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INSTRUMENTAL OBSERVATIONS OF MASS-WASTING IN THE MESTERS VIG DISTRICT, NORTHEAST GREENLAND

BY

A. L. WASHBURN

WITH 45 FIGURES IN THE TEXT, 131 PLATES
AND 43 TABLES

KØBENHAVN
C. A. REITZELS FORLAG
BIANCO LUNOS BOGTRYKKERI A/S
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Abstract

Quantitative observations of mass-wasting were carried out at a number of experimental sites in the Mesters Vig district of Northeast Greenland from 1956 to 1961. In addition to other data, the observations encompassed several thousand theodolite readings of cone targets that were inserted to alternate depths of 10 and 20 cm on diamicton slopes. The experimental sites ranged in mean gradient from 2.5° to 25° and had a spectrum of grain-size, moisture, and vegetational characteristics that permitted certain comparisons.

The following are among the resulting conclusions. The first four are general; the remainder are specific for the Mesters Vig district.

1. Frost creep and gelifluction can be quantitatively distinguished from each other.

2. In gelifluction the influence of moisture can be more important than the influence of gradient or vegetation.

3. Significant gelifluction probably occurs only at moisture values approximating or exceeding the Atterberg liquid limit.

4. Frost creep and creep due to wetting and drying tend to be associated with a retrograde movement that reduces the amount of creep that would otherwise be present.

5. Creep due to wetting and drying is of minor significance compared to frost creep.

6. Frost creep in most places is due mainly to the annual freeze-thaw cycle rather than to short-term freeze-thaw cycles.

7. Either frost creep or gelifluction can predominate in different places on the same slope, depending on variations in local conditions.

8. At the sites investigated in most detail frost creep tends to exceed gelifluction but by not more, and probably less, than 3:1 over a period of years, and either process can predominate in a given year.

9. In "wet" areas there may be a straight-line relation between rate of mass-wasting and sine of gradient.

10. Mass-wasting due to frost creep and gelifluction on a gradient of 10–14° ranged from a mean of 0.9 cm/yr in sectors subject to desiccation during summer, to a mean of 3.7 cm/yr in sectors remaining saturated.

CONTENTS

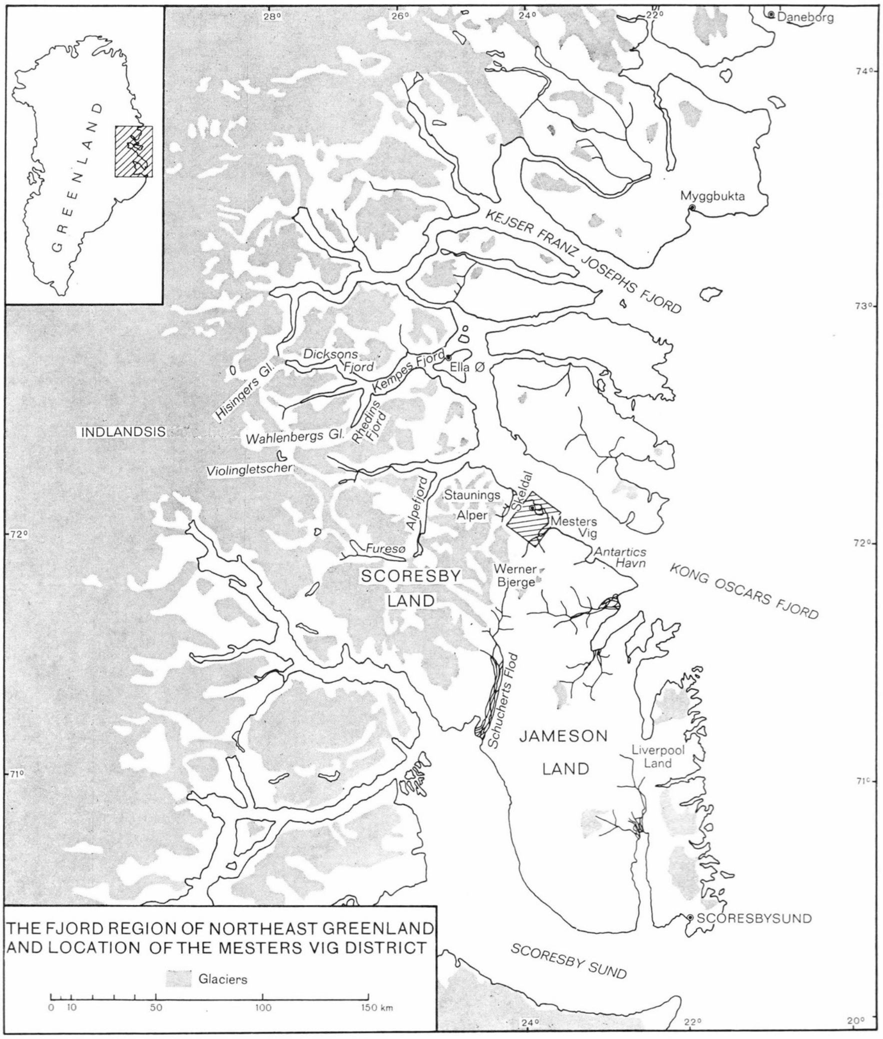

Fig. 1. The fjord region of Northeast Greenland and location of the Mesters Vig district.

Fig. 2. The Mesters Vig district and vicinity.

I. INTRODUCTION

The present number of the *Meddelelser om Grønland* is one of a series of reports resulting from a program of geomorphic and vegetational studies in the Mesters Vig district of Northeast Greenland. The nature of the program and the many people and organizations that assisted it are cited in the General Introduction, which has been published as a separate number of the *Meddelelser* (Washburn, 1965). The writer takes the present opportunity to express again his deep gratitude for the help rendered him, without which the program could not have been undertaken, much less carried out. The writer is also indebted to Colonel J. V. Helk, Professors Arthur L. Bloom, Richard F. Flint, John F. Nye, Hugh M. Raup, Sidney E. White, Herbert E. Wright, Jr., and cand. mag. Anker Weidick for reading major portions of the manuscript of the present report and for their helpful suggestions.

The Mesters Vig district is located on the south side of Kong Oscars Fjord about 50 km from its entrance (figs. 1–2); the coordinates of the Danish Government station at Mesters Vig are lat. 72°14′ N., long. 23°55′ W. The general characteristics of the district, including climate, vegetation, topography, and bedrock and surficial geology are outlined in the General Introduction cited above. Details of the vegetation have been published by Raup (1965a, 1965b), and further reports by him are in preparation.

The metric system is used throughout and all temperatures are in degrees centigrade unless otherwise indicated. Moisture determinations are in percent w (weight water/weight solids) unless otherwise indicated.

Unless otherwise stated, the terminology in this report follows the American Geological Institute *Glossary of geology and related sciences* (Howell, 1960). The nomenclature of sediments follows Washburn, Sanders, and Flint (1963), as a convenient means of characterizing poorly sorted deposits, such as the diamictons (Flint, Sanders, and Rodgers, 1960a, 1960b) in the Mesters Vig district. Based on the Wentworth classification with respect to grain-size limits for gravel, sand, silt and clay sizes, the nomenclature uses the major component for the principal name, with the lesser components applied as modifiers in order of increasing importance. The actual percentages may be given as subscripts; for instance, clayey$_{10}$-sandy$_{20}$-gravelly$_{30}$ silt$_{40}$. Where percentages fall below 5 percent, the component is omitted in the name. Also, where the principal component is within 5 percent of the next component, it has been found useful to join them; for instance, clayey$_{8}$-sandy$_{16}$ gravel$_{36}$-silt$_{40}$. "Fines" in this report refers to silt and/or clay sizes.

The following are some of the abbreviations (singular and/or plural forms) used in this report. For further general information, reference should be made to the General Introduction.

ES	Experimental site(s)
MS	Map summit(s)
MW	Mass-wastingmeter(s)
T	Target(s)
TC	Thermocouple(s)
TCS	Thermocouple string(s)
TG	Thermograph(s)

Figures are numbered consecutively and are confined to the text. Plates in the appendices carry the letter of the appendix; e. g. plate C2. All tables, in contrast to figures and plates, carry Roman numerals. Tables pertaining primarily to the text are numbered consecutively by chapter; e. g. tables VI.1, VI.2. Tables pertaining to appendices are prefixed by the letter of the appendix; e. g. tables D I, D II. Large tables, prepared by computer, follow the appendices.

The present report discusses the results of one of the primary objectives of the Mesters Vig research program—a quantitative study of mass-wasting in an arctic environment. In particular it was hoped that repetitive observations at various seasons over a period of years might provide a better insight into some of the problems of creep and solifluction.

In spite of the importance of obtaining quantitative information on these processes (cf. SAPPER, 1912, p. 262; 1913, p. 107), few such studies have been made aside from some engineering surveys, and most of these have not been concerned with cold environments. However, several recent investigations suggest that the trend toward quantitative geomorphology will soon result in vital information along these lines also (cf. BÜDEL, 1961, p. 365–366; DAHL, 1956, p. 273–275; EVERETT, 1963a, 1963b, 1963c; GRADWELL 1957, p. 799–806; JAHN, 1960, p. 56–57; 1961; KLINGER, 1959; RAPP, 1960a, p. 179–183; 1960b, 1962, 1963, 1964; RUDBERG, 1958, 1962, 1964; P. J. WILLIAMS, 1957, 1962; ZHIGAREV, 1960). Until quantitative data are available, our knowledge of mass-wasting processes will remain purely qualitative, and the interpretation of their environmental implications, present and past, will be imprecise. In particular there is a tendency for periglacial literature to assume more knowledge of mass-wasting processes than is presently available.

2. TERMINOLOGY

Creep

The terms creeping and creep applied to the downslope movement of material were used by DAVISON (1888a, 1888b). In a classic paper stressing frost action as a cause of creep he described heaving of particles at right angles to a slope and their near-vertical collapse following thawing (DAVISON, 1889). According to SHARPE (1938, p. 21) "The general term *creep* may be defined as *the slow downslope movement of superficial soil or rock debris, usually imperceptible except to observations of long duration.*" In addition to rock creep, talus creep, and soil creep, SHARPE (1938, p. 22, 33–46) cited frost-controlled creeps, which he regarded as comprising rock-glacier creep and solifluction. It should be noted that the heaving and settling of particles is not limited to the surface as might be gathered from SHARPE's (1938, p. 27–28) description but may extend through the entire thickness of mantle affected by frost action as elaborated by DAVISON (1889).

Since creep due to frost heaving and subsequent settling of particles will be discussed in some detail in the following and is an important element in mass-wasting, a special name for it is convenient and frost creep will be used. Formally defined for the purposes of this report, frost creep is the ratchetlike downslope movement of particles as the result of frost heaving of the ground and subsequent settling upon thawing, the heaving being predominantly normal to the slope and the settling more nearly vertical. This definition is believed to accord with what is commonly understood to be the nature of creep by frost action. However, it differs from SHARPE's frost-controlled creeps in, among other things, not including solifluction, which the present writer regards as a distinct process.

Solifluction

Solifluction was defined by ANDERSSON (1906, p. 95–96) as follows: "This process, the slow flowing from higher to lower ground of masses of waste saturated with water (this may come from snow-melting or rain), I propose to name *solifluction* (derived from *solum*, "soil", and *fluere*, "to flow")." It is quite generally agreed, usually implicitly but also explicitly (for instance, TABER, 1943, p. 1458; WRIGHT, 1961, p. 941), that the water can also come from thawing of frozen ground.

It should be stressed that ANDERSSON's definition specifies flow and does not limit it to cold climates, although the examples cited by him were from such regions and this has led some authors to believe that his definition should be so restricted. (Cf. for instance, BÜDEL, 1959, p. 297–299; 1961, p. 375; HÖLLERMANN, 1964, p. 65; SALOMON, 1929, p. 5–6; SMITH, 1956, p. 16–17; TROLL, 1947, p. 167.) SCHENK (1954, p. 200, 202) even advocated redefining solifluction to apply only to gravitational movements due to moisture released by thawing of ice lenses. To modify the original definition to include also processes responsible for patterned ground, as is occasionally done (cf. EAKIN, 1916, p. 80–81; SØRENSEN, 1935, p. 7–8; TROLL, 1947, p. 167; 1948, p. 4, 15), permits confusion and was criticized long ago by MEINARDUS (1912a, p. 257; 1912b, p. 15–16, 27–30; 1930, p. 89) and GRIPP (1927, p. 24). That solifluction as defined by ANDERSSON need not be confined to cold climates was recently stressed by RUSSELL (1964) and has been recognized by a number of investigators (BAULIG, 1956, p. 50–51; cf. BAULIG, 1957, p. 926; DYLIK, 1951, p. 5; HANSON, 1950, p. 606; PATERSON, 1940, p. 124; SCHMID, 1955, p. 123–124; SHARPE, 1938, p. 34–35; STECHE, 1933, p. 227; TRICART and CAILLEUX, 1955, p. 127–128; and others). One way to avoid confusion is faithfully to follow ANDERSSON's original definition, as also recently recommended by BUTRYM and others (1964, p. 16), and to have other terms for more precise meanings as the American Geological Institute has done in its *Glossary of geology and related sciences* (HOWELL, 1960, p. 273).

Gelifluction and Congelifluction

In order to eliminate confusion resulting from some investigators restricting solifluction to cold climates and others using it in a more general sense, two related terms have been proposed—gelifluction and congelifluction.

Congelifluction was defined by DYLIK (1951, p. 6): "The author proposes *congelifluction* as a term for earth-flow occurring under conditions of perennially frozen-ground and restricts it to progressive and lateral movements." DYLIK (1951, p. 5) explained his restrictions by stating:

> "Earth-flow is usually termed *solifluction.* But there are distinct differences in the meaning and use of this term. It is used to denote the movements under Arctic or sub-Arctic conditions. However some authors apply it to mean phenomena occurring beyond these climatic limits.

> "Further differences appear with regard to the character of the movement. Most writers use it to denote progressive downslope movement, but some include also nonprogressive differential movement as that which produces involutions and stone-polygons."

Thanks to his explanation, Dylik's meaning is clear, but introduction of earthflow into his definition could be cause for confusion, for earthflow and solifluction are regarded as distinct processes by Sharpe (1938, p. 20) and many others. Following the original definition of solifluction Dylik's objectives are unequivocally and simply attained by defining congeliflu ction as solifluction associated with permafrost.

Gelifluction was defined by Baulig (1956, p. 50–51; cf. also Baulig, 1957, p. 926) as solifluction associated with frozen ground:

> "En régime cryergique***l'ablation des débris***se fait*** surtout par solifluxion—on dirait peut-être plus précisément par *géli(soli)fluxion* (39). Celle-ci consiste*** dans le déplacement lent de matériaux dégélés, saturés d'eau, glissant sur un sous-sol encore gelé (non nécessairement un "tjäle"***)***"

In the accompanying footnote (39) Baulig stated:

> "Il parait abusif de restreindre le sens de "solifluction" (J. G. Andersson, 1906) aux phénomènes cryergiques. Le flux du sol s'observe sous tous les climats, et il joue un rôle de premier ordre sur les pentes des tropiques sur-humides."

The use of the term gelifluction has been recently supported by Hamelin and Clibbon (1962, p. 203) and Hamelin (1963, p. 207).

Both Baulig and Dylik agree that a more precise term than solifluction is needed for application to cold-climate phenomena, and their terms differ only in that gelifluction may be associated with either permafrost or frozen ground lacking permafrost, whereas congelifluction is necessarily associated with permafrost. The present writer agrees that the term solifluction should not be limited to cold-climate phenomena (cf. Washburn, 1947, p. 96) and, where association with frozen ground can be established (which may be difficult in some Pleistocene and older deposits), that introduction of a more precise term would eliminate confusion arising from any implication that solifluction was restricted to such phenomena. However, he questions whether both gelifluction and congelifluction are required. Of the two terms he prefers gelifluction because of its wider applicability and the difficulty of distinguishing between land forms and deposits due exclusively to the one process as opposed to the other. Except for current phenomena and even then, the distinction may be more theoretical than practical, especially where there is deep freezing but no permafrost. Where the distinction can be made, it can be explained without introducing another term.

Comparison of Creep and Solifluction

Maull (1958, p. 99) following Penck (1924, p. 79–90; 1953, p. 97–110) thought that creep and solifluction were essentially alike except that the former was associated with vegetation (*gebundene Massenbewegung*) and the latter was relatively free from such influence (*freie Massenbewegung*). Sharpe (1938, p. 21) advocated considering creep as flow. However, Parizek and Woodruff (1957, p. 654–655) thought that to include creep in flow is misleading and not in line with what Andersson meant by flow. Strahler (1952, p. 929, 933–934) argued that creep and flow are basically different processes. In accepting mineral soil with liberal amounts of water as a plastic solid subject to flow under the control of gravitational stress, he included solifluction but excluded creep; creep, he pointed out, is a distinct process due to random molecular stresses with gravity being a modifying influence only rather than providing the controlling stress. Regarding solifluction as defined by Andersson as a form of creep is also open to criticism in that creep commonly refers to what Sharpe termed soil creep, which is widely recognized as being very different from viscous flow or solifluction (Cotton, 1958, p. 28–29; Gilluly, Waters, and Woodford, 1959, p. 171–173; Longwell and Flint, 1962, p. 143–146; Sigafoos and Hopkins, 1952; Strahler, 1960, p. 318–319; 1963, p. 460–465; Taber, 1943, p. 1456–1458; Thornbury, 1954, p. 84–87; and many others). However, some authors, including Högbom (1910, p. 45–51), Poser (1932, p. 38–39), Smith (1956, p. 16–17), and Williams (1959, p. 4) have regarded creep as a component of solifluction. According to Leopold, Wolman, and Miller (1964, p. 344) "Solifluction is essentially a form of creep***". Still others have left their readers wondering whether they were discussing creep or solifluction or both.

With respect to the Mesters Vig observations, the distinction between frost creep and gelifluction is both theoretical and practical. Frost creep as originally described by Davison (1889) does not imply downslope saturated flow whereas solifluction as originally defined by Andersson (1906, p. 95–96) is dependent on it. In frost creep, particles tend to drop vertically as the underlying support collapses on thawing; in gelifluction, particles throughout a thawed and saturated profile on a slope tend to flow parallel to the surface. A particle tending to drop vertically at depth because of loss of underlying support by thawing also tends to have a downslope component of movement introduced by the weight of overlying material, but a resulting movement beyond the vertical and parallel to the surface implies downslope flow. Such flow under the saturated conditions accompanying thawing in the spring would be gelifluction by definition. The fact that downslope movement in coherent materials tends to cease in the absence of these moisture conditions, as discussed later, demonstrates that saturated flow is involved. Where the entire thawed layer is saturated and undergoing flow, the distinction between frost creep and gelifluction is obvious, and under favorable circumstances the processes can be differentiated and separately measured in the field as was done at several of the experimental sites.

Summary

In summary, in this study frost creep is defined as "the ratchetlike downslope movement of particles as the result of frost heaving of the ground and subsequent settling upon thawing, the heaving being predominantly normal to the slope and the settling more nearly vertical". Contrary to Sharpe (1938, p. 22, 33–35), solifluction is excluded from creep and regarded as a separate process. Solifluction is used as defined by Andersson (1906, p. 95–96) and is not restricted to cold-climate phenomena. Although congelifluction could be appropriately applied to the Mesters Vig phenomena, gelifluction, defined as solifluction associated with frozen ground, has wider application and is more convenient for the purposes of the report.

3. NATURE OF THE DATA

Experimental Sites and Instrumentation

A number of experimental sites were established in the Mesters Vig district in order to obtain quantitative data on creep and gelifluction. They were in the Labben hills, Nyhavn hills, in the vicinity of "Camp Tahoe", and on the upper slope of Hesteskoen[1]). Their location is shown in plate 1, and those pertinent to this report are described in detail in connection with the work at each site.

The instrumentation used at the various experimental sites is described in detail in appendices C, E, G. Orange-colored wood cones (fig. 3) 10 cm high and with a basal diameter of 10 cm, mounted on wood pegs that were inserted in the ground, were employed as targets at all target lines where movement readings were made by theodolite (ES 6–8), and at ES 17. In addition stone targets were used at ES 7. Wood dowels were utilized at the other target lines and also at ES 8. At ES 6–8 the cone targets were spaced 2 m apart (± 1 cm) except where stones interfered, in which event the 2-m interval concerned was omitted and the target placed at the next possible 2-m distance. The pegs on which the cones were mounted were of two lengths—10 cm and 20 cm—so as to permit determinations of possible differences in rate of mass-wasting and frost heaving with depth. Alternating peg lengths were used at ES 6–8, all odd-numbered targets being inserted to the 20-cm depth and even-numbered ones to 10 cm. At ES 17 all the targets were equipped with 10-cm pegs. The bench mark at all the theodolite stations was a round chisel hole 2 cm in diameter. The target lines, mass-wastingmeters, thermographs, and thermocouple strings carry the number of their sites rather than being numbered consecutively. In addition to the above instrumentation, a standard Vicksburg cone pene-

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[1]) Specific experimental sites are abbreviated to ES followed by the number of the site. The numbering reflects the order of establishment (cf. WASHBURN, 1965). ES 1–3, 9–13, and 18–24 were not directly related to studies of mass-wasting and are omitted in the following. ES 4–5 consisted of target lines similar to ES 6–8 but were located where large boulders rather than bedrock had to be used for the theodolite stations. Since the resulting data indicate that the apparently stable boulders very probably moved, ES 4–5 are also omitted from the discussion of mass-wasting, although certain of the data are useful for other investigations.

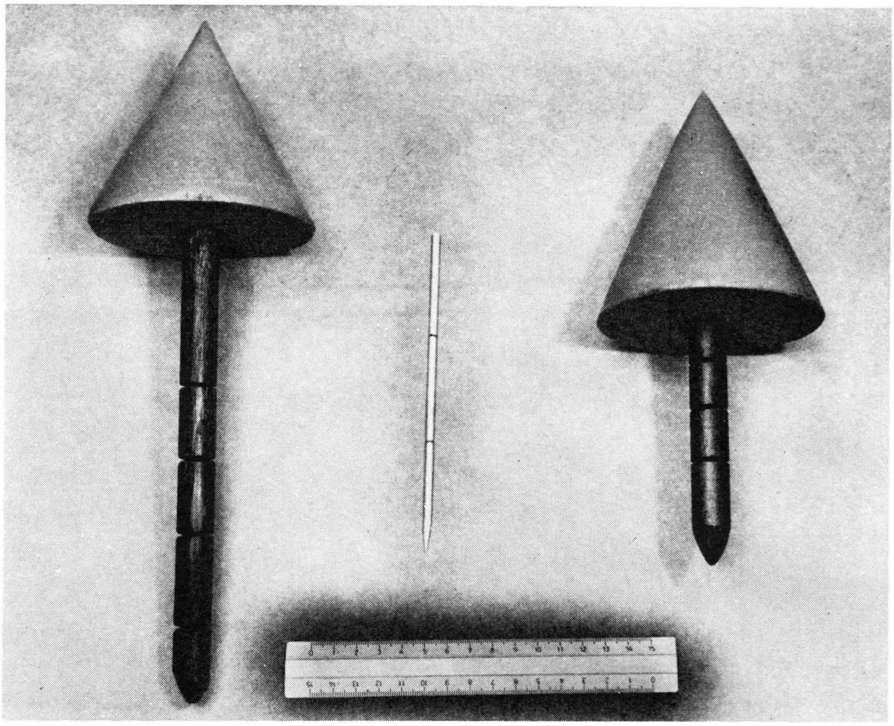

Fig. 3. Types of targets employed at experimental sites. Scale given by 17-cm rule.

trometer (30° cone on half-inch base), loaned by the U. S. Air Force Cambridge Research Center, was employed at ES 6–8, and 15 to measure shear strength.

Measurements

As discussed in appendix C, the accuracy of theodolite readings is regarded as about ±0.15 cm for most readings of the cone targets, and in considering target behavior, only movements in excess of 0.2 cm are believed to be probably significant. Because fluctuations of 0.2 cm and less are disregarded (except as otherwise noted) in computing component movements, total annual target movements may differ slightly from the sum of the components.

All theodolite measurements of target movement were made with respect to the vertical plane through the end points of a target line. The resulting horizontal angles between target tip and vertical plane were converted to distance to the closest 0.05 cm. The true slope movement is this distance adjusted for (1) any change in target attitude (heaving and/or tilting as described in appendix C and detailed in the accompanying tables), (2) the gradient of the slope, and (3) any difference in the trend of a target line and contours (angle of view). Distances cited in discussions of target movement are rounded to the closest 0.1 cm.

The adjustment for angle of view is based on the assumption that the movement is more likely to be down the steepest available slope than in any other direction; exceptions may occur where there are boundary effects, but this assumption is more realistic than the alternative that the movement is normal to the target line regardless of contour trends. Angles of view are approximated from the contour maps of the sites, and in places are little more than estimates. Where angles turned out to be very large with respect to adjacent targets, the targets concerned were excluded from consideration because the flow lines might be unduly complicated. As a result the adjustments are minor in most places. For instance, the difference between the mean annual rate based on horizontal components normal to the target lines and those based on true slope components is only 0.1 cm at ES 7 (1.2 vs. 1.3 cm) and at ES 8 (3.1 vs. 3.2 cm). However, at ES 6 where the average angle of view is greater the difference rises to 0.3 cm (0.7 vs. 1.0 cm).

Adjustment (1) is applied to annual movements but not to the several categories of movement comprising annual movement, described below. This is because attitude changes are known for the annual period only, whereas the movement categories involve shorter periods. However, the resulting errors for the categories are not serious when means are considered. In the case of the dowel targets no attitude adjustments were required, since the measurements were made to the point where the dowels intersected the ground. Adjustments (2) and (3) have been made throughout unless otherwise indicated. Maps, and movement graphs of individual targets (pl. C 1–C 3), however, show the horizontal components as originally observed normal to the target lines, since the shape of the graphs would not be changed and the maps are self-explanatory and project slope distances in terms of the horizontal. In the tables of target movements at ES 6–8, 15–17 (tables C I–C VIII), both the observed and the adjusted measurements are given and permit direct comparisons. The tables also give the standard error of the mean for most means.

Categories of Target Movement

Analysis of target movements involved recognizing 4 categories of movement: jump, gelifluction, retrograde movement, and September movement. The jump is the movement between the last target reading of one year and the first reading of the next. It incorporates the result of ground heaving at right angles to the slope, which is the predominant cooling surface controlling the direction of ice-crystal growth (Taber, 1929, p. 447–450; 1930, p. 308; 1943, p. 1456), even though irregularities would be introduced by varying conductivities in heterogeneous material (HAMBERG, 1915, p. 600–602). The jump may involve some gelifluction if the first reading of the year was made after the ground around a target had thawed. Gelifluction is the movement attributable to flow. Retrograde movement is a backward (upslope) movement with reference to the vertical plane through the end points of a target line. It is real and, as discussed later, is interpreted as due to a tendency for the ground to settle back against the slope, rather than purely vertically, during contraction accompanying thawing and desiccation. September movement is the downslope movement associated with ground heaving and/or gelifluction. The term September movement is useful because of the difficulty of distinguishing between these categories at this time of year. Retrograde movement in September is not included since its category remains unequivocal, but any other autumn movement after the last reading in August is arbitrarily designated as September movement even though some of it may have occurred in late August after the reading. Thus, except as otherwise indicated, in analyzing components of target movement the jump includes the effect of maximum possible ground heaving between the last observation of one year and the first of the next; gelifluction is the minimum possible flow (minimum because some gelifluction may be incorporated in the jump and September movement); and retrograde movement is the component of upslope movement (which is also minimum because its presence may be masked by gelifluction as discussed below). The 4 categories of movement are shown in figure 4, which illustrates a rather typical association as explained below.

The target movement is plotted against background graphs of precipitation and of maximum and minimum temperatures as recorded at the Danish Government station. All the main experimental sites (ES 6–8) were within 100 m altitude and $2^1/_2$ km distance of this station, and the meteorological conditions at most sites closely resembled those at the station as indicated by a comparison of meteorological records. At ES 8 (in general the data also apply to ES 7 because of its proximity), almost continuous thermograph records from May through September 1961 permitted a close comparison for this period, and less complete data for 1960 were of the same order of magnitude. The air thermograph at ES 8 was controlled by occasional readings of a maximum-minimum thermometer that had been checked at the government station. The records were read to the closest 0.5° and are believed to be accurate to ±0.5°. They show that the monthly mean maximum at ES 8 ranged from 0.8° less (May) to 0.3° more (July) than at the government station, and that the monthly mean minimum at ES 7–8 was always slightly higher, the greatest difference from the government station being 1.6° (May). Dif-

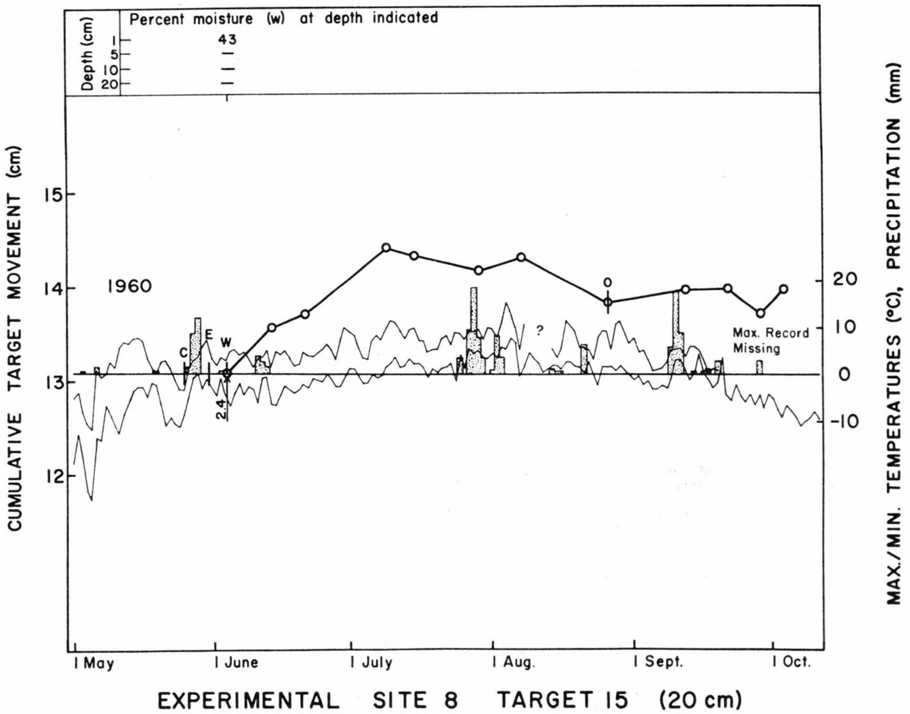

Fig. 4. Sample graph of target movement. Heavy line indicates target movement, light line shows maximum and minimum temperatures, and bar graphs show precipitation.

ferences for a given day might be more, of course, due in part to effects of fog and cloud, and ranged from 6.4° less (July minimum) to 8.4° more (May maximum) than at the government station. Not only were monthly mean maxima and minima similar, but the number of freeze-thaw cycles were also similar. Thus in 1961 for the months indicated, the number of cycles of air temperature involving fluctuations to or through 0° at ES 7–8 and at the government station were, respectively: 13 and 15 for May, 7 and 10 for June, 0 and 0 for July, and 3 and 2 for August (table B I).

The arrow at the beginning of the movement graph in figure 4 indicates the jump in centimeters. The up trend of the movement graph indicates the amount of gelifluction, and the down trend the retrograde movement. The final up trend includes the September movement. Significant target attitudes are given by the letters D or U (downslope or upslope) and by the amount (in cm); a zero alone indicates that the target attitude was neither downslope nor upslope. The associated tick marks give the date of observation. Details of target attitudes are given in tables A I–A III. The letters S (snow) and W (water) where present on other points of the movement graph denote snow and water on the slope

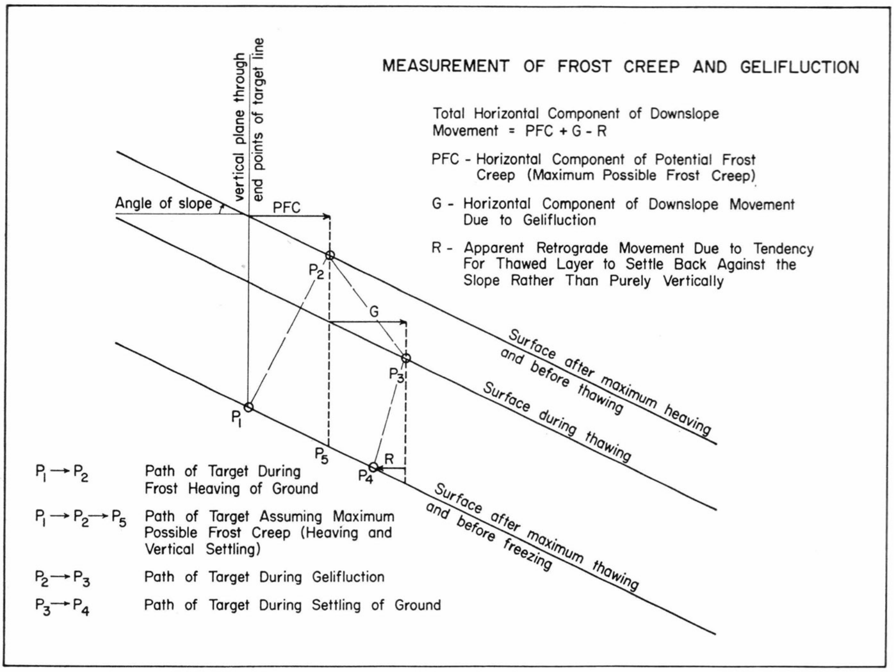

Fig. 5. Diagram of frost creep, gelifluction, and retrograde components of target movement as related to the vertical plane through end points of target line.

within 2 m of a target, as observed through the theodolite during target readings. C (covered), E (exposed), and PE (partially exposed) apply to a target's relation to any snow cover on the dates indicated. The closer together the dates, the closer the approximation to the actual date on which a given target was first snow free in the spring and the adjacent ground first subject to thawing (cf. tables B III–B V). Finally, where moisture determinations were available from within 5–10 m of a target (app. F), they are entered chronologically above the movement graphs. Sampling closer to the target lines while the ground was soft involved the risk of undue disturbance. However, the determinations are believed to be reasonably representative of moisture conditions along the lines.

The interrelations between frost creep, gelifluction, and retrograde movement are illustrated in figure 5. It illustrates the concept that any movement following the jump must be due to flow parallel to the surface rather than to frost creep, provided the maximum possible frost creep is represented by the first target reading of the spring. A similar reasoning has been employed by JAHN (1961, p. 13–14), although he regarded a "frost-caused thrust" as the essential condition and flow as a resultant. Ideally this first reading is made while the ground is still frozen and before there has been any gelifluction. The diagram also shows that the observed retrograde movement need not involve an absolute upslope movement, but like all other measurements is with respect to the vertical plane through the end points of a target line and so involves vertical and horizontal axes rather than axes normal and parallel to the gradient. Thus as the ground becomes reduced in volume and settles during thawing and any desiccation, a point undergoing retrograde movement may still be increasing its downslope position with respect to the latter inclined set of axes. Gelifluction and retrograde movement oppose each other, and the retrograde movement becomes apparent only to the extent that its rate exceeds that of gelifluction.

Two major questions arise in connection with the foregoing exposition: (1) To what extent can the influence of heaving and tilting of the targets themselves, independent of ground movements, be discounted in interpreting the graphs? (2) To what extent may any movement following the jump be due to frost creep rather than to flow? In turn this depends on the frequency and influence of short-term freeze-thaw cycles, especially in the spring. These matters are discussed below.

4. INTRODUCTORY EVALUATION OF THE TARGET DATA

Influence of Target Attitude Changes

Appendix A provides a detailed discussion of the effect of heaving and tilting of the targets themselves as opposed to their slope movements. The analysis indicates that changes of target attitudes do not significantly affect either the number of targets showing a given movement or the amount of such movement, provided a number of targets are considered. Although the data from any one target are unreliable, random movements tend to cancel each other over a period of years and the total movement of a target from 1956–61 is statistically superior to its movement for any given year. For a given category of movement (gelifluction, retrograde, September, or jump) the values that are nonadjusted for target attitude change are regarded as more reliable than the values adjusted for such change. This is because the latter can not allow for relative timing between the mass-wasting and the target attitude change, nor for compensatory attitude changes where a number of targets are concerned. These factors apply only to the component categories. The total movement of a target, on the other hand, includes the algebraic sum of attitude changes and is appropriately adjusted by subtracting this sum, as is done where total annual movements are considered (tables C I–C II, C IV, C VIII). In the discussions of target movement, the targets that showed no attitude changes for certain periods are termed select targets.

Influence of Short-term Zero-degree Cycles

The possibility was also investigated that short-term freeze-thaw cycles in the spring were responsible for major movement by frost creep. As discussed in detail in appendix B, the available evidence indicates that short-term freeze-thaw cycles in the ground are probably infrequent below a depth of 10 cm at ES 6–8. It is concluded that frost creep due to short-term cycles during the thaw season is of minor importance as compared with frost creep resulting from the annual freeze-thaw cycle, except possibly at ES 8, which tends to be snow free earlier than ES 6–7 and is therefore more subject to short-term, spring freeze-thaw cycles. Even here the voluminous thaw water running over the slope in the spring would minimize the frequency of the cycles.

Influence of Wetting and Drying

Creep due to volume changes associated with wetting and drying can not be a significant factor in the target movements at ES 6–8, except in the sense that the effect of drying is represented by the retrograde movement already considered. Any expansion effect associated with moisture is mainly due to ice and resulting frost heaving, since the moisture represented by thawing of the ice occupies less volume than the ice and, except locally in the top 5 cm, is commonly higher than any subsequent moisture content during the thaw season (app. F). The effect of short-term cycles of wetting and drying can be evaluated by comparing the distribution and frequency of rainfall with the graphs of target movement. The results, to be discussed in connection with the individual sites, clearly show that cycles of wetting and drying are least common when movement is greatest.

Influence of Deformation of Frozen Ground

Finally the possibility should be considered that part of the downslope movement might be caused by deformation of ground in the frozen state. Although the subject is complex (cf. SANGER and KAPLAR, 1963; YONG, 1963a, 1963b) and much remains to be learned as pointed out by YONG (1963a, p. 91–92), this possibility is suggested by experiments conducted by VIALOV (1957, p. 6) and by other considerations relating to deformation of permafrost under long-continued stress (MILLER, 1963, p. 12–13). Such movement for gelifluction lobes and terraces seems doubtful in view of the analysis presented by WAHRHAFTIG and COX (1959, p. 403–406) in their study of rock glaciers. However, the possibility that a permafrost slope as a whole might move by deformation of its ice content is not necessarily disproved by their analysis, since the latter is based in part on the thickness of lobes and terraces, and much greater thicknesses could be represented by the entire body of frozen but otherwise unconsolidated material of a slope. For instance, the expectable rate of movement based on the formula cited by WAHR-

HAFTIG and Cox (1959, p. 405)[1]), for a slope of 14° (the upper value of the gradient at ES 7–8) and an assumed thickness of 10 m for frozen but otherwise unconsolidated material with a high ice content, gives a rate of 12 cm/yr, which is about twice the maximum observed rate at ES 7–8. No information is available as to depth to bedrock along target lines 7–8, but 10 m is not impossible. On the other hand the base of the end rod at ES 7, which was near, but not in, permafrost showed very slight movement (0.2 cm/yr) at a depth of 1.4 m (fig. 17), and movement at greater depth would certainly be even smaller. Taking the depth of zero movement as 2 m (the approximate thickness of the active layer at ES 7–8) and applying the formula to this thickness of frozen material gives a surface rate of less than 0.4 cm/yr, calculated on the basis of the material remaining frozen for 9 months. This movement is considerably less than most of the annual movements to be considered. Moreover, where observed movements were of this order of magnitude, only a small part of the 0.4 cm could be ascribed to deformation of ice in the frozen ground, since it would be unreasonable to exclude components due to frost creep and gelifluction. In the absence of evidence to the contrary, it is concluded that any downslope movement due to deformation of ice in frozen ground is unimportant if present at the experimental sites.

Conclusions

The foregoing discussion indicates that changes of target attitude due to tilting and/or heaving of the targets do not seriously affect the record of their movements as related to mass-wasting, provided a number of targets are considered and obviously unreliable ones are excluded.

At most of the experimental sites, frost creep resulting from short-term freeze-thaw cycles is unimportant compared to frost creep due to the annual cycle.

Creep resulting from wetting and drying, and downslope movement due to deformation of ice in the ground are also relatively unimportant at these sites. Consequently frost creep and gelifluction are the main types of mass-wasting requiring analysis here, and they will be stressed in the following.

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1) $V_s = V_b + \frac{pgH^2 \sin A}{2\,\eta}$ where V_s is the velocity at the surface, V_b is velocity at the base (assumed to be 0 here), p is density (assumed to be 1.8 gm/cm^3 here), g is the acceleration of gravity, H is thickness, A is the slope angle, and η is apparent viscosity. The median of the apparent viscosities listed by WAHRHAFTIG and Cox (1959, table 5, p. 406) is 5.3×10^{14} poises and is the value used in arriving at the rates cited in the present discussion. This use of a viscous-flow model is subject to criticism, as recognized by WAHRHAFTIG and Cox (1959, p. 405–406), and models involving a power law may be more realistic. In any event the pertinent data for frozen ground are very meager, and only a first approximation is suggested.

5. EXPERIMENTAL SITE 6

Description

General

Experimental site 6 was in a north-south dell immediately north of the stream between trap knobs MS[1]) 78 m and MS 120 m at the southeast end of the Nyhavn hills (pl. 1).

Much of the slope material in the dell is a diamicton (pls. D1–D2, table D I). Although scarce at the surface, shells are more common at depths below 80 cm. The gradient is 2.5° to 3° and averages 2.5°. A very small poorly defined stream a few centimeters deep and up to 3–4 m wide during the spring thaw, tributary to the stream noted above, runs through the east part of the site. The slope is fairly well vegetated, mainly by grasses, sedges, and turf hummocks. From southeast to northwest along the pertinent part of target line 6 (figs. 6–7), described below, the slope conditions are as follows with respect to the target positions: In the vicinity of T 5–8 the slope is subject to washing by the small stream and is generally barren and gravelly, with scattered plants in places; beyond to about T 34 the surface is much less stony, is vegetated, and has a number of turf hummocks; thence to T 43 at the northwest end of the line the slope is largely bare of vascular plants but has large areas covered with a thin black organic crust in which are some moss mats. Downslope from the target line in this sector, irregular lines of boulders frame lobate areas of fine debris. In most years the northwest part of the target line is buried under a snowdrift until late in the thaw season. This drift accumulates below a small trap knob immediately beyond target line 6 and persists in some years, as in 1957 when T 38–43 remained buried throughout the thaw season. The slope immediately adjacent to the drift is characteristically very wet, but because the drift lies across the line, rather than above it, the zone of maximum saturation tends to shift westward so that the slope receives roughly comparable amounts of meltwater except in the immediate vicinity of the stream. Seepage from upslope tended to affect the entire target line, and the slope as a whole was generally wet. A few moisture determinations are given in table F I.

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[1]) For abbreviations, see p. 8.

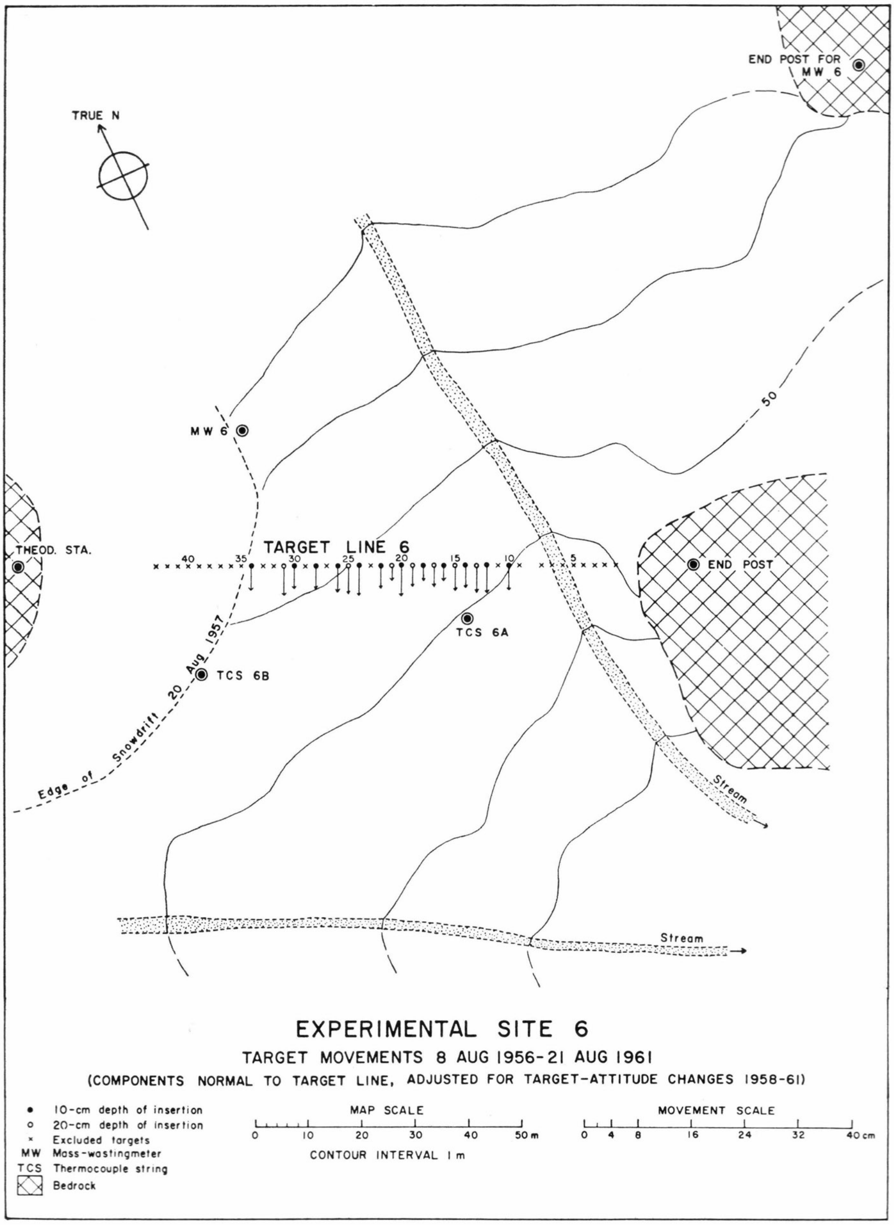

Fig. 6.

Instrumentation

Target line 6. Target line 6 (figs. 6–8) originally comprised 43 cones aligned along an azimuth of 115° (Brunton reading) toward a bedrock reference point, marked by a wood plug in a chisel hole, at an altitude of 53 m at the top and near the west edge of a low trap knob immediately southeast of T 1. The theodolite station at the opposite end of the line

Fig. 7. Experimental site 6. View southeast along target line from theodolite station. Target 43 is circled. (14 Aug. 1956.)

was on bedrock at an altitude of 59 m just southwest of the top of another low trap knob. As at the other major target lines, the targets were spaced every 2 m and the odd-numbered targets were inserted to a depth of 20 cm and the even-numbered ones to 10 cm. The line was established on 8 August 1956.

Along the target line the material was a sandy-silty clay to sandy-clayey-silty gravel, with fines ranging from 20 to 79 percent at a depth of 15–20 cm. At the targets indicated the percentage of fines (in parentheses) for channel specimens representing this depth interval were: T 10 (59), T 15 (79), T 20 (74), T 25 (20), T 30 (45) (pls. D 1 – D 2, table D I). At TCS 6 A the fines ranged from 41 percent (depth 10 cm) to 85 percent (depth ca. 85–90 cm). Determinations of the liquid limit along the target line ranged from 26 percent moisture (T 10) to 70 percent moisture (T 30), with the plastic limit ranging from 20 percent moisture (T 10) to 65 percent moisture (T 30).

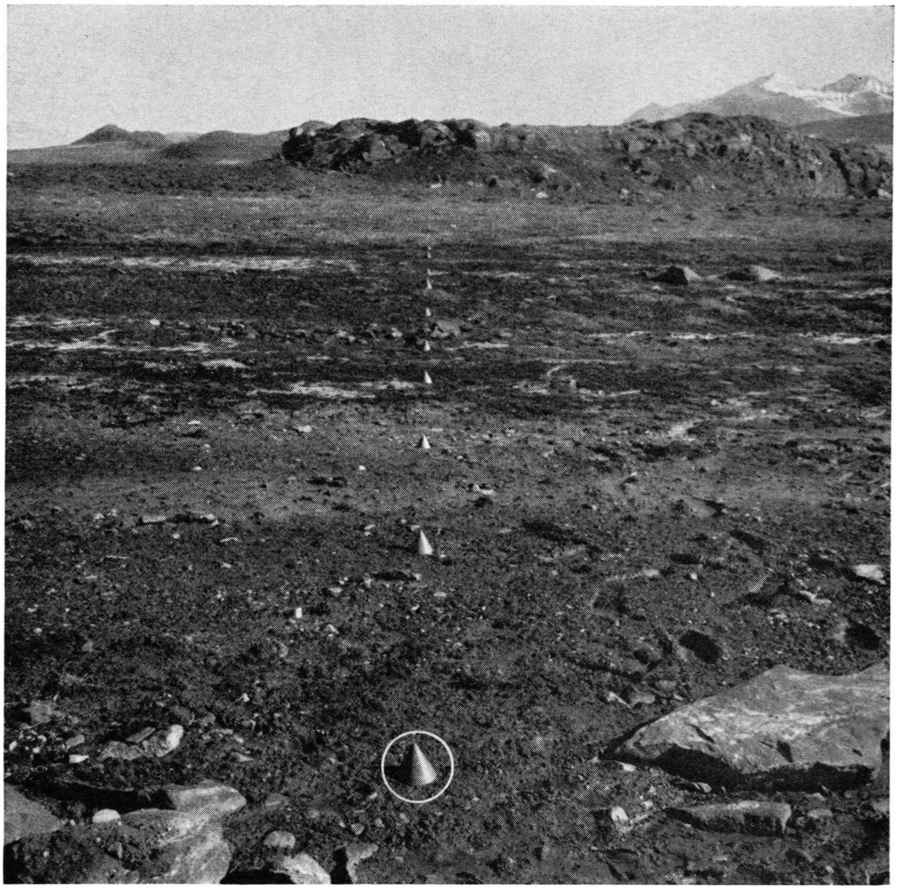

Fig. 8. Experimental site 6. View southeast along target line from below theodolite station. Target 43 is circled. (14 Aug. 1956.)

Mass-wastingmeter 6. MW 6 was located about 25 m above the target line near the northwest end above T 35. It was in the transition zone between the vegetated portion of the slope to the east and the dominantly bare portion to the west, and like the extreme northwest part of the target line it was buried by the snowdrift until late in the thaw season. The pipe of the mass-wastingmeter was inserted to a depth of 104 cm. Since the frost table was at a depth of 136 cm at the time (4 September 1956), the base of the pipe was well above permafrost. The pipe was initially aligned (±0.3 cm) between a bedrock reference point and the theodolite station for the target line, so that displacement of the pipe could be measured in the same way as target movements. The alignment was approximately parallel to the contour. The installation was completed on 8 September 1956 and excavated on 6 August 1959.

Thermocouple strings 6A–6B. Two thermocouple strings were installed downslope from the target line. TCS 6 A was 10 m below T 16 in the vegetated area characterized by turf hummocks, in an interhummock depression between hummocks about 10 cm high. The diamicton here is sandy near the surface and becomes gradually finer grained with depth, being distinctly clayey below 90 cm (pl. D 1, table D I). The lowest thermocouple was at a depth of 104 cm. Ice crystals were first noted at 94 cm and were abundant at 104 cm when the string was installed on 9 August 1956. It was excavated on 6 August 1961. During the interim, the position of individual thermocouples had shallowed by 2–7 cm, presumably as the result of frost heaving.

TCS 6 B was 20 m below T 39 in the dominantly bare sector of the slope associated with the lingering snowdrift. It was located in the central part of a lobate area bordered by boulders and cobbles. The diamicton of the central part is somewhat pebbly at the surface but becomes finer grained with depth as at TCS 6 A. The lowest thermocouple was at 139 cm, and the first ice crystals were at 155 cm. Since TCS 6 B was installed on the same day as TCS 6 A, the frost table at TCS 6 B was appreciably lower than at TCS 6 A, in spite of the slope having been snow free for a shorter period. The probable reasons for this are discussed below. When excavation of the string was attempted in 1961, water was encountered at a depth of 10 cm and the effort was abandoned.

Instrumental Data

Thermocouple Strings 6A-6B

Thermocouple and visual observations show that in the Mesters Vig district the ground remains frozen beneath lingering snowdrifts to within several centimeters of their edges and commonly right to the edge. That this is also characteristic of other parts of Northeast Greenland is indicated by Poser's (1932, p. 21–26) work. At ES 6 the beginning of thawing in the western sector characterized by the snowdrift coincides with the westward retreat of the drift margin. This situation is reflected in the generally later thawing, by about a month or more, of the surface at TCS 6 B than at 6 A (table E I). The lag was present in 1956 when ES 6 was established and was observed in subsequent years, except in 1959 when there was very little snow and the ground at both thermocouple strings was snow free and had begun to thaw by 9 July when the first observations were made.

Once thawing had started at the thermocouple strings, however, it progressed more rapidly at TCS 6 B than 6 A so that, given time enough, thawing progressed to a greater depth at TCS 6 B. This was the case in 1956 when the strings were inserted, and it was demonstrable also in 1959 (table E I). The difference must be due to different diffusivities of the ground at the two thermocouple strings, the controlling difference being the lack of insulating vegetation at TCS 6 B (cf. TYRTIKOV, 1963).

Mass-wastingmeter 6

Measured at ground level, the pipe of MW 6 moved 3.3 cm downslope between 8 September 1956 and 6 August 1959 (table C I).

Target Line 6

General. In analyzing target movements at ES 6, it became necessary to exclude the following targets for the reasons indicated: T 1–3 (on contour trend at strong angle to rest of target line), T 4–9 (subject to disturbance by shallow flooding of small stream in this sector), T 11, 23, 27, 29, 32–33, 35–36 (heaving out of ground, extreme tilting, or possible disturbance by channeling). T 37–43 remained drift covered throughout the summers of 1957 and 1960, which eliminated them from certain comparative studies. With the exceptions noted, total target movements for 1956–61 are illustrated in fig. 6. The several categories of movement are listed in detail in table C I and summarized in table V. The record of the select targets is illustrated by graphs (pl. C 1).

The data pertaining to the categories of movement (jump, gelifluction, retrograde movement, and September movement) are summarized in the following. Because of varying lengths of observation during the program period, these data, although revealing, are less meaningful than total annual movement and rates, which are considered next. Finally, movement records are examined for weather influences. Unless otherwise indicated, totals are for the 5 years of observation (1956–61), the range gives the minimum and maximum movements along the target line, and the mean is the movement as averaged for all the targets.

Jump. The total jump ranged from 3.2 to 8.8 cm and the mean was 6.0 cm.

Gelifluction. The total recorded gelifluction ranged from 0.4 to 2.9 cm and the mean was 1.4 cm.[1])

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[1]) These figures are based on the maximum recorded gelifluction. If the minimum recorded gelifluction in 1957 is used, the range and mean are very similar. The distinction is based on the unusually long gap between the last reading in August and the first in September of that year, and on the question as to whether or not the downslope movement during this period should be counted as gelifluction or September movement. However, since mean air temperatures remained above 0°C and the character of the movement graphs suggests that frost heaving was not a factor until later, the maximum rather than minimum figures for 1957 are used in the total.

This low mean is consistent with the low gradient. The extreme northwest sector of the line, represented by the graphs of T 38, 43 (pl. C 1) but not tabulated because of incompleteness of record, showed particularly low gelifluction totals, probably largely as a result of remaining completely buried in 1957 and 1960. The length of target peg as between the 10-cm and 20-cm lengths did not appear to have any significant effect on the amount of recorded gelifluction. However, peg length did have a notable effect on target heave (as opposed to ground heave) in that attitude checks invariably showed that the mean heave of the 20-cm targets was greater than that of the 10-cm targets and that a higher proportion of the 20-cm targets exhibited heaving (table A I). The longer peg length was also more commonly associated with target tilt.

Retrograde movement. The range of the total recorded retrograde movement was from 0.5 to 6.2 cm. The mean was 3.6 cm. Study of target records and field notes indicated that retrograde movements at ES 6 could occur even where there was water at the surface within 1–2 m of a target (for instance, T 15 and 18 in 1957 and 1958, and T 19 in 1960; cf. graphs, pl. C 1), and that ES 6 as a whole remained saturated longer than most parts of ES 7–8. The southeast half of ES 6, although tending to become somewhat drier than the northwest half, remained characteristically a wet meadow.

September movement. The total September movement ranged from 0 to 1.6 cm, the mean being 0.5 cm.

Annual movement. The summation of the annual movement from late August 1956 to late August 1961 ranged from 3.0 to 7.1 cm, and the mean was 4.9 cm. The mean annual rate was 1.0 cm/yr, the range being from 0.6 to 1.4 cm/yr. There was no significant difference in rate as between 10-cm and 20-cm targets.

The foregoing movement data can be conveniently summarized by means of equations. Thus, the equation for the mean total movement is

$$T_m = J_m + G_m - R_m + S_m + E_m \tag{5.1}$$

where T_m, J_m, G_m, R_m, S_m, and E_m stand for the means of the jump, gelifluction, retrograde movement, September movement, and error, respectively. As applied to ES 6, the figures in centimeters are

$$4.9\,T_m = 6.0\,J_m + 1.4\,G_m - 3.6\,R_m + 0.5\,S_m + 0.6\,E_m \tag{5.2}$$

The error of 0.6 cm is due to the different method of calculating the components and the total. The total is taken directly from the observation totals, adjusted for target-attitude changes in 1959–60 and 1960–61; component movements are nonadjusted for attitude changes, and to be classed as components the movements must exceed 0.2 cm, since the summation disregards all lesser amounts. Because the attitude adjustments would have the effect of unbalancing the equation, the fact that the error is relatively small supports the view that attitude changes do not significantly influence the means.

The largest mean movement was the jump, which exceeded the total mean movement. As explained previously, the jump incorporates the movement due to the annual freeze-thaw cycle and thus includes the maximum resulting frost creep; however, it may also include a variable unmeasured amount of gelifluction, depending on whether the first target observation was made while the target was anchored in frozen ground or after it had become subject to gelifluction. Therefore, the fact that the jump was the largest mean movement does not necessarily indicate that frost creep was greater than gelifluction. This question and the relation of retrograde movement to it are discussed in detail in connection with ES 7–8 where more data are available.

Weather influences. Target records were compared for variations that might be related to weather differences from one year to another or to events within any one year. In 1957, between 14 and 21 September, 63 percent of the targets (12 of 19) in table C I showed an increased movement, which in the case of at least some of the targets, was due to ground heaving associated with the temperature drop of 17–18 September when the maximum temperature remained below 0° for the first time that autumn. Six targets (T 10, 12, 14–15, 18, 28) had movements exceeding 0.2 cm normal to the target line, and 6 others (T 13, 20, 22, 24–25, 31) suggested a correlation with ground heaving by lesser amounts. In 1960, 63 percent of the targets showed movements either indicative (T 18, 20, 22, 24–25) or suggestive (T 12–15, 28, 30–31) of ground heaving during the second half of September. Air-temperature records are deficient for this period but ground temperatures (table E I) showed that freeze-up was well underway by 27 September. Observations had to be terminated too soon in other years to afford similar comparisons.

6. EXPERIMENTAL SITE 7

Description

General

Experimental site 7 was on the southeast side of trap knob MS 112 m near the southeast end of the Nyhavn hills (pl. 1, fig. 9). Small boulders are scattered on the slope, which is generally more stony than ES 6. Most of the slope material is a diamicton (pls. D 3–D 4, table D II). The top several centimeters tend to be coarser than the underlying material, and in places the fines increase progressively with depth, the highest percentage of fines being in lenses. Although shells occur on the slope they are very rare or absent in the immediate neighborhood of the site.

The gradient ranges from 10° to 14°. Vegetation is discontinuous and consists of grasses, sedges, *Dryas octopetala*, *Salix arctica*, and a number of other species. The east third of ES 7 is almost bare of vegetation except for a few scattered plants, and mats of *Dryas* on the fronts of some small turf-banked terraces; the west third is fairly well covered with vegetation, comprising locally a wet-meadow assemblage and areas of turf hummocks; the central third is characterized by an intermediate and transitional plant cover. Details of vegetation distribution are illustrated by figure 10, prepared by Professor HUGH M. RAUP, the writer's colleague in the Mesters Vig program, who is preparing a detailed discussion of the vegetation at ES 7–8 for a separate number of the *Meddelelser*. An extensive snowdrift with long axis up and down the slope accumulated on most of the west third and on the west part of the central third of ES 7 each year, and retreated mainly upslope while narrowing laterally. Drainage from this snowdrift kept the west third of ES 7 much wetter than the remainder throughout the summer, except at the west end where the line impinged on a gravelly slope below the theodolite station. Moisture determinations are given in table F II.

