WASHINGTON STATE DEPARTMENT OF ECOLOGY

Dungeness River and Matriotti Creek Post-Total Maximum Daily Load Data Review

Abstract

The Washington State Department of Ecology (Ecology) is required, under Section 303(d) of the federal Clean Water Act and U.S. Environmental Protection Agency (EPA) regulations, to develop and implement Total Maximum Daily Loads (TMDLs) for impaired waters and to evaluate the effectiveness of the water cleanup plan to achieve the needed improvement in water quality.

In July 2002, EPA approved several TMDLs for fecal coliform bacteria in streams in the Dungeness River basin. The TMDL package includes a *Water Cleanup Plan for Bacteria in the Lower Dungeness Watershed*. Since completion of the TMDL project, the Jamestown S'Klallam Tribe and Clallam County have continued to monitor selected TMDL sites to determine if fecal coliform bacteria levels are improving and if the actions implemented thus far from the water cleanup plan are effective. Ecology analyzed the post-TMDL data that the tribe collected and found significant improvements in bacteria levels in some areas.

Matriotti Creek fecal coliform levels have significantly improved. Several sites now meet the bacteria target levels set for the creek, and all sites monitored showed some improvement. The mouth of Matriotti Creek needs only a 38% further reduction in bacteria levels which is a significant improvement over the 78% reduction that was needed in the year 2000.

The Dungeness River does not yet meet TMDL targets, but improvements in fecal coliform levels were seen during the irrigation season at river mile 0.8. Improvements could be due to decreasing bacteria levels in Matriotti Creek.

Meadowbrook Creek fecal coliform concentrations have increased slightly since completion of the TMDL project, and the creek continues to not meet fecal coliform standards.

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Summary

During 1999, the Washington State Department of Ecology (Ecology), in cooperation with Jamestown S'Klallam Tribe and Clallam County, began conducting a Total Maximum Daily Load (TMDL) study on the lower portion of the Dungeness River and its tributaries, as well as tributaries to Dungeness Bay. The study was conducted in response to concerns about increasing bacteria levels in Dungeness Bay. Portions of Dungeness Bay were closed to shellfish harvest due to the high bacteria levels. After the study was completed, a water cleanup plan to control bacterial pollution was developed. The purpose of this report is to assess the progress toward cleanup of bacterial sources in the lower Dungeness watershed.

The Jamestown S'Klallam Tribe and Clallam County have continued fecal coliform bacteria monitoring at selected TMDL sites on a monthly basis (Figure 1). This report analyzes the tribal and county data to determine if improvements in bacteria levels have occurred in the Dungeness area.

Data analysis shows that Matriotti Creek has made dramatic improvements in fecal coliform levels since the TMDL study was completed in the year 2000. Several sites meet the bacteria target levels set for the creek, and all sites monitored show some improvement. The highest levels of bacteria continue to be seen during the irrigation season (April 15 – October 15). Local efforts to improve water quality should be commended.

In order to meet the TMDL bacteria target, more effort is needed. While TMDL target bacteria levels are being met upstream in Matriotti Creek at river mile 4.8, they are not being met downstream at river mile 1.9. Downstream improvements in bacteria levels are still needed during the irrigation season. Significant improvements in bacteria levels are seen between river mile 0.7 and 0.3, but more improvements are needed to meet the bacteria TMDL targets. At the mouth of Matriotti Creek, a 38% reduction in bacteria levels is needed to meet TMDL targets. This is a significant improvement over the 78% reduction needed four years ago.

Dungeness River currently does not meet TMDL bacteria target levels, but improvements in fecal coliform levels are seen during the irrigation season at river mile 0.8. Improvements could be due to decreasing bacteria levels in Matriotti Creek. Bacteria levels near the mouth of the Dungeness River at river mile 0.2 continue to remain about the same.

Meadowbrook Creek showed slightly increasing levels of fecal coliform concentrations since the TMDL study was completed and still does not meet fecal coliform standards.

Recommendations to improve bacteria levels include:

- For all areas, continue to implement actions recommended in the *Clean Water Strategy for Addressing Bacteria Pollution in the Dungeness Bay and Watershed* and *Water Cleanup Detailed Implementation Plan* (Streeter and Hempleman, 2004).

- Continue monthly monitoring at all sites, and include the following additional sites to help locate pollution sources:
    - Add a Dungeness River site above Matriotti Creek inflow to investigate the possibility of additional irrigation season sources.
    - Add monitoring stations between Matriotti Creek river miles 4.8 and 1.9 and on Mudd Creek to determine locations of pollution sources
    - Add upstream monitoring stations on Meadowbrook Creek to determine locations of pollution sources.
- Monitoring should include flow discharge measurements so that fecal coliform loading can be calculated, especially at the mouth of Matriotti Creek.
- Identify sources of bacteria between Matriotti Creek river miles 0.7 and 0.3. This should include some kind of bacterial source tracking technique.

Introduction

The Washington State Department of Ecology (Ecology) is required, under Section 303(d) of the federal Clean Water Act and U.S. Environmental Protection Agency (EPA) regulations, to develop and implement Total Maximum Daily Loads (TMDLs) for impaired waters and to evaluate the effectiveness of the water cleanup plan to achieve the needed improvement in water quality.

In 2002, EPA approved the Dungeness River and Matriotti Creek TMDL package (Sargeant, 2002) for fecal coliform bacteria. Bacteria sampling for the TMDL was conducted from November 1999 through October 2000. Sampling included sites on the Dungeness River and Matriotti, Hurd, Meadowbrook, and Cooper creeks. The Jamestown S'Klallam Tribe and Clallam County have continued fecal coliform bacteria monitoring at selected TMDL sites on a monthly basis (Figure 1). In addition, Ecology's Environmental Assessment Program has an ambient monitoring station at Dungeness River mile 0.8.

At the request of the Ecology's Southwest Regional Office Water Quality Program and the Jamestown S'Klallam Tribe, Ecology's Environmental Assessment Program reviewed post-TMDL data collected by the Jamestown S'Klallam Tribe. This report assesses the effectiveness of the TMDL implementation program outlined in the *Water Cleanup Plan for Bacteria in the Lower Dungeness Watershed* (Hempleman and Sargeant, 2002) and the progress toward cleanup of bacterial sources.

Study Area

Dungeness River is located in the northeast corner of the Olympic Peninsula and is the major freshwater tributary to Dungeness Bay. The river is 32 miles long and drains 172,517 acres. The upper two-thirds of the watershed is national forest and national park. The lower 13-mile stretch of river flows through mostly private land. The Dungeness River emerges through the foothills at about river mile (RM) 10 to the relatively flat Dungeness valley.

The area climate is mild because it lies in the rain shadow of the Olympic Mountains and close to the Strait of Juan de Fuca and the Pacific Ocean. Annual precipitation varies from 15 inches near Sequim to 80 inches in the headwaters of the Dungeness River.

Due to the low rainfall, the lower Dungeness valley contains an extensive irrigation system to support agricultural crops in the valley. The irrigation land system begins with five diversions from the river between RM 11.1 and 6.7. The irrigation ditch system includes about 270 kilometers of ditches; return flow from some of the irrigation ditches discharges back to the river near the mouth and directly to the inner bay (Rensel, 2003). During the non-irrigation season, the irrigation ditches may also convey stormwater. Flows in both Matriotti and Meadowbrook creeks are augmented as a result of irrigation and ditch leakage, and directly from ditch tailwaters and stormwater.

