



Digitalizing Below-Ground Stormwater Infrastructure

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P4 Infrastructure, Inc.
Brown Deer, WI



Lambeau Field
Green Bay, Wisconsin

March 4, 2026



Whova™ Poll & Trivia Contest

Whova Poll – Check the App

What is your organization's primary challenge(s) when managing below-ground detention and infiltration systems?

How prepared is your organization to implement digital monitoring (e.g. IoT sensors, real-time data) for management of below ground stormwater systems?

What factor most raises questions of performance reliability of your below-ground stormwater detention/infiltration?

What is your current level of experience with digitalization tools for monitoring below ground BMPs (e.g. sensors for water level, infiltration, or storage)?

Which feature would most convince you to adopt real-time digital monitoring for below-ground detention and infiltration?

Trivia Contest – Check the App

First 10 entries in Booth 2 trivia contest in the Whova™ App receives a coffee tumbler



Session Objectives



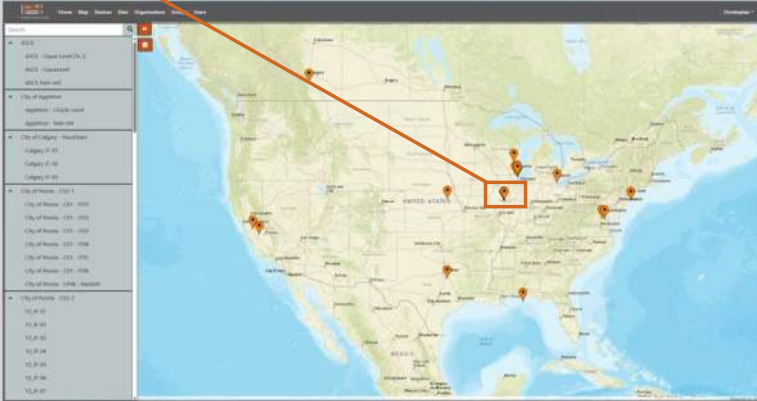
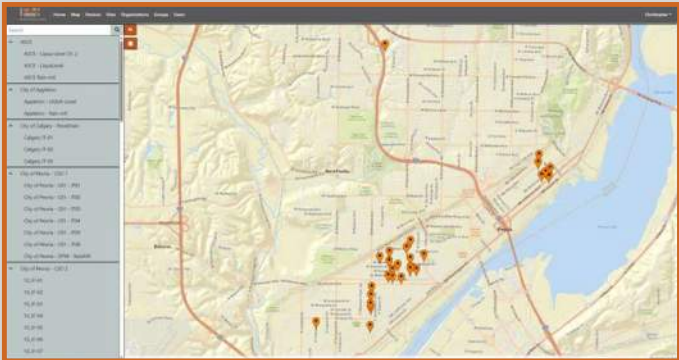
- Identify and discuss the opportunities, data acquired, and value to digitalizing below-ground stormwater infrastructure systems
- Analyze the cost and benefits to digitalization
- Appraise the value of digitalization within the context of watershed-level stormwater management practice

Session Outline



- I. Introduce P4 Infrastructure, Inc.
- II. Outline Value of Below-Ground Stormwater Infrastructure
- III. Outline the Value of Digitalization
- IV. Discuss Examples of Digitalization (motivation for, and value obtained)
- V. Present Opportunities for Digitalization in Stormwater Management
- VI. Discuss Cost versus Value
- VII. Discuss the BIG Picture of Digitalization

P4 Infrastructure, Inc. – Brown Deer, Wisconsin



P4 DIGITALIZATION KITS & SERVICES

<p>Digitalization Kits</p> <ul style="list-style-type: none"> ❖ Water Resources ❖ Site Intelligence ❖ Vibration Monitoring ❖ Battery Powered (Solar Charged) ❖ MINIMAL MAINTENANCE ❖ ECONOMICAL ❖ New or Existing Infrastructure 	<p>Cloud-Based Data Access</p> <ul style="list-style-type: none"> ❖ Wireless (Cellular, WiFi, LoRa) ❖ Browser-Based Viewing & Access (Pin-Drop Access) ❖ 65+ Systems Installed Across North America
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Installation Services

Custom Integration & Private Networks (Real-Time Control)

Precast Concrete Modular Below-Ground Systems - StormTrap™

Images Courtesy of
www.stormtrap.com



Owner Value

- ✓ Durability
- ✓ Speed of Installation
- ✓ Large Watershed Considered
- ✓ Large Volume Capture
- ✓ Preserve Valuable Land Use
- ✓ Maintenance Access

Why Digitalization ?

MS4 Permits & Regulations

- Time Limited
- Re-Certification or Renewal Required
- Maintenance Documentation Required
- Performance Documentation Required

Performance Documentation Expense

On-Site Visual Inspection of Water Level to Document Performance

- Site Visit After Rain Event
- Manual Measurement of Water Level
- Discharge Duration Requires Multiple Visits
- Manual Data Documentation
- Manual Report Generation

QUESTIONS

- How do you schedule weather events to document performance?
- How do you create transparency for stakeholders?
- How can you eliminate arbitrary on-site inspections and maintenance?
- How do you get annual data documenting performance (watershed level)?
- Do you need maintenance?
- How do you generate annual data for MS4 permit renewals?

ANSWER - Digitalization

- ❖ **Personnel Safety**
 - ✓ Only enter vault when necessary
- ❖ **Easy Performance Documentation**
 - ✓ Rainfall Events
 - ✓ Annual Volume Detained
 - ✓ Annual Volume Infiltrated
 - ✓ Watershed-Level Understanding
- ❖ **Data-Driven Decisions**
 - ✓ Maintenance Need (may be none)
 - ✓ Watershed-Level Planning
- ❖ **Easy Regulatory Compliance**
 - ✓ Annual Documentation
 - ✓ Reporting is Data-Driven
- ❖ **Easy Stakeholder Transparency**
 - ✓ Data-Driven Story
 - ✓ Data-Driven Expenditures
 - ✓ GIS Integration

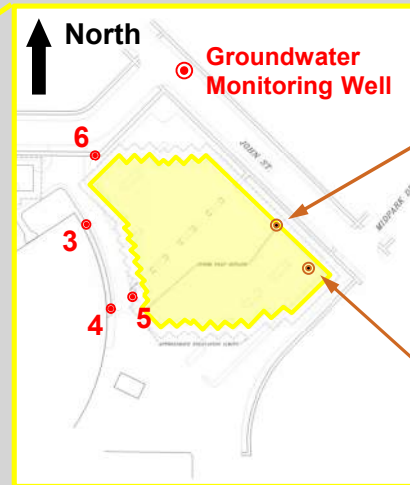
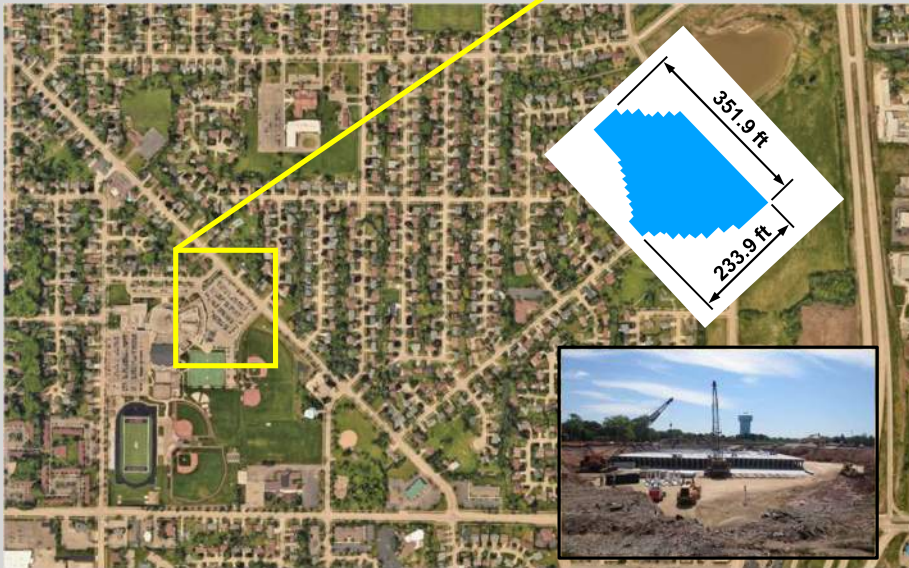
Detention System - Wisconsin

