surface storage losses, since short time scales will usually render losses from evaporation and transpiration insignificant. A possible exception to this usage is for land-locked watersheds.

Since the governing relationships of hydrology are complex and, unlike problems in engineering mechanics, are not easily solved through direct use of the fundamental laws of physics, a wide variety of hydrologic procedures have been developed. Procedures for making time of concentration and rainfall excess calculations, procedures for estimating peak runoff rates at gaged and ungaged sites, procedures for developing design storm hyetographs, and flood hydrograph and hydrologic channel routing procedures are contained in the drainage volume of the design manual.

Drainage studies often follow a similar sequence of calculations for all procedures, because precipitation must be routed through watersheds, channels, and reservoirs. In most cases, stormwater runoff will be estimated using the following general procedure:

1. Divide the watershed into appropriate subareas to correspond with homogeneous land use conditions and the placement of drainage facilities such as inlets, reservoirs, and open channels.

2. Collect and analyze watershed data.

3. Establish design storm conditions as appropriate for the procedure selected.

4. Calculate the peak runoff rate or determine the time distribution of rainfall excess. No further calculations are generally required if only the peak runoff rate is desired.

5. Develop a unit hydrograph for the watershed, if a runoff hydrograph is desired and the procedure selected uses a unit hydrograph.

6. Develop the direct runoff hydrograph, using the unit hydrograph and rainfall excess determined above, as appropriate.

7. Perform downstream channel and reservoir routings, as appropriate.

8. Record the necessary calculation process and the results on the appropriate drainage maps, and in the drainage section of the Design Concept Report, as appropriate.

311.04 OPEN CHANNEL HYDRAULICS

The consideration of open channel hydraulics is an integral part of roadway projects in which artificial channels and improvements to natural channels are a primary concern. Procedures for performing uniform flow calculations that aid in the selection or evaluation of appropriate channel linings, depths, and grades are included in the drainage volume of the design manual. For most artificial channels, the most desirable lining is natural, emerging vegetation, with grass used to provide initial and long-term erosion resistance. If natural vegetation, usually grass, is unfeasible, concrete lining is used. Also, flexible linings comprised of rock riprap asphalt or articulating concrete grids can be used for preventing erosion. Allowable velocities and permissible depths of flow are provided in the drainage volume of the design manual, along with various adaptations of Manning's Equation suitable for evaluating channel capacity.

Open channels can be generally classified as those which occur naturally and those which are man-made or improved natural channels. The later, called artificial channels, include the following types in use on most roadway project:

1. Right-of-way ditches which usually acts as an overland flow interceptor ditch collecting water before it reaches the roadway.
2. Roadside or roadway ditch and (sometime called the “borrow ditch”)
3. Median ditches on divided highway.
4. Outfall ditches for connecting and carrying flows from ditch types 1, 2 and 3, a short distance to a natural outlet or to another, larger conveyance channel.
5. Lateral ditches are a larger size channel, usually used for continuing upstream flows past the project area.
6. Canals are large size conveyance channels.