Chapter I

PROCEDURAL SUMMARY

This chapter was prepared by a committee composed of the individual coordinators for chapters II to XI.

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INTRODUCTION

This chapter summarizes all procedures presented in the handbook. It is meant to provide an overview of the analyses, clarify usage of techniques and information, and indicate the interrelations between the various chapters. Procedural summaries appear for the quantitative chapters II - VII while general summaries are presented for the qualitative chapters VIII - XI. Included here for each quantitative chapter is a basic flow diagram which is briefly explained by component. More detailed flow charts, explanations of procedures, and the logic behind those procedures may be found in the individual technical chapters. The descriptions included in this chapter are provided only for purposes of illustrating interrelationships; they are not to be considered as descriptions of the actual steps necessary for technical analysis.

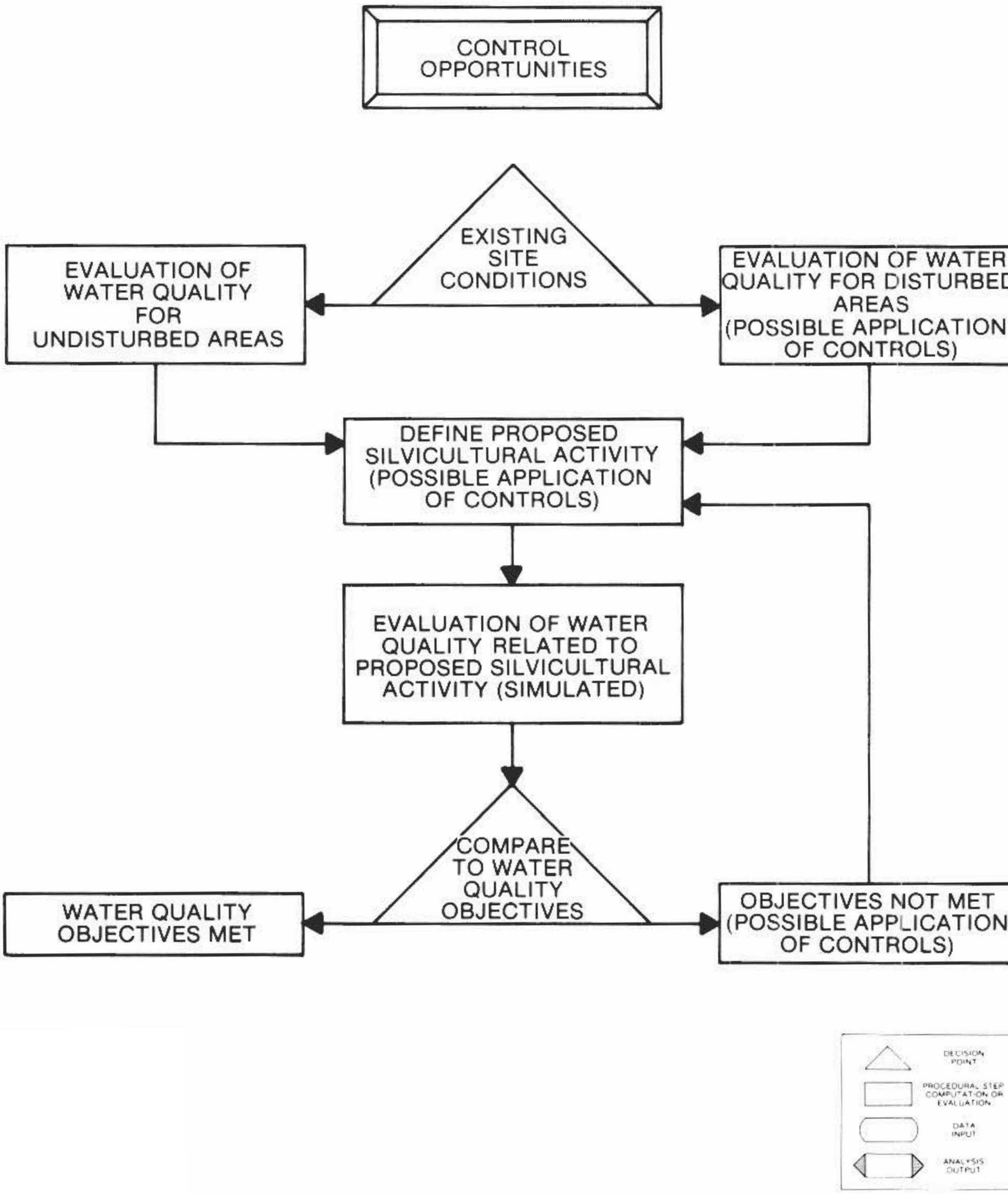


Figure I.1.—Generalized flow diagram for utilizing the control opportunities.

PROCEDURAL SUMMARY FOR CHAPTER II: CONTROL OPPORTUNITIES

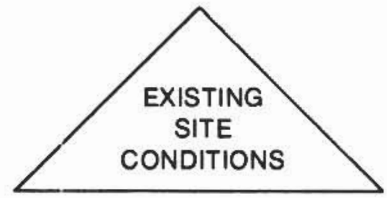
Because silvicultural activities change certain landscape characteristics, primarily by causing soil disturbance, by altering the vegetative cover, and by changing local drainage patterns, the generation and transport of potential pollutants may be accelerated. Utilization of effective control techniques must then be considered.

In this handbook, control techniques are grouped into procedural, preventive, and mitigative categories. Procedural controls are those concerned with administrative actions. Preventive controls apply to the pre-implementation, planning phase of a silvicultural activity. Mitigative controls are physical, chemical, or vegetative measures applied to ameliorate problems that exist now, as well as those that may exist after a silvicultural activity has taken place.

