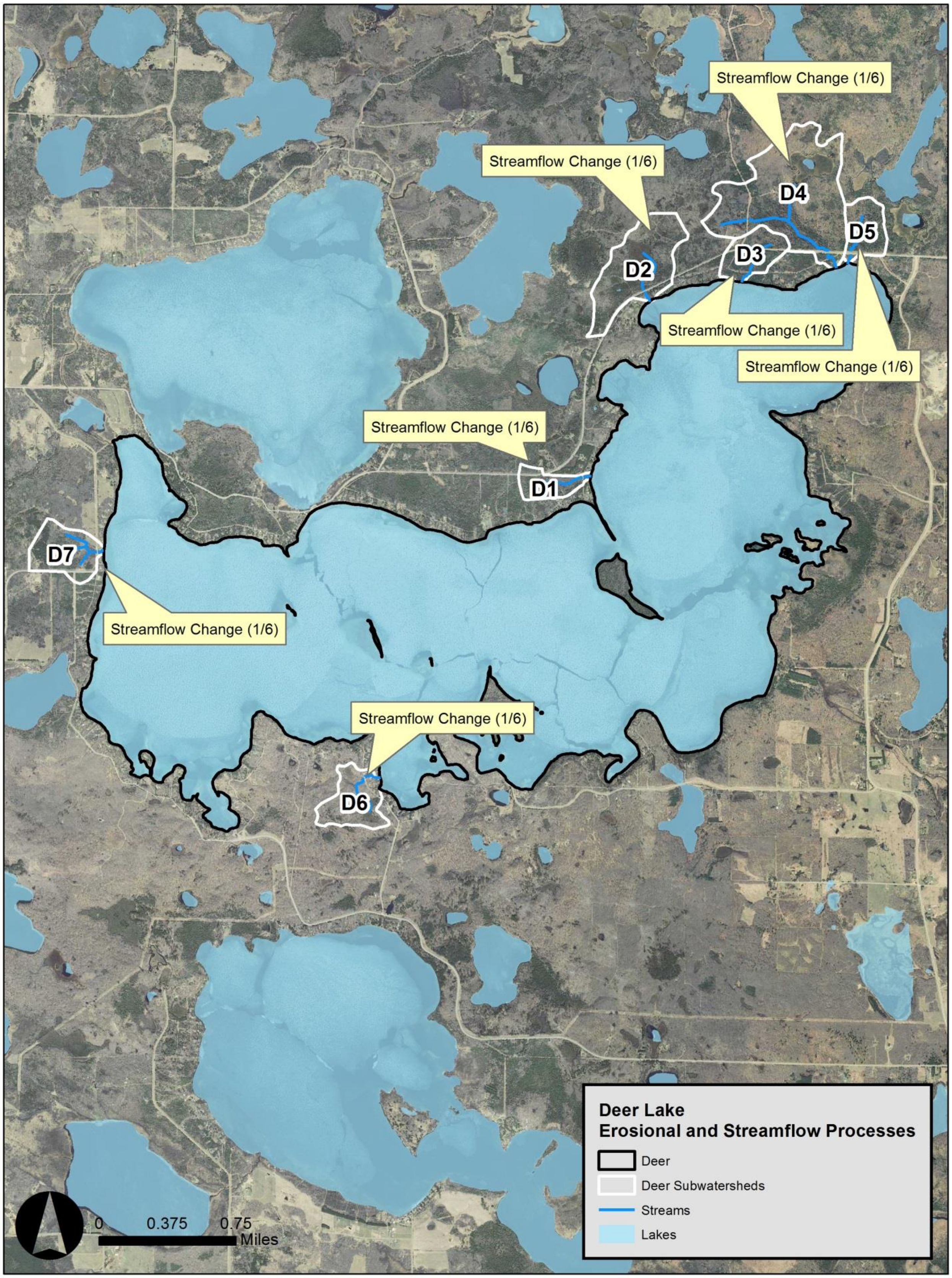


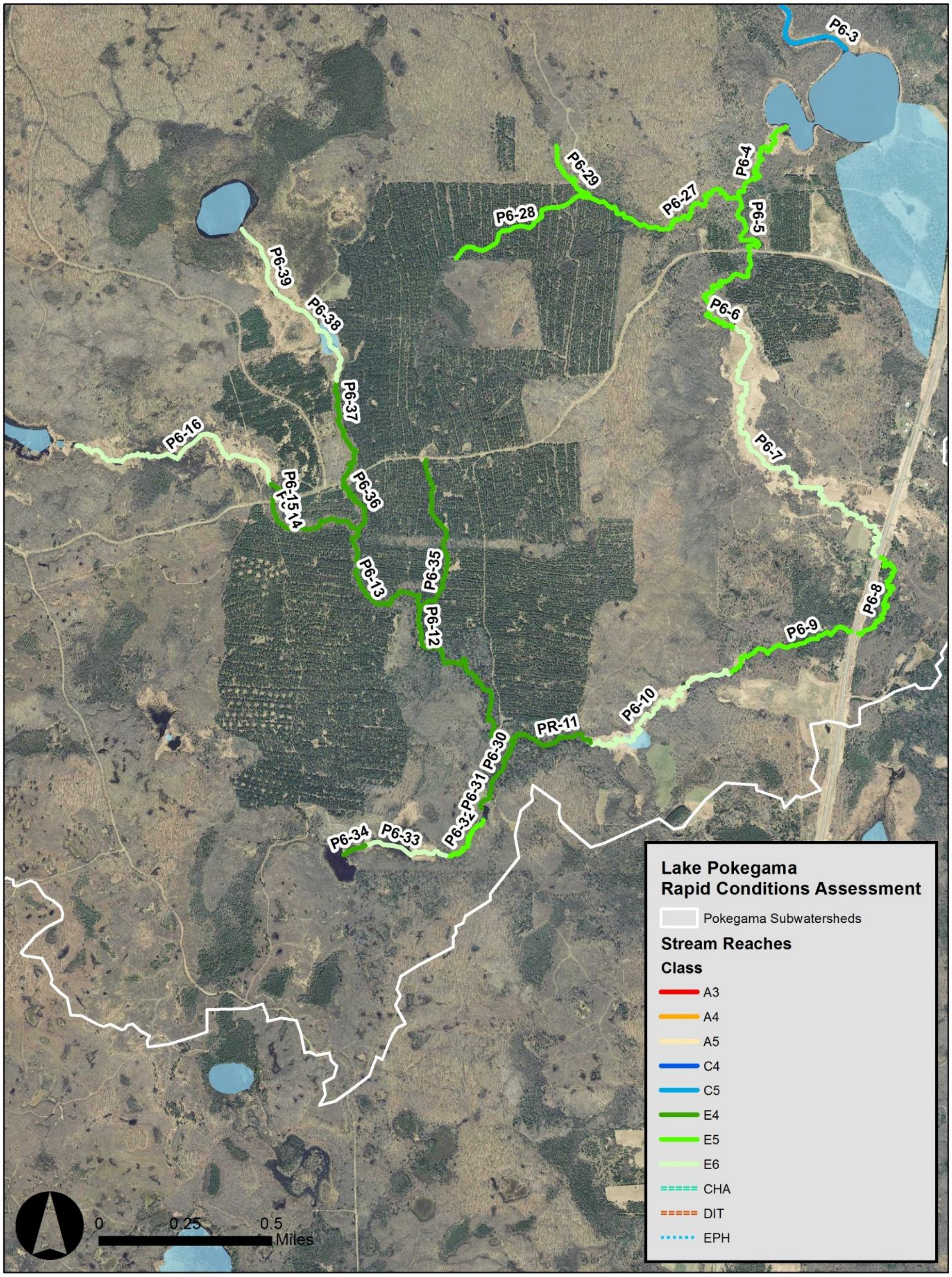
Figure 17. Erosional and streamflow processes within the Deer Lake watershed.



BANK STABILIZATION COST ESTIMATES AND HABITAT RESTORATION

P6.5, P6.11-13, P6.35 – Bank Stabilization and Brook Trout Habitat Improvements

Figure 18. Pokegama subwatershed P6 reaches



Bank Stabilization

It is recommended that a combination of Cedar Tree revetments and toe-wood be installed on the first two bends of P6.5 (Figure 18; Figure 19; Figure 20; Figure 21) for a very tight set of meanders currently still actively eroding as the result of the 2012-2013 storms. Minor channel reformation is also recommended to balance sediment transport to maintain a stable channel form and gravel bottom. Approximately 350 linear feet (as measured from stream center line) of work will be required: approximately 175 feet of outside bank work related to cedar tree and toe-wood and the remaining outside and inside banks likely only needing minor re-grading and bioengineering (~625 feet in total). Bank treatments should focus on the use of cedar tree revetments (approximately 100 linear feet; Figure 22) with toe-wood installations limited to the apex of both bends. Habitat provision should be made be constructing either bank treatment with overhaniging shelter, pool excavation at the two bends and placement of instream boulders.

Figure 19. Pokegama reach P6.5 bank failure.

←Smith Creek Road Bridge (~50 ft south) Flow to Smith Lake→

Looking downstream from the bridge on Smith Creek Road.

Figure 20. Concept toe-wood with soil lifts and live, woody cuttings.

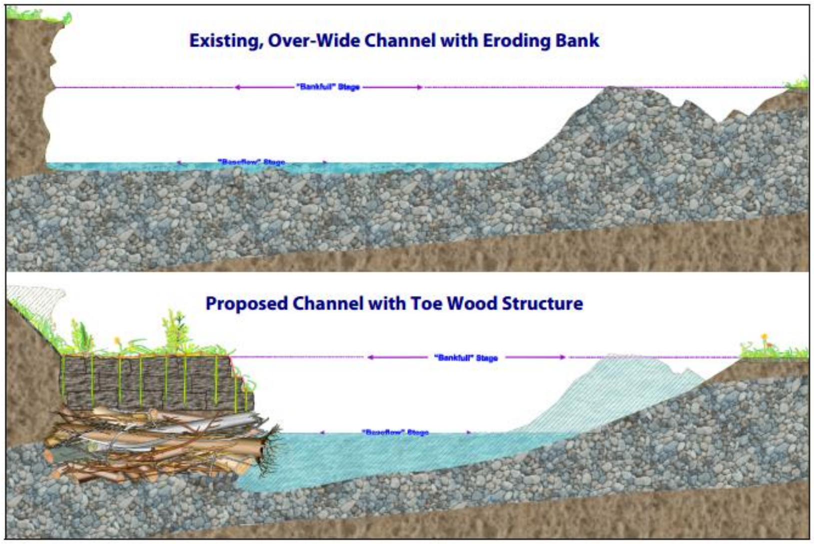


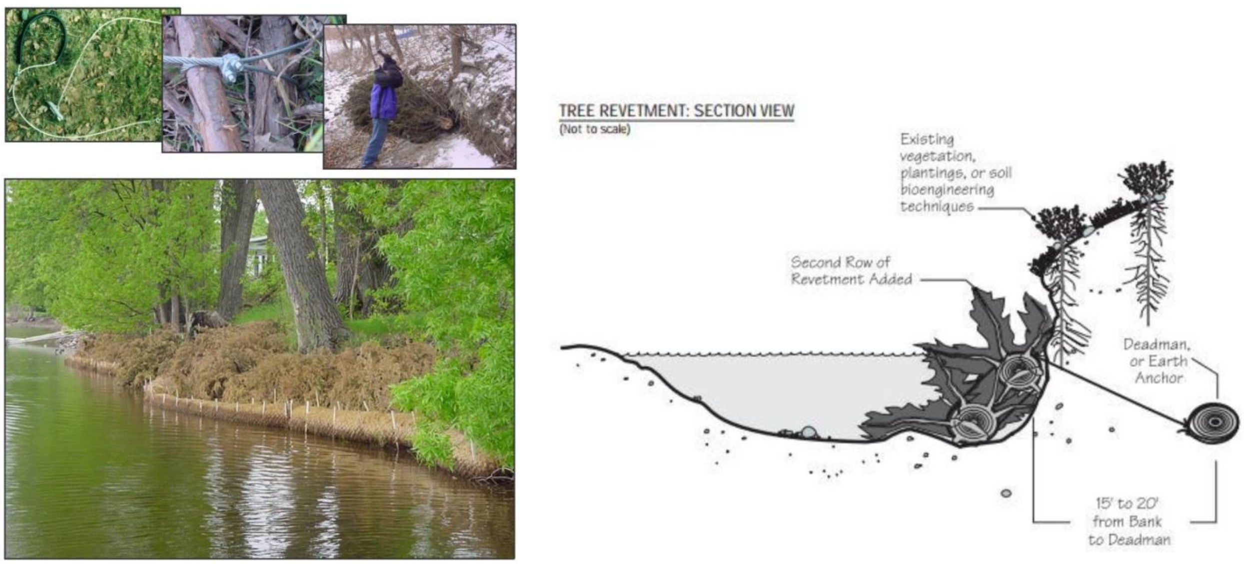
Figure 21. Toe wood and soil lifts, with seeding and woody cuttings, installed within Ravine Park, Sioux City Iowa (HR Green); an example of a much more volitile channel.

