Blackwood Basin Group

Smart Farms Monitoring Manual

A hands-on manual for monitoring soil, water, weeds and pests on your farm

Australian Government

National Landcare Program

Blackwood Basin Group

COMMENTS & REQUESTS FOR FURTHER INFORMATION SHOULD BE DIRECTED TO:

Blackwood Basin Group
+61 8 9769 1129
enquires@blackwoodbasingroup.com.au

PO Box 231 Boyup Brook
Western Australia 6244

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INTRODUCTION

With funding from the Australian Government's National Landcare Program, the Blackwood Basin Group (BBG) has created this Smart Farms Monitoring Manual (Manual) and associated Monitoring Kit (Kit) specifically aimed at landholder implemented farm monitoring and land management.

The Manual includes easy to apply monitoring methods for water and soil so property owners can actively participate in the maintenance and enhancement of their environment.

The BBG encourages property owners to use the Manual and Kit to monitor their environment and to increase their ability and confidence to routinely check, maintain and improve soil and water on their property.

What is Monitoring?

Monitoring is regularly carried out to track changes over time and ensure that activities and methodologies are having their desired effect. Regularly monitoring your soil health, water quality and other environmental parameters will help you to plan for and improve your property and aid in the future proofing of your property, environment and region. A successful monitoring program will help to ensure that your work is effective and can save time and money in the long run.

When conducting your monitoring program(s), it is important to remember that the monitoring methods used should be consistently and regularly applied to ensure that the parameters being measured are comparable over time and between sites. Collecting a small amount of accurate and consistent information using standard procedures is far better than gathering lots of inaccurate and inconsistent information. This will also make reviewing the results and interpreting trends much easier.

There are a number of ways to ensure the quality of your monitoring results, for example:

- Record who did the monitoring, what method was used, and where and when the monitoring took place in case this information assists with interpretation in the future;
- Use standard procedures to measure and record data;
- Ensure all monitoring equipment is calibrated and well maintained;
- Record comments regarding anything that may influence or effect the results at the time of sampling (recent heavy rainfall, water churned by livestock, etc.)

When recording your monitoring results, make sure they are written in pen, clearly legible and dated. Results should be recorded accurately at the time of monitoring.

Why monitor?

The most important reason for monitoring is to detect any problems and adjust by implementing corrective actions. Monitoring provides you with the base information to check and review your actions and make decisions according to those trends and changes. This is all part of the continuous improvement cycle.

Monitoring can also help gauge the level of land management change at the catchment and regional scale. The Blackwood Basin Group will always be interested in knowing the overall trends of your monitoring results. This information can lead to the identification of priority areas and may aid the allocation of on-ground funds.

What is pH?

pH stands for "potential of Hydrogen" and is a measure of the relationship of hydrogen ions (H+) to hydroxyl ions (OH-). The pH scale ranges from 0 to 14, with pH 7.0 being neutral (levels of H+ and OH- are equal at pH 7.0). Readings below 7.0 indicate the soil is "acidic," and readings above 7.0 indicate "alkaline" soil conditions.

Most plants require a soil that is slightly acidic, usually within a pH range of 6.2 to 6.8. Soil pH is very important because it directly affects soil nutrient availability. Plant roots can only absorb nutrients after they have been transformed into certain ionic forms. Only within certain pH ranges can sufficient amounts of these nutrients be transformed into these ionic forms. When the soil pH is outside the desirable range (6.2 to 6.8), the nutrients are literally "tied up in the soil" and are not in a form useful to plants.

There are two methods for measuring pH: methods that use indicator solutions or papers, and a more accurate method using electrodes and a millivoltmeter. Both of these measurement methods are utilised in your Monitoring Kit.

What is electrical conductivity (salinity)?

Salinity refers to the concentration of soluble salts in soil or water. Natural waters contain some dissolved salts such as sodium, magnesium and calcium. Sodium chloride (table salt) is the most common of all the salts and is the main constituent of seawater. Salts based on calcium and magnesium also affect the hardness and alkalinity of water.

The level of salt in water affects its suitability for irrigation, stock and domestic use. Collecting samples of farm water and measuring salinity levels will enable landholders to make better use of limited water resources.