Procedural, preventive, and/or mitigative control practices can be prescribed for various reasons, commonly including: (1) protection of water quality, (2) protection of capital investments such as roads and buildings, and (3) protection of site productivity. It may not be necessary to specifically formulate controls for water quality because the controls imposed for site protection may be adequate to meet water quality objectives. It is logical to first design a management plan to insure protection of site productivity and capital investments. If subsequent analyses show such a plan to be inadequate to meet water quality objectives, additional controls can be prescribed as needed.

The control measures are presented in four different ways. First, there is an activity-impact list that describes each silvicultural activity and its associated resource impacts. Next there is a list of resource impacts and possible control opportunities. Then each control is presented in a series of tables that display their relationship to the variables in each of the technical chapters. Finally, there is a description of each control and whether it is procedural, preventive, or mitigative.

Figure I.1 is a general flow diagram which summarizes the control selection process. This process is explained on the following pages.



The existing water quality must be known so that any changes in the quality following the proposed silvicultural activity can be evaluated. It is essential that some base be established so that impacts can be properly assessed. The existing water quality and site conditions should be measured whenever possible. If this is not feasible, then the existing water quality may be simulated using the procedures provided in the technical chapters or locally derived procedures that have proven effective.

The existing water quality will be greatly influenced by the history of the site, specifically natural (fires, floods, etc.) and man-induced (previous silvicultural operations, mining, etc.) disturbances. It must be determined if the site has been previously disturbed and if the disturbance is a contributing non-point source.

EVALUATION OF WATER QUALITY FOR UNDISTURBED AREAS

The measured or simulated water quality for an undisturbed site or a site that has previously been disturbed but no longer has contributing non-point sources is compared to the water quality objectives that have been established for the site. The objectives should not be exceeded. If they are exceeded, the objectives may be incompatible with the natural conditions and should be reviewed by the appropriate authority.

EVALUATION OF WATER QUALITY FOR DISTURBED AREAS (POSSIBLE APPLICATION OF CONTROLS)

The measured or simulated water quality for a disturbed site is compared to the water quality objectives that have been established for the site. If the objectives are exceeded, mitigative controls should be considered to ameliorate existing non-point sources. If the application of mitigative controls is not feasible, the objectives can be reviewed by the appropriate authority or the management of the site can be reevaluated.

DEFINE PROPOSED SILVICULTURAL ACTIVITY (POSSIBLE APPLICATION OF CONTROLS)

The control opportunities can be used as a reference to help in the formulation of the initial silvicultural plan. Mixtures of preventive, mitigative, and procedural controls can collectively become a silvicultural plan.

EVALUATION OF WATER QUALITY RELATED TO PROPOSED SILVICULTURAL ACTIVITY (SIMULATED)

The water quality that will follow the proposed silvicultural activity is estimated using the simulation procedures provided in the technical chapters or locally derived procedures that have proven effective. The same simulation procedures used for evaluating the existing conditions must be used to simulate the post-silvicultural activity water quality.

COMPARE TO WATER QUALITY OBJECTIVES

The estimated post-silvicultural activity water quality is compared to the established objectives. If the objectives are not exceeded, the proposed silvicultural activity is compatible and may be considered technically acceptable. If the objectives are exceeded, control opportunities should be evaluated and incorporated into a revised silvicultural plan where appropriate.

OBJECTIVES NOT MET (POSSIBLE APPLICATION OF CONTROLS)

When the proposed silvicultural activity results in non-point source pollution such that the water quality objectives are exceeded, control opportunities are evaluated that could be used to reduce these potential impacts. Preventive controls are initially evaluated, and those that are determined to be feasible are incorporated into the silvicultural activity plan. The revised silvicultural activity plan, including additional preventive controls, is evaluated using the simulation procedure. If the estimated water quality following the revised silvicultural activity meets the objectives the activity is considered technically acceptable from a water quality standpoint. If the objectives are exceeded, mitigative controls are evaluated; and those that are determined to be feasible are incorporated into the plan. The revised silvicultural activity plan, including both preventive and mitigative controls, is evaluated using the simulation procedure. The resulting estimated water quality is compared to the objectives. New controls may replace portions of the silvicultural plan or may be simply added to it to form a revised plan. It is recommended that several mixes of controls that meet water quality goals be formulated and presented to the manager.

WATER QUALITY OBJECTIVES MET

The proposed silvicultural activity is technically acceptable if the simulated water quality following that activity meets the objectives set for the stream or stream segment. Implementation follows the appropriate economic and social evaluations. If the proposed silvicultural activity would result in a degradation of water quality that would exceed the objectives, controls should be instituted and the plan revised to incorporate them. If the objectives would be exceeded even when controls have been considered, the objectives should be reviewed or the land uses for the site should be reevaluated.

PROCEDURAL SUMMARY FOR CHAPTER III: HYDROLOGY

The technical procedure begins with a description and an analysis of the hydrologic system of the area under study. Among the many variables considered in the evaluation are precipitation, evapotranspiration, soil water status, and streamflow. All of these variables influence, either directly or indirectly, the availability of energy for generation and/or transport of non-point source pollutants. Thus, results of the hydrologic analyses provide essential input for analysis of non-point source pollution potentials using methods described in subsequent chapters.

Hydrologic response to silvicultural activities varies greatly from region to region, as well as from site to site within a hydrologic region. For those hydrologic regions where snowfall dominates the hydrologic cycle, all pertinent processes, including snow redistribution, are discussed, and methods are presented for evaluation. However, in other parts of the country, some processes, such as snow redistribution are not significant. To account for these regional hydrologic differences, guidelines are presented for modifying the basic, more comprehensive analytic framework.

The objective of this evaluation is to estimate the amount of water potentially available for streamflow that is generated before and after a proposed silvicultural activity. Water available for streamflow is distributed either as an annual hydrograph in which 6-day average discharge values are plotted or as a flow duration curve in which 7-day average discharge values are calculated. Figure I.2 is a flow diagram that outlines the principal steps of the hydrology analysis. A description of the flow diagram follows.