Instrumentation

Target line 7. Target line 7 (figs. 11–13) was laid out on an azimuth of 103° (Brunton reading) approximately parallel to the contour. The reference point was a prominent cairn on bedrock at the summit of

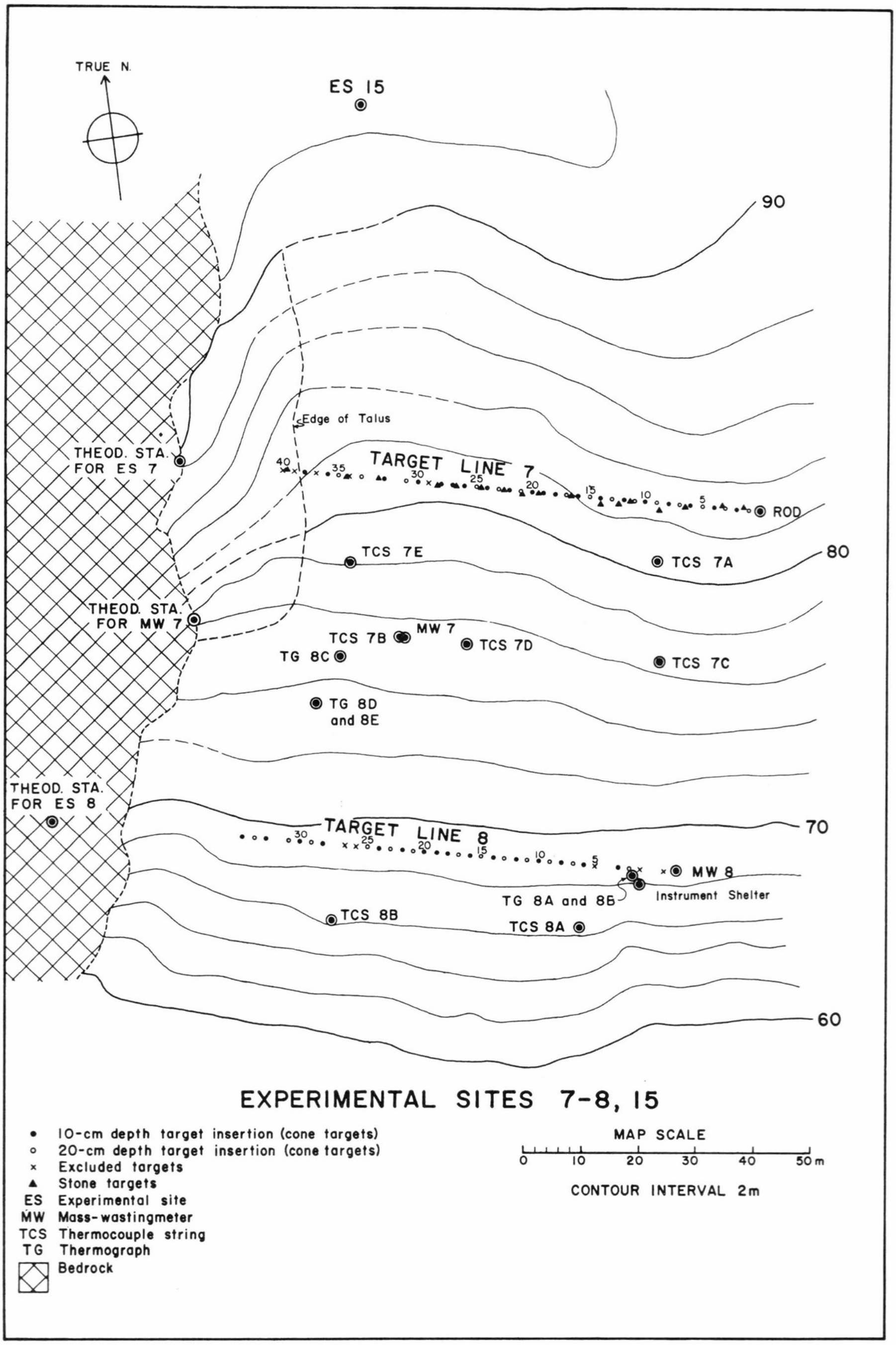

TRUE N.
ES 15
90
Edge of Talus
THEOD. STA. FOR ES 7
TARGET LINE 7
40
35
30
25
20
15
10
5
ROD
80
TCS 7E
TCS 7A
THEOD. STA. FOR MW 7
TCS 7B
MW 7
TCS 7D
TG 8C
TCS 7C
TG 8D and 8E
THEOD. STA. FOR ES 8
TARGET LINE 8
70
30
25
20
15
10
5
MW 8
Instrument Shelter
TG 8A and 8B
TCS 8B
TCS 8A
60
EXPERIMENTAL SITES 7-8, 15
• 10-cm depth target insertion (cone targets)
○ 20-cm depth target insertion (cone targets)
× Excluded targets
▲ Stone targets
ES Experimental site
MW Mass-wastingmeter
TCS Thermocouple string
TG Thermograph
Bedrock
MAP SCALE
0
10
20
30
40
50 m
CONTOUR INTERVAL 2m

Fig. 9.

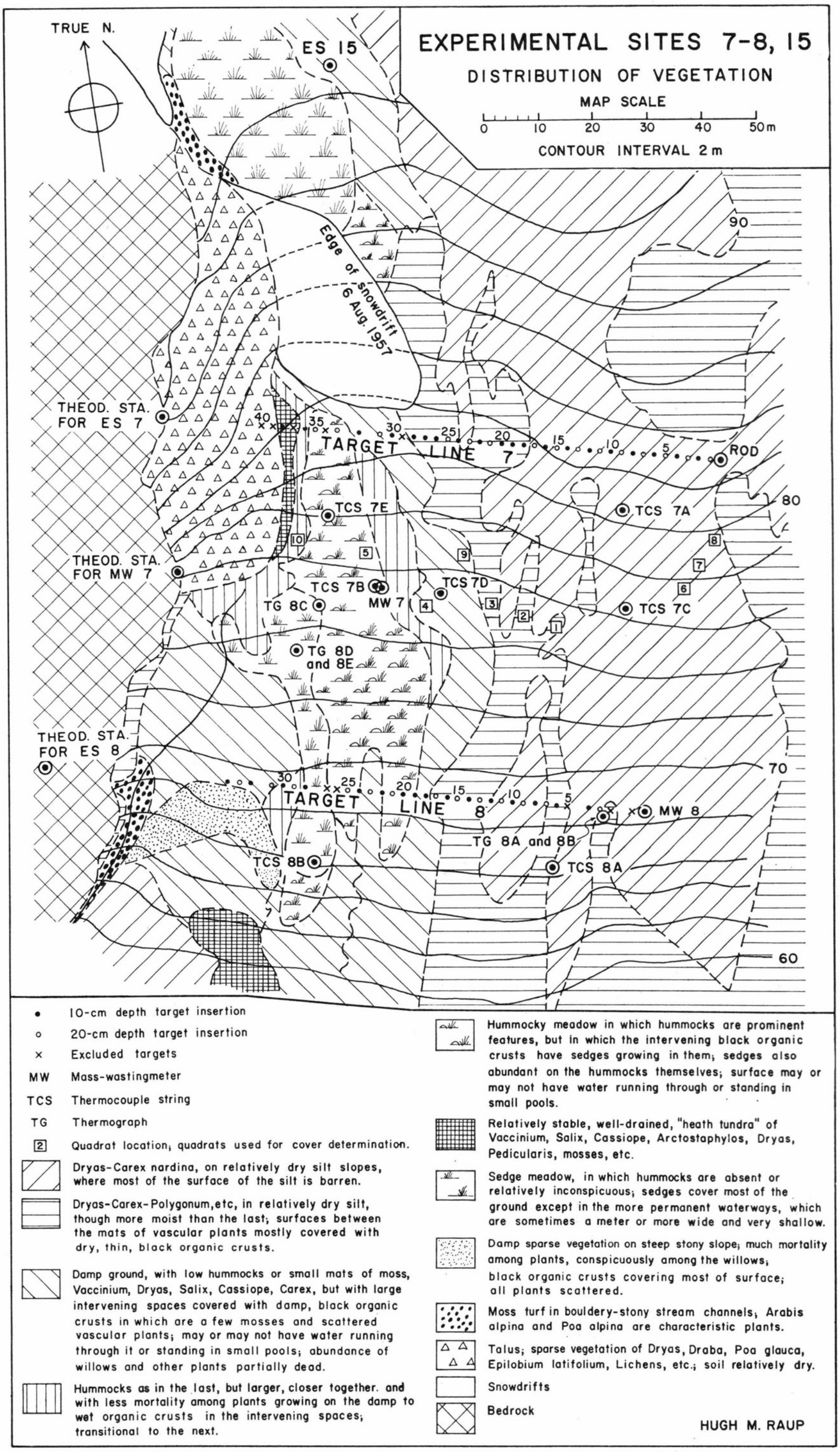

EXPERIMENTAL SITES 7-8, 15
DISTRIBUTION OF VEGETATION
MAP SCALE
0 10 20 30 40 50 m
CONTOUR INTERVAL 2 m
TRUE N.
ES 15
Edge of snowdrift 6 Aug. 1957
90
80
70
60
THEOD. STA. FOR ES 7
THEOD. STA. FOR MW 7
THEOD. STA. FOR ES 8
TARGET LINE 7
TARGET LINE 8
40
35
30
25
20
15
10
5
ROD
TCS 7E
TCS 7A
TCS 7B
TCS 7D
TCS 7C
MW 7
TG 8C
TG 8D and 8E
TG 8A and 8B
MW 8
TCS 8B
TCS 8A
1
2
3
4
5
6
7
8
9
10
• 10-cm depth target insertion
○ 20-cm depth target insertion
× Excluded targets
MW Mass-wastingmeter
TCS Thermocouple string
TG Thermograph
2 Quadrat location; quadrats used for cover determination.
Dryas-Carex nardina, on relatively dry silt slopes, where most of the surface of the silt is barren.
Dryas-Carex-Polygonum, etc, in relatively dry silt, though more moist than the last; surfaces between the mats of vascular plants mostly covered with dry, thin, black organic crusts.
Damp ground, with low hummocks or small mats of moss, Vaccinium, Dryas, Salix, Cassiope, Carex, but with large intervening spaces covered with damp, black organic crusts in which are a few mosses and scattered vascular plants; may or may not have water running through it or standing in small pools; abundance of willows and other plants partially dead.
Hummocks as in the last, but larger, closer together. and with less mortality among plants growing on the damp to wet organic crusts in the intervening spaces; transitional to the next.
Hummocky meadow in which hummocks are prominent features, but in which the intervening black organic crusts have sedges growing in them; sedges also abundant on the hummocks themselves; surface may or may not have water running through or standing in small pools.
Relatively stable, well-drained, "heath tundra" of Vaccinium, Salix, Cassiope, Arctostaphylos, Dryas, Pedicularis, mosses, etc.
Sedge meadow, in which hummocks are absent or relatively inconspicuous; sedges cover most of the ground except in the more permanent waterways, which are sometimes a meter or more wide and very shallow.
Damp sparse vegetation on steep stony slope; much mortality among plants, conspicuously among the willows; black organic crusts covering most of surface; all plants scattered.
Moss turf in bouldery-stony stream channels; Arabis alpina and Poa alpina are characteristic plants.
Talus; sparse vegetation of Dryas, Draba, Poa glauca, Epilobium latifolium, Lichens, etc.; soil relatively dry.
Snowdrifts
Bedrock
HUGH M. RAUP

Fig. 10.

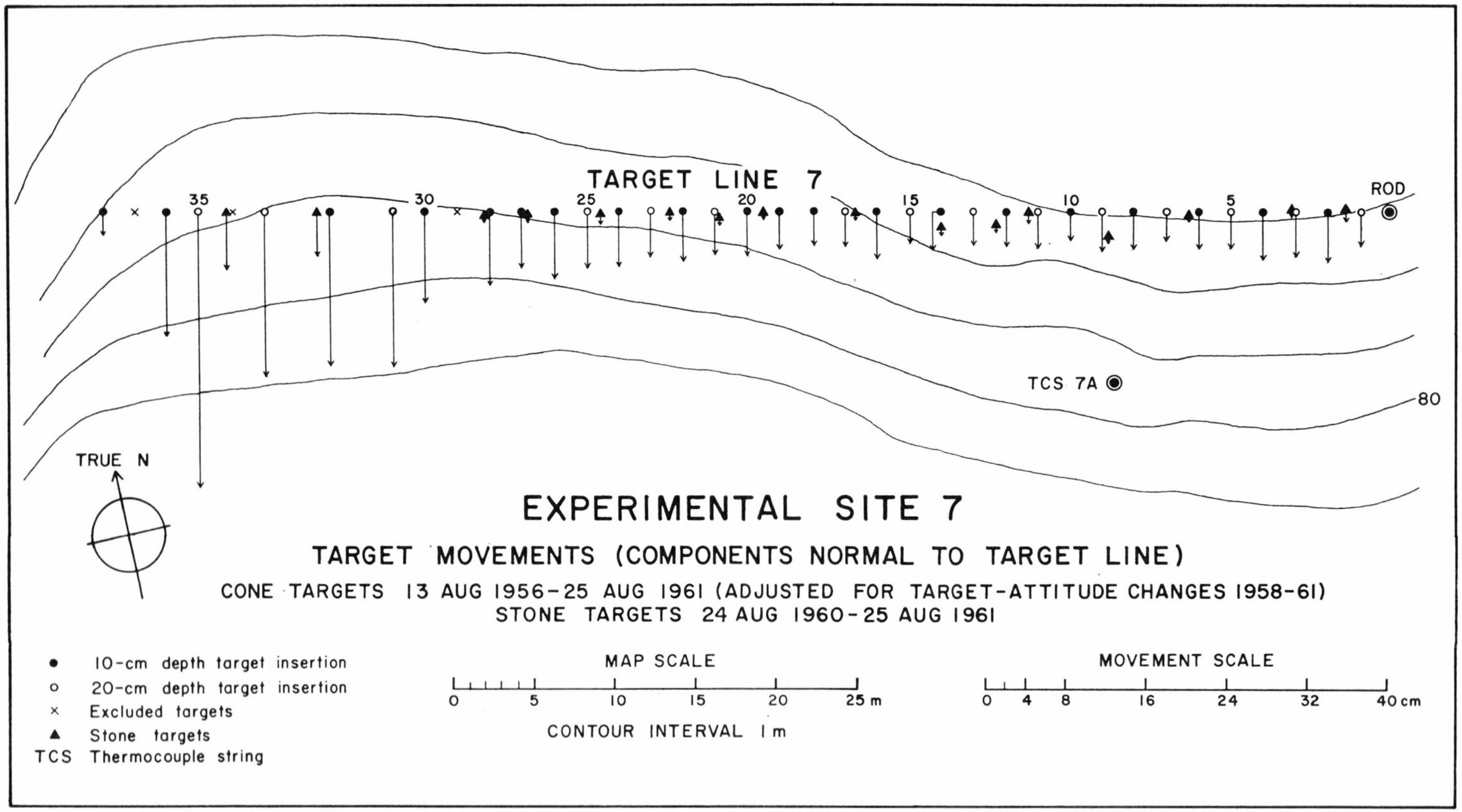

TARGET LINE 7
ROD
35
30
25
20
15
10
5
TCS 7A
80
TRUE N
EXPERIMENTAL SITE 7
TARGET MOVEMENTS (COMPONENTS NORMAL TO TARGET LINE)
CONE TARGETS 13 AUG 1956–25 AUG 1961 (ADJUSTED FOR TARGET-ATTITUDE CHANGES 1958-61)
STONE TARGETS 24 AUG 1960-25 AUG 1961
● 10-cm depth target insertion
○ 20-cm depth target insertion
× Excluded targets
▲ Stone targets
TCS Thermocouple string
MAP SCALE
0 5 10 15 20 25 m
CONTOUR INTERVAL 1 m
MOVEMENT SCALE
0 4 8 16 24 32 40 cm

Fig. 11.

Fig. 12. Experimental site 7. View along azimuth 103° from theodolite station toward bedrock reference point at summit of Fuglevarden. (Cf. fig. 14.) West end of target line 7 is at base of slope in foreground; target 40 is circled. (14 Aug. 1956.)

Fuglevarden (103 m) on the east side of the entrance to Noret (fig. 14). The theodolite station was on a bedrock shelf at an altitude of about 90 m near the base of trap knob MS 112 m and was marked by a chisel hole. The line originally consisted of 40 cone targets and 17 stone targets. The cones were spaced every 2 m (except for 4-m intervals between T 31–32, and T 32–33 due to the presence of stones at the usual 2-m interval). Pegs were of alternate length, odd-numbered targets being equipped with the 20-cm pegs (except for T 19 and 27, which had the 10-cm length because stones prevented deeper emplacement). A steel rod 3.3 m long was inserted at the east end of the line. Auguring indicated that the frost table at the time (11 August 1956) lay below 158 cm, but a stone prevented the rod's being inserted deeper than 137 cm. Except for the stone targets, establishment of the target line was completed on 13 August 1956. The stone targets were selected in July 1960 on the dates indicated by the first reading for each target (pl. C 2).

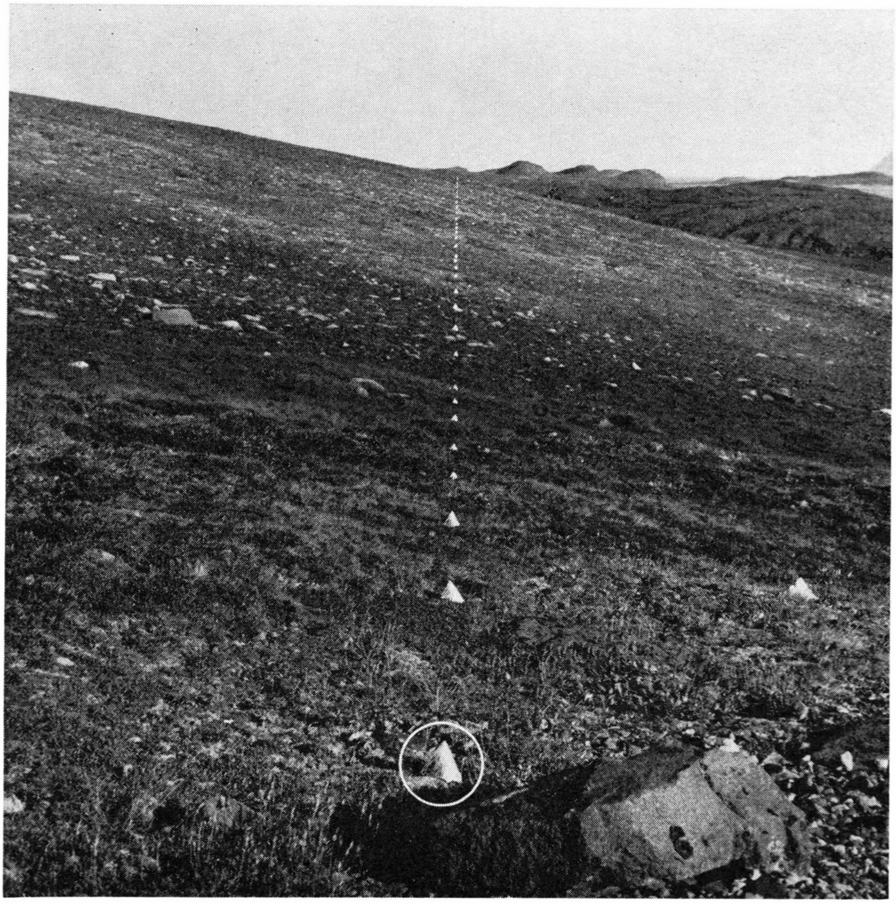


Fig. 13. Experimental site 7. View along azimuth 103° from below theodolite station. Target 40 is circled. (14 Aug. 1956.)

Along the target line, excluding isolated stones that would weight percentages unduly, the diamicton was a gravelly-clayey-sandy silt to a clayey-sandy-silty gravel, with fines ranging from 30 to 63 percent. At the targets indicated the percentages of fines (in parentheses) for depths of 10 and 20 cm, respectively, were: T 5 (53, 54), T 10 (43, 63), T 15 (42, 57), T 20 (54, 52), T 25 (45, 46), T 30 (46, 43), T 35 (36, 30) (pls. D 3–D4, table D II). Elsewhere in the vicinity of the target line the fines ranged from 16 percent (depth 1 cm, 10 m downslope from T 6–7) to 90 percent (depth 20 cm, 5 m downslope from T 34–35). Determinations of the liquid limit along the target line ranged from 14 percent moisture (T 5) to 27 percent moisture (T 25), with the plastic limit ranging from 12 percent moisture (T 5) to 21 percent moisture (T 25).

Based mainly on differences in the character and density of vegetation (fig. 10), which were largely paralleled by moisture differences,

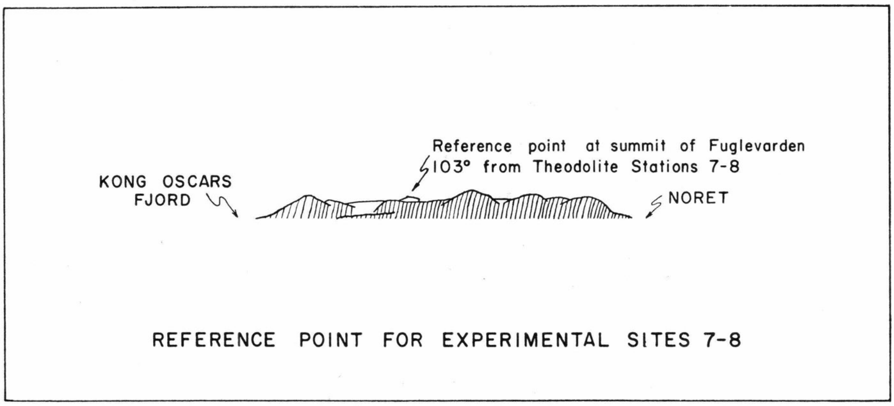


Fig. 14.

target line 7 was divided into "dry" and "wet" sectors. The "dry" sectors included the rod and T 1–28 along the east part of the line and T 38 at the west end; the "wet" sector included the intervening area. The boundaries were transitional, and for short periods, especially in the spring, the "dry" sectors could be fully as saturated as the "wet". The gradients in the "dry" and the "wet" sectors were not very different; in the "dry" the range was from 11.5° to 14° and the average 12.5°, in the "wet" the range was 10° to 12° and the average 10.5°. These gradients are based on the contours and were calculated for the position of each accepted target, and the averages were computed from these approximations. For one or another of the reasons cited in connection with ES 6, T 29, 34, 37, and 39–40 were excluded from consideration in these and other calculations.

Mass-wastingmeter 7. MW 7 was set 28 m downslope from T 31 in the generally wet west third of ES 7 (figs. 9, 15). The pipe of the instrument was aligned between the reference point for target line 7 and a theodolite station on bedrock at the base of trap knob MS 112 m, so that any displacement of the instrument could be detected. The instrument was located in mossy ground between turf hummocks. The diamicton, quite cobbly, was wet (table F II) at the time and very subject to flow. The installation was made on 2 September 1957 and excavated on 5 August 1959.

Thermocouple strings 7 A–7 E. Five thermocouple strings were installed downslope from target line 7 (fig. 9). Thermocouple string 7 A was 10 m downslope from T 8 in the least vegetated, east third of the slope, the nearest vegetation being patches of *Dryas* 30 cm and 65 cm distant. The vicinity was characterized by a diamicton similar to that

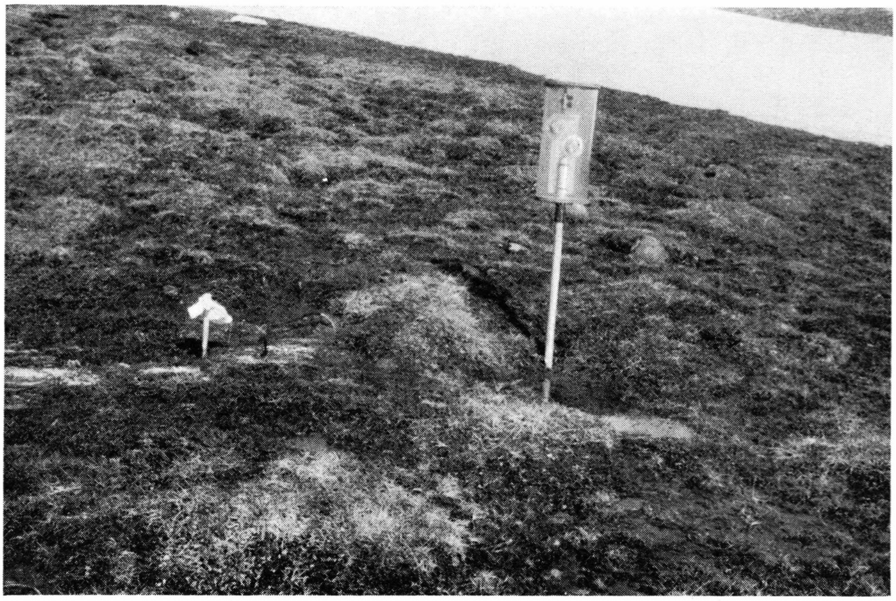


Fig. 15. Experimental site 7. Mass-wastingmeter 7. Thermocouple string 7 B at left. View upslope. Ground saturated from thawing snowdrift in background. (21 June 1958.)

along the target line. The deepest thermocouple at a depth of 139 cm was well above the frost table when installed on 15 August 1956. The string was excavated on 2 August 1961, and the position of the thermocouples was found to have changed very little if any, the maximum change being within the limits of measurement error.

Thermocouple string 7 B was 28 m downslope from T 31 and was associated with, and 1 m west of, MW 7 in the wet-meadow in the west part of the slope. The vegetation here was characterized by turf hummocks, and the string was placed between two of them. The diamicton contained many cobbles. The lowest functioning thermocouple was at a depth of 140 cm, well above the frost table on 2 September 1957 when the installation was made. When the string was excavated on 6 August 1961, it was found that all the thermocouples had become shallower by 14.5–17.5 cm. The considerable heaving in contrast to the little or no heaving of TCS 7 A can be correlated with the characteristically much greater moisture content of the ground in the west part of the slope than in the east part.

The three remaining thermocouple strings at ES 7 (installed in connection with pore-water pressure gages that turned out to be unreliable and are omitted from discussion) were also below target line 7. Thermocouple string 7 C was 28 m downslope from T 5 in the bare and commonly dry part. Thermocouple string 7 D was 28 m downslope from T 23 and, although situated in the "dry" sector, was where moisture and vegetation conditions were becoming transitional to the "wet" sector. Thermocouple string 7 E was 16 m downslope from T 35 in the "wet" sector characterized by turf hummocks. The lowest thermocouple in all 3 strings was at a depth of 130 cm, and the shallower thermocouples were within 1 cm of matching depths in each string. The strings were inserted in 1960 while the ground was still frozen. Although not excavated, it is assumed that they were not significantly affected by heaving during the observation series, which was confined to 1960.

Instrumental Data

Thermocouple Strings 7 A-7 E

All the thermocouple strings (tables E II.1–E II.2) clearly showed the generally later onset of thawing in the west part of ES 7 than in the east, due to the lingering snowdrift over the west part. It is also clear from a comparison of TCS 7 A and TCS 7 C–7 E that in spite of the later beginning of thawing, the temperatures in the west sector tended to catch up and in some instances become higher than those at comparable depths in the east part. For instance, the latter effect is illustrated at most levels by the temperatures on 22 August 1960. Although the seasonal progress of temperatures at TCS 7 B also showed the influence of the lingering snowdrift, a comparison of temperatures with the other strings is inhibited by the paucity of functional thermocouples during 1959–60 and by the heaving of TCS 7 B and the consequent change of thermocouple levels.

Some of the thermocouple readings indicate warm cells and cold cells at depth. Thus during the period 4–15 July 1960, TCS 7 E showed a consistently lower temperature at a depth of about 1 m than at shallower depths and depths 20–30 cm greater; the fact that the subsequent readings fall in a consistent series with respect to depth argues against an instrumental error being involved. Some upfreezing of the frost table at TCS 7E seems to be indicated by the 15 July observations. On 3 October 1960 there was a warm cell centered at a depth of about 85 cm at TCS 7 A and at about 70 cm at TCS 7 C–7 D. On the whole, however, warm cells and cold cells did not appear to be common except at very shallow depths. Significant upfreezing of the frost table is not proved by the temperatures on 3 October, since the warm cells could have resulted from a sequence of freezing, thawing, and freezing again. Maximum air-temperature data are lacking for the latter part of September but the warm spell with rain in early September, shown by the background of the target-movement graphs, might have been the middle member of the sequence.

Mass-wastingmeter 7

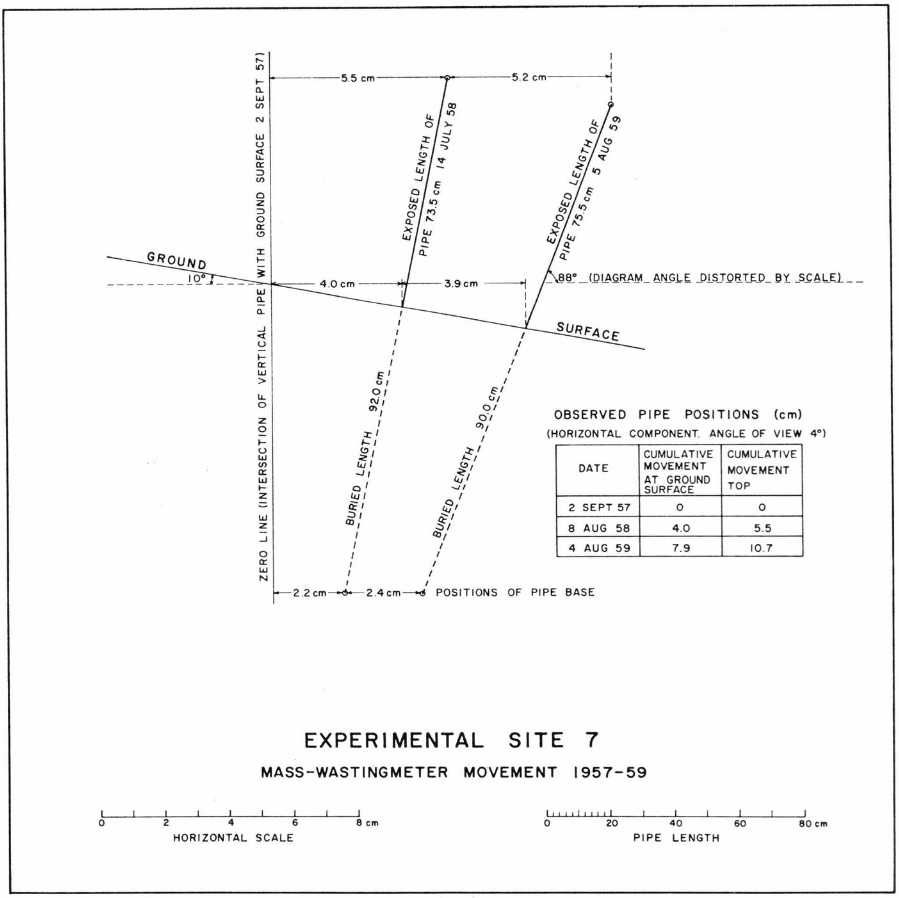
The total downslope movement of the pipe of MW 7, measured at the ground surface, was 8.1 cm from 2 September 1957 to 4 August 1959 (table C II), but at a depth of about 90 cm, at the base of the pipe, the movement was only 4.6 cm (fig. 16). Excavation of the mass-wastingmeter showed that it had not been bent, so that the basal movement could be computed from the geometry of the situation. Since any movement at greater depth should have carried the overlying material with it, the 4.6-cm movement suggests the order of magnitude of actual movement at this depth. No precision can be attached to the amount, because of the possibility that movement of the overlying material may have forced the base downslope, or slightly upslope if the axis of tilting lay above the base.

Target Line 7

General. Total target movements (fig. 11) are given in detail in tables C II–C III and are summarized in table V. The behavior of the select targets, the majority at this site, is illustrated by graphs (pl. C 2). The stone-target movements in figure 11 and table C III are for 24 August 1960–25 August 1961 and agree closely with the movement of nearby cone targets for the same period. Most stone targets in plate C 2 cover a slightly longer but less easily compared interval. Although serving as a check on the behavior of the cone targets, the stone targets do not lend themselves to comparison with the 5-year record of the cone targets, and they are therefore omitted from the following discussion.

The large difference in extent of the "dry" sectors with 29 accepted cone targets, and of the "wet" sector with only 6 accepted targets, has the result that a change of a few meters in sector lengths would materially change mean movement figures for the line as a whole, since the movement figures for each sector are strikingly different. Therefore in the following, although figures are cited for the line as a whole, the figures for the separate sectors are in some respects the most significant.

The order of discussion is similar to that for ES 6. First the data relating to categories of movement are summarized, following which annual movements are summed and rates are discussed. These data then permit an analysis of the relative importance of creep and gelifluction, which indicates that in general frost creep is quantitatively the more important of these processes at ES 7. Next is a discussion of potential frost creep and the proportion that true frost creep holds to



OBSERVED PIPE POSITIONS (cm)
(HORIZONTAL COMPONENT. ANGLE OF VIEW 4°)

DATE	CUMULATIVE MOVEMENT AT GROUND SURFACE	CUMULATIVE MOVEMENT TOP
2 SEPT 57	0	0
8 AUG 58	4.0	5.5
4 AUG 59	7.9	10.7

Fig. 16.

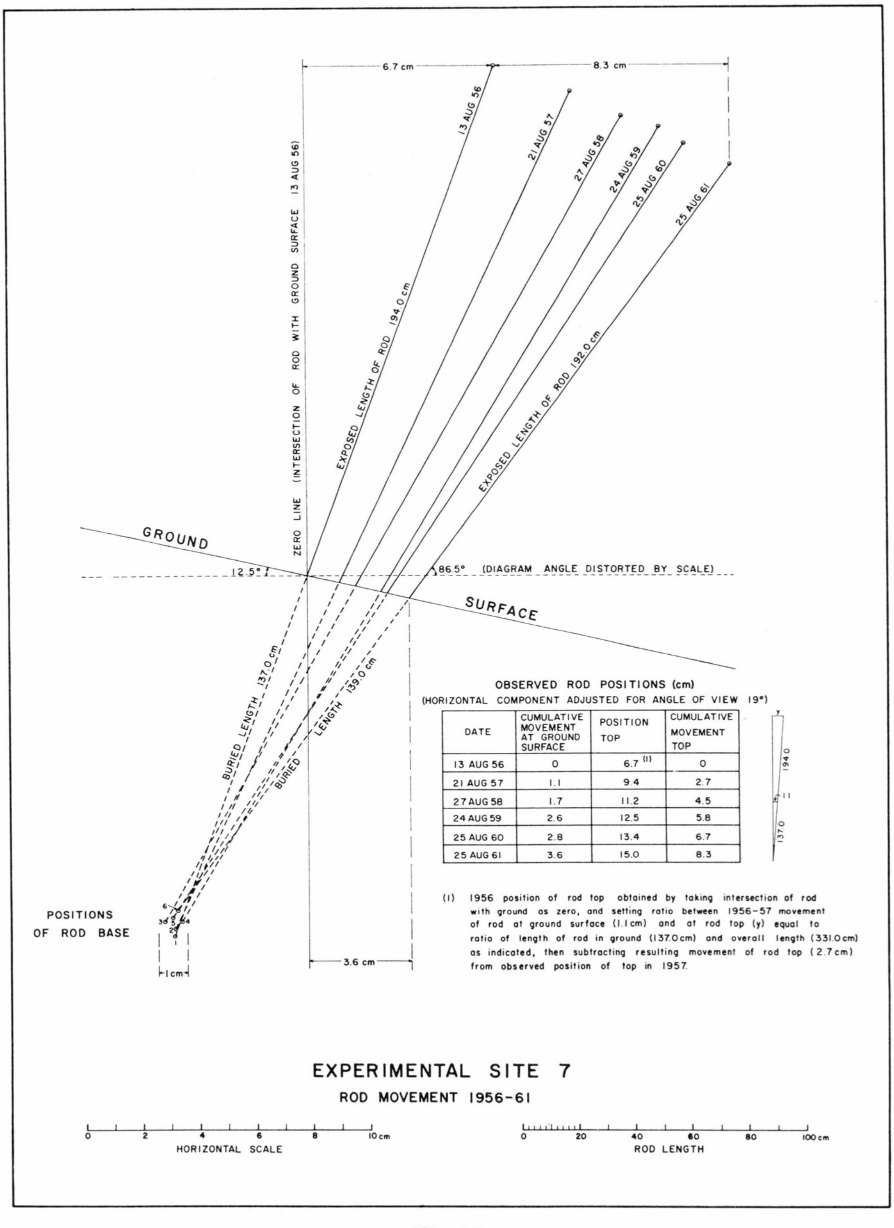
the potential as a result of retrograde movement, and the conclusion is reached that the true frost creep is on the order of 70 percent of the potential creep in the "dry" sectors of target line 7.

Jump. The range of the total jump was from 2.6 to 16.2 cm and the mean was 5.3 cm. T 30–37 roughly bracketed the generally wettest and most densely vegetated sector of the target line (the part most influenced by the lingering snowdrift), and 100 percent of these targets as opposed to 17 percent of the rest showed a jump beyond the mean. Also, the least jump among them exceeded the greatest jump of the rest. The means for the "dry" and the "wet" sectors, respectively, were 4.2 and 10.8 cm, so that the mean jump of the "wet" sector was two and a half times that of the "dry" sectors.

Gelifluction. The range of total recorded gelifluction was from 0.3 to 14.7 cm but the mean was lower than suggested by the range, being only 2.0 cm. A much higher percent of targets in the "wet" part of the line (83 percent) than in the "dry" parts (10 percent) showed above-mean gelifluction. Also, the mean gelifluction in the "wet" part (6.4 cm) exceeded the "dry" mean (1.1 cm) about sixfold. The fact that the greatest gelifluction was associated with the "wet" and most densely vegetated sector, while the east third of the line was almost completely bare, indicates that high moisture is more important than the presence or absence of vegetation in influencing gelifluction on this slope. Other conditions are similar, and in view of the binding effect of vegetation, which should impede movement, it would be unrealistic to argue that it was the vegetation rather than the moisture that promoted gelifluction in the "wet" sector. As between 10-cm targets and 20-cm targets, there was no significant distinction in the amount of movement shown in the "dry" sectors. In the "wet" sector the mean movement of the 20-cm targets was greater than that of the 10-cm targets, but the difference was mainly due to the comparatively large movement of a single 20-cm target (T 35) and the fact that the adjacent 10-cm target (T 34), which was also in the area of greatest gelifluction and showed comparable movement, was excluded because of having been located where channeling might have influenced it. However, as at ES 6, the 20-cm targets showed the greater mean heave and more of them were subjected to heaving (table A II).

Retrograde movement. The recorded total retrograde movement ranged from 0 to 3.7 cm. The mean was 1.8 cm. None of the targets in the "wet" sector, but 72 percent of those in the "dry" sector exceeded the retrograde mean. The "dry" mean was 2.0 cm, the "wet", 0.7 cm, with 5 out of 6 targets in the "wet" part showing some retrograde movement. The fact that above-mean retrograde movement and above-mean gelifluction had inverse associations with respect to the "wet" sector, and that most targets had it with respect to each other (93 percent of the 29 targets showing retrograde movement and/or gelifluction above the mean had the inverse relationship to each other), is consistent with the view that gelifluction masks some retrograde movement. However, to the extent that retrograde movement is a function of drying (discussed later), the inverse relationship could also be explained by greater absolute retrograde movement in the drier sectors of the target line and by the observed greater gelifluction in the wetter sector without necessarily involving interaction of the two processes.

September movement. The range of total September movement was from 0 to 1.5 cm, and the mean was 0.5 cm for the target line as a whole. The means for the "dry" and the "wet" sectors were almost identical, 0.5 and 0.4 cm, respectively.



EXPERIMENTAL SITE 7

ROD MOVEMENT 1956-61

OBSERVED ROD POSITIONS (cm)
(HORIZONTAL COMPONENT ADJUSTED FOR ANGLE OF VIEW 19°)

DATE	CUMULATIVE MOVEMENT AT GROUND SURFACE	POSITION TOP	CUMULATIVE MOVEMENT TOP
13 AUG 56	0	6.7 (1)	0
21 AUG 57	1.1	9.4	2.7
27 AUG 58	1.7	11.2	4.5
24 AUG 59	2.6	12.5	5.8
25 AUG 60	2.8	13.4	6.7
25 AUG 61	3.6	15.0	8.3

(1) 1956 position of rod top obtained by taking intersection of rod with ground as zero, and setting ratio between 1956-57 movement of rod at ground surface (1.1 cm) and at rod top (y) equal to ratio of length of rod in ground (137.0 cm) and overall length (331.0 cm) as indicated, then subtracting resulting movement of rod top (2.7 cm) from observed position of top in 1957.

Fig. 17.

Annual movement. The summation of the annual movement from late August 1956 to late August 1961 ranged from 2.8 to 29.7 cm, adjusted for any target attitude changes in 1959–61, and the mean for the period was 6.6 cm. The annual mean rate was 1.3 cm/yr, the range being from 0.6 to 6.0 cm/yr. The 1.3-cm/yr rate was exceeded by 100 percent of the targets in the "wet" sector but by only 10 percent of those in the "dry" sectors. The mean rate for the "dry" sectors was 0.9 cm/yr, and for the "wet" sectors 3.4 cm/yr, so that the rate was some 4 times greater in the "wet" than in the "dry" sectors. There was no significant difference between the 10-cm targets and the 20-cm targets in the "dry" parts; an apparently somewhat greater movement of the 20-cm targets than of the 10-cm targets in the "wet" part (4.2 cm/yr as opposed to 2.6 cm/yr) was not representative for the reasons cited earlier in connection with gelifluction.

The behavior of the rod, which was in a "dry" sector, presents a special case in view of its relatively deep insertion to 137 cm. Where the rod intersected the ground surface the total movement (3.8 cm) was similar to that of the immediately adjacent targets (table C II). Since it was a steel drilling rod (2.2–2.4 cm diam.), stronger than the pipe of MW 7, which was not bent, and since the rod was not in permafrost, it is assumed that it was not subject to bending and that its movement at the surface was due to tilting as a result of slope movements that were progressively less with depth. Projection of the subsurface part of the rod to the depth of insertion indicates that its movement at this depth was no more than 1 cm in 5 years (fig. 17). Further consideration of the rod movement is reserved for the summary, and its movements (and that of MW 7) are excluded from the following discussion.

The summary equations, in centimeters, are

$$6.6\,T_m = 5.3\,J_m + 2.0\,G_m - 1.8\,R_m + 0.5\,S_m + 0.6\,E_m \tag{6.1}$$

$$4.4\,T_d = 4.2\,J_d + 1.1\,G_d - 2.0\,R_d + 0.5\,S_d + 0.6\,E_d \tag{6.2}$$

$$17.0\,T_w = 10.8\,J_w + 6.4\,G_w - 0.7\,R_w + 0.4\,S_w + 0.1\,E_w \tag{6.3}$$

with equations (6.1), (6.2), (6.3) being, respectively, for the target line as a whole, for the "dry" sectors, and for the "wet" sector (cf. ES 6). As already noted, the contrast between the "dry" and the "wet" sectors with regard to jump, gelifluction, retrograde movement, and total movement is striking.

Frost creep and potential frost creep. In each equation, the jump was again the largest mean movement. As previously outlined, it incorporated the ground heaving due to complete freezing of the active layer and therefore included the maximum potential frost creep resulting from the annual freeze-thaw cycle. However, the actual amount of frost creep (true frost creep) is decreased by the retrograde movement. As will be discussed in detail later, this retrograde movement is probably due to volume decrease and settling of the ground during thawing and any desiccation. Therefore in evaluating the amount of frost creep, the retrograde movement is logically subtracted from the jump movement caused by the heaving responsible for the original volume expansion; it would certainly be illogical to regard the retrograde movement as induced by gelifluction. Also, as already mentioned, in addition to including frost creep, the jump may incorporate a variable amount of gelifluction, depending on whether the first target observation was made before or after thawing had started and a target had become subject to gelifluction. Therefore to calculate the true frost creep the jump must be analyzed with respect to observation dates as related to the beginning of thawing and gelifluction in the spring.

The analysis is made for the periods 24 August 1959–25 August 1960 (table VI. 1) and 25 August 1960–25 August 1961 (table VI. 2), which are the best controlled periods for the purpose. The targets chosen are all the select targets (those with attitude changes $\leqq$ 0.2 cm) that were read within 4 days of exposure from snow. Since there was little if any thawing of the ground beneath the snow, such targets had been subject to negligible gelifluction prior to the first reading of the year. This procedure gives reasonable assurance that all gelifluction is excluded from the jump and that the jump represents the potential frost creep resulting from the ground heaving of the annual freeze-thaw cycle. No ground zero-degree cycles were recorded in June 1960 at soil thermographs 8C–8E (table B I), which were on the same slope as ES 7. Two of these (TG 8D and 8E) were in bare areas and at shallow depths (0–5 cm). Since no targets at ES 7 were exposed before the second half of June (table B IV. 1), and in view of the discussion of frost creep and creep due to wetting and drying in the introductory evaluation of target data, it seems safe to conclude that essentially all the downslope movement during the spring and summer was gelifluction and that spring frost creep was not a factor in 1960. Therefore all possible frost creep is included in the potential frost creep. The same is true for 1961 when all ES 7 targets except three were still snow covered on 14 June (of which only T 36 entered the calculation being considered), and when no ground zero-degree cycles were recorded in the second half of June at any of the thermographs on the same slope (tables B I, B IV.1).

For reasons cited previously, the retrograde movement was subtracted from the potential frost creep in order to arrive at the true frost creep. In one case (T 15, 1959–60 period) the resulting figure for the frost creep on this basis was negative by a small amount (a similar case occurred at ES 8). This may be explained by "excess" retrograde movement, which would be the normal result of deeper thawing than during the preceding summer. With such deeper thawing the ground would settle beyond the amount commensurate with the 1959–60 heave, and any retrograde movement consequent on the additional settling would be in excess of that associated with the 1959–60 heave. This possibility is supported by the fact that the mean air temperatures in July (4.3°) and August (5.5°) 1960 were higher by 0.8° and 1.5° respectively, than in the preceding year (WASHBURN, 1965, table 1, p. 46–51), and that the ground temperatures at depth at ES 7 were also higher at similar times (table E II.1. Cf. TCS 7 A for 20 July 1959 and 19 July 1960, 15 August 1959 and 8 August 1960; TCS 7 B for 23 August 1959 and 22 August 1960). Because negative values of frost creep are regarded as related to ground heaving preceding that of 1959–60, they are included as zero rather than as negative values in computing the true frost creep. The September 1960 movements are included in the 1960–61 analysis because they occurred predominantly in the last half of the month when freeze-up was in progress and, therefore, when the movements would contribute to the potential frost creep of the annual freeze-thaw cycle. No observations were made in September 1959 but the heaving then would be incorporated in the 1959–60 jump. The following data are derived from tables VI. 1–VI. 2, which show the amounts of true frost creep and of potential frost creep, calculated as described above, and their resulting proportions.

For the 1959–60 period, 13 targets meet the specified conditions of stability and dates of exposure. Although there is considerable variation in the movement values of widely separated targets, there is good agreement between a number of adjacent targets, as illustrated by T 2–3, 24–27. It would be unreasonable to expect completely uniform behavior on a microscale between adjacent targets, and the fact that in places the correspondence turned out to be so close lends confidence to the target data. The 1960–61 period is represented by 18 targets that meet the specified conditions. With the exception of the relatively high values for T 14 and 16, the agreement between the movement data for adjacent targets is reasonably good.

For the 1959–60 and 1960–61 periods, in the "dry" sector represented by the targets (the western "dry" sector is excluded from these control periods because T 38 did not meet the exposure limitation), the proportion of mean potential frost creep to retrograde movement, reducing the denominator to unity, is 3.2:1 and 2.9:1, respectively. This similarity in spite of different amounts of absolute movements in the two periods supports the view that the retrograde movement increases proportionately with ground heaving and is related to it. The mean for 1959–61 is 3.1:1. The comparable proportions for the "wet" sector are omitted because they do not appear to be meaningful and the smallness of the sample (2 targets) casts doubt on their significance, although as brought out below they show marked consistency in some respects.

A related proportion is obtained by comparing the true frost creep with the potential frost creep. For the 1959–60 and 1960–61 periods, respectively, the resulting proportions are 0.7:1 and 0.7:1 for the "dry" sector, and 1.0:1 and 0.7:1 for the "wet" sector. Thus, because of the retrograde movement, the true frost creep for each period is only about 70 percent of the potential frost creep in the "dry" sector. In the "wet" sector the mean proportion for both periods combined is 0.9:1. A rough comparison can be made with the data for the 5-year observation period. In summary equation (6.2) for the "dry" sectors, the potential frost creep can not exceed the jump, and the observed retrograde movement is a minimum but probably reasonably representative because the observation periods generally bracketed the times of greatest retrograde movement. Therefore the sum of the jump (4.2 cm) and of the retrograde movement (-2.0 cm) provides an estimate of the true frost creep (2.2 cm). The proportion of true frost creep to potential frost creep would be 2.2:4.2, or 0.5:1, which corresponds moderately well with the 0.7:1 proportion for the "dry"-sector control periods. The 0.5:1 proportion is a maximum for the 5-year period because there is an x amount of gelifluction in the jump, and subtracting it from the jump in the numerator and denominator (assuming $x > 0.2$ cm), gives $\frac{4.2 - x - 2.0}{4.2 - x} < 05:1$. Therefore 0.5:1 is regarded as a better long-term approximation than 0.7:1. From equation (6.3) for the 5-year period in the "wet" sector, the same procedure gives a proportion of frost creep to potential frost creep of 10.1:10.8, or 0.9:1, which is also the mean for the 1959–61 period. Thus the best approximation here would probably not exceed 0.9:1 at a maximum.

Frost creep[1] **and gelifluction.** For the 1959–60 (table VI. 1) and 1960–61 (table VI. 2) periods, respectively, the proportions of frost creep to gelifluction in the "dry" sector are 1.5:1 and 5.3:1. The reason for the different proportions in the two periods probably lies in the differing weather conditions. It is clear from tables VI. 1 and VI. 2 that there was more frost creep and less gelifluction in the 1960–61 period than in the preceding one, and this is supported by the trends of the jump-to-gelifluction proportions for roughly comparable periods as cited above. The less gelifluction can be attributed to the thinner snow cover during the spring of 1961 and the consequently smaller amount and shorter duration of meltwater than in 1960. The rain during the summer of 1960 appears to have been only a minor factor, since the graphs of target movement indicate that most of the gelifluction in the "dry" sector occurred before the rain. The greater frost creep

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[1] In this and other discussions that do not specifically compare true frost creep with potential frost creep, frost creep refers to true frost creep unless otherwise indicated.

in 1961 is perhaps explained by the deeper thawing in 1960 than in 1959, noted earlier, and therefore the subsequently greater ground heaving in 1961 than in 1960. A difference in the retrograde movement could not have been responsible because the retrograde movements were greater in 1961 than in 1960 (tables VI. 1–VI. 2). There was probably a greater depth of thaw in 1961 than in 1960, judging from the higher summer temperatures in 1961, and the greater retrograde movements are consistent with this.

Combining the two periods as previously, the mean proportion of frost creep to gelifluction in the dry sector is 3.4:1. These comparisons indicate that frost creep in the "dry" part of ES 7 can exceed gelifluction by some two to five times, with roughly three being the mean for 1959–61. Comparing this result with the analogous 2.0:1 proportion, represented by the sum of the jump (4.2 cm) and the retrograde movement (–2.0 cm) to the gelifluction (1.1 cm) in the summary equation (6.2) for the "dry" sectors, suggests that the mean for 1959–61 is on the high side for the whole observation period, since any unrecorded gelifluction in the 5 years of observation would be incorporated in the jump and would make the long-term proportion a maximum.[1]) It seems reasonable to conclude that the mean proportion of frost creep to gelifluction in the "dry" sectors of ES 7 did not exceed 2.0:1 for the 5-year observation period.

The proportions of frost creep to gelifluction for the "wet" part of target line 7 are probably not very significant in themselves because of the smallness of the samples. For 1959–60 the proportion is 1.0:1 and for 1960–61 it is 0.5:1 (tables VI. 1–VI. 2). These data are consistent in suggesting that although the amount of frost creep is greater in the "wet" than in the "dry" sector, the gelifluction increases even more, so that the relative contributions of frost creep and gelifluction to the total movement are more nearly alike than in the "dry" sector. This is also consistent with the proportion represented by the sum of the jump (10.8 cm) and the retrograde movement (–0.7 cm) to the gelifluction (6.4 cm) in the summary equation (6.3) for the "wet" part; this proportion is 1.6:1, which is smaller than the 2.0:1 proportion for the "dry" part.

Weather influences. The probable influence of various weather conditions on frost creep and gelifluction in 1959–60 as compared with 1960–61 has been mentioned in the foregoing. Additional weather effects are discussed below.

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[1]) The September component (0.5 cm) is not included in this proportion, but even if this component were treated as wholly frost creep and part of the jump, the proportion would still be approximately 2:1 to the closest integer.

Comparison of target records from one year to another reveals a September movement in 1957 similar to that at ES 6, except more pronounced and starting earlier. Beginning commonly with 7 September, 60 percent (21 of 35) of the cone targets listed in table C II showed a generally abrupt increase of movement, normal to the target line, exceeding 0.2 cm by 24 September (T 5, 8, 12–28, 31–32), and 6 of the remaining 14 targets, and the rod, showed a lesser change suggestive of increased movement. The minimum temperatures indicated by the background graphs were consistently below 0° beginning with 4 September. Precipitation in that month was negligible. In 1958 when only one target (T 17) had a September movement greater than 0.2 cm by the 18th, the mean temperature for the period was 1.4° more than for the first 18 days of September in the previous year and there was more precipitation. The 1959 record did not extend into September. In 1960 the rod and 49 percent (17 of 35) of the cone targets revealed a September movement (to 3 October) exceeding 0.2 cm (T 1–2, 5–6, 13–14, 16, 18, 21–22, 24–28, 31–32), and 12 of the remaining 18 targets suggested increased movement. In spite of the longer observation period and the considerably greater precipitation that might have favored gelifluction, the mean September movement was similar to that in 1957 (table C II). However, the mean September temperature in 1960 was 0.5° higher than in 1957 and, significantly, the most abrupt September movements in 1960 did not come until the end of the month when temperatures were lowest. Thus, the influence of low temperatures at the start of the annual frost heave cycle is apparent in some of the target movements and their variations from year to year.

Rain appears to have affected target movements in 1959 and 1960 when there was more precipitation than in the summers of 1957, 1958, and 1961. In 1959, 24.2 mm fell in the interval 31 July–11 August and was the only appreciable precipitation that summer; all was rain except a little snow on 31 July. Between 24 July and 11 August, the observation dates bracketing this precipitation, 26 percent (9 of 35) targets in table C II indicated an increased rate involving movements greater than 0.2 cm normal to the target line (T 11, 14, 18, 20–22, 25, 27, 30), and the rod and half of the remaining targets (13 of 26) suggested a less pronounced increased rate of downslope movement (T 1–4, 7, 9–10, 16–17, 23, 32, 36) or a decrease of retrograde movement (T 5). In some cases the increased downslope movement reversed an apparent retrograde trend. However, the movements involved were very small and some fall within the possible observational error, so that the correlation is no more than suggestive. In 1960, 54.3 mm of rain fell in the interval 24 July–2 August and was the greatest concentration of precipitation during the observation period. The observation dates most closely associated with the interval were 29 July and 7 August. The first observation date for 5 targets (T 28, 30–33) in table C II was 29 July or later and they are eliminated from consideration. The rod and 70 percent (21 of 30) of the remaining targets suggested either an increased rate of downslope movement (T 1–5, 7–9, 11–12, 16, 18, 25–27, 35–36, 38) or a decrease of retrograde movement (T 13–14, 20), with the former again including cases of reversal from a retrograde trend. As in 1959, the movements of the remaining targets involved were very small (only T 35 exceeded 0.2 cm), but the time bracketed by the observation dates was so short that only slight movement would be expectable.

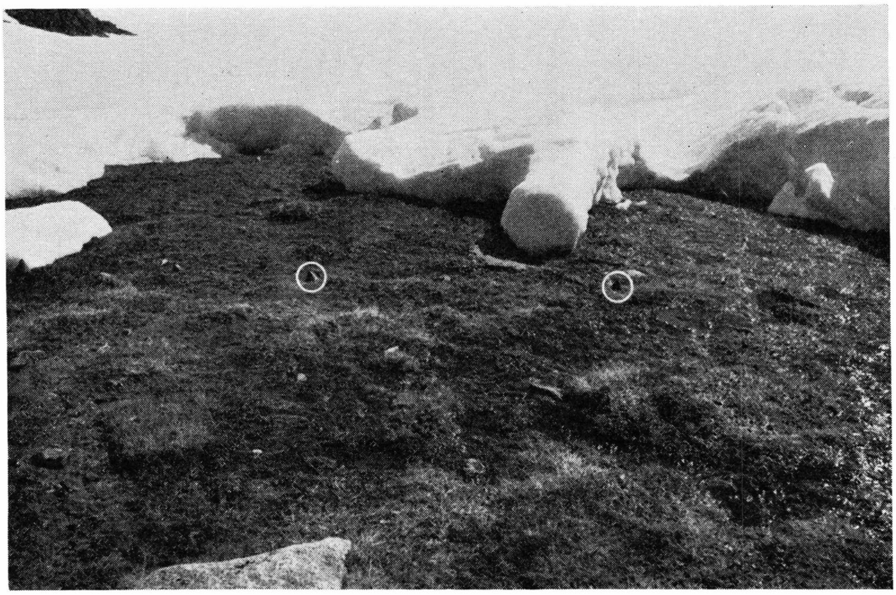

Fig. 18. Experimental site 8. Sheetflow-eroded channel through snowdrift at target line 8. View downslope. Targets 26–27 are circled. (14 June 1960.)

7. EXPERIMENTAL SITE 8

Description

General

Experimental site 8 was located downslope from ES 7 (fig. 9). The slope material is a diamicton (pls. D 5–D 6, table D III) similar to that at ES 7, although isolated boulders are somewhat more common and larger, the largest being 1–2 m in diameter. As at ES 7 the top several centimeters tend to be coarser than the underlying material, and the fines tend to increase with depth.

The gradient ranges from 11° to 14°, and is thus similar to that at ES 7 although the average is slightly steeper. The general aspect of the vegetation is also similar; details are to be discussed by RAUP in a separate number of the *Meddelelser*. The slope can be divided from east to west into 4 parts: predominantly vegetation free, intermediate, comparatively well vegetated, and finally less well vegetated again. There were several differences in species distribution, and turf hummocks were fewer than at ES 7. Figure 10 illustrates details of vegetation distribution. Turf-banked terracettes occur at ES 8 as at ES 7; several particularly well-developed ones, transitional to lobes, are on the frequently saturated west part of the slope. Several broad, comparatively massive but generally poorly defined lobe fronts occur below target line 8. The lobe farthest east, whose front was 14 m downslope from where MW 8 was situated, appears to be related to a shallow earthflow scar in the slope above; the others are probably gelifluction lobes. The eastern lobes were predominantly bare of vegetation whereas the lobe farthest west was comparatively well vegetated. Much of the west half of ES 8 receives abundant moisture from the thawing of the same snowdrift that lingers at ES 7. In some years there is also a marked drift that extends south from the trap cliffs just east of theodolite station 8 and persists into the summer over part of the west half of ES 8. The drainage from the snowdrift at ES 7 and from the thawing of the ground is a pronounced sheetflow on sunny spring days and, where most concentrated, commonly erodes several channels through the lower-lying snowdrift at ES 8 (fig. 18). Moisture determinations are listed in table F III.

Instrumentation

Target line 8. Target line 8 (figs. 19–20) was established roughly parallel to the contour on approximately the same azimuth (103°) by Brunton compass and to the same reference point as for ES 7. The theodolite station, marked by the usual chisel hole, was on a bedrock shelf at an altitude of 74 m at the south end of trap knob MS 112 m. The line originally consisted of 34 cone targets, which had the usual 2-m spacing (except for 4-m intervals between T 1–2, 4–5, 27–28, and 31–32, because of obstructing stones at the 2-m position or because the 2-m position was not visible from the theodolite station). All odd-numbered targets were equipped with 20-cm pegs (except for T 19, which had a 10-cm peg because of a stone at greater depth), and all even-numbered targets had 10-cm pegs. The target line was established on 22 August 1956.

Excluding isolated stones that would unduly weight percentages, the diamicton along the target line was a gravelly-clayey-sandy silt to a clayey-gravelly-silty sand, with fines ranging from 32 to 61 percent. At the targets indicated the percentage of fines (in parentheses) for depths of 10 and 20 cm, respectively, were: T 4 (52, 61), T 10 (52, 55), T 15 (51, 52), T 20 (58, 42), T 25 (41, 49), T 30 (45, 48), T 34 (34, 32) (pls. D 5–D 6, table D III). Elsewhere in the neighborhood of the target line the fines ranged from 18 percent (depth 1 cm, 5 cm downslope from T 4–6) to 89 percent (depth about 100 cm, TCS 8A, 10 m downslope from T 6 (table D III). Determinations of the liquid limit along the target line ranged from 12 percent moisture (T 34) to 32 percent moisture

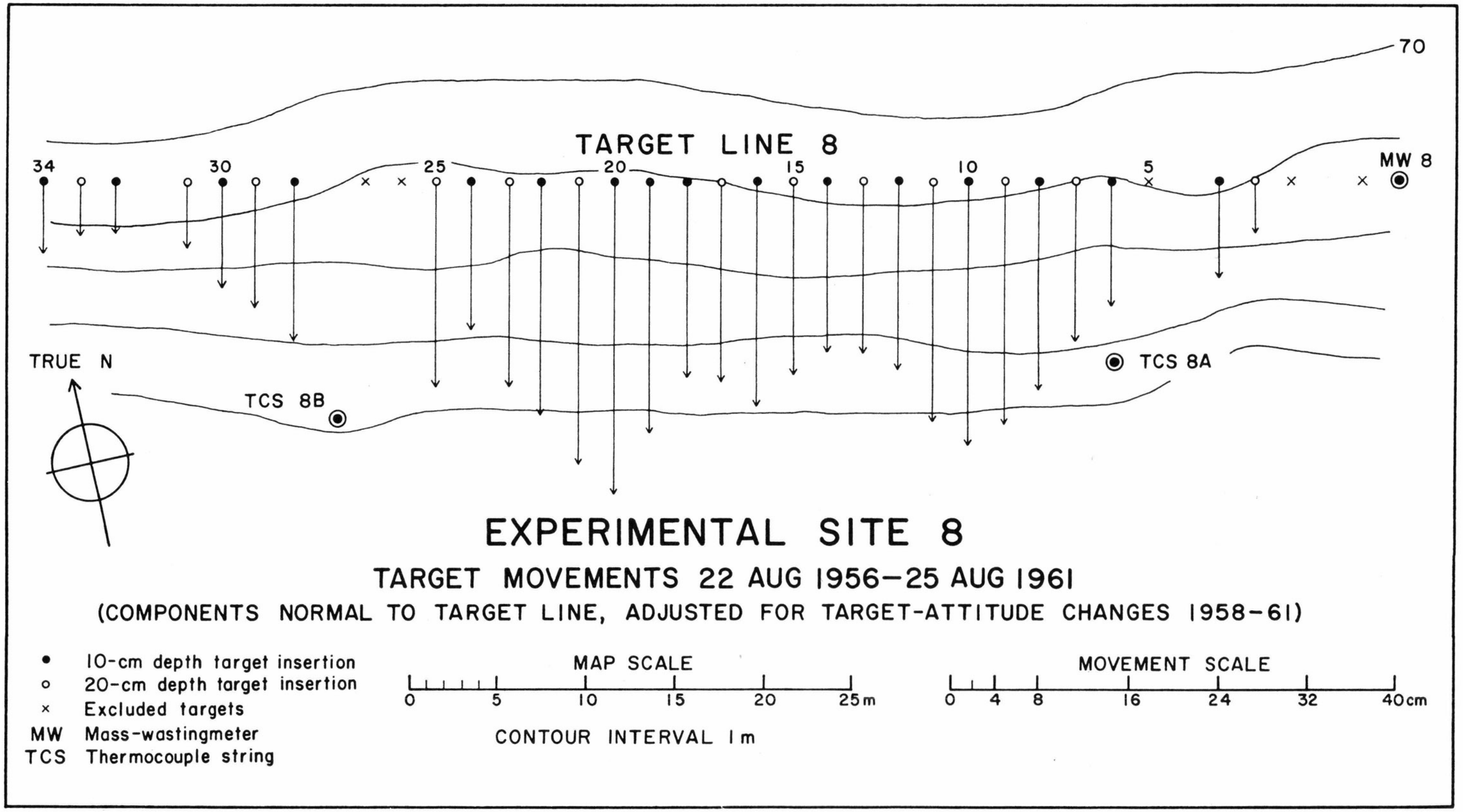
70
TARGET LINE 8
34
30
25
20
15
10
5
MW 8
TRUE N
TCS 8B
TCS 8A
EXPERIMENTAL SITE 8
TARGET MOVEMENTS 22 AUG 1956–25 AUG 1961
(COMPONENTS NORMAL TO TARGET LINE, ADJUSTED FOR TARGET-ATTITUDE CHANGES 1958–61)
● 10-cm depth target insertion
○ 20-cm depth target insertion
× Excluded targets
MW Mass-wastingmeter
TCS Thermocouple string
MAP SCALE
0 5 10 15 20 25m
CONTOUR INTERVAL 1 m
MOVEMENT SCALE
0 4 8 16 24 32 40cm

Fig. 19.

