Ethiopian TVET-System

Irrigation and Drainage Design and Construction

Level-III

Based on March 2017 GC. Occupational Standard

Module Title: Maintaining and Repairing Irrigation Canal and Structures

TTLM Code: EIS IDC 3 TTLM 0920v2

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This module includes the following Learning Guides

LG56: Plan and prepare for work

LG Code: EIS IDC3 M15 LO1-LG-56

LG57: Maintain irrigation channels and drainage assets

LG Code: EIS IDC3 M15 LO2-LG-57

LG58: Check work and restore work site

LG Code: EIS IDC3 M15 LO3-LG-58

LG59: Finalize work

LG Code: EIS IDC3 M15 LO4-LG-59

Instruction Sheet	Learning Guide-56: Plan and prepare for work

This learning guide is developed to provide you the necessary information regarding the following content coverage and topics:

1. Determine Work requirements from plans, drawings, specifications
2. Site checking and hazard identification
3. Appropriate arrangement of drainage and inflow diversion
4. safety requirement of Equipment and excavation method
5. Personal protective equipment

This guide will also assist you to attain the learning outcome stated in the previous page. Specifically, upon completion of this Learning Guide, you will be able to –

- Identify work requirements from plans, drawings, and specifications.
- Identifying potential hazards
- Arrange temporary diversion work from work site.
- Identify tools, equipments and excavation method
- Use Personal protective equipment

Learning Instructions:

1. Read the specific objectives of this Learning Guide.
2. Follow the instructions described below 3 to 4.
3. Read the information written in the information “Sheet 1, Sheet 2, Sheet 3 and Sheet 4”inpage 3, 13, 20,24 and 37 respectively.
4. Accomplish the “Self-check 1, Self-check 2, Self-check 3 and Self- check 4” -” in page 11, 18, 23, 34 and 43 respectively
5. If you accomplish the self-checks, do operation sheet in page 45
6. LAP Test in page 46

Information sheet – 1	Determining Work requirements

1.1 Introduction

An essential aspect of the project, collecting requirements process helps to define project scope during scope management. With some set of tools and techniques to gather requirements for projects, it's the responsibility of a project manager to ensure capturing all the requirements. As a project manager, it's essential to be very agile while collecting requirements and also it is necessary to use appropriate requirement gathering tools during the project lifecycle. Ensuring not to miss any requirements of the project outcome, a project manager is liable for the success of the project.Requirements are not the same as project objectives. The objectives should drive the requirements. Objectives are what you want to accomplish, requirements are how you will accomplish those objectives.

1.2 Extent of work

In repair and maintenance of irrigation assets, the term 'scope of work' or extent of work is a very general term referring to a general description of the work that is expected to be performed under a particular contract. It may be prepared by the client or their consultants and included in tender documentation for construction works. A scope of work can be a useful way of agreeing broad project requirements for both the client and supplier.

Without a defined scope of work, there's no way to know what work must be done. That means it's incredibly important to establish the scope when contracting to show what tasks must be done, who's responsible for those tasks, and the project schedule, and any other necessary details for contractors and subs. Without a clearly defined scope of work, the potential for defects, payment disputes, and project delays will soar.It establishes a baseline of rights and obligations. A scope of work isn't set in stone, though – they're commonly modified via change orders and partial terminations.

There's no single way to set out the scope of work. Still, there are some general considerations that should be included.

- **Project Overview:** A short, concise statement summarizing the project description.
- **Project Deliverables.** This section should detail all the expected project goals that need to be reached throughout the lifespan of the project
- **Project Scope**: The project scope will give you essential details regarding the precise tasks and their technical aspects.
- **Schedule Summary**: Not a full detailed construction schedule, but rather a general list of tasks, and related tasks for the project and when they are expected to be completed.
- **Project Management**: This section of the scope of work will define the administrative procedures on the project. How are change orders handled? When and how are payments going to be issued?
- **Bottom Line:** Proper communication and transparency will prevent construction payment disputes, and that starts with a crystal-clear scope of work. When both parties understand what's expected, everything else tends to fall into place. Plus, referring back to the scope of work keeps parties on task, which helps to complete the build on time and on budget.

1.3 Site boundary

Site boundary means that line beyond which the land or property is not owned, or otherwise controlled by the regulated entity for repair and maintenance work. The law says you must conduct your work without putting members of the public at risk. This includes the public and other workers who may be affected by your work.The project client should provide information about:

- boundaries
- adjacent land usage
- access; and
- measures to exclude unauthorized persons

This will influence the measures contractors take.

Key issues are:

- Managing site access
- Hazards causing risk to the public
- Vulnerable groups

All construction sites require:

- Measures to manage access across defined boundaries; and
- Steps to exclude unauthorized people.

Site boundaries: You need to define boundaries physically, where necessary, by suitable fencing. The type of fencing should reflect the nature of the site and its surroundings.

Determining the boundary is an important aspect of managing public risk. You need to:

- **Plan** what form the perimeter will take;
- **Provide t**he fencing; and
- **Maintain** the fencing.

Questions you need to ask yourself include:

- What is the nature and type of the construction work?
- How heavily populated is the area is?
- Who will need to visit the site during the work?
- Will the site attract children?
- What are the site characteristics (eg existing site boundaries, location, proximity to other buildings)?

Typically, in populated areas, this will mean a two-metre high small mesh fence or hoarding around the site.

Authorization: The principal contractor must take reasonable steps to prevent unauthorized people accessing the site.

- People may be authorized to access the whole site or be restricted to certain areas;
- You must explain relevant site rules to authorized people and undertake any necessary site induction;
- You may need to supervise or accompany some authorized visitors while they are on site or visiting specific areas.

1.4 Locating Utility

Utility location is the process of identifying and labeling public utility mains that are underground. These mains may include lines for telecommunication, electricity distribution, natural gas, cable television, fiber optics, traffic lights, street lights, storm drains, water mains, and wastewater pipesBecause of the many different types of materials different detection and location methods must be used. Preventing damage to underground utility infrastructure is a priority for utility operators and contractors who excavate, drill and bore in areas where there are existing utilities.

Locates are ground markings identifying the position of utility lines based on records or electronic locating equipment, and the associated necessary documentation such as a locate sheet.

Ground markings consist of different colors that are used to reflect each type of infrastructure (gas, hydro, cable, etc.).

Employers are required to:

- Determine the approximate location(s) of utility installations — including sewer, telephone, fuel, electric, and water lines.
- Contact and notify the utility companies or owners involved to inform them of the proposed work.

- Ask the utility companies or owners to establish the location of underground installations prior to the start of excavation work; which includes using detection equipment or other acceptable means to locate utility installations.
- Determine the exact location of underground installations by safe and acceptable means.
- Ensure that while the excavation is open, underground installations are protected, supported, or removed as necessary in order to safeguard workers.

1.5 safe work method

A Safe work method statement (SWMS) is a document that sets out the high-risk work activities to be carried out at a workplace, the hazards arising from these activities and the measures to be put in place to control the risks. One SWMS can be used for work that involves a work activity that requires using powered mobile plant, working at heights of more than 2 meters and working adjacent to a road used by traffic other than pedestrians. A SWMS is classed as an administrative control and is used to support higher order controls to eliminate or minimize risks to health and safety. A SWMS is generally different from other documents that focus on specific tasks or processes, such as a Job Safety Analysis or a Safe Operating Procedure.

The principal contractor, builder and subcontractors should consult with each other to determine who is in the best position to prepare the SWMS. Managers, contractors, leading hands and workers should all be involved in developing a SWMS. Consulting workers and Health and Safety Representative at the workplace they should also be consulted when developing a SWMS. A SWMS must:

- identify the work that is high risk construction work
- specify hazards relating to the high-risk construction work and the risks to health and safety
- describe the measures to be implemented to control the risks, and
- describe how the control measures are to be implemented, monitored and reviewed

1.6.Knowing how to read construction plans

Construction plans (blueprints) are 2-dimensional drawings that explain the details of a project. They provide a unique visual representation of what exactly needs to be built. Information such as dimensions, parts, placement, and materials for each project can all be found in construction drawings to assure the project is completed correctly.

Figure 1: Work plan

They provide construction workers with other important information for the project including building codes, installation techniques, measurements, and quality standards. Depending on the size and complexity of a project, some construction plans will require to be printed on oversized sheets while others may fit in the confines of a notebook. Regardless of how the plans are presented, the importance of understanding construction drawings remains a top priority. Construction plans are required to estimate your costs for materials and labor, obtain your permits, establish a construction schedule, and complete the project in a timely manner. Every project is unique, therefore how you interpret the information is critical. It is a lot like having your own language as a construction worker.

What is Included in a Set of Construction Plans?When learning how to read construction plans, it is essential to understand what is contained within typical

construction plans. Most include a cover page, time block, key notes, general notes, revision block, drawing scale and a legend. It is crucial that you read everything and understand it before you estimate or start the construction project!

Cover Page: This page usually contains a drawing of the actual project. It also includes the title block, revision block, notes, drawing scale and the legend.

Title Block: Each plan contains a "title block." The title block often appears at the beginning of a set of construction plans. The shape, size, and placement of the title block can vary. You will see things like copyright information, revision date, plan number, creation date, scale of the drawing, and sheet number.

The title block's first section lists the blueprint's name, number, and address as well as the location, site, or vendor. If the drawing is part of a set, that information will also be included. If there is a blank in the title block, the drawing is not ready for release. The authority (checker or engineer) will not sign it if there is missing information. The second section of the title block contains routine information. Approval dates and signatures are located here. Should you need more information regarding a project's construction plans, this information should include contact information for further discussion. The final section of the title block is the list of references.

This section lists all other drawings that are related to the building, system, component, as well as all construction plans (blueprints) that were used as a reference or to inspire the project.

- **Revision Block:** Any time there is change to a building, system, or component, the drawing must be redrafted. Those changes are listed in the Revision Block – usually with a date as well.
- **Drawing Scale:** Construction plans (blueprints) are scaled down representations of the final project at a ratio of the actual size. For example, 1/8″ = 1′ (one eighth inch equals one foot). When construction plans are scaled, it helps to put the part into a print size drawing that is easily read by the crew.

- **Key Notes:** The notes will reveal any specifications, details, or information the designer (engineer) thinks may help you understand the drawing. Some notes may even include information as to when the project start time is, for example, “Do not begin work until 7 am.” Information like this can be beneficial to the crew and might even be a requirement of the municipality in which the work is taking place.
- **General Notes:** General notes eliminate the use of lengthy written explanations. It is a note that provides technical information that will apply to the entire drawing.
- **Legend:** Thelegendis used to define thesymbols used in the construction plans (blueprint).

Your company might also have their own symbols for certain items. The important thing is that you understand the meaning of the symbols regarding the plans you are reviewing. Be sure you understand what those symbols represent by reviewing the legend for the drawing that you’re working with. In conclusion, if you are in the construction industry.

Self-check 1	Written Test

I. Choose the best answer form the given alternatives (2 pts each)

1. ___very general term referring to a general description of the work that is expected to be performed under a particular contract.
   A. Scope of work
   B. Objective
   C. Requirement of work
   D. All
2. _____ means that line beyond which the land or property is not owned.
   A. Site boundary
   B. Scope of work
   C. Land usage
3. AccessUtility location is the process of identifying and labeling public utility mains that are underground.
   A. Labeling
   B. Utility location
   C. Positioning
   Grounding
4. Which one of the following is not included in the construction plan?
   A. Cover page
   B. Drawing
   C. Title block
   D. All
5. ____ is a document that sets out the high-risk work activities.
   A. Safe work method statement C. Health and safety
   B. PPE D. All

II. Short Answer Questions

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page:

1. Explain the benefit of understanding extent of work. (2 pts)

2. Briefly describe about utility locating. (3 pts)
3. What is the purpose of temporary water diversion? (3 pts)
4. Why you need to delineate work site boundary? (2 pts)

Satisfactory rating - 10 points: Unsatisfactory - below 10 points

You can ask your teacher for the copy of the correct answers.

Answer Sheet

Score = _____

Rating: _____

Name: _____ **Date:** _____

I. Choose answer

1.____ **2.** ____, **3.** _____ **4.** _____ **5.** _____

II. Short Answer Questions

1._____

2._____

3._____

4._____

Information sheet - 2	Site checking and hazard identification

2.1 Introduction

Often times, you may feel uncertain about the safety of your workplace. It is important to be able to identify any possible safety and health hazards that may be looming around you. If you work on a construction site, you should be even more diligent about safety. Read on to learn how to point out hazards that may exist on your construction site.

2.2 Workplace Hazard

A workplace hazard is any potential interference with the quality of life of your occupation that causes health and safety risks to you or others. The type of hazards varies across industries, and there are hazards you should be aware of on your own job or work site. The most common hazards in the workplace:

- Safety hazards: They include dangerous conditions that can cause injury, illness, or death. These hazards include:
  - ✓ Working from unsafe heights, such as ladders, roofs, or any raised work area.
  - ✓ Unguarded machinery that can harma foot, arm, leg or any other body part
  - ✓ Electrical hazards such as exposed wiring, missing ground pins, and frayed cords.
  - ✓ Confined spaces that can put you in danger to toxic gases, and oxygen deficient environments. These include working in trenches, and dangers such as entering tanks.
- Biological hazards: these are related to working inside schools, colleges and universities, hospitals, laboratories, nursing homes, outdoor occupations, and with animals, people, or infectious plant materials that can potentially expose you to biological hazards, which include the following:
  - ✓ blood and other body fluids
  - ✓ fungi and mold
  - ✓ plants

- ✓ insect bites
- ✓ animal and bird droppings
- ✓ bacteria and viruses

- **Ergonomic hazards:** these hazards are the most difficult to notice because strain put on the body can often times go unnoticed for days on end before experiencing any pain. Short term expose can result in "sore muscles" after being exposed, but long-term exposure can result in serious illnesses on a long-term scale. Such hazards include:
  - ✓ Awkwardly and improperly adjusted workstations and chairs.
  - ✓ Frequent lifting
  - ✓ Repetitive movements causing overuse injuries to hands, arms, or legs
  - ✓ Having to use too much force frequently, which can cause sprains and strain-related injuries.
  - ✓ Excessive exposure to vibration.

2.3 Hazard Identification

Being aware of on-site risks is vital. Before doing any work, take a few minutes to check your surroundings. Think about what you will be doing, what equipment and plant you will need, how you could get hurt and what you'll do if something unexpected happens. Asking yourself these seven simple questions is a good place to start - it could be a life saver.

- **Can I come into contact with an energy source?**
  - ✓ Death and serious injury can occur from exposure to electrical hazards on work sites.
- **Can I come into contact with a hazardous substance?**
  - ✓ Used incorrectly, hazardous substances can cause catastrophic accidents, such as fires and explosions, and serious harm to people who are exposed to them. You can be exposed by breathing them in, through your skin or by swallowing/ingesting them. Exposure can cause: death, cancer, damage to your internal organs like the liver and kidneys, and fertility problems.

