NQF Level: 4 **US No: 116322**

Learner Guide

Primary Agriculture

Manage water Quality parameters

My name: ....

Company: ....

Commodity: .... Date: ....

The availability of this product is due to the financial support of the National Department of Agriculture and the AgriSETA. Terms and conditions apply.

agriculture
Department: Agriculture
REPUBLIC OF SOUTH AFRICA

AgriSETA

Before we start…

Dear Learner - This Learner Guide contains all the information to acquire all the knowledge and skills leading to the unit standard:

Title:	Manage water quality parameters				
US No:	**116322**	**NQF Level:**	4	**Credits:**	3

The full unit standard will be handed to you by your facilitator. Please read the unit standard at your own time. Whilst reading the unit standard, make a note of your questions and aspects that you do not understand, and discuss it with your facilitator.

This unit standard is one of the building blocks in the qualifications listed below. Please mark the qualification you are currently doing:

Title	ID Number	NQF Level	Credits	Mark
National Certificate in Animal Production	48979	4	120	❒
National Certificate in Plant Production	49009	4	120	❒

Please mark the learning program you are enrolled in:

Your facilitator should explain the above concepts to you.

Are you enrolled in a:	Y	N
Learnership?	❒	❒
Skills Program?	❒	❒
Short Course?	❒	❒

This Learner Guide contains all the information, and more, as well as the activities that you will be expected to do during the course of your study. Please keep the activities that you have completed and include it in your **Portfolio of Evidence**. Your PoE will be required during your final assessment.

What is assessment all about?

You will be assessed during the course of your study. This is called *formative assessment*. You will also be assessed on completion of this unit standard. This is called *summative assessment*. Before your assessment, your assessor will discuss the unit standard with you.

Assessment takes place at different intervals of the learning process and includes various activities. Some activities will be done before the commencement of the program whilst others will be done during programme delivery and other after completion of the program.

The assessment experience should be user friendly, transparent and fair. Should you feel that you have been treated unfairly, you have the right to appeal. Please ask your facilitator about the appeals process and make your own notes.

Your activities must be handed in from time to time on request of the facilitator for the following purposes:

- The activities that follow are designed to help you gain the skills, knowledge and attitudes that you need in order to become competent in this learning module.
- It is important that you complete all the activities, as directed in the learner guide and at the time indicated by the facilitator.
- It is important that you ask questions and participate as much as possible in order to play an active roll in reaching competence.
- When you have completed all the activities hand this in to the assessor who will mark it and guide you in areas where additional learning might be required.
- You should not move on to the next step in the assessment process until this step is completed, marked and you have received feedback from the assessor.
- Sources of information to complete these activities should be identified by your facilitator.
- **Please note** that all completed activities, tasks and other items on which you were assessed must be kept in good order as it becomes part of your **Portfolio of Evidence** for final assessment.

Enjoy this learning experience!

How to use this guide …

Throughout this guide, you will come across certain re-occurring "boxes". These boxes each represent a certain aspect of the learning process, containing information, which would help you with the identification and understanding of these aspects. The following is a list of these boxes and what they represent:

Definition

What does it mean? Each learning field is characterised by unique terms and **definitions** – it is important to know and use these terms and definitions correctly. These terms and definitions are highlighted throughout the guide in this manner.

ACTIVITY

You will be requested to complete **activities**, which could be group activities, or individual activities. Please remember to complete the activities, as the facilitator will assess it and these will become part of your portfolio of evidence. Activities, whether group or individual activities, will be described in this box.

Example

Examples of certain concepts or principles to help you contextualise them easier, will be shown in this box.

How am I doing?

The following box indicates a **summary** of concepts that we have covered, and offers you an opportunity to ask questions to your facilitator if you are still feeling unsure of the concepts listed.

My Notes …

You can use this box to jot down questions you might have, words that you do not understand, instructions given by the facilitator or explanations given by the facilitator or any other remarks that will help you to understand the work better.

. . . .

. . . .

. . . .

. . . .

. . . .

. . . .

. . . .

What are we going to learn?

What will I be able to do?

When you have achieved this unit standard, you will be able to:

- Implement corrective actions based on water quality parameters.
- Gain specific knowledge and skills in maintaining water quality and will be able to operate in an animal production environment implementing sustainable and economically viable production principles.
- Correctly assess, analyse and evaluate water quality data and independently decide on the corrective actions within operational technical systems to well defined, but possibly unfamiliar problems.
- Demonstrate a thorough understanding of the reasons, impacts and implications of specific corrective actions related to water quality.
- Implement corrective actions related to the quality of water and water quality systems.
- Evaluate the effects of corrective actions or adjustments on the water quality requirements.

Learning Outcomes

At the end of this learning module, you must be able to demonstrate a basic knowledge and understanding of:

- Names and functions of all the various components of water supply and quality systems.
- Attributes of water related to water quality.
- The requirements of organisms related to their water need.
- The purposes of maintaining relevant water quality for living organisms.
- Measurement and recording technique.
- Water purification techniques and systems.
- Relevant legislation related to the feeding and care of living organisms.
- Relevant legislations related to water use and environmental issues.
- Interpersonal skills related to communication.
- Sensory and documented cues related to water quality.
- Sensory cues related to the water requirements and use of water by living organisms.

What do I need to know?

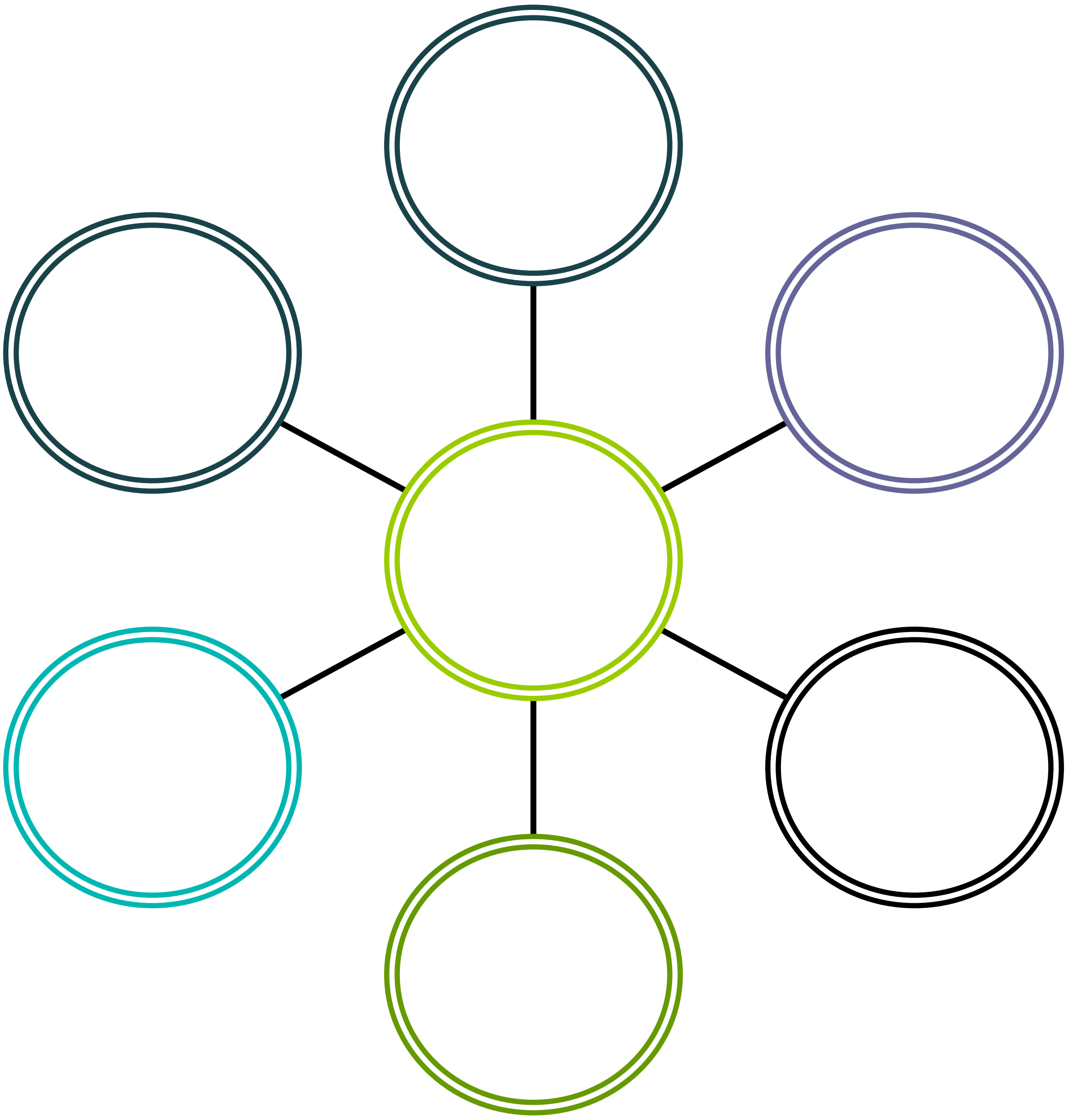
It is expected of the learner attempting this unit standard to demonstrate competence against the unit standard:

- It is assumed that a learner attempting this unit standard will show competence against the following unit standards or equivalent:
- NQF 3: Maintain water quality parameters (116212).
- NQF 3: Recognise and identify the basic functions of the ecological environment (116064).
- NQF 3: Apply routine maintenance and servicing plans and procedures (116275).