DOMINANT PRECIPITATION

The hydrologic evaluation procedure for rainfall dominated regions differs from the hydrologic evaluation procedure for snowfall dominated regions. The predominant form of precipitation is determined, and the corresponding hydrologic evaluation procedure is selected.

RAINFALL DOMINATED AREAS

RAIN

If rainfall dominates the precipitation regime of the watershed of interest, the procedure as outlined below is applied.

SEASONAL PRECIPITATION

An estimate of seasonal precipitation is needed.

SEASONAL EVAPOTRANSPIRATION

Seasonal evapotranspiration is either estimated input or estimated using regional graphs which relate evapotranspiration to season of the year. Latitude is an additional variable needed for the Appalachian Mountain and Highland hydrologic region.

SEASONAL EVAPOTRANSPIRATION ADJUSTED FOR LEAF AREA INDEX REDUCTION AND ROOTING DEPTH

The leaf area index before and after the proposed silvicultural activity is estimated in the field or is derived from basal area-leaf area index relationships developed for the hydrologic region. A reduction in leaf area index results in less water lost through evapotranspiration, which in turn leaves more water available for streamflow. Rooting depth, a reflection of soil depth, influences the

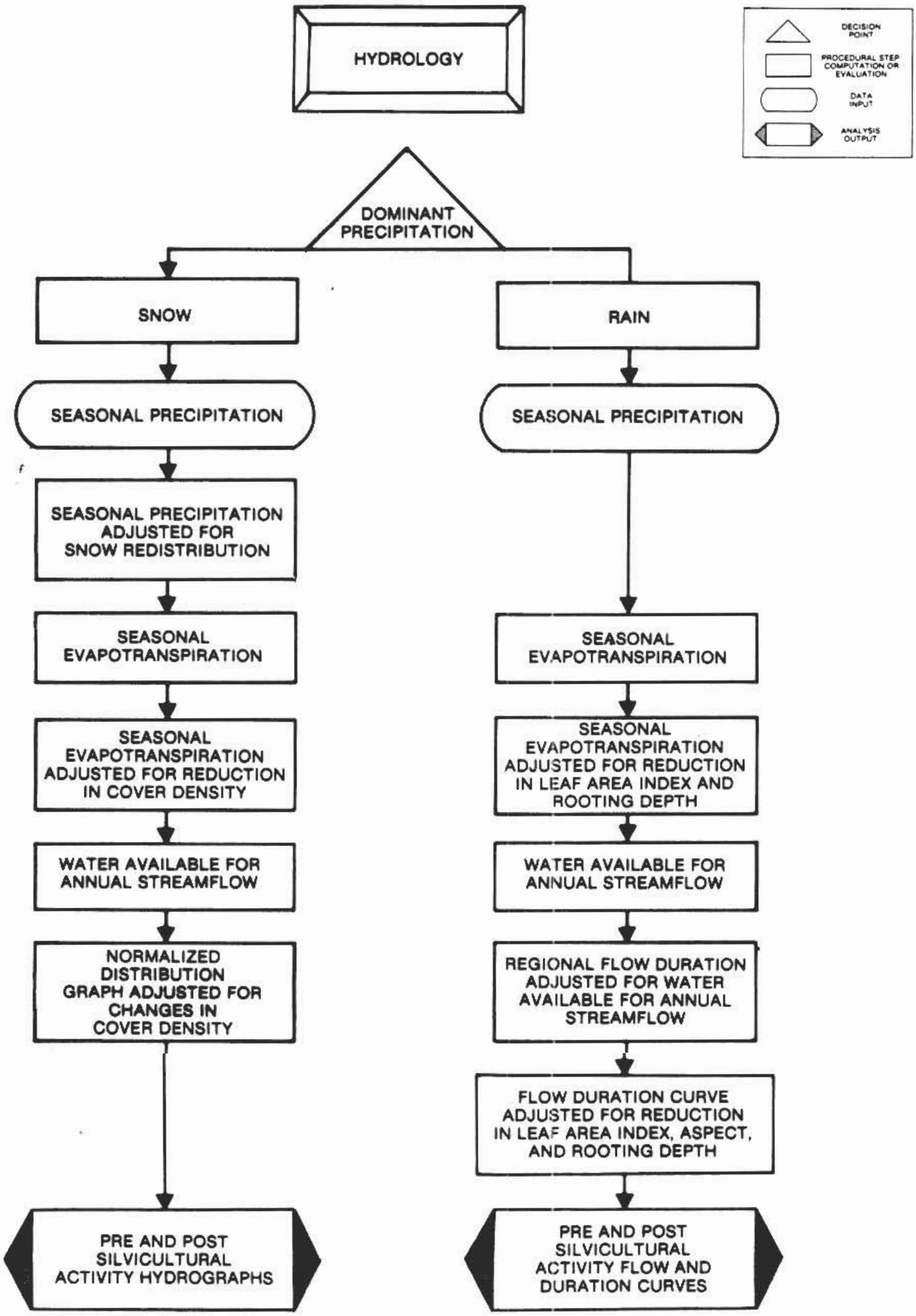


Figure I.2.—Generalized flow diagram for the hydrology analysis.

amount of water available for evapotranspiration. Greater storage capacity results in more water being available to evapotranspiration loss.

WATER AVAILABLE FOR ANNUAL STREAMFLOW

Water available for seasonal streamflow is calculated by subtracting adjusted seasonal evapotranspiration from seasonal precipitation. Summation of water available for seasonal streamflows results in water available for annual streamflow.

