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Soil Moisture Measurement System Selection Guide



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Introduction

This guide is designed to equip irrigating farmers (operators) with the tools and information needed to make informed decisions about soil moisture monitoring, ensuring the right equipment is installed in the right place.

The document starts by outlining both Good Management Practice (GMP) and Best Management Practice (BMP), allowing the operator to determine which standard they intend to meet.

The 'Understanding Irrigation Management Units' flowchart is included to help operators identify and address potential challenges within each Irrigation Management Unit (IMU) or irrigation system type. An irrigation system is defined as a group of irrigation application methods of the same type that can be managed together – meaning they apply the same water depth at the same time. For example, two full pivots operating in sync will be considered one IMU, as could multiple spray lines managing several smaller blocks.

Once the potential challenges within each Irrigation Management Unit (IMU) have been identified, the guide provides a concise sensor comparison table (Table 1). This table outlines the key differences between the most commonly used soil moisture monitoring devices: permanently installed sensors, tensiometers, and neutron probes.

Use Table 1 to gain an overview of the advantages and limitations of each sensor type. Consider practical factors such as the availability of labour to operate and maintain the device, as well as how well each option aligns with your specific requirements. For example, if your resource consent requires continuous data collection, a neutron probe would not be an appropriate choice.

Table 2 outlines the differences between soil moisture monitoring sites under Good Management Practice (GMP) and Best Management Practice (BMP). GMP focuses on collecting the minimum data required to support irrigation scheduling decisions. In contrast, BMP involves multiple reading points at each monitoring site, providing more detailed insights into irrigation effectiveness and offering a more comprehensive understanding of soil moisture dynamics.

Table 3 is designed to assist with correct site selection within the wetted footprint of a given irrigation system. Proper placement is critical, as poor site selection can result in unrepresentative sensor data. For example, a sensor placed at the end of a Rotorainer run may receive excessive water due to draining when the system stops. Similarly, a sensor installed on the edge of a gun irrigator's run may not receive representative water volumes, as droplets at the margins are more easily affected by wind. To ensure accurate readings, sensors must be positioned where they can measure typical application depths within the irrigation system.

Good and Best Management Practices

	GOOD MANAGEMENT PRACTICE This refers to the <u>minimum</u> standard required to achieve good decision making from soil moisture monitoring.	BEST MANAGEMENT PRACTICE (Note: all GMP elements have been adopted plus the items listed below) This refers to the standard that would allow the <u>maximum</u> benefit to decision making from soil moisture monitoring.
Definitions	- An irrigation system is defined as irrigation application methods of the same type that can be managed together (i.e. apply the same depth at the same time). - The definition of a crop type is of similar water use requirements and similar root zone depths.	
Sites	- One soil moisture monitoring site per irrigation system and/or crop. - The site is located in the soil type with the lowest water holding capacity, but that soil type is representative of at least a quarter of the irrigated area.	
Depths	Each site collects data from minimum one (shallow rooted and pasture) or two (permanent crops) depths within the root zone.	+ An additional sensor located below the active root zone to monitor drainage events. + Accurate identification of the root zone to enable precise irrigation management. + Each site collects data from minimum two (shallow rooted and pasture) or three to five (permanent crops) depths.
Set up	- The data from the sensor is graphed so trends can be identified and implemented in irrigation scheduling. - Soil moisture data must be set up with relevant soil moisture parameters of Field Capacity and Stress Point.	+ The soil moisture parameters are assessed by an industry expert.
Data	- It must be possible for the user to calculate soil moisture deficit from the data provided. - Data is not displayed as an average of several sensor sites nor across a time period.	+ The data collected from various depths across the root zone is added to display a total sum of soil moisture content, not averaged. + For calculating the soil moisture deficit for scheduling, the most recent data should be used.
Maintenance	The soil moisture monitoring site is maintained – by changing batteries, cleaning solar panels, and other necessary upkeep – and protected to ensure data quality, and to prevent soil deterioration that could compromise sensor performance.	
Installation		+ The soil moisture monitoring site is installed by a suitably qualified person. This is a specialist area, ideally the person installing the equipment can show some credentials.
Training	The operator receives some basic training in interpreting the soil moisture data and its implementation in irrigation scheduling.	+ The operator receives comprehensive training in interpreting the soil moisture data and its implementation in irrigation scheduling. + All staff in charge of irrigation management receive on-going upskilling in irrigation management and soil moisture monitoring, such as an industry approved training course where the participants receive certificate of completion.

