Infiltration Study

A pilot study to compliment the 2021-2022 LID Inventory

Summary Document

Prepared for:

Georgia Department of Natural Resources, Coastal Resources Division

GEORGIA
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COASTAL RESOURCES DIVISION

Prepared by:

University of Georgia Marine Extension and Georgia Sea Grant

Marine Extension and
Georgia Sea Grant
UNIVERSITY OF GEORGIA

Sea Grant

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Introduction

The Georgia Coastal Management Program has invested in documenting low impact development (LID) practices throughout the eleven-county coastal region of Georgia to better understand their utilization. The Coastal LID Best Management Practice Inventories (LID Inventories) conducted in 2017 and 2022 provide a visual assessment of the practice, along with location and photo-documentation at the time of assessment. More information regarding the performance of coastal Georgia's most common green infrastructure (GI) practice, permeable pavement, would be helpful in making future recommendations regarding maintenance of these systems. There is very little existing data regarding performance of these systems in a coastal environment; therefore, this dataset would also establish a baseline for a subset of permeable pavement installations coast wide.

In conducting the visual assessments associated with the 2017 and 2022 LID Inventories, indicators suggesting varying levels of maintenance for permeable pavement systems in coastal Georgia were observed. Prior to this study little data exists about the infiltration rates of coastal Georgia's most common GI practice, permeable pavement. Permeable pavement surface infiltration rate is beneficial to determine maintenance needs, as well as provide indicators of pollutant removal functionality of a permeable pavement system.

Methodology

Permeable pavement sites were queried from the 2017 and 2022 LID Inventories. This subset was then randomized and twelve sites representing various locations, pavement types and perceived effectiveness ratings were selected for the study. The selected sites and their characteristics are shown in Tables 1 and 2.

Table 1. Infiltration Study sites

Site Name	Address	City	Type	County
Neptune Park Infiltration	550 Beachview Drive	Saint Simons Island	Permeable Interlocking Concrete Pavers	Glynn
St. Simons Public Library	530 Beachview Drive	Saint Simons Island	Permeable Interlocking Concrete Pavers	Glynn
UGA MAREX-Sea Grant: Brunswick Station	715 Bay Street	Brunswick	Permeable Interlocking Concrete Pavers	Glynn
SHRIMP Phase I - PP	St Mary's St	St Mary's	Permeable Interlocking Concrete Pavers	Camden
iResearch	609 E 69th St	Savannah	Permeable Interlocking Concrete Pavers	Chatham
Target	14065 Abercorn Street	Savannah	Permeable Interlocking Concrete Pavers	Chatham
Monkeywrench Bicycles	1708 Frederica Road	Saint Simons Island	Pervious Concrete	Glynn
Wellness Way	7000 Wellness Way	St. Simons Island	Permeable Interlocking Concrete Pavers	Glynn
Riverview Parking Lot	Jekyll Island	Jekyll Island	Pervious Concrete	Glynn
East-State St (near MPC)	Savannah	Savannah	Permeable Interlocking Concrete Pavers	Chatham
First Baptist Church	220 E Memorial Drive	Hinesville	Pervious Concrete	Liberty
Bradwell Park		Hinesville	Permeable Interlocking Concrete Pavers	Liberty

Table 2. Study Site Characteristics

Site Name	County	Approx Age (yrs.)	Perceived Effectiveness 2016	Perceived Effectiveness 2022
Neptune Park Infiltration	Glynn	10+	Poor	Poor
St. Simons Public Library	Glynn	10+	Poor	Poor
UGA MAREX-Sea Grant: Brunswick Station	Glynn	10+	Completed	Fair*
SHRIMP Phase I - PP	Camden	3	N/A	Good
iResearch	Chatham	8	Excellent	Excellent
Target	Chatham	15+	Fair	Fair
Monkeywrench Bicycles	Glynn	10+	Fair	Poor
Wellness Way	Glynn	10+	Excellent	Fair
Riverview Parking Lot	Glynn	1	N/A	Excellent
East-State St (near MPC)	Chatham	2	Good	Poor
First Baptist Church	Liberty	10+	Good	Fair
Bradwell Park	Liberty	0	N/A	Excellent*

Prior to this study, permeable pavement performance had only been visually assessed. Perceived effectiveness is a visual assessment rating developed by the University of Georgia Marine Extension and Goodwyn Mills and Cawood, LLC. The rating considers surface condition, potential infiltration capacity, inlet and outlet conditions, presence of erosion, structure issues present, vegetation (if present), and drainage area conditions. The ratings range from poor to excellent. The Perceived Effectiveness rating conditions can be found in Figure 1.

