Chapter 18
Evaluating Change

18-1. General

a. Sources of change and methods of evaluation.

(1) Flood-runoff from a catchment may change as a consequence of human action. Some human actions are taken with the expressed goal of altering the runoff. Construction of a reservoir in the catchment is an example. Other human actions alter the catchment and conveyance system only as a side effect. Nevertheless, the actions alter the runoff. An example of this is conversion of an agricultural field to a residential neighborhood.

(2) Flood-runoff from a catchment may change also as a consequence of natural phenomena, if the phenomena change the catchment or conveyance system. For example, a lightning-caused range fire may alter the vegetative cover, and consequently, the rate of runoff from a catchment.

b. Illustration. This chapter illustrates the use of the infiltration, runoff, routing, and statistical models described in previous chapters of this document to evaluate the impacts of human action and natural phenomena. Here, the evaluation is limited to analysis of changes to runoff hydrographs, discharge-frequency curves, and rating curves.

18-2. Evaluating Catchment and Conveyance-System Change

a. Effects of change on floods. Catchments and conveyance systems may be modified by human action, such as urbanization, or by natural phenomena, such as lightning-caused range fire. These changes alter runoff hydrographs from single events. Consequently, these changes also alter the discharge-frequency relationship.

According to Leopold (1968),

> ... the two principal factors governing flow regimen are the percentage of (catchment) area made impervious and the rate at which water is transmitted across the land to stream channels. The former is governed by the type of land use; the latter is governed by the density, size, and characteristics of tributary channels...

Development or urbanization in a catchment typically is accompanied by an increase in impervious area. As the impervious area increases, the infiltration decreases. As infiltration decreases, the volume of runoff from a storm increases. As the volume increases, the magnitude of the flood peak increases. An increase in impervious area also speeds the flow of water across the land, and this increases the flood peak. Likewise, improvements to or expansion of the catchment conveyance system speeds the flow and increases the peak.

b. Evaluation with a rainfall-runoff model. The impact of watershed changes can be estimated conveniently with a rainfall-runoff model that includes only parameters that are measurable or parameters that are directly related to catchment characteristics. Given a description of the proposed changes to the catchment or the conveyance system, these parameters can be estimated. An example of a (pseudo) physically based rainfall-runoff model is the kinematic-wave model. Application of this model requires identification of catchment area, flow length, slope, and overland-flow roughness factor. To evaluate the impact of catchment or conveyance-system changes with this model, these parameters are estimated from maps, photographs, inspection, or, in the case of future conditions, from development plans. With the modified parameters, runoff can be estimated for any storm.

(1) The impact on the discharge-frequency curve can be evaluated with a rainfall-runoff model via period-of-record analysis. The period-of-record analysis computes runoff from the entire time series of historical rainfall or from a lengthy series of equally likely rainfall (Chapter 12 of EM 1110-2-1415). The resulting series of runoff is analyzed with the statistical-analysis procedures described in Chapter 12 to define the modified-condition discharge-frequency curve. This analysis is straightforward but data-intensive and time-consuming.

(2) Simulation of selected historical events is an alternative to a complete period-of-record analysis. This procedure uses historical rainfall and runoff data. The existing, present-condition discharge-frequency curve is determined by statistical analysis of the discharge time series. To estimate the modified discharge-frequency curve, a rainfall event is selected from the historical record. The probability of the historical runoff peak corresponding to the event is determined from the existing conditions discharge-frequency curve. Runoff due to the rainfall after catchment and conveyance-system

changes is estimated by simulation, with model parameters selected to represent the modified condition. This peak discharge is assigned the same probability as the existing-condition peak. This is repeated for a range of rainfall events to adequately define the modified discharge-frequency curve.

(3) If historical rainfall and runoff data are not available, the modified-condition discharge-frequency curve can be estimated with hypothetical rainfall. To estimate the discharge-frequency curve, a design storm of specified probability is developed. Runoff due to the rainfall event after catchment and conveyance-system changes is estimated by simulation, with model parameters selected to represent the modified condition. The computed modified-condition peak is assigned the same probability as the design storm. This is repeated for a range of hypothetical rainfall events to adequately define the modified discharge-frequency curve. This procedure is described in Chapter 17.

c. Evaluation with regional rainfall-runoff model parameters. The impact of watershed changes can be estimated with an rainfall-runoff model with calibration parameters, using parameter-predictive equations. With gauged data, these parameters are determined by trial and error, comparing computed hydrographs with observed hydrographs. As described in Chapter 16, predictive equations may be developed to permit estimation of the parameters for ungauged catchments. These predictive equations relate the calibration parameters to catchment characteristics. A simple example is the following equation, proposed by Wright-McLaughlin Engineers (1969) to predict a parameter for Snyder's synthetic unit hydrograph, in the Denver metropolitan area:

$$C_t = \frac{7.81}{I^{0.76}} \quad (18\text{-}1)$$

where

C_t = Snyder's unit hydrograph parameter (paragraph 7-3*c*)

I = catchment impervious area, in percentage.

As a natural catchment is developed, the impervious area typically increases. With (Equation 18-1) and Snyder's model, the resulting change in the unit hydrograph can be predicted. Application of the unit hydrograph permits estimation of the runoff from any storm. Similar equations can be developed and applied to estimate parameters for other rainfall-runoff models.

(1) The SCS loss and unit hydrograph models are especially convenient empirical models for estimating modifications to runoff due to catchment and conveyance-system changes (USDA 1986). The SCS loss model parameter is predicted as a function of land use, soil type, and antecedent-moisture condition. The unit hydrograph model parameter may be predicted as a function of land use, soil type, antecedent-moisture condition, slope, and flow length. For existing, current conditions, these can be observed or measured. For modified conditions, these can be forecasted.

