german cooperation
DEUTSCHE ZUSAMMENARBEIT

Implemented by: giz Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

ግብርና ሚኒስቴር
MINISTRY OF AGRICULTURE

How To Construct Water Spreading Weirs

Training, Teaching, and Learning Material
First Edition

Contents

Instruction on how to use this learning and teaching material

This manual is one of several teaching and learning guides in a series focused on Water Spreading Weirs (WSW) Construction, Flood-based farming, and Biological measures. The authors stress the importance of a comprehensive understanding of WSW construction and biological measures in effectively planning, constructing, and using WSWs for flood-based farming. This knowledge is essential for development agents/learners engaged in community development activities.

In addition to technical knowledge, teachers and learners should also cultivate 'soft skills'. The first step is to familiarize oneself with the Teaching and Learning Guide on Flood-based Farming, WSW construction, and biological measures.

This guide is arranged into four sections or Learning Outcomes (LOs):

Learning Outcome 1	Introduction to the concept of flood-based farming
Learning Outcome 2	Learning outcome 2: Water Spreading Weirs (WSW) based farming
Learning Outcome 3	Learning outcome 3: Crop production using WS-Ws-based farming
Learning Outcome 4	Learning outcome 4: Farming System Management

Each Learning Outcome section comprises:

- Introduction with specific learning outcomes.
- An instruction sheet for teachers suggesting a teaching methodology, the time needed, and guidance through all worksheets.
- An instruction sheet for learners
- Information sheets on the implementation steps, guiding questions for discussion, and self-check test questions.
- Operational sheet, explaining, how to proceed to implement, what is de-

scribed in the information sheet, indicating the required resources. For the Operational Sheets, it is good to realize that they are not stand-alone and can be combined with Learning Outcomes. For example, discussing farming management can be done together with crop selection and suitability.

- LAP-Test.

The guiding questions for discussion are designed to enhance understanding, learning, and reflection on the section's content as well as to serve as a form of self-evaluation. The guide is centred on the active participation of students, integrating what they already know by key adult learning principles and detailing each topic with discussions, outdoor sessions, and/or role plays. A glossary of technical terms at the end of the document explains technical vocabulary and phrases.

Also, since many students of the ATVET colleges are future Development Agents (DA), the Teaching and Learning Guide focuses on their roles and tasks. Content that is especially relevant to the Development Agents is marked throughout the document by this illustration of a meeting:

Specific learning objectives

After you have finished working through this guide you should be able to:

- Know what a WSW is and its advantages.
- Be familiar with the basic WSW terminologies and Special futures of WSW.
- How to read WSW drawings.
- How to carry out measurements and setting out for WSWs.
- Develop a list of activities, quantifying the activities and required materials in the construction of WSWs.
- Understand the importance of excavation, site clearance, and how to prepare for excavation.
- Know how to check the excavation and type of excavation we used for WSW construction.
- What to do and not to do during the construction of WSW.
- Occupational safety, health and environmental concerns during construction of WSW

You should also be fully aware of how to combine physical and biological conservation measures to maximize the livelihood benefits of flood-based farming using WSWs.

Hints and Tips for Training and Teaching

Adult Learning

Adults learn differently from children and so teaching techniques for adults differ from those used with children. The main difference is that adults have considerably more life experience. As a result, adults are keenest to gain information that is most relevant to this lived experience and are inclined to be less interested in that which is not. Key points which help adults learn, therefore, include the following:

Meaningful information	Starting by helping the learners understand why the topic is important and how it can help them – see also specific Learning outcomes
Experience	Recognizing that the learners already have considerable knowledge and life experience and drawing out this experience as often as possible during learning.
Respect	Adults respond best when they feel that they are respected and that they are part of the learning process. Talk with them, not at them.
Self-exploration	Provide time for adult learners to explore ideas (on their own or in small groups). Let them consider how they might use and apply the learning material.

Teaching through facilitation

Facilitation is an important skill that takes practice and patience to improve. It is much easier for teachers to lecture and give instructions than to facilitate group processes in the training set-up. However, to make learning interesting and to get the best results, a teacher facilitates effectively by assuming the following roles:

- The role of a mentor: assist students with empathy, understanding, and encouragement.
- The role of a leader and organizer: initiates demonstrate and set goals as well as boundaries.
- The role of a coach: listens, comment, gives feedback, and inspires.

Conducting an activity

- Communicate clearly and confidently with your students by speaking and writing clearly.
- Make eye contact and try to be calm and confident with your body language.
- When a student asks a question or makes a point, listen carefully, do not interrupt them, and repeat or summarise what you have heard for everyone before responding or asking others to respond to it.
- When explaining ideas, regularly cross-check whether your students have understood what you have said by asking them to summarise, either as individuals or collectively by contributing points.
- As often as possible, elicit information from your students by asking open questions such as: Why? What? How?, rather than closed Yes-No questions.
- Try to encourage everyone in a group to participate and avoid individuals dominating.

Figure 1: Groupwork as part of preparing the WSW construction

Brainstorming ideas

A brainstorm is a bit like a real storm: it happens quickly. Participants pour out their ideas as soon as they come into their heads, like rain falling.
Brainstorming is a particularly effective teaching method for adults because it draws out students' existing knowledge and experience as a starting point for the learning exercise, making it student-centred. If the brainstorm outputs are also written down during the process, all of the collected ideas can be ordered, prioritized, and reworked from their position on the blackboard or cards.

Group work

Some of the most productive learning takes place during group work. Working in groups places both responsibilities for learning and empowerment for self-discovery onto the student, making them active learners rather than passive consumers of information.

Before breaking into groups and starting a given task, it is essential to clarify both the objective and the time frame. Breaking into groups can be done randomly across the class (such as by using a counting system of say 1-2-3-4-5 or by height or age order), or in a more structured way by grouping friends, neighbours, or regular working partners. Grouping the learners in a group with group members they know can have the advantage of ensuring smooth group dynamics.

It is often helpful to select a group moderator whose responsibility is to steer the work towards the objective as well as encourage all members, recording and summarising information. The facilitator should circulate between groups, observing how each group manages the activity and making suggestions or asking helpful questions if necessary. If a group is off track from the topic, give support and guidance to try and lead the group back toward the objective.

Role Plays

During a role play, participants can mimic real life situations. By directly simulating reality, the role-play discussion, drama session, or game raises questions that require discussion, assessment, negotiation, and understanding of real scenarios. In this way, role plays are learning experiences for both the actors and the observers.

Evaluation

The Self-Check Test at the end of each Information Sheet, and the LAP-Test after each Operational Sheet of the TTLM are designed to help the student reflect on the overall content of a given section. Completing both the Self-Check Test and the LAP-Test will reinforce what is understood and learned as well as underline what needs further reflection, reading, discussion, or study.

Integrated Approach for Dry Valley Rehabilitation and Productive Use (DVRPU)

The lowlands of Ethiopia are primarily inhabited by agro-pastoral communities. Climate change is causing longer drought spells and increased incidences of intense floods. This, combined with increased population pressure and intensified demand for livestock grazing land, has contributed to the overexploitation of natural resources. With the widespread degradation of the land now evident in poor vegetation cover and low soil infiltration capacity, the once-replenishing floods from the highlands have become a force of destruction. This is most apparent in the formation of deep gullies along the escarpment floor. The floods no longer nourish the earth but destroy it, along with the livelihoods of millions of people.

This process has begun in most dry valleys, which used to be covered with tall grass in the past. They have lost their resistance to drought, and in most rainy seasons, water does more damage in the form of erosion than it contributes to regeneration. In this situation, Dry Valley Rehabilitation and Productive Use (DVRPU) is a game-changer. It has proven its potential to transform degraded dry valleys into flourishing fields that provide livelihoods for its people.

At the heart of DVRPU is a comprehensive set of measures that address multiple dimensions: social, technical, biological, economic, institutional, and governance, ensuring the successful rehabilitation of entire dry valleys. The core technology employed is a cascade of Water-Spreading Weirs (WSWs). These structures, combined with Dry-Stone Measures (DSMs) and biological measures, work together to slow down the flow velocity of floods. By doing so, water can infiltrate into the soils, increasing groundwater levels and allowing fertile sediment to settle, creating highly productive land and, thus, food security.

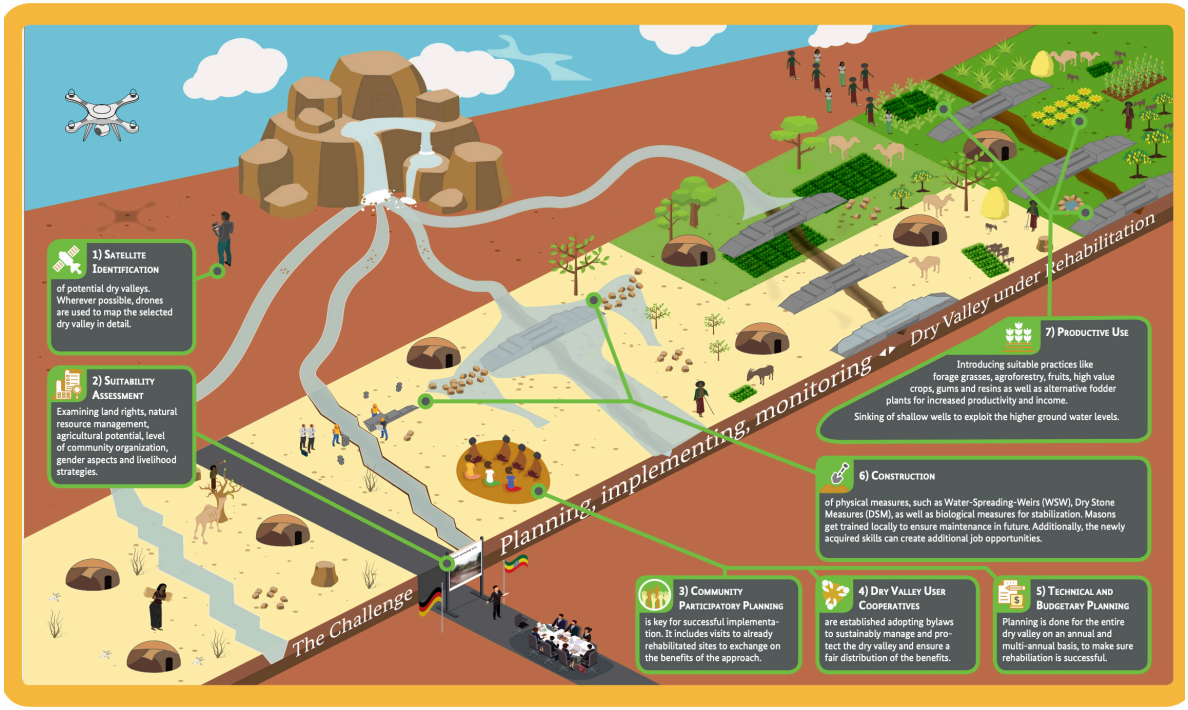
The DVRPU approach is defined in seven crucial steps for the sustainable rehabilitation of dry valleys:

1. Satellite Identification and Dry Valley Delineation
2. Suitability Assessment
3. Community Participatory Planning
4. Dry Valley User Cooperative Societies (DVUCS)

5. Technical and Budgetary Planning
6. Land Rehabilitation Measures
7. Productive Use

One of the key factors for success is the acceptance and active participation of local communities. Their engagement is supported by technical expertise and regulatory frameworks provided by local governments. This collaboration between communities, technical experts, and local governance is vital for the long-term sustainability of the intervention, fostering their active involvement in the planning, implementation, maintenance, and utilization of the rehabilitated lands.

The DVRPU approach offers a sustainable solution that not only rehabilitates the land but also empowers local communities to take charge of their own development and create prosperous futures for themselves.



This TTLM focuses on Water Spreading Weirs (WSWs), which, as indicated above, are the core technology for physical land rehabilitation measures (Step 6). Along with Check Dams and DSM, WSWs have proven highly effective in mitigating erosion and optimizing the utilization of floods for increased food and fodder production and landscape improvement. However, the efficacy of WSWs depends on various factors, including their design, construction quality, and ongoing maintenance.

Water-Spreading Weirs (WSWs) should be masonry structures to withstand a certain level of flood impact. In a dry valley, they should span the entire width of a dry river to spread floodwater over the adjacent land area. When water encounters the weirs, it spreads off their side wings onto a larger surrounding area. Overflow is channeled through a spillway and can be caught by the next weir. WSWs are constructed in cascades to increase the flood spreading effect and to reinforce each other against unseasonable floods.

A cascade or a series of WSWs creates optimal growing conditions over an area of 200 to 800 hectares by increasing the infiltration of floodwaters and the sedimentation of fertile sediments from the highlands. The area of a cascade is measured from the first upstream weir up to the last downstream weir. The upstream weir is located in an area where erosion of the dry valley starts. The final weir is at the area where there is no longer a risk of high erosion, such as relatively flat areas or rocky areas.

Community participation, along with the collaboration of pertinent local institutions throughout the planning, construction, and maintenance stages, is vital for fostering a sense of ownership and ensuring the continued and proper upkeep of the WSWs, thereby guaranteeing their long-term sustainability.

Learning Outcome 1: Introduction to the Water Spreading Weir

Introduction

Every Learning Outcome has a similar structure (apart from an optional operational sheet). In this Introduction you find the specific learning objectives of Learning Outcome 1. The Instructions sheet(s) for both the teacher and the learner tell what is expected from both groups. Following is an information sheet that provides background information, guiding questions, and a self-test.

By the end of this section, you will know what WSWs and its advantages are. Also you will be familiar with the basic WSWs terminologies and the special features of WSWs.

Development Agents (DAs), construction technicians, and trainees need to be fully capable of overseeing the construction of Water Spreading Weirs independently with their working communities. After working through this section, you must come to fully understand the objectives and benefits of WSWs.

Instruction Sheet for Teachers

Teachers should follow the following steps in teaching Learning Outcome 1:

1. Read the Introduction with the specific learning outcome with the learners and brainstorm ideas about WSWs that they already know.
2. Work through the Information Sheet.
3. Show a short video of overflowed WSWs and discuss it with your students. Asking what they see and observe. Alternatively, you could also use the video as the entry point to the lesson.
4. Ask students/trainees to suggest examples of when and where WSWs might be most suitable. Ask them to explain why.
5. Discuss the Guiding Questions.

Teaching methodology

Brainstorming, interactive teaching and learning, group work (listing), and discussions.

Session Plan

- 35 minutes looking at the introduction and brainstorming
- 45 minutes for the Information Sheet;
- 10 minutes for the video
- 45 minutes for the Guiding Questions;

Total time: 2 hours and 15 minutes.

Instruction sheet for Learners

1. Read the introduction with the specific learning objective for Learning Outcome 1.
2. Familiarize yourself, as a potential future construction technician/development agent, with your role in the process.
3. Read the Information Sheet on WSWs.
4. Write down any questions you have.
5. Ask your teacher for support and seek answers to your questions.
6. Try to answer the Guiding questions for discussion and discuss them with classmates about the advantages, disadvantages and other factors regarding WSWs.
7. Test your knowledge by completing the Self-Check Test.

Information Sheet

1. Historical background of WSWs

The first WSWs were introduced in Chad during the 1990s and the technology has been used and improved in Niger and Burkina Faso as well. The first generation of WSWs were built with stone-filled wire baskets, known as gabions. Unfortunately, these were prone to damage. The weir underwent continuous improvements in terms of both efficiency and durability process and the gabions were replaced with cement and natural stone walls.

The construction of WSWs was piloted and implemented in the dry lowlands of Ethiopia particularly in Afar and Somali regions to improve the livelihood and resilience of the pastoral and agro-pastoral communities in the 2010s. By introducing WSWs, it was also aimed to help effectively rehabilitate the degrading dry valleys.

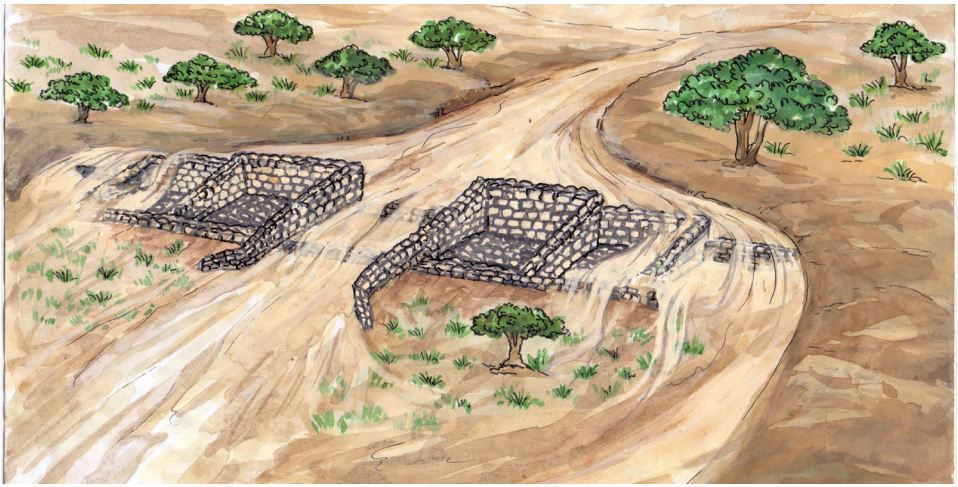


Figure 2: Illustration of Water Spreading Weir during floods

2. Definition of WSWs

WSWs are low retention walls designed to reduce runoff and erosion. They consist of a spillway in the actual riverbed and lateral abutments and wings which gradually decreases in size with increasing distance from the main structure. The abutments at the sides of the spillway are designed to protect both the WSWs and riverbanks from erosion. The abutments are only flooded in exceptional cases with extremely high floodwaters.

A WSW diverts the water to the sides in order to inundate as much surface area as possible above and below the weir. Water infiltrates, and fertile sediments are deposited on the flood area. A WSW consists of stonewalls which are divided into the structural parts of (1) a spillway in the actual riverbed, (2) lateral abutments and (3) wing walls. WSWs need specific natural landscapes, being relatively flat, with a gentle slope and with a clear gully/stream in the lower parts. They are usually constructed adjacent to or within wide riverbeds in lower parts of the watershed.

