50-YEAR FLOOD LINES FOR THE TWO STREAMS PASSING THROUGH PORTION 6 OF THE FARM, NUWERUS 450, DISTRICT WORCESTER

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Introduction and Commission:

African Environmental Development (AED) was commissioned by Borland Enviro CC to develop the 50-year flood lines of the two small streams traversing Portion 6 of the farm Nuwerus 450 (this area hereafter referred to as the "study area"). As neither of these streams have official names, we simply named them Stream 1 and Stream 2 for the purposes of this document – Refer Figure 1.

Stream 1 rises immediately to the south of the study area, while Stream 2 rises within the study area as shown in Figure 1.

Figure 1: The catchments of the two streams at the study area.

Both streams eventually flow into the Toontjies River, flowing generally from east to west (out of picture to the north of Figure 1). The Toontjies River flows into the Nuy River, which in turn, is a tributary of the Breede River. The confluence of the Nuy with
the Breede occurs at the point where it leaves quaternary catchment H40C. After its confluence with the Nuy River, the 337 Km long Breede River continues in a generally east-southeasterly direction up to its mount into the Indian Ocean at Cape Infanta.

As stated above, the study area falls in quaternary catchment H40C. This catchment has a relatively low mean annual precipitation or rainfall (MAP) of 374.92 mm (Midgley et. al. 1994) (Middleton & Bailey, 2005).

Methodology:

The first part of the process comprises the modelling of a “design storm” with a statistical return period of 50-years, falling over each of the two catchments at the study area.

Due to the small size of both catchments (1.403 and 0.366 Km² respectively for Streams 1 and 2, i.e. smaller than ±18 Km² - refer Figure 1), the design storms are derived using a deterministic approach, as opposed to the purely statistical methods used for larger catchment areas. This is done as a result of the difficulty of extrapolating the frequency analyses of peak discharges and experience envelope diagrams for small areas, as the range of enveloped values becomes extremely wide as the catchment area decreases. Another reason is the problem of attempting to assign recurrence intervals to these experience envelopes. Hence, for these small catchments, the conventional procedure is to employ the original Rational Method, an Empirical Method and the Amended Rational Method, as researched, designed and published in Reports No. 1/72, 'Design Flood Determination in South Africa', 1972 and 1/74, ‘A Simple Procedure for Synthesizing Direct Runoff Hydrographs’ 1994, produced by a joint venture between the CSIR and the Hydrological Research Unit (a division of the Department of Civil Engineering at the University of the Witwatersrand).

In the second part of the process, the discharges in m³/s, produced by storms with statistical return periods of 50 years falling over the two catchments, are routed through cross sections across the two streams within the study area, as shown in Figure 2, using Mannings formulas for Open Channel Flow. Mannings roughness coefficients for the streambeds were assessed using satellite photography dated 04 January 2010 (Reference: Google Earth 2010).

At Stream 1, nine cross sections were plotted across representative sections of the stream, one being across the dam wall, while the 10th cross section was plotted across the culvert under the R60 roadway. Similarly at Stream 2, five cross sections were plotted across the lower part of the stream with the 6th cross section across the culvert under the R60 roadway. Due to insufficient data in the upper reaches of the stream, with the result that we were unable to divide the stream into 10 different sections across its width, we used the width of the first cross section and extrapolated this width along the rest upper reaches of this stream.

We used a contour line set provided by the client as part of the revised terms-of-reference to produce the flood lines as shown in Figure 2.
The weighted average discharge produced by storms with statistical return periods of 50 years falling over the two catchments at the study area were 18.44 and 10.64 m³/s for Stream 1 and Stream 2 respectively.

Figure 2: A drawing of part of the study area, showing the cross sections that were used to determine the 50-year flood lines crossing the two streams.

Results:

The elevation containing the maximum discharge, at each cross section along the two streams, was plotted on either side of each of the streams’ centre-lines and transferred, in plan, to the drawing, to demarcate the 50-year flood lines for these streams. The resulting flood lines are supplied as a separate CAD file appended to this report.

Comments:

Coordinate System:
All drawings were done using the following parameters: Metres, Transverse Mercator, Hartbeeshoek’94, and Centre Meridian 19º East.
The program, ArcView/ArcGIS, was used to produce all the drawings in this document. Please note this program swaps the + and – signs of the X and Y coordinates in the drawing when compared to AutoCAD files (i.e. positive north).

**Culverts under the R60 roadway:**
A cross section was produced across each of the two culverts under the R60 to determine the capacity of these culverts in handling the floodwaters produced by a 50-year flood. The dimensions of the culverts were obtained from the drawing; “Sonplaas.dwg”, while photographs of the culverts were obtained from the PDF document, “Sonplaas.pdf”.

In both cases, the culverts would be able to handle the floodwaters, but in the case of Stream 1, the culvert will be swamped (i.e. filled to above its top) and this will cause a small backing up of water upstream from the culvert, reflected in the flood lines. In the case of the culverts at Stream 2, there will not be any backing up of the water.

