Herrera Environmental Consultants, Inc.

Final Memorandum

To Kimberly Swan, Clackamas River Water Providers

From Jennifer Schmidt, Herrera Environmental Consultants

Date May 4, 2012

Subject GIS Septic Systems Risk Analysis Results

Introduction

The Clackamas River is a source of drinking water for more than 300,000 people in Clackamas County and is an important resource for helping to meet future water demand in the region. The Clackamas River Water Providers (CRWP) represents five municipal surface water intakes on the Clackamas River: City of Estacada, Clackamas River Water, North Clackamas County Water Commission, South Fork Water Board, and City of Lake Oswego. In 2010, the CRWP developed a Drinking Water Protection Plan that outlined a series of strategies and programs to address potential threats to source water quality in the Clackamas River watershed. Herrera Environmental Consultants (Herrera) was hired to complete a series of geographic information system (GIS) analyses in order to help to identify potential pathways for pollutant export from the Clackamas River Watershed. The following major high-risk activity categories were identified in the Drinking Water Protection Plan (Clackamas River Water Providers 2010):

- Septic Systems
- Agricultural Activities
- Forestry Activities
- Vulnerable Soils
- Urban Development
- Point-Source Pollutants

The goal of these GIS analyses was to map risk factors known to have a strong negative correlation with drinking water quality in the Clackamas River watershed. Mapped risk "hot spots" for each category will provide a spatial context for both the geography and intensity of risk by activity that can be used by the CRWP help prioritize mitigation efforts. This memorandum focuses specifically on the methods and results of the GIS Septic Systems Assessment portion of the Drinking Water Protection Plan.

Potential Threats from Septic Systems

The Clackamas River Water Providers (CRWP) have identified improperly maintained septic systems as being a significant source of risk to drinking water quality in the Clackamas River watershed. The primary threat to surface water from septic system malfunction is direct runoff of partially treated waste or exfiltration of contaminated groundwater. The major contaminants that can be discharge from malfunctioning septic systems include pathogens, nitrates, organic matter, ammonia, nitrogen, phosphates, synthetic organics, metals, PCPs, and pharmaceuticals (Clackamas River Water Providers 2010).

Approximately 10 to 25 percent of septic systems fail at some point during their operational life. This often results in the release of untreated wastewater into the underlying groundwater and/or nearby surface water (U.S. EPA 2003; Schueler and Holland 2000). The risk of septic system malfunction increases based on the following conditions: 1. septic system age, 2. where site conditions enhance the potential for pollutant movement such as rapidly draining soils, 3. restrictive soils with slow permeability, 4. inadequate setbacks to surface water, 5. locations where a high density of septic systems on smaller lots are concentrated (Joubert et al. 2003).

GIS Septic System Risk Analysis

Herrera performed a GIS analysis to identify potential onsite septic systems and assess the risk of septic system failure to source water quality for all taxlots in the Clackamas River watershed. This methodology involved gathering, ranking, and overlaying five datasets in GIS known to increase the risk of septic system failure:

- Septic system age
- Statistically-significant septic system clusters
- Proximity to surface water and upstream distance from municipal surface water intakes
- Vulnerable soils
- Parcel size

The following sections provide more detailed information on this analysis, including analysis objectives, methds for how each of the five risk datasets were generated, and data sources used and limitations.

Analysis Objectives

The primary objectives of the GIS septic system risk analysis were to:

1. Identify parcels in the Clackamas River watershed with potential on-site septic systems.

2. Assess the risk of septic system failure by mapping high-density septic system clusters, septic system age, proximity to surface water, vulnerable soils, and parcel size.

3. Rank, weight, and overlay each septic system risk factor to produce a map of cumulative predicted risk to source water quality from septic system failure at the parcel level.

Data Sources and Limitations

The primary GIS datasets required to assess septic system risk to source water quality are tax parcel boundaries, residential septic system age, non-residential septic system permits, sanitary sewer utilities, and vulnerable soils. The following sections describe these major datasets in more detail, including any major data limitations that are important to keep in mind when interpreting the GIS septic system risk analysis results. Documentation on all datasets used in the analyses can be found in Table 1. Herrera converted all GIS datasets used in the septic system risk analysis to the Oregon State Plane North HARN 83 map projection, with both the vertical and horizontal datum measured in feet.

Tax Parcel Boundaries and Assessor Data

Herrera used tax parcel boundaries and property data records from the Clackamas County Assessor to help identify potential onsite septic systems and to estimate septic system age, density, and parcel size in the Clackamas River watershed. Tax parcel boundaries were obtained from the Oregon Metro Regional Land Information System (RLIS). RLIS provides an updated parcel boundary dataset in coordination with Clackamas County on a quarterly basis containing detailed information on parcel land use, building square footage, vacancy status, and other attributes helpful for predicting onsite septic system use.

