
Summary Report:
Recovery Potential Screening of North Dakota Watersheds
in Support of Nutrient Management

INTRODUCTION

The US Environmental Protection Agency's (EPA's) Total Maximum Daily Loads (TMDL) Program, in cooperation with state water quality programs, released a long-term TMDL Vision document in December 2013. Part of the TMDL Vision involves increasing states' identification of priority watersheds for restoration and protection efforts over a several-year time frame, and better linkage of TMDLs to these priorities. Previously, a 2011 Office of Water policy memorandum on nutrients had also recommended systematic watershed analysis, comparison and priority setting to obtain better results. EPA's TMDL program has provided watershed data, comparative assessment tools and state technical assistance for the past ten years through the Recovery Potential Screening (RPS) approach and tools (see Attachment 1). In support of state requests for assistance in nutrient-related prioritization, the TMDL program has partnered with several states, including North Dakota, to jointly carry out RPS assessments and develop results to help states consider their watershed nutrient management options systematically with consistent data. These RPS assessments were designed to address primary nutrient-related issues identified by each state using state-specific indicators and data relevant for watershed comparison. This report summarizes the North Dakota project approach and findings, and identifies multiple additional products (e.g., RPS Tools and data files) that were developed along with this overview document.

Background

Recovery Potential Screening (RPS) is a systematic, comparative method for identifying differences among watersheds that may influence their relative likelihood to be successfully restored or protected. The RPS approach involves identifying a group of watersheds to be compared and a specific purpose for comparison, selecting appropriate indicators in three categories (Ecological, Stressor, Social), calculating index values for the watersheds, and applying the results in strategic planning and prioritization. EPA developed the RPS to provide states and other restoration planners with a systematic, flexible tool that could help them compare watershed differences in terms of key environmental and social factors affecting prospects for restoration success. As such, RPS provides water programs with an easy to use screening and comparison tool that is user-customizable for the geographic area of interest and a variety of specific comparison and prioritization purposes. The RPS Tool is a custom-coded Excel spreadsheet that performs all RPS calculations and generates RPS outputs (rank-ordered index tables, graphs and maps). It was developed several years ago to help users calculate Ecological, Stressor, Social, and Recovery Potential Integrated index scores for comparing up to thousands of watersheds in a desktop environment using widely available and familiar software. EPA developed the RPS Tools with embedded indicator data for each of the conterminous states and other selected geographic areas of interest.

North Dakota Department of Health (NDDoH) requested assistance from EPA in 2014 to further the state's efforts in prioritizing watersheds for nutrient management restoration and protection efforts. An RPS assessment project was jointly undertaken by EPA's TMDL program, Tetra Tech (EPA contractor), and NDDoH. Two hundred forty nine (249) base, ecological, stressor, and social indicators were measured at the HUC12 scale and 72 indicators were measured at the HUC8 scale using a combination of national and state datasets. These indicators are compiled in a North Dakota statewide RPS tool (Excel file). The HUC12 watersheds were obtained from the USGS Watershed Boundary Dataset (WBD) in 2014 and include recent State-specific modifications to the HUC12 watersheds. Previously developed national indicators data were area-weighted where appropriate and to match the newer North Dakota WBD HUC12 watersheds in the Tool. The mapping features in the Tool were also updated to reflect the newer WBD HUC12 watersheds. The assessment findings and figures in this document were generated by the North Dakota RPS Tool.

APPROACH

As a starting point, each RPS nutrient project was designed to apply recommendations from the EPA Office of Water 2011 nutrient policy memorandum, which reads in part:

> *Prioritize watersheds on a statewide basis for nitrogen and phosphorus loading reductions*
>
> *A. Use best available information to estimate Nitrogen (N) and Phosphorus (P) loadings delivered to rivers, streams, lakes, reservoirs, etc. in all major watersheds across the state on a Hydrologic Unit Code (HUC) 8 watershed scale or smaller watershed (or a comparable basis.)*
>
> *B. Identify major watersheds that individually or collectively account for a substantial portion of loads (e .g. 80 percent) delivered from urban and/or agriculture sources to waters in a state or directly delivered to multi-jurisdictional waters.*
>
> *C. Within each major watershed that has been identified as accounting for the substantial portion of the load, identify targeted/priority sub-watersheds on a HUC 12 or similar scale to implement targeted N and P load reduction activities. Prioritization of sub-watersheds should reflect an evaluation of receiving water problems, public and private drinking water supply impacts, N and P loadings, opportunity to address high-risk N and P problems, or other related factors.*

The two-stage approach implicit in the text above fits well with the RPS Tool, which easily supports comparing HUC8s in an initial targeting stage and then focuses on screening and comparing HUC12s in a second, implementation-oriented stage, as illustrated in Figure 1. All of the RPS nutrient projects utilize the same general two stage approach (HUC8 or similar larger-scale unit in Stage 1, HUC12 in Stage2), while encouraging state-specific customization of the approach in identifying stage 1 scenarios, establishing state approaches for priority watershed identification, and selection and weighting of the most nutrient-relevant indicators for use in both stages. In this project, the data sources and indicators compiled in the RPS tool, the selections of indicators, choice of demonstration watersheds, and weighting of indicators in the nutrient-related screening runs all took place collaboratively among NDDoH, EPA and its contractor. Nevertheless, this technical project's findings and outputs are not meant to represent decisions or policies of NDDoH, EPA, or any other entity.

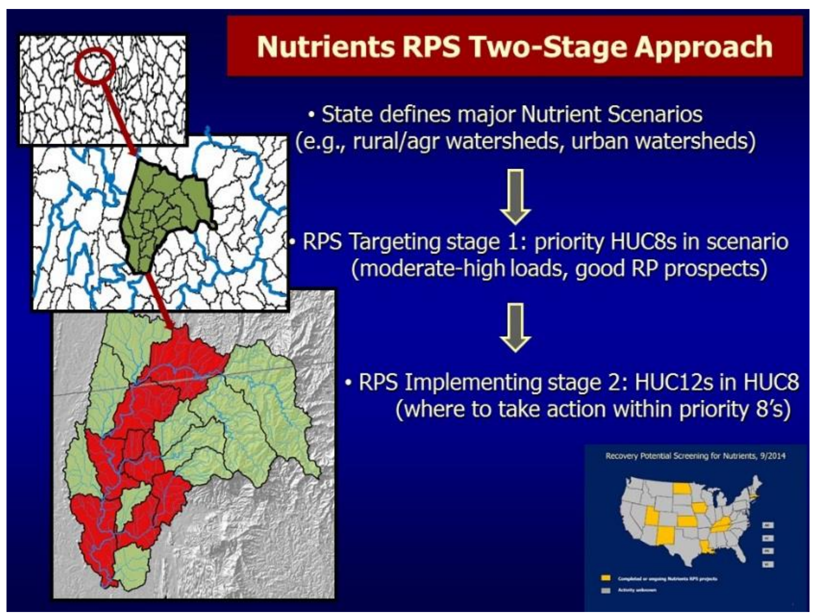

Figure 1. Two-stage conceptual approach utilized in RPS projects for supporting state nutrient management

Stage 1

Identifying Nutrient Scenarios. The RPS Tool is most effective in comparing groups of watersheds that have something in common, such as generally similar landscapes, nutrient sources, impacts and possible management options; for this reason, Stage 1 begins by engaging the state in defining specific types or groups of watersheds with something in common regarding their primary nutrient management challenges. The term "scenario" is used here to describe these sets of shared characteristics that provide a basis for groups of similar watersheds to be compared and contrasted with one another. Nutrient management challenges in any given state can be complex and involve multiple scenarios.

Breaking down a large group of watersheds statewide into smaller, more similar groups and focusing on scenarios most relevant to each group enables a narrower focus on nutrient issues and possible solutions.

For North Dakota, two Stage 1 scenarios of interest were initially selected during a series of conference calls between EPA, NDDoH, and Tetra Tech. The state is divided into eastern and western regions based on predominant land cover (Figure 2 and Table 1). The eastern part of the state which includes the Red River/Lake Winnipeg drainage basin is primarily row crop agriculture, and there is interest in nutrient reduction and restoration. The western part of the state is primarily small grains and rangeland and is in need of nutrient management as land disturbance and population increase due to rapidly expanding oil and gas extraction, which results in new wastewater and stormwater sources. Those HUC8 that are at least 15 percent within North Dakota were included in the Stage 1 analyses.

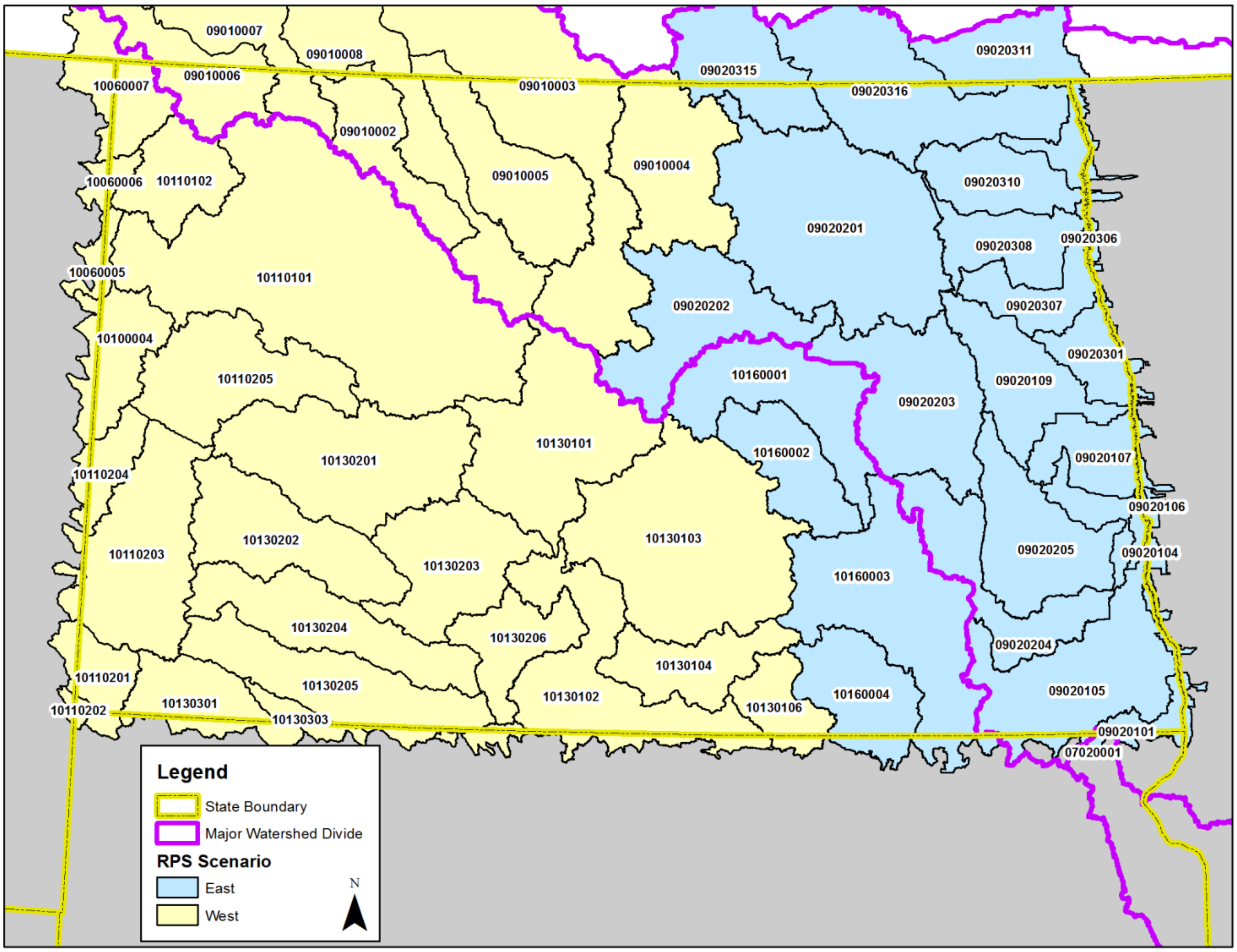

Figure 2. North Dakota HUCs. Scenario 1A ranks blue HUC8s; scenario 1B ranks yellow HUC8s. Note that HUC8 boundaries are clipped to HUC12 boundaries along the state line.

Table 1. North Dakota HUC8s included in analysis

Scenario 1A HUC8s (Eastern)	Scenario 1B HUC8s (Western)
09020101	09010002
09020104	09010003
09020105	09010004
09020107	09010005
09020109	09010006
09020201	09010008
09020202	10060007
09020203	10110101
09020204	10110102
09020205	10110203
09020301	10110204
09020307	10110205
09020308	10130101
09020310	10130102
09020311	10130103
09020315	10130104
09020316	10130106
10160001	10130201
10160002	10130202
10160003	10130203
10160004	10130204
	10130205
	10130206
	10130301

Scenario 1A - Eastern North Dakota HUC8s: Cropland and Drainage Pressures

Scenario 1A screens and compares those HUC8s that are dominated by row crop agriculture in the eastern portion of the state. These HUC8s are often served by tile drainage and ditching and are typically subject to intense tillage practices and fertilizer application. They also often have nutrient-related impairments (Figure 3). Key sources of nutrients in these watersheds include fertilizer application, runoff and erosion from fields and in nearby streams. In addition, expanded urban and human sources such as stormwater and wastewater can be important sources and are represented by population growth. These watersheds may include point sources and other significant non-point sources such as septic systems and feedlots. The purpose of this scenario is to identify those HUC8s where restoration efforts could be focused. Stressor indicators and those social indicators which represent potential for readiness to implement are weighed more heavily.

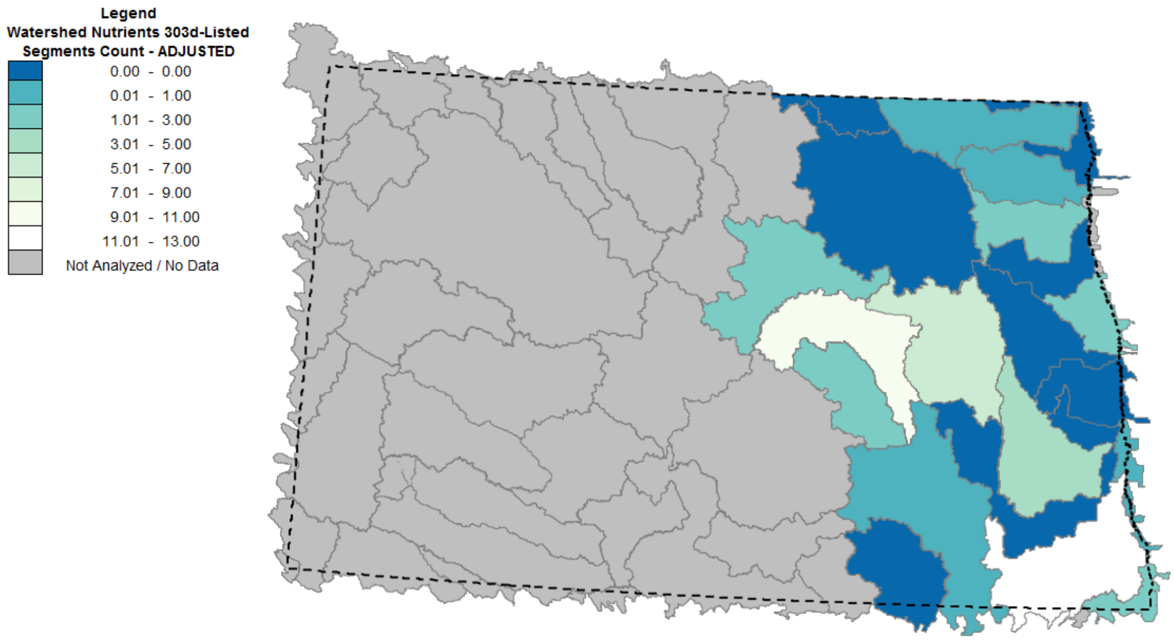

Figure 3. Number of reported nutrient impairments in eastern North Dakota

Scenario 1B - Western North Dakota HUC8s: Rangeland and Energy Production Pressures

Scenario 1B is used to identify HUC8s that are dominated by rural, non-row crop land uses in the western part of the state. These HUC8s are predominately rangeland (grassland and herbaceous land cover) and often include animal agriculture activities. In this part of North Dakota, oil and gas production has been leading to significant increases in population and land disturbance. Pathways for pollutants can include watershed and stream channel erosion, feedlot runoff, and manure management activities. In addition, population growth and wastewater loading associated with development are stressors. The purpose of this scenario is to identify HUC8s with threats that could result in additional nutrient loading and impairments beyond those already reported (Figure 4) and compare differences among these watersheds in terms of several factors that influence restorability. Ecological indicators and those stressor indicators which represent threats are weighed more heavily.

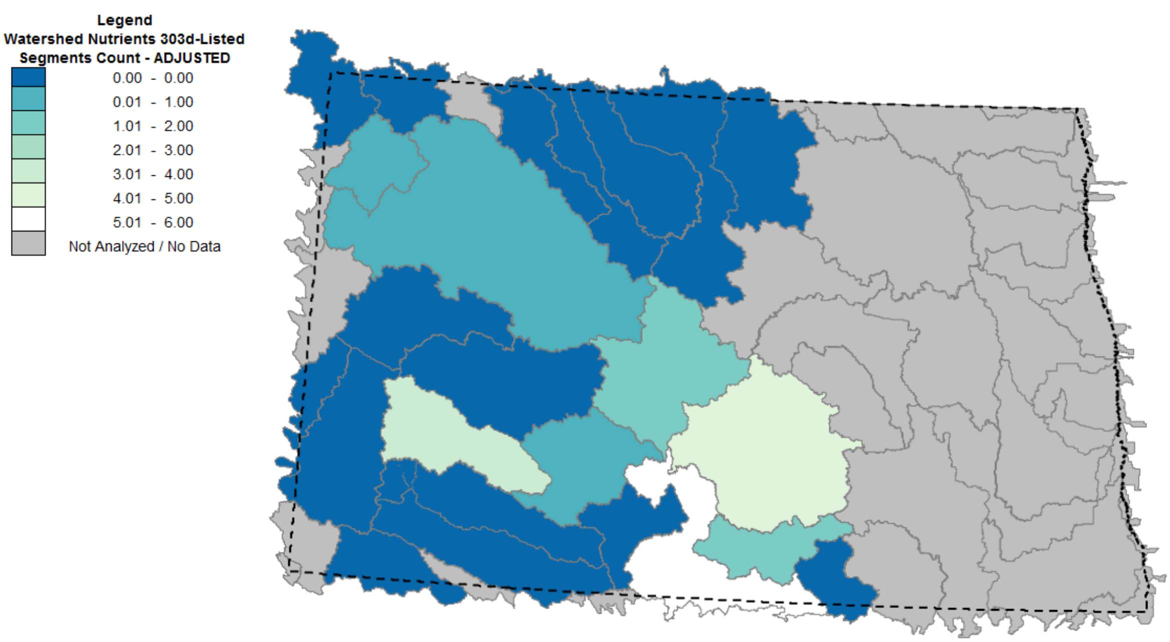

Figure 4. Number of reported nutrient impairments in western North Dakota

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Selection of Stage 1 indicators. Watersheds within each scenario are compared to one another with scenario-specific indicator selections since each scenario differs in nutrient source types and exposure pathways. Indicators for Stage 1 need only to be sufficient for generally comparing watersheds across the state, identifying which watersheds to include in each scenario, and revealing major differences in condition and estimated nutrient loading magnitude as a state selects its first watersheds to assess within each scenario. Using the RPS Tool, two different (scenario-specific) selections of recovery potential indicators (see indicator lists in Table 2 and definitions in Attachment 2) were used to screen North Dakota HUC8s.

