Preliminary Build-Out & Projected Water Quantity Analysis
Step C Instream Flow Grant Addendum
WRIA 14 / Kennedy-Goldsborough Watershed

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for
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1.0 Introduction

This report summarizes the results of an investigation conducted under Step C of the Instream Flow Grant (#G03000042) for Water Resource Inventory Area (WRIA) 14, the Kennedy-Goldsborough watershed. The instream flow grant was awarded to Mason County by the Washington Department of Ecology (Ecology) to characterize water quantity conditions in the watershed—in particular, the relationship between water use, streamflow, and creek-aquifer interactions.

This scope of work was developed as an addendum to the focused hydrogeologic characterization completed earlier this year by Northwest Land & Water, Inc. (NLW; NLW, 2005a). Details of this scope are outlined in a document entitled *Addendum Scope of Work Under the Step C Instream Flow Grant*, which was submitted by NLW to the WRIA 14 Planning Unit on October 18, 2005 (NLW, 2005b).

1.1 Study Objectives

The Johns Creek sub-basin features a substantial area of undeveloped land and poor to good habitat for a variety of fish species. Given its proximity to Shelton and its location in the nearshore area of south Puget Sound, human populations are expected to increase in the future. Likewise, the pressures to develop land and water will increase to meet growing demands. Consequently, the WRIA 14 Planning Unit faces a unique opportunity to proactively manage growth so that people and fish can coexist in a sustainable way in the future.

Land development and population growth in the Johns Creek sub-basin pose two significant challenges in areas where the surface and groundwater systems are connected. First, traditional land development practices and infrastructure can substantially alter the natural hydrologic processes of runoff, recharge, and storage. Such changes impact not only the availability of water for people but also the amount and timing of water delivered to creeks that support fish habitat. Second, withdrawing either surface water or groundwater for domestic, irrigation, or industrial uses reduces the amount of water in local streams. This is true not only for withdrawals inside the Johns Creek sub-basin, but also for wells that lie outside the basin but are hydraulically connected to it through the groundwater system.

One objective of this project, therefore, was to further characterize water-resources in the Johns Creek sub-basin—in particular, to identify possible impacts to flows at the sub-basin scale. This information is a first step in helping planners make decisions that will not only maintain local water supplies but also sustain healthy fish habitat along Johns Creek. Other objectives included projecting future water demand conditions and exploring potential impacts to habitat under one of many possible future development scenarios.

1.2 Background

Located 3 miles from downtown Shelton, the project area is surrounded by the drainage basins for Cranberry, Skokomish, and Goldsborough Creeks. **Figure 1** shows the project area.

Both surface water and local groundwater in this sub-basin drain into Johns Creek, which originates in a large wetland complex near Johns Lake. From its headwaters, the creek flows about 8.3 miles before discharging to Oakland Bay at Bayshore. The upper Johns Creek watershed is characterized by wetlands bordered by open space and tree plantations. The lower watershed features a mix of deciduous, coniferous trees, along with high- and low-density residential development. Some industrial and mining lands cover the lower part of the basin, and some of the Shelton urban growth area (UGA) lies within the southern part.

The Johns Creek sub-basin was one of many covered under the limiting factors analysis (LFA) for WRIA 14 (Kuttel, 2002). The LFA assessed habitat conditions for salmonids along various creeks within the watershed. Factors such as water temperature, water quality, riparian structure, and biological activity were rated over specific creek reaches; these ratings range from poor to good.

1.3 Scope

The scope of work for this project entailed two main tasks—analyzing current water supply conditions (Task 10a) and projecting future conditions (Task 10b)—within the Johns Creek sub-basin (NLW, 2005b).

Under Task 10a, various parameters were assessed to better understand current conditions: creek flows, land use patterns, water consumption, water rights, fish distribution, and precipitation recharge. Estimates of water consumption were then compared to Johns Creek flow statistics and regulatory limits. Task 10b entailed similar analyses but examined future creek flows, land use patterns, water consumption, and precipitation recharge. Estimates of future water consumption were also compared to projected creek flows.

1.4 Warranty

This work was requested by the WRIA 14 Planning Unit and completed by NLW. It was performed, and this draft report was prepared, in accordance with hydrogeologic practices generally accepted at this time, in this area, for the exclusive use of the WRIA 14 Planning Unit, for specific application to the study area. No other warranty, express, or implied, is made.

2.0 Current Conditions

A preliminary analysis of impacts to Johns Creek was conducted by comparing flows to nearby groundwater withdrawals. As part of this analysis, water usage in the sub-basin was estimated after identifying the current population density and rates of consumptive water use.

2.1 Johns Creek Flows

Flows in Johns Creek were monitored by the U.S. Geological Survey (USGS) in the 1940s and 1950s. A substantial gap in reliable, long-term flow data extends to 2003, when the Squaxin Island Tribe (SIT) set up gauging station JOH2, which it still maintains.

Figure 2 shows regulatory flows as described in *WAC 173-514*, along with measured flows for Water Year (WY) 2005, which spans the period from October 1, 2004, through September 30, 2005. Parts of WY2005 were dry compared to the past 60 years (Snover and others, 2005). It was characterized by extremely low precipitation during the fall and winter seasons, with the bulk of annual precipitation occurring in the spring. This pattern is reflected by Johns Creek, which fails to meet minimum instream flow (MISF) requirements for most days in WY2005. **Appendix A** shows historic Johns Creek flow data for "wet" (WY1950) and "dry" (WY1949) years. (Note that the terms "wet" and "dry" are relative to each other (Golder, 2003)). During WY1950, flows met the minimum requirements most days; the opposite is true for WY1949.

Because this study assesses conditions at the basin scale, an estimate of outflow from Johns Creek at Oakland Bay would be valuable. Although the SIT recently installed a gauge at this location (JOH1), such data was unavailable. Instead, seepage flow data at JOH2 was correlated with data from JOH1 using measurements collected for both stations during August 2001 and

July–August 2003. The data are shown below. Based on a linear regression analysis, flow at JOH1 is 1.37 times that at JOH2, plus 2.04 cfs.

Table 1. Flow Data for Johns Creek Gauging Stations JOH2 and JOH1

	Flow, in cfs	
Date	**Synthetic JOH1**	**JOH2**
08/16/01	5.7	2.7
08/14/03	9.1	5.2
08/19/03	8.5	4.7
09/04/03	7.0	3.6

2.2 Population Estimates

To estimate population density in the Johns Creek sub-basin, a land use analysis was conducted to identify developed and undeveloped parcels. Census data was then used to identify the number of people residing in the sub-basin. This population data was used to estimate water use on a per-capita basis.

2.2.1 Land Use Analysis

Figure 3 shows current land uses and zoning in the Johns Creek basin. The parcel data was provided by Mason County's geographic information systems (GIS) department and imported directly into the GIS model developed for this project. Zoning data was also provided by the Mason County GIS department, in the form of an AutoCAD drawing. Zoning for areas outside the UGA was interpreted from this drawing and incorporated into the GIS model.

The parcel data included a "use" field. For developed parcels, this field could indicate the type of business, the size of the home (based on the number of bedrooms), a park or government use, or some other use. Undeveloped parcels were identified by a "vacant" or (more often) "designated" use. **Figure 3** shows developed parcels as orange and undeveloped parcels as green. The undeveloped parcels are further distinguished by different shades of green as either "designated" or "vacant." Current zoning is shown for areas outside the UGA as "rural residential" (RR) 5, 10, or 20 to indicate the minimum allowable lot size in acres.

2.2.2 Population Density

Population data was taken from the 2000 Census (ESRI, 2005), which indicates that 3,426 people live in the Johns Creek sub-basin, with 2,328 residents in the UGA. The current population density within the UGA was estimated to be 3.13 people per acre using these values and the area of developed parcels. This population density considers roads, businesses, parks, schools, and government buildings in the developed area.

2.3 Water Use — Total & Consumptive

Water use was assumed to be 120 gallons per day (gpd) per person[1]. Note that this value represents an average daily rate throughout the sub-basin; per-capita water use in the summer can be substantially higher than in the winter, especially for irrigation[2]. Based on this average daily rate and the estimated current population, total average annual water use in the Johns Creek sub-basin is about 0.41 million gallons per day (mgd) or 0.64 cubic feet per second (cfs).

These supplies are withdrawn predominantly from groundwater sources. However, some of this water returns to the local hydrologic system

[1] *This value is based on the work presented in the Level 1 hydrogeologic assessment (Golder, 2003)*

[2] *Peak summer use can be 1.5 to 3 times higher the average annual use (WDOH, 2001).*

as septic flows or excess irrigation (runoff or infiltration). These returns, which represent water that is available to the local hydrologic system, differ from the *consumptive* use[3] of water. Consumptive use is minimal in the winter but substantial in the summer, when people irrigate turf and landscape. Note that industrial and mining water uses were not quantified in the Johns Creek sub-basin as part of this investigation.

2.4 Impacts to Johns Creek

2.4.1 Approach & Assumptions

Monthly flows in Johns Creek were compared to estimates of monthly consumptive water use under two general scenarios. The goal was to predict a range of impacts (high to low) that would reflect how withdrawals from wells in the sub-basin might potentially impact creek flows. Note that the WRIA 14 hydrogeologic study generally indicates high hydraulic continuity in the Johns Creek area (NLW, 2005a).

