Unlocking the Potential of Groundwater for the Poor

Technical brief

Measuring functionality and performance levels

UPGro Hidden Crisis Research Consortium

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This technical brief is aimed at sharing the learning and approaches developed by the ***UPGro Hidden Crisis Research Project*** to look at how the functionality and performance levels of boreholes equipped with handpumps (HPBs), can be assessed using a common set of definitions and methods. A tiered approach to defining and measuring functionality is found to be useful to examining functionality for different scales and purposes of monitoring. This report is aimed at national and regional actors involved in the provision and monitoring of rural water supply functionality.

The brief sets out the tiered functionality definitions, and accompanying survey methods, which were developed by the project and have been applied in functionality surveys across Ethiopia, Uganda and Malawi [5-7].

The brief provides a summary of:

- The tiered approach to defining and measuring the functionality and performance levels of boreholes equipped with handpumps (HPBs).
- A series of survey methods which were found to be useful by the *Hidden Crisis* project to collect sufficient data to assess HPB functionality across the tiered definition approach.
- A series of guidelines which could form core criteria for assessing functionality and performance levels of water points[1].

This summary should be read in conjunction with the appendices which provide details of the methods and approaches described.

Introduction

Communal groundwater supplies are the main source of improved water provision for many rural areas in Africa and South Asia, and are likely to remain so for decades to come. Despite the reliance on these sources, it is estimated that the number of non-functional water points is 15 to 50% at any one time [1-3] when taking account of quantity, quality, access and service reliability. Understanding the poor functionality of existing communal supplies is, therefore, a priority.

Currently, there is no universally adopted definition of water point functionality, or even what constitutes a functioning water point [4]. The absence of an agreed definition and a framework for assessing functionality inhibits our *(or research community, government, donors and practitioners alike*) ability to identify the scale of the issue, compare different studies, and therefore to build towards solutions.

Recognising this difficulty, there is now a growing effort to work towards developing an agreed functionality definition as a means of tracking progress towards the SDGs. A critical first step is to have a clear benchmark as to what constitutes a functional water point and having standard assessment approaches.

Guidelines for assessing functionality

Based on the findings of the *Hidden Crisis* project, and building on thinking of others [8], the following guidelines are suggested as useful core criteria for assessing functionality of water points:

- **Functionality should be measured against explicitly stated standards of the performance of the water point**. For example, does a water point provide a minimum design yield, and does it provide water which meets the WHO drinking water quality guidelines? Having explicitly stated standards for different aspects of

[1] Defined as Hand-pumped boreholes (HPBs)

functionality, means that functionality data from different regions and surveys can be compared, and better understanding of the level of functionality across wide regions can be developed.

- It should be measured separately from the users' experience of the service provided.
- **Functionality assessments should be tiered, to ensure a minimum top-tier assessment can be completed by all surveys, but allowing for further, more detailed, tiers of assessments to be conducted at local levels.** National Surveys, having to cover very large areas in relatively short time periods, could therefore conduct only the top tier of the full suite of possible assessments in order to assess functionality at a point in time across the country. In contrast, implementing agencies and WASH programmes working in local areas, could conduct several tiers of assessment in order to be able to assess more aspects of functionality performance. The tiered assessment approach ensures information from both types of survey can still be reduced to a top-level measure.
- A distinction should be made between surveying functionality as a snapshot (e.g. for national metrics) and surveying individual water point performance (where a temporal aspect of the water point performance is included in a rapid assessment).

The different uses of the word *functionality* and how functionality fits into thinking of service levels is often an initial stumbling block to developing an agreed understanding of what constitutes a functioning water point. Here we apply functionality as used in engineering: how well the water point performs against its design criteria.

Defining functionality – a tiered approach

The guideline criteria can be usefully applied to develop a tiered approach for defining functionality of HPBs [4] – see box below.

> ### *Defining functionality*
>
> 1. **Binary Functionality** – is the water point working and delivering some water (yes/no)
> 2. **Functionality: yield snapshot** – does the water point work and provide sufficient yield (10 L/min) on the day of the survey
> 3. **Functionality: reliable yield** – does the water point provide sufficient yield (10 L/min) on the day of survey, is it reliable (<30 days downtime in last year) or abandoned (not worked in past year)?
> 4. **Reliable yield and water quality -** as 3 above, and also passes WHO guidelines for inorganic parameters, and TTC.

At its simplest within this approach, functionality is assessed based on a binary definition of 'working'/ 'not working' at the time of a survey. The subsequent levels of assessment beyond this binary definition then provide a more detailed understanding of the yield and reliability of supply. This enables a more refined assessment of functionality to be undertaken where possible, whilst acknowledging that such detailed assessments are not feasible or appropriate in all cases.

We have found in applying these definitions in detailed surveys that using the measure of ***reliable yield*** gives much more useful information about the service level of the water point than a binary assessment, and generally reduces functionality rates by 50% [5-7].

Measuring functionality

Different types of information are required to be collected in order to assess the functionality of a water point according to each of the tiers in the *Hidden Crisis* approach, as illustrated in Fig.1.

The 'binary' and 'yield snapshot' assessments can be undertaken rapidly but the 'reliable yield' assessment takes longer at each water point, and adding in water quality assessments increases the cost and logistical requirements significantly. However, with careful survey design it can be possible to undertake more detailed assessments in a subsample of districts or communities and upscale using the simpler national survey data.

Good statistical design can be used to gain maximum information for limited resources. A binary functionality assessment can be undertaken rapidly for an entire domain – for example a district, region, or even country. By using a stratified two or three staged randomised sampling approach, the number of sites to be visited for the more detailed assessments can be reduced substantially. This sample can then be used to estimate more detailed functionality behaviour for the entire domain. Investment in good survey design can therefore save time and money and give more confidence in the data produced. More guidance and explanation to the two stage randomised sampling approach used by Hidden Crisis project is provided in Appendix 1.

A standard suite of indicators and methods

A set of approaches and techniques were developed and tested by the *Hidden Crisis* project to collect the relevant data to assess HPB functionality for each of the tiered definitions.

A summary of the standard measurement approaches, and how they relate to the tiered definitions of functionality, is presented below. These methods are not definitive and other more streamlined techniques for measuring yield, reliability or water quality are being developed within the Hidden Crisis project and by others. More detailed technical information for each of the methods is provided in Appendix 1, along with a template Field Data Worksheet in Appendix 2.

The Malawi Hidden Crisis team taking filtered water samples for laboratory analysis: Survey 1 Hidden Crisis.

