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Results-based funding for safe drinking water services

How a standard contract design with payment for results can accelerate safe drinking water services at scale

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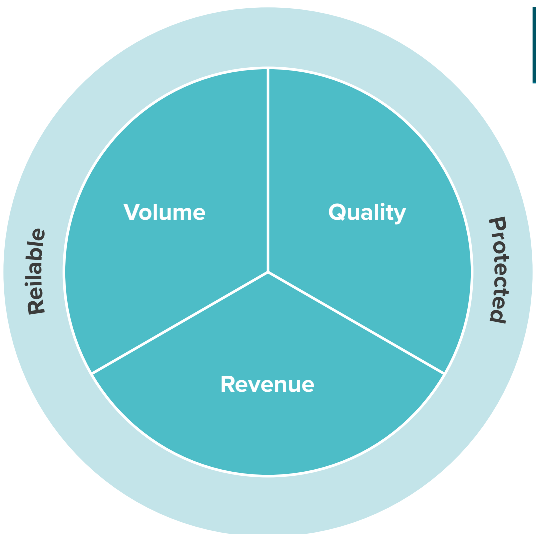
Executive summary

Water quality is a major health and development challenge in rural areas, where safe drinking water coverage lags behind that of urban areas. More than two thirds of the two billion people who lack access to safe drinking water live in rural areas (JMP 2020). Diarrhoeal diseases due to inadequate water services are estimated to cause 485,000 deaths per year. Children bear the biggest burden because exposure to faecal and chemical contamination affects both their physical growth and their mental development. These health impacts have long-term consequences for quality of life, educational attainment, and future employment prospects.

Rural infrastructure investments have accelerated the installation of decentralised water supply without corresponding investment in the management and oversight of drinking water quality. The assumption that certain types of infrastructure provide safe drinking water has been widely disproven, with faecal and chemical contamination common in piped systems and boreholes. Managing drinking water safety in rural areas is difficult due to the distances involved and the cost implications, with ongoing responsibilities primarily borne by users. As a result, drinking water safety remains unmanaged for much of the global rural population, which coincides with the majority of people living in extreme poverty.

Uptime and partners have demonstrated the ability of professional models to improve reliability of water services in rural environments, with results-based funding supporting sustainability and expansion of the services. Recognising that water safety management activities are critical, this working paper presents an approach that advances contracts for results-based funding to incentivise delivery of safe drinking water services. Standardised metrics for water quality, volume, and revenue are proposed within a framework for protected and reliable drinking water services.



A results-based framework for protected and reliable drinking water services

This risk-based approach considers four key principles in the incentive payment design: 1) prioritising risks for continuous improvement of drinking water safety, 2) incentivising action rather than focusing solely on test results, 3) generating data to inform more efficient and effective decision-making at local and national levels, and 4) building community, government, and investor confidence in professional water service provision.

A two-tiered incentive structure links payments to water safety actions which have been demonstrated to be achievable by professional service providers in research and practice. First, an assessment and reporting incentive reflects actions taken to understand the capacity of the system to provide safe drinking water through sanitary inspections and water quality testing and reporting. Second, a management incentive reflects actions taken to address microbial risks and ensure that water delivered to users is free from faecal contamination.

This standard contract design with results-based payments can accelerate safe drinking water services at scale. In Bangladesh, the SafePani programme has used a similar model to ensure water in schools and healthcare facilities is free from faecal contamination through regular actions by a service provider, HYSAWA, securing government investment to scale up the programme. In Kenya, better understanding of water quality risks has led a service provider, FundiFix, to implement chlorination to improve water safety. Building on experiences like these and on the various water safety activities that are already being carried out by service providers in its portfolio, Uptime plans to pilot the payment structure detailed in this working paper to support the delivery of safe drinking water. This approach incentivises continuous improvement in water safety management and facilitates sharing of evidence on water safety risks and management activities. It thus supports professional service providers in contributing towards the achievement of Sustainable Development Goal target 6.1: universal access to safe and affordable drinking water.

Background

Two billion people lack access to safe drinking water

Globally, two billion people are estimated to lack access to safe drinking water (WHO & UNICEF, 2021). The data for this estimate from low- and middle-income countries is limited, primarily informed by nationally representative surveys from 27 countries (Bain et al, 2021). Faecal contamination is recognised as the main priority for drinking water quality management. It continues to contribute to a high health burden internationally, and it is the focus of most testing efforts. Priority chemical contaminants such as fluoride and arsenic are a concern in many countries. However, water chemistry generally becomes a focus only when microbial water quality is well-managed.

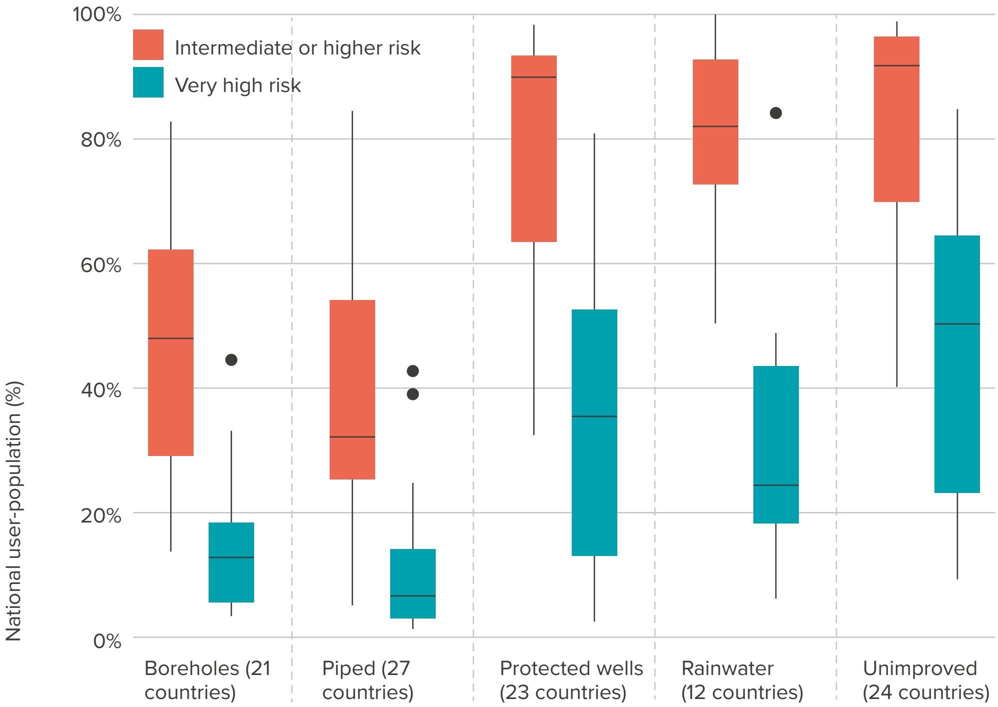


Figure 1: International data on drinking water quality shows that improved water supply technologies often don't provide safe drinking water. The orange box-and-whisker plots show the percentage of national populations that are exposed to faecal contamination across five infrastructure categories, this includes any water sample at the point of collection with 1 or more faecal indicator bacteria per 100mL. The green plots show those exposed to a very high level of faecal contamination risk: samples containing more than 100 faecal indicator bacteria, a smaller proportion of the population but still significant across all infrastructure categories. Source: Bain et al, 2021.

Efforts to extend access to safe drinking water focus primarily on constructing improved infrastructure as defined by the Millennium Development Goals – piped water, boreholes, and protected wells and springs. However, lack of water safety management means that the expected water quality outcomes have not been met. Figure 1 highlights the scale of the problem. A recent study of national monitoring datasets found that faecal contamination was present in piped water supplies for between 5% and 85% of users across 27 low- and middle-income countries. It was even more frequent in boreholes, with a median of almost 50% of users exposed. Faecal contamination was also the norm in rainwater systems and protected wells and springs, which had microbial risk levels that were equivalent to the levels measured in unimproved water supplies. Three countries had exceptionally high percentages of national user-population exposed to a very high level of contamination risk through boreholes (Lao PDR), piped supply (Lao PDR and Sierra Leone), or rainwater (Chad). These countries are represented as outliers in Figure 1.

Lack of access to safe drinking water exerts a substantial health burden, particularly for children. Diarrhoeal diseases remain a leading cause of death in low- and middle-income countries, with lack of access to adequate water estimated to cause 485,000 deaths per year (Prüss-Ustün et al, 2019). In addition to microbial water quality impacts, chemical contamination contributes to chronic health issues ranging from cancer to hypertension (Charles et al, 2019). Children bear the biggest burden due to the impacts of exposure on their growth: ongoing exposure to faecal contamination is linked to stunting and exposure to heavy metals damages cognitive development among other impacts.

Practices to protect water systems and treat water to reduce faecal contamination are well established, and yet are not implemented widely in rural areas. Without the acceleration of drinking water safety management, the world will not meet Sustainable Development Goal (SDG) target 6.1 of universal access to safe and affordable drinking water. Diarrhoeal diseases can be caused even by one drink from an unsafe source, so access to safe drinking water is essential not just at home, but also in the workplace, at school and in all spheres of life. To achieve the reduction in diarrhoea and associated diseases that high-income countries have seen, water supplies in low- and middle-income countries need to be safe as well as reliable, convenient, and affordable to ensure that they are used continuously.

A wide range of treatment interventions have been developed and implemented at different scales to deliver safe drinking water. However, treatment-only interventions have broadly failed to reliably provide safe drinking water due to lack of motivation and resources to sustain the operation and maintenance. While people are willing to pay for increased reliability, they are usually not willing to pay for improvements that reduce water quality risks that are often not readily observed (Hope & Ballon, 2021). Even when water users have access to water quality test results and are willing to pay for water quality improvements, their ability to pay is often constrained as they contend with a wide range of risks (Nowicki et al, 2022). Thus, to achieve better health outcomes, financial support is needed to enable and incentivise regular water quality testing as well as water safety actions to respond to contamination issues.

Rural water safety lags behind

An estimated 69% of the 2 billion people without access to safe drinking water live in rural areas. These areas are characterised by dispersed populations, making networked infrastructure more expensive per capita. Project-based investments commonly opt for small systems such as boreholes with handpumps, but ongoing operation, maintenance, and water safety management are chronically underfunded. Boreholes make use of groundwater reserves to reduce seasonal variability in water supply and to filter out much of the faecal contamination found in surface water. However, while groundwater is usually microbiologically safer than untreated surface water, borehole and handpump systems that aren't managed for quality still frequently fail to provide reliable access to safe water due to both faecal and chemical contamination. Without a single water source that is both convenient and reliable, people access water through multiple water sources and are more likely to include use of unsafe water sources.

The dispersed populations and services in rural areas create challenges for water safety management. Longer travel times to reach water supplies for monitoring and management increase staffing and transport costs. Laboratory services for water quality testing are often not available locally, requiring long travel times and associated costs to access testing. Due to the requirements of speed and cold-storage for accurate microbial testing, use of centralised laboratories is often not feasible. Professionalised service providers can operate fit-for-purpose rural laboratories and maintain field-testing equipment stocks that enable localised testing. Nevertheless, economies of scale and affordability constraints limit the sustainability of testing services without external support. With around 80% of the world's extreme poor living in rural areas (World Bank, 2018), it is critical that financial resources are made available to overcome these challenges and advance water safety management in such contexts.

Regulation of rural water systems is often limited. The challenges of distance and access to appropriate services for testing make it difficult to enforce regulations where the relative cost per user for small systems can become prohibitive. Most potable water quality regulations are designed with the resources and public health risks of large piped water systems in mind. They often require a frequency of testing and a list of parameters that are unrealistic for smaller systems. Countries may lack reliable records of water supply locations in rural areas, and water quality testing during infrastructure installation or in response to outbreak concerns is typically limited and ad-hoc (Aquaya, 2020).

Given the extent of these challenges, it has been widely assumed across the rural water sector that active water safety management is not feasible. Passive approaches involving installation of improved infrastructure have generally been relied upon to ensure safe water supply. As illustrated in Figure 1, this approach is not effective and places the financial and time burden of managing water safety on users who have limited knowledge and/or resources. Small systems serve small populations, so where there is a water safety problem, the impacts remain relatively localised and are less likely to be identified in public health reporting. As a result, risks from single small systems are more difficult to prioritise in public health protection efforts. However, in many countries the majority of the population is served by small systems, especially in rural areas. Thus, it is essential that the collective risks of these systems be managed to advance population health.

