# CHAPTER 3
# APPLICATION CAPABILITIES

## 3. APPLICATION CAPABILITIES

### 3.1 Introduction

Due to its general formulation and physical basis the SHE may be able to give a very detailed and to a large extent physically correct description of the water flow processes. Therefore, the SHE will be applicable to almost any kind of hydrological problem, although extensive further development and refinement is still needed to realise this vision. The flexible model structure combined with the distributed structure and the physical interpretation of the hydrological processes, is expected to provide significant advantages over existing hydrological models for a wide range of applications. Obviously, there are many problems for which the necessary solutions can be obtained using cheaper, conventional rainfall/runoff models. However; for the more complicated problems there may be little alternative but to use a system such as the SHE.

A very important aspect of SHE is its distribution in space, with calculation for every gridsize unit, which depending on the purpose of the application and the hydrological regime may vary from e.g. 25m x 25m to e.g. 2km x 2km. This allows e.g. for examination of the effect on flood flows of different directions of storm propagation across the catchment and also the effects of localised river and groundwater abstraction and recharge.

### 3.2 Fields of Application

Table 1 summarizes some possible fields of application.

Some of the potential and most important fields of application are discussed in the following:

TABLE 1

Possible fields of application for the SHE at different operation scales; for some of the topics a water quality component would need to be added to the existing water quantity model.

| TOPIC | PRIMARY HYDROLOGICAL PROCESS | POSSIBLE SCALE OF OPERATION |
|---|---|---|
| Irrigation Schemes | | |
| Irrigation water requirement | ET/UZ | field |
| Crop production | ET/UZ | project |
| Waterlogging | ET/UZ | field |
| Salinity/irrigation management | UZ | field |
| Land-use Change | | |
| Forest clearance | ET/UZ/SZ | catchment |
| Agricultural practices | ET/UZ/SZ | field/catchment |
| Urbanization | ET/UZ/SZ | catchment |
| Water Developments | | |
| Groundwater supply | SZ | catchment |
| Surface water supply | ET/UZ/SZ | catchment |
| Irrigation | UZ/SZ | project/catchment |
| Streamflow depletion | SZ/OC | catchment |
| Surface water/groundwater interaction | ET/UZ/SZ | project/catchment |
| Groundwater Contamination | | |
| Industrial and municipal waste disposal | UZ/SZ | field/catchment |
| Agricultural chemicals | UZ/SZ | field/project/catchment |
| Erosion/Sediment Transport | OC/UZ | project/catchment |
| Flood Prediction | OC/UZ | catchment |

NOTE: ET = evapotranspiration; UZ = unsaturated zone; SZ = saturated zone; OC = overland and channel flow

1) **Catchment changes.** These include both natural and man-made changes in land-use, such as the effects of forest fires, urbanisation and forest clearance for agricultural purposes. The parameters of a physically-based, distributed model have a direct physical interpretation, which means that they can be evaluated for the new state of the catchment before the change actually occurs. This enables the effects of changes to be examined in advance of such changes. In addition, the characteristically localised nature of catchment changes can easily be accounted for within the spatially distributed model structure.

2) **Ungauged catchments.** An application in a previously ungauged catchment requires the initiation of a programme of fieldwork to provide data and parameters for calibration. Here, the physical significance of its model parameters enables the SHE to be applied on the basis of a much shorter, and therefore more cheaply obtained, hydrometeorological record than is necessary for more conventional models. Similarly, the catchment parameters can be estimated from intensive, short-term field investigations.

3) **Evaluation of irrigation schemes.** A detailed examination of the efficiency of irrigation schemes require a modelling of the surface water/groundwater interaction at a field scale in the command area. The SHE can be used for prediction of crop and irrigation water requirements, water losses in canals and fields, return flow, water logging, effects of drainage etc. By also adding chemical and crop calculational modules, furthermore salinity and crop yield can be examined.

4) **Movement of pollutants and sediments.** In order to model the movement of pollutants and sediments, it is first necessary to model the water flows which provide the basic dispersion mechanism. Most water quality and sediment problems are distributed in nature, so distributed models are the most suitable for supplying the basic information on water flows.

It is noticed, that all the above mentioned fields of applications have not yet been modelled and that several of them require water quality components in addition to the water flow description. However, during the past years the SHE has been utilized within an increasing number of the above fields.

### 3.3 Experience Record

During the initial development (1977-1981), the SHE was tested on several catchments, and further its components have been tested independently. Subsequently, research cooperations were established with several universities and research organizations around the world with the aim of further developing and testing the SHE.

In addition, the SHE has within the last five years been applied in the following projects:

(1) Study of the effects of land use change on floods and sediment loads on catchments in Thailand. This study was carried out in a cooperation between DHI and the Royal Irrigation Department in Thailand. The study included as well field studies as modelling for three catchments ranging from $50km^2$ to $600km^2$.

(2) A study of the environmental impacts of applying nitrogen fertilizers. This study included very detailed modelling of water flow, nitrogen transport and degradation in two geologically different catchments in Denmark of $150km^2$-$500km^2$ size.

(3) A study of contaminant transport and degradation of contaminants from chemical/municipal dumps in landfills in Denmark.

(4) A water supply planning project for the City of Århus (Denmark). This study included a 800km$^2$ regional five layered groundwater model and focused also on the interaction between groundwater and streams.

(5) A study of the effects of irrigation development with focus on subbasins of river Narmada (The present project co-operation with NIH).

(6) A comparative study of different models ability to simulate runoff from medium size catchments in Zimbabwe and Denmark.

(7) A study on transport and dispersion of radionuclides from deep disposal sites through the near-surface and surface hydrological system in the UK.