*Table 2. Stage 1 RPS indicator selections and weights for screening and comparing HUC8s for two North Dakota scenarios. See Attachment 2 for indicator definitions. Those indicators with a * are derived from state-specific datasets.*

Stage 1 Eastern North Dakota - Cropland and Drainage Pressures HUC8 Ranking – Scenario 1A					
Ecological Indicators	**wt**	**Stressor Indicators**	**wt**	**Social Indicators**	**wt**
% natural cover (2011) in watershed*	1	% corn, soybeans or sugar beet in watershed*	2	Count of segments with TMDLs in watershed	2
% natural cover (2011) in riparian zone*	1	% grassland to row crop transition in watershed*	2	% GAP status 1, 2, and 3 in watershed	1
National Fish Habitat Partnership Habitat Condition Index	1	Average TN load (kg/yr) SPARROW (2002) to watershed*	2	% drinking water source protection area*	1
% wetlands (2011 and NWI) in riparian zone*	1	Average TP load (kg/yr) SPARROW (2002) to watershed*	2	% watershed conservation activity in watershed*	2
		% population increase within watershed*	2	% CRP activities in watershed*	2
		Count of drain tile outlets/area in watershed*	2		
		Watershed nutrients 303d-listed segments count	1		
Stage 1 Western North Dakota - Rangeland and Energy Production Pressures HUC8 Ranking – Scenario 1B					
Ecological Indicators	**wt**	**Stressor Indicators**	**wt**	**Social Indicators**	**wt**
% natural cover (2011) in watershed*	1	% in pasture/hay (2011) in watershed*	1	Count of segments with TMDLs in watershed	1
% natural cover (2011) in riparian zone*	1	Average TN load (kg/yr) SPARROW (2002) to watershed*	1	% GAP status 1, 2, and 3 in watershed	1
National Fish Habitat Partnership Habitat Condition Index	2	Average TP load (kg/yr) SPARROW (2002) to watershed*	1	% drinking water source protection area*	1
% wetlands (2011 and NWI) in riparian zone*	1	Count of oil and gas wells/area in watershed*	2	% conservation activity in watershed*	2
		% population increase within watershed*	2	% CRP activities in watershed*	2
		Watershed nutrients 303d-listed segments count	1		

Interpreting the Screening Results

Several products are generated through the screening runs for each scenario. Each watershed (HUC8 or HUC12 scale) in a scenario screening run receives ecological, stressor, and social index scores and ranks. There is also an aggregate Recovery Potential Index (RPI) score and rank for each watershed. Each of these four index values have a possible range from 0 to 100. The ecological, stressor and social indices are each calculated by summing weight-adjusted, normalized indicator values, dividing by the total weight, and multiplying by 100. RPI Scores are calculated as: [Ecological Index +

Social Index + (100 - Stressor Index)] / 3. Note that all scores represent a relative gradient of values only across the watersheds being screened, and do not by themselves define thresholds of condition (e.g., impaired/unimpaired) or restorability.

A higher score implies a watershed may be better suited than others for restoration in the case of the ecological and social indices and the overall RPI. A higher stressor index score implies lower relative recovery potential. Conversely, in the case of rank order, all four indices (ecological, stressor, social and RPI) are rank ordered so that a smaller number (e.g., #1 ranked) implies higher relative recovery potential.

Maps illustrating the watersheds in the screening run are generated by the RPS Tool. The map can be customized to display values for each of the watersheds based on any index or single indicator, and map images can be saved and downloaded. The RPI score is the default map display and provides a commonly used parameter to illustrate the spatial relationship among the watersheds and their general ranking in the screening run.

Bubble plots are also produced for each screening run. These provide a visual tool for comparing the distribution of ecological, stressor and social indices across all watersheds in the screening run, and individual watersheds can be color coded and labeled for specific display purposes. The Y and X axes represent the Ecological and Stressor Index scores respectively and the size of the symbol indicates each watershed's social score. The bubble plot's extra axes position watersheds relative to the median stressor and ecological scores for every screening run. These axes split the plots into four quadrants. For example, watersheds in the upper left quadrant have high ecological scores and low stressor scores. Users may also reset these axes to represent statewide median values or user-defined values, providing more reference context to the relative value gradient of the screened watersheds. Like the map, bubble plot images can be saved and downloaded for later use in documents and presentations. Whereas there is no absolute rule dictating what the actual recovery potential of a watershed is based on these plots, theoretical considerations can be made about the relative position of HUC8s within these plots that may help guide discussion.

For additional information on using the RPS Tool and any of these product formats please see the RPS Tool User Manual and other user support resources online.

STAGE 1 RESULTS

Scenario 1A – Eastern North Dakota HUC8 Screening - Cropland and Drainage Pressures

This scenario compares HUC8s throughout the eastern region of the State to help identify a smaller number of HUC8s that could be focused on for nutrient management and restoration efforts where row crop agriculture is a predominant land cover. A copy of the RPS Tool populated with this scenario's screening results is among project deliverables (see tool files list in Attachment 4).

RPI scores for scenario 1A are displayed in map form in Figure 5 showing the relative geographic distribution of the scenario. RPI scores are a composite of scores for the Ecological, Stressor, and Social Indices for each HUC8, and as such the RPI provides a generalized starting point for comparing watersheds. Overall, the eastern and particularly east-central part of this region includes among the lowest scoring HUCs, while the highest scoring HUC8s tend to be in the western or west-central parts of the region (labeled on Figure 5). These results include all HUC8s in the region, and thus several considerations can be applied to focus on fewer HUC8s of greater interest for nutrient management and restoration. Primarily, HUC8s of interest would likely have evidence of nutrient impairments and significant nutrient loading estimates, but would also have some ecological or social attributes associated with being better prospects for successful restoration. All but eight of the HUC8s within this scenario have nutrient impairments.

Of the top ten scoring HUC8s, four have estimated nutrient loads that are near or greater than the region's median: Western Wild Rice, Lower Sheyenne, Turtle, and Forest. In addition, Upper Sheyenne, Middle Sheyenne, Upper James, Elm, and Western Wild Rice have many more nutrient-related impairments than the other HUC8s in this scenario. All of the top ranking HUC8s exhibit high levels of conservation activities or CRP activities in their watersheds. Many of these HUC8s, depending on the state's priorities, could be important areas for statewide prioritization and restoration efforts.

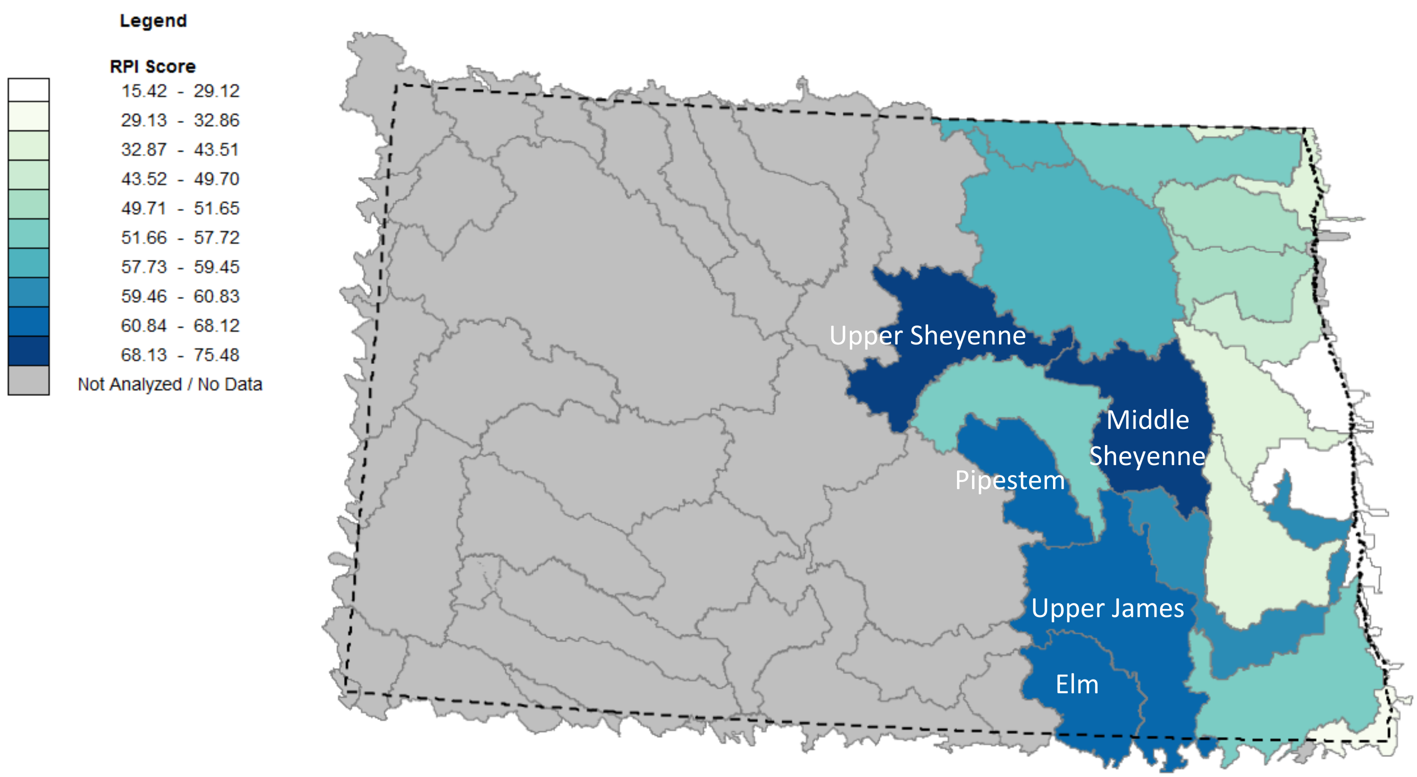

Figure 5. Scenario 1A watershed ranking by RPI score (highest ranked watersheds darkest with labels)

The bubble plot in Figure 6 displays the relative value differences among HUC8s in Ecological, Stressor and Social Index scores by each bubble's size and position on the graph, also showing how these compare to region-wide medians (the horizontal and vertical median lines). The bubble plot highlights HUC8s in orange that have estimated phosphorus or nitrogen yields that are greater than the regions' median yields. Note that Upper Pembina River, Middle Red, Turtle, Elm-Marsh, and Lower Sheyenne HUC8s have higher than average estimated nutrient loads but no identified nutrient impairments. These HUC8s could be candidates for further monitoring and assessment. In the upper right quadrant, the Western Wild Rice displays the highest social score and an above median ecological score, with an elevated stressor score; this might suggest elevated risks of impairment coupled with positive signals about the ecological and social context for restoration opportunities.

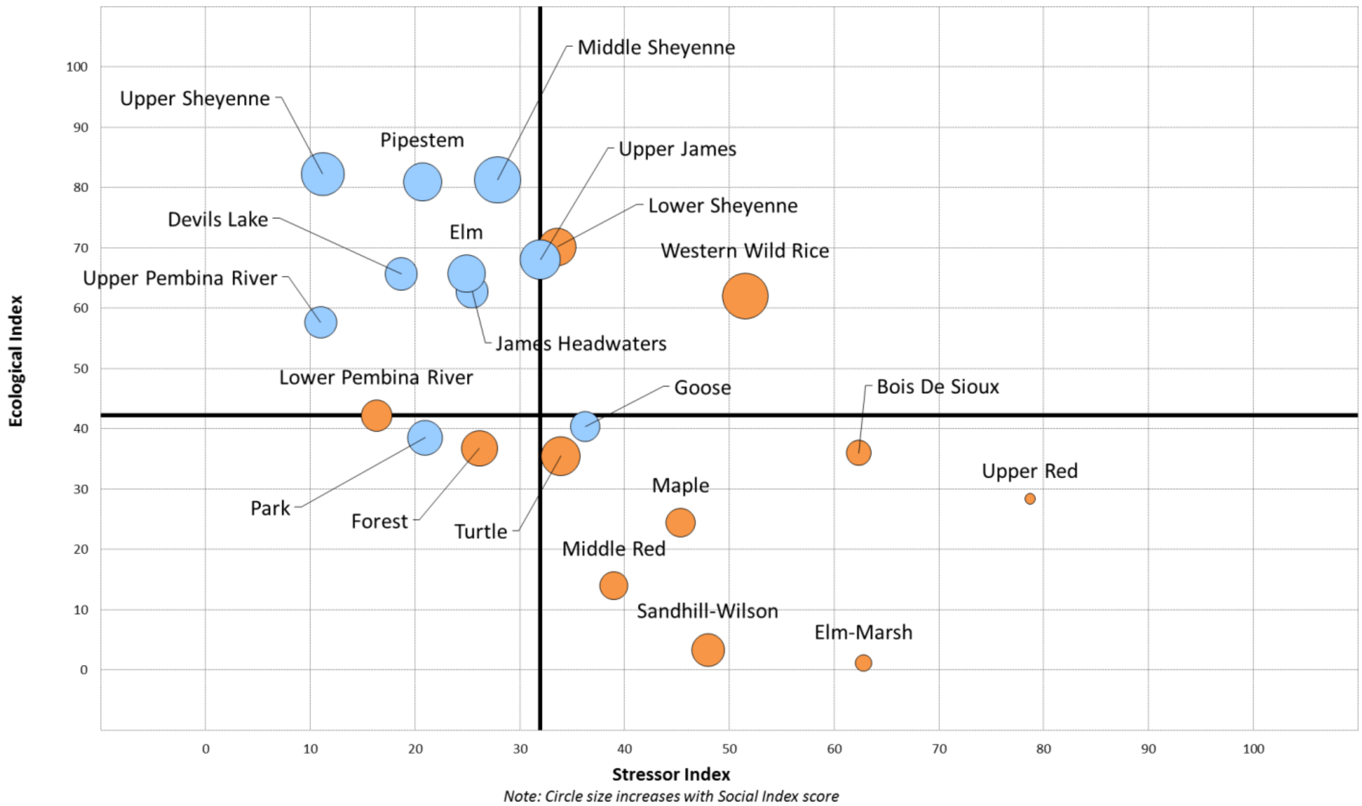

Figure 6. Bubble plot for all scenario 1A HUC8s. Orange bubbles represent HUC8s that have estimated phosphorus or nitrogen yields greater than the region's median. Axes are set to median Ecological Index and Stressor Index scores.

Maps of Ecological and Stressor Index scores for scenario 1A are displayed in Figure 7 and Figure 8. The Ecological Index map shows that high Ecological Index scores are found in the central part of the state. Low Stressor Index scores are found along the boundary with Canada, due in part to a predominance of wheat and other small grains. Additional indicators or different screenings may be warranted in these HUC8s to better understand their recovery potential in light of more specific exposure settings than were considered in this general scenario analysis.

