4.0 Wastewater Characteristics

This chapter presents the existing wastewater characteristics at the WPCF and consists of an evaluation of historical flows and loads, as well as historical per capita and peaking factor calculations. It also presents an analysis that correlates current plant wastewater flows with current rainfall data in an independent effort to produce flow peaking factors. PWWFs have been determined using an extensive collection system modeling approach. This historical data analysis, in conjunction with the rainfall data analysis and the collection system modeling, provide the basis for future flow and load projections. The "Flow and Load Projections" technical memorandum presented a historical flow and load analysis, rainfall flow analysis, population projections, and projections for future flows and loads based on two independent methodologies. The "Wet Weather Peak Flow Analysis" technical memorandum presented the collection system modeling methodology to develop the peak wet weather flows. The following is a summary of the information presented in those technical memorandums.

4.1 Wastewater Flow Characteristics

Two separate analyses of historical flow data were conducted. The first analysis includes assessment of 12 years of historical plant data. The second analysis follows the *Guidelines for Making Wet-Weather and Peak Flow Projections for Sewage Treatment in Western Oregon: MMDWF, MMWWF, PDAF, and PIF*, from the Oregon DEQ (DEQ, 1996).

4.1.1 Historical Seasonal Flow Analysis

Historical flow data from May 1990 through May 2002 were evaluated to determine average, maximum month, maximum week, and maximum day flows. The data analysis was broken up into dry and wet weather seasons. The two seasons align with the effluent requirements as specified in the WPCF's NPDES permit. Flows at the WPCF are measured at the influent Parshall flume. Dry weather includes flows occurring between May 1 and October 31. Historical dry weather average and maximum month flows are depicted in Figure 4.1.1-1. Wet weather includes flows occurring between November 1 and April 30. Historical wet weather average and maximum month flows are depicted in Figure 4.1.1-2. As shown in Figures 4.1.1-1 and 4.1.1-2, rainfall has a significant impact on flows through the treatment plant. For example, the wet weather rainfall in 2000 was 11.03 inches As a result, the seasonal average and maximum month flows through the plant were significantly lower than both 1999 and 2001, which both experienced more than twice the rainfall. Similar trends can be seen during the dry season.

FIGURE 4.1.1-1
Average and Maximum Month Dry Weather Flow
MWMC Facility Plan, Eugene-Springfield

