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**FROM:** Kat Ridolfi, Mike Sullivan, Dave Dilks, Scott Hinz

**PROJECT:**

**TO:** John Cassidy, DC Water  
**CC:** Helene Drago, EPA Region 3  
George Onyullo, DDOE  
**SUBJECT:** Update on Development of DC Bacteria Translators

## Memorandum

### BACKGROUND AND PURPOSE

In 2011, LimnoTech developed a translator equation under a contract to Battelle through an Environmental Protection Agency (EPA), Region 3 task order to assist the District Department of the Environment (DDOE) with the translation of ambient receiving water bacteria measurements and TMDLs from fecal coliform to E. coli. This original DC translator was based on ambient instream monitoring data of paired fecal coliform and E. coli concentrations in DC and adjacent waters (LimnoTech, 2011).

Subsequent to development of this original DC translator, DDOE and DC Water decided to reassess the translator and extend it to include wet weather sources of bacteria. End-of pipe paired samples from CSO and storm water sources in DC were provided by DC Water. This data had been obtained in monitoring carried out by DC Water in the period 2000 to 2001 to support development of the DC Water's LTCP (DC Water and Sewer Authority, 2002).

This memorandum summarizes the methods used to develop the translators and presents the results from this analysis.

### DATA

The data used to develop the original DC translator was composed of paired fecal coliform and E. coli instream monitoring measurements for DC and adjacent waters collected by three agencies: DDOE, the Virginia Department of Environmental Quality (VDEQ), and the Maryland Department of the Environment (MDE). The updated dataset (Attachment 1) contains all of this ambient instream water quality monitoring data as well as end-of-pipe data collected by DC Water at CSO outfalls and separate storm water system (SSWS) outfalls.

### METHODS

Following the methodology of the original DC translator, paired bacteria data were compiled and log-normalized (to base 2). Certain data were removed from consideration that were reported as over or under the reporting limit (and not an actual measurement), such as "conc. >1,600,000; set

to 1,600,000” or “<RL, set to  $\frac{1}{2}$  RL”. If one measurement of the pair had one of these qualifiers, the whole pair was removed from consideration. The paired data were put into a scatter plot using Microsoft Excel, and a line was fitted to the data points.

