Green Roofs: How Do They Affect Water Quality?

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CESE
Center for Environmental Systems Engineering

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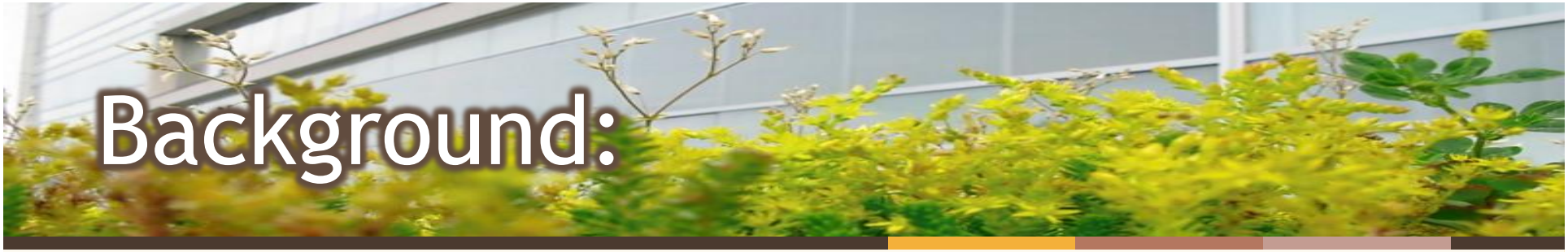
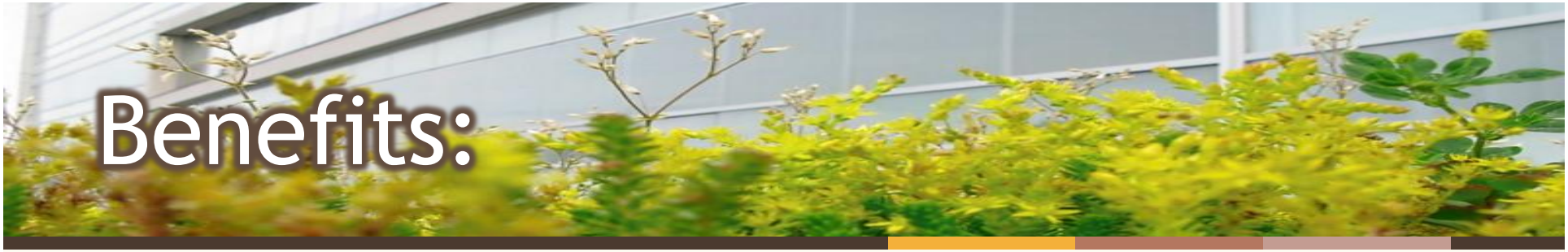
Outline:

- Background
- Benefits
- Questions
- Approach
- Analytes
  - $-NO_3$
  - $-NH_4$
  - -TN
  - -Dissolved Organic Carbon (DOC)
- Summary
- Conclusion
- Future Work
- Results:



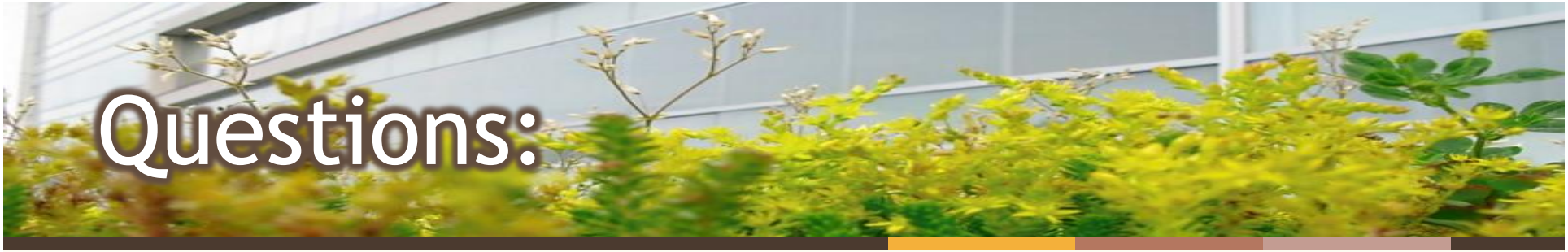
Background:

- The global climate is changing; we must respond and adapt with it
- Green infrastructure is becoming the norm to this revolution
- Green roofs play a vital role in this initiative
- Combined Sewer Systems are one of the drivers for this technology
- Green roofs are categorized by substrate depth; ***extensive*** *(≤ 6”)*, and intensive (> 6”)



Benefits:

- Counteract the urban heat island effects
- Provide insulation
- Positive effect on urban air quality
- Habitat for plant and animal life within the cityscape
- Aesthetically pleasing
- Decrease storm-water runoff
- Water Quality?



Questions:

- How do green roof systems process precipitation chemistry within the urban ecosystem?
- What are the Wet and Bulk loadings in an urban environment and how are they different from the rural environment?
- Does a green roof retain nutrients and contaminants?
- Are there seasonal or startup variations in the performance of a green roof?