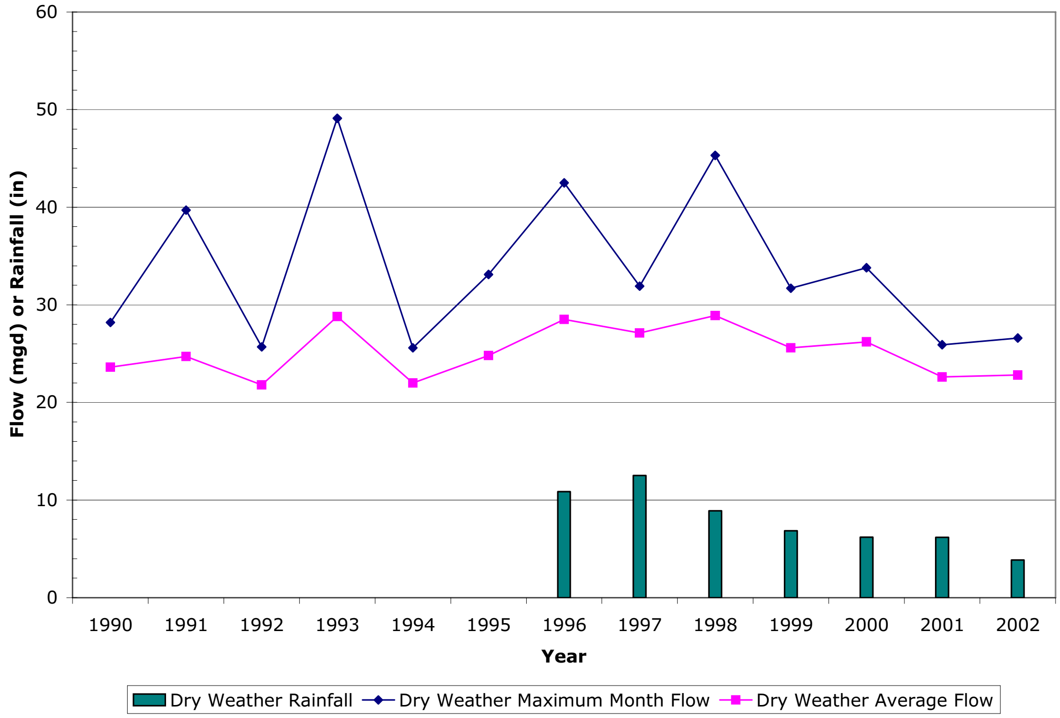
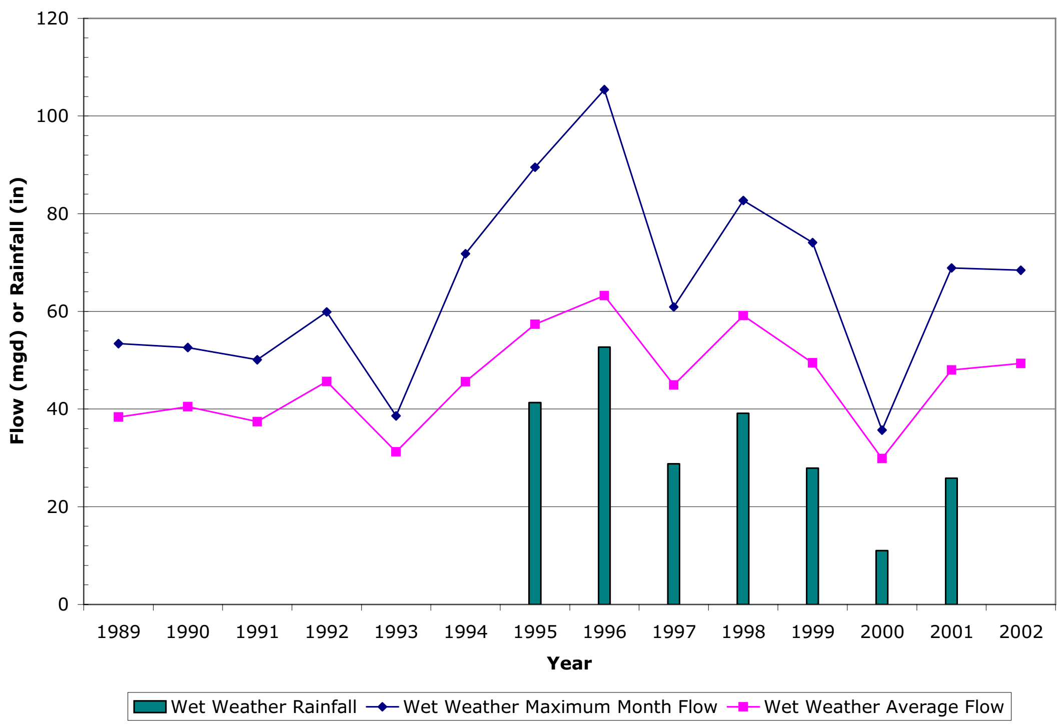


FIGURE 4.1.1-2
Average and Maximum Month Wet Weather Flow
MWMC Facility Plan, Eugene-Springfield



4.1.2 Historical Flow Statistics

Peaking factors are commonly used to estimate future peak flow conditions and are frequently based on analyses of historical average and peak flow data. The methods used for estimating peaking factors involved analysis of historical peaking factors for the years 1990 through 2002 for both dry and wet weather conditions and the DEQ methodology. Peaking factors for flow and load events (maximum month, maximum week, maximum day and peak hour) are ratios of the particular seasonal events to the corresponding seasonal averages.

Tables 4.1.2-1 and 4.1.2-2 present the historical dry and wet weather flow per capita and peaking factor statistics, respectively.