Detailed records were obtained from the Clackamas County Assesor in January 2012 documenting the number of bedrooms, bathrooms, and building age for residential parcels in the Clackamas River watershed. Bedroom and bathroom data was used to help assess potential septic use and building age was used to calculate septic system age. One major limitation of using building age to predict the age of potential septic systems is that it does not take into account potential repairs and replacements that may have occurred over time. Therefore septic system age calculated based solely on building age may overestimate average septic system age in the watershed.

Vulnerable Soils

GIS soil data was obtained from Clackamas County from the United States Department of Agricultural National Resource Conservation Service (NRCS) website. Detailed information about each soil unit was obtained from the NRCS soil survey report for Clackamas County in 1985, and included attributes such as soil permeability, erosion hazard, runoff risk, slope percentage, typical land use by soil type, and specific risks for septic system construction and failure (NRCS 1985). This information was consolidated into a table and joined to the soil type polygons in GIS.

Septic System Permits and Locations

The Oregon Department of Environmental Quality (DEQ) issues Water Pollution Control Facilities (WPCF) permits for domestic wastewater for commercial and larger non-residential septic systems. Herrera obtained the locations of 13 issued WPCF domestic wastewater permits in the Clackamas River watershed from the Oregon Facility Profiler database, which is a database repository of DEQ regulated or permitted facilities and sites in Oregon.

An additional source of potential septic system locations came from four source water assessments completed by Oregon DEQ and the Oregon Department of Human Services with assistance from the Clackamas Basin Watershed Council in 2002-03. The purpose of these assessments was to identify surface water areas that supply public drinking water, identify sensitive areas, and potential contaminant sources that could adversely impact that source of water (Clackamas River Water Providers 2010). Over 1,200 potential contaminant sources (PCS) were identified in the Clackamas River Source Water Assessments and mapped in a GIS dataset, including 24 high-density septic system clusters in the Clackamas River watershed indicated as being of moderate to high risk to source water quality. Herrera extracted the septic system clusters from the overall PCS data for inclusion in the risk analysis.

Sanitary Sewer Utilities

Herrera obtained sanitary sewer mainline and lateral pipe data from Clackamas County Water Environmental Services (WES) for Clackamas County Service District #1 (CCSD #1) to help identify residences within treated sewer district boundaries that may not be connected to the sanitary sewer system. There are several limitations to using this data for predicting potential onsite septic system locations in the Clackamas River watershed that should be kept in mind when interpreting the septic system risk results within treated areas. First, sanitary sewer utility data was only readily available for CCSD #1 and not all sewered cities in the watershed. Second, the lateral pipe network data within CCSD #1 was not comprehensive. Finally, the presence of sewer laterals does not necessarily indicate that a residence is connected to the sewer main line.

Methodology

This section describes the GIS methods used by Herrera to map potential on-site septic system locations; assess septic system failure risk based on septic system age, density, parcel size, vulnerable soils and proximity to water; and rank, weight, and overlay the datasets based on their impact to source water quality.

Table 1. GIS datasets used to help assess the risk from septic systems to source water quality in the Clackamas River watershed.

Dataset Description	Source	Date	Online Metadata (if available)
Aerial photography	United States Department of Agriculture National Agriculture Imagery Program	2009	http://libweb.uoregon.edu/map/orephoto/imagery.html
Sewer district boundaries	Oregon Metro RLIS	November 2011	http://rlismetadata.oregonmetro.gov/index.cfm?startpage=main.cfm?db_type=rlislite
Clackamas River watershed boundary	Oregon Metro RLIS	November 2011	http://rlismetadata.oregonmetro.gov/index.cfm?startpage=main.cfm?db_type=rlislite
Streams and waterbodies	Oregon Metro RLIS	November 2011	http://rlismetadata.oregonmetro.gov/index.cfm?startpage=main.cfm?db_type=rlislite
Taxlot boundaries	Oregon Metro Regional Land Information System (RLIS)	November 2011	http://rlismetadata.oregonmetro.gov/index.cfm?startpage=main.cfm?db_type=rlislite
Building outlines	Oregon Metro RLIS	November 2011	http://rlismetadata.oregonmetro.gov/index.cfm?startpage=main.cfm?db_type=rlislite
Tax assessor table with building age, number of bathrooms, number of bedrooms, and occupancy status	Clackamas County Assessor	Obtained January 2012	None
Zoning designations	Oregon Metro RLIS	November 2011	http://rlismetadata.oregonmetro.gov/index.cfm?startpage=main.cfm?db_type=rlislite
Soil survey boundaries	United States Department of Agriculture Natural Resources Conservation Service (NRCS)	Obtained January 2012	http://soildatamart.nrcs.usda.gov/
Geology unit boundaries	Oregon Department of Geology and Mineral Industries (DOGAMI)	Obtained January 2012	http://www.oregongeology.org/sub/pub%26data/pub%26data.htm
Sewer pipes and laterals	Clackamas County Water Environment Services (WES)	Obtained January 2012	None
Water Pollution Control facilities permit (WPCF) locations for domestic wastewater	Oregon DEQ	Obtained March 2012	http://deq12.deq.state.or.us/fp20/
Potential Contaminant Source (PCS) points	Oregon DEQ	June 2005	http://www.deq.state.or.us/wq/dwp/invresults.htm

First, Herrera used tax parcel boundaries and assessor tables from the Clackamas County Assessor to identify parcels that are both zoned residential and are occupied. Criteria used for determining whether a residential parcel is occupied included land use descriptions and the number of bedrooms and bathrooms. Occupied residential parcels with bathrooms or bedrooms onsite were flagged as being potential onsite septic system candidates. Vacant and non-residential parcels were removed from the analysis.

