Spring Assessment Tool

A simple Citizen Science tool to assess natural springs

This is a product of The Water Research Commission: Project No. K5/2350

water & sanitation
Department:
Water and Sanitation
REPUBLIC OF SOUTH AFRICA

WATER RESEARCH COMMISSION

GroundTruth
Water, Wetlands and Environmental Engineering

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1. INTRODUCTION AND BACKGROUND

1.1 Introduction

South Africa is a water-stressed country, security or management of both groundwater (includes wells, boreholes and springs) and surface water (rivers, streams, dams, etc.) supplies has become a key strategic issue as well as a driver for continued and sustained economic growth and service delivery to the people of South Africa (Parsons and Tredoux, 1995).

Currently, at least two thirds of South Africa's population depend on groundwater resources for domestic water needs (DWAF, 2000). Groundwater is water that exists in pore spaces and fractures in rock and sediment beneath the Earth's surface. It is naturally replenished by surface water from precipitation or snow, and then moves through the soil into the groundwater system where it recharges the water table.

In areas rural areas where rural infrastructure is minimal, communities rely more on informal groundwater source, such as springs as a water source. In addition, it has been mentioned that springs also continue to supply water to major cities in South Africa such as Pretoria. Todd and Mays (2005), defined a spring as a concentrated discharge of groundwater appearing at the ground surface as a current of flowing water. Not only are they known to be a direct source of water for communities but they are also known to have indirect benefits which include their contribution to base flows of streams and rivers. Different types of springs (see sub-section 3.2.2 below) behave differently, depending upon factors such as the characteristics of aquifers feeding the spring.

Although groundwater resources are usually significantly cheaper to develop and manage than surface water, in situations, where they are vulnerable to contamination the cost of treatment may be significant. With that said, there is a critical need for spring water monitoring, management and protection to reduce stress on groundwater resources to secure continued supply of water.

This document serves as a manual for the assessment of the ecological state of spring ecosystems using the Spring Assessment Tool. The key users of the assessment tool include:

- Citizen scientists;
- Communities;
- NGOs;
- Local environmental authorities; and
- Landowners

It is recommended that prior to utilising the tool assessors should review basic literature on spring ecosystems, and where possible, attend various training courses related to the subject. Though this may not be essential, it will aid assessors in the identification of impacts and thereby, improve confidence in the information collected.

The application of the tool includes:

- Determining the current ecological state of the spring system of interest and identifying key impacts to address to maintain or restore the spring's health;
- Monitoring potential impacts to the spring system from any human activities;
- Monitoring for auditing of rehabilitation strategies.

The fields of application include:

- Benchmarking studies (studies that confirm status compared to other springs);
- Scientific research of citizen science studies; and
- Integrated catchment management programmes.

1.2 Background

Currently, South Africa has no formal standardised method or tool for monitoring springs. Due to this gap, the research team has taken the first steps in identifying and drafting a list of the key parameters (factors) regarding springs that require monitoring. These parameters formed the foundation in developing a pilot "Spring Assessment Tool" for application in southern Africa. The objective in developing this index will be to capture relevant information relating to springs and filter this information through to the right institutions and to the relevant authorities.

As part of this process, the team set out to research and find relevant monitoring programmes already in practice in other parts of the world. It helps the team to identify some of the key characteristics and parameters other monitoring programmes use and to see whether these are relevant for springs in Southern Africa. We identified two relevant international organisations using citizen scientists for assessing, monitoring, managing and protecting springs. These included Black Rock National Conservation Area (BRNCA) (McKnight, 2014) and the Springs Stewardship institute (Stevens et al. 2011). Many of the parameters measured by these organisations were relevant for springs in Southern Africa and were integrated into this pilot Spring Assessment Tool (e.g. measuring physical characteristics, such as spring type, discharge and important plants and animals identified) (McKnight 2014).

The index involved different steps of assessment, with varying degrees of intensity. These steps are based on the objectives of the citizen scientists conducting the study. Step 1 purely measures the locality and records the basic features of a spring. This serves as a method which signals that a particular spring may require further assessment. Step 2 and 3 measure more detail, potentially flagging certain springs that require regular monitoring and possibly require some rehabilitation.

2 STRUCTURE OF THE SPRING ASSESSMENT TOOL (SAT)

2.1 Background to the Structure of the Spring Assessment Tool

The Spring Assessment Tool demonstrates how to undertake fieldwork, identify a spring system and the key impacts within and around the spring zone. It can also be used to determine the extent to which these impacts are compromising the ability of the spring to function naturally.

Each impact is rated according to the intensity (concentration) and extent (coverage or size) of the negative impacts. The recorded scores are entered into the SAT model that produces a percentage of change which then determines the ecological condition of the spring. The score is based on the degree of change of the spring system exerted by human influences.

This guide was designed to aid prospective SAT users to:

- Identify the size & shape of the spring system habitat;
- Identify anthropogenic influences and negative impacts to the assessed spring; and
- Rate the intensity of negative impacts.

There are many studies done focused on the potential pollution to groundwater resources and very few done on distance of potential pollution to groundwater resources.

The minimum distance between spring outlet and any potential polluting activity upslope of a spring has to be at least 100 metres (DWAF, 2004). Banda (2013) reviewed that the minimum distance between a borehole and any potentially polluting activity has to be at least 30 metres.

Well/borehole water is mostly from confined aquifer whereas spring water is mostly from unconfined aquifer, which makes spring water more vulnerable to surface activities such as pollution. Therefore, the minimum distance between a spring and any potentially polluting activity has to be double the distance between a borehole and any potentially polluting activity, to be at least 60 metres.

Literature highlighted 10 impacts (within 60m around the spring or 100m if the pollution is upslope of a spring) as the principal negative influencers to the functioning and integrity of spring ecosystems:

- Livestock grazing
- Pollution near the spring
- Physic-chemical changes
- Surface water diversion & flow modification (change in the flow of water)
- Spring structure modification
- Vegetation removal
- Groundwater withdrawal
- Development and path ways
- Invasive Alien Species
- Soil erosion

2.2 Glossary and Description of Potential Impacts on Spring Health

2.2.1 Livestock grazing

Inappropriate or excessive livestock grazing affects springs by compacting or compressing wet soils, breaking down banks, increasing sediment and nutrients. This also reduces plant cover and the presence of desired riparian species.

2.2.2 Pollution near the spring

This refers to the disposal of solid waste around the spring. These solid wastes may infiltrate/percolate the groundwater with rain water and lead to a negative change in the quality of the water.