Excellent	pristine, issues above very minor (represent <10% of surface area), healthy vegetation (if present)
Good	a few issues above, but nothing major (10-25% of surface area)
Fair	moderate clogging, but still seems to work, 25-50% of surface area affected by issues above
Poor	severe clogging, major structural issues, severe erosion, >50% of the area affected by issues above. Also, if permeable pavers are just bricks

Figure 1. Perceived Effectiveness Ratings

Property owners and managers for each site were contacted, and following their permission, each site was evaluated using the Simple Infiltration Test (SIT), developed by North Carolina State University (Winston, et. al., 2016). The SIT methodology was selected because of its replicability, cost of equipment and materials, and test time in comparison with the ASTM test standard. In addition to determining infiltration rates of permeable pavement in coastal Georgia, selecting a methodology that can be taught to local stormwater managers and one that can provide consistent results throughout the region became an important objective.

The SIT infiltrometer was constructed with materials purchased from a local hardware store, secured in place with plumber's putty applied on both inner and outer edges of where the infiltrometer met the permeable pavement surface, and five gallons of water was poured into the infiltrometer to start the test. Three test locations were randomly identified at each site, before arriving on site, and they represented an even distribution

of surface area. A minimum of three SIT replicates were conducted at each of the 12 sites, and the time to infiltrate five gallons was recorded (36 total SITs). Each test was stopped after five minutes and relative water level within the infiltrometer was noted.

Figure 2. Simple Infiltration Test

In a Green Infrastructure Performance Study conducted by Tetra Tech for the City of Grand Rapids, Michigan (2019), the table shown in Figure 3 was presented to determine the pavement condition and maintenance needed based on the time to conduct a single test. This rubric was considered when making notes about infiltration rate and site conditions.

Time it takes water to infiltrate	Condition	Type of Maintenance Needed
<30 seconds	Performing very well. No runoff ever expected.	None
30-90 seconds	Pavement exhibits modest sediment/debris collection. In most cases, the pavement is infiltrating sufficiently well.	None probably needed; but preventative cleaning should be considered.
90-300 seconds	Pavement is clogging; some runoff is probably occurring, but light rains are probably infiltrating.	Clean permeable surface with a regenerative air sweeper vacuum or equivalent.
>300 seconds	Pavement is clogged. Storm events are causing runoff.	Clean permeable surface with a vacuum street sweeper.

Figure 3. Simple Pavement Infiltration Test Results (Table 9 *City of Grand Rapids Green Infrastructure Performance Study*)

Results

The data collected by UGA Marine Extension and Georgia Sea Grant was analyzed by subcontractor, Goodwyn Mills Cawood, LLC. The following results are presented from that analysis. Data is presented using a logarithmic scale for the infiltration rate. A total of 36 tests were performed and analyzed, three at each of the twelve sites.

Three primary outcomes were the focus of the results – (1) infiltration rate based on pavement type, (2) perceived effectiveness rating compared to SIT infiltration rate, and (3) infiltration rate versus age of the practice.

Of the twelve sites assessed, the pavement type was predominately permeable pavers (PICP, n=9), with only three sites having pervious concrete applications. This breakdown, 75% permeable pavers and 25% pervious concrete, is representative of the overall dataset permeable pavement breakdown for the 2022 Inventory and similar to the 2017 Inventory (66% permeable pavers, 28% pervious concrete, 6% other). For each test, the volume (five gallons or 0.67 CUFT) per test time was converted to infiltration rate (in/hr), based on the surface area (4 SQFT). For the average of three tests per site, both pavement types experienced a range of infiltration rates that were as high as 340 in/hr for pervious concrete and 413.5 in/hr for PICP. When clogged, both pavement types also had infiltration rates as low as the minimum testing value (>5 minutes). The distribution of infiltration rates based on permeable pavement type, as shown in Figure 4, were consistent for the collective dataset.