- **Can I be struck by or strike against anything?**
  - ✓ Think about your surroundings, the other contractors on site and how you might be hurt by things like:
  - ✓ Being trapped between a vehicle/plant and a structure
  - ✓ Vehicles/plant colliding with each other or a structure
  - ✓ Items that fall off vehicles/plant (unsecured or unstable loads)
  - ✓ Falling from a vehicle/plant

- **Can I be caught in, on or between anything?**
  - ✓ Tools, plant and vehicles can create serious hazards. Even if you use them every day, it's important to think about how they can hurt you as they are some of the most serious hazards on site. Some things to watch out for are:
  - ✓ Mechanical failure
  - ✓ Operator error
  - ✓ Incorrect/lack of guarding
  - ✓ Being trapped by vehicles or plant
  - ✓ Environmental conditions
  - ✓ Poor design

- **Can I slip, trip or fall on the same or lower level?**
  - ✓ You can be seriously injured, even if you only fall a short distance. Watch out for things like:
  - ✓ Uncovered excavations
  - ✓ Unsecured covers
  - ✓ Slippery surfaces
  - ✓ Working at height (e.g. ladders, scaffolds, cherry pickers etc.)

- **Can I be injured by poor job/plant design?**
  - ✓ Take time to plan your work and make sure you have the right tools and equipment for the job. Speak up if you see someone else doing something unsafe, cutting corners or using the wrong tool for the job.

- ✓ Look out for:
- ✓ New tools or plant with different controls
- ✓ Operator positioning and poor visibility
- ✓ Lack of training
- ✓ Non-compliant equipment
- ✓ Poorly maintained tools, and wear and tear of older tools
- ✓ Tools not being used for their intended purpose
- ✓ Equipment that does not comply to New Zealand standards

- **Can I strain or sprain a muscle?**
  - ✓ You are most at risk from manual handling injuries when:
  - ✓ A load is too heavy, it's difficult to grasp, or it's too large
  - ✓ The physical effort is too strenuous
  - ✓ They are required to bend and twist when handling heavy loads
  - ✓ The task is repetitive

If you see anything unsafe after asking yourself these seven questions, speak up and/or take action to eliminate or minimize the risk.

Figure 2: Construction site hazards

Self-check 2	Written Test

1. Which one of the following is biological hazard

a. Fungi and mold b. Insect bites c. Bacteria and viruses d. All

2. Which one of the following is ergonomic hazard

a.Frequent lifting b. plants c. insects d. all

3.___ is any potential interference with the quality of life of your occupation that causes health and safety risks.

a. Biological hazard b. workplace hazards c. fall d. all

4. During hazard identification which one of the following questions is best.

a. Can I come into contact with an energy source?
b. Can I come into contact with a hazardous substance?
c. Can I be struck by or strike against anything?
d. All

Short Answer Questions

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page:

1. Define work place hazard.
2. Briefly describe common work place hazards.
3. List hazard identification steps.
4. Describe each hazard identification steps?

Note: Each question carries 3 points: Satisfactory rating - 24 points: Unsatisfactory - below 12 points

You can ask your teacher for the copy of the correct answers.

Answer Sheet

Score = _____

Rating: _____

Name: _____ **Date:** _____

I. Choose answer

1. ___ **2.**____ **3.** _____ **4.** _____

II. Short Answer Questions

1. _____

2. _____

3._____

4. _____

Information sheet – 3	Making appropriate drainage and inflow diversion arrangement.

3.1 Introduction

Temporary diversion methods are commonly used to reroute water from a stream or direct flows to a designated portion of the stream channel to allow for construction activities to take place in the stream, along the banks, or beneath the active channel. Temporary diversion methods are often required during the construction of detention ponds, dams, in stream grade control structures, bank protection, utility installation, and other activities, including maintenance, that require working in waterways.

3.2 Temporary Diversion Work

The primary purpose of all temporary diversion methods is to allow for construction to occur in “dry” or dewatered conditions, providing conveyance of stream discharges and protecting water quality by passing upstream flows, up to a specified design event or threshold, around the active construction zone. Temporary diversion methods include temporary diversion channels, pump diversions (water is collected and pumped around the construction activities), piped diversions that operate via gravity, coffer dams, and other similar practices.

Selection and design of temporary diversion methods should consider many factors, including the following.

- Will construction of a temporary diversion cause greater environmental impacts?
- Nature of surrounding land use, property ownership, and easements in the project area.
- Seasonal variations in stream hydrology (base flow versus peak flow).
- Project duration and time of year during which construction will occur.
- Public safety aspects.
- Legal considerations, which are a function of many different factors such as property ownership, history of localized flooding, or parties that will have interest in project

Design and Installation: The following describes the steps necessary for the design and installation of temporary diversion methods.

1. Determine project duration.
2. Determine the time of year in which construction will occur.
3. Apply applicable sizing methodology and perform necessary calculations as discussed below.
4. Determine appropriate method of diversion.
    - Channel Diversion--For smaller streams, construction of dams and detention basins--or, as the site allows, a channel diversion--may divert the entire waterway.
    - Berm or Coffer Dam--A berm or coffer dam is appropriate for streams of all sizes to confine flow to one side of the stream.
    - Piped Diversion--A bypass pipe is generally appropriate for short-duration projects with low base flows.
    - Pumped Diversion--A pumped diversion may be appropriate for short-duration projects with low base flows. It may also be the only option where space for the diversion is limited.
5. Consider developing an emergency action plan, as a precaution, for rapidly removing equipment and materials.

Pump: a pumpis a device that moves fluids (liquidsorgases), or sometimes slurries, by mechanical action, typically converted from electrical energy into Hydraulic energy.

Pumps operate via many energy sources, including manual operation, electricity, engines, or wind power, and come in many sizes, from microscopic for use in medical applications, to large industrial pumps.

Mechanical pumps serve in a wide range of applications such as pumping water from wells, aquarium filtering, pond filtering and aeration, in the car industry for water-cooling and fuel injection, in the energy industry for pumping oil and natural gas or for operating cooling towers and other components of heating, ventilation and air conditioning systems.

Dewatering: Construction dewatering, unwatering, or water control are common terms used to describe removal or draining groundwater or surface water from a riverbed, construction site, caisson, or mine shaft, by pumping or evaporation. On a construction site, this dewatering may be implemented before subsurface excavation for foundations, shoring, or cellar space to lower the water table.

3.3 Maintenance

- Remove debris and sediment from the channel and rebuild and stabilize the ridge as needed.
- Check outlets and make necessary repairs immediately.
- If sediment traps are used as a performance enhancer, remove sediment from traps when they are 50% full.
- When the work area has been stabilized, remove the ridge and fill in the channel to blend with the natural ground. Remove temporary slope drains and stabilize all disturbed areas with vegetation or other erosion control practices.

Self-check 3	Written Test

Short Answer Questions

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page:

1. What is the purpose of installing temporary diversion work?
2. List the factors considered for design and installation of temporary diversion works.
3. List steps for design and installation of temporary diversion works.
4. List maintenance steps of temporary diversion works.

Note: Each question carries 5 points: Satisfactory rating - 20 points: Unsatisfactory - below 10 points

You can ask your teacher for the copy of the correct answers.

Answer Sheet

Score = _____

Rating: _____

Name: _____ **Date:** _____

Short Answer Questions

1._____

2._____

3._____

4. _____

Information sheet - 4	Identifying safety requirement of Equipment and excavation method

4.1 Introduction

Excavation is sometimes the only way of repairing seriously damaged components of drains and canals. At Maintain Drains we offer at top quality excavation & repair services. Our highly skilled a qualified team of professionals are ready to respond to your drainage problem. Equipped with the latest technology, we can repair the drain quickly, whilst also aiming for minimal disruption to you and your property

4.2 Excavation Tools and Machines in Construction

There are different types of soil excavation tools and machines used in construction. Excavation of soil is necessary in construction point of view and it should be done by hand tools or machineries based on the area of the land or depth of excavation. Now a day, for the soil excavation there are so many equipment's are there and these are classified into two types.

1. Hand tools

These are generally used for smaller depths of excavations in small areas. Man power is required to operate these tools. The tools come under this category are explained below.

Spade: Spade is a tool which consists metal plate having sharp edges, the plate is attached to long handle which is generally made up of wood. Because of its sharp edges the soil can be dig easily. The metal plate having less curvature in the spade so, we cannot lift the soil by spade.

Figure 3: Spade

Shovel: Shovel is tool which is used for the purpose of lifting of excavated soil. It is also similar to spade the difference between spade and shovel is the difference in leading edge. The curvature of metal plate of shovel is generally higher when compared to spade so we can hold the soil easily and lifted it. Shovel can also be used for digging purpose in case of soft soils, sand etc.

Figure 4: shovel

Hoe: Hoe is an excavating tool which consists a metal plate attached to a long handle with acute angle. The plate having sharp edge is used to excavate the soil. For small work of excavation, it is widely preferred tool. Sometimes metal plate is replaced by fork type plate.

Figure 5: Hoe

Trowel: Trowel is hand sized tool which is generally used to dig the small trenches in soil or to remove the shallow roots in soil.

Figure 6: Trowel

Rake: Rake is a tools which is having a horizontal rod having metal teeth and is used to remove the small layers of soil.

Figure 7: Rake

Pick axe: Pick axe consists hard spike attached perpendicular to handle. They are used for excavating small trenches in soil. Pick axe can cut the soil even if the soil is of hard type. The metal spike is pointed on one side and wide blade is provided on the other side.

Figure 8: Pick axe

Mattock: This looks like pickaxe. But serious digging is not possible with mattock. Generally, it is used as lifting tool because of its curve shapes metal at its bottom.

Figure 9: Mattock

2. Equipments

These are the tools which are operated by mechanical force and are used for the larger depths of excavations. There are so many types of machine tools with ease of operation are designed in this modern-day period.

Tracked Excavator: This is also called as track hoe. It consists of cabinet and long arm. Long arm again consists of 2 parts. The first part which is closure to cabinet is called as Boom and the other part is called as Dipper-stick. Digging bucket is attached to the end of dipper. This entire system can rotate 360 degrees. In this case Vehicle is moved by traction, so we can use this equipment in mines, forestry, pipeline industries etc. the function of excavator is done by hydraulic fluid so, it is also called as hydraulic excavators.

Figure 10: Tracked Excavator

Wheeled Excavator: This whole arrangement is similar to the tracked excavator except that the movement of vehicle is done by wheels. It can move quickly when compared to tracked excavator but it is not suitable for uneven grounds or hilly areas because of slippery nature. So these are generally used for road constructions etc.

Figure 11: Wheeled Excavator

Back Hoe Excavator: In case of back hoe excavator, the hoe arrangement is on back side and loader bucket is arranged in front of the vehicle. So, two operations digging and loading or lifting is done by hoe and loader. This is widely used equipment nowadays because of its small size and versatility. This is moved with the help of wheels. so, moving from one workstation to another is quickly done.

Figure 12: Tracked Excavator

4.3 Selection Criteria for Earthwork Equipment

- Quantities of material to be moved
- The available time to complete the work the job conditions
- The prevailing soil types, the swell and compaction factors, etc.
- The job conditions include factors such as availability of loading and dumping area, accessibility of site, traffic flows and whether conditions at site.

4.4 Excavation Methods

In construction terms, excavation is the process of removing earth to form a cavity in the ground.

On small sites or in confined spaces, excavation may be carried out by manual means using tools such as picks, shovels and wheelbarrows. Larger scale excavation works

will require heavy plant. Excavation methods are depending on the types of material and purposes.

1. Material types

A common method of classification is by the material being excavated:

- **Topsoil excavation:** This involves the removal of the exposed layer of the earth's surface, including any vegetation or decaying matter which could make the soil compressible and therefore unsuitable for bearing structural loads. The depth will vary from site to site, but is usually in a range of 150-300 mm.
- **Earth excavation:** This involves the removal of the layer of soil directly beneath the topsoil. The removed material (referred to as 'spoil') is often stockpiled and used to construct embankments and foundations.
- **Rock excavation:** This is the removal of material that cannot be excavated without using special excavation methods such as drilling (by hand or with heavy machinery) or blasting with explosives.
- **Muck excavation:** This is the removal of excessively wet material and soil that is unsuitable for stockpiling.
- **Unclassified excavation:** This is the removal of a combination of the above materials, such as where it is difficult to distinguish between the materials encountered.
- **Excavation purpose:** Excavation can also be classified according to the purpose of the work:
- **Cut and fill excavation:** This is the process of excavation whereby the material that is cut or stripped. The removed topsoil and earth can be used as fill for embankments, elevated sections, and so on. It can also be used to form a level surface on which to build, as elevated sections of the site are 'cut' and moved to 'fill' lower sections of the site.
- **Trench excavation:** A trench is an excavation in which the length greatly exceeds the depth. Shallow trenches are usually considered to be less than 6 m deep, and deep trenches greater than 6 m. Trench, or footing, excavation is typically used to form strip foundations, buried services, and so on.

The choice of technique and plant for excavating, supporting and backfilling the trench depends on factors such as; the purpose of the trench, the ground conditions, the trench location, the number of obstructions, and so on.

The common techniques that are used include:

- Full depth, full length: Suitable for long narrow trenches of shallow depth, such as pipelines and sewers.
- Full depth, successive stages: Suitable for deep trenches where works can progress in sequence, reducing the risk of collapse.
- Stage depth, successive stages: Suitable for very deep trenches in confined areas, deep foundations and underpinning.
- Basement excavation: A basement is part of a building that is either partially or completely below ground level.
- Road excavation: This typically involves stripping topsoil and cut-and-fill.
- Bridge excavation: This typically involves the removal of material for the footing and abutments of bridges.
- Dredging: Dredging is the process of excavating and removing sediments and debris from below water level, typically from the bottom of lakes, rivers, harbors, and so on.
- Over excavation: Excavation that goes beyond the depth which is required for the formation of a below ground structure due to the presence of unsuitable material that must be removed.

4.5 Safety requirements

Trenching and Excavation Safety: Protective Systems

As with soil types, there are also different protective systems. Sometimes, the system is established in the way the actual trench is dug out and shaped. Other times, extra equipment and support are required. The most common types of protective systems include sloping, shoring, and shielding.General Safe Excavation Practices:

- Heavy equipment, tools, loads, and other materials should be kept away from trench edges.
- Surcharge loads must be kept at least 2 feet from trench edges.

- Underground utilities should be designated, properly marked, and understood by workers.
- Hard hats must be worn at all times in every trench and excavation work zone.
- Barricade materials such as fencing and tape should be used to keep unauthorized persons from walking near the excavation site.
- Mark and locate utilities: Employers must ensure all gas, electrical and other services are located and marked in and near the area to be excavated.
- Adjacent structures: Constructors must prevent damage to adjacent structures by engaging a professional engineer who must specify in writing the precautions to be taken.
- Soil strength: Determine the soil type to protect excavation walls from collapsing.
- Wall stability: Strip the wall of a trench or excavation of any loose rock or other material, including ice, that may slide, roll or fall on a worker.
- Equipment: Keep heavy equipment, excavated soil or rock and construction material at least one meter away from the upper edges of the trench or excavation.
- Work space: Maintain a clear work space of at least 18 inches between the wall of an excavation and any formwork, masonry or similar wall.
- Fall protection: Provide a barrier at least 1.1 meters high at the topifan excavation does not meet regulatory slope requirement and ismore than2.4 meters deep.
- Protect yourself: Never enter a trench deeper than 1.2 meters unless the walls are sound, made of solid rock, properly sloped, shored or protected by a trench box. Never work alone in a trench.
- Protective systems: Workers must be protected against trench or excavation cave-ins and other hazards using three basic methods:
  - ✓ Sloping which involves cutting back trench walls at an angle, inclined away from the excavation.

- ✓ Shoring which helps support trench and excavation walls to prevent movement of soil, underground utilities, roadways and foundations. Timber and hydraulic systems are the most commonly used supports to shore up walls.