Owner and Location

- City of Appleton, Wisconsin
- Appleton East High School

Motivation for Digitalization

- Document System Performance
- Understand Impact on Groundwater



P4 Infrastructure Kits

Rain-mX – Rainfall & Environment

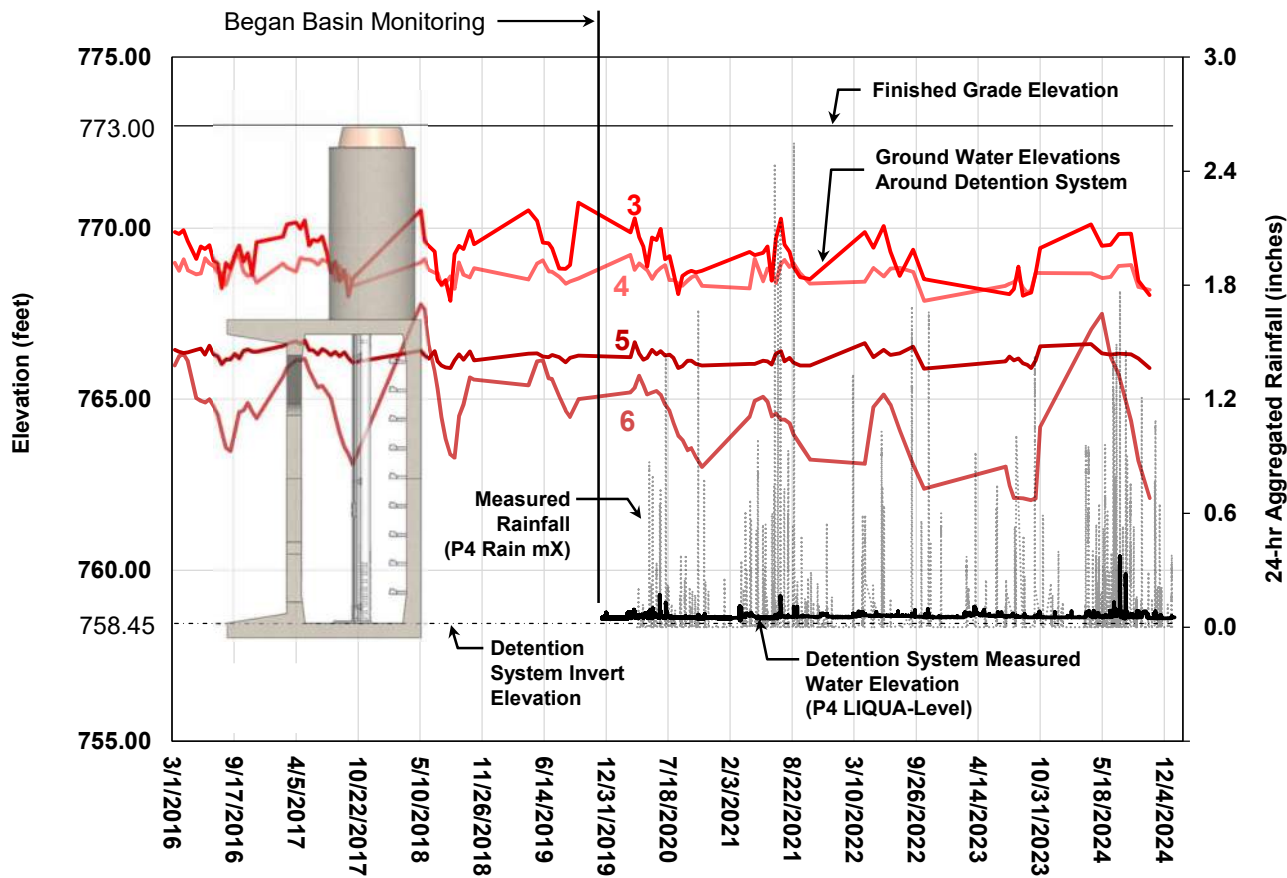
- ✓ Battery Powered (solar charged)
- ✓ 10-minute Rainfall Data
- ✓ 10-min, 7-hr and 24-hr Rainfall Aggregation
- ✓ Cellular Data Transmission
- ✓ Plug-and-Play Components

LIQUA-Level – Water Level

- ✓ Battery Powered (solar charged)
- ✓ 10-minute Water Level Data
- ✓ 8-foot Measuring Range (0.25" resolution)
- ✓ Mounting Within Vault at Access Manhole
- ✓ Cellular Data Transmission
- ✓ Plug-and-Play Components

Installation by P4 Infrastructure, Inc.

Digitalization Value



Owner Value

- **Significant Dataset**
 - ✓ December 17, 2019, to Present
 - ✓ Over 720,000 Contiguous Data Points
- **ONE Maintenance Event** (battery replacement)
- **Autonomous and Time Correlated Data Acquisition** (rainfall and vault water level)
- Continuous Water-Level Measurements to Complement Manual Ground Water Level Measurements
- **Data Documenting Vault has NO IMPACT on Groundwater**
- **Data Documenting that Precast Module Sealing System is Working Perfectly**
- **Data-Driven Understanding of Urban Watershed Hydrology**
- **Data-Driven Maintenance Decisions**
- **NO NEED TO ENTER VAULT**

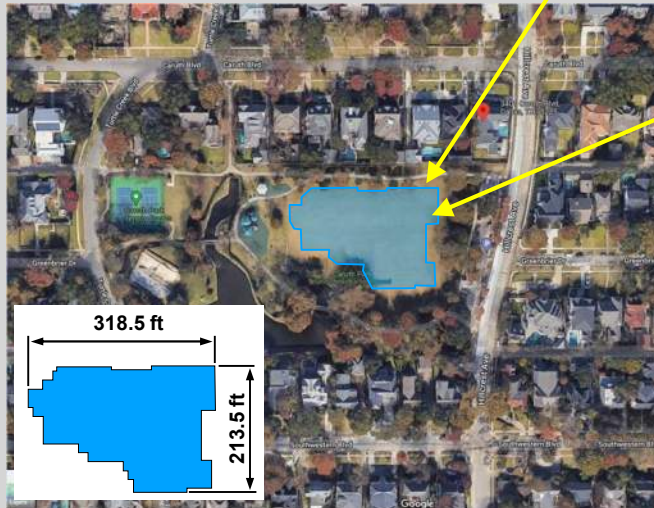
Detention System - Texas

Owner and Location

- City of University Park, TX
- Caruth Park

Motivation for Digitalization

- Document System Performance
- Understand Urban Hydrology
- Data-Driven Decision Making
- Stakeholder Transparency