Revision of Water quality – Level 3

Water quality management system

The following diagram gives the main activities linked to a water quality system of a farm. Re-familiarise yourself with the activities and components with reference to the relevant unit standard.



My Notes ...

. . . .

. . . .

. . . .

Session 1 Water quality data

After completing this session, you should be able to:
SO 1: Correctly assess, analyse and evaluate water quality data and independently decide on the corrective actions within operational technical systems to well defined, but possibly unfamiliar problems.

In this session we explore the following concepts:

- A thorough understanding of the effects of certain physical factors is demonstrated and is related and applied as a standard procedure or a corrective action to relevant plant or animal species.
- A thorough understanding of the effects of certain chemical factors is related to and applied as a standard procedure or a corrective action to relevant plant or animal species.
- A thorough understanding of the effects of certain microbiological characteristics is related to and applied as a standard procedure or a corrective action to relevant plant or animal species.
- A thorough understanding of the effects of certain biological processes is related to and applied as a standard procedure or a corrective action to relevant plant or animal species.
- A thorough knowledge and understanding of the principles and use of operational technical systems is related, integrated and applied as a standard procedure or a corrective action to relevant plant or animal species.

1.1 Introduction

When mentioning data, one would normally think of a laboratory report. When it comes to the assessment, analyses and evaluation process however, observations and records from the farm are equally important.

Although methods vary in the degree of sophistication, the results are of equal importance in the process. A simple observation, such as feeling the grittiness of the deposits in the pipe lines, is of no less importance than determining the concentration of sodium using an ICP costing R1 million.

The majority of the data required in a management system to assess, analyse and evaluate water quality management is generated on the farm. Analyses by outside facilities are limited to the analyses of the water itself and sometimes deposits found in the system. These analyses are mostly used to confirm on-farm analyses and observations.

Usually the water quality manager (WQM) has little say in the quality of the water received on the farm. The quality is good, marginal or poor. The task of the WQM is to improve those water quality factors that can be improved and manage the others to minimise their impact on profitability and the environment.

In general, water quality factors impact on the irrigation system, soil productivity and crop production. The challenge is to decide when to take action to eliminate the factors and when to manage the impact. The framework for all these decisions is the profitability of production in a sustainable environment.

1.2 Effects of physical water quality factors

The main effect of the physical water quality factors (PWQF) is blocking or clogging of the emitters. The standard set by the Department of Water Affairs and Forestry (DWAF, 1996) for the clogging hazard of water is as follows:

Rating	***Suspended Solids per Litre Water (mg)***
Minor hazard	less than 50mg
Moderate hazard	50mg to 100mg
Severe hazard	more than 100mg

Apart from the PWQF the chemical (CWQF) and microbiological (MWQF) factors also contribute to clogging of emitters. These can be tabulated according to DWAF as follows.

	Unit	***Low Hazard***	***High Hazard***
Physical Water Quality Factors			
Suspend solids	mg per litre	<50	>100
Chemical Water Quality Factors			
pH		<6	>8
Bicarbonates	me per litre	<1.64	>3.28
	mg per litre	<100	>200
Calcium	me per litre	<0.50	>2.50
	mg per litre	<10	>50
Manganese	mg per litre	<0.10	>1.50
Iron	mg per litre	<0.20	>1.50
Sulphide	mg per litre	<0.20	>2.00
Total dissolved solids (TDS)	mg per litre	<500	>2,000
EC	mS per m	<75	>300

Microbiological Water Quality Factors			
Total bacteria	Number per millilitre	<10,000	>50,000

Note: The following conversion factors apply to the units of the table above:

me per litre = mg per litre / equivalent weight

Equivalent weight = atomic weight/ charge of the ion.

The effects of clogged emitters are so devastating on production that water classified as having a *Low Clogging Hazard* still needs treatment, because some of these factors have a cumulative effect on the irrigation system. Therefore, apart from the initial analysis of the water, continuous monitoring these factors in the piping and emitters is essential.

The above classification needs adjustment based on the hazard that can be caused by the accumulation in the pipes. The assessment is done as in the example below:

Example

Assessing Water Quality Control Systems

PWQF: Suspended Solids	Assessment	Actions	Comments
< 50mg per litre	Minor clogging hazard but can accumulate. Requires action.	Filtration	Suspended solids will accumulate in the piping and will eventually cause emitters to clog[1].
Suspended solids 50-100mg per litre	As above	Filtration	As above[1].
> 100mg per litre	Needs action	Sedimentation, cyclones, filtration,	These techniques and level of physics and engineering fall outside the scope of this material. Seeks specialised advice.

The rate of accumulation of suspended solids as well as the agglomerating effect of the bacteria will depend on a number of factors, including temperature, flow rate in the pipes, temperature, etc. The requirement should be included in the specifications for the filtration system. This forms part of an irrigation system design and a filtration system should be installed with the capacity to handle the load of solids for the specific water.

1.3 Effects of chemical factors

Assessing, analysing and evaluating date relating to the chemical water quality factors and determining the best course for corrective action are much more complicated than is the case with data relating to physical water quality factors.

Certain chemical factors cannot be corrected economically and the water quality manager can only take steps to limit the impact on production and the environment. The type of irrigation system used, i.e. micro-jets or drippers, also have an influence on the actions that can be taken to correct and/or minimise the impact.

Corrective actions include those to improve the CWQF and those to reduce the impact on the environment and on crop production.

Chemical Water Quality Factor	Measurement	Assessment	Actions	Comments
pH	<6.00	Is suitable for most pesticide and nutrient sprays and need no treatment. Some pesticides and nutrient sprays need a higher pH.	None Buffer the pH at the desired level.	Half-life of pesticides depends on the pH of the spray solution. Buffer solutions for various pH levels are available. Consult supplier.
		The corrosion potential of the water is high. Treatments are required.	This is a specialised action. Seeks expert advice.	A low pH in combination with a low salt will increase the corrosion potential. The Corrosively Index (CI) is used to evaluate this.
		No need to use acids in drip irrigation systems.		Nutrient solutions can be formulated without addition of acids, provided the added chemicals will not increase the pH.
	6.00-7.00	Solutions of some pesticides and nutrient sprays need to be acidified.	Identify the pesticides and nutrients and select the appropriate acid.	The main contributor to high pH is bicarbonates. However, there is no correlation between pH and the bicarbonate concentration.

		Acidification of irrigation water used in a drip system is an option. Reduce the pH while adding nutrients and utilise the nutrients already in the water.	Select the most suitable acid or buffer solution.	Water with this pH level usually contains Ca, Mg and S which should be incorporated in the formulation of the nutrient solutions.
	7.00-8.00	Solutions of most pesticides and nutrient sprays need to be acidified.	Select the most suitable acid or buffer solution.	
		In combination with high Ca levels, scale forming and clogging are possible.	Acidify continuously for drippers and *ad hoc* for micro-jets.	Langelier Index is an indicator of the potential for scale formation.
		Acidification of water used in micro-jet systems can possibly be justified during July to November.		Acidification can also be undertaken on an *ad hoc* basis to clean the system. Water applied through micro-jets is seldom acidified, mostly due to the cost of the acids and the lack of proof of benefits.
		Acidification of irrigation water used in drip systems is a must to reduce pH, add nutrients and utilise the nutrients already in the water.		Using nitric and/or phosphoric acid will reduce the pH and add nitrogen and/or phosphorus without much change in EC.
	> 8.00	In conjunction with high Ca concentrations clogging and scale forming are real threats.	Acidify.	The volume of acids required to reduce the pH might be so much that N and P is over-supplied. Other acids are required. Consult a specialist advisor.
EC	<75	Low salt content. Requires no special attention.	Monitor the metal and cement components for signs of corrosion.	A leaching requirement (LR) of up to 10% is necessary.