- Prefabricated support systems which can prevent soil cave-ins.
- "Competent person": Trenches and excavations must be inspected daily for hazards, and when conditions change,beforeworkers enter them. This must be done by a "competent person".
- Entry and exit:Provide safe access and egress for workers at excavations by means of ladders, steps, ramps, or other safe methods of entering or exiting. Trenches must have ladders placed in the area protected by the support system and be accessible in the event of a collapse.

Self-check 4	Written test

I. Choose the best answer.

1. Which one is hand tool?
   a. Shovel b. excavator c. pump d. all
2. Selection criteria for earthwork equipment
   a. Quantities of material to be moved
   b. The available time to complete the work the job conditions
   c. The prevailing soil types, the swell and compaction factors
   d. All
3. ____ the removal of the exposed layer of the earth's surface.
   a. Topsoil excavation
   b. Earth excavation
   c. Rock excavation
   d. All
4. ____ an excavation in which the length greatly exceeds the depth.
   a. Trench b. excavation c. ditch d. All
5. ____ which involves cutting back trench walls at an angle, inclined away from the excavation.
   a. Shoring b. Sloping c. Prefabricated support systems d. all

II. Short Answer Questions

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page:

1. Based on this lesson what is the function of excavation.
2. List types of hand tools used for excavation purpose.
3. List criteria for selecting excavation equipments.
4. Briefly describe common methods of excavation based on the material being excavated.
5. Explain excavation safety requirements.

Note: Each question carries 2 points: Satisfactory rating - 18 points: Unsatisfactory - below 9 points

You can ask your teacher for the copy of the correct answers.

Answer Sheet

Score = _____

Rating: _____

Name: _____ **Date:** _____

I. Choose answer

1. ___ **2.** ____ **3.** ____ **4.** _____ **5.** _____

II. Short Answer Questions

1._____

2._____

3._____

4. _____

5._____

Information sheet - 5	Selecting, using and fitting of Personal protective equipment

5.1 Introduction

PPE is required to reduce employees' exposuresto hazards when engineering or administrativecontrols are not feasible or effective in reducingthese exposures to acceptable levels. Employersmust determine all exposures to hazards in theirworkplaces and determine if workers should usePPE for protection.If using PPE to reduce employee exposure to hazards, start and maintain a PPE program including:

- Methods to identify and evaluate workplacehazards and determine if issuing PPE is an appropriate control measure;
- Plan development to select, maintain andevaluate its use;
- Training of employees using the PPE;
- Program vigilance to determine its effectiveness in preventing employee injury or illness.

We recommend the following guidelines for PPE use:

- Wear hard hats for protection from falling orflying objects.
- Maintain work shoes in good condition forsolid and secure footing;
- Wear a warning vest in traffic areas;
- Use proper eye and face protection when you have exposer.
- Wear gloves when there is danger of burns,abrasions, cuts or lacerations.
- Wear respirators approved by the NationalInstitute for Occupational Safety & Healthwhere and when job hazards make them necessary.
- Wear rubber boots, gloves and aprons whenexposed or in contact with raw sewage ofwastewater systems. Provide sanitary washing facilities for cleanup.

5.2 Personal protective equipment

The term 'personal protective equipment' (PPE) refers to a vast group of products (e.g. safety helmets, safety footwear and harnesses, eye protection, gloves, high-visibility

clothing, etc.) designed with the aim to protect users against low-, medium- and high-level hazards.

There are eight types of personal protective equipment critical for the defense of users against hazards.

I. Head protection

Wearing PPE for head protection will help you avoid any harm that may come to you from falling materials or swinging objects.

Examples of head protection equipment:

- Helmets;
- Hard hats;
- Bump Caps;
- Guards;
- Accessories.

Figure 13: Hardhats

II. Hand protection

The hand protection equipment can ensure protection against heat, cold, vibrations, burns, cuts by sharp objects, bacteriological risks and chemical contamination.

Examples of hand protection equipment:

- Work gloves and gauntlets;

- Wrist cuff arm nets.

Activities requiring hand protection equipment:

- Construction and outdoor work;
- Working with vibrating apparatus;
- Working in hot or cold environments;
- Working with chemicals and hazardous elements;
- Manual handling of abrasive or sharp objects.

Figure 14: hand protection

III. Eye and face protection

Numbers are scary! Every day, 600+ workers worldwide suffer from eye injuries. Such injuries can be avoided simply by wearing the proper eye and face protection equipment.

As examples of such PPE can be mentioned the following ones:

- Safety glasses and goggles;
- Eye and face shields;
- Eyewear accessories;
- Over specs;
    - Visors.

Figure 15: Eye protection

You are encouraged and advised to wear eye and face protection equipment when:

- Working with lasers or power-driven tools;
- Using gas or vapour under pressure;
- Performing welding operations;
- Handling hazardous substances

IV. Respiratory protection

The respiratory protection covers a broad group of PPE: breathing apparatus, full face or half mask respirators, powered respirators, protective hoods, disposal face masks, detectors, monitors, etc. Adequate training on how users should use the equipment is always required.This type of PPE must be present when being in contact with large amounts of gases, powders, dust and vapors.


Figure 16: Face masks

V. Foot protection

The foot protection equipment is designed to protect the feet and legs against various hazards, such as extreme temperatures, crushing, piercing, slipping, cutting, chemicals and electricity. It is typically required when users are involved in construction activities, working in very cold or hot environments, working with chemicals and forestry, or when manually handling heavy objects.


Figure 17: Safety shoes

As examples of foot protection equipment can be pointed out the following ones:

- Safety boots and shoes;
- Anti-static and conductive footwear.

VII. Height and access protection

This type is highly specialized, and it usually requires users to undergo thorough training before they are allowed to use it. The height and access protection equipment must be inspected periodically by a competent person to ensure it is still fit for use and the health and safety of users is not threatened in any way.

Figure 18: Fall-arrests

As examples of height and access protection equipment can be mentioned the following ones:

- Fall-arrest systems;
- Body harnesses;
- Lowering harnesses;
- Rescue lifting;
- Energy absorbers, and others.

Self-check 5	Written Test

I. Choose the best answer.

1. _____a product with the aim to protect users against low-, medium- and high-level hazards.

   a. PPE b. chemicals c. protection d. all

2. Which one of the following is head protection.

   a. Helmets b. Guards c. Hard hats d. All

3. Which activities requiring hand protection equipment.

   a. Construction and outdoor work.
   b. Working with vibrating apparatus.
   c. Working in hot or cold environments
   d. All

4. Which of the following is eye and face protection.

   a. Visors
   b. Safety glasses and goggles
   c. Eye and face shields
   d. All

II. Short Answer Questions

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page:

1. What is the purpose of PPE?
2. List and describe major PPE types.
3. List the PPE application procedures.

Note: Each question carries 4 points: Satisfactory rating - 28 points: Unsatisfactory - below 14 points

You can ask your teacher for the copy of the correct answers.

Answer Sheet

Score = _____

Rating: _____

Name: _____ **Date:** _____

Choose answer

1. ___ **2.** ____ **3.** ____ **4.** ____ **5.** _____

Short Answer Questions

1._____

2._____

3._____

Operation Sheet 1	Making appropriate drainage and inflow diversion arrangement.

Tools and Equipment's

- Design document
- Shovel, hoe, spade, Rake, pick axe, meter
- Excavator (based on the size of excavation site)

Procedures

1. Get relevant data of work site including discharge rate of irrigation canal.
2. Select the feasible diversion type based on the site condition.
3. Design diversion work based on the inflow capacity.
4. setting out work
5. Finalize excavation and soil removal.
6. Make safe access and egress arrangements for personnel and equipment
7. Provide facility for safe disposal of unexpected excess water.
8. Prepare routine maintenance plan.

LAP Test 1	Practical Demonstration

Name: _____ **Date:** _____

Time started: _____ **Time finished** _____

Instructions: Given the necessary materials you are required to perform the following tasks within 3 hour.

1. Making appropriate drainage and inflow diversion arrangement(3hr)

InstructionSheet	Learning Guide- 57: Maintain irrigation channels, drainage assets and associated fittings.

This learning guide is developed to provide you the necessary information regarding the following content coverage and topics:

- Routine inspections of asset condition and operational capacity
- Conducting routine inspection of work area
- Identifying and correcting System faults
- Identifying, selecting, placing and joining components of drainage system
- Prefabricated drain sections
- Construction of in situ Cast components
- Removing of Debris, silt and obstructions
- Performing preventative maintenance program

This guide will also assist you to attain the learning outcome stated in the previous page. Specifically, upon completion of this Learning Guide, you will be able to –

- Routine inspections of asset condition and operational capacity
- Conducting routine inspection of work area
- Identifying and correcting System faults
- Identifying, selecting, placing and joining components of drainage system
- Prefabricated drain sections
- Construction of in situ Cast components
- Removing of debris, silt and obstructions
- Performing preventative maintenance program

Learning Instructions:

1. Read the specific objectives of this Learning Guide.
2. Follow the instructions described below 3 to 4.
3. Read the information written in the information “Sheet 1, Sheet 2, Sheet 3 and Sheet 4”inpage 49, 59, 63 and 82, 92respectively.
4. Accomplish the “Self-check 1, Self-check 2, Self-check 3 and Self- check 4” -” in page 57, 62, 80 and 91, 95 respectively
5. If you accomplish the self-checks, do operation sheet in page 96 and 97
6. LAP Test in page 99

Information sheet – 1	Routine inspections of asset condition

1.1 Introduction

Surface irrigation schemes typically include a large number of relatively low-cost assets, of several different types and functions, spread over a large area. The fitness of an asset to perform its function is assessed by field inspection. However, the assessment method has been adapted for use by relatively unskilled staff (overseers). Since some problems require experienced engineering judgment, a two-stage procedure has been adopted. In the first stage, condition is assessed by relatively unskilled staff using standard forms. Components which are rated Poor or Very Poor may require a second-stage investigation by engineering staff.

1.2 Assessing the Condition of assets

This section describes procedures for determining the condition of infrastructure, condition being judged in terms of hydraulic effectiveness and structural integrity. The final output of the Procedure defines priorities for work. Selected items can be detailed and costed. Structures of principal importance such as diversion weirs, dams and impounding embankments require formal inspections by experienced engineers. Standard engineering inspection preformas have not been included in the Procedure, but could be prepared by the user, if required.

Table 1: Basic structure types for condition assessment

Basic structure types for condition assessment:

- Intake
- Gated cross regulator/check
- Gated offtake/ Head regulator
- Drop/chute
- Cross drainage culvert
- Aqueduct/flume
- Syphon
- Flow measurement structure
- Canal reach
- Drain
- Inspection road
- Side weir/escape

It is also clearly essential to regularly inspect structures such as diversion weirs, barrages and embankment dams. However, it is felt that inspections of such structures require experienced engineering judgment based on an Engineer's inspection.

An asset may fail to perform its intended hydraulic functions whilst still structurally sound. It may also fail structurally, with some associated hazard. The scoring is intended to reflect the fitness of the asset for its function.

A general question "Does the overall condition concern you?" is included on all assessment forms. It is intended to allow an overseer to highlight a concern which may not be explicitly covered in the YES/NO question format. It allows for the following situations:

1.3 Engineer's inspection

An Engineer's inspection should be undertaken if the overseer responds positively to the question "Does the overall condition concern you?" or where the engineer believes there is a problem. Engineer's Inspection:

- To confirm the overseer's assessment.
- To identify underlying causes of observed deterioration.
- To estimate progression of actual or potential problems
- To define and plan necessary rehabilitation actions.
- To define requirements for site surveys/investigations.

The inspection should result in an overall classification based on the condition of the worst element. Inspection forms specific to particular structures, such as barrages, diversion weirs and dams, incorporating questions designed to determine the fitness of elements for their function, can be drawn up by individual users.

1.4 Selecting priorities

Once an inventory of asset condition is prepared, the priority of works is based on the benefit actually, or potentially, foregone.

1.4.1 System operation

Information will be obtained from discussions with operations staff, from the observation of structures and water levels in the field, from review of operations manuals, and review of original design criteria and assumptions, where these are available. To assess the impact of scheme operation on cropping intensity and/or yields, and identify what variations exist between intended and actual practice, the flow control methods and water delivery pattern for which the scheme was originally design, must be defined.Ask staff to describe actual operational practices. Consider:

- Is rotational supply implemented?
- How frequently are settings changed?
- Which structures are monitored and adjusted?
- Are water levels maintained at design level?

1.4.2 Inappropriate design

Are there areas of land within the scheme area that are out of command or receive inadequate water due to insufficient or badly sited off-takes, or poor canal alignment? Has incorrect or inappropriate design of any structure, canal reach or drain resulted in insufficient conveyance capacity or the failure of the structure to function as required?

Check the following factors:

- Canal embankment slopes too steep
- Insufficient cross drainage
- Insufficient escape capacity
- High losses in distribution or field systems

1.4.3 Deterioration of System Infrastructure

Detailed information on deterioration of infrastructure, and its likely impact on hydraulic performance, will be obtained using the condition assessment procedure. Early, discussions with operations staff can indicate the location of problems arising from structural deterioration. Information obtained in this way should be cross-checked through the condition assessment procedure and localized studies of hydraulic

performance, where these are required. Does the condition of any component of the irrigation or drainage networks restrict conveyance capacity, threaten structural stability or otherwise lead to reduced water supply or flooding?

A drainage plan indicates the location and layout of lateral and main drains, outfalls, surface water inlets and other structures in the field. It is a very important document to use for future maintenance. Keep this document with the property deed, so that even if the property ownership changes, the drainage information are kept with the farm.

A good drainage plan includes the following:

- Date of construction
- Name of installer (i.e., contractor or landowner)
- Identification of any changes made during installation from the original plan
- Lateral spacing, size, depth, grade, footage and material
- Main location, material, size, depth, grade and capacity
- Details of any construction problems encountered during the installation
- Location of all outfalls, surface water inlets and other structures
- Location of utilities, sand pockets, springs, etc., that may affect future maintenance

The contractor should provide a copy of the plan of the drainage system to the landowner following the completion of the job. If a formal plan has not been provided by the contractor or if the landowner does the installation, a simple pencil sketch that provides the same information is acceptable. In the absence of a proper plan, obtain an aerial photograph of the work area, similar to that shown in figure below, to show the drainage system.

Figure 19: Drainage System layout

Using the drainage plan as a guide, locate, inspect and mark all outfalls and surface water inlets for reference when spreading nutrients on the property and for future maintenance. Use a durable, permanent marker that is highly visible above crops and tall grass. Ensure the workmanship of the system is good, as there will be limited time to access the warranty period provided by the contractor, typically one year following installation.

Confirm that all surface water inlets are fitted with a proper guard or grate to keep debris and trash out of the subsurface drainage system. Ensure that a grate or rodent guard is installed on all outfall pipes to prevent unwanted entry by burrowing animals such as rodents, muskrats, rabbits and foxes. Check for burrowing animal activity around the outfalls; if any signs exist, arrange to have the animals legally removed.

Figure 20: Drainage outlet

The water that discharges from the outfall can cause erosion in the receiving drainage channel or natural watercourse. Check to see if the contractor has installed sufficient erosion protection to prevent this from happening.

Figure 21: Drainage outlet

It is important that the drainage system is periodically inspected and maintained over its life span. The ideal time to inspect the system is in the spring, late fall and after a significant rainfall event – when the soil is wet and the drains are running.

Prompt repair of any noted issues will ensure that the system is always in good working order and will prevent a more serious issue from developing.
Remember to make records of any maintenance/repairs and changes to the system on the drainage plan. This will ensure that there is always an accurate plan of the system for future inspection and maintenance.

