Application of steady flow model to overcome inundation based on eco drainage system in the Port Area of Dobo City, Aru Islands Regency

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Abstract. This research was carried out in inundation that occurred in the Port area of Dobo City, Aru Islands Regency. Inundation that occurs is due to the unavailability of adequate and well-arranged drainage. This research aims to plan a drainage system in the Port area of Dobo City that can overcome the inundation that arises and the influence of tides. Data processing is carried out with two analyzes including hydrological analysis and hydraulic analysis. For hydraulic analysis, this includes cross section planning and drainage system modeling with HEC-RAS 4.0. In conventional drainage in the case of high tides, the results of the modeling show that the overflow of water on the channel that will occur is at an elevation of +2.48 m. After adding a long storage with dimensions of 1.2 m x 3.5 m along 101.6 m and sea walls as high as +2.48 m. The results of the modeling show that the inundation height that will occur is at an elevation of +0.61 m. Of the several scenarios that are performed for the most optimal two-door openings, which are opened by 30 cm which later the water will be at +12 cm elevation. Whereas the most optimal one-door openings are opened by 70 cm which later the water will be at +6 cm elevation.

1. Introduction

Inundation that occur are mainly caused by the absence of a drainage system that is able to accommodate runoff discharge that occurs [2]. Drainage originating from the verb ‘to drain’ which means drying or draining water, is the terminology used to express systems related to handling the problem of excess water both above and below the surface of the land. Generally, the drainage system in the Port area of Dobo City is a natural drainage channel that has not been properly arranged to channel inundation that occurs in the area. This is exacerbated by the amount of sedimentation and garbage that covers the canal so that it reduces the capacity of existing channels.

An alternative solution that can be done to solve the inundation problem in the Dobo City Port area and fulfill the zero delta Q policy principle is to use a drainage system based on Eco Drainage. Eco drainage is defined as an effort to manage excess water (rainwater) with various methods including by accommodating through water reservoirs to be used directly, accommodating in artificial reservoirs, permeating and flowing to nearby rivers without increasing the burden on the river concerned and always maintain the system so that it can be sustainably efficient [4]. The main priority in realizing this concept is by managing surface runoff through developing facilities to endure rainwater (rainfall retention fascilities) so there is no inundation on the trunk channel [3]. Based on its function, rainwater detention facilities can be in the form of storage types and infiltration types.
2. Methodology
In data processing carried out with two analyzes including hydrological analysis and hydraulic analysis [5]. Hydrological analysis carried out included analysis of probability distribution, probability distribution test, planned rainfall calculation, analysis of time concentrate, rainfall intensity analysis, and the last is calculation of planned flood discharge by dividing the planning area into several sub-catchments (sub catchments), all hydrology analysis calculations is carried out using Microsoft Excel 2010. For hydraulics analysis, includes cross section channel planning and drainage network modeling using HEC-RAS 4.0 to determine the happening of back water on water level elevation profile [6].

Furthermore, eco drainage system planning is carried out by adding a long storage to the planned drainage channel [7]. Planning is done to determine the dimensions of the long storage also to know the amount of discharge that can be accommodated in the long storage. After knowing the dimensions of the long storage and obtained technical data about the height and time of tide occurring, following by the outlet door scenario planning in anticipating back water caused by tides. Furthermore, after the planning phase is completed, proceed with making conclusions and suggestions [8].

3. Analysis and Discussion
The flood discharge plan is the most important part and is the basis for determining the capacity and dimensions of water buildings. In this plan, the determination of the amount of planned flood discharge carried out using a rational method where the discharge used in the planning is the peak flood discharge [9].

| Channel | Discharge m³/s | Channel | Discharge m³/s | Channel | Discharge m³/s |
|---------|----------------|---------|----------------|---------|----------------|
| 1.a     | 0.080          | 8a      | 0.048          | 11.a    | 0.028          |
| 2.a     | 0.038          | BC 5    | 0.644          | BC 9    | 0.827          |
| BC 1    | 0.118          | 8b      | 0.064          | 11.b    | 0.002          |
| 4a      | 0.190          | 9b      | 0.799          | 12.b    | 0.048          |
| 1.b     | 0.051          | 9.a     | 0.178          | 12.a    | 0.042          |
| 4b      | 0.143          | 10.a.a  | 0.002          | 12.c.a  | 0.002          |
| 2.b     | 0.026          | BC 6    | 0.180          | 12.c    | 0.003          |
| 3.a     | 0.071          | 10.a.b  | 0.007          | BC 10   | 0.051          |
| BC 2    | 0.071          | 10.a    | 0.219          | 12.d.a  | 0.002          |
| 3.b     | 0.049          | 10.a.c  | 0.014          | 12.d    | 0.003          |
| 5.a     | 0.177          | 10.a.d  | 0.016          | 13.a    | 0.307          |
| BC 3    | 0.367          | BC 7    | 0.234          | 13.b    | 0.885          |
| 6.a.a   | 0.004          | 10.b.a  | 0.002          | 14.a    | 0.313          |
| 6.a     | 0.065          | 10.b    | 0.266          | 14.b    | 0.890          |
| BC 4    | 0.065          | 10.b.b  | 0.013          | BC 11   | 0.931          |
| 6.b     | 0.054          | 10.b.c  | 0.014          | 15.b    | 0.087          |
| 5.b     | 0.169          | BC 8    | 0.280          | BC 12   | 0.087          |
| 7       | 0.597          | 11.a.a  | 0.016          | 15.a    | 1.046          |