	75-125	Suitable for most soils and crops.	Apply the leaching (LR) requirement for the particular water during each irrigation cycle.	When the LR of between 10% and 15% is added to the volume of water applied, the salts will not accumulate in the root-zone.
	126-200	Not suitable for irrigation of crops with conventional systems.	Consult a specialist.	When the EC of the water is greater than 150mSm^{-1} plants need energy to utilise the water and production will suffer.
	>200	Not suitable for irrigation unless specialised equipment and techniques are implemented.	Consult a specialist.	
SAR	<1.00	No sodium hazard.	None	
	1.00-3.00	Crusting is possible.	Monitor the infiltration of water into the soil. If runoff occurs, consider the application of gypsum.	Crusting will slow down the infiltration rate and free water will accumulate on the surface. This is the first sign of the detrimental effect of too high sodium content.
	>3.00	The sodium hazard needs attention.	Consult a specialist.	
Ca	>50mg/litre	In combination with a high pH, high carbonate or bicarbonate concentration will cause clogging.		
Mg	>50mg/litre	Continuous use of the water will induce a potassium deficiency in plants.	Monitor the potassium level in the soil and leaves and act accordingly.	Magnesium and potassium act mutually antagonistic, i.e. they oppose each other's uptake and functioning.
Cl>	50mg/litre	High chloride concentrations promote salinity in	Monitor the chloride levels in the leaves and soil and avoid	The leaves will accumulate the absorbed chlorine

		the root-zone and can cause scorching of leaves when used for spraying.	wetting leaves with the water during irrigation.	until toxic levels are reached. The edges of the leaves can be scourged and leaf drop will occur.
B	>1.0mg/litre	Boron toxicity may develop.	Monitor the boron concentration in the leaf. Consult a specialist.	Symptoms of an excess of boron includes yellowing of the tips, development of chlorotic blotches and premature leaf drop.
Nitrogen	>20mg/litre	Using this water during January to June may result in poor fruit quality.	Monitor the N concentration in the leaves as well as the colour development of the fruit.	For proper development of the orange colour of the fruit, little or no nitrogen must be applied during January to June.

Buffer Solution Buffer solutions have the ability to absorb or release protons (hydrogen or acid ions) in a solution in order to keep the pH constant. Buffers have a limited pH range and different buffers must be used to buffer the pH at various levels.

Chlorosis and Negrosis Chlorosis is the yellowing of local areas on a leaf. This is usually the first sign of a detrimental incidence in or on the leaf. The cells are not dead and sometimes the reaction can be reversed. Negrosis is the step following chlorosis when the cell die and brown areas or spots appears on and in the leaf. Negrosis is irreversible.

Apart from the salts in the water that can cause clogging, salts added as fertilisers can also aggravate the clogging hazard. This however forms part of the course on fertigation where compatibilities and order of mixing will be discussed.

1.4 Effects of microbiological and biological factors

In fruit production, the microbiological and biological water quality factors (BWQF) are limited to those that promote the growth of bacteria and slimes in the piping after filtration. The bacterial and slime growth act as agglomerating agents to bind other suspended material into lumps that will block the emitters. The growth is aggravated by addition of nitrogen, phosphorus and organic carbon (molasses, organic acids or buffers). Applying nutrient solutions through the irrigation system will stimulate the growth of the microbes.

Treatment is applied before, during or after filtration. The best results are however obtained when the complete system (filters, supply lines, laterals and emitters) is disinfected. Drip irrigation systems need continuous disinfection. This decision should be based on historical data and current analyses, including those of the deposits in the piping and emitters.

Although DWAF indicates that less than 10,000 organisms per ml poses a low clogging hazard, the bacteria multiply in the pipes and any number will eventually clog the emitters. The bacteria population in the system must be monitored continuously and action taken accordingly. The most effective method to determine the presence of the different microbes is to evaluate the deposits in the pipes when flushing the system. See the table in Session 2.

1.5 Principles and use of operational technical systems

The technical systems involved in water quality management are so closely related to the irrigation and fertigation systems that they are usually also managed by the irrigation manager. These include the filtration, acid and disinfectant applicators. Only under extreme conditions will such technical systems be managed by the water quality manager.

Dosing apparatus

Acidification and disinfection are done by using the same equipment as for applying fertilisers. The selection and operation of these systems form part of the irrigation program. The equipment consists mainly of dosing apparatus which will introduce the acid or chlorine into the irrigation water. Two groups of dosing equipment are available (Koegelenberg & Conradie, 2000).

- Passive dosing apparatus

  This group includes apparatus that sucks the acid or chlorine solution into the stream of water in the pipes. This can be done at the suction end of the irrigation pump, a venture system, or a pressure tank connected to the irrigation system.

  - Using the irrigation pump for dosing

    The reservoir with acid or chlorine is connected to the intake end and the chemicals are sucked into the system in the same way as the water. The volume can be regulated by a tap. This is a simple and cheap method, but the acid and chemicals may damage the pump.

  - Using a venturi for dosing

The venturi is fitted in the pipeline. When water flows through the venture, a localised drop in pressure is caused. The container with the chemicals is connected to the area of decreased pressure and the chemicals are forced into the pipeline by atmospheric pressure and carried by the water. The rate of intake can be regulated.

- Using a pressurised tank for dosing

  A tank is connected at two points to the irrigation pipe. Between the two connecting points, a valve or tap is fitted to create higher pressure at the first point. The water flows through the tank and, due to the lower pressure at the second point, re-enters the pipeline on its way to the trees.

♦ Active dosing apparatus

This group represents all the types of pumps that are used to force the solutions of the chemicals into the pipe line. These include pumps utilising centrifugal forces, screws, diaphragms, pistons, peristalsis and gears to force the chemical solutions into the irrigation system.

- Filtration equipment

  The filtration system forms an integral part of the irrigation system, but the type and capacity depend on the quality of the irrigation water. Three types of filtration systems are available.

- Mesh or screen filters

  Mesh filters are made of stainless steel or nylon compounds. The size of the openings and the total mesh area determine the capacity of the filter. Mesh filters are used to filter water of good quality but that contains sand and silt. It is not suitable to remove algae form water.

  The mesh number refers to the number of cross wires per square inch that create the openings.

Example

Standard Filtration Grades

Size of Openings (microns)	300	250	200	130	100	80
Size of Openings (mm)	0.30	0.25	0.20	0.13	0.10	0.08
Mesh Number	50	60	75	120	155	200

- Ring or disc filters

  Ring filters have a three-dimensional filtering action and a higher capacity than mesh filters for the same measurements. The filter unit consists of a number of flat plastic discs with grooves on the flat side. When packed together in a cylinder, they form a surface with small channels form the outside to the inside of the cylinder. Water is filtered when it flows from the outside to the inside of a cylinder through this maze of tiny grooves. Ring filters are cleaned by backwashing, when water flows from the inside to the outside of the cylinder.

- Sand Filters

  Sand filters remove organic and inorganic material, but not suspended clay particles, from the water. It is also a three dimensional system with a high capacity. The particle sizes of the sand used are specified to remove suspended solids with a diameter of as small as 80 microns (0.08 mm). The lower the flow rate through the sand filter, the better the filtration. Sand filters are always used in conjunction with a disc or mesh filter.

ACTIVITY

Please complete Activity **1:**

Worksheet

What is the main effect of the PWQF?
Why is a clogged emitter detrimental to production?
Which factors will stimulate the growth of microbes in the irrigation system?

The pH of the water is 7.85. List your assessments and actions to be taken to optimise this chemical water quality factor.
Why is an EC of more than $150 mSm^{-1}$ an important parameter in production?
Why is an SAR value of >1 is a negative factor in production?
What is the effect of a high concentration of magnesium on the potassium status of trees?
Dosing apparatus used to apply acids and disinfectants are grouped into which two groups?
Name three types of filters used to remove PWQF from irrigation water?

My Notes ...

. . . .

. . . .

. . . .

. . . .

. . . .

. . . .

. . . .

How am I doing?

Concept (SO 1)	I understand this concept	Questions that I still would like to ask
A thorough understanding of the effects of certain physical factors is demonstrated and is related and applied as a standard procedure or a corrective action to relevant plant or animal species.		
A thorough understanding of the effects of certain chemical factors is related to and applied as a standard procedure or a corrective action to relevant plant or animal species.		
A thorough understanding of the effects of certain microbiological characteristics is related to and applied as a standard procedure or a corrective action to relevant plant or animal species.		
A thorough understanding of the effects of certain biological processes is related to and applied as a standard procedure or a corrective action to relevant plant or animal species.		
A thorough knowledge and understanding of the principles and use of operational technical systems is related, integrated and applied as a standard procedure or a corrective action to relevant plant or animal species.		

My Notes ...

. . . .

. . . .

. . . .

. . . .

. . . .

Session 2 Understand the impact of corrective actions

After completing this session, you should be able to:
SO 2: Demonstrate a thorough understanding of the reasons, impacts and implications of specific corrective actions related to water quality.

In this session we explore the following concepts:

- A wide range of scholastic and technical concepts related to water and all its aspects is recalled.
- An analysis of collected data or information and the reasons for specific corrective actions are explained and presented.
- Information, especially within the context of corrective actions is independently accessed, analyzed and evaluated.