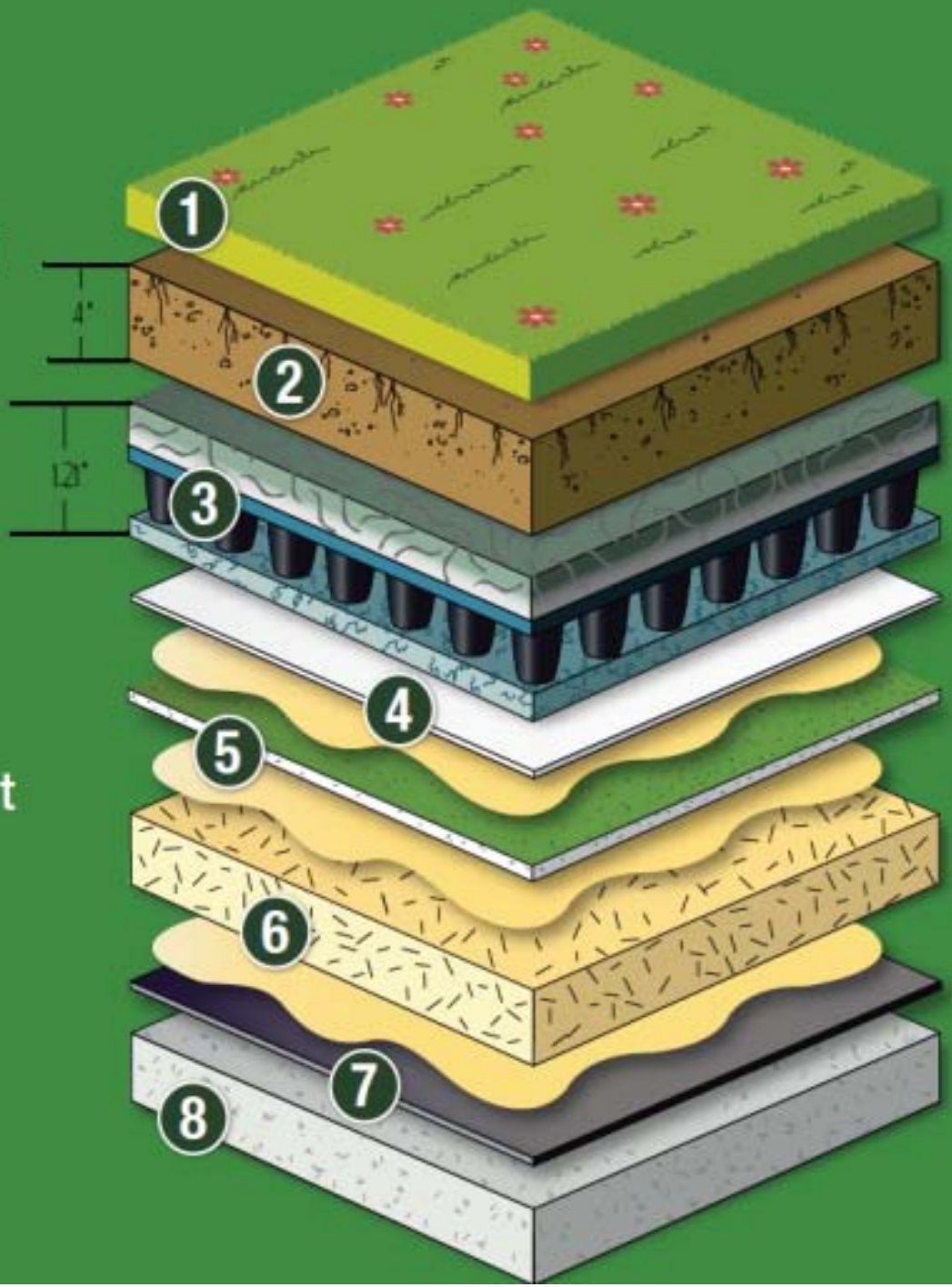
Approach:

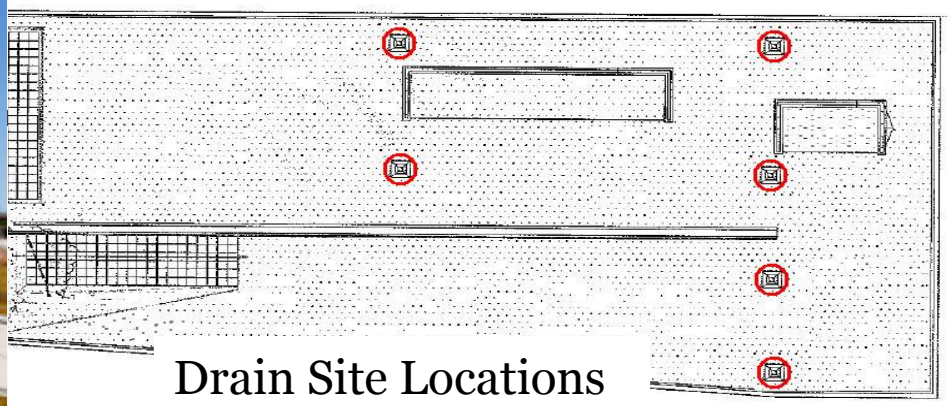
- Site Description:
  -Located in downtown Syracuse, N.Y.
  - Extensive roof with a 4" substrate
  - 17,000 ft2
  - 15% average slope
  - 6 different sedum species
  -Roof was completed in August 2009, collection began in April 2010

