Study flood routing Mamak Dam and evaluate the River Mamak to convey the flood design, Lombok, Indonesia

I W Sutapa
Faculty of Engineering, University of Tadulako, Palu, Central Sulawesi, Indonesia.
JL. Sukarno – Hatta Km. 8 Palu, Central Sulawesi, Indonesia
Email: wsutapa@yahoo.com

Abstract. The purpose of this study was to determine the effectiveness of the Mamak Dam in controlling the volume of flooding and the capacity of the Mamak River to deliver the design flood. The investigation was carried out with a survey at the study site and collected secondary data. The methodology carried out was in the form of routing floods through reservoir by routing floods through the level pool routing. The profile of the Mamak River uses unsteady flow with the of HECRAS 4.1 software. The conclusions from this study are: 1). Mamak Dam can extend the peak flood time from 5 to 6 hours to 10 to 12 hours; reducing the flood of Mamak Dam between 107.51 m$^3$/s to 232.96 m$^3$/s or equivalent to 60.44% to 41.75% according to the return period of the flood discharge. 2). The flood discharge that comes from the overflow of the Mamak Dam is not able to be fully flowed by the Mamak River resulting in flooding, both annual flooding and for 25 years return period. 3). To overcome this flood, the flood dikes planned to vary in height from 0.81 m to 3.2 m.

1. Introduction
Flooding is one of the most dangerous natural disasters, especially Flash floods. This has attracted attention both in the academic world and in the wider world because of its dangerous nature and potential which results in economic damage and loss of life [1].

Flood routing is a way to determine the time and flow rate (flow hydrograph) at a point in the flow based on the hydrograph that is known to be upstream [2]. The routing for floods through a reservoir is intended to analyze the reservoir retention factor if it is flooded with certain event opportunities. The flood analysis was carried out because the flood hydrograph before abundant spillway flowed through the dam reservoir, thus the peak of the flood would be reduced by the function of the reservoir.

In the Mamak River, there is the Mamak Dam which functions as flood control, Micro Hydro Power Plant, Irrigation, fisheries and tourist attractions. The Mamak River has a significant flood potential (damaged power), the affected areas are in Lape and Lopok Subdistricts, flooding is as high as ±1 m and soaking the Sumbawa - Bima axis road. The cliffs in the river channel have erosion due to flooding and endanger the houses and roads which are access to the local village and vice versa. Even though there was a cliff reinforcement built by the Department of Settlement and Regional Infrastructure of West Nusa Tenggara Province in 2011 to secure the Sumbawa-Bima Axis Road but it had not functioned optimally because it was still often flooded.
2. Materials and Method

2.1. Research location
Administratively the research location is in Lape District and Lopok Sub-District, Sumbawa Regency, West Nusa Tenggara Province (NTB), Indonesia. According to the river basin, the research location is in the Sumbawa River Region (WS 03.03.A3), precisely located in: the Moyo River Basin (watershed number 46).

![Figure 1. Research location](image)

2.2. Supporting data
The data needed in this study are primary and secondary data. Primary data was obtained by direct survey to the location of the study to determine the condition of the Mamak River, flood-prone areas, land cover and socio-economic conditions of the communities around the study site. While secondary data is obtained from the Nusa Tenggara I River Regional Office in year 2017 [3]. Secondary data needed in this study were: flood discharge design of the Mamak River, longitudinal and cross section of the Mamak River, equation of runoff discharge in the overflow of the Mamak Dam, and Arch of Mamak Reservoir Capacity.

2.3. Study literature
2.3.1. Equation of flood routing. The flood routing in this study uses the level pool routing method with the equation [4]:

\[ 1 - Q = \frac{dS}{dt} \]  \hspace{1cm} \text{(1)}

2.3.2. Flood routing through reservoir. Outflow from spillway overflow is calculated based on the rating curve flowing above the crest dam. The calculation of the outflow hydrograph of the water reservoir is determined by the following equation [5-7]:

\[ S_{j+1} - S_j = \frac{I_j + I_{j+1}}{2} \Delta t - \frac{Q_j + Q_{j+1}}{2} \Delta t \]  \hspace{1cm} \text{(2)}

