Big Data/Data Analytics in Urban Sewershed Sensor Networks

Thursday, May 3, 2018

1:00-2:30 pm ET

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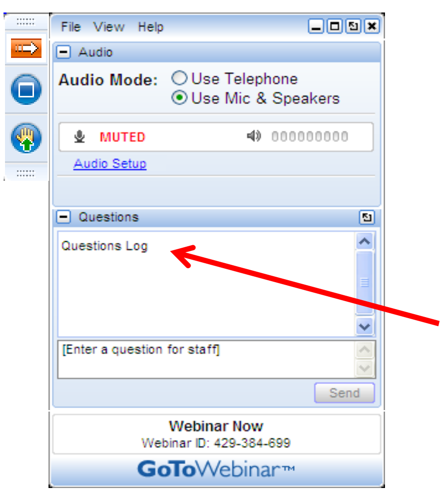
How to Participate Today



- **Audio Modes**
  - Listen using Mic & Speakers
  - Or, select “Use Telephone” and dial the conference (please remember long distance phone charges apply).
- **Submit your questions using the Questions pane.**
- **A recording will be available for replay shortly after this web seminar.**

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Today's Moderator

Walter Graf
Water Research Foundation

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Today's Speakers

Raja Kadiyala, Ph.D.
Vice President and Senior Technology Fellow
Global Director for Digital Solutions, Jacobs

Kenneth Thompson
Senior Technology Fellow Global Technology
Leader IoT and Smart Sensors, Jacobs

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Agenda

1:00 Welcome and Introductions

1:10 Opening Remarks
Walter Graf, Water Research Foundation

1:20 Leveraging Other Industries - Big Data Management
Raja Kadiyala, Jacobs

1:50 Designing Sensor Networks and Locations on an Urban Sewershed Scale
Kenneth Thompson, Jacobs

2:20 Questions and Answers

2:30 Adjourn

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Leveraging Other Industries - Big Data Management

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SWAN THE SMART WATER NETWORKS FORUM

R2T

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Overall project goal

Determine the current capabilities and state of knowledge of **IoT** and **Big Data** processing within the water industry and certain non-water sectors

Task goals

- Task 1 – Survey Water and Wastewater Utilities
  - Determine the current state of the use of BD/IoT
- Task 2 – Survey Water Industry Organizations and IT Research Firms
  - Identify use of BD/IoT in water/wastewater sector vs other industries
- Task 3 – Survey Large Firms in Non-Water Sector
  - Provide a non-water sector comparison to the data gathered in Task 1
- Task 4 – Determine Trends and Future Technology Paths
  - Identify trends for BD/IoT across three development horizons

BD/IoT – Big Data analytics and IoT

Definitions

- IoT: The network of physical objects that contain embedded technology to communicate and interact with their internal states or the external environment (Gartner)
- Big Data: defined by four characteristics (NIST):
  - Volume – size of the dataset
  - Variety – data is from multiple sources
  - Velocity – rate of flow of the data
  - Variability – changes in other characteristics

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Task 1 - Survey Results

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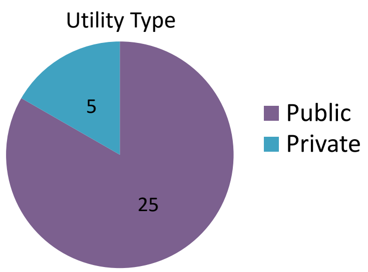
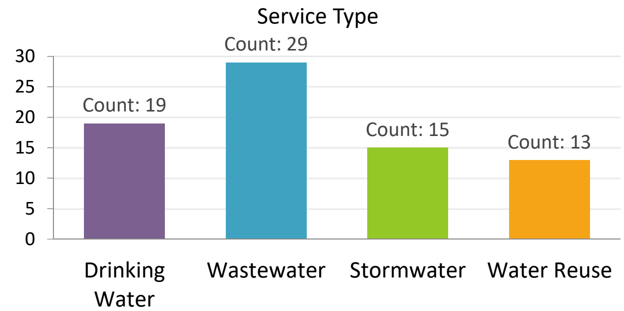
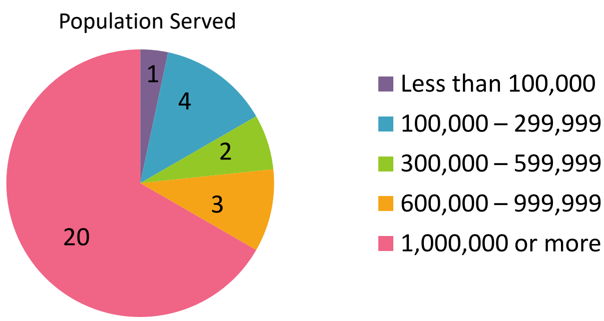
Demographics



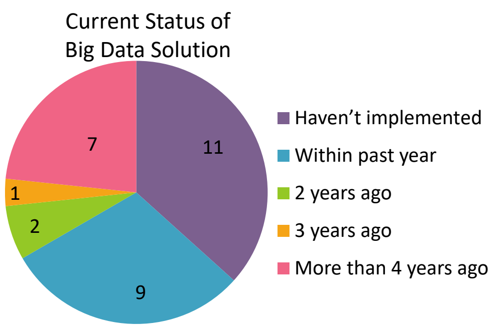


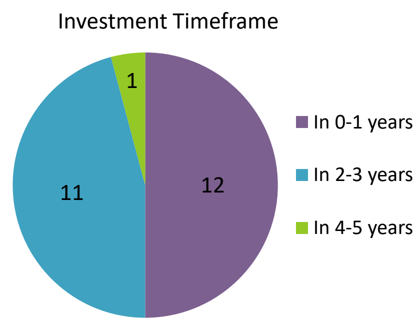


Types of Challenges

	Low	Med	High
	Count	Count	Count
Aging of utility infrastructure	0	6	24
Managing capital costs	2	12	16
Managing operational costs	3	10	17
Justifying improvements/rate requirements	3	11	16
Resilience/Reliability	5	9	15
IT infrastructure (servers, network, storage)	5	12	13
Data management (databases, visualization and analysis tools)	7	6	17
Industrial control systems (SCADA, PLCs, DCS)	6	11	13
Aging workforce	3	5	22
Treatment technology	12	11	7

Big data status and investment timeframe





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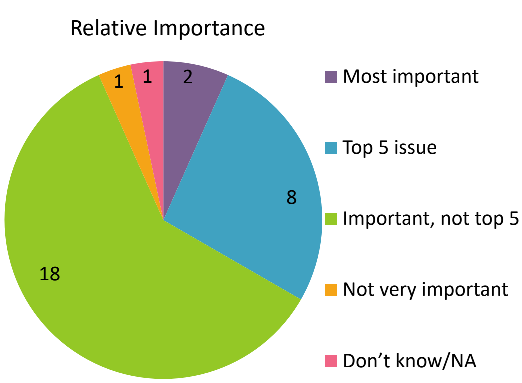
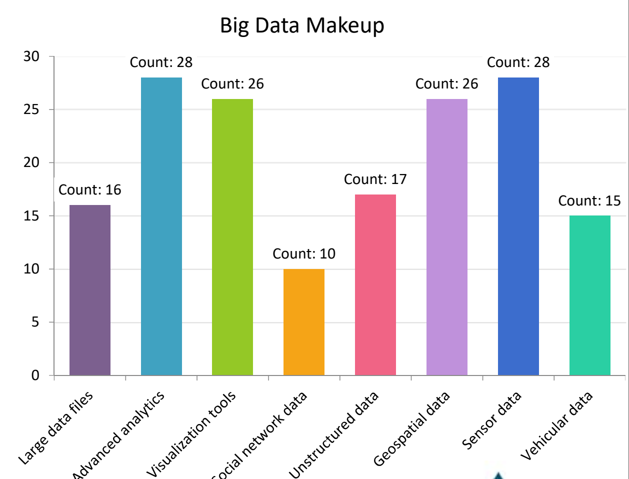
Importance and components





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Importance of system

	Low	Med	High
	Count	Count	Count
Advanced metering infrastructure (AMI)	14	3	12
Customer information system (CIS)	9	0	20
Computerized maintenance management systems (CMMS)	2	1	27
Laboratory information management systems (LIMS)	2	2	26
Supervisory control and data acquisition (SCADA) system	0	0	30
Enterprise asset management system	5	4	21
Surveillance and Reponses System (SRS)	14	7	8

