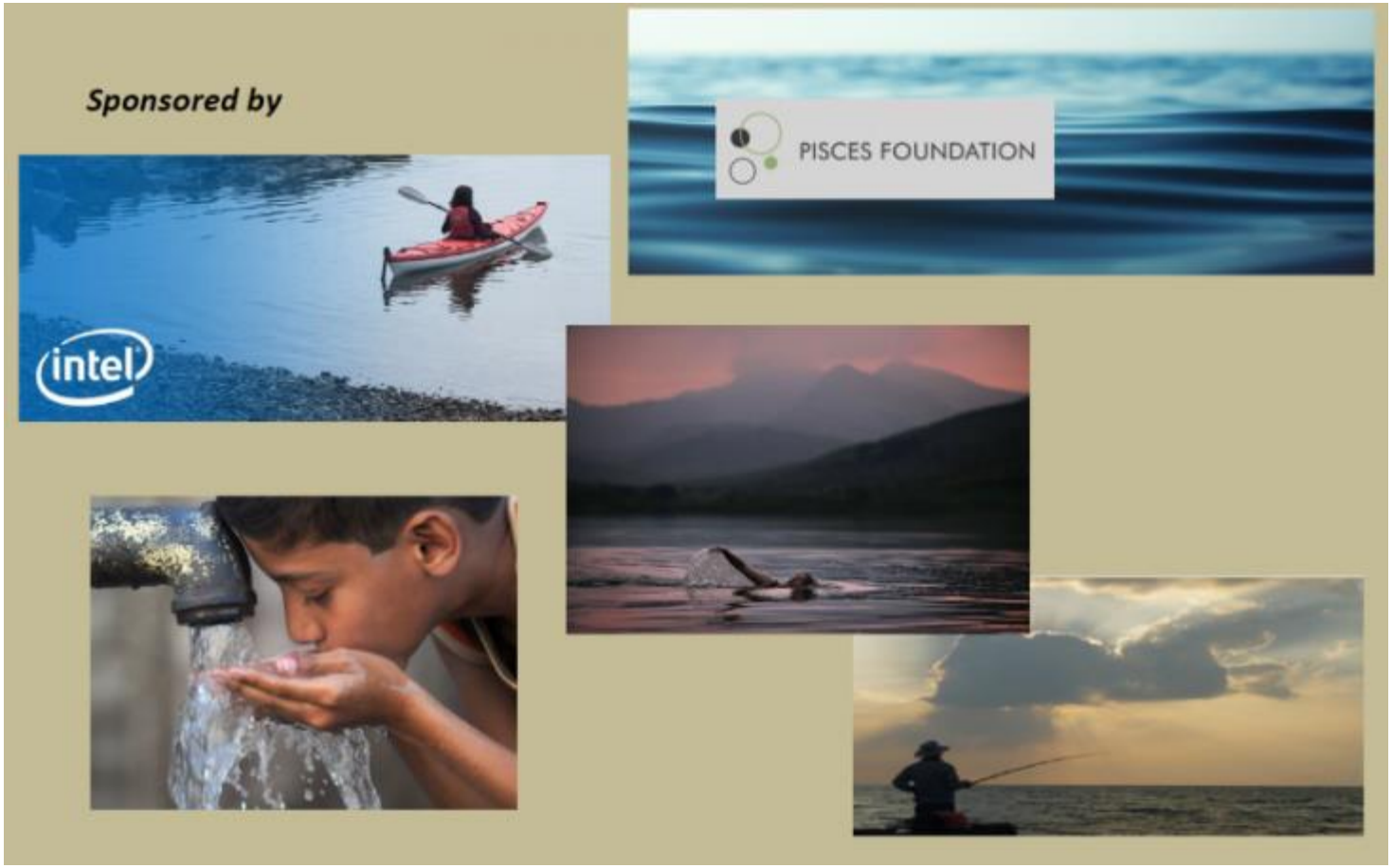
# LOW COST WATER QUALITY MONITORING NATIONAL SURVEY



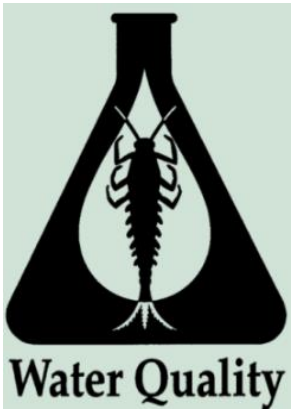
# LOW COST WATER QUALITY MONITORING NATIONAL SURVEY

## Background

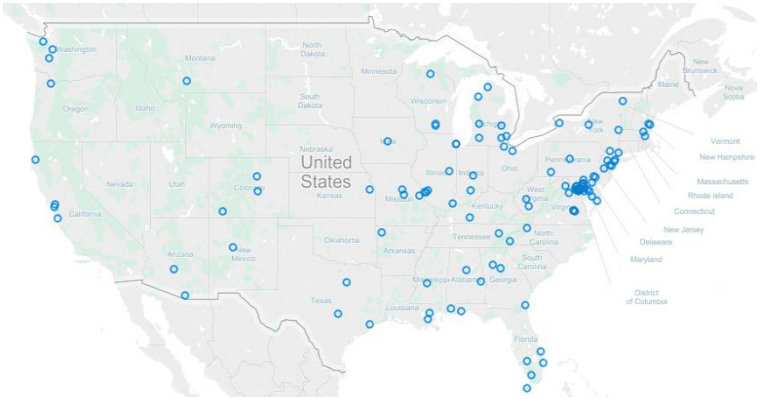
- 2015: Pisces Foundation & Intel Corporation project leaders agree to sponsor a survey of selected groups doing water resource monitoring to better understand gaps between their current and desired:
  - ✓ **Water monitoring practices**
  - ✓ **Reporting**
  - ✓ **Information sharing technologies**

- 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

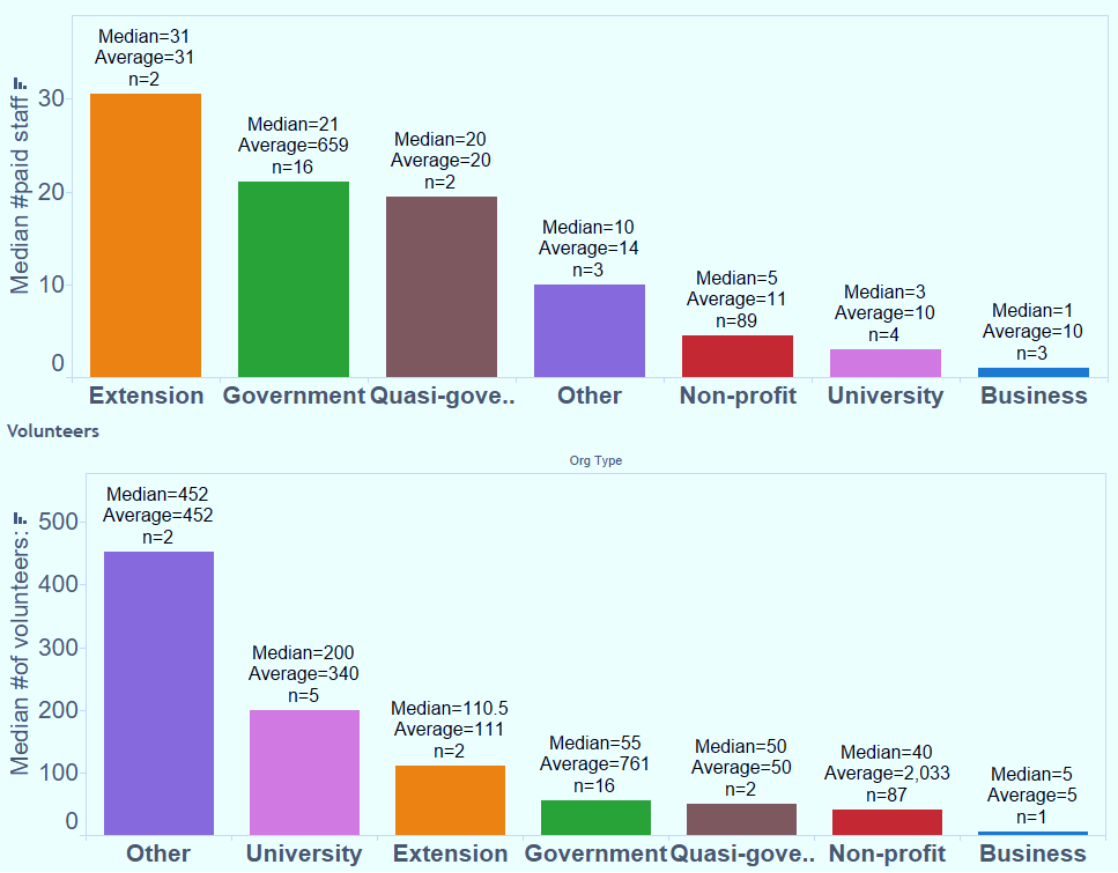
- Key Characteristics:
  - ✓ **130 respondents—all but 3 in U.S.**
  - ✓ ***Very knowledgeable*—50% monitoring program leads & 78% were either staff, volunteers, or had strong program knowledge**
  - ✓ **Several respondents represented their regional/national staff network**
  - ✓ ***Geographically broad* representation—42 states**
  - ✓ **Mostly non-profits (72%) & govt. (16%) respondents**
  - ✓ **50% answered a *watershed* was their service area**

- Top 3 of 11 mission areas identified were:
  - ✓ **Watershed restoration or protection(80%)**
  - ✓ **Water monitoring or assessment (73%)**
  - ✓ **Public education (68%)**
  - ✓ **Remaining mission areas all scored below 50%**

# LOW COST WATER QUALITY MONITORING NATIONAL SURVEY -- Survey Audience Profile

## Staffing Strength by Organization Type

- As anticipated, non-profit organizations typically have few paid staff
- Universities, as might be expected, had high numbers of volunteers (students)



