

TO: Mr. Kevin Larson, H2Opportunities (H2Opps), Mr. Gil Pezza, Michigan Economic Development Corporation (MEDC)

FROM: Mr. James W. Ridgway, PE, Ms. Tonya Lewandowski, and Ms. Meghan Price – Environmental Consulting & Technology, Inc. (ECT)

CC: Mr. Joe Kramer, Parjana Distribution (PD)

RE: Energy-Passive Groundwater Recharge Product (EGRP®) Pilot Demonstration Project on Belle Isle, Detroit, Michigan

DATE: February 10, 2016

EXECUTIVE SUMMARY

This report supersedes our earlier report dated March 10, 2015 reporting on the effectiveness of the Energy-Passive Groundwater Recharge Product (EGRP®) to reduce the total runoff from an urban park. This report includes all of the additional data collected in 2015.

The results of this study document that:

1. ECT observed no standing water at the Test Site once the EGRP® became substantially acclimated.
2. There was no measurable impact on the water quality of the affected groundwater.
3. Smaller storms no longer contributed to stormwater runoff from the Test Site.
4. The groundwater elevation was not negatively impacted by the EGRP® installation.
5. The total runoff measured in the storm sewers exiting the Test Area was reduced by 80%.

Environmental Consulting & Technology, Inc. (ECT) was hired as an independent 3rd party reviewer for a stormwater reduction demonstration project on Belle Isle in Detroit, Michigan. The purpose of the project was to document the effectiveness of the EGRP® in reducing the stormwater runoff volume from a Test Site. This document summarizes ECT's data collection and analysis of the EGRP® system from 2013-2015.

Data logging, storm sewer flow metering, and groundwater elevation piezometer instrumentation were deployed at both the Test and Control Sites (see Figure 1 below) to provide total daily storm sewer flow and groundwater elevation data. Data was collected and analyzed beginning October 31, 2013, prior to any EGRP® installation to establish existing site conditions. EGRP® installation was completed by late June, 2014 and data collection continued at both the Test and Control Sites. Within approximately 2-3 months of completed EGRP® installation, the runoff from the Test Site relative to the rainfall began to be noticeably reduced. Thus the data is aggregated in a manner to differentiate the effectiveness of the technology in three distinct phases: pre-installation, acclimation, and post acclimation. After substantial (post) acclimation of the EGRP®, the total volume of stormwater discharged from the Test Site was reduced by over 80% when comparing the pre- and post-installation precipitation vs. rainfall runoff volumes.

Furthermore, the EGRP® did not affect the groundwater levels or quality based upon data collected from the groundwater elevation instrumentation at the Test and Control Sites. The groundwater elevations at the Test Site remained consistent with the groundwater elevations at the Control Site. Groundwater elevation monitoring did not detect a discernible trend or relationship between fluctuations in the groundwater elevation



Figure 1: Site Layout

and the presence of EGRP[®]s. No deleterious effects to groundwater quality were observed as a result of the EGRP[®] installation. *E. coli* and chloride were monitored in shallow piezometers at both the Test and Control Site. No discernible or substantive differences were measured in general water quality of the two sites.

1.0 INTRODUCTION

1.1 Background

This project was initiated to estimate the amount of stormwater that could be eliminated from the Belle Isle storm sewer collection system. Stormwater on the approximately 982-acre Belle Isle Park is currently collected in a network of separate storm sewers leading to a combined sewer and then transported to the Detroit Water and Sewerage Department (DWSD) Wastewater Treatment Plant. The result is excessive stormwater being delivered to the plant for treatment, resulting in charges for the associated cost to treat that water. DWSD continues to seek ways of reducing peak discharge flows by reducing the stormwater that enters the system as a cost effective means of reducing their cost of compliance for their combined sewer overflow control program. They also are investigating means of equitably charging for stormwater discharges. From all points of view, it is advantageous to reduce/eliminate stormwater from the collection system.

Parjana[®] Distribution, LLC (PD) initially proposed a demonstration project to H2Opportunities (H2Opps) for design and construction of a stormwater mitigation technology known as Energy-Passive Groundwater Recharge Product (EGRP[®]). The fundamental premise of this project was that the installation of EGRP[®]s would reduce the amount of water delivered to the storm sewer system. H2Opps is a non-profit entity dedicated to evaluating water and wastewater technologies and assisting the technology providers in bringing those technologies to market. The initial study was extended an additional year to provide a larger, more representative data set.

1.2 Objectives

The objective of the demonstration project was to determine the effectiveness of EGRP[®]s in reducing the volume of stormwater delivered to DWSD from Shelter Area 5 and to quantify that reduction.

1.3 EGRP[®] Understanding

This study was not asked to evaluate the EGRP[®] product but rather, simply document the effectiveness once installed and acclimated. The technology providers claim that EGRP[®] provides a path that allows water to move more freely horizontally within the soil matrix. The top of the installed EGRP[®] is typically two feet below ground surface. A cap is installed in a manner to prevent direct channeling of water from the surface and/or upper layers to the groundwater table.