P4 Infrastructure Kits

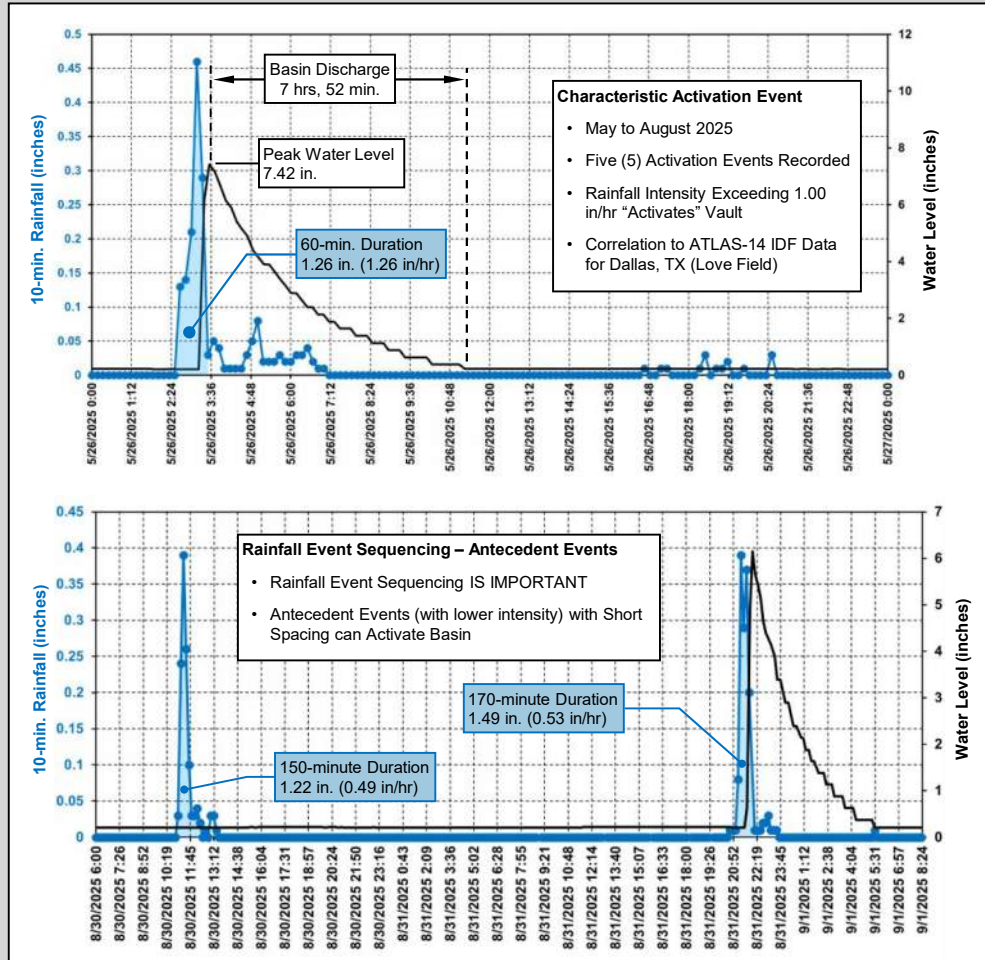
Rain-mX – Rainfall & Environment

- ✓ Battery Powered (solar charged)
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- ✓ Plug-and-Play Components

LIQUA-Level – Water Level

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- ✓ Mounting Within Vault at Access Manhole
- ✓ Cellular Data Transmission
- ✓ Plug-and-Play Components

Installation by City of University Park, TX



Owner Value

- **Significant Dataset**
 - ✓ April 2024, to Present
 - ✓ Over 180,000 Contiguous Data Points
- **Autonomous and Time Correlated Data Acquisition** (rainfall and vault water level)
- **Data-Defined Activation Events**
- **Correlation of Measured Demand and Response to ATLAS-14 IDF Data**
- **Data-Driven Understanding of Urban Watershed Hydrology**
- **Data-Driven Model Calibration**
- **Data-Driven Planning for Future Vault Design**
- **Data-Driven Maintenance Need**
- **Stakeholder Transparency**

Infiltration Basin - Illinois



Owner and Location

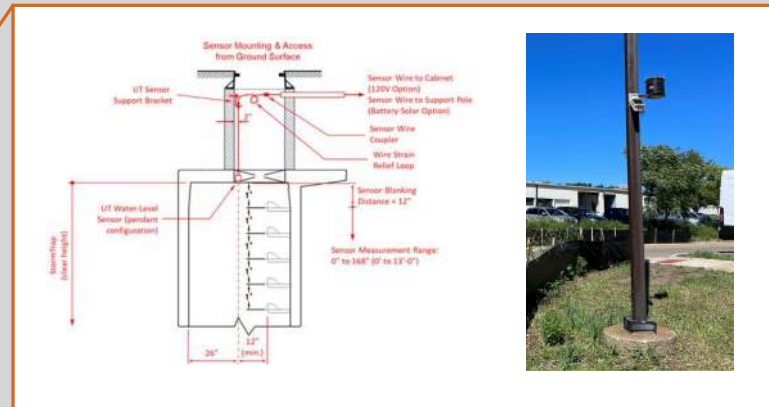
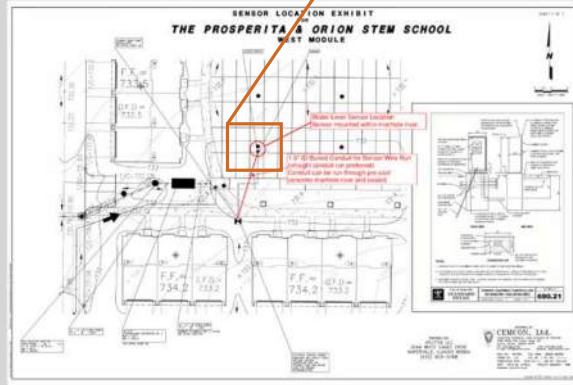
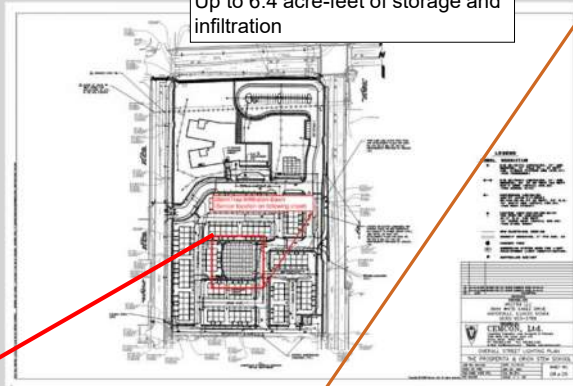
- Private Developer (Townhomes and STEM School)
- City of Naperville, Illinois

Motivation for Digitalization

- Satisfy City of Naperville Requirements
- Master Association Mandate
- Prepare Annual Reports on Hydraulic Function and Operational Integrity of the Stormwater Management System

Digitalization System

13,225 sq-ft (0.30 acre) plan area
Up to 6.4 acre-feet of storage and
infiltration