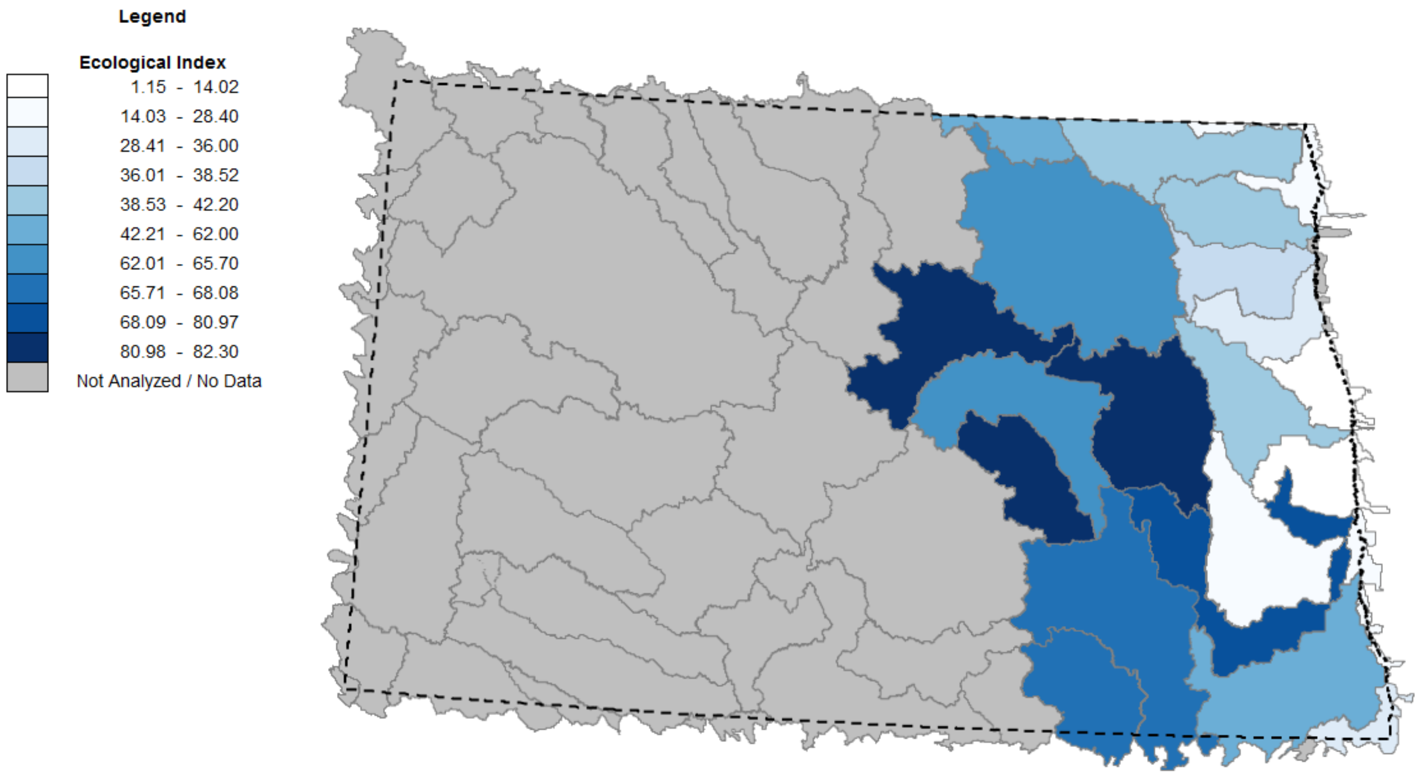

Figure 7. Ecological ranking (darker blue implies better for restoration)

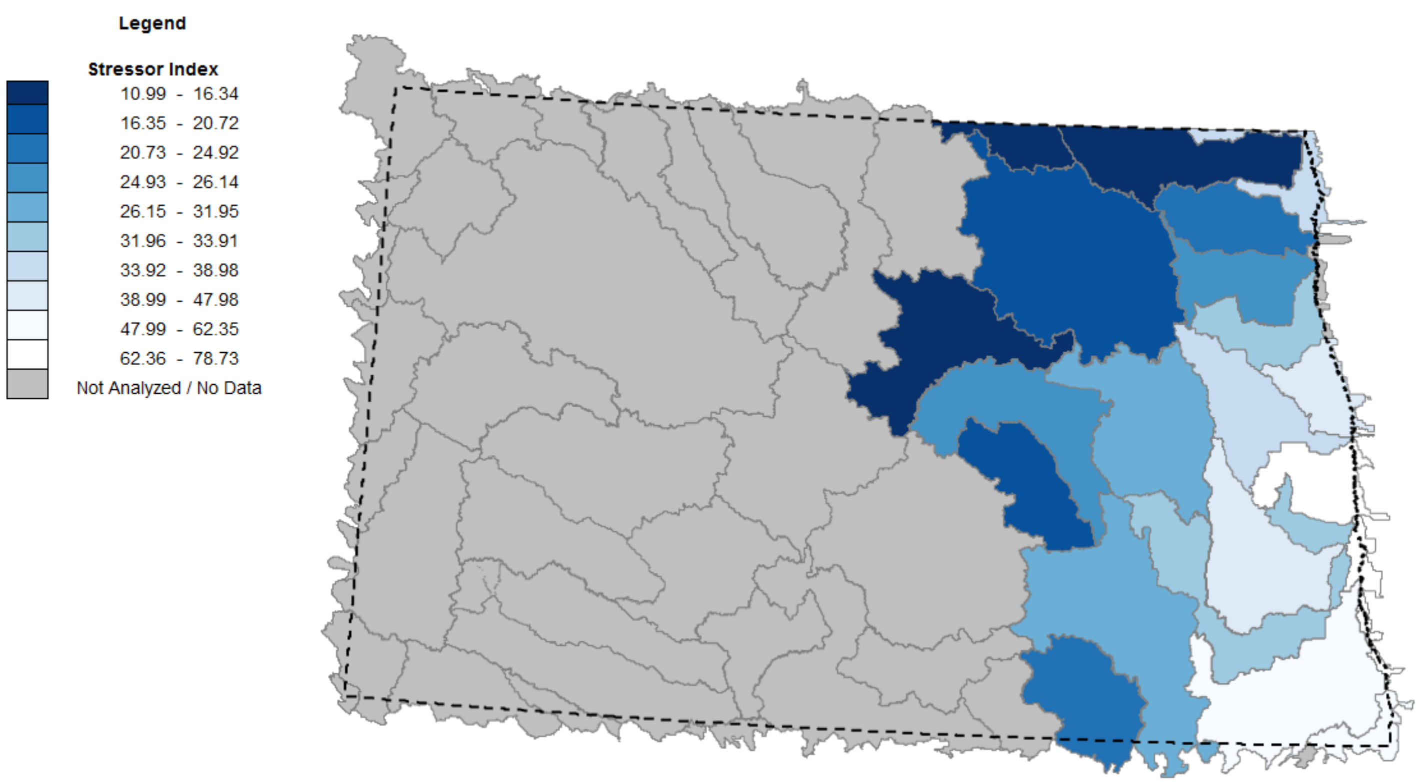

Figure 8. Stressor ranking (darker blue implies better for restoration)

Table 3 contains Ecological, Stressor, Social, and RPI scores for the scenario 1A HUC8s, in order of descending RPI score and color-coded by quartile per RPI score. This tabular format is another option for presentation of Stage 1 results that can be used to compare and contrast HUC8s. In interpreting this table, preferred HUC8s for nutrient management do not necessarily have to be those with the highest RPI scores but instead could consider one or more of the component index scores (e.g., the watersheds in the top ecological, stressor, or social quartile, or various combinations). For example, Middle Sheyenne and Upper James rank in the top 5 overall for RPI, but also have much higher (worse) Stressor Index scores indicating potentially threatened HUC8s.

Table 3. Index and RPI scores for scenario 1A. HUC8s are ordered by RPI score. Cells are shaded (darker is better) according to rank (black = 76 - 100th percentile; dark gray = 51-75th percentile; light gray = 26-50th percentile; white = 0-25th percentile). ***BOLD*** *indicates HUC8s that have estimated phosphorus or nitrogen yields greater than the region's median.*

Watershed ID	Watershed Name	Ecological Rank	Stressor Rank	Social Rank	RPI Rank
09020202	Upper Sheyenne	1	2	3	1
09020203	Middle Sheyenne	2	10	1	2
10160002	Pipestem	3	5	6	3
10160003	Upper James	5	11	4	4
10160004	Elm	6	7	8	5
09020204	**Lower Sheyenne**	4	12	7	6
09020201	Devils Lake	7	4	12	7
09020315	**Upper Pembina River**	10	1	14	8
09020105	**Western Wild Rice**	9	18	2	9
10160001	James Headwaters	8	8	13	10
09020316	Lower Pembina River	11	3	15	11
09020310	Park	13	6	10	12
09020308	**Forest**	14	9	9	13
09020307	**Turtle**	16	13	5	14
09020109	Goose	12	14	16	15
09020205	**Maple**	18	16	17	16
09020311	**Middle Red**	19	15	18	17
09020101	**Bois De Sioux**	15	19	19	18
09020301	**Sandhill-Wilson**	20	17	11	19
09020104	**Upper Red**	17	21	21	20
09020107	**Elm-Marsh**	21	20	20	21

Scenario 1B - Western North Dakota HUC8 Screening - Rangeland and Energy Production Pressures

This scenario identifies HUC8s that could be the focus of nutrient management efforts in the western part of North Dakota, where rangeland is a predominant land use and there are increasing pressures on water quality from development of oil and gas resources and related population growth. In contrast to scenario 1A's focus on largely existing nutrients impairments and restoration challenges, scenario 1B compares HUC8s based on a combination of their current nutrients issues and emerging future nutrient sources. A HUC in this scenario may be of high interest even if it has little current nutrient impairment, if expected future sources of nutrient loading are substantial. A copy of the RPS Tool populated with this scenario's screening results is among project deliverables.

RPI scores for scenario 1B are displayed in map form in Figure 9 and Table 4, showing the relative geographic distribution of the scenario. RPI scores are a composite of scores for the Ecological, Stressor, and Social Indices.

Integrating these three indices makes the RPI score frequently useful as an overall comparison metric, but it is capable of masking the importance of each of the component index scores, such as when two extreme scores in the same HUC cancel each other out. Thus, it is always important to examine all the indices to determine the HUC8s of high interest for the purpose at hand. For reasons discussed below, the RPI score is often not the preferred index to identify candidate HUC8s and the individual RPS indices are more useful; however, the RPI provides a useful starting point for comparison.

In this scenario, top RPI scores generally involve HUCs with fairly low stressor indices and either a high ecological or social index score. Top RPI scoring HUC8s in this scenario include Lower Cannonball (10130206), Willow (09010004), and West Missouri Coteau (10130106). All of the top ranked HUC8s have nutrient impairments or fairly high nutrient yields, however, and thus may be of high interest for nutrients management. In addition to these HUC8s, some of this scenario's HUC8s with high Ecological index scores also have some of the largest population increases (8-9%) that may indicate emerging (rather than existing) nutrient issues, most notably Middle Little Missouri (10110203) and Lower Little Missouri (10110205). Based on their high ecological scores accompanied by evidence of high emerging threats, these HUCs could be of high interest for nutrients management proactive strategies. Based only on RPI score, however, these HUCs would appear to be 'middle of the pack' and of no particular interest.

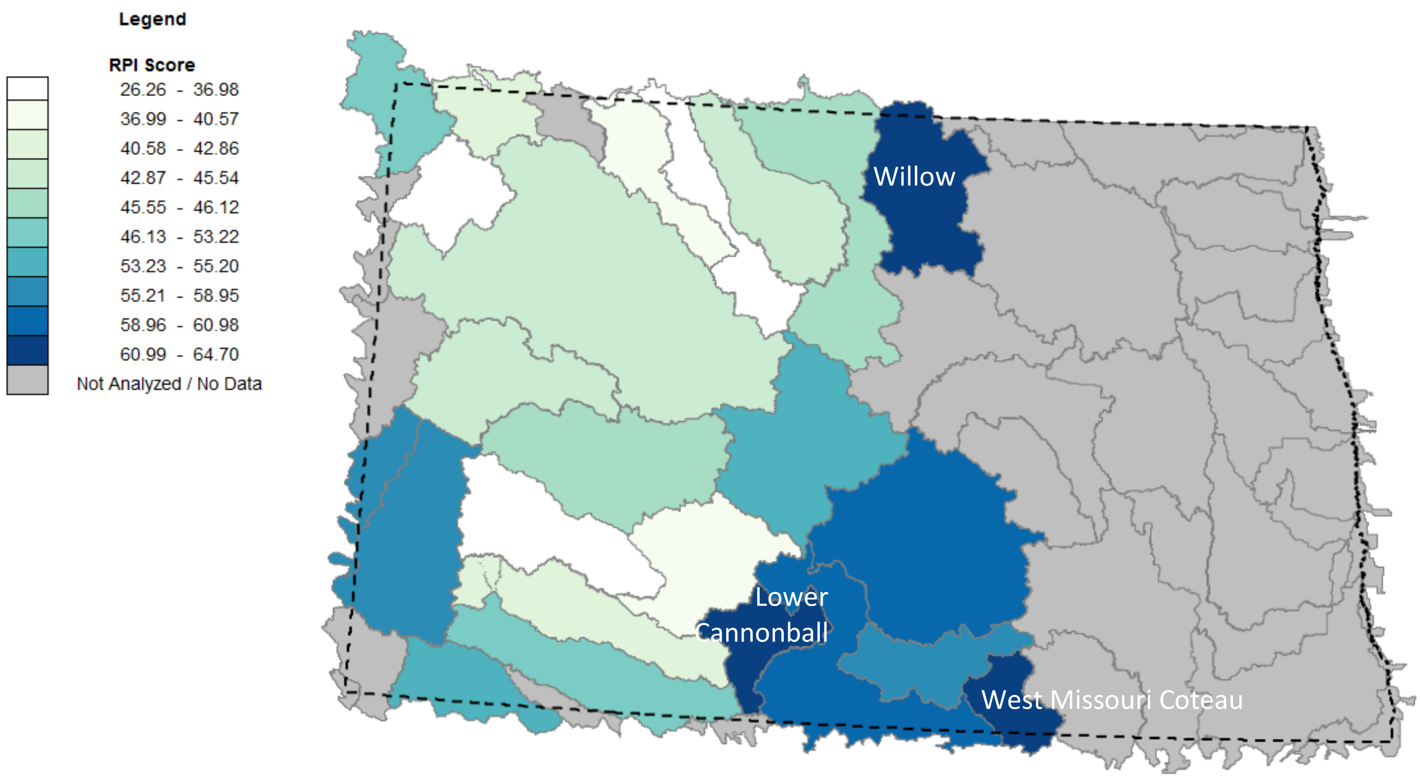

Figure 9. Scenario 1B RPI scores

Table 4 contains Ecological, Stressor, Social, and RPI scores for scenario 1B, in order of descending RPI score and color-coded by quartile per RPI score. This tabular format is another option for presentation of Stage 1 results that can be used to compare and identify HUC8s for scenario 1B nutrient management efforts. Lower Cannonball and Upper Lake Oahe rank high ecologically and have lower levels of stressors, but have lower Social Index scores. These watersheds may benefit from additional education and outreach, specifically related to conservation activities. Middle Little Missouri and Lower Little Missouri rank highest for Ecological Index, but also have very high increases in population. These two HUC8s currently have no nutrient impairments and have fairly low nutrient loads potentially indicating HUC8s that are in need of protection rather than restoration.

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*Table 4. Index and RPI scores for scenario 1B. HUC8s are ordered by RPI score. Cells are shaded (darker is better) according to rank (black = 76 - 100th percentile; dark gray = 51-75th percentile; light gray = 26-50th percentile; white = 0-25th percentile). **BOLD** indicates HUC8s that have higher existing nutrient loads and italics represent HUC8s that have higher Ecological Index scores and high levels of emerging threats (based on population growth).*

Watershed ID	Watershed Name	Ecological Rank	Stressor Rank	Social Rank	RPI Rank
10130206	**Lower Cannonball**	4	1	10	1
09010004	**Willow**	5	8	4	2
10130106	**West Missouri Coteau**	10	2	5	3
10130102	Upper Lake Oahe	3	5	15	4
10130103	**Apple**	6	7	8	5
10130104	**Beaver**	13	6	2	6
10110203	***Middle Little Missouri***	2	16	13	7
10110204	Beaver	7	10	11	8
10130301	North Fork Grand	19	3	6	9
10130101	**Painted Woods-Square Butte**	12	9	7	10
10130205	Cedar	20	11	1	11
10060007	Brush Lake Closed Basin	22	4	14	12
09010003	**Lower Souris**	8	23	9	13
10130201	Knife	11	13	18	14
10110205	*Lower Little Missouri*	1	24	24	15
09010005	**Deep**	18	17	12	16
10110101	Lake Sakakawea	9	20	16	17
10130204	**Upper Cannonball**	23	15	3	18
09010006	**Long Creek**	16	14	19	19
10130203	**Lower Heart**	14	12	23	20
09010002	**Des Lacs**	17	21	17	21
09010008	**Moose Mountain Creek-Souris River**	15	19	20	22
10130202	**Upper Heart**	21	22	21	23
10110102	Little Muddy	24	18	22	24

The bubble plot for scenario 1B (Figure 10) reflects the relative value differences among HUC8s in Ecological, Stressor and Social Index scores by each bubble's size and position on the graph, also showing how these compare to scenario-wide medians (the horizontal and vertical median lines). For this scenario, HUC8s are widely distributed in each of the bubble plot quadrants. This figure highlights those HUC8s that may be of higher interest for nutrient management, either by combination of a high RPI score and higher nutrient loads (in green), or a combination of high ecological score and high emerging stressors related to projected population growth (in orange).

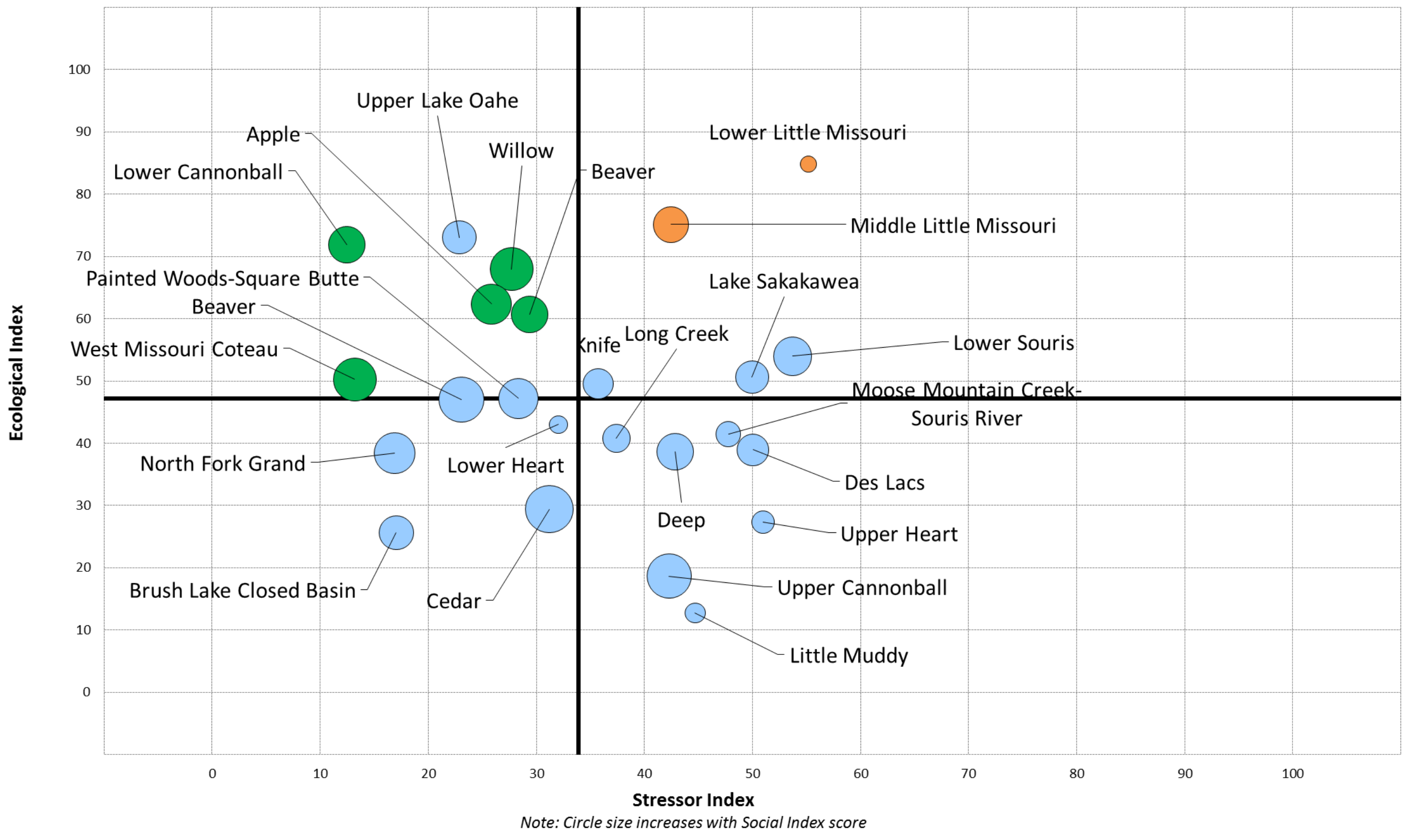

Figure 10. Bubble plot for all 1B HUC8s based on RPI score derived from scenario 1B indicators. Green bubbles represent high overall scoring HUC8s with higher existing nutrient loads. Orange bubbles represent HUC8s that have higher Ecological Index scores and emerging threats (based on population growth). Axes are set to median Ecological Index and Stressor Index scores.