(2) A GIS is helpful for developing the physical-feature data base required for evaluation of changes. A GIS is a computerized data base management system with spatial references for all data. The simplest GIS is a rectangular grid superimposed on a map of the catchment. Pertinent characteristics are determined and stored in a data base for each cell of the grid. For example, for the SCS models, land-use type, soil type, moisture condition, slope, and length can be stored. Once stored, the characteristics can be retrieved and mapped. They also can be manipulated for use with parameter predictive equations, such as those that predict loss rate parameters for the SCS model. A GIS is convenient for evaluating runoff changes due to future catchment or conveyance systems (DeBarry and Carrington 1990). With proposed land-use types stored in the GIS, the modified-condition model parameters can be determined easily, and the runoff can be computed. Of course, the reliability is a function of the quality of the data stored and the reliability of the parameter-predictive equations.

(3) Given rainfall-runoff model parameters determined with predictive equations, the impact of watershed and conveyance-system changes on the discharge-frequency curve can be evaluated using the same procedures described for the model with physically based parameters. A period-of-record analysis can be performed to develop a modified condition time series. Alternatively, selected historical or hypothetical events can be simulated.

d. Evaluation with regional frequency-model parameters. The lumped impact of watershed and conveyance-system changes on the discharge-frequency curve can be evaluated with frequency-based model parameter predictive equations. Paragraph 16-6 of this document describes how frequency-based model parameters or discharge-frequency relationships may be related to catchment characteristics. If these characteristics can reflect catchment and conveyance-system changes, the equations can directly predict the modified-condition discharge-frequency curve.

(1) Quantiles for the modified discharge-frequency curve can be estimated with a predictive equation. For example, Sauer et al. (1983) propose the following equation to estimate the 0.01-probability peak discharge for a developed urban catchment:

$$UQ100 = 2.50\ A^{0.29} SL^{0.15} (RI2+3)^{1.76} (ST+8)^{-0.52} (13-BDF) SIP - 0.28 IA^{0.06} RQ100^{0.63} \tag{18-2}$$

where

$UQ100$ = discharge, in cubic feet per second

A = catchment contributing area, in square miles

SL = channel slope, in feet per mile

$RI2$ = basin rainfall, in inches

ST = basin storage, in percentage

BDF = basin development factor (0 to 12)

IA = impervious area, in percentage

$RQ100$ = equivalent rural peak discharge, in cubic feet per second

$RQ100$ is estimated independently with statistical analysis of the historical time series. For forecasted or proposed changes, the slope, storage, development factor, and impervious area can be estimated. With (Equation 18-2), the modified 0.01-probability discharge is estimated. Similar equations can be developed for other quantiles or with other catchment characteristics.

(2) Equations can also be developed to predict the statistical model parameters as a function of catchment characteristics. For example, the standard deviation in (Equation 12-9) can be correlated with catchment characteristics. The resulting equation could permit estimation of current, future, existing, or proposed condition parameters. With these parameters and the distribution equation, the discharge-frequency relationship is defined.

18-3. Procedure for Evaluating Damage-Reduction Plans

a. Damage-reduction measures. Flood damage can be reduced by decreasing flow rate, decreasing the depth of water, and decreasing directly the damage caused by flooding. Table 18-1 lists measures that reduce flood damage, classifying each by impact. A mitigation plan comprises one or more of these measures.

b. Plan evaluation criterion. The effectiveness of any plan is quantified in terms of inundation-damage reduction benefit. Guidelines for Federal water-resources planning define this as:

$$E(B_{IR}) = \left[E(D_{exist}) - E(D_{plan})\right] \tag{18-3}$$

where

B_{IR} = inundation-reduction benefit

D_{exist} = existing-condition flood-damage cost (without a plan)

D_{plan} = flood-damage cost with the plan in place

E = the expected value (USWRC 1983).

Chapter 7 of EM 1110-2-1415 describes alternative approaches to computing the expected value. The most widely used approach in USACE is the frequency technique. To compute expected damage with the frequency technique, the damage-frequency curve is derived by transforming the annual-maximum discharge-frequency curve with the elevation-discharge (rating) function and the elevation-damage function. This is illustrated by Figure 18-1. The expected damage is the area beneath (the integral of) this damage-frequency relationship. The Hydrologic Engineering Center's Expected Annual Flood Damage (EAD) computer program derives the damage-frequency curve following this procedure and integrates the result numerically (USACE 1984a).

(1) For computation of expected damage, the hydrologic engineer must define the discharge-frequency curve and rating functions for existing and proposed conditions, accounting for current and future catchment and conveyance-system conditions. Table 18-2 shows how the

Table 18-1
Damage-Reduction Measures, Classified by Impact

Decrease Flow Rate	Decrease Depth of Flooding	Decrease Damage Directly
Reservoir	Channel alteration	Floodplain management
Diversion	Levee/ floodwall	Floodproofing
Watershed management		Flood warning and preparedness planning

functions are modified by each of the damage-reduction measures listed in Table 18-1.

(2) Mathematical tools described in Part II of this document and in EM 1110-2-1416, EM 1110-2-1413, and EM 1110-2-1415 are used for the analysis.

c. Summary of evaluation procedures. The economic impact of catchment and conveyance system changes and of flood-damage mitigation measures is determined via solution of Equation 18-3. This may be accomplished as follows:

(1) Define the existing-condition discharge-frequency curve, rating, and elevation-damage functions. To define the discharge-frequency curve, rainfall-runoff and routing models or statistical models are used. To define the rating function, routing models or the hydraulics models described in EM 1110-2-1416 may be employed.

(2) Derive the damage-frequency curve using the procedure illustrated by Figure 18-1. Integrate to compute expected inundation damage for the existing condition.

(3) Identify the plan to be evaluated. Perform the analyses necessary to define modifications to the discharge-frequency curve, rating, and elevation-damage functions due to the plan. These analyses may require rainfall-runoff and routing models, statistical models, or hydraulics models.