P4 Infrastructure Kits

Rain-mX – Rainfall & Environment

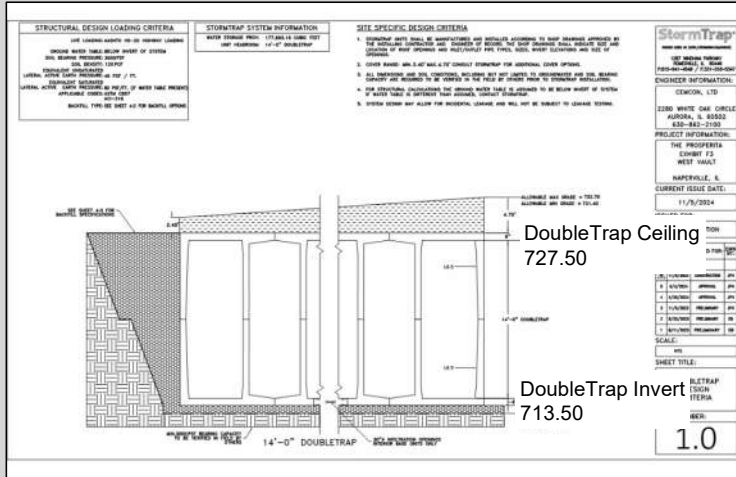
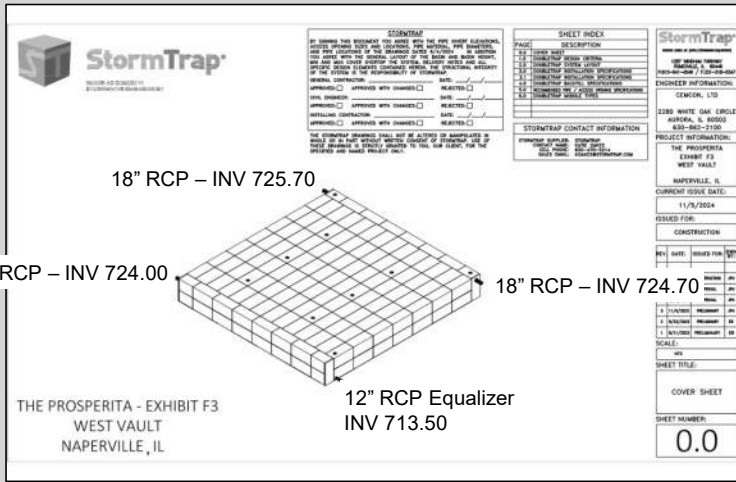
- ✓ Battery Powered (solar charged)
- ✓ 10-minute Rainfall Data
- ✓ 10-min, 7-hr and 24-hr Rainfall Aggregation
- ✓ Cellular Data Transmission
- ✓ Plug-and-Play Components

DEPTH – Water Level (ultrasonic)

- ✓ Mounting Within Manhole Riser (access from surface)
- ✓ 120V Power (buried conduit run to existing electrical cabinet by others)
- ✓ 10-minute Water Level Data
- ✓ 14-foot Measuring Range (0.08" resolution)
- ✓ Cellular Data Transmission
- ✓ Plug-and-Play Components

Installation by P4 Infrastructure, Inc.

System Response Characterization



Scenario B and Proposed
1.19 cfs of Infiltration

Elevation	Area (sq. ft.)	Area (ac.)	Incremental Volume (ac.-ft.)	Cumulative Volume (ac.-ft.)	Sensor Reading (in.)
710.00				0.000	
711.00		0.250		0.250	
712.00		0.250		0.500	
713.00		0.250		0.750	
713.50	0.00			0.750	168.00
713.75	4,222.62			0.847	165.00
714.00	8,445.24			0.944	162.00
714.25	12,667.87			1.041	159.00
714.50	16,890.49			1.138	156.00
714.75	21,113.11			1.235	153.00
715.00	25,335.73			1.332	150.00
715.25	29,558.35			1.429	147.00
715.50	33,780.98			1.525	144.00
715.75	38,003.60			1.622	141.00
716.00	42,226.22			1.719	138.00
716.25	46,448.82			1.815	135.00
716.50	50,671.44			1.913	132.00
716.75	54,894.07			2.010	129.00
717.00	59,116.69			2.107	126.00
717.25	63,339.31			2.204	123.00
717.50	67,561.93			2.301	120.00
717.75	71,784.56			2.398	117.00
718.00	76,007.18			2.495	114.00
718.25	80,229.80			2.592	111.00
718.50	84,452.42			2.689	108.00
718.75	88,675.04			2.786	105.00
719.00	92,897.66			2.883	102.00
719.25	97,120.28			2.980	99.00
719.50	101,342.90			3.077	96.00
719.75	105,565.51			3.173	93.00
720.00	109,788.13			3.270	90.00
720.25	114,010.75			3.367	87.00
720.50	118,233.38			3.464	84.00
720.75	122,455.99			3.561	81.00
721.00	126,678.62			3.658	78.00
721.25	130,901.24			3.756	75.00
721.50	135,123.87			3.852	72.00
721.75	139,346.49			3.949	69.00
722.00	143,569.11			4.046	66.00
722.25	147,791.73			4.143	63.00
722.50	152,014.35			4.240	60.00
722.75	156,236.98			4.337	57.00
723.00	160,459.58			4.434	54.00
723.25	164,682.20			4.531	51.00
723.50	168,904.82			4.628	48.00
723.75	173,127.44			4.724	45.00
724.00	177,350.07			4.821	42.00
724.25	181,572.69			4.918	39.00
724.50	185,795.31			5.015	36.00
724.75	190,017.93			5.112	33.00
725.00	194,240.56			5.209	30.00
725.25	198,463.18			5.306	27.00
725.50	202,685.80			5.403	24.00
725.75	206,908.42			5.500	21.00
726.00	211,131.04			5.597	18.00
726.25	215,353.66			5.694	15.00
726.50	219,576.27			5.791	12.00
726.75	223,798.89			5.888	9.00
727.00	228,021.51			5.985	6.00
727.25	232,244.13			6.082	3.00
727.50	236,466.76			6.179	0.00
730.00			0.24	6.419	

Sensor Data Synthesis

- ✓ Sensor Reading = 168"
BASIN NOT ACTIVATED
- ✓ Sensor Reading > 42"
INFILTRATION
- ✓ Sensor Reading < 42"
STORM SEWER DISCHARGE INFILTRATION
- ✓ Sensor Reading "stuck" > 42"
SLOW INFILTRATION
SUMP PUMP ACTIVATION (?)

Water-Level to Staged Basin Volume

Rainfall Events – Rain-mX (Correlation to IDF Data)