Understanding irrigation management units

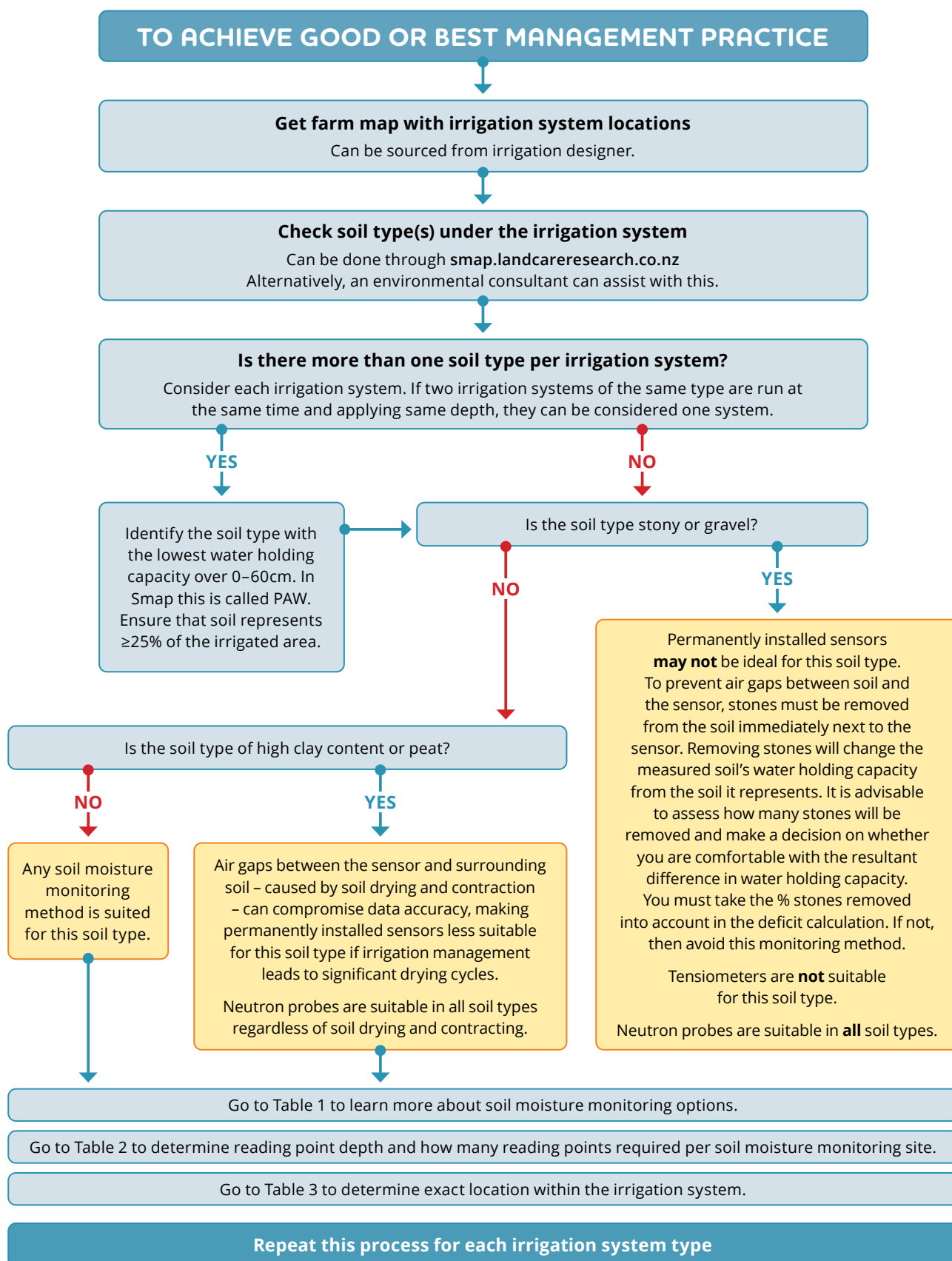
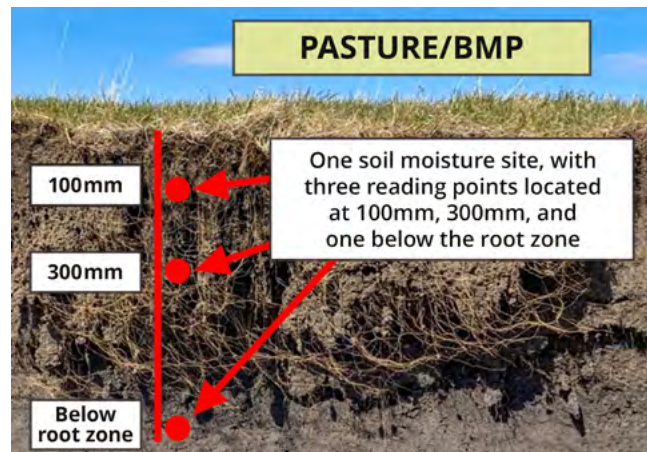
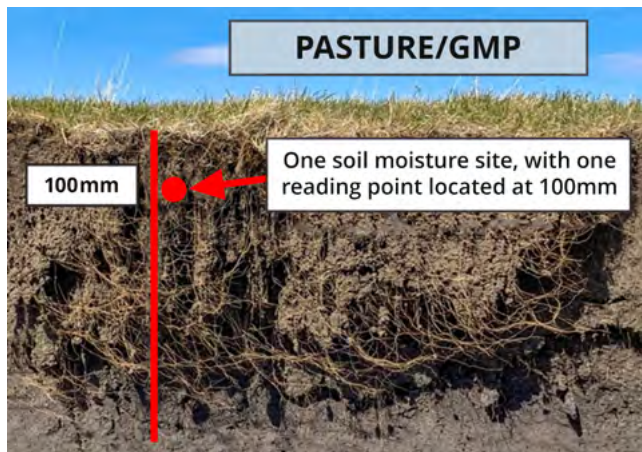