Blue Earth Soil and Water Conservation District used toe wood sod mats along the Le Sueur River on Blue Earth County, Minnesota. HR Green has also used toe wood sod mats on systems in Iowa. In both cases, the channels were significantly more unstable and with larger peak flows. The costs of toe wood sod mats range significantly depending upon the ability to position an excavator above the bank where it is easier to drive wood posts into the bed and back into the bank; as opposed to needing to cut into banks if positioned within the channel. Costs also are affected by the depth of the installation from the water's edge back the terminus of the buried material. In as such, a $200 per linear foot estimate is used as a mid-range cost.

Materials

- On-site trunks, larger braches, soil and rock fill
- Geojute erosional control matting, for soil lifts
- Seed, live woody cuttings and plugs

Figure 22. Cedar Tree revetment example and typical cross section



Anoka Conservation District (ACD) and the author have been installing Cedar Tree Revetments along various creeks, mid-sized rivers (e.g., the Rum) and major rivers (e.g., the St. Croix and Mississippi) for over a decade with great success. The estimated cost of Cedar Tree revetments assumed for this site is $7000 assuming the ACD information below, with the exception that is expected that harvesting of cedar trees will be carried out by a contractor using 2 staff over the course of 1 week (cutting and transport to site).

The ACD has provided a cost breakdown for Cedar Tree Revetments (note that Agency Labor per site will likely be far less for the P6.5 site):

Labor for 5 sites averaging 100 linear feet each

- Agency labor – This included all aspects of getting a program up and running and soliciting landowners.
    - 194 hrs admin and planning (securing a tree source, landowner soliciting and contracts, design, materials ordering, etc)
    - 84 hrs harvesting cedar trees
    - 11 hrs gathering willow stakes
    - 103 hrs doing installation oversight of a work crew.

TOTAL hrs = 392 hrs divided by 5 parcels = 78.5 hrs per site.

- Installation crew – 5 person crews from the MN Conservation Corps (MCC), installing 100 linear ft per day. Their crews cost about $275/day.

Materials

- Duckbill anchors - $15.27/ea
- Galvanized cable ¼" - $0.24/ft
- Horseshoe clamps ¼" - $0.26/ea
- DNR permit fee - $100

Brook Trout Habitat Improvements

Smith Creek is a designated trout stream within Pokegama subwatershed 6. Public fishing access is nearly continuous access on the main branch (P6.4-16) and one tributary (P6.36-39). Though the channels have seen impacts in the past due to logging, these reaches have either since recovered or are partially recovered in terms of stability. However, habitat recovery is variable.

It is recommended that the SWCD consider collaboration with the MNDNR, Trout Unlimited and Minnesota Conservation Corps to implement Brook Trout habitat restoration on these reaches with focus on reaches P6.11-13 and P6.35. Because the focus of this study was on channel stability and health, no formal mapping of the extent of habitat improvement need was made. In as such, no estimate is made herein on the costs associated with Brook Trout habitat restoration until an assessment of needs, extent and site access is made should this recommendation be pursued. Costs would include mapping, design, wood and rock materials, channel grading, bioengineering and erosion control. Labor can be split between contracted and volunteer labor via the MCC, Trout Unlimited and stakeholder partners such as the Blandin Company, for example. Funding can be applied for through Legacy Funds with matching potential from stakeholders.

The following suggestions are made to provide key conceptual components of habitat improvements, though several other needs for design are required. Optimal Brook Trout habitat is characterized by clear, cold water with silt-free rocky substrates within riffle-run systems. The optimal substrate size for embryos ranges from 0.34-5.05 cm. Pool-riffle ratios of 1:1 is preferred with pools being slow and deep. Streambanks need to be well vegetated and instream cover needs to be abundant to provide refuge. As a major limiting factor for Brook Trout is bank cover, supplemental brush cover is recommended along banks in conjunction with undercut banks. Low current velocity should be less than 15cm/s and most suitable water depths, between pools, is typically greater than 15 cm. instream cover should consist of logs, larger rocks and rocky substrates. As with all trout species, canopy cover is important in maintaining cool water temperatures (Fish and Wildlife Service, 1982). This is becoming a crucial design factor for management of trout in the midwest given predictions of steadily increasing water temperatures resulting from global warming (Climate and Hydrology presentation by Matt Mitro at the 9th Annual Driftless Area Symposium, 2017).

The most critical period of flow for Brook Trout is base flow. Base flows greater than 55% of the average annual daily flow is optimal while those less than 25% of annual daily flow is considered detrimental to maintaining trout habitat (U.S. Fish and Wildlife Service, 1982). The current condition of P6.11-13 consists of aggraded beds suggesting base flows are insufficient to transport sediments and maintain gravel substrate.

Overwinter cover is critical to annual survivorship in trout species. Therefore, connectivity to Smith Lake and wetlands that do not freeze over are important considerations. Though the entirety of the P6 reaches were not inspected for fish barriers, restoration design needs to plan on their removal if encountered.

APPENDIX 3: BIBLIOGRAPHY

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APPENDIX 4: ASSESSMENT FORMS

Stream Assessment Form			
Date:	11/11/2016	**Field Staff:**	S. Tracy
Stream/Drainage:	D1		
Reach ID:	-	**Station:**	-
GPS Waypoint ID:	-		
Watershed Description Outwash rolling topography, fully wooded			
Watershed Area (acres)	30	**Valley Form (I-XI)**	
LEVEL 1			
Land Uses and Impacts (remote and in-field review)			
~~Urban~~	~~Suburban~~	**Rural**	
~~Agricultural~~	~~Silvicultural~~	~~Fires~~	
~~Channelization~~	~~Flood Control, Clearing, Vegetation Removal, Dredging, Levees~~	~~Reservoir Storage, Hydropower~~	
~~Diversions, Depletions~~	~~Grazing~~	**Roads**	
~~Mining~~	~~In-channel Mining~~		
Erosional and Streamflow Processes (remote and in-field review)			
Surface Erosion	~~1 2 3 4~~	Mass Erosion	~~1 2 3 4 5~~
Streamflow Change	~~1 2 3 4 5~~ **6**	Channel Processes	~~1 2 3 4 5 6~~
Channel Impacts	~~1 2~~	Valley Type (I-XI)	

Notes:

The results of the land use impacts and erosional and stream process review did not elevate this watershed to the rapid stream condition, Pfankuch or channel morphological data assessments or surveys. No apparent watershed or channel modification was detected in historical aerial photography review. Conditions today resemble that of 1991. Minor impacts on subsurface flow may be possible given roads positioned low in the watershed, proximal to the lake, but no apparent adverse effects on base flow was noted. Little to no flow was detected upstream or downstream of road crossings. No apparent adverse effect of roadways or rural land uses on stream channels. No apparent unnatural sources of sediment and phosphorus to streams.

<u>POTENTIAL PROJECT</u>:

No potential projects were identified within this watershed.

Stream Assessment Form			
Date:	11/11/2016	**Field Staff:**	S. Tracy
Stream/Drainage:	D2		
Reach ID:	-	**Station:**	-
GPS Waypoint ID:	-		
Watershed Description Outwash rolling topography, fully wooded			
Watershed Area (acres)	47	**Valley Form (I-XI)**	
LEVEL 1			

Land Uses and Impacts (remote and in-field review)		
~~Urban~~	~~Suburban~~	**Rural**
~~Agricultural~~	~~Silvicultural~~	~~Fires~~
~~Channelization~~	~~Flood Control, Clearing, Vegetation Removal, Dredging, Levees~~	~~Reservoir Storage, Hydropower~~
~~Diversions, Depletions~~	~~Grazing~~	**Roads**
~~Mining~~	~~In-channel Mining~~	

Erosional and Streamflow Processes (remote and in-field review)			
Surface Erosion	~~1 2 3 4~~	Mass Erosion	~~1 2 3 4 5~~
Streamflow Change	~~1 2 3 4 5~~ **6**	Channel Processes	~~1 2 3 4 5 6~~
Channel Impacts	~~1 2~~	Valley Type (I-XI)	

Notes:

The results of the land use impacts and erosional and stream process review did not elevate this watershed to the rapid stream condition, Pfankuch or channel morphological data assessments or surveys. No apparent watershed or channel modification was detected in historical aerial photography review. Conditions today resemble that of 1991. Minor impacts on subsurface flow may be possible given roads positioned low in the watershed, proximal to the lake, but no apparent adverse effects on base flow was noted. Little to no flow was detected upstream or downstream of road crossings. No apparent adverse effect of roadways or rural land uses on stream channels. No apparent unnatural sources of sediment and phosphorus to streams.

POTENTIAL PROJECT:

No potential projects were identified within this watershed.

Stream Assessment Form			
Date:	11/11/2016	**Field Staff:**	-
Stream/Drainage:	D3		
Reach ID:	-	**Station:**	-
GPS Waypoint ID:	-		
Watershed Description Outwash rolling topography, fully wooded			
Watershed Area (acres)	18	**Valley Form (I-XI)**	
LEVEL 1			
Land Uses and Impacts (remote and in-field review)			
~~Urban~~	~~Suburban~~	**Rural**	
~~Agricultural~~	~~Silvicultural~~	~~Fires~~	
~~Channelization~~	~~Flood Control, Clearing, Vegetation Removal, Dredging, Levees~~	~~Reservoir Storage, Hydropower~~	
~~Diversions, Depletions~~	~~Grazing~~	**Roads**	
~~Mining~~	~~In-channel Mining~~		
Erosional and Streamflow Processes (remote and in-field review)			
Surface Erosion	~~1 2 3 4~~	Mass Erosion	~~1 2 3 4~~ 5
Streamflow Change	~~1 2 3 4 5~~ **6**	Channel Processes	~~1 2 3 4 5 6~~
Channel Impacts	~~1~~ 2	Valley Type (I-XI)	

Notes:

The results of the land use impacts and erosional and stream process review did not elevate this watershed to the rapid stream condition, Pfankuch or channel morphological data assessments or surveys. No apparent watershed or channel modification was detected in historical aerial photography review. Conditions today resemble that of 1991. Minor impacts on subsurface flow may be possible given roads positioned low in the watershed, proximal to the lake, but no apparent adverse effects on base flow was noted. Little to no flow was detected upstream or downstream of road crossings. No apparent adverse effect of roadways or rural land uses on stream channels. No apparent unnatural sources of sediment and phosphorus to streams.

POTENTIAL PROJECT:

No potential projects were identified within this watershed.

Stream Assessment Form			
Date:	11/11/2016	**Field Staff:**	S. Tracy
Stream/Drainage:	D4		
Reach ID:	-	**Station:**	-
GPS Waypoint ID:		-	
Watershed Description Outwash rolling topography, fully wooded			
Watershed Area (acres)	94	**Valley Form (I-XI)**	
LEVEL 1			
Land Uses and Impacts (remote and in-field review)			
~~Urban~~	~~Suburban~~	**Rural**	
~~Agricultural~~	~~Silvicultural~~	~~Fires~~	
~~Channelization~~	~~Flood Control, Clearing, Vegetation Removal, Dredging, Levees~~	~~Reservoir Storage, Hydropower~~	
~~Diversions, Depletions~~	~~Grazing~~	**Roads**	
~~Mining~~	~~In-channel Mining~~		

Erosional and Streamflow Processes (remote and in-field review)			
Surface Erosion	~~1 2 3 4~~	Mass Erosion	~~1 2 3 4 5~~
Streamflow Change	~~1 2 3 4 5~~ **6**	Channel Processes	~~1 2 3 4 5 6~~
Channel Impacts	~~1 2~~	Valley Type (I-XI)	

Notes:

The results of the land use impacts and erosional and stream process review did not elevate this watershed to the rapid stream condition, Pfankuch or channel morphological data assessments or surveys. No apparent watershed or channel modification was detected in historical aerial photography review. Conditions today resemble that of 1991. Minor impacts on subsurface flow may be possible given roads positioned low in the watershed, proximal to the lake, but no apparent adverse effects on base flow was noted. Little to no flow was detected upstream or downstream of road crossings. No apparent adverse effect of roadways or rural land uses on stream channels. No apparent unnatural sources of sediment and phosphorus to streams.