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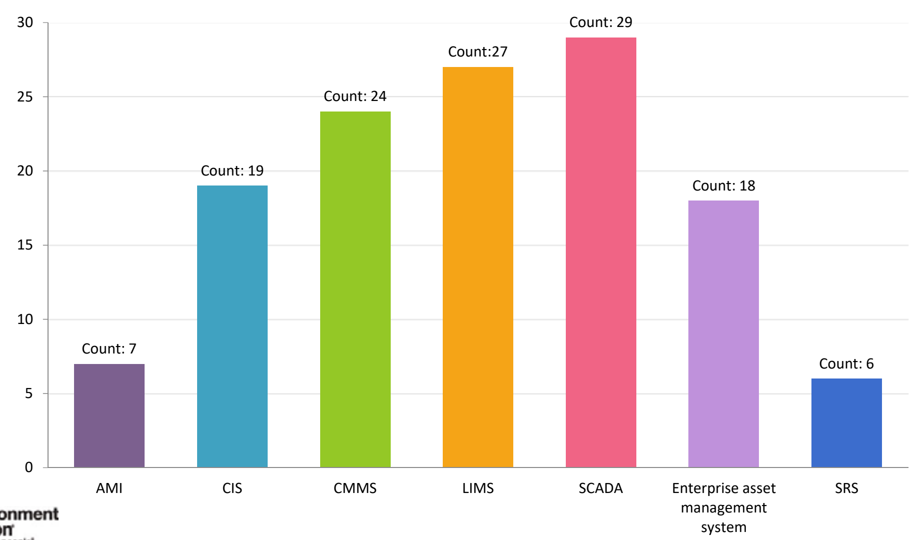
Systems used on a daily basis



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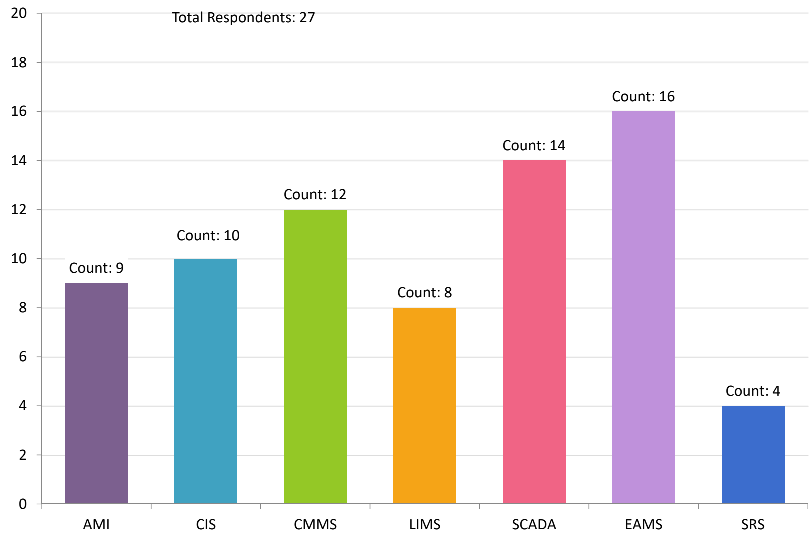
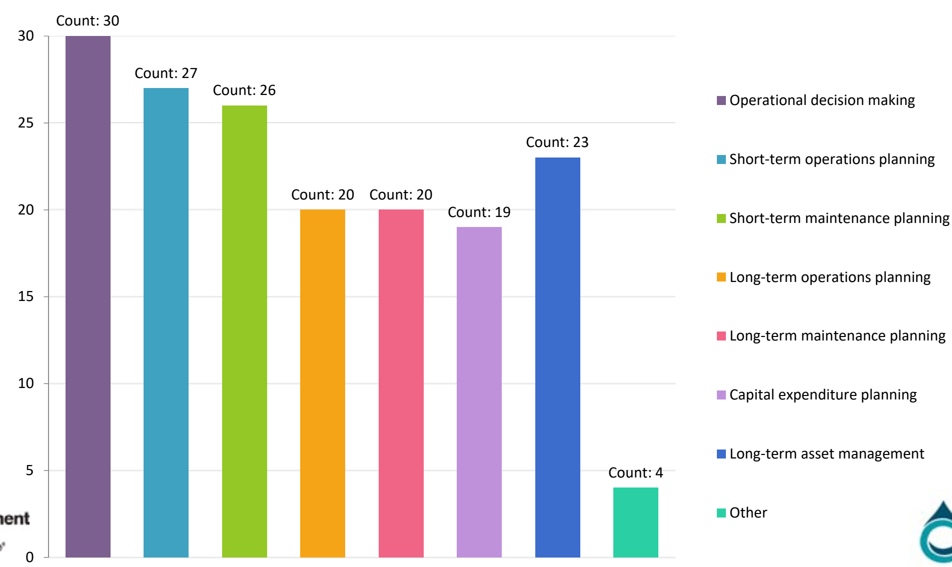
Systems most likely to implement, upgrade or extend



Use of system



Expected benefits

	Low	Med	High
	Count	Count	Count
Optimal operation of treatment plants and networks,	3	2	25
Predict system and equipment failure	1	5	24
Accelerate the speed with which new capabilities and service are deployed	5	10	15
Decrease expenses through operational cost efficiencies	1	5	24
Mitigate knowledge loss from aging workforce	1	9	20
Improve workforce management	2	4	24
Extract greater value from existing analytical tools	3	5	22
Reduce non-revenue water to minimize water and revenue losses	12	3	14
Reduce pollution events	8	9	13

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Skill availability within utility

	Low	Med	High
	Count	Count	Count
Management (storage, indexing and retrieval) of Big Data	5	10	15
Off-line analysis of Big Data	13	8	9
Real-time analysis of Big Data	16	10	4
Maintenance of systems to manage and analyze Big Data	8	11	11

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Big Data's impact over next five years

	Low	Med	High
	Count	Count	Count
Impacting customer relationships	5	6	19
Changing the way we organize operations	4	3	23
Making the business more-data-focused	3	4	23

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Impediments on adoption

	Low	Med	High
	Count	Count	Count
Data security	5	8	17
Data quality	0	8	22
Lack of budget	7	12	11
Lack of talent to implement big data	5	8	17
Lack of talent to run big data processing and analytics on an ongoing basis	5	4	21
Resistance to integrate existing systems	6	12	12
Procurement limitations on big data vendors	15	12	3
Lack of middle management adoption and understanding	5	15	10
Lack of data governance policies and practices	7	14	9

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Task 2 – What can the Water Industry Learn from Other Industries?

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Analytics Overview

Basic Analytics	
Performance Management	
Advanced Analytics	
Complex Event Processing	Natural Language Processing
Multivariate Statistical Analysis	Text Mining
Time-series Analysis	Entity Extraction
Deep Learning and Machine Learning	Sentiment Analysis
Predictive Modeling	Semantic Analysis
Ensemble Modeling	Behavioral Analytics
Constraint-based Optimization	Social Network Analysis
	Social Media Analytics

- ← What happened in the past?
- ← What is happening at this moment?
- ← What will happen?
- ← What is most likely to happen?
- ← What might happen if we give it a little nudge?

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Why Use Big Data in the Water Industry?

- Traditional analytics can be used for some applications.
- Big Data analytics will extend existing solutions and enable them to be far more effective by utilizing larger quantities of data
  - Data from thousands of sensors reporting multiple times a minute
  - Data from non-traditional sources such as social media platforms
  - Algorithms to predict future events such as predictive maintenance

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Interim Findings

- Lessons learned from other industries can be applied to the water industry.
- Key fundamentals, foundations, and processes can be leveraged.
- The need for data quality is common among industries.
- Utilize the best quality data from reliable sources to create information and knowledge.
- The basis for the approaches are similar: build small solutions in an experimental manner before transitioning to production.

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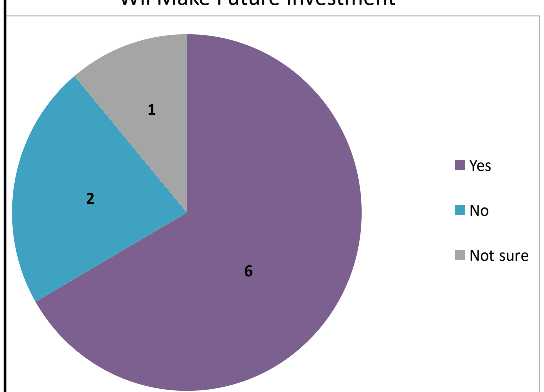
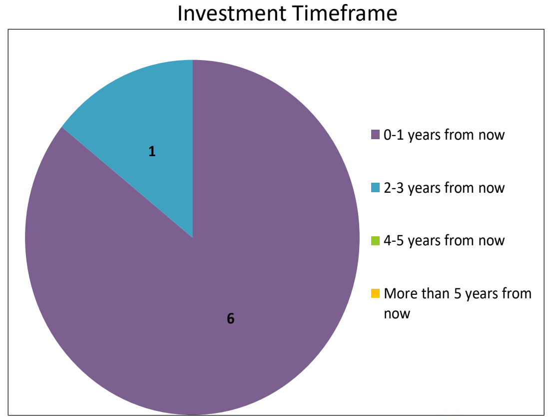
Task 3 – Non-water sector survey

