Estimating Nutrient Loads in Urban Runoff under Colorado's Regulation 85

Project Sponsors:

Urban Drainage and Flood Control District

Colorado Stormwater Council

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Overview

- Background: Colorado's Nutrient Regulations 85 and 31
- MS4 Requirement: "Data Gap Analysis"
- Project Approach
  - Colorado Data
  - National Data—National Stormwater Quality Database (NSQD—Pitt)
- DRAFT Findings
- Conclusions—what do we know about nutrients in urban runoff in Colorado?

Colorado's Nutrient Regulations

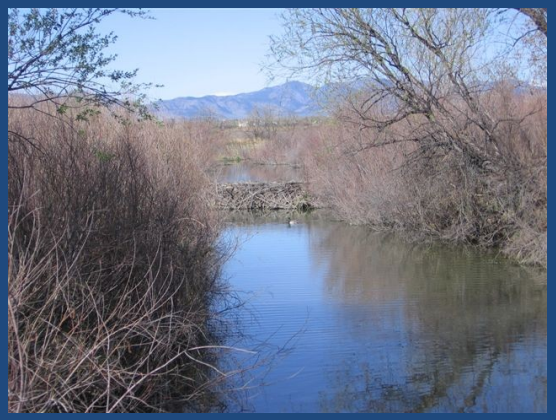
- Regulation 31—relates to instream standards
  - Adds criteria for total phosphorus, total nitrogen, chlorophyll-a
  - Interim criteria—10-year window for most streams
- Regulation 85—relates to discharge permits
  - Requirements for municipal WWTP and certain industrial discharges:
    - Numeric effluent limits (TIN & TP)
    - Instream monitoring
  - Requirements for MS4s:
    - Public education and outreach
    - Pollution prevention/good housekeeping for municipal operations
    - "Data gap analysis" for MS4 stormwater discharges
  - Also discusses non-point sources

“Discharge Assessment Data Report” (Due to Division by October 31, 2014)

- “Identify information that exists and the need for additional monitoring to be conducted in the future to determine the approximate nitrogen and phosphorus contribution to state waters due to discharges from MS4.”
- “Document the availability of existing data, and [provide] a “Gap Analysis” that identifies the need for additional information (e.g., monitoring data or studies), in accordance with the requirements of [the regulation].”

Reg. 85 Load Estimation Approaches Allowed in Data Gap Report

- Monitoring data from the MS4 discharge or downstream waters
- Monitoring data from other entities
- Land-use based models
- Land-use based data from literature



