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# SUSTAINABLE URBAN DRAINAGE DESIGN IN BOR COUNTY-SOUTH SUDAN

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**ABSTRAK**

Urbanisasi dan peningkatan populasi di Kabupaten Bor memberikan tekanan pada lingkungan karena semakin banyak lahan yang dieksploitasi dan kawasan perkotaan yang ada semakin berkembang dan padat sehingga memberikan tekanan tinggi untuk menangani risiko perubahan iklim. Sistem drainase perkotaan harus dirancang untuk menciptakan ketahanan terhadap banjir di wilayah yang berkelanjutan, dimana pengelolaan banjir merupakan salah satu tantangan yang perlu diatasi. Rumusan penelitian ini bertujuan untuk menjawab beberapa faktor kunci mengenai perancangan sistem drainase perkotaan yang berkelanjutan sebagai sarana untuk mengurangi risiko banjir, meningkatkan kualitas air, dan mendorong pembangunan berkelanjutan. Tipe drainase yang digunakan adalah tipe saluran terbuka dan termasuk seri non level dengan bagian-bagiannya meliputi saluran utama, dimensi sub saluran, dan sumur resapan. Untuk dapat mencapai sistem drainase perkotaan yang berkelanjutan dan berketahanan, kita harus menangani volume air limpasan dengan data curah hujan selama 10 tahun yang penting untuk proses pelaksanaan banjir yang selalu berubah setiap tahunnya. Sangat penting untuk merancang dan mengimplementasikan fasilitas dan sistem yang berkelanjutan, dan multifungsi untuk merancang SUDS di Bor dengan metode hidrolik dan hidrologi. Proses implementasinya perlu menggunakan pendekatan estimasi biaya yang mencakup mitigasi banjir dan manfaat tambahannya, dalam jangka panjang dan jangka pendek secara bersamaan. Dari hasil perhitungan hujan rencana sebesar 73,82 mm/hari untuk kala ulang 2 tahun, dan 93,08 mm/hari untuk kala ulang 5 tahun. Data tersebut kemudian dijadikan dasar perencanaan dimensi saluran dengan beberapa saluran sistem drainase perkotaan. Hasil yang diperoleh berupa tinggi total dimensi utama 5 meter, lebar total 3,52 meter, dan panjang 76 meter dengan pengendalian pengamanan stabilitas tanah terhadap daya dukung sebesar 5m3/s. Rencana anggaran untuk perkiraan total biaya sebesar Rp 15.511.693.828.

**Kata kunci** : Banjir, Desain Drainase Perkotaan Berkelanjutan, HEC-RAS

***ABSTRACT***

*Urbanization and an increase in the population in Bor County put pressure on the environment as more land is exploited and existing urban areas are further developed and densified which already put high pressure to handle the risks of climate change. Urban drainages system should be designed to create more resilience to floods for sustainable areas, where flood management is one of the challenges that need to be tackled. This research formulation aims to answer some of the key factors regarding designing a sustainable urban drainage system as a means of reducing the risks of flooding, improving water quality, and promoting sustainable development. The type of drainage used is the open channel type and includes the non-level series with parts including the main channel, sub channels dimensions, and infiltrations wells. To be able to achieve a sustainable and resilient urban drainage system, we have to handle the volume of runoff water with rainfall data for 10 years which is important for the flooding implementation process which changes reputably each year. It is crucial to design and implement facilities and systems that are sustainable, and multifunctional for designing SUDS in Bor with hydraulic and hydrology methods. The implementation process needs to use cost estimation approaches that include flood mitigation and co-benefits, in the long-term and short-term simultaneously. From the results, the design of rain is 73.82 mm/day for 2 years return period, and 93.08 mm/day for 5 years return period. The data is then used as the basis for planning the channel dimensions with several channels of the urban drainage system. The results are in form of total main dimension height of 5 meters, total width of 3.52 meters, and length of 76 meters with the security control of soil stability to carry capacity of 5m3/s. The budget plan for total cost estimation is IDR 15.511.693.828.*

***Keywords :*** Flood, Sustainable Urban Drainage Design, HEC-RAS

## 1. INTRODUCTION

Bor County is the place that has quite a lot of lowland and tropical areas. The study land is the mostly lowland and the North has a slightly tit topography. In the south of Bor has a very low topography, where in this area there is a need of designing sustainable urban drainage design system for the control flooding.

