# Green Roads for Water Training in Sudan

Wad Madani, 15-20 January 2023

## Surface Drains and cross drainage measures

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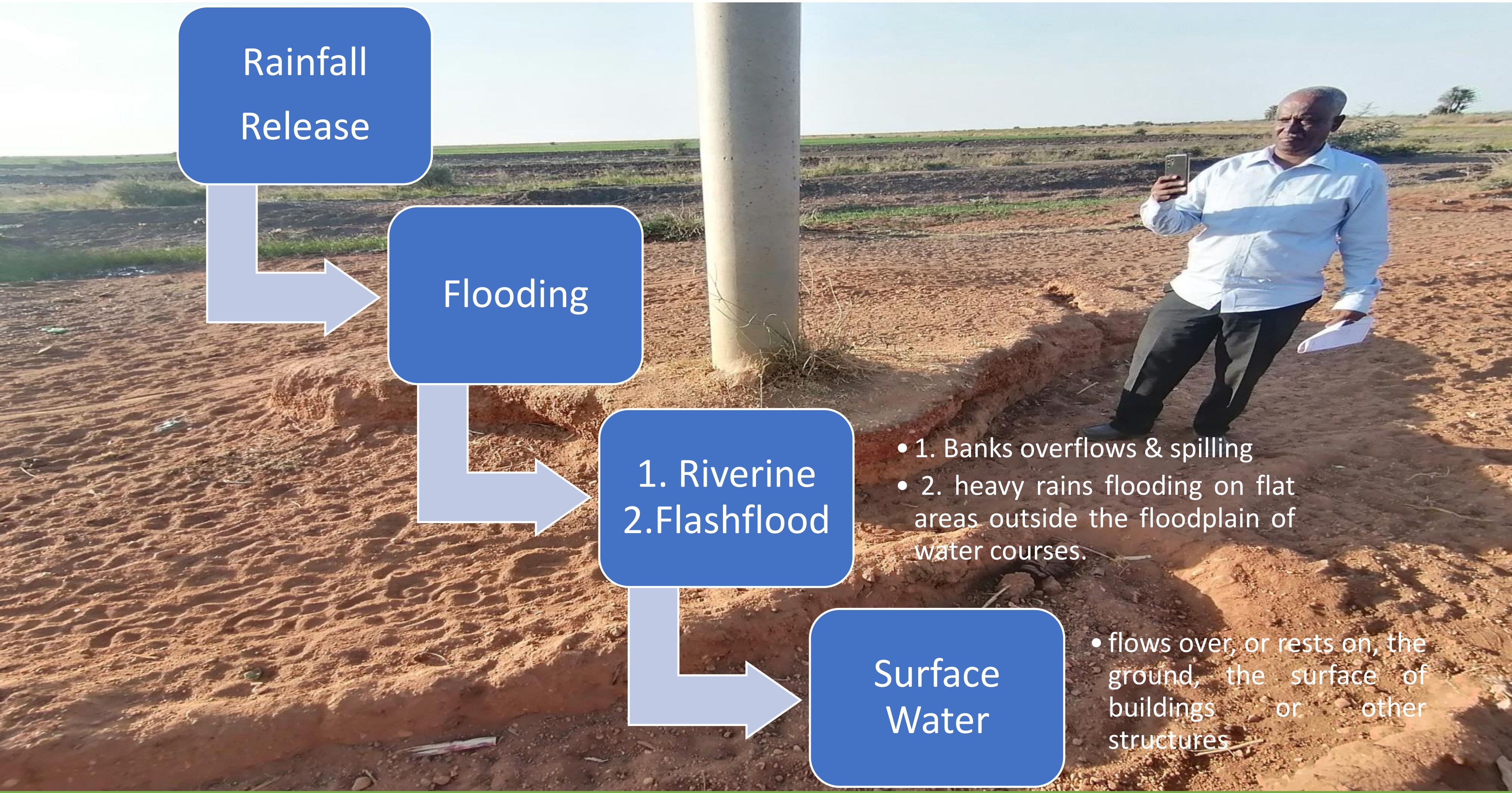
# Introduction



