Chemical and Microbiological Quality of Stormwater Runoff Affected by Dry Wells; A Case Study in Millburn, NJ

Leila Talebi[1], Robert Pitt[2]

[1] PhD Candidate, Department of Civil, Construction and Environmental Engineering, The University of Alabama, Tuscaloosa, Alabama. Email: ltalebi@crimson.ua.edu

[2] Cudworth Professor, Director of the Environmental Institute, Department of Civil, Construction and Environmental Engineering, The University of Alabama, Tuscaloosa, Alabama Email: rpitt@eng.ua.edu

1

Introduction and Background

- A dry well is a subsurface discharge device for the disposal of stormwater.
- Their main function is to infiltrate stormwater to relatively shallow depths, resulting in reduced surface runoff rates and volumes.
- Typical dry wells in Millburn, NJ are 4 ft diameter and 6 ft tall perforated concrete chambers surrounded by 2 feet of gravel on all sides, including below the chamber. The bottom of the dry well device (including the lower rock layer) is therefore about 10 ft below the ground surface.

- NJ State requirements: the subgrade soil permeability rate must be sufficient to drain the stored runoff within 72 hours.

2

Introduction and Background

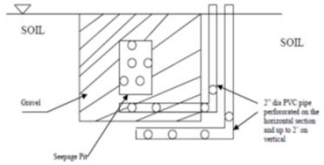
Purpose: to investigate the hydraulic performance of the dry wells along with water quality changes associated with the dry well operation.

The majority of the dry wells examined during this study received runoff from roofs, while some also received runoff from surrounding paved driveway and parking areas, and from landscaped areas.

3

Methods and Materials: Sampling

- Three dry wells during new construction had both a shallow monitoring well placed directly beneath the concrete chamber (sampling water similar to the water in the dry well tank), along with a deep monitoring well located at least 60 cm (2 ft) beneath the deepest depth of the seepage pit gravel.
- A new water storage cistern was also sampled at the inlet and from the outlet.
- Eight to ten storms were sampled (all samples were analyzed in duplicate.)



4

Methods and Materials

Rain Depths for Monitored Events

Date	Rain Depth
10/20/2010	0.10 in.*
7/29/2011	0.15 in.*
8/5/2011	0.14 in.*
08/10/2011	0.12 in.*
08/16/2011	0.15 in.
08/17/2011	0.20 in.
08/18/2011	0.10 in.
08/22/2011	0.50 in.
08/25/2011	0.25 in.
08/28/2011**	9 in.

*The data from these rains was obtained from http://www.wunderground.com/ while the other rains were obtained from on-site rain gages.
**Hurricane Irene rain began about 3:00 pm on 08/27/2011 and finished at about 10:00 am on 08/28/2011, producing record rainfall for the area.
(1 in. = 25.4 mm)

5

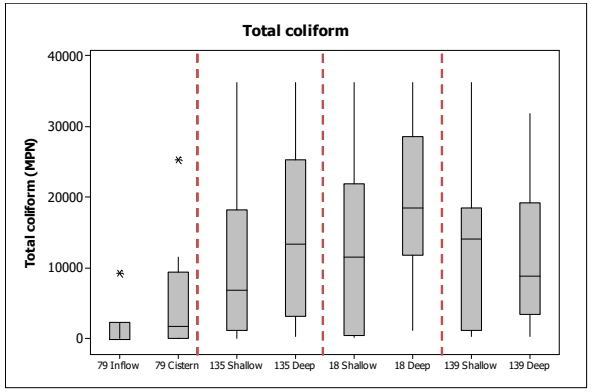
Methods and Materials

- The samples were analyzed in laboratories of the University of Alabama for bacteria: (total coliform and *E. coli* screening analyses), total nitrogen (TN), nitrate plus nitrite (NO_3 plus $NO_{2)}$, total phosphorus (TP), and chemical oxygen demand (COD).
- Lead, copper, and zinc were analyzed at a commercial laboratory (Stillbrook Environmental Testing Laboratory in Fairfield, AL).
- Selected samples were also analyzed for pesticides by the EPA (not reported here).

