Identifying Best Practices for Maintaining Stormwater Drywell Capacity

Scientific Studies Program by:

California State Polytechnic University, Pomona

Presentation by:

Dr. Ali Sharbat (PhD, PE), Dr. Mehrad Kamalzare (PhD, PE)

Study Overview

Summary of Study:

- Track the infiltration capacity of recently installed drywells over a period of **five years**
- **Five drywell sites** will be carefully selected to represent a range of factors, including:
  - Drywell design & construction
  - Pre-treatment methods
  - Operations / maintenance practices
  - Drywell's basin size & annual runoff volume
  - Land use & traffic volumes
  - Soil types

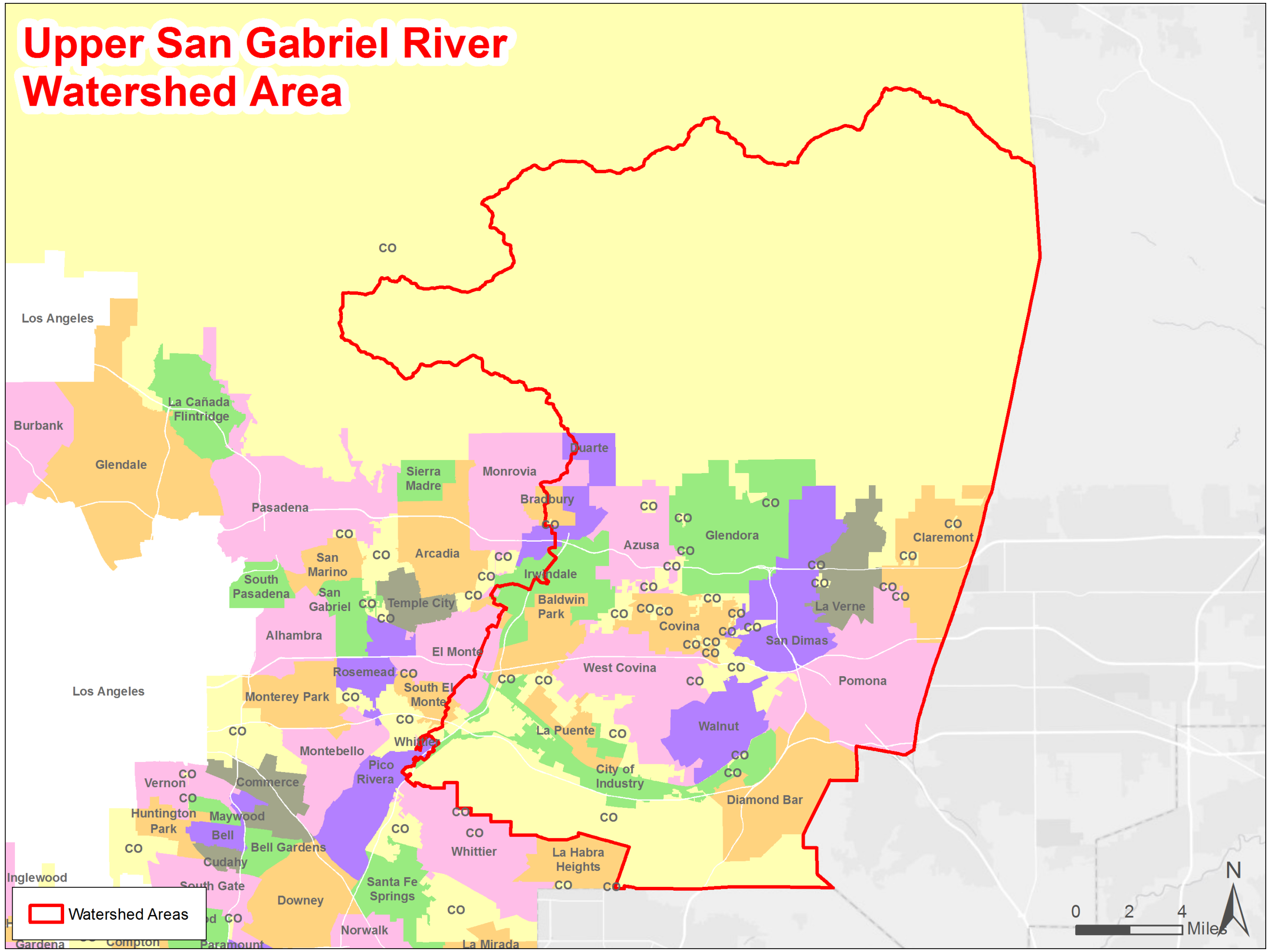
Why?