Essential general data

Key general location information should always be collected, in addition to the specific information collected from the survey methods listed below. Examples of these key data are: date of the visit; the village name where the HPB is located; the coordinates and elevation of the HPB position, which can be collected using a hand held GPS or mobile apps, such as mWater; and the name of the village chairperson or community member who facilitated access to the

HPB. It was essential that communities were happy for the survey to take place, and their consent was recorded on the day of the survey. Early engagement with communities several weeks in advance of the survey was an integral part of the survey process to ensure communities had sufficient awareness and understanding of what the survey tests would involve, so they could make an informed choice to participate.

Measuring binary functionality

The first tier assessment of functionality – binary functionality – assesses if the handpump is physically working and providing some water, of any amount, at the time of the survey visit.

This can be measured by operating several strokes of the handpump to see if any water is provided.

Measuring yield snapshot

The second tier definition of functionality assesses a HPB to be functioning if it is providing a sufficient design yield at the time of the survey visit. A sufficient yield was defined to be a minimum of 10 litres per minute (L/min) for this assessment. This was based on the guidance within the installation and maintenance manuals [9] for Afridev and India Mark II handpumps; and, the design requirements of rural water supply [10] which propose rural community HPBs should serve no more than 250 people each requiring 25 litres per day. The assessment criteria of 10 L/min can, however, be changed to conform to other types of water supply and design specification.

A 30 minute stroke test was used to assess if the yield of HPBs was capable of meeting and sustaining at least 10 L/min. If the flow rate is less than 10 litres per minute in the final 2 minutes of the test, this indicates that the HPB is unlikely to meet the design requirements. Appendix 1 provides a full description of the methodology used to conduct the stroke test, and an accompanying field data recording template is provided in Appendix 2.

The findings from the first major survey phase in *Hidden Crisis* suggest that a 5 minute stroke test is almost as good a predictor of yield as the 30 minute test. Therefore, given the time and logistical savings for the shorter test, we recommend that this is adopted at all sites where a binary test is undertaken.

The Uganda Hidden Crisis team undertaking a stroke test: Survey 1 Hidden Crisis.

Measuring Reliable yield

A HPB is defined in the third functionality assessment tier, to be of 'reliable yield' if the water point provides a sufficient yield with less than 30 days cumulative downtime in a year.

This temporal dimension of the physical service performance level, was assessed from user re-call by conducting Water Point User Surveys, in addition to the Tier 1 and 2 functionality assessments.

User re-call of several different aspects of reliability (number of breakdowns in a year, number of days downtime, length of individual breakdowns, and types of breakdown) were collected and triangulated to assess if the total cumulative downtime of the water point is <30 days in the last year, or significantly above this. More detail to how these user surveys were conducted, and the template user survey can be found in the Appendices.

It is important to note the difficulties in assessing the accuracy of user re-call and this is probably the weakest part of the survey methodology. We argue that re-call of water point breakdown is likely to be better than for instances of illness where recall is shown to be weak. Technical measures such as smart hand pumps, which have an inbuilt monitor in the handle to measure usage, or citizen monitoring could also be used to give measures of reliability. More work is required in this area to give more confident measures of reliability.

Measuring Reliable yield, including water quality

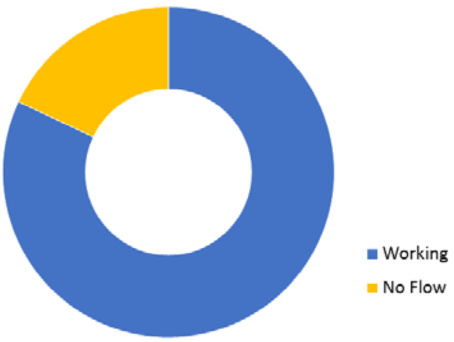
The fourth and final tier assesses a HPB to be functional if it is reliably providing a sufficient quantity and quality of water year round. This is the most detailed and expensive (time and cost) assessment tier to carry out and, therefore, only appropriate and feasible to be carried out at a smaller sub-sample of water points within detailed local monitoring programmes. The exact cost of measuring water quality parameters depends on laboratory fees, and how many parameters are measured using field test kits.

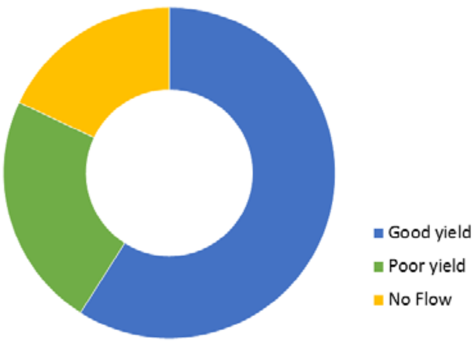
The *Hidden Crisis project* assessed water quality to be sufficient if both the inorganic water chemistry and microbiological quality met the World Health Organisation (WHO) guidelines for drinking water. These water quality parameters can be assessed by a combination of in situ field techniques, and collecting samples for analysis in the laboratory. Microbiological quality, for example, was based on incubation and plate counts of colony forming units (cfu) to quantify Thermotolerant coliforms (TTCs), an indicator of faecal contamination. Appendix 1 provides full detail of the different techniques, and field procedure for water quality sampling.

Water point survey being conducted next to the water point with water users in Uganda.

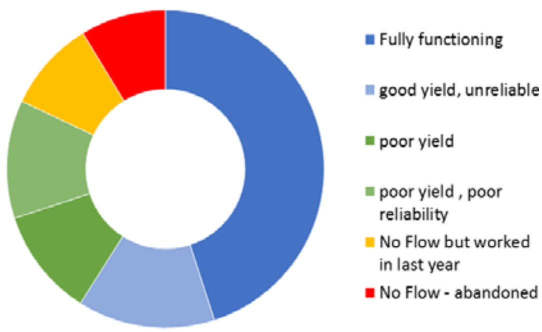
Example: the different levels of information provided by the functionality assessments

The tiered HPB functionality assessments developed by the *Hidden Crisis project* provide an increasing level of detail to understanding the functionality and physical service performance level of HPBs. From our surveys, we found binary functionality estimates of 55-83% [5-7] – generally very close to existing government surveys. However, when accounting for yield in the 'yield snapshot' survey we found that a significant proportion of those that were working did not produce the design yield – and functionality dropped to 34-67% [5-7].





Results developed from a randomised sample of water points within a country, from: Binary functionality assessment (top); and the Design Yield assessment approach (bottom).