Illinois State Water Survey Bulletin 75

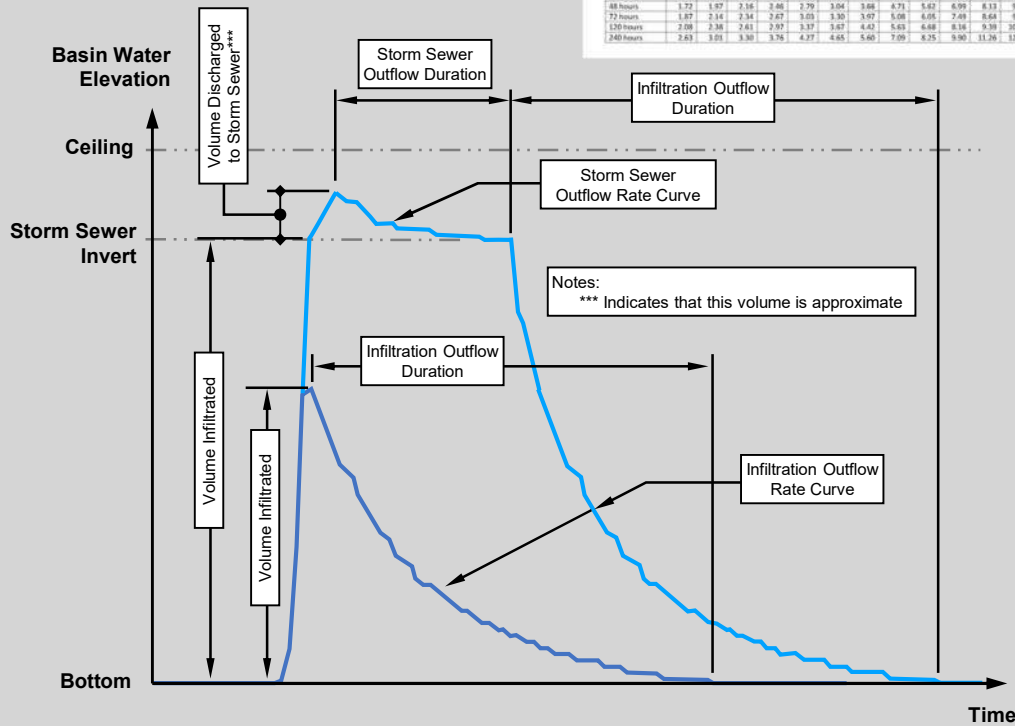
Duration	2"	3"	4"	6"	8"	1"	2"	5"	10"	25"	50"	100"	500"
	month	month	month	month	month	year	year	year	year	year	year	year	year
5 minutes	0.19	0.27	0.34	0.27	0.31	0.33	0.40	0.52	0.62	0.77	0.90	1.03	1.35
10 minutes	0.33	0.50	0.61	0.47	0.55	0.58	0.70	0.90	1.08	1.35	1.58	1.80	2.36
15 minutes	0.42	0.69	0.83	0.61	0.69	0.75	0.90	1.16	1.39	1.74	2.03	2.32	3.04
30 minutes	0.58	0.86	0.73	0.63	0.64	1.03	1.24	1.50	1.81	2.39	2.78	3.17	4.16
1 hour	0.74	0.84	0.93	1.05	1.10	1.30	1.57	2.07	2.42	3.03	3.53	4.03	5.28
2 hours	0.91	1.04	1.14	1.30	1.48	1.41	1.94	2.49	2.99	3.74	4.35	4.97	6.52
3 hours	1.00	1.15	1.26	1.64	1.63	1.77	2.14	2.75	3.30	4.13	4.80	5.49	7.20
6 hours	1.19	1.35	1.48	1.68	1.61	2.08	2.51	3.20	3.86	4.84	5.63	6.43	8.42
12 hours	1.37	1.56	1.71	1.95	2.21	2.41	2.91	3.74	4.48	5.61	6.53	7.46	9.78
18 hours	1.48	1.69	1.85	2.11	2.39	2.61	3.14	4.04	4.84	6.06	7.05	8.06	10.57
24 hours	1.57	1.80	1.97	2.24	2.58	2.77	3.34	4.30	5.15	6.45	7.50	8.57	11.24
48 hours	1.72	1.97	2.16	2.46	2.79	3.04	3.68	4.71	5.62	6.99	8.13	9.28	12.10
72 hours	1.87	2.14	2.34	2.67	3.03	3.30	3.97	5.08	6.06	7.49	8.64	9.85	12.81
120 hours	2.08	2.38	2.61	2.97	3.37	3.67	4.42	5.63	6.68	8.16	9.39	10.66	13.81
240 hours	2.63	3.01	3.30	3.76	4.37	4.65	5.60	7.09	8.25	9.90	11.36	12.85	16.00

Basin Water Level – P4 DEPTH

System Performance Characteristics:

Pure Infiltration Outflow

Combined Infiltration & Storm Sewer Outflow



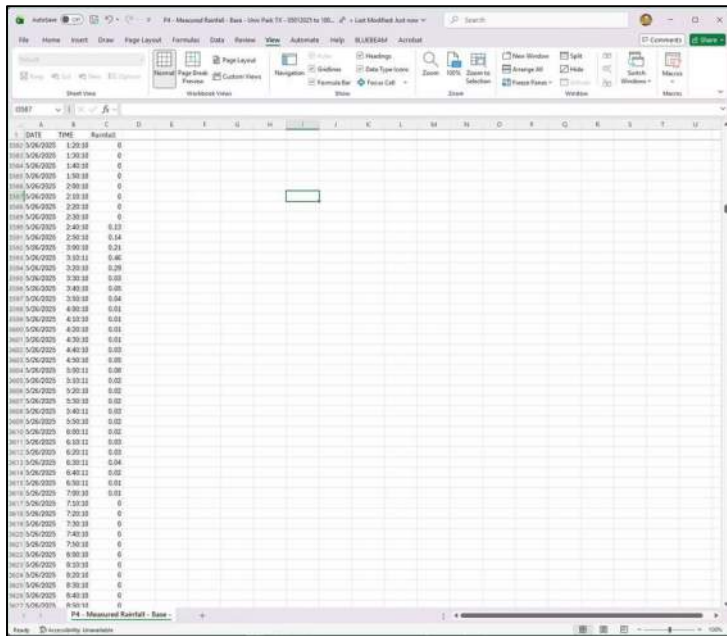
Owner Value

- **Quantify & Classify Rainfall Events**
 - ✓ Amount, Intensity & Duration
 - ✓ Correlate to ISWS Bulletin 75 IDF Data
- **Document Vault Response**
- **Correlate Vault Response to Rainfall Event**
- **Correlate Vault Response to Cumulative Volume Captured/Infiltrated**
- **Documentation of Runoff Captured/Infiltrated**
- **Easy Reporting** to Satisfy City of Naperville Requirements
- **System Performance Documentation for Property Turnover** (Developer to Association)

Opportunities – SWMM & WinSLAMM

Phase I in Workflow

- 1.) Existing SWMM or WinSLAMM Model Built with Design
- 2.) Rain-mX Data (10-minute) Downloaded in CSV Format
- 3.) CSV File Easily Parsed to DATE, TIME, Rainfall Columns within Excel (or another spreadsheet tool)



DATE	TIME	Rainfall
2023/06/09	1:20:00	0
2023/06/09	1:30:00	0
2023/06/09	1:40:00	0
2023/06/09	1:50:00	0
2023/06/09	2:00:00	0
2023/06/09	2:10:00	0
2023/06/09	2:20:00	0
2023/06/09	2:30:00	0
2023/06/09	2:40:00	0.23
2023/06/09	2:50:00	0.14
2023/06/09	3:00:00	0.21
2023/06/09	3:10:00	0.46
2023/06/09	3:20:00	0.29
2023/06/09	3:30:00	0.03
2023/06/09	3:40:00	0.06
2023/06/09	3:50:00	0.04
2023/06/09	4:00:00	0.02
2023/06/09	4:10:00	0.01
2023/06/09	4:20:00	0.01
2023/06/09	4:30:00	0.01
2023/06/09	4:40:00	0.01
2023/06/09	4:50:00	0.00
2023/06/09	5:00:00	0.00
2023/06/09	5:10:00	0.02
2023/06/09	5:20:00	0.02
2023/06/09	5:30:00	0.02
2023/06/09	5:40:00	0.02
2023/06/09	5:50:00	0.02
2023/06/09	6:00:00	0.02
2023/06/09	6:10:00	0.02
2023/06/09	6:20:00	0.02
2023/06/09	6:30:00	0.04
2023/06/09	6:40:00	0.02
2023/06/09	6:50:00	0.02
2023/06/09	7:00:00	0.02
2023/06/09	7:10:00	0
2023/06/09	7:20:00	0
2023/06/09	7:30:00	0
2023/06/09	7:40:00	0
2023/06/09	7:50:00	0
2023/06/09	8:00:00	0
2023/06/09	8:10:00	0
2023/06/09	8:20:00	0
2023/06/09	8:30:00	0
2023/06/09	8:40:00	0
2023/06/09	8:50:00	0
2023/06/09	9:00:00	0