(4) Derive the modified-condition damage-frequency curve, using the modified functions. Integrate the damage-frequency curve to compute expected damage with the changes.

(5) Solve (Equation 18-3) to compute inundation-reduction benefit.

(6) If catchment, channel, and economic conditions are dynamic, repeat steps 1-5 for each year of analysis.

d. The remainder of this chapter describes technical procedures for evaluating changes to the discharge-frequency curve and rating function as a consequence of flood-damage reduction plans.

18-4. Evaluating Reservoir and Detention Basins

a. Reservoir performance. A reservoir stores flood runoff and then releases it downstream to the channel over a longer period of time. This operation reduces the peak flow rate, resulting in lower water-surface elevation and less damage. The primary impact of the reservoir is modification of the discharge-frequency curve, as illustrated by Figure 18-2.

(1) The effectiveness of the reservoir depends on its capacity, location, and operation rules.

(2) The capacity limits the amount of runoff that can be collected and held for release at a nondamaging rate.

(3) The location governs the amount of runoff that the reservoir can control, since a reservoir will store only inflow from the area upstream. The reservoir operation rules determine the manner of release.

b. Reservoir modeling fundamentals. The performance of a reservoir or detention basin is evaluated with the routing procedures described in Chapter 9. The fundamental relationship used is the continuity relationship:

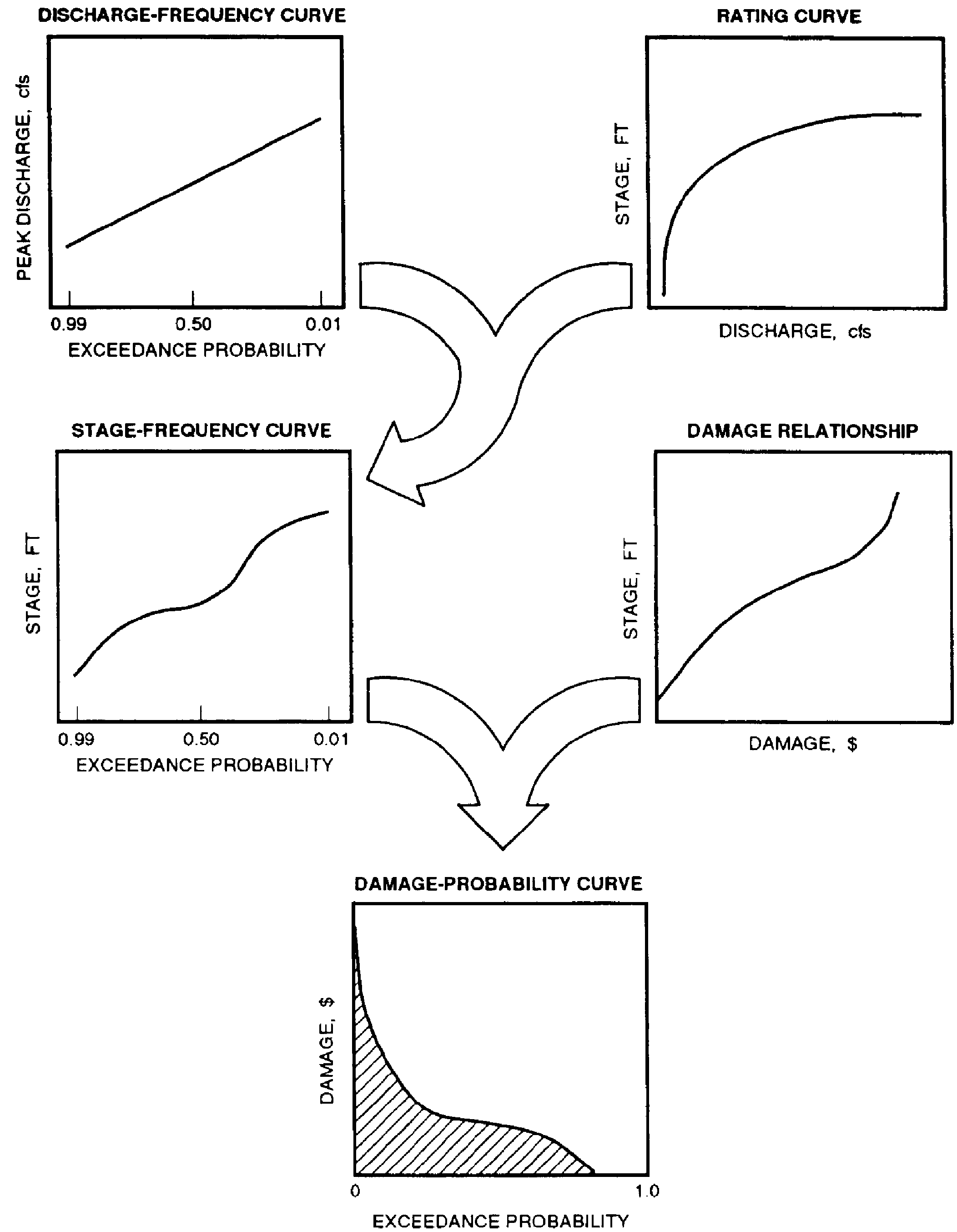

Figure 18-1. Derivation of damage-frequency curve from discharge-frequency curve, rating function, and elevation-damage function

Table 18-2
Evaluation Requirements of Damage Mitigation Measures

	Function(s) modified by measures in category		
Category of Measure	Discharge-probability	Elevation-discharge	Elevation-damage
Reservoir	X	-	-
Diversion	X	-	-
Watershed management	X	-	-
Channel alteration	X[1]	X	-
Levee/floodwall	X[1]	X	X
Floodplain management	-	-	X
Floodproofing	-	-	X
Flood warning and preparedness planning	-	-	X[2]

[1] If floodplain storage altered significantly.
[2] Evaluation requires subjective analysis.

$$S_{t-1} + I_t dt - O_t dt = S_t \qquad (18\text{-}4)$$

where

S_{t-1} = storage at the end of time interval t - 1

I_t = average reservoir inflow rate during interval t

dt = length of time interval

O_t = average reservoir outflow rate during interval t

S_t = reservoir storage at the end of interval t

This equation is solved recursively to determine the reservoir storage and release hydrographs. Solution requires specification of the initial volume in storage in the reservoir (S_t for t = 0), specification of the reservoir operation rules, and specification of the reservoir inflow hydrograph (I_t for all t).