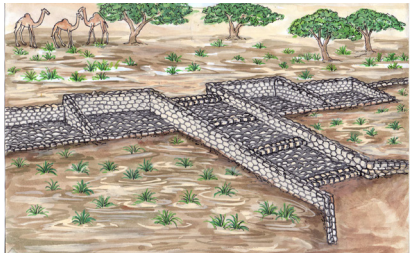


Figure 3: Water Spreading Weir along a dry stream in Afar

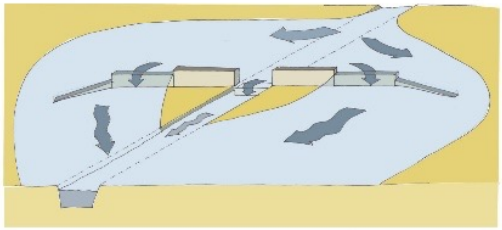


Figure 4: Schematic WSW set-up

3. Concept and special features of WSWs

The WSW concept is a technique which developed from the concept of natural resource management, combined with construction of hydraulic structures in the stream bed. The WSW has a number of special features.. Understanding these

will help to appreciate the role a WSW can play in restoring the landscape. The following features are important to be aware of:

- WSWs are not dams or barrages
- The function of WSWs is to spread flood water and its sediments, reduce the velocity of flow and enhance the water infiltration
- The water flows away from the middle of the valley/gulley to the banks.
- The effect on the downstream of the weir are often more important than the upstream.
- WSWs are especially well suited for large-scale rehabilitation of degraded wide valley floors
- WSWs are designed to stop gully erosion in valley floors
- WSWs are easier to manage and maintain than dams, they are also more economical to construct
- Siltation upstream of a high weir stabilises the weir and stores ground water / soil moisture
- WSW abutments are designed to protect both the weir and riverbanks below from erosion
- The primary uses for WSWs in the Ethiopian Lowland context are agricultural and pastoral use

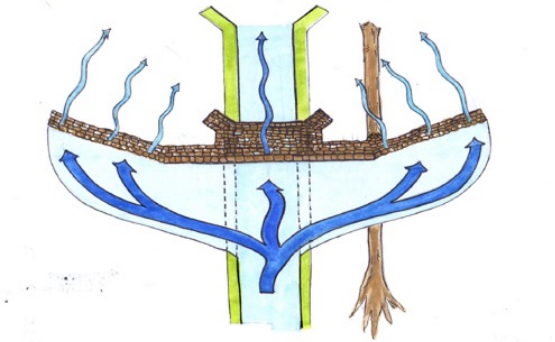


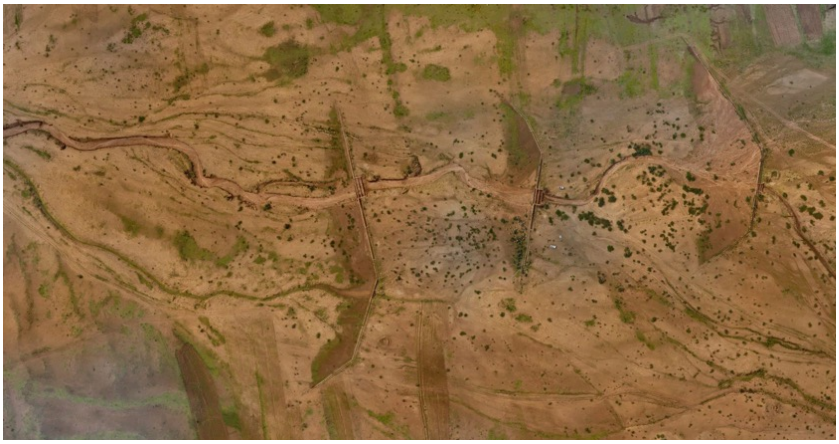
Figure 5: As a result of the WSW the water flows away from the middle of the gully to the banks

Importance of constructing WSWs in cascades.

Water Spreading Weirs modify the valley floor by increasing infiltration and retention of moisture. One weir alone will seldom solve all the erosion problems of a wide valley: weirs are usually constructed in cascades consisting of three or more WSWs, at certain intervals down the river valley, in order to reduce the speed of floodwater in steps. The construction of the cascade can take place over a series of years, depending on the development of the gully downstream and upstream of the constructed WSW.

The WSW sites over the whole cascade should be planned ahead and constructed within a time period of more than one year. The cost will hereby decrease due to sedimentation upstream of the sites and the resulting decrease on construction volume.

Water Spreading Weirs are also combined with other soil and water conservation measures such as Dry-Stone Measures (DSM) and biological conservation such as planted sisal, elephant grass or others in order to achieve the maximum result of the interventions.



Aerial view of three WSWs built in cascades

4. Advantages of WSWs

4.1. Production, resilience and livelihood potential benefits: these are often the direct benefits for rural people. Some of them are short-term benefits. These are:

- Increased resilience to effects of heavy rainfalls, such as gully formation
- Increased resilience to climate change in regions experiencing higher variability of rainfall
- Increased availability of water
- Increase of productivity through increased yields or second crop
- Increase of cultivated area
- Increased grazing area and animal production
- Increased fodder production
- Improved food security
- Increased income and possibility of livelihood diversification

4.2. Ecological benefits: these are mostly indirect benefits for rural people, with medium to long term impacts. Some of the ecological benefits are:

- Increased water availability
- Increased soil moisture
- Reduced surface runoff
- Reduced soil loss
- Reduced gully formation; or gully formation avoided or halted.
- Recharge of the (shallow) groundwater
- Increased biomass
- Increased soil organic matter
- Increased animal and plant diversity
- Improved/healthy ecosystem

4.3. Socio-economic benefits: these are mostly indirect benefits, with medium to long-term impacts. The socio-economic benefits are:

- Increased options for Income Generating Activities (IGA) and alternative skills development such as cropping, processing, water management, etc.
- Improved community organization and strengthening of community institutions, strengthening the functioning of the community.
- Improved natural resource management and conservation knowledge.
- Reduced workload for women as they have to cover shorter distances to fetch water.

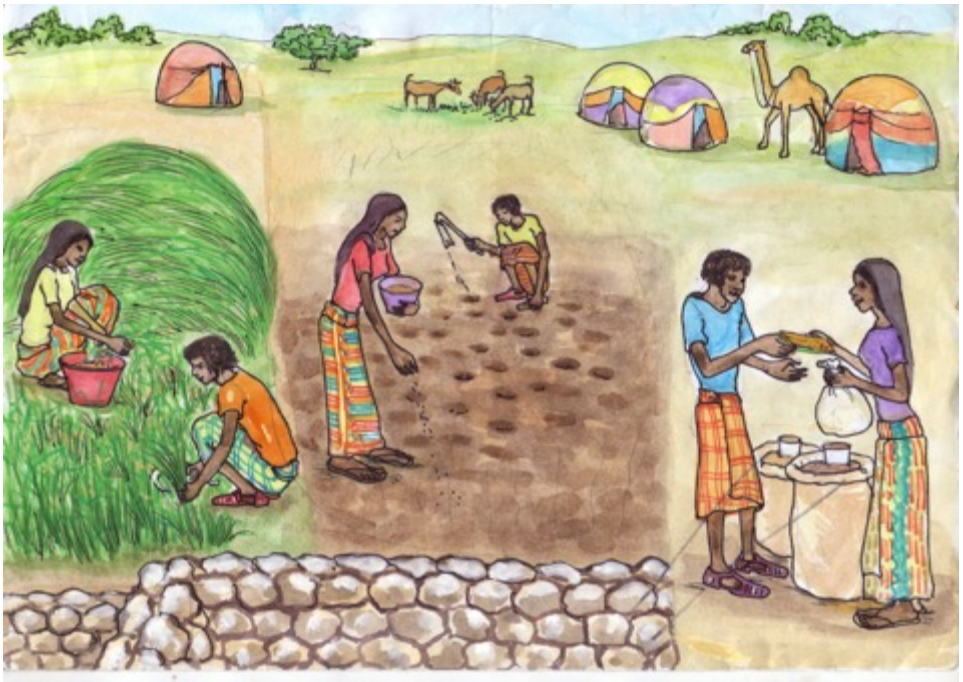


Figure 6: Benefits of WSW, growing fodder, planting vegetables and harvesting.

Guiding questions for discussion

1. Explain the benefit of a WSW to your classmate.
2. What is the basic concept of a WSW?
3. How will a WSW contribute to the rehabilitation of land?
4. How do WSWs lead to the spread of flood water to the target fields by the sides of the weir?
5. Name the structure parts of the WSW.

Self-Check Test

Name	
Date	
Time started	
Time finished	

Instructions

Answer all the questions listed below. Illustrations may be necessary to aid some explanations/answers.

Part I: Multiple Choice

1. The structural part of WSW that is constructed at the valley bottom is: **(1pt)**
    1. Counter wall
    2. Wing walls
    3. Spill over basin
    4. Micro basin

2. All options below are real benefits/functions of WSWs except: **(1pt)**
    1. Decrease water infiltration into the soil
    2. Increase water table/ groundwater recharge
    3. Trap sediments and organic matter
    4. Reduce surface run-off

Part II: Short Answer

3. Write down the Special features of WSWs? **(4 pts.)**
4. Describe the basic tip that we consider on the WSWs **(3pts.)**
5. Explain the special features of the WSWs **(3pts)**?

6. Write at least three impacts of WSWs? **(3 pts)**
Note: Satisfactory rating points 10 and above. Unsatisfactory points below 10
You can ask your instructor for a copy of the correct answers.

If your answer differs from that of your instructor for a very single point do not proceed to the next learning, rather improve the same information sheet until you feel comfortable with the new knowledge.

Score:
Rating:

Learning Outcome 2: Setting out WSWs; measurements and calculations

Introduction

Every Learning Outcome has a similar structure. In this **Introduction** you find the specific learning objectives of Learning Outcome 2 i.e. Setting out WSW, measurements and calculation. The **Instructions sheet(s)** for both the **Teacher** and the **Learner** tell what is expected from both groups. Following is an **Information sheet** that provides background information, guiding questions, and a self-test. Finalizing, when applicable, an **Operational sheet** tells you how to proceed with the implementation of what is described in the information sheet.

By the end of this Learning outcome section, you should know:

- how to read drawings
- how to carry out measurements and setting out for WSWs
- In addition, you will know the basic principle and calculations in the construction of WSWs.

Instruction Sheet for Teachers

Teachers should follow the following steps in teaching Learning Outcome 2:

1. Work through the Information Sheet.
2. Show the necessary pictures to the students about the measurement to set out.
3. Give an example for the calculation part to your students and ask them technical questions to know how they understand the measurement part.
4. Discuss the Guiding Questions.

Teaching methodology

Brainstorming, interactive teaching, and learning, group work (listing), and discussions.

Session Plan

- 25 minutes looking at the introduction and brainstorming
- 2 hours for the Information Sheet; Setting the WSWs, Basic measurements and calculations of water spreading weirs
- 15 minutes for the pictures
- 45 minutes for the Guiding Questions;

Total time: 3 hours and 25 minutes.

Instruction sheet for Learners

1. Read the introduction with the specific learning objective for Learning Outcome 2. Familiarise yourself, as a potential future construction technician, with your role in the process.
2. Read the Information Sheet on setting out, measurement and calculations.
3. Write down any questions you have.
4. Ask your teacher for support and seek answers to your questions.
5. Try to answer the Guiding Questions and discuss them with classmates
6. Test your knowledge by completing the Self-Check Test.

Information Sheet

Standards and codes

The WSW design depends on the profile of natural ground. For instance, in case of flat lands or for areas that do not have deep gullies, the design will have only one level of height. In the other areas, if the site has deep gullies and multiple gullies, the design will be different and there are basic standards and codes to know in WSW design and construction, which will come back on the design drawings of the WSW. These are:

- The height difference between counter wing, high wing and low wing under different conditions
- The maximum height difference between the main weir and low wing
- Reasons to propose counter wing heights and lengths
- Foundation, wall and basin thickness and depth, based on bedrock and soil properties.
- Masonry wall for wings and counter bearing

1. Drawing reading

Drawing from which a design is constructed is often called detail drawing because it describes and gives the dimensions of the detailed parts being presented. In the case of a WSW design, it includes drawings of the top view, elevation views and cross-sectional view. The following are the types of drawing and their contents:

Working drawing:

Drawings should be:

- Clearly representative
- Easily understandable

- Comprehensive
- Free from unnecessary notes (repetitive details)
- Accurately drawn
- Drawn with appropriate symbols and proper convention
- Dimensioned well
- Drawn by referring code
- Logically and rarely arranged to give a balanced layout on the Short paper
- Drawn in appropriate scale

Design drawing

Design drawings are concerned with the presentation of design solutions. The drawings provide information about basic structural details of the design. Such drawings are more needed to convey information about the appearance and dimensions of WSWs to the builders. Therefore, the presentation should be easily understood.

Working drawing contents

Working drawings translate the design drawings to the situation on the ground and the finished or working drawings that are made by the engineer/designing engineer, which are used by the contractor should include the following sheets.

1. Top, elevation view (side rear and front view) drawing,
2. Cross sectional view drawing

Top and Front View Drawing

The top view is horizontal plane of projection, which is plane suspended above and parallel to the top of the object. The top view of an object shows the width and length dimensions. A front view is a projection view obtained by drawing perpendiculars from all points on the edges of the part to the plane of projection.

The WSWs top and front view drawings typically contains:

- Main weir basin width
- Main wall reference height
- Masonry wall height
- Masonry foundation height coordinate points
- Alignment
- Structural total length
- Structural section division
- Structural benchmark point (zero zero)
- Basin type
- Section length
- Profile elevation
- Profile length.

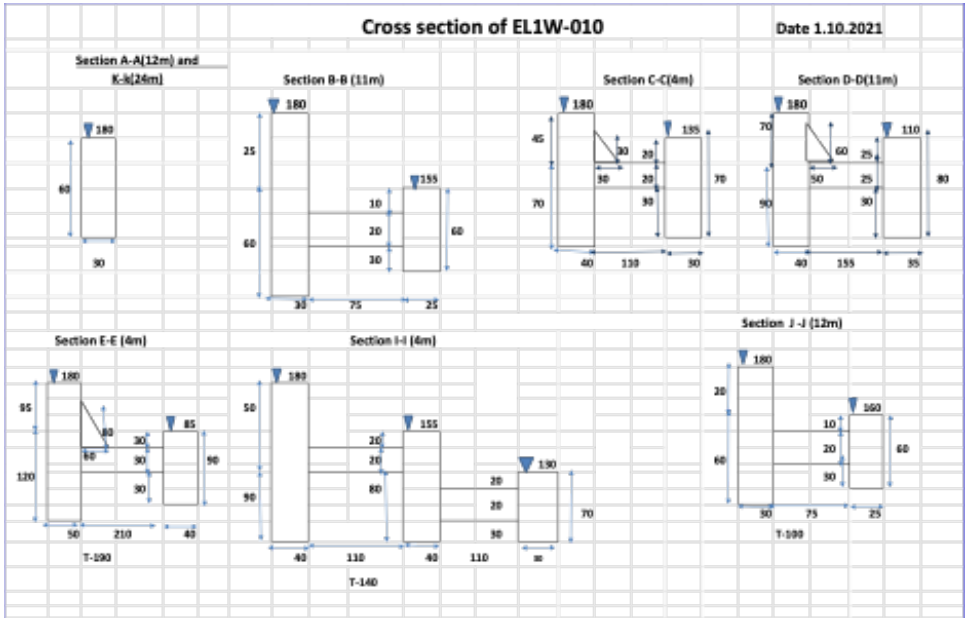
Cross sectional view drawing

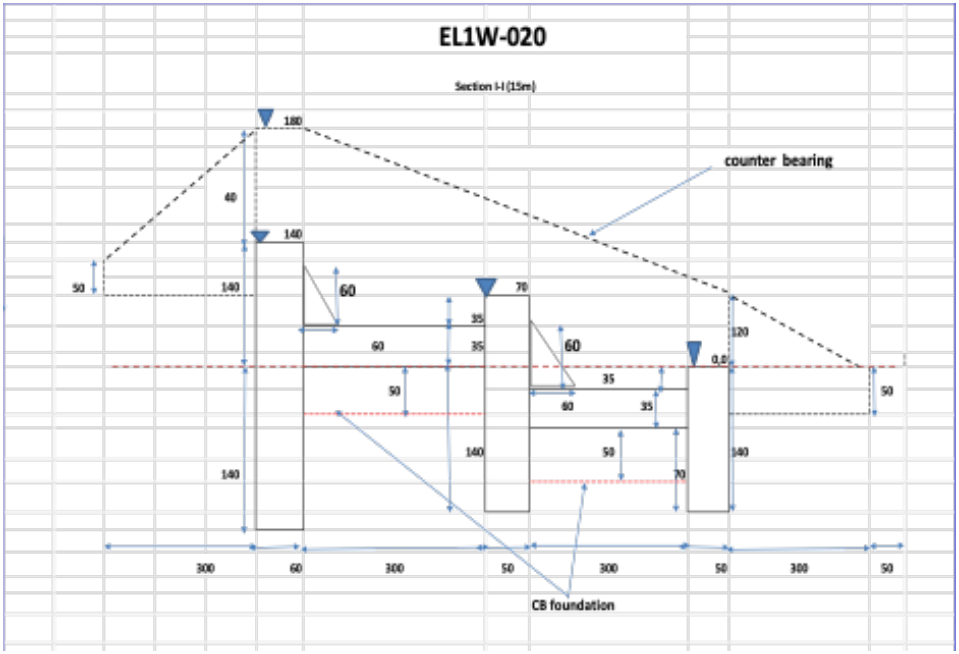
Cross sectional view or drawing that shows what the inside of something looks like after a cut has been made across it. The cross section view Detail drawing contains:

- Wall height
- Wall foundation
- Wall width
- Section length
- Basin type
- Basin height
- Basin width
- Counter wall height
- Counter wall width
- Counter wall depth

- Support wall height width
- Reference point elevation
- Counter barring width
- Counter barring height
- Counter barring length
- Side wall protection width
- Sidewall protection height
- Sidewall protection length.

Example - Cross section view drawing





2. Measurement

To construct a WSW, it is necessary to set the design on the ground There are basic measurements and calculations to be carried out to begin our construction work. In this section, we learn about the steps, measurements, purposes, and calculations we use in the construction of WSWs, which are important in the setting out of the WSWs.

Definition and purpose of measurements

Taking measurements includes determining the necessary values and targets like size, length & height, amount volume, weight, capacity, or other aspects with an instrument marked in standard units. This improves and verifies the right value and allows for the drawing to be transferred to the ground situation. In the process, the values from the drawings are translated and adapted to the ground situation, whilst maintaining the right proportions and design standards. Values that are used for the construction of WSWs are measured in the terms of scale with set of numbers. From the drawing you will establish the height/depth, width and length calculate the related volumes.

Tools used for the design and construction of WSW are:

- Measurement equipment required for measurements
    1. Water level / sprit level
    2. Survey instrument
    3. Range pole
    4. Meter (tape) 30 to 50m
    5. GPS
- Other tools required for measurements:
    1. String
    2. Hammer
    3. Iron bar or wood sticks /pegs
    4. Shovel
    5. Pick axe
    6. Machete
- Stationary
    1. Marker
    2. Pen
    3. Note book
    4. Ink/ Spray

The use of the measuring equipment is explained in the Operational Sheet.

In the next section on setting out, you will learn how to use the different tools and how to translate the values from the drawings to the values to be used on the ground.

3. Setting out

Setting out translates the technical plan to the reality on the ground by placing wooden sticks and other markers to guide the construction of the WSW. Setting out of the WSW is essential in order to understand exactly how construction will be done and to show technical profile, which indicates heights, diameters, lengths and reference points of the planned structure, that have been drawn and finalized by the technical team.