To measure salinity in soil or water, an electrical current is passed between two electrodes. The electrical conductivity (or ‘EC’) of a soil or water sample is influenced by the concentration and composition of dissolved salts. Salts increase the ability of a solution to conduct an electrical current, so a high EC value indicates a high salinity level.

EC is recorded in multiple units of measurement and it is important to understand the different units of measurement and how to convert between them. The table below shows the different units used to measure salinity and their relationship to each other.

deciSiemens per metre (dS/m)		**milliSiemens per centimetre (mS/cm)**		**microSiemens per centimetre (µS/cm)**		**electrical conductivity (EC)**		**parts per million (ppm)**
1	=	1	=	1000	=	1000	=	640
4	=	4	=	4000	=	4000	=	2560

Note that the conversion to ppm is only an estimate dependent on temperature and types of salt.

The water quality meter provided in your Kit measures in units of mS/cm and µS/cm.

THE MONITORING KIT

The Monitoring Kit has been developed by the BBG to provide you with some basic monitoring equipment, as well as the relevant procedures and record sheets to undertake effective monitoring on your property.

The type of equipment, procedure and records that you will need to keep for effective monitoring will depend on which monitoring activities you plan to do. This manual is designed to help you through various monitoring activities using the equipment compiled in the Monitoring Kit.

Monitoring Kit Contents

- Canvas Bag
- Smart Farms Monitoring Manual (including field record sheet templates)
- Clipboard, notebook, pen and permanent marker
- Multi-parameter PCTestr 35 water meter (with spare batteries)
- Soil pH test kit
- Digital scales
- Ruler
- Digital weather station
- Hand Trowel/Shovel
- Glass sample jar (x2)
- Calibration solutions
    - Buffer Solution pH 4 (200ml)
    - Buffer Solution pH 7 (200ml)
    - Conductivity Solution 1413uS/cm (200ml)
    - Conductivity Solution 12.88mS/cm (200ml)
- Southern Weeds and their Control Booklet
- Pest Smart Glovebox Guide (x4)

How to use the Kit

Use all equipment according to their instructions, found in each monitoring section of the Manual or as provided by the manufacturer. Make sure to prepare or calibrate each item, as applicable, before use.

Record sheet templates are provided at the end of the Manual to help you with your monitoring program.

If you have any questions about how to use your Kit or would like to share your monitoring data with others, please get in contact the Blackwood Basin Group.

WATER MONITORING

The health of any environment depends heavily on water quality and quantity. The main issues that impact water quality on properties include excess nutrients, sedimentation, salinity, contamination from pollutants and changing stream flows. Regularly monitoring water quality will assist you in identifying impacts early so you can implement water management strategies at your property.

The Kit contains a Multi-parameter PCTestr 35 water meter that can analyse water samples for pH, conductivity and temperature. Each water meter comes with an instruction sheet and this Manual provides more detailed instructions to assist with its use.

The glass bulb on the meter measures pH and the two metal probes measure electrical conductivity (EC). The bulb and probes need to be completely submerged with the sample and free from air bubbles to take an accurate reading.

The water meter should ideally be rinsed in distilled water, patted dry and capped before storing away after use.

Calibrating Your Water Meter

Regularly calibrating your water meter is important to make sure that the measurement provided is accurate. Calibration is achieved using calibration solutions that have a known water quality to force the meter to reset to the current measurement.

Calibration of the water meter should ideally be done each time you use the meter to ensure accurate results. If you are measuring several samples at a time, calibration is only required before you measure the first sample.

The glass jar provided in the Kit can be used for calibration. Pour the minimum amount needed to immerse the glass bulb and metal probes on the meter to perform the calibration.

Solutions to calibrate the meter should be replaced annually or as per the use by date on the bottle. Please contact the Blackwood Basin Group if you require additional calibration solution, or you can contact a supplier directly.

pH Calibration

Calibration solutions for pH 7 and pH 4 are provided in the Kit.