Rainfall Release

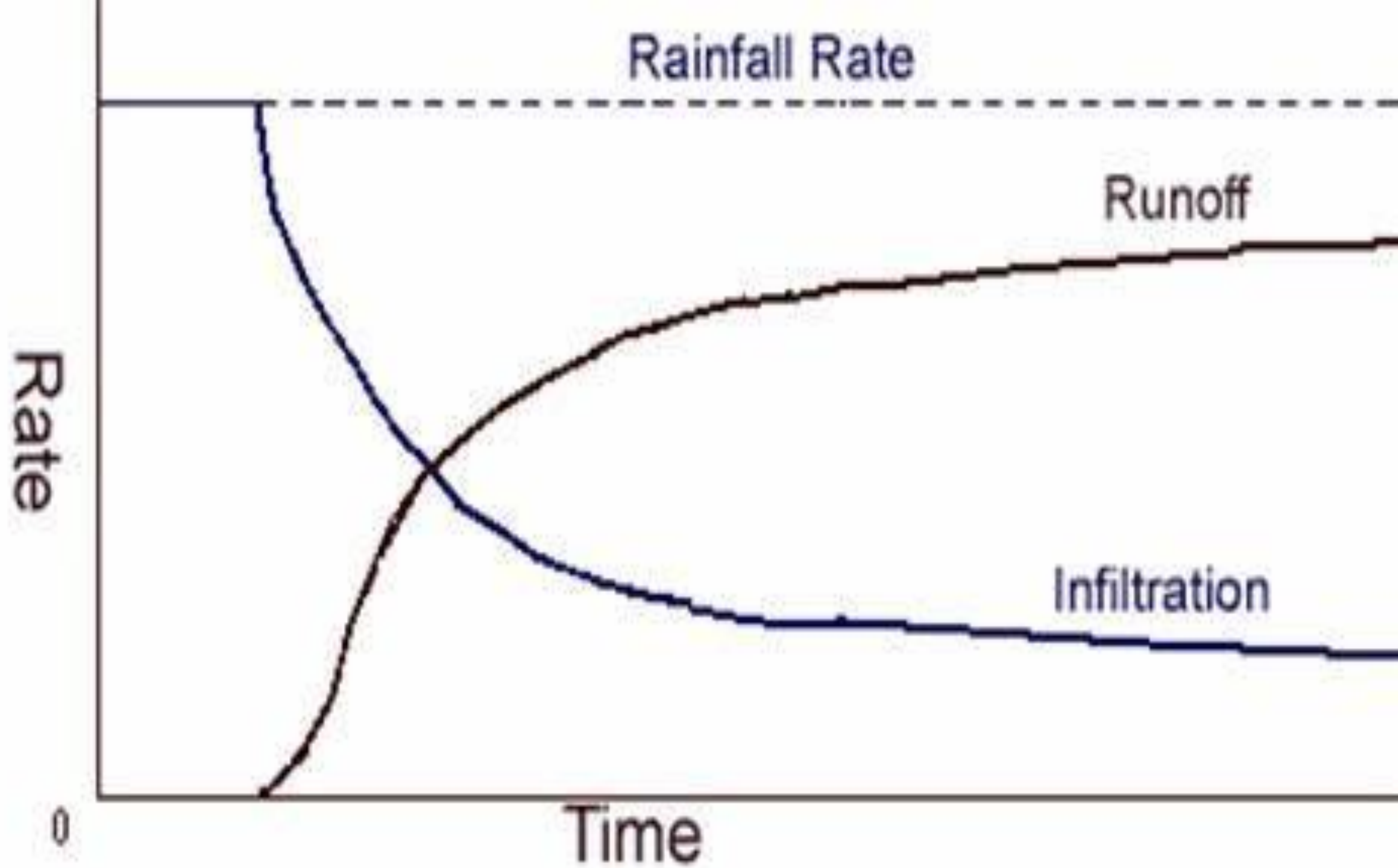
Flooding

1. Riverine
2.Flashflood

- 1. Banks overflows & spilling
- 2. heavy rains flooding on flat areas outside the floodplain of water courses.

Surface Water

- flows over, or rests on, the ground, the surface of buildings or other structures


Rainfall Rate
Runoff
Infiltration
Rate
0
Time

# Negative Impacts

GREEN ROADS FOR WATER

META META

# General Assessment of the Effects of Floods

| Description of effect and location | Mild Effect | Moderate Effect | Severe effect |
|---|---|---|---|
| **Riverbank erosion** (along the main Nile) | | | X |
| **Soil Erosion** – (along the Blue Nile and Atbara rivers and the main Nile) | | | X |
| **Biodiversity** | X | | |
| **Silting** of agricultural land | | X | |
| **Water Quality** - Deposits of physical and chemical waste in the Nile. | | | X |

# Key Point -1

- ✓ A proper Surface drainage system shapes and molds the land into a watershed that can convey the runoff into an organized drainage system comprising of trench drains, catch basins, and storm sewers. If the surface drainage is below par, it will have a dangerous impact on the subsurface drainage.