- Collection units:
  -Wet collection
  -Bulk collection
  -Six different drainage sites across the green roof

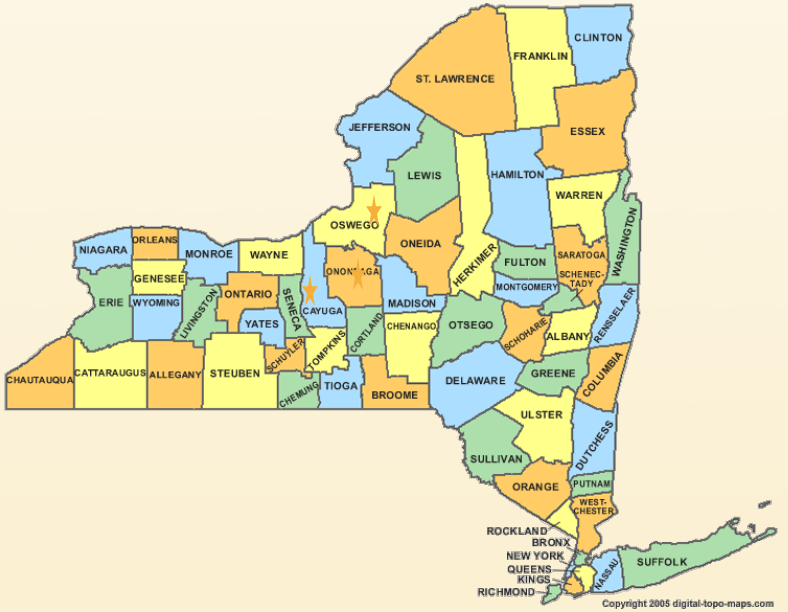
- Sampling:
  -Collection was done on a weekly basis. The samples were collected in polyethylene and glass bottles, then preserved at 4°C

1. Sedum
2. Lightweight, FLL-Approved Growth Media
3. MiraDRAIN® G4 Drainage Composite
4. Adhered Sure-Weld® TPO Single-Ply Membrane
5. Adhered Moisture-Resistant Gypsum Board
6. Adhered ISO
7. CCW 725TR
8. Concrete Deck