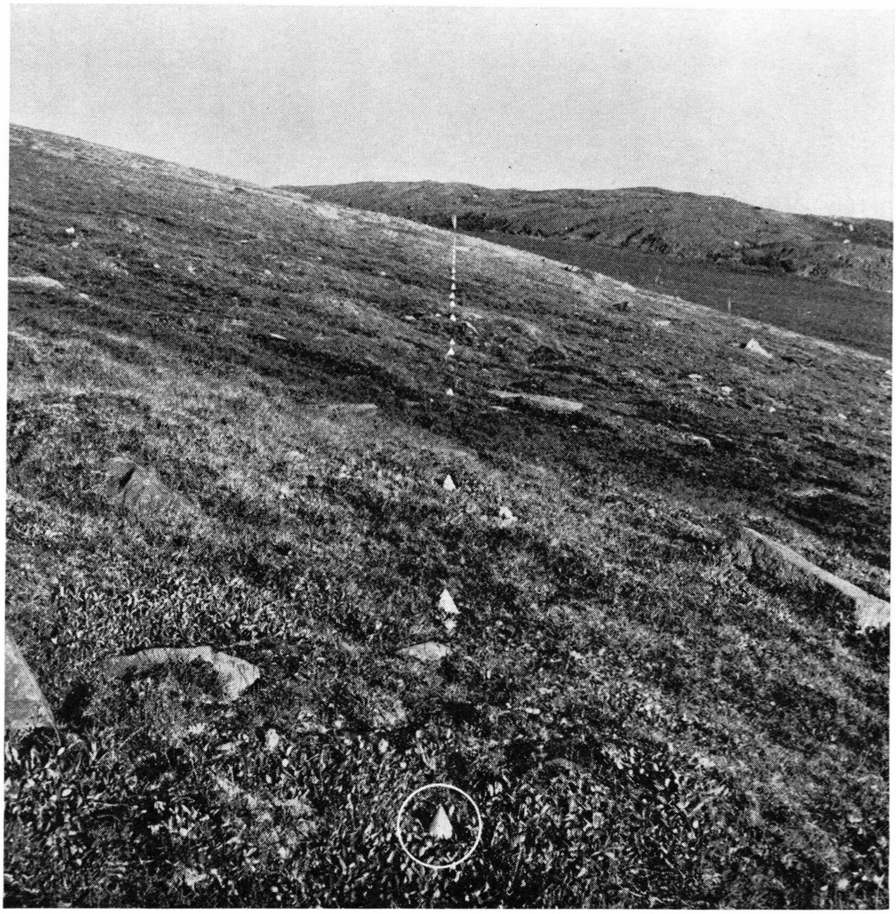

Fig. 20. Experimental site 8. View along azimuth 103° from near west end of target line 8; target 29 is circled. Mass-wastingmeter 8 is at far end of target line. (22 Aug. 1956.)

(T 25), with the plastic limit ranging from 11 percent moisture (T 34) to 25 percent moisture (T 25).

Target line 8 was divided into "dry" and "wet" sectors on the same basis as at ES 7. The "dry" sectors included MW 8, T 1–17 and T 31–34; the "wet" sector was the intervening area. However, the distinction between "dry" and "wet" was less prominent than at ES 7 and the boundaries were correspondingly less well defined. As at ES 7 and excluding MW 8, the range of the gradient in the "dry" sectors was 11.5° to 14° and the average 12.5°. Comparing "wet" sectors, the slope was slightly steeper than at ES 7, the range being from 11° to 13° and the average 11.5°. The gradients were determined from figure 19 according to the procedure cited for ES 7. Again, as at ES 6–7, several targets

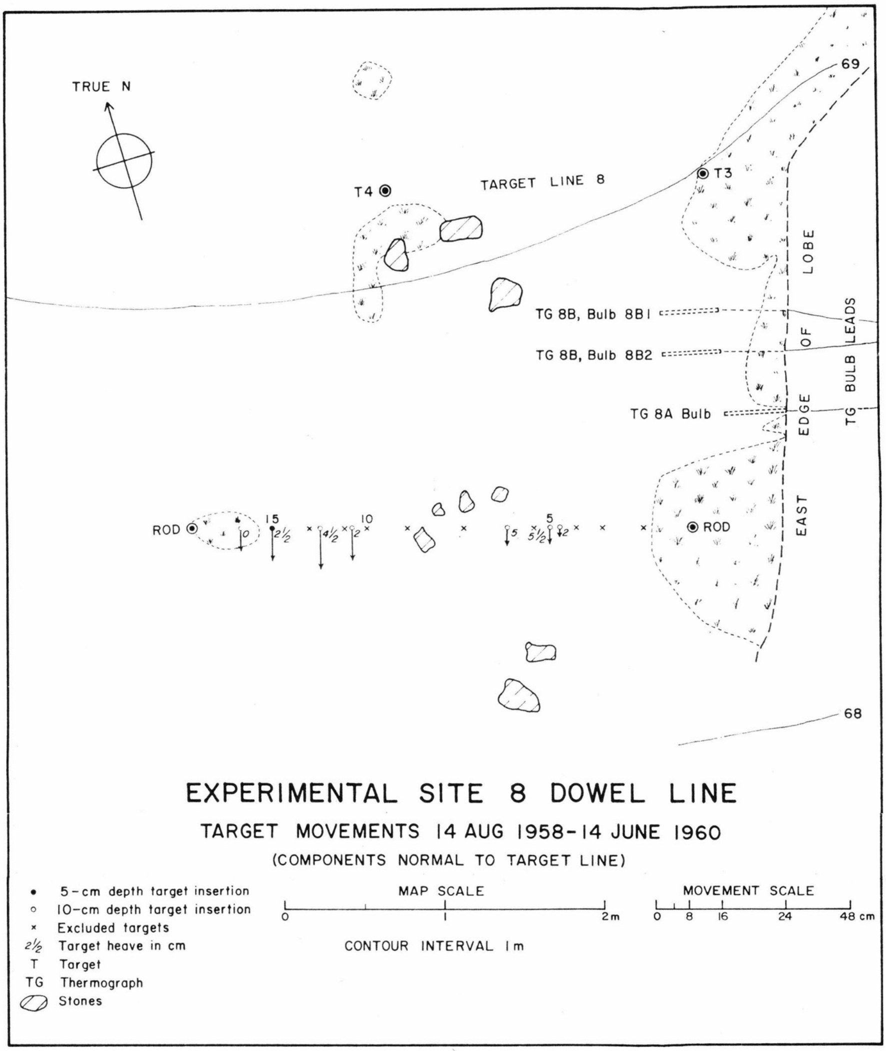

Fig. 21.

were excluded from consideration in conformity with the criteria discussed in connection with ES 6, the targets involved being T 1–2, 5, and 26–27.

Dowel line. In addition to target line 8, a line of dowel targets was laid out on an azimuth of 106°, roughly parallel to and at the east end of target line 8 near T 3–4 (figs. 21–22). (Another dowel line at right angles was discontinued.) The installation was associated with two thermograph installations (TG 8A and 8B) and was in the upslope part and near the cast edge of an irregular low lobe whose front lay some

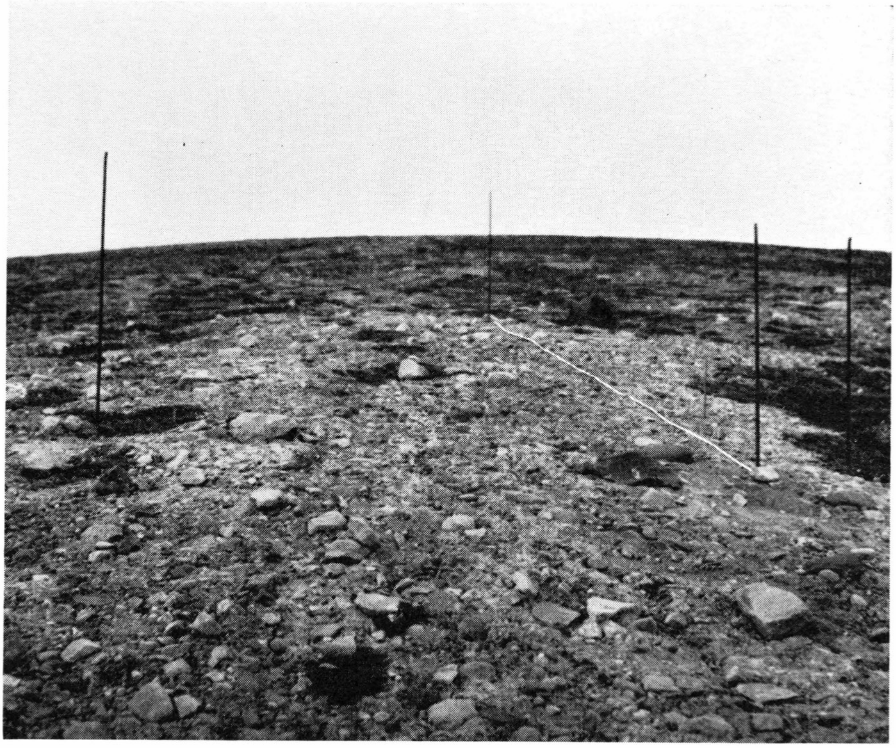

Fig. 22. Experimental site 8. Dowel line. View north-northeast diagonally upslope. (Cf. fig. 21.) (Photo by FRED PESSL, Jr., 18 Aug. 1958.)

40 m below target line 8. The end points for the dowels were steel rods inserted in the ground to a depth of about 1 m; they were not in permafrost and provided only a relative reference frame for the dowels. The dowels were aligned along piano wire stretched between the end points and were inserted to depths of either 5 cm or 10 cm. Small stones prevented uniform spacing and strict alternation of 5-cm and 10-cm insertions. Figure 21 gives details of spacing and depths of insertion. In the immediate vicinity is a clayey-sandy-silty gravel with liquid and plastic limits of 20 and 15 percent moisture, respectively (table D III, sp. 60-8-21 a). The appearance of the surface, which was largely bare of vegetation, is illustrated by figure 22. The installation was made on 14 August 1958, and the last readings were taken on 14 June 1960 by which time most of the dowels were no longer standing.

Mass-wastingmeter 8. MW 8 was emplaced at the east end of the target line, 2 m beyond T 1, and aligned on the same bedrock reference point as the target line. The instrument was in the central area of the broad low lobe associated with the shallow earthflow scar in the slope

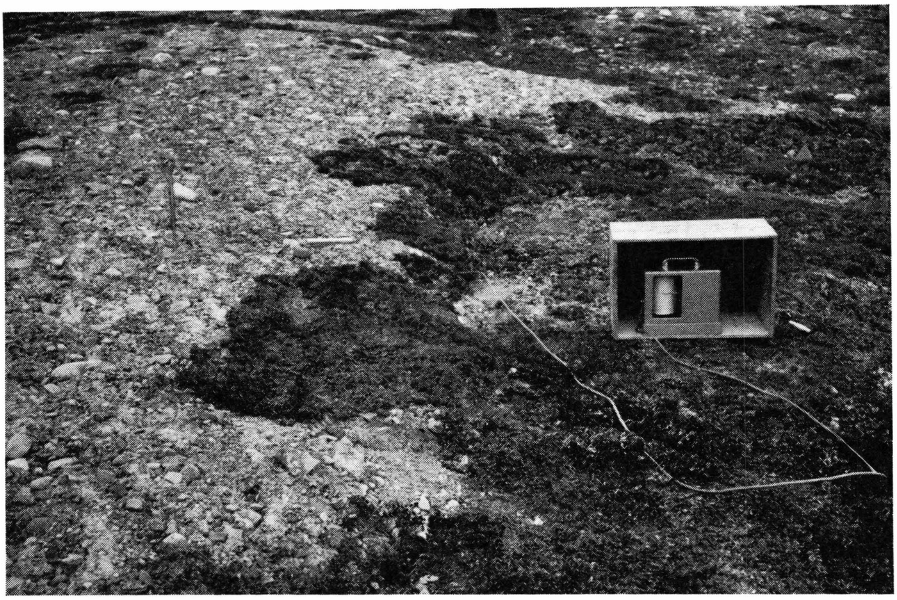

Fig. 23. Experimental site 8. Thermograph 8A installation. View upslope. 16-cm rule marks location of bulb. (2 Aug. 1958.)

above. The diamicton encountered in the augur hole for the instrument was moderately stony throughout, distinctly sandier at a depth of about 100 cm than above, and obviously moist but not saturated below a depth of about 10 cm down to 110 cm, the maximum depth of auguring. No frost was encountered, and the base of the mass-wastingmeter pipe was set at a depth of 100 cm. The instrument was emplaced on 16 August 1956 and excavated on 5 August 1959.

Thermocouple strings 8A–8B. Two thermocouple strings were inserted downslope from target line 8 (fig. 9). TCS 8A, in the generally bare east third of the slope, was 10 m below T 6 and directly downslope and 67 m from TCS 7A. Although auguring for its installation was stopped by a stone at a depth of 177 cm, the diamicton encountered (table D III) was somewhat less stony at depth than at the surface. No frost was encountered but the diamicton at the bottom of the hole was wet.

Thermocouple string 8B was located 13.5 m downslope from T 27 in the central area of a rather poorly defined gelifluction lobe in the comparatively well-vegetated west third of the slope. The installation was about midway across the lobe (8.5 m wide here) and 4.5 m upslope from the base of the front, which was 20–30 cm high and gently sloping. The diamicton (table D III) was somewhat coarser than at TCS 8A. Several boulders occurred in the immediate vicinity of the lobe. The vegetation of the area had its greatest concentration along a slight, up-and-down-

Fig. 24. Experimental site 8. Thermograph 8 B installation. View west prior to backfilling. Bulb 8 B 1 at right, bulb 8 B 2 at left. 17-cm rule as scale. (21 Aug. 1960.)

slope depression, and the lobe was along the approximate axis of the depression. The vegetation was thinner on the tread of the lobe than elsewhere nearby and was even more scattered slightly upslope from the thermocouple string. Auguring extended to a depth of 147 cm without meeting frozen ground (21 August 1956). The material encountered was moist at the surface and more so at depth, but not so wet as to flow into the augur hole and fill it.

Soil thermographs 8 A–8 E. Five soil thermographs and an instrument shelter housing an air thermograph and maximum and minimum thermometers were also installed at ES 8. The shelter was located near the east end of target line 8, 2 m downslope from T 2. The altitude of the shelter was about 68 m and its height 2 m, the same height as the shelter at the Danish Government station. This instrumentation was established in 1960 to compare the temperature regime at ES 7–8 with the records at the government station, and by extrapolation from them to estimate temperatures at ES 7–8 for periods prior to 1960.

Soil thermograph 8 A was the single-pen type. It was located just west of the instrument shelter and in conjunction with the dowel line near the east end of target line 8 (fig. 21). The bulb of the thermograph was emplaced 1.5 m downslope from T 3 into the east side of the low lobe mentioned in connection with the dowel line. The side of the lobe at this point was 15 cm high, and lateral auguring permitted the bulb

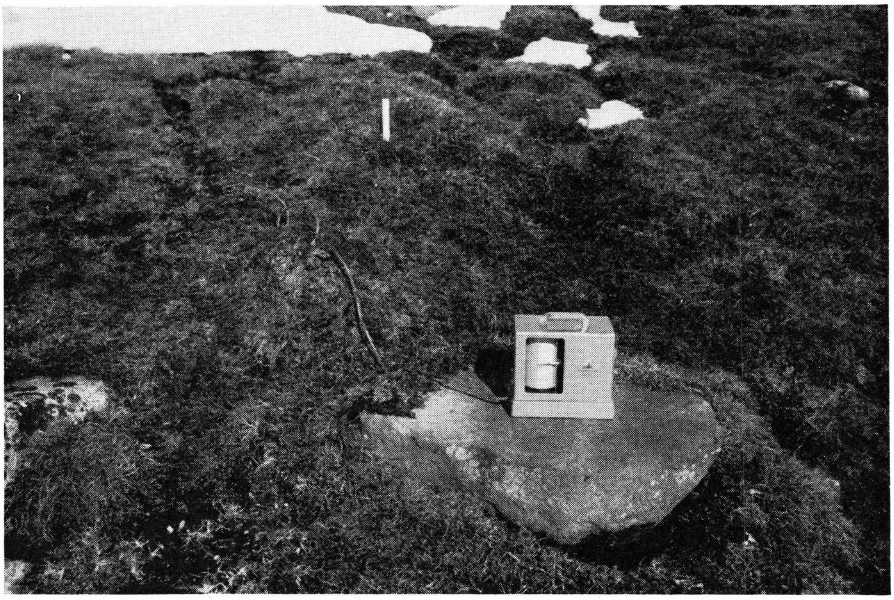

Fig. 25. Experimental site 8. Thermograph 8C installation. View upslope. 17-cm rule marks location of bulb. (20 May 1960.)

to be inserted parallel to the contour and nearly horizontally at a depth of 12 cm without disturbing the surface appreciably (fig. 23). Following insertion, the hole was backfilled. The diamicton in the vicinity is a clayey-sandy-silty gravel (table D III, sp. 60-8-21 a). The tread of the lobe was almost completely bare but the margins were partially vegetated, with *Dryas* mats predominating. In places the diamicton appeared to be breaking through the marginal vegetation. The installation was made on 2 August 1958 and the records cover the periods 4 August–23 September 1958, and 7 May–24 August 1959. Recalibration in an ice bath following removal of the instrument indicated it had been reading 0.6° (1° F) too high, probably due to jarring during transport to the site, and this correction has been applied to the resulting data.

Soil thermograph 8B was the dual-pen type. It was installed near, and took the place of, TG 8A near the east end of target line 8 (figs. 21, 24). Both bulbs of the instrument were inserted by excavating a small shallow trench, auguring laterally and pushing in the bulbs beyond the face of the excavation, then backfilling so that the surface of the ground above the bulbs remained unbroken. Bulb 8B1 was placed at a depth of 12 cm (measured to top of bulb), parallel to the general contour, about 0.7 m diagonally downslope from T 3 and 0.3 m upslope and 0.3 m west of the bulb of TG 8A. The instrument shelter was 3 m to the

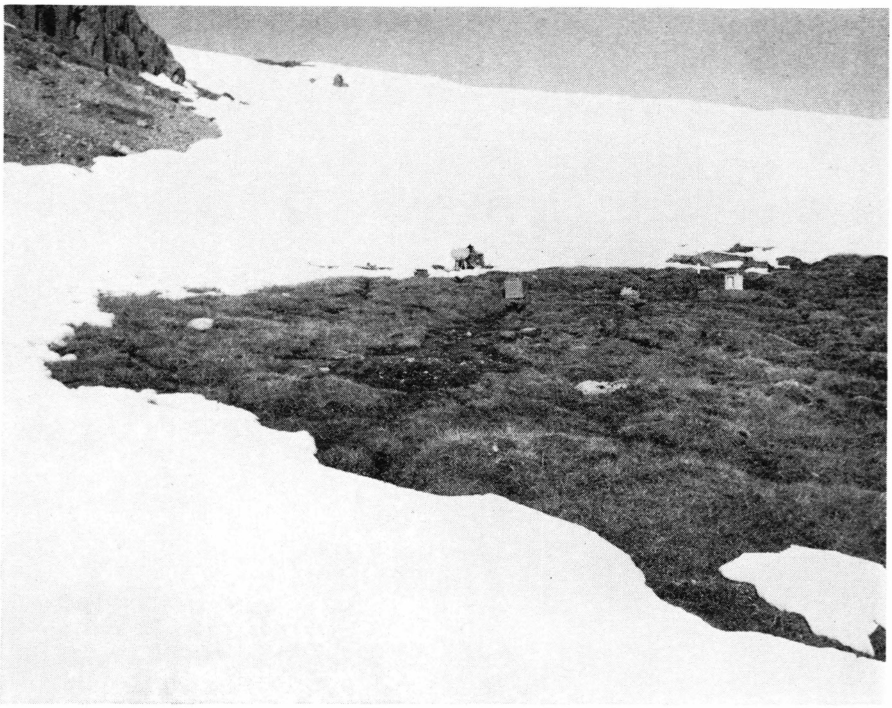

Fig. 26. Experimental site 8. Small gelifluction lobe at head of which thermographs 8D and 8E were installed. View upslope with thermograph 8C in background. (20 May 1960.)

east. Bulb 8B2 was at a depth of 5 cm, 23 cm directly downslope from bulb 8B1 and parallel to it in clayey-sandy-silty gravel (table D III, sp. 60-8-21 a). Both bulbs were in vegetation-free ground; the closest growths to the bulbs were a *Dryas* patch 20 cm diagonally upslope from bulb 8B1 and another *Dryas* patch 25 cm east of bulb 8B2. The installation was made on 21 August 1960, after the bulbs had been calibrated in an ice bath at the site. The records cover the periods 22 August–3 October 1960, and 2 May–27 August 1961.

Soil thermograph 8C was the single-pen type. It was located in the generally wet area with turf hummocks in the west third of the slope, 33 m upslope from T 28 of target line 8 (fig. 9). Using the lateral auguring method adopted for TG 8A and 8B, the bulb was inserted at a depth of 6 cm parallel to the contour in an irregular turf hummock (fig. 25). The hummock had a maximum relief of 15 cm and was elongate downslope, its long diameter measuring 170 cm and its short diameter 140 cm. It consisted mainly of moss with some vascular plants, principally *Vaccinium*, *Rhododendron*, and *Carex Bigelowii.* The installation was made on 17 May 1960. As the original calibration was not made at the site,

Fig. 27. Experimental site 8. Thermograph 8 D and 8 E installations. Bulb 8 D at depth 5 cm; location and orientation indicated by 17-cm rule. Bulb 8 E flush with surface at left of bulb 8 D and at right angles to it. View upslope. (3 June 1960.)

the bulb was withdrawn on 15 August 1960 for recalibration in an ice bath and was immediately reinserted in exactly the same position. Since the instrument had been recording 0.3°(0.5°F) too low, probably because of jarring during transport to the site, the temperature data prior to this date have been corrected accordingly. The records cover the period 17 May–3 October 1960, and 2 May–27 August 1961.

Soil thermograph 8 D, a single-pen type, was downslope from TG 8 C and 24 m upslope from T 29 of target line 8 in the "wet" sector of the slope (fig. 9). It was located at the upslope, poorly defined beginning of an irregular gelifluction lobe (fig. 26), some 6 m long and up to 2.5 m across, which had a vegetated front up to 20 cm high but was otherwise a somewhat branched, bare area flush with the better vegetated surroundings. The bulb was inserted in a bare spot measuring 35 × 40 cm whose surface suggested needle-ice activity, and where needle ice was subsequently observed. The spot had a relief of 4 cm, and the ground was so wet and soft when the installation was made that the bulb could be pushed down and in from the side without auguring, so that it lay, roughly parallel to the contour, at a depth of 5 cm (measured to top of the bulb) beneath an unbroken surface (fig. 27). A trickle of water from farther up the slope tended to keep the spot saturated and to undercut slightly its upslope edge. The installation was made on 15 May

1960 and the depth of thaw 3 days later was 12–15 cm. Recalibration was carried out on 15 August 1960 in the same manner as at TG 8C. It was found that the instrument had been recording 1.7°(3°F) too high, so that the prior temperature data have been adjusted by this amount. The records cover the periods 17 May–3 October 1960, and 2 May–27 August 1961.

Soil thermograph 8E was also the single-pen type. The bulb was immediately adjacent and at right angles to the bulb of TG 8D on its upslope side. The bulb of TG 8E was flush with the surface of the ground, which was 4 cm below the crest of the spot in which the bulb of TG 8D was placed and was therefore somewhat wetter and had a film of water over it for a considerable period (fig. 27). A very thin, discontinuous coating of black organic crust covered part of the surface, which was otherwise bare. The bulb was painted gray and nearly matched the predominant color of the ground so that any temperature variation due to color difference was minimized. The installation was made on 23 May 1960 when the depth of thaw at both bulbs was 20–24 cm. Recalibration on 15 August 1960 (cf. TG 8C and 8D) indicated that the instrument had been recording 0.6°(1°F) too low, and the temperature data prior to this date have been corrected by this amount. As described in appendix E, this correction and those previously cited could generally be confirmed by the nature of the temperature curves themselves. The records cover the periods 23 May–3 October 1960, and 2 May–27 August 1961.

Instrumental Data

Thermocouple Strings 8A-8B

Comparison of temperatures at comparable depths as between TCS 8A and 8B is restricted by the scarcity of functioning thermocouples near the surface and by the depth changes associated with frost heaving of the thermocouple strings (table E III). Nevertheless, several trends are apparent. They are illustrated by the following comparisons.

Thermocouple 6 (TCS 8A) was at a depth of 136 cm when emplaced and at a depth of 131.5 cm when excavated, and TC 1 (TCS 8B) had emplaced and excavated depths of 139 cm and 130 cm, respectively. Thus, throughout the observation period TC 1 (TCS 8B) was at a similar or greater depth than TC 6 (TCS 8A); yet the negative temperatures it indicated were consistently higher than those at TC 6 (TCS 8A) on the same dates (cf. June 1958 observations, table E III). A similar relationship holds for the next higher-lying thermocouples in each thermocouple string, and is logically explained by the insulating effect of the snowdrift that tended to form over the west third of ES 8 where TCS 8B was located, whereby the ground there would be less affected by low winter temperatures than at TCS 8A.

Another aspect is shown by a comparison of TC 13 (TCS 8A) with TC 9 (TCS 8B). The former had an emplaced depth of 66 cm and an excavated depth of 62 cm; the latter had emplaced and excavated depths, respectively, of 65 cm and 54 cm. In this case, therefore, TC 13 (TCS 8A) was at a similar or greater depth than TC 9 (TCS 8B) during the observation period; yet the positive temperatures it indicated early in the season were generally higher (by up to 1.8°) than at TC 9 (TCS 8B), the inverse relationship to that noted above. The situation is explained by the earlier start of thawing at TCS 8A as compared to the snowdrift location of TCS 8B.

The temperature difference between TC 13 (TCS 8A) and TC 9 (TCS 8B) decreased progressively after the initial readings in each year so that by autumn the temperatures were commonly equal, or had crossed over and the temperature at TC 9 (TCS 8B) had become the higher. Similar trends were not confined to this pair of thermocouples, and it is clear that the ground at TCS 8B tended to warm up more rapidly than at TCS 8A once thawing had started. The difference in the amount of vegetation at TCS 8A and 8B was not a factor in this tendency, for to the extent the vegetation acted as an insulator it should have affected the entire active layer and have promoted a slower rise of temperature at TCS 8B than at TCS 8A where the ground was almost bare. The diamicton at the two localities is not greatly different. On the other hand, the moisture difference was very appreciable (table F III), and the tendency can be explained by diffusivity differences resulting from it. At TCS 8A the diamicton near the surface dried soon after thawing, and as air replaced water in the pore spaces the diffusivity of the near-surface material would have become less. At TCS 8B, however, there was continuing abundant moisture from the snowdrifts that linger on the west third of ES 7–8, and saturation and a relatively high diffusivity would have been maintained.

The trends and differences of temperature at TCS 8A–8B illustrate the important effect of moisture on thawing and the seasonal variations that may be involved. Judging only from the absence at TCS 8A of any insulating vegetation or lingering snowdrift that would inhibit thawing as compared with TCS 8B, it would be easy to assume that the active layer at TCS 8A would be appreciably thicker than at TCS 8B. That this is not necessarily the case is shown by the similar or higher positive temperatures at the lowest thermocouple (TC 1) of TCS 8B than at a similar or lesser depth (TC 6) at TCS 8A.

Observations during freeze-up are fragmentary because in most years it was necessary to leave the field before freeze-up was complete.

However, the observations at TCS 8B on 3 October 1960 (table E III) indicate some upfreezing from the permafrost table as well as downfreezing from the surface in that year. Although near-surface data from TCS 8B are lacking because of broken leads, visual observation that the surface was hard frozen, and records from TG 8D and 8E nearby indicating negative temperatures near the surface make it seem very unlikely that any significant warming following freezing had penetrated below a depth of 10 cm during the preceding days. Therefore the 0.0° temperatures at TC 7 and 9 represented a warm cell trapped by initial downfreezing from the surface, and the negative temperatures below it represented upfreezing from the permafrost table.

Soil Thermographs 8A-8E

The thermograph data are reported in tables B I–B II and are discussed in detail in appendix B. Certain data are particularly pertinent to target line 8 and are cited below in that connection.

Mass-wastingmeter 8

The total downslope movement of the pipe of MW 8 from 17 August 1956 to 4 August 1959 was 4.2 cm, measured at ground level (pl. C 3, table V). The annual movement for 1956–57 (17 August–21 August) was 2.0 cm and for 1957–58 (21 August–26 August) was 1.4 cm (table C IV). The bearing of these data are discussed in connection with target line 8.

Dowel Line

As shown by fig. 21, the dowels still standing on 14 June 1960 showed a downslope movement, at ground level and with respect to a string between the transverse end points, of 1–3 cm since their emplacement on 14 August 1958. The mean movement was 1.7 cm and the mean rate, 0.9 cm/yr (table C V). These movements, believed to be accurate to ±0.2 cm, are relative to the end points only. The maximum relative rate (1.6 cm/yr) is similar to the absolute rate of the closest cone target (T 4 – 1.8 cm/yr) of target line 8. Allowing for slight movement of the end rods, which were inserted to a depth of about 1 m, the movement of the dowels was consistent with that of the nearest cone targets.

All the dowels inserted to a depth of 5 cm, except one, were out of the ground by 14 June 1960. Of the dowels that had been inserted to a depth of 10 cm, one was out of the ground and the remainder had been raised from 0 to 5.5 cm. Geese frequented the vicinity of ES 7–8 in the spring and may have plucked out some of the dowels; however, heaving of the cone targets and other frost-action phenomena on the slope suggest that frost heaving was the primary process responsible for the ejection of the dowels.

Target Line 8

General. Total target movements (fig. 19) are listed in detail in table C IV and are summarized in table V. Of the 29 targets listed, 20 qualified for the select group, and their movement is illustrated by graphs (pl. C 3). There were 18 targets in the "dry" sectors and 11 targets in the "wet", so that the distribution of targets was much better balanced than at ES 7. In the following, the order of discussion follows the same pattern as for ES 6–7.

Jump. The jump totals ranged from 4.8 to 21.9 cm, the mean being 13.3 cm. On the basis of the same criteria used at ES 7, T 18–30 approximately bracketed the generally wettest and most heavily vegetated sector of the line, which was again the part most influenced by lingering snowdrifts, and 55 percent of these targets exceeded the mean jump. Although the maximum jump was in the "wet" sector, there were also high values in the "dry" sectors. This is also reflected by 39 percent of the targets in the latter exceeding the mean for the target line as a whole, and by the mean jump for the "dry" sectors (12.2 cm) approaching that for the "wet" sector (15.1 cm).

Gelifluction. The total recorded gelifluction ranged from 0 to 7.9 cm, the mean being 4.3 cm. The highest value was in the "dry" sectors rather than in the "wet", and 61 percent of the targets in the "dry" sectors but only 55 percent of those in the "wet", exceeded the mean. However, the mean recorded gelifluction for the "wet" sector (4.6 cm) was slightly greater than that for the "dry" sectors (4.1 cm). The probable reasons for the "wet" sector apparently not showing more gelifluction than the rest of the line are discussed later. There was no significant distinction in gelifluction as between 10-cm targets and 20-cm targets in either the "wet" or the "dry" parts of the target line. The 20-cm targets, however, again were more subject to heaving and showed the greater heave (table A III).

Retrograde movement. The total retrograde movement ranged from 1.1 to 4.2 cm. The mean was 2.6 cm. Whereas only 27 percent of the targets in the "wet" sector exceeded this mean, 61 percent of those in the "dry" sectors surpassed it. A related association with dryness is illustrated by the fact that the mean for the "dry" sectors was 2.9 cm, as opposed to 2.0 cm for the "wet" sector. Of the 25 targets that exhibited gelifluction and/or retrograde movement in excess of the means for the line, 76 percent had inverse relationships to each other in showing only one or the other category of movement in excess but not both.

September movement. The range of total September movement was from 0 to 1.4 cm, and the mean for all targets was 0.3 cm. For the "dry" and the "wet" sectors, respectively, the means were 0.2 cm and 0.4 cm.

Annual movement. The summation of the annual movement from late August 1956 to late August 1961, adjusted for any attitude change in 1959–61, ranged from 4.6 to 28.3 cm, the mean being 15.9 cm. Thus, the mean rate was 3.2 cm/yr, the range being from 0.9 to 5.7 cm/yr. The 3.2-cm/yr rate was exceeded by 64 percent of the targets in the "wet" sector and by 44 percent of those in the "dry" sectors, and there was thus much less difference in these percentages than at ES 7. The mean rates for the "dry" and the "wet" sectors, respectively, were 2.9 cm/yr and 3.7 cm/yr, so that here, too, there was much less distinction than at ES 7. Within the respective sectors the rates for the 10-cm targets and the 20-cm targets were practically identical.

The summary equations, in centimeters, are

$$15.9\ T_m = 13.3\ J_m + 4.3\ G_m - 2.6\ R_m + 0.3\ S_m + 0.6\ E_m \qquad (7.1)$$

$$14.3\ T_d = 12.2\ J_d + 4.1\ G_d - 2.9\ R_d + 0.2\ S_d + 0.7\ E_d \qquad (7.2)$$

$$18.5\ T_w = 15.1\ J_w + 4.6\ G_w - 2.0\ R_w + 0.4\ S_w + 0.4\ E_w \qquad (7.3)$$

with equations (7.1), (7.2), (7.3) being, as previously (cf. ES 7), for the target line as a whole, for the "dry" sectors, and for the "wet" sector, respectively. The difference between these sectors has the same trend as at ES 7 but is much less striking.

Frost creep and potential frost creep. As at ES 7, a calculation can be made of the relative importance of true frost creep and potential frost creep. However, the data are more restricted in that the theodolite station was usually so deeply buried beneath a snowdrift during the spring and early summer that it could not be occupied until most of the targets had been exposed from the snow for so long that the possibility of significant gelifluction could be excluded only for the period 26 August 1960–25 August 1961 (table VII). The possibility of some spring frost creep being represented in the downslope movement in May and first half of June 1961 can not be excluded. During the first half of May there were only 0–4 zero-degree cycles recorded at depths of 5–6 cm by soil thermographs 8B–8C, which were in snow-free places, but there were 15 zero-degree cycles (and 8–12 cycles having a minimum amplitude of 1°) at these same spots from mid May to mid June (table B I), and some targets (T 3–4, 6–16) showed a pronounced slackening or cessation of movement after mid June. However, these targets were in a sector that tended to dry early. Also, there were almost certainly fewer zero-degree cycles at a depth of 20 cm than 5 cm, and the discussion of frost creep in the introductory evaluation of target data, and the similarity in movement of 10-cm and of 20-cm targets, suggest that the contribution from spring frost creep was minimal. This conclusion is supported by (1) the fact that most targets (T 4, 7–21, 23, 25) in 1960–61 had a downslope rate from 30 May to 8 June, when there were only 0–3 zero-degree cycles recorded at depths of 5–12 cm at TG 8B–8D, that was similar to, or greater than, the rate from mid May to June when there were 13–15 cycles at the same places, and (2) the fact that the rate of some targets (T 15, 17–25, 28–30) after mid June, when zero-degree cycles were no longer recorded at any of the thermographs, was not significantly less and in several cases greater than their earlier rate. The effect of any creep due to wetting and drying was clearly minimal, for there was only one period of precipitation when movement was prominent and this was before the ground had begun to dry appreciably. Therefore the downslope movement after the jump is treated as gelifluction and the jump is regarded as incorporating all the potential frost creep.

The method followed in the analysis (table VII) is identical to that for the comparable calculations at ES 7. Fifteen targets meet the required conditions of stability and dates of exposure; 8 targets were in the eastern "dry" sector and 7 in the "wet" sector, so that as at ES 7 the western "dry" sector is unrepresented in the 1960–61 control period. The larger sample of targets in the "wet" sector here than at ES 7 is helpful. Again there was good agreement between the movement of adjacent targets – for example T 8–9, 13–15, and 28–29, which included both 10-cm and 20-cm targets.

The proportion of potential frost creep to retrograde movement for the 1960–61 period is 3.0:1 and 3.7:1 for the "dry" and the "wet" sectors, respectively. The rough similarity of proportions, in spite of different movement amounts, is again evidence that retrograde movement increases proportionately with ground heaving and is related to it.

The proportion of true frost creep to potential frost creep for the same period is 0.7:1 for both the "dry" and the "wet" sectors. For the 5-year period the jump in summary equation (7.2) gives the maximum potential frost creep in the "dry" sectors; the true frost creep is the sum of the jump (12.2 cm) and the retrograde movement (–2.9 cm), or 9.3 cm. The proportion of frost creep to potential frost creep for the "dry" sectors is thus 9.3:12.2 or 0.8:1. For the "wet" sector, the comparable figures from summary equation (7.3) are jump 15.1 cm, retrograde movement −2.0 cm, and therefore a proportion of true frost creep to potential frost creep of 13.1:15.1, or 0.9:1. The close correspondence between all these proportions is striking and justifies the conclusion that for the 5-year period the true frost creep at ES 8 was some 70–80 percent of the potential frost creep in the "dry" sectors, and 70–90 percent in the "wet" sector, with the lower percentages being the more probable in view of the fact that the higher are based on the summary equations and represent maxima. (Cf. discussion of ES 7.)

Frost creep and gelifluction. For the 1960–61 period the proportion of frost creep (true frost creep) to gelifluction in the "dry" sector is 0.4:1, and in the "wet", 0.7:1 (table VII). On this basis frost creep was subordinate to gelifluction in both sectors. However, the possibility cannot be excluded that some frost creep due to spring freeze-thaw cycles is included in the gelifluction figures, although the amount if any is believed to be minor. Taking the extreme case and calculating all the movement in May 1961 as frost creep, the proportion in the "dry" sector is 0.9:1 and in the "wet", 1.1:1. Taking the more probable 0.4:1 and 0.7:1 proportions, there was less frost creep in the "dry" part than in the "wet", as expectable. The "dry" part, however, showed as much gelifluction, the mean proportion of frost creep to gelifluction for the "dry" and the "wet" sectors, respectively, being 0.9:2.5 and 1.6:2.2 before reducing the denominators to unity. (The difference between the denominators is too small to be significant.) Probably the gelifluction was particularly high in the 1960–61 period, in part because of early exposure of the targets to thaw water from the slope above, in part because of the rain of 2–4 June (39.6 mm). The probable explanation for the similarity in denominators is similarity in length of exposure of the targets (table B V) and the fact that the targets in the eastern "dry" sector were on a generally steeper gradient (by up to 3°) than the targets in the "wet" sector, so that during comparable times of intense saturation, the targets in the "dry" sector tended to move a little farther. This would tend to offset the stabilizing effect of earlier moisture reduction in the "dry" sector while the "wet" sector was still subject to gelifluction. As explained earlier, both sectors can be equally saturated during the intense spring thaw, but commonly the one tended to dry out sooner than the other, so that moisture differences became apparent.

From equation (7.2) for the "dry" sectors, the proportion represented by sum of the jump (12.2 cm) and retrograde movement (−2.9 cm) to the gelifluction (4.1 cm) for the 5-year observation period is 2.3:1. From summary equation (7.3) for the "wet" part, the proportion represented by sum of the jump (15.1 cm) and retrograde movement (−2.0 cm) to the gelifluction (4.6 cm) is 2.8:1. Comparison of these proportions with the proportion of frost creep to gelifluction for the 1960–61 period strongly suggests that the amount of gelifluction included in the jump is considerable.

Weather influences. In 1957 only 14 percent (4 of 29) of the targets listed in table C IV showed a downslope movement, normal to the target line, exceeding 0.2 cm from 7–24 September (T 18–19, 22–23). In addition 14 of the remaining 25 targets, and the mass-wastingmeter, suggested a September movement by lesser amounts or by appreciable changes of trend. Beginning with 4 September the minimum temperatures indicated by the background graphs were consistently below 0°, and precipitation in September was negligible. Thus, 62 percent (18 of 29) of the targets suggested movement by frost creep during September. It is probably significant that the only targets that exhibited appreciable movement then were located in the "wet" sector, where ground heaving would have been most prominent. In September 1958 none of the targets (with the doubtful exceptions of T 4, 32) showed downslope movement up to the 17th when the last observations were made. The mean temperature for the period was appreciably greater (by 1.4° for the first 18 days of September) than for the same period in 1957 and there was also greater precipitation. There were no September observations in 1959. The September movement in 1960 (to 3 October) was marked in that 45 percent (13 of 29) of the targets showed downslope movement exceeding 0.2 cm (T 4, 7–8, 10, 12, 15, 18–20, 22, 31–32, 34), and 13 of the remaining 16 targets suggested a lesser movement. By far the most prominent movement came at the end of the month when temperatures were lowest and precipitation least.

Summer precipitation was considerable in 1959, 1960, and 1961. In 1959 it was concentrated in the period 31 July–11 August. The closest target observation dates were 24 July and 4 August; the next was not until 21 August. From 31 July through 3 August, the precipitation was 17.1 mm, the bulk of it on 1 August (12.7 mm). Between 24 July and 4 August, a fourth (7 of 28) of the targets in table C IV (T 19 was excluded for lack of data) suggested a sharp reversal from retrograde to downslope movement (T 3–4, 7, 13, 17, 24), and a number of others were consistent with increased downslope movement. Except for T 3–4, however, the movements did not exceed 0.2 cm (as expectable in view of the short time span involved), and the suggested correlation is very tenuous. The summer precipitation in 1960 was the most concentrated of the 5-year period and was more definite in its effects than any other. From 24 July to 2 August there was an accumulation of 54.3 mm. The target dates most closely associated with this period were 29 July and 7 August. Between these dates and excluding T 32–34, which emerged from the snow too late to be considered, about one quarter (6 of 26) of the targets in table C IV showed a marked change in trend and an increase in movement exceeding 0.2 cm (T 3, 17, 22–23, 28–29). Of the remaining targets, all except T 10 showed a similar although lesser movement or, in a few instances, a decrease of retrograde movement. Thus the movement of 96 percent (25 of 26) of the targets could be correlated with the precipitation if movements of less than 0.25 cm are regarded as significant. Again it must be admitted that such small amounts are within the limits of error, but somewhat larger movements point in the same direction and the high percent of correlation is impressive. As in other cases of short time intervals at ES 7–8, only slight movement would be expectable. In 1961 there were 39.6 mm of rain from 2–4 June, 38.8 mm of it being on 3–4 June. It fell while the slope was saturated from melting snow on the slope above (including the area of ES 7, which was still buried), and the targets did not show a general pronounced quickening of movement. Rather the effect seems to have favored a continued high rate of movement that resulted in greater than average gelifluction, especially in the "dry" sectors, as compared with other years.

8. EXPERIMENTAL SITE 15

Description

General

Experimental site 15 was a small gelifluction lobe near the crest of the Nyhavn slope on which ES 7–8 were located (pl. 1, fig. 9). The material was less stony here than on much of the slope. The general gradient in the vicinity was 4°. The lobe (figs. 28–30) extended about 6 m up-and-downslope and was about 2 m wide near its lower end. Near the upper end it had a prominent arm extending south. The lobe front was some 8 cm high and had a gradient of 12°–14°. The tread had a gradient of 3°. The front was banked by vegetation, and in most places vegetation surrounded the lobe, but the tread was bare except for several small islands of vegetation. The lobe lay in the domain of a snowdrift and along the main line of seepage from it during the thaw season after the lobe emerged from beneath the drift. The exact position and size of the drift varied considerably from year to year, and in some years the drift supplied enough meltwater to keep the lobe saturated most of the summer (table F IV).

Instrumentation

Two lines of dowels were set out in a cross pattern, one line being up-and-downslope along the axis of the lobe (20° line) and the other transverse (113° line). The dowels were aligned along a string between wood end posts, which were driven as deeply as possible, ranging in depth from some 40 to 85 cm. Since they were not in permafrost, only relative movement could be recorded as at most of the dowel installations. The spacing and depth of insertion of the dowels was 10 cm except in a few places where a stone interfered. Details are given by figure 28. The installation was made on 28 July 1957 and abandoned on 20 June 1960.

To depths of 5–10 cm the central area of the lobe tread consisted of clayey-gravelly-sandy silt with 53–54 percent fines; the central area of the front was somewhat coarser grained, ranging from clayey-gravelly-

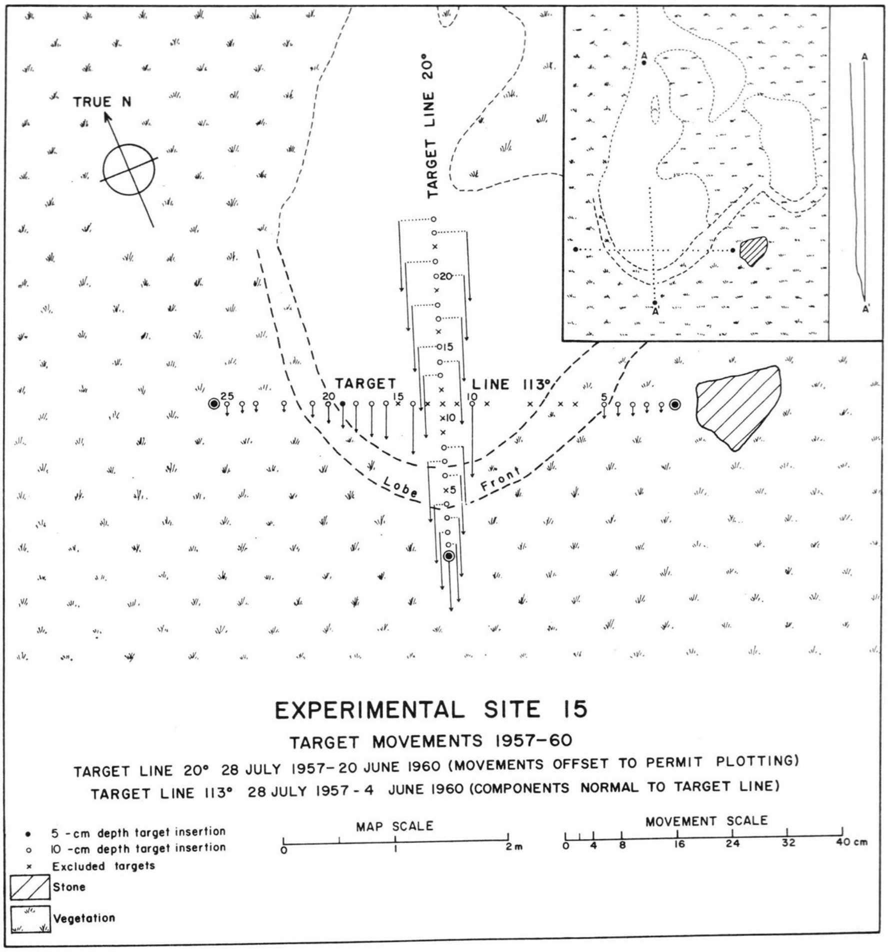

Fig. 28.

sand-silt with 47 percent fines to gravelly-sandy silt with 44 percent fines (pl. D 8, table D IV). For the 4 specimens analyzed, the liquid limit ranged from 15 to 17 percent moisture; the plastic limit, from 11 to 12 percent moisture.

Instrumental Data

Following establishment of ES 15 on 28 July 1957, comparative observations were attempted on several occasions but, since the dowels could not be closely approached without disturbance, the movements could only be estimated. Inconsistencies showed that these estimates were unreliable, and only the final observations involving actual measure-

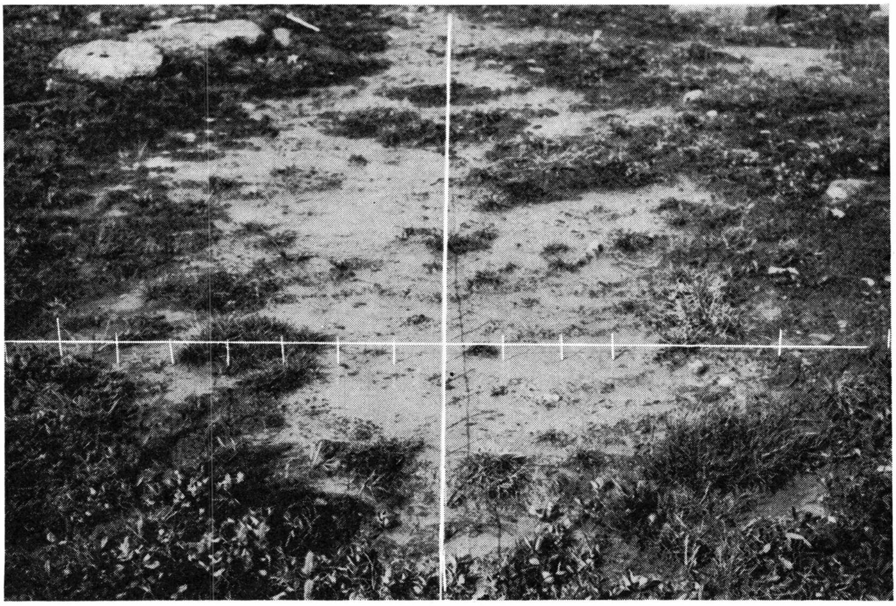

Fig. 29. Experimental site 15. View upslope along target line 20° on 28 July 1957 when line was established. (Cf. fig. 28.)

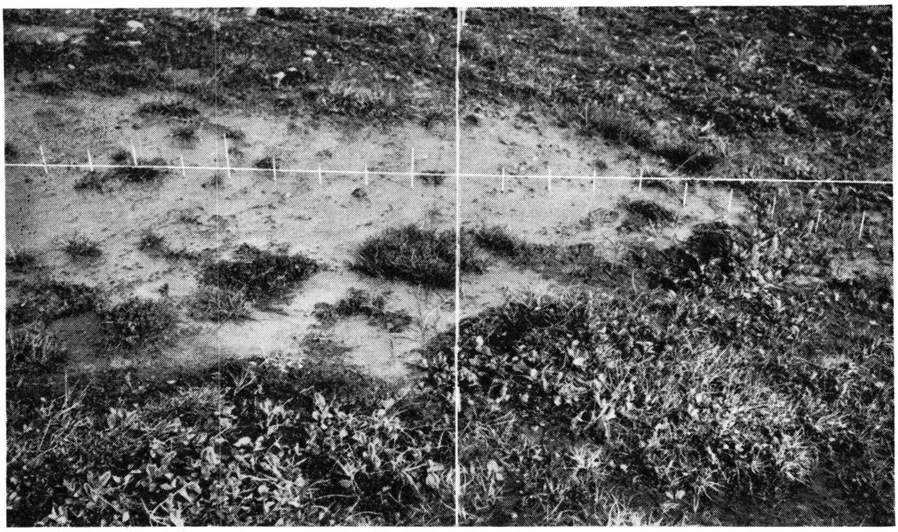

Fig. 30. Experimental site 15. View east-southeast along target line 113° on 28 July 1957 when line was established. (Cf. fig. 28.)

ments are reported (fig. 28, table C VI); the measurements are believed to be accurate to ±0.2 cm for the transverse line and ±1 cm for the axial line. By the time of the final reading a number of dowels had heaved out of the ground and most of the others had developed a downslope tilt.

Fig. 31. Experimental site 15. View east-southeast on 4 June 1960 showing downslope displacement and tilt of dowels along target line 20°. (Cf. fig. 30.)

As indicated by figure 28, the dowels in the transverse line (113° line) had developed a bow-shaped alignment convex downslope, the maximum relative movement being in the center and amounting to 10.5 cm. From the center it decreased rather regularly toward the margins of the lobe (table C VI). The maximum movement was 3.7 cm/yr; the mean rate was 1.0 cm/yr.

In the axial line (20° line) the top dowels were deflected toward the south arm of the lobe and showed a component of movement normal to the line of as much as 15 cm. Shallow grooves left on the bare ground by running water, and the proximity to the lingering snowdrift showed that this part of the target line was particularly wet and subject to flow. Not only had the individual dowels moved but islands of vegetation had moved downslope as units, although by exactly how much is not known. These movements were rather shallow as indicated by the comparative stability of the end post. The major changes are suggested by a comparison of figures 29 and 32. Because so many dowels were missing and the movements large, targets in the upper sector could not be positively identified with respect to their point of origin, and further consideration of this sector is omitted. The movement along the remainder of the up-and-downslope line was determined by taping the inter-dowel distances and comparing them with the original 10-cm separations. It was then assumed that T 13, the dowel closest to the transverse line, had moved an amount similar to the mean (8.8 cm) of T 10 and 14 of that line, which were originally equally spaced on either side of the axial line. Calculated on this basis, the movement along the axial line showed a regular decrease downslope toward the lobe front from a total of 10.1 cm at T 24 to 7.9 cm at the lower end post. This region of movement included a small patch of vegetation at T 18 and vegetation at the front.

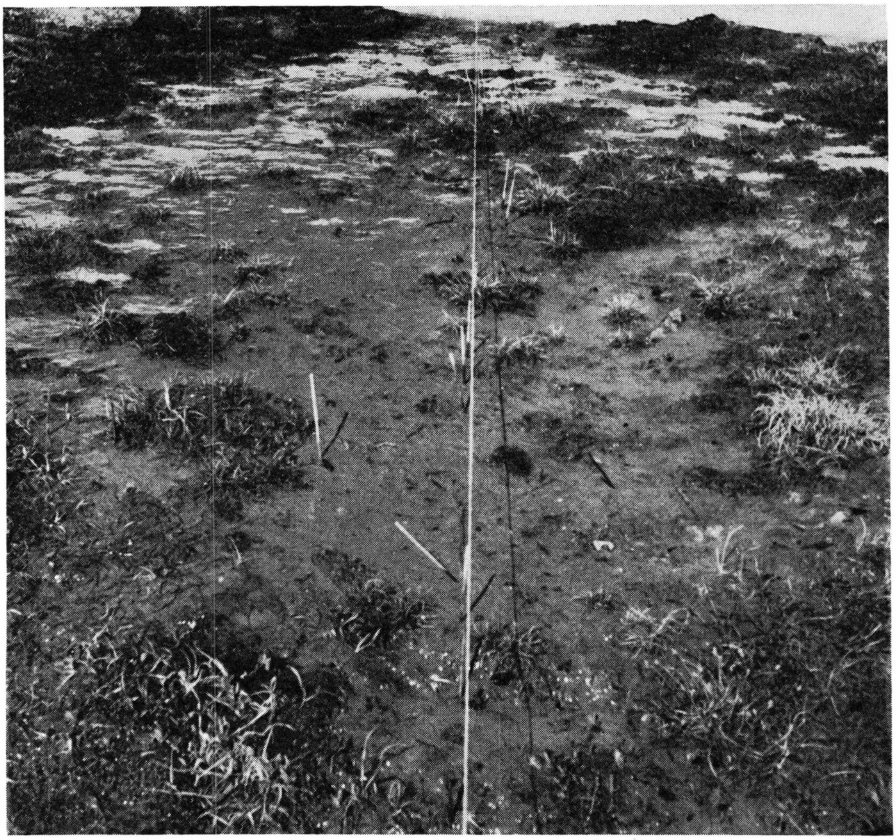

Fig. 32. Experimental site 15. View upslope on 20 June 1960 showing lateral displacement of dowels along target line 20°. The dowels by vegetation at left belong to target line 113°. Cf. figs. 28–29).

The mean rate was 3.1 cm/yr, exclusive of the end post. The fact that the movement was near the axis of the lobe may explain why the lower end post moved with respect to the end posts for the transverse line. Again it must be emphasized that these movements were relative only; the absolute movements were surely somewhat greater.

Dowel heaving varied considerably, the observed amount ranging from 0 to 9.0 cm, but very probably a number of dowels that were missing had been heaved out of the ground and thus implied a heave of 10 cm. In general the heave was least where there was vegetation. This tendency prevailed not only along the vegetated border of the lobe but also in a small patch of vegetation along the axis at T 18, where the dowel heave was but 2.5 cm as contrasted with 7 and 7.5 cm in adjacent bare areas.

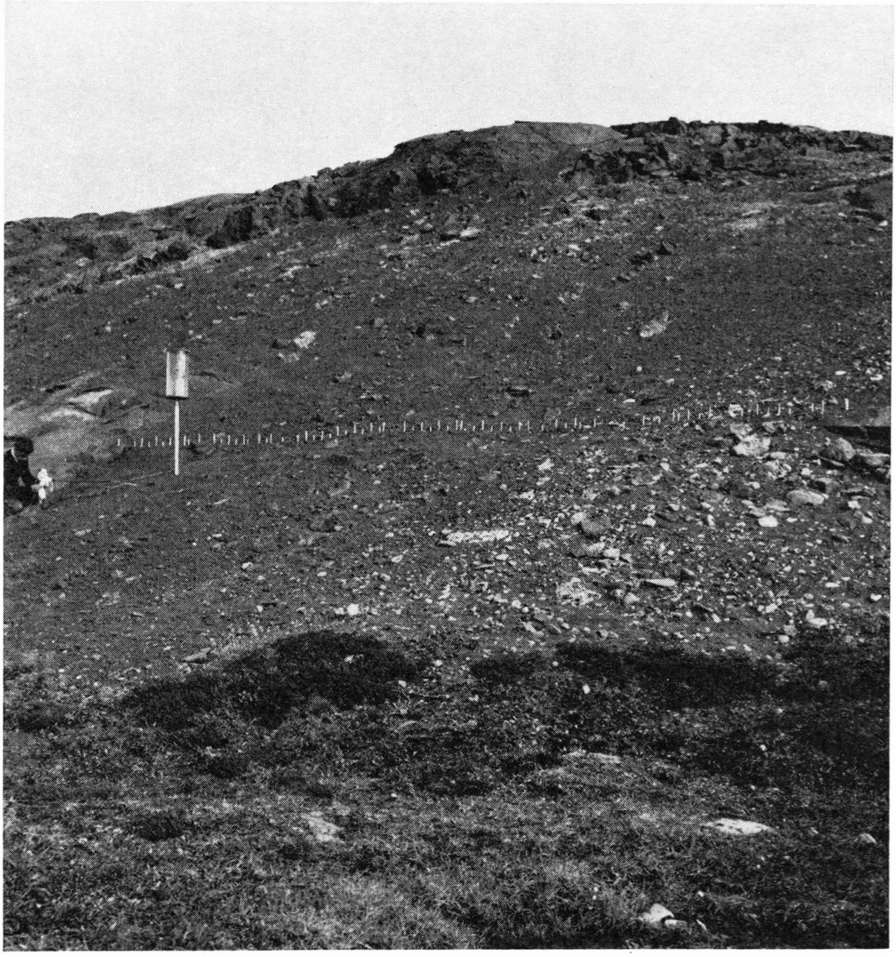

Fig. 33. Experimental site 16. View northeast diagonally upslope. Target line 16 extends between trap outcrops in middle ground; mass-wastingmeter 16 below it at left. (22 Aug. 1957.)

9. EXPERIMENTAL SITE 16

Description

General

Experimental site 16 was in the Nyhavn hills near ES 15. It lay between the 100-m and 110-m contours just west of the crest of trap knob MS 112 m (pl. 1). The slope (fig. 33) forms the east side of a small dell and has a gradient range of 22° to 29° along the line; the average is 25° for those portions of the slope that encompassed the accepted targets in 1960, or 24° for the accepted targets in 1961. The regolith here con-

Fig. 34. Experimental site 16. Trap grus encroaching on vegetation at base of slope. Scale given by 16-cm rule. (29 July 1957.)

sists dominantly of trap grus forming a gravelly sand, interrupted by small outcrops of coarse-grained trap bedrock. The thickness of the regolith ranged from a feather edge where it met the bedrock to a maximum measured thickness of 91 cm in the excavation for the mass-wastingmeter and the thermocouple string. An estimated 75 percent of the surface consisted of grus up to 4 mm in diameter, about 15 percent of pebble-size material, and the remainder of cobbles and a few small boulders. Most of the cobbles and boulders were erratics. As at ES 7–8, the surface material tended to be coarser than the underlying material, which was notably lacking in fines (pl. D 9, table D V). The excavation for the mass-wastingmeter showed the regolith to be characterized by a faint crude stratification parallel to the slope. An important characteristic of this and other grus slopes is the permeability and dryness. The snow cover tended to disappear from the upper part of the slope first, and the surface grus here could be quite dry while snow was still present a meter or so lower down the slope. That desiccation could extend to considerable depth is shown by the moisture determinations (table F V. In the table the relatively high moisture shown for the top 3 cm reflected recent precipitation). The grus slope was completely bare except for a few scattered bits of vegetation (*Dryas*, *Vaccinium*, *Carex*, *Epilobium*, *Salix*), but along the flat bottom of the dell there was a fairly continuous shrub tundra. In places along the boundary between the bare grus and this shrub tundra the grus overlay the vegetation and was obviously encroaching on it (fig. 34).

