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Title: An Analysis of Two Adjacent Agricultural Watersheds in West Central Oregon.

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Two small adjacent watersheds on the west-central edge of the Willamette Valley of western Oregon were studied. Information was gathered on existing conditions to determine the suitability of the two watersheds for a paired-watershed study design.

A soil survey was conducted using slightly modified soil series previously established for the area. Distributions of the major soil series in the two watersheds were compared. Four transects were sampled using extracted soil cores and hand augering. Results of the transects closely paralleled pre-existing geomorphic schemes. Land-use patterns of the two watersheds were identified and compared. Streamflow and suspended sediment levels of the two watersheds were monitored and the effects of eight storms were compared.

The soil survey revealed more diversity in the number of major soil series and greater percentages of heavier textured soils in watershed D3. Most of its forestland occurred on heavy textured soils,

whereas most of the forestland in watershed D4 occurred on moderate textured soils. Watershed D3 had almost twice the percentage of cultivated wheatland as watershed D4, whereas D4 had greater percentages of area in grassland. These differences suggest that the soils of D3 might have lower infiltration and permeability than the soils of D4, conditions which are more conducive to lower baseflows and greater runoff and erosion.

D3 has a fairly extensive tile drain network and D4 has three settling basins. The impact of these management structures is not apparent.

Streamflow, suspended sediment levels, and precipitation for eight storms were compared. Comparisons of hydrographs indicated different response times in storm hydrograph rise for D3 and D4. Determination of these delay factors and adjusting streamflow values accordingly revealed a highly significant relationship between the streamflow levels, indicating a consistent hydrologic relationship between D3 and D4. D3 had consistently lower baseflow levels than D4.

Comparisons of suspended sediment levels revealed consistently higher sediment levels in D3 which resulted in greater total yields in all eight storms.

These results indicate an unequal but consistent hydrologic relationship between the two watersheds and that they are suitable for a paired-watershed study design.

An Analysis of Two Adjacent Agricultural Watersheds in West Central Oregon

by

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TABLE OF CONTENTS

List of Figures

List of Tables

AN ANALYSIS OF TWO ADJACENT AGRICULTURAL WATERSHEDS IN WEST CENTRAL OREGON

Chapter 1. INTRODUCTION

In recent years there has been increasing interest in non-point source pollution and water quality in rural areas. Watershed studies have proven to be a useful means to explore these topics. The diffuse nature of non-point source pollution complicates identification of contributing sources and conditions. Watersheds are naturally delineated, distinct hydrologic units which make up the landscape mosaic and provide a means of subdividing and simplifying the complex integrated nature of non-point source pollution.

Numerous watershed studies provide information on areas ranging in size from less than one square kilometer to many thousands (Rothacher, 1965). Most studies have been instituted by large organizations such as the U.S. Forest Service. Less information is available for smaller watersheds (e.g. less than 500 ha) frequently associated with small family farms. Of the pertinent studies, the more intensive investigations provide greater accuracy and detail in the information obtained. These intensive studies, however, can easily exceed the resources available to small groups of people. For these groups, more simplified study designs may provide the needed information at lower costs of equipment and manpower.

1.1. Objectives

The study was undertaken in response to the interest expressed by a group of small scale farmers of limited resources. The overall purpose was to evaluate a preselected study site in terms of existing water quality, specifically suspended sediment, and in terms of suitability of continued monitoring of the effects of management practices on water quality.

The primary goal of this study was to gather baseline or "current conditions" information on the study area. This generated two more specific objectives.

1) To compare and contrast two watersheds. The intent was to explore the similarities and differences of the two watersheds so as to determine the suitability of the study area for paired-watershed studies.
2) To tentatively determine if a consistent hydrologic relationship exists between the two watersheds. This would indicate the feasibility of assessing future land use manipulations on one of the watersheds, using the other as a control.

1.2. Literature Review

The wide variety of interests and objectives of watershed studies has generated numerous study designs of which no two are exactly the same. Different study designs provide different information and as such, are determined by the needs of the particular land-users.

1.2.1. Study designs

Most in-situ watershed studies are combinations or adaptations of four major types. Individual study modifications are the results of the particular study focus and the environmental conditions encountered. Some designs are general purpose with others being more specialized, each type having inherent strengths and associated limitations.

1.2.1.1. Individual Watersheds - investigations which involve the study of a watershed with little or no attention given to nearby or adjacent watersheds.

Some of the advantages of this design are that it is relatively simple and quick. Though such studies can be very detailed and complex, they are not further complicated by comparisons to other areas. Such studies generally require shorter calibration periods; as little as one year. This design is well suited for focusing on resource inventories (Young and Klawitter, 1968).

Some of the limitations of the design lie in the lack of flexibility and verifiability. Such studies generate information specific to only one site. Any extrapolation of information to other locales is at best hypothetical. All watersheds are susceptible to climatic variability. However, this design lacks an associated watershed or other means of separating watershed response to deliberate changes (ie. land use) from extraneous natural fluctuations.

1.2.1.2. Paired Watersheds - investigations of two watersheds in conjunction with one another.

The chief advantage of paired watershed studies is in providing a means of assessing the results of change(s) in vegetation, land use, management, etc., via comparison with a control watershed (see review by Ward, 1971). By understanding the relationships between the two watersheds, this design can represent a "before and after manipulation" comparison. This design also minimizes the masking effect which occurs when small changes in environmental conditions coincide with changes generated by watershed manipulation. For example, subsequent changes in streamflow might reflect climatic rather than treatment induced phenomena.

The limitations of this design result from its more extensive nature. A lengthy calibration period of three or more years is required before manipulation of one watershed can be undertaken, tying up materials and land-use (Ward 1971). Though some additional flexibility occurs, only a limited number of manipulations are possible per experiment run. Each run must be monitored for years with the control watershed unmanipulated. The latter in particular poses a much more difficult problem in agricultural than in forested lands.

Though this design facilitates the identification of small precipitation changes affecting hydrologic behavior, it remains susceptible to errors from more extensive climatic changes. Significant climatic changes can modify the response of one or both watersheds to the extent where the existing relationship becomes incompatible with the calibration relationship.

The paired watershed design was used in the first sound and successful watershed study, the classic Wagon Wheel Gap Experiment (Bates and Henry, 1928). It was also the initial design of the Fool Creek

Watershed study (Martinelli, 1964) and the Coweeta Watershed study (Penman, 1963). All three sites have been instrumental in the investigation of changing water yields and quality associated with manipulations of forested watersheds.

1.2.1.3. Multiple Watersheds - comparisons involving more than two watersheds simultaneously to investigate changes in vegetation or management practices; essentially an expansion of the paired watershed design.

The chief advantage of the multiple watershed design is the greater number of comparisons that can be made during one experimental run. The multiple comparisons also make any hydrologic anomalies more evident because treatments can be compared to one another as well as to the control.

The primary disadvantages are the even longer calibration periods required (six to ten years) and the more extensive and expensive nature of the design (Ward 1971). A long term commitment of materials, funding, and control of the study area is necessary. Many of the existing studies required five to ten years for initial results and ten to twenty years for completion.

There are two variations of the overall design.

Adjacent - these are multiple watersheds that are contiguous or are in relatively close proximity to each other, such that they share essentially the same weather conditions. This was the design to which the Coweeta Experimental Watershed study was later expanded into the studies of streamflow changes resulting from hardwood harvesting techniques (Weitzman and Reinhart, 1957). It is also the design employed in the detailed streamflow calibration studies in the H.J. Andrews Experimental Forest in Oregon (Rothacher et. al., 1967). Wicht (1966) reported on its use, limitations, and suitability in Southern Africa.

Nested - multiple watersheds in which subwatersheds of larger ones are manipulated and compared. This was the design used at the Coulee Experimental Forest in Wisconsin to study interactions of cropland surrounded by hardwood forests (Curtiss, 1966).

1.2.1.4. Models - mathematical equations used in the attempt to empirically describe the functioning of watersheds. Virtually all watershed studies incorporate the use of statistical representations of hydrologic relationships, or modeling as a supplimentary tool. Many other studies have a primary focus of modeling in which field data represent the supplimentary, albeit initial, component.

Much progress has been made via the use of complex mathematical models to establish and portray the interrelationships among watershed parameters. Modeling constitutes an entire field in itself and is beyond the scope of this study. However, all modeling must ultimately be based upon data generated by in-situ watershed studies.

1.2.2. Focus Affects Study Design and the Type of Results

The focus of a study and the environmental circumstances determine the choice of study design. Existing studies pursue a variety of objectives such that techniques and subsequent results are often unique to a specific situation with only some overlap in design with other studies. Nonetheless, some major groupings of watershed investigations can be identified.

Streamflow manipulation - studies in which the primary goal is to observe changes in volume and timing of stream discharge resulting from land-use or management changes.

Discharge data are essential to watershed studies as they represent the integrated net functioning of complex basin systems. In these studies, discharge is the end product rather than just one of the many variables.

Vegetation modification in water-limited areas may decrease vegetative consumption and increase discharge values. Partial logging on Colorado's Fraser Experimental Forest caused significant increases in stream discharge (Goodell, 1958; Martinelli, 1964). Results from paired contiguous watersheds were assessed after a 12 year calibration period and a 5 year post treatment period. Results showed a 3 area-inch (23.5%) increase in annual water yield, mostly as increased spring runoff, with a slight increase in the low summer and early fall flows. The increased streamflow was attributed to decreased evapotranspiration and reduced vegetative interception.

In the Pacific Northwest, where precipitation levels are much higher, studies of logging effects on streamflow have generated similar results. Detailed watershed studies on the H.J. Andrews Experimental Forest (Rothacher et al., 1967; Rothacher, 1970) also demonstrated increased streamflow after logging. Three watersheds were compared after a 6 year and 10 year calibration period and a 5 year treatment-post treatment period. The dramatic increase of almost 18 area-inches in annual yield was attributable to the higher precipitation levels and greater storage capacity of the soils. 80% of the increased discharge occurred during the winter rains (October to March). With no noticable change in peak flows from the largest storms, the increased discharge was attributed to reduced transpiration and vegetative interception/evaporation. In both studies, logging resulted in a more rapid streamflow response to precipitation and a quicker recession in baseflow values after storm events.

Other streamflow studies have explored vegetative manipulation (e.g. reforestation) to maximize water retention. Short term delays and reductions in peak discharges are useful in flooding reduction. Long term delaying of average peak discharge can be useful in maintaining irrigation or hydroelectric sources over a greater period of time (Ward, 1971).

At Coshocton, Ohio paired watersheds showed an annual 0.3 area-inch decrease in streamflow following reforestation (Harrold et al., 1962). 70% of the decrease occurred during the dormant season, indicating increased interception losses and increased groundwater (baseflow) recharge. Results also showed a delayed response in streamflow attributed to increased infiltration.

Water quality - studies which focus on changes in water quality, particularly sediment levels, due to land-use or management changes.

Most watershed studies include water quality variables as indicator variables. Other studies use changes in water quality as a primary focus. At the Pine Tree Branch watershed in Tennessee, reforestation and erosion-reduction management achieved a small progressive decrease in annual stream discharge over the 5 year post-treatment period (TVA, 1955). Peak flows and sediment levels were significantly reduced and were attributable primarily to the conservation measures.

Other studies have investigated water quality via the effects of vegetation or management changes on the movement of fertilizers, herbicides, or insecticides (Ward, 1971).

General studies - some of the recent studies have been broader, focusing on the processes of watershed systems rather than just the net response to specific manipulations. Detailed energy and water balance studies attempt to break down watershed variables into their various subcomponents (Ward, 1971). Such subcomponent data collection requires extensive monitoring of all possible inputs and outputs of watershed hydrology and energy dynamics. The validity of these budgets is dependent upon comprehensive variable information and the accuracy with which it is collected. Difficulties still remain in adequately quantifying some variables (e.g. groundwater movement, variable transpiration rates, etc.) and thereby completing such budgets satisfactorily. Extensive use of mathematical models has been used in recent years to fill in variable gaps (Ward, 1971).

The extensive basic research program at Sleeper River watershed in Vermont (Johnson, 1969) is a contemporary, interdisciplinary approach to investigating the diverse contributing components in watershed processes. In addition to hydrologic and energy investigations the vegetation patterns and nutrient cycling conditions contributing to storm runoff are being evaluated. Such programs are fundamental in exploring the causes and specific nature of watershed processes.

Literally hundreds of studies have pursued the myriad types and consequences of human impact upon various watershed parameters. In addition to those mentioned, these include the effects of grazing, urbanization, stripmined land reclamation, and fire hazard reduction (Ward, 1971). But in all cases some type of "pre-existing conditions" analysis must be made available to provide the basis of assessing the results of changes in watershed conditions.

Chapter 2. CHARACTERIZATION AND COMPARISON OF THE WATERSHEDS

2.1. Introduction

2.1.1. General setting. The study area was located on the western edge of the Willamette Valley, northwest of the town of Dallas, in northern Polk County, Oregon (Fig. 1). The site was on one of several separate upland groups that constrict the Willamette Valley. This constriction divides the larger valley system into its northern and southern subcomponents (Beattie, 1962). The two larger upland groups immediately to the east of the study area have been designated the Amity and Eola hills (Baldwin 1976, Gerlderman 1970). The study site was located on the northern slopes of a smaller distinct upland unit just west of these hills. The site consisted of two adjacent watersheds (Fig. 2). The small streams within these watersheds coalesce as they flow down from the rounded hills out onto the broad valley floor. There they merge and drain into Salt Creek. The overall sloping trend is north-northwest facing, though slopes of all compass headings can be found.

The entire site was subdivided into quadrants for the convenience of the study. Instrumentation requirements and a desire to avoid tile drain fields resulted in measurement station placement close to the base of the hills. This slightly reduced the size of the study area from the natural topographic boundaries of the watersheds. The western watershed is 65.52 hectares in size and was designated as D3. The eastern watershed is 76.06 hectares in size and was designated as D4.

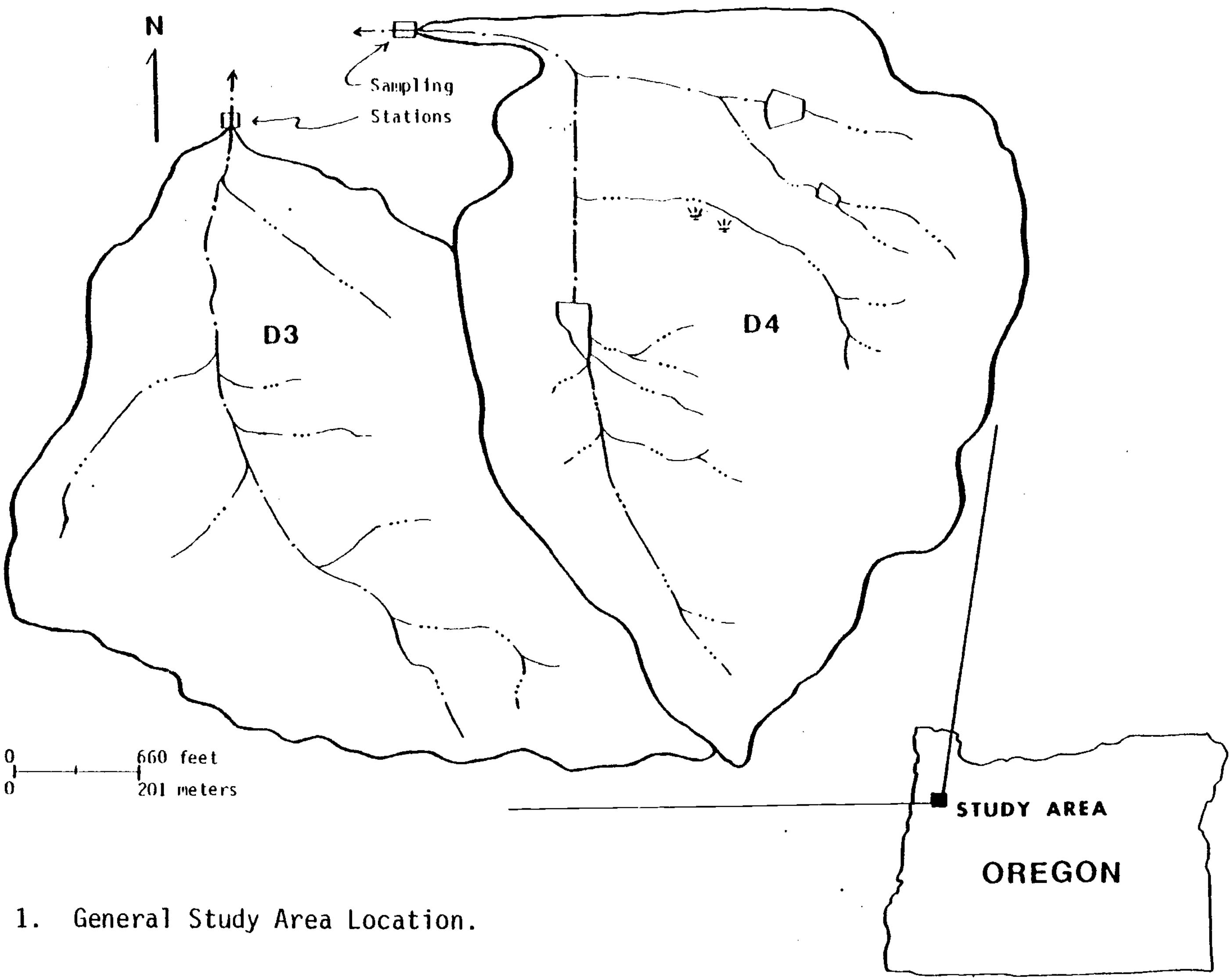

FIGURE 1. General Study Area Location.

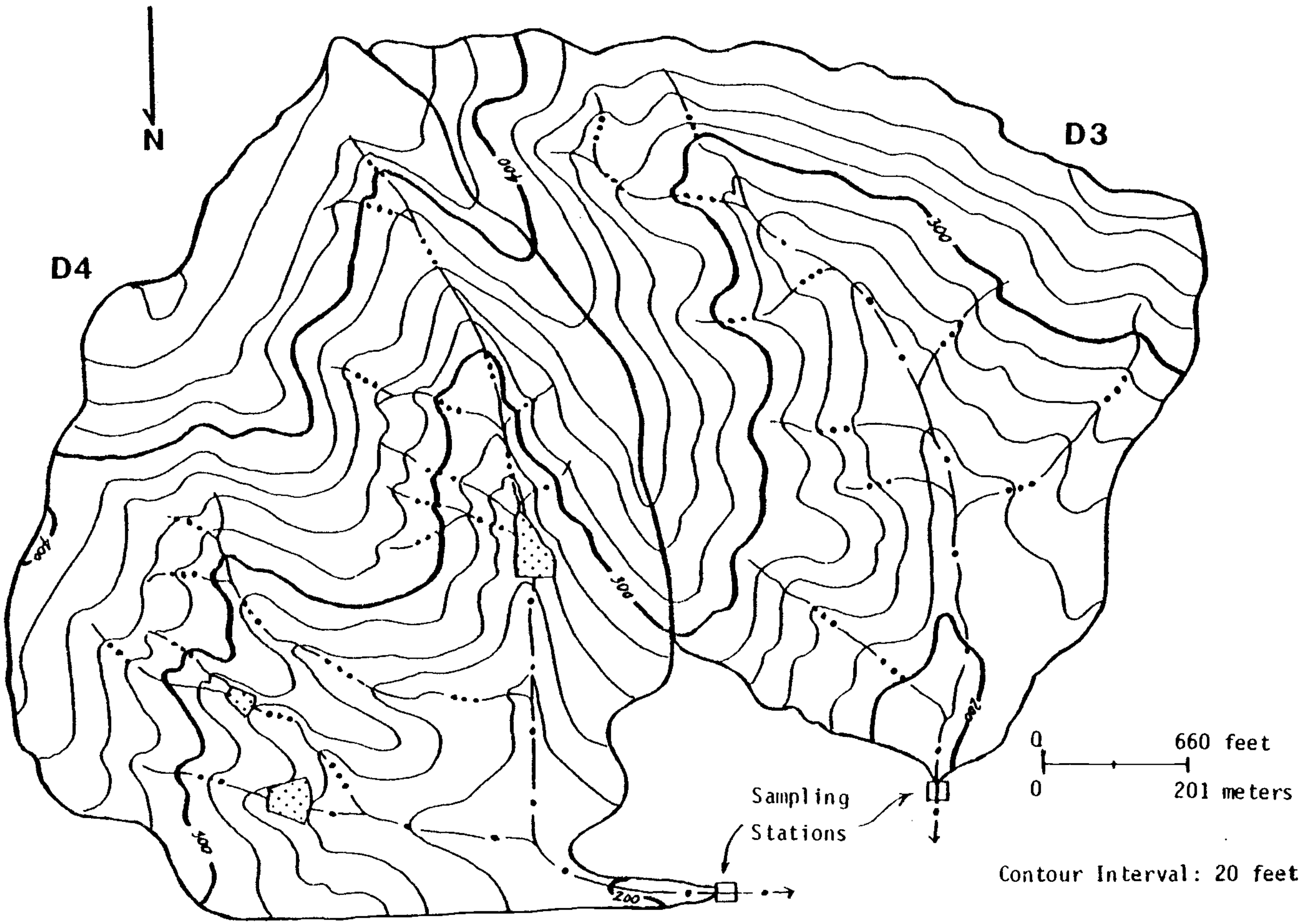

FIGURE 2. Topographic Map of the Study Area (after U.S.G.S., 1970). Orientation of this and subsequent maps are reversed.

Elevations ranged between 58 meters and 146 meters above sea level.

2.1.2. Climate. The climate of the Willamette Valley is a modified marine climate (Bates, 1980) characterized by cool wet winters and warm dry summers. The closest weather station is in Dallas, Oregon, 11.3 kilometers to the southeast. There the mean annual temperature is 10.9°C (51.6°F). The average annual January temperature is 3.4°C (38.2°F) and the average annual July temperature is 18.4°C (65.1°F). The average annual precipitation is 127.9cm (50.35 inches), of which an average 15cm (6 inches) occurs as snowfall (N.O.A.A., 1977).

2.1.3. Vegetation and Human Activities. The native vegetation patterns of the area have been altered by the long established agricultural practices in the vicinity. Most of the original oak stands and grassed-prairies have been converted to grain crops or pasture. Young dense Oregon White oak woodlots are extensive in the upper reaches of the watersheds and have a thick understory of wild rose, poison oak, snowberry and grasses. Douglas fir trees occur in the well established woodlots. Red alder occurs in the wetter forested areas. Cattails and sedges are common in the open wet areas, around stock ponds, and along waterways. Trailing blackberry, poison oak, wild rose, and isolated oak trees also occur along fence rows. A plum orchard once occupied a small area (2 ha) in D3, but the last trees were removed several years prior to this study. There are several small scattered groups of pear, plum, and apple trees in each watershed. Neighboring areas have extensive fruit and filbert orchards. Perennial grasses are also grown nearby, though not currently in the study area. Agricultural crops consist of winter wheat and some oats which cover the majority of the fields. Each year some of the fields are left fallow.

Sheep grazing was carried on near the farm residence complex contained in D4. An old, established road network throughout the study area has affected the peripheral watershed boundaries, particularly in D4. There, the truncation of small swales and the diversion of several ephemeral streams to road ditches are evident.

2.2. Geology

2.2.1. Regional. The Willamette Valley is the long, narrow, gently sloping trough bounded by the Cascade Mountain range on the east and the Oregon Coast range on the west. The Cascade range consists largely of volcanic rocks whereas the Coast range is comprised mainly of marine and nonmarine sedimentary rocks with some intercalated igneous rocks (Baldwin, 1976). The South Yamhill River drains a portion of the eastern side of the Coast range and its foothills and is a tributary of the Willamette River. Salt Creek, into which both watersheds drain is a tributary of the South Yamhill River.

2.2.2. Structure. The Southern Yamhill River Valley lies on the eastern edge of the Oregon Coast range geanticline. The valley consists of a broad easterly trending downwarp that runs roughly transverse to the northward trending folds which dominate the Coast range geanticline immediately to the west (Baldwin et al, 1955). Some scattered faults occur within the downwarp but not in the study area.

There are also minor folds and flexures within the valley system, of which the upland portion of the study area is an example. During this study, field observations of scattered erosional exposures, road cuts, and soil cores in the upland areas reveal extensive folds in the underlying rock strata. No overall sloping trend of the folds was discernable. A dominant sloping trend in porous rock strata can indicate subsurface watershed boundaries that are not the same as surface watershed boundaries.

2.2.3. Composition. The downwarp exposes successively younger rock in an easterly direction. In decreasing age, from west to east, the sequence consists of the Siletz River Volcanics, Tyee Formation Yamhill Formation, Nestucca Formation, Tuffaceous sedimentary rocks, gabbroic sills and dikes (Baldwin et al; 1955). Most of the formations are covered by Pleistocene and Holocene sediments (Fig. 3).

Field observations in the study area during the current study revealed interbedded layers of gray micaceous and tuffaceous shale, siltstone and thinly bedded fine sandstone. Occasional lenses or thin beds of coarse gray and black sandstone and small gravels were also observed during this study. Where these materials occur, they exhibit well defined stratification but poor grading. These strata weather rapidly at or near the surface resulting in an ubiquitous weathered "rind" or saprolite layer that can be many feet thick. These materials break down further to yield brightly colored yellow, red, and reddish brown silty clay loams and clays.

These mid-to-late Eocene deposits have been identified as the upper Nestucca Formation (Baldwin et al., 1955; Baldwin, 1964). The

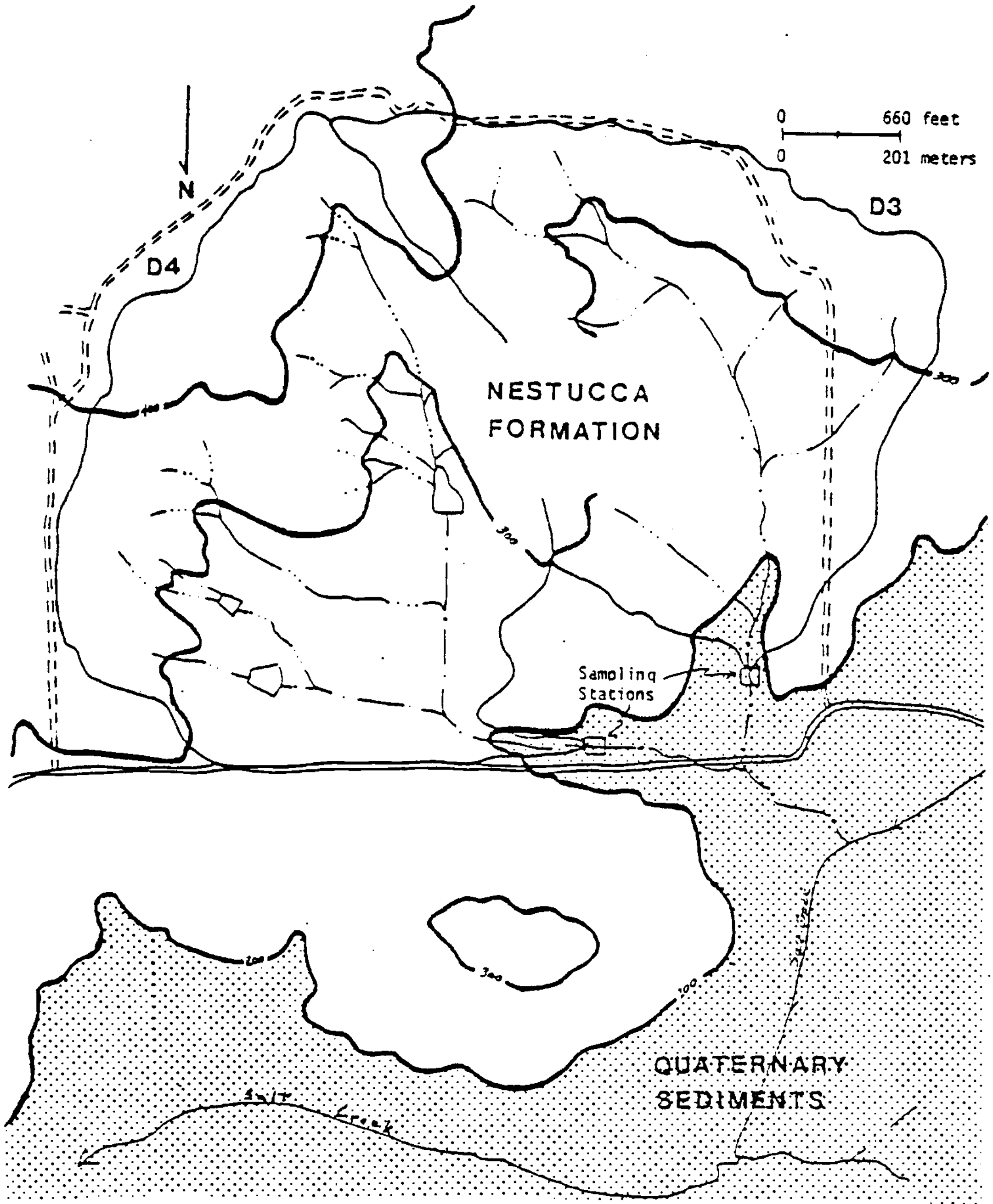

FIGURE 3. Geologic Map of the Study Area (after Baldwin et. al,1955).

distinctive diatomaceous fossil evidence and the usual basaltic and volcanic breccia flows, characteristic of the Nestucca Formation near the coast, phase out in a south-easterly direction and disappear completely in the vicinity of the study area. Later studies in the Dallas Quadrangle two kilometers to the south mapped portions of the same upland unit as including sandy micaceous siltstone components of the Spencer Formation (Baldwin, 1964). That and earlier work (Schlicker 1962) expanded the mapping of the Spencer Formation further to the north. This indicates the transitional nature between the upper Nestucca Formation and the Spencer Formation in and around the study area. The absence of the visual diagnostic criteria of the Nestucca Formation coupled with the similarities in composition, age, and occurrence with the Spencer Formation, indicate that the boundaries between the Nestucca and Spencer Formations in this area are largely arbitrary (Baldwin et al., 1955; Baldwin, 1964).

Mantling the sedimentary bedrock and its weathered crust below elevations of 122 m, are successive layers of Quaternary aged mixed alluvium and lacustrine sediments of the Rowland and Willamette Formations (Baldwin et al., 1955; Baldwin, 1976; Balster and Parsons, 1969). The silts are thin and indistinct near the 122 m elevation. They increase gradually in thickness and morphological clarity with decreasing elevation. Below the 67 m elevation, the sediments exceed two meters in thickness, and the nearly level lowland area is little affected by the deeply buried bedrock.

There are three distinct strata of alluvial deposits and weathered residuum. The oldest and lowermost are heavy-textured materials which show pronounced developmental features such as moderate to strong soil structure, common-moderately thick clay films and iron and manganese oxide concretions. This stratum, with its landscape and elevational occurrence and degree of development, is similar to the Diamond Hill and Elkins Road paleosols (Gelderman 1970; Glasmann, 1979).

The middle unit consists of brown to gray brown alluvial sediments. They tend to be lighter in texture, silty clay loams, and exhibit less pronounced developmental features such as moderate structure and few, thin clay films. This unit occurs throughout the study area below elevations of 80 meters, except on eroded surfaces. Based on field measurements, stratigraphic position, and elevations, this unit appears to be the Irish Bend member (Gelderman, 1970, Glasmann, 1979).

The topmost unit exhibits still less development and is uniformly silt loam. It occurs throughout the study area below elevations of 122 meters. Above 116 meters this unit thins quickly and becomes less distinct. These sediments correspond in stratigraphic position, elevation range, and field characteristics to the Greenback member (Gelderman, 1970; Glasmann, 1979).

Earlier studies (Glenn, 1965, Glasmann, 1979) have identified the presence of glacially ice-rafted erratics that were deposited along with these upper lacustrine sediments. A few large rounded gravels and cobbles were found imbedded in the Willamette Formation sediments on both watersheds.

Some post-depositional erosion has redistributed alluvium in the low lying areas of the watersheds and continues to be an ongoing process. After particularly intense rainstorms, small ephemeral alluvial fans can be observed at the base of the upland areas. This phenomenon is accentuated by farming activities that result in plant cover removal. However, cultivation annually mixes the soil surface and thereby obscures the recent depositional story.

2.3. Soils and Geomorphology

2.3.1. Soil Map

2.3.1.1. Methods. Through the years three county soil surveys have been conducted which include the study site and adjacent areas (Torgerson, et al, 1927; Otte et al., 1974; Knezvich, 1982[1]). The scales of these surveys were too small to adequately account for the localized variability. To provide adequate resolution a new survey was conducted at a larger scale. Existing soil series from the most recent survey was used to provide continuity with prior work and thus to facilitate landowner use. Field observations were combined with aerial photograph interpretation (photo scale 8"=1 mile). Field observations centered on hand-augering to a depth of 1.5 meters wherever it seemed appropriate. More detailed profile information was gathered from 32 undistorted soil cores collected by using a Giddings Hydraulic Soil Sampler.

