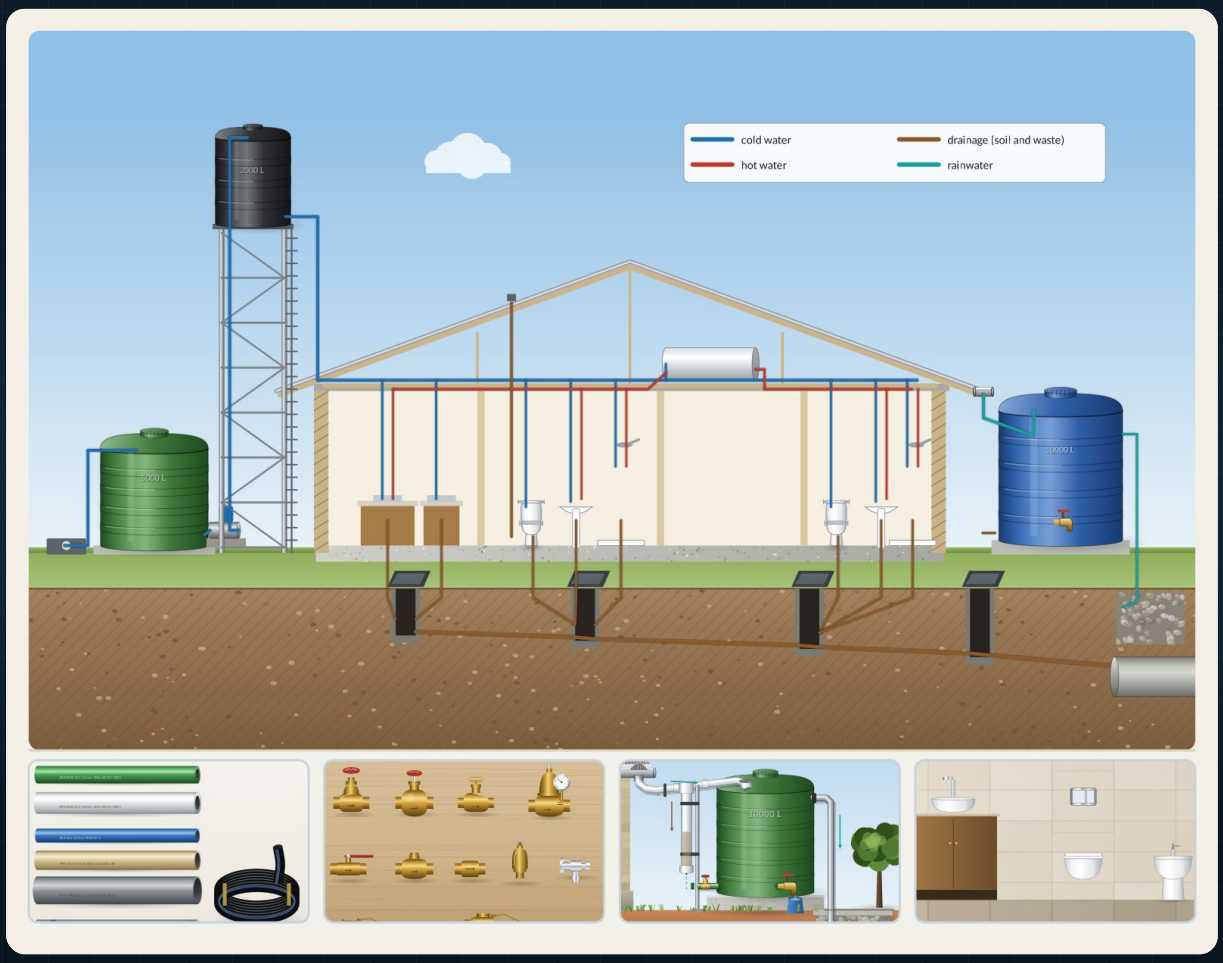
KNQF LEVEL 4 · TVET CDACC CYCLE 3

Plumbing Level 4

A Practical Study Guide for Kenyan Trainees

Water supply & tanks · Rainwater harvesting · Drainage · Sanitary appliances



Realistic pictures **Step-by-step tasks** **Mock assessments**

For trainees, RPL candidates, trainers and plumbing fundis

Alphonce Kimutai Kirui

Aligned to the TVET CDACC Competency-Based Modular Curriculum, Plumbing KNQF Level 4

Plumbing Level 4

A Practical Study Guide for Kenyan Trainees

Water Supply System II · Rainwater Harvesting System · Drainage System Installation II · Sanitary Appliances II · Industry Training
Kenya National Qualifications Framework (KNQF) Level 4

Alphonce Kimutai Kirui

Plumbing Level 4: A Practical Study Guide for Kenyan Trainees
First edition, November 2026

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Published by the author. Website: alphoncekirui.com

About the curriculum

This book follows the topics and units of the TVET CDACC Competency-Based Modular Curriculum and Occupational Standard for Plumbing, KNQF Level 4 (Cycle 3, greened edition, programme code 0732 354 B), and the assessment documents for Plumber Level 4. It covers the four Level 4 units (Module II): Water Supply System II (CON/CU/PLM/CR/01/4/MB, 60 hours), Rainwater Harvesting System (CON/CU/PLM/CR/02/4/MB, 80 hours), Drainage System Installation II (CON/CU/PLM/CR/03/4/MB, 60 hours) and Sanitary Appliances II (CON/CU/PLM/CR/04/4/MB, 60 hours), together with the 320 hours of industry training in the construction sector. The Level 3 units of the qualification (Module I: Water Supply System I, Sanitary Appliances Installation I and Drainage System Installation I) are covered in the companion book, *Plumbing Level 3: A Practical Study Guide for Kenyan Trainees*, by the same author. Unit titles and codes are used for reference only.

This is an independent study guide. It is not published or endorsed by TVET CDACC, TVETA or the Ministry of Education. Always follow the current official curriculum and your trainer's guidance.

Safety and accuracy notice

Plumbing work can injure and kill. People fall from tank stands, ladders and roofs; trenches collapse without warning; septic tanks, manholes and chambers can hold hydrogen sulphide and too little oxygen to breathe; pumps, electric showers and power tools can give an electric shock; sewage carries disease; and full tanks are very heavy. The methods in this book are for training under the supervision of a qualified trainer, always with the correct personal protective equipment. Never enter a septic tank, manhole, water tank or deep chamber; never work in an unsupported trench deeper than your supervisor allows; and leave all electrical work on pumps, heaters and whirlpool baths to a licensed electrician. Values given as "typical" or "example" (pressures, flows, falls, sizes, test values, quantities and prices) are general guidance only: always follow the drawing, the job specification, the manufacturer's instructions and your county and water company. Follow the current Kenyan laws and rules, including the National Building Code 2024, the Occupational Safety and Health Act 2007 and its rules, the Water Act 2016, the Public Health Act, the Environmental Management and Co-ordination Act and the Sustainable Waste Management Act 2022. Prices and tariffs are approximate (2026) and vary by town.

Names of people, businesses, email addresses, websites and phone numbers used in examples are made up for teaching. Pipes, fittings, appliances and equipment are described by type, not by brand.

Illustrations and photographs

The illustrations in this book were drawn for it. They are realistic teaching illustrations and are not to scale unless dimensions are given. Charts marked "typical" or "example" show typical shapes and values, not measured data, and the example rainfall is not a real weather station. Photographs come from Wikimedia Commons under free licences (public domain, CC BY or CC BY-SA); some have been resized or cropped. Each photograph is credited under the picture, and the full list of credits is at the back of the book.

How this book was made

Automated tools, including AI writing and drawing assistants, were used under the author's direction to help draft the text, draw the illustrations and charts, and check calculations, cross-references and layout. The content was checked against the curriculum documents and against published sources such as the National Building Code 2024, the Ministry of Water's practice manual, makers' data and Kenyan law, and the author is responsible for it. If you find a mistake, please report it through alphoncekirui.com so that it can be corrected in the next edition.

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Preface

Look along any street in a Kenyan town and you will see the work of plumbers: a black tank on a steel stand above a rental block, a green rainwater tank beside a mabati-roofed house, a line of inspection chambers running to the county sewer, a new lodge with wall-hung WCs and a whirlpool bath in the suite. County water often comes only two or three days a week, so every home needs storage. The long and short rains pour off millions of roofs that could fill tanks. Towns are laying new sewers, and the National Building Code 2024 now sets clear rules for drains, tests and rainwater. Behind each of these jobs is a plumber who can draw the system, count and price it, set it out to levels, install it, test it and hand it over. That is the Level 4 plumber.

This guide covers the new units of the Plumbing KNQF Level 4 course (Module II): Water Supply System II, Rainwater Harvesting System, Drainage System Installation II and Sanitary Appliances II, together with the 320 hours of industry training and the assessments that lead to your certificates. The Level 3 units of the qualification (Module I: Water Supply System I, Sanitary Appliances Installation I and Drainage System Installation I) are not repeated here. They are covered in the companion book, *Plumbing Level 3: A Practical Study Guide for Kenyan Trainees*, which this book calls "the Level 3 guide". Where a Level 4 job uses a Level 3 skill, such as cutting and fusing PPR, fixing a basin or laying a drain to a fall, this book gives a short reminder and points you to the right chapter of the Level 3 guide.

The book is written for trainees in vocational training centres and technical colleges, for candidates seeking recognition of prior learning, for trainers, and for working plumbers and fundis in contractors' firms, hotel and hospital maintenance teams, water companies and tank and rainwater installers who want their skills recognised. Everything is explained in plain English, with realistic drawings, worked calculations using Kenyan prices, tariffs and conditions, practical tasks with record sheets, and checklists matched to the way you will be assessed.

Above all, work safely. Tank stands and roofs, trenches, septic tanks and manholes kill plumbers every year in Kenya. Learn the safety rules in Chapter 2 before you climb, dig or lift a cover, and keep to them on every job. And save water: a Level 4 plumber who stops a leak, fits a low-flow shower or fills a tank from the roof does more for a family's budget than almost anyone else on site.

Alphonce Kimutai Kirui
Bomet, November 2026

How to use this book

This book follows the Level 4 part of the Plumbing course from start to finish. It covers the four Level 4 core units and the industry training, in the same order as your training. You can read it cover to cover, or study one unit at a time if you are taking a part qualification. Topics that all four units share, such as safety, measurements, pressure, flow and levels, are taught once in Part 1. The Water Supply part teaches the drawing and costing methods in depth (Chapters 4 and 5); the later units use the same methods and add only their own drawings, symbols and quantities. Level 3 topics are summarised and referred to the Level 3 guide.

The course at a glance

Part	What it covers	Training time
1. Getting started, safety and science	The Level 4 plumber and the course, assessment, safety at height, in trenches and near confined spaces, green practice, measurements, head and pressure, flow, demand, falls and levels	Used throughout (about 16 hours of the four units)
2. Water supply system II	Unit 1 (CON/CU/PLM/CR/01/4/MB): schematic and isometric drawings, take-off, schedules and quotations, storage tanks, stands and pumps, pipework, valves, tests and repairs	60 hours
3. Rainwater harvesting system	Unit 2 (CON/CU/PLM/CR/02/4/MB): harvesting methods, drawings, yield and tank sizing, costing, fabricating rainwater goods, installing, testing and maintaining	80 hours
4. Drainage system installation II	Unit 3 (CON/CU/PLM/CR/03/4/MB): drainage plans and long sections, costing, levelling and setting out, Code air test and other tests, faults, maintenance and waste-water treatment	60 hours
5. Sanitary appliances II	Unit 4 (CON/CU/PLM/CR/04/4/MB): layouts, schedules and estimates, fixing concealed cisterns, wall-hung WCs, bidets, whirlpool baths and showers, testing and commissioning	60 hours
6. Industry training and assessment	The industry training, the mentoring tool and portfolio, running plumbing jobs, a small plumbing business, and mock assessments for all four units	320 hours of industry training

The new Level 4 work is 60 + 80 + 60 + 60 = 260 hours of units plus 320 hours of industry training: 580 hours (58 credits). The full Level 4 qualification also includes the three Level 3 units (Module I, 300 hours), covered in the Level 3 guide: 880 hours (88 credits) in all.