TABLE 4.1.2-1
Historical Dry Weather Flow Statistics
MWMC Facility Plan, Eugene-Springfield

	Flow Per Capita (gpcd)	Maximum Month Peaking Factor	Maximum Week Peaking Factor	Maximum Day Peaking Factor	Peak Hour Peaking Factor
Minimum	105	1.1	1.2	1.5	2.3
Average	128	1.3	1.7	2.3	2.8
Maximum	147	1.5	2.8	3.9	4.0

TABLE 4.1.2-2
Historical Wet Weather Flow Statistics
MWMC Facility Plan, Eugene-Springfield

	Flow Per Capita (gpcd)	Maximum Month Peaking Factor	Maximum Week Peaking Factor	Maximum Day Peaking Factor	Peak Hour Peaking Factor
Minimum	139	1.2	1.5	2.3	(a)
Average	227	1.4	1.9	2.8	(a)
Maximum	275	1.6	2.5	3.4	(a)

(a) Determined by collections system modeling, see *Wet Weather Peak Flow* Technical Memorandum. The projected peak hour flow in 2025 is 277 mgd and the projected wet season average flow is 68.2 mgd (see Chapter 5) so the effective 2025 peaking factor for peak hour is approximately 4.0.

4.1.3 DEQ Methodology Peaking Factor Analysis

The *Guidelines for Making Wet-Weather and Peak Flow Projections for Sewage Treatment in Western Oregon: MMDWF, MMWWF, PDAF, and PIF* (DEQ, 1996) present instructions on calculating current flow rates. A statistical analysis of historical data from 2000 and 2002 was used to predict current peak flow rates. The maximum month flows for dry weather and wet weather are predicted using rainfall recurrence data obtained from the National

Oceanic and Atmospheric Administration, National Climatic Data Center, *Climatography of the United States No. 20, 1971-2000*, Eugene Mahlon Sweet Airport Station (NOAA, February 2004). The peak day average flow (PDAF) was predicted using daily precipitation and flow data for January through May, the months that groundwater affects I/I rates in the system. Using a probability distribution, the peak week and peak instantaneous flow rates were predicted. Table 4.1.3-1 presents the peaking factors derived from the DEQ methodology. Additional details regarding the development of these peaking factors is presented in the *Flow and Load Projections* technical memorandum.

TABLE 4.1.3-1
DEQ Methodology Flow Peaking Factors
MWMC Facility Plan, Eugene-Springfield

Dry Weather Maximum Month	Wet Weather Maximum Month	Wet Weather Maximum Week	Peak Day	Peak Instantaneous
1.9	1.5	2.0	2.7	4.0

4.1.4 Infiltration and Inflow

Many communities typically experience higher flow rates in their wastewater collection systems during rain events. These flow responses to rainfall (and sometimes snowmelt) will usually vary according to storm volume and intensity, as well as the amount and duration of antecedent rainfall (rainfall in the days preceding the particular rain event). The flow response to rainfall/snowmelt can generally be referred to as RDII (rainfall dependent infiltration and inflow). It corresponds with that portion of a wastewater collection system hydrograph that is above the normal base flow. The ratio of RDII (volume or peak flow rate) to precipitation is generally referred to as the RDII "return rate."

Infiltration and inflow are two distinct contributors to a wet weather hydrograph, but there is no clear demarcation between them. Inflow enters sewers through direct stormwater connections such as roof leaders, illegal drain connections, and leaky manhole covers in depressed or sump areas. Infiltration is produced by rainfall and/or snowmelt that has been sustained long enough to soak into the soil and produce temporary saturated soil conditions. Elevated wet season groundwater levels also contribute to the amount of infiltration in the wastewater collection system. Groundwater infiltration tends to vary within the collection system as a function of long-term soil moisture, groundwater levels, and the relative depths of sewers. Infiltration enters sewers directly through cracks and faulty deteriorated joints, and indirectly through basement sump pumps.

RDII can be reduced through rehabilitation of the wastewater collection system. Rehabilitation can include repair or replacement of facilities, relining of facilities, and disconnection of inflow sources.

Previous Infiltration and Inflow Studies

During the mid 1970s, a Sewer System Evaluation Study (SSES) was performed for the Eugene and Springfield sewer system study areas to assess the amount of RDII entering the collection systems. The study estimated that in 1978 the peak flow to the planned regional

WPCF would be 264 mgd. The SSES also predicted quantities of RDII that could be cost-effectively removed. These removal estimates formed the basis for the 175-mgd design flow rate of the WPCF.

Subsequent studies for Eugene (City of Eugene Public Works/Engineering Urban Sanitary Sewer Master Plan, 1992) and Springfield (City of Springfield Sanitary Sewer Master Plan, July 1980), documented RDII as significant contributors to systemwide wastewater peak flow rates. The studies recommended continued and additional funding to rehabilitate the respective systems to correct structural deficiencies and reduce RDII contributions.