2.3.3. Hydraulic HEC-RAS 4.1 model. Analysis of water level profiles with unstable conditions uses the help of the HEC RAS (River Analysis System from the US Army Corps of Engineers) package version 4.1, January 2010, with a hydrodynamic model. This model can solve energy equations and water flow momentum equations [8-10]:

Energy equation:

\[ Y_2 + Z_2 + \frac{a_2}{2g} V_2^2 = Y_1 + Z_1 + \frac{a_1}{2g} V_1^2 + h_e \]  \hspace{1cm} \text{(3)}
The application of Newton’s second law for the movement of water between two cross sections can use the momentum change formula in units of time, can be written:

\[ P_2 - P_1 + W_x - F_f = Q \cdot \rho \cdot \Delta V_x \]  

(4)

2.4. Methodology

To complete this study several analyses carried out include:

1. Calculating the function of deposits versus the Mamak Reservoir outflow

   The data needed are in the form of an overflow discharge equation for the Mamak Dam and the arch capacity of the Mamak Reservoir.

   Equation of overflow discharge of Mamak Dam:

   \[ Q = C_d \times B \times H^{3/2} \]  

   (5)

   Where: \( C_d \) = discharge coeff. = 2.1; \( B \) = overflow width = 36 m; \( H \) = height of water over spill, m

2. Flood routing of the Mamak Reservoir

   The data needed is in the form of the calculation of the function of deposits versus outflows and the inflow of flood discharge designed by the Mamak River. Whereas the results of this flood routing are in the form of outflows or discharge coming out of the overflow of the Mamak Reservoir. This discharge is used for hydraulic analysis on the Mamak River.

3. Analysis of the Mamak River hydraulics

   Hydraulic analysis of the Mamak River using the help of HEC-RAS 4.1 software. Data needed are: hydrological data, topographic measurement data (topographic maps, situation maps of the Mamak River, longitudinal and cross profiles of the Mamak River) and river data (data on river channel conditions and riverbanks to estimate flow roughness coefficients).

   In summary, the scope of the mathematical model HEC RAS Version 4.1 are:

   a. Schematization of existing network systems
   b. Selection of boundary condition and initial condition
   c. Running model designs with various alternatives
   d. Evaluation of running results
   e. Recommendations for the water system are based on the selection of alternative design models

3. Results and Discussion

3.1. Function of deposits versus outflow of Mamak reservoir

| Water Level (m) | Yj | Storage (m³) | Discharge (m³/s) | Xj (m³/s) | (2S / Δt)+Q |
|----------------|----|-------------|-----------------|----------|-------------|
| 0.00           | 0.00 | 0.00       | 0.00            | 0.00     |
| 0.10           | 2.39 | 301000.00  | 169.61          | 341.21   |
| 0.20           | 6.76 | 602000.00  | 514.09          | 1034.87  |
| 0.30           | 12.42| 903000.00  | 1204000.00      | 1214.83  |
| 0.40           | 19.13| 1204000.00 | 688.01          | 1214.83  |
| 0.50           | 26.73| 1505000.00 | 862.84          | 1391.87  |
| 0.60           | 35.14| 1806000.00 | 1038.47         | 1569.55  |
| 0.70           | 44.28| 2107000.00 | 1214.83         | 1747.82  |
| 0.80           | 54.09| 2408000.00 | 1391.87         |          |
| 0.90           | 64.55| 2709000.00 | 1569.55         |          |
| 1.00           | 75.60| 3010000.00 | 1747.82         |          |
| Water Level (m) | Yj Discharge (m³/s) | Storage (m³) | Xj (m³/s) |
|----------------|---------------------|-------------|-----------|
| 1.10           | 87.22               | 3311000.00  | 1926.66   |
| 1.20           | 99.38               | 3612000.00  | 2106.05   |
| 1.30           | 112.06              | 3913000.00  | 2285.95   |
| 1.40           | 125.23              | 4214000.00  | 2466.34   |
| 1.50           | 138.89              | 4515000.00  | 2647.22   |
| 1.60           | 153.00              | 4816000.00  | 2828.56   |
| 1.70           | 167.57              | 5117000.00  | 3010.35   |
| 1.80           | 182.57              | 5418000.00  | 3192.57   |
| 1.90           | 197.99              | 5693000.00  | 3360.77   |
| 2.00           | 213.83              | 5968000.00  | 3529.38   |
| 2.10           | 230.07              | 6243000.00  | 3698.40   |
| 2.20           | 246.69              | 6518000.00  | 3867.80   |
| 2.30           | 263.70              | 6793000.00  | 4037.59   |
| 2.40           | 281.09              | 7068000.00  | 4207.75   |
| 2.50           | 298.84              | 7343000.00  | 4378.28   |
| 2.60           | 316.94              | 7618000.00  | 4549.17   |
| 2.70           | 335.40              | 7893000.00  | 4720.40   |
| 2.80           | 354.21              | 8168000.00  | 4891.99   |
| 2.90           | 373.35              | 8443000.00  | 5063.91   |
| 3.00           | 392.83              | 8718000.00  | 5236.16   |

