Treatment Plant Flow and Wasteload Projections

2010–2060

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King County

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1. INTRODUCTION

This report documents the methodology and results of the 2014 flow and wasteload projections for King County's three regional treatment plants: West Point, South, and Brightwater plants. It then compares the projected flows and loads with design capacities at the plants to determine if additional capacity will be needed in the next 50 years. The following sections provide background on the history and nature of these projections and on the delineation of the County's wastewater service area to facilitate the projections.

Background

It is important to consider future capacity needs when designing wastewater facilities because the expected lifetime of the facilities can exceed 50 years. Accordingly, King County has projected flows 30 to 50 years into the future for its regional facilities since the first wastewater comprehensive plan was adopted in 1958.

King County's Wastewater Treatment Division (WTD) uses average wet weather flow (AWWF) as a summary parameter to evaluate available capacity at its wastewater treatment plants. Because some portions of treatment plants are amenable to phasing, the plants are usually built in increments to handle the hydraulic peak flow as the region grows. Solids handling capacity is also a critical factor in determining the timing for new treatment plant facilities.

In general, WTD updates its treatment plant flow and loading projections every 10 years using population and employment forecasts provided by the Puget Sound Regional Council (PSRC) that reflect the most recent U.S. Census data. WTD also evaluates and updates other key planning assumptions, such as water use, water conservation, and the service area growth rate. Previous projections are as follows:

- Using 1990 as the base year, the Wastewater 2020 Plus plan was developed to assess the County's long-term wastewater conveyance and treatment needs and to amend the existing 1959 Sewer Comprehensive Plan. The Wastewater 2020 Plus plan described capacity and limitations of existing facilities through 1996.
- The Regional Wastewater Services Plan (RWSP) used 1995 as the base year for its projections of wastewater system needs through 2030.
- The last major projections, using 2000 as the base year, occurred as part of the 2004 RWSP comprehensive review. These projections extended through 2050 and relied on PSRC's 2003 population and employment forecasts based on the 2000 U.S. Census.

The most recent projections, described in this report, were made in 2014 as part of the 2007–2013 RWSP comprehensive review. The projections extend through 2060, using 2010 as the base year and relying on 2013 PSRC forecasts based on the 2010 U.S. Census.

Projections of future peak flows for the treatment plants are being developed as part of the 2015 Conveyance System Improvement Program plan update. Capacity requirements will be reevaluated when these forecasts become available. Of the factors that affect treatment plant capacity, peak flows are expected to have the greatest sensitivity to future climate change. Current scientific knowledge and projections on how climate change is expected to affect peak flows will be incorporated into a sensitivity evaluation as part of the peak flow projections.

Service Area Delineation

The initial step in developing wastewater projections is to divide King County's wastewater service area into hydrologic (model) basins. Service areas for each treatment plant consist of all the hydrologic basins that send flow to that plant. These service areas are shown in Figure 1.

The general boundary of each model basin was determined through the placement of flow meters installed during the 2009–2011 Decennial Flow Monitoring project. A number of data sources, including local agency sewer comprehensive plans and available mapping of local sewers, were used to determine the area tributary to each modeling flow meter. Because the model basins will be used for future flow estimation, the boundaries of the basins were placed to encompass the future basin limit for eventual build-out conditions, not just the currently sewered area. The actual boundary for each model basin was defined geographically using the King County GIS parcel coverage as a basis.

Population, land use, and sewered acreage projections for each of these basins were then prepared. The primary purpose for classifying the service area is to distinguish between sewered and unsewered areas and to further distinguish unsewered areas as potentially sewerable or unsewerable. Sewerable areas are used in planning for future flows. Various sources of information, including sewer comprehensive plans, local sewer maps, aerial photography (2010), and parcel data were used to create a GIS layer with the proper boundaries and classifications.

The flow projections assumed that each treatment plant received all the flows from its service area as of 2010, even though the Brightwater Plant was not fully operational until 2012. This assumption made the process to project flows from this baseline year more consistent.

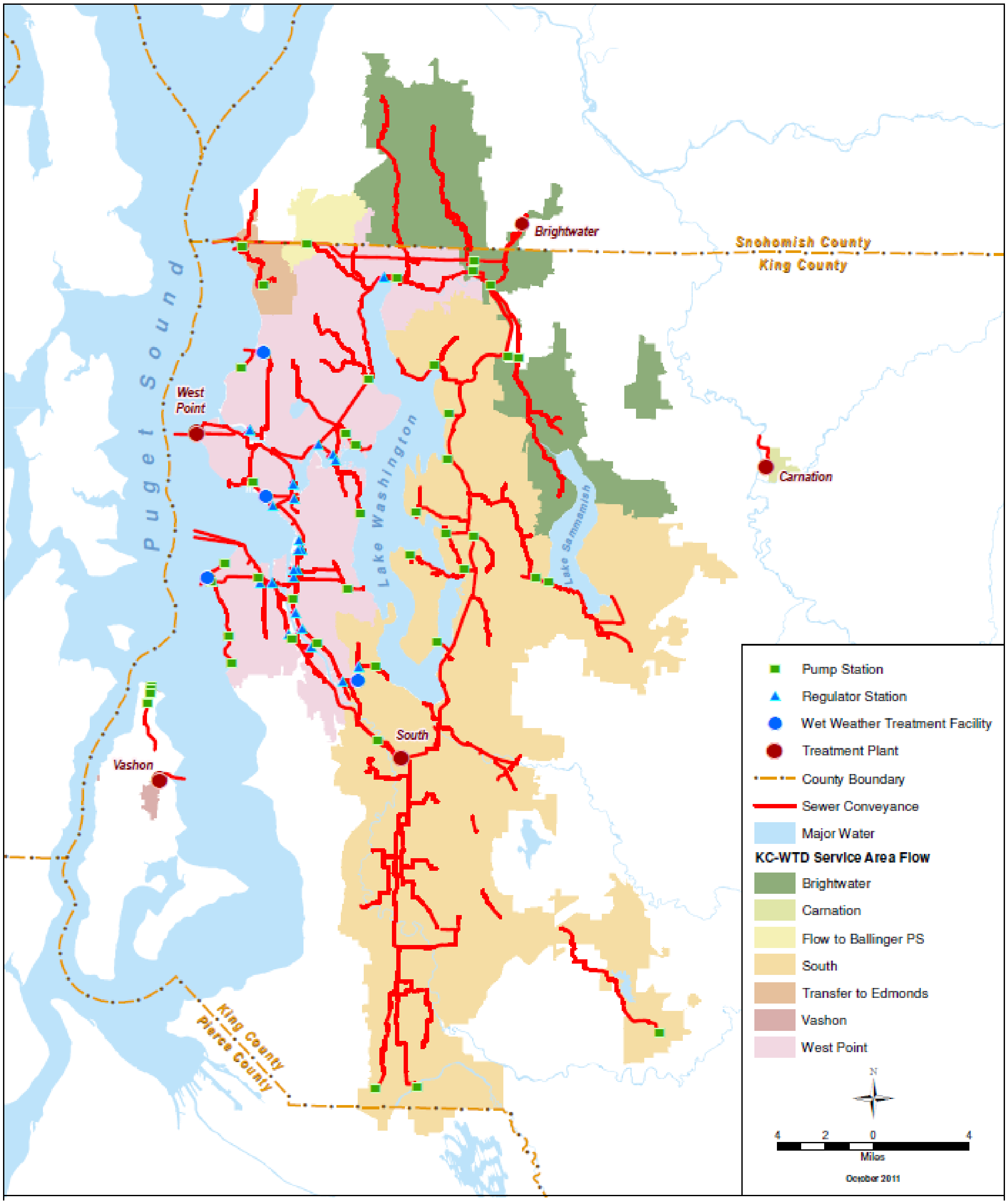

Figure 1. Service Areas for King County Wastewater Treatment Plants

2. WASTEWATER FLOW PROJECTIONS

This chapter describes the methodology and results of estimating current (2010) and projecting future flows at King County's three regional treatment plants.

General Approach

Wastewater treatment plant flow consists of two components: base wastewater flow (sewage) and infiltration and inflow (I/I). Base flow is primarily a function of how many households and businesses are connected to the sewer system. I/I is primarily a function of the extent of sewered area served by the wastewater collection system and on the response of the system to rainfall and groundwater conditions.[1]

King County's wastewater flow projection process is depicted in Figure 2. To forecast wastewater treatment plant flow, current (2010) base flow was estimated by multiplying population in each treatment plant area by flow factors representing average daily volumes of wastewater generated per person. Base flow projections were combined with I/I components to estimate dry weather and wet weather flows. I/I was assumed to be the difference between measured flow and base flow.

This report addresses average wet weather flow (AWWF) and average dry weather flow (ADWF) at the regional treatment plants. It does not address peak flows. Peak flows for the separated system are forecasted as part of the Conveyance System Improvement (CSI) Program, and peak flows for the combined system are addressed through the Combined Sewer Overflow (CSO) Control Program.[2]

The definitions of AWWF and ADWF differ depending on whether the collection system is combined or separated:

- The Brightwater and South plant service areas are separated systems. Their AWWF is defined as the average of all flows during the months of November through April. The ADWF is the average of all flows during the months of May through October.
- Because the West Point service area has combined sewers, the AWWF is defined as the average of all non-storm flows in the months of November through April. The ADWF for the combined system is the average of all non-storm flows during May through October. Non-storm flows are calculated using flow data on days in which no more than 0.02 inch of rain has fallen at any two gauging stations during that day or the preceding day.

The flow factors, derived from analysis of current conditions, were combined with a set of planning assumptions to estimate future flow rates. These future flow rates were used to estimate when upgrades to treatment facilities will be required.

[1] Base flow is wastewater (not including I/I) that originates from homes, businesses, and industries. Infiltration is groundwater that seeps into sewers through holes, breaks, joint failures, defective connections, and other openings; inflow is stormwater that rapidly flows into sewers via roof and foundation drains, catch basins, downspouts, manhole covers, and other sources.
[2] Information on the CSI Program is available at http://www.kingcounty.gov/environment/wastewater/CSI.aspx; information on the CSO Control Program is available at http://www.kingcounty.gov/environment/wastewater/CSO.aspx.

The flow projection equation is as follows:

$$Q = R * fR + C * fc + I * fi + As * fs$$

Where:

Q = total plant non-storm flow
R = residential sewered population
fR = per capita residential flow contribution
C = commercial employment sewered population
fc = per commercial employee contribution
I = industrial employment sewered population
fi = per industrial employee contribution
As = sewered acreage
fs = per acre infiltration/inflow contribution

Base Wastewater Flow

Puget Sound Regional Council (PSRC)

- Forecast population/employment by model basins
- Forecast population and employment through 2040

King County Wastewater Treatment Division (WTD)

1. **Define Who Is Sewered**
   - Overlay local agency sewer maps
   - Define sewered area
   - Identify current sewered population
2. **Project Population/Employment/ Sewered Areas**
   - Project extension of PSRC data
   - Assume potentially sewerable areas are 100% sewered by 2060
3. **Determine Future Commercial, Industrial, and Residential Per-Capita Flow Factors**
   - Review water consumption and industrial discharge data
   - Estimate effects of future water conservation
4. **Project Base Wastewater Flow**
   Apply flow factors to population and employment projections

Inflow and Infiltration (I/I) Flows

King County Wastewater Treatment Division (WTD)

1. **Collect Current I/I Data**
   - Measure flows by tributary basin
   - Calibrate hydrologic and hydraulic models to flow data
   - Use flows at treatment plants to estimate current average I/I
   - Use recent developments to estimate new sewered area I/I
2. **Project Future I/I**
   - Add new sewered area
   - Assume new area I/I is same as estimated from recent developments
   - Assume no change in average wet weather I/I for treatment plant service areas
   - Assume peak I/I increases 7% per decade for deterioration in conveyance system through 2060

Total Wastewater Flow (sum of base and infiltration/inflow flows)

Figure 2. Wastewater Flow Projection Process

Current (2010) Flows

Base Flow

To estimate current base wastewater flow, the 2010 residential and employment populations by model basin were combined with a spatial analysis of the parcels with sewer connections to estimate the population served by sewers. All commercial and industrial businesses were assumed to be served by sewers. Per-person flow factors were estimated from winter water usage rates reported by water purveyors. Daily consumption rates were estimated for residential, commercial, and industrial populations for both inside and outside Seattle because recent history shows that consumption in Seattle is different than in other sewered areas.