Check for any signs of erosion of the drainpipe trench following rain events, especially in the first few years. Inspect the mains and laterals a couple of days after a heavy rainfall to look for any signs of ponding or excessive wet spots in your field. This may indicate that a blocked drain exists and will need to be repaired.

Uniformity of crop growth is another good indicator of a properly functioning drainage system. Ideally, the field should dry evenly and produce similar yields. Watch for changes in crop yield in different areas of the field annually to see if there is a slower developing problem in the drainage system that may need repair. Take periodic aerial photographs of the farm to get an overview of the drainage system and to identify potential drainage problems.

When drains get plugged, water rises to the surface at the point of the water stoppage. Dig up the drain at the wet spot and repair it. Mark any locations of concern and contact a licensed contractor to complete the repair as soon as reasonably possible. If the fields are wet, it may be better to wait for drier conditions to make the repairs to avoid damaging the soil structure.

Figure 22: Broken Drainage pipe

Self-check 1	Written Test

I. Choose the best answer

1. Which one of the following is engineer's inspection
   a. Confirming the overseer's assessment
   b. Identifying underlying causes of observed deterioration
   c. estimating progression of actual or potential problems
   d. All
2. Which of the following is a point used to identify wrong design of a system.
   a. Insufficient cross drainage
   b. Canal embankment slopes are slightly steep.
   c. sufficient escape capacity
   d. No losses in distribution

3.. ____indicates the location and layout of lateral and main drains, outfalls, surface water inlets and other structures in the field.

a. Drainage plan b. irrigation plan c. laterals d. all

4. Which is basic structure needs routine inspection

a. Drain b. syphon c. canal reaches d. all

II. Short Answer Questions

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page:

1. What the difference between overseer's inspection and engineer's inspection?
2. List basic irrigation structures need routine inspection.
3. List factors considered operational efficiency of irrigation system.
4. What is the benefit of work plan on inspection work.

Note: Each question carries 3 points: Satisfactory rating - 6points: Unsatisfactory - below 6 points

You can ask your teacher for the copy of the correct answers.

Answer Sheet

Score = _____

Rating: _____

Name: _____ **Date:** _____

Choose answer

1.. ___ **2..** ___ **3..** ____ **4..** ____

Short Answer Questions

1._____

2._____

3._____

4. _____

Information sheet – 2	Conducting routine inspection of work site

2.1 Introduction

Construction projects involve the co-ordination of a great number of people, materials and components. Regular inspection is a crucial part of ensuring that the works progress as intended, both in terms of quality and compliance. Inspections will be carried out for a number of different purposes throughout the duration of a project.

The inspection process is separate from the contractor's own supervision of the works. Inspection is carried out purely to give an independent view of the works either for the client or a third party, the term supervision might imply taking some responsibility for the works, when in fact contractual responsibility lies with the contractor.

2.2 Quality and progress

Inspection ofthe maintenanceworks will be carried out as they proceed toverifycompliancewith the requirements of thecontract documents. Site inspectors(orclerks of works) may be provided as an additionalserviceby the existingconsultant team, or could be newappointments.They may be basedon sitepermanently or may make regular visits. Specialistinspectionsmay also be necessary for specific aspects of theprojectsuch as; theclient'senvironmental policy,site waste management plan,accessibility, and so on.

Site inspectorsprovide an independent assessment of theworksand will generallyreportto thecontract administrator. They are likely to keep asitediary, attendconstruction progress meetingsand to produce regular writtenreports. They had limitedpowerother than to inspect; they could condemn work

Site inspector

Specificinspectionsmay also be carried out during theconstruction phaseas part of the generalcontract administrationprocess:

- Condition surveysof neighboringstructuresprior tocommencementof theworks.

- Regularvaluationinspectionsto assessprogressof theworksin order tovalueinterm payments.
- Witnessingcommissioning.
- Inspection prior tocertificationofpractical completion.
- Inspectionafterhandoverof thesiteto theclient on certificationofpractical completion.
- Inspection the end of thedefects liability periodto prepare a schedule.
- Inspectiononcompletionof therecitificationofdefectsset out on theschedule of defects.

consultants generally have a responsibility to provide periodicinspectionunder the terms of theirconditionsof engagement.

2.3 Health and safety

Inspections are also necessary to ensurecompliancewithhealth and safety. These can be internalinspectionscurried out by thecontractor,third partyaudits or externalinspectionsby theHealth and Safety executive.

Health and safety inspectionsmay be necessary in relation to:

- Prevention of falls andpersonal fall protection systems.
- Work at height.
- Workplatforms such asscaffoldand mobile platforms.
- Laddersand stepladders.
- Personal protectionequipment, including head protection.
- Plant, vehicles and otherequipment.
- Storage.
- Siteconditionsand order.
- Avoidance of obstructions.
- Prevention of unauthorizedaccess to thesite.

It is important thatinspectiontiming and frequency is properly organized, that properreportsare prepared and that action is taken if necessary.

Inspectionreportsmight contain the following information:

- Details of the person making the report.

- Details of the person theinspectionwas carried out for.
- Location ofthe inspection.
- Date and time of the inspection.
- Description of the nature of the inspection.
- Detailsofhealth and safetyrisksidentified.
- Detailsof any action taken.
- Detailsof any further action required.

Self-check 2	**Written Test**

Short Answer Questions

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page:

1. Briefly describe the inspection of the maintenance works.
2. List components of inspection reports.
3. List the concerning areas of health and safety inspection.

Note: Each question carries 4 points: Satisfactory rating - 12 points: Unsatisfactory - below 6 points

You can ask your teacher for the copy of the correct answers.

Answer Sheet

Score = _____

Rating: _____

Name: _____ **Date:** _____

Short Answer Questions

1._____

2._____

3._____

Information sheet – 3	**Identifying and correcting System faults**

3.1 Introduction

The functioning of an irrigation canal network depends not only on how the network is operated, but also on the condition of the canals and on the condition of the hydraulic structures. If no attention is paid to the canal system, plants may grow and the problem of siltation may arise. Plant growth and sedimentation not only impede the flow in a canal, they also diminish the area of the cross-section. A reduction in the capacity may result in overtopping and a limit on water supply to the fields.

Figure 22 [a]: Operating canal Figure 22 [b]: Damaged canal

3.2 Common problems in structures

The main problems, which in many cases result from incorrect operation and lack of proper maintenance, that affect the proper functioning of hydraulic structures can be summarized as:

- leakage,
- erosion,
- siltation, and
- rot and rust (corrosion).

Problems such as the disappearance of movable parts from structures or vandalism and demolition are difficult to prevent, but they can be minimized by involving farmers in canal operation and maintenance, and by cultivating the sentiment that structures are a communal resource and therefore proper maintenance is a responsibility of the community.

Leakage and erosion can be the result of poor design or construction, such as:

- Walls may be too thin,
- Foundations of structures may be too weak,
- Materials used, such as the blocks from which a structure is made, may not be strong enough for the purpose,
- The concrete mix used in constructions may be too sandy,
- Back-fill may not have been compacted sufficiently, or
- The structure may not be properly connected to the canal.

The most common problems seen in structures are leakage, erosion, siltation, rot and rust.

- **Leakage:** The water level upstream of a structure is higher than the downstream water level. Therefore, water may search for another way underneath or along the structure, or even through a crack in the bottom or sides of the structure to this lower level. The moment that water has found a small path there is a leakage problem, and at the same time the beginning of an erosion problem. Leaking water will enlarge the path by washing out the soil and so the leakage will increase. Finally, the structure will collapse if the process is not stopped.

  The upstream water level is so high that water can flow along the dam. If no action is taken to remedy this the structure can be undermined by erosion and will collapse.

  To avoid such a problem, the structure can be equipped with vertical cut-offs. They hinder the water flow along and underneath the structure. The cut-offs are

part of a structure and can be driven into the bed and the embankments of a canal.The intake structure is provided with cut-offs. They are dug deep into the canal banks and into the canal bed. The drop structure is also equipped with cut-offs. After installation, the earth of the canal banks around the cut-offs should be well compacted.

- **Erosion:** Sections of an unlined canal immediately downstream of a structure or downstream of a lined canal section often suffer from erosion. Downstream of a structure the canal bed may suffer from a water jet that flows through a gate or pipe, or it will be caved in by water that spills over a weir. In both situations a stilling basin is needed to dissipate the energy of the incoming water. The basin should be constructed immediately downstream of the weir or pipe. It is usually part of the structure.The transition from a lined section of a canal to an unlined section is also a risk zone. If no care is taken, the lining will be undermined and will finally collapse.

- **Siltation**: The deposition of soil and debris can affect the functioning of a structure. If, for instance, a stilling basin collects soil deposits the available water mass diminishes and energy dissipation will be less effective. Similarly, in the case of soil deposits in a flow division box, the division of the flow will be less accurate due to changes in flow velocities and water levels.The same applies for intake structures, such as the pumping station. Large volumes of sand in the intake chamber of the pumps causes damage to the pumps and will lead to sand deposits in the canal system too. Siltation is difficult to avoid.

Depending on the local conditions, large sand traps could be constructed at the upper end of the main canal.

Figure 24 [a]: Operating canal Figure 24 [b]: Silted canal

- **Rot and rust:** Wooden and steel parts in structures suffer from being alternately wet and dry. The wooden parts will rot and disintegrate, while steel parts will rust, expand and get jammed in the slides. All such corrosion affects in a negative way the operation of the structures. Routine maintenance is necessary to avoid these problems, or to reduce their effect to a minimum.

3.3 Main problems in a canal network

The main problems that can be found in an irrigation canal network include:

- Limited amounts of water available at the water source;
- Illegal manipulation of canals and structures;
- Siltation;
- Plant growth;
- Water losses;
- Frequent overtopping; and
- Low water levels due to canal erosion.

Bad design or bad construction may also be the cause of sub-optimal functioning of a scheme. A canal may be too small to supply enough water to irrigate the area served by the canal, and if the discharge needed is supplied to such a canal, it will be

excessive and water will overtop. Also the water level in a canal may have been wrongly determined, and if it is too low water may not enter the fields by gravity. Check structures or even pumps will then be needed to supply the fields with sufficient water.
If the minimum required free board levels are not respected, canals can easily overtop in emergencies. Canal slopes which are too steep may suffer erosion from high flow velocities. When construction materials are not well chosen, canals may collapse. Lack of maintenance of the canal network will also cause severe problems.

Three of the problems mentioned above, and which are of a technical character, are described below in detail: water losses; overtopping; and canal erosion.

3.3.1 Water losses

A well designed and constructed canal system transports water from the source to the farmers' fields with a minimum amount of water loss. However, water losses will occur and can seriously reduce the efficiency of water delivery. Water may be lost by seepage, leakage, or both.

Seepage: Water that seeps through the bed and sides of a canal will be lost for irrigation. This so-called 'seepage loss' can be significant where a canal is constructed from material which has a high permeability.
Seepage can be reduced by:

- reinforcing the canal bank or
- sealing or lining the canal bed and sides.

Leakage: Water may also be lost for irrigation by leakage. This water does not seep, but flows through larger openings in the canal bed or sides.
Leaks can develop in several ways:

- by rat or termite holes in a canal bed or sides;
- eroded and washed canal bank;
- small tunnels started by seepage water in a badly compacted or sandy section of a canal bank;

- seepage around structures, leading to severe leakages;
- gates which are not tightly sealed;
- cracked concrete canal linings, or joints that are not tightly sealed; or
- torn asphalt or plastic lining.

Leakage often starts on a small scale, but the moment that water has found a way through a canal embankment a hole will develop through which water will leak. If the leakage is not stopped in time, the tunnel becomes larger and the canal bank may be washed away at a certain moment.

In the case of a lined canal, the canal foundation may be undermined after some time and the canal will collapse. Serious leakage can be avoided when the canal system is inspected frequently and when repairs are carried out immediately. The longer a hole or crack is left, the larger it will become.

3.3.2 Overtopping

Water in a canal may rise unexpectedly due to several reasons:

- The incoming flow through the canal off take may be much greater than the canal capacity;
- Obstacles such as stones, blocks or plant growth in the canal may dam up the water
- Outlets from a canal may be closed which should be open;
- rain or other water may be draining into the irrigation canal; or

Overtopping causes erosion of the canal banks and may lead to serious breaches. It can be avoided by improving the operation of the system.

To prevent overtopping, which can happen even in the best irrigation systems, a spillway - also called an emergency outlet - can be installed in the canal bank so that excess flow can be spilled without harming the canal.

3.3.3 Canal erosion

The sides and bed of an unlined canal are sometimes badly attacked by scouring water. This process is called erosion. Canal bends and sections downstream of structures in

particular are susceptible to erosion, since local flow velocities can be very high and the direction of flow changes suddenly, causing turbulence.

The embankments have collapsed and the cross-section no longer has its original shape: it has become irregular. The canal banks have become smaller and the bed is wider than before. When the embankments of a canal are not very solid, erosion can result in leakage. Another problem is that the eroded soil will be deposited, known as siltation, in structures downstream of the eroded canal section. This may cause a malfunctioning of the structures and causing the flow to overtop the bank. Erosion by water can be prevented by:

- Reducing the flow velocity, and
- Making the inner canal banks more stable,
- Lining may be a solution.

Wetting and drying of the earth embankments may also cause the banks to crack. Cracks can become small gullies through the process of erosion.

3.4 Maintenance work of irrigation structures

A properly designed and constructed hydraulic structure functions well for as long as it is operated well and maintained with care. That means that there is neither leakage nor erosion, that the channels and structures are clean, and that there are no rusty or rotten movable parts in the structures.

To achieve such a situation, regular maintenance is required, and even if maintenance is well carried out, repairs may be needed after some time.

Minor problems in structures, like a leakage or rusty iron parts, may become important if they are neglected. Frequent inspections and regular maintenance will help limit any damage.

3.4.1 Inspection

A canal system, and in particular the structures, can be safeguarded from problems such as leakage, erosion, siltation, rot and rust by regular inspection and immediate repair action. Since the canals are inspected regularly, structures can be inspected at the same time. This makes it possible quickly to spot the beginning of leakage, erosion or rust. A quickly executed repair will stop the problem while it is still a small one, and before it escalates into serious damage. Inaccessible structures and lots of plant growing on the canal embankments make inspection time-consuming, and it will also be difficult to see water leaking if the walls of a structure are hidden from view.

3.4.2 Maintenance

Maintenance of structures consists of two main activities:

- Cleaning and de-silting, and
- Painting and lubricating.

Cleaning and de-silting: Sand deposits and plant growth can cause changes in flow velocity through structures, and so the functioning of the structure will be less effective. Removal of sand deposits and other obstacles such as stones and plants should be carried out frequently. Plant growth should also be removed from the outside of structures. This is necessary to allow quick inspection.

Paintingandlubrication:Structures are alternately wet or dry, and this causes rot in wooden parts and rust to form on iron parts. Frequent painting preserves these parts from rot or rust. To prevent movable iron parts like sluice gates and valves from being jammed, regular lubrication is essential.

A crack in a wall or in the floor of a structure and through which water leaks must be repaired as soon as it is observed. Such a repair on a check structure constructed of blocks is described here.

- Clean the wall or the floor round the crack. Remove any sand, clay and plant growth.
- Make the crack larger and deeper.

- Fill the hole with a cement-sand mortar and smooth with a trowel.