Before the setting out can take place, the site needs to be cleared. Site clearance is essential because the construction may be made in different type of earth structure like at rangeland plain, bush and forest or at farm areas. So, it has to have the right measurements by visualizing and measuring the exact values in our drawing. Clearing the site will make the setting out and taking the measurements easier.

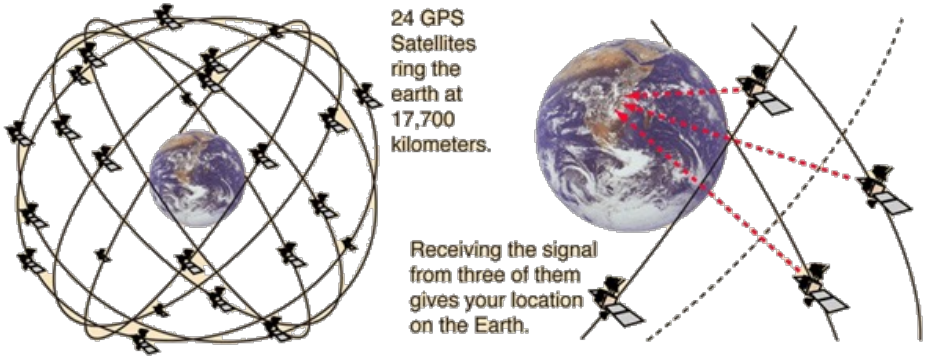
Figure 7: Setting out the WSW

Layout and GPS

Layout is the practice of transferring the design onto the land itself. This process locates the fixed points in every boundary and other necessary structural parts in accordance with the drawing and marks them on the site through wooden sticks or pegs.

To locate the points a GPS (global position system) device can be used. The GPS device uses a network of satellites to determine positions on the globe and provides you with a reference coordinate. The GPS system can be used to identify important locations and boundaries, as shown on the drawing. You should

measure initial, finial and other necessary points in the structure of the WSW, according to the drawing and record them for future reference.
Depending on type of GPS device used, the number of satellites available, and whether a base-station is used, GPS typically has an accuracy of 0.3 – 5.0 meters. The below picture shows how signal from different satellites is combined into a GPS location.



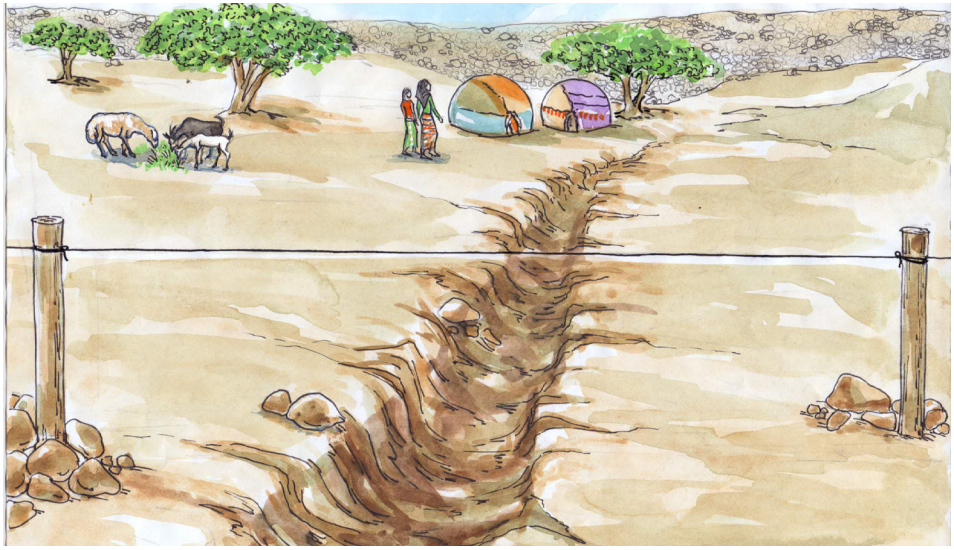
Source: http://hyperphysics.phy-astr.gsu.edu/hbase/gps.html

An example of the GPS points of a constructed site, taken after construction has finalized, in which the coordinates of the boundaries/corners of the structural elements are noted down.
The format of the GPS coordinate is Degrees (°), Minutes (') and Seconds ("), together with a North (N) – South (S) and East (E) – West (W) indication.

	N	E
LEFT END	12°15’ 44.5’’	39°54’17.01”
CENTER OF MAIN WEIR	12°15’ 42.4’’	39°54’18.2”
RIGHT TURNING	12°15’ 38.4’’	39°54’22.6”
RIGHT END	12°15’ 37.6’’	39°54’23.0”

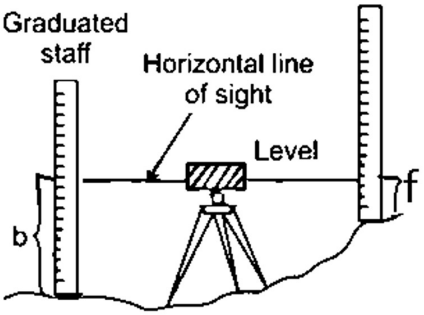
Adjust the alignment

Setting out on uneven ground, and particularly measuring distances, require you to apply some simple geometry. It means to arrange the values in a straight line or in correct relative position. In our case, we adjust the horizontal alignment by connecting the structure end to end using the top view of the design and GPS points by putting wood or range pools for each section as markers of the location.



Measure the height of wall

WSW has different types of wall, so we adjust the height of the wall by putting marks on wood for each section using the design.



How to calculate the main wall height?

- setup survey instrument
- staff read Benchmark (BM) and calculate
- BM(0,0)- B= F

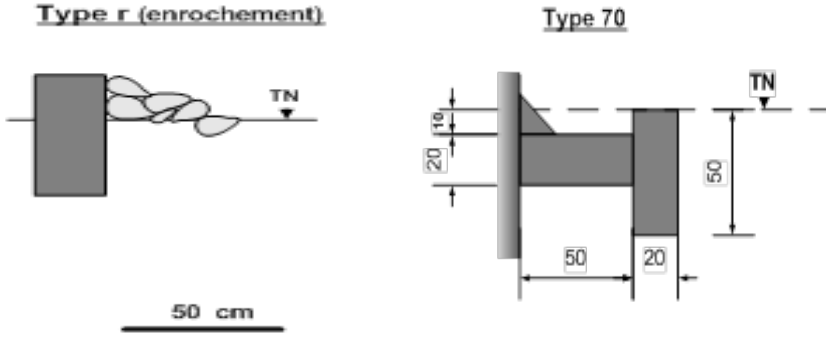
Note:
- BM = lowest point of elevation (0,0),
- B = height of main wall,
- F = main wall staff reading value

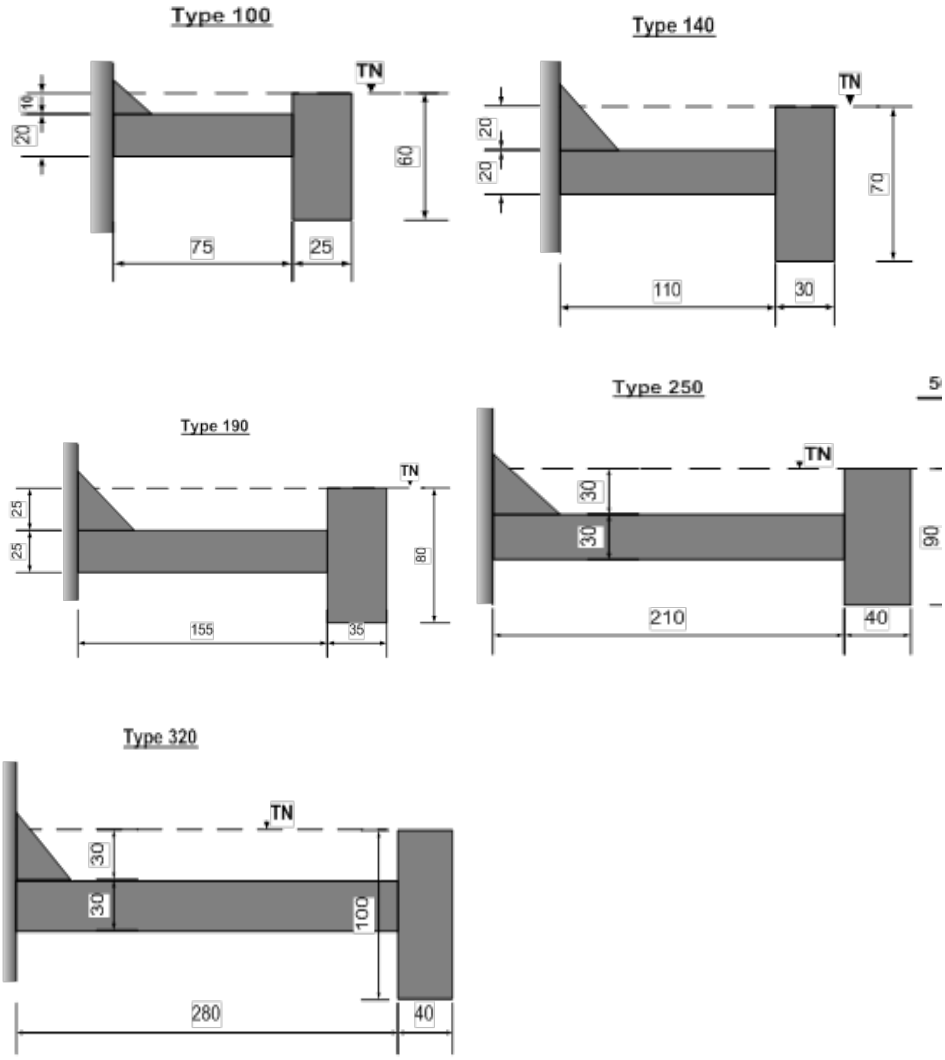
Measure basin depth and width

The basin structure is an important element of a WSW. The water discharge from the main wall upstream might have a high velocity and, therefore, high erosion potential. The basin will provide a barrier to the area of high velocity flow that reduces the velocity before the water returns back to the natural river channel downstream of the structure. This is important to prevent undercutting of the structure.

In the construction of WSW there are different basin types that depend on the natural ground conditions so we should use the right basin type in each section using cross-sectional design or side view drawing.

Below are design drawings of the different basin types, with their respective names.



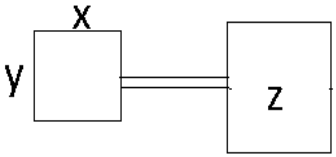

Type 100
TN
10
20
60
75
25
Type 140
TN
20
20
70
110
30
Type 190
TN
25
25
80
155
35
Type 250
TN
30
30
90
210
40
Type 320
TN
30
30
100
280
40

Measure counter wall height

Water returns back to the natural river channel downstream of the structure. Therefore, the counter wall reduces erosion on the downstream side of the WSW as the construction of the structure is levelled with the original ground level, the counter wall slows down the water and prevents a large drop by the water. Therefore adjusting the counter wall height construction point is critically important, in order to ensure the counter wall is constructed sufficiently deep below the ground field level. This can be done by putting marks on wood for each section. Here is an example of how to calculate counter wall.

How to calculate counter wall

X+Y=Z



X (top main wall) + Y (wall height) = Z (counter wall)

The height of the counter wall (including the part below the ground) is based on the level of the main wall (top main wall = X) plus the wall height of the main wall (Y) relative to the ground level.
Note that the design may change after setting out work because the height of counter wall will be different from the place where the profile was collected. So, adjustment is needed based on the prepared design and the actual terrain.

In the setting out process, it is important to include a reference for wall height, counter wall height and also for the mass excavation. These references will function as a reminder of the design measurements of the Water Spreading Weir and during the excavation it is important not to loose the references.

4. Principle of WSWs and calculation of quantities

Principle

In the introduction it was explained that one of the principles of WSWs is water and soil conservation. What WSWs do is cause temporary flooding of the adjacent land area above and below the weir. The function of a WSW is to facilitate for the water to flow from the centre of the valley to the sides. The effect on the land downstream of the weir is often more important than upstream effects. Thus, the main aim of the WSW is to flood the valley, in order to prevent and reverse gully formation. In addition, it helps the flooding of the valley with water, leading to additional infiltration of moisture, which can, as an example, be utilized in crop cultivation.

Standards and codes

The WSW design depends on the profile of natural ground. For instance, in case of flat lands or for areas that do not have deep gullies, the design will have only one level of height. In the other areas, if the site has deep gullies and multiple gullies, the design will be different and there are basic standards and codes to know in WSW design and construction. These are:

- The height difference between counter wing, high wing and low wing under different conditions
- The maximum height difference between the main weir and low wing
- Reasons to propose counter wing heights and lengths
- Foundation, wall and basin thickness and depth, based on bedrock and soil properties.
- Masonry wall for wings and counter bearing

The standard and codes will be further explained in the next section.
A WSW has different height levels or steps and these are part of the structures in WSW. The structures (elements) in the WSW are:

1. Counter bearing wing
2. High wing
3. Low wing
4. Spillway
5. Counter weir and counter wall.

We should know and consider all those parts of the structure while we design and construct.

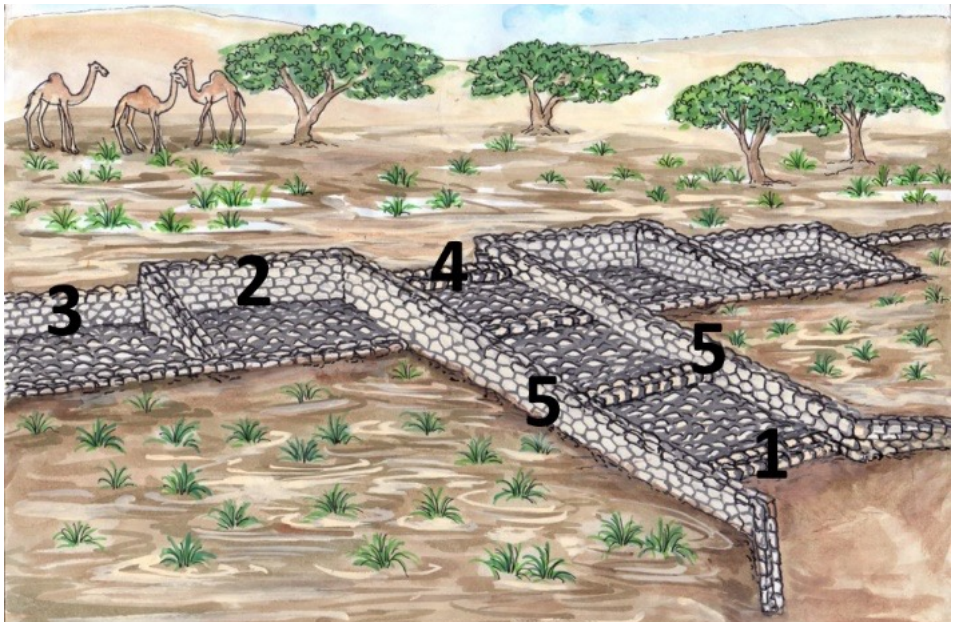
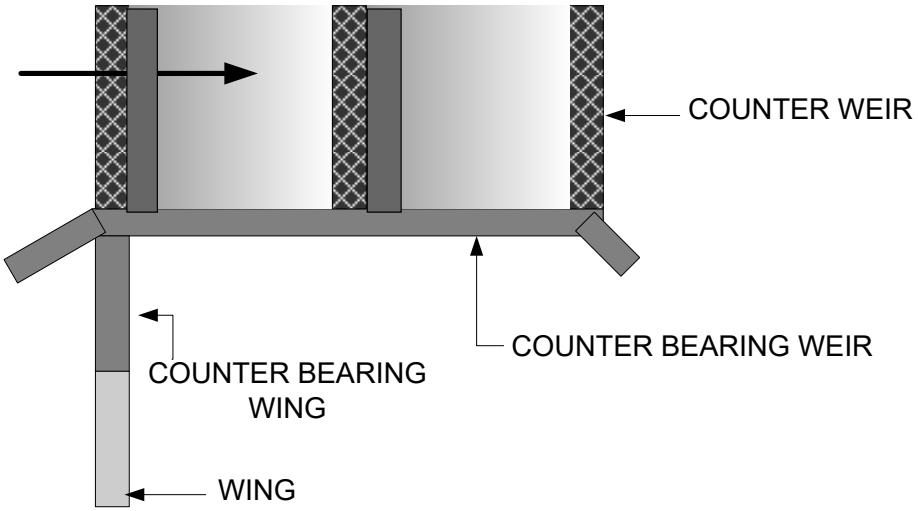


Figure 8: Elements of the Water Spreading Weir

Basic tips to know

- Know the type of the main weir, whether it is single, double or triple. Decide based on the main weir the maximum wall height. This height is important or the only input to decide for the weir to be single, double or triple basin and how much the width of each basin should be.
- For the foundation depth and thickness, we use the wall height from the profile design.
- Strictly follow the standard types of basin types and decide based on:

    1. wall height
    2. expected water layer. Using those two inputs we can look at which basin type is appropriate for which section.



