Herrera Environmental Consultants, Inc.

Memorandum

To	Kimberly Swan, Clackamas River Water Providers
From	Jennifer Schmidt, Herrera Environmental Consultants
Date	December 6, 2013
Subject	GIS Hazardous Materials Spill Risk Analyses Results and Recommendations

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 identifying potential threats to source water quality and outlining a series of strategies and programs to help protect the Clackamas River as a viable long-term source of high-quality drinking water. As part of this effort, the CRWP identified hazardous materials spills as being a high risk factor that could affect drinking water quality in the Clackamas River watershed. Potential spills from commercial and industrial areas, railroad lines, transportation activities along I-205, HWY 26 (crosses North Fork of Deep Creek near junction of HWY 26 and 212), HWY 211 and HWY 212/224, and road bridges crossing the Clackamas River are of particular concern (Clackamas River Water Providers 2010).

As part of a proactive effort to help first responders act rapidly and avoid the initial confusion that often accompanies a spill, the CRWP is interested in developing a GIS-based emergency response plan for the Clackamas River watershed. The purpose of this plan is to: 1) provide the location and intensity of potential contaminant sources; 2) identify critical resources to be prioritized for protection in the event of a spill (e.g. surface water intakes and sensitive habitat); 3) outline site specific spill response strategies, equipment availability, command post locations, first responder bases, and other logistical information; and 4) identify potential spill response constraints, including seasonal weather patterns and access issues, reach-specific flow velocities, and infrastructure such as narrow roads and bridge loading rates.

The Clackamas River watershed drains more than 940 square miles and contains several major highways, three Portland General Electric (PGE) hydroelectric facilities, the Union Pacific railroad line, and numerous bridges, tunnels, ditches, and other transportation infrastructure. Rather than focusing emergency response planning efforts on the entire watershed, the CRWP hired Herrera Environmental Consultants (Herrera) to complete a GIS risk analysis that 1) identifies historic and potential spill “hot spots” as well as dangerous road segments and 2) maps the locations of sensitive resources to prioritize for protection. The results of this effort highlight small, manageable portions of the watershed that are most likely to experience significant impacts in the event of a spill, as well as where spills are most likely to occur. This memorandum focuses specifically on the methods, results, and limitations of the GIS Hazardous Materials Spill Risk Analyses completed for the Clackamas River watershed in November 2013. Discussion of how these results can be used to inform emergency response efforts and recommendations for next steps are also included.

Potential Threats from Hazardous Material Spills

The Clackamas River Water Providers (CRWP) have identified potential spills involving the release of hazardous materials or petroleum products during transit along the river or from commercial or industrial facilities with hazardous material storage tanks as being a significant source of risk to drinking water quality in the Clackamas River watershed. A recurring theme associated with major spills or releases is confusion and uncertainty for first responders in the initial hours following an event. It is during these early hours however when the possibility to contain the spill still exists. Once a large spill enters a flowing body of water, it can quickly become out of control, impacting downstream critical resources such as drinking water intakes, endangered or threatened species habitat, spawning beds, nesting areas, hydroelectric facilities, wetlands, and well fields (Clackamas River Water Providers 2010).

GIS Hazardous Materials Spill Risk Analyses

Herrera completed a series of GIS analyses and mapping exercises to assess potential and historic spill risk hot spots and identify sensitive downstream resources to protect in the event of a release near the Clackamas River or its tributaries. These analyses were completed for the following four risk categories:

- Transportation Infrastructure and Safety
- Historic and Repeat Spills
- Hazardous Substance Storage Facilities and Potential Contaminant Sources
- Sensitive Resources

The following sections provide more detailed information on these analyses, including analysis objectives, methods used to quantify risk, data sources used and limitations, and results.

Analysis Objectives

The primary objectives of the GIS hazardous materials spill risk analyses were to:

1. Identify potential threats from accidental or intentional releases of dangerous or hazardous materials in the Clackamas River watershed, focusing specifically on:

a) High vehicle accident areas, railroad lines (including the bridge across the Clackamas River), bridges, and dangerous highway segments;

b) Historic and repeat spill areas;

c) Chemical, fertilizer, and fuel storage facilities (except for tanks with small storage capacity) in the Clackamas River watershed.

2. Locate and prioritize critical resources in the watershed that should be protected in the event of a release, such as surface water intakes and critical habitat.

3. Overlay the results of the hazardous materials spill risk analyses with mapped critical resources to identify those resources that are immediately downstream of areas with the highest potential risk of a future release.

Data Sources and Limitations

The primary GIS datasets required to assess the potential impact of a hazardous materials spill on source water quality in the Clackamas River can be derived from the following agency databases: 1) Oregon Department of Environmental Quality (DEQ) Emergency Response Information System (ERIS) (also known as OpsCenter); 2) Oregon State Fire Marshall (OSFM) Hazardous Substance Information System (HSIS); 3) Oregon DEQ Facility Profiler; and 4) Oregon Department of Transportation (ODOT) Crash Analysis and Reporting databases. Other important datasets used to support this effort include ODOT Safety Priority Index System (SPIS) sites and highway segments and critical fish and wildlife habitat. The following sections describe these datasets in more detail, including any major limitations that are important to keep in mind when interpreting the GIS hazardous materials spill risk analysis results. Documentation on all datasets used in the analyses can be found in Table 1. Herrera converted all GIS datasets used to the Oregon State Plane North HARN 83 map projection, with both the vertical and horizontal datum measured in feet.

Emergency Response Information System (ERIS) Database

Oregon DEQ requires that a spill be reported when it meets any of the following criteria: 1) any amount of oil is released to waters of the state; 2) oil spills on land are in excess of 42 gallons; and/or 3) hazardous materials are released that are equal to, or greater than, the quantity listed in the Code of Federal Regulations, 40 CDR Part 302 (List of Hazardous Substances and Reportable Quantities) (DEQ 2013). Details about these reported spills are stored in the DEQ Emergency Response Information System (ERIS) database, and reported spill data in the Clackamas River watershed is available from July 1996 to present.

Herrera obtained statewide historic spill locations extracted from the ERIS database that are current as of October 1, 2012. This dataset contains detailed information on each reported spill, including the facility or spill site name, release date, a detailed description of the spill, the material and quantity released, and the type of facility (e.g. business, private or commercial motor vehicle, industrial plant, etc.). This data was used to map the clustering and severity of spills from both mobile sources and fixed facilities and to identify locations that have had repeat spills.

One limitation of the ERIS database is that approximately 4% of spills statewide do not contain latitude and longitude coordinates. Herrera used street address or intersection data where available to map spills without coordinate information; however, 3% of reported spills statewide did not contain sufficient information to map their locations. These records were removed from further analysis.

Oregon OSFM Hazardous Substance Information System (HSIS) Database

The Oregon Community Right to Know Unit (CR2K) collects, validates, and disseminates information on hazardous substances located throughout the state. This information is then made available to the public, emergency responders and planners, and local and state agencies via the Hazardous Substance Information System (HSIS) database so that informed decisions can be made on how to protect the environment and the public from hazardous material incidents (OSFM 2013). Facilities that use, store, manufacture, or dispose of reportable quantities of a hazardous substance are required to complete an HSIS form annually; detailed information on reporting requirements can be found in the HSIS Survey Instruction booklet (http://www.oregon.gov/osp/SFM/docs/cr2k/cr2k_general/surveyinstrbook.pdf).

Herrera obtained statewide hazardous substance facility locations extracted from the HSIS Public Version database that are current as of November 15, 2013. This database is identical to the Fire Version database made available to fire service personal and other emergency responders, but all confidential and secured information (such as the specific onsite storage location at a facility) have been removed. The Public Version dataset contains detailed facility and hazardous substance information, including the facility name, type of business activity, number of employees, the substance type, quantity, physical state, and hazard class for each hazardous substance reported by the facility, whether the substance meets Environmental Protection Agency (EPA) Extremely Hazardous Substance (EHS) reporting levels, and the current hazard ranking used to determine the facility fee schedule. This data was used to map clustering of facilities storing hazardous substances and to identify facilities with high maximum reported storage quantities. It was also used to identify the number of hazardous substances reported at each facility.

Approximately 38% of reported hazardous substances in the HSIS database did not contain latitude and longitude coordinates. Herrera used street address or intersection data where available to map facilities without coordinate information; however, 5% of reported hazardous substances statewide did not contain sufficient information to map their locations. These records were removed from further analysis.

Oregon DEQ Facility Profiler Database

The Oregon DEQ Facility Profiler is a web-based database that contains information maintained by DEQ on regulated or permitted facilities and sites, including permitted air and water dischargers, hazardous and solid waste sites, cleanup sites, and leaking and underground storage tanks. Each regulated or permitted facility in the watershed contains a summary report with basic information about the facility as well as links to more specific information for each facility at the relevant DEQ or EPA program website. It is not uncommon for sites in the Facility Profiler database to belong to multiple programs. A list of these facilities with latitude and longitude information was extracted from the database and mapped in GIS by program.

It is important to keep in mind that site information in the Facility Profiler database is primarily summary in nature and does not include detailed site-specific information such as NPDES permitted discharge amounts. Without detailed facility-specific permit information, it is difficult to accurately compare the magnitude of risk between facilities. The amount of information available in the database varies significantly by program; full site-specific records can be obtained for an individual facility from DEQ on request.

Oregon DOT Crash Analysis and Reporting Database

Oregon DOT requires that a motor vehicle crash be reported when it meets any of the following criteria: 1) the crash involves death or bodily injury; 2) damage to reporting driver's vehicle is over $1,500; 3) damage to any vehicle is over $1,500 and any vehicle is towed from the scene as a result of damage from the accident; or 4) damage to any one person's property other than a vehicle involved in the accident is over $1,500 (ODOT December 2013). The Crash Analysis and Reporting Unit maintains ten years of crash data at all times, with vehicle crashes coded for city streets, county roads, and state highways. This data is stored and made available to the public through the web-based ODOT Crash database.

Herrera extracted annual crash locations in Clackamas County between January 1, 2008 and May 30, 2013 and mapped the data in GIS using latitude and longitude coordinates. This data was used to map historic crash clusters and identify dangerous road segments. Detailed information on all fields contained in the Crash database can be found in the Statewide Crash Data System Motor Vehicle Traffic Crash Analysis and Code Manual (http://www.oregon.gov/ODOT/TD/TDATA/car/docs/2007CodeManual_v2.1.w.pdf).

Safety Priority Index System (SPIS) Sites

The purpose of the Oregon DOT Safety Priority Index System (SPIS) program is to identify and rank those state highway locations with potential safety problems that are most likely to benefit from crash reduction countermeasures and to make safety a factor in roadway improvement project planning and decision making (ODOT December 2013). To generate SPIS data, a formula is applied annually to each 0.1-mile segment of highway that combines crash frequency (25%), crash rate (25%), and crash severity (50%) to assign an overall safety score to each segment. The top 5% of all site scores in the state are prioritized for further investigation; mapped GIS data includes the top 10% of all site scores in the state.

Herrera obtained two GIS datasets from the SPIS program to use in the Transportation Infrastructure and Safety analysis: 1) SPIS 2009-2011 results showing sites in the Clackamas River watershed that are within the top 10% of potential safety problems in the state; and 2) highway segments classified by the number of fatal crashes between 2009 and 2011.

Threatened and Endangered Species Critical Habitat

The State of Oregon and the federal government maintain separate lists of threatened and endangered species, which are species that are at some degree of risk of becoming extinct (ODFW 2013). Herrera obtained GIS data from the U.S. Fish and Wildlife Service (USFWS) showing critical habitat areas for threatened, endangered, and candidate fish and wildlife species listed at either the state or federal level in the Clackamas River watershed. Critical habitat includes one fish species listed as threatened at the federal level only (Steelhead), one fish species listed as threatened at the state and federal levels (Chinook Salmon), and one bird species listed as threatened at the state and federal levels (Northern Spotted Owl). These areas should be considered as high-priority for protection in the event of a spill.

Methodology

This section describes the GIS methods used by Herrera to assess the potential risk from hazardous material spills to source water quality in the Clackamas River watershed based on the following categories: 1) Transportation Infrastructure and Safety; 2) Historic and Repeat spills; 3) Hazardous Substance Storage Facilities and Potential Contaminant Sources; and 4) Sensitive Resources. A brief discussion of the results of each analysis category are included in this section; discussion of overall results and relationships between analysis categories are included in the Results section.

Transportation Infrastructure and Safety

High vehicle usage and other transportation-related activities increase the risk of leaks or spills of petroleum and other hazardous materials that can have a significant impact on sensitive resources and drinking water quality in the Clackamas River watershed (CRWP 2010). As part of this effort, Herrera completed a series of GIS analyses focusing specifically on transportation infrastructure and safety to help identify dangerous roadway corridors and other high-risk transportation activities where spills are most likely to occur.

Mapping Transportation Infrastructure

Herrera used GIS data from ODOT and Oregon Metro RLIS to produce a comprehensive map of transportation infrastructure in the Clackamas River watershed, including: more than 125 miles of highways and major arterials; major state highway freight routes along HWY 212 and HWY 26, the Union Pacific railroad line, which crosses the Clackamas River at a railroad bridge at the bottom of the Clackamas River watershed; and 110 bridges, 11 of which are listed by ODOT in 2013 as functionally obsolete. A functionally obsolete bridge is one that cannot safely service the volume or type of traffic using it. Although these bridges are not unsafe for all vehicles, they have older design features that prevent them from accommodating current traffic volumes and modern vehicle sizes and weights; about 15 bridges become newly classified as structurally deficient in Oregon each year (ODOT May 2013). Functionally obsolete bridges cross the Clackamas River at McLoughlin Boulevard at the bottom of the watershed and HWY 211 near City of Estacada.

Mapped transportation infrastructure in the Clackamas River watershed is shown in Map A.

Table 1. GIS Datasets Used to Assess Risk from Hazardous Material Spills to Source Water Quality in the Clackamas River watershed.

Dataset Description	Source	Date	Online Metadata (if available)
Emergency Response Information System (ERIS) database	Oregon Department of Environmental Quality (DEQ)	October 1, 2012	http://www.deq.state.or.us/lq/cu/emergency/reportspill.htm
Facility Profiler Database	Oregon DEQ	November 2013	http://deq12.deq.state.or.us/fp20/
Hazardous Substance Information System (HSIS) database	Oregon State Police Office of State First Marshal (OSFM)	November 2013	http://www.oregon.gov/osp/SFM/docs/CR2K/CR2K_General/ManualHSIS.pdf
Crash Reporting and Analysis Database	Oregon Department of Transportation (ODOT)	January 2008 to May 2013	http://www.oregon.gov/ODOT/TD/TDATA/car/docs/2007CodeManual_v2.1.w.pdf
Clackamas River watershed boundary	Oregon Metro RLIS	November 2013	http://rlismetadata.oregonmetro.gov/index.cfm?startpage=main.cfm?db_type=rlislite
Streams and water bodies	Oregon Metro RLIS	November 2013	http://rlismetadata.oregonmetro.gov/index.cfm?startpage=main.cfm?db_type=rlislite
Freight system routes	ODOT	November 2013	None – obtained via FTP site
Bridge locations	ODOT	November 2013	None – obtained via FTP site
Highways or major arterials	Oregon Metro RLIS	November 2013	http://rlismetadata.oregonmetro.gov/index.cfm?startpage=main.cfm?db_type=rlislite
Arterials	Oregon Metro RLIS	November 2013	http://rlismetadata.oregonmetro.gov/index.cfm?startpage=main.cfm?db_type=rlislite
Safety Priority Index System (SPIS) site percentiles	ODOT	2009 to 2011	http://www.oregon.gov/ODOT/HWY/TRAFFIC-ROADWAY/Pages/spis.aspx
Railroads	Oregon Metro RLIS	November 2013	http://rlismetadata.oregonmetro.gov/index.cfm?startpage=main.cfm?db_type=rlislite
Dam locations	Oregon Department of Fish and Wildlife (ODFW)	June 22, 2012	https://nrimp.dfw.state.or.us/DataClearinghouse/default.aspx?p=202&XMLname=44.xml
Fish hatchery locations	ODFW	May 3, 2006	https://nrimp.dfw.state.or.us/web%20stores/nrimp/pub/gis/other/meta/hatch-v3.htm
Critical habitat	U.S. Fish and Wildlife Service	November 2013	http://ecos.fws.gov/crithab/
Wetlands	Oregon Metro RLIS	November 2013	http://rlismetadata.oregonmetro.gov/index.cfm?startpage=main.cfm?db_type=rlislite
National Wetland Inventory	Oregon Metro RLIS	November 2013	http://rlismetadata.oregonmetro.gov/index.cfm?startpage=main.cfm?db_type=rlislite

Table 1 (continued). GIS Datasets Used to Assess Risk from Hazardous Material Spills to Source Water Quality in the Clackamas River watershed.

