Chapter

Program Description of the Diffusion Hydrodynamic Model

Theodore V. Hromadka II and Chung-Cheng Yen

Abstract

The numerical algorithm, with a focus on the interface element that is used in the diffusion hydrodynamic model, is presented in this chapter. The source program was written in FORTRAN language, and it can be downloaded from this book companion website. The channel, flood plain, and the interface flow details are discussed.

Keywords: flood plain, overflow, control volume, water elevation, channel interface

1. Introduction

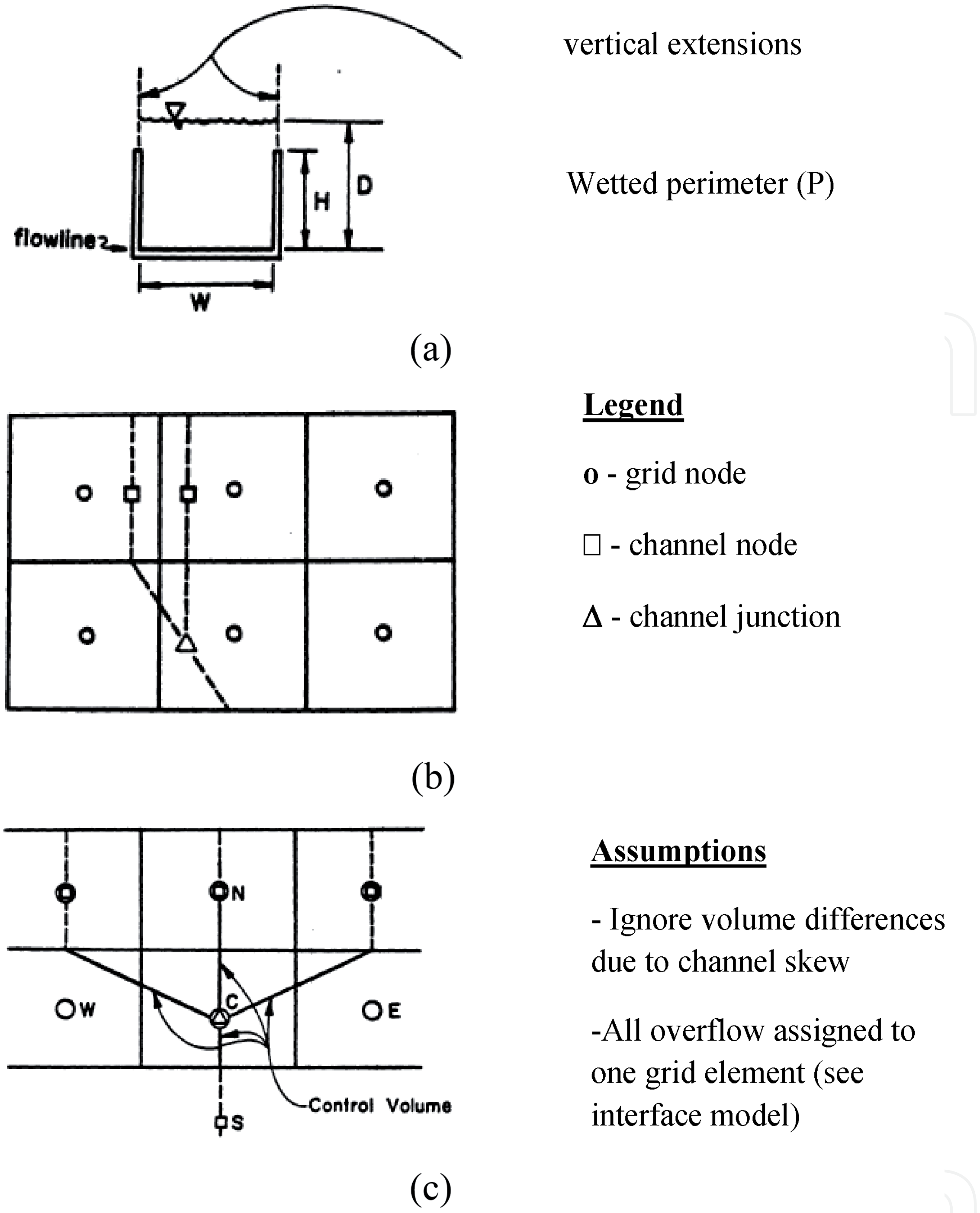
A computer program for the two-dimensional diffusion hydrodynamic model which is based on the diffusion form of the St. Venant equations [1–5] where gravity, friction, and pressure forces are assumed to dominate the flow equation will be discussed in this section.

The DHM consists of a 1-D channel and 2-D flood plain models, and an interface sub-model. The one-dimensional channel element utilizes the following assumptions:

- Infinite vertical extensions on channel walls (**Figure 1**)
- Wetted perimeter is calculated as shown in **Figure 1(a)**
- Volumes due to channel skew are ignored (**Figure 1(b)**)
- All overflow water is assigned to one grid element (**Figure 2**)

The interface model calculates the excess amount of water either from the channel element or from the flood plain element. This excess water is redistributed to the flood plain element or the channel element according to the water surface elevation.