Incorporating water safety in professional service delivery models

Increasingly, professional service delivery models are being applied to improve the reliability of rural water supplies; for example, evidence from Kenya demonstrates reductions in the duration of handpump breakdowns from several weeks to less than 2 days (Foster et al, 2022). Professionalised approaches use a combination of proactive maintenance and accountability for rapid repairs, and they create economies of scale by providing services to a portfolio of water supplies. Although this scale is typically not sufficient for full cost-recovery, it nevertheless creates important administrative and operational efficiencies. These principles and activities can be leveraged to support water safety through prevention, monitoring and action in response to water quality threats.

Many professional water service providers already incorporate water safety activities in their models. In 2021, Uptime with REACH undertook a global survey of professional service delivery providers (Nilsson et al, 2021). Across 257 service providers, 98% reported that they are engaged in at least one type of water safety activity, including water source protection, drinking water quality monitoring, reporting water quality issues, and/or treating water. These responses demonstrate that service providers have intent and capacity to undertake water safety activities, to varying degrees. However, as illustrated in Figure 2, not all service providers engaged in all activities.

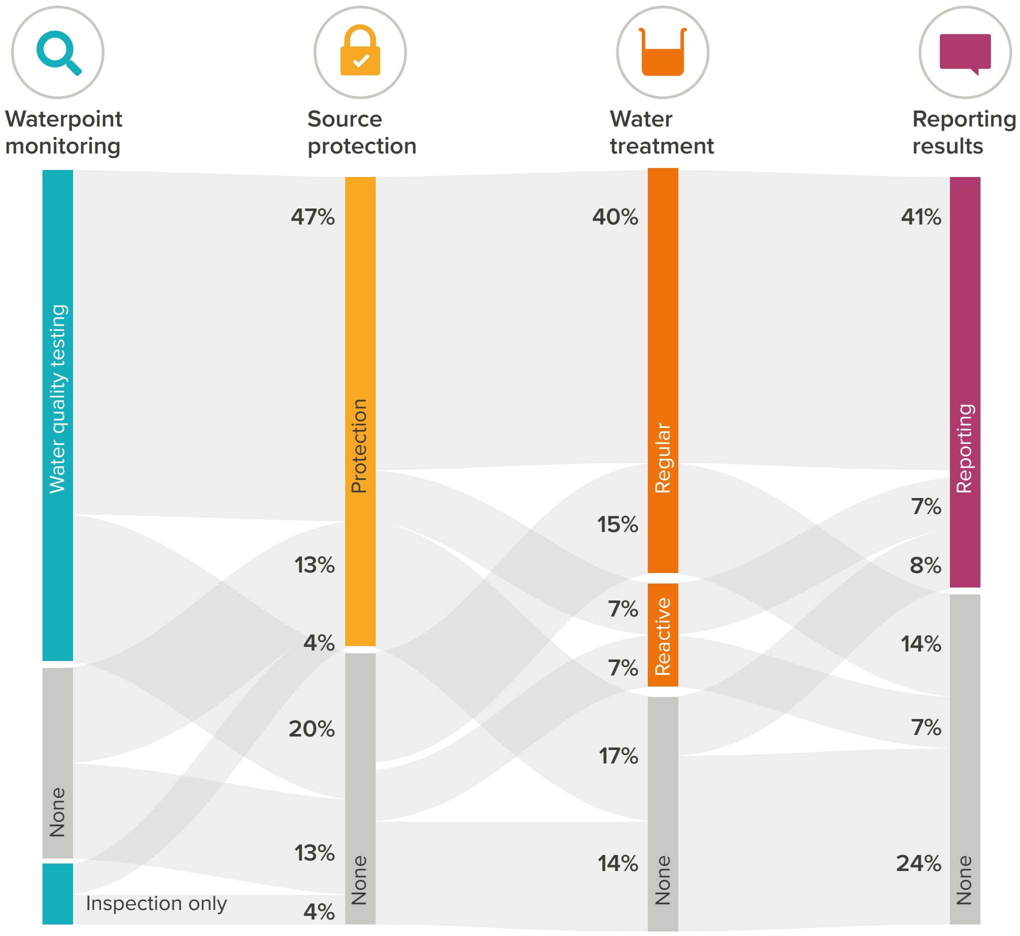


Figure 2: Water safety activities among service providers are common but not consistent: Waterpoint safety activities reported by 257 service providers across the world. Source: Nilsson et al, 2021.

There is no standard or common approach for incorporating water safety in professional service provision models. Service providers typically develop their own approach, which varies depending on whether they build or adopt water supply infrastructure. In the 2021 global survey, only a third of the service providers reported doing all types of water safety activities (Figure 2). There is a need to provide effective guidance for incorporating water safety in professional service delivery models. This guidance must recognise the variety of service arrangements and challenges arising from varying local contexts. In 2023, the World Health Organization (WHO) is releasing revised Guidelines for drinking-water quality: small water supplies, which will include professionally managed services for the first time. This working paper sets out a framework for water safety management that aligns with the new international guidance and can mobilise funding to support service providers in advancing their water safety activities.

Box 1: Service delivery arrangements, origin of infrastructure, and water safety

Water safety approaches vary depending on service delivery arrangements and origins of infrastructure:

1. **Build**: service providers that design, build, and operate new water infrastructure can select a high-quality water source and incorporate source protection and treatment steps that address water safety risks.
2. **Adopt**: service providers that assume responsibility for existing water infrastructure may be able to address some prioritised water safety risks through rehabilitation or operational adjustments, but source water quality and options for implementing treatment will be constrained.

Photos show water service providers repairing handpumps.

Risk-based approaches to delivering safe drinking water services

Risk-based approaches that consider health outcomes to prioritise resources are globally recognised as best practice for managing drinking water safety. The water safety plan methodology incorporates principles from international standards of risk management: assessing risks, prioritising management of risks, recording and reporting risk assessment, and taking management actions. Risk management is oriented around continuous improvement, recognising the need to prioritise actions that address the greatest risks within the available resources, and requiring management to evolve as priorities change over time in response to changing risks and improving understanding of risks. It is important to differentiate drinking water quality test results, or the quality of water delivered from a waterpoint as measured at a single point in time, from the wider approach to water safety that proactively manages risks to ensure users have consistent access to hazard-free water (Charles et al, 2021).

Water safety planning approaches were developed for large piped utilities, but have been adapted to a variety of contexts that incorporate different types of small water supplies including community managed supplies. These adaptations adhere to the same risk-based principles while recognising important differences in the level of resources and capacity that are typically available. Water safety planning approaches for large utility systems include extensive water quality assessments and climate change adaptation measures. For community managed supplies, water safety plans are often focused solely on localised hygiene issues that can be managed through education in the absence of water quality data and limited financial resources. In contrast to stand-alone community managed supplies, professional service providers work with a collection of small water supplies at a scale that allows for pooling of resources and capacity. Water safety actions can therefore be prioritised based on a larger service population.

04 21 16	**Assessed**	Waterpoint / system has a low sanitary risk. Water quality monitoring is up to date.
04	**Reported**	Relevant authorities and community leadership are informed of water safety status.
04	**Managed**	Good water safety status is maintained.

Figure 3: Key risk assessment domains applied to rural water management activities undertaken by professionalised service providers.

In this working paper, we adapt water safety plans to professional service provision models considering key domains of assessing, reporting, and managing risks (Figure 3). In addition to the core activities that ensure reliability of water supplies, service providers can implement sanitary inspections and water quality monitoring to assess water safety risks, report these to communities and authorities, and take proactive and strategic actions to improve safety. Drinking water testing identifies when users have been exposed. Test results are to verify that a water system is working effectively, not as the sole mechanism to identify risks.

Service providers can prioritise remedial actions across their area of operation to address risks identified by both sanitary inspections and water quality testing. Remedial actions might include repairs and maintenance to improve the protection of the water supply, disinfection of the water supply, or other forms of water treatment. Reporting water safety status to community leadership and the government ensures transparency and accountability and is a key part of risk-based management approaches. This has the advantage of enabling service providers to demonstrate the work that they are doing and their successes in improving access to safe drinking water. Reporting helps generate investment to further address priority risks.

Box 2: Water safety terms

- Sanitary inspections: visual checklists of infrastructure-related hazards such as fencing, water pooling, and cleanliness focused on microbiological hazards. These provide clear guidance for actions needed to improve protection of water supplies and improve water safety. Standard protocols and guidance on actions are available from WHO (see Box 3).

- Water safety plans: risk-based approach to management and continuous improvement of water safety. These address the quantity of supplied water meeting microbiological, organoleptic, and chemical quality thresholds, prioritising actions to address the most important water safety risks first.

Understanding threats to drinking water safety

An extensive international knowledge-base on drinking water safety threats has helped inform the design of the approach described in this working paper. In this section we explore three types of drinking water quality – microbiological, chemical, and organoleptic – considering a range of issues that relate to the risk-based domains of the approach:

- Assessment: What is the nature of the human health threat? How does it vary spatially and temporally? Are there appropriate guidelines to apply? Are laboratory services available?
- Reporting: Availability of reporting guidance and consideration of reporting objectives, with attention to community and political sensitivities.
- Management: Availability and applicability of management responses, including considerations of community acceptance.

Microbiological contamination is the most critical issue from a health perspective. It causes acute health impacts, is relevant to all drinking water supplies globally, and is associated with well-understood remedial actions. The WHO Guidelines for drinking-water quality specify that no faecal indicator bacteria should be detectable in 100mL. This guidance has been widely adopted by governments, so 0 faecal indicator bacteria / 100mL can be considered a standard and appropriate target for safe water management. The wide application of this guideline also means that testing capacity is generally available either through accredited laboratories, through technology to set up local laboratories, or through appropriate field kits. These latter two are particularly important because the speed of sample processing is a key factor in data accuracy, since bacteria populations can grow or die-off in storage at a rapid rate. It is important that water samples are kept cool and processed within six hours of collection, which can limit the feasibility of using centralised laboratories due to the transport distances involved.

E. coli is the most widely used indicator of faecal contamination, and is the indicator that is most specific to faecal contamination. Nevertheless, we must recognise that *E. coli* is not representative of all types of microorganisms that pose a threat to human health. Notably, *Cryptosporidium*, a leading cause of diarrhoeal disease in children in low- and middle-income countries, is a more robust organism that survives longer than *E. coli* in the environment and is largely resistant to chlorination. Viruses, being smaller than *E. coli*, are more mobile in soil and aquifer matrices, and in filtration systems, travelling farther than bacteria. Opportunistic pathogens may also colonise biofilms in water systems. These microorganisms can be present in the absence of *E. coli* or other faecal indicator bacteria, posing a particular risk to immunocompromised people. On the other hand, *E. coli* itself can colonise biofilms and can grow in water, soil, sediment, and vegetal environments, so its presence is not always indicative of recent faecal contamination (Nowicki et al, 2021).

Understanding microbiological risks requires understanding the drivers of water quality variability. Microbiological risks can change rapidly, especially in response to rainfall or changes in temperature. Seasonal patterns are common where there are clear annual patterns, such as in monsoonal climates. Such patterns can be less prominent in areas where rainfall is more spatially sporadic. Local factors like waterpoint type and sanitary conditions are also important drivers of variability. For example, in rural Kitui county in Kenya, open wells and earth dam reservoirs are consistently contaminated, but there is high variability in *E. coli* measurements from piped supplies, handpumps, and tanks with a mix of rainwater and groundwater (Figure 4).

Figure 4: Heatmap of monthly *E. coli* results from monitoring of 79 water supply points in Kitui County, Kenya in 2019-20 highlighting variability in the quality of water. The risk categories for the *E. coli* results reflect guidance from the WHO: low (<1 MPN/100 mL), intermediate (1–10 MPN/100 mL), high (11–100 MPN/100 mL), very high (101–1000 MPN/100 mL), and highest (>1000 MPN/100 mL). White squares indicate missing measurements when samples were not taken. Data from Nowicki et al. (2022).