<u>POTENTIAL PROJECT</u>:

No potential projects were identified within this watershed.

Stream Assessment Form			
Date:	11/11/2016	**Field Staff:**	S. Tracy
Stream/Drainage:	D5		
Reach ID:	-	**Station:**	-
GPS Waypoint ID:	-		
Watershed Description Outwash rolling topography, fully wooded			
Watershed Area (acres)	17	**Valley Form (I-XI)**	
LEVEL 1			
Land Uses and Impacts (remote and in-field review)			
~~Urban~~	~~Suburban~~	**Rural**	
~~Agricultural~~	~~Silvicultural~~	~~Fires~~	
~~Channelization~~	~~Flood Control, Clearing, Vegetation Removal, Dredging, Levees~~	~~Reservoir Storage, Hydropower~~	
~~Diversions, Depletions~~	~~Grazing~~	**Roads**	
~~Mining~~	~~In-channel Mining~~		

Erosional and Streamflow Processes (remote and in-field review)			
Surface Erosion	~~1 2 3 4~~	Mass Erosion	~~1 2 3 4 5~~
Streamflow Change	~~1 2 3 4 5~~ **6**	Channel Processes	~~1 2 3 4 5 6~~
Channel Impacts	~~1 2~~	Valley Type (I-XI)	

Notes:

The results of the land use impacts and erosional and stream process review did not elevate this watershed to the rapid stream condition, Pfankuch or channel morphological data assessments or surveys. No apparent watershed or channel modification was detected in historical aerial photography review. Conditions today resemble that of 1991. Minor impacts on subsurface flow may be possible given roads positioned low in the watershed, proximal to the lake, but no apparent adverse effects on base flow was noted. Little to no flow was detected upstream or downstream of road crossings. No apparent adverse effect of roadways or rural land uses on stream channels. No apparent unnatural sources of sediment and phosphorus to streams.

<u>POTENTIAL PROJECT</u>:

No potential projects were identified within this watershed.

Stream Assessment Form			
Date:	11/11/2016	**Field Staff:**	S. Tracy
Stream/Drainage:	D6		
Reach ID:	-	**Station:**	-
GPS Waypoint ID:	-		
Watershed Description Forested Supraglacial Drift Complex			
Watershed Area (acres)	23	**Valley Form (I-XI)**	
LEVEL 1			
Land Uses and Impacts (remote and in-field review)			
~~Urban~~	~~Suburban~~	**Rural**	
~~Agricultural~~	~~Silvicultural~~	~~Fires~~	
~~Channelization~~	~~Flood Control, Clearing, Vegetation Removal, Dredging, Levees~~	~~Reservoir Storage, Hydropower~~	
~~Diversions, Depletions~~	~~Grazing~~	**Roads**	
~~Mining~~	~~In-channel Mining~~		
Erosional and Streamflow Processes (remote and in-field review)			
Surface Erosion	~~1 2 3 4~~	Mass Erosion	~~1 2 3 4 5~~
Streamflow Change	~~1 2 3 4 5~~ **6**	Channel Processes	~~1 2 3 4 5 6~~
Channel Impacts	~~1 2~~	Valley Type (I-XI)	

Notes:

The results of the land use impacts and erosional and stream process review did not elevate this watershed to the rapid stream condition, Pfankuch or channel morphological data assessments or surveys. No apparent watershed or channel modification was detected in historical aerial photography review. Conditions today resemble that of 1991. Minor impacts on subsurface flow may be possible given roads positioned low in the watershed, proximal to the lake, but no apparent adverse effects on base flow was noted. Little to no flow was detected upstream or downstream of road crossings. No apparent adverse effect of roadways or rural land uses on stream channels. No apparent unnatural sources of sediment and phosphorus to streams.

<u>POTENTIAL PROJECT</u>:

No potential projects were identified within this watershed.

Stream Assessment Form			
Date:	11/11/2016	**Field Staff:**	S. Tracy
Stream/Drainage:	D7		
Reach ID:	-	**Station:**	-
GPS Waypoint ID:	-		
Watershed Description Forested Supraglacial Drift Complex			
Watershed Area (acres)	60	**Valley Form (I-XI)**	
LEVEL 1			
Land Uses and Impacts (remote and in-field review)			
~~Urban~~	~~Suburban~~	**Rural**	
~~Agricultural~~	~~Silvicultural~~	~~Fires~~	
~~Channelization~~	~~Flood Control, Clearing, Vegetation Removal, Dredging, Levees~~	~~Reservoir Storage, Hydropower~~	
~~Diversions, Depletions~~	~~Grazing~~	**Roads**	
~~Mining~~	~~In-channel Mining~~		
Erosional and Streamflow Processes (remote and in-field review)			
Surface Erosion	~~1 2 3 4~~	Mass Erosion	~~1 2 3 4 5~~
Streamflow Change	~~1 2 3 4 5~~ **6**	Channel Processes	~~1 2 3 4 5 6~~
Channel Impacts	~~1 2~~	Valley Type (I-XI)	

Notes:

The results of the land use impacts and erosional and stream process review did not elevate this watershed to the rapid stream condition, Pfankuch or channel morphological data assessments or surveys. No apparent watershed or channel modification was detected in historical aerial photography review. Conditions today resemble that of 1991. Minor impacts on subsurface flow may be possible given roads positioned low in the watershed, proximal to the lake, but no apparent adverse effects on base flow was noted. Little to no flow was detected upstream or downstream of road crossings. No apparent adverse effect of roadways or rural land uses on stream channels. No apparent unnatural sources of sediment and phosphorus to streams.

POTENTIAL PROJECT:

No potential projects were identified within this watershed.

Stream Assessment Form			
Date:	10/14/16	**Field Staff:**	ST, TM
Stream/Drainage:	P1		
Reach ID:		**Station:**	-
GPS Waypoint ID: -			
Watershed Description Forested, supraglacial drift complex			
Watershed Area (acres)		**Valley Form (I-XI)**	

LEVEL 1

Land Uses and Impacts (remote and in-field review)		
Urban	**Suburban**	Rural
Agricultural	Silvicultural	Fires
Channelization	Flood Control, Clearing, Vegetation Removal, Dredging, Levees	Reservoir Storage, Hydropower
Diversions, Depletions	Grazing	**Roads**
Mining	In-channel Mining	

Erosional and Streamflow Processes (remote and in-field review)			
Surface Erosion	~~1 2 3 4~~	Mass Erosion	~~1 2 3 4 5~~
Streamflow Change	~~1 2~~ **3 4** ~~5 6~~	Channel Processes	**1** ~~2 3 4 5 6~~
Channel Impacts	~~1 2~~	Valley Type (I-XI)	

Rapid Condition Assessment (field review)					
Channel Condition		Hydrologic alteration		Riparian zone	
Bank stability		Water appearance		Nutrient enrichment	
Barriers to fish movement		Instream fish cover		Pools	
Invertebrate habitat					
Total score divided by total scored: /7 = 8.7	≤6 Poor 6.1-7.4 Fair 7.5-8.9 Good ≥9 Excellent	**Advance to Channel Morphological Data Collection if final score is < 7.5**			

LEVEL 2

Channel Morphological Data			
Step 1 – Reach			
Flow Regime		Stream Size and Order	
Meander Patterns		Depositional Patterns	
Channel Blockages			
Step 2 – Cross Section Morphology			
Pfankuch Channel Stability Rating			
Bankfull Width (ft)		Low Bank Height (ft)	
Max Bank Height (ft)		Bank Height Ratio (LBH/MBH)	
Bankfull Depth (ft)		Bankfull X-Section AREA (ft^2)	
Width/Depth Ratio (W_{bkf} / D_{bkf})		Maximum Depth (ft)	
Width of Flood-Prone Area (ft)		Entrenchment Ratio	
Channel Materials $D_{50\ @\ Riffle}$ (mm)		Channel Materials $D_{84\ @\ Riffle}$ (mm)	
Largest Particle from Bar Sample (mm)		Water Surface Slope (rise/run)	

Channel Sinuosity		Meander Width (ft)	
Meander Width Ratio		Rosgen Stream Type	
Step 3 – Cross Section Bank Characteristics			
Study Bank Height (ft)		Study Bank Length (ft)	
Root Depth (ft)		Root Density (%)	
Bank Angle (degrees)		Surface Protection (%)	
Near Bank Maximum Depth (ft)			
Bank Material (select one)	Bedrock, Boulders, Cobble, Gravel or Composite, Sand, Silt/Clay		

Notes:

No streams assessed on first visit in this subwatershed. Streams lead to a wetland before discharging to the lake.

<u>POTENTIAL PROJECT</u>:

No potential projects were identified within this watershed.

Stream Assessment Form			
Date:	10/14/16	**Field Staff:**	ST, TM
Stream/Drainage:	P2		
Reach ID:		**Station:**	-
GPS Waypoint ID: -			
Watershed Description Forested, supraglacial drift complex, developed, ditched			
Watershed Area (Acres)		**Valley Form (I-XI)**	

LEVEL 1

Land Uses and Impacts (remote and in-field review)		
Urban	**Suburban**	Rural
Agricultural	Silvicultural	Fires
Channelization	Flood Control, Clearing, Vegetation Removal, Dredging, Levees	Reservoir Storage, Hydropower
Diversions, Depletions	Grazing	**Roads**
Mining	In-channel Mining	

Erosional and Streamflow Processes (remote and in-field review)

Surface Erosion	~~1 2 3 4~~	Mass Erosion	~~1 2 3 4 5~~
Streamflow Change	**1 2 3 4** ~~5~~ **6**	Channel Processes	**1 2 3** ~~4 5 6~~
Channel Impacts	**1 2**	Valley Type (I-XI)	

Rapid Condition Assessment (field review)

Channel Condition	1	Hydrologic alteration	1	Riparian zone	1
Bank stability	10	Water appearance		Nutrient enrichment	-
Barriers to fish movement	1	Instream fish cover		Pools	
Invertebrate habitat	1				
Total score divided by total scored: 15/6 = 2.6	$\leq$6 Poor 6.1-7.4 Fair 7.5-8.9 Good $\geq$9 Excellent	**Advance to Channel Morphological Data Collection if final score is < 7.5**			

LEVEL 2

Channel Morphological Data

Step 1 – Reach			
Flow Regime		Stream Size and Order	
Meander Patterns		Depositional Patterns	
Channel Blockages			
Step 2 – Cross Section Morphology			
Pfankuch Channel Stability Rating			
Bankfull Width (ft)		Low Bank Height (ft)	
Max Bank Height (ft)		Bank Height Ratio (LBH/MBH)	
Bankfull Depth (ft)		Bankfull X-Section AREA (ft^2)	
Width/Depth Ratio (W_{bkf} / D_{bkf})		Maximum Depth (ft)	
Width of Flood-Prone Area (ft)		Entrenchment Ratio	
Channel Materials $D_{50\ @\ Riffle}$ (mm)		Channel Materials $D_{84\ @\ Riffle}$ (mm)	
Largest Particle from Bar Sample (mm)		Water Surface Slope (rise/run)	

Channel Sinuosity		Meander Width (ft)	
Meander Width Ratio		Rosgen Stream Type	
Step 3 – Cross Section Bank Characteristics			
Study Bank Height (ft)		Study Bank Length (ft)	
Root Depth (ft)		Root Density (%)	
Bank Angle (degrees)		Surface Protection (%)	
Near Bank Maximum Depth (ft)			
Bank Material (select one)	Bedrock, Boulders, Cobble, Gravel or Composite, Sand, Silt/Clay		

Notes:

This is not a stream, but a drainage ditch. In as such, Land Use Impacts and Hillslope Process help to estimate relative sediment and nutrient potential to Lake Pokegama. No ditch BMPs for rate or water quality were observed. Rip rap was observed in several locations and the ditch appeared to be stable. Not every linear foot of the ditch was visited.

<u>POTENTIAL PROJECT</u>:

Ditch checks, step-pool morphology, water quality swale, potential in-line iron enhanced sand filtration (UMN Saint Anthony Field Lab research results pending).