Comprehensive RDII reduction programs in both cities fulfill NPDES waste discharge permit requirements. Both cities' programs include varying degrees of flow monitoring, TV inspection, smoke testing, and manhole inspections as appropriate. Unfortunately, the programs have not been as effective in controlling excessive peak flows as estimated in the 1978 SSES study. Limited success with RDII reduction programs has also been the case for many other communities around the state and country.

The inability of RDII rehabilitation programs to achieve desired targets formed the impetus for the September 2000 Wet Weather Flow Management Plan (WWFMP; CH2M HILL, 2000), which evaluated and recommended individual technologies or combinations of technologies to manage wet weather flows. The WWFMP estimated more up-to-date and realistic rates of RDII reduction that could be expected as a result of collection system rehabilitation projects. For the purposes of the WWFMP study, two groups of system rehabilitation were evaluated: (1) rehabilitation of main lines and laterals within the public right-of-way (lower lateral), and (2) rehabilitation of the same but including portions of the laterals that are outside the public right-of-way (upper lateral). The two types of rehabilitation are referred to as "public only" and "public and private." Public only includes the entire collection system within the right-of-way limits, independent of ownership.

The cities of Eugene and Springfield have collected a large amount of data in the last 5 to 10 years to measure the effectiveness of their system rehabilitation programs. The data comprise flow records taken before and after implementation of rehabilitation in specific areas. These data were used for estimating the operational and economic benefits of further system rehabilitation activity. All local data from both cities represented system rehabilitation within the public rights-of-way. Neither city has performed comprehensive system rehabilitation of the private laterals outside of rights-of-way; consequently, all local data used in the WWFMP analyses represent the public-only condition.

The WWFMP team performed a three-phase analysis of the data. The first phase involved a preliminary review of the raw data that resulted in a general assessment of system rehabilitation benefit. The second involved a quantitative comparison of basin-specific data. This examination reviewed pre- and post-rehabilitation RDII quantities relative to type and amount of system rehabilitation per sub-basin. Both local and other agency data were reviewed. The third phase identified performance measures to be used in later analyses of wet weather flow management strategies. Along with performance measures, the economic costs of system rehabilitation were reviewed.

Rehabilitation Practices and History

Most of the data used in estimating RDII reduction as a result of public-only system rehabilitation are from City of Eugene projects and monitoring. The data are relatively recent and considered appropriate as a basis for RDII reduction estimates. The City of Springfield has also performed public-only system rehabilitation, but their data are not as current and often represent unique system conditions. Post-rehabilitation monitoring was not typically performed in Springfield. Therefore, the description of rehabilitation practices in this section is based on work performed by the City of Eugene. It was assumed that RDII reduction conclusions developed using City of Eugene data would also apply to the Springfield system.

The City of Eugene has focused its wastewater rehabilitation efforts on sub-basins with high wet weather to dry weather flow ratios. The City has extensive video inspection data showing collection system defects. These data have been evaluated by staff who have assigned deficiency ratings to pipe reaches. These deficiency ratings, along with flow monitoring, have been the basis for prioritizing and implementing City of Eugene public-only system rehabilitation.

The majority of the lines rehabilitated to date were 8 inches in diameter. For the most part, the main line was 5 to 10 feet deep and the average depth of the service lines was about 4 feet deep at the edge of the right-of-way.

Eugene's comprehensive public system rehabilitation approach includes rehabilitating the majority of the main line, building services and connections, and manholes within the right-of-way. City staff have most often selected trenchless liner as the rehabilitation method. Replacing building service connections at the main and sections of service lines located within the public right-of-way has also been a major component of the City's rehabilitation effort. For building service lines within the public right-of-way, the City has installed, through open excavation, new PVC pipe with rubber-gasketed joints and taps at the main line. An additional component of the rehabilitation program involves modifying manholes to reduce the surface inflow potential, and sealing the interior barrel sections and bases (where needed) with internal cement-based material to reduce or eliminate infiltration. In a few cases, the City performed a spot repair on a segment of pipe instead of lining the whole pipe. For these cases, the whole segment and its associated length were counted as being rehabilitated.

