limitations, and limiting velocity are parameters for which design standards can be set.

Two other approaches, however, are available that quantify risk on projects that involve highway facilities designed to encroach within the limits of a flood plain. These are risk assessment and economic analysis. Risk assessment is a subjective analysis of the risks engendered by various design alternatives, without detailed quantification of flood risks and losses. It may consist of developing the construction costs for each alternative and subjectively comparing the risks associated with each alternative. Economic analysis (sometimes called risk analysis) encompasses a complete evaluation of all quantifiable flood losses and the costs associated with them for each structure alternative. This can include damage to structures, embankments, surrounding property, traffic-related losses and scour or stream channel change. The level of expense and effort required for an economic analysis is considerably higher than for a risk assessment, and selection of the process to be used should be based on the size of the project and the potential risk involved. A risk assessment is usually more appropriate for small structures or for structures whose size is highly influenced by non-hydraulic constraints.

Policy dictates that hydraulic facilities be designed so that highway facilities will perform without significant damage or hazard to people or property during the appropriate standard design frequency flood. Risks associated with floods of magnitudes greater than the standard design frequency flood should be evaluated in accordance with the risk evaluation levels presented in this section. If warranted, a design based on a lower or higher frequency flood may be used. The minimum design frequency for bridges on main highways, however, is 50 years.

A typical example would be a major cross drain box culvert for a primary highway. The standard design frequency would be a 50-year frequency flood. A design based on this frequency should be produced in the "traditional" manner, including development of feasible alternatives. The alternatives would be compared for cost and for risks associated with the 50-year frequency flood. The lowest total cost structure that met the design constraints would be the preferred design. This design should then be investigated for the 100-year flood.

### 311.02.03 Data Collection

Identification of drainage data needs should be a part of the early planning phase of a project, when appropriate procedures for performing hydrologic and hydraulic calculations are selected. Several categories of data may be relevant to a particular drainage project, including published data such as precipitation, soils, land use, topography, streamflow and flood history. Published mapping is usually inadequate, so field investigations and surveys are necessary to determine drainage areas, identify pertinent features, obtain high water information, survey lateral ditch alignments and survey bridge and culvert crossings. In addition, hydrology calculations for a watershed or larger drainage area will usually require some sort of topographic mapping. The preferred mapping is using aerial photography showing contour elevations using digital techniques is preferred. Manual ground surveys are usually adequate for smaller areas. The requirements in more detail are as follows:

**A. Data Collection Procedure**: Drainage data should be collected before calculations are initiated, under the following general guidelines:

1. Identify data needs, sources, and uses. Much of this information will have to be provided in the concept report and kept in the supporting files.

2. Collect published data, based on sources identified in Step 1.

3. Compile and document the results of Step 2, and compare data needs and uses with published data availability. Identify any additional field data needs.

4. Collect field data based on needs identified in Steps 1 and 3.

5. Compile and document the results of Step 4.

**B. Published Data**: At present, there is limited published data with regards to soils, land use,