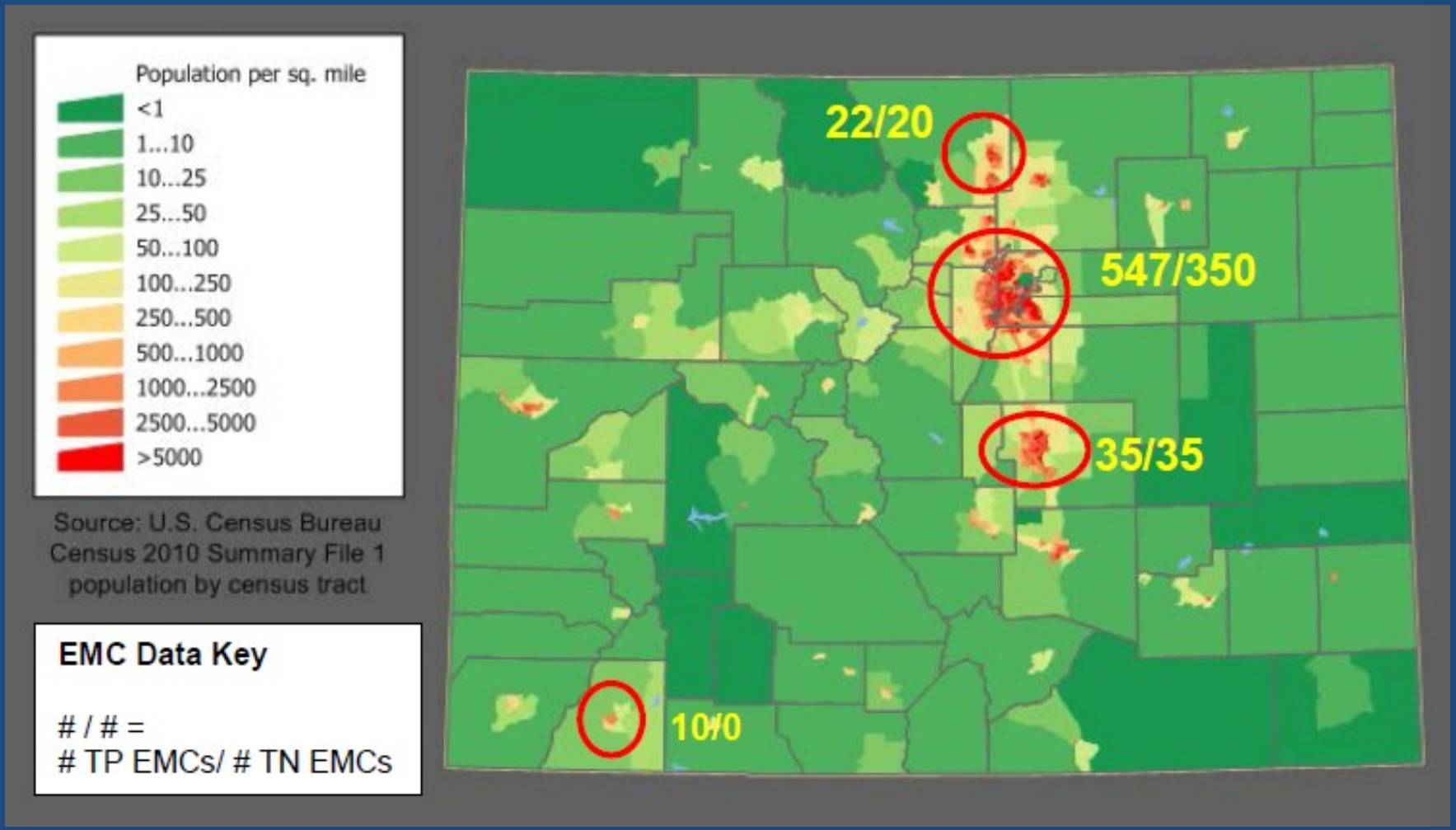
Before we get started…
The Big Picture is Nutrient Loads

- Nutrient Concentration x Flow Volume = Load
- The data gap question focuses on the concentration component of load estimation.
- However, hydrology is the big difference by land uses and for different parts of the state.
- Methods for runoff volume calculations are well-documented by UDFCD and others.

Approach Selected for Data Gap Report

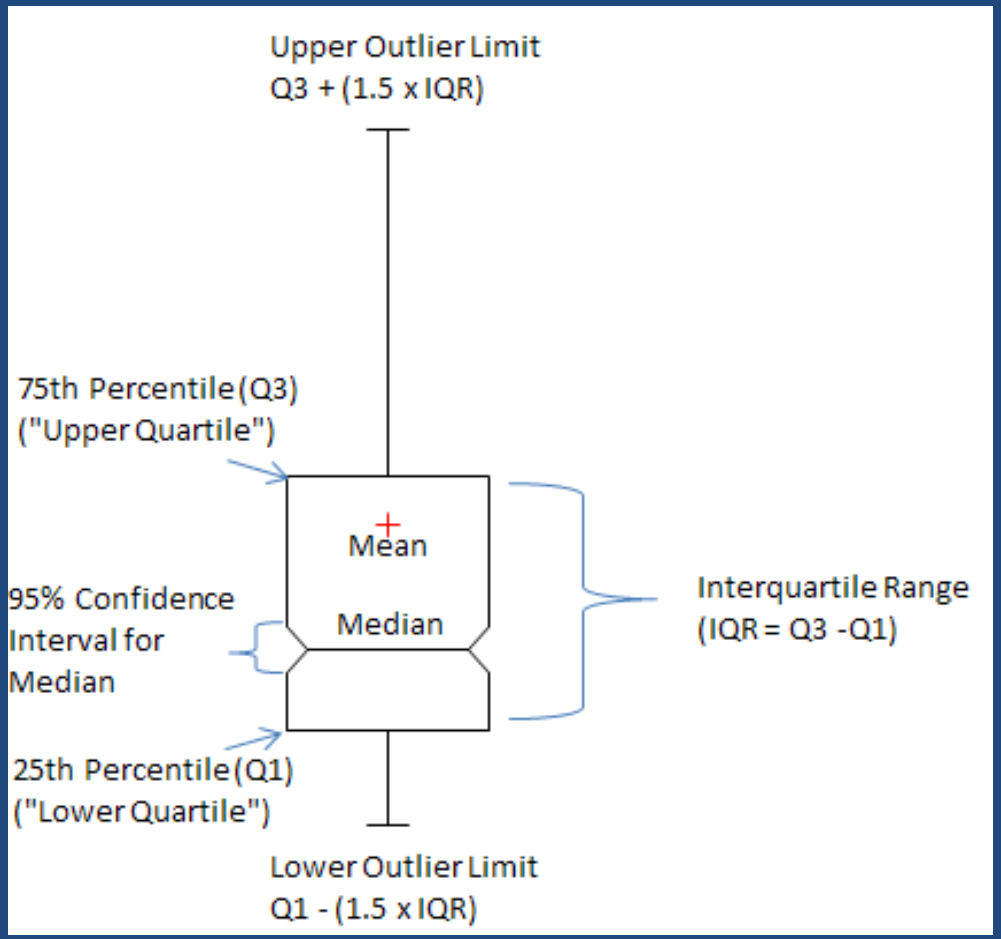
- Colorado EMC data for urban stormwater runoff
- Primary Data Sources
  - DRURP (1980's)
  - Phase 1 permit monitoring (1990's)
  - UDFCD BMP monitoring (inflow data)
  - Other BMP monitoring (ACWWA, Grant Ranch)
  - CSU/City of Fort Collins
  - CDOT Permit-required monitoring
- Supplementary Data
  - City and County of Denver outfall monitoring (grabs)