- Tremendous uncertainties in drywell performance & appropriate maintenance procedures
- Drywell systems may be improperly managed and maintained resulting in degraded capacity over time

Outcome

- Identify **best practices** for different drywells with various site conditions & disseminate the findings
- Benefits to local disadvantaged communities (DACs) (workforce development and local stormwater infrastructure improvements)
- Development of trained work-force by the University
- Support regional sustainability goals by promoting stormwater capture and local water supply recharge

Study Location



- **Watershed to be Studied:**
  - Upper San Gabriel River Watershed
- **Study Location:**
  - Locations will be further chosen from both existing and proposed drywell locations
- **Benefits for the entire LA County:**
  - The implementation of updated best practice will benefit tax-payers via increased drywell cost-effectiveness
  - Improved & more resilient stormwater treatment, reduced pollutant runoff, and enhanced water quality

Similar Studies

- This study would be **the first of its kind** by identifying best practices for maintaining drywell capacity. It appears that there is no study to quantify the effectiveness of LID/GSI maintenance protocols in extending the longevity of drywells
- **Sedimentation compartments** and **vegetative pretreatment** systems were demonstrated to reduce the clogging rate of infiltration systems. (Edwards et. al., 2016)
- **Infiltration infrastructure are prone to clogging** even if there are no suspended sediments introduced to the infrastructure, as evidenced by multiple studies examining physical, chemical, and biological clogging mechanisms in soil columns (Baveye et. al., 1998). These mechanisms are commonly observed in practice, and various physical and chemical causes of clogging have been documented.
- **The geometry of the pore space** is closely related to the **chemical properties of solid particles** in soils. Factors such as electrolyte concentration, organic compound, acidity, redox potential, mineralogical composition of the soil, surface characteristics, and chemical reactions all influence the shape and stability of the pores, and the value of hydraulic conductivity.
- Various carbon/energy sources, such as **plant residues**, and hydrocarbones have been found to both accelerate and enhance soil clogging (Frankenberger et al., 1979). Moreover, addition of **nitrogen** affects clogging (Frankenberger et al., 1979).

Study Details

Study Goals

- Determine which commonly used **drywell design / construction methods** provide the best balance between *cost* and *long-term performance*;
- Determine which common **pre-treatment** and **maintenance** practices provide the best balance between *cost and long-term performance*;
- Determine how **soil characteristics** can impact long-term drywell performance and provide recommendations for design and maintenance to address fine-grained soils.
- Develop guidelines for **maintenance practices** and frequency, for different levels of **land-use and traffic loading**;
- Train next generation of **workforce** for the local industry.

❖ **Stormwater Infiltration is a cost-effective, resilient approach for managing wet weather impacts, that provides many community benefits.**

Study Details

Watershed Benefits

- More accurate and customized post-construction planning for O&M
- More accurate budgeting for drywell maintenance
- More groundwater recharge for less money
- More sustainable and resilient drywells in the watershed

❖ Better efficiency and long-term performance of drywell systems

❖ Better water quality and improved local water supply (aligned with SCW Goals)