Future investment and timeline

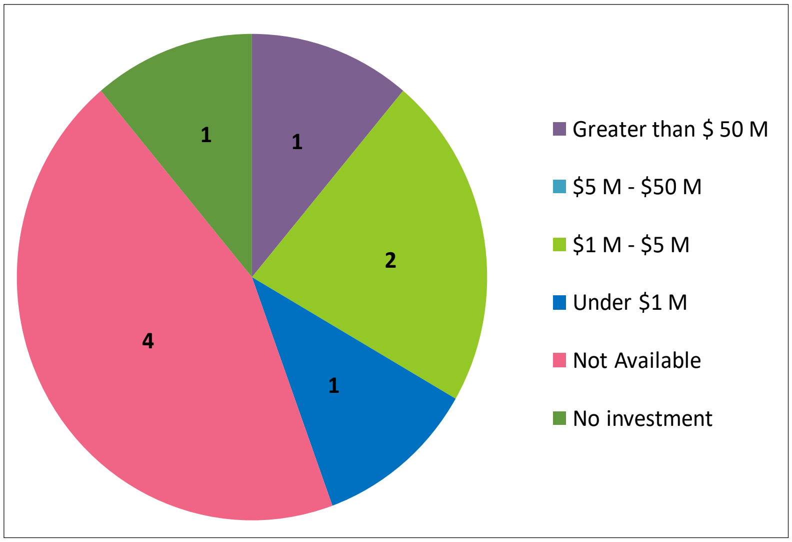
Wil Make Future Investment



Investment Timeframe



Investment level



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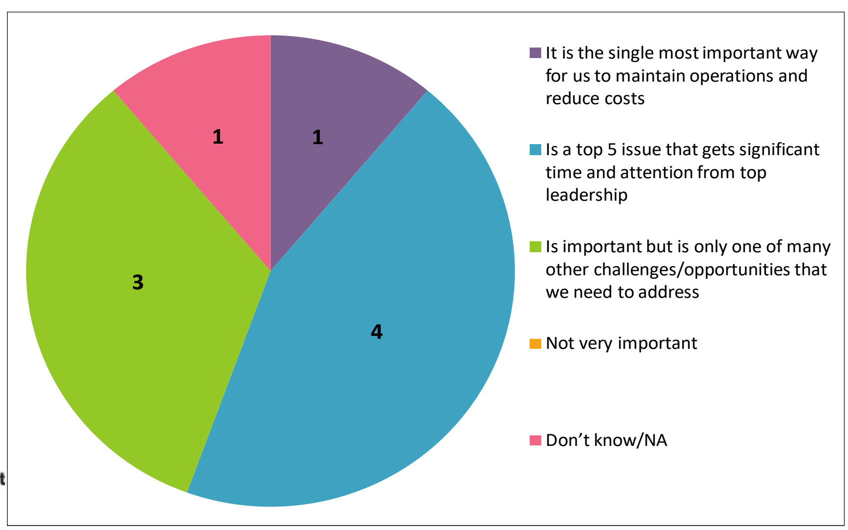
Importance



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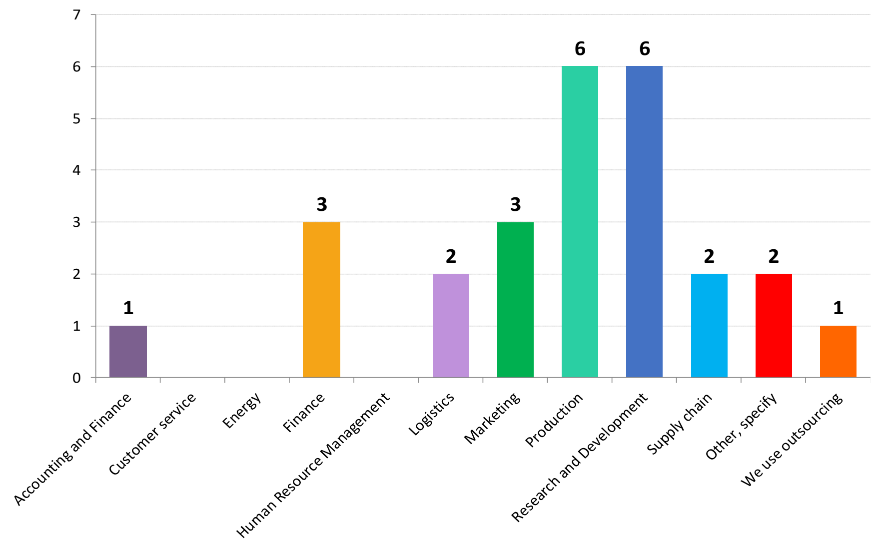
Adoption by department



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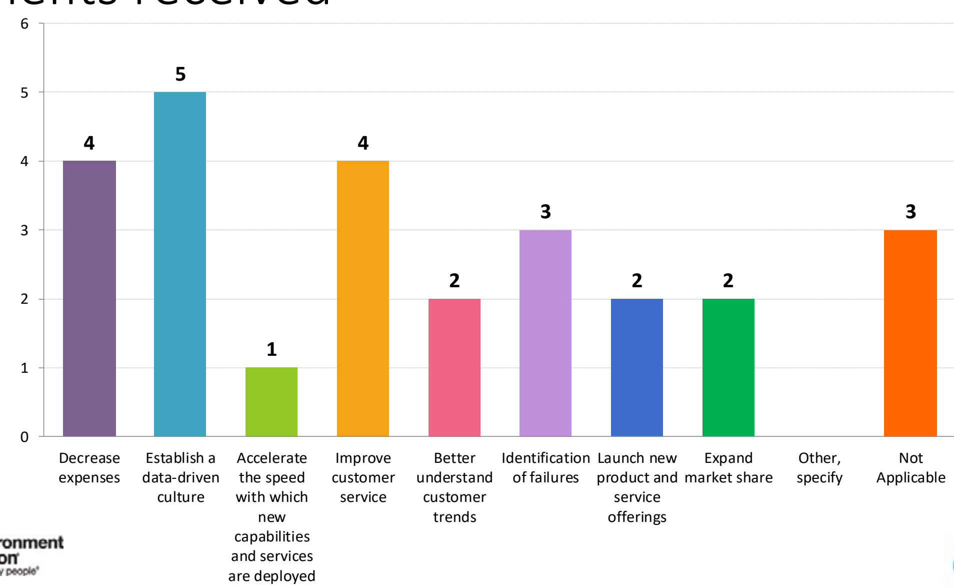
Benefits received



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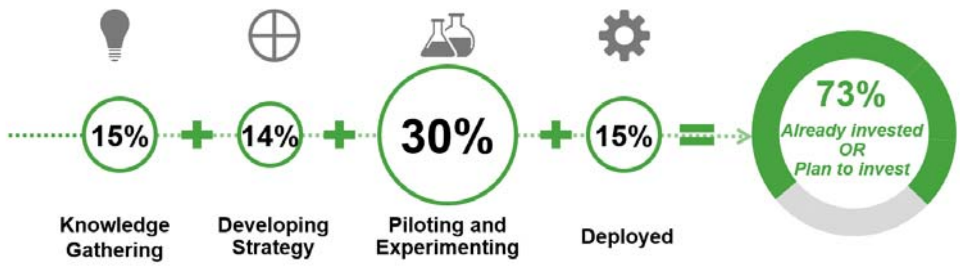
Non-water: Deployment Stage



Source: Gartner

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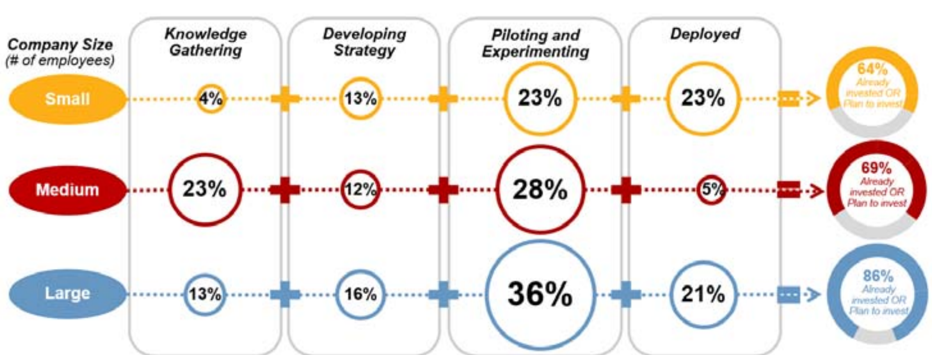
Non-water: Stage by company size