2.3.1.2. Results. The map legend was drawn from map units in existing surveys (Fig. 4, Table 1). In categories such as elevation,

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[1]Polk County survey completed 1982 but still in press.

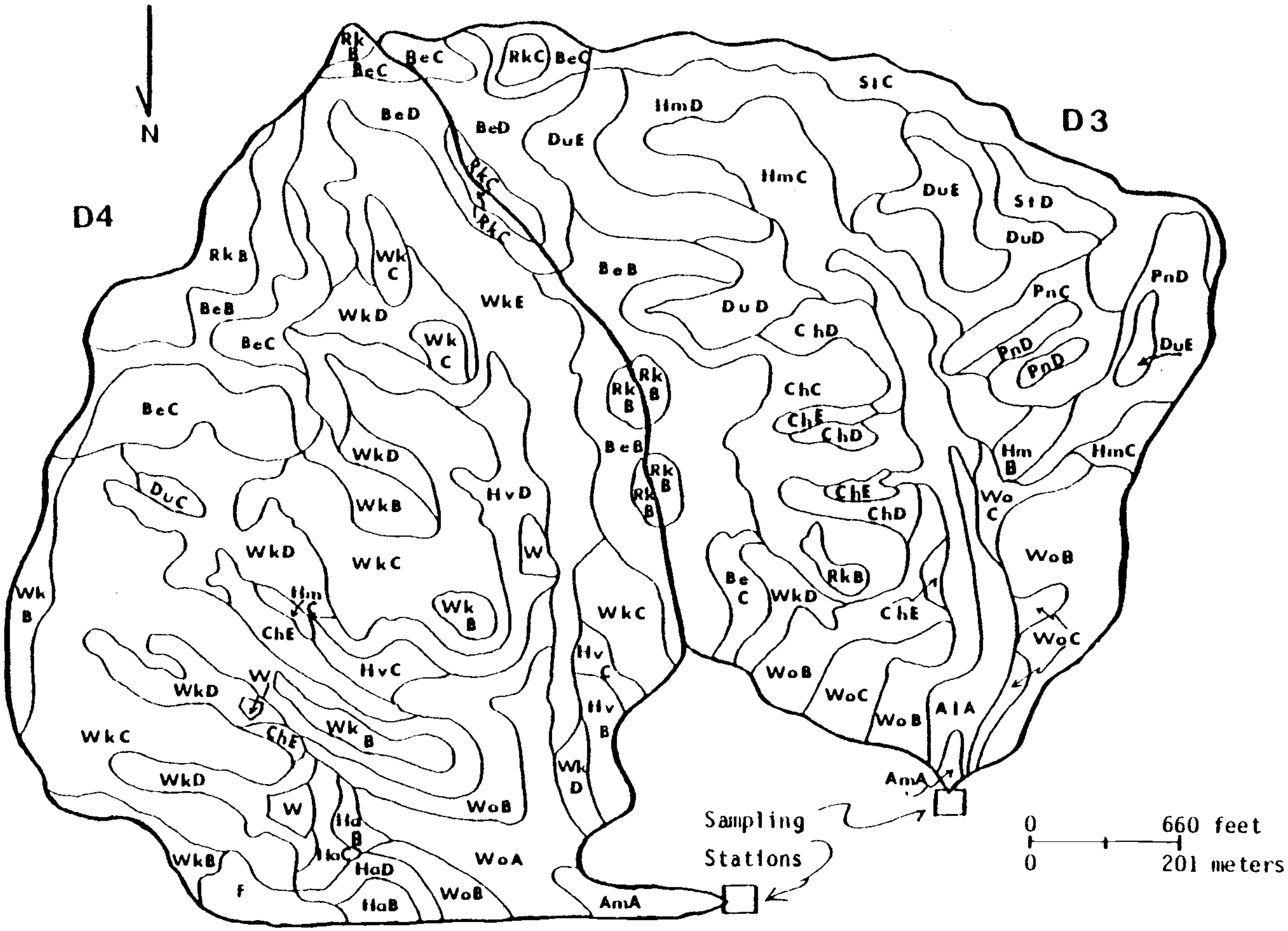

FIGURE 4. Soil Map of the Study Area.

TABLE 1. Soil Map Legend.

SYMBOL	SERIES NAME	SLOPE CLASS (%)
AlA	Aloha silt loam	0- 3
AmA	Amity silt loam	0- 3
BeB	Bellpine silty clay loam	3- 7
BeC	Bellpine silty clay loam	7-12
BeD	Bellpine silty clay loam	12-20
ChC	Chehulpum silt loam	7-12
ChD	Chehulpum silt loam	12-20
ChE	Chehulpum silt loam	20-30
DuC	Dupee silt loam	7-12
DuD	Dupee silt loam	12-20
DuE	Dupee silt loam	20-30
F	(farm residence)	-----
HaB	Hazelair silt loam	3- 7
HaC	Hazelair silt loam	7-12
HaD	Hazelair silt loam	12-20
HmB	Helmick silt loam	3- 7
HmC	Helmick silt loam	7-12
HmD	Helmick silt loam	12-20
HvB	Helvetia silt loam	3- 7
HvC	Helvetia silt loam	7-12
HvD	Helvetia silt loam	12-20
PnC	Panther silty clay loam	7-12
PnD	Panther silty clay loam	12-20
RkB	Rickreall silty clay loam	3- 7
RkC	Rickreall silty clay loam	7-12
StC	Steiwer silty clay loam	7-12
StD	Steiwer silty clay loam	12-20
W	(water-settling basins)	-----
WkB	Willakenzie silt loam	3- 7
WkC	Willakenzie silt loam	7-12
WkD	Willakenzie silt loam	12-20
WkE	Willakenzie silt loam	20-30
WoA	Woodburn silt loam	0- 3
WoB	Woodburn silt loam	3- 7
WoC	Woodburn silt loam	7-12
WoD	Woodburn silt loam	12-20

color and texture, the information may indicate a more limited range than that allowed for in the soil series range of characteristics. The information presented may not always represent the modal concept for a series.

The map units, as delineated, frequently contain inclusions of associated soils or variants of the series indicated. This is partly attributable to the variability of the sloping planes and thinly bedded nature of the bedrock.

Soil Mapping Unit Descriptions

All colors listed are moist field conditions. All textures are apparent field textures. Terminology follows standard definitions (Soil Survey Staff, 1975). Series classifications are listed in Table 2.

AlA: Aloha silt loam is a very deep, somewhat poorly drained soil formed in mixed old allivium. It occurs on valley terraces near drainage ways and the toe slopes of rolling hills. Elevations range from 58 to 67 meters with slopes of 0-3%. A generalized horizon sequence is A1, B1, B2, C. The A1 horizon is a very dark grayish brown (10YR 3/2) silt loam, 15 to 23 cm. thick. The B1 horizon is a dark brown (10YR 4/3) heavy silt loam, 12 to 23 cm. thick. The B2 horizon is a dark brown (10YR 4/3) heavy silt loam, 25 to 58 cm thick. The C horizon is a brown (10YR 5/3) silt loam more than 75 cm thick. Mottles become common within 50 cm of the surface.

TABLE 2: Soil Series Classification

SYMBOL	SERIES NAME	U.S.D.A. CLASSIFICATION
Al	Aloha silt loam	Fine-silty, mixed, mesic Aquic Xerochrept
Am	Amity silt loam	Fine-silty, mixed, mesic Argiaquic Xeric Argialboll
Be	Bellpine silty clay loam	Clayey, mixed, mesic Xeric Haplohumult
Ch	Chehulpum silt loam	Loamy, mixed, mesic, shallow Entic Ultic Haploxeroll
Du	Dupee silt loam	Fine, mixed, mesic Aquultic Haploxeralf
Ha	Hazelair silt loam	Very-fine, mixed, mesic Aquultic Haploxeroll
Hm	Helmick silt loam	Very-fine, mixed, mesic Aquic Xerochrept
Hv	Helvetia silt loam	Fine, mixed, mesic Ultic Argixeroll
Pn	Panther silty clay loam	Very-fine, montmorillonitic, mesic Typic Haplaquoll
Rk	Rickreall silty clay loam	Clayey, mixed, mesic, shallow Xeric Haplohumult
St	Steiwer silty clay loam	Fine-loamy, mixed, mesic Ultic Haploxeroll
Wk	Willakenzie silt loam	Fine-silty, mixed, mesic Ultic Haploxeralf
Wo	Woodburn silt loam	Fine-silty, mixed, mesic Aquultic Argixeroll

Discontinuities have been identified (Geldermann, 1970, Glasmann, 1979) in the Willamette Formation in which this series has formed. The appropriate nomenclature has not yet been recognized in the soil series horizonation.

Ama: Amity silt loam is a very deep, somewhat-poorly drained soil formed in mixed old alluvium. It borders drainage ways and occupies depressions on broad valley terraces near the footslopes of low rounded hills. Elevations range from 58 to 61 meters with slopes of 0-3%. A generalized horizon sequence is A1, A2, IIB2t, IIC. The A1 horizon is a very dark grayish brown (10YR 3/2) silt loam, 25 to 46 cm. thick. The A2 horizon is a gray (10YR 5/1) silt loam, 0 to 20 cm. thick. The IIB2t horizon is a grayish brown (10YR 5/2) to dark grayish brown (2.5Y 4/2) silty clay loam to heavy silty clay loam. Total IIB2t thickness ranges from 23 to 58 cm. The IIB2t horizon has common, moderately thick clay films on ped faces and in pores. The IIC horizon is an olive brown (2.5Y 4/4) silty clay loam to silty clay and occurs at depths below 90 cm. Mottles begin to occur between 15 and 25 cm. of the surface.

BeB, BeC, BeD: Bellpine silty clay loam is a moderately deep, well drained soil formed in colluvium and residuum from tuffaceous sedimentary bedrock. It occurs on broad hilltops and steep hillsides of uplands. Elevations range from 92 to 146 meters with slopes from 3 to 20%. A generalized horizon sequence is A1, B1, IIB2t, IIICr. The A1 horizon is a dark brown (7.5YR 3/2) light silty clay loam, 13 to 23 cm. thick. The B1 horizon is a brown (7.5 YR 4/4) silty clay loam, 0 to 25 cm. thick. The IIB2t horizon is reddish brown (5YR 4/4) to brown

(7.5YR 4/4) heavy silty clay loam to silty clay. Total IIB2t thickness ranges from 30 to 64 cm. Common, moderately thick clay films occur on the ped faces and in pores. There are up to 30 to 40% highly weathered siltstone and sandstone chips in the lower part of the IIB2t horizon. The IIICr is a pinkish gray (7.5YR 7/2) and reddish brown (5YR 5/4) highly weathered siltstone and sandstone. It occurs between 50 and 102 cm. of the surface.

BeB - slopes range from 3 to 7%. This unit occupies broad ridges, saddles, and hillside benches. Profiles tend to be somewhat deeper in the saddles and concave surfaces, with a paralithic contact occuring between 76 to 102 cm. Average depths to the paralithic contact on ridge tops are 64 cm.

BeC - slopes range from 7 to 12%. This unit occupies the rolling shoulders of hillsides and the upper reaches of small drainageways and swales. Depths to paralithic contact are approximately 76 cm.

BeD - slopes range from 12-20%. This unit occurs on the steeper side slopes of hills, ridges, and drainageways. Depths to paralithic contacts range from 64 to 102 cm.

ChC, ChD, ChE: Chehulpum silt loam is a shallow, well drained soil formed in mixed alluvium over colluvium and residuum from weathered sedimentary rocks. It occupies erosional surfaces on the shoulders and steep side slopes of upland hills, and the very steep sidewalls of drainageways. It most frequently occurs on south and westerly facing slopes. Elevations range from 80 to 100 meters. It occurs extensively in D3 between 80 and 86 meters. Slopes range from 7 to 30%. A typical horizon sequence is A1, IICr. The A1 horizon is a very dark brown (10YR 2/2) and very dark grayish brown (10YR 3/2) silt loam, 25 to 50 cm. thick. Some profiles have an A3 or B1 horizon based on color (10YR 4/4), 5 to 10 cm thick. Weathered siltstone and sandstone fragments occur throughout the profile but are concentrated just above the IICr horizon. The IICr horizon consists of highly weathered siltstones and fine sandstones that have common, thin clay films on the fracture planes.

ChC - slopes range from 7 to 12%. This unit occurs on the rolling shoulders of hilltops and broad ridges. Profiles tend to be 38 to 50 cm. deep to a paralithic contact.

ChD - slopes range from 12 to 20%. This unit occurs on the steep shoulders and side slopes of hills. Average depths to the paralithic contact are somewhat shallower ranging from 30 to 50 cm.

ChE - slopes range from 20-30%. This unit occupies the actively eroding backslopes of steep hillsides and drainageway sideslopes. Depths to the paralithic contact range from 25 to 38 cm. Partially weathered bedrock fragments occur on the surface and throughout the profile.

DuC, DuD, DuE: Dupee silt loam is a deep, somewhat poorly drained soil formed in colluvium and residuum from sedimentary rocks. At elevations below 122 meters these materials are mantled by a thin cap of mixed alluvium. It occurs in swales, depressions, drainageways and on side slopes of rolling hills. Elevations range from 85 to 116 meters with slopes of 7 to 30%. A generalized horizon sequence is A1, B1, B2t, IIC. The A1 horizon is a dark brown (10YR 3/3) silt loam, 15 to 23 cm thick. The B1 horizon is a dark yellowish brown (10YR 4/4) heavy silt loam, 10 to 15 cm thick. The B2t horizon is a dark yellowish brown (10YR 4/4) to brown (10YR 5/3) silty clay loams and silty clays. The B2t horizon ranges from 50 to 102 cm thick, and has common, thin to moderately thick clay films on the ped faces. The IIC horizon consists of weathered variegated sandstone and siltstone with a Cr occurring between 102 and 152 cm. Colors are commonly light brown (10YR 6/3) and light brownish gray (2.5YR 6/2). Mottles are common, beginning at depths of 15 to 25 cm. Their first occurrence usually corresponds to the lower part of the B1 horizon.

Below elevations of 122 meters, the widespread occurrence of lacustrine silts in the Willamette Valley leads one to suspect that the horizonation should indicate a discontinuity, perhaps between the B1 and B2t horizons. This has not yet been recognized in this series nomenclature.

There appears to be a close relationship between the occurrence of Dupee soils and the characteristics of the underlying bedrock that supercedes landscape position. Dupee soils are not found exclusively in depressions or on benches. They also occur on broad sideslopes and in steep drainageways. There is morphological evidence of a seasonally perched watertable along the B1-B2t horizon interface. It is not uncommon to find active seep spots on all slope phases during the rainy winter season.

DuC - slopes range from 7 to 12%. This unit occurs on gentler hill sideslopes and benches. Profiles tend to be deeper with a paralithic contact between 115 and 152 cm.

DuD - slopes range from 12 to 20%. This unit occurs on the steeper hill sideslopes and along drainageways. Typical depths to a paralithic contact range from 102 to 127 cm.

DuE - slopes range from 20 to 30%. This unit occurs in steep drainageway sideslopes and headwalls, frequently where moisture comes to the surface. Typical depths to a paralithic contact range from 90 to 115 cm.

F: this unit represents a farm complex including a residence, utility structures, and a small fruit orchard. The slopes range from 3 to 12% and the dominant soils are Willakenzie to the east and Hazelair to the west.

HaB, HaC, HaD: Hazelair silt loam is a moderately shallow, somewhat poorly drained soil formed in stratified medium and fine textured materials overlying weathered sedimentary rocks. It occurs on slightly convex footslopes and sides of rolling hills that merge into the main valley terrace. Elevations range from 76 to 110 meters, with slopes of 3 to 20%. A generalized horizon sequence is A1, B2, IIC1, IIICr. The A1 horizon is a dark brown to dark yellowish brown (10YR 3/3 to 10YR 3/4) silt loam, 15 to 25 cm thick. The B2 horizon is a dark brown (10YR 3/3) silty clay loam, 8 to 25 cm thick. The IIC horizon consists of a light olive brown (2.5Y 5/4) to dark grayish brown (2.5 Y 4/2) clay loam, 25 to 64 cm. thick. Mottles first appear in the lower B2 horizon and are strongly expressed in the IIC1 horizon. The

IIICr horizon is a variegated brownish yellow (10YR 6/6) weathered sandstone with light brownish gray (10YR 6/2) clay lenses, and begins at depths of 50 to 100 cm.

Below elevations of 122 meters the widespread occurrence of lacustrine silt mantles gives rise to the profiles in the study area having more silty A1 and B1 horizons than this same soil series has elsewhere.

HaB - slopes range from 3 to 7%. This unit occurs on low rolling hilltops and benches. Depths to paralithic contact tend to be from 75 to 100 cm.

HaC - slopes range from 7 to 12%. This unit occurs on low rolling hillsides and toeslopes that merge into old valley terraces. Depths to a paralithic contact range from 64 to 90 cm.

HaD - slopes range from 12 to 20%. This unit occurs on steep sideslopes and on small drainageway sidewalls of low hills merging with old valley terraces. Depths to a paralithic contact range from 50 to 90 cm.

HmB, HmC, HmD: Helmick silt Loam is a very deep, somewhat poorly drained soil formed in mixed alluvium and colluvium over residuum weathered from siltstone and sandstone. It occurs on footslopes and sideslopes of rolling hills. Elevations range from 73 to 122 meters with slopes of 3 to 20%. A generalized horizon sequence is A1, B2, IIC. The A1 horizon is a dark brown (10YR 3/3 and 10YR 4/3) silt loam and heavy silt loam. Total A1 horizon thickness ranges from 18 to 40 cm. The B2 horizon is a brown (10YR 5/3) heavy silty clay loam, 12 to 23 cm thick. The IIC horizon is a grayish brown (2.5Y 5/2) and light brownish gray (2.5Y 6/2) mottled clays, which exceed a thickness of 64 cm. Weathered sedimentary rock chips are common in the lower IIC horizon. The underlying bedrock is weathered siltstone and sandstone. Depths to a paralithic contact generally exceed 153 cm. However, there are inclusions of profiles that have such a contact between depths of 130 to 153 cm.

HmB - slopes range from 3 to 7%. This unit occurs on gently sloping footslopes with paralithic contact at depths exceeding 153 cm.

HmC - slopes vary from 7 to 12%. This unit occurs on footslopes and sideslopes of rolling hills and associated drainageways. Depths to a paralithic contact generally exceed 153 cm.

HmD - slopes range from 12 to 20%. This unit occurs on the steeper sideslopes and headwalls of drainageways. Depths to a paralithic contact generally range from 130 cm to greater than 153 cm.

HvB, HvC, HvD: Helvetia silt loam is a deep, moderately well drained soil formed in alluvium of mixed origin over weathered sedimentary rocks. It occurs on footslopes and sideslopes of low hills that merge into old valley terraces. Elevations range form 73 to 92 meters with slopes of 3 to 20%. A generalized horizon sequence is A1, B1, B2t, B3. The A1 horizon is a dark brown (10YR 3/3) silt loam, 13 to 46 cm thick. The B1 horizon is a dark yellowish brown (10YR 4/3) light silty clay loam, 10 to 20 cm thick. The B2t horizon is a dark yellowish brown (10YR 3/4, 10YR 4/4) and yellowish brown (10YR 5/4) heavy silty clay loam and light silty clay. The B2t horizon ranges from 30 to 90 cm thick and has common, moderately thick clay films throughout. The B3 horizon is a dark yellowish brown (10YR 4/4) silty clay loam, 15 to 30 cm thick. Common, faint mottles occur in the lower part of the B2t horizon and throughout the B3 horizon. There is paralithic contact with weathered siltstone or sandstone at depths of 127 to 153 cm, with occasional pedons reaching 170 cm.

The widespread occurrence of surficial lacustrine silts in the Willamette valley below elevations of 122 meters have recently led to the recognition of a discontinuity (Glasmann, 1979). The appropriate nomenclature has not yet been included in this series.

HvB - slopes range from 3 to 7%. This unit occurs on nearly level old valley terraces and footslopes of low rolling hills.

HvC - slopes vary from 7 to 12%. This unit occurs on the convex sideslopes of old valley terraces and on benches on low rolling hills.

HvD - slopes vary from 12 to 20%. This unit occurs on steep valley terraces and low rolling hill sideslopes.

PnC, PnD: Panther silty clay loam is a deep, poorly drained soil formed in mixed alluvium and colluvium over weathered siltstone and shale. It occurs on convex sideslopes and toeslopes of rolling hills, and in drainageways. Elevations range from 67 to 122 meters, with slopes of 7 to 20%. A generalized horizon sequence is A1, B2g, Cg, Cr. The A1 horizon is a dark brown (10YR 3/3) light silty clay loam, 18 to 40 cm thick. Some profiles, particularly at lower elevations, have a heavy silt loam texture. Some profiles have an AB or B1 horizon. The B2g horizon is a dark grayish brown (2.5Y 4/2) or 10YR 4/1 to olive brown (2.5Y 4/3) or 10YR 4/4 silty clay loam to silty clay. Total B2g thickness ranges from 40 to 90 cm. The Cg is a brown (10YR 5/3), yellowish brown (10YR 5/8) and grayish brown (10YR 5/2) silty clay loam to silty clay. Thickness ranges from 18 to 30 cm. It contains many weathered siltstone fragments. Mottles frequently begin to occur in the lower portion of the A1 horizon and are common throughout the B2g horizon. The Cr horizon, which begins between depths of 100 and 150 cm is variegated weathered siltstone and shale. Colors are light brownish-gray (10YR 6/2) and brownish yellow (10YR 6/6).

Some profiles between 80 and 86 meters appear to be truncated between the B2g and the Cg horizons. In these profiles the paralithic contact occurs between 90 and 115 cm. Some profiles exhibit morphological evidence of a seasonally perched water table along the A1-B2g horizon interface. During rain storms lateral through-flow along this zone frequently gives rise to small rills in plowed fields.

PnC - slopes range from 7 to 12%. This unit occurs on convex footslopes and broad sloping interfluves. The depth to a paralithic contact is generally 115 to 140 cm except between elevations of 79 to 86 meters, where depths range from 90 to 115 cm.

PnD - slopes vary from 12 to 20%. This unit occurs on sideslopes associated with small swales and drainageways. Depths to a paralithic contact range from 100 to 130 cm, except between elevations of 79 to 86 m where depths range from 95 to 115 cm.

RkB, RkC: Rickreall silty clay loam is a shallow, well drained soil formed in fine textured colluvium and residuum from weathered siltstone and sandstone. It occurs on the old erosional surfaces of high convex hilltops and ridges. Elevations range from 104 to 146 meters with slopes of 3 to 12%. A generalized horizon sequence is A1, B1, B2t, Cr. The A1 horizon is a dark brown (7.5YR 3/2) light silty clay loam, 8 to 15 cm thick. The B1 horizon is a dark brown (7.5YR 4/4) silty clay loam, 5 to 10 cm thick. The B2t horizon is a strong brown (7.5YR 4/6) silty clay loam and silty clay. Total B2t thickness ranges from 18 to 28 cm. Common, moderately-thick clay films and weathered siltstone and sandstone fragments occur throughout the B2t horizon. The Cr horizon is variegated pinkish gray (7.5YR 7/2) and reddish brown (5YR 5/4) weathered sandstone and siltstone. The paralithic contact occurs at depths between 25 and 50 cm.

RkB - slopes range from 3 to 7%. This unit occurs on slightly convex hilltops, broad ridge tops and saddles. Depth to paralithic contact ranges from 30 to 46 cm except in the saddles where depths average 50 cm. There are inclusions of Bellpine soils, particularly in the saddles.

RkC - slopes vary from 7 to 12%. This unit occurs on the convex sideslopes of hills and ridgetops. Depths to a paralithic contact are generally 25 to 38 cm.

StC, StD: Steiwer silty clay loam is a moderately deep, well drained soil formed in mixed alluvium over colluvium and residium from weathered sandstone and siltstone. It occurs on the broad upper ridges and sideslopes of rolling hills. Elevations range from 92 to 116 meters with slopes of 7 to 20%. A generalized horizon sequence is A1, B1, B2, IICr. The A1 horizon is a dark brown (7.5YR 3/2) light silty clay loam, 15 to 25 cm thick. The B1 horizon is a dark brown (7.5YR 4/2) silty clay loam, 5 to 15 cm thick. The B2 horizon is a dark brown (7.5YR 4/4) silty clay loam, 30 to 63 cm thick. Weathered siltstone fragments occur throughout the B2 horizon but are concentrated in the lower portion of the horizon. The IICr horizon is a partially weathered strong brown (7.5YR 5/6) to pinkish red (7.5YR 7/2) variegated siltstone with sandstone lenses. The IICr occurs at depths of 50 to 100 cm.

StC - slopes vary from 7-12%. This unit occurs on broad convex ridge tops.

StD - slopes range from 12-20%. This unit occurs on the steep upper slopes of rolling hills.

W: Water basins consisting of farm ponds constructed in drainageways.

WkB, WkC, WkD, WkE: Willakenzie silt loam is a moderately deep, well drained soil formed in mixed alluvium over colluvium and residuum from siltstone and fine sandstone. It occurs on the tops and sideslopes of convex, low rolling hills that merge into old valley terraces. Elevations range from 73 to 122 meters, with slopes of 3 to 30%. A generalized horizon sequence is A1, B1, B2t, IIC, IICr. The A1 is a very dark grayish brown (10YR 3/2) siltloam, 8 to 23 cm. thick. The B1 is a dark brown (7.5YR 3/4) light silty clay loam, 18 to 25 cm. thick. The B2t horizon is a dark brown (7.5YR 4/4) silty clay loam, 40 to 70 cm. thick. The IIC horizon is a strong brown (7.5YR 5/6) light silty clay loam, 5 to 20 cm. thick. Weathered sandstone chips are common throughout the IIC horizon. The IICr horizon is a variegated pinkish gray (7.5YR 6/2) and reddish brown (5YR 5/4) partially weathered sandstone with siltstone lenses. Depths to the IICr range from 75 to 100 cm with an average depth of approximately 100 cm. The Wk map unit has inclusions of a Willakenzie deep variant that features a thicker IIC horizon and a paralithic contact occurring between depths of 100 and 140 cm.

The discontinuity (Glasmann, 1979) associated with lacustrine silts below elevations of 122 meters has not yet been recognized as a component of this series. Hence it is not reflected in the horizon nomenclature.

WkB - slopes range from 3 to 7%. This unit occurs on slightly convex hilltops and ridgetops of low rolling hills. Depths to a paralithic contact are generally from 90 to 140 cm. thick.

WkC - slopes range from 7 to 12%. This unit occurs on broad convex hillsides, sideslopes and benches. Depths to a paralithic contact range from 90 to 140 cm.

WkD - slopes vary from 12 to 20%. This unit occurs on the headwalls and sideslopes of small drainageways and swales. Depths to a paralithic contact vary from 90 to 127 cm.

WkE - slopes range from 20 to 30%. This unit occurs on steep hillsides and drainageway sideslopes. Depths to a paralithic contact range from 75 to 127 cm.

WoA, WoB, WoC, WoD: Woodburn silt loam is a deep, well drained soil formed in lacustrine silts over old mixed alluvium. It occurs on broad, gently rolling old valley terraces and at the footslopes of low rolling hills. Elevations range from 64 to 80 meters with slopes of 0 to 20%. A generalized horizon sequence is A1, B2t, B3t, C1, IIC2. The A1 horizon is a very dark grayish brown (10YR 3/2) siltloam, 25 to 43 cm thick. The B2t horizon is a dark brown (10YR 4/3), brown (10YR 5/3), and yellowish brown (10YR 5/4) heavy silt loam and silty clay loam. Total B2t horizon-thickness ranges from 30 to 50 cm with common, thin to moderately thick clay films throughout. The B3t horizon is a dark brown (10YR 4/3) to yellowish brown (10YR 5/4) heavy silt loam or silty clay loam. Total B3t horizon thickness ranges from 40 to 75 cm. The C horizon is a dark brown (10YR 4/3) to yellowish brown (10YR 5/6) heavy silt loam and silty clay loam. The C horizon thickness exceeds 50 cm.

The discontinuity recently identified in lacustrine silts below elevations of 122 meters (Glasmann, 1979) has not yet been recognized in this soil series. Hence the horizonation here does not reflect its presence.

WoA - slopes range from 0 to 3%. This unit occurs on nearly level old valley terraces at the footslopes of low rolling hills. There are inclusions of heavier textured, somewhat-poorly drained soils adjacent to drainageways which were too small to delineate.

WoB - slopes vary from 3 to 7%. This unit occurs on broad tops of old valley terraces and on the gently rising toeslopes below rolling hills.

WoC - slopes range from 7 to 12%. This unit occupies small swales, drainage ways, and old valley terrace sideslopes.

WoD - slopes vary from 12 to 20%. This unit occurs on the steeper footslopes of the transition from old valley terraces rising to low rolling uplands.

2.3.1.3. Discussion

2.3.1.3.1. Major soils and slope groups. In terms of percent of watershed per series, there is a more even distribution of soils in D3 than D4. D3 has five soils which occupy 10% or more of its area while D4 has only two soils occupying 10% or more of its area (Table 3). D3 has seven series that make up 5% or more of its area while D4 has only four series that occupy 5% or more of its area.

Three soil series each comprise more than 10% of the total study area: Willakenzie (29.9%), Bellpine (16.0), and Woodburn (13.5%). Bellpine is the dominant series found above elevations of 122 m and occurs commonly in both watersheds. Willakenzie occurs between elevations of 73 to 122 m but is limited almost exclusively to D4. Woodburn is the dominant soil between elevations of 64 and 80 m. It occurs more widely in D3 (18.5%) but is also important in D4 (9.0%). Five other series make up 8.3% or more of D3 but cover less than 2% of D4 (Table 3).

Many of the soils of the study area tend to have somewhat lighter textures than the modal concept of their respective series. This is particularly true of the upper solum in those soils occurring at elevations below 122 m because of the influence of surficial lacustrine silts. Though less pronounced, the lower sola of these soils generally have somewhat lighter textures. Bellpine, which occurs above

TABLE 3. Soil Series Distribution.

SYMBOL	SERIES	%D3	%D4	%TOTAL STUDY AREA
Al	Aloha	3.0	0	1.4
Am	Amity	0.2	1.1	0.7
Be	Bellpine	15.2	16.8	16.0
Ch	Chehulpum	12.6	1.7	6.7
Du	Dupee	13.4	0.3	6.3
Ha	Hazelair	0	2.7	1.5
Hm	Helmick	15.6	0.2	7.4
Hv	Helvetia	0	7.0	3.7
Pn	Panther	9.6	0	4.5
Rk	Rickreall	2.4	4.5	3.5
St	Steiwer	8.3	0	3.8
Wk	Willakenzie	1.2	54.5	29.9
Wo	Woodburn	18.5	9.0	13.5
F	(farm)	0	1.4	0.7
W	(water-settling basins)	0	0.8	0.4

92 m, is at elevations where the influence of lacustrine silts is minor or absent. Bellpine is most frequently associated with textures of silty clay loams over clays. In the study area, however, textures tend to be silt loams or light silty clay loams over silty clay loams or silty clays. This slight shift from the modal concept is not surprising in light of the predominantly silty nature of the bedrock that underlies most of the vicinity.

Of particular interest is the observation that D3 has more "clayey" soils than D4 and more heavier textured soils in general based on family textural classes (Table 4) 25.2% of D3 has soils with very-fine family textural classes (greater than 60% clay in the fine earth fraction). Only 3.0% of D4 has soils in the same category. 56.2% of D3 has soils with fine, very-fine, or clayey family textural classes (greater than 35% clay in the fine earth fraction). 31.6% of D4 occurs in the same categories.

By contrast there are only minor differences between the two watersheds in terms of the percentages of hectarage in the given slope groups (Table 5). In the steepest slope group, E (20-30% gradients), 13.0% of D4's area occurs vs. 7.8% of D3's area. In slope groups exceeding gradients of 12% (D and E), 40.1% of D3's area is included as compared to 33.3% of D4's area. For slope groups with gradients exceeding 7% (C, D, and E), 75.0% of D3's area is included as compared to 68.3% of D4's area.

2.3.1.3.2. Paleo-erosional Zone: There are a variety of observations that are associated with the elevation zone between 79 and 86 m. This zone corresponds very close elevationally to that observed by

TABLE 4. Distribution of Soils by Family Textural Groups.