Stream Assessment Form			
Date:	10/14/16	**Field Staff:**	ST, TM
Stream/Drainage:	P3		
Reach ID:		**Station:**	-
GPS Waypoint ID: -			
Watershed Description Semi-forested, supraglacial drift complex, undifferentiated and peat lands			
Watershed Area (Acres)		**Valley Form (I-XI)**	

LEVEL 1

Land Uses and Impacts (remote and in-field review)		
Urban	Suburban	**Rural**
Agricultural	Silvicultural	Fires
Channelization	Flood Control, Clearing, **Vegetation Removal**, Dredging, Levees	Reservoir Storage, Hydropower
Diversions, Depletions	Grazing	**Roads**
Mining	In-channel Mining	

Erosional and Streamflow Processes (remote and in-field review)

Surface Erosion	~~1 2 3 4~~	Mass Erosion	~~1 2 3 4 5~~
Streamflow Change	**1** ~~2 3~~ **4** ~~5 6~~	Channel Processes	**1** ~~2 3 4 5 6~~
Channel Impacts	~~1~~ **2**	Valley Type (I-XI)	

Rapid Condition Assessment (field review)

Channel Condition		Hydrologic alteration		Riparian zone	
Bank stability		Water appearance		Nutrient enrichment	
Barriers to fish movement		Instream fish cover		Pools	
Invertebrate habitat					
Total score divided by total scored: /7 =	≤6 Poor 6.1-7.4 Fair 7.5-8.9 Good ≥9 Excellent	**Advance to Channel Morphological Data Collection if final score is < 7.5**			

LEVEL 2

Channel Morphological Data

Step 1 – Reach			
Flow Regime		Stream Size and Order	
Meander Patterns		Depositional Patterns	
Channel Blockages			
Step 2 – Cross Section Morphology			
Pfankuch Channel Stability Rating			
Bankfull Width (ft)		Low Bank Height (ft)	
Max Bank Height (ft)		Bank Height Ratio (LBH/MBH)	
Bankfull Depth (ft)		Bankfull X-Section AREA (ft^2)	
Width/Depth Ratio (W_{bkf} / D_{bkf})		Maximum Depth (ft)	
Width of Flood-Prone Area (ft)		Entrenchment Ratio	
Channel Materials $D_{50\ @\ Riffle}$ (mm)		Channel Materials $D_{84\ @\ Riffle}$ (mm)	
Largest Particle from Bar Sample (mm)		Water Surface Slope (rise/run)	

Channel Sinuosity		Meander Width (ft)	
Meander Width Ratio		Rosgen Stream Type	
Step 3 – Cross Section Bank Characteristics			
Study Bank Height (ft)		Study Bank Length (ft)	
Root Depth (ft)		Root Density (%)	
Bank Angle (degrees)		Surface Protection (%)	
Near Bank Maximum Depth (ft)			
Bank Material (select one)	Bedrock, Boulders, Cobble, Gravel or Composite, Sand, Silt/Clay		

Notes:

North branch of stream network within densely forested, undisturbed peat lands and expected to be stable and in good condition. Southern branch of stream network: lower half within peat and alder swamps and in good condition; upper half divided by pond and within mixed agricultural landscape (corn, soybeans and hay). Upper watershed of south branch with corn, soybeans and hay production. Pond acts somewhat as a buffer for stream (traps a portion of sediment and pollutants mobilized from ag-lands. Streams appear in good condition overall.

Potential Project: NRCS agricultural BMPs including inter-rill cover cropping, early and late season cover crops, stream buffers, grassed waterways, WASCOB, nutrient management plan.

Stream Assessment Form			
Date:	10/14/16	**Field Staff:**	ST, TM
Stream/Drainage:	P4		
Reach ID:		**Station:**	-
GPS Waypoint ID: -			
Watershed Description Semi-forested, Supraglacial drift complex			
Watershed Area (Acres)		**Valley Form (I-XI)**	

LEVEL 1

Land Uses and Impacts (remote and in-field review)		
Urban	Suburban	**Rural**
Agricultural	Silvicultural	Fires
Channelization	Flood Control, Clearing, **Vegetation Removal**, Dredging, Levees	Reservoir Storage, Hydropower
Diversions, Depletions	Grazing	**Roads**
Mining	In-channel Mining	

Erosional and Streamflow Processes (remote and in-field review)

Surface Erosion	~~1 2 3 4~~	Mass Erosion	1 2 3 4 5
Streamflow Change	**1** ~~2 3~~ **4** ~~5 6~~	Channel Processes	1 2 3 4 5 6
Channel Impacts	**1 2**	Valley Type (I-XI)	

Rapid Condition Assessment (field review)

Channel Condition		Hydrologic alteration		Riparian zone	
Bank stability		Water appearance		Nutrient enrichment	
Barriers to fish movement		Instream fish cover		Pools	
Invertebrate habitat					
Total score divided by total scored: /7 =	<u><</u>6 Poor 6.1-7.4 Fair 7.5-8.9 Good <u>></u>9 Excellent		**Advance to Channel Morphological Data Collection if final score is < 7.5**		

LEVEL 2

Channel Morphological Data

Step 1 – Reach			
Flow Regime		Stream Size and Order	
Meander Patterns		Depositional Patterns	
Channel Blockages			
Step 2 – Cross Section Morphology			
Pfankuch Channel Stability Rating			
Bankfull Width (ft)		Low Bank Height (ft)	
Max Bank Height (ft)		Bank Height Ratio (LBH/MBH)	
Bankfull Depth (ft)		Bankfull X-Section AREA (ft^2)	
Width/Depth Ratio (W_{bkf} / D_{bkf})		Maximum Depth (ft)	
Width of Flood-Prone Area (ft)		Entrenchment Ratio	
Channel Materials $D_{50\ @\ Riffle}$ (mm)		Channel Materials $D_{84\ @\ Riffle}$ (mm)	
Largest Particle from Bar Sample (mm)		Water Surface Slope (rise/run)	

Channel Sinuosity		Meander Width (ft)	
Meander Width Ratio		Rosgen Stream Type	
Step 3 – Cross Section Bank Characteristics			
Study Bank Height (ft)		Study Bank Length (ft)	
Root Depth (ft)		Root Density (%)	
Bank Angle (degrees)		Surface Protection (%)	
Near Bank Maximum Depth (ft)			
Bank Material (select one)	Bedrock, Boulders, Cobble, Gravel or Composite, Sand, Silt/Clay		

Notes:

Mostly private land with type 3 wetland up to culvert at road. Downstream outlet channelized but stable. A pristine Black Ash and Black Spruce swamp is located west of the type 3 wetland on its west side and had 2-6 inches of standing water between hummocks on the field visit.

<u>POTENTIAL PROJECT</u>:

No potential projects were identified within this watershed.

Stream Assessment Form			
Date:		**Field Staff:**	ST, TM
Stream/Drainage:	P5		
Reach ID:	3	**Station:**	
GPS Waypoint ID:			
Watershed Description Forested, rural, supraglacial drift complex			
Watereshed Area (Acres)		**Valley Form (I-XI)**	

LEVEL 1

Land Uses and Impacts (remote and in-field review)		
Urban	Suburban	**Rural**
Agricultural	**Silvicultural**	Fires
Channelization	Flood Control, Clearing, **Vegetation Removal**, Dredging, Levees	Reservoir Storage, Hydropower
Diversions, Depletions	Grazing	**Roads**
Mining	In-channel Mining	

Erosional and Streamflow Processes (remote and in-field review)

Surface Erosion	~~1 2 3 4~~	Mass Erosion	~~1 2 3 4 5~~
Streamflow Change	~~1 2 3~~ **4** ~~5 6~~	Channel Processes	**1** ~~2 3 4 5 6~~
Channel Impacts	~~1~~ **2**	Valley Type (I-XI)	

Rapid Condition Assessment (field review)

Channel Condition		Hydrologic alteration		Riparian zone	
Bank stability		Water appearance		Nutrient enrichment	
Barriers to fish movement		Instream fish cover		Pools	
Invertebrate habitat					
Total score divided by total scored:	<u><</u>6 Poor 6.1-7.4 Fair 7.5-8.9 Good <u>></u>9 Excellent	Advance to Channel Morphological Data Collection if final score is >_______.			

LEVEL 2

Channel Morphological Data

Step 1 – Reach			
Flow Regime		Stream Size and Order	
Meander Patterns		Depositional Patterns	
Channel Blockages			
Step 2 – Cross Section Morphology			
Pfankuch Channel Stability Rating			
Bankfull Width (ft)		Low Bank Height (ft)	
Max Bank Height (ft)		Bank Height Ratio (LBH/MBH)	
Bankfull Depth (ft)		Bankfull X-Section AREA (ft^2)	
Width/Depth Ratio (W_{bkf} / D_{bkf})		Maximum Depth (ft)	
Width of Flood-Prone Area (ft)		Entrenchment Ratio	
Channel Materials $D_{50\ @\ Riffle}$ (mm)		Channel Materials $D_{84\ @\ Riffle}$ (mm)	
Largest Particle from Bar Sample (mm)		Water Surface Slope (rise/run)	

Channel Sinuosity		Meander Width (ft)	
Meander Width Ratio		Rosgen Stream Type	
Step 3 – Cross Section Bank Characteristics			
Study Bank Height (ft)		Study Bank Length (ft)	
Root Depth (ft)		Root Density (%)	
Bank Angle (degrees)		Surface Protection (%)	
Near Bank Maximum Depth (ft)			
Bank Material (select one)	Bedrock, Boulders, Cobble, Gravel or Composite, Sand, Silt/Clay		

Notes:

It is doubtful that this subwatershed regularly discharges water to Lake Pokegama. The watershed upstream of South Crystal Springs Road (H250) is fully forested and drains to a series of ponds and wetlands. The potential stream channel west of South Crystal Springs Road was accessed via forestry roads mid-way through the watershed, as well as at the outlet. There was no evidence of channel formation within the valley delineated for this subwatershed, though some wetland facultative and obligate species occurred in the bottom of the valley, sporadically. A small wetland was observed at the outlet of the valley before draining under South Gama Beach Road to the lake, though no evidence of perennial flow was observed (i.e. no formed channel and with 100% vegetative cover fully erect and with no debris deposits above current water level).

<u>POTENTIAL PROJECT</u>:

No potential projects were identified within this watershed.

Stream Assessment Form			
Date:		**Field Staff:**	
Stream/Drainage:	P6		
Reach ID:	5	**Station:**	
GPS Waypoint ID:			
Watershed Description Forested Till Plain, Outwash and Supraglacial Drift Complex			
Watereshed Area (Acres)		**Valley Form (I-XI)**	

LEVEL 1

Land Uses and Impacts (remote and in-field review)

Urban	Suburban	Rural
Agricultural	**Silvicultural**	Fires
Channelization	Flood Control, Clearing, **Vegetation Removal**, Dredging, Levees	Reservoir Storage, Hydropower
Diversions, Depletions	Grazing	**Roads**
Mining	In-channel Mining	

Erosional and Streamflow Processes (remote and in-field review)

Surface Erosion	~~1 2 3 4~~	Mass Erosion	~~1 2 3 4 5~~
Streamflow Change	**1** ~~2~~ **3** **4** ~~5 6~~	Channel Processes	**1** ~~2 3 4 5 6~~
Channel Impacts	~~1~~ **2**	Valley Type (I-XI)	

Rapid Condition Assessment (field review)

Channel Condition	8	Hydrologic alteration	8	Riparian zone	10
Bank stability	9	Water appearance		Nutrient enrichment	9
Barriers to fish movement	8	Instream fish cover		Pools	
Invertebrate habitat	10				
Total score divided by total scored: 62/7 = 8.9	<6 Poor 6.1-7.4 Fair 7.5-8.9 Good >9 Excellent		**Advance to Channel Morphological Data Collection if final score is < 7.5**		

LEVEL 2

Channel Morphological Data

Step 1 – Reach			
Flow Regime		Stream Size and Order	
Meander Patterns		Depositional Patterns	
Channel Blockages			
Step 2 – Cross Section Morphology			
Pfankuch Channel Stability Rating	Fair		
Bankfull Width (ft)	6	Low Bank Height (ft)	
Max Bank Height (ft)		Bank Height Ratio (LBH/MBH)	
Bankfull Depth (ft)	1.5	Bankfull X-Section AREA (ft^2)	
Width/Depth Ratio (W_{bkf} / D_{bkf})	4	Maximum Depth (ft)	
Width of Flood-Prone Area (ft)	40	Entrenchment Ratio	6.7
Channel Materials $D_{50\ @\ Riffle}$ (mm)		Channel Materials $D_{84\ @\ Riffle}$ (mm)	
Largest Particle from Bar Sample (mm)		Water Surface Slope (rise/run)	

Channel Sinuosity	1.6	Meander Width (ft)	
Meander Width Ratio		Rosgen Stream Type	E5
Step 3 – Cross Section Bank Characteristics			
Study Bank Height (ft)		Study Bank Length (ft)	
Root Depth (ft)		Root Density (%)	
Bank Angle (degrees)		Surface Protection (%)	
Near Bank Maximum Depth (ft)			
Bank Material (select one)	Bedrock, Boulders, Cobble, Gravel or Composite, Sand, Silt/Clay		

Notes:

Large bank cut (~8-ft) downstream of new bridge off Smith Creek Trail access off Highway 169. Brook trout (~8-inch) and Caddisfly cases observed. A review of Google EarthPro revealed that the 2012 storms likely caused major damage in this section of P6-5 leading to a temporary bridge installation in 2013 and potential bank stabilization work. The current bridge appears to have been installed following that work.

