Spokane River Non-Point Source Analysis Project Supplemental Phase 1 Land Use to Phosphorus Concentrations Correlation

Supplemental Phase 1 Study
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Prepared by:

HDR Engineering, Inc.

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Spokane River Non-Point Source Analysis Project
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Introduction

The following discussion presents the results of the Supplemental Phase 1 land use to phosphorus concentration correlation as part of the surface water analysis of the Spokane River watershed phosphorus dataset. The non-point source phosphorus analysis is one of many activities related to the Spokane River Dissolved Oxygen Total Maximum Daily Load (TMDL). The phosphorus studies, credibility and relevance review, database creation, and Phase 1 groundwater analyses are described in separate documents (Geo, 2008a; Geo, 2008b). The total phosphorus and orthophosphorus analyses are also described in separate documents (HDR, 2009a; HDR, 2010). The ultimate goal of the non-point source analysis project is to identify and prioritize locations for non-point phosphorus reductions activities such as best management practice (BMP) implementation projects.

The Washington State Department of Ecology has stated "Phosphorus and other nutrients and organic matter have polluted the Spokane River, causing it to violate water-quality standards. These pollutants deplete dissolved oxygen in the river and Lake Spokane. To address the problem, a cleanup plan, also known as a total maximum daily load (TMDL), will set allocations for how much of the pollutants (such as phosphorus and ammonia) each of the major dischargers and other sources will be allowed to discharge at very low levels. The amounts will be set to protect water quality and bring the river into compliance with state water-quality standards and the federal Clean Water Act" (Ecology, 2009). The TMDL is the basis for the non-point source analysis project including this task, an assessment of the correlation between nonpoint source total phosphorus and orthophosphorus and land uses which will be used in developing the reduction plan.

Approach to Phase 1 Surface Water Analysis

The surface water analysis included identifying and selecting technical approaches to apply to select locations in the Spokane River watershed. The approaches and locations were limited in Phase 1 to meet multiple objectives including the following:

1. Provide a basis for prioritizing and selecting more detailed approaches for Phase 2 analyses
2. Summarize phosphorus concentrations and loads from a large area (approximately 6,580 square mile watershed)
3. Summarize phosphorus concentrations and loads from a large dataset (approximately 15,000 data points)
4. Meet Phase 1 schedule constraints; and provide a relatively rapid assessment of the data
5. Meet Phase 1 budget constraints

The analyses selected for the Phase 1 surface water study were those that could be completed relatively rapidly, with minimal intermediate data computational steps, and provide a basis for a simple and straightforward presentation. The results provide insights into changes in phosphorus concentration and/or loads both temporally and spatially. Comparisons of the graphs indicate where and when the greatest total phosphorus loads occur. The six analyses selected for the Phase 1 surface water study are as follows:

1. Times Series Plots
2. Data Charts
3. Average Monthly Phosphorus Loadings
    a. Average Monthly Phosphorus Loadings by Year
4. Average Monthly Phosphorus Loadings for 2001
    a. Average Monthly Phosphorus Loading by Flows
5. Average Seasonal Phosphorus Concentrations and Loadings
6. Land Use to Phosphorus Correlation

Analyses 1 through 5, along with one subbasin for 6, were completed for total phosphorus as described in a separate document (HDR, 2009a). Analyses 1 through 5 were also completed for orthophosphorus as described in a separate document (HDR, 2010). This report provides the results of item 6 for total and orthophosphorus for all subbasins (Figure 1, Spokane River flows from Coeur d'Alene Lake to Long Lake to Franklin D. Roosevelt Lake).

This combination of selected locations and analyses allows for initial observations about the dataset to be made, along with questions and hypotheses to be posed about the cause and effect relationships that may be occurring. These questions and hypotheses will be useful for prioritizing and selecting the Phase 2 analyses. The Phase 2 analyses may include some of the same analytical approaches used in Phase 1, but in new locations and with additional techniques including those previously identified such as: stream segment analysis, load analysis by subbasin or sub-subbasin, and episodic or event-based loading analysis (HDR, 2009b).

More specifically, the Phase 1 analysis included an example land use to total phosphorus correlation for the Hangman Creek subbasin. Presented in the sections below is the Supplemental Phase 1 phosphorus (total and orthophosphorus) to land use correlations for all the subbasins.

Summary of Supplemental Phase 1 Land Use Correlation

A review of the Supplemental Phase 1 land use to phosphorus correlations is useful to make observations about where concentrations of phosphorus are higher or lower relative to land uses. (Point sources are not identified on the subbasin figures and may be impacting the observed concentrations more than the surrounding land uses.) Developed, transitional and shrub/range/low vegetation areas appear to have the most consistent impact on phosphorus concentrations throughout the watershed. Specific areas and activities related to agriculture (crops and animals) and forestry have impacts resulting in higher concentrations but overall throughout the watershed appear to have less impact than development. A summary of the observations from the Supplemental Phase 1 is provided in Table 1. Total phosphorus and orthophosphorus generally follow similar trends in concentrations and relationships to land uses.

The average phosphorus concentration and land cover/zoning figures presented below are helpful for seeing the spatial distribution of phosphorus data and land uses. A summary of the data in the figures is presented in Table 2 and Table 3. The summary has the highest total phosphorus as wetlands in the Lower Spokane subbasin followed by agriculture in the Lower Spokane, Little Spokane and Hangman subbasins. The Lower Spokane and Hangman subbasins have five of the six highest values. Orthophosphorus has a less distinctive pattern although wetlands in the Lower Spokane subbasin and range in the Hangman subbasin are the two highest.

Table 1. Observations of Potential Land Use to Phosphorus Concentrations

Subbasin	Land uses associated with greater total phosphorus concentrations	Land uses associated with greater orthophosphorus concentrations	Land uses with uncertain impacts	Other observations
Lower Spokane	Developed areas	Developed areas	Forest, shrubs	Most of the subbasin does not have phosphorus data
Little Spokane	Developed areas, hay/pasture, agriculture	Developed areas, hay/pasture, agriculture	Forest, rural/transitional	Some high phosphorus concentrations in the uppermost reaches of the subbasin
Hangman	Developed areas, agriculture	Developed areas, agriculture	Forest	Significant intermix of land uses make land use correlations uncertain
Upper Spokane, WA	Developed areas, lakeside	Developed areas, lakeside	Areas surrounding core development: transitional, rural, forested	Some high phosphorus concentrations in the southern Spokane Valley
Upper Spokane, ID	Developed areas	Developed areas	Forested, rural	Most of the subbasin has few phosphorus data which are low in concentration and may not be representative
Pend Oreille	Rural	Rural	Forested	The subbasin has few phosphorus data for interpretation
Coeur d'Alene Lake	Agriculture, wetlands	Rural, wetlands	Forested	Most of the phosphorus data in the subbasin are around Coeur d'Alene Lake and River
Upper Coeur d'Alene	None	None	Forested	The subbasin has few phosphorus data for interpretation
South Fork Coeur d'Alene	Developed areas	Developed areas	Forested	Most of the subbasin does not have phosphorus data
St. Joe	Developed areas	Developed areas, forested	Forested	Most of the subbasin does not have phosphorus data

Table 2. Summary of Average Total Phosphorus Concentration and Land Cover/Zoning

Average Total Phosphorus (ug/L) Total Number of Samples Number of Locations					
Subbasin	**Agriculture**	**Developed**	**Forest**	**Range**	**Wetlands**
Lower Spokane	58 10 1	31 990 48	38 51 4	55 24 2	82 12 2
Little Spokane	56 170 13	35 948 92	37 299 21	32 210 14	23 137 11
Hangman	70 219 57	55 817 109	36 31 8	45 4 4	n/a
Upper Spokane, WA	n/a	21 3,427 137	24 396 18	2 273 11	n/a
Upper Spokane, ID	4 4 2	11 294 16	10 1 1	n/a	n/a
Pend Oreille Lake	n/a	11 7 7	n/a	n/a	n/a
Coeur d'Alene Lake	27 81 9	27 652 38	30 50 5	14 32 1	n/a
Upper Coeur d'Alene	n/a	9 168 1	7 31 5	8 1 1	n/a
South Fork Coeur d'Alene	n/a	20 107 8	16 99 6	20 293 7	33 162 1
St. Joe	7 53 1	24 149 5	38 491 18	48 139 11	37 216 5

Table 3. Summary of Average Orthophosphorus Concentration and Land Cover/Zoning

Average Orthophosphorus (ug/L) Total Number of Samples Number of Locations					
Subbasin	**Agriculture**	**Developed**	**Forest**	**Range**	**Wetlands**
Lower Spokane	n/a	12 184 10	12 48 4	24 32 2	54 16 2
Little Spokane	n/a	18 98 10	23 189 13	15 113 7	23 23 5
Hangman	n/a	12 6 2	12 27 1	48 4 2	n/a
Upper Spokane, WA	n/a	13 1,229 57	8 115 10	6 135 5	n/a
Upper Spokane, ID	n/a	14 39 6	13 4 1	n/a	n/a
Pend Oreille Lake	n/a	n/a	20 1 1	n/a	n/a
Coeur d'Alene Lake	n/a	19 3 2	36 5 1	21 27 1	n/a
Upper Coeur d'Alene	n/a	10 94 1	9 70 24	10 2 1	n/a
South Fork Coeur d'Alene	n/a	13 100 11	7 108 7	10 425 7	20 179 2
St. Joe	17 86 2	18 124 7	29 481 12	36 293 33	22 251 9

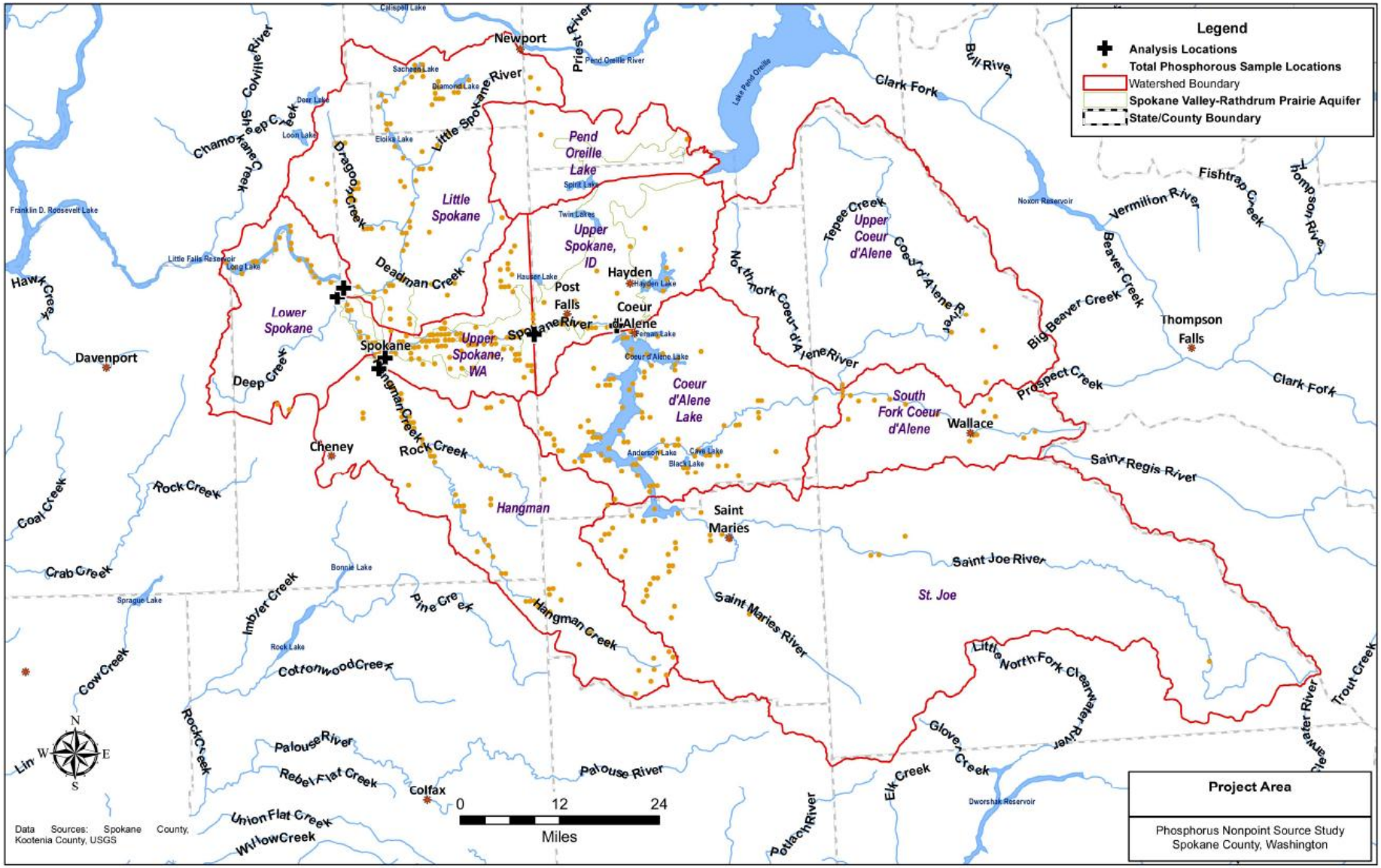

Figure 1. Project Location Map with Subbasins

6.0 Land use to Phosphorus Correlation

Objective
Examine linking land use to phosphorus (total and ortho) loads to provide a connection between non-point sources and the TMDL loads. Phosphorus loads may be associated with land uses and the potential best management practices are typically specific to the land use.

Linkage to TMDL
Provide a comparison of classification of land uses in the TMDL and load allocations for non-point sources.

Results
The Spokane River watershed was divided into ten subbasins for Phase 1. The subbasins, in a downstream to upstream order, are:

- Lower Spokane,
- Little Spokane,
- Hangman,
- Upper Spokane, WA,
- Upper Spokane, ID,
- Pend Oreille,
- Coeur d'Alene Lake,
- Upper Coeur d'Alene,
- South Fork Coeur d'Alene, and
- St. Joe.

Recent comprehensive land use zoning information from the Counties along with the USGS land cover data (current version from 2001) were used for the land use. The land use data sources are summarized in Appendix A. The land use values vary depending on the source. For consistency in the subbasin figures, the land uses were connected to consistent terms for the figures as shown in Appendix B. Definitions for the land uses are shown in Appendix C.

The following sections describe the Supplemental Phase 1 findings.

6.1 Lower Spokane Subbasin

Land use and average phosphorus concentrations in the Lower Spokane subbasin are shown in Figure 6.1 and Figure 6.2. The comprehensive land use zoning information from the City of Spokane and Spokane County are shown. The USGS land cover data from 2001 are shown for the portion of the subbasin in Lincoln and Stevens Counties. Major streams from the National Hydrography Dataset (NHD) are shown for the stream network.

For most of the Lower Spokane subbasin, including the largely agricultural and rural areas such as the area north of Deep Creek, phosphorus data are not available. Most of the phosphorus data are from or near the Spokane River.

The greatest average total phosphorus concentrations appear to be near the City of Spokane, Suncrest, and the confluence with the Little Spokane River, or generally areas with more developed land uses. The samples along the Spokane River corridor in forested and shrub areas generally have lower phosphorus concentrations compared to the phosphorus concentrations in areas near urban/suburban land uses. The largely agricultural and rural areas including Coulee Creek, Spring Creek, Deep Creek, and South Fork Deep Creek did not have phosphorus samples to include in the analysis. With few data from other land uses, the land use correlation is uncertain for the Lower Spokane subbasin.

In the Lower Spokane subbasin, samples from fewer locations have been analyzed for orthophosphate than total phosphorus. Of the samples that are available, the distribution pattern is similar to that of total phosphorus samples. The greater concentrations of orthophosphate appear to be related to developed areas.

Phosphorus concentrations do not appear to simply increase from upstream to downstream along the Spokane River. Greater phosphorus concentrations exist near the confluence with Hangman Creek and near the confluence with the Little Spokane River. However, these are also developed areas so it is unclear if the greater concentrations are due to the streams or surrounding land uses.