The results of this study would suggest that, with acclimation time, the improved water movement in this upper two feet allows the upper soils to retain their filtering/cleaning properties while increasing the rate of infiltration. The better aerated and “healthier” void space that remains after acclimation provides the benefits documented in this study. The mechanisms of water movement through the soil allow more effective transition between wet and dry conditions which facilitates water transfer between soil particles.

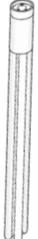
	<p><u>EGRP[®] Description</u> <u>Name:</u> EGRP[®] (Energy-Passive Groundwater Recharge Product) <u>Base Lengths:</u> 5' (1.524 m), 10' (3.048 m), 20' (6.096 m) & 40' (12.192 m) <u>Diameter:</u> 1 ¼" (31.75 mm) <u>Color:</u> Natural Transparent Clear, Colorless <u>Material:</u> Polyethylene per EGRP[®] Specifications <u>Material characteristics:</u> Environmentally Safe, Excellent Corrosion and Abrasion Resistance and Working Temperature -20°F to 180°F (-29°C to 82°C)</p>
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Diagram 1: EGRP[®] Description

The PD design team states that the effectiveness and performance of the EGRP[®] requires site specific analysis. Each site is different and must be viewed as independent from other sites. Typically the goal of any project is to increase the rate of infiltration. The design would, therefore, determine the quantity of water to be managed, compare that quantity to the rate of infiltration expected after full acclimation, and then, if necessary, determine the amount of storage require to manage large (“design”) storms. PD designers indicate that soil type will determine spacing and number of EGRP[®]s required. Installation of the EGRP[®]s is performed by drilling holes with a compression auger and moving the soil outward rather than removing it. This allows for easy insertion of the EGRP[®]s. During the acclimation process, the soils refill the void space surrounding the EGRP[®].

2.0 STUDY DESIGN

2.1 Storm Sewer Configuration

The initial task was to identify the drainage patterns of the Test Site and the Control Site. The site is extremely flat and very poorly drained which resulted in standing water after even minor storms. This often made the sites unusable as picnic areas and/or any other recreational activity.

The storm sewer collection system on Belle Ilse is very old and poorly documented. A survey team was contracted to map the storm sewer configuration in Shelter Areas 4, 5 and 6 and to establish top-of-casing