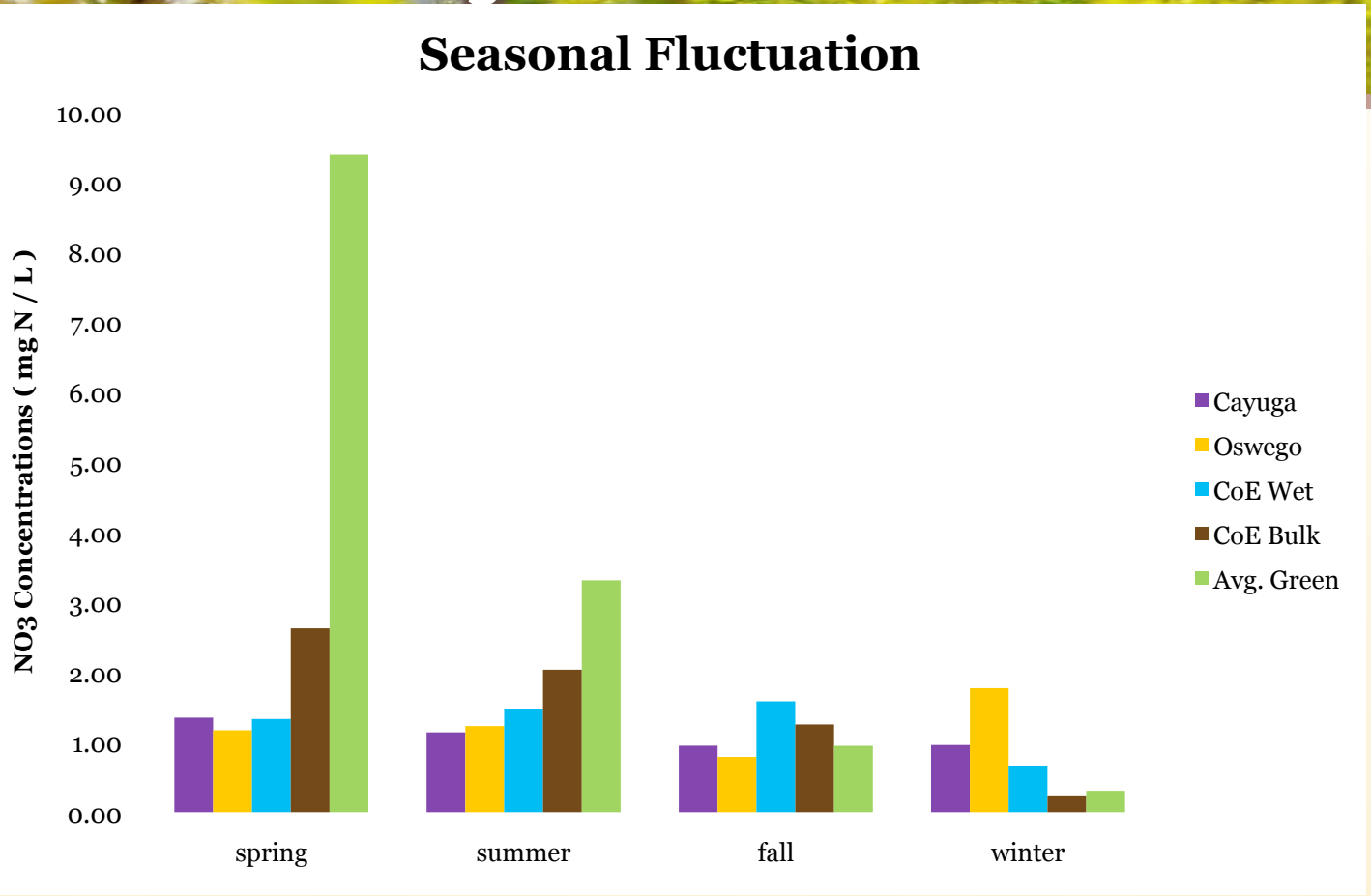
Drain Site Locations



Analytes:

- pH
- Acid neutralizing capacity (ANC)
- Dissolved Inorganic Carbon (DIC)
- **Dissolved Organic Carbon (DOC)**
- **Total Nitrogen**
- **Ammonia (NH_4)**
- **Anions** (F, Cl, SO_4, **NO_3**, PO_4)
- Aluminum (inorganic, monomeric, organic)
- Cations (Na, Mg, Al, P, K, Ca, Cu, Zn)
- Mercury *(Only for wet and bulk collection)