General Distribution of Nutrient Monitoring EMCs in Colorado Relative to Population



Statistical Methods

- Basic descriptive statistics
- Boxplots
- Time-series plots
- Cumulative frequency distribution
- Normal probability plots
- Hypothesis testing
  - Kruskal-Wallis
  - Mann-Whitney
  - Dunn's Procedure
- Spearman correlation analysis & scatter plot matrices



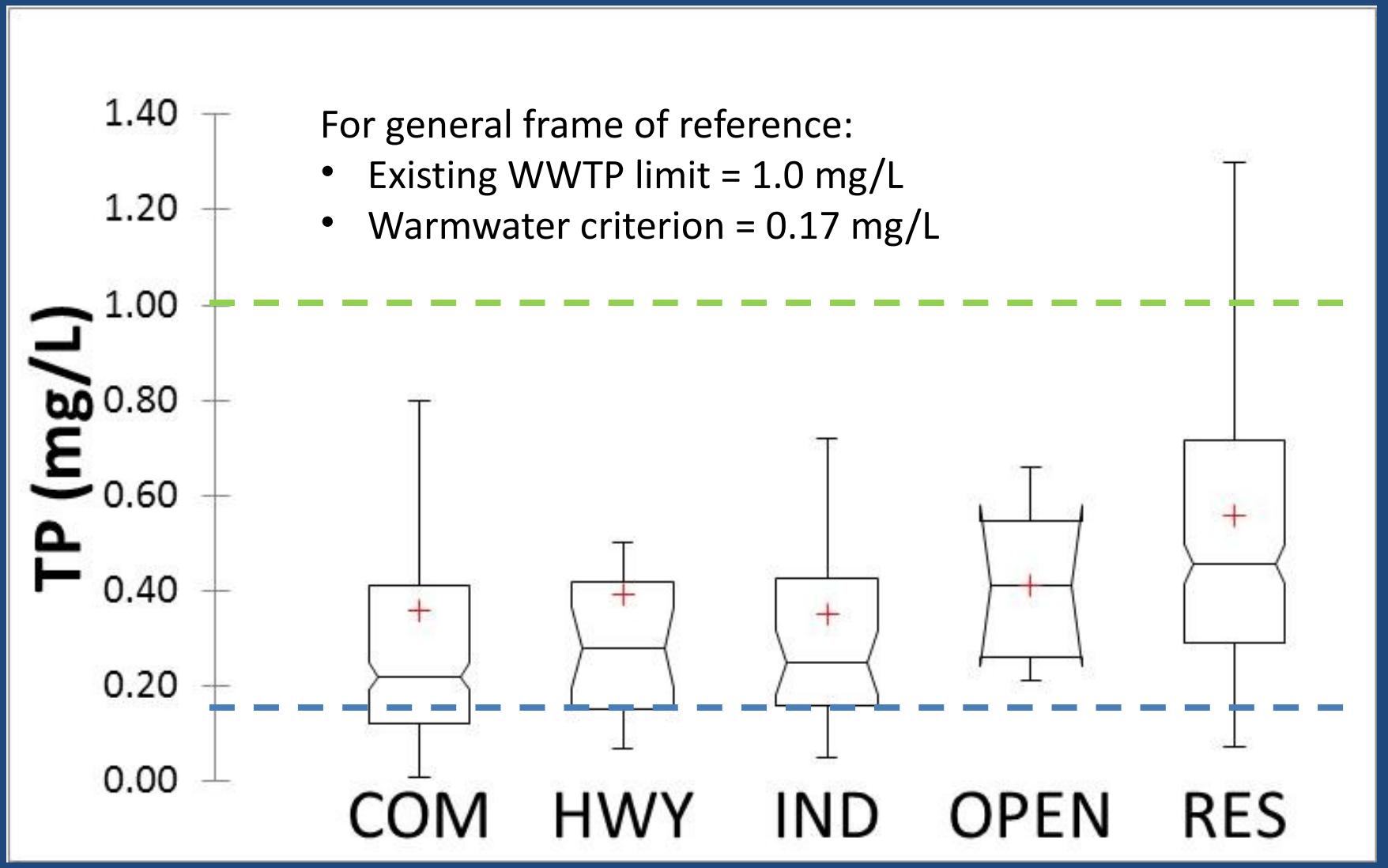
Colorado Total Phosphorus (mg/L)in Runoff