Dataset Description	Source	Date	Online Metadata (if available)
Population Density (based on 2010 U.S. Census)	Oregon Metro RLIS	November 2013	http://rlismetadata.oregonmetro.gov/index.cfm?startpage=main.cfm?db_type=rlislite
Nursing home locations	U.S. Department of Health and Human Services	2009	http://www.oregon.gov/DAS/CIO/GEO/docs/metadata/2010_02_26_or_nursing_homes.shp.xml
Hospital locations	Oregon Metro RLIS	November 2013	http://rlismetadata.oregonmetro.gov/index.cfm?startpage=main.cfm?db_type=rlislite
School locations	Oregon Metro RLIS	November 2013	http://rlismetadata.oregonmetro.gov/index.cfm?startpage=main.cfm?db_type=rlislite
Correctional institutions	U.S. Department of the Interior (DO1)	2008	http://www.oregon.gov/DAS/CIO/GEO/docs/metadata/2009_12_30_or_ci_q409.shp.xml

Mapping Road Corridor Safety

Herrera used Oregon Safety Priority Index System (SPIS) data for 2009 to 2011 as a metric for mapping overall roadway safety data in the Clackamas River watershed. As the results of this analysis show on Map B, the highest number of fatal and serious crashes during this time period occurred on HWY 26 between Sandy and HWY 212 (which is also a statewide freight system route), with more than 10 serious or fatal accidents occurring per 5-mile segment. This section of highway also includes several SPIS sites ranked in the top 5% of transportation safety concern sites in Oregon, clustered primarily around the City of Sandy and at the HWY 212/26 junction. Other top 5% SPIS site clusters include the area near the junction of HWY 221 and HWY 224 and on HWY 213 at the intersection with Clackamas River Road; these roadway segments had 1-2 serious crashes (Category 2) and 6-9 serious crashes (Category 4) per 5-mile segment respectively.

Identifying Historic Vehicle Crash Hot Spots

Herrera used the ODOT Crash Analysis and Reporting database to map the locations of more than 9,300 reported vehicle crashes (regardless of severity) in the Clackamas River watershed between January 2008 and May 2013. Herrera then ran a kernel density analysis to identify those roadways in the watershed with the highest historic crash density and categorized the results into moderate, high, and very high crash hotspots. As the results of this analysis show on Map C, the highest density of historic crashes have occurred on roadways near the bottom of the watershed where I-205 crosses the Clackamas River. Other high-density crash hotspots include roadways north of the Clackamas River near the area where HWY 212 runs through the City of Happy Valley and near HWY 26 in the City of Sandy. These results are consistent with the dangerous highway segments identified by mapping the 2009-11 SPIS data.

It is important to keep in mind that vehicle crash hot spots were mapped based on all reported crashes between January 2008 and May 2013 and do not represent where hazardous spills from motor vehicles have occurred. Methodology and results of the analysis of risk from historic and repeat spills in the Clackamas River watershed are included in the next section.

Historic and Repeat Spills

The purpose of the Transportation Infrastructure and Safety analyses are to identify dangerous road segments where vehicle collisions are most likely to occur that could result in a hazardous spill; however, this does not take into account where historic spills have actually happened. To better assess spill risk, Herrera used the Oregon DEQ ERIS database to complete a series of GIS risk analyses to map clusters of historic and repeat hazardous substance spills in the Clackamas River watershed from both mobile and fixed sources.

Mapping Historic Mobile Spills

Historic spills tracked in the Oregon DEQ ERIS database fall into two primary categories: spills from mobile sources such as vehicles and railways and spills from fixed locations such as businesses and storage tanks. Since the locations of spills from mobile sources are likely to be less predictable over time and potentially more randomly distributed than fixed sources, Herrera analyzed these two categories of spill data separately.

To analyze historic spill risk from mobile sources, Herrera extracted and mapped 58 spill locations from the ERIS database that were listed as coming from one of the following: aircrafts (1); commercial, private, and tank truck motor vehicles (50); railways (3); and public or recreational vessels (4). Herrera then ran a kernel density analysis to identify those areas in the Clackamas River watershed with the highest density of historic spills from mobile sources. As the results of this analysis show in Map D, most spill hot spots from mobile sources are clustered near the bottom of the watershed around I-205, HWY 212, and the Union Pacific Railroad. Approximately 30% of historic spills from mobile sources are not clustered, with locations mapped throughout the watershed.

Although the SPIS data shows that HWY 26 is one of the most dangerous roadway segments in the watershed, it is interesting to note that there are no historic spill locations or clusters mapped in this area. This implies that historically HWY 26 has been much more dangerous from a death and injury standpoint than from hazardous spills.

Mapping Historic Spills from Fixed Sources

Herrera extracted and mapped 57 spill locations from the ERIS database that were listed as coming from one of the following fixed sources: aboveground storage tanks (ASTs) (7); bulk petroleum storage (1); businesses (5); construction sites (2); containers or drums (9); dams (1); drug labs (2); electrical equipment (7); underground storage tanks (USTs) (2); heavy equipment (3); industrial plants (1); pipelines (1); sewers (1); wells (2); and unknown or other sources (13). Herrera then ran a kernel density analysis to identify areas in the watershed with the highest density of historic spills from fixed sources. As shown on Map E, spill hot spots from non-mobile sources are primarily clustered north of the Clackamas River near HWY 212, with other hot spots shown at the bottom of the watershed, south of the Clackamas River near Springwater Road, and just downstream of the Mt. Hood National Forest Boundary. The fixed source spill data generally shows a higher degree of clustering than the mobile spill data, with approximately 18% of historic fixed source spills being in locations throughout the watershed that are not in mapped hot spots.

Six historic spill locations in the ERIS database within the Clackamas River watershed have had repeat or multiple spills associated with the same facility, address, or latitude and longitude coordinates. These sites include: 1) 2 spills associated with the Fred Meyer Distribution Trucking Company (12108 SE Hwy 212); 2) 2 spills associated with the Northwest Pipeline Corporation (15124 S Springwater Road); 3) 2 spills associated with the Sunrise Business Park II (12402 SE Jennifer Street); 4) 10 spills associated with the Safeway Distribution Center (16800 SE Evelyn Street); 5) 6 spills associated with the latitude and longitude coordinates mapped just downstream of the Mt. Hood National Forest boundary; and 6) 14 spills associated with the latitude and longitude coordinates mapped in the Happy Valley City limits north of HWY 212. Repeat spill locations are shown on Map E.

Calculating Cumulative Historic Spill Risk from Fixed Sources

Herrera assigned a cumulative risk score to each historic spill from a fixed source based on the following criteria: 1) whether the location is part of a mapped spill cluster; 2) proximity of the spill to the Clackamas River; 3) the spill quantity; and 4) whether repeat spills have occurred at the location. The goal of this analysis is to allow the CRWP to reach out to specific facilities or areas that have historically been a high spill risk based on quantity, frequency, or density of hazardous releases and proximity to the Clackamas River.

Table 2 shows the scoring criteria assigned to each spill location. The results of this analysis are shown on Map F with each location assigned a low-to-very-high spill risk score; out of a possible total score of 25, the maximum observed combined score in the Clackamas River watershed is 24 (Safeway Clackamas Distribution Center).

Table 2. Scoring criteria applied to each fixed source historic spill locations to determine aggregate historic spill risk to source water quality in the Clackamas River watershed.

	Ranking Factor	Ranking Criteria
Proximity to the Clackamas River	< 500 feet	5
	500 to 1,000 feet	4
	1,000 to 2,500 feet	3
	2,500 feet to 5,000 feet	2
	> 5,000 feet	1
Has the site had more than one historic spill?	Yes	10
	No	0
Is the site in a mapped spill hot spot?	Yes	5
	No	0
Spill quantity	< 5 gallons or pounds	1
	5 to 25 gallons or pounds	2
	25 to 75 gallons or pounds	3
	75 to 150 gallons or pounds	4
	> 150 gallons or pounds	5

There are several important considerations to keep in mind when interpreting the results of this analysis. First, scores assigned to historic spill quantities do not take into account the hazardous spill type; all spills of similar quantities are weighted equally, regardless of how hazardous the substance is. Second, proximity to the Clackamas River is measured as an "as the crow flies" distance, and does not take into account downstream distance and potential hazards from a spill entering the nearest tributary to the Clackamas River. This may result in distance being either over or underestimated, depending on the location of the spill. Finally, this analysis focused on fixed source historic spills only.

Hazardous Substance Storage Facilities and Potential Contaminant Sources

The improper handling and storage of petroleum and hazardous chemicals by facilities in close proximity to the Clackamas River poses a significant potential threat to source water quality. To better assess the distribution and magnitude of this risk, Herrera completed a series of GIS analyses focusing on the density and storage capacity of known hazardous material storage facilities and other permitted potential contaminant sources in the Clackamas River watershed.

Mapping HSIS Storage Facilities

Herrera extracted and mapped 548 facilities that use, store, manufacture, or dispose of reportable quantities of more than 3,500 hazardous substances in the Clackamas River watershed. Hazardous substances are stored as liquids, solids, and gases; 6% of the reported substance have a current hazard ranking of 1 (minimally hazard), 90% have a current hazard ranking of 2 (generally hazardous), less than 1% have a current hazard ranking of 3 (very hazardous), and 4% have a current hazard ranking of 4 (registered chemical).

As a first step in this analysis, Herrera ran a kernel density analysis to map where the highest density of hazardous substance storage facilities are in the watershed, regardless of current hazard ranking or physical state. As the results of this analysis show on Map G, the hazardous substance storage facilities are highly clustered, with the largest hotspots being north of the Clackamas River and west of the Union Pacific Railroad, at the very bottom of the watershed in Oregon City, in Sandy and Estacada, and on HWY 212 northwest of Sandy. It is important to keep in mind that hotspots on Map G do not indicate a history of spills or violations and that hazardous substance types, quantities, and physical states are not considered; this map is simply showing where high density clusters of facilities using, storing, manufacturing, or disposing of reportable quantities of hazardous substances are located.

Another metric that Herrera used to assess risk from hazardous substance storage facilities is to analyze the number of unique reportable substances per facility. This ranged from just one substance to 90 or more; the results of this analysis are shown on Map H.

Analyzing Risk from HSIS Storage Facilities Storing Large Quantities

Each facility that submits reportable quantities of hazardous substances to the HSIS database is required to provide an average and maximum storage amount for reported substances. To better assess the magnitude of risk from hazardous substance storage facilities in the Clackamas River watershed, Herrera extracted and mapped locations from the HSIS database that are using, storing, manufacturing, or disposing of large maximum quantities (> 10,000 gallons or > 5,000 pounds) of hazardous substances, with hazardous substances in liquid and solid formats being analyzed separately. Herrera ran kernel density analyses to identify clusters of facilities storing large quantities of hazardous substances, with the results for high-volume liquid storage shown in Map I and the results for large-quantity solids storage shown in Map J.

As shown on Map I, the largest cluster of facilities storing more than 10,000 gallons of hazardous liquids is north of the Clackamas River and west of the Union Pacific Railroad, with several non-clustered high-volume facilities also located at the bottom of the watershed. The largest quantities of liquids stored in the watershed (greater than 50,000 gallons) are from facilities reporting acetone, antifreeze, diesel, diesel fuel, gasoline, liquid sugar, used motor oil, and soybean oil.

As shown on Map J, the largest cluster of facilities storing more than 5,000 pounds of solids is also north of the Clackamas River and west of the Union Pacific Railroad in the same location as the high-volume liquid facility clustering. There are several additional hotspots in the eastern portion of the watershed west and northwest of Sandy where large volumes of hazardous substance solids are stored. The largest quantities of solids (greater than 100,000 pounds) are from facilities reporting activated carbon, aluminum ingots, cement, mortar, fertilizer topdress, flour/flour mixes, fly ash, lead acid batteries, sugar, and zinc sulfate.

It is important to keep in mind when interpreting the results of these analyses that although the HSIS database contains hundreds of unique chemicals and hazardous substances, all liquids and all solids shown on Maps I and J were analyzed together. The methodologies used did not account for different chemical toxicities, travel times, and dilution rates that would need to be considered during a hazardous spill. It is also possible that a much smaller quantity of very hazardous chemicals would pose as significant of a risk to source water quality if a spill were to occur as a large quantity of a less hazardous substance would.

Mapping Facility Profiler Database Data

Risks to source water quality from fixed point source pollution in the Clackamas River watershed include contaminant releases to groundwater and surface water, hazardous spills, and effluent discharges. Much of point source pollution in Oregon is regulated under the U.S. Clean Water Act through National Pollution Discharge Elimination System (NPDES) permits (Clackamas River Water Providers); there are, however, several other types of permits and reporting procedure requirements for point source facilities in the Clackamas River watershed that may be useful for assessing the overall threat to source water quality. These include hazardous waste generators (shown on Map N); environmental cleanup site information (ECSI) (shown on Map K); underground and leaking underground storage tanks (UST and LUST) (shown on Map L); landfills and other solid waste generators (shown on Map M); and water pollution control facilities (shown on Map O).

In May 2012, Herrera completed a Point Source Pollutants risk analysis for the CRWP that mapped the locations and density of all permitted facilities in the Clackamas River watershed from the Oregon DEQ Facility Profiler database. Herrera has updated these maps (as shown in Maps K through O) to incorporate permit changes that may have occurred in the last 18 months; however, overall trends are unlikely to have changed significantly since that analysis was completed. For more detailed information on potential permitted facilities and trends in the Clackamas River watershed, please see the Point Source Pollutants Analysis report on the Clackamas River Water Providers website (http://www.clackamasproviders.org/images/stories/GIS_Point_Source_Pollutants_Analysis%20Results.pdf).

Sensitive Resources

An important component of emergency response planning is to identify sensitive resources to prioritize for protection in the event of a release, including natural resources and critical habitat, as well as population characteristics that are important to consider as part of a comprehensive spill response plan.

Mapping Sensitive Resources and Habitat

Herrera mapped sensitive resources in the Clackamas River watershed that might be impacted by a spill. This included four surface water intakes; critical chinook salmon, steelhead, and northern spotted owl critical habitat; wetlands; fishery locations; and dams and hydroelectric facilities. It is difficult to quantify risk to these resources; therefore, the purpose of this analysis was to gather and map sensitive resources to prioritize in the event of a spill rather than to attempt to quantify risk. These resources are shown on Map P.

Most sensitive resources used in this analysis are based on statewide and countywide GIS data sources. An important next step in developing a GIS-based emergency response plan will be to work with stakeholders to use local on-the-ground knowledge to map additional sensitive resources that may not be captured by the statewide dataset, such as specific spawning beds or bird nests.