Actual residential gallons per capita per day (gpcd) of winter water usage for the years 2008 through 2012 were averaged for each purveyor and further apportioned to each treatment plant basin using PSRC population data for the period. Because water purveyors generally combine commercial and industrial gallons per employee per day usage (gped), WTD used King County Industrial Waste Program records to estimate per-employee industrial water use (process waste discharge plus the per-employee commercial daily usage). The data contained the regulated monthly discharge volume for each discharger. For some dischargers required to report volumes, the data included monthly volumes from 2008 through 2012. The Industrial Waste data also contained the number of employees for each discharger.

Industrial discharge rates were estimated as follows:

- All industrial dischargers were assumed to be listed in the data obtained from the Industrial Waste Program, per King County Code Chapter 28.84.
- Dischargers in the dataset who were not classified as industrial employers by PSRC were removed. These dischargers were primarily healthcare facilities and biotechnical companies.
- Flows from SeaTac airport's deicing facility, construction dewatering discharges, and utility discharges from facilities such as landfills, stormwater decant stations, and transfer stations were removed because the flows are not related to industrial activity. These non-population based flows were accounted for separately.[3]
- Industries that did not monitor their discharge volumes were assigned a discharge rate consisting of their permitted discharge rate multiplied by the ratio of monitored-to-permitted discharge rates.
- Flow rates were summarized by treatment plant service area and normalized by the number of employees to calculate the 2010 industrial process flow factor.

The resulting residential, commercial, and industrial flow factors, shown in Table 1, were multiplied by average population and employment numbers for the period to estimate base 2010 wastewater flow for each plant. The non-population based industrial flows were added to the base flows shown in Table 1.

[3] A decant station is a stormwater disposal facility that treats liquids and solids collected from the cleaning of drainage systems designed to collect stormwater.

Additional detail on the development of current base flow estimates can be found in the Updated Planning Assumptions for Wastewater Flow Forecasting (King County Department of Natural Resources and Parks, 2014).

Table 1. 2010 Flow Factors, Population/Employment, and Estimated Base Wastewater Flow

	West Point		South Plant		Brightwater
	Inside Seattle	Outside Seattle	Inside Seattle	Outside Seattle	Outside Seattle
Flow Factor					
Residential (gpcd)	46	54	46	54	54
Commercial (gped)	30	18	30	18	18
Industrial (gped)	61	49	68	56	45
Population/Employment					
Residential	557,784	84,941	42,098	635,259	206,784
Commercial	469,348	24,154	6,510	400,087	97,382
Industrial	33,081	537	486	55,242	15,620
Base Flow					
Population-based flow (mgd)	46.80		46.76		13.62
Dry weather non-population based flow[a] (mgd)	0.47		0.45		0.17
Wet weather non-population based flow[a,b] (mgd)	0.44		1.01		0.19
Total dry weather base flow (mgd)	47.27		47.22		13.79
Total wet weather base flow (mgd)	47.24		47.77		13.81

gpcd = gallons per capita per day; gped = gallons per employee per day; mgd = million gallons per day.
[a] Flows from some dischargers that were not linked to employment, primarily from landfill leachate and stormwater decant stations. Construction dewatering discharges to West Point are allowed only during the dry weather months. Some discharges, such as those from stormwater decant stations, occur mostly during the wet weather months.
[b] Excluding flows from SeaTac airport deicing operations, which contribute an average of 0.7 mgd to wet weather flows.

Measured Flows at Treatment Plants

The average ADWF and AWWF measured at the treatment plants from May 2007 through May 2013 was used to characterize the 2010 base year. The actual values were adjusted to account for flow transfers between service areas because the Brightwater plant was under construction. To exclude year-to-year variability, the analysis assumed that each treatment plant received all flows from its service area. Flow meters in the conveyance system were used to estimate Brightwater flows prior to its startup. Flows above the calculated base flow were scaled by the ratio of observed rainfall to the long-term average rainfall.

South Plant

The measured and adjusted ADWF and AWWF for May 2007 through May 2013 for the South Treatment Plant and their averages for this period are presented in Table 2. Flows at the York Pump Station were used to calculate and subtract the amount of flow transferred to South Plant from the Brightwater service area. Flows from SeaTac deicing operations were also subtracted.

Table 2. May 2007–May 2013 Flows to South Treatment Plant, Adjusted for Flow Transfers and Relative Rainfall

Average Dry Weather Flow			Average Wet Weather Flow		
Period	**Flow (mgd)**	**Flow (mgd)[a]**	**Period**	**Flow (mgd)**	**Flow (mgd)[a]**
5/1/2007 – 11/1/2007	67.43	59.33	11/1/2007 – 5/1/2008	83.56	75.18
5/1/2008 – 11/1/2008	56.11	54.09	11/1/2008 – 5/1/2009	83.39	73.30
5/1/2009 – 11/1/2009	69.30	55.93	11/1/2009 – 5/1/2010	85.10	71.47
5/1/2010 – 11/1/2010	67.29	55.68	11/1/2010 – 5/1/2011	96.58	75.61
5/1/2011 – 11/1/2011	62.76	58.32	11/1/2011 – 5/1/2012	88.62	73.09
5/1/2012 – 11/1/2012	71.58	57.63	11/1/2012 – 5/1/2013	83.97	77.04
Average		56.83			74.28

[a] Adjusted for flow transfers and rainfall.

West Point Plant

The measured and adjusted ADWF and AWWF for May 2007 through May 2013 for the West Point Treatment Plant and their averages for this period are presented in in Table 3. Flows at the Kenmore Pump Station plus flow meters in the conveyance lines were used to calculate and subtract he flows transferred to West Point from the Brightwater service area. Flows were also adjusted for additional flow sent to Edmonds from the Lake Ballinger Pump Station that was treated by the County after 2012.

Table 3. May 2007–May 2013 Flows to West Point Treatment Plant, Adjusted for Flow Transfers and Relative Rainfall

Average Dry Weather Flow (non-storm days)			Average Wet Weather Flow (non-storm days)		
Period	**Flow (mgd)**	**Flow (mgd)[a]**	**Period**	**Flow (mgd)**	**Flow (mgd)[a]**
5/1/2007 – 11/1/2007	79.60	75.76	11/1/2007 – 5/1/2008	83.21	77.35
5/1/2008 – 11/1/2008	77.53	69.10	11/1/2008 – 5/1/2009	75.81	70.42
5/1/2009 – 11/1/2009	67.80	59.55	11/1/2009 – 5/1/2010	84.99	72.37
5/1/2010 – 11/1/2010	70.71	56.70	11/1/2010 – 5/1/2011	89.26	73.43
5/1/2011 – 11/1/2011	76.10	68.38	11/1/2011 – 5/1/2012	75.35	69.26
5/1/2012 – 11/1/2012	66.95	59.38	11/1/2012 – 5/1/2013	82.90	75.10
Average		64.81	Average		74.50

[a] Adjusted for flow transfers and rainfall.

Brightwater Plant

The measured and adjusted ADWF and AWWF for May 2007 through May 2013 for the Brightwater Treatment Plant and their averages for this period are presented in presented in Table 4. The Brightwater plant started treating flow on September 8, 2011. Effluent from the treatment plant was conveyed to South Plant until November 2, 2012, when Brightwater began discharging directly to Puget Sound. Measured flows at Brightwater were obtained for September 2011–May 2013. Flows from previous years were calculated from the flow transfers to West Point and South plants using flow data from the Kenmore Pump Station, Kenmore Interceptor, Swamp Creek Trunk, and York Pump Station.

Table 4. May 2007–May 2013 Historical Flows to Brightwater Treatment Plant, Adjusted for Flow Transfers and Relative Rainfall

ADWF			AWWF		
Period	Flow (mgd)	Flow (mgd)[a]	Period	Flow (mgd)	Flow (mgd)[a]
5/1/2007 – 11/1/2007		16.11	11/1/2007 – 5/1/2008		16.41
5/1/2008 – 11/1/2008		11.81	11/1/2008 – 5/1/2009		17.52
5/1/2009 – 11/1/2009		14.95	11/1/2009 – 5/1/2010		17.93
5/1/2010 – 11/1/2010		16.00	11/1/2010 – 5/1/2011		19.26
5/1/2011 – 11/1/2011	4.91	12.37	11/1/2011 – 5/1/2012	10.27	17.64
5/1/2012 – 11/1/2012	10.12	14.71	11/1/2012 – 5/1/2013	15.87	17.79
Average		14.33			17.76

[a] Adjusted for flow transfers and rainfall.

Infiltration and Inflow

I/I was estimated based on the 2010 sewered area. Average wet weather I/I (AWW I/I) was calculated by subtracting the total base flow from the AWWF (Table 5). Average dry weather I/I (ADW I/I) was generated by subtracting the total base flow from the 2010 ADWF (Table 6). I/I is expressed as gallons per acre per day (gpad).

Table 5. Calculated 2010 Average Wet Weather Infiltration/Inflow for Treatment Plants

Treatment Plant	Average Wet Weather Flow (mgd)	Base Wastewater Flow (mgd)	Sewered Area (acres)	Average Wet Weather Infiltration/Inflow (gpad)
West Point	74.50	47.24	62,153.76	440
South Plant	74.28	47.77	78,742.63	340
Brightwater	17.76	13.81	22,221.44	180

Table 6. Calculated 2010 Average Dry Weather I/I for Treatment Plants

Treatment Plant	Average Dry Weather Flow (mgd)	Base Wastewater Flow (mgd)	Sewered Area (acres)	Average Dry Weather Infiltration/Inflow (gpad)
West Point	64.81	47.27	62,153.76	280
South Plant	56.83	47.22	78,742.63	120
Brightwater	14.33	13.79	22,221.44	20

Future Flows (2010–2060)

Future flows were estimated as the sum of the future base wastewater flow and future I/I:

- The future base flow was calculated from the flow factors multiplied by the projected population and employment.
- Planning assumptions, such as unsewered potentially sewerable areas and effects of water conservation, affected the projections.
- The non-population based industrial flows were added to the base flow for each treatment plant. Future non-population based industrial flows were taken as a constant value of the 2010 average less the flows that originated from Brightwater-related construction projections.
- Flows from the SeaTac airport deicing facility were included with the future non-population based industrial flows.
- Future I/I was estimated as the product of the average wet or dry weather I/I and the future sewered service area.
- No additional flow was added to the projections as a result of the CSO Control Program. It was assumed that CSO storage basins will be drained within 24 hours. Because AWWF for the West Point service area excludes days with rain on the preceding day, flows from CSO storage would not be included in the calculated AWWF.

Planning Assumptions

Table 7 shows the planning assumptions used in the 2004 RWSP review flow projections and the updated assumptions used for the 2014 projections. Some of the assumptions remain the same, and some pertain to the conveyance system only. Explanations of updated assumptions related to treatment plant flow projections are as follows:

- **Population.** For its latest flow projections, WTD used the 2013 PSRC population forecasts aggregated to WTD model basins. These forecasts extend to 2040. WTD linearly extrapolated the 2040 estimates to the year 2060.[4]

[4] More detail on the population forecast can be found in the Updated Planning Assumptions for Wastewater Flow Forecasting (King County Department of Natural Resources and Parks, 2014).