Phase II in Workflow

- 4.) Generate Measured (real) Rainfall Input Files:
 - ✓ ?.ran – WinSLAMM Input Rain File
 - ✓ ?.txt – SWMM Input Rain File

Options for Generation:

- User-Written Scripts (e.g., Python, R, Bash)
- Large Language Models (LLM) and Artificial Intelligence (AI):
 - ChatGPT
 - Grok
 - Gemini
 - Claude (Anthropic)
 - DeepSeek
- P4 Infrastructure, Inc. Service

REAL Rainfall for Hydrologic Modeling

- ✓ Calibrate (improve) an Accepted Hydrologic Model with REAL Rainfall Input
- ✓ Document Annual Pollutant Capture with Accepted Model and REAL Rainfall (MS4 & TMDL Regulatory Compliance Reporting)

MSRP's & Owner Value

Water-Level Kits – Cellular

Stand-Alone Support (computer outside manhole, stand-alone pole)

1. P4 DEPTH Kit – \$5,025
2. Annual Cloud Compute Subscription – \$225/yr
3. Installation by P4 (180-mile service radius) – \$1,925
4. Requires low-voltage conduit run by others

Self-Contained in Manhole

1. P4 DEPTH Kit - \$5,895 (includes composite MH cover)
2. Annual Cloud Compute Subscription – \$225/yr
3. Installation by P4 (180-mile service radius) – \$1,050

Rain-mX Kit - Cellular

1. P4 Rain-mX Kit - \$2,280
2. Annual Cloud Compute Subscription – \$225/yr
3. Conveniently located in watershed (on existing pole, or flat rooftop)
4. P4 Installation included with water-level kit installation

Owner Value

Data-Driven Decision Making

- Understanding Rainfall Events and their Impact on Stormwater Infrastructure
 - ✓ Document Activation Events
 - ✓ Correlation to IDF Data
- Better Design
 - ✓ Calibrate Future Models
 - ✓ Better Prediction of Storage Need
- Consideration of Water-Quality
 - ✓ MS4 and TMDL Compliance

Bang for the Buck

- Digitalization Capital Expenditure
 - ✓ Passive Systems Described are VERY LOW
 - ✓ Active Systems are VERY HIGH
- Annual Data Transmission and Viewing Expenditures Small
- Passive Digitalization System Maintenance Cost Minimal
 - ✓ Remote & Autonomous Health Monitoring
 - ✓ Systems Require Minimal Maintenance
 - ✓ Modular
 - ✓ Plug-and-Play Component Exchange

An Easy Button

- Maintenance
 - ✓ Avoid Arbitrary Visits and Interventions
 - ✓ Data-Driven Scheduling
- MS4 and TMDL Documentation
 - ✓ Data-Driven
 - ✓ Annual Pollutant Capture using Accepted Model and REAL Rain Data

Data-Driven Transparency

- City Council Presentations
- Public Works Meetings
- GIS Integration

BIG Picture

PASSIVE Systems – KISS (Keep It Simple Steve)

Workflow Simplicity

- Consistent with Standard Practice
- No Front-End Design Complexity
- Avoid Mixing Digitalization into Front-End Design

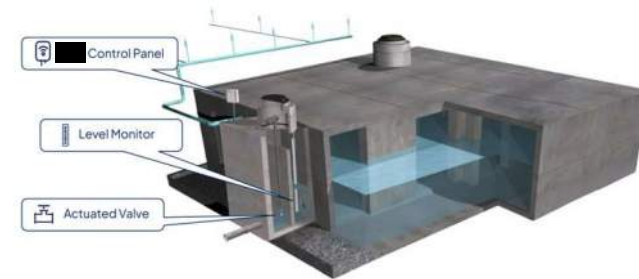
Data-Documented Performance

- Rainfall Demand
- Infrastructure Component Performance
- Watershed-Level Performance

Maintenance

- Minimize maintenance considerations and expense
- Ensure component replacement is simple and economical
- Let documented infrastructure performance define the need for maintenance

ACTIVE Systems – Real-Time Control (RTC)



Benefits

- ✓ Real-Time Control of Discharge
- ✓ Optimize Storage/Infiltration Availability
- ✓ Match Pre- and Post-Development Discharge

Challenges

- Need RTC in Designer Workflow
- Maintenance
 - Failure has Consequences
 - Electro-Mechanical Valve
- Reliance on Weather Forecasting
 - Accuracy
 - Reliability
- Power Requirements (? Interruption ?)
- **SIGNIFICANT** Capital Investment

? Questions ?

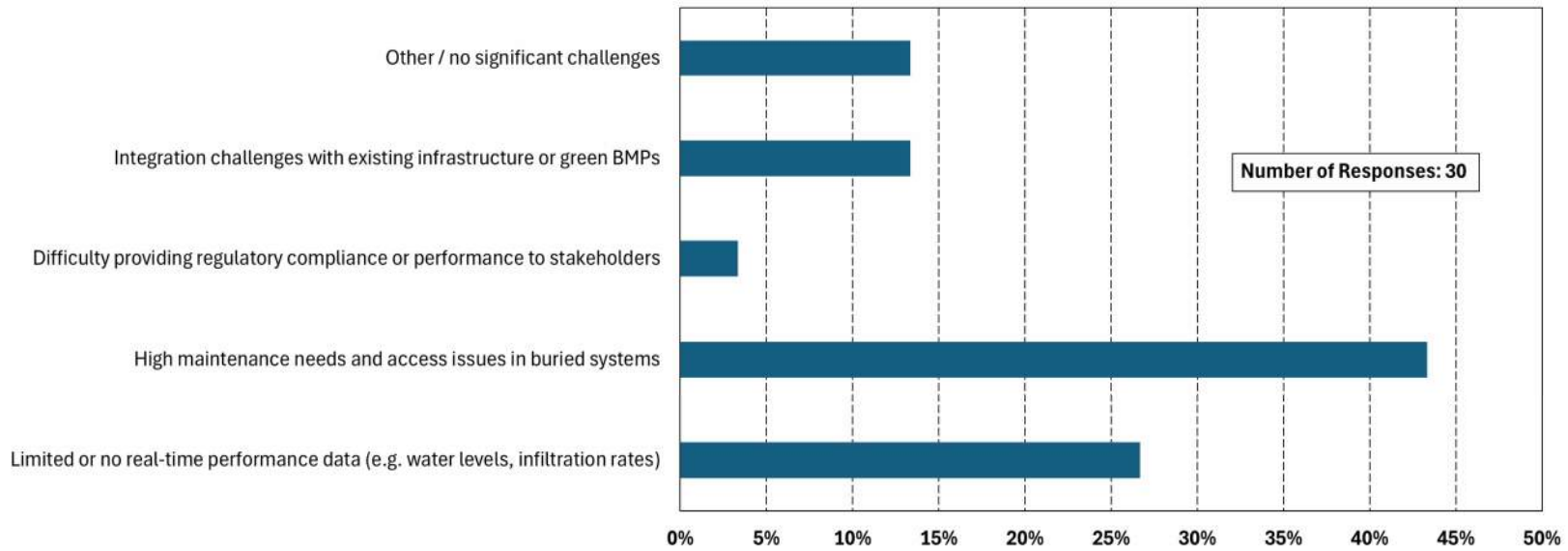


P4 INFRASTRUCTURE

**PLEASE Visit Booth 2
Enter the Trivia Contest through Whova**

Audience Poll - Results

What is your organization's primary challenge when managing below-ground detention and infiltration systems?