While a waterpoint may have no faecal contamination at one point in time, global evidence demonstrates that changes in contamination are likely (Figure 5) (Charles et al, 2022), necessitating management to address risks. Programmes to manage water safety should be designed with consideration of variability and the limitations of *E. coli* as an indicator. Sanitary inspections and operation and maintenance protocols can help to proactively identify pathways and causes of contamination from damage to infrastructure and environmental issues and can support protection of water systems. Operational monitoring, such as for turbidity, residual chlorine, or user reports of changes in colour or taste, should be used to improve understanding of the system and allow prioritisation of rapid actions for systems where water quality has changed.

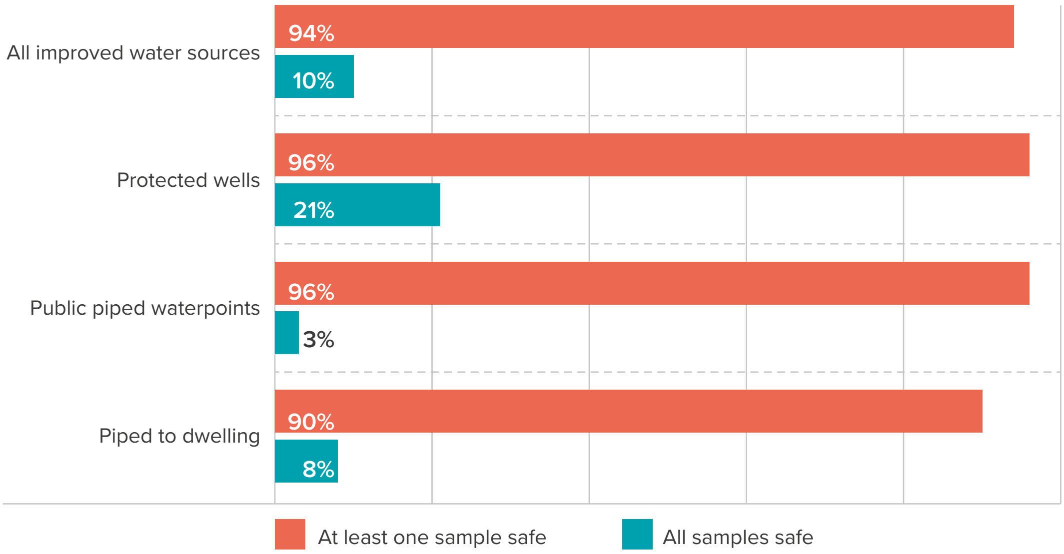


Figure 5: Sampling across multiple seasons from 3,207 waterpoints in Bangladesh, Nepal, and Tanzania demonstrated the variability in water quality, with only 10% of improved water sources delivering water that was consistently free from *E. coli*. Based on data from Charles et al (2022).

Although approaches to managing microbiological contamination are well-understood, availability of quality products and materials through local supply chains in rural areas is often lacking. A multi-barrier approach is recommended to ensure water safety, with activities ranging from addressing risks identified in sanitary inspections to implementing disinfection-based treatment. There is also good availability of materials and training to support communication about microbiological contamination, with hygiene education commonly focusing on the risks of microbial contamination in drinking-water and household environments more broadly.

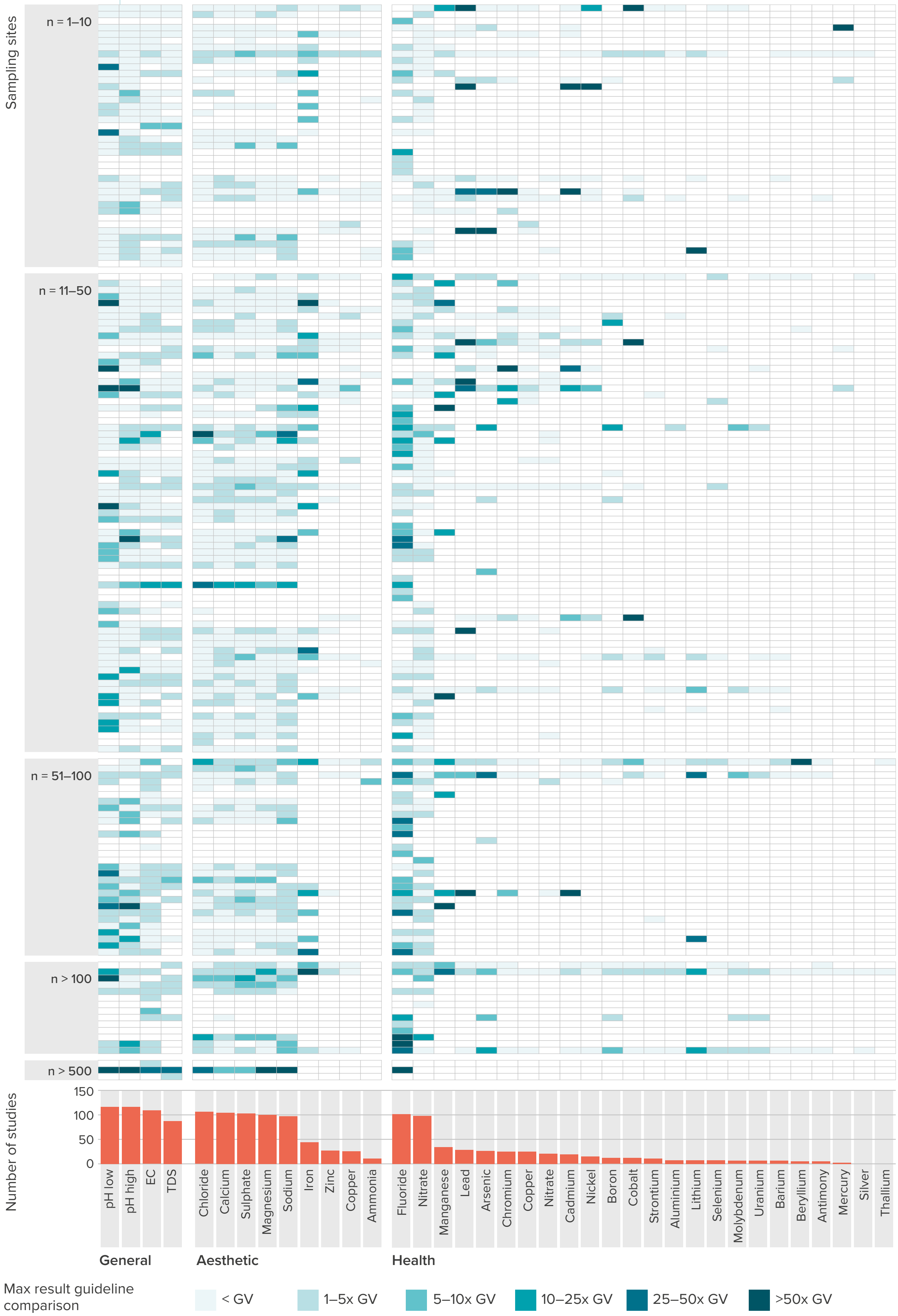
Service providers may need to consider how best to communicate about their water safety management activities to ensure communities recognise the benefits for their health and do not become suspicious of the water service. This is particularly relevant where community attitudes to certain treatment technologies exist, for example dislike of the taste of chlorine or beliefs that certain water treatments lead to infertility.

Chemical contamination, from geogenic (from the soil or rock), biological (for example, from algal blooms), or anthropogenic sources, poses more challenges for risk management due to the wide range of potential parameters of concern. Chemical parameters have different patterns of spatial and temporal variability, and management is often hindered by limitations in testing availability and difficulties in mitigating pollution and providing effective treatment. The health risks to users are usually secondary to microbiological threats because chemical contamination of water is generally at concentrations that present health risks only with consumption over long timescales. In this case, one drink of contaminated water is not the hazard, but rather the aim is to avoid continuous consumption, especially during key developmental stages in pregnancy and childhood. Chemistry remains an important and often overlooked health threat where improved infrastructure is assumed to provide 'safe' drinking water: for example, a review of groundwater quality research representing 8,665 water sources in Ethiopia and Kenya found that only six studies (4%) reported no chemical contamination above guidelines levels (Figure 6) (Nowicki et al, 2023).

The drivers of water chemistry variability depend on the source of the hazards. Geogenic contaminants will typically have more consistent levels of contamination than microbiological parameters, although weather-driven dilution and concentration effects are still relevant especially for water sources that are influenced by fast recharge rates and short water residence times. Additionally, chemical contamination will change over the lifetime of a water system due to environmental changes and breakdown of infrastructure. Professionally managed services offer the opportunity to aggregate water chemistry data at scale across the area of operation, allowing the frequency of sampling at any one waterpoint to be reduced.

Assessing water chemistry risks should be a priority before designing long-term monitoring and management programmes. This is due to the wide range of potential parameters of concern and the availability and cost of testing for specific parameters, especially if laboratories are not locally available. Many chemical parameters have minimal degradation when samples are stored correctly, so samples can be sent for analysis at centralised laboratories. There are exceptions, however: more complex chemicals, including some pesticides and pharmaceutically active compounds, will degrade more quickly and require more timely and specialised analysis. These compounds are particularly difficult to assess because many areas will not have timely access to laboratories that are equipped to measure them. Field methods have not been developed for these challenging compounds, but they are readily available for key operational parameters, such as electrical conductivity (EC) and turbidity, which can be indicative of general water quality patterns. Field methods for these operational parameters provide good accuracy if instruments are calibrated regularly. Colorimetric test kits are also useful for operational monitoring such as for measuring chlorine residuals. Field kits also exist for some parameters of health concern such as lead, arsenic, and fluoride, although accuracy and ease-of-use is more limited.

Figure 6 (next page): Chemical contamination in groundwater is common. The heatmap shows the frequency of studies reporting exceedance of general, aesthetic, and health-related water chemistry guidelines. 160 studies of groundwater quality in Ethiopia and Kenya were included. Comparison was made to national standards from Kenya and Ethiopia or international guidelines from the WHO when national standards are not available. Data from Nowicki et al (2023).


Sampling sites
n = 1–10
n = 11–50
n = 51–100
n > 100
n > 500
Number of studies
150
100
50
0
pH low
pH high
EC
TDS
Chloride
Calcium
Sulphate
Magnesium
Sodium
Iron
Zinc
Copper
Ammonia
Fluoride
Nitrate
Manganese
Lead
Arsenic
Chromium
Copper
Nitrate
Cadmium
Nickel
Boron
Cobalt
Strontium
Aluminium
Lithium
Selenium
Molybdenum
Uranium
Barium
Beryllium
Antimony
Mercury
Silver
Thallium
General
Aesthetic
Health
Max result guideline comparison
< GV
1–5x GV
5–10x GV
10–25x GV
25–50x GV
>50x GV

Due to the broad range of potential water chemistry risks, management responses are varied. Most treatment methods will only remove a fraction of chemical contamination, so multiple stages may be needed in treatment systems where high levels are present. Reverse osmosis treatment can provide effective removal of many chemicals, but it is energy intensive and it creates a more concentrated waste stream that needs to be carefully managed to avoid increasing local pollution. Due to the chronic nature of chemical contamination, a risk-based approach can be used to identify and prioritise water chemistry management responses over time.

Reporting of water chemistry and public health messaging can be complex and politically-influenced due to perceived responsibilities for water quality and public perceptions of risk. Before starting water quality testing, service providers may wish to consider early public health messaging, possibly in partnership with the government, to raise awareness of the need for testing and the potential responses. When reporting chemistry results, it is important to contextualise the risk in relation to microbial risks so that water users are not unintentionally encouraged to choose faecally-contaminated alternative sources.

Organoleptic issues. Anything that changes the taste, smell or appearance of water can affect the way people use water for different purposes, like drinking, cooking, laundry, or otherwise. Common organoleptic issues include turbidity, salinity, iron, and other chemical parameters. Organoleptic concerns may not represent a direct health risk, but nevertheless impact health indirectly by reducing the consistent use of otherwise safe water. For example, a person increases their risk from diarrhoeal disease if they choose to drink water from an unprotected dug well instead of a protected borehole because they do not like the mineralised taste of the groundwater. In other cases, organoleptic parameters may be directly associated with health risks. Turbidity can be useful as an operational indicator of a change in water quality that may signal an increase in health risk, as increases in turbidity can indicate surface water intrusion with increased pathogen load. Organoleptic parameters can also have an impact on the effectiveness of water treatment processes. For example, high turbidity water must be filtered or otherwise clarified before it can be effectively disinfected, and iron will increase chlorine demand requiring higher doses for effective disinfection.