- **Water conservation.** A water conservation planning assumption was developed based on winter-time water use conservation projections obtained from several water purveyors. The assumption is that water conservation will reduce the 2010 flow factors (per-capita and per-employee water use) by 5 percent in each of the next two decades, for a total of a 10 percent reduction by 2030. No additional reduction is assumed after 2030.
- **Sewered Area.** It is now forecast that 100 percent of the unsewered potentially sewerable area will be sewered by 2060, rather than the earlier assumption of 2050.
- **I/I degradation.** To assess how to project the AWW I/I, available service area and flow data from South Treatment Plant between 1985 and 2012 was reviewed. The yearly AWW I/I was then normalized by the ratio of wet season rainfall to average rainfall (Figure 3). Normalization by rainfall reduced the year-to-year variation, yet no discernable trend was apparent. Based on this analysis, the 2010 ADW I/I and AWW I/I (gpad) were used for all future years.

Table 7. Previous and Updated Planning Assumptions

Category	Previous Assumption	Updated Assumption
Planning horizon	2050	50-year planning horizon (2060)
Extent of eventual service area	Potentially sewerable areas in Urban Growth Areas of King County's wastewater service area	Same
Future population	2003 Puget Sound Regional Council (PSRC) forecast	2013 PSRC forecast
Water use	Base Year 2000 Seattle residential: 56 gpcd Other residential: 66 gpcd Commercial: 33 gped Industrial: 55 gped	Base Year 2010 Inside Seattle[a] Residential: 46 gpcd Commercial: 30 gped Industrial: 61–68 gped Outside Seattle Residential: 54 gpcd Commercial: 18 gped Industrial: 45–56 gped
Water conservation	A 10% reduction in per-capita and per-employee water consumption between 2000 and 2010 and no additional reduction after 2010	A 10% reduction in per-capita and per-employee water consumption between 2010 and 2030 and no additional reduction after 2030
Sewered area growth rate	90% of unsewered sewerable area in 2000 is sewered by 2030, 100% by 2050	100% of unsewered sewerable area in 2010 is sewered by 2060, at a rate of 20% per decade starting in 2010
Average wet weather I/I degradation (treatment plants)	Increase of 7% per decade up to a maximum of 28%	No degradation
Design flow (separated conveyance system)	20-year peak flow	Same

Category	Previous Assumption	Updated Assumption
Degradation of peak I/I (separated conveyance system)	Model basin peak I/I in 2000 with assumed increase of 7% per decade up to a maximum of 28% (over 4 decades)	Model basin peak I/I in 2010 with assumed increase of 7% per decade through the planning horizon
New construction I/I (separated conveyance system)	1,500 gpad with 7% degradation per decade increase to approximately 2,000 gpad over 4 decades	2,000 gpad plus assumed I/I degradation (7% per decade) through the planning horizon

gpcd = gallons per capita per day; gped = gallons per employee per day; gpad = gallons per acre per day; I/I = infiltration/inflow.
[a] Because of the large difference between industrial and commercial water usage inside and outside Seattle, the analysis used separate employment usage factors for Seattle.
[b] The data did could not determine any apparent trend for AWWF I/I degradation rate.

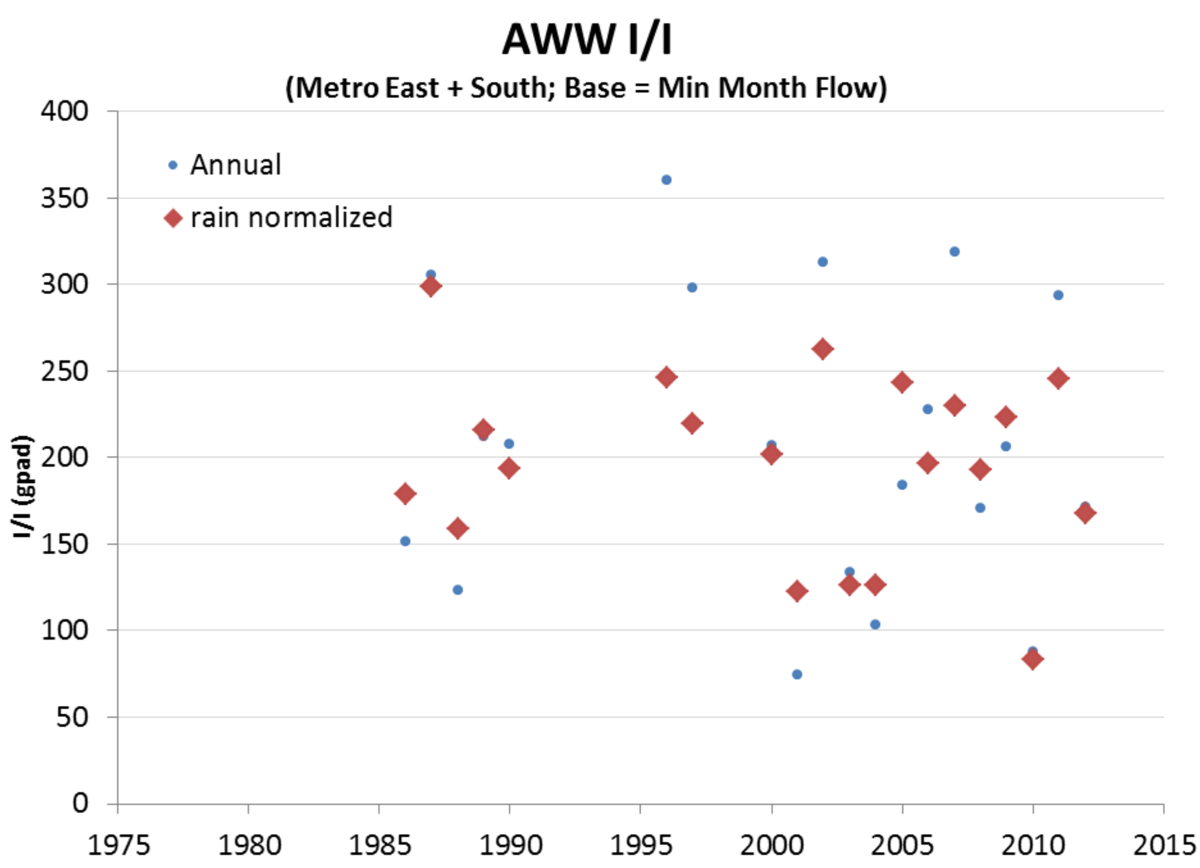

Figure 3. Average Wet Weather Infiltration/Inflow from South Plant Flow Data and Sewered Area with Base Flow Estimated as the Minimum Month Flow

Projected Average Wet Weather Flows Through 2060

The results of the wet weather flow forecasts are presented in Table 8 and shown in Figure 4. The table summarizes the projected AWWF forecasts for each treatment plant service area. It includes the AWWF for the baseline years used for the Wastewater 2020 (1990) and 2004 RWSP review (2000) projections. Startup of the York Pump Station in 1992 contributed to the 1990−2000 AWWF increase at South Plant and decrease at West Point as flows were transferred to South Plant. The decline in flow from 2000−2010 is consistent with the reduction in water usage during the same period (King County Department of Natural Resources and Parks, 2014).

AWWF at West Point and South plants declined about 15 percent between 2000 and 2010−2011, despite increased population. (Figure 4 shows that some flows from West Point were temporarily diverted to South Plant through the North Creek Pump Station until Brightwater came online.) This decline was due in part to water conservation and in part to Brightwater beginning operations. The AWWF is expected to slowly increase, even with increased water conservation, because of population growth. South Plant AWWF is forecast to increase at a faster rate, which reflects the higher population growth rate forecast for its service area.

Table 8. Historical and Projected Average Wet Weather Flows for the Treatment Plants, 1990–2060

	Average Wet Weather Flow (mgd)							
	1990[a]	2000[b]	2010[c]	2020	2030	2040	2050	2060
West Point	106.90	99.30	74.59	79.08	80.13	84.93	90.45	96.18
South Plant	70.80	97.30	75.25	82.97	88.53	98.06	106.89	115.96
Brightwater	0.00	0.00	17.64	19.73	21.10	24.28	26.65	29.09
Total	177.70	196.60	167.48	181.78	189.76	207.28	223.99	241.23

[a] From Table 8-9 of *Wastewater 2020 Plus: Existing Conditions;* used as the baseline for Wastewater 2020 projections.
[b] From Table A-1 of Appendix A: Population and Flow Analysis by Wastewater Basin; of the *Regional Wastewater Services Plan 2004 Update;* used as the baseline for 2004 projections.
[c] Average of May 2007– May 2013, adjusted for flow transfers from Brightwater service area.

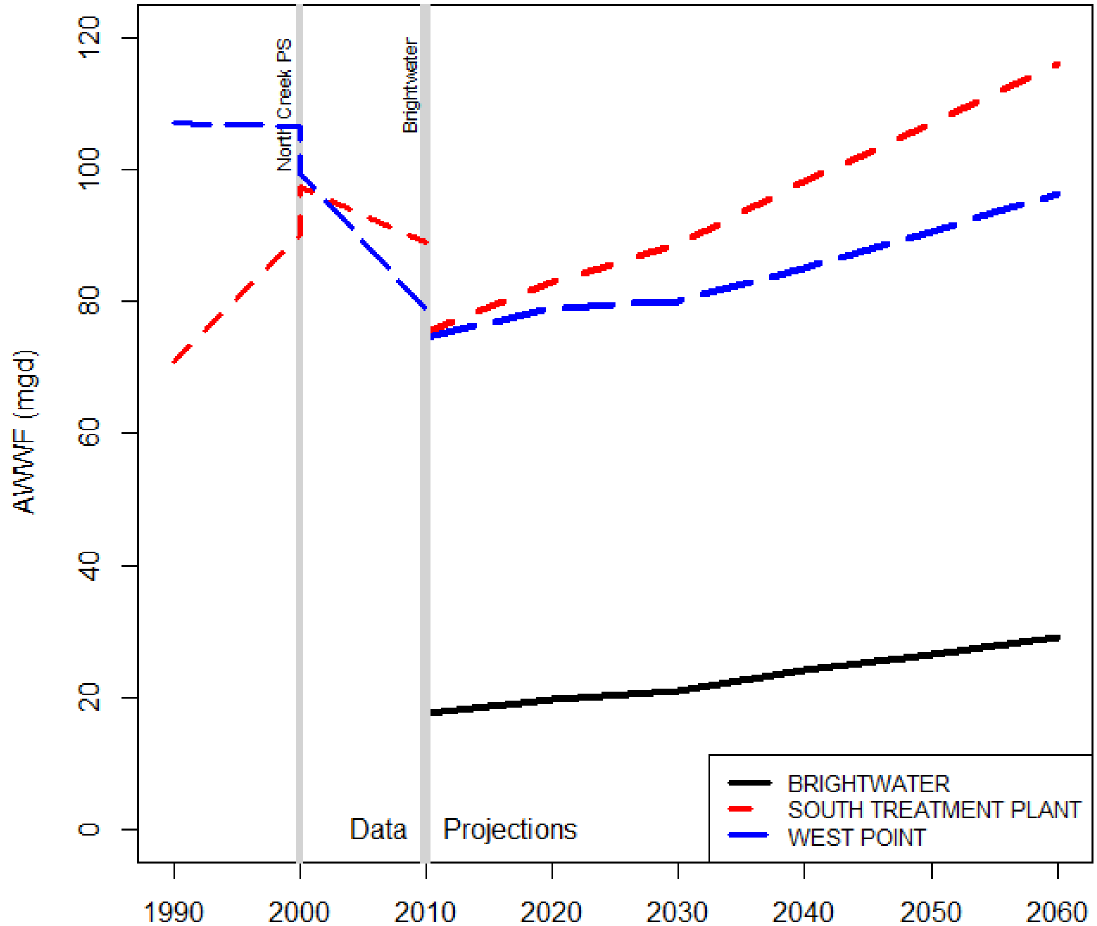

Figure 4. Historical and Projected Average Wet Weather Flows by Treatment Plant (shown as if Brightwater came online in 2010), 1990–2060

3. WASTELOAD FORECASTS

Solids loadings (wasteloads) at the treatment plants were estimated for 2010 and for 2010−2060 by applying loading factors to population and employment projections. Daily total suspended solids (TSS) and biochemical oxygen demand (BOD) measured at the plants were used as a basis for estimating current and future solids loadings.[5]

Current (2010) Loadings

To estimate existing (2010) wasteloads, the influent BOD and TSS measurements from 2007 through 2012 for each plant were averaged and adjusted for flow transfers to or from Brightwater. Residential, commercial, and industrial per-person daily loading factors were developed based on these average wasteloads and on population and employment during this period.