Hydraulics analysis carried out to plan the dimensions of the channel that is able to pass the planned flood discharge. Hydraulics analysis includes calculation of channel capacity, flow velocity, and the amount of discharge that can be flowed by the channel.
Table 2. Calculation of hydraulics analysis

| Channel | b (m) | h (m) | Qhydraulics (m³/second) |
|---------|-------|-------|------------------------|
| 1.a     | 0.5   | 0.4   | 0.089                  |
| 2.a     | 0.6   | 0.5   | 0.152                  |
| BC 1    | 0.6   | 0.6   | 0.191                  |
| 4.a     | 0.6   | 0.6   | 0.191                  |
| 1.b     | 0.4   | 0.4   | 0.065                  |
| 4.b     | 0.6   | 0.5   | 0.152                  |
| 2.b     | 0.3   | 0.3   | 0.030                  |
| 3.a     | 0.5   | 0.4   | 0.089                  |
| BC 2    | 0.4   | 0.4   | 0.065                  |
| 3.b     | 0.5   | 0.4   | 0.089                  |
| 5.a     | 0.6   | 0.6   | 0.191                  |
| BC 3    | 0.8   | 0.8   | 0.411                  |
| 6.a.a   | 0.3   | 0.2   | 0.018                  |
| 6.a     | 0.5   | 0.4   | 0.089                  |
| BC 4    | 0.5   | 0.4   | 0.089                  |
| 6.b     | 0.4   | 0.4   | 0.065                  |
| 5.b     | 0.6   | 0.6   | 0.191                  |
| 7       | 1.0   | 0.9   | 0.654                  |
| 8.a     | 0.4   | 0.4   | 0.065                  |
| BC 5    | 1.0   | 0.9   | 0.654                  |
| 8.b     | 0.4   | 0.4   | 0.065                  |
| 9.b     | 1.1   | 1.0   | 0.854                  |
| 9.a     | 0.6   | 0.6   | 0.191                  |
| 10.a.a  | 0.3   | 0.2   | 0.018                  |
| BC 6    | 0.6   | 0.6   | 0.191                  |
| 10.a.b  | 0.3   | 0.2   | 0.018                  |
| 10.a    | 0.7   | 0.6   | 0.238                  |

After all the dimensions used for calculating the hydraulic discharge are able to accommodate the planned flood discharge, it is then added with a free board of 10 cm on each channel. Material used in the channel using precast concrete (U-ditch). The dimensions of the channel used on each channel showed on table 3.

Table 3. Channel dimension

| Channel | Dimension (mm) | Channel | Dimension (mm) |
|---------|----------------|---------|----------------|
| 1.a     | 500 x 500      | 10.a.c  | 300 x 400      |
| 2.a     | 400 x 400      | 10.a.d  | 300 x 400      |
| BC 1    | 600 x 600      | BC 7    | 700 x 800      |
| 4.a     | 600 x 700      | 10.b.a  | 300 x 300      |
| 1.b     | 400 x 500      | 10.b   | 700 x 800      |
| 4.b     | 600 x 600      | 10.b.b  | 300 x 400      |
| 2.b     | 300 x 400      | 10.b.c  | 300 x 400      |
| 3.a     | 500 x 500      | BC 8    | 800 x 800      |
| BC 2    | 400 x 500      | 11.a.a  | 300 x 400      |
| 3.b     | 500 x 500      | 11.a    | 300 x 400      |
| 5.a     | 600 x 700      | BC 9    | 1100 x 1200    |
Table 3. Channel dimension (cont.)