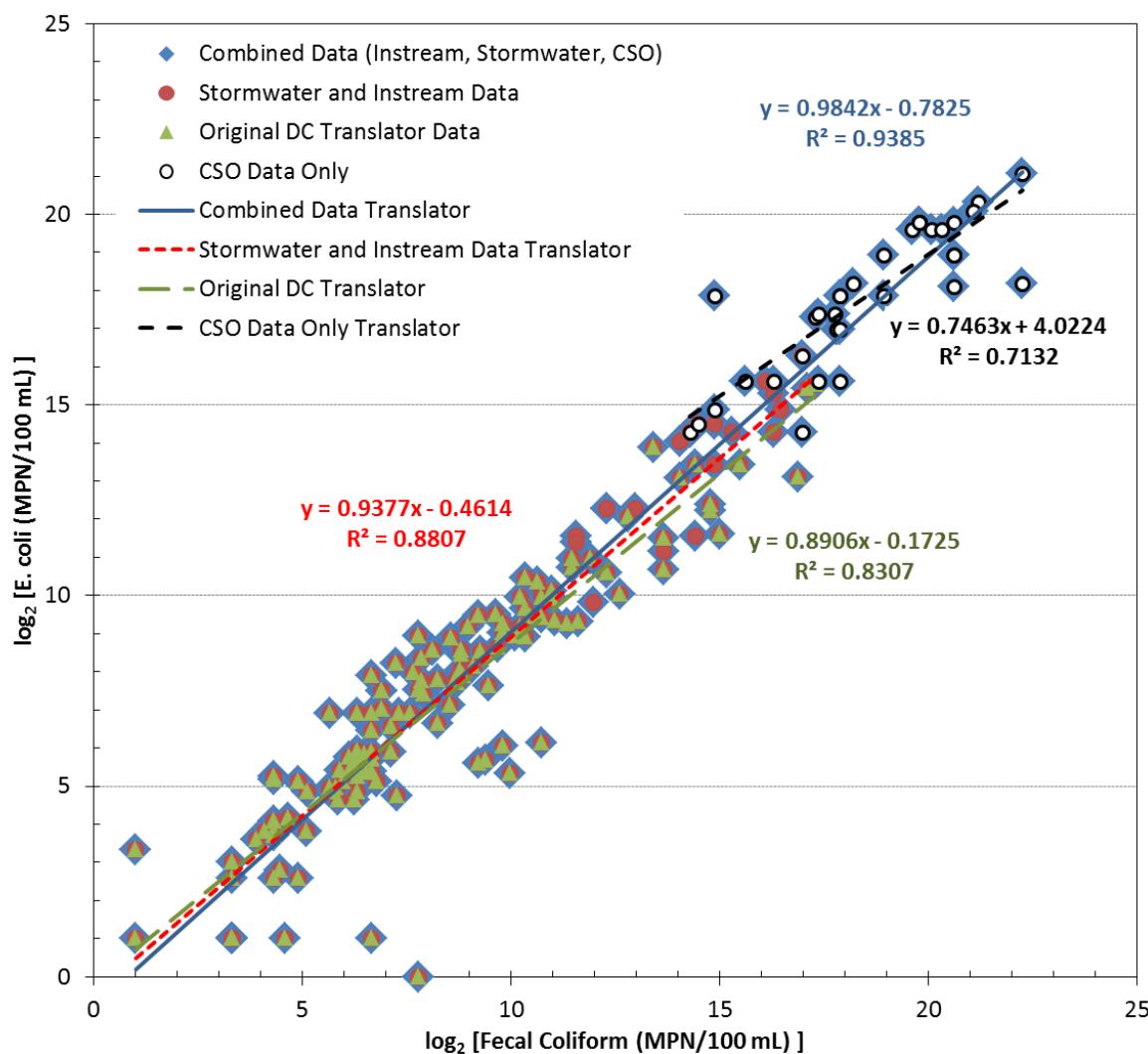
## RESULTS

Translators for three new groups of data were developed:

- CSO data only
- Combined with instream, CSO and SSWS data
- Instream and SSWS data (no CSO data)

The new translator regressions are shown graphically in Figure 1 along with the original DC translator.

**Figure 1. Comparison of Original DC Bacteria Translator and New Translators**



A comparison of all four of the translators developed is presented in Table 1. The regression equation for each translator is shown along with the coefficient of determination ( $r^2$ ). In addition, the range of bacteria concentrations and the median concentration for each data grouping is defined. Extrapolation of any individual translator equation beyond the limits of the observed range of the concentration data on which they were individually developed – both upper and lower – is not recommended.

**Table 1. Comparison of Bacteria Translators Developed using Paired Monitoring Data**

	Original DC Translator	CSO Data Only Translator	Combined Data (Instream, Stormwater, CSO) Translator	Stormwater and Instream Data Translator				
<b>Equation *</b>	$y = 0.8906x - 0.1725$	$y = 0.7463x + 4.0224$	$y = 0.9842x - 0.7825$	$y = 0.9377x - 0.4614$				
<b>R<sup>2</sup></b>	0.83	0.71	0.94	0.88				
<b>Observed Paired Data Ranges (MPN/100 mL)</b>								
	Fecal Coliform	E. Coli	Fecal Coliform	E. Coli	Fecal Coliform	E. Coli	Fecal Coliform	E. Coli
<b>Min</b>	2	1	20,000	20,000	2	1	2	1
<b>Max</b>	160,000	48,000	5,000,000	2,200,000	5,000,000	2,200,000	160,000	80,000
<b>Median</b>	220	120	270,000	240,000	900	520	376	219

\*  $y = E. coli$ ,  $x = \text{fecal coliform}$

Statistical significance testing was done comparing each of the alternate translators to the original DC translator. F-test results indicate that each translator is significantly different than the original DC translator at the 95% confidence level (i.e.  $p < 0.05$ ).