In addition, South Plant loads included septage from septage haulers, solids from the Vashon and Carnation treatment plants, and loadings from the SeaTac Airport deicing facility. West Point loads included street washoff that enters through the combined system.

Loading Factors

Table 9 shows the residential, commercial, and industrial loading factors used to estimate 2010 solids loadings to the treatment plants. The sections that follow describe how these loading factors were derived.

Table 9. Residential, Commercial, and Industrial Loading Factors for Treatment Plant Service Areas (2010)

	Biochemical Oxygen Demand	Total Suspended Solids
West Point		
Residential (lbs/capita/day)	0.15	0.16
Commercial (lbs/employee/day)	0.0375	0.04
Industrial (lbs/employee/day)	0.4775	0.17
Street washoff (lbs/day)	0	24,700
South Plant		
Residential (lbs/capita/day)	0.15	0.16
Commercial (lbs/employee/day)	0.0375	0.04

[5] WTD measures BOD_5, which is the amount of dissolved oxygen consumed in five days by biological processes breaking down organic matter.

Industrial (lbs/employee/day)	0.4775	0.17
Septage Loading (lbs/day)	4,500	14,000
SeaTac Deicing (lbs/day)	2,740	0
Brightwater		
Residential (lbs/capita/day)	0.15	0.16
Commercial (lbs/employee/day)	0.0375	0.04
Industrial (lbs/employee/day)	0.4775	0.17

Industrial Loading Factors

Industrial discharge and monitoring data obtained from King County's Industrial Waste Program were used to estimate the contribution of industrial loadings to each treatment plant. The available data from 2008 through 2012 was used. Loading was calculated as the discharge rate multiplied by the TSS or BOD concentration.

Monitored discharge rates were substantially lower than the permitted level. Industrial discharge rates were estimated as follows:

- All industrial dischargers were assumed to be listed in the data obtained from the Industrial Waste Program, per King County Code Chapter 28.84.
- Dischargers who were not classified as industrial employers by PSRC were removed. These were primarily healthcare facilities, construction dewatering discharges, and utility discharges from facilities such as landfills and transfer stations.
- Flows from SeaTac airport's deicing facility were removed because the flows are not related to industrial activity. These flows were accounted for separately.
- Industries that did not monitor their discharge volumes were assigned a discharge rate consisting of their permitted discharge rate multiplied by the ratio of monitored-to-permitted discharge rates.

King County's Industrial Waste Program charges facilities an additional fee to cover the costs of treating high-strength wastewater with TSS in excess of 400 milligrams per liter (mg/L) (equivalent to parts per million) or BOD greater than 300 mg/L. The waste strength from these high-strength dischargers is monitored regularly; the average waste strength from each discharger was used to calculate the annual wasteload. BOD and TSS discharge concentrations from other permitted dischargers are not measured. For these dischargers, a TSS concentration of 200 mg/L and a BOD concentration of 150 mg/L were applied to the monitored discharge flow rates.

Using these average discharge concentrations and rates, the 2010 wasteloads from industrial processes were calculated (Table 10). The industrial wasteloads shown in Table 10 were divided by the 2010 industrial employment estimates to obtain the per-employee industrial process loading factor for each treatment plant service area (Table 11). To account for loads generated by industrial employees, the commercial per-employee loading factor was added to the per-employee industrial process loading factor to obtain the total loading from each industrial employee (as shown in Table 9). Although some commercial enterprises, such as restaurants and hotels, could contribute higher loadings than just from the employees themselves, it was assumed for simplicity that the only commercial loading is from the employees only.

The calculated industrial per-employee loading factor for the South Plant service area is approximately 50 percent higher than for the West Point or Brightwater service area, reflecting the mix of industries in the South Plant service area. To expedite the forecasting process, one per-employee 2010 industrial loading factor for BOD and one for TSS were used to represent all three treatment plants. The South Plant per-employee industrial loading factors were selected for use because they are the highest and it is important to forecast its loads as accurately as possible.

Table 10. Calculated 2010 Industrial Wasteloads for Treatment Plants

	Biochemical Oxygen Demand (lbs/day)	Total Suspended Solids (lbs/day)
West Point service area	9,894	2,686
South Plant service area	24,710	7,109
Brightwater service area	4,821	1,586

Table 11. 2010 Industrial Per-Employee Loading Factors for Treatment Plants

	Biochemical Oxygen Demand (lbs/employee/day)	Total Suspended Solids (lbs/employee/day)
West Point service area	0.29	0.08
South Plant service area	0.44	0.13
Brightwater service area	0.31	0.10
Selected loading factor	**0.44**	**0.13**

Residential and Commercial Loading Factors

To estimate 2010 residential and commercial loading factors, the calculated 2010 industrial wasteload was subtracted from the total measured wasteload for each treatment plant. Also subtracted from the total for South Treatment Plant were loadings attributed to the septage, Carnation and Vashon treatment plant solids, and SeaTac deicing loadings:

- Septage loading estimates for 2010 were obtained from the South Plant Process Control Section. An estimate of 4,010 pounds/day BOD and 12,400 pounds/day TSS were contributed from septage at the South Treatment Plant. These values include solids transferred to South Plant from the Carnation and Vashon treatment plants.

- Solids loadings from the SeaTac airport deicing facility were assumed to be a constant load to South Plant, estimated at 2,810 pounds/day BOD and 80 pounds/day TSS.

The remaining loadings were assumed to be composed of a combination of residential and commercial loadings. It was also assumed that the commercial daily per-employee loading factor is one-fourth of the residential daily per-capita loading factor, the same proportion used in previous projections and originally determined in deriving loading factors for the Wastewater 2020 Plus analysis. The following equations represent the process for determining the residential and commercial loading factors.

Remaining wasteloads = residential loading factor ×population + commercial loading factor × employment

Remaining wasteloads = residential loading factor × population + residential loading factor/4 × employment

Remaining wasteloads = residential loading factor × (population + employment/4) (solving for residential loading factor)

The residential and commercial loading factors are shown in Table 12. One residential and one commercial loading factor were selected to be used for all treatment plant service areas. Even though the calculations showed some differences, the differences were likely caused by slight anomalies in the data because it was assumed that individuals would contribute the same loadings regardless of treatment plant service area.

As noted in the Wastewater 2020 Plus analysis, it appears that a significant amount of suspended solids enters the West Point collection system from street washoff. This washoff is included in the 2010 loading rates for the West Point Plant.

Table 12. 2010 Residential and Commercial Per Capita Loading Factors for Treatment Plants

	Biochemical Oxygen Demand (lbs/capita/day)		Total Suspended Solids (lbs/capita/day)	
	Residential	Commercial	Residential	Commercial
West Point service area	0.15	0.0375	0.19	0.0475
South Plant service area	0.15	0.0375	0.16	0.04
Brightwater service area	0.17	0.0425	0.16	0.04
Selected loading factor	**0.15**	**0.0375**	**0.16**	**0.04**

Comparison of Estimated and Measured 2010 Loading Rates

The loading rates calculated using the 2010 residential, commercial, and industrial loading factors were compared to the average of actual loading rates measured at the treatment plants in 2007−2013 in order to assess the accuracy and appropriateness of the calculation methodology. As shown in Table 13, the differences were minor. The difference in TSS was only +/–1 percent for each plant. The differences in BOD ranged from –5 percent at Brightwater to +5 percent at West Point.

Table 13. Calculated and Actual 2010 Loading Rates to Treatment Plants

	Biochemical Oxygen Demand (lbs/day)			Total Suspended Solids (lbs/day)		
	Calculated[a]	Actual[b]	Difference	Calculated[a]	Actual[b]	Difference
West Point	130,968	125,290	5%	152,992	151,308	1%
South Plant	150,703	146,478	3%	148,115	149,740	-1%
Brightwater	42,128	44,490	-5%	39,636	39,864	-1%

[a] Calculated using 2010 loading factors.
[b] Average of May 2007–May 2013, adjusted for flow transfers.

Future Wasteloads (2010–2060)

The 2010 loading factors were multiplied by population and employment forecasts by decade through 2060. Projected solids loadings from completed CSO storage and treatment facilities were added to the West Point Treatment Plant projections.

The 2010 daily loading rates (pounds per day) for the non-population based loads (such as deicing facility discharge and street washoff) were used for all decades. The future loading rate for septage was increased from the 2007–2013 average loading rate and was based on 2011 and 2012 daily loads (more than the 2010 load because one septage receiver left the market in 2009).

CSO Control Solids Loading Rates

Flow returned to West Point from CSO storage projects or solids returned from CSO treatment facilities will increase annual waste loads at West Point. CSO storage flows were estimated at 125 mg/L TSS and 125 mg/L BOD. CSO treatment facilities were assumed to remove 85 percent of the solids on an annual basis. All CSO control projects were assumed to be completed between 2020 and 2030. These additional loads were added to projections for 2030 and later.

The estimated discharge volumes and wasteloads for CSO sites are shown in Table 14.

Table 14. Estimated Wasteloads Resulting from CSO Control Projects

	Annual Discharge Volume (MG)		
CSO Site	Before Control	After Control	Controlled Volume (MG)
Storage			
Hanford #1	0.1	0.0	0.1
Chelan	17.2	4.1	13.1
3rd Ave W	17.1	4.0	13.1
W. Michigan	1.0	0.6	0.4

Terminal 115	2.4	2.4	0.1
University	19.4	15.7	3.7
Montlake	28.8	10.8	17.9
11th Ave N	1.2	1.2	0.0
Storage Total			48.5
Treatment			
Michigan	91.2	13.0	78.2
Brandon	29.9	6.0	23.9
Hanford #2	202.7	23.4	179.3
Lander	92.5	8.9	83.6
King	9.1	2.9	6.2
Kingdome	195.1	14.6	180.5
Treatment Total			551.8

Assumptions:
- Average total suspended solids (TSS) in CSOs = 125 mg/L
- Average biochemical oxygen demand (BOD) in CSOs = 125 mg/L
- 85% removal at CSO treatment facilities

Estimated loads after all CSO projects are completed:

TSS load =1,500 lbs/day
BOD load = 1,500 lbs/day

Projected Wasteloads

Annual average BOD loading projections for each treatment plant service area in 10-year increments from 2010 to 2060 are presented in Table 15. Similarly, average annual TSS estimates are presented in Table 16.

Table 15. Projected Average Annual Biochemical Oxygen Deman Loading Rates

	Biochemical Oxygen Demand (lbs/day)							
	1990[a]	**2000**	**2010[d]**	**2020**	**2030**	**2040**	**2050**	**2060**
West Point	136,407	146,099[b]	130,968	147,509	156,822	169,140	183,014	197,213
South Plant	103,475	147,235[c]	150,703	171,516	186,844	208,127	226,470	245,473
Brightwater	0	0	42,128	48,583	53,340	62,486	68,220	74,156
Total	239,882	293,333	323,799	367,608	397,006	439,753	477,704	516,842

[a] Table 8-13 of *Wastewater 2020 Plus: Existing Conditions.*
[b] Average of 1999–2001 from Table 2-5, Brightwater facilities plan, May 2005.
[c] Table 3-5, South Treatment Plant raw wastewater loadings and peaking factors, 1997–2002, South Plant rerating study.
[d] Average of May 2007–May 2013, adjusted for flow transfers from Brightwater service area.