- Land uses appearing most correlated with greater total phosphorus concentrations:
    - Developed areas
- Land uses appearing most correlated with greater orthophosphorus concentrations:
    - Developed areas
- Land uses with uncertain impacts:
    - Forest, shrubs
- Other observations
    - Most of the subbasin does not have phosphorus data

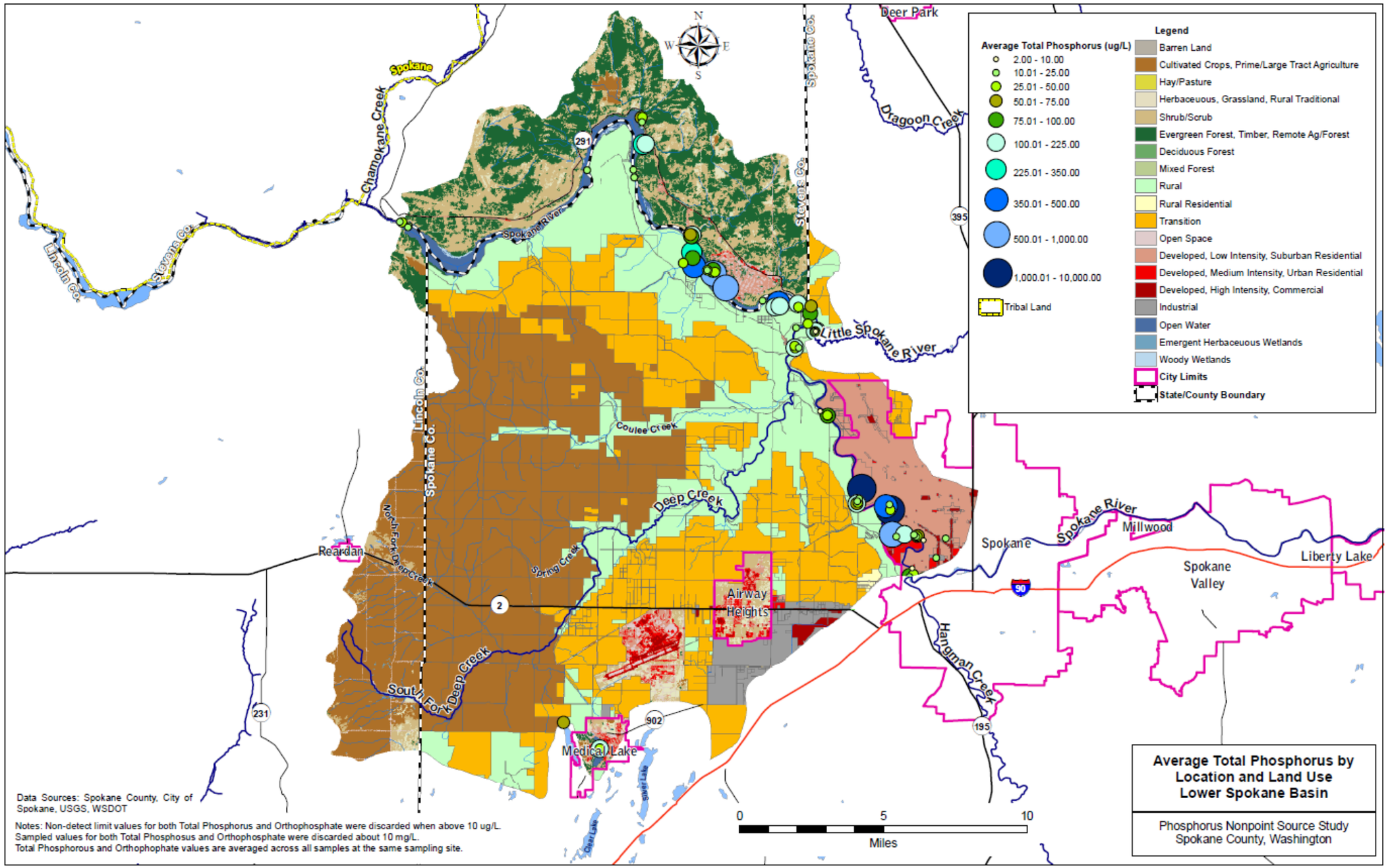

Figure 6.1. Average Phosphorus Concentration and Land Cover/Zoning with Stream Network for Lower Spokane Basin

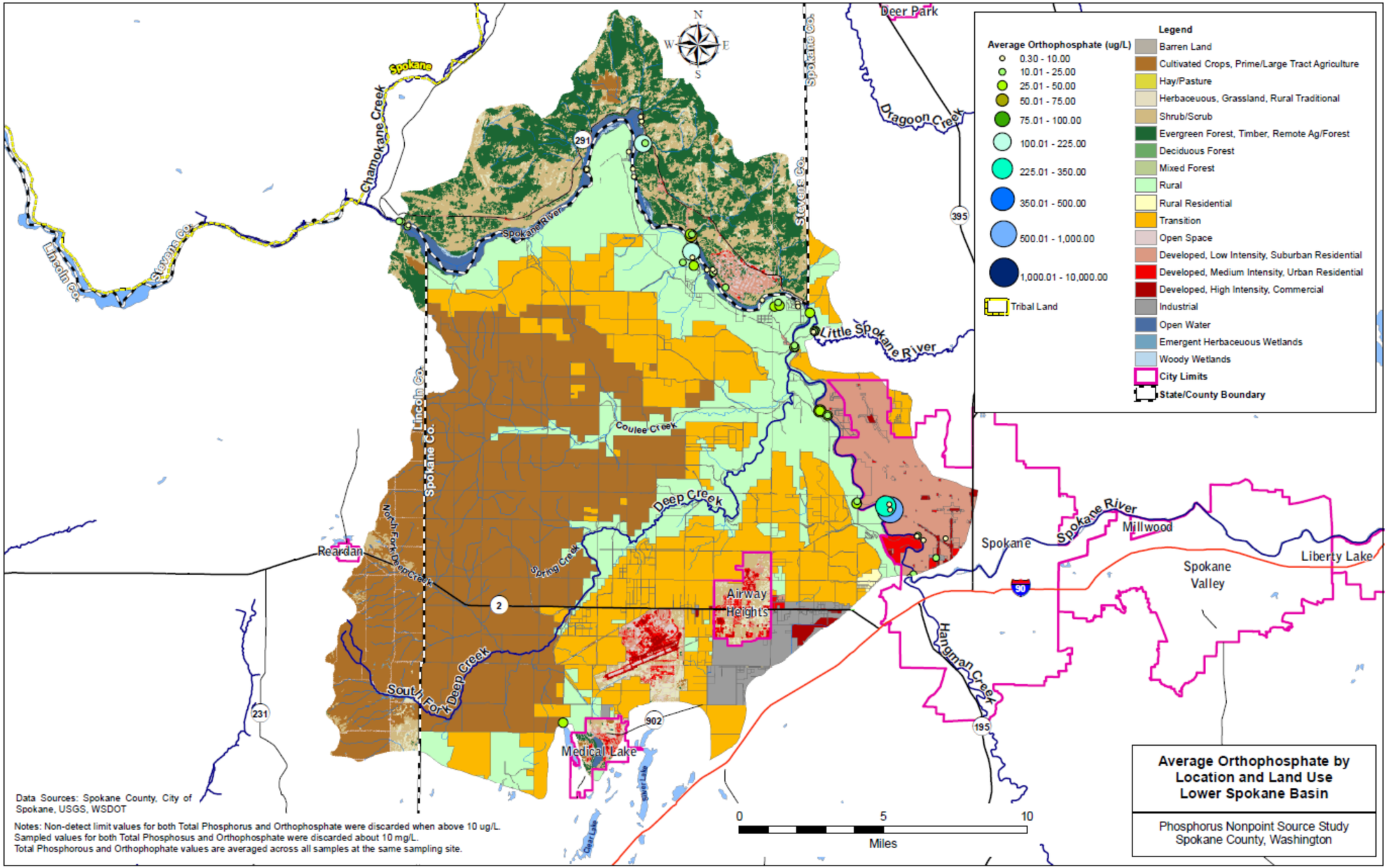

Figure 6.2. Average Orthophosphorus Concentration and Land Cover/Zoning with Stream Network for Lower Spokane Basin

6.2 Little Spokane Subbasin

Land use and average phosphorus concentrations in the Little Spokane subbasin are shown in Figure 6.3 and Figure 6.4. The comprehensive land use zoning information from Spokane County, the City of Spokane, and Bonner County are shown. The USGS land cover data from 2001 are shown for the portion of the subbasin in Pend Oreille and Stevens Counties. Major streams from the National Hydrography Dataset (NHD) are shown for the stream network.

The greatest average total phosphorus concentrations appear to be associated with locations of development and hay/pasture. For example, the areas north of the City of Spokane and near Deer Park have average phosphorus concentrations greater than other areas in the subbasin. Higher phosphorus concentrations in the West Branch Dragoon Creek area and the area north of the confluence of the West Branch Little Spokane River and Little Spokane River where the land use is agriculture and hay/pasture also exist. With hay/pasture land uses, there is the potential for higher numbers of animals in the area. There is also a high density of septics around the lakes, such as Reflection Lake. Higher phosphorus concentrations appear to correlate to the developed and agricultural land uses of the subbasin. The lowest phosphorus concentrations occur in the forested and grassland areas of the subbasin.

In the Little Spokane subbasin, fewer samples have been analyzed for orthophosphate, especially along Dragoon Creek. Of the samples that are available, the distribution pattern is similar to that of total phosphorus samples. The greater concentrations of orthophosphate appear to be related to development. However, samples of orthophosphate in the City of Spokane are less than those along the Little Spokane River north of the City of Spokane in rural areas and on the edge of developed areas.

Total phosphorus and orthophosphate concentrations do appear to generally increase from upstream to downstream along the Little Spokane River and Deadman Creek, and vary along Dragoon Creek. Localized impacts may be the cause of the higher phosphorus concentration in the upper parts of the watershed; whereas, the general increase of phosphorus downstream parallels the trend in increasing areas of developed land use.

- Land uses appearing most correlated with greater total phosphorus concentrations:
    - Developed areas, hay/pasture, agriculture
- Land uses appearing most correlated with greater orthophosphorus concentrations:
    - Developed areas, hay/pasture, agriculture
- Land uses with uncertain impacts:
    - Forest, rural/transitional
- Other observations
    - Some high phosphorus concentrations in the uppermost reaches of the subbasin

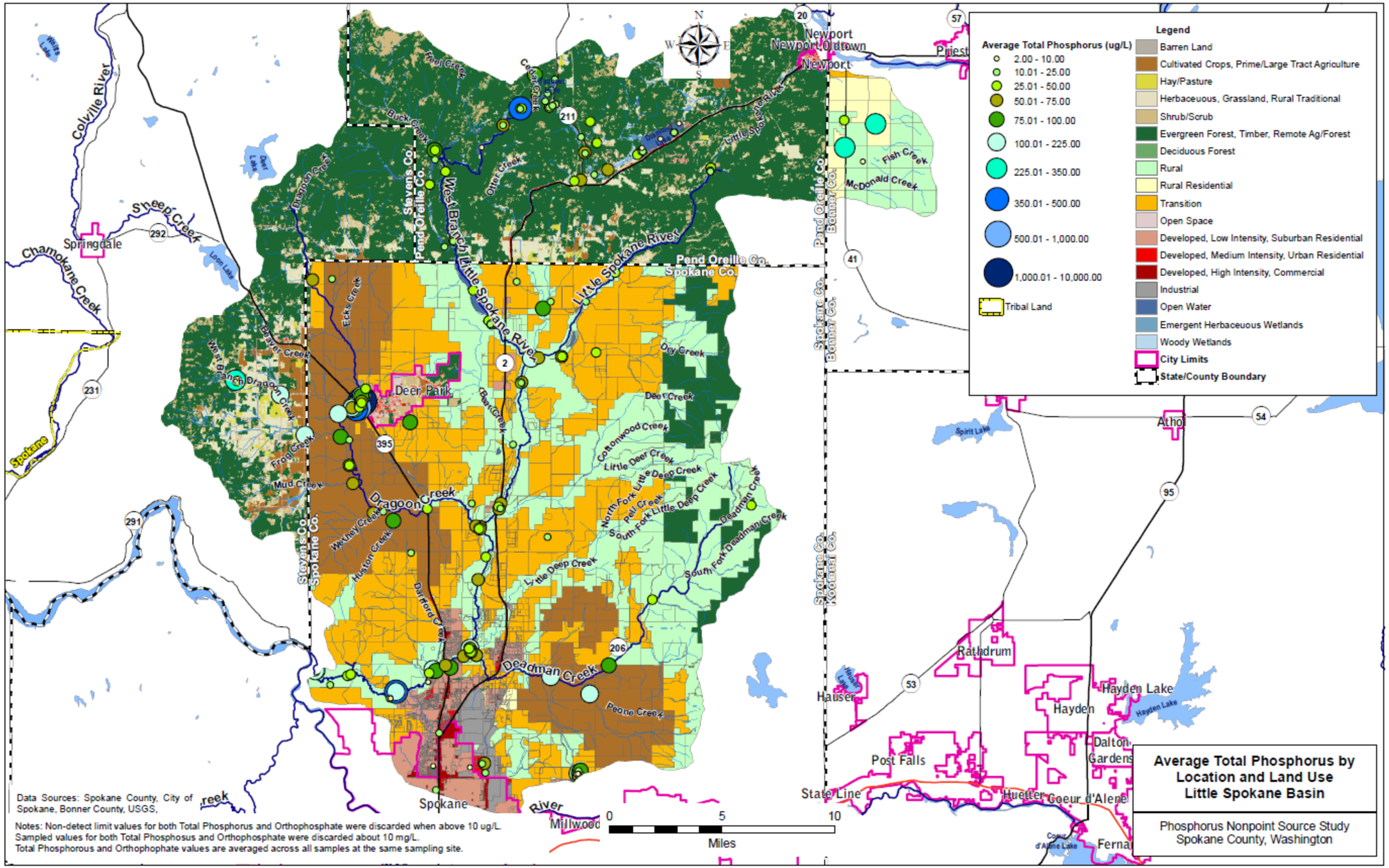

Figure 6.3. Average Phosphorus Concentration and Land Cover/Zoning with Stream Network for Little Spokane Basin

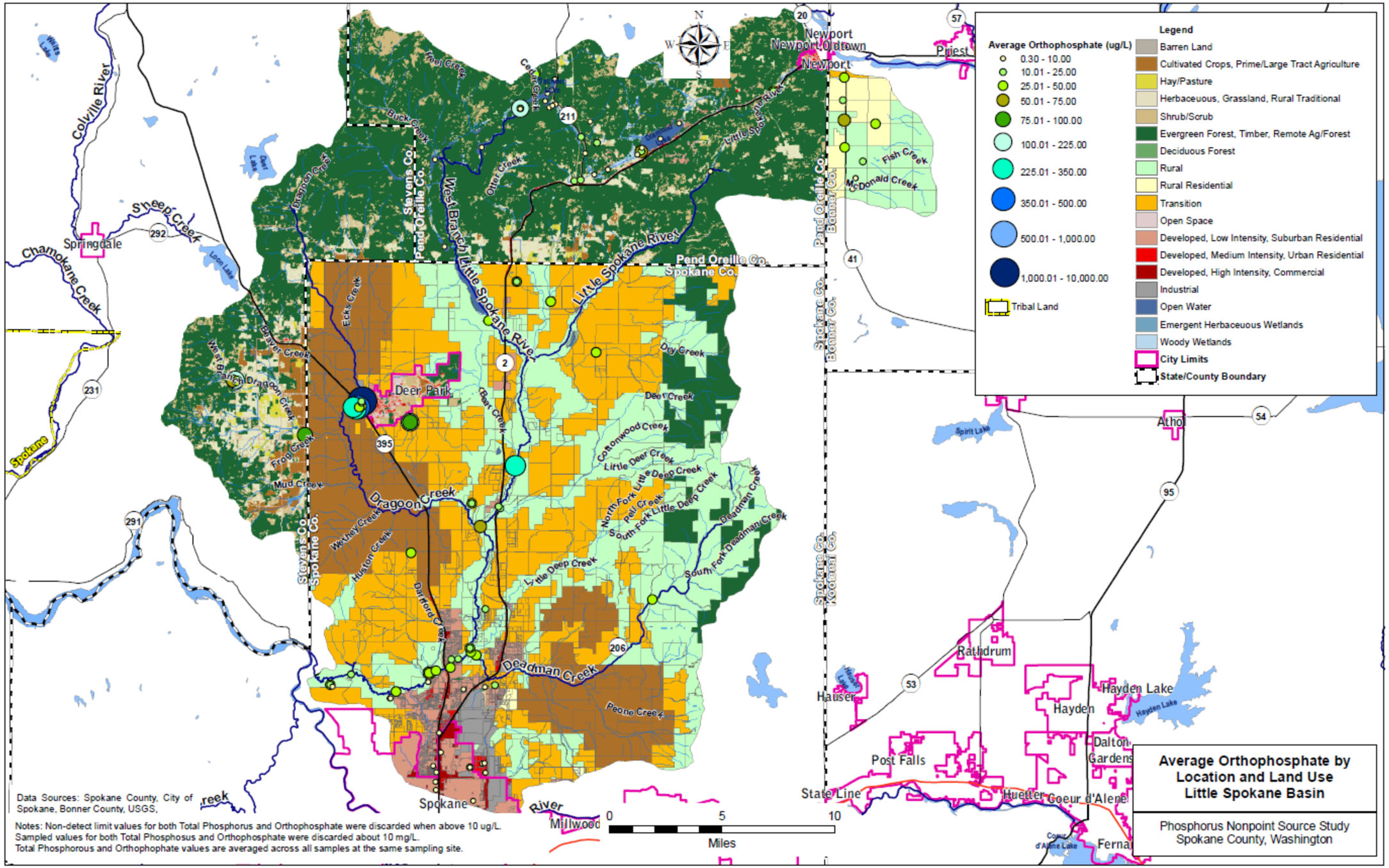

Figure 6.4. Average Orthophosphorus Concentration and Land Cover/Zoning with Stream Network for Little Spokane Basin

6.3 Hangman Creek Subbasin

Land use and average phosphorus concentrations in the Hangman Creek subbasin are shown in Figure 6.5 and Figure 6.6. The comprehensive land use zoning information from the City of Spokane, City of Cheney, Spokane County, and Kootenai County are shown. The USGS land cover data from 2001 are shown for the portion of the subbasin in Whitman and Benewah Counties. Major streams from the National Hydrography Dataset (NHD) are shown for the stream network.

The greatest average total phosphorus concentrations appear to be associated with locations of greater development. For example, near the communities of Rockford, Fairfield, Tekoa, and Spangle, the average phosphorus concentrations are greater than other areas of the subbasin. The area where Hangman Creek crosses the state line and a suburban area of the City of Spokane also have greater phosphorus concentrations.

In the Hangman Creek subbasin, fewer samples have been analyzed for orthophosphate. Of the samples that are available, the distribution pattern is similar to that of total phosphorus samples. The greater concentrations of orthophosphate appear to be related to development.

Phosphorus concentrations do not appear to simply increase from upstream to downstream along Hangman Creek. There are greater phosphorus concentrations in some of the tributaries including Rock Creek and the tributaries where Spangle and Rockford are located. Although fewer samples of orthophosphate are available, the trends are typically similar to total phosphorus.