CLAY CONTENT (%)	FAMILY PARTICLE-SIZE CLASS	D3 %D3	D3 %TOTAL	D4 %D4	D4 %TOTAL
18-35	Fine silty, fine loamy	31.2	14.5	64.5	34.7
<35	Loamy	12.6	5.8	1.7	0.9
35-59	Fine	13.4	6.2	7.3	3.9
>35	Clayey	17.6	8.1	21.3	11.5
>60	Very-fine	25.2	11.7	3.0	1.6
$\Sigma > 35$	Fine, very-fine, clayey	56.2	26.0	31.6	17.0

TABLE 5. Distribution of Watershed Area by Slope Groups

SLOPE CLASSES (%)	%D3	%D4
A (0- 3)	3.3	5.6
B (3- 7)	21.7	23.9
C (7-12)	34.9	35.0
D (12-20)	32.3	20.3
E (20-30)	7.8	13.0
OTHER (farm and settling basins)	0.0	2.2
D+E	40.1	33.3
C+D+E	75.0	68.3

Glassmann (1979) and described as a paleo-shoreline erosional zone. Three adjacent interfluves in the northeast corner of D4 which descend gradually from 98 to 73 m above mean sea level. These interfluves all have gentle, relatively uniform slope gradients. However, there are several subtle yet distinct breaks in slope. The most pronounced break occurs on all three interfluves at an elevation of roughly 86 m and corresponds to the upper limit of the paleo-erosional zone. In all three cases the change in slope occurs between long runs of otherwise uniform slopes. Soil profiles at this slope break are markedly shallower than profiles either above or below it. Elsewhere in the study area this upper boundary slope break is only sporadically repeated. The most visible of these occurs on the hillsides along the western-most edge of D3.

Several other less distinct slope breaks occur on two of the aforementioned interfluves in D4 between 84 and 79 m. The 79 m elevation, which corresponds to the lower limit of this paleo-erosional zone, occurs across the rounded and eroded noses of the interfluves. Consequently, this lower limit is indistinct, and if any physical record existed it has been masked or eliminated. Elsewhere in the study area this lower boundry is seen only as a sudden deepening of profiles without any corresponding slope break.

Except for the interfluves in D4 and the hillside in western D3, this paleo-erosional zone generally occurs across steeper and more complex land forms. The result is that these rather subtle slope breaks are not readily apparent, if they occur at all. But there are several consistent morphological features which are widespread within the zone. In almost every instance there is a pronounced lessening of profile depth by 20 to 40 cm relative to the pedons above or below the zone. The shallowest profiles occur near the upper boundary (86 m). This decreased depth is coupled with changes in the nature of the horizon boundary between the lower soil solum and the underlying bedrock.

In most profiles in which a Cr horizon occurs, the boundary of the overlying horizon is a transition zone. This boundary is consistently observed to be gradual and occasionally diffuse. However, within the paleo-erosion zone this boundary is much sharper and is typically observed to be clear or abrupt.

The shallow Chehulpum soil is another unique characteristic associated with the paleo-erosion zone. This series occurs almost exclusively between elevations of 79 and 92 m in D3. Except for a few small erosional surfaces in D4, this is the only area below 128 m in which shallow soils occur. The area occupies the western flank of a broad ridge in D3. The soils between 84 and 92 m occur across the convex shoulder of the ridge, thus occupying natural erosional surfaces. Consequently it is not surprising that the upper limit of the Chehulpum area is somewhat higher than 86 m elevation usually indicated for the paleo-erosional zone.

Similar landforms elsewhere in the study area also exhibit shallower profiles on interfluve noses and very steep sideslopes within this paleo-erosional zone. But unlike the Chehulpum area, these otherwise similar landforms consistently have markedly deeper profiles on the gentler slopes and in swales. The Chehulpum area uniformly exhibits shallow soils on both erosional and depositional subcomponents of the landscape.

The Chehulpum area occurs on an old intensively farmed field and some profiles on the most erosion prone surfaces show thinning of the A horizon or mixing of the A and B horizons. However, most profiles have complete solums; for the most part, they have not been radically thinned by agricultural practices.

Some areas of the 79 to 86 m zone deviate from the general trends previously described. The equivalent elevation range directly across the small valley from the Chehulpum area is on a north-northeast facing slope. The soils that occur there are deeper and heavier textured than Chehulpum. Despite these differences, the B3-Cr contact does continue to reflect a more sudden transition, and the profiles are relatively shallower than the same soils above and below the zone.

Both watersheds have a primary stream that extends deep into their uplands. As one progresses into the interior along these drainageways, profile features characteristic of the 79 to 86 m zone become less well expressed. Profiles become more similar in thickness and morphological characteristics to adjacent soils above and below the zone. Whether this potential discrepancy is a contradiction of the paleo-erosional shoreline theory (Glasmann, 1979), or whether it represents a more complex depositional and developmental environment in the drainageways is not clear. Glasmann (1979) proposed a paleo-erosional shoreline environment, associated with glacial floodwaters, as the cause of soil morphological features in the 79 to 86 m zone that are similar to those observed in this study area.

The field observations in this study area do not uniformly support the paleo-erosional shoreline hypothesis. However, the discrepancies are inconclusive and do not necessarily contradict such a theory.

2.3.1.3.3. Paleosols and Relict Soils. Gelderman (1970) and Glasmann (1979) discussed a variety of paleosols in studies at nearby sites. Several of those paleosols occur in portions of this study area.

Above 122 m the elevations and landforms correspond to older geomorphic surfaces upon which paleosol development has been commonly observed (Balster and Parsons, 1968; Glasmann, 1979). Soil textures are heavier throughout the profiles than textures at lower elevations, ranging from silty clay loams to silty clays. These areas are mostly mapped as Bellpine. On immediately adjacent areas below 122 m, textures are noticeably lighter, ranging from heavy silt loams to silty clay loams. These areas are mapped as Willakenzie. Soil structure grades in the B horizons are consistently strong above 122 m and moderate below 122 m. Colors are redder above 122 m, ranging in hues from 7.5YR to 5YR, in contrast to the predominantly 10YR hues below 122 m. Clay films are common and moderately thick to thick on the ped faces and in pores in the Bt horizons above 122 m. Iron-Manganese concretions occur sporadically.

Even at the highest elevations, however, relict soil development is not as strongly expressed as it is in the Elkins Road paleosol (Glasmann, 1979). No profiles exhibit the greater thicknesses, many concretions, or dominant 5YR hues associated with the Elkins Road paleosol (Glasmann, 1979).

Numerous holes were hand augered on hillsides, broad knolls, saddles, and other likely paleosol locations, to a maximum elevation of 155 m. No profiles in the study area or nearby vicinity reflected the extreme development associated with the Elkins Road or Diamond Hill paleosols. This seems to be partly due to the influence of the very silty bedrock that dominates the underlying strata of the entire area.

Below elevations of 122 m paleosols occur as the lower component of the soil solum. Between 86 and 122 m a few scattered deep, strongly developed profiles occur on hillside benches. But more typically the paleosols appear truncated; partially degraded Bt horizons which grade into the underlying C or Cr horizons of the Nestucca/Spencer Formation. Between 79 and 86 m the paleosol components are even more truncated and fragmentary. Below 79 m paleosol components quickly become deeply buried by the occurrence of the Irish Bend member.

The Irish Bend sediments exhibit strong development representing somewhat younger paleosols. They typically correspond to the IIB2t and IIC horizons. Colors have hues of 10YR and 7.5YR; 5YR hues found at higher elevations are very rare. Soil structure grades are moderate to strong. Iron-manganese concretions and stains are very common. Clay skins are common, moderately thick to thick on ped faces and pores. Textures are typically silty clay loams or heavy silt loams. Some profiles are gleyed and many contain extensive mottling throughout much of the Irish Bend materials. If there are catena-like counterparts to the older paleosols found at higher elevations, the evidence is deeply buried and does not appear in the upper two meters of the soil.

2.3.1.3.4. Perched Watertables. Most of the soil series mapped below 122 m consist of a silt cap mantling a heavier textured substratum. It is fairly common to encounter profiles which exhibit morphological evidence of temporarily perched water tables along the boundary between these two texturally different layers. The 2 to 8 cm transition zone may exhibit slightly lighter color values and the presence of thin silt coats on ped faces. This transition is also associated with a thin zone of mottling in an otherwise well drained soil. During heavy winter rain storms the steeper slope phases of these soils become saturated immediately above the heavier textured Bt horizons, which remain unsaturated at least temporarily. This results in lateral downslope flow along the textural boundary. Sometimes this lateral movement generates rill development which can become locally extensive but which rarely cuts deeper than the A1/Bt horizon interface. Examples of such profiles occur in soil cores W12 and W14, Appendix 4.

Although such profiles can be fairly common in small areas, for most pedons this partially eluviated zone is not extensive enough and/or pronounced enough to be included in the horizonation.

2.3.2. Transects

2.3.2.1. Location and Purpose. The purpose for conducting transects was to provide more detailed profile information than obtainable by hand augering. Four different soil core transects were conducted across similar landforms (Fig. 5). One transect extended over a majority of the range of elevations found in the study area (transect

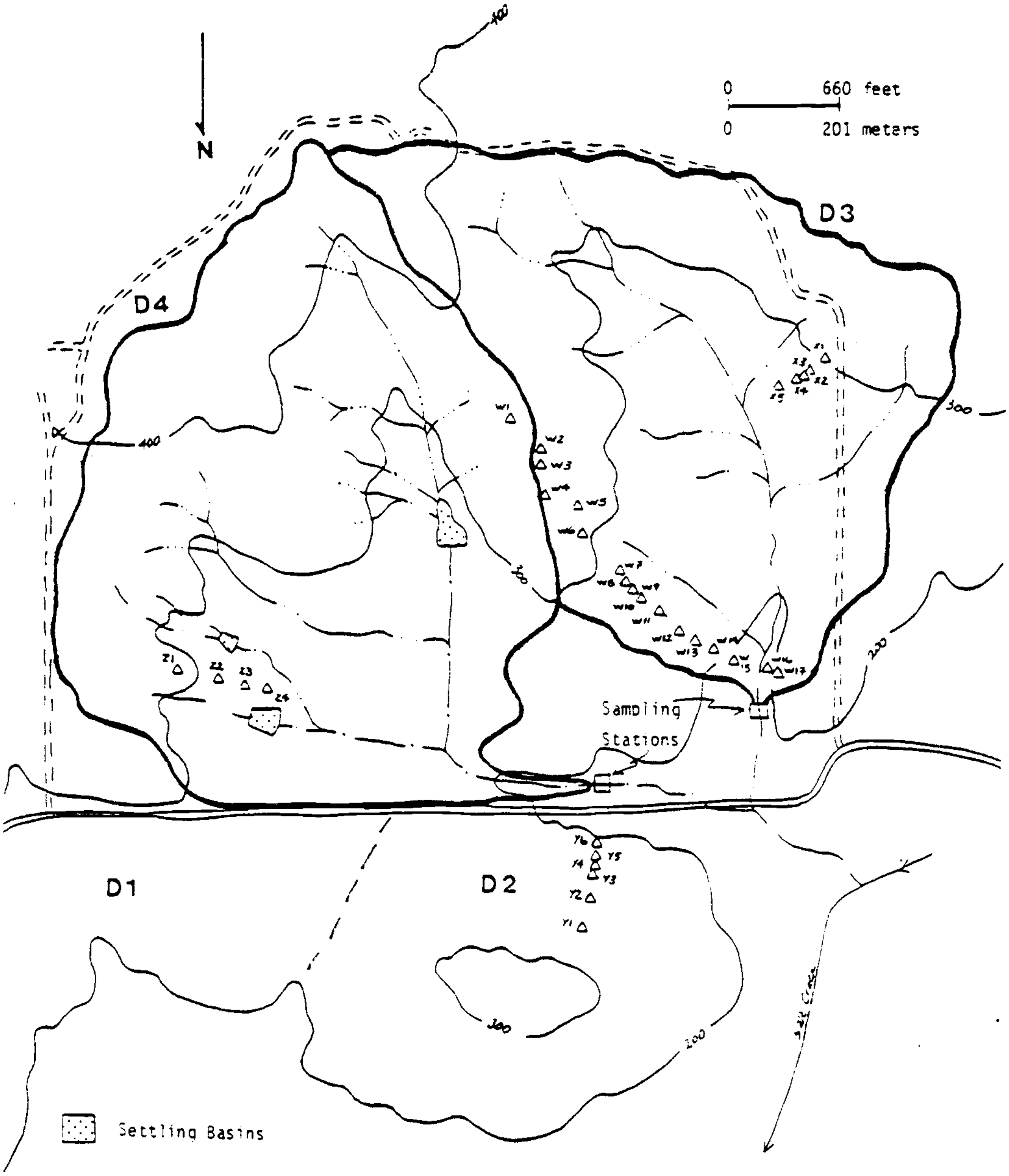

FIGURE 5. Transect Location Map.

W). The other three transects were shorter, less intensive, and conducted across what initially appeared to be the more complex portions of the landscape. The intent was to sample accessible landforms which appeared similar in form and elevations to obtain a clearer estimate of variability. Transect Y was conducted on an adjacent hillside that was within the larger watershed basin but not actually contained within the paired watershed boundaries (Fig. 5).

2.3.2.2. Methods. The field procedure consisted of the use of a Giddings Hydraulic Soil Sampler mounted on the bed of a military jeep to extract 4 cm diameter soil cores. Maximum sampling depth was approximately 245 cm. Cores frequently did not reach this maximum depth due to the presence of bedrock or heavy textured horizons. Sampling points on transect W were located no more than 76 m apart and were collected more frequently in areas that contained slope breaks or other indicators of potential changes in soil types. The other three transects were sampled in a more flexible fashion such that sampling was concentrated only in areas indicating soil changes. No maximum distance between samples was maintained. Elevations were determined by a combination of techniques. Ground location was carefully ascertained by compass triangulation and pacing. That information was transferred to the aerial photograph base map. Correlations were made between the base map and a 7-1/2 minute U.S.G.S. topograhic map (Ballston, Oregon-SE 1/4 of Sheridan 15' quadrangle). 10 ft contour intervals were determined by interpolation from the 20 ft map contours. 5 ft increments are hypothetical but were occasionally used in the soil core data to infer subtle elevational differences which appeared to be significant in the field.

2.3.2.3. Results. Schematic summaries and interpretations of soil core data are presented in Figs. 6-10. More detailed soil profile information is presented in Appendix A1.2.

2.3.2.3.1. Transect W: This transect extends across the long broad ridge that separates the watersheds D3 and D4 and then descends into D3 near the nose of the ridge (Fig. 5). Transect W crosses four of the five soil-geomorphic groups that occur in the study area.

i) The highest soil geomorphic group occurs above elevations of 122 m and consists of two components; a relict paleosol and the parent rocks of the Nestucca/Spencer Formation (Fig. 6). This group is in a forested area and was inaccessible to the Gidding's probe. Hand augered holes were made to verify the general characteristics and trends. Soil textures are heavy, ranging from silty clay loams to silty clays. Color hues are 7.5YR and 5YR. Strong soil developmental features such as moderately thick to thick clay films and common iron-manganese concretions in the Bt horizons are typical. The underlying Nestucca/Spencer Formation generally consists of highly weathered variegated siltstone and fine sandstone. There appears to be less variability in the bedrock here than occurs at lower elevations.

The soils mapped on this surface are Rickreall and Bellpine, which in this case represent differences only in profile depth. They occur on a broad gently sloping series of ridges and knobs, presumably occupying the oldest and most stable geomorphic surface in the area. These characteristics, soil types, land forms and elevation ranges

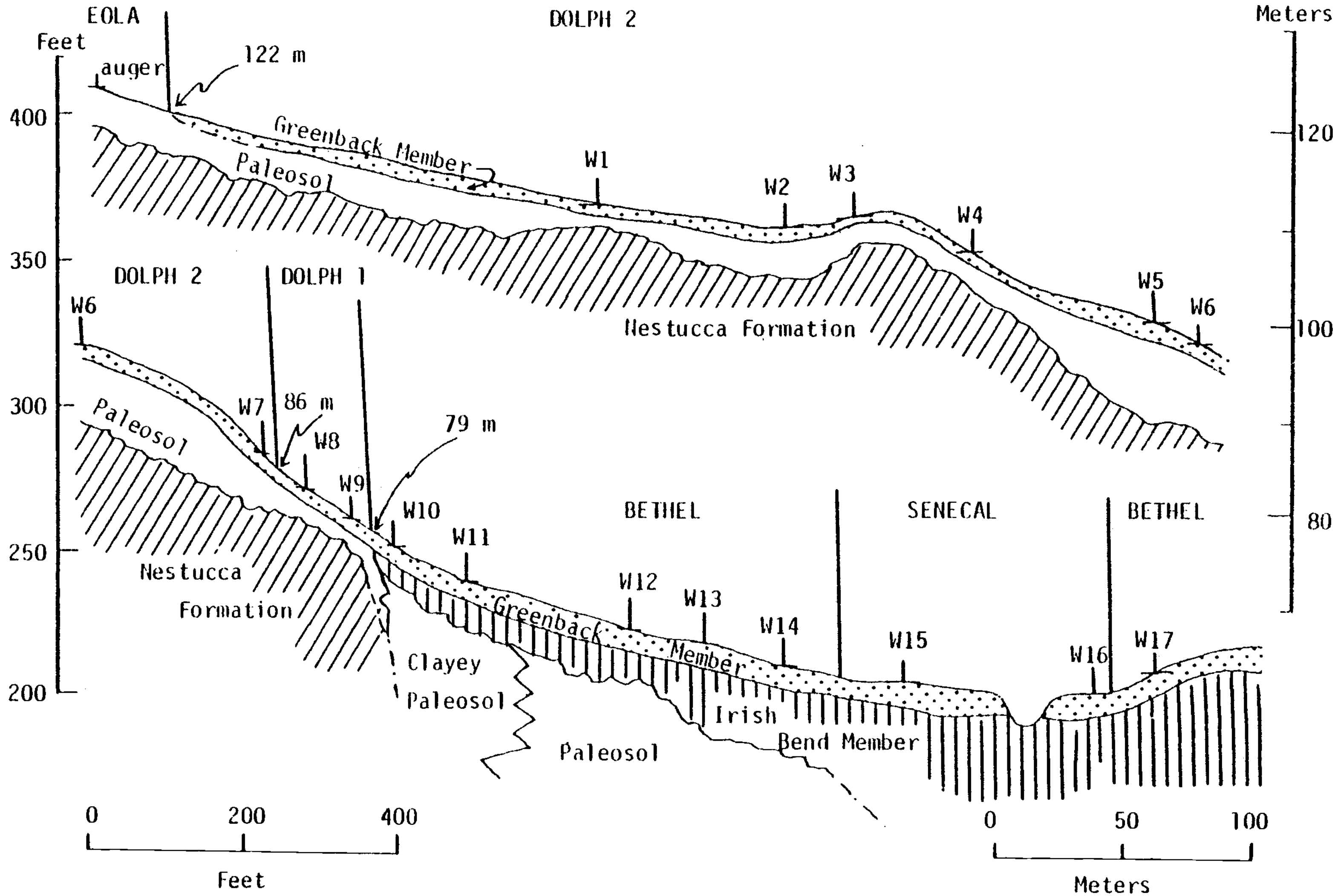

FIGURE 6. Schematic Interpretation and Summary of Transect W.

correspond to the Eola surface, an occasional inclusion of the Looney unit mapped in this area by Balster and Parsons (1968).

ii) The next two soil-geomorphic groups are closely related and correspond to the Dolph 1 and Dolph 2 surfaces identified by Glasmann (1979). Both groups are composed of the same three geologic components, although there are some differences in their expression.

The Dolph 2, the more extensive of the two groups, occurs between 122 and 86 m. The topmost stratum is the Greenback member and consists of uniform, dark brown silt loam. Its initial appearance at roughly 122 m denotes the upper limit of the Dolph unit. The Greenback member quickly attains the average depth of 20 cm measured at core W1. It continues to gradually increase in thickness with decreasing elevation to a maximum thickness of 36 cm at core W7. Some localized anomalies occur. In core W5 which occurs near the bottom of a swale, this stratum is somewhat overthickened. In cores W4 and W3 which occur on a shallow ridge knob, there is a slight thinning of this stratum. The Greenback member also thins slightly in cores W8 and W9. Since the deposition of the Greenback sediments postdates the paleo-erosional thinning of the Dolph 1 paleosol (Glasmann, 1979), the thinning of the Greenback member probably represents more recent surficial erosion on the steeper slopes within the Dolph units.

The second soil-stratigraphic component beneath the Dolph surface is the truncated buried paleosol which consists of 7.5YR silty clay loams. The strong soil development is reflected by the moderate to strong soil structure grades and the many thick clay films.

The boundary between the Greenback member and the paleosol is abrupt to clear. There is no evidence of a remnant paleosol A horizon. The fields crossed by the transect have been repeatedly plowed and the Ap horizon lies directly on the IIB2t horizon in core W1, indicating probable horizon mixing. Even where the Ap horizon doesn't completely extend through the Greenback member as in cores W2, W5, and W6, the paleosol lacks a buried A horizon and the contact with Greenback silts is quite evident.

The paleosol soil stratigraphic component is consistent morphologically across the entire Dolph surface except in one category: thickness. Beneath the Eola surface, the paleosol thickness averages approximately 70 cm except on ridges and knobs where the average thickness is approximately 30 cm (cores W1 and W3). Thickness gradually increases with decreasing elevation on the Dolph 2 surface (core W2 vs. cores W5 and W6). This trend is disrupted between 86 and 79 m on the Dolph 1 surface. There the average paleosol thickness decreases from approximately 70 to 50 cm. Overall profile thickness decreases from an average of 110 cm to 80 cm in cores W5 and W6 vs. W7, W8, and W9. This demonstrates the general thinning of profiles that is characteristic of the Dolph 1 surface, though it doesn't exhibit the almost complete elimination of the paleosol observed at the Elkins Road study site (Glasmann, 1979).

The paleosol strata on the Dolph 1 surface show some additional morphological changes in cores W7, W8, and W9. Soil textures are light silty clay loams rather than the heavy silty clay loams or silty clays observed on the Dolph 2 and Eola surfaces. Clay films are not as pronounced nor commonplace, and soil structure grades are mostly moderate rather than strong. On both Dolph subcomponents color hues are 7.5YR rather than the redder 5YR hues observed on the Eola surface. But in spite of these differences, it seems clear that the buried truncated paleosol component of the entire Dolph surface is an extension of the relict paleosol observed on the adjacent Eola surface.

The third stratigraphic component beneath the Dolph surface, the Nestucca/Spencer Formation, is also the same as that observed beneath the Eola Surface. It consists of highly weathered siltstone and fine sandstone layers interspersed with occasional lenses of small gravels. Although not observed in transect W, considerable variability does occur in the Nestucca/Spencer Formation. Heavier textured soils such as Panther, Dupee, Chehulpum and Helvetia are mapped on other Dolph areas where the Nestucca/Spencer Formation has weathered to yield clays and clay loams.

Bellpine, Rickreall, and Willakenzie are mapped on the Dolph surface in the area of transect W. Bellpine, which would normally be restricted to the Eola surface was extended onto the upper portions of the Dolph. There the Greenback silt cap is particularly thin and the dominant profile and depth characteristics closely match the Bellpine series.

The Dolph surfaces and their soils occur on complex land forms. They occupy broad ridges, steeper upper and middle sideslopes, swales, and interfluves. These land forms and the Eola surface can occur as inclusions in the Looney map unit (Balster et al., 1968). The upland portions of the study area were previously mapped as the Looney surface (Balster et al, 1968). Also included in the Looney unit are contemporary natural erosional surfaces (Balster et al, 1968). This provides additional support to the alternative hypothesis of profile thinning from active rather than just paleo-erosional conditions in the Chehulpum soils mentioned in the soils map discussion.

iii) The fourth soil-geomorphic group ranges from approximately 79 to 64 m. It consists of 3 major soil-stratigraphic components. The upper component is the Greenback member.

This stratum is consistently dark brown silt loam. It increases in thickness with decreasing elevation, as observed in the sequential cores W10, W12 and W14 with thicknesses of 36, 46, and 58 cm, respectively. Core W17, which occurs across the drainageway on a similar surface and at an elevation the same as core W14, has a thickness of 61 cm.

The second stratigraphic component is the Irish Bend member. Textures are dominantly heavy silt loams and silty clay loams with mostly 10YR hues. Soil structure grades are moderate with few to common clay films that are thin to occasionally moderately thick. Total thickness is approximately 38 cm at the higher elevations (i.e. cores W11 and W12) but increases sharply to greater than 152 cm at the lower elevations (cores W14 and W17). Few to common iron-manganese concretions frequently occur. Mottling occurs extensively in cores W10, W11, W13. However, mottling is less extensive elsewhere along the transect and typically occurs along the upper boundary indicating a seasonally perched water table (cores W12 and W14). Some profiles exhibit no mottling in this strata (core W17).

The third soil-stratigraphic component is a paleosol; possibly a downslope catena-like counterpart to the paleosol component observed beneath the Dolph and Eola surfaces based on the lower color values, mottles, and mangans. At the higher elevations on the Bethel surface the depth to the paleosol averages roughly 76 cm (cores W10, W11, W12). At the lower elevations, depths to the paleosol progressively increase (cores W13 and W14 at 198 and 213 cm respectively). Textures range from silty clay loams to silty clays with hues of both 10YR and 7.5YR. Soil structure grades are moderate to strong with common to many clay films on the ped faces. Iron-manganese concretions are few to common and distinct.

This component does not appear on the matching geomorphic surface across the drainageway (core W17), unless it lies at depths exceeding 244 cm. The Nestucca/Spencer Formation is also deeply buried and consequently not visible within the sampling range.

The Bethel surface occupies gently sloping old valley terraces and escarpments. Soils mapped along the transect are dominantly Woodburn, though Willakenzie, Hazelair, and Helvetia are mapped on this surface elsewhere in the study area. These soil series, the elevations at which they occur, and the land forms on which they were observed, correspond to the Bethel geomorphic surface (Geldermann, 1970; Glasmann, 1979).

iv) The fifth soil-geomorphic group occurs at the lowest elevations of the transect, at approximately 64 m, and consists of only two soil-stratigraphic components.

The first component is the dark brown silt loam of the Greenback member; approximately 51 cm thick. The second component is the Irish

Bend member. The morphological characteristics are similar to those described for the Bethel surface with several important exceptions. Though some mottling occurs in pedons on the Bethel surface, mostly indicating seasonal perching, on this surface mottling is extensive throughout most profiles. The extensive mottling and corresponding color changes to gleyed colors indicate a change in drainage class from moderately-well drained to somewhat-poorly drained.

This geomorphic surface occupies the nearly level narrow valley bottom which is part of the old valley terrace system. The soil series mapped on this surface are Aloha and Amity. These soils and the elevations at which they occur represent the Senecal surface (Balster and Parsons, 1969). This surface is of only minor extent in the study area but is quite extensive in the lowlands immediately adjacent to the lower ends of both watersheds.

2.3.2.3.2. Transect X: This transect is located immediately to the southwest of transect W, across the small valley that is the dominating landscape feature of watershed D3 (Fig. 5). It consists of five cores and several supplementary hand augered holes. The transect occurs between elevations of 76 and 94 m on a northeast facing minor interfluve that occurs on the cultivated side slope of a large hill complex. The dominant characteristic of this transect is variability, which parallels the variable nature of the underlying Nestucca/Spencer formation. The resulting changes in drainage and soil textures are pronounced.

i) The upper four cores occur on the Dolph 2 surface (Fig. 7). As in transect W, three major soil-stratigraphic components are associated with this surface. The topmost component is the dark brown silt loam of the Greenback member. Its morphology and trend of thickening downslope are similar to those observed in transect W. Core X2 exhibits mottling in the lower portion of this component, but the other cores do not. Cores X3 and X4 have AB horizons which contain intermixed but distinct materials of both the Greenback members and the underlying paleosol, indicating some mixing along this boundary. Transect X extends along the edge of an area that formerly supported a 2 ha orchard. This mixing of the A and B horizons may be an artifact of old tree root action or mixing due to tree removal.

The second component is a buried truncated paleosol. Core X4 has a IIB1 horizon but the other cores begin this component with IIB2 horizons. The expression of this component is quite different from the paleosol observed in transect W. Overall differences are greater variability in textures and colors and the presence of extensive mottling in transect X.

Core X1 includes a paleosol component only 53 cm thick as compared to 91 cm thicknesses for cores X2, X3, and X4. Core X1 occurs near the top of the interfluve, close to a small access road. Evidence described below suggests that it occurs on an erosional surface. This is the only core in which the Ap horizon lies directly on the paleosol without a transition horizon. Consequently some artificial mixing of horizons is likely though not enough to have yet changed the texture of the Ap horizon. Many fragments of the weathered bedrock have been brought to the surface nearby. Soil textures of the paleosol in core X1 are heavy silt loams in contrast to the heavy silty clay loams

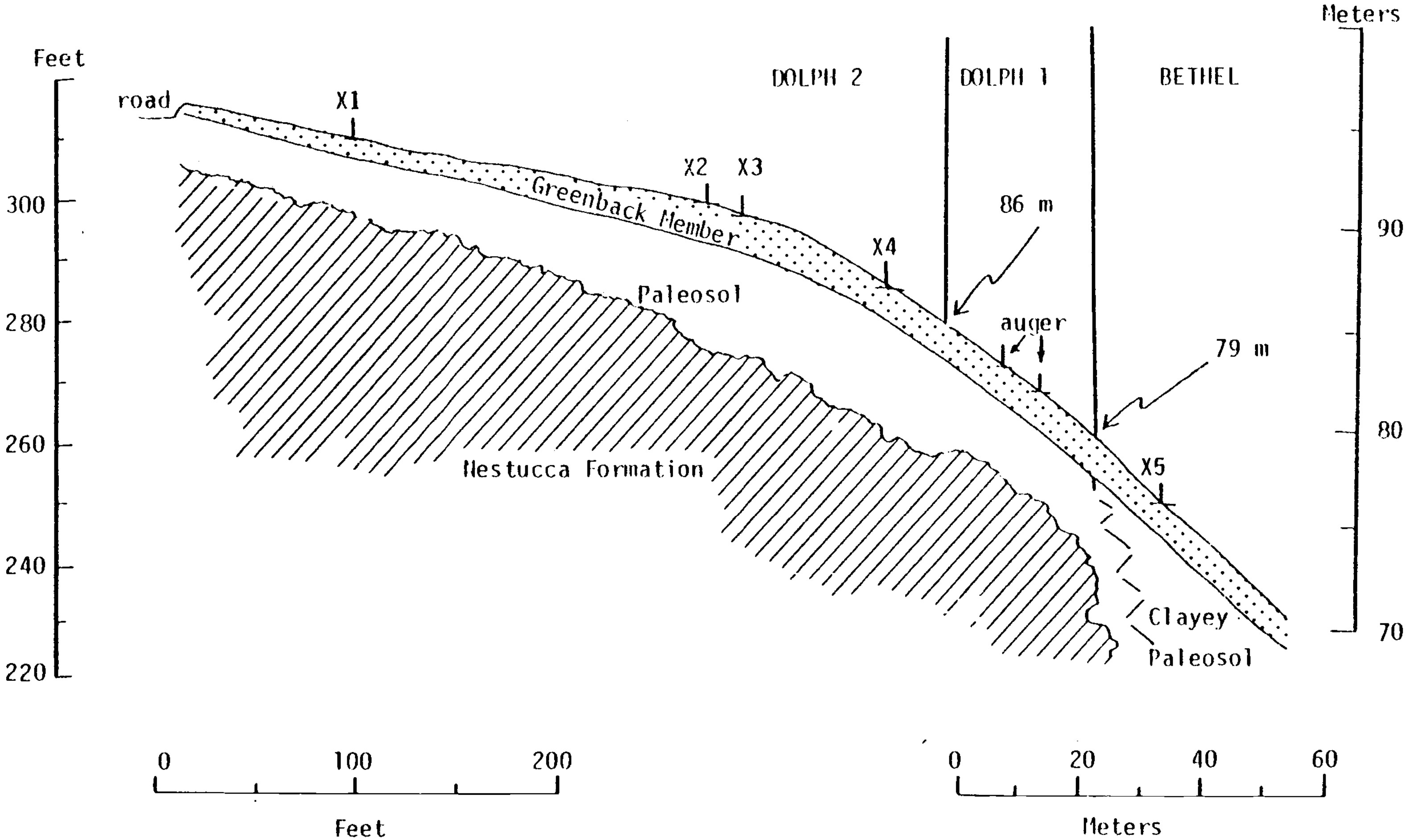

FIGURE 7. Schematic Interpretation and Summary of Transect X.

observed in cores X2 and X3; the latter being more typical of the overall area. Clay films are few and thin while mottling is extensive and begins within 20 cm of the surface.

The third component of core X1 is the variegated highly weathered siltstones of the Nestucca/Spencer Formation. It begins at 69 cm, which is much shallower than the average 125 cm depth that is typical for cores X2, X3, and X4.

Cores X2 and X3 were sampled 5 m apart, and in spite of many similarities, they exemplify the variability of the area around transect X. The topmost component is the Greenback member and is quite similar in both cores.

The second component is the truncated buried paleosol and exhibits more variability. Core X2 has gleyed colors (10YR 4/1, 6/2 m) and is mottled throughout. Core X3 is mottled but lacks gleyed colors (10YR 4/4 m). Soil textures are silty clay loams in both cores. However, X3 has many, moderately thick, clay films, but core X2 has only a few thin clay films in the same IIB2 horizons.

The third component, the Nestucca/Spencer formation, is virtually the same in both cores and consists of highly weathered siltstones.

Core X4 has many of the same features of cores X2 and X3. The most notable differences occur in soil texture and color. Core X4 has textures of heavy silt loams in the IIB horizons compared to the silty clay loams found in X2 and X3. Colors are darker in value and chroma than observed in transect W, but gleying is marginal.