The TMDL study and post-TMDL monitoring focuses on the Dungeness River and its tributaries below RM 3.2 (north of the Highway 101 bridge). Major tributaries to the river in this stretch include Matriotti Creek and Hurd Creek. Meadowbrook Creek, a tributary to Dungeness Bay, is also included in the TMDL and follow-up monitoring. Meadowbrook Creek is a small tributary that enters the bay to the east of the Dungeness River. Land uses in the area are described in the Dungeness River and Matriotti Creek TMDL Study (Sargeant, 2002).

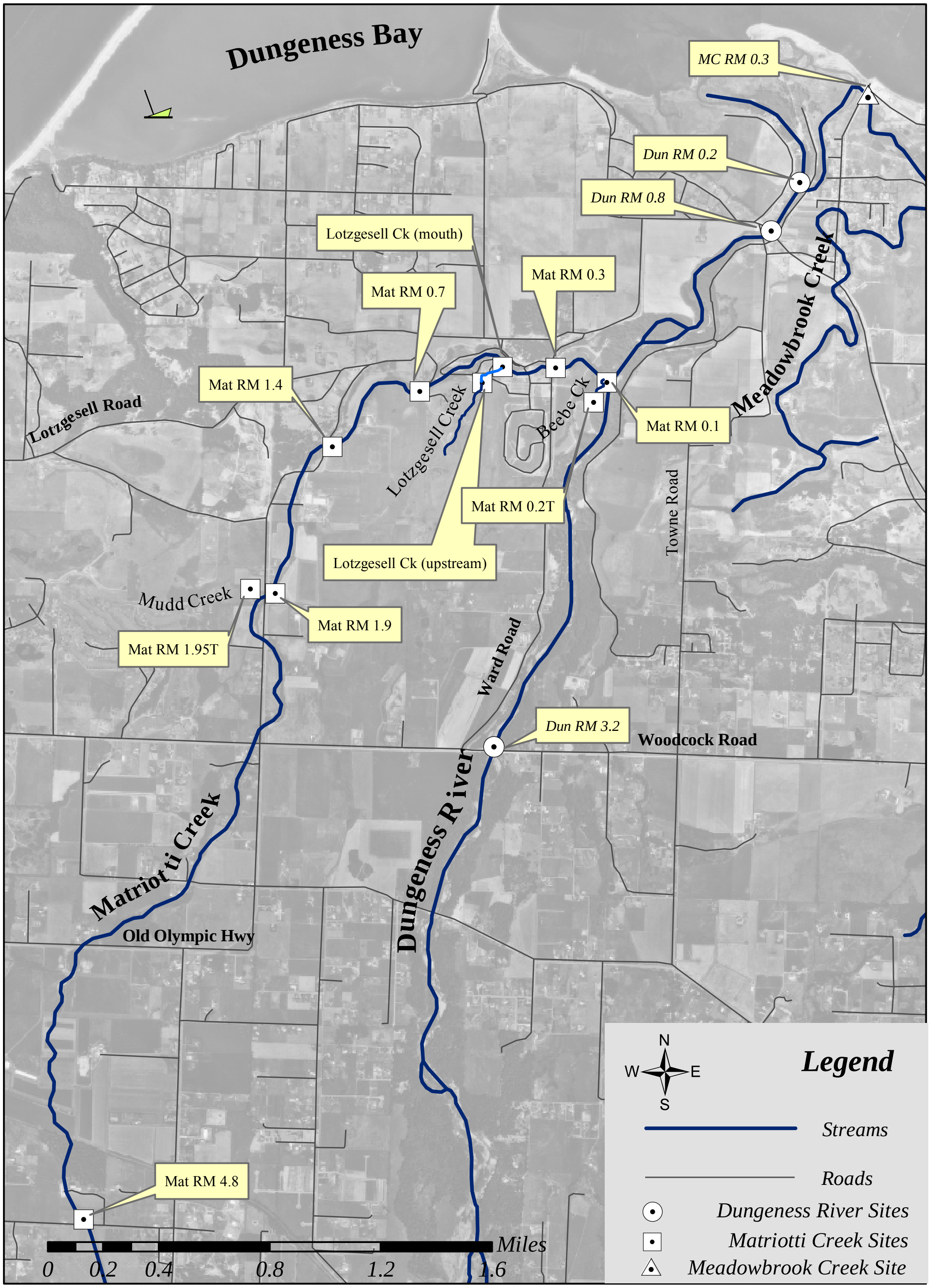

Figure 1. Dungeness River and Matriotti Creek Post TMDL Monitoring Sites

Data Analysis

Fecal coliform data from Ecology's TMDL study (November 1999 - October 2000), local data (November 2000 - May 2004), and Ecology's ambient data for Dungeness RM 0.8 (October 2000 - May 2004) were used in data analysis for this review. Ecology uses the membrane filter (MF) method for fecal coliform analysis. The majority of the post-TMDL fecal coliform samples were analyzed by the Clallam County Laboratory using the MF method. Occasional samples were analyzed by the state Department of Health Laboratory using most probable number (MPN) analysis for fecal coliform. All data collected were used for data analysis. Field duplicates results were arithmetically averaged for data analysis.

For select sites, irrigation and non-irrigation season data were analyzed separately. The irrigation period is April 15 through October 15, with the non-irrigation period being the remainder of the year.

Post-TMDL data were available for several sites on Matriotti Creek, the Dungeness River, and Meadowbrook Creek at RM 0.3. Data for these sites were analyzed using Excel® spreadsheet software for descriptive statistical analysis and paired t-tests to determine differences in water quality between sites. A non-parametric Seasonal Kendall Trend test was used to determine statistically significant trends at each site using the statistical analysis program WQHYDRO (Aroner, 2001). To determine trend significance, a two-tailed test with a significance level of 0.10 was used. A significance level (α, or alpha) of 0.10 (alternately known as a confidence level of 90%) indicates (for a two-tailed test) that a 0.05 maximum probability of error is acceptable to conclude that a significant increasing or decreasing trend exists (for an overall error potential of 10%).

It is important to determine if trends, whether decreasing or increasing, are statistically significant. In statistics, "significant" means the trend is probably true and not due to chance. If a confidence level of 90% is used, the findings have a 90% chance of being true or a 10% chance of not being true.

In this report, fecal coliform bacteria (FC) data are presented graphically by time and station through the use of box plots. A box plot gives a graphical display of the distribution of the data. The box contains all data between the 10th and 90th percentiles, and the horizontal line within the box represents the geometric mean (Figure 2). The lines extending above and below the box represent the minimum and maximum fecal coliform values, and indicate the data's overall range.

