Canal as a Solution to Reduce a Puddle in the Drainage System of Passo - Ambon City
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Abstract—Due to the low infiltration capacity as the effect of land expansion into buildings / concretization in an area will have an impact on the surface flow rate which results in a drainage system that is not optimal. For this reason, routine flooding / inundation in Passo area is minimized by involving the canal of Passo as a water body that can manage flooding. The average rainfall data of 14 years is used to model the rainfall plan and land use data of 0.4-0.7 in the way tonihatu watershed is a variable of runoff coefficient. For the planned discharge with a 25-year return period of 14.84 m³/sec with the Nakayasuyang synthetic hydrograph used to model the channel capacity of 46 nodes. From the simulation results of the existing condition, only 3 nodes are safe, after that the flow model and channel capacity are improved according to the channel characteristics requirements, the simulation results show the ability of the safe channel capacity to discharge the planned system.

Keywords—Nakayasu, Canal, Passo, land use.

I. INTRODUCTION
Excessive development in Ambon City has disrupted the balance of the water system which can be seen from the high number of surface runoffs, due to the low infiltration capacity as the result of the expansion of land into buildings / concretization in an area. The direct loss felt is a decrease in soil production capacity, high surface runoff, and sedimentation rates. Existing conditions in the city of Ambon, especially Passo, are experiencing a lot of problems with the urban drainage system that urgently needs to be addressed, including the problem of the malfunctioning of the network system, in this case the canal (long storage) which causes flooding.

In addition, an increase in demographic growth and urbanization has led to an irregular city morphology, slum, and squatter settlement, as the second developing city in Ambon city area, it is feared that in the next 10 years Passo will stagnate, so there is no more land that can be built. Based on the foregoing, a form of handling is needed by increasing / normalizing the urban drainage system so that rainwater flow is expected to be more optimal and shorter drying cycle times in the area.

II. REVIEW OF LITERATURE
The flood estimation equation that will be used for tertiary drainage is calculated based on the Rational formula while for secondary and primary drainage the Nakayasu formula is used.

\[ Q_p = \frac{1}{3.6} CIA \]  \hspace{1cm} (1)

\[ I = \frac{(R_{24}/24)}{(24/10^3)} \]  \hspace{1cm} (2)

where:
- \( Q_p \) = peak flood discharge (m³/second)
- \( I \) = Concentration time (hour)
- \( R_{24} \) = Maximum daily rainfall (in 24 hours)

And \( tc \) is the concentration time that can be calculated by the equation \( tc = L/V \), dan

\[ V = 72 \left( \frac{H}{L} \right)^{0.6} \]

Where:
- \( L \) = River length in the flow area (km)
- \( V \) = Flood creepage speed (km/hour)
- \( H \) = the height of the furthest point upstream from the observation point (km)

\[ Q_p = \frac{A.R_0}{3.60 \times (0.3T_p + T_{0.3})} \] \hspace{1cm} (3)

where:
- \( Q_p \) = peak flood discharge (m³/second)
- \( A \) = watershed area (km²)
- \( R_0 \) = unit rain (mm)
- \( T_p \) = the time period from the beginning of the rain until the peak of the flood (hour)
- \( T_{0.3} \) = the time taken by the decline debit, from
the main discharge to the discharge, 30% of peak discharge (hour)

\[ \text{C}_{\text{All}} = \frac{C_1 A_1 + C_2 A_2 + C_3 A_3 + \ldots + C_n A_n}{A_1 + A_2 + A_3 + \ldots + A_n} \]

flow coefficient from the flow area
A = area of flow (km²)

III. METHODOLOGY

Based on the Ambon city spatial plan (RTRW) in 2011-2031 against SWP (development area unit) Passo and surrounding areas are service areas that are quite extensive to include Ambon Inner Bay (TAD)

IV. RESULT AND DISCUSSION

- Hidrology Analysis
Regional rainfall has been calculated by the Arithmetic method and has produced a maximum annual daily rainfall as in Table

| Type of distribution | Condition | Results | Information |
|----------------------|-----------|---------|-------------|
| Normal               | Cs = 0    | 0.004 > 0 | not accepted |
| Log Normal           | Cs = 3Cv + Cv² | 1.226 < 0.167 | not accepted |
| Log Pearson III      | Cs ≠ 0    | 0.004 > 0 | not accepted |
| Gumbel               | Cs ≤ 1.1396 | 0.004 > 1.1396 | not accepted |
|                      | Ck ≤ 5,400² | 1.991 < 4,400² | be accepted |