2.2.3 Physico-chemical modification

Physico-chemical modification may arise from point sources such as municipal and industrial wastewater effluent or storm water discharge points; or diffuse sources such as excessive run-off from surrounding landscape. Dungs from livestock grazing, pit latrines, sullage and waste disposal sites, agricultural and related activities are also included. These modifications lead to extra nutrients entering the spring system. These extra nutrient inputs may intensify aquatic animals and plants development, particularly invasive alien plants, and may lead to root fanning towards the channel, and shading. Nutrients can also lead to blue-algae in spring water.

2.2.4 Surface water diversion and flow modification (changes in the flow of water)

This term refers to the alteration of water flow from the ground to the surface area, either by changing water flow direction, or volume. This modification can be caused by factors such as the installation of pipes to harvest water directly from the spring. Some species such as spring-snails, like to live in a place that is not modified or impacted (McKnight, 2014). Altering a springs' discharge affects the productivity of aquatic and riparian habitats, in turn lowering the number of plants and animals of the site.

2.2.5 Spring structure modification

Spring modification is the alteration of the natural physical shape of the banks by physical man-made structures, such as building walls around the spring.

2.2.6 Vegetation removal

This is the removal of vegetation through activities such as livestock grazing, harvesting by people, excessive or non-naturally occurring fires, recreational activities and other activities that may cause the removal of vegetation near a spring.

2.2.7 Groundwater withdrawal

This is the extraction of groundwater through boreholes and wells. Extracted water would be used for things such as irrigation, industrial and domestic use. Its impact affects the spring discharge and can reduce spring source discharge.

2.2.8 Development and pathways

This is a broad category, including all infrastructures and buildings around the spring, and also included in this are tracks created by livestock migration.

2.2.9 Invasive Alien Species (IASs)

Invasive alien species are plants, animals, pathogens and other organisms that are non-native to an ecosystem and which may cause economic or environmental harm or adversely affect human health. In particular, they impact adversely upon biodiversity, including decline or elimination of native species through competition, predation, or transmission of pathogen and the disruption of local ecosystems and ecosystem functions (CBD, 2006).

Invasive Alien Species also negatively influence the spring habitat as some invasive alien plants tend to utilise more water than indigenous plants and change natural temperature cycles through excessive shading of the channel.

2.2.10 Soil erosion

Soil erosion is the washing away of the earth's topsoil by wind or water. Although, it is a natural process, it can be accelerated by excessive human and animal activity. This accelerated soil erosion can change the outlook of the spring and can also remove the indigenous plants needed for maintaining integrity of the natural ecosystem.

3. METHOD TO UNDERTAKE THE SPRING ASSESSMENT TOOL ASSESSMENT

The purpose of this section is to provide the user with the necessary guidelines to collect field data to assess and monitor the ecological condition of a spring.

Good practices when using the tool:

a) Obtain landowner permission when and where required;

b) Thoroughly read and ensure you understand the method and manual;

c) Understand basic spring ecology and functioning by reading background information on springs;

d) Attend basic ecological education and training courses (if available);

e) Do a full investigation on the spring system you are interested in; and

f) Regularly refer to the photographic and illustrative guide section of this manual when rating impacts.

3.1 Checklist of Items Needed to Determine Spring Condition

Before undertaking fieldwork, the assessor should make sure they have all the items required to undertake the assessment, or that might prove useful in the field (Table 3.1).

*Table **Error! No text of specified style in document.**.1 Summary of essential and potentially useful fieldwork items for the Riparian Health Audit*

Item	Essential	Potentially Useful
Field sheet	✓	
Suitable pencil and eraser	✓	
Notebook	✓	
Clipboard	✓	
Photographic and illustrative guide for the manual	✓	
Camera or camera phone	✓	
Notebook	✓	
Global Positioning System (NB: this could be in your phone)	✓	
First aid kit	✓	
miniSASS Net (including hand net)	✓	
Measuring tape (100 m long)	✓	
Gumboots		✓
Binoculars		✓
Spare batteries		✓
Machete		✓

3.2 STEP 1 – Site Overview

There is certain information that needs to be collected before you begin your spring condition assessment. These steps facilitate the assessment and provide a base of data to work from. These preliminary activities include:

- Determine the spring location
- Determine the type of spring
- Determine surrounding land cover/use
- Geomorphology of the area

3.2.1 Name and location of the spring

The location is the place (or site) where the spring is situated. The site name and Geographic Positioning System (GPS) coordinates must be recorded on the data fieldwork sheet. If you don't have a dedicated GPS, the GPS on a smart phone can be used. If your phone has the geo-tag function, consider taking a geo-tag photo of the spring. You could add this photo in to your report later. If you have access to aerial or ortho-photo maps of the area these can be very useful to gain an overview of the area when you are not in the field. If you have access to a computer and the internet; try to get a satellite image of the site from Google Earth (you can download the program for free: https://www.google.com/earth/).

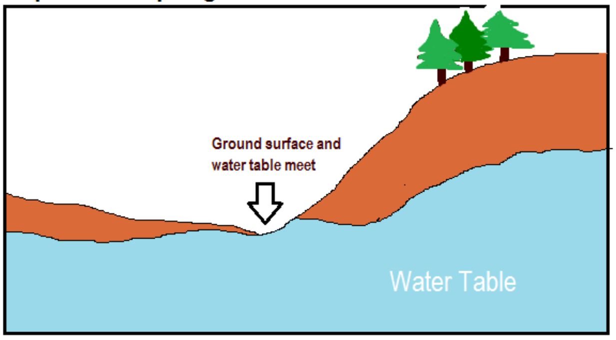
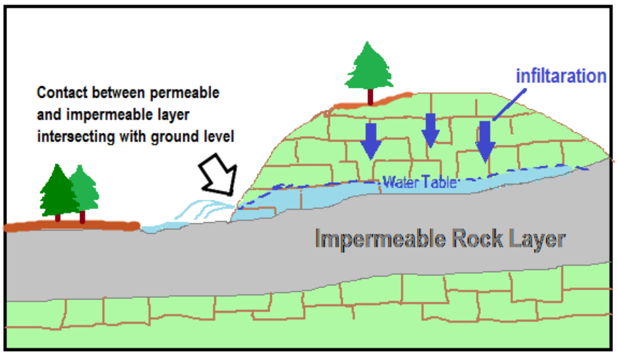
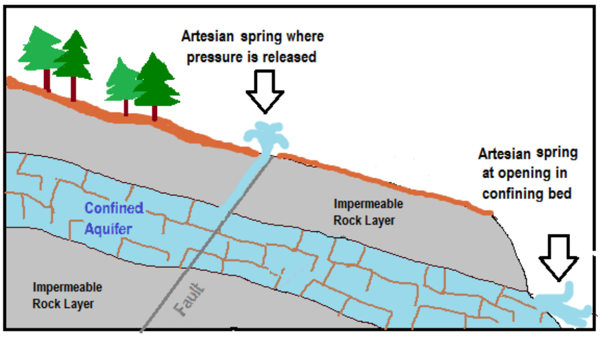
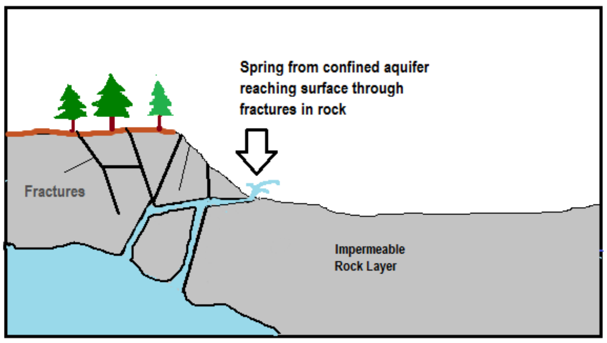
HINT: Google Earth can also give you "time-lapse" images (images of the same place taken in different years) of the site, so you can investigate what the site looked like a few years ago.