Land Use	#	Min	Max	25th %	Median	75th %	Mean	COV
COM	277	0.01	6.30	0.12	**0.22**	0.41	0.36	1.47
HWY	25	0.07	2.60	0.15	**0.28**	0.42	0.39	1.25
IND	39	0.05	1.30	0.16	**0.25**	0.43	0.35	0.81
OPEN	7	0.21	0.66	0.26	**0.41**	0.54	0.41	0.39
RES	254	0.07	2.71	0.29	**0.46**	0.72	0.56	0.69

- Residential significantly higher than other urban land uses.
- No significant difference among other urban land uses (COM-HWY-IND).

**Draft findings 10-9-2013, subject to change. Additional statistical analyses in report.*

Colorado TP Boxplots by Land Use



**Draft findings 10-9-2013, subject to change.*

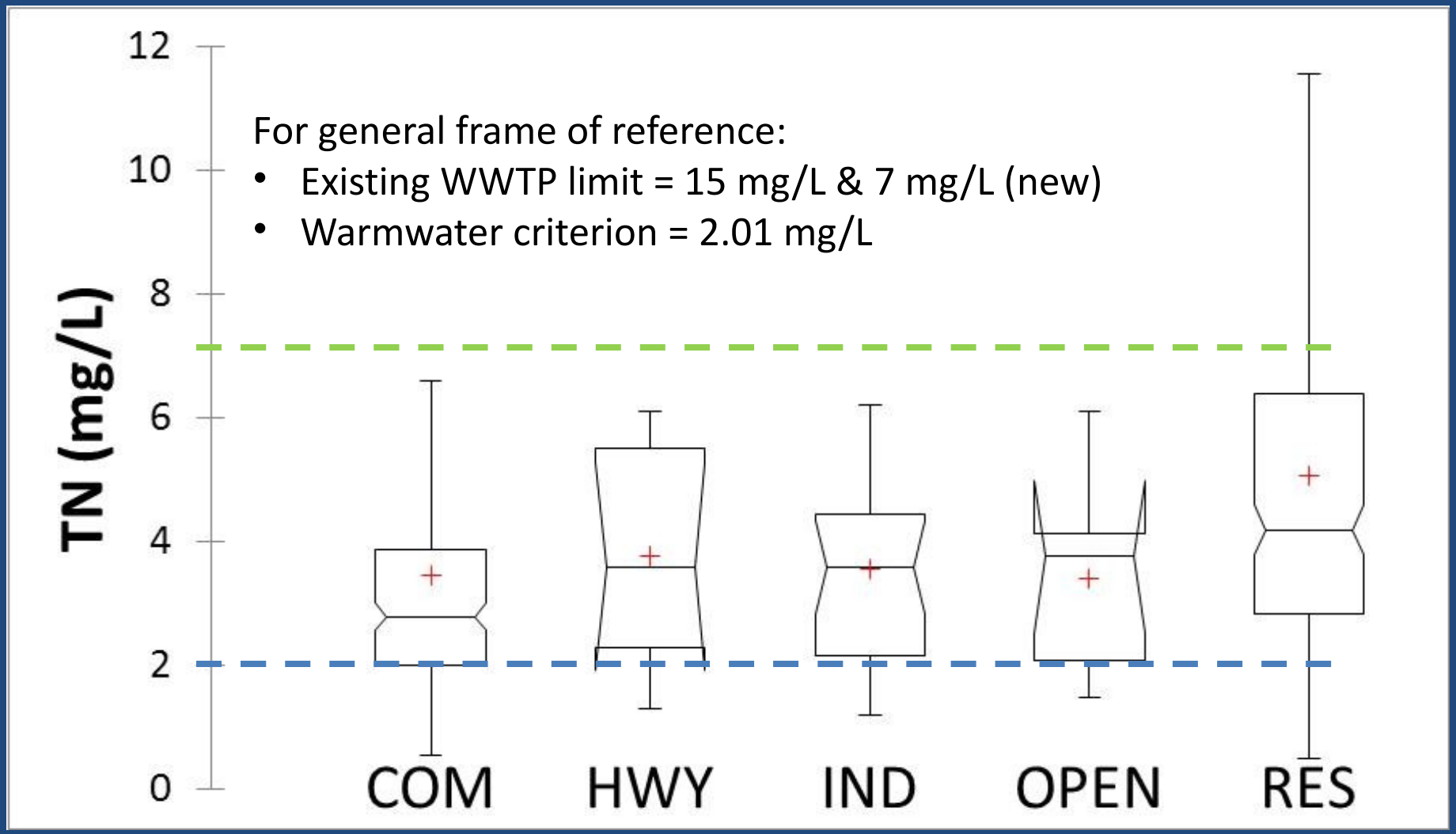
Colorado Total Nitrogen (mg/L) in Runoff