To calibrate the pH meter:

1. Press On/Off to turn meter on and Mode Ent to select **pH mode** as needed.
2. Rinse the sensor with clean water. Immerse the sensor into the pH buffer solution and press ▲ CAL. The primary display will now show the un-calibrated pH value, while the secondary display should search for and lock on to the closest automatic calibration value.
3. Allow the primary display to stabilise, then press Mode Ent to confirm the calibration value. The primary value will blink briefly before the secondary value automatically scrolls through the remaining pH buffers available for calibration.
4. Repeat steps 2 & 3 with the additional calibration buffer.

EC (Salinity) Calibration

Calibration solutions for 1413uS/cm and 12.88mS/cm are provided in the Kit.

To calibrate the EC meter:

1. Press On/Off to turn meter on and Mode Ent to select **conductivity mode** as needed.
2. Rinse the sensor with clean water. Immerse the sensor into the calibration solution and press ▲ CAL. The primary display will now show the un-calibrated value, while the secondary display should search for and lock on to the closest automatic calibration value.
3. Allow the primary display to stabilise, then press Mode Ent to confirm the calibration value. The primary value will blink briefly before returning to measurement mode.
4. Repeat steps 2 & 3 with the additional calibration standard.

Collecting a Water Sample

When collecting a water sample for analysis, it is important that the sample is representative of the water being monitored.

If sampling from a creek or river (flowing water), aim to take the sample from the middle of the water body where the flow is the greatest and is fully mixed. A bucket or scoop can be tied onto a long stick, extendable pole or rope to reach the centre of the water body from the bank.

If sampling from a dam or lake, collect a sample as far from the edge as is possible unless you are monitoring water quality for stock in which case take the sample closest to where the stock usually drinks.

If sampling from a water distribution network (e.g. from pipes, tanks and taps for irrigation or household water supply) consider taking samples from multiple locations within the network and running taps/pumps for a period of time before taking the sample to make sure the water being tested in representative.

The containers used to collect samples should be thoroughly rinsed (ideally triple rinsed) with the water from the source you will be testing. This ensures that any contaminants that may be in the container are removed. You should also make sure your hands are clean before taking the sample and that you clean your hands afterwards.

The water meter only requires enough water to immerse the glass bulb and metal probes in the sample (2 to 3 cm depth), so there is no need to collect large samples of water for analysis.

Samples should be measured as soon after collection as possible – ideally within 24 hours – for the most accurate results. The temperature of the sample should also be maintained to as close to 25 ºC as possible for the most accurate results. Samples can be stored in the shade or in an eski to prevent from overheating.

Measuring a Water Sample

Pour the water sample into a container that has been thoroughly rinsed (ideally triple rinsed) with the water that is being sampled. The container should have an opening that is wide enough for the water meter to fit into - the glass jar provided in the Kit can be used for this purpose.

Pour the minimum amount needed to immerse the glass bulb and metal probes on the meter to perform the measurement.

pH Testing

1. Press On/Off to turn meter on and Mode Ent to select **pH mode**.
2. Stir the meter in the sample gently and make sure there are no air bubbles on the glass bulb and that it is fully submerged. The meter will automatically display the temperature of the sample, it is important for this to be as close to 25 ºC as possible otherwise results will not be as accurate.
3. Wait for the pH reading to stabilise; this may take several minutes.
4. Test your remaining samples by repeating the steps above.
5. Press On/Off to turn the meter off, rinse in clean water, pat dry and replace the cap after sampling.

Electrical Conductivity (Salinity) Testing

1. Press On/Off to turn meter on and Mode Ent to select **conductivity mode**.
2. Stir the meter in the sample gently and make sure there are no air bubbles on the metal probes and that they are fully submerged. The meter will automatically display the temperature of the sample, it is important for this to be as close to 25 ºC as possible otherwise results will not be as accurate.
3. Wait for the EC reading to stabilise; this may take several minutes. The EC meter will read in micro-Siemens (µS/cm) if the sample is below 2000 µS/cm. If the sample is above 2000 µS/cm the EC meter will read in milli-Siemens (mS/cm). When reading any results care should be taken to check the units displayed.
4. Unit conversions can be seen below:

Definitions:
mS/cm – milli-Siemen per centimetre
µS/cm – micro-Siemen per centimetre