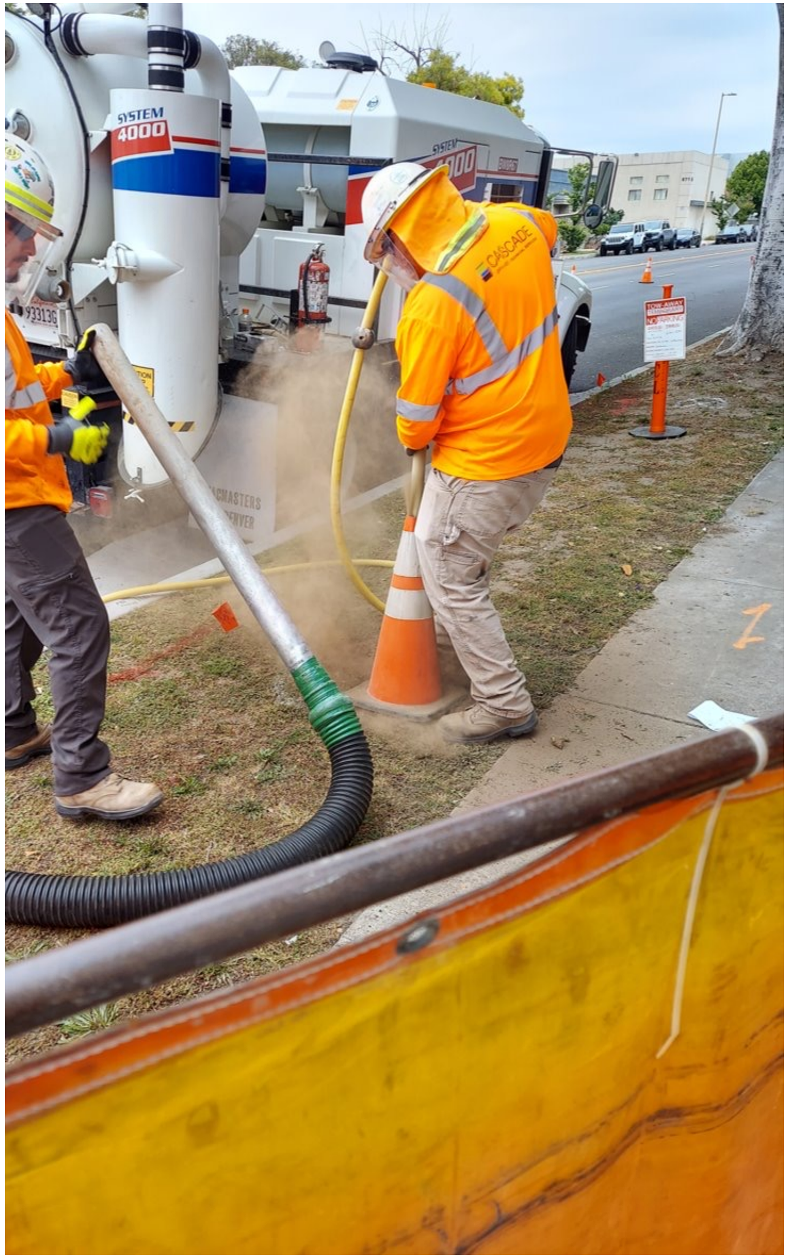
❖ **This study's recommendations will <u>optimize the return on investment</u> from stormwater infrastructure, and contribute to the longevity of drywell systems.**

Full-scale drywell test by CPP Team

(City of Glendale)

Scope of Work

- Task 1: Study-site selection
- Task 2: Operations documentation
- Task 3: Planning the field program
- Task 4: Infiltration testing
- Task 5: Field visits for O&M activities
- Task 6: Outreach and engagement
- Task 7: Reporting and publication



Scope of Work and Schedule

Phase	Description	Completion Date
Task 1	Study-Site Selection	06/30/2025
Task 2	Operations Documentation	12/31/2025
Task 3	Planning Field Program	09/30/2025 + (Q1 every following year)
Task 4	Infiltration Testing	06/31/2029
Task 5	Field Visits for O&M Activities	06/31/2029
Task 6	Outreach & Engagement	06/31/2029
Task 7	Reporting & Publications	06/31/2029

	2024-25				2025-26				2026-27				2027-28				2028-29			
Tasks	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
1: Study-Site Selection	■	■	■	■																
2: Operations Documentation			■	■	■	■														
3: Planning Field Program			■	■	■				■				■				■			
4: Infiltration Testing			■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
5: Field Visits: O&M Activities					■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
6: Outreach & Engagement							■	■			■	■			■	■			■	■
7: Reporting & Publications																	■	■	■	■

Funding Request

WASC	Year 1	Year 2	Year 3	Year 4	Year 5	TOTAL
CSMB	*$79,989*	*$81,181*	*$82,176*	*$80,937*	*$84,588*	*$408,871*
LLAR	*$79,989*	*$81,181*	*$82,176*	*$80,937*	*$84,588*	*$408,871*
LSGR	*$79,989*	*$81,181*	*$82,176*	*$80,937*	*$84,588*	*$408,871*
NSMB	*$79,989*	*$81,181*	*$82,176*	*$80,937*	*$84,588*	*$408,871*
RH	*$79,989*	*$81,181*	*$82,176*	*$80,937*	*$84,588*	*$408,871*
SCR	*$79,989*	*$81,181*	*$82,176*	*$80,937*	*$84,588*	*$408,871*
SSMB	*$79,989*	*$81,181*	*$82,176*	*$80,937*	*$84,588*	*$408,871*
ULAR	*$208,972*	*$211,953*	*$214,440*	*$211,343*	*$220,470*	*$1,067,178*
USGR	**$199,972**	**$202,953**	**$205,440**	**$202,343**	**$211,470**	**$1,022,178**
TOTAL	***$968,867***	***$983,173***	***$995,112***	***$980,245***	***$1,024,056***	***$4,951,453***

