

5. Estimate of Pollutant Loads and Required Load Reductions

LDC analyses for Plum Creek were performed for the 3 monitoring stations where water quality monitoring data are currently collected. These analyses indicate that *E. coli* bacteria loads exceeding regulatory limits occur across most flow conditions at all 3 of the monitored sites. In addition, some nutrients exceed desirable levels at selected locations. However, there are differences in trends at the individual monitoring stations with regard to the severity and timing of high bacteria and nutrient loads. These differences coincide with variations in flow patterns in the creek and with variations in land use across the Plum Creek Watershed (Figure 5.1). The following sections provide the results of analyses for bacteria and nutrients for each of the 3 monitoring stations in the Plum Creek Watershed.



Figure 5.1. Clear Fork at Lockhart State Park. Analysis by load duration curves indicates patterns and timing of pollutant loads in Plum Creek.

BACTERIA

Uhland Monitoring Station

In upstream portions of the watershed, as indicated by analysis of data from the monitoring station near Uhland (Figure 5.2), high *E. coli* loads occur across streamflows, with greatest loads during high flow and moist conditions. This indicates that both nonpoint and point sources are potential contributors of bacteria in the upper part of Plum Creek. A 65% reduction during moist conditions is required to bring the *E. coli* load in Plum Creek to acceptable levels in this area, while *E. coli* load reductions of about 51% and 26% are needed during mid-range and low flows, respectively. In dry periods, flow may be largely comprised of point source discharges, as there are few perennial stream inputs in this area of the watershed. Utilizing a conservative approach, a 65% *E. coli* load reduction will be the target in this section of the watershed.

Lockhart Monitoring Station

Although quarterly sampling at the Lockhart water quality monitoring station has resulted in fewer data points than the other 2 locations, results indicate that significant exceedences do occur, but these are mostly during dry conditions and low flow periods (Figure 5.3). As there is little surface runoff to carry pollutants from nonpoint sources under these conditions, these load values are likely due to direct deposition and point discharges. A 15% reduction in *E. coli* loads during dry conditions is needed to improve bacteria levels in the middle section of the watershed and will be utilized as the reduction target.

Luling Monitoring Station

The Luling monitoring station showed high bacteria loads during all flow conditions (high flows, moist conditions, mid-range flows, and dry conditions) in southern portions of Plum Creek (Figure 5.4). This trend is similar to what is shown by the Uhland monitoring station. While this segment of the stream is not currently listed as being impaired by either geometric mean or the grab sample method of water quality data analysis, high levels of bacteria inputs especially during runoff events should be addressed to prevent future increases and impairment of designated stream uses. Results of the LDC analysis indicate that a 41% reduction is needed during moist conditions, an 11% reduction during median flows, and an 8% reduction during dry conditions. Again, using a conservative approach to address current and potential future problems across all flow regimes, a 41% reduction in bacteria loading will be the target in this section of the watershed. A summary of the bacteria load reduction target for this and other monitoring stations can be found in Table 5.1.

Annual Loads and Load Reductions

The mean annual bacteria load (cfu/year) for each of the 3 monitoring stations and associated 95% confidence intervals are presented in Table 5.1. In addition, recommended load reductions and target loads for each station based on LDC analysis are given.

