LOW COST WATER QUALITY MONITORING NATIONAL SURVEY



LOW COST WATER QUALITY MONITORING NATIONAL SURVEY

Background

- 2015: Pisces Foundation & Intel Corporation project leaders agree to sponsor a survey of selected groups doing water resource monitoring to better understand gaps between their current and desired:
 - ✓ Water monitoring practices
 - ✓ Reporting
 - ✓ Information sharing technologies
- Goal was to empower citizens to protect their water through information gained or managed with the use of low-cost technologies
- National Steering Committee of non-profit, business, academic and government experts guided survey development & distribution



LOW COST WATER QUALITY MONITORING NATIONAL SURVEY

Survey Audience Profile

- Key Characteristics:
 - ✓ 130 respondents—all but 3 in U.S.
 - Very knowledgeable—50% monitoring program leads & 78% were either staff, volunteers, or had strong program knowledge



- ✓ Several respondents represented their regional/national staff network
- ✓ Geographically broad representation—42 states
- ✓ Mostly non-profits (72%) & govt. (16%) respondents
- ✓ 50% answered a *watershed* was their service area

LOW COST WATER QUALITY MONITORING NATIONAL SURVEY

Monitoring Program Profile

- Rivers and streams (89%) are monitored most, followed by a distant (32%) for stormwater or wastewater discharges. Yet, only a few monitored drinking water supplies (6%)
- Top 5 of 15 monitoring program objective areas were:
 - ✓ Create long term data sets (77%)
 - ✓ Education (75%)
 - ✓ Target problem areas (59%)
 - ✓ Report pollution incidents (51%)
 - ✓ Change community behavior (50%)
- Remaining program objective areas scored below 50%



LOW COST WATER QUALITY MONITORING NATIONAL SURVEY-- Monitoring Program Profile

- Top 4 of 8 program barriers
 - ✓ Funding amount (69%)
 - ✓ Funding stability (64%)
 - ✓ Staff time (58%)
 - ✓ Equipment (41%)
- Considering funding and people resources are the top two barriers, it is significant to note that
 equipment emerges as the third leading barrier.

30% monitor water volume,64% do not and 6% are unsure



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LOW COST WATER QUALITY MONITORING NATIONAL SURVEY-- Monitoring Program Profile

Data collection

 Of the 13 possible answers for data collection methods--3 are deployed by most organizations:

\checkmark	Field test kits	74% (59)
\checkmark	Grab samples & lab analysis	69% (55)
\checkmark	Multi-parameter meters/sensors	49% (39)

 Notably, only a few organizations make use of various types of monitoring stations or cell phone monitoring

grab samples and lab analysis	68.75%	55
prepared samples and lab analysis	23.75%	19
field test kits	73.75%	59
lab test kits	16.25%	13
single parameter electronic meters or sensors	28.75%	23
multi-parameter meters or sensors	48.75%	39
other	8.75%	7
custom assembled sensors	7.50%	6
unattended monitoring stations without telemetry	13.75%	11
unattended monitoring stations with telemetry	5.00%	4
long term fixed stations with flow controls without telemetry	1.25%	1
long term fixed stations with flow controls with telemetry	3.75%	3
cell phone reporting	13.75%	11

LOW COST WATER QUALITY MONITORING NATIONAL SURVEY-- Monitoring Program Profile

Data Sharing

- Data sharing is largely accomplished through:
 - ✓ Annual or periodic reports 61% (48) 58% (46)
 - **Community outreach** \checkmark
 - ✓ Online database
 - ✓ Online map with results
- Alternative water monitoring & information sharing technologies are principally:

56% (44)

42% (33)

- ✓ GIS mapping 74% (39)
- \checkmark Phone apps 38% (20)
- Data is shared with:
 - ✓ Govt. water quality, wildlife & natural resource agencies at federal, state, & local levels
 - ✓ General public, news agencies
 - \checkmark Stakeholders like farmers, watershed groups, families, board members, funders
 - ✓ Academic sectors including universities, schools, teachers, students