Land Use	#	Min	Max	25th %	**Median**	75th %	Mean	COV
COM	168	0.54	16.63	2.01	**2.79**	3.88	3.45	0.71
HWY	9	1.30	6.10	2.30	**3.60**	5.50	3.78	0.45
IND	23	1.20	8.70	2.15	**3.60**	4.44	3.56	0.49
OPEN	7	1.49	6.12	2.08	**3.76**	4.14	3.40	0.44
RES	191	0.51	22.77	2.83	**4.19**	6.38	5.06	0.64

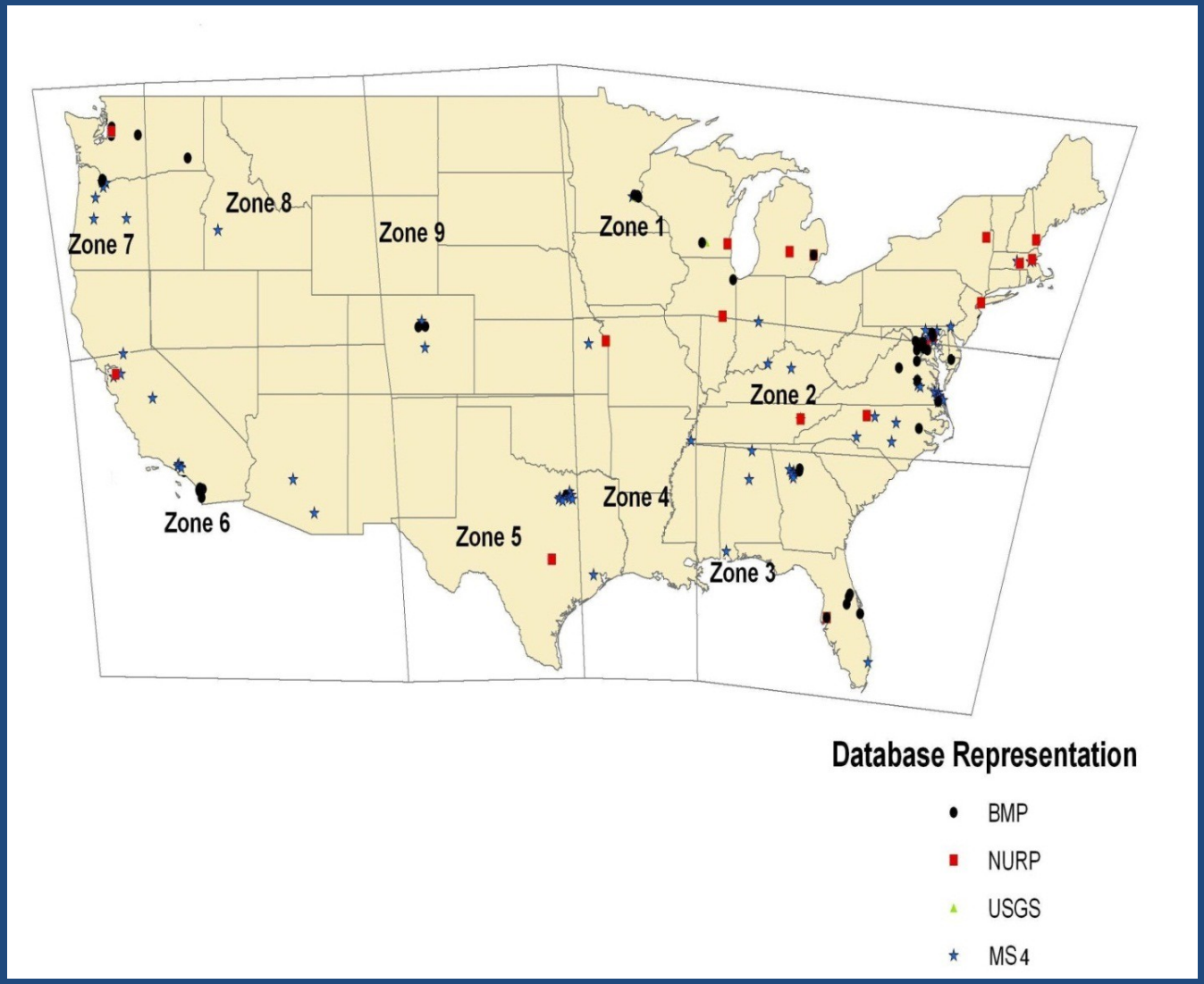
- Residential significantly higher than other urban land uses.
- No significant difference among other urban land uses (COM-HWY-IND).