What is in each chapter

- **What you will learn:** the chapter's goals, with the unit, learning outcome and training hours it belongs to.
- **Key words:** the trade words you need, explained simply. More are in the Glossary at the back.
- **Explanations and drawings:** each topic explained step by step, with realistic labelled illustrations, schematics, isometrics, plans and long sections, charts, drawn forms and photographs.
- **Worked examples:** head and pressure, tank sizes, take-offs, quotations, roof yield and monthly balances, gutter girths, falls, levelling, air tests, septic tanks, flow tests and water bills worked through with real numbers.

- **Practical tasks:** real workshop and site jobs with the tools, materials, steps, safety points and a "Record your results" table to fill in. Do them with your trainer.
- **Check your competence:** a checklist of what an assessor will expect you to show. Tick each item when you can do it without help.
- **Practice questions:** answers, with full working for calculations, are at the back of the book.

Look out for these boxes

SAFETY FIRST

Hazards and how to stay safe. Never skip these.

GREEN TIP

Ways to save water, energy and materials, choose low-VOC and water-efficient products, and handle waste correctly.

TRAINER'S TIP

Advice from experienced trainers and plumbers to help you work faster and better.

COMMON MISTAKES

Errors trainees often make, and how to avoid them.

ON SITE IN KENYA

How the topic looks on real Kenyan jobs: homes and rental blocks, schools, lodges and hotels, county water companies and sewers, tank and rainwater installers.

WORKED EXAMPLE

A calculation worked step by step with real numbers.

About the pictures and diagrams

This book uses realistic illustrations of real tanks, pumps, pipes, appliances and sites, schematic and isometric drawings, plans and long sections, charts, drawn forms and photographs. Labels and thin leader lines point to the parts that matter. The colours follow the Level 3 guide: **cold water blue**, **hot water red**, **drainage (soil and waste) brown**, and, new at Level 4, **rainwater and storm water teal**. Arrows show the direction of flow, and drains always fall away from the building. Red marks a danger, fault or mistake; green marks the correct way or a water-saving choice. Values marked "Example — follow the drawing and the maker's instructions" are typical, not rules. Some photographs show real sites where people are not following every safety rule; the captions point this out. Always wear the PPE shown in Chapter 2.

PART 1

Getting Started, Safety and Science

What a Level 4 plumber does beyond Level 3, how the four Level 4 units and the industry training are trained and assessed, and how this book links to the Level 3 guide. Then the safety, health and green practice that every Level 4 job shares (work on tank stands and roofs, trenches and confined spaces, pumps and electricity, waste), and the science and calculations all four units use: measurements and conversions, head and pressure, flow and friction, water demand, falls and levels.

Chapter 1: Moving Up to Level 4: The Plumber Who Plans, Costs and Installs
Chapter 2: Safety, Health and Green Practice on Level 4 Jobs
Chapter 3: Plumbing Science and Calculations for Level 4

CHAPTER 1

Moving Up to Level 4: The Plumber Who Plans, Costs and Installs

WHAT YOU WILL LEARN

- Describe what a Level 4 plumber does beyond Level 3.
- Explain how the course is built: units, codes, hours, credits and industry training.
- Explain in outline how you will be assessed and where the marks are.
- Describe the Kenyan plumbing scene, including the National Building Code 2024 and the water sector.
- Plan a career path and work professionally with clients and other professionals.
- Find your way around this book and your Level 4 workshop.

Course overview · Units CON/CU/PLM/CR/01/4/MB, 02/4/MB, 03/4/MB, 04/4/MB and industry training

At Level 3 you learned to install and repair the plumbing of a house: pipes, taps, a WC, a basin and the drains outside. At Level 4 you take charge of whole systems. You draw them, count and price the materials, mount the storage tanks, harvest the rain from the roof, set out drains to levels and commission the bathrooms. This chapter shows you the road ahead.

Key words

Schematic drawing
A simple line diagram that shows how the parts of a system connect, not their exact positions.

Take-off
Measuring and counting materials from a drawing so they can be ordered and priced.

Quotation
A written price for a job: materials, labour, transport, overheads and profit.

Commissioning
Filling, testing and checking a finished installation before handing it to the client.

Unit of competency
A block of the course with its own assessment and certificate.

Element
A main task inside a unit, such as "cost water supply materials".

PC weighting
The marks given to each performance criterion (PC) in formative assessment.

Greened curriculum
A curriculum that builds water saving, safe materials and waste control into every task.

National Building Code 2024
Kenya's building code, enforced by the National Construction Authority (NCA).

Industry training
Supervised work in a real workplace, often called attachment.

1.1 What a Level 4 Plumber Does

A Level 3 plumber installs pipework and appliances from a drawing someone else made, under supervision. A Level 4 plumber does more:

- **prepares schematic and isometric drawings** of whole water, rainwater, drainage and bathroom systems;
- **takes off quantities and prices a job**, from the materials schedule to a full quotation;
- **installs and mounts storage tanks** on bases and stands, with pumps, valves and the pipework to every floor;
- **plans, fabricates and installs rainwater systems**, including sheet-metal gutters made in the workshop;
- **sets out site drainage to levels**, then tests and maintains drains and treats waste water on site;
- **fixes the full range of sanitary appliances**, such as bidets, concealed cisterns, shower trays and whirlpool baths, and commissions them;
- **guides Level 3 juniors** and speaks for the plumbing work with clients, contractors and inspectors.

Table 1.1 shows how the same kind of job grows at Level 4. Figure 1.1 shows a Level 4 workshop set up for this work, and Figure 1.2 shows how the four units cover one house.

Table 1.1 From Level 3 to Level 4: the same job, more responsibility

Job	Level 3 plumber	Level 4 plumber
Water supply	Runs pipes and fits valves from a drawing	Draws the schematic, sizes the storage, mounts the tanks and pump, tests the system
Rainwater	Fixes a bought gutter	Sizes the tank from roof area and rainfall, fabricates and installs the gutters, tests and maintains
Drainage	Lays pipes to a fall and fits a chamber	Sets out the whole site drain from a bench mark, air-tests it, plans on-site treatment
Sanitary	Fixes a basin and a WC	Lays out an ensuite or toilet block, prices it, fixes and commissions every appliance
Paperwork	Fills a job card	Writes the materials schedule, quotation, test record and handover sheet

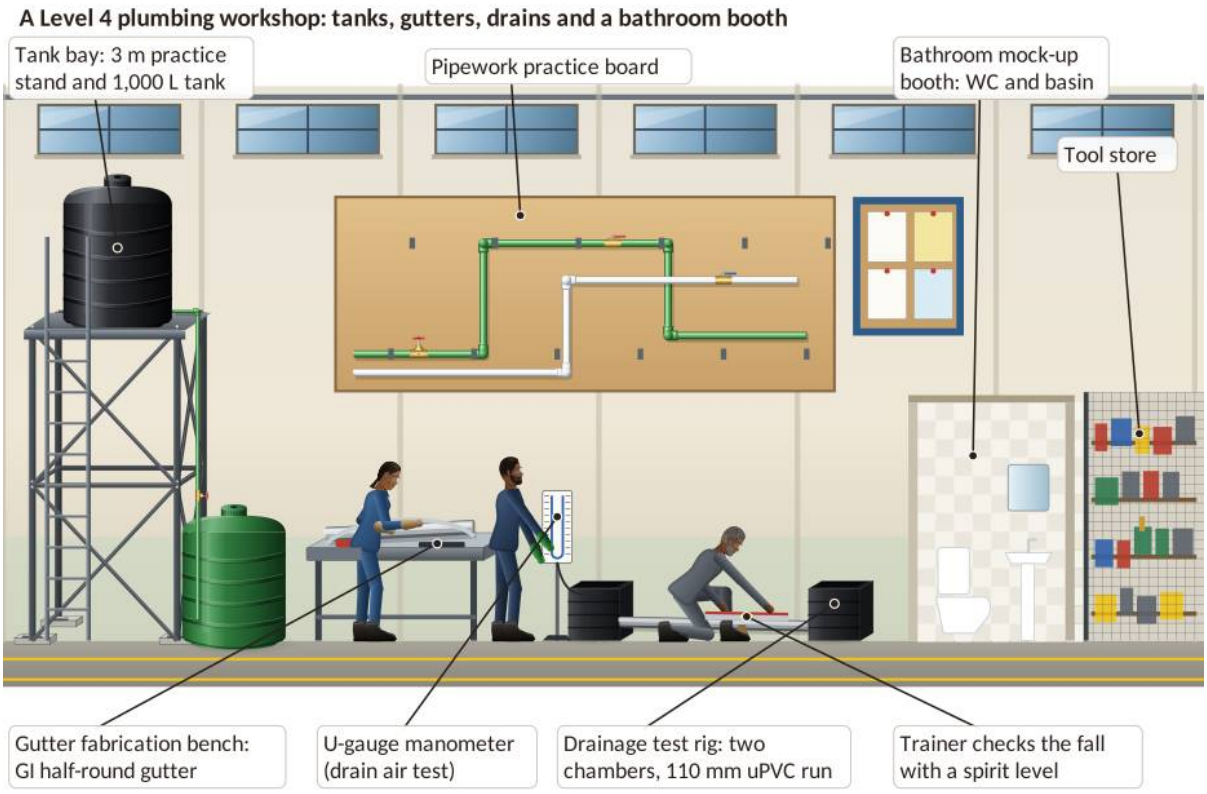


Figure 1.1 A Level 4 plumbing workshop at a county VTC. Each bay matches a unit: tanks on a practice stand, gutter fabrication, a drainage test rig and a bathroom mock-up booth.

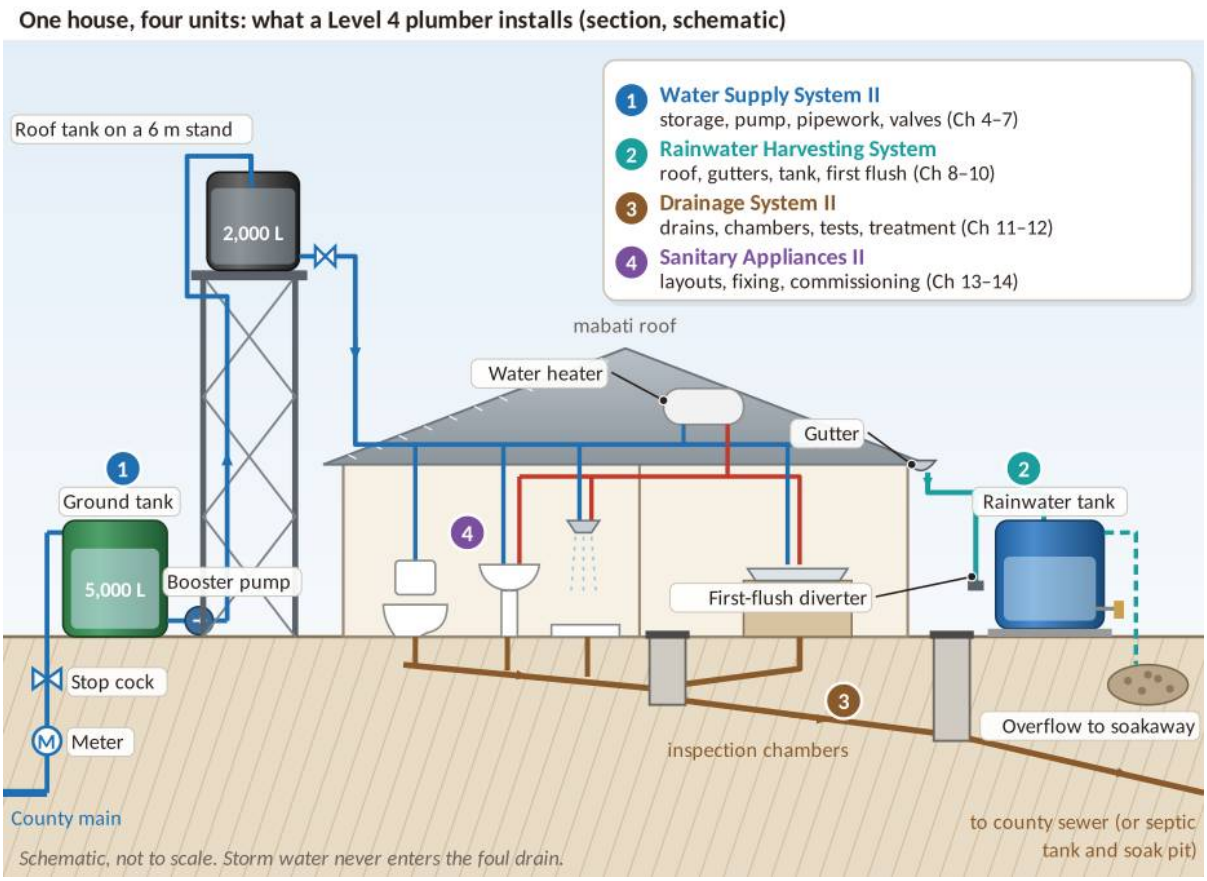


Figure 1.2 One house, four units: the scope of the four Level 4 units in a bungalow section. Cold water blue, hot red, rainwater teal, drainage brown; drains fall away from the house.