The next step was to overlay the remaining parcels with sewer district and sewered city boundaries in the Clackamas River watershed to identify parcels that are likely connected to a wastwater treatment system. These boundiares include Clackamas County Service District #1, City of Sandy, City of Gladstone, City of Estacada, and City of Oregon City. The starting assumption was that all parcels within these areas boundaries are connected to wastewater treatment systems and are unlikely to be using onsite septic system; however, a small number of parcels within treated areas may still be using septic systems To identify these parcels within, Herrera obtained GIS data showing major sewer lines and sewer laterals where available and overlaid this data with parcel boundaries and aerial photography. Occupied residential parcels not showing lateral pipe connections to the main sanitary sewer lines were flagged, and all other parcels within treated areas were removed from the analysis.

Approximately 9,000 potential residential onsite septic system locations were identified in this analysis. In addition to these parcels, Herrera included approximately 13 additional septic system locations to the analysis where Oregon DEQ had issued WPCF to larger non-residential facilities and approximately 20 septic system cluster locations identified in the 2002-03 Clackamas River Source Water Assessments. This information was first reviewed to ensure that duplicate data wasn’t being added to the analysis prior to completing this step.

All potential septic system parcels mapped by Herrera are shown in Figure 1.

Estimated On-site Septic System Age

More than half of the approximately 20 million septic systems used in the United States were installed over 30 years ago when on-site rules were nonexistent or poorly enforced (U.S. EPA 2003; Novotny and Olem 1994). Herrera estimated septic system age for each potential parcel in this analysis using the effective year the property was built, which was obtained from the Clackamas County Assessor. Using this metric, approximately 76 percent of potential septic system parcels in the Clackamas River watershed are greater than 30 years old. Estimated septic system age for all parcels included in this analysis is shown in Figure 2.

Identifying High-Density Septic Systems Clusters

Septic systems clustered with other systems on small lots pose a significant threat to source water quality (U.S. EPA 2003). Herrera mapped statistically-significant clusters of septic systems in the Clackamas River watershed using the following methodology.

First, Herrera converted the potential septic system parcels polygons to centerpoints. Then a grid of 2-acre polygons was generated covering the entire watershed and the number of septic system parcel centerpoints within each pixel was calculated. The results of this step are shown in Figure 3. Finally, Herrera ran a hot-spot analysis on the polygon grid to identify high-density septic system parcel clusters. Approximately 6,250 of the total 9,000 potential septic systems identified in the Clackamas River watershed are in clusters. These are shown in Figure 4.

Calculating Proximity to Surface Water

Herrera calculated linear distance of each potential septic system parcel to the mainstem Clackamas River. Then upstream distance to the closest surface water intake was calculated to account for pollutant attenuation in the surface water system.

Mapping Vulnerable Soils

Septic systems rely on the soil to remove harmful contaminants and pathogens from wastewater before the contaminants can affect source water quality. The soils that pose the highest risk to septic system failure are:

- *Dense or impermeable soils:* Water moves through these layers more slowly than it is applied to the soil surface as precipitation, so these restricting soil horizons become saturated wth water (Lee et al. 2004).
- *Rapidly-draining soils:* Wastewater is transmitted through the soil faster than the soil can treat it, placing groundwater supplies at risk. Examples of rapidly-draining soils include coarse sand and gravelly layers commonly found near large rivers.
- *Bedrock:* Water-restricting bedrock zones result in satured soils below septic system absorption fields, and often cause inadequate wastewater treatment. Bedrock layers cannot transmit natural rainfall let allone the added effluent applied at rates of two to seven times the normal precipitation rate.

Herrera used the NRCS soil survey for Clackamas County (NRCS 1985) to identify and map these vulnerable soil categories in the Clackamas River watershed.

Calculating Aggregate Septic System Risk

After Herrera mapped potential onsite septic systems and analyzed risk of septic system failure from septic system age, density, soil drainage, and water proximity, the next step completed was to rank and overlay the datasets together to determine aggregate risk from septic systems to source water quality in the Clackamas River watershed. This analysis was completed using the following methodology.

First, the attributes for each individual dataset were assigned a ranking scheme on a scale of 1 to 5, with a value of 1 indicating a low risk of septic system failure to source water quality and a value of 5 indicating a high risk. The ranking scheme for each dataset was determined using two primary methods. The first method ranked each dataset relatively based on an analysis of the distribution of its attributes. For example, proximity to surface water was analyzed by calculating the linear distance of each parcel centerpoint to the Clackamas River. This generated values ranging from within a few feet many miles, and the data was then ranked by analyzing the natural statistical breaks in the data range. This method is essentially comparing each potential septic system parcel to the other systems in the Clackamas River watershed and ranking the distances accordingly. The second method involved assigning scientifically meaningful rankings to dataset attributes based on literature reviews of best available science. Table 2 shows the detailed ranking scheme applied to each dataset.