(1) The initial storage selected for solution of Equation 18-4 depends on the reservoir condition to be evaluated. If the proposed reservoir has no permanent pool, the initial storage is zero. If the impact of successive storms is of interest, the initial storage for each event, after the first, is the final storage of the preceding storm. If the reservoir is a multiple-purpose reservoir, a portion of the reservoir is allocated to flood control, and a portion is allocated to conservation. The reservoir operator strives to keep the conservation pool full, as releases or withdrawals from this pool satisfy water supply and energy demands. The operator tries to keep the flood-control pool empty. For analysis of reservoir operation during a flood, the initial storage depends on the success or likely success in meeting the goal. If the flood-control pool is empty, the total flood-control volume is available. Most reservoir flood-control operation studies assume this to be the case.

(2) The reservoir operation rules relate inflow, storage, and outflow. For a simple detention pond, the rules are fixed by the hydraulic characteristics of the structure. For example, for a simple detention pond with an uncontrolled conduit outlet and an ungated spillway, the operation rules can be determined via the orifice and weir equations. These equations will define the outflow as a function of reservoir water-surface elevation. With a site

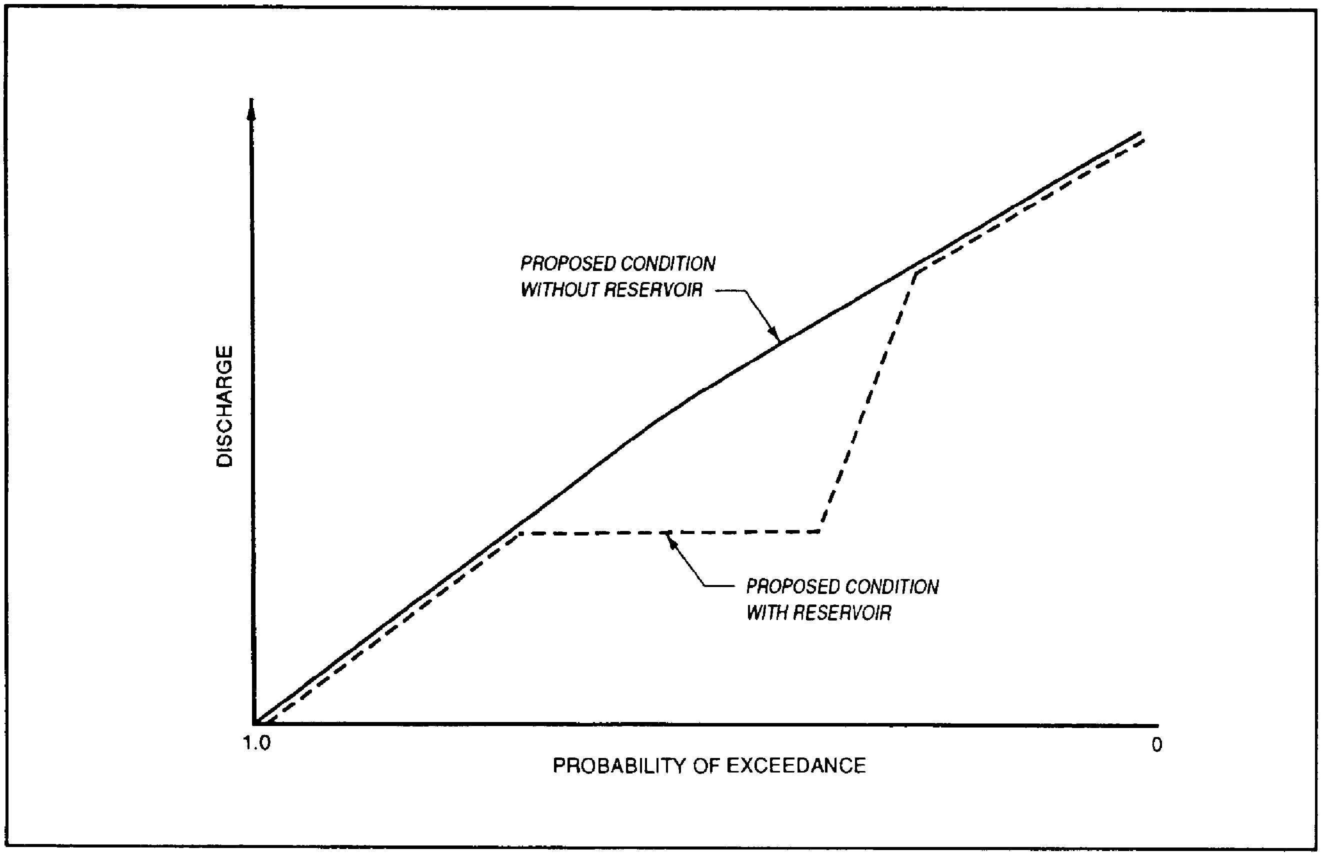

Figure 18-2. Discharge-frequency curve modification due to reservoir

elevation-area description, the elevation can be related tostorage. This will permit solution of (Equation 18-4) and simulation of reservoir performance. For a gated flood-control reservoir, the rules are constrained by hydraulics and defined by economic, environmental, social, and political criteria.