Mapping Population Density and Evacuation Challenges

In addition to mapping sensitive natural resources and habitats, Herrera also attempted to quantify population density and to map community facilities that would pose challenges in the event of an evacuation, such as hospitals, schools, nursing homes, correctional facilities, and childcare facilities. The results of this analysis are shown on Map Q. Although it is unlikely that an evacuation will be necessary to respond to threats to source water quality, this is nonetheless useful data to have for a comprehensive emergency response plan that may expand to include strategies for responding to other types of disasters in the future

Results and Recommendations

The results of the hazardous materials spill risk analyses for the Clackamas River watershed show risk hotspots at the bottom of the watershed from historic and repeat spills, hazardous substance storage facilities, and roadway safety and historic vehicle crashes. This is significant because there are four surface water intakes located on the section of the Clackamas River between Johnson Creek and the confluence with the Willamette River; these intakes should be considered critical for protection during future emergency response planning efforts. In addition, this section of the Clackamas River is considered to be critical habitat for Chinook and Steelhead salmon, which are both listed as threatened species at the federal level. There are also numerous wetlands mapped in this area through either National Wetland Inventory or Oregon Metro RLIS. The results of the historic and mobile spill and hazardous substance storage facility cluster analyses overlaid with sensitive resource data (shown in Maps R, S, and T) clearly show that the bottom of the watershed should be the primary focus for future emergency response planning efforts. Additional areas could include Sandy and Estacada and along the HWY 212 freight system route.

A comprehensive emergency response plan: 1) provides the location and intensity of potential contaminant sources; 2) identifies critical resources to be prioritized for protection in the event of a spill such as surface water intakes and sensitive habitat; 3) outlines site-specific spill response strategies, equipment availability, command post locations, first responder bases, and other logistical information; and 4) identifies potential spill response constraints, including seasonal weather patterns and access issues, reach-specific flow velocities, and infrastructure such as narrow roads and bridge loading rates (HEC 2011). The results of the analyses outlined in this document provide a good starting point for addressing the first two emergency response plan goals. Next steps to consider include the following:

- There is a significant amount of data regarding hazardous substances stored in the OSFM database, including chemical types, hazard types, hazard scores, average and maximum stored volumes, and more. All hazardous substances were analyzed together for these analyses; to further target emergency response planning efforts, the CRWP could work with partner agencies and stakeholders to identify key hazardous substances of concern (such as petroleum) and perform a targeted risk analysis that focuses specifically on the distribution, intensity, and transportation routes to and from facilities storing these substances.

- The GIS risk analyses completed for this project did not take into account the pathway that a spill might take to surface water, such as through storm water outfalls. Future analysis could focus on potential spill pathways from high-risk clusters identified in these analyses to the Clackamas River.

- This project included mapping data provided in a spill response survey that was conducted by the CRWP in 2013. This survey included questions related to response areas and capabilities, spill equipment availability, spill response planning efforts, and more. 10 agencies and organizations responded to this survey with varying degrees of detail. As a next step, the CRWP should use the information provided in the survey to identify where more detail on specific locations and logistics is needed from agencies to support planning effort. This could include sending a follow-up survey asking for clarification from a subset of respondents where the information provided was insufficient for mapping efforts. The ultimate goal of this effort is to be able to locate as accurately as possible where resources are available and overlap and where there may be critical response gaps. Future efforts should also include mapping logistics such as potential emergency response bases, boat ramps, staging areas, and property access restrictions.

- The CRWP should contact key organization and agencies in the watershed who may already have done facility-specific spill response planning, including Portland General Electric and the Union Pacific Railway.

- The CRWP should coordinate with partner agencies and other key stakeholders to conduct an emergency response planning workshop where stakeholders can contribute to the development of site-specific spill response strategies, and the gathering of information on equipment availability, sensitive resources, communication details, and other logistics. This workshop could also include brainstorming on the most appropriate methods to use for estimating potential contaminant travel time in the Clackamas River in the event of a release.

- One important subset of sensitive resources data that was not included in these analyses are sites with cultural and archaeological significance. Workshop planning efforts should include representatives from tribes and the State Historic Preservation Office to help discuss how best to incorporate this data into planning efforts without identifying specific locations.

- The results of the GIS risk analyses described in this document and the information gathered in an emergency response planning workshop are the core components needed to develop a web-based and/or mobile GIS watershed emergency response tool that can be distributed to first responders for use in the event of an emergency. As a next step in this process, the CRWP should conduct a needs assessment to identify key hardware, software, personnel resources, and application requirements to support this system.

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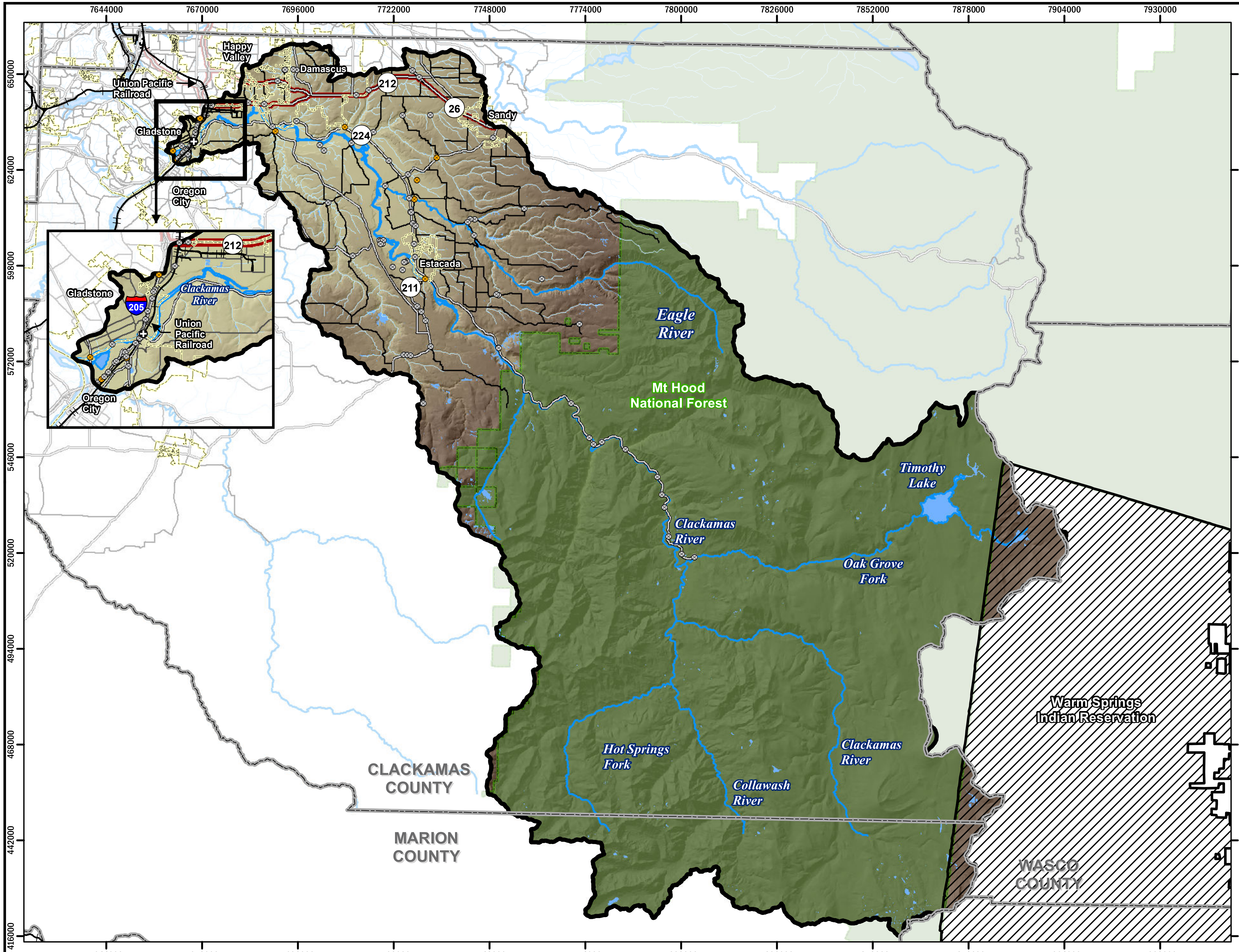
FIGURES

TRANSPORTATION INFRASTRUCTURE AND SAFETY:

MAP A - Transportation Infrastructure



Legend

- Bridge
- Functionally obsolete or structurally deficient bridge
- Railroad bridge
- Freight system route
- Railroad
- Highway or major arterial
- Arterial
- County boundary
- Clackamas River Watershed boundary
- Warm Springs Indian Reservation
- City limits
- River
- Waterbody
- Stream
- National Forest boundary

N

0 2.5 5 10

Miles

Clackamas River Water Providers

Working together to protect and conserve our drinking water.

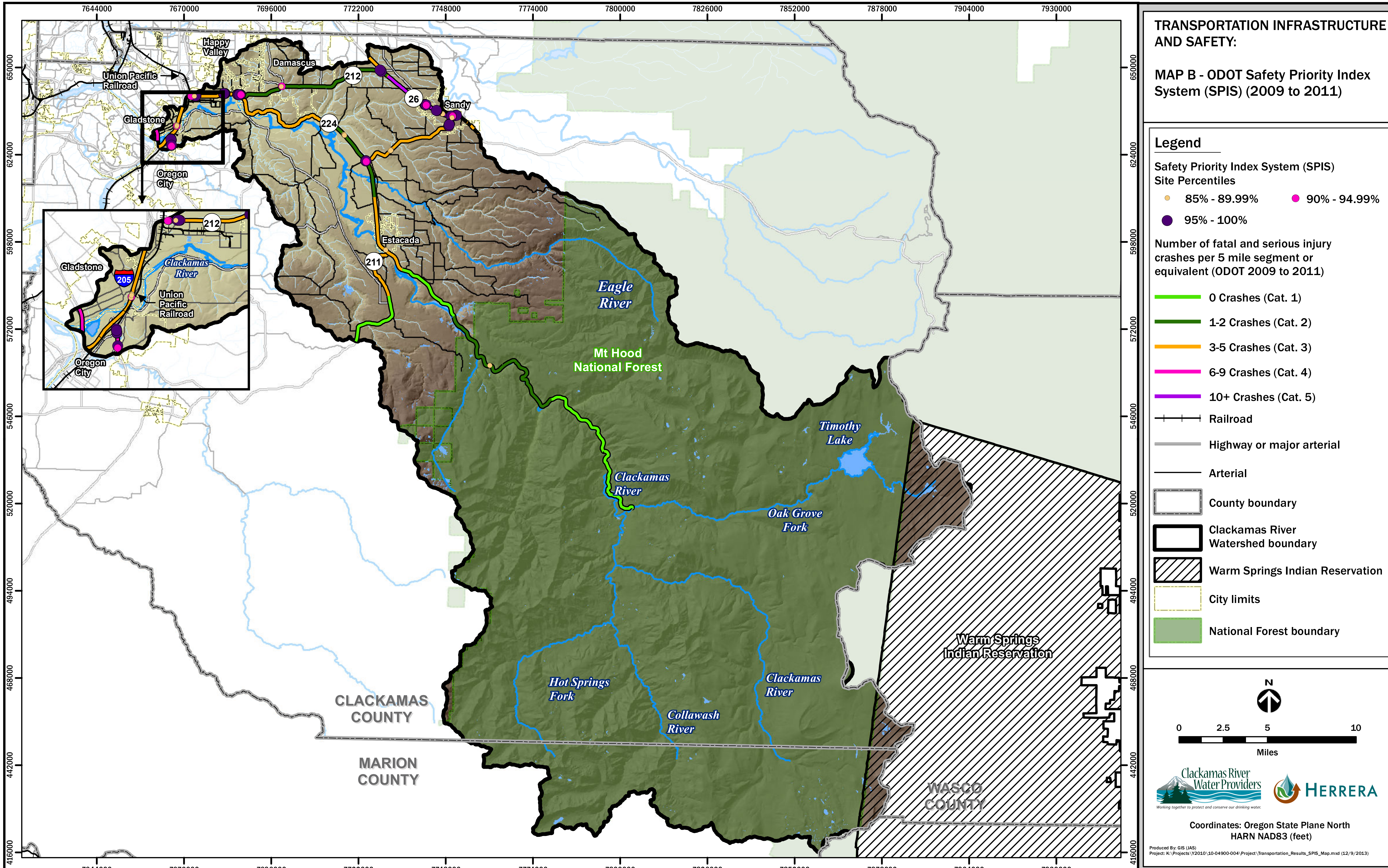
HERRERA

Coordinates: Oregon State Plane North
HARN NAD83 (feet)

Produced By: GIS (JAS)
Project: K:\Projects\Y2010\10-04900-004\Project\Transportation_Infrastructure.mxd (12/9/2013)

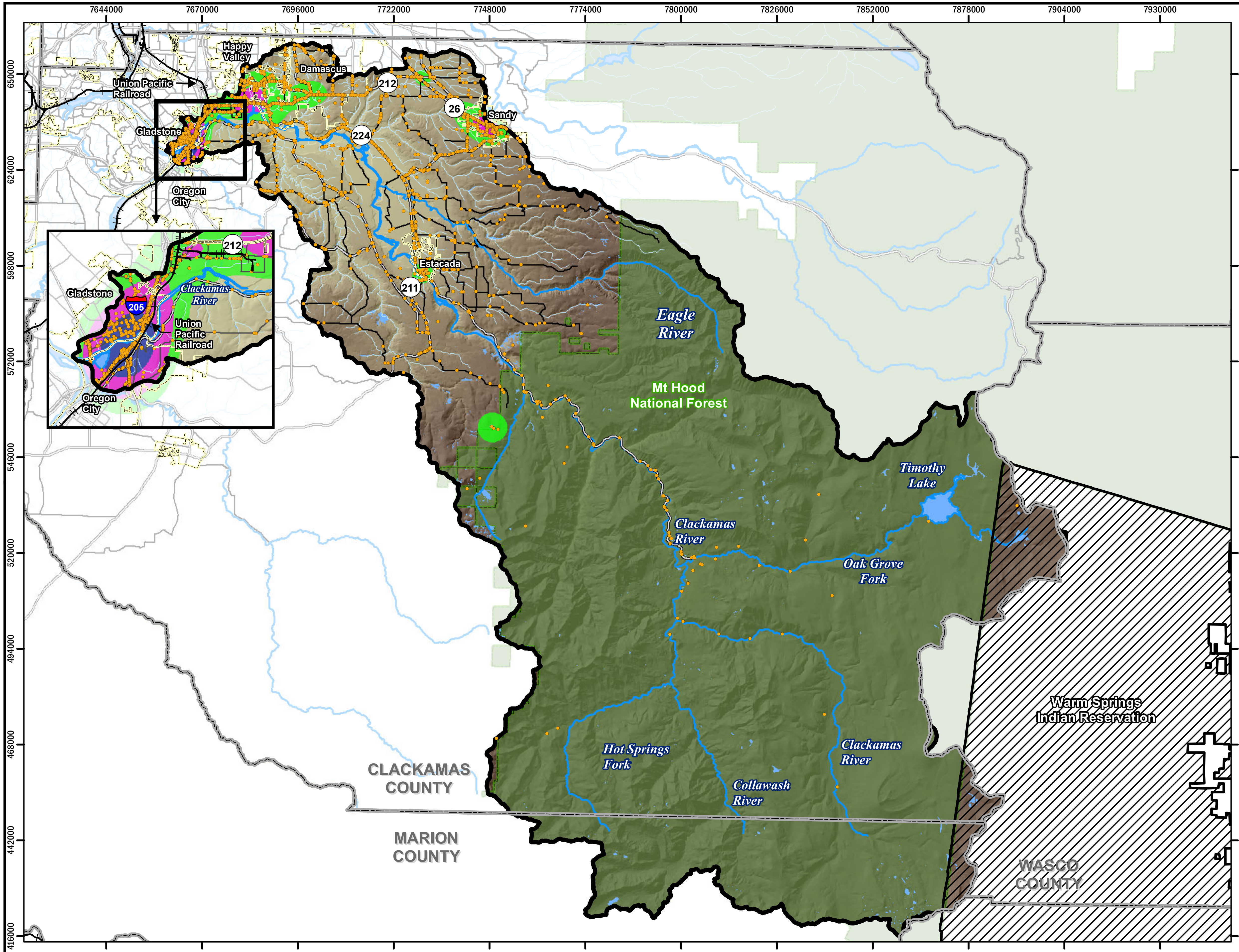
TRANSPORTATION INFRASTRUCTURE AND SAFETY:

MAP B - ODOT Safety Priority Index System (SPIS) (2009 to 2011)



TRANSPORTATION INFRASTRUCTURE AND SAFETY:

MAP C - Vehicle Crash Locations (2008 to 2013) and Crash Hot Spots



Legend

- Vehicle crash location (01/08 - 05/13)
- Moderate crash hotspot
- High crash hotspot
- Very high crash hotspot
- Railroad
- Highway or major arterial
- Arterial
- County boundary
- Clackamas River Watershed boundary
- Warm Springs Indian Reservation
- City limits
- River
- Waterbody
- Stream
- National Forest boundary

N

0 2.5 5 10

Miles

Clackamas River Water Providers

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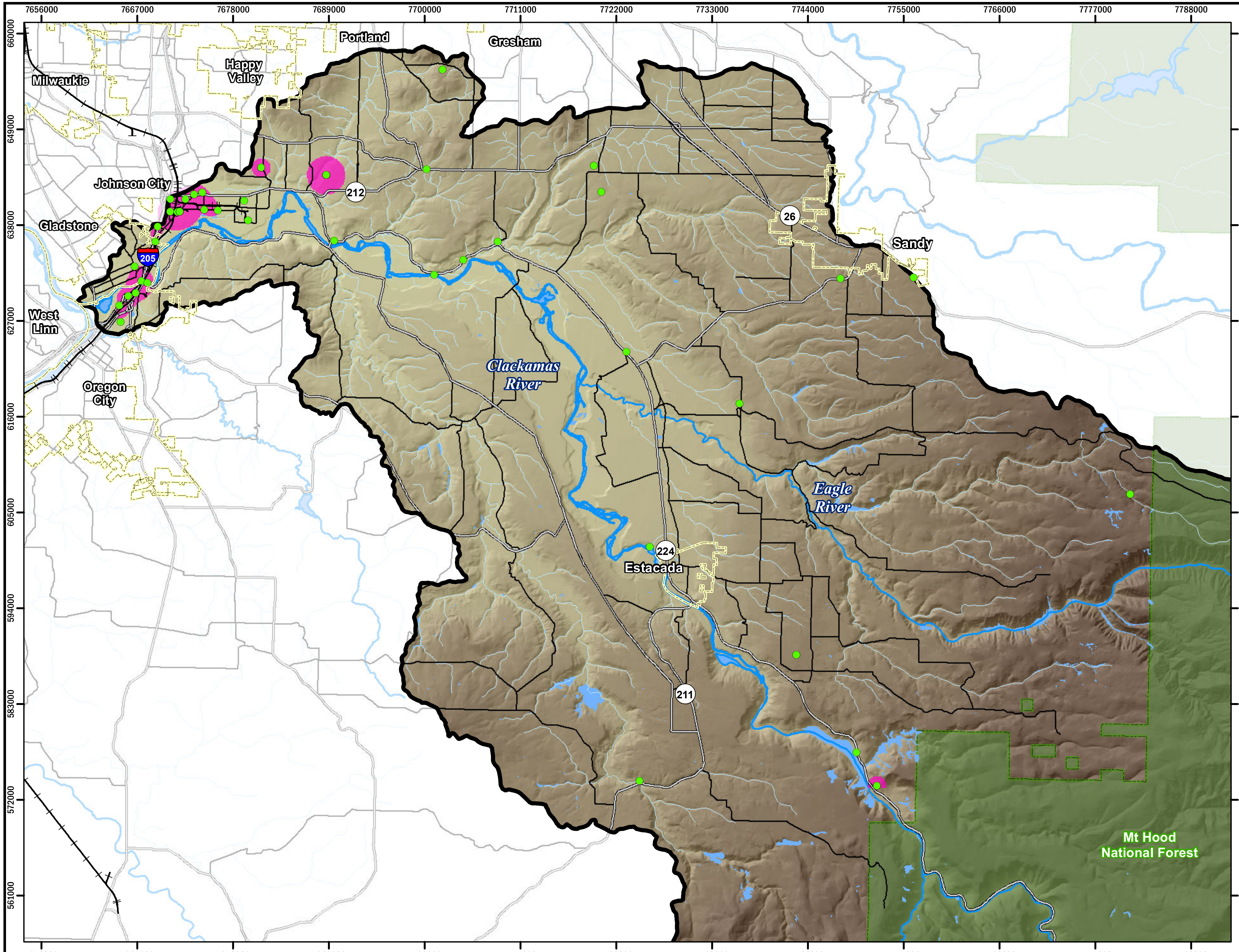
HERRERA

Coordinates: Oregon State Plane North HARN NAD83 (feet)

Produced By: GIS (JAS)
Project: K:\Projects\Y2010\10-04900-004\Project\Transportation_Results_Crash_Map.mxd (12/9/2013)



HISTORIC AND REPEAT SPILLS:

MAP D - Historic Spills from Mobile Sources

Legend

- Historic spill from a mobile source (vehicle, railroad, or vessel)
- Mobile spill hot spot
- Railroad
- Highway or major arterial
- Arterial
- County boundary
- Clackamas River Watershed boundary
- City limits
- River
- Waterbody
- Stream
- National Forest boundary

N

0 1 2 4

Miles

Clackamas River Water Providers

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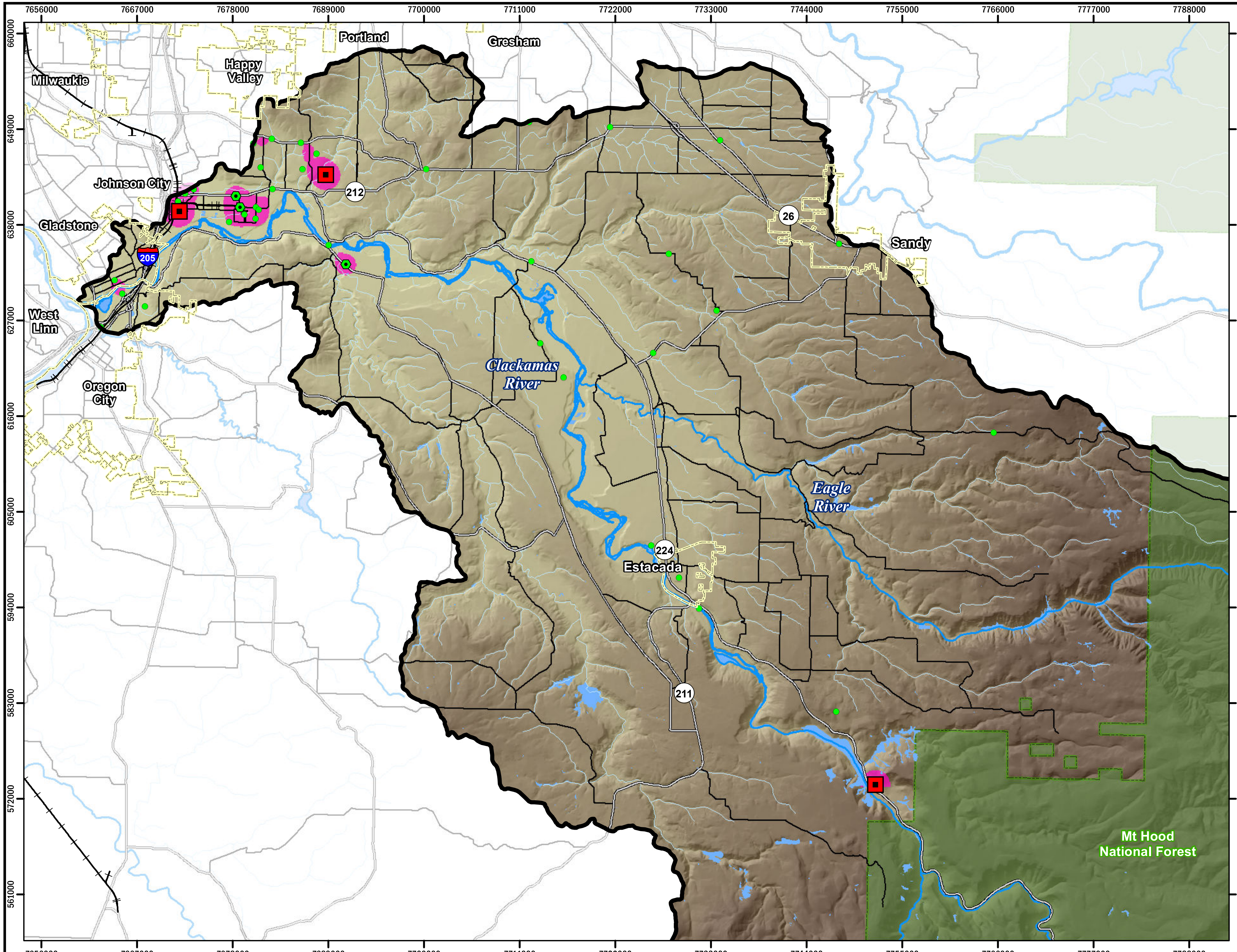
HERRERA

Coordinates: Oregon State Plane North HARN NAD83 (feet)

Produced By: GIS (JAS)
Project: K:\Projects\Y2010\10-04900-004\Project\Tranportation_Results_Spill_Clusters_Map.mxd (12/9/2013)

HISTORIC AND REPEAT SPILLS:

MAP E- Historic Spills from Non-Mobile Sources



Legend

- Historic spill from a non-mobile source
- Non-mobile spill hot spot
- Number of repeat spills
  - 2
  - > 2
- Railroad
- Highway or major arterial
- Arterial
- County boundary
- Clackamas River Watershed boundary
- City limits
- River
- Waterbody
- Stream
- National Forest boundary

N

0 1 2 4

Miles

Clackamas River Water Providers

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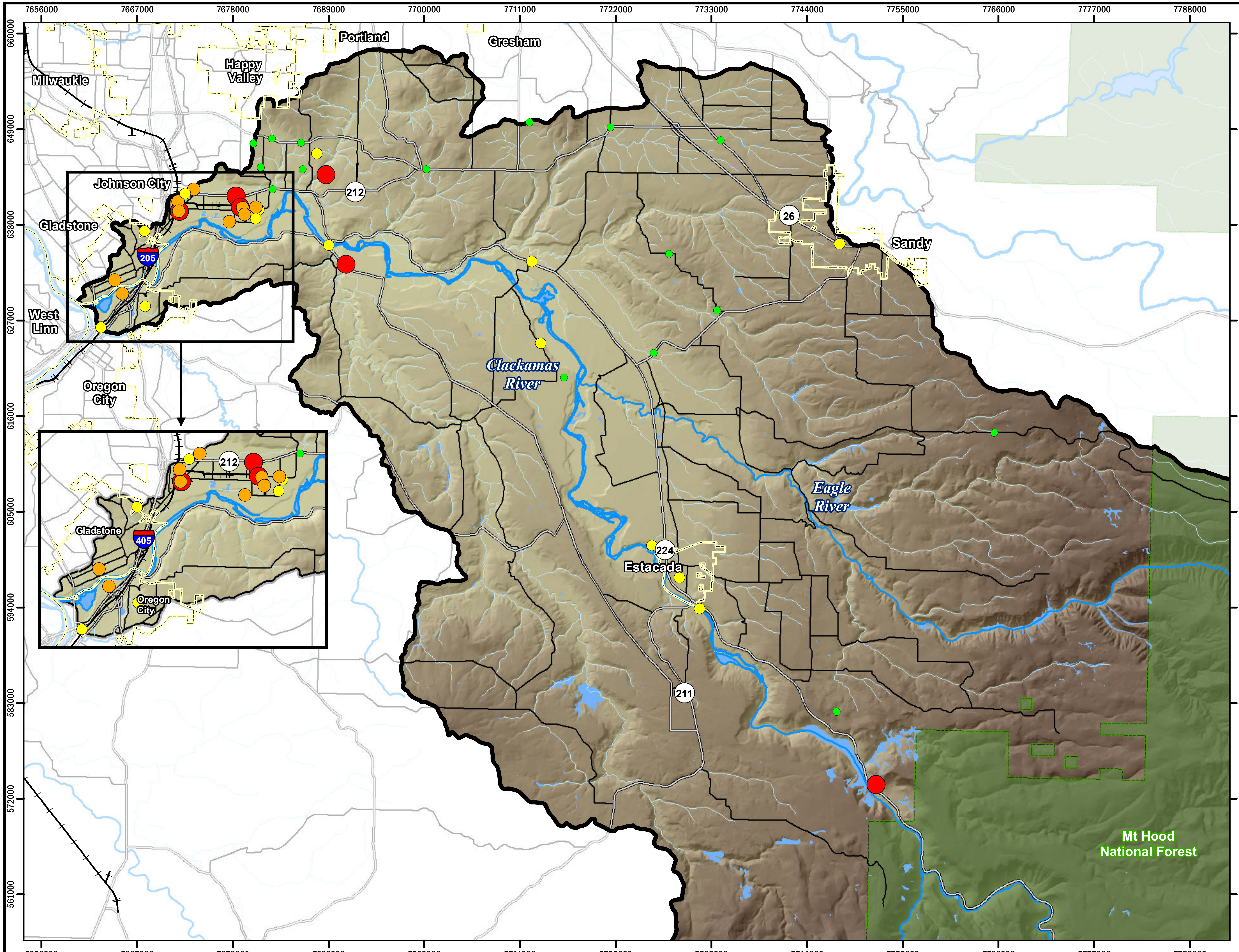
HERRERA

Coordinates: Oregon State Plane North
HARN NAD83 (feet)

Produced By: GIS (JAS)
Project: K:\Projects\Y2010\10-04900-004\Project\Historic_Spill_Locations_Results_Map.mxd (12/9/2013)

HISTORIC AND REPEAT SPILLS:

MAP F- Combined Historic Spill Risk from Non-Mobile Sources Based on Spill Quantity, Frequency, Density, and Proximity to the Clackamas River