# Key Point -2

✓ Surface drainage assists with the regulated removal of surface runoff on account of the irrigation, precipitation, spring thaw, irrigation, or anything else that leads to surface water accumulation. If the overflow is not dealt in time, it may have an adverse impact on the land and surrounding structures. Improper planning may lead to erosion and sedimentation.

# Key Point -3

- ✓ An effective surface drainage system is the only way to cope with heavy volumes of surface water accumulation after bouts of intense rainfall. The lack of one may overwhelm and saturate the capacity of the soil to absorb water, which could lead to extensive flooding and changes in landscape structure.

# Types of Surface Drainage System

1. Open drains (المصارف المفتوحة )
2. Humps and Hollows (الحدب و الأجواف)
3. Levees (السدود)
4. Grassed waterways (المجاري المائية المعشبة)

# 1. Open Drains

**Shallow**

- Up to 300 mm deep (hand shovel)
- They help remove water from shallow depressions and direct them to a larger drain or a stream.
- Not suitable for draining a large area of land ( a temporary arrangement).

**Medium Depth**

- 300 mm to a meter deep (excavator)
- Typically V-shaped and flat at the bottom and a gradient that is steep enough.
- They are best suited for flat areas.

**Large**

- Several meters deep & wide (dragline excavators, bulldozers, or scrapers)
- Capable of evacuating large volumes of water.

# 2. Humps and Hollows

- a system where a surface is shaped into parallel humps separated by hollows.

- allows the humped shapes to shed excess moisture into the hollows which double up as shallow surface drains.

- Ideal for areas where tile or mole drainage is not possible on account of inadequate depth or fall of the soil.

- This system creates a series of lateral surface drains that help discharge water into headland drains. One can use formulae to calculate the size of the drain taking into account the amount of water required to be removed.

- The spacing between the humps may vary between 10 to 20 meters depending upon the speed with which the water needs to be removed. The greater the space between the humps, the slower will be the rate of discharge of water.

# 3. Levees

- Levees are surface channels usually created on land with a gradient in such a manner that the soil removed to create these forms a levee on the downslope of these channels.

- This helps the surface runoff not build so much velocity while flowing down a slope that it starts eroding the land. The banks or levees have to follow the lay of the slope and make the water flow down gently and not create make the lane below susceptible to landslips.

- Ideally, such levees should have a spacing of 30 to 50 meters for slopes that possess a gradient of five to twelve degrees.

- Every levee can cater to an area of about 3 hectares with a total length that is less than 400 meters.

- Care must be taken to establish a grass cover immediately after creating a levee, or the channel could quickly erode.

# 4. Grassed Waterways

- Typically quite shallow and maybe narrow to a few meters in width.
- Can be used to regulate drain outflows going down slopes, so as to cheaply prevent erosion
- The ratio between the vertical and horizontal sections of the waterway needs to be in 1:4 proportion.
- A necessary prerequisite of such a waterway is a dense expanse of grass.
- The quantity of water to be evacuated, as well as the steepness of the slope, will have a bearing on both the size and the shape of the waterway.
- The steeper the slope, the wider should be the waterway.
- The bottom of the waterway should be horizontal to enable the water to spread out evenly.
- It is important that such waterways not be constructed in areas prone to erosion, or they will fail.

# Types According to Function

**Case of National Irrigation Schemes (Gezira, New Halfa …etc)**

1> Scape Drain (K57, K77, K108, K169, K 65)

2> Protective Drain (AlShawal, Sabir …)

3> Collective Drain (Wad Matar, Abu Gareen …)

# Cross Drainage Works (Measures)

- A cross drainage work is a structure that is constructed at the crossing of a canal and a natural drain, to prevent the drain water from mixing with the canal water. By mixing two or three streams are to be combined into one and only one cross drainage makes the structure economical.