Since water users are aware of organoleptic issues, reporting test results for these parameters will generally not be contentious. Local guidelines may differ from WHO guidance so reporting should be well-contextualised. Some governments may object to summarised reports that show widespread organoleptic failings across many water supplies, and the sensitivity of such information should be handled with consideration of political motivations.

Recognising barriers to advancing water safety

The approach that we present in this working paper has been developed in consultation with professional service providers, and it is based on collaborative research and practice. It is designed with recognition of the barriers that service providers face in advancing water safety. The water safety approach aims to set targets that are realistic in the challenging environments in which service providers operate.

We have focused on measurements that can foster a water safety culture that prioritises protecting and responding to water quality risks. We have not prioritised measurement of health outcomes because poor baseline data and the multiple sources of contamination that people are exposed to will confound attempts to directly link achievements in water safety with changes in community health outcomes. To establish this link would require a scale of evaluation that is infeasible and inappropriate for water service providers to implement.

Many of the barriers to advancing water safety have already been explored. They are briefly outlined here:

Access to materials and testing. Supply chain interruptions for materials that enable water treatment, monitoring, and efficient processing of samples submitted to laboratories are common barriers to expansion of water safety activities.

Capacity to respond in a timely manner. Service providers that use a circuit rider approach to work in areas with great distances or difficult travelling conditions may find it challenging to respond to water safety issues quickly since mechanics may have moved on before test results are available.

Processes and culture for sharing data. If water safety information is not already publicly shared, increasing water quality monitoring and communication may affect relationships with water users, managers, and government (Nowicki et al, 2020). Additionally, the lack of regulation may mean that governments are not ready to accept data for rural water systems.

Culture of continuous improvement. For water safety to advance, a culture of continuous improvement that encourages learning from evidence to deliver improvements in policy and practice is needed. This approach is reflected in the WHO guidelines, and it must be adopted across the rural water sector from management to regulation. A narrow focus on meeting unrealistic water quality targets will not motivate testing and assessment activities.

A framework for protected and reliable drinking water services

Uptime has designed and implemented contracts for results-based payments that incentivise reliability of water services through standardised volume and revenue metrics (McNicholl et al, 2021). The aim of this document is to explore how new metrics can be integrated into the contract design to further incentivise water safety actions by service providers. The approach is informed by a framework that considers aspects of reliability, protection, volume, quality, and revenue (Figure 7). It aims to ensure that results-based payments reflect reliable water services where water safety has been protected through monitoring and active management. The framework and corresponding results-based payment structure have been designed in accordance with the principles outlined below.

Figure 7: **A results-based framework for protected and reliable drinking water services.**

Improving drinking water safety. There are a large number of pathogens and chemicals that can contaminate drinking water, posing a risk to the health of the consumer. High cost and limited availability of testing facilities may prevent comprehensive monitoring and management of all contaminants in many rural contexts. However, the priority risks are well established. Testing water quality is important, but it is not enough if actions aren't taken to improve water safety. The approach is designed to focus on improving drinking water safety, prioritising the greatest risks and supporting continuous improvement to work towards safer water supplies. While there are a range of ways to define 'safe drinking water', including focusing only on faecal contamination, we avoid using that term as an outcome. The target here is to provide water of 'good water safety' status, focusing firstly on the immediate risks from faecal contamination, but recognising the chronic risks from chemical contamination.

Incentivising action. Water safety is improved through management actions. Water quality will change with weather, with degradation of infrastructure, and with changes in the local environment. The framework design focuses on incentivising actions to help water service providers identify and act on changes in water quality. This approach recognises that water safety issues are dynamic and ubiquitous, so the design focuses on actions taken – to assess water quality, to share information on the water safety status, and to respond when threats are identified.

Learning through data. Water quality data are often scarce for rural water supplies, limiting the evidence on which to base decisions at the local level and at the national level. Collation of water quality monitoring data over time and across systems can provide important information to help learn about trends and threats to water safety. Collecting and collating water quality data may help providers understand patterns of risk, whether these be related to seasons, operations, infrastructure, or otherwise. Better understanding of risks can inform proactive actions. For example, in Bangladesh, collation of data from testing of 176 small water systems highlighted frequent detection of *E. coli* in rainwater harvesting tanks, leading to the implementation of chlorination. At the national level, sharing data with government authorities helps them to plan strategic support for small drinking water systems such as through understanding where chemical contamination is a concern, and what infrastructure and management practices are more or less appropriate in different settings.

Building confidence. Collecting data on water safety and reporting via Uptime can help to build investor confidence that water safety is being addressed. Sharing data with the government and with communities can improve their confidence in the water supply and in the service provider. Data from different seasons may help to encourage use of single sources year-round, increasing the financial sustainability of those systems and reducing psychosocial distress and maladaptive coping mechanisms within the community.

This approach aims to incentivise water safety behaviours, but it does not aim to be a comprehensive regulation system for water service providers. Uptime's contracted service providers are already implementing many water safety measures. This approach seeks to standardise a minimum level of water safety actions, and recognises many providers will exceed this. The framework does not replace national requirements and it remains the responsibility of the service provider to meet national regulations.

In the rest of this working paper we set out a results-based payments structure which is oriented around these principles of improving drinking water safety, incentivising action, learning through data, and building confidence.

Structuring results-based payments for water safety

The results-based payment structure for water safety builds on three key domains of water safety plans: (1) assessing and understanding water safety risks, (2) reporting risks and actions to community leadership and to the government, and (3) prioritising management activities to address the greatest risks on appropriate time scales. Incentive payments are organised, as presented in Figure 8, in line with Uptime's existing results-based payment structure to provide:

- **an assessment and reporting incentive** to ensure a minimum amount of revenue to cover costs of delivering water safety services, dependent on satisfactory achievement of assessment and reporting activities, and
- **a management incentive** to encourage safer drinking water services, dependent on satisfactory achievement and maintenance of good water safety status (as defined in Table 5).

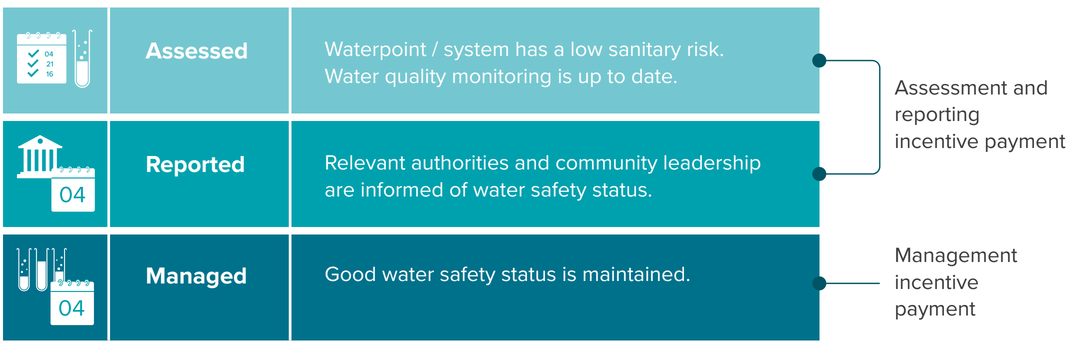


Figure 8: Water safety domains are aligned with tiered incentive payments.

In this section, we set out the details of the measures for the three domains of assessed, reported, and managed. We then summarise the associated reporting and auditing metrics and further expand on the payment conditions.

Assessed

	Assessed	Waterpoint / system has a low sanitary risk. Water quality testing is up to date.

The first step towards unlocking an incentive payment for each waterpoint is to complete water safety assessment tasks and ensure that the infrastructure is appropriate to provide safe drinking water. Waterpoints that have (a) a sanitary inspection that confirms a low-risk score, and (b) the required water quality tests completed within the required timeframe will satisfy the 'assessed' criteria. The frequency and type of tests specified for the purpose of results-based contracting presented here focus on verification of performance and incentivising continuous improvement. These do not replace national requirements and it remains the responsibility of the service provider to meet national regulations.

Sanitary inspections

Sanitary Inspections (SI) provide a standardised method to assess if water supply infrastructure is capable of providing safe water. SIs involve a checklist that can be completed quickly in routine visits. The checklists prompt examination of the integrity of the infrastructure and the hygiene of the area. SIs are more effective if they are undertaken regularly throughout the year to capture risks that can change rapidly, such as from damage to the infrastructure that may not otherwise affect reliability, and also seasonal changes as some risks are easier to identify after rain. SIs are done using standardised forms provided by the WHO. WHO SI packages also provide suggestions of appropriate remedial action for any hazard identified.

To qualify for an assessment and reporting incentive payment, a water supply must have low risk status. Achieving low risk status may require that the service provider undertake repairs and improvements to support water safety as well as reliability. Some activities may also require community engagement, such as waste management near the waterpoint. The remaining risks represent potential threats to water safety which the service provider may want to prioritise for action.

Here, we define low-risk status as a maximum of two hazards present for any SI. Handpumps should have at least twice-yearly low-risk SI results to meet the 'assessed' criteria. At least twice-yearly inspection, as part of operation and maintenance visits or water quality sampling visits, is intended to capture seasonal variability and potential changes in the infrastructure and environment that may contribute to contamination of the water.

For piped systems, separate SIs are needed for different components such as water sources, storage tanks, piped networks, and kiosks or taps. To achieve low-risk status for a waterpoint in a piped system, SIs for each of the separate components serving that waterpoint can have a maximum of two hazards present. The frequency of inspection differs between the piped network system as a whole (annual) and the water collection points (quarterly):

- For a piped system as a whole, the SIs for ground or surface water sources, piped networks, and storage tanks should be completed annually. These component inspections may occur over multiple visits across the year with all sections assessed within the year. Key risks being assessed are pipe leakages and breakages, and integrity and condition of storage structures.
- For piped system water collection points, the 'assessed' criteria differentiate between community collection points and individual household taps. Public community water collection points, including kiosks and tap stands, should be inspected quarterly.
- Privately owned taps which are not the responsibility of the service provider do not need to be included in the SIs. For taps that the service provider is responsible for but which serve a single household, at least 2.5% of the total number of taps in a system should be randomly selected on a rotating basis for quarterly inspection. For household taps, most of the potential hazards in the SI checklist are predominantly related to household hygiene arrangements and practices, which the service provider can encourage but not mandate. Thus, in these cases, eligibility for the assessment and reporting incentive payment is based only on the infrastructure-based SI checklist items that are within the control of the service provider. Service providers are encouraged to share the SI resources with households to encourage good water point hygiene.

Table 1: Minimum proposed frequencies for sanitary inspections by infrastructure type

Infrastructure type	Sanitary inspections frequency
Handpump	semi-annually
Piped scheme	
per source	annually
per storage tank site	annually
per distribution network	annually
per public collection point (kiosk, tap stand)	quarterly
per 2.5% of household connections	quarterly*
	*exempt if management responsibility is delegated to the household

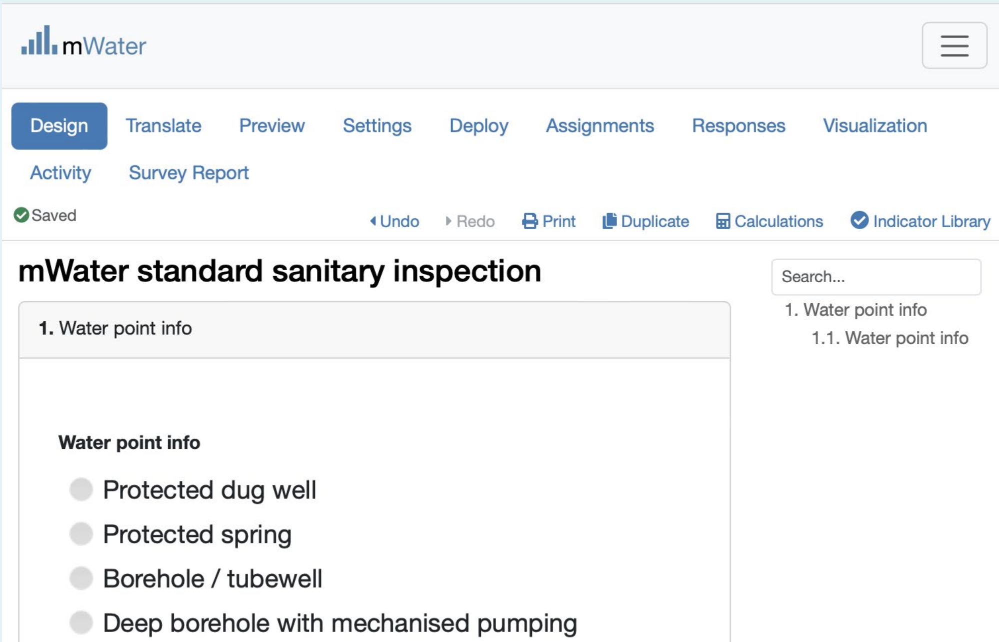
Box 3: Sanitary inspection forms

The WHO has developed updated sanitary inspection forms and management information sheets that cover a wider range of water systems.[1]

- Dug well with a handpump
- Dug well with windlass
- Tubewell with a handpump
- Borehole with a motorised pump
- Spring
- Rainwater collection and storage
- Piped distribution – Storage tank
- Piped distribution – Network
- Piped distribution – Tap stand
- Kiosk
- Filling station and cart
- Surface water source and intake
- Household practices

Box 4: Using digital tools for collecting and managing sanitary inspection data

Digital tools are available to support collection and management of sanitary inspection data. The mWater platform (**www.mwater.co**), for example, includes generic sanitary inspection surveys that are based on WHO guidance. These surveys can be used directly or can be modified for local context, which is recommended by the WHO. The mWater platform is free to access and the surveys and datasets can be used on smart-phones, tablets, and computers. mWater provides users with options to contribute data to public databases and it can facilitate data reporting to specific recipients.