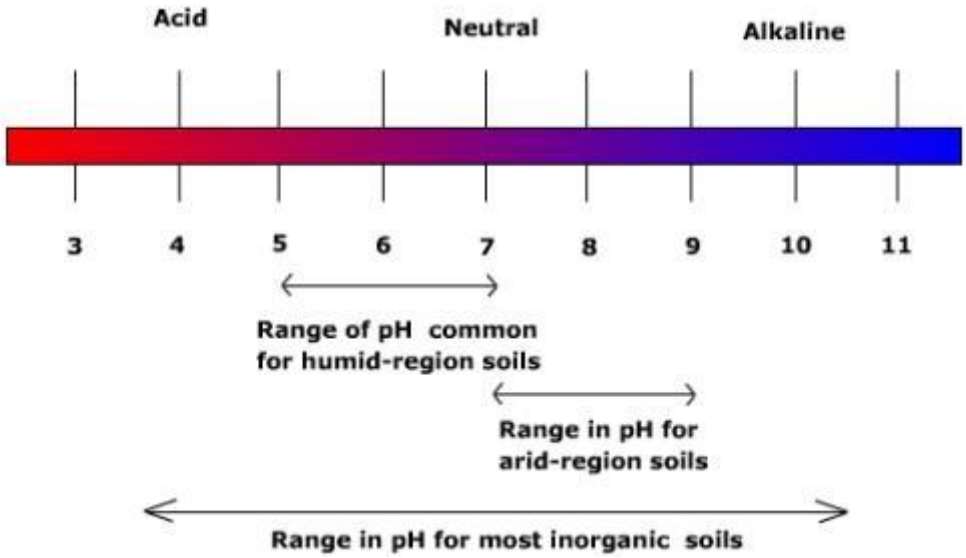
Conversions:
µS/cm ÷ 10 = mS/m
mS/cm x 100 = mS/m

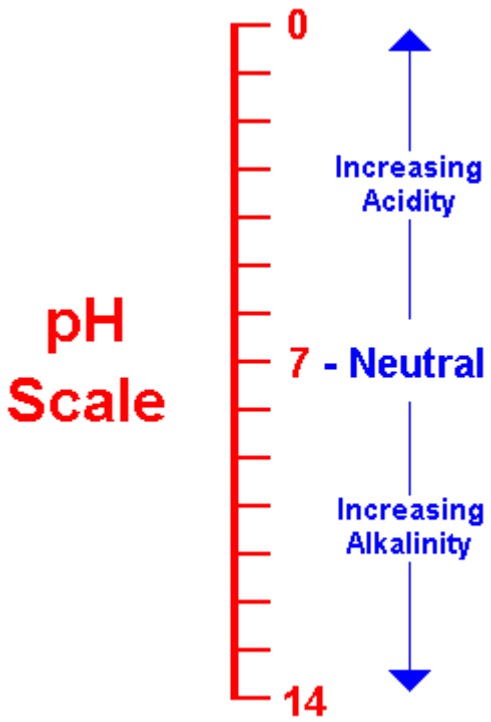
5. Test your remaining samples by repeating the steps above.
6. Press On/Off to turn the meter off, rinse in clean water, pat dry and replace the cap after sampling.