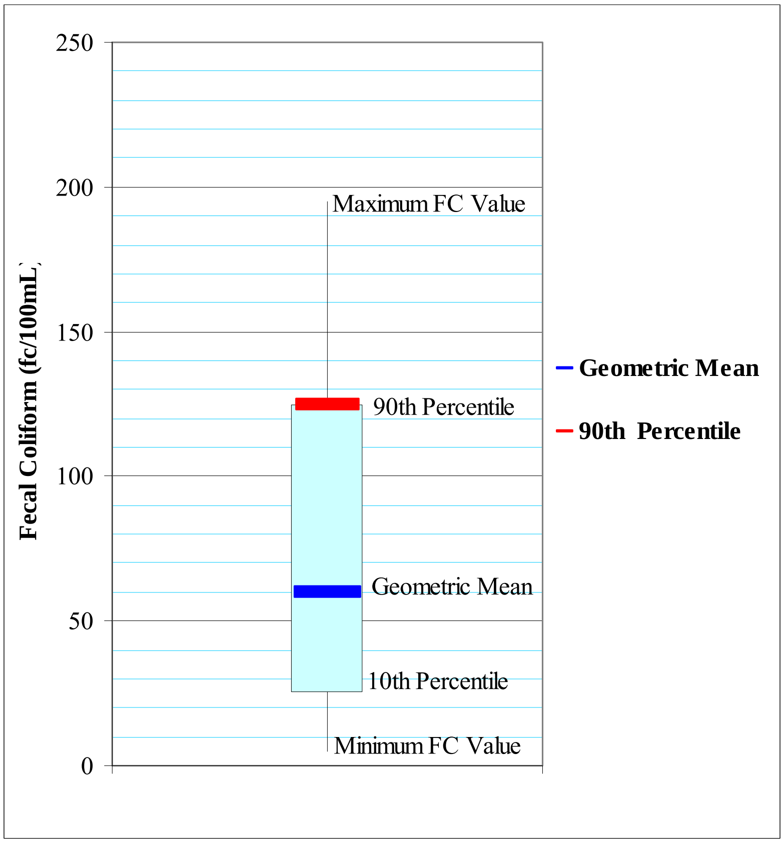

Figure 2. Box Plot Diagram.

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Results

Dungeness River

The TMDL study calls for a geometric mean fecal coliform (fc) bacteria target of 13 fc/100mL and a 90^{th} percentile of 43 fc/100mL for the Dungeness River from RM 3.2 downstream to 0.2. For the period of TMDL sampling, the Dungeness River at RM 3.2 met the TMDL fecal coliform target.

Table 1 presents the geometric mean and 90^{th} percentile for Dungeness River sites for the period of the TMDL (November 1999 - October 2000), the past two years (April 2002 - May 2004), and all five years of data (November 1999 - May 2004).

Table 1. Summary of Dungeness River Fecal Coliform Data for the TMDL Period, the Most Recent Two Years, and All Data.

Site and monitoring period	Significant trend present?*	Geometric mean (target = 13 fc/100mL)	90th percentile (target = 43 fc/100mL)	Number of samples (n)	Meets TMDL target?
RM 3.2					
TMDL (Nov 99-Oct 00)		5	26	18	Yes
Recent 2 Yrs (Apr 02-May 04)		4	24	23	Yes
All (Nov 99-May 04)	No trend	4	19	57	
RM 0.8					
TMDL (Nov 99-Oct 02)		18	82	18	No
Recent 2 Yrs (Apr 02-May 04)		10	55	45	No
All (Nov 99-May 04)	No trend	11	58	95	
RM 0.2					
TMDL (Nov 99-Oct 02)		15	47	18	No
Recent 2 Yrs (Apr 02-May 04)		12	54	21	No
All (Nov 99-May 04)	No trend	11	46	73	

* To determine if a trend in bacteria levels exists, all data, including TMDL data, were used for analysis.

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At the most upstream TMDL site, Dungeness RM 3.2, the Seasonal Kendall trend test results show no significant trend toward increasing or decreasing bacteria levels from November 1999 through May 2004. This site continues to meet the TMDL targets set for the mouth (Figure 3).

At both Dungeness RM 0.8 and 0.2, there is also no statistically significant trend toward increasing or decreasing bacteria levels from November 1999 through May 2004. Fecal coliform monitoring is conducted at Dungeness RM 0.8 by Ecology's Environmental Assessment Program and the Jamestown S'Klallam Tribe; consequently, there are more data available for this site. Summary data in Table 1 for Dungeness RM 0.8 show that, while there is no statistically significant decrease in fecal coliform levels since the TMDL, decreases in bacteria levels can be seen. This may be an improvement in fecal coliform levels or an artifact of the larger sample size.

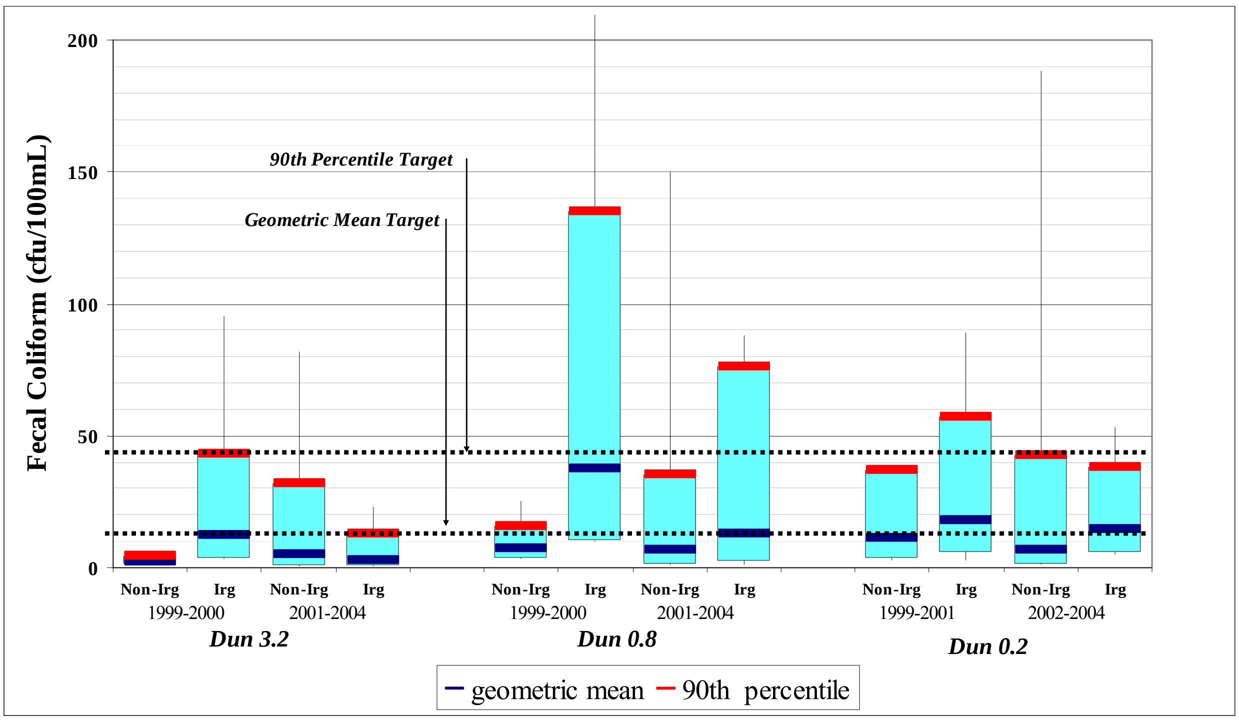

Figure 3. Dungeness River Irrigation and Non-Irrigation Season Fecal Coliform Data for the TMDL and the Most Recent Two-Year Period of Data (2002-2004).

Sites at Dungeness RM 0.8 and 0.2 do not meet the TMDL fecal coliform target for the irrigation season (Figure 3). Dungeness River at RM 3.2 continues to meet the TMDL target for fecal coliform bacteria. During the non-irrigation season, increasing concentrations of bacteria are seen from upstream to downstream. For the irrigation season, bacteria concentrations increase from RM 3.2 to 0.8 and decrease from RM 0.8 to 0.2.

