Technical Memorandum

To:	Kahle Jennings & Andy Oien, City of Centralia
From:	Glenn Mutti-Driscoll & Dan Matlock, Pacific Groundwater Group
Re:	City of Centralia Groundwater Nitrate Evaluation
Date:	July 20, 2017

The City of Centralia has concerns about the potential for nitrate contamination in the Centralia Outwash Gravel Aquifer (COGA), a shallow water supply aquifer underlying the City. The recharge area for the COGA aquifer is designated a Critical Aquifer Recharge Area (CARA), and encompasses much of the City to the north and west of the Skookumchuck River and Chehalis River confluence. Septic systems within the City limits and in unincorporated areas of the Urban Growth Area (UGA) overlie the CARA, and may cause nitrate contamination within the shallow aquifer. Most septic systems overlying the CARA are in the Fords Prairie and Waunch Prairie areas. However, since most of the City's active production wells are in the Fords Prairie area, nitrogen loading in this part of the City is of greatest concern.

This memorandum summarizes work performed by Pacific Groundwater Group to compile and review existing groundwater nitrate data, identify potential sources and land uses that may contribute nitrate to the shallow aquifer, consider the relative value of conducting localized nitrate studies on specific septic systems, and recommend monitoring locations for a shallow groundwater nitrate monitoring network.

HISTORICAL GROUNDWATER NITRATE DATA

Groundwater nitrate data in and near the City of Centralia were compiled and reviewed from various sources, including:

- City of Centralia and Lewis County Environmental Health Department groundwater study data, which includes groundwater nitrate samples from 1972, 1974, and 1990 from domestic wells in the Fords Prairie area.
- Department of Health water quality data from the Sentry database, which includes groundwater nitrate data collected between 1981 and 2016 from City of Centralia production wells and other local Group A and B water systems.
- Department of Ecology groundwater data (download from the EIM database) collected in 2004 as part of the report entitled *Hydrology and Quality of Groundwater in the Centralia-Chehalis Area Surficial Aquifer* (Pitz and others, 2005).

Figures 1 and 2 are maps that plot historical nitrate concentrations in the vicinity of the COGA. Figure 1 presents maximum observed nitrate concentrations from each well, while Figure 2 presents the most recent nitrate concentration observed at each well. In Figure 2 the age of the most recent sample is symbolized by decade. In general, these figures show that groundwater nitrate concentrations can be elevated in the COGA (regional background nitrate concentrations are generally less than 1 mg/L-N in Western Washington), but have not historically exceeded the drinking water Maximum Contaminant Level (MCL) of 10 mg/L-N.

ANALYSIS OF POTENTIAL NITRATE SOURCES AND RISK FACTORS

As part of the potential nitrate source analysis, the distribution of soils, parcels with septic drain fields, and potential point sources were reviewed and mapped to assist in understanding where the nitrate leaching risk is high.

Lewis County soils mapped by NRCS overlying the COGA are primarily Spanaway gravelly sandy loam and Newberg fine sandy loam. These course-grained soils and nearly all soils overlying the COGA have high nitrate leaching potentials (as calculated by the NRCS), which indicates that there is a high likelihood that nitrate can mobilize out of the root zone and into the underlying aquifer.

Parcel data from Lewis County was obtained and processed by the City to identify parcels where septic systems are likely present. If parcels overlying the COGA were in an area without sanitary sewer and had building footprints of greater than 1,000 square feet, they were identified as potential septic system parcels. Potential septic system parcels are plotted in Figure 3.

Numerous potential nitrate point source locations overlying the COGA were reviewed and identified, and generally fell within the following categories:

- Livestock/dairy facilities: identified facilities include the Bob Oke Game Farm (which has a pheasant population of roughly 40,000), and the now closed Leprechaun Holsteins dairy (which was a concentrated animal feeding operation that closed circa 2005 on Galvin Road). Animal waste or residual waste from these facilities could impact groundwater nitrate concentrations.
- Infiltration features: the City owns 65 dry wells, which help minimize storm water runoff to the Chehalis or Skookumchuck rivers. However, runoff infiltrating at dry wells or other infiltration features can pose a risk to aquifer water quality since contaminants (including nitrogen from fertilizer, pet waste, and in some cases failing septic systems) can enter the shallow aquifer more directly and with less soil treatment. Other locations that may have focused storm water infiltration occurring include facilities with industrial storm water general permits as granted by the Department of Ecology. Dry well locations and facilities with industrial stormwater permits are also shown in Figure 3. It should be noted that other potential infiltration facilities (associ-

ated with WSDOT roadways, quarries, private property improvements, or heavily irrigated properties) may exist and have not been mapped as part of this evaluation.