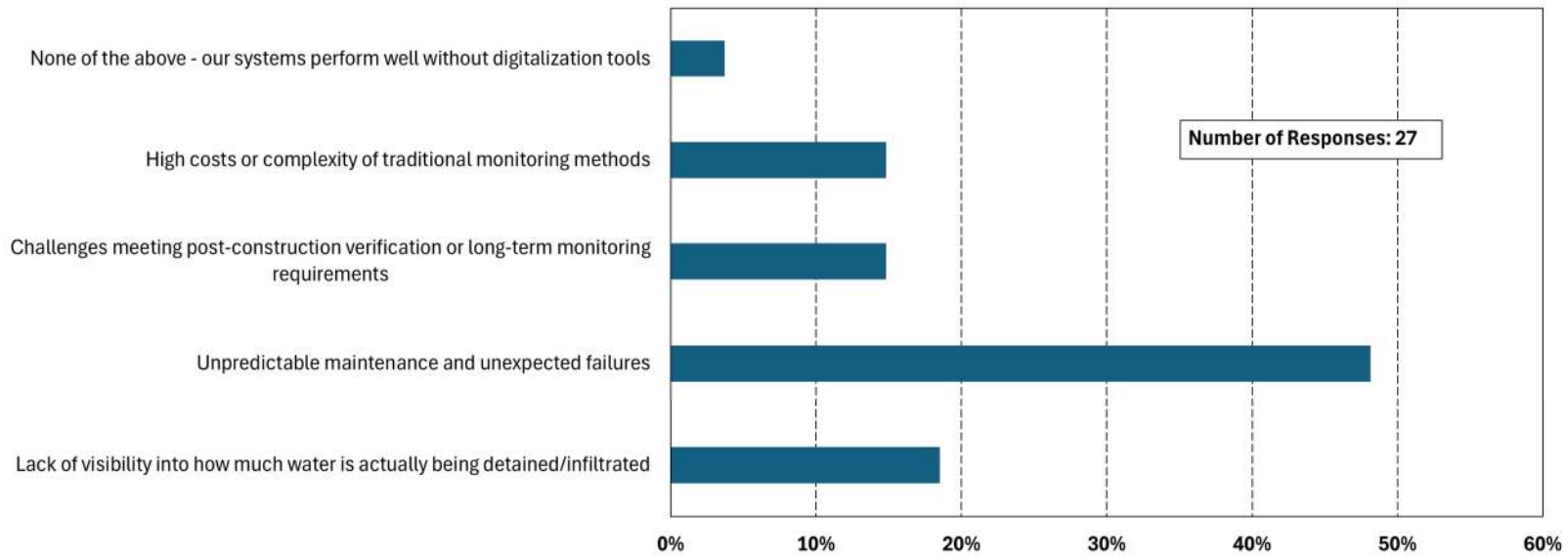
73% are challenged with limited real-time performance data, high maintenance need and access issues

13% perceive integration challenges with existing infrastructure and green BMPs

86% of respondents face challenges that P4 Infrastructure kits and services can help them overcome

Audience Poll - Results

What factor most raises questions regarding performance or reliability of your below-ground detention/infiltration systems?

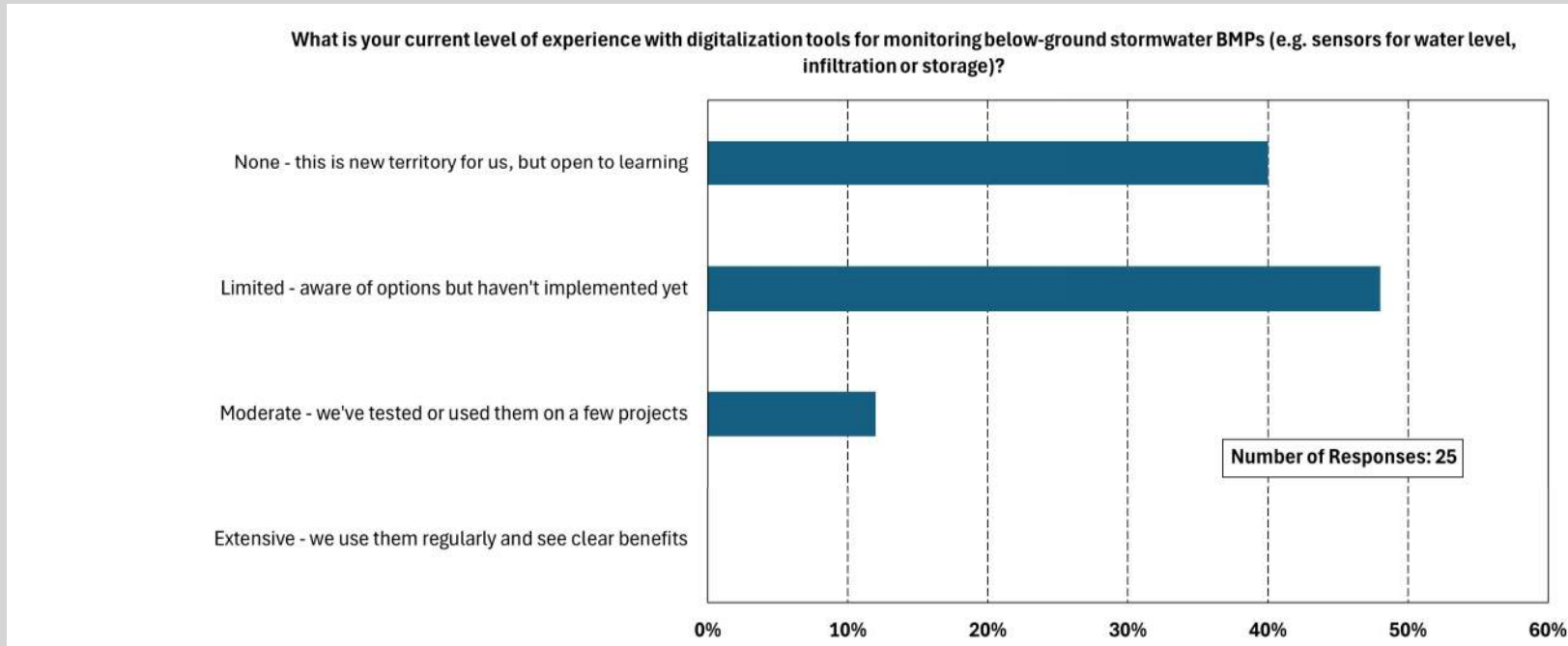


81% of respondents question how much stormwater is being detained/infiltrated, when maintenance and unexpected failures may occur, and meeting post-construction verification and/or long-term performance monitoring

15% of respondents are concerned with high costs and complexity of traditional monitoring methods

96% of respondents face questions that P4 Infrastructure kits and services can help them answer