Table 2. Ranking, ranking criteria, and weighting factors applied to each GIS dataset to determine the risk from septic systems to source water quality in the Clackamas River watershed.

Dataset	Ranking Factor	Ranking Criteria	Dataset Weight
Septic System Age	1 to 30 years	1	1
	31 to 50 years	3	
	> 50 years	5	
High-Density Septic System Cluster	Yes	5	2
Linear Distance to the Clackamas River	0 to 0.25 miles	5	2
	0.25 to 0.5 miles	4	
	0.5 to 1 miles	3	
	1 to 2	2	
	> 2 miles	1	
Upstream Distance to Surface Water Intake	0 to 0.5 miles	5	1
	0.5 miles to 1	4	
	1 to 2	3	
	2 to 5	2	
	> 5	1	
Vulnerable Soils	Very Slow to Moderately Slow Permeability	5	1
	Rapid Permeability		
	Bedrock Presence		
	Steep Slopes		

The next step was to determine whether any of the datsets in the septic system risk analysis should be weighted as posing a more significant risk to source water quality than the others. For example, two potential septic system parcels may both be approximately 500 feet upstream of a source water intake from the location where a straight line drawn from each intersects with the

Clackamas River. However, the linear distance to the Clackamas River may be 500 feet for one parcel and 5 miles for the other. For this reason, linear distance to the Clackamas River was weighted more heavily than upstream distance to the nearest surface water intake. Weighting factors applied to each dataset are also shown in Table 2.

After a ranking scheme and weighting factor had been applied, the next step was to convert each dataset to a raster grid with 10-meter pixels and overlay the grids together to calculate a cumulative risk value for each pixel and map the data into low, moderate, and high risk categories. The results of this analysis showing cumulative risk from septic systems on source water quality in the Clackamas River are shown in Figure 5.

Results and Recommendations

Of the approximately 9,000 potential septic system parcels identfied in the Clackamas River watershed, about 4500 were ranked as very low or low risk for septic system failure, 3500 were ranked as moderate risk, and 1000 were ranked as high risk. The most appropriate method for analyzing the risk analysis output is to focus on overall geographic risk trends rather than parcel-level results due to the potential for data anomalies. It is also important to keep in mind that the potential septic system parcels have not been field-verified and are locations are predictive only. Verification of the presence, age, and condition of septic systems parcels shown in high-risk clusters is an important next step to help focus septic system management strategies.

As indicated in Figure 5 the regions with the highest risk for septic system failure are located upstream of Estacada and Northeast of Oregon City / South of Highway 224. If future pollutant source tracking or modeling efforts identify septic systems as a potential pollutant source of concern, the systems located in these regions should be targeted first for system upgrades. If additional monitoring is implemented to try to identify pollutant sources in the watershed, the septic risk mapping data can be used to help select sites that could potentially isolate the water quality signal from septic systems. Additionally, if a modeling effort is developed to help to quantify pollutant loading from various sources, these GIS septic data will serve as valuable model input.

Herrera recommends that this analysis be repeated every five years to account for changes in septic system permit requirements, residential density, and potential septic system decommissioning. The following adjustments could also be made when the analysis is repeated to help refine the results:

1. Upstream distance from surface water intakes could be calculated based on travel time from the nearest tributary to the Clackamas River rather than linear distance (Geosyntec Consultants 2011).

2. Clackamas County WES has two networked (in-house only) programs to look for septic system records: Permits Plus and Application Extender. A public information

station onsite could be used to help confirm and identify additional onsite septic systems within treated areas.