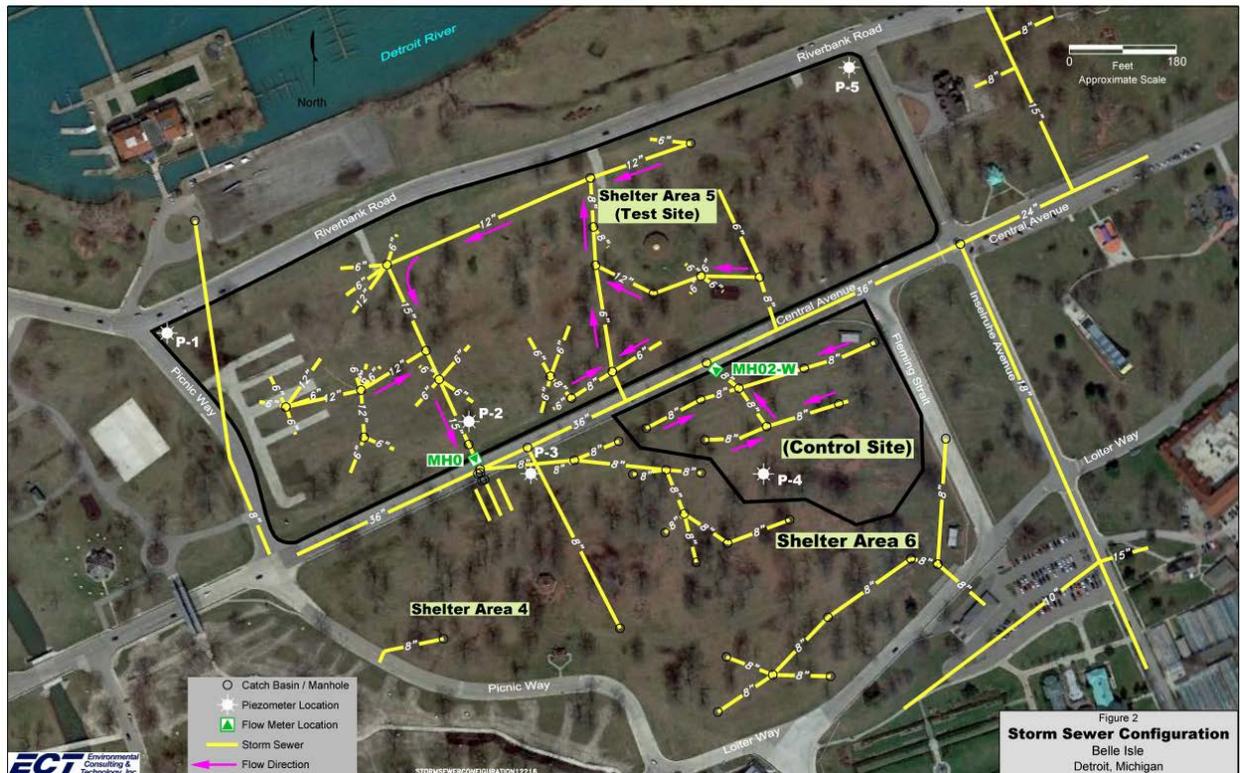


Figure 2: The Existing Stormwater Infrastructure in Place on Both the Test and Control Sites.

elevations for the groundwater monitoring wells to allow for referencing groundwater elevation monitoring data. Figure 2 (see above) shows the storm sewer layout, as best determined, for the evaluated site and the location of piezometers P-1 through P-5. Stormwater from Areas 4, 5, and 6 flows to a 36-inch diameter sewer main extending beneath Central Avenue and is ultimately pumped off-island to the DWSD combined sewer system and on to the wastewater treatment facility.

Based upon the survey investigation, the Control Site was located within Shelter Area 6 and is estimated to be 4.40 acres. The Test Site was located within Shelter Area 5 and covered approximately 23 acres. Both of these areas are depicted on Figures 1, 2, and 3 for reference.

2.2 Site Conditions/ Piezometer Installation

Belle Isle consists predominantly of interbedded sands and clays covered by “urban fill” (original wetlands were filled to make the island available). The boring logs completed during piezometer installation confirm this stratigraphy, with the sediment down to 20 feet logged as sandy or silty clays with occasional lenses of poorly sorted sand found at P-1 (13-15’), P-2 (12-14’), and P-3 (18-20’). Piezometers were carefully installed in 2013 to monitor the quality of shallow groundwater prior to the installation of the EGRP®. Five piezometers (P-1 through P-5) were installed using Geoprobe® Macro Core methods to create 3.25-inch boreholes. The boreholes were driven either to the shallowest observable saturated permeable zone, or 20 feet below ground surface, whichever occurred first. A piezometer was installed in each borehole. The assembly comprised of a 1-inch diameter PVC casing fitted with a 5-foot long 0.010-inch slotted PVC screen. The annulus was backfilled with filter pack sand to approximately one foot above the top of the screen and then granulated bentonite was added to one foot below ground surface. Each piezometer-head was completed with an expandable plug and a flush-to-ground surface protective vault. The piezometer locations are shown on Figure 2, and the boring and piezometer construction logs are included in Appendix B.

Once the survey information was obtained for the existing storm sewer and topographical layout of the Control and Test Sites, it was determined that P-2 was most representative of the Test Site and P-4 of the Control Site (see Figures 1, 2, and 3).

2.3 Flow Monitoring

Stormwater flows leaving the site through the storm sewer collection system were measured using eight Teledyne ISCO 2150 area velocity meters (flow meters) with low profile sensors. Flow data was captured from the Test Area (Area 5) and the Control Areas (Area 6). Figure 2 (above), shows the location and designation of flow meters in closest proximity to the Control and Test Areas.

2.4 Water Level Logging

Groundwater levels were captured using water level data loggers (Divers®) in the piezometers to record changes in groundwater levels.

2.5 Precipitation Recording

Daily precipitation was obtained from the weather station located at the Dossin Museum on Belle Isle, approximately ¼ mile from the project area as reported to *Weather Underground*®. The data was downloaded directly from the *Weather Underground* web site (<http://www.wunderground.com/personal-weather-station/dashboard?ID=KMIDETRO6>).

2.6 Groundwater Sampling and Analysis

To document the groundwater quality, samples were collected on October 10, 2014 from piezometers on the Control and Test Sites, and analyzed for several common surface runoff contaminants - specifically, chloride, total dissolved solids, phosphorus, and *E. coli*. The slow/low recharge of the wells did not support the “low-flow/minimum drawdown” technique and therefore the wells were simply purged dry and a sample collected from each upon recharge and submitted to the lab for analysis. Laboratory results are included as Appendix C, and Table 1 (below) below provides a summary of the results.