No cores were collected on the Dolph 1 surface (79 to 86 m) but two holes were later hand augered to verify profile characteristics.

The only significant differences between them and core X4 was in heavier textures in the IIB2 horizons (silty clay loams) and shallower profiles. As seen in transect W the IICr occurs at approximately 95 cm on the Dolph 1 surface as compared to the 125 cm depths seen in core X2, X3 and X4 on the Dolph 2 surface.

ii) Core X5 occurs on the Bethel surface at an elevation of approximately 76 m and is considerably different from the previous cores. It consists of two major soil-stratigraphic components. The topmost component is the dark brown silt of the Greenback member with a thickness of 28 cm. This is thinner than in cores X2, X3, and X4 and is a localized anomaly of the dominant trend of this stratum for increasing thickness with decreasing elevation.

The second component consists of silty clays and exhibits the major deviation from the cores above it and from transects W and Y. These materials occur immediately below the discontinuity of the Greenback member and are too heavy textured to represent the silty Irish Bend member which typically occurs in this position (transects W and Y). Possibly the Irish Bend Member has been eroded away leaving the heavier textured paleosol that underlies it (core W10, W11, and Y3, Y5). However, unlike cores in transects W and Y, core X5 doesn't exhibit the iron manganese concretions typically seen in the buried paleosol.

Another alternative is that these sediments represent the Malpass member clay sediments noted at similar elevations on old valley terraces in adjacent areas (Gelderman, 1970). The Malpass member's age is approximately equivalent to that of the Irish Bend member and is thought to possibly reflect localized clay deposition resulting from turbidity currents. The sediments have been observed to occur in swales and on flats and to reach a maximum thickness of over a meter (Gelderman, 1970). Core X5 occurs partway down into a minor swale just off the nose of a minor interfluve. In any case, there is insufficient evidence to strongly support either hypothesis and the member to which the lower portion of core X5 belongs remains unclear.

Transect X clearly demonstrates the heavier textured and somewhat poorly to poorly drained nature of the soils in this part of watershed D3. It also demonstrates some of the variability possible within even short distances on the seemingly uniform sideslopes of the uplands of the study area.

2.3.2.3.3. Transect Y: This transect occurs in the north east quadrant of the study area, D2 (Fig. 5). Although it belongs to the drainage network of the small study area basin it is not contained within watershed D4 due to drainage alterations arising from a light-duty county road. This location was chosen because of accessiblity and the apparent similarities in land form and elevations to the major elevational areas of interest. It provided one of the best opportunities to obtain samples across the transition from the uplands to the old valley floor terraces. The transect extends along a minor cultivated interfluve from a rounded hill out onto the valley floor. It consists of 6 cores ranging in elevations from 84 to 67 m and crosses two soil-geomorphic surfaces (Fig. 8).

i) Core Y1 occurs on the Dolph 1 surface and consists of three soil-stratigraphic components. The topmost component consists of the dark brown silt loams of the Greenback member, virtually the same in morphology as that observed in transects W and X.

The second component is a buried truncated paleosol that exhibits moderate development. Soil textures are heavy silt loam to light silty clay loam with moderate to strong soil structure grades. Clay films are common to many and thin on the ped faces. Many medium sized saprolite chips occur throughout this component. The colors, textures and large number of weathered parent material chips suggest a close tie between this paleosol and the underlying bedrock.

The third component is the highly weathered, variegated siltstone of the Nestucca/Spencer formation which first occurs at a depth of 89 cm in core Y1. While this depth coincides with the shallower profiles associated with the Dolph 1 surface, in this situation the relationship is more tenuous. Core Y1 occupies a contemporary erosional surface; the steep sideslope immediately below the convex shoulder of a rounded hill. This position would be expected to result in shallower profiles regardless of paleo-erosional conditions.

ii) The other five cores occur on the Bethel surface and exhibit a variety of trends and transitions that are typical for the study area. The topmost soil-stratigraphic component is the dark brown silt loam of the Greenback member. Soil structure grades are moderate. Cores Y2, Y3, Y4 and Y6 are a cleary sequential example of the Greenback member increasing in thickness with decreasing elevation. Core Y5 is an exception to the sequence but could be the result of cultivation.

The second soil-stratigraphic component is the Irish Bend member. Soil structure grades are moderate to strong and textures range from

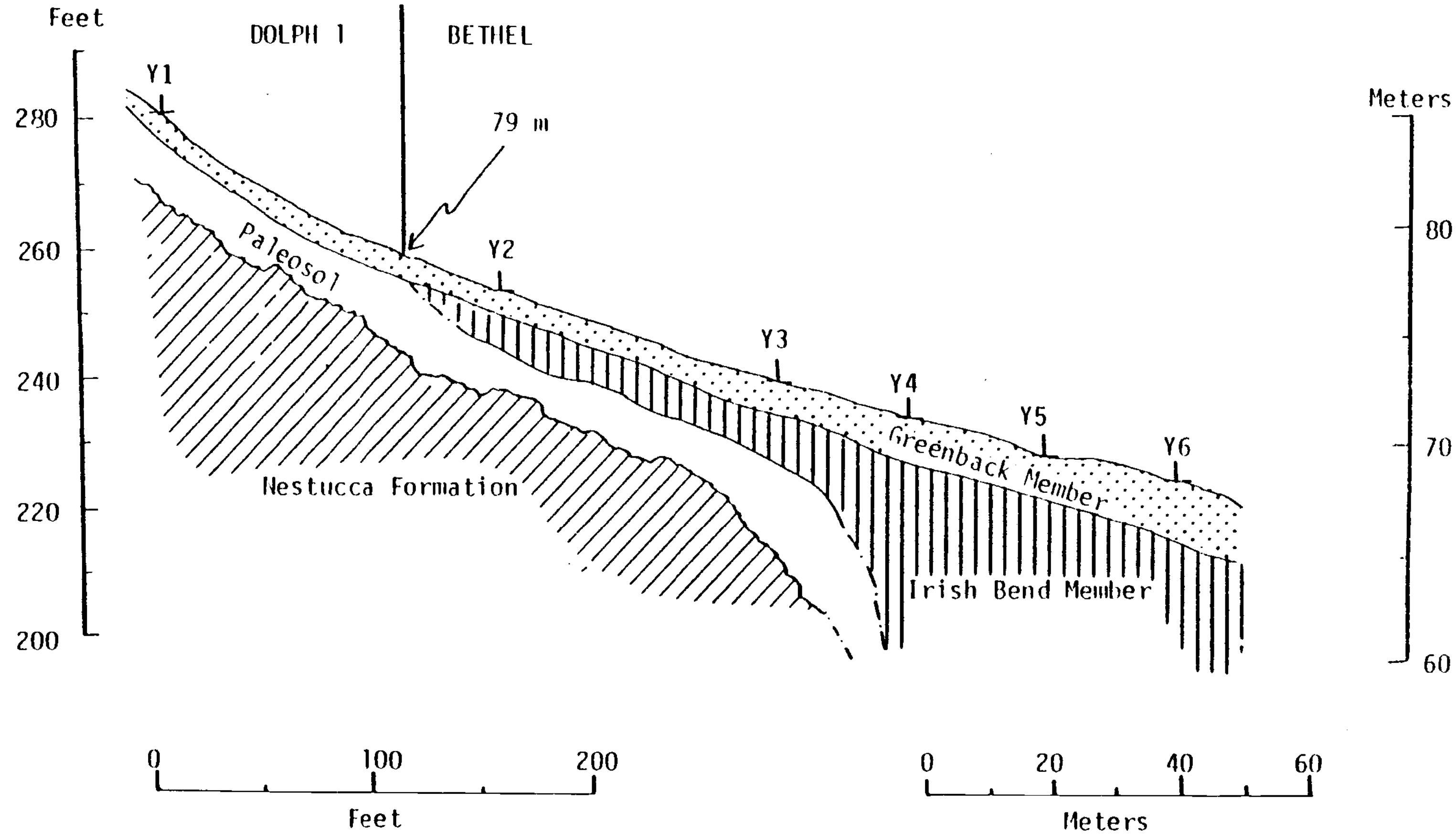

FIGURE 8. Schematic Interpretation and Summary of Transect Y.

heavy silt loam to silty clay loam. Clay films are few to common and thin on the ped faces. There are common to many, thin silt coats on ped faces. Mottling is extensive throughout the Irish Bend component. The stratum is roughly 50 cm thick in cores Y2 and Y3 and excedes 150 cm in cores Y4, Y5, and Y6.

The third soil-stratigraphic component, the buried paleosol remnants, occurs only in cores Y2 and Y3. This component is characterized by heavier textures; silty clay loam to heavy silty clay loam. Soil structure grades are predominantly strong, and saprolitic fragments are common. Clay films are common to many and thin on the ped faces. Core Y2 shows a color change from the overlying stratum but core Y3 does not.

The fourth soil-stratigraphic component is the highly weathered Nestucca/Spencer Formation bedrock which also only appears in cores Y2 and Y3. In core Y2 it first occurs at approximately 110 cm and consists of variegated saprolitic siltstones. In core Y3 it first occurs at 188 cm and consists of multicolored saprolitic sandstone.

Transect Y exhibits well the nature of the Greenback member both in gross morphology and occurrence. It also shows the initial occurrence and downslope thickening of the Irish Bend member. The expression of the paleosol is not as strong as in transects W and X. Textures are noticeably lighter, clay films are thinner, and iron-manganese concretions are minimal. Silt coats are common to many in the Irish Bend member and common in the paleosol. Drainage conditions across the Bethel surface are marginally moderately well drained. Colors are generally dark and frequently have moist chromas of 2 or 3.

2.3.2.3.4. Transect Z: This transect occurs in the northeast corner of watershed D4 (Fig. 5). It consists of 4 cores that descend across a long cultivated interfluve ranging in elevation from 96 to 78 m. It crosses two geomorphic surfaces.

i) Core Z1 consists of three soil-stratigraphic components and occurs on the Dolph 2 surface (Fig. 9). The topmost is the shallow dark brown silt loam of the Greenback member. In core Z1 the Ap horizon lies directly on the second component, the buried paleosol. Some mixing from cultivation is likely but has thus far been insufficient to visibly alter the still dominant characteristics of the Greenback member. The buried paleosol component consists of silty clay loam. Soil structure grades are moderate to strong with common to many thin clay films on the ped faces. Saprolitic bedrock fragments are common in the lower part of the paleosol. The lower horizon of the paleosol is much lighter in texture, has a weak structure grade, and has many saprolitic rock fragments. It is obviously strongly influenced by the underlying bedrock.

The third component is the variegated saprolitic siltstone of the Nestucca/Spencer Formation which first appears at roughly 105 cm. The overall characteristics are quite similar to those observed in transect Y, except for the darker chromas and the absence of mottling.

Core Z2 occurs just below a minor slope break that corresponds to the upper limit of the Dolph 1 surface. It consists of the same three soil-stratigraphic components as does Core Z1.

The topmost component is the silt loam of the Greenback member. It is somewhat thicker than observed in Core Z1 but this could be an

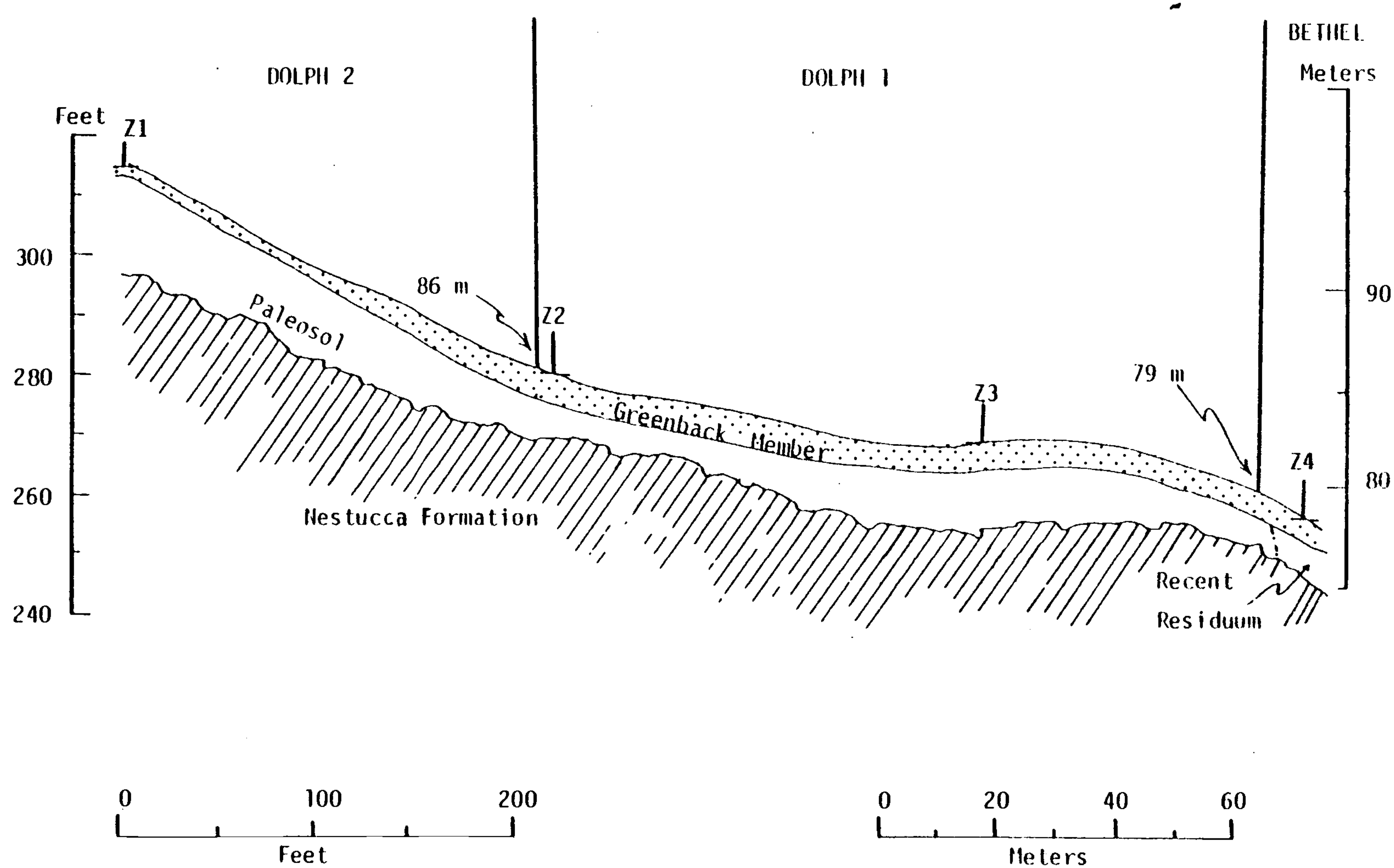

FIGURE 9. Schematic Interpretation and Summary of Transect Z.

artifact from cultivation and its position at the toe of a slightly steeper slope.

The second soil-stratigraphic component is the buried paleosol. Soil textures are silty clay loams with moderate to strong soil structure grades. Clay films are common to many and thin to moderately thick on the ped faces. Total thickness is only 30 cm compared to 84 cm at core Z1. This parallels the thinning or absence of the paleosols on the Dolph 1 surface observed in transects W and Y.

The third component is the variegated saprolitic siltstone of the Nestucca/Spencer formation. It first appears at 64 cm as compared to roughly 100 cm at cores Z1 and Z3.

Core Z2 is a clear example of total profile thinning associated with the Dolph 1 surface. The thinning is restricted to the paleosol component, and in this core, the Greenback member is thicker than it is at core Z1.

Core Z3 also occurs on the Dolph 1 surface. The Greenback member is essentially the same as observed in core Z2. The paleosol component is roughly 60 cm thick, which is twice as thick as in core Z2 but still much thinner than at Core Z1. The paleosol has silty clay loam textures and moderate soil structure grades. Clay films are common and thin to moderately thick on the ped faces. Mottles occur throughout the paleosol. The underlying weathered Nestucca/Spencer formation consists of saprolitic siltstones and is first encountered at a depth of 97 cm.

ii) Core Z4 occurs on the eroded shoulder of a hill at approximately 78 m which coincides with the Bethel surface elsewhere in the study area. The topmost soil-stratigraphic component is the unusually thin silt loam of the Greenback member. The next component is a silt loam that lacks the development seen in the paleosols. Whether it represents the appearance of the Irish Bend member seen at this elevation in transects W and Y or more recent residuum weathered from the saprolitic bedrock is not clear. The gradual nature of the lower boundary, the lack of any clay films, and the silt loam texture would seem to support the latter source.

Transect Z shows graphically the general watershed trend for shallower profiles on the Dolph 1 surface, with the shallowest profiles being found near the 86 m elevation.

2.4. Land-Use and Management Practices

2.4.1. Land Use Patterns

Althouth it is difficult to quantify differences in land use patterns in a meaningful way, a variety of observations are worth considering to better understand this study area. Land use was broken into five categories: Forestland - Old, Young; Cropland - Wheat, Grass; Other (Fig. 10, Tables 6 and 7).

2.4.1.1. Forestland. These are areas dominated by well established trees under which no cultivation has recently, if ever, taken place.

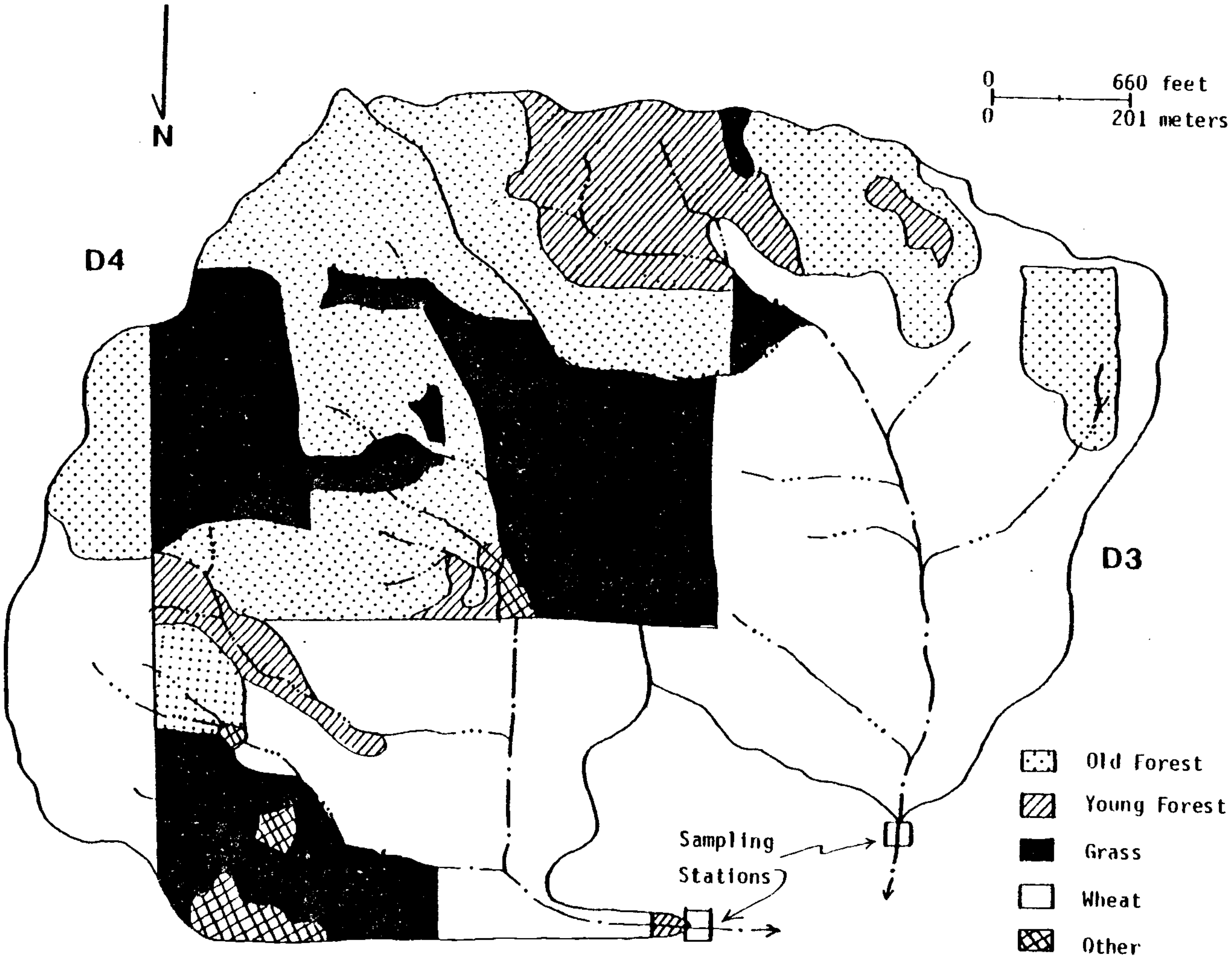

FIGURE 10. Land-use Distribution Map.

TABLE 6. Comparisons of Forested Areas in D3 and D4.

FAMILY PS* (% clay)	D3-FORESTED AREAS OLD ha	(%)	YOUNG ha	(%)	TOTAL ha	(%)	D4-FORESTED AREAS OLD ha	(%)	YOUNG ha	(%)	TOTAL ha	(%)
<35	1.98	(3.03)	1.78	(2.72)	3.76	(5.75)	17.07	(22.44)	3.18	(4.18)	20.25	(26.62)
>35	12.34	(18.83)	6.91	(10.54)	19.25	(29.37)	8.52	(11.21)	0.46	(0.60)	8.98	(11.81)
Σ	14.32	(21.86)	8.69	(13.26)	23.01	(35.12)	25.59	(33.65)	3.64	(4.78)	29.23	(38.43)

*PS = Particle-size.

TABLE 7. Comparisons of Cropland Areas in D3 and D4.

FAMILY PS* (% clay)	D3-CROPLAND AREAS WHEAT ha	(%)	GRASS ha	(%)	TOTAL ha	(%)	D4-CROPLAND AREAS WHEAT ha	(%)	GRASS ha	(%)	TOTAL ha	(%)
<35	24.73	(37.74)	0.24	(0.37)	24.97	(38.11)	17.75	(23.33)	12.40	(16.30)	30.15	(39.63)
>35	12.75	(19.45)	4.79	(7.31)	17.54	(26.76)	3.99	(5.25)	11.03	(14.51)	15.02	(19.76)
Σ	37.48	(57.19)	5.03	(7.68)	42.51	(64.87)	21.74	(28.58)	23.43	(30.81)	45.17	(59.39)

*PS = particle size.

Both watersheds have much of their forests at the higher elevations in the upper reaches of the drainage networks (Fig 10).

i) Old Forest. These lands are comprised of old stands of mature hardwoods, predominantly Oregon White oak, with some conifers (Douglas fir) beginning to pierce the closed canopy. Groundcover consists largely of wild rose and other low shrubs, and sparse grasses. Approximately 22% of D3 is in old forest cover compared to 34% of D4 (Table 6).

ii) Young Forest. These lands have previously been cleared and are now covered by younger stands of mixed hardwoods and shrubs. The canopy is not yet closed and the thick understory is dominated by grasses with some shrubs. Included in this unit are a few small areas of mature hardwood woodlots that have been extensively thinned resulting in a relatively open canopy with a heavily grassed understory. Approximately 13% of D3 vs. 5% of D4 is in young or open forest.

The total area in forestland is approximately the same in both watersheds (35.1% of D3 vs. 38.4% of D4). Of these areas, the majority of D3's forestland (84%) occurrs on heavy textured soils; based on soil series family particle-size classes (Table 6). More of D4's forestland is in old forest (33.7% of D4 vs 21.9% of D3) with the majority of its forestland (70%) occurring on lighter textured soils.

2.4.1.2. Cropland. These are areas recently cultivated and consisting of either active cropland or pastures. Grasslands are located in the mid to upper reaches of both watersheds (Fig 10). The wheat areas are concentrated at the lower elevations in the lowest reaches of both watersheds. D4 does have one wheat area along its upper perimeter; it occurs on a low to mid elevation ridge.

i) Wheat. These areas were actively cultivated just prior to the hydrologic measuring period and were planted almost exclusively with winter wheat. A small area of oats in D4 was also included in this unit because of the relative uniformity of land use compared to the other identified units. During the hydrologic measuring period, young plants had already emerged and provided a partial ground cover.

The wheat land in D3 (57.2%) is by far the largest land use component of that watershed, compared to D4 (28.6%) in which it is the third largest land use unit (Table 7).

ii) Grass. These lands consist of pastures that were not cultivated the summer preceding the monitoring season. The ground surface was characterized by a moderate to thick grass cover. Some of the fields in D4 had been cut for silage leaving a coarse stubble with undisturbed root crowns. Grasslands comprise 30.8% of D4 but only 7.7% of D3.

The total percent of area of each watershed in cropland is approximately the same (64.9% of D3 vs 59.4% of D4). However, the distribution between grass and wheat is different for the two watersheds. D3's croplands are almost exclusively wheat (57.2%), most of which occurs on medium textured soils (37.7% of D3). D4's croplands are almost equally split between wheat and grasslands (28.6% vs. 30.8% respectively). Approximately three fourths of D4's wheatland (23.3%)

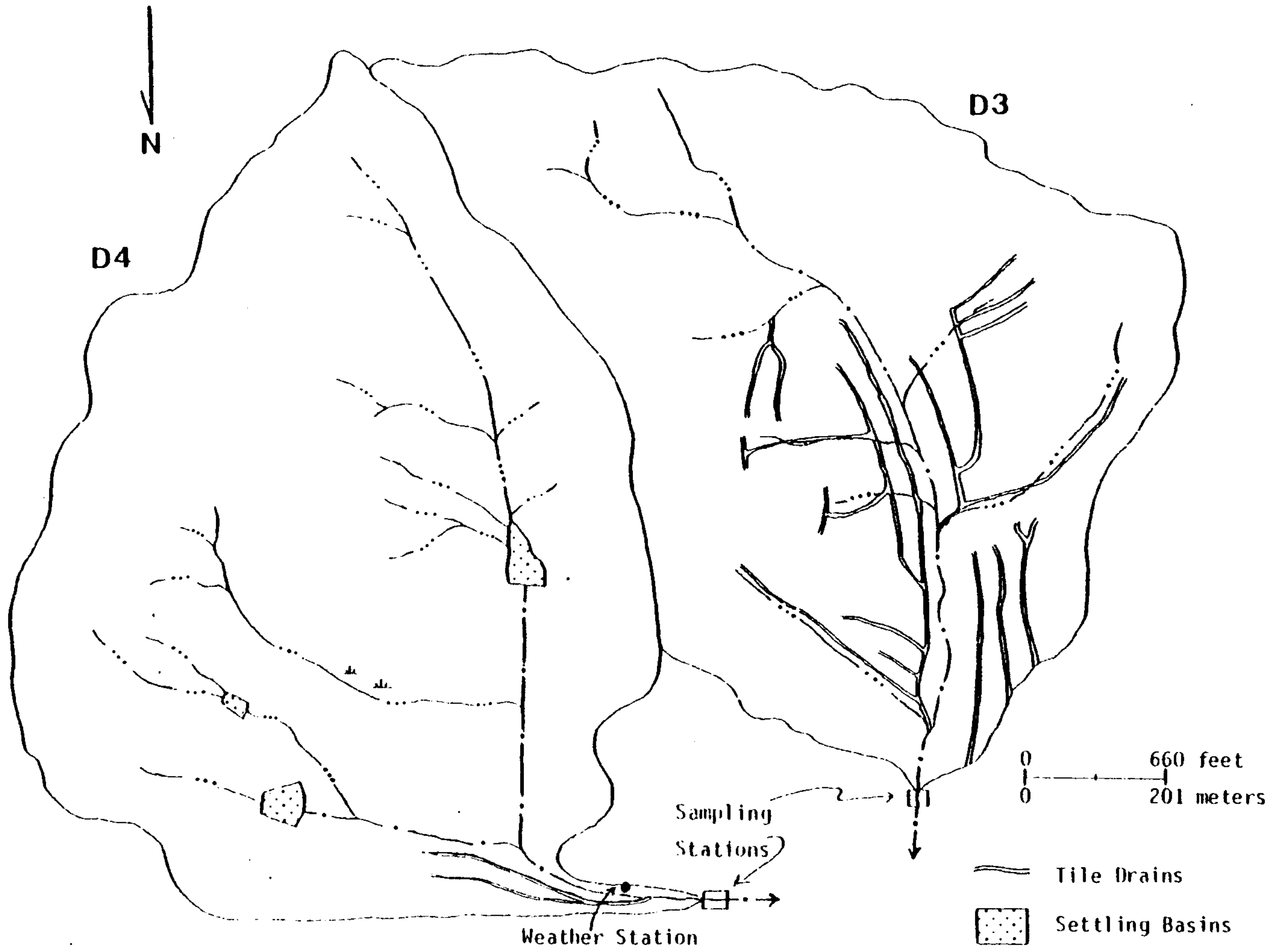

FIGURE 11. Tile Drain Network and Settling Basin Location.

occurs on medium textured soils.

2.4.1.3. Other. These are areas in D4 that are either included in the farmyard or in three water reservoirs. They comprise a total of 2.8% of D4's total area.

2.4.1.4. Grazing. A small flock of sheep was grazed on the grassland unit surrounding the farm yard in northeastern D4. Though the grass was cropped fairly short, grazing was not extreme and the ground cover was excellent with little evidence of disturbed or bare soil. Stream bank conditions in the affected area were good, being well covered with vegetation with only an occasional crossing with its associated disturbed bank areas of minor extent. No separate land use unit was designated.

2.4.2. Management Practices

Three additional management observations are pertinent to the study.

2.4.2.1. Settling Basins. Watershed D4 has three farm ponds and one wet area (Fig. 11) that receive the inputs of over half of the drainage network. These areas most likely affect the hydrology of the watershed. Separate monitoring of these reservoirs was not feasible so their actual impact must remain speculative. Watershed D3 has no comparable structures or wet areas.

2.4.2.2. Tile Drains. Watershed D3 has a fairly extensive tile drain network (Fig. 11) functioning along the toe-slopes of the upland areas. The bulk of the network drains into the natural drainageways at tributary junctions upstream of the sampling station. The partial network in the extreme northwestern corner that does not empty upstream of the sampling station was observed to be in poor repair with a nonfunctioning outlet downstream. Another smaller partial system on the east side of the drainageway affects roughly a two hectare area and is functional, draining away from, and downstream of, the sampling station.

Watershed D4 also has a minor, functioning tile line in its lowest reaches. It empties into the main stream upstream of the sampling station.

2.4.2.3. Grassed Waterways. Both watersheds have drainageways that largely follow the naturally occurring stream network. Some channel manipulation was done years ago and all channels are now well established vegetated waterways. Shrub and cattail growth line the drainageways in addition to grasses. Both watersheds have sporadic, minor pockets of bank slumping, none of which occur near the sampling stations. Some small areas of sediment accumulation were observed in channel bottoms but these appeared to be natural sediment bedloads in transit, none of which occurred near the sampling stations.

Chapter 3. HYDROLOGIC RELATIONSHIPS

3.1. Introduction

Both watersheds are dominated by valleys that contain year-round low volume streams. Minimal but consistent baseflows were observed even during the dry summer of 1977 which followed a record drought period for the area the preceding winter. Watershed D3 consists of a single valley system with ephemeral stream tributaries flowing into it from side swales and gullies (Fig 2). D3's measurement station is located appoximately 100 m from upland areas with their greater slope gradients.

Watershed D4 which consists of three major stream subsystems exhibits a more branched stream system than does D3. All of D4's stream subsystems are interrupted by farm ponds or depressional wet areas above their mutual confluences. The northeasterly stream system consists of several gully systems that drain the swales of a lower lying hill area. Its two major branches are interrupted by farm ponds. The central stream system drains a slightly higher upland area. Its flow is interrupted midway by a wet area in which the main drainageway becomes temporarily less distinct amidst dense sedges and cattails. The southern stream system dominates the largest valley and its tributary gully and swale network. Its flow is interrupted by the largest of the farm ponds just above the main valley floor. All three streams coalesce out on the main valley floor and then flow approximately 325 m to the sampling station. This station is at a considerably greater distance from the sharply steeper slope gradients of the uplands than the station in watershed D3.

All drainageways are vegetated. Some small eroded and denuded areas occur within the drainage networks. However these areas are isolated, of minor extent, and are largely confined to the upland areas.

3.2. Methods and Measurements

Because of the intent to minimize costs and required manpower it was desireable to focus on only a few major hydrologic parameters. The major parameters chosen for monitoring were precipitation (P), streamflow (Q), and suspended sediment (SS).

Eight storm events were monitored simultaneously on both watersheds during the winter of 1977-1978. These eight storms were of sufficient intensity to produce significant changes in streamflow and suspended sediments. Other storms of low intensity or duration were not monitored. Several larger storms were not analyzed due to equipment malfunctions.