<u>POTENTIAL PROJECT</u>: Additional bank stabilization work should be considered at this location to provide infrastructure and trout habitat resiliency. Bioengineering with possible toe-wood sod matting should be evaluated in Task 3 of this assessment. In-stream habitat structure should be considered for Brook Trout in any design.

Stream Assessment Form			
Date:		**Field Staff:**	
Stream/Drainage:	P6		
Reach ID:	6	**Station:**	
GPS Waypoint ID:			
Watershed Description Forested Till Plain, Outwash and Supraglacial Drift Complex			
Watershed Area (Acres)		**Valley Form (I-XI)**	

LEVEL 1

Land Uses and Impacts (remote and in-field review)		
Urban	Suburban	Rural
Agricultural	**Silvicultural**	Fires
Channelization	Flood Control, Clearing, **Vegetation Removal**, Dredging, Levees	Reservoir Storage, Hydropower
Diversions, Depletions	Grazing	**Roads**
Mining	In-channel Mining	

Erosional and Streamflow Processes (remote and in-field review)

Surface Erosion	~~1 2 3 4~~	Mass Erosion	~~1 2 3 4 5~~
Streamflow Change	**1** ~~2~~ **3 4** ~~5 6~~	Channel Processes	**1** ~~2 3 4 5 6~~
Channel Impacts	~~1~~ **2**	Valley Type (I-XI)	

Rapid Condition Assessment (field review)

Channel Condition	9	Hydrologic alteration	7	Riparian zone	10
Bank stability	10	Water appearance		Nutrient enrichment	8
Barriers to fish movement	10	Instream fish cover		Pools	
Invertebrate habitat	9				
Total score divided by total scored: 63/7 = 9	<6 Poor 6.1-7.4 Fair 7.5-8.9 Good >9 Excellent	**Advance to Channel Morphological Data Collection if final score is < 7.5**			

LEVEL 2

Channel Morphological Data

Step 1 – Reach			
Flow Regime		Stream Size and Order	
Meander Patterns		Depositional Patterns	
Channel Blockages			
Step 2 – Cross Section Morphology			
Pfankuch Channel Stability Rating	Good		
Bankfull Width (ft)	9	Low Bank Height (ft)	
Max Bank Height (ft)		Bank Height Ratio (LBH/MBH)	
Bankfull Depth (ft)	1.5	Bankfull X-Section AREA (ft^2)	
Width/Depth Ratio (W_{bkf} / D_{bkf})	6	Maximum Depth (ft)	
Width of Flood-Prone Area (ft)	>100	Entrenchment Ratio	11
Channel Materials $D_{50\ @\ Riffle}$ (mm)		Channel Materials $D_{84\ @\ Riffle}$ (mm)	
Largest Particle from Bar Sample (mm)		Water Surface Slope (rise/run)	

Channel Sinuosity	1.3	Meander Width (ft)	
Meander Width Ratio		Rosgen Stream Type	E5
Step 3 – Cross Section Bank Characteristics			
Study Bank Height (ft)		Study Bank Length (ft)	
Root Depth (ft)		Root Density (%)	
Bank Angle (degrees)		Surface Protection (%)	
Near Bank Maximum Depth (ft)			
Bank Material (select one)	Bedrock, Boulders, Cobble, Gravel or Composite, Sand, Silt/Clay		

Notes:

One 8-inch Brook Trout observed. One wooded portion of P6-6 was not included in this assessment. A GPS point was taken in the wooded portion. Caddisfly casings observed. Clay clumps observed on the channel bottom (unclear geomorphic process). Upper bank vegetation dominated by Canada Bluejoint Grass.

POTENTIAL PROJECT:

No potential projects were identified within this watershed.

Stream Assessment Form			
Date:		**Field Staff:**	S. Tracy and Kim Y.
Stream/Drainage:	P6		
Reach ID:	12	**Station:**	
GPS Waypoint ID:			
Watershed Description Forested Till Plain			
Watershed Area (Acres)		**Valley Form (I-XI)**	

LEVEL 1

Land Uses and Impacts (remote and in-field review)		
Urban	Suburban	Rural
Agricultural	**Silvicultural**	Fires
Channelization	Flood Control, Clearing, **Vegetation Removal**, Dredging, Levees	Reservoir Storage, Hydropower
Diversions, Depletions	Grazing	**Roads**
Mining	In-channel Mining	

Erosional and Streamflow Processes (remote and in-field review)

Surface Erosion	~~1 2 3 4~~	Mass Erosion	~~1 2 3 4 5~~
Streamflow Change	**1** ~~2~~ **3 4** ~~5 6~~	Channel Processes	**1** ~~2 3 4 5 6~~
Channel Impacts	~~1~~ **2**	Valley Type (I-XI)	

Rapid Condition Assessment (field review)

Channel Condition	3	Hydrologic alteration	10	Riparian zone	10
Bank stability	7	Water appearance		Nutrient enrichment	7
Barriers to fish movement	10	Instream fish cover		Pools	
Invertebrate habitat	10				
Total score divided by total scored: 57/7 = 8.1	<u><</u>6 Poor 6.1-7.4 Fair 7.5-8.9 Good <u>></u>9 Excellent	**Advance to Channel Morphological Data Collection if final score is < 7.5**			

LEVEL 2

Channel Morphological Data

Step 1 – Reach			
Flow Regime		Stream Size and Order	
Meander Patterns		Depositional Patterns	
Channel Blockages			
Step 2 – Cross Section Morphology			
Pfankuch Channel Stability Rating	Fair		
Bankfull Width (ft)	4	Low Bank Height (ft)	
Max Bank Height (ft)		Bank Height Ratio (LBH/MBH)	
Bankfull Depth (ft)	1.25	Bankfull X-Section AREA (ft^2)	
Width/Depth Ratio (W_{bkf} / D_{bkf})	3.2	Maximum Depth (ft)	
Width of Flood-Prone Area (ft)	30	Entrenchment Ratio	7.5
Channel Materials $D_{50\ @\ Riffle}$ (mm)		Channel Materials $D_{84\ @\ Riffle}$ (mm)	
Largest Particle from Bar Sample (mm)		Water Surface Slope (rise/run)	

Channel Sinuosity	1.2	Meander Width (ft)	
Meander Width Ratio		Rosgen Stream Type	E4
Step 3 – Cross Section Bank Characteristics			
Study Bank Height (ft)		Study Bank Length (ft)	
Root Depth (ft)		Root Density (%)	
Bank Angle (degrees)		Surface Protection (%)	
Near Bank Maximum Depth (ft)			
Bank Material (select one)	Bedrock, Boulders, Cobble, Gravel or Composite, Sand, Silt/Clay		

Notes:

This reach starts as a stable Alder/Grass channel that increases gradient through a small section of unstable banks below a remnant (>20 years) clear cut that extends to the bank edge. Bar formation exists mid-channel and on inside bends below bank failures (<2.5 feet). A stable C-type channel follows leading to an aggradation section. Increased and silt bar formation occurs downstream (point and lateral). Evidence of various-aged forestry cutting occurs along this section with setbacks ranging from 100 feet (10-20 year old cuts with poplar regeneration) to 500 feet (newest cuts) outside of the stream valley corridor. Evidence of abandoned channels exists in the actively building floodplain. The valley changes to a confined V-shaped valley and the channel sinuosity approaches 1 with steep valley slopes protected by berms and sediment basins associated with current forest cutting to the east on top of the bluff.

This reach illustrates channel response to forestry practices through time. Old cuts were extensive and reached to the edge of the channel. Abandoned channels downstream of these cuts suggest the stream underwent significant erosion and sedimentation until it relocated to its current position. No apparent forestry activity was observed in the headwaters (stable, trout streams) leading to this reach. Headwaters varied in gradient and included sections similar in gradient to this reach. Active erosion occurs in the high gradient transition from the Alder/Grass section in proximity to remnant and current forest cuttings, and it is possible that the stream remains in a state of disequilibrium, trying to settle into a new form. This reach is likely at a mid-point in its evolution from a previous condition to what will likely become a steep C-channel leading to the entrenched A-channel with low sinuosity.

Downstream of this reach, the stream gradient lessens and the valley form again opens up to a less entrenched form with a moderate to high stream width to depth ratio. Evidence of gravels and sand deposition occur as small point bars and the channel does not appear to be widening. As mentioned above, the forest is actively being cut on top of the eastern bluff and has BMPs in place to control runoff rate, surface erosion and sediment export. Cutting was occurring on the day of field observation and no determination of Forestry BMPs efficacy was possible, though it is expected that current practices far exceed the observed forestry practices that occurred 10-30 prior in this reach.

<u>Potential Project:</u> No restorative action is recommended for this reach at this time. However, it is recommended that first order headwaters are preserved or only very selectively cut to maintain channel equilibrium from this point downstream. In addition, this reach presents a unique opportunity to

establish monitoring and further historical review (desktop and in-field) to develop a case study for the conservation effectiveness of modern forestry as compared to historical practices. Results can inform UPM Blandin Paper on the effectiveness of their conservation BMP selection and implementation.

Stream Assessment Form			
Date:		**Field Staff:**	ST and KY
Stream/Drainage:	P6		
Reach ID:	13	**Station:**	
GPS Waypoint ID:			
Watershed Description Forested Till Plain			
Watershed Area (Acres)		**Valley Form (I-XI)**	

LEVEL 1

Land Uses and Impacts (remote and in-field review)		
Urban	Suburban	Rural
Agricultural	**Silvicultural**	Fires
Channelization	Flood Control, Clearing, **Vegetation Removal**, Dredging, Levees	Reservoir Storage, Hydropower
Diversions, Depletions	Grazing	**Roads**
Mining	In-channel Mining	

Erosional and Streamflow Processes (remote and in-field review)

Surface Erosion	~~1 2 3 4~~	Mass Erosion	~~1 2 3 4 5~~
Streamflow Change	**1** ~~2~~ **3 4** ~~5 6~~	Channel Processes	**1** ~~2 3 4 5 6~~
Channel Impacts	~~1~~ **2**	Valley Type (I-XI)	

Rapid Condition Assessment (field review)

Channel Condition	10	Hydrologic alteration	10	Riparian zone	10
Bank stability	10	Water appearance		Nutrient enrichment	10
Barriers to fish movement	10	Instream fish cover		Pools	
Invertebrate habitat	10				
Total score divided by total scored: 70/7 = 10	$\leq$6 Poor 6.1-7.4 Fair 7.5-8.9 Good $\geq$9 Excellent	**Advance to Channel Morphological Data Collection if final score is < 7.5**			

LEVEL 2

Channel Morphological Data

Step 1 – Reach			
Flow Regime		Stream Size and Order	
Meander Patterns		Depositional Patterns	
Channel Blockages			
Step 2 – Cross Section Morphology			
Pfankuch Channel Stability Rating	Good		
Bankfull Width (ft)	4	Low Bank Height (ft)	
Max Bank Height (ft)		Bank Height Ratio (LBH/MBH)	
Bankfull Depth (ft)	1.25	Bankfull X-Section AREA (ft^2)	
Width/Depth Ratio (W_{bkf} / D_{bkf})	3.2	Maximum Depth (ft)	
Width of Flood-Prone Area (ft)	60	Entrenchment Ratio	15
Channel Materials $D_{50 \text{ @ Riffle}}$ (mm)		Channel Materials $D_{84 \text{ @ Riffle}}$ (mm)	
Largest Particle from Bar Sample (mm)		Water Surface Slope (rise/run)	

Channel Sinuosity	1.1	Meander Width (ft)	
Meander Width Ratio		Rosgen Stream Type	E4
Step 3 – Cross Section Bank Characteristics			
Study Bank Height (ft)		Study Bank Length (ft)	
Root Depth (ft)		Root Density (%)	
Bank Angle (degrees)		Surface Protection (%)	
Near Bank Maximum Depth (ft)			
Bank Material (select one)	Bedrock, Boulders, Cobble, Gravel or Composite, Sand, Silt/Clay		

Notes:

Pristine headwaters stream. 6-inch Brook Trout observed and minnows.

POTENTIAL PROJECT:

No potential projects were identified within this watershed.