Parameter	Units	MDEQ Part 201, Non-residential Drinking Water Criteria	Lake St. Clair Regional Monitoring Project – Median Dry weather (23 sites/16 events) Surface Water	Lake St. Clair Regional Monitoring Project median wet weather (13 sites/10 events) Surface Water	P-2 (Test)	P-4 (Control)
Total Phosphorus	mg/L	240	0.059	0.14	0.082	0.23
Chloride	mg/L	250	130	111	670	1,400
Total Dissolved Solids	mg/L	500	534	420	<40	<40
<i>E. coli</i>	cfu/100 mL		93	1,333	21	12

Table 1: Groundwater Quality Results – Belle Isle, Michigan

ECT noted that the Chloride concentrations recorded in the groundwater at all sampled piezometers was significantly higher than typical groundwater readings of 35-125 mg/L. For purposes of this study, it was noted that the Chloride levels were high on both the Control and Test Sites. The intent of this study was not to determine the cause of this high Chloride, but to document the fact that the Test Site levels did not indicate the EGRP®’s adversely affected the levels when compared to the Control Site.

3.0 RESULTS

The EGRP® installation design was completed by PD staff. The EGRP®s were installed by PD personnel with the approximate location of the EGRP® lines (multiple EGRP®s arranged in a linear array) shown on Figure 3 (see below).

According to the PD design team, acclimation periods for the EGRP® varies by site and can be influenced by environmental factors such as: soil type, climate, depth to groundwater, etc. For the Belle Isle site, flow data began to show less runoff from the Test Site approximately 3 months after the EGRP®s installation was complete. Measurable results showed the biggest reduction after a substantial acclimation period of approximately 9 months on Belle Isle. As the data shows, runoff versus rainfall curves drastically improved during the time period 3 months – 15 months post installation.

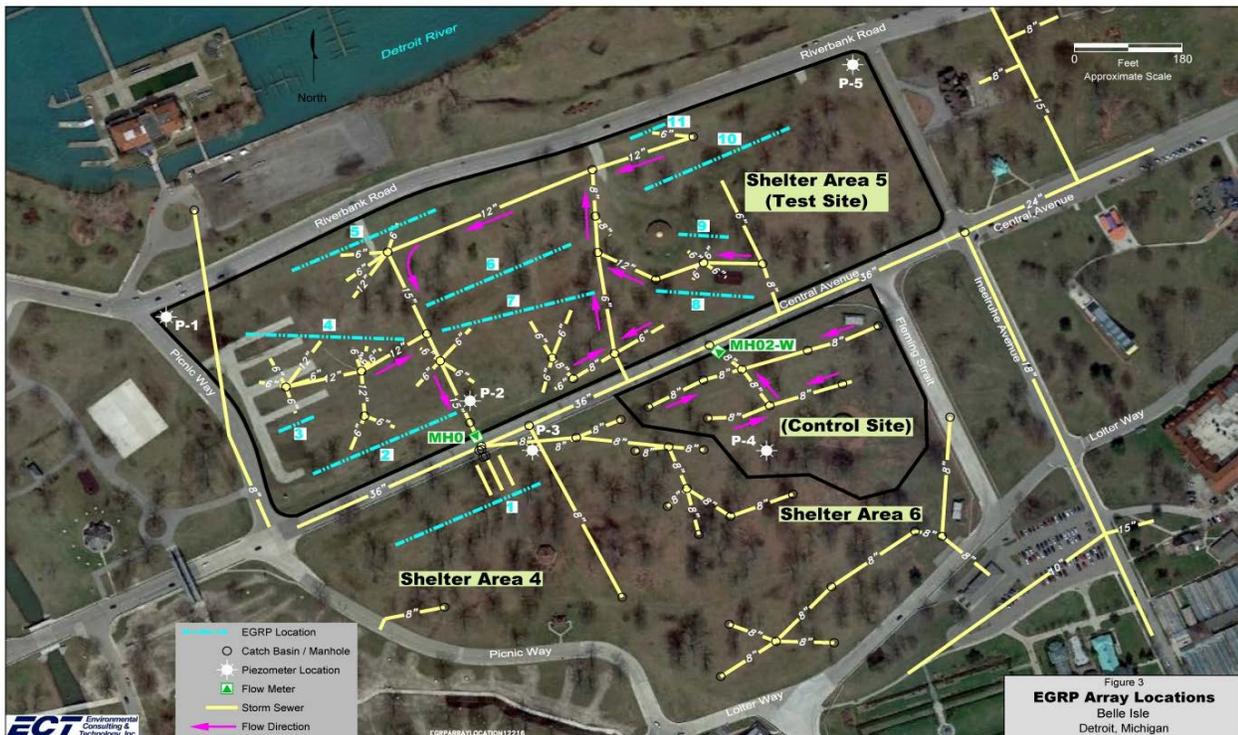


Figure 3: Location of EGRP® Arrays Installed

3.1 Water Table Response

The soils at the installation site were very tight - predominantly of interbedded sands and clays covered by “urban fill.” The water table (potentiometric surface) varied with location and precipitation from ½ to 6 feet below ground surface. The water level response at each location along with the daily precipitation rate is graphed on Figure 4 (below). The groundwater elevation response recorded at the piezometers did not show any clear changes resulting from the installation of the EGRP®s. The storm sewer invert elevations were surveyed in approximately 11’ to 13’ below existing ground elevation, while the EGRP®s are installed 7’ to 42’ below the ground elevation and are shown visually on Figure 4. Both of these entities extend well into the water table. This supports the claim that the baseline flow reported is likely the result of inflow and infiltration (I/I) due to an aged storm sewer system.