1.2 Where This Book Fits in the Course

The TVET CDACC curriculum for Plumbing Level 4 (Cycle 3, greened edition; programme code 0732 354 B) has two modules. **Module I** holds the three Level 3 units: Water Supply System I, Sanitary Appliances Installation I and Drainage System Installation I. **Module II** holds the four new Level 4 units in Table 1.2. Industry training of 320 hours completes the course.

This book covers **only Module II and the industry training**. Module I is taught in the companion book, *Plumbing Level 3: A Practical Study Guide for Kenyan Trainees*, called "the Level 3 guide" from now on. If you enter with KCSE and no Level 3, study the Level 3 guide alongside this one, because this book assumes its skills.

Table 1.2 The Level 4 units and where this book teaches them

Unit	Code	Hours	Credits	Chapters
Water Supply System II	CON/CU/PLM/CR/01/4/MB	60	6	4–7
Rainwater Harvesting System	CON/CU/PLM/CR/02/4/MB	80	8	8–10
Drainage System Installation II	CON/CU/PLM/CR/03/4/MB	60	6	11–12
Sanitary Appliances II	CON/CU/PLM/CR/04/4/MB	60	6	13–14
Industry training (construction sector)	—	320	32	15
New Level 4 work		**580**	**58**	

From here on the book calls Unit 3 "Drainage System II". Chapters 2 and 3 cover the safety and science that all four units share. The occupational standard prints the same units with OS instead of CU, and the PC weighting tool you may be given uses the earlier .../MA version codes; they refer to the same units (Chapter 15, Table 15.2 lists such differences between the documents).

The whole course is 300 + 260 + 320 = 880 hours (88 credits); one credit is ten hours. The 880 hours include Module I but not the Level 3 attachment (Figure 1.3). If you already hold Plumbing Level 3, ask your institution about credit for Module I.

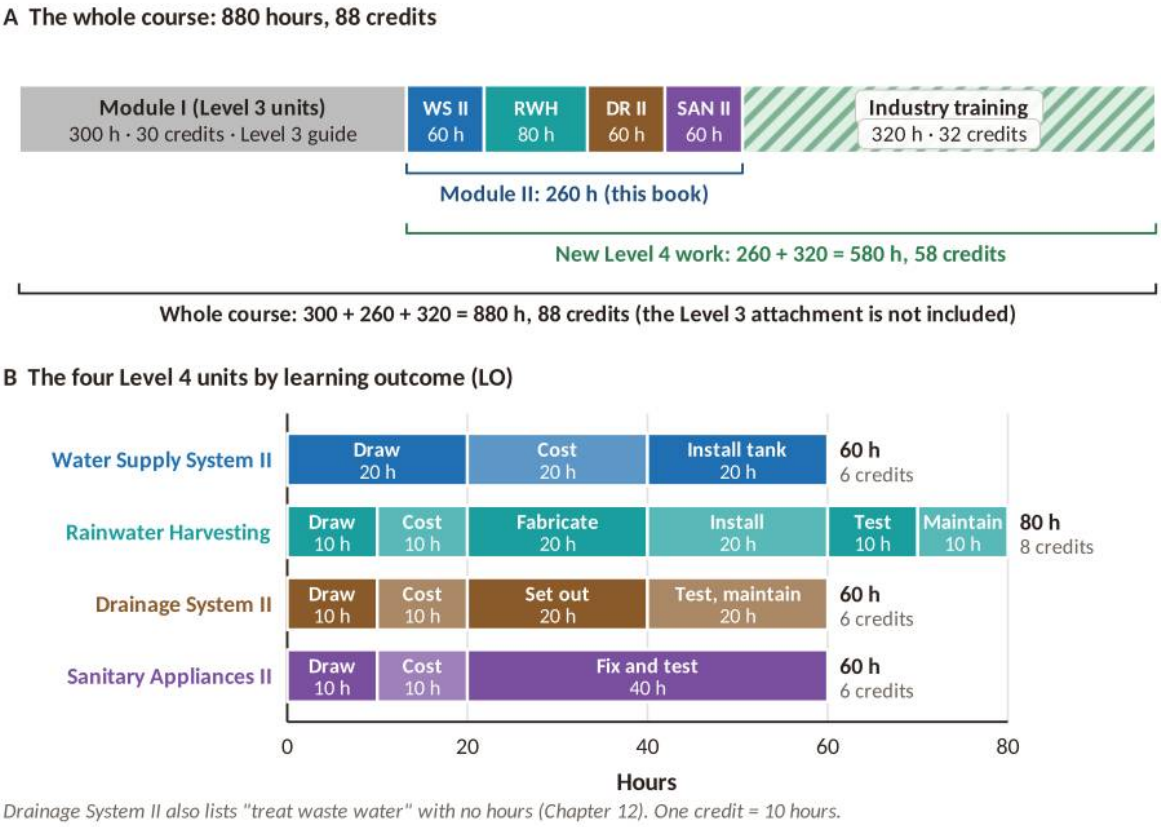


Figure 1.3 The course map. A: the whole course; this book covers Module II and the industry training. B: the four Level 4 units split into learning outcomes. Every unit has a drawing and a costing outcome.

1.2.1 Entry, trainers and industry training

You can enter with a KCSE mean grade of D− (minus) or a Plumbing Level 3 certificate. Your trainer holds at least a Level 5 craft certificate in plumbing or a related trade and is registered by TVETA. The 320 hours of industry training are spent in the construction sector: after all the units if you take the full qualification, or shared equally between the units if you take a part qualification. Dual-training trainees follow the dual training policy. A workplace mentor assesses you with a mentoring tool; Chapter 15 explains it.

WORKED EXAMPLE 1.1: HOURS TO WEEKS

Your VTC trains for 40 hours a week. How long are the Level 4 units, the industry training, all the new Level 4 work and the whole course?

Weeks = hours ÷ hours per week

Level 4 units: 260 h ÷ 40 h/week = **6.5 weeks**

Industry training: 320 h ÷ 40 h/week = **8 weeks** (40 working days of 8 hours)

New Level 4 work: 580 h ÷ 40 h/week = **14.5 weeks**

Whole course: 880 h ÷ 40 h/week = **22 weeks**

Sense-check: 6.5 + 8 = 14.5 weeks, and adding Module I (300 h = 7.5 weeks) gives 22 weeks. Holidays, revision and assessment weeks make the calendar time longer.

1.3 The Greened Curriculum

Your curriculum is "greened". Every unit asks you to choose eco-friendly materials, save water and energy, and control waste. On a plumbing job this is practical, not a slogan:

- **Save water.** Fix leaks first, fit low-flow taps and dual-flush cisterns, keep hot-water runs short, harvest rainwater.
- **Choose safe, long-life materials.** KEBS-marked pipes, low-VOC sealants and adhesives, lead-free materials on drinking water.
- **Reduce, reuse, recycle.** Plan cuts, reuse clean offcuts, keep PPR, uPVC, HDPE and metal scrap separate for recycling.
- **Dispose correctly.** Follow the Sustainable Waste Management Act 2022 and NEMA rules; nothing goes into drains or rivers.

Chapter 2 teaches these habits in detail, and every chapter has a "Green tip".

GREEN TIP

A tap that drips once a second wastes over 10 litres a day: more than 3,650 litres a year, nearly enough to fill two 2,000 L roof tanks. When a client asks for a quotation, check every tap and cistern first. Fixing leaks is the cheapest water a client will ever "buy".

1.4 How You Will Be Assessed

Your course follows competency-based education and training (CBET): you prove you can do the job to industry standard, mostly with your hands while an assessor watches and asks questions. The Level 3 guide, Chapter 1, explains units, elements and performance criteria. Here is the outline; Chapter 15 explains the rules in full.

- Each unit is assessed **formatively** (during training, at least once per element) and **summatively** (at the end).
- Unit score = 60% formative + 40% summative. In every assessment, theory carries 10% and practical 90%.

- Ratings: 80–100 Attained Mastery; 65–79 Proficient; 50–64 Competent; 49 and below Not Yet Competent. "Y" records assessment malpractice or irregularities.
- You work individually, in a real or simulated workplace, with the equipment, materials, instructions and deadlines of a real job. Evidence comes from practical tasks, projects, your portfolio, oral and written questions and third-party reports.
- Your assessor is licensed by TVETA as a trainer and registered by TVET CDACC to assess the unit; an industry expert may assess with them.

TVET CDACC issues a **Certificate of Competency** for each core unit you pass, a **Statement of Attainment** for a certifiable element, and the **Kenya National Certificate in Plumbing Level 4** when you pass every unit. Recognition of prior learning (RPL) can lead to part or all of the qualification.

> **WORKED EXAMPLE 1.2: WEIGHTED UNIT SCORE**
>
> Chebet's formative marks in Rainwater Harvesting average 72. Her summative mark is 61. What is her unit score and rating?
>
> Unit score = 0.6 × formative + 0.4 × summative
>
> = 0.6 × 72 + 0.4 × 61 = 43.2 + 24.4 = **67.6**
>
> 67.6 lies in the 65–79 band, so she is rated **Proficient**.
>
> Sense-check: the score must lie between 61 and 72, nearer to 72 because formative carries more weight. It does.

1.4.1 Where the marks are

Each element carries marks in the PC weighting tool, and each unit adds up to 100 or 101, so marks are almost percentages (Figure 1.4). Three lessons stand out. Drawing and costing together carry half of Water Supply System II and of Sanitary Appliances II, so paperwork is real work. Setting out alone carries 40 of the 101 marks in Drainage System II. Fabricating and installing rainwater goods carry half of the Rainwater Harvesting unit.

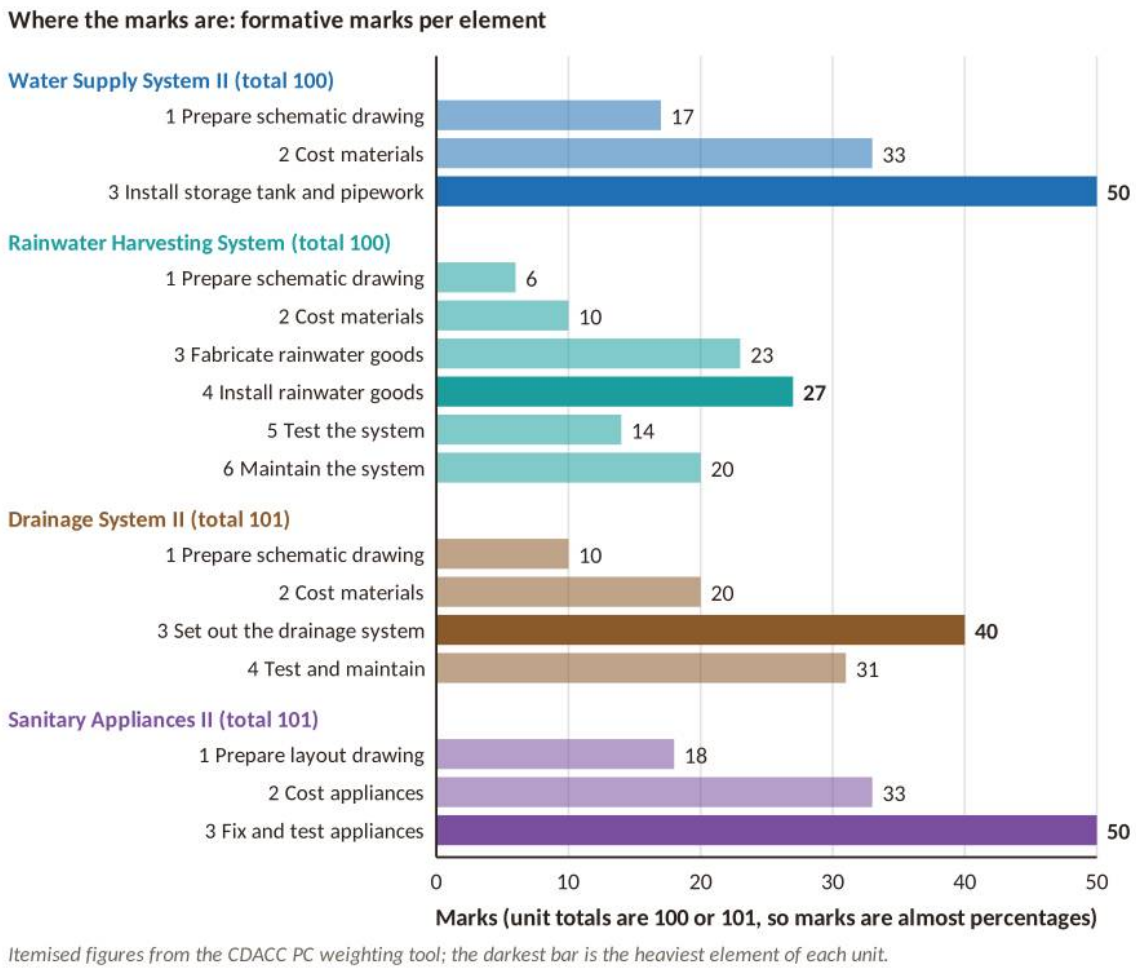


Figure 1.4 Where the marks are in formative assessment, element by element. Unit totals are 100 or 101, so the marks read almost as percentages.