Source: Gartner

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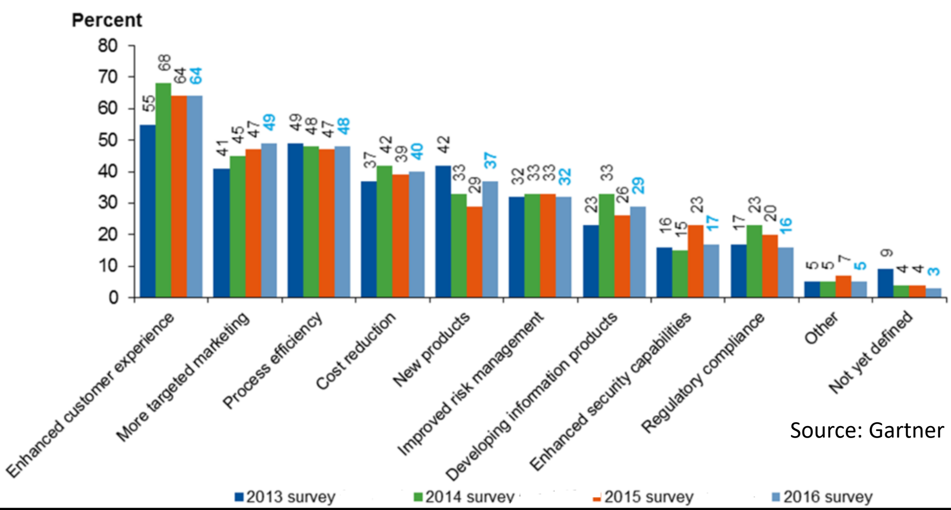
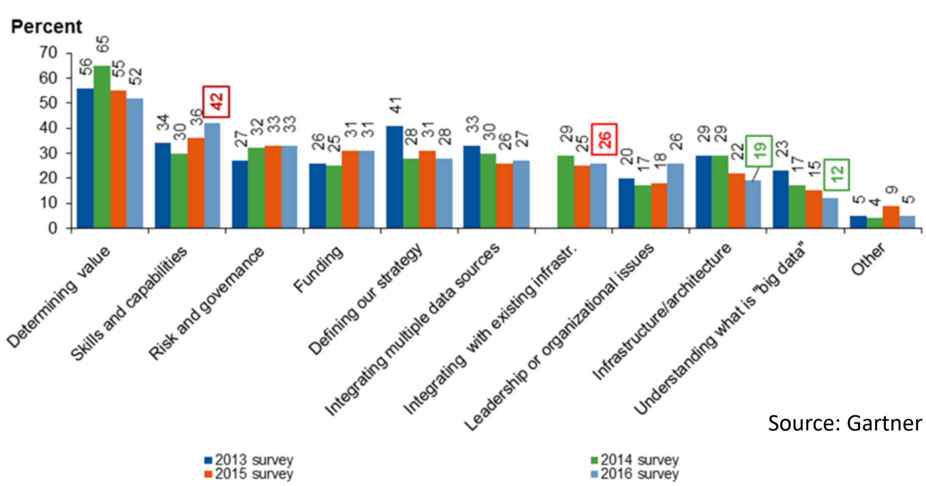
Non-Water: Benefit



Source: Gartner

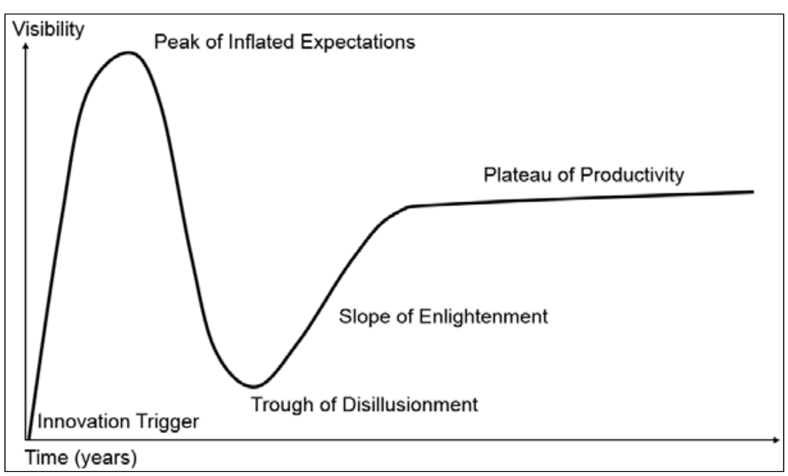
Non-water: challenges



Source: Gartner

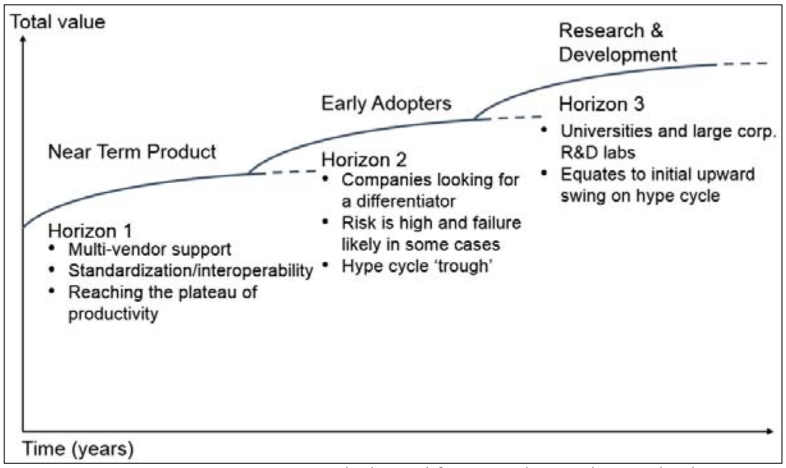
Task 4 – Future Trends

Technology hype cycle



(Adapted from Gartner, 2018)

Three horizon view



(Adapted from Baghai, Coley, and White, 1999)

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Trends

- Horizon 1: Near-term products of interest include 5G cellular networking, automated machine learning, and Apache Spark
- Horizon 2: Technologies in the early adoption phase include deep learning and machine learning for cybersecurity
- Horizon 3: Technologies in the research and development phase include generative adversarial networks and quantum computing

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Interim Findings

- Generally, the water/wastewater industry hasn't embraced Big Data analytics and IoT as rapidly as other industries.
- There is still a 'wait and see' element within the water sector that is impacting adoption. This will ease as more lighthouse examples are implemented.
- While utilities are collecting a fair amount of data, data quality is an issue that hampers utilization of the data.
- Solutions are available to support various individual applications.
- Future technologies are becoming available that will ease implementation of analytics.

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Designing Sensor Networks and Locations on an Urban Sewershed Scale

THE SMART WATER NETWORKS FORUM

Project goals

- Identify available sensor technologies being used (Survey)
- Identify use cases and IoT strategies for improving operations and management of urban sewersheds
- Host an industry stakeholder workshop
- Create potential use cases (based on SENG6R16 and SENG7R16) to be demonstrated in Phase II

Project milestones

Milestones
Milestone 1 – Industry survey compilation of results
Milestone 2 – Expert workshop summary
Milestone 3 – Summary of available sensor technologies
Milestone 4 – Summary of use cases identified
Milestone 5 – Deliver Final Report

Survey Results

Survey Participants

- **20** Utilities:
  - 16 from US (representing 9 states), 2 from Europe, 1 South America, 1 South-East Asia
  - 30 questions in the survey
- **20** Technology Providers:
  - 27 questions in the survey

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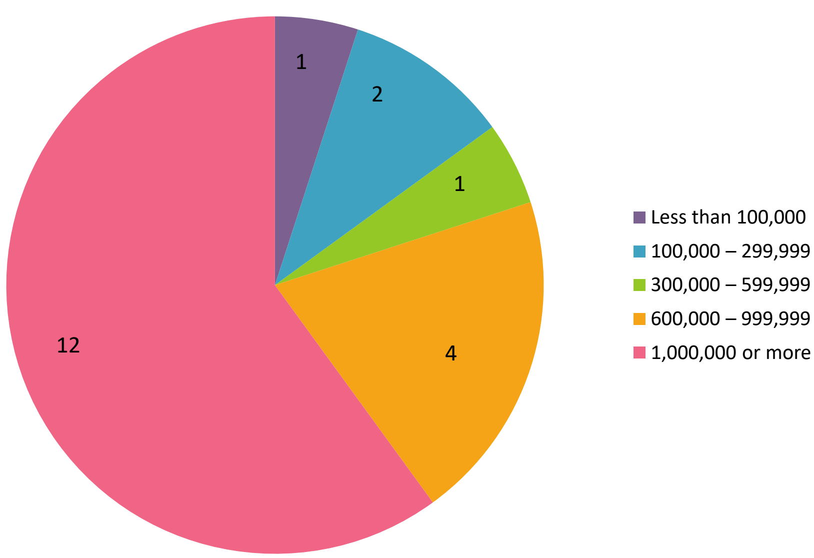
What population does your utility serve?