With regard to RDII reductions attributable to system rehabilitation, Eugene-Springfield's experience was compared with that of other agencies within and outside of Oregon. As in Eugene and Springfield, monitoring data from other agencies were typically obtained within a few years of completing system rehabilitation projects, so the data were not necessarily representative of RDII reduction over the long-term. Data representing RDII reduction over the long-term were not identified. In general, agencies were found to address system rehabilitation in one of three ways:

1. Rehabilitation of main lines only (no portion of the lateral).
2. Rehabilitation of main lines and lower laterals (that portion of the lateral in the public right-of-way).

3. Rehabilitation of main lines as well as upper and lower laterals (the entire lateral, both in the public right-of-way and on private property to the structure served).

Hydraulic Modeling

A hydraulic model was developed to depict existing and future flows in the wastewater collection system, and the expected RDII reduction benefits in the system for both public-only and public and private rehabilitation efforts based on the estimated RDII reductions attributable to system rehabilitation.

The response of the sewer system to immediate and antecedent rainfall during the wet weather events of the 1997-1998 monitoring period was analyzed as part of the WWFMP. As a first step in analyzing the monitoring data, the diurnal base flow hydrograph for selected storms was subtracted to obtain the RDII hydrograph.

For the WWFMP study, flow inputs were developed from regression equations, and were modified to reflect the experience of MWMC operations personnel and the observations of return ratio at monitor locations. The regression equations provided a method to generate the RDII component of the flow input hydrograph for each monitoring location for any storm of interest. Although the method is a good one, it can be deficient if the equation is applied to storms that differ significantly in character (intensity, pattern, and volume) from the storm for which the equation was created.

As part of the task of updating the MWMC MOUSE hydraulic model for this 2004 Facilities Plan, the model was recalibrated using the latest flow monitor data from six permanent MGD Technologies monitor installations (herein referred to as MGD monitors) within the collection system and one at the WPCF. Changes to the collection system pipes and pump stations were also incorporated into the updated model. The methodologies used to generate model flow inputs were different than those used for the WWFMP, although the relative distribution of flows within the collection system and the peak flow at the WPCF were consistent with the WWFMP.

The MOUSE dry weather flow module was used to create the diurnal sanitary flow based on population, and the MOUSE RDII module was used to generate system RDII flows from rainfall. This change in methodology allowed all of the flow inputs to be generated within the hydraulic model rather than as separate computations external to the MOUSE model. More detailed information on the subject of the wastewater collection system hydraulic modeling analysis is given in the March 2004 "MWMC Wastewater Facility Plan—Wet Weather Peak Flow Analysis" technical memorandum (see Volume 2).

Assumptions for system rehabilitation identified under the WWFMP were incorporated in the future conditions model runs (2025 and buildout). The magnitude of RDII response for new development was estimated through a review of existing sewershed areas that represent fairly new and consistent construction.

The WWFMP used a peak rainfall dependent infiltration and inflow (RDII) rate of 2,000 gallons per additional future developed acre per day for the 5-year storm event. This value was obtained from an analysis of four historical storm events in 1998. Standard unit peak RDII rates used by other agencies, and the measured RDII response at monitors F20 and F21, which drain the Santa Clara/River Road areas, were reviewed. F20 has a peak rate of less than 1,000 gpad for the 5-year storm event, and F21 has peak rate of 1,400 gpad. These basins drain areas with relatively new and uniform construction techniques. However, because they are only 5 to 10 years old and increased I/I may occur over time, a rate of 2,000 gpad was recommended as the value to use in the model for future undeveloped areas.

The updated MOUSE model also uses the 2,000 gallons per acre per day peak RDII rate for all future developed areas. System rehabilitation recommendations included in the WWFMP for existing and future conditions were assumed to have been implemented for the 2025 peak flow estimates. These rehabilitation projects were included in the WWFMP as a result of the cost-effectiveness analysis that identified projects to reduce peak flows in the collection system.

4.2 Wastewater Loading Characteristics

BOD and TSS concentrations at the WPCF are measured using 24-hour composite samples collected and analyzed by plant personnel.

4.2.1 Historical Seasonal Loading Analysis

Historical loading data from May 1990 through May 2002 were evaluated, with corresponding flow data, to determine average, maximum month, maximum week, and maximum day BOD and TSS loads. The data analysis was broken up into dry and wet weather seasons. The two seasons align with the effluent requirements as specified in the WPCF's NPDES permit. Dry weather includes flows occurring between May 1 and October 31. Historical dry weather average and maximum month loads are depicted in Figure 4.2.1-1. Wet weather includes flows occurring between November 1 and April 30. Historical wet weather average and maximum month loads are depicted in Figure 4.2.1-2.