It happens often that the bed and banks of a canal immediately downstream of a structure, or downstream of a lined canal section, are undercut by the erosive force of the water flow and cave in. If such an erosion process is allowed to continue the structure or canal lining will be undermined and finally it will collapse. Undermining can be avoided by the construction of a screen or cut-off. The cutoff protects the foundation of the structure.

A procedure for the repair of an undermined structure and the construction of a screen is given opposite.

- Excavate a trench in the eroded canal bed and sides. The trench should be at least 0.20 m deeper than the eroded bed.
- Refill the hole under the lining with earth, and compact.
- Erect a concrete or masonry screen in the canal bed and in the banks of the canal, and connect it correctly to the lining of the canal or structure.
- Refill the rest of the hole and firmly compact the backfill.

3.5 Maintenance and repair works canals

A good maintenance programme can prolong the life of canals. A routine, thorough programme should be kept to.

It consists of cleaning, weeding, desilting, re-shaping, and executing minor repairs.

- Bushes or trees on canal embankments should be removed. They may obstruct the water flow and their roots will open the compacted soil in the banks and cause the development of leakages.
- Plants, silt and debris in the canal should be removed. While cleaning the canal bed, care must be taken that the original shape of the cross-section is kept. For this, a wooden frame, or template, with the exact dimensions of the designed cross-section of the canal being cleaned, can be of great help.

- Breaches and rat holes in the embankments should be filled with compacted soil, inside as well as outside of the embankment. For compacting, the soil should be wetted.
- Weak sections and sections of canal embankments where people or animals cross the canal should be strengthened with compacted soil or with bricks.
- Eroded sections of a canal should be rebuilt to the original shape. For maintenance operations it is important to organize farmers and to involve them in the activities.

Figure 25: Maintenance of canal

Reduction of Seepage Losses

Parts of a canal bank or the entire bank can be highly permeable to water. Water that seeps through the banks will be lost for irrigation and may create waterlogging in the fields and roads adjacent to the canal. There are two ways to overcome seepage problems, either

- Reduce the permeability of the canal bank, or
- Line the canal.

Repair of a leak: Most irrigation canals will leak. A hole or a crack in the bank of a canal, through which water is leaking, is easily observed since the fields adjacent to the leaking canal will be wet. Leaks should be repaired immediately after they have been observed. The procedure for repairing a leak is:

- Empty the canal and indicate the location of leakage with pegs. They are placed at its entrance in the canal bed and at its exit in the outer bank.
- Remove the vegetation and keep it apart. Excavate the canal bank to well below and besides the leak. The canal bank which leaks is excavated in steps, with the smallest step well below the leak.
- Rebuild the canal bank by filling the bank in layers with moist soil, and compact each layer well.

For lined canals, the same procedure as above can be followed but with one difference: before the bank is excavated, part of the canal lining should be removed. After filling and compacting the earth bank, the lining should be reconstructed.

Canal repair: An eroded canal or canal embankment needs at some time to be reshaped. First the repair of an eroded canal is described, and second the repair of gullies and cracks in an eroded canal embankment. Reshaping an eroded cross-section.

The reshaping and widening of an eroded cross-section involves the following steps:

- Construct a wooden template. If the original side slopes had been constructed too steeply and thus were unstable, make the template so that the new side slopes are flatter. The top width of the canal is then larger while the bed width remains the same. Care must be taken to avoid narrowing the original canal bank crest widths.
- Hammer in reference pegs to indicate the original level of the canal banks on each side of the canal. Excavate the bed and sides of the eroded canal section in steps until they reach slightly below the actual bed level so that the new soil to be placed will make better contact with the original ground surface.
- Fill and compact moist soil layer by layer, using the template for final shaping. Each layer to be compacted should not be thicker than 5 to 10 cm.
- Check the cross-section and bank levels with the template and the reference pegs.

Repair of cracks and gullies in a canal embankment The repair of cracks and gullies can be executed as follows:

- Remove any plants from banks which show cracking and in which small gullies have been formed by overtopping water or by heavy rainfall.
- In the case of deep cracks and gullies, excavate the bank partly. Small cracks are to be filled with fine textured soil, moistened and compacted.
- Rebuild the bank by filling in layers and compacting the moist soil.

3.6 Causes of drainage failure

Some farmers suffer from drainage problems not because they have no drains, but because the existing drainage system has collapsed, become blocked, or are otherwise in need of repair and rehabilitation. Many more will find that the nearest convenient point of discharge for a new drainage system is an existing primary drainage pipe or canal that needs attention if it is to function properly.

Collapse and blockage are the principal types of drainage failure. Each of these can have several causes. Collapse of drains can occur through:

- erosion of the bottom and sides of the drain (scouring);
- excessive pressure of water in the ground beneath and beside the drain lining
- vehicles passing over or too close beside the drains; -root growth, especially from nearby trees;
- crown corrosion in closed drains containing sewage.

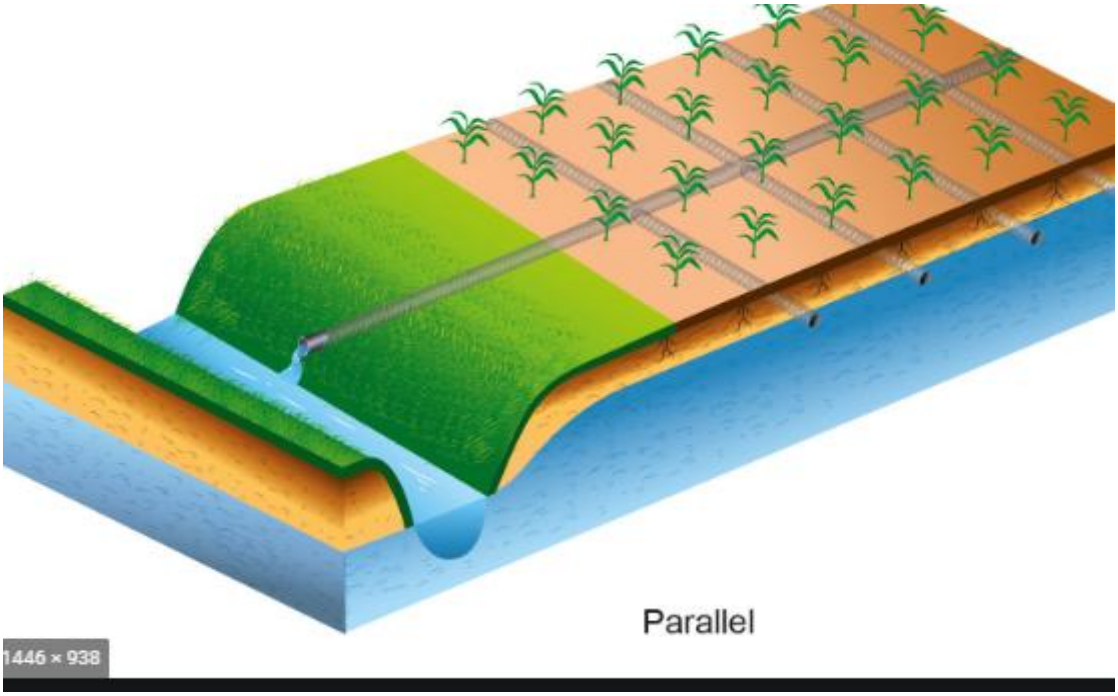

Figure 26: Drainage network

The causes of blockage can be:

- Accumulation of refuse, leaves and earth in the drain;
- Structures such as houses or bridge piers erected in the drain and obstructing the flow;
- Excessive vegetation growing in drainage channels;
- Silt deposited in low sections owing to misalignment or where the slope is insufficient and cleaning is not regular enough.

Drainage systems, particularly in the minor system network, might include pipelines, open channels, natural surface channels and canals.

The major drainage system wouldalmost certainly include open channels and natural watercourses. A subsurface drainage system is a significant financial investment.

There is no better way to protect that investment than with regular and proper inspection and maintenance of the system. Even a well-designed and constructed system, built to last a lifetime, must be carefully maintained.

The five pillars of an effective subsurface drainage system are:

- Quality material – including pipe, envelope/filter (if necessary), fittings, risers, etc.
- Proper design – completed by a licensed drainage contractor or a professional engineer
- Proper installation – completed by a licensed drainage contractor
- Compatible land management practices
- Regular inspection and maintenance

3.7 Maintenance of drainage system

Properly designed and constructed drainage systems require minimal maintenance and repair after the first few years following installation. However, it is important that a new subsurface drainage system be carefully inspected and maintained for the first two or three years.

Any weak spots that have developed in the lateral and main drains and any backfilled areas that have settled can be remedied and filled in. There is some ongoing maintenance to complete every year but this should be minimal for most systems.

If the drainage system becomes blocked with tree roots:

- Reroute the drainage pipe away from the tree.
- Remove and replace the section of blocked drains and remove the tree causing the problem.
- Replace the drain using continuous non-perforated pipe for a distance of 15 m on either side of the tree.

Some commercial crops have roots that grow into drain lines and clog them. Roots from annual crops such as alfalfa, brome grass, rye grass, canola and sugar beets will usually clear themselves when the crop is harvested.

If a problem is encountered:

- Avoid growing the problem crops again.
- Flush the roots from the drain pipe using low-pressure jet cleaning.

- Remove and replace the blocked section with a larger diameter drain pipe.

Silt boxes and catch basins are often installed at critical points in the system. Inspect and clean them out annually. Ensure their covers fit tightly and are free from structural damage. These structures should always remain locked to prevent unwanted access and tampering.

Check for any signs of wash-ins and blow-outs, which can indicate that there is a broken drain pipe, and surface water has entered the drain. At the first sign of the smallest surface hole, repair the damage before too much sediment enters the subsurface drainage system and reduces its hydraulic capacity.

Figure 27: Damaged drainage pipe

Consider these options if the drainage system is filled with sediment and is not functioning properly:

- Renovate subsurface drains that have become filled or partly filled with sediment.
- Dig up, clean and re-lay existing clay or concrete drain pipes. Consider digging and re-laying only where the drainage pipe is not damaged,

carelessly laid with joints having wide gaps or not protected with a cover material to exclude sediment.

- Clean lateral drains through the use of sewer-cleaning rods or flushing if the deposit is only for a short stretch of pipe. Thick deposits over the length of the pipe are difficult to remove.

Cleaning subsurface drains uses the same procedures as cleaning sanitary sewers.

- Holes are dug down to the drain at intervals of 10–25 m, depending upon the size of the drain and the amount of sediment to be removed. A short section of the drain is removed to allow a fabricated steel rod with a hook or corkscrew end, or short-jointed sewer rods, to be inserted into the drain. After the rod has been pulled through the drain several times, clean the drain further with a ball of barbed wire or a chain.
- Flushing the drain is also recommended. To flush and clean a drain, a reasonable supply of water must be available. Special drain-flushing equipment is available, and the success of the procedure depends on the nature of the deposit in the drain. Use a large volume of water for flushing rather than high pressure. There may be regulatory concerns with flushing any sediment into the receiving water body.

Surface Water Inlets: Inspect all surface water inlets twice a year (spring and fall), and ensure that all of the markers are still in place and clearly visible. Re-mark if necessary.

Figure 28: Drainage inlet

Remove any trash, debris or plant material that has accumulated around the inlet to make sure that it functions properly. Check the structural integrity of the riser inlets and repair or replace, if necessary.

Outfalls: Examine end pipes and any erosion control such as riprap aprons for scour and undermining and to confirm that water is not draining from under and/or around the end pipe. Check the end pipe for damage. Remove any trash, debris or plant material that has accumulated around the end pipe to ensure that it continues to function properly. Make any repairs or replace the grate or rodent guard if necessary, to prevent unwanted entry by burrowing animals. Check for any new animal activity around your outfalls. If signs exist, arrange to have the animals legally removed.

Self-check 3	Written Test

I. Choose the best answer

1. Which of the following is the common problem of irrigation structures

   a. Leakage b. erosion c. Siltation d. rot and rust e. all

2. The reason for leakage and erosion of irrigation structures.

   a. Walls may be too thin
   b. The concrete mix used in constructions may be too sandy
   c. Back-fill may not have been compacted sufficiently
   d. All

3. Which of the following is a factor for developing leaks

   a. By rat or termite holes in a canal bed or sides.
   b. Seepage around structures
   c. gates which are not tightly sealed
   d. All

4. Which one of the following is not canal maintenance

   a. Weeding b. desilting c. re-shaping d. none

5. Activity used to avoid overtopping.

   a. Reducing discharge
   b. Increasing velocity
   c. Increasing water volume
   d. all

II. Short Answer Questions

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page:

1. List and describe common problems of irrigation structure.
2. List the common problems of the canal networks.
3. Maintenance of structures consists of two main activities.
4. Write solutions for blocked drainage networks.
5. Briefly describe the maintenance activities of irrigation structures

Note: Each question carries 2 points: Satisfactory rating - 18 points: Unsatisfactory - below 9 points

You can ask your teacher for the copy of the correct answers.

Answer Sheet

Score = _____

Rating: _____

Name: _____ **Date:** _____

Choose the best answer

1..___ 2.._____ 3.._____ 4. ____ 5. ____

Short Answer Questions

1._____

2._____

3._____

4._____

5._____

Information sheet – 4	Identifying, placing and joining drainage components and associated fittings

4.1 Introduction

Subsurface Drain defines as a conduit such as corrugated plastic tubing, tile, or pipe, installed beneath the ground surface to collect and/or convey drainage water. This sub drainage system contains different components like drain mains, laterals, outlets/outfalls, fittings, and pumps. They are briefly described in the next section.

4.2 Identifying drainage components and fittings

4.2.1 Drain pipes

Drain pipes are large pipes that carries away the discharge of excess irrigation water. Clay, concrete and plastic pipes give satisfactory results if they meet quality standards and are properly installed. Collector pipes are made of concrete or plastic. However, perforated corrugated plastic collectors, wrapped with a sheet envelope, may be installed comparatively easily if the surrounding soil consists of quicksand or has other “quick” properties.

4.2.2 Lateral drain pipes

Laterals are the smaller diameter pipes used to collect the water from the area to be drained. These then deliver the drainage water to larger water pipes or main drains.

4.2.3 Outfalls

Outfalls connect the main drain of a subsurface drainage system to an outlet such as a drainage channel or natural watercourse.

Protect the outfall from erosion, undermining, settlement, ice damage, rodents, silting, shifting and damage by machinery and livestock. If possible, use a length of continuous rigid, non-perforated pipe (usually corrugated metal pipe) as an end pipe for the outfall.

4.3 Selecting components of Drainage

In theory, there are valid considerations to select specific types of drainpipe. In practice, selection is mostly based on cost comparison and on local availability. In addition, the following observations may be relevant:

- If all types of pipe are available, the use of corrugated plastic pipes has distinct advantages
- If pipes are not locally available, local manufacture of concrete pipes is the most straightforward and the easiest to implement. It requires less skill than manufacturing other types of pipe, and is already economical on a small scale.
- The manufacturing cost of small diameter pipe (i.e. < 100 mm) is usually of the same order for clay tiles, concrete tiles and plastic. For large diameter pipes, however, concrete is usually the cheapest and plastic the most expensive.

4.3.1 Clay tiles

Clay tile may be either porous or glazed. Pipe sections are abutted against each other and water enters through the joints. Good quality pipes are adequately baked and are free from cracks and blisters. Standard drainpipe sizes are 50, 65, 75, 80, 100, 130, 160, and 200 mm inside diameter. Current clay tiles have lengths of 300 or 333 mm.