3.2.2 Type of spring

A spring is defined by the rate (how fast) and behaviour of the discharge. Discharge is the water flowing out of the spring. (In other words, the spring can be described by how fast the water is flowing out of the spring, as well as how the water flows out of the spring.) Discharge depends on a number of things, such as the type of aquifer (underground water) feeding the spring. Spring "types" are based on their characters and can be classified into the following types (Mahamuni et al., 2012):

*Table **Error! No text of specified style in document.**.2 Summary of different types of springs*

Type of Spring	**Description**
Depression Springs	formed where the ground surface intersects the water table
Contact Springs	created by permeable water bearing formation overlaying a less permeable formation that intersects the ground surface
Artesian Springs	resulting from releases of water under pressure from confined aquifers either at an outcrop of the aquifer or through an opening in the confining bed
Fracture Springs	issuing out of the ground where fractures lead water to the surface out of impervious aquifers
Tubular Springs	issuing from confined channels, such as lava tubes or solution channels, connecting with groundwater

Depression Spring  	Formed where the ground surface intersects the water table
Contact Spring  	Created by permeable water bearing formation overlaying a less permeable formation that intersects the ground surface
Artesian Spring  	Resulting from releases of water under pressure from confined aquifers either at an outcrop of the aquifer or through an opening in the confining bed
Fracture Spring  	Water issuing out of the ground where fractures lead water to the surface out of impervious aquifers

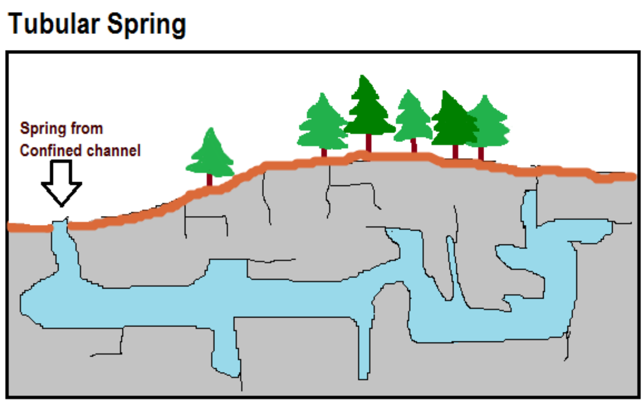
	Water issuing from confined channels, such as lava tubes or solution channels (where the rock has dissolved away), connecting with groundwater

Figure Error! No text of specified style in document..1 *illustrative guide to various types of springs*

3.2.3 Land cover/use

Land cover or land use refers to activities practiced on the earth's surface surrounding the spring. These could include activities such as residential, business, industrial, agricultural, and forestry. There are two potential ways to determine land use/cover. If you have access to a computer & the internet, you could use Google Earth to see what the current land use is. However if you don't have these tools, you can determine the land use when you visit the site.

To facilitate the assessment of a spring's condition it is recommended that a fieldwork map is generated. These maps provide a useful background study & understanding of the current land-use and potential impacts at the site. Additional notes can be added to the map to provide more information on the site.

Handy hint: make notes about anything relevant to the site, either on the map or in a notebook. The Information might be useful when you get back to the classroom or office, especially if you are assessing a number of springs.

3.2.4 Geomorphology of the area

Geomorphology is the branch of geology that studies the form of earth's surface. In this section, the main focus is the rock and soil types of the area around the spring. To facilitate the assessment of a spring's condition it is recommended that research or knowledge about geomorphology of the area where spring located is well known. These include information such as overlaying formation of the area; parent rock and soil types:

- **Parent rock types**: Igneous (andersite, basalt, dacite, diorite, gabbro, granite, peridotite, rhyolite); Metamorphic (gneiss, marble, marble, quartzite, slate, schist); and Sedimentary (coal, conglomerate, dolomite, evaporates, limestone, mudstone, sandstone, siltstone).
- **Soil types**: Sand - soils with particle sizes ranging from 2.0 to .05 mm; Silt/Loam - soils with particle sizes ranging from .05 to .002 mm; and Clay - soils with particles sizes smaller than .002 mm.

The major factors affecting the groundwater availability are permeability and porosity. Permeability refers to the ease with which water flows within a rock formation or soil to transmit water while porosity is the ratio of the voids to the total volume of material.

Groundwater moves very slowly through sediments with low permeability, such as clay. This allows more time for minerals to dissolve. In contrast, sediments with high permeability, such as sand, allow groundwater to move more quickly. There is less time for minerals to dissolve and thus the groundwater usually contains lower levels of dissolved minerals (Todd and Mays, 2005).

3.3 STEP 2 – Rating Impacts

Once the impacts have been identified according to the information given in section 2.2, each impact must be rated. The rating system varies from 0 (No impact) – 25 (Critical impact) and it is dependent on the intensity (concentration) and extent (coverage or size) of the impact. In other words, how much has the spring changed, compared to what it would look like naturally, or before the impacts. Table 3.2 provides a guideline to enable the rating of impacts.