Standards and Codes for WSW design

The procedures on how to read the design and how to set out the right measurements have been covered in the previous information sheet

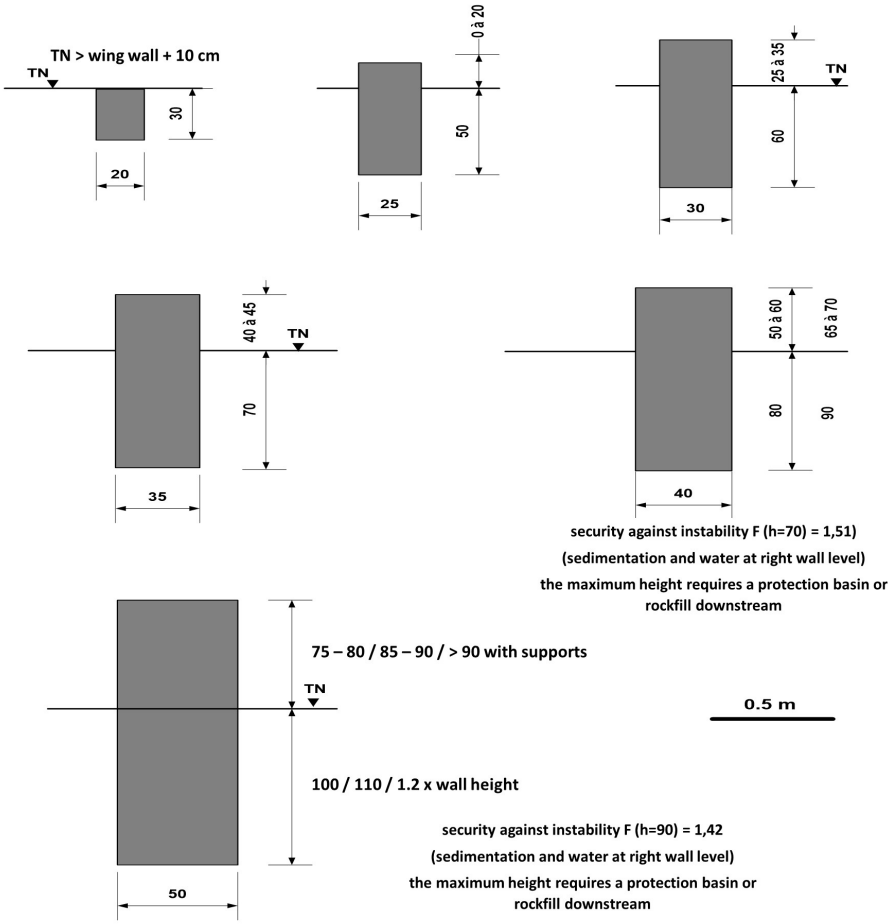


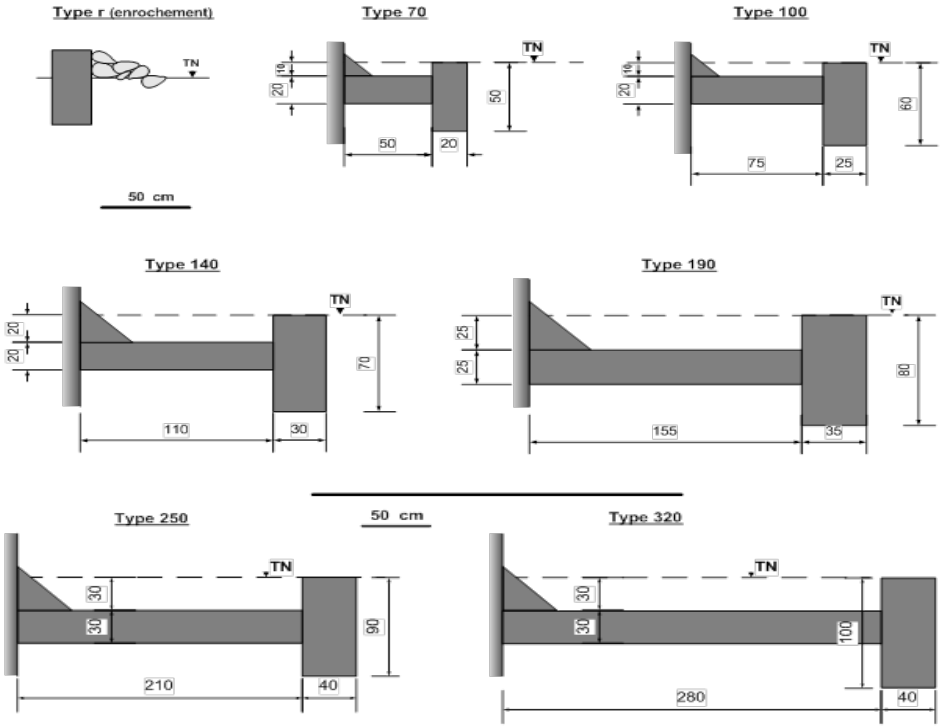
Table:

height H [cm]	Impermeable Curtain [cm]	Absorption basin[1)] [cm]		size wallets [cm]	
		Sbd1	Sbd2	weir	alongside
Simple weir					
50 à 70	80	200 à 350	-	50	50
75	90	250 à 500	-	50	50
80	100	250 à 500		50-60	50-60
Double weir					
100 à 140	80	200 - 450	200 - 450	50	50
145 à 150	90	250 - 400	250 - 300	50	50
155 à 160	100	250 - 500	250 - 500	50-60	50-60

Table:

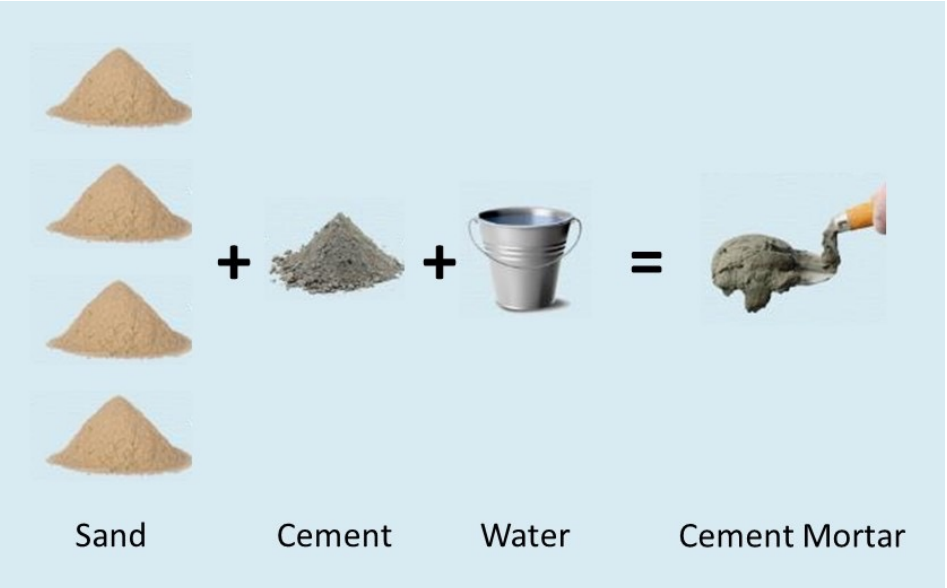
Water layer [cm]	Height for counter bearing or wing [cm]					
	20 - 25	30 - 35	40 - 50	55 - 70	75 - 90	> 90
0 - 10	r/70	r/70	70	70	100	100
10 - 20	r/70	r/70/100	100	100	140	140/190
20 - 35	r/70	70/100	100	140	190	190
35 - 50	70	100	140	190	250/320	SC
50 - 70	100	140/190	250/320	SC	SC	SC
> 70	100	190/250	SC	SC	SC	SC

SC: Special Condition section


Type r (enrochement)
TN
Type 70
TN
10
20
50
50
20
Type 100
TN
10
20
60
75
25
50 cm
Type 140
TN
20
20
70
110
30
Type 190
TN
25
25
80
155
35
50 cm
Type 250
TN
30
30
90
210
40
Type 320
TN
30
30
100
280
40

Estimation quantities

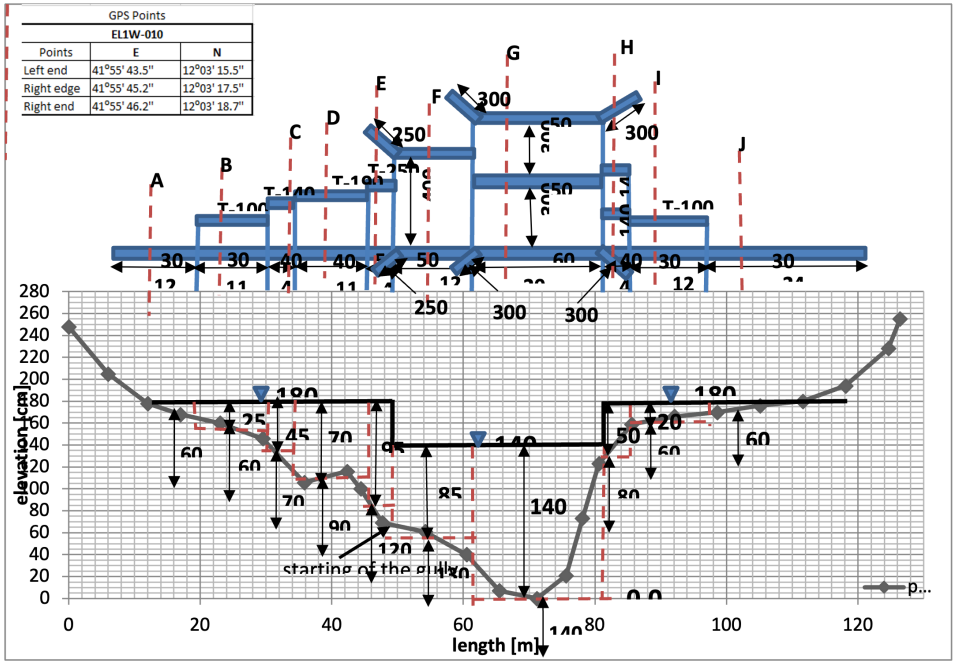
A quantity estimate includes a list of quantities needed to complete a project. Its purpose is to give the client a complete list of all the quantities required for the project and what the cost will be for each quantity, we can estimate the cost of construction or unit cost of masonry. In the masonry work we use the stone type of rubble stone. For mortar work cement to sand ratio is 1: 4 this means using 20% cement and 80% of sand.



In the construction of WSWs, it is recommended to use bigger stones which has an effect on mortar ratio. As per this assumption: the ratio will go up to 20 % to 80%. Under this assumption, the required amount of materials per m3 of masonry work is:

Material/ Labour	Quantity	Comment
Cement	0.7 – 1.0 Quintal or 70 – 100 kg	
Stone	1.00 – 1.25 m^3.	For 1 m^3 of stonework you require `1.25 m^3 of stone to compensate for wastage during construction
Sand	0.32 m^3 or 8 measurement boxes	One box equals to 0.40m*0.50m*0.20m= 0.04 *8 = 0.32m3
Water	100 – 300 litres	
Masons	3 m^3/day/person	The average daily performance of mason per day is 3m3.
Daily labour		Depending on the site requirements and distances for the transport of materials
Excavation	4 – 10 m^3/day/person	The volume of work is based on the type of the soil, if the soil contain too much moisture, it is difficult to excavate. In this case the average volume of excavation by a single person is 4-5m3. On other hand if the soil contain less moisture, a single person can excavate 8-10m3 per day. For excavation cost estimation is required

Example of constructed water spreading Weir quantity estimation.



Example:- Calculate volume of work for section A

- Section A
- Length=12m
- Wall height above ground=0.5m
- Basin type=T140
- Wall strength (width)=0.5m
- Wall foundation (depth)=0.7m

* Masonry foundation M3

- =Length × width × depth
- =12m × 0.5m × 0.7m
- = 4.2 M3

* Excavation
    - ~mass excavation
    - =T140 × length
    - =1.10m × 0.5m × length
    - =1.10m × 0.5m × 12m
    - = 6.6 M3
* Counter wall excavation
    - =T140 × length
    - =0.2m × 0.3m × length
    - =0.2m × 0.3m × 12m
    - =0.72 M3
* Masonry wall above ground
    - =Length × height above ground × width
    - =12m × 0.5m × 0.5m
    - =3 M3

Summary	Total (M3)	Total
Mass Excavation	6.6	
Counter wall excavation	0.72	Total excavation = 6.6 + 0.72= 7.2 m3
Masonry foundation	4.2	
Masonry wall	3.0	Total masonry = 4.2 + 3.0 = 7.2 m3

Guiding questions for discussion

1. What is the importance of measurements and calculations?
2. State all the measurements in WSW.
3. What are lay out and GPS points?
4. Define the term horizontal alignment and tell to your classmates the purpose of adjusting an alignment.
5. Discuss about the meaning, purpose and types of basin.

Self-Check-Test

Name	
Date	
Time started	
Time finished	

Instructions

Answer all the questions listed below. Illustrations may be necessary to aid some explanations/answers.
Part I: Multiple choice

1. which part is the first step of layout? (1pt)
   - Basin high
   - wing wall high
   - alignment
   - all of the above

2. Which one is the standard basin height of type 250? (1pt)
   - 25
   - 80
   - 50
   - 70

3. Which construction tool is used to check height of the counter wall? (1pt)
   - meters
   - survey instrument
   - water level
   - all of above

Part II: Short answer

1. How can we get main wall height using survey instrument? (4pt)
2. What is the use of GPS? (3pt)
3. List the parts of the water spreading weir structure. (3pt)
4. What is the use of horizontal alignment? (3pt)

Rating

Note- Satisfactory rating points 10 and above. Unsatisfactory points below 10.
You can ask your instructor for a copy of the correct answers.
If your answer differs from that of your instructor for a very single point do not proceed to the next learning, rather better work on the same information sheet until you acquire all the necessary information

Score:
Rating:

Operational sheet

The DA/construction technician can implement the weir construction with the community together. As DA/Construction technician, you will know and implement all the necessary steps and processes in the weir construction. This includes how to read the design drawing, setting out the structure on the ground, knowing the basic principle and calculation for the construction. In addition to this you should to implement and supervise closely the community in order to construct the right weir for the community.

Objective

To educate the students how to construct the WSW and give all the necessary knowledge and skill to construct the right spreading weir to the community.

Examples of required Instruments

1. Steel tapes

2. Automatic Levels

3. Water level / sprit level,

4. GPS device

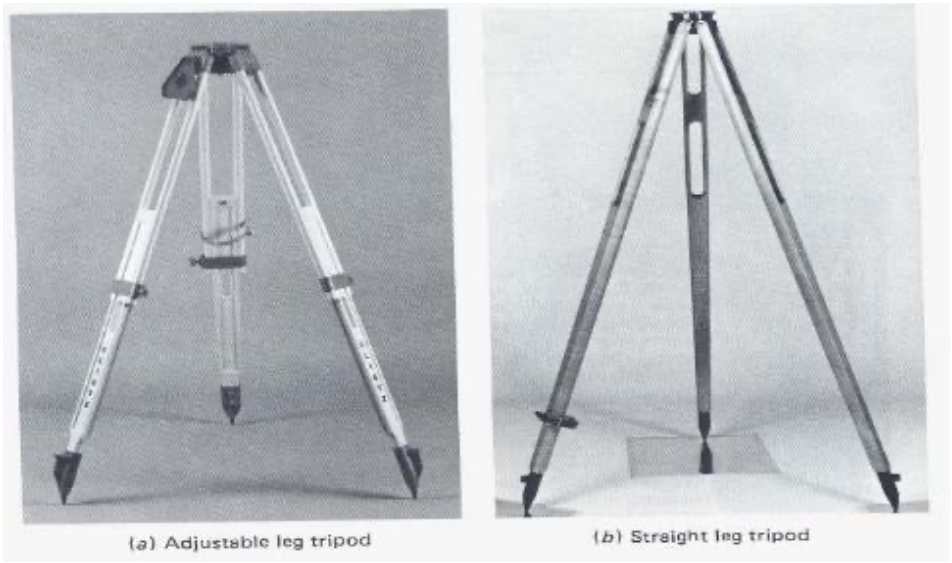
5. Additional instruments:

Spray, string, range pole, meter 50m, marker, pen, note book, hammer, iron bar or wood sticks / pegs, gravel, shovel, pick axe, machete.

How to measure

Setting Up and Levelling the Instrument
The level must be securely mounted on top of a three-legged wooden or aluminium stand called a tripod. Two basic types include an adjustable-leg tripod and a fixed-leg tripod.

1. The adjustable leg model is convenient for setups on steeply sloping ground and is more easily transported when closed.
2. The fixed leg type is more rigid and provides greater stability for precise levelling work.



(a) Adjustable leg tripod

(b) Straight leg tripod

3. The instrument is either screwed directly on to the tripod head or attached with a fastening screw assembly.

(c) Tripod head adaptor

4. Levelling is done by screwing the instrument, indicated by the coincidence of a spirit bubble and 'bull's-eye' of a circular level vial. It must always be kept in mind that turning any screw on a three-screw level slightly changes the HI (height of the instrument).

Note: Never turn a levelling screw of a three-screw levelling head once a BS (backsight) reading has been taken and an HI established.

LAP-Test

Name	
Date	
Time Started	
Time finished	

General instructions

Task - Setting up the levelling instrument following the necessary steps.

- You are to accomplish the tasks provided in the specific instructions.
- You are given 30 minutes to complete them.
- All your questions and clarifications should be addressed to the teacher only.
- Submit the documented results of your tasks to your teacher upon completion.

Learning Outcome 3: Excavation

Introduction

Every Learning Outcome has a similar structure. In this Introduction you find the specific learning objectives of Learning Outcome 3 (Excavation). The Instructions sheet(s) for both the Teacher and the Learner tell what is expected from both groups. Following is an Information sheet that provides background information, guiding questions, and a self-test. Finalizing, when applicable, an Operational sheet tells you how to proceed with the implementation of what is described in the information sheet.

By the end of this Learning outcome section, you should:

- Understand the importance of excavation, site clearance, and how to prepare for excavation.
- Be able to know how to check the excavation and type of excavation we used for WSW construction.

Instruction Sheet for Teachers

Teachers should follow the following steps in teaching Learning Outcome 3:

1. As you go through this Learning Outcome section together with your class, do not start by lecturing them about Water Spreading Weirs from the Information Sheet. Instead, read the Introduction with the specific learning outcome with them.
2. Look at Information Sheet. Go through each excavation step, one by one, using the illustrations and asking students to explain each step to their classmates.
3. Then go through the guiding questions and ask the students to try answering them, especially the more technical questions.
4. Take your group out of the classroom for ten minutes and look for the

excavation and specify type of excavation and know how to check the excavation work.

5. Finalize the Learning Outcome using the guiding questions of the Operational Sheet.

Teaching methodology

Brainstorming, interactive teaching, and learning, and discussions.
Session Plan

- 30 minutes for introduction and brainstorming
- 45 minutes for Information Sheet
- 60 minutes for the outdoor exercise
- 45 minutes for the Operational Sheet
  Total: 3hours.

Instruction sheet for Learners

1. Read the Introduction.
2. Work through the Information Sheet (construction steps) and note down any clarification questions you have.
3. Ask support from your teacher to get answers to your questions.
4. Try to answer the guiding questions and discuss them with your classmates.
5. Note down any extra questions for your teacher and get the answers from them afterwards.
6. Complete the self-check test.
7. Continue with Information Sheet on dos and don’ts.
8. Try to answer the guiding questions.
9. Note down any extra questions for your teacher and get the answers from them afterwards.
10. Complete the self-check test.
11. Work through the Operational Sheet and again try to answer the guiding questions.
12. Complete the LAP-Test.

Information sheet

1. Importance of excavation

Excavation is the process of removing earth, rock and other materials with a tool or equipment. Next to proper setting out, conducting proper excavation will ensure quality of construction work. Accordingly, excavating as per the design is obligatory. In the excavation process we implement two steps:

1. mass excavation
2. trench excavation.

Excavation is important for the following reasons:

- To bring the sub grade to the required level, grade and line.
- To remove unsuitable materials from the sub grade
- To prevent saturation of soil in a service or if the water cannot be removed to neutralize any bad effects by the use of appropriate materials that are stable even when saturated.
- Excavation will contribute for assuring the quality of construction work
- To install bedding materials.

2. Site clearance

The preliminary site works for a construction begins with site clearance. The WSW will be constructed at the allocated site. The site can be at rangeland, plain, forest or farm, thus with different types of vegetation. Therefore it is necessary to clear the site before starting the excavation work. All vegetation such as bushes and scrubs, should be removed. The roots of trees and bushes must be dug out and cleared away for the area where the WSW will be constructed. Special attention shall be given to the ecology- careful removal of rare tree and animal species could be required.

3. Preparation for excavation

To start the excavation work, we should prepare the materials and tools required for the excavation. After site clearance, we will tie a rope on the right place, which is remarked while in the setting out and assign laborers in each section to start the excavation. Next, we start the mass excavation.