For comparative purposes, Table 2 presents the E. Coli concentrations predicted using each of the four translator equations for an extreme range of fecal coliform concentrations. The predicted values beyond the valid range for each translator (that is, beyond the limits of the observed range of the concentration data on which the individual translators were developed) are noted with shading and a red font. For example, the translation of CSO fecal coliform concentrations lower than 20,000 MPN/100 mL (see Table 1) cannot be used to provide a technical justification for why that particular translator may be conservative, or not, with respect to the conversion of a CSO fecal coliform WLA to E. coli.

**Table 2. Predicted E. Coli Concentrations Using Various Translators.**

Fecal Coliform (MPN/100 ml)	Predicted E. coli (MPN/100ml)*			
	Original DC Translator	CSO Data Only Translator	Combined Data (Instream, Stormwater, CSO) Translator	Stormwater and Instream Data Translator
200	99	<b>847</b>	107	104
1,000	417	<b>2,817</b>	521	472
10,000	3,239	<b>15,706</b>	5,026	4,092
100,000	25,181	87,572	48,467	35,449
500,000	<b>105,578</b>	291,075	236,249	<b>160,335</b>
939,270	<b>185,114</b>	465,969	439,404	<b>289,595</b>
1,000,000	<b>195,737</b>	488,273	467,352	<b>307,118</b>
5,000,000	<b>820,682</b>	1,622,947	2,278,087	<b>1,389,085</b>

\* Extrapolated E. coli levels, shown in red, are included for illustrative and comparative purposes only.

In summary, if a single translator approach is used for storm water and boundary sources, then the one based on stormwater and instream data (excluding CSO data) appears to be reasonable for the range of bacteria levels to which it would be applied. The LTCP-based EMC for E. coli of 686,429 MPN/100 mL is recommended for conversion of CSO WLAs in the TMDL update.

## REFERENCES

DC Water and Sewer Authority, Final Report: 2002. Combined Sewer System Long Term Control Plan. Washington, DC.

LimnoTech, 2011. Final Memo Summarizing DC Bacteria Data and Recommending a DC Bacteria Translator (Task 2). Prepared for EPA Region 3, Philadelphia, PA

## Attachment 1. Raw Data Used to Develop Bacteria Translators.

Type	Location	Data Source	Date	Fecal Coliform (#/100 ml)	E. Coli (#/100 ml)
CSO	019BP	DC Water	6/15/2000	900,000	900,000
CSO	019BP	DC Water	6/15/2000	500,000	500,000
CSO	019BP	DC Water	6/22/2000	170,000	50,000
CSO	019BP	DC Water	6/22/2000	30,000	240,000
CSO	019BP	DC Water	6/22/2000	80,000	50,000
CSO	019BP	DC Water	8/3/2000	1,600,000	500,000
CSO	019BP	DC Water	8/27/2000	240,000	240,000
CSO	019BP	DC Water	8/27/2000	500,000	240,000
CSO	10	DC Water	6/22/00	1,600,000	500,000
CSO	10	DC Water	6/22/00	900,000	900,000
CSO	10	DC Water	7/16/2000	900,000	900,000
CSO	10	DC Water	8/6/2000	1,600,000	900,000
CSO	12	DC Water	2/28/2000	30,000	30,000
CSO	12	DC Water	3/27/2000	900,000	900,000
CSO	12	DC Water	3/27/2000	220,000	170,000
CSO	12	DC Water	3/28/2000	130,000	20,000
CSO	12	DC Water	8/27/2000	50,000	50,000
CSO	21	DC Water	2/27/2000	160,000	160,000
CSO	21	DC Water	3/21/2000	2,400,000	1,300,000
CSO	21	DC Water	3/21/2000	1,100,000	800,000
CSO	21	DC Water	3/27/2000	20,000	20,000
CSO	21	DC Water	4/8/2000	5,000,000	300,000
CSO	21	DC Water	4/25/2000	800,000	800,000
CSO	21	DC Water	4/25/2000	5,000,000	2,200,000
CSO	21	DC Water	5/19/2000	2,200,000	1,100,000
CSO	21	DC Water	9/19/2000	1,300,000	800,000
CSO	21	DC Water	9/19/2000	230,000	130,000
CSO	21	DC Water	9/19/2000	230,000	130,000
CSO	49	DC Water	3/21/2000	23,000	23,000
CSO	49	DC Water	9/19/2000	1,600,000	280,000
CSO	49	DC Water	9/19/2000	240,000	240,000
CSO	49	DC Water	9/19/2000	300,000	300,000
CSO	49	DC Water	9/19/2000	170,000	170,000
CSO	49	DC Water	9/19/2000	240,000	50,000
CSO	49	DC Water	9/19/2000	240,000	130,000