First, a monthly withdrawal characteristic curve was developed for WY2005 based on pumpage data from the City of Shelton. A similar curve was then developed using Port of Shelton data. Each curve was scaled to reflect an average annual rate of water use of 0.41 mgd for the Johns Creek sub-basin (see Section 2.3 above). The curves were then used to estimate a year-round withdrawal base rate that represents nonconsumptive use—in other words, water that would remain in the sub-basin, assuming it is not removed via sewer conveyance. This base rate was calculated as an average withdrawal for the months of October 2004 through May 2005, inclusive. It was subtracted from the summer monthly withdrawals for June, July, August, and September 2005. The difference is assumed to be irrigation water used predominately for domestic, public, and commercial landscape, yard, and turf. Note that actual consumptive water use varies from year to year according to climate patterns. For example, during dry conditions, the irrigation season may begin in spring or extend to fall.

Because the local aquifers form a laterally continuous system, impacts from pumping wells outside the sub-basin were also considered. Group A and B wells, listed in **Appendix B**, were identified within approximately 0.5 mile of the sub-basin boundary. Also included were the Port of Shelton wells and the City of Shelton wells, which pump at high rates, even though they lie outside this half-mile boundary extension. Water use from the Group A and B sources was estimated by applying a factor of 350 gpd to the total number of connections. This value is based on Appendix D of *Water System Design Manual, August 2001* (WDOH, 2001). Actual pumpage data was used for City and Port of Shelton wells. Note that no exempt domestic wells outside the sub-basin were considered in this analysis.

Note also that the impacts to Johns Creek from withdrawals inside or outside the sub-basin are assumed to affect creek flows rapidly. Actual impacts will lag in time because they reflect the depth, distance, and aquifer properties between the creek and each well.

Table 2. Average Annual Water Use Outside the Sub-Basin—WY2005

Source	mgd	cfs
Group A wells (1474 connections)	0.52	0.80
Group B wells (124 connections)	0.04	0.07
City of Shelton wells	0.93	1.44
Port of Shelton wells	0.06	0.09

[3] *Consumptive uses result in a net loss to the hydrologic system. Water that is "lost" to evapotranspiration is considered consumptive use, for example.*

Scenario 1: High-Impact Assumptions

The Port-based curve was used for Scenario 1 because it showed a substantial fraction of the annual withdrawal occurring in the summer. Scenario 1 assumes that monthly withdrawals of water would otherwise discharge to Johns Creek; therefore, a withdrawal of 1 gallon from the aquifer system represents 1 gallon that would have eventually flowed in the creek. It also assumes that, of the water used for summer irrigation, 100 percent is consumptive. For wells outside the sub-basin, pumping from Group A, B, and Port of Shelton wells was assumed to reduce flows by a factor of 30 percent—in other words, for every 10 gallons of water pumped, flows in Johns Creek were assumed to be reduced by 3 gallon. For the City of Shelton wells, which lie outside the half-mile band around the sub-basin, pumping was assumed to affect flows by a factor of 15 percent.

Scenario 2: Low-Impact Assumptions

The City-based curve was used for Scenario 2. Scenario 2 assumes that monthly withdrawals represent 25 percent of the total pumped water that would otherwise discharge to Johns Creek; therefore, a withdrawal of 1 gallon from the aquifer system represents 0.25 gallon that would have eventually flowed in the creek. It also assumes that, of the water used for summer irrigation, 50 percent is consumptive. For wells outside the sub-basin, pumping from Group A, B, and Port of Shelton wells was assumed to reduce flows by a factor of 20 percent—in other words, for every 10 gallons of water pumped, flows in Johns Creek were assumed to be reduced by 2 gallons. Pumping from City of Shelton wells was assumed to affect flows by a factor of 5 percent.

2.4.2 Results & Interpretation

Flow statistics, summarized below in **Table 3**, were calculated for both Johns Creek gauging stations for comparison to water use.

Table 3. Flow Statistics for Johns Creek Stations—WY2005

	JOH2 (cfs)	Synthetic JOH1 (cfs)
October	11.0	
November	13.7	
December	27.6	
January	22.4	
February	22.6	
March	19.1	
April	29.4	
May	22.6	
June	12.8	
July	9.2	
August	5.7	9.9
September	5.4	9.4
7-day low flow	3.7	7.1

Table 4 (next page) summarizes the results of the flow / water use comparison for JOH2 and JOH1. Potential impacts are shown as a percentage of creek flow under the high- and low-impact assumptions (Scenarios 1 and 2). This percent is calculated as the impact divided by the sum of the creek flow statistic plus the impact.

Note that inherent in this comparison is the assumption that impacts to Johns Creek affect flows at station JOH2 (approximate creek mile 2.5). Although this is an instructive comparison, some impacts to Johns Creek would be felt downstream of station JOH2. Points farther downstream of JOH2 including JOH1 likely integrate more of the sub-basin-wide impacts.

Table 4. Impacts to Johns Creek as a Percentage of Median Flow—WY2005

	JOH2 (%)		Synthetic JOH1 (%)	
	Hi	Low	Hi	Low
October	3	2	---	---
November	2	2	---	---
December	1	1	---	---
January	2	1	---	---
February	2	1	---	---
March	2	1	---	---
April	1	1	---	---
May	2	1	---	---
June	6	3	---	---
July	18	5	---	---
August	31	11	21	6
September	31	6	20	4
7-day low flow	39	9	25	5

These calculations show that impact ranges from about 1 to 3 percent of the median monthly flows at JOH2 for October through May. From June through September, impacts range from 3 ("low"—Scenario 2) to 31 ("high"—Scenario 1) percent. Impact for the 7-day low flow ranges from 9 to 39 percent. At JOH1, the "low" to "high" impact ranges from 4 to 25 percent, including the 7-day low flow.

This analysis relies on assumptions about consumptive use and the relationship between withdrawals and creek flows. The results are preliminary in nature and provide only a starting point for making planning decisions or pursuing additional studies. These assumptions, although considered reasonable, were selected to represent a range of conditions. This analysis could be refined considerably by investigating conditions at individual wells. Factors that influence pumping impacts include distance to the creek, local aquifer characteristics, and well depth and construction. Approaches for refining this analysis can vary from analytical methods to the development and calibration of a numerical flow model.

2.5 Water Rights

Tables 5 and 6 (pages 15 through 17) summarize existing water right permits, pending applications, claims, and certificates for surface water and groundwater, respectively. All water rights information in WRIA 14 was extracted from Ecology's Water Rights Tracking System (WRATS) database and imported into the project GIS[4]. Water rights commonly include a point of withdrawal located by a quarter-quarter-section designation; this point was assumed to lie at the center of this location. Water rights without a quarter-quarter-section designation were located at the center of a section.

Tables 5 and 6 cover the area within the boundary of the Johns Creek basin and includes total withdrawal or diversion rates for each subgroup of water rights. Unfortunately, many water rights records in the WRATS database include no information about the allowable annual volumetric withdrawals (Qa) or maximum instantaneous rates (Qi). In the sub-basin, groundwater right permits account for 45,700 acre-feet (63.1 cfs, Qa), certificates account for 352 acre-feet (0.49 cfs, Qa), and new applications account for 7,740 gpm (10.7 cfs, Qi[5]). New applications for surface water rights and certificates account for 35 and 8.5 cfs (Qi), respectively.

[4] *Note that if data in **Tables 5 and 6** is analyzed further, it should be validated using original archive documentation on file with Ecology.*

[5] *Qi was used for this calculation because most Qa values are not shown in WRATS for this category.*

Withdrawals and diversions associated with water rights were compared to the annual average Johns Creek flow for WY2005—19.7 cfs. If these rights are currently being exercised, the current flow statistics reflect that impact. Although it is unlikely these rights are currently being fully exercised, this comparison provides an order-of-magnitude insight about the relationship between allocations and flows.

Table 7. Water Right Allocations as a Percentage of Flow at Gauging Station JOH2

Type	% of Flow
Groundwater right permits (Qa)	321
Groundwater right certificates (Qa)	2
New applications, groundwater (Qi)	54
Surface water certificates (Qi)	43
New applications, surface water (Qi)	178

2.6 Fish Distribution

Fish distribution data were obtained in digital form from the Washington Department of Fish & Wildlife's (WDFW's) SalmonScape website (WDFW, 2005). These data indicate the presence (either presumed or documented) of five species: fall chum, summer chum, coho, winter steelhead, and chinook. **Table 8** (page 18) summarizes the various life stages of these species. This life-stage data, provided by the SIT, is based on historical stream surveys and smolt trapping data. Chinook are not listed because tribal staff have not observed them in Johns Creek.

The SalmonScape data indicates that one or more species may occupy most of Johns Creek from its mouth to a point near Johns Lake, as well as along the "Cold Water" tributary (**Figure 1**). Consequently, the entire length of Johns Creek provides actual or potential habitat for at least one species. Those entities involved in developing conservation efforts as part of protection measures should consider the entire spatial extent of habitat used by these species.