Maps of Ecological and Stressor Index scores for scenario 1B are displayed in Figure 11 and Figure 12. There is no apparent geographic pattern to the Ecological Index, but the highest (worst) Stressor Index scores cluster close to the western state boundary. It is unusual to see that two of the highest-scoring HUCs ecologically (darkest blue in Figure 11) are also among the most stressed (white in Figure 12) based on the indicator choices used (Middle and Lower Little Missouri); most often, highly stressed HUCs also display low ecological scores. Both of these watersheds have high population increases, and Middle Little Missouri has an existing wastewater discharger, contributing to the higher stressor scores. This might imply that these high-ranking areas may have good ecological structure but be under emerging threats from relatively new stressors captured in the choice of stressor indicators.

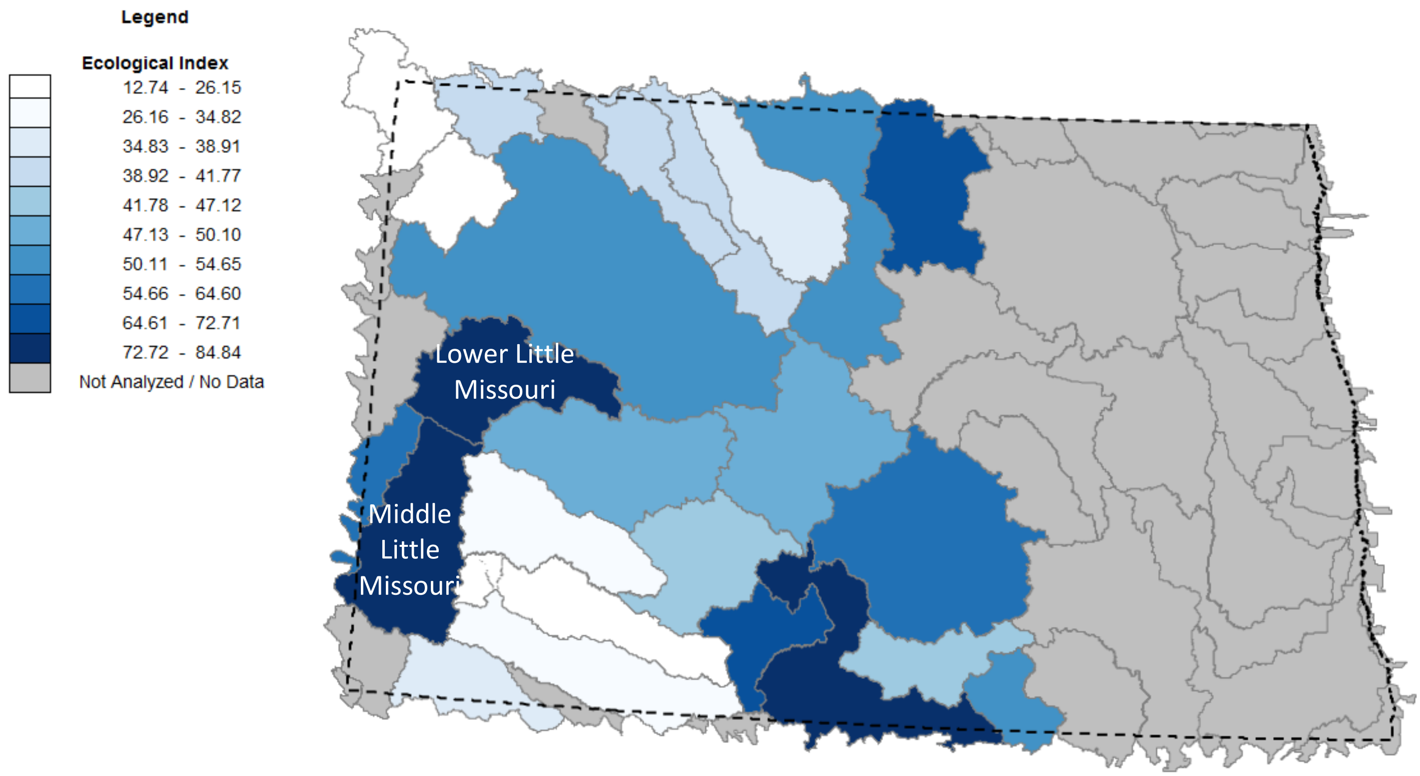

Figure 11. Scenario 1B Ecological Index (darker blue implies better for restoration)

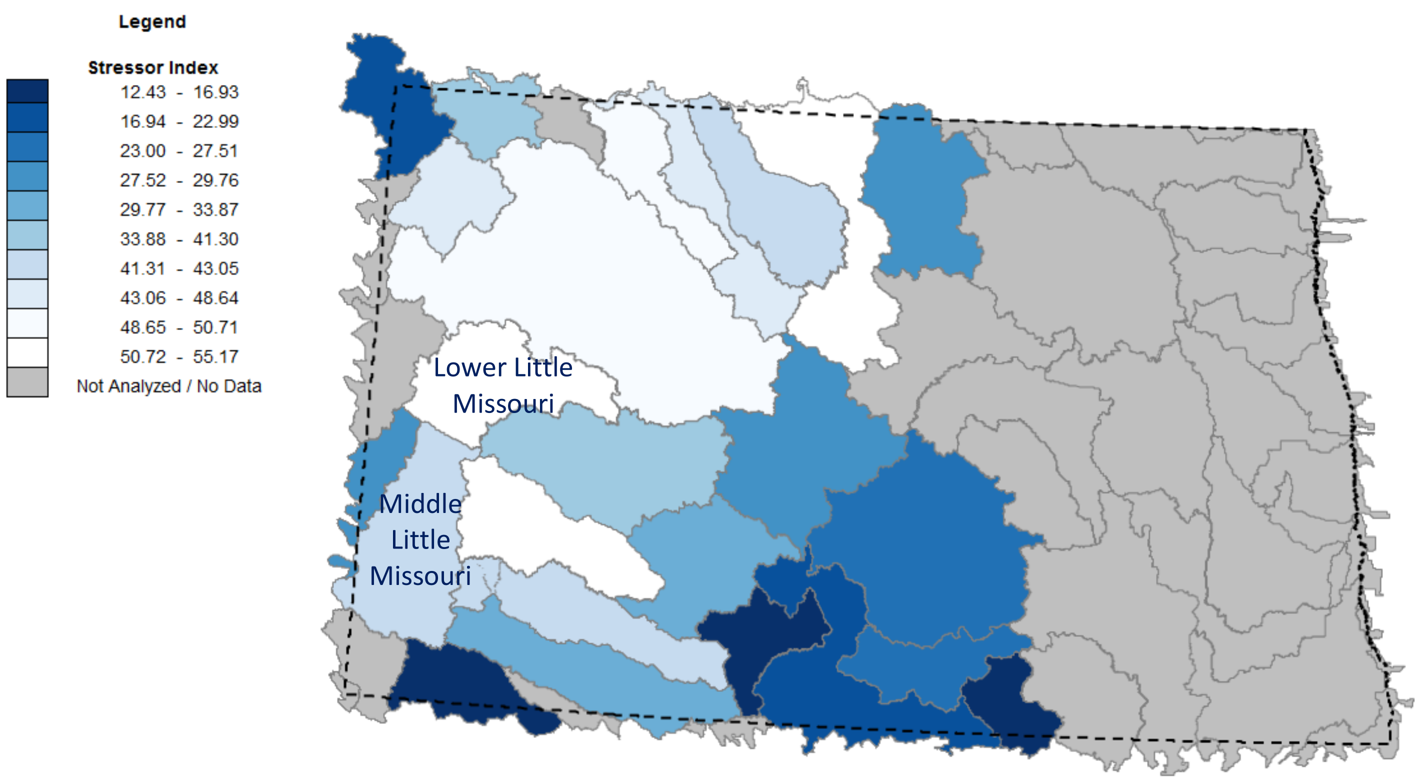

Figure 12. Scenario 1B Stressor Index (darker blue implies better for restoration)

A particular indicator of high interest can also be used to evaluate HUC8s, in this case percent population increase could be used to determine those HUC8s with higher levels of emerging threat (Figure 13). Population increases in the western part of North Dakota are attributed in part to oil and gas development, but are associated with expected increases in nutrient loading. Increased population may result in stress on aquatic and natural resources in the form of wastewater discharges and land development. HUC8s with higher levels of population increase may be good candidates for nutrient management strategies emphasizing pollution prevention rather than restoration in this scenario, especially where their ecological index scores imply existing structure and function may still be relatively intact. In Figure 13, some of the same high-scoring HUCs for ecological index also show top levels of population growth.

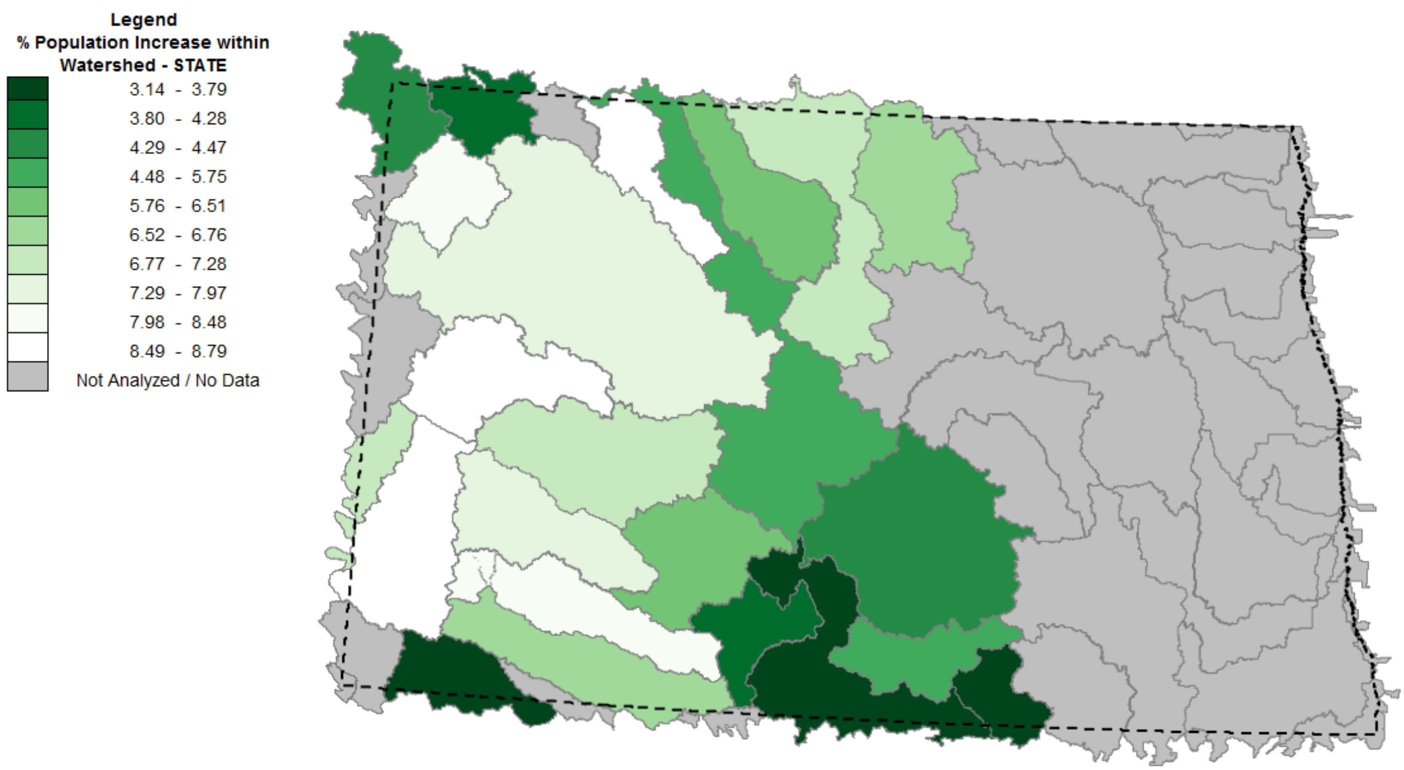

Figure 13. Population increase within HUC8s

STAGE 2 RESULTS

Typically, several Stage 1 HUC8s in each scenario are selected by the state as an initial 'focus group' in which to demonstrate the RPS assessment approach at the smaller HUC12 scale. Identifying a demonstration group may target early adopters or high-interest watersheds, but is not meant to assign priority or preclude a state's assessment of their remaining watersheds over time. Selections can be based on a Stage 1 screening, expert opinion, or a combination of both. The Stage 1 approach allows inclusion of specific watersheds that did not fully meet scenario criteria if a compelling reason existed for their inclusion (e.g., significant progress in planning or addressing nutrient issues typical of the scenario). Ideally, Stage 1 indicators, criteria and expert judgment combine to identify watersheds that not only have loading issues, but also show traits relevant to better restorability. For North Dakota, a Stage 2 demonstration is provided for a HUC8 in each of the two scenarios, including Park River - 09020310 (scenario 1A) and the Lake Sakakawea - 10110101(scenario 1B).

Stage 2 screening is performed on HUC8s individually and compares the HUC12s within a single HUC8 to each other. The more extensive array of indicators available at HUC12 scale enables more specific targeting of indicators relevant to implementing nutrient management activities. Stage 2 screenings were completed on two demonstration HUC8s: Park

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Lake and Sakakawea. These constitute one demonstration HUC8 for each Stage 1 scenario. Screenings are included in this document to serve as an example of Stage 2 methods and results. As with the Stage 1 screenings, a separate copy of the RPS tool for each of the demonstration HUC8s has been archived for delivery to NDDoH with other products (see Attachment 4).

Park (09020301)

The Park River HUC8 is tributary to the Red River and Lake Winnipeg in eastern North Dakota. Typical of the Eastern 1A scenario from stage 1, the HUC8 is primarily comprised of agricultural land uses (e.g., sugar beets, small grains, potatoes, corn). It is located along the escarpment that borders historical glacial Lake Agassiz and extends onto the flatter, fine-grained lake bed which ultimately discharges to the Red River. The lower portion of the HUC8 is typically artificially drained by ditches or drain tile. The upper part of the HUC8 has coarser soils and some remaining wetland areas.

Nutrient reduction is a priority in this HUC8 as well as providing flood mitigation as part of larger efforts in the Red River Basin. Key questions to be addressed by the Stage 2 analysis include:

1) Which HUC12s have the greatest potential for multiple benefits including both flood mitigation and nutrient reduction? These HUC12s will have characteristics that increase the likelihood of nutrient loading and larger areas of potentially restorable wetlands. They may also have existing nutrient TMDLs, high nutrient yields, and high scoring social indices.
2) Which HUC12s are under-assessed with the greatest potential for nutrient issues and which HUC12s should be priorities for assessment and potentially TMDL development (based on watershed characteristics)?

The Park HUC8 includes 25 HUC12s. Different indicators were used to address each of the Stage 2 questions; these are presented below and defined in Attachment 3.

Which HUC12s have the greatest potential to provide multiple benefits including both flood mitigation and nutrient reduction?

Indicators selected to represent potential for providing multiple benefits in the Park HUC8 are provided in Table 5. Flood mitigation opportunities are represented by *% wetlands in the riparian zone* and the *% restorable wetlands* in the watershed. In the Red River basin, these low lying areas that have been traditionally drained could be used for flood water storage. As additional information becomes available in the Basin on potential flood storage areas, new indicators can be added to the analysis. From a water quality perspective, phosphorous loading is particularly important for downstream receiving waters (Red River and Lake Winnipeg) as well as for the Park River. Identifying areas where phosphorus loads are highest and land covers are primarily cultivated crops (as an additional indicator of high nutrient loads) can help focus implementation activities where the most nutrient reductions can be made.

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*Table 5.Park HUC8, Stage 2 indicators to address questions regarding multiple benefits. See Attachment 3 for indicator definitions. Those indicators with a * are derived from state-specific datasets.*

Park (09020301) - Multiple Benefits		
Ecological Indicators	**Stressor Indicators**	**Social Indicators**
% natural cover (2011) in watershed*	% cultivated crops (2011) in watershed*	Count of segments with TMDLs in watershed
% natural cover (2011) in riparian zone*	% grassland to row crop transition in watershed*	% drinking water source protection area in watershed*
National Fish Habitat Partnership Habitat Condition Index*	Count of drains/area in watershed*	% CRP activities in watershed*
% wetlands (2011 and NWI) in riparian zone*	Average TN load (kg/yr) SPARROW (2002) to watershed*	% potentially restorable wetlands
	Average TP load (kg/yr) SPARROW (2002) to watershed*	% conservation activity in watershed*
	% urban (2006) in watershed	

Table 6 summarizes selected indicators that can be used to identify HUC12s that have a higher proportion of agricultural lands, high phosphorus yields, and higher levels of restorable wetlands. HUC12s that rank high for all three indicators could be selected as better candidates to provide multiple benefits (both water quality and water quantify) from flood mitigation projects (e.g., City of Grafton-Park River HUC12). In addition, the table includes the Social Index scores that could be further used to select candidate HUC12s, the higher Social Index scores can represent those areas that are already doing important conservation work and therefore may be ready for additional implementation. For example, those HUC12s that have high (upper quartile) *% cultivated crops* and high (upper quartile) *% restorable wetlands* such as the Willow Creek HUC12s, Salt Lake, Saint John's Church, and Lower North Branch Park River could be good candidates for flood mitigation projects. Of these, HUC12s with lower ranked social scores (e.g., Middle and Lower Willow Creek) could be good candidate for additional outreach and education.

Table 6. Park HUC8, select indicators color-coded in quartiles according to normalized indicator or index scores (dark blue = 76 -100th percentile; medium blue = 51-75th percentile; light blue = 26-50th percentile; white = 0-25th percentile).