<b>CSO</b>	49	DC Water	9/19/2000	130,000	80,000
<b>Instream</b>	1AHUT000.01	VDEQ	7/19/2005	550	280
<b>Instream</b>	1AHUT000.01	VDEQ	8/30/2005	450	350
<b>Instream</b>	1AHUT000.01	VDEQ	11/28/2005	200	250
<b>Instream</b>	1AHUT000.01	VDEQ	1/18/2006	1600	1300
<b>Instream</b>	1AHUT000.01	VDEQ	3/1/2007	120	180
<b>Instream</b>	1AHUT000.01	VDEQ	5/3/2007	300	220
<b>Instream</b>	1AHUT000.01	VDEQ	7/16/2007	280	380
<b>Instream</b>	1AHUT000.01	VDEQ	9/17/2007	820	400
<b>Instream</b>	1AHUT000.01	VDEQ	11/27/2007	1300	1400
<b>Instream</b>	1AHUT000.01	VDEQ	1/30/2008	500	580
<b>Instream</b>	1AHUT000.01	VDEQ	3/3/2008	75	25
<b>Instream</b>	1AHUT000.01	VDEQ	5/7/2008	120	180
<b>Instream</b>	ANA08	DDOE	July 2010	5000	1553
<b>Instream</b>	ANA14	DDOE	July 2010	1700	691
<b>Instream</b>	ANA21	DDOE	July 2010	72	41
<b>Instream</b>	ANA21	DDOE	August 2010	600	49
<b>Instream</b>	ANA29	DDOE	10/4/2007	220	1
<b>Instream</b>	CA	MDE	6/7/2005	22000	11000
<b>Instream</b>	CA	MDE	6/8/2005	2800	2000
<b>Instream</b>	CA	MDE	6/14/2005	80	54
<b>Instream</b>	CA	MDE	6/15/2005	110	35
<b>Instream</b>	CA	MDE	6/21/2005	10	6
<b>Instream</b>	CA	MDE	6/28/2005	900	520
<b>Instream</b>	CA	MDE	7/12/2005	150	300
<b>Instream</b>	CA	MDE	7/13/2005	120	130
<b>Instream</b>	CA	MDE	7/19/2005	700	200
<b>Instream</b>	CA	MDE	7/20/2005	160	120
<b>Instream</b>	CA	MDE	7/26/2005	670	51
<b>Instream</b>	CA	MDE	7/27/2005	300	100
<b>Instream</b>	CA	MDE	8/2/2005	20	38
<b>Instream</b>	CA	MDE	8/3/2005	30	6
<b>Instream</b>	CA	MDE	8/9/2005	120000	8900
<b>Instream</b>	CA	MDE	8/10/2005	3100	640
<b>Instream</b>	CA	MDE	8/16/2005	60	43
<b>Instream</b>	CA	MDE	8/17/2005	100	120
<b>Instream</b>	CA	MDE	8/23/2005	30	35
<b>Instream</b>	CA	MDE	8/24/2005	80	38
<b>Instream</b>	CA	MDE	8/30/2005	140	94
<b>Instream</b>	CA	MDE	8/31/2005	100	42
<b>Instream</b>	CA	MDE	9/6/2005	35	29