Legend

Cumulative historic spill risk score

- Low
- Moderate
- High
- Very high

Railroad

Highway or major arterial

Arterial

County boundary

Clackamas River Watershed boundary

City limits

River

Waterbody

Stream

National Forest boundary

N

0 1 2 4

Miles

Clackamas River Water Providers

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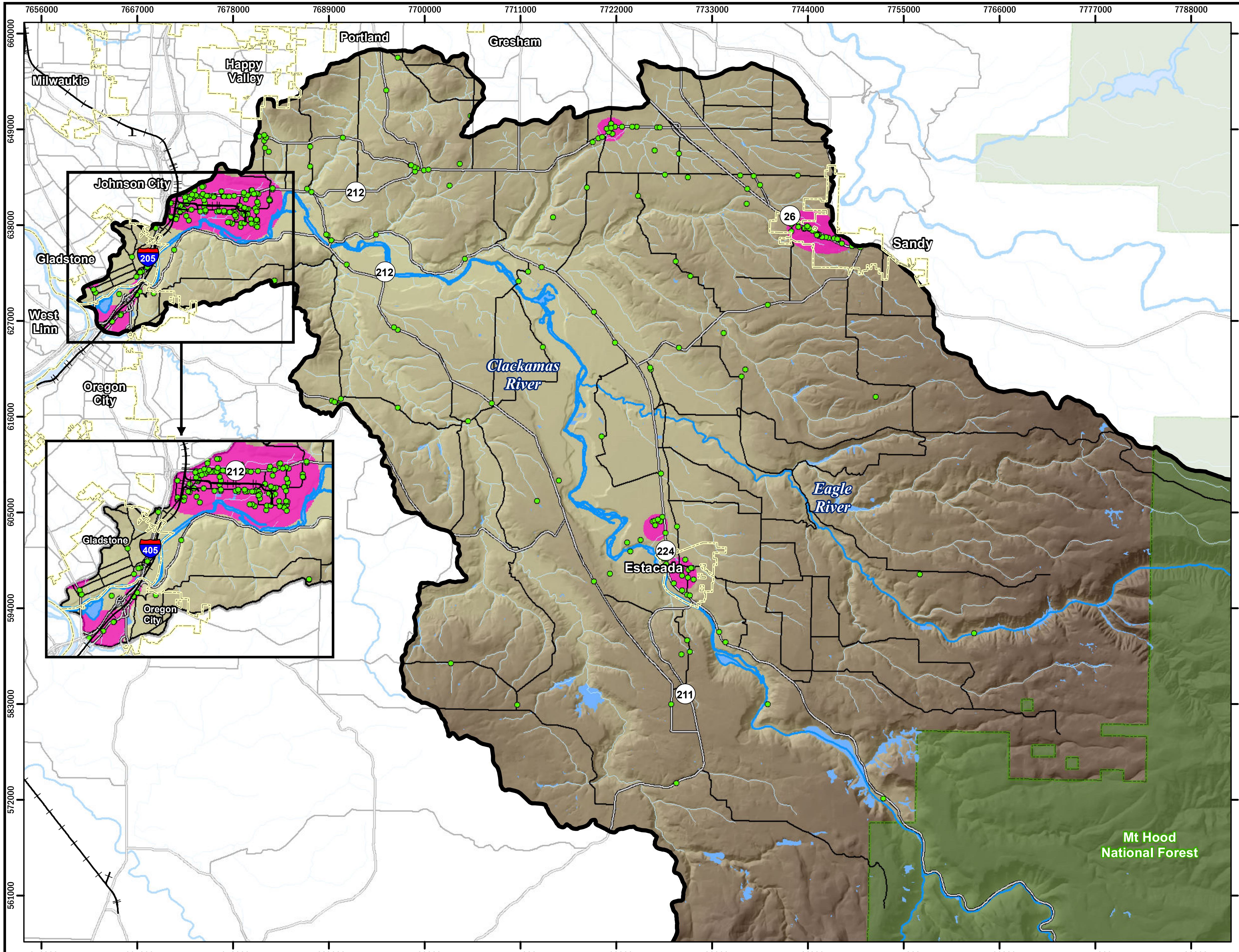
HERRERA

Coordinates: Oregon State Plane North HARN NAD83 (feet)

Produced By: GIS (JAS)
Project: K:\Projects\Y2010\10-04900-004\Project\Historic_Spill_Locations_Cumulative_Results_Map.mxd (12/9/2013)

HAZARDOUS SUBSTANCE STORAGE FACILITIES AND POTENTIAL CONTAMINANT SOURCES:

MAP G - Hazardous Substance Storage Facilities



Legend

- Chemical storage facility listed in the HSIS database
- HSIS facility cluster
- Railroad
- Highway or major arterial
- Arterial
- County boundary
- Clackamas River Watershed boundary
- City limits
- River
- Waterbody
- Stream
- National Forest boundary

N

0 1 2 4
Miles

Clackamas River Water Providers
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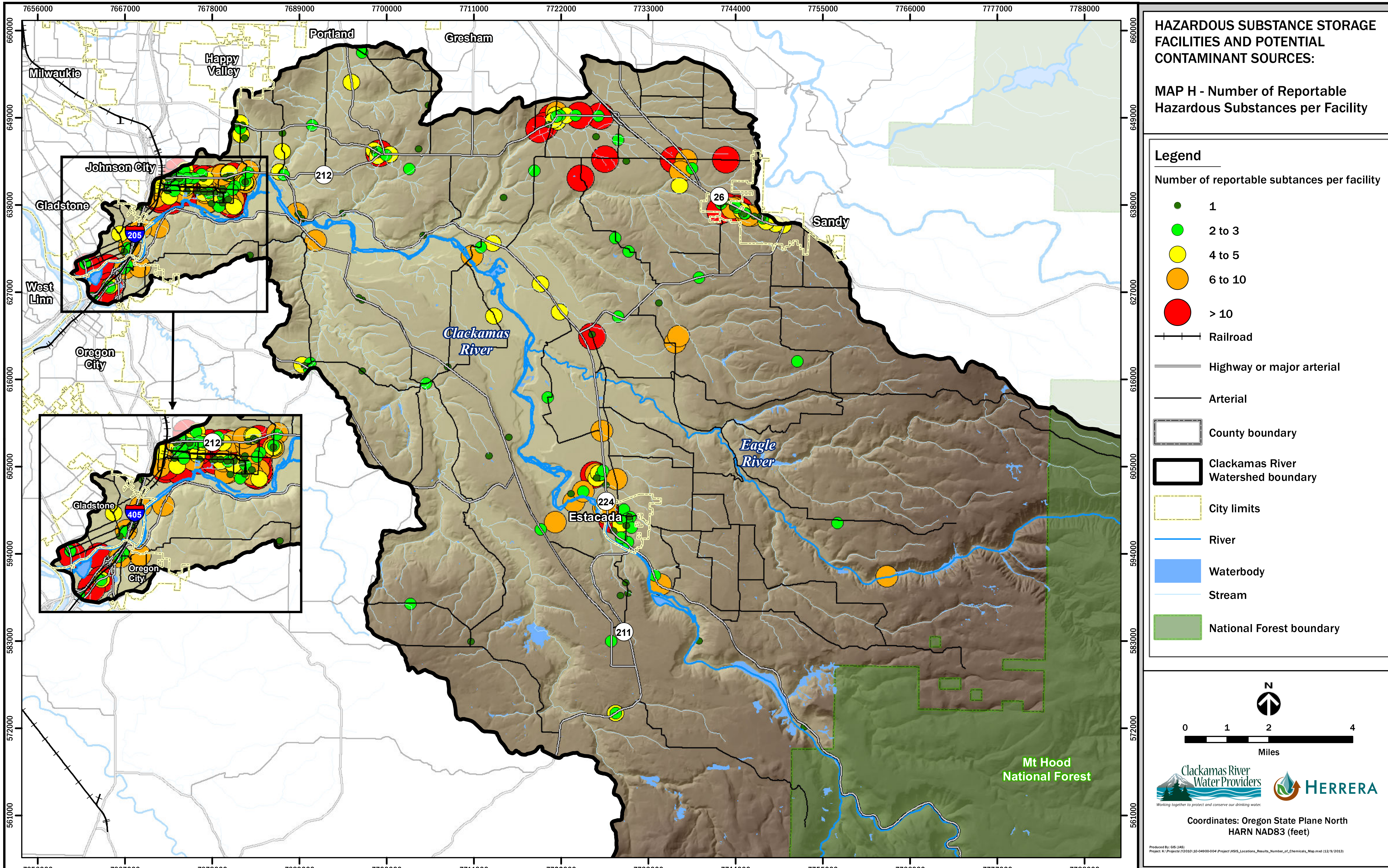
HERRERA

Coordinates: Oregon State Plane North HARN NAD83 (feet)

Produced By: GIS (JAS)
Project: K:\Projects\Y2010\10-04900-004\Project\HSIS_Locations_Results_Map.mxd (12/9/2013)



HAZARDOUS SUBSTANCE STORAGE FACILITIES AND POTENTIAL CONTAMINANT SOURCES:
MAP H - Number of Reportable Hazardous Substances per Facility
Legend
Number of reportable subtances per facility
1
2 to 3
4 to 5
6 to 10
> 10
Railroad
Highway or major arterial
Arterial
County boundary
Clackamas River Watershed boundary
City limits
River
Waterbody
Stream
National Forest boundary
N
0 1 2 4
Miles
Clackamas River Water Providers
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HERRERA
Coordinates: Oregon State Plane North HARN NAD83 (feet)
Produced By: GIS (JAS)
Project: K:\Projects\Y2010\10-04900-004\Project\HSIS_Locations_Results_Number_of_Chemicals_Map.mxd (12/9/2013)
Portland
Gresham
Happy Valley
Milwaukie
Johnson City
Gladstone
West Linn
Oregon City
Sandy
Estacada
Clackamas River
Eagle River
Mt Hood National Forest
212
205
26
224
211
405
7656000
7667000
7678000
7689000
7700000
7711000
7722000
7733000
7744000
7755000
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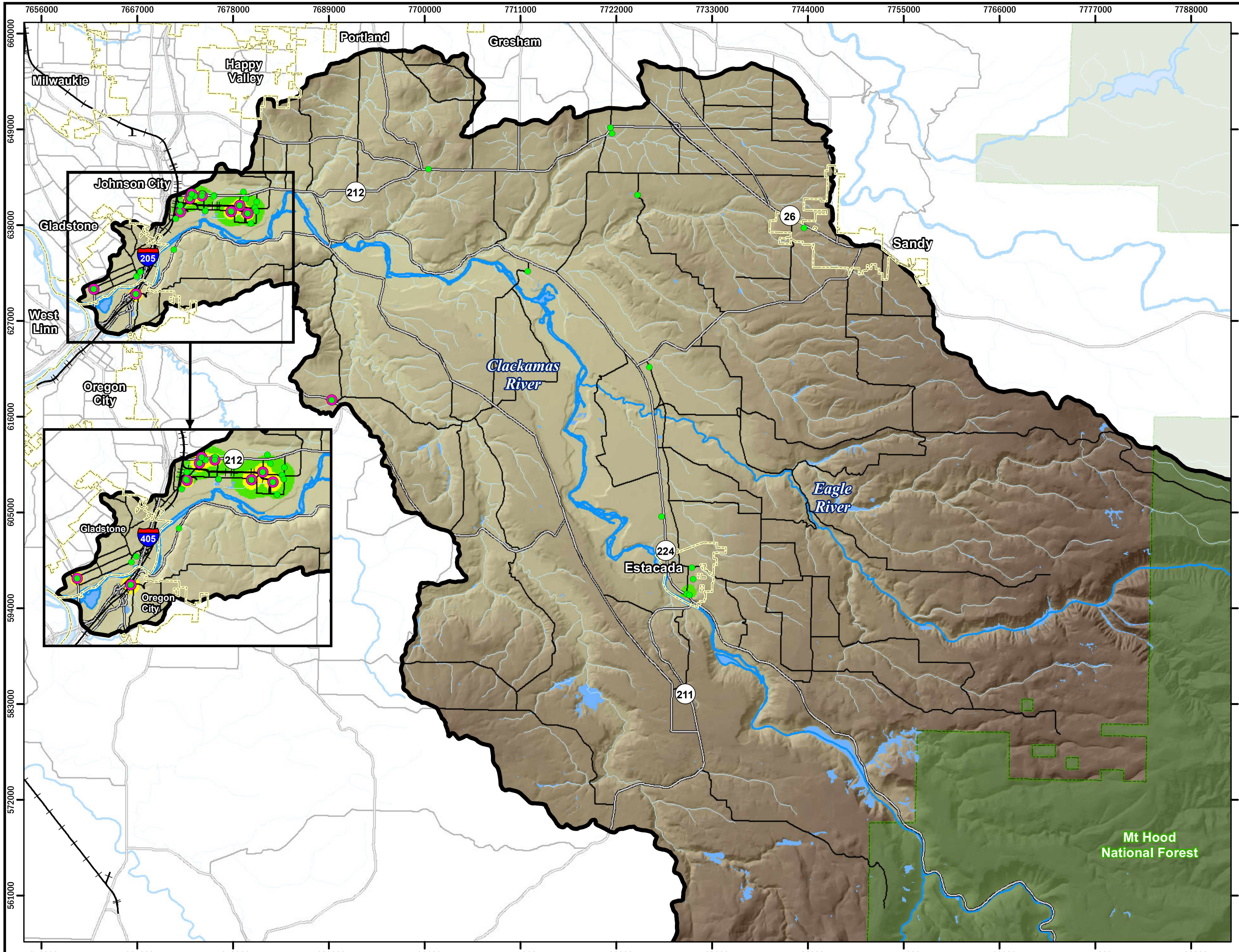
594000
583000
572000
561000



HAZARDOUS SUBSTANCE STORAGE FACILITIES AND POTENTIAL CONTAMINANT SOURCES:

MAP I - Hazardous Substance Storage Facillity Reportable Quantities (Liquids Only)

Legend

- Maximum reportable storage quantity > 10,000 gallons (liquids only)
- Maximum reportable storage quantity > 50,000 gallons (liquids only)
- Cluster of facilities with > 10,000 gallons
- Cluster of facilities with > 50,000 gallons
- Railroad
- Highway or major arterial
- Arterial
- County boundary
- Clackamas River Watershed boundary
- City limits
- River
- Waterbody
- Stream
- National Forest boundary

N

0 1 2 4

Miles

Clackamas River Water Providers

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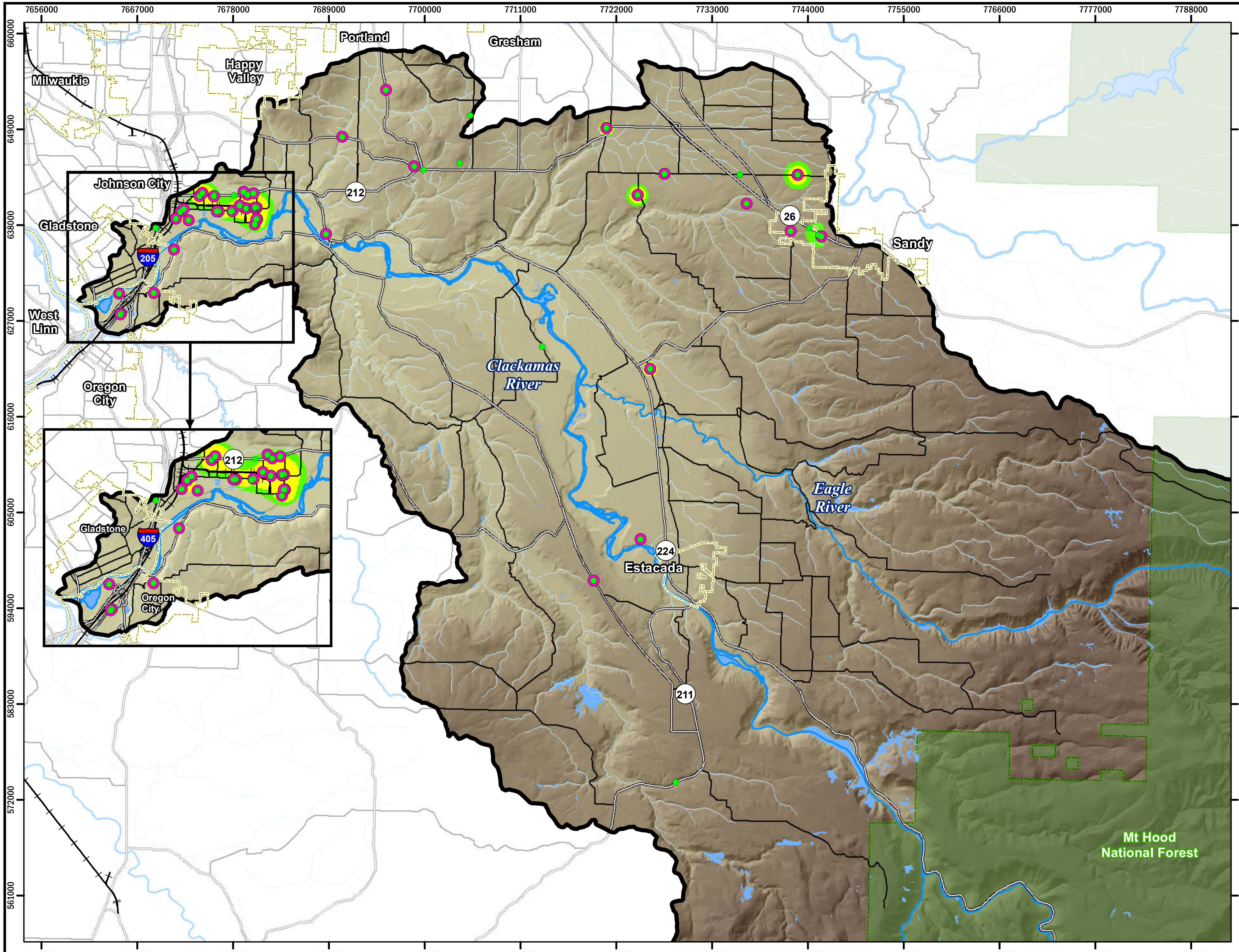
HERRERA