2.1 Scholastic and technical concepts related to water

The reason for any water treatment should be to:

- Improve the quality,
- Minimise the negative effect of the water quality factor on the soil, tree, and environment; and/or
- Improve economic returns.

For every water treatment, or corrective action, there is a side-effect, or implications, which is not always desirable. Before taking corrective actions, consider the consequences, which in many cases develop over time. Apart from the direct effects and the side-effects of a treatment, the cost-efficiency must also be considered that needs to be considered, for instance desalting irrigation water will have a positive effect on production, the soil and environment but is simply too expensive.

Treatment	***Desired Effect***	***Impact***	***Side Effect***
Sedimentation	Sedimentation removes some insoluble material at low cost.	Sedimentation dams nd extra pumping facilities are required.	Sedimentation dams silt-up and require removal of the silt. The frequency depends on the concentration of the insoluble material and size of the dam.

Filtration	Filtration reduces emitter blockages.	A major must for micro-irrigation.	None, but without filtration the clogged or partly clogged emitters will supply too little water to the trees and production will be reduced.
Decreasing pH	Lowering the pH make pesticides more effective.	Improve effectiveness of treatment, hence fewer treatments or lower concentrations and better production.	Acidifiers/buffers must be compatible with pesticide. Some pesticides MUST NOT be acidified and can cause damage to fruit and leaves when acidified.
	Lowering the pH to improve solubility and utilisation of nutrients.	Acids add another ion to the water while it removes the bicarbonates. Nitric acid adds nitrate; phosphoric acid adds phosphate and sulphuric acid adds sulphates.	Citrus requires the majority of the nitrogen during July to October and little during February to June. The presence of nitric acid may cause problems. With micro-jets, phosphoric acid is not an effective source of P. Waters with a high pH usually contains high concentrations of sulphates.
Lowering EC	Lowering the EC will improve production, etc.	Currently too expensive for irrigation and foliar sprays. Electro-magnetic treatment will decrease surface tension of water and could assist in leaching salts from the root-zone.	Need to meet the leaching requirement for this combination of soil, water and crop. Extra water will be required.
Disinfection	Disinfection will reduce blockages.	A major must for micro especially drip irrigation.	

2.2 Data analysis

The process of assessing, analysing an evaluating data starts with a comparison of the laboratory results with the standard set of norms (DWAF). Thereafter, a series of questions and answers will add value until satisfactory decisions can be made.

Example

Data analysis

The laboratory report indicates that the water contains 55mg per litre suspended solids, which is, according to the above rating, a minor clogging hazard. This data must be assessed, analysed and evaluated to make a sound business decision. Is it necessary to filter water to remove the 55mg per litre suspended solids? If the concentration of suspended solids were 155mg per litre, it would have been clear that the water required to be filtered.

To assess, analyse and evaluate the data additional information is required, for instance:

- Was the sample taken correctly?
- Are the 55mg suspended solids clay and/or silt particles, plastic cuttings, seeds or organic debris? If this can be established, it may be possible to address the specific source.
- How many emitters were blocked in the past three months / six months / year?

All the extra information is generated on the farm and, if properly recorded, add value to the current results and support a proper decision. Every time you answer one of these questions, you make the final decision easier and more valuable.

Example

Evaluating the PWQF before filtration

	Information	***Decision***	***Questions***
1	68mg suspended solids per litre water.	Minor clogging hazard.	What type of solids?
2	Solids consist of silt, clay and plastic cuttings.	Train staff to use sharp knives when repairing plastic tubing.	How many emitters clogged the past three months?
3	3% of emitters were clogged in the past three months.		Can this be detected before it impacts on production?
4	Easily, with current monitoring system.	Prevent plastic in the system and continue with current filtration system.	

Example

Evaluating the PWQF after filtration

	Information	**Decision / Conclusion**	**Questions**
1	78mg suspended solids per litre water.	Minor clogging hazard.	What type of solids?
2	Solids consist of silt, clay and slimy material.	Ineffective filtration and build-up of microbes.	What protocols are followed to clean the system?
3	Chlorination, but not done in last four months. Flushing laterals once per month according to	Investigate breach of protocol.	Maintenance records for filtration system are required.

	protocol.		
4	Not available.		How many emitters clogged?
5	16% the past three months.	Investigate breach of protocol.	How can developments like these be prevented and/or detected in time? What material clogged the emitters?
6	Whitish precipitate that dissolves in acid and slimy substances.	Possibly calcium carbonate and bacterial slimes.	When was the water analysed and what was the pH, calcium, bicarbonate concentration and bacterial counts?
7	March 2005 pH=7.5 Ca=30mg Bicarbonate=125mg Bacteria=1500 per litre	Compared to pervious analysis, not much change in the composition.	

The procedure for assessing, analysing and evaluating data and taking decisions on corrective actions are based on actual measurements, but value is added to the analytical data by using historic records. The process does not stand alone but forms part of a management system. Any breach in recordkeeping decreases the value of any current data.

The following table serves as a guide to identify the causes of clogging together with some recommendations to correct the problem. (Hansen et al. 1992)

Cause	**Solution**
Whitish precipitate indicates carbonates. The pH is usually >7, 5 and HCO_3 content >120mg per litre.	Continuous application of acid to maintain a pH in the water of between 5.0 and 7.0. Or Shock treatment with acid at a pH of 4 for 30 to 60 minutes.
Reddish precipitate indicates iron deposits. The water contains >0,1mg Fe per litre.	Aerate the water – suitable for water containing > 10mg Fe per litre. Chlorination at a rate of 1mg chlorine per 0.7mg Fe per litre. Apply the chlorine before the filter in order to remove the precipitated iron. Reduce the pH to 4.00 for 30 to 60 minutes every day to dissolve the Fe precipitated during the day to prevent accumulation.
Dark / black precipitate indicates manganese deposits. The water contains >0, 1 mg Mn per litre.	Apply chlorine at a rate of one mg per 1.3mg Mn per litre water before the filter to remove the precipitated Mn.
Reddish slime indicates bacteria using iron in their metabolism.	Chlorinate at a rate of 1mg chlorine per 0.7mg Fe per litre continuously or 10 to 20mg chlorine for 30 to 60 minutes. Apply

The Fe content >0, 1 mg per litre.	the chlorine before the filter in order to remove the precipitated iron.
Whitish fluffy slime indicates sulphur bacteria. The water contains >0,1mg S.	Chlorinate at a rate of 1mg chlorine per 4 to 8mg S per litre continuously or 10 to 20mg chlorine for 30 to 60 minutes.
Algae and other slimes.	Chlorinate at a rate of 0.5 to 1.0mg chlorine continuously or 10 to 20mg chlorine for 20 minutes at the end of the irrigation cycle.
Black gritty precipitate indicates iron sulphide at a concentration of > 0.10mg per litre water.	Continuous application of acid to maintain a pH in the water of 5.0 to 7.0.

Definition

Aeration Aeration means the addition of air or oxygen to water. The simplest method is to spray water into a dam through the air, where it will dissolve oxygen. Another method is to bubble air through water.

Activity

Please complete Activity **2.**
Have a class discussion and write key notes for yourself

What are the reasons for treating irrigation water?
Are all pesticides more efficient at a pH less than 6.00?
Lists four types of precipitates that can accumulate in emitters and irrigation pipes.

How am I doing?

Concept (SO 2)	I understand this concept	Questions that I still would like to ask
A wide range of scholastic and technical concepts related to water and all its aspects is recalled.		
An analysis of collected data or information and the reasons for specific corrective actions are explained and presented.		
Information, especially within the context of corrective actions is independently accessed, analysed and evaluated.		

My Notes ...

. . . .

. . . .

. . . .

. . . .

. . . .

. . . .

. . . .

. . . .

. . . .

. . . .

. . . .

Session 3 Corrective actions

After completing this session, you should be able to:
SO 3: Implement corrective actions related to the quality of water and water quality systems.

In this session we explore the following concepts:

- Water quality and processing systems are explained and described.
- Quality management systems, as related to water quality are described.
- Quality in existing implemented water quality assurance systems is maintained.
- Water quality and processing systems, ensuring water quality and integrity is maintained.

3.1 Water quality and processing systems

Most micro irrigation systems include one or more processing systems to improve the quality of irrigation water. For the irrigation of citrus by means of micro-jets and drippers filtration, acidification and disinfection are standard procedures. The frequency of acidification and disinfection depends on the quality of the irrigation water.

Filtration

Designing an irrigation system usually includes the filtration system. The type and number of filters depend on the quality of the irrigation water and the type of irrigation system. Little or no filtration is required for flood irrigation, while a dripper system will almost always use some sort of filtration.

The filtrations system may include one or more of the following:

- Sedimentation dams
- Cyclones
- Sand filters
- Mesh filters
- Disc filters

The operation and maintenance procedures are prescribed by the supplier or manufacturer of the system, and will not be discussed in this section. However, these procedures should form part of the system's management protocols.