2.7 Precipitation Recharge

The two hydrologic processes—runoff and recharge—play an important role in both the storage and movement of water that originates as precipitation. Groundwater flow rates and patterns are strongly influenced by the recharge process. Golder (2003) estimated recharge rates of 24.6 inches per year over the entire Johns Creek sub-basin. At the parcel scale, factors influencing recharge include precipitation, soil type, slope, surficial geology, and land cover. The highest rates of recharge occur in areas where precipitation is high, soils are coarse, and evapotranspiration rates are low. For example, precipitation falling on coarse soils will recharge aquifers at much higher rates than it will in urban areas covered with pavement, which is impervious and facilitates runoff.

The interactions between Johns Creek and the shallower aquifer system play a crucial role in supporting habitat for fish and other aquatic species. The dynamic exchange of surface water and groundwater creates unique physical, chemical, and biological conditions. For example, the discharge of cold groundwater into the creek can maintain the low water temperatures that fish require, even during the warm summer months. It also maintains refugia and other habitat features such as floodplain wetlands and spring-fed channels that might otherwise dry up in the summer months.

Geochemical data for summer flows in Johns Creek indicate that the creek is fed predominately by shallow groundwater in the wetland or upper reach. In the canyon or lower reach, it receives some intermediate to deep groundwater (from stratigraphically deeper hydrogeologic units) as well. Consequently, efforts to protect creek flows should focus on preserving the flow patterns in the shallow and intermediate aquifers in the creek vicinity. In addition, new land and water projects in the Johns Creek basin should be evaluated with this awareness.

3.0 Future Conditions

In this section, the Johns Creek flows, land use and population, water use, and precipitation recharge are projected into the future. Although these projections do not target a specific time, much of the discussion that follows applies to the next half century.

3.1 Projected Climate Effects

The Climate Impacts Group (CIG) at the University of Washington (UW) has described the effects of climate change over the next half century (Snover and others, 2005). The CIG's climate models project a warming trend in the Pacific Northwest, at a rate of roughly 0.2–1.0°F (0.1–0.6°C) per decade, at least to the year 2050. On average, temperatures will warm 1.8°F (1.0°C) by the 2020s and 3.0°F (1.7°C) by the 2040s, relative to 1970–1999 average temperature. In addition, most climate models suggest only modest (0–10 percent) increases in winter precipitation and annual precipitation by mid-21st century; these changes are less certain than warming and will still largely fall within the range of variability observed in the 20th century.

Environmental systems may respond to changes in temperature, precipitation, or both. Some systems that respond primarily to precipitation have probably already experienced the range of variability expected over the next century. One such example is flow in a rain-fed river. Systems that respond primarily to temperature, on the other hand, will likely need to adapt to new and continually changing conditions. Systems that respond to variations in both temperature and precipitation—such as the plants and animals of the Puget Sound region—will also likely be forced to adjust to conditions that differ from those in the past.

Although climate change is certainly expected over the next 50 years, climate models agree only on the general warming trend described above; predictions of specific effects differ.

3.2 Population Estimates

The current land use and zoning information, shown on **Figure 2**, was used to project the population of the sub-basin under full build-out conditions. For this analysis, the current population density of 3.13 people per acre was applied to undeveloped parcels in the UGA using GIS methods. Under full build-out conditions, the projected population would be 4,615. This value assumes that the percentage of developed acreage currently used for roads, parks, schools, and businesses will remain constant in the future. It is slightly lower than an estimate derived by converting all currently undeveloped parcels to ones with homes.

Outside the UGA, the current zoning was used to project population at full build-out. GIS methods were used to calculate the area of undeveloped land in RR5, RR10, and RR20 zones. From this, the maximum number of allowable parcels was calculated for each zone. If an undeveloped parcel of 100 acres was located within an area zoned as RR20, the parcel was assumed to be subdivided into five 20-acre parcels, with one "estimated residential unit" (ERU) occupying each. Based on these assumptions, the projected number of ERUs outside the UGA was estimated to be about 521. Note that any changes to current zoning would affect these estimates.

Table 9. Summary of Projected Population Growth in the Johns Creek Sub-Basin

Projected growth in UGA, based on current population density	2,328 people
Current population in UGA	2,287 people
Projected population in UGA	4,615 people
Projected number of ERUs outside UGA	521

3.3 Water Use – Total & Consumptive

Future water use (total and consumptive) was estimated based on the population projections discussed above.

Within the UGA, future per-capita water use was assumed to remain at 120 gpd per person. For areas outside the UGA, future water use per ERU was assumed to be 350 gpd. Based on these assumptions, water use in the sub-basin is projected to be 0.74 mgd or 1.14 cfs.

Table 10. Summary of Projected Water Use in the Johns Creek Sub-Basin

Use	mgd	cfs
In the UGA	0.55	0.86
By ERUs, outside the UGA	0.18	0.28
Total	*0.74*	*1.14*

3.4 Impacts to Johns Creek

Consumptive water use was compared to Johns Creek flow statistics at JOH2 and JOH1 (Section 2.4.2). This analysis indicates that the projected future impact from consumptive use ranges from about 1 to 3 percent of the median monthly flows at JOH2 for October through May; from June through September, impact ranges from 4 (low) to 43 (high) percent. Impact for the 7-day low flow ranges from 10 to 53 percent. At JOH1, impacts range from 4 to 37 percent, including the 7-day low flow. These values are based on the assumptions explained in Section 2.4.1. "High" refers to Scenario 1 assumptions, whereas "Low" refers to Scenario 2.

Table 11. Impacts to Johns Creek as a Percentage of Monthly Median Flow—Projected Future Conditions

	JOH2 (%)		Synthetic JOH1 (%)	
	High	Low	High	Low
October	3	2	---	---
November	2	2	---	---
December	1	1	---	---
January	2	1	---	---
February	2	1	---	---
March	2	1	---	---
April	1	1	---	---
May	2	1	---	---
June	9	4	---	---
July	27	7	---	---
August	43	14	31	9
September	43	7	30	4
7-day low flow	53	10	37	6

Comparison of the current (WY2005) and future conditions (**Tables 4 and 11**) indicates that summer Johns Creek flows will be reduced between 1 and 14 percent. This results solely from the increased water use in the Johns Creek sub-basin based on the future condition population.

Like the analysis performed for current conditions, this one relies heavily on assumptions about consumptive use and the relationship between withdrawals and creek flows. Note that the future growth in water withdrawals adjacent to, and outside of, the Johns Creek sub-basin were not included in the analysis. The results are preliminary in nature and provide only a starting point for making planning decisions or pursuing additional studies.

3.5 Precipitation Recharge

Land development practices modify hydrologic processes such as runoff and recharge (Konrad and others, 2005). Such practices include clearing vegetation and soil, grading surfaces, filling depressions (wetlands, for example), compacting soils, and constructing buildings, roads, and drainage systems. They reduce the water-storage capacity of hill slopes, soils, and the vegetation that covers them. Development affects both impermeable soils, such as tills, as well as permeable ones, such as gravel. Because clearing reduces the thickness of soils overlying the tills, they become saturated faster during storms, a condition that reduces shallow subsurface flow and increases overland flow. When organic soil layers are cleared from overlying gravels, shallow subsurface flow increases. Both conditions occur in the Johns Creek basin.

Furthermore, shallow groundwater flow paths are truncated by artificial drainage networks formed by roads, ditches, water mains, and storm sewers. Runoff travels more rapidly via shortened, overland paths, open channels, and pipes to streams. The changes combine to produce several effects:

- A faster rise and recession of streamflow
- Higher peak rates
- Higher flow volumes from a given amount of precipitation

Substantial and traditional land development in the Johns Creek sub-basin could potentially alter the rates and timing of natural creek flows. Discharge rates may increase during the wet season because of higher runoff. Likewise, baseflow—which is fed by groundwater discharge—could also decrease. Such changes bode ill for both people and fish. Those who rely on shallow wells may note declines in water levels. Fish in Johns Creek have adapted to seasonal and spatial patterns of water flow and storage.

Low impact development (LID) is a relatively new stormwater-management approach that mimics a site's natural hydrology by infiltrating, filtering, storing, evaporating, and detaining runoff through the use of small, cost-effective, landscape features. Incorporating LID practices in the Johns Creek area would help reduce the traditional effects of development on the hydrologic system.

4.0 Management Actions

This section lists some preliminary management actions that planners could implement to help protect water resources in the Johns Creek sub-basin. These actions are designed to begin addressing the significant findings of this report:

- Fish population, diversity, and habitat quality vary from poor to good.
- WY2005 flows at station JOH2 failed to meet MISF during most of the year.
- Climate models predict a warming trend that may increase surface water temperatures.
- Much of this sub-basin currently features low-density development or undeveloped lands.
- Current annual consumptive use inside and outside the Johns Creek sub-basin may represent 3 to 39 percent of summer creek flows.
- Summer flows in Johns Creek are projected to be reduced by 1 to 14 percent under future development and population scenarios.

4.1 Recommendations for Extending this Analysis

As previously noted, the analyses presented in this report could be refined significantly to provide better information for making sound water-management decisions. Recommended actions include:

- Assessing the impacts of water development in the Johns Creek vicinity under different population densities and zoning. This is particularly important if zoning differs or changes from the assumptions of this study.

- Performing soil, slope, and geologic analyses to identify areas in the Johns Creek vicinity that warrant special consideration during land development. These include areas were existing conditions, if disrupted, would have a negative impact on Johns Creek hydrology and habitat.