Coordinates: Oregon State Plane North HARN NAD83 (feet)

HAZARDOUS SUBSTANCE STORAGE FACILITIES AND POTENTIAL CONTAMINANT SOURCES:

MAP J - Hazardous Substance Storage Facillity Reportable Quantities (Solids Only)



Legend

- Maximum reportable storage quantity > 5,000 pounds (solids only)
- Maximum reportable storage quantity > 10,000 pounds (solids only)
- Cluster of facilities with > 5,000 pounds
- Cluster of facilities with > 10,000 pounds
- Railroad
- Highway or major arterial
- Arterial
- County boundary
- Clackamas River Watershed boundary
- City limits
- River
- Waterbody
- Stream
- National Forest boundary

N

0 1 2 4

Miles

Clackamas River Water Providers

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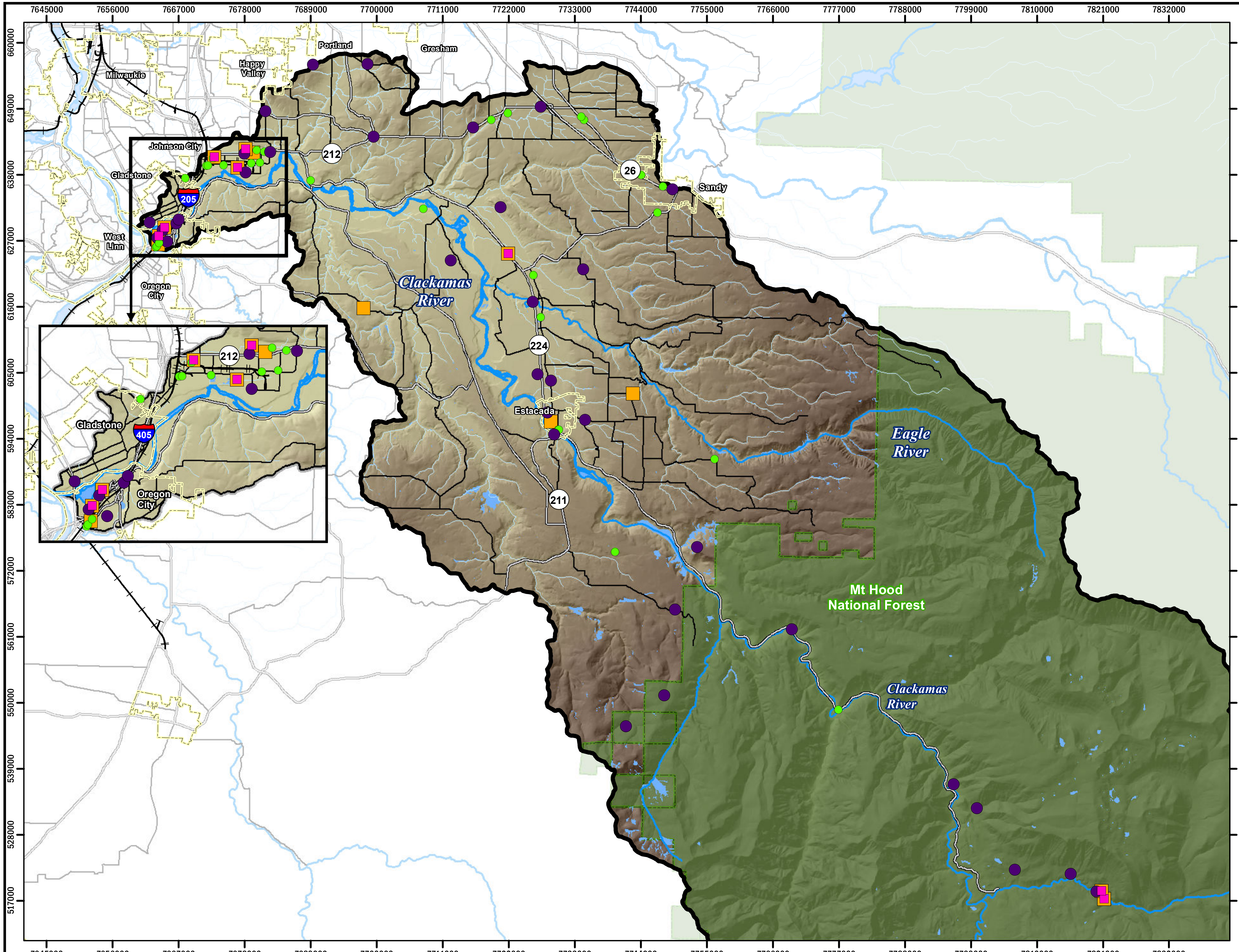
HERRERA

Coordinates: Oregon State Plane North
HARN NAD83 (feet)

Produced By: GIS (JAS)
Project: K:\Projects\Y2010\10-04900-004\Project\HSIS_Locations_Results_Pound_Quantities.mxd (12/9/2013)



HAZARDOUS SUBSTANCE STORAGE FACILITIES AND POTENTIAL CONTAMINANT SOURCES:

MAP K - Environmental Cleanup Site Information (ECSI) Location

Legend

Site listed in the Environmental Cleanup Site Information (ECSI) database

- No further action required
- Suspect site requiring further investigation
- Confirmed Release List (CRL) site
- Inventory of Hazardous Substance site
- Railroad
- Highway or major arterial
- Arterial
- County boundary
- Clackamas River Watershed boundary
- City limits
- River
- Waterbody
- Stream
- National Forest boundary

N

0 1.5 3 6

Miles

Clackamas River Water Providers

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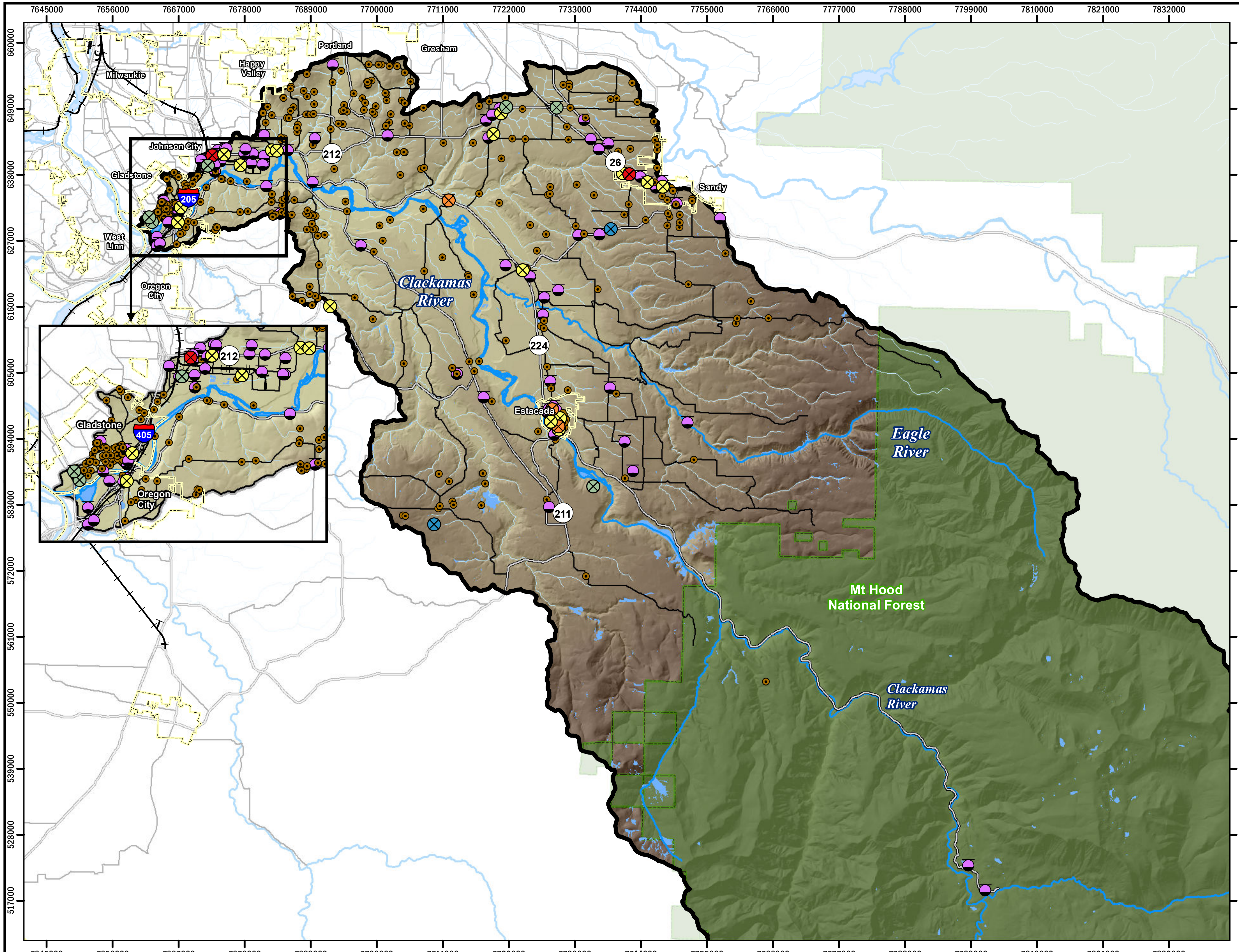
HERRERA

Coordinates: Oregon State Plane North
HARN NAD83 (feet)

Produced By: GIS (JAS)
Project: K:\Projects\Y2010\10-04900-004\Project\ECSI_Results_Map.mxd (12/9/2013)



HAZARDOUS SUBSTANCE STORAGE FACILITIES AND POTENTIAL CONTAMINANT SOURCES:

MAP L - Underground Storage Tanks (UST) and Leaking Underground Storage Tanks (LUST) - Dec 2013

Legend

Underground Storage Tank (UST)

- 400 to 1,000 gallons
- 1,000 to 5,000 gallons
- 5,000 to 10,000 gallons
- 10,000 to 15,000 gallons
- > 15,000 gallons

Leaking Underground Storage Tank (LUST)

- Regulated tank
- Non-regulated tank

- Railroad
- Highway or major arterial
- Arterial
- County boundary
- Clackamas River Watershed boundary
- City limits
- River
- Stream
- Waterbody
- National Forest boundary

N

0 1.5 3 6

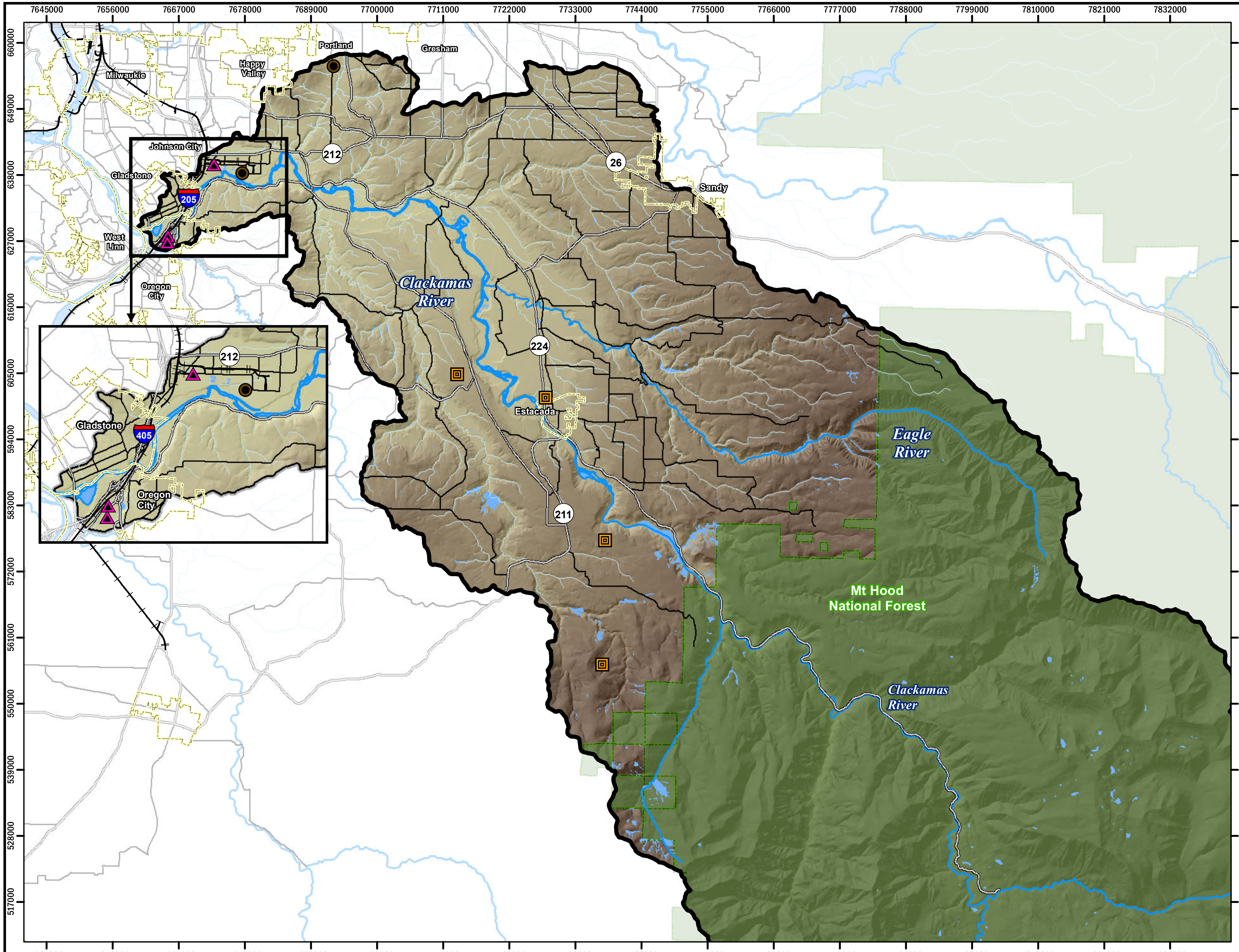
Miles

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

HERRERA

Coordinates: Oregon State Plane North HARN NAD83 (feet)

Produced By: GIS (JAS)
Project: K:\Projects\Y2010\10-04900-004\Project\Other_Facilities_Results_Map.mxd (12/9/2013)



HAZARDOUS SUBSTANCE STORAGE FACILITIES AND POTENTIAL CONTAMINANT SOURCES:

MAP M - Solid Waste Disposal Sites and Landfill Permits - December 2013

Legend

Solid waste disposal site and landfill permits

- Compost
- Industrial
- Municipal
- Railroad
- Highway or major arterial
- Arterial
- County boundary
- Clackamas River Watershed boundary
- City limits
- River
- Stream
- Waterbody
- National Forest boundary