WORKED EXAMPLE 1.3: MARKS TO A PERCENTAGE

In a formative assessment of Sanitary Appliances II, Mutua gains 78 of the 101 marks. What percentage and rating is this?

Percentage = marks gained ÷ total marks × 100

= 78 ÷ 101 × 100 = **77.2%**

77.2 lies in the 65–79 band: **Proficient**.

Sense-check: 78 marks of 101 is a little less than 78%, as expected when the total is just over 100.

1.5 Plumbing in Kenya Today

Most Kenyan towns ration piped water. In many estates the county water comes "twice a week", so homes store it in ground tanks, pump it to roof tanks on steel or masonry stands, and harvest rain from mabati (iron-sheet) roofs. Schools, churches and clinics catch rain in plastic and masonry tanks; in Machakos, Kitui and Makueni whole communities depend on rock catchments and sand dams. New estates connect to county

sewers, while rural homes, schools and farms use septic tanks, soak pits and bio-digesters. Apartments, hotels and lodges now expect ensuites with concealed cisterns, wall-hung WCs and instant or solar-heated showers (Figure 1.5).

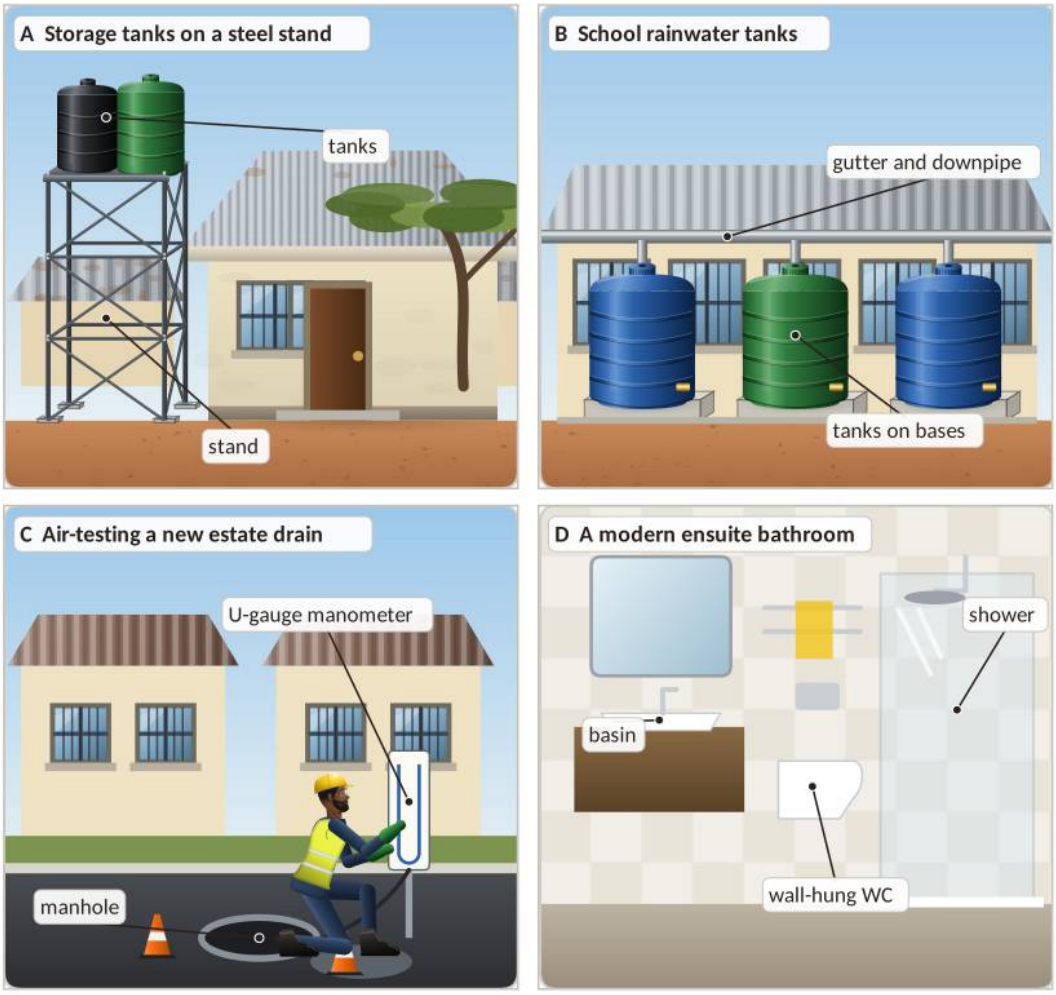


Figure 1.5 Level 4 work across Kenya: storage tanks on a stand at a peri-urban home (A), rainwater tanks at a school (B), an air test on a new estate drain (C) and a modern ensuite (D).



Figure 1.6 A storage tank on a steel stand beside a home in Gachie, Kiambu County: the everyday Kenyan answer to rationed supply, and the kind of installation you will mount in Chapter 6.

Photo: Queen Asali, CC BY-SA 4.0, via Wikimedia Commons

1.5.1 The rules you work under

The **National Building Code 2024** is the current Kenyan code. It was published as Legal Notice No. 47 of 2024, came into force on 1 March 2025 and replaced the old building by-laws of 1968. The NCA enforces it, and county governments approve building plans and inspect the work. Two examples you will meet in this book: storm water must not enter a sewer, and drains must be designed for inspection, testing and cleaning. The Code also expects new buildings to provide for rainwater harvesting and storm-water drainage.

Water services follow the **Water Act 2016**. WASREB licenses the county water companies (water services providers) and approves their tariffs. Only the water company connects a building to its main. Other bodies you will meet are NEMA (environment and effluent), KEBS (standards), EPRA (electricity and solar water heating) and the Water Resources Authority (boreholes and abstraction). International codes such as the BS EN standards and the International Plumbing Code are useful references, but the job specification and the Kenyan Code come first.

> **ON SITE IN KENYA**
>
> A landlord in Kasarani asks you to "fix the pressure" on the top floor of his rental block. You find a booster pump connected straight to the water company's supply pipe. This is illegal: Nairobi's water company charges a penalty of KSh 10,000 for pumping directly from the supply line, and the pump starves the neighbours. The legal answer is a ground tank filled from the main through a float valve, with the pump drawing from the tank. A Level 4 plumber explains the rule, draws the correct layout and prices it.

1.6 Your Career at Level 4

Figure 1.7 shows the ladder from Level 3 to Level 6 and the specialisms that open at Level 4. An employed Level 4 plumber in Kenya typically earns about KSh 30,000–60,000 a month (an estimate; it varies by town and employer). Many plumbers also run their own small businesses, which Chapter 15 covers.

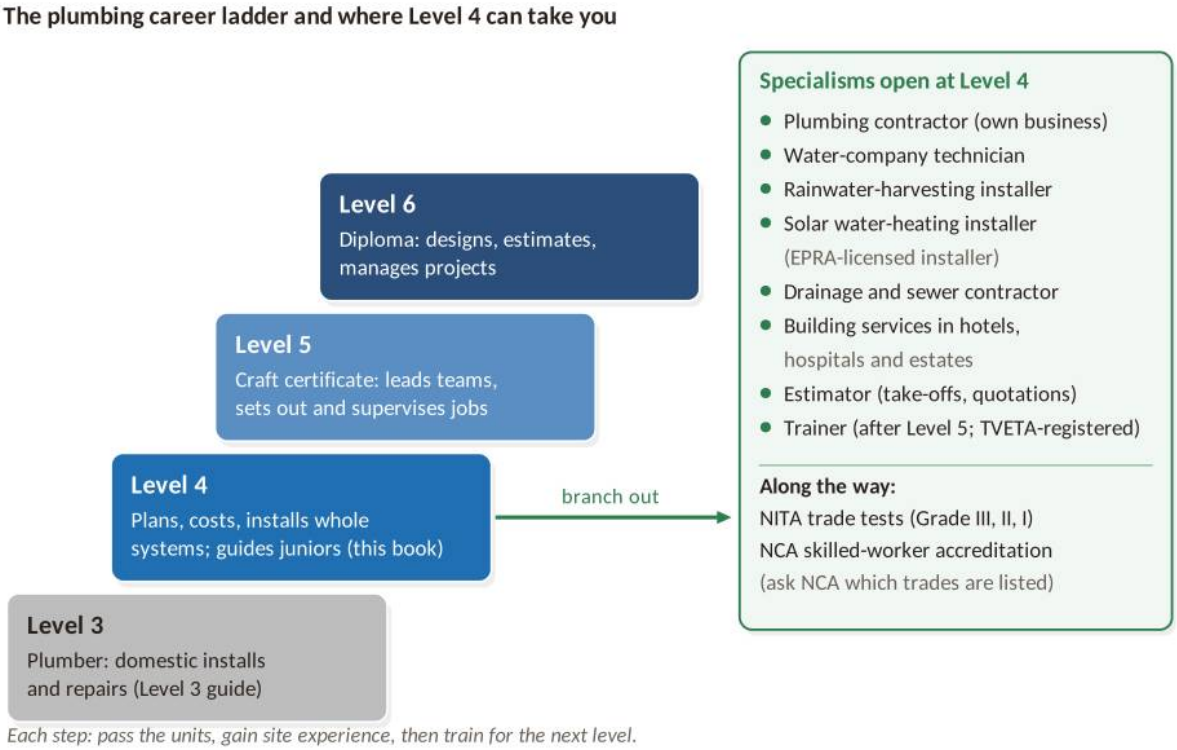


Figure 1.7 The plumbing career ladder from Level 3 to Level 6, and the specialisms a Level 4 plumber can branch into.

Three steps add value to your certificate. **NITA trade tests** (Grades III, II and I) are well known to employers; ask NITA or your trainer about the current plumbing test. The **NCA** accredits skilled construction workers (the card currently costs KSh 1,000 and lasts three years); ask NCA whether your trade class is listed. If you want to install solar water heaters, EPRA's 2025 regulations require installers to be licensed; without that licence you connect the pipework under a licensed installer.

1.7 Working Professionally

At Level 4 people will judge you on how you work as well as what you install.

- **Clients.** Explain the job, the price and the timetable in plain words. Put agreements in writing. Leave the site clean.
- **Quantity surveyors and engineers.** Follow their drawings and bills of quantities; ask in writing when something is unclear; never change a design without approval.
- **County inspectors and water-company staff.** Keep work open for inspection until it is approved, and keep your test records ready.
- **Juniors.** Show, watch, then let them try. Check their safety first.

Use your phone well. Photograph every stage before it is covered: these photos go into your portfolio and protect you if a client complains later. Learn a spreadsheet for take-offs and quotations. WhatsApp quotations are common; make them professional, with your name, the date, an itemised list, the validity period and the payment terms.