HUC12 ID	HUC12 Name	% in Cultivated Crops (2011) in Watershed - STATE	Average TP Load (kg/yr) SPARROW (2002) to Watershed - STATE	% Potentially Restorable Wetlands - STATE	Social Index Score
090203100101	Upper North Branch Park River	83.80	21.60	65.00	15.98
090203100102	Middle North Branch Park River	61.59	21.24	55.00	19.34
090203100103	Upper Cart Creek	58.51	20.79	46.00	31.48
090203100104	Middle Cart Creek	58.08	20.35	60.00	29
090203100105	Lower Cart Creek	84.69	20.36	82.00	24.6
090203100106	Saint John's Church	93.90	21.57	92.00	29.8
090203100107	Lower North Branch Park River	88.82	33.59	85.00	30.24
090203100201	Headwaters Middle Branch Park River	58.93	34.90	41.00	20.92
090203100202	Upper Middle Branch Park River	56.59	32.93	46.00	19.38
090203100203	Middle Middle Branch Park River	63.94	28.23	68.00	27.14
090203100204	Lower Middle Branch Park River	75.87	34.25	72.00	30.8
090203100301	Headwaters South Branch Park River	87.14	35.33	56.00	21.2
090203100302	Upper South Branch Park River	66.60	35.85	44.00	21.9
090203100303	Middle South Branch Park River	45.85	36.58	44.00	27.74
090203100304	Fairdale Slough	39.77	42.65	33.00	33.38

HUC12 ID	HUC12 Name	% in Cultivated Crops (2011) in Watershed - STATE	Average TP Load (kg/yr) SPARROW (2002) to Watershed - STATE	% Potentially Restorable Wetlands - STATE	Social Index Score
090203100305	Lower South Branch Park River	55.32	42.78	32.00	65.18
090203100306	090203100306	72.24	36.36	61.00	33.16
090203100307	Outlet South Branch Park River	72.20	42.53	57.00	29.96
090203100401	Upper Willow Creek	77.71	22.94	76.00	38.66
090203100402	Middle Willow Creek	91.86	22.59	91.00	20.36
090203100403	Lower Willow Creek	93.82	27.89	93.00	23
090203100404	Salt Lake	88.63	25.94	92.00	25.16
090203100501	City of Grafton-Park River	86.79	44.01	85.00	32.18
090203100502	Horseshoe Coulee-Park River	90.34	46.74	84.00	17.16
090203100503	Dipple Drain-Park River	87.32	96.15	90.00	19.88

<u>Which HUC12s are under-assessed with the greatest potential for nutrient issues and which HUC12s should be priorities for assessment and potentially TMDL development (based on watershed characteristics)?</u>

Indicators used to address this question are provided in Table 7. These indicators are identical to Table 5 with the exception of the social indicators. Social indicators now include the extent of assessment and monitoring activities. In the Park HUC8, there are no streams that have been assessed for nutrients, however lakes and reservoirs have been assessed in many areas (Figure 14). The following HUC12 information is also extracted from the Tool dataset:

- Three out of 25 HUC12s have monitoring sites (Lower South Branch Park River, Outlet South Branch Park River, and City of Grafton-Park River)
- Two HUC12s include impaired waters (Dipple Drain-Park River and Lower South Branch Park River)
- A TMDL has been completed in Lower South Branch Park River.

*Table 7. Park HUC8, Stage 2 indicators to address questions regarding assessment and TMDL development. See Attachment 3 for indicator definitions. Those indicators with a * are derived from state-specific datasets.*

Park (09020301) - Assessment		
Ecological Indicators	**Stressor Indicators**	**Social Indicators**
% natural cover (2011) in watershed*	% cultivated crops (2011) in watershed*	Count of segments with TMDLs in watershed
% natural cover (2011) in riparian zone*	% grassland to row crop transition in watershed*	# of monitoring sites*
National Fish Habitat Partnership Habitat Condition Index*	Count of drains/area in watershed*	% watershed streamlength assessed
% wetlands (2011 and NWI) in riparian zone*	Average TN load (kg/yr) SPARROW (2002) to watershed*	% watershed waterbody area assessed
	Average TP load (kg/yr) SPARROW (2002) to watershed*	
	% urban (2006) in watershed	

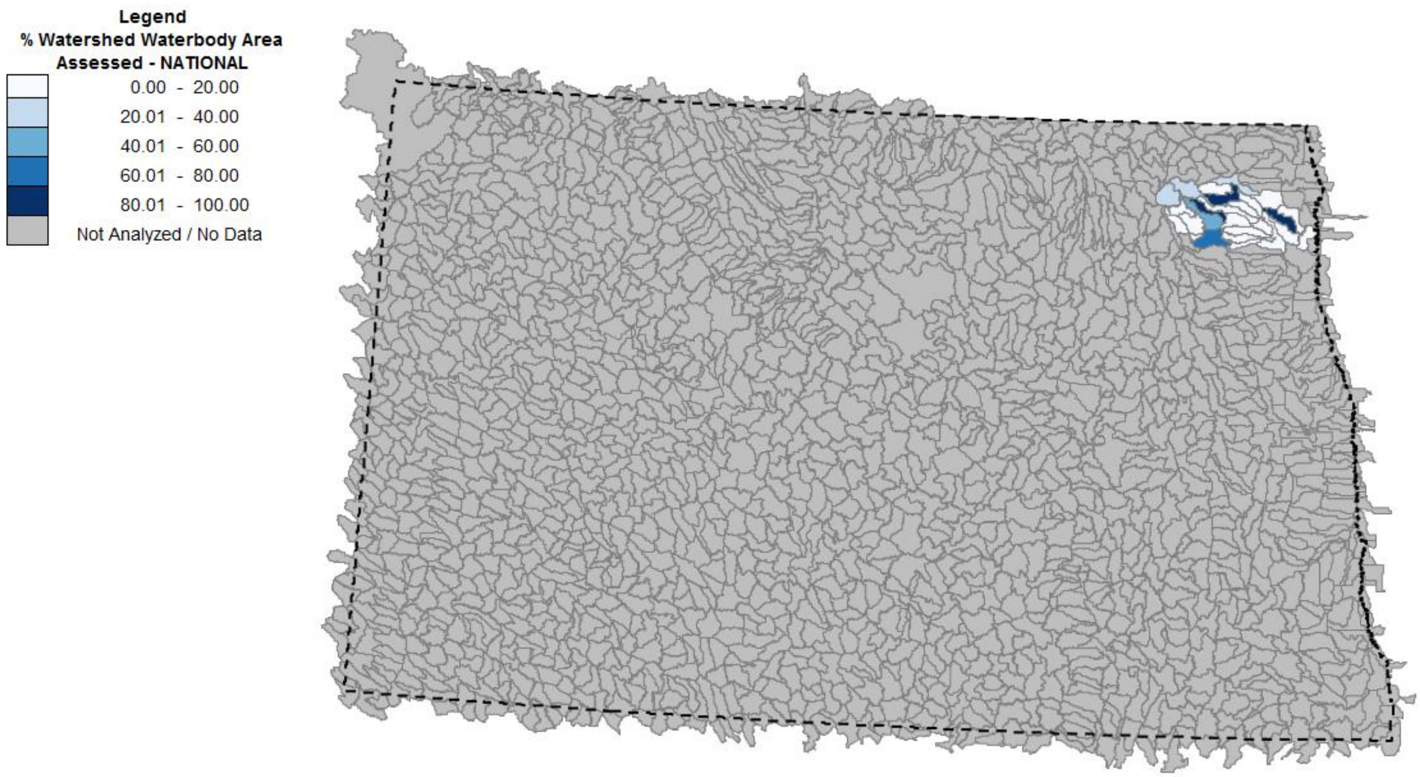


Figure 14. Percent of lake/reservoir area that has been assessed, Park HUC8.

Figure 15 presents the bubble plot for all Park HUC12s color-coded by *% waterbody area assessed*. Those HUC12s that are dark green have been assessed fairly well (e.g., Salt Lake, Lower South Branch Park River, Upper Middle Branch Park, and Middle Cart Creek). HUC12s on the right half of the bubble plot have higher than average stressor scores that could be good candidates to focus monitoring and assessment activities. Outlet South Branch Park River and City of Grafton-Park River have monitoring sites established indicating that two of these HUC12s are already being evaluated; Horseshoe Coulee-Park River and Dipple Drain-Park River could be important candidates for monitoring and assessment if the intention is to identify nutrient impaired waters. Each of these four HUC12s also have high nutrient loads, density of tiles, and % cultivated cropland.

Individual stressor indicators can also potentially be used to represent overall nutrient loading such as the three examples in Figure 16: *average TP load, % grassland to row crop conversion*, and *% cultivated crops.* HUC12s that have similar indicator scores may have similar impairments. Dipple Drain-Park River stands out as a highly stressed system as compared to the other HUC12s in the Park River HUC8, however efforts may be better focused on those HUC12s in the upper right quadrant that have higher than average stressor scores but still retain higher levels of ecological structure such as 90203100306 and Middle Middle Branch Park River.

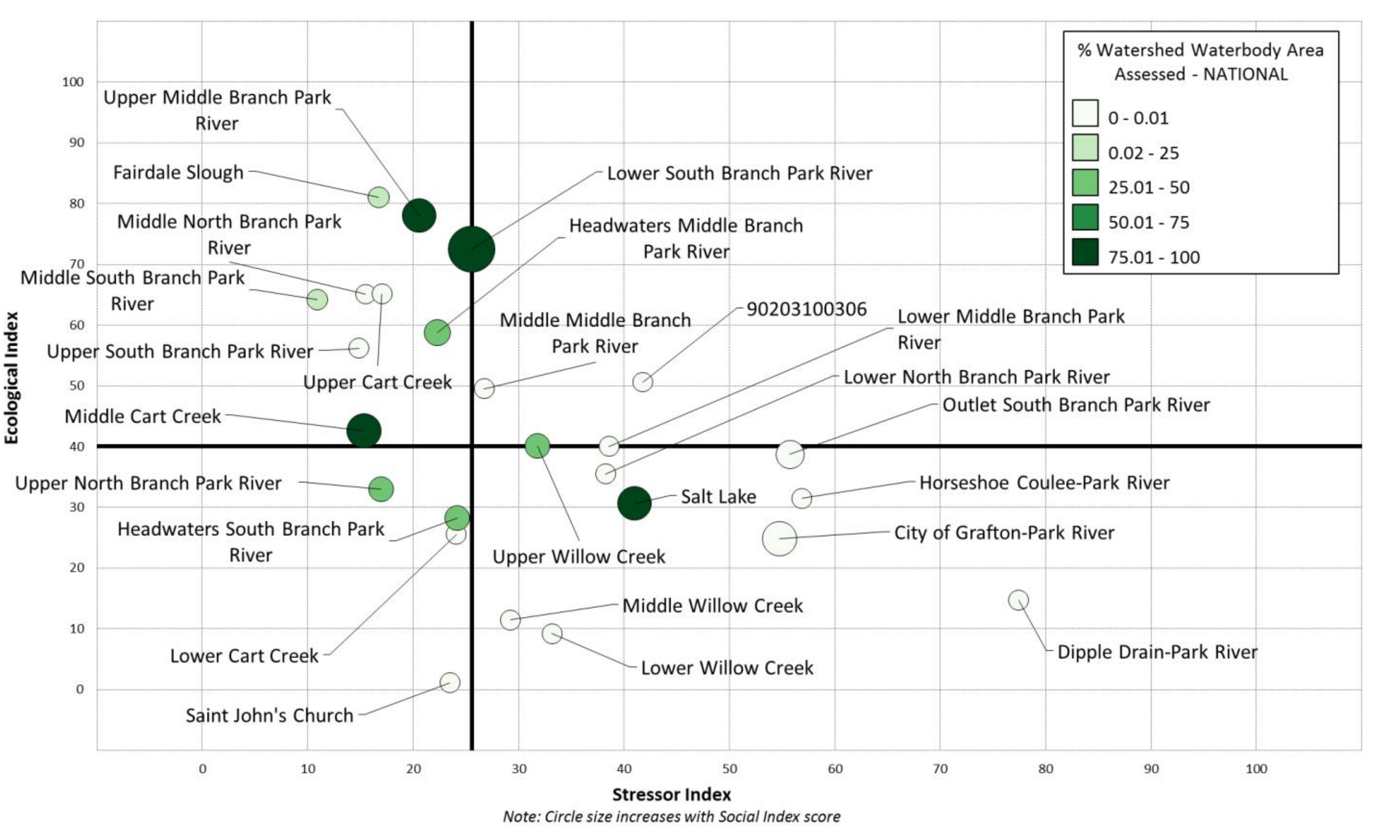
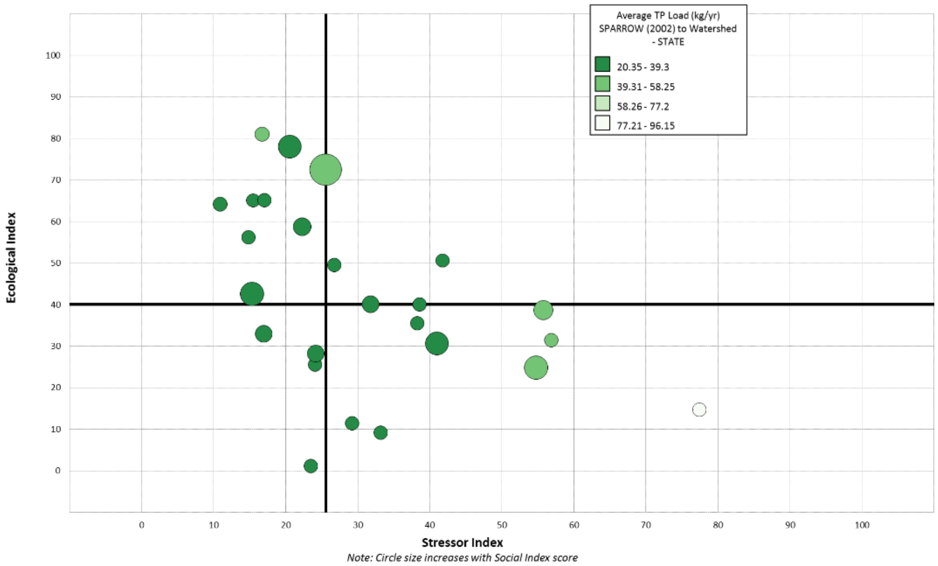
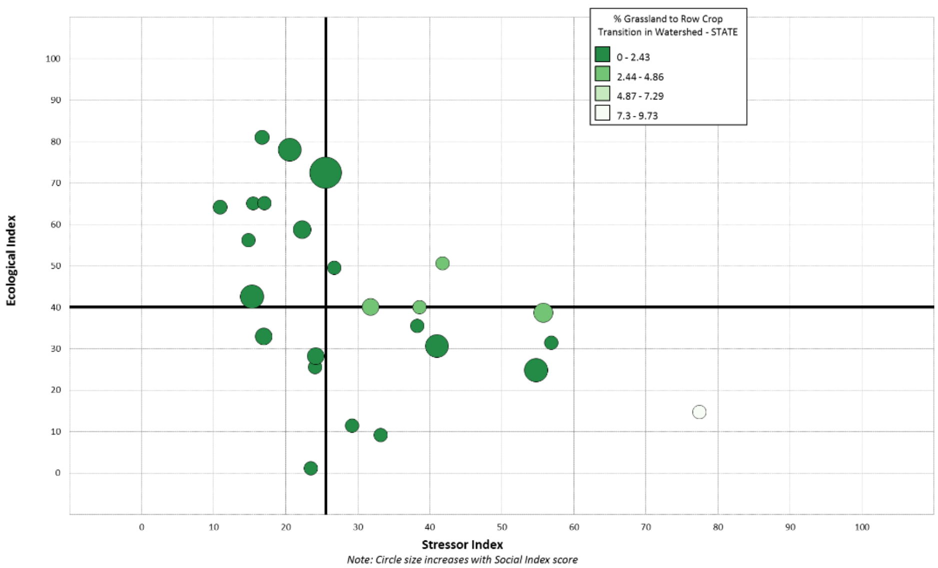


Figure 15. Park HUC8, color-coded bubble plot based on % of waterbodies assessed.





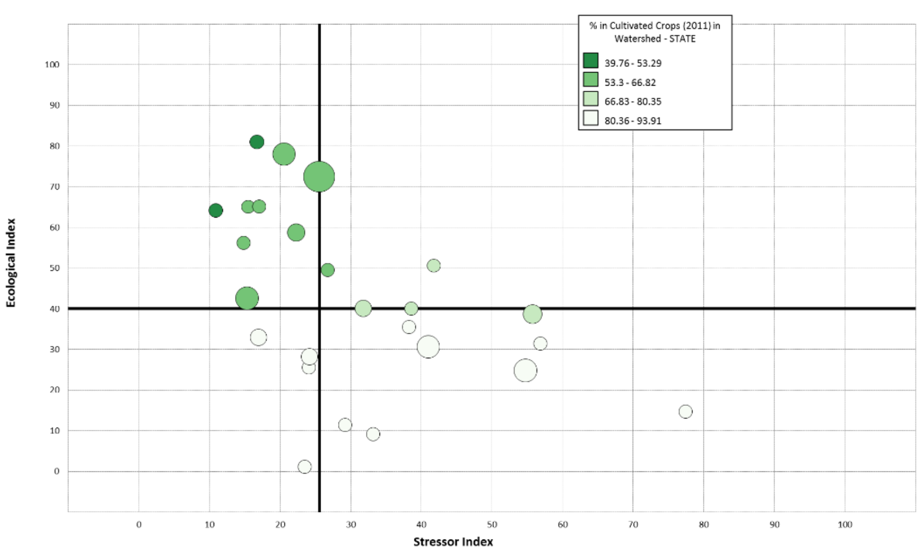


Figure 16. Single stressor indicators highlighted in three bubble plots, Park HUC8. Lightest colors are highest stressor values.

Lake Sakakawea (10110101)

Lake Sakakawea is a large reservoir located along the Missouri River in the western part of North Dakota. The lake's watershed is primarily characterized by grasslands and livestock grazing. Oil and gas production is potentially a significant stressor. This reservoir has been identified as a high priority in the state's nutrient reduction strategy. In addition, there is interest in identifying important areas for protection in this HUC8 based on vulnerability. The Lake Sakakawea HUC8 includes 181 HUC12s. Indicators used in this screening analysis are presented in Table 8 (see definitions in Attachment 3).