4. Mass excavation

It is the process of removing a large volume of soil, the first step is mass excavation, we excavate the basin per its design. We use counter wall reference and mass excavation reference considering the basin type. Mass excavation should be conducted as per the given reference depth. The fertile topsoil shall also be removed with care.

5. Check out mass excavation

Mass excavation completion should be checked by measuring the width and depth of the excavation by using the meter and levelling instrument.
For example:- if the proposed basin is type T-190, the depth of mass excavation is 50 centimetres from counter wall reference, and the width of the basin is 190 centimetres plus wall thickness. This is to check that mass excavation is our exact value.

Figure 9: Excavation

6. Trench excavation

Trench excavation is an excavation to open a narrow opening in the ground. This is excavated after the mass excavation. We excavate to the main wall and counter wall to make the structure strong, this is the foundational work for the WSW. The main counter wall trench excavation will continue after the mass excavation.

7. Check out depth and width of the trench excavation

Depth and width of counter wall and main wall. These should be checked before starting the construction work. But, in case of special conditions where construction is challenging, such as sandy soil, the depth of main wall foundation will be adapted, that means we increase the depth of the excavation.

Figure 10: Trench Excavation

8. Excavation water reservoir

The reservoir is a tank we use to store water for our construction. We excavate a reservoir during construction time, the length and width equal to 3m and the depth is 1m. And the reservoir is lined with a plastic sheet to avoid the infiltration of the water also it helps us not to lose the water. We decide the number of our reservoir based on the length of the structure.

9. Cleaning and throughout the excavated soil

After excavation, we should clear our working area by depositing the excavated soil at least 1 meter away from the construction area, on the upstream side of the structure. This shall be done without affecting the soil structure- top soil shall be dumped on top. It is kept at the upstream area to avoid downstream erosion and to avoid for the material to fall back into the excavated area. Excavated water reservoirs shall be filled with the excavated material and levelled.

Figure 11: Cleaning the excavated area

Guiding questions for discussion

1. Discuss the importance of excavation? And type of excavation we use for?
2. What are the major points to check the excavation work?
3. What is reservoir means and why do we excavate a reservoir?
4. Discuss about the excavation work and its step?
5. why should the excavation depth be adjusted in the case of sandy soils?
6. why should the excavated materials deposited upstream of the building site?

Self-Check Test

Name	
Date	
Time started	
Time finished	

Instructions

Answer all the questions listed below. Illustrations may be necessary to aid some explanations/answers.

Part I: choose the best answer

1. Which part is the first step of Excavation? (1pt)
   - trench excavation
   - mass excavation
   - all of the above

2. How much is the standard mass Excavation depth of type 250? (1pt)
   - A.30
   - B.80
   - C.50
   - D.70

3. Which construction material can check excavation depth and width? (1pt)
   - meters
   - survey instrument
   - water level
   - all of above

Part II: short answer

1. Explain the use of Excavation? (3pt)
2. How can we measure depth of Excavation? (3pt)
3. Why the excavation soil should be back fill? (3pt)
4. What you will do if the excavated soil type is sandy soil? Write the solution you will do and explain why? (4pt)

Rating

Note Satisfactory rating points 10 and above. Unsatisfactory points below 10.
You can ask your instructor for a copy of the correct answers.
If your answer differs from that of your instructor for a very single point do not proceed to the next learning, rather better work on the same information sheet until you acquire all the necessary information

Score:
Rating:

Operational sheet

As construction technician you will know the importance of excavation, necessary steps and preparations for the excavation work, in addition to this you should to implement and supervise closely the community in order to construct the right weir for the community.

Objective

To educate the students how to construct the water spreading weir and give all the necessary knowledge and skill to construct the right spreading weir for the community

Excavation process

1. First assign laborers and clean the site
2. Preparation for excavation means tie rope on the right place and start the excavation
3. Mass excavation
4. Check out mass excavation
5. Trench excavation
6. Check out the depth and width excavation
7. Excavate water reservoir based on the design
8. Cleaning and throughout the Back Fill Soil

LAP-Test

Name	
Date	
Time Started	
Time finished	

General instructions

- You are to accomplish the tasks provided in the specific instructions.
- You are given 1 hours to complete them.
- All your questions and clarifications should be addressed to the teacher only.
- Submit the documented results of your tasks to your teacher upon completion.

Task

Excavate and prepare a part of the WSW basin. Bringing all tools we use for excavation.

Learning Outcome 4: Constructing Water Spreading Weir

Introduction

Every Learning Outcome has a similar structure. In this introduction, you find the specific learning objectives of Learning Outcome 4. The Instructions sheet(s) for both the Teacher and the Learner tell what is expected from both groups. Following is an Information sheet that provides background information, guiding questions, and a self-test. Finalizing, when applicable, an Operational sheet tells you how to proceed with the implementation of what is described in the information sheet.

By the end of this Learning outcome section, you will

- Understand the basics of water spreading weir construction
- How to use surveying instrument during construction
- How to calculate height and depth of Water spread Weir structure using surveying instrument during construction
- Construction steps of water spreading weir structure
- How to manage labour and construction materials

Figure 12: Building the basin

Instruction Sheet for Teachers

Teachers should follow the following steps in teaching Learning Outcome 4:

1. As you go through this Learning Outcome section together with your class, do not start by lecturing them about the construction of WSWs from the Information Sheet. Instead, read the Introduction with the specific learning outcome with them and brainstorm ideas about what they expect to learn from this Learning Outcome.

2. Start from the Introduction; what do we want to achieve from this Learning Outcome?
3. Before starting with Information Sheet (construction steps), ask the students to mention all steps that have already been completed
4. Look at Information Sheet (construction steps). Go through each construction steps
5. Then go through the guiding questions and ask the students to try answering them, especially the more technical questions. If you think it is necessary and helpful to increase memorization of the construction steps, think of your own additional questions to ask.
6. Continue with Information Sheet on dos and don'ts. Repeat the same procedure as for the previous Information Sheet

Teaching methodology

Brainstorming, interactive teaching, and learning, and discussions.

Session Plan

- 45 minutes for Information Sheet – construction steps
- 20 minutes for Information Sheet – do and don'ts
- 2 hours for the outdoor exercise
- 40 minutes for the Operational Sheet
  Total 3 hours and 45 minutes

Instruction sheet for Learners

- Read the introduction with the specific learning objective for Learning Outcome 4. Familiarise yourself, as a potential future development agent, with your role in the process.
- Work through Information Sheet (construction steps) and note down any clarification questions you have.
- Ask support from your teacher to get answers to your questions
- Try to answer the guiding questions and discuss them
- Note down any extra questions for your teacher and get the answers from them afterwards
- Complete the self-check test
- Continue with Information Sheet on dos and don'ts
- Try to answer the guiding questions
- Note down any extra questions for your teacher and get the answers from them afterwards.
- Complete the self-check test
- Work through the Operational Sheet and again try to answer the guiding questions
- Complete the LAP-Test

Figure 13: Construction site for a Water Spreading Weir

Information sheet

1. Preparation of mortar

Mortar is a jointing medium in masonry work. To prepare cement mortar, we use three ingredients: cement, sand, and water (free from clay and other impurities) with proper proportions. The mortar is prepared manually by hand mixing the three basic ingredients (i.e. cement, sand, and water). This improves certain characteristic of mortar as follows:

- Improve workability.
- Accelerate setting or hardening.
- Reduce heat evolution.
- improve durability.
- Import waterproofing properties.
- Reduce shrinkage during setting.

2. Mixing ratio

The standard mortar mixing ratio is one part cement to three parts sand. This varies depending on the type of mortar you need for your construction. Usually for WSWs we use 1:4 it means one bag of cement with 4 parts of sand. Ensure the cement and sand is completely mixed before adding the water. On the construction of WSWs a mixing ratio error can cause a structural damage. The most commonly mix batching boxes size is 50 cm x 40 cm x 20 cm. Method of Batching is done in two ways:

1. By volume (volume batching): this is used in WSW construction.
2. By weight (weight batching)

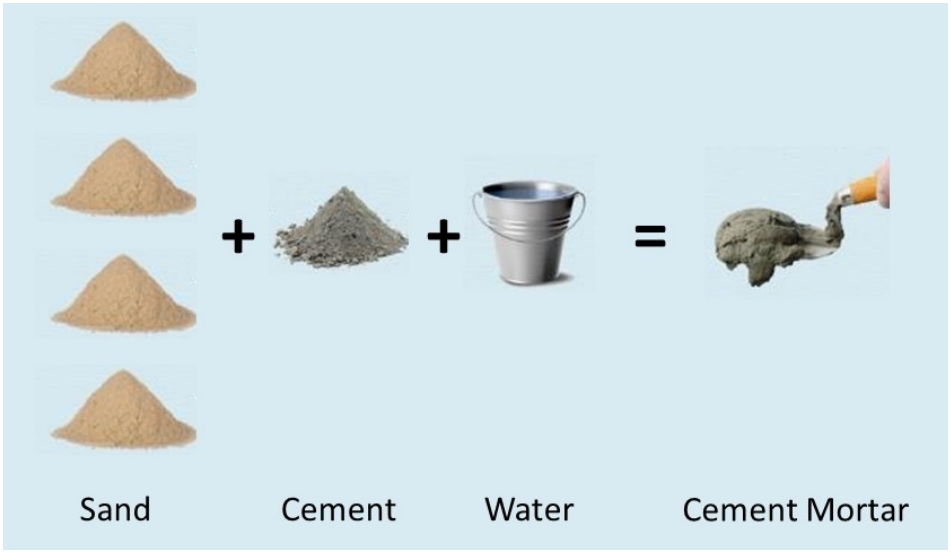

Sand
Cement
Water
Cement Mortar

Figure 14: Mixing the mortar with sand, cement and water

1. Weight batching

Batching of cement - Cement is always measured by weight. Mostly it is used in terms of bags. One bag of cement weighs 50 Kg with a volume of 35 litres (0.035m3). Cement should not be batch by volume because its weight per unit volume varies according to the way the container is filled.

2. Volume batching

Batching by volume - a gauge box, with standard measurements, is used for batching sand by volumes is shown in the figure below. The box should not be too shallow. It should be completely filled with sand.

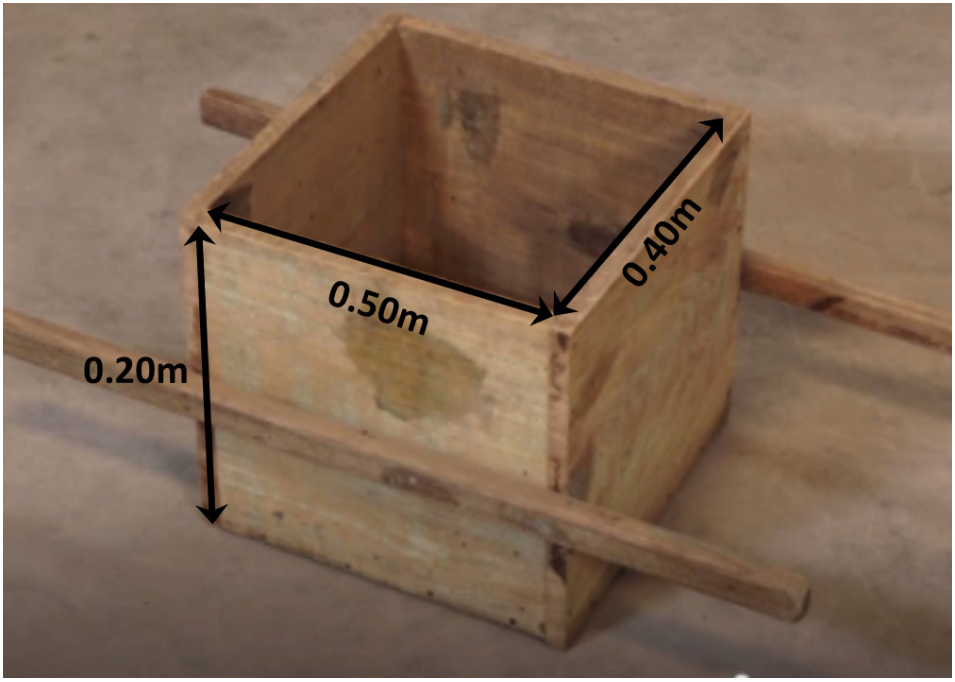


Figure 15: Gauge box used for volume batching

Working procedure

Following is the stepwise procedure for mixing mortar (Mixing procedure).

1. Spread out a measured quantity of sand evenly on the mixing platform
2. Spread to cement uniformly on this sand and mix it till the colour of the mixture is uniform
3. Spread this mixture evenly again on the platform and pour water slowly into it half to three quarters of the total quantity required and start remixing taking care to see that no water escapes the mixture. Do not make the mortar too wet as it will make the application more difficult.
4. Normally mixing time should not exceed 3 minutes

Note:-

- The mixed mortar should not be left unused more than 45 minutes, Because it will lose its strength due to the chemical reaction of the ingredients. Also once the cement is wet, we should not use it again, it will lose the strength. Therefore we should only prepare the required amount of mortar for the construction. If we have more mortar than needed we should cover it with a plastic sheet to avoid drying of the mortar within a few minutes.
- At the end of the day do not forget to wash the mixing platform or surface and hand tools to clean them and avoid hardening of the mortar on the tools.

Information Sheet 2 – Constructing Water Spreading Weir

1. Material quality (physical test on the field)

Quality is a standard of materials, maybe the standard in their rate, thickness, height, or appearance.

Quality Control: Inspection, testing, or examination to ensure materials and products were produced to conform to specified requirements. In the construction of WSWs there are some field tests to know the material quality and here are some of them.

- Sand should be clean and coarse and should be free from organic materials
- Check the cement manufacture date it should not be more than 3 months old
- Stone should not be smooth, fractured and porous or should have low water absorption

Figure 16: Washing stones before using them in the WSW

2. WSWs construction techniques

Construction will be continuing after check-up of excavation work. Accordingly, each section or all excavation work completion. Construction method, cement ratio, proper putting of cement, way of stone, cement utilization and proper watering are taken into account. The following are the steps and techniques of WSW construction.

- Lay stone and mortar together at the same time
- Lay stone as closely and tight fitting as possible
- Build a rough surface along the top of the weir
- Fitting the stone and cement together at the same time
- Working with large stones
- Place excavated soil on the upper side of the weir after the construction.

Note: Before starting construction make sure all construction materials are on site

3. Sequence of WSWs construction

To construct the WSW, we should follow the sequence in order to construct the right WSW and make them more durable and effective to their purpose and function, as follows:

1. Wall trench construction and counter wall trench excavation
2. Triangle support construction: wall construction integrated with triangle support basin
3. Basin Construction , Counter wall construction
4. Finalize wall construction

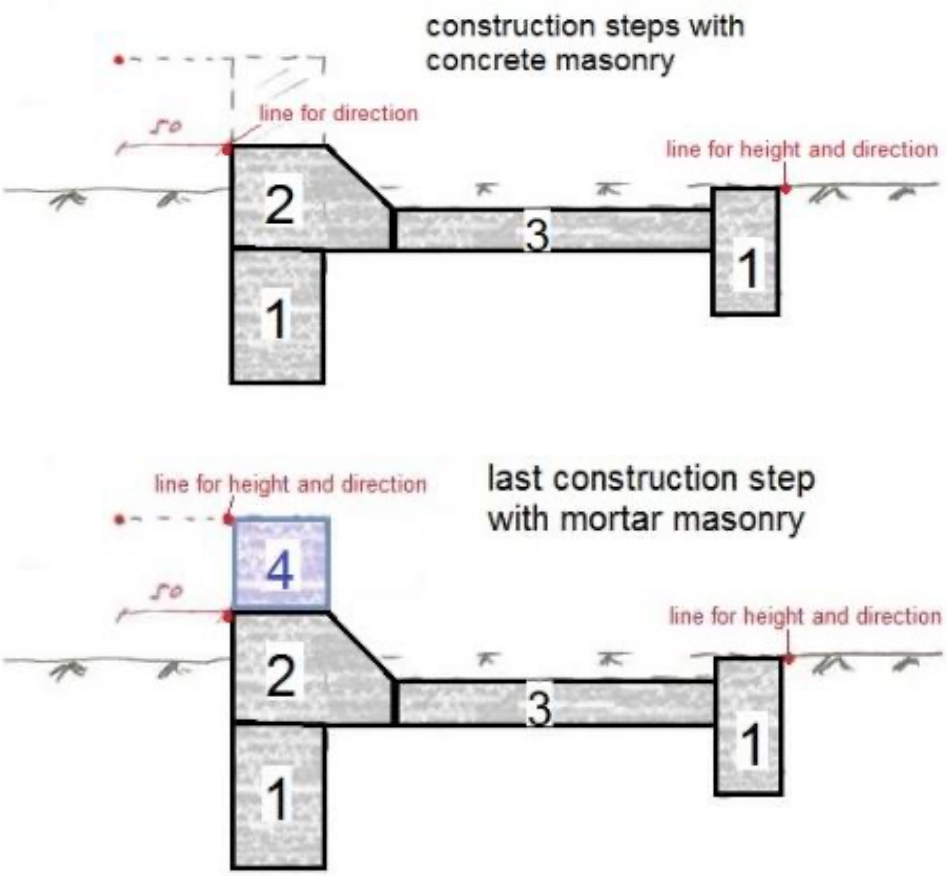


Figure 17: Construction Steps in integrated construction techniques

Construct main Wall

We use a masonry wall to construct a weir. The surface over which the water flows is known as the crest. The flow of water that moves over the top of this crest is known as the napped. The main wall of the weir is constructed as a straight wall. If needed, triangular supporting buttresses can be added at right angles, built upwards from the base of the structure. All excavated soil should then be filled back to the main wall, to improve its stability and prevent water to be channelled by the excavated soil. The prepared mortar should be filled in carefully between the stones, followed by rendering where necessary.

WSW wall masonry is a type of masonry construction that uses stones and mortar. This construction technique is used for WSW foundations and retaining walls. The stones used for masonry construction are natural rocks. These natural rocks should not be cut and dressed into proper shape because the structure should be strong in order to use it in masonry construction. Stones are one of the most durable and strong construction materials.