Table 16. Projected Average Annual Total Suspended Solids Loading Rates

	Total Suspended Solids (lbs/day)							
	1990[a]	**2000**	**2010**[d]	**2020**	**2030**	**2040**	**2050**	**2060**
West Point	187,729	187,991[b]	152,992	169,198	179,581	191,605	206,001	220,744
South Plant	112,037	147,077[c]	148,115	169,527	186,702	207,534	226,478	246,126
Brightwater	0	0	39,636	46,389	51,628	60,312	66,238	72,378
Total	299,766	335,068	340,743	385,114	417,911	459,450	498,717	539,249

[a] Table 8-13 of *Wastewater 2020 Plus: Existing Conditions*.
[b] Average of 1999–2001 from Table 2-5, Brightwater facilities plan, May 2005.
[c] Table 3-5, South Treatment Plant raw wastewater loadings and peaking factors, 1997–2002, South Plant rerating study.
[d] Average of May 2007–May 2013, adjusted for flow transfers from Brightwater service area.

4. IMPLICATIONS OF FLOW AND WASTELOAD PROJECTIONS

Findings show that AWWF has decreased approximately 15 percent over the last decade, which is in line with the substantial reduction in water use that has occurred. Projections show that AWWF will start to slowly increase as additional water conservation opportunities taper off and population continues to grow.

The estimated per-person contribution to wasteloads has remained relatively consistent since 1990. Population growth and flow transfers have resulted in increased loadings to South Treatment Plant. Flow transfers away from the West Point Treatment Plant and projects aimed at reducing stormwater appear to have kept BOD loading relatively constant and reduced TSS loads at West Point. Wasteloads are projected to continue to increase proportionally to population growth.

The following sections give the design flow and loading capacities of each treatment plant and then discuss the findings in relation to the capacities of each plant.

Treatment Plant Design Capacities

The AWWF and average loading design capacities of the three regional treatment plants are presented in Table 17.

Table 17. Current Treatment Plant Design Capacities for Flows and Loadings

Treatment Plant	Average Wet Weather Flow (mgd)	Average Annual Biochemical Oxygen Demand (lbs/day)	Average Annual Total Suspended Solids (lbs/day)
West Point	133	168,000	181,000
South Plant	115	220,000	201,000
Brightwater[a]	29 (36)	50,442 (62,660)	50,093 (62,227)

[a] Values in parenthesis represent capacities after the planned addition by 2020 of additional membrane cassettes and associated equipment.

Comparison of Projections to Design Capacities

West Point Treatment Plant

Figure 5 presents the actual and projected (1990−2060) AWWF and average annual BOD and TSS loadings compared to design capacities of the West Point Treatment Plant. Conclusions from the projections are as follows:

- AWWF design capacity of 133 mgd is not expected to be exceeded before 2060.

- The TSS capacity of 181,000 pounds per day will be exceeded by around 2030.
- BOD loading will exceed the plant capacity of 168,000 pounds per day about 10 years after TSS capacity is exceeded.

The Wastewater 2020 Plus analysis concluded that the design wasteloads would be the capacity constraint at West Point. The report included the following discussion of the possibility that West Point's solids loading capacity may be greater than the current design values:

> Establishment of the West Point plant design wasteloads for BOD and TSS was complicated during the 1985 design by solids from Metro's [King County's] Renton Treatment Plant [South Treatment Plant], which were being transported in the influent of the West Point plant via pipeline. The impact of these solids was unknown. The activated sludge treatment process was sized using primary effluent BOD and TSS and not influent BOD and TSS because the analysis indicated that South Plant sludge did not appear to impact the primary effluent. Using this process, the average annual TSS loading was estimated to be between 135,000 and 190,000 pounds per day. In 1988, digesters were on-line at King County's South Treatment plant, and solids were no longer transported to West Point. Actual solids measured at West Point, following the cessation of the transport of Renton plant [South Plant] solids to the plant, indicated the wasteloading at West Point to be approaching the design loading.
>
> The capacity of the West Point plant can be limited by either the activated sludge treatment process (aeration tanks, oxygen generation system, secondary sedimentation tanks) or the solids handling process (gravity belt thickeners, anaerobic digesters, centrifuges).
>
> During design, sensitivity analyses were conducted to determine the impacts of higher and lower wasteloads. The potential impacts of higher influent wasteloads are summarized below:
>
> - Early construction of additional aeration tanks
> - Early construction of additional secondary sedimentation tanks
> - Additional high purity oxygen generation capacity or additional trucking of liquid oxygen to West Point from commercial oxygen generation facilities
> - Addition of one gravity belt thickener
> - Potential requirement of additional anaerobic digesters to handle saturation wasteloads

Since the Wastewater 2020 analysis, measures have been taken to reduce flow and loading rates at West Point, including several projects to remove stormwater from the collection system and the transfer of some flow to South Plant after startup of the York and North Creek Pump Stations and subsequent transfer of these flows to Brightwater. However, the Wastewater 2020 discussion remains relevant. West Point is predicted to reach its design TSS capacity around 2030.

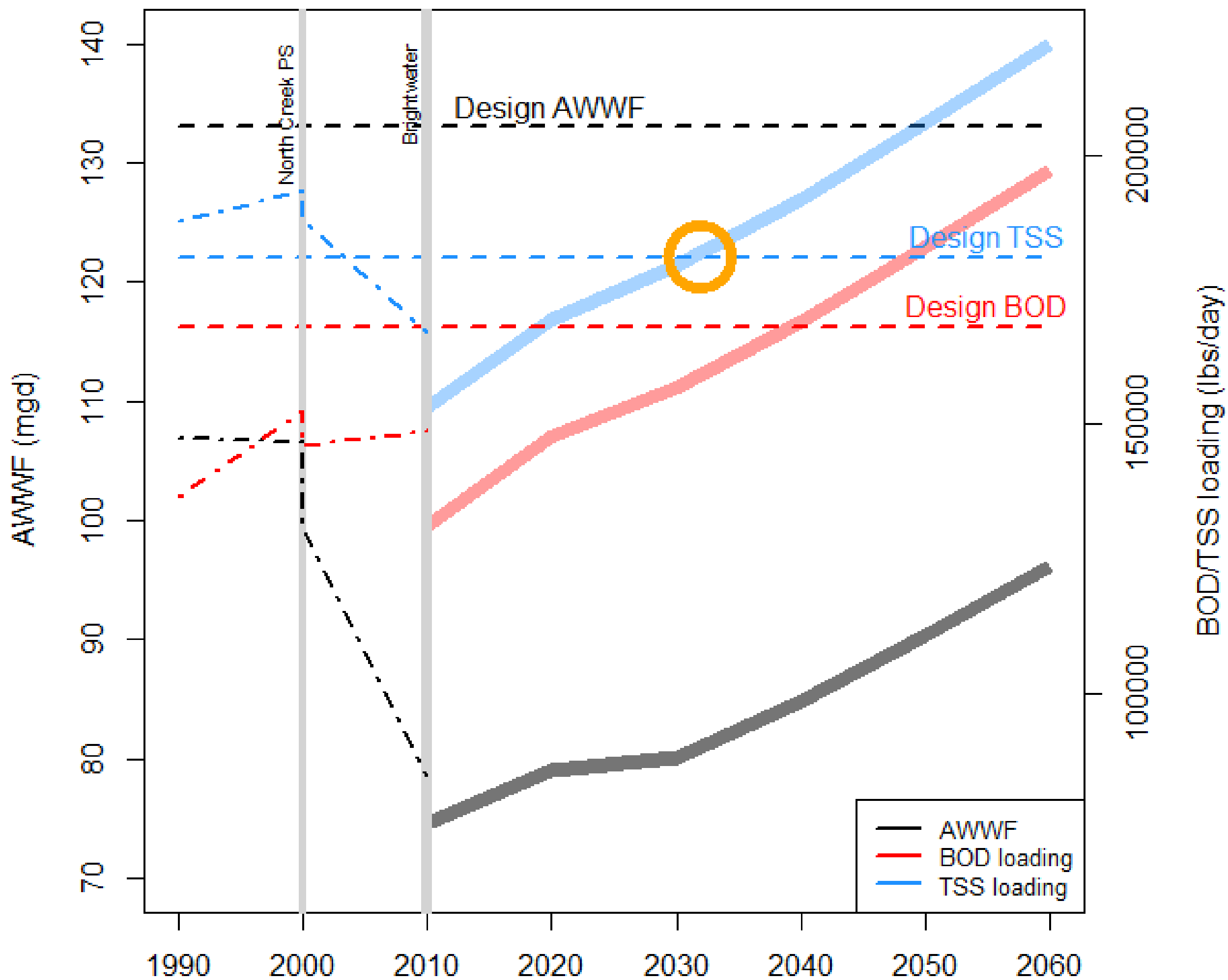

Figure 5. Actual and Projected Flow and Wasteloads to West Point Treatment Plant Compared to Design Capacities, 1990–2060

South Treatment Plant

Figure 6 presents the actual and projected (1990–2060) AWWF and average annual BOD and TSS loadings compared to design capacities of the South Treatment Plant. Conclusions from the projections are as follows:

- AWWF may be at capacity of 115 mgd in 2060.
- The TSS design loading of 201,000 pounds per day is projected to be exceeded by around 2035.
- BOD design loading of 220,000 pounds per day is projected to be exceeded about 10 years after TSS capacity is exceeded.

The limiting design wasteloads at South Plant were identified as the secondary clarifier solids loading rate and mixed liquor settleability (Brown and Caldwell, 2004).