*Table 8. Lake Sakakawea HUC8, Stage 2 indicators. See Attachment 3 for indicator definitions. Those indicators with a * are derived from state-specific datasets.*

Lake Sakakawea (10110101)		
Ecological Indicators	**Stressor Indicators**	**Social Indicators**
% natural cover (2011) in watershed*	% in cultivated crops (2011) in watershed*	% drinking water source protection area*
% natural cover (2011) in riparian zone*	% urban change 2001-2006 in watershed	% tribal lands in HUC12
National Fish Habitat Partnership Habitat Condition Index*	Watershed mean soil erodibility	% conservation activity in watershed*
% wetlands (2011 and NWI) in riparian zone*	Count of oil and gas wells/area in watershed*	% CRP activities in watershed*
	Count of active CAFO/AFO permits/area in watershed*	Watershed segments with TMDLs count
	Count of permitted animals in watershed/area*	% restorable wetlands
	Average TP load (kg/yr) SPARROW (2002) to watershed*	
	Average TN load (kg/yr) SPARROW (2002) to watershed*	

Figure 17 presents the Lake Sakakawea results color-sorted by RPI score. As seen on the map, HUC12s with higher RPI scores are generally in the headwater areas. These HUC12s have higher Ecological Index scores and are found in the upper left quadrant of the bubble plot. Boggy Creek (-12101), Skunk Creek (-2101), and Saddle Butte Bay (-2903) have the highest overall RPI scores based on the selected indicators.

Specific questions to be addressed by this Stage 2 analysis include:

1) Which HUC12s contribute the largest nutrient loads to the reservoir? These will be HUC12s with characteristics that imply high nutrient loading such as erodible soils, land use, point sources, slope, etc.
2) Which HUC12s have the highest level of vulnerability from a nutrient standpoint? These HUC12s will have good ecological indices and higher levels of stressors.

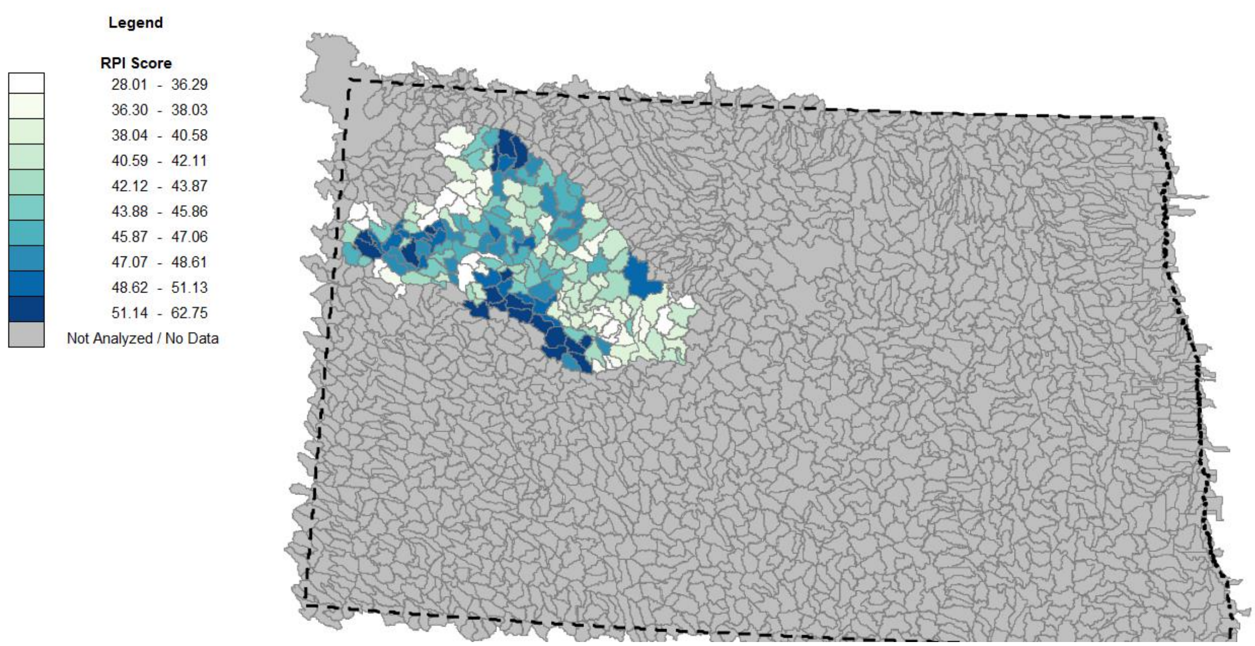


Figure 17. Lake Sakakawea RPI scores.

<u>Which HUC12s contribute the largest nutrient loads to the reservoir?</u>

Figure 18 shows bubble plots for both total phosphorus and total nitrogen loads for all HUC12s. Table 9 summarizes those HUC12s that have the highest yields (upper quartile) for both total nitrogen and total phosphorus yield. These HUC12s have the highest nutrient loading, according to the SPARROW-derived indicators. This is an example of how to use specific indicators to answer a question. Data for every indicators is provided in the Tool and can be summarized, plotted, and mapped separately.

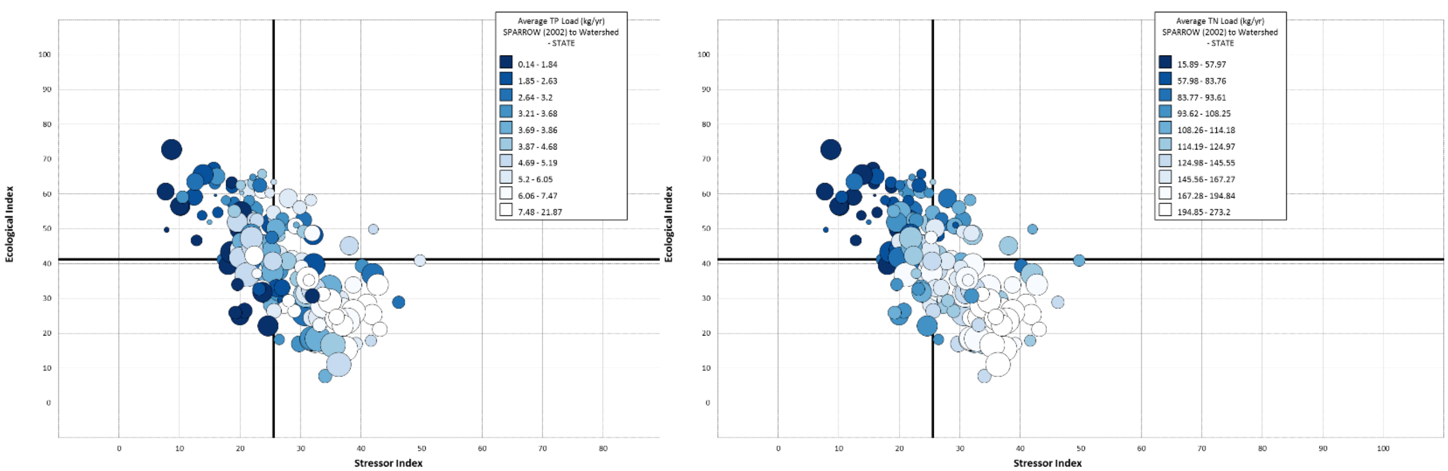


Figure 18. Nutrient loading bubble plot, total phosphorus on the left, total nitrogen on the right. Data derived from SPARROW model outputs. The highest estimated loads are the white bubbles

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Table 9. HUC12s in the upper quartile for both nitrogen and phosphorus yield.

Watershed ID	Watershed Name	Average TN Load (kg/yr) SPARROW (2002) to Watershed - STATE	Average TP Load (kg/yr) SPARROW (2002) to Watershed - STATE
101101012802	Round Top Hill	240.98	5.93
101101012808	Middle Deepwater Creek	256.22	6.21
101101012401	Spring Valley Church	243.71	6.34
101101012702	Lower Crane Creek	153.95	6.45
101101011403	Beauty Valley	180.08	6.46
101101012701	Upper Crane Creek	153.98	6.48
101101011602	White Lake	167.98	6.49
101101012805	Lucky Mound Church	246.18	7.04
101101012804	Bethlehem Church	273.20	7.66
101101012803	Town of Roseglen	258.26	8.12
101101012810	Lower Deepwater Creek	191.16	8.79
101101013203	Blackwater Cemetery	230.68	9.24
101101013202	Blackwater Lake	233.77	9.27
101101013305	East Branch Douglas Creek	202.42	9.29
101101013201	Town of White Shield	231.21	9.32
101101013204	Town of Emmet	231.29	9.68
101101013306	Douglas Creek Bay	194.84	9.99
101101013004	Sixmile Creek	184.47	10.00
101101012809	101101012809	215.55	10.45
101101012801	Upper Deepwater Creek	242.46	11.09
101101011103	The Swamp	237.85	21.09
101101011101	Nelson Lake	243.20	21.86

In addition to evaluating modeled nutrient load indicators, other indicators could also provide additional information on those HUC12s with the potential for high loadings. For example, areas with a high proportion of agricultural lands may have higher nutrient loading (Figure 19 and Table 10).

HUC12s with the highest nutrient loads may be good candidates for focused nutrient reduction activities, but additional analysis can be used to further evaluate HUC12s with regard to restorability. Figure 20 provides three example bubble plots that can inform nutrient loading and restorability, depending on which sources are of interest such as roads, human use, and cultivated cropland. These three stressor indicators help to identify differences amongst the HUC12s, specifically if certain stressors are more important than others in a particular HUC12. Road density and human use were not included in the overall screening analysis, however all of the indicator data are available for summary in data tables, bubble plots or maps, regardless of whether the data were used in a screening analysis.

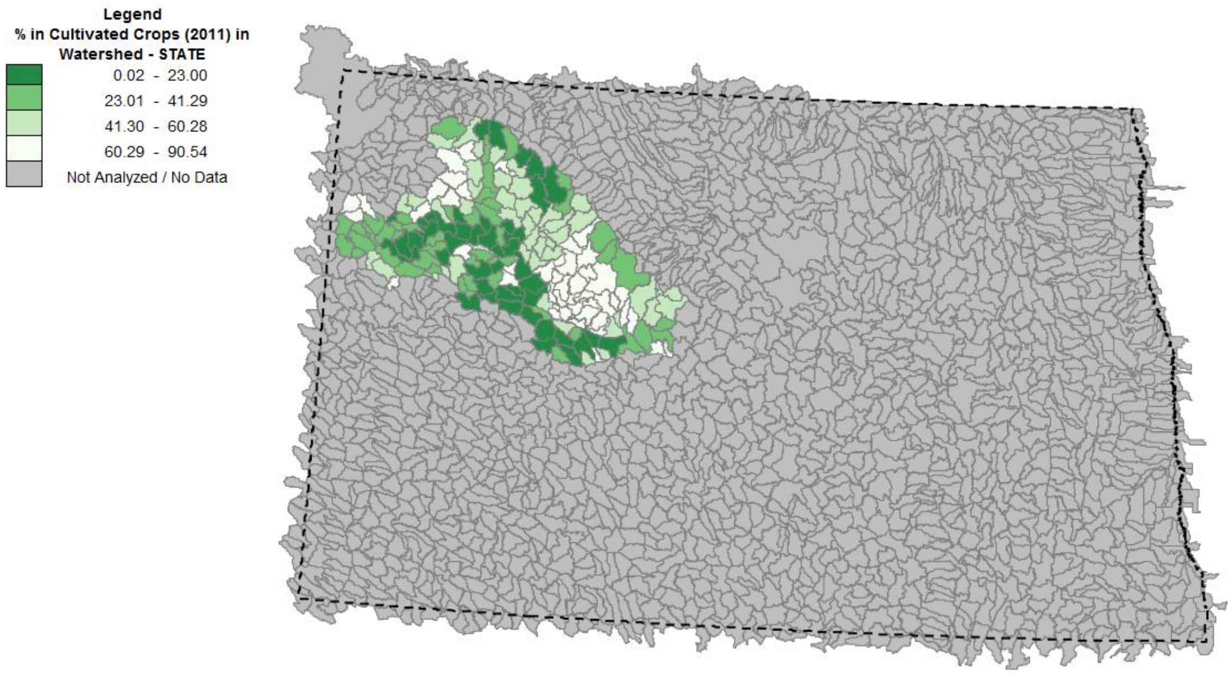


Figure 19. HUc12s color-coded by percent cultivated crops.

Table 10. HUC12s with greater than 75% cultivated crops

Watershed ID	Watershed Name	% in Cultivated Crops (2011) in Watershed
101101012808	Middle Deepwater Creek	76.17
101101010501	Arnegard Dam	76.43
101101012802	Round Top Hill	77.26
101101010202	Middle Painted Woods Creek	77.89
101101012806	Paint Hill	78.96
101101013203	Blackwater Cemetery	79.13
101101012803	Town of Roseglen	79.28
101101013702	Wolf Creek	79.32
101101012401	Spring Valley Church	79.53
101101010201	Upper Painted Woods Creek	80.26
101101010902	Upper Beaver Creek	80.41
101101011001	Upper Sand Creek	81.69
101101012801	Upper Deepwater Creek	82.18
101101013202	Blackwater Lake	82.85
101101012603	101101012603	83.95
101101012805	Lucky Mound Church	84.04
101101012604	101101012604	84.20
101101012807	101101012807	86.10
101101012504	Saint Pauls Church	87.39
101101012804	Bethlehem Church	87.70
101101010401	Upper Stony Creek	90.54

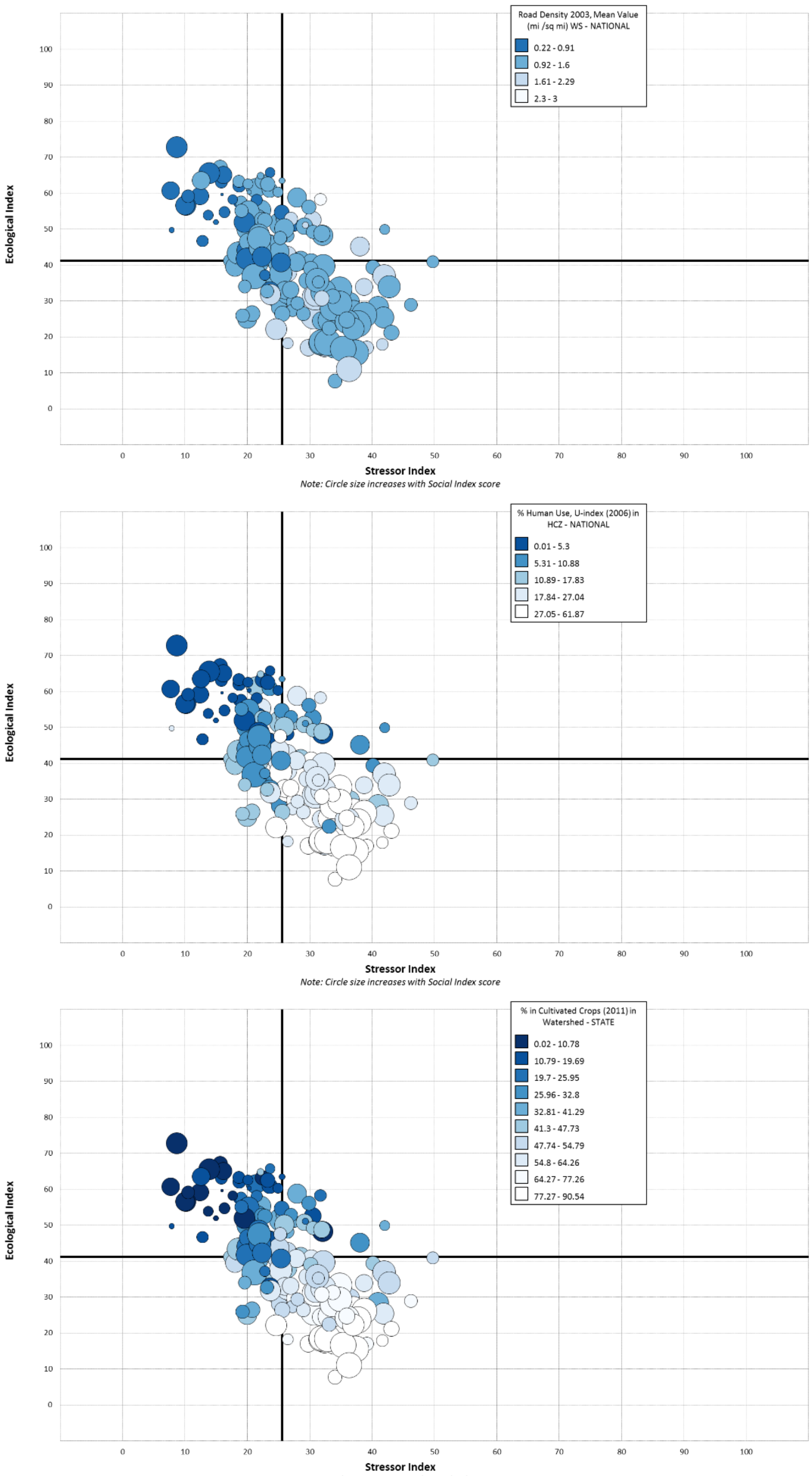


Figure 20. Indicator-specific bubble plots that can use used to further sort HUC12s. Note that indicators not included in the overall screening can also be summarized in the Tool bubble plots by adding a color gradient. The higher scores for these stressor indicators are the lighter colors.

A closer look at the modeled phosphorus loadings in Figure 21 reveals several watersheds that have high phosphorus loads with higher than average Ecological Index scores including Camp Creek, North Fork Clarks Creek, Four Bears Bay, Lower Crane Creek, and Sloulin International Airport HUC12s. Combining this information with the data from stressor-specific bubble plots in Figure 20 provides additional insight on restorability. For example, Camp Creek has the highest overall Stressor Index score and a high proportion of cultivated cropland. Four Bears Bay has a high density of roads and Sloulin International Airport has a fairly high value for human use impacts. Lower Crane Creek has the highest modeled phosphorus load with moderate levels of stressors, indicating that it is likely the cumulative effects of several stressors in this HUC12 leading to the high phosphorus loads. These HUC12s may be better candidates for nutrient reduction activities since they maintain higher levels of ecological structure and therefore may have higher potential for restoration.