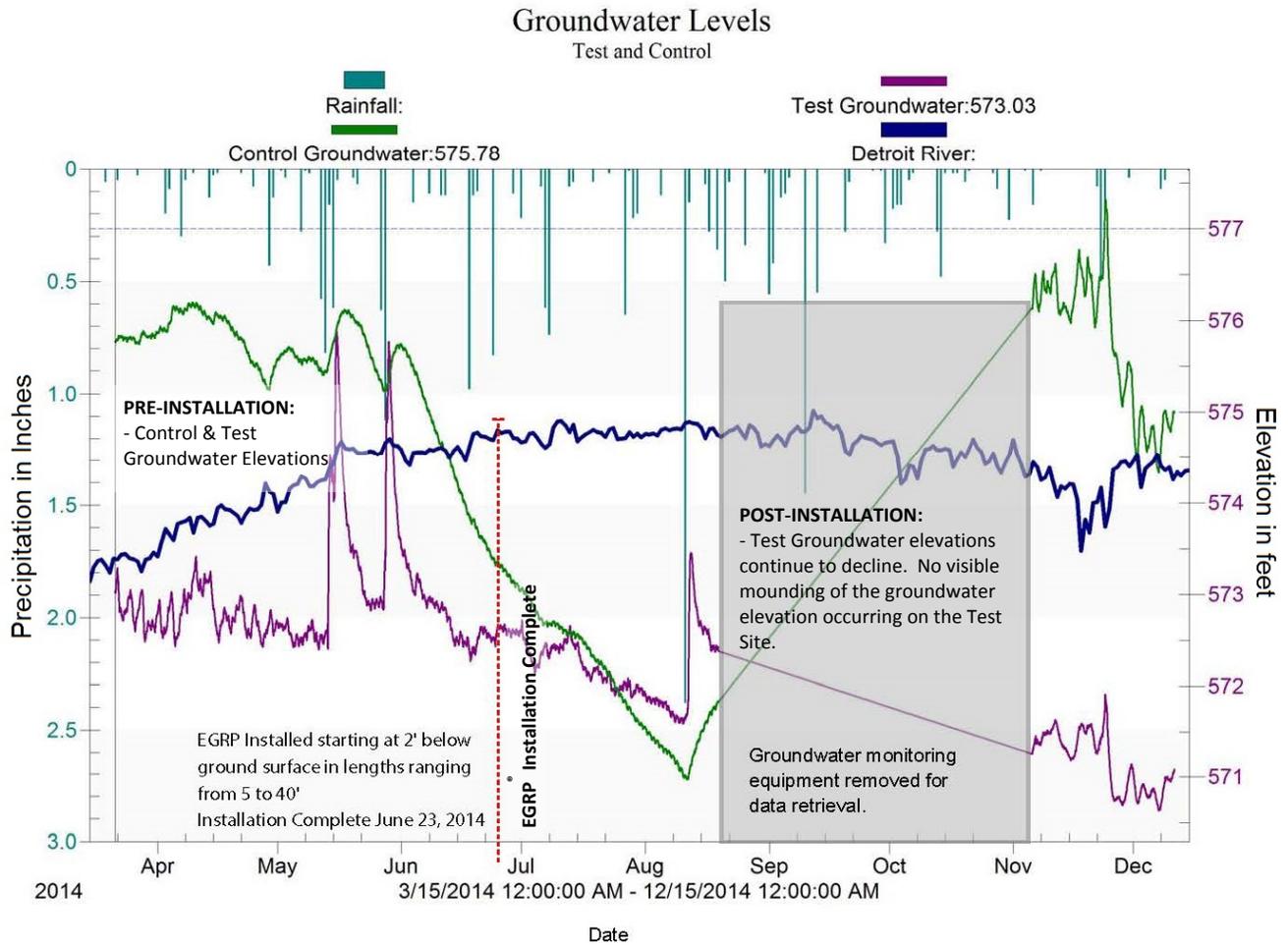


Figure 4: Groundwater and Detroit River Level Elevations

Groundwater data was not collected in 2015, therefore the raw data is not included with this report. It was included with the original report as Appendix C and is available upon request.

3.3 Groundwater Quality Sampling

On October 10, 2014, groundwater was collected from Test Area and Control Area piezometers for comparison. The results are summarized on Table 1 (above) and compared with Michigan Department of Environmental Quality (MDEQ) Non-residential Drinking Water cleanup criteria, and with average results from the Lake St. Clair Regional Monitoring Project (dry and wet weather). The results do not indicate any significant differences between the Test and Control locations. Based on the limited sampling, there does not appear to be any discernible adverse effect to shallow groundwater quality due to the installation of EGRP[®]s on the Test Area.