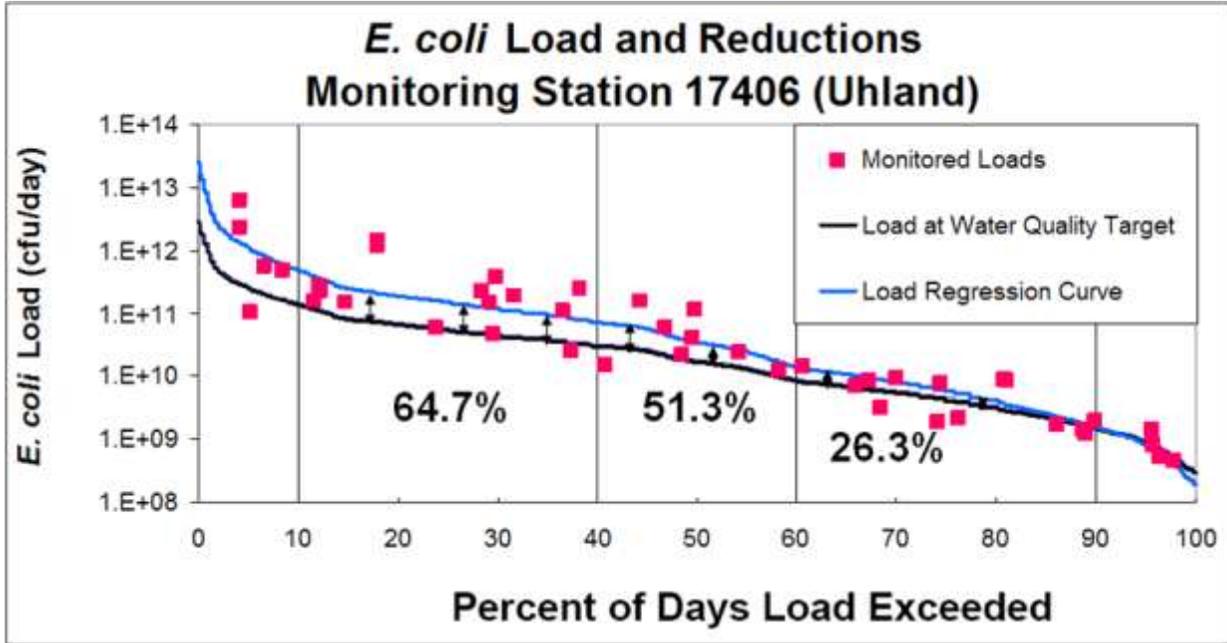


Figure 5.2. *E. coli* load duration curve for station 17406 near Uhland in Hays County.

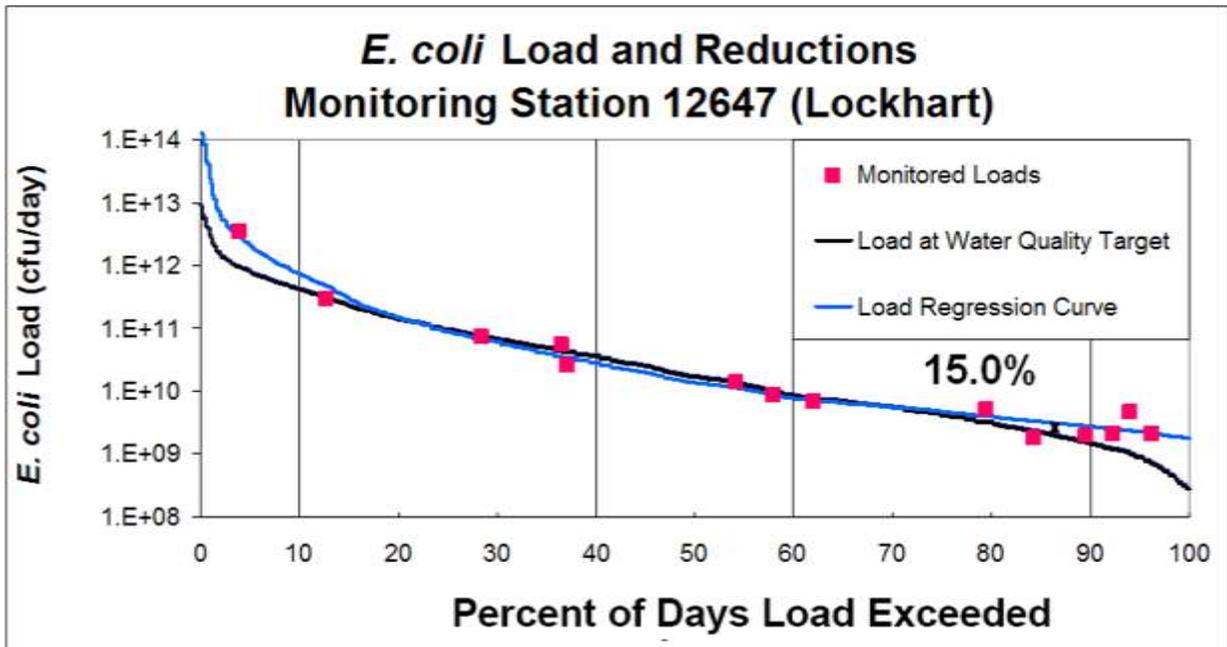


Figure 5.3. *E. coli* load duration curve for station 12647 near Lockhart in Caldwell County.