3.2.1. Precipitation

Precipitation was monitored by using continuous recording rain gauges which have a minimum resolution of 0.254 mm (0.01 in) of precipitation. The primary recording unit was situated in the weather station in the northwest corner of D4 (Fig 11). A backup unit was situated at the sampling station in D3. In nonmountainous terrain, for areas one square mile or less in size, it is assumed that such point measurements are reasonably accurate indicators of precipitation over the entire area. Precipitation data were compiled into 30 minute increments. Pertinent precipitation information is included in Figs 12-19, and in Appendix Table A3.

3.2.2. Streamflow and Suspended Sediments

Two additional parameters, streamflow and suspended sediment concentration, were chosen as indicators of erosion potential and water quality under natural storm conditions. These parameters were desirable because of the relative ease in obtaining them. Other studies have shown that estimations of erosion levels should include the baseload sediment component, as this can comprise a significant percentage of the total stream sediment load. However, as this was beyond the scope of the study, suspended sediment load was more simply obtained by the use of automated sampling devices. As suspended sediment load reflects the order of magnitude of erosion levels, it can be effectively used to detect relative changes in sediment yields as a function of differing storm conditions. More importantly, it can be used to compare the similarities or differences between paired watersheds regardless of the absolute sediment levels.

FIGURES 12-19: Storm Hydrographs, Suspended Sediment Graphs, Precipitation Record.

(Q = —o—o— , SS = - - -Δ- - , P = ⏋)

- for general storm characteristics and suspended sediment summaries refer to Appendix Tables A4. and A5.

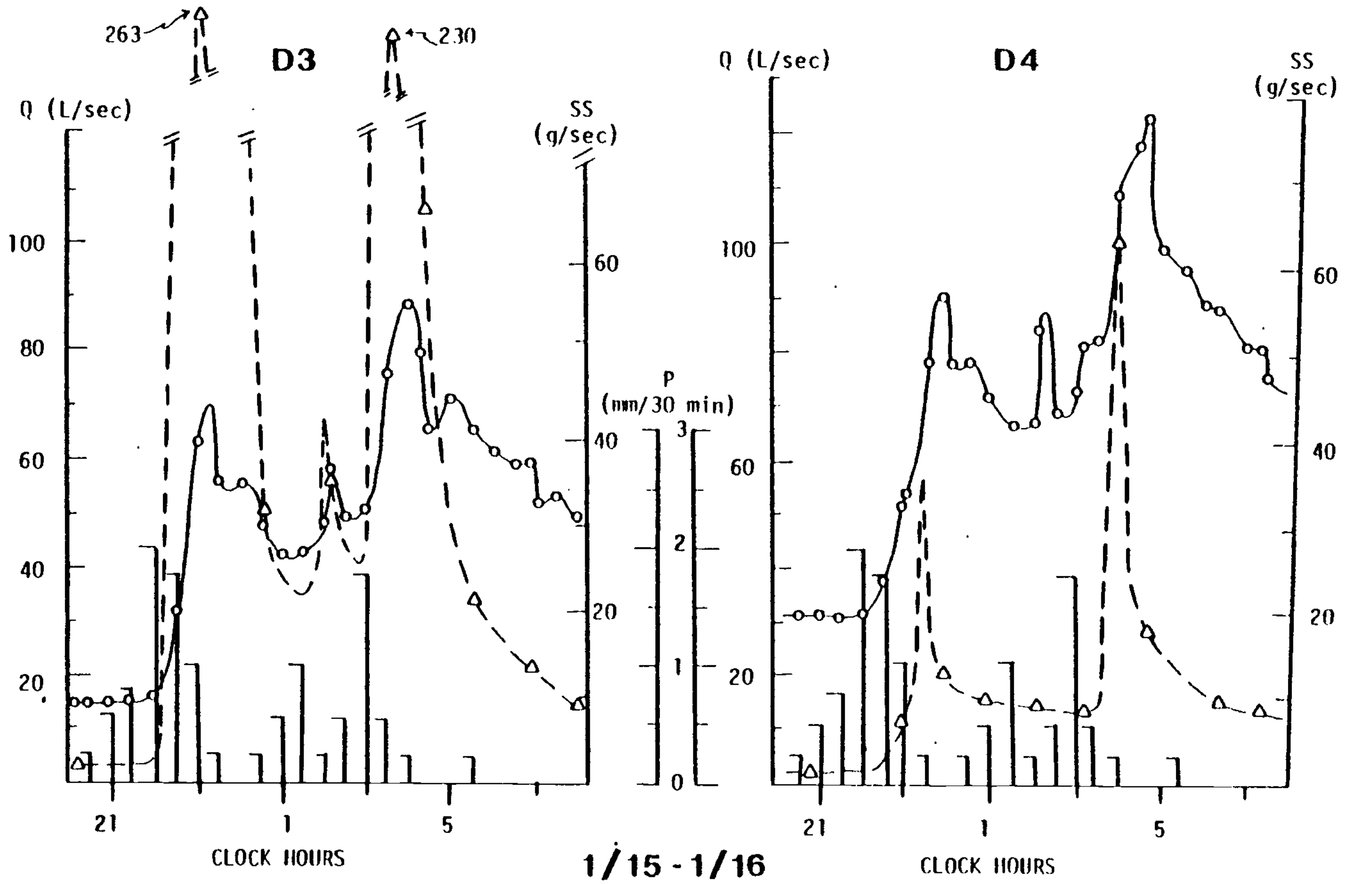

FIGURE 12. Storm Graphs for 1/15-1/16.

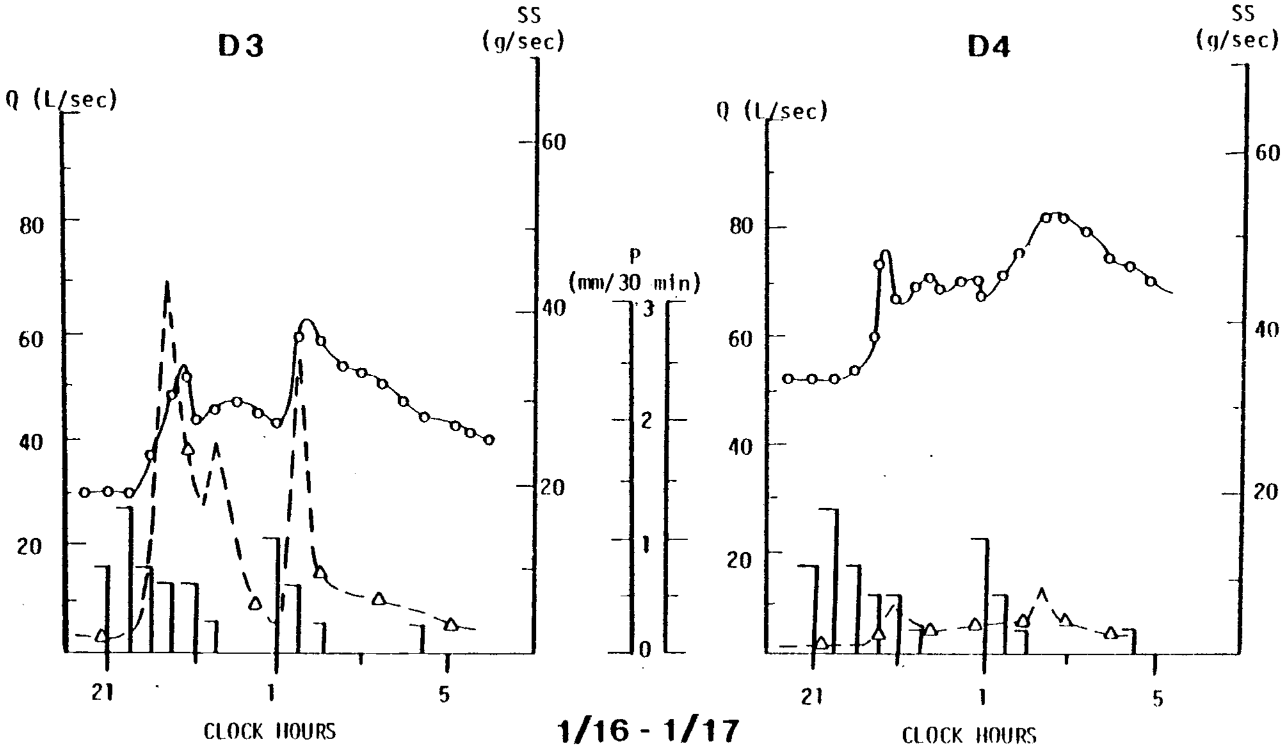

FIGURE 13. Storm Graphs for 1/16-1/17.

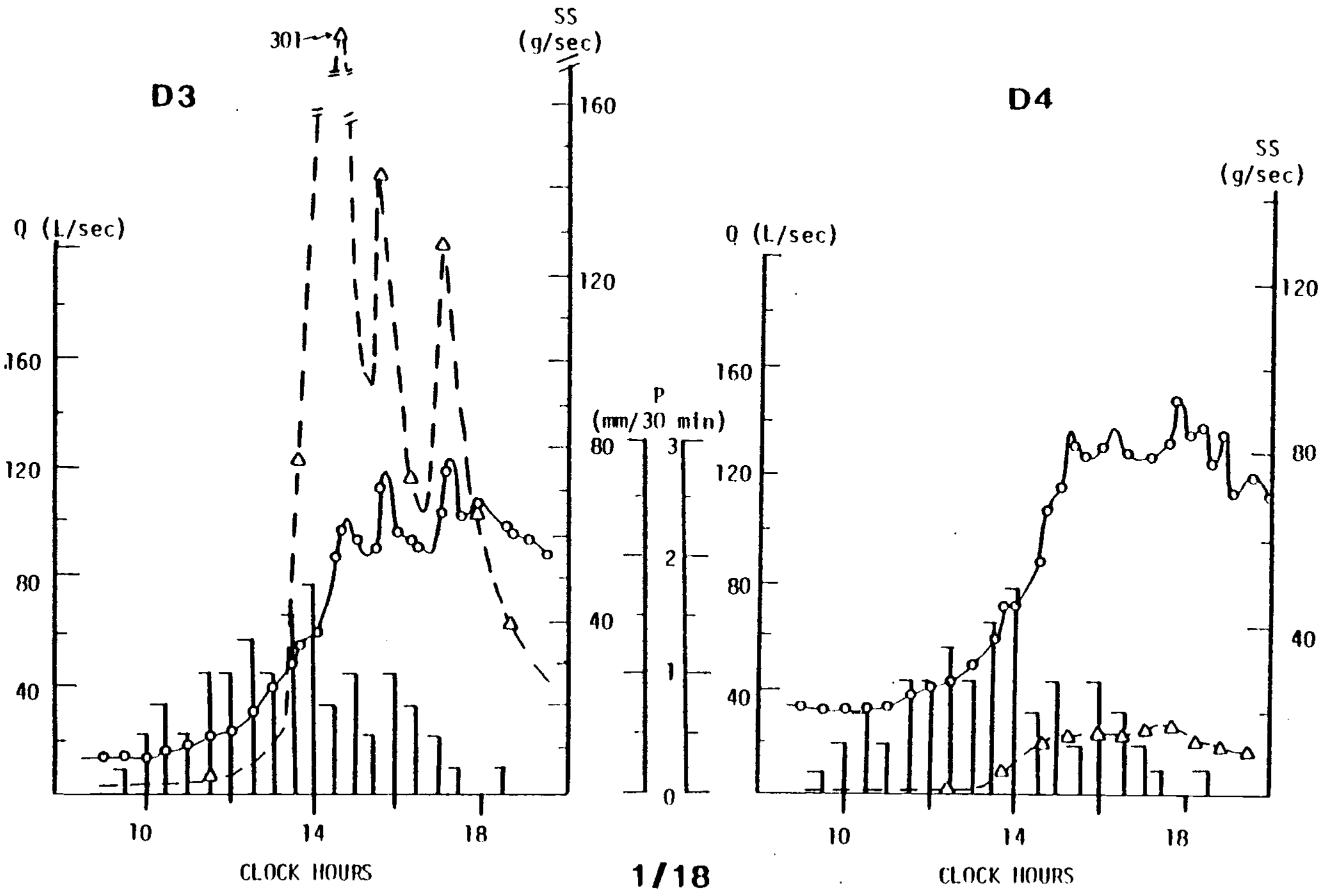

FIGURE 14. Storm Graphs for 1/18.

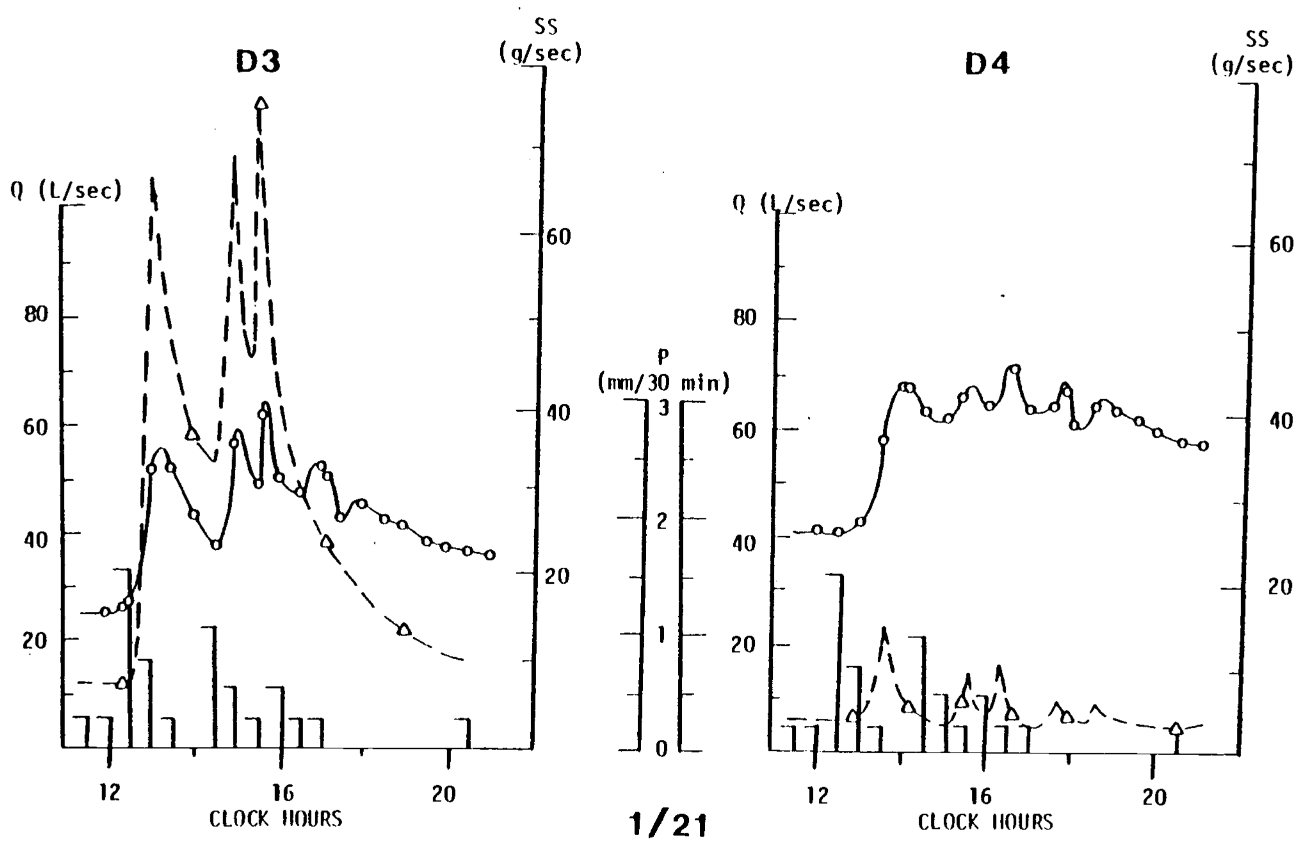

FIGURE 15. Storm Graphs for 1/21.

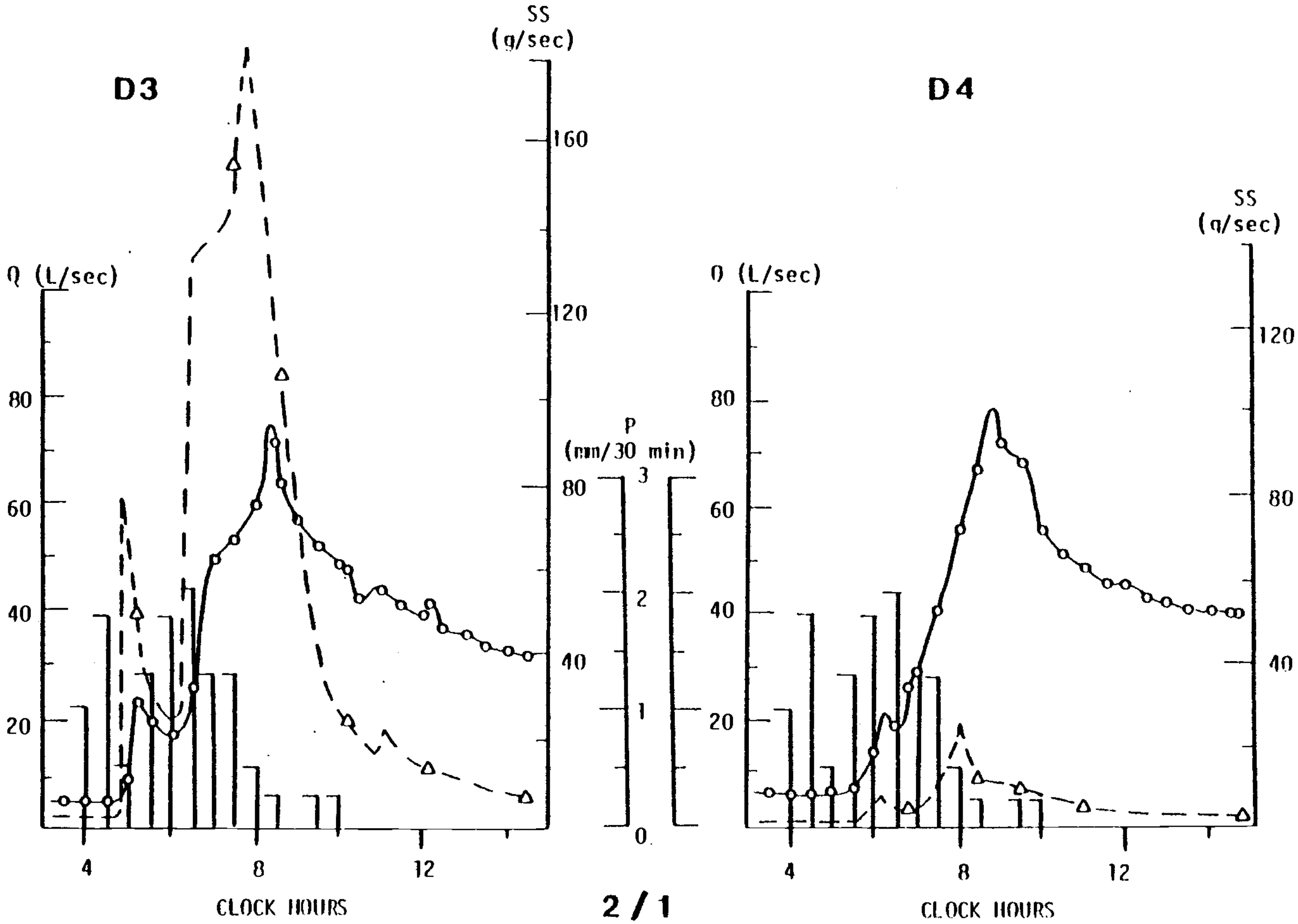

FIGURE 16. Storm Graphs for 2/1.

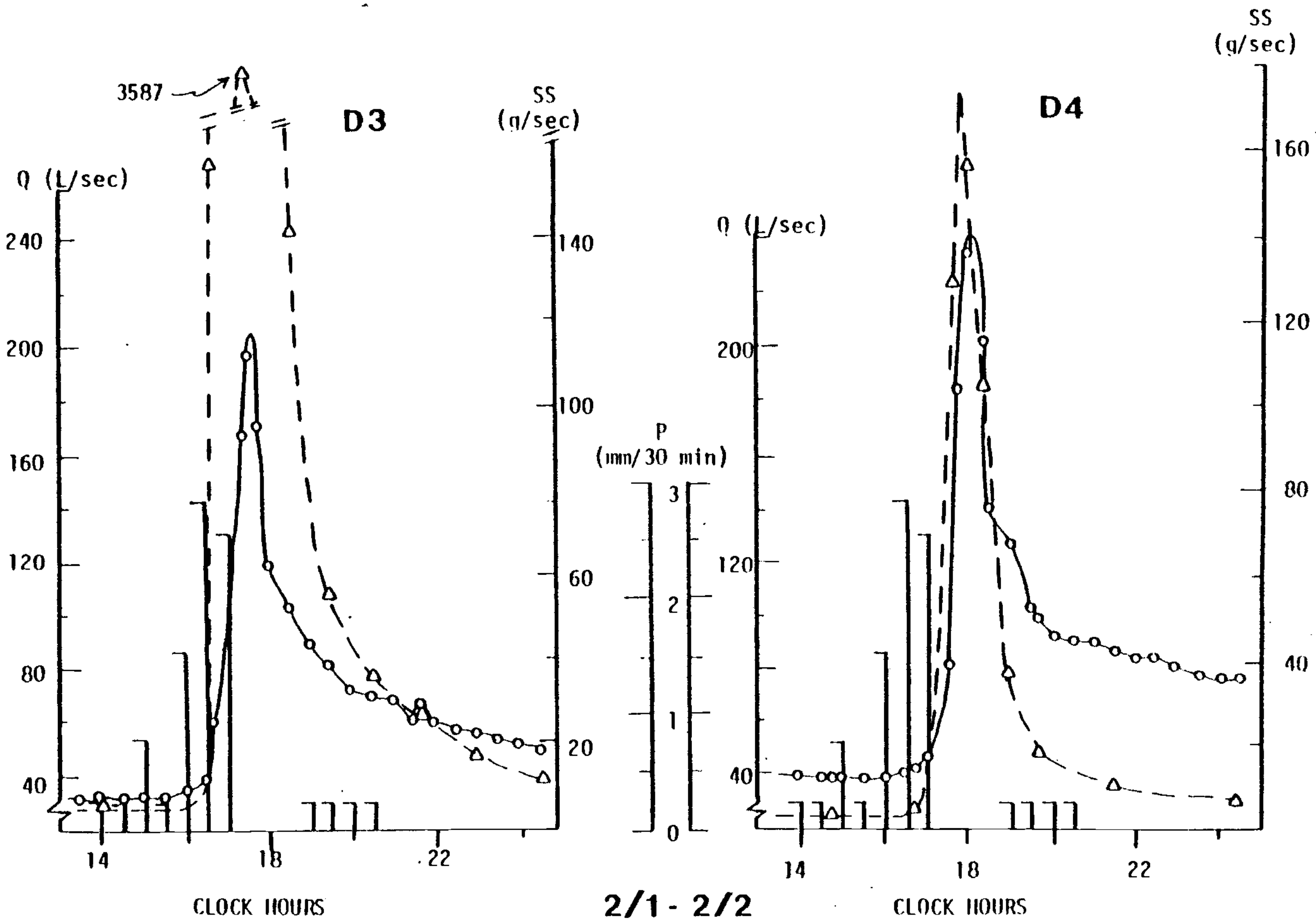

FIGURE 17. Storm Graphs for 2/1-2/2.

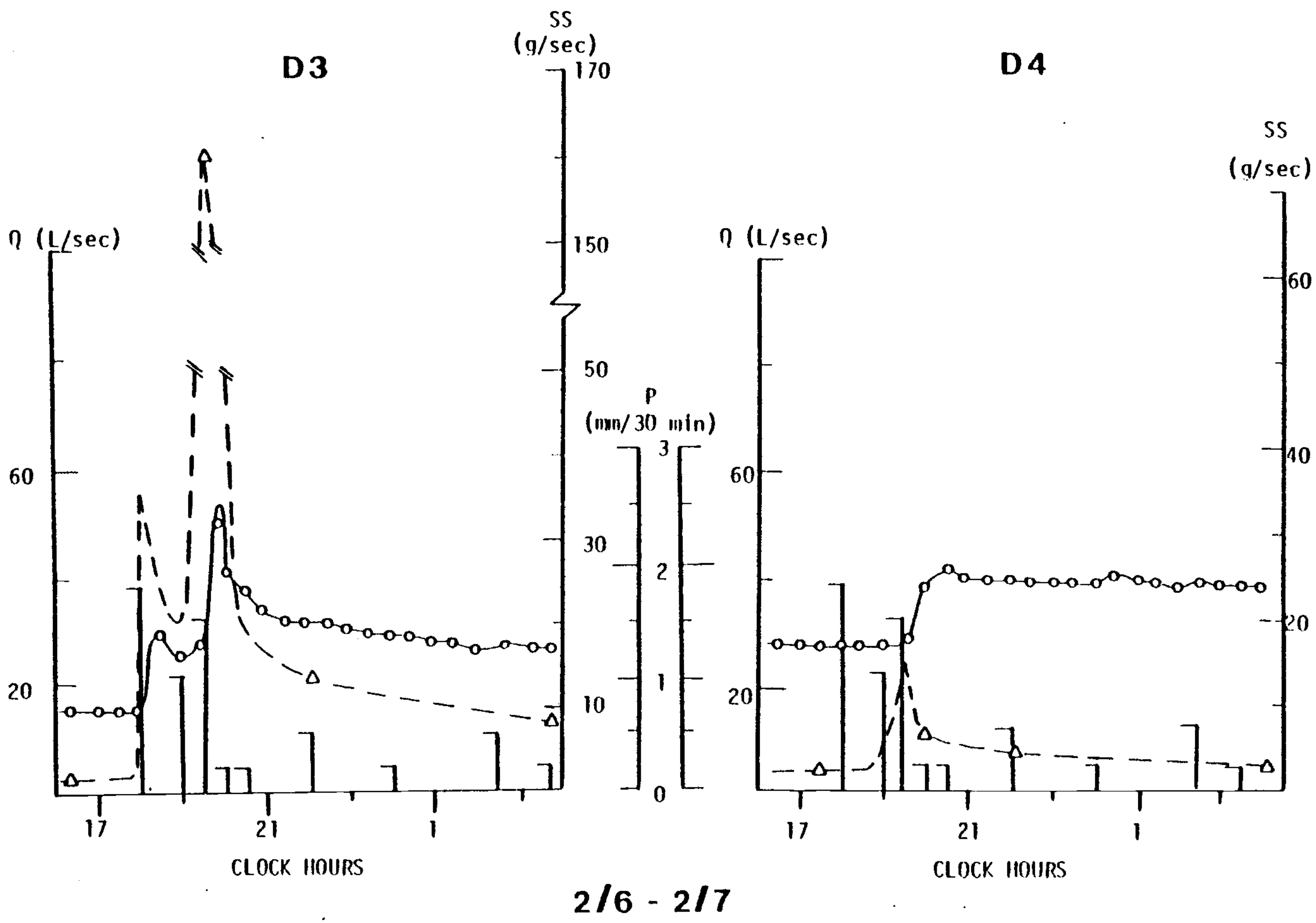

FIGURE 18. Storm Graphs for 2/6-2/7.

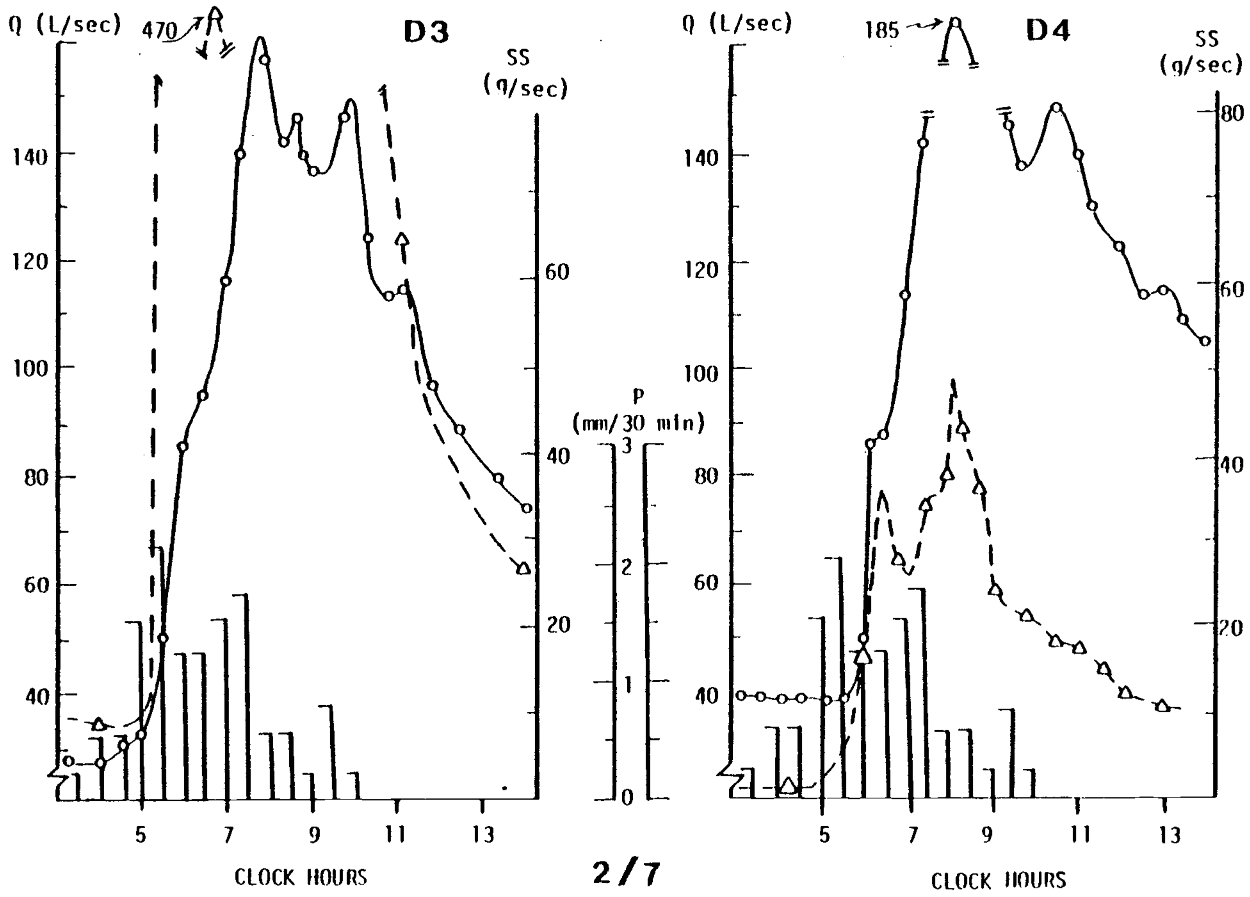

FIGURE 19. Storm Graphs for 2/7.

3.2.2.1. Methods

Streamflow (Q) was monitored on both watersheds. The monitoring devices included the use of calibrated fiberglass H - flumes to provide accurate stream channel geometrics. Streamflow was monitored by using an automated "Isco" flowmeter and printer which provided accumulated Q measurements at 30 minute intervals for both watersheds. Back-up and supplimentary monitoring was provided by "Steven's Water Stage" recorders which generated continuous stream hydrographs.

Water samples were collected by "Isco Automated Water samplers" in conjunction with the flowmeters. These samples were collected at predetermined streamflow volume intervals of 283, 162.5L (10,000 ft^3). The water samples were later analyzed to determine suspended sediment concentrations. These "point" measurements facilitated the reconstruction of storm hydrographs with corresponding suspended sediment levels. The differences in streamflow levels of the two watersheds made it impractical to collect synchronized water samples.

3.2.2.2. Results

3.2.2.2.1. Delay Factors. The time required for streamflow response from the onset of precipitation was different in the two watersheds. The mean Delay Factor (DF) is the mean time (in minutes) between the start of precipitation and the first observed increase of Q. The mean Delay Factor for each watershed was calculated from data from seventeen different storm groups, some of which included multiple precipitation pulses (Appendix Table A2.). Each distinct pulse of precipitation was treated as an individual event. An unpaired student's t test was conducted on the data. Results indicate that there was a highly significant difference ($\alpha \leq .001$) between the mean delay factors for the two watersheds (Table 8, Appendix Table A2.).

Table 8: Comparison of Watershed Delay Factors (DF).

Watershed	Mean Delay Factor	S.E. of Estimate
D3	50 min.	3 min.
D4	75 min.	5 min.

On the average, the initial increase in Q at the D3 sampling station will occur 50 minutes after the onset of precipitation. Antecedent watershed conditions and the nature of the precipitation event will cause some deviations from the mean. Watershed D4 exhibits the same kind of behavior, although the lag-time is longer. This difference in delay factors clearly points to some undetermined yet fundamental difference(s) in the hydrologic nature of the watersheds. The difference may in part reflect the difference in soil distributions and ground cover discussed in Chapter 2. Watershed D3 has larger percentages of wheatland and heavy textured soils than D4. Both conditions could be expected to contribute to more rapid runoff than the moderate textured soils and extensive grass cover occurring in D4. D3 exhibits a quicker hydrograph response than D4.