Evaluation and monitoring it is not graduated if the major even disasters can occur, such as river overflow. When higher intensity rain hits the area, it can cause flood that will descend downwards and can destroyed some houses in the affected areas. Flooding itself occurs due to the overflow of river water due to the inability of the river body to accommodate the water discharge.

The flash flood that occurs on July 12, 2020, in Bor county in Jonglei State, it was caused by river overflow and heavy rainfall which broke the dyke along the river Nile with lots of water due to high rain intensity. Designing sustainable urban drainage system also need to be implemented in a new aerator retrofitted into already exploited area. This could make it possible to create urban areas that that are able can challenges of climate of change and urbanization and create multifunction, sustainable and flood mitigated regulating of water flow that should be considered as an important aspect when designing a sustainable urban drainage design system that can be able to deliver ecosystem services to the urban environmental and urban water management system.

In addition, protecting and securing the regulating waterflow capacities of the urban ecosystem must be connected to related polices and choices of urban planning that are dealing with the risks management.

## 2. METHODE

In order to design an urban drainage system there are several things that are done in the process. The first is to conduct a survey of the areas affected by flash floods to find out the material transported and the collect data from the relevant agencies. The next stage is to determine the planned flood discharge and proceed with determining the placement of the by analyzing the river and collecting data using Arcmap, Surfer application and HEC-RAS software. Next, select the type of channels by identifying discharge and planning the design of the drainage channel along with it. The final stage is selecting the implementation method and making a budget plan for the cost of making sustainable urban drainage system.

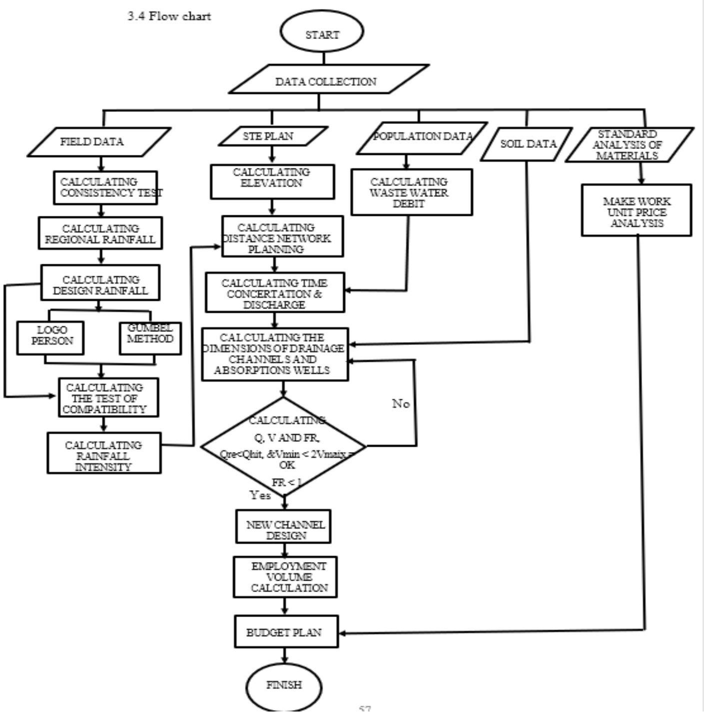


Figure 1 Flowchart

## 3. RESULTS AND DISCUSSION

### Drainage Network Map

The location of Bor drainage design was chosen based on the river flow and rainfall intensity which is relatively straight without any bends and has a small river bottom width. Bor drainage design channel locations are generally not in plain locations, but more in lowland areas because the scale of work is quite large and requires enough time. Bor urban drainage design construction is carried out in areas that produce sediment and garbage which are generally located in the upstream part.

The location of the Bor urban design drainage plan in Bor county, Jonglei State, was taken from image captured using a Google Map and then processed using several applications such as *surfer13*, and *Arch Map*. The results of processing *the software* obtained an area of 20.8 km 2 long, and obtain a topographical map of the Bor area. After getting the contour, cross cuts were made at several points. This study used 5 observation points from the results of topographic maps by using ARC GIS. Then according to the determination of the width of the river bed smallest, the third point was chosen as the location of the Bor drainage channel. The third point is located in a relatively straight river channel without any bends and has the smallest river bottom width of the five points, which is 0.15 meters.