This FORTRAN program has the capabilities to simulate both one-and two-dimensional surface flow problems, such as the one-dimensional open channel flow and two-dimensional dam-break problems illustrated in the preceding pages. Engineering applications of the program will be presented in the next chapter.



Legend

o - grid node

□ - channel node

Δ - channel junction

Assumptions

- Ignore volume differences due to channel skew

-All overflow assigned to one grid element (see interface model)

Figure 1.
One-dimensional channel flow element characteristics: (a) element geometrics, (b) element associations to grid elements, and (c) channel element connections.

2. Interface model

2.1 Introduction

The interface model modifies the water surface elevations of flood plain grids and channel elements at specified time intervals (update intervals). There are three cases of interface situations: (1) channel overflow, (2) grid overflow, and (3) flooding of channel and grid elements.

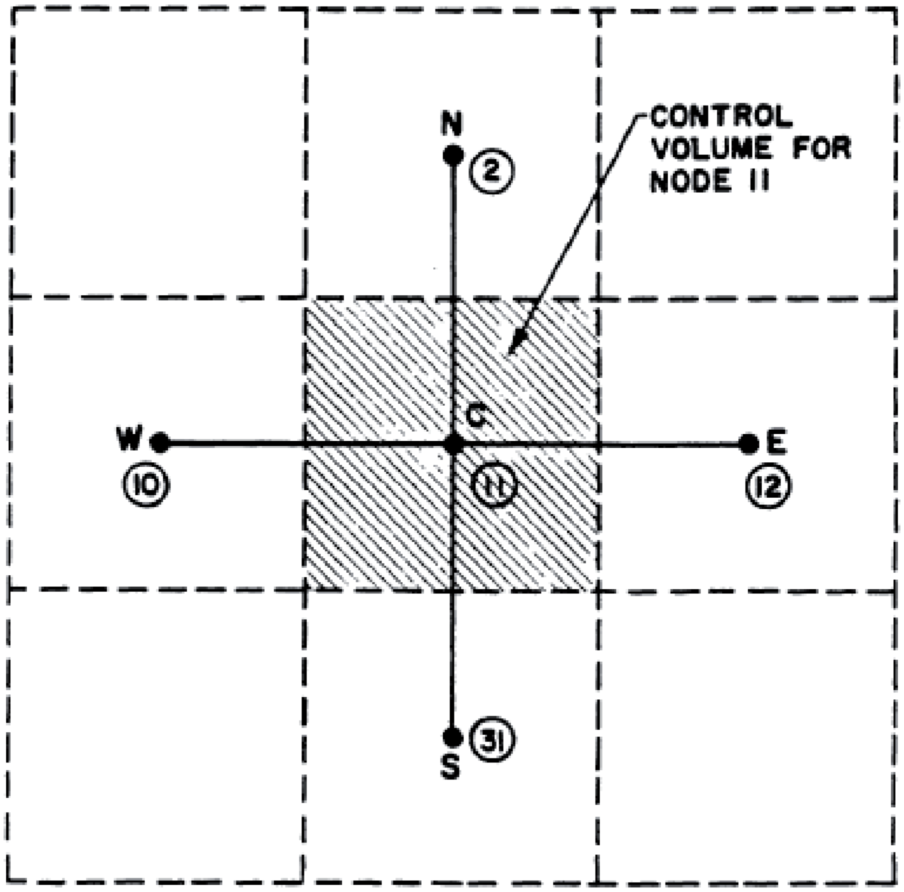


Figure 2.
Grid element nodal molecule.

2.2 Channel overflow

When the channel is overflowing; the excess water is temporarily stored in the vertically extended space (**Figure 3(b)**). Actually, it is the volume per unit length. This excess water is the product of the depth of water, the width of the channel, and the length of the channel and is subsequently uniformly distributed over the grid elements. In other words, the new grid water surface elevation is equal to the old water surface elevation plus a depth of hw/L, and the channel water surface elevation now matches the parent grid water surface elevation.

2.3 Grid overflow

When the water surface elevation of the grid element is greater than a specified surface detention (**Figure 3(a)**), the excess water drains into the channel element, and the new water surface elevation is changed according to the following two conditions (**Figure 3(c)**), (a) if $v > v'$, where v denotes the excess volume of water per unit length and v' denotes the available volume per unit length, the new water surface of the grid element is $A^{NEW} = A^{OLD} - (v - v')/L$, and the new water surface elevation of the channel element is also equal to A^{NEW}, and (b) if $v \leq v'$, the new water surface elevation of the grid element is $A^{NEW} = A^{OLD} - h$ and the new water surface elevation of the channel element is $B^{NEW} = B^{OLD} + v/w$.