REGIONAL FLOW DURATION CURVE ADJUSTED FOR WATER AVAILABLE FOR ANNUAL STREAMFLOW

A regional flow duration curve is selected from those provided or is supplied by the user. It is adjusted for the water available as annual streamflow prior to the silvicultural activity. The flow duration curve is based upon 7-day average discharge values.

FLOW DURATION CURVE ADJUSTED FOR REDUCTION IN LEAF AREA INDEX, ASPECT, AND ROOTING DEPTH

The post-silvicultural activity flow duration curve is calculated by adjusting the pre-silvicultural activity flow duration curve for the leaf area index reduction and aspect and rooting depth for the site. This is done with a least squares equation.

PRE- AND POST-SILVICULTURAL ACTIVITY FLOW DURATION CURVES

Pre- and post-silvicultural activity flow duration curves for 7-day average values are plotted.

SNOW DOMINATED AREA

SNOW

If snow dominates the precipitation regime of the watershed of interest, the procedure outlined below is applied.

SEASONAL PRECIPITATION

An estimate of seasonal precipitation is needed.

SEASONAL PRECIPITATION ADJUSTED FOR SNOW REDISTRIBUTION

For geographic areas in which snow redistribution is likely, the size and orientation of open areas must be known to evaluate the potential redistribution of snow. The amount of snow that is redistributed is determined largely by the size of the opening in the overstory.

SEASONAL EVAPOTRANSPIRATION

Seasonal evapotranspiration is either estimated input or estimated using regional graphs which relate precipitation and aspect to evapotranspiration. More water is lost by evapotranspiration from southern aspects than from northern aspects.

SEASONAL EVAPOTRANSPIRATION ADJUSTED FOR REDUCTION IN COVER DENSITY

A reduction in cover density may result in a reduction of evapotranspiration loss. Cover density changes may be estimated from basal area-cover density relationships.

WATER AVAILABLE FOR ANNUAL STREAMFLOW

Water available for seasonal streamflow is calculated by subtracting adjusted seasonal evapotranspiration from seasonal precipitation. Summation of water available for seasonal streamflow yields water available for annual streamflow.

NORMALIZED DISTRIBUTION GRAPH ADJUSTED FOR CHANGES IN COVER DENSITY

The normalized distribution graphs for the hydrologic region are selected. These graphs represent the distribution of annual flow as a percentage which occurs during consecutive 6 day intervals. Distribution graphs are presented for open and fully forested areas. Interpolation is necessary to obtain a normalized distribution graph for silvicultural treatments intermediate to fully forested and open.

PRE- AND POST-SILVICULTURAL ACTIVITY HYDROGRAPHS

Multiplication of values on the normalized distribution graph by the water available for annual streamflow and a conversion factor results in a hydrograph with units of cubic feet/second. Hydrographs for each silvicultural activity area are calculated separately and then summed to give the pre- or post-silvicultural activity hydrograph for the entire watershed.

PROCEDURAL SUMMARY FOR CHAPTER IV: SURFACE EROSION

A Modified Soil Loss Equation is presented as a method that may be used to estimate surface erosion from disturbed sites. Tables, graphs, and equations are used for the evaluation process. To apply these tools, information characterizing soils, topography, and ground cover must be obtained for a given site.

The objective of this analysis procedure is to estimate the quantity of accelerated soil loss (tons/year) and the amount that might reach a stream under given silvicultural activity conditions. Soil loss is based on four factors to evaluate the detachment of soil particles on a site. If this detached material is not delivered to a water course, there will be no degradation of water quality.

Estimates of sediment which may be delivered to a stream system are based on eight factors. The model delivers eroded material across a reference boundary, such as out of a clearcut block and into an adjacent area.

Figure I.3 is a flow diagram that outlines the principal steps involved in a surface erosion evaluation. A narrative explaining the flow diagram follows.

ONSITE ESTIMATED SURFACE SOIL LOSS

Estimated potential surface erosion is based upon a modified version of Wischmeier and Smith's Universal Soil Loss Equation. Modifications were made to adopt their equation to forested situations and silvicultural activities. The modified equation uses the four following factors: (1) rainfall, (2) soil erodibility, (3) slope gradient and slope length of disturbed site, and (4) the vegetation present and management applied. The solution of the equation gives estimated soil loss in tons/acre/year. When multiplied by the acres disturbed, the result is tons/year.

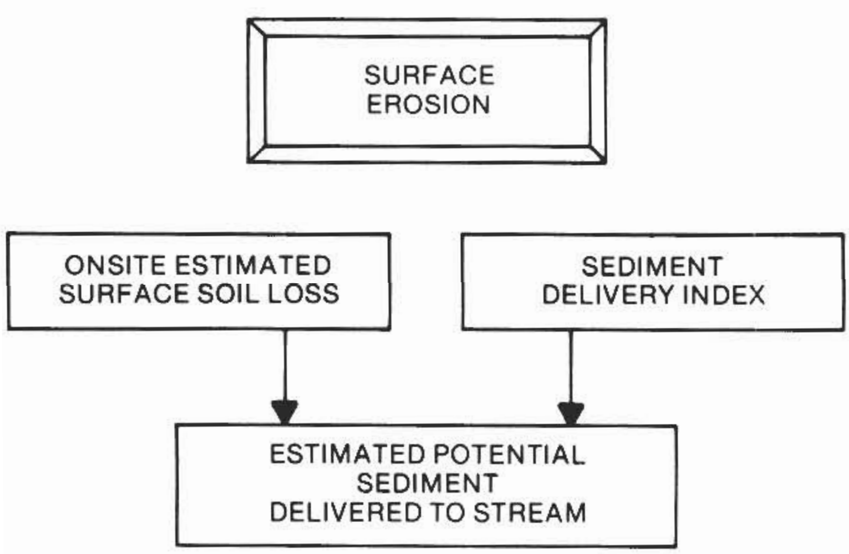


Figure I.3.—General flow diagram for the surface erosion analysis.