Table Error! No text of specified style in document.**.3A guideline to rating impacts in terms of the change caused by the possible impacts or coverage of the impact to the spring health.**

Rating	Percentage Change or Coverage	Description
0.0	0	No Impact
0.5	1-10	Minor Impact
1.0	11-20	
1.5	21-30	Moderate impact
2.0	31-40	
2.5	41-50	Large impact
3.0	51-60	
3.5	61-70	Serious impact
4.0	71-80	
4.5	81-90	Critical impact
5.0	91-100	

To aid in data collection a field sheet is provided where site information and impact ratings can be noted (Figure 3.1).

The accurate rating of impacts is of great importance. If the data recorded is inaccurate and is used in catchment management programs, the wrong decisions may be made by management.

If assessors are unsure of a rating for a particular impact it would be useful to discuss with colleagues on the rating that should be given. Ideally, although not essential, a team could undertake the assessment to ensure that all impacts are observed and a variety of perspectives considered.

The details of the site need to be filled in on the field sheet used before the sheet is completed. In the absence of a GPS for determining the coordinates, detailed information about the location of the spring should be filled in accordingly.

	Date:					Project name:							
	Area name:					GPS cords; Lat:				Long:			
	Spring name:												
	Spring type:					Land cover/use							
	Comments/notes												
	NB: Rate each impact from 0-25; Please refer to manual for rating guidelines												
	Impacts										**TOTAL SCORE**	**PERCENTAGE OF CHANGE**	**ECOLOGICAL CONDITION**
	Livestock grazing	Pollution	Physic-chemical modification	Surface water diversion	Spring Modification	Vegetation Removal	Groundwater withdrawal	Development and Path ways	Invasive Alien species	Water Erosion			
Score													
total	25	25	25	25	25	25	25	25	25	25	250		

Figure ***Error! No text of specified style in document.****.2* **Field sheet used for Spring Assessment Tool**

The impact ratings recorded are used to create a score that indicates the percentage of change that has occurred to the spring system from its natural (original) condition. The score then gives us an Ecological Condition (EC) that describes the condition of the system (**Error! Reference source not found.**).

Table ***Error! No text of specified style in document.****.4 Summary of scores and percentage of change and their respective Ecological Condition for the Spring Assessment Tool*

Calculated percentage change	Ecological Condition
0-20	Natural
21-40	Good
41-60	Fair
61-80	Poor
81-100	Very Poor (Critical)

3.4 STEP 3 - Data Entry into the Spring Assessment Tool

The following section provides information on data entry into the SAT model and the calculation of the Ecological Condition. It is divided into three sub-sections for two different categories of assessors:

- Use of rating impacts
- Use of miniSASS for aquatic biota (only on flowing water)
- Comparison of the rating impacts and miniSASS results

3.4.1 Use of rating impacts

The various impact ratings are summed and converted to a percentage of the maximum total impact rating. An example of the calculation of the Spring Ecological Condition is provided below (Figure 3.2). Following the calculation of the percentage of change, the ecological condition is determined to provide information on the health of the stream (Table 3.3).

	IMPACTS												
	Livestock Grazing (0-5)	Pollution (0-5)	Physico-chemical modification (0-5)	Surface water diversion (0-5)	Spring modification (0-5)	Vegetation removal (0-5)	Groundwater withdrawal (0-5)	Development and pathways (0-5)	Invasive alien species (0-5)	Soil erosion (0-5)	Total Score	Percentage Changed (score/potential total)*100	Ecological Condition
Score	1	1	2	3	1	3	2	1	1	1	16	32	GOOD
Potential Total	5	5	5	5	5	5	5	5	5	5	50		

Figure ***Error! No text of specified style in document.****.3* Example showing the calculation of the Spring Ecological condition using the impacts ratings.

3.4.2 Use of miniSASS for aquatic biota

The miniSASS tool should be used to assess the health of a spring by determining the composition of macro-invertebrates living in the spring or those found in the water that outflows from the spring. More information about miniSASS can be assessed from the following website (http://www.minisass.org/en/) and interpretation of miniSASS score is shown in Table 3.5 below:

Table ***Error! No text of specified style in document.****.5 Interpretation of miniSASS score*

ECOLOGICAL CATEGORY (CONDITION)	RIVER CATEGORY	
	SANDY TYPE	ROCKY TYPE
Unmodified (NATURAL condition)	**> 6.9**	**> 7.2**
Largely natural/few modifications (GOOD condition)	**5.9 to 6.8**	**6.2 to 7.2**
Moderately modified (FAIR condition)	**5.4 to 5.8**	**5.7 to 6.1**
Largely modified (POOR condition)	**4.8 to 5.3**	**5.3 to 5.6**
Seriously/critically modified (VERY POOR condition)	**< 4.8**	**< 5.3**

3.4.3 Comparison of the results

MiniSASS helps to give information about the quality of the water after it moves way from the source. However, as previously mentioned the MiniSASS method may only be used if the spring flows out, if this is indeed the case then the results from the miniSASS can be integrated into the results from the spring ecological condition to thus produce better conclusions of the health of the spring studied.

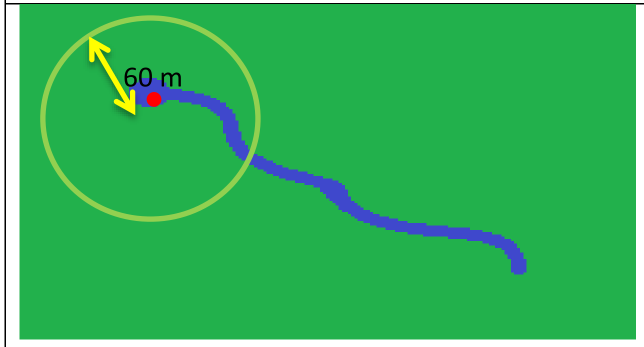
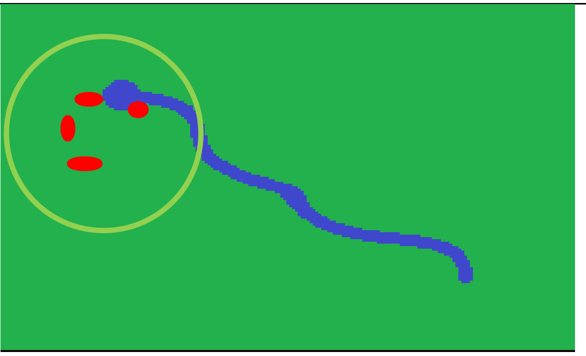
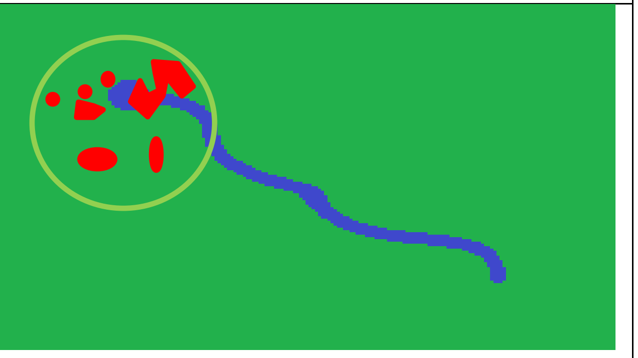
Table 3.5. Example of a site overview sheet, this sheet is to be completed before the spring health assessment is conducted.

