8.0 SUMMARY OF KEY FINDINGS AND RECOMMENDATIONS

8.1 Wellhead Protection Area Delineations

Capture zones delineated by the most recent MODFLOW modeling differ slightly from the capture zone delineations prepared in 1997 and 2010. The current delineations more accurately reflect the hydrogeologic setting, pumping rates, and planned expansion of the City's water supply. We recommend that the capture zones delineated at 13.3 mgd total pumping (maximum installed capacity) be used as the basis of the 1-year, 5-year and 10-year well head protection area (WHPA) delineations. The WHPA's should include the 10% safety factor as shown in Figure 3-8.

As more hydrogeologic data are collected, we recommend that the City consider re-evaluating the model in 2 or 3 years. Future calibrations should be based on a more recent depiction of groundwater elevations and additional aquifer testing data (e.g. pumping tests), as available.

The City's groundwater model should be updated to include newly acquired wells (e.g. Lakeland Manor and Lathrop). Water quality should be routinely assessed at these wells to determine if additional monitoring wells or increased frequency of monitoring is needed in these areas.

8.2 Contaminant Source Inventory

While there are relatively few documented contaminant sources within the City's WHPA's, there are sources that warrant continued management and monitoring. The supplemental remedial investigation related to TCE and PCE at the Palermo Wellfield may reveal additional contamination concerns and should be monitored closely.

Although nitrate levels are well below the drinking water standard, the City should continue monitoring for nitrate since increasing trends have been noted at some wells (e.g. MW-96-16, -18, and -20). The City should also evaluate potential sources of nitrates near wells that are experiencing elevated levels (e.g. fertilizer application or spills of nitrogen-rich compounds).

Stormwater infiltration, both from UIC wells and infiltration ponds remains a potential source of contamination that cannot be readily characterized with existing information. Emerging contaminants (both personal care products and PFC's) are another potential source of contamination that cannot be readily characterized with existing information.

The groundwater management strategies outlined in Section 5.0 will address the contaminant source concerns identified in this WHPP.

8.3 Groundwater Management Strategies

Tumwater's current wellhead protection ordinance and associated land use provisions in the City's code reflect a proactive and protective approach to the City's drinking water. The five overall strategies applied to protecting groundwater are as follows:

Strategy #1: ***Collaborate*** with county and state agencies in groundwater protection efforts.

Strategy #2: ***Strengthen City policies***, development review process and program management to ensure groundwater goals are met.

Strategy #3: ***Monitor groundwater quality*** to detect contamination, evaluate pollution reduction efforts, and conduct research to better understand risks to groundwater.

Strategy #4: ***Implement social awareness programs*** to change behaviors that place groundwater at risk, and raise awareness about aquifers and the need for groundwater protection.

Strategy #5: ***Prevent groundwater contamination*** in Aquifer Protection Overlay Districts through spill prevention and spill response initiatives.

These strategies remain relevant and effective in managing groundwater quality and a number of more detailed recommendations have been developed to continue implementing and improving these strategies. Three general areas of improvement are noted here:

1. **Updating City Ordinances:** There are several areas where existing ordinances should be updated and improved based on the findings and recommendations of the WHPP. The updates and additions do not substantively change existing ordinances, and primarily address consistency and completeness with this WHPP.
2. **Stormwater:** Further assessment and management of the potential for groundwater contamination by stormwater should be initiated. Although there are existing regulations and design standards related to stormwater management, this appears to be the most "unmanaged" potential pathway for contaminants to enter groundwater within the City's WHPA's.
3. **Emerging Contaminants:** Additional assessment and collaboration with the LOTT Alliance on the issue of emerging contaminants is warranted. This includes both personal care products and industrial products (like PFC's) which might enter groundwater via multiple pathways.

8.4 Cost Estimates

Table 8-1 provides estimates of staff effort and additional contracting costs associated with the recommended programmatic updates to the WHPP. The approximate staff effort is estimated at approximately one full time person to cover the recommended program updates and is based on experience working with other cities; exact level of effort for each recommendation component is uncertain but was distributed equally in Table 8-1 for planning purposes. Additional contract costs are also estimated for preliminary planning purposes.

