6. SVRP Aquifer Inputs into the Little Spokane River

The Little Spokane River is a tributary to the Spokane River, entering the Spokane River at river mile 56.3 just downstream of Nine Mile Dam. The lower Little Spokane River overlays the Little Spokane River Arm of the SVRP aquifer (Figure 71). In the 7-mile stretch between the USGS Dartford gage (12431000) and the USGS near Dartford gage (12431500), the Little Spokane River gains flow from the SVRP aquifer. Estimates of groundwater inflows range from 244 cfs to 254 cfs between July and October (USGS). It is thought groundwater inflows below the USGS near Dartford gage to the mouth of the Little Spokane is minimal.

Four groundwater monitoring locations representing two locations of groundwater discharge to the Little Spokane River: Waikiki Springs (6306P01s and 6306P01s2) and Griffith Springs at the Spokane Hatchery (6211J01s and 6211K01). No flow measurements exist for Waikiki or Griffith Springs, though the springs themselves are likely a relatively small input to the Little Spokane River. For this study, they are considered representative of the groundwater quality entering the Little Spokane River.

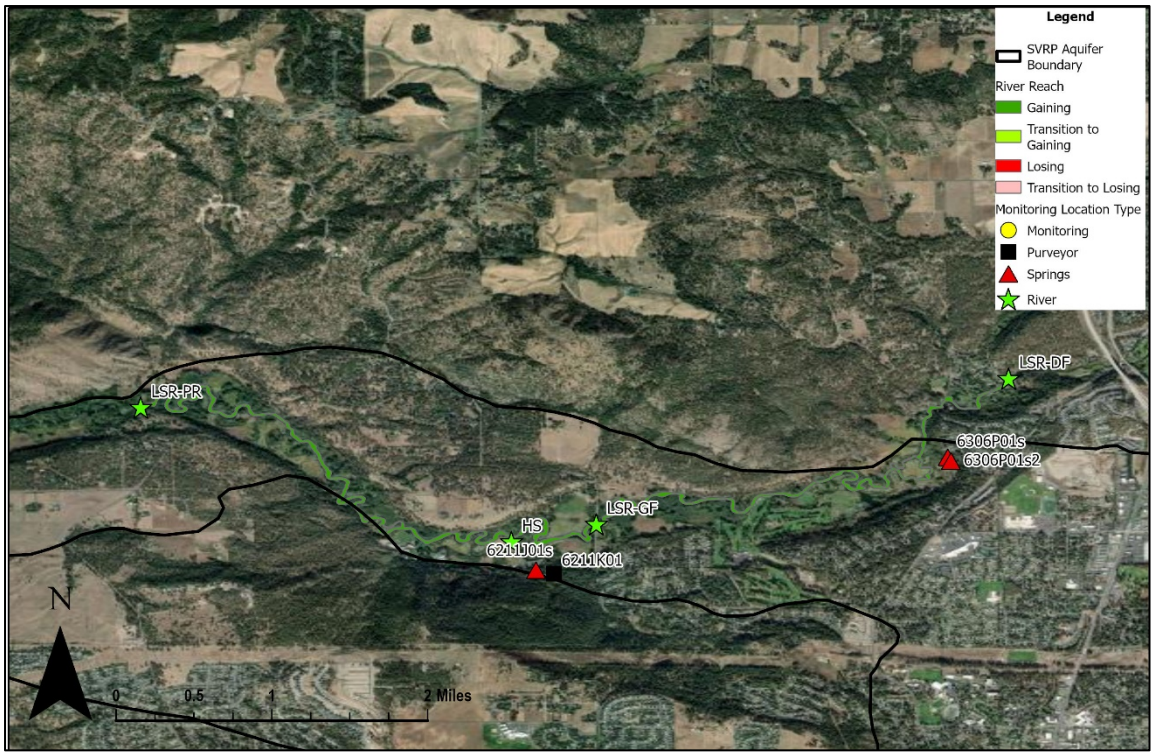

Figure 71. Aerial view of the Little Spokane Arm of the SVRP aquifer including both groundwater and surface monitoring locations. Groundwater monitoring locations include Waikiki Springs (6306P01s and 6306P01s2), Griffith Springs (6211J01s), and the Spokane Hatchery well (6211K01) and Little Spokane River (LSR) monitoring locations include the LSR at Dartford (LSR-DF), LSR near Griffith Springs (LSR-NGS), the Hatchery Slough (HS) and LSR at Painted Rocks (LSR-PF).