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Matriotti Creek

The TMDL study calls for a geometric mean fecal coliform (fc) bacteria target of 60 fc/100mL and a 90th percentile of 170 fc/100mL for Matriotti Creek and its tributaries. Matriotti Creek data analysis included the following sites: Matriotti Creek at RM 0.1, 0.3, 0.7, 1.4, 1.9, and 4.8. Tributary (t) sites included the mouth of Beebe Creek (RM 0.2t), Lotzgesell Creek (RM 0.6t), and Mudd Creek (RM 1.95t).

Table 2 presents the geometric mean and 90th percentile for Matriotti Creek sites for all the data, during the past two years (including two irrigation and non-irrigation periods), and during the TMDL period (November 1999 - October 2000). Note that the past two-year, data-analysis time period differs between sites; this is due to different data sets and monitoring periods available for analysis.

At Matriotti RM 4.8, there is no significant trend toward increasing or decreasing bacteria levels from November 1999 through May 2004. TMDL data (1999-2000) for this site met the bacteria targets set in the TMDL. To determine if this site still meets standards, the most recent two years of irrigation and non-irrigation season data were examined (October 2001-May 2004). During this period, the site continued to meet the TMDL target values (Table 2).

Table 2. Summary of Matriotti Creek Fecal Coliform Data for the TMDL Period (Nov 1999 - Oct 2000), and the Most Recent Two Years (as noted), and All Data (as noted).

Site and monitoring period	Significant trend present?*	Geometric mean (target = 60 fc/100mL)	90th percentile (target = 170 fc/100mL)	Number of samples (n)	Meets TMDL targets?
RM 4.8					
TMDL (Nov 99-Oct 00)		21	160	18	Yes
Recent (Oct 01-May 04)		14	64	20	Yes
All (Nov 99-May 04)	No trend	18	111	44	
RM 1.95t (Mudd Creek)					
TMDL (Nov 99-Oct 00)		239	1613	18	No
Recent (Apr 02-May 04)		74	353	24	No
All (Nov 99-May 04)	Statistically significant Improving trend	116	683	58	
RM 1.9					
TMDL (Nov 99-Oct 00)		124	602	18	No
Recent (Apr 02-May 04)		65	268	24	No, due to irrigation season levels
All (Nov 99-May 04)	No trend	83	372	58	
RM 1.4					
TMDL (Nov 99-Oct 00)		129	563	18	No
Recent (Oct 01-Apr 04)		53	169	19	No, due to irrigation season levels **
All (Nov 99-Apr 04)	Statistically significant Improving trend	93	376	48	
RM 0.7					
TMDL (Nov 99-Oct 00)		113	607	18	No
Recent (Oct 01-Apr 04)		31	134	21	Yes
All (Nov 99-Apr 04)	Statistically significant Improving trend	55	267	52	
0.6t (Lotzgesell upstream)					
TMDL (Nov 99-Oct 00)		42	238	18	No
Recent (Oct 01-July 03)		19	80	21	Yes
All (Nov 99-July 03)	No trend	27	121	49	
Mouth of Lotzgesell					
TMDL	Not sampled				
Recent (Apr 02-May 04)		54	173	24	Yes
All (Nov 00-May 04)	No trend	47	152	40	Yes

Site and monitoring period	Significant trend present?*	Geometric mean (target = 60 fc/100mL)	90th percentile (target = 170 fc/100mL)	Number of samples (n)	Meets TMDL targets?
RM 0.3					
TMDL (Nov 99-Oct 00)		599	2350	18	No
Recent (Apr 02-May 04)		142	439	23	No
All (Nov 99-May 04)	Statistically significant Improving trend	209	929	59	
RM 0.2t (Beebe Creek)					
TMDL (Nov 99-Oct 00)		40	266	17	No
Recent (Oct 01-July 03)		19	80	21	Yes
All (Dec 99-July 03)	Statistically significant Improving trend	26	124	48	
RM 0.1					
TMDL (Nov 99-Oct 00)		279	783	18	No
Recent (Apr 02-May 04)		68	276	25	No
All (Nov 99-May 04)	Statistically significant Improving trend	110	496	60	

* To determine if a trend in bacteria levels exists, all data including TMDL data were used for analysis.
** While this site met the TMDL target 90th percentile, > 10% of the samples exceeded 170 fc/100 mL.

The mouth of Mudd Creek at Matriotti RM 1.95t showed a statistically significant trend toward decreasing fecal coliform levels (Figure 4). The lower dashed line represents the geometric mean fecal coliform target, and the upper line represents the 90th percentile target. Mudd Creek did not meet TMDL targets set during TMDL sampling and still does not meet the TMDL target set for this creek, although it is getting closer (Table 2).

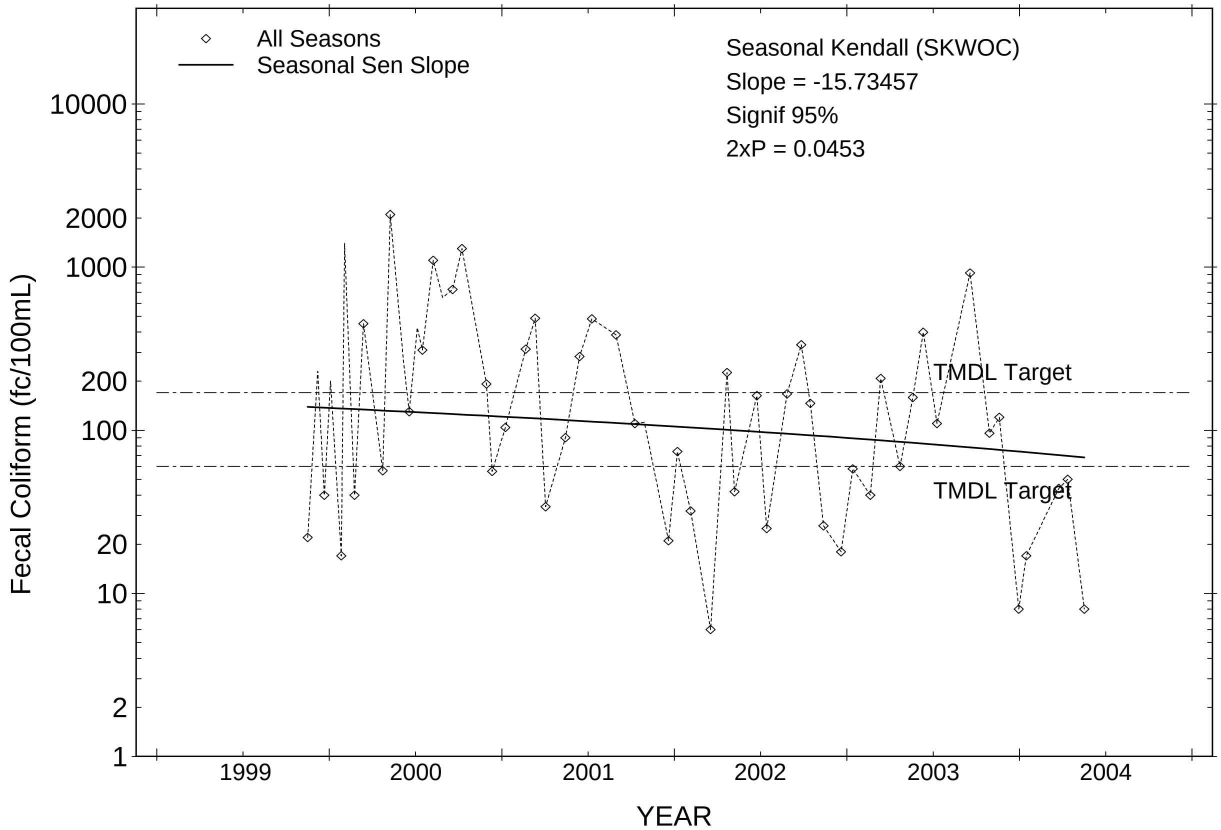

Figure 4. A Seasonal Kendall Trend Test Shows Significant Decreases In Fecal Coliform Levels on Mudd Creek, a Tributary to Matriotti Creek at RM 1.95t.