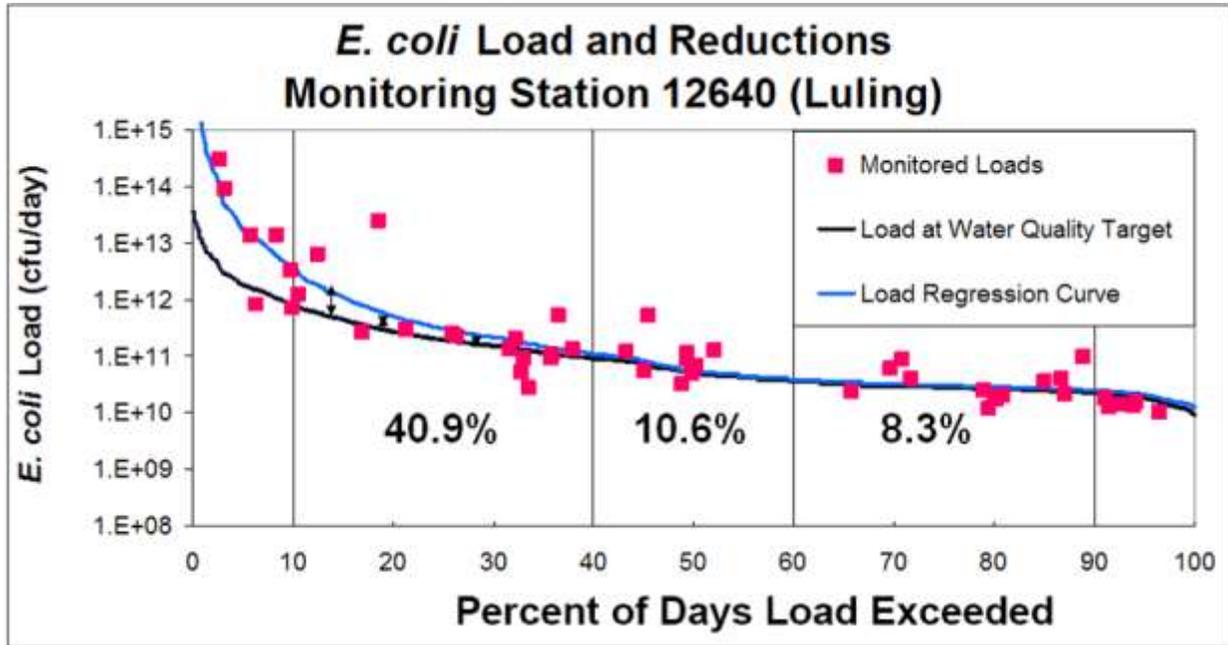


Figure 5.4. *E. coli* load duration curve for station 12640 near Luling in Caldwell County.

Table 5.1. Annual load characteristics and *E. coli* reductions for each station (in billions of cfu).

Monitoring Station	Mean Annual <i>E. coli</i> Load (cfu/year)	Minimum 95% CI ¹	Maximum 95% CI ¹	Load Reduction (cfu/year)	Target Load (cfu/year)
Uhland (17406)	1.12E+05	8.74E+04	1.36E+05	7.28E+04	3.92E+04
Lockhart (12647)	4.26E+05	2.46E+05	6.06E+05	6.39E+04	3.62E+05
Luling (12640)	3.02E+07	1.04E+07	5.01E+07	1.24E+07	1.78E+07

¹ The 95% confidence interval for minimum and maximum nutrient loads.

Bacteria Load Trends and Processes at Work

Table 5.2 presents a summary of the estimated average annual bacteria load categorized by flow condition for the 3 monitoring stations. The highest *E. coli* loads occur during periods of higher flow in Plum Creek, which include bankfull stages and floods (Figure 5.5). However, these events occur on average only 10% of the time. High flows occur in association with runoff events which carry high concentrations of bacteria, nutrients, and other pollutants from the surrounding landscape. Additionally, bacteria that are associated with sediments in Plum Creek may be stirred up and resuspended in the water column, contributing to the pollutant load during high flows. As a result, bacteria loads in Plum Creek may be elevated both by the increased concentrations of *E. coli* bacteria in surface runoff and the potential resuspension of bacteria in stream sediments. As flows and contributions from nonpoint sources decrease, point sources and direct deposition become dominant contributors in dry periods.

Table 5.2. Estimated average annual *E. coli* loads (in billions of cfu) under different flow conditions at each water quality station in Plum Creek.

Monitoring Station	Loading by Streamflow Condition				
	High Flows (cfu/year)	Moist Conditions (cfu/year)	Mid-Range Flows (cfu/year)	Dry Conditions (cfu/year)	Low Flows (cfu/year)
Uhland (17406)	8.83E+04	6.31E+03	1.39E+03	2.19E+02	3.65E+01
Lockhart (12647)	4.02E+05	5.77E+03	5.48E+02	5.48E+02	7.30E+01
Luling (12640)	2.93E+07	2.07E+04	2.26E+03	1.10E+03	7.30E+02