The more detailed Reliable Design Yield assessment approach, enables a more nuanced understanding of physical service levels of functionality of water points to be developed.

This understanding can be developed further at local levels using the third and fourth functionality assessment tiers. Adding in reliability, we found that functionality (reliable yield) estimates were 23-58% [5-7], showing that a large proportion of water sources did not reliably provide the design yield. This detailed assessment gives much more detail on the actual service levels experienced by communities.

Other information useful to collect

Collection of general information about the HPB's was found to be very valuable to informing understanding of the HPB, in additional to the specific information collected from the survey methods listed above. For example, age of the HPB, type of handpump, and the original borehole construction and lithological log data, are all useful in developing understanding of a water point history. A full list of additional information useful to collect can be seen within the Field Worksheet Template in Appendix 2.

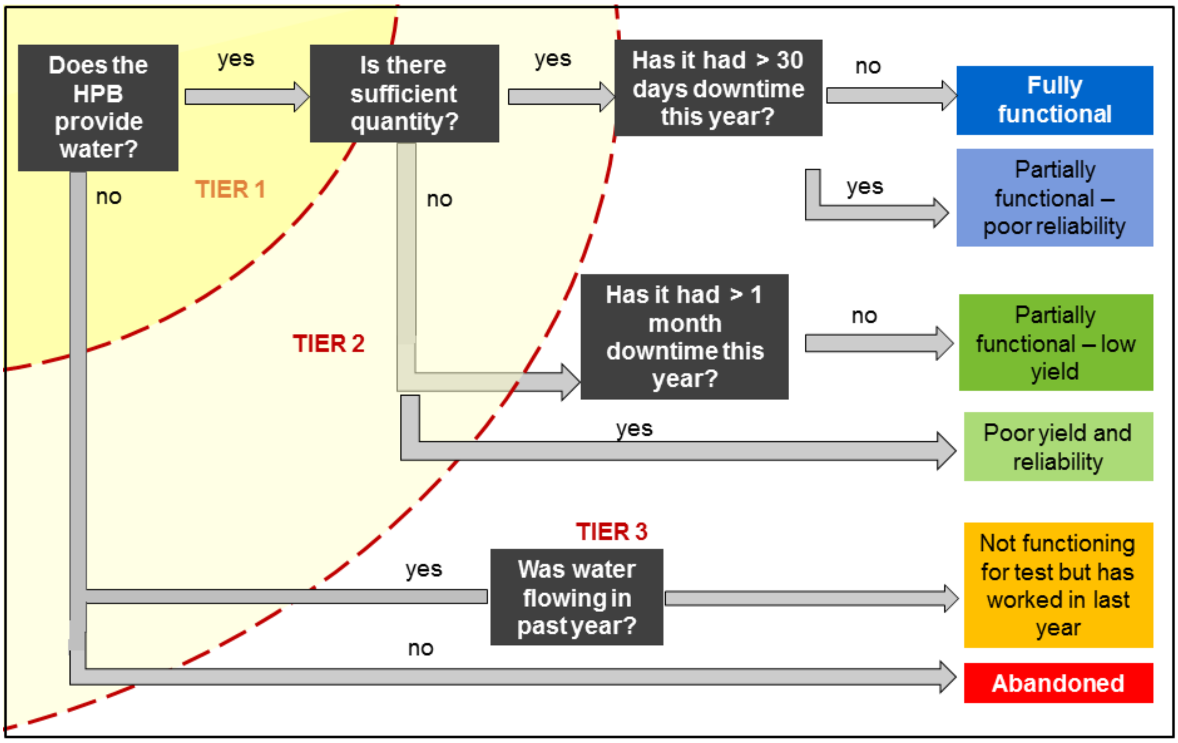


Fig. 1 – A tiered approach to assess the functionality of a water point based on the reliability of HPB yield.

References

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[2] Lockwood and Smits. 2011.
[3] Banks and Furey. 2016.
[4] Bonsor et al. 2018. https://doi.org/10.1007/s10040-017-1711-0
[5] Kebede et al. 2017. http://nora.nerc.ac.uk/id/eprint/516998/
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[9] Erpf, K. 2007. India Mark Handpump specifications. SKAT-RWSN. Revision 2.
[10] MacDonald et al. 2008. Hydrogeology Journal, 16; 6, 1065-1075. http://nora.nerc.ac.uk/id/eprint/5106/

Appendix 1 – Detailed methods used to assess functionality

Further information is detailed below in **Appendix 1** for each of the field methods which were carried out, and found useful, by the *Hidden Crisis project* to provide sufficient data to assess each of the tiered functionality and physical service performance levels.

Appendix 2 provides a copy of the field worksheet which was used to record the accompanying data collection.

Survey design

A binary functionality assessment can be undertaken rapidly for an entire domain – for example a district, region, or even country. More detailed functionality assessments, which include water quality assessments increases the cost and logistical requirements significantly, and it is not possible to conduct detailed assessments at a large number of sites.

Good statistical design can, however, be used to gain maximum information for limited resources. By using a stratified two or three staged randomised sampling approach, the number of sites to be visited for the more detailed assessments can be reduced substantially. This sample can then be used to estimate more detailed functionality behaviour for the entire domain.

The Hidden Crisis project used a two stage randomised sampling approach – first to randomly choose districts the survey would be conducted in, and then secondly to randomly choose communities to work in. This approach was used to select 200 sites within each of the three countries.

1. Selection of districts
The following data about each of the districts was collected:
Population (rural where possible) ; number of boreholes with handpumps; Functionality of water points from national surveys; Hydrogeology; Climate, rainfall and number of wet days; A measure of poverty; Whether available to survey – i.e. can WaterAid easily work there, is it accessible?

Procedure for district selection:
1. Stratification:

- classify hydrogeology into two categories (basement or sedimentary)
- classify climate into wet / dry based on number of wet months and the total annual rainfall
- classify poverty into two: above median and below median

2. Sub sample to only districts that are accessible to work in and also have a minimum number of shallow boreholes.

3. Explore how the three stratifications help with sampling efficiency and also enable a representative sub sample from the rest of the country

4. Choose the most efficient stratification and randomly choose 4 – 6 districts to work in.

5. If the random selection does not include a district that is very important to sample from a political or future research reason, then add this in as a wild card.es in the first major survey phase.