- Wastewater facilities: public and private wastewater treatment facilities, facilities with a state waste discharge permit, and biosolids treatment facilities are also mapped in Figure 3. The application of treated wastewater or biosolids to land, or potential spills at these facilities could impact groundwater nitrate concentrations.
- Agricultural land and parks: agricultural lands exist in the western portion of Fords Prairie near the Chehalis River. Over fertilization of these lands could potentially impact groundwater nitrate concentrations. Potential over fertilization at other large grassy areas (including parks, ball fields, schools, and cemeteries) could also impact groundwater nitrate concentrations. Agricultural lands and parks were reviewed but not specifically mapped as part of this task, and can be readily identified on aerial photos.
- Large Onsite Sewage Systems (LOSS): available LOSS data from Department of Health were downloaded and reviewed, and no LOSS facilities were identified in the Centralia area. However, available data for download were only current through 2008, and therefore it is possible that newer LOSS facilities constructed in the Centralia area were not identified as part of this task.
- Chehalis River: water quality data from the Chehalis River, which has an ammonia TMDL, was reviewed to assess the likelihood of the COGA being contaminated by groundwater-surface water interactions. The Chehalis River was identified as losing in both May and October 2004 downstream of the Skookumchuck confluence (and south of Fords Prairie), which indicates that Chehalis River water enters the COGA in this vicinity (Pitz and others, 2005). Measurement locations west of Fords Prairie indicate that the Chehalis River seasonally loses water beginning in the mid-summer months (Pitz and others, 2005). Water quality data collected from the Chehalis River as part of the dry season TMDL study (Pickett, 1994) near Centralia found total nitrogen concentrations of up to 1.66 mg/L-N, nitrate + nitrite concentrations of up to 0.66 mg/L-N, and ammonia concentrations of up to 1.29 mg/L-N. These relatively low concentrations indicate that though water from the Chehalis River recharges the COGA and contributes to groundwater nitrate concentrations, local aquifer concentrations are generally higher than background Chehalis River concentrations, and therefore surficial land use is likely the primary cause of locally elevated groundwater nitrate concentrations.

LOCAL SEPTIC MONITORING

The City has access to install monitoring wells or lysimeters on two properties with either recently installed or soon-to-be installed septic systems. The City additionally has a monitoring agreement with the Bob Oke Game Farm, which is downgradient of an unsewered area and houses roughly 40,000 pheasants.

Research regarding the impacts of septic systems on groundwater nitrate concentrations spans from 1970s through the present, with studies defining contaminant concentrations in septic effluent, groundwater nitrate concentrations beneath and downgradient of septic drainfields, soil water concentrations in the unsaturated zone beneath drainfields, and the effects of high densities of septic drainfields. A local study examining the impacts of septic systems in the Fords Prairie area could be of value for defining local conditions relating to denitrification, recharge volume, aquifer mixing, and long-term concentration trends. However, since extensive literature exists regarding general septic impacts, we recommend using City resources to create a broadly focused groundwater monitoring network that can be used to monitor long-term spatial and temporal changes in groundwater nitrate concentrations. Focused local evaluations generally require three or more wells to be installed on each property and an extensive list of sampling analytes, which results in large amounts of data for individual parcels, but not across a broader area such as Fords Prairie.

A more general evaluation regarding nitrate loading on these properties and/or the Fords Prairie area could be pursued in the future using a nitrogen loading model, where nitrogen loads to groundwater are calculated based on literature values (or local values when available) and groundwater concentrations are estimated using aquifer hydraulic parameters and background concentrations. This type of approach is typically used to estimate total contaminant loads and resulting groundwater nitrate concentrations for broad unsewered areas with multiple potential nitrogen sources. Nitrate data can be used to calibrate or validate these models, and to document changes over time due to changes in land use.

RECOMMENDED MONITORING WELL LOCATIONS, DESIGN, AND ACTIONS

Based on the above review of potential nitrate source areas, areas with elevated groundwater nitrate concentrations, City production wells, and recommended areas for future water supply development (PGG, 2016), we recommend that monitoring wells be installed at the following locations. These locations are mapped in Figure 4.