**Draft findings 10-9-2013, subject to change. Additional statistical analyses in report.*

Colorado TN Boxplots



NSQD v.3 Runoff Characterization Data by U.S. EPA Rain Zone



Comparison CO TP to EPA Rain Zones

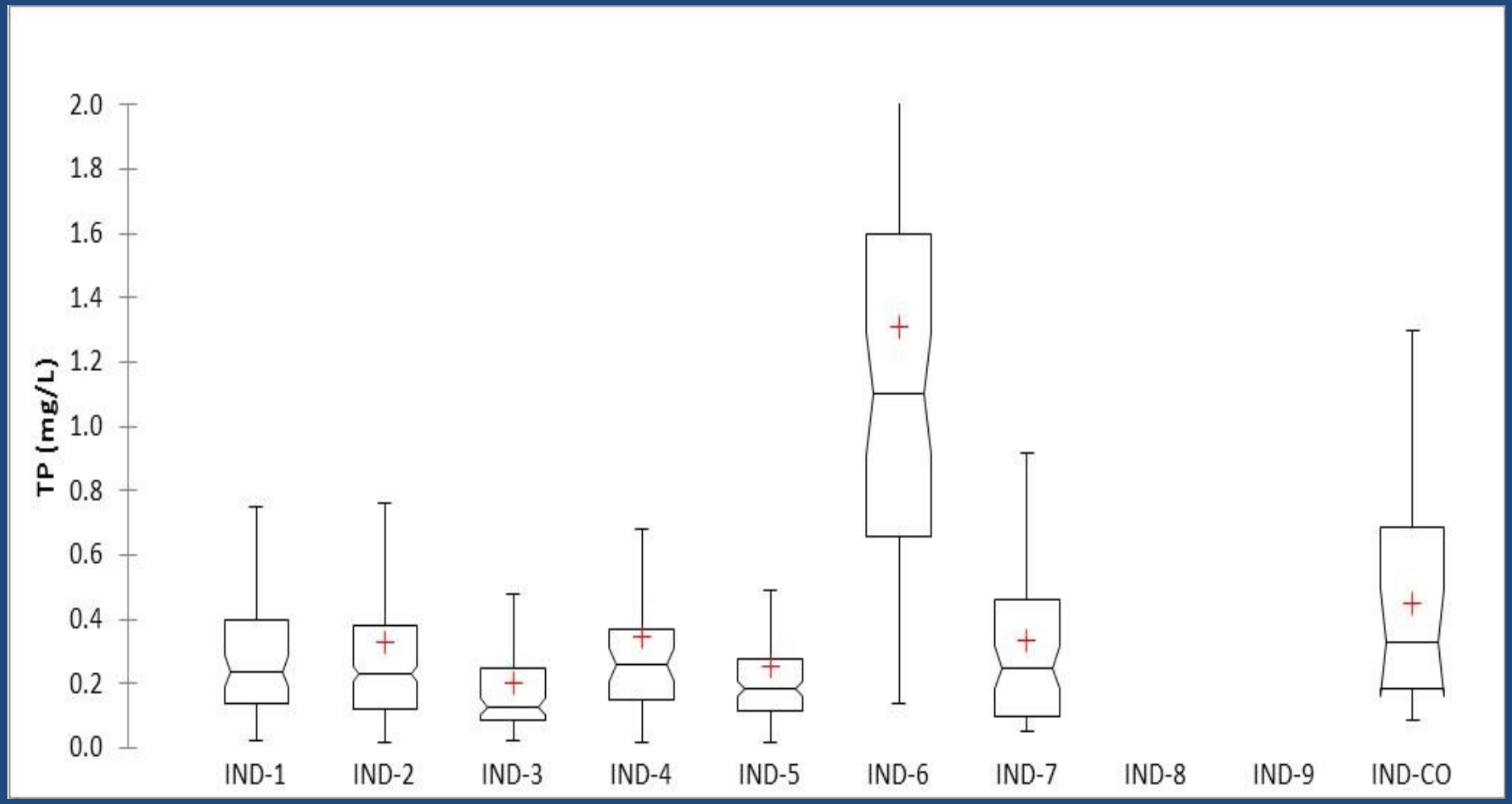
(Kruskal-Wallis/Dunn's Procedure)