2. Selection of communities

The aim of this selection procedure is to find 40 communities with handpumps to work in within each district. Note that this selection must be random to be valid. Below is a suggested procedure for doing this:

1. Get a list of all the communities which have at least one borehole with a hand pump – and available to survey (it may be that some are not accessible for some reason – i.e. a broken bridge etc.)
2. List the village names 1, 2, 3,…
3. Have a bowl with bits of paper numbered 1 – 200, folded over so you can't read the numbers
4. Get someone to randomly choose 40 (+10 reserves) bit of paper
5. The 40 (+10 reserves) will correspond to 40 (+10 reserves) communities selected
6. These communities are the ones selected to survey.

Note - To enable a statistical scaling back up to the national level information must also be gathered on how many communities there are in every other district in the country.

3. Selection of individual water points to survey

On entering a community make a list of the number of boreholes with handpumps in the village. Note that it is important that this includes all the boreholes in the village, whether they are working or not.

If there is more than 1, number each borehole with handpump. Then choose one to sample using a random number generator (again this can be done by pulling numbers out of a bucket like above.

Measuring Binary functionality

The first tier of functionality assessment – Binary functionality – assesses if the handpump is physically working and providing some water, of any amount or quality, at the time of the survey visit.

This was measured by *Hidden Crisis* by operating several strokes of the handpump at the time of the survey visit to see if any water was provided at all by the hand-pumped borehole (HPB). This was then recorded as a visual observation within the field worksheet (Appendix 2).

Measuring Functionality - Yield snapshot

The second tier of functionality assessment – Yield snapshot – assesses if the handpump is physically working and providing sufficient yield (10 L/min) at the time of the survey.

A 30 minute stroke test was trialled by the *Hidden Crisis* to assess if the yield of a HPB was capable of meeting this criteria on the day of the survey. The HPB was assessed to pass if the yield provided in the final 2 minutes of the test is ≥10 L/min. A 30 minute duration was initially selected and trialled by Hidden Crisis, as this was estimated to be the time taken to purge the water stored in the HPB, based on a typical borehole volume and pumping rate. A constant rate of 40 strokes per minute was maintained throughout the test, to ensure a constant minimum demand was placed on the HPB.

An interesting finding from the results of the first major survey phase of *Hidden Crisis* – which conducted stroke tests on 600 HPBs across Ethiopia, Uganda and Malawi – is that this 30 minute stroke test method could, potentially, be reduced to a 5 minute stroke test. This would make the assessment method much easier to conduct in the field, and potentially endorse in large-scale surveys. This is based on the observation that the majority of HPBs which displayed a yield equivalent to ≥10 l/min within the first 5 minutes of the test in the *Hidden Crisis* surveys, continued to maintain this yield to the end of the test – see Figure 2. Only 7.5% of the HPBs displayed a decline in yield after the first 5 minutes, and <2% displayed an increase in yield.

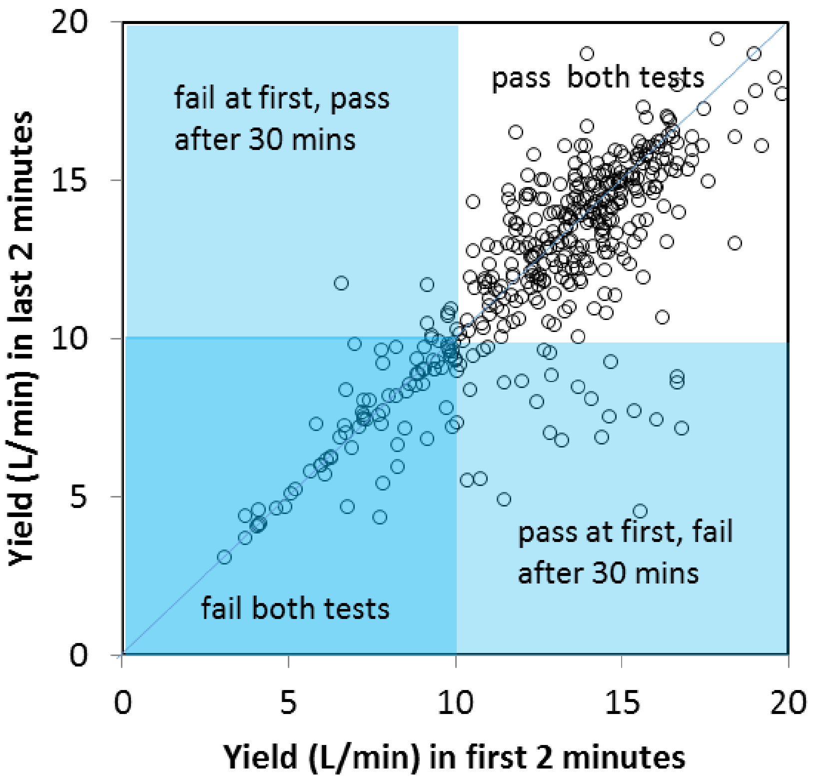

Figure 2 – Results from the 30 minute stroke test method used in the first major survey phase of Hidden Crisis. The plot shows a comparison of the yield estimated in the first five minutes, to the last five minutes.

Conducting a Stroke Test – field methodology

Conducting the test requires:

- 4 people:
  - Pumper
  - Stroke Counter
  - Bucket Changer
  - Recorder/Time Keeper/Conductor
- The following equipment:
  - Tally counter
  - Stop watch x 2
  - 10 litre clear plastic buckets x 4 (12 or 15 litre buckets, with a clear 10 litre mark, can also be used).
  - Relevant field sheets
  - Pencil
  - Rubber
  - Metronome

Field method:

1. Position the bucket changer at the spout and have 3 buckets lined up and empty.
2. Place the metronome on top of the pump head and start it at a rate of 40 beats per minute
3. Begin pumping the hand pump handle at a rate of 40 strokes per minute. This will be roughly 2 strokes every 3 seconds.
4. Observe the spout and record the number of strokes before water first emerges from the spout.
5. Continue pumping until the flow is consistent.
6. Once a continuous flow of water is achieved, check that everyone is in position, and then begin the test, by starting the two stopwatches at the same time.
7. Maintaining the same stroke rate of 40.
8. Collect all the water emerging from the spout in an empty bucket.
9. Record the time when each bucket is filled to the 10 litre mark.
10. When nearing each minute count down from 5 seconds and on zero, have the stroke counter shout out their count. Record this.
11. Continue the test for a period of 5 minutes, maintaining as close as possible the same stroke rate. After 5 minutes, stop the test.