The samples from forested and shrub areas generally have lower phosphorus concentrations; whereas, higher phosphorus concentrations are from areas with agricultural and urban/suburban land uses. Higher phosphorus concentrations appear to correlate to large agricultural areas including middle California Creek, the reach between Latah and Waverly, near the confluence of Rattler Run Creek with Hangman Creek, and Little Hangman Creek and the area along the Stateline. The large areas of agriculture with conservation program or other buffers around the creeks appear to generally have greater total phosphorus concentrations.

The reaches of lower Rock Creek and Hangman Creek above the confluence with Rock Creek appear to be surrounded by land uses that are forestry/conservation program. Phosphorus concentrations while not the lowest in the subbasin are on the lower end of the spectrum. The urban growth area promotes on-site septic systems and community drainfields, which are counterproductive to controlling non-point source phosphorus.

- Land uses appearing most correlated with greater total phosphorus concentrations:
    - Developed areas, agriculture
- Land uses appearing most correlated with greater orthophosphorus concentrations:
    - Developed areas, agriculture
- Land uses with uncertain impacts:
    - Forest
- Other observations
    - Significant intermix of land uses make land use correlations uncertain

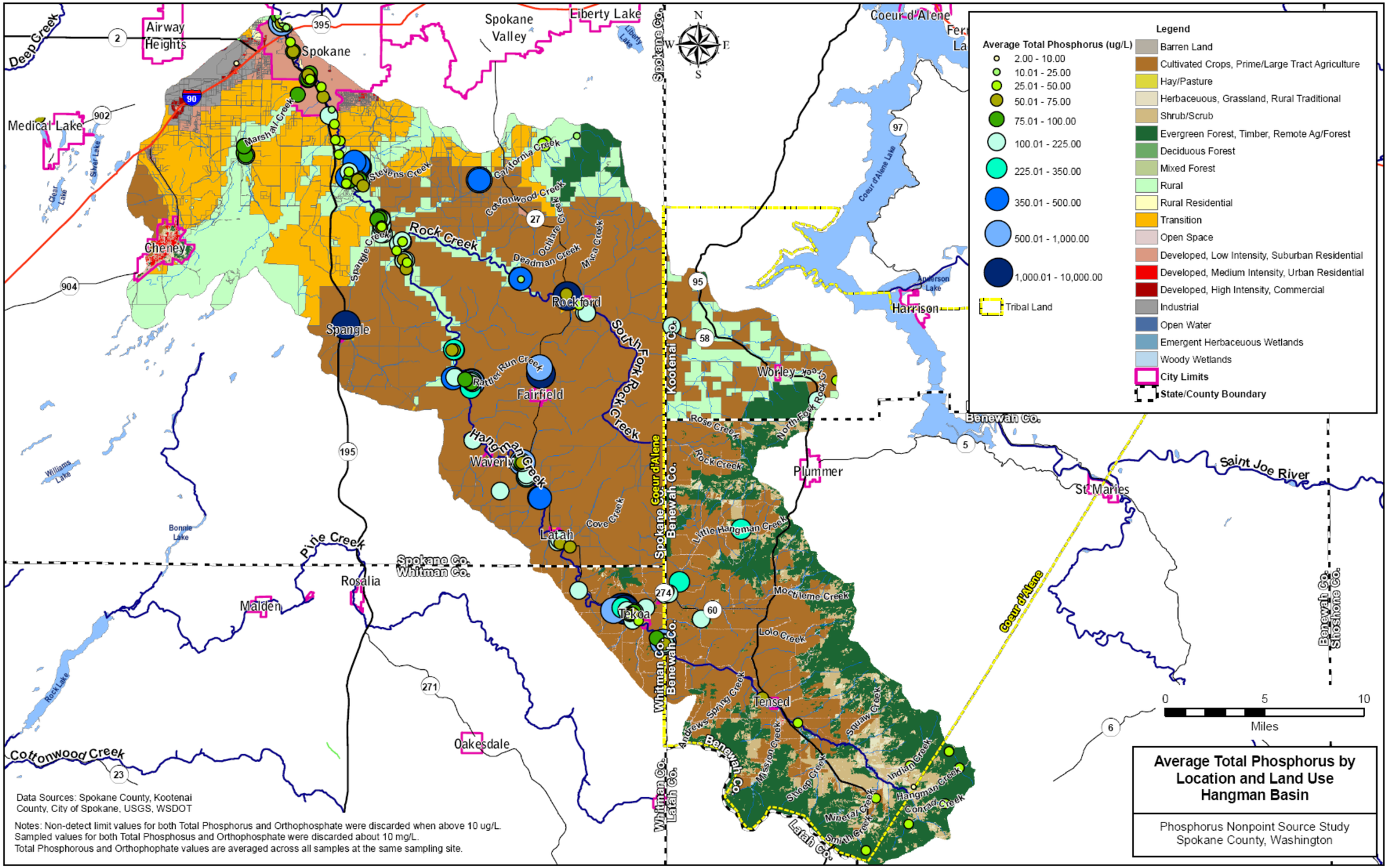

Figure 6.5. Average Phosphorus Concentration and Land Cover/Zoning with Stream Network for Hangman Creek

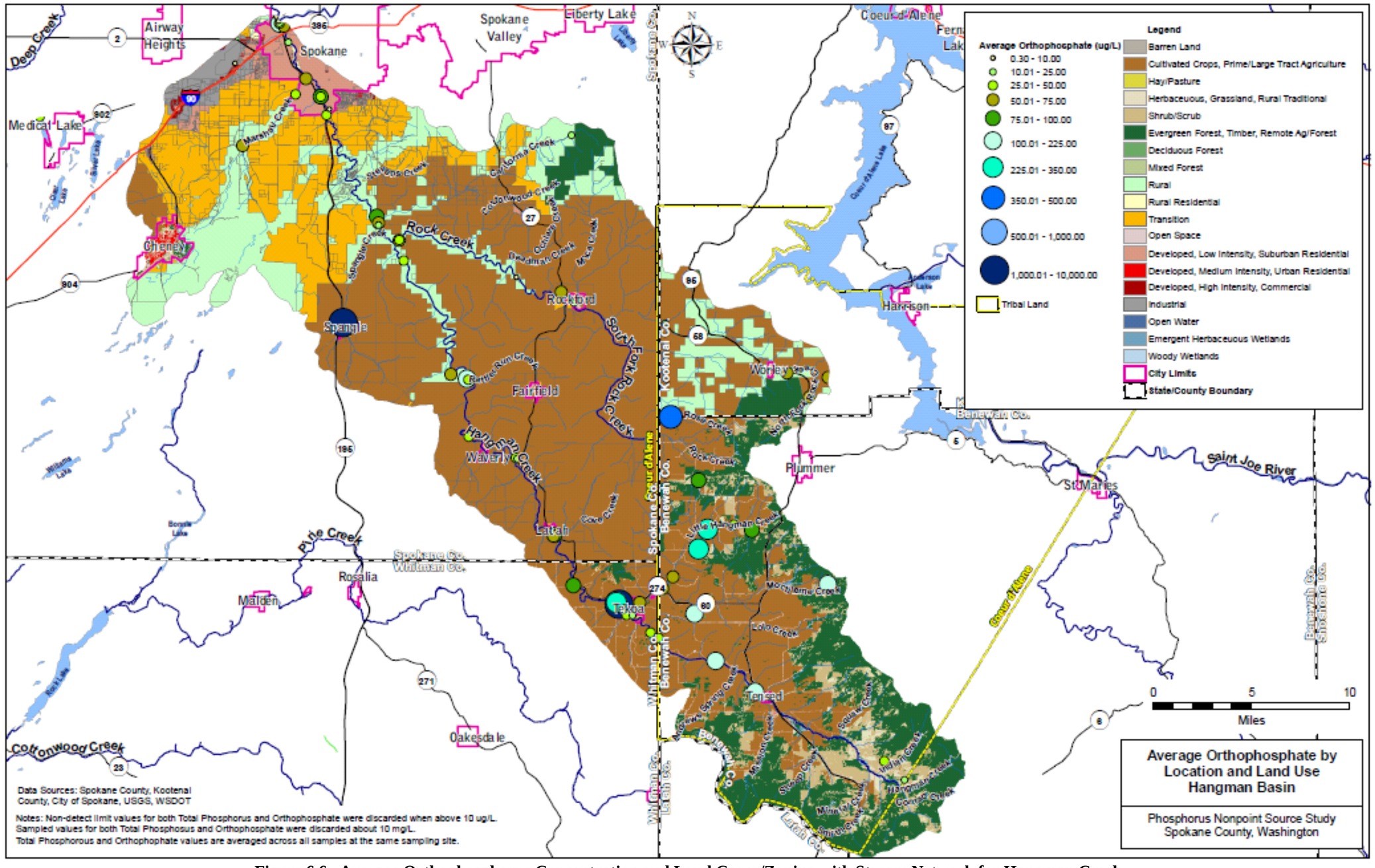

Figure 6.6. Average Orthophosphorus Concentration and Land Cover/Zoning with Stream Network for Hangman Creek

6.4 Upper Spokane, WA Subbasin

Land use and average total phosphorus concentrations in the Upper Spokane, WA subbasin are shown in Figure 6.7 and Figure 6.8. The comprehensive land use zoning information from the City of Spokane and Spokane County are shown. Major streams from the National Hydrography Dataset (NHD) are shown for the stream network.

The majority of the total phosphorus samples for this subbasin are in areas of development. Additionally there are higher concentrations near Newman Lake and Liberty Lake. There are elevated total phosphorus concentrations in the Liberty Lake area, although the land use surrounding the upstream portion of Liberty Creek is classified as rural to transitional, the elevated phosphorus could be due to development.

Total phosphorus concentrations are variable along the Spokane River where the surrounding land use is low, medium, and high density. For example, several samples along the Spokane River in the Spokane Valley exhibit extremely high total phosphorus concentrations.

In the Upper Spokane, WA subbasin, fewer samples have been analyzed for orthophosphate, especially on Liberty Creek, in Liberty Lake, and near Newman Lake, where no orthophosphate samples are available. Of the samples that are available, the distribution pattern is similar to that of total phosphorus samples. The greatest orthophosphate results occur away from the main stem of the Spokane River but still in developed areas.

Land uses that appear to be most related to phosphorus concentrations in the subbasin are developed lands. The forested and rural areas have few samples available in the subbasin.

- Land uses appearing most correlated with greater total phosphorus concentrations:
    - Developed areas, lakeside
- Land uses appearing most correlated with greater orthophosphorus concentrations:
    - Developed areas, lakeside
- Land uses with uncertain impacts:
    - Areas surrounding core development: transitional, rural, forested
- Other observations
    - Some high phosphorus concentrations in the southern Spokane Valley

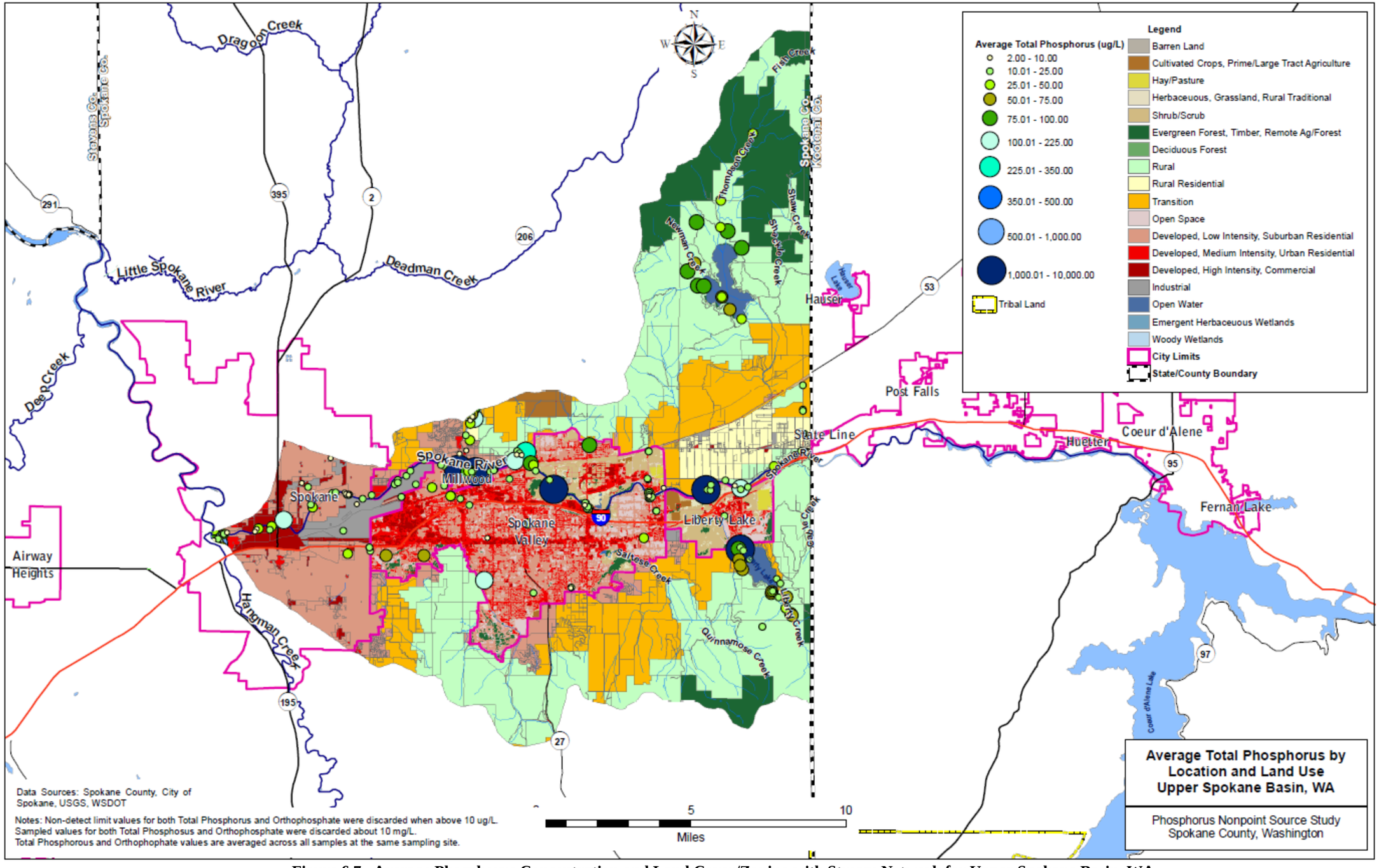

Figure 6.7. Average Phosphorus Concentration and Land Cover/Zoning with Stream Network for Upper Spokane Basin, WA

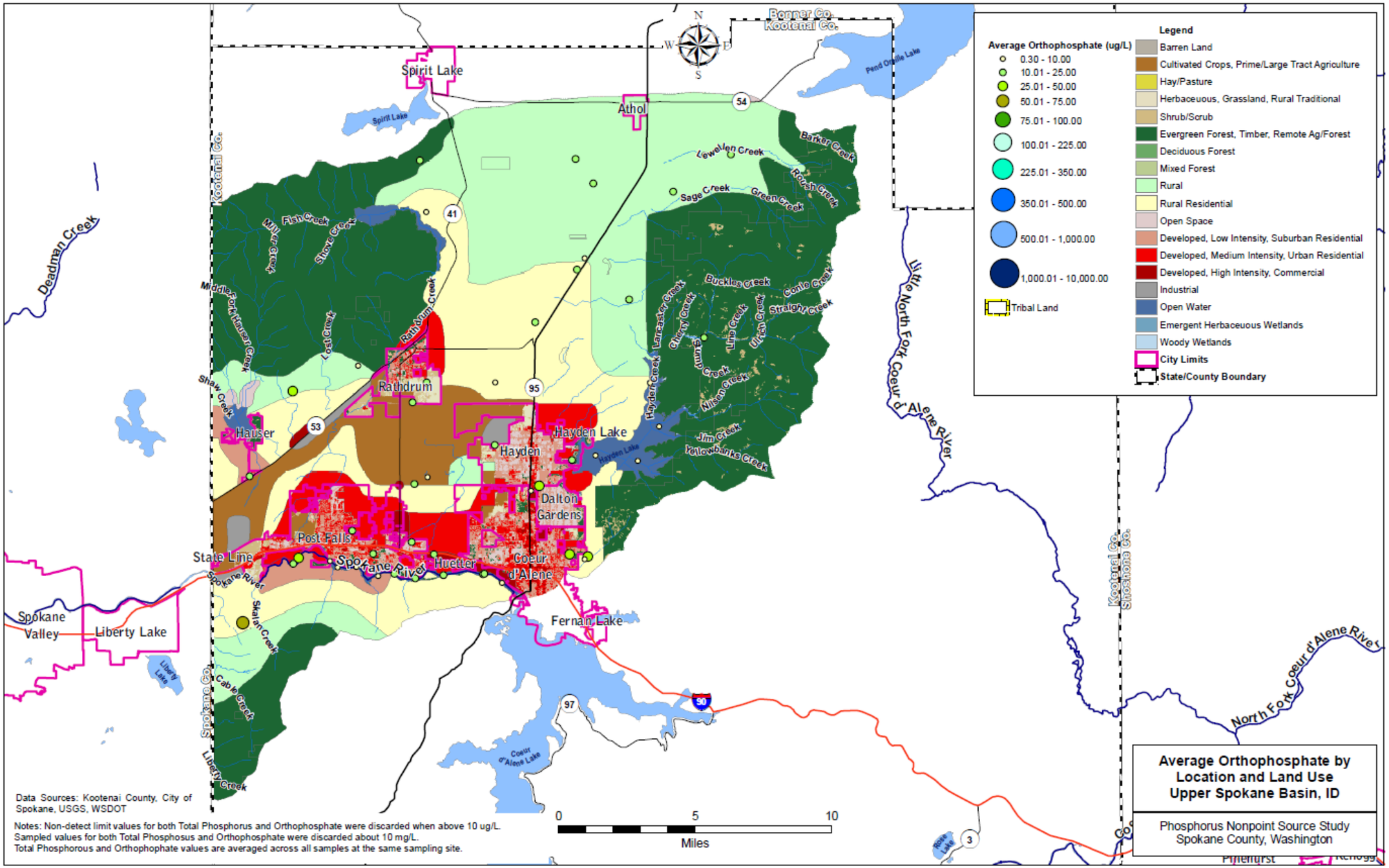

Figure 6.8. Average Orthophosphorus Concentration and Land Cover/Zoning with Stream Network for Upper Spokane Basin, WA

6.5 Upper Spokane, ID Subbasin

Land use and average phosphorus concentrations in the Upper Spokane, ID subbasin are shown in Figure 6.9 and Figure 6.10. The comprehensive land use zoning information from the City of Spokane and Kootenai County are shown. Major streams from the National Hydrography Dataset (NHD) are shown for the stream network.