6

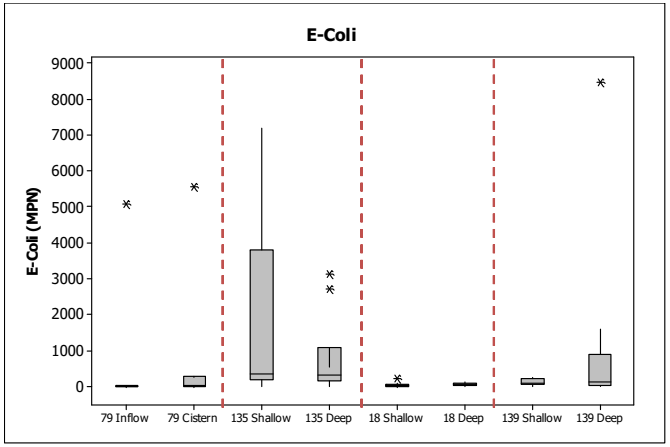
Bacteria

- IDEXX method within 24 hr of sampling (UDL: 2,419.2 MPN/100 mL but all were diluted 10X)



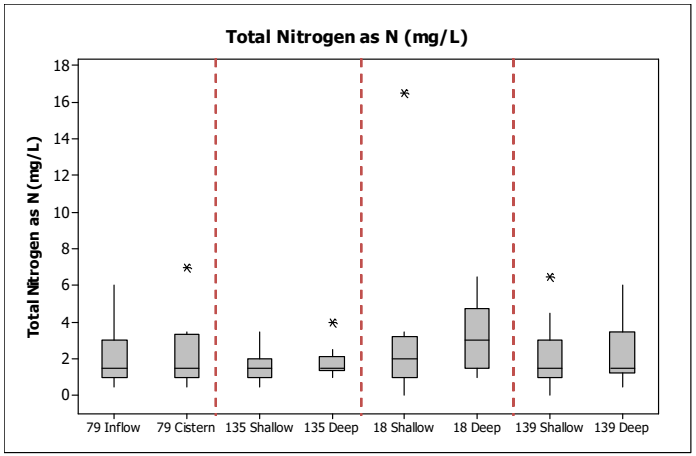
7

Bacteria



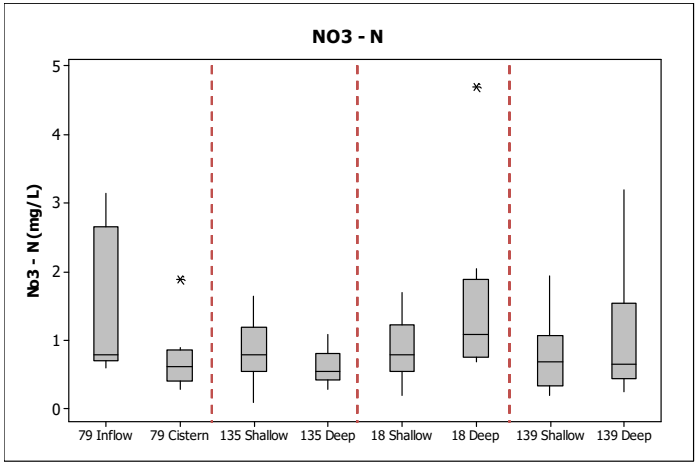
8

Nutrients



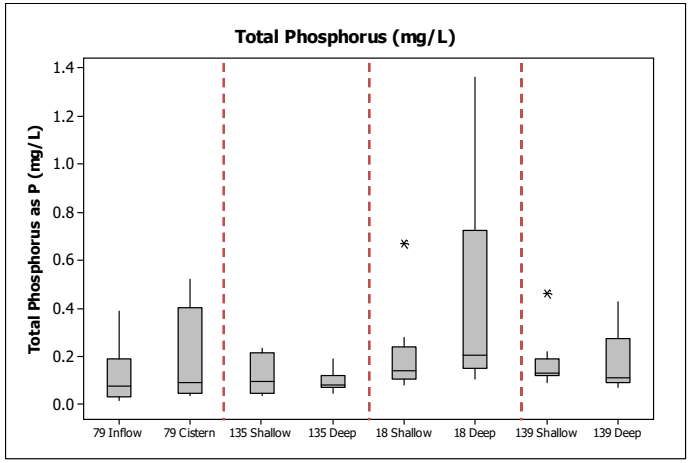
9

Nutrients



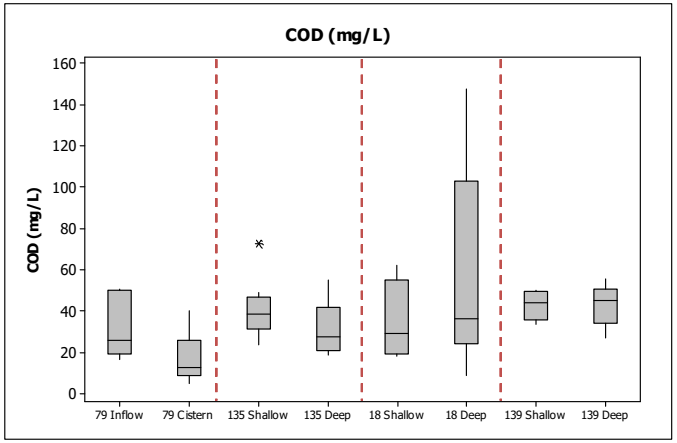
10

Nutrients



11

Chemical Oxygen Demand (COD)



12

Metals

	79 Inflow[1]	79 Cistern[2]	135 Shallow[3]	135 Deep[3]	18 Shallow[4]	18 Deep[4]	139 Shallow[4]	139 Deep[4]
Lead (mg/L) (Note: Detection Limit = 0.005 mg/L								
Number of Samples	3	3	2	4	9	9	4	1
Average	0.0063	0.034	0.014	0.021	0.071	0.092	0.01	0.38
St Dev	0.0011	0.048	0.0007	0.0081	0.11	0.11	0.0032	NA
Copper (mg/L) (Note: Note: Detection Limit = 0.02 mg/L)								
Number of Samples	7	8	10	10	3	2	10	1
Average	0.67	0.26	NA	NA	0.03	0.055	NA	0.1
St Dev	0.27	0.36	NA	NA	0.01	0.007	NA	NA
Zinc (mg/L) (Note: Detection Limit = 0.02 mg/L)								
Number of Samples	6	8	5	7	2	3	3	2
Average	0.11	0.046	0.062	0.057	0.045	0.04	0.027	0.065
St Dev	0.032	0.039	0.046	0.031	0.007	0.01	0.012	0.064

13

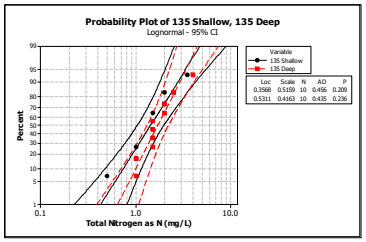
Metals

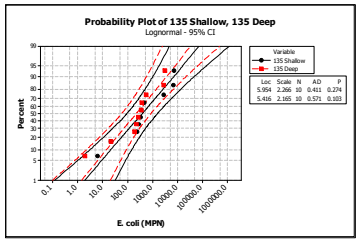
- Many were below the method detection limit (BDL).
- The maximum observed concentration for lead (380 µg/L) occurred in a deep monitoring well sample under a dry well.
- The maximum observed concentration of copper (1,100 µg/L) occurred in a cistern influent sample (possibly due to copper roof gutters on the home).
- The concentrations of zinc in all samples ranged from BDL to 140 µg/L.

14

Statistical Analyses

Log-normal Probability Plots and Anderson-Darling Test Statistics





- Most of the data are seen to overlap within the limits of the 95% confidence limits, indicating that the data are likely from the same population.
- The data seem to generally fit a straight line on log-normal plots, indicating likely log-normal data distributions, and as supported by the Anderson-Darling test statistic.

15

Mann Whitney Test

- If the data are not normally distributed, or the distribution is unknown or mixed (as in this case), then nonparametric statistical tests are needed.
- The Mann-Whitney test is a nonparametric test for paired data (simultaneous observations from both sampling locations) that considers the actual observation values (and not just relative values as in the less powerful Sign Test).
- This test performs a hypothesis test of the equality of the two population medians and calculates the corresponding point estimate and confidence interval. The probability of these two medians being the same (within the confidence interval) is then calculated.