What if no water? – If at the start, no water emerges, continue the test as per the above instructions until 120 strokes have been reached (3 minutes). If no water emerges, record this and stop the test. In the case of abandoned HPBs, or one with no water, the pump rods are often disconnected and removed from handpump. In this instance, there is often no resistance in the hanpump, when the handle is moved up and down – and in these cases the test should not be started at all.

Tips

- A separate person should be solely using the tally counter to count the number of strokes.
- It is important the pumpers maintain full length strokes throughout the test.

- If a longer stroke test (>5 minutes) is conducted, 2 pumpers will be required. The pumpers should switch over pumping the HPB every 5 minutes, to minimise fatigue and help ensure a constant pumping rate of the hand pump is maintained throughout the stroke test.
- Always make sure that at least 2 buckets are full of water at all times so that if the HPB stops working, water is available for the water quality component.

Key indicators

The key indicator is if the flow rate of at least 10 litres per minute is maintained throughout the 5 minute test. If the flow rate is less than 10 litres per minute in the final 2 minutes of the test, this indicates that the standard of 600 litres per hour is unlikely to be achieved.

A second indicator is whether at least 50 litres of water is delivered during the 5 minute test. A failure to achieve this indicates that the HPB will not satisfy the standard of 600 litres per hour.

Measuring Functionality - Reliable yield

The third tier of functionality assessment – Reliable yield – assesses if a HPB is providing a sufficient yield reliably over the last year.

This reliability element was assessed by conducting Water Point User Surveys in Hidden Crisis, in addition to Tier 1 and Tier 2 assessments.

Appendix 2 provides a copy of the Water Point User survey questions which were asked to gather user re-call information to several different aspects of reliability over the last year (e.g. number of breakdowns in a year, the number of days downtime, length of individual breakdowns, and types of breakdown). The questions are designed to uncover increasingly depth of information for each aspect of performance of the water point. This information provided by interviewees was then used to assess if the total cumulative downtime of the water point was <30 days (1 month) in the last year, or significantly above this.

Conducting Water Point User Surveys – field methodology

Identifying user interviewees: Ideally, the Water Point Surveys should be completed by members of the water committee, as they are likely to have the best knowledge and insight to the water point performance and reliability. Water point users can also provide valuable insight to the water point performance.

It is important user interviewees feel comfortable completing the survey questionnaire with you. Water point users, for example, can be interviewed to one side of the HPB without fear of their answers being reported to the water management committee. Before commencing the survey it is essential to ask all interviewees if they are willing to answer the questions about the water point performance, and to use a local translator if required. It is also helpful to reassure interviewees that the answers will not be shared with anyone outside of the research team.

Measuring Functionality – Reliable yield including water quality

Water quality is assessed to be of sufficient quality if the inorganic water chemistry and Thermotolerant coliform (TTC) concentrations meet the World Health Organisation (WHO) guidelines for drinking water.

The WHO parameters and guideline values which must be met are shown in Table 1.

Parameter	**WHO guidelines**
Electrical Conductivity	
pH	
Turbidity	
Nitrate	
Iron	
Manganese	0.4 mg/L
Arsenic	0.01 mg/L
Fluoride	1.5 mg/L
Ammonia	
Total Dissolved Solids	
Thermotolerant (faecal) Coliforms	0 cfu/100 mL

These water quality parameters are assessed by a combination of in situ field techniques, and by collecting samples for analysis in the laboratory. The field-based tests are detailed below first, followed by the procedure for collecting water samples for laboratory analysis.

Conducting field water chemistry assessments – field methodologies

Field probe measurements
The following parameters can be measured by in-situ field measurement probes:

- Electrical Conductivity
- pH
- Turbidity

1. Measurements should be undertaken immediately after the stroke test finishes, using the last bucket of water collected.
2. The three field meter probes should be placed into the bucket, and the readings taken until they have stabilised.
3. The final readings, and the length of time taken for the readings to stabilise should be recorded on the Field Sheet (Appendix 2).

Tips:
It is important that all buckets are kept clean and are thoroughly washed during the pumping test to remove any potential contaminants. The probes should also be washed between each site using distilled water, and calibrated each morning using reference calibration fluids.

Field microbiological water quality measurements

Measurement of Thermotolerant (faecal) Coliform concentrations (TTCs)

In the first major survey phase of the Hidden Crisis project, Thermotolerant (faecal) Coliform concentrations (TTCs) were measured using a Delagua testing kit and overnight incubation of water samples. TTC plate counts were conducted the next day following overnight incubation in the portable Delagua unit. This provides a reliable and accurate means of assessing TTC, however, it is time consuming and labour intensive, requiring well trained staff adhering to rigorous procedures.

Other methods can be used to assess the level of concentrations of TTCs within water samples in the field.

Aquagenx bag test being used within the Hidden Crisis project.

Measurement of tryptophan-like fluorescence (TLF) using a hand-held field probe[2].

> Ecoli cells have been shown to directly emit TLF and also excrete compounds that fluoresce in the TLF region in laboratory experiments[3]. The field probe measures TLF instantaneously using LED UV-based fluorimeters, and then expresses TLF intensity as an equivalent concentration of dissolved tryptophan in parts per billion. The approach is easy to apply in field, and can provide a means of estimating TTCs with an effective detection limit of 10 cfu/100 mL if the correct protocol is used[4]. This means it can be used for identifying samples with medium, high or very high risk according to the WHO risk categories.

Measurement of Ecoli using Aquagenx Bags.

> The Aquagenx Compartment Bag Test (CBT) detects and quantifies bacteria in a 100 mL sample. It scores a Most Probable Number (MPN) test results by a field colour match, to determine ecoli concentrations. The CBT Kit enables ambient temperature incubation at 25° Celsius and above, and works at variable temperatures. The approach is easy to apply in field, and results are obtained typically within 24 hours.

Collecting water samples for laboratory analysis – inorganic water quality

The following inorganic water quality parameters listed below were derived from laboratory analysis. As a result, these parameters, are the most expensive to measure, and represent the most detailed level of investigation, which might not always be possible to be employed outside of scientific research projects, or very detailed programme monitoring.

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[2] Lapworth D.J. and Sorensen J.P.R. 2018. BGS-UKRI Briefing Note: Tryptophan-like fluorescence (TLF) as a rapid screening tool for assessing faecal contamination risk in groundwater. BGS Open Report OR/18/058, pp 3

[3] Sorensen et al. 2018. https://doi.org/10.1016/j.scitotenv.2017.11.162

[4] Ward J., Lapworth DJ, Sorensen J, Nowicki, S. (2018). Assessing microbiological contamination in groundwater sources: Field note on using Tryptophan-like Fluorescence (TLF) probes. BGS Open Report OR/18/042, pp 12.