Instrumentation

Target line 16. Target line 16 (fig. 35–36) was laid out on an azimuth of 353°, parallel to the contour, between two outcrops of trap. Originally it contained 68 dowels aligned along two thin wires, one vertically above the other, strung between wood end posts firmly seated in holes chiseled into the bedrock. The double wires were employed in order to assure a vertical orientation of the dowels, which was difficult to achieve with a single string or wire because of the steepness of the grus slope. With few exceptions the dowels were spaced 10 cm apart and to alternating depths of 5 and 10 cm, the exceptions being due to interference by stones. Details of spacing and depth of insertion are given by fig. 35. The target line was established on 17 August 1957 and attempts were made to measure displacements from year to year. However, the line was too long to permit reliable identification of individual dowels until 29 May 1960 when firm snow just below the line permitted a close enough approach to the dowels to make direct measurements to ±0.2 cm without disturbing the grus. In previous years the snow was too far from the line when the site could be first visited to allow this procedure, but repeated sighting along the target line clearly indicated that the movement was progressive. The next direct measurements were on 18 August 1961 when the line was abandoned and disturbance of the slope was no longer a factor, although care was taken in measuring dowels not to disturb adjacent ones. In a few instances fox or hare tracks adjacent to dowels that showed attitude changes suggested that certain dowels had been disturbed. However, since these dowels were commonly among the missing at the time of the final tabulation, it is improbable that disturbance by animals significantly affected the tabulated movements.

Near the center of the target line and 1 m downslope from it the grus ranged from sandy gravel at a depth of 1 cm to a silty-gravelly sand at a depth of 10–20 cm. The content of fines ranged from 1 percent at a depth of 1 cm to 15 percent at a depth of 10 cm, but decreased to 2–8 percent at a depth of 20 cm (pl. D 9, table D V). All specimens were nonplastic.

Mass-wastingmeter 16. MW 16 was 90 cm downslope from the target line near its north end (fig. 35–36). The base of the pipe rested

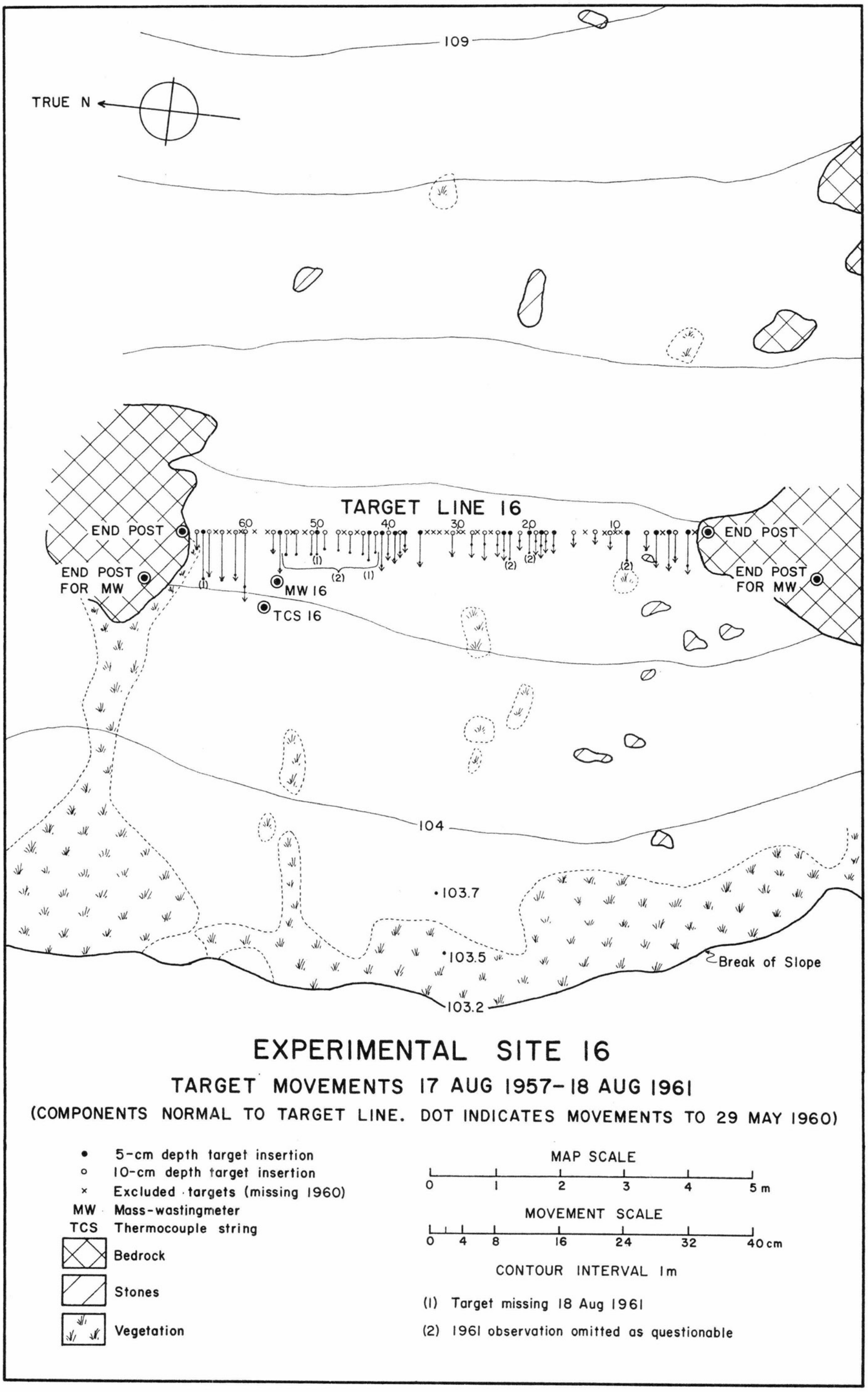
109
TRUE N
TARGET LINE 16
60
50
40
30
20
10
END POST
END POST FOR MW
MW 16
TCS 16
(1)
(2)
104
103.7
103.5
103.2
Break of Slope
EXPERIMENTAL SITE 16
TARGET MOVEMENTS 17 AUG 1957–18 AUG 1961
(COMPONENTS NORMAL TO TARGET LINE. DOT INDICATES MOVEMENTS TO 29 MAY 1960)
• 5-cm depth target insertion
o 10-cm depth target insertion
× Excluded targets (missing 1960)
MW Mass-wastingmeter
TCS Thermocouple string
Bedrock
Stones
Vegetation
MAP SCALE
0 1 2 3 4 5 m
MOVEMENT SCALE
0 4 8 16 24 32 40 cm
CONTOUR INTERVAL 1 m
(1) Target missing 18 Aug 1961
(2) 1961 observation omitted as questionable

Fig. 35.

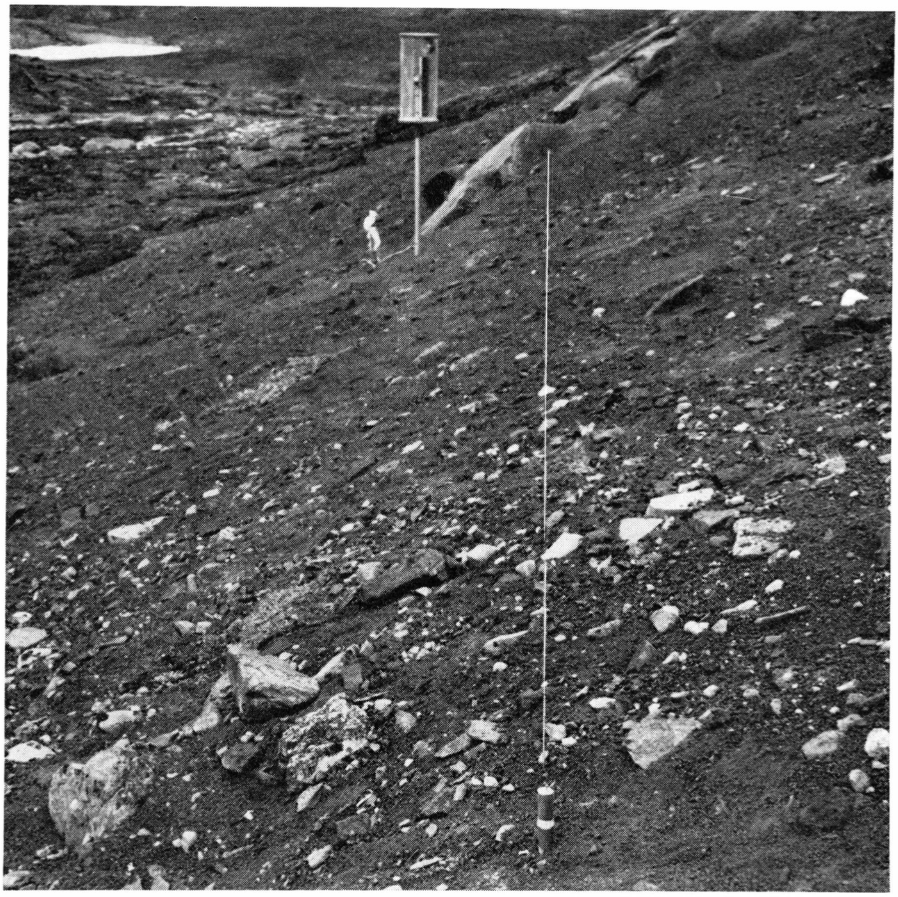

Fig. 36. Experimental site 16. View 353° along target line 16 on 17 Aug. 1957 when line was established. Mass-wastingmeter 16 below target line at left. Scale given by fig. 35.

on bedrock at a depth of 86 cm, and the instrument was aligned between reference points on the bedrock outcrops at the ends of the target line so that any displacement could be measured. Three bricks were connected by wires through holes in the pipe of the instrument to the dials in the above-ground portion, as described in appendix C. The top brick lay flat with its longest dimension parallel to the contour; its base was 2 cm beneath the surface of the grus so that the point of attachment of the wire was flush with the surface. The intermediate brick was at a depth of 23 cm, and the lowest brick at a depth of 55 cm, measured at the wires; both these bricks were oriented with their longest dimension vertical. The installation was made on 15 August 1957 prior to the establishment of target line 16; the observations were terminated and the bricks excavated on 4 August 1959 when it was thought that the Mesters Vig program would be concluded in that year. The effect, if any, of the emplacement and removal of the mass-wastingmeter on the stability of the slope above was negligible. Grus along the position of the target line was not disturbed during the emplacement and the writer understands that great care was also taken during the removal. In any event the lack of appreciable difference between the behavior of the dowels immediately above the position of mass-wastingmeter 16 and of those remote from it proves that any effect was negligible.

Thermocouple string 16 and thermometers. TCS 16 was installed 40 cm downslope from the pipe of MW 16 and 20 cm farther north. The leads were close enough to the bedrock outcrop at the north end of target line 16 so that the thermocouples could be read without treading on the grus slope. The grus in which the thermocouple string was placed was similar in all respects to that along the target line and was equally bare of vegetation. The string reached to within 1 cm of bedrock, which was at a depth of 91 cm at this point. No frozen ground was encountered at the time of installation (15 August 1957). Because a number of the leads had been broken (probably chewed) between the last readings in 1957 and the first in 1958, soil thermometers reading directly to 0.2° were employed in 1958 and 1959 to obtain temperatures at 5-cm intervals between depths of 5 and 25 cm. The thermometers were between TCS 16 and the nearby bedrock outcrop, and so far as possible they were left at the required depths between readings in order to avoid disturbing the grus. Surface temperatures were read with an ordinary thermometer having an accuracy of ±1°.

Instrumental Data

Thermocouple String 16 and Thermometers

The earliest spring observations were on 23 and 28 May 1958 when thawing had already reached a depth of 25–30 cm. Ground temperatures increased to mid or late July when the trend reversed, although plus temperatures prevailed throughout the profile as late as mid September (table E IV). High surface temperatures during sunny spells were characteristic and were aided by the dark color and bareness of the grus slope. The maximum recorded was 38°, 30° higher than the maximum air temperature at the government station on the same day (9 June 1958). A surface increase of 10° in 1.5 hours diminished to an increase of 3° at a depth of 10 cm and of 0.1° at a depth of 25 cm (9 July 1958).

Mass-wastingmeter 16

The data from MW 16 are of value in indicating that any downslope movement at depth is very small. The dial readings for the two years of observation showed no movement exceeding a fraction of a centimeter, and careful measurements of brick positions and of the mass-wastingmeter pipe at the time of excavation confirmed that movements, if any, did not exceed 1.5 cm and were probably within the limits of error in comparing initial and final brick positions. The fact that the wires to the bricks were not deformed as at the other sites where mass-wastingmeters had been installed also indicated relative stability at depth. Although the pipe had developed a slight downslope tilt, it did not exceed 1°. As compared with dowel movements, the immobility of the surface brick was probably due to the fact that the attached wire was under tension, which would have had no effect on a brick firmly gripped at depth but could have inhibited movement of the surface brick.

Target Line 16

Total dowel movements (fig. 35) are listed in detail in table C VII. A number of dowels were missing when the direct measurements were made, and since earlier observations were largely estimates, these dowels are excluded from table C VII. Disturbance by animals was one reason for a dowel being missing from its original position, but probably a minor one judging from the scarcity of tracks. Other causes probably include frost heaving, pressure of overlying snow, and wind. That frost action was not absent in spite of the few fines and generally low moisture in the grus, was indicated by the obvious heaving of some dowels and by other evidence of frost action in nearby grus. The measurements in table C VII refer to the base of a dowel at ground level.

As might be suspected, the dowels that had been inserted to the 10-cm depth tended to remain standing longer than the shallower dowels. When the final observations were made, about 40 percent of the 5-cm group remained as compared with almost 90 percent of the 10-cm group (table C VII).

All the dowels showed movement and most developed a downslope tilt (fig. 37). Adjacent dowels were commonly consistent in the general magnitude of their movement downslope, so that a certain regularity appeared in spite of inconsistencies. Thus the greatest movement was near the north end of the target line where the slope was steepest. For the 2.8 years of record to 29 May 1960, the total movement ranged from 0.9 to 8.2 cm, the mean for all dowels being 3.1 cm; the mean rate was

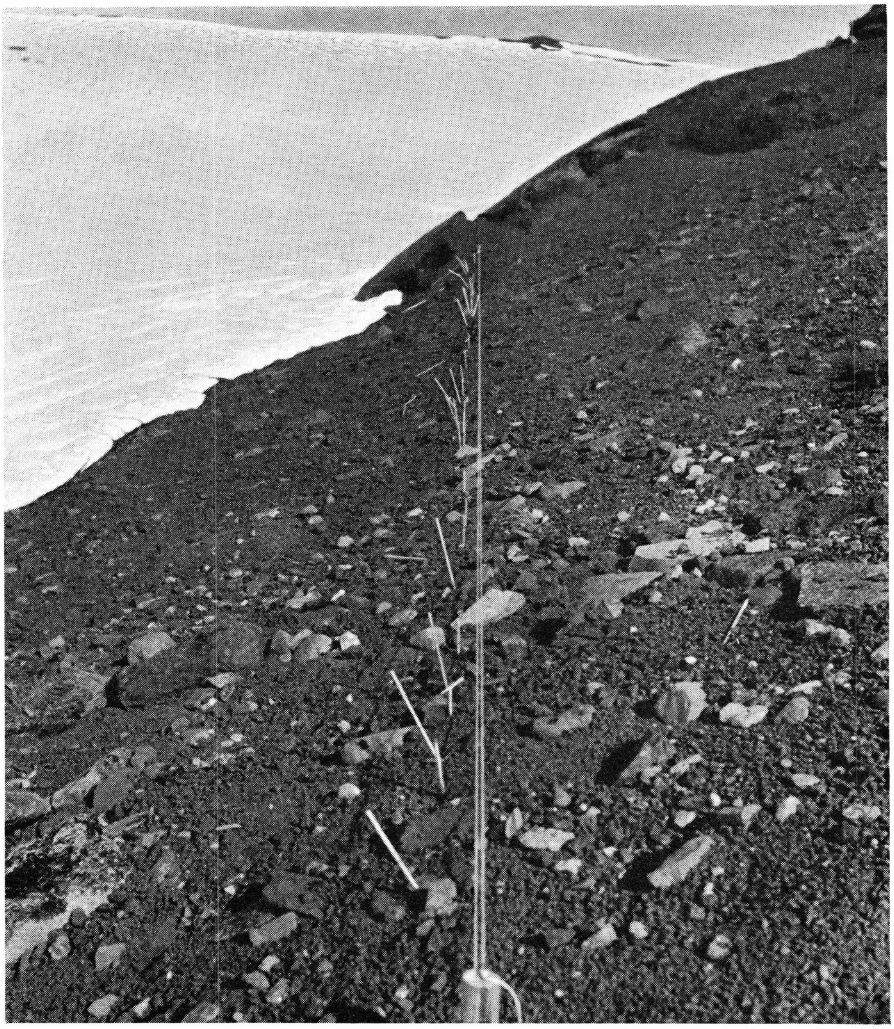

Fig. 37. Experimental site 16. View 353° along target line 16 on 31 May 1960 showing displacement and tilt of dowels. (Cf. figs. 35–36.)

1.1 cm/yr (table C VII). For this same period the dowels at the 5-cm depth tended to move farther than those at the 10-cm depth, the respective means being 3.4 cm and 2.9 cm; the mean rate of movement for the dowels at the 5-cm depth was 1.2 cm/yr; for those at the 10-cm depth, 1.1 cm/yr. For the 4 years of record to 18 August 1961, the total movement ranged from 1.4 to 10.0 cm, the mean being 3.7 cm, and the mean rate 0.9 cm/yr. There was no difference in movement of the 5-cm and the 10-cm dowels, the mean rate being 0.9 cm for both.

Summary

In summary it can be said that for this slope of 22°–29°, characterized by loose grus with few fines and low moisture, (1) there is but little disturbance at depth, (2) the rate of movement in the top 5 cm is about the same as at a depth of 10 cm, (3) the mean rate is about 1 cm/yr, (4) this rate is much less than where gelifluction is demonstrably active in saturated material on slopes considerably less steep. As discussed later in comparing the data from the various sites, it is probable that mass-wasting at ES 16 is largely by creep.

10. EXPERIMENTAL SITE 17

Description

General

Experimental site 17 was a large gelifluction lobe on the east slope of Hesteskoen at an altitude of about 750 m (pl. 1). The general appearance of the lobe is illustrated by figs. 38–41. The material is a very stony diamicton, mainly a clayey-silty-gravelly sand, probably partly till and partly local debris frost wedged from the sandstone bedrock. As at the other experimental sites, the diamicton tends to be coarsest in the top several centimeters (pl. D 10, table D VI). Pebbles and cobbles are very common (figs. 40–41) and isolated small boulders dot the surface of the tread. The slopes adjacent to the lobe are even more stony at the surface; the area immediately downslope from the front, for instance, exhibits mainly cobbles (fig. 39).

The gradient in the immediate vicinity of the lobe ranges from 15° to 23°. The lobe front was up to 3 m high; in places it had an angle exceeding 45° and very locally was almost vertical. The angle of the tread was consistently about 12°. The maximum width of the lobe was about 20 m and the maximum length up and down the slope some 30 m, although exact limits were difficult to define except at the front. Snow conditions in the vicinity of the lobe were quite variable, but massive drifting was common. In 1956 there was no snow near the lobe on 21 July; in 1957 none on 5 August; in 1958 none (at least on the lobe) on 16 July; and in 1959 none on 12 July; however, in 1960 the lobe was completely covered on 6 June and probably considerably later, and had snow patches within 10 m as late as 29 August. Whenever the lobe was visited in July or August the axial area of the tread was either very damp or saturated, and trickles of water were noted on several occasions. Moisture determinations are given in table F VI. Vegetation was sparse except on the front and lateral margins of the lobe near the front where grasses, sedges, willows and heaths formed a rather dense cover. Some 22 species of vascular plants were seen on the tread, all of them scattered or in small patches. Adjacent to the lobe the ground was even more bare, being completely free of vegetation over considerable stretches.

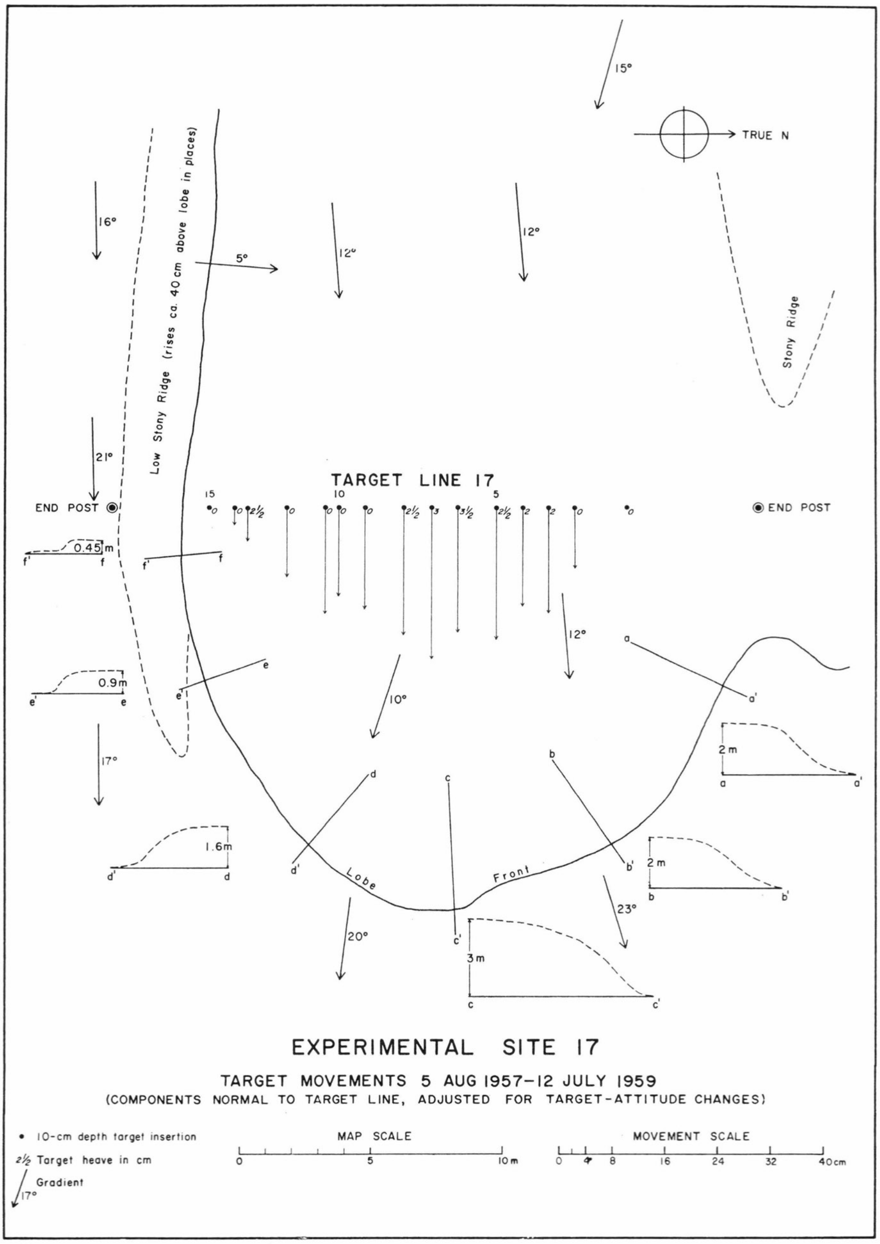
15°
TRUE N
16°
Low Stony Ridge (rises ca. 40 cm above lobe in places)
5°
12°
12°
Stony Ridge
21°
TARGET LINE 17
15
10
5
END POST
END POST
0
0
2½
0
0
0
0
2½
3
3½
2½
2
2
0
0
0.45 m
f'
f
f'
f
12°
a
a'
0.9 m
e'
e
e'
e
10°
2 m
a
a'
17°
b
d
c
1.6 m
d'
d
d'
2 m
b'
b
b'
Lobe
Front
23°
20°
c'
3 m
c
c'
EXPERIMENTAL SITE 17
TARGET MOVEMENTS 5 AUG 1957–12 JULY 1959
(COMPONENTS NORMAL TO TARGET LINE, ADJUSTED FOR TARGET-ATTITUDE CHANGES)
• 10-cm depth target insertion
2½ Target heave in cm
Gradient
17°
MAP SCALE
0
5
10 m
MOVEMENT SCALE
0
4
8
16
24
32
40 cm

Fig. 38.

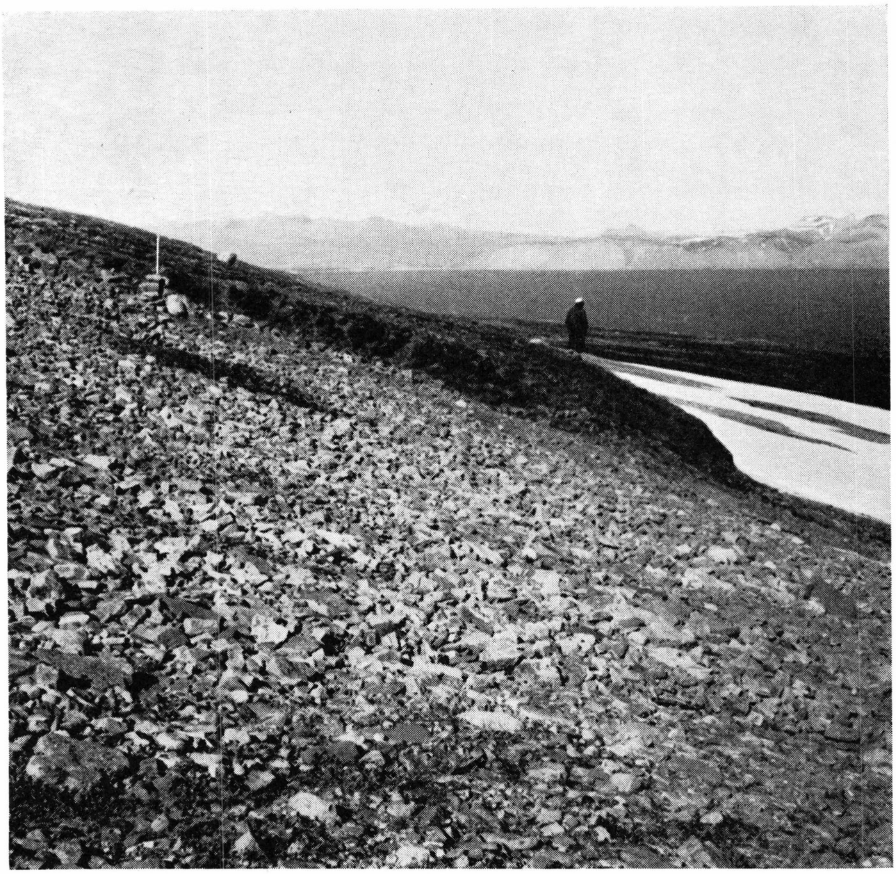

Fig. 39. Experimental site 17, east slope of Hesteskoen. View north; Kong Oscars Fjord in background. (5 Aug. 1957.)

Instrumentation

A target line of 15 cone targets was established on the tread parallel to the contour. (A line at right angles was also established but is disregarded because of unreliable data.) The targets were inserted to a uniform depth of 10 cm but the spacing was somewhat irregular because of stones; these and other details are illustrated by fig. 38. The end points were wood posts beyond the tread, held in place by pyramids of stones since the material here was too stony to permit the posts being driven into the ground. The end points were therefore subject to mass-wasting and provided a framework against which only relative, and therefore minimum, target movement could be measured. The targets were set out, as nearly vertical as possible by eye, along a string between the end points. Resurveys included measurement of tilt, and the move-

Fig. 40. Experimental site 17, east slope of Hesteskoen. View south. (5 Aug. 1957.)

ments (table C VIII) are adjusted for attitude changes on the basis that there was no tilt initially. Since the adjustment reduced the observed movements (mean decrease 9 percent) the result is again minimum. The line was established on 5 August 1957 and the concluding measurements were made on 12 July 1959.

Two meters downslope from T 14 the diamicton was a clayey-silty-gravelly sand to a clayey-gravelly-silty sand; the content of fines ranged from 24 percent at a depth of 1 cm to 34 percent at a depth of 5 cm, and was 31–33 percent at depths of 10 to 45 cm (pl. D 10, table D VI). Consistent with this similarity in the 5 specimens analyzed, the liquid limit was consistently 19–20 percent moisture, and the plastic limit 14–16 percent moisture.

Fig. 41. Experimental site 17, east slope of Hesteskoen. View 1° along target line 17 on 5 Aug. 1957 when line was established.

Instrumental Data

For the two-year period the downslope target movement ranged from −2.6 cm next to the borders to 23.5 cm at the axis (fig. 38, table C VIII. The nonadjusted movements were measured to the closest 0.5 cm). The mean rate was 7.6 cm/yr. The negative movement of 2.6 cm next to the borders may have been due to slight downslope tilting of the end posts, in which event all the movements would have been reduced by a similar amount. The possibility of shearing effects introducing a slight "back eddy" seems unlikely. However, in view of the uncertainties the negative movement is omitted from the means. In any event the target movements are minimum only as previously discussed. The increase in movement toward the axis was fairly regular and, as at ES 15, led to the targets assuming a bow-shaped alignment convex downslope (figs. 38, 42).

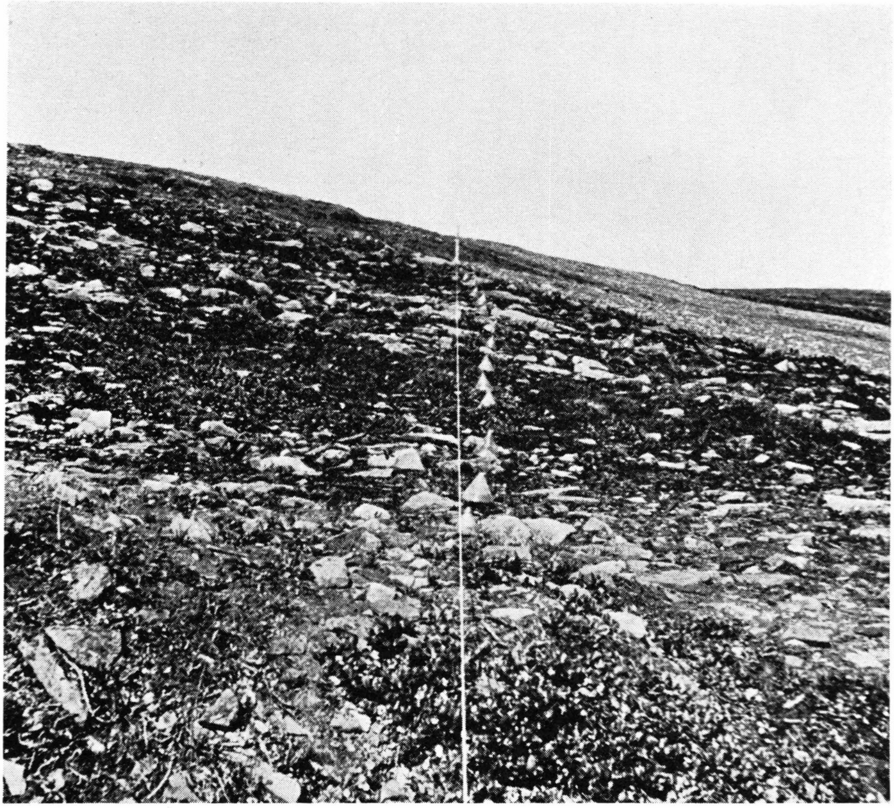

Fig. 42.

The rate of movement at the axial point, 12.4 cm/yr, was the highest measured in the Mesters Vig district, about twice that of any target at ES 7–8 where the content of fines in the diamicton was greater and the gradient was similar. Taking the gradient as 12°, the thickness of the lobe as 3 m (the maximum height of the front), and applying the formula used by Wahrhaftig and Cox (1959, p. 405), cited on p. 24, the rate would be 1.0 cm/yr. On this basis any movement similar to that of rock glaciers is minimal and could not explain the difference in rate as compared to ES 7–8. Neither does there seem to have been greater moisture than in the "wet" sectors of ES 7–8. Quantitative data are lacking on the significance of frost creep at ES 17, but the altitude of the lobe and its orientation toward the northeast argue for more frequent freeze-thaw cycles and greater frost creep than at ES 7–8.

The target heaves ranged from 0 to 3.5 cm, the greatest being in the axial area (fig. 38). The fact that frost action was most pronounced in the axial area where the movement was also greatest supports the view that frost creep played a large role in the movement.

11. SUMMARY AND COMPARISON OF EXPERIMENTAL SITES 6–17

Annual Movement

The annual movement, considering all accepted targets at each site, both axial and the transverse target lines at ES 15, and an axial point at ES 17, was as follows:

Annual Movement

ES	Movement (cm/yr)
6	1.0
7	1.3
8	3.2
15	1.0 (transverse) 3.1 (axial)
16 (1957–59)	1.1
17	7.6 (transverse) 12.4 (axial)

The median for ES 7–8 is 2.3 cm/yr, which is remarkably close to the average of 2.0 cm/yr that Rapp (1960a, p. 182) calculated for a 25-cm-thick layer on slope of similar gradient in Kärkevagge, northern Lapland. For a layer 20–30 cm thick on a gradient of 11° in Barentsöya, Spitsbergen, Büdel (1961, p. 365; cf. 1963, p. 277) reported a rate of 1.5–3 cm/yr depending on the grain size of the layer. Jahn (1960, p. 56; 1961, p. 12–13) reported a rate of 1–3 cm/yr for a 3°–4° slope of wet clayey material on the north side of Hornsund, Spitsbergen, with all the movement occurring in the spring. Rudberg (1958, table I, p. 115; 1962, table II, p. 317), for a 5° slope on "water-saturated solifluction soil" in the Tärna region of southern Lapland, found a mean rate of 0.9 cm/yr in 1956–57 and of 1.8 cm/yr in the following year (a rate cited for 1955–56 is omitted because it is inconsistently reported). For a "Wet solifluction soil in grass-covered area" on a gradient of 5° in the Norra Storfjäll region, Rudberg (1964, table 2 – item 1, p. 199) found minimum mean rates of 0.9 to 3.8 cm/yr for various target assemblages and periods (1955–63). Caine (1963, table 1, p. 173) reported median movements of 10.7–25.4 cm between November 1961 and May 1962 for stones on a

15° gradient with sorted stripes in the Lake District of England. To only a minor extent at ES 6 but to a much greater degree at ES 7–8, there was a marked difference in moisture conditions along the target lines, as already described. Since the number of targets in the "dry" and the "wet" parts varied between the target lines at ES 7–8, and the greatest movement was characteristically in the wettest sectors, the mean rates cited above are less meaningful than those for the "dry" and the "wet" parts considered separately. For comparative purposes ES 6 was clearly "wet", ES 16 was "dry", and both ES 15 and 17 were "wet". Thus considered, the rates were:

Annual Movement

ES	Mean Gradient (degrees)		Movement (cm/yr)	
	'Dry"	"Wet"	"Dry"	"Wet"
6	2.5	2.5	–	1.0
7	12.5	10.5	0.9	3.4
8	12.5	11.5	2.9	3.7
15[1])	–	3.5	–	1.1 (transverse)
	–	3.0	–	3.1 (axial)
16	25.0	–	1.1 (1957–59)	–
17	–	12.0	–	7.6 (transverse)
	–	12.0	–	12.4 (axial)

The low rate at ES 6 correlates well with the low gradient (2.5°). The "wet"-sector rates for ES 7 and ES 8 were, respectively, 3.4 and 3.7 times that for ES 6. These values plot as a sine function of the gradient (fig. 43)[2]). Although the data are strictly local and very limited, the correlation between gradient and movement in these "wet" areas is supported by the fact that the points lie very close to a straight line through the origin, which can be regarded as an additional point.

The situation in the "dry" sectors of ES 7–8 was different in that the rate at ES 8 (2.9 cm/yr) was some three times that of ES 7 (0.9 cm/yr). This markedly higher "dry"-sector rate at ES 8 is a partial explanation for the higher annual rate for target line 8 as a whole; another factor is that fewer targets in the "dry" parts of ES 8, as compared with ES 7, entered into the computation of the mean rate for the entire target line. The reason for the markedly higher annual movement in the "dry" sectors of ES 8 is another matter. The principal difference between the "dry" sectors of ES 7–8 lies in their length of exposure, which reflects

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[1]) T 20–21 of the transverse line and T 4,6 of the axial line at ES 15 were associated with very local and relatively steep (8°–12°) gradients, and they are therefore not considered in this tabulation. Their inclusion, however, would make negligible difference.

[2]) Within the limits considered the values also plot as a tangent or a degree function of the gradient, but the sine function is cited because it represents the force parallel to the gradient.

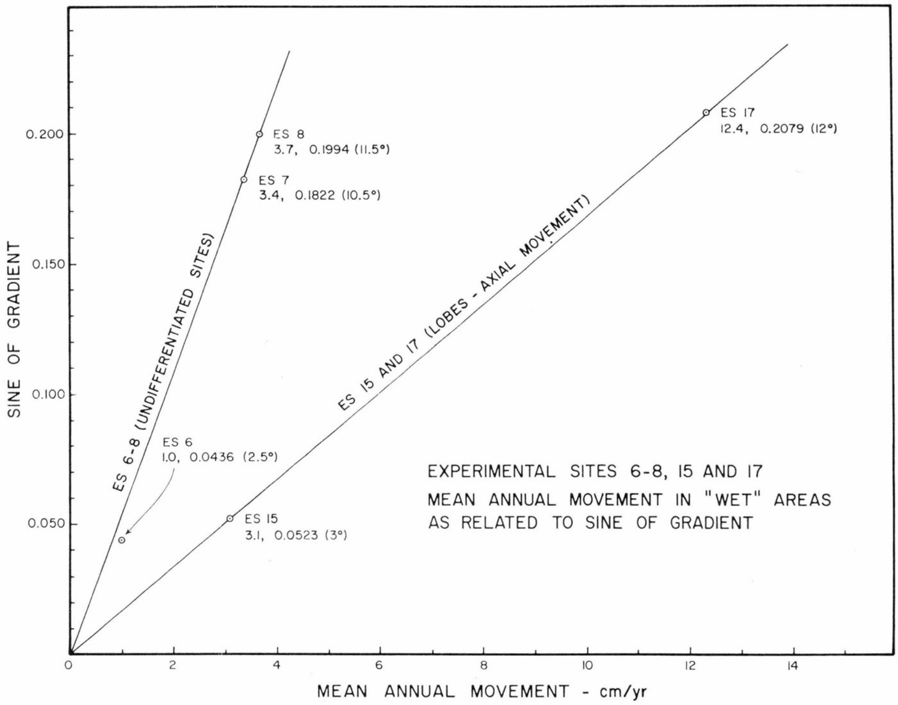


Fig. 43.

topographic influences and differential accumulation of snow. Target line 8 lay within several meters of a steepening of the gradient on the downslope side and was part of a slope convexity whose east extension beyond the influence of the snowdrift tended to be windswept and to have a relatively thin snow cover, so that the sector was commonly exposed from the snow sooner than the slope above and below. (The convex brow of the hill above ES 7, where not influenced by the snowdrift associated with that site, showed the same tendency but at a much greater distance from target line 7.) This difference in time of exposure is illustrated by the target exposure dates (tables B IV–B V) and by figure 44. Greater-than-average gelifluction at ES 8 in June 1961, due to rain while ES 7 was still snow covered, is probably also a factor. Other factors seem to be relatively unimportant. The mean and the range of the gradient are identical in the "dry" sectors of ES 7–8. The grain-size analyses along the target lines at ES 7–8 (pl. D 7, tables D II–D III) indicate that these sectors have a similar content of fines, averaging 51 percent at ES 7 (silt 33, clay sizes 18) and 48 percent at ES 8 (silt 32, clay sizes 16). The mean liquid limits along the target lines (18 percent moisture at ES 7 and 16 percent at ES 8) are comparable (tables D II–D III), as are also most moisture determinations that coincide in date

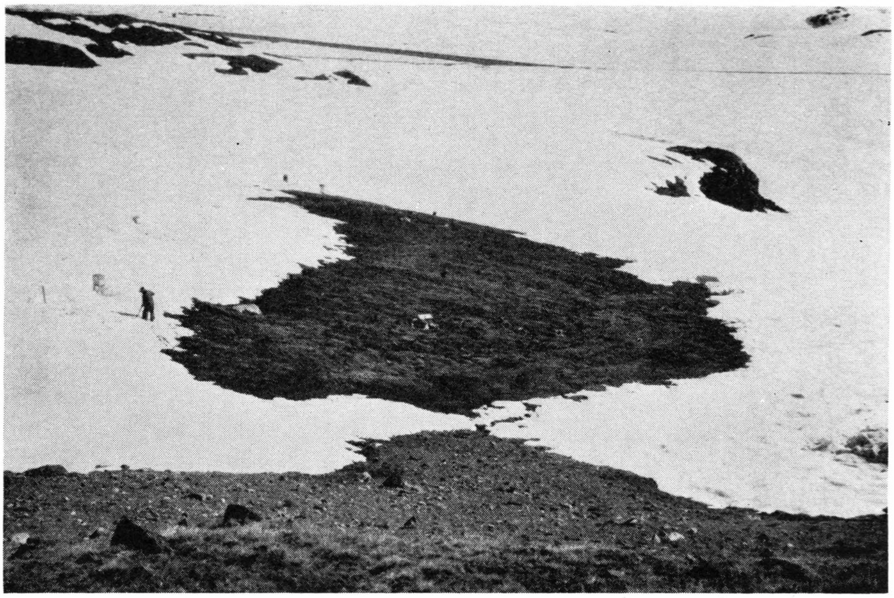


Fig. 44. Experimental site 8. Early exposure from snow. View southeast, diagonally across target line 8, from theodolite station for experimental site 7. T 1 of target line 8 is at far end of bare area. (14 June 1960.)

(tables F II–F III). The exposure difference between ES 7 and 8 is in the critical time of the year when the exposed parts of ES 8, especially in the eastern "dry" sector and in the "wet" sector, would tend to be saturated with thaw water from the snow on the slope above, and gelifluction would be correspondingly favored. This may explain both the downslope movement bulge centered on T 10 of target line 8 (fig. 19) and the occurrence of a gelifluction lobe whose front was some 40 m downslope from T 10. In any event the longer period of intense gelifluction at ES 8 early in the thaw season is probably the critical factor accounting for the difference in "dry"-sector rates at ES 7 and 8. The possibility of spring frost creep also being involved at ES 8 was discussed in connection with that site and the conclusion was reached that it was probably not very important.

Experimental sites 15 and 17 are similar in being gelifluction lobes and "wet" sites, but they differ appreciably in gradient, the nature of the mineral soil, in lobe size and, expectably, in rate of movement. At ES 15 the mean rate ranged from 1.1 cm/yr along the transverse (113°) target line to 3.1 cm/yr along the axial (20°) line, and at ES 17 (a transverse line) the mean rate was 7.6 cm/yr and the axial rate, based on the central target of the transverse line, was 12.4 cm/yr. These are relative and therefore minimum rates. That movement along the axial line of a lobe should be the most rapid is inherent in the lobe form and accords with previous observations (DEGE, 1941, p. 95–96; 1943, p. 321–325; JAHN, 1960, fig. 7, p. 57; 1961, p. 11–12, pl. 9; RAPP, 1960a, fig. 69, p. 181; WASHBURN, 1947, p. 92). The lobe particularly studied by DEGE was on a gradient of 6° in Albert I Land and consisted of very wet fine sand with few stones. His observations, which followed several days of considerable precipitation in August and were started as soon as motion became apparent, showed movement ranging from 2 to 19 cm in 3 days. It would seem that this rate reflected unusually high pore-water pressures consequent on the precipitation. The lobes investigated by JAHN, on the north side of Hornsund, Spitsbergen, were of clayey material and had a gradient of 7° (JAHN, 1960, p. 56) or 5° on the treads (JAHN, 1961, p. 10). The maximum movement ranged from 5 to 12 cm/yr, depending on the lobe and the year. For a lobe amply supplied with meltwater and on a gradient of 18°–25° in Kärkevagge, northern Lapland, RAPP (1960a, p. 181; 1962, p. 305–306; 1963, p. 4) reported a maximum rate of 25–30 cm/yr. For a lobe on a gradient of 30° in the same region, RUDBERG (1964, table 3 (item 6), p. 200) reported rates ranging from 5.0 cm/yr at the surface to 0.2 cm/yr at a depth of 60 cm (1957–60). In the Norra Storfjäll region of southern Swedish Lapland, he found a maximum rate of 4.3 cm/yr (1955–62) on a 20° gradient, and on gradients of 10–35°, mean rates ranging from 0.3 to 3.2 cm/yr at the surface to 0.0 cm/yr at the depth of 70 cm (1956–62) (RUDBERG, 1964, table 2 (item 2), table 3 (items 1–4), p. 199–200); data on grain-size and moisture parameters are lacking.

If it is assumed that the 1.1 cm/yr rate for the transverse line at ES 15 approximates the absolute rate, it agrees with the 1.0 cm/yr rate at ES 6, where the gradient and probably moisture conditions are similar. However, the comparison probably would be as misleading as comparison of the axial rate. The behavior of a prominent gelifluction lobe is probably quite different from that of a largely undifferentiated slope sector, otherwise it would be difficult to account for lobe formation. At ES 15 and 17 the axial rates, plotted against the sine of the gradient, lie on a straight line through the origin (fig. 43), the point of zero gradient and movement. Although only 3 points are involved, they suggest a rate-gradient relation similar to that at ES 6–8 but involving higher rates for comparable gradients. The target lines at ES 6–8 did not cross any well-defined lobes, and the higher rates at ES 15 and 17 support the concept that lobes are loci of particularly rapid movement. This concept is also inherent in the difference between the axial rate of the lobes and of the targets that extended into the bordering areas beyond the lobes. At ES 15 the fact that the lobe lay immediately downslope from a prominent snowdrift and along the main line of seepage from it indicates that moisture concentration was the predominant cause of differential movement here. At ES 17, also, the lobe was in an area of prominent drifting. Lobes develop precisely because they are loci of accelerated movement, and as observed by RUDBERG (1962, p. 316) moisture concentrations and/or topographic conditions are the two most important causes of development if other factors remain constant. RAPP (1960a, p. 181–182; 1962, p. 305–306) suggested that lobe development starts slowly, builds up to a maximum, then tapers off. However, changes in location and size of snowdrifts constitute a significant variable in many places.

In fact whether or not lobes are involved, variations in length of exposure from snow and, as stated by RUDBERG (1962, p. 316), "variations in water supply***caused by variations in snow cover" must represent a very general and important cause of changes in rates of frost creep and gelifluction.

Slope movement and other conditions at ES 16 are very different from the other experimental sites. Considering that the mean gradient is about twice that at any of the other sites, the mean rate of movement, 1.1 cm/yr, is very low. That the slope material is grus and has a very low moisture content, even in the spring, is also in sharp contrast to the other sites, and the low annual movement clearly reflects this difference in slope conditions. The low percentage of fines and low moisture in the grus suggest that saturated flow is lacking and that the movement is mainly by creep. Some frost creep seems probable in view of evidence of frost action at ES 16 as noted in the discussion of the site, but dry creep related to thermally induced expansion and contraction of grus particles (DAVISON, 1888a, 1888b), and displacements due to disturbance of the loose particles by wind, rain, and animals, may be important. In places creep of snow is probably also a significant process promoting creep of underlying material (COSTIN and others, 1964; HAEFELI, 1953, p. 248; 1954, p. 62; MATHEWS and MACKAY, 1963; WILLIAMS, 1962, p. 358), although snow has also been regarded as an inhibiting factor (CAINE, 1963, p. 176–177; SMITH, 1960, p. 78). Snow creep would be particularly likely to affect loose material like grus, and by tilting dowels may have led to some erroneous creep values even though the measurements were made at ground level; however, a number of 10-cm dowels remained essentially vertical. A check on 18 July 1964 showed that the mean rate of still vertical dowels (there were 12) was 0.8 cm/yr, the values ranging from 0.6 to 1.0 cm/yr. (Such errors would not be a factor at the other experimental sites where the mineral soil is finer grained and hard frozen beneath the snow.) The probable absence of gelifluction at ES 16 and the obviously "dry" nature of that site satisfactorily account for the lack of correlation with the "wet"-sector rate/gradient relation that applies to ES 6–8.

Frost Creep and Potential Frost Creep

At ES 6 the data are lacking for analyzing the relation between true frost creep and potential frost creep on the basis of control periods as at ES 7–8. However, assuming that the proportion of true frost creep to potential frost creep is approximated by the proportion of the sum of the jump and retrograde movement to the jump in the summary equation (5.2) for ES 6 (cf. discussion for ES 7–8), the proportion is 2.4:6.0 or 0.4:1. In any case the proportion indicates that the true frost creep is probably no more than 40 percent of the potential frost creep, since an unknown amount but certainly some gelifluction is included in the jump.

For ES 7 the best approximations indicate that true frost creep was about 50 percent of the potential frost creep in the "dry" sectors and did not exceed 90 percent of it in the "wet" sector. For ES 8 it was concluded that the best approximation is probably 70 percent in both sectors. These estimates, which are based on exactly the same procedures, suggest that because of retrograde movement the effectiveness of the potential frost creep resulting from the annual freeze-thaw cycle was reduced by 10 to 50 percent at ES 7–8. Data on this subject are lacking for ES 15–17.

Frost Creep and Gelifluction

From the summary equation (5.2) for ES 6, the proportion of frost creep (true frost creep as represented by the sum of the jump and the retrograde movement) to measured gelifluction is 2.4:1.4, or 1.7:1 with the denominator reduced to unity. As previously, control periods are lacking for ES 6. Since some gelifluction may be incorporated in the frost creep as calculated above, the proportion is maximum.

At ES 7 the "dry"-sector proportion of frost creep to gelifluction ranges from 1.5:1 to 5.3:1, as calculated from the 1959–61 control periods (tables VI. 1–VI. 2), but it was concluded from the summary equation for the "dry" sectors that the proportion for the 5 years of observation did not exceed 2.0:1. Similarly, the proportion for the "wet" sector ranges from 0.5:1 to 1.0:1 on the basis of the same control periods, and the maximum proportion averaged over the entire observation period is 1.6:1.

At ES 8 the proportion of frost creep to gelifluction for the "dry" sectors is 0.4:1 for the 1960–61 control period (table VII), and a maximum of 2.3:1 for the 5-year period. For the "wet" sector the proportion is 0.7:1 for the control period, and a maximum of 2.8:1 over the whole observation period.

Comparing "dry" sectors at ES 7–8, the maximum proportion of frost creep to gelifluction for the 5-year period ranges from 2.0:1 to 2.3:1; similarly the range for the "wet" sectors (including ES 6) is from 1.6:1 to 2.8:1. Thus, for the program period and depending on the experimental site, frost creep accounted for a maximum of about one and a half to three times as much movement as gelifluction. The control periods indicate that the proportions may vary considerably from place to place and from year to year. For a given place in consecutive years (ES 7, 1959–60 and 1960–61), the proportion in a "dry" sector varied from 1.5:1 to 5.3:1, and in a "wet" sector from 0.5:1 to 1.0:1. As between places in a given year (ES 7 and 8, 1960–61), the variation in a "dry" sector was from 5.3:1 to probably 0.4:1 (or less probably about 1:1), and in a "wet" sector from 0.5:1 to probably 0.7:1 (or less probably about 1:1). The uncertainty in the proportions for ES 8 is explained in the discussion of that site. Although the "wet"-sector sample from ES 7 is very small for the control periods, the results derived from it are reasonably consistent in consecutive years. They support the larger sample from ES 8 in 1960–61, and the combined data indicate that: (1) The proportion of frost creep to gelifluction in the "wet" sectors is much less variable than in the "dry" sectors. (2) Compared with gelifluction, frost creep in the "wet" sectors of ES 7–8 in 1960–61 contributed from half as much to no more than an equal amount of movement, and thus accounted for some 30 to 50 percent of the total movement in these sectors. (3) The maximum possible contribution of frost creep (one and a half to three times the gelifluction, depending on the experimental site) for the "wet" sectors over the 5-year period may exceed the actual amount by a factor of 3.

The data from ES 15–17 have only little to offer on the relation of frost creep to gelifluction. At ES 15, a "wet" site, gelifluction probably exceeded frost creep by a significant amount, since the gradient is so slight, and the number of freeze-thaw cycles on the same exposure at ES 7–8 were so few, that the ratchetlike action of creep could hardly account for the observed movement. At ES 16, a "dry" site, creep is clearly paramount as discussed in the summary of annual movements, although dry creep probably predominates over frost creep. Finally at ES 17, a "wet" site, both frost creep and gelifluction are believed to be very important, as mentioned in the discussion of that site and in the summary of annual movements.

The relative importance of frost creep and gelifluction has long been subject to discussion with quantitative evidence at a minimum. HÖGBOM (1910, p. 45–51; 1914, p. 298, 301, 328–384; 1926, p. 256–261), among others, regarded both processes as significant. However, it is not clear, as is sometimes claimed (cf. SCHMID, 1955, p. 125–126), that he regarded frost creep as the most important, for he abandoned the term *Regelationsfliesserde*, stressed the difficulty of evaluating the relative significance of the processes, and did not exclude flow from a role in *"festen" Solifluktion* or *undifferenzierte Fliesserde* (HÖGBOM, 1914, p. 330, 358–363). SAPPER (1912, p. 261; 1913, p. 104–108) stressed pure flow, and FRÖDIN (1914, p. 235–237; 1918, p. 3–4) cited evidence for the predominant role of water and flow, whereas BESKOW (1930, p. 624–626) believed that moisture had an indirect role only and that movement is mainly by minute slips along melting ice lenses. POSER (1932, p. 38–40) argued that although local conditions determine whether frost creep or gelifluction is the more important, flow phenomena show that on the whole gelifluction is the main process. Also DEGE (1938, p. 36–38, 100; 1941, p. 93–97, 121) concluded that local conditions determine the issue, a conclusion concurred in by TROLL (1947, p. 166). SIGAFOOS and HOPKINS (1952) emphasized the distinction between frost creep and gelifluction as processes, and JAHN (1961, p. 13–14) recognized the possibility of distinguishing quantitatively between frost creep and gelifluction but regarded the former as essential for the latter, rather than considering them as separate processes. As noted by SCHMID (1955, p. 21), observations refer to different localities and quantitative data on rates of movement have been largely lacking. The Mesters Vig data help to fill the gap and demonstrate not only that the relative importance of frost creep and gelifluction depends on local conditions but that the conditions can be very local indeed and can vary from year to year.

Influence of Grain Size on Movement

General

Grain size, other conditions being equal, influences both the moisture content of mineral soil and its behavior at a given moisture content. The high porosity and permeability of pure gravel and coarse sand promote good drainage and afford little opportunity for frost-action effects or for saturated flow, except where seepage pressures cause intergranular pressures to be ineffective (cf., for instance, PECK, HANSON, and THORNBURN, 1953, p. 60). These materials can be regarded as essentially stable under conditions where finer grain sizes favor frost creep and gelifluction.

Fines, on the other hand, tend to remain wet longer than coarser grain sizes because of capillarity and relatively low permeability. Very importantly, during freezing moisture migrates to form the segregated ice that causes heaving and is a basic requirement for frost creep. During thawing the release of this moisture is an important factor in gelifluction. The instability of soils in freezing and thawing ("frost susceptibility") generally increases with increasing content of fines (silt and clay sizes combined) and is influenced by the degree of sorting or uniformity. Following CASAGRANDE (1932, p. 169) engineers have commonly accepted, as a rule of thumb, that the minimum content of fines necessary for "frost susceptibility" is 3–10 percent, depending on the uniformity of the soil (Arctic Construction and Frost Effects Laboratory, 1958, p. 28–30). This criterion is subject to many factors (DÜCKER 1956, 1958). Experiments show that "Soils of even similar gradations may vary significantly in frost behavior" (LINELL and KAPLAR, 1959, p. 89), and that "*Changes in volume are produced in samples which are considered "non-frost susceptible" in present engineering standards*" (CORTE, 1961, p. 10; cf. CORTE, 1962, p. 20). In any event, except at ES 16, the high content of fines and the grain-size distribution of the mineral soil at the Mesters Vig experimental sites make the soil highly "frost susceptible" by any criterion.

The nature of the fines themselves is significant. Clays with expandable structure are able to hold more water but tend to be less "frost susceptible" than clays in which the water is relatively free to move and build ice lenses. In general strong frost heaving is more likely to be associated with kaolinite than bentonite or montmorillonite (DÜCKER, 1940; GRIM, 1952; LINELL and KAPLAR, 1959, p. 92–99). Illite in concentrations up to 6 percent is especially conducive to heaving, but its effect decreases at higher percentages (LAMBE, 1958, p. C 7; pl. C 2). According to X-ray analyses by Dr. PIERRE BISCAYE, to whom the writer is indebted for the work, clay-size fractions from depths of 10–20 cm along the target lines at ES 7–8, and 15 show illite as the dominant clay mineral, with chlorite being the only other clay mineral present. Calcite, feldspar, quartz and possibly amphibole occur in trace quantities. Expandable minerals are thus lacking.

The difference in grain size and mineralogy between silt and clay is particularly significant for frost-action effects and flow: (1) Silt is more permeable than clay and clay sizes, and permits quicker capillary rise and distribution of moisture; moreover, moisture migration associated with freezing is relatively easier in silt and tends to produce a greater ice content, as recognized long ago by JOHANSSON (1914, p. 84, 93–94) and investigated in detail by BESKOW (1935, 1947), and others. LINELL and KAPLAR (1959, fig. 3, p. 86; p. 88) found that silts and lean (slightly plastic) clays generally exhibit considerably higher heave rates than fat (plastic) clays. "Clays" in the engineering terminology they used includes all grain sizes less than 0.074 mm that produce plasticity (Waterways Experiment Station, 1953, p. 3–4). Thus, laboratory experiments "*** suggest that the larger the impermeabilizing effect of the fines, the smaller the frost heave they produce. Since the liquid limit is a measure of the impermeabilizing effect under certain conditions, one might expect an inverse relation between liquid limit and ability to produce heave" (LAMBE, 1958, p. C 9). (2) Silt lacks true cohesion and slakes readily, whereas clay minerals tend to adhere to each other because of absorbed water, and give an element of shear strength that silt lacks (TAYLOR, D. W., 1948, p. 320–321). (3) In silt the liquid limit and the plasticity index are lower than in clay sizes (cf. JOHANSSON, 1914, p. 59–61; LINELL and KAPLAR, 1959, table 1, p. 102–103), and the flow curve used in liquid-limit determinations has a correspondingly low slope (TAYLOR, D. W., 1948, fig. 3.2, p. 29; 65–66). Although above the liquid limit there can be a "quick" consistency in which flow may or may not occur depending on a triggering force, silty mineral soil requires less moisture than clayey soil to pass through this state and flow under the influence of gravity alone (ACKERMANN, 1948a, p. 24; 1948b, p. 430–434, 453; 1950, p. 15–16; figs. 3–5, p. 25–27; 1959, p. 5–6, 31; fig. 2, p. 51; fig. 4, p. 53).

JOHANSSON (1914, p. 91–92) stressed that solifluction is primarily associated with flowing soil (*Fliesserde*) having a grain size ranging from 0.05 to 0.0006 mm. This would include mainly silt, although in the Wentworth classification it would also comprise some clay-size particles. True clay minerals, however, were specifically excluded by JOHANSSON. That silty diamictons are particularly prone to flow has also been recognized by a number of other workers, including SCHMID (1955, p. 52–53), SIGAFOOS and HOPKINS (1952, p. 181), and SØRENSEN (1935, p. 21–28). From this point of view BÜDEL (1959, p. 303–304) is misleading in arguing that clay minerals and clay-size particles are more favorable than silt for gelifluction. Because mechanical weathering tends to outstrip chemical weathering in cold climates (RAMANN, 1915, p. 280–281; BLANCK, 1919, p. 422–423; BLANCK, RIESER, and MORTENSEN, 1928, p. 689–698), silt commonly predominates over clay minerals and clay-size particles, and when associated with frost action this predominance may be one of the important reasons for the significance of frost creep and gelifluction in such climates.

Experimental Sites

The preceding discussion indicates that the silt content may be a critical variable in comparing the mass-wasting characteristics of a mineral soil, other conditions being equal. At the Mesters Vig sites discussed, excluding ES 16 where fines are largely lacking, both silt and clay sizes are common, but silt generally predominates.

The mean percent of silt and clay sizes along the target lines at ES 7–8 (pl. D 7, tables D II–D III) is as follows:

	"Dry"			"Wet"		
	Silt	Clay sizes	Total fines	Silt	Clay sizes	Total fines
ES 7	33	18	51	29	9	38
ES 8	32	16	48	36	11	47
Mean	33	17	50	33	10	43

Although the silt content is similar in the "dry" and the "wet" sectors of ES 7–8, the content of clay sizes is less in the "wet" sectors. As a result the proportion of silt to clay is about 2:1 in the "dry" and 3:1 in the "wet" sectors. This higher proportion of silt to clay in the "wet" sectors may be a factor in the higher rate of movement there. That it is not the dominant factor is apparent from the fact that the higher rate of movement is not so much the consequence of faster movement when gelifluction is active but of more continuous movement throughout the thaw season. This latter situation, discussed in the following section, is so obviously related to the difference in moisture conditions in the "dry" and the "wet" sectors that the moisture factor is clearly paramount. The continued presence of meltwater in the "wet" sectors may be responsible for some eluviation of clay sizes and may thus still further promote movement to the extent that an increase in the proportion of silt to clay sizes from 2:1 to 3:1 is significant.