# LOW COST WATER QUALITY MONITORING NATIONAL SURVEY

## Monitoring Program Profile

- 79% have monitoring programs, 18% do not, 3% are unsure
- 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%
- 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%)

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

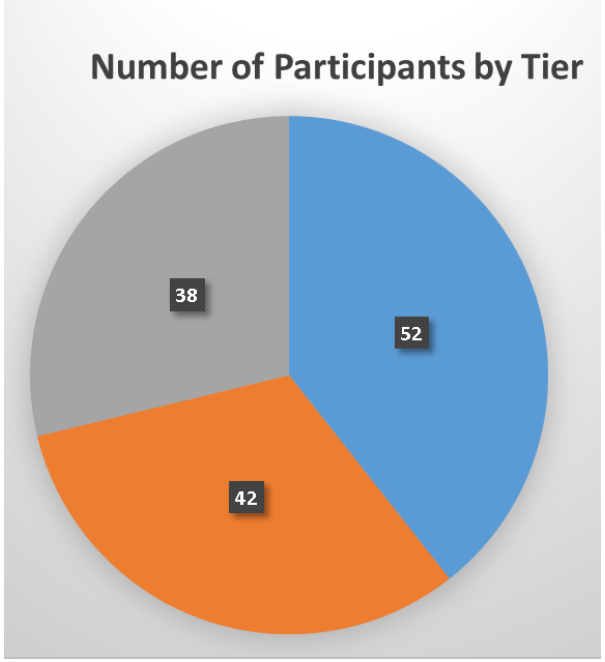
## Monitoring Program Approach

- Somewhat surprising is the strong deployment of all Tier methods, particularly Tier 3

- **Tier 1**: basic monitoring methods, equipment and QAQC, used for screening

- **Tier 2**: advanced methods, better equipment, more QAQC training, used as a local decision support tool

- **Tier 3**: expert methods, equipment and training, used to support policy/regulatory decisions and scientific findings

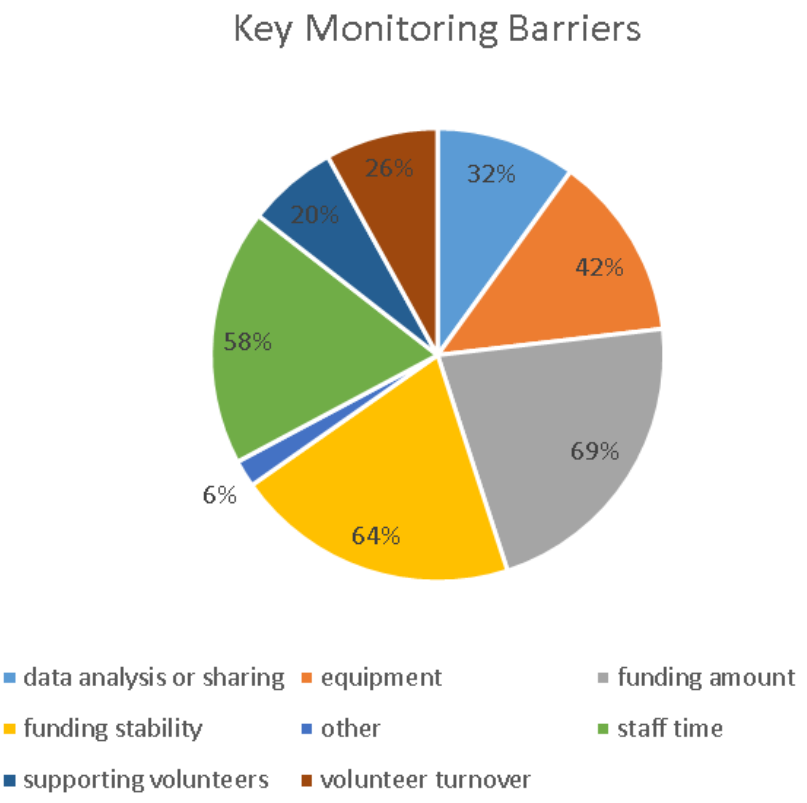


# LOW COST WATER QUALITY MONITORING NATIONAL SURVEY-- Monitoring Program Profile

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

- 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.



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

## Data collection

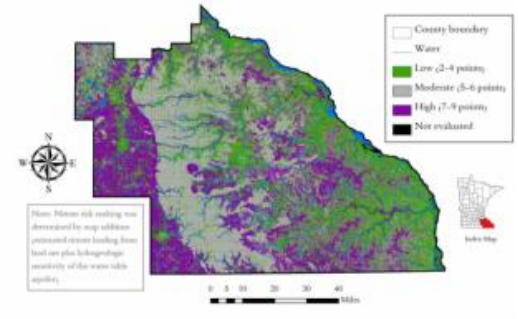
- Of the 13 possible answers for data collection methods--3 are deployed by most organizations:
  - ✓ **Field test kits** **74% (59)**
  - ✓ **Grab samples & lab analysis** **69% (55)**
  - ✓ **Multi-parameter meters/sensors** **49% (39)**

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

| | | |
|---|---|---|
| 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



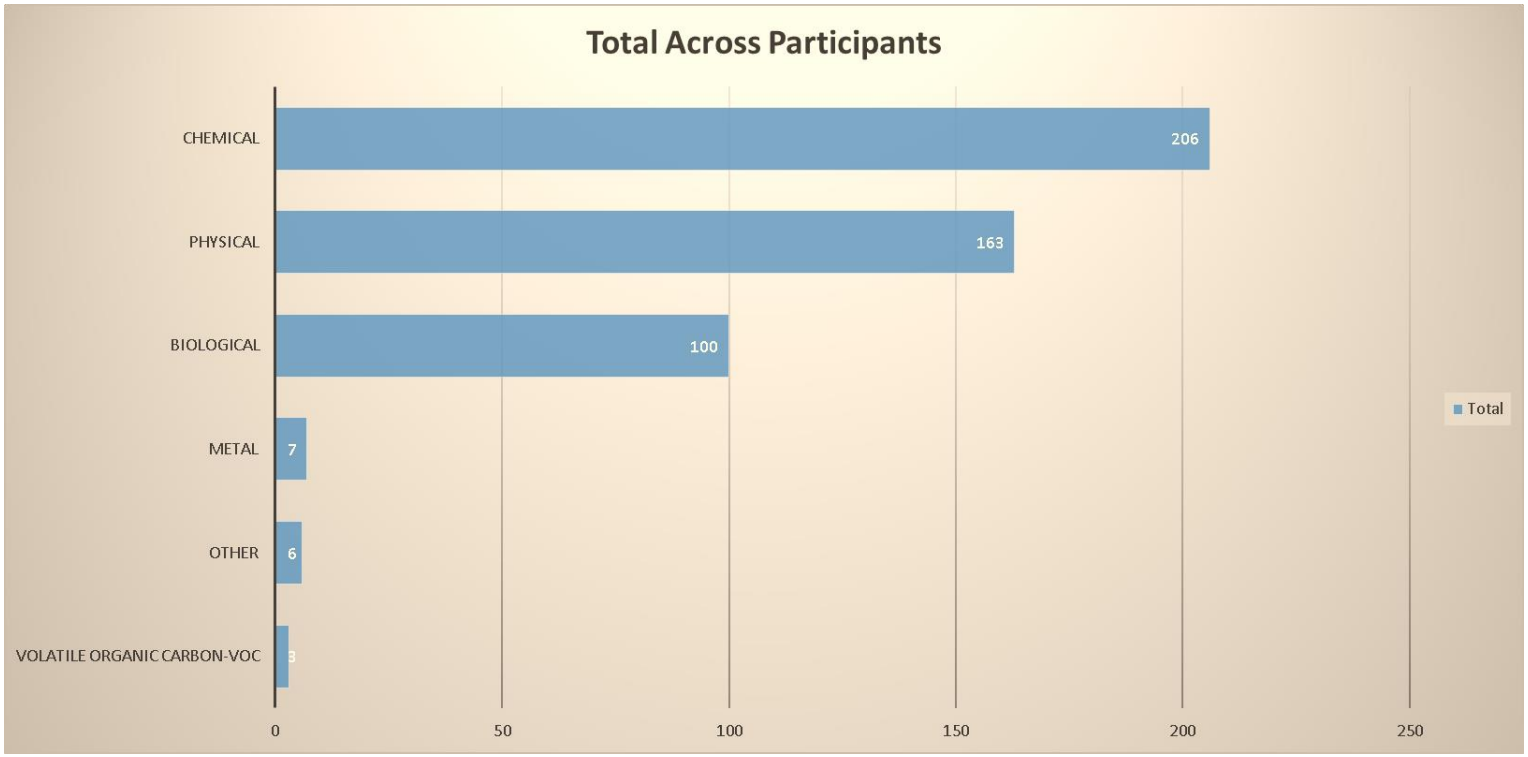

- Data sharing is largely accomplished through:
  - ✓ **Annual or periodic reports** **61% (48)**
  - ✓ **Community outreach** **58% (46)**
  - ✓ **Online database** **56% (44)**
  - ✓ **Online map with results** **42% (33)**

- Alternative water monitoring & information sharing technologies are principally:
  - ✓ **GIS mapping** **74% (39)**
  - ✓ **Phone apps** **38% (20)**