Name of Spring	Location	Type of spring	Is this a got or a cold spring	Land-uses around the spring	Is the spring being used	Notes on the geomorphology of the spring	Is the spring in an easy accessible area	Does the spring dry up at any time of the year	Is the spring protected from any outside influences

4 PHOTOGRAPHIC AND ILLUSTRATIVE GUIDE TO IMPACTS

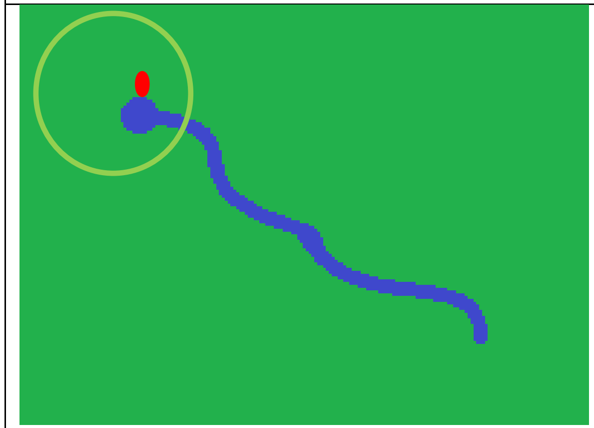
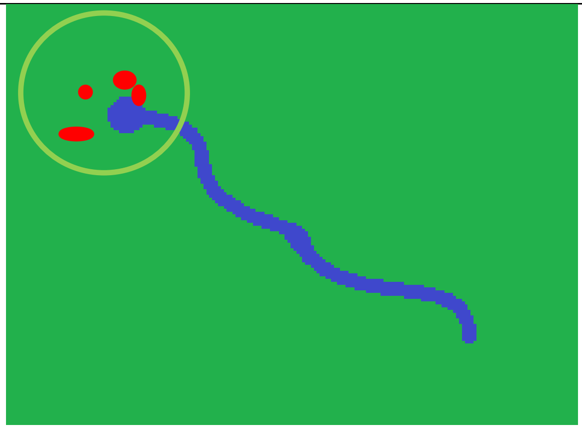
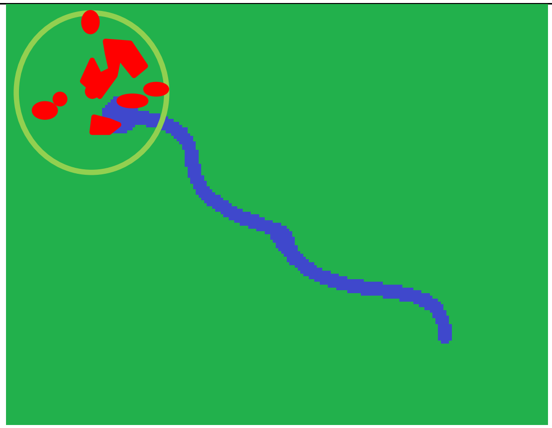
Below is a photographic and illustrative guide to aid in identifying and rating the potential impacts considered in the Spring Assessment Tool. Remember: we are looking at impacts within 60 meters around the spring.

4.1 Livestock grazing

Rating 0.5 - 1	Rating 1.5 - 3	Rating 3.5 - 5
Minimal livestock grazing	Moderate and extensive livestock grazing	Intensive and extensive livestock grazing
		
		

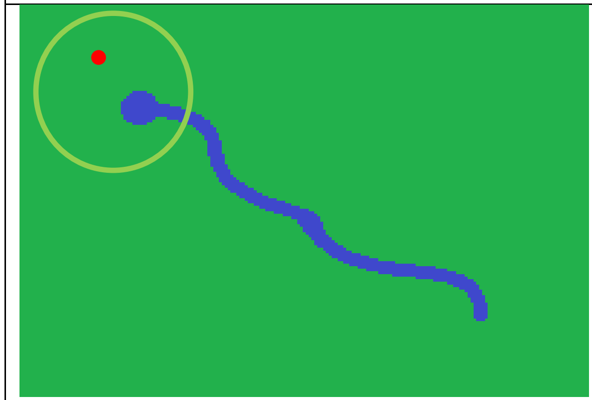
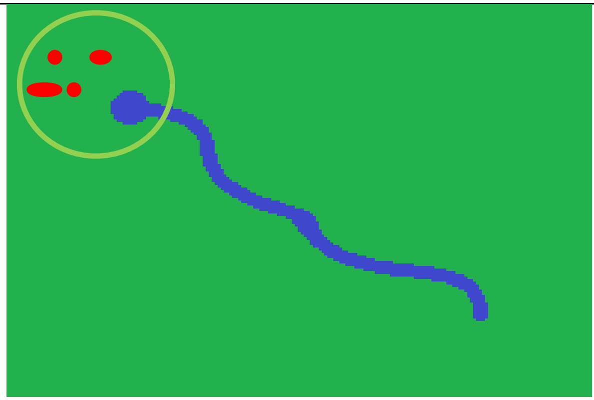
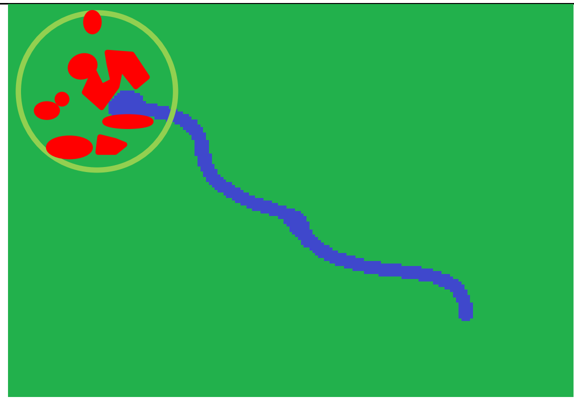
4.2 Pollution

The impacts should be rated on the intensity and extent of coverage around the spring area