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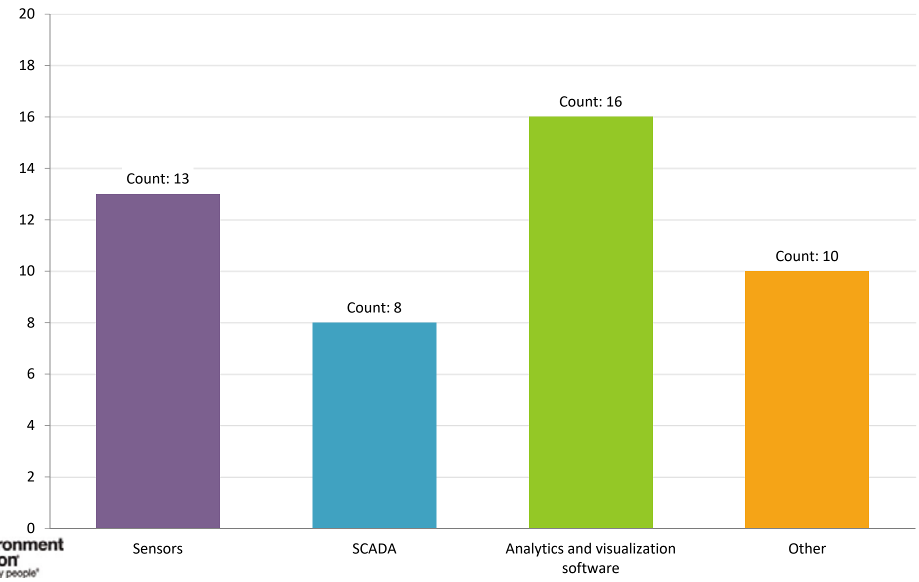
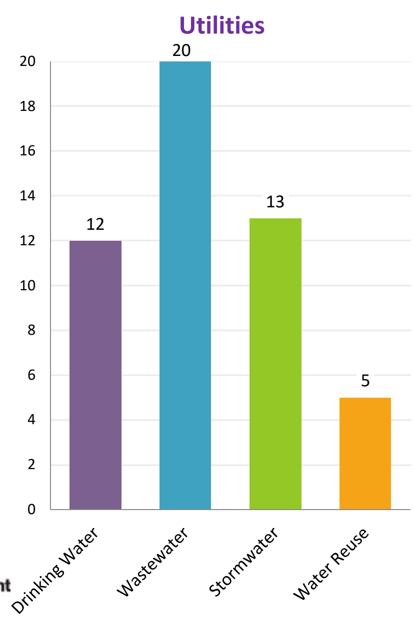
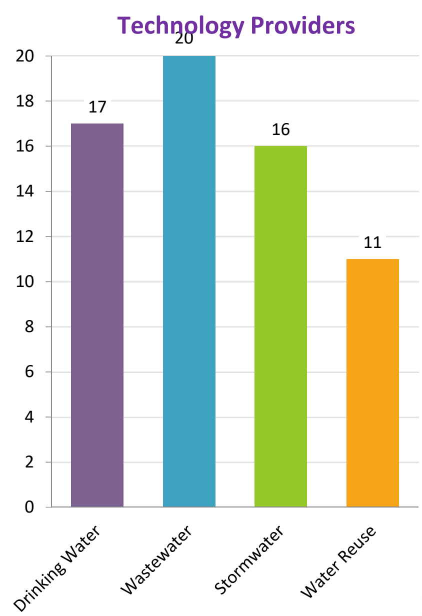
What technologies does your organization supply to water and wastewater utilities? Please select all that apply.

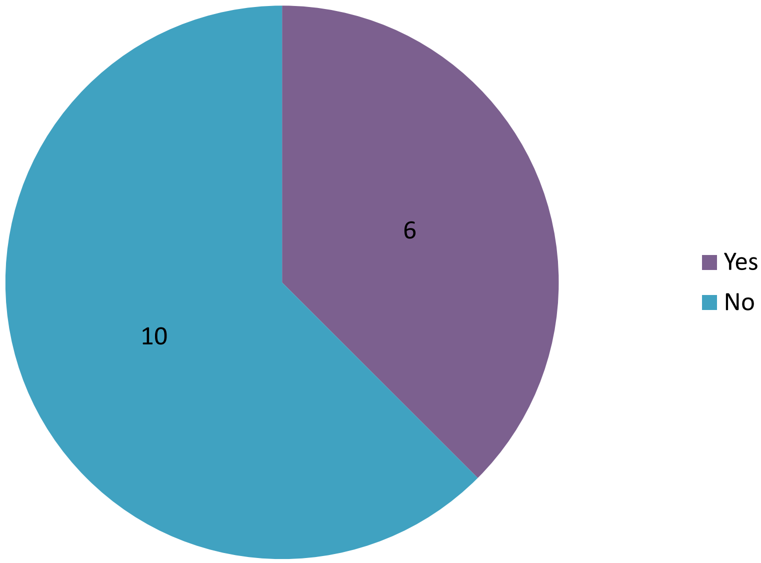


What types of facilities does your utility currently manage?





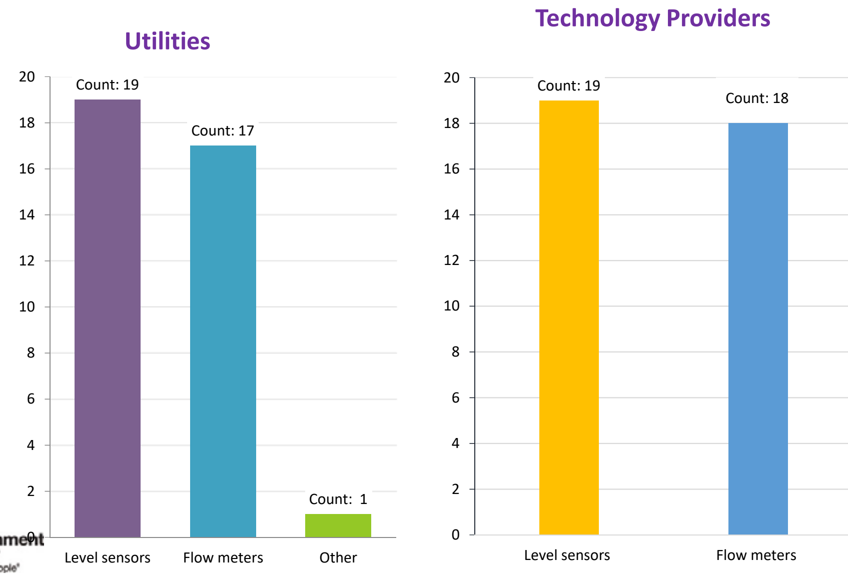
FOR U.S. UTILITIES: Are you currently under a regulatory agreement such as a Consent Decree or Stipulated Order?



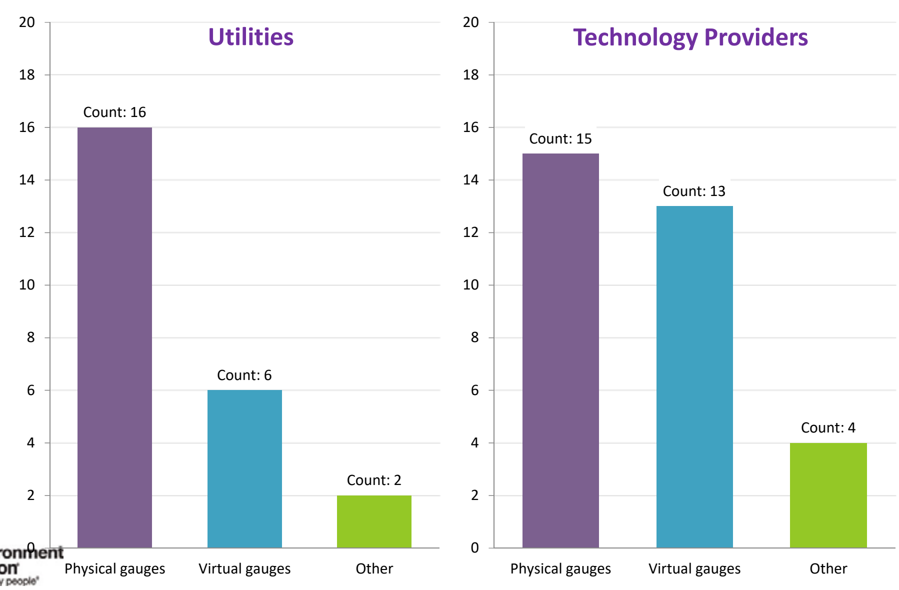
What are your utility's main sewershed network challenges/services? (Adjusted to a 1-3 rating)