Water levels are taken on top of a spillway, where the elevation of the overflow crest is +60.00 m. In column (2) is the outflow discharge over the Mamak Dam overflow crest which is calculated using equation (5). Column (3) is the volume of storage in the elevation above the overflow of the Mamak Dam obtained from the arch data of the reservoir capacity of the Mamak Dam. Column (4) is obtained from the equation \((2S/\Delta t) + Q\), where \(\Delta t\) = interval of 1 hour (3600 seconds); \(S\) is storage (column 3) and \(Q\) is the discharge from column (2).

3.2. Flood routing of the Mamak reservoir

| Time Index (hour) | Time (hour) | Inflow (I) (m³/s) | (I₁ + I₁⁺) (m³/s) | (2S₁ / \(\Delta t\)) - Q₁ | (2S₁⁺ / \(\Delta t\)) + Q₁⁺ Outflow (m³/s) |
|------------------|-------------|-------------------|-------------------|---------------------------|---------------------------------------------|
| 0                | 0           | 0.00              | 0.00              | 0.00                      | 0.00                                        |
| 1                | 1           | 4.63              | 4.63              | 4.55                      | 4.63                                        | 0.08                                        |
| 2                | 2           | 30.26             | 34.90             | 38.80                     | 39.45                                       | 0.65                                        |
| 3                | 3           | 99.92             | 130.19            | 166.22                    | 168.99                                      | 2.77                                        |
| 4                | 4           | 161.14            | 261.06            | 414.93                    | 427.27                                      | 12.34                                       |
| 5                | 5           | **177.87**        | 339.01            | 729.63                    | 753.94                                      | 24.31                                       |
| 6                | 6           | 150.19            | 328.06            | 1017.43                   | 1057.69                                     | 40.26                                       |
| 7                | 7           | 117.65            | 267.83            | 1232.69                   | 1285.27                                     | 52.58                                       |

Water levels are taken on top of a spillway, where the elevation of the overflow crest is +60.00 m. In column (2) is the outflow discharge over the Mamak Dam overflow crest which is calculated using equation (5). Column (3) is the volume of storage in the elevation above the overflow of the Mamak Dam obtained from the arch data of the reservoir capacity of the Mamak Dam. Column (4) is obtained from the equation \((2S/\Delta t) + Q\), where \(\Delta t\) = interval of 1 hour (3600 seconds); \(S\) is storage (column 3) and \(Q\) is the discharge from column (2).