From the distribution test results for \( dk = 3 \) and \( \alpha = 5\% \), then from the chi square test table obtained \( X² = 7.815 \). From the above calculation obtained \( x² = 4.571 \) this value is smaller when compared with the critical value of \( x² \) with degrees of freedom (dk) = 3 the critical \( f² \) value is 7.815. then the Gumbel distribution can be accepted.

- Land Use
In calculating the flood discharge the plan needs to be determined in advance the value of the drainage coefficient, the amount of which depends on the designation of the land
(land use). At the research location found a land use coefficient of 40-70

- **Tidal Data**
  Tidal data used as modeling input used observations for 14 days. Taken on the upstream canal.

- **Runoff discharge analysis**
  For the purposes of the analysis of the drainage system, the maximum rainfall data used for the planned return period of the drainage system is 5 years. To determine the dimensions of the drainage channel it is assumed that the condition of water flow is in a normal condition (steady uniform flow) where the flow has a constant velocity with respect to distance and time.

- **Discharge flood plans**
  The amount of the planned flood discharge is determined by adding up the amount of surface runoff and dirty water discharge. In this study the surface runoff (rainwater) discharge used is a discharge with a return period of 25 years, as shown in table 2

### Table 2 Discharge system plan

| No | Channel | Channel segment | Qrain (m^3/det) | Q accumulative (m^3/det) | Qdesign (m^3/det) |
|----|---------|----------------|----------------|-------------------------|------------------|
| 1  | A       | a0-a1          | 0.8663         | 0.0034                  | 0.8697           |
| 2  | B       | b0-b1          | 0.8663         | 0.0006                  | 0.8669           |
| 3  | C       | c0-c1          | 0.9531         | 0.0053                  | 0.9584           |
| 4  | D       | d0-d1          | 0.4754         | 0.0032                  | 0.4786           |
| 5  | E       | e0-e1          | 0.2640         | 0.0016                  | 0.2656           |
| 6  | F       | f0-f1          | 0.4998         | 0.0022                  | 0.5020           |
| 7  | G       | g0-g1          | 0.2416         | 0.0016                  | 0.2431           |
| 8  | H       | h0-h1          | 1.5761         | 0.0026                  | 1.5788           |
| 9  | I       | i0-i1          | 0.9289         | 0.0022                  | 0.9301           |
| 10 | J       | j0-j1          | 0.7114         | 0.0015                  | 0.7129           |
| 11 | K       | k0-k1          | 1.1430         | 0.0017                  | 1.1446           |
| 12 | L       | l0-l1          | 0.4906         | 0.0012                  | 0.4918           |
| 13 | M       | m0-m1          | 0.2289         | 0.0009                  | 0.2299           |
|    | Total   |                |                |                         | 9.2734           |

- **Design Flood Hydrograph**
  For the purposes of the calculation of the flood hydrograph, it is necessary to have a base flow calculation.