Stream Assessment Form			
Date:		**Field Staff:**	
Stream/Drainage:	P6		
Reach ID:	27	**Station:**	
GPS Waypoint ID:			
Watershed Description Forested Till Plain and Outwash			
Watershed Area (Acres)		**Valley Form (I-XI)**	

LEVEL 1

Land Uses and Impacts (remote and in-field review)		
Urban	Suburban	Rural
Agricultural	**Silvicultural**	Fires
Channelization	Flood Control, Clearing, **Vegetation Removal**, Dredging, Levees	Reservoir Storage, Hydropower
Diversions, Depletions	Grazing	**Roads**
Mining	In-channel Mining	

Erosional and Streamflow Processes (remote and in-field review)

Surface Erosion	~~1 2 3 4~~	Mass Erosion	~~1 2 3 4 5~~
Streamflow Change	**1** ~~2~~ **3 4** ~~5 6~~	Channel Processes	**1** ~~2 3 4 5 6~~
Channel Impacts	~~1~~ **2**	Valley Type (I-XI)	

Rapid Condition Assessment (field review)

Channel Condition	9	Hydrologic alteration	8	Riparian zone	10
Bank stability	10	Water appearance		Nutrient enrichment	10
Barriers to fish movement	9	Instream fish cover		Pools	
Invertebrate habitat	10				
Total score divided by total scored: 66/7 = 9.4	≤6 Poor 6.1-7.4 Fair 7.5-8.9 Good ≥9 Excellent	**Advance to Channel Morphological Data Collection if final score is < 7.5**			

LEVEL 2

Channel Morphological Data

Step 1 – Reach			
Flow Regime		Stream Size and Order	
Meander Patterns		Depositional Patterns	
Channel Blockages			
Step 2 – Cross Section Morphology			
Pfankuch Channel Stability Rating	Good		
Bankfull Width (ft)	4	Low Bank Height (ft)	
Max Bank Height (ft)		Bank Height Ratio (LBH/MBH)	
Bankfull Depth (ft)	1.25	Bankfull X-Section AREA (ft^2)	
Width/Depth Ratio (W_{bkf} / D_{bkf})	3.2	Maximum Depth (ft)	
Width of Flood-Prone Area (ft)	30	Entrenchment Ratio	7.5
Channel Materials $D_{50\ @\ Riffle}$ (mm)		Channel Materials $D_{84\ @\ Riffle}$ (mm)	
Largest Particle from Bar Sample (mm)		Water Surface Slope (rise/run)	

Channel Sinuosity	1.3	Meander Width (ft)	
Meander Width Ratio		Rosgen Stream Type	E5
Step 3 – Cross Section Bank Characteristics			
Study Bank Height (ft)		Study Bank Length (ft)	
Root Depth (ft)		Root Density (%)	
Bank Angle (degrees)		Surface Protection (%)	
Near Bank Maximum Depth (ft)			
Bank Material (select one)	Bedrock, Boulders, Cobble, Gravel or Composite, Sand, Silt/Clay		

Notes:

Cedar bog. 8-inch Brook Trout observed.

<u>POTENTIAL PROJECT</u>:

No potential projects were identified within this watershed.

Stream Assessment Form			
Date:		**Field Staff:**	
Stream/Drainage:	P6		
Reach ID:	28	**Station:**	
GPS Waypoint ID:			
Watershed Description Forested Till Plain			
Watershed Area (Acres)		**Valley Form (I-XI)**	

LEVEL 1

Land Uses and Impacts (remote and in-field review)		
Urban	Suburban	Rural
Agricultural	**Silvicultural**	Fires
Channelization	Flood Control, Clearing, **Vegetation Removal**, Dredging, Levees	Reservoir Storage, Hydropower
Diversions, Depletions	Grazing	**Roads**
Mining	In-channel Mining	

Erosional and Streamflow Processes (remote and in-field review)			
Surface Erosion	~~1 2 3 4~~	Mass Erosion	~~1 2 3 4 5~~
Streamflow Change	**1** ~~2~~ **3 4** ~~5 6~~	Channel Processes	**1** ~~2 3 4 5 6~~
Channel Impacts	~~1~~ **2**	Valley Type (I-XI)	

Rapid Condition Assessment (field review)					
Channel Condition	10	Hydrologic alteration	10	Riparian zone	10
Bank stability	10	Water appearance		Nutrient enrichment	9
Barriers to fish movement	7	Instream fish cover		Pools	
Invertebrate habitat	7				
Total score divided by total scored: 63/7 = 9	≤6 Poor 6.1-7.4 Fair 7.5-8.9 Good ≥9 Excellent	**Advance to Channel Morphological Data Collection if final score is < 7.5**			

LEVEL 2

Channel Morphological Data			
Step 1 – Reach			
Flow Regime		Stream Size and Order	
Meander Patterns		Depositional Patterns	
Channel Blockages			
Step 2 – Cross Section Morphology			
Pfankuch Channel Stability Rating	Good		
Bankfull Width (ft)	3	Low Bank Height (ft)	
Max Bank Height (ft)		Bank Height Ratio (LBH/MBH)	
Bankfull Depth (ft)	1	Bankfull X-Section AREA (ft^2)	
Width/Depth Ratio (W_{bkf} / D_{bkf})	3	Maximum Depth (ft)	
Width of Flood-Prone Area (ft)	20	Entrenchment Ratio	6.7
Channel Materials $D_{50\ @\ Riffle}$ (mm)		Channel Materials $D_{84\ @\ Riffle}$ (mm)	
Largest Particle from Bar Sample (mm)		Water Surface Slope (rise/run)	

Channel Sinuosity	1.1	Meander Width (ft)	
Meander Width Ratio		Rosgen Stream Type	E5
Step 3 – Cross Section Bank Characteristics			
Study Bank Height (ft)		Study Bank Length (ft)	
Root Depth (ft)		Root Density (%)	
Bank Angle (degrees)		Surface Protection (%)	
Near Bank Maximum Depth (ft)			
Bank Material (select one)	Bedrock, Boulders, Cobble, Gravel or Composite, Sand, Silt/Clay		

Notes:

Tea-colored water. Potential reference stream. Cedar bog. Stream gradient increase upstream.

<u>POTENTIAL PROJECT</u>:

No potential projects were identified within this watershed.

Stream Assessment Form			
Date:		**Field Staff:**	ST and KY
Stream/Drainage:	P6		
Reach ID:	36	**Station:**	
GPS Waypoint ID:			
Watershed Description Forested Till Plain			
Watershed Area (Acres)		**Valley Form (I-XI)**	

LEVEL 1

Land Uses and Impacts (remote and in-field review)		
Urban	Suburban	Rural
Agricultural	**Silvicultural**	Fires
Channelization	Flood Control, Clearing, **Vegetation Removal**, Dredging, Levees	Reservoir Storage, Hydropower
Diversions, Depletions	Grazing	**Roads**
Mining	In-channel Mining	

Erosional and Streamflow Processes (remote and in-field review)

Surface Erosion	~~1 2 3 4~~	Mass Erosion	~~1 2 3 4 5~~
Streamflow Change	**1** ~~2~~ **3 4** ~~5 6~~	Channel Processes	**1** ~~2 3 4 5 6~~
Channel Impacts	~~1~~ **2**	Valley Type (I-XI)	

Rapid Condition Assessment (field review)

Channel Condition	10	Hydrologic alteration	10	Riparian zone	10
Bank stability	10	Water appearance		Nutrient enrichment	10
Barriers to fish movement	10	Instream fish cover		Pools	
Invertebrate habitat	10				
Total score divided by total scored: 70/7 = 10	≤6 Poor 6.1-7.4 Fair 7.5-8.9 Good ≥9 Excellent	**Advance to Channel Morphological Data Collection if final score is < 7.5**			

LEVEL 2

Channel Morphological Data

Step 1 – Reach			
Flow Regime		Stream Size and Order	
Meander Patterns		Depositional Patterns	
Channel Blockages			
Step 2 – Cross Section Morphology			
Pfankuch Channel Stability Rating	Good		
Bankfull Width (ft)	3	Low Bank Height (ft)	
Max Bank Height (ft)		Bank Height Ratio (LBH/MBH)	
Bankfull Depth (ft)	1	Bankfull X-Section AREA (ft^2)	
Width/Depth Ratio (W_{bkf} / D_{bkf})	3	Maximum Depth (ft)	
Width of Flood-Prone Area (ft)	20	Entrenchment Ratio	6.7
Channel Materials $D_{50\ @\ Riffle}$ (mm)		Channel Materials $D_{84\ @\ Riffle}$ (mm)	
Largest Particle from Bar Sample (mm)		Water Surface Slope (rise/run)	

Channel Sinuosity	1.3	Meander Width (ft)	
Meander Width Ratio		Rosgen Stream Type	E4
Step 3 – Cross Section Bank Characteristics			
Study Bank Height (ft)		Study Bank Length (ft)	
Root Depth (ft)		Root Density (%)	
Bank Angle (degrees)		Surface Protection (%)	
Near Bank Maximum Depth (ft)			
Bank Material (select one)	Bedrock, Boulders, Cobble, Gravel or Composite, Sand, Silt/Clay		

Notes:

Triple-barrel culverts at Smith Creek Trail crossing. Pristine headwaters stream. Minnows observed.

<u>POTENTIAL PROJECT</u>:

No potential projects were identified within this watershed.

Stream Assessment Form			
Date:	10/12/16	**Field Staff:**	ST, TM, MS, KY
Stream/Drainage:	P7		
Reach ID:	7	**Station:**	-
GPS Waypoint ID: -			
Watershed Description Forested Till Plain			
Watershed Area (Acres)	225 ac	**Valley Form (I-XI)**	IX

LEVEL 1

Land Uses and Impacts (remote and in-field review)

Urban	Suburban	Rural
Agricultural	**Silvicultural (very light, selective)**	Fires
Channelization	Flood Control, Clearing, **Vegetation Removal**, Dredging, Levees	Reservoir Storage, Hydropower
Diversions, Depletions	Grazing	**Roads**
Mining	In-channel Mining	

Erosional and Streamflow Processes (remote and in-field review)

Surface Erosion	~~1 2 3 4~~	Mass Erosion	~~1 2 3 4 5~~
Streamflow Change	~~1 2 3 4 5~~ **6**	Channel Processes	~~1 2 3 4 5 6~~
Channel Impacts	~~1 2~~	Valley Type (I-XI)	IX

Rapid Condition Assessment (field review)

Channel Condition	10	Hydrologic alteration	10	Riparian zone	10
Bank stability	10	Water appearance		Nutrient enrichment	10
Barriers to fish movement	5	Instream fish cover		Pools	
Invertebrate habitat	10				
Total score divided by total scored: 65/7 = 9.3	≤6 Poor 6.1-7.4 Fair 7.5-8.9 Good ≥9 Excellent	**Advance to Channel Morphological Data Collection if final score is < 7.5**			

LEVEL 2

Channel Morphological Data

Step 1 – Reach			
Flow Regime	P2,1,3	Stream Size and Order	S2(1)
Meander Patterns	M3	Depositional Patterns	B1
Channel Blockages	D4		
Step 2 – Cross Section Morphology			
Pfankuch Channel Stability Rating	Stable		
Bankfull Width (ft)	6	Low Bank Height (ft)	1
Max Bank Height (ft)	1.5	Bank Height Ratio (LBH/MBH)	0.7
Bankfull Depth (ft)	1.25	Bankfull X-Section AREA (ft^2)	7.5
Width/Depth Ratio (W_{bkf} / D_{bkf})	4.8	Maximum Depth (ft)	1
Width of Flood-Prone Area (ft)	≥15	Entrenchment Ratio	2.5
Channel Materials $D_{50\ @\ Riffle}$ (mm)	SAND	Channel Materials $D_{84\ @\ Riffle}$ (mm)	FINE GRAVEL

Largest Particle from Bar Sample (mm)	MED SAND	Water Surface Slope (rise/run)	~2%
Channel Sinuosity	1.3	Meander Width (ft)	32
Meander Width Ratio	3.5	Rosgen Stream Type	E5b
Step 3 – Cross Section Bank Characteristics			
Study Bank Height (ft)	2	Study Bank Length (ft)	20
Root Depth (ft)	24	Root Density (%)	80
Bank Angle (degrees)	90	Surface Protection (%)	30
Near Bank Maximum Depth (ft)	1.25		
Bank Material (select one)	Bedrock, Boulders, Cobble, Gravel or **Composite**, Sand, Silt/Clay		

Notes:

Corrugated metal, 4-ft, culvert with less than 1-foot of drop to water surface (no rain in the past week). Older mature maples and young Balsam Fir along banks. Approximately a 2% grade.

<u>POTENTIAL PROJECT</u>:

No potential projects were identified within this watershed.