- Plotting creek flows during other recent water years, if available, to identify how they differ from WY2005 conditions.

- Developing a stewardship program for those living adjacent to Johns Creek. This would allow locals to implement land use practices that promote the conservation or improvement of natural flow and ecological conditions. **Figure 4** shows the parcels adjacent to the creek, where such efforts should start.

- Working with the SIT to prioritize important features along Johns Creek—features that warrant restoration and/or protection for their habitat-forming or habitat-controlling characteristics. This prioritization should include an assessment of the potential benefits of source substitution (see section 4.2.1) on the creek-reach scale.

- Identifying active groundwater rights and claims, as well as exempt water rights, to better estimate water use.

- Quantifying mining and other industrial water uses and assessing their potential impact on Johns Creek flow—now and in the future.

- Identifying active surface water rights (**Figure 4**) and illegal diversions. The Planning Unit should evaluate how replacing these diversions with deep wells might benefit Johns Creek, particularly in relation to the water use rates summarized in this report.

- Integrating the findings, recommendations, and concepts of this report and the hydrogeologic investigation report (NLW, 2005b) with the alternatives evaluation by the “the Partners” in the Shelton Regional Water Supply System (Parametrix, 2005). The same integration should occur with the alternatives evaluation in the Shelton Regional Wastewater Facilities Plan (Cosmopolitan Engineering Group, 2005).

In addition to these analyses, the Planning Unit should consider developing a rule under the instream flow resource protection program for JOH1, which lies about 0.25 miles from the outlet of the Johns Creek basin. This would reduce future uncertainty about water availability in the lower reach of the creek.

4.2 Future Management Concepts & Recommendations

Balancing the future water needs of people, fish, and other species in the Johns Creek sub-basin will require rational and creative action—today. Local resource planners and managers are faced with a range of key issues that involve not only water itself, but also:

- Land and water development practices
- Regulatory flows versus measured flows
- Water, land (property), and treaty rights
- Stakeholder support
- Leadership and political will

This report begins to address the first three issues. More technical work is needed to support decisions that will be presented and reworked as the process of building stakeholder support, leadership, and political will ensues.

The following list of management concepts and supporting recommendations is intended for discussion by the Planning Unit. It does not cover all possible concepts; rather, it should serve as a guide for developing future land and water resource scenarios. Many factors will play a role in determining which concepts are viable. The *Draft WRIA 14 Watershed Management Plan* (PTCS, 2005) contains a list of options that address many of the concepts presented here in greater detail.

4.2.1 Concept 1: Source Substitution

Source substitution involves developing interties so suppliers can import water into the Johns Creek sub-basin or adjacent areas. This management strategy would offset some portion of the current and/or future water use that would otherwise impact creek flows. Ideally, water would be conveyed from areas that are less vulnerable to pumping impacts. Interties provide the flexibility to pump wells in a way that not only best controls the magnitude and timing of impacts but also considers the status of streamflows and the location of quality habitat.

The scale of this concept can be regional—for example, moving water from deep wells near downtown Shelton to the Johns Prairie area. It can also be local. Intertying Group A water systems could give suppliers the flexibility to pump deep wells during the summer and shallow wells during periods of high creek flow. This type of management scenario could reduce impacts to Johns Creek substantially.

However, source substitution measures may increase land development in the Johns Creek sub-basin. Planners must consider the potential effects of new development.

Recommendations

- Evaluate how each supply well located in or near the sub-basin impacts flows in Johns Creek. This analysis could be performed by constructing and calibrating a digital flow model or by applying professional judgment to the conceptual hydrogeologic model.
- Use the results of this supply well evaluation to identify the feasibility of source substitution and to design an appropriate system.

4.2.2 Concept 2: Water Reuse & Conservation

This concept entails using reclaimed water for irrigation and industrial processes, thereby offsetting pumping from existing or new wells. The Planning Unit has already completed initial work on identifying a storage and recovery site near Johns Creek (SLR, 2004). This project could potentially reduce dependence on groundwater pumping near the creek and provide reclaimed water for directly enhancing creek flows.

Many in water conservation experts believe that residents can reduce water use without appreciably changing their lifestyles. Some water resource planners have identified feasible conservation measures that could amount to a per-capita savings of 25 percent in the near future.

Recommendations

- Evaluate the benefits and costs of using reclaimed water in the John Prairie area using a simple water balance and/or a digital flow model.
- Examine the net benefits to flows in Johns Creek in relation to expected future water consumption in the sub-basin.
- Develop educational and incentive programs to assist homeowners and industry to reduce water consumption.

4.2.3 Concept 3: Conservation Easements

This concept involves placing key land that lies adjacent to, or upgradient from, the creek under conservation easements. Agreements would be crafted between current property owners and a conservation entity to protect flows, water quality, and habitat. Another option is to purchase land outright, although this is usually much more expensive.

Recommendations

- Prioritize lands that offer high resource value for protecting Johns Creek habitat.
- Investigate the feasibility of easements, covenants, or land trusts, starting with highest priority lands.

4.2.4 Concept 4: Critical or Sensitive Areas

This concept involves using existing ordinances or developing new ones that protect natural flow processes that allow conservation of existing hydrologic processes for the benefit of people and fish.

Recommendations

- Review existing regulations and critical areas to determine if they adequately protect water resources.
- Promote LID practices.
- Develop new ordinances, if necessary, based on sound scientific data. Incorporate all factors the effect hydrologic process and human influences on these processes.

5.0 References

Cosmopolitan Engineering Group, 2005. *City of Shelton, Washington State Department of Corrections, Washington State Patrol Academy, and Port of Shelton Wastewater Treatment Engineering Report*. Consultant report prepared as part of the *Shelton Regional Wastewater Facilities Plan*, dated April 2, 2005.

ESRI, 2005. Census 2000 TIGER/Line Data. Accessed online at *http://www.esri.com/data/download/census2000_tigerline/*

Golder Associates, 2003. *Kennedy-Goldsborough Watershed (WRIA 14) Phase II-Level 1 Assessment*. Consultant's report prepared for the WRIA 14 Planning Unit, dated March 2003.

Konrad C.P., Booth D.B., and Burges S.J., 2005. *Effects of Urban Development in the Puget Sound Lowland, Washington, on Interannual Streamflow Patterns: Consequences for Channel Form and Streambed Disturbance*. Water Resources Research, v.41, W07009, 2005.

Kuttel, M., 2002. *Salmonid Habitat Limiting Factors Water Resource Inventory Area 14, Kennedy-Goldsborough Basin, Final Report—November 2002*. Olympia, WA: Washington State Conservation Commission.

Northwest Land & Water, 2005a. *Addendum Scope of Work Under the Step C Instream Flow Grant*. Prepared for the WRIA 14 Planning Unit, dated October 18, 2005.

Northwest Land & Water and Plateau Technical Communication Services, 2005b. *WRIA 14 / Kennedy-Goldsborough Watershed Phase II Hydrogeologic Characterization*. Consultant report prepared for the WRIA 14 Planning Unit, dated December 31, 2005.

Parametrix, 2005. *Draft City of Shelton, Water Comprehensive Plan Amendment and Project Report for the Shelton Area Regional Water System*. Prepared for the City of Shelton, dated January 2005.

Plateau Technical Communication Services, 2005. *Draft WRIA 14 Watershed Management Plan*. Dated 09/13/05.

Sapik D.B., Bortleson, G.C., Drost, B.W., Jones, M.A., and Frych, E.A., 1988. *Ground-Water Resources and Simulation of Flow in Aquifers Containing Freshwater and Seawater, Island County, Washington*. U. S. Geological Survey, Water-Resources Investigations Report 87-4182, Tacoma, WA.

SLR International Group, 2004. *Draft Hydrogeologic Conceptual Model and Feasibility Review, WRIA 14 Water-Storage Grant*. Consultant report prepared for the WRIA 14 Planning Unit.

Snover, A.K., P.W. Mote, L. Whitely Binder, A.F. Hamlet, and N.J. Mantua, 2005. *Uncertain Future: Climate Change and its Effects on Puget Sound*. A report for the Puget Sound Action Team by the Climate Impacts Group (Center for Science in the Earth System, Joint Institute for the Study of the Atmosphere and Oceans, University of Washington, Seattle).

Washington Department of Fish & Wildlife, 2005. SalmonScape data for Johns Creek in Mason County, Washington. Accessed online at *http://wdfw.wa.gov/mapping/salmonscape*.

Washington State Department of Health, 2001. *Water System Design Manual, August 2001*. Appendix D: Background and Development of Residential Water Demand vs. Precipitation.

