Urban Water Fun!

John E. McCray
Civil & Environmental Engineering Department
Colorado School of Mines
jmccray@mines.edu
303-273-3490

South Platte River Urban Water Partnership Quarterly Meeting

19 Feb 2019

ReNUWIt: Reinventing the Nation's Urban Water Infrastructure

Topics Today

1. Request participation from SPRUWP on new NSF funded workshops related to beneficial use of stormwater (…. Gasp!….).
2. Talk on our automated urban water stormwater quality sampling program (including dry weather flows and snowmelt sampling).
3. Talk on one of our new green-infrastructure technologies for stormwater treatment under development at Mines. This one is about engineered streambeds for improving urban water quality in streams and channels.
4. If time, a brief overview of some other stormwater green infrastructure technologies/efforts ongoing at Mines.

1. NSF Funded Workshop to Brainstorm Ideas to Overcome Policy / Legal Barriers to Beneficial Stormwater Use in the Front Range

Participants: Mines, ReNUWIt, CWCB, Front Range Stakeholders (SPRUWP?)

What: 2 or 3 workshops based on a particular case study to get the discussion started. Each workshop could build on the next. If successful, could pursue additional funding (CWCB, NSF, etc) to continue the workshops and perhaps formalize a working group

When: Late Summer or Fall

Where: TBD. Likely at Mines, or at front range organizations

Partners: Looking for partners to promote the agenda and co-host (CWCB, SPRUWP, CSC, CAFSM, UDFCD, etc..)

Call for Interested Organizations / Individuals:

E-mail John McCray and Katie Spahr: jmccray@mines.edu; kspahr@mines.edu

With Subject Line: Stormwater Beneficial Use Workshops

2. Stormwater Quality Related to Infill Re-development in Denver:

Storm Sewer Monitoring for Data-Based Decision Making

John E. McCray, PhD

Kyle Gustafson, MS Student; Kimberly Slinski, PhD;

Colorado School of Mines

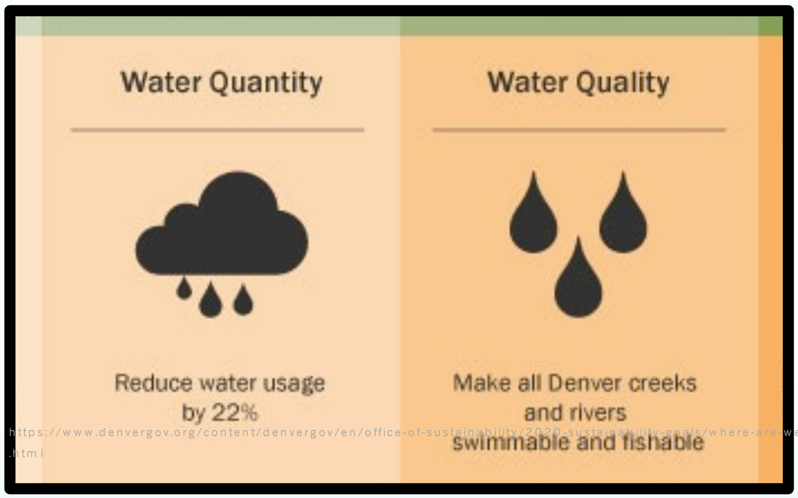
Presented to

South Platte River Urban Water Partnership

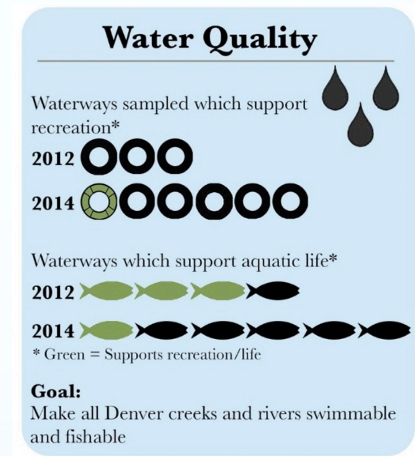
19 Feb 2019

ReNUWIt: Reinventing the Nation's Urban Water Infrastructure

Partnership with City of Denver: 2020 Sustainability Goals



https://www.denvergov.org/content/denvergov/en/office-of-sustainability/2020-sustainability-goals/where-are-we-now-.html



Rapid Growth with **Infill Re-Development**

Berkeley neighborhood in west Denver

More stormwater runoff

Lot size < 1 acre: stormwater quality control **<u>not</u>** required

→ Expect degraded stormwater quality

Urban Water Quality Sampling
Data-Driven Decision Making - Is it better?

- Automated sampling of storm events from storm sewers, including flow and water quality with real time monitoring
- Identify potential water quality impacts from urban basins undergoing different stages of infill development.
- Inform new policies regarding water quality mitigation for infill development
- Inform development, location and scale of green infrastructure for stormwater quality enhancement.
- Determine "local" Event Mean Concentrations (EMCs) for infill-developed neighborhoods, compare to city-wide residential EMCs.