Clay tile is very durable and highly resistant to weathering and deterioration in aggressive soil conditions e.g. in soils containing sulphates and corrosive chemicals. Has excellent bearing strength.

4.3.2 Concrete tiles

Concrete pipes are used mostly in medium to large sizes, with inside diameters of 100, 150 and 200 mm and up, and section lengths of 0.60, 0.91, 1.22 and 2.40 m. Tile over 300 mm inside diameter is usually reinforced. Butt joints are common. Pipes should be well formed, finished, free from cracks and chips, and properly cured.

Pipes made with ordinary cement are liable to deteriorate in acidic and high sulphates soils, and by water carrying certain alkali salts or other chemicals.

Concrete pipes should not be used at locations where industrial waste or house refuse has been collected. Special high sulphate-resistant cements and high-density concrete should be used to resist chemical attack.

4.3.3 Plastic drainpipes

The main advantage of plastic pipes is their low weight per unit length, greatly reducing transportation cost. An additional cost-saving factor is the reduced need for the labour, required for installation. Smooth plastic pipes were made of rigid polyvinyl chloride (PVC).

Corrugated plastic pipes were advantageous, viz.:

- Light weight
- Long, continuous length
- Flexibility for handling, transportation and installation.
- Easy wrapping with envelope materials.
- lower labor cost for manufacture, handling, transportation and installation.
- Inert to all common soil chemicals.

Corrugated pipes also have disadvantages, compared to clay and concrete pipes:

- Vulnerability to deterioration from UV-radiation when exposed to sunlight for long periods, especially if made of PVC.
- Increased brittleness at low temperatures.
- Increased deflection risk at high temperatures and excessive stretch during installation.
- Lower deflection resistance under permanent load.
- Risk of collapse under sudden load
- Smaller transport capacity.
- Not fire resistant.
- Not easy to relocate in the field with a tile probe without damaging the pipe.

4.3 4 Pipe accessories

Subsurface drainage systems require accessories and special structures such as pipe fittings (couplers, reducers, junctions, end caps), gravity or pumped outlets, junction boxes, non-perforated rigid pipes, blind inlets, surface inlets, controlled drainage or sub irrigation facilities, and cleaning provisions. Some fittings are made by pipe manufacturers, others are manufactured by specialized companies, and others are fabricated on the spot.

4.3.5 End caps

End caps prevent the entrance of soil at the upstream drain-end opening. They can be made of the corresponding pipe material but any other durable flat material can be used for this purpose as well.

4.3.6 Couplers

Corrugated pipes generally have external ‘Snap-On’ couplers to connect pipes of the same diameter. Internal couplers can be used with the trenchless technique to prevent separation of connected pipes when passing through the pipe feeder device. Pipes can also be connected internally by making a slit in the end of the upstream pipe and forming a cone that is pushed into the end of the downstream pipe. Such connections are not very reliable and do impede the discharge of water and suspended solids.

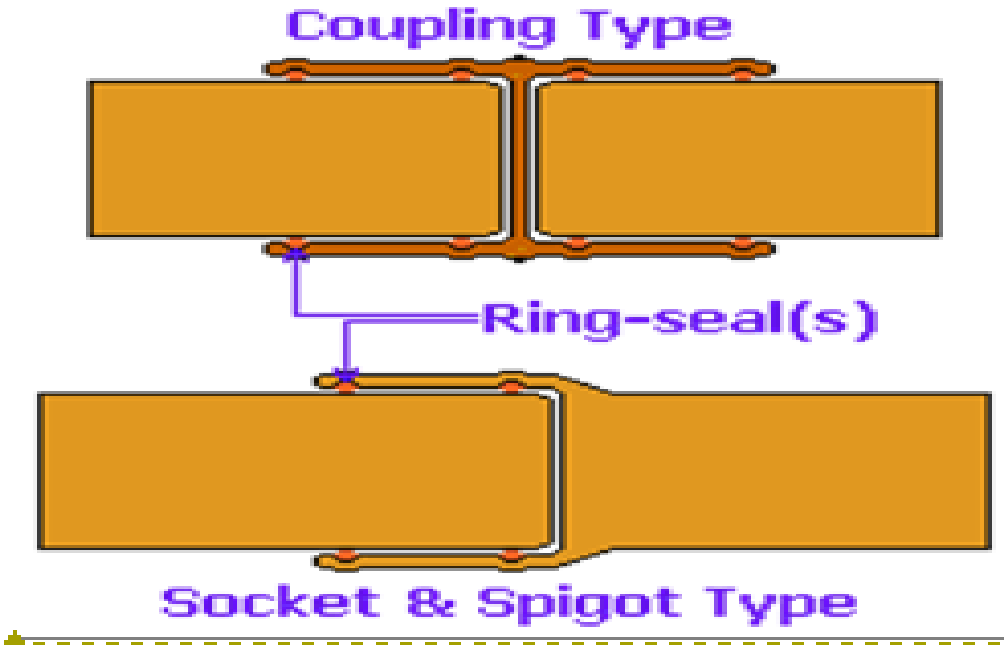

Figure 29: couplers

4.3.7 Reducers

Reducers connect two pipe ends of different diameters.

4.3.8. Pipe fittings

A wide range of pipe fittings, made of various raw materials, is commercially available for all kinds of pipes. Fittings for clay, concrete and corrugated plastic pipes are generally made by the various pipe manufacturers and therefore they are mostly not interchangeable.

4.4. Protection structures

4.4.1. Drain bridges

The undisturbed natural soil in which the pipes are laid normally has enough strength to support the pipe. However, when the drain crosses a soft spot where the soil has not yet settled, e.g. a filled-in former ditch, drain bridges should be used to maintain the level of the drain during settlement of the soil.

4.4.2. Inlets

- **Blind inlets:** Blind inlets are intended to drain stagnant pools, while sediments are intercepted. Durable material, such as stones, gravel and coarse sand is preferred as trench backfill.
- **Surface inlets:** Surface water inlets are incidentally used to evacuate surface water from localized areas through the drainage system. A proper silt trap is essential to prevent or reduce drain siltation. Surface inlets are usually made of masonry or cast-in-place concrete, but concrete and rigid plastic pipes can also be used. A metal grating is usually installed to restrict the entry of trash and waste.
- **Pumped outlets:** Pumps are used for the discharge of water from a drainage system into an outlet ditch, when gravity outflow is not possible because of insufficient outlet depth.

  Pumped outlets are more expensive than gravity outlets, not only because of the initial cost of equipment, but also due to costs associated with maintenance and power consumption.

4.5. Placing of components and associated fittings

4.5.1. Laying pipes

Pipes are typically laid within trenches and extreme caution must be exercised when working in trenches. Collapse of trenches is a very, very frightening experience (don't ask!), and has resulted in moderate to severe injuries, loss of limbs and, in far too many cases, loss of life.

Figure30: Pipe laying

4.5.2. Pipe-laying basics

Typical laying methods for the 3 most common types of pipes are considered below. Handling, cutting and jointing will vary for each type of pipe and its associated range of fittings, but the general principles remain the same.

Pipes should be laid in straight lines to a steady gradient. A taut string line, sight rails or, more commonly nowadays, a laser line is used to ensure accuracy in alignment and level. The bedding is prepared in advance, with a recess scooped out to accommodate sockets, if necessary.

Pipes should be laid on a full bed of granular material and not propped up on bricks, bits of stone, broken flagstones, etc. The pipe should be settled into the bedding or have the bedding packed beneath it until it is at the correct alignment and level as indicated by the guide line (string or laser).

4.5.3. Laying Plain-ended Pipes (clayware or plastic)

As noted above, many drainage systems are termed 'Plain-ended'. This refers to the pipes, which have no integral socket and rely on couplings to join together pipes and

fittings. This type of system has some advantages over socket and spigot types, in that the separate couplings offer greater flexibility and off-cuts from pipes can utilized by simply adding a coupling to each end.

The ends of the pipes, whether they are plastic ware or clayware, are chamfered when new. Pipes and fittings that have been cut may need to have the cut end chamfered on-site; cut ends to plastic ware can be easily chamfered by means of a file, whereas clayware requires skilled use of a light hammer to 'fettle' the cut end, or the use of a special pipe-trimming tool.

- lubricate end of pipe/fitting and coupling*
- slide coupling onto pipe/fitting
- lubricate receiving end of coupling and end of next pipe/fitting
- slide next pipe/fitting into coupling
- repeat as required

Plastic ware drainage is available with 2 types of jointing:

- Ring-seal
- Solvent-weld

Ring-seal jointing may be found as separate couplings or the pipes and fittings might have in-built couplings with identifiable 'female' and 'male' ends, known as sockets (f) and spigots (m). The spigot or coupling is lubricated and the pipes brought together with gentle force.

Solvent-weld systems rely on the pipes, couplings and fittings being 'glued' together by means of a special solvent. Individual manufacturers provide jointing instructions, and the correct solvents/adhesives for their individual ranges. Again, there may be separate or in-built couplings, depending on the particular system chosen.

It is essential that the manufacturers' jointing instructions are followed to the letter, and that solvent cements are not mixed between different products/manufacturers.

4.5.4. Laying Socketed Clayware

Plastic ware is simply cut to size using a handsaw, full-size hacksaw or angle grinder, and then using a file to chamfer the newly-cut end.

Clayware (along with other harder materials) requires special cutting tools. The two most common methods are to use either a power cut-off saw or a pipe-cutting tool, which wraps around the pipe, placing a series of hardened-steel discs in direct contact with the barrel of the pipe, and then relies on pressure being exerted via the lever-handles to 'snap' the pipe at the required point.

4.5.5. Fittings and Access Points

There is a huge range of fittings available for all types of drainage systems. These include gullies, hoppers, traps, bends, and junctions as standard items, as well as access chambers, rodding eyes and inspection chambers which are designed to grant access for inspection and/or maintenance. Manholes tend to be larger chambers (at least 600mm width), with half-pipes known as 'channels' set into the base (see other drainage pages).

Self-check 4	Written Test

Short Answer Questions

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page:

1. List components of sub-surface drainage system.
2. List drainage system fittings.
3. Briefly describe types of plastic ware jointing.
4. what is the difference of pumped outlet from gravity?

Note: Each question carries 5 points: Satisfactory rating - 20 points: Unsatisfactory - below 10 points

You can ask your teacher for the copy of the correct answers.

Answer Sheet

Score = _____

Rating: _____

Name: _____ **Date:** _____

Short Answer Questions

1. _____
2. _____
3. _____
4. _____

Information sheet – 5	Performing preventative maintenance program

5.1 Introduction

Irrigation system maintenance on golf course involves four major efforts: calibration and auditing, preventive maintenance, corrective maintenance, and record keeping. Good system management starts with good preventive maintenance procedures and recordkeeping.

5.2 Preventive maintenance

Preventative maintenance Preventative maintenance is work that, if carried out, will result in preventing more expensive maintenance or repair work at a later date. A classic example of preventative maintenance is the prevention of seepage around or under hydraulic structures; if seepage is identified and remedial action taken in good time, the collapse of the structure can be prevented, saving considerable expense.

Priority areas for preventative maintenance include:

- Checking for seepage around or under structures, especially if there is a high-pressure head across the structure;
- Grading of embankments and canal/ drain inspection/access roads to avoid ponding of water and gulling;
- Closing river intake gates before high flood levels in the river, both to avoid excessive discharges in the canal and
- Intake of water with high sediment loads;
- Painting of metal and wood components, particularly gates and gate frames

5.2.1 Reducing the permeability of a canal bank

The permeability of a canal bank can be reduced by compacting the center, or core of the embankment. The core is first excavated by digging a narrow trench, and then replaced with soil in layers, compacting each layer. The compacted core should extend above the water level. The procedure is:

- Remove the vegetation on the canal bank and the top of the bank.

- Excavate a narrow trench near the inner side of the canal bank. A trench is excavated in the permeable section of the canal. The width of the trench is at least 0.5 x the water depth in the canal. The bottom of the trench should be some 20 cm below the original ground surface elevation
- Compact the bottom of the trench with a manual tamper and replace the soil in layers of about 5 to 10 cm each. The soil should be moist when being compacted. When the excavated material is rather sandy, the core should be filled with other material which contains more clay. Each layer is wetted and the wetted soil is then compacted. Wetting the soil is conditional for good compaction, since the aggregates in soil that is moist will disintegrate by tamping, while those in dry soil will not.
- Fill and compact the trench until the top is reached.

5.2.2 How to avoid Overtopping

Overtopping of a canal section is caused by an excessive discharge in that section in relation to the actual canal capacity. Canal banks which are frequently overtopped are very probably eroded and lowered, and thus the actual capacity will be less than the original capacity for which the canal has been designed.

Overtopping can be avoided in two ways, either:

- Reduce the discharge, or
- Increase the canal capacity.

No explanation is necessary for the first solution, and so only the second solution, which reestablishes the canal capacity, is described below.

The procedure to re-establish a canal capacity by rebuilding its banks is:

- Remove the vegetation, if any. Hammer pegs in the canal bank at both sides of the section concerned. (With these pegs and a rope the level of the section can be checked).
- Excavate the top and sides of the bank like stairs.

- Rebuild the bank by filling the excavated portion with clayey soil. Fill by layers of 5 to 10 cm and compact it in wet condition. While raising the embankment, check the level regularly.
- Trim the sides and lay grass sods on the bank when the top is reached.

When it is impossible to avoid high water levels, an emergency outlet, or spillway, can be installed. An emergency outlet consists of a protected lowered section of a canal embankment and a protected outlet to the drainage system. Such a structure will allow water to escape into the drainage system without damaging the canal banks.

5.2.3 Preventing erosion

Erosion of an irrigation canal may be prevented by either:

- Reducing the flow velocity, or
- Lining the canal.

Reducing the flow velocity,the flow velocity in a canal can be reduced by reducing the canal bed slope. To avoid such an excessive canal bed slope in the steep area, the slope of the canal can be modified by constructing part of the canal in cut and part in fill, which however involves moving large volumes of earth. The volume of earth movement in cut and fill can be reduced by installing drop structures, which connect two sections of a canal with different elevations. In order to have the same canal capacity, the canal cross-section has to be made bigger. Of course, it is not easy to rebuild an existing canal in order to modify its bed slope.

Self-Check 5	Test

Directions: Choose the best answer for the following questions. Use the Answer sheet provided:

1. ___ will result in preventing more expensive repair work at a later date.
   a. Corrective maintenance
   b. preventive maintenance
   c. reactive maintenance
   d. All
2. Which of the following is priority areas for preventative maintenance?
   a. Checking for seepage
   b. Grading of embankment
   c. Painting of metal and wood components
   d. All
3. ____of a canal section is caused by an excessive discharge in that section in relation to the actual canal capacity.
   a. Overtopping b. flooding c. erosion d. siltation.
4. Which of the following is a measure used to reduce erosion of canals?
   a. Lining b. Reducing flow velocity c. a & b d. none
5. Overtopping can be avoided by___.
   a. Reduce the discharge
   b. Increase the canal capacity
   c. Reduce velocity
   d. All except **c**

Note: **Satisfactory rating - 5 points** **Unsatisfactory - below 5 points**

Answer Sheet

Score = _____

Rating: _____

Name: _____ **Date:** _____

Short Answer Questions

1. ___ 4. _____
2. ___ 5. _____
3. __

Operation Sheet 1	Correcting system faults

Tools and Equipments

- Shovel, hoe, spade, Rake, pick axe, meter
- Selected soil.
- Wood, peg
- Compacting power tool

Procedures

1. Construct a wooden template
2. Select the feasible diversion type based on the site condition.
3. Hammer in reference pegs to indicate the original level of the canal banks on each side of the canal.
4. Fill and compact moist soil layer by layer, using the template for final shaping.
5. Check the cross-section and bank levels with the template and the reference pegs.