Rain Zone		Colorado Land Use				
Rain Zone	Description	COM (282)	HWY (41)	IND (23)	OPEN (7)	RES (261)
1	Great Lakes/ Northeast	Higher (263)	NSD (3)	NSD (74)	Higher (139)	Higher (498)
2	Mid-Atlantic	NSD (621)	Lower (177)	Higher (360)	NSD (106)	Higher (1923)
3	Southeast	NSD (141)	Higher (14)	Higher (108)	--	Higher (410)
4	Lower Miss. Valley	NSD (50)	--	NSD (49)	NSD (18)	NSD (91)
5	Texas	Higher (112)	NSD (246)	Higher (108)	NSD (67)	Higher (206)
6	Southwest	Lower (35)	NSD (135)	Lower (61)	NSD (2)	NSD (67)
7	Northwest	NSD (84)	NSD (24)	Higher (76)	--	Higher (331)
8	Rocky Mtns.	*Lower (7)*	--	NSD (1)	--	NSD (15)

Higher/Lower/NSD = indicates whether Colorado's TP results are higher, lower or not significantly different statistically from another other rain zone;

(#) = number of samples in data set

Colorado TP Data vs. NSQD Data for EPA Rain Zones: Industrial Land Uses



Comparison CO TN to EPA Rain Zones

(Kruskal-Wallis/Dunn's Procedure)

		Colorado Land Uses (#) = number of samples in data set				
Rain Zone	**Description**	**COM (171)**	**HWY (9)**	**IND (23)**	**OPEN (7)**	**RES (195)**
1	Great Lakes/Northeast	Higher (12)	--	NSD (6)	Higher (5)	Higher (30)
2	Mid-atlantic	Higher (76)	--	NSD (87)	Higher (57)	Higher (111)
3	Southeast	Higher (37)	NSD (14)	NSD (28)		Higher (49)
4	Lower Miss. Valley	Higher (26)	--	NSD (29)	NSD (12)	Higher (56)
5	Texas	--	--	--	--	--
6	Southwest	NA (2)	--	NSD (10)	--	NA (3)
7	Northwest	--	--	--	--	--
8	Rocky Mtns.	--	--	--	--	--

Higher/Lower/NSD = indicates whether Colorado's TP results are higher, lower or not significantly different statistically from another other rain zone;
(#) = number of samples in data set

Nutrient Load Estimation

$$Load\ \left[\frac{lb}{ac}\right] = 0.226\ \times EMC\ \left[\frac{mg}{L}\right] \times Runoff\ [in]$$