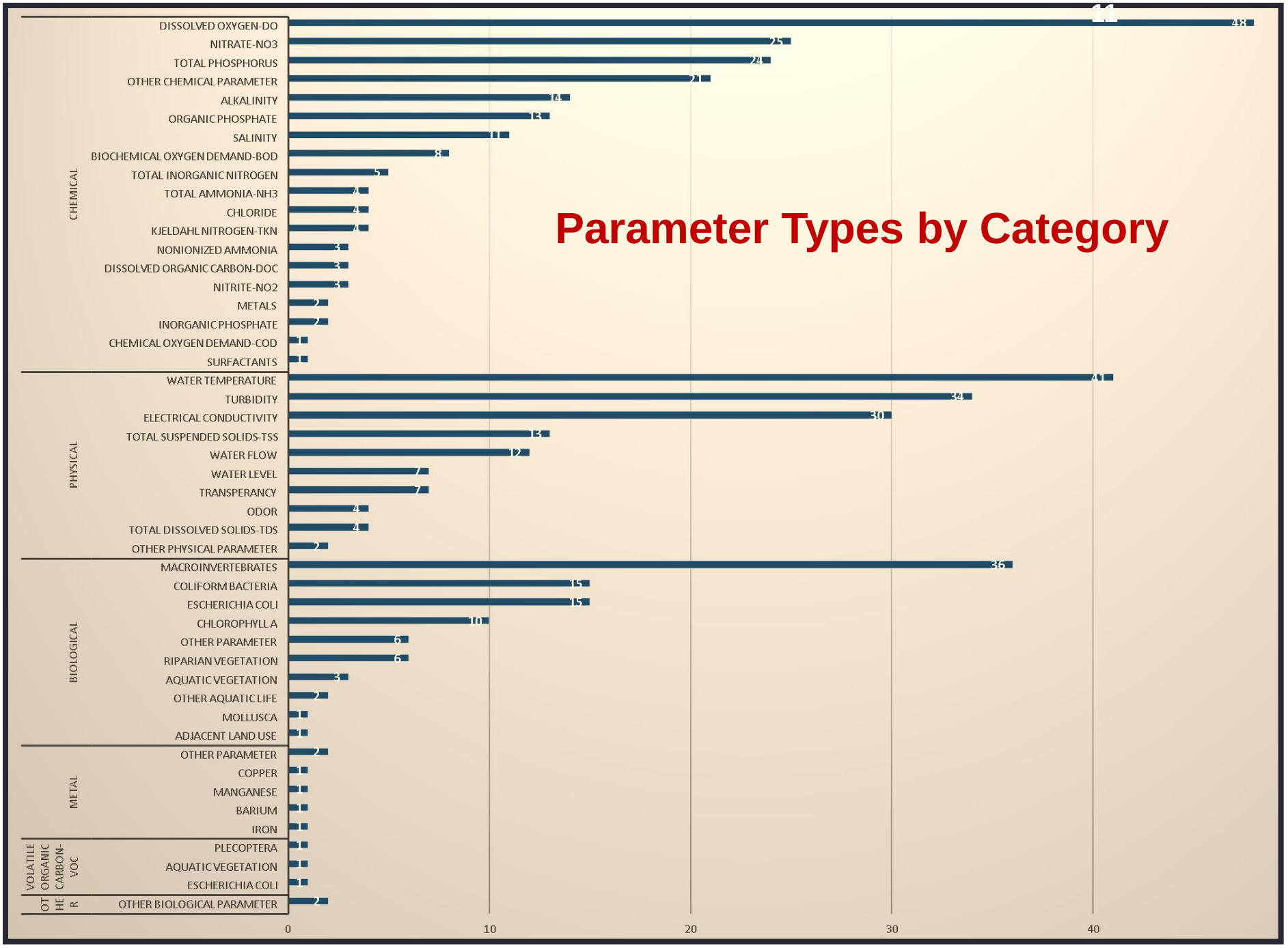
- Data is shared with:
  - ✓ **Govt. water quality, wildlife & natural resource agencies at federal, state, & local levels**
  - ✓ **General public, news agencies**
  - ✓ **Stakeholders like farmers, watershed groups, families, board members, funders**
  - ✓ **Academic sectors including universities, schools, teachers, students**

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

## Parameters*

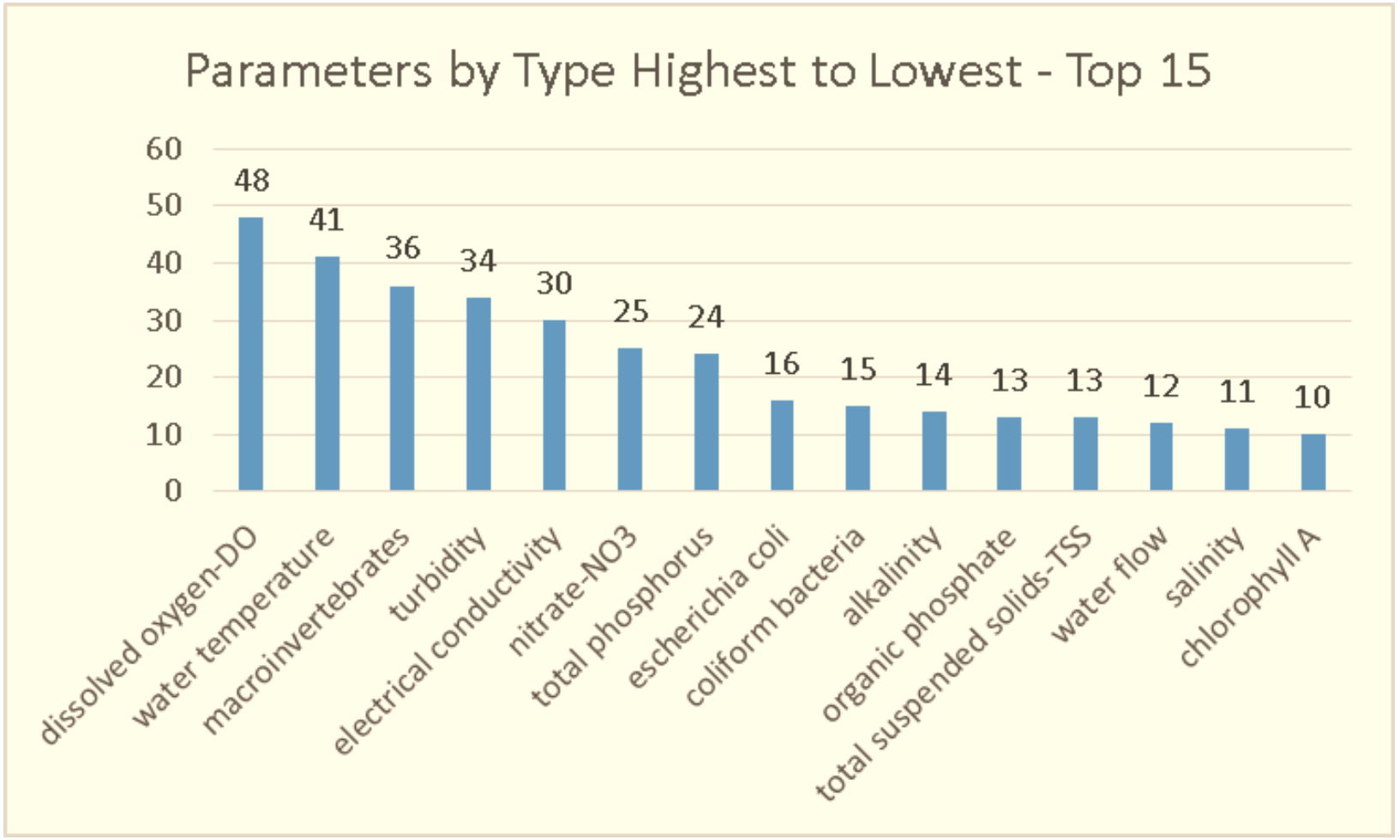



* Respondents completing at least: 1 parameter = 97; 3 p's = 63; 5 p's = 46; 7 p's = 32; 9 p's = 22; 10 p's = 20


Parameter Types by Category
CHEMICAL
DISSOLVED OXYGEN-DO 48
NITRATE-NO3 25
TOTAL PHOSPHORUS 24
OTHER CHEMICAL PARAMETER 21
ALKALINITY 14
ORGANIC PHOSPHATE 13
SALINITY 11
BIOCHEMICAL OXYGEN DEMAND-BOD 8
TOTAL INORGANIC NITROGEN 5
TOTAL AMMONIA-NH3 4
CHLORIDE 4
KJELDAHL NITROGEN-TKN 4
NONIONIZED AMMONIA 3
DISSOLVED ORGANIC CARBON-DOC 3
NITRITE-NO2 3
METALS 2
INORGANIC PHOSPHATE 2
CHEMICAL OXYGEN DEMAND-COD 1
SURFACTANTS 1
PHYSICAL
WATER TEMPERATURE 41
TURBIDITY 34
ELECTRICAL CONDUCTIVITY 30
TOTAL SUSPENDED SOLIDS-TSS 13
WATER FLOW 12
WATER LEVEL 7
TRANSPERANCY 7
ODOR 4
TOTAL DISSOLVED SOLIDS-TDS 4
OTHER PHYSICAL PARAMETER 2
BIOLOGICAL
MACROINVERTEBRATES 36
COLIFORM BACTERIA 15
ESCHERICHIA COLI 15
CHLOROPHYLL A 10
OTHER PARAMETER 6
RIPARIAN VEGETATION 6
AQUATIC VEGETATION 3
OTHER AQUATIC LIFE 2
MOLLUSCA 1
ADJACENT LAND USE 1
METAL
OTHER PARAMETER 2
COPPER 1
MANGANESE 1
BARIUM 1
IRON 1
VOLATILE ORGANIC CARBON-VOC
PLECOPTERA 1
AQUATIC VEGETATION 1
ESCHERICHIA COLI 1
OTHER
OTHER BIOLOGICAL PARAMETER 2
0
10
20
30
40