LOW COST WATER QUALITY MONITORING NATIONAL SURVEY -- Parameters



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LOW COST WATER QUALITY MONITORING NATIONAL SURVEY -- Parameters



LOW COST WATER QUALITY MONITORING NATIONAL SURVEY -- All Monitoring Parameters

- most use manual data collection methods, yet fewer prefer this approach
- Some are unsure what they prefer, while more want a fully automatic approach
- Differences become more apparent with some individual parameters



- fully automatic (continuous recording sensor) 23
- manual methods (e.g. test kit, grab sample) 296
- other (please specify) 14
- semi-automatic methods (e.g. meter, sensor) 117
- (blank) 6





- fully automatic (continuous recording sensor) 79
- manual methods (e.g. test kit, grab sample) 185
- not sure 25
- other (please specify) 9
- semi-automatic methods (e.g. meter, sensor) 119
- (blank) 39

LOW COST WATER QUALITY MONITORING NATIONAL SURVEY-- All Monitoring Parameters



- most are engaged with basic levels of precision
- More prefer to transition into advanced and expert precision levels

LOW COST WATER QUALITY MONITORING NATIONAL SURVEY -- Analysis: Data Collection & Precision

- DO #1 parameter collected
- The DO graph illustrates how their preferences shift, for example many respondents want to fully automate DO collection and shift toward expert & advanced levels of precision



Current Collection Approach Preferred Collection Approach Current Level of Precision Preferred Level of Precision 12

LOW COST WATER QUALITY MONITORING NATIONAL SURVEY -- Analysis: Data Collection & Precision

- Water temperature ranked #2: Many respondents want to fully automate data collection & several would move to advanced levels of precision
- Macroinvertebrates ranked #3: Data shifts are modest. Advances in automation & precision levels could be possible through regional collaboration on DNA
- Turbidity ranked #4: Respondents signal a clear need for both better data collection and precision levels with their turbidity monitoring



LOW COST WATER QUALITY MONITORING NATIONAL SURVEY -- Analysis: Data Collection & Precision

- Nitrate-NO3 ranked #6 and total phosphorus ranked #7: no clear trends for future collection & precision
- Yet, respondents say parameters that are most useful to monitor but can't now, are <u>nutrients e.g. nitrogen & phosphorus</u> in various forms, especially:
 - \checkmark in real time
 - $\checkmark\,$ with sensors and;
 - ✓ continuous monitoring
- Parameters ranked below total phosphorus were briefly examined. Note that E. coli & coliform bacteria are used as contamination indicators
- Nutrients & bacteria are among the top 5 parameters in need of lowcost monitoring improvement



LOW COST WATER QUALITY MONITORING NATIONAL SURVEY -- Equipment



LOW COST WATER QUALITY MONITORING NATIONAL SURVEY -- Equipment



Other examples of features needed:

- \checkmark simple intuitive interface and use
- ✓ be easy to calibrate and store
- ✓ user-friendly for volunteers
- ✓ small, and easy to carry in field

LOW COST WATER QUALITY MONITORING NATIONAL SURVEY -- Equipment

Most respondents had little knowledge of promising low cost equipment:

✓ No knowledge =74%

Price ranges of "low cost " equipment:

- ✓ Low range—75% of the respondents were clustered between 0-\$100
- ✓ High range great variability—a majority (57%) clustered between \$500-\$5,000

Equipment borrowing participation:

- 64% don't participate, 36% do. Examples why they do:
 - equipment is loaned to volunteers, schools, monitoring partners
 - ✓ equipment is borrowed from EPA, State organizations, nonprofit organizations



LOW COST WATER QUALITY MONITORING NATIONAL SURVEY -- Equipment

Equipment availability:

- 84% of respondents believe widespread availability of low cost equipment could affect major improvements in water quality
- Many factors limit progress towards better water quality. These themes emerged:
 - greater affordability, more group/individual participation possible
 - more data can be collected in more places to fill gaps in knowledge & needed action
 - ✓ better public awareness and engagement about the nature & scale of the problem
 - ✓ may help catalyze broader action



LOW COST WATER QUALITY MONITORING NATIONAL SURVEY -- Low-cost Data Access & Sharing Tech