Table 5. Summary of Johns Creek Sub-Basin Water Rights by Certificates, Permits, Applications, and Claims for Groundwater

Document Number	Priority Date	Q_a, in Acre Feet	Q_i, in gpm	Township	Range East	Section	Quarter Section	Quarter-Quarter Section	Name	Purpose Code
Permits (total 63.1 cfs - Qa)										
G2-*00699PWRIS	01/06/48	16100	10000	20	3	5			Rayonier Inc	CI
G2-*00732PWRIS	02/10/48	5600	3470	20	3	5			Rayonier Inc	CI
G2-*00793PWRIS	03/31/48	5600	3500	21	3	31			Rayonier Inc	CI
G2-*00945PWRIS	07/03/48	6000	3700	21	3	32			Rayonier Inc	CI
G2-*00975PWRIS	08/10/48	6000	3700	21	3	31			Rayonier Inc	CI
G2-*00998PWRIS	09/17/48	3200	2000	21	3	31			Rayonier Inc	CI
G2-*00999PWRIS	09/17/48	3200	2000	21	3	33			Rayonier Inc	CI
		45,700	**28,370**							
New Applications (total 10.7 cfs - Qi)										
G2-*00733AWRIS	02/10/48	0	3470	20	3	5			Rayonier Inc	CI
G2-*00758AWRIS	03/04/48	0	3500	21	3	32			Rayonier Inc	CI
G2-28494	05/19/92	0	50	21	4	25			Fuller, Keith	DM
G2-28544	05/18/92	35	85	20	3	4			Shelton Port	CI IR
G2-28996	01/19/94	0	175	21	4	25			Drake, Herman	DM
G2-29008	01/21/94	0	150	21	4	25			Drake, Herman	DM
G2-29266	08/21/95	0	110	21	4	35			Hofert Family Trust	DM
G2-30087	12/16/02	0	200	21	3	33			BB&R	CI DS
		35	**7,740**							
Claims (total 0.02 cfs - Qa)										
G2-030145CL		0		20	4	1			Wottom	DG
G2-032798CL		0		21	3	32			Nichols	DG
G2-034334CL		0		20	3	5			Martindale	DG ST
G2-045472CL		0		20	3	5			Cuzick	DG ST
G2-047132CL		0		20	4	1			Brotche Jr.	DG
G2-058486CL		0		20	3	5			Hodgson	DG
G2-064436CL		0		20	3	5			Turner	DG
G2-070732CL		0		21	4	27			Nelson	DG
G2-085279CL		0		20	3	4			Hutchins	DG
G2-089242CL		0		20	3	5			Knauf	DG IR
G2-089243CL		0		20	3	5			Knauf	DG IR
G2-101255CL		0		21	3	31			Cook	DG
G2-103936CL		0		20	3	5			Garrison	DG IR
G2-105454CL		0		20	3	4			Peste & Stohr Douglas Fir	DG IR ST
G2-106285CL		0		20	4	1			Valley	DG IR
G2-108870CL		0		20	3	5			Schumacker	DG IR
G2-108872CL		0		20	3	4			Simpson	DG
G2-114766CL		0		20	3	5			Addington	DG
G2-132332CL		0		20	3	5			West	DG IR ST
G2-132392CL		0		20	3	5			Depoe	DG IR
G2-132392CL		0		20	3	5			Depoe	DG IR
G2-134893CL		0		20	3	5			Steehler	DG IR
G2-145911CL		0		21	4	35			J Hofert Co	DG
G2-148139CL		0		20	3	5			Savage	DG

Table 5. Summary of Johns Creek Sub-Basin Water Rights by Certificates, Permits, Applications, and Claims for Groundwater

Document Number	Priority Date	Q_a, in Acre Feet	Q_i, in gpm	Township	Range East	Section	Quarter Section	Quarter-Quarter Section	Name	Purpose Code
G2-148931CL		0		20	3	5			Palmer	DG IR
G2-160848CL		0		21	3	31			Plews	DG ST
G2-162602CL		0		20	3	5			Woods	DG IR
G2-000518CL		0		20	3	5			Mccallum	DG IR
G2-003293CL		0		20	3	5			Emmons	DG IR
G2-006128CL		0		20	4	1			Seymour	DG
G2-007182CL		0		20	4	1			Blevins	DG IR ST
G2-008238CL		0		20	3	4			WA State Hwy Dept	DG
G2-011961CL		0		20	4	1			Hatch	DG
G2-012020CL		0		20	4	1			Johnston	DG
G2-012232CL		0		20	3	5			McCallum	DG
G2-014247CL		0		20	3	4			Shelton	DG
G2-015374CL		0		20	3	5			Palmer	DG
G2-016039CL		0		20	3	5			Addington	DG
G2-016170CL		0		20	3	5			Mendenhall	DG
G2-043437CL		0		20	3	5			Drebick	DG ST
G2-051649CL		0		20	4	1			Seymour	DG
G2-078259CL		0		20	4	1			Starr	DG
G2-092435CL		0		20	3	4			Olson	DG
G2-098264CL		0		20	3	4			G R Kirk Co	DG
G2-114518CL		0		20	3	5			Davis	DG
G2-114570CL		0		20	3	5			Martinell	DG ST
G2-132661CL		0		20	3	4			Moore	DG IR ST
G2-136372CL		0		21	3	31			Plews	DG IR ST
G2-136477CL		0		20	3	5			Depoe	DG IR ST
G2-155644CL		0		20	3	4			Bechtold	DG
G2-157511CL		0		20	4	1			Cowles	DG
G2-09800716CL		16	0	20	4	1			Evergreen Mobile Estates	DG
		16	**0**							
Certificates (total 0.49 cfs - Qa)										
G2-01135C	04/02/71	161	210	20	3	6	NE/NE	NE/NE	Oak Park Water Co	DM
G2-20099CWRIS	04/11/72	17	45	20	4	2	SE/SE	SE/SE	McDougal	DM FR
G2-22511CWRIS	05/29/74	3	25	20	4	1			Starr	DS IR
G2-25245CWRIS	05/22/79	10	50	20	3	5	SW/NE	SW/NE	Evergreen Land & Water	DM
G2-27879C	10/05/90	161	500	20	3	6	NE/NE	NE/NE	Oak Park Water Co	DM
		352	**830**							

Note: Data in this table should be validated using original archive documentation on file with WA Dept. of Ecology

Table 6. Summary of Johns Creek Sub-Basin Water Rights by Certificates, Permits, Applications, and Claims for Surface Water

Document Number	Priority Date	Q_a, in Acre Feet	Q_i, in cfs	Township	Range East	Section	Quarter Section	Quarter-Quarter Section	Name	Purpose Code
Permits (total 0 cfs)										
S2-*15345PWRIS	03/18/59	0	0	21	4	27			Brevug John E ET UX	DS IR
New applications (total 35 cfs - Qi)										
S2-*02721AWRIS	09/26/29	0	10	20	4	1			Shelton City	MU
R2-*20829AWRIS	03/22/68	39	0	20	4	1			Snively Edna Rae	RE
S2-*08234AWRIS	02/17/48	0	25	20	3	5			Rayonier Inc	CI
Change applications (total 0 cfs)										
CS2-*01937	06/27/99	0	0	20	3	3	NE/SW	NE/SW	Bayshore Inc	DM
Certificates (total 8.5 cfs - Qi)										
S2-*02717CWRIS	09/23/29	0	0	20	4	1			Muller L	DS IR
S2-*01937AWC	12/09/26	0	3	20	3	3	NE/SW	NE/SW	Bayshore Inc	CI DS IR
S2-*01937AWC	12/09/26	0	3	20	3	3	NE/SW	NE/SW	Bayshore Inc	CI DS IR
S2-*01937AWC	12/09/26	0	3	20	3	3	NE/SW	NE/SW	Bayshore Inc	CI DS IR
S2-22510CWRIS	05/29/74	2	0	20	4	1			Starr Laurence D	IR
R2-*21403CWRIS	01/21/69	15	0	20	3	6	SE/NE	SE/NE	Rosand M O	FR FS RE WL
S2-*19187CWRIS	08/06/65	1	0	20	4	1			Hatch E O	IR
S2-*16620CWRIS	04/04/61	40	0	20	4	1	SW/NE	SW/NE	Burnett J A ET UX	IR ST
S2-*12405CWRIS	06/12/53	0	1	20	3	5	SE/NW	SE/NW	Fitz C	IR
S2-*12192CWRIS	03/25/53	0	0	20	4	1			Ferris F E	DS IR

Note: Data in this table should be validated using original archive documentation on file with WA Dept. of Ecology

Table 8: Life Stages of Fish in Johns Creek

Information provided by the Squaxin Island Tribe

	Fall (Normal) Chum [1]	Summer (Early) Chum [1]	Coho		Winter Steelhead		
Oct	In migration/ spawning	In migration/ spawning	In migration [1]	Rearing [2]	---	Rearing [2]	---
Nov	In migration/ spawning	In migration/ spawning	In migration [1]	Rearing [2]	---	Rearing [2]	---
Dec	In migration/ spawning	---	In migration [1]	Rearing [2]	---	Rearing [2]	---
Jan	In migration/ spawning	---	In migration [1]	Rearing [2]	In migration/ spawning [1]	Rearing [2]	---
Feb	Rearing/ outmigration	Rearing/ outmigration	---	Rearing [2]	In migration/ spawning [2]	Rearing [2]	---
Mar	Rearing/ outmigration	Rearing/ outmigration	---	Rearing [2]	In migration/ spawning [2]	Rearing [2]	---
Apr	Rearing/ outmigration	Rearing/ outmigration	Out migration [1]	Rearing [2]	In migration/ spawning [2]	Rearing [2]	Out migration [1]
May	---	---	Out migration [1]	Rearing [2]	In migration/ spawning [2]	Rearing [2]	Out migration [1]
Jun	---	---	Out migration [1]	Rearing [2]	In migration/ spawning [2]	Rearing [2]	Out migration [1]
Jul	---	---	---	Rearing [2]	---	Rearing [2]	---
Aug	---	---	---	Rearing [2]	---	Rearing [2]	---
Sept	In migration	In migration	In migration [1]	Rearing [2]	---	Rearing [2]	---