Table 2. Results of calculation of flood routing for Mamak reservoir year Q₁₀₁
| Time Index | Time (hour) | Inflow (I) (m$^3$/s) | (I$_j$ + I$_j+1$) (m$^3$/s) | (2S$_j$ / Δt) - Q$_j$ (m$^3$/s) | (2S$_{j+1}$ / Δt) + Q$_{j+1}$ (m$^3$/s) | Outflow (m$^3$/s) |
|------------|-------------|-----------------------|-----------------------------|--------------------------------|-------------------------------------|-----------------|
| 8          | 8           | 87.72                 | 205.37                      | 1377.82                        | 1438.05                             | 60.23           |
| 9          | 9           | 66.58                 | 154.30                      | 1466.88                        | 1532.12                             | 65.24           |
| 10         | 10          | 52.00                 | 118.58                      | 1516.95                        | 1585.46                             | 68.51           |
| 11         | 11          | 41.09                 | 93.09                       | 1539.82                        | 1610.04                             | 70.22           |
| 12         | 12          | 32.72                 | 73.81                       | 1543.27                        | 1613.63                             | 70.36           |
| 13         | 13          | 26.36                 | 59.08                       | 1533.01                        | 1602.35                             | 69.34           |
| 14         | 14          | 21.64                 | 48.00                       | 1513.14                        | 1581.01                             | 67.87           |
| 15         | 15          | 18.06                 | 39.70                       | 1486.75                        | 1552.84                             | 66.09           |
| 16         | 16          | 15.15                 | 33.21                       | 1455.84                        | 1519.95                             | 64.11           |
| 17         | 17          | 12.76                 | 27.91                       | 1421.73                        | 1483.76                             | 62.03           |
| 18         | 18          | 10.75                 | 23.51                       | 1385.43                        | 1445.24                             | 59.81           |
| 19         | 19          | 9.06                  | 19.81                       | 1347.75                        | 1405.24                             | 57.49           |
| 20         | 20          | 7.63                  | 16.69                       | 1309.32                        | 1364.44                             | 55.12           |
| 21         | 21          | 6.43                  | 14.06                       | 1271.36                        | 1323.37                             | 52.01           |
| 22         | 22          | 5.41                  | 11.84                       | 1234.08                        | 1283.20                             | 49.12           |
| 23         | 23          | 4.56                  | 9.97                        | 1197.66                        | 1244.06                             | 46.4            |
| 24         | 24          |                      |                             | 1153.80                        | 1197.66                             | 43.86           |
| 25         | 25          |                      |                             | 1112.21                        | 1153.80                             | 41.59           |
| 26         | 26          |                      |                             | 1072.78                        | 1112.21                             | 39.43           |
| 27         | 27          |                      |                             | 1035.39                        | 1072.78                             | 37.39           |
| 28         | 28          |                      |                             | 999.94                         | 1035.39                             | 35.45           |

Inflow ($I$) in column (3) is the flood $Q_{1.01}$ year flood discharge data. Column (4) is inflow plus the next inflow in the flood hydrograph. Column (6) is column (4) plus column (5). Column (7) is $Q$ outflow obtained from the calculation of the savings versus outflow function in Table 1. The value obtained from column (6) is plotting in column (4) from the calculation of the function of the savings versus outflow then interpolated in column (2) so that column outflow is obtained (7). Column (5) is column (6) minus column (7).
In Figure 2 shows that the inflow discharge that enters the Mamak Dam is 177,871 m$^3$/s (the result of the calculation of the flood discharge design of Q$_{1.01}$ year return period) is reduced to 70.36 m$^3$/s (outflow in the overflow of the Mamak Dam). The results of the calculation of the Mamak Dam flood routing for other return periods are presented in Table 3. The percentage reduction in flood discharge is presented in Table 4. From Tables 3 and 4 it can be seen that the presence of the Mamak Dam can extend the peak flood time from 5 to 6 hours to 10 up to 12 hours; reducing flooding that exits Mamak Dam between 107.51 m$^3$/s to 232.96 m$^3$/s or equivalent to 60.44% to 41.75% according to the return period of the flood discharge.