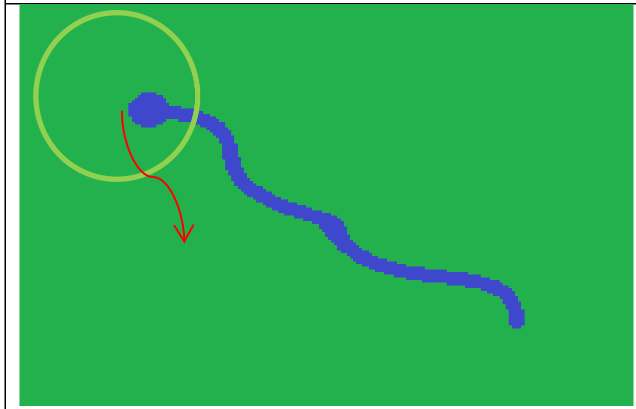
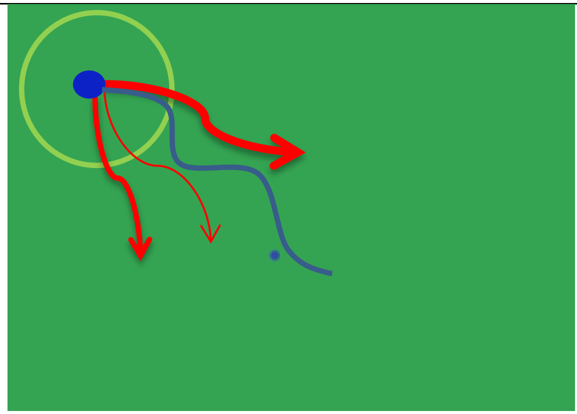
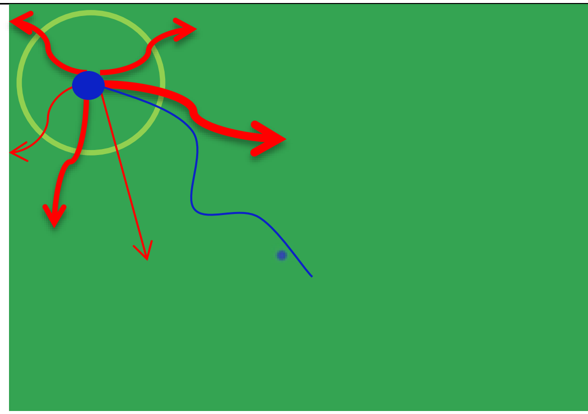
Rating 0.5 - 1	Rating 1.5 - 3	Rating 3.5 - 5
Minimal pollution	Moderate and extensive pollution	Intensive and extensive pollution
		

4.3 Physic-chemical modification

The impact rating is based on the extent of the impact or discharge rate of chemicals to the surrounding

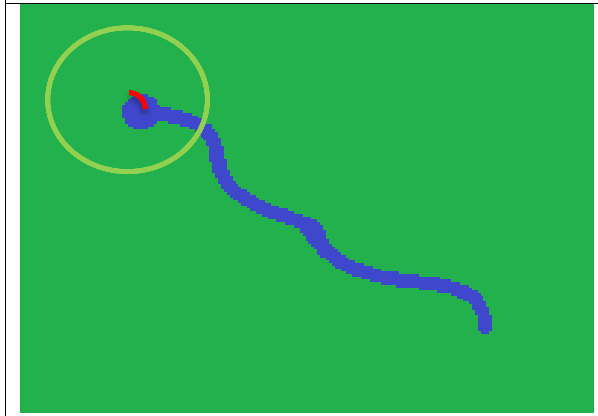
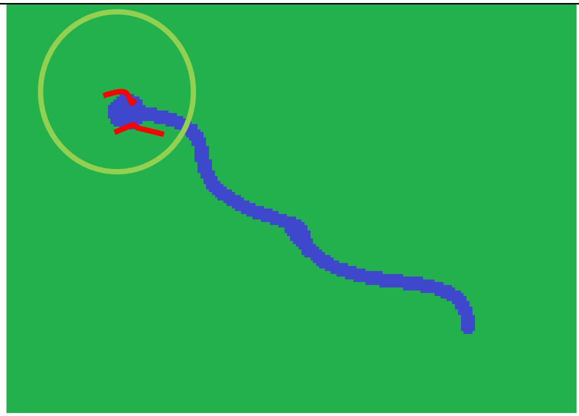
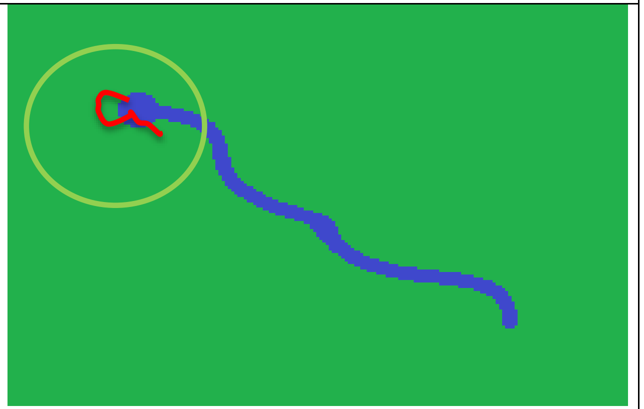
Rating 0.5 - 1	Rating 1.5 - 3	Rating 3.5 - 5
Minimal chemical spillage	Moderate and extensive chemical spillage	Intensive and extensive chemical spillage
		
		

4.4 Surface water diversion

Rating 0.5 - 1	Rating 1.5 - 3	Rating 3.5 - 5
Minimal Surface water diversion	Moderate and extensive Surface water diversion	Intensive and extensive Surface water diversion
		
		