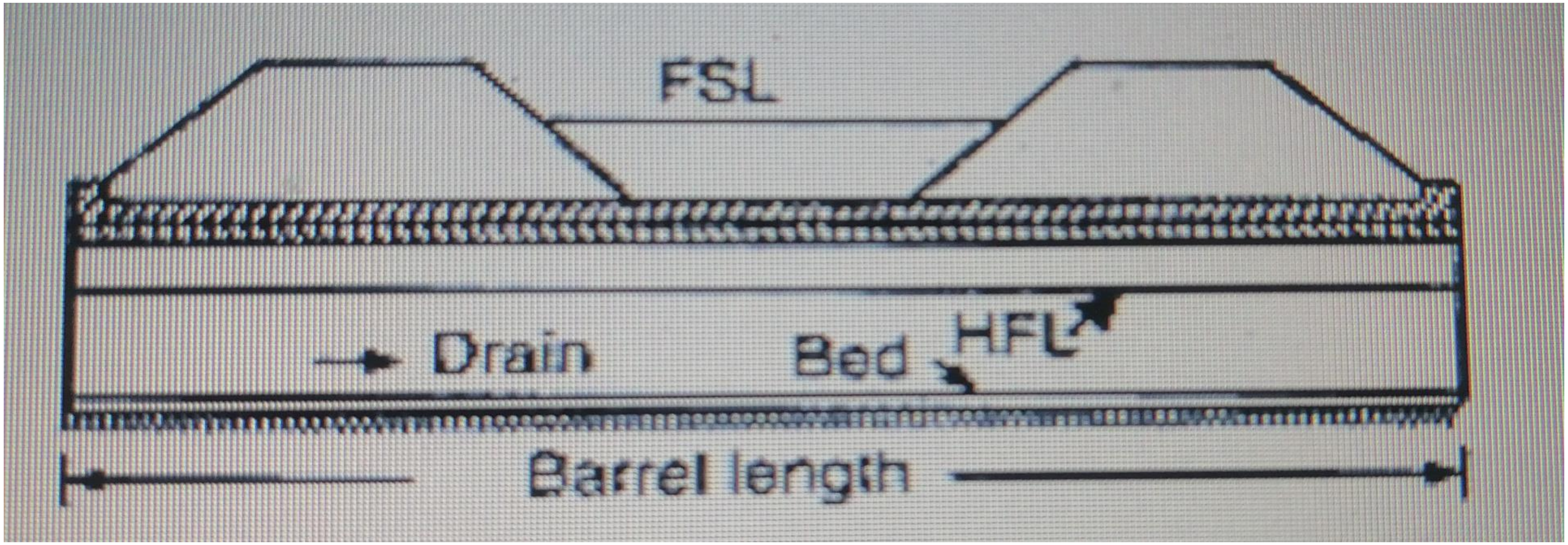
- Cross drainage works is a structure constructed when there is a crossing of canal and natural drain, to prevent the drain water from mixing into canal water. This type of structure is costlier one and needs to be avoided as much as possible. Cross drainage works can be avoided in two ways: By changing the alignment of canal water way.

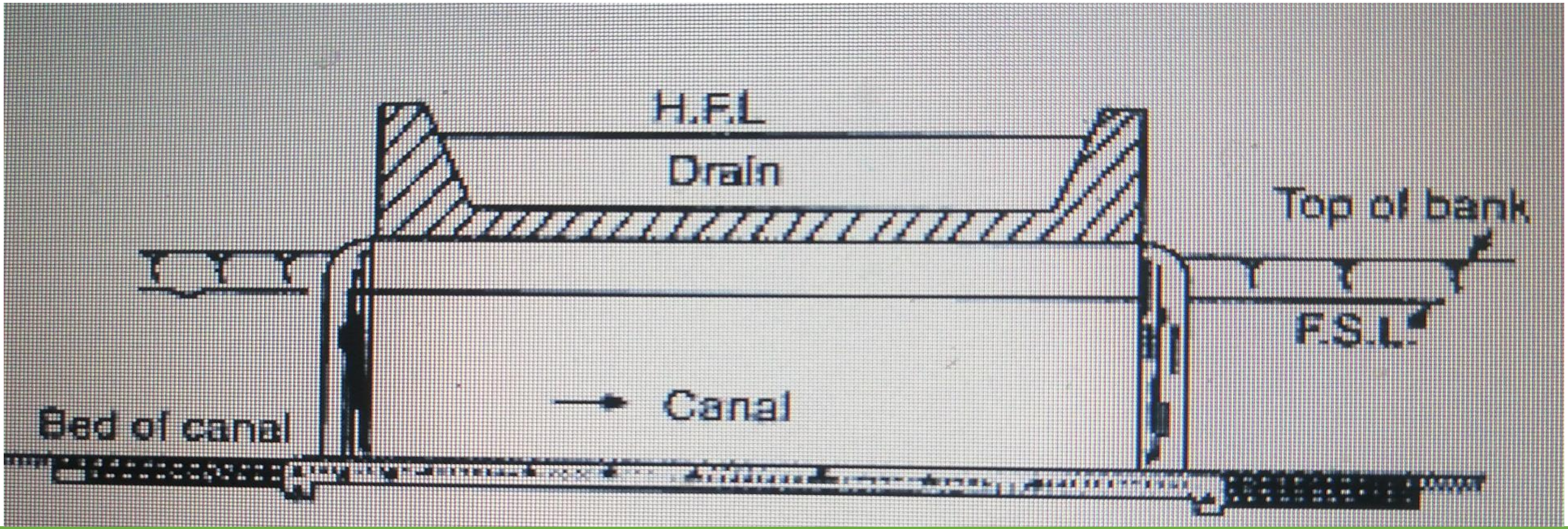
# Different Types of Cross Drainage Works