Acidification

Acidification is done by using techniques that vary in their degree of sophistication. The techniques include pre-dilution of the acid before adding it to the irrigation water; adding the concentrated acid to the water during irrigation by means of pumps or a suction action. Pumps and suction units used for this purpose are controlled manually or by computer.

Whatever technique is used, the operation and maintenance instructions will be supplied by the supplier or manufacturer. These procedures should form part of the system's management protocols.

Acidification is also done to dissolve carbonates of calcium and magnesium which pose a clogging hazard by continuous application of acids, such as in hydroponics, or by using a so-called shock treatment. The shock treatment allows the acid at a concentration of 0.6% (Leading drip irrigation supplier, 1998) to remain in the system for one hour, after which it is flushed out with irrigation water. The 0.6% concentration is applicable only when the concentration of the various acids is:

- Hydrochloric acid 33-35%;
- Sulphuric acid 70%;
- Nitric acid 60%; and
- Phosphoric acid 85%

If the concentration of the available acids differs from these values, adapt the % with a factor of 0.6 x % stated / % available.

Example

Adapting the Acid Concentration

Nitric acid is available at a concentration of 70%.
0.6 x % stated / % available
= 0.6x60/70
= 0.51%

Nitric acid is the most preferred chemical for this purpose, because all nitrates are soluble in water and nitrate is also an essential nutrient.

The following procedures are recommended (Leading drip irrigation supplier, 2000):

- Calculate the volume water in the system at operating pressure;
- Calculate the volume acid required to add 0.6% acid to the volume of water in the system;
- Connect the injector pump to the irrigation system to be cleaned after the filter;
- Start the irrigation system and let it gain operating pressure;
- Inject the acid into the system over a period of at least 10 minutes;
- Stop the irrigation to the specific block for one hour;

- Resume irrigation for at least another hour to flush-out the acid and regain the pH in the soil/root zone before the acidification process.

Disinfection

Disinfection of the water and system is done by applying sodium or calcium hypochlorite, hydrogen peroxide, ozone or other disinfectants. Hypochlorite and hydrogen peroxide are the most commonly applied agents. The principle of disinfection is that the chemicals kill the microbes, oxidize some of the simple organic molecules and even manganese and iron. These chemicals can be used in a maintenance or corrective program.

- Maintenance Application

  In the maintenance program, these chemicals are applied at frequencies determined by historical data and current assessments and/or analyses. The microbial counts in the irrigation water initiate the inclusion in the maintenance program. Data on clogged drippers or micro-jets and analyses of the deposits in the pipes determine the frequency.

- Corrective Application

  Corrective or shock treatments are done to bring the microbial population down to acceptable levels in a short period. This is done by applying the chemical at a high concentration at the end of the irrigation cycle.

Chlorination

Chlorine is a strong oxidising agent. It oxidises organic deposits and slimes to carbon dioxide. In this process, the living organisms are killed. Iron and manganese will also be oxidised to prevent precipitation. Microbes, iron and manganese must be in contact with the chlorine for a minimum period and at a minimum concentration in order for the oxidation to be completed.

☐

Information – Chlorination
Chloride is formed when chlorine has oxidised organic material or manganese. In the process the chlorine atom is reduced to the inactive chloride form. Chloride will not oxidise organic material and at a moderate concentration kill microbes.

Recommended Concentrations for Active Chlorine for Various Management Systems

Purpose of Chlorination	*Method of Chlorination*	*Recommended Concentration (mg/litre)*	
		Injection	*End Emitter*
Prevention of organic growth on the inside of pipes.	Continuous	3 to 5	>1
	Periodically*	10	>3
Cleansing the system.	Continuous	5-10	>3
	Periodically*	15	>5

- Inject the chlorine during the last 30 to 60 minutes of the irrigation cycle and leave it in the system over night.

The following procedures are recommended:

- Apply the chlorine as closely as possible to the system to be cleaned;
- The pH of the water should be between 6.5 and 7.2;
- When chlorination is done to precipitate iron and manganese, apply the chlorine before the filters;
- Before chlorination, flush the laterals properly;
- Free chlorine must be present at a concentration between 1mg and 5mg per litre at the emitter furthest from the injection, otherwise chlorination is incomplete;
- Chlorine concentrations exceeding 100mg per litre may damage certain parts of the system;
- Never mix chlorine and acid;
- Use protective clothing and safety gear when handling acids and chlorine.

3.2 Water quality management systems.

A water quality management system needs to be developed according to the requirements of the irrigation system; the quality of the incoming water and the quality of water required at the trees. The requirements for a flood irrigation system will be much less stringent than with a drip irrigation system where water with almost no suspended solids and a pH of 6.50 is required.

To develop a management system, one has to identify the quality required, the improvements that can be made, sub-optimal quality factors that must be managed and what to measure to be in a position to manage the improvements and impact on the soil and trees.

The most common water quality processes that need to be managed with micro irrigation are the filtration, acidification and disinfection.

Filtration

The filtration process forms part of the irrigation system and is managed by the irrigation manager. However, specific points to measure the concentration of suspended solids must be identified, monitored, recorded and assessed continuously. These critical control points (CCP) must include:

- Incoming water;
- Water after filtration;
- Debris when flushing the pipes;
- Water when backwashing the filters; and

- Clogged emitters

  Measurements and recordkeeping of this data enable the manager to take corrective steps before an incident occurs that causes damage.

CCP	***Frequency***	***Measurement***
Incoming water.	Twice per annum.	Insoluble suspended material in mg per litre.
After filtration.	Twice per annum or whenever repairs or maintenance have been done on the filtration system.	Insoluble suspended material in mg per litre.
Debris in pipes.	Monthly.	Insoluble suspended material. Identify the type and possibly the origin and estimate the volume / mass. Distinguish between silt (poor filtration), slimes (inadequate disinfection) and sand (valves that do not operate properly).
Backwashing water.	Base this decision on historic data of the incoming water and debris in pipes.	Insoluble suspended material in mg per litre.
Clogged emitters.	One or at least 10% of the clogged emitters should be opened and the deposit analysed in order to identify the case and origin.	Insoluble suspended material in mg per litre. Identify the composition with acid (carbonates will fizz, other salts will dissolve), by colour (red = iron, black = organic) and by touch (plastic, silt and clay and/or slimes).

The frequency in the table above reflects the minimum. Recorded data, the quality of the incoming water and seasonal variation will determine the actual frequency. Remember, rather a too high than a too low frequency.

Acidification

Acidification is not always required when micro-irrigation is practised. It is usually required in open Hydroponic systems or other drip systems during July to September / October for citrus. Its use is determined by economic decisions and the added nitrogen, phosphorus or sulphur should form part of the total fertilisation program.

Managing the pH of the irrigation water can be done manually or continuously aided by a pH-sensor and a computer. The acidification process of irrigation water can also be managed by recording the volume of water treated and the volume of acid used in the process. These volumes should add up to the estimated acid usage. The volume of acid is best be determined by a chemical titration. Otherwise the volume can be calculated based on the concentration of carbonates and bicarbonates.

The volumes of nitric acid and phosphoric acid required to acidify irrigation water to pH 6.0-6.5 are based on the concentration of the bicarbonates.

Bicarbonate me (mg) per litre water	Acid Required ml per 1000 litres water	
	Nitric Acid[1]	Phosphoric Acid[2]
0.10 (6.1)	7	2.86
0.20 (12.2)	15	5.71
0.30 (18.3)	22	8.57
0.40 (24.4)	30	11.43
0.50 (30.5)	37	14.29

1. 60% with a normality of 13.7 and density of 1.36
2. 85% with a normality of 36.4 and density of 1.69

When the volume of acid required is determined by titration, the volume to be added to the water can be calculated. Monitoring the acidification process can then be done as follows:

Orchard 11	Date	Acid Required ml/1000 litres
	19/05/2004	126
	11/06/2005	135

Date	Water Applied x 1000 litres	Acid Added Litres	Acid added ml/1000 litres	Difference %
15/07/2005	112,506	15,750	140	+3,7
16/08/2005	150,103	19 ,513	130	-3,7
15/09/2005	172,252	22,900	133	-1,5
18/10/2005	199,000	28,100	141	+4,4

Date	Water Applied x1000	Acid Applied Litres	Acid Added ml/1000 litres	Difference %	pH
15/07/2005	112,506	15,750	140	+3.7	6.34
16/08/2005	150,103	19,513	130	-3.7	6.12
15/09/2005	172,252	22,900	133	-1.5	6.31
18/10/2005	199,000	28,100	141	+4.4	6.45

Choose the recordkeeping system that suits the requirements best, but ensure that it supplies the correct and sufficient information for management to optimise conditions and prevent any hazardous incident.

Instead of acids available commercially, buffer solutions can be applied. The advantages of buffer solutions are that it is safer to use and over dosing is less of a problem.