Influence of Moisture on Gelifluction

That a high water content in the mineral soil should promote gelifluction (and with suitable temperature fluctuations, frost creep) is almost axiomatic, whether the water comes from rain or meltwater (cf. ANDERSSON, 1906, p. 95–96), the effect of water in promoting flow being to reduce shear strength by building up porewater pressure rather than by acting as a lubricant, as emphasized by TERZAGHI (1950, p. 91) and NEILSEN (1960, p. 102). The correlation between moisture and movement was demonstrated by comparing moisture conditions and movement rates between the "dry" and the "wet" sectors of ES 7, as brought out in the discussion of that site. Similar observations have been reported by RAPP (1960 a, p. 182; 1962, p. 306; 1963, p. 5) and RUDBERG (1962, p. 316–317; 1964, p. 202) among others.

In view of the relation between moisture and movement, the low rate for the "dry" sector of ES 7 has the following important implications when compared with other sectors at ES 6–8: (1) The similarity of this rate (0.9 cm/yr) to that of ES 6 (1.0 cm/yr), contrasted with the much lower gradient but generally higher moisture at ES 6, demonstrates that moisture is more important than gradient in promoting movement. (2) As noted in the discussion of ES 7, the association of the low rate there with the dominantly bare part of the slope, and of a much higher rate with the comparatively well-vegetated but wetter part of the slope, shows that moisture also affects movement more importantly than the presence or absence of vegetation. Both these points are supported by the high rate of movement on the gentle and bare "wet" lobe at ES 15 and by the low rate on the steep and bare "dry" slope at ES 16, although at the latter the comparison refers to creep only.

Point (2) merits additional comment because vegetation has been regarded as impeding movement sufficiently to warrant distinguishing between "free" and "bound" gelifluction (*"freie" und "gebundene" Solifluktion*) and recognizing a circumpolar domaine of the former as a frost-debris zone (*Frostschuttzone*) and of the latter as a milder climate tundra zone (*Tundrenzone*) (BÜDEL, 1948, p. 30–33; 1950, p. 12–13). WILSON (1952, p. 249) stated that "***the development of more than a meagre vegetation, however, generally prevents soil movement (and so patterning) by the stabilizing effect of the roots." On the other hand, HÖGBOM (1910, p. 46; 1914, p. 331–332, 360–363), although recognizing an impeding effect of vegetation, believed that vegetation is more likely to be affected by gelifluction than *vice versa*. There is an intimate interaction between gelifluction and vegetation, with some types of growth being more compatible with gelifluction than others (FRÖDIN, 1918, p. 1–14; SEIDENFADEN, 1931; SØRENSEN, 1935, p. 56), but SØRENSEN (1935, p. 56, 63–64) argued that, even so, plants were generally so strongly influenced by gelifluction that they were a function of it. Others have stated that vegetation, by retaining water and retarding runoff, actually favors slope movements (SIGAFOOS and HOPKINS, 1952, p. 182). The Mesters Vig observations show that vegetation-covered and bare slopes can exist side by side and that the influence of moisture and, through it, gelifluction can predominate over an impeding effect of vegetation. Therefore to the extent that this is also true of other environments and that the rapidity of gelifluction can determine whether or not a given type of vegetation can survive, it is misleading to distinguish between "free" and "bound" gelifluction and to establish domaines for them.

Following the jump, gelifluction along the target lines at ES 7–8 was generally superseded in the driest parts by retrograde movement or no movement. This indicates that most of the movement represented by the low rate in the driest parts is more a reflection of a short period of high moisture during the spring and early summer than of just a slower movement throughout the summer. The conclusion is supported by a number of the target graphs and by the situation described for the eastern "dry" sector of ES 8, where the high rate of movement appeared to be primarily related to saturation resulting from early exposure to meltwater from the slope above. Although the mean content of fines in the diamicton at ES 7–8 is very similar in the "dry" and the "wet" sectors (50 and 43 percent, respectively), there is a difference in the proportion of silt to clay sizes that may influence the rate of movement, as discussed in the previous section. However, the dependence of movement on moisture is so clear that this difference in the diamicton must be a relatively minor influence.

Since gelifluction is usually greater than retrograde movement, the latter is not likely to mask gelifluction. Consequently, the low rate of movement in the driest parts of a slope indicates a boundary condition above which gelifluction is active and below which it ceases to have an appreciable effect. On the basis of the evidence pertaining to the influence of gradient and vegetation, this boundary condition at ES 7–8 is controlled primarily by moisture and only secondarily by gradient and vegetation conditions. Omitting September movements because of their possible association with frost heaving, the available gelifluction data suggest that the range of the boundary condition is roughly 15- to 20-percent moisture at the target depths of 10 or 20 cm, or at a depth of 5 cm in the case of the stone targets at ES 7. In general when moisture contents were above this range the targets concerned showed gelifluction exceeding 0.2 cm, below the range they did not, and within it gelifluction was present in some instances and absent in others. Although in some cases suggestive only, examples of these correlations are provided by movement graphs of the appendix-C targets associated with moisture determinations (pl. C 1, T 14–15, 18, 34, 38; pl. C 2, T 6–7, 12–14, 16–18, 23–28, 35–36, 38, stone targets 3, 11–14; pl. C 3, T 6, 10, 12–13, 19–20, 23–24, 28, 31, 34). The moisture data are scattered but graphs of several targets (for example, pl. C 2, T 35 (1961); pl. C 3, T 6 (1960, 1961), T 19–20 (1960)) show within a single season most of the spectrum described. However, several exceptions to the suggested correlation are illustrated by these same targets in that they show high enough moisture values for one or two (but not all) determinations at the target depths to suggest gelifluction when none was observed. The explanation may lie in the fact that moisture specimens could not be taken from the exact target sites, and exact correspondence of moisture values is unlikely. The general pattern, however, is clear.

As indicated in the discussion of ES 7–8, a number of target readings suggest renewed or increased gelifluction following rain in 1959 and 1960. Although the amount of movement was too small to be conclusive, the coincidence in timing shown by a number of targets argues for the reality of the correlation. This correlation is contrary to JAHN's (1961, p. 11–12) and RAPP's (1960a, p. 182) observations, based on work elsewhere, that movement is restricted to freeze-thaw periods, but is entirely consistent with the view that the moisture content of thawed ground is a critical factor that may promote gelifluction or, where frozen ground is absent, solifluction unrelated to frozen ground. In the Mesters Vig climate, however, as in Spitsbergen (cf. Sapper, 1912, p. 260) and probably most polar environments, meltwater is more important than rain for gelifluction. The Atterberg liquid limit (cf. Taylor, D. W., 1948, p. 64–66) of the mineral soil at the 10-cm depth at equal intervals along the target lines at ES 7–8 ranges from 13 to 32 percent moisture based on 14 determinations, the mean value being 19 percent. For the 20-cm depth and a like distribution of targets, the range is from 12 to 22 percent and the mean is 17 percent (tables D II–D III). The similarity of these means to the range of the boundary condition cited above and independently arrived at, suggests that gelifluction on this slope occurs only when the moisture content of the fines in the mineral soil approximates or exceeds the liquid limit. Above this limit there is little or no shear strength in the fines, a condition promoting flow, and below this limit the shear strength increases rapidly so that gelifluction becomes unlikely. The rapid increase in shear strength along the target lines at ES 7–8 is evident from the low plasticity index (the difference between the liquid and plastic limits), which ranges from 0 to 7.

However, the diamicton, as distinct from its content of fines, may have some strength during gelifluction as indicated by penetrometer readings (tables G II–G III). The readings, although fragmentary, are consistent with the critical moisture ranges just discussed and show that the corresponding critical shear strength for the diamicton is 3–4 kg/cm^2 (40–60 lb/in^2), above which gelifluction is inhibited and below which it is highly probable.

The data from ES 15–17, although less critical, support the conclusion that the Atterberg limits, especially the liquid limit, constitute an important parameter in gelifluction. At ES 15 where gelifluction was very active, as discussed in the description of the site and in the summary and comparison of annual movement at ES 6–8, 15–17, the liquid limit of the mineral soil ranged from 15 to 17 percent moisture based on 4 determinations (table D IV). Moisture determinations for the site (table F IV) are fragmentary and were limited to surface determinations (depth 0–2 cm) for fear of disturbance, but together with visual observations at more frequent intervals the determinations suggest that the liquid limit is approximated or exceeded at depths greater than 2 cm during much of the thaw season in most years. Gelifluction was probably also very active at ES 17, where the liquid limit was 19–20 percent, based on 5 determinations (table D VI). Moisture observations for ES 17 (table F VI) are also few but where made show that the limit was approximated or exceeded to depths of at least 10 cm, except at the borders of the lobe, as late as mid July 1958 and late August 1960. At ES 16 the grus is nonplastic.

Movement at Depth

At ES 16 the dowels that were inserted to the 5-cm depth and those inserted to the 10-cm depth showed negligible difference in rate of downslope movement. For the 2.8-year period there was a 0.1 cm difference in favor of the 5-cm dowels (1.2 vs. 1.1 cm/yr); for the 4-year period the rate was the same (0.9 cm/yr).

At ES 6–8 there was apparently no significant difference in downslope movement between the targets inserted to the 10-cm depth and those inserted to the 20-cm depth, even though the latter generally showed the greater target heave. A similar correlation between heave and depth of target insertion for 35-cm and about 60-cm targets was reported from Spitsbergen by Czeppe (1959, p. 199, 201; 1960, p. 149).

However, based on the behavior of MW 7 and of the rod at ES 7, there was a marked difference between downslope movements to depths of 20 cm and those at depths of about 90 and 140 cm. In each case, thawing extended deeper than the depth indicated. As noted in connection with MW 7, which was in a "wet" area, the basal movement of the mass-wastingmeter suggests that the movement at the 90-cm depth was on the order of 4.6 cm in 2 years, or 2.3 cm/yr (fig. 16), whereas the surface movement in the same place was at least 4.3 cm/yr (table C II). The surface movement was very probably somewhat greater because of the amount that presumably occurred while MW 7 was still firmly anchored in the downward-thawing frost table. Similar evidence provided by the rod, which was in a "dry" area, suggests a movement not exceeding 1 cm in 5 years, or 0.2 cm/yr, at the 140-cm depth (fig. 17), whereas the minimum surface movement was 0.8 cm/yr (table C II). Interpolating to a depth of 1 m and assuming a linear function as a rough approximation, the decrease from the surface movement was at least 51 percent for the "wet" area and 54 percent for the "dry" area, or about half of the surface movement in each case. Although these depth movements are imprecise for reasons cited in connection with MW 7, they support the following evidence from elsewhere that frost creep and gelifluction diminish with depth and are restricted to a shallow zone. Thus, Caine (1963, p. 173) reported negligible movement below a depth of 10 cm in an area of active sorted stripes in the Lake District of England. Rudberg (1958, p. 116; 1962, table 3, p. 318; fig. 2, p. 319; pl. 2 opp. p. 321; 1964, table 3, p. 200; fig. 5 in pocket), using test pillars, showed that movement decreases rapidly with depth in solifluction slopes in

Swedish Lapland; in the Kärkevagge region he found that movement decreased from 5 cm/yr to 2–3 cm/yr at depths of 50–70 cm (1957–60), and for the Norra Storfjäll region he reported that "At a depth of 50–70 cm there is generally no measurable movement any more" (RUDBERG, 1964, table 3, p. 200; p. 201). SMITH (1960, p. 77) found that stakes inserted to a depth of 50 cm on a 21° slope at South Georgia did not move, whereas those at depths of 25 cm and 10 cm had the same maximum (5 cm) and minimum (2.5 cm) annual movements, with the mean movement being greatest for the shallow stakes. WILLIAMS (1962, fig. 4, p. 359) illustrated a vertical velocity profile, associated with a lobelike feature in Labrador, that showed the main movement to be above a depth of about 40 cm.

That initially vertical targets such as dowels and rods tend to tilt downslope after a time is in part probably associated with a decrease in mass-wasting from the surface downward. However, snow creep may be a factor also (MATHEWS and MACKAY, 1963; WILLIAMS, 1962, p. 358), especially at ES 16 where the slope consists of loose grus, and at such sites the creep of snow may well be a factor promoting creep of a surface layer.

Nature of Retrograde Movement

Observations sufficiently precise to reveal retrograde movement were restricted to ES 6–8 and are detailed in the discussion of the sites.

Experimental site 6 was regarded as "wet" throughout, and the mean total retrograde movement is anomalously high compared with ES 7–8 as shown by the following summary.

Mean Retrograde Movement
1956–61
cm

ES	"Dry"	"Wet"
6	–	−3.6
7	−2.0	−0.7
8	−2.9	−2.0

The anomaly may be explained, at least in part, by assigning some of the retrograde movement to a differential collapse of thawing ground toward the stream near the southeast end of target line 6. Because of the orientation of the line relative to the stream (fig. 6), a sagging of the ground with this component would have such an effect. Differential collapse would be expectable near the stream because growth of ice lenses would be particularly favored here where moisture values would tend to be high, and subsequent thawing would tend to reach deeply as the result of early snow removal by the stream and exposure of the ground to thawing. The stream would also tend to promote thawing in its vicinity because moisture promotes increased conductivity (TERZAGHI, 1952, fig. 3, p. 9), although the effect tends to be offset, at high moisture contents, by increased specific heat of the thawed ground (KERSTEN, 1949, p. 75). The fact that both the maximum jump and maximum retrograde movement occur adjacent to the stream and decrease away from it supports the above explanation.

At ES 7–8 there are no complications introduced by differing trends of contours and target line as related to possible differential thawing and settling of a slope near a stream. The data are easier to evaluate and are reasonably consistent between the two target lines. As indicated by the summary table, there was a marked difference in the retrograde movement as between the "dry" and the "wet" sectors of both lines. Since this was also true of the gelifluction, it raises the question of the influence of the one process on the other.

If retrograde movement can occur where the moisture content of the mineral soil is adequate for gelifluction, these movements may tend to counteract each other to a degree. The minimum moisture content for gelifluction probably approximates the liquid limit as discussed in connection with the influence of moisture. However, the presence of water at the surface of the ground where retrograde movement is recorded does not necessarily prove a moisture content adequate for gelifluction, since the moisture content at depth might be less, as indicated by a number of moisture determinations that showed excess water at the surface and much lower values below (tables F II–F III). On the other hand observations (pl. C 1, T 18 (1958); pl. C 2, T 25 (1958), T 27 (1960), stone target 13 (1960); pl. C 3, T 23 (1960), T 28 (1960)) do suggest that retrograde movement can occur where the moisture content at depths to 20 cm is 15–20 percent, approximately the liquid limit of the soil. Also T 25–27 at ES 8 showed retrograde movement in 1957 in spite of water being at the surface within 1 m of the targets throughout most of the period of retrograde movement. This argues for high moisture beneath the surface in view of the continuous condition. Although T 26–27 at ES 8 were excluded from the calculation of target totals because of the possibility of disturbance by channeling in 1960, the theodolite observations and attitude check in 1957 indicated that the retrograde movement cited for 1957 was real and not related to target heaving or tilting. The fact that all three targets showed almost identical movement patterns supports this conclusion. A similar instance was noted at ES 6, where T 18–20 (pl. C 1) showed retrograde movement in 1960 in spite of the fact that T 19–20 were in standing water and T 18 was within 1–2 m of water most of the time. Thus, the evidence indicates that retrograde movement can occur under saturated conditions, but it does not prove that it also occurs above the liquid limit, for complete saturation persists through the plastic range. Nevertheless, the fact that persistent excess water was present at the surface in some places where retrograde movement was observed shows that this movement probably occurred under conditions favorable to gelifluction. Since gelifluction predominates in wet areas it would normally mask any retrograde movement in them. The matters considered have an important bearing on the nature of the retrograde movement, discussed below.

The retrograde movement described in the preceding paragraphs is of considerable theoretical interest. A number of discussions of creep imply or state that mineral soil, expanded at right angles to the surface of the ground by frost action or wetting, settles vertically upon contraction (cf., for instance, GILLULY, WATERS, and WOODFORD, 1959, p. 172; SIGAFOOS and HOPKINS, 1952, p. 178 and fig. 2 (their legends for figs. 2 and 5 are interchanged)). However, several authors have specifically indicated that settling does not occur vertically. Although KERR (1881) described creep deposits and stressed the role of frost, the first recognition of the mechanism of frost creep dates from DAVISON's classic paper, in which DAVISON (1889, p. 256–257) stated:

> "Imagine a layer of damp earth resting on an inclined surface, and exposed to the action of frost. The water in the interstitial pores will be frozen to a depth depending on the intensity and duration of the frost. If the particles of soil be not closely packed, the water will, in freezing, expand into the spaces between them, and the relative position of the particles may not be altered in consequence. But this cannot often be the case, for freshly-turned earth is soon rendered close and compact by a few showers of rain. The distances between the separate particles will thus as a rule be increased when the water between them is frozen. Now, the soil being compact and, except near the edges of the mass, continuous, the only direction in which expansion can readily take place is outwards and perpendicular to the surface. Every particle of soil in the frozen layer will therefore be displaced from its original position along the line of the normal (or perpendicular) to the surface of the soil; and, if the water be equally diffused throughout, the amount of the displacement will be proportional to the distance of the particle from the surface to which freezing extends. The more intense and lasting the frost, the thicker will be the frozen layer, and the greater the displacement of the surface particles.
>
> "On the recurrence of warmer weather, the interstitial ice will be melted, and in melting will contract, and the particles will return, not, as they came, along the normal to the surface, but in a direction nearly vertically downwards owing to their weight; not quite vertically, however, because the adherence of each particle to its neighbours, by reason of the water between them, tends to bring it back towards its old position. The particles will thus after every frost and thaw occupy a lower position down the slope than they did before; and the whole outer layer of the soilcap will in this way creep slightly downwards, the creeping being greatest at the surface, and diminishing downwards to zero at the greatest depth to which freezing extended."

In DAVISON's experiments the departure from the vertical during settling "***approximately bisected the angle between the vertical and the normal to the surface of the soil" (DAVISON, 1889, p. 259). SHARPE (1938, p. 27; fig. 3A, p. 28) followed DAVISON in citing a departure from the vertical, and SCHMID 1955, p. 99, fig. 24) recognized, on the basis of field experiments, that settling was not exactly vertical, although he diagrammed it as such. YOUNG carried out experiments somewhat similar to DAVISONS' but dealing with wetting and drying; he reported (YOUNG, 1960, p. 121):

> "On wetting, expansion took place perpendicular to the surface; on drying, gravity tends to cause contraction in a vertical direction, but due to cohesion the observed contraction was in a direction intermediate between the vertical and perpendicular to the surface."

Later, on the basis of further observations, YOUNG (1963. p. 129) wrote:

> "The unexpected feature of the results is that the components of movement perpendicular to the ground surface substantially exceed the parallel (down-slope) components. This is difficult to explain in terms of soil creep, in which material is removed from a slope by transportation to the slope foot. The perpendicular movement could be accounted for by a loss from the soil of material released by weathering and carried away in solution or suspension by ground-water, thereby causing a direct removal of material from the slope."

LEOPOLD, WOLMAN, and MILLER (1964, p. 352) observed a possible uphill movement of target pins on a forested slope and they suggested "***that the pins are rotating—owing to greater downhill movement below the surface than at the surface***", but the magnitude of the observed movement was so slight as to be equivocal and no firm conclusions were drawn.

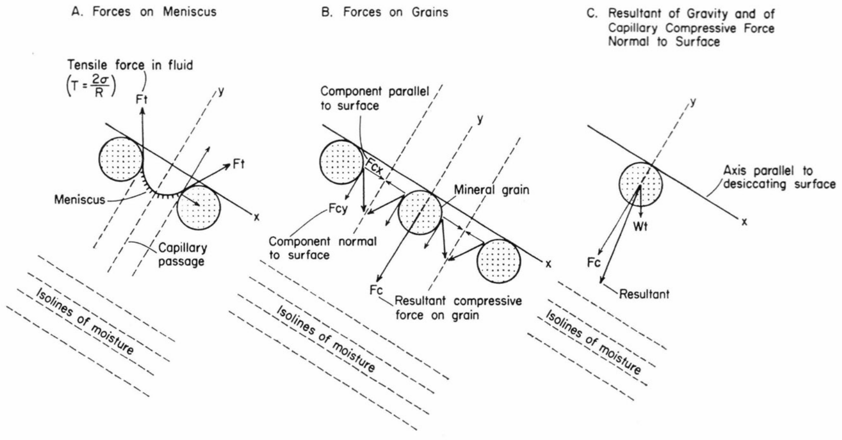
The Mesters Vig observations of retrograde movement (cf. WASHBURN, 1962; 1965, p. 40) support the view that there is a departure from the vertical as the mineral soil contracts and settles during thawing and drying. That the retrograde movement is not spurious was demonstrated in the introductory evaluation of independent target heaving and tilting as factors in target movement. The same analysis that eliminated the possibility of upslope tilting of targets as a general explanation also eliminates, for the Mesters Vig occurrences, the hypothesis that differential subsurface flow might force the bottom of the target pegs downslope and thus introduce an apparent retrograde movement by tilting the cones upslope. Desiccation cracking on a slope can cause retrograde movement but it can not be a general explanation, for it implies that an equal number of targets be moved upslope and downslope, and the percentages cited in the introductory evaluation in connection with random influences eliminates this possibility. Furthermore, although desiccation cracking was prominent at some experimental sites, it was not observed at ES 6 and appeared to be minor at ES 7–8.

YOUNG's (1963, p. 129) suggestion that material carried away in ground water is the explanation is hardly tenable for the Mesters Vig situation, since some retrograde movements could be measured over a period of days and movements were prominent when the slope was driest.

The orientation of clay particles can affect the direction of contraction during desiccation. WARKENTIN and BOZOZUK (1961) reported that a lake clay with particles oriented parallel to the horizontal had a vertical contraction three times the horizontal, but that a marine clay with random orientation of particles contracted uniformly. If clay particles at the Mesters Vig experimental sites were oriented parallel to the slope, this might be a factor in the retrograde movement. However, in view of the fact that the slope material is a diamicton and of marine origin, it seems unlikely that the effect, if any, is significant.

DAVISON's conclusion that cohesion is responsible for the departure from the vertical during settling is believed to be correct, but he did not explain exactly what he meant by cohesion or why it should operate directionally. The *Glossary of geology and related sciences*, following TERZAGHI (1950, footnote, p. 88), defines cohesion as"1. The resistance of a material, rock or sediment against shear along a surface which is under no pressure" (HOWELL, 1960, p. 56). There is an important distinction between true cohesion, which is relatively permanent, and apparent cohesion, which is caused by capillary pressure and may be very temporary depending on moisture conditions (TAYLOR, D. W., 1948, p. 320–321). Both types of cohesion can be present below the liquid limit but what slight strength remains above the liquid limit is primarily due to true cohesion. Although apparent cohesion is lost upon immersion, it can be an important strength factor during the complete saturation that exists between the liquid and shrinkage limits, and between these limits becomes increasingly effective as the moisture content becomes lower; for some mineral soils, cohesion also increases below the shrinkage limit. This effect of desiccation on the strength of soils varies with soil type (TERZAGHI and PECK, 1948, p. 126–127).

Reduction in volume of mineral soil by withdrawal of moisture is not limited to the region below the liquid limit but can also occur above it. This is demonstrated by the observed start of desiccation cracking above this limit (CORTE and HIGASHI, 1964, table 1, p. 2; fig. 3, p. 5). In summary of the above: (1) drying, but not necessarily dryness is involved during reduction of soil volume by loss of moisture; (2) cohesion, apparent and true, can impart considerable shear strength in completely saturated soils; and (3) true cohesion can be responsible for some shear strength even above the liquid limit.



CAPILLARY FORCES ACTING ON AN INCLINED PLANE PARALLEL TO A DESICCATING SURFACE, AND RESULTANT CONSIDERING GRAVITY

Fig. 45.

Turning to the directional effect of cohesion, if apparent cohesion is involved a case can be made for slope control of the capillary pressures as illustrated by figure 45. The slope surface is the evaporating surface, or is parallel to it if the capillary fringe does not reach the top of the ground. As a result in essentially uniform material the moisture gradient is at right angles to the slope. Resultant capillary pressures would therefore be oriented normal to the slope and parallel to it. The parallel pressure might produce desiccation cracks; the pressure normal to the slope would tend to contract the mineral soil along the normal and so cause a departure from the vertical during settling. Capillary pressures can be many times as strong as the effect of gravity (TAYLOR, D. W., 1948, p. 144–146), and a settling of drying soil back against a slope becomes almost inevitable. As previously stated this effect should occur on slopes that are thoroughly saturated as well as on drier slopes, so long as the mineral soil is losing volume by capillary movement of moisture to an evaporating surface.

To what extent this settling back against a slope can occur above the liquid limit is problematical. As discussed earlier, direct measurement in the field is difficult because gelifluction may mask any retrograde movement that would be evidence of the departure from the vertical. However, to the extent that the mineral soil is coherent by virtue of true cohesion, including the binding effect of vegetation, a departure from the vertical could occur as the result of differential sagging, such as might occur where there was unequal depth of thaw or inequalities of material. For instance, boulders whose bases were in frozen ground might act as support points and introduce unequal settling of adjacent thawed material. Conceivably differential sagging could explain the retrograde movement that was associated with standing surface water as described earlier, where capillary pressure could not be a factor.

The preceding explanation of retrograde movement applies regardless of whether the moisture in the ground is derived from thawing of contained ice, from exterior meltwater, or from wetting unrelated to thawing of any kind. As noted earlier, experimental results of frost creep (Davison, 1889) and of creep due only to wetting and drying (Young, 1960) show that a departure from the vertical during contraction is common to both. (Frost creep caused by needle ice at the surface would not normally involve retrograde movement and is not considered in this connection.) Climatically, frost creep and creep caused by wetting and drying can be very distinct, but in some environments they may be impossible to separate and in any environment the retrograde movement common to each is similar if not identical. Creep due to frost action, and nonfrost creep due to volume changes resulting from wetting and drying, are two of the most widespread and important types of creep known. Yet, that they are usually less per cycle of expansion and contraction than would be the case in the absence of retrograde movement seems to have been neglected, in spite of the fact that frost creep and its nonvertical settling were correctly described by Davison many years ago.

Weather Influences

The effects of moisture and temperature on gelifluction and frost creep involve conditions that may be different from year to year, depending on the weather. That weather influences are recognizable in some of the target movements should be clear from the discussion of ES 6–8, the only sites with sufficiently detailed information for such correlation.

The effect of low September temperatures on frost creep was clearly revealed by some targets and suggested by others in 1957 and 1960. In 1957 the effect was suggested by 63 percent of the targets at ES 6, 77 percent at ES 7, and 62 percent at ES 8. In September 1960, 83 percent of the targets at ES 7, and 90 percent at ES 8 suggested movement by frost creep, the higher percentages in 1960 reflecting observations to later in the month than in 1957.

The influence of rain on movement was most apparent in 1959, 1960, and 1961 when there was more precipitation than during any other of the observation seasons. In 1959, 24.2 mm of precipitation in the interval 31 July–11 August appeared to promote the movement of 63 percent of the targets at ES 7, the target observation interval being 24 July–11 August. The observation dates at ES 8 were such that the period 24 July–4 August afforded the closest check, and during this period a fourth of the targets appeared to show the effect of 17.1 mm of precipitation.

In 1960 the influence was much more marked. There was 54.3 mm of rain in the interval 24 July–2 August. The bracketing target-observation period at ES 7 was 29 July–7 August, and during it 70 percent of the targets showed a movement that appeared to correlate with the precipitation. At ES 8 during the observation interval 29 July–7 August, 96 percent of the targets suggested such a correlation. The general influence of the precipitation is quite clear, but the percentages are put in suggestive terms because many of the movements did not exceed 0.2 cm for the stated intervals and there is a possibility of some spurious movements being included. Although some of the targets at ES 6 suggested the influence of the 1960 precipitation, others indicated a retrograde movement for the same period and the picture is confused, possibly because of the very low gradient and the effect of growing vegetation adjacent to targets.

In 1961, 39.6 mm of rain fell in the period 2–4 June. Target line 7 was still snow covered. Target line 8 was already thoroughly soaked from thawing snow on the slope above and most targets were already actively moving. As a result the effect of the rain was apparently not so much to quicken the rate of movement as to maintain a high rate over a longer than normal period.

Thus, the influence of rain on movement was apparent (especially at ES 7–8), a finding contrary to the conditions found by RAPP (1960 a, p. 182; 1962, p. 306) in northern Lapland. Much more important than rain, however, was snow. The distribution and duration of snow cover were critical factors influencing gelifluction as shown by the difference in movement between the "dry" and the "wet" sectors of ES 7–8.

CONCLUSIONS

The evidence from the Mesters Vig experimental sites supports the following general conclusions.

1. Frost creep and gelifluction can be quantitatively distinguished from each other.
2. Frost creep and creep due to wetting and drying are associated with a retrograde movement that reduces the amount of creep that would otherwise be present.
3. Retrograde movement is probably due primarily to capillary effects during desiccation, but unequal sagging of coherent regolith as the result of inequalities of material and/or differential thawing may also be involved.
4. In solifluction the influence of moisture can be more important than the influence of gradient or vegetation.
5. The Atterberg liquid limit is an important parameter in solifluction, and significant solifluction probably occurs only at moisture values approximating or exceeding the liquid limit.
6. Diamictons, as distinct from their fines on which liquid limits are based, may have shear strengths greater than those suggested by the liquid limit.
7. Mass-wasting due to creep and gelifluction decreases rapidly with depth.
8. Frost creep is particularly intense on slopes characterized by abundant fines.
9. Dry creep is important on slopes characterized by grus.

In addition the evidence from the Mesters Vig experimental sites supports the following conclusions with specific application to these sites.

1. The moisture for frost creep and gelifluction is derived mainly from meltwater, particularly from snow.
2. Creep due to wetting and drying is of minor significance compared to frost creep.
3. Frost creep at most sites is due mainly to the annual freeze-thaw cycle rather than to short-term freeze-thaw cycles.

4. In mass-wasting due to creep and gelifluction, an increase or decrease in rate of the one process tends to be accompanied by a similar, but not necessarily proportionate, change in the other.

5. Either frost creep or gelifluction can predominate in different places on the same slope, depending on variations in local conditions.

6. At the sites investigated in most detail frost creep tends to exceed gelifluction but by not more, and probably less, than 3:1 over a period of years, and either process can predominate in a given year.

7. Gelifluction lobes originate as loci of differential movement due to moisture concentrations; in some lobes gelifluction predominates, in other perhaps frost creep.

8. The observed axial rates of gelifluction lobes ranged from at least 3.1 cm/yr for a lobe on a gradient of 3°, to at least 12.4 cm/yr for a lobe on a gradient of 12°.

9. In "wet" areas there may be a straight-line relation between rate of movement and sine of gradient, but with different rate-gradient values for lobes than for undifferentiated slopes.

10. Absolute values of mass-wasting due to frost creep and gelifluction on a gradient of 10–14° ranged from a mean of 0.9 cm/yr in sectors subject to desiccation during summer, to a mean of 3.7 cm/yr in sectors that remained saturated. If maintained for 1000 years, these rates would result in movements of 9–37 m.

11. The boundary moisture content required for gelifluction on the above gradient, with the diamicton present, approximates 15–20 percent moisture and is similar to the liquid limit.

12. The corresponding shear strength of the diamicton, as distinct from its fines, is on the order of 3.4 kg/cm^2 (40–60 lb/in^2).

Finally, as a general commentary, the knowledge of mass-wasting processes in cold climates is still largely qualitative, and the interpretation of past effects of creep and solifluction is correspondingly imprecise and questionable. Improved instrumentation and methods, especially for studying variation of movement with depth, would materially advance quantitative studies.

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APPENDIX A.
INFLUENCE OF TARGET ATTITUDE CHANGES

CONTENTS

General

Obviously it is critical to evaluate the effect of heaving and tilting of the targets themselves, as opposed to the effect of slope movement. Complex situations could arise. A target tilted downslope might heave and then, in the spring when the ground thawed, its peg might slip back into its hole with the result that there would be no change in target attitude when the autumn check was made; yet pseudo slope movements would have been introduced, first downslope then retrograde. The combined effect of target heaving and tilting can be best studied for ES 6–8 and for 1960 and 1961, the sites and years for which the most accurate information is available.

In this and subsequent analyses of target movement, certain targets are eliminated from general consideration because they: (1) remained continuously buried beneath snowdrifts from one year to another; (2) were located on a contour that was at an unduly large angle to the rest of the target line; (3) were subjected to possible disturbance by animals, man, or drainage; (4) were subjected to obviously excessive disturbance by frost action. In the tables of target attitudes (tables A I–A III) these are designated as excluded targets.

The role of animals in causing disturbance of a target is regarded as minimal because of the scarcity of tracks in the immediate vicinity of targets and because of the generally uniform rather than erratic trend of target movements. Although geese were a menace to thermocouple wires, only one cone target showed possible evidence of having been nibbled.

Three groups of targets are considered by the analyses: (1) a general group comprising all cone targets except those excluded as described above; (2) a select group of cone targets consisting of all of the general group whose downslope or upslope attitude change from August to August (incl.) in the years indicated did not exceed 0.2 cm; and (3) stone targets (ES 7 only). The stone targets were cobbles along target line 7 that were selected for comparative studies in 1960; because of the lack of sharp points they could not be read as accurately as the cone targets but they were presumably less subject to heaving and tilting, since most were lying flat on the surface or were only shallowly imbedded in the ground. If critical data are lacking for a target, the target is questioned in the appropriate column of the tables and is omitted for that part of the analysis. A questioned target is not necessarily excluded from all consideration since it might still provide useful data; for instance, the amount of tilt might not be significant if the tilt change were downslope and only tilt-induced retrograde movement were being considered. Target movements for 1959–61, observed normal to the target line and adjusted for any changes in target attitude, are compared in tables A IV–A VI. As explained in appendix C, the attitude adjustments are to allow for changes due to heaving and/or tilting of targets. Examination of the tables reveals that the proportions derived from comparing the select group of targets with the nonadjusted targets of the general group are very similar. This supports the view that in general changes of target attitude were not a controlling influence in determining target movement for a group of targets, although they exerted a dominant influence in individual cases. The data in tables A IV–A VI are listed according to jump, gelifluction, retrograde movement, September movement, and annual movement. In much of the following discussion these data are summarized in terms of the percent of targets involved in a given category of movement; as a measure of reliability for each case, the tables list the number of targets involved, expressed as a proportion.

Retrograde Movement as an Example

Taking retrograde movement in 1960 as an example for analysis, and combining data for ES 6–8 (table A VII), 76 percent of the general group and 73 percent of the select group of cone targets showed retrograde movement in excess of 0.2 cm if no adjustment is made for attitude changes (observed movement). Correcting for such changes, the figures become, respectively, 58 percent and 70 percent (adjusted movement). Thus the select targets, considering both adjusted and nonadjusted values, showed only a 3–6 percent difference from the nonadjusted targets of the general group and, judging from the percentages, the behavior of the select group as a whole conformed much more to that of the nonadjusted targets than to the adjusted targets of the general group. Presumably the stone targets at ES 7 are most nearly comparable to the select targets in stability; in any event 81 percent of them showed retrograde movement exceeding 0.2 cm.

For retrograde movement in 1961, 93 percent of the general group and 93 percent of the select group showed movement exceeding 0.2 cm on the nonadjusted basis. On the adjusted basis the respective figures are 74 percent and 93 percent. The select targets, whether adjusted or nonadjusted, showed no difference from the figure for the nonadjusted targets of the general group and, therefore, again appeared to conform closely to them in behavior. Although the stone targets showed almost no retrograde movement exceeding 0.2 cm, the observation period involved was much shorter than for the cone targets in 1961 and also much shorter than for the stone targets in 1960, and the possibility of recording retrograde movement was correspondingly curtailed.

The retrograde record of the stone targets and of the select targets is regarded as reasonably reliable because these targets have been least subject to attitude changes resulting from heaving or tilting. The near identity of adjusted and nonadjusted percentages for the select targets reflects this situation. The observation that the record of these targets corresponds closely to that of the nonadjusted, and not to the adjusted, targets of the general group is reasonable, because: (1) adjustments for upslope attitude changes can be misleading in that such changes may have been absorbed by reduction of downslope movement and may not have affected retrograde movement, depending on the relative timing of the attitude change and the other movements; (2) adjusted values do not take account of downslope attitude changes of targets that do not show retrograde movement, and such changes would tend to mask retrograde movement and thereby reduce the number of targets showing it. Thus, (1) percentages based on adjusted targets of the general group are minimum only; (2) percentages based on select targets (both nonadjusted and adjusted) and on nonadjusted targets of the general group are closely similar and their order of magnitude is supported by the record of the stone targets; (3) from the above and the fact that changes of target attitude have been greater and more frequent for the nonadjusted targets of the general group than for the select targets, it follows that recorded changes of target attitude have not significantly affected the number of targets participating in retrograde movement.

The possibility of a tilted target's heaving and then slipping back to its former position, thus introducing pseudo slope movements without change of recorded target attitude, was also investigated. Turning again to retrograde movement, the model would be represented by targets with a downslope tilt, since heaving of the target itself would then produce the effect of downslope movement, and the subsequent back slipping would simulate later retrograde movement, which is the normal sequence of slope movements indicated by the targets. However, for the years analyzed (1960 and 1961), this coincidence of downslope attitude, no attitude change, and retrograde movement was exhibited by only 4–6 percent of the 83 targets at ES 6–8 and at no one of these sites did it exceed 16 percent (table A VII).

It might be argued that there should be a 50 percent chance for a target to tilt either upslope or downslope – therefore that half the targets at ES 6–8 could show a downslope movement and half an upslope movement due only to tilt effects rather than to slope movements, and (allowing for deviation) that the recorded upslope movements are illusory. This argument does not stand up because: (1) considerably less than 50 percent of the targets showed upslope attitude changes exceeding 0.2 cm (tables A IV–A VI; cf. columns giving effect of attitude changes); (2) the argument does not apply to the select targets and stone targets, yet more of these showed retrograde movement than did the targets with upslope attitude changes; (3) depending on site and year, 67–100 percent of the nonadjusted targets showed retrograde movement; (4) except at ES 7 (where in 1960 only 49 percent of the adjusted general group show retrograde movement), even the adjusted targets, which represent a minimum and improbably low proportion of the targets participating in retrograde movement as discussed above, have well over 50 percent of their number showing such movement.

From what has been said, it seems clear that changes of target attitude do not significantly influence the number of targets involved in retrograde movement, but the question remains as to how seriously such changes affect the magnitude of the recorded movement. The answer, derived from tables A IV–A VI, is summarized in table A VII. Considering all the retrograde targets at ES 6–8 for 1960 and attitude changes for 1959–60, the mean change upslope and the mean change downslope are both 0.2 cm; for 1961 the mean change upslope is 0.2 cm and the change downslope, 0.1 cm. Thus, some retrograde targets affected by attitude changes may have showed too much retrograde movement and others too little, depending upon when the attitude change took place with respect to the retrograde movement, but on the average the attitude changes tended to compensate each other.

Summary

In summary of the foregoing discussion it can be said that changes of target attitude did not significantly affect either the number of targets that showed retrograde movement or the amount of such movement, provided a number of targets are considered. Retrograde movement was selected for detailed analysis because the phenomenon is little known and it was important to evaluate its reality and quantitative reliability. A similar analysis for jump and gelifluction would be repetitious but a perusal of tables A IV–A VI shows that the results would be similar. September movement is more difficult to evaluate because of fewer data but its lack of correlation with target attitude changes supports its validity. Taking all the targets at ES 6–8 that showed September movement in 1960, only 14 percent (5 of 35) had attitude changes that might have been responsible for the movement. Moreover, the mean attitude changes downslope or upslope were small for all categories of movement, not only for retrograde movement, and tended to compensate each other. Thus, the maximum mean change for all the accepted targets at any site from 1959 through 1961 (including any two consecutive years of that period) was 0.3 cm, and the maximum mean noncompensated amount was 0.2 cm (less than the minimum mass-wasting movement included in the tables), although the standard errors of the mean (defined in app. C) were comparatively large.

For a given category of movement (jump, gelifluction, retrograde, or September), the nonadjusted values are regarded as more reliable than the adjusted values. This is because adjusted values can not allow for relative timing between such movement and target attitude changes, or for compensatory attitude changes where a number of targets are concerned. However, these factors apply only to these component categories. The total movement of a target, on the other hand, includes the algebraic sum of attitude changes and is appropriately adjusted by subtracting this sum, as has been done where total annual movements of cone targets are considered (tables C I–C II, C IV, C VIII); this correction need not correspond to the final target attitude, since some targets had an initial tilt. In general the correction is minor compared to the total movements. The above analysis indicates that although changes of target attitude may seriously affect the readings of some individual targets, they do not seriously influence mean readings where a number of targets are concerned. Additional evidence for accepting cone targets as valid indicators of mass-wasting is provided by the similar behavior of the stone targets (table C III) and by the progressive nature of most movements (tables C I–C II, C IV).

As a whole the evidence eliminates the possibility that the cone targets were controlled by heaving and/or tilting of the targets themselves or by any other random movements if a number of targets are considered. Obviously the data from any one target are unreliable (even though random movements tended to cancel each other over a period of years), and the total movement of a target for the whole period of observation (1956–61) is statistically superior to the movement for any given year.

APPENDIX B.

INFLUENCE OF SHORT-TERM ZERO-DEGREE CYCLES

CONTENTS

Tables

General

In order to evaluate the possibility that spring freeze-thaw cycles were responsible for major movement by frost creep, an analysis was made of air temperatures and ground temperatures as related to dates when targets were first exposed from the snow and the adjacent ground was thus subject to thawing. The analysis will first consider temperatures, then target exposure dates in relation to temperature. The pertinent instrumentation is described in appendix E.

Temperature Data

Soil thermograph 8A was in a vegetation-free spot near the east end of target line 8, and its bulb was at a depth of 12 cm. TG 8B was in approximately the same place and was a dual-pen instrument with bulbs at depths of 5 cm and 12 cm. TG 8C, 8D, and 8E were between the target lines of ES 7 and ES 8 in an area that generally became snow free earlier than any targets at ES 6 or ES 7.[1]) Although listed with ES 8, they were also representative of the environment at ES 7 except for this difference in snow cover. The ground at TG 8C was insulated by vegetation; the bulb was at a depth of 6 cm but the resulting data are grouped with data from 5-cm depths. TG 8D recorded the temperature at a depth of 5 cm in a nearby vegetation-free spot, and TG 8E was on a bare surface adjacent to TG 8D. Bulb depths were checked upon excavation to avoid discrepancies due to possible upfreezing.

Ground-temperature cycles to 0°, and cycles passing 0° by at least (to nearest degree) 1°, 2°, 3°, and 4° as recorded by these instruments, are given in table B I, which also shows comparative cycles of air temperature at the Danish Government station and at ES 8. Air temperature conditions at ES 7 were essentially identical to those at ES 8. Temperature cycles involving changes to or through 0° do not necessarily constitute freeze-thaw cycles, especially in the ground where the freezing point may be depressed, and the term zero-degree cycle is preferred in the following unless a cycle entailing freezing and thawing is specifically meant. Where zero-degree ground cycles are cited in the following discussion, they refer to cycles passing 0° with an amplitude $\geq 0°$ at a depth of about 5 cm unless otherwise indicated.

Essentially the only months that require analysis are May through October, since ground cycles in other months are very rare or absent. For the two years of record (1960–61) for the 5-cm depth, the number of cycles observed at ES 8 were: first half of May, 0–4; second half of May, 6–15; first half of June, 0–2; second half of June, 0; July, 0; August, 0; first half of September, 0–3; second half of September, 0–6. Data for October are lacking. Presence or absence of snow cover was the critical factor determining the variation in number of cycles in May.

Indirect evidence regarding the frequency of zero-degree cycles in the ground is obtained from estimating the extent to which they are represented by zero-degree cycles in the air and then extrapolating from meteorological records. This method is full of assumptions but may be provide an order of magnitude if carefully applied. The ground-temperature records permit direct comparison. One attempt at correlation is illustrated by table B II, which is based on the total

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[1]) The location of the soil thermographs is described in detail under ES 8. Although thermographs 8C–8E were in the west third of the slope characterized by two extensive snow drifts, they lay between them, and the early exposure of the area in which the thermographs were placed was in part due to meltwater from the drifts. The meltwater probably tended to dampen freeze-thaw cycles, but this was also true of most of the rest of the slope until the snow disappeared from above the target lines. By this time freeze-thaw cycles were no longer present in most years.

number of cycles in a given period rather than on cycle-to-cycle correlation, and which uses a different minimum air-temperature amplitude for May and the second half of September than for June through the first half of September. The minimum amplitude above and below 0° for May and the second half of September is ≥ 0°, and that for the other months is ≥ 4°. Following previous usage, FRASER (1959, p. 42) and COOK and RAICHE (1962) allowed for a greater temperature swing below 0° than above, but FRASER noted that the cooling effect of permafrost should be taken into account in northern regions, and COOK and RAICHE (1962, p. 76) stated that "Probably it is impossible to define the parameters of a universally acceptable freeze- thaw cycle." In view of the many uncertainties inherent in the method (cf. MATTHEWS, 1962), the present analysis makes no attempt to introduce a different amplitude value for air temperatures below 0° than for those above it. No amplitude on either side of 0° is maintained for the ground-temperature cycles in any month on the conservative basis that either freezing or thawing of the ground is possible at 0° or only slightly below it, given sufficient time. Because of lag effects and variations introduced by freezing-point depression (cf. Arctic Construction and Frost Effects Laboratory, 1958, p. 31–35, 40–41; COOK and RAICHE, 1962, p. 75–76; LANGE and MCKIM, 1963; WASHBURN, 1956, p. 843), the actual number of freeze-thaw cycles in the ground would probably differ from and, because of the lag effects, be fewer than the number of zero-degree cycles thus indicated. The analysis (table B II) suggests that at a depth of 5 cm and in the absence of snow cover the number of zero-degree cycles in the ground from May through September is crudely approximated by the number of zero-degree cycles in the air for each of these months, the amplitude in each case being as indicated. The greatest departures from this scheme are for the second half of May when there were 11 air cycles and 6–8 ground cycles in 1960, and 11–13 air cycles and 15 ground cycles in 1961. Averaging both years, the correlation is good. The number of cycles at a depth of 12 cm tended to be fewer than at the 5-cm depth except for the first half of June in 1961 when there were 7 cycles at the 12-cm depth as opposed to 0-2 cycles at the 5-cm depth (table B I). The former may have represented upfreezing of the frost table. The discrepancies illustrate the difficulties and dangers of applying the method, even where there are overlapping records of air-and-ground temperatures in a locality. If applied to periods of movement observations at ES 6–8 when data on zero-degree cycles in the ground are otherwise lacking as in 1957, the method suggests that the frequency of cycles at a depth of 5 cm was similar to that in subsequent years.

Relation to Snow Cover

In order relate frequency of zero-degree ground cycles, as defined above, to snow cover and target exposure, the data for ES 6–8 are considered separately for each site. As discussed in connection with the target movements and in appendix A, certain targets are excluded from comparative analyses. At ES 6 they include T 38–39, 43, which remained snow covered in some years and are listed separately in table B III with respect to earliest possible exposure, since they did not enter the movement calculations. There remained 19 targets at ES 6, 51 targets (35 cone, 16 stone) at ES 7, and 29 targets at ES 8. The following data are derived mainly from tables B I, B III–B IV and from the summary in table B II. The years considered are 1957–61 but the record is deficient in some years. The following percentages are given to the nearest 5 percent.

At ES 6 snow-cover data for May and June are lacking in 1959 and 1961, but judging from general conditions it seems unlikely that any targets were exposed during the first half of May. In May 1958 and 1960 no targets were exposed and the same is probably true for May 1957. In the first half of June the percent of exposed targets ranged from 20 percent (1958) to 75 percent (1960), the average being 45 percent. Most of the targets concerned were along the east half of the target line. In general for the period 1957–61 the majority of targets considered were exposed by the end of June. The first half of June is the critical interval because freeze-thaw cycles were commonly inhibited by the snow cover in May and, judging from the record at ES 8, there were probably no zero-degree ground cycles in the summer after mid June. During the critical interval there were 0–2 cycles at a depth of 5 cm at ES 8, depending on the year (1960 or 1961) and spot. If a similar frequency is assumed for this depth at ES 6, it would give as a first approximation for ES 6 an average of 1 zero-degree ground cycle in the spring and none during the summer.

At ES 7, with the exception of one target in 1961, there were probably no targets exposed in the first half of May during the period 1957–61. In the second half of May the percent of exposed targets ranged from 0 (1960 and probably 1957) to 15 percent (1958), with the data for 1959 being deficient. For the first half of June the percent of exposed targets varied from 0 (1960) to 60 percent (1958, 1961), the average being 35 percent. Most of the early exposed targets were along the east half of the target line. The majority of targets lay exposed during the second half of June, although some in the west part of the line remained covered into July. The first half of June was again the critical interval. In May the snow cover deterred freeze-thaw cycles except for a very small number of targets, and no zero-degree cycles in the ground were recorded on the same slope at ES 8 between mid June and the autumn. For the first half of June there were 0–2 cycles at a depth of 5 cm during the period for which observations are available (1960–61). Comparing this with the number of exposed targets, it seems reasonable to conclude that at ES 7 an average of 1 zero-degree cycle at the depth of 5 cm could have affected about one third of the targets in the spring but no targets during the summer, with any spring effects being essentially confined to the east half of the target line.

At ES 8 targets were commonly exposed earlier than at ES 6 or ES 7, probably mainly because target line 8 was at the outer edge of a break in slope where wind tended to inhibit as much snow accumulation as at ES 6–7. Data for the spring of 1959 are lacking. During the first half of May in the other years, from 0 percent (1958 and probably 1960) to 55 percent (1961), and during the second half of May 30 percent (1960) to 90 percent (1957, 1961) of the targets were exposed; the average for the first half of May is about 25 percent (the 1960 data are deficient) and for the second half, 70 percent. Except in 1960 all or almost all the targets lay exposed by mid June, the average being 90 percent. There was no generally regular east to west progression of exposure as at ES 6 and ES 7. Early May was not a critical interval. Although over half the targets were exposed during the first half of May in 1961, there were only 0–4 zero-degree ground cycles at a depth of 5 cm; no cycles were recorded at a depth of 12 cm. Only 2 air cycles occurred at either the government station or ES 8. In the other years few or no targets were exposed at this time, except in 1957 when the number of air cycles was low (5) and, by extrapolation, the number of zero-degree ground cycles probably also low. The critical period was the second half of May. Within it the number of cycles at a depth of 5 cm in snow-free spots ranged from 6–8 (1960) to 15 (1961). Combining the median value for the 5-cm depth with the average percent of exposed targets (1957–58, 1960–61) results in the estimate that at ES 8 some 11 zero-degree ground cycles can be expected to occur at this depth at 70 percent of the targets during this period. In June there were only 0–2 cycles recorded at a depth of 5 cm as previously noted.

The spring zero-degree ground cycles at ES 8 occurred during the period when the slope tended to be wettest. That frost creep during this period was probably minimal compared to gelifluction is suggested by the fact that rates of target movement when cycles were most frequent were similar to, or less than, when cycles were few or absent, as discussed in connection with frost creep and potential frost creep at ES 8.

There is less information on zero-degree ground cycles in the autumn than earlier in the year. Thermograph records for the depth of 5 cm are available for 1960 only; for a depth of 12 cm they are available for 1958 (to 18 Sept.) and 1960. The fragmentary data indicate that for September at the 5-cm depth there were 0–9 cycles, and at the 12-cm depth, 2 cycles. Comparison with air-temperature cycles in 1958 and 1960, and extrapolation from them to other years of the program, suggest that only in September 1957, when the ground was bare, was any comparable frequency of ground cycles to be expected. Thermocouple observations of ground temperature for late September 1956 and for late September and early October 1960 (tables E I–E III) indicate that much of the active layer tends to be at a negative temperature in October. This and the presence of snow in October (Washburn, 1965, table 1, p. 46–51) argue for few if any ground cycles in that month in spite of continued ai cycles with amplitudes of up to 4° on either side of 0°. Fraser (1959, p. 45–49) pointed out that daily temperature amplitudes are commonly less, and "freeze-thaw" cycles fewer, in the autumn than in the spring. The Mesters Vig observations support the view that short-term zero-degree cycles in the ground are also fewer. In any event the effect of such cycles as occur is included in the jump, rather than gelifluction, category of target movement.

Fluctuations of the Frost Table at Depth

The foregoing discussion cited zero-degree cycles to depths of about 5–10 cm, whereas half the cone targets were at a depth of 20 cm. As a first approximation, there were even fewer cycles here than at shallower depths in view of the fact that the amplitude of temperature fluctuations decreases with increasing depth. However, although it seems certain that short-term freeze-thaw cycles at Mesters Vig are infrequent at depths below about 10 cm as a result of zero-degree cycles of air temperature, it is theoretically possible for a decrease of surface temperature, even in the positive range, to result in a rise of the frost table in a permafrost environment. Such a rise would occur if the frost table were losing heat more rapidly downward than it was being supplied from above. Upfreezing of the frost table has been reported by several investigators, including Sukacheva (1911, p. 57; cf. Meinardus, 1930, p. 40), Müller (1954, p. 130–131), R. S. Taylor (1956, p. 109–112, 118, pl. 21–23)1)), U. S. Army Corps of Engineers (cf. Washburn, 1956, footnote 19, p. 842), and Drew and others (1958, p. 700).

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1) Certain of Taylor's data (pl. 21–23) appear to involve instrumental errors, judging from internal inconsistencies such as simultaneous fluctuations of the zero-degree isotherm at different depths and places where the amplitude of the fluctuations increases with depth, so that some of the data are suspect as they pertain to short-term fluctuations of the frost table. However, frequent oscillations of the frost table were considered probable by Schmertmann and Taylor (1965, p. 50) on the basis of the available data.

Upfreezing of the frost table during a summer cool spell seems to be indicated by observations at ES 7 (table E II.2, TCS 7 E, 11–15 July 1960), but such observations were rare at Mesters Vig and the supporting evidence is meager. The presence of undetected zero-degree cycles at or near the frost table at ES 8 is suggested by the June 1961 record for the dual-pen soil thermograph 8 B, since the bulb at the 5-cm depth showed no cycles while the bulb at the 12-cm depth recorded 7 cycles ((table B I), which would be consistent with short-term rises of the frost table. However, the 5-cm bulb was 23 cm downslope from the 12-cm bulb, and there is no certainty that depth was the only variable. Once thawing started at the surface of the ground, the following circumstances would minimize the frequency of short-term freeze-thaw cycles at the frost table during the period of rising mean air temperatures: (1) During this period the temperature gradient involving positive temperatures is commonly much stronger than the gradient involving negative temperatures (tables E I–E III). (2) Fluctuations of ground temperature decrease markedly with increasing depth as measured, for instance, by Jahn (1948a, p. 125–131, 142; 1948b, p. 55). Although Czeppe (1960, p. 150–151; 1961, diag. VII, p. 22, p. 55, 61) reported numerous oscillations across 0° at a depth of 5 cm in Spitsbergen, he found none below a depth of 20 cm in the spring; in the autumn there were none below a depth of 30–50 cm (cf. also Jahn, 1961, p. 9; 1963, p. 9). At Cornwallis Island in the Canadian Arctic, Cook and Raiche (1962, table 1, p. 67) using continuous Speedomax recording equipment found 23 cycles in the range −2.2° to 0° (28° F to 32° F) at the ground surface but only one cycle at a depth of 2.5 cm and none at depths of 10 cm and 20 cm. Citing additional observations from elsewhere by Haywood (1961, p. 9; analyzed by Andrews, 1963, p. 171) and observations by Saint-Onge (cf. Saint-Onge, 1963), Cook (1963, p. 6, cf. p. 4) stated "***Results from arctic Canada show that there are no cycles apart from the annual cycle at depths below a few centimeters." (3) The number of zero-degree cycles (i. e., allowing for the maximum possible frequency of freeze-thaw cycles as opposed to the more restrictive definitions followed by Cook and Raiche) also decreases with increasing depth (table B I). (4) The latent heat of crystallization would dampen the effect of a freezing temperature following a thaw.

Even if short-term freeze-thaw cycles instigated by positive-range fluctuations of surface temperature are frequent at the frost table, it still remains to be proved that their cumulative effect on frost creep is significant. There are several arguments against its importance: (1) In general decreasing temperatures above the frost table in the late summer (tables E I–E III) would tend to favor upward movements of the frost table, and if important frost creep were a result of short-term fluctuations of the frost table at depth such creep might be expected to be as great in the late summer as earlier. However, at Mesters Vig the greatest movement (aside from that associated with the jump and winter freezing) occurred characteristically in the first part of the thaw season and tended to stop during the summer except where the ground was saturated. (2) Even during the first part of the thaw season the greatest movement did not necessarily coincide with the period when the most ground cycles were recorded and, therefore, when any freeze-thaw cycles and attendant frost creep should have been at a maximum. At both ES 7 and ES 8 a number of movement graphs show a rate of movement that was essentially the same after zero-degree ground cycles were no longer recorded as it was while they were operative. (3) The greatest downslope movement was invariably associated with periods of high moisture near the surface of the ground during the thaw season.

Summary

In summary, the evidence indicates that: (1) Short-term freeze-thaw cycles in the ground are infrequent at depths greater than about 10 cm at ES 6–8. This conclusion is consistent with SØRENSEN's (1935, p. 10–16, 30) view regarding the paucity of freeze-thaw cycles in the ground at Ella Ø, with FRASER's (1959, p. 44–45) data showing that freeze-thaw air cycles in Canada are much less frequent in the Arctic than farther south, and with COOK's (1963, p. 4, 6) finding from arctic Canada "***that there are no cycles, apart from the annual cycle at depths below a few centimeters." (2) Frost creep is usually of minor importance in the downslope movement that occurs during the thaw season except possibly at ES 8, which tends to be snow free earlier than ES 6–7 and is therefore more subject to zero-degree cycles (cf. discussion of ES 7–8 in the summary and comparison of ES 6–17).

Appendix C.

TARGET MOVEMENT OBSERVATIONS

CONTENTS

General

The instrumentation and related procedures used to obtain the data reported in the target tables and graphs included the following.

Mass-wastingmeters

Mass-wastingmeters were designed to measure mass-wasting at depth as well as at the surface of the ground, but in general they turned out to be unsatisfactory. The instrument consisted of an aluminum pipe, 183 cm long, with outside diameter 3.8 cm and inside diameter 2.5 cm, through which three wires passed over small pulleys to three dial gages, one for each wire, at the top of the pipe. The dials were protected by a transparent plastic hood (fig. 36). The 3 wires led out through the pipe at three different heights above its base; the end of each wire was attached to a rectangular brick measuring 4×5×9 cm, and each brick was buried at different depths in a backfilled slit trench downslope from the pipe. The pipes were inserted vertically, as near the permafrost table as possible, and the position of each pipe was accurately determined by theodolite or tape so that any subsequent movement of the pipes could be measured. Supposedly any displacement of the bricks after burial would be indicated on the dial in degrees. Although readings could not indicate direction of movement, it was hoped that after excavation of the bricks comparison of initial and final brick positions and of initial and final positions of a mass-wastingmeter itself would permit some correlation of time and magnitude of brick movement with direction.

Four mass-wastingmeters were installed, one each at ES 6–8 and 16. As indicated, the instruments were largely unsatisfactory. The pipes were too short for their bases to become anchored in permafrost; as a result they were subject to heaving, which led to stresses on the wires and to readings that reflected heaving rather than movement of the bricks. Moreover, excavation revealed that the wires themselves had been affected independently of the bricks at some of the experimental sites. However, the readings provided useful information at ES 16, and, as the pipes were inserted in the ground to greater depths than any cone target, all the instruments served a useful function as targets. The data are discussed in connection with the experimental sites listed above.

Mass-wasting targets

Cones. Orange-colored cones were aligned across a number of slopes to measure mass-wasting; heaving of the cones also provided information on frost action. The cones (fig. 3) were of wood, had a basal diameter and height of about 10 cm, and were mounted on creosoted wood pegs 1.5 cm in diameter that were ringed with grooves to promote anchorage in the ground. There were two peg lengths—10 and 20 cm—so that any differences in behavior of the ground above and below a depth of 10 cm could be detected.

Data on heaving and tilting of targets are given in tables A I–A III. Besides noting downslope or upslope tilt during theodolite readings, target attitudes were examined, generally once a year, by walking below the target line when the ground became firm enough to minimize danger of disturbing the targets. This was necessary since only the tip of some targets could be seen from the theodolite station and there was no other way of obtaining data on attitude changes. Theodolite readings preceding and following close approaches to the targets guaranteed that none of the targets on which calculations are based were affected by this procedure. In the few cases of probable disturbance from this or other accidental cause, the target concerned was excluded from further consideration. In 1957 and 1958 target attitudes were generally estimated rather than measured because of the fear of treading too closely to the targets; in particular, tilts were difficult to estimate and are therefore reported with respect to direction only. Both heave and tilt of targets were measured from 1959 through 1961, after it had become clear that the targets could be approached closely without disturbance at the end of each season when the ground was hard in most places. It was impractical to measure the heave directly on the peg of the cone targets, and measurements were commonly made from the basal edge of the cone to the ground on several sides and the results averaged to the closest 0.5 cm. A question mark following the heave figure in tables A I–A III indicates that because of vegetation or some other factor the heave could be determined on only one side of the cone.

Any change in heave of a target tilted downslope or upslope, and/or any change in such tilt, would affect the position of the tip and, consequently, the movement observations. The effect of such attitude changes was determined by measuring, on the ground, the horizontal distance between (a) the vertical from the target tip and (b) the axis of the target where the peg intersected the ground. These measurements were generally reproducible to within 0.2 cm, and the target movement readings for 1959–61 were evaluated with respect to such changes. Although no such correction could be applied to earlier readings, it seems probable that any attitude changes tended to cancel each other when all the targets along any one line are considered. This was true for 1959–61 when, taking 10-cm and 20-cm targets independently, the attitude changes from one year to another at ES 6–8 resulted in a mean downslope or upslope effect that did not exceed 0.2 cm, except at ES 6 in 1959–60 when there was a 0.4 cm change for the 20-cm targets.

Stones. As a check on the behavior of cone targets as compared with stones at the surface of the ground, stones in immediate proximity to target line 7 were selected for observation. The stones, of various lithologies and mainly of cobble size, lay shallowly imbedded in the ground or were on top of it. All were essentially flatlying rather than on edge. It was difficult to pick stones that had sharp enough high spots for accurate theodolite readings but 16 stones proved to be reasonably satisfactory from this point of view, although the accuracy is probably less than for the tip of the cone targets. The stones were marked with red paint; disturbance of the stones or cone targets by stepping near them during the marking was avoided by using a small brush at the end of a long stick. The distribution of the stones and their annual movement is discussed in connection with ES 7.