SEDIMENT DELIVERY INDEX

The delivery index is used to estimate the amount of eroded material on a disturbed site that might reach the closest stream channel. The index is estimated from factors that are assumed to control sediment delivery: (1) available water for surface runoff, (2) texture of the eroded material, (3) amount of ground cover present in the area between the disturbed site and stream channel, (4) overall slope shape, (5) slope gradient of the land, (6) distance material must travel between the disturbed site and stream channel, (7) surface roughness, and (8) special characteristics of a local site, if applicable.

The delivery index represents the fraction of the available sediment which might reach a stream.

ESTIMATED POTENTIAL SEDIMENT DELIVERED TO STREAM

The onsite annual estimated surface soil loss in tons/year is multiplied by the delivery index to obtain an estimate of the quantity of material that may be delivered to a stream. The result is in tons/year. This estimated value is required as input into the analysis of total potential sediment production (chapter VI).

PROCEDURAL SUMMARY FOR CHAPTER V: SOIL MASS MOVEMENT

The chapter on soil mass movement provides a method for identifying and qualitatively assessing the site factors and management activities that increase the hazard of soil mass movement. Soil mass movements are classified into two general types: (1) the debris avalanche-debris flow, and (2) the slump-earthflow. Overall ratings can be made in terms of high, moderate, or low hazard.

Only material that is delivered directly to a channel system is considered under soil mass movement. It is recognized that mass movement produces a supply of erodible material that may reach stream channels at a much later date than the actual mass movement event and that considerable onsite resource damage may occur. Unless the material reaches a channel, however, no water quality degradation would occur. The effect that any failure will have on water quality degradation depends primarily on the size and volume of material reaching a channel and the energy of the stream system for transport.

The information obtained from the soil mass movement evaluation is used as input to the total potential sediment estimation (chapter VI).

The objective of this analysis procedure is to estimate the hazard of a soil mass movement and to estimate the quantity of mass movement material, in tons, that may be deposited in a water course given the pre- and post-silvicultural activity conditions. Silvicultural activities may have the potential to increase the hazard and/or size of a mass movement occurrence as well as the amount of material that may reach a stream.

Figure I.4. outlines the principal steps for the soil mass movement analysis. A description of those steps follows.

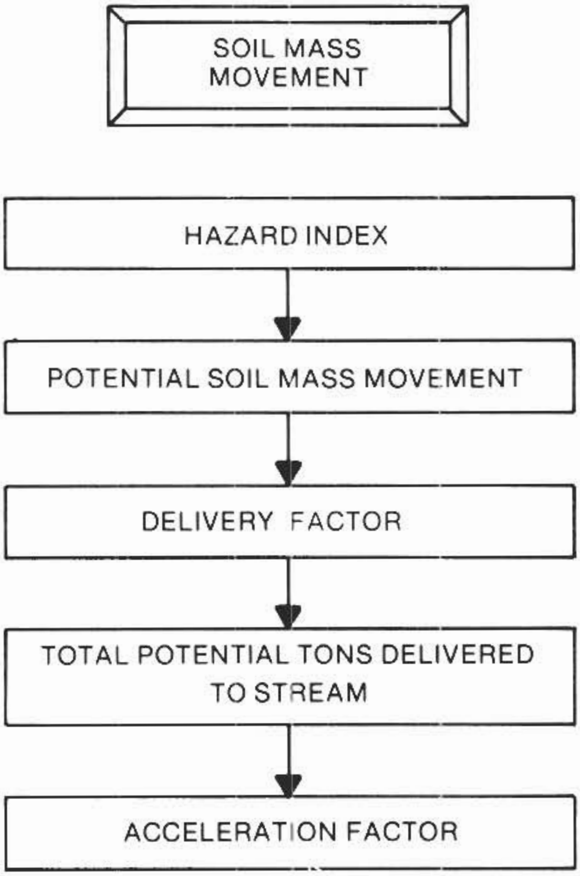


Figure I.4.—General flow diagram for the soil mass movement analysis.

HAZARD INDEX

The hazard index of a soil mass movement occurrence is determined by the type of movement, slump–earthflow versus debris avalanche–debris flow, and a variety of onsite parameters and silvicultural activities. The more critical factors include: (1) slope gradient, (2) slope configuration, (3) soil depth, (4) soil texture, (5) bedding structure and orientation, (6) precipitation, (7) drainage, (8) vegetation, (9) harvest methods, and (10) roads. The result of this subjective evaluation is a hazard index—high, medium, or low. The hazard index indicates the intensity of analysis that may be necessary to adequately evaluate mass movement.

POTENTIAL SOIL MASS MOVEMENT

The potential quantity of mass movement, in tons, that could occur is estimated. The average volume of mass movement that has occurred on the site in the recent past is determined by type (slump-earthflow, or debris avalanche-debris flow), or a subjective estimate is made where there is no history of mass movement. The volume of material is converted to tons based upon the type and bulk density of material that would be carried in a mass movement event.

DELIVERY FACTOR

The quantity of material in tons that would be delivered to a stream is estimated according to: (1) type of mass movement, (2) position of failure on slope, (3) slope gradient, and (4) uniformity of slope. The delivery factor is expressed as a percent.

TOTAL POTENTIAL TONS DELIVERED TO STREAM

The potential mass movement in tons is multiplied by the delivery factor to estimate the quantity of material that would enter a stream. The results are expressed in tons.

ACCELERATION FACTOR

For determination of the quantity of soil mass movement delivered to a stream channel due to silvicultural activity, measurements should be made on an area with similar characteristics and a history of silvicultural activity comparable to that being proposed for the area under analysis. The ratio of soil mass movement due to silvicultural activity to that from natural causes is given as an acceleration factor. The potential increase in soil mass movement due to implementation of the proposed silvicultural activity can be estimated by multiplying the acceleration factor by the natural soil movement occurring on the area. This estimated value is used as input into the total potential sediment analysis (chapter VI).