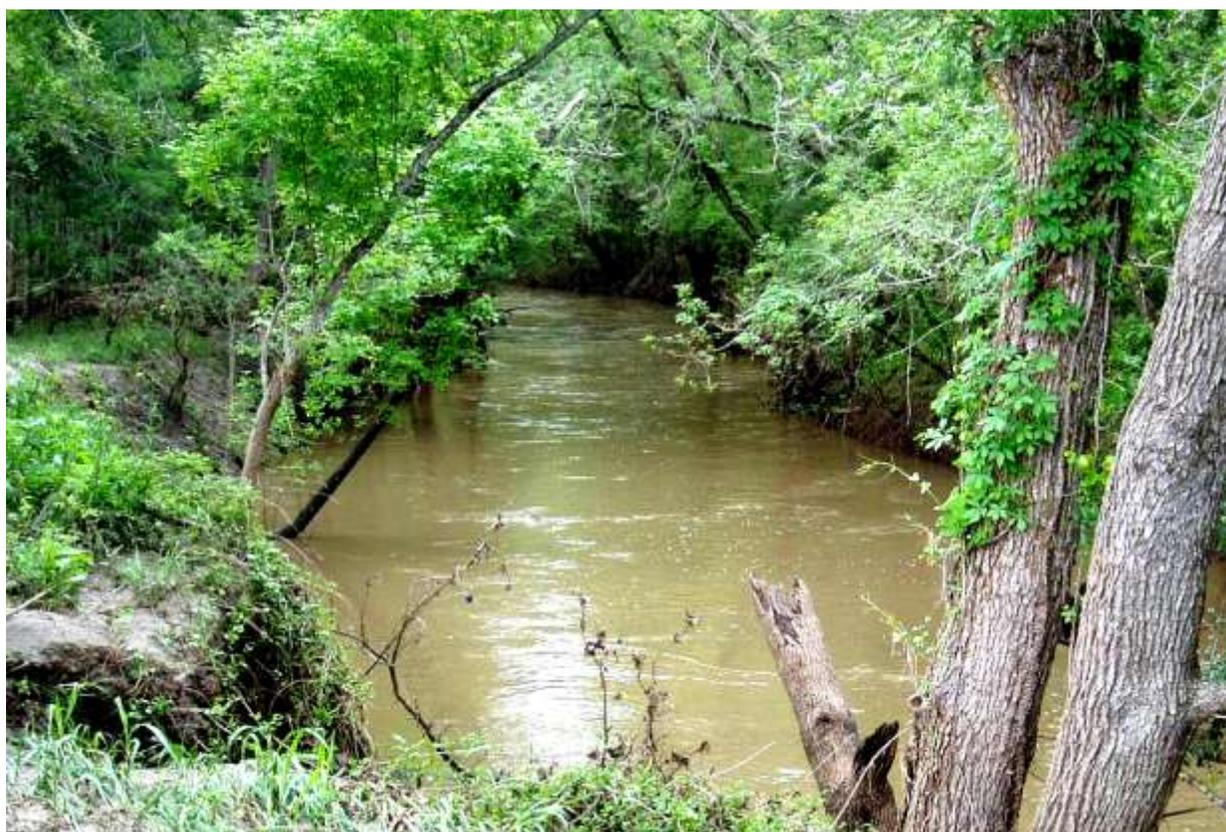


Figure 5.5. Plum Creek at bankfull stage. The highest loads of *E. coli* bacteria in Plum Creek typically occur during high flow conditions.

NUTRIENTS

Uhland Monitoring Station

The Uhland monitoring station reflects high nutrient levels that consistently exceed the TCEQ screening criteria during dry conditions (Figure 5.6). This may indicate a high level of background nitrates, contributions from point sources, or a combination of both factors. Optimally, nitrate concentrations should be reduced by 43% in this northern portion of the watershed. However, as described in the Management Measures section, contributions from natural sources of nitrate will affect implementation efforts. This portion of the watershed is not listed as having nutrient concerns for total phosphorus, and the majority of water quality samples collected at this location were below the target concentration for phosphorus (Figure 5.7). However, during dry conditions, many samples exceeded the target. As a result, a 27% reduction in the total phosphorus load at this site is necessary to be proactive in preventing the area from being listed in the future. Table 5.3 provides a summary of loading and reductions for nutrients at the Uhland monitoring station.