	Utilities			Technology Providers		
	1	**2**	**3**	**1**	**2**	**3**
Compliance monitoring (regulation)	10	4	6	3	3	14
Capacity issues (inflow and infiltration)	3	4	13	1	2	17
Pump (lift) station upgrades/improvements	1	10	9	1	9	10
Inter-agency conflict/communication	8	5	7	6	8	6
Combined Sewage Overflows (CSO's)	13	2	5	2	3	15
Sanitary Sewage Overflows (SSO's)	9	7	4	2	4	14
External flooding and pollution	7	7	6	0	8	12
Customer flooding	9	4	7	4	10	6
Asset management	1	10	9	1	5	14

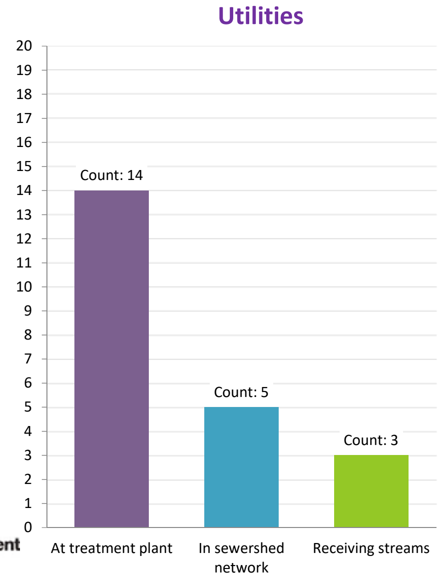
Which online sensors does your utility use to measure water levels or flow in the sewershed network(s)?

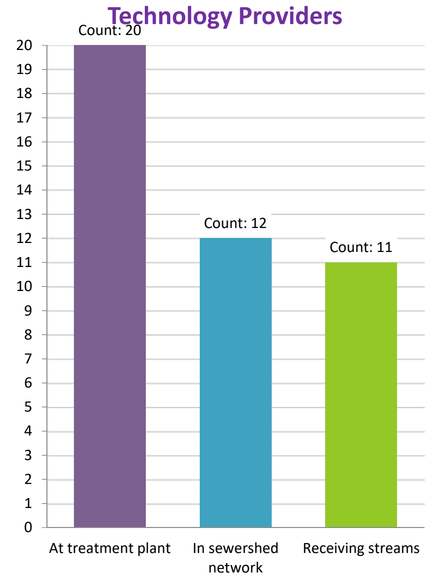


Which rain gauge sensors does your utility use to measure and transmit data about current sewershed weather conditions?

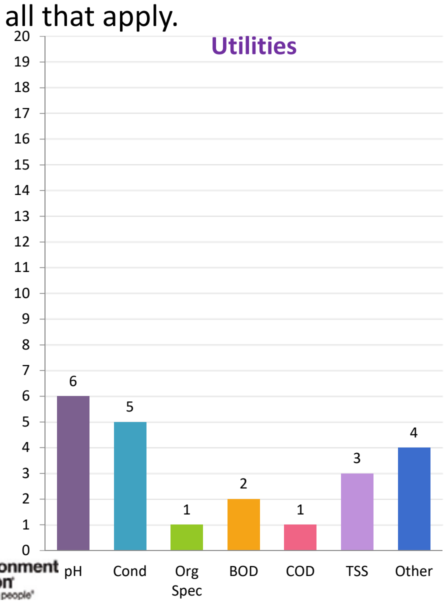


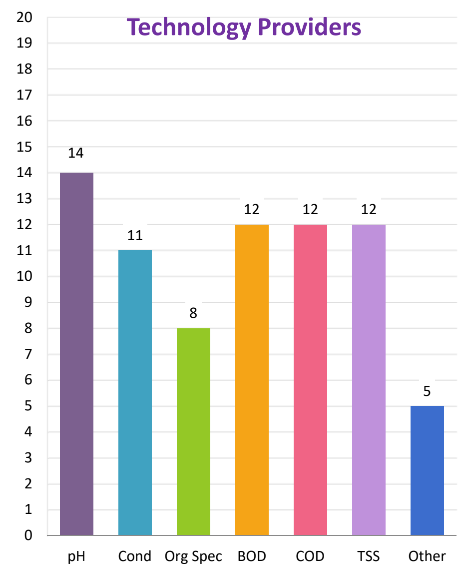
Does your utility use online sensors to measure water quality in the sewershed network(s)? Please select all that apply.



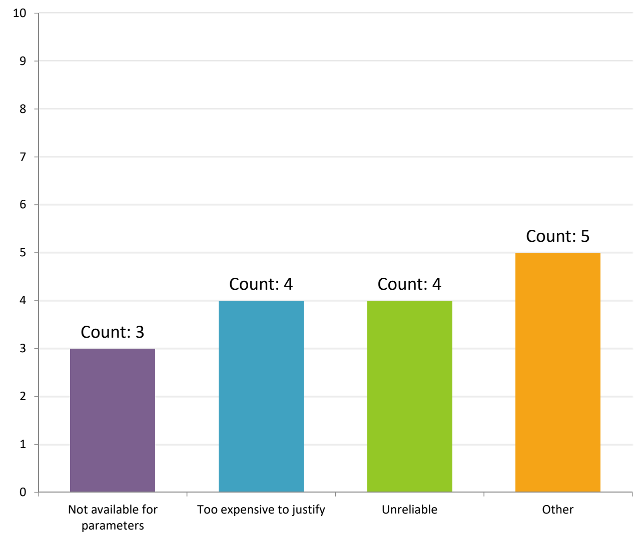


If your utility does use online sensors to measure water quality in the sewershed network, which parameters do you measure? Please select all that apply.





For the parameters that you would like to measure, but currently can't, why can't you measure them? Please select all that apply.



Total Respondents: 12

If your utility does not use any type of online sensors, what barriers do you see for implementing them? (Adjusted to a 1-3 rating)

	Utilities			Technology Providers		
	1	**2**	**3**	**1**	**2**	**3**
Unreliable data (False alarms)	5	3	4	9	6	3
Too expensive (acquisition)	4	4	5	3	3	11
Too expensive (O&M)	2	4	7	3	4	11
Lack of skilled personnel	5	6	2	4	8	6
Organizational barriers	8	3	2	5	5	8
Lack of a business case	4	2	7	7	6	5
Lack of suitable technology				9	2	6

If your utility does use any type of online sensors, what were the main driving forces (rationale) for adopting them? (Adjusted to a 1-3 rating)

	Utilities			Technology Providers		
	1	**2**	**3**	**1**	**2**	**3**
Research	5	6	3	12	3	3
Real-time Control	3	3	8	2	3	13
Regulation/Compliance Monitoring	2	2	9	1	3	14
Early Warning System (sewershed or influent)	0	4	10	0	3	16

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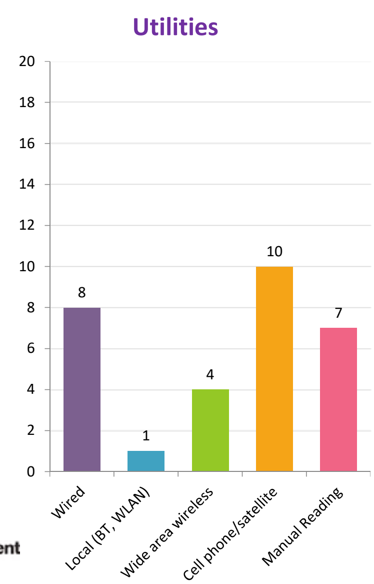
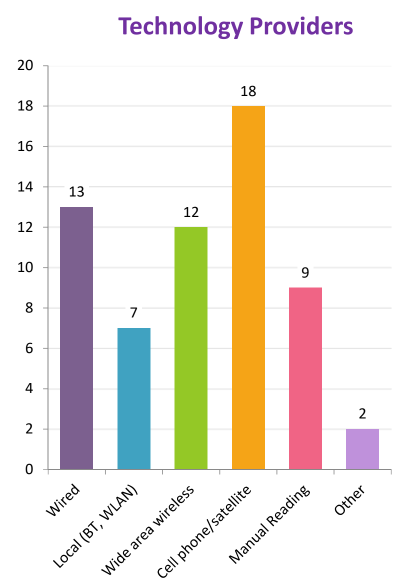
If your utility does use online sensors, what type of communications system do you use predominantly? Please select all that apply.