FIGURE 4.2.1-1
Dry Weather Maximum Month Loads
MWMC Facility Plan, Eugene-Springfield

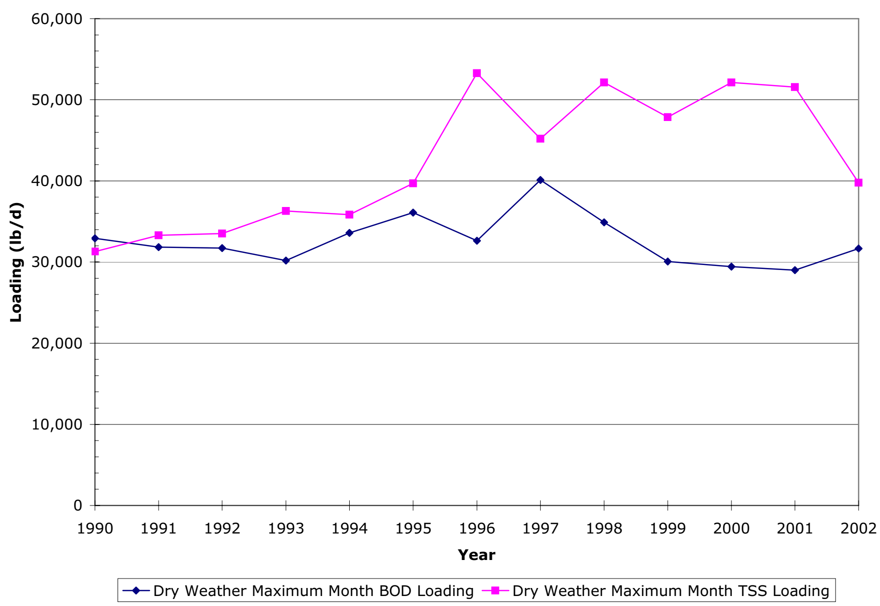
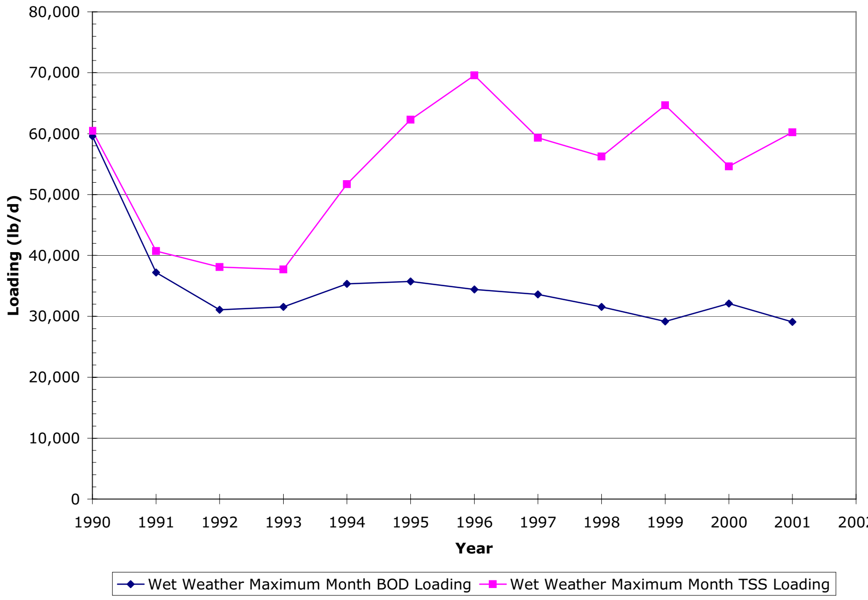


FIGURE 4.2.1-2
Wet Weather Maximum Month Loads
MWMC Facility Plan, Eugene-Springfield



4.2.2 Historical Loading Statistics

Per capita loads are commonly used to estimate future loading conditions and are frequently based on analyses of historical seasonal average data. To calculate the average seasonal per capita domestic wastewater loads, it is necessary to correlate historical population information with the historical seasonal average domestic wastewater loading data. These per capita values are then used in conjunction with projected populations to estimate future domestic seasonal wastewater loads to the WPCF. In addition, peaking factors for maximum month, maximum week, and maximum day were developed from the seasonal historical data.