- Nitrate
- Iron
- Manganese
- Arsenic
- Fluoride
- Ammonia
- Total Dissolved Solids

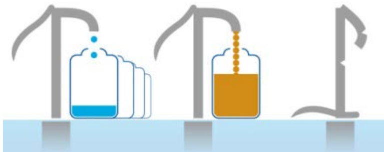
These parameters can all be measured using field techniques (e.g. Iron can be measured with a hand-held colorimeter), however, field estimates are generally not as reliable as laboratory estimates as a result of interferences, and detection limit issues.

Appendix 2 – Template Field Survey Forms

General Information			
Village Name		Borehole ID	
Borehole Location - Decimal longitude		Decimal latitude	
Borehole Elevation		Date of Completion	
Name of Assessor		Date of Assessment	

Visual Observations

Usage			
Is the borehole in use?	Yes	No	Comments
Is there a queue at the borehole?	Yes	No	If yes, describe



Water Quantity – Pumping Test

Bucket Volume ________litres

Bucket No.	Time
1	
2	
3	
4	
5	
6	
7	
8	
9	
10	
11	
12	
13	
14	
15	
16	
17	
18	
19	
20	
21	
22	
23	
24	
25	
26	
27	
28	
29	
30	
31	
32	
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45	
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47	
48	
49	
50	
51	
52	
53	
54	
55	
56	
57	
58	
59	
60	

Strokes before Water ___________strokes

Time (min)	Cumulative Stroke Total
1	
2	
3	
4	
5	
6	
7	
8	
9	
10	
11	
12	
13	
14	
15	
16	
17	
18	
19	
20	
21	
22	
23	
24	
25	
26	
27	
28	
29	
30	

Leakage Test

No. of strokes before water (after 30 mins of rest)	

Notes

Water Quality

Sampling Time	

Probe Measurements

Temperature (°C)	
pH	
Electrical Conductivity (µS/cm)	
Turbidity (NTU)	
Tryptophan (µg/l)	

Sample Bottles (Please tick and name)

Sample	**Tick**	**Bottle Name**
30ml		
60ml		
Microbiology		

Field Test Results

Total Iron (mg/l)	

Alkalinity	Reading	Sample Volume (circle and delete)	Acid Cartridge (circle and delete)
Titration 1		100ml / 50ml	0.16N / 1.6N
Titration 2		100ml / 50ml	0.16N / 1.6N

Total Thermotolerant Coliforms – Count (cfu/100ml)	

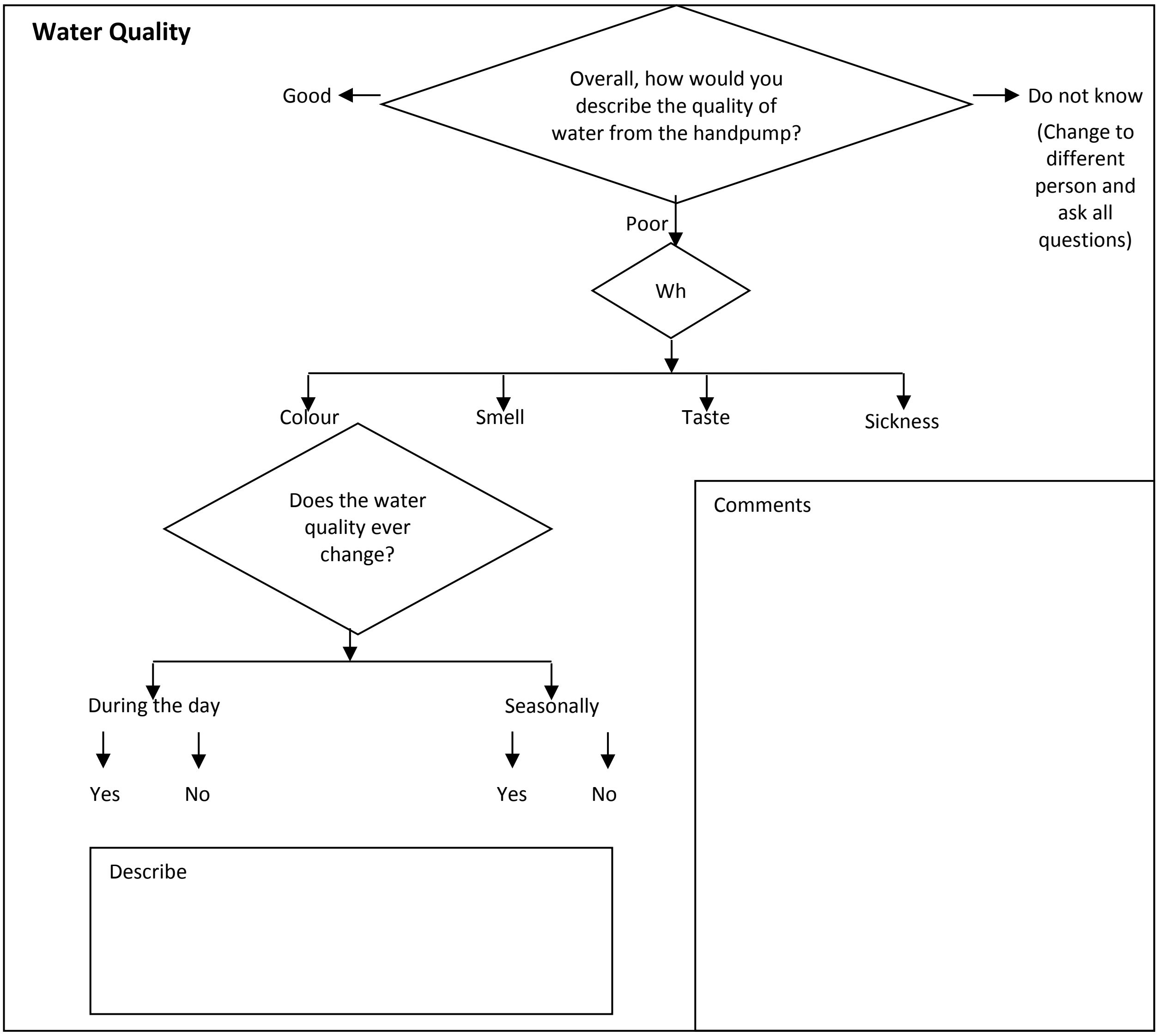
Visual Observations

General Information				
General condition of water point	Good	Bad	Moderate	Comments
Comments				