Sampling Locations

- West - Rapidly developing + highly developed -
- Central - Highly developed – (Tennyson District)
- East - Slowly developing

Site	Area (ac)	Impervious Area (Ac)	Impervious (%)
West	328	184	56%
Central	79	47	60%
East	393	181	45%
Total	800	411	51%

Infill – Central Basin

Tennyson St.
2014

Tennyson St.
2017

Infill – Central Basin

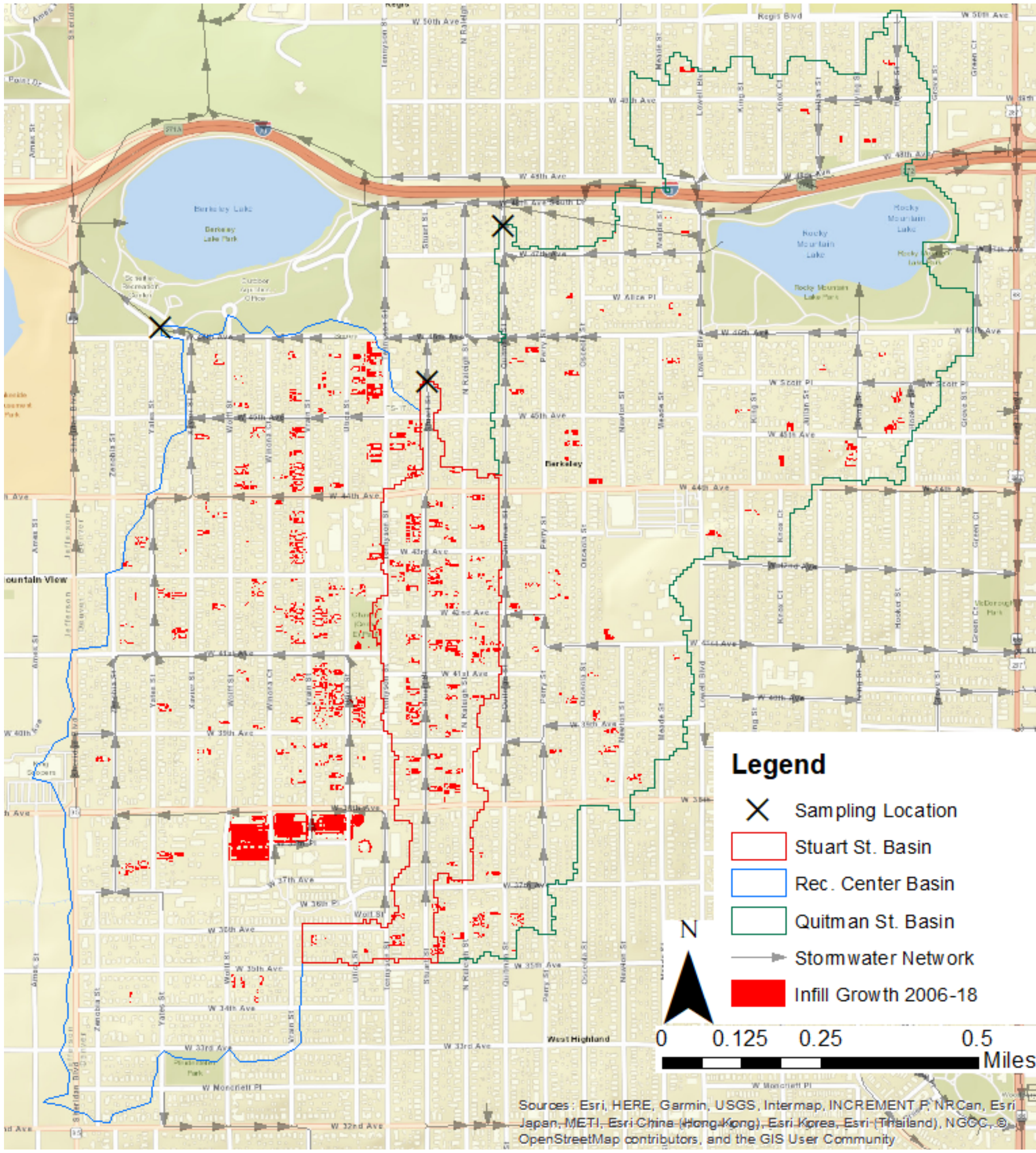
Stuart St.
2012

Stuart St.
2017

Infill - East Basin

Near Quitman St.
2011

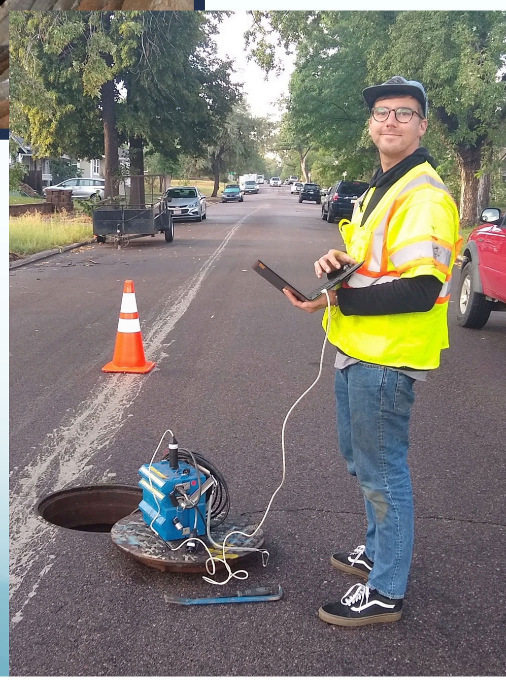
Near Quitman St.
2017



Infill Changes 2004-18

	SST (Ac.)	QST (Ac.)	REC (Ac.)
Building	2.6 (66%)	2.3 (68%)	6.4 (51%)
Driveway	0.5 (12%)	0.4 (13%)	1.2 (9%)
Parking	0.0 (0%)	0.1 (2%)	2.4 (19%)
Sidewalk	0.5 (12%)	0.3 (9%)	1.6 (13%)
Other	0.4 (10%)	0.3 (9%)	1.0 (8%)
Total (Acres)	4.0	3.3	12.6
Basin Area (Acres)	79.3	392.7	328.3
Percent Change	**5.0%**	**0.8%**	**3.8%**