Tables 4.2.2-1 and 4.2.2-2 present the historical dry and wet weather BOD per capita and peaking factor statistics, respectively.

TABLE 4.2.2-1
Historical Dry Weather BOD Loading Statistics
MWMC Facility Plan, Eugene-Springfield

Year	BOD Loading Per Capita (ppcd)	Maximum Month Peaking Factor	Maximum Week Peaking Factor	Maximum Day Peaking Factor
Minimum	0.12	1.1	1.2	1.4
Average	0.15	1.2	1.4	1.7
Maximum	0.19	1.3	1.7	2.4

TABLE 4.2.2-2
Historical Wet Weather BOD Loading Statistics
MWMC Facility Plan, Eugene-Springfield

Year	BOD Loading Per Capita (ppcd)	Maximum Month Peaking Factor	Maximum Week Peaking Factor	Maximum Day Peaking Factor
Minimum	0.11	1.1	1.3	1.5
Average	0.15	1.2	1.5	1.9
Maximum	0.23	1.6	1.9	2.4

Tables 4.2.2-3 and 4.2.2-4 present the historical dry and wet weather TSS per capita and peaking factor statistics, respectively.

TABLE 4.2.2-3
Historical Dry Weather TSS Loading Statistics
MWMC Facility Plan, Eugene-Springfield

Year	TSS Loading Per Capita (ppcd)	Maximum Month Peaking Factor	Maximum Week Peaking Factor	Maximum Day Peaking Factor
Minimum	0.17	1.1	1.2	1.6
Average	0.19	1.2	1.4	2.3
Maximum	0.20	1.4	1.8	4.0

TABLE 4.2.2-4
Historical Wet Weather TSS Loading Statistics
MWMC Facility Plan, Eugene-Springfield

Year	TSS Loading Per Capita (ppcd)	Maximum Month Peaking Factor	Maximum Week Peaking Factor	Maximum Day Peaking Factor
Minimum	0.18	1.1	1.3	2.0
Average	0.23	1.2	1.5	2.9
Maximum	0.26	1.6	2.0	4.3

4.3 Selected Design Factors

The selected per capita and peaking factor for flows and loads were chosen based on comparison of the results from the historical data analysis, the DEQ methodology, and best engineering judgment. Specific justification for the final selected values is presented in the *Flow and Load Projections* technical memorandum.

4.3.1 Wastewater Flows

Table 4.3.1-1 presents the selected design factors for flow.

TABLE 4.3.1-1
Selected Flow Per Capitas and Peaking Factors
MWMC Facility Plan, Eugene-Springfield

Seasonal Average Per Capita Values		
Parameter	**Dry Weather Value**	**Wet Weather Value**
Flow (gpcd)	129	229
Peaking Factor Values		
Flow Condition	**Dry Weather Value**	**Wet Weather Value**
Average	1.0	1.0
Maximum Month	1.5	1.6
Maximum Week	2.2	2.4
Maximum Day	3.2	3.3
Peak Hour	4.0	N/A

4.3.2 Wastewater Loads

Tables 4.3.2-1 and 4.3.2-2 present the selected design factors for BOD and TSS loading, respectively.

TABLE 4.3.2-1
Selected BOD Loading Per Capitas and Peaking Factors
MWMC Facility Plan, Eugene-Springfield

Seasonal Average Per Capita Values		
Parameter	**Dry Weather Value**	**Wet Weather Value**
CBOD (ppcd)	0.185	0.185
Peaking Factor Values		
Condition	**Dry Weather Value**	**Wet Weather Value**
Average	1.0	1.0
Maximum Month	1.3	1.3
Maximum Week	1.5	1.6
Maximum Day	2.0	2.3

TABLE 4.3.2-2
Selected TSS Loading Per Capitas and Peaking Factors
MWMC Facility Plan, Eugene-Springfield

Seasonal Average Per Capita Values		
Parameter	**Dry Weather Value**	**Wet Weather Value**
TSS (ppcd)	0.205	0.26
Peaking Factor Values		
Condition	**Dry Weather Value**	**Wet Weather Value**
Average	1.0	1.0
Maximum Month	1.4	1.3
Maximum Week	1.8	2.0
Maximum Day	2.5	3.0