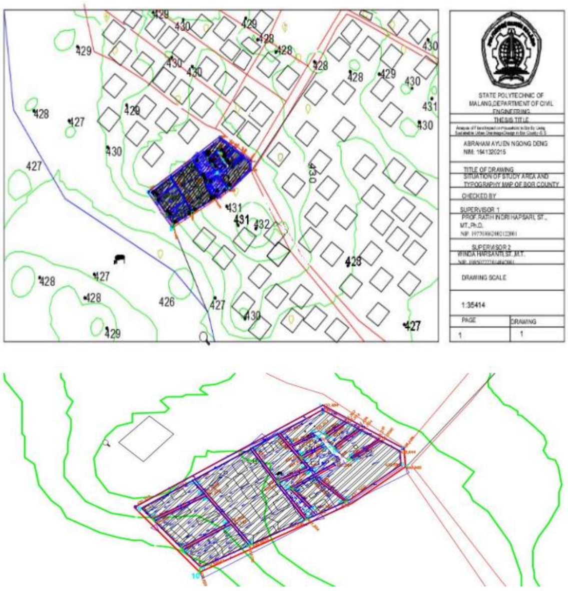

Figure 2 Drainage Layout Network Map

**Consistency Test**

The rain data consistency Test is used to correct inaccuracies in the data obtained. The consistency test is calculated using the Double mass curves testing method with the following steps which are as follow.

1. Determine one main station for observation and add up the value of annual rainfall from the 3 closest stations for comparison.

2. Calculate the cumulative rainfall data at the main station and the average rainfall data for comparison stations. Then depicted them on a graph.

3. The graph curve that has been drawn is checked for changes in slope. The data is inconsistent if the curve depicted has a bend or fracture, and data correction needs to be done, by calculating the value of the new trend and the old trend. Else if the curve formed is a straight line, the data is consistent.

4. Calculating the correction factor and correcting the data by multiplying the data which is assumed not to be in a straight line with the correction factor and the graphing the correction data.

5. Multiply the correction factor with the annual rainfall value in the year before the fault occurred. Then plot it on a graph with corrected cumulative value of the main station.

6. Recalculating the new trend (m1) and the old trend (m2) using the correct data. After that, calculate the correction factor if the correction factor is f = 1. Then the maximum rainfall data for that station is consistent and feasible to proceed to the next stage for example of Rek station consistency Test.

Table 1 Consistency Test of Rek Station

| Year | STA | | | Cum. REK | Averange YEI &BOR | Cum. Averange YEI & BOR |
|---|---|---|---|---|---|---|
| | REK(A) | YEI(B) | BOR(C) | | | |
| 2021 | 1544 | 1499 | 1501 | 1544 | 1500 | 1500 |
| 2020 | 1275 | 1296 | 1206 | 2819 | 1251 | 2751 |
| 2019 | 1382 | 1151 | 1382 | 4201 | 1266.5 | 4017.5 |
| 2018 | 1275 | 1278 | 1275 | 5476 | 1276.5 | 5294 |
| 2017 | 1415 | 1454 | 1410 | 6890.7 | 1432 | 6726 |
| 2016 | 1911 | 1626 | 1626 | 8801.7 | 1626 | 8352 |
| 2015 | 1486 | 1427 | 1397 | 10287.7 | 1412 | 9764 |
| 2014 | 1246 | 1246 | 1246 | 11533.7 | 1246 | 11010 |
| 2013 | 956 | 1024 | 926 | 12489.7 | 975 | 11985 |
| 2012 | 1279 | 1334 | 1245 | 13769 | 1289.5 | 13274.5 |
| X | **13769** | **13335** | **13214** | Yaxis | | Xaxis |
| | | | | **77812.35** | | |

Table 1 shows the cumulative average values of Sta. YEI and Sta. Bor which will be used as values on the X-axis and the cumulative values of Sta. Rek which will be used as values on the Y-axis in the double graph as follows.