Interpreting and Recording Results

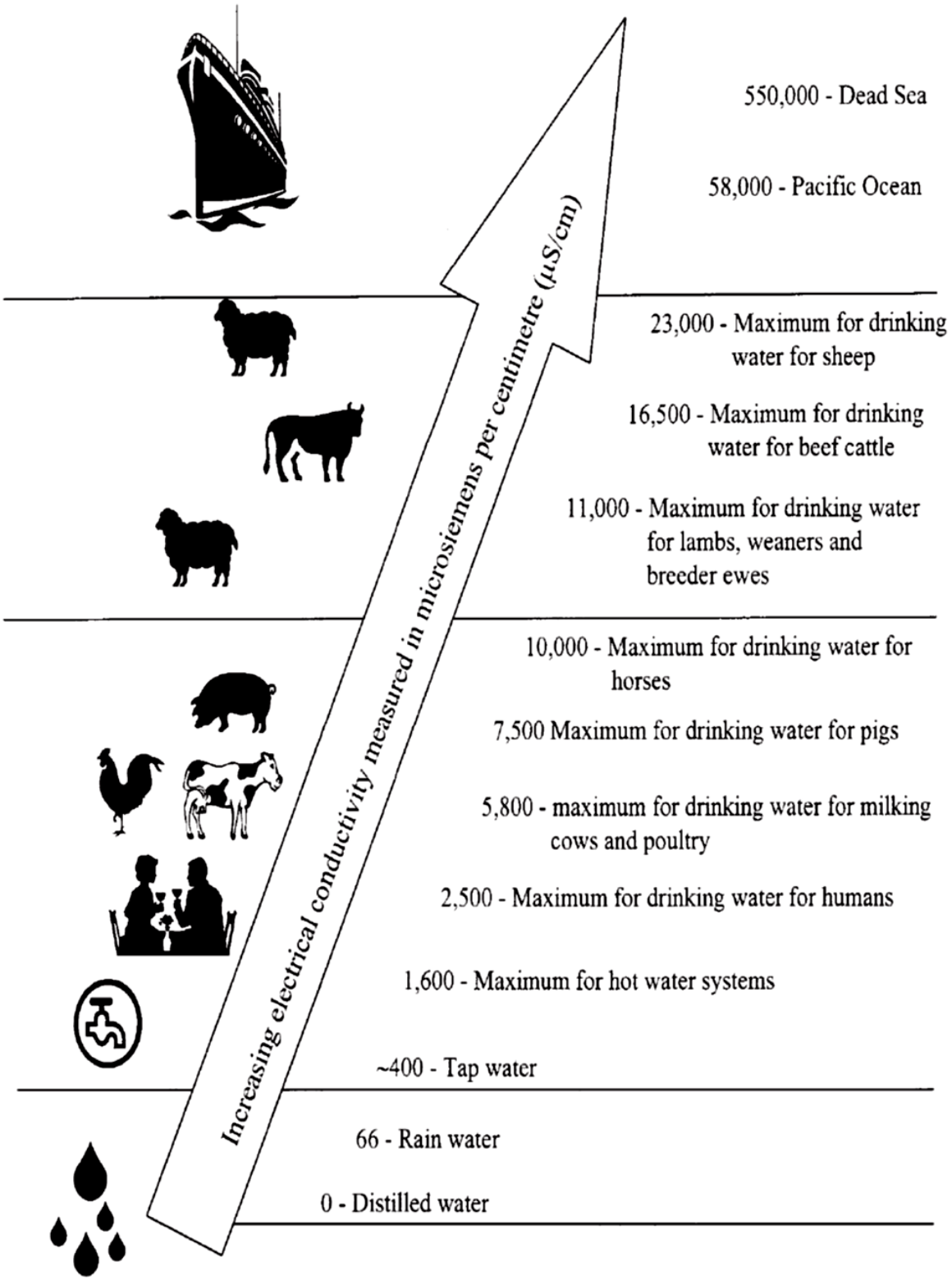
The figures provided below and on the next page are provided to assist you with the interpretation of your water quality results.

The record sheet template at the end of the Manual can be used to record your monitoring results.





Salinity Scale Reference Sheet



SOIL MONITORING

Soil is a dynamic medium that is influenced by physical factors including soil type, time, climate, and water balance. There are several aspects that you need to consider when thinking about the health of soils – soils must be physically, chemically and biologically balanced to be productive and stable.

There are a vast range of monitoring activities and analyses that can be carried out on soils, many requiring specialist expertise and laboratory analysis. This Manual provides information on methods that can be readily applied without specialist knowledge or expensive equipment on your property to measure common parameters. Monitoring your soils can help to not only provide information on the success of your on-ground actions but can assist in the decision-making for application of fertilisers and soil uses and can provide valuable long-term information for your property.

The following equipment in your kit will assist in monitoring the various soil and land aspects of your property.

- Soil pH test kit – measures soil pH
- EC/pH meter – measures salinity and pH levels in water or soil solutions.