- Type – 1: Cross drainage work carrying canal over the drain (HFL<FSL)
- Type – 2: Cross Drainage work carrying drain over the canal (HFL>FSL)
- Type –3: Cross drainage works admitting canal water into the canal

Eng. Ahmed Ibrahm Ishag + Others – Enumerate some Examples from Sudan

(Irrigation Schemes, Roads, WH projects … etc – Syphons, Aqueducts … etc.)


FSL
Drain
Bed
HFL
Barrel length


H.F.L
Drain
Top of bank
F.S.L.
Canal
Bed of canal

# Design of SDS for Highways

- ✓ Surface drainage system (SDS) is most important in Highway engineering.
- ✓ A pavement without proper drainage facilities will not serve for long time (Sustainability).
- ✓ The water or rainfall on road should be collected by side drains which carries the drain water to nearest stream or any water course.
- ✓ So, prior to the construction of road, the designer should leave required space for providing proper drainage facilities as well as the pavement should also be constructed with minimum camber.

## (A) Hydrologic Analysis

- Water Cycle (infiltration, evaporation, run off ...

- Factors affecting run off:
  - ✓ Rate of rain fall
  - ✓ Moisture condition
  - ✓ Soil type
  - ✓ Ground cover presence
  - ✓ Topography

- Run off estimation Rational Method:

$$Q = C\ i\ A_d$$

*Where,*

$Q$ = run off ($m^3$/sec)
$C$ = run off coefficient
$i$ = intensity of rain fall (mm/sec)
$A_d$ = area of drainage ($m^2$)

Run off coefficient "C" is the ratio of run off to the rate of rainfall. So, it is not same for all types of surfaces. It varies for different types of surfaces and its values for different surfaces are as follows:

| Type of Surface | Coefficient of run off |
|---|---|
| Pervious soil surface | 0.05 - 0.30 |
| Soil covered with turf | 0.30 - 0.55 |
| Impervious soil | 0.40 - 0.65 |
| Gravel & WBM roads | 0.35 – 0.70 |
| Bituminous & C.C roads | 0.80 – 0.90 |

***For different surfaces:***

$$C = (A_1 C_1 + A_2 C_2 + A_3 C_3) / (A_1 + A_2 + A_3)$$

**Where, C1,C2 &C3 and A1, A2 & A3 are the coefficients & segmental areas.**

# Estimation of Rainfall Intensity "i":

**Step 1:** Estimate **Inlet Time (Ti)** – Time of equilibrium (defined as the time required for the rain in falling on the most remote point of the tributary area), using the Following equation:

$$Ti = 0.885^{*} (L^3/F)^{0.385}$$

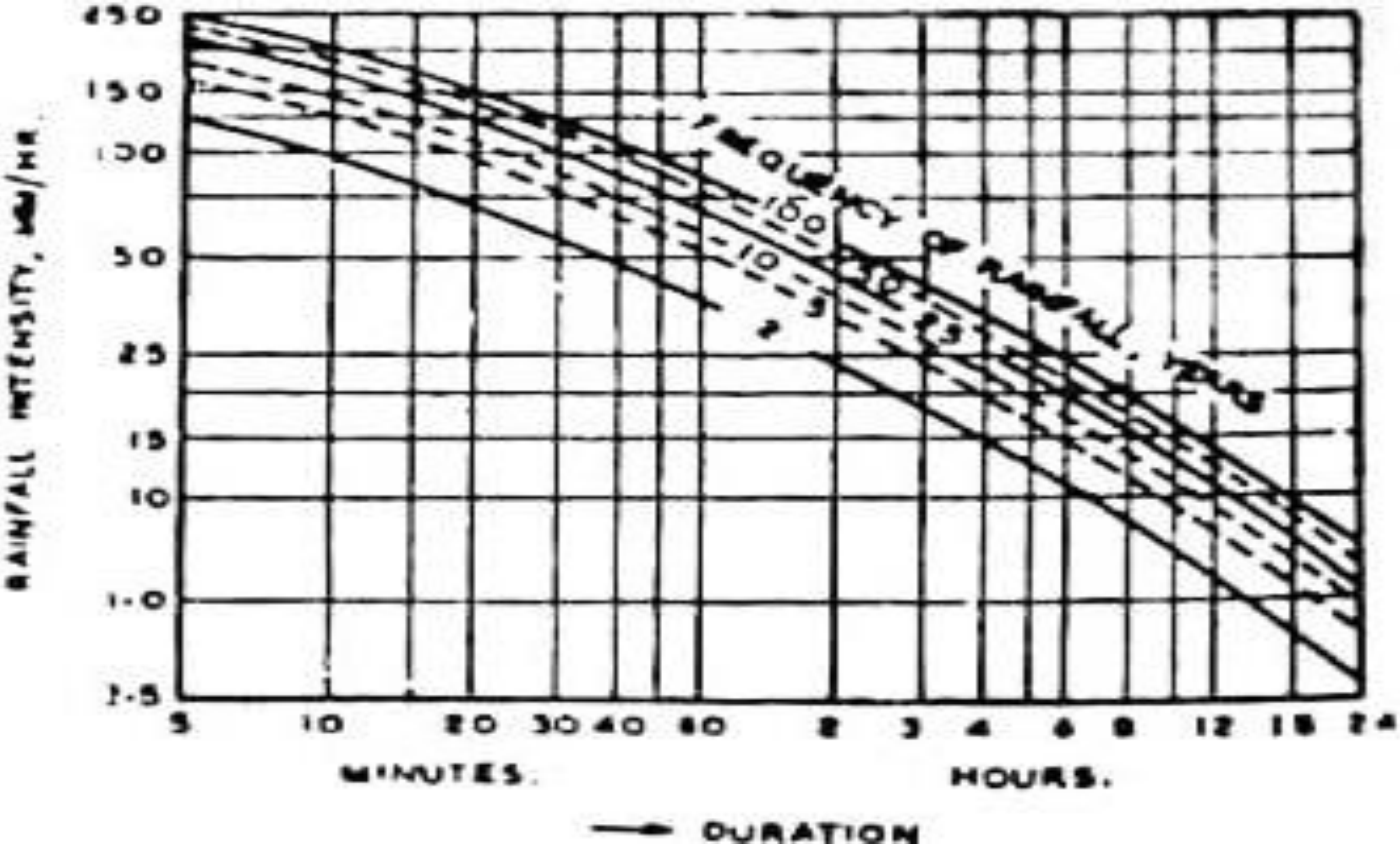
Where, L is the length of overland flow and F is the fall of level.

**Step 2:** Estimate **Travel Time (Tt):** the time required for water to travel from inlet of drainage to the outlet. This is calculated from the velocity allowed in the drainage line and generally it is kept at 0.3 – 1.5 m/sec.

**Step 3:** Time of Concentration (Tc): the time needed for water to flow from the most remote point in a watershed to the watershed outlet.
It is a function of the topography, geology, and land use within the watershed.

$$Tc = Ti + Tt$$

**Drainage Area (Ad):** is calculated by studying on the topographical maps of that region.


RAINFALL INTENSITY, MM/HR.
450
150
100
50
25
15
10
1.0
0.5
FREQUENCY OF RAINFALL, YEARS
100
50
25
10
5
2
5
10
20
30
40
60
2
3
4
6
8
12
18
24
MINUTES.
HOURS.
DURATION

- Estimation of Peak Flow - Design Sheet File - MoIWR:

$$Q = C\,A_d^{(2/3)}$$

| | |
|---|---|
| $Q$ | Design Discharge ($m^3/s$) |
| $A_d$ | Drainage area in (feddans) – GIS |
| $C$ | Runoff Coefficient (150 North Gezira, 270 South Gezira) |