References

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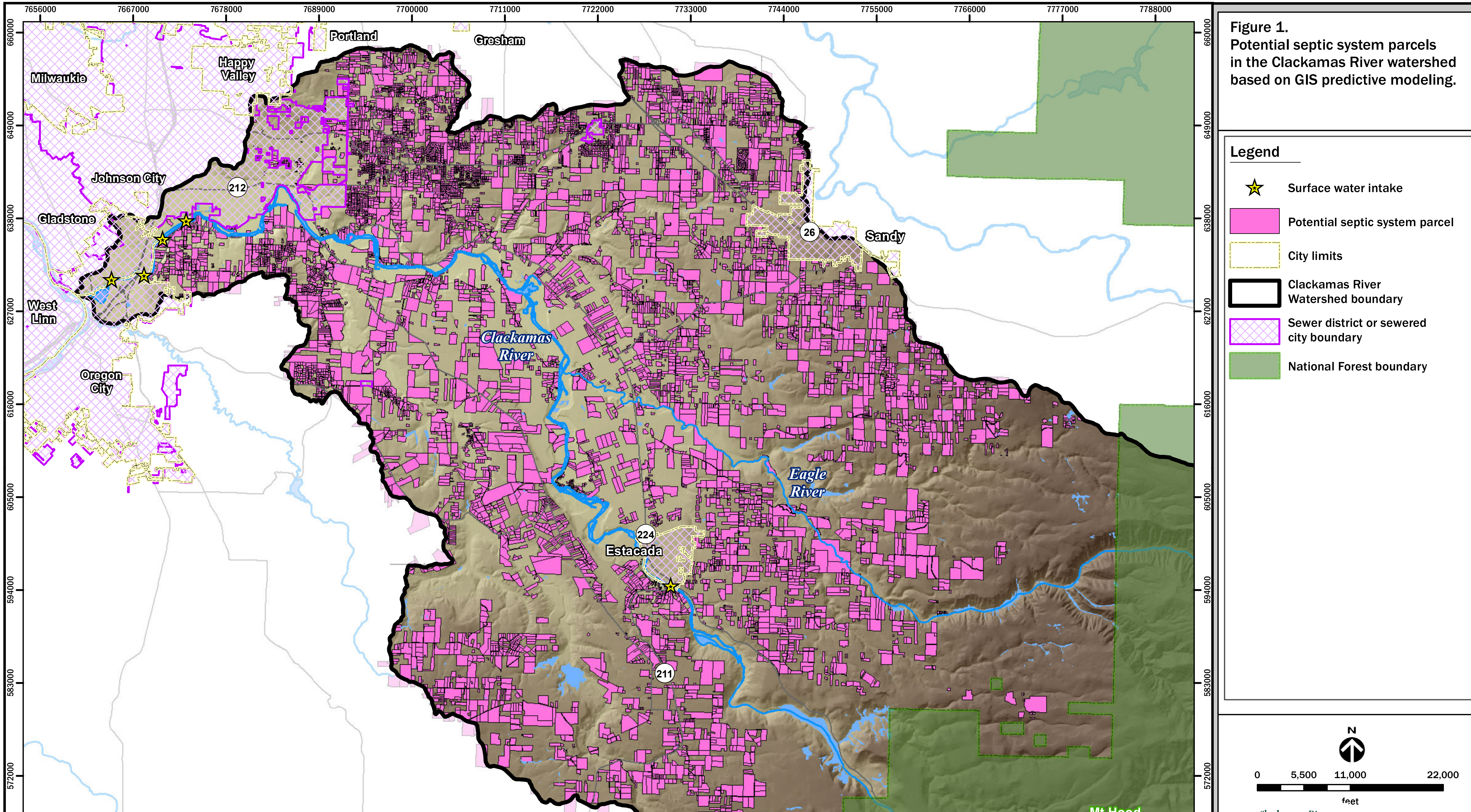
U.S. EPA. 2003. Voluntary National Guidelines for Management of On-Site and Clustered (decentralized) Wastewater Treatment Systems. EPA 832-B-03-001. U.S. Environmental Protection Agency. March 2003.

FIGURES

Figure 1.
Potential septic system parcels in the Clackamas River watershed based on GIS predictive modeling.



Coordinates: Oregon State Plane North HARN NAD83 (feet)