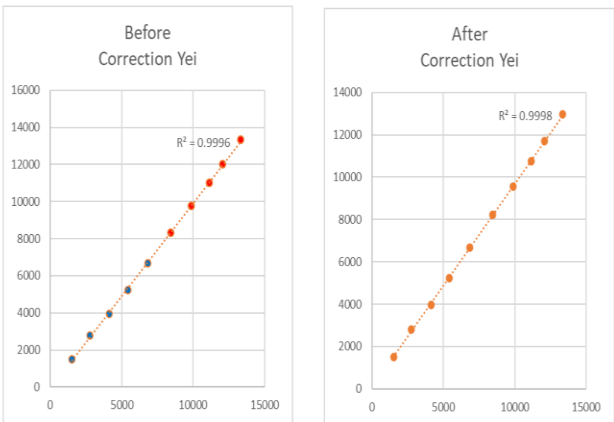


*Figure 3: Show chart of Annual rainfall data for correction of Yei before and after*

**Design Flood**

The design flood discharge is the amount of flood discharge of a certain repeat period which is determined as the basis for determining the hydraulic capacity and dimensions of the building, this intended so that damage that can be caused either directly or indirectly by flooding does not occurs as long as the flood magnitude has not been exceeded. The following is the formular used to determine the design flood discharge.
Example of Calculating 1-4 channels:

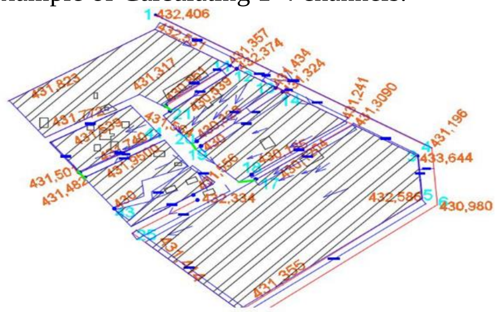


*Figure 4: Flood Channel Design*
*Source: Calculation from AutoCAD*

Equation of Flood Discharge

$$Q = C.I.A$$

Q = Flood discharge (m3/s)
C = Runoff coefficient = 0,7
I = Rainfall intensity ( mm/hour) = 0,00007216887917 m/s
A = Catchment area (m2, km2, ha) = 803,2347 m2
Q = 0,7 X 0,00007216887917 X 803,2347
Q = 0,040578 m3/s

From the example of calculating channels 1-4 , the flood discharge that occurs on channels 1-4 is 0,040578 m3/s

Table 2 Design Flood in Bor County

| I | | A | C | Qrain |
|---|---|---|---|---|
| mm/hour | m/s | m2 | | m3/d |
| 353.4178678 | 9.8172E-05 | 145 | 0.7 | 0.0099644 |
| 350.4446605 | 9.7346E-05 | 125 | 0.7 | 0.0085178 |
| 328.8624164 | 9.1351E-05 | 150 | 0.7 | 0.0095918 |
| 323.0944333 | 8.9748E-05 | 148.567 | 0.7 | 0.0093336 |
| 349.564885 | 9.7101E-05 | 135.3938 | 0.7 | 0.0092028 |
| 350.0717819 | 9.7242E-05 | 132.6551 | 0.7 | 0.0090298 |
| 282.9152605 | 7.8588E-05 | 100.5866 | 0.7 | 0.0055334 |
| 350.5428883 | 9.7373E-05 | 125.3343 | 0.7 | 0.0085429 |
| 226.4274669 | 6.2897E-05 | 167.01112 | 0.7 | 0.0073531 |
| 296.7212392 | 8.2423E-05 | 167.583 | 0.7 | 0.0096688 |
| 358.1565621 | 9.9488E-05 | 142.4881 | 0.7 | 0.0099231 |

**Infiltration Wells**

In determining the dimensions of the infiltration wells the parameters needed area the soil permeability values and the diameter of the infiltration well to be made, these parameters are used to find the height of the infiltration well (H). The placement of the location of the infiltration pond and the shape of the well must also be considered, the sump must be more than 10 m from the septic tank, this distance must be considered because the water from the infiltration well must be mixed with water from the septic tank.

The value of soil permeability is obtained from determining the type of soil in the area under study. After knowing what types of soil exist at the location, look for the permeability value in the table (FAO 2012. drainage design) factor for AFO in drainage paper, 38, page 12. It is known that the type of soil in the studies area is sandy-loam, sand and clay soils, so the permeability value of the soil is 0.33m/day, while the units used are in m/second therefore 0.33/1658 = 0.00019990 m/second, the diameter for infiltration wells used 1 m. The following is an example of calculating the dimensions of an infiltration well.