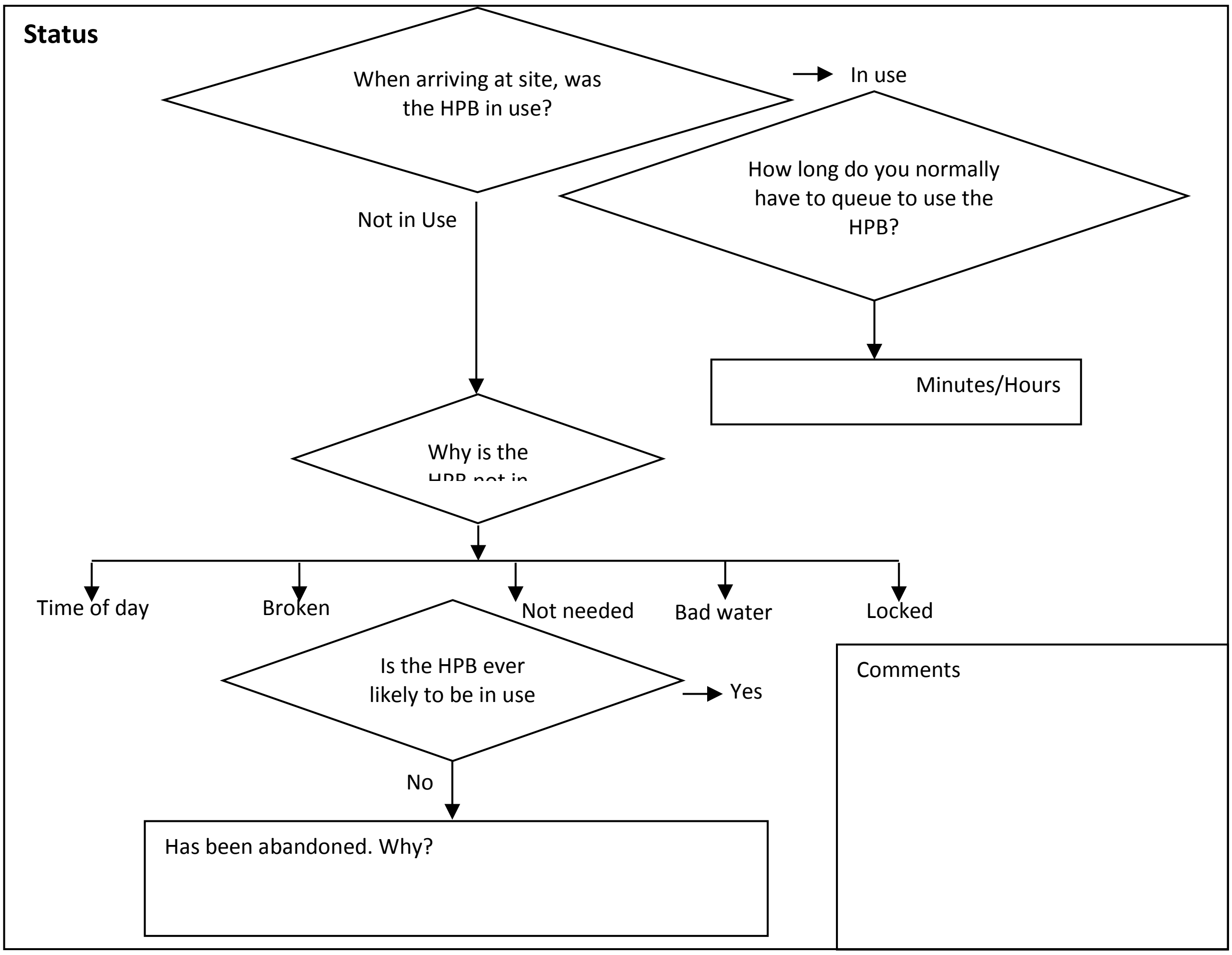
Handpump				
Pump Type	India Mark II		Afridev	Other
Handpump complete and intact?	Yes	No	If no, detail	
Handpump handle moves freely?	Yes	No	If no, describe movement	
Does the pump stand move?	Yes	No	If yes, describe	
Noise/rattling when pumped?	Yes	No	If yes, describe	

Platform			
Is there an Apron of radius > 1 m	Yes	No	If no, detail
Is the Apron cracked or damaged ?	Yes	No	If no, detail
Is the drainage faulty – allowing ponding within 2 m?	Yes	No	If no, describe movement
Is the fence missing or faulty?	Yes	No	If yes, describe
Water			
Water flows freely?	Yes	No	If no, describe
Does the water smell?	Yes	No	If yes, describe smell
Is the water clear?	Yes	No	If no, describe colour and appearance
Is the apron stained?	Yes	No	comments

User Questionnaire



Status


When arriving at site, was the HPB in use?
In use
How long do you normally have to queue to use the HPB?
Minutes/Hours
Not in Use
Why is the
Time of day
Broken
Not needed
Bad water
Locked
Is the HPB ever likely to be in use
Yes
No
Has been abandoned. Why?
Comments

Water Quantity

Do you have to stop pumping and wait before you can get

Do not know

No

Yes

Details (starts ok then harder to pump and then only a dribble? Describe what happens.)

Does the borehole ever produce less water than normal during the dry season?