Notes:
Coho and winter steelhead may occupy Johns Creek for 2 years; therefore, different life stages may coexist
1 Documented Presence
2 Presumed Presence

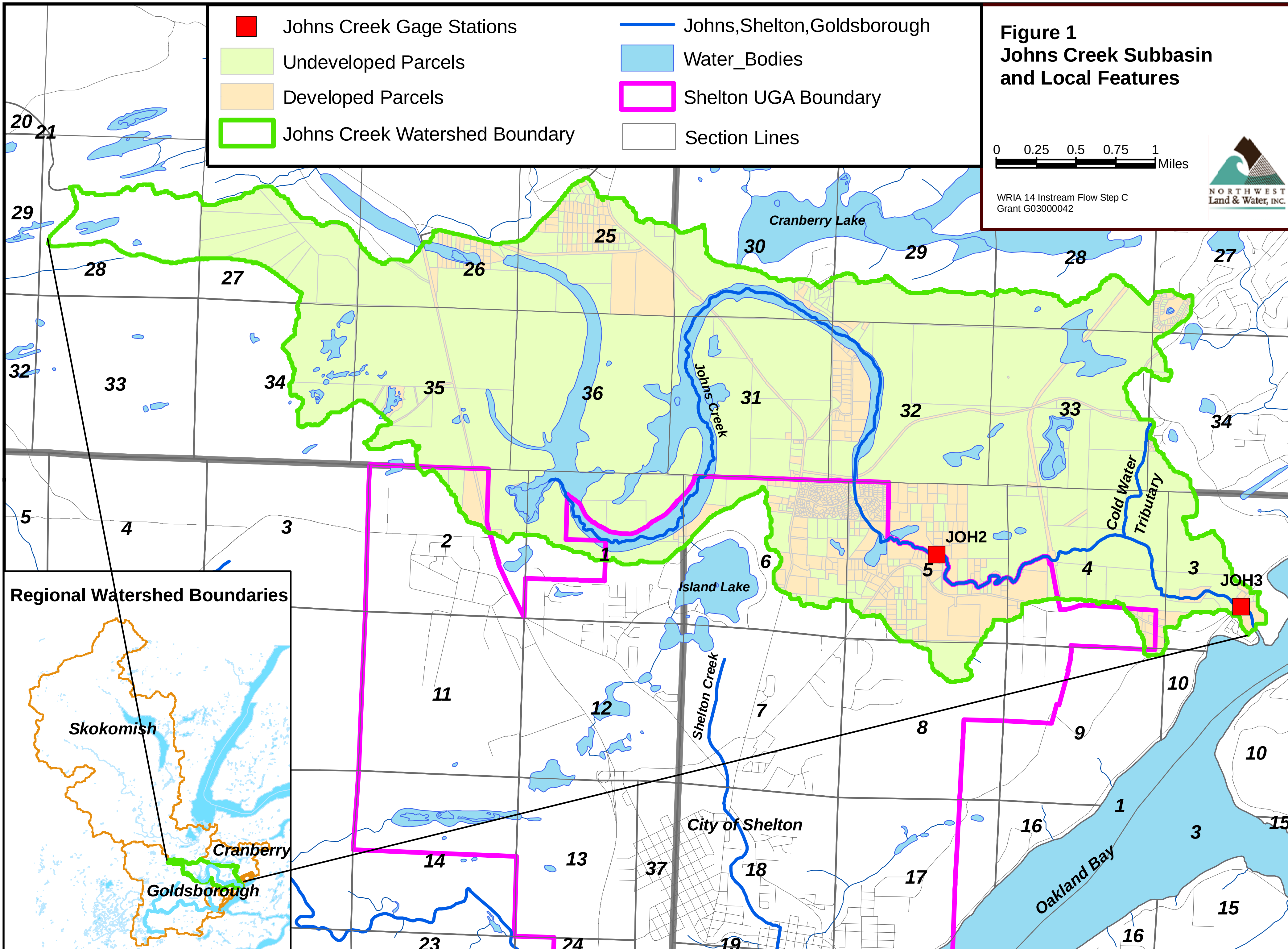
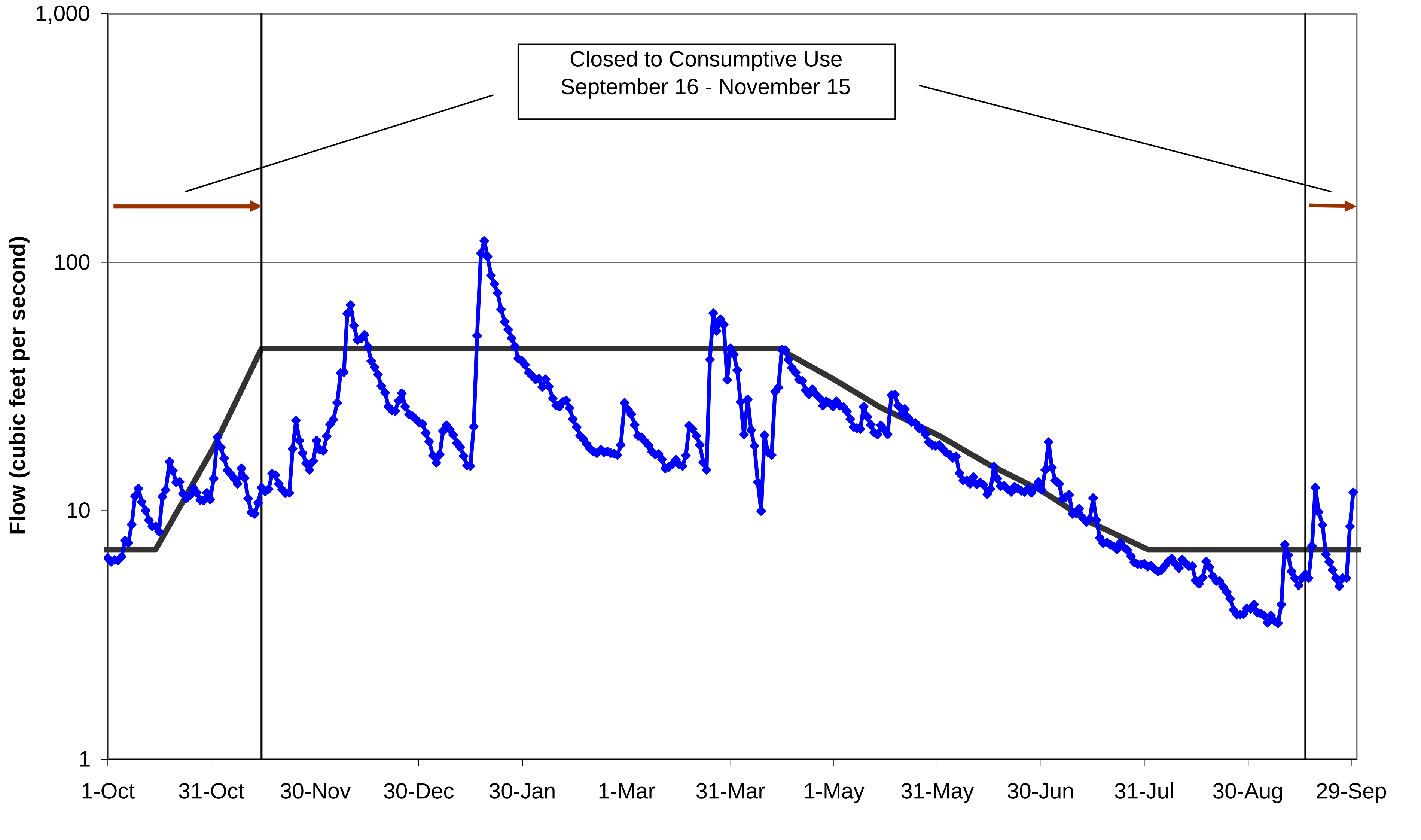


Figure 1
Johns Creek Subbasin and Local Features
Johns Creek Gage Stations
Undeveloped Parcels
Developed Parcels
Johns Creek Watershed Boundary
Johns,Shelton,Goldsborough
Water_Bodies
Shelton UGA Boundary
Section Lines
0 0.25 0.5 0.75 1 Miles
WRIA 14 Instream Flow Step C
Grant G03000042
NORTHWEST Land & Water, INC.
Cranberry Lake
Johns Creek
Island Lake
Shelton Creek
City of Shelton
Oakland Bay
Cold Water Tributary
JOH2
JOH3
Regional Watershed Boundaries
Skokomish
Cranberry
Goldsborough