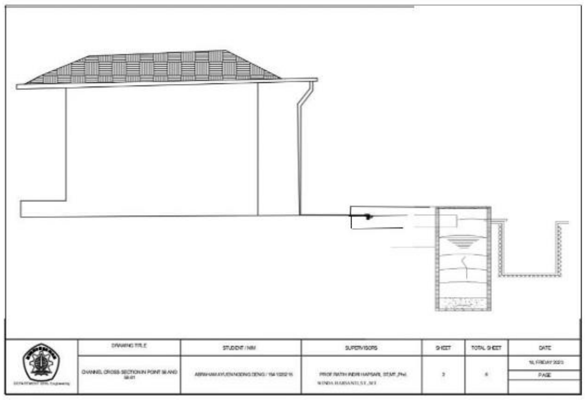

*Figure 5. Infiltration Wells*
*Source: Design from AutoCAD*

1. Calculating the Depth of the well:

   K = 0.000583

   $H = \frac{Q}{F.K}\left[1 - e^{\frac{-F..K}{\pi.R^2}}\right]$

   $H = \frac{0.00499}{2.75.0.000583}\left[1 - e^{\frac{-2.75..0.000583}{\pi.0.5^2}}\right]$

   H = 3.11 m

2. Well Debit

   Q = C.I.A =

   Roof Slope = 1% 0.01

   Designed Rainfall = 93.174 mm/ days

   L0 = 92.932 m

   Ld = 52.454 m

   nd = 0.013

(Brick C) = 0.013

$T0 = \left(\frac{2}{3} . 3.28. L0 . \frac{nd}{\sqrt{S}}\right)$

$T0 = \left(\frac{2}{3} . 3.28. 92.932 . \frac{0.013}{\sqrt{0.01}}\right)^{0.167}$

T0 = 1.728 min

$Td = \frac{Ld}{60.V}$

$Td = \frac{52.454}{60.1.5} = 0.58$ min

Tc = t0 + td =1. 728+0.58

Tc = 2.308 min = c

Tc = 2.308/60 = 0.039 second

$I = \frac{R24}{24} . \left(\frac{24}{tc}\right) )^{2/3}$

$I = \frac{93.174.24}{24} . \left(\frac{24}{0.039}\right) )^{2/3}$

I = 283.8715 mm/hour

I = 283.8715/ (60.60.1000) m/s

=0.00007885 m/s

Q = C.I.A = C = 0.013

I = 0.00007885 m/s

A = 4874.66 m2

Q = C.I.A = 0.013. 0.00007885. 4874.66

Q = 0.005 m3/ s

3. Full Time of Infiltration Well:

$T = \frac{V}{\frac{1}{2} x \pi x R^2 K}$

$T = \frac{29.17324}{\frac{1}{2} x 3.142 x 0.5^2 X 0.000583}$ = 127408.9441 seconds

change to minutes.

T = 127408.9441/3600 = 35.39

T = 35.39 minutes

In summary, the calculations indicate that an infiltration well with a concrete bud having a diameter of 1 m, depth of 3.11 m, and capacity of 29.17324 m3 will effectively handle the drainage requirements for a housing complex of 177 houses with specific parameters, including a roof slope of 1%, designed rainfall of 93.174 mm/day, and a coefficient of infiltration (C) of 0.013. The well's total infiltration time is 35.39 minutes, with a calculated infiltration rate of 0.005 m3/second.

**Channel Dimensions**

After calculating the total discharge that comes from the discharge of roads, houses and sewage which has been reduced by the discharge that enters the well, the next calculation is to determine the dimensions of the channel that meet and are most economical, here is an example of calculation for the dimensions of the point 1-4 channels.

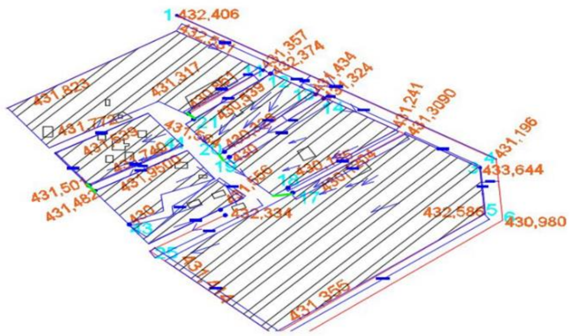


*Figure 6. Channels 1-4*
*Source: Calculations.*

Qreno = 0.010 m3/s
Ld. = 151.754 m
Elevation land of Surface plan point 1 = 432.406 meters
Elevation land of surface plan point 2 = 431.196 meters