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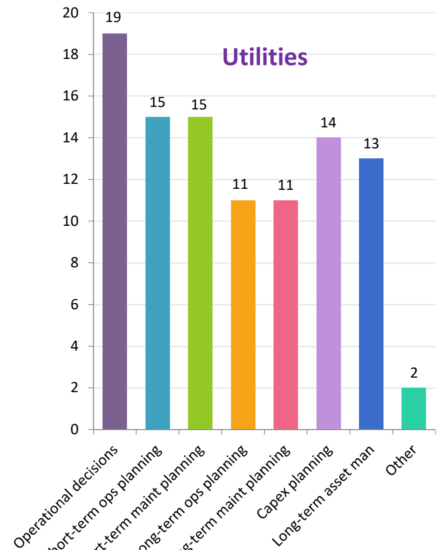
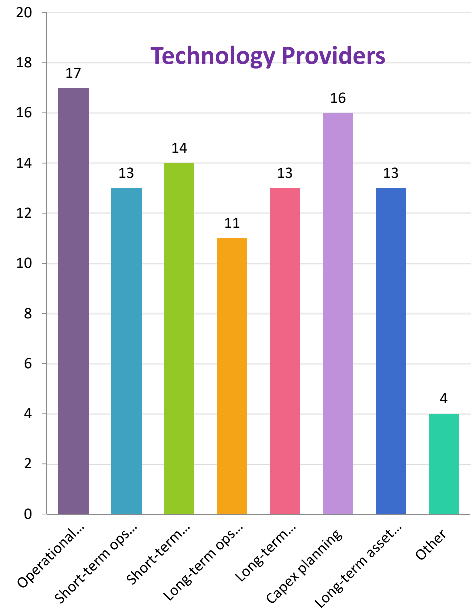
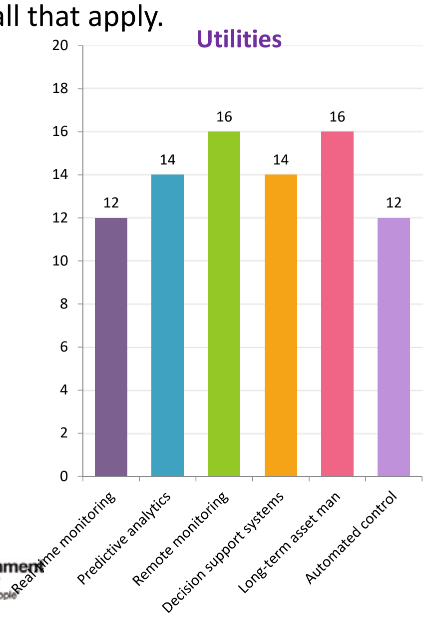
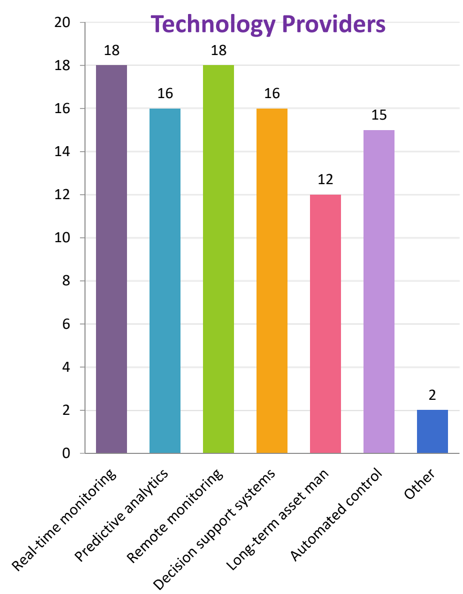
What does the information get used for? Please select all that apply.





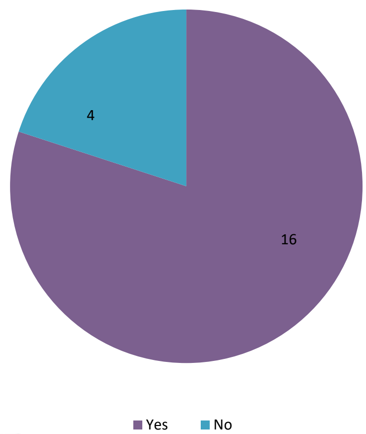
Does your utility have interest in using any of the following advanced, online sewershed network technologies or processes? Please select all that apply.



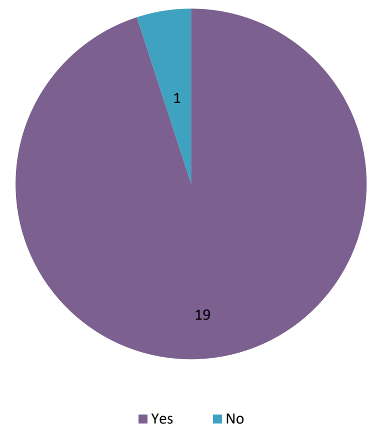


Does your utility have a supervisory, control and data acquisition system (SCADA) installed and monitoring a sewershed network?

Utilities



Technology Providers



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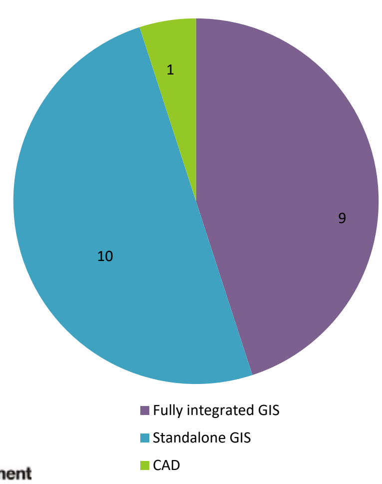
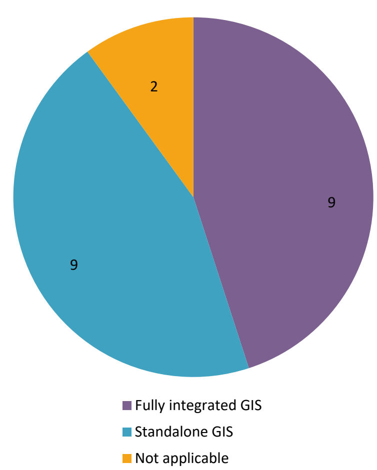
Does your utility currently have sewer system assets mapped in a Geographic Information System (GIS)? If so, what type?

Utilities



Technology Providers



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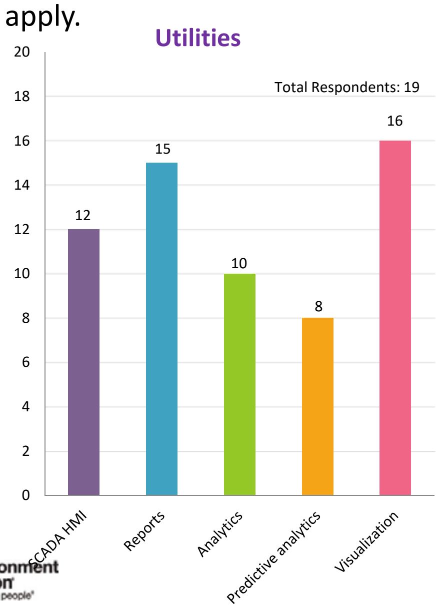
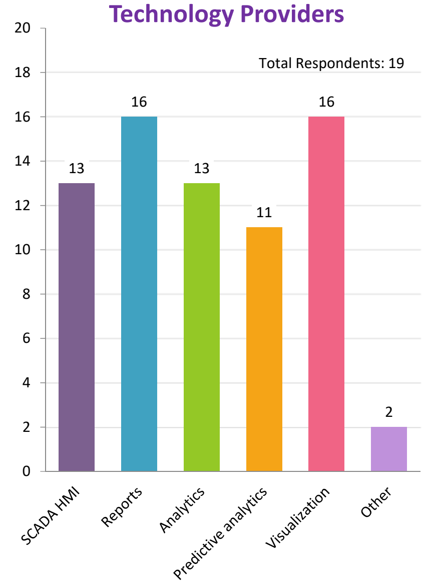
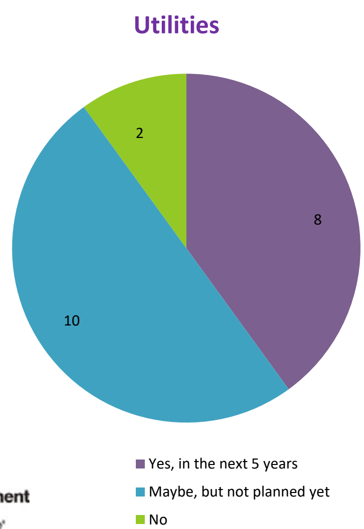
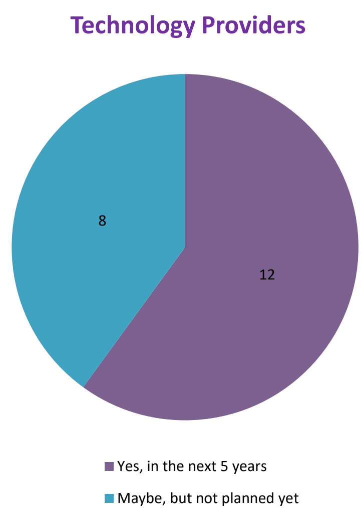
Does your utility use any of the following to analyze information from the different sewershed network data streams? Please select all that apply.