1 Full updated versions will be released in 2023. Available versions from the WHO website.

Water quality testing

Water quality testing under the approach aims to verify that water systems are providing safe drinking water and that the protections and treatment processes that have been put in place to safeguard the system are effective. The frequency and methods of testing varies for microbiological and chemical parameters because the risks vary over different scales. These are dealt with separately here. The requirement to qualify for an assessment and reporting incentive payment is that testing is up to date as part of the broader monitoring programme, with the required tests completed. The assessment and reporting incentive payment is not dependent on the results of the tests.

Microbiological

All water systems should be monitored for *E. coli*, which is the preferred indicator in the WHO Guidelines for drinking-water quality (WHO, 2011). *E. coli* are the most specific indicator of faecal contamination. They are a subset of the group of coliforms called thermotolerant (faecal) coliforms. This larger group also includes bacteria that are weakly associated with faecal contamination. Thermotolerant coliforms will be detected more frequently, but since they are less specific to faecal contamination, they will not accurately reflect risk and using them as indicators can trigger unnecessary concerns and lead to less effective prioritisation of actions. For example, in one study in Bangladesh, thermotolerant coliforms were detected in more than twice as many systems as *E. coli* (Mahmud et al, 2019). Due to the seasonality in faecal contamination risks, *E. coli* testing is best done at multiple times per year in different seasons.

For handpumps, *E. coli* should be tested at least two times per year in different seasons for each handpump.

For piped water, *E. coli* should be tested quarterly from water access points in different seasons. Sampling points include, as a minimum:

- an access point close to the source,
- an access point after any storage tank, and
- at least one access distal point toward the end of the distribution network. In multi-directional piped networks that have multiple end-point taps, the selection of the end-point sampling location should be rotated.

Table 2: Minimum proposed frequencies for *E. coli* testing by infrastructure type

Infrastructure type	*E. coli* testing frequency
Handpump	semi-annually
Piped scheme	
access point close to source	quarterly
access point after each storage tank site	quarterly
one distribution point per 5,000 water users	quarterly

Sampling from boreholes or storage tanks can introduce water quality risks unless there is a readily available sampling tap or appropriate T-junction; where adequate sampling points aren't available the next accessible point can be used. The number of sampling locations per quarter is intended to reflect the population served and the number of storage tanks within the system. For a system with one tank, a minimum of three sampling locations per quarter per 5,000 water users is appropriate.

Routine sampling should not be undertaken immediately after a repair or other intervention to the system that may impact on water quality as these results are not likely to be representative. However, additional sampling after repair and maintenance works is encouraged to understand how water quality risks introduced by these inventions can be mitigated (for example, through shock chlorination or temporary advisories to water users).

The use of standard sampling and testing methods is required to be eligible for the assessment and reporting incentive payment. This includes disinfecting taps and handpump spouts, either by flaming or wiping with alcohol, and then flushing them before sampling so that samples reflect the safety of the water supply and are not influenced by local hygiene issues at the collection point. Standard methods instruct that samplers disinfect their hands before collecting samples and that samples be collected in sterile containers. The WHO guideline of no detectable *E. coli* in 100mL is widely adopted internationally and is practical in all situations. The range of methods available that are suitable for use are outlined in Table 3, with more detail available in Bain et al, 2012. The list can be updated to reflect the most reliable and cost-effective options as new methods emerge to analyse *E. coli* more rapidly and inexpensively, and as alternative microbial risk indicators are developed.

Table 3: Summary of *E. coli* testing methods.

Method	Pros	Cons
Membrane filtration for colony-forming unit approach e.g. Compact dry *E. Coli*, m-Coliblue	Inexpensive options available including mixing and sterilising growth medium on-site Low plastic consumables waste options available High upper detection limit with serial dilution High accuracy with experienced technicians	Relatively slow and labour intensive Quality of results depends on technician technique and interpretation experience Strongly impacted by turbidity, possibly requiring pre-processing of samples in some settings Consistent power-supply often required for incubation over a 24-48-hour period
Multiple compartment tests for most probable number approach e.g. IDEXX Quantitray with Colilert, Aquagenx Compartment Bag Test (CBT)	Easy to use and robust to technician error Not labour intensive Range of upper detection limits available based on the number of compartments in the test Options for ambient temperature incubation in warm settings (Aquagenx CBT) Options for 18-hour incubation turn-around (IDEXX Colilert-18) Less sensitive to sample turbidity than membrane filtration methods	Results are statistically derived estimates High amount of plastic consumables waste Relatively expensive cost per test Consistent power-supply often required for incubation over an 18-48-hour period
Drop plate approach e.g. Petrifilm	Few consumables, light and easy to transport Quick sample processing time Only requires small sample volumes	Processes small volumes (1ml samples) so results must be multiplied Consistent power-supply often required for incubation over a 24-48-hour period Quality of results depends on technician technique and interpretation experience
Presence / absence approach e.g Colilert	Easy to use Not labour intensive Options for 18-hour incubation turn-around (IDEXX Colilert-18)	No range in results Consistent power-supply often required for incubation an 18-48-hour period

Service providers may also conduct operational monitoring such as for pH, temperature, electrical conductivity, turbidity, and chlorine residual. Physicochemical operational parameters are best measured on-site and fit-for-purpose local laboratories can support maintenance and calibration of the necessary sampling equipment. Operational monitoring can provide timely information on changes in the water system to help inform management of issues that may inform operational adjustments or require further investigation. These operational monitoring data (with the exception of electrical conductivity, see below) is not required for incentive payments but is useful for auditing water safety activities of the service provider.

Box 5: Choosing a laboratory or setting one up?

There are different factors to consider when deciding where to submit water quality samples for analysis. Three options are highlighted here:

- field tests that can be rapidly deployed at the waterpoint such as dipsticks tests and probes;
- accredited, centralised laboratories, such as national reference laboratories, that provide high-spec instrumentation for a wide range of analyses;
- fit-for-purpose laboratories operated by the service provider to enable targeted testing specific to their needs.

For microbiological (*E. coli*) testing, samples should be stored on ice and analysed within six hours. Additionally, because of the immediate threat to health, quick and reliable results are needed to ensure actions can be taken rapidly. Methods, including field tests, are described in Table 3. Due to the issues of distance to accredited laboratories and capacity to deliver quick results, SafePani and FundiFix have developed fit-for-purpose laboratories to test for *E. coli*, using IDEXX QuantitrayTM and membrane filtration methods, respectively. These laboratories are located in the service provider area of operations, ensuring samples are processed within six hours, and that results are available the next day.

For analysis to identify water chemistry risks, samples can generally be stored, transported and analysed over longer timescales as most of the parameters of interest are relatively stable and usually will not represent an immediate threat to health. For these tests, accredited laboratories are recommended for access to equipment that can analyse a wide range of parameters to a sufficient standard of accuracy and precision. Routine analysis also helps to improve capacity within accredited laboratories. Fit-for-purpose laboratories can be developed; however, the cost of equipment is often prohibitive. Water Mission uses a combination of in-house tests for regular monitoring and certified laboratory tests to provide quality assurance. FundiFix carried out an initial chemistry assessment phase using a fluoride ion selective electrode probe in their fit-for-purpose lab, and sending samples to research and commercial laboratories to verify the probe results and for other chemistry measures.

Field tests for trace element contaminants like arsenic or selenium are not considered appropriate for risk assessment within the water safety approach described in this working paper because the tests that are currently available are not sufficiently sensitive. Field tests can be considered in the future when they can produce results that are useful for reliable assessment against drinking water standards.

Operational sampling, such as for turbidity, chlorine residual, or electrical conductivity, is often done effectively with field tests and probes supported by fit-for-purpose laboratories.

For each type of analysis method, it is important to implement Quality Assurance and Analytical Quality Control (QA/AQC) to ensure consistency and confidence in the results. For every 10 samples analysed, it is standard to conduct blank and duplicate samples, with results used to ensure reliability.

- **Blanks**: Standard methods instruct that *E. coli* blanks be conducted using sterile water or a reliable form of bottled drinking water. Distilled water and deionised water are acidic when in equilibrium with the air, so they are not appropriate for *E. coli* test methods. It is a good idea to conduct both field blanks and laboratory blanks. Field blank samples are prepared in the field in the same manner as a regular sample. Lab blanks are prepared in the lab. The blank samples provide a negative control and can help identify any cross-contamination issues that may be occurring during sample collection in the field or during processing of the samples in the lab.
- **Duplicates**: A duplicate sample is taken immediately after a primary sample. It provides information on replicability of results. For fit-for-purpose laboratories or field tests, accredited laboratories may also be used for duplicate samples to verify a small set of results on an annual basis where practicable.

Chemical

Risks from chemical contaminants will vary depending on geology, water system materials, and pollution sources. Addressing chemical risks may involve installation of treatment systems, improving source protection, replacing infrastructure, or selecting a new water source. Since these actions typically occur over longer timescales than for addressing microbial risks, and since water chemistry health threats are usually not acute, less frequent monitoring is recommended than for microbiological parameters. The requirement adopted for the water safety approach aims to assess the risks from chemical contamination, prioritised based on information on global prevalence, and encourage awareness of chemical water quality concerns. It recognises that there may be long lists of potential chemical contaminants included in appropriate regulations, and seeks to encourage a continuous improvement approach to develop understanding of chemical water quality concerns over time. This approach recognises financial limitations and supports prioritising risks based on health concerns, to advance towards a high level of water safety. It aims to provide recognition of service providers that have completed full water quality assessments when building or rehabilitating the infrastructure that they manage. The approach may also provide a platform to accelerate chemical water quality monitoring.

The costs of monitoring chemical water quality include equipment maintenance and calibration, vehicle costs, shipping costs, laboratory costs, and staff costs, and may vary depending on local laboratory capacity or testing approaches. Recognising the cost and the longer timescales for action, the monitoring programme for chemicals requires each system to be assessed once over a three-year period for a limited number of chemicals. Table 4 indicates the priorities for water chemistry analysis over a three-year initial assessment phase. It also outlines expected monitoring frequency, thereafter, based on likely sources of contamination. Chemistry samples should be collected from distal taps to account for infrastructure-related parameters such as lead and potential concentration, dilution, or degradation processes within the water supply system.

Table 4: Prioritisation and monitoring timeframes for chemical parameters

Parameters	Timescale for first assessment	Monitoring frequency
Electrical conductivity*	3 years	Minimum every 5 years Or, when taste or operational monitoring indicates change.
Arsenic Fluoride	3 years	Every 5 years if identified as a concern in the area

* Water chemistry samples should be analysed by accredited laboratories, but electrical conductivity (EC) probes can be used in the field. Regular calibration should be undertaken with records available for audit. Where probes are used, monitoring frequency can be increased in line with *E. coli* sampling frequency to track seasonal changes.