### Table 3. Nakayasu Synthetic Hydrograph Unit

| Time | Curved up | Curved Down | Total | Debit Hydrograph Unit |
|------|-----------|-------------|-------|-----------------------|
| 0.37 | 0.910     | 2.865       | 3.78  | 0.0000                |
| 1.00 | 2.354     | 2.354       | 4.71  | 0.0000                |
| 3.00 | 2.87      | 2.87        | 5.74  | 0.0000                |
| 4.00 | 3.37      | 3.37        | 6.74  | 0.0000                |
| 5.00 | 4.09      | 4.09        | 8.08  | 0.0000                |
| 6.00 | 4.81      | 4.81        | 9.62  | 0.0000                |
| 7.00 | 5.54      | 5.54        | 10.58 | 0.0000                |
| 8.00 | 6.26      | 6.26        | 12.52 | 0.0000                |
| 9.00 | 6.98      | 6.98        | 13.96 | 0.0000                |
| 10.00 | 7.70     | 7.70        | 15.40 | 0.0000                |
| 11.00 | 8.42     | 8.42        | 16.84 | 0.0000                |
| 12.00 | 9.15     | 9.15        | 18.20 | 0.0000                |
| 13.00 | 9.87     | 9.87        | 18.74 | 0.0000                |
| 14.00 | 10.59    | 10.59       | 21.18 | 0.0000                |
| 15.00 | 11.31    | 11.31       | 22.62 | 0.0000                |
| 16.00 | 12.03    | 12.03       | 24.06 | 0.0000                |
| 17.00 | 12.76    | 12.76       | 26.52 | 0.0000                |
| 18.00 | 13.48    | 13.48       | 28.00 | 0.0000                |
| 19.00 | 14.20    | 14.20       | 30.20 | 0.0000                |
| 20.00 | 14.92    | 14.92       | 33.14 | 0.0000                |
| 21.00 | 15.64    | 15.64       | 36.78 | 0.0000                |
| 22.00 | 16.36    | 16.36       | 39.14 | 0.0000                |
| 23.00 | 17.09    | 17.09       | 40.98 | 0.0000                |
| 24.00 | 17.81    | 17.81       | 42.69 | 0.0000                |

- **Hydraulics Analysis**
  For the cross-section analysis in this study the HEC – RAS 4.1 program was used.