Audience Poll - Results

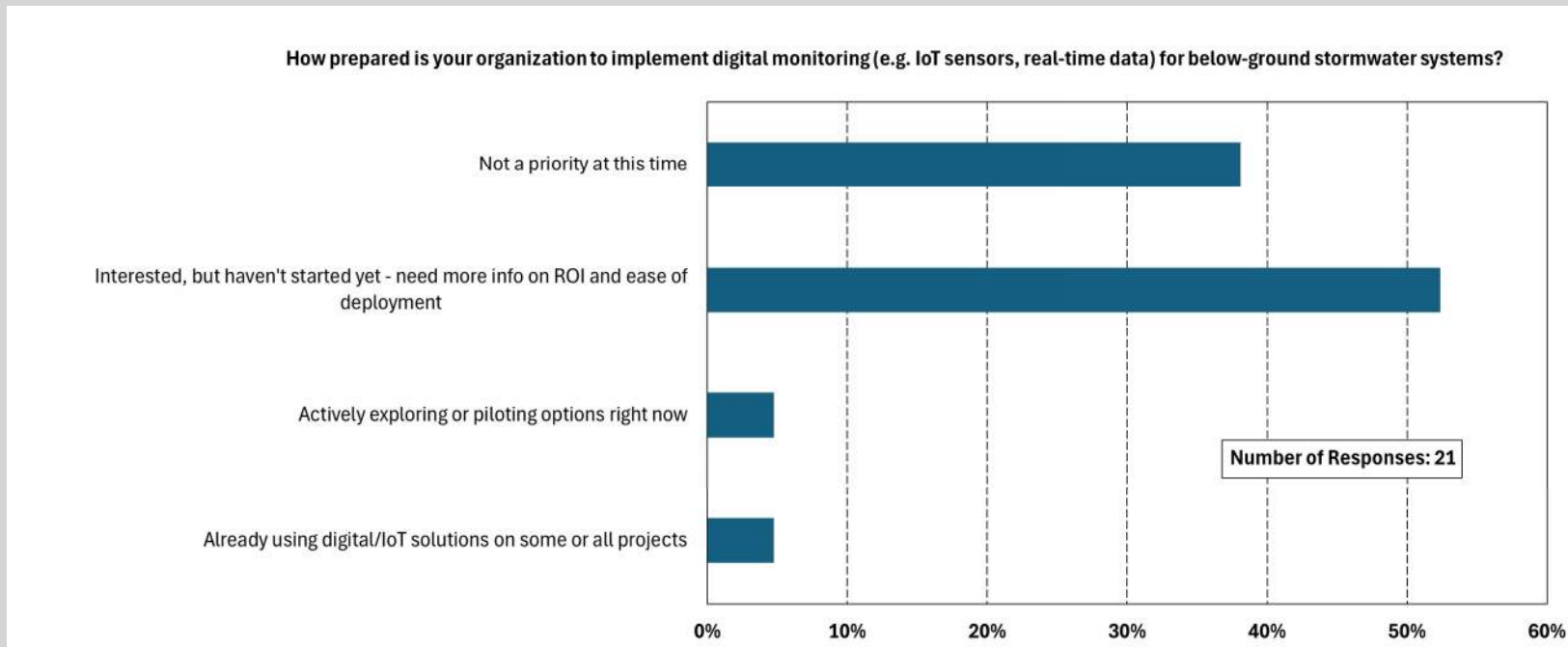


60% of respondents have limited to no experience with digitalization tools for stormwater infrastructure monitoring

12% of respondents have experience with IoT systems via test cases

P4 Infrastructure NEEDS to continue its educational efforts

Audience Poll - Results

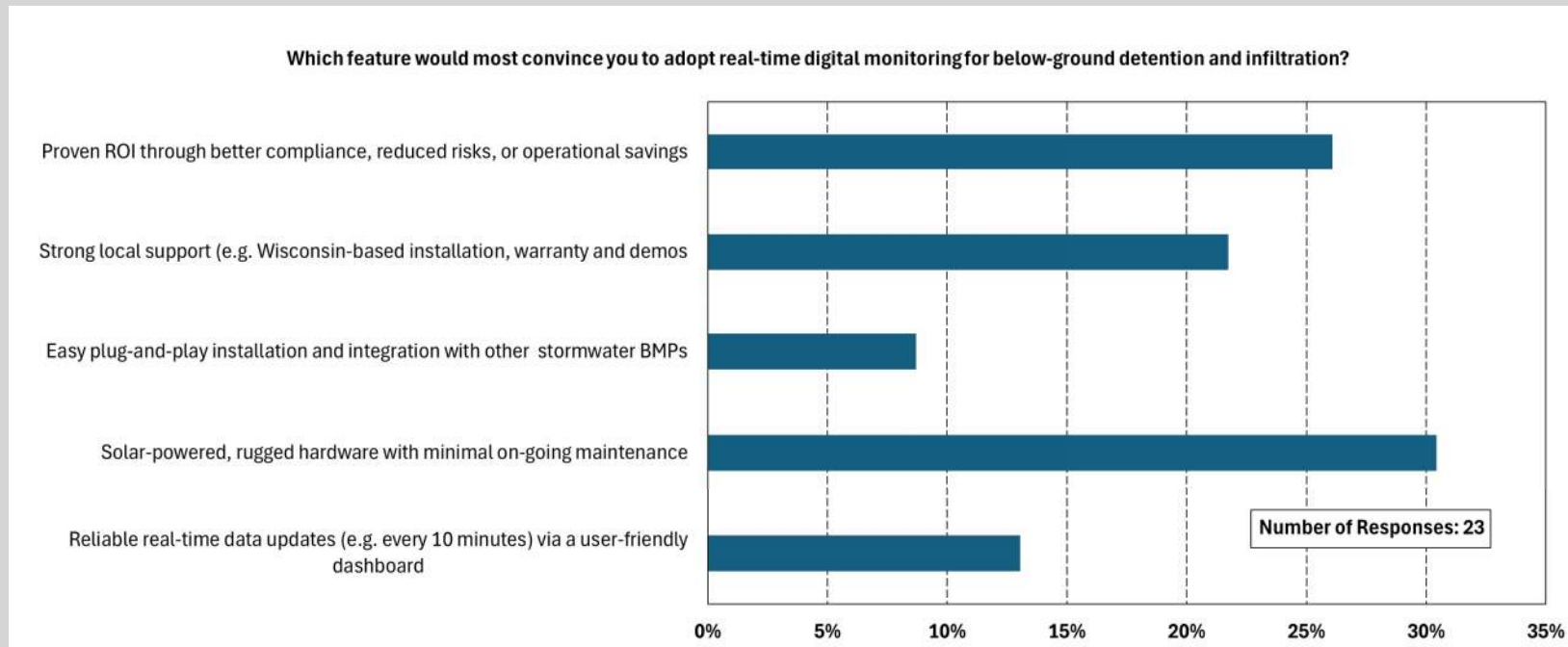


38% of respondents do not see digital monitoring as a priority currently.

62% of respondents are already using IoT digitalization solutions on some projects, are actively exploring applications, or are interested.

P4 Infrastructure **NEEDS** to continue its educational efforts and conduct greater outreach to define ROI for its kits.

Audience Poll - Results



74% of respondents see value in the foundations of the P4 digitalization kits.

26% of respondents would like to see proven ROI regarding better compliance, reduced risks, and/or operational savings.

P4 Infrastructure has products (kits) that meet market expectations.

P4 needs to work harder at expressing the value of its products with ROI consistent with market expectations.