- **Disinfection**

Disinfection can be done continuously or periodically. Measuring the concentration of the free chlorine at the most distant emitter, is the best method to ensure that the treatment was done on all emitters at an effective concentration. Additional information, such as mass hypochlorite applied and intervals of application can assist in managing the process.

3.3 Maintaining quality in water quality management systems

The quality of any management system depends on the:

- Relevance of the measurements taken
- Accuracy of measurements
- Frequency of testing
- Frequency of data assessment
- Frequency of reporting
- Relevance of measurements

A management system can be killed by too much meaningless data. Too many measurements require time and effort and are the first thing to be neglected when time is limited. A few measurements that can be done quickly and accurately and that have a meaningful input on the decision making process, should be selected.

The most appropriate measurements that can be done on the farm are pH and EC. Although the EC measurement cannot tell what type of salts is dissolved, in a management system it can tell the magnitude of changes. Comparing the latest EC measurement with that on record, including that of the laboratory report, indicates changes and whether additional actions or tests are justified. A hand-held module pH-meter or pH strips and an EC-meter that can be used in the orchards with ease should be available. Follow the instructions of the supplier to ensure accuracy.

Record the data immediately and/or transfer it to the data base for water management.

The concentration of suspended solids in the water is another simple measurement that can be included in the management system.

Other important measurements are the concentration of sodium, chloride and boron, as well as the SAR. These can only be done in a laboratory and should form part of the report on the complete analyses of the water.

The quality of a water quality management system (WQMS) depends on what is done with the data and not how much data is collected. Collect data that can be used to optimise the production of citrus in a sustainable environment.

- Accuracy of the measurements

Measurements on the farm and in the orchard cannot be as accurate as those done in a laboratory. However, on-farm measurements should be accurate enough to give results similar to that of the laboratory. The procedures used on the farm should also include standard solutions for pH (pH-buffers) and EC. However, always strive to measure as accurately as possible without increasing the cost too much. Hand-held instruments that are calibrated regularly are usually very accurate. Laboratory results should be of a high standard.

- Frequency of testing

The quality and the variation in quality will dictate the frequency of testing. Water from a huge storage dam, such as the Gariep or Kwena dams, have a fairly constant composition and the frequency of testing will be low.

The quality of irrigation water in a river like the Olifants River in the Lowveld is subjected to more fluctuations and will necessitate frequent testing.

Historical data can be used to determine the frequency required to optimise WQM. If no data is available, start with a complete laboratory testing followed by weekly testing of pH and EC on the farm until enough data is collected to set a schedule.

- Frequency of data assessment

Data is collected to optimise the application of the water. If it is not analysed and evaluated regularly, the whole WQMS is useless. The very reason for a WQMS is to monitor the quality so that actions can be taken before damage is done to the crop, the trees or the environment.

In a sound WQMS, evaluation and assessment of data are done soon after logging the data into the recording system. If any change that can have an impact is detected, it should be reported immediately, even in a formally structured management system.

- Frequency of reporting

The reporting system depends on the management on the farm. On a small farming unit where the farm manager is also the water quality manager, reporting on and assessing the collected data can be the same process.

The frequency will also depend on the variations in the quality of the water. With few and insignificant changes, a report on water quality should be filed at least once a year.

Where the quality of the water changes more rapidly, the reporting should be scheduled to avoid disasters, to facilitate corrective or preventative actions and to ensure that the relevant people or department get the message in time.

3.4 Maintaining water quality management systems

A WQMS that is of relevance to optimise the irrigation system, production and environment, is maintained almost by the fact that is it being used continuously. When the quality of the water is poor or fluctuate, the operations are dependent on the information. The WQMS forms such an important part of the farming operations that its priority will greatly ensure that the system is maintained.

A system that is only used on an *ad hoc* basis will let the manager down when it is needed the most. This often happens with constant supply of moderate or good quality water. Under such conditions, the measurements, recordkeeping and evaluations are neglected. For these reasons, a formal schedule should be compiled and senior management should enforce the maintenance thereof by requesting regular reporting according to a fixed schedule.

Fluctuations in the quality of the water depend to a large extent on the activities upstream. This information can also be used to determine the frequency of measurements and reporting. Industries letting effluent into the upstream can cause major fluctuations.

The minimum requirement is a laboratory report twice per annum, before and after the rainy season. Thereafter, the frequency will depend on the quality of the water and the type of irrigation.

In the third example in section 2 of chapter 2, the management system was neglected and not properly maintained. The problems experienced at that time were due to a poorly maintained system and not to a major change in the quality of the water. This incident could have been prevented if the quality management system, including frequent reporting, was maintained. The cost of replacing 13% of the drippers and the loss in production outweighs the cost of maintaining the WQMS.

My Notes ...

. . . .
. . . .
. . . .
. . . .
. . . .
. . . .
. . . .
. . . .

ACTIVITY

Please complete Activity **3:**

Research and discover

1. According to the standard set by leading drip irrigation supplier, the concentration of 60% nitric acid in the system should be 0.6%. Calculate the concentration if the acid available has a concentration of 50%.
2. Why is nitric acid the preferred acid in lowering the pH of irrigation water?
3. What is the meaning of a maintenance and corrective treatment?
4. Describe the terms chlorine and chloride.
5. Name the three common water quality treatment processes.
6. Can all the CWQF be improved? Motivate your answer.

7. What is the best method to determine the volume acid required to acidify the water to a certain pH?
8. Name the best method to evaluate the chlorination process.
9. Describe in short what "relevance of measurements" means.
10. What CWQF can accurately be measured on the farm or in the orchard?

How am I doing?

Concept (SO 3)	I understand this concept	Questions that I still would like to ask
Water quality and processing systems are explained and described.		
Quality management systems, as related to water quality are described.		
Quality in existing implemented water quality assurance systems is maintained.		
Water quality and processing systems, ensuring water quality and integrity is maintained.		

Session 4 Effects of corrective actions

After completing this session, you should be able to:
SO 4: Evaluate the effects of corrective actions or adjustments on the water quality requirements.

In this session we explore the following concepts:

- Evaluate the effects of corrective actions or adjustments on the water quality requirements.
- The implementation of corrective actions or adjustments on water quality, supply and integrity is evaluated
- Further adjustments or adaptations to water supply and quality management systems are proposed.
- Water quality management systems are in place and reported on continuously.

4.1 Corrective actions on water quality, supply and integrity

The actions to improve the quality of irrigation water are limited to filtration, disinfection and acidification. At this stage the most important quality factor, the EC or total dissolved solids, can not be improved economically. We can add to the water but, apart from the carbonates and bicarbonates, we cannot remove soluble salts from water economically. Therefore other methods are employed to make unsuitable water more suitable to increase the water supply for irrigation.

The simplest method is to mix waters of a low and high salt content in order to get water with a medium, but acceptable, salt content. If the waters are mixed in equal portions (50:50) the EC of the mix will be half the sum of the two separate EC's.

My Notes ...

. . . .
. . . .
. . . .
. . . .
. . . .
. . . .
. . . .

Example

Calculating the EC of Mixed Water Source

The EC of source A is 25 and that of Source B 125mSm-1. If these two sources are mixed at equal volumes (one volume of A plus one volume of B), the estimated EC of the mix will be:

1 x 25 + 1 x 125 /2

= 75mSm-1, i.e. good quality water

If the sources are mixed at different ratios, the estimated EC can be calculated as follows:

Volumes of A EC=25 mSm-1	***Volumes of B EC=125 mSm-1***	***Formula***	***Estimated EC mSm-1***
1	1	1 x 25 + 1 x 125 / 1 + 1	75.00
2	1	2 x 25 + 1 x 125 / 2 + 1	58.33
3	1	3 x 25 + 1 x 125 / 3 + 1	50.00
1	3	1 x 25 + 3 x 125 / 1 + 3	100.0

Another fairly simple method is the electron magnetic treatment of hard water. In this process, the surface tension of water is decreased by passing the water through a tube-like instrument constructed of dissimilar metals. The process adds electrons to the water which reduce the surface tension and increase the carrying capacity of the water. Equipment is available in South Africa and installation and maintenance is done according to the specifications of the suppliers.

At this stage it is more important to deal with the salts than to desalt the water. Desalting of irrigation water is currently not cost-effective.

4.2 Recommendations for corrective actions

The effects of some recommendations for corrective actions can easily be evaluated, especially those with a direct influence on water quality. Adjusting the pH of water to be applied as a pesticide spray is for instance very easy and is done by merely measuring the pH and drawing a conclusion.

The effects of other recommendations can be quite difficult to evaluate. Evaluating recommendations to counteract the high concentration of chlorides in the water requires other information, such as yield and fruit quality data.

The simplest way to do this, is to list the factor to be improved (what to improve), the "before" measurement (why), the recommendation (how) and the "after" measurement (result).

My Notes ...

. . . .

. . . .

. . . .