Dowels. Wood dowels were utilized to record mass-wasting and frost action at a number of experimental sites. The dowels were 0.3 cm in diameter and 15 cm long, and had a black circle at 5 cm and another at 10 cm above their base to facilitate uniform penetration (fig. 3). The dowels were set out and read with reference to strings or wires stretched between end posts. At ES 16 the end points were wood plugs in bedrock, but ES 15 and the dowel line at ES 8 were in localities where the end points could not be so firmly fixed, and the readings therefore represent relative and minimum, rather than absolute, movement.

Theodolite Observations

The theodolite employed was a Wild T-2, and the cone targets were set out and read with this instrument at ES 6–8. It was also used for reading the stone targets at ES 7.

The theodolite stations and end points for the target lines of ES 6–8 were on bedrock. Sighting was to the tips of the cones, which were read to the closest second of arc. Eight consecutive test runs on the same target line on the same day, with realignment of the theodolite on end reference points between runs, showed a maximum difference of 3 seconds for any one target. In general the possible error due to centering of the theodolite, alignment on end reference points, and sighting of target tips is believed to amount to an apparent target displacement of less than 0.15 cm at 100 m for any one series of readings of a target line.

Routinely two series of readings were made each time a target line was reported, and the results were averaged if consistent within the above limits of error. If they were inconsistent, a third series of readings was run. After completing a series, the theodolite was rechecked against the end reference point to eliminate the possibility of serious error from any change in alignment of the instrument during the series; because the instrument was reset between series, any alignment errors were noncumulative. Readings were commonly made in the shade of an umbrella or in the natural shade of cliffs or clouds. With each series, notes were kept of ground conditions adjacent to targets and of target attitudes (heave and tilt) as seen through the theodolite; conditions included presence of any snow or water and growth of vegetation. Target readings were reduced to centimeters of displacement, and these movements are summarized in table V and, for select targets, also in plates C 1–C 3. Detailed data are given in tables C I–C IV.

Tables

The target-movement tables (tables C I–C VIII) and most other tables in the appendices were set up at the Yale University Computer Center. Not only was this procedure a convenience in tabulating data uniformly, but in the case of the target-movement tables the computer operations materially reduced the possibility of errors in the lengthy calculations involved in transforming angular measurements of movement into metric equivalents, and then making the adjustments for angle of view, gradient, and target attitude changes. The fact that most of the movement distances had been previously calculated by logarithms afforded an additional check. Adjustments for attitude changes (tables A I–A III) are restricted to the annual movements and their summation for reasons cited in the text discussion of the nature of the data. The other adjustments are applied throughout unless otherwise indicated, but the original measurements are also provided for comparison. The standard error of the mean ($\bar{\sigma}$)¹) is given for most means. Tables C I–C IV give movements in centimeters to two decimal places because of restrictions imposed by the computer program. However, all figures should be read as if to the closest tenth of a centimeter in conformity with the other movement tables and the text. The writer is indebted to Professor Horace Winchell for programming suggestions and to Mrs. Judith Mallozzi and Miss Vivian Reich for the actual programming.

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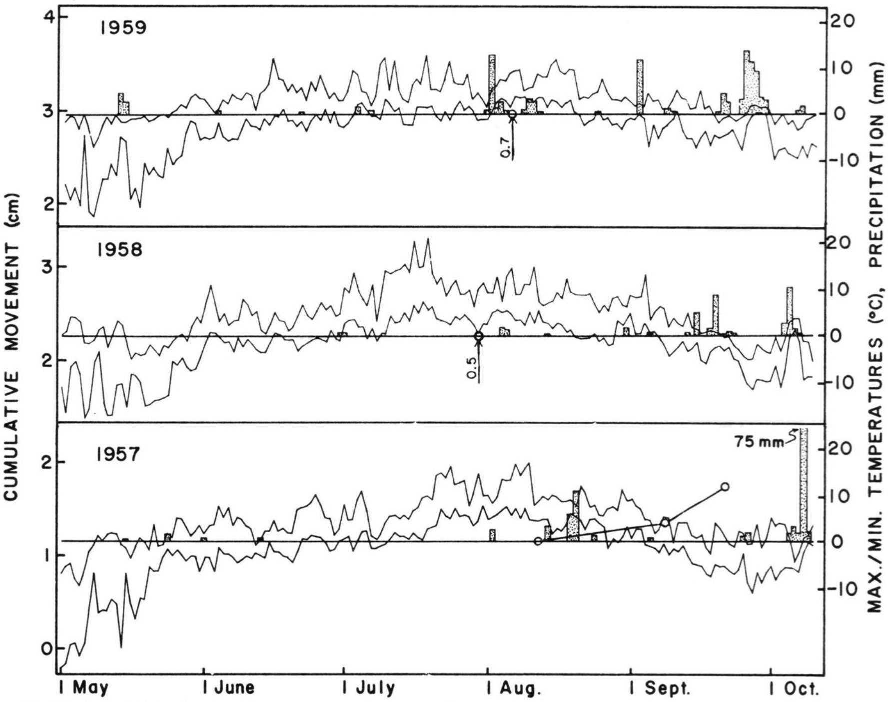
¹) Defined as $\sqrt{\frac{\Sigma x_i^2}{n(n-1)} - \frac{\bar{x}^2}{n-1}}$ (Wallis and Roberts, 1956, p. 251, 367–377). It is related to the standard deviation (σ) by the expression, $\bar{\sigma} = \frac{\sigma}{\sqrt{n}}$.



EXPERIMENTAL SITE 6 MASS-WASTINGMETER (at ground surface)

Plate C 1-1.

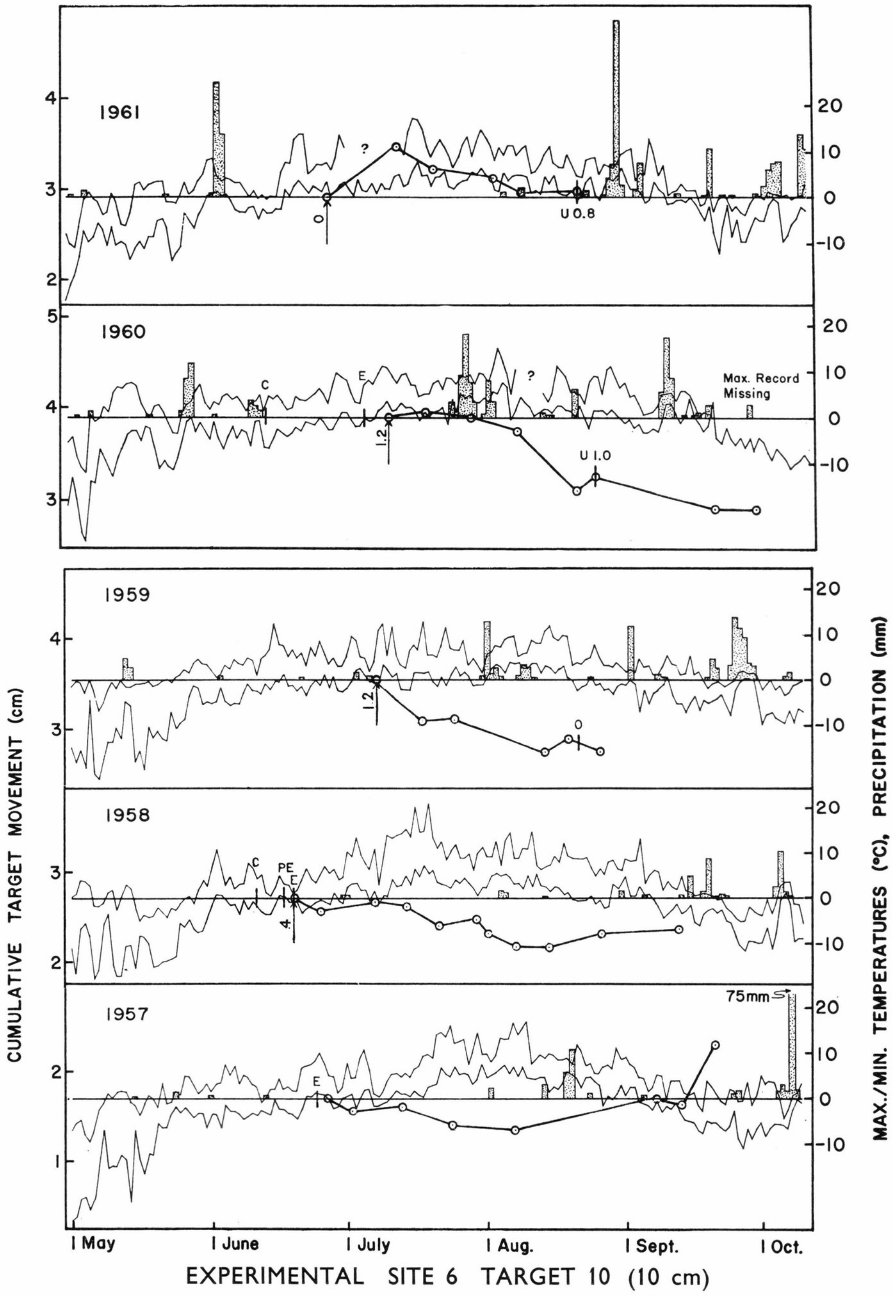

1961
1960
1959
1958
1957
CUMULATIVE TARGET MOVEMENT (cm)
MAX./MIN. TEMPERATURES (°C), PRECIPITATION (mm)
?
0
U 0.8
C
E
1.2
U 1.0
Max. Record Missing
1.2
0
C
PE
E
4
E
75mm
20
10
0
-10
1 May
1 June
1 July
1 Aug.
1 Sept.
1 Oct.
EXPERIMENTAL SITE 6 TARGET 10 (10 cm)

Plate C 1–2.

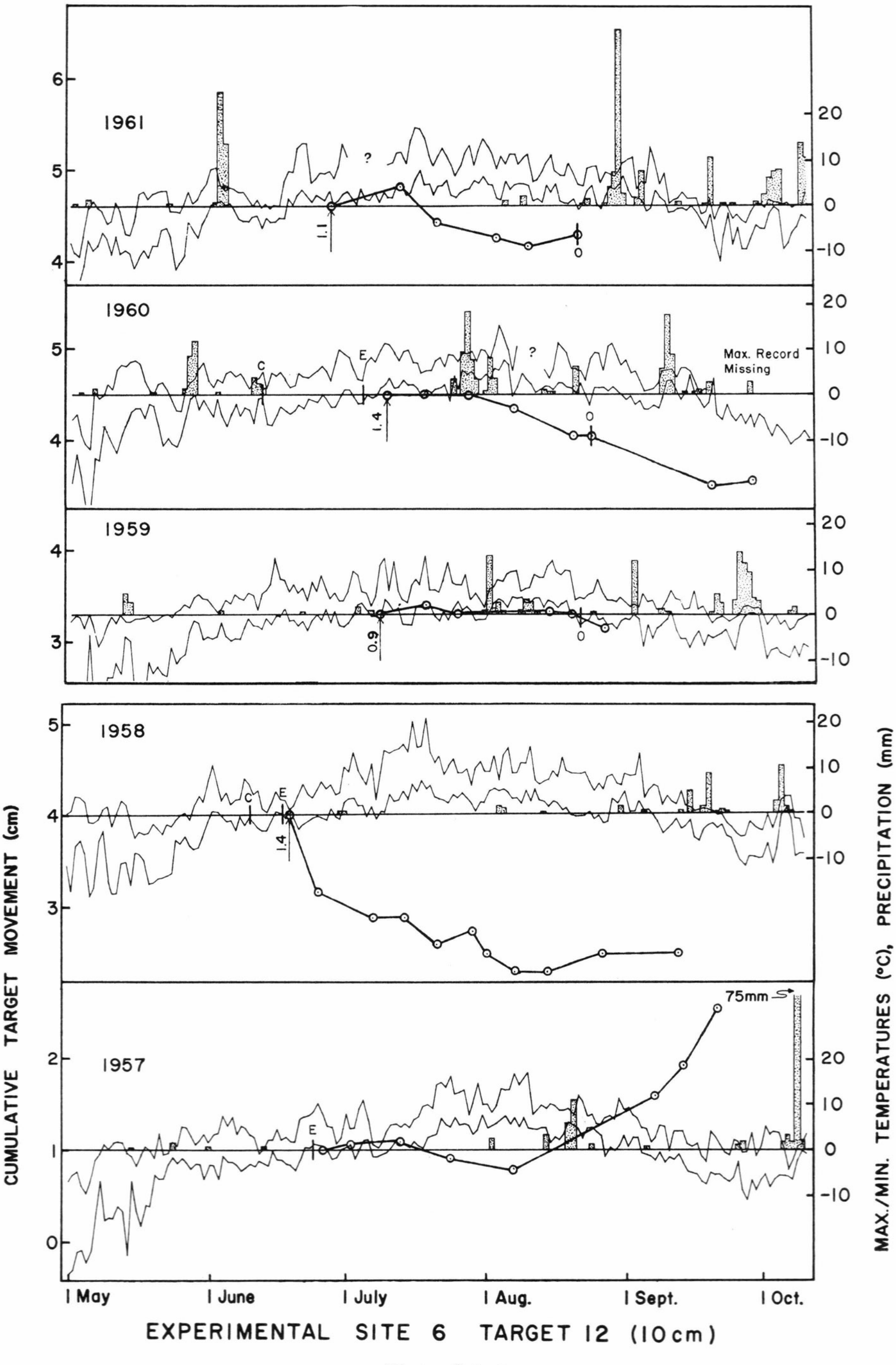

1961
1960
1959
1958
1957
?
C
E
1.1
1.4
0.9
O
Max. Record Missing
75mm
CUMULATIVE TARGET MOVEMENT (cm)
MAX./MIN. TEMPERATURES (°C), PRECIPITATION (mm)
6
5
4
3
2
1
0
20
10
-10
I May
I June
I July
I Aug.
I Sept.
I Oct.
EXPERIMENTAL SITE 6 TARGET 12 (10 cm)

Plate C 1–3.

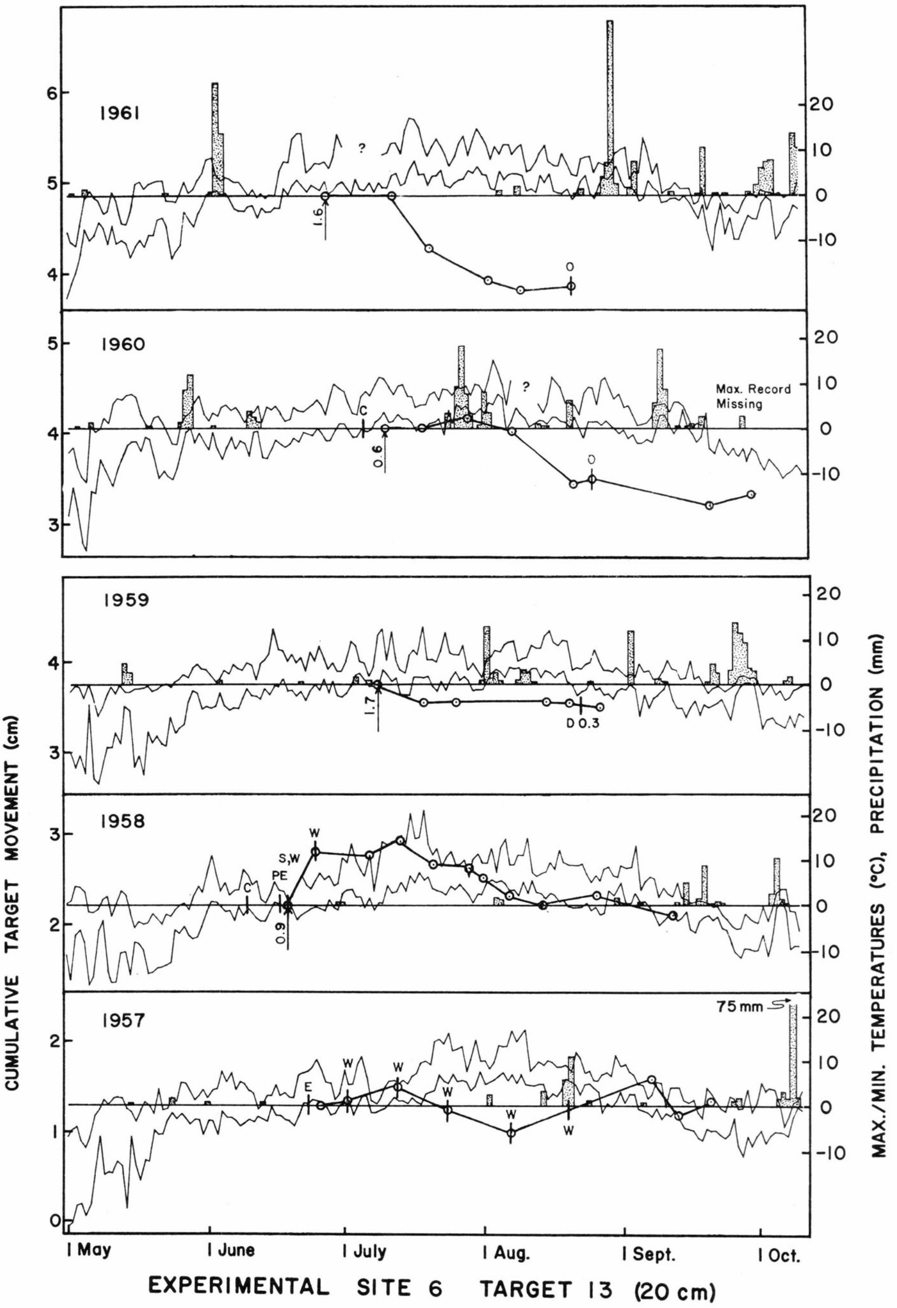
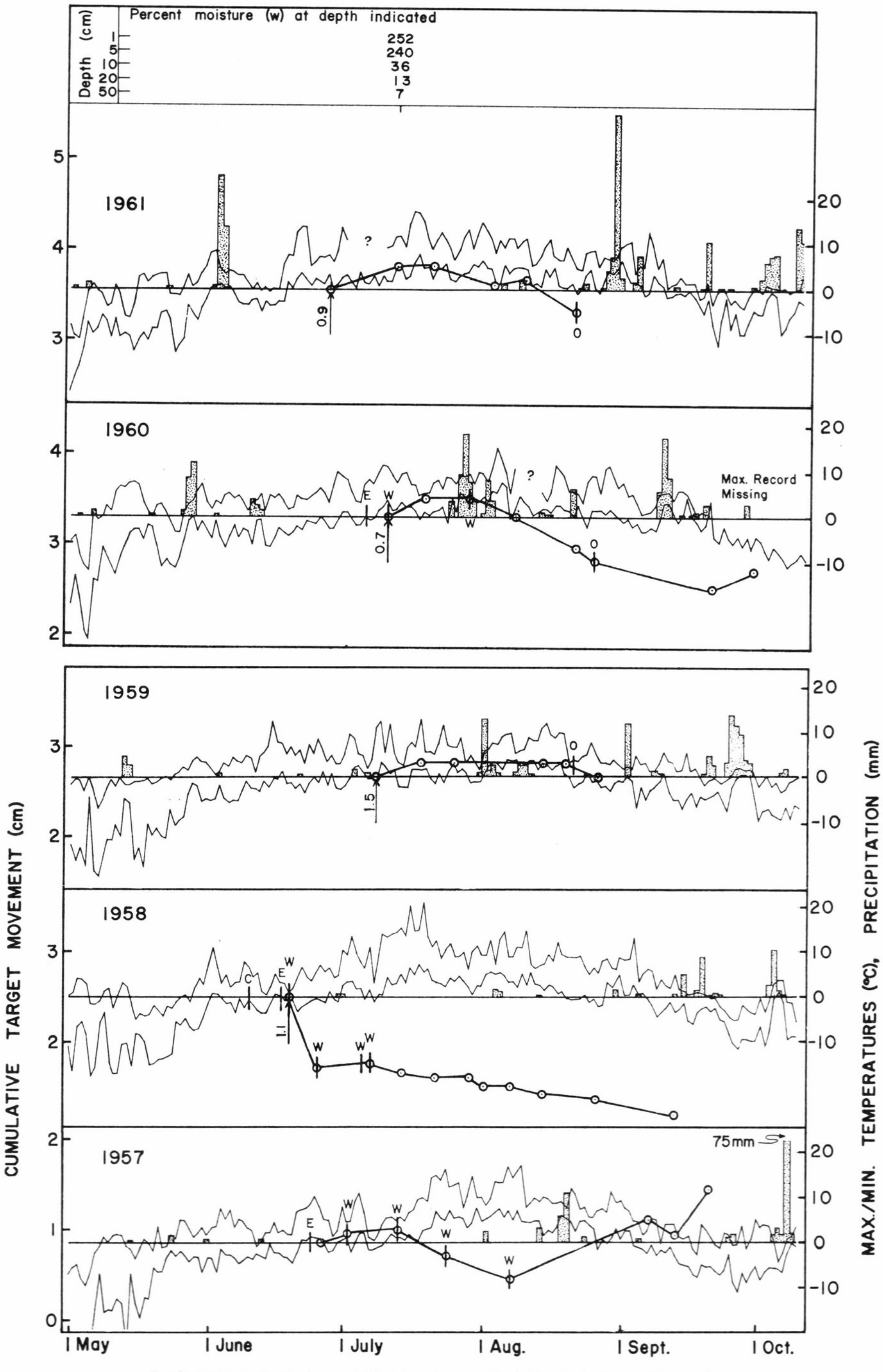

1961
1960
1959
1958
1957
1.6
0.6
1.7
0.9
?
O
C
E
W
S,W
PE
D 0.3
Max. Record Missing
75 mm
6
5
4
3
2
1
0
20
10
0
-10
I May
I June
I July
I Aug.
I Sept.
I Oct.
CUMULATIVE TARGET MOVEMENT (cm)
MAX./MIN. TEMPERATURES (°C), PRECIPITATION (mm)
EXPERIMENTAL SITE 6 TARGET 13 (20 cm)

Plate C 1–4.



EXPERIMENTAL SITE 6 TARGET 14 (10 cm)

Plate C 1–5.

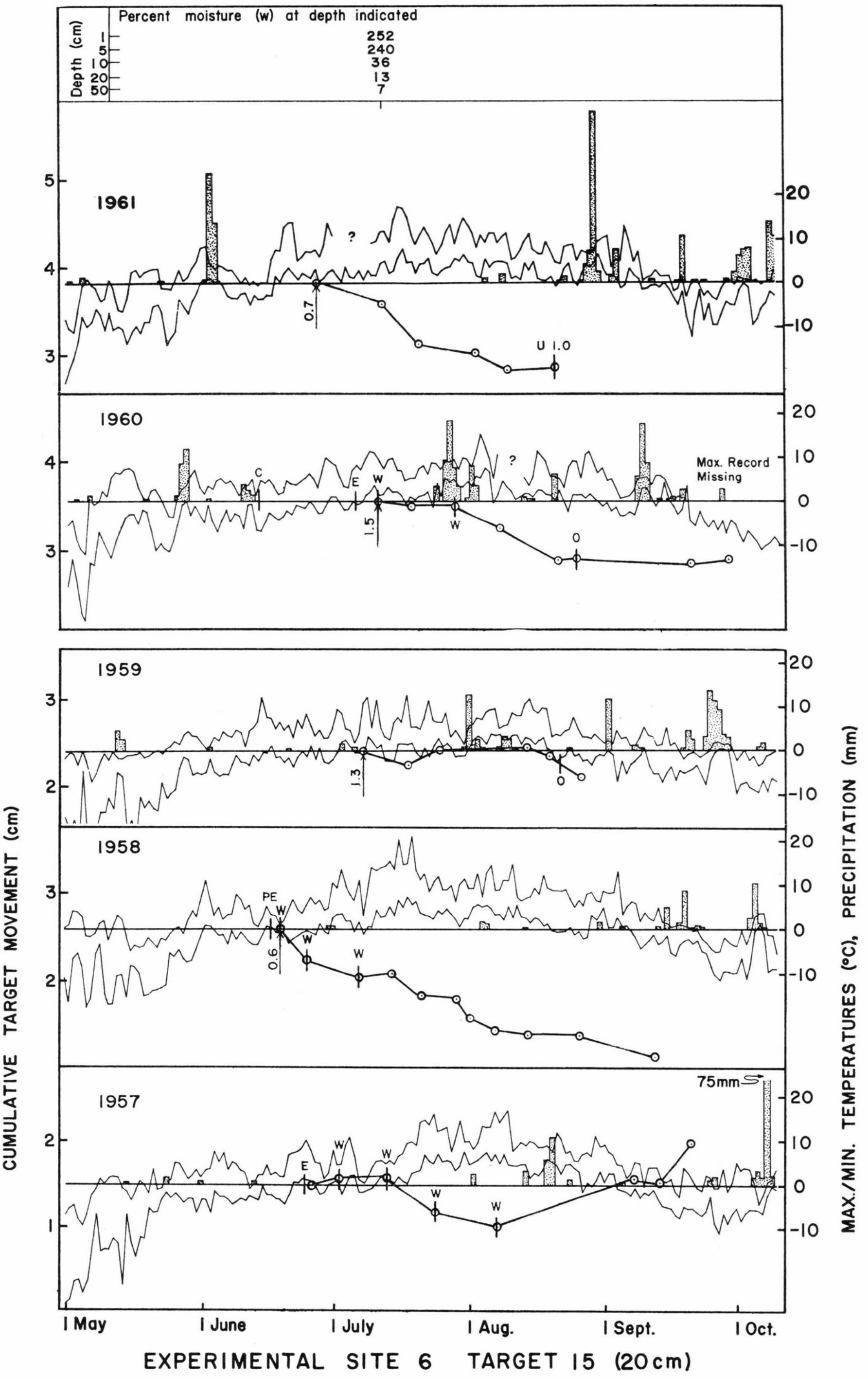
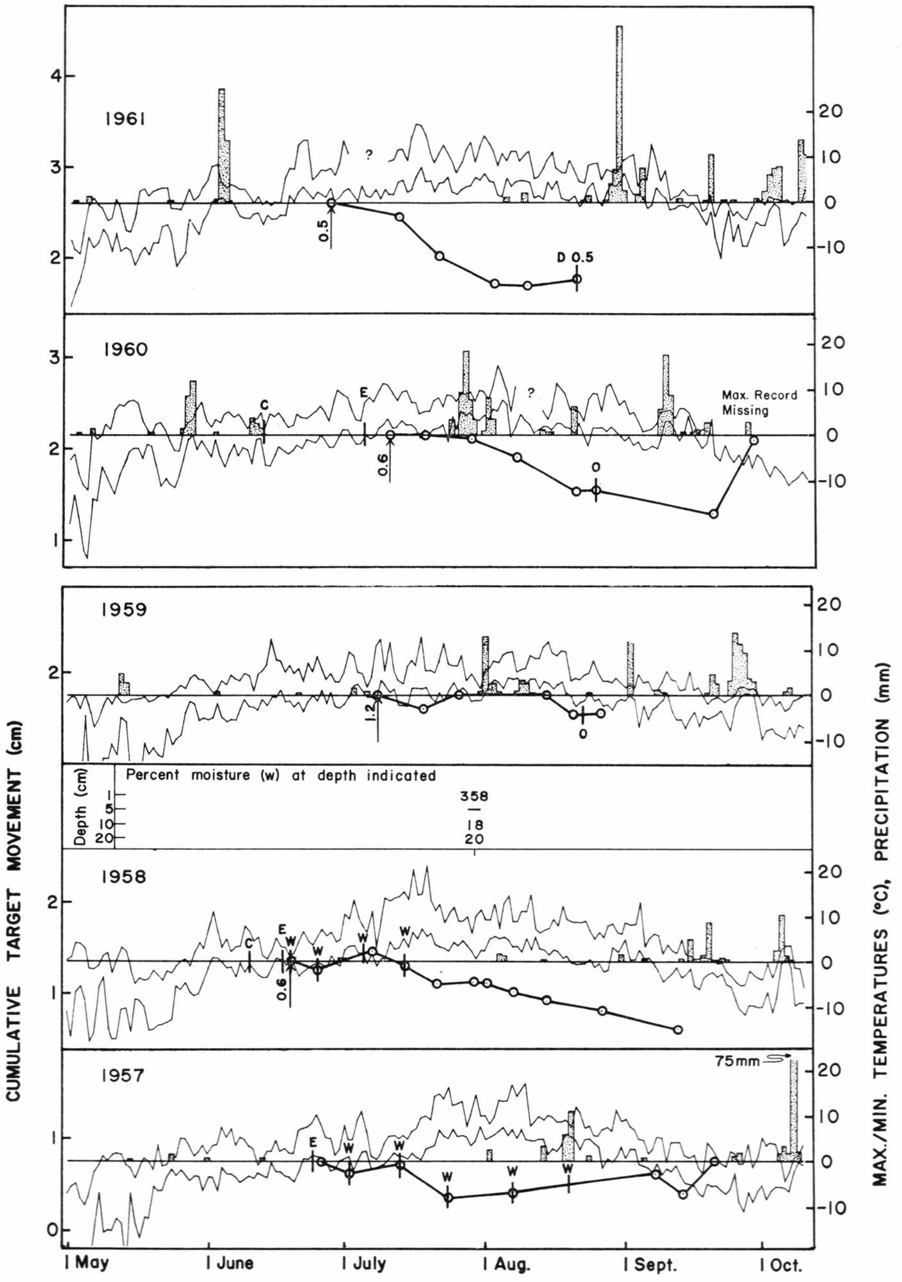
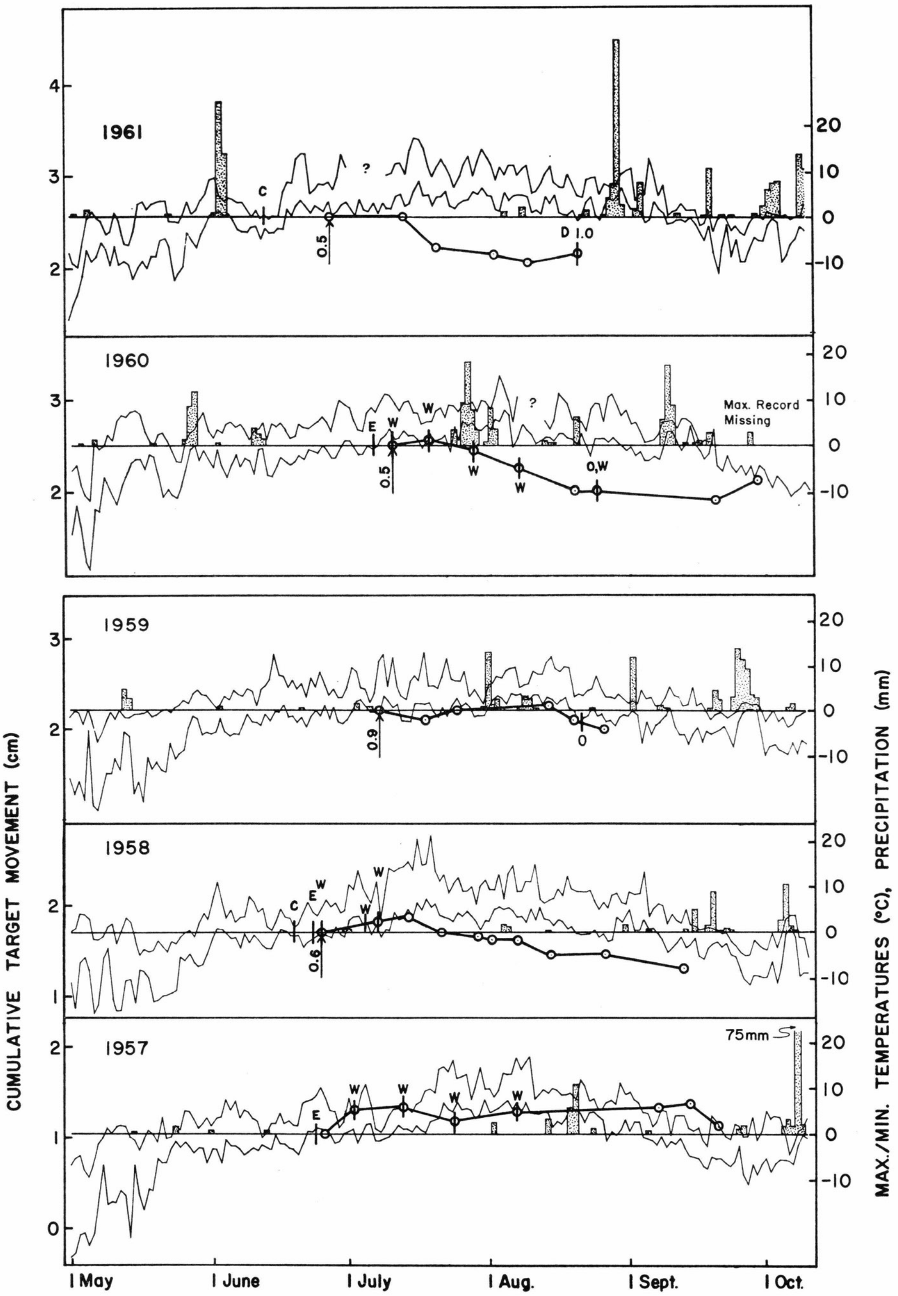

Percent moisture (w) at depth indicated
Depth (cm)
1 252
5 240
10 36
20 13
50 7
1961
1960
1959
1958
1957
0.7
U 1.0
?
E
W
C
1.5
O
Max. Record Missing
1.3
PE
0.6
75mm
CUMULATIVE TARGET MOVEMENT (cm)
MAX./MIN. TEMPERATURES (°C), PRECIPITATION (mm)
1 May
1 June
1 July
1 Aug.
1 Sept.
1 Oct.
EXPERIMENTAL SITE 6 TARGET 15 (20cm)

Plate C 1–6.



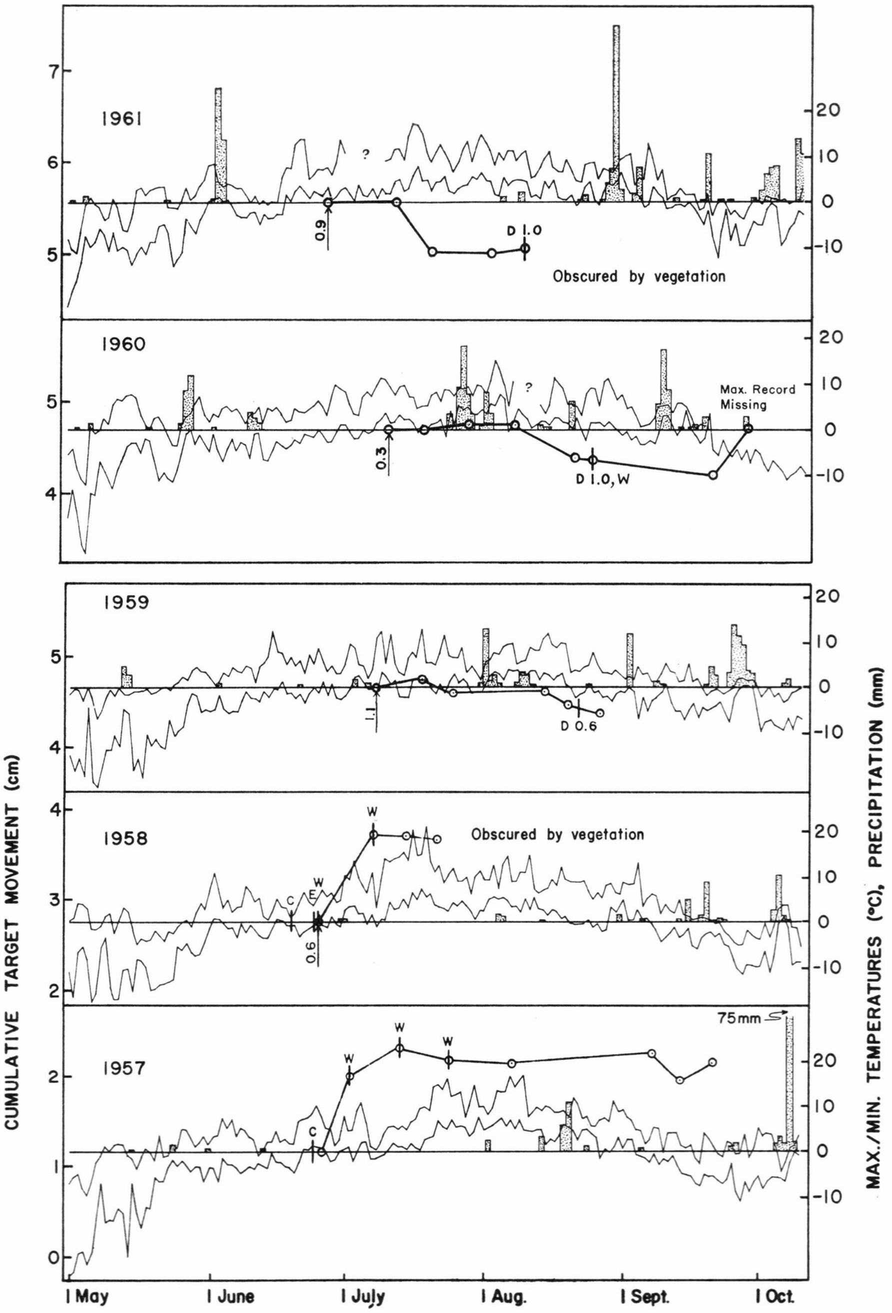
EXPERIMENTAL SITE 6 TARGET 18 (10 cm)

Plate C 1–7.



EXPERIMENTAL SITE 6 TARGET 19 (20 cm)

Plate C 1–8.



EXPERIMENTAL SITE 6 TARGET 20 (10 cm)

Plate C 1–9.

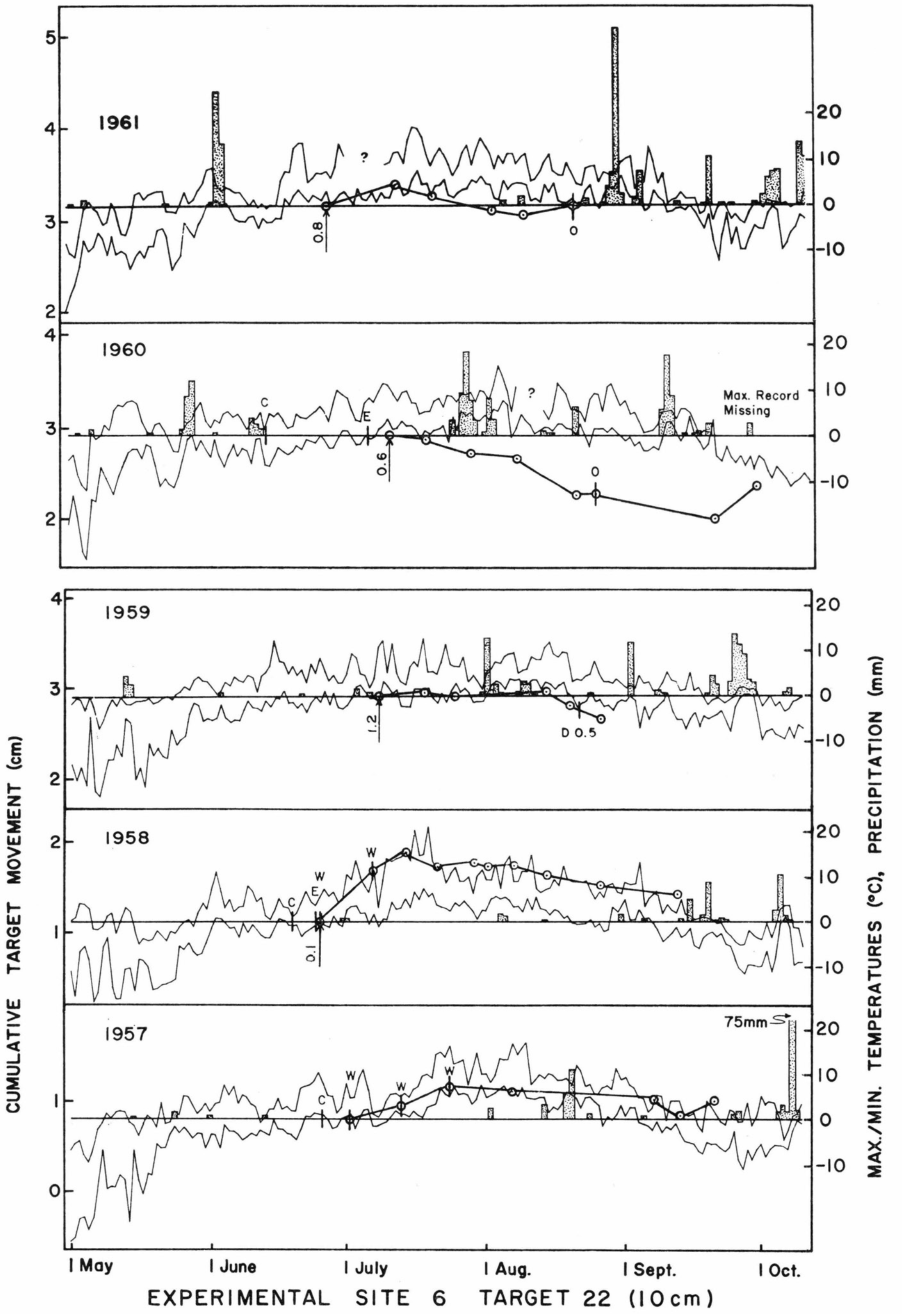
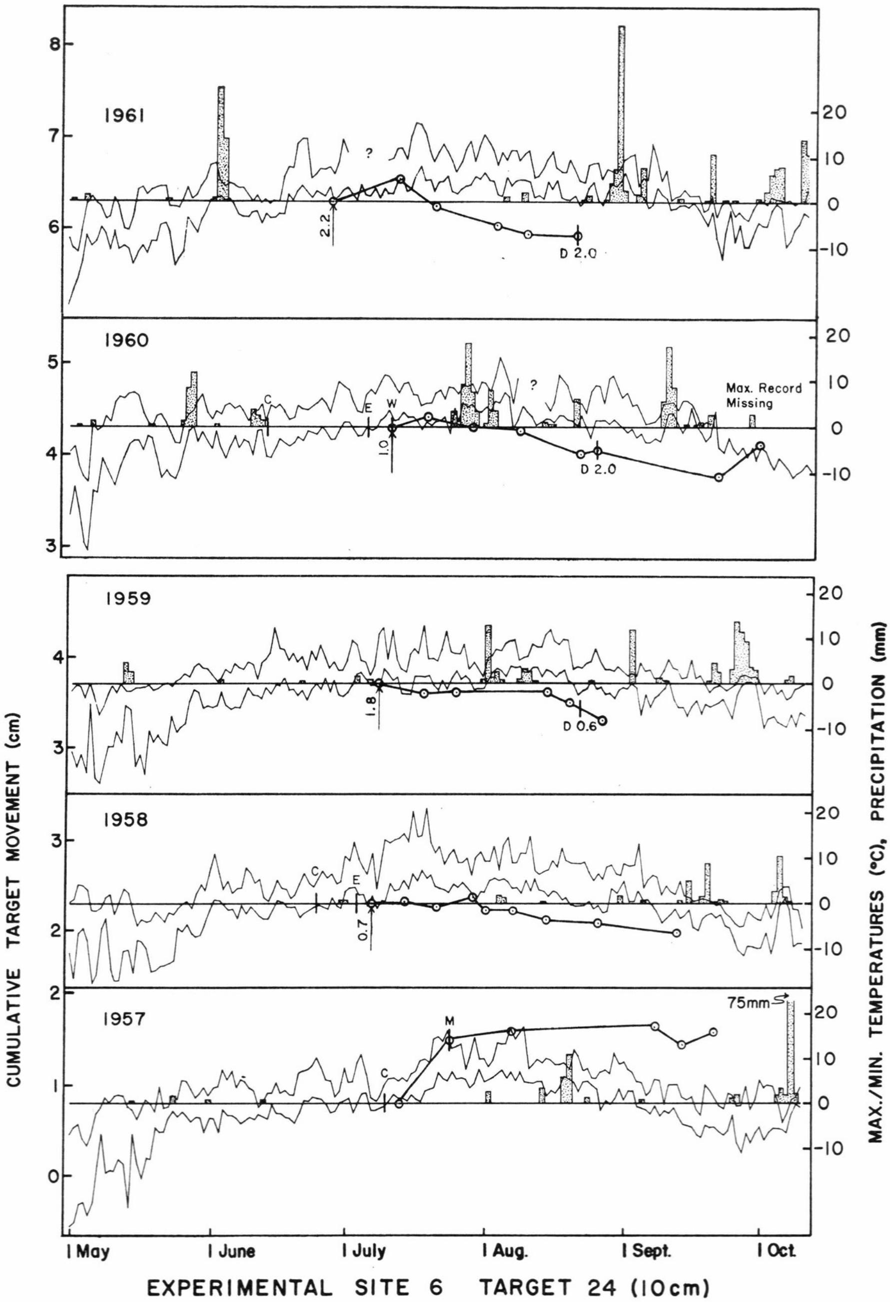

1961
1960
Max. Record Missing
1959
1958
1957
75mm
C
E
W
D 0.5
0.8
0.6
1.2
0.1
0
?
5
4
3
2
1
0
20
10
-10
CUMULATIVE TARGET MOVEMENT (cm)
MAX./MIN. TEMPERATURES (°C), PRECIPITATION (mm)
1 May
1 June
1 July
1 Aug.
1 Sept.
1 Oct.
EXPERIMENTAL SITE 6 TARGET 22 (10cm)

Plate C 1–10.



EXPERIMENTAL SITE 6 TARGET 24 (10cm)

Plate C 1–11.

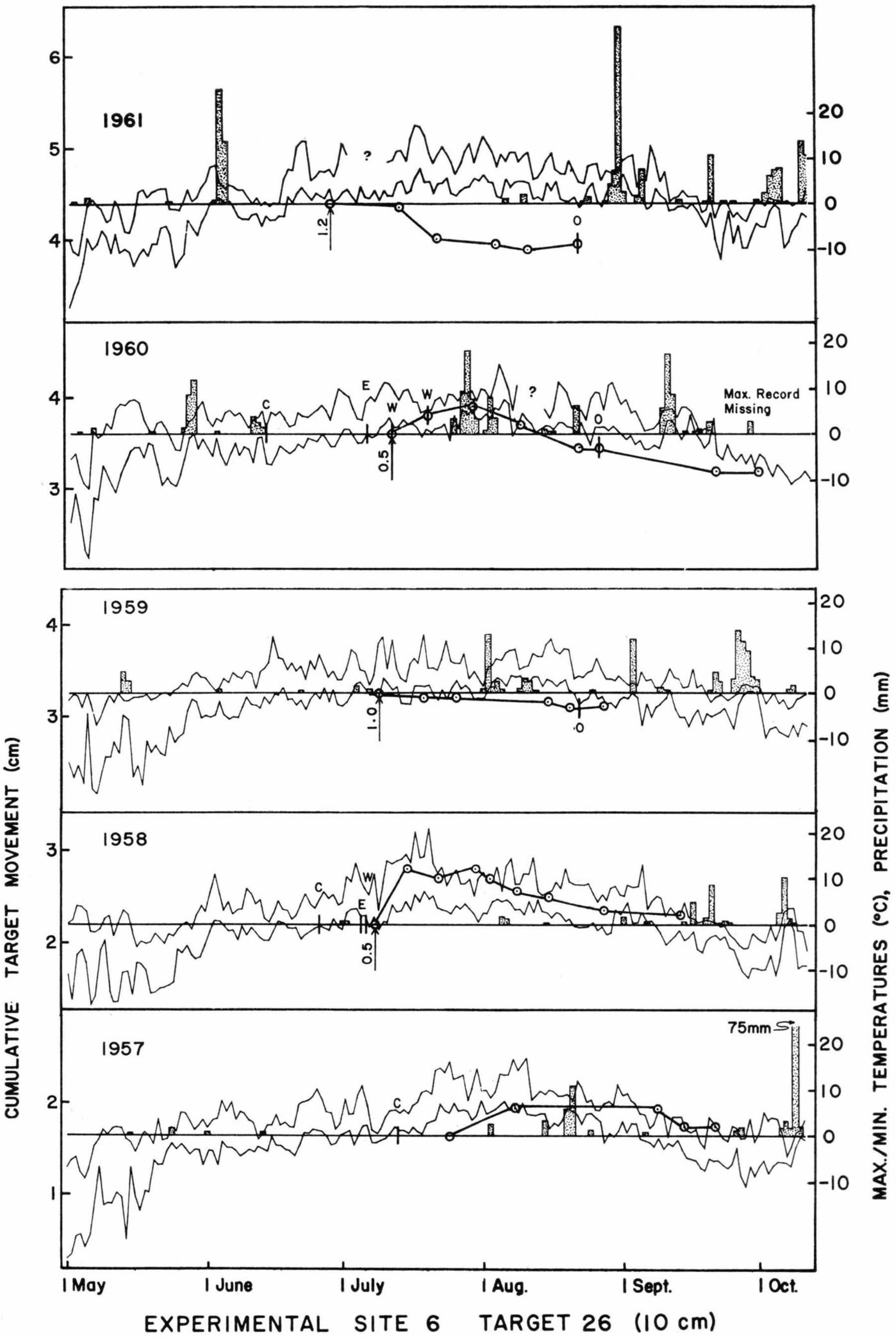
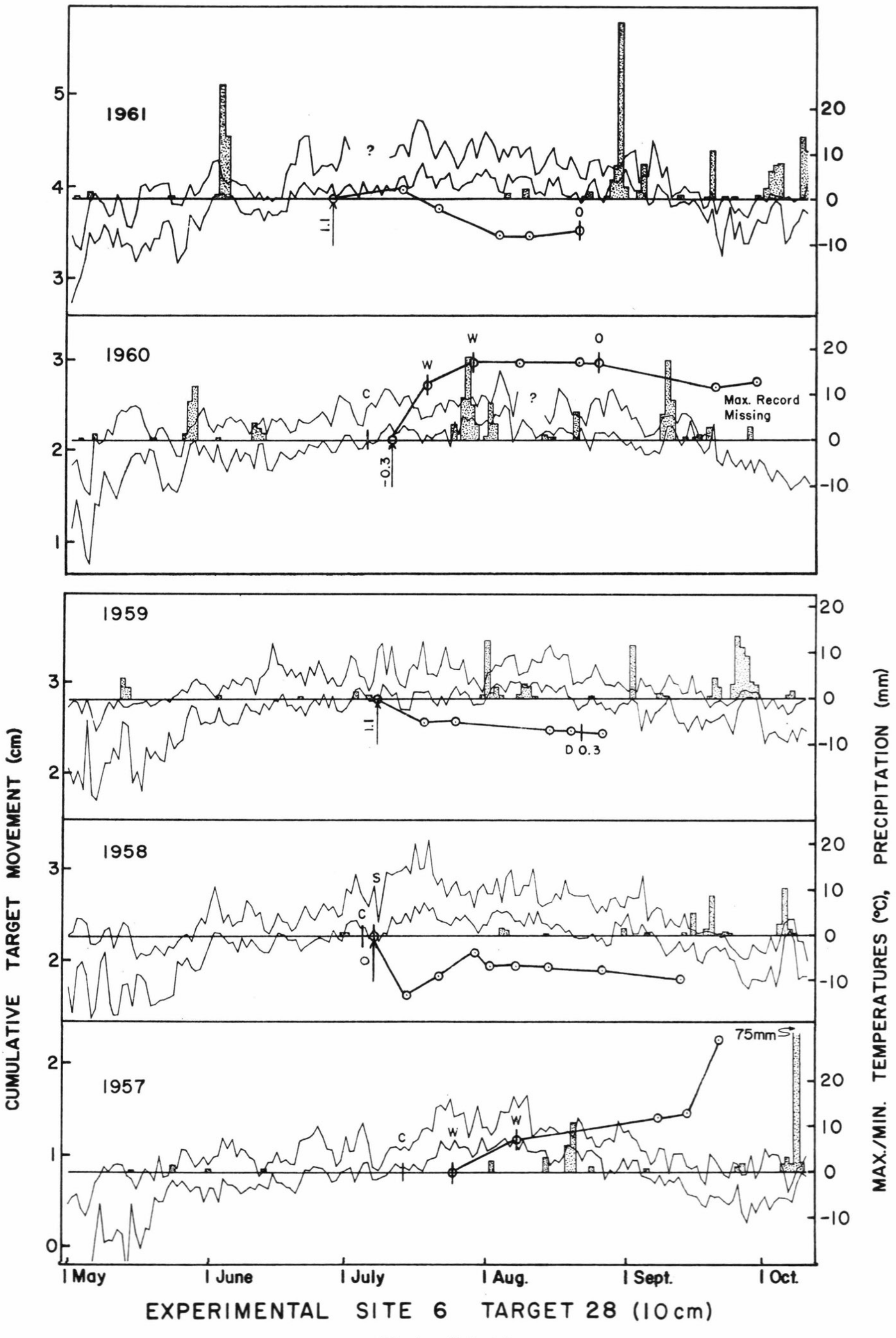

1961
1960
1959
1958
1957
CUMULATIVE TARGET MOVEMENT (cm)
MAX./MIN. TEMPERATURES (°C), PRECIPITATION (mm)
Max. Record Missing
75mm
1.2
0.5
1.0
0.5
C
E
W
W
?
0
I May
I June
I July
I Aug.
I Sept.
I Oct.
6
5
4
3
2
1
20
10
0
-10
EXPERIMENTAL SITE 6 TARGET 26 (10 cm)

Plate C 1–12.



EXPERIMENTAL SITE 6 TARGET 28 (10 cm)

Plate C 1–13.

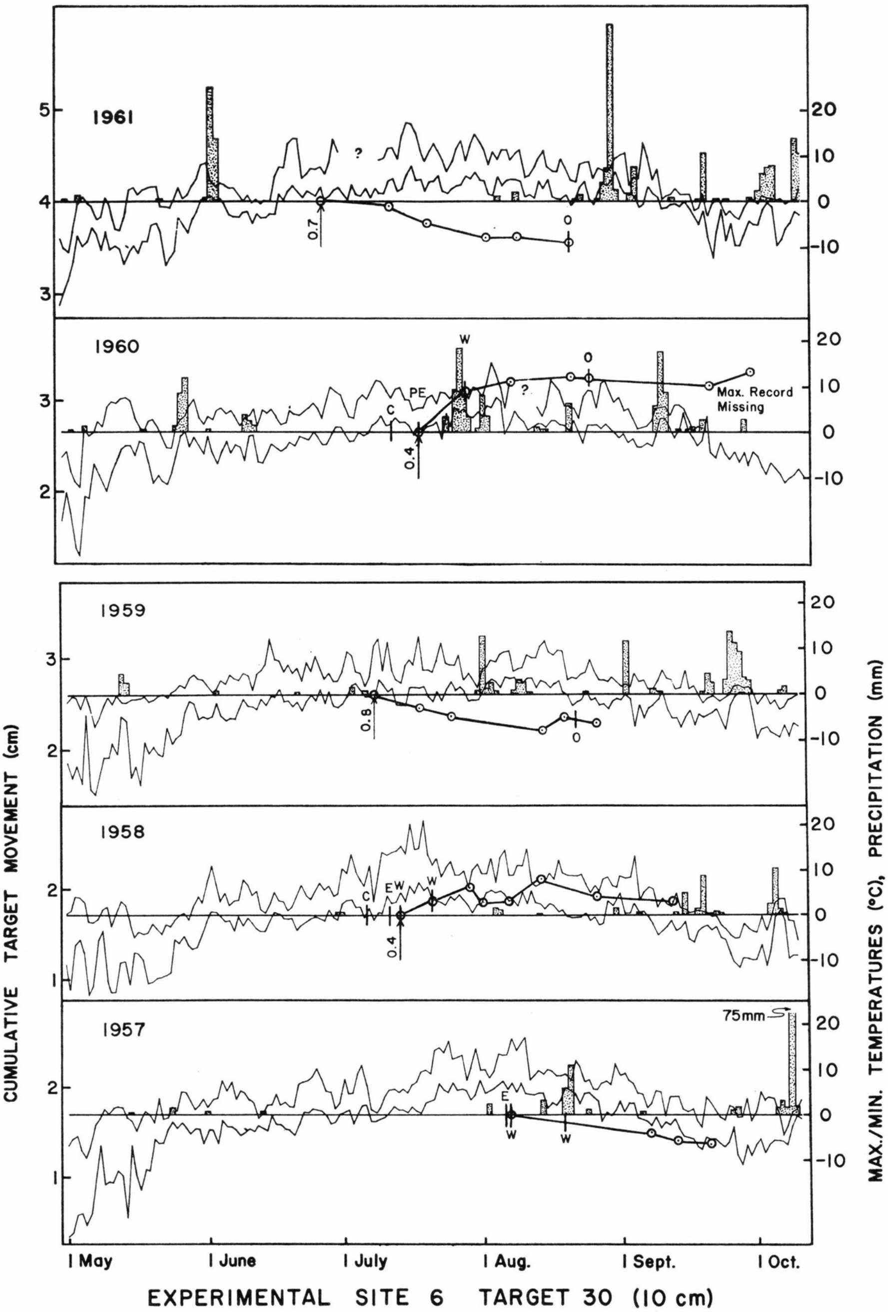

1961
1960
1959
1958
1957
5
4
3
2
1
20
10
0
-10
?
0.7
0
W
PE
C
0.4
Max. Record Missing
0.8
EW
0.4
E
W
75mm
I May
I June
I July
I Aug.
I Sept.
I Oct.
CUMULATIVE TARGET MOVEMENT (cm)
MAX./MIN. TEMPERATURES (°C), PRECIPITATION (mm)
EXPERIMENTAL SITE 6 TARGET 30 (10 cm)

Plate C 1–14.