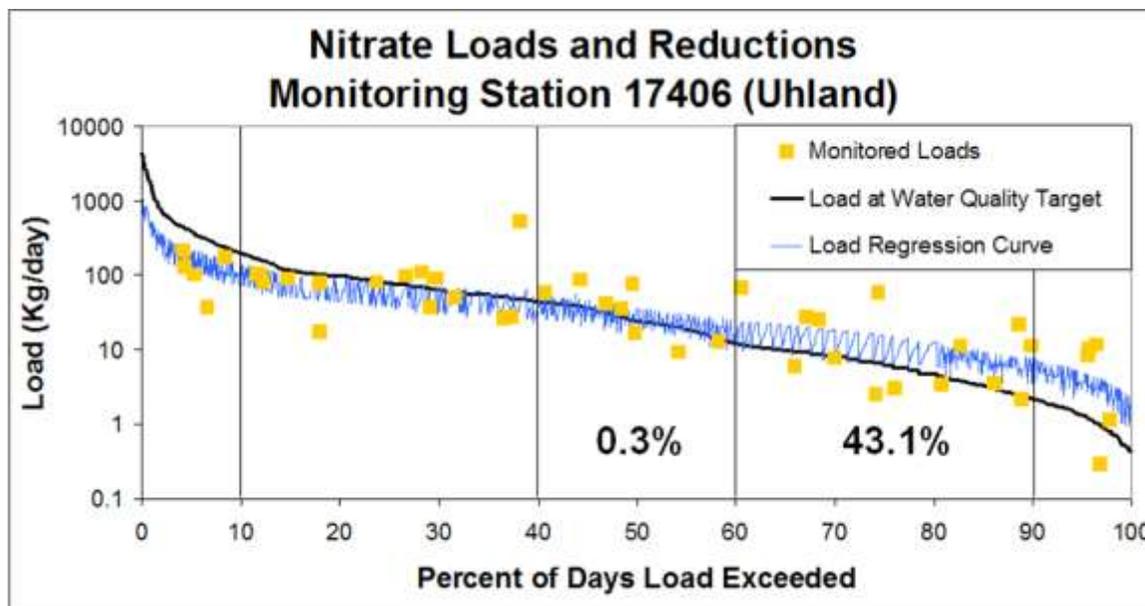


Figure 5.6. Nitrate load duration curve for station 17406 near Uhland in Hays County.

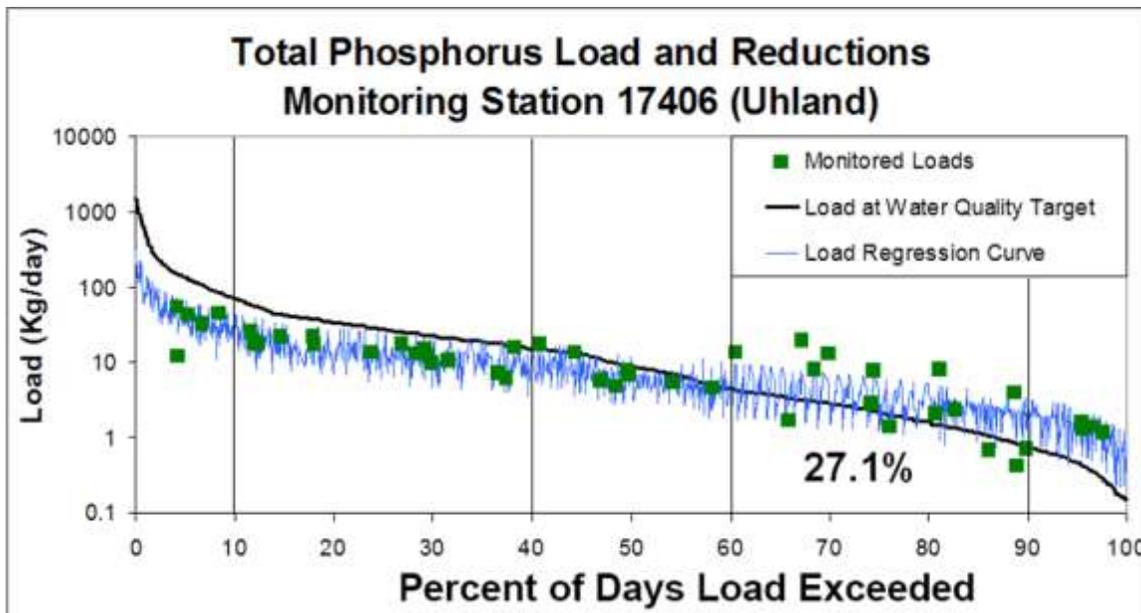


Figure 5.7. Total phosphorus load duration curve for station 17406 near Uhland in Hays County.

Table 5.3. Annual load characteristics and needed reductions for nutrients at the Uhland monitoring station.

Nutrient	Mean Annual Nutrient Load (kg/year)	Minimum 95% CI	Maximum 95% CI	Load Reduction (kg/year)	Target Load (kg/year)
Nitrate	18,062	16,581	19,543	7,767	10,295
Total P	4,425	4,082	4,768	1,195	3,230
Ortho P ¹	-	-	-	-	-

¹ Not monitored at this location.

Lockhart Monitoring Station

Based on sampling at the Lockhart monitoring station, the central portion of Plum Creek was listed as having nutrient concerns for nitrates. Nitrates exceeded the screening criteria during all but highest flows, with significant exceedences under dry conditions (Figure 5.8). An 18% reduction in nitrate loads is necessary during moist conditions to bring these nutrients to acceptable levels, and reductions of 66% and 80% are required for nitrates in mid-range flows and dry conditions, respectively. As a conservative measure, 80% will be the reduction target for nitrates in the central portion of the Plum Creek Watershed.