3.2.2.2.2. Steamflow Features. There is a relationship between precipitation and streamflow levels as observed in Figs. 12-19. However, a linear regression analysis of P and Q values (Appendix Table

A3) revealed no statistically significant relationships between P and Q values. This reflects the complex nature of the relationships of streamflow to precipitation and other watershed parameters. Streamflow levels are affected by precipitation intensity and duration in addition to volume. Antecedent moisture conditions also affect Q levels. All other parameters being equal, for moderate to low volume precipitation events Q values will be lower proceding dry watershed conditions then Q values proceding moist watershed conditions. This results from the recharging of temporary water storage capacities in the watersheds (Hewlett, 1982).

Tentative analysis of hydrographs indicated a likely relationship between the streamflows (Q) of the two watersheds. To explore this possibility, a linear regression was conducted on data from eight storms (Figs. 12-19, Appendix Table A3.). Results indicate that a highly significant relationship exists ($\alpha \leq .001$) between Q3 and Q4 ($R^2 = 0.80$, n = 117; Appendix Table A3). When the Q values for both watersheds were adjusted by incorporating the appropriate delay factor determined previously, a linear regression of these adjusted Q's demonstrated an improved relationship in terms of R^2 values ($R^2 = 0.93$, n = 117; Appendix Table A3.).

These results indicate a close relationship between the two watersheds with regards to the response of streamflow hydrographs. Although the difference in total watershed area between D3 and D4 (D3 is 13.9% smaller than D4) does not affect the existence of a consistent relationship between their respective hydrographic responses, it does affect the magnitude of the differences between their respective responses. Graphical comparisons of Q values and Q values adjusted to an equivalent-area basis, D3Q values increased by 13.9%, revealed a variety of basic differences in the hydrographic responses of the two watersheds (ex. Fig. 20).

Baseflow: Watershed D3 has a consistently lower baseflow prior to the initial rise in Q during a storm event. Typically the baseflow of D3 is approximately 65% of that in D4, ranging from 47% on 1/18 (10:00) to 85% on 2/1-2/2 (16:00). The higher baseflow levels of D4 may reflect the soil and land-use patterns described in Chapter 2. D4 has greater percentages of moderate textured soils particularly in forested areas. These forested areas are associated with upland aceas in which the porous bedrock occurs closer to the surface than it does at lower elevations. The combination of shallower profiles and moderate textured soils in D4 suggest conditions which are more conducive to infiltration, deep percolation, and subsequently higher baseflows than the heavy textured soils dominant in D3.

Antecedent moisture conditions strongly affect overall baseflow levels in both watersheds. The very low initial levels of Q on 2/1 followed a 5 day period of negligible precipitation. The low values on 1/15-1/16, 1/18, and 2/6-2/7 follow periods of more than 30 hours without significant precipitation. The higher initial Q values of the other storms arise from the wetter field conditions due to more closely preceding precipitation events.

Watershed D3 appears to have generally lower peak Q values but when compared on an equivalent basis it freqently equals or slightly exceeds the corresponding peak Q values of D4.

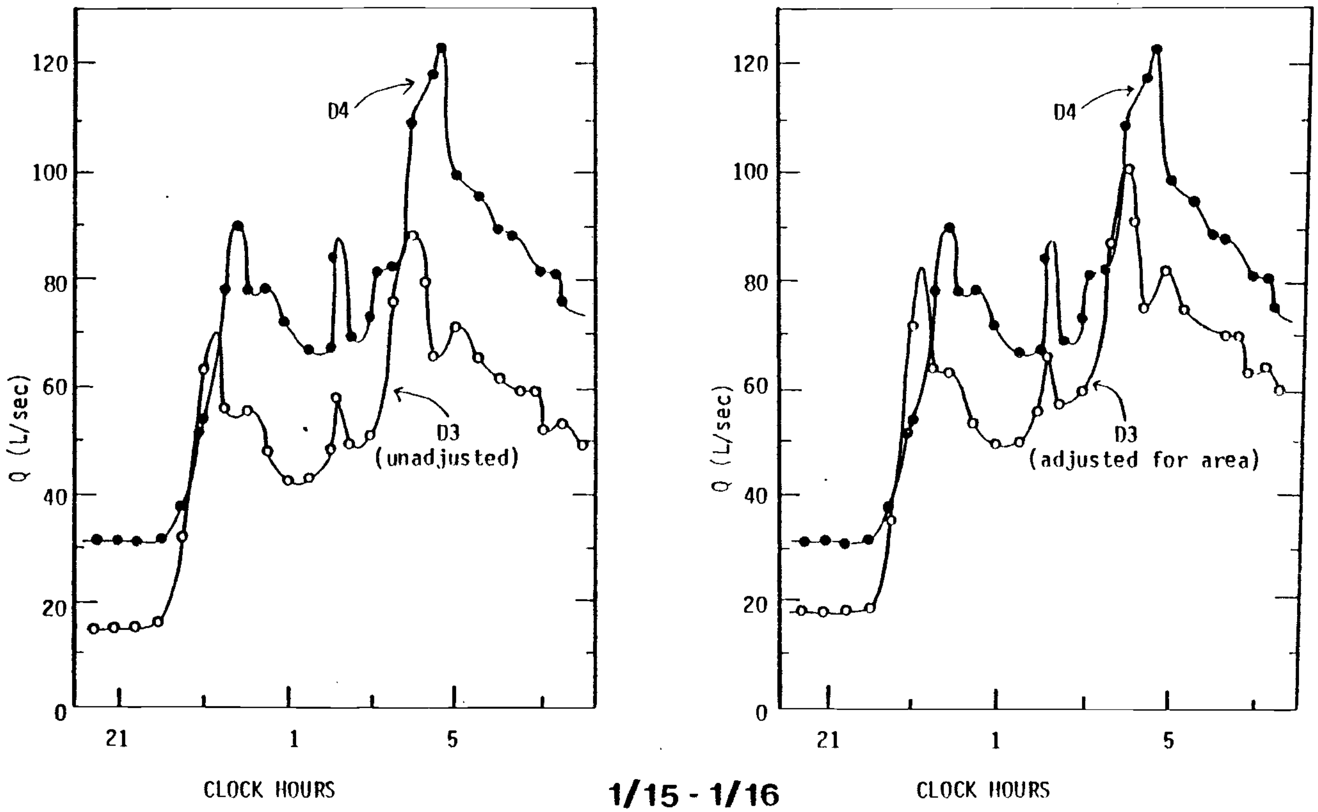

FIGURE 20. Comparisons of Natural Q-Values and Q-Values Adjusted for Area Difference.

On the descending hydrograph limb, D3's Q values are approximately 78% of that in D4; ranging from 64% on 1/21 (20:00) to 95% on 1/18 (19:00). These slightly higher percentages and the higher Q values on the descending hydrograph limb indicate contributions from storm runoff and throughflow from recharged groundwater reservoirs.

Sensitivity: Watershed D3 exhibits greater perturbations in its hydrographs to small pulses of precipitation within a storm event. For isolated precipitation pulses with identifiable responses well within the storm or on the descending limb, D3 shows greater hydrograph sensitivity. The rising hydrographic limb, which are grossly affected by antecedent moisture conditions, were not included in the sensitivity comparisons.

For pulses of 0.51 mm on 1/21 and 2/1, D3 shows only a minor response while D4 shows little or no response. On the descending limb on 1/15-1/16 and 1/21 D3 responds noticeably to 0.76 mm precipitation where as D4 shows almost no response. The 1.54 mm pulse starting at 14:30 on 1/21 elicts a solid response in D3 and a noticeable but lesser response from D4.

These results suggest that under saturated conditions there may be a detectable difference between the levels of precipitation which will generate a significant hydrograph response for each watershed. A larger data population would be necessary to conclusively determine this phenomonen. To identify such "threshold levels" precise rainfall intensity information would be required. The lack of response from D3 and D4 to 1.02 mm of precipitation within a ninety minute period on 2/1-2/2 contrasts the responses to lesser precipitation levels cited previously. This illustrates that total precipitation alone does not provide the entire story.

3.2.2.2.3. Suspended Sediments. SS samples were collected in both watersheds at synchronized volume intervals which did not occur at the same time because of the different streamflow rates of D3 and D4. This situation combined with the wide spacing of measurement points across the rising limb of the storm hydrographs prevented meaningful statistical comparisons. Analysis of SS is further complicated by the complex nature of this parameter. SS is not consistently related to Q. SS values for the same Q are very different on the rising limb and the descending limb of the hydrograh. It is more closely related to changes in the slope of Q (Hewlett, 1982). SS values increase as the slope of Q increases and decreases as the slope of Q begins to decrease. This is clearly seen in Figures 12-19; peak SS precedes peak Q.

SS is also affected by other parameters, particularly rainfall intensity. To adequately explore this relationship a larger data population including more detailed rainfall intensity data is needed than is available here. However, the sequence of storms based on total suspended sediment yield corresponds to the sequence of storms based on the maximum 30 min. precipitation (Table A5 and A4). The sequence of storms based on total precipitation does not correspond to the sequence of storms based on total suspended sediment yield (Tables A4, A5).

Graphical comparisons of SS levels show that D3 has consistently higher overall SS levels during each storm event (Figs 12-19). Total SS yield per event is consistently and markedly greater from D3 than D4 (Table A5.). SS levels tend to rise with increased precipitation intensity in both watersheds but to much higher levels in D3. This may be related to the soil and land-use distributions discussed in Chapter 2.

Watershed D3 has greater percentages of cultivated wheatland than does D4. Cultivated cropland is more subject to erosion than undisturbed grasslands (Whicht, 1966). Consequently D3 appears to have greater percentages of land that are particularly subject to erosion than does D4.

Watershed D3 also has greater percentage of heavy textured soils than D4. The heavy textured soils may contribute to greater levels of rapid runoff than moderate textured soils which dominate D4 and hence may represent more erosive conditions.

Chapter 4. SUMMARY AND CONCLUSIONS

4.1. Soils

4.1.1. Distribution

No great differences exist in the soil series occurring in both watersheds except in their distributions and percentages of the area they cover. D3 has a broader range of major soils; five series which exceed 10% of the watershed area and a combined area of 75%. D4 has only two series exceeding 10% in area, with a combined area of 71%. Similarly D3 has seven series exceeding 5% in area with a combined watershed area total of 93%. D4 has only four series exceeding 5% in area with a combined watershed area total of 87%.

Along with this greater range of major series, D3 has more heavy textured soils, based on family particle-size classes; 56% of D3 vs 32% of D4. In addition 25% of D3 has very fine textured (>60% clay) soils compared to only 3% of D4. These differences have hydrologic implications. All other parameters being equal, heavy textured soils have lower infiltration rates than do moderate textured soils. This can result in generating more rapid storm runoff which can in turn generate a quicker hydrograph response.

D4 has a greater distribution of moderate textured soils (18-35% clay based on family particle-size classes). These soils overlying highly weathered bedrock are conducive to deep water percolation supportive to groundwater reserves. D3 having heavier textured soils at equivalent geomorphic positions would not be as conducive to infiltration and deep percolation in these areas.

D3 has greater percentages of shallow soils than D4 (15% of D3 vs 6% of D4). In D3 these shallow profiles generally occur in drainageways and on steep cropped hillslopes which can readily contribute to storm runoff. Much of the smaller portions of D4 in the same category occur as forested knolls or ridges surrounded by broad shoulders with deeper profiles. This pattern is generally more conducive to ground water percolation than to generating storm runoff.

Soils distribution based on percent-slope categories shows great similarity between the watersheds both in the percentages and their distribution. The great bulk of both watersheds occur on relatively moderate (3-20%) slope gradients and occur in very similar proportions within that range.

4.1.2. Paleosols and Perching

Both relict and buried paleosols are common components in both watersheds. Above elevations of 122 m the relict profiles are strongly developed, reflecting the age and stability of thel and forms they occupy. These areas also contain localized pockets of eroded and thinned profiles which parallels conditions on similar geomorphic surfaces elsewhere in the Willamette Valley.

Below 122 m the paleosol components become buried at increasing depths with decreasing elevation, if they haven't been eliminated by erosion. These patterns of occurrence have hydrologic in addition to geomorphic implications.

The interface between the paleosols and the overlying mantle of coarser and younger sediments frequently exhibits morphological evidence of temporarily perched water tables and/or lateral water movement. Mottling and traces of leaching occur along fracture systems and on outer ped surfaces and are not unusual. Where they occur on steep hillslopes, these conditions indicate potential seep spots (i.e. Soil core X2). During the winter rainy season with saturated profiles and subsequent perching, such locations could likely be contributing source areas for storm runoff (Hewlett, 1982). These features can be observed in the moderate textured soils but are more strongly expressed in the heavy textured soils. Watershed D3 with its greater percentage of heavy textured soils exhibits these features over a wider area.

Based solely on field evidence the transects repeat or parallel previous work in similar or nearby areas. The observed geomorphic surfaces fit reasonably well into the units devised and described for the Willamette Valley (Balster and Parsons, 1969; Gelderman, 1970; Glassmann, 1979).

4.2. Hydrologic Relationships

The hydrologic responses of D3 and D4 are different, yet consistent. The stream hydrographs, which represent a net parameter or a summation of all other watershed parameters, indicate that an unequal yet consistent hydrologic relationship exists between D3 and D4.

4.2.1. Delay Factors. The highly significant statistical difference in mean response time indicates a fundamental hydrologic difference between D3 and D4. D3's hydrograph mean response time is 25 minutes shorter than D4's mean response time. This quicker response of D3 can be partially attributed to the location of its sampling station. It lies approximately one-third of the distance of D4's station from major upland areas. The closer proximity to upland areas with greater slope gradients and shorter delays in storm runoff may contribute in part to the overall delay factor discrepancy. Lowland stream gradients are essentially the same in both watersheds and thus not a factor.

The settling basins will contribute to delays in downstream hydrograph response prior to being full. However, the delay factors do not consistently decrease in duration across the storm event. The continued variability throughout an event indicates that surges continue to occur in D4 as they do in D3 despite the presence of the basins.

4.2.2. Streamflow. The highly significant linear regressions confirm a consistent hydrograph relationship between D3 and D4. This suggests that one watershed could be used as an unmanipulated control in a paired watershed design. It could be used to generate an expected response for comparison to the manipulated watershed. To adequately specify a descriptive equation of this relationship for future watershed manipulations and comparisons, a larger storm population over a wider range of storm sizes would be necessary.

Within the consistent hydrolographic relationship, various differences occur. D3 has a consistently lower baseflow before and after storm events. Comparing watersheds on an equivalent area basis does not account for the differences in baseflow. Despite the lower baseflow in D3, neither watershed exhibits consistently dominant peak Q values.

D3's hydrograph shows greater sensitivity to small perturbations in precipitation. This phenomenon may be at least partly due to the influence of the settling basins in D4. These reservoirs act to dampen the amplitudes of minor hydrograph pulses. This effect is not discernible at moderate to high volume streamflow pulses.

Though the settling basins exert some influence on hydrograph response in D4, they do not represent a dominant factor. If the settling basins were a major influence one would expect to observe marked differences in the relationship between D3 and D4 between storm following dry vs. wet antecedent watershed conditions. Storms on 1/16-1/17 (Figure 12), 2/1-2/2 (Figure 17), and 2/7 (Figure 19) are the latter components of sequential storm events. There are no consistent differences in hydrograph response compared to those storms following drier antecedent conditions, except for the initially lower Q values stemming from the recharging of temporary storage capacities.

The major impact of the settling basins seems to be under low volume conditions with their influence becoming proportionately smaller as storm size increases.

4.2.3. Suspended Sediment. There are dramatic differences in the levels of SS provided in D3 vs. D4 under the same conditions. D3's base level of SS preceding a given event is always larger than that found in D4, although both are relatively low. Both watersheds return to slightly higher SS base levels very quickly after peak SS levels as observed on 1/15-1/16 (Figure 12), 2/1 (Figure 16), and 2/1-2/2 (Figure 17). However, D3 exhibits drastically higher peak SS values in all events. The maximum yield in D3 varies up to 23 times that of D4 on 2/1-2/2 (Figure 17) on an equivalent-area basis. The magnitude of the response in both watersheds appears to be strongly influenced by the level of rainfall intensity. The largest SS producing event in both watersheds (2/1-2/2) has the largest total precipitation in a 30 minute period (Figure 17). Similar patterns of the highest SS levels occurring immediately after maximum 30 minute intensity was observed in the other events. The only exception to this is on 2/6-2/7 (Figure 18) which proceded relatively dry watershed conditions. Inadequate SS data points span the hydrograph peaks and this SS graph is largely estimated. However, one can expect SS levels to reflect the Q graph in which the maximum 30 minute intensity is the initial precipitation and does not generate the peak Q levels. Consequently, for low precipitation events especially proceeding dry antecedent moisture conditions the given generalities may not apply.

Both watersheds exhibit peak SS levels prior to peak Q levels, reflecting the relationship of SS to changes in the slope of the Q graph.

4.3. Land-use and Management Practices

4.3.1. Land-use Patterns. There is little difference in the total area in forestland or the distribution between old and young forests in D3 and D4. The major difference is the occurrence of 84% of D3's forestland on heavy textured soils. The reverse is true in D4 where 70%

of its forestland is on moderate textured soils. Forest cover increases infiltration rates and decreases overland runoff. D4's combination of forestland and moderate textured soils are likely to be more conducive to infiltration and deep perculation than D3's combination of forestland and heavy textures. It is possible that these differences in land-use contribute to the differences in baseflow between D3 and D4.

The total areas of D3 and D4 in the cropland category are very similar, comprising close to 60% of both watersheds. The major difference is in the distribution of wheat and grasslands. Slightly less than two-thirds of D3 is in wheat compared to only one-third of D4. Grasslands make up approximately 8% of D3 but make up 31% of D4. Grassland cover is more conducive to infiltration and reducing overland flow than tilled wheatland. D4's much greater grassland area and much less wheatland than D3 is more conducive to increased infiltration and lower sediment production than D3's reversed distribution. These latter land-use patterns could well be major contributing factors to the dramatically higher SS levels observed in D3, and the higher baseflow Q values of D4.

4.3.2. Settling Basins. The farm ponds and wet area of D4 function as sediment traps, particularly for bedload. Using SS as the monitored parameter minimizes the impact of the settling basins on measured sediment levels.

It is possible that there is an initial dilution effect of the SS first entering the ponds, resulting in a delayed rise in measured SS downstream. On the descending limb of the hydrograph, D3 and D4 have different absolute values but behave in a very similar fashion. This indicates that there may be an initial influence by the settling basins but it is not consistent across the entire suspended sediment graph.

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APPENDICIES

APPENDIX TABLE A1.1.

ABBREVIATIONS AND EXPLANATORY COMMENTS FOR APPENDIX TABLE A1.2., SOIL CORE DESCRIPTIONS

The format and abbreviations used here largely follow those used in Soil Taxonomy (Soil Survey Staff, 1975) and Soil Survey Manual (Soil Survey Staff, 1951).

Horizon: standard USDA, SCS, horizonation nomenclature

Depth: presented in metric (and English) units

Color: Munsell [R] notation

Field Texture:
- sil silt loam
- hsil heavy silt loam
- lsicl light silty clay loam
- sicl silty clay loam
- hsicl heavy silty clay loam
- sic silty clay

Mottles, etc.: includes mottles, saprolite chips, Fe (Iron) and Mn (Manganese) cutans

Abundance -
- f few (<2% of surfaces)
- c common (2-20%)
- m many (>20%)

Size -
- 1 fine (<5 mm)
- 2 medium (5-15 mm)
- 3 large (>15 mm)

Contrast -
- f faint
- d distinct
- p prominent

Color - Munsell [R] notation

Apparent Structure - (structure size not included because core diameter limited ped size to <40 mm).

Grade -
1 weak
2 moderate
3 strong

Form -
gr granular
sbk subangular blocky
abk angular blocky
m massive

Remnant rock structure - residual fracture faces and planes derived from the weathering of the underlying bedrock.

Consistence

Dry (D)		Moist (M)	
so	soft	vfr	very friable
sh	slightly hard	fr	friable
h	hard	fi	firm
vh	very hard	vfi	very firm

Wet (W)			
os	nonsticky	op	nonplastic
ss	slightly sticky	sp	slightly plastic
s	sticky	p	plastic
vs	very sticky	vp	very plastic

Films, etc.: includes clay films, silt coatings and organic stains (conc. - concentrated; sap - saprolite).

Frequency -
1 few (5-25% of the surfaces)
2 common (25-50%)
3 many (50-90%)

Thickness -
n thin
mk moderately thick
k thick

Location -
pf on ped faces
po in pores and root channels

Apparent Boundary: (boundary topography not mentioned because of 40 mm core diameter.)

Distinctness -
A abrupt <2.54 cm
C clear 2.54-6.35 cm
G gradual 6.35-12.70 cm
D diffuse >12.70 cm

APPENDIX TABLE A1.2.

Soil Core Descriptions (explanations and abbreviations are listed in Table A1.1.)

CORE: 1 QUADRANT: D4 ELEVATION: 113 m

TRANSECT: W ASPECT: North SLOPE: 6%

HORIZON	DEPTH	COLOR	FIELD TEXTURE	MOTTLES etc.	APPARENT STRUCTURE	CONSISTENCE[1] D	M	W	FILMS etc.	APPARENT BOUNDARY
	cm (inches)									
Ap	0-20 (0-8)	7.5YR 3/2 m 7.5YR 3/4 d	sil	--------	1gr	sh	vfr	ss sp	------	A
IIB2	20-38 (8-15)	7.5YR 4/4 m 7.5YR 5/4 d	sicl	--------	2sbk	h	fr	ss sp	2n clay films on pf, po	C
IIB3	38-51 (15-20)	7.5YR 4/6 m 7.5YR 5/6 d	sicl	m1d saprolite chips 10YR 6/3 m 10YR 8/2 d 5YR 5/6 m 5YR 6/8 d	2sbk	h	fr	ss sp	3k clay films on pf, conc. near the lower boundary	G
IICr	51-125+ (20-49+)	Variegations: 10YR 6/3 m 10YR 8/2 d 7.5YR 5/8 m 7.5YR 7/8 d 5YR 5/6 m 5YR 6/8 d	saprolitic sandstone with siltstone lenses	Fe and Mn cutans on fracture faces: 5YR 4/6 m 5YR 5/6 d 10YR 2/1 m 10YR 3/2 d	remnant rock structure	--	--	--	2mk clay films on fracture faces	--

[1] CONSISTENCE: D=dry soil, M=moist soil, W=wet soil

CORE: 2 QUADRANT: D3 ELEVATION: 79 m

TRANSECT: W ASPECT: South SLOPE: 3%

HORIZON	DEPTH	COLOR	FIELD TEXTURE	MOTTLES etc.	APPARENT STRUCTURE	CONSISTENCE[1] D	M	W	FILMS etc.	APPARENT BOUNDARY
	cm (inches)									
Ap	0-18 (0-7)	7.5YR 3/2 m 7.5YR 3/6 d	sil	--------	1gr	sh	vfr	ss sp	------	A
A3	18-25 (7-10)	7.5YR 3/2 m 7.5YR 4/2 d	sil	--------	2gr	h	fr	ss sp	------	C
IIB2t	25-51 (10-20)	5YR 4/4 m 5YR 5/4 d	sicl	--------	2sbk	h	fi	ss p	2mk clay films on pf, po	G
IIB3t	51-84 (20-33)	5YR 4/6 m 5YR 5/6 d	sicl	cld saprolite chips: 10YR 5/8 m 10YR 8/8 d	3sbk	vh	fi	ss p	3mk clay films on pf, po	G
IICr	84-120+ (33-47+)	Variegations: 10YR 6/3 m 10YR 8/2 d 7.5YR 5/8 m 7.5YR 6/8 d	saprolitic siltstone with fine sandstone lenses	---------	remnant rock structure	--	--	--	2k clay films on fracture faces	--

[1] CONSISTENCE: D=dry soil, M=moist soil, W=wet soil

CORE: 3 QUADRANT: D3 ELEVATION: 81 m

TRANSECT: W ASPECT: South SLOPE: 4%

HORIZON	DEPTH	COLOR	FIELD TEXTURE	MOTTLES etc.	APPARENT STRUCTURE	CONSISTENCE 1/ D	M	W	FILMS etc.	APPARENT BOUNDARY
	cm (inches)									
Ap	0-18 (0-7)	7.5YR 3/2 m 7.5YR 3/4 d	sil	--------	1gr	sh	vfr	ss sp	------	A
IIB2t	18-36 (7-14)	7.5YR 4/4 m 7.5YR 5/6 d	1sicl	--------	2sbk	h	fr	ss sp	2mk clay films on pf, po	C
IIB3t	36-48 (14-19)	7.5YR 4/6 m 7.5YR 5/6 d	sicl	cld saprolitic fragments 10YR 6/3 m 10YR 8/2 d 5YR 5/6 m 5YR 6/8 d	2sbk	h	fr	ss p	2mk clay films on pf, po	G
IICr	48-71+ (19-28+)	Variegations: 10YR 6/3 m 10YR 8/2 d 7.5YR 5/6 m 7.5YR 6/8 d	saprolitic siltstone	--------	remnant rock structure	--	--	--	2mk clay films on fracture planes	--

1/ CONSISTENCE: D=dry soil, M=moist soil, W=wet soil

CORE: 4 QUADRANT: D3 ELEVATION: 107 m

TRANSECT: W ASPECT: North SLOPE: 4%

HORIZON	DEPTH	COLOR	FIELD TEXTURE	MOTTLES etc.	APPARENT STRUCTURE	CONSISTENCE[1] D	M	W	FILMS etc.	APPARENT BOUNDARY
	cm (inches)									
Ap	0-20 (0-8)	7.5YR 3/2 m 7.5YR 3/4 d	sil	--------	1gr	sh	vfr	ss sp	------	A
IIB1	20-30 (8-12)	7.5YR 4/4 m 7.5YR 5/4 d	sicl	--------	1sbk	h	fr	ss sp	2n clay films on pf, po	C
IIB2	30-43 (12-17)	7.5YR 4/4 m 7.5YR 5/4 d	sicl	--------	2sbk	h	fr	ss sp	2n clay films on pf, po	C
IIB3	43-61 (17-24)	7.5YR 4/6 m 7.5YR 5/6 d	sicl	mld saprolite chips: 10YR 6/3 m 10YR 6/2 d 5YR 5/6 m 5YR 6/8 d	2sbk	h	fr	ss sp	3k clay films on fracture faces	C
IICr	61-160+ (24-63+)	Variegations: 10YR 6/3 m 10YR 8/2 d 7.5YR 5/8 m 7.5YR 7/8 d 5YR 5/6 m 5YR 6/8 d	saprolitic sandstone with siltstone lenses	Fe and Mn cutans on fracture faces 5YR 4/6 m 5YR 5/6 d 10YR 3/1 m 10YR 3/1 d	remnant rock structure	--	--	--	2k clay films on fracture faces	--

[1] CONSISTENCE: D=dry soil, M=moist soil, W=wet soil

CORE: 5 QUADRANT: D3 ELEVATION: 101 m

TRANSECT: W ASPECT: West SLOPE: 7%

HORIZON	DEPTH	COLOR	FIELD TEXTURE	MOTTLES etc.	APPARENT STRUCTURE	CONSISTENCE[1/] D	M	W	FILMS etc.	APPARENT BOUNDARY
	cm (inches)									
Ap	0-18 (0-7)	7.5YR 3/2 m 7.5YR 3/4 d	sil	--------	1gr	sh	vfr	ss sp	------	A
A3	18-41 (7-16)	7.5YR 3/2 m 7.5YR 3/5 d	sil	--------	2gr	sh	vfr	ss sp	------	C
IIB2	41-66 (16-26)	5YR 4/4 m 5YR 5/4 d	hsil	--------	2sbk	h	fr	ss sp	2n clay films on pf, po	G
IIB3	66-102 (26-40)	5YR 4/6 m 5YR 5/6 d	hsil	mld saprolite chips: 10YR 6/3 m 10YR 8/2 d 7.5YR 5/8 m 7.5YR 6/8 d	2sbk	h	fr	ss sp	3mk clay films on pf, and saprolite chips conc. near lower boundary	D
IICr	102-132+ (40-52+)	Variegations: 10YR 6/3,5/8 m 10YR 8/2,7/8 d 7.5YR 5/8 m 7.5YR 6/8 d	saprolitic sandstone with siltstone lenses	Fe and Mn cutans on fracture faces: 5YR 4/6 m 5YR 5/6 d 10YR 2/1 m 10YR 3/1 d	remnant rock structure	--	--	--	2n clay films on fracture faces	--

1/ CONSISTENCE: D=dry soil, M=moist soil, W=wet soil

CORE: 6 QUADRANT: D3 ELEVATION: 98 m

TRANSECT: W ASPECT: West-southwest SLOPE: 11%

HORIZON	DEPTH	COLOR	FIELD TEXTURE	MOTTLES etc.	APPARENT STRUCTURE	CONSISTENCE 1/ D	M	W	FILMS etc.	APPARENT BOUNDARY
	cm (inches)									
Ap	0-20 (0-8)	7.5YR 3/2 m 7.5YR 3/4 d	sil	--------	1gr	sh	vfr	ss sp	------	A
AB	20-30 (8-12)	7.5YR 4/4 m 7.5YR 4/6 d	sil	--------	2sbk	sh	fr	ss sp	------	C
IIB2t	30-91 (12-36)	5YR 3/6 m 5YR 4/6 d	hsicl	--------	3sbk	h	fi	ss p	2n clay films on pf, 2n silt coatings on pf, po	C
IIB3t	91-117 (36-46)	5YR 3/6 m 5YR 4/6 d	hsicl saprolitic gravel pseudo-morphs	mld saprolite chips: 10YR 6/3 m 10YR 8/2 d 7.5YR 5/8 m 7.5YR 6/8 d	2sbk	h	fi	ss p	3k clay films on pf, conc. near lower boundary, 2n silt coatings on pf	G
IICr	117-124+ (46-49+)	Variegations: 10YR 6/3,5/8 m 10YR 8/2,7/8 d 7.5YR 5/8 m 7.5YR 6/8 d	saprolitic sandstone with fine gravel psuedo-morphs and siltstone lenses	Fe and Mn cutans on fracture faces: 5YR 4/6 m 5YR 5/6 d 10YR 2/1 m 10YR 3/1 d	remnant rock structure	--	--	--	2k clay films and 2n silt coatings on fracture faces	--

1/ CONSISTENCE: D=dry soil, M=moist soil, W=wet soil

CORE: 7

TRANSECT: W

QUADRANT: D3

ASPECT: West

ELEVATION: 87 m

SLOPE: 18%

HORIZON	DEPTH	COLOR	FIELD TEXTURE	MOTTLES etc.	APPARENT STRUCTURE	CONSISTENCE[1] D	M	W	FILMS etc.	APPARENT BOUNDARY
	cm (inches)									
Ap	0-23 (0-9)	10YR 3/3 m 10YR 5/3 d	sil	--------	1gr	sh	fr	ss sp	------	A
B1	23-36 (9-14)	7.5YR 3/4 m 7.5YR 5/4 d	sil	--------	2sbk	h	fr	ss sp	2n clay films on pf	C
IIB2t	36-56 (14-22)	7.5YR 4/4 m 7.5YR 5/4 d	sicl	--------	3sbk	h	fi	ss p	3k clay films on pf	C
IIB3	56-76 (22-30)	7.5YR 4/4 m 7.5YR 5/4 d	hsil	cld saprolite chips: 7.5YR 5/8 m 7.5YR 6/8 d	2sbk	h	fr	ss sp	2n, 1k clay films on pf, po conc. near lower boundary	G
IICr	76-124+ (30-49+)	Variegations: 10YR 6/3,5/8 m 10YR 8/2,7/8 d 7.5YR 5/8 m 7.5YR 6/8 d	saprolitic sandstone with siltstone lenses	Fe and Mn cutans on ped faces, fracture faces: 5YR 4/6 m 5YR 5/6 d 10YR 5/8 m 10YR 7/8 d	remnant rock structure	--	--	--	2n clay films on fracture faces	

[1] CONSISTENCE: D=dry soil, M=moist soil, W=wet soil

CORE: 8 QUADRANT: D3 ELEVATION: 82 m

TRANSECT: W ASPECT: West-northwest SLOPE: 18%

HORIZON	DEPTH	COLOR	FIELD TEXTURE	MOTTLES etc.	APPARENT STRUCTURE	CONSISTENCE[1] D	M	W	FILMS etc.	APPARENT BOUNDARY
	cm (inches)									
Ap	0-20 (0-8)	10YR 3/3 m 10YR 5/3 d	sil	--------	1gr	sh	vfr	ss sp	------	A
A3	20-33 (8-13)	10YR 3/3 m 10YR 5/3 d		--------	2gr	sh	vfr	ss sp	------	C
IIB21	33-51 (13-20)	7.5YR 3/4 m 7.5YR 5/4 d	sil	--------	2sbk	h	fr	ss sp	1n clay films on pf	C
IIB22t	51-66 (20-26)	7.5YR 4/4 m 7.5YR 5/4 d	lsicl	cld saprolite chips: 10YR 6/8 m 10YR 8/2 d	3sbk	h	fr	ss sp	2n clay films on pf	C
IIB3	66-76 (26-30)	7.5YR 4/4 m 7.5YR 5/4 d	sil	cld saprolite chips: 10YR 6/8 m 10YR 8/2 d	2sbk	h	fr	ss sp	2n clay films on pf	A
IICr	76-130+ (30-51+)	Variegations: 10YR 6/8 m 10YR 8/2 d 7.5YR 5/8 m 7.5YR 6/8 d	saprolitic siltstone	Fe and Mn cutans on fracture faces: 5YR 4/6 m 5YR 5/6 d 10YR 2/1 m 10YR 3/1 d 10YR 5/8 m 10YR 7/8 d	remnant rock structure	--	--	--	3n clay films on fracture faces	--