Reporting under the water safety approach does not replace national requirements and it remains the responsibility of the service provider to meet national regulations. Variability between requirements in different countries and potentially poor alignment of requirements to account for resources available for small systems make it challenging to set standardised chemical performance targets. Service providers may decide to expand their chemical analyses, such as to meet appropriate national regulations, or to align with chemical analysis packages offered by laboratories. However, this information does not need to be reported to be eligible for the assessment and reporting incentive payment. The financial and logistical aspects of implementation will be reviewed as the water safety approach is applied with partners in different countries.

Monitoring electrical conductivity is prioritised under the water safety approach. Electrical conductivity (EC) is an indicator for salinity and overall ionic chemistry composition. This has implications for acceptability of the drinking water taste. It can also be associated with health implications from the presence of sodium or other ions. Salinity originates from geological weathering, seawater intrusion, or land management practices. It can change rapidly and vary seasonally. Including EC as an indicator of salinity, rather than specifying measurement of chloride or other ions associated with salinity, encourages service providers to use electrical conductivity as an operational metric. With this approach, data will be collected at scale to understand trends in salinization of water supplies.

Arsenic and fluoride are geogenic contaminants that are considered high-priority chemical parameters at a global level due to their prevalence and their impacts on human health. They are, therefore, the focus of the initial assessment. Manganese, lead, nitrate, selenium, and uranium are additionally recognised as key contaminants of concern in WHO's Guidelines for drinking-water quality. Where testing capacity is not available for either arsenic or fluoride, service providers can discuss with Uptime the possibility of substituting other key contaminants of concern.

After this initial three-year period, in line with the approach for continuous improvement, the priorities for water chemistry testing for health-based parameters can be revisited with reference to (a) existing water quality results and (b) international and national drinking-water safety guidance and standards. Monitoring frequency depends on prevalence and sources:

- For primarily geogenic contaminants, concentrations vary spatially, including with depth of groundwater. Where systems are in an area with known geogenic contamination, even if the system initially tests within acceptable limits, continuing monitoring allows assessment of any changes that might arise in response to changes in the source water concentration or to the integrity of the infrastructure. If the area of water supply operations is not an area of known geogenic contamination and if in the initial assessment, concentrations of these parameters are not concerning (with samples that are representative of different water sources and different depths of aquifers), then the area can be considered low risk and further monitoring of existing systems is not needed.
- For contaminants that are associated with materials in the water system, subsequent monitoring is not needed if no concerns are identified within the area of operations and new fixtures and fittings are lead-free.
- Contaminants associated with anthropogenic pollution, for example from agriculture or industry, can be considered in light of the potentially polluting activities ongoing in water source catchment areas.

The monitoring frequency is the same for handpumps or piped water systems. For piped systems, samples should be taken from towards the end of the distribution system to represent potential contamination from the distribution systems as well as the source water. For complex distribution systems, it may be useful to sample multiple taps especially when considering contaminants associated with the infrastructure such as lead.

Reported

04	**Reported**	Relevant authorities and community leadership are informed of water quality status.

The second step that is required to access an assessment and reporting incentive for each waterpoint is to report the results of the water safety assessment to the agreed authorities and community leadership. This includes sanitary inspection results, faecal contamination results, and chemical water quality results.

The aim of reporting is to raise awareness of water quality issues to support local and national level action, for example to help communicate the need for chlorination, and to build confidence in professional service provision to deliver drinking water that is safer than unprotected, unmanaged alternatives.

The relevant reporting pathways should be agreed with the service provider during results-based contracting. These pathways are context-appropriate; they should reflect the expectations and capabilities of authorities and community leadership in the service-provider's area of operations. Figure 9 provides examples of reporting pathways used by professional services providers.

Government authorities: Small drinking water services are often not included in national regulatory structures. The reporting pathways may differ for piped water systems and handpumps; where possible results can be reported together to reflect the overall actions of the service provider.

- **If rural water services are regulated**: Where formal regulatory structures exist for the type of drinking water services provided, reporting should meet those requirements in terms of frequency and type of reporting to a specified entity. The timing and content of those reports may differ from the reporting requirements of the water safety approach. Where the regulator requires less reporting, service providers may look at sharing interim reports, either as informal reporting or in real-time via databases like mWater, in order to align their reporting with the requirements of the approach.
- **If the existing water sector regulation does not include rural water services**: Where formal regulatory structures exist, but don't apply to the services provided, reporting can follow the process for regulated systems as much as possible. Where this is not possible, the process for where formal regulatory structures do not exist can be followed.
- **If no water sector regulation is established**: Where formal regulatory structures do not exist, the service provider can identify appropriate entities for informal reporting of water safety status and water quality test results. This may include local level government bodies and/or national level Ministry for water supply and/or health.

Provider:	Reporting to:	Reporting what:
SafePani in Bangladesh No national regulatory body or requirements	Community leader at school or healthcare facility	Notified within 48 hours of *E. coli* detection, notified of actions
	Government steering committee	Water safety status, and database of all test results including chemical test results, reported quarterly
Fundifix in Kenya	Community leader at school or healthcare facility or community-based water management committee	Notified within 48 hours of *E. coli* detection, notified of actions
	County government Ministry of Water	Water safety status, and database of all test results including chemical test results, reported quarterly
EOS International in Honduras and Nicaragua	Community water board	• Notified immediately of chlorine concentration during monthly visits • Water safety results, including *E. coli* + coliform bacteria reported within a week (Honduras) or within 24 hours (Nicaragua)
	Secretary of Health (Honduras) Ministry of Health (Nicaragua)	• Chlorine monitoring results database available monthly, upon request • Water safety results, including *E. coli* + coliform bacteria reported within a month in-line with national requirements (Honduras) or upon request (Nicaragua)

Figure 9: Examples from professional service providers of what and to whom they report.

In contexts where water quality is not commonly monitored and data are generally unavailable, reporting water quality results to government authorities may pose certain risks. Service providers may come under biased scrutiny simply for making data available, exposing themselves to penalties for any perceived deviation from the national drinking water quality standards. The intent of the water safety approach is to increase the data available to decision makers and raise awareness of water quality threats; where there is concern that this will place a water service provider at risk, it may be appropriate to implement an adapted version of this approach with different reporting structures.

Community leadership: The purpose of reporting to community leadership is to encourage the caretaking of sanitary conditions around water supplies and to help water users make informed choices about the water supplies that they use. Reporting should be designed to build capacity for local water safety practices and to build trust in the water service provider.

Reporting should highlight results that identify health threats and results that demonstrate that serviced water supplies are safer than the alternatives. When *E. coli* are detected, it represents an immediate threat to health, so timely reporting is important. Community leadership should be notified of the risk as soon as possible within 48 hours; this may be done by phone. Risk should be communicated with reference to the broader water supply context and it is helpful to provide information on how to respond to water quality threats (Nowicki et al, 2022). Training may be provided before reporting to further help communities understand how to respond. This is part of building capacity within communities to understand and navigate water safety.

Effective risk communication will often require an explanation of relative risk. Particularly, it should be emphasised that unprotected alternative water sources such as dug wells or surface water are substantially less-safe options. The relative severity and urgency of microbial threats compared to chemical threats may also be an important point to communicate. Reporting monitoring results alongside information about the water supply sanitary inspection and the management actions that have been taken to protect and treat water quality can provide reassurance that the service provider is actively working to maintain or improve water quality.

Depending on the circumstances, water quality results can motivate community leaders to improve local caretaking of serviced water supplies and to better communicate the value of these supplies to community members. Community leaders should be encouraged to share water safety information with water users so that users can understand the improved safety of serviced supplies and know how to further protect themselves through maintaining good hygiene around water sources and collection points, choosing safer water sources more consistently and accepting treated water, or using household water treatment methods during periods when water quality is unsafe. Better understanding of the relative safety of serviced supplies may also increase willingness to pay for water quality management.

Water service providers may consider reporting directly to users, depending on local dynamics and whether the service provider can feasibly allocate time and labour to this task. However, despite the potential benefits of reporting to users, there may be concerns from authorities or community leadership regarding informing water users about contamination. If water safety data are not currently shared, increasing water quality monitoring and communication of results may affect relationships between service providers, water users, and government authorities.

Concerns about informing users about contamination are often rooted in the limitations of service providers to address issues in a timely manner. Under these circumstances, there is a wariness of unintended consequences including (Nowicki et al, 2020):

- unintentionally encouraging users to switch to less-safe sources, such as surface water, if they are informed that handpumps or piped supplies are contaminated;
- causing water supplies to be shut-off / closed due to water quality concerns, thereby negating benefits such as proximity and sufficiency of water, which may be crucial for livelihoods, health, and wellbeing;
- distracting from urgent microbial threats by directing focus to chemistry contaminants that represent long-term health risks.

These considerations underscore the importance of providing context when communicating water quality results. More broadly, the concerns of authorities and community leadership regarding water quality reporting, and the associated politics, are a key reason for applying a flexible approach to reporting requirements. Reporting pathways will be agreed with the service provider during results-based contracting so that they can be contextually appropriate.

Special considerations for water chemistry reporting

Communication of chemical water quality status may be hindered by the time lag between sampling and receiving the test results and by government reporting processes. It may also be more difficult to communicate chemistry results to the community leadership or users in a productive way if neither the service provider nor community are equipped to manage chemical water contaminants. In these situations, reporting to authorities is particularly important. Just as context is important for reporting microbial test results, chemistry results should be reported with due consideration of the need to prioritise the most severe health risks. Reporting strategies should be sensitive to the potential to cause unintended consequences and psychosocial distress if attention is drawn to risks that are unmanageable, have potential to become exaggerated, or that are linked to social stigma.

Managed

04	**Managed**	Good water safety status is maintained.

If all required microbial results for a waterpoint are within acceptable limits – either directly from routine test results being within acceptable limits, or if all microbial water quality issues have been resolved because of actions taken by the service provider – then the waterpoint is considered to have achieved good water safety status and qualifies for an additional management incentive payment.

For good water safety status, each system must have a low risk score based on sanitary inspection and meet the WHO guideline of no detectable *E. coli* per 100mL, using one of the approved testing methods outlined in Table 3. The WHO guideline is widely adopted internationally and is practical in all situations. Achieving good water safety status requires that actions have been taken to manage any water safety hazards identified from water quality monitoring within appropriate timeframes, with retesting to verify the impact of the action. For faecal contamination risks, actions to improve water safety should be undertaken within 1 week, with retesting to occur after an appropriate window to allow the action to have an impact.

Table 5 sets out the different levels of water safety status as defined for this framework. Poor status fails to meet the criteria for sanitary inspection hazards and/or microbiological contamination. High status represents a system that meets the requirement for good status, and additionally meets national chemical water quality standards.

Table 5: Water safety status

	Sanitary inspection risk	Microbiological contamination	Chemical contamination
Measurement	**WHO standard sanitary inspection forms**	***E. coli* using approved methods and supported by QA/AQC records**	**Appropriate methods in accredited laboratory or supported by QA/AQC and calibration records**
Poor status	Medium or higher (>2 hazards identified)	≦1 cfu per 100mL	Not applicable
Good status	Low (0-2 hazards identified)	<1 cfu per 100mL	Not applicable
High status			Waterpoint has been screened and relevant parameters are below national standard levels

Where remedial actions are required, retesting should only occur after the system has had time to return to standard operating conditions. For example, if shock chlorination is used, the sample for retesting should be taken after a few days when the chlorine residual is no longer detectable. The types of actions that may be required include:

- Maintaining sanitary conditions including repairing leaks, replacing inadequate covers, and keeping fences in good repair so that animals are prevented from contaminating the environment around the water supply;
- Cleaning waterpoints and implementing shock chlorination to kill bacteria and viruses from local contamination sources;
- Establishing or improving inline treatment and/or disinfection by chlorination or UV; and
- Establishing point of collection chlorination options.

Household water treatment systems, such as filters and chlorination, may be provided during short-term water quality issues if provided within 1 week can allow qualification for the additional management incentive payment. However, they are not appropriate for longer than one reporting period as a management response for longer-term, and will not allow qualification for the additional management incentive payment in subsequent reporting periods if used for over 3 months.

Where travel times make repeat visits challenging, addressing faecal contamination risks within a week may pose problems. Management incentive payments will be made for systems achieving good water status, where actions have not been needed, which will help to subsidise costs across the service providers' portfolio. Additionally, service providers may consider proactive treatment options, such as shock chlorination after sampling, or providing the community with follow-up chlorination and testing kits. Broader water quality management action may also help ensure the water point meets the criteria for the next sampling period.