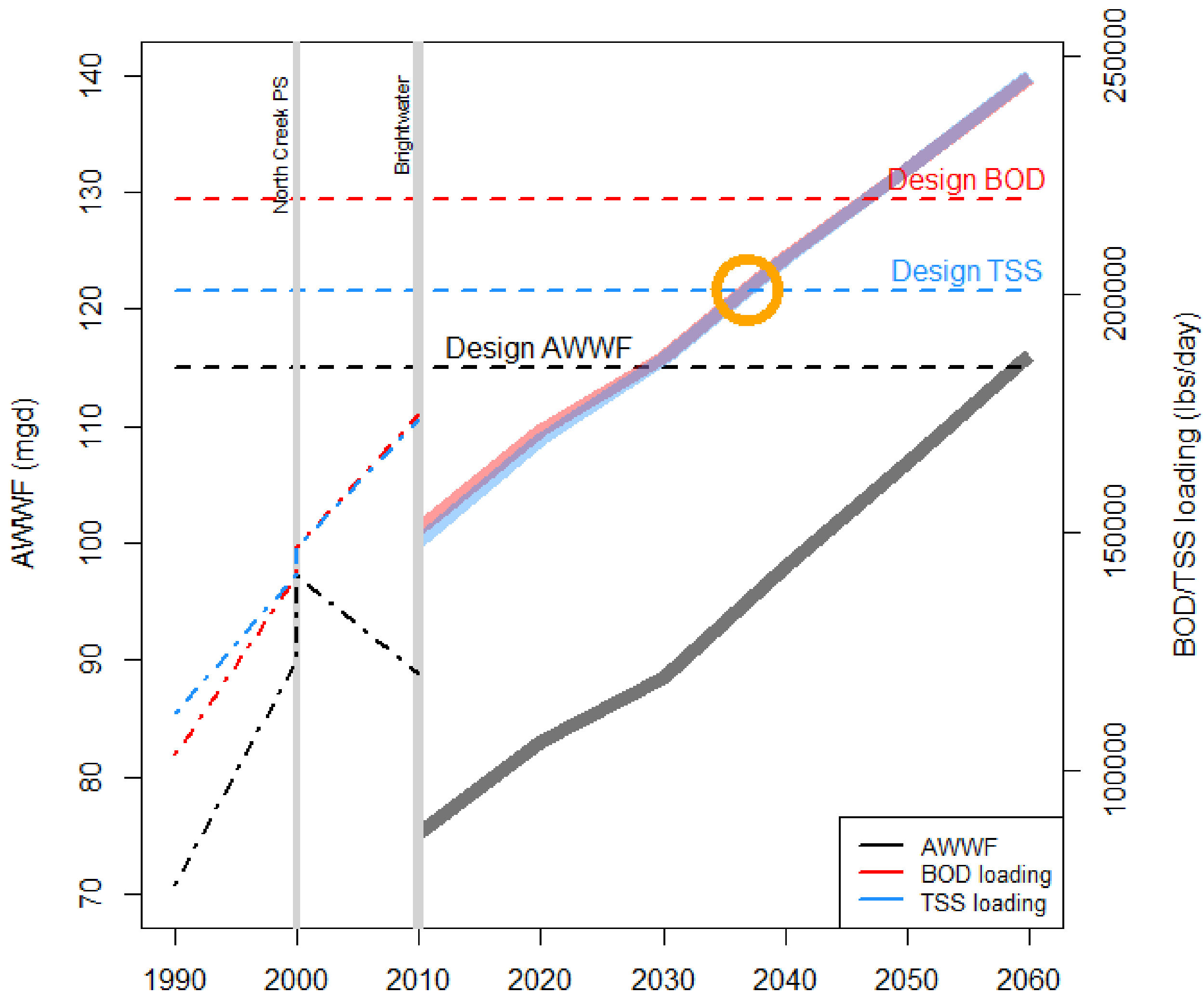

Figure 6. Actual and Projected Flow and Wasteloads to South Treatment Plant Compared to Design Capacities, 1990–2060

Brightwater Treatment Plant

Figure 7 presents the actual and projected (1990–2060) AWWF and average annual BOD and TSS loadings compared to design capacities of the Brightwater Treatment Plant. All flow from the Brightwater service area is included. The capacities assume that additional membrane cassettes and other associated equipment planned for 2020 will be installed. Conclusions from the projections are as follows:

- AWWF is not expected to reach its capacity of 36 mgd before 2060.
- The TSS design loading of 62,227 pounds per day is projected to be exceeded in the late 2030s.
- BOD design loading of 62,660 pounds per day is projected to be exceeded in the late 2030s.

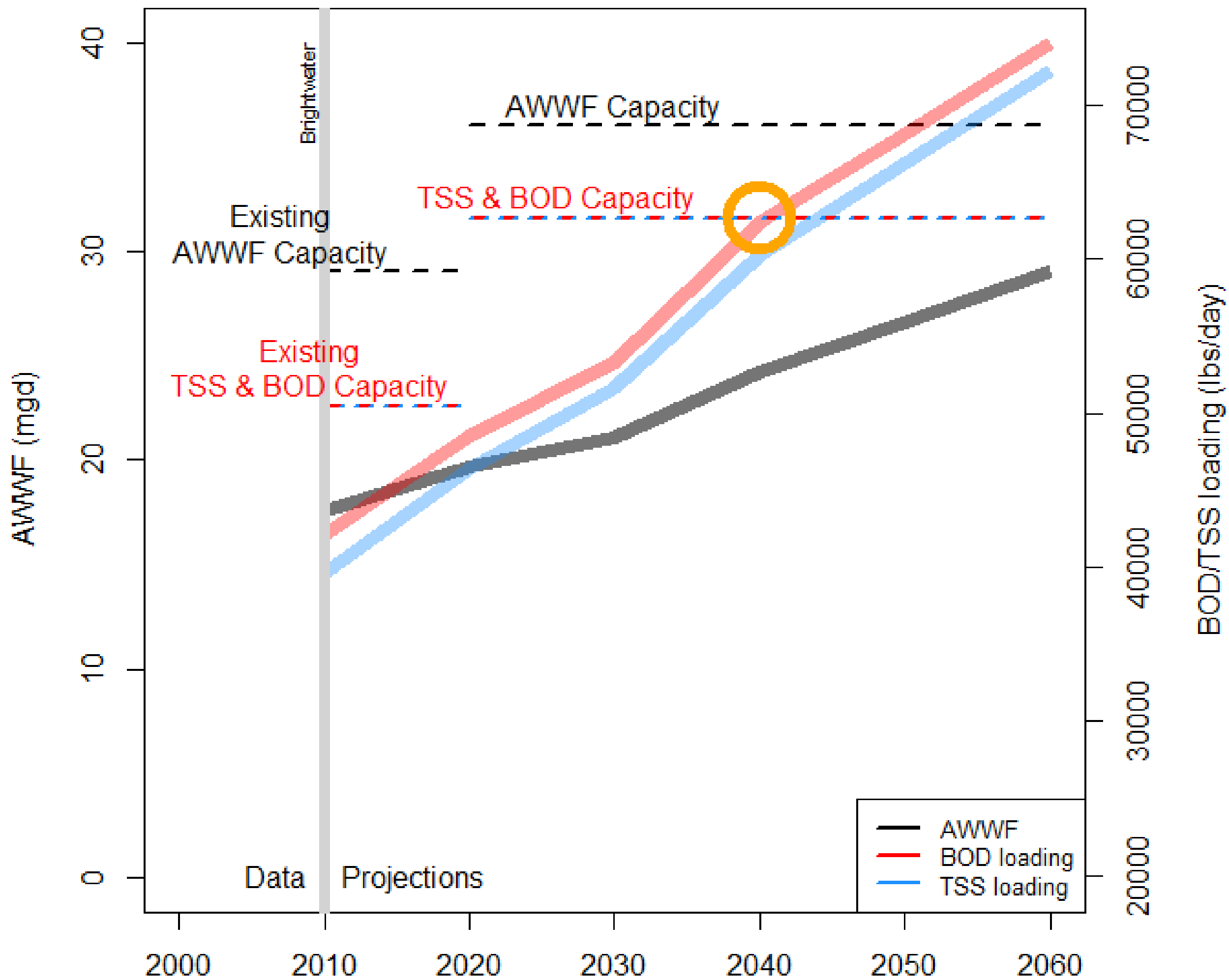

Figure 7. Projected Flow and Wasteloads to Brightwater Treatment Plant

5. REFERENCES

Brown and Caldwell. 2004. *South Plant Capacity and Re-Rating Evaluation*. Seattle, WA.

King County Department of Metropolitan Services. 1994. *Wastewater 2020 Plus Existing Conditions.* Prepared by HDR Engineering for the King County Department of Metropolitan Services, Water Pollution Control Department, Capital Facilities Planning and Program Management. Seattle, WA.

King County Department of Natural Resources and Parks. 2014. *Updated Planning Assumptions for Wastewater Flow Forecasting*. Wastewater Treatment Division. Seattle, WA.

King County Department of Natural Resources and Parks. 2005. *Facilities Plan, Brightwater Regional Wastewater Treatment System*. Wastewater Treatment Division. Seattle, WA.

Appendix A - Comparison to Previous Projections

King County has used a similar process to project flows and loads to its treatment facilities since the Wastewater 2020 Plus studies conducted in the 1990s. Similar analyses were conducted for the RWSP, the 2004 RWSP Update, and the 2007 CSI Program Update. A similar but simplified methodology was also used for the 1985 Facilities Plan and Renton Population and Flow Study. This section compares the flow and loading projections, as well as the unit loading factors obtained from these studies.

Previously Used Flow Factors

The residential flow factor of 60 gallons per capita per day (gpcd) has been used historically by King County and formerly by Metro to develop both the South and West Point systems. The industrial and commercial flow factors of 75 and 35 gallons per employee per day (gped), respectively, were derived based on permitted flow for industrial processes and on modeling and measured flows at the plants for commercial employees. Using measured flows along with King County's hydraulic model and the assumption that residential flows equal 60 gpcd, the relationship between commercial flow and dry-weather I/I was established. Dry-weather flows include base sanitary flow plus dry-weather I/I. The estimated flows derived from population and sewered area compare closely with the flows measured from each treatment plant in the years around 1990.

Table A-1. Historical Flow Factors

Flow Factors		1980[c]	1985[c]	1990[d]	1995[e]	2000[f]	2005[g]	2010	Difference 2010 – 1990
Residential (gal/capita/day)	In Seattle Other	80	60	60	60	50 60	50 60	46 54	-23% -10%
Commercial (gal/empl/day)	In Seattle Other	a	20	35	35	30	30	30 18	-14% -49%
Industrial (gal/empl/day)	In Seattle Other	b	250	75	75	50	50	61-68 45-56	-19% -25%

Notes:

a Included in domestic unit flow
b Total flow used instead of factor (3.5 mgd) taken from Metro's Pretreatment Industrial Waste records
c Renton Service Area Population and Flow Study, Technical Memorandum 104, Table 1.
d WasteWater 2020 Plus Existing Conditions, page 7-4.
e SNOFLOW95.XLS
f SNOFLOW03_5_22.XLS – flow factors for 2010 after water conservation
g Flows&Loads.xls - flow factors for 2010 after water conservation

King County derived AWWF for the base planning year of 1990 by measuring flow at the treatment plants over several years and adjusting these flows using rainfall data to reflect an average wet period during historical conditions. This approach is unique to King County and has been approved by the Washington State Department of Ecology. The South Treatment Plant service area collection system is a separated system, and its AWWF definition is the average of all flows during the months of November through April (six months). For the West Point collection system, which has a combined sanitary and stormwater conveyance system, the AWWF is defined as the average of all non-storm flows during the months of November through April.

Average Wet Weather I/I (AWW I/I) is the difference between the AWWF and the base sewage flow, normalized by the sewered area. Similarly, the Average Dry Weather I/I (ADW I/I) is the difference between the ADWF and the base sewage.

Table A-2. Historical Average Wet Weather I/I Rates (gpad)

AWW I/I (gpad)	1958[a]	1980[b]	1985[c]	1988[d]	1990[e]	1995[f]	2000[g]	2005[h]	2010	Difference 2010 - 1990
West Point			800		614	648	576	601	440	-28%
South Plant	1200	260	300[i]	350[i]	288	256	401	400	340	18%
Brightwater					-	-	-	-	180	-

Notes:

a Metropolitan Seattle Sewerage and Drainage Survey, 1958 given in (d)

b Wastewater Management Plant – Lake Washington/Green River Basins, 1980 given in (d)

c 1985 Final Plan for Secondary Treatment Facilities (for separated systems) given in (d)

d Renton Service Area Population and Flow Study, Technical Memorandum 104, Table 2.

e Projection for 2010 from WasteWater 2020 Plus Existing Conditions, calculated from 2010V1 summary table in Appendix B as AWWF I/I (mgd) / Sewered Area (ac) for West Point basin and Renton Plant Basin. This reflects the combination of separated and combined basins flowing to each plant. The base I/I factors (Table 8-3) are:

Basin	ADW I/I (gpad)	AWW I/I (gpad)
Metro West Side	555	907
All Other Basins (1990)	95	226
All Other Basins (2010)*	108	257

* where an I/I multiplier of 1.14 (Table 8-5) was applied to the 1990 I/I factors for all except the Metro West Side basins. These values match the WRBKB-V1.XLS workbook

f Projection for 2010 from SNOFLOW95.XLS, sheet 2010V1, calculated as AWWF I/I (mgd) / Sewered Area (ac)

g Projection for 2010 from Population and Flow Analysis by Wastewater Basin, 2004, Table A-2. Also in SNOFLOW03_5_22.XLS sheet 2010, calculated as AWWF I/I (mgd) / Sewered Area (ac)

h Projection for 2010 from Flows&Loads.xls (2007 CSI Update), with corrections, sheet 2010, calculated as AWWF I/I (mgd) / Sewered Area (ac)

i value for existing sewers in 1988. I/I assumed to increase linearly to 400 gpad in 2030.