1) WWTP area, Goodrich Road- the WWTP area has been identified as a potential future water supply source based on high aquifer yields (PGG, 2016). The area has septic and agricultural parcels upgradient of it, and the former Symons Frozen Foods processing plant (at 619 Goodrich Road) has previously applied processing waste to fields in the vicinity.

2) Limerick Dairy area, Galvin Road: high groundwater nitrate concentrations have previously been detected near the former dairy, which is now owned by the Port of Centralia. This area has also been identified for its future water supply potential.

3) Borst Park: Borst Park is in the WHPAs for the active Tennis Court production wells and the Borst Park production wells (which may serve as future water sup-

ply wells). Monitoring in this area would be beneficial since it is within the capture zones of these wells and is upgradient of the agricultural and septic parcels in Fords Prairie.

4) Fords Prairie Elementary School: historic Test Well 8 was installed on this property and the area has the potential for future water supply development. This property is also in the mapped WHPA for the Eshom well.

5) Kuper Road: high groundwater nitrate concentrations have historically been observed along Kuper Road, and this Port of Centralia property has been identified as a potential future water supply source.

6) Bob Oke game farm vicinity: the Bob Oke game farm raises roughly 40,000 pheasants and has had high groundwater nitrate concentrations detected at its well. The production well, however, is in the northeast corner of the game farm and appears to be upgradient of the pheasant farm and downgradient of multiple properties on septic tanks. Additionally, the game farm well is 70 years old and the elevated nitrate concentrations observed in it could be due to a lack of a surface seal or seal failure. The existing production well at the game farm should be examined to assess if a surface seal is present, and if not, a monitoring well should be installed nearby.

7) 1300 block of Kayu Lane: in the groundwater sampling conducted by the City in 1990, a cluster of wells with along Kayu Lane had elevated nitrate concentrations ranging up to 7 mg/L as N. This historic hotspot should be monitored, and more recent groundwater nitrate data from the Trailer Village Laundromat cleanup (if it exists, as discussed below), should be reviewed since multiple septic tanks upgradient of Kayu Lane have been removed and converted to sewer since 1990.

8) Ives Road west of Sandra Avenue: this area has historically had elevated concentrations and has numerous agricultural parcels and homes served by septic tanks in the area.

9) Waunch Prairie: though not the focus of this evaluation, a monitoring well downgradient of the numerous septic parcels in the Waunch Prairie area should be considered as part of a City-wide groundwater monitoring network.

The recommended general design for the proposed monitoring wells is that each well be constructed out of 2-inch diameter schedule 40 PVC, and that the wells are 40 feet deep with 25 foot screens extending from 15 to 40 feet depth. The screen should be 10 slot (0.01 inch) with 10-20 silica sand filter pack. A bentonite surface seal should extend to approximately 12 feet. The wells should be installed using a sonic drill rig.

In addition to the proposed monitoring well locations, several other locations with existing wells or data are recommended for monitoring and/or review:

- Fords Prairie wells 1 and 2 and the Eshom well should have nitrate samples collected from them. The Fords Prairie and Eshom wells were last sampled individually for nitrate in 2005, and since then blended water quality samples have been collected for DOH monitoring at the Fords Prairie water treatment facility. In 2005, nitrate concentrations at Fords Prairie Well 1, Fords Prairie Well 2, and Eshom were 5.6 mg/L as N, 6 mg/L as N, and 3.7 mg/L as N, respectively. Given that several properties on septic appear to be upgradient of the Fords Prairie wells but not the Eshom well, routine sampling from all three of these wells could be beneficial. Higher concentrations may routinely exist at the Fords Prairie wells, but could be diluted by water from the Eshom well in the blended samples. It is our understanding that water samples can be directly collected from the well heads of Fords Prairie Wells 1 and 2, but the Eshom well would need to have its sample collected at the Fords Prairie water treatment facility when the other two wells are not pumping.
- Obtaining and reviewing groundwater data collected as part of the Trailer Village Laundromat PCE cleanup is strongly recommended. A brief review of readily available documents associated with this cleanup indicates that multiple monitoring wells associated with this project are present in Fords Prairie, and may have historic nitrate and/or water level data. Access to these monitoring wells could result in cost savings (one of the existing monitoring wells on the 1300 block of Kayu Lane is a recommended location for nitrate monitoring).