The highest number of total phosphorus samples occurs along the Spokane River in developed areas and the communities of State Line, Post Falls, Huetter, and Coeur d'Alene. The majority of the total phosphorus samples for this subbasin are in areas with the greatest densities of people. These areas show the highest and lowest concentrations of phosphorus in the subbasin. The few samples from areas not in Spokane River corridor generally have low concentrations.

Orthophosphate samples are fairly consistent throughout the subbasin and across various land uses. For example, the rural, rural residential, and developed areas all show average orthophosphate values of 10 to 25 ug/L.

Total phosphorus concentrations do not appear to consistently increase from upstream to downstream along the Spokane River. Land uses that appear to be most related to phosphorus concentrations in the subbasin are developed lands. However, the forested areas and rural areas of the subbasin have sparse data coverage.

- Land uses appearing most correlated with greater total phosphorus concentrations:
    - Developed areas
- Land uses appearing most correlated with greater orthophosphorus concentrations:
    - Developed areas
- Land uses with uncertain impacts:
    - Forested, rural
- Other observations
    - Most of the subbasin has few phosphorus data which are low in concentration and may not be representative

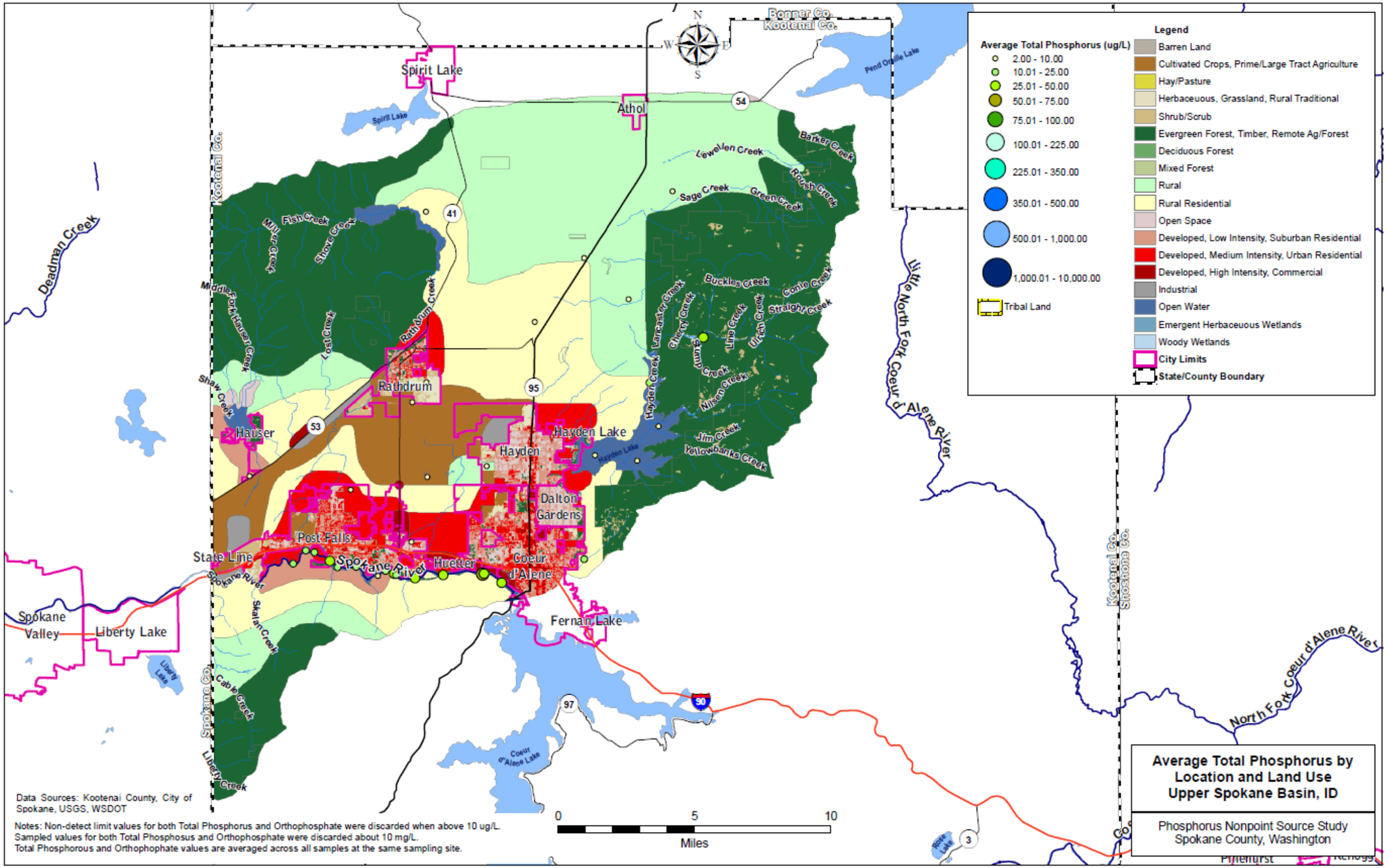

Figure 6.9. Average Phosphorus Concentration and Land Cover/Zoning with Stream Network for Upper Spokane Basin, ID

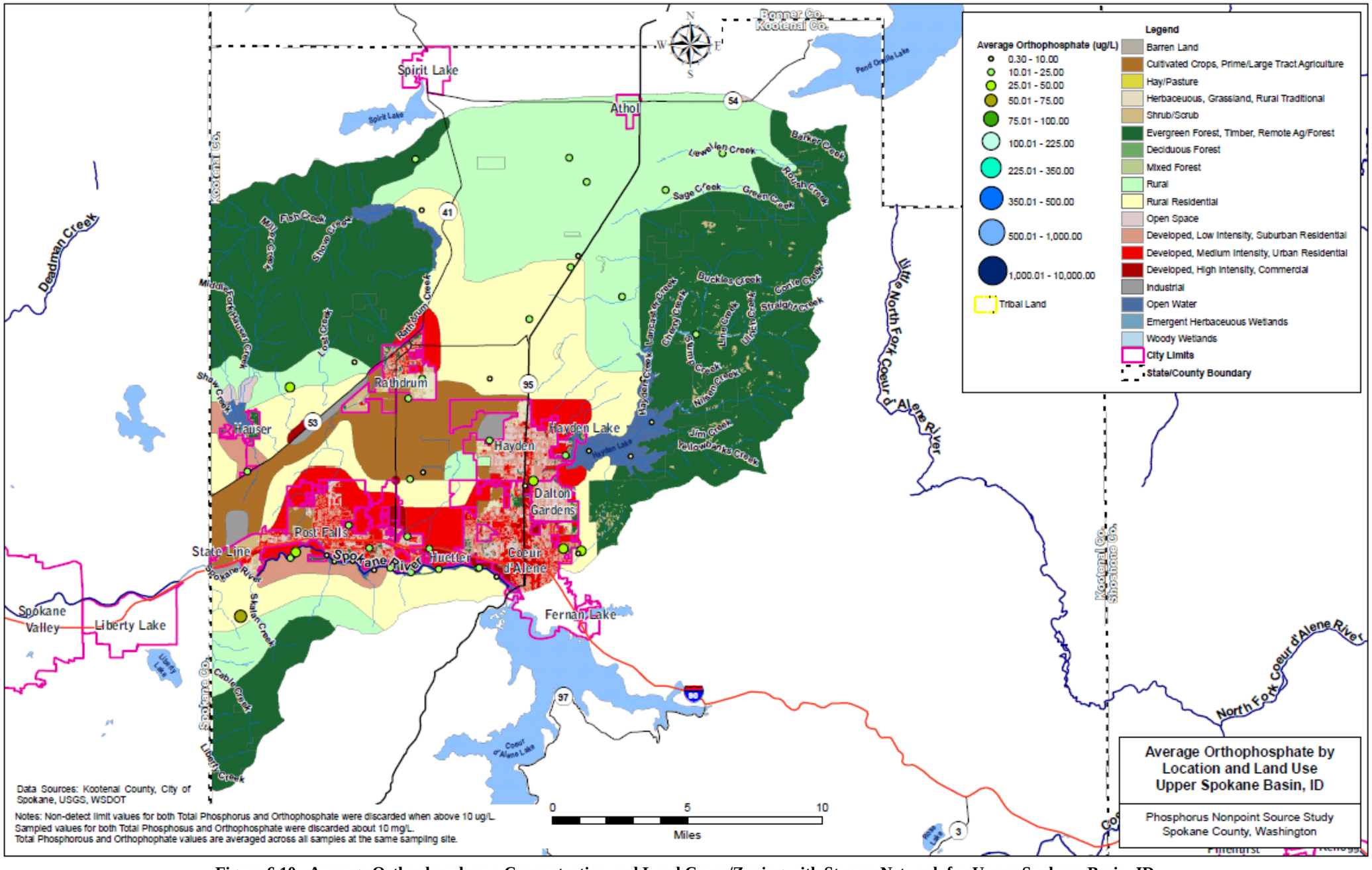

Figure 6.10. Average Orthophosphorus Concentration and Land Cover/Zoning with Stream Network for Upper Spokane Basin, ID

6.6 Pend Oreille Subbasin

Land use and average phosphorus concentrations in the Pend Oreille subbasin are shown in Figure 6.11 and Figure 6.12. The comprehensive land use zoning information from Spokane, Bonner, and Kootenai Counties are shown. The USGS land cover data from 2001 are shown for the portion of the subbasin in Pend Oreille County. Major streams from the National Hydrography Dataset (NHD) are shown for the stream network.

In general, limited total phosphorus and orthophosphate data are available in the subbasin. The rural and rural residential land uses contain all of the available data for both total phosphorus and orthophosphate. The forested areas of the subbasin have no data available.

The total phosphorus data that are available are located in land use delineated as rural residential areas in Bonner County. These data show relatively low values of total phosphorus. No data were available for the Spirit Lake area, another developed area in the subbasin.

More orthophosphate sampling results were available in the subbasin than total phosphorus results. Orthophosphate data at locations with total phosphorus show slightly higher concentrations, and like total phosphorus in the subbasin, the majority of the samples are available in the rural residential area. Only one sample of orthophosphate is available in the Spirit Lake area and is at the same level as samples in the rural residential land use.

- Land uses appearing most correlated with greater total phosphorus concentrations:
    - Rural
- Land uses appearing most correlated with greater orthophosphorus concentrations:
    - Rural
- Land uses with uncertain impacts:
    - Forested
- Other observations
    - The subbasin has few phosphorus data for interpretation

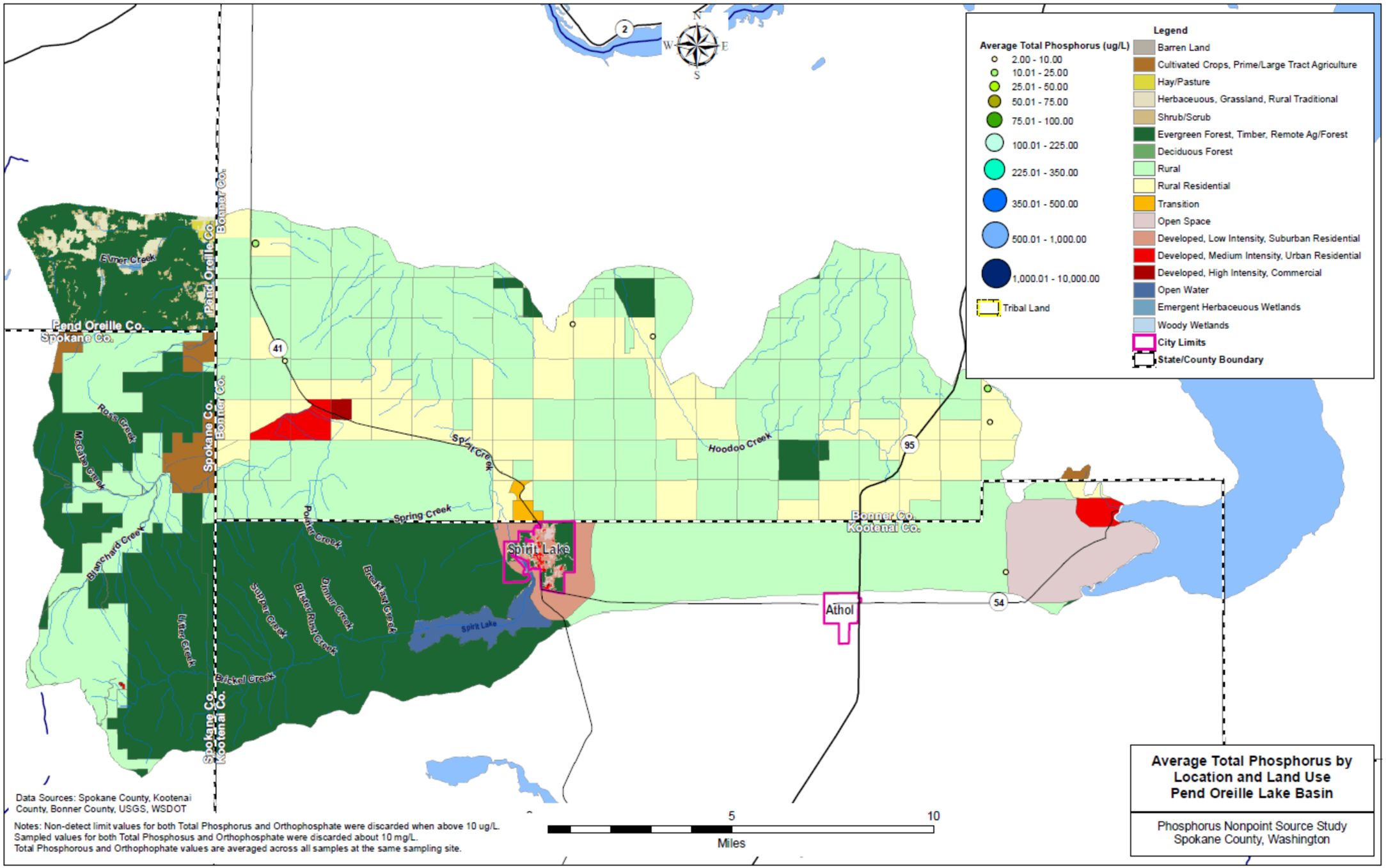

Figure 6.11. Average Phosphorus Concentration and Land Cover/Zoning with Stream Network for Pend Oreille Lake Basin

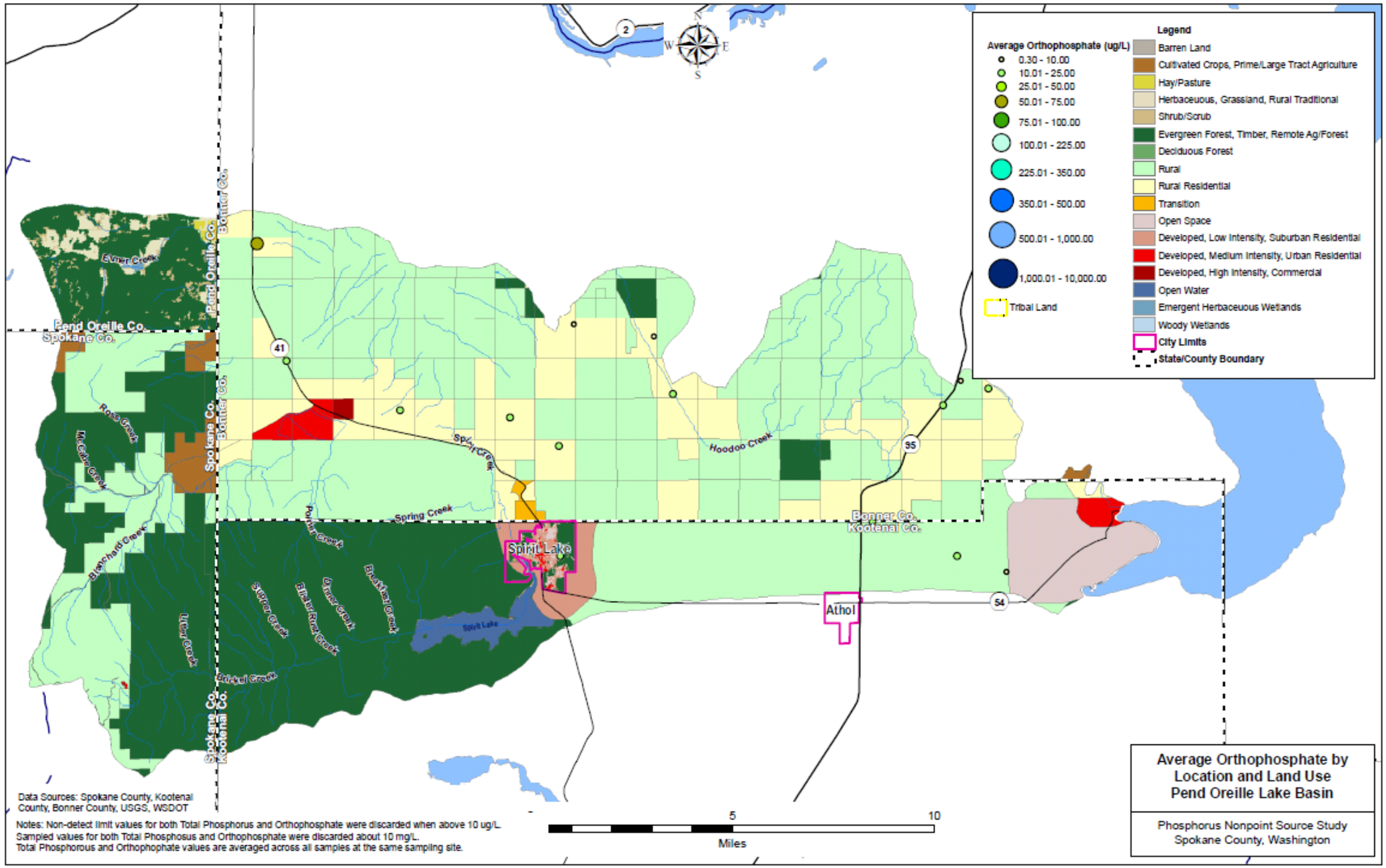

Figure 6.12. Average Orthophosphorus Concentration and Land Cover/Zoning with Stream Network for Pend Oreille Lake Basin

6.7 Coeur d'Alene Lake Subbasin

Land use and average phosphorus concentrations in the Coeur d'Alene subbasin are shown in Figure 6.13 and Figure 6.14. The comprehensive land use zoning information from Spokane County and Kootenai County are shown. The USGS land cover data from 2001 are shown for the portions of the subbasin in Shoshone and Benewah Counties. Major streams from the National Hydrography Dataset (NHD) are shown for the stream network.