Results: NO_3

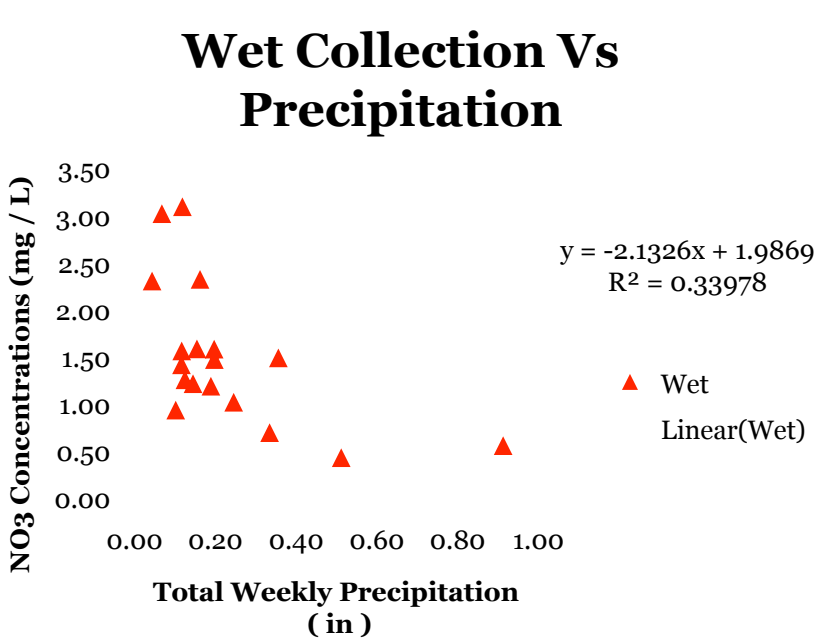


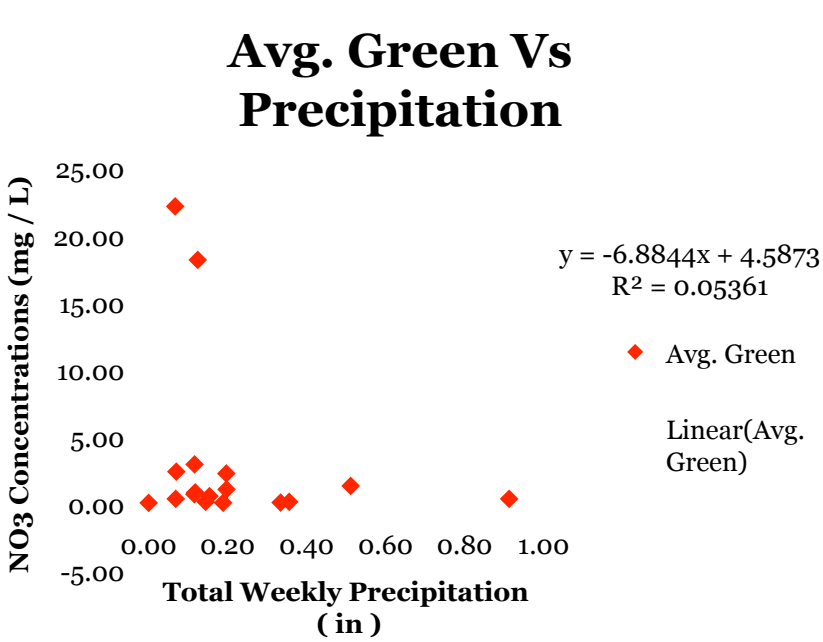
Depositional Loading	(kg / Ha) spring	(kg / Ha) summer	(kg / Ha) fall	(kg / Ha) winter	(kg / Ha) annual
cayuga:	2.92	3.48	2.06	1.76	9.97
oswego:	3.49	3.90	3.33	8.15	19.01
Wet avg:	1.08	3.06	2.87	0.89	7.90
Bulk avg:	2.13	4.25	2.27	0.31	8.95
Green roof avg:	7.63	6.91	1.72	0.42	16.67

EPA drinking water standard is 10 mg/L NO3

Results: NO_3

Dilution effects:

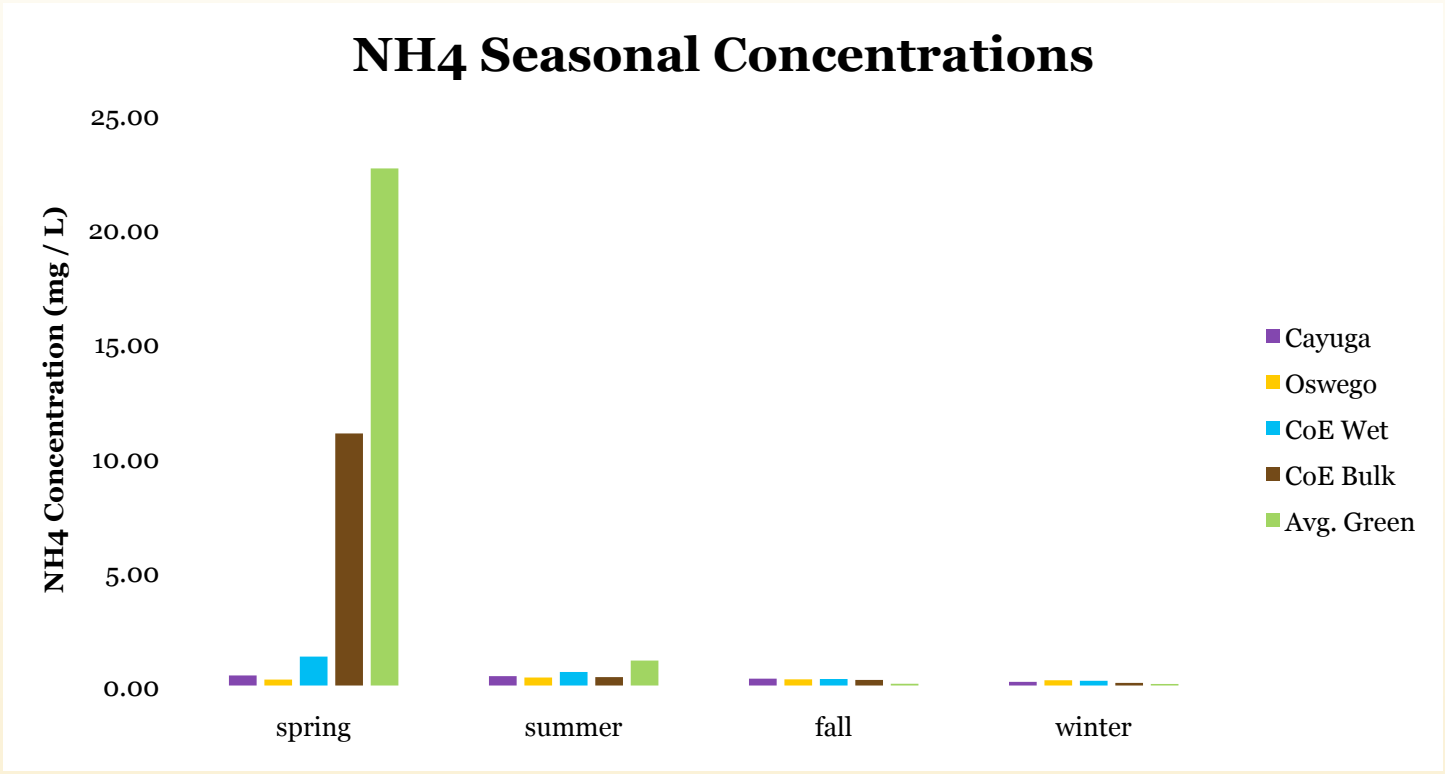




These graphs are representative for all other analytes; large precipitation event is followed by a dilution effect, and a low correlation for the green roof