  Though outside this scope of work, a review of the mapped Trailer Village PCE plume indicates that the former laundromat is in the Eshom Well's capture zone (which is why a stripping tower is necessary at the Fords Prairie treatment facility). The delineated Eshom WHPA from the 1999 WHPP, however, does not overlap with this PCE source, and the WHPA boundary is approximately 900 feet north of the former laundromat. Figure 5 is a reproduced figure from the 2010 Trailer Village Consent Decree (State of Washington, 2010), and shows that actual groundwater flow toward the Eshom Well has a significant flow component from the southeast, which is not represented by the existing WHPA. The existing Eshom WHPA has groundwater flow originating from the east and northeast (shown in Figure 1). Given that WHPAs have not been delineated for the Fords Prairie wells and that the Eshom WHPA is most likely inaccurate (based on both the Trailer Village PCE plume and groundwater flow directions calculated by Pitz and others (2005) and shown in Figures 1 through 4), we recommend that City update its WHPAs for the Fords Prairie area. For a WHPA update, groundwater elevation data will need to be compiled for updating or creating a groundwater flow model. Groundwater elevations from the proposed network of monitoring wells could provide supplemental and valuable information for defining groundwater elevations in the Fords Prairie area and assessing if seasonal changes in groundwater flow direction occur.
- In addition to the monitoring wells associated with the Trailer Village Laundromat, several other existing wells could possibly be used for groundwater nitrate monitoring and could help reduce monitoring well installation costs. Test well 8 at the Fords Prairie Elementary School, the water supply well at the Bob Oke game farm, and several monitoring wells associated with the former Symons frozen foods facility on

Goodrich Road are in areas where groundwater nitrate monitoring wells are recommended. Each of these potential wells, however, would need to be inspected to evaluate their integrity and reliability for sampling.

At all proposed monitoring locations, quarterly sampling is recommended for at least 2 years to assess if seasonality exists in local groundwater nitrate concentrations. Field parameters measured should include depth to water, pH, specific conductance, and temperature. Laboratory samples should be analyzed for nitrate. All measuring points should be surveyed to provide elevations control for assessing groundwater flow directions.

Sampling of pharmaceuticals and personal care products (PPCPs) for a blended sample from the Fords Prairie well field should also be considered every three years (at the same frequency as required by DOH for volatile organic compound sampling) since PPCPs are typically present in groundwater if septic loading is significant. Additionally, at least one sampling event where the field parameters dissolved oxygen and/or oxidation/reduction potential (ORP) are measured at all monitoring wells should be considered so that reducing conditons in the COGA aquifer are known (reducing conditions can facilitate the break down nitrate via denitrification). Other nitrogen species (such as ammonium and total nitrogen) or fecal coliform sampling could be considered in the future to help define the presence of other nitrogen species or to identify potential sources and travel times to the aquifer.

GROUNDWATER NITRATE MONITORING NETWORK COST ESTIMATE

A cost estimate for the installation of wells, sampling equipment and laboratory costs[1] is presented below.

- Installation of nine 2-inch diameter PVC monitoring wells to 40 feet with stick up monuments, with one hour of well development per well and installed with a sonic drill rig: $48,800.

- Lab cost per sampling event, assuming that 12 wells (the nine proposed monitoring wells, and production wells Fords Prairie 1, 2, and Eshom) are sampled for nitrate: $520 per sampling event.

- PGG consulting fees including geologic logging and coordination with driller, hiring and coordination with a private utility locator, well installation memorandum with well logs, sampling pump purchase and installation, and two groundwater sampling events for City staff training: $24,700.

- It is our understanding that the City owns a water quality field meter for measuring field parameter stabilization during groundwater sampling. We assume that it

[1] Costs do not include any PGG markup and assume that subcontract drilling and lab work would be paid directly by the City.

can measure pH, specific conductance, and temperature, and therefore purchase or rental costs for a field meter are not included in this estimate.

- All monitoring wells should have their measuring points surveyed with an accuracy of 0.01 feet vertically and 0.1 feet horizontally. For this estimate, we assume that the City of Centralia survey crew will survey the wellheads.

- A review of groundwater nitrate data following the first year of nitrate monitoring is recommended, and every five years thereafter is recommended. PGG review costs are not included in the estimates above.

REFERENCES

Pacific Groundwater Group, 2016. Interim Drought Vulnerability Assessment to Optimize Existing Production Wells City of Centralia. Consultant's report for the City of Centralia. April 12, 2016.

Pickett, P.J., 1994. Upper Chehalis River Total Maximum Daily Load Study. Washington State Department of Ecology Publication 94-126.