Produced By: GIS (JAS)
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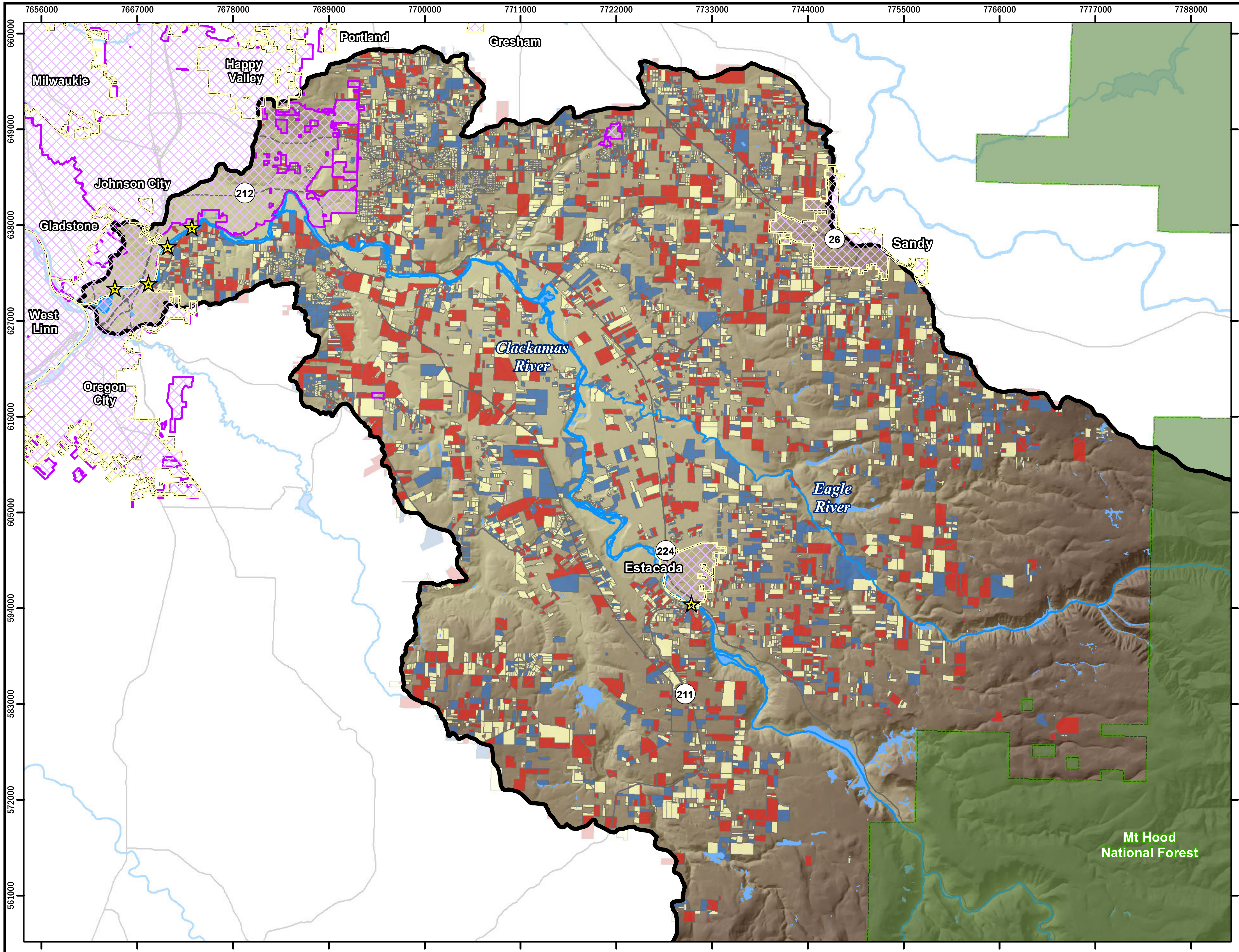

Figure 2.
Estimated septic system age in the Clackamas River watershed based on GIS predictive modeling.

Legend

Estimated septic system age (years)

- 2 - 30
- 31 - 50
- 51 - 142
- Surface water intake
- City limits
- Clackamas River Watershed boundary
- Sewer district or sewered city boundary
- National Forest boundary

N

0 5,500 11,000 22,000
feet

Clackamas River Water Providers
Working together to protect and conserve our drinking water.

HERRERA

Coordinates: Oregon State Plane North HARN NAD83 (feet)

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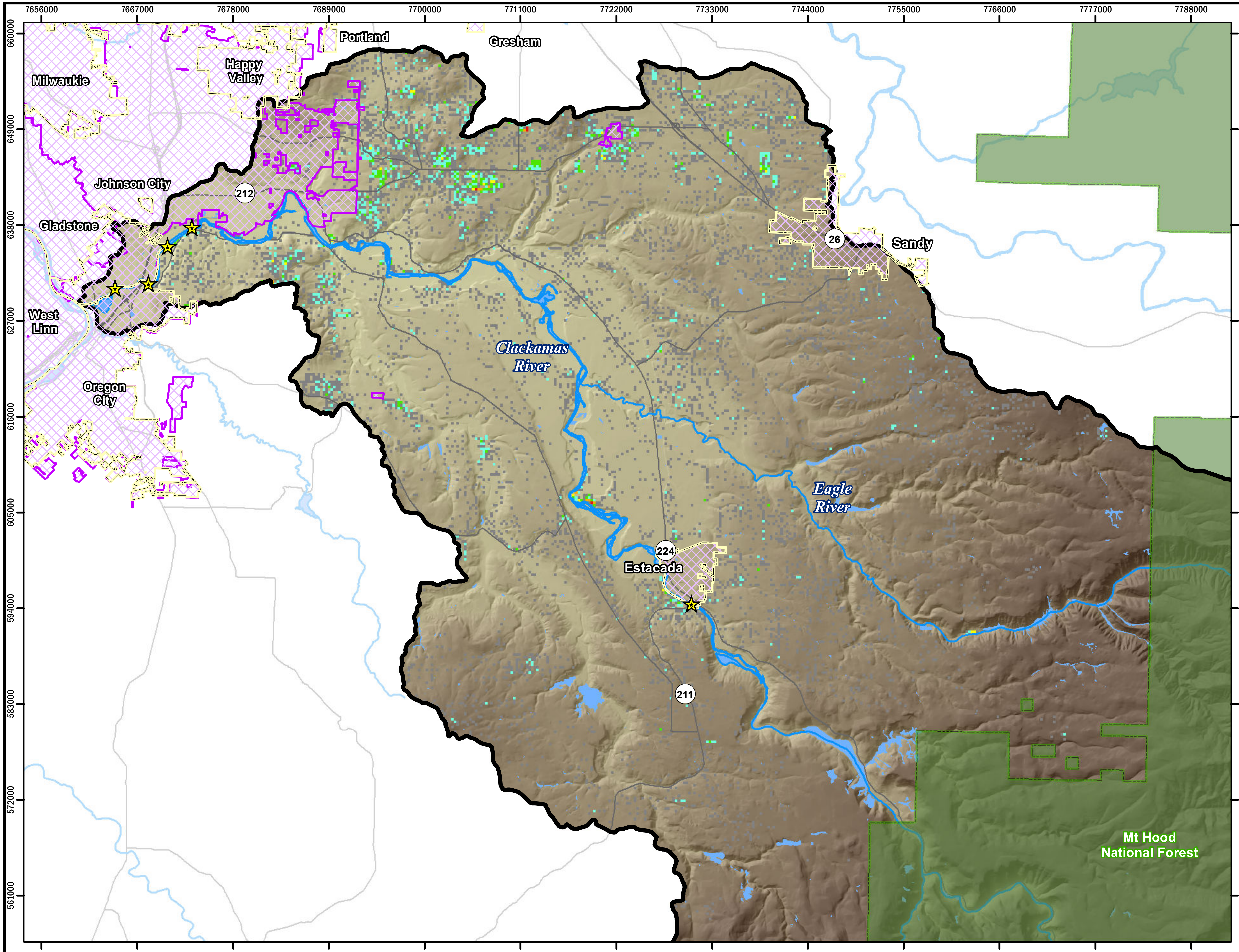