Figure 18: Constructing the main wall

Figure 19: Constructed main wall of water spreading weir

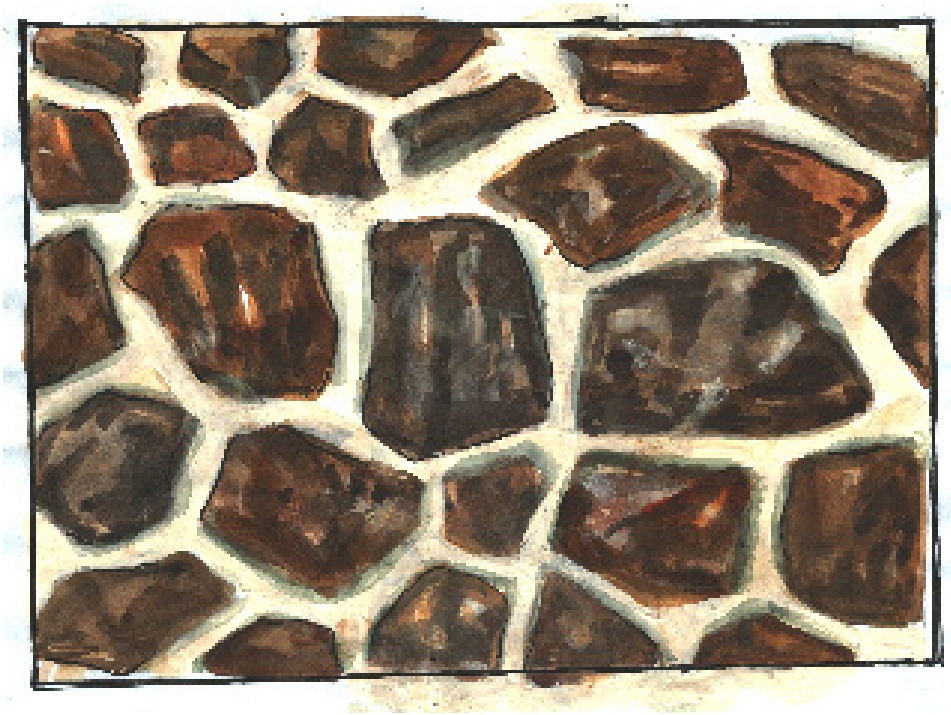


Figure 20: Detail of constructed wall showing the stone shape

Construct counter and support walls and section division

Construction of the counter wall follows after the installation of the foundation. Masonry comprising large stones and mortar is used for all walls and basins. The section division is a wall constructed at the right angle to the weir axis. It is extended up to the upstream end of the main wall head regulator. In case of one section off-taking from each section of the river, one divide wall is provided on front of each of the head regulators of the off- takes.

Figure 21: finishing the wall

How to check counter wall height

From your main wall reference point decrease your wing wall high referring from the cross-sectional drawings.

Figure 22: Counter wall and section division

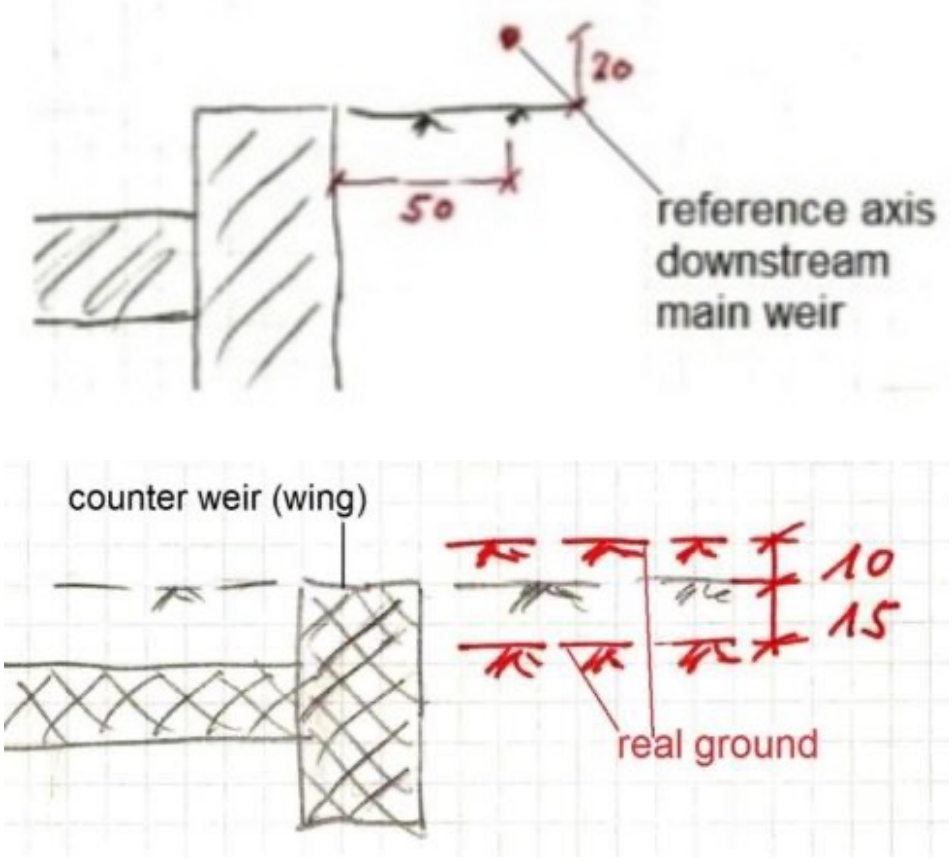


Figure 23: Determining the wing wall height in relation to the actual ground level

Construct basin

The basin structure is an important element of WSWs. It is the part where the water discharges from the main wall upstream and where it has high velocity and thus high erosion potential. The basin provides an area for high velocity flow to be reduced before the water returns back to the natural river channel downstream of the structure

On the day of construction prepare the drums of water for concrete mixing at the site. The water should be clean. If the sand is dry, pour 1 jerrican (20 litres) of water and mix it in advance. Then, additional water should be sprayed and mixed to keep proper consistency.

How to check basin height

From your counter wall reference height decrease your basin depth referring from the cross sectional design

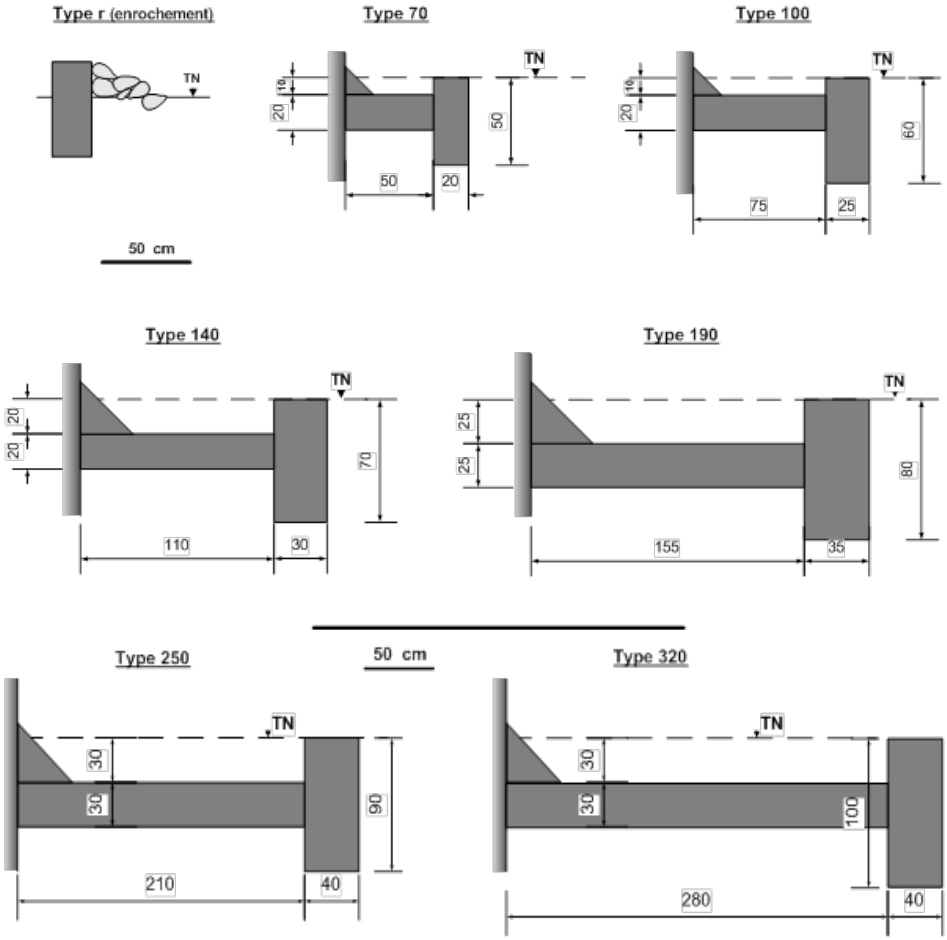


Figure 24: Water Spreading Weir standard basin type

Figure 25: Under construction basin structure

4. Curing and watering

After finalized construction to ensure a durable structure, sufficient watering of all rendered walls and basins is important. It must be carried out both during construction and after the construction for a number of days. Insufficient watering will lead to a reduction of the strength of the concert and mortar this will to increased wear of the structure and future maintenance during the flow of water. The curing time after the construction is 15 days, it is recommended to water the WSW in the early morning and night time at 6 pm, otherwise, the sun will absorb the water that can cause a crack which damages the weir.

Figure 26: Covering the constructed WSW to ensure good curing

Figure 27: Watering the newly constructed WSW

5. Backfill

At the back of the weir wing wall and main wall of the structure the excavated soil should be backfill end to end of water spreading weir structure.

6. Quality inspection

A WSW can only function and be sustainable if it is correctly constructed, used and maintained. The most important stakeholder community members who will most directly benefit from, but also use and protect a WSWs system must be

involved right from starting of the construction stages. the Major points inspected during in the construction are:

- Material quality such as know the quality of:
    1. Sand- not mixed with soil
    2. cement- not expired
    3. water- check if it is clear
    4. stone- is not smooth, fragile and porous
- check the construction is the same with the design of the drawing.

Inspection after construction is necessary to crate sustainability:

- Check the WSW is constructed correctly
- Use the WSW properly
- Maintain at the right time
- Feel responsible for the spreading weir after the construction.

Figure 28: Checking the levelling of the WSW as part of quality control

7. Periodical maintenance

Considering the actual topography or required amount of conservation or depth of the gully, we will have step-by- step construction. After the first construction and rehabilitation we will continue a second construction or height increment which is initiated by engineers based on the type of damages. Most of the time we maintain with one year gap, after the rainy season has passed, because there is chance of a high flood during this season, so most damages occur during this time interval.

That will give chance for spreading of the water to continue after the area behind the WSW is sited up. An added advantage is that the flooded area increases the moisture content, creating more space for crop cultivation.

In case of flood damage, we will work on timely follow-up and maintenance work. For height increment and maintenance work, we first observe the site then taking a profile from the structure, after that we can recommend the type of maintenance based on the damage that occurs in every section, next to that we estimate volume of work in each section. Finally, we prepare the design and section drawing for the maintenance site. For design and section drawing we can follow the same procedure and techniques as we used for new site construction.

Figure 29: Periodic maintenance for the damaged basin.

Guiding questions for discussion

1. Why is it important to follow construction steps?
2. Can you Name all structural parts of water spreading weir?
3. What is periodic maintenance? Discuss the purpose of the maintenance.

Self-Check Test

Name	
Date	
Time started	
Time finished	

Instructions

Answer all the questions listed below. Illustrations may be necessary to aid some explanations/answers.

Part I: choose the best answer

1. What is the first step for the construction? (2pt)

- basin
- wing wall
- wall foundation

2. What is the use of section division? (2pt)

- To support basin.
- To support the main wall
- all

Part II: short answer

1. What is the function of basin structure? (3pt)
2. Write the sequence of the construction. (3pt)
3. What is quality means? List the physical tests we take in the field. (3pt)
4. List down the WSW construction techniques. (3pt)

Rating

Note Satisfactory rating points 10 and above. Unsatisfactory points below 10.
You can ask your instructor for a copy of the correct answers.
If your answer differs from that of your instructor for a very single point do not proceed to the next learning, rather better work on the same information sheet until you acquire all the necessary information

Score:
Rating:

LAP-Test

Name	
Date	
Time Started	
Time finished	

Objective

To educate the students on how to construct the water spreading weir and give them all the necessary knowledge and skill to construct the right spreading weir for the community.

Construction process

- Check the excavation is finalized using the design
- Check measurements and landmarks using survey instruments, and you should have the latest version of the technical plan in your hand.
- Check all needed construction materials are on site.
- Explain the parts of water spreading wire and steps of construction
- Organize the masons and labour in groups to work together with a foreman. Explain the Number of working hours, the type of work to be done by Foreman, masons and labour

General instructions

- You have to accomplish the tasks provided in the specific instructions.
- All your questions and clarifications should be addressed to the teacher only.
- Submit the documented results of your tasks to your teacher upon completion

Tasks

Construct part of a counter wall, main wall and main spill wall

Information Sheet 3: Do’s and Don’ts for Construction

WSWs are exposed to enormous powers of water and sediment flowing over them. It will be constructed on dry river valleys and the flood challenges \ the structure. They therefore need to be extremely strong and stable. Several mistakes can be made during construction which hugely weaken the overall structure and result in unnecessarily high damage, frequent maintenance requirements, unsustainability and less-than-intended impact. It is therefore extremely important to follow the simple do’s and don’ts illustrated on the following pages during the planning and construction of the weir.

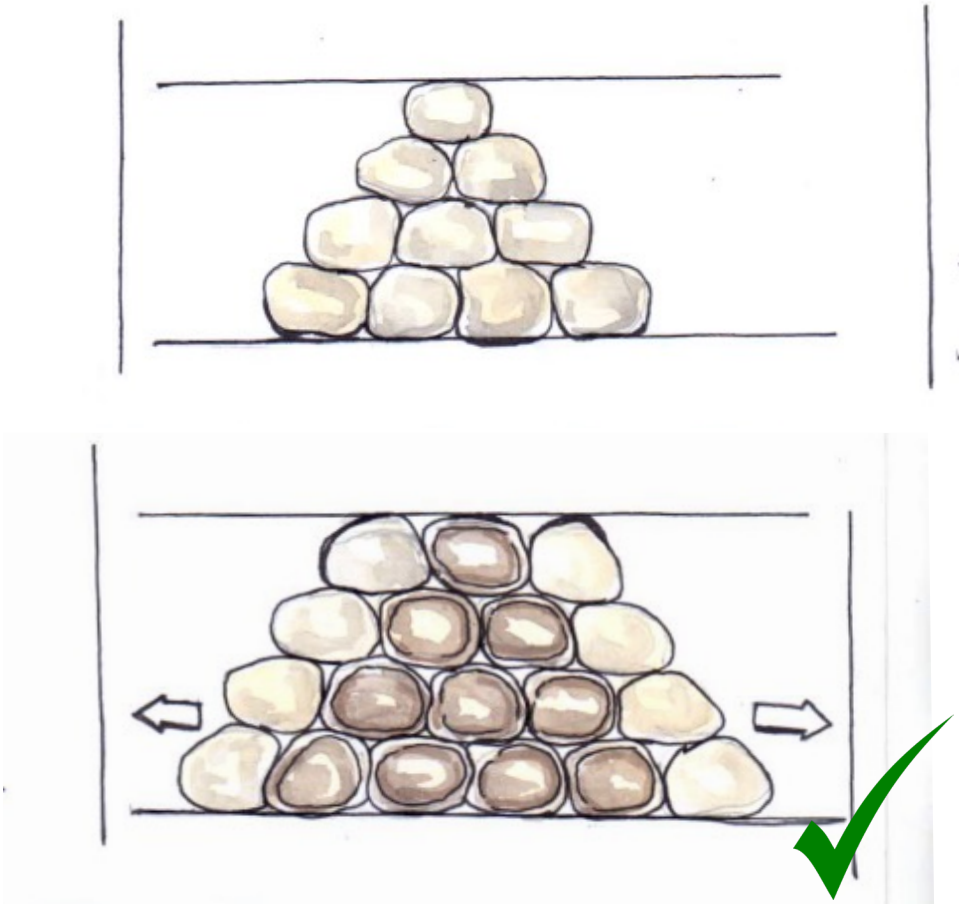
Pictures Do’s and Don’ts for WSW Construction

Remove dirt from stones before constructing with them.

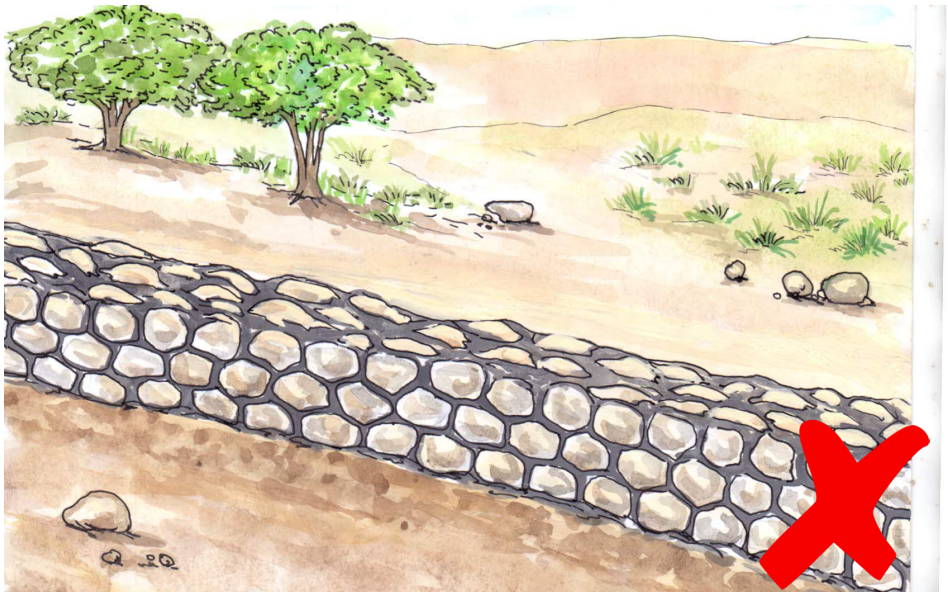
Never work with dirty stones – the weir will not be stable!

Making the stone and cement together at the same time.

Do not fill the cement in any case without placing the stone first



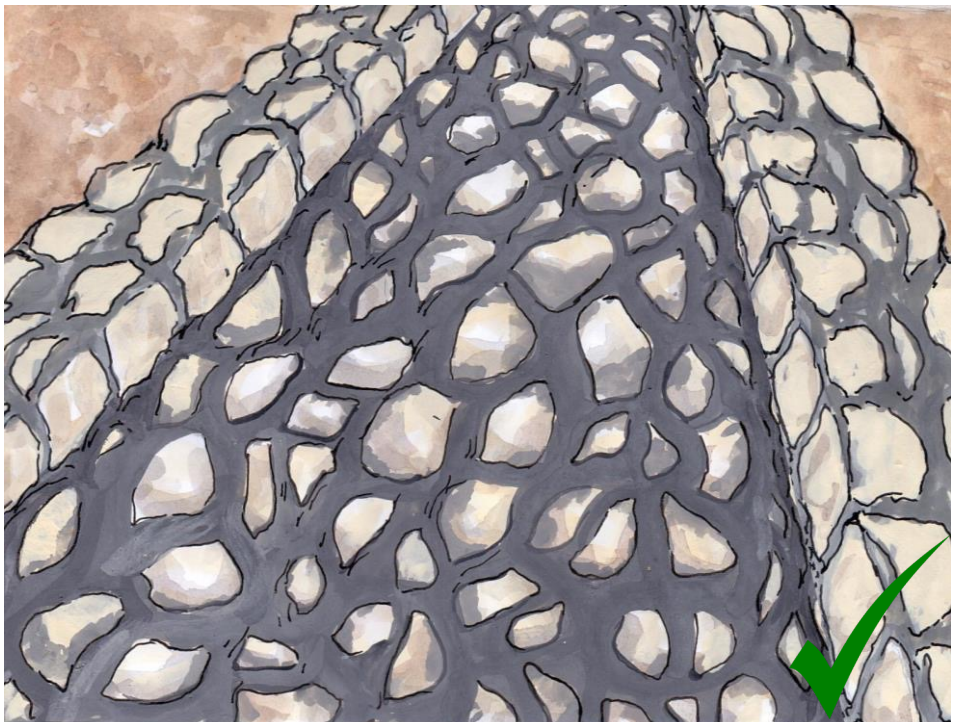
First build it in a triangular shape and then expand it.