PROCEDURAL SUMMARY FOR CHAPTER VI: TOTAL POTENTIAL SEDIMENT

This chapter provides an analytical framework for evaluating potential changes in sediment discharge associated with silvicultural activities. Changes in sediment discharge due to introduced sources (surface erosion and soil mass movement) and flow related increases are evaluated.

The quantitative evaluation of suspended sediment and bedload sediment is based on locally derived regression equations. These procedures are designed to be used below the silvicultural activity, generally at the mouth of third order drainages. Impacts to channel geometry are qualitatively evaluated using bedload transport-stream power curves developed from local data.

Figure I.5 outlines the principal steps for the total potential sediment analysis.

SUBDRAINAGE AND STREAM REACH CHARACTERIZATION

After a suitable site has been selected, data can be collected for the suspended sediment and bedload rating curves. This data should be obtained on a third order drainage that is below the proposed silvicultural activity. To evaluate effects of channel encroachments, stream reaches immediately below or adjacent to the silvicultural activity should be selected for a quantitative evaluation.

The soil mass movement and surface erosion analyses, as outlined in chapters IV and V, characterize the subdrainage with respect to the introduced sources that are a result of the proposed silvicultural activity and provide input into the total potential sediment calculations.

STREAMFLOW HYDROGRAPHS OR FLOW DURATION CURVES

The streamflow hydrographs or flow duration curves for the pre- and post-silvicultural activities are obtained from "Chapter III: Hydrology."

SEDIMENT RATING CURVES AND CHANNEL STABILITY

Measured suspended sediment concentrations and concurrent stream discharges for a wide range of flows collected on the third order drainage are plotted. The relationship can then be expressed mathematically in a sediment rating curve. Using the pre- and post-silvicultural activity hydrographs, the change in suspended sediment discharge is calculated in tons/year. Appropriate data should also be collected on the third order stream reach so that a channel stability rating may be made. This data may be used to form a basis for determining the limits for stream stability changes.

INTRODUCED SOURCE SOIL MASS MOVEMENT COARSE AND FINE

The output from the soil mass movement analysis described in chapter V is expressed in terms of total potential tons of material delivered to the stream. The quantity of material is an estimate of the total potential soil mass movement material that may be delivered to the closest available drainageway following the silvicultural activity. The total volume of material is expressed as the percentage of coarse and of fine (wash load) material. Assuming this material is all available during the first year after the activity, the percent of fines can be used as a part of the total suspended sediment that is compared with the water quality objective.

The coarse material is used with the bedload-transport stream power curve to provide a qualitative estimate of potential stream channel changes. The total volume is one component of the total sediment of all sources that are available within the watershed.