Results: NH_4^+

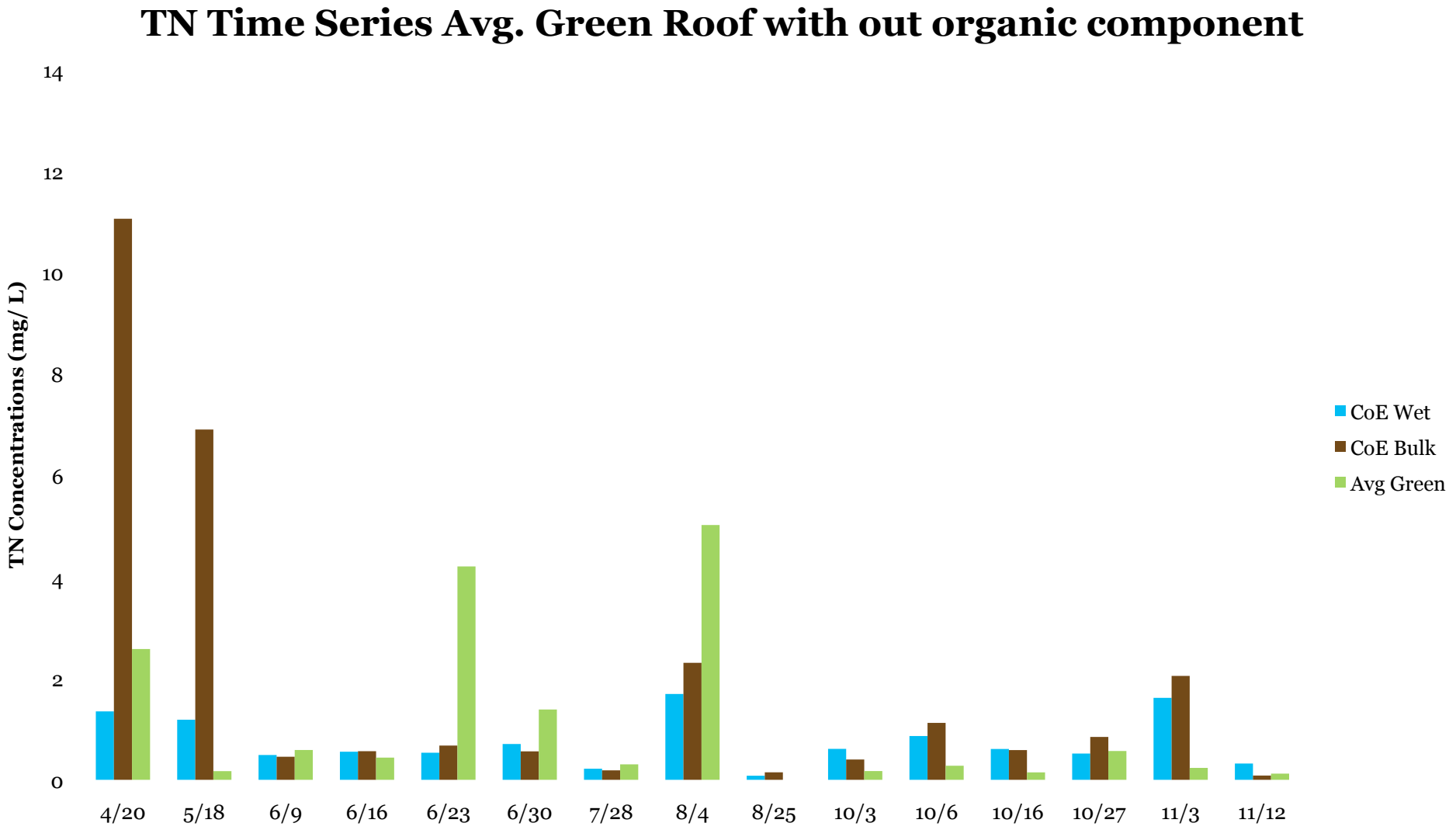
- Ammonium is a byproduct of decomposition