COMMON MISTAKES

- Treating drawing and costing as "office work" and leaving them to the end. They carry about half the marks in two units.
- Quoting from memory without measuring the site, then losing money on the job.
- Pumping from the main, or connecting storm water to a sewer, because the client asked for it.
- Covering pipework before it is tested and photographed.

1.8 How to Use This Book

Each chapter opens with what you will learn, the unit, learning outcome and hours. Key words come first; boxes mark safety, green tips, trainer's tips, common mistakes, Kenyan site examples and worked examples. Practical tasks end with a "Record your results" table for your portfolio. Each chapter closes with a summary, a competence checklist and ten practice questions; answers with full working are at the back. Values in this book are **typical examples**: figures carry the note "Example — follow the drawing and the maker's instructions", and on a real job you follow the drawing, the manufacturer's instructions and your county or water company.

TRAINER'S TIP

Start your Level 4 portfolio today with five dividers: the four units and industry training. Every drawing, take-off, quotation, test record and dated photo goes behind the right divider the same day. Assessors trust a portfolio that grew week by week.

SAFETY FIRST

The Level 4 workshop has hazards that the Level 3 bays did not: a tank stand, sheet-metal edges, test pressures and open chambers. On your first visit, look but do not climb, switch on or open anything. Climbing the practice stand needs a harness and your trainer's permission (Chapter 2).

Practical task 1.1: Know your Level 4 workshop and site

Tools and equipment

- Overall, safety boots and helmet
- Clipboard, pen and the record sheet below
- Phone camera
- Steel tape measure

Materials

- Workshop layout sketch (A4)
- Portfolio file with five dividers

Steps

1. With your trainer, walk round the workshop and yard with all equipment switched off.

2. Find the tank-installation bay: note the stand height, the tanks and how they are tied down.
3. Find the gutter fabrication bench and the sheet-metal tools.
4. Find the levelling instruments: spirit levels, water level, automatic or laser level and staff.
5. Find the test equipment: pressure test pump and gauge, U-gauge manometer, drain plugs, smoke and dye kit.
6. Find the stores, the PPE store and harnesses, the first-aid box, fire extinguishers and the main electrical isolator.
7. Mark everything on your sketch. Note the condition of each item and anything unsafe, and report it to your trainer.
8. Photograph the bay layout, date the photo and file it with this sheet in your portfolio.

Safety

- Do not climb the stand, open chambers, switch on pumps or pressurise anything during this task.
- Wear gloves when handling sheet metal; keep clear of anyone working.

Record your results

Item	Location	Details (size, rating, quantity)	Condition / safety notes
Tank stand and tanks			
Fabrication bench and tools			
Levelling instruments			
Pressure pump and gauge			
Manometer, plugs, smoke and dye kit			
PPE and harnesses			
First aid and fire equipment			

Chapter summary

- A Level 4 plumber draws, prices, installs, tests and commissions whole systems and guides juniors.
- This book covers Module II (260 h) and industry training (320 h): 580 h and 58 credits. Module I is in the Level 3 guide; the whole course is 880 h.
- The four units are Water Supply System II, Rainwater Harvesting System, Drainage System II and Sanitary Appliances II.
- Unit score = 0.6 × formative + 0.4 × summative; theory 10%, practical 90%; 50 is Competent.
- Drawing and costing carry about half of two units; setting out carries 40 marks in Drainage System II.
- The National Building Code 2024, enforced by the NCA, is the current Kenyan code; water companies are licensed by WASREB.
- Work professionally, photograph every stage and keep your portfolio up to date.

Check your competence

- [ ] I can name the four Level 4 units with their codes and hours.
- [ ] I can explain why the course is 880 hours but the new Level 4 work is 580 hours.
- [ ] I can calculate a weighted unit score and give the rating.
- [ ] I can say which element carries most marks in each unit.
- [ ] I can name the current Kenyan building code and the body that enforces it.
- [ ] I can explain why a pump must never draw directly from the water main.
- [ ] I can describe three specialisms open to a Level 4 plumber.
- [ ] I can locate the main equipment and safety items in my Level 4 workshop.

Practice questions

1. Name the four Level 4 units, with their codes and hours.
2. The Level 4 units and industry training add up to 580 hours, but the course total is 880 hours. Explain the difference.
3. Your evening class trains for 30 hours a week. How many weeks will the 260 hours of Level 4 units take?
4. Oral: what is the difference between a Certificate of Competency, a Statement of Attainment and the Kenya National Certificate in Plumbing Level 4?
5. Otieno's formative average in Drainage System II is 70. What summative score does he need to reach Proficient (65)? Could he still reach Attained Mastery?
6. In a formative assessment of Drainage System II a trainee gains 62 of the 101 marks. Give the percentage and the rating. How many more marks would make her Proficient?
7. Which element carries the most marks in each Level 4 unit, and what does this tell you about how to study?
8. Fault-finding: a landlord in Kasarani complains that (a) the top-floor flats get no water while the ground floor has some, and (b) in the rains the manhole in the compound overflows with sewage. Give a likely cause of each and the unit of this book that deals with it.
9. Oral: name the current Kenyan building code, the body that enforces it, and two requirements from it that affect plumbers.
10. Practical: complete Task 1.1, then set up your Level 4 portfolio. List two pieces of evidence you will file behind each of the five dividers.

PART 3

Rainwater Harvesting System

Unit 2: Rainwater Harvesting System (CON/CU/PLM/CR/02/4/MB, 80 hours). Harvesting methods, drawings, roof yield, demand and tank sizing by formula and monthly balance, first flush, gutters and downpipes, schedules and quotations; fabricating gutters, downpipes, brackets and fittings from plain sheet; installing, testing and maintaining roof rainwater systems.

Chapter 8: Planning a Rainwater Harvesting System
Chapter 9: Fabricating Rainwater Goods
Chapter 10: Installing, Testing and Maintaining Rainwater Systems

CHAPTER 8

Planning a Rainwater Harvesting System

WHAT YOU WILL LEARN

- Describe the main rainwater harvesting methods used in Kenya and choose one for a site.
- Name the parts of a roof system and explain how each protects water quality.
- Prepare pictorial, scale and schematic drawings of a rainwater system.
- Work out roof yield from rainfall data, set demand priorities and size a tank by the rough formula and the monthly balance.
- Size first-flush diverters, gutters and downpipes, and site the tank within the rules.
- Take off quantities, prepare a materials schedule and price a quotation.

Unit: Rainwater Harvesting System · CON/CU/PLM/CR/02/4/MB · Learning outcomes 1 and 2 · About 18 hours

Almost every mabati roof in Kenya could fill a tank, yet many still pour their water onto the ground. A Level 4 plumber is asked the client's real questions: how much water will this roof give, how big a tank do I need, and what will it cost? This chapter answers them. Chapter 9 fabricates the gutters and Chapter 10 installs, tests and maintains the system.

Key words

Catchment
The surface that collects the rain: a roof, a rock face or the ground.

Runoff coefficient
The share of the rain that actually reaches the tank, such as 0.8 for a good mabati roof.

Yield
The water a catchment gives in a month or a year, in litres or m^3.

Dry spell
A period of little or no rain between rainy seasons.

First flush
The first, dirtiest water off a roof at the start of a storm, sent away from the tank.

Leaf screen
A mesh at the gutter outlet or tank inlet that stops leaves and insects.

Monthly balance
A month-by-month count of water in, water out and water left in the tank.

Rock catchment
A bare rock surface with small walls or gutters that lead runoff into a tank.

Sand dam
A wall across a seasonal river that traps sand, which then holds water.

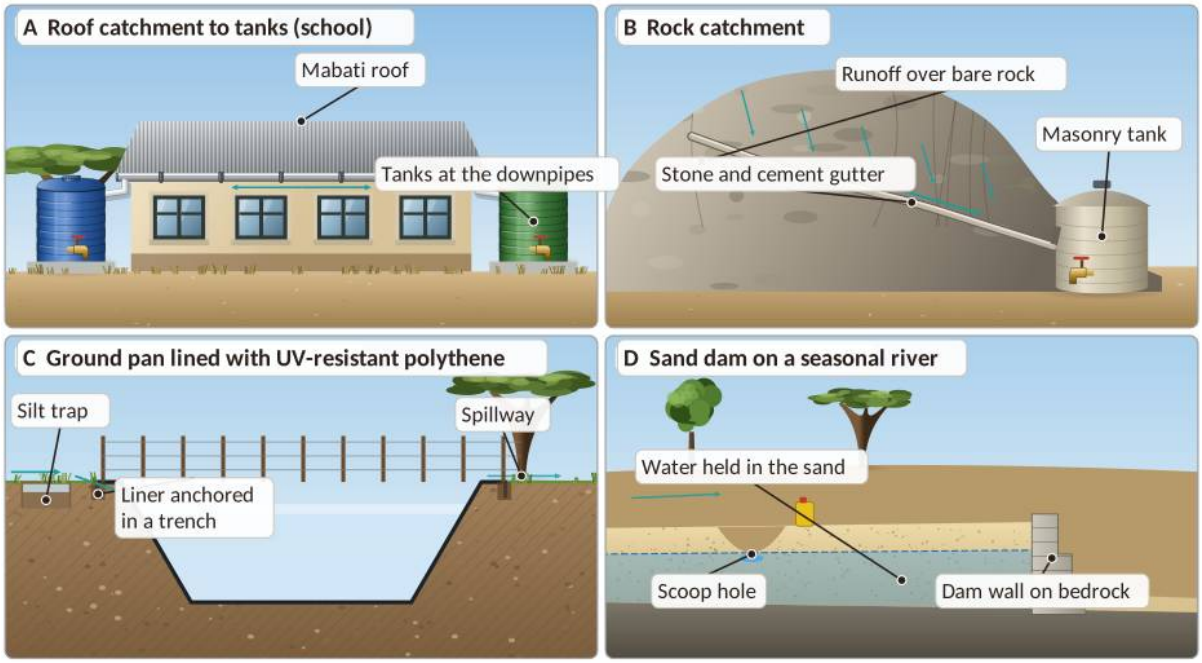
Recharge pit
A stone-filled pit that lets overflow soak back into the ground.

8.1 Why Harvest Rain in Kenya

County water is rationed in most towns, many boreholes are salty or expensive, and rural households in dry counties walk far for water. At the same time, heavy storms in the long rains (March to May) and short rains (October to December) flood roads and wash away soil. Harvesting turns that runoff into a supply. The National Building Code 2024 expects new buildings to provide for rainwater harvesting and storm-water drainage; check what is required for your building with the county. Counties, the National Water Harvesting and Storage Authority and many NGOs fund tanks for schools and health centres. With rainfall becoming less reliable, storage that carries a household through dry spells is valuable work.

8.2 Harvesting Methods

Figure 8.1 shows four methods. The curriculum also names others; know what each is for.



Not to scale. Pans, dams and rock catchments are community works designed by engineers.

Figure 8.1 Four ways of harvesting rain in Kenya: (A) roof catchment to tanks, (B) rock catchment, (C) a ground pan lined with UV-resistant polythene, (D) a sand dam across a seasonal river.

- **Roof catchment to tanks:** the plumber's main work. Clean water for homes, schools, churches and clinics.
- **Rock catchment:** in Machakos, Kitui and Makueni, small walls and stone gutters on bare granite domes lead runoff to masonry tanks or dams. Large yields for whole villages.
- **Ground or surface catchment:** runoff from fields and compounds led into an excavated pan or pond, lined with UV-resistant polythene to stop seepage, with a silt trap and a spillway. Water for livestock and irrigation, not drinking without treatment. Earth dams are larger versions designed by engineers.
- **Sand dams and sub-surface dams:** a wall across a seasonal river traps sand; the sand stores water safe from evaporation, drawn from a scoop hole or a well.
- **Road runoff:** water from murram roads led by mitre drains into pans or farms.

- **Green roofs:** flat roofs planted with soil and plants. They slow runoff, cool the building and reduce flooding, but they yield little, stain the water and need a strong waterproofed roof designed by an engineer.
- **Recharge pits:** overflow led into stone-filled pits returns water to the ground.

Large ground tanks are often built in masonry or ferrocement, as at many Kenyan schools (Figure 8.2). The structure is the engineer's and mason's work; the plumber sizes the system, makes the connections and keeps the water clean.