Table A-3. Historical Average Dry Weather I/I Rates (gpad)

ADW I/I (gpad)	1958[a]	1980[b]	1985[c]	1988[d]	1990[e]	1995[f]	2000[g]	2005[h]	2010	Difference 2010 - 1990
West Point			400		353	377	399	451	280	-21%
South Plant	300	180	180[i]	275[j]	127	125	134	221	120	-6%
Brightwater					-	-	-	-	20	-

Notes:
a Metropolitan Seattle Sewerage and Drainage Survey, 1958 given in (d)
b Wastewater Management Plant – Lake Washington/Green River Basins, 1980 given in (d)
c 1985 Final Plan for Secondary Treatment Facilities (for separated systems) given in (d)
d Renton Service Area Population and Flow Study, Technical Memorandum 104, Table 2.
e Projection for 2010 from WasteWater 2020 Plus Existing Conditions, calculated from 2010V1 summary table in Appendix B as AWWF I/I (mgd) / Sewered Area (ac) for West Point basin and Renton Plant Basin. See note (e) of Table A-2.
f Projection for 2010 from SNOFLOW95.XLS, sheet 2010V1, calculated as AWWF I/I (mgd) / Sewered Area (ac)
g Projection for 2010 from Population and Flow Analysis by Wastewater Basin, 2004, Table A-2. Also in SNOFLOW03_5_22.XLS sheet 2010, calculated as AWWF I/I (mgd) / Sewered Area (ac)
h Projection for 2010 from Flows&Loads.xls (2007 CSI Update), with corrections, sheet 2010, calculated as AWWF I/I (mgd) / Sewered Area (ac)
i value for existing sewers in 1988. I/I assumed to increase linearly to 300 gpad in 2030.
j value for existing sewers in 1988. I/I assumed to increase linearly to 350 gpad in 2030.

Between 2000 and 2010 there was an effort both by King County and SPU to seal leaky tide gates to eliminate salt water entering they conveyance system. This effort is likely to account for a large part of the large decrease in ADW I/I and AWW I/I in the West Point system.

Previously Used Loading Factors

The loading factors that were historically used to forecast TSS and BOD loadings are shown in Table and Table. Only factors for residential population and industrial employment were used in the 1985 Facilities Plan and the Renton Population and Flow Study for projecting loadings. The commercial load was assumed to be incorporated in the residential loading factor. The West Point and South Plant factors were assumed to be identical. No loading factors were used for septage or street washoff in the 1985 Facilities Plan. The Renton Population and Flow Study included a loading rate for septage.

The loading factors developed in the Wastewater 2020 Plus studies included a commercial loading factor, as well as septage and street washoff. Industrial loading factors were allowed to vary between West Point and South Plant, based on permitted industrial loads from the Industrial Waste Program.

Table A-4. Historical TSS Loading Factors

TSS	1985[a]	1990[b]	1995[c]	2000[d]	2005[e]	2010	Difference 2010 – 1990
Residential (lbs/capita/day)	0.20	0.166[f]	0.166	0.166	0.17	0.160	-4%
Commercial (lbs/emp/day)	0[g]	0.05	0.05	0.05	0.05	0.040	-20%
Industrial (lbs/emp/day)	0.28	WP 0.18 SP 0.175[f]	WP 0.18 SP 0.175	WP 0.18 SP 0.175	WP 0.12 SP 0.10	0.13	-28% -26%
Street Washing (lbs/day)		47,000	47,000	47,000	47,000	24,700	-47%
Septage Loading (lbs/day)	9,000[h]	12,000	12,000	12,000	8,000	14,000	+17%
SeaTac DeIcing (lbs/day)		-	-	-	-	-	-

Notes:
a – same values were used in the 1985 Facility Plan and the Renton Service Area Population and Flow Study. Renton Service Area Population and Flow Study, Technical Memorandum 104, Table 4. Septage from Table 8.
b - Projection for 2010 from WasteWater 2020 Plus Existing Conditions, Table 8-8.
c - SNOFLOW95.XLS, sheet 1990BASE
d - SNOFLOW03_5_22.XLS (2004 RWSP Update), sheet 1990BASE
e - Flows&Loads.xls (2007 CSI Update), with corrections, sheet "inputs"
f – value in report was rounded; value shown was used for calculations
g - commercial load included in the residential loading factor
h – projection for 2005

Table A-5. Historical BOD Loading Factors

BOD	1985[a]	1990[b]	1995[c]	2000[d]	2005[e]	2010	Difference 2010 - 1990
Residential (lbs/capita/day)	0.20	0.150	0.150	0.150	0.165	0.150	-
Commercial (lbs/emp/day)	0[f]	0.036[g]	0.036	0.036	0.05	0.0375	4%
Industrial (lbs/emp/day)	0.43	WP 0.38 SP 0.27	WP 0.38 SP 0.27	WP 0.38 SP 0.27	WP 0.27 SP 0.19	0.44	16% 63%
Street Washing (lbs/day)		-	-	-	23,000	-	-
Septage Loading (lbs/day)	3,800[h]	3,900[h]	3,900	3,900	2,700	4,500	+15%
SeaTac DeIcing (lbs/day)		-	-			2,810	-

Notes:
a – same values were used in the 1985 Facility Plan and the Renton Service Area Population and Flow Study. Renton Service Area Population and Flow Study, Technical Memorandum 104, Table 4. Septage from Table 8.
b - Projection for 2010 from WasteWater 2020 Plus Existing Conditions, Table 8-8.
c - SNOFLOW95.XLS, sheet 1990BASE
d - SNOFLOW03_5_22.XLS (2004 RWSP Update), sheet 1990BASE
e - Flows&Loads.xls (2007 CSI Update), with corrections, sheet "inputs"
f – value in report was rounded; value shown was used for calculations
g - commercial load included in the residential loading factor
h – projection for 2005

Comparisons in the following tables do not include projections from the 1985 Facilities Plan or the Renton Population and Flow Study because those studies developed projections for 2005 and 2030, but not for 2010. The historical projections for the 2010 residential sewered population, commercial and industrial employment are shown in Table. Projections for sewered residential population and commercial employment has been relatively consistent, with a noticeable reduction in commercial employment in 2010, corresponding with the economic downturn. Projections for industrial employment have been diminishing since 1990, with current employment levels only about 63% of what was expected in 1990.

The corresponding flows and waste loads from these historical studies are shown in Table. Projections for base sewage and average wet weather flows have trended downward since 1990, with the greatest reduction between 2000 and 2010. These reductions mirror the changes in flow factors shown in Table. The waste load projections are reflective of changes in the loading factors (Table and Table), as well as the lower than projected industrial employment. The contribution of the various factors to the change in projected waste load is shown in Table. The projected TSS load has been reduced by about 15% from a combination of factors. The greatest reduction was from street wash-off, presumably due to projects intended to reduce the amount of stormwater entering the system, including flow diversions at Green Lake and Ravenna Creek. The reduced commercial loading factor, followed by the reduced residential population and residential loading factor were the next largest causes of the reduction in TSS. The current estimate of BOD loading is similar to the 1990 projection, with the slight reduction in projected residential sewered population partially balanced by the loading from SeaTac de-icing facility. The reduction in commercial employment was also partially balanced by an increase in the commercial BOD loading factor. Since there is not an accurate method to determine the commercial BOD loading factor, changes in this loading factor are more likely due to changes in the methodology used to analyze the data than changes in loading rates.

Table A-6. Historical System-Wide Population and Employment Projections for Year 2010

Sewered Population / Employment	1990 projection for 2010[a]	1995 projection for 2010[b]	2000 projection for 2010[c]	2005[d]	2010	Difference 2010 - 1990
Residential	1,569,287	1,531,050	1,518,022	1,465,751	1,526,866	-3%
Commercial	1,056,033	1,060,294	1,114,858	1,107,862	997,481	-6%
Industrial	167,778	147,984	136,250	137,427	104,966	-37%

a – WasteWater 2020 Plus Existing Conditions, Appendix B, Table 2010V1 (Vision 1 scenario)
b - SNOFLOW95.XLS, sheet 2010V1
c - Population and Flow Analysis by Wastewater Basin, 2004, Table A-2. Also in SNOFLOW03_5_22.XLS sheet 2010
d - Flows&Loads.xls (2007 CSI Update), with corrections, sheet 2010

Table A-7. Historical System-Wide Flow and Loading Projections for Year 2010

2010 Forecasts	1990 projection for 2010[a]	1995 projection for 2010[b]	2000 projection for 2010[c]	2005[d]	2010	Difference 2010 - 1990
Base Sewage Flow	143.7	140.1	125.0	122.3	108.6	-24%
AWWF (mgd)	243.6	237.4	212.9	206.7	167.5	-31%
BOD (lbs/day)	326,635[e]	316,427[f]	312,684[g]	330,206	323,799	-1%
TSS (lbs/day)	401,847	392,282	390,767	374,352	340,743	-15%

a – WasteWater 2020 Plus Existing Conditions, Appendix B, Table 2010V1 (Vision 1 scenario)
b - SNOFLOW95.XLS, sheet 2010V1
c - Population and Flow Analysis by Wastewater Basin, 2004, Table A-2. Also in SNOFLOW03_5_22.XLS sheet 2010
d - Flows&Loads.xls (2007 CSI Update), with corrections, sheet 2010
e - tabulated summary gave Lake Forest and McAleer&Lyon basins WP loading factors instead of SP loading factors, a difference of 10 lbs/day.
f - tabulated summary gave Lake Forest and McAleer&Lyon basins WP loading factors instead of SP loading factors, a difference of 13 lbs/day.
g - tabulated summary gave Lake Forest and McAleer&Lyon basins WP loading factors instead of SP loading factors, a difference of 6 lbs/day.

Table A-8. Comparison of 1990 to 2010 Wasteload Projections by Component

Loading Difference 2010 – 1990 projection	TSS	% of 1990 projection	BOD	% of 1990 projection
Total Load (1990 projection for 2010)	401,847	100%	326,635[a]	100%
Total Load (2010)	340,743	84.8%	323,799	99.1%
Change in Loading				
Residential	-16,203	-4.0%	-6,363	-1.9%
Commercial	-12,902	-3.2%	-612	-0.2%
Industrial	-11,700	-2.9%	796	0.2%
Street Washing	-22,299	-5.5%		
Septage	2,000	0.5%	600	0.2%
SeaTac De-Icing			2,742	0.8%
Total Difference	-61,105	-15.2%	-2,836	-0.9%

Notes:
a – tabulated summary gave Lake Forest and McAleer&Lyon basins WP loading factors instead of SP loading factors, a difference of 10 lbs/day.