(3) The reservoir inflow hydrograph depends on the study objective. If the goal is to define the modified discharge-frequency curve, one option is to evaluate reservoir performance with a long series of historical or synthetic inflows. The operation is simulated with the series to define the reservoir outflow. Statistical analysis procedures described in Chapter 12 are applied to the outflow series to estimate the modified discharge-frequency curve.

(4) Alternatively, the discharge-frequency curve can be estimated by evaluating performance for a limited number of historical events. The current, without-reservoir condition discharge-frequency curve is found with methods of Chapter 12. To estimate the modified discharge-frequency curve, a runoff event is selected from the historical inflow record. The probability of the historical runoff peak corresponding to the event is determined from the discharge-frequency curve. The peak with the reservoir is estimated by simulation. This controlled peak discharge is assigned the same probability as the existing-condition peak. This is repeated for a range of runoff events to adequately define the modified discharge-frequency curve.

(5) The modified-condition discharge-frequency curve can be estimated also with hypothetical runoff events. Such a runoff event is developed from rainfall-runoff analysis with rain depths of known probability or from discharge duration-frequency analysis. In the first case, a design storm of specified probability is developed with procedures described in Chapter 13. The corresponding runoff hydrograph is computed with a rainfall-runoff model. This runoff hydrograph is inflow to the reservoir. In the second case, a balanced inflow hydrograph is developed. This balanced hydrograph has volumes for specified durations consistent with established

volume-duration-frequency relations. For example, a 0.01-probability balanced hydrograph is developed so the peak 1-hr volume equals the volume with probability 0.01 found through statistical analysis of runoff volumes. Likewise, the hydrograph's 24-hr volume equals the volume with probability 0.01. With either of the hypothetical inflow events, reservoir operation is simulated and the outflow peak is assigned the same probability as the inflow hydrograph. This procedure is repeated for a range of hypothetical rainfall events to adequately define the modified discharge-frequency curve. Strictly speaking, this is appropriate only if the reservoir has no permanent pool. Otherwise, the outflow depends on the inflow and the initial storage.

c. Dam-safety studies. The discharge-reduction benefit of a reservoir is accompanied by the hazard of dam failure. The impact of this failure can be estimated with hydraulics models described in EM 1110-2-1416 or with the routing models of Chapter 9 of this document. Three aspects of dam failure must be considered: formation of a breach, an opening in the dam as it fails; flow of water through this breach; and flow in the downstream channel. For analysis, the reservoir outflow hydrograph is computed with Equation 18-4 as before. However, the operating rules change with time as the breach grows. For convenience in analysis, a breach is assumed to be triangular, rectangular, or trapezoidal and to enlarge at a linear rate. At each instant that the breach is known, the flow through the breach can be determined with principles of hydraulics. Flow through the downstream channel is modeled with one of the routing models.

18-5. Evaluating Channel Alterations and Levees

a. Channel-alteration performance. Channel alterations include enlarging the channel, smoothing the channel, straightening the channel, and removing or minimizing obstructions in the channel. Enlarging the channel increases its flow-carrying capacity. The other alterations lessen the energy loss, thus permitting a given discharge to flow at a lesser depth. The primary impact of increasing the flow-carrying capacity or lessening the energy loss is modification of the rating function, as illustrated by Figure 18-3.

b. Channel-alteration modeling. The performance of a channel alteration is evaluated with river hydraulics models described in EM 1110-2-1413. These physically based models have physically based parameters that are modified to reflect changes to channel characteristics.

(1) The HEC-2 computer program (USACE 1982) is a well-known tool for evaluating channel alterations. This program implements a model of gradually varied steady flow in a rigid-boundary channel. That model uses the physical dimensions of the channel and indices of channel roughness directly in estimating flow depth. To evaluate the impact of proposed channel enlargement, the channel dimensions are modified in the program input to reflect the changes. Repeated solution of the gradually varied steady-flow equations with HEC-2 yields the rating function for a specified channel configuration.

(2) For modeling the impacts of changes in an alluvial channel, a movable-bed model should be used. Program HEC-6 (USACE 1990c) implements such a model.

c. Levee performance. A levee or floodwall reduces damage by reducing floodplain flooding depth. It does so by blocking overflow from the channel onto the floodplain when the capacity of the channel is exceeded. The rating function, as modified by a levee, is shown in Figure 18-4. A levee may also modify the discharge-frequency curve. The levee restricts flow onto the floodplain, eliminating the natural storage provided by the floodplain. This restriction may increase the discharge downstream of the levee for a specified probability. Further, as the natural channel is narrowed by the levee, the velocity may increase. This too may increase the discharge for a given probability.

d. Levee modeling.

(1) Introduction of a levee alters the effective channel cross section. The impact of this change can be determined with the physically based river hydraulics models. As with channel alteration, the impact of a levee can be determined by modifying the parameters which describe the channel dimensions. Repeated application of the model with various discharge magnitudes yields the rating function for a specified levee configuration.

(2) Modifications to the discharge-frequency curve due to a levee are identified with the river hydraulics models or with routing models described in Chapter 9. Either models the impact of storage on the discharge hydrograph and will reflect the loss of this storage. For example, the modified puls routing model determines the channel outflow hydrograph with a relationship of channel discharge to channel storage. A levee will reduce the channel storage for discharge magnitudes that exceed the