Sampling Procedures



- ISCO Auto-samplers connected to flow sensors
- Real-time flow measurement
- Triggers above base flow
- Lab analysis within 24 hours
- Precipitation from RainVieux

  Corroborated with weather station in study area

Sampling Procedures

Water Quality Measure	Lab Method/Analysis Equipment	Sample Hold Time
TSS	EPA Standard Method 2540D	7 days
TDS and Conductivity	Cole-Parmer Traceable	24 hours
pH	Accumet AB15	24 hours
Total Recoverable Metals	EPA Standard Method 3015A/ICP-AES	7 days
Phosphorous	Hach TNT 843	24 hours
Ammonia	Hach TNT 831	24 hours
Nitrate	Hach TNT 835	24 hours
Nitrite	Hach TNT 839	24 hours
FIB and E. coli	Idexx Colilert	24 hours

Sampling Procedures

- Time-weighted - Discrete or Composite
  - Provides time series of concentrations
- Flow-weighted - Discrete or Composite
  - Provides higher accuracy for surface water load estimates
  - Composite sampling reduces labor and lab costs while still providing EMC values
- Grab samples for dry weather flows
  - Quantifies background concentrations
  - Irrigation, car washes, groundwater, residential sump pumps.

Rain Events Captured

- **9 rain events captured**
  - 7 at Rec Center
  - 6 at Quitman St.
  - 3 at Stuart St.
- **Antecedent Dry Period: 1-8 Days**
- **All storms smaller than 2-yr storm events**
  Rainfall 0.02-0.40”
- **Peak flow: 0.007-0.25 m^3/s**
- **+1 snowmelt event captured.**

Date	Ant. Dry Days	Storm Return Period	Rainfall (in.)	Peak Rainfall Inten. (in/5mins)	Peak Flow (m3/s)
7/2/18	8	<2yr/30min	0.02	0.00	0.007
7/7/18	5	<2yr/2hr	0.24	0.06	0.062
7/15/18	8	<2yr/2hr	0.39	0.02	0.08
7/23/18	7	<2yr/10min	0.11	0.01	0.027
7/24/18	1	<2yr/10min	0.02	0.02	0.032
8/18/18	3	<2yr/10min	0.20	0.14	0.251
8/21/18	2	<2yr/30min	0.05	0.01	0.009
9/5/18	5	<2yr/1hr	0.40	TBD	TBD
10/5/18	2	<2yr/10min	0.16	0.03	0.031

Infill/ Local EMCs

Red – Local EMC value exceeded city-wide EMC.

Blue Boxes - Local EMC smaller than city-wide EMC.

		Phospho. as P (mg/L)	Nitrite+ Nitrate (mg/L)	TSS (mg/L)	TDS (mg/L)	FIB (MPN/100mL)	E. Coli (MPN/100mL)
	UDFCD EMC	0.5	1.0	221.0	146.0	NA	NA
7/2/2018	West	0.4	2.7	156.9	428.9	NA	NA
7/7/2018	West	1.1	1.8	218.1	133.5	7.7E+06	1.6E+06
7/15/2018	West	0.6	1.4	120.3	72.6	1.5E+05	9.0E+05
7/23/2018	West	1.4	4.4	132.5	157.5	1.3E+06	1.0E+06
	East	1.0	2.7	52.1	342.9	1.3E+06	8.6E+05
7/24/2018	West	0.4	2.1	90.4	149.3	6.7E+06	5.4E+04
	East	0.7	2.8	73.0	217.2	1.3E+06	3.5E+04
8/18/2018	East	0.8	1.8	275.1	97.4	1.1E+06	3.7E+05
	Central	0.9	1.6	93.9	59.8	8.7E+05	2.1E+05
8/21/2018	East	0.4	4.2	26.9	469.4	NA	NA
	Central	0.3	3.3	47.4	349.3	NA	NA
	West	0.4	3.9	51.2	372.3	NA	NA
9/5/2018	East	0.8	0.9	46.9	33.2	8.1E+05	1.6E+04
	Central	1.1	1.7	207.6	63.4	1.3E+06	7.0E+03
10/5/2018	East	1.5	3.2	59.0	167.0	1.1E+06	4.2E+05
	Central	1.2	3.0	29.0	145.5	1.3E+06	3.3E+05
Mean (SD)		0.7 (0.3)	2.8 (1.0)	127.9 (87)	239.1 (138)	2.6E+6 (3E+6)	6.4E+6 (5E+5)