Water quality samples from the Lockhart monitoring station also resulted in nutrient concerns for both measures of phosphorus in that region. High levels of orthophosphorus and total phosphorus are most common during dry conditions, potentially indicating contributions from point sources and/or direct deposition. A 49% decrease in orthophosphorus and a 5% decrease in total phosphorus are necessary under dry conditions in order to meet water quality targets based on the nutrient screening criteria (Figures 5.9 and 5.10). Table 5.4 provides a summary of loading and reductions for nutrients at the Lockhart monitoring station.

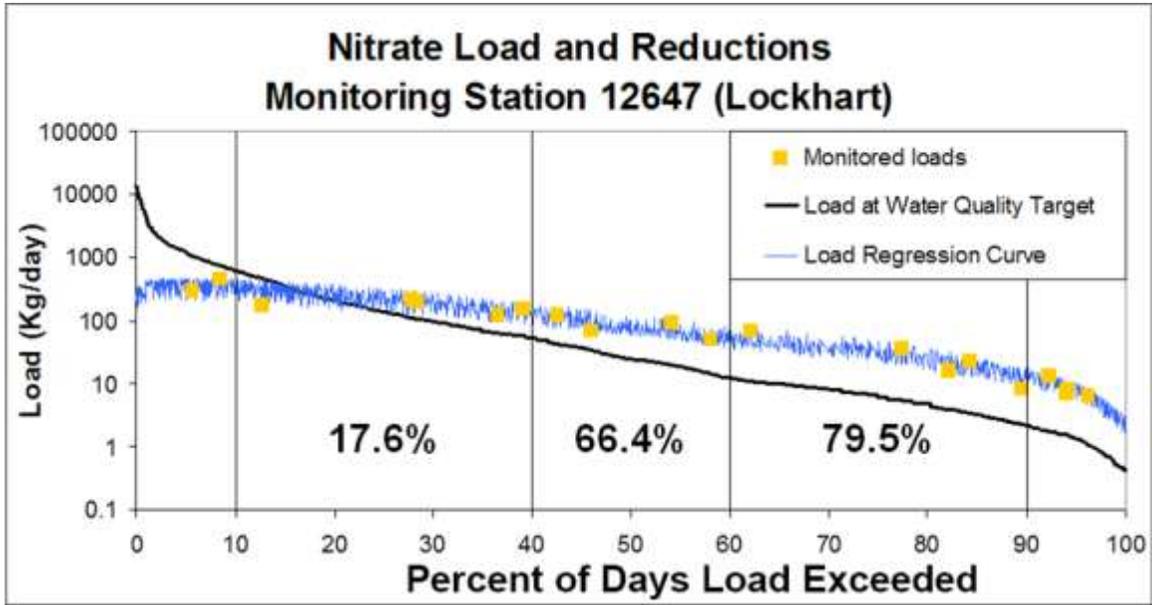


Figure 5.8. Nitrate load duration curve for station 12647 near Lockhart in Caldwell County.

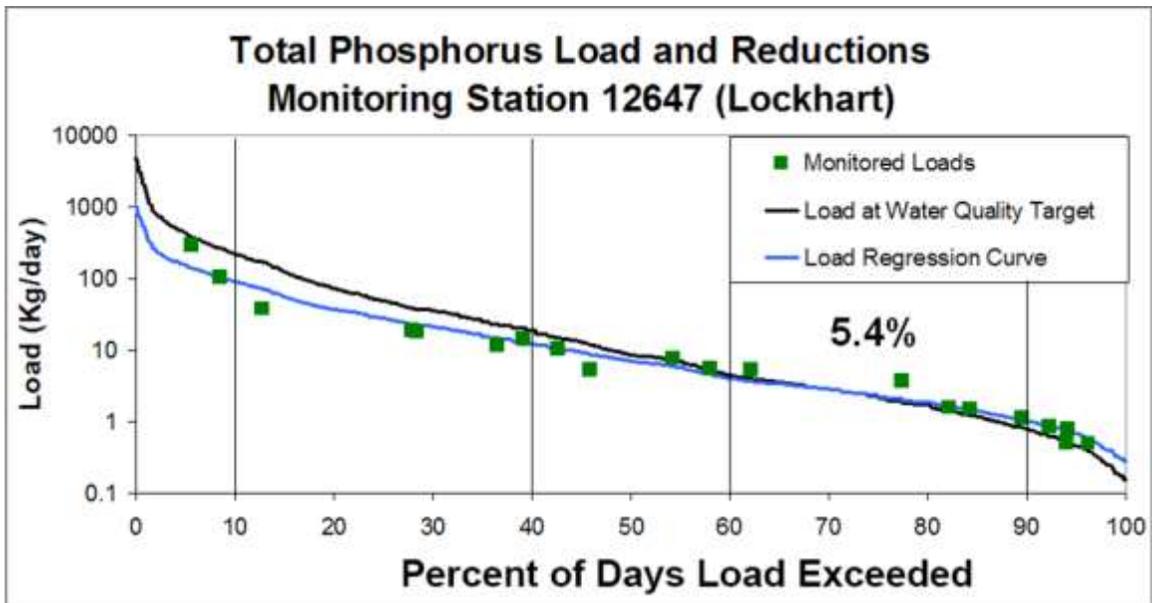


Figure 5.9. Total phosphorus load duration curve for station 12647 near Lockhart in Caldwell County.