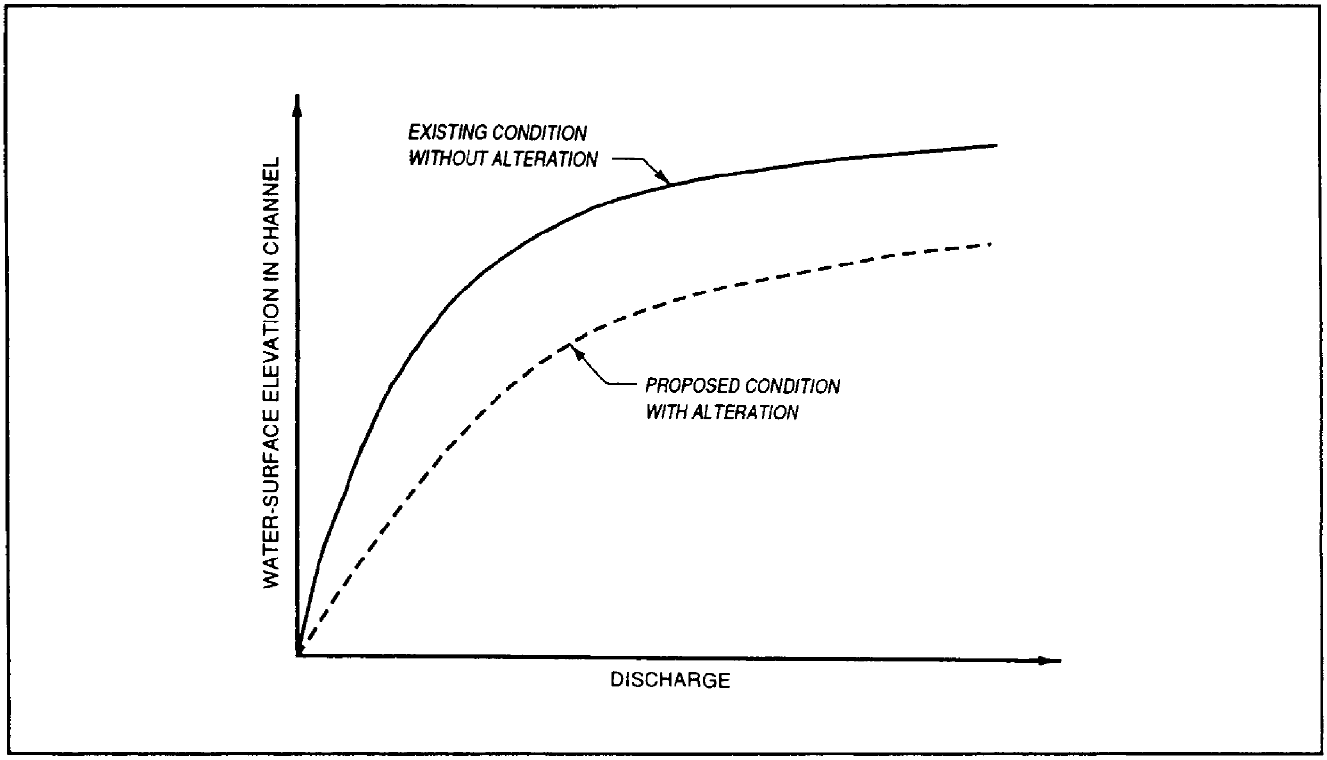

Figure 18-3. Rating function modification due to channel alteration

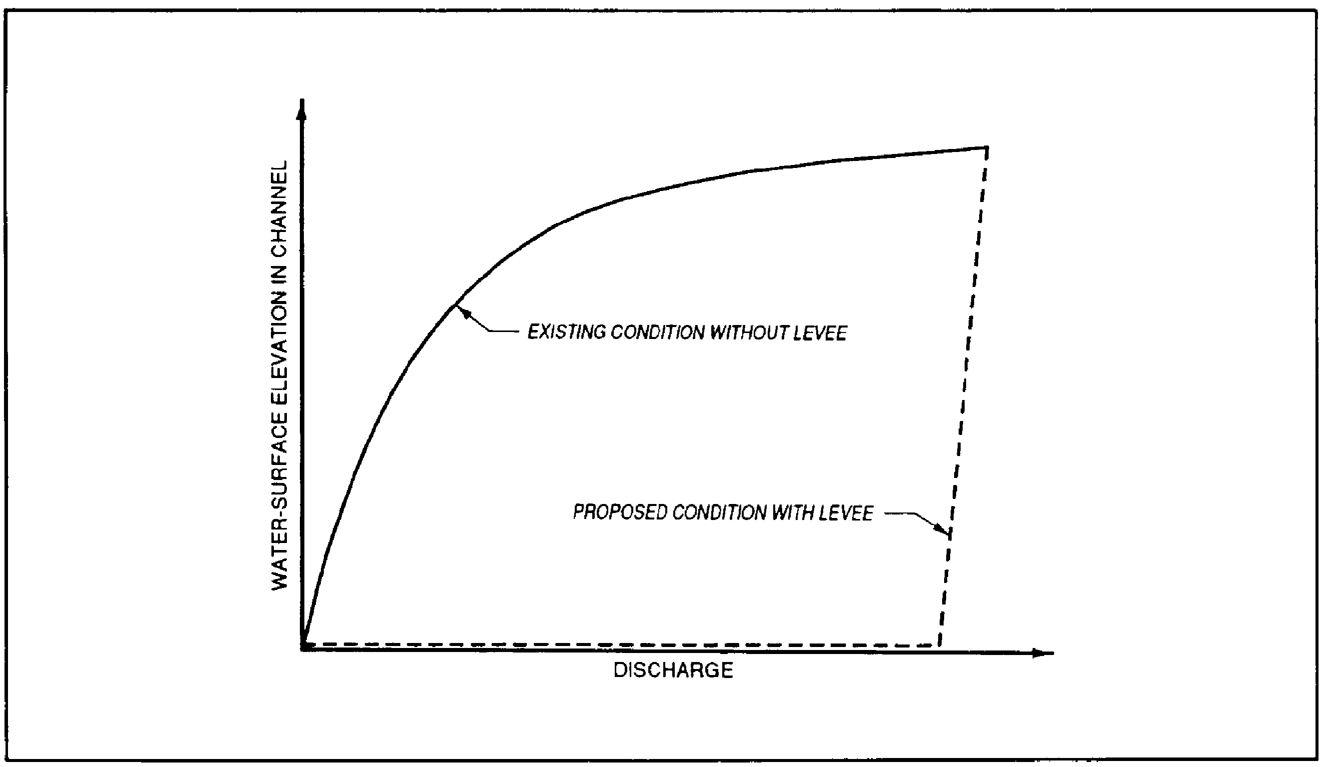

Figure 18-4. Rating function modification due to levee

channel capacity. Historical or hypothetical runoff hydrographs can be routed with the selected model to determine discharge peaks with the proposed levee.