$Slope = \frac{Elevation\ of\ the\ point\ 1 - Elevation\ of\ the\ point\ 2}{Length\ of\ the\ Channels\ 1-4}$

$Slope = \frac{432.406 - 431.196}{151.754} = 0.004$

Slope = 0.004
Channel Shape = Rectangle
Channel Material = Stone Masonry
Channel Width (b) = 0.15 meter
Channel Height (h) = 0.15 meter
Area (A) = bxh = 0.15 x 0.15 = 0.023 m2
P = b+2h = 0.15+2. 0.15 =0.45 m
R = A/p = 0.023/0.45 = 0.05 m

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

n = 0.013
V = 1/0.013. $0.051^{2/3}$. $0.004.^{1/2}$
V = 0.662 m/s
Q Count = 1/n. $R^{2/3}$ $S^{1/2}$ hxb =
Q-Count = 0.015 m3/s

$Fr = \frac{V}{\sqrt{9.81.h\ 0.15^{0.5}}}$

$Fr = \frac{0.662}{(9.81\ X 0.15)^{0.5}} = 0.546$

Freeboard Height = 1/3.h
FB = 1/3. 0.15 = 0.05 m

**Control**

1. Debit (Q Capacity = Q-Calculation)

In discharge control the conditions used are that the capacity discharge must be the same as the flooding discharge control with discharge Q-capacity is 0.015 m3/s and Q-calculation is 0.015 m3/s. With a debit difference of 0.000 m3/s. So, the discharge control meets the requirements.

2. Flow Speed (Vmin<Vmax)

The Speed used of the river stone is 0.2 Vmin s and maximum of 2 m/s. And the results obtained from the calculations are 0.892 m/s. So, the speed of control is qualifying for the design channel dimensions.

3. Fr<1

For the Fronde number used is subcritical flow namely Fr<1. So, the Fronde number on the 1-4 channel = if (0.546<1 "OK", NOT OK") is OK"). So, the Fr control is qualifying for the design of dimensions channel.

Water surface level = planned ground level – Freeboard

Initial elevation level= 432.531

Freeboard (rd) = 0.050

Water surface level = 432.531-0.050 = 432.48 meters

Bottom pass elevation = Water surface elevation – height (h) of channel.

Bottom pass elevation = 432.48- 0.15 = 432.33 meters

Top channel elevation = Height (H)+ Bottom elevation level

Top Elevation = 0.2 m+432.33 m = 432.53 meters

For initial water control = Water Surface elevation level – Initial Elevation level

Initial water level control = 432.48- 432.531 = -0.050

Table 3Channel Dimension Calculation

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Start Elevation | | | End Elevation | | | Water Levels Control | |
| Water face | bottom Pass | Top channel | Water face | bottom Pass | Top channel | | |
| | | | [33] | [34] | | | |
| 432 | 432 | 433 | 432 | 432 | 432 | -0.05 | -0.05 |
| 432 | 432 | 432 | 430 | 430 | 431 | -0.05 | -0.05 |
| 430 | 430 | 431 | 430 | 430 | 431 | -0.93 | -0.93 |

**Long and Cross-section Drawing**

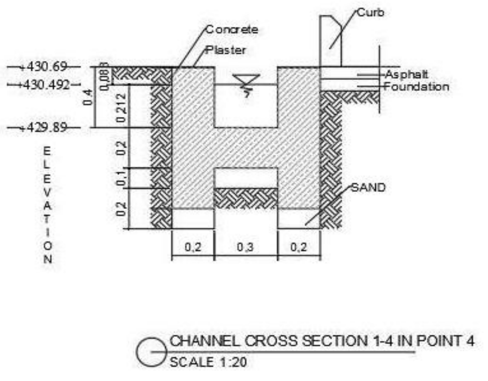


*Figure 7. Effective Main channel Height*
*Source: AutoCAD 2022 Design Calculations and Results*

**Cross-section**

The channel width (B1) can be calculated using formula (SNI 2851, 2015) below:

$B_1 = \alpha \, x \sqrt{Qd}$

$B_1 = 4 \, x \sqrt{0.01}$ = 0.4 mm = 4m

The overflow height (h3) is obtained from the equation below

This: h= ½.400 = ½ x 400 = 200mm

h3= 200x0.001 = 0.2 m

h3 = 0.2 meters

After knowing the value of h3 then the width of the upstream can be determined using the formula (SNI 2851,2015) as follows:

$B2 = B1 + 2m2 \times h3$

$B2$ = 4+2 (0.5) x 0.2 = 4.2 m

h = 0.15

Determine the speed of water over the channel design accordingly with the formula (SNI 2851, 2015):

$q = \frac{\text{Q discharge}}{(B1+B2)/2} = \frac{0{,}040578 \text{ m3/s}}{(4+4.2)/2}$ = 0.099 m3/dtk/m

$vo = \frac{Q0}{h3} = \frac{0.099 \text{ m3/s}}{0.2}$ = 0.025 m/dtk

The guard height is obtained from the guard height table adjust to the amount of design rain discharge. From the resulting rain discharge of 0.01 m3 /sec then high guard according to table 5 of 0.401 m.

**Foundation Depth (hp)**

The depth of the main dam foundation can be calculated using the formula (SNI 2851, 2015):

$h_p = (\frac{1}{4} \; until \; \frac{1}{3})$+(h3+h)

hp = $(\frac{1}{4} \, x$ 0.2+0.15) = 0.2 m

$(\frac{1}{3})$+(h3+h) = $\frac{1}{3} \, x$ 0.2+0.15) = 0.2166

The foundation depth used is between 0.2 m and 0.2166 m and selected is as deep as 1.2 m.

Figure 5. Main channel Foundation Design
Source: AutoCAD 2021 Design Calculations and Results

**Long Section Channel**

Downstream slope (n) 0.013 n main channel body of 0.004: 0.013 can be known by using the formula:

$n = vo \sqrt{\frac{2}{gxht}}$

$n = 0.662 \sqrt{\frac{2}{9.81 \, x(3x1.5)x3}}$ = 0.0814

FB(Freeboard) = $\frac{1}{3}\ x\ h$

FB = = $\frac{1}{3}\ x\ 0.15$ = 0.05

Q-Capacity = 0.01 m3/s, Q-design = 0.015 m3/s

Q- Planning = IF (0.015>=0.01;"Ok";" Not Ok") = Ok

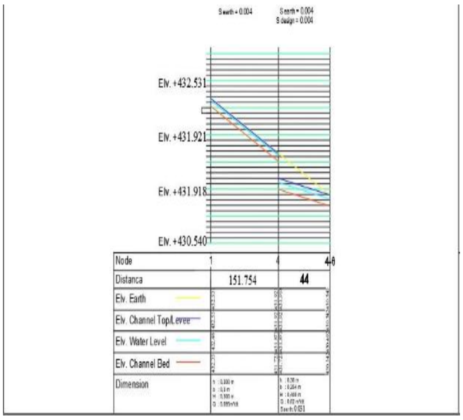


*Figure 8. Main channel body slope*
*Source: AutoCAD 2021 Design Calculations and Results*

**Culvert Building Dimensions**

In addition to channel or canals with rectangle section-section, there are also channel cross-sections that are circular in shape or better known as culverts. Here is an example of calculating the dimensions of 22-21 culverts.

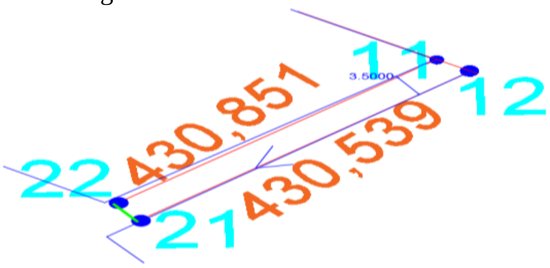


Figure 4. 1 Culvert for 22-21

Source: Calculations.