- Estimation of Peak Flow - Curve Number Method:

Peak Flow (Qp) = f(Drainage area, land cover, soil type, hydrological condition and time of concentration)

$$Q_d = \frac{(P - 0.2S_t)^2}{P + 0.8S_t}$$

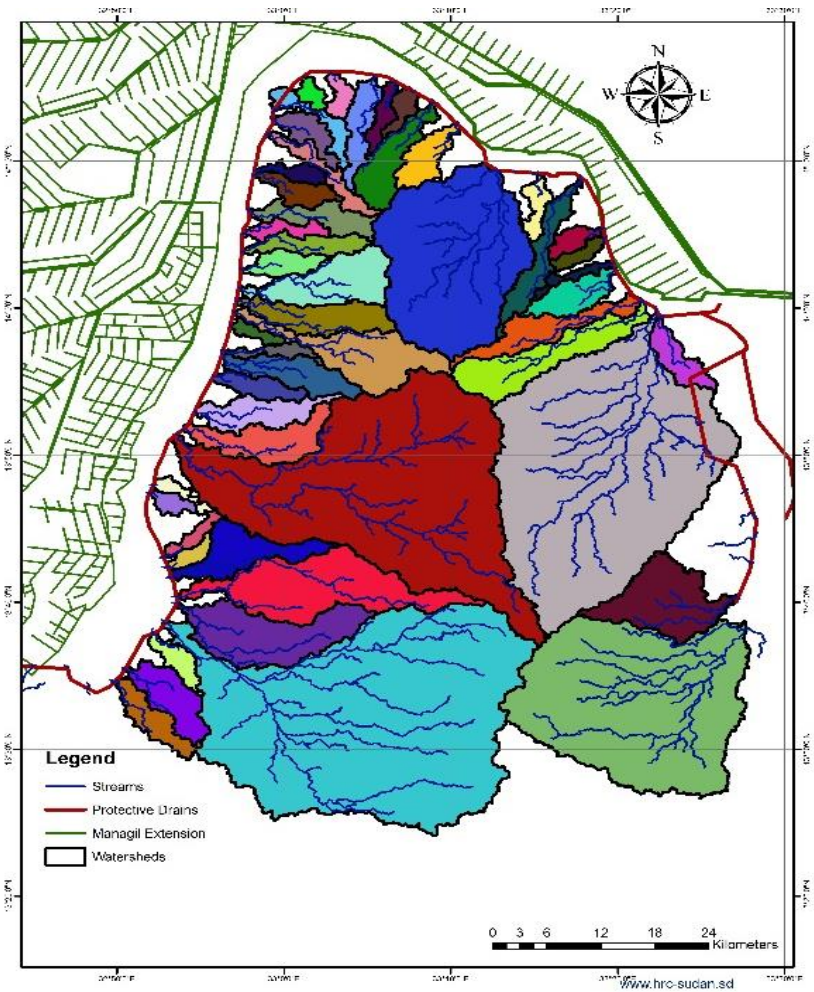
| | |
|---|---|
| $Q_d$ | runoff depth (mm) |
| P | 24-hours precipitation depth (mm) |
| $S_t$ | Soil retention (mm) = 25.4(1000/CN – 10) |

$$Q_p = q_u \cdot A \cdot Q_d$$

| | |
|---|---|
| $Q_p$ | Peak discharge ($m^3/s$) |
| $q_u$ | unit peak discharge ($m^3/s/Km^2/mm$) – empirical equation based on type of rainfall distribution ( 4 types according to SCS) |
| A | Drainage area ($Km^2$) |

# Example ( AL Shawal Protective Drain):

| Reach | Distance (km) | CN method Peak Discharge( ) | Design Sheet Formula( ) | Maximum value ( ) |
|---|---|---|---|---|
| R1 | 45 | 10.3 | 6.2 | 10.3 |
| R2 | 10 | 12.1 | 11.6 | 12.1 |
| R3 | 5 | 13.4 | 12.0 | 13.4 |
| R4 | 13 | 14.4 | 12.2 | 14.4 |
| R5 | 5 | 14.9 | 12.7 | 14.9 |
| R6 | 15 | 17.7 | 14.9 | 17.7 |
| R7 | 20 | 20.3 | 15.6 | 20.3 |
| R8 | 8 | 20.9 | 16.3 | 20.9 |
| R9 | 12 | 21.0 | 16.7 | 21.0 |
| R10 | 8 | 21.0 | 17.4 | 21.0 |
| R11 | 7 | 21.0 | 18.9 | 21.0 |
| R12 | 17 | 21.0 | 19.4 | 21.0 |
| R13 | 15 | 21.0 | 23.9 | 23.9 |
| R14 | 12 | 24.9 | 25.8 | 25.8 |
| R15 | 8 | 24.9 | 30.3 | 30.3 |