Collecting a Soil Sample

When collecting a soil sample for analysis, it is important that the sample(s) collected are representative of the area being monitored. Soil characteristics can change significantly over short distances, so taking multiple samples over even a small area is recommended until more is known about the spatial variability of a site. The number of samples and spacing of samples required to get an accurate representation of an area will be different for each site.

When determining the number and location of soil samples to be measured, consider the following sampling methods:

- walk a transect (line) across the site collecting samples at regular intervals;
- sampling depth should be appropriate for the land use (e.g. root depth for the vegetation at the site, planned farrow depth, etc);
- divide the site into ‘zones’ of same/similar characteristics and take a number of samples from each zone;
- divide the site into ‘zones’ where different soil management activities have been conducted and take a number of samples from each zone;
- target sampling in areas of high risk or known poor performance to obtain “worst case scenario” results;
- multiple samples can be combined to obtain bulk ‘average’ conditions across an area.

The containers used to collect samples should be clean and clearly labelled with the sample number and sample depth for easy identification later. Glass or plastic containers can be used, including clean jars and plastic zip lock bags. If you plan to send your soil samples away for further laboratory analysis, the laboratory will supply you with collection jars/bags and instructions on sample volumes and other preparation requirements.

At each sample location, scrape away the surface groundcover and organic matter. Make a neat hole approximately 10 cm deep and cut a thin sliver/scoop of soil from the

side of the hole avoiding the first couple of centimetres. Place your sliver/scoop in a collection container. If you are collecting samples to obtain a bulk average of the area, combine your samples in a single collection bucket, making sure the samples are mixed thoroughly together. If you are taking multiple samples and analysing separately, collect your soil in multiple smaller labelled containers.

Repeat the process for as many samples and depths as you need to make an accurate representation of the area. Take at least one sliver/scoop of soil from each sample site.

Record where each sample has been taken either by description or by marking sampling sites on a map.

Measuring a Soil Sample

Soil pH Test Kit Procedure

Each soil pH test kit comes with instructions and this Manual provides more detailed instructions to assist with its use.

Steps:

1. Place a small soil sample (about half a teaspoon) on the white testing plate.
2. Add a few drops of Indicator Liquid Dye and stir the sample with the stick provided in the kit. Add just enough dye to stir the sample into a thick paste.
3. Dust the white Barium powder from the puffer bottle on to the moist paste and the powder will change colour within a minute.
4. Compare and match the colour developed on the paste with the colour chart in the kit to establish the pH value.
5. Wash the plate and stirring stick thoroughly after each test in order to avoid cross contamination.

Soil Salinity (EC) Testing Procedure

1:5 weight-to-volume ($EC_{1:5}$w/v) method

This system requires accurate scales for light weights and accurate water volume measurement.

The steps below have been summarised from information provided by the Department of Primary Industries and Regional Development, and the following website should be referred to for more information: https://www.agric.wa.gov.au/soil-salinity/measuring-soil-salinity

Steps:

1. measure 1 part by weight (grams) air-dried soil to 5 parts by volume (mL) distilled water
2. agitate the soil mix to get 95% dissolution of salts, then allow the mix to settle:
    a. 24 hours for low EC soils
    b. 3 hours for high EC soils
3. measure the EC of the solution using the water meter,
4. interpret the salinity class of the EC measure to allow for soil texture differences using the table below.

Salinity classes in electrical conductivity as $EC_{1:5}$ or EC_e, for different soil textures (from: https://www.agric.wa.gov.au/soil-salinity/measuring-soil-salinity)				
Salinity class	**$EC_{1:5}$ range for sands (mS/m)**	**$EC_{1:5}$ range for loams (mS/m)**	**$EC_{1:5}$ range for clays (mS/m)**	**EC_e range (mS/m)**
Non-saline	0–14	0–18	0–25	0–200
Slightly saline	15–28	19–36	26–50	200–400
Moderately saline	29–57	37–72	51–100	400–800
Highly saline	58–114	73–145	101–200	800–1600
Severely saline	115–228	146–290	201–400	1600–3200
Extremely saline	>228	>290	>400	>3200

Estimating Soil Texture by Hand

Soil texture is an estimate of the amount of sand, silt and clay particles present in the soil. Many physical characteristics of the soil depend on texture, including drainage and structure, which in turn affect how effectively plants will grow in the soil. The clay and organic matter help to bind soil particles together, forming stable aggregates, which are an indicator of good soil structure, good soil drainage, root and seedling penetration, and aeration. In general, field texture is a reasonable guide to soil behaviour for agricultural management.