The greatest average total phosphorus concentrations appear to be associated with agricultural land uses. For example, the highest concentrations of total phosphorus occur along Lake Creek on the west side of Coeur d'Alene Lake in tribal land and along the Coeur d'Alene River in the southeast portion of the subbasin. Relatively elevated total phosphorus concentrations in agricultural land uses also exist along Fighting Creek, Bellgrove Creek, and Lamb Creek, on the south and west sides of Coeur d'Alene Lake. These total phosphorus concentrations are all associated with the land use of large tracts of cultivated crops. Fertilization, plowing and other agricultural practices can often result in increasing phosphorus concentrations.

In developed areas, like the communities of Fernan Lake and Harrsion, few total phosphorus samples are available. In a developed area, one sample of elevated total phosphorus does exist in the community of Fernan Lake.

In the Coeur d'Alene Lake subbasin, fewer samples have been analyzed for orthophosphate. Of the samples that are available, the distribution pattern is similar to that of total phosphorus samples. The greater concentrations of orthophosphate appear to be related to agriculture and rural residential development. These samples all show relatively low levels of total phosphorus and orthophosphate.

Land uses that appear to be most related to phosphorus concentrations in the subbasin are agriculture and rural residential lands. The forested areas have few samples available in the subbasin.

- Land uses appearing most correlated with greater total phosphorus concentrations:
  - Agriculture, wetlands
- Land uses appearing most correlated with greater orthophosphorus concentrations:
  - Rural, wetlands
- Land uses with uncertain impacts:
  - Forested
- Other observations
  - Most of the phosphorus data in the subbasin are around Coeur d'Alene Lake and River

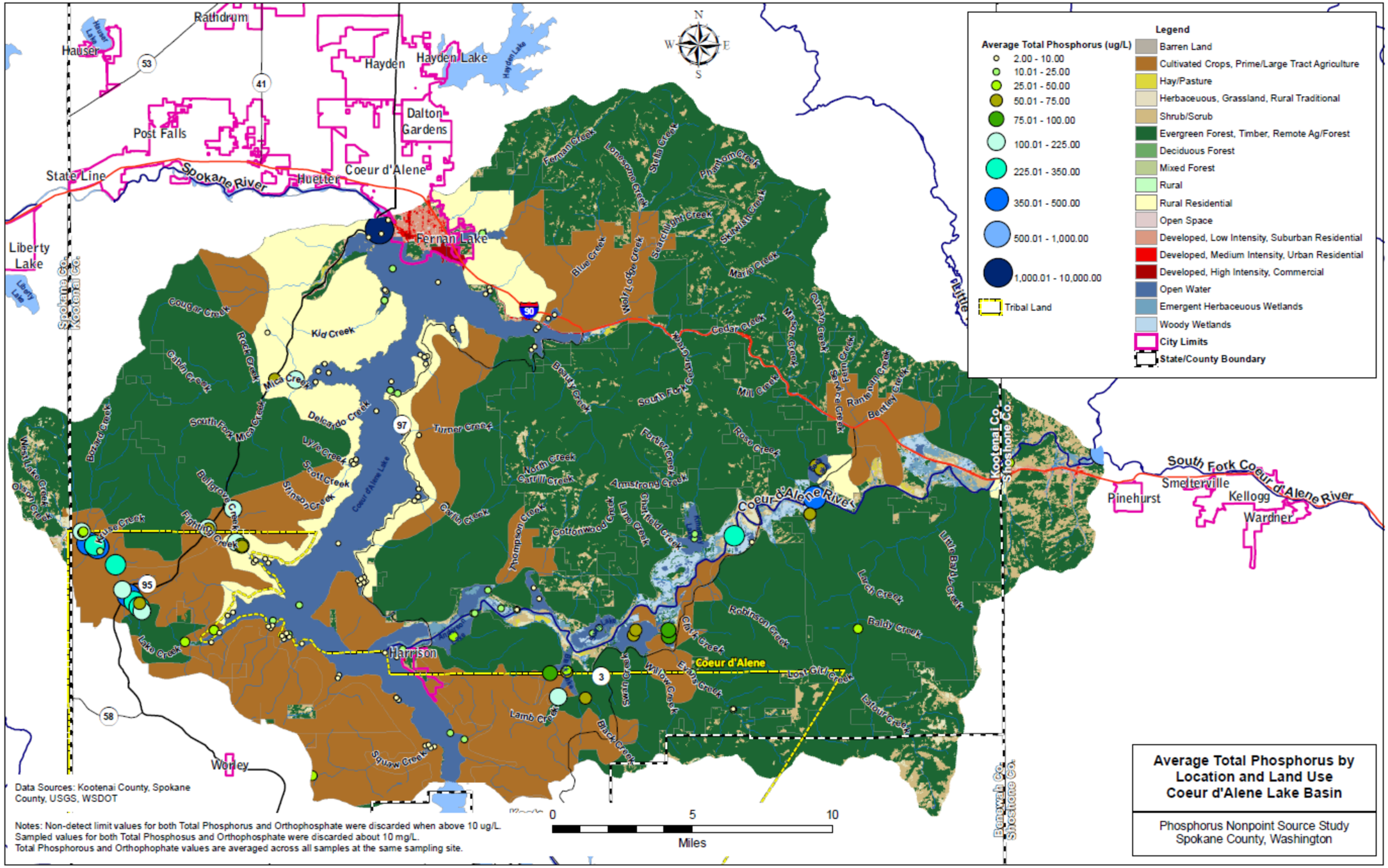

Figure 6.13. Average Phosphorus Concentration and Land Cover/Zoning with Stream Network for Coeur d'Alene Lake Basin

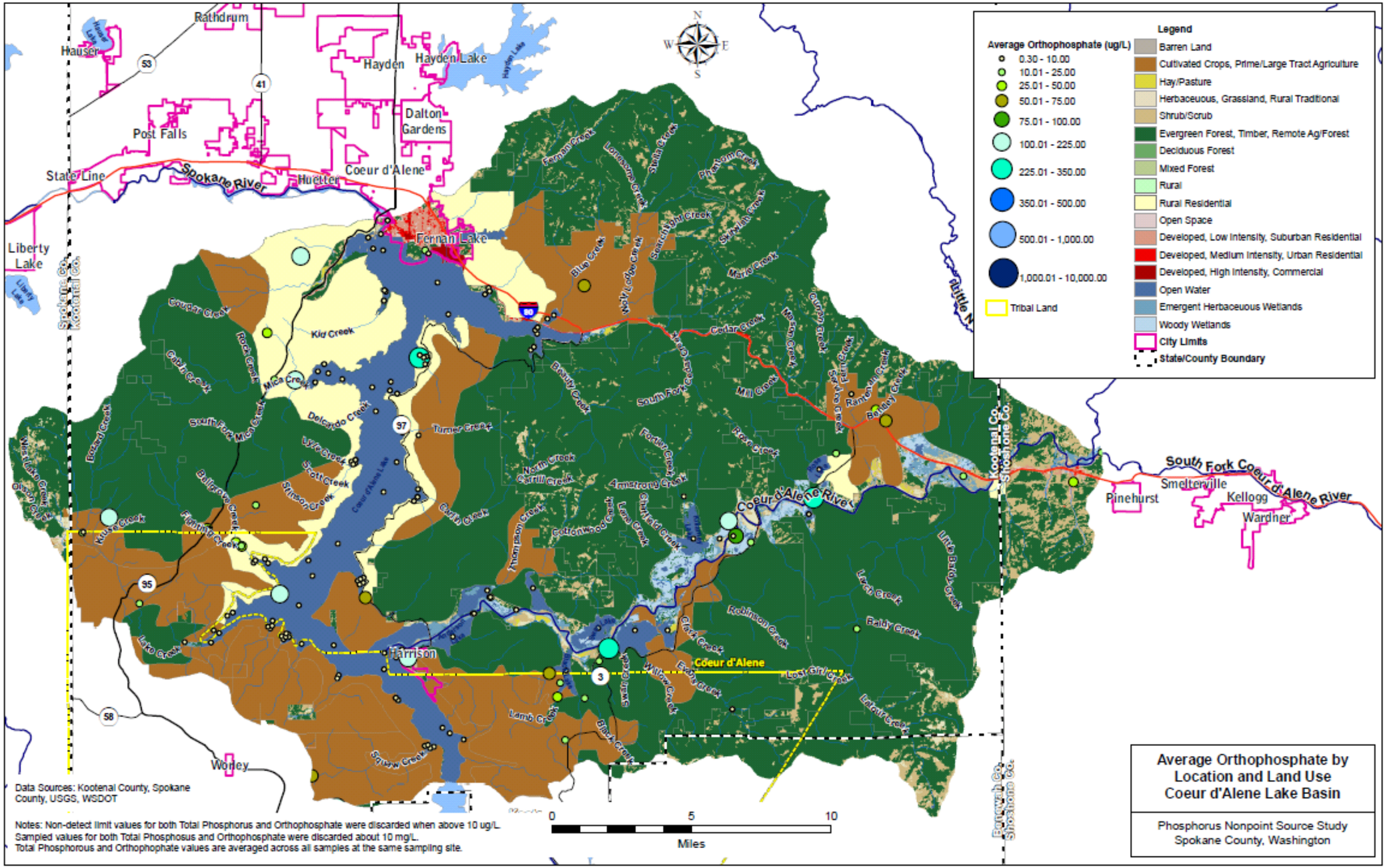

Figure 6.14. Average Orthophosphorus Concentration and Land Cover/Zoning with Stream Network for Coeur d'Alene Lake Basin

6.8 Upper Coeur d'Alene Subbasin

Land use and average phosphorus concentrations in the Upper Coeur d'Alene subbasin are shown in Figure 6.15 and Figure 6.16. The comprehensive land use zoning information from Bonner County and Kootenai County are shown. The USGS land cover data from 2001 are shown for the portion of the subbasin in Whitman and Benewah Counties. Major streams from the National Hydrography Dataset (NHD) are shown for the stream network.

The Upper Coeur d'Alene subbasin is almost entirely forested area and the majority of the subbasin is part of the Coeur d'Alene National Forest. In general, only a few samples of total phosphorus and orthophosphate in the Upper Coeur d'Alene subbasin are available. Total phosphorus samples are available on the downstream reaches of the North Fork Coeur d'Alene River and several of its tributaries. These samples show low concentrations of phosphorus with one high-concentration which may not be representative of overall conditions.

Several samples in the most downstream reach of the North Fork Coeur d'Alene River exhibit the largest phosphorus concentrations in the subbasin. Orthophosphate samples in the subbasin are also very low and concentrated in the southern portion of the subbasin.

- Land uses appearing most correlated with greater total phosphorus concentrations:
  - None
- Land uses appearing most correlated with greater orthophosphorus concentrations:
  - None
- Land uses with uncertain impacts:
  - Forested
- Other observations
  - The subbasin has few phosphorus data for interpretation

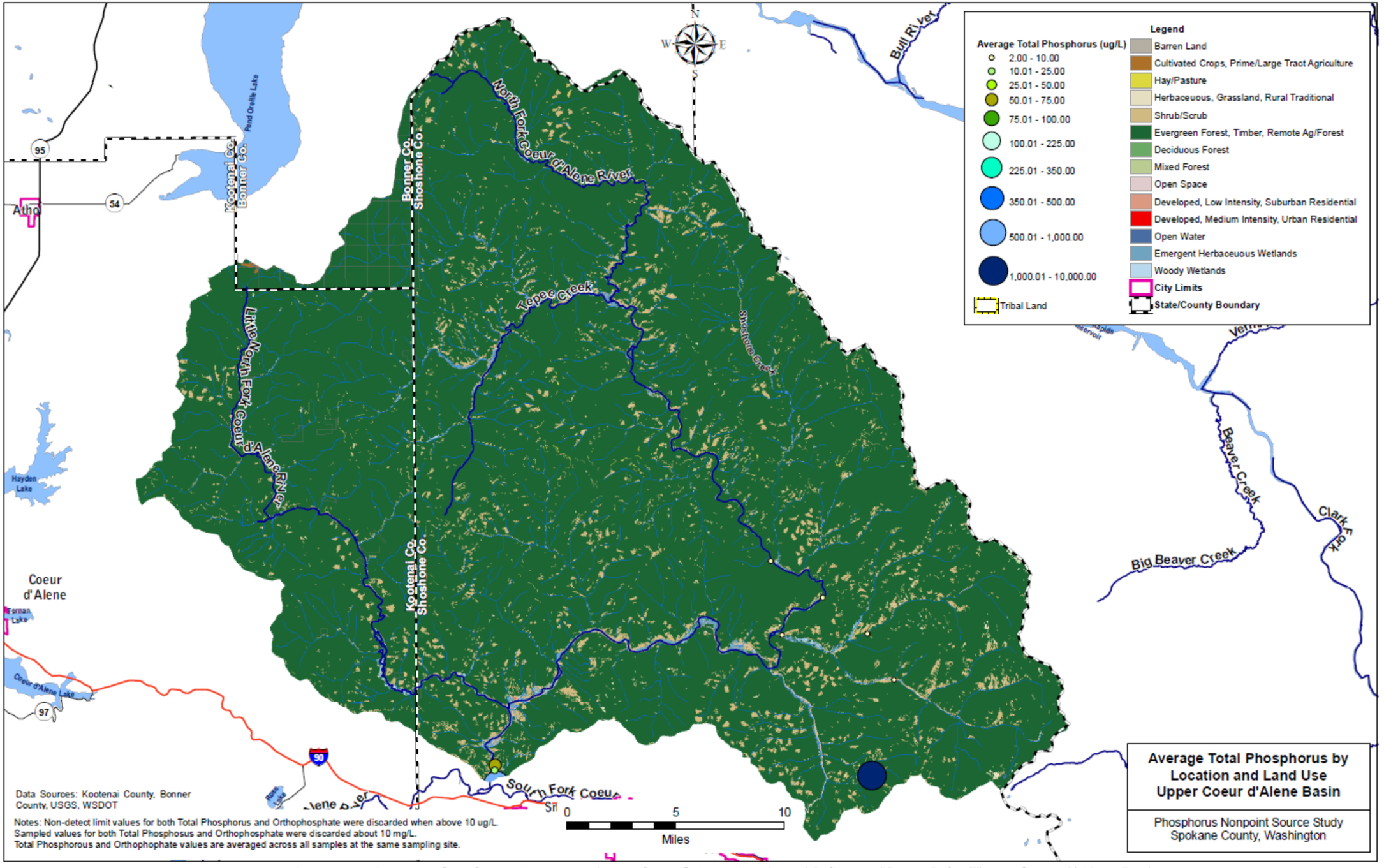

Figure 6.15 Average Phosphorus Concentration and Land Cover/Zoning with Stream Network for Upper Coeur d'Alene Basin