**Figure 2.** Relationship between inflow hydrograph and outflow hydrograph (Q$_{1.01}$)

**Table 3.** The results of the recapitulation of the flood routing of the Mamak reservoir

| Time (hour) | Design Flood Q$_{1.01}$ Inflow | Design Flood Q$_{2}$ Inflow | Design Flood Q$_{5}$ Inflow | Design Flood Q$_{10}$ Inflow | Design Flood Q$_{25}$ Inflow | Design Flood Q$_{50}$ Inflow |
|------------|--------------------------------|----------------------------|-----------------------------|----------------------------|----------------------------|----------------------------|
| 0          | 0.00                           | 0.00                       | 0.00                        | 0.00                       | 0.00                       | 0.00                       |
| 1          | 4.63                           | 0.88                       | 7.82                        | 0.14                       | 9.89                       | 0.18                       |
| 2          | 30.26                          | 0.65                       | 51.06                       | 1.09                       | 64.59                      | 1.39                       |
| 3          | 99.92                          | 2.77                       | 168.60                      | 5.99                       | 213.27                     | 8.47                       |
| 4          | 161.14                         | 12.34                      | 271.88                      | 23.43                      | 343.92                     | 33.04                      |
| 5          | 177.87                         | 24.31                      | 300.12                      | 53.12                      | 379.64                     | 74.76                      |
| 6          | 150.19                         | 40.26                      | 253.41                      | 85.68                      | 320.55                     | 120.04                     |
| 7          | 117.65                         | 52.58                      | 198.50                      | 110.83                     | 251.09                     | 154.41                     |
| 8          | 87.72                          | 60.23                      | 148.01                      | 125.39                     | 187.22                     | 170.74                     |
| 9          | 66.58                          | 65.24                      | 112.34                      | 134.45                     | 142.10                     | 185.49                     |
| 10         | 52.00                          | 68.51                      | 87.74                       | 139.27                     | 251.09                     | 154.41                     |
| 11         | 41.09                          | 70.22                      | 69.33                       | 141.05                     | 87.70                      | 192.71                     |
| 12         | 32.72                          | 70.36                      | 55.20                       | 139.59                     | 69.83                      | 189.22                     |
| 13         | 26.36                          | 69.34                      | 44.48                       | 135.80                     | 56.27                      | 180.19                     |
| 14         | 21.64                          | 67.87                      | 36.51                       | 131.46                     | 46.18                      | 175.52                     |
| 15         | 18.06                          | 66.09                      | 30.47                       | 126.51                     | 38.54                      | 170.32                     |
| 16         | 15.15                          | 64.11                      | 25.56                       | 121.39                     | 32.34                      | 160.15                     |