Matriotti Creek at RM 1.9 showed no significant trends toward increasing or decreasing fecal coliform levels. Data presented in Table 2 show that the geometric mean and 90th percentile fecal coliform values have decreased since the TMDL sampling. During both the TMDL sampling and for the most recent two years of sampling, this site did not meet the TMDL target for Matriotti Creek. This site currently meets the geometric mean target but does not yet meet the 90th percentile part of the criterion.

Matriotti Creek at RM 1.4 showed a statistically significant trend toward decreasing fecal coliform levels (Figure 5). During both the TMDL for the most recent two years of sampling, this site did not meet the TMDL target for Matriotti Creek, but Table 2 shows that bacteria levels have significantly improved since the TMDL sampling.

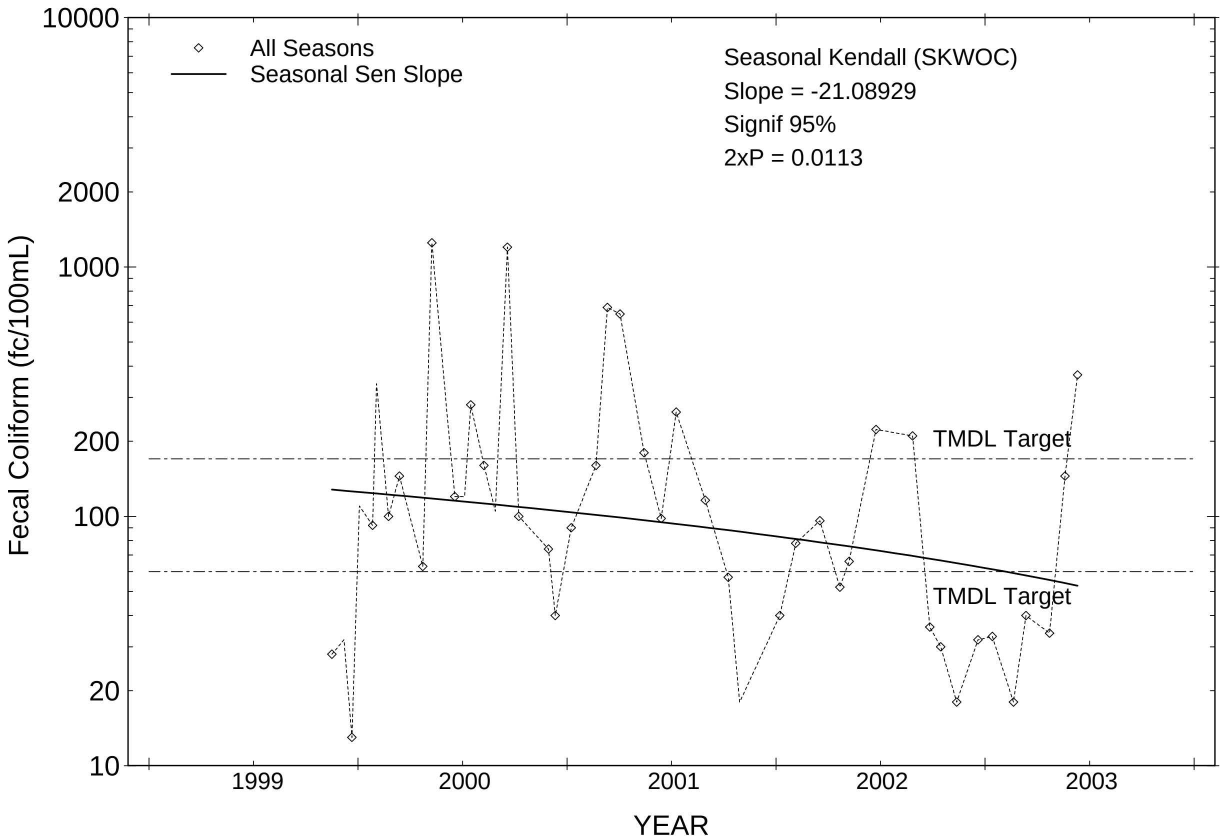

Figure 5. A Seasonal Kendall Trend Test Shows Significant Decreases in Fecal Coliform Levels at Matriotti Creek RM 1.4.

Matriotti Creek at RM 0.7 showed a statistically significant trend toward decreasing fecal coliform levels (Figure 6). Data for this site are available until September 2003. For the last two years of sampling, this site met the TMDL target set for Matriotti Creek. During the TMDL study, this site did not meet the TMDL target.