Our calculations were done assuming there were no obstructions at the entrances of the culverts. It is, however, necessary for only one tree of fence post (or other similar item dislodged by the flood) to turn sideways at the entrance of the culverts and cause an obstruction against which other debris will accumulate, further restricting the flow through the culverts. This would modify the flood lines in the vicinity of the road significantly. We are, however, unable to model such an eventuality. This must, however, be kept in mind and the entrances to the culverts should be kept clean of vegetation or other obstructions/debris at all times.

**Issues relating to the Dam in Stream 1:**
We were requested to model various scenarios at the dam in Stream 1.

This dam, as it is at present, has a wall higher than 5 m and will contain a volume of water of over 96 000 m³ (i.e. >50 000 m³) at full supply level. These two factors places this dam within the requirements of Chapter 12 (Safety of Dams) of the National Water Act of 1998 (Act 36 of 1998). As it stands presently, this dam must be registered in terms of the requirements of the act and will be subject to the inspection and maintenance requirements as specified in this chapter of the act.

Furthermore, the dam at present does not have a proper spillway and in the event of a storm with a return period of 50- or 100-years falling over the catchment, could fail due to overtopping with potentially serious results to the R60 roadway and other downstream users. For this reason we recommend to lower the wall of the dam on its eastern side to an elevation of 322.5 metres above mean sea level (mamsl). This will bring the dam wall down to <5-m in height and the volume at full supply level will be just a bit less than 40 000 m³. If this is done, the dam will fall outside the scope of Chapter 12 of the Act and no registration would be required. It would also be safer as it would have a properly constructed spillway.

Although it is not part of the scope of work for this particular study to provide accurate engineering drawings of the spillway, we nevertheless modified the contour map slightly to enable us to do a cross section across the modified dam wall with the proposed spillway. The dam as it is at present (no spillway) is shown in **Figure 3**, while the dam with the proposed spillway in place is shown in **Figure 4**. In both these figures we also included the 50-year flood lines, also shown in **Figure 2**.
Figure 3: The dam as it is at present without any spillway

Figure 4: The dam in Stream 1 with a spillway with a base elevation of 322.5 mamsl
In Figures 2, 3 and 4, 50-year flood lines with the following colour coding were used:

- **Solid yellow lines and dotted red lines**: 50-year flood lines with the dam as it is at present. The dotted red lines are inferred lines where the contour line survey did not cover the particular area. In Figure 2 the solid yellow lines are actually solid red lines.

- **Green lines**: 50-year flood lines with a proper spillway with a base height of 322.5 mamsl and flood width at this elevation of not less than 17 m, in place in the eastern side of the dam wall.

- **Dark blue lines**: 50-year flood lines assuming that there was no dam at all. Please note that the accuracy of the flood lines is not guaranteed under, and in the immediate vicinity of the dam wall.

**Flood Lines in the Upper Reaches of Stream 2:**
To accurately model flood lines, we are required to construct cross sections which can be divided into at least 5 sub-sections on either side of the stream centre line, based on the elevation. In other words this means that a cross section must cross at least 5 contour lines on either side of the stream centre. In the case of the upper reaches of Stream 2, however, the channel in which the water flows was so shallow that this was not possible using the available contour lines. We therefore inferred these lines basing the width of the lines on the first cross section where it was possible to cross 5 contour lines, i.e. Cross Section 1 at Stream 2. These flood lines are also referred to as “inferred flood lines” and are not as accurate as the actual modelled flood lines further downstream in Stream 2. However, we ensured that where errors were made, these were always made on the side of safety, i.e. if we were not sure of the width between the flood lines, we would rather increase the width between the two flood lines, i.e. err on the side of safety.
50-Year Flood Lines:
Non-perennial streams at Portion 6 of the farm Nuwerus 450

Certification of Methods Used

18/07/2011

TO WHOM IT MAY CONCERN,

This is to certify that the 50-year flood discharge volumes for the stream at Portion 6 of the farm Nuwerus 450 were derived using methods described in the Report No 1/74 “A Simple Procedure for Synthesizing Direct Runoff Hydrographs” of the Hydrological Research Unit, a division of the Department of Civil Engineering of the University of the Witwatersrand.

The 50-year return period storms were synthesized from direct run-off hydrographs developed using methods described in Report No. 1/72 “Design Flood Determination in South Africa” of the same unit.

Both the above reports were developed as a joint venture between the CSIR and the University of the Witwatersrand and are considered to be the only accurate methods for use under rainfall conditions in South Africa.

The flood discharges determined in terms of paragraph 1 were routed through cross-sections plotted across the streams at regular intervals and using Mannings theory for Open Channel Flow. These design floods through these cross sections produced the flood elevations for the 50-year return period storms, as indicated in the accompanying CAD files.

The contour lines used for this project were obtained from the client. It must be borne in mind that the accuracy of the flood lines is directly proportional to the accuracy of these contour lines.

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References:


CAD Drawings:

Please double-click on the above icon to open the zipped folder containing the CAD files in AutoCAD, ArcView, DXF and Google Earth file formats