16

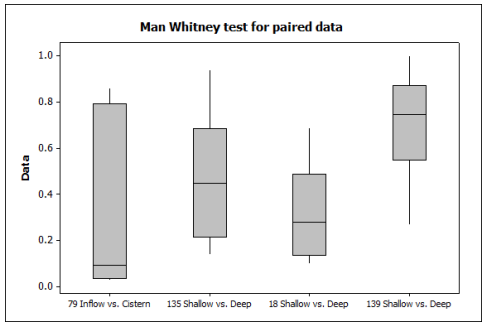
Mann Whitney Test

- The Mann Whitney test was performed using MINITAB to test if the shallow samples have significantly higher or lower concentrations than the deep monitoring well samples (same comparison test for inflow vs. cistern).
- To make sure that the populations have the same shape, over-laying probability plots were made for the two pairs of data in the previous probability plots. In all the cases, the straight lines were close to each other and the bandwidths were quite similar.

17

Mann Whitney Test

- Except for the bacteria and COD results for the cistern site, all paired sample sets did not indicate significant differences for these numbers of samples at the 0.05 level.
- The cistern median total coliform values were greater than the inflow median values, indicating possible re-growth; however, the median *E. coli* and COD cistern values were less than the inflow values.



18

Paired Sign Test for Metal Analyses

- Due to large amounts of non-detected metal results, the Mann Whitney test could not be used. However, the sign test can be used if at least one value of a pair had a detectable result, allowing the identification of the larger value of the pair.
- The null hypothesis: the population medians are similar.
- In each pair of observations, a comparison was made to determine if there is an increase from the shallow sample to the deep sample or if there was a decrease.
- If the calculated p value is less than 0.05, then the null hypothesis will be rejected and the data are assumed to originate from different sample populations.
- No statistically significant differences are seen between the sample sets for these heavy metals for the numbers of samples available.

19

Summary of Paired Sign Test for Metal analysis

Metal	79 Inflow vs. 79 Cistern	135 Shallow vs. 135 Deep	18 Shallow vs. 18 Deep	139 Shallow vs. 139 Deep
Lead	> 0.06	> 0.06	0.18	> 0.06
Copper	0.125	*	>0.06	*
Zinc	0.45	0.45	>0.06	>0.06

***** All the results are below the detection limit (BDL), therefore it is not possible to do a statistical comparison test

20

Conclusion

- Shallow and deep samples collected beneath three dry wells and samples at the inflow and in the cistern during ten storm events were analyzed for total coliforms, *E. coli*, total nitrogen, NO_3 plus NO_2, total phosphorus, COD, lead, copper, and zinc.
- Statistical analyses indicated that the differences in water quality between the shallow and the deep samples were not significant (p values were > 0.05).
- However, significant differences were found ($p < 0.05$) between the quality of inflow samples and cistern samples for total coliforms (increased values possibly indicating re-growth), *E. coli*, and COD (reduced values).

21

Conclusion

- These findings indicate that the dry wells did not significantly change any of the water quality concentrations for the stormwater constituents observed.
- If the influent water quality is of good quality, the dry wells can be a safe disposal method for stormwater quality. However, the bacteria and lead concentrations exceeded the groundwater disposal criteria for New Jersey and may require treatment, if the aquifer is critical.
- The deep monitoring well sample was located at least 1.3 m (4 ft) below the bottom of the dry well (which itself was about 8 ft beneath the ground surface), more than the typical spacing requirement (3 ft) to groundwater. This distance was not sufficient to result in significant or important reductions in the stormwater constituents. It is possible that longer subsurface flow paths would result in concentration reductions.

22

Acknowledgement

The information reported in this paper was excerpted from a research report funded by the Urban Watershed Management Branch, **U.S. Environmental Protection Agency**, Edison, NJ, 08837, as part of the project: *Evaluation and Demonstration of Stormwater Dry Wells and Cisterns in Milburn Township, New Jersey* (EP-C-08-016).

23

Thank you

Comments/Questions?

24