Stream Assessment Form			
Date:		**Field Staff:**	TM
Stream/Drainage:	P8		
Reach ID:	1	**Station:**	-
GPS Waypoint ID: -			
Watershed Description Forested, supraglacial drift complex			
Watershed Area (Acres)		**Valley Form (I-XI)**	IX

LEVEL 1

Land Uses and Impacts (remote and in-field review)		
Urban	Suburban	Rural
Agricultural	Silvicultural	Fires
Channelization	Flood Control, Clearing, Vegetation Removal, Dredging, Levees	Reservoir Storage, Hydropower
Diversions, Depletions	Grazing	**Roads**
Mining	In-channel Mining	

Erosional and Streamflow Processes (remote and in-field review)

Surface Erosion	~~1 2 3 4~~	Mass Erosion	~~1 2 3 4 5~~
Streamflow Change	~~1 2 3 4 5 6~~	Channel Processes	~~1 2 3 4 5 6~~
Channel Impacts	~~1 2~~	Valley Type (I-XI)	IX

Rapid Condition Assessment (field review)

Channel Condition	5	Hydrologic alteration	8	Riparian zone	9
Bank stability	8	Water appearance		Nutrient enrichment	9
Barriers to fish movement	6	Instream fish cover		Pools	
Invertebrate habitat	6				
Total score divided by total scored: 51/7 = 7.3	≤6 Poor 6.1-7.4 Fair 7.5-8.9 Good ≥9 Excellent	**Advance to Channel Morphological Data Collection if final score is < 7.5**			

LEVEL 2

Channel Morphological Data

Step 1 – Reach			
Flow Regime		Stream Size and Order	
Meander Patterns		Depositional Patterns	
Channel Blockages			
Step 2 – Cross Section Morphology			
Pfankuch Channel Stability Rating	Fair		
Bankfull Width (ft)	3	Low Bank Height (ft)	
Max Bank Height (ft)		Bank Height Ratio (LBH/MBH)	
Bankfull Depth (ft)	1	Bankfull X-Section AREA (ft^2)	
Width/Depth Ratio (W_{bkf} / D_{bkf})	3	Maximum Depth (ft)	
Width of Flood-Prone Area (ft)	25	Entrenchment Ratio	8.3
Channel Materials $D_{50\ @\ Riffle}$ (mm)		Channel Materials $D_{84\ @\ Riffle}$ (mm)	
Largest Particle from Bar Sample (mm)		Water Surface Slope (rise/run)	

Channel Sinuosity		Meander Width (ft)	
Meander Width Ratio		Rosgen Stream Type	E5
Step 3 – Cross Section Bank Characteristics			
Study Bank Height (ft)		Study Bank Length (ft)	
Root Depth (ft)		Root Density (%)	
Bank Angle (degrees)		Surface Protection (%)	
Near Bank Maximum Depth (ft)			
Bank Material (select one)	Bedrock, Boulders, Cobble, Gravel or Composite, Sand, Silt/Clay		

Notes:

<u>POTENTIAL PROJECT</u>:

No potential projects were identified within this watershed.

Stream Assessment Form			
Date:		**Field Staff:**	ST
Stream/Drainage:	P8		
Reach ID:	2	**Station:**	-
GPS Waypoint ID: -			
Watershed Description Forested, supraglacial drift complex			
Watershed Area (Acres)		**Valley Form (I-XI)**	I

LEVEL 1

Land Uses and Impacts (remote and in-field review)		
Urban	Suburban	Rural
Agricultural	Silvicultural	Fires
Channelization	Flood Control, Clearing, Vegetation Removal, Dredging, Levees	Reservoir Storage, Hydropower
Diversions, Depletions	Grazing	Roads
Mining	In-channel Mining	

Erosional and Streamflow Processes (remote and in-field review)

Surface Erosion	~~1 2 3 4~~	Mass Erosion	~~1 2 3 4 5~~
Streamflow Change	~~1 2 3 4 5 6~~	Channel Processes	~~1 2 3 4 5 6~~
Channel Impacts	~~1 2~~	Valley Type (I-XI)	I

Rapid Condition Assessment (field review)

Channel Condition	7	Hydrologic alteration	7	Riparian zone	10
Bank stability	7	Water appearance		Nutrient enrichment	10
Barriers to fish movement	5	Instream fish cover		Pools	
Invertebrate habitat	10				
Total score divided by total scored: 56/7 = 8	≤6 Poor 6.1-7.4 Fair 7.5-8.9 Good ≥9 Excellent		**Advance to Channel Morphological Data Collection if final score is < 7.5**		

LEVEL 2

Channel Morphological Data

Step 1 – Reach			
Flow Regime		Stream Size and Order	
Meander Patterns		Depositional Patterns	
Channel Blockages			
Step 2 – Cross Section Morphology			
Pfankuch Channel Stability Rating	Fair		
Bankfull Width (ft)	3	Low Bank Height (ft)	
Max Bank Height (ft)		Bank Height Ratio (LBH/MBH)	
Bankfull Depth (ft)	1	Bankfull X-Section AREA (ft^2)	
Width/Depth Ratio (W_{bkf} / D_{bkf})	3	Maximum Depth (ft)	
Width of Flood-Prone Area (ft)	4	Entrenchment Ratio	1.3
Channel Materials $D_{50\ @\ Riffle}$ (mm)		Channel Materials $D_{84\ @\ Riffle}$ (mm)	
Largest Particle from Bar Sample (mm)		Water Surface Slope (rise/run)	

Channel Sinuosity		Meander Width (ft)	
Meander Width Ratio	1.1	Rosgen Stream Type	A3
Step 3 – Cross Section Bank Characteristics			
Study Bank Height (ft)		Study Bank Length (ft)	
Root Depth (ft)		Root Density (%)	
Bank Angle (degrees)		Surface Protection (%)	
Near Bank Maximum Depth (ft)			
Bank Material (select one)	Bedrock, Boulders, Cobble, Gravel or Composite, Sand, Silt/Clay		

Notes:

A road patch on H17 and modern culvert suggest a recent culvert replacement (circa 2012-2013).

This is a steep gradient, step-pool, entrenched reach with varying degrees of eroding to fully vegetated banks. There are signs of mostly fully-recovered channel reworking and high flow bypasses (also re-vegetated presumably following the 2012-2013 storms).

<u>POTENTIAL PROJECT</u>:

No potential projects were identified within this watershed.

Stream Assessment Form			
Date:	10/14/16	**Field Staff:**	ST
Stream/Drainage:	P9		
Reach ID:	2	**Station:**	-
GPS Waypoint ID: -			
Watershed Description Forested, supraglacial drift complex			
Watershed Area (Acres)		**Valley Form (I-XI)**	

LEVEL 1

Land Uses and Impacts (remote and in-field review)

Urban	**Suburban**	**Rural**
Agricultural	Silvicultural	Fires
Channelization	Flood Control, Clearing, **Vegetation Removal**, Dredging, Levees	Reservoir Storage, Hydropower
Diversions, Depletions	Grazing	**Roads**
Mining	In-channel Mining	

Erosional and Streamflow Processes (remote and in-field review)

Surface Erosion	~~1 2 3 4~~	Mass Erosion	~~1 2 3 4 5~~
Streamflow Change	**1** ~~2~~ **3** ~~4 5 6~~	Channel Processes	**1** ~~2 3 4 5 6~~
Channel Impacts	~~1~~ **2**	Valley Type (I-XI)	

Rapid Condition Assessment (field review)

Channel Condition	10	Hydrologic alteration	10	Riparian zone	10
Bank stability	7	Water appearance		Nutrient enrichment	7
Barriers to fish movement	10	Instream fish cover		Pools	
Invertebrate habitat	7				
Total score divided by total scored: 61/7 = 8.7	≤6 Poor 6.1-7.4 Fair 7.5-8.9 Good ≥9 Excellent	**Advance to Channel Morphological Data Collection if final score is < 7.5**			

LEVEL 2

Channel Morphological Data

Step 1 – Reach			
Flow Regime		Stream Size and Order	
Meander Patterns		Depositional Patterns	
Channel Blockages			
Step 2 – Cross Section Morphology			
Pfankuch Channel Stability Rating	Fair		
Bankfull Width (ft)	3	Low Bank Height (ft)	
Max Bank Height (ft)		Bank Height Ratio (LBH/MBH)	
Bankfull Depth (ft)	1	Bankfull X-Section AREA (ft^2)	
Width/Depth Ratio (W_{bkf} / D_{bkf})	3	Maximum Depth (ft)	
Width of Flood-Prone Area (ft)	80	Entrenchment Ratio	27
Channel Materials $D_{50\ @\ Riffle}$ (mm)		Channel Materials $D_{84\ @\ Riffle}$ (mm)	
Largest Particle from Bar Sample (mm)		Water Surface Slope (rise/run)	

Channel Sinuosity		Meander Width (ft)	
Meander Width Ratio		Rosgen Stream Type	E5
Step 3 – Cross Section Bank Characteristics			
Study Bank Height (ft)		Study Bank Length (ft)	
Root Depth (ft)		Root Density (%)	
Bank Angle (degrees)		Surface Protection (%)	
Near Bank Maximum Depth (ft)			
Bank Material (select one)	Bedrock, Boulders, Cobble, Gravel or Composite, Sand, Silt/Clay		

Notes:

Gauge station at road crossing below flared end culvert (~30-in)

POTENTIAL PROJECT:

No potential projects were identified within this watershed.

Stream Assessment Form			
Date:	10/14/16	**Field Staff:**	ST
Stream/Drainage:	P9		
Reach ID:	3	**Station:**	-
GPS Waypoint ID: -			
Watershed Description Forested, supraglacial drift complex			
Watershed Area (Acres)		**Valley Form (I-XI)**	

LEVEL 1

Land Uses and Impacts (remote and in-field review)

Urban	**Suburban**	**Rural**
Agricultural	Silvicultural	Fires
Channelization	Flood Control, Clearing, **Vegetation Removal**, Dredging, Levees	Reservoir Storage, Hydropower
Diversions, Depletions	Grazing	**Roads**
Mining	In-channel Mining	

Erosional and Streamflow Processes (remote and in-field review)

Surface Erosion	~~1 2 3 4~~	Mass Erosion	~~1 2 3 4 5~~
Streamflow Change	**1** ~~2~~ **3** ~~4 5 6~~	Channel Processes	**1** ~~2 3 4 5 6~~
Channel Impacts	~~1~~ **2**	Valley Type (I-XI)	

Rapid Condition Assessment (field review)

Channel Condition	3	Hydrologic alteration	3	Riparian zone	10
Bank stability	7	Water appearance		Nutrient enrichment	7
Barriers to fish movement	7	Instream fish cover		Pools	
Invertebrate habitat	10				
Total score divided by total scored: 47/7 = 6.7	$\leq$6 Poor 6.1-7.4 Fair 7.5-8.9 Good $\geq$9 Excellent	**Advance to Channel Morphological Data Collection if final score is < 7.5**			

LEVEL 2

Channel Morphological Data

Step 1 – Reach			
Flow Regime		Stream Size and Order	
Meander Patterns		Depositional Patterns	
Channel Blockages			
Step 2 – Cross Section Morphology			
Pfankuch Channel Stability Rating	Poor		
Bankfull Width (ft)	3	Low Bank Height (ft)	
Max Bank Height (ft)		Bank Height Ratio (LBH/MBH)	
Bankfull Depth (ft)	1	Bankfull X-Section AREA (ft^2)	
Width/Depth Ratio (W_{bkf} / D_{bkf})	3	Maximum Depth (ft)	
Width of Flood-Prone Area (ft)	80	Entrenchment Ratio	27
Channel Materials $D_{50\ @\ Riffle}$ (mm)		Channel Materials $D_{84\ @\ Riffle}$ (mm)	
Largest Particle from Bar Sample (mm)		Water Surface Slope (rise/run)	

Channel Sinuosity		Meander Width (ft)	
Meander Width Ratio		Rosgen Stream Type	E5
Step 3 – Cross Section Bank Characteristics			
Study Bank Height (ft)		Study Bank Length (ft)	
Root Depth (ft)		Root Density (%)	
Bank Angle (degrees)		Surface Protection (%)	
Near Bank Maximum Depth (ft)			
Bank Material (select one)	Bedrock, Boulders, Cobble, Gravel or Composite, Sand, Silt/Clay		

Notes:

Stream meanders through Alder bod and black spruce and is potentially at risk of cattle grazing (unable to confirm). Minor aggradation of sediments observed, less than upstream – possible hydrologic effects of upstream beaver dam (P9-5).

POTENTIAL PROJECT:

No potential projects were identified within this watershed.