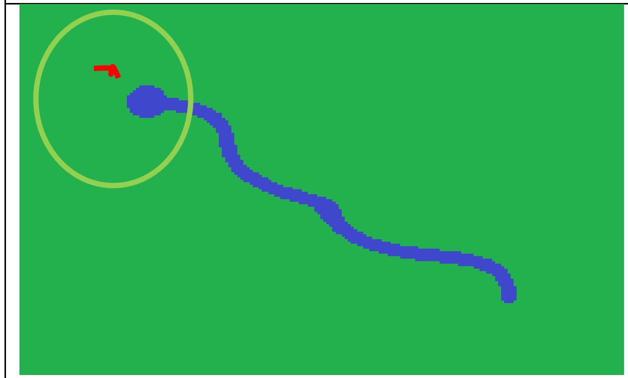
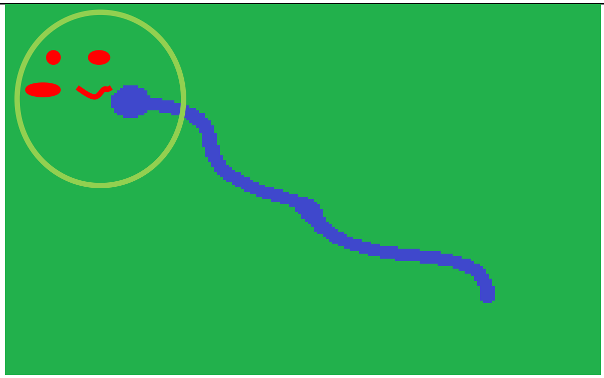
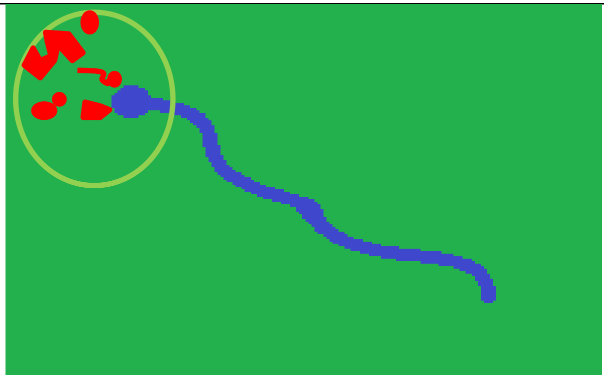
4.5 Spring modification

The rating should be based on the longitudinal extensiveness of the modification around the spring

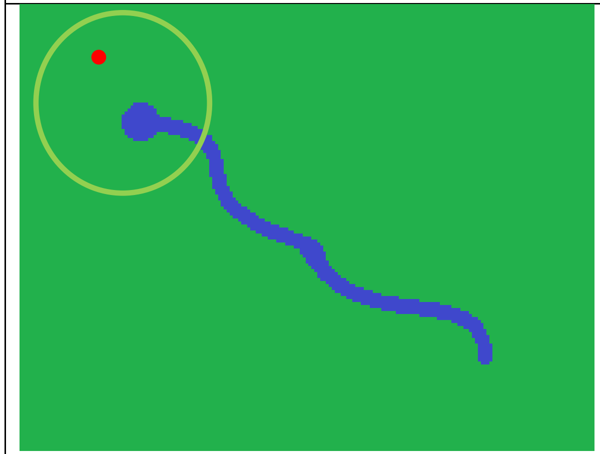
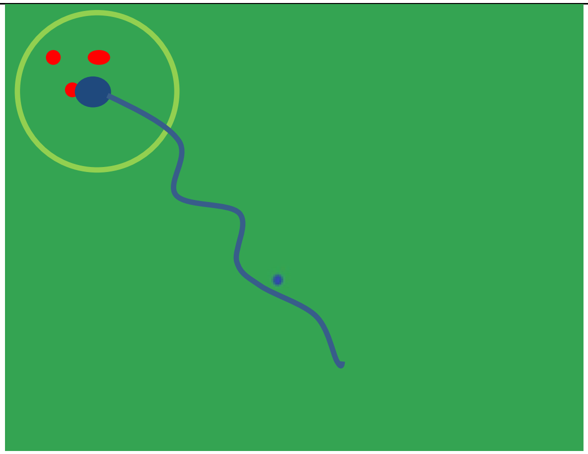
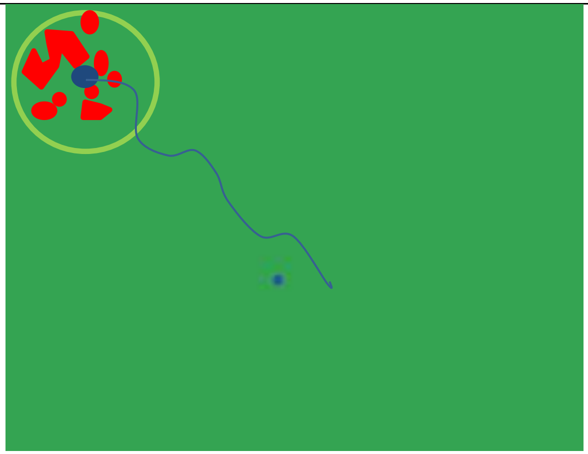
Rating 0.5 - 1	Rating 1.5 - 3	Rating 3.5 - 5
Minimal Spring modification	Moderate and extensive Spring modification	Intensive and extensive Spring modification
		
		

4.6 Vegetation removal

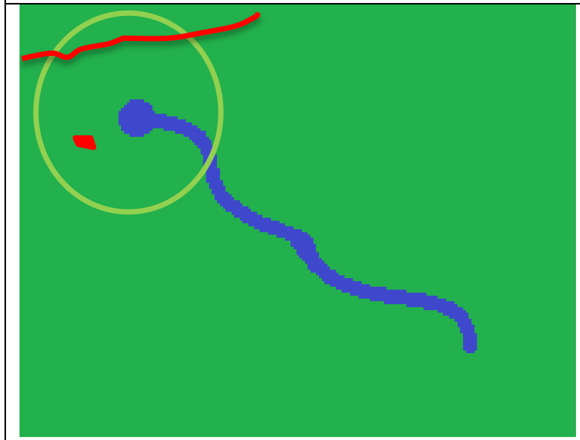
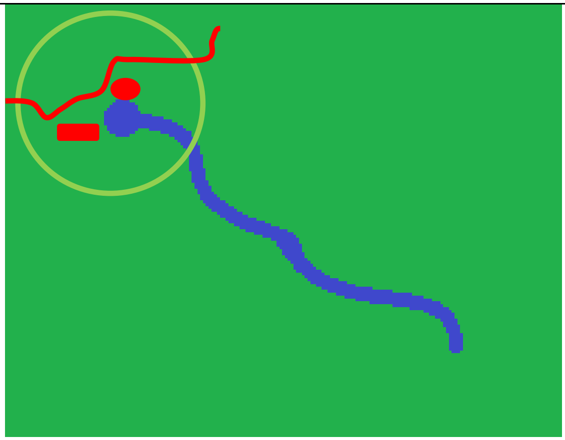
The impact rating should be based on the extent of vegetation removal

Rating 0.5 - 1	Rating 1.5 - 3	Rating 3.5 - 5
Minimal vegetation removal	Moderate and extensive vegetation removal	Intensive and extensive vegetation removal
		
		