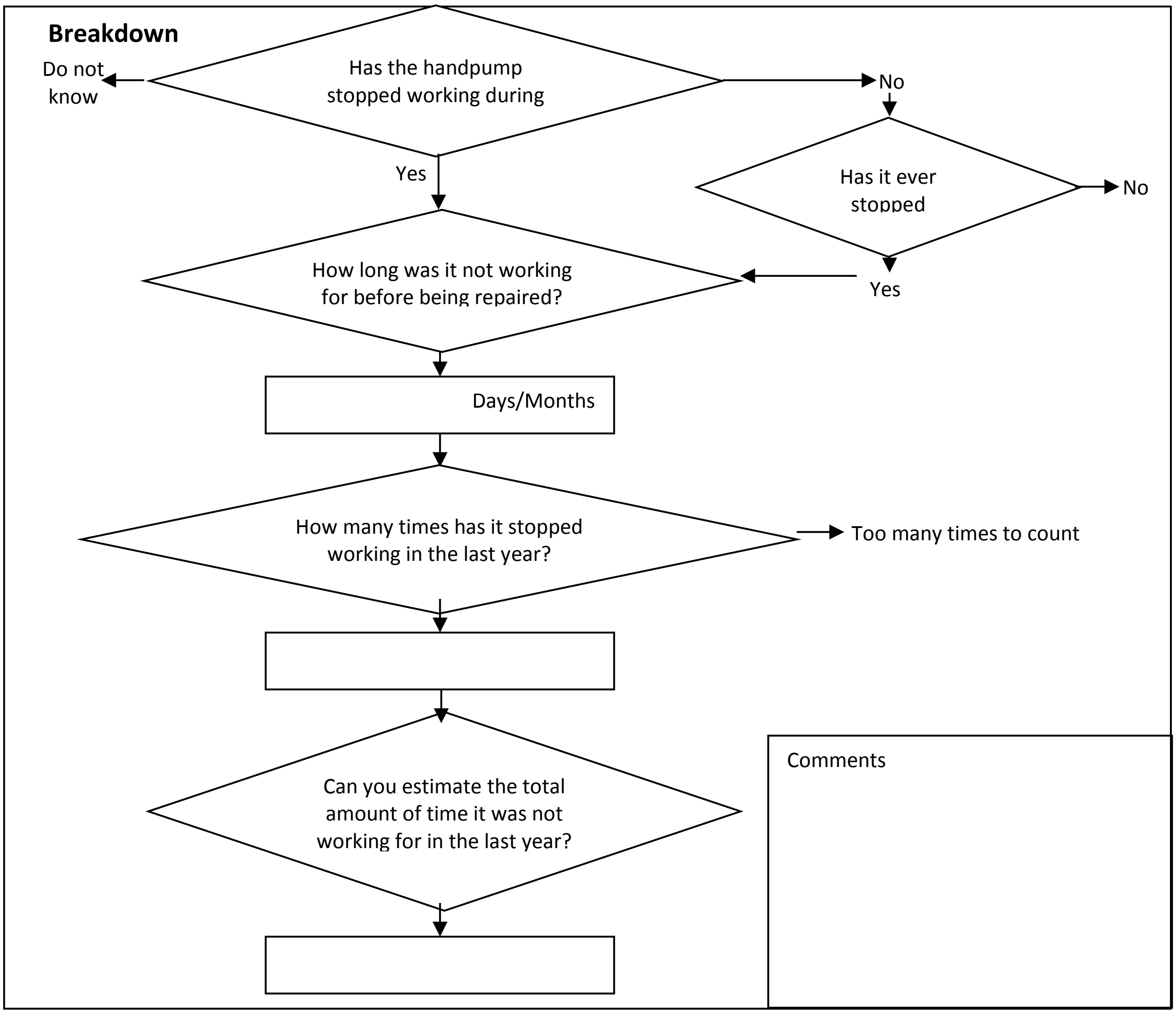
Do not know

No

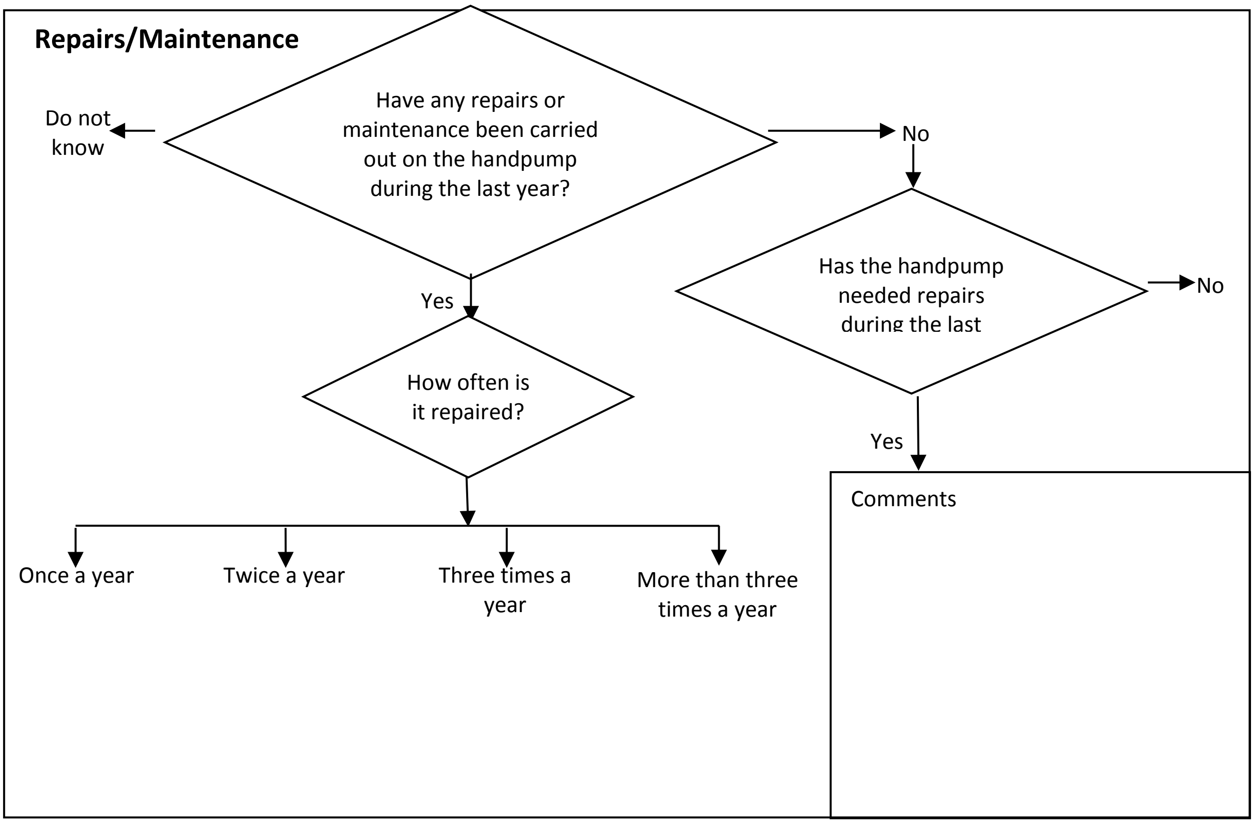
Yes

Details

Comments


Breakdown
Has the handpump stopped working during
Do not know
No
Yes
Has it ever stopped
No
Yes
How long was it not working for before being repaired?
Days/Months
How many times has it stopped working in the last year?
Too many times to count
Can you estimate the total amount of time it was not working for in the last year?
Comments

Repairs/Maintenance



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