e. Interior drainage. A levee or floodwall blocks the natural drainage of local runoff into the channel. This local runoff may cause flooding and must be considered in levee planning. Rainfall-runoff and routing models described in this document can be used to estimate the volume and time distribution of local runoff. Facilities for managing the water are described in EM 1110-2-1413. Often, a detention pond is used to store the interior drainage. The water is pumped from the pond into the channel. The performance of the pond can be simulated with routing models similar to those used for analysis of a reservoir or detention pond. Analysis procedures are described in detail in EM 1110-2-1416.

18-6. Evaluating Other Alternatives

a. Diversion. A diversion reduces the peak flow downstream of its location by reducing the volume of water flowing in a channel reach. This discharge reduction causes the discharge-frequency curve to be modified as illustrated by Figure 18-5. Figure 18-6 is a plan view of a diversion. This diversion includes a bypass channel and a control structure. The control structure could be a simple overflow weir, a pipe through an embankment, or a gated, operator-controlled weir. When the flow rate in the main channel reaches a threshold, the control structure diverts a portion of the flow into the bypass channel. The volume and flow rate in the main channel is reduced, thus eliminating or reducing damage to the downstream property. Downstream, the bypass and the main channel join. There, the diverted water flows into the main channel.

(1) The performance of a diversion is evaluated with routing models described in Chapter 9 of this document. At the control structure, a hydraulics model estimates the distribution of flow into the bypass and flow in the main channel. This model may be as complex as the 2-D models described in EM 1110-2-1416 or a simple as a rating curve, based on 1-D steady-flow analysis, which defines diversion-channel flow as a function of main-channel flow. Passage of flow in the diversion channel and in the main channel is modeled with a routing model, such as the puls model.