3.2 Flow Monitoring

The flow monitoring information documented a substantial reduction in the amount of flow contributing to the sewer system. In fact, this reduction was likely the result of two major reductions in flow contributions – a reduction in the amount of stormwater runoff, and the near elimination of elevated groundwater from entering the porous stormwater collection system.

The significant reduction in runoff volume in the Test Area compared to the runoff from the Control Area for the same periods shows that the installation of the EGRP[®] has resulted in less surface water accumulation and runoff (i.e., less overall water volume to the storm sewers during the monitoring period). This comparison illustrates the effectiveness of the EGRP[®] once substantial acclimation is achieved. Based upon the groundwater elevation information and the lack of standing water on the Test Site, this indicates the EGRP[®]'s effectiveness in allowing the soils to “accept” more precipitation as it falls allows for more rapid infiltration, and therefore, significantly reduces both total stormwater volume and peak runoff rate from the site.

In 2013, 2014, and 2015 flow meters were installed in sewer structure locations MH02-W (Control Site) and MHO (Test Site). These meters recorded sewer flow (gallons/day) through December 2015. Data for this time period was analyzed based upon recorded information. When sampling equipment failed for short periods of time, estimated values were calculated based on average flow relative to water level for recorded results.

Cumulative daily flows in gallons/acre were compared with cumulative precipitation in millions of gallons to account for the difference in acreage between the Test Site area. Figure 5 (below) shows this information is broken down in three distinct time periods based upon EGRP[®] installation and assumed substantial acclimation dates. Measurable results for runoff reduction were obtained based upon the pre-installation flow data versus the post-substantial acclimation time period when compared with precipitation. Figure 5 summarizes the cumulative precipitation and cumulative flow for both the Test Site and the Control Site (on a gallons/acre basis) for the three periods initializing the cumulative totals to zero for each period. This figure illustrates how precipitation throughout the entire test period impacted the flows on the Test and Control Sites (i.e. both sites experienced high flux mimicking rainfall events). Conversely, after EGRP[®] substantial acclimation is complete, the change in flow is noticeably less when compared with the change in precipitation, even during high rainfall events. The Test Site experiences a more significant reduction based upon pre-installation flow. This is shown in recognizing how high the Test Site flow curve is above the rainfall flow prior to installation, yet once substantial acclimation is complete, the reduction in flow is clear based upon how much lower the Test Site flow curve is when compared to rainfall. The data appears to identify that the Test Site experiences reduced flux after EGRP[®] substantial acclimation is complete. The EGRP[®] system is clearly reducing the peak changes in flow, even when the change in precipitation is high.