Operation Sheet 2	Repair of a leak from lined canal

Tools and Equipments

- Shovel, hoe, spade, Rake, pick axe, meter
- cement
- Wood, peg
- Compacting power tool

Procedures

1. Empty the canal and indicate the location of leakage with pegs
2. Select the feasible diversion type based on the site condition.
3. Remove the vegetation and keep it apart. Excavate the canal bank to well below and besides the leak.

4. Rebuild the canal bank by filling the bank in layers with moist soil, and compact each layer well.
5. Part of the canal lining should be removed. After filling and compacting the earth bank, the lining should be reconstructed.

Operation Sheet 3	Repair of drainage line blocked with tree root

Tools and Equipments

- Shovel, hoe, spade, Rake, pick axe, meter
- Drain pipe

Procedures

- Reroute the drainage pipe away from the tree.
- Dig up, remove and replace the section of blocked drains and remove the tree causing the problem.
- Replace the drain using continuous non-perforated pipe for a distance of 15 m on either side of the tree.

Operation Sheet 4	Identifying, placing and joining drainage components and associated fittings

Tools Required

1. Chisel point bar
2. Cordless drill
3. Garden rake
4. Hammer
5. Level
6. Line level
7. Spade
8. Tape measure
9. Utility knife

10. Wheelbarrow

Materials Required

1. Crushed rock
2. Drain cover
3. Drain tubing
4. Dry well
5. Fabric sock
6. Landscape fabric
7. Stakes
8. Y-fittings

Procedures

1. Dig an adjoining trench
2. Connect the drain tube
3. Cover the tube with fabric
4. Make sure the tube slopes to drain the water
5. Attach a cover over the end of the tube
6. Dealing with Backfill.

LAP Test	Practical Demonstration

Name: _____ **Date:** _____

Time started: _____ **Time finished** _____

Instructions: Given the necessary materials you are required to perform the following tasks within 4 hours.

1. Identifying, placing and joining drainage components and associated fittings (1hr)
2. Conduct correcting system faults (1 hour).
3. Conduct repair of leak in the lined canal (1 hour).
4. Conduct repair of blocked drainage line (1 hour).

Instruction Sheet	Learning Guide – 58: Check work and restore work site

This learning guide is developed to provide you the necessary information regarding the following content coverage and topics:

- Backfilling, compacting and restoring work site
- Checking Repaired or replaced components and earthworks

This guide will also assist you to attain the learning outcome stated in the previous page. Specifically, upon completion of this Learning Guide, you will be able to –

- Backfill, compact and restore work site
- Check Repaired or replaced components and earthworks

Learning Instructions:

1. Read the specific objectives of this Learning Guide.
2. Follow the instructions described below 3 to 6.
3. Read the information written in the information “Sheet 1and Sheet 2”in page 101 and 107 respectively.
4. Accomplish the “Self-check 1 and Self- check 2” -” in page 106 and 108 respectively
5. If you earned a satisfactory evaluation from the “Self-check” proceed to “Operation Sheet 1 in page 109
6. Do the “LAP test” in page 110

Information sheet - 1	Backfilling, compacting and restoring work site

1.1 Introduction

Most areas require that the soil surface and vegetation be restored to a pre-construction condition. This may necessitate removal and stockpiling of topsoil and temporary preservation of particular vegetation until post-construction revegetating is accomplished. Revegetating and promoting vegetation should be based on local conditions and requirements. If a project traverses hills or steep terrain, erosion control devices may be required in combination with revegetation efforts.

1.2 Backfilling

Backfilling is the process of reusing or replacing the soil that is removed during the excavation of trenches, foundation, and ground bearing slabs or other groundwork to support and strengthen a structure. Backfill can be made up of the same soil that was removed during excavation, or can be a mixture of imported soil, rocks and stones depending on the structural requirements. The need for backfilling will be established during ground investigations which will also be used by the engineers to formulate a design. Backfill is quantified in m3.

Excess soil might be taken away from site or set aside for use in other parts of the project at a later stage. When excavated material is set aside for later use it should be protected from the elements.

1.3 Compaction

Place and compact filling in uniform layers of thickness appropriate to the nature of material and the compaction equipment being used. Layers shall extend for the full width of embankments and shall be placed such that they are parallel to the finished surface. In earth fills the maximum layer thickness generally shall be 150mm compacted.

However, greater thicknesses will be permitted subject to the ability of compaction equipment to achieve specified densities. No layer shall be less than 100mm thick

compacted. Where area is to be planted or grassed, the top 500mm is to be compacted to a level not exceeding 85% of the modified maximum dry density.

Reduce layer thicknesses as necessary to ensure the achievement of specified densities.

1.4 Reinstatement/site stabilization

During and after works there are likely to be areas of disturbance and exposed soils. These disturbed areas pose an environmental risk, the most common risk being the discharge of sediment. Sediment (e.g. clay, dirt and sand) is natural substance. However, it can have significant adverse effects on aquatic environments. Increased amounts of sediment in waterways can:

- Clog the gills of fish and damage other sensitive tissues through abrasion.
- Suffocate aquatic plants, fish and insects by smothering them.
- Reduce the amount of light entering the water, which can stop plants and algae growing – removing a major food source for fish and insects.
- Increase the risk of flooding. No project is complete until the site/works area is fully stabilized.

Environmental practices and controls

- Stage works to minimize the amount of disturbed area on site.
- Put in place diversions (e.g. bunding, sandbags etc.) at stages uphill of the site to divert clean storm water around the works. This will help to reduce the amount of contaminated water that you have to manage.
- Install storm water catch pit protection measures as a form of secondary control on downstream receiving catchpoints.

1.5 Common site stabilization/reinstatement practices

1.5.1. Top soiling

Top soiling involves the placement of topsoil over a prepared area. Top soiling is not an effective stabilization/ reinstatement practice by itself, and forms part of other techniques by providing a medium for vegetative growth. Top soiling however provides some limited short-term stabilization by protecting sub-soils and absorbing water.

Top soiling should be used:

- Before top soiling make sure that storm water protection measures, as a form of secondary control, are in place and remain until the site is stabilized
- On relatively flat sites
- With mulching techniques until vegetation establishes.

Revegetation techniques:

- Grass The planting and establishment of grass is a quick growing option to stabilize a site. Key things to do when grassing:
- Before grassing make sure that storm water protection measures, as a form of secondary control, are in place and remain until the site is stabilized.
- Topsoil if required to provide a good seed bed and ensure quick successful establishment of grass and vegetation.
- Apply seed at the recommended application rate.
- Apply mulch to stabilize the area and to help with moisture retention.
- Maintain seeded area to assist with germination and ensure a stabilized site.

General planting: Planting is a reinstatement practice that is typically used when existing vegetation has been removed as part of site works. Planting can protect against erosion and provides shade to reduce the regrowth of weeds. However, trees and shrubs take a significant amount of time to produce enough root growth to stabilize a site. When planting:

- Plant during the planting season (March to August).
- Improve establishment of planting and reduce maintenance costs by the use of weed fabrics prior to planting.
- Mulch deeply around the plantings as it will help suppress weed growth and help stabilize the area.

Figure31: Site reinstatement

Turfing: Turfing involves the placement of a continuous cover of pre-grown grass turf and is typically used for areas that require immediate stabilization such as in residential areas, the banks of watercourses, and steep locations. Turfing has advantage of providing immediate site reinstatement as well as being suitable for landscaping.

Key things to do when turfing:

- Before turfing, the site should be properly prepared with the application of fertilizers, grading of the site and clearing of any debris.
- If the laying of turf occurs in summer months the soil area may require light irrigation before the application of turf.
- When laying the turf do not stretch or overlap.
- Water the freshly laid turf area daily if there has been no rainfall.
- Apply fertilizer when required in accordance with supplier's specifications.
- Mowing of the vegetated area should not occur until the turf is firmly rooted.

Mulching: Mulching involves the application of a protective layer of straw or other suitable material to the exposed surface protecting soils and reducing runoff. Mulching

also helps to maintain moisture and promote establishment of desirable vegetation. Key things to do when mulching:

- Before mulching make sure that storm water protection measures, as a form of secondary control, are in place and remain until the site is stabilized.
- Application of mulch should be at an appropriate rate that provides good coverage of all exposed soil.
- The application of mulch should be uniform and will typically be done by hand.
- Ensure mulch is compacted to prevent it becoming dislodged during rainfall.
- For the best results, total surface coverage must be maintained. Mulch may need to be reapplied as is settles or breaks down.

1.6 Monitoring and maintenance

It is important that during and after works you:

- Check the condition of the stabilization practice on a regular basis particularly after rainfall.
- Ensure that construction equipment does not disturb the reinstated area. This can be done by erecting a temporary barrier fence to restrict movement of equipment.
- Regularly inspect and clean out sediment controls and secondary catch pit protection.

Once the site is fully stabilized remove environmental controls. Inspect storm water catchpoints and remove any contamination associated with site works.

Self-check 1	Written Test

Short Answer Questions

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page:

1. Define backfilling, compaction and site reinstatement.
2. Briefly describe common site stabilization practices.

Note: Each question carries 10 points: Satisfactory rating - 20 points: Unsatisfactory - below 10 points

You can ask your teacher for the copy of the correct answers.

Answer Sheet

Score = _____

Rating: _____

Name: _____ **Date:** _____

Short Answer Questions

1._____

2._____

Information sheet – 2	Checking Repaired or replaced components and earthworks

1.1 Introduction

Checking repaired or replaced components is the part of quality management that ensures products and services comply with requirements. It is a work method that facilitates the measurement of the quality characteristics of a unit, compares them with the established standards, and analyses the differences between the results obtained and the desired results in order to make decisions which will correct any differences.Technical specifications define the type of controls that must be carried out to ensure the construction works are carried out correctly. They include not only products and materials, but also the execution and completion of the works.

One way of controlling quality is based on the inspection or verification of finished products. This reception control is usually carried out by people who were not involved in the production activities, which means that costs can be high, and preventative activities and improvement plans may not be effective.

It is a final control, located between producer and client, and although it has the advantage of being impartial, it has a large number of drawbacks, such as slow information flows, and that the inspectors are not familiar with the circumstances of production and are not responsible for the production quality. The plan must be drafted by the contractor before the start of the construction works and will be reviewed throughout its execution.

The control activities (verification of compliance with specifications, validation of specific processes, monitoring of activities, inspections and tests), which the units, materials or services undergo must also be established. These activities can be defined through inspection, testing plans, action plans and where applicable specific tests (for example, load tests for structures).

Self-check 2	Written Test

Short Answer Questions

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page:

1. What is the benefit of checking repaired components of irrigation and drainage system?
2. List the activities carried for checking repaired components.

Note: Each question carries 5 points: Satisfactory rating - 10 points: Unsatisfactory - below 5 points

You can ask your teacher for the copy of the correct answers.

Answer Sheet

Score = _____

Rating: _____

Name: _____ **Date:** _____

Short Answer Questions

1. _____

2._____

Operation Sheet 1	Backfilling, compacting and restoring work site

Tools and materials

- Shovel, hoe, spade, Rake, pick axe, meter
- Grass, soil, mulch

Procedures

1. Design landscape.
2. Soiling.
3. Planting/revegetation
4. Mulching.
5. Monitoring and maintenance

LAP Test 1	Practical Demonstration

Name: _____ **Date:** _____

Time started: _____ **Time finished** _____

Instructions: Given the necessary materials you are required to perform the following tasks within 1:3 hour.

1. Backfilling, compacting and restoring work site (1:30 hour).

Instruction Sheet	Learning Guide - 59: Finalize Work

This learning guide is developed to provide you the necessary information regarding the following content coverage and topics:

- Checking and storing Equipment, tools and materials
- Completing Workplace records and process

This guide will also assist you to attain the learning outcome stated in the previous page. Specifically, upon completion of this Learning Guide, you will be able to –

- Check and store equipment, tools and materials
- Complete workplace records and process.

Learning Instructions:

1. Read the specific objectives of this Learning Guide.
2. Follow the instructions described below 3 to 4.
3. Read the information written in the information “Sheet 1, Sheet 2, Sheet 3 and Sheet 4”inpage 112 and 120 respectively.
4. Accomplish the “Self-check 1, Self-check 2, Self-check 3 and Self- check 4” -” in page 118 and 128 respectively
5. If you accomplish the self-checks, do operation sheet in page 41 and 42
6. LAP Test in page 43

Information sheet - 1	Checking and storing Equipment, tools and materials

1.1 Introduction

Site storage involves the provision of adequate space, protection and control for materials, components and equipment that are to be kept on a construction site during the building process.

There are several factors to be considered when deciding on the amount and nature of storage required.

- Physical properties: The size, shape, weight and mode of delivery.
- Organization: The planning process to ensure unloading is available and storage space has been allocated.
- Control: Processes for checking the quality and quantity of materials on delivery, and monitoring stock holdings.
- Protection: The necessary protection for durable and non-durable materials and components from damage.
- Security: Guarding against theft and vandalism.
- Costs: Costs associated with handling, transporting and stacking requirements, the workforce required, heating and/or lighting that may be required, facilities to be provided for subcontractors, and so on.
- Processing: What needs to be done to materials before they can be used. Is there packaging that needs to be removed or returned?
- Programme: When are items required, what is the risk to the project of them not being available, how long in advance are they ordered and how long they will be on site.
- Ownership: Who is legally responsible for items, who will be using them and who owns them? See Materials on site for more information.

Site allocation: Failure to adequately plan for storage space can result in congestion, or having more materials on site than storage space allows for. The most appropriate position on site in terms of handling, storage and convenience should be determined.
Unloading deliveries should take place in a clearly marked designated area, away from other site operations, supervised by a competent person. The distance between storage areas and the area materials are to be used should be reduced as much as possible to keep the time and cost required to transport them from place to place at a minimum. Alternatively, storage areas could be positioned within the reach of a tower crane which can then be used to move materials as required.

Theft: Materials and equipment may need protection from theft and vandalism, particularly when left out in the open where they have the potential to be removed late at night by opportunistic thieves. Close boarded fences are often used which are similar to hoarding, or chain link fencing with precast concrete posts, sometimes incorporating a 45° crank which faces out.

Health and safety: There are certain health and safety issues to consider when storing items on site. Items which are stacked must be stable to ensure they will not fall onto workers. Workers should not climb or walk on top of materials which are stacked as they could shift and cause them to fall.
Stored items should not block or obstruct escape routes.

The type of material being stored also needs to be taken into account. If it is hazardous, it may require specific precautions and control measures such as bunds for toxic substances or it may need to be kept separate from other substances to prevent a reaction.

To reduce the risk of an accident, special containers are required to store hazardous chemicals and dangerous goods. These types of containers may have special provisions for things like natural ventilation, special compartments, electrical earthing, and warning signs.

Materials storage: Different types of material will have different storage requirements, in particular depending on whether they are durable or non-durable.

Drainage pipes: These are usually supplied loose or strapped together on timber pallets. They should be stacked horizontally with ends reversed in alternate rows. A driven-in timber stack or column of loose bricks can be used to form end restraints.

Timber: Timber and other joinery items should be stored horizontally and covered in a scaffold rack, although provision should be made for free air flow, usually by the rack having open ends and sides, while having a top that is covered. It is advisable for different timber sizes to be kept separate.