Qreno = 0.04 m3/s

Ld. = 98 meters

Elevation land of Surface plan point 22 = 430.851 meters

Elevation land of surface plan point 21 = 430.539 meters

Slope = $\frac{Elevation\ of\ the\ point\ 22 - Elevation\ of\ the\ point\ 21}{Length\ of\ the\ Channels\ 22-21}$

Slope = $\frac{430.851-430.539}{98}$ = 0.004

Channel shape = Rectangle

Channel Material =stone masonry (n =0.013)

Diameter = 1.2 m

Box Culvert 400x400x100

h= ¾ .400 = ¾ x 400 = 300

h = 300x0.001 = 0.3 m

h = 0.3 meters

b = 400 mm change to m= 400x0.001

b = 0.4 m

A = b.h = 0.4 x 0.3 = 0.12 m2

P = b+2h = 0.4 +2x 0.3

P = 1 m

R = Area/parameter

R = 0.12/1 = 0.12 m

V = 1/n. $R^{2/3}$. $S^{1/2}$

n = 0.013

V = 1/0.013. $0.12^{2/3}$. $0.004.^{1/2}$

V = 1.235 m/s

Q Count = 1/n. $R^{2/3}$ $S^{1/2}$ hxb =

Q Count = 1/0.013 .$0.12^{2/3}$ .$0.004^{1/2}$ 0.3x0.4 = 0.15 m3/s

Q-Count = 0.15 m3/s

Fr = $\frac{V}{\sqrt{9.81.h}^{\ 0.5}}$

Fr = $\frac{1.235}{(9.81\ X0.3)^{0.5}}$ = 0.720

Freeboard Height = 1/3.h

FB = 1/3. 0.3 = 0.1 m

**Channel Design Sediment Mass Capacity Volume**

According to (Hassan, 2019) the calculation of the sediment mass capacity requires some data such as the channel plan height (H) 3 m; river elevation before Bor channel +1,084.00 m; river base elevation Bor channel point +1,081.00 m; total river length (L) 7881 m; and the width of the river (B)

Tan$\theta$ = $\frac{1{,}084-1{,}081}{7881}$ = 0,0004,$\frac{1}{n}$ = $\frac{1}{0.0004}$ = 2627 m

1. Find the length of the river L1

L1= $2 \times n \times H$ = (2 × 2627 × 3) = 15,762 m

2. Find the length of the river L2

$L2 = 3 \times n \times H$ = 3 × 2627 × 3 = 23,643m

3. Find the area of A1

$A1 = 1/2 \times H \times L1$

A1 = ½ x 3 x15.762 m = 23,643 m2

4. Find the total area of A

$\sum A = 1/2 \times H \times L2$

$\sum A$ = 1/2× 3 × 23,643 = 35,464 $m2$

5. Finding the sediment mass capacity (Vs)

$Vs = \sum A \times B_{river}$

$Vs$ = 35, 464 × 3,08 = 109,231 $m3$

**Budget Plan**

The budget plan includes preparatory work; earthworks; masonry and stucco work; concrete works; and steel fiber concrete work which requires a total budget of IDR 15.511.693.828 based on analytical calculations (Ministry of Public Works and Public Housing, 2021-2022).

## 4. CONCLUSIONS

**CONCLUSIONS**

Based on the results of designing sustainable urban drainage system on both the major and minor roads in Bor Town, South Sudan, the following results are obtained.

1. There is no channel existing before.

2. The channel will be built around the housing and beside the roads of Bor City
3. The rain design on Bor roads is 93.179 mm/day and flood design discharge are 0.0435 m3/s with the return period of 10 years.
4. After the calculation of infiltration wells the significant discharge capacity to reduce the flood impacts on the household in Bor was Q = 0.005 m3/s
5. The dimensions of the planned infiltration well have a diameter of 1 m and a height of 3.108 m, while the planned channel dimensions are rectangular in shape with concrete material with different a diameter. the calculation results show that the largest is 1.8 m wide and of 1.35 m high.
6. The cost required for this sustainable urban drainage design system is IDR 15.511.693.828 for the construction time is 21.7weeks and 105 working days

## SUGGESTIONS

As for some recommendations that might be useful for readers in for students general and for students in particular,

1. As a planner, I suggested that, there must be monitoring and implementation plan for the SuDs measures, considering the stakeholder engagement, funding sources, and coordination with authorities if there is a need for re-designing of channels dimensions in a maximum of 10 years in the future for the preventing of flooding.
2. In a planning of the drainage channel we must be careful in the calculations of rainfall data including determining the slope and dimensions of the channel, so that the water can flow through drainage channel with a right planned direction.
3. Before planning a drainage, topographical, hydrological and unit price analysis data must be completed and up-to- date.
4. Complementary building such as infiltration well, chamber control and inlets need to be maintained to prevent damage.
5. Development of the extensive water resources management infrastructure is needed in Bor city.

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