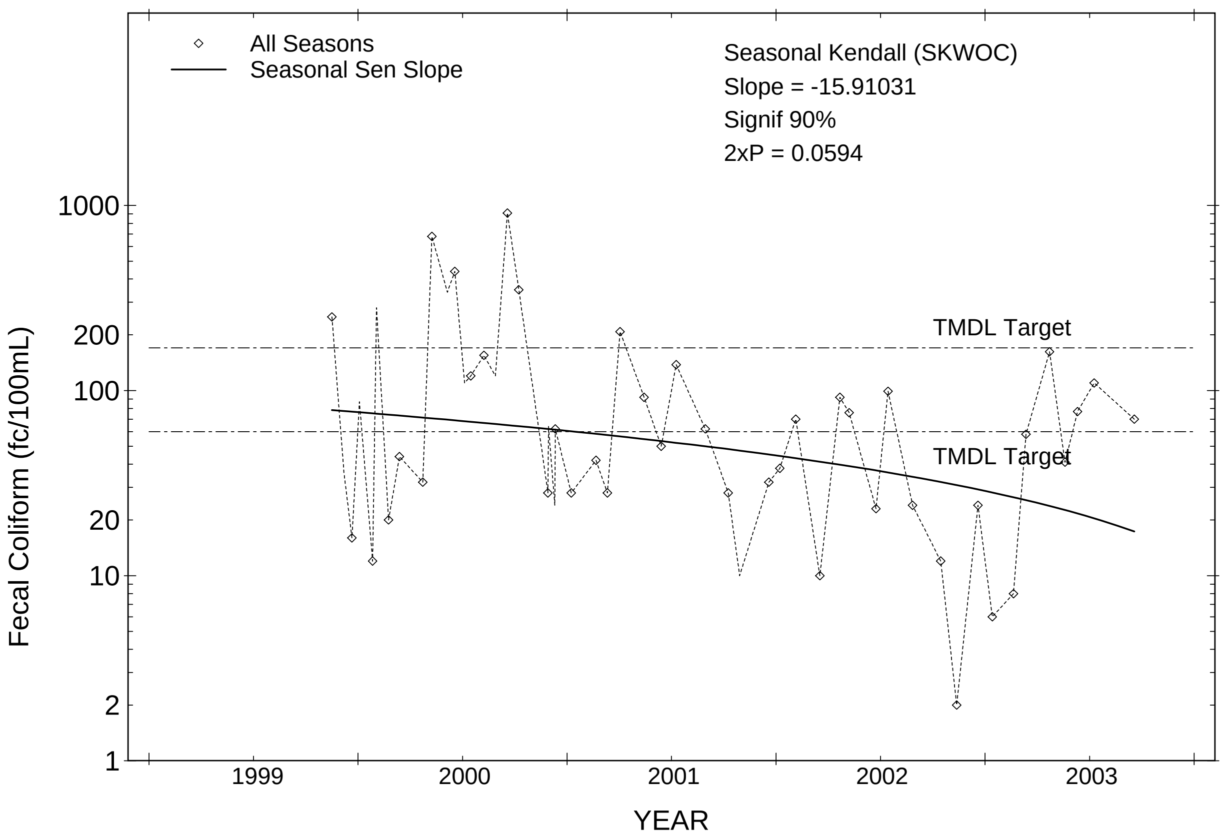

Figure 6. A Seasonal Kendall Trend Test Shows Significant Decreases in Fecal Coliform Levels at Matriotti Creek RM 0.7.

Lotzgesell Creek is a tributary to Matriotti Creek at RM 0.6. At the upstream Lotzgesell Creek site, identified as Mat0.6t in the TMDL, there have been improvements in bacteria levels but not statistically significant. Data for this site are available only through July 2003. For the last two years of sampling, this site met its target, in contrast to during the TMDL study when it did not meet the target.

After the TMDL study was completed, a site at the mouth of Lotzgesell Creek was added (LOTZBEAR), due to high fecal coliform levels between Matriotti Creek RM 0.7 and 0.3. Sampling started in November 2000 and continued through May 2004. A trend test for the mouth site showed no significant decreases or increases in bacteria levels. For the sampling period, this site met the TMDL target.

Matriotti Creek at RM 0.3 showed statistically significant improvement in fecal coliform levels (Figure 7). Table 2 shows that the geometric mean and 90th percentile fecal coliform values have decreased since the TMDL sampling. During both the TMDL and post-TMDL sampling, this site had some of the highest bacteria levels on Matriotti Creek. While this site still does not meet the TMDL target for the most recent two years of sampling, bacteria levels have greatly improved.

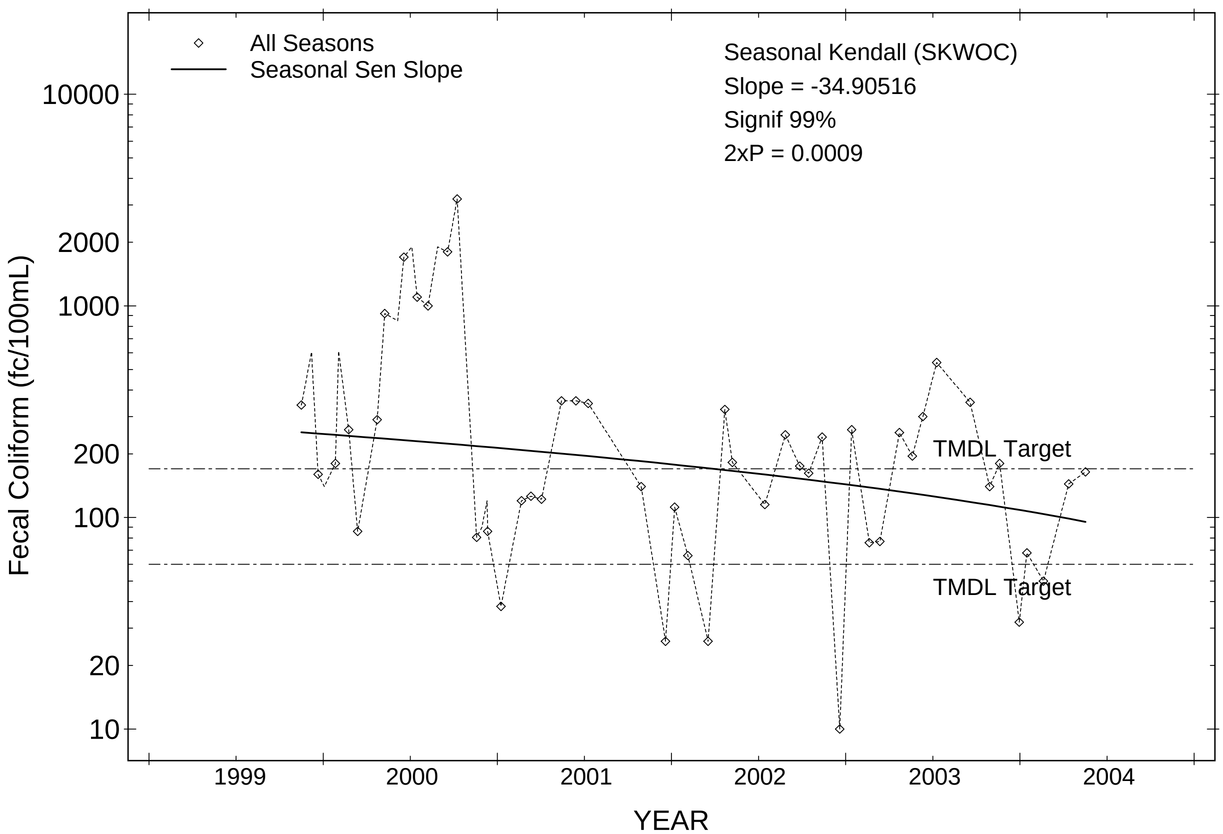

Figure 7. A Seasonal Kendall Trend Test Shows Significant Decreases in Fecal Coliform Levels at Matriotti Creek RM 0.3.

At the mouth of Beebe Creek, a tributary to Matriotti Creek at RM 0.2, there is a statistically significant decrease in bacteria levels (Figure 8). Data for this site are available through July 2003. For the last two years of sampling, this site met the TMDL target, in contrast to during the TMDL study period when it did not.