**Table 4.** The percentage reduction in flood discharge of Mamak Dam

| Time (hour) | Design Flood $Q_{1.01}$ | Design Flood $Q_{2}$ | Design Flood $Q_{5}$ | Design Flood $Q_{10}$ | Design Flood $Q_{25}$ | Design Flood $Q_{50}$ |
|------------|--------------------------|----------------------|----------------------|------------------------|-----------------------|------------------------|
| 0          | 0.00%                    | 0.00%                | 0.00%                | 0.00%                  | 0.00%                 | 0.00%                  |
| 1          | 64.54%                   | 56.27%               | 46.18%               | 36.51%                 | 26.36%                | 18.06%                 |
| 2          | 52.19%                   | 44.48%               | 36.51%               | 26.36%                 | 18.06%                | 15.15%                 |
| 3          | 40.84%                   | 36.51%               | 25.56%               | 18.06%                 | 15.15%                | 12.85%                 |
| 4          | 30.50%                   | 25.56%               | 15.15%               | 12.85%                 | 10.24%                | 8.27%                  |
| 5          | 21.16%                   | 15.15%               | 8.27%                | 6.78%                  | 5.23%                 | 4.01%                  |
| 6          | 13.83%                   | 8.27%                | 4.01%                | 3.01%                  | 2.31%                 | 1.83%                  |
| 7          | 9.22%                    | 4.01%                | 1.83%                | 1.41%                  | 1.13%                 | 0.92%                  |
| 8          | 6.41%                    | 1.83%                | 0.92%                | 0.71%                  | 0.56%                 | 0.46%                  |
| 9          | 4.61%                    | 0.92%                | 0.46%                | 0.37%                  | 0.29%                 | 0.24%                  |
| 10         | 3.46%                    | 0.46%                | 0.24%                | 0.20%                  | 0.16%                 | 0.13%                  |
| 11         | 2.54%                    | 0.24%                | 0.13%                | 0.11%                  | 0.09%                 | 0.08%                  |
| 12         | 1.91%                    | 0.13%                | 0.08%                | 0.07%                  | 0.06%                 | 0.05%                  |
| 13         | 1.50%                    | 0.08%                | 0.05%                | 0.04%                  | 0.04%                 | 0.03%                  |
| 14         | 1.20%                    | 0.05%                | 0.03%                | 0.02%                  | 0.02%                 | 0.02%                  |
| 15         | 1.00%                    | 0.03%                | 0.02%                | 0.02%                  | 0.02%                 | 0.02%                  |
| 16         | 0.83%                    | 0.02%                | 0.02%                | 0.02%                  | 0.02%                 | 0.02%                  |
| Time (hour) | Design Flood Q₁₀₀ | Design Flood Q₅₀ | Design Flood Q₂₅ | Design Flood Q₁₀ | Design Flood Q₅ | Design Flood Q₂ |
|------------|-------------------|------------------|------------------|-----------------|----------------|----------------|
|            | Inflow | Outflow | Inflow | Outflow | Inflow | Outflow | Inflow | Outflow | Inflow | Outflow | Inflow | Outflow |
| 17         | 12.76  | 62.03   | 21.53  | 114.45  | 27.24  | 150.08  | 36.96  | 173.38  | 36.17  | 204.80  | 40.04  | 229.32  |
| 18         | 10.75  | 59.81   | 18.14  | 107.87  | 22.95  | 140.59  | 31.13  | 162.03  | 30.47  | 189.28  | 33.73  | 211.32  |
| 19         | 9.06   | 57.49   | 15.28  | 101.59  | 19.33  | 131.71  | 26.22  | 151.15  | 25.67  | 175.60  | 28.41  | 194.81  |
| 20         | 7.63   | 55.12   | 12.87  | 95.68   | 16.28  | 123.34  | 22.09  | 141.16  | 21.62  | 163.44  | 23.93  | 179.94  |
| 21         | 6.43   | 52.01   | 10.84  | 89.20   | 13.72  | 114.33  | 18.61  | 130.51  | 18.21  | 150.42  | 20.16  | 165.19  |
| 22         | 5.41   | 49.12   | 9.13   | 83.32   | 11.55  | 106.20  | 15.68  | 120.73  | 15.34  | 138.72  | 16.98  | 151.98  |
| 23         | 4.56   | 46.40   | 7.69   | 77.91   | 9.73   | 98.63   | 13.21  | 111.92  | 12.92  | 128.26  | 14.31  | 140.16  |
| 24         | 43.86  | 72.97   | 92.05  | 104.03  | 104.03 | 118.78  | 118.78 | 129.54  |        |        |        |        |
| 25         | 41.59  | 68.45   | 85.87  | 96.80   | 96.80  | 110.17  | 110.17 | 119.94  |        |        |        |        |
| 26         | 39.43  | 64.22   | 80.29  | 90.24   | 90.24  | 102.41  | 102.41 | 111.21  |        |        |        |        |
| 27         | 37.39  | 60.44   | 75.10  | 84.25   | 84.25  | 95.35   | 95.35  | 103.37  |        |        |        |        |
| 28         | 35.45  | 56.88   | 70.38  | 78.78   | 78.78  | 88.89   | 88.89  | 96.21   |        |        |        |        |

Table 4. Percentage of difference in inflow and outflow of Mamak reservoir

| Discharge (m³/s) | Inflow | Outflow | Difference | Percentage (%) |
|------------------|--------|---------|------------|----------------|
| 177.87           | 70.36  | 107.51  |            | 60.44%         |
| 300.12           | 141.05 | 159.07  |            | 53.00%         |
| 379.64           | 192.71 | 186.93  |            | 49.24%         |
| 433.86           | 231.02 | 202.84  |            | 46.75%         |
| 504.09           | 283.43 | 220.66  |            | 43.77%         |
| 557.96           | 325.00 | 232.96  |            | 41.75%         |

3.3. River hydraulics

Hydraulics analysis of the Mamak River in the lower reaches of the Mamak Dam using HEC-RAS 4.1 software. The results are presented in the following figure and table.