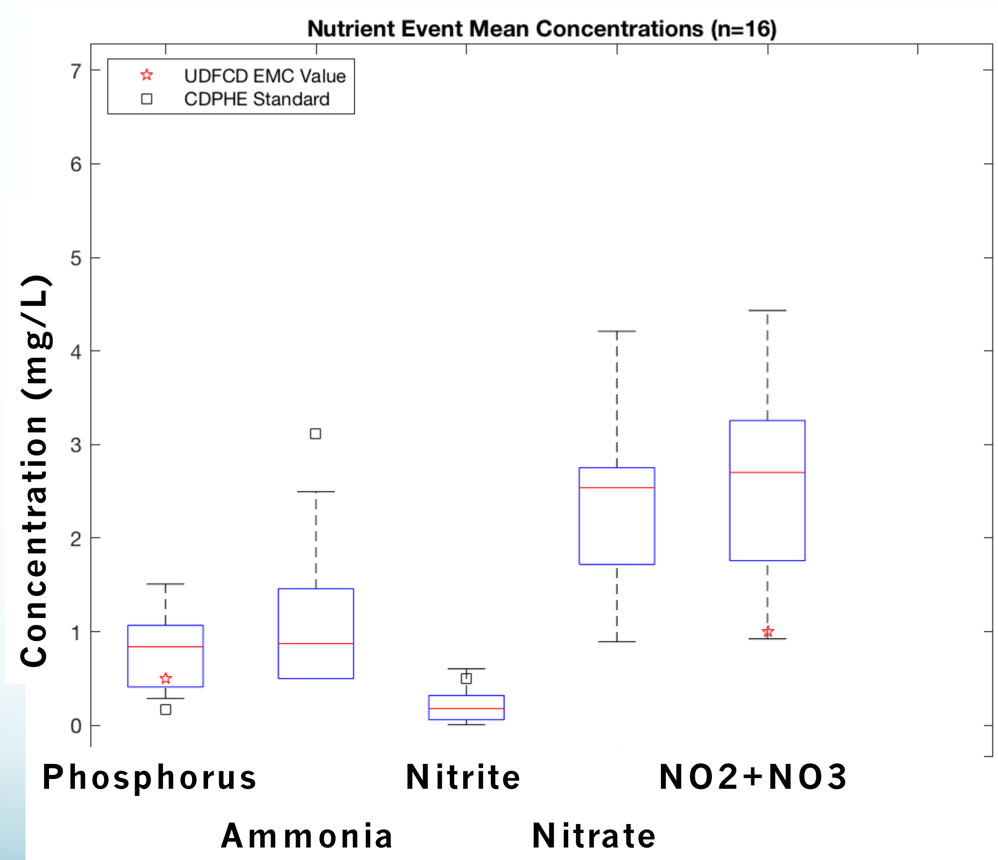
Infill/ Local EMCs

Red – Local EMC value exceeded City-wide EMC.

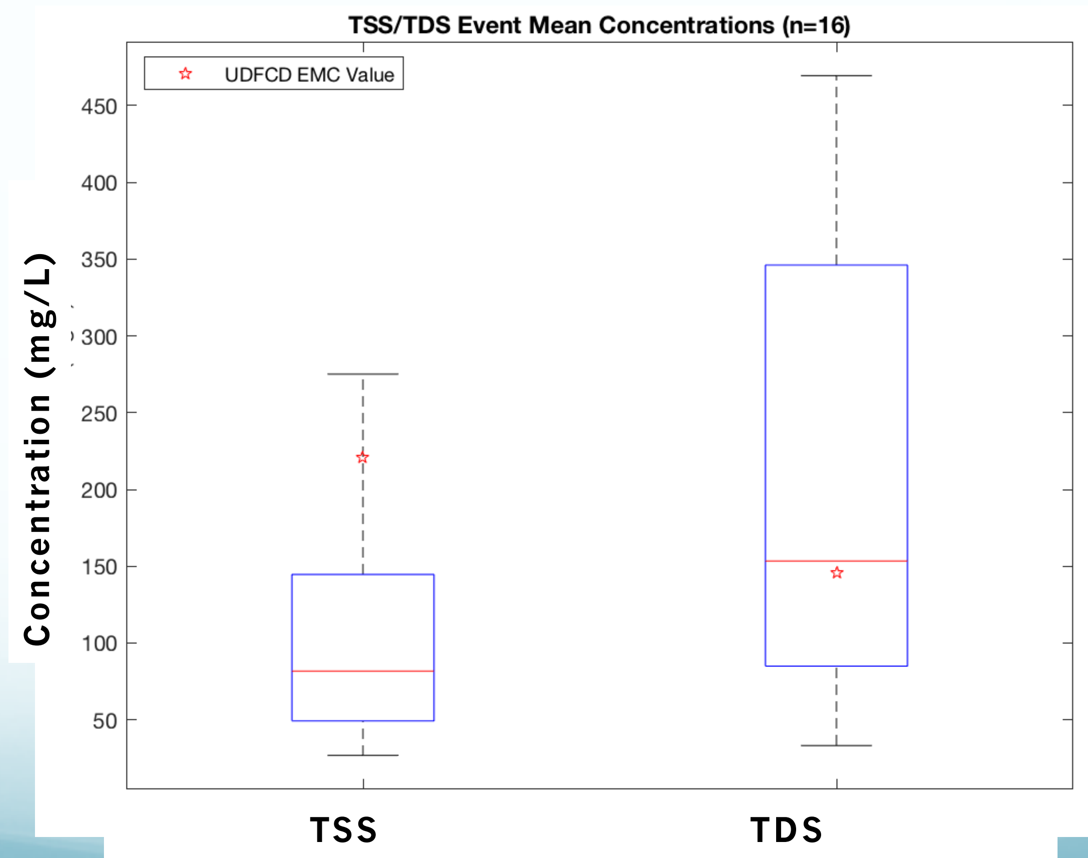
Blue Boxes - Local EMC smaller than city-wide EMC.