Figure 3.
Number of potential septic systems per two acres in the Clackamas River watershed based on GIS predictive modeling.

Legend

Number of septic systems per two acres

- 1
- 2
- 3
- 4
- 5
- 6
- Surface water intake
- City limits
- Clackamas River Watershed boundary
- Sewer district or sewered city boundary
- National Forest boundary

N

0 5,500 11,000 22,000
feet

Clackamas River Water Providers — Working together to protect and conserve our drinking water.
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Coordinates: Oregon State Plane North HARN NAD83 (feet)

Produced By: GIS (JAS)
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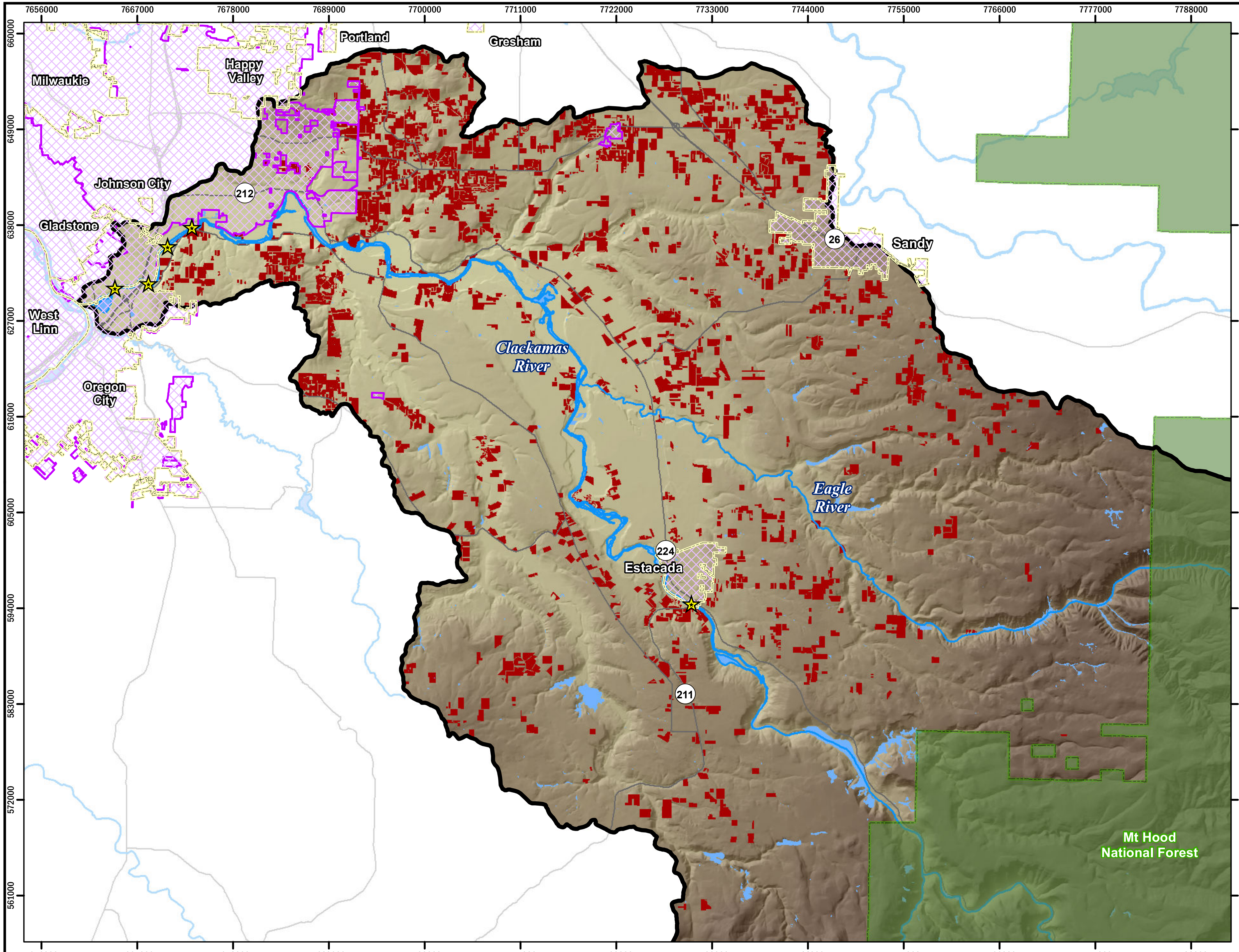
Figure 4.
Potential high-density septic system clusters in the Clackamas River watershed based on GIS predictive modeling.