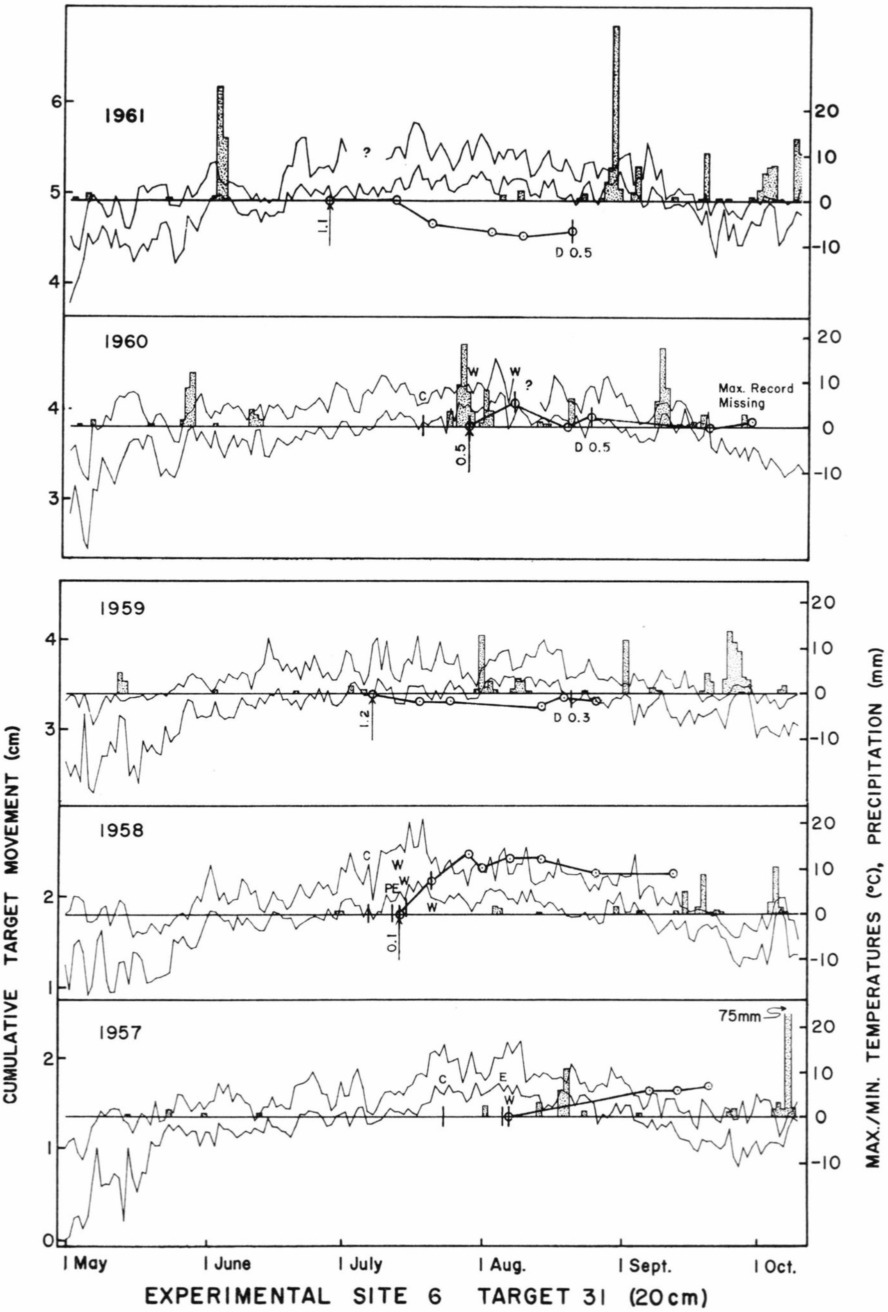
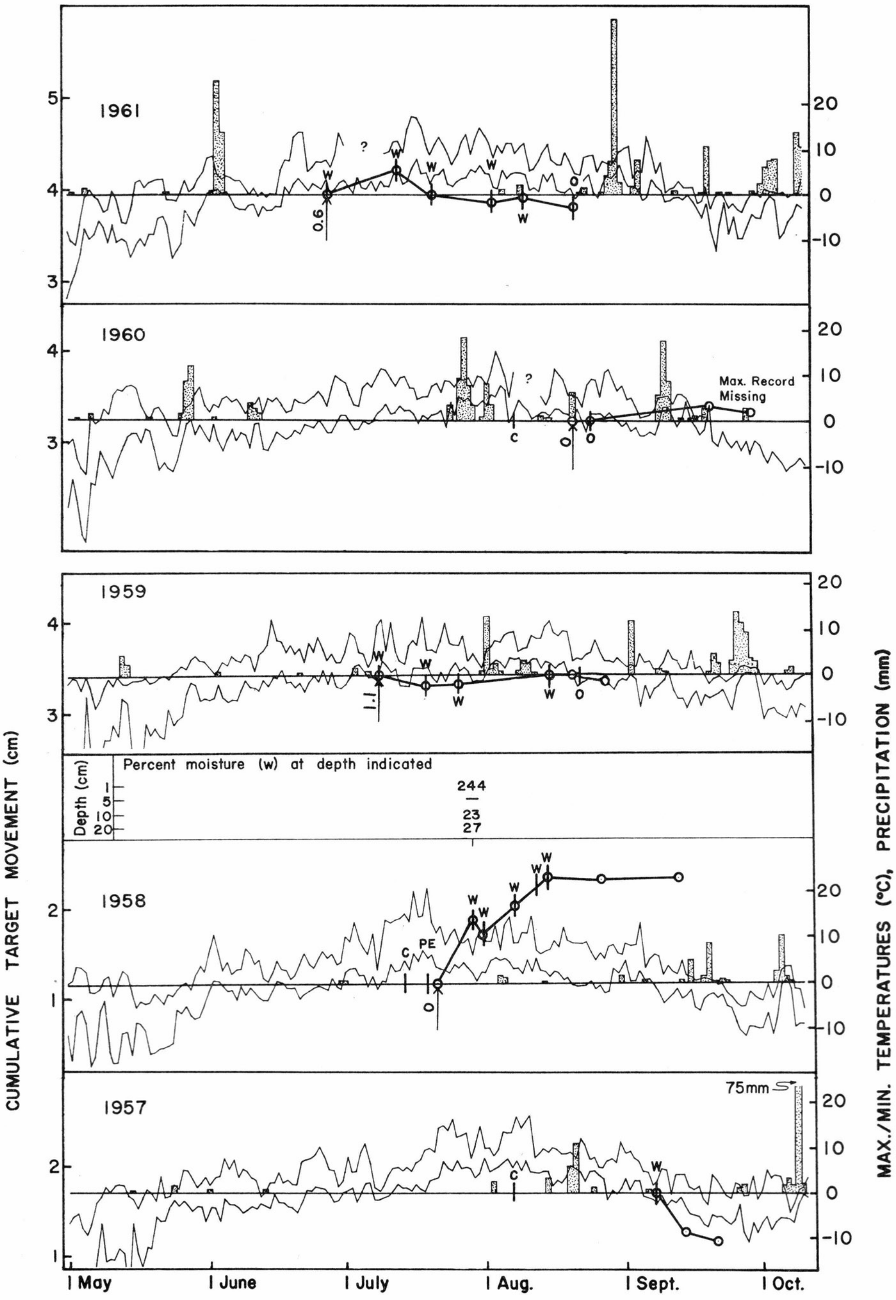
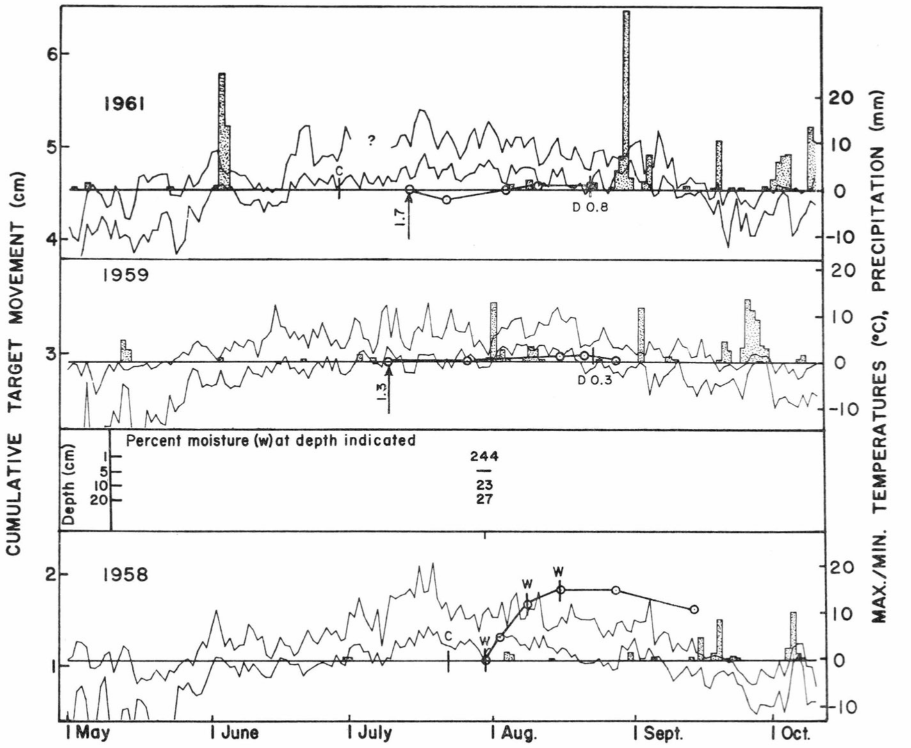

1961
1960
1959
1958
1957
?
1.1
D 0.5
W
W
?
C
Max. Record Missing
0.5
D 0.5
1.2
D 0.3
C
W
PE
W
W
0.1
75mm
C
E
W
CUMULATIVE TARGET MOVEMENT (cm)
MAX./MIN. TEMPERATURES (°C), PRECIPITATION (mm)
6
5
4
3
2
1
0
20
10
0
-10
1 May
1 June
1 July
1 Aug.
1 Sept.
1 Oct.
EXPERIMENTAL SITE 6 TARGET 31 (20cm)

Plate C 1–15.

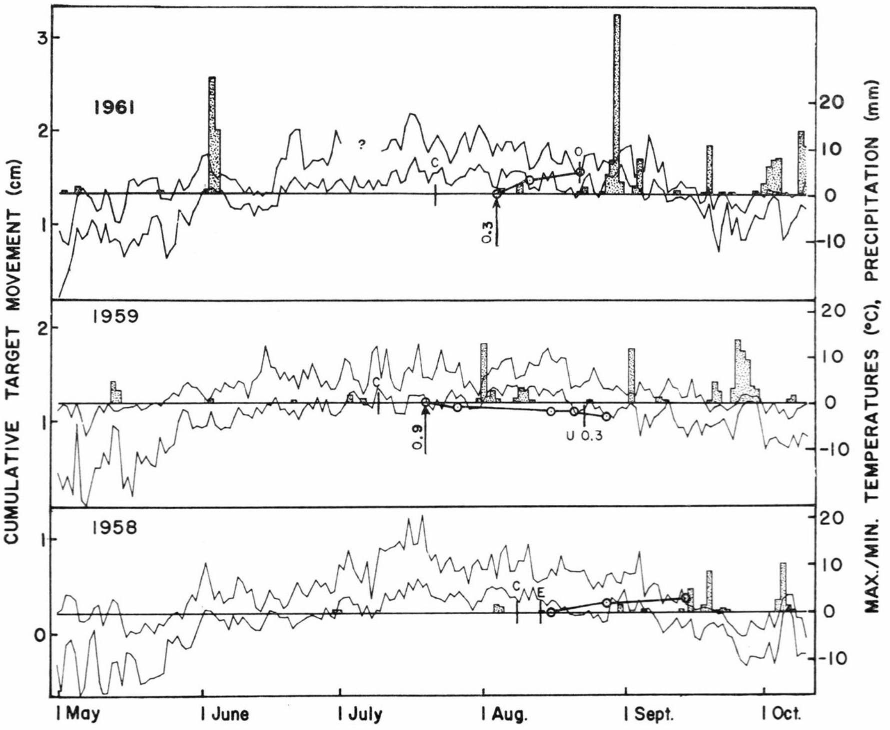


EXPERIMENTAL SITE 6 TARGET 34 (10 cm)

Plate C 1–16.

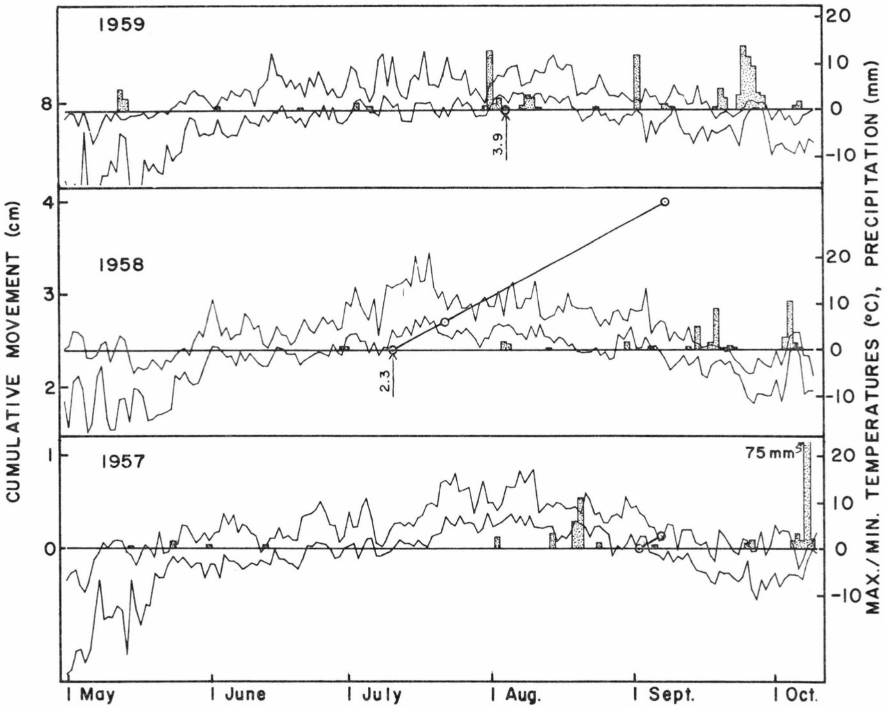


EXPERIMENTAL SITE 6 TARGET 38 (10 cm)



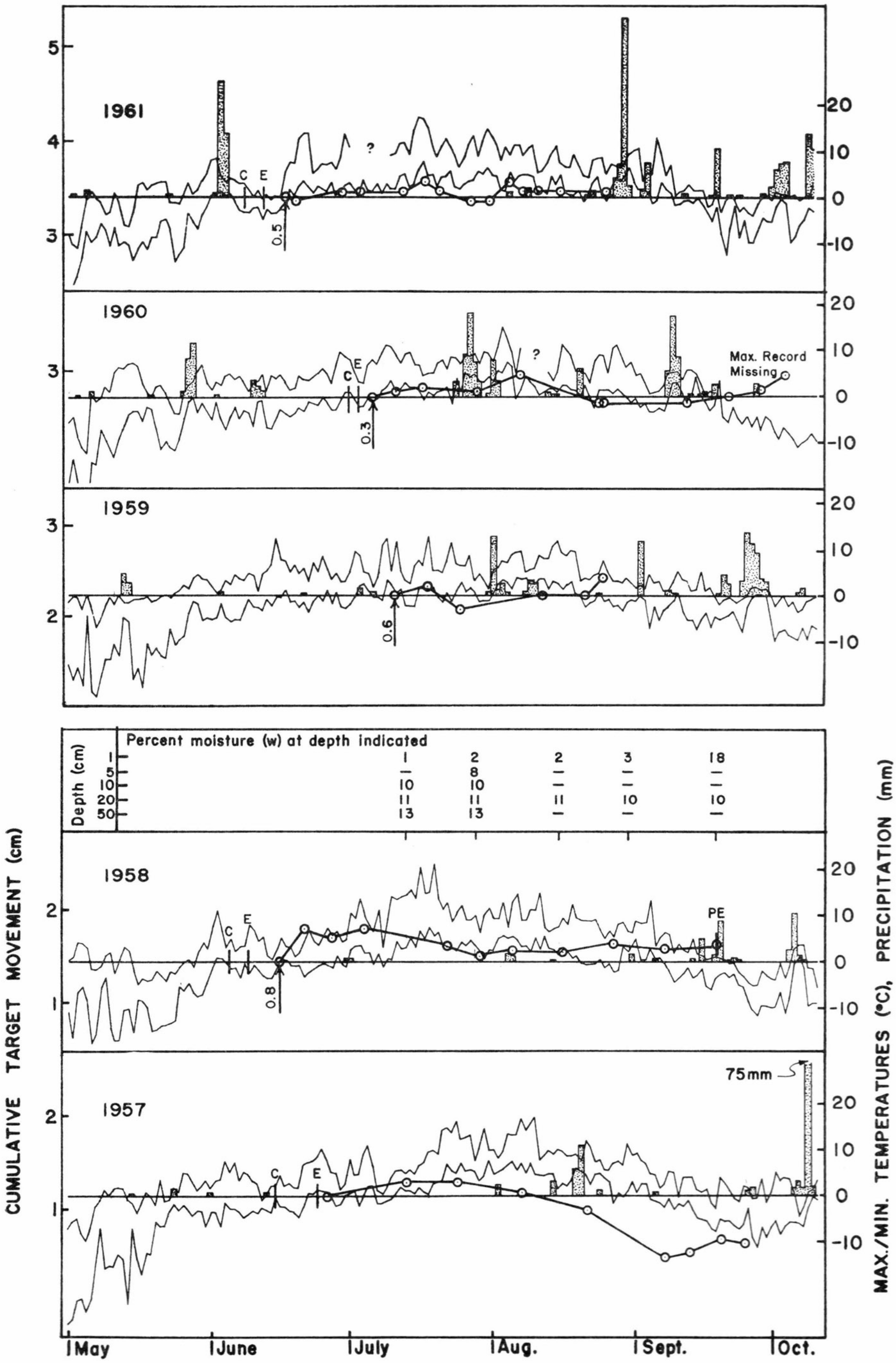
EXPERIMENTAL SITE 6 TARGET 43 (20 cm)

Plate C 1–17.



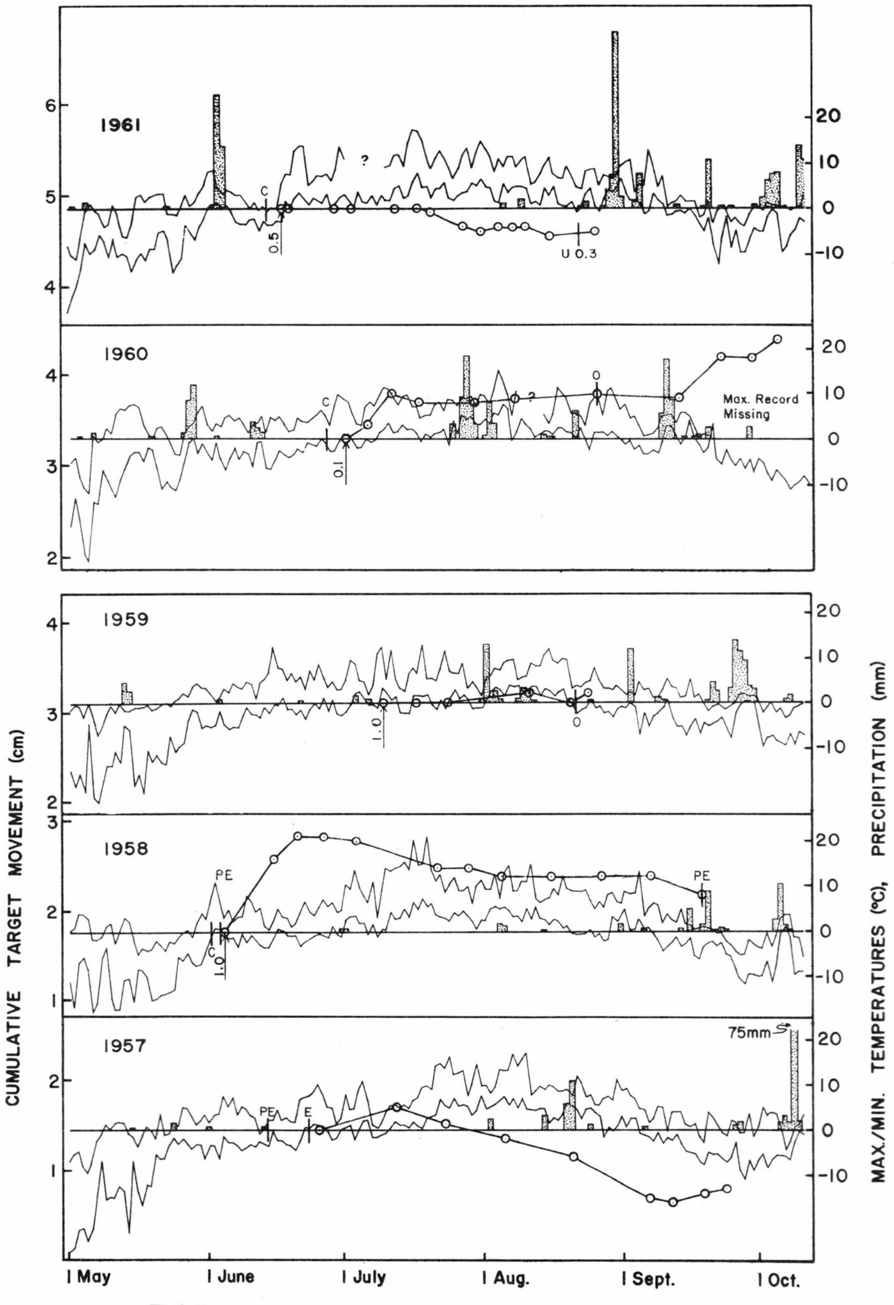
EXPERIMENTAL SITE 7 MASS-WASTINGMETER (at ground surface)

Plate C 2-1.



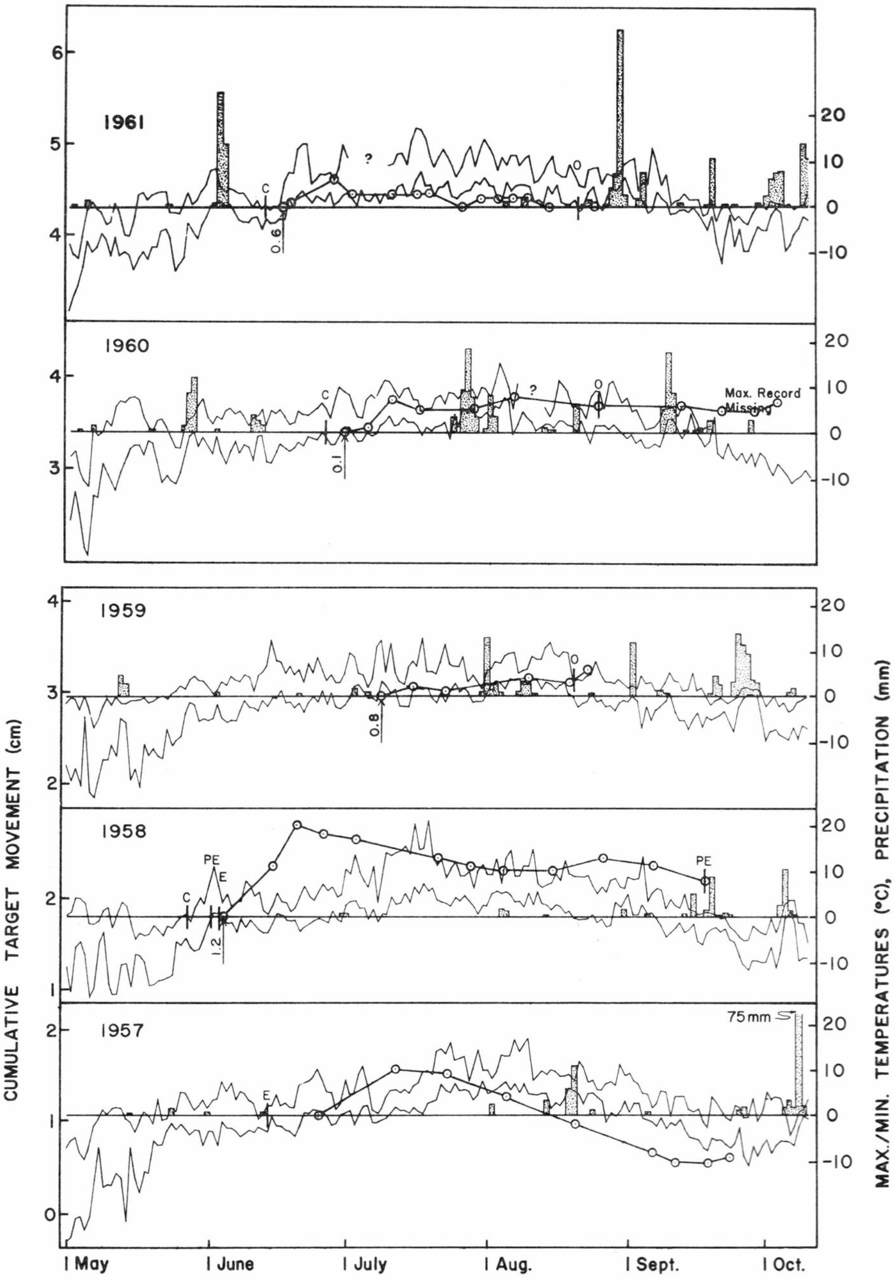
EXPERIMENTAL SITE 7 ROD (at ground surface)

Plate C 2–2.



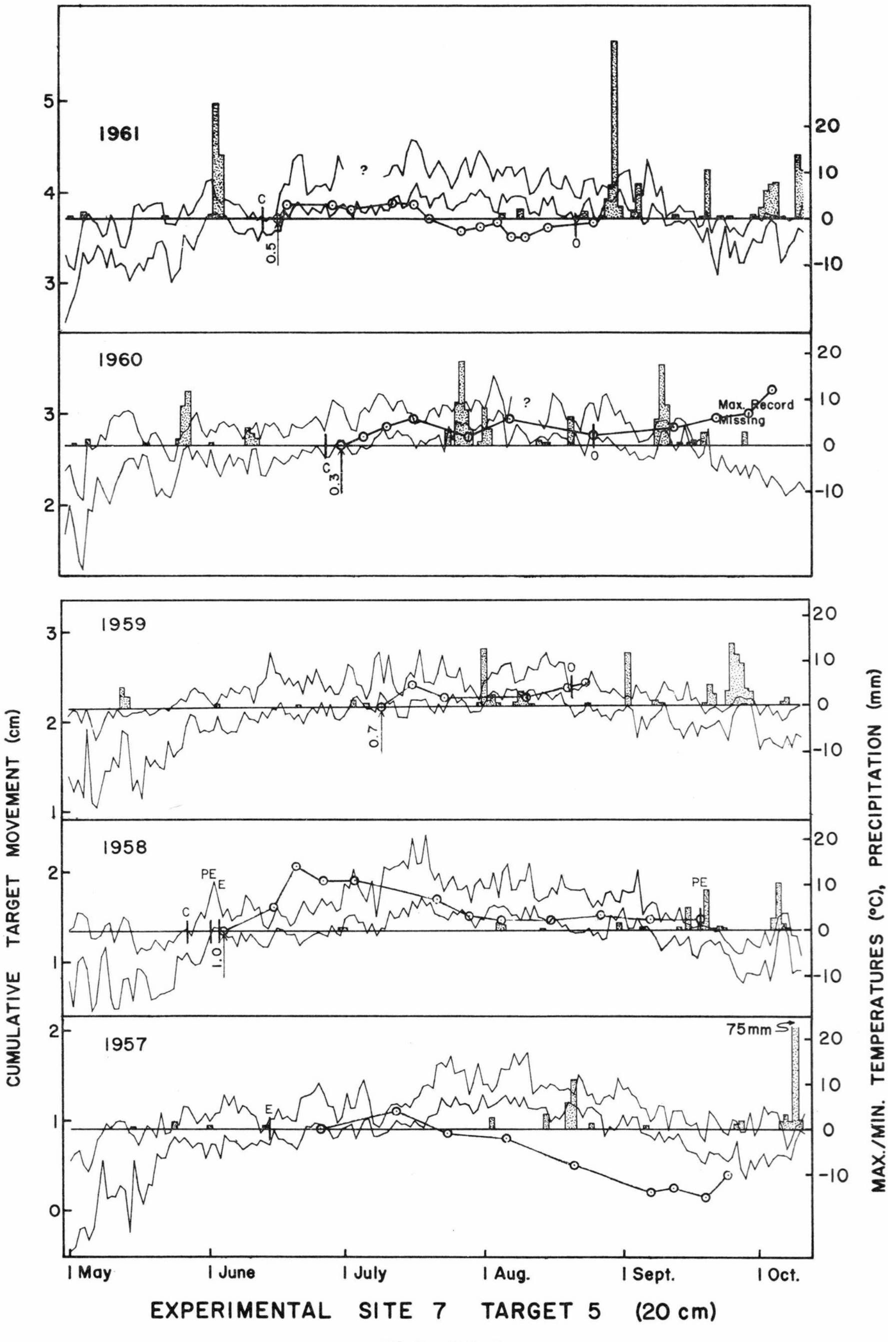
EXPERIMENTAL SITE 7 TARGET 2 (10cm)

Plate C 2–3.



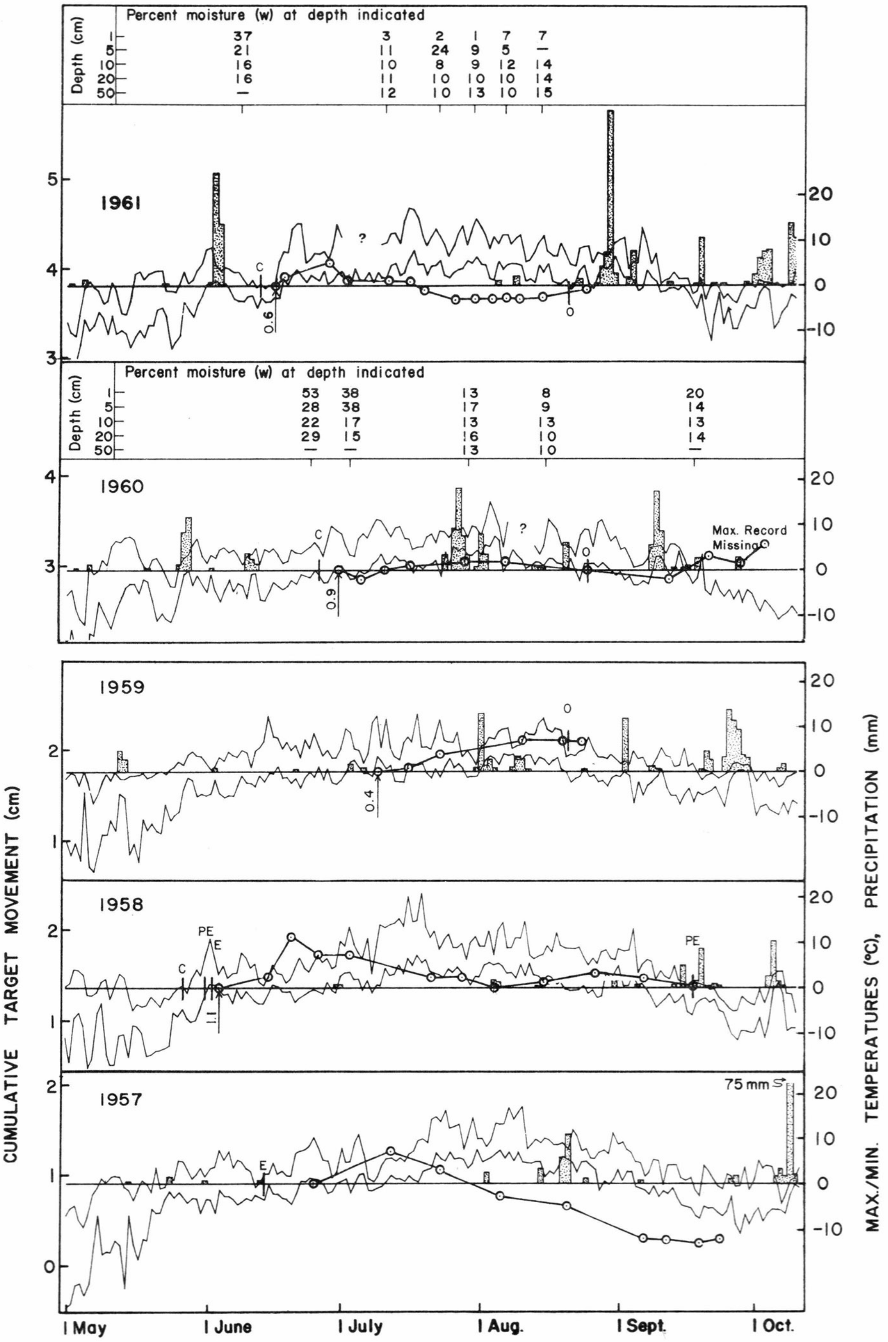
EXPERIMENTAL SITE 7 TARGET 3 (20 cm)

Plate C 2–4.



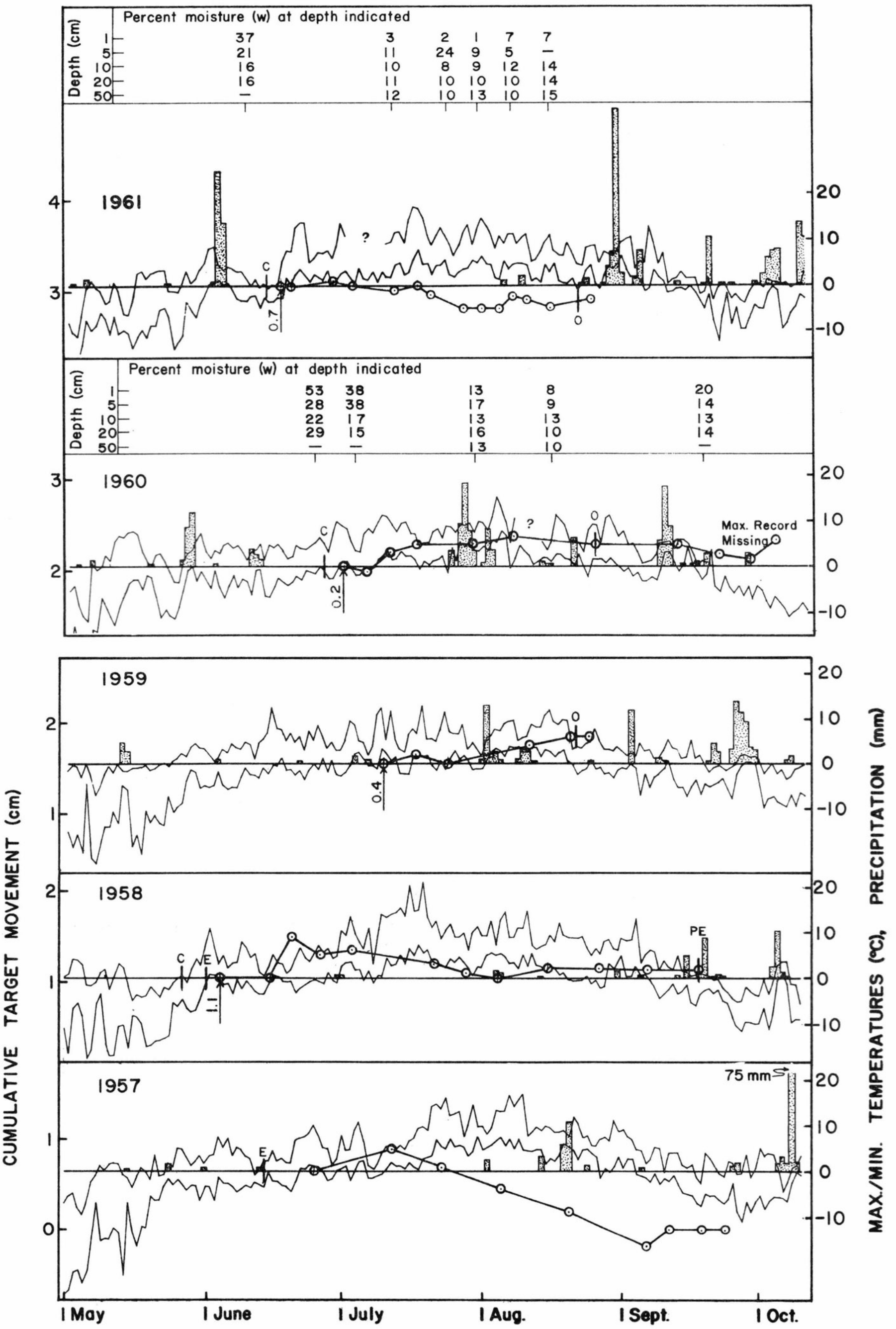
EXPERIMENTAL SITE 7 TARGET 5 (20 cm)

Plate C 2–5.



EXPERIMENTAL SITE 7 TARGET 6 (10 cm)

Plate C 2–6.



EXPERIMENTAL SITE 7 TARGET 7 (20cm)

Plate C 2–7.

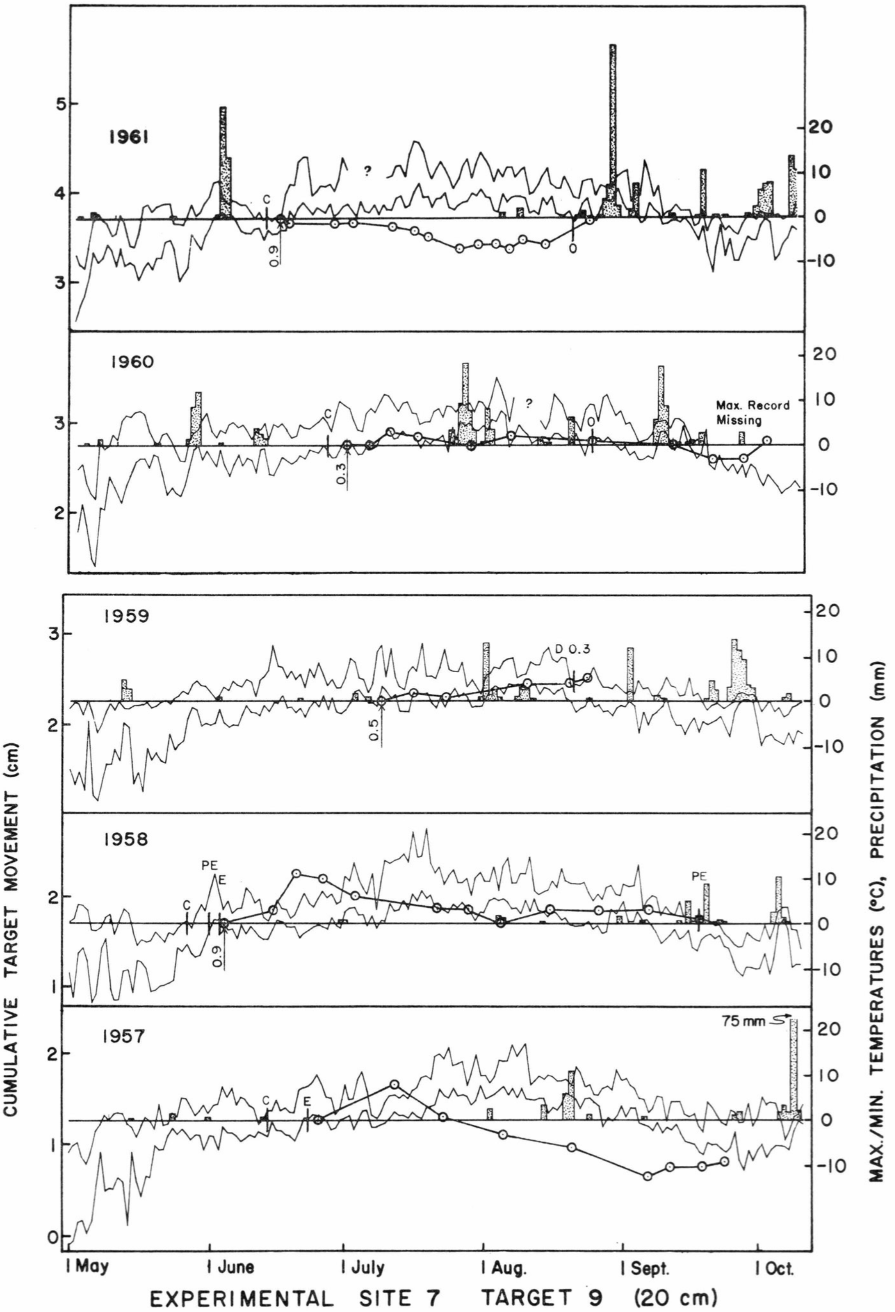
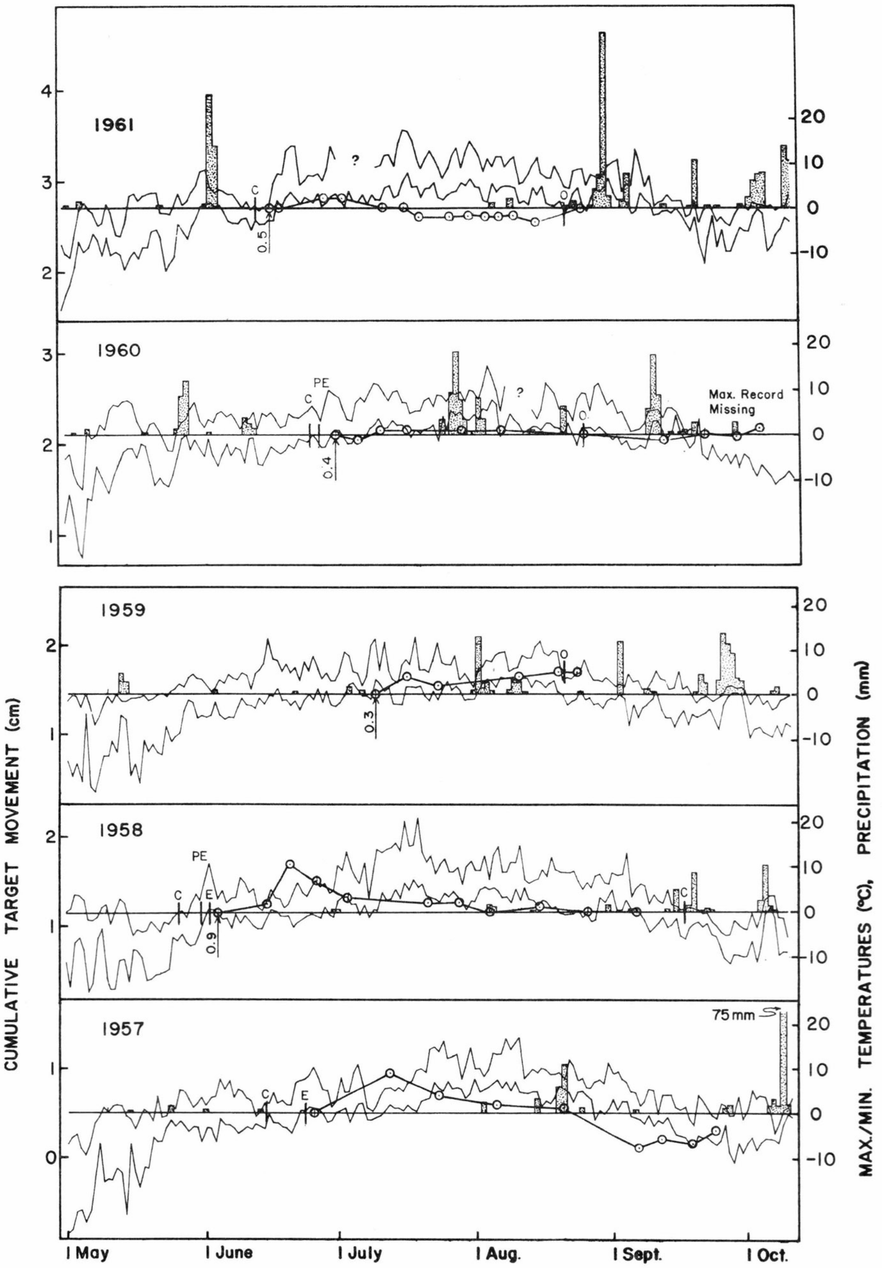

1961
1960
1959
1958
1957
Max. Record Missing
75 mm
C
E
PE
D 0.3
0.9
0.3
0.5
0
?
CUMULATIVE TARGET MOVEMENT (cm)
MAX./MIN. TEMPERATURES (°C), PRECIPITATION (mm)
20
10
0
-10
1 May
1 June
1 July
1 Aug.
1 Sept.
1 Oct.
EXPERIMENTAL SITE 7 TARGET 9 (20 cm)

Plate C 2–8.



EXPERIMENTAL SITE 7 TARGET 10 (10 cm)

Plate C 2–9.

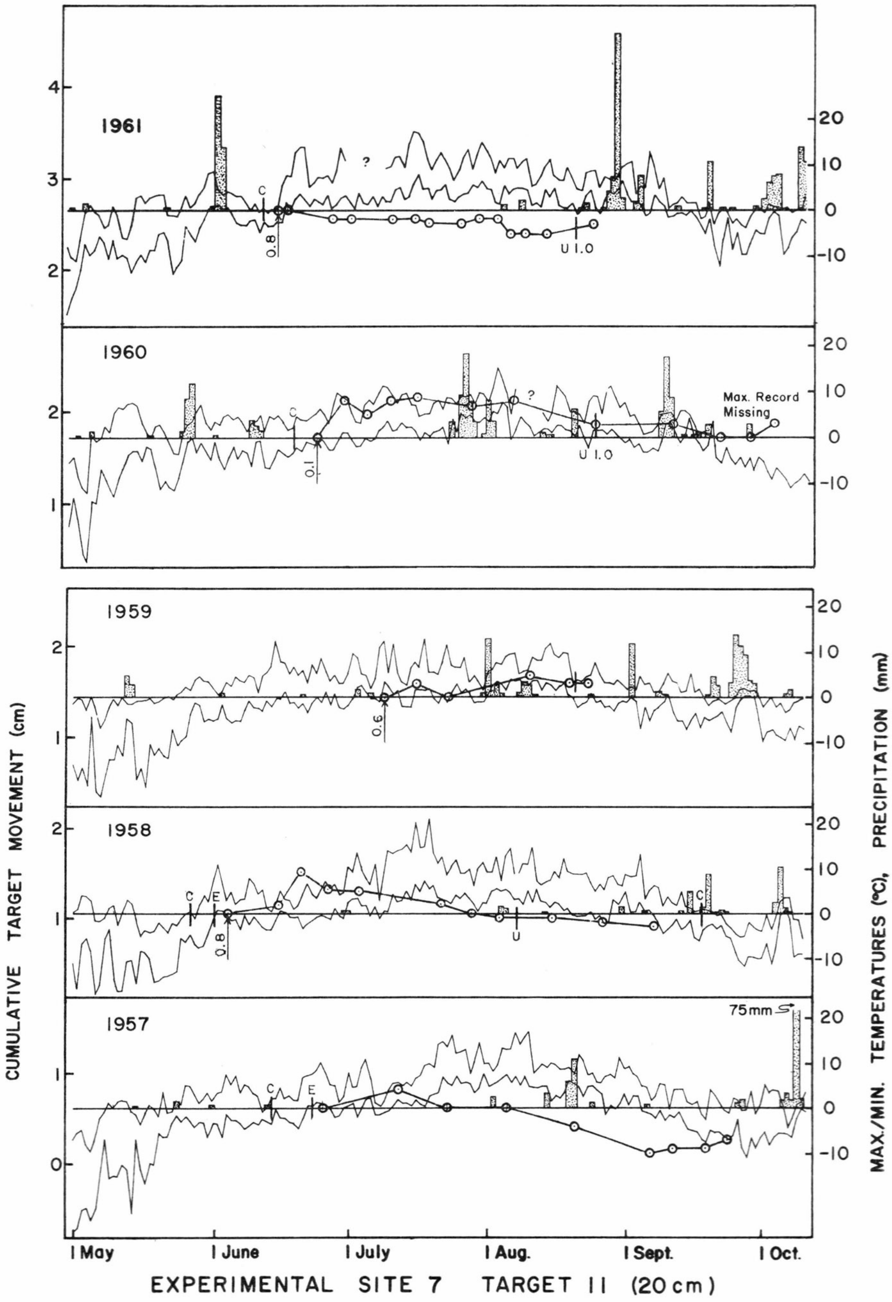
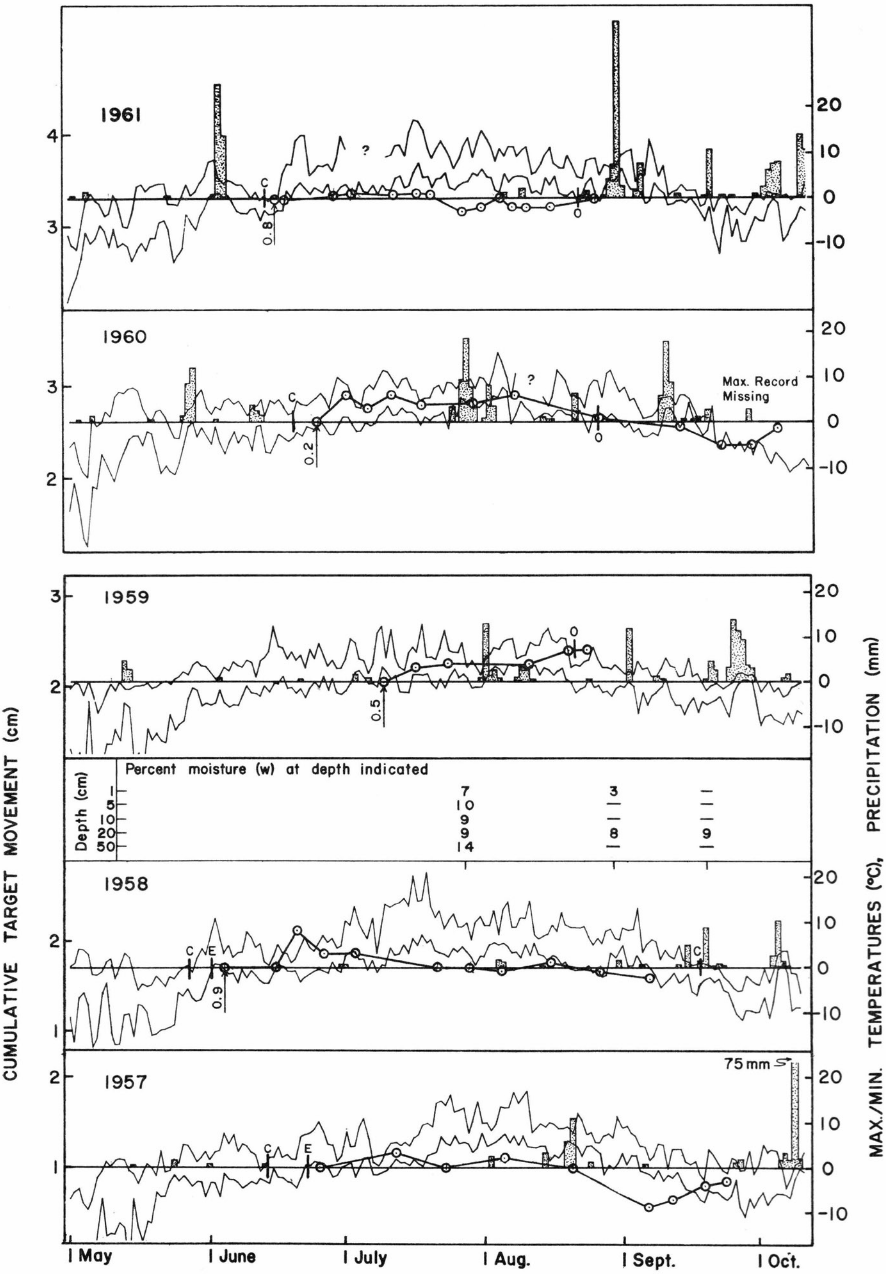
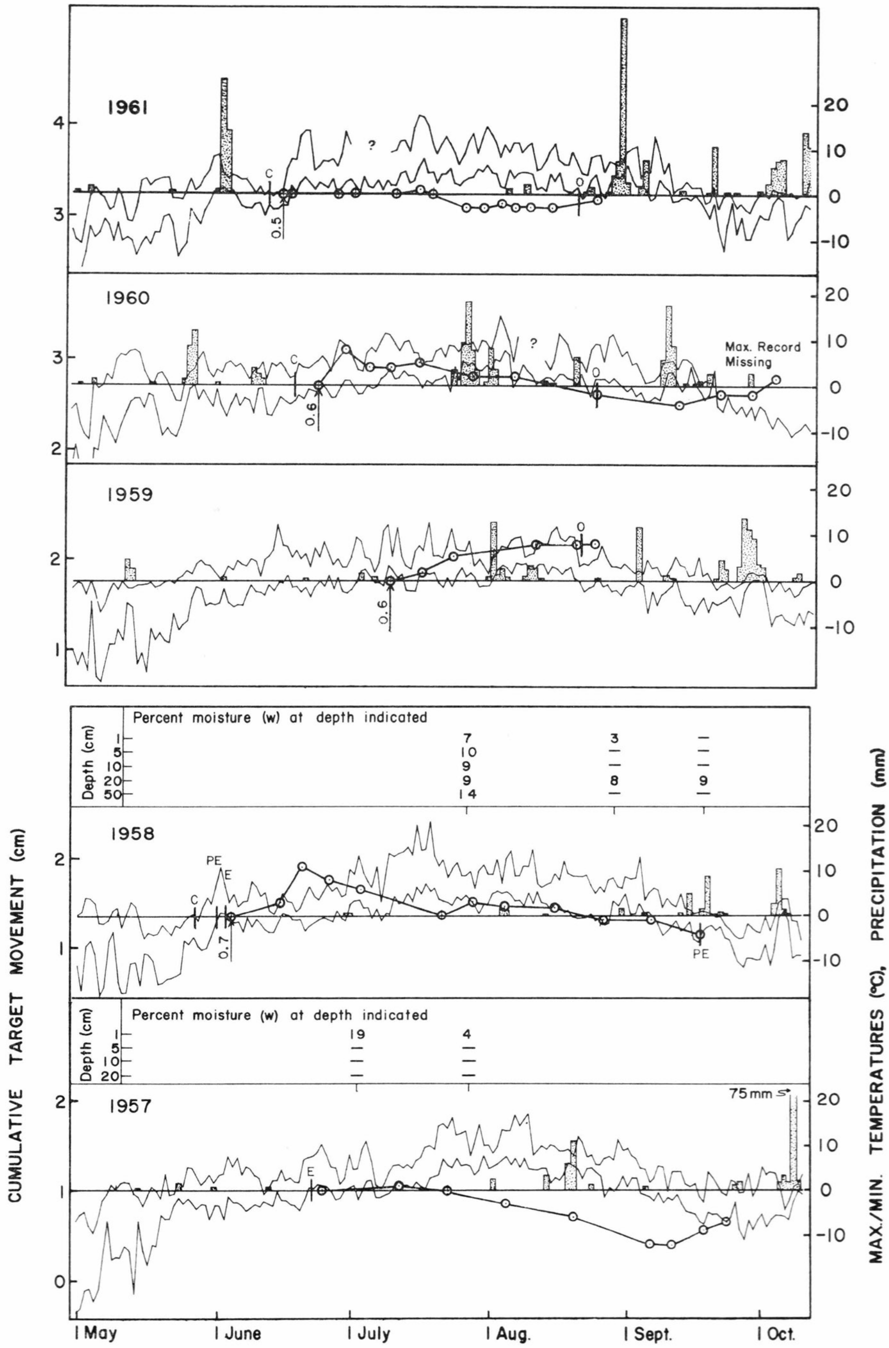

1961
1960
1959
1958
1957
CUMULATIVE TARGET MOVEMENT (cm)
MAX./MIN. TEMPERATURES (°C), PRECIPITATION (mm)
4
3
2
1
0
20
10
0
-10
C
E
U
0.8
0.1
0.6
U 1.0
?
Max. Record Missing
75mm
I May
I June
I July
I Aug.
I Sept.
I Oct.
EXPERIMENTAL SITE 7 TARGET 11 (20 cm)

Plate C 2–10.



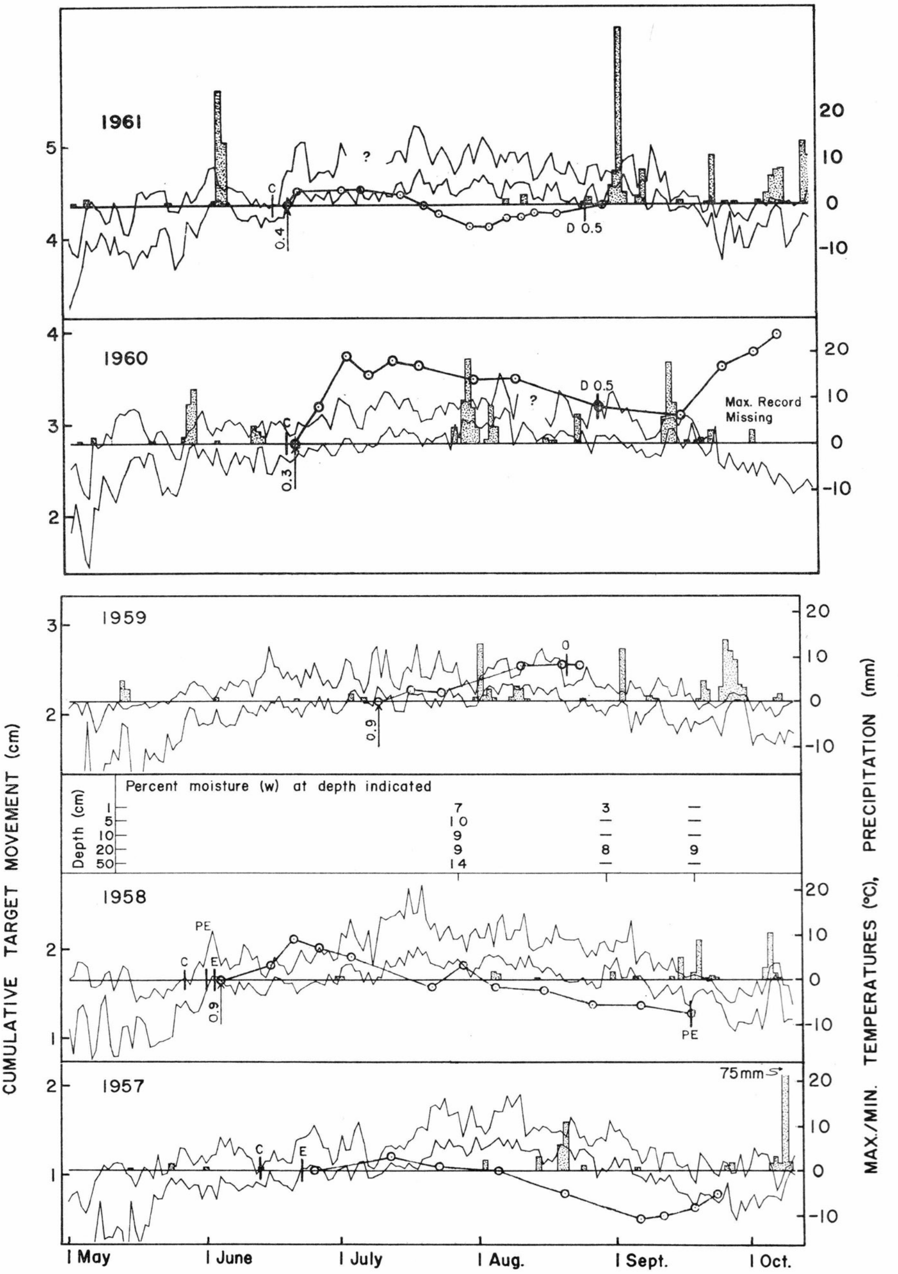
EXPERIMENTAL SITE 7 TARGET 12 (10 cm)

Plate C 2–11.



EXPERIMENTAL SITE 7 TARGET 13 (20cm)

Plate C 2–12.



SITE 7 TARGET 14 (10 cm)

Plate C 2–13.

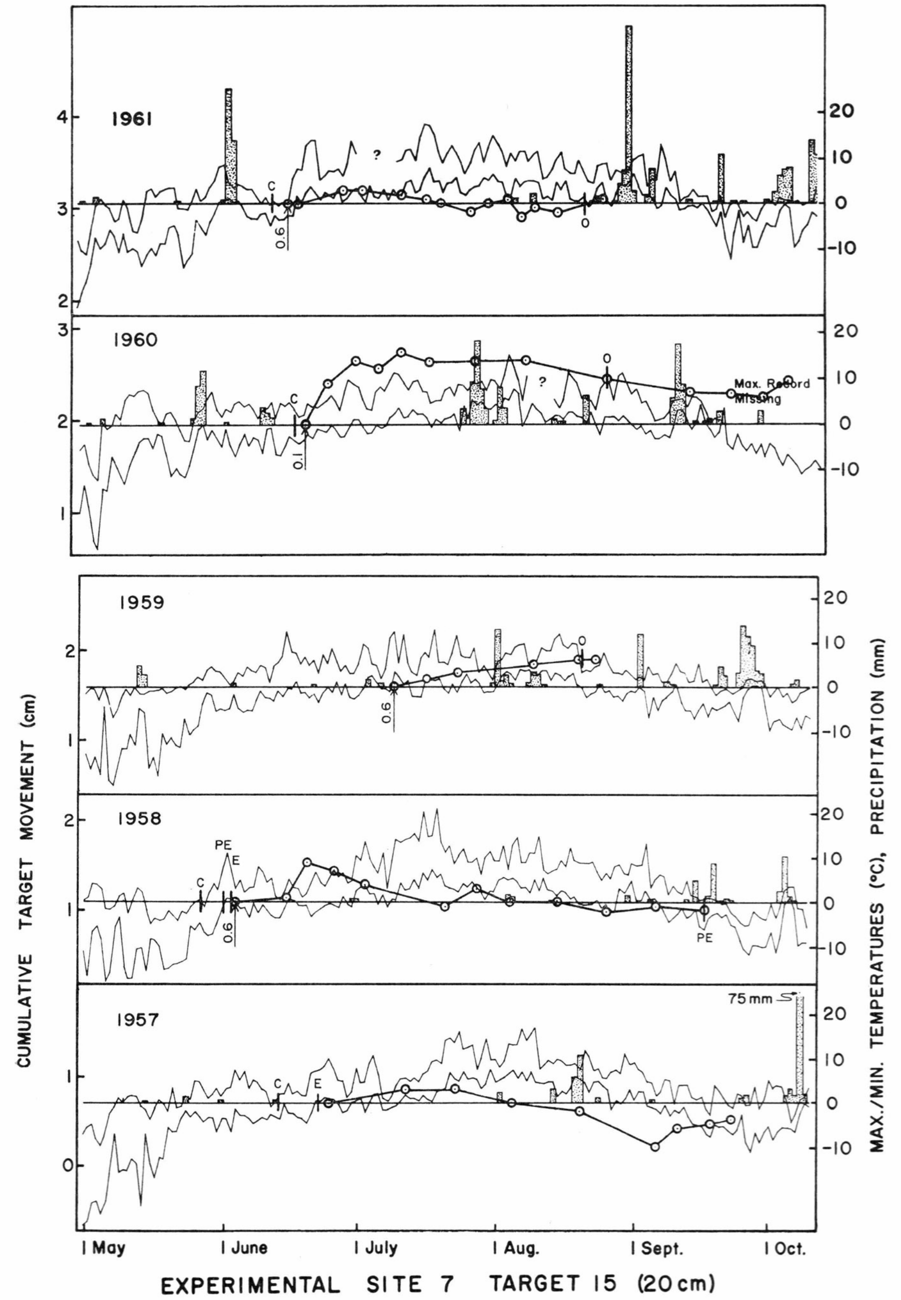
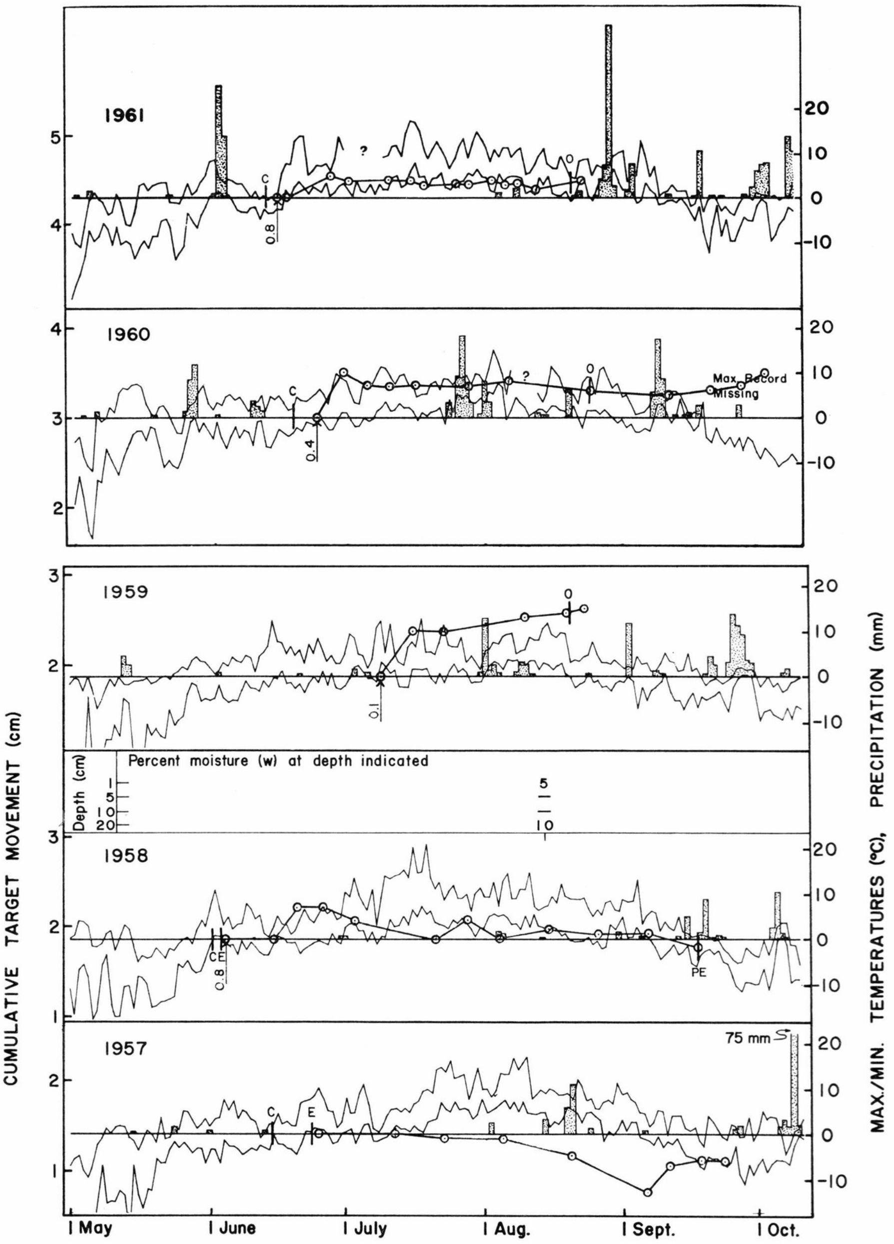
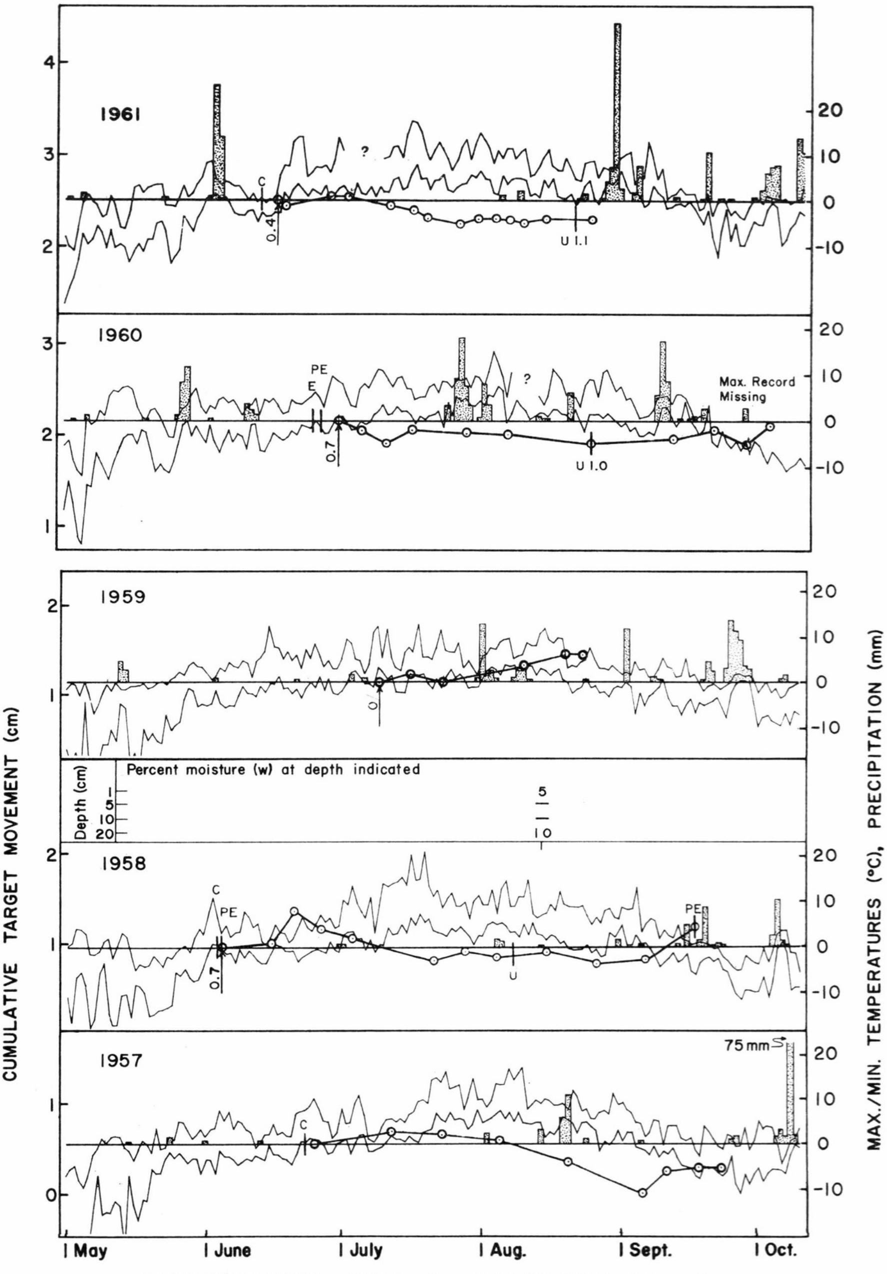

1961
1960
1959
1958
1957
CUMULATIVE TARGET MOVEMENT (cm)
MAX./MIN. TEMPERATURES (°C), PRECIPITATION (mm)
C
0.6
0.1
?
O
PE
E
Max. Record Missing
75 mm
20
10
0
-10
4
3
2
1
0
I May
I June
I July
I Aug.
I Sept.
I Oct.
EXPERIMENTAL SITE 7 TARGET 15 (20 cm)

Plate C 2–14.