[1] CONSISTENCE: D=dry soil, M=moist soil, W=wet soil

CORE: 9 | QUADRANT: D3 | ELEVATION: 79 m

TRANSECT: W | ASPECT: Northwest | SLOPE: 13%

HORIZON	DEPTH	COLOR	FIELD TEXTURE	MOTTLES etc.	APPARENT STRUCTURE	CONSISTENCE[1/] D	M	W	FILMS etc.	APPARENT BOUNDARY
	cm (inches)									
Ap	0-20 (0-8)	10YR 3/2 m 10YR 5/3 d	sil	--------	1gr	sh	vfr	os sp	------	AS
A3	20-25 (8-10)	10YR 3/2 m 10YR 5/3 d	sil	--------	2gr	sh	vfr	os op	------	C
IIB1	25-36 (10-14)	10YR 3/4 m 10YR 5/3 d	hsil	--------	2sbk	h	fr	ss sp	1n clay films on pf, 1n silt coatings on pf, po	C
IIB22	36-66 (14-26)	10YR 3/4 m 10YR 5/4 d	hsil	f1d saprolite chips: 10YR 6/8 m 10YR 7/8 d	2sbk	h	fr	ss sp	3n clay films on pf, 2n silt coatings in po	G
IIB3	66-91 (26-36)	10YR 4/4,4/6 m 10YR 5/4,5/6 d	hsil	m1d and f2d saprolite chips: 10YR 6/8 m 10YR 7/8 d 2.5Y 7/4 m 2.5Y 8/2 d	2sbk	h	fr	ss sp	3n clay films on pf, 2n silt coatings in po	C
IICr (cont.)	91-124+ (36-49+)	Variegations: 10YR 6/8 m 10YR 7/8 d	saprolitic siltstone	Fe and Mn cutans on fracture faces: 5YR 3/4 m 5YR 4/6 d	remnant rock structure	h	fi	ss sp	3n, 1k clay films on fracture faces,	--

[1/] CONSISTENCE: D=dry soil, M=moist soil, W=wet soil

HORIZON	DEPTH	COLOR	FIELD TEXTURE	MOTTLES etc.	APPARENT STRUCTURE	CONSISTENCE 1/ D M W	FILMS etc.	APPARENT BOUNDARY
IICr (cont.)		2.5Y 7/4 m 2.5Y 8/2 d		5YR 2/1 m 5YR 3/1 d			2n silt coatings on fracture faces	

1/ CONSISTENCE: D=dry soil, M=moist soil, W=wet soil

CORE: 10 QUADRANT: D3 ELEVATION: 76 m

TRANSECT: W ASPECT: West SLOPE: 13%

HORIZON	DEPTH	COLOR	FIELD TEXTURE	MOTTLES etc.	APPARENT STRUCTURE	CONSISTENCE[1] D	M	W	FILMS etc.	APPARENT BOUNDARY
	cm (inches)									
Ap	0-20 (0-8)	10YR 3/2 m 10YR 5/3 m	sil	--------	1gr	sh	vfr	ss sp	------	A
A3	20-36 (8-14)	10YR 3/2 m 10YR 5/4 d	sil	--------	2sbk	sh	vfr	ss sp	1n silt coatings on pf	C
IIB1	36-51 (14-20)	5YR 4/4 m 5YR 6/4 d	hsil	f1f mottles: 5YR 5/6 m 5YR 6/6 d	2sbk	h	fi	ss sp	1n silt coatings on pf, 1n clay films on pf, po	C
IIB21t	51-74 (20-29)	5YR 4/4 m 5YR 6/4 d	hsil	c1d mottles: 5YR 5/6 m 5YR 7/6 d f1d mangans: 5YR 2.5/1 m 5YR 2.5/1 d	2abk	vh	fi	ss sp	2mk clay films on pf, 1n silt coatings on pf	C
IIB22t	74-117 (29-46)	10YR 4/6,5/4 m 10YR 5/6,6/6 d	hsicl	m1d, f2d mottles: 5YR 5/8 m 5YR 6/8 d c1d mangans: 5YR 2.5/1 m 5YR 2.5/I d	3abk	vh	fi	s p	3k clay films on pf, po 2n silt coatings in po	G
IIIB3 (cont.)	117-218+ (46-86+)	10R 4/6 m 10R 5/6 d	hsicl	m1d mottles:	2abk	vh	fi	ss p	3k clav films on pf, po	--

[1] CONSISTENCE: D=dry soil, M=moist soil, W=wet soil

HORIZON	DEPTH	COLOR	FIELD TEXTURE	MOTTLES etc.	APPARENT STRUCTURE	CONSISTENCE 1/ D M W	FILMS etc.	APPARENT BOUNDARY
IIIB3 (cont.)		5YR 5/8 m 5YR 6/8 d fld mangans: 5YR 2.5/1 m 5YR 2.5/1 d					In silt coatings on po	

1/ CONSISTENCE: D=dry soil, M=moist soil, W=wet soil

CORE: 11 QUADRANT: D3 ELEVATION: 73 m

TRANSECT: W ASPECT: West-northwest SLOPE: 10%

HORIZON	DEPTH	COLOR	FIELD TEXTURE	MOTTLES etc.	APPARENT STRUCTURE	CONSISTENCE[1] D	M	W	FILMS etc.	APPARENT BOUNDARY
	cm (inches)									
Ap	0-20 (0-8)	10YR 3/2 m 10YR 5/3 d	sil	---------	1gr m plowpan at 18-20 cm	sh	fr	os op	------	A
A12	20-36 (8-14)	10YR 3/2 m 10YR 5/3 d	sil	---------	2gr	sh	fr	os op	------	C
A13	36-46 (14-18)	10YR 3/3 m 10YR 5/3 d	sil	--------	2sbk	sh	fr	os op	-------	C
IIB1	46-61 (18-24)	10YR 4/4 m 10YR 6/4 d	sil	f1f mottles 10YR 5/6 m 10YR 6/6 d	2sbk	h	fr	os op	2n silt coatings in po	C
IIB21t	61-76 (24-30)	10YR 5/4 m 10YR 7/4 d	hsil	c1d mottles: 10YR 5/6 m 10YR 7/6 d f1d mangans: 5YR 2.5/1 m 5YR 2.5/1 d	3sbk	vh	fr	ss sp	1k, 2n silt coatings on pf, po	C
IIIB22t	76-127 (30-50)	10YR 6/3,5/3 m 10YR 8/1,7/2 d	hsicl	m1d, c2d mottles: 10YR 5/8 m 10YR 6/8 d c1d mangans: 5YR 2.5/1 m 5YR 2.5/1 d	3sbk	vh	fi	ss p	3n silt coatings on pf, 1k, 3n clay films on pf, po	C
(cont.)										

[1] CONSISTENCE: D=dry soil, M=moist soil, W=wet soil

HORIZON	DEPTH	COLOR	FIELD TEXTURE	MOTTLES etc.	APPARENT STRUCTURE	CONSISTENCE[1] D	M	W	FILMS etc.	APPARENT BOUNDARY
(cont.)										
IIIB23t	127-168 (50-66)	10YR 5/3,6/3 m 10YR 7/2,6/4 d	hsicl	mld mottles: 10YR 4/6 m 10YR 5/8 d fld mangans: 5YR 2.5/1 m 5YR 2.5/1 d	3sbk	vh	fi	ss p	3n silt coatings on pf 2k, 3n clay films on pf, po	C
IIIB3	168-178+ (66-70+)	7.5YR 4/4,5/2m 7.5YR 5/6,6/4d	sic	mld mottles: 7.5YR 5/6 m 7.5YR 7/8 d cld mangans: 5YR 2.5/1 m 5YR 2.5/1 d	3sbk	vh	fi	ss p	1n silt coatings on pf 1k, 3n clay films on pf, po	--

[1] CONSISTENCE: D=dry soil, M=moist soil, W=wet soil

CORE: 12 QUADRANT: D3 ELEVATION: 69 m

TRANSECT: W ASPECT: West-northwest SLOPE: 10%

HORIZON	DEPTH	COLOR	FIELD TEXTURE	MOTTLES etc.	APPARENT STRUCTURE	CONSISTENCE 1/ D	M	W	FILMS etc.	APPARENT BOUNDARY
	cm (inches)									
Ap	0-18 (0-7)	10YR 3/2 m 10YR 5/3 d	sil	--------	1gr	sh	fr	ss op	------	A
A12	18-36 (7-14)	10YR 3/2 m 10YR 5/4 d	sil	--------	2gr	sh	fr	ss op	------	A
A3	36-46 (14-18)	10YR 3/3 m 10YR 5/4 d	sil	--------	2gr	sh	fr	ss op	------	C
IIB1	46-61 (18-24)	10YR 5/4 m 10YR 6/3 d	hsil	f1d mottles: 10YR 4/6 m 10YR 6/8 d f1d Fe and Mn cutans: 5YR 4/6 m 5YR 5/6 d 10YR 2/1 m 10YR 3/1 d	2sbk	h	fr	ss op	------	C
IIB21	61-76 (24-30)	10YR 5/3 m 10YR 7/2 d	sil	c1d, c2d mottles: 10YR 4/6 m 10YR 6/8 d c2d Fe & Mn cutans 5YR 4/6 m 5YR 5/6 d 10YR 2/1 m 10YR 3/1 d	2sbk	h	fr	ss op	------	A
(cont.)										

1/ CONSISTENCE: D=dry soil, M=moist soil, W=wet soil

HORIZON	DEPTH	COLOR	FIELD TEXTURE	MOTTLES etc.	APPARENT STRUCTURE	CONSISTENCE[1/] D	M	W	FILMS etc.	APPARENT BOUNDARY
(cont.)										
IIIB22t	76-120 (30-47)	7.5YR 4/4 m 7.5YR 5/4 d	sicl	c2d Fe and Mn cutans: 5YR 4/6 m 5YR 5/6 d 10YR 2/1 m 10YR 3/1 d	3sbk	vh	fi	ss p	3k clay films on pf, po	C
IIIB23t	120-178 (47-70)	7.5YR 4/4 m 7.5YR 5/4 d	sicl	f1d Fe and Mn 5YR 4/6 m 5YR 5/6 d 10YR 2/1 m 10YR 3/1 d	3sbk	vh	fi	ss p	3k clay films on pf, po	G
IIIB3	178-224+ (70-88+)	7.5YR 4/4 m 7.5YR 5/4 d	sicl	--------	2sbk	h	fi	ss p	2k clay films on pf	--

1/ CONSISTENCE: D=dry soil, M=moist soil, W=wet soil

CORE: 13 QUADRANT: D3 ELEVATION: 67 m

TRANSECT: W ASPECT: West-northwest SLOPE: 10%

HORIZON	DEPTH	COLOR	FIELD TEXTURE	MOTTLES etc.	APPARENT STRUCTURE	CONSISTENCE[1/] D	M	W	FILMS etc.	APPARENT BOUNDARY
	cm (inches)									
Ap	0-23 (0-9)	10YR 3/2 m 10YR 5/3 d	sil	--------	1gr	sh	fr	ss op	------	A
A12	23-46 (9-18)	10YR 3/2,5/4 m 10YR 5/3,6/3 d	sil	f1d mottles: 10YR 4/6 m 10YR 6/8 d	2gr	sh	fr	ss op	------	A
IIB21	46-69 (18-27)	10YR 5/4 m 10YR 6/3 d	sil	c1d mottles: 10YR 4/6 m 10YR 6/8 d f1d mangans: 10YR 2/1 m 10YR 3/1 d	2sbk	h	fr	ss op	------	C
IIB22	69-79 (27-31)	10YR 5/3 m 10YR 7/2 d	sil	c1, 2d mottles: 10YR 4/6 m 10YR 6/8 d c2d mangans: 10YR 2/1 m 10YR 3/1 d	2sbk	vh	fr	ss op	------	A
IIB23t	79-91 (31-36)	10YR 5/3 m 10YR 7/3 d	hsil	f1f mottles: 10YR 4/6 m 10YR 6/8 d f1d mangans: 10YR 2/1 m 10YR 3/1 d	2sbk	vh	fi	ss sp	3n clay films on pf, 2n organic stains on pf, po	G
(Cont.)										

1/ CONSISTENCE: D=dry soil, M=moist soil, W=wet soil

HORIZON	DEPTH	COLOR	FIELD TEXTURE	MOTTLES etc.	APPARENT STRUCTURE	CONSISTENCE[1] D	M	W	FILMS etc.	APPARENT BOUNDARY
(cont)										
IIB3	91-160 (36-63)	10YR 5/4 m 10YR 7/2 d	sil	c1d mottles: 10YR 5/6 m 10YR 7/6 d	2sbk	h	fr	ss sp	2n clay films in po, 1n organic stains on pf	D
IIC1	160-198 (63-78)	10YR 5/4 m 10YR 7/2 d	hsil	m1d mottles: 10YR 5/6,5/8 m 10YR 7/6,6/8 d	2sbk	h	fr	ss sp	------	A
IIIC2	198-224 (78-88)	10YR 4/2,5/3 m 10YR 7/4,6/3 d	sicl	m2,3d mottles: 10YR 4/6,5/6 m 10YR 5/8,6/6 d c1d mangans: 10YR 2/1 m 10YR 3/1 d	2sbk	h	fi	ss p	3n clay films on pf, po	C
IIIC3	224-241+ (88-95+)	10YR 5/2 m 10YR 6/1 d	sicl	c2d mottles: 10YR 4/6,5/6 m 10YR 5/8,6/6 d	2abk	vh	fi	ss p	1n clay films in po	--

[1] CONSISTENCE: D=dry soil, M=moist soil, W=wet soil

CORE: 14 QUADRANT: D3 ELEVATION: 64 m

TRANSECT: W ASPECT: West-northwest SLOPE: 7%

HORIZON	DEPTH	COLOR	FIELD TEXTURE	MOTTLES etc.	APPARENT STRUCTURE	CONSISTENCE[1] D	M	W	FILMS etc.	APPARENT BOUNDARY
	cm (inches)									
Ap	0-20 (0-8)	10YR 3/2 m 10YR 5/3 d	sil	--------	1gr	sh	fr	os op	------	A
A12	20-48 (8-19)	10YR 3/2 m 10YR 5/3 d	sil	--------	2gr (upper 2.5cm) 0m - plowpan	sh	fr	os op	------	C
B1	48-58 (19-23)	10YR 4/3 m 10YR 6/3 d	sil	f1f mottles: 7.5YR 5/4 m 7.5YR 6/6 d	2sbk	sh	fr	os op	------	C
IIB21t	58-76 (23-30)	10YR 5/3 m 10YR 7/4 d	hsil	c2d mottles: 10YR 4/6 m 7.5YR 5/8 d	2sbk	h	fr	os op	1n clay films on pf, po	C
IIB22t	76-132 (30-52)	10YR 4/3 m 10YR 7/2 d	sicl	c2d mottles: 10YR 4/6 m 7.5YR 5/8 d c2d mangans: 10YR 2/1 m 10YR 3/1 d	2sbk	vh	fi	ss so	3mk clay films on pf, po	C
IIB3	132-165 (52-65)	10YR 5/4 m 10YR 8/3 d	hsil	--------	1sbk	h	fi	os op	1n clay films on pf,po	G
IIC1	165-213 (65-84)	10YR 6/4 m 10YR 8/2 d	hsil	--------	1sbk	h	fi	os op	1n clay films in po	A
(cont.)										

[1] CONSISTENCE: D=dry soil, M=moist soil, W=wet soil

HORIZON	DEPTH	COLOR	FIELD TEXTURE	MOTTLES etc.	APPARENT STRUCTURE	CONSISTENCE[1] D	M	W	FILMS etc.	APPARENT BOUNDARY
(cont.)										
IIIC2	213-229 (84-90)	7.5YR 5/6 m 7.5YR 7/6 d 10YR 7/4 m 10YR 5/3 d	sicl	m3p mottles: 7.5YR 5/6 m 7.5YR 7/6 d	2sbk	h	fi	ss sp	2mk clay films on pf	C
IIIC3	229-239+ (90-94+)	10YR 5/2 m 10YR 7/2 d	sicl	f2d mottles: 10YR 6/2 m 10YR 7/6 d	2abk	vh	fi	ss p	1n clay film	--

[1] CONSISTENCE: D=dry soil, M=moist soil, W=wet soil

CORE: 15 QUADRANT: D3 ELEVATION: 63 m

TRANSECT: W ASPECT: West SLOPE: 7%

HORIZON	DEPTH	COLOR	FIELD TEXTURE	MOTTLES etc.	APPARENT STRUCTURE	CONSISTENCE[1] D	M	W	FILMS etc.	APPARENT BOUNDARY
	cm (inches)									
Ap	0-23 (0-9)	10YR 3/2 m 10YR 5/2 d	sil	--------	1gr	sh	fr	ss op	------	A
A12	23-36 (9-14)	10YR 3/2 m 10YR 5/2 d	sil	--------	2sbk	sh	fr	ss op	------	A
B1	36-51 (14-20)	10YR 4/3,5/3 m 10YR 5/3,6/3 d	sil	c1f mottles: 10YR 6/4 m 10YR 7/4 d	2sbk	sh	fr	ss sp	------	C
IIB21t	51-69 (20-27)	10YR 5/3,6/3 m 10YR 7/2,7/3 d	hsil	c1f mottles: 10YR 6/4 m 10YR 7/4 d c2d mottles: 10YR 5/8 m 10YR 7/8 d f1d mangans: 10YR 2/1 m 10YR 3/1 d	3sbk	h	fr	ss sp	2n silt coatings on pf	C
IIB22t (cont.)	69-89 (27-35)	10YR 5/2,6/2 m 10YR 7/2,8/1 d	hsil	c1d mottles: 10YR 5/8,6/8 m 10YR 6/8,7/8 d f1d mangans: 10YR 2/1 m 10YR 3/1 d	3sbk	h	fr	ss sp	3n silt coatings on pf, po	C

[1] CONSISTENCE: D=dry soil, M=moist soil, W=wet soil

HORIZON	DEPTH	COLOR	FIELD TEXTURE	MOTTLES etc.	APPARENT STRUCTURE	CONSISTENCE[1] D	M	W	FILMS etc.	APPARENT BOUNDARY
(cont.)										
IIB23t	89-122 (35-48)	10YR 5/2,5/4 m 10YR 7/1,7/3 d	hsil	f1f mottles: 10YR 5/6 m 10YR 6/6 d f1d mangans: 10YR 2/1 m 10YR 3/1 d	3sbk	h	fi	ss sp	2n clay film on pf, 1n silt coatings on pf,po 1n organic stains in ol root channel	G
IIB3	122-178 (48-70)	10YR 6/3,5/3 m 10YR 7/2,7/3 d	sil	f1f mottles: 10YR 5/6 m 10YR 6/6 d	2sbk	sh	fr	ss sp	1n silt coatings on pf,po 1n organic stains in ol root channel	D
IIC1	178-226 (70-89)	10YR 5/2,5/3 m 10YR 7/1,7/2 d	sil	c1d mottles: 10YR 5/4,5/6 m 10YR 6/4,6/6 d f1d mangans: 10YR 2/1 m 10YR 3/1 d	2sbk	h	fr	ss sp	1n silt coatings on pf,po 1n organic stains in ol root channel	G
IIC2	226-244+ (89-96+)	10YR 5/2,5/3 m 10YR 7/3,7/3 d	sil	c1d mottles: 10YR 4/8,5/6 m 10YR 5/8,6/8 d	2sbk	h	fr	ss sp	1n organic stains in ol root channel	--

[1] CONSISTENCE: D=dry soil, M=moist soil, W=wet soil

CORE: 16 QUADRANT: D3 ELEVATION: 61 m

TRANSECT: W ASPECT: Northeast SLOPE: 4%

HORIZON	DEPTH	COLOR	FIELD TEXTURE	MOTTLES etc.	APPARENT STRUCTURE	CONSISTENCE[1] D	M	W	FILMS etc.	APPARENT BOUNDARY
	cm (inches)									
Ap	0-20 (0-8)	10YR 3/2 m 10YR 5/2 d	sil	--------	1gr	sh	fr	ss op	------	A
A12	20-33 (8-13)	10YR 3/2 m 10YR 5/2 d	sil	c1f mottles: conc. near lower boundary: 10YR 6/4 m 10YR 7/4 d	2sbk	sh	fr	ss op	-------	C
B1	33-46 (13-18)	10YR 4/3 m 10YR 5/3 d	sil	c2f mottles: 10YR 5/6 m 10YR 6/6 d	2sbk	sh	fr	ss op	------	C
IIB21t	46-79 (18-31)	10YR 5/3,6/3 m 10YR 7/3,6/4 d	hsil	c2d mottles: 10YR 5/6 m 10YR 6/8 d 10YR 5/8 m 10YR 7/8 d	3sbk	h	fr	ss sp	2n silt coatings on pf	C
IIB22t	79-102 (31-40)	10YR 5/3 m 10YR 7/3 d	hsil	c1f mottles: 10YR 5/6 m 10YR 6/8 d f1d mangans: 10YR 2/1 m 10YR 3/1 d	3sbk	h	fi	ss sp	2n clay films on pf, 2n silt coatings on pf, 1n organic stains on pf	C
IIB23t (cont)	102-140 (40-55)	10YR 5/3,6/3 m 10YR 6/4,7/4 d	hsil	c1,2f mottles: 10YR 5/6 m 10YR 6/8 d	3sbk	h	fi	ss sp	2n clay films on pf,	D

[1] CONSISTENCE: D=dry soil, M=moist soil, W=wet soil

HORIZON	DEPTH	COLOR	FIELD TEXTURE	MOTTLES etc.	APPARENT STRUCTURE	CONSISTENCE[1] D	M	W	FILMS etc.	APPARENT BOUNDARY
(cont.)										
IIB23t				fld mangans: 10YR 2/1 m 10YR 3/1 d					1n silt coatings on pf 2n organic stains on pf	
IIC1	140-196 (55-77)	10YR 5/2,5/3 m 10YR 7/2,7/3 d	sil	c1f mottles: 10YR 5/4 m 10YR 6/6 d	2sbk	sh	fr	ss sp	2n silt coatings on pf,po 1n organic stains in old root channels	G
IIC2	196-231+ (77-91+)	10YR 5/3,5/4 m 10YR 6/3,7/4 d	sil	c1f mottles: 10YR 5/4 m 10YR 6/4 d f2d mottles; 10YR 5/6 m 10YR 6/8 d	2sbk	sh	fr	ss sp	2n silt coatings on pf,po 1n organic stains in old root channels	--

[1] CONSISTENCE: D=dry soil, M=moist soil, W=wet soil

CORE: 17 QUADRANT: D3 ELEVATION: 64 m

TRANSECT: W ASPECT: East-southeast SLOPE: 8%

HORIZON	DEPTH	COLOR	FIELD TEXTURE	MOTTLES etc.	APPARENT STRUCTURE	CONSISTENCE[1] D	M	W	FILMS etc.	APPARENT BOUNDARY
	cm (inches)									
Ap	0-20 (0-8)	10YR 3/2 m 10YR 5/2 d	sil	---------	1gr	sh	fr	os op	------	A
A12	20-38 (8-15)	10YR 3/3 m 10YR 5/3 d	sil	--------	2gr	sh	fr	os op	------	C
B1	38-61 (15-24)	10YR 3/3 m 10YR 6/3 d	sil	--------	2sbk	h	fr	os op	------	G
IIB21t	61-84 (24-33)	10YR 4/3 m 10YR 6/3 d	lsicl	c2d mangans: 10YR 2/1 m 10YR 3/1 d	2sbk	vh	fi	ss sp	2n clay films on pf	C
IIB22t	84-140 (33-55)	10YR 4.5/3 m 10YR 6/3 d	lsicl	f1f mangans: 10YR 2/1 m 10YR 3/1 d	3sbk	vh	fi	ss sp	3n, 2k clay films on pf, po	G
IIB3	140-173 (55-63)	10YR 5/4 m 10YR 6/4 d	sil	--------	2sbk	h	fr	ss sp	2n clay films on pf, po	D
IIC	173-244+ (63-96+)	10YR 5/4 m 10YR 6/4 d	sil	f1f mottles: 10YR 6/6 m 10YR 6/8 d	1 sbk	sh	fr	ss op	1n clay films on pf, po	--

[1] CONSISTENCE: D=dry soil, M=moist soil, W=wet soil

CORE: 1 QUADRANT: D3 ELEVATION: 95 m

TRANSECT: X ASPECT: Northeast SLOPE: 8%

HORIZON	DEPTH	COLOR	FIELD TEXTURE	MOTTLES etc.	APPARENT STRUCTURE	CONSISTENCE[1/] D	M	W	FILMS etc.	APPARENT BOUNDARY
	cm (inches)									
Ap	0-20 (0-8)	10YR 3/3 m 10YR 5/3 d	sil	--------	1gr	sh	vfr	os op	------	A
IIB21	20-38 (8-15)	10YR 4/3 m 10YR 6/3 d	sil	clf mottles: 10YR 5/4 m 10YR 6/4 d fld saprolite chips: 7.5YR 5/8 m 7.5YR 6/8 d	2sbk	h	fr	ss sp	------	C
IIB22	38-48 (15-19)	10YR 4/3 m 10YR 6/3 d	hsil	mlf mottles: 10YR 5/6 m 10YR 6/4 d cl,2d saprolite chips: 7.5YR 5/8 m 7.5YR 6/8 d	2sbk	h	fi	ss	ln clay films on pf, po	C
IIB3	48-69 (19-27)	10YR 5/2,5/3m 10YR 6/2,6/3d	hsil	ml,2d saprolite chips: 7.5YR 5/6,5/8 m 7.5YR 7/6,6/8 d	3sbk	h	fi	ss sp	ln clay films on pf, po	G
IICr (cont.)	69-127+ (27-50+)	Variegations: 7.5YR 5/8 m 7.5YR 6/8 d	saprolitic siltstone	--------	remnant rock structure	--	--	--	ln clay films on fracture faces	

[1/] CONSISTENCE: D=dry soil, M=moist soil, W=wet soil

HORIZON	DEPTH	COLOR	FIELD TEXTURE	MOTTLES etc.	APPARENT STRUCTURE	CONSISTENCE[1] D M W	FILMS etc.	APPARENT BOUNDARY
(cont.)								
IICr		10YR 7/2 m 10YR 8/1 d						

[1] CONSISTENCE: D=dry soil, M=moist soil, W=wet soil

CORE: 2

TRANSECT: X

QUADRANT: D3

ASPECT: Northeast

ELEVATION: 91 m

SLOPE: 10%

HORIZON	DEPTH	COLOR	FIELD TEXTURE	MOTTLES etc.	APPARENT STRUCTURE	CONSISTENCE[1] D	M	W	FILMS etc.	APPARENT BOUNDARY
	cm (inches)									
Ap	0-18 (0-7)	10YR 3/3 m 10YR 5/3 d	sil	--------	1gr	sh	vfr	ss op	------	A
B1	18-38 (7-15)	10YR 4/2,5/3m 10YR 6/3 d	hsil	c1f mottles: 10YR 5/6 m 10YR 6/6 d	2sbk	h	fr	ss sp	------	C
IIB21g	38-61 (15-24)	10YR 4/1 m 10YR 6/1 d	1sicl	c1d mottles: 10YR 4/6 m 10YR 5/6 d	2sbk	h	fi	ss p	1n clay films on pf, po	C
IIB22g	61-91 (24-36)	10YR 4/1 m 10YR 6/1 d	sicl	m2d mottles: 10YR 4/6 m 10YR 5/6 d	3sbk	h	fi	ss p	1n clay films on pf, po	C
IICg	91-127 (36-50)	10YR 6/2 m 10YR 7/1 d	sicl	c1d mottles: 10YR 4/6 m 10YR 6/8 d f1d saprolite chips: 10YR 7/2 m 10YR 8/1 d	2sbk	h	fr	ss p	------	G
IICr	127-173+ (50-68+)	Variegations: 7.5YR 5/8 m 7.5YR 6/8 d 10YR 7/2 m 10YR 8/1 d	saprolitic siltstone	--------	remnant rock structure	--	--	--	------	---

[1] CONSISTENCE: D=dry soil, M=moist soil, W=wet soil

CORE: 3 | QUADRANT: D3 | ELEVATION: 90 m

TRANSECT: X | ASPECT: Northeast | SLOPE: 10%

HORIZON	DEPTH	COLOR	FIELD TEXTURE	MOTTLES etc.	APPARENT STRUCTURE	CONSISTENCE[1] D	M	W	FILMS etc.	APPARENT BOUNDARY
	cm (inches)									
Ap	0-20 (0-8)	10YR 3/3 m 10YR 5/3 d	sil	---------	2gr	sh	fr	ss sp	------	A
AB	20-30 (8-12)	10YR 3/3,4/4 m 10YR 5/3,5/4 d	hsil	f1d saprolite chips: 10YR 5/8 m 10YR 6/8 d	2sbk	h	fi	ss p	------	C
IIB21t	30-66 (12-26)	10YR 4/4 m 10YR 5/4 d	sicl	f2d mottles: 10YR 4/2 m 10YR 5/1 d f1d saprolite chips: 10YR 5/8 m 10YR 6/8 d	3sbk	vh	fi	s p	3mk clay films on pf	G
IIB22t	66-91 (26-36)	10YR 4/4 m 10YR 5/4 d	sicl	c2d mottles: 10YR 4/2 m 10YR 5/1 d f1d saprolite chips: 10YR 5/8 m 10YR 6/8 d	3sbk	vh	fi	s p	3mk clay films on pf	G
IIC (cont.)	91-122 (36-48)	10YR 4/4 m 10YR 5/4 d	hsil	c1d mottles: 10YR 4/1 m 10YR 5/1 d	2sbk	h	fi	s p	2n clay films on pf	G

[1] CONSISTENCE: D=dry soil, M=moist soil, W=wet soil

HORIZON	DEPTH	COLOR	FIELD TEXTURE	MOTTLES etc.	APPARENT STRUCTURE	CONSISTENCE[1/] D	M	W	FILMS etc.	APPARENT BOUNDARY
(cont.)										
IIC				cld saprolite chips: 10YR 5/8 m 10YR 6/8 d						
IICr	122-236+ (48-93+)	Variegations: 7.5YR 5/8 m 7.5YR 6/8 d 10YR 7/2 m 10YR 8/1 d	saprolitic siltstone	--------	remnant rock structure	--	--	--	2n clay films	--

1/ CONSISTENCE: D=dry soil, M=moist soil, W=wet soil

CORE: 4 QUADRANT: D3 ELEVATION: 86 m

TRANSECT: X ASPECT: Northeast SLOPE: 12%

HORIZON	DEPTH	COLOR	FIELD TEXTURE	MOTTLES etc.	APPARENT STRUCTURE	CONSISTENCE[1] D	M	W	FILMS etc.	APPARENT BOUNDARY
	cm (inches)									
Ap	0-18 (0-7)	10YR 3/3 m 10YR 5/3 d	sil	--------	1gr	sh	vfr	ss op	------	A
AB	18-30 (7-12)	10YR 3/3,4/4m 10YR 5/3,5/4d	hsil	--------	2gr	h	fr	ss sp	------	C
IIB1	30-43 (12-17)	10YR 4/4 m 10YR 5/4 d	hsil	c2d mottles: 10YR 4/4 m 10YR 5/4 d	1sbk	h	fi	ss sp	------	C
IIB21	43-76 (17-30)	10YR 3/3 m 10YR 4/3 d	hsil	c2d mottles: 10YR 4/4 m 10YR 4/6 d	2sbk	h	fi	ss sp	2n clay film on pf	G
IIB22t	76-112 (30-44)	10YR 4/2 m 10YR 5/3 d	lsicl	c2d mottles: 10YR 4/4 m 10YR 5/4 d	3sbk	vh	fi	ss sp	3n clay film on pf, po	C
IIB3	112-122 (44-48)	10YR 4/3 m 10YR 4/4 d	hsil	c2d mottles: 10YR 4/4 m 10YR 4/5 d c1d saprolite chips: 10YR 3/1 m 10YR 4/4 d	2sbk	h	fr	ss sp	2n clay film on pf	C
IICr	122-239+ (48-94+)	Variegations: 10YR 3/1,4/4m 10YR 4/1,4/6d	saprolitic sandstone w/ siltstone lenses	--------	remnant rock structure	--	--	--	------	--