Table A-8. Comparison of 2000 to 2010 Wasteload Projections by Component

Loading Difference 2010 – 1990 projection	TSS	% of 2000 projection	BOD	% of 2000 projection
Total Load (2000 projection for 2010)	390,767	100%	312,684[a]	100%
Total Load (2010)	340,743	87.2%	323,799	96.6%
Change in Loading				
Residential	-7,693	-2.0%	1,327	0.4%
Commercial	-15,844	-4.1%	-2,729	-0.9%
Industrial	-6,189	-1.6%	9,175	2.9%
Street Washing	-22,299	-5.7%		
Septage	2,000	0.5%	600	0.2%
SeaTac De-Icing			2,742	0.9%
Total Difference	-50,024	-12.8%	11,115	3.6%

Notes:
a – tabulated summary gave Lake Forest and McAleer&Lyon basins WP loading factors instead of SP loading factors, a difference of 6 lbs/day

Appendix B – Projections by Planning Basin

Table B-1. Year 2010 Updated Population and Flow Projections by Basin

Planning Basin	Sewered Residential Population	Commercial Employment	Industrial Employment	Sewered Area (ac)	Base Flow (mgd)	ADW I/I (mgd)	AWW I/I (mgd)	ADWF (mgd)	AWWF (mgd)
Combined System	542,081	458,479	33,732	50,793	40.8	13.3	21.7	54.0	62.5
Hidden Lake	18,188	7,816	90	2,276	1.1	0.6	1.0	1.8	2.1
NE Lake Washington	167,603	180,061	6,935	19,911	12.7	2.5	6.8	15.2	19.5
North Green River	59,152	58,593	14,793	9,679	5.1	1.3	3.4	6.4	8.5
North Lake Sammamish	85,265	50,002	7,737	9,853	5.9	0.2	1.8	6.0	7.6
North Lake Washington	170,161	59,048	8,188	18,783	10.6	2.2	5.2	12.8	15.8
NW Lake Washington	72,633	26,668	337	6,504	4.2	1.8	2.9	6.0	7.0
SE Lake Washington	40,514	6,397	280	5,403	2.3	0.6	1.8	3.0	4.2
South Green River Auburn Planning Zone	68,559	42,882	10,827	9,191	5.1	1.1	3.1	6.2	8.2
South Green River Kent Planning Zone	66,011	24,610	4,430	5,937	4.3	0.7	2.0	5.0	6.3
South Green River Soos Planning Zone	56,818	12,400	604	5,701	3.3	0.7	1.9	4.0	5.3
South Lake Sammamish	88,094	39,853	4,065	10,014	5.7	1.2	3.3	6.9	9.0
South Lake Washington	91,787	30,671	12,950	9,074	6.2	1.1	3.1	7.3	9.3
Non-population Based Flows						0.9	2.2	0.9	2.2
System Total	1,526,866	997,481	104,966	163,118	107.2	28.2	60.3	135.4	167.5

Table B-2. Year 2020 Updated Population and Flow Projections by Basin

Planning Basin	Sewered Residential Population	Commercial Employment	Industrial Employment	Sewered Area (ac)	Base Flow (mgd)	ADW I/I (mgd)	AWW I/I (mgd)	ADWF (mgd)	AWWF (mgd)
Combined System	594,005	571,046	38,039	50,793	44.5	13.3	21.8	57.7	66.2
Hidden Lake	20,810	8,788	73	2,276	1.2	0.6	1.0	1.9	2.2
NE Lake Washington	197,222	222,835	7,326	19,911	14.3	2.6	7.0	16.9	21.4
North Green River	74,085	77,738	15,549	9,679	6.0	1.4	3.7	7.4	9.6
North Lake Sammamish	98,372	66,602	7,946	9,853	6.5	0.2	1.8	6.7	8.4
North Lake Washington	201,251	73,709	8,419	18,783	11.9	2.3	5.7	14.3	17.7
NW Lake Washington	78,715	30,931	482	6,504	4.3	1.8	2.9	6.2	7.2
SE Lake Washington	44,865	7,903	282	5,403	2.5	0.7	2.0	3.1	4.4
South Green River Auburn Planning Zone	81,669	45,535	11,399	9,191	5.6	1.3	3.8	6.9	9.3
South Green River Kent Planning Zone	76,120	31,083	4,697	5,937	4.7	0.8	2.2	5.5	6.9
South Green River Soos Planning Zone	65,782	15,868	699	5,701	3.7	0.9	2.5	4.6	6.2
South Lake Sammamish	98,916	54,029	4,086	10,014	6.2	1.4	3.9	7.6	10.1
South Lake Washington	102,796	40,170	12,921	9,074	6.6	1.2	3.3	7.8	10.0
Non-population Based Flows						0.9	2.2	0.9	2.2
System Total	1,734,608	1,246,237	111,918	163,118	118.0	29.4	63.7	147.4	181.8

Table B-3. Year 2030 Updated Population and Flow Projections by Basin

Planning Basin	Sewered Residential Population	Commercial Employment	Industrial Employment	Sewered Area (ac)	Base Flow (mgd)	ADW I/I (mgd)	AWW I/I (mgd)	ADWF (mgd)	AWWF (mgd)
Combined System	619,068	641,108	36,386	50,793	45.0	13.3	21.8	58.2	66.8
Hidden Lake	24,230	8,699	53	2,276	1.3	0.7	1.0	2.0	2.3
NE Lake Washington	219,510	251,663	6,883	19,911	15.1	2.6	7.2	17.7	22.3
North Green River	82,660	94,037	14,804	9,679	6.3	1.5	3.9	7.8	10.2
North Lake Sammamish	106,386	81,413	7,829	9,853	6.8	0.2	1.9	7.0	8.7
North Lake Washington	225,959	80,597	8,021	18,783	12.6	2.4	6.3	15.1	18.9
NW Lake Washington	84,180	31,924	502	6,504	4.4	1.8	2.9	6.2	7.3
SE Lake Washington	48,979	8,460	277	5,403	2.5	0.7	2.1	3.3	4.6
South Green River Auburn Planning Zone	95,464	59,588	10,897	9,191	6.2	1.6	4.4	7.7	10.6
South Green River Kent Planning Zone	82,541	34,359	4,564	5,937	4.8	0.8	2.4	5.6	7.2
South Green River Soos Planning Zone	77,496	18,386	716	5,701	4.1	1.1	3.0	5.2	7.1
South Lake Sammamish	112,269	62,471	3,710	10,014	6.7	1.5	4.5	8.2	11.1
South Lake Washington	113,811	43,478	12,737	9,074	6.9	1.3	3.6	8.2	10.5
Non-population Based Flows						0.9	2.2	0.9	2.2
System Total	1,892,553	1,416,183	107,379	163,118	122.6	30.5	67.2	153.1	189.8

Table B-4. **Year 2040 Updated Population and Flow Projections by Basin**

Planning Basin	Sewered Residential Population	Commercial Employment	Industrial Employment	Sewered Area (ac)	Base Flow (mgd)	ADW I/I (mgd)	AWW I/I (mgd)	ADWF (mgd)	AWWF (mgd)
Combined System	643,709	714,700	39,751	50,793	48.2	13.3	21.9	61.5	70.0
Hidden Lake	27,319	10,075	70	2,276	1.5	0.7	1.0	2.2	2.5
NE Lake Washington	237,951	292,266	8,418	19,911	16.7	2.7	7.5	19.4	24.2
North Green River	90,569	117,032	16,310	9,679	7.1	1.6	4.2	8.8	11.3
North Lake Sammamish	117,096	94,217	9,873	9,853	7.6	0.2	2.0	7.8	9.6
North Lake Washington	271,232	93,612	9,173	18,783	15.1	2.6	6.8	17.7	21.9
NW Lake Washington	96,716	38,140	634	6,504	5.1	1.8	2.9	6.9	8.0
SE Lake Washington	51,127	9,787	308	5,403	2.7	0.8	2.2	3.4	4.9
South Green River Auburn Planning Zone	111,346	71,087	11,912	9,191	7.2	1.8	5.0	8.9	12.2
South Green River Kent Planning Zone	91,406	36,099	4,583	5,937	5.3	0.9	2.6	6.2	7.9
South Green River Soos Planning Zone	92,411	22,318	1,089	5,701	4.9	1.2	3.5	6.2	8.4
South Lake Sammamish	127,384	82,780	4,140	10,014	7.7	1.7	5.0	9.5	12.8
South Lake Washington	126,393	53,315	13,075	9,074	7.7	1.4	3.9	9.0	11.5
Non-population Based Flows						0.9	2.2	0.9	2.2
System Total	2,084,659	1,635,428	119,336	163,118	136.6	31.7	70.6	168.3	207.3

Table B-5. Year 2050 Updated Population and Flow Projections by Basin

Planning Basin	Sewered Residential Population	Commercial Employment	Industrial Employment	Sewered Area (ac)	Base Flow (mgd)	ADW I/I (mgd)	AWW I/I (mgd)	ADWF (mgd)	AWWF (mgd)
Combined System	695,613	800,464	40,944	50,793	52.7	13.3	21.9	66.0	74.6
Hidden Lake	29,596	11,284	72	2,276	1.6	0.7	1.0	2.3	2.7
NE Lake Washington	258,785	327,338	8,671	19,911	18.3	2.8	7.7	21.1	26.0
North Green River	99,241	131,076	16,799	9,679	7.8	1.7	4.4	9.5	12.2
North Lake Sammamish	127,580	105,523	10,169	9,853	8.3	0.2	2.0	8.5	10.4
North Lake Washington	298,744	104,845	9,448	18,783	16.6	2.7	7.3	19.3	23.9
NW Lake Washington	104,536	42,717	653	6,504	5.5	1.8	2.9	7.4	8.4
SE Lake Washington	56,002	10,961	317	5,403	2.9	0.8	2.3	3.7	5.2
South Green River Auburn Planning Zone	123,679	79,617	12,269	9,191	7.9	2.0	5.7	9.9	13.6
South Green River Kent Planning Zone	100,181	40,431	4,720	5,937	5.8	1.0	2.8	6.7	8.6
South Green River Soos Planning Zone	102,631	24,996	1,122	5,701	5.4	1.4	4.1	6.9	9.5
South Lake Sammamish	141,483	92,714	4,264	10,014	8.6	1.9	5.6	10.5	14.2
South Lake Washington	139,137	59,713	13,467	9,074	8.4	1.5	4.1	9.9	12.5
Non-population Based Flows						0.9	2.2	0.9	2.2
System Total	2,277,209	1,831,679	122,916	163,118	149.9	32.9	74.1	182.8	224.0

Table B-6. **Year 2060 Updated Population and Flow Projections by Basin**

Planning Basin	Sewered Residential Population	Commercial Employment	Industrial Employment	Sewered Area (ac)	Base Flow (mgd)	ADW I/I (mgd)	AWW I/I (mgd)	ADWF (mgd)	AWWF (mgd)
Combined System	747,577	893,375	42,136	50,793	57.4	13.3	21.9	70.7	79.3
Hidden Lake	31,886	12,594	74	2,276	1.8	0.7	1.1	2.4	2.8
NE Lake Washington	279,885	365,333	8,923	19,911	20.0	2.9	7.9	22.8	27.9
North Green River	108,124	146,290	17,289	9,679	8.5	1.8	4.7	10.3	13.2
North Lake Sammamish	138,229	117,771	10,465	9,853	9.0	0.2	2.1	9.3	11.2
North Lake Washington	327,118	117,015	9,723	18,783	18.2	2.9	7.9	21.1	26.1
NW Lake Washington	112,368	47,675	672	6,504	6.0	1.9	2.9	7.8	8.9
SE Lake Washington	60,994	12,234	326	5,403	3.2	0.9	2.4	4.0	5.6
South Green River Auburn Planning Zone	136,520	88,859	12,627	9,191	8.7	2.2	6.3	10.9	15.0
South Green River Kent Planning Zone	109,173	45,124	4,858	5,937	6.3	1.1	3.0	7.3	9.3
South Green River Soos Planning Zone	113,269	27,898	1,154	5,701	6.0	1.6	4.6	7.6	10.6
South Lake Sammamish	156,162	103,475	4,388	10,014	9.5	2.1	6.2	11.6	15.6
South Lake Washington	152,272	66,644	13,860	9,074	9.2	1.5	4.4	10.7	13.6
Non-population Based Flows						0.9	2.2	0.9	2.2
System Total	2,473,577	2,044,285	126,496	163,118	163.7	34.0	77.5	197.7	241.2