SUMMARY

This dissertation study deals with current knowledge and methodical approaches to the derivation of design flood hydrograph characteristics for ungauged catchments with area less than 100 km^2. The flood hydrograph characteristics are peak flow, volume and shape of hydrograph.

The main idea of this study is, that the shape of every flood hydrograph, either observed or theoretical (design), should be explainable and reasonable relative to causal factors, which are:

- amount of precipitation (real or hypothetical) and its time and areal distribution,
- morphological characteristics of a catchment (its slope, length and slope of main flow path etc.) and river channel,
- soil characteristics and land use.

The aim of this study is mainly:

- the flood regime assessment of rivers in the Czech Republic under current conditions, the analysis of flood regime changes in the past and the outline of trends in the future,
- the evaluation of the influence of physio-geographical characteristics of catchments for the derivation of main flood hydrograph design characteristics (flood wave volume, shape of hydrograph and peak flow),
- the assessment of current methodology for the derivation of design values of maximum discharges (focused on Q_{100} for ungauged catchments with area less than 100 km^2),
- a proposal of a new approach for the derivation of Q_{100} for small ungauged catchments,
- the description of elements of uncertainty for the derivation of design maximum discharges for small catchments.

The main and the most important assets and conclusions of this study can be summarized as follows:

1. *Flood regime assessment*

    - A new index of flood regime (I_{FR}) based on annual peak flows was derived and computed for the sites of selected gauging stations in the Czech Republic.

- It is possible to state that winter or mixed flood regimes prevail in the CR, a distinct summer flood regime occurs especially in the Odra river basin and in several regions of southern Bohemia,
- Flood regime is related to ratios of maximum winter and summer precipitation and to geographical location of catchment. Flood regime strongly depends on prevailing wind direction bearing moist (and warm) air masses as potential source of heavy precipitation or snowmelt. Leeward and windward effects are also very important.
- I_{PR} values were compared for the time periods 1926–1975 and 1976–2005. It was recognized from changes in I_{PR} values that the most significant change has been taking place in the Berounka basin (from more of a winter to a mixed flood regime). This fact has caused the change of flood regime in the Vltava river and also in the Labe river downstream. It is possible to state that changes in flood regime in other basins have not been significant.

2. *Impact of physio-geographical factors on hydrograph shape*

- Flood runoff increases non-linearly with the amount of causal precipitation. This is the main conclusion resulting from assessment of real flood events.
- Hydrograph shape and peak flow magnitude depend above all on areal and time distribution of precipitation (in small catchments mainly), and also on moments of confluence of flood waves in the main river and its tributary. For larger catchments an attenuation of flood waves in river channels and inundation is also very important.
- The impact of other physio-geographical (mainly morphological) characteristics of catchments cannot be simply quantified solely from assessment of real flood events, therefore it is necessary to use appropriate modelling tools and techniques for these purposes.
- Because of its simplicity and usability a catchment linear model has proven itself a suitable modelling tool. The model contains parameters, which are independent of the total amount and time distribution of precipitation. One such common parameter is response time, which summarizes influence of all relevant physio-geographical catchment characteristics.
- Results of model simulations of flood waves show, that response time and therefore peak flow is most influenced (besides size of catchment area) by basin slope and

infiltration ability of soil surface. Otherwise it seems that length of maximum flow path and catchment shape are less important.

- From results of field studies it is clear, that in natural catchments (those with little human influence) subsurface flow prevails during the forming of flood runoff. So called „hortonian" (surface) runoff is limited only in the part of the catchment with little infiltration ability and it also takes place during occurrences of extreme heavy precipitation with strong intensity.

- Statistical evaluation was carried out of annual maximum 1-3day values of snow water equivalent drops and precipitation for winter hydrological half-year (1st November – 30th April). Data was prepared for every year of the time period 1961–2005 for all climatological stations with observation periods at least 30 years. From this assessment it seems, that in several stations (in mountainous regions) this data has not been representative and has not had desirable accuracy. This fact was proved by comparison of observed values of snow cover height and the results of mathematical model of snowmelt. General use of this data for derivation of design hyetographs therefore is not possible. It will be necessary to establish more accurate measurement of snow water equivalent in mountainous and forested regions.

3. *Methodical approaches for derivation of design flood hydrograph characteristics*

- Methodical approaches above all depend on desired output, that means, whether output is only peak discharge values or complete flood hydrograph with certain recurrence time.

- Maximum specific discharges q_{max} (or peak flows) from small catchments (with area less than 50–100 km^2) are mainly estimated by empirical non-linear regression equations, where catchment area is the main independent variable. Other physio-geographical characteristics of catchments are mostly incorporated into these relationships, e.g. basin slope or slope of maximum flow path, influence of forested area, annual precipitation etc. Only rarely is some characteristic of maximum precipitation included in these equations.

- Extrapolation of statistical characteristics of maximum discharges is used for estimation of q_{max} mostly for larger ungauged catchments. These characteristics were obtained from observation in water gauging stations. This method could present some risk, if it was used for catchments with short-term observation periods or for very small catchments. The main reasons are different meteorological causes of flood waves forming on small catchments in comparison with larger catchments.

- A new regression equation for estimation of maximum specific discharge with 100 years recurrent interval (q_{100}) was derived. The main reason for doing this was to incorporate all relevant physio-geographical characteristics forming peak discharge into the mentioned relationship. The equation is valid for catchment areas from 5 to 100 km^2. There are two independent variables in this equation: catchment area and so called "*index of extremity*", which is a cumulative factor representing a certain form of energy. It includes the amount of 100year effective rainfall and an average velocity value of flowing water inside the catchment. The mentioned equation was derived using current Q_{100} values in gauging station sites v ČR with catchment area less than 100 km^2. Length of observation in selected stations had to be 30 years and more.
- Deterministic rainfall-runoff models are used for estimation of all flood hydrograph characteristics for small ungauged catchments. The most common approach is some form of linear modelling of catchments, e.g. unit hydrograph. The main disadvantage of this approach is subjective selection of design hyetograph; the main advantage is the possibility of incorporation of all important physio-geographical factors with potential influence during flood wave forming.

It can be concluded that design characteristics of flood waves will always be of probabilistic nature. Their values will always lie in a certain confidence interval, but the margin of uncertainty is impossible to determine exactly. However the hydrologist as producer of design hydrological data is able to reduce the degree of uncertainty using adequate methodologies. These methodical approaches must respect the influence of all-important physio-geographical factors forming rainfall-runoff process and they must also respect all sources, which were obtained from direct observations of meteorological and hydrological data.