		As (ug/L)	Cd (ug/L)	Cu (ug/L)	Pb (ug/L)	Zn (ug/L)
	UDFCD EMC	**NA**	**NA**	**22.0**	**14.0**	**115.0**
	Detection Limit	8.0	0.6	2.9	5.0	4.1
7/2/2018	**West**	15.6	BDL	60.65	27.53	347.10
7/7/2018	**West**	BDL	BDL	38.61	6.99	117.33
7/15/2018	**West**	BDL	BDL	26.87	BDL	118.24
7/23/2018	**West**	BDL	BDL	51.92	28.50	262.49
	East	BDL	BDL	31.21	10.71	140.35
7/24/2018	**West**	BDL	BDL	32.01	BDL	136.50
	East	BDL	BDL	23.51	BDL	105.47
8/18/2018	**East**	BDL	BDL	37.5	BDL	191.2
	Central	BDL	BDL	39.9	BDL	267.4
8/21/2018	**East**	BDL	BDL	18.3	BDL	71.3
	Central	BDL	BDL	25.8	9.0	149.0
	West	BDL	BDL	19.6	BDL	97.8
9/5/2018	**East**	BDL	BDL	BDL	BDL	48.0
Mean (SD)		**NA**	**NA**	**33.8 (13)**	**16.5 (11)**	**157.9 (84)**