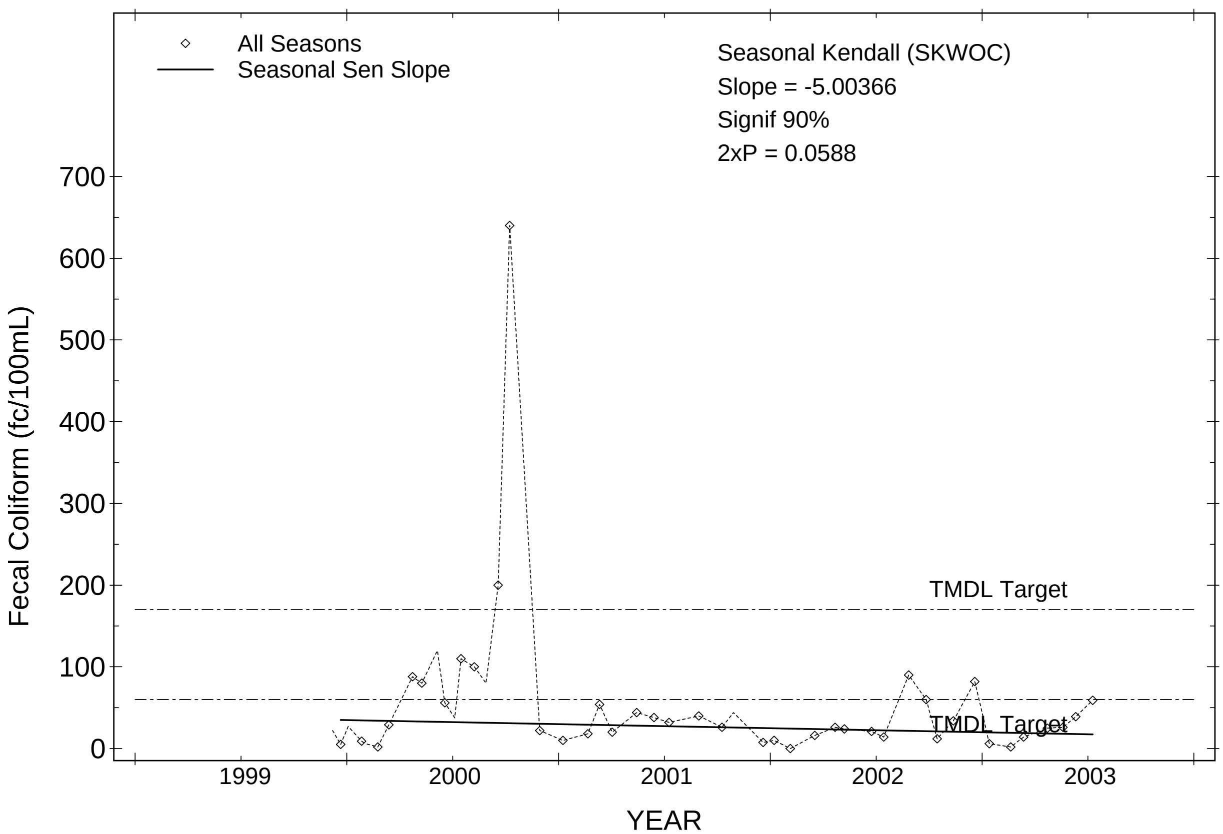

Figure 8. A Seasonal Kendall Trend Test Shows A Significant Decrease in Fecal Coliform Levels on Beebe Creek, a Tributary to Matriotti Creek at RM 0.2t.

The mouth of Matriotti Creek (RM 0.1) shows statistically significant improvement in fecal coliform levels (Figure 9). Table 2 shows that the geometric mean and 90th percentile fecal coliform values have decreased since the TMDL sampling. During TMDL sampling and for the most recent two years, this site does not meet its TMDL targets; however, bacteria levels have greatly improved.

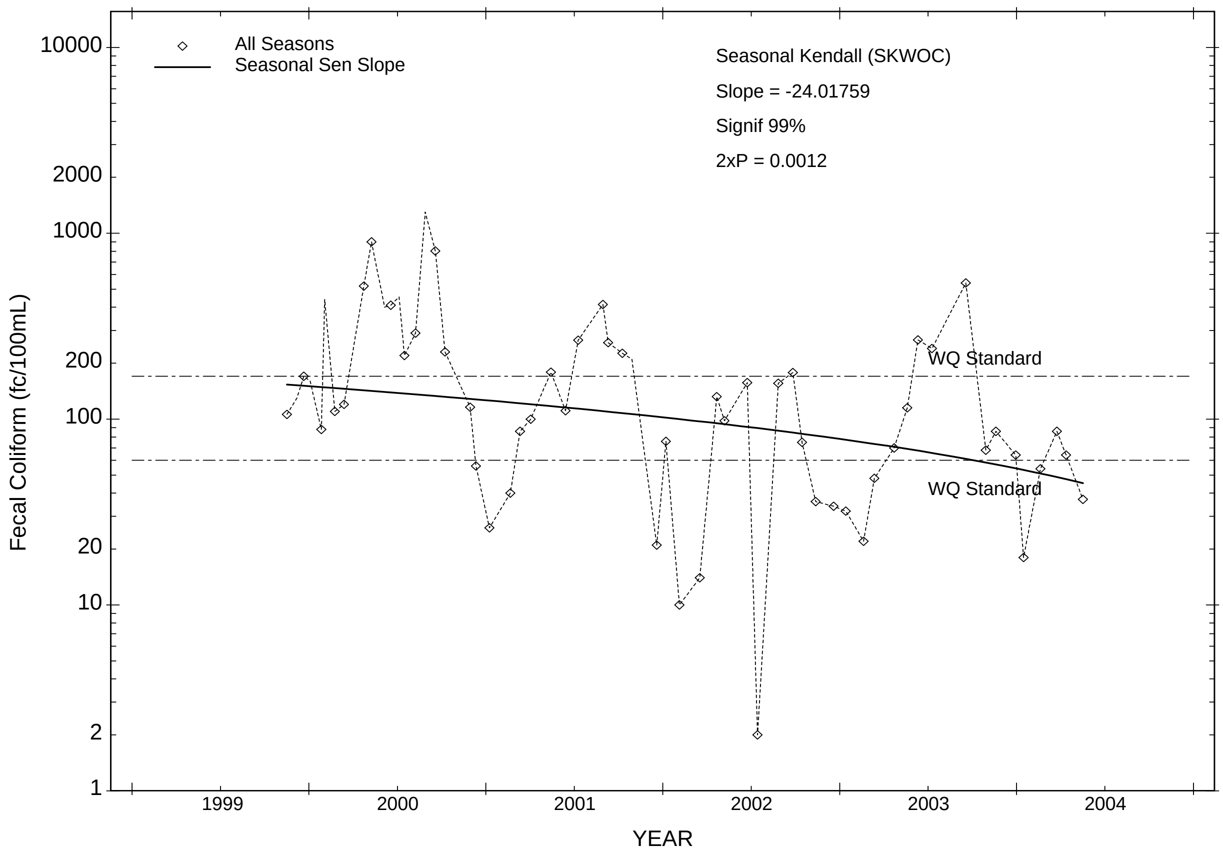

Figure 9. Seasonal Kendall Trend Test Shows a Significant Decrease in Fecal Coliform Levels at the Mouth of Matriotti Creek, RM 0.1.

The statistical rollback method (Ott, 1995) was used to determine the bacteria reduction currently needed to meet the Matriotti Creek TMDL target. A description of the statistical rollback method and how it is used to determine necessary pollutant reductions is detailed in the TMDL report (Sargeant, 2002).

Using the last two years of data (April 2002-May 2004, n=25) a bacteria reduction of 38% is needed at the mouth of Matriotti Creek to meet the TMDL target. This is an improvement from the 78% reduction cited in the TMDL report.

While significant improvements in bacteria levels are seen between RM 0.7 - 0.3, more improvement is needed to meet the TMDL target. Lotzgesell Creek at RM 0.6 meets the TMDL target and does not appear to be a source of bacteria to this reach.

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Figure 10 presents irrigation and non-irrigation season data for the TMDL period and the most recent two years of sampling for Matriotti Creek RM 0.7 - 0.1. Data show that the highest fecal coliform levels occur during the irrigation season.