- To estimate nutrient loads from urban land uses:
  - ✓precipitation data
  - ✓runoff volume calculations
  - ✓nutrient EMC data
- For runoff volume calculations:
  - drainage area
  - land use
  - imperviousness
  - soil type
- Water Quality Capture Optimization and Statistics Model (WQ-COSM) (UWRI 2011)

Example Spreadsheet Approach Based on WQ-COSM

Site Name: CSC Template
Drainage Area: 10.00 acres

From WQ-COSM
From USDCM Storage Chapter for Land Use
Run for A, B and C/D for each Land Use
EMCs from Data Analysis for Land Use

Percentile Distribution of Runoff-Producing Precipitation Events		Landuse Imperviousness	Hydrologic Soil Group	Runoff	Runoff Event Mean Concentration (EMC) for Land Use	Runoff Pollutant Load	Estimated Event Load
Percentile	Precipitation Depth (in)*	Single Family Residential	A, B or C/D	Runoff (in)	Landuse TP (mg/L)	TP (lb/acre)	TP (lb)
1%	0.080	40%	C/D	0.032	0.47	0.003	0.03
5%	0.090	40%	C/D	0.036	0.47	0.004	0.04
10%	0.100	40%	C/D	0.040	0.47	0.004	0.04
15%	0.100	40%	C/D	0.040	0.47	0.004	0.04
20%	0.100	40%	C/D	0.040	0.47	0.004	0.04
25%	0.100	40%	C/D	0.040	0.47	0.004	0.04
30%	0.100	40%	C/D	0.040	0.47	0.004	0.04
35%	0.120	40%	C/D	0.048	0.47	0.005	0.05
40%	0.140	40%	C/D	0.056	0.47	0.006	0.06
45%	0.170	40%	C/D	0.068	0.47	0.007	0.07
50%	0.200	40%	C/D	0.080	0.47	0.008	0.08
55%	0.202	40%	C/D	0.081	0.47	0.009	0.09
60%	0.240	40%	C/D	0.096	0.47	0.010	0.10
65%	0.280	40%	C/D	0.112	0.47	0.012	0.12
70%	0.310	40%	C/D	0.124	0.47	0.013	0.13
75%	0.380	40%	C/D	0.152	0.47	0.016	0.16
80%	0.450	40%	C/D	0.180	0.47	0.019	0.19
85%	0.570	40%	C/D	0.228	0.47	0.024	0.24
90%	0.770	40%	C/D	0.308	0.47	0.033	0.33
95%	1.100	40%	C/D	0.463	0.47	0.049	0.49
99.5%	2.517	40%	C/D	1.184	0.47	0.126	1.26
100%	4.820	40%	C/D	2.975	0.47	0.316	3.16

*Events < 0.08 in excluded to account for impervious depression storage.

Overall Conclusion

- A significant EMC-based urban runoff data set is available to characterize nutrient loads in urban runoff in Colorado.
- Data Report provides statistical characterization of TP & TN concentrations by land use for this purpose.
- Additional monitoring for purposes of general characterization of nutrients in urban runoff in Colorado is likely not necessary to meet requirements of Regulation 85.
- However, in watersheds where nutrient impairments are identified in the future and urban stormwater runoff is a likely contributor, then targeted monitoring to identify watershed-specific nutrient sources may be beneficial to help prioritize selection and placement of BMPs.

Other Specific Findings

- Colorado nutrient EMC data set:
  - TP (n = 602) & TN (n = 398)*
  - Represents most urban land uses
  - Residential and commercial are particularly strong
- Median TP for EMCs by land use in Colorado ranges from 0.22 to 0.46 mg/L, with statistically significant differences among some land uses.*
- TP in residential runoff is statistically higher than commercial, industrial and highway land uses.
- Median TN for EMCs by land use in Colorado ranges from 2.79 to 4.19 mg/L, with statistically significant differences among some land uses.*
- TN in residential runoff is statistically higher than commercial, industrial and highway land uses.

**Draft findings, subject to change.*

Findings (cont.)

- Median untreated TN & TP by land use are all higher than interim instream water quality standards—including runoff from natural areas.
- Median untreated TN & TP by land use are all lower than the Reg. 85 WWTP discharge limits.
- Colorado TP is within ranges observed in other EPA Rain Zones.
- Colorado TN tends to be higher than ranges observed in other EPA Rain Zones.
- Rain Zone 6 (Southwest) may be useful for supplementing western Colorado data set.

Questions?

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