Cement: Since any contact with direct or airborne moisture can cause cement to set, it must be kept dry. Small quantities of bagged cement should be stacked to a height no more than 1 m, on a raised dry platform such as a timber pallet.
Medium quantities of bagged cement may need to be stored in a watertight and fireproof shed, with galvanized steel sides and adjustable legs on bearing plates. Large quantities of loose cement should be stored in a cement storage silo

Aggregates: It is essential for different aggregate types and sizes to be kept separate. They should be stored on a clean, hard, free-draining surface, surrounded by retaining and separating walls of bulk timbers. Stored aggregates should be regularly monitored for moisture content.

1.2 Tool and Equipment Maintenance

All tools, equipment, and vehicles must be properly maintained so that workers are not endangered. Construction regulations require inspections of vehicles, tools, machines, and equipment before use.

Preventive maintenance is the systematic care and protection of tools, equipment, machines, and vehicles in order to keep them in a safe, usable condition, that limits downtime and extends productivity. We must always be aware that maintenance tasks themselves are potentially hazardous and can result in injury. The successful maintenance program is:

- Well organized and scheduled
- Controls hazards
- Defines operational procedures
- Trains key personnel.

Most manufacturers can provide maintenance schedules for their equipment. Large companies with a fleet of vehicles/equipment typically have a comprehensive maintenance program due to the capital investment and/or leasing agreements.

Smaller companies may lease equipment and maintenance services may be included in the leasing agreement.

General requirements for equipment maintenance include:

- Obtaining a copy of the maintenance schedule recommended by the manufacturer.
- Ensuring that maintenance is performed as required.
- Ensuring that the person(s) performing the maintenance are competent (e.g. licensed mechanic).
- Retaining records of maintenance/service conducted.
- Specifying who is responsible for overseeing equipment maintenance and where the records are kept.
- Setting up a system for removal and tagging of damaged or defective tools and equipment.

Basic Tool Maintenance: Being in the construction industry, our tools and equipment are the livelihood of our business. Regular maintenance will increase the service life

and performance of your equipment. Take good care of your tools and they will last a lifetime! Store them well, keep them clean and well-maintained, and you won't regret it.

Clean your tools: After a long day's work, cleaning might be the last thing on your mind but remember, your tools have been hard at work and will be covered with dirt and grime. Take a few seconds before packing up to give them a quick wipe down.

Cleaning your tools doesn't have to be difficult at all if you're prepared:

- Hand/Garden tools: Most hand tools can be cleaned simply by wiping them down with a rag. If you find that they are in need of more than just a wipe down, give them a good wash with soap and water. On the handles, linseed oil on a damp rag will do the trick
- Power tools: As always, safety first so make sure the tool is unplugged before any cleaning. If you have an air compressor, it will prove useful in helping you get the dust off it, otherwise, wipe it down and lubricate any moving parts. Be sure to check the manufacturers manual for any cleaning instructions Whilst toolboxes don't need to be cleaned on a daily basis, make sure you clean them out every once in a while. Set aside some time once a month, empty out our tools and wipe them out.

Figure 32: Tool cleaning

Lubricate tools: By coating the internal components with special oil, you can prevent corrosion which happens when moisture or condensation gets into the tools.

1.3 Inspect (and repair) tools regularly

As part of your OHS procedure, tool inspections should be done at the end of each job for any sign of damage and function faults. Attending to repairs in a timely manner will ensure that you not only avoid any last-minute hassles and onsite delays but also ensure your safety whilst using them.

Some of the things to look for during inspections:

- Loose, cracked or splintered handles.
- Mushroomed heads on tools like chisels and wedges.
- Corrosion and rust. If the damage isn't too bad removing the rust should be relatively easy
- Cracked housing on power tools.
- Power tools that don't start easily.

- Frayed insulation or exposed wires.

1.4 Store tools with care

When your tools are not in use, how you store them is just as important as the work you put into keeping them in good condition. Keep your tools covered up to keep them away from dirt and rain and remember to inspect tools that haven't been used in a while to check for any signs of damage or corrosion.

- Keep your tools in a dry place.
- Hang your garden tools.
- Store power tools in their original cases
- Use silica gel packs or rust collector.

Tool maintenance requires quite a commitment on your part but being proactive in the maintenance of your assets will reduce unnecessary expenses relating to repairs and replacement of faulty equipment in the future.

Self-check 1	Written Test

I. Choose the best answer

1____ factors to be considered when deciding on the amount and nature of storage required.

a. Physical properties b. Protection c. Costs d. all

2. Which of the following is not successful maintenance program of tools and equipments.

a. Trains key personnel
b. Controls hazards
c. Well organized and scheduled
d. None

3. The things you look during inspection of tools and equipments

a. Loose, cracked or splintered handles
b. Mushroomed heads on tools like chisels and wedges
c. Corrosion and rust
d. All

4. Which one of the following is a point that is considered to keep tools in a good conditions.

a. Hang your garden tools
b. Keep your tools in a dry place
c. Store power tools in their original cases
d. All

II. Short Answer Questions

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page:

1. What is the importance of proper construction material, tools and equipments? storage?
2. List the successful maintenance program of construction equipments and tools.
3. List some of the things to look during inspections of tools.

Note: Each question carries 3 points: Satisfactory rating -21 points: Unsatisfactory - below 10 points

You can ask your teacher for the copy of the correct answers.

Answer Sheet

Score = _____

Rating: _____

Name: _____ **Date:** _____

Choose answer

1. ___ **2.** ___ **3.** ____ **4.** ____

Short Answer Questions

1._____

2._____

3._____

Information sheet – 2	Completing Workplace records and process

2.1 Introduction

The extent of the record keeping required will depend on the type of project. A balance must be maintained between keeping adequate records in preparation for a dispute arising, and attempting to record everything, which is can be difficult, time consuming and costly.

Some record-keeping requirements, such as recording the minutes of meetings for example, may be carried out at the discretion of the individual organization, with different frequency rates, levels of detail, and time for which records must be kept, appropriate for different situations. Other records may be a legal or contractual requirement, following prescribed rules.

There are a number of reasons for record keeping:

- Legal requirements.
- Contractual requirements.
- To control work.
- To provide data for future work.

2.2 Completing Workplace records and process

The extent of the record keeping required will depend on the type of project. A balance must be maintained between keeping adequate records in preparation for a dispute arising, and attempting to record everything, which is can be difficult, time consuming and costly.

Records at Construction Site

The following are the various records that need to be maintained at construction site,

1. Drawings

First and foremost, import records to be maintained on site are the working drawings approved by the clients and design engineer, based on which all the construction activities take place on site. There is different type of drawings required for construction, some of the basic required drawings are,

- Structural drawing
- Finishing drawing etc.

2. Contract Agreement

Contract agreement documents including all sets of drawings, including amendments, a copy of approval of organization, corporation authorities need to be maintained at construction sites till the completion of construction projects. These documentsprovide permission and guidelines for all the activities carried out at the construction site.

3. Time and Progress Charts or CPM Charts

These charts help in tracking the construction activities from time to time and help in effective planning, scheduling and controlling the construction projects activities. These charts need to be approved from the concerned authorities.

4. Works Diary

Works diary of a construction project should indicate contract agreement number, name of work, amount of contract, date of commencement of work, date of completion and extension time granted.

All the relevant details need be entered daily in the works diary. This diary serves as an authentic record. Following details need to be entered in this diary with due care:

- Weather at site
- Important materials brought to site with their approximate quantity
- Types of transport working at site
- Types of tools and plants being used at site
- Important items of works completed and passed on the particular date
- Visits of VIPs and their remarks if any.

5. Works Passing Records

This record maintains all the activities to be carried out at construction site. It consists of an index page with details of all items of works to be done under the contract and other pages with details of progress of each works. This helps in tracking the progress of each activity of construction and helps in pre-planning for other remaining activities which starts after completion of current activity. This also helps in acquiring approvals before time for activities to be started.

6. Tests Results Record

This is an important record to be maintained at construction site as a proof for construction quality. This record consists of tests of various materials such as cement, sand, aggregates, water, steel reinforcement used at construction site, test records of concrete cubes, concrete cylinders, slump tests etc.

These records are arranged as an index page with details of each materials, page numbers of records etc. Individual pages consist of each material, with their test dates, results etc.

All the tests carried out at site or in laboratory are recorded in this record book. Some of the tests carried out at construction sites for civil works are:

- Cube tests for concrete works for each location or structural members.
- Sieve analysis of coarse aggregates, impact or abrasion tests.
- Sieve analysis of coarse sand for concrete works, masonry sands for masonry works, plastering and pointing works etc.
- Tests for impurities of aggregates and sands.
- Bulking of sand test for concrete and masonry works.
- Slump tests and compacting factor tests for concrete works.
- Crushing strength test, tolerance, water absorption test, efflorescence tests of bricks, stones or masonry work.
- Moisture contents of timber.
- Manufacturer tests reports provided by the vendors for admixtures, reinforcing steels etc.

7. Cement Register

This record is maintained with details of receipts, daily consumptions and remaining balance of cement at site. This record also consists of manufacturing dates of cement, date of receipt and test reports of cement at site or manufacturers test reports.

8. Register for Approval of Samples

This record provides details of all the samples for construction materials that has been approved or rejected by the clients. Approvals from the client are necessary for the construction materials to be used before commencement of the project. All the samples approved by the clients need to be kept separately along with their tests reports with approvals of the clients and contractors till the completion of the work.

9. Records of Changes, Deviation Orders and Amendments

Many a times during the construction projects, there are deviations or changes or amendments to the contract documents and work activities from time to time during construction project as required by the clients. These changes can be in a drawing, specifications or additional works.

A record of all such deviation orders and amendments to contract agreement together with their financial effect should be maintained along with approval or signatures from the clients. If these changes involve in any extension of time of the contract, these should also be recorded.

10. Measurement Books

The measurement book is a record for all the construction activities carried out and approved by the client. These records are important for a contractor to maintain and help during billing claims. Any extra work done is also recorded in this book with notes.

11. Labor Attendance Record and Daily Wages Sheet

Generally, for labor contractor payments, daily or every shift attendance record is kept. Apart from the above, technical staff attendance, engineers, supervisors, and peon attendance register is kept.

12. Periodic Bills Record

Bills on work till date from the previous bill and work checked by engineer-in-charge put up for the payment.

Minutes: Minutes should be taken for all meetings, especially the annual general meeting (AGM) and management committee, as they serve as record of what happened during a meeting (see also Meetings). Approved minutes provide an official record of:

- attendance;
- business discussed;
- correspondence received;
- reports tabled;
- decisions made; and
- resolutions adopted.

The level of detail recorded in the minutes may vary between associations but any decisions recorded should clearly state:

- what decision has been made;
- who will be responsible for its implementation;
- when the decision is to be implemented by;
- if the decision is to be reviewed, and if so, when and by whom; and
- who should be notified of the decision and how?

The minutes must also record when a committee member has disclosed a material personal interest in a matter being considered by the committee (see also Individual committee members' responsibilities).

Notice of meetings: Notice of association meetings and special resolutions must be given to all members within the notice periods specified in the rules of association. Copies of notices showing the date issued should be kept in case of a later dispute. Notices are often filed with the related minutes.

Certificate of Incorporation: The certificate of incorporation is issued when the association is first incorporated or if a change of name occurs. It is important the certificate is stored safely as it is evidence of the association's corporate status. The certificate can be required for example, when applying for funding grants or opening a bank account.

If the original certificate cannot be located the committee may apply through associations Online for a duplicate certificate to be issued.

Financial records: The Act requires records to be kept of the association's finances. Taxation and industrial legislation also require financial records to be kept. Access to accurate and up-to-date financial information also ensures that the association and its services remain viable.The requirements of the Act are:

- associations must keep sufficient accounting (or financial) records so that the financial transactions, financial position and performance of the association are correctly recorded;
- these records need to be kept in a way that will allow true and fair accounts (or financial statements) to be prepared, and so that these accounts can be conveniently audited if required; and
- the financial records are required to be kept for at least seven years.

Depending on the association's annual revenue there may be additional accounting requirements to be met. These requirements are discussed in detail in Accounts and Auditing.

Annual report: Many associations compile an annual report that summarizes the main achievements and highlights of the past 12 months.

There is no set format for an annual report, but it is usually submitted to members at the AGM and includes:

- Chairperson's report.
- Staff report.
- Activity report.
- Annual statistics.
- Annual financial report.
- Interest stories, highlights and low points.
- List of staff, management and volunteers.

Where an annual report is produced, it is usual to include the annual financial report. As an annual financial report is required under the Act, it is a convenient way of ensuring that the association meets its obligation to submit its annual accounts to its members at the AGM.

Many associations also distribute an annual report as a public relations exercise. Some funding agreements require annual reports. Employment records

- In addition to the records required by the Australian Taxation Office (ATO) and State and Commonwealth industrial laws (see Employment), associations may wish to set up employment related record systems. These could include:
- Recruitment records such as job descriptions, selection criteria, related industrial agreements, advertisements, selection processes and outcomes;
- Formal records of any meeting or discussion related to issues of employee performance and position review;
- Formal documentation of all proceedings related to any grievance;
- Records on staff training and professional development; and
- Copies of all correspondence and memoranda relating to individual conditions of employment, changes or requests.
- Safety records

The following health and safety records should be kept in a separate file for easy access and reference:

- Complaints;
- Incidents;
- Risk management analysis;
- Training details;
- Safety committee minutes; and
- Copies of specific management committee resolutions.

Insurance records: Copies of all insurance policies should be kept in a secure place. Changes to policies should be updated on the files immediately when they are received. Insurance policies may require an association to keep specific records for the purposes of validating a policy. For example, health declarations or assets registers. Associations must notify their insurer as soon as possible after events such as an accident, theft or fire. It is important associations keep copies of all notifications and correspondence to prevent the possibility of any dispute regarding an association's obligations.

Service delivery records: Some associations need to keep service delivery records in order to:

- Acknowledge achievements;
- Minimize risk of professional negligence;
- Facilitate communications and change overs;
- Ensure industry or professionally based requirements are met; and
- Assist in evaluation and planning.

This may take the form of statistic sheets, case files or employee reports. Funding arrangements may also require certain records to be kept and reported on.

Self-check 2	Written Test

I. Choose the best answer

1. What is the reason for work site record keeping?
   a. To control work
   b. To provide data for future work
   c. Legal requirements
   d. All
2. Which of the following record is maintained in the construction site?
   a. Drawings b. Contract Agreement c. Works Diary d. all
3. Approved minutes not provide an official record of.
   a. Attendance b. Reports tabled c. Decisions made d. none
4. Which one of the following is health and safety records?
   a. Complaints b. Training details c. Incidents d. all
5. Which one of the following is service delivery records?
   a. Acknowledge achievements
   b. Assist in evaluation and planning
   c. Minimize risk of professional negligence
   d. All

II. Short Answer Questions

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page:

1. List the reason for record keeping.
2. List the construction site records.
3. Define minutes?
4. List the health and safety record keeping?

Note: Each question carries 2 points: Satisfactory rating - 18 points: Unsatisfactory - below 9 points

You can ask your teacher for the copy of the correct answers.

Answer Sheet

Score = _____

Rating: _____

Name: _____ **Date:** _____

I. Choose answer

1. ___ **2.** ____ **3.** ____ **4.** ____ **5.** ___

II. Short Answer Questions

1._____

2._____

3._____

4. _____

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