The steps below and explanatory figures have been summarised from information provided by the Department of Primary Industries and Regional Development, and the following website should be referred to for more information: https://www.agric.wa.gov.au/soil-constraints/soil-texture-estimating-hand

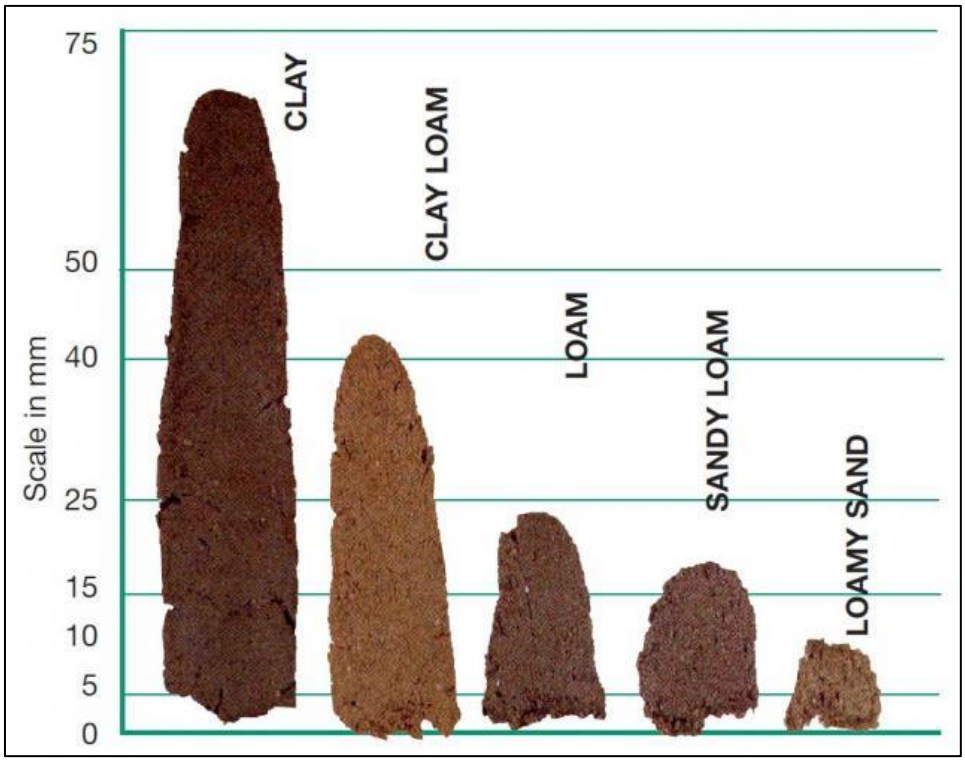
Steps:

1. Take a small handful of soil to fit comfortably in the palm of your hand. Add enough water to make a bolus or ball.

2. Knead the bolus for 1–2 minutes, adding more water or soil until it just stops sticking to your fingers. Note how the soil feels when kneading it: gritty (sandy), silky (silty) or plastic/sticky (clay). If you can't make a bolus, the soil is very sandy.

3. If you can make a bolus, form a soil ribbon by gently pressing out the soil between your thumb and index finger to form a hanging ribbon. The ribbon should only be 2–3mm thick.

4. The more clay you have in your soil, the longer your ribbon will be. The figure below will help you interpret the clay content in your soil.



WEED AND PEST MONITORING

Recognising, monitoring and managing weed and pest species is an important role for every landholder. The following resources in your Kit will assist in identifying and monitoring pests and weeds on your property.