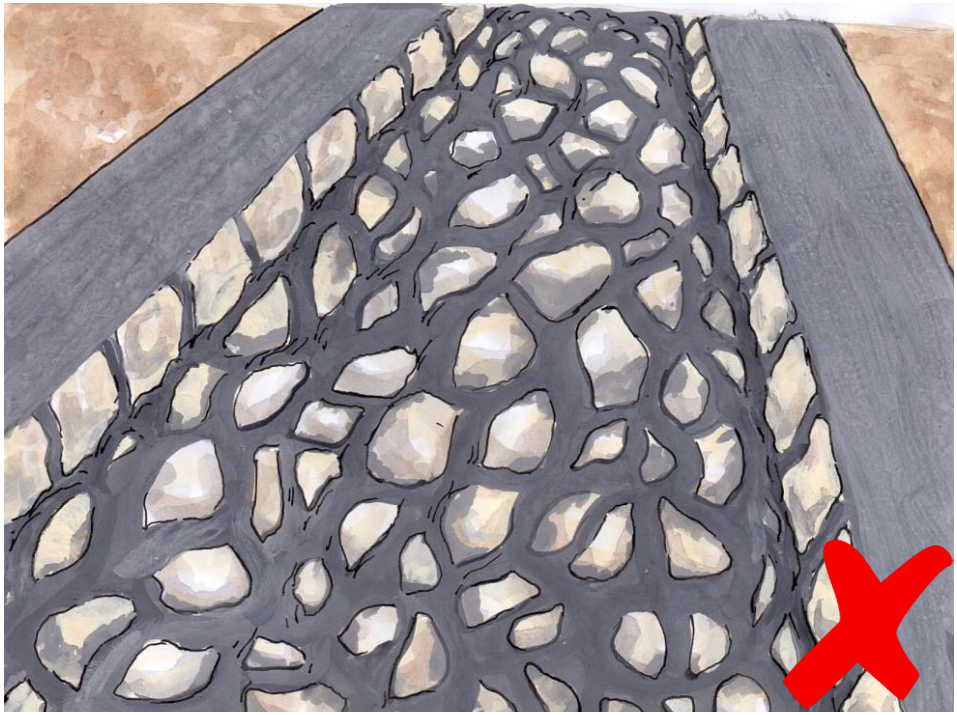
Do not built in a long straight lines, line by line, because a single line is not built at once, and a repeated or overlapping straight line construction does not have strength.

Place the stones as close as possible

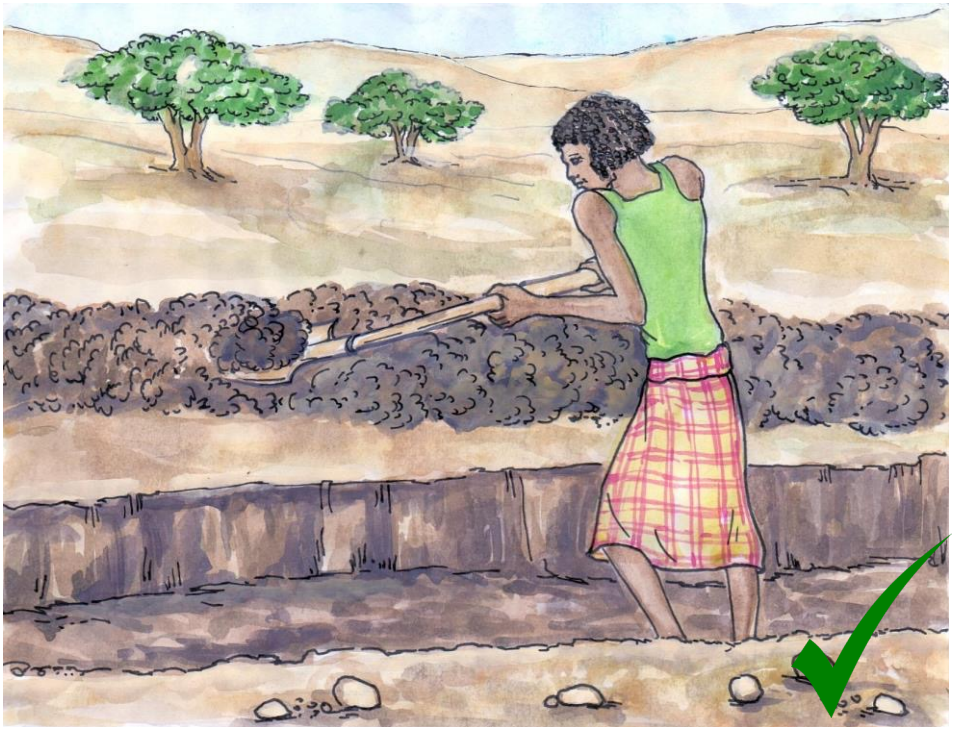
They should not be kept apart in any way, leaving no gaps between the stones.



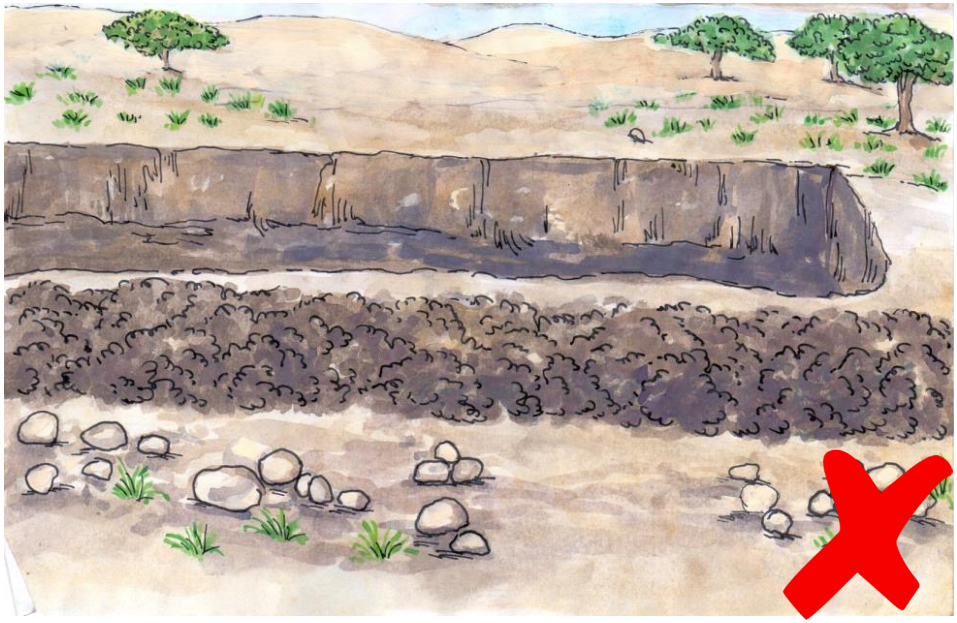
Making the upper part of the building rough because it is used to slow down the speed of the water.



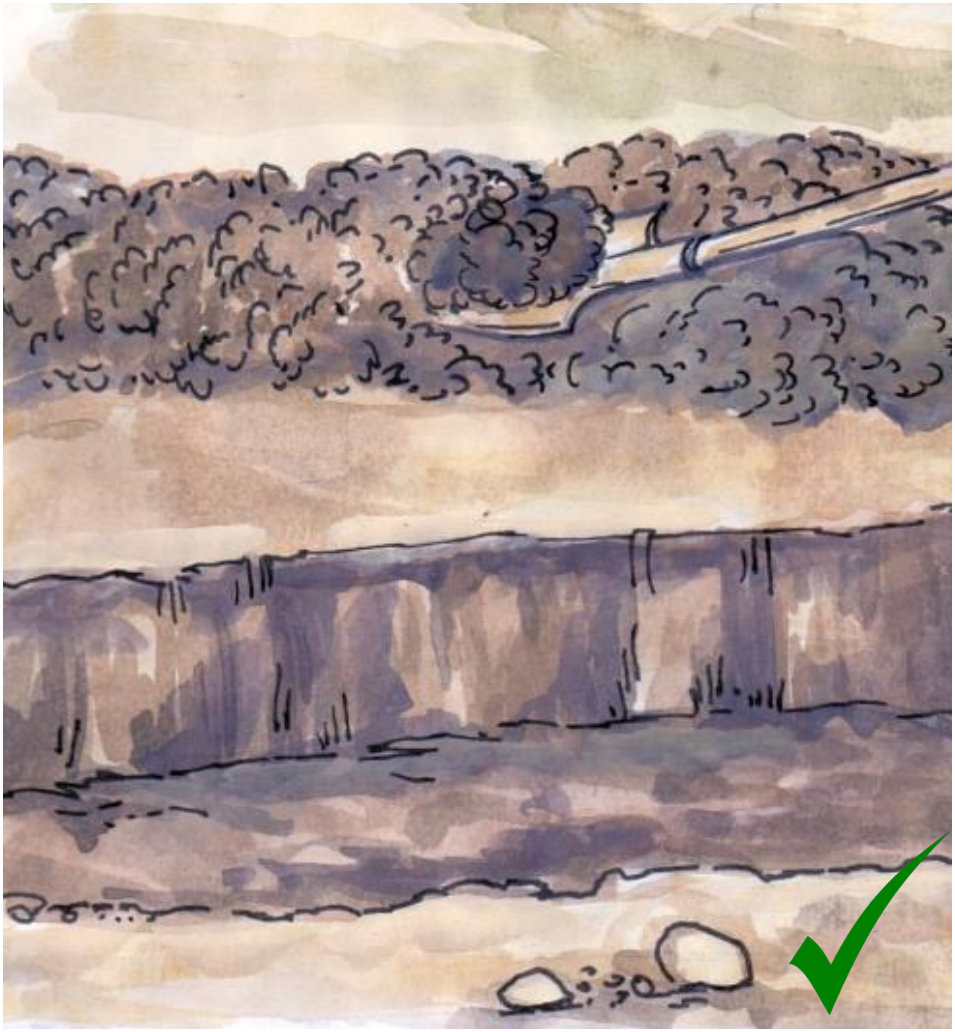
Never make smooth surface



Throwing the excavated soil up from the construction, that is, placing the soil from the direction where the water comes down



Never place the excavated soil on the downstream of the WSW during construction

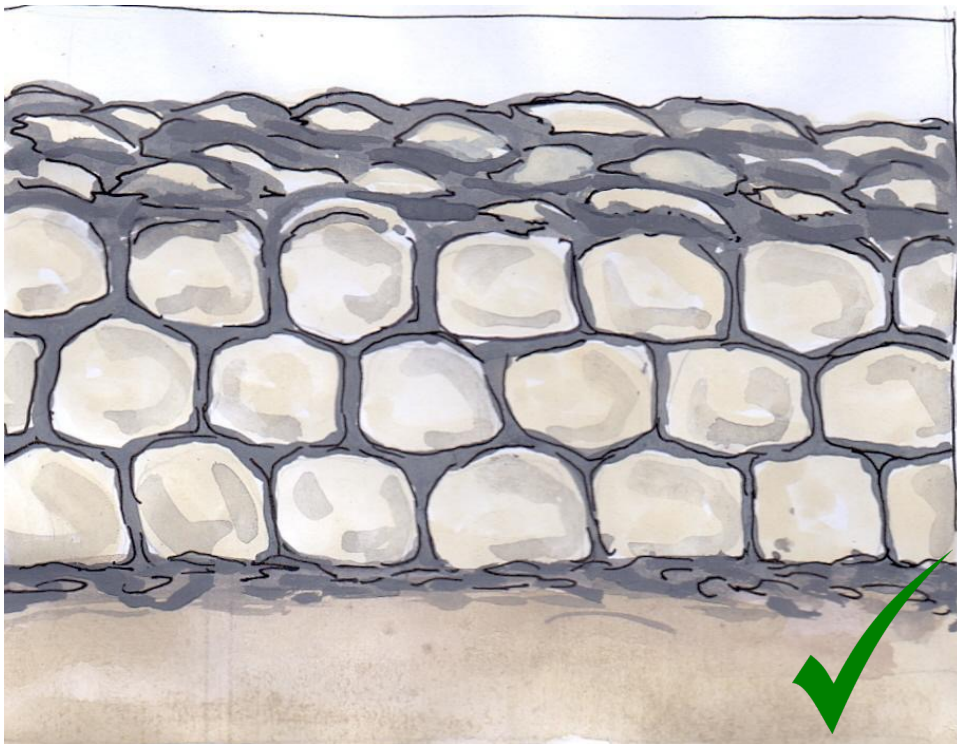


Keep the soil away from the trench.

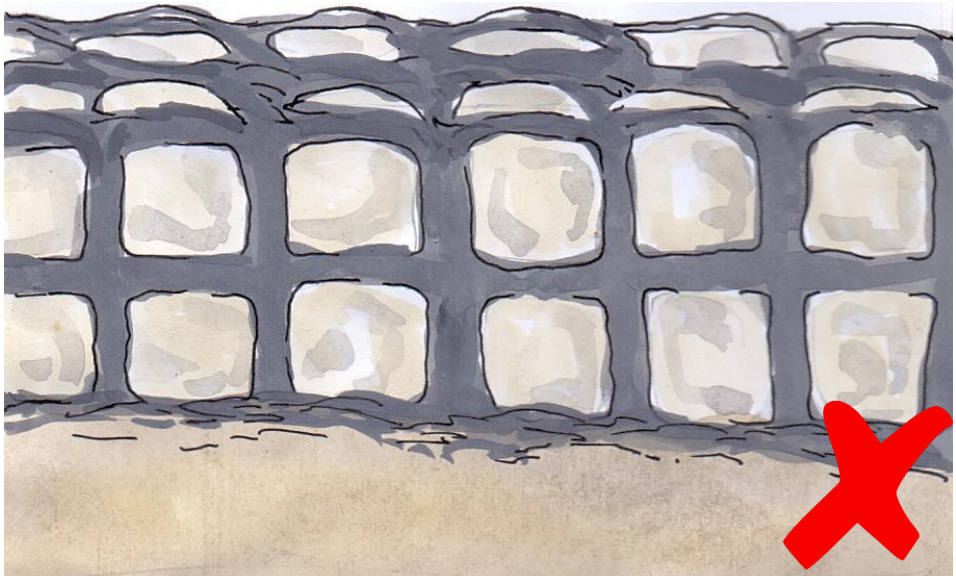
Do not place the soil on the edge of the trench so that the soil does not go back into the trench

Use large stones for WSW construction.

It is not necessary to grind all the stones.

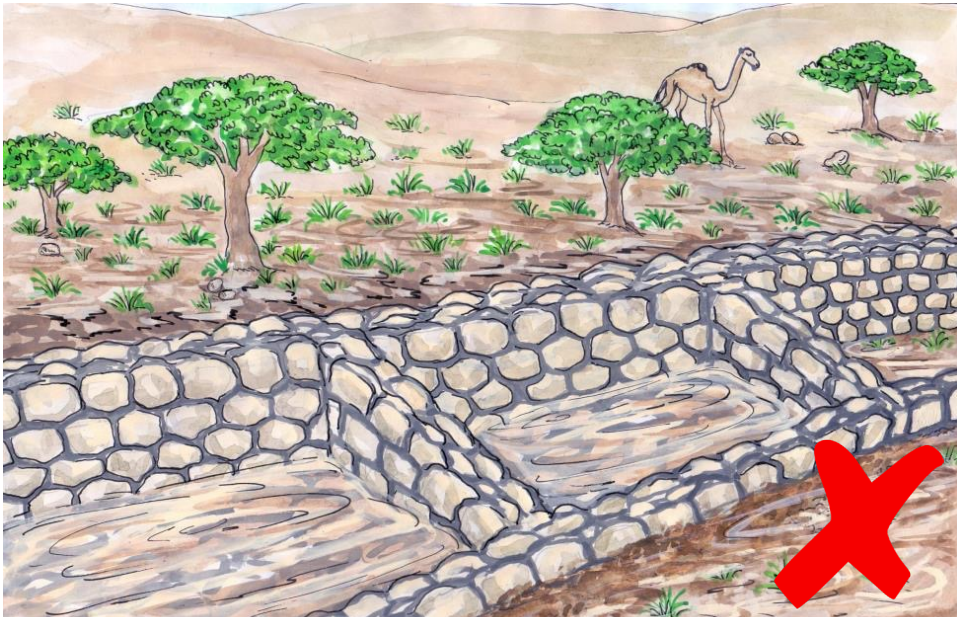


stack the stone in different form.



Do not stack the stone in a straight line.

When the foundation is dug, it should be deep and also follow the instructions given.



Shallow digging over heavy clay soils allows the soil to be easily washed away by the water.

Learning Outcome 5: Occupation Health, Safety and Environmental Procedures

Every Learning Outcome has a similar structure. In this introduction, you find the specific learning objectives of Learning Outcome 5. The Instructions sheet(s) for both the Teacher and the Learner tell what is expected from both groups. Following is an Information sheet that provides background information, guiding questions, and a self-test.

By the end of this Learning outcome section, you will

- Understand the basics of Occupational Health and Safety (OHS) relevant to the WSWs construction
- The difference between personal, workplace and material safety
- The role of environmental plans in WSWs construction

Teachers should follow the following steps in teaching Learning Outcome 5:

Instruction Sheet for Teachers

1. As you go through this section with your class, give them the necessary knowledge about Occupational Health and Safety (OHS) and essential tips about environmental protection
2. Then ask them the purpose of OHS and Environmental protection
3. Work through the Information Sheet: - Implement and Monitor OHS and environmental policies and procedures
4. Show them first aide treatments
5. Ask students how first aid treatments process
6. Discuss the Guiding questions for discussion.

Teaching methodology

Brainstorming, interactive teaching and learning, group discussion

Session Plan

- 10 minutes looking at the introduction
- 45 minutes for the Information Sheet; Implement and Monitor OHS and environmental policies and procedures
- 25 minutes for first aid exercise
- 20 minutes for the Guiding Questions;
  Total time: 1 hour and 40 minutes.

Instruction sheet for Learners

1. Read the Learning Outcome.
2. Read Information Sheet and understand how to implement OHS and environmental protection producers and policies
3. Write down any questions of clarification, that you might have.
4. Ask your teacher for support, and get answers to your questions.
5. Try to answer the Guiding Questions.
6. Complete the self-check-test.
7. Read the Operational Sheet
8. Complete the LAP-Test.