Pitz, C.F, Sinclair, K.A., and A.J. Oestreich, 2005. Hydrology and Quality of Groundwater in the Centrali-Chehalis Area Surficial Aquifer. Washington State Department of Ecology Publication 05-03-040.

State of Washington, 2010. Lewis County Superior Court No. 10-2-01721-4 Consent Decree. Court Documentation from State of Washington Department of Ecology vs Coluccio Family LLC.

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Waste Treatment Plant Well
Dry Creek
Chehalis River
Lincoln Creek
Lincoln Creek Rd
Galvin Rd
Eshom Street Well
Fords Prairie #2
Fords Prairie #1
Eshom Rd
N Scheuber Rd
Harrison Ave
Johnson Rd
Borst Ave
Oakland Ave
Tennis Court Wells 1 & 2
Fords Prairie
Coffee Creek
Downing Rd
Downing St Well
State Route 507
Big Hanaford Rd
Hanaford Creek
Skookumchuck River
Waunch Prairie
N Tower Ave
W Reynolds Ave
Washington Street Wells 1 & 2
K Street Well
Riverside Park Well
North Tower Well
N Pearl St
W 4th St
Marion St
China Creek
Little Hanaford Rd
Fort Borst Lake
Hayes Lake
W 1st St
Borst Park Well 1
Borst Park Well 2
Chehalis River
Scammon Creek
Cooks Hill Rd
Plummer Lake
Yew St
W Main St
W Locust St
E Locust St
N Gold St

City Production Wells
City Test Wells
1-Year Time-of-Travel
5-Year Time-of-Travel
10-Year Time-of-Travel
Buffer Zone

Groundwater Flow Directions (Pitz, et al, 2005)
City Limits
Mapped Extent of Centralia Outwash Gravel Aquifer

Maximum Observed Nitrate Concentrations (mg/L-N)
0.00 - 1.00
1.01 - 2.50
2.51 - 5.00
5.01 - 7.50
7.51 - 10.00

N
0 Feet 2,000

Figure 1

Maximum Observed Groundwater Nitrate Concentrations

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Most Recent Nitrate Data (mg/L-N)

	0.0 to 1.00	1.01 to 2.50	2.51 to 5.00	5.01 to 7.50
1970s	◇	◇	◇	◆
1980s	✚	✚	✚	✚
1990s	○	○	○	●
2000s	□	□	□	■
2010s	☆	☆	★	★

- City Production Wells
- City Test Wells
- City Limits
- Mapped Extent of Centralia Outwash Gravel Aquifer
- Groundwater Flow Directions (Pitz, et al, 2005)

N

0 Feet 2,000

Figure 2

Most Recent Observed Groundwater Nitrate Concentrations

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Potential Nitrate Point Sources
- Wastewater/Biosolid/Livestock Facilities
- General Industrial Stormwater Permits
- Groundwater Flow Directions (Pitz, et al, 2005)
- City Production Wells
- City Test Wells
- Dry Well
- City Limits
- Building Outline
- Potential Septic Parcels
- Parcels with No Structures
- Sewered Parcels
- Nitrate Monitoring Agreement
- Mapped Extent of Centralia Outwash Gravel Aquifer

N

0 Feet 2,000

Figure 3

Potential Nitrate Source Areas

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Waste Treatment Plant Well
Dry Creek
Chehalis River
Lincoln Creek
Lincoln Creek Rd
Calvin Rd
Eshom Street Well
Fords Prairie #2
Fords Prairie #1
Eshom Rd
Fords Prairie
Harrison Ave
Johnson Rd
N Scheuber Rd
Borst Ave
Oakland Ave
Tennis Court Wells 1 & 2
Fort Borst Lake
Hayes Lake
Borst Park Well 1
Borst Park Well 2
Chehalis River
Scammon Creek
Cooks Hill Rd
Plummer Lake
Yew St
W Main St
W Locust St
N Gold St
E Locust St
W 1st St
W 4th St
N Pearl St
N Tower Ave
Washington Street Wells 1 & 2
K Street Well
Riverside Park Well
North Tower Well
W Reynolds Ave
Waunch Prairie
Coffee Creek
Downing Rd
Downing St Well
State Route 507
Big Hanaford Rd
Hanaford Creek
Skookumchuck River
Manon St
China Creek
Little Hanaford Rd