Example

Evaluating the Effect of Corrective Actions

What	Why	How	Result
pH 8.23	Reduce the pH from 8.23 to increase efficacy of pesticide sprays.	Apply 200ml buffer per 100 litres water buffer Z to reach pH 5.5.	pH of the spray mix = 5.5.
Suspended solids = 85mg per litre.	Moderate clogging hazard.	Filtration.	10mg solids per litre water.
Bacterial count = 15,000 per ml.	Slimes forming a definite hazard.	Chlorinate continuously with 3 mg free chlorine per litre water.	Measured free chlorine at most distant emitter = 2 mg per litre.

A huge component of this evaluation relies on the information that necessitates the action. For instance; research results proved that pesticide A is twice as effective at pH 5.5 as at 7.00 or higher. The WQM must have access to this data supplied by a competent institution.

Recommendations to reduce the impact of the indirect effects of water quality need to be done in conjunction with the person responsible for the fertilisation and soil maintenance programs. Usually these recommendations involve multi-disciplinary inputs and can seldom be evaluated by simplistic measurements.

4.3 Reporting on water quality management systems

The importance, frequency and scope of reporting depend on the quality of the water received on the farm or at the orchard. With good quality water, where hardly any improvements or actions to reduce the impact on the trees and soil are required, a laboratory analyses twice per annum will be sufficient. As the water quality gets worse, more attention, actions and measurements are required. Reporting then needs to be more involved and should include assessments, actions and outcomes.

A reporting system should include the following basic elements:

- The current quality of the water
- Comparisons with previous qualities, i.e. asking the question: Is the quality deteriorating?
- Actions to improve or maintain the quality or limit the impact
- Schedule for actions to be taken
- Outcome of the actions

Data for reporting purposes are collected on an ongoing basis according to a planned schedule. The frequency and type of measurements depend on the quality of the water, the irrigation system and soil type.

Example

Reporting on Water Quality

Requirements	***Frequency***	***Measurements***
Laboratory report.	Twice per annum.	Complete analyses for irrigation purposes.
Comparison with historical data.	At least once per annum.	All data on laboratory report and that collected on farm.
List of quality factors that require attention.	Depending on water quality but at least once per annum.	The "before" and "after" measurements.
Report from the advisors on specific inputs.	Whenever an advisor was consulted.	According to the advisors recommendations/report.

The report must be concise and short and should report in detail on quality factors that are important in terms of impact on soil, trees, environment, profitability and sustainability. A prediction of the quality of the water over the next year (short term) and five years (medium term) should be included. If any major actions are required, this should be properly investigated and addressed in the budget.

ACTIVITY

Please complete Activity **4:**
Experiment

Two water sources are available for irrigation. Source A is of good quality with an EC of 30mSm^{-1} and source B has an EC of 130mSm^{-1}. How can the volume of irrigation water with an acceptable quality be increased?
Estimate the EC of the mix when two waters with an EC of 100 and 50 mSm^{-1} are mixed in a ration of 1 to 2.

How am I doing?

Concept (SO 4)	I understand this concept	Questions that I still would like to ask
The implementation of corrective actions or adjustments on water quality, supply and integrity is evaluated.		
Further adjustments or adaptations to water supply and quality management systems are proposed.		
Water quality management systems are in place and reported on continuously.		

My Notes ...

. . . .
. . . .
. . . .
. . . .
. . . .
. . . .
. . . .
. . . .
. . . .
. . . .
. . . .
. . . .
. . . .

Glossary

Term	Description
BWQF	Biological water quality factors.
CWQF	Chemical water quality factors.
DWAF	Department of water affairs and forestry.
EC	Electrical Conductivity.
PWQF	Physical water quality factors.
TDS	Total dissolved solids.
WQM	Water quality manager.
WQMS	Water quality management system

My Notes …

. . . .
. . . .
. . . .
. . . .
. . . .
. . . .
. . . .
. . . .
. . . .
. . . .
. . . .
. . . .
. . . .

Am I ready for my test?

- Check your plan carefully to make sure that you **prepare in good time**.
- You have to be found **competent** by a qualified **assessor** to be declared competent.
- Inform the assessor if you have any **special needs** or requirements **before** the agreed date for the test to be completed. You might, for example, require an interpreter to translate the questions to your mother tongue, or you might need to take this test orally.
- Use this worksheet to help you prepare for the test. These are **examples** of **possible questions** that might appear in the test. All the information you need was taught in the classroom and can be found in the learner guide that you received.

1. ***I am sure*** *of this and understand it well*
2. ***I am unsure*** *of this and need to ask the Facilitator or Assessor to explain what it means*

Questions	1. I am sure	2. I am unsure
1. Identify the water source on the farm where you are performing your practical work.		
2. List all the water quality factors that might affect this water source and categorise the risks according to chemical, physical or microbiological factors.		
3. Obtain values for the following regarding the water that you are investigating: pH EC SAR Ca Mg Cl B N Total suspended solids. Dissolved Oxygen.		
4. Now assess the water and decide on required actions.		
5. What type of filtration system will have to be installed if this water is to be used for irrigation purposes? Be very specific regarding type of filter and pore sizes.		

6. What will the result and/or advantage be of your actions on the water.		
7. What is the clogging hazard of the water and what can you do about it.		
8. Would you aerate the water? If yes, how and why?		
9. Would you consider acidification of the water? If yes, how and why?		
10. Would you disinfect the water? If yes, how and why?		
11. Would you chlorinate the water? If yes, how and why?		
12. How often will you perform these tests on the water in future?		
13. What will you test routinely on the water in future?		
14. What will you do with the data that you obtain from each of these water tests?		
15. If you were in charge of water quality management, what would you report and to whom would you report it?		

My Notes ...

. . . .
. . . .
. . . .
. . . .
. . . .
. . . .
. . . .

Checklist for practical assessment …

Use the **checklist** below to help you prepare for the part of the practical assessment when you are observed on the **attitudes** and **attributes** that you need to have to be found competent for this learning module.

Observations	Answer Yes or No	Motivate your Answer (Give examples, reasons, etc.)
Can you identify problems and deficiencies correctly?		
Are you able to work well in a team?		
Do you work in an organised and systematic way while performing all tasks and tests?		
Are you able to collect the correct and appropriate information and / or samples as per the instructions and procedures that you were taught?		
Are you able to communicate your knowledge orally and in writing, in such a way that you show what knowledge you have gained?		
Can you base your tasks and answers on scientific knowledge that you have learnt?		
Are you able to show and perform the tasks required correctly?		
Are you able to link the knowledge, skills and attitudes that you have learnt in this module of learning to specific duties in your job or in the community where you live?		

- The assessor will complete a checklist that gives details of the points that are checked and assessed by the assessor.
- The assessor will write commentary and feedback on that checklist. They will discuss all commentary and feedback with you.
- You will be asked to give your own feedback and to sign this document.
- **It will be placed together with this completed guide in a file as part of you portfolio of evidence.**
- The assessor will give you feedback on the test and guide you if there are areas in which you still need further development.

Paperwork to be done …

Please assist the assessor by filling in this form and then sign as instructed.

Learner Information Form				
Unit Standard	**116322**			
Program Date(s)				
Assessment Date(s)				
Surname				
First Name				
Learner ID / SETA Registration Number				
Job / Role Title				
Home Language				
Gender:	Male:		Female:	
Race:	African:	Coloured:	Indian/Asian:	White:
Employment:	Permanent:		Non-permanent:	
Disabled	Yes:		No:	
Date of Birth				
ID Number				
Contact Telephone Numbers				
Email Address				
Postal Address			Signature:	

Bibliography

Books:

DWAF: **South African Water Quality Guidelines**, 1996, Vol. 4, Department of Water Affairs and Forestry, Pretoria

Ford, H.W., **The Problem of Drippers Clogging and Methods for Control**, 1985, SA Irrigation Journal, Oct/Nov, University of Florida, USA

Hanson, B., Grattan, S., Prichard, T. and Schwankl, L, **Drip Irrigation for Row Crop**, 1992, University of California, Davis

Koegelenberg, F. and Conradie, G., **Voedingsbesproeiing**, 2000, ARC Institute for Agricultural Engineering, Silverton

Leading drip irrigation supplier, **Thin-Walled Irrigation Dripperline Installation and Maintenance Manual**, 1998, Israel

Leading drip irrigation supplier, **Maintenance of Drip Irrigation Systems**, 2000, Pamphlet, RSA

Uys, W., **The Performance and Care of Drip Irrigation Emitters**, 2000

Terms & Conditions

Acknowledgements

- **Project Management:**

  M H Chalken Consulting

  IMPETUS Consulting and Skills Development

- **Donors:**

  Citrus Academy

- **Authenticator:**

  Rural Integrated Engineering

- **Technical Editing:**

  Mr C Klindt

- **Language Editing:**

  Mr D Erasmus

- **OBE Formatting:**

  Ms P Prinsloo

- **Design:**

  Didacsa Design SA (Pty) Ltd

- **Layout:**

  Ms A du Plessis

  Ms N Matloa

SOUTH AFRICAN QUALIFICATIONS AUTHORITY

REGISTERED UNIT STANDARD:

Manage water quality parameters

SAQA US ID	**UNIT STANDARD TITLE**		
116322	Manage water quality parameters		
SGB NAME	**NSB**	**PROVIDER NAME**	
SGB Primary Agriculture	NSB 01-Agriculture and Nature Conservation		
FIELD		**SUBFIELD**	
Agriculture and Nature Conservation		Primary Agriculture	
ABET BAND	**UNIT STANDARD TYPE**	**NQF LEVEL**	**CREDITS**
Undefined	Regular	Level 4	3
REGISTRATION STATUS	**REGISTRATION START DATE**	**REGISTRATION END DATE**	**SAQA DECISION NUMBER**
Registered	2004-10-13	2007-10-13	SAQA 0156/04

PURPOSE OF THE UNIT STANDARD

A learner will be able to implement corrective actions based on water quality parameters. In addition they will be well positioned to extend their learning and practice into other areas of agriculture and water management.