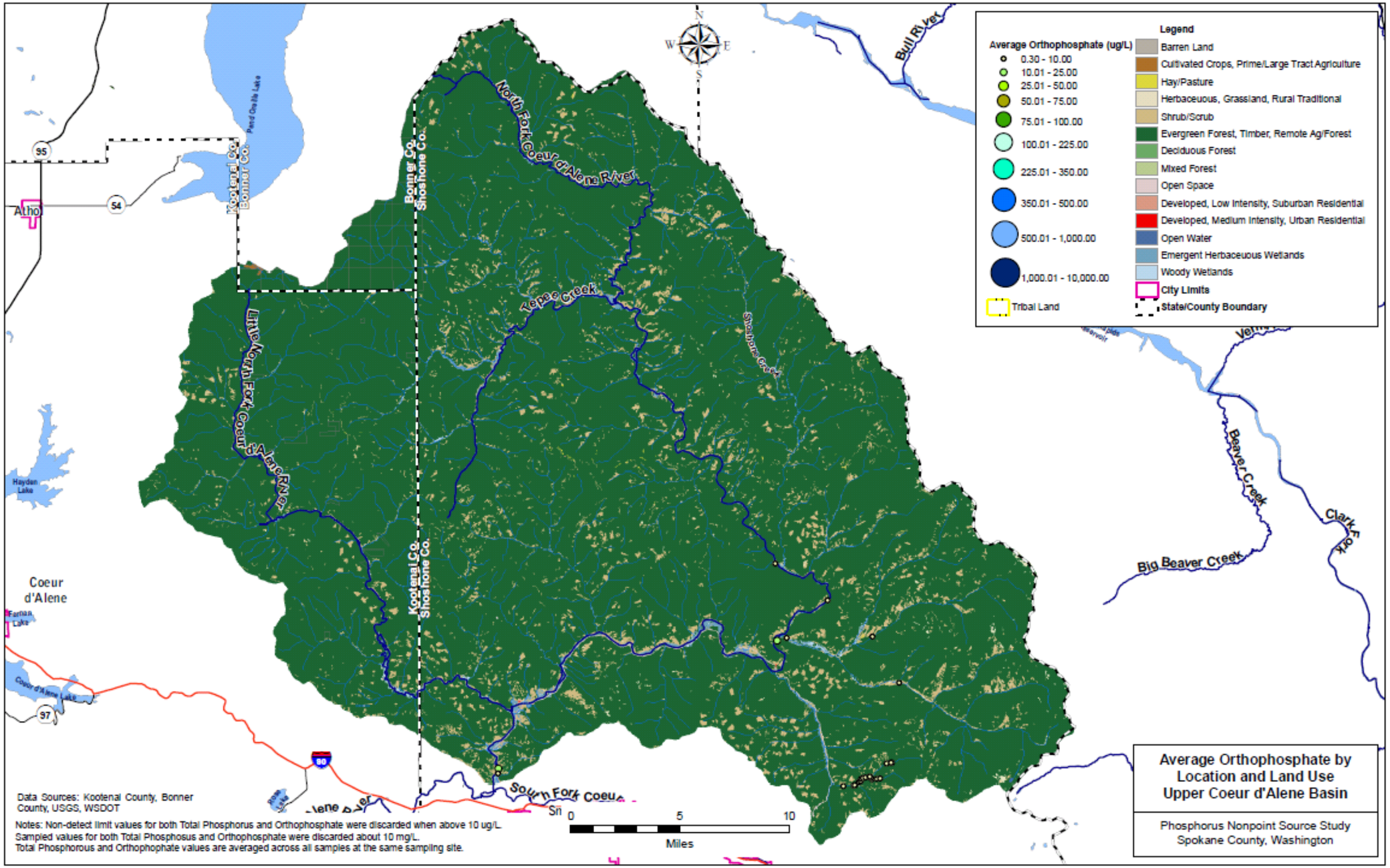

Figure 6.16. Average Orthophosphorus Concentration and Land Cover/Zoning with Stream Network for Upper Coeur d'Alene Basin

6.9 South Fork Coeur d'Alene Subbasin

Land use and average phosphorus concentrations in the South Fork Coeur d'Alene subbasin are shown in Figure 6.17 and Figure 6.18. The comprehensive land use zoning information from Kootenai County is shown. The USGS land cover data from 2001 are shown for the portion of the subbasin in Shoshone and Benewah Counties. Major streams from the National Hydrography Dataset (NHD) are shown for the stream network.

The majority of the South Fork Coeur d'Alene subbasin is forested, except for a corridor of development along Interstate Highway 90. The greatest phosphorus concentrations appear to be associated with these areas of development. For example, near the communities of Pinehurst, Smelterville, Kellogg, and Mullan, the average phosphorus concentrations are greater than in other areas of the subbasin. However, only two samples of total phosphorus located in the forested areas along the East Fork of Ninemile Creek and along Canyon Creek are available outside this corridor of development.

In the South Fork Coeur d'Alene subbasin of the orthophosphate samples that are available, the distribution pattern is similar to that of total phosphorus samples. The greater concentrations of orthophosphate appear to be related to development. As with total phosphorus, few orthophosphate samples are available in the forested areas of the subbasin. Three samples of orthophosphate are located in the forested areas of Bear Creek watershed, along the East Fork of Ninemile Creek, and along Canyon Creek.

Phosphorus concentrations do appear to increase from upstream to downstream along South Fork Coeur d'Alene River from low phosphorus values in Mullan to elevated levels near Smelterville and Pinehurst. Few samples are available for tributaries to the South Fork Coeur d'Alene River. Slightly greater phosphorus concentrations exist in East Fork of Ninemile Creek.

Land uses that appear to be most related to phosphorus concentrations in the subbasin are related to development. However, the subbasin is mostly forested and there are few samples available for comparison.

- Land uses appearing most correlated with greater total phosphorus concentrations:
    - Developed areas
- Land uses appearing most correlated with greater orthophosphorus concentrations:
    - Developed areas
- Land uses with uncertain impacts:
    - Forested
- Other observations
    - Most of the subbasin does not have phosphorus data

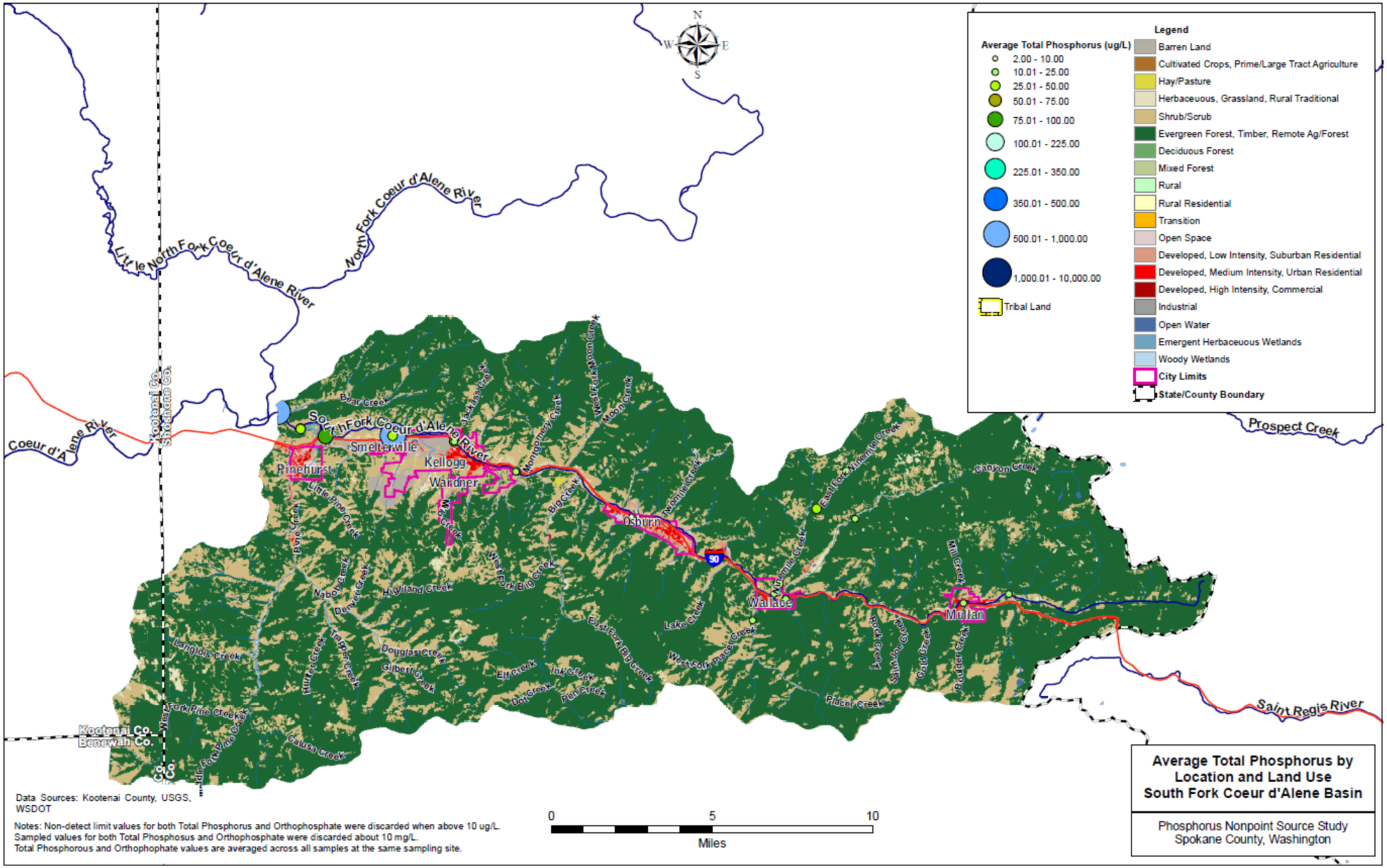

Figure 6.17. Average Phosphorus Concentration and Land Cover/Zoning with Stream Network for South Fork Coeur d'Alene Basin

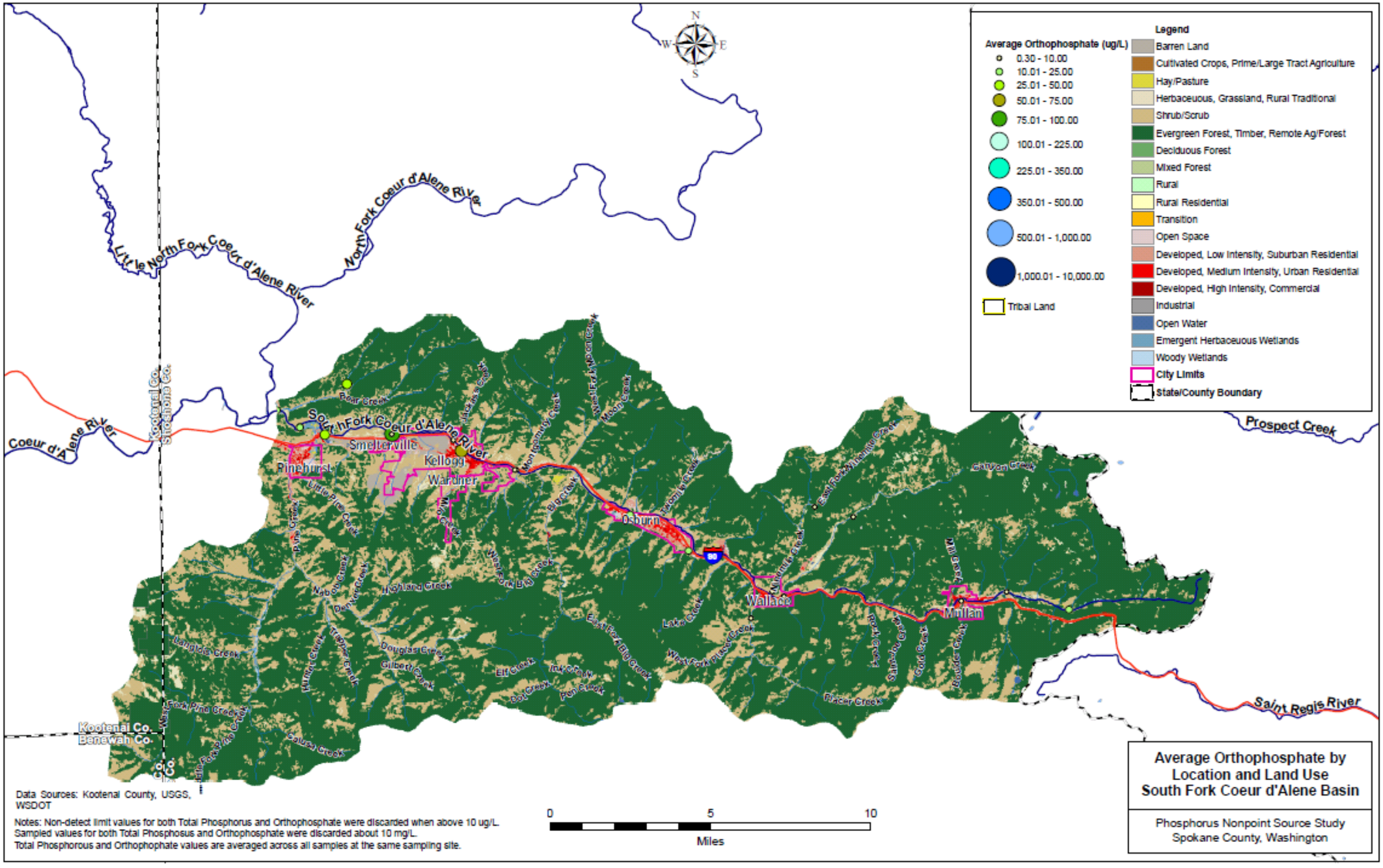

Figure 6.18. Average Orthophosphorus Concentration and Land Cover/Zoning with Stream Network for South Fork Coeur d'Alene Basin

6.10 St. Joe Subbasin

Land use and average phosphorus concentrations in the St. Joe subbasin are shown in Figure 6.19 and Figure 6.20. The comprehensive land use zoning information from Kootenai County is shown. The USGS land cover data from 2001 are shown for the portion of the subbasin in Shoshone, Benewah, Clearwater, and Latah Counties. Major streams from the National Hydrography Dataset (NHD) are shown for the stream network.

The majority of the St. Joe subbasin is classified as forest or shrub land use, but the greatest phosphorus concentrations appear to be associated with locations of greater development. For example, near the communities of Plummer and St. Maries, the average phosphorus concentrations are greater than in other areas of the subbasin.

In the St. Joe subbasin, the distribution pattern of orthophosphate is similar to that of total phosphorus samples. However, the greater concentrations of orthophosphate appear to be more evenly spread between development and forested areas. For example, the orthophosphate concentrations along Santa Creek, Benewah Creek, and a tributary near the Shoshone and Benewah County line show elevated levels of orthophosphate in forested or shrub-covered areas.

Phosphorus concentrations do not necessarily appear to increase from upstream to downstream along St. Joe River or Saint Maries River although few samples are available along either river. There are greater phosphorus concentrations in some of the tributaries, including Benewah Creek and Little Plummer Creek.

Land uses that appear to be most related to phosphorus concentrations in the subbasin are related to development. However, elevated orthophosphate samples in forested areas area show that these land uses are also impacting phosphorus concentrations.

- Land uses appearing most correlated with greater total phosphorus concentrations:
    - Developed areas
- Land uses appearing most correlated with greater orthophosphorus concentrations:
    - Developed areas, forested
- Land uses with uncertain impacts:
    - Forested
- Other observations
    - Most of the subbasin does not have phosphorus data

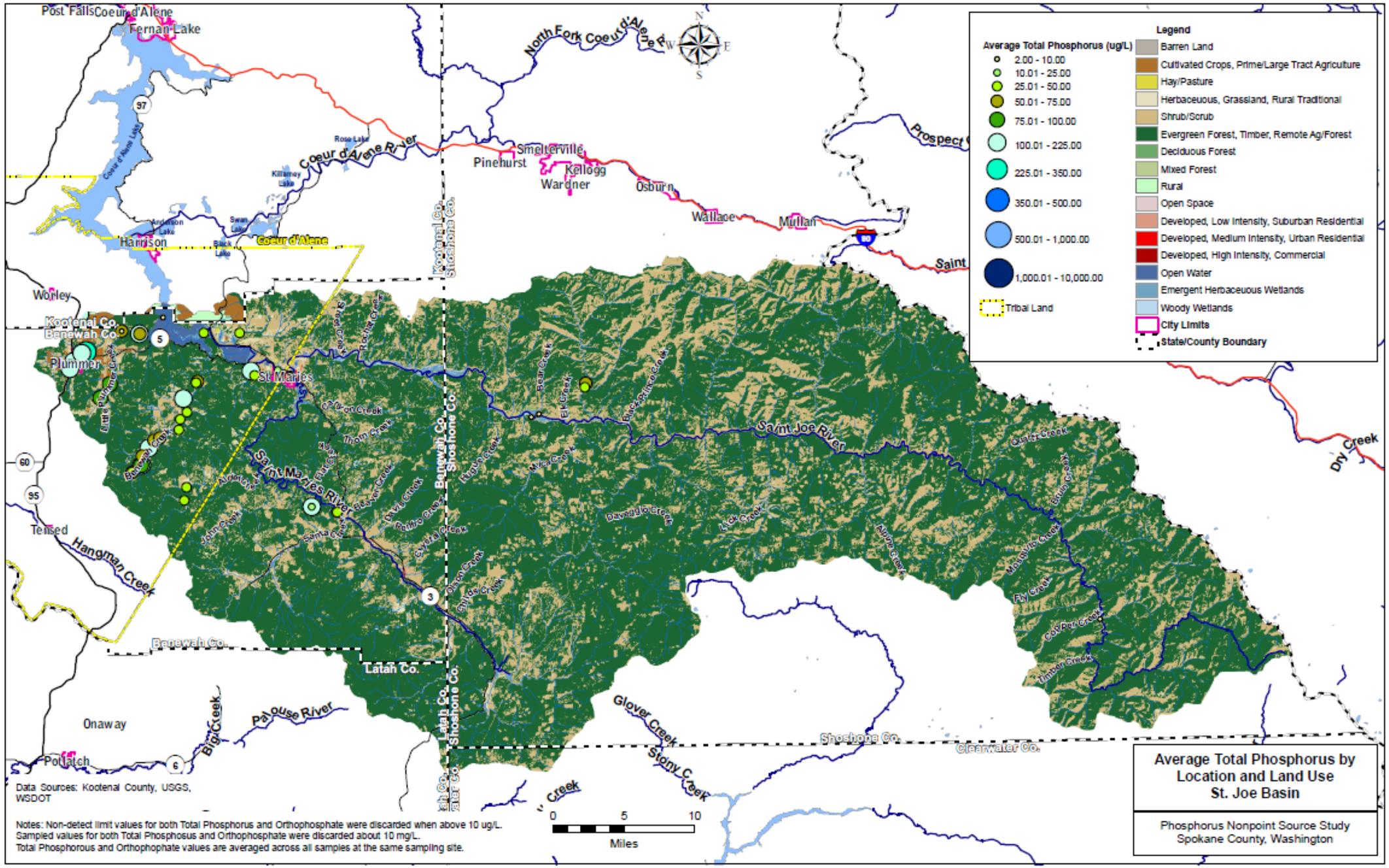

Figure 6.19. Average Phosphorus Concentration and Land Cover/Zoning with Stream Network for St. Joe Basin