To determine groundwater influence from the SVRP aquifer on the Little Spokane River, EIM data for the Little Spokane River was used from three locations: Little Spokane at Dartford (LSR-DF), Little Spokane near Griffith Springs (LSR-NG), and Little Spokane at Painted Rocks/Rutter Parkway (LSR-PR) (Figure 71). The Dartford and Painted Rocks locations are adjacent to the USGS Dartford and near Dartford gages, respectively. Therefore, the river locations cover the length of the gaining reach and provide locations upstream, in between, and downstream of the groundwater monitoring locations. In addition, the EIM

data for the Hatchery Slough (HS) tributary near its confluence with the Little Spokane River was used due to the County's Griffith Springs monitoring location being upstream of this point (Figure 71). The Hatchery Slough is where water from Griffith Springs combines with the outflow from the hatchery before discharging into the Little Spokane River.

Data available for both groundwater and surface water monitoring locations for the 20-year period include temperature, pH, conductivity, dissolved oxygen, chloride, nitrogen, total phosphorus, and SRP. It should be noted that only data from June through September was used for two reasons: 1) data for the Little Spokane near Griffith Springs is limited to these months; and 2) this is when the groundwater is expected to primarily influence the river and, therefore, the contribution of the tributary, Dartford Creek, can be disregarded. Though Dartford Creek enters the Little Spokane River just below the Dartford gage, it's influence during low flow periods is expected to be minimal compared to groundwater. For example, the discharge of Dartford Creek at 2.37 cfs, which is 1 percent of the inflows occurring. Groundwater contributes 188 cfs to the Little Spokane River at the Dartford gage (Kimbrough et al, 2005).

Further, some unusual phosphorus data in EIM was excluded. The EIM database records for Little Spokane at Dartford include total phosphorus levels ranging from 24 to 103 mg/L measured from January 1999 to September 1999. These data were recorded for Site LS6, one of the two EIM sites at the Dartford location and conflicted with data recorded for the second site, 55B082, from the same dates. For example, the phosphorus level on January 11 at LS6 was 76 mg/L and for 55B082 it was 0.087 mg/L. It is possible the reported units for the Site LS6 data were intended to be in micrograms per liter (ug/L) rather than milligrams per liter (mg/L) as indicated. This would make the apparently high values more like those reported for Site 55B082 and other river locations. Even so, since these data appeared unusual and values could not be confirmed, they were not used in this analysis.

Groundwater influence along a gaining reach is usually represented by decrease in river temperatures and an increase in river conductivity. Median river temperatures go from 15.5 C at Dartford to 13.8 C at Near Griffith and 13.2 C at Painted Rocks (Figure 72). The smaller decrease in temperature between the Near Griffith and the Painted Rocks locations may be partly due to the Hatchery Slough discharge, which is warmer (median = 12.9 C) than the cooler groundwater at Griffith Springs. Median river conductivity increases between Dartford and Near Griffith (218 to 287 uS/cm) due to groundwater as expected. However, conductivity decreases between Near Griffith and Painted Rocks (median = 264 uS/cm), though the conductivity at Hatchery Slough is just as high as the contributing groundwater.

Temperature and conductivity data along the Little Spokane River between Dartford and Painted Rocks demonstrate the trends of a gaining reach but suggests that groundwater influence may not be as strong in the lower half. This corresponds with information from GeoEngineers (2009) indicating 68 percent of the groundwater inputs occur between the Dartford and the Near Griffith locations and 32 percent occur between Near Griffith and Painted Rocks locations.