N

0 1.5 3 6

Miles

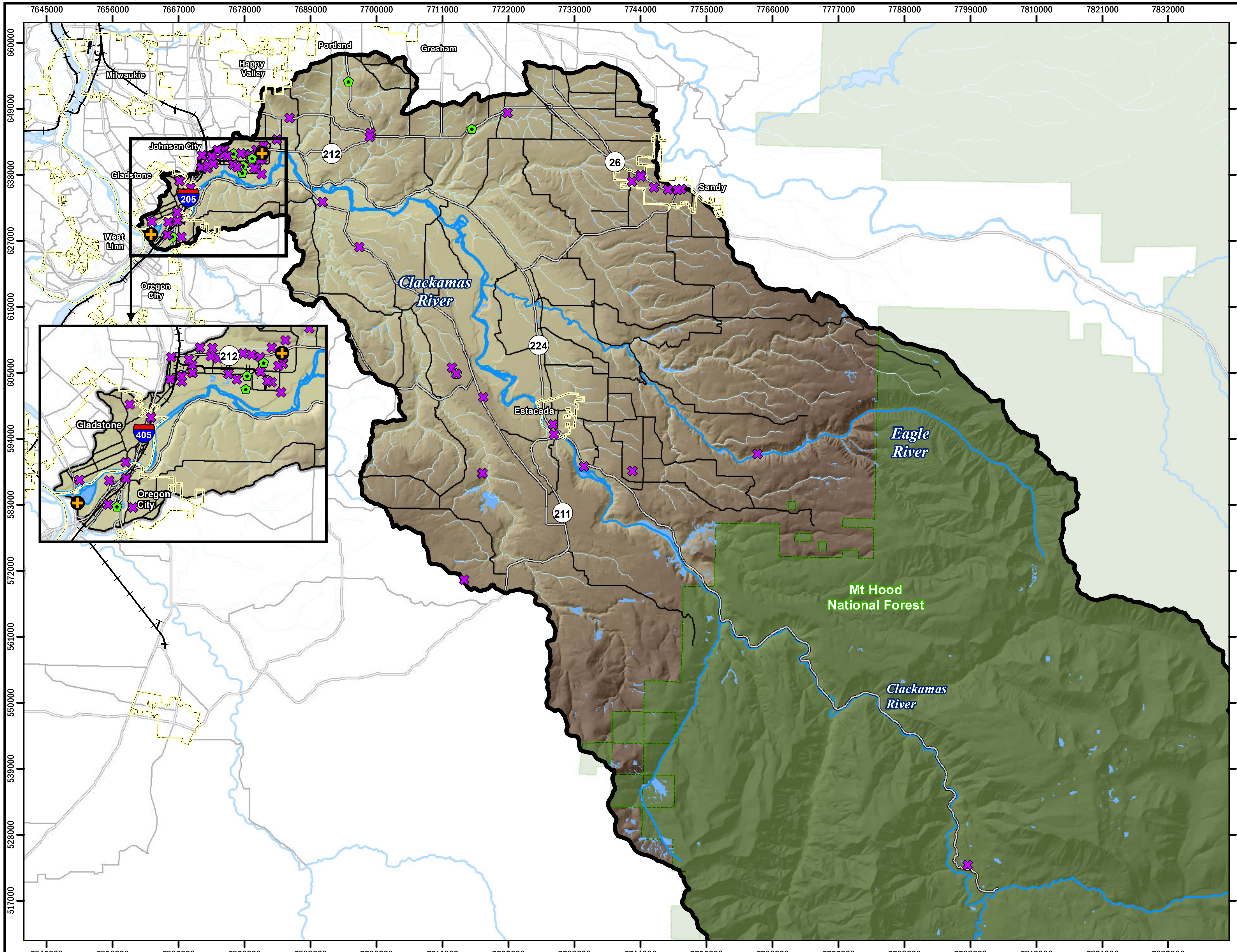
Clackamas River Water Providers

Working together to protect and conserve our drinking water.

HERRERA

Coordinates: Oregon State Plane North HARN NAD83 (feet)

Produced By: GIS (JAS)
Project: K:\Projects\Y2010\10-04900-004\Project\Other_Facilities_Results_Map.mxd (12/9/2013)



HAZARDOUS SUBSTANCE STORAGE FACILITIES AND POTENTIAL CONTAMINANT SOURCES:

MAP N - Hazardous Waste Generators - December 2013

Legend

Hazardous waste generator

- Conditionally exempt generator (CEG)
- Small quantity generator (SQG)
- Large quantity generator (LQG)

- Railroad
- Highway or major arterial
- Arterial
- County boundary
- Clackamas River Watershed boundary
- City limits
- River
- Stream
- Waterbody
- National Forest boundary

N

0 1.5 3 6

Miles

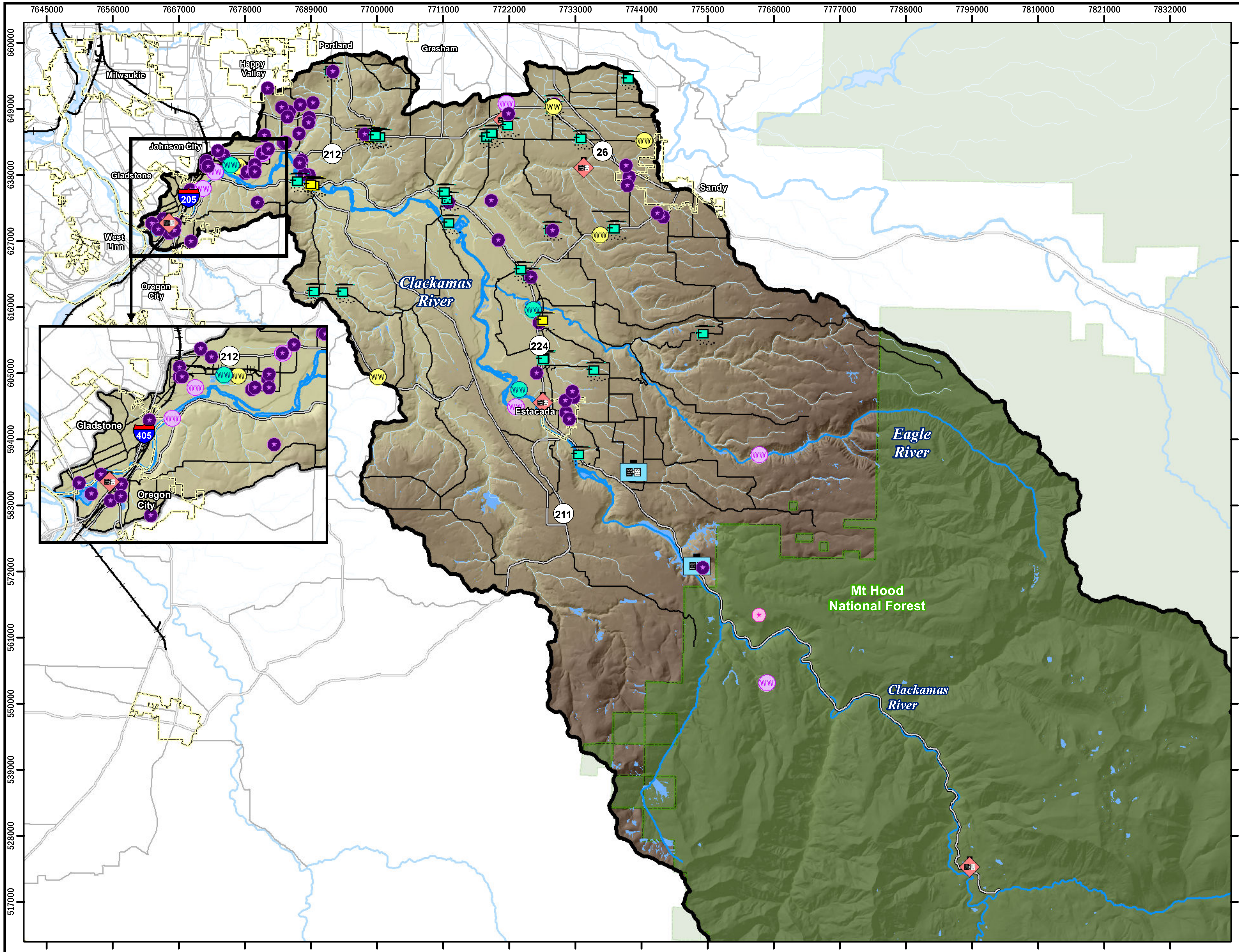
Clackamas River Water Providers

Working together to protect and conserve our drinking water.

HERRERA

Coordinates: Oregon State Plane North HARN NAD83 (feet)

Produced By: GIS (JAS)
Project: K:\Projects\Y2010\10-04900-004\Project\Other_Facilities_Results_Map.mxd (12/9/2013)



HAZARDOUS SUBSTANCE STORAGE FACILITIES AND POTENTIAL CONTAMINANT SOURCES:

MAP O - Water Quality Permits - December 2013

Legend

Individual National Pollutant Discharge Elimination System (NPDES) permit
- Domestic wastewater treatment facility
- Industrial storm water discharge
- Industrial wastewater discharge

Individual Water Pollution Control Facility (WPCF) permit
- Domestic on-site sewage system
- Domestic wastewater treatment facility
- Industrial wastewater discharge

General NPDES Permit
- Industrial storm water discharges
- Industrial wastewater discharges

General WPCF Permit
- Domestic on-site sewage system
- Industrial wastewater discharges

- Highway or major arterial
- Arterial
- Railroad
- Clackamas River Watershed boundary
- National Forest boundary

N

0 1.5 3 6

Miles

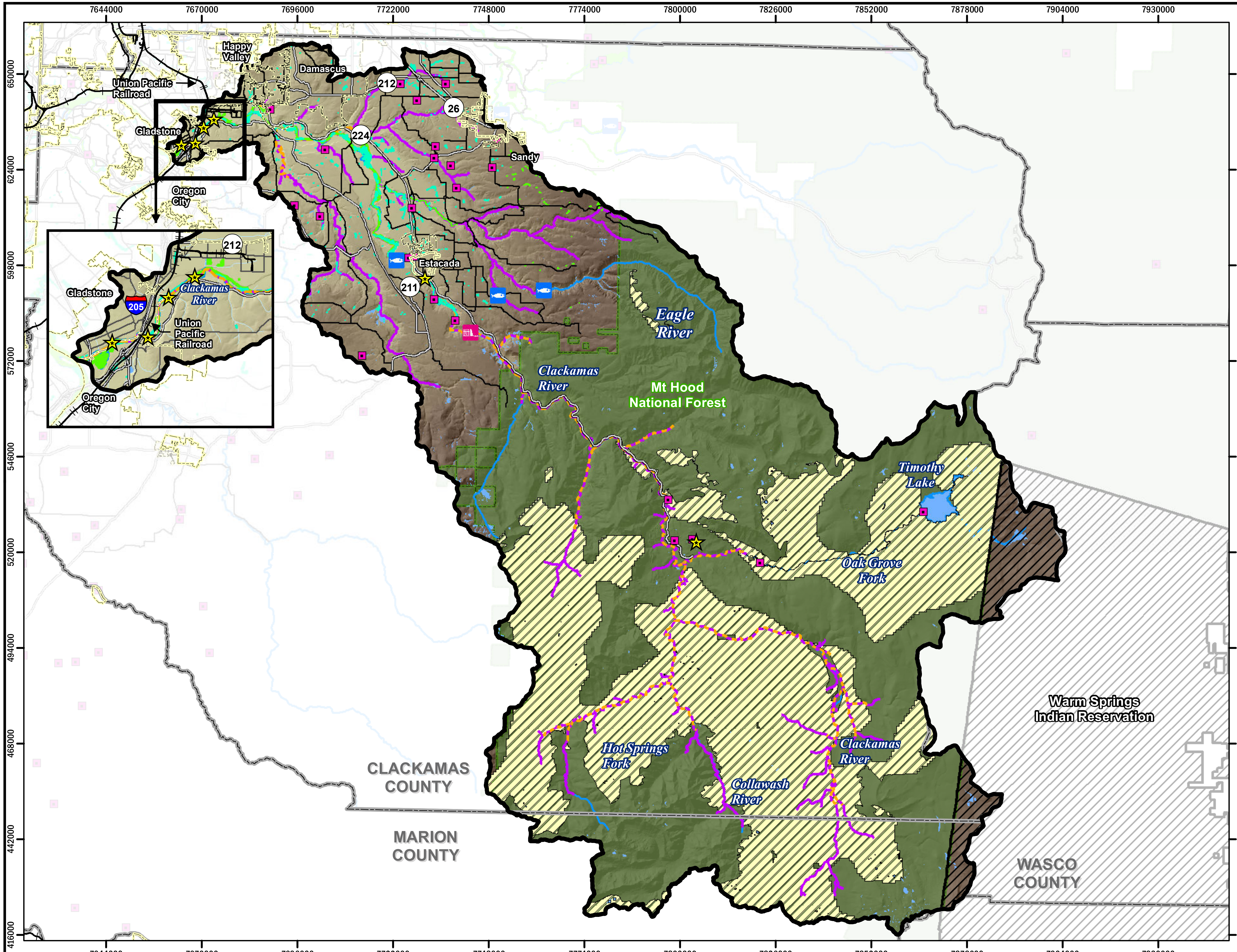
Clackamas River Water Providers

Working together to protect and conserve our drinking water.

HERRERA

Coordinates: Oregon State Plane North HARN NAD83 (feet)

Produced By: GIS (JAS)
Project: K:\Projects\Y2010\10-04900-004\Project\NPDES_Results_Map.mxd (12/9/2013)



SENSITIVE RESOURCES:

MAP P - Sensitive Resources and Habitat

Legend

- Major Dam
- Other Dams
- Fish hatchery
- Surface water intake

Critical fish habitat (threatened species)

- Chinook salmon
- Steelhead
- Northern spotted owl critical habitat (threatened species)
- Wetlands (RLIS)
- National Wetland Inventory (NWI)
- Highway or major arterial
- Arterial
- Railroad
- County boundary
- Clackamas River Watershed boundary
- City limits
- Waterbody
- Stream
- River
- National Forest boundary

N

0 2.5 5 10

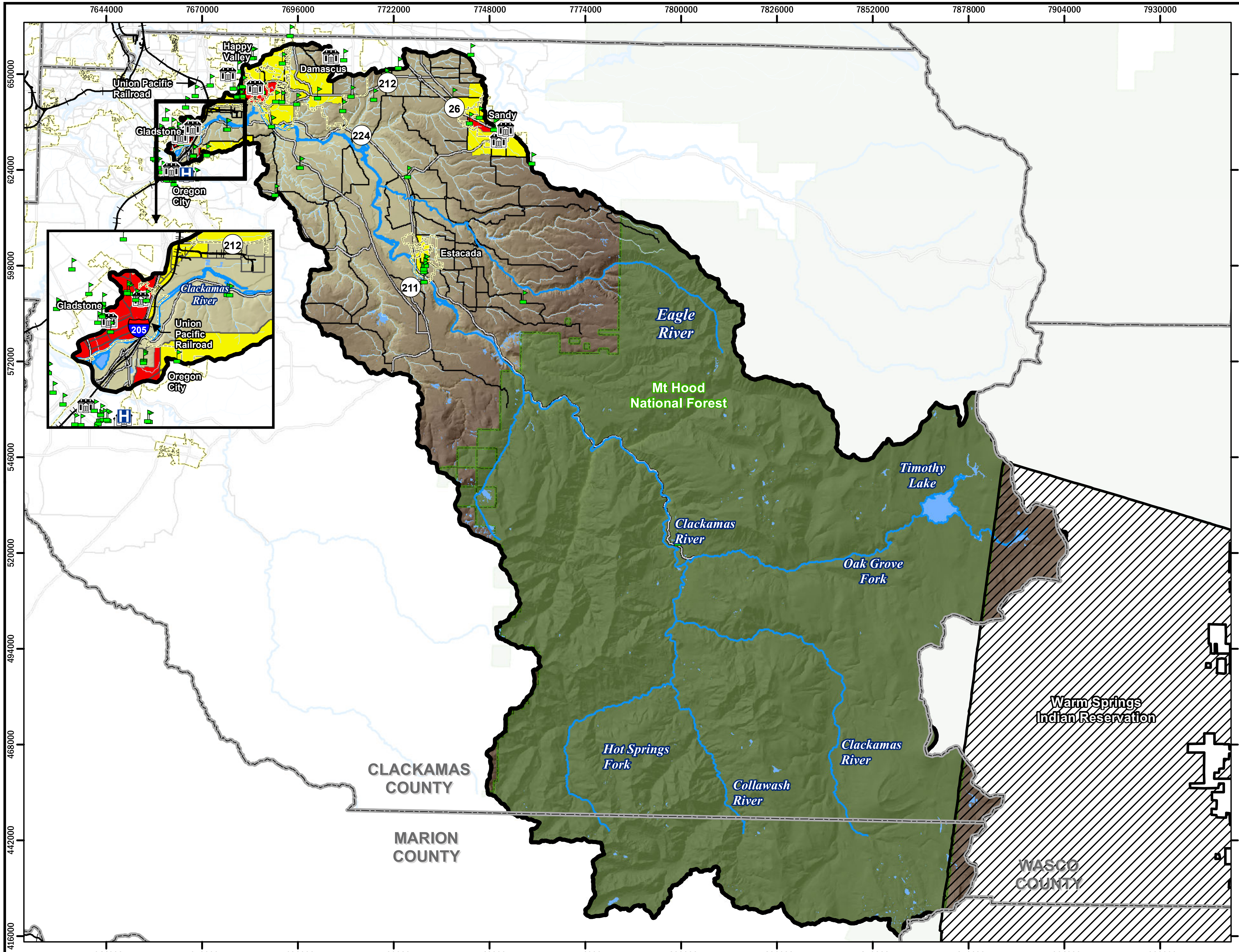
Miles

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

HERRERA

Coordinates: Oregon State Plane North HARN NAD83 (feet)

Produced By: GIS (JAS)
Project: K:\Projects\Y2010\10-04900-004\Project\Sensitive_Resources_Map.mxd (12/9/2013)



SENSITIVE RESOURCES:

MAP Q - Population Density and Evacuation Challenges

Legend

- Hospital
- Nursing home or assisted living facility
- School

Population Density (2010)

- < 1
- 1 to 5
- > 5
- Railroad
- Highway or major arterial
- Arterial
- County boundary
- Clackamas River Watershed boundary
- Warm Springs Indian Reservation
- City limits
- River
- Stream
- National Forest boundary

N

0 2.5 5 10

Miles

Clackamas River Water Providers

Working together to protect and conserve our drinking water.