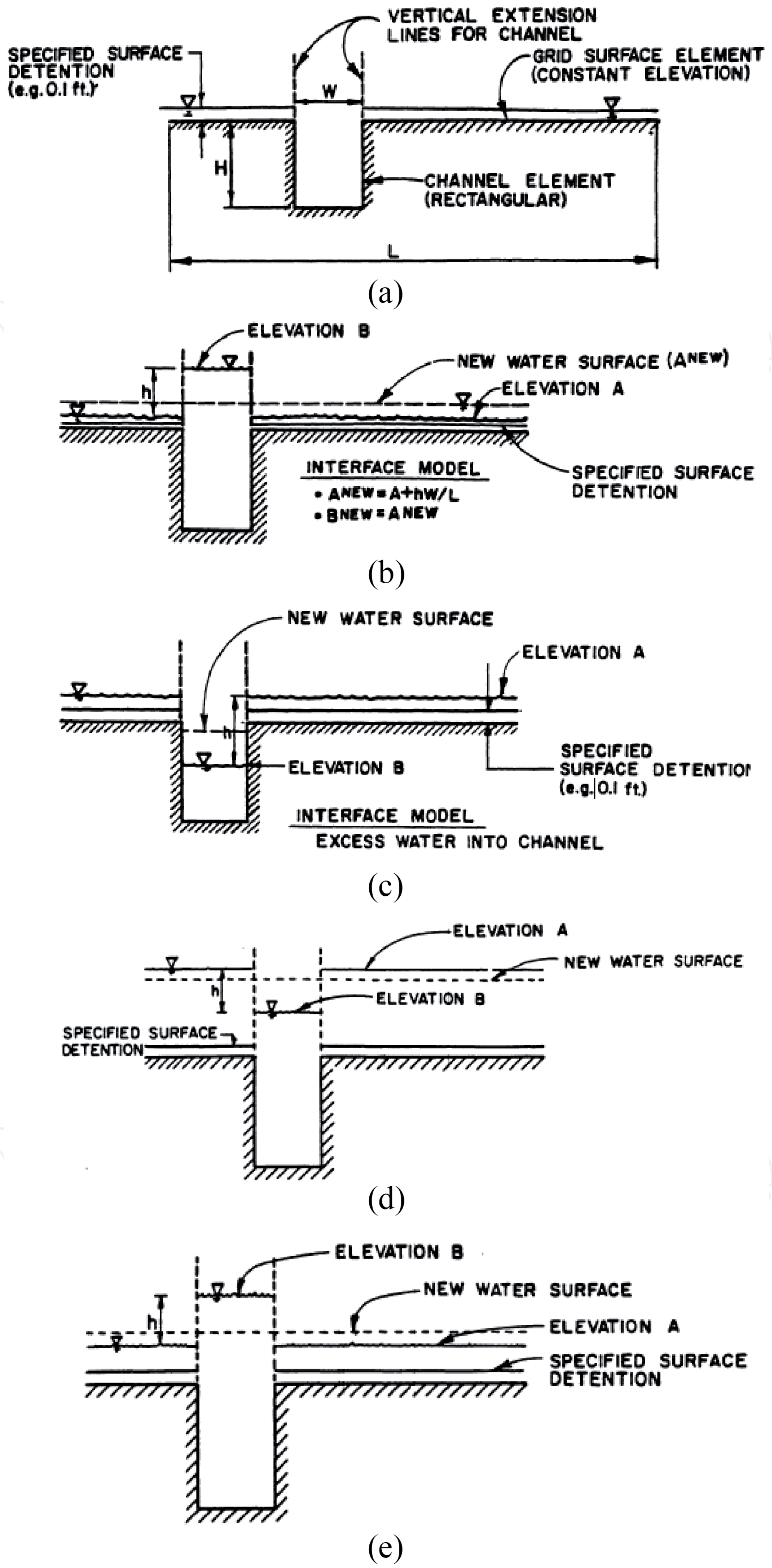


Figure 3.
Diffusion hydrodynamic interface model: (a) model interface geometries, (b) channel overflow interface model, (c) grid overflow interface model, (d) grid-channel flooding interface model, and (e) channel-grid flooding interface model.

2.4 Flooding of channel and grid

When flooding occurs, the water surface elevations of the grid and channel elements are both greater than the specified surface detention elevation. Two cases have to be considered as follows:

1. If A > B (**Figure 3(d)**), the new water surface elevation of the grid element is $A^{NEW} = B^{OLD} + \frac{h(L-w)}{L}$, and the new water surface elevation of the channel element is equal to A^{NEW}.
2. If A < B (**Figure 3(e)**), the new water surface elevation of the grid element is $A^{NEW} = A^{OLD} + \frac{h_* w}{L}$, and the new water surface elevation of the channel element is equal to A^{NEW}.

3. Conclusions

The characteristic features of the diffusion hydrodynamic model are detailed with a focus on its ability to model the interface. The interface component in the model can modify the water elevation in the grids along the flood plain and channel to account for different overflow scenarios, which are also illustrated.

Author details

Theodore V. Hromadka II [1*] and Chung-Cheng Yen[2]

1 Department of Mathematical Sciences, United States Military Academy, West Point, NY, USA

2 Tetra Tech, Irvine, CA, USA

*Address all correspondence to: ted@phdphdphd.com

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