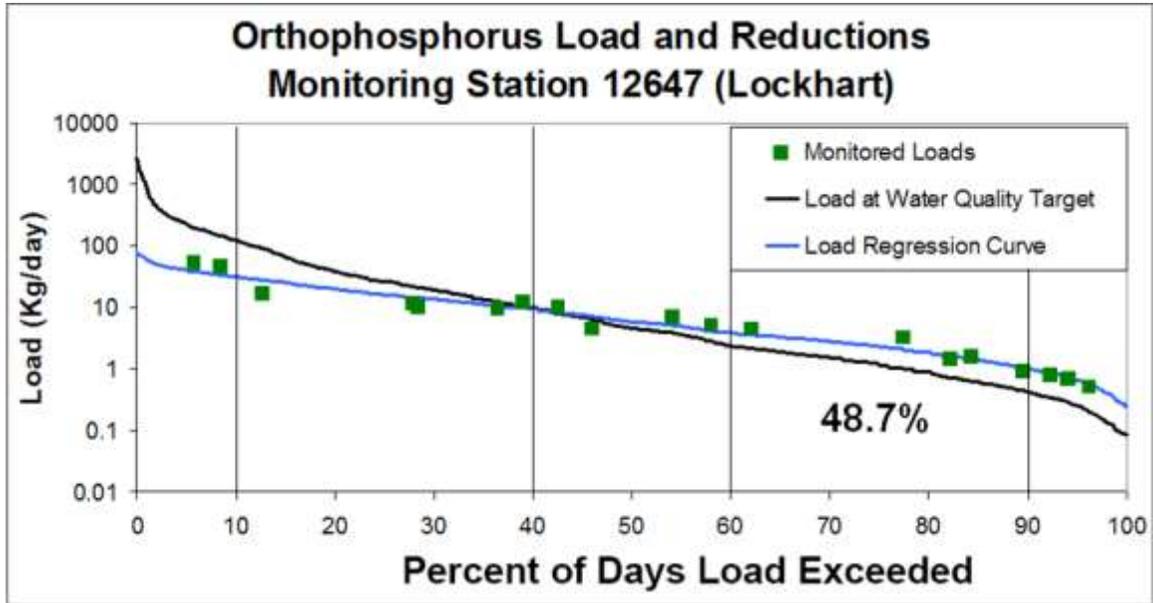


Figure 5.10. Orthophosphorus load duration curve for station 12647 near Lockhart in Caldwell County.

Table 5.4. Annual load characteristics and needed reductions for nutrients at the Lockhart monitoring station.

Nutrient	Mean Annual Nutrient Load (kg/year)	Minimum 95% CI	Maximum 95% CI	Load Reduction (kg/year)	Target Load (kg/year)
Nitrate	47,295	45,174	49,416	37,836	9,459
Total P	12,275	10,853	13,697	614	11,661
Ortho P	4,238	4,007	4,470	2,077	2,162

Luling Monitoring Station

As in other sections of Plum Creek, nitrate concerns exist in the southern portion of the watershed, based on water quality data from the Luling monitoring station. Though a number of individual samples exceed the state screening criteria at this site, the mean of all samples lies very near the target level for nitrate (Figure 5.11). As a result, only a 1% reduction in nitrate loads is required to meet water quality targets during dry conditions. Total phosphorus samples rarely exceed the nutrient screening criteria at this location, and the mean level of phosphorus is well below the target (Figure 5.12). As a result, no load reduction is required for phosphorus in the southern portion of the watershed. Table 5.5 provides a summary of loading and reductions for nutrients at the Luling monitoring station.

