VILLANOVA UNIVERSITY
COLLEGE OF ENGINEERING

CENTER FOR RESILIENT WATER SYSTEMS

A Seasonal Evaluation of SCMs in Series (infiltration Trench and Cistern): Captures Volumes, Infiltration Rates, and Maintenance

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OVERVIEW

- The application of several stormwater control measures (SCMs) in series as a treatment train has become popular over implementing a single treatment measure.
- A vegetated swale, 2 rain gardens, a cistern-pump system, and an infiltration trench are known as the Villanova Treatment Train, which was constructed in October 2011.
- This design provides adaptive capacity to capture more runoff and provide dynamic operation during different seasons.
  - The infiltration trench's performance is related to low and high temperatures and water depth. The change in the recession rate is attributed to warmer and colder months (seasonality).
  - Using a dynamic pump cistern system increases functionality and eases the performance of the treatment train by adapting the system to reliable scenarios in real-time control.

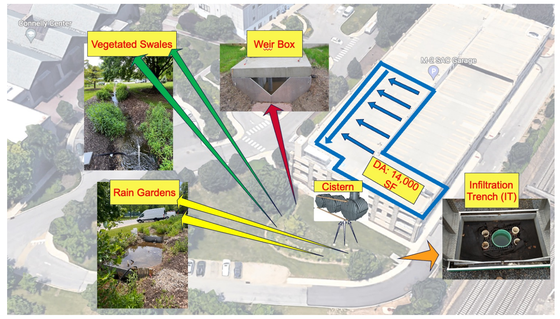
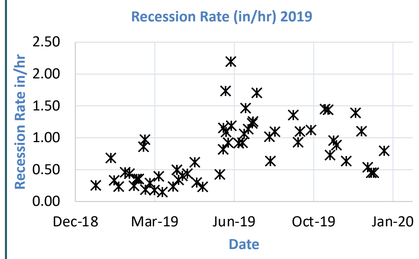


Figure 1: Stormwater control measures (SCMs) in series at the Treatment Train

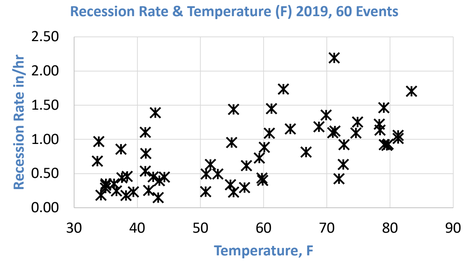
METHODS

- The contribution area is a 100% impervious and parking deck.
- The instrumentation (pressure transducers) is connected to the OptiRTC data logger, where the infiltration trench (IT) and cistern's water level were monitored.
- Rainfall data was taken from the nearest rain gauge and recorded at 5 minutes intervals.
- Continuous rainfall and water level data were used for performance analysis using observed data from July 2016 to December 2020.
- Based on the infiltration trench design, the minimum accepted water depth elevation was >8 in (0.67 feet) to avoid stagnation point (a false event).
- A recession rate calculator was created in MATLAB to calculate the infiltration rate.
- A 10 % of gap between real (93 in) and conceptual (83 %) water levels to indicate when IT storage is full.
- An interactive decision tree was created to enable real-time control at the treatment train site.

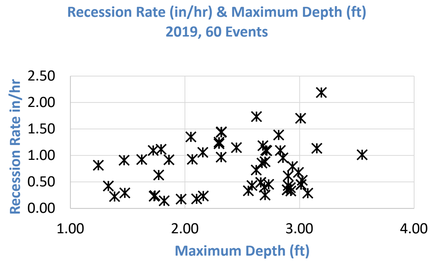
RESULTS



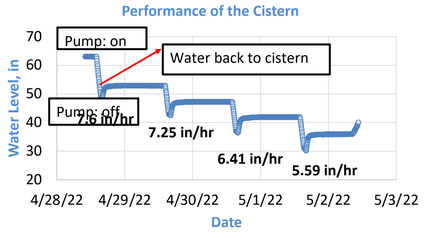
Graph 1: Recession Rate 2019



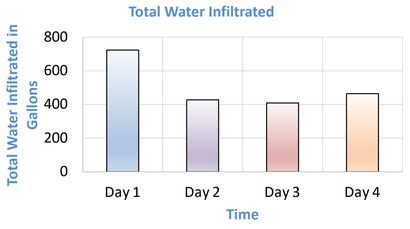
Graph 2: Recession Rate vs Temperature 2019



Graph 3: Recession Rate vs Depth 2019



Graph 4: Performance of the Cistern over 4 days in 2022



Graph 5: Total Water Infiltrated over 4 days in 2022

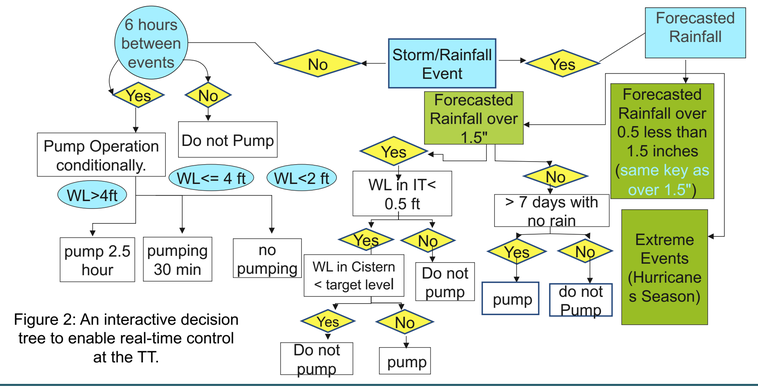


Figure 2: An interactive decision tree to enable real-time control at the TT.

DISCUSSION

- The design capture of the IT is 0.3 in (0.76cm). However, storm events never created overflow, showing that the IT was reached infrequently and it performed adequately.
- The recession rates in IT from 2016-2020 showed a seasonality (higher recession rates attributed to warmer months and lower recession rates)
- The observed water level recession limbs for different storm events did not demonstrate a dependency on the recession rates due to the design ratio of the treatment site.
- The design capture of the cistern is 0.8 in (2.0 cm). For dry periods, the pump operated (3 continuous hours) at a drawdown rate of 7.6 in/hr when the soil media was dry. However, the pump operation can be continuous (more than 3 hours), and it showed a drawdown rate of 0.5 in/hr.
- The total water infiltrated was from 700 gal (dry soil media) to 400 gal (wet soil media).
- The rainfall storm events have been decreasing for this study. It was observed that there were fewer rainfall events for 2019-2020 than in the previous years, but with more extreme short and high-intensity rainfall events below 0.5 inches.

FUTURE WORK

- Inflow & outflow study over each SCM's element
- Dynamic monitoring at the Treatment Train
- Expand infiltration rate analysis to 2021-2022
- Install new pressure transducers
- Analyze the infiltration rate and ponding depth over the swales and rain gardens

REFERENCES

1. Ebrahimian, A., Sokolovskaya, N., and Wadzuk, B. (2021). "Modeling dynamic performance of urban infiltration trench systems: Methodology and a case study in Philadelphia." *Journal of Hydrology*, 594, 125938.

1. Strifling, B. D. (2020). "Real-time control of Stormwater Management Systems." *Marquette University Law School Faculty Blog*, <https://law.marquette.edu/facultyblog/2020/04/real-time-control-of-stormwater-management-systems/> (Sep. 28, 2022).

Funded by: The Pennsylvania DEP Growing Greener Grant with support of Opti.