Instream	CA	MDE	9/7/2005	155	27
Instream	CA	MDE	9/13/2005	370	140
Instream	CA	MDE	9/14/2005	100	52
Instream	CA	MDE	9/20/2005	63	35
Instream	CA	MDE	9/21/2005	70	54
Instream	CA	MDE	9/27/2005	450	380
Instream	CA	MDE	9/28/2005	100	87
Instream	CA	MDE	10/4/2005	90	57
Instream	CA	MDE	10/5/2005	72	45
Instream	CA	MDE	10/11/2005	1400	700
Instream	CA	MDE	10/12/2005	1200	580
Instream	CA	MDE	10/18/2005	240	170
Instream	CA	MDE	10/25/2005	2000	1100
Instream	CA	MDE	10/26/2005	1700	1000
Instream	CA	MDE	7/12/2007	2600	610
Instream	CA	MDE	7/19/2007	56	31
Instream	CA	MDE	7/26/2007	58	25
Instream	CA	MDE	8/2/2007	92	41
Instream	CA	MDE	8/9/2007	80	45
Instream	CA	MDE	8/16/2007	80	29
Instream	CA	MDE	8/23/2007	1300	480
Instream	CA	MDE	9/13/2007	460	240
Instream	CA	MDE	9/20/2007	140	60
Instream	CA	MDE	9/27/2007	20	14
Instream	CA	MDE	10/4/2007	100	53
Instream	CA	MDE	10/25/2007	7100	4300
Instream	DC OUT (1)	MDE	6/20/2006	3800	2000
Instream	DC OUT (1)	MDE	6/27/2006	160000	48000
Instream	DC OUT (1)	MDE	7/11/2006	50	31
Instream	DC OUT (1)	MDE	7/25/2006	2	10
Instream	DC OUT (1)	MDE	8/1/2006	10	2
Instream	DC OUT (1)	MDE	8/8/2006	100	60
Instream	DC OUT (1)	MDE	8/15/2006	10	8
Instream	DC OUT (1)	MDE	8/22/2006	10	2
Instream	DC OUT (1)	MDE	8/29/2006	10	2
Instream	DC OUT (1)	MDE	9/12/2006	10	2
Instream	DC OUT (1)	MDE	9/19/2006	100	2
Instream	DC OUT (1)	MDE	9/26/2006	10	2
Instream	DC OUT (1)	MDE	10/3/2006	2	2
Instream	DC OUT (1)	MDE	10/17/2006	140000	44000
Instream	DC OUT (1)	MDE	10/24/2006	20	36

<b>Instream</b>	DC OUT (1)	MDE	10/31/2006	10	2
<b>Instream</b>	KNG02	DDOE	July 2010	220	185
<b>Instream</b>	KNG01	DDOE	August 2010	6200	1046
<b>Instream</b>	PMS01	DDOE	July 2010	20	17
<b>Instream</b>	PMS10	DDOE	July 2010	80	61
<b>Instream</b>	PMS21	DDOE	August 2010	1700	70
<b>Instream</b>	PMS29	DDOE	July 2010	20	13
<b>Instream</b>	PMS29	DDOE	August 2010	900	66
<b>Instream</b>	PMS44	DDOE	August 2010	1000	40
<b>Instream</b>	PMS51	DDOE	July 2010	20	17
<b>Instream</b>	RCR01	DDOE	August 2010	400	218
<b>Instream</b>	RCR09	DDOE	August 2010	230	326
<b>Instream</b>	RCR01	DDOE	July 2010	226	185
<b>Instream</b>	SA(3)	MDE	7/12/2007	2800	1700
<b>Instream</b>	SA(3)	MDE	7/19/2007	15	12
<b>Instream</b>	SA(3)	MDE	7/26/2007	24	2
<b>Instream</b>	SA(3)	MDE	8/2/2007	22	7
<b>Instream</b>	SA(3)	MDE	8/9/2007	34	14
<b>Instream</b>	SA(3)	MDE	8/16/2007	20	6
<b>Instream</b>	SA(3)	MDE	8/23/2007	900	610
<b>Instream</b>	SA(3)	MDE	9/13/2007	190	120
<b>Instream</b>	SA(3)	MDE	9/20/2007	50	29
<b>Instream</b>	SA(3)	MDE	9/27/2007	17	14
<b>Instream</b>	SA(3)	MDE	10/4/2007	25	18
<b>Instream</b>	SA(3)	MDE	10/25/2007	11000	15000
<b>Instream</b>	TBR01	DDOE	July 2010	17000	8704
<b>Instream</b>	TD001	DDOE	July 2010	1300	816
<b>Instream</b>	THM01	DDOE	August 2010	230	219
<b>Instream</b>	THR01	DDOE	August 2010	376	473
<b>Instream</b>	THR01	DDOE	July 2010	33000	3148
<b>Instream</b>	TWB01	DDOE	July 2010	13000	1640
<b>Instream</b>	TWB06	DDOE	August 2010	220	488
<b>Instream</b>	WA(1)	MDE	6/20/2006	28000	4800
<b>Instream</b>	WA(1)	MDE	6/27/2006	28000	5400
<b>Instream</b>	WA(1)	MDE	7/11/2006	2000	980
<b>Instream</b>	WA(1)	MDE	7/25/2006	2100	650
<b>Instream</b>	WA(1)	MDE	8/1/2006	790	730
<b>Instream</b>	WA(1)	MDE	8/8/2006	13000	2900
<b>Instream</b>	WA(1)	MDE	8/15/2006	1100	490