### Fig.5: Nakayasu Hydrograph of the Passo Canal

### Fig.6: Geometry Data Input
Table 4. Condition of existing channels

| Node | Total Debit (m³/sec) | Elevation (m) | Qdeh_str | Water level (m) | Velocity (m/sec) | Top width (m) | Information |
|------|---------------------|--------------|----------|----------------|-----------------|--------------|-------------|
| 46   | 14.84               | 1.15         | 1.06     | 0.41           | 2.46            | 0.37         | 20 overflowed |
| 45   | 14.84               | 1.85         | 1.85     | 0.63           | 2.45            | 0.41         | 20 overflowed |
| 44   | 14.84               | 1.91         | 1.92     | 0.62           | 2.45            | 0.42         | 20 overflowed |
| 43   | 14.84               | 1.23         | 1.43     | 0.72           | 2.44            | 0.52         | 20 overflowed |
| 42   | 14.84               | 1.94         | 1.85     | 0.63           | 2.44            | 0.39         | 20 overflowed |
| 41   | 14.84               | 1.56         | 1.57     | 0.63           | 2.43            | 0.52         | 20 overflowed |
| 40   | 14.84               | 1.19         | 1.18     | 0.85           | 2.4             | 0.88         | 20 overflowed |
| 39   | 14.84               | 1.42         | 1.36     | 0.82           | 2.39            | 0.6          | 20 overflowed |
| 38   | 14.84               | 1.91         | 1.92     | 0.94           | 2.35            | 0.99         | 20 overflowed |
| 37   | 14.84               | 1.95         | 2.05     | 0.64           | 2.32            | 1.13         | 20 overflowed |
| 36   | 14.84               | 2.09         | 2.03     | 0.64           | 2.23            | 1.54         | 20 overflowed |
| 35   | 14.84               | 1.61         | 1.45     | 1.03           | 1.94            | 2.19         | 12.41 overflowed |
| 34   | 14.84               | 1.01         | 1.42     | 1    | 1.73            | 1.76         | 20 overflowed |
| 33   | 14.84               | 0.97         | 0.66     | -0.28          | 1.63            | 0.63         | 20 overflowed |
| 32   | 14.84               | 0.33         | 0.31     | -0.22          | 1.63            | 0.45         | 20 overflowed |
| 31   | 14.84               | 0.87         | 0.53     | 0.01           | 1.62            | 0.41         | 20 overflowed |
| 30   | 14.84               | 0.79         | 0.78     | 0.04           | 1.62            | 0.53         | 20 overflowed |
| 29   | 14.84               | 0.7          | 0.63     | -0.31          | 1.62            | 0.47         | 20 overflowed |
| 28   | 14.84               | 1.04         | 0.97     | 0.02           | 1.6             | 0.61         | 20 overflowed |
| 27   | 14.84               | 1.03         | 1.01     | 0.02           | 1.58            | 0.8          | 20 overflowed |
| 26   | 14.84               | 1.03         | 1.05     | 0.03           | 1.56            | 0.73         | 20 overflowed |
| 25   | 14.84               | 0.99         | 0.92     | 0.01           | 1.55            | 0.72         | 20 overflowed |
| 24   | 14.84               | 1.01         | 0.91     | 0.01           | 1.53            | 0.86         | 20 overflowed |
| 23   | 14.84               | 1.32         | 1.3      | -0.02          | 1.14            | 2.66         | 5.4 overflowed |
| 22   | 14.84               | 0.97         | 0.7      | -0.24          | 1.34            | 0.6          | 20 overflowed |
| 21   | 14.84               | 0.7          | 0.85     | -0.24          | 1.32            | 0.94         | 20 overflowed |
| 20   | 14.84               | 0.86         | 0.57     | -0.37          | 1.32            | 0.65         | 20 overflowed |
| 19   | 14.84               | 1.02         | 1.06     | -0.39          | 1.16            | 1.83         | 19.09 overflowed |
| 18   | 14.84               | 0.41         | 0.5      | -0.45          | 1.21            | 0.75         | 20 overflowed |
| 17   | 14.84               | 0.55         | 0.54     | -0.44          | 1.18            | 0.95         | 20 overflowed |
| 16   | 14.84               | 0.51         | 0.61     | -0.47          | 1.17            | 0.89         | 20 overflowed |
| 15   | 14.84               | 0.35         | 0.19     | -0.55          | 1.17            | 0.59         | 20 overflowed |
| 14   | 14.84               | 0.32         | 0.29     | -0.48          | 1.16            | 0.64         | 20 overflowed |
| 13   | 14.84               | 0.78         | 0.84     | -0.79          | 1.14            | 0.88         | 20 overflowed |
| 12   | 14.84               | 1.07         | 1.51     | -0.29          | 1.06            | 1.31         | 9.53 safe |
| 11   | 14.84               | 2.07         | 2.14     | -0.18          | 1.01            | 1.31         | 10.34 safe |
| 10   | 14.84               | 2.02         | 2.05     | -0.21          | 0.99            | 1.08         | 12.3 safe |
| 9    | 14.84               | -0.71        | -0.25    | -0.72          | 0.98            | 0.68         | 20 overflowed |
| 8    | 14.84               | -0.31        | -0.19    | -0.76          | 0.97            | 0.79         | 20 overflowed |
| 7    | 14.84               | -0.27        | -0.11    | -0.49          | 0.94            | 0.83         | 20 overflowed |
| 6    | 14.84               | -0.27        | 0.02     | -0.59          | 0.91            | 0.58         | 16.79 overflowed |
| 5    | 14.84               | -0.56        | -0.17    | -0.91          | 0.89            | 0.77         | 20 overflowed |
| 4    | 14.84               | -0.36        | -0.68    | -0.92          | 0.86            | 0.85         | 20 overflowed |
| 3    | 14.84               | -0.36        | -0.56    | -0.93          | 0.85            | 0.72         | 20 overflowed |
| 2    | 14.84               | -0.62        | -0.93    | -1.37          | 0.84            | 0.66         | 20 overflowed |
| 1    | 14.84               | -0.98        | -0.83    | -1.39          | 0.84            | 0.47         | 20 overflowed |
| 0    | 14.84               | -0.93        | -0.48    | -1.35          | 0.83            | 0.58         | 20 overflowed |

Cross-section Planning

Normalization of the Passo channel with a single cross section is planned with the Manning formula. The type of cross section used follows the maximum cross section capacity because the channel dimension capacity that can be changed in maximum conditions is depth only.
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V. CONCLUSION

1) In Sub-watersheds that contribute to the flow in the Passo city drainage system that discharges the flow in the canal, the flow will be directed so that the Passo Canal system is no longer burdened with part of the discharge from the micro drainage system according to the Hydrological and Hydrolytic plan criteria.

2) For the channel dimensions in the existing condition the channel capacity is sufficient to accept the flood load of the planned 25-year return period, while the plan conditions for the channel dimensions that pass through the access road still follow the channel dimensions of the exciting conditions.
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