Figure 3. Profile of the water level of the Mamak River discharge Q₁₀₀ year
Table 5. Location distribution of the Mamak River flood $Q_{1.01}$ year

| No | Cross profile | Benchmark | Location     |
|----|---------------|-----------|--------------|
| 1. |               | S.8       | Leweng Village |

Also, in the location of point S.99 (Berora Village), S.111 (Muhajirin Village), S.139 (Langgam Village) and S.146 (Kebuyet Village) is occurred flooding. Therefore, it can be seen that, for annual floods that occur on the Mamak River, it is not able to be accommodated by the river body resulting in flooding. This is in accordance with the results of a field survey where the floods did occur every year.

Table 6. Location distribution of the Mamak River flood $Q_{25}$ years

| No | Cross profile | Benchmark | Location     |
|----|---------------|-----------|--------------|
| 1. |               | M15 – M19, M24 | Tabose Village |

Also, in the location of point M.15 (Tabose Village, S.13 (Leweng Village), S.44 (Mamak Village), S.59 (Mekasari Village), S.73 (Sekayu Village), S.80 (Serange Village), S.100 (Berora Village), S.101 (Muhajirin Village), S.140 (Langgam Village), S.146 (Kebuyet Village), and S.189 (Lapok Village) is occurred flooding. Therefore, it can be seen that for the $Q_{25}$ flood discharge year the location of the flood is more widespread and inundates several other villages.

To overcome the danger of flooding, a simulation model was made on HEC-RAS with a flood embankment at the $Q_{25}$ year flood discharge. The results are presented in Table 7. From Table 7, it can be seen that the variation of dikes planned is between 0.81 m to 3.2 m according to the location of the flood event.
Table 7. Cross profile of the Mamak River condition of embankments, discharge Q_{25} years

| No | Cross profile | Benchmark | Location |
|----|---------------|-----------|----------|
| 1. | [Diagram Image] | S189 | Lopok Village |

4. Conclusions
Some conclusions that can be taken from this study include: 1). Mamak Dam can extend the peak flood time from 5 to 6 hours to 10 to 12 hours; reducing flooding that exits Mamak Dam between 107.51 m³/s to 232.96 m³/s or equivalent to 60.44% to 41.75% according to the return period of the flood discharge. 2). The flood discharge from the overflow of the Mamak Dam is unable to be accommodated by the body of the Mamak River resulting in flooding, both annual flooding and for 25 years return period. 3). To overcome this flood, the flood dikes planned to vary in height from 0.81 m to 3.2 m.

Acknowledgements
The author would like to thank the Director of Dinamika Rancang Semesta Engineering Consultant for the work of the Survey of Mamak Investigation River Flood Control Design in Sumbawa Regency. Office of the River Basin of Nusa Tenggara I, Lombok, West Nusa Tenggara so that it can be used as material for writing this article.

References
[1]. Saharia M, Kirstette E P, and Vergara H 2017 *Journal of Hydrology* **548** 524-535.
[2]. Triatmodjo B 2009 *Applied Hydrology* (Yogyakarta: Beta Offset).
[3]. Dinamika Rancang Semesta Engineering Consultant 2016 *Investigation Survey of Mamak River Flood Control Design in Sumbawa Regency* (Lombok: Office of the River Basin of Nusa Tenggara I, Lombok, West Nusa Tenggara).
[4]. Soemarto CD 1987 *Engineering Hydrology* (Surabaya: Usaha Nasional)
[5]. Nugroho H 2011 *Hydrology Application* (Malang: Jogja Mediatama)
[6]. Edy Sriyono 2013 *Journal Engineering* **3** 84-91.
[7]. Tithan R, Masimin, Eldina F 2018 *Civil Eng. J. Syiah Kuala University* **1** 1027-1048.
[8]. Istiarto 2015 *HEC-GeoRAS*. [http://istiarto.staff.ugm.ac.id](http://istiarto.staff.ugm.ac.id). Retrieved 17 June 2019.
[9]. Restu W, Soedarsono, Tia M 2016 *Foundation Journal* **5** 51-61.
[10]. Rian M S P, C Maitri, P C Nugroho, Ade H 2017 *Civil Engineering Communication Media* **23** 91-101.