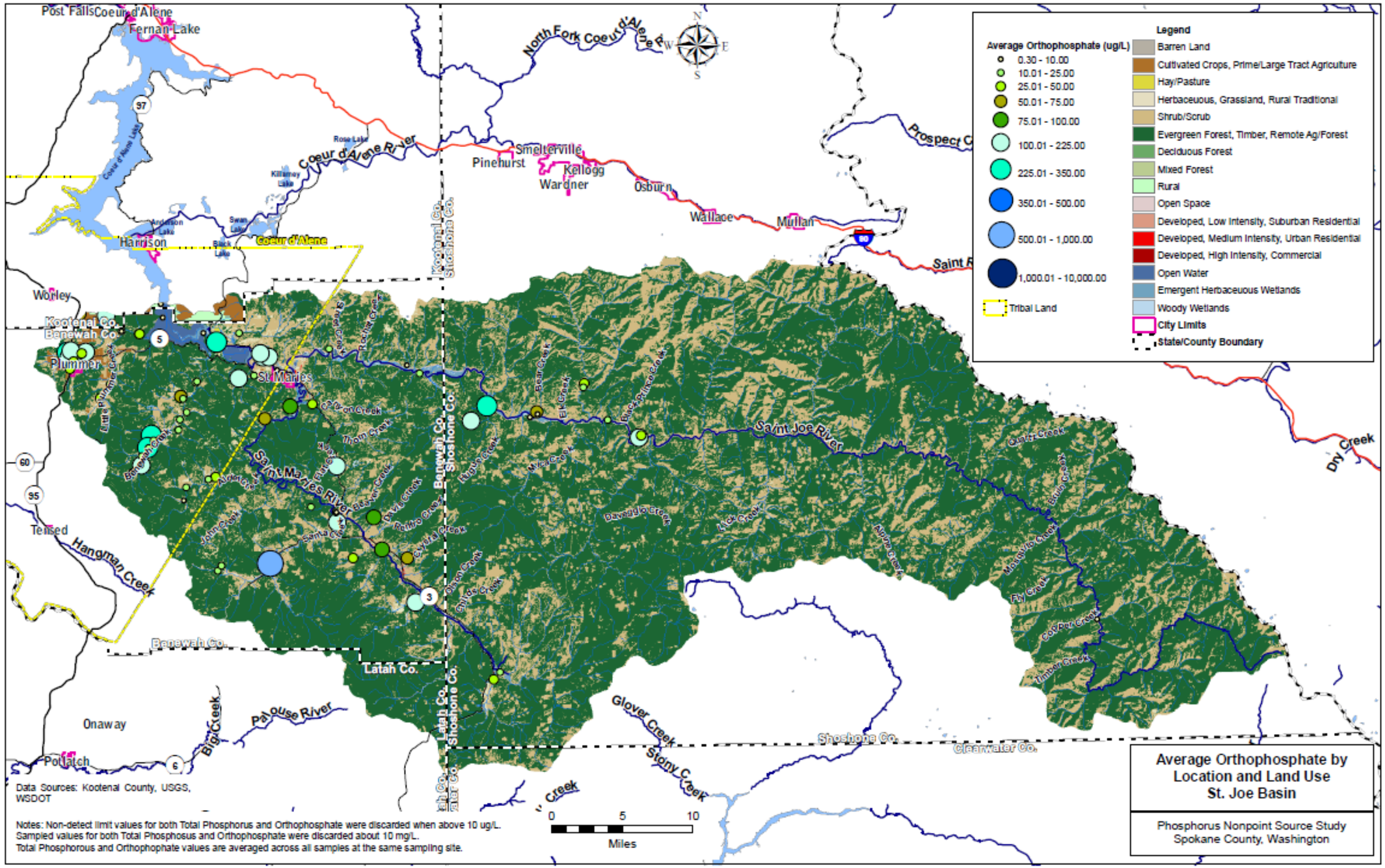

Figure 6.20. Average Orthophosphorus Concentration and Land Cover/Zoning with Stream Network for St. Joe Basin

6.11 Spokane River Watershed Summary

Average total phosphorus and orthophosphorus for the Spokane Basin are shown in Figure 6.21 and Figure 6.22, respectively. In general across the basin, fewer samples of orthophosphate are available than of total phosphorus. The greatest average total phosphorus concentrations appear to be associated with locations of greater development. In most cases in the basin, the areas of greatest development are near rivers and streams. The samples from forested and shrub areas generally have lower phosphorus and orthophosphate concentrations; whereas, higher phosphorus concentrations are from areas with agricultural and urban/suburban land uses.

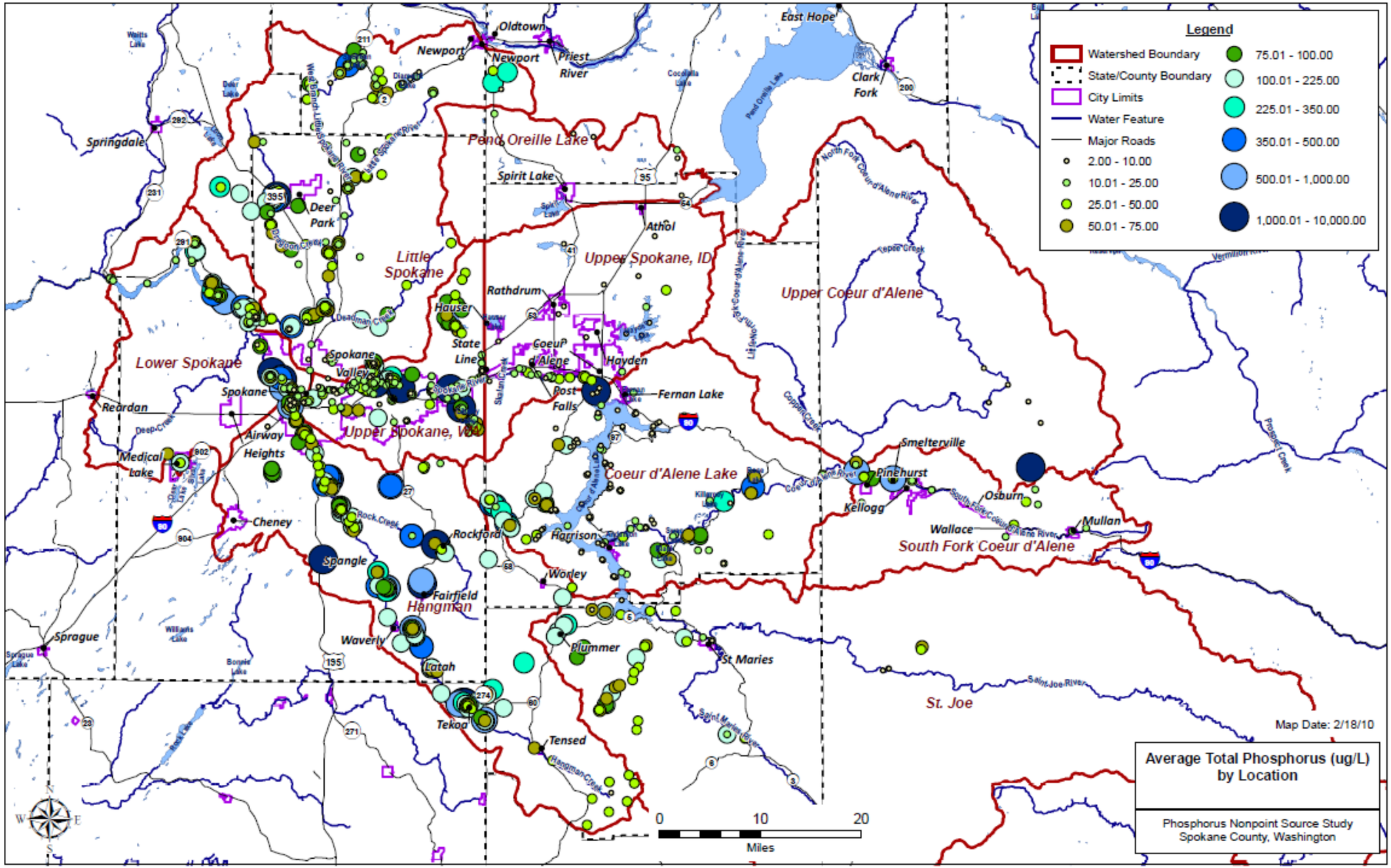

Figure 6.21. Average Phosphorus Concentration and Land Cover/Zoning with Stream Network for Spokane River Watershed

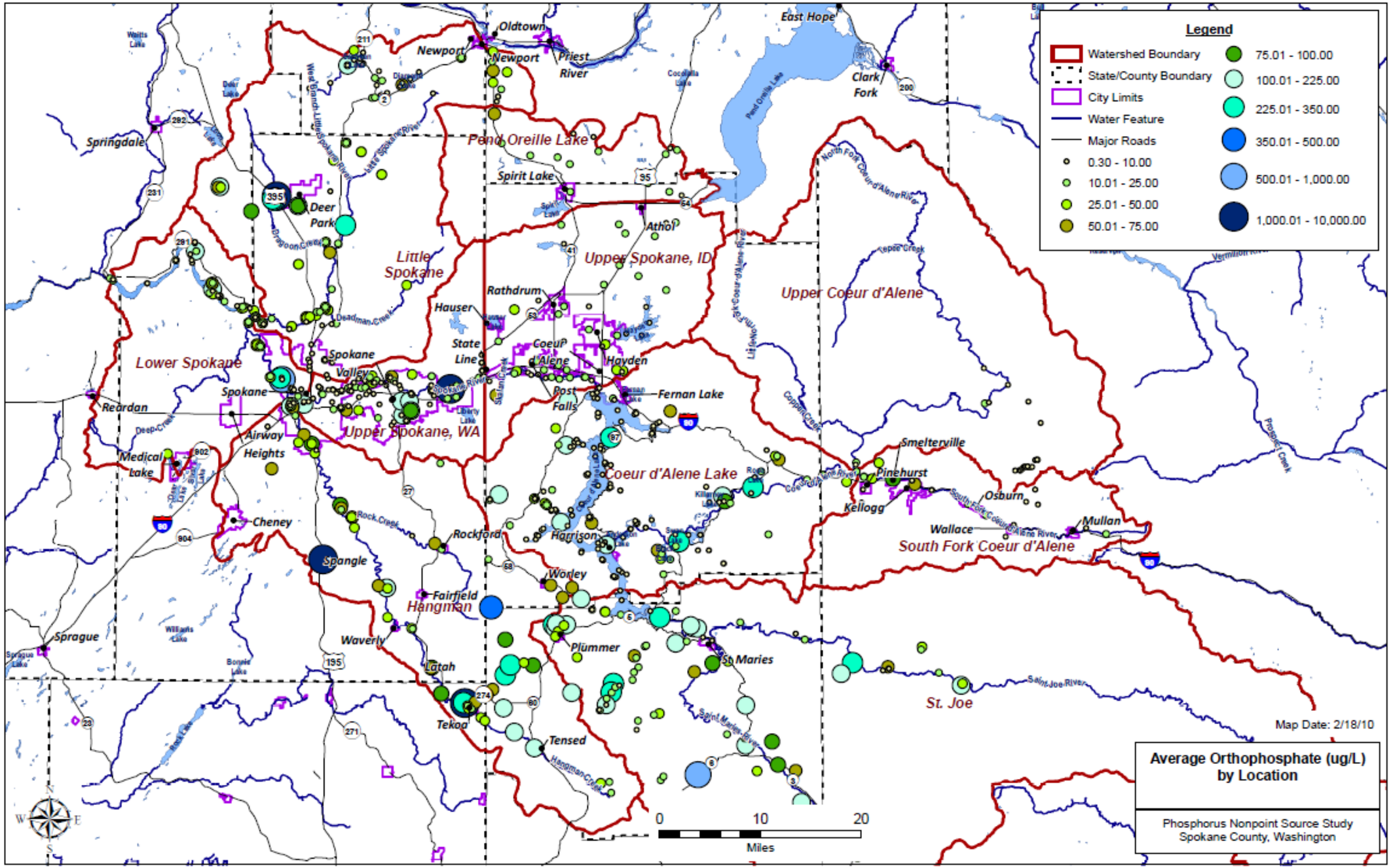

Figure 6.22. Average Orthophosphorus Concentration and Land Cover/Zoning with Stream Network for Spokane River Watershed

Citations

Ecology. 2008. Spokane River and Lake Spokane Dissolved Oxygen Total Maximum Daily Load, Water Quality Improvement Report. Publication No. 07-10-073. May 2008. Department of Ecology, State of Washington, Olympia, WA.

Ecology. 2009. Frequently Asked Questions about Protecting Oxygen in the Spokane River. 04-10-073, September 2004. Washington State Department of Ecology, Olympia, WA. http://www.ecy.wa.gov/biblio/0410073.html

Geo. 2008a. GeoEngineers Memorandum, Subject: Phase 1 Non-Point Study – Credible Data Review Approach. June 26, 2008.

Geo. 2008b. GeoEngineers Memorandum, Subject: Database Structure and Data Entry Specifications, Spokane County Bi-State Nonpoint Source Phosphorus Study, Phase 1, November 18, 2008.

HDR. 2009a. Spokane River Non-Point Source Analysis Project Phase 1 Surface Water Total Phosphorus Data Analysis.

HDR. 2009b. HDR Memorandum, Subject: Spokane River Non-Point Source Analysis Project, Options for Phosphorus Data Analysis Draft, March 31, 2009.

HDR. 2010. Spokane River Non-Point Source Analysis Project Supplemental Phase 1 Surface Water Orthophosphorus Data Analysis.

Appendix A. Land Use Data Sources

Idaho

- Bonner County
    - Digital zoning (downloaded 12/2009; 2008 update)
    - and comprehensive plan (downloaded 12/2009; 2006 update)
- Shoshone County
    - No web site
- Latah County
    - On line comprehensive plan; have to pay for digital data ($250 for zoning)
- Benewah County
    - No web site
- Kootenai County
    - Digital zoning (no metadata, downloaded 12/2009)
    - and comprehensive plan (no metadata, downloaded 5/2009)
    - City of Coeur d'Alene
    - City of Post Falls
- Clearwater County
    - Zoning online – downloaded .jpg 12/2009

Washington

- Spokane
    - Digital Zoning (2007 – no metadata)
    - City of Spokane
        - Digital zoning (June 2008)
        - and comprehensive plan (June 2008)
    - City of Cheney – land use .pdf
- Pend Oreille
    - No zoning or comprehensive plan – digital download roads file 12/2009
- Stevens
    - Zoning and comprehensive plan online – downloaded .pdf 12/2009. Can order GIS data
- Lincoln
    - Zoning online – downloaded .pdf 12/2009
- Whitman
    - Already done – only touches Hangman

Land Use / Land Cover Datasets

National land cover datasets – 2001; USGS

The National Land Cover Database 2001 land cover layer for mapping zone 01 was produced through a cooperative project conducted by the Multi-Resolution Land Characteristics (MRLC) Consortium. The MRLC Consortium is a partnership of federal agencies (www.mrlc.gov), consisting of the U.S. Geological Survey (USGS), the National Oceanic and Atmospheric Administration (NOAA), the U.S. Environmental Protection Agency (EPA), the U.S. Department of Agriculture (USDA), the U.S. Forest Service (USFS), the National Park Service (NPS), the U.S. Fish and Wildlife Service (FWS), the Bureau of Land Management (BLM) and the USDA Natural Resources Conservation Service (NRCS). One of the primary goals of the project is to generate a current, consistent, seamless, and accurate National Land cover Database (NLCD) circa 2001 for the United States at medium spatial resolution. This landcover map and all documents pertaining to it are considered "provisional" until a formal accuracy assessment can be conducted. For a detailed definition and discussion on MRLC and the NLCD 2001 products, refer to Homer et al. (2004) and http://www.mrlc.gov/mrlc2k.asp.

The NLCD 2001 is created by partitioning the U.S. into mapping zones. A total of 66 mapping zones were delineated within the conterminous U.S. based on ecoregion and geographical characteristics, edge matching features and the size requirement of Landsat mosaics. Mapping zone 01 encompasses whole or portions of several states, including the state of Washington. Questions about the NLCD mapping zone 01 can be directed to the NLCD 2001 land cover mapping team at the USGS/EROS, Sioux Falls, SD (605) 594-6151 or mrlc@usgs.gov.