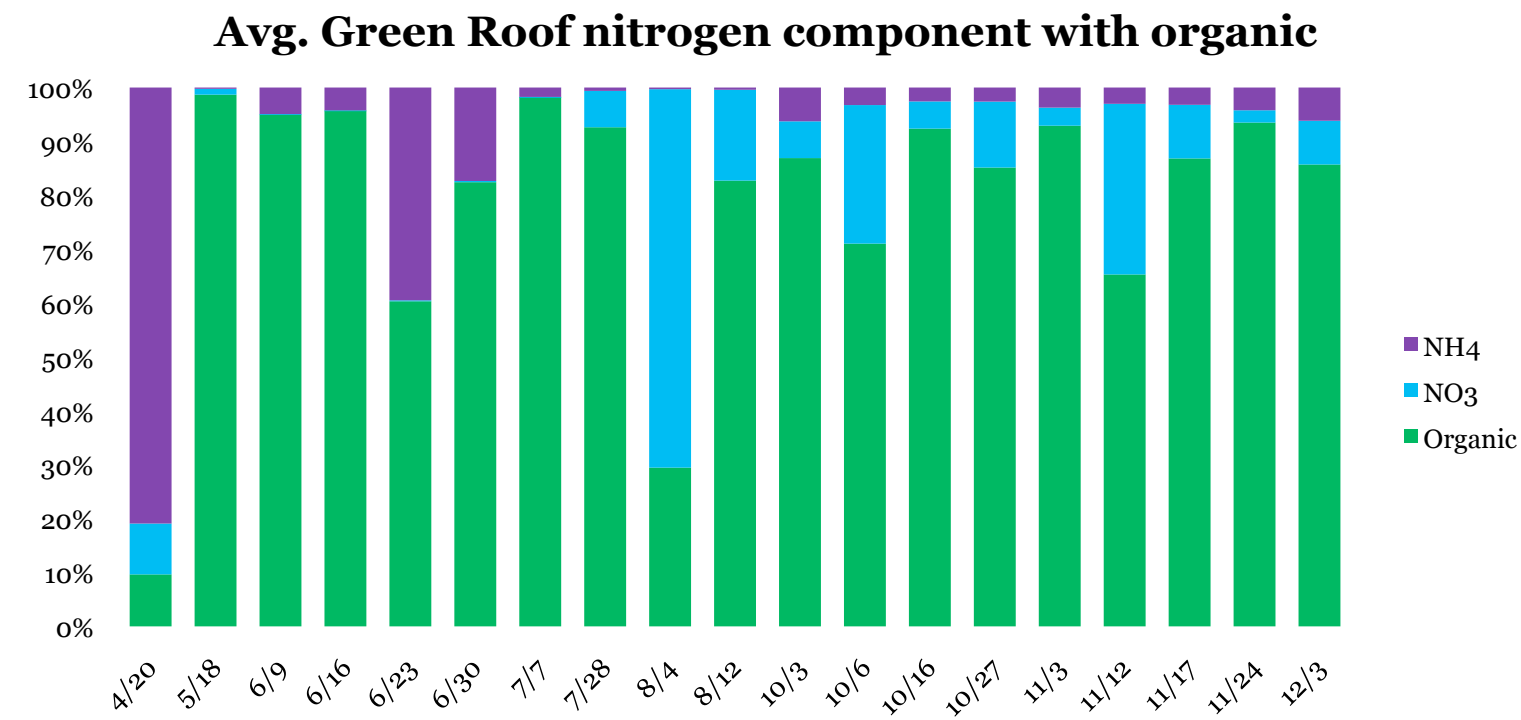
Depositional Loading	(kg / Ha) spring	(kg / Ha) summer	(kg / Ha) fall	(kg / Ha) winter	(kg / Ha) annual
cayuga:	0.95	1.25	0.65	0.30	3.16
oswego:	0.77	1.10	1.15	1.06	3.99
Wet avg:	1.03	1.24	0.52	0.28	3.06
Bulk avg:	8.96	0.77	0.44	0.16	10.32
Green roof avg:	18.38	2.28	0.14	0.09	20.89

Results: Total Nitrogen (TN)

- Total Nitrogen is the sum of all forms of nitrogen; NH_4, NOx, Organics, etc.