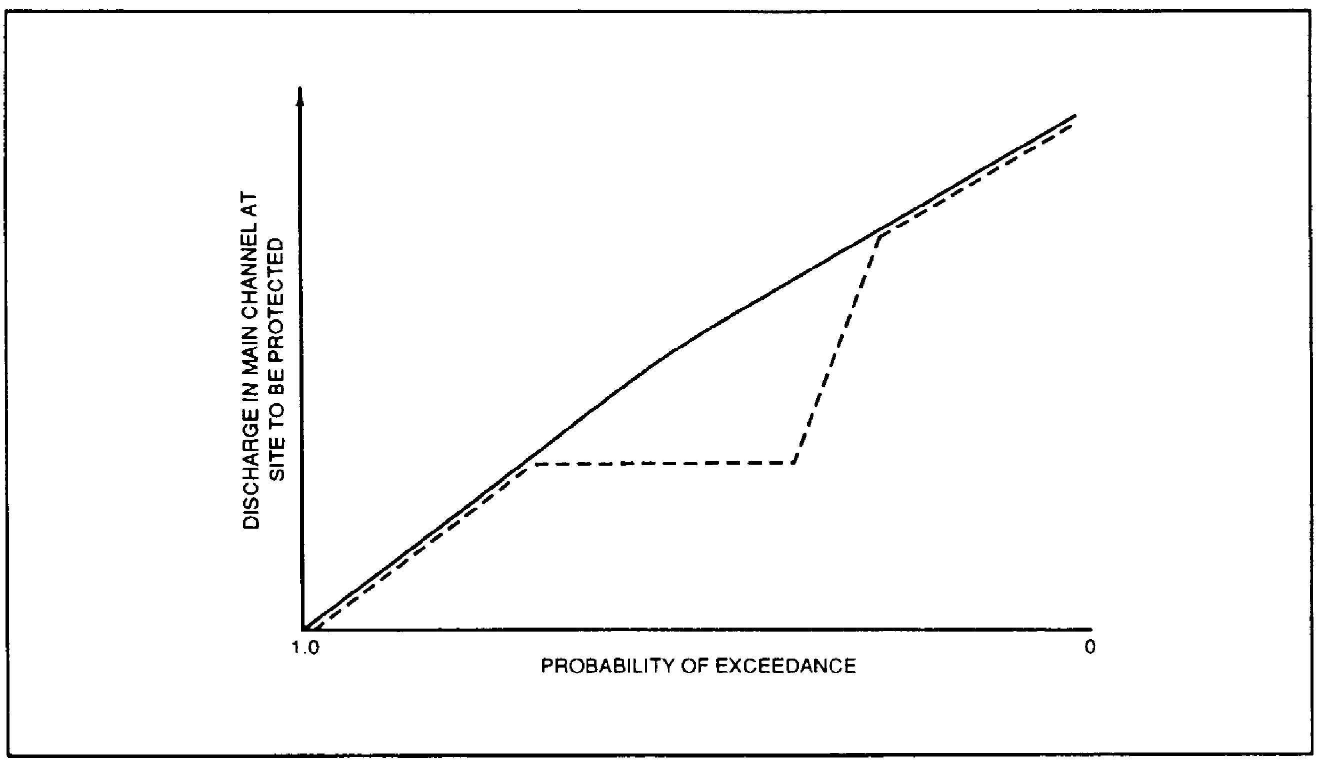

Figure 18-5. Discharge-frequency curve modified due to diversion

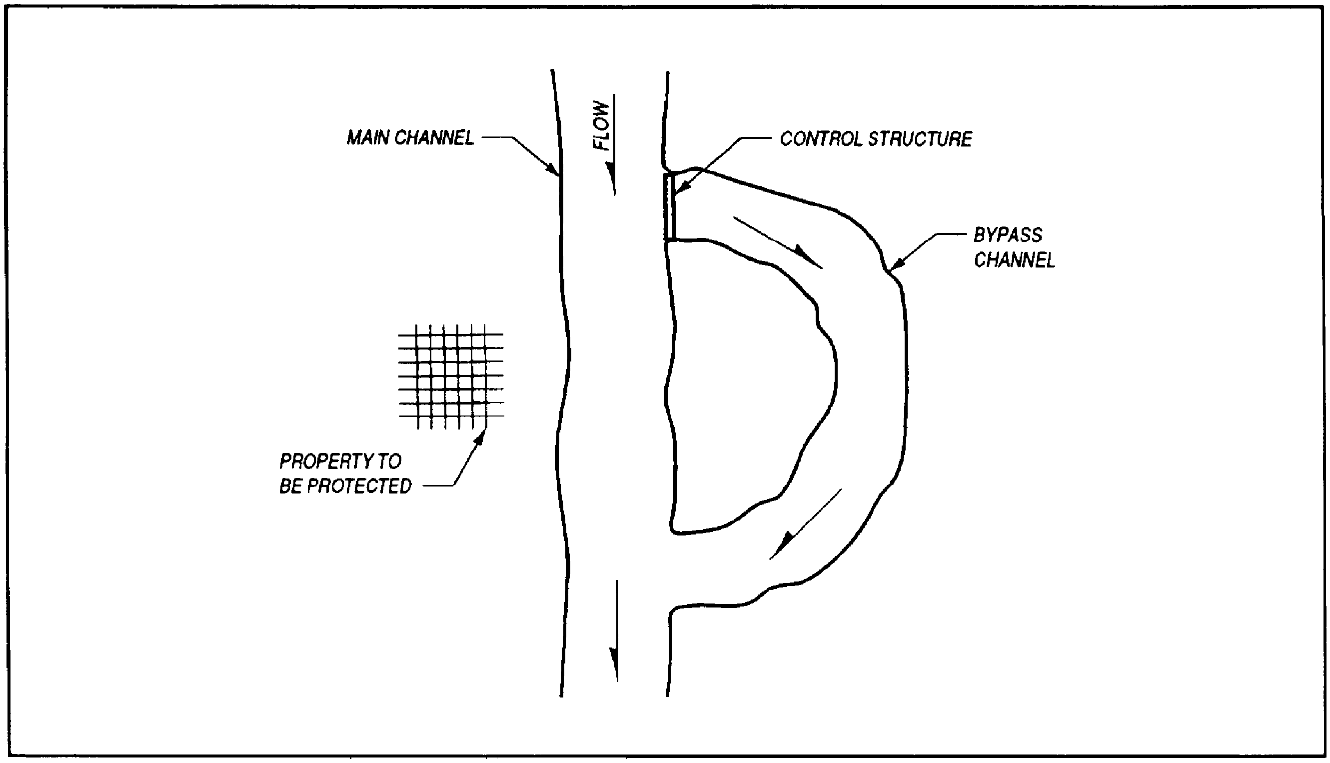

Figure 18-6. Plan view of diversion

(2) The impact of a diversion on the discharge-frequency curve can be evaluated via period-of-record analysis or simulation of selected events. With the period-of-record analysis, the historical discharge time series is analyzed to estimate channel flow when the proposed diversion operates. The resulting modified main-channel discharge time series is analyzed with statistical procedures to define the discharge-frequency curve. Otherwise, operation of the diversion with selected historical or hypothetical runoff hydrographs can be simulated. As with a reservoir, the resulting peaks are assigned probabilities equal the probabilities of the peaks without the diversion. For small events, the diversion has little or no impact on the discharge-frequency curve, since little or no water is diverted from the main channel. As the discharge magnitude increases, the diversion functions and diverts water up to its capacity. For larger events, the discharge reduction possible is constrained by the capacity of the diversion.

b. Watershed management. Watershed management includes vegetation and crop management, terracing and contour plowing, and drainage control. Whereas urbanization in a catchment increases the volume and speeds runoff, these measures decrease the volume and/or slow the runoff.

(1) Vegetation and crop management ensure that land is covered with vegetation during the rainy season. This increases infiltration by impeding flow and making the soil more permeable.

(2) Terracing and contour plowing alter the shape of catchment surfaces, increasing storage, slowing flow, and increasing infiltration.

(3) Storm drainage control intercepts runoff and diverts or detains it, much like a reservoir or detention basin does. This reduces the runoff peak by spreading the runoff volume over a longer time period.

(4) The impact of watershed management measures is evaluated with the same procedures used to evaluate catchment and conveyance-system changes. A statistical model may be used with predictive equations for the model parameters. These predictive equations must include terms descriptive of watershed management modifications. Otherwise, the impacts of watershed

management may be predicted with a rainfall-runoff model. As described in paragraph 18-2, such a model permits evaluation of changes to runoff hydrographs. Through period-of-record analysis or by simulating selected historical or hypothetical events, the modified-condition discharge frequency curve can be estimated.

c. Floodplain management. Floodplain management decreases future damage by reducing vulnerability of future development. This may be accomplished with land-use ordinances, subdivision regulations, zoning laws, building codes, or real estate statutes.

(1) A floodplain land-use ordinance could restrict land uses that are dangerous due to water or erosion hazards. This will change the future elevation-damage function.

(2) Floodplain management may also modify the future discharge-frequency curves and future rating functions. For example, if future development in the floodplain is restricted, the impervious area may increase as old structures are razed and land is returned to a natural state. The impact of such modification can be evaluated using procedures described in paragraph 18-2.