The water safety approach does not include a chemical water quality requirement to achieve good water safety status. The priority is to incentivise actions for microbial water safety. Chemical risks are commonly more difficult to resolve and, as they are usually not an immediate risk, it is often appropriate to have a longer timeframe to resolve. A provisional category for high water safety status may be added in the future to include compliance with national standards for chemical water quality status for select parameters (Figure 10). Reporting results to government and community leadership will likely create pressure for action on chemical threats.

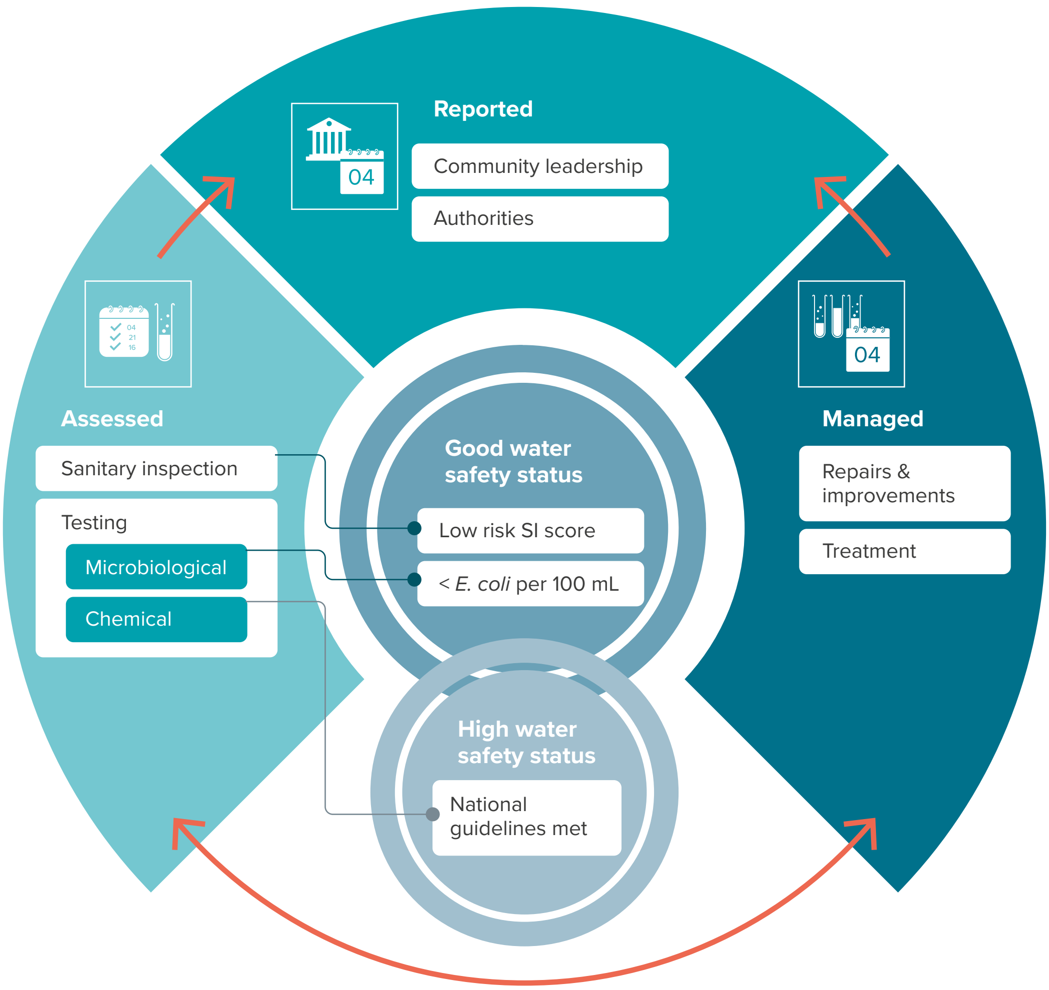
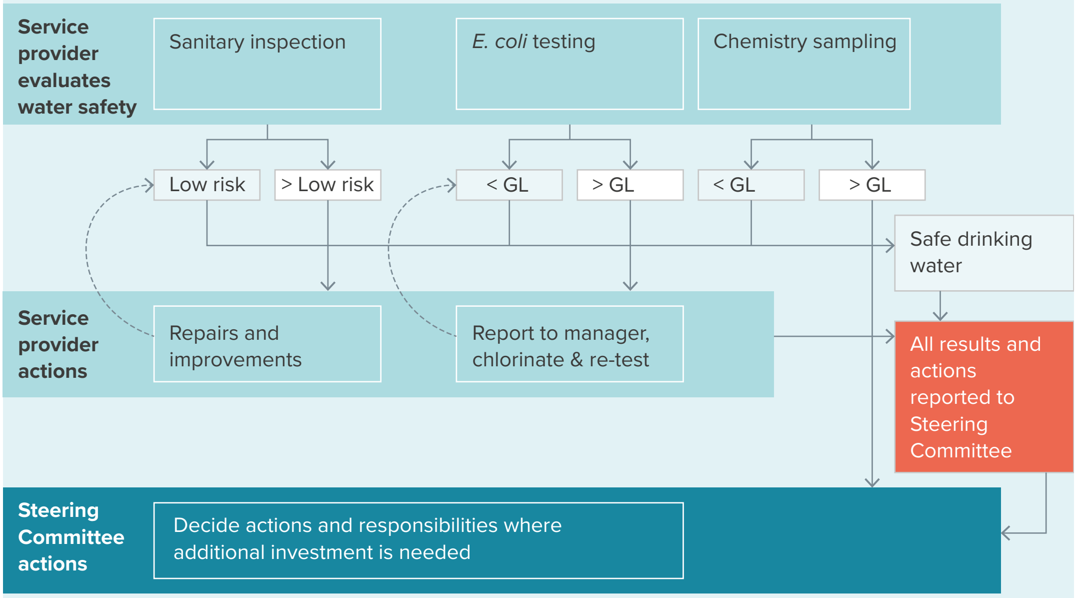


Figure 10: Improving water safety status through assessment, reporting, and management.

Box 6: Actions to manage water safety concerns: SafePani, Bangladesh

Photo shows the service provider sampling water quality from a handpump

For the SafePani program, actions to respond to water safety concerns are outlined in the diagram below. The service provider undertakes repairs and improvements to ensure the sanitary inspection risk remains low, including cleaning rain water harvesting catchment and raising the plinth above flood level for handpumps. When *E. coli* is detected, the service provider reports the issue to the manager of the school or healthcare facility, taking care to ensure that they understand the risk and appropriate responses, and to minimise the risk of using worse water sources. They also shock chlorinate the system and retest after one week to ensure it has been effective. For chemical water quality results, these are reported to the local water manager, relevant government departments and to the steering committee, who then take responsibility to identify investments and actions.



GL = Guideline level

Box 7: Water management actions

Examples of water quality management responses:

Filtration and disinfection. A media filtration and reverse osmosis system in Bangladesh

Source protection. A fenced handpump with plinth installed by Water for Good in Central African Republic

Reactive chlorination. Chlorine manually dosed to rainwater harvesting tanks in Bangladesh

Passive chlorination. An in-line chlorination system installed by EOS International in Honduras

Box 8: Chlorination devices for rural water systems

A range of different devices can be used to implement chlorine disinfection treatment in rural contexts. Passive chlorinator devices operate without electricity. Some of these are commercially available, but there are also instructions available for fabricating basic models from common materials that water engineers and mechanics regularly use in building and maintaining small piped water schemes. Some common design types for passive chlorinators used in rural areas are:

- **Floaters**, which are filled with chlorine tablets and can be left to float in water tanks (as is commonly done for chlorination of swimming pools). These devices are easy to construct and deploy but they don't allow good control of chlorine dosing.
- **T-chlorinators**, which can be built using PVC pipe sections and installed in-line to dose flowing water from slowly dissolving chlorine tablets made from trichloroisocyanuric acid (TCCA), which may also referred to as trichloro-s-triazinetrione. (Note that T-chlorinators can also use calcium hypochlorite tablets, but these may make dosing more difficult to control because $Ca(ClO_2)_2$ dissolves relatively quickly.)
- **Venturi-style chlorinators**, which require specialised fabrication. These devices are installed in-line and they use water pressure differentials to automatically dose liquid chlorine into the water supply.
- **Tap-attached chlorinators** (such as AquatabsFlo or AkvoTur designs), which are installed at water taps and use cartridges of sodium dichloroisocyanurate (NaDCC) or TCCA tablets to dose water as it flows out of the tap.

More details can be found in a recent review paper by Lindmark et al, 2022.

Photo shows members of a water service provider in April 2022 making pre-installation adjustments to a Venturi-style chlorinator developed by BlueTap.

Passive chlorinators will not be compatible with all water supply infrastructure types. In cases where passive devices are not suitable, **manual chlorine dispensers** may be a useful option. These dispensers require users to manually dose their drinking water after filling containers at a public waterpoint. These devices are typically the only option for handpump waterpoints where it is impractical to install in-line passive chlorinators. Manual dispensers have had good uptake in parts of Kenya, Uganda and Malawi where organisations like Evidence Action have included them in rural water safety programs.

Some factors that should be considered when choosing a passive chlorination technology for a particular water scheme include the cost, the maintenance requirements, and the compatibility with water supply infrastructure parameters like pipe sizes and flow rates. The form of chlorine (liquid, tablet, powder) that is required is also an important consideration – where adequate supply chains are not accessible for purchasing chlorine, it may be possible to generate liquid chlorine on-site if electricity is at least intermittently accessible.

Metrics and auditing

The metrics for reporting and auditing are presented in Table 6. These have been designed to encourage best practice to advance water safety.

Table 6: Summary of quarterly reporting and proposed audit metrics

Quarterly metrics		Annual audit metrics
Metric	**Description**	
	Assessed	
SI risk score(s)	Number of risks identified per component assessed, and date assessed.	Review of full SI records. Random site visits to confirm SI results.
Sampling date(s)	Date when *E. coli* and chemical samples were collected.	Information on quality assurance / quality control procedures in sampling and lab records (duplicates, blanks, calibration logs).
Test result(s)	Pass/fail results for *E. coli*. Chemical test results may be delayed; payment is based on sample being taken and sent for analysis.	

Quarterly metrics		Annual audit metrics
Metric	**Description**	
04	**Reported**	
Date reported to relevant authority	Date when result was reported to government authority.	Examples of reports and records of correspondence
Date reported to community leadership	Date when result was reported to community leadership. *E. coli* results are aimed to be shared within 48 hours.	
04	**Managed**	
Date action taken	Date when a specific action was taken in response to a failed water quality test. For faecal contamination, actions are aimed to be taken within 1 week. Multiple actions may be needed.	Documentation supporting actions taken, including but not limited to photographs and operational monitoring records.
New test: date and result	Date and result of test conducted after each action. For faecal contamination, a test result showing a pass result following actions taken by the service provider is required within 2 weeks to qualify for the management incentive payment.	Information on quality assurance / analytical quality control procedures in in sampling and lab records (duplicates, blanks, calibration logs).

Payments

Based on these metrics, waterpoint payments are released as depicted in Figure 11:

- **No water safety payment** – A waterpoint is disqualified from receiving a water safety payment if it has not been inspected, if it has more than two hazards identified in sanitary inspections, or if it has not been tested within the required timeframe for all of the required microbial or chemical parameters.
- **Assessment and reporting incentive payment** – A waterpoint qualifies for an assessment and reporting incentive if it has a low sanitary risk status (0-2 risks) confirmed by an up-to-date sanitary inspection, has been tested within the required timeframe for all required microbial and chemical parameters, and all of the available test results have been reported through the appropriate authority and community leadership reporting channels within the required timeframes (48 hours for *E. coli* results, 4 weeks for chemical results).

- **Management incentive payment** – Once requirements for an assessment and reporting incentive payment have been achieved, a waterpoint can qualify for an additional management incentive payment if microbial test results are within acceptable limits (<1 *E. coli* / 100mL). If a routine test contains *E. coli*, action must be taken to improve the safety of the waterpoint within the required timeframe of 1 week and a follow-up test within 2 weeks must be free from *E. coli*. Repeat testing without a corresponding action reported is not sufficient evidence of resolving an issue.