Knowledge of beneficial low-cost data access & sharing technologies

- ✓ Low awareness—78% of respondents are unaware
- Examples mentioned: Stroud Research Center has described such devices; National Water Quality Portal; Google Drive; Publiclab.org research note system; ESRI data sharing platforms; Chesapeake Commons Water Reporter App; <u>www.globe.gov</u>/; Swim Guide affiliates; <u>http://crowdhydrology.geology.buffalo.edu/</u>

Great perceived needs for low-cost data access & sharing technologies

- ✓ Quality & reliability of data
- ✓ Sharing of water quality information with environmental advocates, local govt. officials
- ✓ Low unit cost of the data
- ✓ Crowd sourcing & sharing of water quality data

Price ranges of "low cost" data access & sharin technologies

- ✓ Low range—67% of the respondents were clustered between 0-\$50
- ✓ High range great variability—(60%) clustered between \$100-\$1,000



LOW COST WATER QUALITY MONITORING NATIONAL SURVEY -- Water Monitoring Stories

- Final section of survey, developed by Intel staff, asked respondents to tell a story about a monitoring experience
- Stories provide additional depth for follow-up but cannot be shared due to privacy policy
- Most respondents feel the stories they told are common
- Respondents ranked the difficulty associated with their stories under prescribed categories.
 Non-profits said taking action was hardest and data sharing was easiest.



LOW COST WATER QUALITY MONITORING NATIONAL SURVEY -- Key Findings

GOAL

- We wanted to survey select groups doing water resource monitoring to better understand gaps between their current and desired:
 - ✓ Water monitoring practices
 - ✓ Reporting
 - ✓ Information sharing technologies
- Our goal was to help empower citizens to protect their water through information gained or managed with the use of **low-cost technologies**
- The following key findings will assist our efforts to move forward in partnership with other interested parties to help expand the role that low-cost technologies play in protecting and enhancing water quality

LOW COST WATER QUALITY MONITORING NATIONAL SURVEY -- Key Findings

- 84% of respondents believe widespread availability of low-cost equipment could affect major improvements in water quality
- Top 4 perceived needs for low-cost monitoring equipment:
 - ✓ target problem areas
 - ✓ use as a screening tool for advanced/expert level monitoring/investigation
 - ✓ report pollution incidents
 - as part of monitoring & verification protocols for nutrient trading programs, BMPs, restoration projects, etc.
- Top parameters for low-cost (under \$100) monitoring improvements:
 - ✓ nutrients (N and/P forms)
 - ✓ bacteria (fecal coliform, E. coli, etc.)
 - ✓ dissolved oxygen
 - ✓ turbidity
 - ✓ temperature

LOW COST WATER QUALITY MONITORING NATIONAL SURVEY -- Key Findings

Top 4 most desired features in new equipment:

- ✓ equipment durability
- ✓ in-field data entry
- ✓ remote sensing & data loggers
- ✓ automatic metadata capture
- 78% of respondents lack knowledge of beneficial low-cost data access & sharing technologies that could benefit their program
- Top 4 perceived needs for low-cost (less than \$50) data access and sharing technologies:
 - ✓ quality and reliability of the data
 - ✓ low unit cost of the data
 - ✓ sharing of water quality information with environmental advocates
 - ✓ sharing of water quality information with local government officials

LOW COST WATER QUALITY MONITORING NATIONAL SURVEY-- Implications and Potential Next Steps

- Identify available low cost nutrient monitoring technologies identified as priorities from the survey, their capabilities, and cost
- Share best practices and promote the use of peer supported tools for collecting and sharing water quality information.
- Demonstrate how improved technology to collect and share information can empower citizen organizations to protect and restore their rivers, lakes and streams.
- Promote improvements in technology and explore market incentives through collaborative efforts with NGOs, academics, and technology providers to ensure that the market is meeting the needs of citizens for clean water.