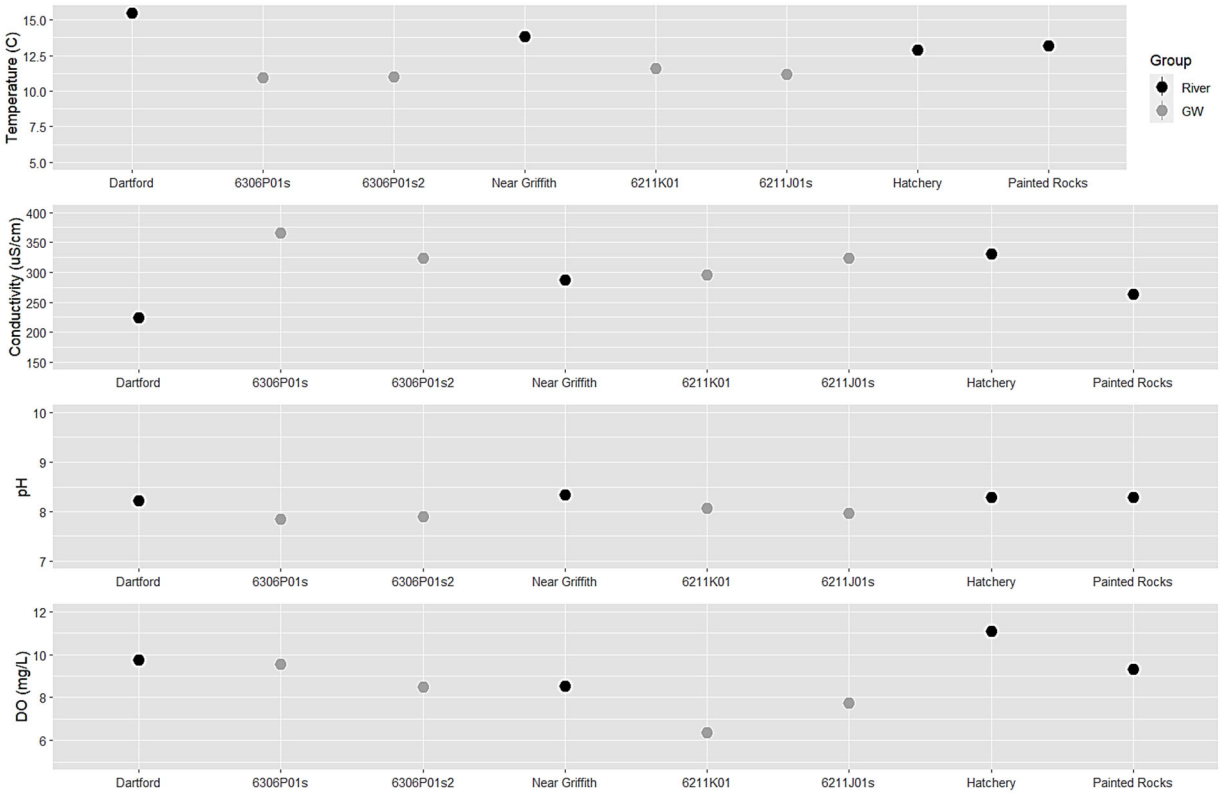

Figure 72. Median temperature, conductivity, pH, and dissolved oxygen (DO) concentrations at four groundwater (GW) and four surface water monitoring locations on the Little Spokane River (LSR). River locations are arranged, left to right, in the direction of flow from the Dartford gage to Painted Rocks, with Waikiki Springs (6306P01s and 6306P01s2) entering the river upstream of the Near Griffith Springs location and the groundwater from the Spokane Hatchery well (6211K01) and Griffith Springs (6211J01s) entering the Hatchery Slough tributary.

The Little Spokane River's pH and dissolved oxygen (DO) levels are not as affected by the groundwater inputs. The river's pH is generally around 8.3 at each location, and groundwater is around 7.8 at Waikiki Springs and 8.0 at Griffith Springs. The river's DO levels are generally between 8.5 and 9.5 mg/L though groundwater is slightly lower. The outflow from the hatchery appears to introduce DO in the Hatchery Slough, given the slough has higher levels than measured at Griffith Springs (Figure 72).

Data suggests groundwater is a source of chloride and nitrates in the Little Spokane River, given that groundwater levels are generally higher than the river. However, the river's median chloride and nitrate concentrations are similar at each location (~5 and 1 mg/L, respectively) suggesting some mechanism for diluting the groundwater chloride and nitrate inputs along this section. The outflow from the hatchery does not appear to greatly increase chloride or nitrate levels in the Hatchery Slough above the inputs from Griffith Springs (Figure 73).