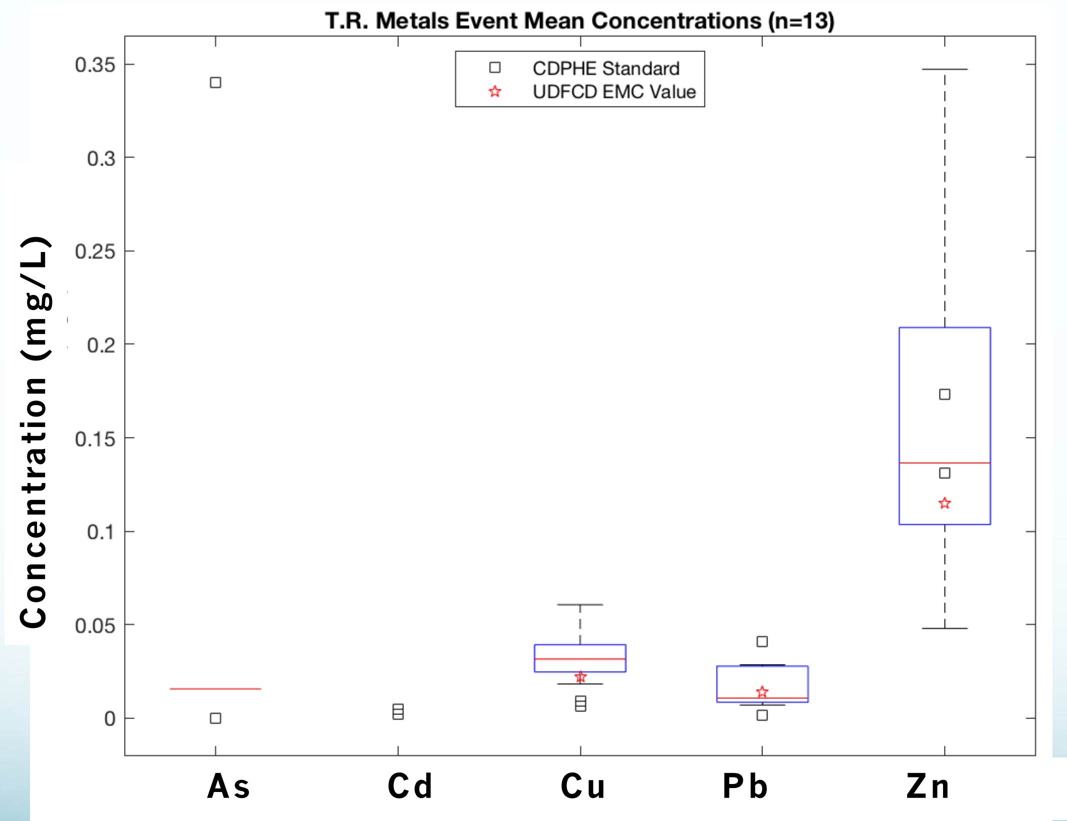
Local EMCs vs City Wide: Nutrients



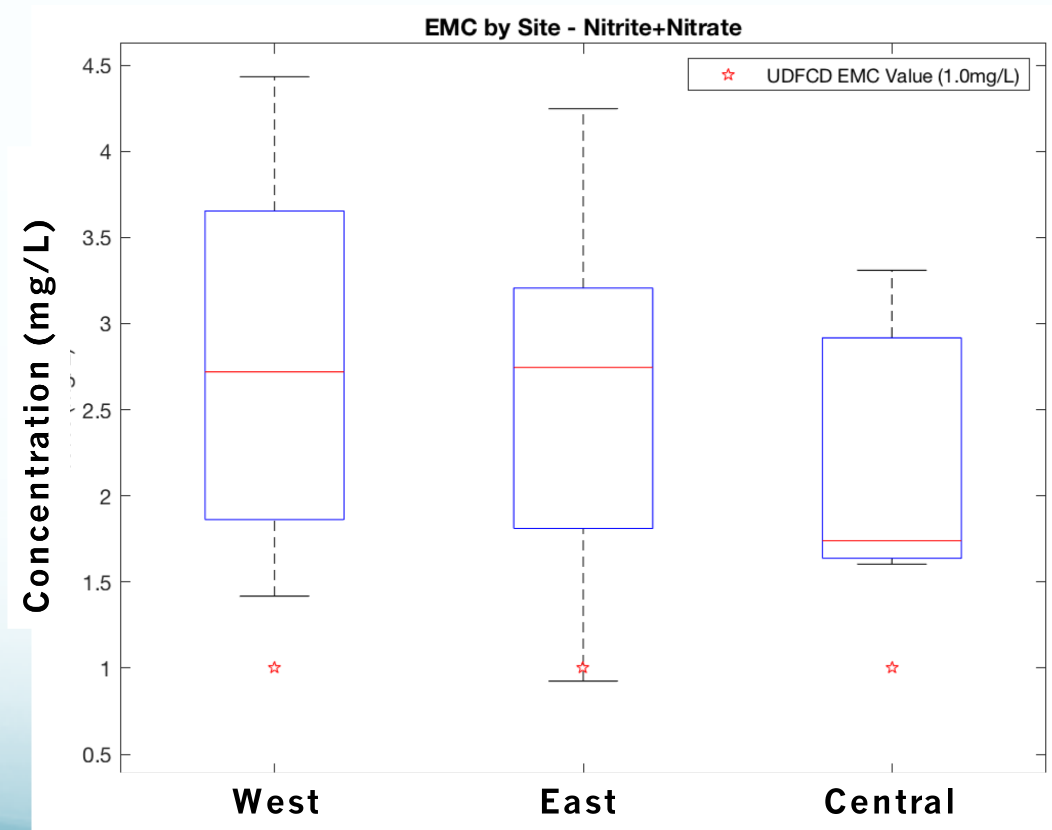
Local EMCs vs City Wide: TSS, TDS



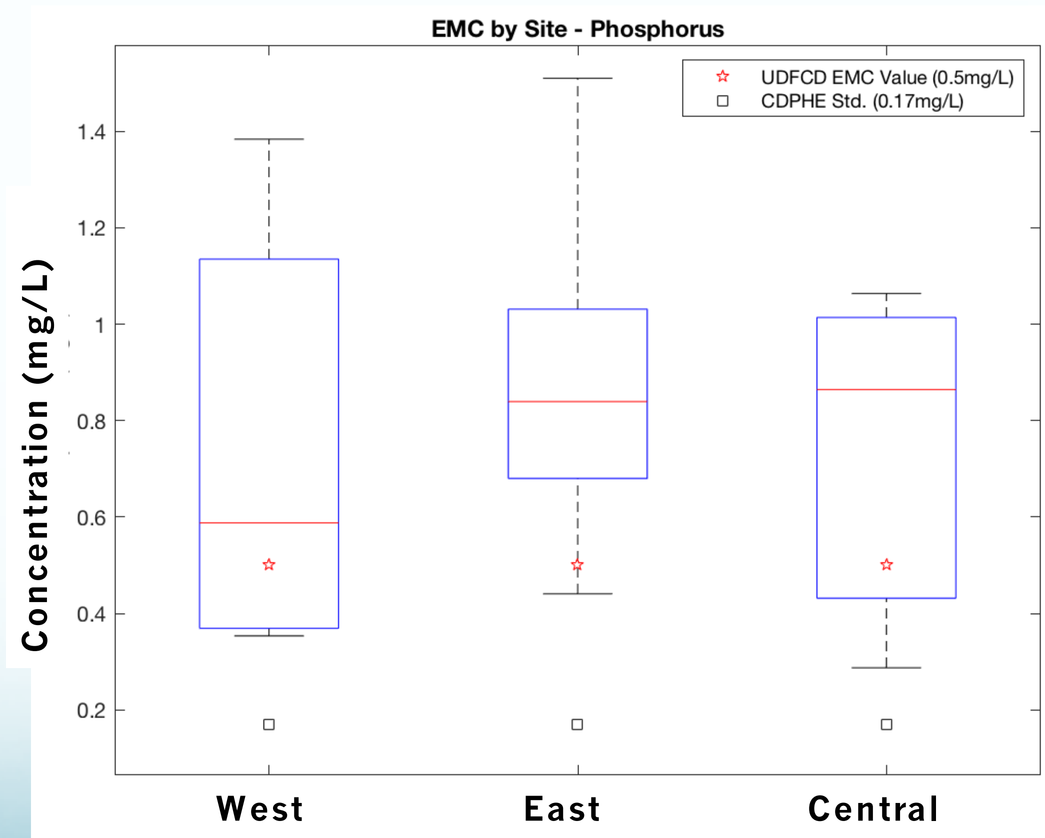
Local EMCs vs City Wide: Metals



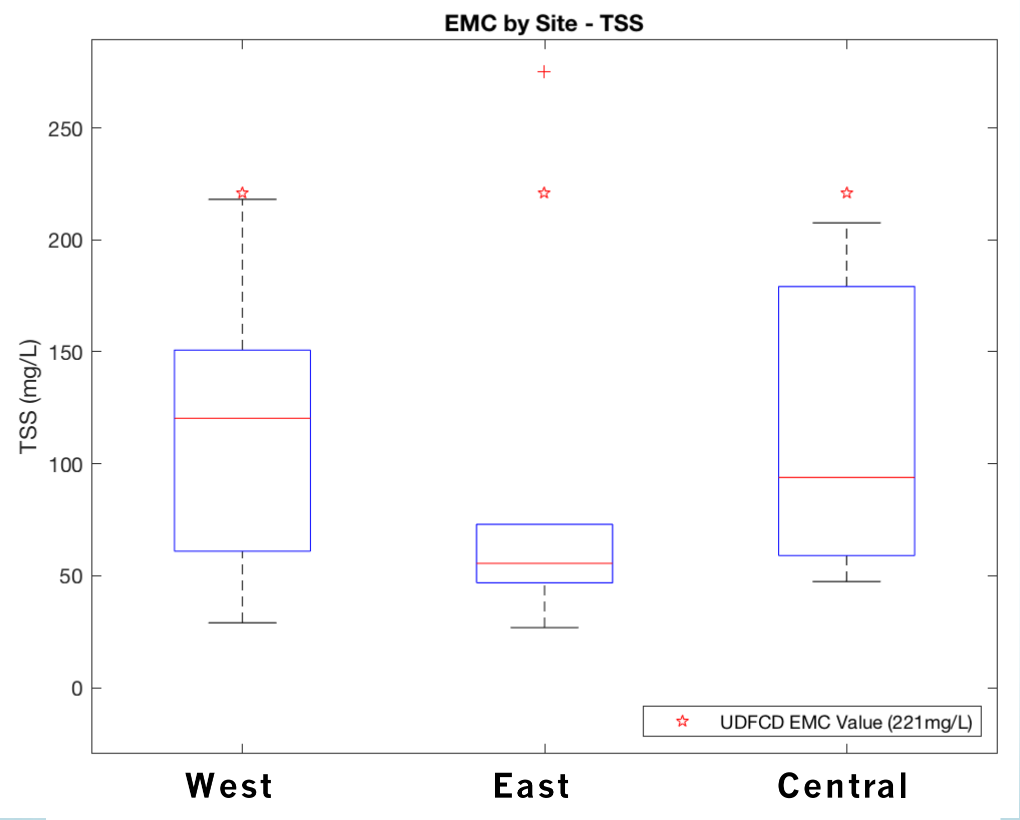
EMCs by Site: Nitrogen



EMCs by Site: Phosphorus



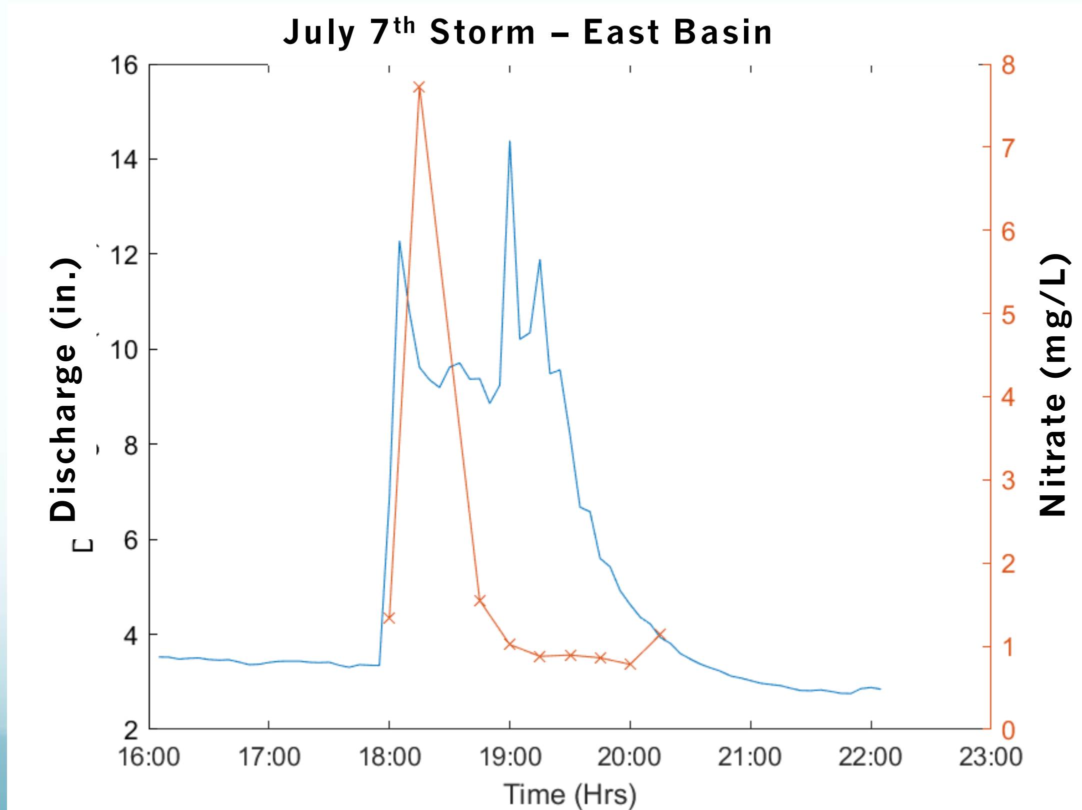
EMCs by Site: TSS



Evidence of First Flush and Washout

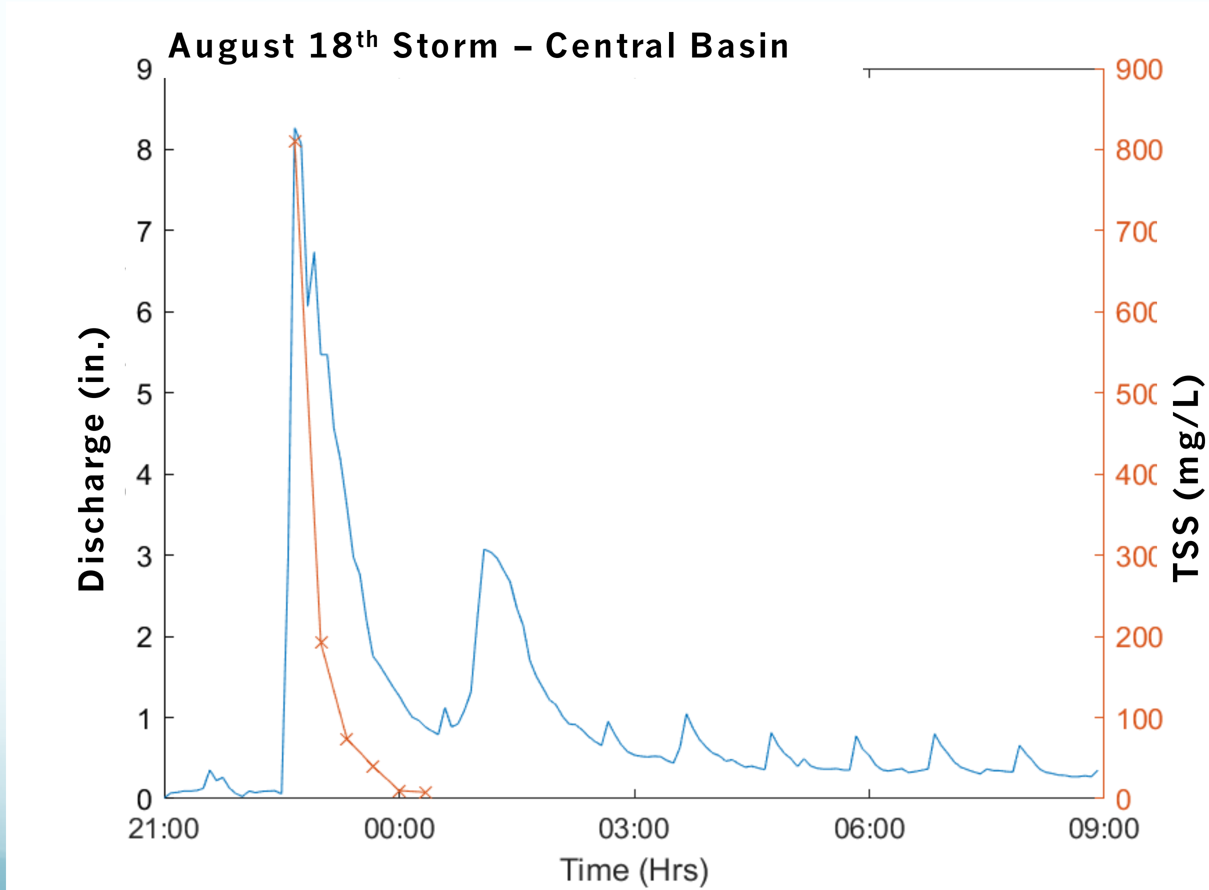
- First flush and washout consistent for nutrients and TSS

Nitrates



Evidence of First Flush and Washout

TSS



Water Quality Correlated with .....?

METHODS

- Independent variables:
  - Total Rainfall
  - Rainfall Intensity
  - Antecedent Dry Days
  - Impervious Coverage Initial "univariate" analysis using Pearson's correlation coefficients
- Statistical significance if P-values are below 0.05

PRELIMINARY RESULTS

- Significant correlation between Intensity and TDS, TSS, nitrogen