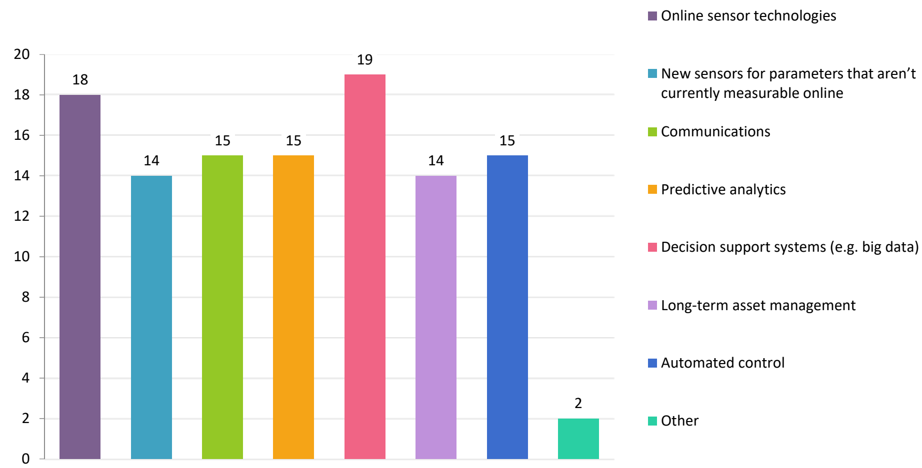


Does your utility intend to significantly increase your investments in advanced, online sewershed network management, as part of your long-term strategy?





As a supplier of technologies to water and wastewater utilities, where do you expect new products with new capabilities will be available in the next 5 years?



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Additional comments about what keeps you up at night:

Count	Response
1	Lack of risk management, lack of real-time information, lack of appropriate instrumentation and monitoring.

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Case Studies

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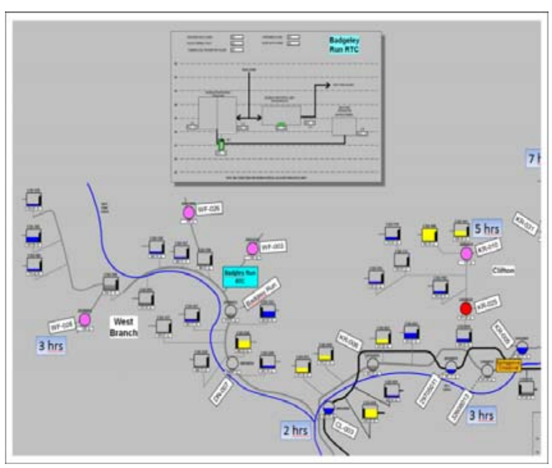
Metropolitan Sewer District of Greater Cincinnati (MSDGC)

- Contains more than 200 combined sewer overflow points (11 Billion Gallons overflow annually)
- 3.2 billion dollars US EPA Consent Decrees
- Today MSDGC has monitoring equipment installed at more than 650 locations throughout its entire collection system.
- The long-term goal of the system is to maximize the storage, conveyance and treatment capacity of the wastewater system during wet weather.
- While still early in its deployment, benefits of the system have already been demonstrated.
    - Improved maintenance of wet weather facilities and remote control of facilities for quicker response to extreme events.
    - Dedicated wet weather SCADA reduced overflows from the collection system an average of 400 million gallons per year, at a cost of $0.01/gallon. Traditional cost ranges between $0.40 to $1.00 per gallon

SEWERSHED INFORMATION

CUSTOMERS: 226,000
AREA: 290 square miles
GRAVITY: 641 miles
PRESSURIZED: 19 miles
SEWER TYPE: Combined



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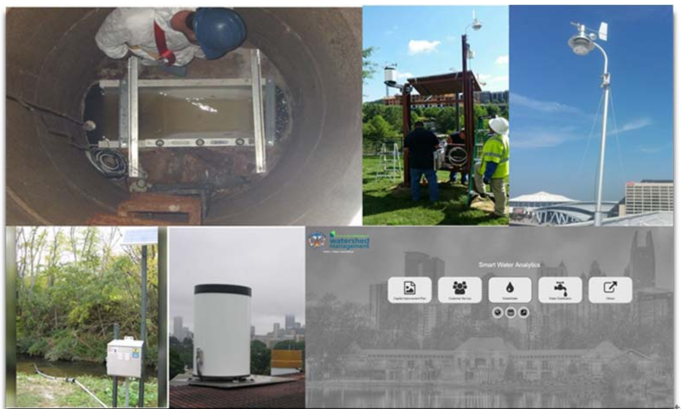
City of Atlanta Department of Watershed Management

- The utility is under a consent decree to reduce these overflows.
- The goals for the system include meeting consent degree requirements, hydraulic model calibration, and monitoring sanitary and combined sewer overflow optimization and effectiveness.
- Parameters being monitored: level, flow, velocity, temperature, rainfall gauges (city and USGS)
- Sensors have been placed at the exit of each sewershed and along the large outfalls and trunks for model calibrations and in sanitary pipes from adjacent cities and counties for billing purposes
- Benefits include:
  - Alert reporting for mobile viewer
  - Diversion of sewer spills and minimized volume of spills
  - Building a historical profile on a site

SEWERSHED INFORMATION

CUSTOMERS: 1.2 million
AREA: 132 square miles
GRAVITY: 641 miles (combined)
1575 miles (sanitary)
PRESSURIZED: 1 mile
SEWER TYPE: Combined and Sanitary



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Interim Findings

- Use of sensor technology in urban sewersheds is still in it's infancy
- Most technology solutions attempt to solve a single, isolated problem rather than consider the holistic sewershed system
- It is difficult to determine ROI for technology applications in the sewershed
- The parameters most typically monitored in the sewershed are flow and level
- The main challenges for the wastewater industry include capacity issues, aging infrastructure, and asset management
- Technology companies are leading the development of new sensors and analytic packages for the future

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Potential Use Cases for Phase II

- **Use Case No. 1:** Managing dry weather (SSO) and wet weather (CSO) overflows through data correlation and enhanced operational practices.
- **Use Case No. 2:** Developing video analytics for different types of pipeline materials to rapidly identify problems that lead to I&I.
- **Use Case No. 3:** Evaluating water quality to reduce the environmental impact of CSOs.
- **Use Case No. 4:** Monitoring for conditions that might cause pipe corrosion (e.c., H2S levels) and control chemical feed.
- **Use Case No. 5:** Energy Optimization for WWTPs
- **Use Case No. 6:** Water quality impacts on receiving waters during extreme weather events

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Upcoming RFP IWS-07-17

Release Early May 2018

Designing Sensor Networks and Locations on an Urban Sewershed Scale with Big Data Management and Analytics

Current Budget $350,000

IWS-17-07 Objectives

- Consolidate the results of the two Phase I projects (Leveraging Other Industries- Big Data Management (SENG7R16) and Designing Sensor Networks and Locations on an Urban Sewershed Scale (SENG6R16)) into a combined demonstration project.
- Conduct demonstration projects at multiple utilities to validate sensor-based, real-time monitoring/metering and models/decision support systems on sewershed/sub-sewershed scales, including the applying of analytics to solve sewershed network management issues.
- Develop a framework for the development of sensor-based networks that incorporates new and emerging monitoring/metering technologies for real-time decision making.

Suggested Approach

- Develop monitoring/metering regime at demonstration sites, including determination of sensor locations based on in-place models/decision support system requirements.
- Assess the findings from sensor-based network demonstrations, and develop frameworks to guide sensor-based network development in the future, including the interface between the sensor-based network and in-place models/decision support systems.
- Apply analytics to network datasets to address sewershed management issues, may apply to drinking water management (can include inside the fence applications) and identify next steps in improved system control.
- Develop guidelines to establish sensor-based, sewershed water quality and quantity monitoring networks and water quality and quantity monitoring/metering and data evaluation and characterization.
- Develop and evaluate a toolkit for the industry for taking data to information, knowledge and wisdom, which will include best practices for data analytic and visualization tools.
- Beta test the toolkit with a major utility partner and 2-3 leading utilities.
- Prepare final report.

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Additional Information

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Phone (571) 384-2102
wgraf@waterrf.org

Expressions of interest to participate:
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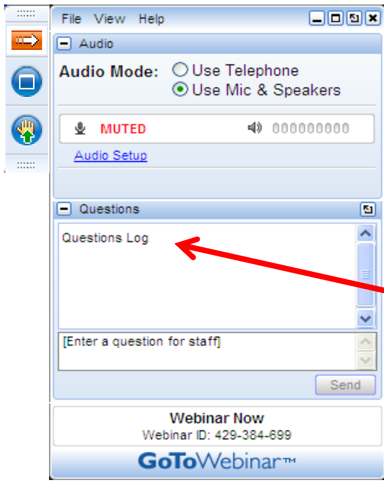
Questions for Our Speakers?



- **Submit your questions using the Questions Pane.**

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Thank You

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