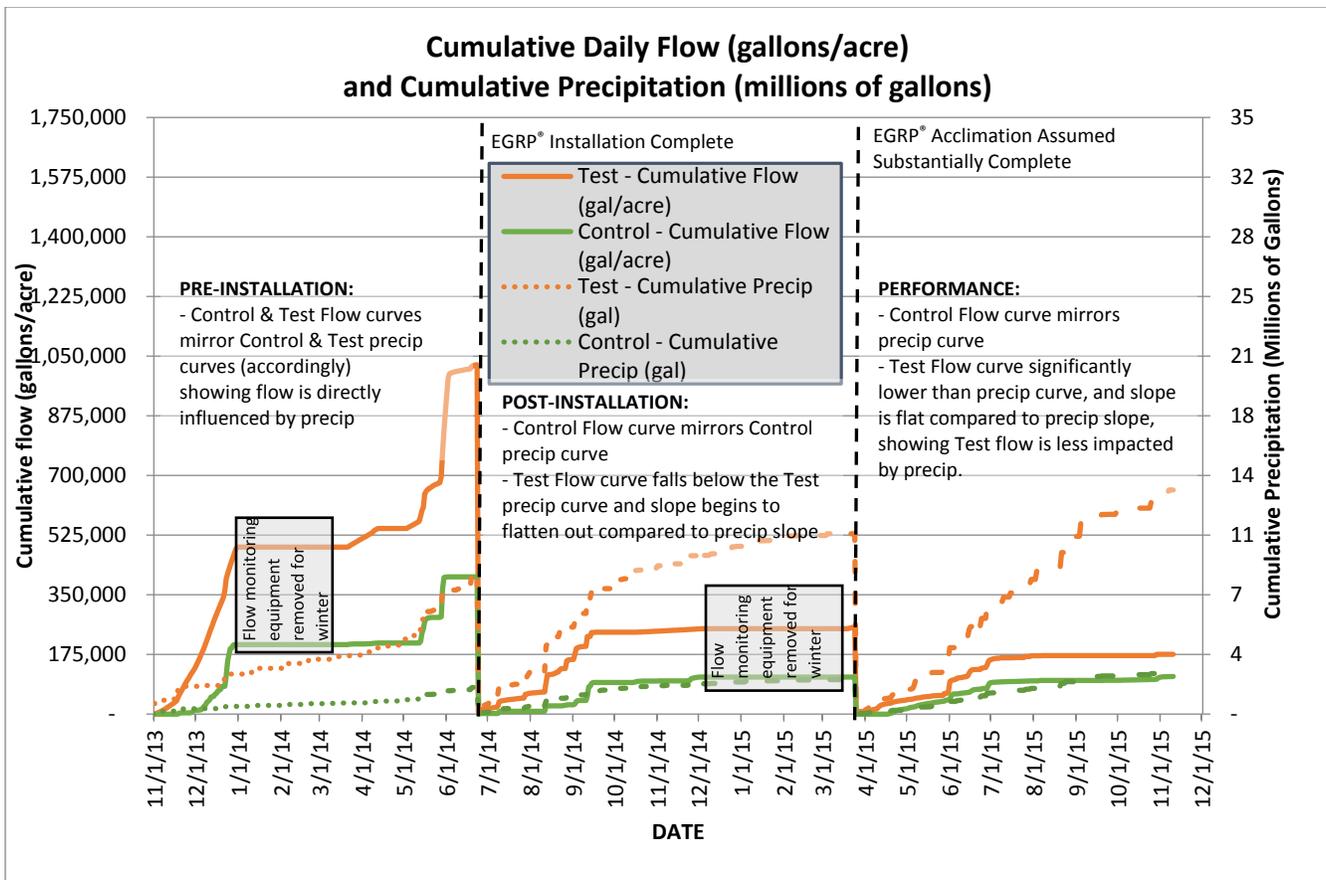


Figure 5: Cumulative Daily Flow and Precipitation

Some results are clear from this information:

1. Prior to installation of the EGRP[®]s, the amount of runoff exceeded the amount of rainfall by a factor of 2. Clearly the drainage system was capturing flow from a much larger area which was likely influenced by the Detroit River elevation and the water in the nearby lagoon system.
2. After EGRP[®] installation, the influence of the larger area has been eliminated and the runoff is much less than the precipitation.
3. The runoff flow curve for the Control Site closely mimics the rainfall flow curve (runoff flow directly impacted by rainfall).
4. The runoff flow curve for the Test Site flattens significantly when compared to the rainfall flow curve (rainfall having less of a direct impact on the amount of runoff flow).
5. The amount of runoff from the Test Site is only 20% of the precipitation volume.

Test Site results in Figure 5 show that, without EGRP[®], the change in stormwater flow mirrors the change in precipitation (i.e. the slopes of the two lines are similar). Control Site results show that after EGRP[®] installation, the stormwater flow increases more slowly (i.e. the slope is flatter) than the precipitation. This proves that the area of EGRP[®] installation washed out the continuous infiltration and inflow (I/I) from the nearby Detroit River and pond on Belle Isle, in addition to reducing the rainfall runoff into the existing storm infrastructure.

Figure 6 (below) summarizes the precipitation and flow totals for the Test Site for the three periods initializing the cumulative totals to zero for each period.