Appendix B. Mapping

NHDM for flowlines and water features

Jurisdiction	Code Values	Mapped To	Code Value Explanation
St. Joe Basin			
Kootenai County Comprehensive Plan			
	AGRICULTURE	Cultivated Crops, Prime/Large Tract Agriculture	
	FEDERAL_LANDS	not shown	
	LEGEND	not shown	
	RURAL	Rural	
	SURFACE_WATER_SURFACE_AREA	Open Water	
	TIMBER	Evergreen Forest	
	TRIBAL_TRUST	Rural	
	OPEN_SPACE_LIMITED_RES	Open Space	
Benewah			
Latah			
Shoshone			
Clearwater			
Coeur d'Alene Lake Basin			
Kootenai County Comprehensive Plan			
	AGRICULTURE	Cultivated Crops, Prime/Large Tract Agriculture	
	COMMERCIAL	Developed, High Intensity, Commercial	
	FEDERAL_LANDS	not shown	
	OPEN_SPACE_LIMITED_RES	Open Space	
	RURAL	Rural Residential	
	RURAL_RESIDENTIAL	Rural Residential	
	SURFACE_WATER_SURFACE_AREA	Open Water	
	TIMBER	Evergreen Forest	
	TRIBAL_TRUST	Rural	
Spokane County			
Shoshone			

Jurisdiction	Code Values	Mapped To	Code Value Explanation
County			
Benewah County			
South Fork Coeur d'Alene Basin			
Kootenai County Comprehensive Plan			
	TIMBER	Evergreen Forest	
Benewah			
Shoshone			
Lower Spokane Basin			
Spokane County Zoning			
	HDR	Developed, Medium Intensity, Urban Residential	Medium Density Residential
	LDR	Developed, Low Intensity, Suburban Residential	Low Density Residential
	LI	Industrial	Light Industrial
	LTA	Cultivated Crops, Prime/Large Tract Agriculture	Large Tract Agriculture
	MU	Developed, Medium Intensity, Urban Residential	Mixed Use
	MZ	Rural	Mineral Land
	NC	Developed, High Intensity, Commercial	Neighborhood Commercial
	R-5	Rural Residential	Rural Residentail/1 DU per 5 acres
	RAC	Developed, Low Intensity, Suburban Residential	Rural Activity Center
	RC	Developed, High Intensity, Commercial	Regional Commercial
	RCV	Rural	Rural Conservation
	RT	Transition	Rural Traditional
	UR	Transition	Urban Reserve
City of Spokane Zoning			
	Center and Corridor	Developed, High Intensity,	

Jurisdiction	Code Values	Mapped To	Code Value Explanation
		Commercial	
	Commercial	Developed, High Intensity, Commercial	
	High Density Residential	Developed, Medium Intensity, Urban Residential	
	Industrial	Industrial	
	Low Density Residential	Developed, Low Intensity, Suburban Residential	
	Medium Density Residential	Developed, Low Intensity, Suburban Residential	
	Neighborhood Retail	Developed, Medium Intensity, Urban Residential	
	Office	Developed, Low Intensity, Suburban Residential	
City of Airway Heights			
City of Medical Lake			
Fairchild Air Force Base			
Lincoln County			
Stevens County			
Upper Spokane Basin, Idaho			
Kootenai County Comprehensive Plan			
	AGRICULTURE	Cultivated Crops, Prime/Large Tract Agriculture	
	COMMERCIAL	Developed, High Intensity, Commercial	
	FEDERAL_LANDS	not shown	
	INDUSTRIAL	Industrial	
	OPEN_SPACE_LIMITED_RES	Open Space	
	RURAL	Rural	
	RURAL_RESIDENTIAL	Rural Residential	
	SUBURBAN_RES	Developed, Low Intensity, Suburban Residential	
	SURFACE_WATER_SURFACE_AREA	Open Water	
	TIMBER	Evergreen Forest	
	URBAN_RES	Developed, Medium Intensity,	

Jurisdiction	Code Values	Mapped To	Code Value Explanation
		Urban Residential	
City of Rathdrum			
City of Hayden			
City of Hayden Lake			
City of Dalton Gardens			
City of Coeur d'Alene			
City of Post Falls			
City of State Line			
Upper Spokane Basin, Washington			
Spokane County Zoning			
	CC	Developed, High Intensity, Commercial	Community Commercial
	FZ	Evergreen Forest	Forest Land
	HDR	Developed, Medium Intensity, Urban Residential	High Density Residential
	LDAC	Developed, Medium Intensity, Urban Residential	Limited Development Area - Commercial
	LDR	Developed, Low Intensity, Suburban Residential	Low Density Residential
	LI	Industrial	Light Industrial
	MDR	Developed, Medium Intensity, Urban Residential	Medium Density Residential
	MU	Developed, Medium Intensity, Urban Residential	Mixed Use
	MZ	Rural	Mineral Land
	NC	Developed, High Intensity, Commercial	Neighborhood Commercial
	R-5	Rural Residential	Rural Residentail/1 DU per 5 acres
	RAC	Developed, Low Intensity, Suburban Residential	Rural Activity Center
	RC	Developed, High Intensity, Commercial	Regional Commercial
	RCV	Rural	Rural

Jurisdiction	Code Values	Mapped To	Code Value Explanation
			Conservation
	RT	Transition	Rural Traditional
	STA	Cultivated Crops, Prime/Large Tract Agriculture	Small Tract Agricultural
	UR	Transition	Urban Reserve
City of Spokane Zoning			
	Center and Corridor	Developed, High Intensity, Commercial	
	Central Business District	Developed, High Intensity, Commercial	
	Commercial	Developed, High Intensity, Commercial	
	High Density Residential	Developed, Medium Intensity, Urban Residential	
	Industrial	Industrial	
	Low Density Residential	Developed, Low Intensity, Suburban Residential	
	Medium Density Residential	Developed, Low Intensity, Suburban Residential	
	Neighborhood Retail	Developed, Medium Intensity, Urban Residential	
	Office	Developed, Low Intensity, Suburban Residential	
City of Spokane Valley			
City of Liberty Lake			
Little Spokane Basin			
Spokane County Zoning			
	CC	Developed, High Intensity, Commercial	Community Commercial
	FZ	Evergreen Forest	Forest Land
	HDR	Developed, Medium Intensity, Urban Residential	High Density Residential
	HI	Industrial	Heavy Industrial
	LDAC	Developed, Medium Intensity, Urban Residential	Limited Development Area - Commercial
	LDR	Developed, Low Intensity,	Low Density

Jurisdiction	Code Values	Mapped To	Code Value Explanation
		Suburban Residential	Residential
	LDR-P	Developed, Medium Intensity, Urban Residential	Low Density Residential Plus
	LI	Industrial	Light Industrial
	MDR	Developed, Medium Intensity, Urban Residential	Medium Density Residential
	MU	Developed, Medium Intensity, Urban Residential	Mixed Use
	MZ	Rural	Mineral Land
	NC	Developed, High Intensity, Commercial	Neighborhood Commercial
	R-5	Rural Residential	Rural Residentail/1 DU per 5 acres
	RAC	Developed, Low Intensity, Suburban Residential	Rural Activity Center
	RC	Developed, High Intensity, Commercial	Regional Commercial
	RCV	Rural	Rural Conservation
	RT	Transition	Rural Traditional
	STA	Cultivated Crops, Prime/Large Tract Agriculture	Small Tract Agricultural
	UR	Transition	Urban Reserve
City of Spokane Zoning			
	Center and Corridor	Developed, High Intensity, Commercial	
	Commercial	Developed, High Intensity, Commercial	
	High Density Residential	Developed, Medium Intensity, Urban Residential	
	Industrial	Industrial	
	Low Density Residential	Developed, Low Intensity, Suburban Residential	
	Medium Density Residential	Developed, Low Intensity, Suburban Residential	
	Neighborhood Retail	Developed, Medium Intensity, Urban Residential	
	Office	Developed, Low Intensity, Suburban Residential	
Bonner County Comprehensive Plan			

Jurisdiction	Code Values	Mapped To	Code Value Explanation
	Ag/Forest Land	Rural	
	Rural Residential	Rural Residential	
	Suburban Growth Area	Transition	
	Transition	Transition	
Stevens County			
Pend Oreille County			
City of Deer Park			
Pend Oreille Lake Basin			
Spokane Couny Zoning			
	FZ	Evergreen Forest	Forest Land
	LDAC	Developed, Medium Intensity, Urban Residential	Limited Development Area - Commercial
	RC	Developed, High Intensity, Commercial	Regional Commercial
	RCV	Rural	Rural Conservation
	RT	Transition	Rural Traditional
Kootenai County Comp Plan			
	OPEN_SPACE_LIMITED_RES	Open Space	
	RURAL	Rural	
	RURAL_RESIDENTIAL	Rural Residential	
	SUBURBAN_RES	Developed, Low Intensity, Suburban Residential	
	SURFACE_WATER_SURFACE_AREA	Open Water	
	TIMBER	Evergreen Forest	
	URBAN_RES	Developed, Medium Intensity, Urban Residential	
Bonner County Comp Plan			
	Ag/Forest Land	Rural	
	Neighborhood Commercial	Developed, High Intensity, Commercial	
	Prime Ag/Forest Land	Cultivated Crops, Prime/Large Tract Agriculture	
	Remote Ag/Forest	Evergreen Forest	

Jurisdiction	Code Values	Mapped To	Code Value Explanation
	Resort Community	Developed, Medium Intensity, Urban Residential	
	Rural Residential	Rural Residential	
	Transition	Transition	
Pend Oreille County			
City of Spirit Lake			
Hangman Basin			
Spokane County			
	CC	Developed, High Intensity, Commercial	Community Commercial
	FZ	Evergreen Forest	Forest Land
	HDR	Developed, Medium Intensity, Urban Residential	High Density Residential
	LDR	Developed, Low Intensity, Suburban Residential	Low Density Residential
	LI	Industrial	Light Industrial
	LTA	Cultivated Crops, Prime/Large Tract Agriculture	Small Tract Agricultural
	MDR	Developed, Medium Intensity, Urban Residential	Medium Density Residential
	MU	Developed, Medium Intensity, Urban Residential	Mixed Use
	MZ	Rural	Mineral Land
	NC	Developed, High Intensity, Commercial	Neighborhood Commercial
	R-5	Rural Residential	Rural Residentail/1 DU per 5 acres
	RAC	Developed, Low Intensity, Suburban Residential	Rural Activity Center
	RC	Developed, High Intensity, Commercial	Regional Commercial
	RCV	Rural	Rural Conservation
	RT	Transition	Rural Traditional
	UR	Transition	Urban Reserve
Kootenai County			
	AGRICULTURE	Cultivated Crops, Prime/Large Tract Agriculture	
	TIMBER	Evergreen Forest	

Jurisdiction	Code Values	Mapped To	Code Value Explanation
	TRIBAL_TRUST	Rural	
City of Spokane			
	Center and Corridor	Developed, High Intensity, Commercial	
	Central Business District	Developed, High Intensity, Commercial	
	Commercial	Developed, High Intensity, Commercial	
	High Density Residential	Developed, Medium Intensity, Urban Residential	
	Low Density Residential	Developed, Low Intensity, Suburban Residential	
	Medium Density Residential	Developed, Low Intensity, Suburban Residential	
	Neighborhood Retail	Developed, Medium Intensity, Urban Residential	
	Office	Developed, Low Intensity, Suburban Residential	
	Residential Agricultural	Rural Residential	
Benewah County			
Whitman County			
City of Cheney			
City of Waverly			
City of Spangle			
City of Fairfield			
City of Latah			
City of Tekcoa			
City of Tensed			
City of Worley			
Other Datasets			
National Hyrdology Dataset, Medium Resolution			
	Flowlines		
	Waterbody areas		
Sub-basins			
	8 digit HUCs		
Cities			
	Idaho, from Idaho State Tax		

Jurisdiction	Code Values	Mapped To	Code Value Explanation
	Commission		
	Washington, WSHDOT, based on Washington State Office of Financial Management		
Tribal Lands			
	National Map, Lands greater than		
National Landcover Datasets, USGS			
	National Landcover Datasets, 2001, from Washington		

Appendix C. Land Use Definitions

Description of land uses and cover is from Spokane County, Building and Planning Maps website (http://www.spokanecounty.org/bp/content.aspx?c=2299) and the USGS Land Cover Institute, LNCD Land Cover (http://landcover.usgs.gov/index.php).

Barren Land
Areas characterized by bare rock, gravel, sand, silt, clay, or other earthen material, with little or no "green" vegetation present regardless of its inherent ability to support life. Vegetation, if present, is more widely spaced and scrubby than that in the "green" vegetated categories; lichen cover may be extensive.

Open Space
Open space is those areas preserved for parks, recreation, and nature areas.

Deciduous Forest
Areas dominated by trees where 75 percent or more of the tree species shed foliage simultaneously in response to seasonal change.

Open Water
All areas of open water or permanent ice/snow cover.

Mixed Forest
Areas dominated by trees where neither deciduous nor evergreen species represent more than 75 percent of the cover present.

Shrub/Scrub
Areas characterized by natural or semi-natural woody vegetation with aerial stems, generally less than 6 meters tall, with individuals or clumps not touching to interlocking. Both evergreen and deciduous species of true shrubs, young trees, and trees or shrubs that are small or stunted because of environmental conditions are included.

Large Tract Agriculture, Cultivated Crops
Large Tract Agricultural areas are primarily devoted to grain, legume, and grass seed production. Non-resource-related uses are generally prohibited. Residences will usually be associated with farming operations. Density: 1 dwelling unit per 40 Acres.

Rural Traditional, Grassland
Rural lands in this category will include large-lot residential uses and resource-based industries, including ranching, farming, mining and forestry operations. Industrial uses will be limited to industries directly related to, and dependent on, natural resources. New non-resource-related industry would be allowed, provided it meets the requirements for a major industrial development outside the UGA (see policy RL.5.1a and RCW 36.70A.365). Rural-oriented recreational uses will also play a role in this category. Rural clustering would be allowed in this category without bonus density. Density: The density of the Rural Traditional category is 1 dwelling unit per 10 acre.

Rural Conservation
The Rural Conservation category applies to environmentally sensitive areas, including critical areas and wildlife corridors. Criteria to designate boundaries for this category were developed from Spokane County's Critical Areas program and a study by the University of Washington titled, Wildlife Corridors and Landscape Linkages, An Approach to Biodiversity Planning for Spokane County, Washington. The category will encourage low-impact uses and utilize clustering and/or other open space techniques to protect sensitive areas and preserve open space. Density: The density of the Rural Conservation category is 1 dwelling unit per 20 acres, with a bonus density of 1 dwelling unit per 10 acres for preserving open space and environmentally sensitive areas through clustered housing.

Forest Land, Evergreen Forest
Forest land areas are primarily devoted to wood production. Non-resource related uses are generally prohibited. Residences are allowed but will be located on relatively large parcels to minimize conflicts with forestry operations.

Mineral Land
Mineral land areas are primarily devoted to sand, gravel, and rock or clay production. Related products such as concrete, asphalt and brick are also produced. Agriculture and forestry may be conducted on mineral resource lands but residences are generally limited to caretaker residences associated with mining or a related industry.

Community Center
Community Centers are higher intensity mixed-use areas designed to serve two or more neighborhoods. Community Centers will generally serve an area equivalent to a junior high or high school attendance area and may have a mix of uses, including commercial, civic, high-density residential and recreational uses.

Mixed Use
Mixed-use Areas are intended to enhance travel options, encourage development of locally-serving commercial uses, medium-density apartments and offices along transportation corridors identified on the Land Use Plan Map. Mixed-use areas discourage low-intensity, auto-dependent uses and focus on a pedestrian orientation with an emphasis on aesthetics and design.

Regional Commercial
Regional Commercial designates intensive commercial areas intended to attract customers from the County at large and other outlying areas. Regional shopping centers and major commercial areas will be designated with this classification. Residences in conjunction with business and/or multifamily developments may be allowed, with performance standards that ensure compatibility. Small-scale industrial parks may be allowed in this category, provided neighborhood concerns are addressed through a public hearing process.

Urban Growth Area
The Urban Growth Area includes those lands that are considered for growth within a 40-year planning horizon. These areas are given special consideration, such as low-density, large-lot development, so that land uses established in the near future do not preclude their eventual

conversion to urban densities. For example, a 1-acre to 5-acre per lot subdivision pattern in these areas would create parcels that would be difficult to divide to urban densities. Innovative techniques such as residential clustering may be used to allow residential development rights and ensure that these areas will be available in the future. The use of public water systems or community wells is encouraged. Community drain fields may also be appropriate in the Urban Reserve category. Density: The density of the Urban Reserve category is 1 dwelling unit per 20 acres, which may be increased to 1 dwelling unit per 5 acres for clustered housing. Within a cluster subdivision, the remainder lot must be reserved for future urban use. The minimum lot size in a cluster subdivision could be as low as 10,000 sq. ft; the maximum lot size is 1 acre.

Low Density Residential
Low Density Residential is a residential category that includes one (1) to, and including, six (6) dwelling units per acre.

Medium Density Residential
Medium Density Residential is a residential category that includes greater than six (6) and including fifteen (15) dwelling units per acre.

High Density Residential
High Density Residential is a residential category that includes greater than fifteen (15) dwelling units per acre.

Rural-5
The Rural Residential-5 category would allow a 1-dwelling-unit-per-5-acre density in areas that have an existing 5-acre or smaller subdivision lot pattern. The provision of public water service may be appropriate for these areas. Rural residential clustering is allowed in this category. Density: The density of the Rural Residential-5 category is 1 dwelling unit per 5 acres.

Rural Activity Center
The Rural Activity Center (RAC) category identifies rural residential centers supported with limited commercial and community services. RAC's consist of compact development with a defined boundary that is readily distinguishable from surrounding undeveloped lands. RAC's often form at crossroads and develop around some focal point, which may be a general store or post office. Other typical uses might include a church, school, restaurant, gas station, and other small shops. Commercial uses are intended to serve the surrounding rural area or, in some instances, the traveling public. RAC's must have an identified boundary established on the Comprehensive Plan Map. Density: The maximum residential density in a Rural Activity Center category is 4 dwelling units per acre.

Light Industrial
Light Industrial is intended for industrial areas that have a special emphasis and attention given to aesthetics, landscaping and internal and community compatibility. Light Industry areas are comprised of predominantly industrial uses but may incorporate office and commercial uses. Residential uses should be prohibited.