Study Team

- Cal Poly Pomona
  - Ali Sharbat, PhD, PE - *Water Resources Engineering*
  - Mehrad Kamalzare, PhD, PE - *Geotechnical Engineering*
  - Alan Fuchs, PhD - *Filtration Engineering*
  - Seema Shah-Fairbank, PhD, PE - *Water Resources Engineering*
  - Yasser Salem, PhD, PE - *Professional Civil Engineer*

- Cal Poly Pomona Students (Future workforce for local stormwater projects)

- University of California Santa Barbara
  - Hugo Loaiciga, PhD, PE - *Hydrologist*

- Private Consultants
  - Scott Kindred, P.E. (Kindred Hydro, Inc., State of Washington) - *Hydrogeologist and Drywell expert*

- Local Drywell Experts
  - Geologists, engineers, and drywell Contractors
  - Local drywell and stormwater infrastructure experts

Summary of Benefits

Benefits to Technical Community:

- Better Stormwater Infiltration Project Planning
- Identifying Best Practices - Accepted by Stakeholders - for Drywell Maintenance with Various Site Conditions
- Accurate and Cost-Effective Drywell Systems

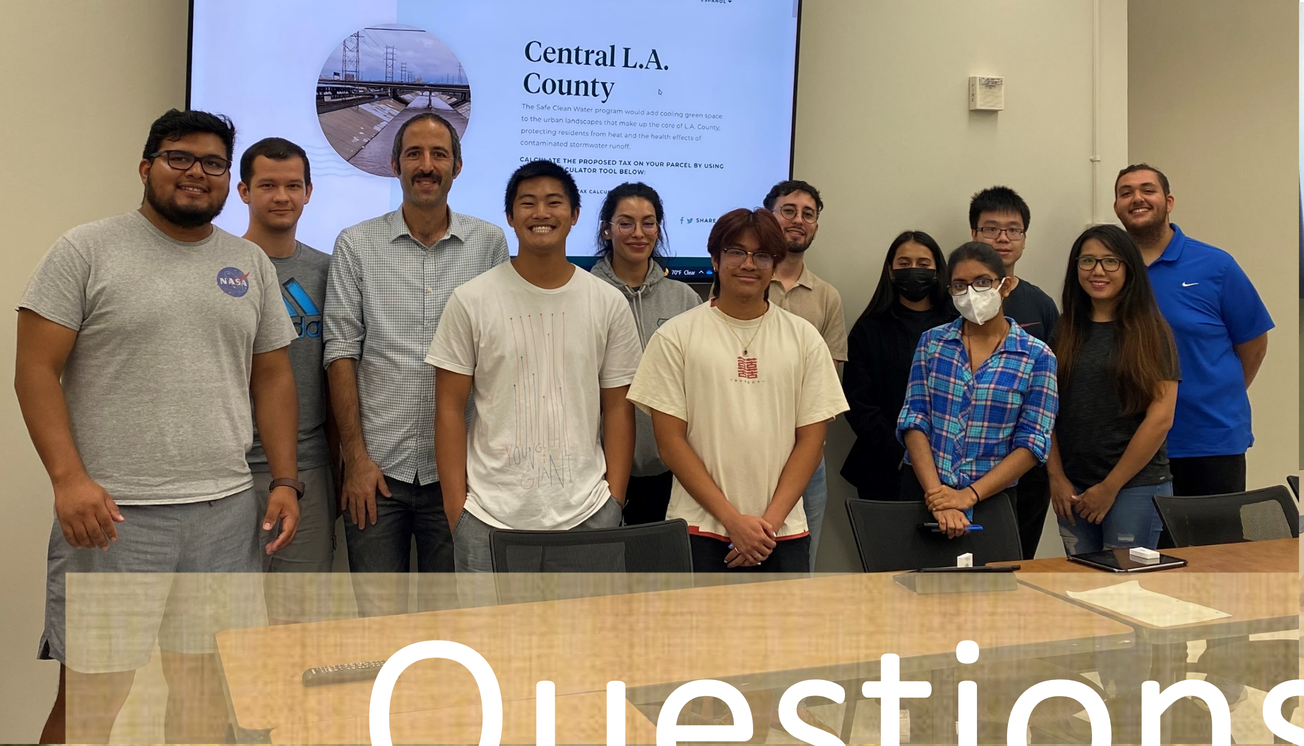
Benefits to LA County Taxpayers:

- Municipalities will get the <u>best value</u> for their investment in stormwater infiltration.
- Helping the community meet stormwater management and water-supply objectives <u>faster and cheaper</u>.
- Developing technical skills of <u>underserved minority students</u> at Cal Poly Pomona.
- Serving local <u>Disadvantaged Communities</u> by improving the existing stormwater infrastructure.

Summary of Benefits

Broader Impacts of the Scientific Study for Regional Workforce Development:

- Developing technical skills of underserved minority students at Cal Poly Pomona
- Offering Senior Project (EGR 4810/4820/4830) focused on stormwater engineering
- Developing a new technical elective course focused on Low Impact Development and Green Infrastructure
- Developing of a certificate program focused on stormwater engineering through CPP Extended University
- Hosting minority students sponsored by NSF and Department of Education in our scientific study project
- More than 90 students directly involved



Questions

References

1. Al Mamun, A., Shahriar, S., & Nuruzzaman, M. (2020). Review on uncertainty of the firstflush phenomenon in diffuse pollution control. Applied Water Science, 10(1), 53. https://doi.org/10.1007/s13201-019-1127-1
2. ASCE. (2003). Long-term Groundwater Monitoring: State of the Art. Prepared by the Task Committee on the State of the Art in Long-term Groundwater Monitoring Design. Reston, VA: ASCE.
3. Australian Rainfall and Runoff. (2021). A Guide to Flood Estimation, Commonwealth of Australia. https://arr.ga.gov.au/
4. Baveye, P., Vandevivere, P., Hoyle, B. L., DeLeo, P. C., & Sanchez de Lozada, D. (1998). Environmental Impact and Mechanisms of the Biological Clogging of Saturated Soils and Aquifer Materials. Critical Reviews in Environmental Science and Technology, 28(2), 123-191. https://doi.org/10.1080/10643389891254197
5. California Department of Water Resources. (2010). Stormwater Management Guidelines: Developing and Implementing Stormwater Quality Plans. Retrieved from https://water.ca.gov/-/media/DWR-Website/Web-Pages/Programs/All-Programs/Stormwater-Resources/Publications/StormwaterManagementGuidelines.pdf
6. City of Los Angeles. (2018). Toward A Greener Los Angeles, The Wilmington Urban Greening Plan. LA Sanitation, Los Angeles, California. http://www.lastormwater.org
7. Stormwater Management Practices and Procedures Manual (2017), Anne Arundel County, Maryland.
8. Edwards, E. C., Harter, T., Fogg, G. E., Washburn, B., & Hamad, H. (2016). Assessing the effectiveness of drywells as tools for stormwater management and aquifer recharge and their groundwater contamination potential. Journal of Hydrology, 539, 539-553.
9. Environmental Protection Agency. (1999). The Class V Underground Injection Control Study. Vol. 3: Storm Water Drainage Wells. Appendix E. Office of Ground Water and Drinking Water.
10. Faibishenko, B. A. (1985). Effect of entrapped air on water permeability of soils. Kiev State University. Translated from Vodnye Resursy, 4, 48–60. Water Resources, 304–315.
11. Felhendler, R., Shainberg, I., & Frenkel, H. (1974). Dispersion and hydraulic conductivity of soils in mixed solutions. Trans. Int. Cong. Soil Sci., 10th (1), 103–112.
12. Frenkel, H., Goertzen, J. O., & Rhoades, J. D. (1978). Effect of clay type and content, exchangeable sodium percentage, and electrolyte concentration on clay dispersion and soil hydraulic conductivity. Soil Science Society of America Journal, 42, 32–39.
13. Geesey, G. G., Mittelman, M. W., & Lieu, V. T. (1987). Evaluation of slime-producing bacteria in oil field core flood experiments. Appl. Environ. Microbiol., 53(2), 278–283.
14. Geosyntec. (2020). California Dry Well Guidance Research and Recommendations.
15. Gupta, R. P., & Swartzendruber, D. (1962). Flow-associated reduction in the hydraulic conductivity of quartz sand. Soil Sci. Soc. Am. Proc., 26, 6–10.
16. Houle, J. J., Roseen, R. M., Ballestero, T. P., Puls, T. A., & Sherrard Jr, J. (2013). Comparison of maintenance cost, labor demands, and system performance for LID and conventional stormwater management. Journal of environmental engineering, 139(7), 932-938.