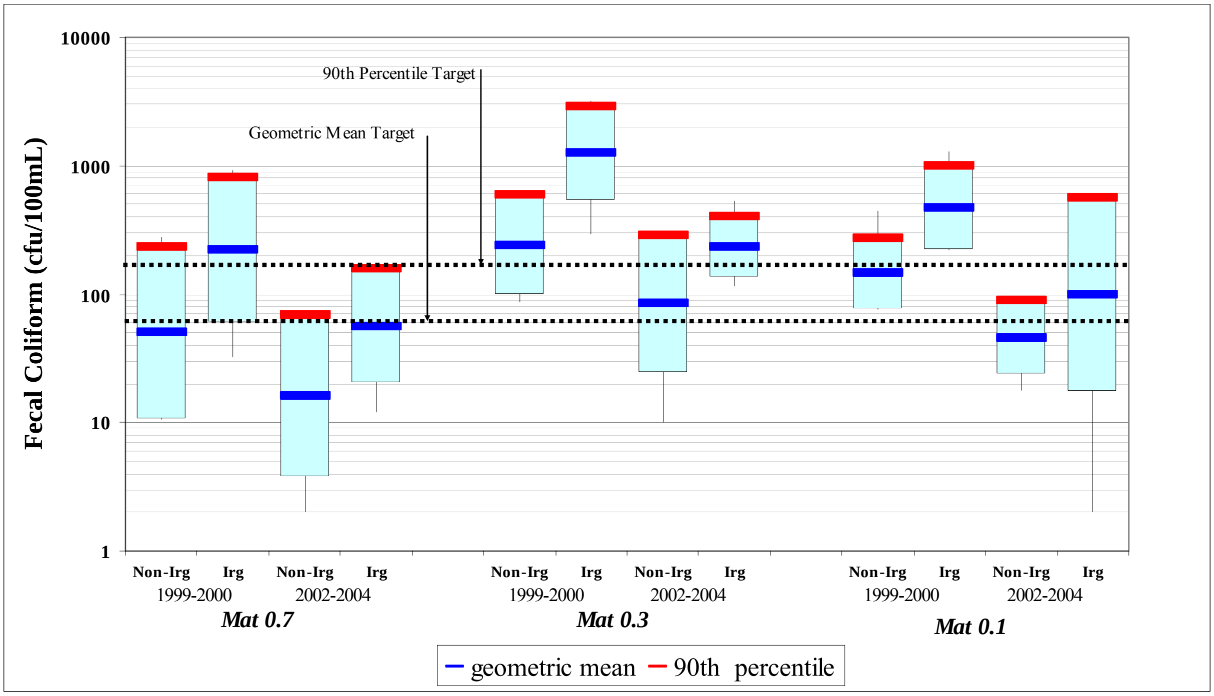

Figure 10. Lower Matriotti Creek Irrigation and Non-irrigation Season Fecal Coliform Data for the TMDL and the Most Recent Two Years of Data.

From RM 0.3 to the mouth, a paired t-test (two-tailed, α=0.05) showed a statistically significant decrease in fecal coliform values. In addition, Beebe Creek at RM 0.2t meets the TMDL target. During the non-irrigation season, the TMDL target is met at the mouth of Matriotti Creek.

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Meadowbrook Creek and Slough

Meadowbrook Creek and Slough must meet the Class AA water quality standard. Currently Class AA freshwater must meet a geometric mean fecal coliform of 50 fc/100mL and a 90th percentile of 100 fc/100 mL. Continuous data were available for Meadowbrook Creek at RM 0.3. Due to lack of access to TMDL sites at the mouth of Meadowbrook Creek (RM 0.1) and Meadowbrook Slough (RM 0.05), data for these areas could not be analyzed for bacteria trends.

Meadowbrook Creek at RM 0.3 showed increases in fecal coliform levels, though the trend was not statistically significant. This site did not meet Class AA freshwater standards for fecal coliform during the TMDL study or for the past two years of sampling. During the TMDL, the fecal coliform geometric mean was 43 fc/100mL, and the 90th percentile was 206 fc/100mL (n=19). For the last two years of sampling, the fecal coliform geometric mean was 55 fc/100mL, and the 90th percentile was 256 fc/100mL (n=24).

Conclusions and Recommendations

Dungeness River

Conclusions

While the Dungeness River sites have not shown statistically significant changes in fecal coliform bacteria levels, the Dungeness at river mile (RM) 0.8 showed decreases in fecal coliform during the irrigation season (Table 1). This may have been due to improvements in water quality upstream including Matriotti Creek, or it may have been due to an artifact in sampling frequency.

Fecal coliform levels at Dungeness RM 0.2 remained about the same.

Increases in irrigation season bacteria levels were seen from Dungeness RM 3.2 to 0.8, even though Matriotti Creek bacteria levels have improved. It is possible that other irrigation season sources occurred between RM 3.2 and 0.8.

Recommendations

- For all sites, continue to implement the *Clean Water Strategy for Addressing Bacteria Pollution in the Dungeness Bay and Watershed* and *Water Cleanup Detailed Implementation Plan* (Streeter and Hempleman, 2004).
- Continue monthly monitoring at all three Dungeness River sites, and add a Dungeness River site above Matriotti Creek to investigate the possibility of additional irrigation season sources.

Matriotti Creek

Conclusions

Matriotti Creek has shown dramatic improvement in fecal coliform levels since the TMDL study was completed in the year 2000. Several sites met their TMDL targets, and all sites showed improvement. The highest levels of bacteria continued to be seen during the irrigation season. Local efforts to improve water quality should be applauded.

More effort is needed to meet the TMDL targets. While the TMDL target was met at the most upstream site (RM 4.8), downstream (RM 1.9) the TMDL target was not met due to higher fecal coliform values during the irrigation season. Due to the lack of flow data (and thus fecal coliform loading data), it was difficult to determine locations of sources. While high levels of fecal coliform in Mudd Creek (1.95t) may be contributing to the higher levels at RM 1.9, there also may be sources in the RM 4.8 - 1.9 reach.

From RM 1.9 to 1.4, fecal coliform levels seemed to improve; however, a paired t-test (two-tailed, α=0.10) showed there was no significant difference between fecal coliform levels at either site. The sampling periods for these two sites were slightly different. From Matriotti RM 1.4 to 0.7, fecal coliform levels improved, with the TMDL target being met at RM 0.7. A paired t-test (two-tailed, α=0.05) showed statistically significant improvement in downstream fecal coliform levels, again with the caution that sampling periods for these two sites were slightly different.

While significant improvements in bacteria levels were seen between RM 0.7 - 0.3, more improvement is needed to meet the TMDL target. Lotzgesell Creek at RM 0.6t met the TMDL target and did not appear to be a source of bacteria to this reach. Possible sources in this reach include animal access to the creek, an on-site sewage system, and non-domestic wildlife. Non-domestic wildlife may be attracted to this reach due to food or habitat availability.

Decreasing fecal coliform levels were seen between Matriotti Creek RM 0.3 and the mouth.

Recommendations

- Monitoring should include flow discharge measurements so that fecal coliform loading can be calculated.
- To better define locations of bacterial sources between Matriotti RM 4.8 and 1.9, including Mudd Creek, more monitoring stations should be included between RM 4.8 and 1.9 and on Mudd Creek.
- Sources of bacteria between Matriotti Creek RM 0.7 and 0.3 should be identified. This should include some kind of bacterial source tracking technique.
- Flow discharge measurements should be obtained at Matriotti RM 0.1 to determine if a decrease in loading is occurring along with the decreasing fecal coliform concentrations.

Meadowbrook Creek and Slough

Conclusion

Meadowbrook Creek had slightly increasing levels of fecal coliform bacteria at the mouth of the creek.

Recommendations

- Start monthly monitoring at upstream sites on Meadowbrook Creek, specifically Meadowbrook Creek at Sequim-Dungeness Way, to locate sources of bacteria.
- Monitoring should include Meadowbrook Slough and the mouth of Meadowbrook Creek.

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