Table 8-1: Estimated Costs for WHPP Recommendations

Program	No.	Recommendation	Approximate Staff Effort and Cost Estimate
Collaboration	**C-1**	Revive regional groundwater program	0.2 FTE [1] + $30,000 [2]
	C-2	Participate in the WA Agency Response Network	
	C-3	Prepare revisions to Drainage Manual	
Ordinances	**O-1**	Ordinance Revisions	0.2 FTE + $30,000
	O-2	Minimum Development Density White Paper	
	O-3	Adopt updates Drainage Manual	
City Outreach	**CO-1**	Social Marketing Recommendations	0.2 FTE [1] + $10,000 [2]
	CO-2	Education at Local Retailers	
	CO-3	City Website	
	CO-4	Promote Individual Spill Response Planning	
Prevention	**P-1**	Contact Site Owners in EDR Survey	0.2 FTE [1] + $50,000 [2]
	P-2	Contact Septic System Owners	
	P-3	Evaluate Status of Inactive Wells	
	P-4	Decommission heating oil tanks	
	P-5	Tax parcel cross-referencing	
	P-6	New water connections well surveys	
	P-7	Storm Drain Labeling	
	P-8	Update Contaminant Source Inventory	
	P-9	Continue to Implement Contingency Planning	
Contingency Planning	**CP-1**	Absorbents, Stationing, Signage	0.2 FTE [1] + $50,000 [2]
	CP-2	Water System Operator Training	
	CP-3	Spill History Review	

Notes:
1. FTE= City Staff Full Time Equivalent estimated at approximately one full time person based on recommendations and experience working with other cities. Exact level of effort for each recommendation component is uncertain.
2. Estimated Contract Support

Preliminary estimated costs for the recommended well installations and maintenance are summarized in Tables 8-2 and 8-3. Costs for a drilling contractor are based on prices provided to Golder by Holt Services, Inc., in November 2015. The overall cost for installation of each well includes a fee of $2,500 for engineering and oversight. It is recommended that the City request competitive bids from several drilling contractors prior to installation of monitoring wells.

Table 8-2: Preliminary Cost Estimate for Recommended Well Installations and Maintenance [1]

	Well	Anticipated Screen Depth[2]	Estimated Cost
	Recommended Well Installations [3]		
M-1	1. Hytec Well (replacement, new pump)	40-50	$9,000
M-2	2. SWWF-MW-1 (new well/pump) 3. SWWF-MW-2-2 (new well/pump; replaces Zorad)	70-80 70-80	$11,000 $11,000
M-3	4. MW 96-19 (replacement)	15-30	$7,000
M-4	5. Burkey Well (replacement) 6. Connelly (replacement) 7. Jacobson Well (replacement) 8. Marsh Well (replacement)	60-70 40-50 110-120 50-60	$9,000 $8,000 $12,000 $9,000
	Recommended Well Maintenance [4]		
M-5	*1. MW 96-18 (Install new QED Pump)* *2. MW 96-20 (examine/lower existing pump)*	--	$1,000 $1,000[5]
M-6	3. MWES-11 4. MW-96-15	--	$35 $35
	Total		$80,000

Notes:
1. Estimated costs for ***Recommended Well Installations*** include drilling contractor costs and approximated engineering oversight costs of $2,500 per well; replacement wells are assumed to reuse existing QED pumps. Costs for ***Recommended Well Maintenance*** are for materials only (see note 4).
2. Wells are assumed completed at bottom of screen.
3. Estimated construction costs are for hollow stem auger drilling methods. Well construction is assumed to be schedule 40 PVC (0.01-inch slotted screen) and includes above-ground monuments with protective bollards.
4. Estimates do not include labor costs (it is assumed City and/or Thurston County staff can complete these tasks); County Staff rates were approximately $44/hr under the existing 2011 monitoring agreement.
5. Assumes existing pump must be replaced; equipment costs would be less than $100 if existing pump is intact and can be lowered and does not include labor costs, see note 4).

Table 8-3: Changes to Monitoring and Associated Costs

	Action	Parameters to Monitor	Estimated Annual Cost[1]
M-7	Measure groundwater levels in MW-93-04	Water levels	--dependent on City staffing--
M-8	Monitor parameters in two new monitoring wells (SWWF-MW-1 and -2).	Quarterly for VOCs, water levels, nitrate, Inorganic suite.	$4,000[1]
M-9	Increased frequency of monitoring in EPA-ES-11	Add quarterly monitoring for VOCs	$900
M-10	Increased frequency of monitoring in MW-96-15, -16, -18, -20; EPA-ES-11 and Hytec #1.	Add quarterly monitoring for nitrate	$600
M-11	Add CECs (Section 4.3.5) to all monitoring wells; analysis completed every 2nd year (i.e. 6 wells, per year on a rotating schedule	Add bi-annual monitoring for CECs (EPA methods 1694 and 1698)	$2,000
		Total Cost	$8,000

Notes:
1. Represents annual laboratory costs based in AmTest Laboratories standard rates in 2015; cost does not reflect labor costs for the City or Thurston County.