Assessing Progress Toward Reducing E. coli Levels in Dry Weather Discharges From Denver's MS4

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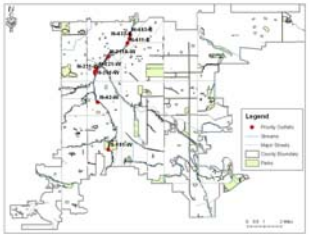
Background

The E. coli TMDL for Segment 14 of South Platte River identifies dry weather discharge from Denver's storm sewers as a source of E. coli in the segment and assigns a wasteload allocation of 126 CFU / 100 mL to Denver's MS4. The wasteload allocation was implemented into Denver's MS4 Permit in March of 2009 through a special section on E. coli control. That section includes the following requirements:

- ❑ Identification of problem storm drainage basins and implementation of the following BMPs
  - ❑ Clean and video storm and sanitary sewers
  - ❑ Identify and repair sanitary / storm cross connections
  - ❑ Eliminate illicit connections to storm sewers
  - ❑ Conduct annual analysis of E. coli data to assess progress towards reducing E. coli levels in dry weather discharges

The permit grants a 10 year compliance schedule to meet the wasteload allocation

Nine Priority Basins



Over 300 storm drainage basins were screened to determine if E. coli levels in dry weather discharges exceed the wasteload allocation. Screening identified nine basins that exceed the wasteload allocation. The locations of outfalls for the nine "priority" basins are shown on this map.

Annual Analysis

Each year, Denver attempts to answer the following questions as part of the annual analysis:

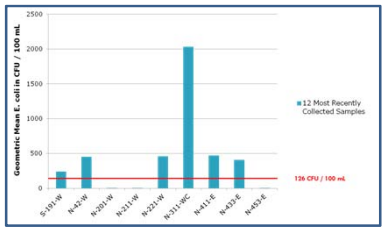
- ❑ Do dry weather discharges from storm sewers meet the E. coli wasteload allocation?
- ❑ Are E. coli levels in dry weather discharges from the priority basins decreasing?
- ❑ Is BMP Implementation effective at reducing E. coli levels in dry weather discharges from the priority basins?

This poster presents the results of the 2011 annual analysis for the nine priority outfalls / basins.

1. Do dry weather discharges from storm sewers meet the E. coli wasteload allocation?

Methodology

Denver's MS4 permit bases compliance with the wasteload allocation on the geometric mean for the 12 most recently collected samples for each basin. Samples are collected at the basin's outfall into the South Platte River.



Mean E. coli level in dry weather discharges from the priority outfalls based on the twelve most recently collected samples from each priority basin's outfall. Samples collected between late 2009 through the end of 2011.

Results of Analysis

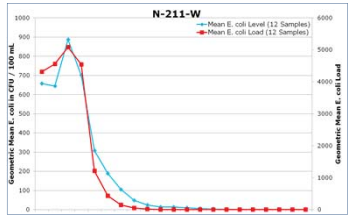
Based on the most recent 12 samples, N-201-W, N-211-W, and N-453-E are all in compliance with the wasteload allocation. Additional analysis (see below) indicates that these basins have been in compliance with the wasteload allocation for several years.

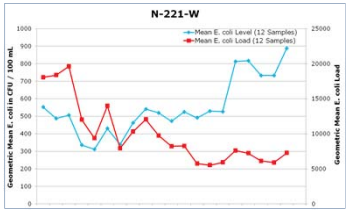
2. Are E. coli levels in dry weather discharges from the priority basins decreasing?

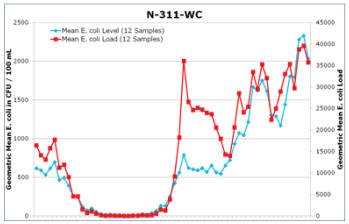
Methodology

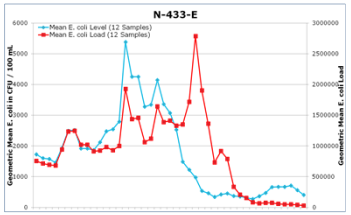
E. coli level and load data were evaluated using time series plots and statistical techniques. Time series plots showing successive rolling 12 sample geometric means for both E. coli level and E. coli load were constructed and the Mann-Kendall test was used to determine if observed graphical trends were statistically significant.