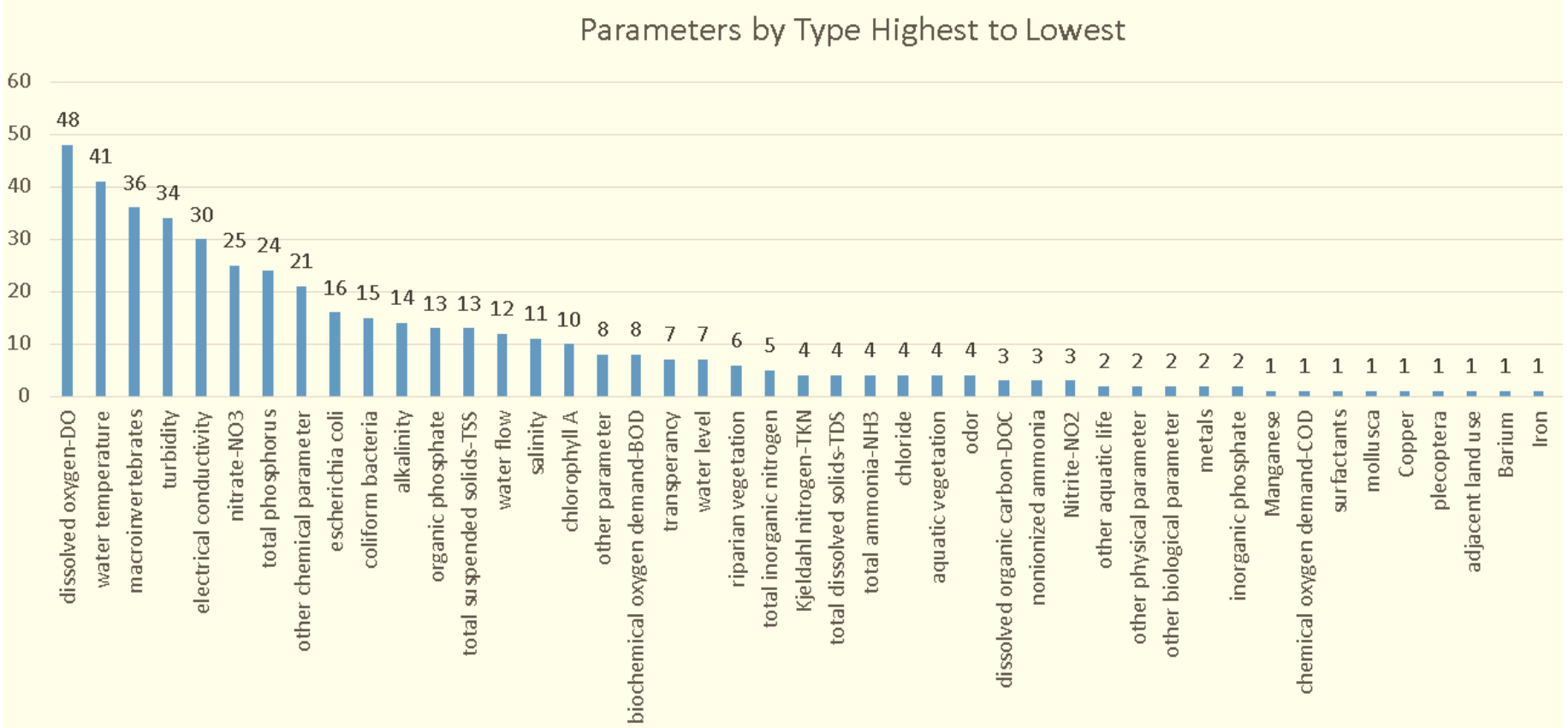
# LOW COST WATER QUALITY MONITORING NATIONAL SURVEY-- Monitoring Program Profile