17. Kindred, J. S., & Reynolds, W. D. (2020). Using the borehole permeameter to estimate saturated hydraulic conductivity for glacially over-consolidated soils. Hydrogeology Journal, 29(5), 1909-1924.
18. Los Angeles County Department of Public Works. (2020). Stormwater Management System Overview. Retrieved from https://dpw.lacounty.gov/epd/stormwater/
19. Los Angeles County Department of Public Works. (2021). Measure W: Safe Clean Water Program. Retrieved from https://safecleanwaterla.org/
20. Maloney, E. D., Camargo, S. J., Chang, E., Colle, B., Fu, R., Geil, K. L., ... & Zhao, M. (2014). North American climate in CMIP5 experiments: Part III: Assessment of twenty-first-century projections. Journal of Climate, 27(6), 2230-2270.
21. Minnesota Department of Transportation, 2009. Issues of Concern Related to Underground Infiltration Systems for Stormwater Management and Treatment, pp. 1–13. <http://www.lrrb.org/media/reports/TRS0903.pdf>.
22. McGauhey, P. H., & Krone, R. B. (1967). Soil Mantle as a Wastewater Treatment System (Final Report, Report 67–11). Sanitary Engineering Research Laboratory, University of California, Berkeley, CA.
23. McGauhey, P. H., & Winneberger, J. H. (1964). Causes and Prevention of Failure of Septic-Tank Percolation Systems. Sanitary Engineering Research Laboratory, University of California, Berkeley, CA.
24. Mouhoumed, R., Ekmekcioglu, O., & Ozger, M. (2023). A hybrid MCDA approach for delineating sites suitable for artificial groundwater recharge using drywells. Journal of Hydrology, 620(Part A), 129387.
25. National Research Council. (2009). Urban Stormwater Management in the United States. National Academies Press.
26. Pupisky, H., & Shainberg, I. (1979). Salt effects on the hydraulic conductivity of a sandy soil. Soil Science Society of America Journal, 43, 429–433.
27. Rengasamy, P., McLeod, A. J., & Ragusa, S. R. (1996). Effects of dispersible soil clay and algae on seepage prevention from small dams. Agricultural Water Management, 29, 117–127.
28. Sasidharan, S., Bradford, S., Simunek, J., & Kraemer, S. (2021). Comparison of recharge from drywells and infiltration basins: A modeling study. Journal of Hydrology, 594, 125720.
29. Shainberg, I., & Levy, G. (1992). Physico-chemical effects of salts upon infiltration and water movement in soils. In R. J. Wagenet, P. Baveye, & B. A. Stewart (Eds.), Interacting processes in soil science (pp. 37–93). Lewis Publishers.
30. Shainberg, I. (1984). The effect of electrolyte concentration on the hydraulic properties of sodic soils. In I. Shainberg & J. Shalhevet (Eds.), Soil salinity under irrigation: Processes and management (pp. 49–99). Springer-Verlag.
31. Shaw, J. C., Bramhill, B., Wardlaw, N. C., & Costerton, J. W. (1985). Bacterial fouling in a model core system. Applied and Environmental Microbiology, 49, 693–701.

Scope of Work

- **Task 1: Study-Site Selection:**

In this task, the core team will work closely with local agencies, cities, and other stakeholders in each watershed basin to finalize the list of drywells for the study. Two to five drywells will be identified for the study in each watershed. A scoring matrix will be developed to assess each site based on the following 9 criteria: 1. Age of Drywell, 2. Drywell Design and Construction, 3. Pre-Treatment Methods, 4. Land-use and Traffic Loading Scenarios, 5. Soil Types, 6. Proximity to a Nearby Fire Hydrant, 7. Minimal Disturbance to Residents and Businesses, 8. Minimal Traffic Control Requirements, and 9. Minimal Access and Permitting Challenges.

- **Task 2: Drywell Operations Documentation**

This task will involve conducting interviews with municipalities that have significant experience in installing, operating, and maintaining drywell systems. These municipalities, located within the western United States, have relied on drywells for many decades, resulting in a wealth of anecdotal knowledge regarding the long-term capacity of these systems.