Learners will gain specific knowledge and skills in maintaining water quality and will be able to operate in an animal production environment implementing sustainable and economically viable production principles.

They will be capacitated to gain access to the mainstream agricultural sector, in animal production, impacting directly on the sustainability of the sub-sector. The improvement in production technology will also have a direct impact on the improvement of agricultural productivity of the sector.

LEARNING ASSUMED TO BE IN PLACE AND RECOGNITION OF PRIOR LEARNING

It is assumed that a learner attempting this unit standard will show competence against the following unit standards or equivalent:

- NQF 3: Maintain water quality parameters.
- NQF 3:Recognize and identify the basic functions of the ecological environment.
- NQF 3: Apply routine maintenance and servicing plans and procedures.

UNIT STANDARD RANGE

Range statements are neither comprehensive nor necessarily appropriate to all contexts. Alternatives must however be comparable in scope and complexity. These are only as a general guide to scope and complexity of what is required.

UNIT STANDARD OUTCOME HEADER

N/A

Specific Outcomes and Assessment Criteria:

SPECIFIC OUTCOME 1

Correctly assess, analyze and evaluate water quality data and independently decide on the corrective actions within operational technical systems to well defined, but possibly unfamiliar problems.

OUTCOME RANGE

This will include:
- Physical factors such as temperature, suspended solids, plankton, clay turbidity.
- Chemical factors such as: dissolved gasses such as oxygen, ammonia, and pH.
- Dissolved solids such as: salinity, super saturation, pollutants, and heavy metals.
- Microbiological characteristics: (E. coli, Vibrio sp., Salmonella sp., algal blooms, and possible diseases.)
- Biological processes such as: photosynthesis, nitrogen cycle, decomposition, and energy budgets.
- Operational technical systems: aeration, filtration, protein skimming, screening, bio-filtration, degassing, nutrient stripping, sterilization such as ozonation, UV sterilization and chlorination.

ASSESSMENT CRITERIA

ASSESSMENT CRITERION 1

A thorough understanding of the effects of certain physical factors is demonstrated and is related and applied as a standard procedure or a corrective action to relevant plant or animal species.

ASSESSMENT CRITERION 2

A thorough understanding of the effects of certain chemical factors is related to and applied as a standard procedure or a corrective action to relevant plant or animal species.

ASSESSMENT CRITERION 3

A thorough understanding of the effects of certain microbiological characteristics is related to and applied as a standard procedure or a corrective action to relevant plant or animal species.

ASSESSMENT CRITERION 4

A thorough understanding of the effects of certain biological processes is related to and applied as a standard procedure or a corrective action to relevant plant or animal species.

ASSESSMENT CRITERION 5

A thorough knowledge and understanding of the principles and use of operational technical systems is related, integrated and applied as a standard procedure or a corrective action to relevant plant or animal species.

SPECIFIC OUTCOME 2

Demonstrate a thorough understanding of the reasons, impacts and implications of specific corrective actions related to water quality.

ASSESSMENT CRITERIA

ASSESSMENT CRITERION 1

A wide range of scholastic and technical concepts related to water and all its aspects is recalled.

ASSESSMENT CRITERION 2

An analysis of collected data or information and the reasons for specific corrective actions are explained and presented.

ASSESSMENT CRITERION 3

Information, especially within the context of corrective actions is independently accessed, analyzed and evaluated.

SPECIFIC OUTCOME 3

Implement corrective actions related to the quality of water and water quality systems.

ASSESSMENT CRITERIA

ASSESSMENT CRITERION 1

Water quality and processing systems are explained and described.

ASSESSMENT CRITERION 2

Quality management systems, as related to water quality are described.

ASSESSMENT CRITERION 3

Quality in existing implemented water quality assurance systems is maintained.

ASSESSMENT CRITERION 4

Water quality and processing systems, ensuring water quality and integrity is maintained.

SPECIFIC OUTCOME 4

Evaluate the effects of corrective actions or adjustments on the water quality requirements.

ASSESSMENT CRITERIA

ASSESSMENT CRITERION 1

The implementation of corrective actions or adjustments on water quality, supply and integrity is evaluated.

ASSESSMENT CRITERION 2

Further adjustments or adaptations to water supply and quality management systems are proposed.

ASSESSMENT CRITERION 3

Water quality management systems are in place and reported on continuously.

UNIT STANDARD ACCREDITATION AND MODERATION OPTIONS

The assessment of qualifying learners against this standard should meet the requirements of established assessment principles.

It will be necessary to develop assessment activities and tools, which are appropriate to the contexts in which the qualifying learners are working. These activities and tools may include an appropriate combination of self-assessment and peer assessment, formative and summative assessment, portfolios and observations etc.

The assessment should ensure that all the specific outcomes; critical cross-field outcomes and essential embedded knowledge are assessed.

The specific outcomes must be assessed through observation of performance. Supporting evidence should be used to prove competence of specific outcomes only when they are not clearly seen in the actual performance.

Essential embedded knowledge must be assessed in its own right, through oral or written evidence and cannot be assessed only by being observed.

The specific outcomes and essential embedded knowledge must be assessed in relation to each other. If a qualifying learner is able to explain the essential embedded knowledge but is unable to perform the specific outcomes, they should not be assessed as competent. Similarly, if a qualifying learner is able to perform the specific outcomes but is unable to explain or justify their performance in terms of the essential embedded knowledge, then they should not be assessed as competent.

Evidence of the specified critical cross-field outcomes should be found both in performance and in the essential embedded knowledge.

Performance of specific outcomes must actively affirm target groups of qualifying learners not unfairly discriminate against them. Qualifying learners should be able to justify their performance in terms of these values.

- Anyone assessing a learner against this unit standard must be registered as an assessor with the relevant ETQA.

- Any institution offering learning that will enable achievement of this unit standard or assessing this unit standard must be accredited as a provider with the relevant ETQA.

- Moderation of assessment will be overseen by the relevant ETQA according to the moderation guidelines in the relevant qualification and the agreed ETQA procedures.

UNIT STANDARD ESSENTIAL EMBEDDED KNOWLEDGE

The person is able to demonstrate a basic knowledge of:

- Names and functions of all the various components of water supply and quality systems.
- Attributes of water related to water quality.
- The requirements of organisms related to their water need.
- The purposes of maintaining relevant water quality for living organisms.
- Measurement and recording technique.
- Water purification techniques and systems.
- Relevant legislation related to the feeding and care of living organisms.
- Relevant legislations related to water use and environmental issues.
- Interpersonal skills related to communication.
- Sensory and documented cues related to water quality.
- Sensory cues related to the water requirements and use of water by living organisms.

UNIT STANDARD DEVELOPMENTAL OUTCOME

N/A

UNIT STANDARD LINKAGES

N/A

Critical Cross-field Outcomes (CCFO):

UNIT STANDARD CCFO IDENTIFYING

Problem solving: Relates to all specific outcomes.

UNIT STANDARD CCFO WORKING

Teamwork: Relates to all specific outcomes.

UNIT STANDARD CCFO ORGANIZING

Self Management: Relates to all specific outcomes.

UNIT STANDARD CCFO COLLECTING

Interpreting information: Relates to all specific outcomes.

UNIT STANDARD CCFO COMMUNICATING

Communication: Relates to all specific outcomes.

UNIT STANDARD CCFO SCIENCE

Science and Technology: Relates to all specific outcomes.

UNIT STANDARD CCFO DEMONSTRATING

The world as a set: Relates to all specific outcomes.

UNIT STANDARD CCFO CONTRIBUTING

Self-development: Relates to all specific outcomes.

UNIT STANDARD ASSESSOR CRITERIA

N/A

UNIT STANDARD NOTES

N/A