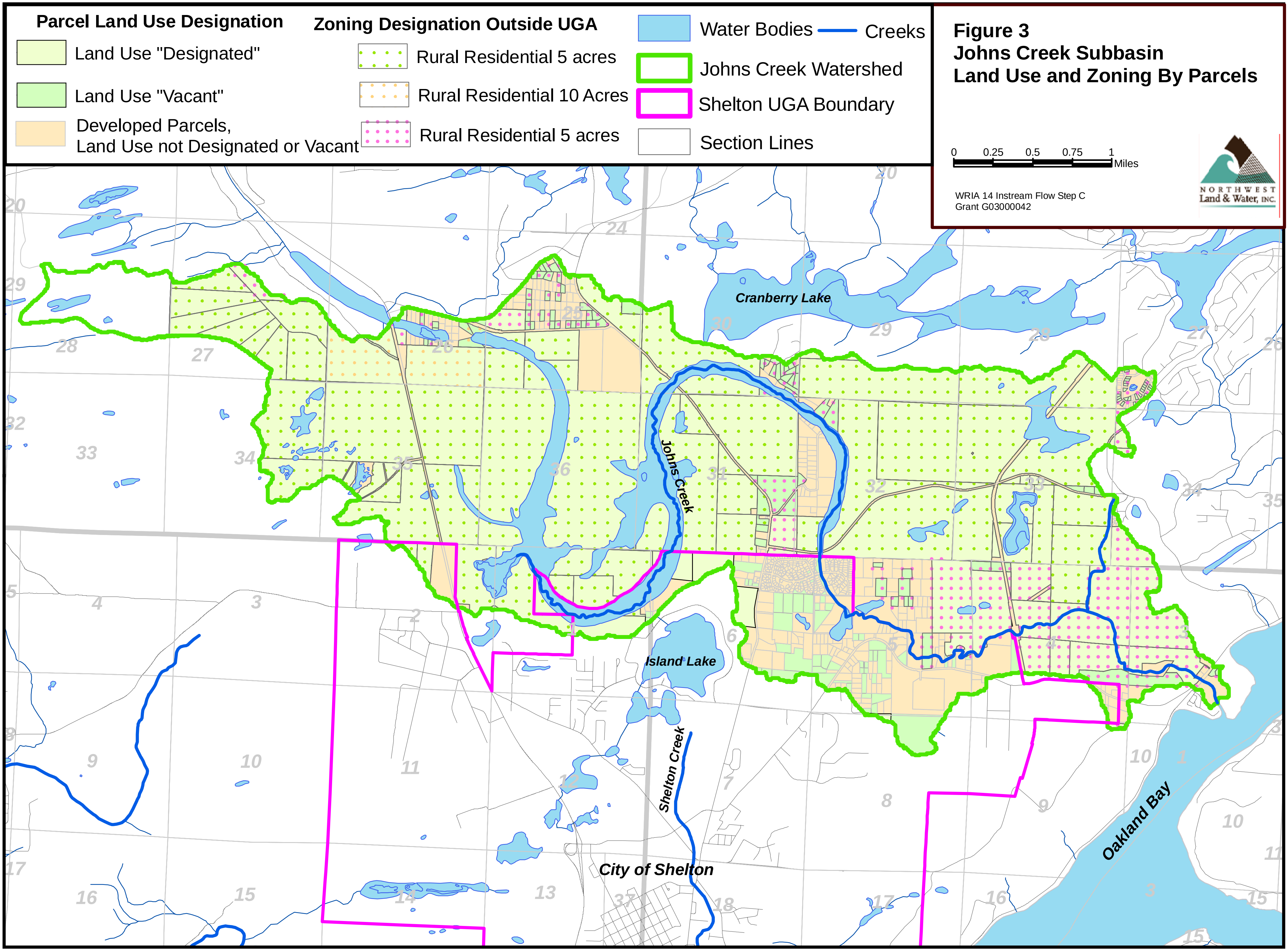


Note: Minimum Instream Flow (MISF) source Chapter 173-514.
WY2005 flow data source : Squaxin Island Tribe

Figure 2
Johns Creek Flows -
MISF and Water Year 2005

WRIA 14 Step C Instream Flow Grant G03000042

NORTHWEST Land & Water, INC.


Parcel Land Use Designation
Land Use "Designated"
Land Use "Vacant"
Developed Parcels,
Land Use not Designated or Vacant
Zoning Designation Outside UGA
Rural Residential 5 acres
Rural Residential 10 Acres
Rural Residential 5 acres
Water Bodies
Creeks
Johns Creek Watershed
Shelton UGA Boundary
Section Lines
Figure 3
Johns Creek Subbasin
Land Use and Zoning By Parcels
0
0.25
0.5
0.75
1
Miles
WRIA 14 Instream Flow Step C
Grant G03000042
NORTHWEST Land & Water, INC.
Cranberry Lake
Johns Creek
Island Lake
Shelton Creek
City of Shelton
Oakland Bay

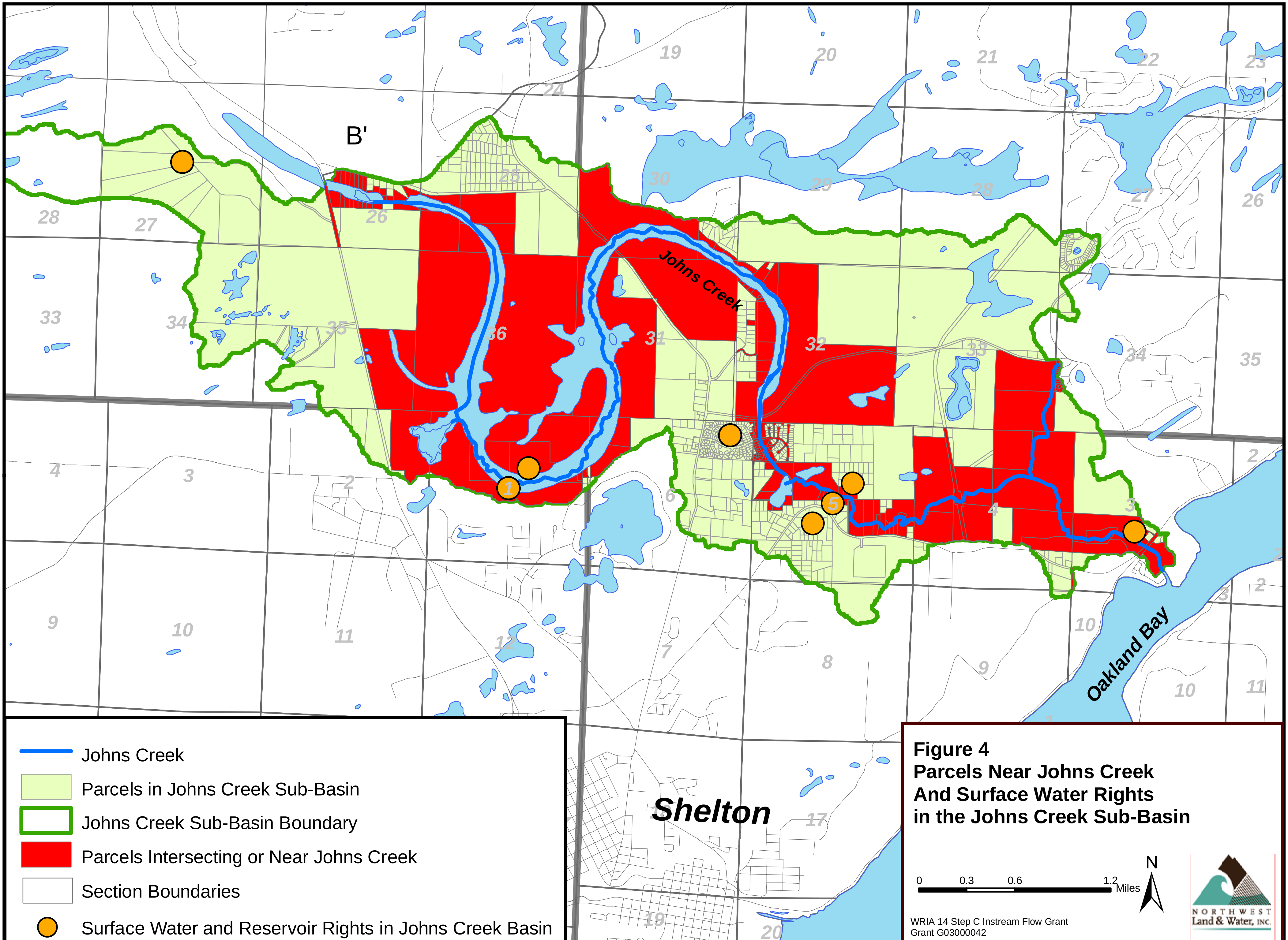
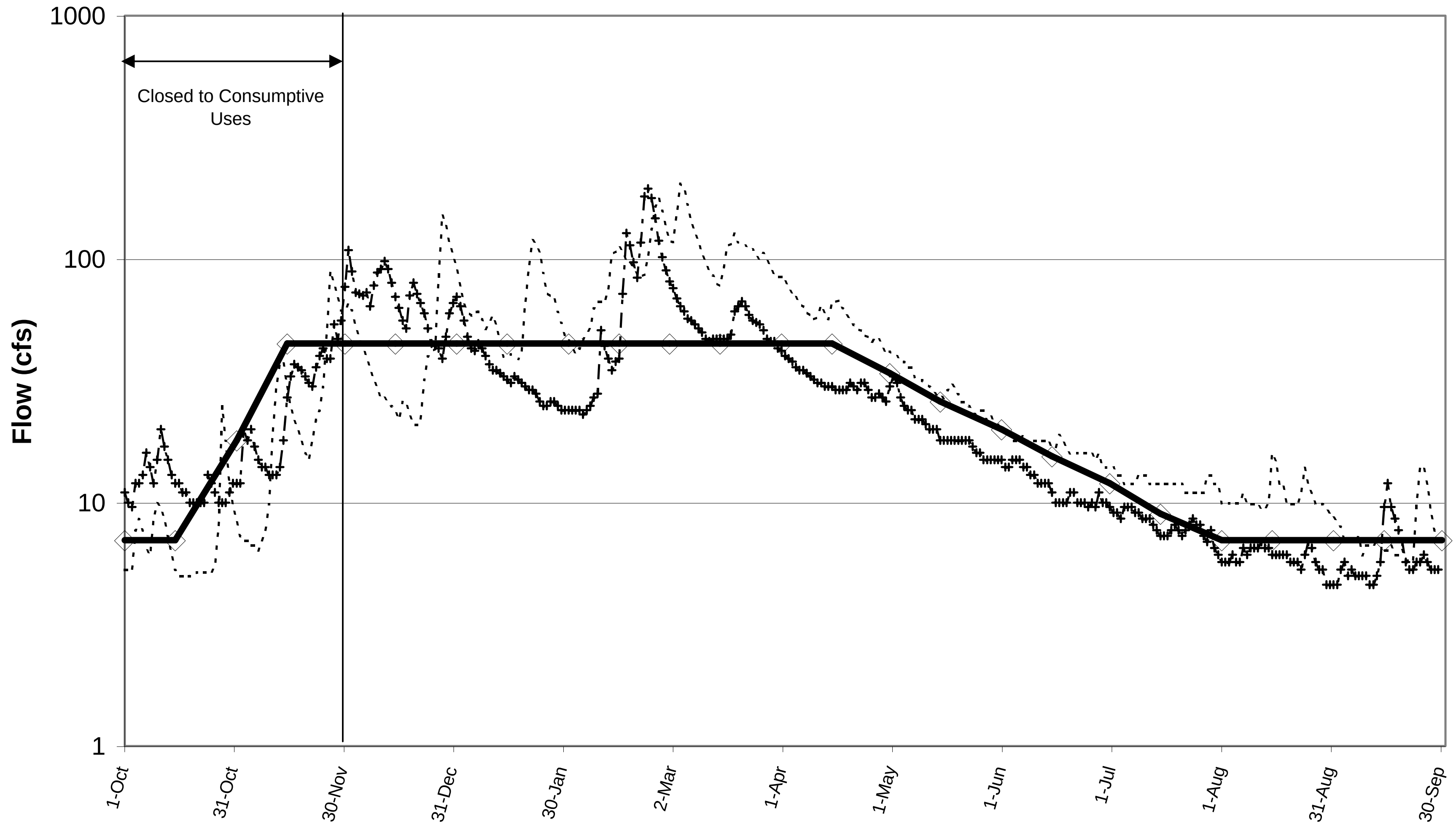