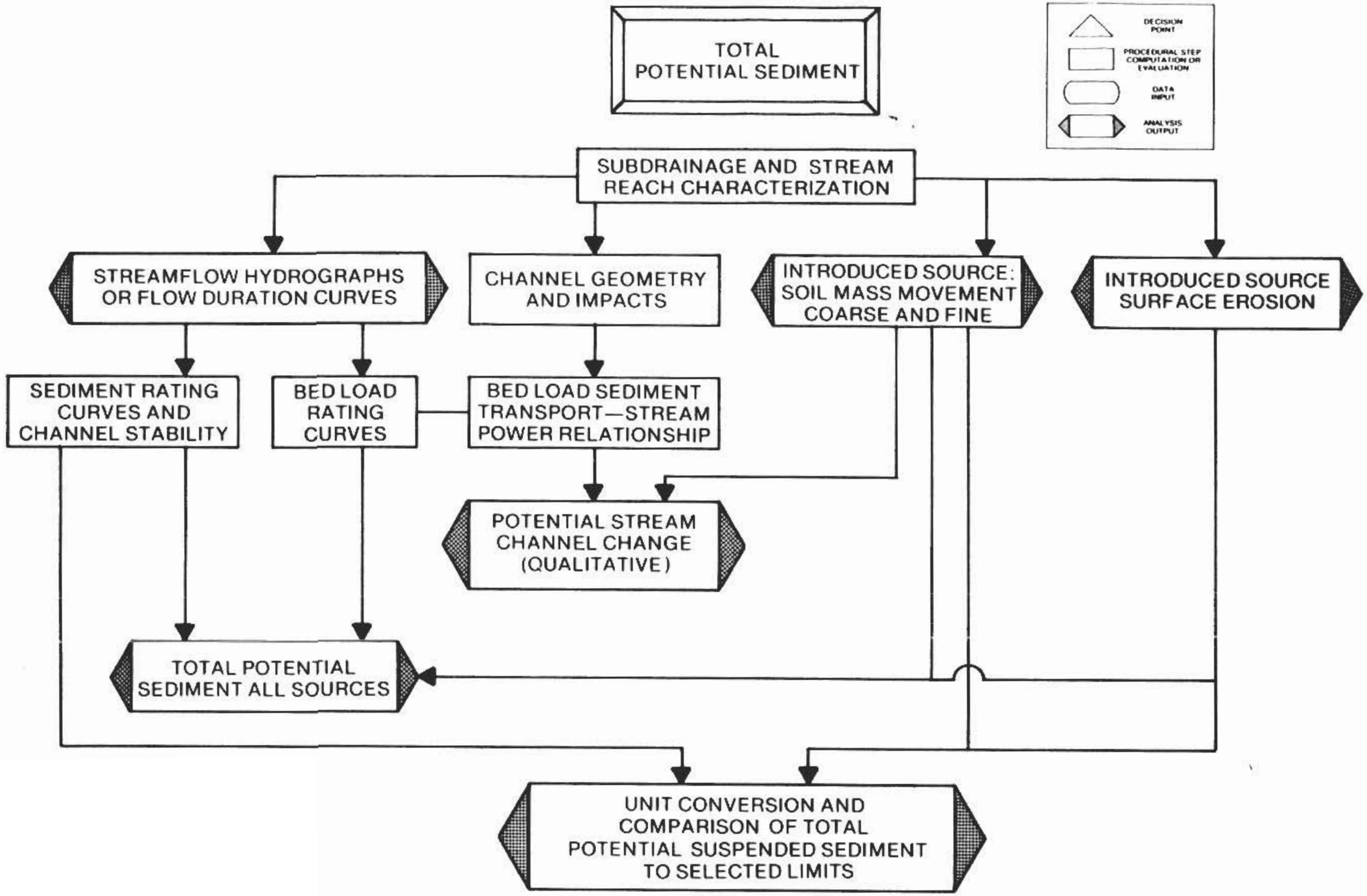


Figure I.5.—General flow diagram for the total potential sediment analysis.

INTRODUCED SOURCE SURFACE EROSION

This is the volume of delivered eroded material introduced as a result of the silvicultural activity. It is expressed as tons/year. This volume is added to the total suspended sediment increases and compared to the water quality objective.

UNIT CONVERSION AND COMPARISON OF TOTAL POTENTIAL SUSPENDED SEDIMENT TO SELECTED LIMITS

Selected maximum limits for suspended sediment in milligrams/liter, as set by water quality objectives, are converted to tons for comparative purposes. Typical objectives may be state sediment standards or stream channel stability threshold limits.

All potential suspended sediment increases due to streamflow increases, surface erosion, and wash load (silts and clays) contributed from soil mass movement processes are combined. If the water quality objective has been exceeded, appropriate controls for the introduced sources must then be identified and a reanalysis performed.

BEDLOAD RATING CURVES

Applying the same procedures used for the suspended sediment rating curves, a bedload rating curve for the third order stream reach is prepared. Pre- and post-silvicultural activity hydrographs or flow duration curves are used to determine the flow-related changes in bedload discharge. These curves are also used to develop bedload-stream power relationships for a qualitative evaluation of stream channel response.

CHANNEL GEOMETRY AND IMPACTS

Changes in the variables affecting stream power are evaluated based on the potential changes anticipated for given silvicultural activities and measured channel characteristics. The calculations are utilized to obtain qualitative interpretations of stream channel response.

BEDLOAD SEDIMENT TRANSPORT-STREAM POWER RELATIONSHIP

This relationship is developed from measured bedload data and channel geometry for the third order stream. The variables are: (1) width, (2) surface water slope, (3) particle size of bed material in transport, (4) bedload transport rates, and (5) stream discharge, all obtained over a wide range of flows. This relationship is used to determine qualitative changes in channel response from introduced soil mass movement material and changes in stream power.

POTENTIAL STREAM CHANNEL CHANGES (QUALITATIVE)

This is a qualitative output of the changes that can be expected in terms of scour and deposition within a channel. These changes are due to alterations in stream power and/or introduced soil mass movement material.

TOTAL POTENTIAL SEDIMENT ALL SOURCES

This is a composite of increases in sediment discharge made available within the watershed as a result of silvicultural activity. It is composed of all sources of sediment including: (1) suspended sediment due to increased stream flow, (2) bedload sediment due to increased stream flow, (3) surface erosion from all sources, and (4) soil mass movement from all sources.

This is used to compare the pre-activity to post-activity sediment discharge. An index of the total potential increases can be determined. Although expressed in tons/year, temporal and spatial distributions are not analyzed.

PROCEDURAL SUMMARY FOR CHAPTER VII: TEMPERATURE

Increased water temperature can be either beneficial or detrimental to the water resource. For streams that are cooler than optimum, a moderate increase in temperature could increase productivity and have a beneficial effect on the aquatic environment. However, streams having temperatures that approach critical threshold limits during the summer months could reach lethal levels if these temperatures were increased.

When the removal of shading vegetation along stream channels increases the stream's exposure to heating from solar radiation, it also increases the potential for a rise in water temperature. The magnitude of the increase is a function of the following variables: (1) the amount of canopy removed, (2) length of time the stream is exposed to direct solar radiation, (3) streambed material, (4) stream width, (5) stream discharge, and (6) subsurface inflow. The described procedure, based upon the use of a temperature model, provides a means of assessing the influence of these variables as they are affected by silvicultural activities and control practices. Downstream temperature changes are evaluated using a mixing ratio.

The objective of this procedural analysis is to estimate the maximum potential daily temperature increase (in degrees Fahrenheit) above the pre-silvicultural activity water temperature. Silvicultural activities may remove vegetation that provides shade to the water surface. The loss of this shading may result in increased water temperatures.

Figure I.6 outlines the principal steps in evaluating the potential change in stream temperature.