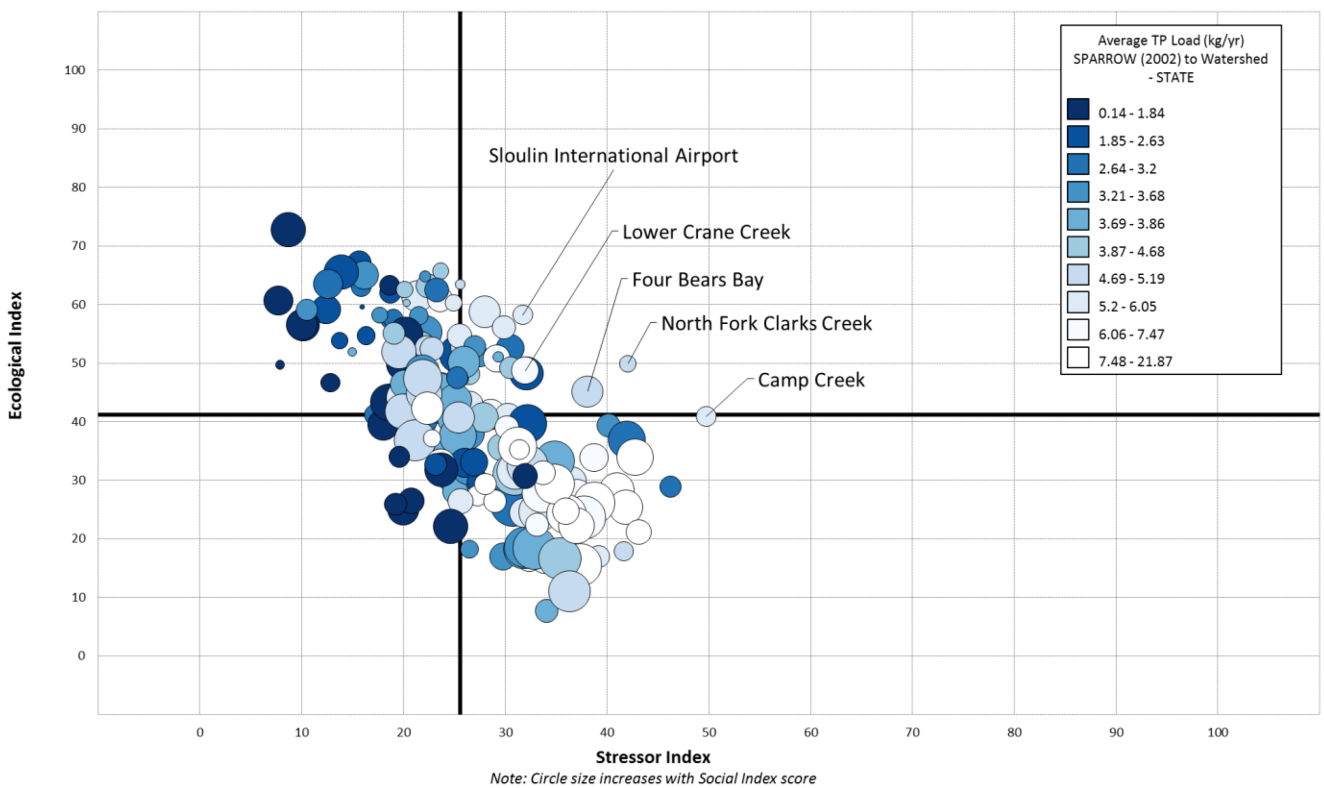


Figure 21. Lake Sakakawea bubble plot color-coded by average TP load.

<u>Which HUC12s have the highest level of vulnerability from a nutrient standpoint?</u>

HUC12s that are vulnerable to nutrient loading and associated impacts but are currently in better than average condition occur in the upper right quadrant of the bubble plot (Figure 22). These HUC12s, including Sloulin international Airport, Lower Dry Fork Creek, Lower Crane Creek, Red Lake, North Fork Clarks Creek, and Four Bears Bay have better than average Ecological Index scores but higher than average Stressor Index scores and therefore may be at higher risk for future degradation and potential new impairments.

Activities that result in human disturbance (e.g., roads, housing) can create further vulnerabilities in a watershed as relate to nutrients. Current threats provided by oil and gas exploration activities (Figure 23) further focuses potential vulnerable HUC12s (Lower Dry Fork Creek, Lower Crane Creek, North Fork Clarks Creek, and Four Bears Bay). Increasing conservation and protection activities in these watersheds could minimize or prevent future degradation.

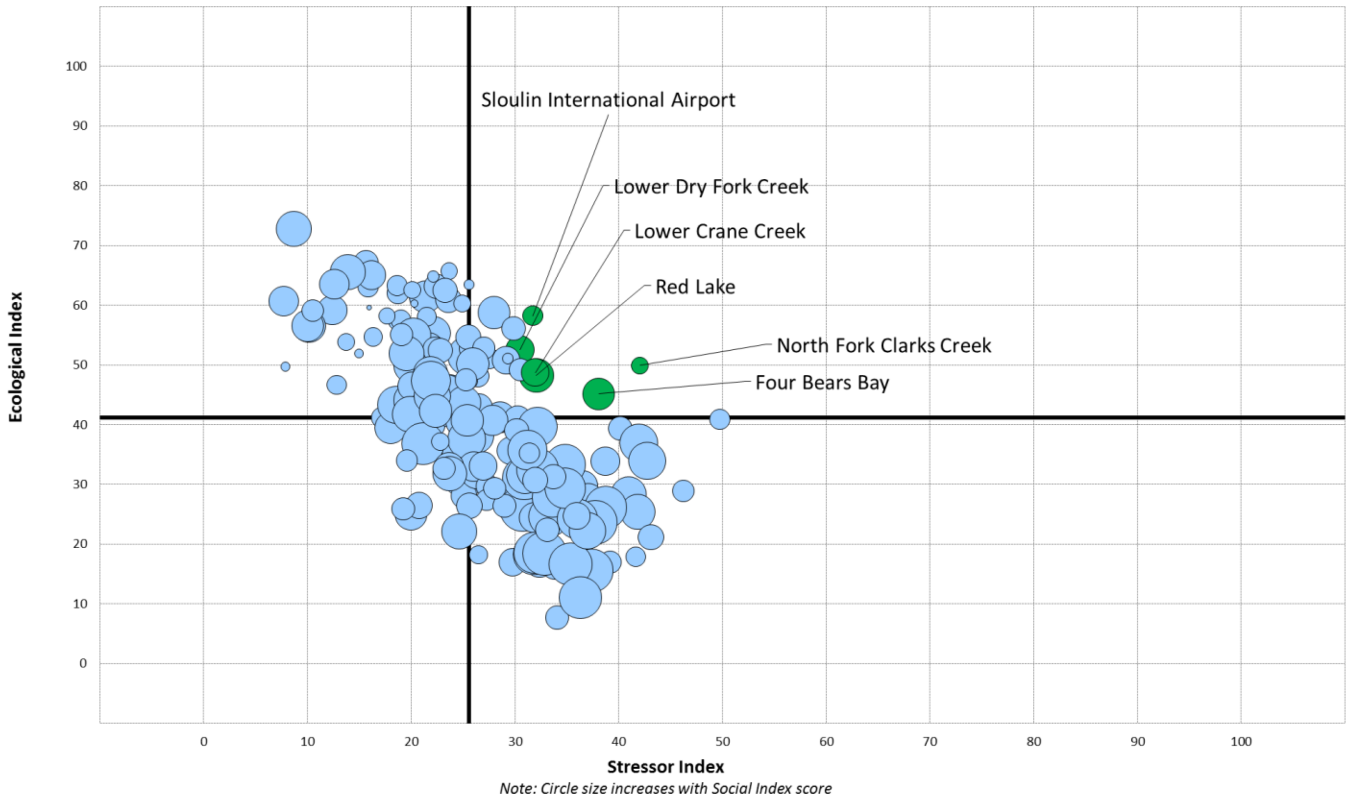


Figure 22. Examples of vulnerable HUC12s in the Lake Sakakawea HUC8.

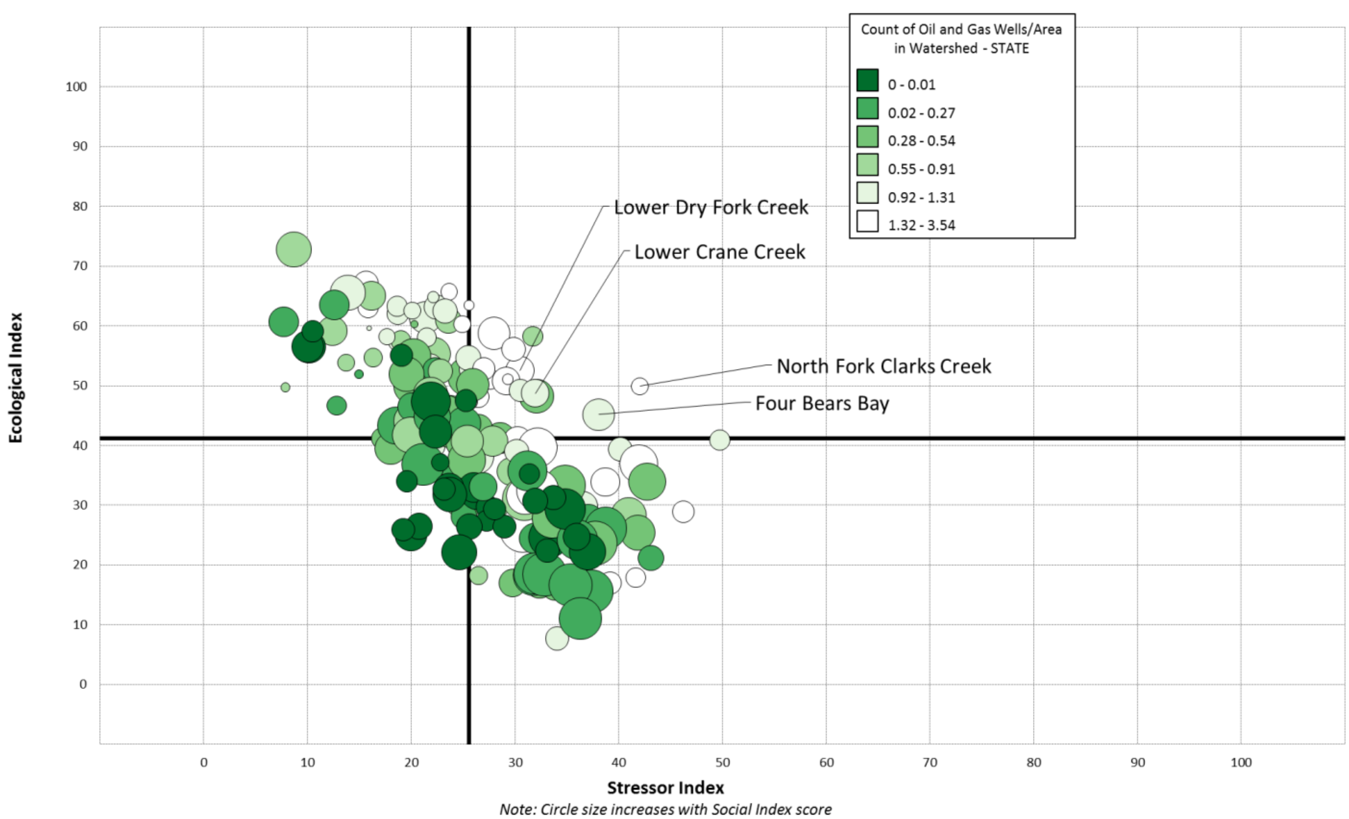


Figure 23. Oil and gas exploration threats, Lake Sakakawea.

SUMMARY AND RECOMMENDATIONS

This document summarizes the usage of Recovery Potential Screening (RPS) to compare watersheds at two scales (HUC8 and HUC12) for purposes of informing possible watershed management options and priorities for nutrient management. Utilizing georeferenced data provided primarily by NDDoH, EPA and additional sources, this project compiled indicators (base, ecological, stressor and social) at one or both watershed scales that were used to screen and compare watersheds in a two-stage process. In the first stage, North Dakota's HUC8s were screened with two separately developed sets of indicators selected to identify and rank watersheds according to geographic location in the state. Based on these first stage screenings and other criteria, two watersheds were selected as demonstration HUC8s for further analysis in the second stage (Lake Sakakawea and Park).

Stage two screenings were performed on each of the demonstration HUC8s that scored and compared each HUC8's component HUC12s using more detailed sets of indicators that drew from HUC12-scale metrics. Whereas the purpose of Stage 1 was to compare and recognize like groups of scenario watersheds at the larger scale, Stage 2's purpose was to examine and reveal potential opportunities for nutrient management action at the more localized HUC12 scale. As a demonstration of the RPS Tool, no priorities among HUC12s were selected in this project but numerous alternatives and analytical techniques were presented. Products include this summary report, a master RPS Tool file, and separate screening files that archived the results from the Stage 1 and Stage 2 screenings. Opportunities for NDDoH and other users from this point forward may include:

Become adept at RPS Tool desktop use. Despite the extensive amount of data it holds and the wide variety of comparisons among watersheds that these data can support, the RPS Tool is actually a fairly simple spreadsheet tool. As novice users of Excel far outnumber GIS specialists, for many more people this tool opens the door to simple but useful forms of spatial data analysis, systematic comparisons among watersheds, and a variety of visualization tools – on their own desktops. A wider circle of users will be able to perform quick 'what-if' screenings to compare watersheds on the spur of the moment and gain insights on what may be worth a greater investment of time and effort with more technical analytical tools.

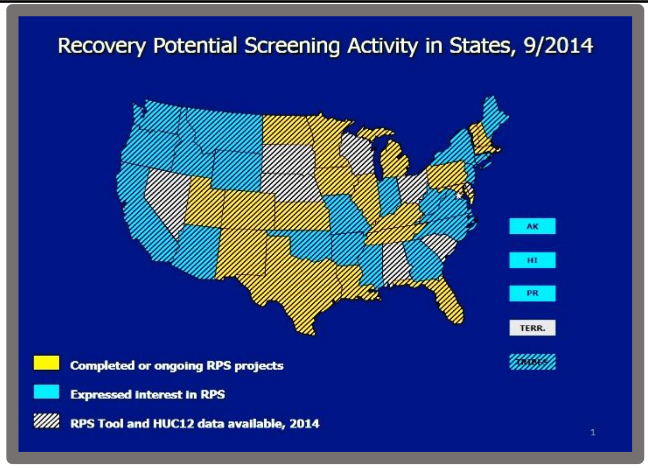
Apply the RPS Tool to other screening topics. Although this effort focused on a nutrients application of RPS, the North Dakota dataset could support numerous other screening themes and purposes that can be explored in the interest of long-term priority setting for restoration and protection. Other screening topics might include sediment, metals, pathogens, or any other prominent cause of impairment. Or in contrast, screenings might focus on a valued resource such as watersheds with coldwater fisheries, or drinking water sources, or major outdoor recreational sites. The RPS Tool might be used to develop a first-cut identification of healthy watersheds for protection, or rank likely eligibility for specific types of pollution control incentives. With both the TMDL Program and the Non-Point Source Control Program promoting watershed priority-setting, the range of opportunities is widespread.

Refine the available data and selection of indicators. Even within this nutrient application of RPS, opportunities always exist to add more relevant data or refine previous screenings as new insights are gained. The RPS Tool is structured to accept additional indicator data from a user that can then be made part of future screenings. New data needn't be statewide, and a local user may still use the tool after adding new data for a limited set of their local subwatersheds. Further, previous analyses can be refined by structured group processes to assign consensus weights to indicators, or by correlation analyses designed to narrow down indicator selections and better differentiate watersheds. For example, varying North Dakota's available HUC8 indicators and re-screening could allow for considering nutrient delivery to the Gulf of Mexico as well as comparing HUC8s based on instate effects only.

Galvanize state/local restoration and protection dialogue and partnering. RPS offers a mechanism for state-local collaboration. Rather than assume that the RPS indicators are a static dataset, or that the HUC8 screenings shouldn't be additionally adjusted or customized, further tailoring to the circumstances and data of each locale is appropriate and encouraged. Some HUC8s may host watershed groups, researchers and other sources of continued analysis and refinement of the available indicators and techniques that can be accommodated by this versatile tool. Further, if local organizations do engage with IDNR and enhance their RPS Tool copies, they may provide valuable dialogue on addressing local as well as statewide interests in watershed priority-setting and improved nutrient management.

Attachment 1

RECOVERY POTENTIAL SCREENING: SUMMARY



- Recovery Potential Screening (RPS) is a systematic, comparative method for identifying differences among watersheds that may influence their relative likelihood to be successfully restored or protected. The EPA Office of Wetlands, Oceans and Watersheds (OWOW) created RPS jointly with the EPA Office of Research and Development (ORD) in 2004 to help states and others use limited restoration resources wisely, with an easy to use tool that is customizable for any geographic area of interest and a variety of specific comparison and prioritization purposes.

- The main programmatic basis for RPS includes the TMDL Program (e.g., prioritized schedule for listed waters; where best to implement TMDLs; Integrated Reporting of Priority waters under the TMDL Vision) and the Nonpoint Source Program (e.g., annual program strategies; prioritization to aid project funding decisions; collaboration with Healthy Watersheds), but several other affiliations also exist.

- Since 2005, several hundred RPS indicators have been incrementally compiled through literature review, identifying states' indicator needs and preferences, and collaboration with others (ORD EnviroAtlas, Region 4 Watershed Index). Most have been applied in a series of statewide RPS projects. In 2009, an RPS paper was published in the refereed journal *Environmental Management*. The one-stop RPS Website hosts a library of indicators, RPS tools, case studies and step by step RPS instructions.

- As of September 2014, RPS projects and statewide databases have been either initiated or completed in 20 states (**see figure**). Approximately that many additional states have expressed interest in RPS usage, but Branch resources have not previously been able to support these requests.

- The RPS Tool is key to RPS' ease of use, widespread applicability and speed. This tool is an Excel spreadsheet that contains all watershed indicators, auto-calculates key indices, and generates rank-ordered tables, bubble plot graphics and maps that can be user-customized. Any novice Excel user can quickly become fluent in using the RPS Tool.

- Statewide RPS Tools and data have now been developed for each of the lower 48 states. These contain 207 indicators measured for every HUC12, and enable customizable desktop screening, rank ordering, graphics plotting and mapping without advanced software or training. Individual, state-specific RPS Tools were distributed to every lower 48 state and all EPA Regions in July 2014 (HI and AK in planning).