8.3 The Parts of a Roof System and Water Quality

Figure 8.3 shows the bungalow's system. Follow a raindrop: it runs off the **catchment** (the roof) into the **gutter**, which falls to an **outlet** with a **leaf screen**. A **downpipe** or conveyance pipe carries it through a **first-flush diverter**, which holds back the dirtiest first water, and into the tank through a **screened inlet**. The tank has a closed **lid**, a **tap** above the base, a **washout valve** at the lowest point, and an **overflow** that leads surplus water to a **soak or recharge pit**.



Figure 8.2 A masonry rainwater tank fed from the roof of a classroom block at Khaimba Primary School, Kenya. The gutter runs along the eaves to a pipe over the tank.

Photo: SuSanA Secretariat, CC BY 2.0, via Wikimedia Commons

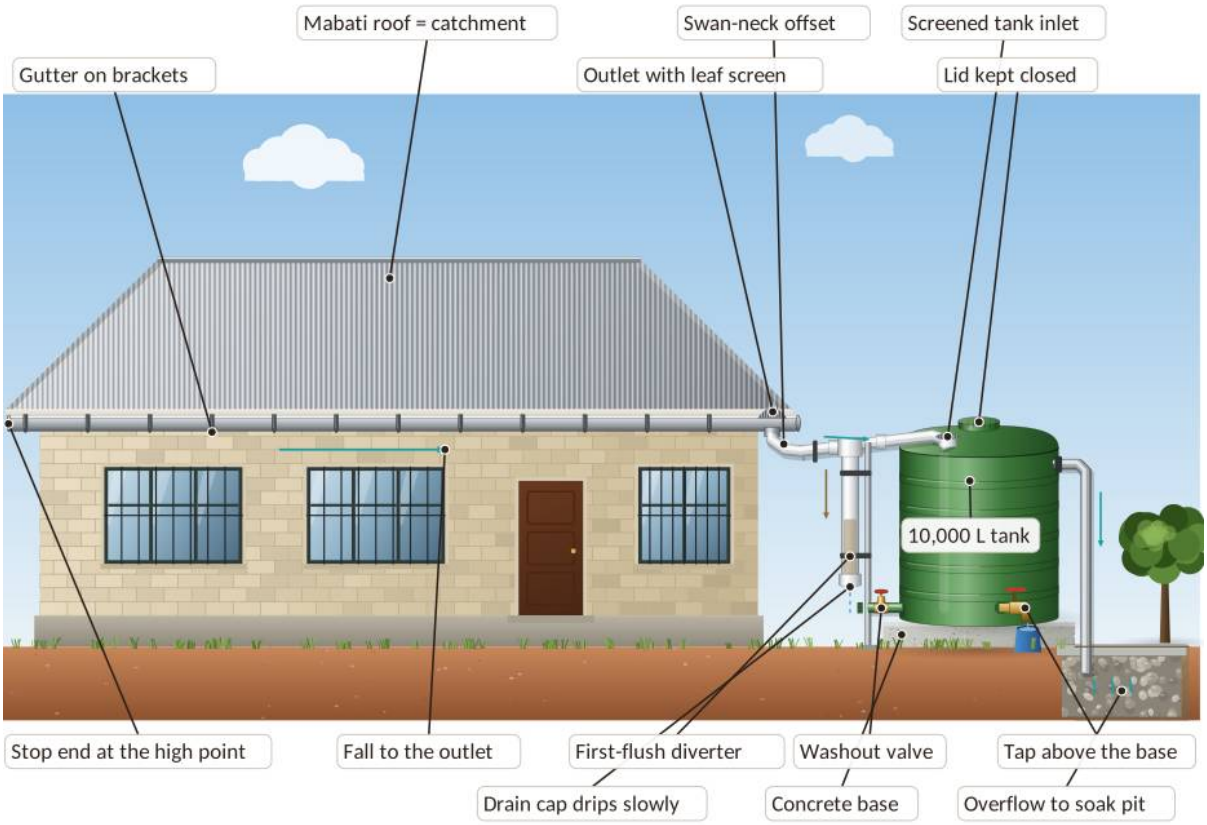


Figure 8.3 A complete roof rainwater harvesting system on the bungalow. Teal arrows show the path of the rain from the roof to the tank.

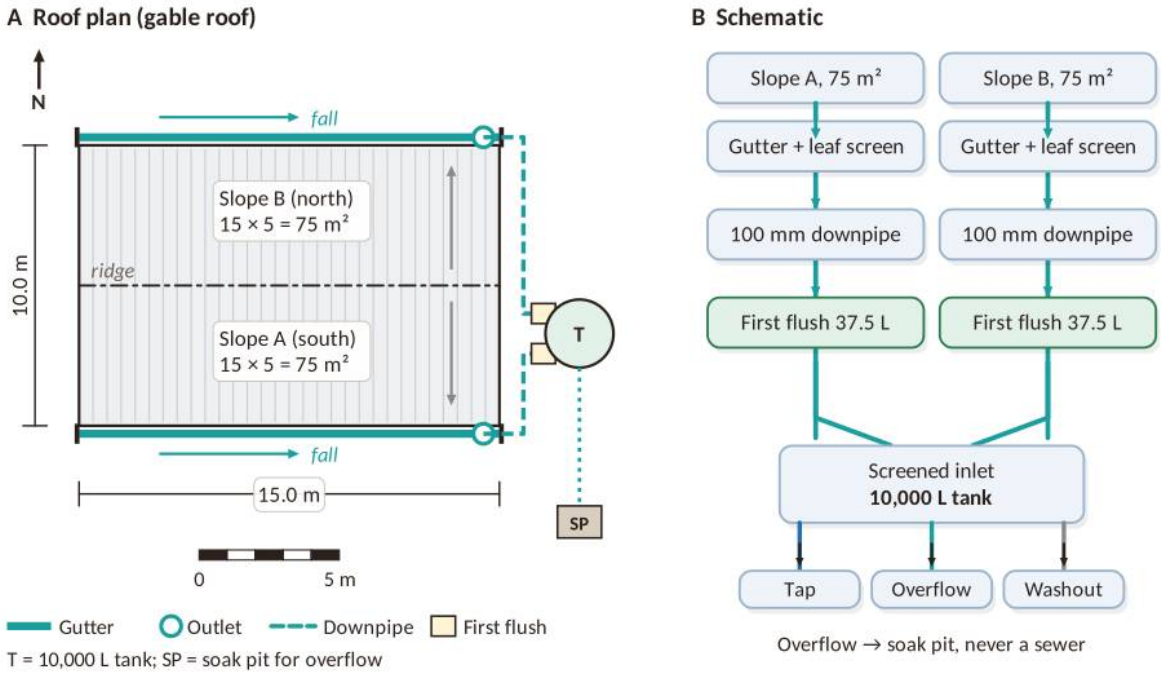
Roof water is fairly clean, but bird droppings, dust, leaves and insects get in. Every part above has a quality job: screens keep out leaves and mosquitoes; the first flush removes most of the dirt; a dark, closed tank stops algae and keeps children and animals out; drawing water above the floor leaves sediment behind. Even so, treat roof water for drinking by boiling or an approved method. Do not harvest drinking water from thatch or freshly painted roofs, and avoid lead-based paints and flashings.

8.4 Drawings for Rainwater Harvesting

Chapter 4 taught the drawing method; this section adds what rainwater drawings must show.

- **Freehand site sketch:** made during the survey. Roof shape, eaves lengths, ridge, valleys, fascia condition, existing gutters, trees, latrines, septic tank and drainage, and where a tank could stand. Measure the roof on plan (Chapter 3, Figure 3.2).
- **Pictorial drawing:** shows the client what the finished system will look like (Figure 8.3).
- **Scale roof plan:** eaves lines, roof slopes with their areas, gutter runs with the high points and fall arrows, outlets, downpipes, first-flush diverters, tank, overflow and soak pit, with dimensions, scale bar and north point.
- **Schematic:** the flow from each catchment area to the tank and from the tank to tap, overflow and washout.

Draw rainwater lines in teal (cold water stays blue) and add a legend. Figure 8.4 shows the bungalow's gable roof: two slopes of 75 m², each with a gutter falling to an outlet at the east end, two downpipes, two first-flush diverters and one 10,000 L tank.



Example — follow the drawing and the maker's instructions. Plan scale shown by the bar; schematic not to scale.

Figure 8.4 The bungalow roof plan with catchment areas, gutter falls, outlets, downpipes, first-flush diverters and tank (A), and the same system as a schematic (B). Example.

8.5 Supply: Rainfall and Runoff

Rain is measured in millimetres. One millimetre of rain on one square metre of roof is one litre (Chapter 3). So:

Yield (L) = roof plan area (m²) × rainfall (mm) × runoff coefficient

The **runoff coefficient** allows for water lost to splash, wetting the roof, evaporation and overflow. This book uses **0.8** for mabati or tile roofs in good condition, **0.7** for old or dusty roofs or when unsure, and **0.2 or less** for thatch, which is not suitable for drinking water. Always state the coefficient you used. Roofs carrying solar panels or solar roof tiles still harvest well: rain runs off the glass into the same gutters. Measure the plan area as before, keep panel brackets and cables clear of the gutter line, and leave panel fixing and wiring to a licensed solar installer.

Get rainfall for your area from the Kenya Meteorological Department or a nearby station: monthly averages over many years, and if possible the driest years. Kenya's rainfall varies greatly. A UK Met Office climate profile for Nairobi, for example, gives a long-term mean of about 615 mm a year: about 310 mm in March to May, about 200 mm in October to December and about 80 mm in January and February, with little in between. This book's examples use two patterns (Table 8.1).

Table 8.1 Example monthly rainfall used in this book (mm; not a real station — use local records)

Area	J	F	M	A	M	J	J	A	S	O	N	D	Year
Highland town	50	50	120	250	180	50	30	30	40	130	180	90	1,200
Semi-arid town	30	20	70	120	30	5	5	5	10	60	160	85	600

In the semi-arid pattern the short rains bring more than the long rains, as in much of Machakos, Kitui and Makueni.

WORKED EXAMPLE 8.1: BUNGALOW YIELD AGAINST DEMAND

Roof plan area 150 m^2; example rainfall 1,200 mm a year; good mabati, coefficient 0.8.

Yield = 150 × 1,200 × 0.8 = **144,000 L a year** (144 m^3), an average of 395 L a day.

The family's whole use is 900 L a day (Chapter 3), so roof water alone cannot replace the county supply. Two lower demands are possible:

Everything except WC flushing and the garden, 50 L per person: 6 × 50 = 300 L/day = 109,500 L a year. The roof gives 1.32 times this over a year.

Drinking and cooking only, about 10 L per person (example): 6 × 10 = 60 L/day = 21,900 L a year.

Sense-check: 144 m^3 is about 7,200 jerricans, a big resource, but it arrives mostly in two rainy seasons.

8.6 Demand and Priorities

Demand is people × litres per person per day (the Kenyan demand table is in Chapter 3, Figure 3.7). For rainwater, agree **priorities** with the client, because the roof and the budget are limited: drinking and cooking first, then washing and bathing, then laundry, and last WC flushing, livestock and gardens. Water for flushing and gardens can come from a second tank, grey water or the county supply. At a school, drinking water and handwashing come first.

8.7 Sizing the Tank

8.7.1 The rough formula

The Ministry of Water's *Practice Manual for Water Supply Services in Kenya* (2005) gives a quick estimate:

C = 0.03 × D × (T + 2), where C is the tank size in m^3, D the daily demand in litres and T the longest dry spell in months.