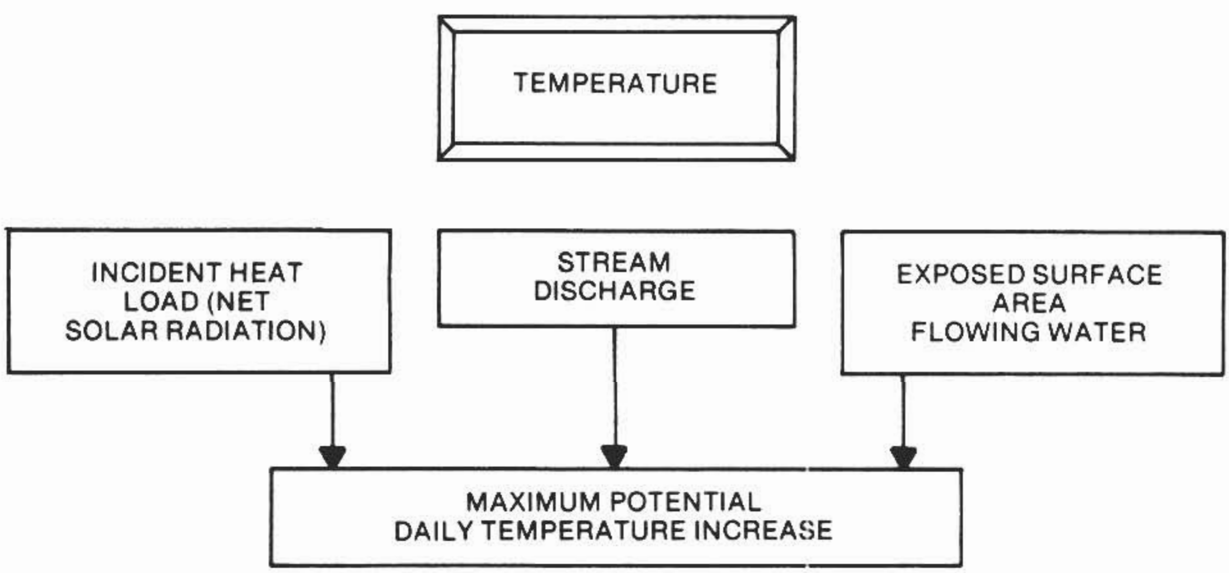


Figure I.6.—General flow diagram for the temperature analysis.

INCIDENT HEAT LOAD (NET SOLAR RADIATION)

Incident heat load (net solar radiation), H, is the source of heat influx that causes the water temperature to increase. The amount of solar radiation that is received by a stream from the sun is determined primarily by: (1) latitude of the site, (2) time of year, and (3) time of day. These variables have been combined in figures and graphs and an estimated value of net solar radiation in BTU/ft^2-minute is obtained.

STREAM DISCHARGE

The magnitude of the water temperature increase is determined in part by the volume of water that is flowing in the stream. Discharge should be measured during the time of year when water temperature is critical for pre-silvicultural activity conditions. However, if the hydrology analysis (chapter III) indicates that there may be a significant change in discharge during this critical time period following the silvicultural activity, the discharge estimated by the hydrology analysis should be used. Discharge is expressed as cubic feet/second.

EXPOSED SURFACE AREA FLOWING WATER

Net solar radiation acts as a direct heat influx only when the radiation strikes the exposed water surface. Shading keeps this radiation from striking the water surface. However, because streams are generally not completely shaded, some solar radiation strikes the water surface even in the undisturbed condition. Silvicultural activities may not completely expose the stream. Brush, shrubs, noncommercial tree species, and/or trees remaining after a portion of a stand is cut may provide some shade. The surface area of a stream exposed by the silvicultural activity must be estimated in square feet.

MAXIMUM POTENTIAL DAILY TEMPERATURE INCREASE

Maximum potential daily temperature increase can be estimated by evaluating the factors noted above: (1) net solar radiation, (2) discharge, and (3) exposed surface area of flowing water. The estimated temperature increase above the pre-silvicultural activity water temperature is given in degrees Fahrenheit. This estimated increase is compared to water quality objectives for stream temperature.

SUMMARY OF CHAPTER VIII: PROCEDURAL EXAMPLES

An example is provided to illustrate the procedures that have been described in the preceding technical chapters. Two hypothetical watersheds with proposed silvicultural activities, one in a rain-dominated area and one in a snow-dominated area, are presented. Each step in the various procedures is described, along with the data needs and any subjective evaluation that is required. Use of the control chapter is also illustrated to select preventive and mitigative controls.

SUMMARY OF CHAPTER IX: DISSOLVED OXYGEN AND ORGANIC MATTER

Silvicultural activities can potentially reduce the concentration of dissolved oxygen in the water to the lethal level for some aquatic species through introduction of organic materials and increased water temperatures. The state-of-the-art is such that it is not possible to rigorously quantify the impacts associated with the introduction of organic material to the aquatic system. This chapter describes, in general terms, the processes involved and identifies situations which may create undesirable consequences.

Water temperature, elevation, aeration potential, type of aquatic life present, and stream uses are considered in the discussion. Essential control measures can then be selected to protect the values involved.

SUMMARY OF CHAPTER X: NUTRIENTS

Nitrogen and phosphorus are the nutrients generally cited as having the greatest potential for impacting water quality in a forest environment. Streams may show symptoms of overenrichment if there is a continuous supply of nutrients and substantial periods of low water flow, but generally there is minimal opportunity for buildup of nutrients in streams due to continual transport by water.

The discussion in this chapter places major emphasis on the sources of nitrogen and phosphorus in the forest environment, the intracycle processes in the forest, and the nitrogen and phosphorus outputs from the forest.

Models for predicting soluble and insoluble nutrient losses from silvicultural activities are not sufficiently developed and tested for general application. Therefore, only qualitative guidelines are given for evaluating soluable nutrient changes within a system.

SUMMARY OF
CHAPTER XI: INTRODUCED CHEMICALS

Fertilizers and pesticides (insecticides, herbicides and fungicides) are chemicals commonly introduced into a watershed as part of silvicultural activities. Introduced fertilizers enter a water course by direct application of fertilizer to the water surface or by leaching and subsequent subsurface flow of dissolved compounds or decomposition products. The impact of pesticides on water quality depends primarily on the following five factors: (1) toxicity to man and aquatic organisms, (2) mobility, (3) persistence, (4) accuracy of placement, and (5) orientation to streams.

This chapter is directed primarily to a discussion of the types of pesticides and fertilizers used, and to the types of impacts that have been observed on-site and in the aquatic ecosystem. The disposition of introduced chemicals in the forest environment is discussed. Because procedures for quantifying the impacts have not been developed for general application, no attempt has been made to quantify control effectiveness.