## Parameters



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

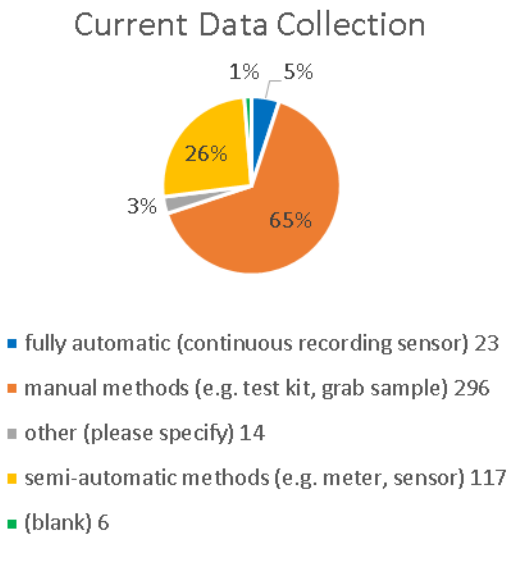
## Parameters

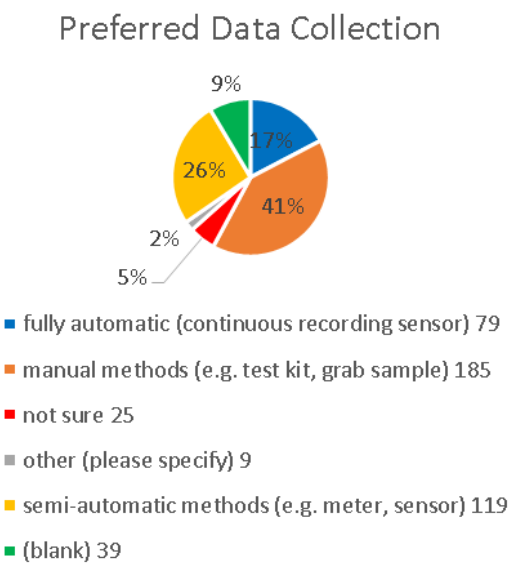


# LOW COST WATER QUALITY MONITORING NATIONAL SURVEY-- Monitoring Program Profile

**Parameters—data collection**

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

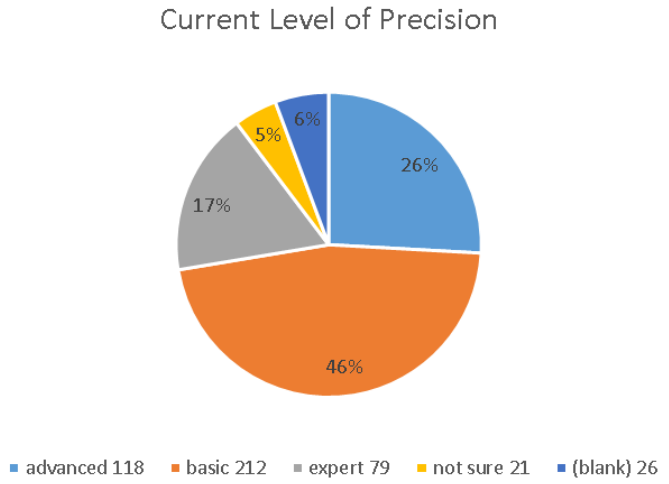


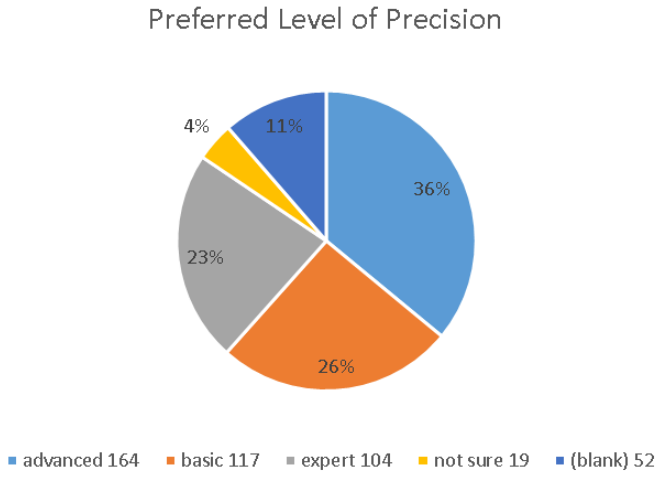



# LOW COST WATER QUALITY MONITORING NATIONAL SURVEY-- Monitoring Program Profile

**Parameters—precision level**

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

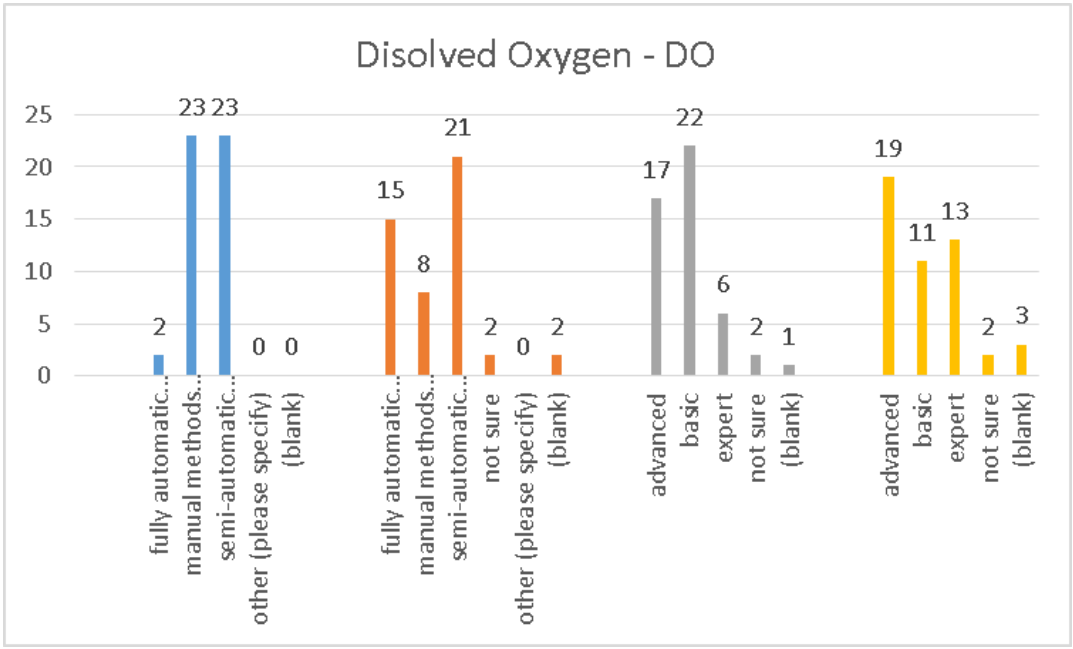


# LOW COST WATER QUALITY MONITORING NATIONAL SURVEY -- Monitoring Program Profile

## Analysis of Select Top Individual Parameters—data collection & precision

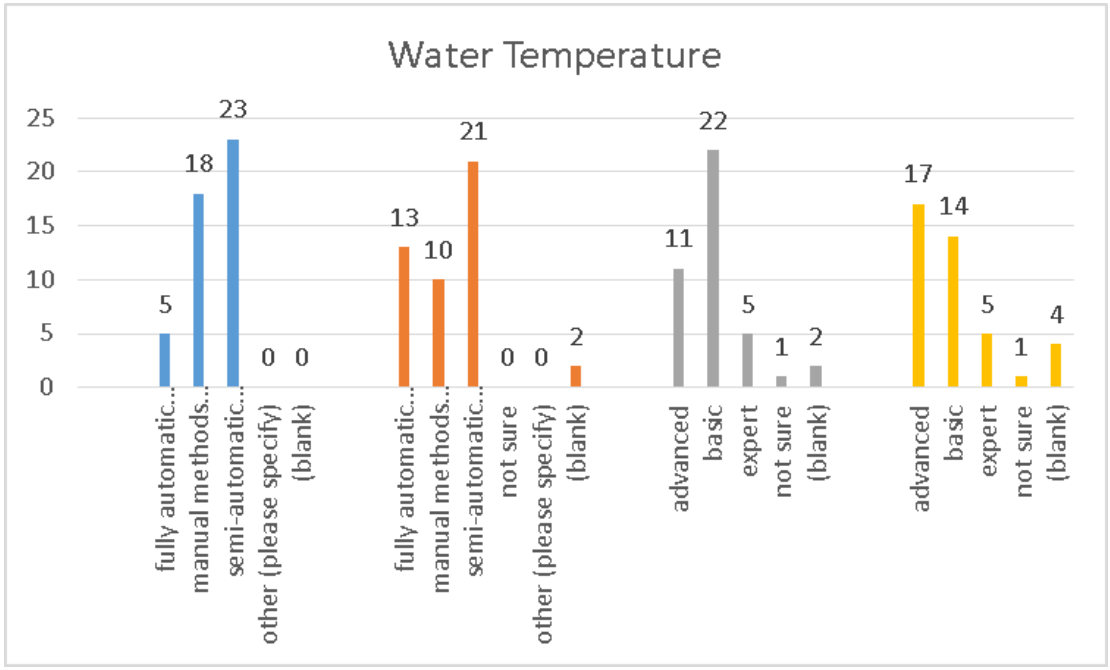
- DO ranked #1
- Many respondents want to fully automate DO collection and continue to shift toward expert & advanced levels of precision



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

## Analysis of Select Top Individual Parameters—data collection & precision

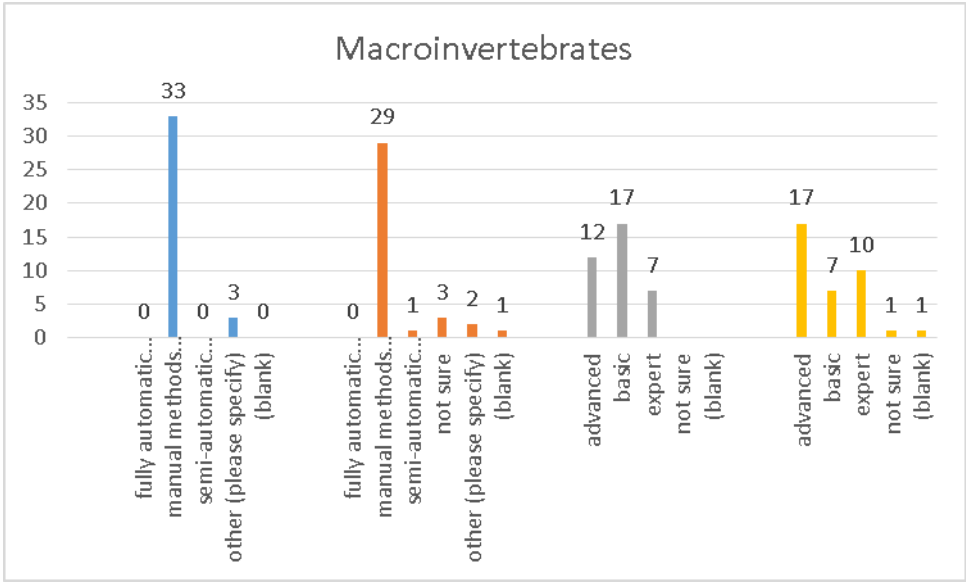
- Water temperature ranked #2
- Many respondents want to fully automate data collection & several would move to advanced levels of precision



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

## Analysis of Select Top Individual Parameters—data collection & precision

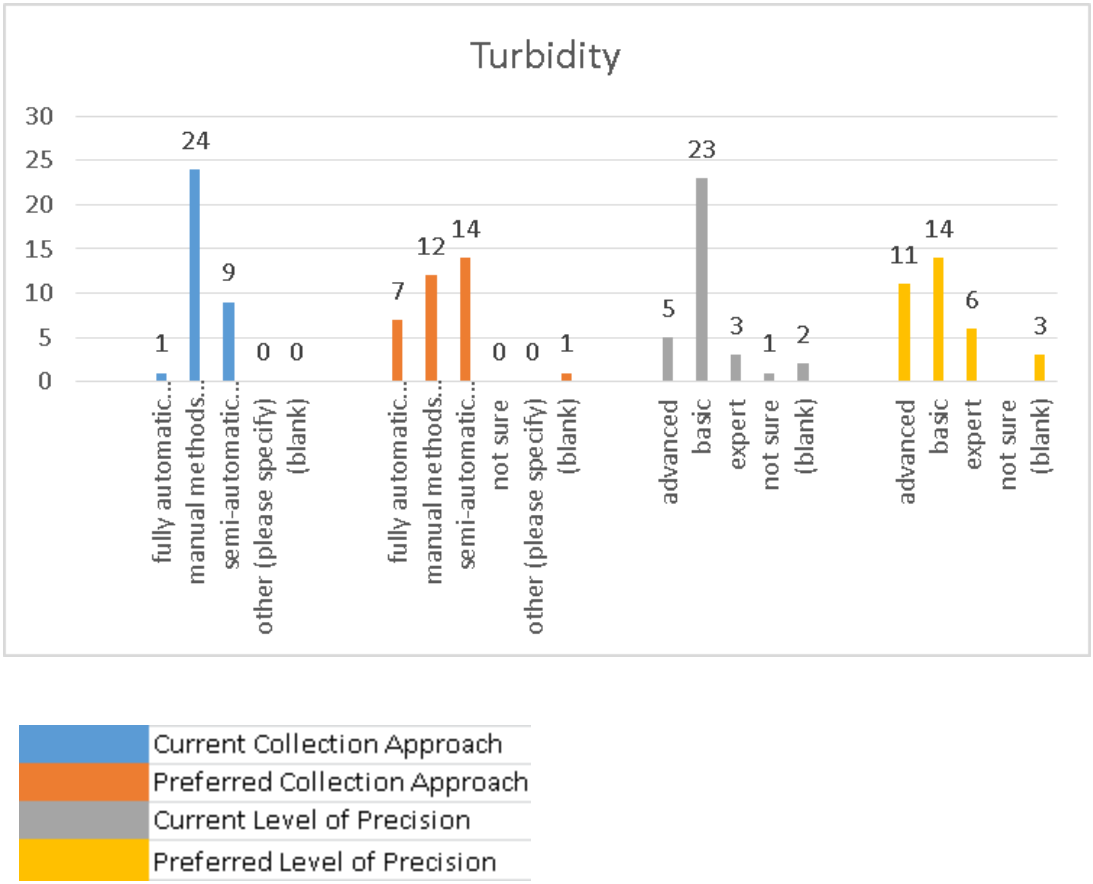
- Macroinvertebrates ranked #3
- Data shifts are modest. Note that advances in automation & precision levels could be possible through regional collaboration on DNA
- Requires building taxonomic library of species and PCR equipment that can process homogenized or water column samples



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

## Analysis of Select Top Individual Parameters—data collection & precision

- Turbidity ranked #4
- Respondents are signaling a clear need for both better data collection and precision levels with their turbidity monitoring



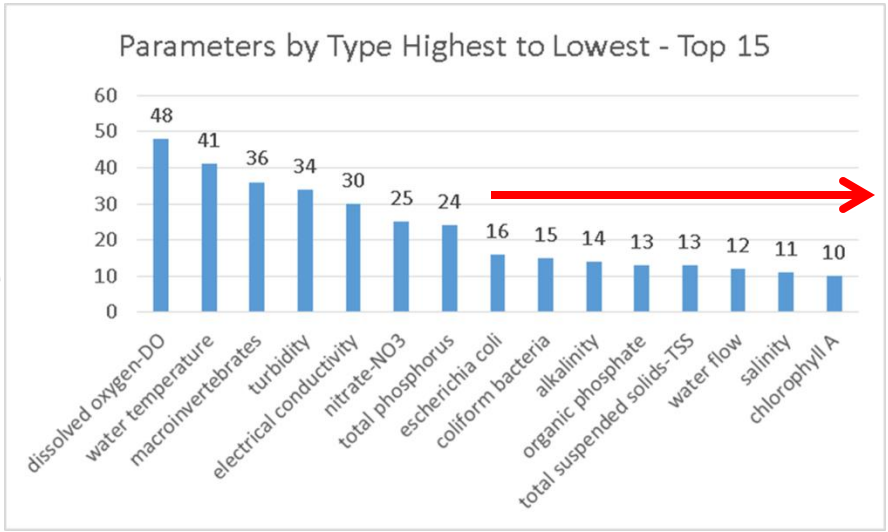
# LOW COST WATER QUALITY MONITORING NATIONAL SURVEY -- Monitoring Program Profile