By engaging in interviews with representatives from these municipalities, we aim to gather valuable firsthand information and document their experiences.

- **Task 3: Planning the Field Program**

This task will involve conducting a detailed assessment of the selected drywell locations in collaboration with the relevant agencies responsible for overseeing these sites.

By working closely with these agencies, we will gather information about the specific characteristics and conditions of each drywell site.

The survey process will involve evaluating the accessibility of each drywell and assessing the availability of nearby fire hydrants.

We will thoroughly examine the requirements for permits, right of entry, and any other necessary documentation to ensure compliance with legal and regulatory protocols. In cases where access to the drywell sites is challenging, we will develop appropriate strategies to obtain the required permissions.

Scope of Work (cont.)

- ## Task 4: Infiltration Testing and Flow Rate Monitoring

Initial Infiltration testing will be conducted in each of the drywells as soon as the appropriate and suitable drywells were identified in each watershed ideally starting Q4 of year 1 of the project.

A constant head infiltration test will be conducted in each drywell by adjusting the flow rate to maintain a constant ponding depth in the drywell for a period of 4-6 hours. A pressure transducer will be installed in the bottom of the drywell to monitor the ponding depth during the test. Water will be supplied by the nearest fire hydrant and the flow rate will be measured using a flow meter.

A pressure transducer will be installed in the drywell following the infiltration test to monitor water levels and document runoff events during the duration of the study.

The water level data will be downloaded twice a year.

Based on results of the infiltration testing and methods provided by Kindred and Reynolds (2020), the water levels can be used to estimate flow rates into the drywells and determine how much runoff is infiltrated through the drywell. This is a much more cost-effective way to estimate runoff compared with retrofitting the drywells to include a flow meter.

Infiltration testing will be conducted every year in all the drywells to determine the change in capacity over time and evaluate the effects of different runoff volumes and any changes in operation and maintenance procedures.

- ## Task 5: Filed visits for Operation and Maintenance Activities

The primary objective of this task is to compile a comprehensive record of the maintenance activities undertaken, which will contribute to understanding the relationship between maintenance practices and the long-term performance of drywells. This task involves comprehensive tracking and documentation of maintenance activities conducted at each drywell throughout the duration of the study.

It is anticipated that the municipality responsible for the drywell will carry out regular maintenance activities to ensure optimal functionality. To facilitate this process, the project team will maintain close communication with the maintenance staff, actively monitoring and recording both past and planned maintenance activities.

The project team will be physically present at the drywell sites to observe and document a selected number of maintenance events. By being on-site, they will have the opportunity to gather valuable firsthand information about the maintenance procedures employed. Whenever feasible, the team will document the quantity and nature of materials removed during each maintenance event, distinguishing between trash and sediment.

Scope of Work (cont.)

- **Task 6: Outreach and Engagement**

The purpose of this task is to ensure that potential users of these drywell infiltration testing and design methods are engaged during the study and the methods meets their needs when the work is complete. Outreach and engagement will include:

  - Forming an Advisory Committee
  - Integration into Engineering Courses
  - Workshops with interested stakeholders to present results and solicit feedback.
  - Presentations at conferences and technical meetings.
  - Regular emails to present results and solicit feedback.

Outreach will be targeted at stakeholders such as regulators, municipal stormwater managers, and civil/geotechnical/hydrogeologic professionals that regularly conduct infiltration testing and design.

- **Task 7: Documentation and Reporting**

Interim quarterly reports will be submitted during the course of the project. All the interim reports and field procedures developed in the previous tasks will be compiled and summarized in a single technical report. This technical report will summarize the results of the study and provide an assessment of the best practices for stormwater drywell systems. In addition, the results of this study will be summarized and presented to the sponsoring Watershed Area Steering Committees. This will provide the region with methodology for optimal site selection, pre-treatment, drywell design and maintenance plan. The student research assistants participating in this scientific project will undergo comprehensive training, equipping them with the necessary skills and knowledge to contribute to the local stormwater engineering industry. To ensure a smooth transition and knowledge transfer, a peer-mentoring system will be established, connecting graduates from the project with the subsequent cohort of students involved in the ongoing study.

It is expected that one or more peer-reviewed papers will be produced and submitted to a technical journal for publication. This process will ensure that the study results are subject to technical review.