Proposed Monitoring Well Locations
City Production Wells
City Test Wells
Groundwater Flow Directions (Pitz, et al, 2005)
Mapped Extent of Centralia Outwash Gravel Aquifer
City Limits
Public Parcels

N
0 Feet 2,000

Figure 4

Recommended Monitoring Well Locations

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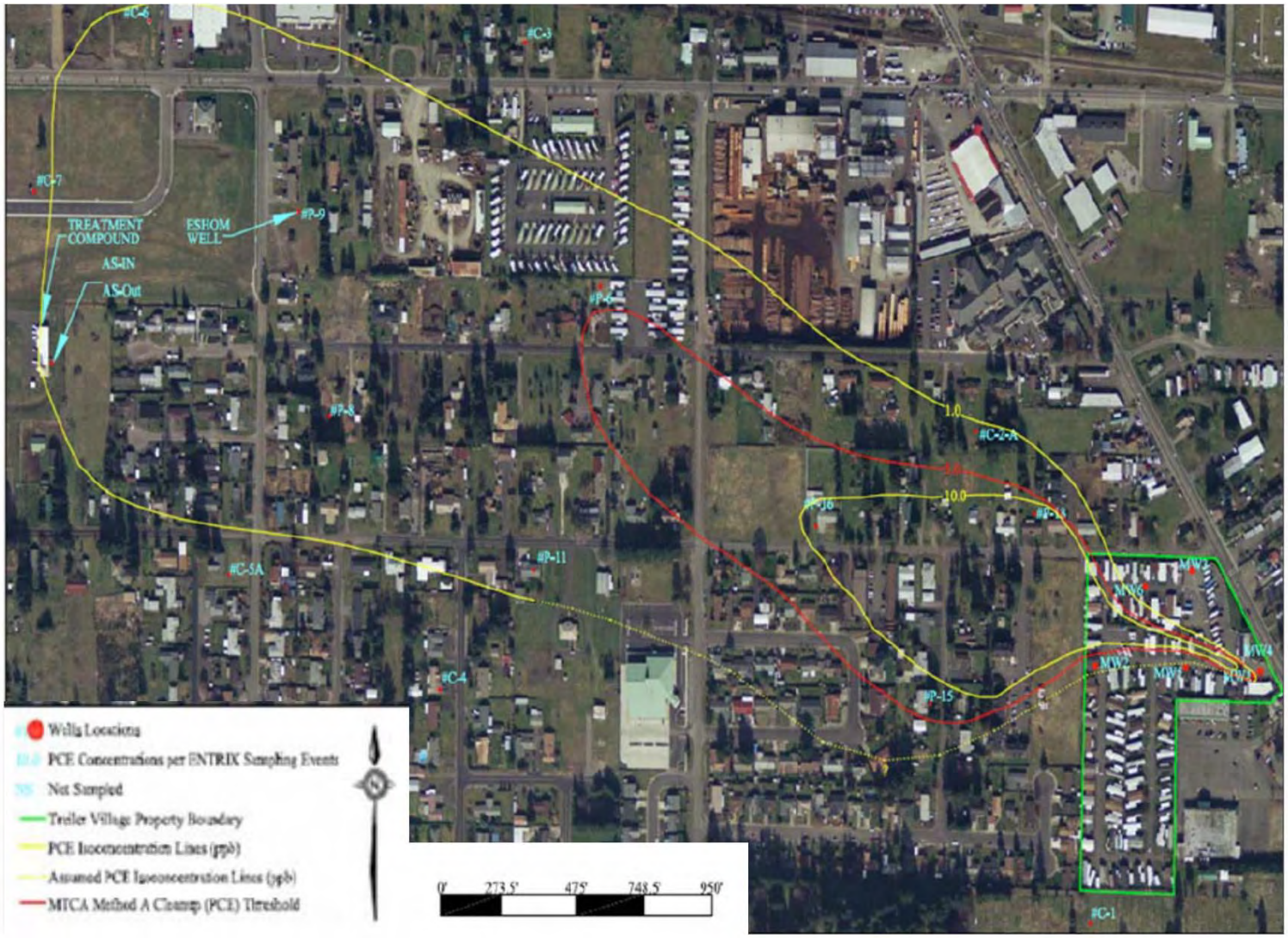

Note:

-Figure from 2010 Consent Decree (State of Washington, 2010), and originally produced by Environ.

Figure 5
Historically Mapped Extent of Trailer Village PCE Plume

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