## Analysis of Select Top Individual Parameters

- Nitrate-NO3 ranked #6 and total phosphorous ranked #7 did not reveal clear trends for future collection & precision

- Yet, respondents say parameters that are *most useful to monitor but can't now, are nutrients e.g. nitrogen & phosphorus* in various forms, especially:
  - ✓ **in real time**
  - ✓ **with sensors and;**
  - ✓ **continuous monitoring**

- Parameters ranked below total phosphorous were examined. Note E. coli and coliform bacteria are used as contamination indicators

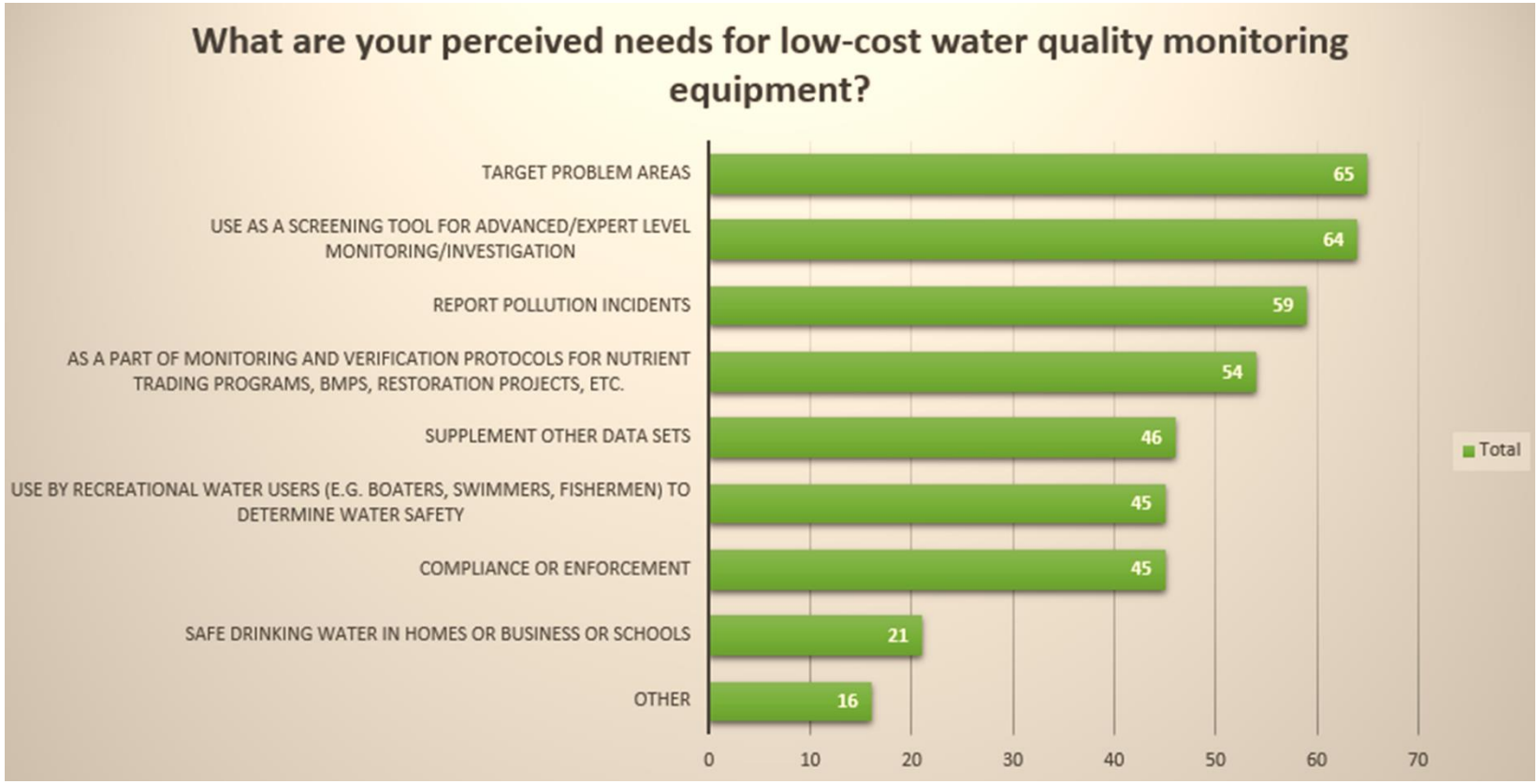


# LOW COST WATER QUALITY MONITORING NATIONAL SURVEY -- Equipment

- Most respondents had little knowledge of promising low cost equipment:
  - ✓ No knowledge =74% versus  Knowledge Yes = 26%


- Examples of specific suggestions from respondents
  - ✓ http://www.lamotte.com/en/biopaddles
  - ✓ RetaiN Kits
  - ✓ Ott MF Pro Flow Meter
  - ✓ PME miniDOT DO logger / http://pme.com/products/minidot
  - ✓ FlowWatch Flow Meter: http://www.forestry-suppliers.com/product_pages/Products.asp?mi=65971&itemnum=94356&title=Flowatch%20Flowmeter/Anemometer
  - ✓ GPS/sonar fish finders, drone/UAV technology
  - ✓ new test kits for phosphorus, if accurate, like this http://hannainst.com/products/checker-colorimeters/parameter/phosphorus.htm
  - ✓ We are conducting research to develop new low cost organic carbon and nitrate sensors. There are also efforts in GLEON, the Global Lake Ecological Observatory Network, to do the same. gleon.org.

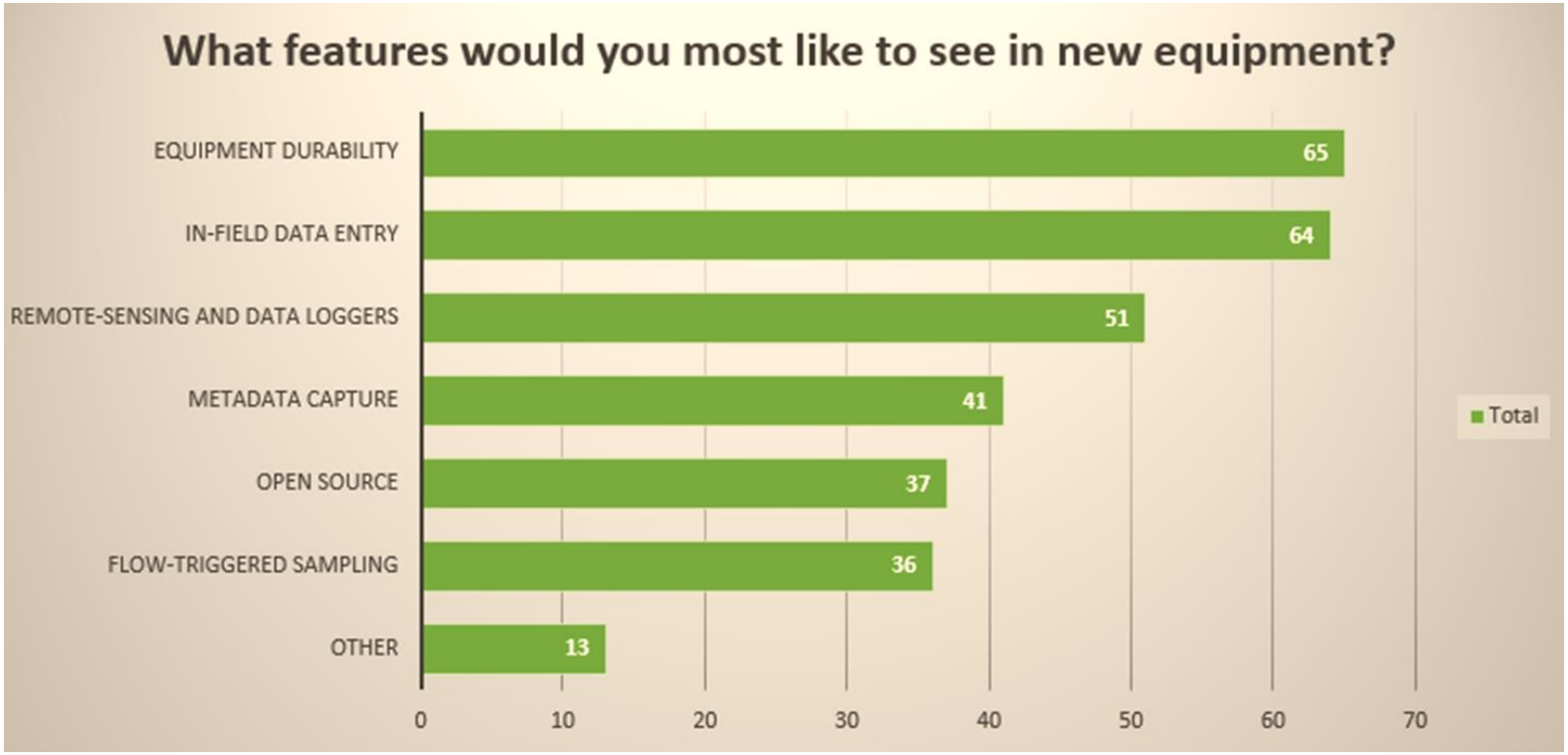
# LOW COST WATER QUALITY MONITORING NATIONAL SURVEY -- Equipment




Other examples of needs mentioned:

- ✓ **educational use in class rooms, data collection, use by non-experts**
- ✓ **wilderness water quality monitoring**
- ✓ **low enough cost so theft of devices would not hurt programs**
- ✓ **getting technology in marginalized communities to allow them to share information and be represented**

# LOW COST WATER QUALITY MONITORING NATIONAL SURVEY -- Equipment




Other examples of features needed:

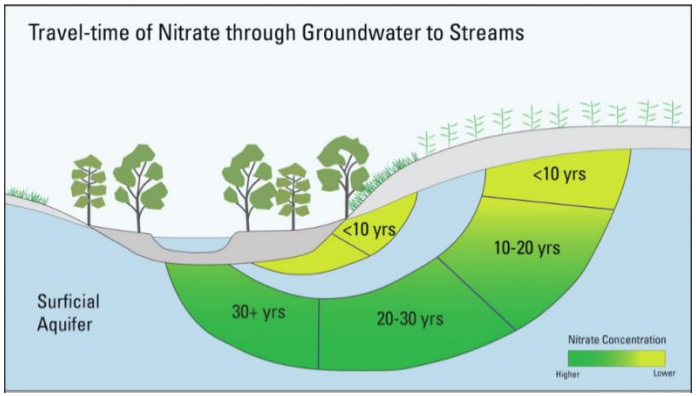
- ✓ **simple intuitive interface and use**
- ✓ **be easy to calibrate and store**
- ✓ **user-friendly for volunteers**
- ✓ **small, and easy to carry in field**

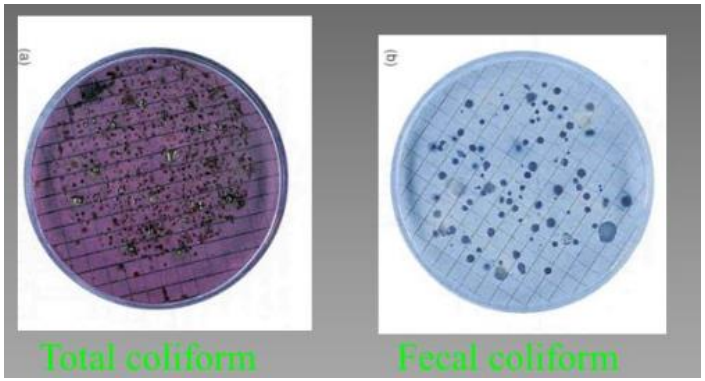
# LOW COST WATER QUALITY MONITORING NATIONAL SURVEY -- Equipment

**Parameters to Focus on for Low Cost Equipment:**

- 74 write-in responses (58%)
- Most mentioned –24 times, was **nutrients** (N and/P forms)
- Second – 14 times, were forms of **bacteria** (fecal coliform,E. coli, etc.)
- Third– 10 times, was **dissolved oxygen**
- Fourth – 6 times, was **turbidity**, followed by **water temperature**—5 times

- Some preferences emerging, compare parameters monitored rankings:
  - ✓ **DO, water temp., turbidity ranked 1,2, 4**
  - ✓ **N & P forms ranked 6,7**
  - ✓ **E. coli & coliform bacteria ranked 8,9 & taken together would move up to #6 of all parameters monitored**

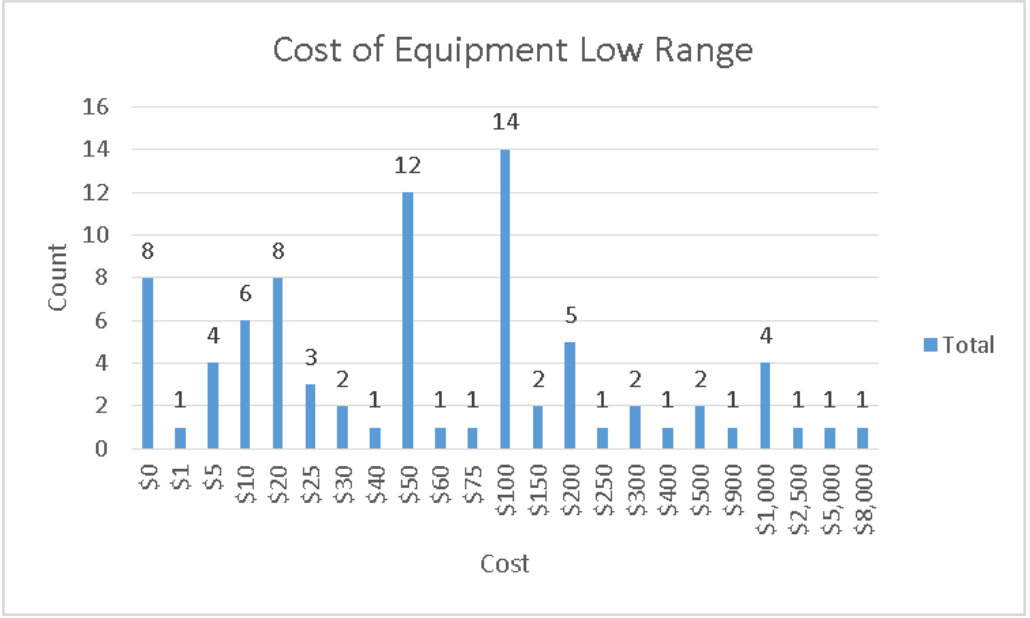


# LOW COST WATER QUALITY MONITORING NATIONAL SURVEY -- Equipment

**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, non-profit 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; www.globe.gov/; Swim Guide affiliates; http://crowdhydrology.geology.buffalo.edu/**

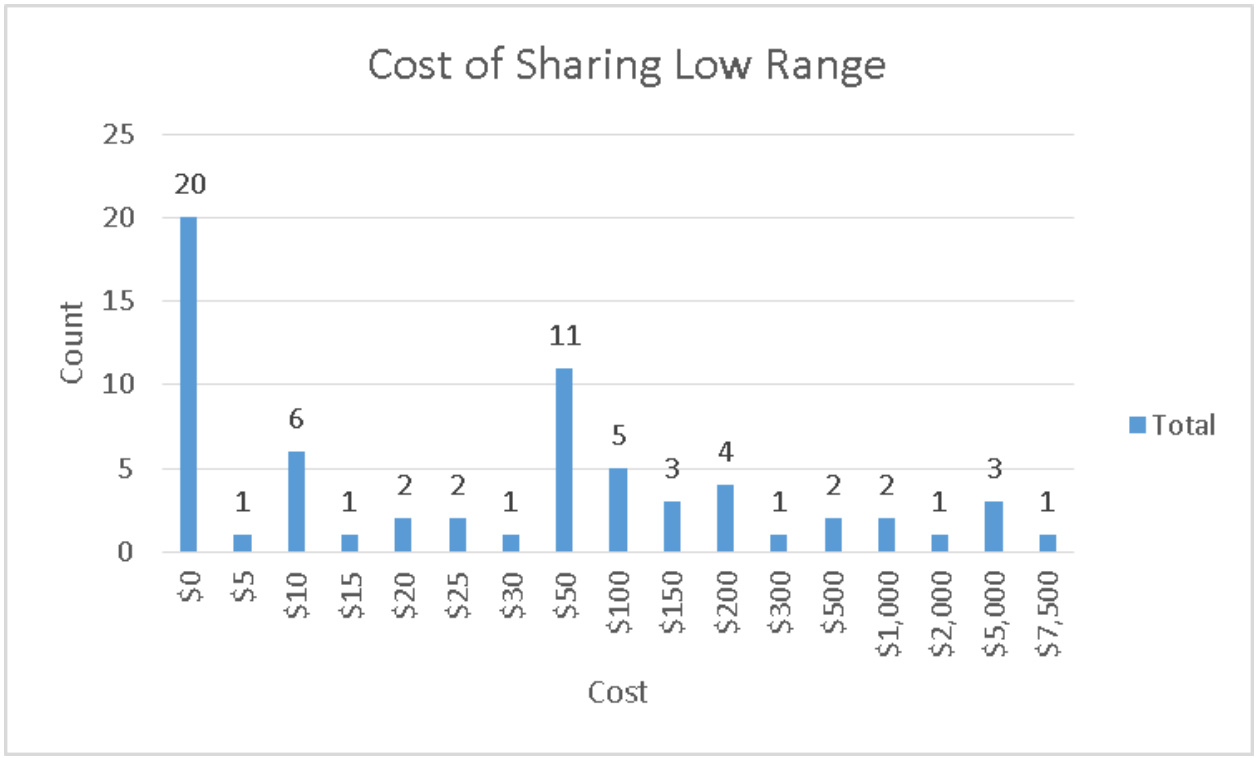
**Greatest perceived needs for low-cost data access & sharing technologies**

| | | |
|---|---|---|
| crowd sourcing and sharing of water quality data | 8.00% | 8 |
| sharing of water quality information with environmental advocates | 12.00% | 12 |
| sharing of water quality information with local government officials | 11.00% | 11 |
| quality and reliability of the data | 21.00% | 21 |
| low unit cost of the data | 12.00% | 12 |
| compliance or enforcement | 6.00% | 6 |
| reporting pollution incidents | 5.00% | 5 |
| other | 25.00% | 25 |
| Total | 100% | 100 |