Figure 4
Parcels Near Johns Creek And Surface Water Rights in the Johns Creek Sub-Basin

Appendix A:
Johns Creek Actual Flows and MISF Regulations, Figure 7.11, Golder, March 2003



Legend

- Wet Year Flow (WY 1950)
- Dry Year Flow (WY 1949)
- Instream Flow Requirements

FIGURE 7.11: Johns Creek Actual Flows and MISF Regulations

WRIA 14 Planning Unit
Level 1 Assessment

Golder Associates

Appendix B:
Summary of Public Water System Wells in Johns Creek Basin and Within Half-Mile Buffer of Basin Boundary

Appendix B. Summary of Public Water System Wells in Johns Creek Basin and Within Half-Mile Buffer of Basin Boundary

Location	Water System ID	Group Type	System Name	Number of Wells	Connections
Basin	1213	A	RHODODENDRON PLACE	1	17
Basin	4900	A	BAYSHORE	1	34
Basin	7483	A	BAYSHORE GOLF CLUB	1	2
Basin	44150	A	LAKE LIMERICK WATER	3	915
Basin	62675	A	OAK PARK WATER SYSTEM	2	237
Basin	802	B	HELLICKSON WATER	1	8
Basin	2630	B	RAINIER PLACE WATER SYSTEM	1	6
Basin	2782	B	STONEBRIAR #1	1	6
Basin	2783	B	STONEBRIAR #2	1	6
Basin	2784	B	STONEBRIAR #3	1	6
Basin	3655	B	ROLLING HILLS WATER SYSTEM	1	6
Basin	4677	B	D AND D 2	1	6
Basin	4678	B	D AND D 3 WATER SYSTEM	1	7
Basin	4679	B	D AND D 1 WATER SYSTEM	1	6
Basin	5349	B	LAKE PARK NO. 2	1	8
Basin	5352	B	LAKE PARK NO. 3	1	6
Basin	5353	B	LAKE PARK NO. 4	1	8
Basin	5354	B	LAKE PARK NO. 1	1	6
Basin	5539	B	LEXINGTON PLACE A	1	6
Basin	5540	B	LEXINGTON PLACE B	1	2
Basin	5623	B	SNOWY OWL #3	1	3
Basin	5624	B	SNOWY OWL #1	1	3
Basin		B	SNOWY OWL #2	0	
Basin	7878	B	D AND D 4	1	2
Basin	7879	B	D AND D 5	1	2
Basin	8309	B	SNOWY OWL #4 WATER SYSTEM	1	6
Basin	8310	B	SNOWY OWL #7 WATER SYSTEM	1	6
Basin	8311	B	SNOWY OWL #5 WATER SYSTEM	1	6
Basin	8312	B	SNOWY OWL #6 WATER SYSTEM	1	6
Basin	20801	B	PLATT WATER SYSTEM	1	2
Basin		B	JOHNS PRAIRIE WATER SYSTEM	0	
Basin		B	G.R. KRIK COMPANY	0	
Basin	65114	B	TIFFANY WATER SYSTEM	1	6
Basin		B	SHELTON MAINTENANCE SITE	0	
Buffer	530	A	S AND P PROPERTIES WS	1	3
Buffer	620	A	PORT OF SHELTON JOHNS PRAIRIE WS	1	15
Buffer	2993	A	WASHINGTON STATE PATROL ACADEMY WS	1	38
Buffer	3224	A	HIAPARK WATER SYSTEM	4	38
Buffer	7614	A	CORNERSTONE INDUSTRIAL PARK WS	2	9
Buffer		A	PURDY CREEK WS	0	

Buffer	12560	A	CHERRY PARK	1	32
Buffer	24154	A	EVERGREEN MOBILE ESTATES	3	54
Buffer	32660	A	HIDDEN HAVEN MOBILE HOME PARK	2	75
Buffer	36180	A	ISLAND LAKE MANOR	1	69
Buffer	45271	A	PINEWOOD PLACE 1 WS	1	4
Buffer	68835	A	PORT OF SHELTON SANDERSON FIELD WS	2	29
Buffer	70755	A	RAE LAKE	2	36
Buffer	70791	A	RAINBOW LAKE	1	63
Buffer	83408	A	SPRINGWOOD	1	32
Buffer	98184	A	WOODLAND MANOR	2	62
Buffer	321	B	SHELTON SPRINGS ROAD	1	3
Buffer	600	B	AIRPORT HOME TRACTS WS	1	11
Buffer	1569	B	PINE ACRES C WATER SYSTEM	1	3
Buffer	2369	B	MASON COUNTY PUD 3 WS	1	4
Buffer	3298	B	CARDONA WATER EAST	1	6
Buffer	3302	B	CARDONA WATER WEST	1	6
Buffer	3480	B	MCHARGUE	1	2
Buffer	3555	B	WEST COAST LATVIAN EDUCATION WS	1	7
Buffer	4040	B	PINE PARK	1	6
Buffer	4393	B	HIAWATHA #3 WATER SYSTEM	1	6
Buffer	4394	B	HIAWATHA #4 WATER SYSTEM	1	6
Buffer	4395	B	HIAWATHA #5	1	2
Buffer	4752	B	BLACK B 345	1	2
Buffer	4757	B	BLACK C 346	1	2
Buffer	5234	B	LAKE WOOD WATER SYSTEM	1	10
Buffer	5432	B	STROM TWO-PARTY	1	2
Buffer	5476	B	PINE ACRES B WATER SYSTEM	1	6
Buffer	5485	B	PARKER	1	2
Buffer	5917	B	CATFISH LAKE 1 - 341 WATER SYSTEM	1	4
Buffer	5918	B	CATFISH 2 - 342 WATER SYSTEM	1	3
Buffer	5920	B	PINE PARK #2	1	6
Buffer	5942	B	LILLIWAUP BAY #1	1	1
Buffer	6159	B	SHELTON DANCE CENTER	1	2
Buffer	6203	B	SHELTON CHURCH OF THE NAZARENE	1	2
Buffer	7655	B	RIDGE CREEK	1	3
Buffer	7657	B	MISKA, RALPH	1	2
Buffer	7951	B	ALLEN WATER SYSTEM	1	3
Buffer	10843	B	CENTRAL SHOP	1	1
Buffer	13616	B	STOCK - SOBOTKA # 1	1	4
Buffer	13641	B	STOCK - SOBOTKA W.W. # 2	1	4
Buffer	15090	B	PJS INC WATER SYSTEM	1	3