Table 1: Sensor comparison

MOST COMMON PERMANENTLY INSTALLED SENSORS		Tensiometer	Neutron Probe
Soil type suitability	Silt and sandy loams. Air gaps around the sensor can reduce data suitability. These gaps may form in stony soils or when peat and clay soils contract during drying.	All soil types except stony soils.	All soil types. This sensor does not require perfect contact with soil for optimum performance.
Installation ease	This is a specialist area ; care should be taken to ensure the installer can show credentials and in-depth knowledge of the importance of correct installation.		
Ease of data interpretation	Easy if presented as v/v% or mm. Ask to see the data display prior to purchasing.	Difficult to relate reading to mm.	Easy. Data interpreted by service provider.
Units	Displayed data should be converted to v/v% or mm rather than displayed as the raw data that is measured.	kPa (cba)	Displayed data should be converted to v/v% or mm .
Labour intensity for correct operation	Low-Moderate for user. Will need to clean solar panel and change batteries, along with regular data integrity checks (especially if consent conditions require continuous data).	Moderate for user. May need daily water refill.	Low for user, High for service provider. Provided access tubes are not damaged.
Readings per sensor	Some sensors offer only one reading per sensor. If you wish/require multiple readings across root zone (e.g. to meet BMP), purchase several sensors or purchase a vertical soil moisture sensor probe with several reading points along its length.	If several readings are required at different depth, additional tensiometers are required.	Several readings per root zone are provided. The number of readings provided can match the individual situation's requirements.
Measurement radius	Varies between brands and models but is generally between 30mm and 100mm. Be aware that the smaller the measuring range the larger the impact of removing stones from the sample area.	≤50mm	100mm (wet soil) – 200mm (dry soil)
Data capture frequency	Can be adjusted to meet requirements. This will affect how often you can adjust your irrigation schedule, and some consent condition require continuous data. The more frequent readings will be more demanding on battery.	Hourly – Daily	5 – 7 days
Data logging capability	Some consents will require soil moisture monitoring data that is logged and read at pre-determined intervals. Data logging ensures data is not lost.		
Telemetry capability	Some consents will require soil moisture data to be transmitted at pre-determined intervals. This is not possible with neutron probes.		

Table 2: Number of reading points and installation depth

The placement depth of soil moisture sensors should correspond to the crop's root zone depth. Sensors must provide data that reflects both the soil moisture deficit and the effectiveness of irrigation events. The number of sensor reading points and their installation depths help the operator determine the appropriate irrigation depth and timing, ensuring water is applied efficiently and reaches the active root zone.



GOOD MANAGEMENT PRACTICE

NUMBER OF READING POINTS AND INSTALLATION DEPTH PER SOIL MOISTURE MONITORING SITE

	How many sensors	Suggested depth	Comments
Pasture	Minimum of 1 soil moisture reading points.	The first sensor located at 100mm	- The temperature reading from the 100mm sensor can be used for farm management as this is the standard measuring depth for soil temperature. - Ensure the logger (if using) can accommodate several sensors (if using multiple individual sensors). - Do a cost comparison between vertical sensor probe with multiple reading points vs multiple individual sensors installed at different depths.
Arable crops	Minimum of 1 soil moisture reading points.	The first sensor located at 100mm.	
Trees and vines	Minimum of 2 soil moisture reading points.	The first located at 100mm, the remainder at 100mm–200mm spacing.	