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

**Price ranges of "low cost" data access & sharing 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

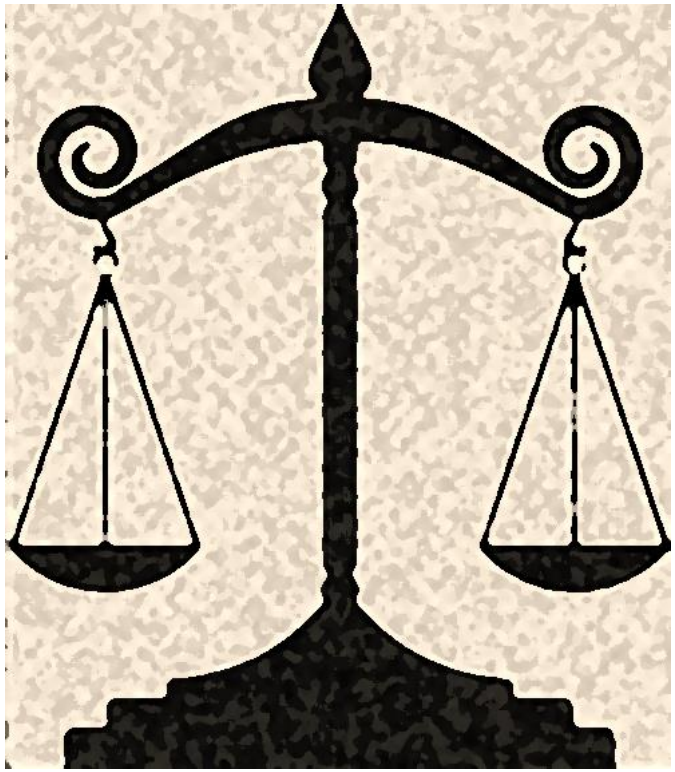
- Final section of survey, developed by Intel staff, asked respondents to tell a story about a monitoring experience
- Stories provide additional depth for follow-up but can't be shared due to privacy policy
- 74 stories completed, 58 of which were categorized into 1 of 3 basic types:
  - ✓ monitoring was a **challenge** 57% (33)
  - ✓ a **workaround** was used to monitor 10% (6)
  - ✓ monitoring was **working well** 33% (19)
- 16 stories, about (22%) were not categorized by respondents themselves

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

- Respondents asked to score:
  - ✓ how common the situation was
  - ✓ whether the effect on monitoring was positive/negative
- What the main challenges were more/less about:
  - ✓ economic & business challenges
  - ✓ usability or user adoption challenges
  - ✓ technology or implementation challenges
- How difficult/easy associated activities were:
  - ✓ gathering data
  - ✓ accuracy of data
  - ✓ analyzing data
  - ✓ taking action based on data

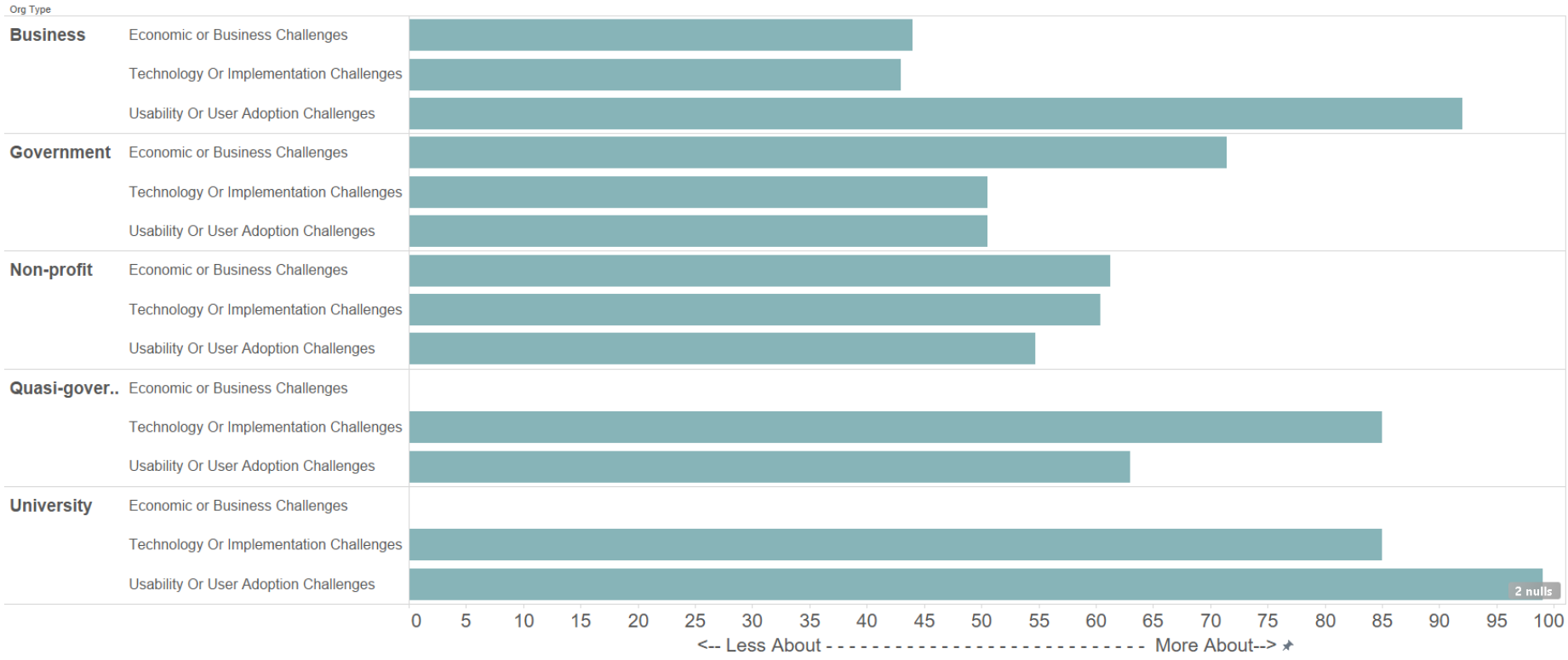
# LOW COST WATER QUALITY MONITORING NATIONAL SURVEY -- Water Monitoring Stories

- Overall Results: mean story scores (on a scale of 0-100) were recorded for:
  - ✓ **How common/uncommon the stories were – 69**
  - ✓ **The positive/effect on monitoring – 55**
  - ✓ **If they were more/less about economic & business challenges – 61**
  - ✓ **If they were more/less about technology or implementation challenges – 60**
  - ✓ **If they were more/less about usability or user adoption challenges – 58**



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

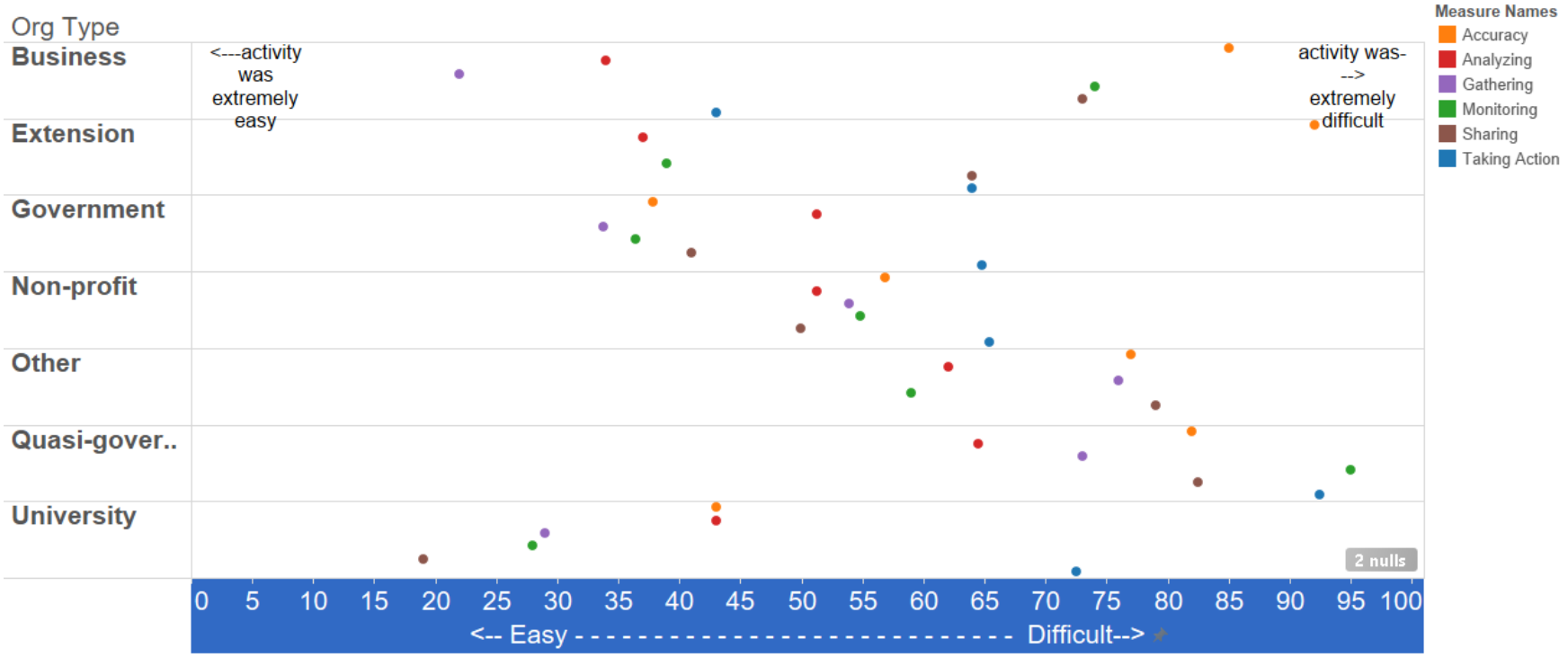
## What the Challenges Were About by Organization Type




* Note: businesses and Universities represent limited numbers of respondents.

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

## Difficulty of Story Related Activities by Organization Type




* Stories provide additional depth for follow-up

# LOW COST WATER QUALITY MONITORING NATIONAL SURVEY -- Key Findings

**GOALS**

- 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 4 parameters for low-cost** (under $100) **monitoring improvements:**
  - ✓ nutrients (N and/P forms)
  - ✓ bacteria (fecal coliform, E. coli, etc.)
  - ✓ dissolved oxygen
  - ✓ turbidity

# 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