[1] CONSISTENCE: D=dry soil, M=moist soil, W=wet soil

CORE: 5 QUADRANT: D3 ELEVATION: 76 m

TRANSECT: X ASPECT: East-northeast SLOPE: 13%

HORIZON	DEPTH	COLOR	FIELD TEXTURE	MOTTLES etc.	APPARENT STRUCTURE	CONSISTENCE[1/] D	M	W	FILMS etc.	APPARENT BOUNDARY
	cm (inches)									
Ap	0-18 (0-7)	10YR 3/2 m 10YR 5/2 d	sil	--------	1gr	sh	vf	ss sp	------	A
B1	18-28 (7-11)	10YR 3/3,4/4 m 10YR 5/3,6/4 d	hsil	--------	2sbk	h	fi	ss p	------	C
IIB21t	28-56 (11-22)	10YR 4/2,4/6 m 10YR 5/2,5/6 d	sic	c1f mottles: 10YR 4/2 m 10YR 5/2 d f1d saprolite chips: 10YR 5/8 m 10YR 7/8 d	2sbk	vh	vfi	s p	2n clay films on pf, po	G
IIB22t	56-91 (22-36)	10YR 4/4 m 10YR 5/4 d	sic	c1,2d mottles: 10YR 5/2 m 10YR 6/2 d c1d saprolite chips: 10YR 5/8,7/2 m 10YR 7/8,8/2 d	2abk	vh	vfi	s p	3mk clay films on pf, po	C
IIB23t	91-168 (36-66)	10YR 4/4 m 10YR 5/4 d	sic	c1d saprolite 10YR 5/8,7/2 m 10YR 7/8,8/2 d	2abk	vh	vfi	s p	3mk clay films on pf, po	G
IIC1 (cont.)	168-196 (66-77)	10YR 4/4 m 10YR 5/4 d	sic	m2d mottles: 10YR 4/1,4/2 m 10YR 6/1,6/2 d	3abk	vh	vfi	s p	3mk clay films on pf	G

1/ CONSISTENCE: D=dry soil, M=moist soil, W=wet soil

HORIZON	DEPTH	COLOR	FIELD TEXTURE	MOTTLES etc.	APPARENT STRUCTURE	CONSISTENCE[1/] D	M	W	FILMS etc.	APPARENT BOUNDARY
(cont.)										
IIC1				f1f saprolite chips: 10YR 5/8 m 10YR 7/8 d						
IIC2	196-203+ (77-80+)	10YR 4/4 m 10YR 5/4 d	sic	m2d mottles: 10YR 4/1,4/2,4/6 m 10YR 6/1,6/2,5/8 d f1f saprolite chips: 10YR 5/8 m 10YR 7/8 d	3abk	vh	vfi	s p	3mk clay films on pf	--

1/ CONSISTENCE: D=dry soil, M=moist soil, W=wet soil

CORE: 1 QUADRANT: D1 ELEVATION: 85 m

TRANSECT: Y ASPECT: South SLOPE: 18%

HORIZON	DEPTH	COLOR	FIELD TEXTURE	MOTTLES etc.	APPARENT STRUCTURE	CONSISTENCE[1/] D	M	W	FILMS etc.	APPARENT BOUNDARY
	cm (inches)									
Ap	0-20 (0-8)	10YR 3/2 m 10YR 5/3 d	sil	--------	1gr	sh	fr	ss sp	------	A
A12	20-38 (8-15)	10YR 3/3 m 10YR 4/3 d	hsil	--------	2gr	h	fr	ss p	------	C
IIB2	38-79 (15-31)	10YR 4/3 m 10YR 5/3 d	hsil	m2d saprolite chips: 10YR 5/8 m 10YR 6/8 d	2sbk	h	fr	ss p	2n clay films on pf	C
IIB3	79-89 (31-35)	10YR 4/2,6/2 m 10YR 5/2,7/2 d	hsil	m2d saprolite chips: 10YR 4/8 m 10YR 6/8 d	3sbk	vh	fi	ss sp	3n clay films on pf	C
IICr	89-127+ (35-50+)	Variegations: 10YR 6/2,5/8 m 10YR 7/2,6/8 d	saprolitic siltstone	-------	remnant rock structure	--	--	--	3n clay films on pf	--

1/ CONSISTENCE: D=dry soil, M=moist soil, W=wet soil

CORE: 2 | QUADRANT: D1 | ELEVATION: 78 m

TRANSECT: Y | ASPECT: South | SLOPE: 10%

HORIZON	DEPTH	COLOR	FIELD TEXTURE	MOTTLES etc.	APPARENT STRUCTURE	CONSISTENCE[1] D	M	W	FILMS etc.	APPARENT BOUNDARY
	cm (inches)									
Ap	0-20 (0-8)	10YR 3/2 m 10YR 5/2 d	sil	-------	1gr	sh	fr	ss sp	------	A
A12	20-30 (8-12)	10YR 3/2 m 10YR 5/2 d	sil	-------	2gr	sh	fr	ss sp	------	C
IIB2	30-79 (12-31)	10YR 4/2 m 10YR 4/2 d	lsicl	c1d mottles: 10YR 4/8 m 10YR 5/8 d	2sbk	h	fi	ss p	2n clay films on pf	G
IIIB3	79-109 (31-43)	2.5Y 6/2 m 2.5Y 7/2 d	sicl	c1d mottles: 10YR 5/6 m 10YR 7/6 d f1f saprolite chips: 10YR 8/6 m 10YR 8/3 d	3sbk	h	fi	ss p	2n clay films on pf 2n silt coatings on pf	G
IIICr	109-124+ (43-49+)	Variegations: 7.5YR 5/8 m 7.5YR 6/8 d 10YR 8/6 m 10YR 8/3 d	saprolitic siltstone	-------	remnant rock structure	--	--	--	2n clay films on fracture faces	--

[1] CONSISTENCE: D=dry soil, M=moist soil, W=wet soil

CORE: 3 | QUADRANT: D1 | ELEVATION: 73 m

TRANSECT: Y | ASPECT: South | SLOPE: 10%

HORIZON	DEPTH	COLOR	FIELD TEXTURE	MOTTLES etc.	APPARENT STRUCTURE	CONSISTENCE[1] D	M	W	FILMS etc.	APPARENT BOUNDARY
	cm (inches)									
Ap	0-20 (0-8)	10YR 3/2 m 10YR 5/2 d	sil	--------	2gr	sh	fr	ss sp	-------	A
A12	20-43 (8-17)	10YR 3/2 m 10YR 5/2 d	hsil	--------	2sbk	sh	fr	ss p	------	C
IIB21	43-56 (17-22)	10YR 4/2 m 10YR 5/3 d	lsicl	clf mottles: 10YR 4/6 m 10YR 5/6 d	2sbk	h	fi	ss p	1n silt coatings on pf	C
IIB22t	56-97 (22-38)	10YR 5/3 m 10YR 6/3 d	sicl	m1d mottles: 10YR 4/6 m 10YR 6/6 d	2sbk	vh	fi	ss p	2n clay films on pf 2n silt coatings on pf	G
IIIB3t	97-135 (38-53)	10YR 4/3 m 10YR 5/3 d	hsicl	m1f mottles: 10YR 4/6 m 10YR 5/4 d	3sbk	vh	vfi	ss p	3n clay films on pf 2n silt coatings on pf	G
IIIC	135-188 (53-74)	10YR 4/4 m 10YR 5/4 d	hsicl	clf mottles: 10YR 4/6 m 10YR 5/4 d c1,2d saprolite chips: 10YR 5/8 m 10YR 6/8 d	2sbk	vh	vfi	ss p	3n clay films on pf	G
(cont.)										

[1] CONSISTENCE: D=dry soil, M=moist soil, W=wet soil

HORIZON	DEPTH	COLOR	FIELD TEXTURE	MOTTLES etc.	APPARENT STRUCTURE	CONSISTENCE[1/] D	M	W	FILMS etc.	APPARENT BOUNDARY
(cont.)										
IIICr	188-203+ (74-80+)	Variegations: 10YR 5/8,5/2m 10YR 6/8,6/3d	saprolitic sandstone	----------	remnant rock structure	--	--	--	--------	--

1/ CONSISTENCE: D=dry soil, M=moist soil, W=wet soil

CORE: 4

TRANSECT: Y

QUADRANT: D2

ASPECT: South

ELEVATION: 72 m

SLOPE: 7%

HORIZON	DEPTH	COLOR	FIELD TEXTURE	MOTTLES etc.	APPARENT STRUCTURE	CONSISTENCE[1] D	M	W	FILMS etc.	APPARENT BOUNDARY
	cm (inches)									
Ap	0-23 (0-9)	10YR 3/2 m 10YR 5/2 d	sil	---------	2gr	sh	fr	ss op	------	A
A12	23-53 (9-21)	10YR 3/1 m 10YR 5/2 d	sil	---------	2sbk	h	fr	ss sp	------	C
IIB21	53-69 (21-27)	10YR 4/2 m 10YR 5/2 d	hsil	clf mottles: 10YR 4/6 m 10YR 5/6 d	2sbk	h	fr	ss p	------	C
IIB22	69-97 (27-38)	10YR 5/2 m 10YR 7/2 d	lsicl	mld mottles: 10YR 4/6 m 10YR 6/6 d fld mangans: 10YR 2/1 m 10YR 3/1 d	3sbk	h	fr	ss p	1n clay films on pf 2mk silt coatings on pf, po	G
IIB3	97-163 (38-64)	10YR 5/2 m 10YR 6/3 d	lsicl	mld mottles: 10YR 4/6 m 10YR 6/6 d fld mangans: 10YR 2/1 m 10YR 3/1 d	3sbk	vh	fi	ss p	1n clay films on pf 2n silt coatings on pf,po	G
IIC1 (cont.)	163-191 (64-75)	10YR 4/2 m 10YR 6/3 d	lsicl	clf mottles: 10YR 5/6 m 10YR 6/6 d	2sbk	vh	fi	ss p	2n clay films on pf 1n silt coatings on pf,po	G

[1] CONSISTENCE: D=dry soil, M=moist soil, W=wet soil

HORIZON	DEPTH	COLOR	FIELD TEXTURE	MOTTLES etc.	APPARENT STRUCTURE	CONSISTENCE[1] D	M	W	FILMS etc.	APPARENT BOUNDARY
(cont.)										
IIC1				vfld mangans: 10YR 2/1 m 10YR 3/1 d						
IIC2	191-201+ (75-79+)	10YR 5/6 m 10YR 6/6 d	lsicl	c2d saprolite chips: 10YR 5/2 m 10YR 7/2 d	2sbk	vh	fi	ss p	2n clay films on pf ln silt coatings on pf, po	--

[1] CONSISTENCE: D=dry soil, M=moist soil, W=wet soil

CORE: 5 QUADRANT: D1 ELEVATION: 70 m

TRANSECT: Y ASPECT: South SLOPE: 8%

HORIZON	DEPTH	COLOR	FIELD TEXTURE	MOTTLES etc.	APPARENT STRUCTURE	CONSISTENCE[1] D	M	W	FILMS etc.	APPARENT BOUNDARY
	cm (inches)									
Ap	0-20 (0-8)	10YR 3/2 m 10YR 5/2 d	sil	--------	2gr	sh	fr	ss sp	------	A
A12	20-46 (8-18)	10YR 3/2 m 10YR 4/2 d	hsil	--------	2sbk	h	fr	ss p	------	C
IIB21	46-66 (18-26)	10YR 4/2 m 10YR 6/2 d	hsil	c1f mottles; 10YR 4/6 m 10YR 5/6 d	3sbk	h	fi	ss p	2n silt coatings on pf	C
IIB22	66-102 (26-40)	10YR 5/2 m 10YR 7/1 d	lsicl	c1d mottles; 10YR 4/6 m 10YR 6/6 d	3sbk	h	fi	ss	3n silt coatings on pf,po	G
IIB3	102-147 (40-58)	10YR 5/2 m 10YR 7/1 d	sicl	m1,2d mottles; 10YR 4/6,4/8 m 10YR 6/6,6/8 d	2sbk	vh	fi	ss p	1n clay films on pf 2n silt coatings on pf, po	C
IIC1	147-185 (58-73)	10YR 4/3 m 10YR 6/3 d	lsicl	c1d mottles: 10YR 4/6 m 10YR 6/6 d c1d mangans: 10YR 2/1 m 10YR 2/1 d	2sbk	h	fi	ss p	1n clay films on pf 2n silt coatings on pf,po	G
IIC2 (cont.)	185-208+ (73-82+)	10YR 5/4 m 10YR 6/4 d	lsicl	c2d mottles: 10YR 5/2 m 10YR 7/2 d	2sbk	h	fi	ss p	1n clay films on pf	--

1/ CONSISTENCE: D=dry soil, M=moist soil, W=wet soil

HORIZON	DEPTH	COLOR	FIELD TEXTURE	MOTTLES etc.	APPARENT STRUCTURE	CONSISTENCE[1] D M W	FILMS etc.	APPARENT BOUNDARY
(cont.)								
IIC2				cld Fe and Mn cutans: 5YR 4/6 m 5YR 5/6 d 10YR 2/1 m 10YR 2/1 d			In silt coatings on pf	

[1] CONSISTENCE: D=dry soil, M=moist soil, W=wet soil

CORE: 6 QUADRANT: D1 ELEVATION: 67 m

TRANSECT: Y ASPECT: South SLOPE: 8%

HORIZON	DEPTH	COLOR	FIELD TEXTURE	MOTTLES etc.	APPARENT STRUCTURE	CONSISTENCE[1] D	M	W	FILMS etc.	APPARENT BOUNDARY
	cm (inches)									
Ap	0-20 (0-8)	10YR 3/2 m 10YR 5/2 d	sil	--------	1gr	sh	fr	ss sp	------	A
A12	20-43 (8-17)	10YR 3/2 m 10YR 5/2 d	sil	--------	2sbk	sh	fr	ss sp	------	C
B21	43-64 (17-25)	10YR 4/2 m 10YR 6/2 d	sil	f1f mottles: 10YR 5/4 m 10YR 6/4 d	2sbk	sh	fr	ss sp	2n silt coatings on pf,po	C
IIB22t	64-86 (25-34)	10YR 5/2 m 10YR 7/2 d	hsil	c1f mottles: 10YR 5/8 m 10YR 7/8 d	3sbk	h	fi	ss p	1n clay films on pf, po 3n silt coatings on pf,po	G
IIB3t	86-122 (34-48)	10YR 5/2 m 10YR 7/2 d	hsil	m2d mottles: 10YR 4/6 m 10YR 6/8 d	2sbk	h	fi	ss p	1n clay films on pf, po 2n silt coatings on pf, po	G
IIC1	122-132+ (48-52+)	10YR 5/3 m 10YR 7/2 d	sil	c1d mottles: 10YR 4/6 m 10YR 6/8 d f1d Fe & Mn cutans 10YR 2/1 m 10YR 2/1 d 5YR 4/6 m 5YR 5/6 d	2sbk	h	fi	ss sp	2n silt coatings on pf, po	--

[1] CONSISTENCE: D=dry soil, M=moist soil, W=wet soil

CORE: 1 QUADRANT: D4 ELEVATION: 96 m

TRANSECT: Z ASPECT: West SLOPE: 11%

HORIZON	DEPTH	COLOR	FIELD TEXTURE	MOTTLES etc.	APPARENT STRUCTURE	CONSISTENCE[1] D	M	W	FILMS etc.	APPARENT BOUNDARY
	cm (inches)									
Ap	0-20 (0-8)	10YR 3/3 m 10YR 5/3 d	sil	--------	2gr	sh	fr	ss sp	------	A
IIB21t	20-41 (8-16)	10YR 4/4 m 10YR 5/4 d	lsicl	--------	2sbk	h	fr	ss p	2n clay films on pf	C
IIB22t	41-86 (16-34)	10YR 5/3 m 10YR 5/4 d	sicl	c1d saprolite chips: 10YR 5/6 m 10YR 6/8 d	3sbk	vh	vfi	s p	3n clay films on pf, po	G
IIB3	86-104 (34-41)	10YR 5/3 m 10YR 5/4 d	hsil	m1,2d saprolite chips: 10YR 5/6 m 10YR 6/8 d	2sbk	h	fi	ss p	2n clay films on pf	G
IICr	104-117+ (41-46+)	Variegations: 10YR 6/3 m 10YR 6/4 d 7.5YR 6/4 m 7.5YR 6/8 d	saprolitic siltstone	---------	remnant rock structure	--	--	--	2n clay films on pf	--

1/ CONSISTENCE: D=dry soil, M=moist soil, W=wet soil

CORE: 2 QUADRANT: D4 ELEVATION: 85 m

TRANSECT: Z ASPECT: West SLOPE: 7%

HORIZON	DEPTH	COLOR	FIELD TEXTURE	MOTTLES etc.	APPARENT STRUCTURE	CONSISTENCE[1] D	M	W	FILMS etc.	APPARENT BOUNDARY
	cm (inches)									
Ap	0-18 (0-7)	10YR 3/3 m 10YR 5/3 d	sil	--------	1gr	sh	fr	ss sp	------	A
B1	18-33 (7-13)	10YR 4/3 m 10YR 5/3 d	hsil	cld saprolite chips: 10YR 5/6 m 10YR 6/8 d	2sbk	h	fi	ss p	1n clay films on pf	C
IIB2t	33-53 (13-21)	10YR 5/2 m 10YR 5/3 d	sicl	f1f mottles: 10YR 4/4 m 10YR 4/6 d cld saprolite chips: 10YR 5/6 m 10YR 6/8 d	3sbk	vh	vfi	s p	3mk clay films on pf, po	C
IIB3t	53-64 (21-25)	10YR 6/2 m 10YR 6/3 d	sicl	cld saprolite chips: 2.5YR 6/2 m 2.5YR 7/4 d	2sbk	h	fi	ss p	2n clay films on pf	C
IICr	64-109+ (25-43+)	Variegations: 7.5YR 4/8 m 7.5YR 5/8 d 2.5YR 6/2,6/4 m 2.5YR 7/2,7/4 d	saprolitic siltstone	--------	remnant rock structure	--	--	--	2n clay films on fracture faces	--

1/ CONSISTENCE: D=dry soil, M=moist soil, W=wet soil

CORE: 3 QUADRANT: D4 ELEVATION: 82 m

TRANSECT: Z ASPECT: West SLOPE: 8%

HORIZON	DEPTH	COLOR	FIELD TEXTURE	MOTTLES etc.	APPARENT STRUCTURE	CONSISTENCE[1] D	M	W	FILMS etc.	APPARENT BOUNDARY
	cm (inches)									
Ap	0-20 (0-8)	10YR 3/3 m 10YR 5/3 d	sil	--------	1gr	sh	vfr	ss op	--------	A
B1	20-36 (8-14)	10YR 4/3 m 10YR 6/3 d	hsil	--------	2sbk	h	f	ss sp	--------	C
IIB2t	36-66 (14-26)	7.5YR 4/2 m 7.5YR 5/3 d	sicl	c2d mottles: 7.5YR 4/4 m 7.5YR 5/4 d	2sbk	h	fi	ss sp	2n clay film on pf, po	C
IIB3t	66-97 (26-38)	7.5YR 4/2,4/4 m 7.5YR 5/3,4/6 d	sicl	c2d mottles: 7.5YR 4/6 m 7.5YR 5/6 d f1f saprolite chips: 7.5YR 3/1 m 7.5YR 4/1 d	2sbk	h	fi	ss sp	2mk clay films on pf, po	C
IICr	97-122+ (38-48+)	Variegations: 7.5YR 3/1,4/4 m 7.5YR 4/1,4/6 d	saprolitic siltstone	--------	remnant rock structure	--	--	--	1mk, 2n clay films on fracture faces	--

1/ CONSISTENCE: D=dry soil, M=moist soil, W=wet soil

CORE: 4 QUADRANT: D4 ELEVATION: 78 m

TRANSECT: Z ASPECT: West SLOPE: 12%

HORIZON	DEPTH	COLOR	FIELD TEXTURE	MOTTLES etc.	APPARENT STRUCTURE	CONSISTENCE[1] D	M	W	FILMS etc.	APPARENT BOUNDARY
	cm (inches)									
Ap	0-20 (0-8)	10YR 3/3 m 10YR 5/3 d	sil	--------	2gr	sh	fr	ss sp	------	A
AB	20-30 (8-12)	10YR 3/3 m 10YR 5/3 d	sil	f2f mottles; 10YR 4/3 m 10YR 4/4 d	2sbk	sh	fr	ss sp	------	C
IIB2	30-56 (12-22)	7.5YR 3/4 m 7.5YR 4/4 d	sil	m2f mottles: 10YR 4/3 m 10YR 4/4 d cld saprolite chips: 10YR 6/6 m 10YR 7/2 d	2sbk	h	fr	ss sp	------	G
IICr	56-97+ (22-38+)	Variegations: 10YR 6/6,7/2m 10YR 7/2,8/3d	saprolitic sandstone	--------	remnant rock structure	--	--	--	------	--

[1] CONSISTENCE: D=dry soil, M=moist soil, W=wet soil

APPENDIX TABLE A2. Delay Factor Data.

DATE	ONSET OF P (clock hours)	D3 FIRST RESPONSE (clock hours)	D3 DELAY FACTOR (min.)	D4 FIRST RESPONSE (clock hours)	D4 DELAY FACTOR (min.)
1/15	21:00	22:00	60	22:00	60
1/16	21:00	21:30	30	21:30	30
1/17	1:00	1:30	30	1:30	30
1/18	10:00	10:30	30	10:45	45
1/21	12:00	13:00	60	13:30	90
1/21	14:00	15:00	60	15:30	90
1/21	15:50	17:00	70	17:50	120
2/1	3:30	5:00	90	5:30	120
2/1	14:30	15:30	60	16:15	105
2/1	15:45	16:30	45	17:00	75
2/2	2:30	3:30	60	4:00	90
2/2	10:45	--	--	12:30	105
2/2	13:45	14:30	45	14:30	45
2/6	1:45	--	--	2:30	45
2/6	9:30	10:30	60	11:00	90
2/6	17:30	18:30	60	19:00	90
2/6	18:45	19:30	45	20:00	75
2/7	4:45	5:30	45	6:00	75
2/7	14:45	15:30	45	16:00	75
2/7	18:45	19:30	45	20:00	75
2/7	20:30	21:30	60	22:00	90
2/8	1:20	2:00	40	2:30	70
2/8	15:30	16:30	60	17:00	90
2/9	6:00	6:30	30	6:30	30
2/9	12:30	13:10	40	13:45	75
2/12	10:00	10:30	30	--	--
			n= 24		n= 25
			x= 50		x= 75
			s.e.= 3		s.e.= 5

APPENDIX TABLE A3. Streamflow and Adjusted Streamflow Data.[1]

Date: 1/15-1/16

CLOCK HOURS	P (mm)	QD3 (L/sec)	QD4 (L/sec)	ADJ.QD3 (L/sec)	ADJ.QD4 (L/sec)
20:30	0.254	15.3	32.2	15.3	32.4
21:00	0.508	15.3	32.2	15.9	34.8
21:30	0.762	15.3	32.2	26.7	44.7
22:00	2.032	16.2	32.6	52.4	65.4
22:30	1.778	31.9	37.1	59.0	82.8
23:00	1.016	62.6	52.2	55.9	83.0
23:30	0.254	57.3	78.5	50.0	74.6
0:00	0	55.2	87.1	44.6	68.3
0:30	0.254	47.4	78.8	43.6	66.6
1:00	0.508	43.3	70.3	62.0	69.0
1:30	1.016	43.7	66.2	52.1	72.2
2:00	0.254	49.2	67.0	52.4	77.5
2:30	0.508	53.5	71.0	68.3	91.8
3:00	1.778	51.9	73.5	85.5	110.2
3:30	0.508	76.5	81.5	81.7	112.6
4:00	0.254	90.0	102.1	74.1	101.5
4:30	0	77.6	118.3	69.0	93.0
5:00	0	72.4	106.8	64.5	87.6
5:30	0.254	67.3	96.3	60.6	83.6
6:00	0	63.1	89.8	57.2	80.4

Date: 1/16-1/17

CLOCK HOURS	P (mm)	QD3 (L/sec)	QD4 (L/sec)	ADJ.QD3 (L/sec)	ADJ.QD4 (L/sec)
21:00	0.762	28.2	52.4	34.0	56.7
21:30	1.270	30.2	52.5	43.4	63.3
22:00	0.760	35.9	53.6	64.0	68.2
22:30	0.508	47.2	59.8	46.8	69.5
23:00	0.508	48.8	66.9	46.5	69.5
23:30	0.254	45.8	69.5	45.7	69.4
0:00	0	46.9	68.4	44.6	70.0
0:30	0	45.1	69.5	54.3	73.1
1:00	1.016	44.4	67.8	58.8	78.0
1:30	0.508	59.3	70.8	55.5	80.9
2:00	0.254	58.5	75.4	53.2	79.9
2:30	0	54.0	80.7	51.3	76.7

[1] Q-values adjusted for delay factor: QD3-50 min.= ADJ.QD3 and QD4-75 min.=ADJ.QD4.

APPENDIX TABLE A8. (cont.)

Date: 1/18

CLOCK HOURS	P (mm)	QD3 (L/sec)	QD4 (L/sec)	ADJ.QD3 (L/sec)	ADJ.QD4 (L/sec)
10:00	0.762	17.0	35.6	18.1	37.8
10:30	0.762	17.5	35.7	20.0	39.9
11:00	0.508	18.7	36.8	22.1	42.6
11:30	1.016	20.6	38.7	27.7	47.7
12:00	1.016	22.8	41.1	36.0	55.9
12:30	1.270	30.2	44.5	45.7	66.0
13:00	1.016	38.9	51.1	55.6	80.2
13:30	1.524	49.1	60.7	53.9	101.9
14:00	1.778	60.1	71.4	89.7	122.9
14:30	0.762	80.9	89.2	91.6	129.9
15:00	1.016	92.8	117.5	94.7	128.6
15:30	0.508	113.3	129.2	94.3	128.8
16:00	1.016	95.1	132.1	100.5	133.0
16:30	0.762	91.0	129.0	106.3	139.5
17:00	0.508	119.2	127.7	105.4	139.2
17:30	0.254	103.0	150.1	101.1	132.4
18:00	0	106.7	138.3	96.4	124.7
18:30	0.254	99.4	125.4	90.5	117.8
19:00	0	94.1	115.4	84.1	111.7

Date: 1/21

CLOCK HOURS	P (mm)	QD3 (L/sec)	QD4 (L/sec)	ADJ.QD3 (L/sec)	ADJ.QD4 (L/sec)
12:00	0.254	25.2	42.5	44.0	50.8
12:30	1.524	27.8	42.3	52.5	63.3
13:00	0.762	52.1	43.0	45.9	65.8
13:30	0.254	52.7	58.5	38.9	63.1
14:00	0	42.5	68.0	50.0	64.1
14:30	1.016	37.1	63.5	51.4	65.1
15:00	0.508	55.9	62.6	49.6	67.8
15:30	0.254	49.2	65.6	48.2	67.1
16:00	0.508	49.8	64.5	50.2	64.0
16:30	0.254	47.4	70.8	46.1	62.3
17:00	0.254	51.6	63.4	44.4	62.3
17:30	0	43.3	64.5	43.4	64.4

APPENDIX TABLE A3. (cont.)

Date: 2/1

CLOCK HOURS	P (mm)	QD3 (L/sec)	QD4 (L/sec)	ADJ.QD3 (L/sec)	ADJ.QD4 (L/sec)
4:00	1.016	5.0	6.8	6.8	11.1
4:30	1.778	5.0	6.8	7.3	16.6
5:00	0.508	9.0	6.8	12.3	22.6
5:30	1.270	20.1	7.6	17.3	33.4
6:00	1.778	16.2	14.6	23.9	48.1
6:30	2.032	25.5	18.6	35.7	89.4
7:00	1.270	49.6	26.6	50.8	61.4
7:30	1.270	52.8	40.3	63.2	69.6
8:00	0.508	59.9	56.0	70.5	70.1
8:30	0.254	71.1	66.9	69.3	62.7
9:00	0	59.4	72.4	50.0	54.4
9:30	0.254	52.2	67.8	46.4	49.6
10:00	0.254	48.9	57.6	44.0	47.3
10:30	0	45.1	51.3	41.5	45.9

Date: 2/1-2/2

CLOCK HOURS	P (mm)	QD3 (L/sec)	QD4 (L/sec)	ADJ.QD3 (L/sec)	ADJ.QD4 (L/sec)
14:00	0.254	32.4	40.6	32.2	39.6
14:30	0.254	32.2	40.3	32.4	40.4
15:00	0.762	32.2	39.2	34.8	41.5
15:30	0.254	32.4	40.1	37.4	45.3
16:00	1.524	36.0	40.7	54.9	64.5
16:30	2.794	38.1	42.3	139.8	151.5
17:00	2.540	63.2	48.3	157.4	202.5
17:30	0	178.1	80.7	118.1	153.1
18:00	0	147.1	222.3	94.0	113.9
18:30	0	103.7	182.6	82.9	100.0
19:00	0.254	89.2	123.5	76.2	93.9
19:30	0.254	79.8	104.3	72.1	90.3
20.00	0.254	74.4	95.8	70.1	88.4
20:30	0.254	70.9	92.0	62.8	87.1
21:00	0	69.7	88.6	61.3	84.6

APPENDIX TABLE A3. (cont.)

Date: 2/6-2/7

CLOCK HOURS	P (mm)	QD3 (L/sec)	QD4 (L/sec)	ADJ.QD3 (L/sec)	ADJ.QD4 (L/sec)
18:00	1.778	14.2	27.1	25.8	32.1
18:30	0	28.6	27.2	25.2	37.8
19:00	1.016	24.9	27.5	39.9	39.0
19:30	1.778	27.8	36.7	40.1	39.1
20:00	0	47.5	39.0	34.8	39.1
20:30	0.254	38.2	39.0	32.0	39.0
21:00	0	33.7	39.2	30.7	39.0
21:30	0	31.6	39.0	30.6	39.0
22:00	0.508	30.7	39.0	30.5	39.0
22:30	0	30.5	39.0	29.3	39.1

Date: 2/7

CLOCK HOURS	P (mm)	QD3 (L/sec)	QD4 (L/sec)	ADJ.QD3 (L/sec)	ADJ.QD4 (L/sec)
4:00	0.762	26.4	39.2	31.8	39.0
4:30	0.508	30.0	39.0	44.6	43.9
5:00	1.524	32.7	39.0	73.9	67.6
5:30	1.778	50.7	39.0	91.9	102.1
6:00	1.524	85.6	48.8	110.3	126.8
6:30	1.270	95.2	86.5	129.4	144.5
7:00	1.524	118.0	117.7	150.0	167.4
7:30	1.778	135.3	135.9	155.4	175.9
8:00	0.508	157.6	153.1	144.9	158.4
8:30	0.508	154.5	181.7	134.4	144.6
9:00	0.254	140.3	170.0	135.7	142.7
9:30	0.762	131.7	146.8	128.0	140.7
10:00	0	138.0	142.4	118.3	134.0
10:30	0.254	123.2	143.0	108.6	126.1
11:00	0	116.1	138.4	99.1	119.7

Linear regression equations: N = 117

$$QD4 = 11.81 + 1.02(QD3)$$
$$r^2 = 0.80$$

$$ADJ.QD4 = 12.86 + 1.08(ADJ.QD3)$$
$$r^2 = 0.93$$

APPENDIX TABLE A4. Summary of Storm Characteristics.

SUMMARY OF STORM CHARACTERISTICS

DATE	1/15-16	1/16-17	1/18	1/21	2/1	2/1-2	2/6-7	2/7
DURATION (HOURS)	9	5	9	5½	6	6½	6	7½
PRECIPITATION TOTAL (mm)	11.938	6.096	14.732	5.842	12.192	6.858	5.334	12.954
MAX. 30-MIN. PRECIPITATION	2.032	1.270	1.778	1.524	2.032	2.794	1.788	2.032

APPENDIX TABLE A5. Suspended Sediment Storm Characteristics.

	DATE	1/15-16	1/16-17	1/18	1/21	2/1	2/1-2	2/6-7	2/7
	MEASUREMENT PERIOD (CLOCK HOURS)	21:30- 9:30	21:30- 6:00	12:00- 22:00	12:30- 21:00	4:30- 15:00	16:00- 0:30	17:30- 1:00	4:30- 17:00
D3	TOTAL SUSPENDED SEDIMENT (kg/ha)	40.1	5.6	35.9	13.2	28.9	217.2	10.8	90.9
D3	BASEFLOW SUSPENDED SEDIMENT (kg/ha)	3.2	1.3	4.6	4.9	4.7	7.2	4.1	11.6
D4	TOTAL SUSPENDED SEDIMENT (kg/ha)	6.5	1.4	4.9	2.1	2.8	12.2	1.7	10.2
D4	BASEFLOW SUSPENDED SEDIMENT (kg/ha)	4.1	0.8	2.3	1.3	1.1	4.2	1.3	6.1