BEST MANAGEMENT PRACTICE

NUMBER OF READING POINTS AND INSTALLATION DEPTH PER SOIL MOISTURE MONITORING SITE

	How many sensors	Suggested depth	Comments
Pasture	Minimum of 3 soil moisture reading points.	The first sensor located at 100mm, subsequent 100mm–200mm below. Last sensor located below root zone (dig hole to determine root zone)	- The temperature reading from the 100mm sensor can be used for farm management as this is the standard measuring depth for soil temperature. - Ensure the logger (if using) can accommodate several sensors (if using multiple individual sensors). - Do a cost comparison between vertical sensor probe with multiple reading points vs multiple individual sensors installed at different depths.
Arable crops	Minimum of 3 soil moisture reading points.	The first sensor located at 100mm, subsequent 100mm–200mm below. Last sensor located below root zone (dig hole to determine root zone).	
Trees and vines	Minimum of 4 soil moisture reading points.	The first located at 100mm, the remainder at 100mm–200mm spacing. Last sensor located below root zone (dig hole to determine root zone).	

Table 3: Location within the irrigation system

The location of the soil moisture site will depend on the irrigation system it is installed within.

For more comprehensive information on site selection including what to avoid refer to IrrigationNZ's Resource Book 11.

	Recommended location	What to avoid	Comments
Centre pivots	Install site about 2/3 of the length of the pivot.	Not in first 1/3 of spans, not in last 1/3 of spans, not in overhang, corner arm or gun. Make sure you avoid wheel tracks.	Always install it in an area where the plants are healthy and representative of the irrigated crop.
Variable rate	A site per key management zone.	Use the above as a site selection guide but primary focus is management zones.	Always install it in an area where the plants are healthy and representative of the irrigated crop.
Micro drip irrigation	100mm–300mm from emitter. Site must be in crop row/mound. Be prepared to shift sensor if results don't appear logical or representative.	Never install directly under emitter. Don't install interrow.	Coarse textured soils require it to be closer (100mm) to the emitter while fine textured soils allow it to be further away (300mm)
Fixed grid and overhead irrigation, including micro sprinklers	Within overlap (wetted area of more than one sprinkler). Consider using a catch can test to identify the best representative location.	Avoid area directly under a sprinkler stand. Avoid outside row of sprinklers	In orchard setting, it is not necessary to locate it in the tree row, provided there is evidence of root growth in the selected site. Water redistribution as a result of the impact of wind is a common issue for these systems. If possible, select a sheltered site.
Multiple moveable sprayline systems (e.g. K-line)	Between pods and 1/2 way of wetted radius.	If the soil moisture monitoring site protrude above ground, make sure it does not interfere with movement of pod lines.	Always install it in an area where the plants are healthy and representative of the irrigated crop. Accurate repeated placement of spraylines is critical to representative soil moisture data.
Lateral	Select a site along the length of the lateral.	Avoiding wheel tracks, hydrants, overhang and gun.	Always install it in an area where the plants are healthy and representative of the irrigated crop.
Travelling irrigator (guns and rotorainers)	The site must be more than wetted diameter away from the end or start of the run and no closer to the edge of the wetted footprint than 20m.	Avoid ends of run, avoid overlap areas. If the soil moisture monitoring site protrude above ground, make sure it does not interfere with movement of the irrigator.	Always install it in an area where the plants are healthy and representative of the irrigated crop.

Checklist for operator's decisions

I have determined what my Irrigation Management Units are. Refer the flow chart on page 3.		
I have identified the soil type with the lowest water holding capacity, representing $\geq 25\%$ of the area irrigated with this irrigation system.		
My preferred sensor options are... Refer to Table 1.		
The number of reading points and installation depth I have determined will be... Refer to Table 2.		
The location within the irrigation system of the soil moisture monitoring site will be... Refer to Table 3.		
I have made decisions that will lead to...	GOOD MANAGEMENT PRACTICE	BEST MANAGEMENT PRACTICE

Definitions

Full point and field capacity

Terms used to describe the amount of water a soil can hold after gravity drainage.

Stress point and refill point

Terms used to describe the point at which water availability limits plant growth.

Industry expert

An industry expert in soil moisture measurement in New Zealand typically has 5–10 years of hands-on experience across various soil types and land uses, with proven skill in installing, calibrating, interpreting, and maintaining monitoring systems. They often hold relevant tertiary qualifications and are recognised by industry bodies, councils, or training programmes for their applied expertise.

Basic training

Basic training can be provided by the provider, it should include how to log in, an explanation of the data as it is displayed under that log-in. An explanation on how to use the data in irrigation scheduling as in how to calculate irrigation deficit. In addition to this, who to call if something goes wrong.

Comprehensive training

The comprehensive training includes basic soil science, terms and definition of soil moisture parameters.

- How soil moisture parameters relate to soil types.
- Irrigation scheduling from soil moisture data.
- Analysis of soil moisture at depth.
- Identification of active root zone.
- Analysis of irrigation events and effectiveness at depth.
- Comprehensive cover of saturation and the effects.

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