WORKED EXAMPLE 8.2: ROUGH TANK SIZE FOR THE BUNGALOW

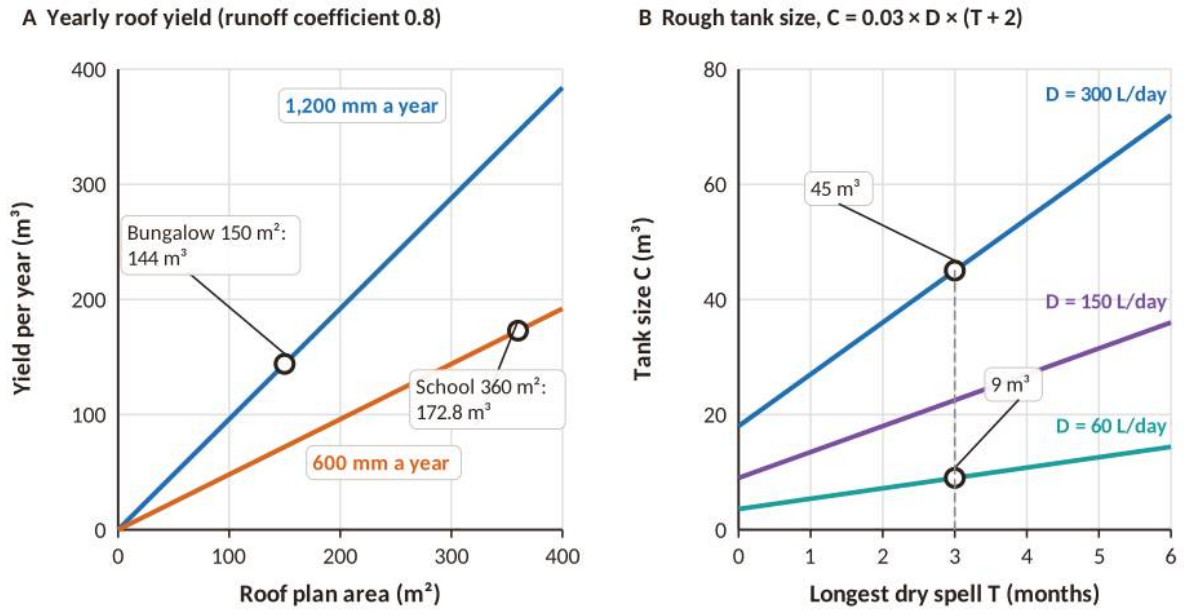
Longest dry spell in the example pattern: about 3 months (July to September), so T = 3.

Full demand, D = 300 L/day: C = 0.03 × 300 × (3 + 2) = **45 m^3**. That is four 10,000 L tanks and a 5,000 L tank: KSh 352,000 for tanks alone at book prices. Too costly for this family.

Drinking and cooking, D = 60 L/day: C = 0.03 × 60 × (3 + 2) = **9 m^3** → choose one **10,000 L tank**.

Sense-check: a 10,000 L tank holds 167 days of drinking and cooking water, or about 33 days of the 300 L/day demand.

Figure 8.5 shows both relations: yield grows in a straight line with roof area and rainfall, and the rough tank size grows with demand and the length of the dry spell.



A: yield = area × rainfall × 0.8. B: rough sizing rule from the Practice Manual for Water Supply Services in Kenya (MWI 2005); D = daily demand. Example values — check with the monthly balance and local rainfall records.

Figure 8.5 How roof area, rainfall, demand and dry spell drive the design: (A) yearly yield against roof plan area; (B) the rough tank size from the Ministry of Water formula (example values).

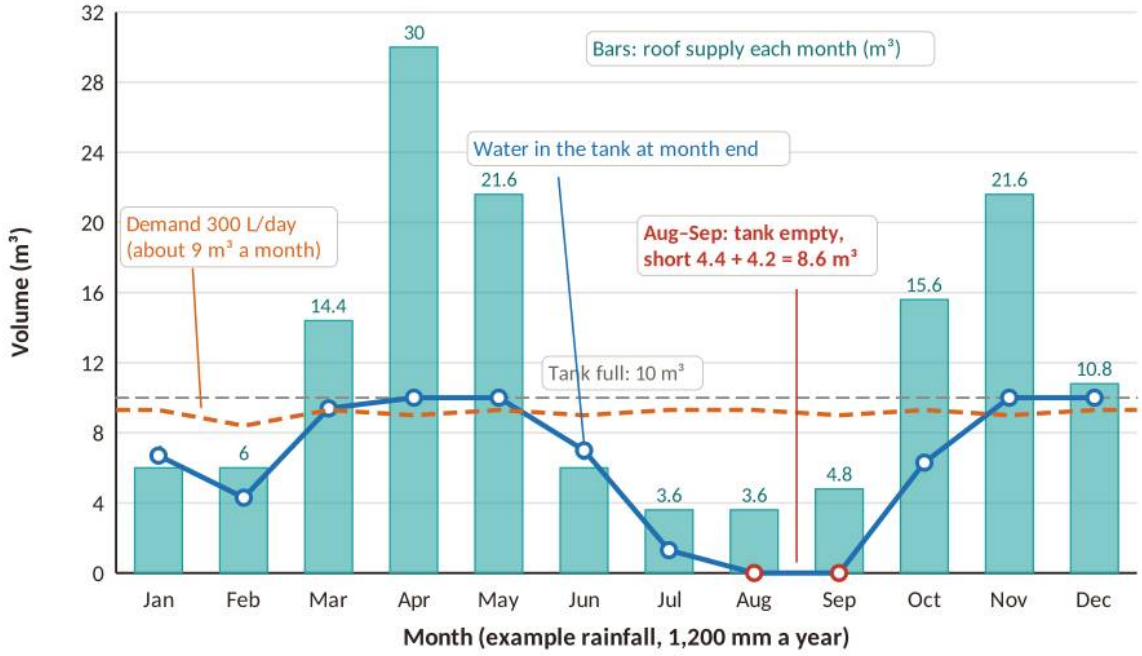
8.7.2 The monthly balance

The rough formula ignores the real pattern of rain. The **monthly balance** follows it month by month: water in the tank at the end of a month = water at the start + roof supply − demand. The tank cannot hold more than its size (the extra overflows) or less than nothing (a shortfall). Start the count at the end of a rainy season with the tank full and run through the year twice, so the result does not depend on the starting guess. Table 8.2 tests a 10,000 L tank against the full 300 L/day demand. The roof supply each month is 150 × rainfall × 0.8 ÷ 1,000 m³, which is 0.12 m³ for every millimetre of rain.

Table 8.2 Monthly balance for the bungalow: 10 m³ tank, demand 300 L/day (example; m³)

Month	Rain (mm)	Supply	Demand	In tank at month end	Overflow	Shortfall
Jan	50	6.0	9.3	6.7	0	0
Feb	50	6.0	8.4	4.3	0	0
Mar	120	14.4	9.3	9.4	0	0
Apr	250	30.0	9.0	10.0	20.4	0
May	180	21.6	9.3	10.0	12.3	0
Jun	50	6.0	9.0	7.0	0	0
Jul	30	3.6	9.3	1.3	0	0
Aug	30	3.6	9.3	0	0	4.4
Sep	40	4.8	9.0	0	0	4.2
Oct	130	15.6	9.3	6.3	0	0

Month	Rain (mm)	Supply	Demand	In tank at month end	Overflow	Shortfall
Nov	180	21.6	9.0	10.0	8.9	0
Dec	90	10.8	9.3	10.0	1.5	0
Year	1,200	144.0	109.5		43.1	8.6



Example values — 150 m² roof, runoff coefficient 0.8. Use rainfall records for your own area.

Figure 8.6 Monthly balance for the bungalow with a 10,000 L tank and a demand of 300 L a day (Table 8.2): the tank runs dry in August and September (example rainfall).

Read the result (Figure 8.6). The 10,000 L tank meets the full 300 L/day in ten months out of twelve, and runs dry in August and September, 8.6 m³ short. Meanwhile 43.1 m³ overflows in the rains. Repeating the balance with bigger tanks shows that about 19 m³ would carry the full demand through this example year, far less than the 45 m³ of the rough formula, which is deliberately on the safe side. A drier year needs more, so designers run the balance with the driest years on record, or add a margin. For 150 L/day the 10,000 L tank never empties in this example year.

8.7.3 Choosing the tanks

Round up to a size you can buy and carry to site. Several tanks side by side can be added later and isolated for cleaning; one large tank usually costs less per litre (Chapter 6, Figure 6.2). For very large volumes, masonry or ferrocement tanks built on site can be cheaper; compare quotes. Let the client decide with the figures in front of them: the 10,000 L tank for drinking and cooking now, a second tank when money allows.

8.8 The School Example

The day secondary school in Makueni has 600 pupils and two classroom blocks, each with about 180 m² of mabati roof (Figure 8.7).

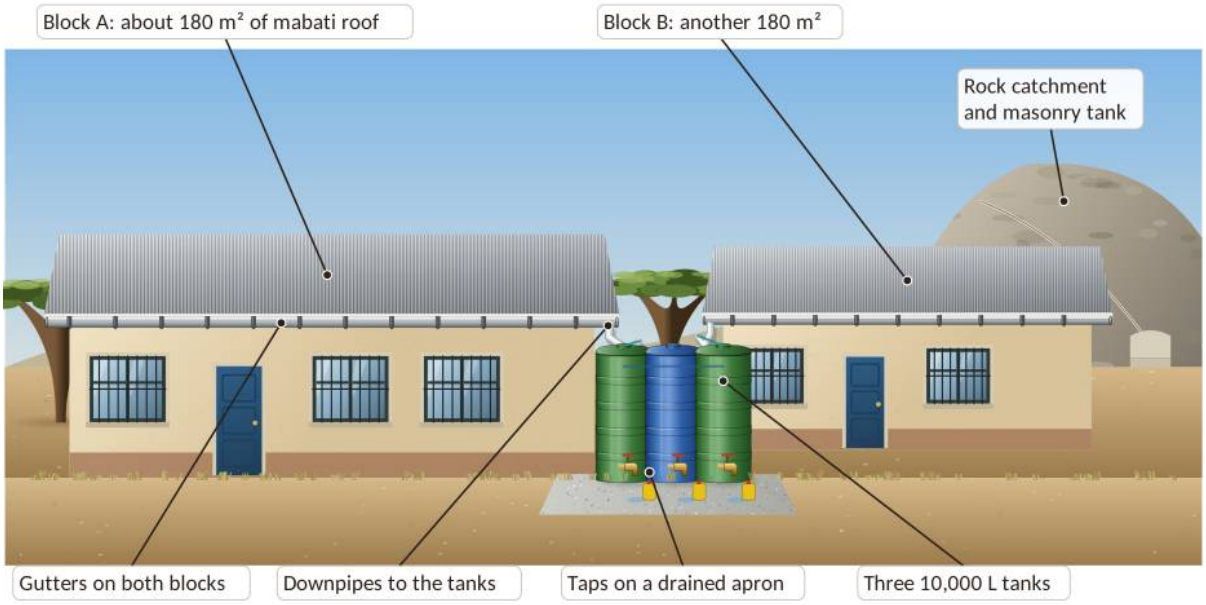


Figure 8.7 The Makueni day school: two classroom blocks of about 180 m² each drain to a row of three 10,000 L tanks.

WORKED EXAMPLE 8.3: CAN THE ROOFS SUPPLY THE SCHOOL?

Roof area = 2 × 180 = 360 m². Example rainfall 600 mm a year; coefficient 0.8.

Yield = 360 × 600 × 0.8 = **172,800 L a year**.

Day school with WCs, 25 L per pupil (Chapter 3): 600 × 25 = 15,000 L/day. The roofs give only 172,800 ÷ 15,000 = **11.5 days** of that.

Drinking and handwashing, about 5 L per pupil (example): 3,000 L/day → 172,800 ÷ 3,000 = **57.6 days**.

Drinking only, about 2 L per pupil (example): 1,200 L/day → **144 days**. The three 10,000 L tanks (30,000 L) hold 25 days of drinking water.

Sense-check: a Kenyan school year has well over 150 school days, far more than 58, so roof water cannot carry the whole school. Keep it for drinking, add tanks or the nearby rock catchment, and use other water for WCs.

In this semi-arid pattern most of the school's water arrives in November and April. Tanks must be big enough to catch those months and to carry the school through the dry months between them. Tanks also serve hand-washing stations at toilet blocks (Figure 8.8); keep their taps above a drained apron so the area does not become muddy.



Figure 8.8 Rainwater tanks on plinths beside a school toilet block, filled from the roof by a downpipe and used for handwashing. Compare the plinths with a drained apron and check that every tank has a closed lid and screened inlet.

Photo: SuSanA Secretariat, CC BY 2.0, via Wikimedia Commons

8.9 First Flush, Gutters and Downpipes

A **first-flush diverter** fills a chamber with the first water off the roof; when it is full, a ball seals it and clean water passes on to the tank. A small drain cap empties it slowly between storms. A common rule is **about 0.5 L per m² of roof**, more for dusty roofs near murram roads. Chapter 10 installs and services diverters.