<b>Instream</b>	WA(1)	MDE	8/22/2006	440	260
<b>Instream</b>	WA(1)	MDE	8/29/2006	620	370
<b>Instream</b>	WA(1)	MDE	9/12/2006	100	240
<b>Instream</b>	WA(1)	MDE	9/19/2006	1200	1000
<b>Instream</b>	WA(1)	MDE	9/26/2006	600	710
<b>Instream</b>	WA(1)	MDE	10/3/2006	420	210
<b>Instream</b>	WA(1)	MDE	10/17/2006	46000	11000
<b>Instream</b>	WA(1)	MDE	10/24/2006	80	120
<b>Instream</b>	WA(1)	MDE	10/31/2006	50	120
<b>SSWS</b>	Hickey Run	DC Water	9/15/1999	20,000	20,000
<b>SSWS</b>	Hickey Run	DC Water	9/15/1999	20,000	20,000
<b>SSWS</b>	Hickey Run	DC Water	9/15/1999	40,000	20,000
<b>SSWS</b>	Hickey Run	DC Water	10/17/1999	90,000	30,000
<b>SSWS</b>	Hickey Run	DC Water	11/2/1999	30,000	23,000
<b>SSWS</b>	Hickey Run	DC Water	11/2/1999	23,000	23,000
<b>SSWS</b>	Hickey Run	DC Water	2/14/2000	4,000	900
<b>SSWS</b>	Hickey Run	DC Water	2/14/2000	3,000	3,000
<b>SSWS</b>	Hickey Run	DC Water	2/18/2000	1,700	1,100
<b>SSWS</b>	Hickey Run	DC Water	2/18/2000	8,000	5,000
<b>SSWS</b>	Suitland Pkwy	DC Water	9/15/1999	20,000	20,000
<b>SSWS</b>	Suitland Pkwy	DC Water	9/15/1999	80,000	40,000
<b>SSWS</b>	Suitland Pkwy	DC Water	9/21/1999	80,000	20,000
<b>SSWS</b>	Suitland Pkwy	DC Water	9/21/1999	130,000	80,000
<b>SSWS</b>	Suitland Pkwy	DC Water	10/17/1999	13,000	2,300
<b>SSWS</b>	Suitland Pkwy	DC Water	10/17/1999	17,000	17,000
<b>SSWS</b>	Suitland Pkwy	DC Water	11/2/1999	70,000	50,000
<b>SSWS</b>	Suitland Pkwy	DC Water	11/2/1999	30,000	11,000
<b>SSWS</b>	Suitland Pkwy	DC Water	2/14/2000	22,000	3,000
<b>SSWS</b>	Suitland Pkwy	DC Water	2/14/2000	3,000	2,700
<b>SSWS</b>	Suitland Pkwy	DC Water	2/18/2000	5,000	5,000
<b>SSWS</b>	Suitland Pkwy	DC Water	2/18/2000	5,000	5,000