## (B) Hydraulic Analysis

**A = Q/V**

- V (allowable velocity) from table below
- "S" (longitudinal slope) is to be calculated by Manning's formula:

- "R" hydraulic radius = Area/Wetted perimeter

$$V = \frac{1}{n} R^{\frac{2}{3}} S^{\frac{1}{2}}$$

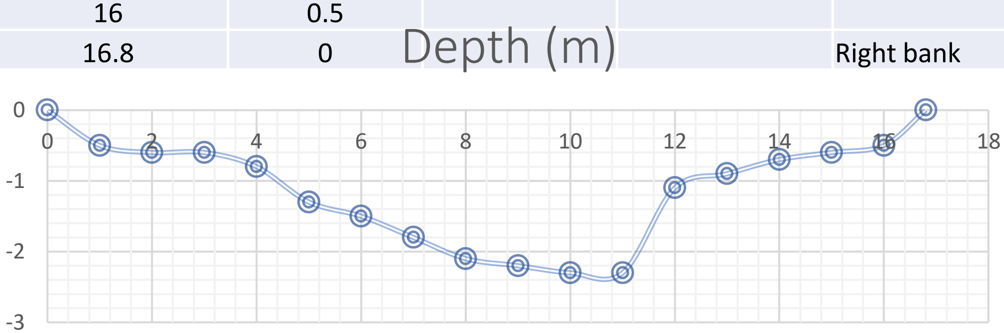
| **Soil type** | **Allowable velocity (m/sec)** |
|---|---|
| Sand or silt | 0.30 – 0.50 |
| Loam | 0.60 – 0.90 |
| Clay | 0.90 - 1.50 |
| Gravel | 1.20 – 1.50 |
| Soil with grass | 1.50 – 1.80 |

| Lining material | Manning’s roughness coefficient, n |
|---|---|
| Ordinary soil | 0.02 |
| Soil with grass layer | 0.05 – 0.10 |
| Concrete lining | 0.013 |
| Rubble lining | 0.04 |

**This method is mostly used for designing side drains of roads.**

# Examples (Field Measurements -)

| Distance (m) | Depth (m) | Area (m2) | Perimental (m) | Remarks |
|---|---|---|---|---|
| 0 | 0 | | | Left bank |
| 1 | 0.5 | | | |
| 2 | 0.6 | | | |
| 3 | 0.6 | | | |
| 4 | 0.8 | | | |
| 5 | 1.3 | | | |
| 6 | 1.5 | | | |
| 7 | 1.8 | | | |
| 8 | 2.1 | | | |
| 9 | 2.2 | | | |
| 10 | 2.3 | | | |
| 11 | 2.3 | | | |
| 12 | 1.1 | | | |
| 13 | 0.9 | | | |
| 14 | 0.7 | | | |
| 15 | 0.6 | | | |
| 16 | 0.5 | | | |
| 16.8 | 0 | | | Right bank |




n = 0.035

Bed level 5km d/s = 409.640 m

Bed level 3 km u/s = 410.920

Estimate Q using Manning's Formula?

# Some Practices ( ✓, X)

# Need Co-ordination

بسم الله الرحمن الرحيم

MINISTRY OF TRANSPORT, ROADS & BRIDGES

مشروع الجزيرة
GEZIRA SCHEME

## إدارة مشروع الجزيرة
## بالتعاون مع
## وزارة الطرق والجسور

# تدشين الطرق الزراعية بمشروع الجزيرة

## ( 29 طريقاً بطول 410 كيلو متراً )

تحت رعاية : مجلس السيادة و مجلس الوزراء بالحكومة الإتحادية

إفتتاح الطرق على يد السيد / والي ولاية الجزيرة و محافظ مشروع الجزيرة

الزمان : 16 يناير 2023م

المكان : رئاسة مشروع الجزيرة - بركات

GREEN ROADS FOR WATER

META

HRC SUDAN

# Thank you!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