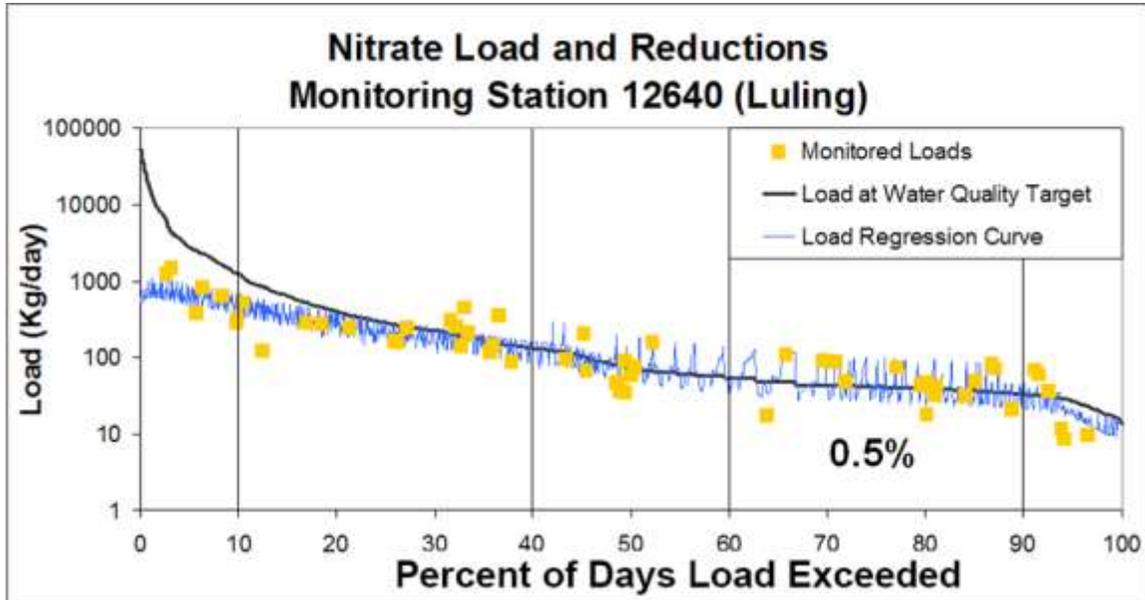


Figure 5.11. Nitrate load duration curve for station 12640 near Luling in Caldwell County.

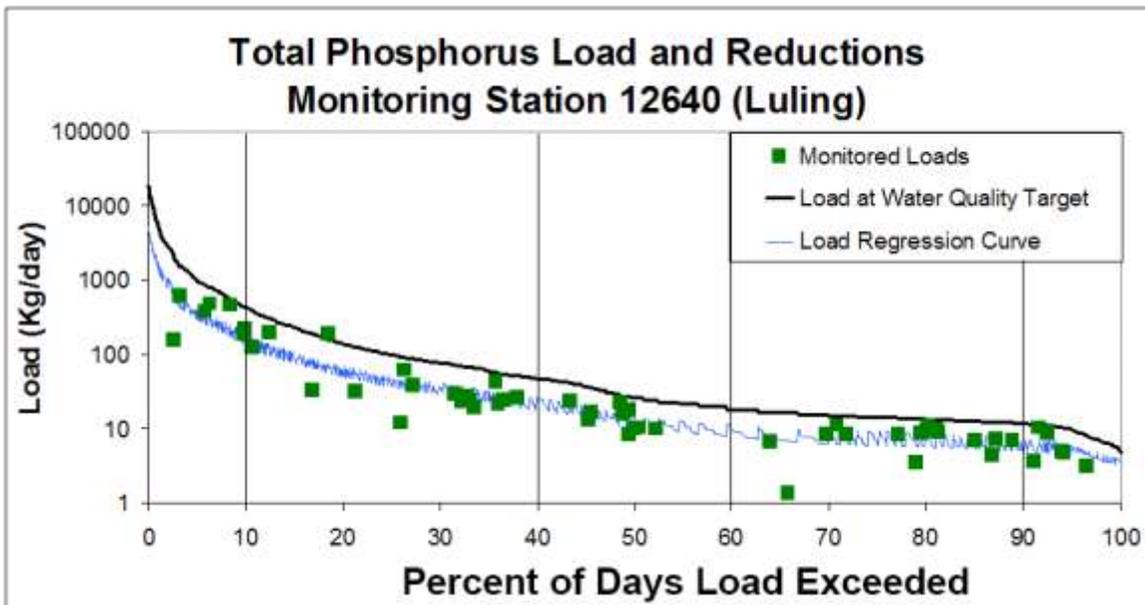


Figure 5.12. Total phosphorus load duration curve for station 12640 near Luling in Caldwell County.

Table 5.5. Annual load characteristics and needed reductions for nutrients at the Luling monitoring station.

Nutrient	Mean Annual Nutrient Load (kg/year)	Minimum 95% CI	Maximum 95% CI	Load Reduction (kg/year)	Target Load (kg/year)
Nitrate	63,738	60,290	67,185	637	63,100
Total P	32,000	26,485	37,516	0	32,000
Ortho P ¹	-	-	-	-	-

¹ Not monitored at this location.