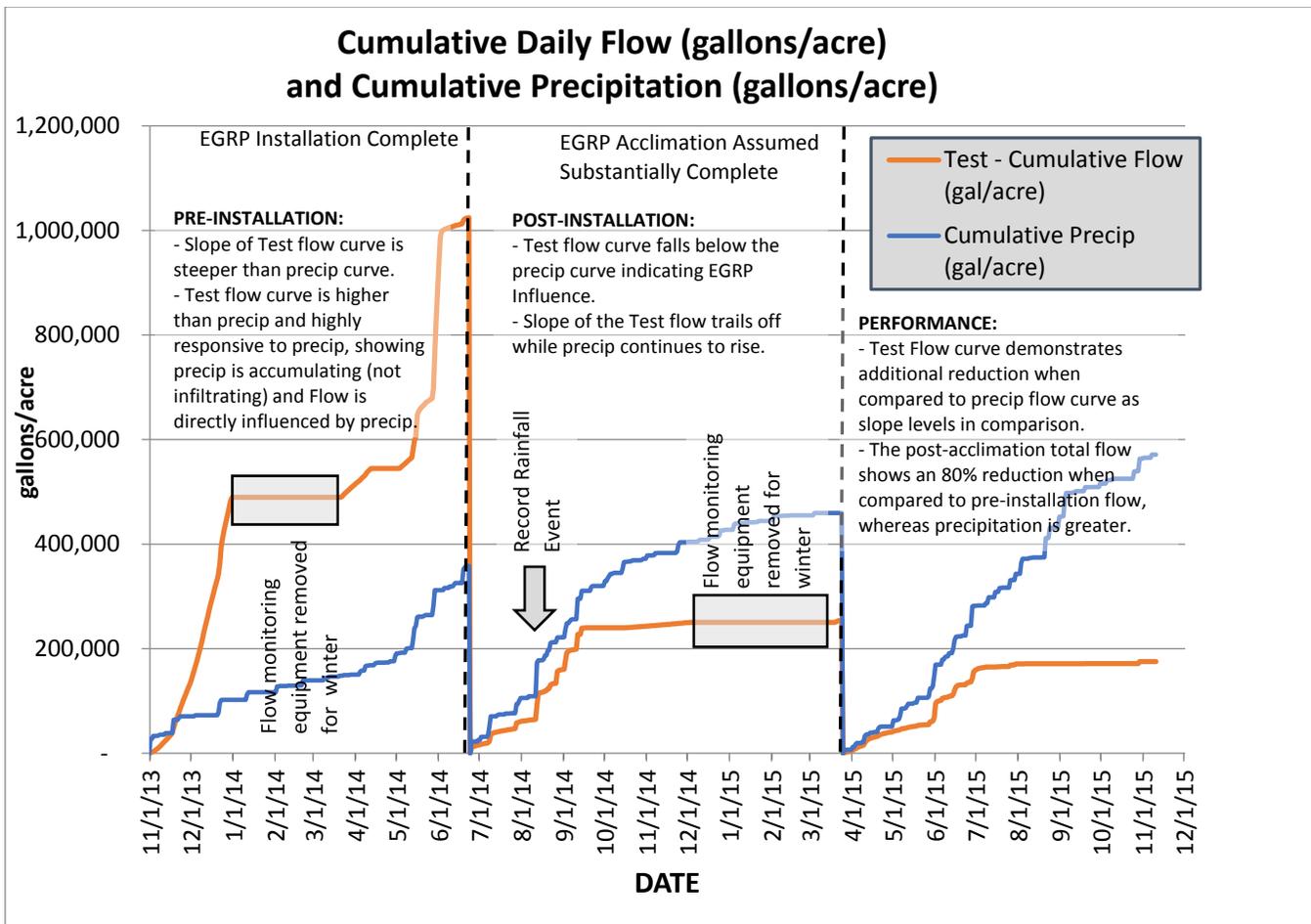


Figure 6: Test Site Cumulative Daily Flow

The stormwater volume data from the Test Site was compared using volumes from the pre-installation period, the acclimation period, and the post acclimation period (each corrected for precipitation volume). Actual flow measured at the Test Site was 3,501,315 gallons per inch of precipitation prior to EGRP® installation in June, 2014. Final flow at the Test Site after full acclimation through December, 2015 was measured to be 599,388 gallons per inch of precipitation. This data as well as flow meters recording total storm sewer flow (gallons/day) documents an approximately 80% reduction in total flow.

Putting this reduction in context:

- The City of Detroit experiences approximately 31” of rainfall per year.
- Prior to the EGRP® installation, the expected stormwater runoff from the 23 acre Test Site on Belle Isle was over 55 million gallons/year delivered to the DWSD collection system;
- Post EGRP® Installation (Substantial Acclimation Complete), the Test Site storm sewer will deliver less than 6 million gallons/year to the DWSD collection system.

All of the accumulated data from the flow meters is included as Appendix E.

4.0 DISCUSSION AND CONCLUSIONS

This study successfully documented that the EGRP[®] technology could significantly increase infiltration, reduce surface water runoff without adversely affecting the groundwater quality or level. The Belle Isle location was selected as a test site because of its history of surface water ponding during precipitation events and because the shallow geology of the island is similar to that of a large portion of Detroit and southeast Michigan.

The results of this study document that:

- 1) ECT observed no standing water at the Test Site once the EGRP[®] became substantially acclimated.
- 2) There was no measurable impact on the water quality of the affected groundwater.
- 3) Smaller storms no longer contributed to stormwater runoff from the Test Site.
- 4) The groundwater elevation was not negatively impacted by the EGRP[®] installation.
- 5) The total runoff measured in the storm sewers exiting the Test Area was reduced by 80%.
- 6) Increased infiltration on the Test Site indicate the upper areas of the soil column in the Test Area became better drained thereby reducing the saturated soils immediately adjacent to the old and permeable drainage network.

The flow monitoring and observations to site conditions document a significant decrease in surface water accumulation and runoff to the storm sewer system draining the Test Area subsequent to the installation and acclimation of the EGRP[®] arrays compared to the Control Site. Discharge via the storm sewer system draining the Test Area was reduced approximately 80% compared to the pre- EGRP[®] installation period. Figure 6 clearly illustrates this reduction in flow when comparing flow recorded during the pre-installation time period with that of the post-acclimation time period, even though precipitation was higher during the post-acclimation time period.