Information Sheet – Implementing OHS and environmental procedures in WSW Construction

In this section you will know what OHS means and how you can implement all the environmental protection methodologies and practices. Every person should be aware of the steps to be taken in the case of an emergency.

OHS procedures are used to ensure that the working environment is safe for any unsafe activity to happen to the employee, contractor, or other person who is responsible for the construction. In case of unsafe working conditions, all activities should be stopped by the authorized personnel in order to ensure that no accidents will occur. In addition to that, these OHS procedures are useful in order to protect the project from any damage and troubles and make it safe until the construction is done.

Necessary OHS terms to know and its definition

Accident - Unplanned event that has caused injury to a person.
Incident - Unplanned event that has resulted in property damage to equipment or operations interruption.
First Aid - Any immediate (one time) care or treatment given to a person suffering from any injury or illness, until professional medical care can be provided.
First Aid Injury - Is a minor work-related injury or illness that calls for only simple "First Aid" treatment and does not call for follow–up to treatment by a health care professional. First Aid Injuries do not result in lost time from work restrictions.
Lost Time Injury (LTI) - Lost Time Injury is a work-related injury or illness that results in an individual being unable to work on a subsequent scheduled workday or shift.
Major Injury - Major Injuries including fractures (not fingers or toes) amputation, dislocation, hip or spine, loss of sight (either temporary or permanent) burn or penetration of eye, injury caused by electricity or requiring resuscitation or over 24 hours stay in hospital

Fatality (Work-Related) - Work-related fatality is a death resulting from an injury or illness (during the work period /connected to the work).
Reportable Incident - A work-related incident consists of or results in:
Fatality - Reportable Serious Injury or Reportable Dangerous Occurrences

1. Personal safety

Various forms of accidents occur at various stages of construction and in various operations. In order to avoid these accidents, we should have to follow the following safety precautions.

- Some of the tools and materials are sharp and dangerous; please observe standard safety of works.
- Place the tools and materials in a safe and proper location when it is not in use.
- Observe proper use of the tools and materials to avoid accidents during layout.
- Follow proper dress code and safety shoes during the activity.

2. Workplace safety

Workplace procedures and work instructions are followed for ensuring safety. The Purpose of this procedure is to provide a definitive standard for Health, Safety and Environmental (HSE) incidents

- Ensure that a common and consistent procedure is implemented for HSE
- Legal rights and responsibilities of the workplace parties
- The ways in which OHS is managed in the workplace and legal requirements

Follow workplace safety

- The preliminary site works for construction project usually begin after the site facilities are set up. Clearing the site is essential. First, all vegetation such as bushes should be removed. The roots of trees and bushes must be dug out and cleared away.
- Work practices have contributed positively to quality, productivity, working conditions, and promote cooperation and good relationships.
- Work is made consistent with workplace standards relating to anti-discrimination and workplace harassment.
- Give first aid if any accident is happening which means giving treatment to a person suffering from any injury or illness, until professional medical care can be provided.
- Hazards in the work area are recognized and reported to designated personnel according to workplace procedures.
- Contribute to a productive working environment
- Reportable Occupational Illness/Disease and Major or Moderate Environment Incidents.

Most of the time accidents are occurs due to the following reasons

- Not wearing personal protective equipment (PPE) at the work site.
- No proper handling of materials.
- Not Reporting First Aid injuries.
- No provision of access/egress.
- Smoking at Site.
- Working at site without completing safety induction.
- Non reporting of Site Injuries/ Incidents/Significant environmental Incidents.
- Improper disposal of waste materials.
- Stooling, Urinating at Site.
- Entering Site after consumption of Alcohol and Drugs.
- Stealing, Destroying company property.
- Not implementing the control measure as per the Risk Assessment.
- Executing activity without approved risk assessment.

- No proper packing/sealing of materials applied while transportation/ shifting of wastes, which results in public complaints.

3. Material safety

We should keep our construction safe by implementing these measures on the site.

Material Handling

Material handling operations are key to having a productive workplace and completing the job in a timely matter. Keeping the site safe is critical to protect equipment,

Understanding Common Material Handling

Here are common risks, according to OSH.

- Injuries caused by falling objects
- Example: - survey tools like theodolite, GPS and so on.
- Minimizing the Risks
- Safe Storage and Disposal of Materials
- Storing materials improperly can result in serious injury. Here are the OSH guidelines for material storage:
- Sustain safe storage areas by removing any trip or fire hazards
- At the end of the construction project, we don't want to keep unused materials sitting around.
- Another essential requirement is to provide the appropriate bins for trash and wastes

4. Apply environmental plans and procedures in WSWs construction

Environmental procedures are the written statement and principles to manage the environment effects and aspects of operation. Every stage of construction work has a measurable impact on the environment.
For example transportation of material from the source to the construction site has its own environmental pollution also improper waste removal and disposal also have an impact to the environment. Therefore, the responsible party should develop procedures based on the impacts. In the construction of WSWs, we should apply these procedures to protect the environment.

- Cleaning the place where we mixed the cement because it damages the environmental particularly the soil .
- Clean the water reservoir that , we dug to store water and after we finish the construction we should restore the soil we excavate.
- Restoring the soil we dug for the construction
- As much as we can create a comfortable environment for the employees and local communities choices.

Guiding questions for discussion

1. What is OHS means?
2. State types of safety?
3. What are environmental policies and procedures ?
4. Discuss about workplace safety?
5. 6 what is first aid mean and discuss the use of first aid ?

Self-Check Test

Name	
Date	
Time started	
Time finished	

Instructions

Answer all the questions listed below.

Part I: Multiple choice

1. Which one of the following we apply for environmental protection in WSW? (2pt)
    1. Cleaning the place where we mixed the cement
    2. Clean the water reservoir, we dug to store water and after we finish the construction
    3. Dispersing the soil we dug for the construction
    4. All

2. Which one is a reason of accident occurrence? (2pt)
    1. Not wearing personal protective equipment (PPE) at work site.
    2. No proper handling of materials
    3. Not Reporting of First Aid injuries.
    4. No provision of access/egress.
    5. all the above

Part II: short answer

1. What does personal safety mean? **(3pt)**
2. What does material safety mean? **(3pt)**
3. List down the environmental procurers we use in the WSW construction? **(3pt)**
4. List down reasons for accident occurrence. **(3pt)**

Rating

Note Satisfactory rating points 10 and above. Unsatisfactory points below 10.
You can ask your instructor for a copy of the correct answers.
If your answer differs from that of your instructor for a very single point do not proceed to the next learning, rather better work on the same information sheet until you acquire all the necessary information

Score:
Rating:

Operation sheet

The DA/ Construction technician can implement every occupational safety and environmental procedures to create safe working environment also to protect the environment at the same time.

Objective

To Educate the students what are the occupational safety and standards in the working area and how to implement occupational safety and environmental procedures.

Implement OHS and environmental

1. Implement personal and work area safety
    1. Wear proper dress code during the activity.
    2. observe whether the work area is safe
    3. Place the tools and materials in a safe and proper location
    4. Give first aid if any accident has happened
    5. Reportable Occupational Illness/Disease
2. Implement environmental procedures
    1. Cleaning the place where we mixed the cement
    2. Clean and restore the soil of the excavated water reservoir.
    3. Restoring the soil we dug for the construction
    4. create a comfortable environment for the employees

LAP-Test

Name	
Date	
Time Started	
Time finished	

General instructions

- You have to accomplish the tasks provided in the specific instructions.
- All your questions and clarifications should be addressed to the teacher only.
- Submit the documented results of your tasks to your teacher upon completion

Tasks

Tell to your teacher the purpose of OHS and environmental procedures , how we use them? And what are the basic procedure we use in construction time?

Glossary of technical terms

Area under rehabilitation	An area where interventions are implemented designed to improve soil, water and vegetation conditions by reducing land degradation.
Area under protection	Defined as area, which is managed by a community under the governance of a participatory land use plan at community level with corresponding by-laws. The adherence should result in observable improvements of used natural resources, e.g., through cultivation area.
Available Water Capacity (AWC)	The water available for plant growth held between Field Capacity and Permanent Wilting Point.
Bare land	It is land of limited ability to support life and in which less than one third of the area is covered by vegetation or other cover. It may be constituted of bare exposed rock, strip mines, quarries and gravel pits. In general, it is an area of thin soil, sand or rocks.
Cascade	A cascade is a series of Water-Spreading Weirs that reinforce themselves creating optimal growing conditions over an area of 200 to 800 hectares by increased infiltration of flood waters and the sedimentation of fertile sediments from the highlands. The area of a cascade is measured from the first upstream weir up to the last downstream weir. The upstream weir will be located in an area where erosion of the dry valley starts. The final weir will be at the area where there is no longer a change for high erosion (i.e. relatively flat areas, rocky areas, etcetera).
Climate	Also known as the “average weather” over a long period of time (generally 30 years). Within climate different variables (temperature, precipitation, and wind) can be identified.

Community	People who are living within or outside of the dry valley and utilizing the available natural resources within that dry valley. The contribution of community be considered for developing sense of ownership and as a checkpoint to know how the system is functioning properly and necessary to the target communities.
Cropland	is defined as land used primarily for production of food and forage whether rain fed or irrigated; this category includes both cultivated and non-cultivated lands.
Dry Forest	Any vegetation found in areas with limited water resources and low annual precipitation which fall within an altitude range of 500 to 1500 meters above sea level. These forests are composed of several tree species adapted to limited water conditions including forage, timber, charcoal and gums and resins producing species
Dry Stone Measures	are structures constructed from loose stones laid along the contour lines. They are constructed in a series, and the measures can be used to fill smaller gullies (up to 1.5 m depth) feeding into the dry valley and disperse runoff in flatter areas. They are designed to reduce the speed of water flow, retain organic matter and deliver a water-spreading effect (although less than a water-spreading weir). DSMs function best in combination with biological protection.
Dry Valley	A dry valley is defined as a segment of a dry river valley receiving seasonal floods from the highlands. The dry valley upper and lower boundaries are defined by a non-erodible base made up of stones or an intact floodplain. The dry valley includes all run-off areas within the upper and lower boundary towards the dry valley. It includes all the natural resources in a basin, especially water, soil, and vegetative factors. At the socioeconomic level a dry valley includes people, the farming system (including livestock) and interactions with land resources, coping strategies, social and economic activities and cultural aspects.

Field Capacity (FC)	Refers to the relatively constant soil water content reached after 48 hours of drainage of water from saturated soil. Drainage occurs through the transmission pores (greater than about 0.05 mm diameter, but note that field capacity can correspond to pores ranging from 0.03 to 0.1 mm diameter). The FC concept only applies to well-structured soils where drainage of excess water is relatively rapid; if drainage occurs in poorly structured soils, it will often continue for several weeks, and so poorly structured soils seldom possess a clearly defined FC. FC is best determined in the field by saturating the soil and measuring its water content after 48 hours of drainage have elapsed. Soil at field capacity feels very moist to the hands.
Flood Based Farming	the process of utilizing excess runoff (floods) for growing food, fodder or fuel in areas where no other options are possible
Gabion Check Dams	are placed and anchored in gullies, function similarly to masonry check dams but with some distinct features. These dams, reinforced by sturdy mesh wire known as gabion, are designed to be lower in height compared to traditional masonry check dams. They are particularly effective in stabilizing deeper gullies and controlling the flow of water. So that soil can settle behind the gabion wall, and allow water to flow over it, mitigating the force of floods.
Harvest	The season/ process of gathering crops, leaves, fruits from a specific target species.
LAP-test	Learning Accomplishment Profile Test, examined by an assessor.
Leguminous plant	A plant that is able to fixate the nutrient nitrogen. This increases the fertility of the soil.

Live Check Dams	These are innovative structures designed to combat erosion while minimizing the costs of establishment. This method involves strategically planting suitable species to form a horizontal barrier across the gully bottom. By effectively reducing the velocity of flowing water in the gully, live check dams serve as a defence against erosion.
Maintenance	Making sure that over time the desired effect of a measure (in this case biological measure) still intact is.
Masonry Check Dams	are a non-permeable, low-based masonry structure that span the entire width of a riverbed. Masonry check dams are constructed at deep, preferably stony gullies with a depth of up to four meters. If necessary, they can be increased in height after each rainy season to fill the gully. The final stage, once level, check dams can be upgraded to a WSW.
Pasture land	Pastureland/Rangeland: Extensive area of land on which the vegetation is predominantly grasses, shrubs and is managed as a natural ecosystem. It is a significant source of livestock feed and of livelihoods for stock raisers and herders.
(Agro-) Pastoralism	is a traditional system that combines agriculture and livestock management. Communities practice both crop cultivation and animal rearing for sustenance and livelihoods. This approach maximizes resource utilization and is commonly practiced in arid or semi-arid regions.
Permanent Wilting Point (PWP)	Refers to the water content of soil that has been exhausted of its available water by a crop, such that only non-available water remains. The crop then becomes permanently wilted and cannot be revived when placed in a water-saturated atmosphere. At this point the soil feels nearly dry or only very slightly moist.

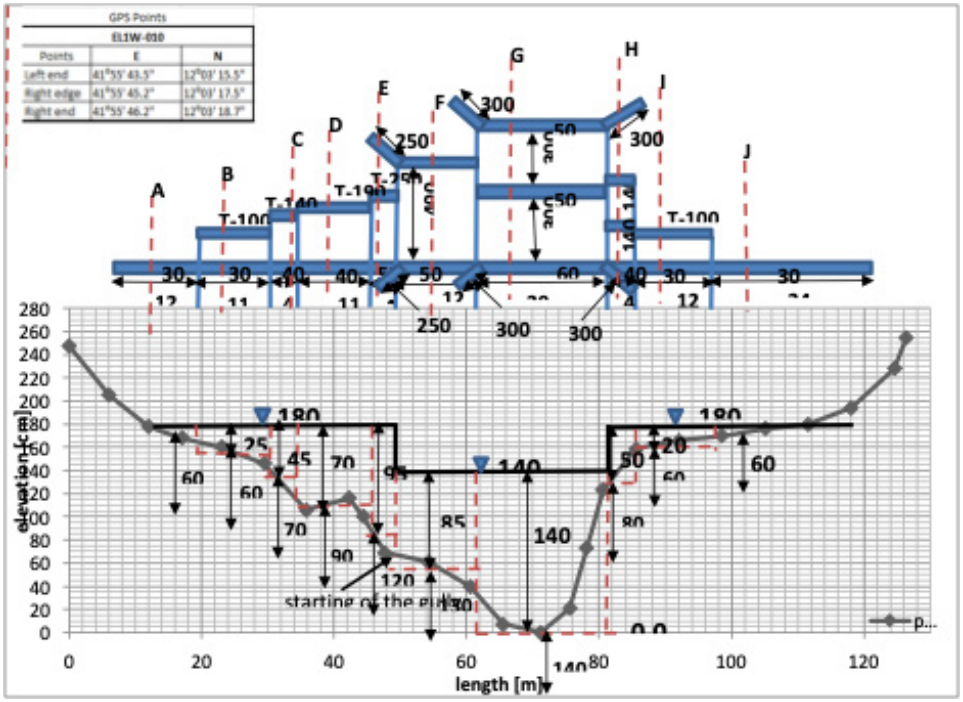
Primary users	People living within the delineated dry valley or using area within the delineated dry valley permanently
Productive Use	is the utilization of a delineated dry valley for biomass production like for food, fodder, fuel and fibre crops. Residual moisture for crop/fodder production and drinking water for livestock and humans.
Runoff	Water that flows over the land surface entering rivers, lakes or other reservoirs.
Saturation	Soil's water content when practically all pore spaces are filled with water. This is a temporary state for well-drained soils, as the excess water quickly drains out of the larger pores under the influence of gravity, to be replaced by air.
Seasonal Grassland	Land covered the natural growth of graminea and herbaceous vegetation or a land sown with introduced grass and leguminous for the grazing of livestock. Generally open and continuous flat areas dominated by grass.
Secondary users	People living outside the delineated area but moving through and utilizing the resource temporarily. There might be a traditional resource use agreement with the primary users.
Shrubland	is land with shrubs/bushes/combined canopy cover ≤ 10%. Shrubs and bushes are woody perennial plants with <2m in height at maturity in situ. Scrubs are low bushes and stunted trees, mostly spiny either deciduous or evergreen. On scrubland, more than half of the surface of the ground is bare of vegetation.
Slope	The side of a hill or mountain, the inclined face of a cutting, canal or embankment, or other inclination from the horizontal. The steepness of a slope can be expressed as a percentage, the term 'gradient' also being used.

Soil Erosion	The wearing away of the land surface by physical forces such as rainfall, flowing water, wind, ice, temperature change, gravity or other natural or anthropogenic agents that abrade, detach and / or remove soil or geological material from one point on the earth's surface to another. Soil erosion is normally a natural process occurring slowly over extensive geological timescales, but wherever the natural rate has been accelerated by anthropogenic activity, soil erosion becomes a process of rapid degradation and an immediate and identifiable threat to soil.
Transect	Also known as a 'transect walk'. This is a method used to explore the spatial dimensions of people's realities by factoring social aspects of a community into the layout of its natural and other resources. A transect is normally conducted following resource mapping the village in order to facilitate triangulation of the data generated on a resource map. The transect depicts a cross-section of agro-ecological zones and provides a comparative assessment of these zones in terms of topography, land type, land use, ownership, access, soil 104 type, soil fertility, vegetation, crops, problems, opportunities, solutions and other parameters.
Vegetative strips	planting of grasses and bushes in line along WSW or DSMs structures. Example: Elephant grass strip is highly suitable for WSW. Sisal and Sansevieria are also suitable for DSM by integrating additional physical structure like trench.
Water Spreading Weir (WSW)	are masonry structures constructed in a dry valley which spans the entire width of a dry river to spread floodwater over the adjacent land area. Water encounters the weirs and spreads off its side wings onto a larger surrounding area, overflow is channelled through a spillway and can be caught by the next weir. WSWs are constructed in cascades to increase the flood spreading effect and to reinforce each other against unseasonable floods etc.

Annex

Annex 1

Example -top & front view sketch



Imprint

Published by
Ethiopian Federal Ministry of Agriculture
Natural Resources Management Directorate
P.O. Box 62347, Addis Ababa, Ethiopia
Tel: +251-1-6462373
Fax: +251-1-6462366
E-mail: info@moa.gov.et

Supported by
German Federal Ministry for Economic
Cooperation and Development (BMZ)

GIZ Lowland Soil Rehabilitation Project (LSRP)
Rahem Building, 1st floor, Diaspora Square, Megenagna
P.O.Box 100 009, Addis Ababa, Ethiopia

Text
MetaMeta & GIZ Lowland Soil Rehabilitation Project (LSRP)

Design
MetaMeta

Illustration credits
Senayit Worku

Layout
Madiha al Junaid

As of
August 2023

Get in touch
E-mail: dvrpu4you@gmail.com


german
cooperation
DEUTSCHE ZUSAMMENARBEIT
implemented by
giz
MINISTRY OF AGRICULTURE