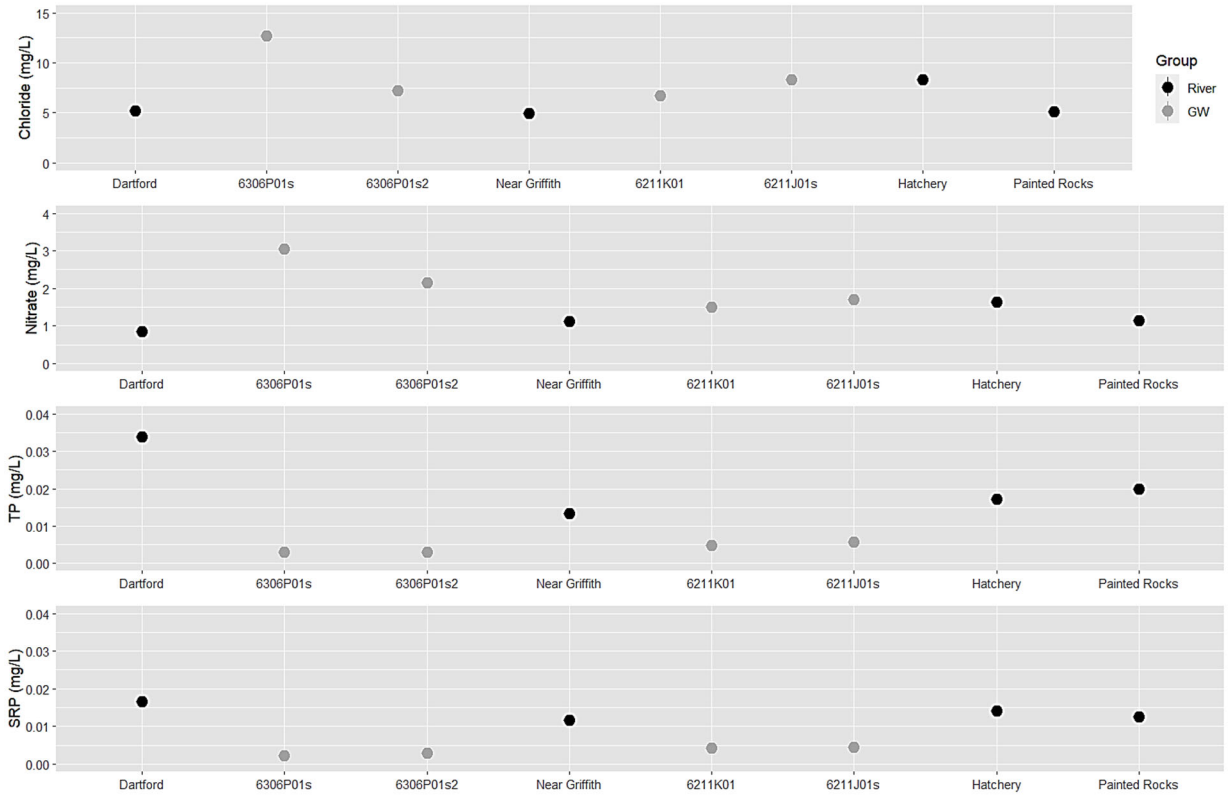

Figure 73. Median nitrate and total phosphorus at four groundwater (GW) and four surface water monitoring locations on the Little Spokane River (LSR). River locations are arranged, left to right, in the direction of flow from the Dartford gage to Painted Rocks, with Waikiki Springs (6306P01s and 6306P01s2) entering the river upstream of the Near Griffith Springs location and the groundwater from the Spokane Hatchery well (6211K01) and Griffith Springs (6211J01s) entering the Hatchery Slough tributary.

Groundwater levels of total phosphorus and SRP are generally lower than the river along this section of the Little Spokane River, suggesting groundwater serves to dilute river phosphorus levels contributed from other sources. The total phosphorus levels decrease from 0.04 mg/L at the Dartford gage to 0.02 mg/L at Painted Rocks, and SRP levels decrease from 0.02 to 0.01 mg/L (Figure 73). The median total phosphorus and SRP concentration at the Hatchery Slough (0.0193 and 0.0149 mg/L, respectively) is about three times the median concentrations at Griffith Springs (0.0057 and 0.0045 mg/L), indicating the hatchery outflow is likely the source of phosphorus in the slough.