Summary of Results-Trend Analysis









	Period of Record	Number of Samples	Number of 12 Sample Means	E. coli Levels Trend	Statistical Significance (p)	E. coli Load Trend	Statistical Significance (p)
S-191-W	2006-2001	35	24	Decrease	0.30	**Decrease**	**0.00**
N-42-W	2007-2001	19	7	Increase	0.20	Decrease	0.55
N-201-W	2006-2001	34	23	**Decrease**	**0.00**	**Decrease**	**0.00**
N-211-W	2006-2001	32	21	**Decrease**	**0.00**	**Decrease**	**0.00**
N-221-W	2006-2001	32	21	**Increase**	**0.00**	**Decrease**	**0.00**
N-311-W	2006-2001	71	60	**Increase**	**0.00**	**Increase**	**0.00**
N-411-E	2006-2001	55	44	**Increase**	**0.01**	Increase	0.22
N-433-E	2006-2001	54	43	**Decrease**	**0.00**	**Decrease**	**0.00**
N-453-E	2006-2001	32	21	**Decrease**	**0.00**	**Decrease**	**0.00**

Summary of Results of Mann-Kendall test on E. coli levels and E. coli loads from priority outfalls. Bold values are statistically significant.

Denver Environmental Health
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2. Are E. coli levels in dry weather discharges from the priority basins decreasing (cont.)?

Results of Trend Analysis

Maintenance efforts have yielded improvements in E. coli levels and loads in dry weather discharges from many of the priority outfalls. N-311-W remains as the biggest challenge to compliance with the wasteload allocation.

A statistically significant increase in E. coli levels in dry weather discharges does not always imply E. coli loading is increasing.

3. Is BMP implementation effective at reducing E. coli levels in dry weather discharges from the priority outfalls?

Methodology

E. coli levels and E. coli loads from before and after BMP implementation were also analyzed for each outfall using the Wilcoxon Rank Sum test to determine if there were any differences between the two populations of data.

Results of Wilcoxon Rank Sum Tests

Outfall	Number of Pre-Implementation Samples	Median of Pre-Implementation E. col Levels	Number of Post-Implementation Samples	Median of Pre-Implementation E. coli Levels	Change in E. coli Level	Statistical Significance (p)
S-191-W	45	250	0	n/a	n/a	n/a
N-42-W	15	510	4	125	Decrease	0.1334
N-201-W	15	660	33	1	Decrease	0.1169
N-211-W	**13**	**440**	**32**	**5.5**	**Decrease**	**0.0095**
N-221-W	**15**	**3600**	**31**	**660**	**Increase**	**0.0016**
N-311-W	**17**	**6600**	**71**	**660**	**Increase**	**0.0013**
N-411-E	9	1090	55	440	Decrease	0.3440
N-433-E	17	2700	50	900	Decrease	0.1537
N-453-E	**25**	**140**	**15**	**1**	**Decrease**	**0.0000**

Summary of results of Wilcoxon Rank Sum test on E. coli levels from priority outfalls. Bold values are statistically significant.

Outfall	Number of Pre-Implementation Samples	Median of Pre-Implementation E. coli Load	Number of Post-Implementation Samples	Median of Pre-Implementation E. coli Load	Change in E. coli Load	Statistical Significance (p)
S-191-W	45	4900	0	n/a	n/a	n/a
N-42-W	15	8520	4	1740	Decrease	0.0512
N-201-W	10	7325	29	4	Decrease	0.2885
N-211-W	**7**	**4160**	**28**	**4**	**Decrease**	**0.0412**
N-221-W	**11**	**45000**	**27**	**8820**	**Decrease**	**0.0496**
N-311-W	**10**	**318500**	**66**	**23900**	**Increase**	**0.0035**
N-411-E	9	53100	49	22000	Decrease	0.6366
N-433-E	13	643200	45	470000	Decrease	0.6016
N-453-E	**19**	**3500**	**15**	**4**	**Decrease**	**0.0000**

Summary of results of Wilcoxon Rank Sum test on E. coli loads from priority outfalls. Bold values are statistically significant.

Change in Results After BMP Implementation

Results of the analysis of data before and after BMP implementation are not as clear cut as hoped but the trend analysis for many basins are encouraging. Interpretation of the analysis was complicated by the following factors:

- Small data sets, in particular before BMP implementation
- Some cleaning and maintenance efforts may have occurred in the priority basins prior to tracking of maintenance data in City databases
- BMP implementation is ongoing and may affect the analysis

It is difficult to determine if specific BMPs or suites of BMPs were more effective than others due to simultaneous implementation of the BMPs. It is unlikely that Denver will ever be able to determine if a certain BMP is more effective than another.

Conclusions

Long-term trends for both E. coli levels and E. coli loading are positive in most of the priority basins

- N-311-WC remains as the biggest challenge

BMP implementation appears to be improving E. coli levels in dry weather discharges from many of the priority basins

- As more data become available, confidence in results of statistical analyses will increase

N-411-E

N-201-W

N-433-E

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