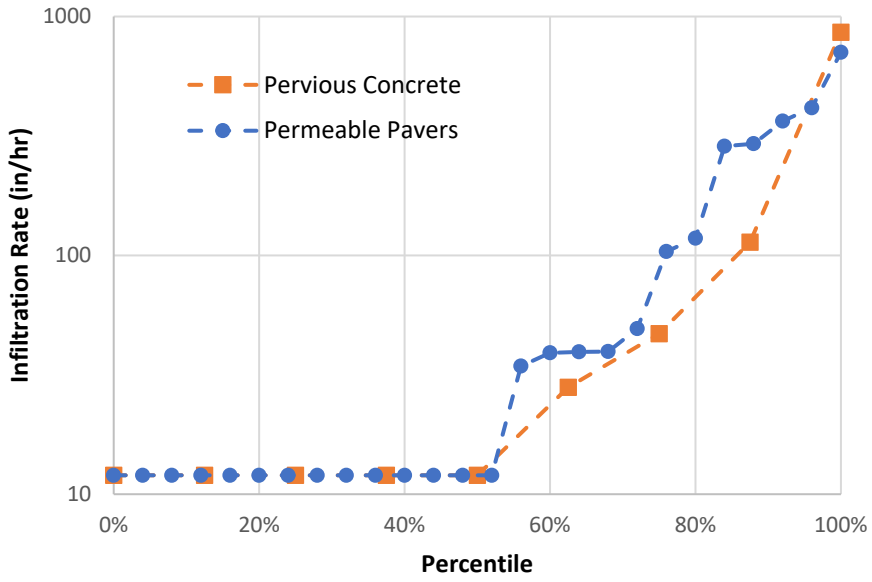

Figure 4. Infiltration Rate by Pavement Type

Additionally, when comparing the perceived effectiveness with infiltration rate the response from recent assessments (2021-2022) is clearly demonstrated, as shown in Figure 5. Ratings of “excellent” or “good” correspond with high infiltration rates (three out of four sites had an average site infiltration rate of greater than 300 in/hr) and “fair”

and “poor” are consistently very low. Unfortunately, five out of the eight sites had all SIT tests time out (>5 minutes) or infiltration rates less than 24 in/hr, and this included two “poor” and three “fair” sites. One “excellent” site had an average infiltration rate of 19.5 in/hr, which indicates that there may be an underlying issue that was not identified with the visual inspection.