Gutters and downpipes need **about 1 cm² of cross-section for every m² of roof** they drain. A round downpipe of diameter d has area π d² ÷ 4, so the diameter needed is d = 2 √(A ÷ π) with A in cm². Gutters are laid to a fall of about 1:200 to 1:500 towards each outlet (Chapter 10 sets this out).

WORKED EXAMPLE 8.4: FIRST FLUSH AND DOWNPIPES FOR THE BUNGALOW

First flush for the whole roof = 150 × 0.5 = **75 L**, so 37.5 L for each 75 m² slope and its diverter.

Each downpipe drains 75 m², so it needs 75 cm². d = 2 × √(75 ÷ 3.142) = 2 × 4.89 = 9.8 cm = **98 mm** → use a **100 mm (4")** downpipe (78.5 cm²).

Each gutter also needs about 75 cm². A 150 mm half-round gutter gives π × 7.5² ÷ 2 = 88.4 cm²: enough. A 120 mm half-round gives only 56.5 cm²; with it, add a second outlet so each serves 37.5 m².

Sense-check: one large downpipe for the whole roof would need 150 cm², about 138 mm across; two 100 mm downpipes are cheaper and easier.

8.10 Siting the Tank and the Rules

- **Near the downpipes**, so conveyance pipes are short, with the tank inlet below the gutter outlets so water flows by gravity.

- **On a firm, level base** designed for the full weight: 10,000 L is about 10 tonnes (Chapter 6).
- **Tap high enough** to fill a jerrican or bucket, above a drained apron.
- **Away from pollution:** latrines, septic tanks, soak pits and rubbish pits, and uphill of them (Chapter 6, Section 6.4).
- **Overflow** led away from foundations to a soak or recharge pit or a storm drain. The National Building Code 2024 forbids storm water entering a sewer.
- **Access** for cleaning and repair; shade where possible; lids secured against children; not under overhanging trees.

The Water Act 2016 does not require a permit to store water in a tank built for that purpose. Pans, dams and taking water from rivers are different: ask the Water Resources Authority and the county, and larger works may need NEMA approval. Tanks that are part of a new building appear on the plans approved by the county. Open tanks breed mosquitoes, which public health officers can act on.

SAFETY FIRST

- Surveying roofs and gutters is work at height: ladder at 1 in 4, footed or tied, 1 m above the eaves; harness clipped to an anchor on roofs; crawling boards on old or fragile sheets; never on wet roofs or in wind (Chapter 2).
- Never enter a tank, even an empty one; tanks are confined spaces. Measure from outside.
- Open pans and ponds drown children and livestock: fence them and fit a way out.
- Keep ladders and tools clear of overhead power lines along the eaves.

8.11 Costing the System

Use the Chapter 5 method: take off quantities from the roof plan, add waste (5% on pipes and gutters, 10% on small fittings), round up to stock lengths, price at market rates, then build the quotation. Table 8.3 is the schedule for the bungalow in Figure 8.4.

Table 8.3 Materials schedule for the bungalow rainwater system (approximate 2026 prices, KSh; example)

Item	Unit	Qty	Rate	Amount
PVC gutter, 4 m lengths	No.	8	1,500	12,000
Gutter brackets	No.	40	120	4,800
Stop ends	No.	4	400	1,600
Gutter outlets	No.	2	400	800
Gutter joints (example price)	No.	6	400	2,400
PVC downpipe 100 mm, 4 m lengths	No.	4	1,350	5,400
Downpipe bends (example price)	No.	6	400	2,400
Downpipe clips	No.	14	100	1,400
First-flush diverter kits	No.	2	3,000	6,000

Item	Unit	Qty	Rate	Amount
10,000 L plastic tank	No.	1	78,000	78,000
Brass gate valve ¾" (washout)	No.	1	1,200	1,200
Brass bib tap ¾" (example price)	No.	1	800	800
uPVC 160 mm pipe, 6 m (overflow for both 100 mm inlets; example price)	No.	1	4,000	4,000
Tank connectors, sockets, PTFE, screws (example)	Item	1	2,500	2,500
Concrete tank base materials (example)	Item	1	9,000	9,000
Materials total				**132,300**

WORKED EXAMPLE 8.5: QUANTITIES AND QUOTATION FOR THE BUNGALOW

Gutters: 2 × 15 m = 30 m × 1.05 = 31.5 m ÷ 4 = 7.9 → **8 lengths**.

Brackets about every 0.9 m: 15 ÷ 0.9 = 16.7 → 17 spaces → 18 brackets per gutter; 36 × 1.1 = 39.6 → **40**.

Downpipes (from the plan): two drops of 1.5 m plus about 10 m of conveyance pipe along the east gable = 13 m × 1.05 = 13.65 m ÷ 4 = 3.4 → **4 lengths**. Clips about every 1.2 m: 13 ÷ 1.2 = 10.8 → 11 spaces → 12; × 1.1 = 13.2 → **14**.

Materials total (Table 8.3) = KSh 132,300. Labour: plumber 3 days × 3,000 + helper 3 days × 1,000 = KSh 12,000. Prime cost = KSh 144,300.

Transport (example) KSh 3,000; overheads 10% × 144,300 = KSh 14,430; profit 10% × (144,300 + 3,000 + 14,430) = KSh 16,173.

Total before VAT = **KSh 177,903**; with VAT at 16% (if registered) = 177,903 + 28,464.48 = **KSh 206,367.48**.

Sense-check: the tank is about 60% of the materials, so tank choice drives the price. The system costs about KSh 18 per litre of storage before VAT.

GREEN TIP

Every litre harvested is a litre not pumped from a borehole or treated by the county. Lead overflow into a re-charge pit or garden, not the road. Use the tank water for drinking and cooking, and plan a second tank or grey water for flushing and gardens. Choose UV-stabilised tanks and gutters that last.

COMMON MISTAKES

- Using the sloping roof area or forgetting the runoff coefficient.
- Sizing from the yearly total, which hides the dry months.
- Promising full demand from a roof that cannot give it.
- Leaving out the first flush or the screens, then blaming the tank for dirty water.
- Downpipes and gutters too small for the roof area they drain.
- Overflow onto foundations or into a sewer.
- Quoting the tank but forgetting the base, washout, tap and overflow pipe.

ON SITE IN KENYA

A church in Kitui asks for "the biggest tank we can afford". The trainee measures 240 m² of roof and finds the short rains are the main season there. A monthly balance shows that a 30 m³ masonry tank would overflow in November and stand empty by July, while two 10,000 L tanks plus a fenced ground pan for the garden use the roof better and cost less. The committee chooses the plan they can see on paper.

TRAINER'S TIP

Do the monthly balance in a spreadsheet with one row per month and one cell for the tank size. Change the tank size and watch the shortfall column. Clients understand a table of empty months far better than a formula.

Practical task 8.1: Survey a roof and size a rainwater system

Tools and equipment

- Tape measure, ladder (footed), harness where needed
- Sketch pad, scale rule, A3 paper, calculator or spreadsheet
- Compass or phone for the north point

Materials

- Local rainfall records (or Table 8.1)
- Demand table (Chapter 3)
- Record sheet

Steps

1. Sketch the building freehand; measure the eaves lengths and roof shape on plan; note the roof material and condition.
2. Mark possible tank positions, latrines, soak pits and drains.
3. Draw the roof plan to scale with slopes, areas, gutter runs, falls, outlets, downpipes, diverters, tank and overflow.
4. Work out the yearly and monthly yield.
5. Agree the demand priorities with your "client"; work out the daily demand.
6. Size the tank by the rough formula and check it with a monthly balance.
7. Size the first flush, gutters and downpipes; draw the schematic.

Safety

- Ladder footed by a partner; no climbing on fragile sheets; stay clear of power lines.

Record your results

Item	Value and unit
Roof plan area and coefficient	
Rainfall used (source)	
Yearly yield	
Demand (people × L/day)	

Item	Value and unit
Tank size: rough formula / balance / chosen	
First flush; gutter and downpipe sizes	

Practical task 8.2: Prepare the materials schedule and quotation

Tools and equipment

- Your drawings from Practical task 8.1
- Calculator or spreadsheet, phone for supplier prices

Materials

- Schedule and quotation templates (Chapter 5)
- Two supplier price lists

Steps

1. Take off gutters, brackets, stop ends, outlets, joints, downpipes, bends, clips, diverters, tank, valves, overflow pipe and base.
2. Add waste and round up to stock lengths.
3. Get two prices for the five most costly items.
4. Complete the schedule and the quotation with labour, transport, overheads, profit and VAT if registered.
5. List exclusions and present the quote to your "client".

Safety

- When checking site lengths, follow the Practical task 8.1 rules for ladders and roofs.

Record your results

Item	Unit	Quantity	Rate (KSh)	Amount (KSh)
Total				

Chapter summary

- Methods: roof catchment, rock catchment, ground pans, sand dams, road runoff, green roofs and recharge pits.
- Screens, a first flush, a closed dark tank and a tap above the floor protect water quality; treat drinking water.
- Rainwater drawings add catchment areas, gutter falls, outlets, diverters, tank and overflow, in teal with a legend.
- Yield = plan area × rainfall × runoff coefficient (0.8 good mabati, 0.7 unsure).
- Set demand priorities: drinking and cooking first.
- Rough size C = 0.03 × D × (T + 2); check with a monthly balance using local rainfall.
- First flush about 0.5 L/m²; gutters and downpipes about 1 cm² per m² of roof.
- Overflow never to a sewer; cost the system by the Chapter 5 method.

Check your competence

- [ ] I can describe the main harvesting methods and choose one for a site.
- [ ] I can name every part of a roof system and its job.
- [ ] I can survey a roof and draw a scale roof plan and schematic.
- [ ] I can calculate yield from rainfall data and a runoff coefficient.
- [ ] I can size a tank by the rough formula and by a monthly balance.
- [ ] I can size a first-flush diverter, gutters and downpipes.
- [ ] I can site a tank within the rules.
- [ ] I can prepare a materials schedule and quotation for a rainwater system.

Practice questions

1. Describe four rainwater harvesting methods and say where in Kenya each suits.
2. Explain how the first flush, screens and the tap position protect water quality.
3. A church has 240 m² of old mabati roof (coefficient 0.7) in an area with 800 mm of rain a year. Find the yearly yield and the average per day.
4. A family of 8 wants 15 L each a day for drinking and cooking. The longest dry spell is 4 months. Use the rough formula to size the tank, and choose tanks from sizes of 2,000, 3,000, 5,000 and 10,000 L.
5. A 120 m² roof drains to two downpipes. Find the first-flush volume for each and the downpipe diameter needed.
6. Using the semi-arid pattern in Table 8.1, find the supply from a 100 m² roof (coefficient 0.8) in November and in July. How many days would a full 5,000 L tank last at 150 L/day with no rain?
7. Oral: explain to a school board why its roofs cannot supply all its water and what the water should be used for first.
8. State three legal or Code points a plumber must respect when planning a rainwater system.
9. Fault-finding: a new system's tank water is brown and smells after the first storms, and in heavy rain water pours over the gutter at the outlet. Give the likely causes and what you would change.
10. Practical: survey a workshop or classroom roof, draw the roof plan to 1:100 and prepare a materials schedule for its gutters, downpipes and tank.

Enjoyed this sample?

This free sample of **Plumbing Level 4** has the front matter, Chapter 1 and the full Chapter 8 on planning a rainwater harvesting system: harvesting methods, the parts of a roof system, drawings, roof yield and demand, sizing the tank by formula and monthly balance, first flush, gutters and downpipes, siting rules and a priced quotation. The complete guide has **15 chapters** and **283 pages**. It covers all four Level 4 units (Water Supply System II, Rainwater Harvesting System, Drainage System Installation II and Sanitary Appliances II) plus the 320-hour industry training: schematic and isometric drawings, take-offs and quotations; storage tanks, stands and booster pumps; fabricating and installing gutters; drainage levels, setting out and the National Building Code 2024 air test; waste-water treatment; wall-hung WCs, bidets and whirlpool baths, testing and commissioning.

It also includes 117 realistic illustrations, diagrams, charts and photos, 62 worked examples, 27 practical tasks with record sheets, 150 practice questions with full answers, four mock assessments, a 222-term glossary, a symbols and typical-values quick reference and photocopiable logbook, pressure-test, air-test and commissioning record sheets.

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