Coordinates: Oregon State Plane North HARN NAD83 (feet)

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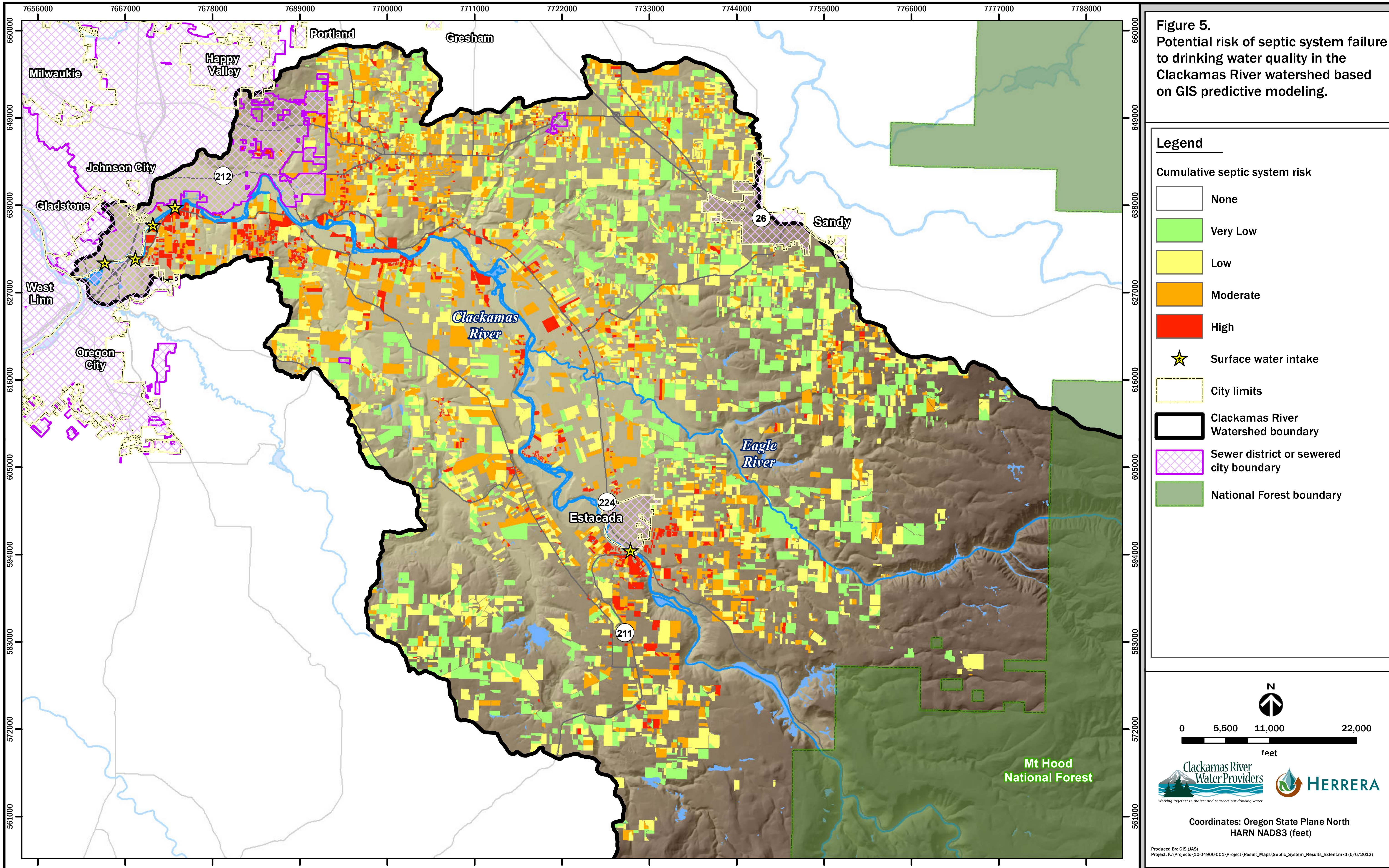
Figure 5.
Potential risk of septic system failure to drinking water quality in the Clackamas River watershed based on GIS predictive modeling.



Coordinates: Oregon State Plane North HARN NAD83 (feet)

Produced By: GIS (JAS)
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