LOW COST WATER QUALITY MONITORING EQUIPMENT SCAN FOR NUTRIENTS

Goal of Scan

- Determine availability/adequacy of existing low cost (<\$100) monitoring equipment to detect nutrient parameters (nitrogen & phosphorus)
- Survey participants wanted equipment with sensors to gather realtime, continuous data

Importance

- Nutrient concentrations in agricultural & urban development basins significantly greater than naturally occurring background levels
- Example: agricultural streams about 6x greater than background levels & 2-10x greater than USEPA recommended regional nutrient criteria to protect aquatic life
- Low-cost equipment needed in more locations to know when/where excessive nutrients may be causing health risks for people/wildlife
- Low-cost equipment will facilitate location of remedial BMPs & policy changes to address problematic land use & management practices and potentially reduce staff time/expenditures





LOW COST WATER QUALITY MONITORING EQUIPMENT SCAN FOR NUTRIENTS

What Gaps Exist?

- Low-cost equipment is available for basic screening of some nutrient parameters including nitrates, ammonia, and orthophosphates. Low-cost equipment is not available:
 - To meet preferred characteristics of providing continuous, real-time results for nutrient parameters
 - To provide rapid field results for determining total nitrogen & total phosphorus
 - These are important comparative indicators for measuring against standard, regional criteria used to assess stream and groundwater health



Summary of Selected Low-cost¹ Nutrient Water Quality Monitoring Equipment

Parameter	Equipment Type ²	Availability Status	Detection Limits Adequacy ³	Price /Range	Examples of Potential Uses
Nitrate-nitrogen NO3-N	Test kits—field	Widel y available	Sufficient	\$60-\$90	Detect human health Maximum Contaminant Level (MCL) Screen groundwater wells & stream hot spots
Ammonia nitrogen NH3-N	Test kits—field	Widely available	Mixed	\$80-\$90	Screenfor potential exceedances of aquatic organism acute/chronic health conditions
Orthophosphate	Test kits—field	Limited vendors	Insufficient	\$62-\$103	 Screenfor elevated phosphatelevels for excess fertilizers, waste discharges
Nitrate-nitrogen NO3-N	Sensor/loggers— classroom settings, continuous sampling	Limited vendors	Sufficient	Approx. \$400	Study nitrogen cycle Detect human health Maximum Contaminant Level (MCL) Screen groundwater wells & stream hot spots
Orthophosphate	Photometer—field	Limited vendors	Sufficient	\$49-\$229	Screenfor elevated phosphatelevels for excess fertilizers, waste discharges

¹Low-cost was defined as at or near \$100. Some equipment that exceeds this threshold was examined to provide information about threshold cost levels. ²All equipment types provide self- contained results that do not require laboratory analysis. Equipment does not operate autonomously and is for single test results except for the sensor/loggers –which substantially exceed the low-cost threshold.

³Based on sufficiency to detect levels at or above estimates for national background concentrations of nutrients in streams and groundwater--reference pg. 52 of USGS Circular 1350: The Quality of Our Nation's Water: Nutrients in the Nation's Streams and Groundwater, 1992-2004.

LOW COST WATER QUALITY MONITORING EQUIPMENT SCAN FOR NUTRIENTS

Potential Next Steps

- Independent and jointly funded initiatives to improve types/functions of low-cost nutrient monitoring equipment by:
 - Sponsoring prizes, maker faires, and/or technology accelerators to improve the types of equipment available to NGOs (and others)
 - Demonstrating market demand so that technology companies (large and small) will expand the range of low cost nutrient monitoring equipment on their own
 - Working with technology investors (philanthropic, venture capitalists, etc.) to expand investment in this sector
 - Establishing a database of low-cost nutrient monitoring equipment to support citizen science & volunteer-based water quality monitoring activities/projects of non-profit organizations



LOW COST WATER QUALITY MONITORING NATIONAL SURVEY-- Contacts

- For suggestions of follow-up activities to support the survey/scan findings please contact:
 - ✓ Jillian McClain, jmcclain@piscesfoundation.org
 - ✓ Please include the following information:
 - $_{\odot}$ Name and contact info of person submitting suggestion
 - Description of specific suggestion
 - $\circ\,$ Potential partners for the effort
 - What it would accomplish