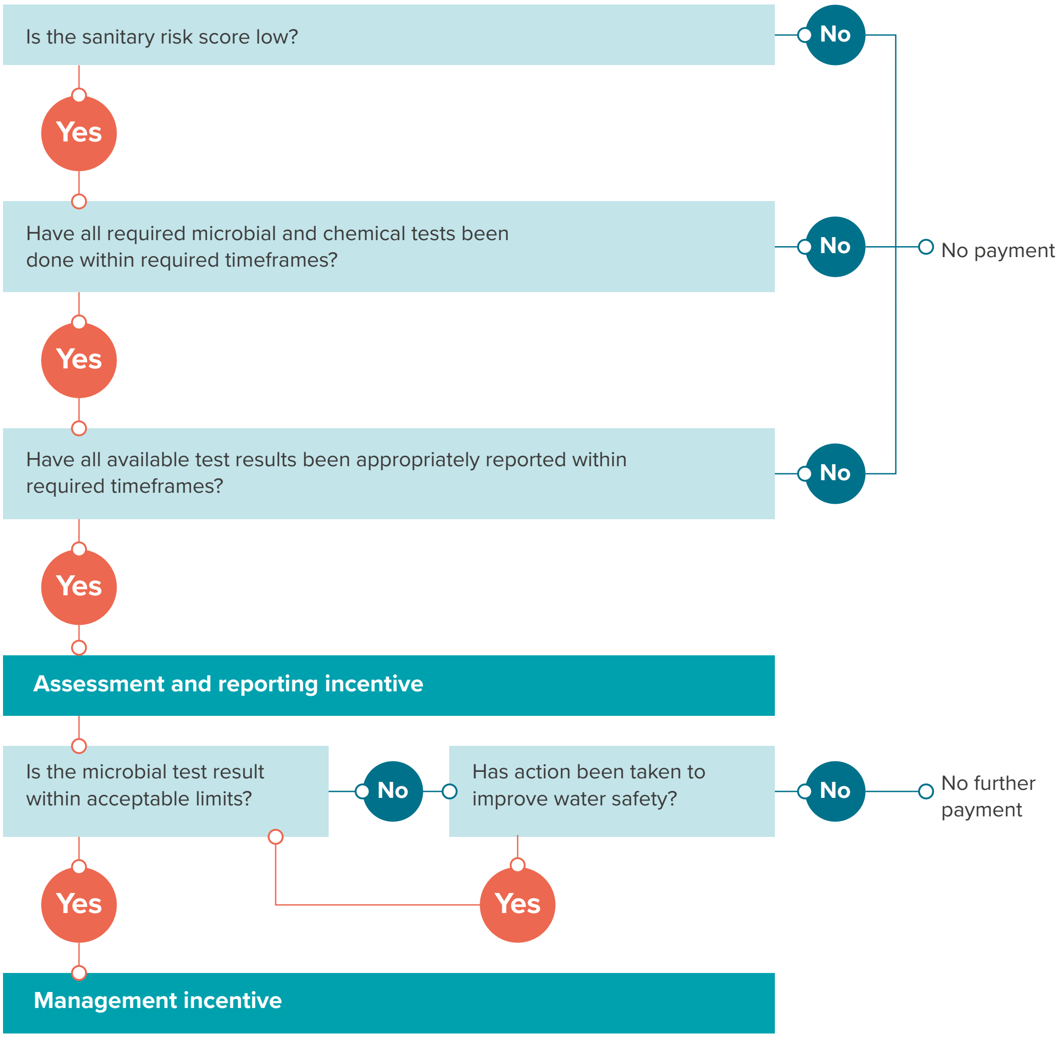


Figure 11: Water safety results-based payment scenarios.

Eligibility of water collection points

The approach we describe has been developed based on professional service providers working with a range of system types in a range of rural contexts. It is designed to be suitable for all types of water supply systems. Our survey of professional service providers highlights that most providers are undertaking at least some water safety actions (monitoring, reporting, and/or managing). This approach is intended to strengthen and systematise these existing water safety management efforts.

It is important to consider whether water is used for drinking, for at least part of the year. Not all water supplies that require maintenance will be used for drinking water. This may be due to organoleptic issues, perceptions of safety, or various aspects of convenience. If water is used for drinking, it is assumed that organoleptic issues are not critical. However, it should be noted that, when better alternatives are not available, some people rely on water sources that have potentially unsafe salinity levels or otherwise unacceptable organoleptic issues. Organoleptic issues and the availability of alternative water supplies may be seasonally variable.

The approach developed in this working paper focuses on water safety for water supplies that are used for drinking throughout the year. Nevertheless, if a water source is used for drinking water at any time of the year, it can be included for water safety management activities and results-based payments. However, if a supply is only used for part of the year, service providers may find that it is not appropriate to include it in year-round water safety management efforts.

Results-based funding to accelerate safe drinking water services at scale

Progress to provide access to safe drinking water service is off-track globally, especially in rural areas. Professional services providers have achieved substantial improvements in reliability of rural drinking water services, and almost all are already undertaking actions to manage drinking water safety. Improving, standardising, and accrediting their work on water safety is a pathway to accelerate access to safe drinking water services at scale.

This paper has proposed how water safety can be considered in contracts for results-based payments. This approach is not intended to replace national regulatory processes, but seeks to increase the use of data to inform water safety at the local and national level. In many contexts, rural services providers may be working without clear regulation, or with regulation that is not adapted for decentralised or remote systems. In these situations, the approach provides guidance for collecting and reporting data on water safety. In contexts with active national regulators, the approach will increase funding for service providers to deliver safer drinking water in line with national regulatory requirements.

In all scenarios, the approach supports development of the following aspects of water safety practice to build investor confidence that the provider is advancing water safety management through their services. Service providers will establish standardised:

- **Record of proactive water safety actions**. Water service providers will have records that appropriate sanitary inspections have been undertaken for all waterpoints, and the actions that have been taken to address identified risks.
- **Water safety monitoring records**. Water service providers will have records that demonstrate that monitoring is on-going. This will include a record of microbiological monitoring (particularly *E. coli*) and chemical monitoring. Records will include test results and reports of actions taken in response to identified risks.
- **A record of sharing water safety information with users and authorities**. A track record of transparency in water safety information ensures compliance with national regulations, helps to build service provider relationships and reputation, and provides evidence to advocate for and prioritise water safety actions.
- **Evidence that demonstrates progress towards safe water**. Achievement of good water safety status demonstrates active management of microbial drinking water quality, with good awareness of chemical water quality issues that might be prioritised for further water safety improvements.

The operational subsidy required to achieve reliable water services with no more than three days of breakdown per quarter under Uptime's existing results-based contracts is less than 1 USD per user. The additional cost of delivering water safety management remains relatively small as it leverages existing visits for maintenance and repairs.

Historical project-based funding has focused on water safety costs in the implementation phase with variable oversight resulting in waterpoints being commissioned without achieving adequate status. Water quality problems are then inherited by operators or users who assume management responsibilities. While this practice has reduced water access costs, it has transferred water quality service costs to users. Based on the international survey of providers, we know many operators are aware of and implementing different responses and incurring the costs. Many bilateral agencies and foundations make explicit commitments to advance water safety outcomes. For the work proposed in this report to advance, these commitments would need to take the form of results-based funding support to test and iterate the ideas proposed.

In Bangladesh, the SafePani model has demonstrated application of contracts for results-based funding to improve drinking water safety in rural schools and healthcare centres. In this programme, estimates for the cost of delivery at district scale (REACH, 2023), which includes set up of laboratories for *E. coli* testing, requires an additional 25% on the annual running costs, with reliable provision of safe drinking water estimated to cost less than 1 USD per student in the schools serviced. The outcomes of this programme at the pilot phase has led to commitment from the Government of Bangladesh to invest in SafePani as it scales up to provide safe drinking water to 1,700 schools and 300 healthcare centres across rural areas of Khulna district.

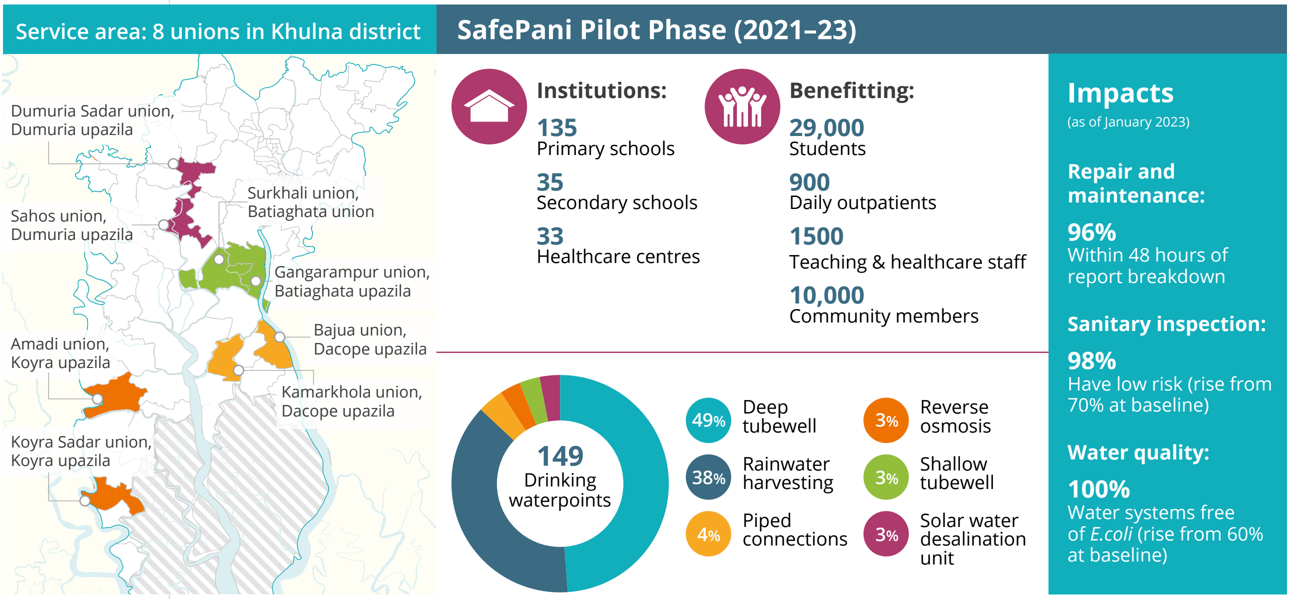


Figure 12: Achievements of the SafePani pilot in delivery of safe and reliable water services to schools and healthcare centres in rural Bangladesh.

Another key benefit of the SafePani model has been the opportunity to learn from the data. The management of multiple systems within a local area can help to build information on trends more quickly. These include spatial trends associated with chemical contamination, such as contaminants in shallow or deep aquifers, or in certain areas. It also includes trends in system performance, with trends in water quality concerns in rainwater harvesting systems readily identifiable in less than a year. This accumulation of data for service providers, governments, and internationally can help to understand trends and inform decisions to advance water safety for all.

Conclusions

Results-based funding has demonstrated progress in advancing reliability for rural water supplies. This paper proposes how standard metrics and incentive payments can be introduced into contracts for results-based funding to incentivise delivery of safe drinking water services. Drinking water safety in rural areas has often been incorrectly assumed through infrastructure alone. In contrast, the approach presented in this working paper combines active management of acute microbiological threats with awareness raising of chronic water chemistry hazards, strengthening availability of data to service providers and governments on water quality risks and successful mitigation approaches. Through results-based funding, the work of rural water service providers to support achievement of SDG6.1 can be recognised, incentivised, and demonstrated to governments and funders to help leverage further support. In the coming year, this approach will be piloted with Uptime's contracted partners in different countries to assess its utility in different contexts. For this work to advance, funders and governments will need to commit support for testing, iterating, and scaling the water safety approach to results-based funding.

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Uptime

Uptime is a global initiative to keep drinking water flowing for millions of rural people through results-based funding to achieve Sustainable Development Goal 6.1.

www.uptimewater.org

REACH

REACH is a global research programme to improve water security for 10 million poor people in Africa and Asia by 2024. It is funded by the Foreign, Commonwealth and Development Office (FCDO). In Bangladesh, the programme is a collaboration between UNICEF, Bangladesh University of Engineering and Technology (BUET), University of Dhaka, the International Centre for Diarrhoeal Diseases, Bangladesh (icddr,b) and the University of Oxford.

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