| Channel | Dimension   | Channel | Dimension   |
|---------|-------------|---------|-------------|
|         | mm          |         | mm          |
| BC 3    | 800 x 900   | 11.b    | 300 x 300   |
| 6.a.a   | 300 x 300   | 12.b    | 400 x 500   |
| 6.a     | 500 x 500   | 12.a    | 400 x 400   |
| BC 4    | 400 x 500   | 12.c.a  | 300 x 300   |
| 6.b     | 400 x 500   | 12.c    | 300 x 300   |
| 5.b     | 600 x 700   | BC 10   | 400 x 500   |
| 7       | 1000 x 1000 | 12.d.a  | 300 x 300   |
| 8.a     | 400 x 500   | 12.d    | 300 x 300   |
| BC 5    | 1000 x 1000 | 13.a    | 800 x 800   |
| 8.b     | 400 x 500   | 13.b    | 1100 x 1200 |
| 9.b     | 1100 x 1100 | 14.a    | 800 x 800   |
| 9.a     | 600 x 700   | 14.b    | 1100 x 1200 |
| 10.a.a  | 300 x 300   | BC 11   | 1200 x 1200 |
| BC 6    | 600 x 700   | 15.b    | 500 x 500   |
| 10.a.b  | 300 x 300   | BC 12   | 500 x 500   |
| 10.a    | 700 x 700   | 15.a    | 1200 x 1200 |

The eco drainage modeling is carried out by adding long storage to the downstream of the planned drainage system combined with the sea wall. The following are the results of modeling on eco drainage:

![Eco drainage modeling results](image)

Figure 1. Eco drainage modeling results

Gate opening scenarios and their effect on decreasing water level on the channel. Modeling carried out with 7 openings scenarios.

- Two Gate Opened 20 cm, in this scenario modeling results show that there is still overflow around the overflow channel which occurs as high as 14 cm. From the results of this modeling, the reduction results obtained by 13.7%.
• Two Gate Opened 30 cm, in this scenario modeling results show that there has been no overflow occurs around the channel. From the results of this modeling, the reduction results obtained by 30.4%.
• Two Gate Opened 50 cm, in this scenario modeling results show that there has been no overflow occurs around the channel. From the results of this modeling, the reduction results obtained by 60.2%
• One Gate Opened 20 cm, Another Gate Closed, in modeling this scenario, there is still an overflow occurs around the overflow channel which occurs as high as 26 cm. From the results of this modeling, the reduction in water level obtained by 6.2%.
• One Gate Opened 30 cm, Another Gate Closed, in modeling this scenario, there is still an overflow occurs around the overflow channel which occurs as high as 20 cm. From the results of this modeling the results of the reduction in water level obtained by 9.9%.
• One Gate Opened 50 cm, Another Gate Closed, in modeling this scenario, there is still an overflow occurs around the overflow channel which occurs as high as 7 cm. From the results of this modeling the results of the reduction in water level obtained by 18%.
• One Door Gate 70 cm, Another Gate Closed, In modeling this scenario is found that there is no overflow occurs around the channel. From the results of this modeling the results of the reduction in water level obtained by 41.6%.

The results of gate opening scenarios can be informs at graphics below

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**Figure 2.** Reduction of discharge based on scenario
Figure 3. Comparison of water surface

- = Scenario 1  = Scenario 4  = Scenario 7
- = Scenario 2  = Scenario 5
- = Scenario 3  = Scenario 6

4. Results and Conclusion

Based on the results of planning data analysis and modeling results in the HEC-RAS 4.0, it can be concluded that:

- From the results of the calculation of the plan flood discharge obtained for the downstream discharge of the drainage system is 1.046 m³/second.
- In conventional drainage when sea tides occur, the results of the modeling show that water overflows on the channel that will occur are at an elevation of +2.48 m.
- After adding long storage with dimensions of 1.2 m x 3.5 m along 101.6 m and sea walls as high as + 2.48 m. The results of the modeling show that the inundation height that will occur is at an elevation of +0.61 m. With an overflow height of 36 cm. So that the construction of longitudinal reservoirs in the drainage system will reduce the inundation height by 1.87 m
- From several scenarios carried out for the most optimal two-door openings by opening 30 cm which later the water will be at an elevation of +0.12 m. Whereas the most optimal one-door openings are opened by 70 cm which later the water will be at an elevation of +0.06 m.

References

[1] Idfi G 2017 Perbandingan Model Aliran Banjir Unsteady Flow dan Steady Flow pada Sungai Ngotok Ring Kanal. Jurnal Bangunan, 22(2), 31-40.
[2] Istiarto 2014 HEC-RAS Steady or Unsteady Flow Analysis (istiarto.staff.ugm.ac.id)
[3] Anggrahini 1997 Hidrolika Saluran Terbuka (CV. Citra Media, Surabaya)
[4] Chow V T 1992 Open Channel Flow., (Erlangga, Jakarta)
[5] Harto S Br 1993 Analysis of Hydrology. (PT Gramedia Utama, Jakarta)
[6] Lensley, Ray K, Franzini and Joseph B. 1991 Teknik Sumber Daya Air Jilid II, (CV. Citra Media, Surabaya)
[7] Soemarto C D 1987 Hydrology Engineering, (Erlangga, Jakarta.)
[8] Suhartanto E 2008 The Manual Book of HEC-HMS and Application at Water Resource Management, (CV Citra, Malang)
[9] Triatmojo B 2008 Hidrologi Terapan (Beta Offset, Yogyakarta)