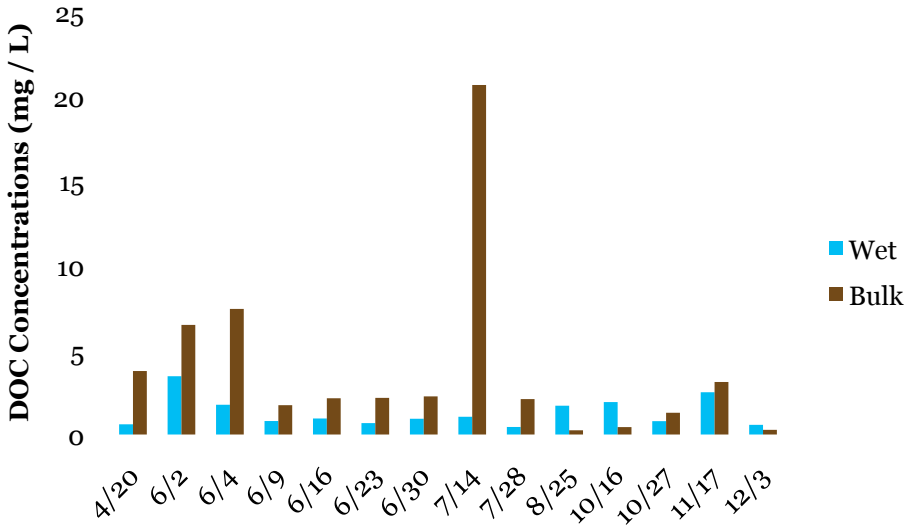
Results: NO_3^- and NH_4^+

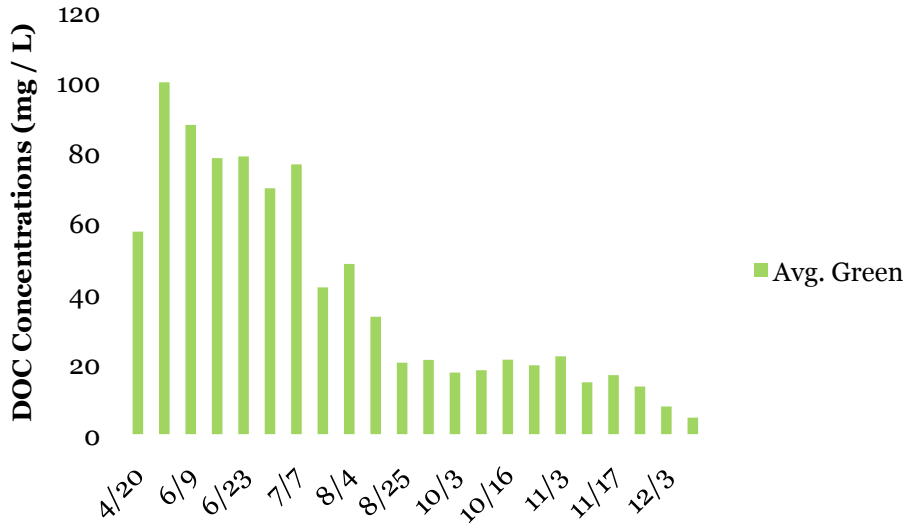


- Wet and Bulk don't show a seasonal change in NH_4 and NO_3 concentrations
- The green roof shows marked changes throughout the seasons.
- Nitrifying bacteria are very temperature dependent

Results: Dissolved Organic Carbon (DOC)

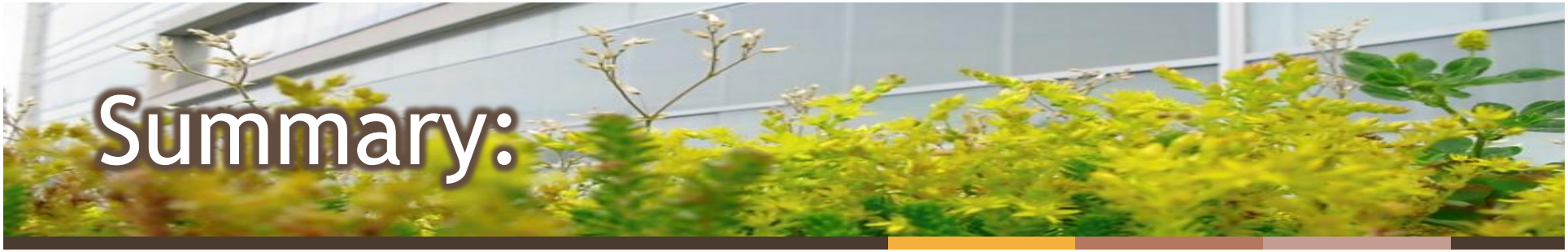
Average levels of DOC hover around 5mg / L





*Single, extreme value may be due to bird droppings.

•DOC concentrations decline as the growing season ends
•Typical influent DOC for WWTP may be around 70 mg/L



Summary:

- Wet and Bulk deposition are fairly similar in the rural environment, but divergent in the urban.
- Urban environment has higher concentrations for analytes
- There are marked seasonal changes for the green roof's runoff chemistry

Conclusions:

- Seasonal variations play a very important role on the performance of green roofs
- Green Roofs appear to be a source of nitrogen, but it may be leaching from the soil
- Additional monitoring is required in order to discern between startup effects, and true seasonal variations

Future Measurements:

- Install flow sensors on the green roof
- Install soil moisture sensors
- Install soil temperature sensors
- Ongoing measurements of the reference roof system

Special Thanks:

- Syracuse University
- Syracuse Center of Excellence
- Center for Environmental Systems and Engineering
- Charles T. Driscoll

Sources:

- National Atmospheric Deposition Program (NRSP-3). 2011. NADP Program Office, Illinois State Water Survey, 2204 Griffith Dr., Champaign, IL 61820.