- Southern Weeds and their Control Booklet
- Pest Smart Glovebox Guide (x4)

The Southern Weeds and their Control booklet provides easy identification of common weeds and their methods of control using readily available cultural, biological and herbicidal control techniques. The weeds are divided into four colour coded groups based on their life form: Grasses, Herbs, Vines and Trees, Shrubs and Cacti. Within the front cover of the booklet other useful resources are listed to further assist with weed identification and control.

The Pest Smart Glovebox Guides provide information on the control of the most common vertebrate pests in our region: foxes, rabbits, wild dogs and pigs. Poison baiting, trapping, fencing, shooting and other control techniques are described in detail, and references to further information and contacts are provided.

Note that the Blackwood Basin Group has fox and cat traps available for free hire and your local Shire may also have other resources available for local landholders.

MONITORING TRENDS

Once you begin monitoring the water and soil at your property, you can review your results over time to determine the influences of the seasons and whether your actions are having the desired on-ground effect that you want (i.e. are your actions having a positive effect, is the problem improving, are your plans being achieved)?

The way you review your monitoring records will, of course, depend on the type of record you have taken, your personal preference of how you want to see the data and your resources. Monitoring data can be recorded on summary record sheets, collated in tables for easy comparison across sites and over time, or can be shown in Excel graphs to clearly demonstrate trends that might be occurring.

The easiest way to review trends over an area (spatial changes) is to take the same measurement at the same time at different locations. The number and distance between samples (sampling density) will be dependent on the spatial variation at your site and what you are trying to achieve with the monitoring program.

The easiest way to review trends over time (temporal changes) is to take the same measurement at the same location at a certain frequency over time. The frequency that you take the sample can be seasonal (e.g. during each summer and winter to observe the influence of rainfall on water quality in a dam), or reactive to the implementation of a management practice (e.g. before, during and after applying lime at different rates to increase the pH of the soil).

When interpreting information from different sites or taken at different times, and when interpreting unusual results, it is important to consider if the observation is a true reflection of the site conditions or if the result could be an error that needs correction. Things to consider when reviewing your results include:

- Were the samples collected and measured in the same way?
- Was the sample representative of the area being measured?
- Was the sample container clean and uncontaminated?
- Was the water meter calibrated and were the units recorded correctly?
- Can the results be attributed to unseasonable conditions (e.g. unseasonably wet summer/high summer rainfall will affect expected salinity trends) or to manual interventions (e.g. application of chemicals)?
- Can the result be verified (e.g. take the sample again or re-check the measurement again)?

If you are not sure how to interpret your monitoring results or would like assistance to collate your results, contact the team at the Blackwood Basin Group.

Once you are confident that your monitoring results are a true reflection of the site conditions, you can make an assessment on whether your management methods need to change to meet the objectives for your property. When reviewing your monitoring results, consider the following questions:

- Is the monitoring program telling me what I need to know? Do I need to take samples more/less regularly, at more/less/different locations and/or monitor other parameters?
- Do I need to continue monitoring the issue/impact?

- Have my actions changed, improved, controlled or exacerbated the issue I'm addressing?
- Are there any changes that I could make to improve the issue?
- Am I achieving my targets and objectives; do I need to change my targets and objectives?

Ongoing monitoring and review can assist you in forecasting and adapting to changes and allow for good decision making for your property.

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Monitoring Record Sheet – Water pH / EC

Date	Sampling Location / ID	pH	EC (include units mS or µS)	Notes

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Monitoring Record Sheet – Water pH / EC

Date	Sampling Location / ID	pH	EC (include units mS or µS)	Notes

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Monitoring Record Sheet – Water Meter Calibration Records

Date	Calibration Performed	Comments/Notes

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Monitoring Record Sheet – Water Meter Calibration Records

Date	Calibration Performed	Comments/Notes

Monitoring Record Sheet – Monthly Climate and Weather Data

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Month						
DAY	RAINFALL (mm)	Min Temp (ºC)	Max Temp (ºC)	Wind speed, direction	Humidity (%)	Comments
1						
2						
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Monitoring Record Sheet – Monthly Climate and Weather Data

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Month						
DAY	RAINFALL (mm)	Min Temp (ºC)	Max Temp (ºC)	Wind speed, direction	Humidity (%)	Comments
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