- Low correlation for most variables due to "small" data set relative to natural variability
- No significant correlation between any parameters and impervious cover, but likely swamped by rainfall intensity (working on this one).
- Need to conduct an multivariate analysis or filter out impact of intensity (expected) to test for other variables.

Snowmelt Sampling

1 round, 3 locations with replicates

	Peak Flow (m3/s)	P (mg/L)	NH4 (mg/L)	NO2 (mg/L)	NO3 (mg/L)	TSS (mg/L)	Cond. (mg/L)	TDS (mg/L)	FIB (MPN/100mL)	Ecoli (MPN/100mL)
Storm flow Mean	**0.300**	**0.8**	**1.1**	**0.2**	**2.4**	**117**	**311**	**205**	**2,092,120**	**488,262**
SD	0.7	0.4	0.7	0.2	0.9	88	213	141	2,431,639	509,949
Snowmelt Mean	**0.004**	**0.1**	**0.9**	**0.6**	**2.3**	**109**	**4,287**	**2,827**	**44,097**	**NA**
SD	0.003	0.1	0.3	0.0	0.7	54	1,725	1,141	59,984	NA

Summary

- Local "neighborhood-scale" EMCs notably larger than City-wide EMC values for Nutrients, TDS, Cu, and Zn.
- FIB and E. coli levels extremely high during wet weather events
- First flush effects are noted for TSS and most nutrients, indicating contaminant build up and wash off - no significant first flush effect for metals
- High levels of variability. Statistical correlation with rainfall intensity, but no significant correlation with impervious coverage, antecedent dry days, likely due to relatively "limited data"… we are getting more!
- **If data are to be used for decision making with confidence, a rigorous multi-season data set is needed.**

Moving Forward

- Need to capture more storms to overcome variability
- Evaluate relationships between water quality parameters and impervious cover
- May need to add or refine sampling locations to capture different stages of Infill.
- Remote sensing methods to better track and evaluate re-development and impervious cover change on more frequent time intervals
- Inform policy and potential new regulations
- Winter snowmelt sampling? Urban Drool?