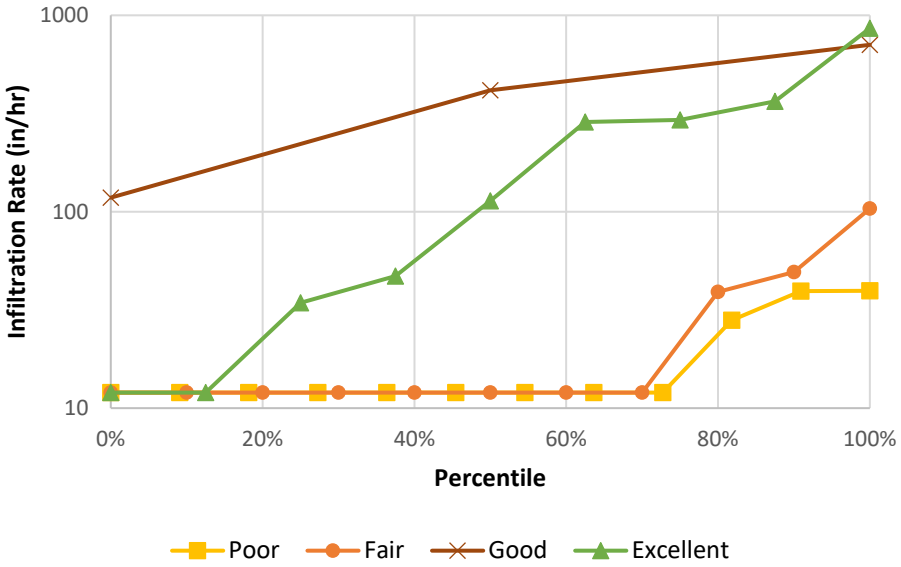

Figure 5. Perceived Effectiveness Rating and Infiltration Rate

In addition to maintenance frequency, the installation’s age can also affect permeable pavement performance, as shown in Figure 6. Four of the twelve sites have been installed in the past three years, and these included the top three sites with fastest infiltration rate. The other eight sites ranged from eight to more than fifteen years old. Installation age was estimated based on historical aerial imagery. Newly constructed sites (0-3 years) have higher infiltration rates than older sites. It is hypothesized that many of the sites in the category that are over eight years old have never been maintained, so this is the reason for the decline in infiltration rate. Of the new sites, the one with the lowest infiltration rate also was the only one with extensive overhead vegetation. The presence overhead vegetation contributes more to sediment/debris accumulation, leading to an accelerated level of clogging. Whereas systems with a very low sediment load, little overhead vegetation, and minimal drainage area tend to exhibit higher infiltration rates despite the age of the site installation.

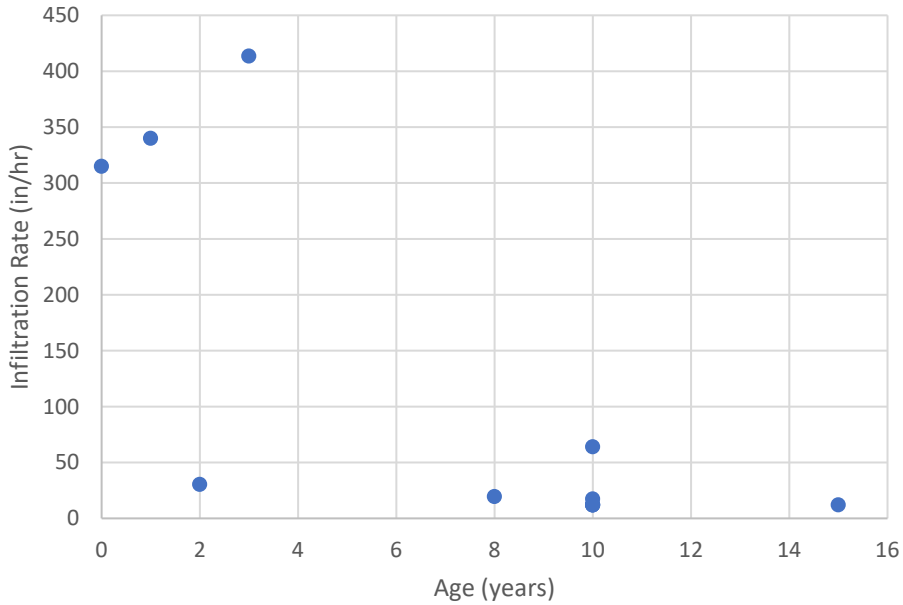

Figure 6. Infiltration Rate versus Age

Due to the quick timeline of this pilot study a training for municipal staff was unable to be fully developed; however, many interactions with local engineering staff, municipal inspections and maintenance professionals, and the public occurred. Their observations of the ease of testing and the need for these data to support maintenance scheduling affirmed this work and supports the study recommendations.

Recommendations

This pilot study to determine surface infiltration rates of permeable pavement confirmed that the SIT is a useful methodology, confirmed and enhanced the effectiveness evaluation from the previous visual assessments, and supports the need for additional data and better understanding of stormwater best management practice performance in the unique environment found on the Georgia coast. Based on this work the following are recommended:

1. Additional monitoring and performance research of stormwater green infrastructure in a coastal environment is useful in informing permeable pavement maintenance frequency.
2. The SIT is effective and accessible for all municipalities in Coastal Georgia. Training and field demonstrations are needed to help inspection and maintenance professionals grasp the importance of these tools when assessing for practice performance.