4.7 Groundwater withdrawal

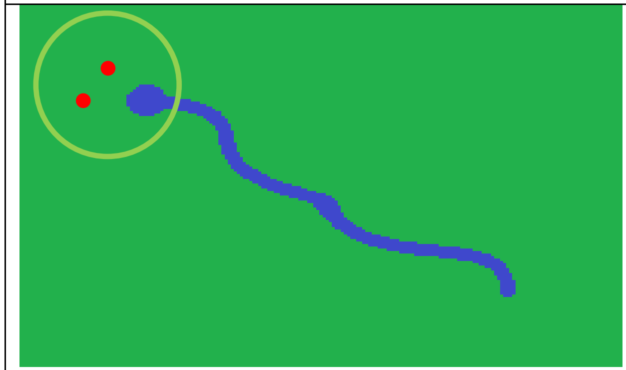
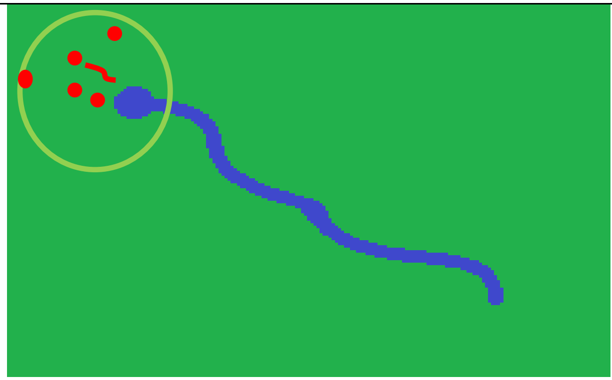
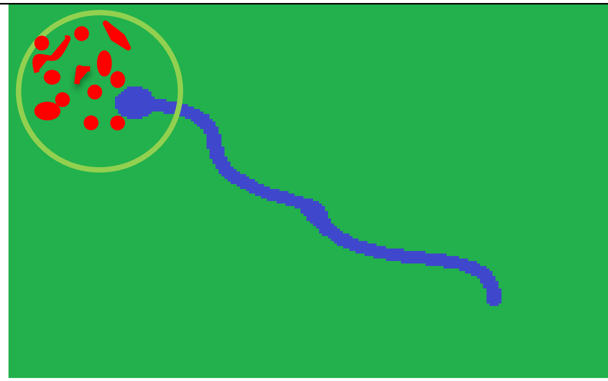
Rating 0.5 - 1	Rating 1.5 - 3	Rating 3.5 - 5
Minimal water extraction	Moderate and extensive water extraction	Intensive and extensive water extraction
		

4.8 Developments and path ways

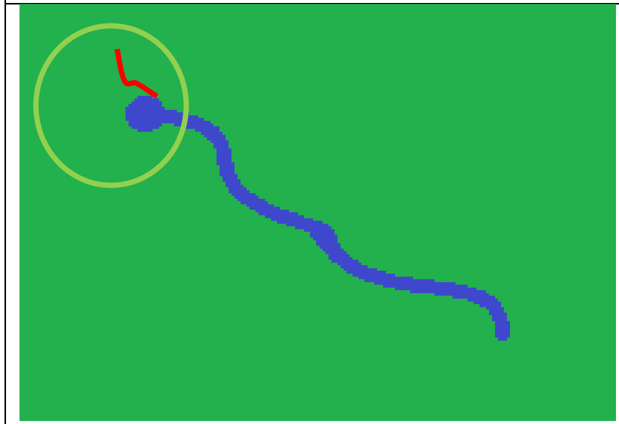
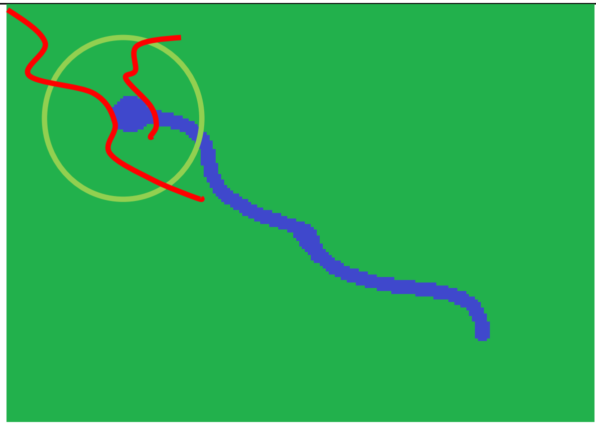
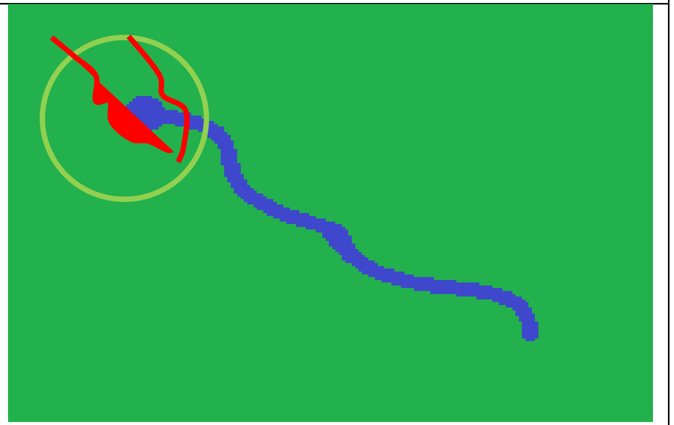
Rating 0.5 - 1	Rating 1.5 - 3	Rating 3.5 - 5
Minimal livestock of developments and path ways	Moderate and extensive of developments and path ways	Intensive and extensive of developments and path ways
		
		

4.9 Invasive Alien Species

Impacts should be rated according to their abundance and intensity within the spring area.

Rating 0.5 - 1	Rating 1.5 - 3	Rating 3.5 - 5
Minimal Invasive Alien Species	Moderate and extensive Invasive Alien Species	Intensive and extensive Invasive Alien Species
		
		

4.10 Erosion

Rating 0.5 - 1	Rating 1.5 - 3	Rating 3.5 - 5
Minimal erosion	Moderate and extensive erosion	Intensive and extensive erosion
		
		

5. COMMENTS AND CONCLUSION

Comments and conclusion part must be done by experts on the field of Spring Assessment Tool such as hydrologist, hydrogeologist or experienced person in the field of spring groundwater.
The assessors must have thorough knowledge on possible impacts on groundwater recharge, regardless the issue of distance from the spring source; and thorough knowledge on potential contamination sources include livestock gathering points, pit latrines and waste disposal sites located upslope from the spring outlet.

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