- RPS is playing/may soon play a pivotal role in each of the following:
  - Prioritizing watersheds for nutrient management (projects in 9 states)
  - Identifying state priority watersheds for TMDL Vision/Integrated Reporting 2016-2022
  - Improving state/local interactions in states with RPS projects
  - Enabling Tribes to screen and compare their watersheds for purposes similar to states
  - Helping the Healthy Watersheds program by providing a national preliminary assessment
  - Jointly (OW and EPA Region 4) creating the Watershed Index Online (WSIO) interactive tool

- Contact: Doug Norton, WB/AWPD/OWOW at norton.douglas@epa.gov or 202-566-1221.

Attachment 2: North Dakota Stage 1 HUC8 Indicator Descriptions

Green denotes ecological indicators, red are stressor indicators, and blue are social indicators. These indicators are based on data that end at the state-line, therefore watersheds were clipped to the state line and all metrics were calculated based on this area. All North Dakota-specific indicators are denoted with “STATE”.

HUC8 METRIC	DESCRIPTION
% Natural Cover (2011) in Watershed - STATE	The percentage of the HUC within the state considered "Natural Cover" based on the 2011 NLCD. "Natural Cover" is considered the following NLCD codes~classes: 41~Deciduous Forest, 42~Coniferous Forest, 43~Mixed Forest, 52~Shrub/Scrub, 71~Grassland/Herbaceous, 90~Woody Wetlands, and 95~Emergent Herbaceous Wetlands.
% Natural Cover (2011) in RZ - STATE	The percentage of the Riparian Zone (RZ) in the HUC within the state considered "Natural Cover" based on the 2011 NLCD. "Natural Cover" is considered the following NLCD codes~classes: 41~Deciduous Forest, 42~Coniferous Forest, 43~Mixed Forest, 52~Shrub/Scrub, 71~Grassland/Herbaceous, 90~Woody Wetlands, and 95~Emergent Herbaceous Wetlands.
% Wetlands (2011 and NWI) in RZ - STATE	The percentage of the Riparian Zone (RZ) in the HUC within the state considered "Wetlands": NLCD codes~classes 90~Woody Wetlands and 95~Emergent Herbaceous Wetlands in the 2011 NLCD, or a wetland in US Fish and Wildlife Service’s National Wetland Inventory (NWI) state-wide data set.
NFHAP Habitat Condition Index - NATIONAL	Likelihood of suitable fish habitat, based on National Fish Habitat Action Plan Assessment
Watershed Streamlength 303d-Listed Nutrients - ADJUSTED	Length of stream features listed as impaired due to nutrient-related causes and requiring a TMDL under Section 303(d) of the Clean Water Act in HUC12 (kilometers). Calculated from the EPA Office of Water "303(d) Listed Impaired Waters" NHD-indexed dataset. Only includes length of lines meeting criteria for classification as "streams" and with "Nutrients", "Organic Enrichment/Oxygen Depletion", "Algal Growth", or "Noxious Aquatic Plants" listed as a parent cause of impairment. Criteria for stream classification include: (1) feature has NHD REACHCODE with FTYPE equal to StreamRiver, CanalDitch, or Connector; (2) feature has NHD REACHCODE with FTYPE equal to Artificial Path and FTYPE of corresponding NHDArea feature is StreamRiver; or (3) feature is custom-added to the EPA Reach Address Database and is not in the NHD (blank NHD REACHCODE).
% in Corn, Soy, Sugar Beet (2013) in Watershed - STATE	The percentage of the HUC within the state that are designated as Corn, Soybeans, or Sugar beet by the 2013 USDA National Agricultural Statistics Service (NASS), Cropland Data Layer (CDL). The areas are estimated using the following CDL codes~classes: 1~Corn, 5~Soybeans, 12~Sweet Corn, 26~Dbl Crop WinWht/Soybeans, 41~Sugar Beets, 225~Dbl Crop WinWht/Corn, and 241~Dbl Crop Corn/Soybeans.
% in Pasture/Hay (2011) in Watershed - STATE	The percentage of the HUC within the state classified as 'Pasture/Hay' (code 81) by the 2011 NLCD. See definitions above.
% Grassland to Row Crop Transition in Watershed - STATE	This indicator was derived using a grid produced by researchers at South Dakota State University who estimated the percent of grasslands in a 560-meter grid cell that has transitioned from grassland to corn/soybean in the Upper Midwest of the US. The researchers used the USDA NASS CDL data sets from 2006 to 2011 for their analysis. Using the grid provided by the University the average percent of transition within each HUC was derived using ESRI ArcMap's Spatial Analyst Zonal Stats as Table tool.

HUC8 METRIC	DESCRIPTION
% Population Increase within Watershed - STATE	The percent population increase was derived using data provided as part of the U.S. Census Bureau's American Community Survey (ACS) 5-year estimates for the period from 2009 to 2013. Different population data are provided for each census tract. The data used for the creation of this indicator were estimates of the total population, percent moved from a different county, percent moved from different state, and percent moved from abroad. The percent increase in overall population of a census tract was estimated by summing the (total x %moved from different county) + (total x %moved from different state) + (total x %moved from abroad). Next, the summed census tract-scale data was intersected with HUC boundaries and applied using an area-weighted averaging approach for each HUC.
Count of Oil and Gas Wells/Area in Watershed - STATE	The number (i.e., count) of oil and gas related wells with a “Status” of ‘Active’, ‘Drilling’, or ‘Temporarily Abandoned’ and a “Well Type” of ‘Oil or Gas Well’, or ‘Salt Water Disposal’; as identified by the GIS point coverage attributes available online from the North Dakota Department of Mineral Resources--within each HUC area divided by the HUC area in square kilometers.
Count of Drains/Area in Watershed - STATE	The number (i.e., count) of drainage network outlets--as identified by the GIS point coverage (file named “Drains”) available online from the North Dakota State Water Commission--within each HUC area divided by the HUC area in square kilometers.
Average TN Load (kg/yr) SPARROW (2002) to Watershed - STATE	The average estimated load of Total Nitrogen (TN) from upland areas within each HUC. The estimates of loading were derived from two USGS SPARROW 2002 model outputs (Upper Midwest/Great Lakes and Missouri River Basin models, MRB3 and MRB4, respectively). SPARROW model outputs were assigned to SPARROW model subwatersheds that were then used to create an area-weighted average loading rate (kg/km/yr) for each HUC. The area-weighted average loading rate (kg/km/yr) was multiplied by the HUC(km) to reach this indicator's values in kg/yr.
Average TP Load (kg/yr) SPARROW (2002) to Watershed - STATE	The average estimated load of Total Phosphorus (TP) from upland areas within each HUC. The estimates of loading were derived from two USGS SPARROW 2002 model outputs (Upper Midwest/Great Lakes and Missouri River Basin models, MRB3 and MRB4, respectively). SPARROW model outputs were assigned to SPARROW model subwatersheds that were then used to create an area-weighted average loading rate (kg/km/yr) for each HUC. The area-weighted average loading rate (kg/km/yr) was multiplied by the HUC(km) to reach this indicator's values in kg/yr.
Watershed Segments with TMDLs Count - ADJUSTED	The count of TMDLs in the HUC within the state (July 2014). This indicator was derived using the number of unique state-assigned water segment IDs in the EPA Office of Water "Impaired Waters with TMDLs" NHD-indexed dataset. For more information go to http://www.epa.gov/sites/production/files/2015-11/documents/rp3existplan1109.pdf. The national data was processed to assign appropriate values to the ND-specific version of HUC12s.
Percent GAP status 1, 2 and 3 WS - NATIONAL	Percent of HUC8 by total area that is in GAP analysis program’s protection and conservation status categories 1, 2, and 3
% Drinking Water Source Protection Area - STATE	The percentage of source water protection area (SPA) in the watershed. This indicator was derived using data available from the State's GIS website whereby the total areas of Community and Non-Community areas designated as surface water only (i.e., excluded groundwater protection areas) were summed within each HUC and divided by the HUC area within the state.
% CRP Activities in Watershed - STATE	The percent of the HUC with Conservation Reserve Program lands as reported in 2007 (considered to be the most recently reported year of peak activity). The report of acres by HUC12 was provided by the USDA Farm Service Agency and is based on Common Land Unit data on December 29, 2014. HUC12 data were also aggregated at the HUC8 scale. For HUCs that extend outside of the state, the final area used to derive this indicator was area-weighted to only include that part within the state.

HUC8 METRIC	DESCRIPTION
% Conservation Activity in Watershed - STATE	The percent of HUC that has a NRCS practice that would benefit water quality. Data range included 1995-2015. Dataset includes 152 different NRCS practices, selected by North Dakota because they have a beneficial effect on water quality. Source data provided by USDA through a Conservation Cooperators memorandum of understanding with North Dakota. Contact Ann Fritz at North Dakota Department of Health for further information. For HUCs that extend outside of the state, the final area used to derive this indicator was area-weighted to only include that part within the state.

Attachment 3: North Dakota Stage 2 HUC12 Indicator Descriptions

Green denotes ecological indicators, red are stressor indicators, and blue are social indicators. All North Dakota-specific indicators are denoted with “STATE”.

HUC12 Metric	Description
NFHAP Habitat Condition Index - STATE	Likelihood of suitable fish habitat, based on National Fish Habitat Action Plan Assessment
% Natural Cover (2011) in Watershed - STATE	The percentage of the HUC within the state considered "Natural Cover" based on the 2011 NLCD. "Natural Cover" is considered the following NLCD codes~classes: 41~Deciduous Forest, 42~Coniferous Forest, 43~Mixed Forest, 52~Shrub/Scrub, 71~Grassland/Herbaceous, 90~Woody Wetlands, and 95~Emergent Herbaceous Wetlands.
% Natural Cover (2011) in RZ - STATE	The percentage of the Riparian Zone (RZ) in the HUC within the state considered "Natural Cover" based on the 2011 NLCD. "Natural Cover" is considered the following NLCD codes~classes: 41~Deciduous Forest, 42~Coniferous Forest, 43~Mixed Forest, 52~Shrub/Scrub, 71~Grassland/Herbaceous, 90~Woody Wetlands, and 95~Emergent Herbaceous Wetlands.
% Wetlands (2011 and NWI) in RZ - STATE	The percentage of the Riparian Zone (RZ) in the HUC within the state considered "Wetlands": NLCD codes~classes 90~Woody Wetlands and 95~Emergent Herbaceous Wetlands in the 2011 NLCD, or a wetland in US Fish and Wildlife Service’s National Wetland Inventory (NWI) state-wide data set.
% in Cultivated Crops (2011) in Watershed - STATE	The percentage of the HUC within the state classified as 'Cultivated Crops' (code 82) by the 2011 NLCD. See definitions above.
% Urban (2006) in Watershed - NATIONAL	% of HUC12 with urban cover (2006 National Land Cover Dataset version 1; Land classes 21, 22, 23, 24)
% Urban Change 2001-06 WS - NATIONAL	% of HUC12 Change in urban cover (2001 2006 National Land Cover Change Dataset version 1; 21, 22, 23, 24)
% Grassland to Row Crop Transition in Watershed - STATE	This indicator was derived using a grid produced by researchers at South Dakota State University who estimated the percent of grasslands in a 560-meter grid cell that has transitioned from grassland to corn/soybean in the Upper Midwest of the US. The researchers used the USDA NASS CDL data sets from 2006 to 2011 for their analysis. Using the grid provided by the University the average percent of transition within each HUC was derived using ESRI ArcMap's Spatial Analyst Zonal Stats as Table tool.
Count of Oil and Gas Wells/Area in Watershed - STATE	The number (i.e., count) of oil and gas related wells with a “Status” of ‘Active’, ‘Drilling’, or ‘Temporarily Abandoned’ and a “Well Type” of ‘Oil or Gas Well’, or ‘Salt Water Disposal’; as identified by the GIS point coverage attributes available online from the North Dakota Department of Mineral Resources--within each HUC area divided by the HUC area in square kilometers.
Count of Drains/Area in Watershed - STATE	The number (i.e., count) of drainage network outlets--as identified by the GIS point coverage (file named “Drains”) available online from the North Dakota State Water Commission--within each HUC area divided by the HUC area in square kilometers.
Average TN Load (kg/yr) SPARROW (2002) to Watershed - STATE	The average estimated load of Total Nitrogen (TN) from upland areas within each HUC. The estimates of loading were derived from two USGS SPARROW 2002 model outputs (Upper Midwest/Great Lakes and Missouri River Basin models, MRB3 and MRB4, respectively). SPARROW model outputs were assigned to SPARROW model subwatersheds that were then used to create an area-weighted average loading rate (kg/km/yr) for each HUC. The area-weighted average loading rate (kg/km/yr) was multiplied by the HUC(km) to reach this indicator's values in kg/yr.

HUC12 Metric	Description
Average TP Load (kg/yr) SPARROW (2002) to Watershed - STATE	The average estimated load of Total Phosphorus (TP) from upland areas within each HUC. The estimates of loading were derived from two USGS SPARROW 2002 model outputs (Upper Midwest/Great Lakes and Missouri River Basin models, MRB3 and MRB4, respectively). SPARROW model outputs were assigned to SPARROW model subwatersheds that were then used to create an area-weighted average loading rate (kg/km/yr) for each HUC. The area-weighted average loading rate (kg/km/yr) was multiplied by the HUC(km) to reach this indicator's values in kg/yr.
Count of Active CAFO/AFO Permits/Area in Watershed - STATE	The number (i.e., count) of active, permitted Confined Animal Feeding Operations (CAFO) and Animal Feeding Operations (AFO) as described in the State's NDPDES permits program database divided by the HUC12 area in square kilometers.
Count of Permitted Animals in Watershed/Area - STATE	The number of animals from all active, permitted Confined Animal Feeding Operations (CAFO) and Animal Feeding Operations (AFO) as described in the State's NDPDES permits program database divided by the HUC12 area in square kilometers.
Watershed Mean Soil Erodibility - NATIONAL	Average soil erodibility (K) factor in HUC12. Calculated from the "STATSGO2" soil attribute dataset.
Count of Water Quality Monitoring Sites in Watershed - STATE	The number (i.e., count) of monitoring sites in the HUC that have records of Total Phosphorus (TP) or Total Nitrogen (TN) samples between 2004 and 2013 (note -- number does not include Index of Biological Integrity (IBI) sampling sites).
Watershed Streamlength Assessed - ADJUSTED	Length of stream features assessed under Section 305(b) of the Clean Water Act in HUC12 (kilometers). Represents only the most recent assessment cycle that the state has provided to EPA as geospatial data. Calculated from the EPA Office of Water "305(b) Waters as Assessed" NHD-indexed dataset. Only includes length of lines meeting criteria for classification as "streams". These criteria include: (1) feature has NHD REACHCODE with FTYPE equal to StreamRiver, CanalDitch, or Connector; (2) feature has NHD REACHCODE with FTYPE equal to Artificial Path and FTYPE of corresponding NHDArea feature is StreamRiver; or (3) feature is custom-added to the EPA Reach Address Database and is not in the NHD (blank NHD REACHCODE).
Watershed Waterbody Area Assessed - ADJUSTED	Area of lakes, estuaries, and other areal water features assessed under Section 305(b) of the Clean Water Act in HUC12 (square kilometers). Calculated from the EPA Office of Water "305(b) Waters as Assessed" NHD-indexed dataset.
Watershed Segments with TMDLs Count - ADJUSTED	The count of TMDLs in the HUC within the state (July 2014). This indicator was derived using the number of unique state-assigned water segment IDs in the EPA Office of Water "Impaired Waters with TMDLs" NHD-indexed dataset. For more information go to http://www.epa.gov/sites/production/files/2015-11/documents/rp3existplan1109.pdf. The national data was processed to assign appropriate values to the ND-specific version of HUC12s.
Percent potentially restorable wetlands WS - NATIONAL	Estimated percent of land within each HUC12 that may be suitable for wetland restoration.
% Drinking Water Source Protection Area - STATE	The percentage of source water protection area (SPA) in the watershed. This indicator was derived using data available from the State's GIS website whereby the total areas of Community and Non-Community areas designated as surface water only (i.e., excluded groundwater protection areas) were summed within each HUC and divided by the HUC area within the state.
% CRP Activities in Watershed - STATE	The percent of the HUC with Conservation Reserve Program lands as reported in 2007 (considered to be the most recently reported year of peak activity). The report of acres by HUC12 was provided by the USDA Farm Service Agency and is based on Common Land Unit data on December 29, 2014. HUC12 data were also aggregated at the HUC8 scale. For HUCs that extend outside of the state, the final area used to derive this indicator was area-weighted to only include that part within the state.

HUC12 Metric	Description
% Conservation Activity in Watershed - STATE	The percent of HUC that has a NRCS practice that would benefit water quality. Data range included 1995-2015. Dataset includes 152 different NRCS practices, selected by North Dakota because they have a beneficial effect on water quality. Source data provided by USDA through a Conservation Cooperators memorandum of understanding with North Dakota. Contact Ann Fritz at North Dakota Department of Health for further information. For HUCs that extend outside of the state, the final area used to derive this indicator was area-weighted to only include that part within the state.
% Tribal Lands	Percent of total area constituting Tribal lands; otherwise blank. Analysis based on PLUS2 WBD snapshot HUC12 dataset and Tribal information from http://epamap5.epa.gov/ArcGIS/rest/services/EMEF/Tribal/MapServer/4 EPA Tribal data for the conterminous US, including all lands associated with Federally-recognized tribal entities— Federally recognized Reservations, Off-Reservation Trust Lands, and Census Oklahoma Tribal Statistical Areas.

Attachment 4: North Dakota RPS Tool file names and contents

The following are RPS Tool files completed during this project and delivered to NDDoH for statewide and HUC8 or HUC12-specific use. Except for ND RPS-Scoring-Tool-032216, all these files contain archived results for each geographic area and scenario as named.

RPS Tool File Name	Content
ND RPS-Scoring-Tool-032216	ND RPS Tool with all HUC8 and HUC12 data, no screening content saved (master copy for all new screening statewide or on HUC subsets)
HUC8_SCENARIO 1A_ND RPS-Scoring-Tool-021016	ND RPS Tool with screening results for HUC8 Scenario 1A
HUC8_SCENARIO 1B_ND RPS-Scoring-Tool-021016	ND RPS Tool with screening results for HUC8 Scenario 1B
HUC12_ Park_MultBenefits_ND RPS-Scoring-Tool-032216	ND RPS Tool with Stage 2 results for HUC12 screening for Park HUC8 – Multiple Benefits
HUC12_ Park_Assess_ND RPS-Scoring-Tool-032216	ND RPS Tool with Stage 2 results for HUC12 screening for Park HUC8 - Assessment
HUC12_ Sakakawea_ND RPS-Scoring-Tool-032216	ND RPS Tool with Stage 2 results for HUC12 screening for Lake Sakakawea HUC8