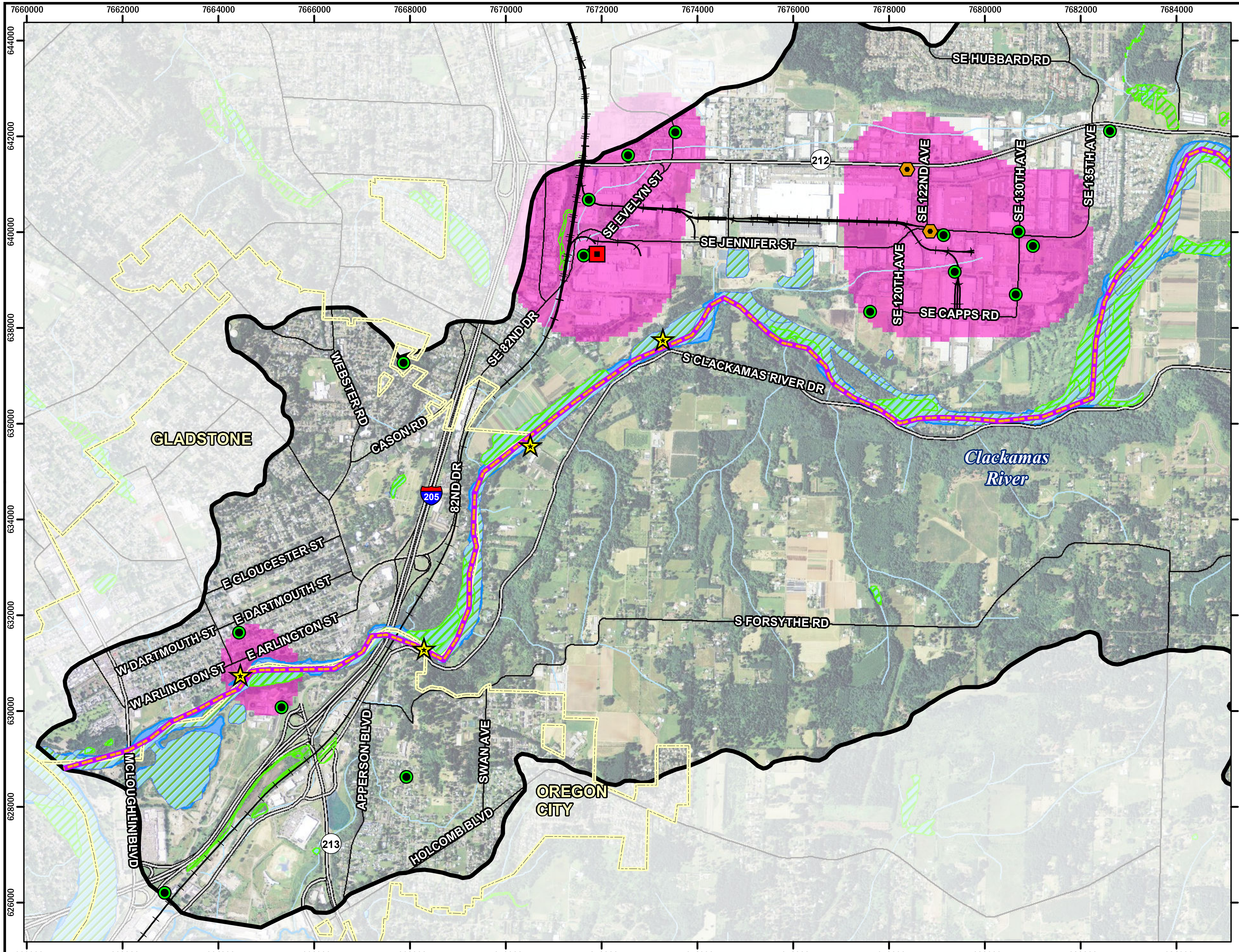
HERRERA

Coordinates: Oregon State Plane North HARN NAD83 (feet)

Produced By: GIS (JAS)
Project: K:\Projects\Y2010\10-04900-004\Project\Population_and_People_at_Risk.mxd (12/9/2013)

COMBINED RESULTS:

MAP R- Combined Historic Spill Risk From Non-Mobile Sources and Sensitive Resources Overlay



Legend

- Historic spill from a non-mobile source
- Number of repeat spills: 2; > 2
- Historic spill hotspot
- Surface water intake
- Critical fish habitat (threatened species)
  - Chinook salmon
  - Steelhead
- Wetlands (RLIS)
- National Wetland Inventory (NWI)
- Railroad
- Highway or major arterial
- Arterial
- Clackamas River Watershed boundary
- City limits
- River
- Stream

N

0 1,000 2,000 4,000

Feet

Clackamas River Water Providers

Working together to protect and conserve our drinking water.

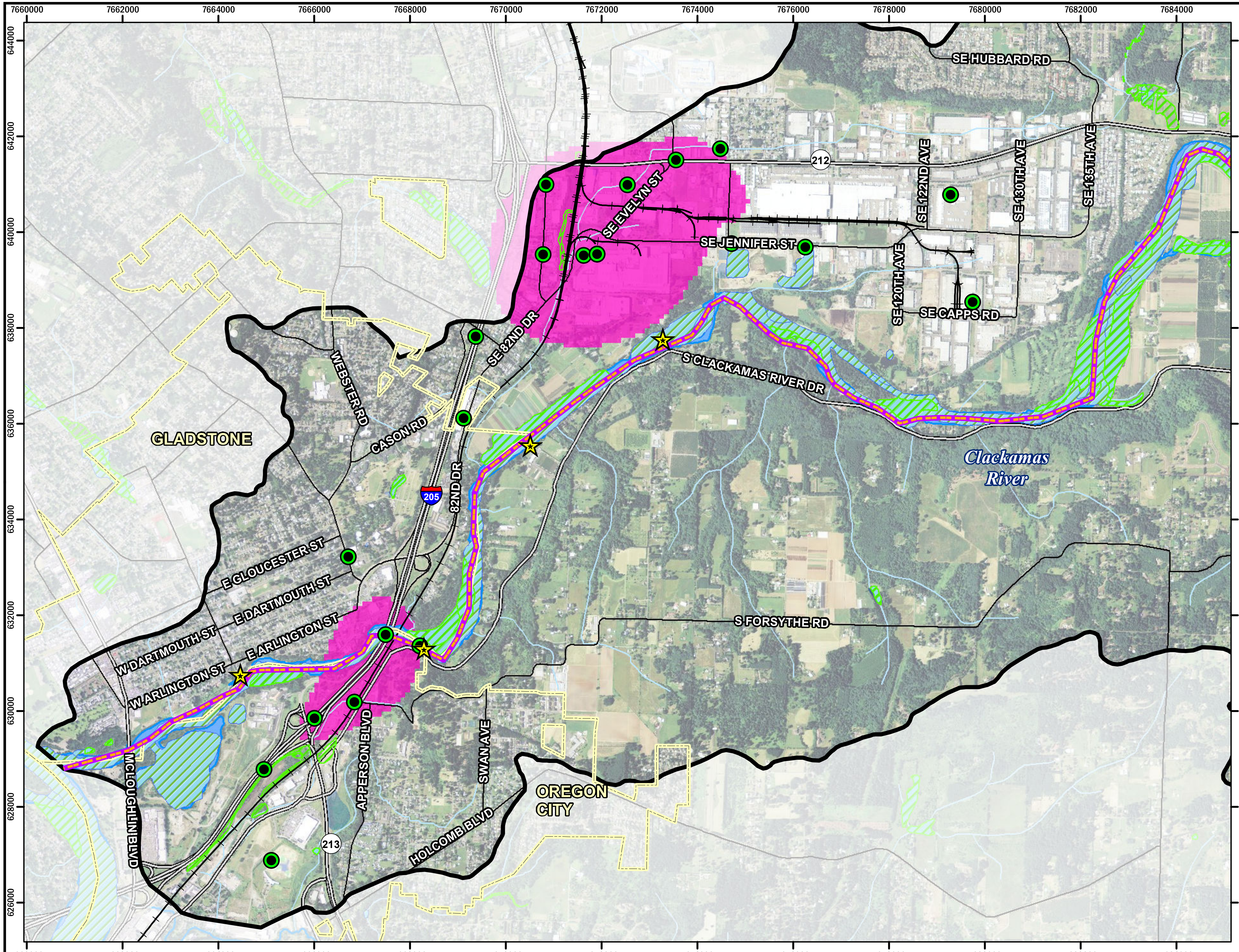
HERRERA

Coordinates: Oregon State Plane North HARN NAD83 (feet)

Produced By: GIS (JAS)
Project: K:\Projects\Y2010\10-04900-004\Project\Historic_Spill_Results_Sensitive_Resources_Overlay.mxd (12/10/2013)

COMBINED RESULTS:

MAP S - Combined Historic Spill Risk From Mobile Sources and Sensitive Resources Overlay



Legend

- Historic spill from a mobile source
- Historic spill hotspot
- Surface water intake

Critical fish habitat (threatened species)

- Chinook salmon
- Steelhead
- Wetlands (RLIS)
- National Wetland Inventory (NWI)
- Railroad
- Highway or major arterial
- Arterial
- Clackamas River Watershed boundary
- City limits
- River
- Stream
- Waterbody

N

0 1,000 2,000 4,000

Feet

Clackamas River Water Providers

Working together to protect and conserve our drinking water.

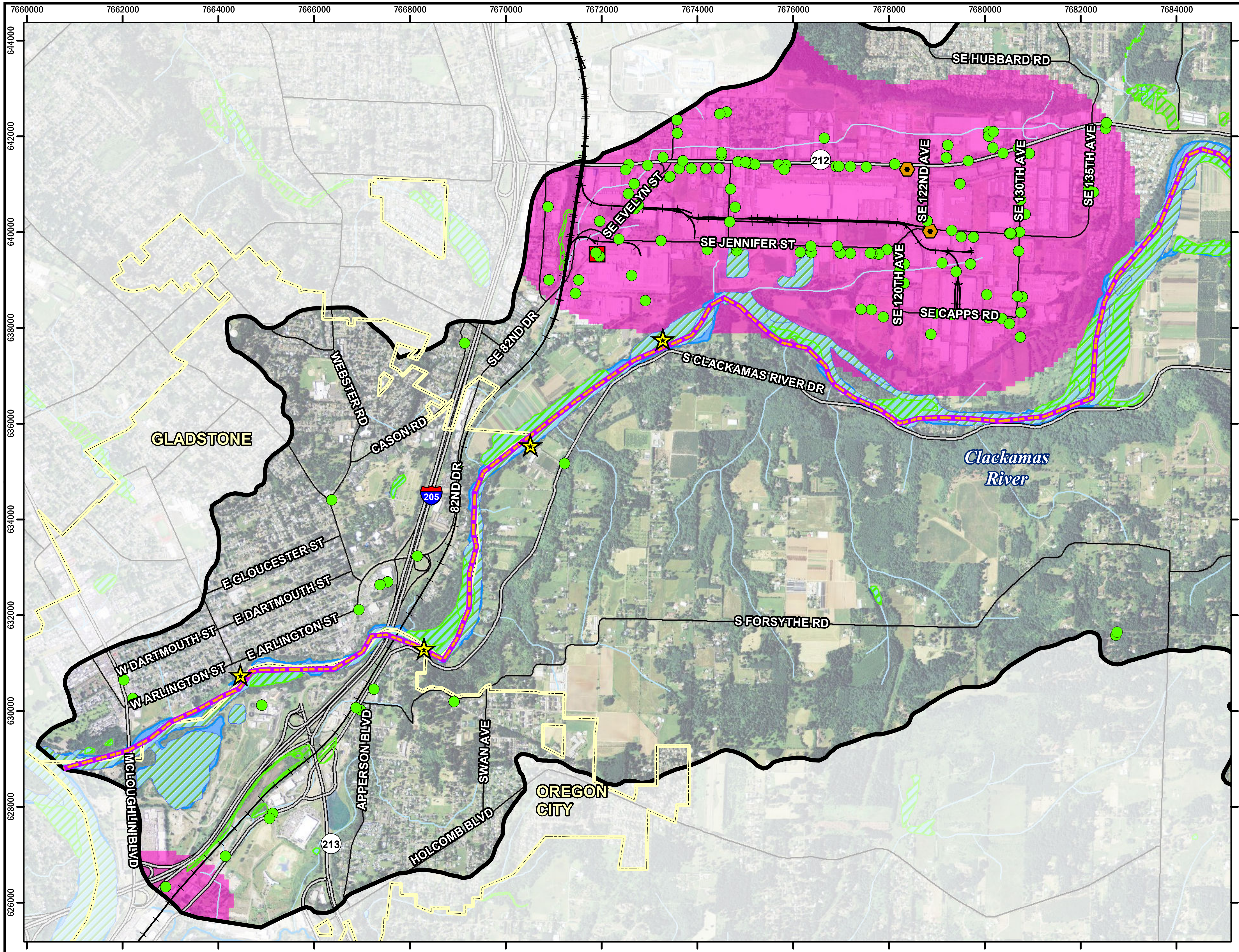
HERRERA

Coordinates: Oregon State Plane North HARN NAD83 (feet)

Produced By: GIS (JAS)
Project: K:\Projects\Y2010\10-04900-004\Project\Historic_Spill_Results_Sensitive_Resources_Overlay.mxd (12/10/2013)

COMBINED RESULTS:

MAP T - Combined Hazardous Substance Storage Facility Locations and Sensitive Resources Overlay



Legend

- Hazardous substance storage facility listed in the HSIS database
- HSIS facility cluster
- Surface water intake

Critical fish habitat (threatened species)

- Chinook salmon
- Steelhead
- Wetlands (RLIS)
- National Wetland Inventory (NWI)
- Railroad
- Highway or major arterial
- Arterial
- Clackamas River Watershed boundary
- City limits
- River
- Stream

N

0 1,000 2,000 4,000

Feet

Clackamas River Water Providers

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HERRERA

Coordinates: Oregon State Plane North HARN NAD83 (feet)

Produced By: GIS (JAS)
Project: K:\Projects\Y2010\10-04900-004\Project\Historic_Spill_Results_Sensitive_Resources_Overlay.mxd (12/10/2013)