Stream Assessment Form			
Date:	10/14/16	**Field Staff:**	ST
Stream/Drainage:	P9		
Reach ID:	4	**Station:**	-
GPS Waypoint ID: -			
Watershed Description Forested, supraglacial drift complex			
Watershed Area (Acres)		**Valley Form (I-XI)**	

LEVEL 1

Land Uses and Impacts (remote and in-field review)		
Urban	**Suburban**	**Rural**
Agricultural	Silvicultural	Fires
Channelization	Flood Control, Clearing, **Vegetation Removal**, Dredging, Levees	Reservoir Storage, Hydropower
Diversions, Depletions	Grazing	**Roads**
Mining	In-channel Mining	

Erosional and Streamflow Processes (remote and in-field review)

Surface Erosion	~~1 2 3 4~~	Mass Erosion	~~1 2 3 4 5~~
Streamflow Change	**1** ~~2~~ **3** ~~4 5 6~~	Channel Processes	**1** ~~2 3 4 5 6~~
Channel Impacts	~~1~~ **2**	Valley Type (I-XI)	

Rapid Condition Assessment (field review)

Channel Condition	3	Hydrologic alteration	3	Riparian zone	10
Bank stability	7	Water appearance		Nutrient enrichment	7
Barriers to fish movement	7	Instream fish cover		Pools	
Invertebrate habitat	10				
Total score divided by total scored: 47/7 = 6.7	≤6 Poor 6.1-7.4 Fair 7.5-8.9 Good ≥9 Excellent	**Advance to Channel Morphological Data Collection if final score is < 7.5**			

LEVEL 2

Channel Morphological Data

Step 1 – Reach			
Flow Regime		Stream Size and Order	
Meander Patterns		Depositional Patterns	
Channel Blockages			
Step 2 – Cross Section Morphology			
Pfankuch Channel Stability Rating	Poor		
Bankfull Width (ft)	3	Low Bank Height (ft)	
Max Bank Height (ft)		Bank Height Ratio (LBH/MBH)	
Bankfull Depth (ft)	1	Bankfull X-Section AREA (ft^2)	
Width/Depth Ratio (W_{bkf} / D_{bkf})		Maximum Depth (ft)	
Width of Flood-Prone Area (ft)	50	Entrenchment Ratio	16.7
Channel Materials $D_{50\ @\ Riffle}$ (mm)		Channel Materials $D_{84\ @\ Riffle}$ (mm)	
Largest Particle from Bar Sample (mm)		Water Surface Slope (rise/run)	

Channel Sinuosity		Meander Width (ft)	
Meander Width Ratio		Rosgen Stream Type	E5
Step 3 – Cross Section Bank Characteristics			
Study Bank Height (ft)		Study Bank Length (ft)	
Root Depth (ft)		Root Density (%)	
Bank Angle (degrees)		Surface Protection (%)	
Near Bank Maximum Depth (ft)			
Bank Material (select one)	Bedrock, Boulders, Cobble, Gravel or Composite, Sand, Silt/Clay		

Notes:

Active clear cutting on private land during field assessment, to wetland edge. Cattle grazing on same property above stream corridor.

Stream meanders through Alder bod and black spruce and is potentially at risk of cattle grazing (unable to confirm). Aggradation of sediments observed – possible hydrologic effects of upstream beaver dam (P9-5).

POTENTIAL PROJECT:

No potential projects were identified within this watershed.

Stream Assessment Form			
Date:	10/14/16	**Field Staff:**	TM
Stream/Drainage:	P9		
Reach ID:	5	**Station:**	-
GPS Waypoint ID: -			
Watershed Description Forested, supraglacial drift complex			
Watershed Area (Acres)		**Valley Form (I-XI)**	VIII

LEVEL 1

Land Uses and Impacts (remote and in-field review)		
Urban	**Suburban**	**Rural**
Agricultural	Silvicultural	Fires
Channelization	Flood Control, Clearing, **Vegetation Removal**, Dredging, Levees	Reservoir Storage, Hydropower
Diversions, Depletions	Grazing	**Roads**
Mining	In-channel Mining	

Erosional and Streamflow Processes (remote and in-field review)

Surface Erosion	~~1 2 3 4~~	Mass Erosion	~~1 2 3 4 5~~
Streamflow Change	**1** ~~2~~ **3** ~~4 5 6~~	Channel Processes	**1** ~~2 3 4 5 6~~
Channel Impacts	~~1~~ **2**	Valley Type (I-XI)	

Rapid Condition Assessment (field review)

Channel Condition	10	Hydrologic alteration	9	Riparian zone	10
Bank stability	10	Water appearance		Nutrient enrichment	7
Barriers to fish movement	5	Instream fish cover		Pools	
Invertebrate habitat	6				
Total score divided by total scored: 57/7 = 8.1	≤6 Poor 6.1-7.4 Fair 7.5-8.9 Good ≥9 Excellent	**Advance to Channel Morphological Data Collection if final score is < 7.5**			

LEVEL 2

Channel Morphological Data

Step 1 – Reach			
Flow Regime		Stream Size and Order	
Meander Patterns		Depositional Patterns	
Channel Blockages			
Step 2 – Cross Section Morphology			
Pfankuch Channel Stability Rating	Good		
Bankfull Width (ft)	3	Low Bank Height (ft)	
Max Bank Height (ft)		Bank Height Ratio (LBH/MBH)	
Bankfull Depth (ft)	1	Bankfull X-Section AREA (ft^2)	
Width/Depth Ratio (W_{bkf} / D_{bkf})	3	Maximum Depth (ft)	
Width of Flood-Prone Area (ft)	>100	Entrenchment Ratio	30
Channel Materials $D_{50\ @\ Riffle}$ (mm)		Channel Materials $D_{84\ @\ Riffle}$ (mm)	
Largest Particle from Bar Sample (mm)		Water Surface Slope (rise/run)	

Channel Sinuosity		Meander Width (ft)	
Meander Width Ratio		Rosgen Stream Type	E5
Step 3 – Cross Section Bank Characteristics			
Study Bank Height (ft)		Study Bank Length (ft)	
Root Depth (ft)		Root Density (%)	
Bank Angle (degrees)		Surface Protection (%)	
Near Bank Maximum Depth (ft)			
Bank Material (select one)	Bedrock, Boulders, Cobble, Gravel or Composite, Sand, Silt/Clay		

Notes:

Active clear cutting on private land during field assessment, to wetland edge. Cattle grazing on same property above stream corridor.

Stream meanders through Alder bod and black spruce and is potentially at risk of cattle grazing (unable to confirm). Aggradation of sediments observed – possible hydrologic effects of upstream beaver dam (P9-5).

<u>POTENTIAL PROJECT</u>:

No potential projects were identified within this watershed.

Stream Assessment Form			
Date:	10/14/16	**Field Staff:**	TM
Stream/Drainage:	P9		
Reach ID:	8	**Station:**	-
GPS Waypoint ID: -			
Watershed Description Forested, supraglacial drift complex			
Watershed Area (Acres)		**Valley Form (I-XI)**	VIII

LEVEL 1

Land Uses and Impacts (remote and in-field review)		
Urban	**Suburban**	**Rural**
Agricultural	Silvicultural	Fires
Channelization	Flood Control, Clearing, **Vegetation Removal**, Dredging, Levees	Reservoir Storage, Hydropower
Diversions, Depletions	Grazing	**Roads**
Mining	In-channel Mining	

Erosional and Streamflow Processes (remote and in-field review)

Surface Erosion	~~1 2 3 4~~	Mass Erosion	~~1 2 3 4 5~~
Streamflow Change	**1** ~~2~~ **3** ~~4 5 6~~	Channel Processes	**1** ~~2 3 4 5 6~~
Channel Impacts	~~1~~ **2**	Valley Type (I-XI)	

Rapid Condition Assessment (field review)

Channel Condition	10	Hydrologic alteration	9	Riparian zone	10
Bank stability	10	Water appearance		Nutrient enrichment	7
Barriers to fish movement	5	Instream fish cover		Pools	
Invertebrate habitat	6				
Total score divided by total scored: 57/7 = 8.1	<6 Poor 6.1-7.4 Fair 7.5-8.9 Good >9 Excellent	**Advance to Channel Morphological Data Collection if final score is < 7.5**			

LEVEL 2

Channel Morphological Data

Step 1 – Reach			
Flow Regime		Stream Size and Order	
Meander Patterns		Depositional Patterns	
Channel Blockages			
Step 2 – Cross Section Morphology			
Pfankuch Channel Stability Rating	Good		
Bankfull Width (ft)	3	Low Bank Height (ft)	
Max Bank Height (ft)		Bank Height Ratio (LBH/MBH)	
Bankfull Depth (ft)	1	Bankfull X-Section AREA (ft^2)	
Width/Depth Ratio (W_{bkf} / D_{bkf})	3	Maximum Depth (ft)	
Width of Flood-Prone Area (ft)	60-80	Entrenchment Ratio	20-27
Channel Materials $D_{50\ @\ Riffle}$ (mm)		Channel Materials $D_{84\ @\ Riffle}$ (mm)	
Largest Particle from Bar Sample (mm)		Water Surface Slope (rise/run)	

Channel Sinuosity		Meander Width (ft)	
Meander Width Ratio		Rosgen Stream Type	E5
Step 3 – Cross Section Bank Characteristics			
Study Bank Height (ft)		Study Bank Length (ft)	
Root Depth (ft)		Root Density (%)	
Bank Angle (degrees)		Surface Protection (%)	
Near Bank Maximum Depth (ft)			
Bank Material (select one)	Bedrock, Boulders, Cobble, Gravel or Composite, Sand, Silt/Clay		

Notes:

<u>POTENTIAL PROJECT</u>:

No potential projects were identified within this watershed.

Stream Assessment Form			
Date:	10/14/16	**Field Staff:**	TM
Stream/Drainage:	P9		
Reach ID:	9	**Station:**	-
GPS Waypoint ID: -			
Watershed Description Forested, supraglacial drift complex			
Watershed Area (Acres)		**Valley Form (I-XI)**	VIII

LEVEL 1

Land Uses and Impacts (remote and in-field review)		
Urban	**Suburban**	**Rural**
Agricultural	Silvicultural	Fires
Channelization	Flood Control, Clearing, **Vegetation Removal**, Dredging, Levees	Reservoir Storage, Hydropower
Diversions, Depletions	Grazing	**Roads**
Mining	In-channel Mining	

Erosional and Streamflow Processes (remote and in-field review)

Surface Erosion	~~1 2 3 4~~	Mass Erosion	~~1 2 3 4 5~~
Streamflow Change	**1** ~~2~~ **3** ~~4 5 6~~	Channel Processes	**1** ~~2 3 4 5 6~~
Channel Impacts	~~1~~ **2**	Valley Type (I-XI)	

Rapid Condition Assessment (field review)

Channel Condition	10	Hydrologic alteration	9	Riparian zone	10
Bank stability	10	Water appearance		Nutrient enrichment	7
Barriers to fish movement	5	Instream fish cover		Pools	
Invertebrate habitat	6				
Total score divided by total scored: 57/7 = 8.1	≤6 Poor 6.1-7.4 Fair 7.5-8.9 Good ≥9 Excellent	**Advance to Channel Morphological Data Collection if final score is < 7.5**			

LEVEL 2

Channel Morphological Data

Step 1 – Reach			
Flow Regime		Stream Size and Order	
Meander Patterns		Depositional Patterns	
Channel Blockages			
Step 2 – Cross Section Morphology			
Pfankuch Channel Stability Rating	Good		
Bankfull Width (ft)	3	Low Bank Height (ft)	
Max Bank Height (ft)		Bank Height Ratio (LBH/MBH)	
Bankfull Depth (ft)	1	Bankfull X-Section AREA (ft^2)	
Width/Depth Ratio (W_{bkf} / D_{bkf})	3	Maximum Depth (ft)	
Width of Flood-Prone Area (ft)	>100	Entrenchment Ratio	30
Channel Materials $D_{50\ @\ Riffle}$ (mm)		Channel Materials $D_{84\ @\ Riffle}$ (mm)	
Largest Particle from Bar Sample (mm)		Water Surface Slope (rise/run)	

Channel Sinuosity		Meander Width (ft)	
Meander Width Ratio		Rosgen Stream Type	E5
Step 3 – Cross Section Bank Characteristics			
Study Bank Height (ft)		Study Bank Length (ft)	
Root Depth (ft)		Root Density (%)	
Bank Angle (degrees)		Surface Protection (%)	
Near Bank Maximum Depth (ft)			
Bank Material (select one)	Bedrock, Boulders, Cobble, Gravel or Composite, Sand, Silt/Clay		

Notes:

POTENTIAL PROJECT:

No potential projects were identified within this watershed.