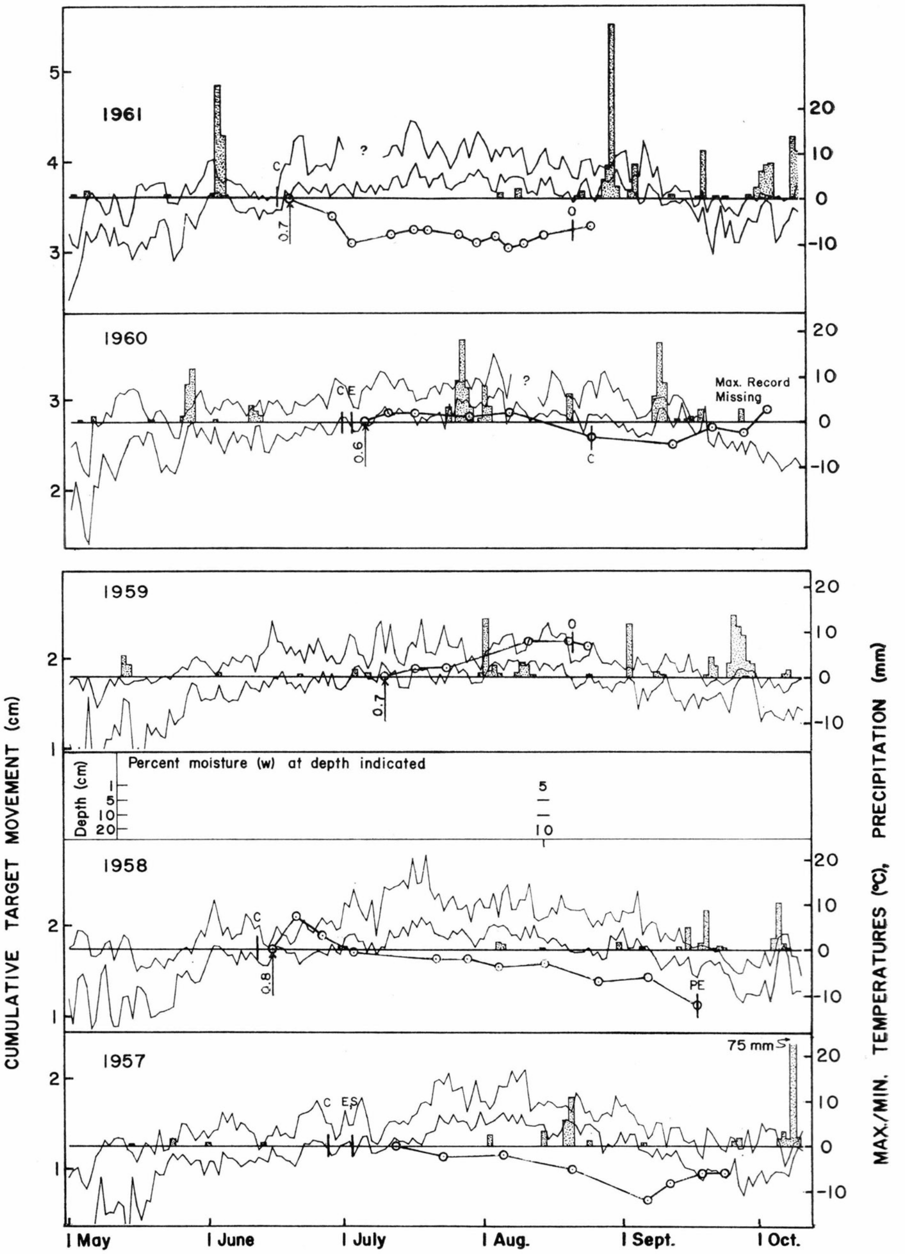
EXPERIMENTAL SITE 7 TARGET 16 (10 cm)

Plate C 2-15.



EXPERIMENTAL SITE 7 TARGET 17 (20 cm)

Plate C 2–16.



EXPERIMENTAL SITE 7 TARGET 18 (10 cm)

Plate C 2–17.

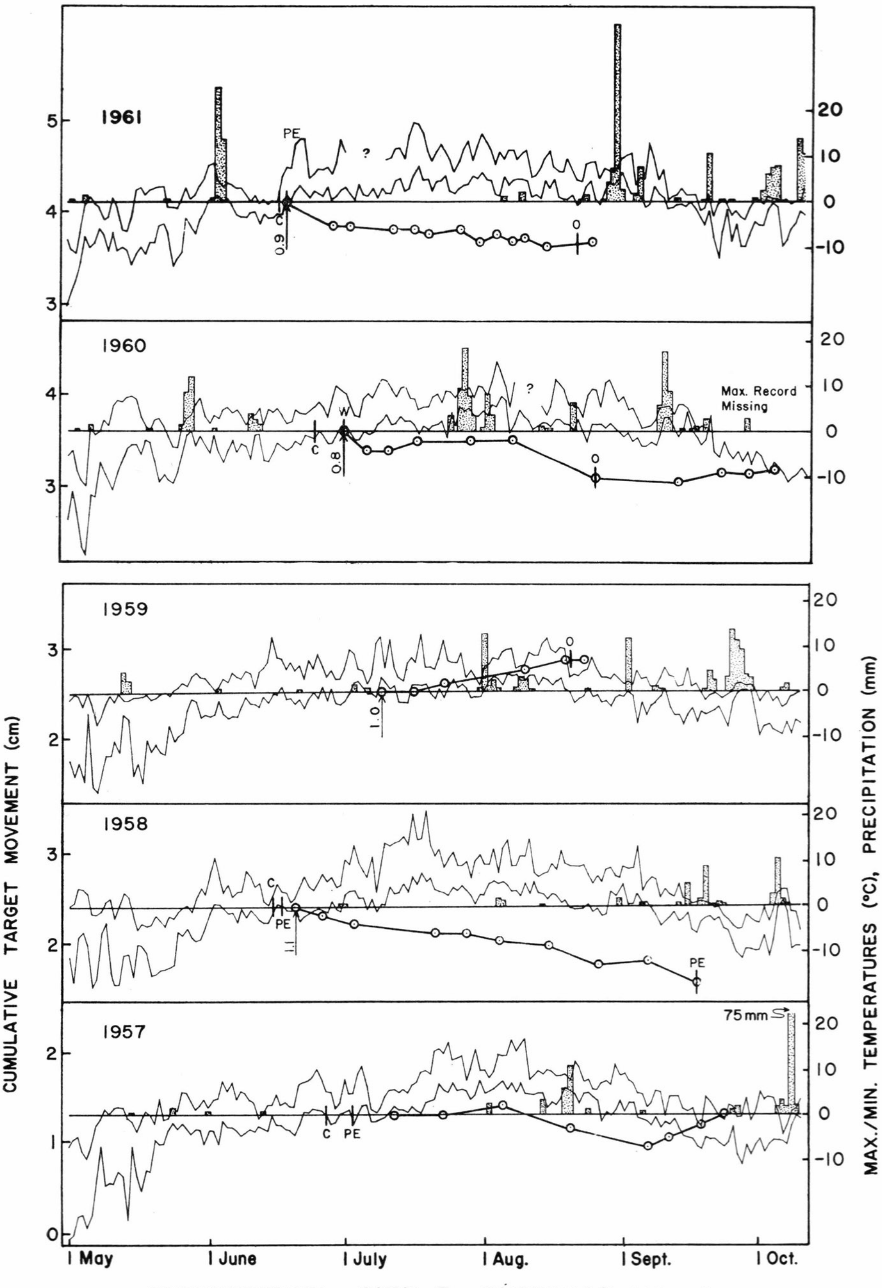
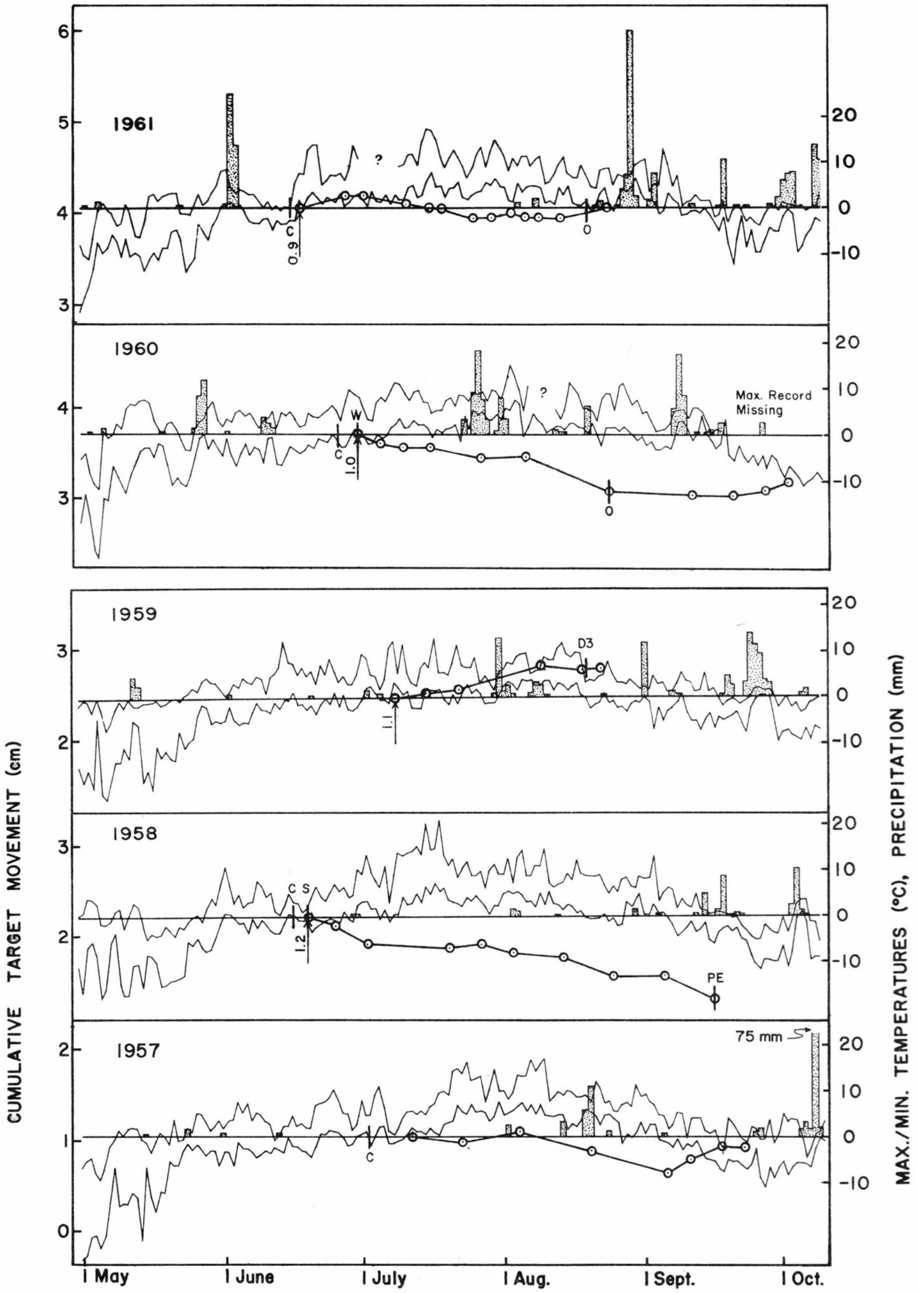

1961
1960
1959
1958
1957
PE
?
C
0.9
O
W
C
0.8
Max. Record Missing
1.0
PE
1.1
75 mm
PE
C PE
CUMULATIVE TARGET MOVEMENT (cm)
MAX./MIN. TEMPERATURES (°C), PRECIPITATION (mm)
I May
I June
I July
I Aug.
I Sept.
I Oct.
EXPERIMENTAL SITE 7 TARGET 19 (10 cm)

Plate C 2–18.



EXPERIMENTAL SITE 7 TARGET 20 (10 cm)

Plate C 2–19.

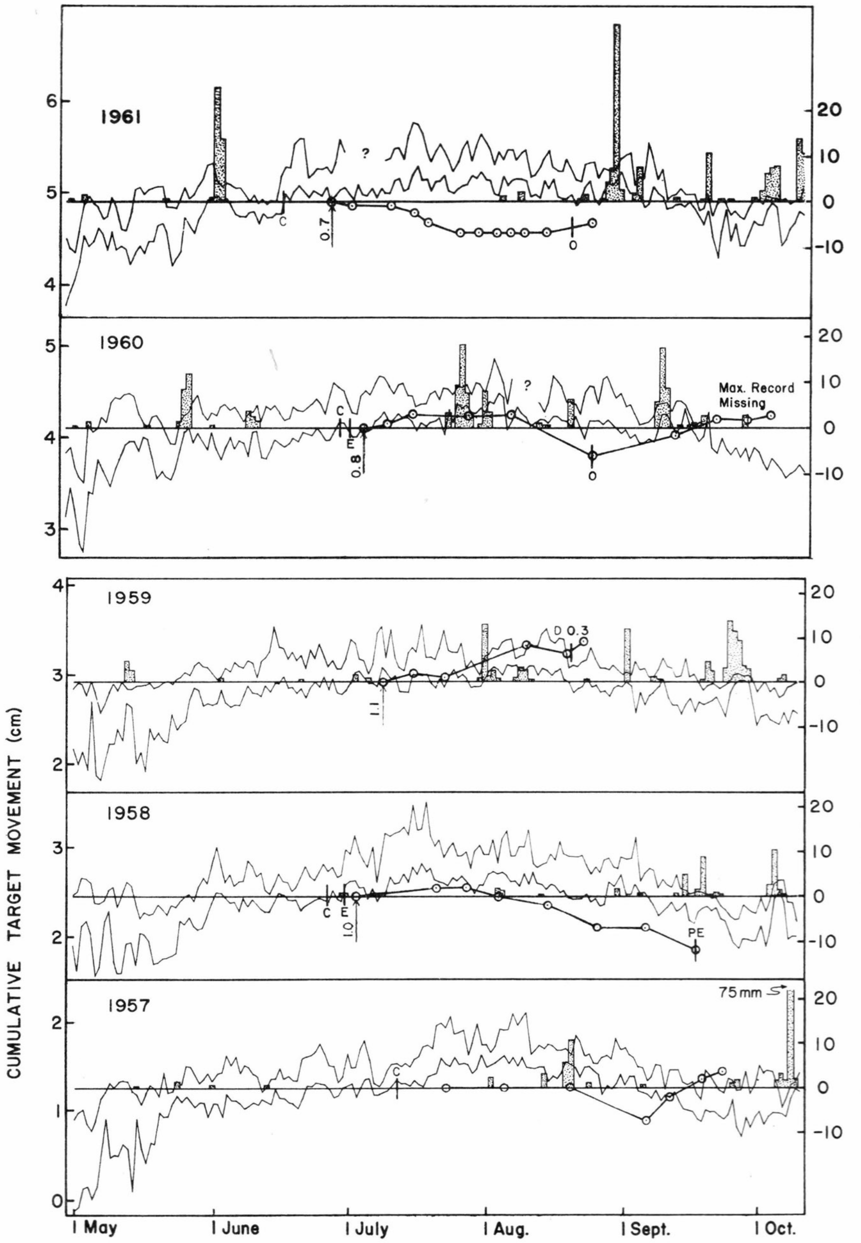
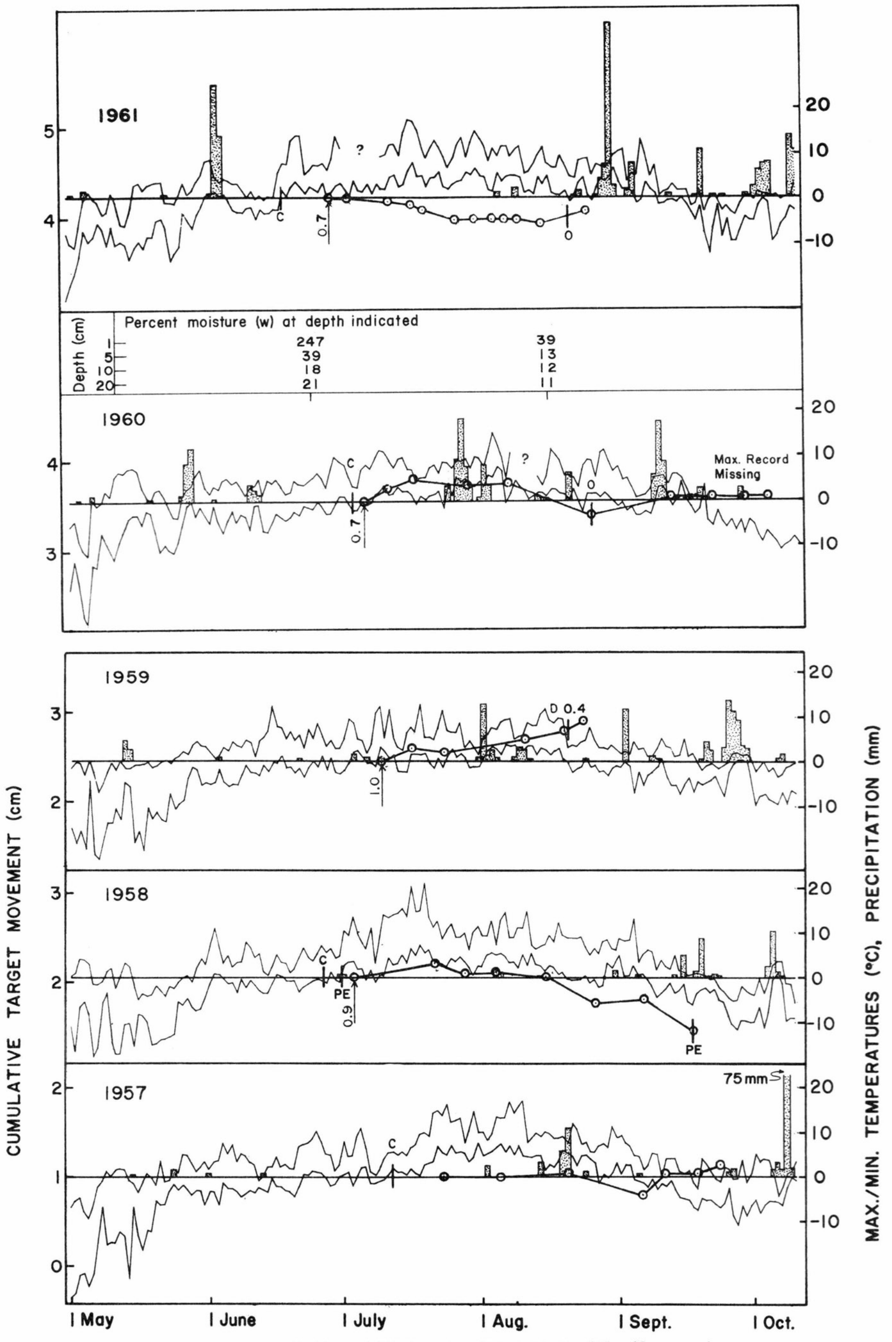
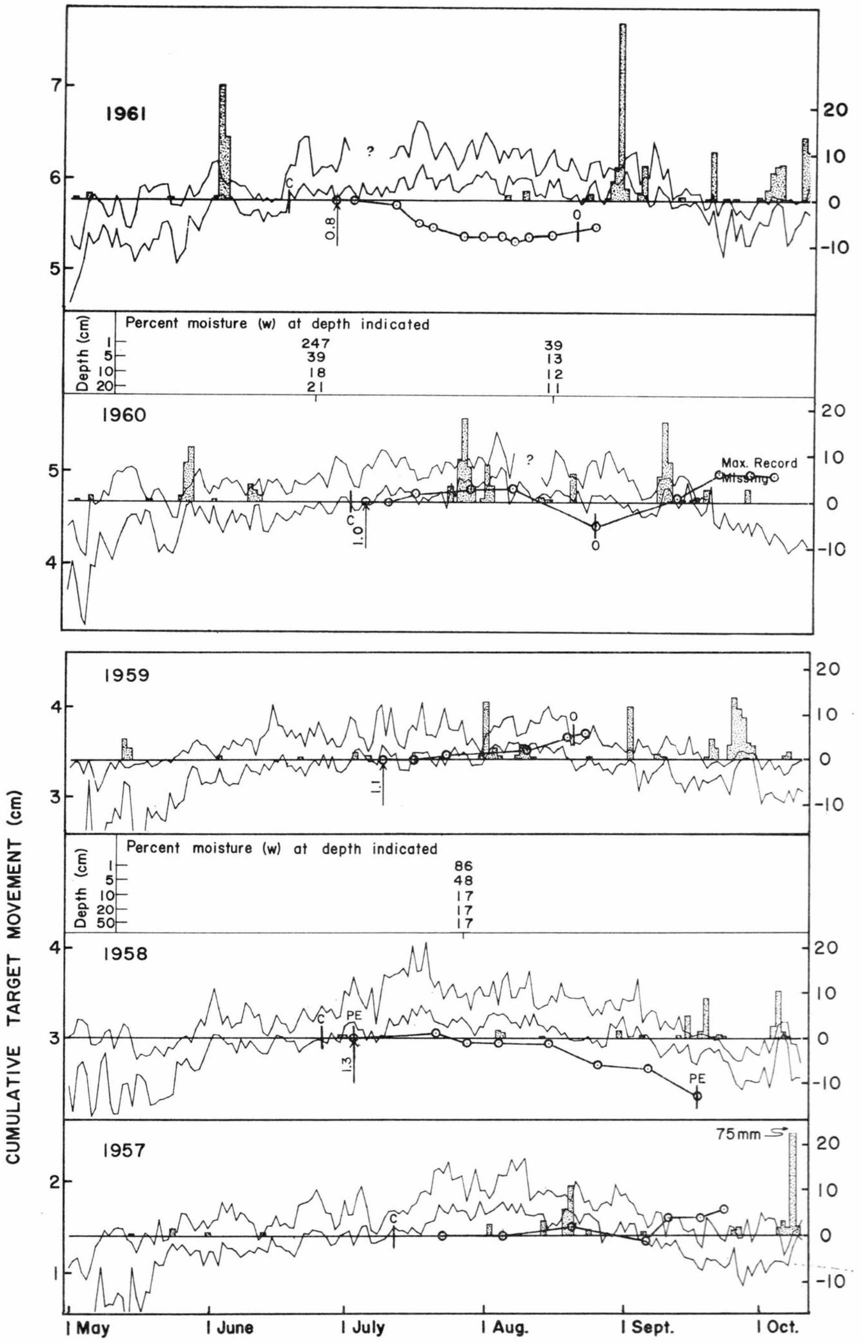

1961
1960
1959
1958
1957
CUMULATIVE TARGET MOVEMENT (cm)
MAX./MIN. TEMPERATURES (°C), PRECIPITATION (mm)
Max. Record Missing
75 mm
C
E
D 0.3
PE
0.7
0.8
1.1
1.0
?
I May
I June
I July
I Aug.
I Sept.
I Oct.
EXPERIMENTAL SITE 7 TARGET 22 (10 cm)

Plate C 2–20.



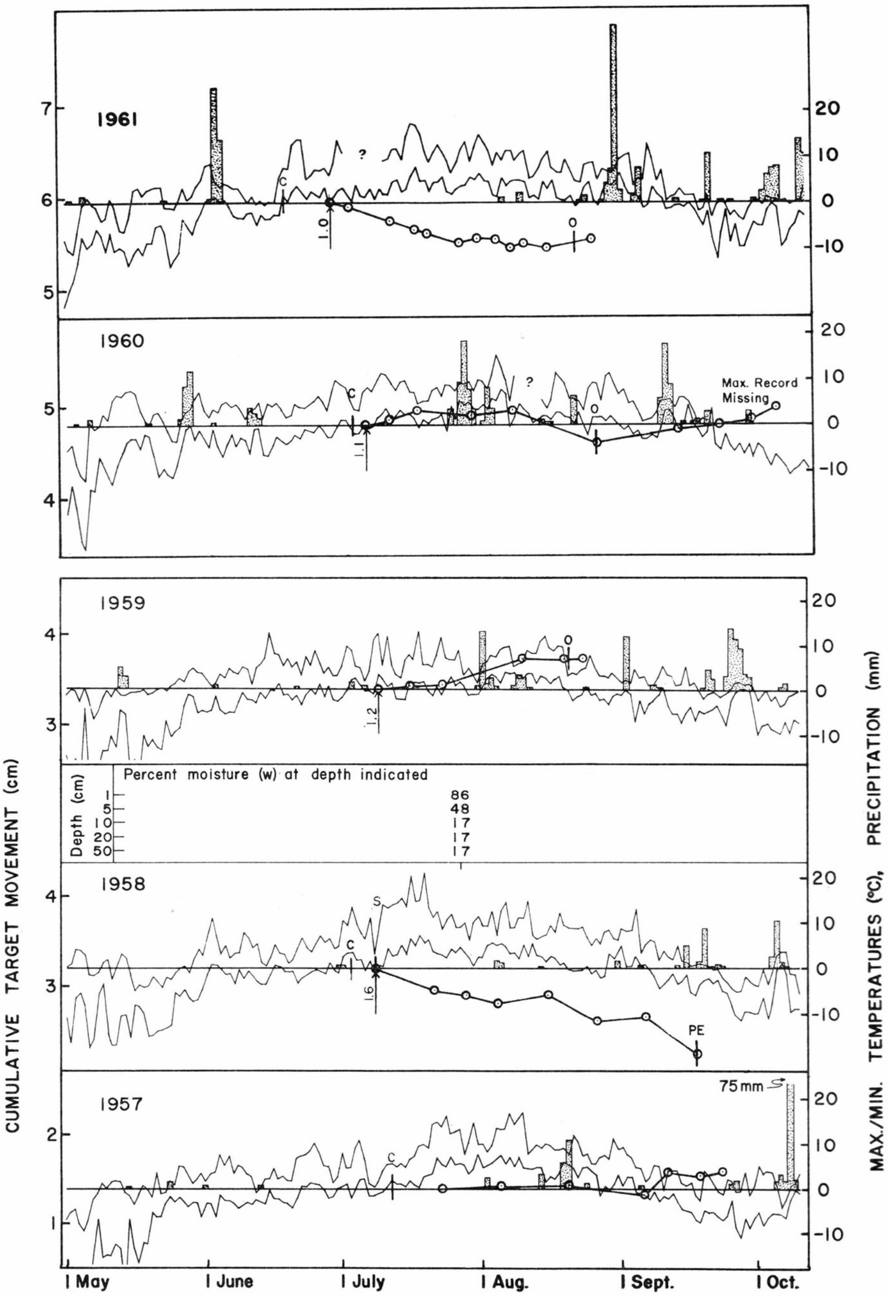
EXPERIMENTAL SITE 7 TARGET 23 (20 cm)

Plate C 2–21.



EXPERIMENTAL SITE 7 TARGET 24 (10cm)

Plate C 2-22.



EXPERIMENTAL SITE 7 TARGET 25 (20 cm)

Plate C 2–23.

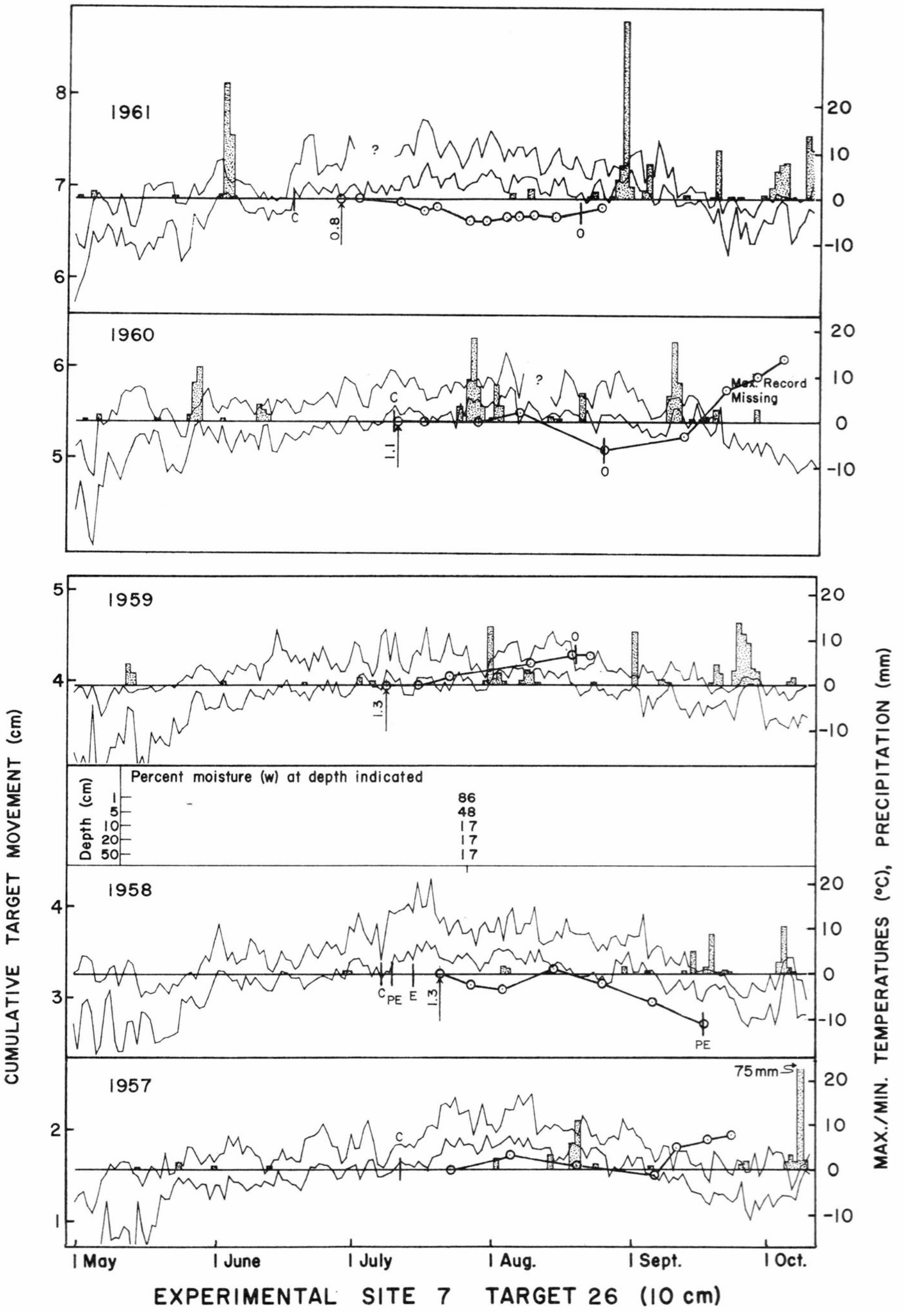
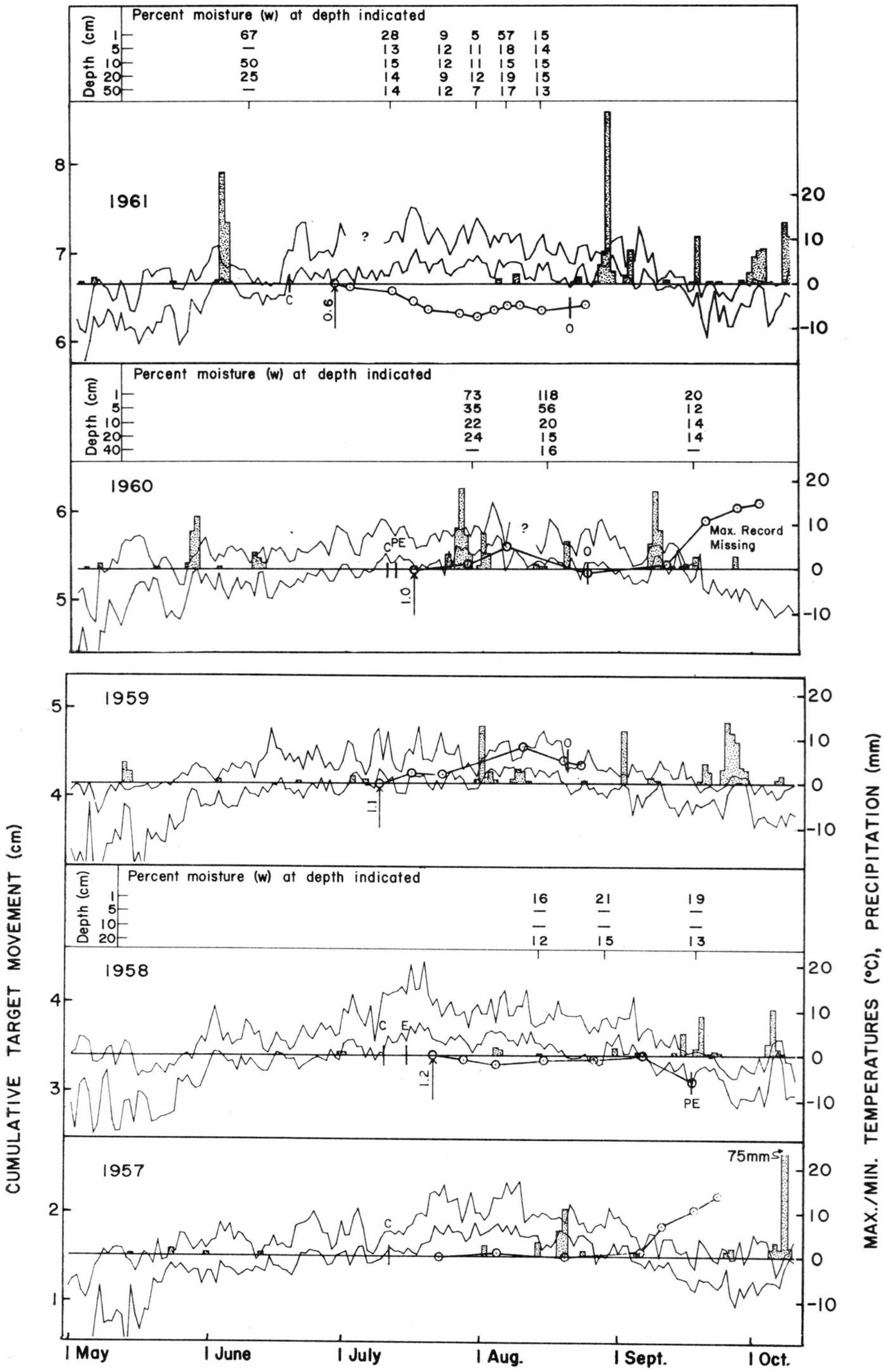
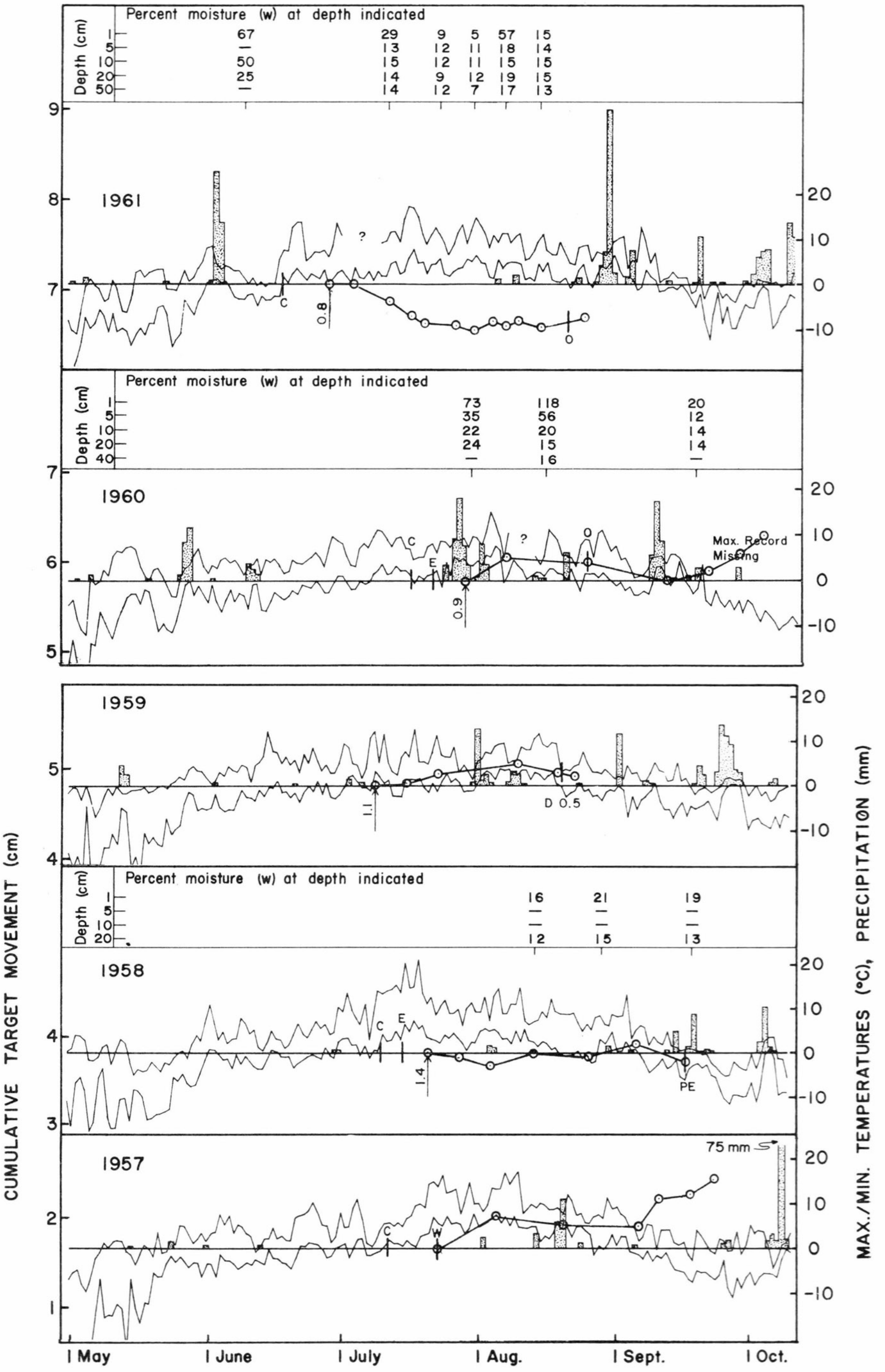

1961
1960
1959
1958
1957
Max. Record Missing
Percent moisture (w) at depth indicated
Depth (cm)
1
5
10
20
50
86
48
17
17
17
75mm
C
PE
E
O
0.8
1.1
1.3
1.3
?
8
7
6
6
5
5
4
4
3
2
1
20
10
0
-10
CUMULATIVE TARGET MOVEMENT (cm)
MAX./MIN. TEMPERATURES (°C), PRECIPITATION (mm)
1 May
1 June
1 July
1 Aug.
1 Sept.
1 Oct.
EXPERIMENTAL SITE 7 TARGET 26 (10 cm)

Plate C 2–24.



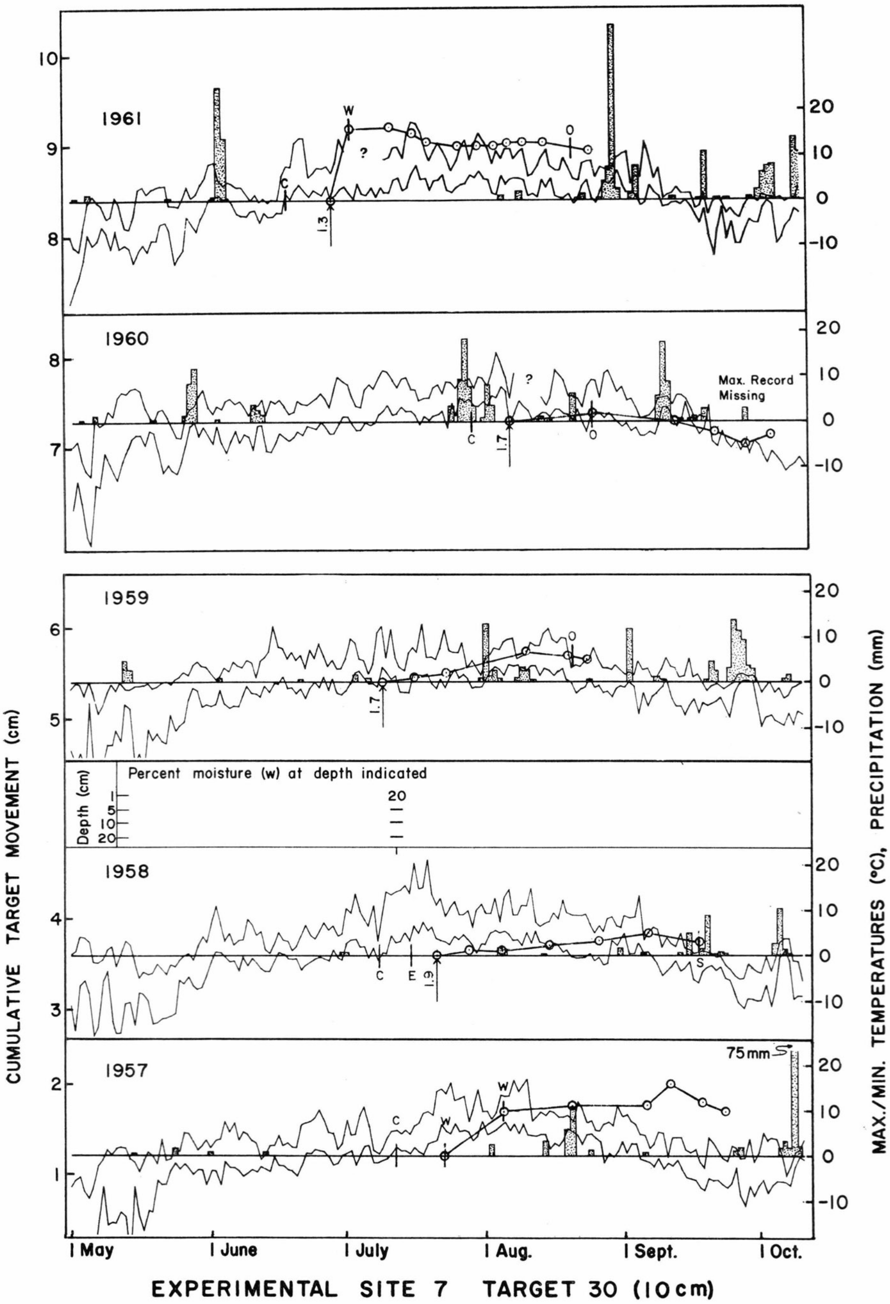
EXPERIMENTAL SITE 7 TARGET 27 (10 cm)

Plate C 2–25.



EXPERIMENTAL SITE 7 TARGET 28 (10cm)

Plate C 2–26.



EXPERIMENTAL SITE 7 TARGET 30 (10cm)

Plate C 2–27.

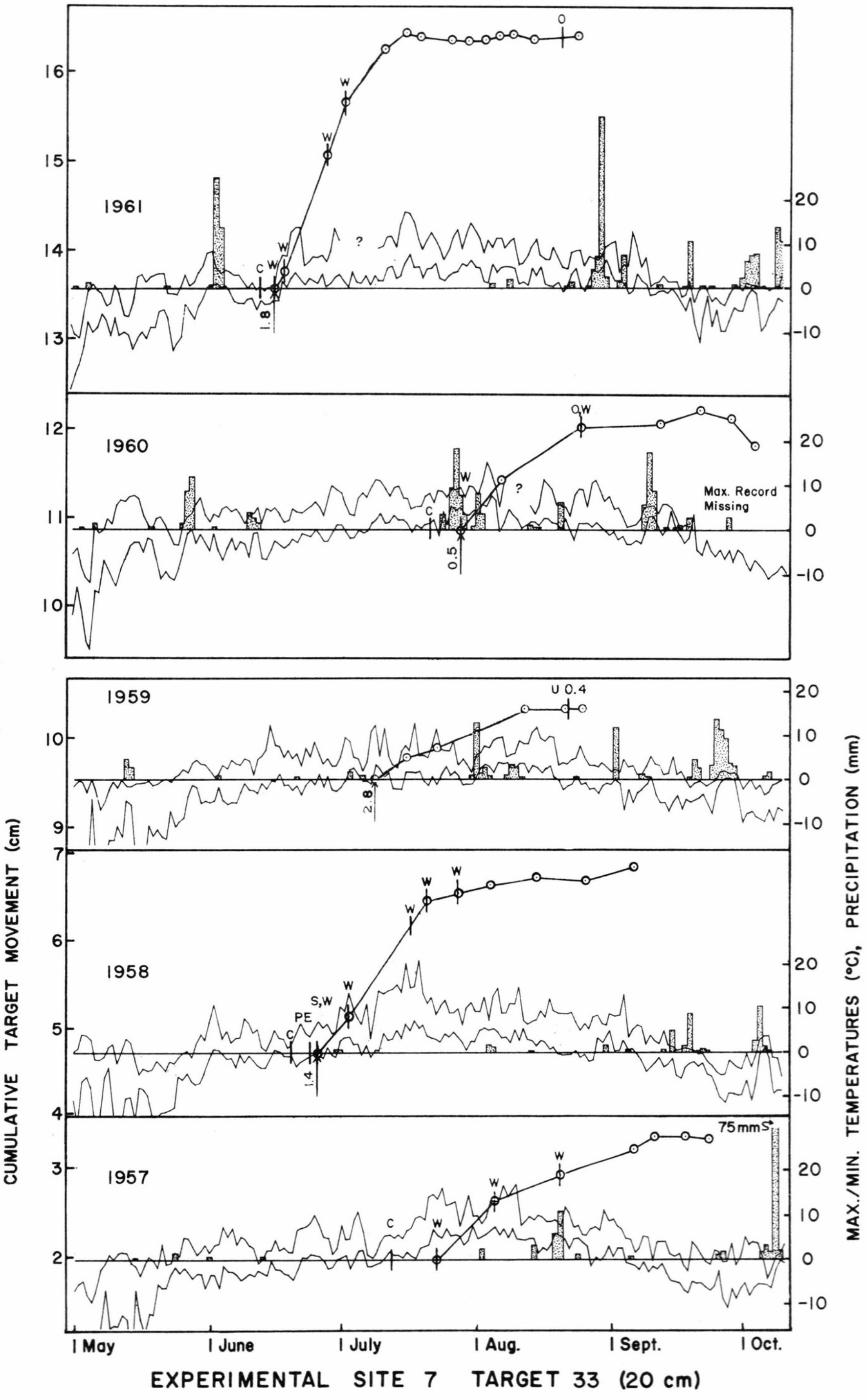
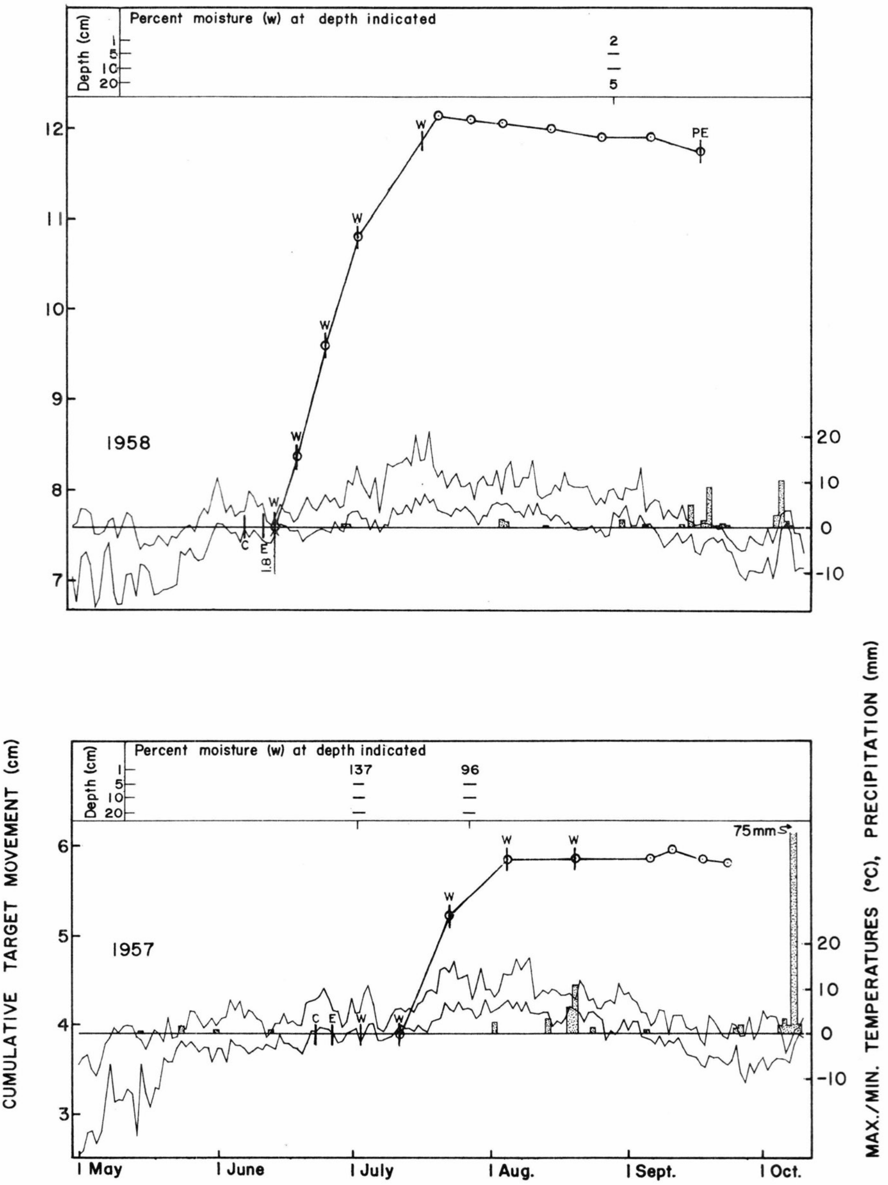
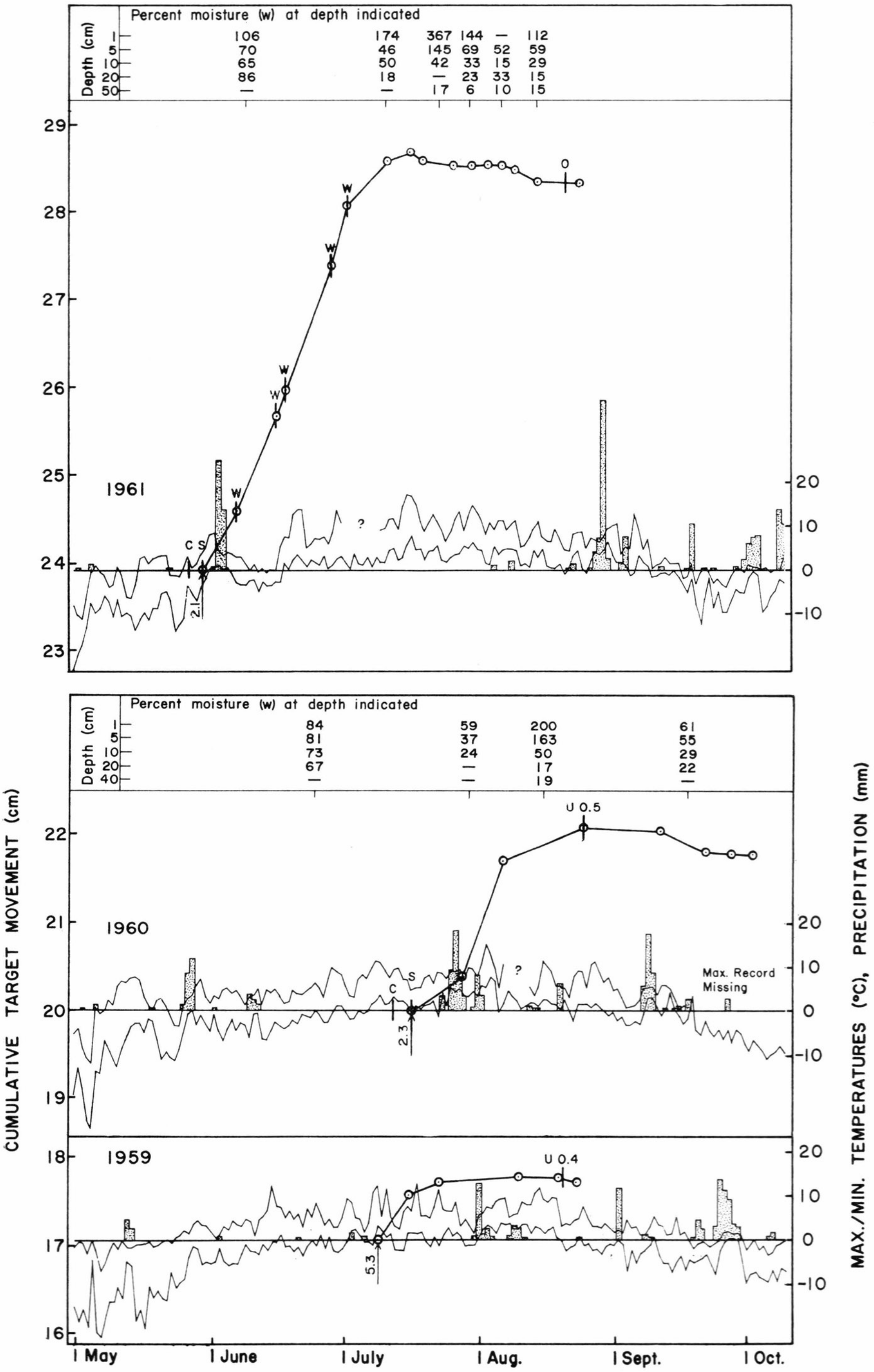

1961
1960
1959
1958
1957
CUMULATIVE TARGET MOVEMENT (cm)
MAX./MIN. TEMPERATURES (°C), PRECIPITATION (mm)
16
15
14
13
12
11
10
9
7
6
5
4
3
2
20
10
0
-10
C
W
1.8
O
?
0,W
0.5
Max. Record Missing
U 0.4
2.8
PE
S,W
1.4
75 mms
I May
I June
I July
I Aug.
I Sept.
I Oct.
EXPERIMENTAL SITE 7 TARGET 33 (20 cm)

Plate C 2–28.



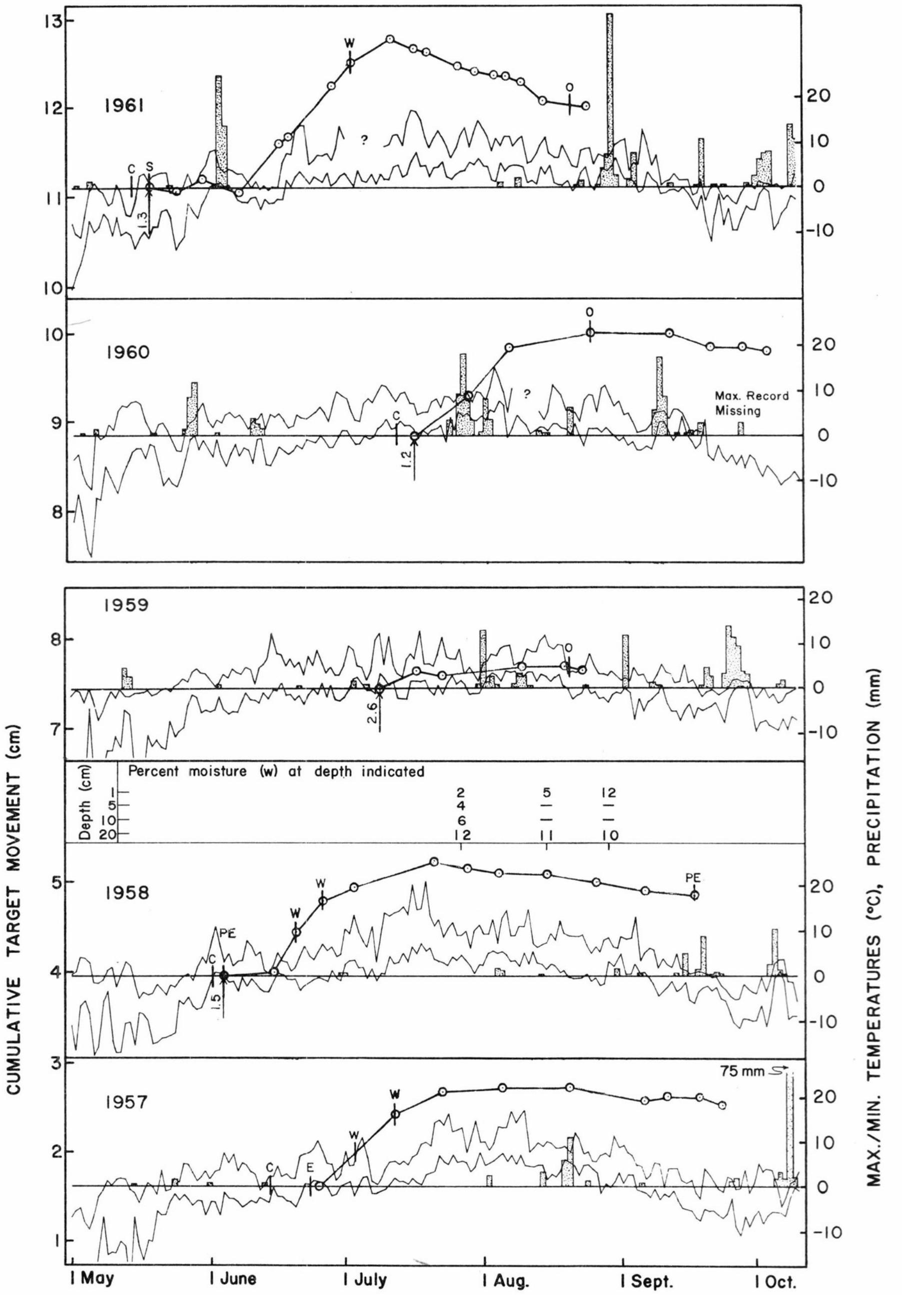
EXPERIMENTAL SITE 7 TARGET 35 (20 cm)

Plate C 2–29.



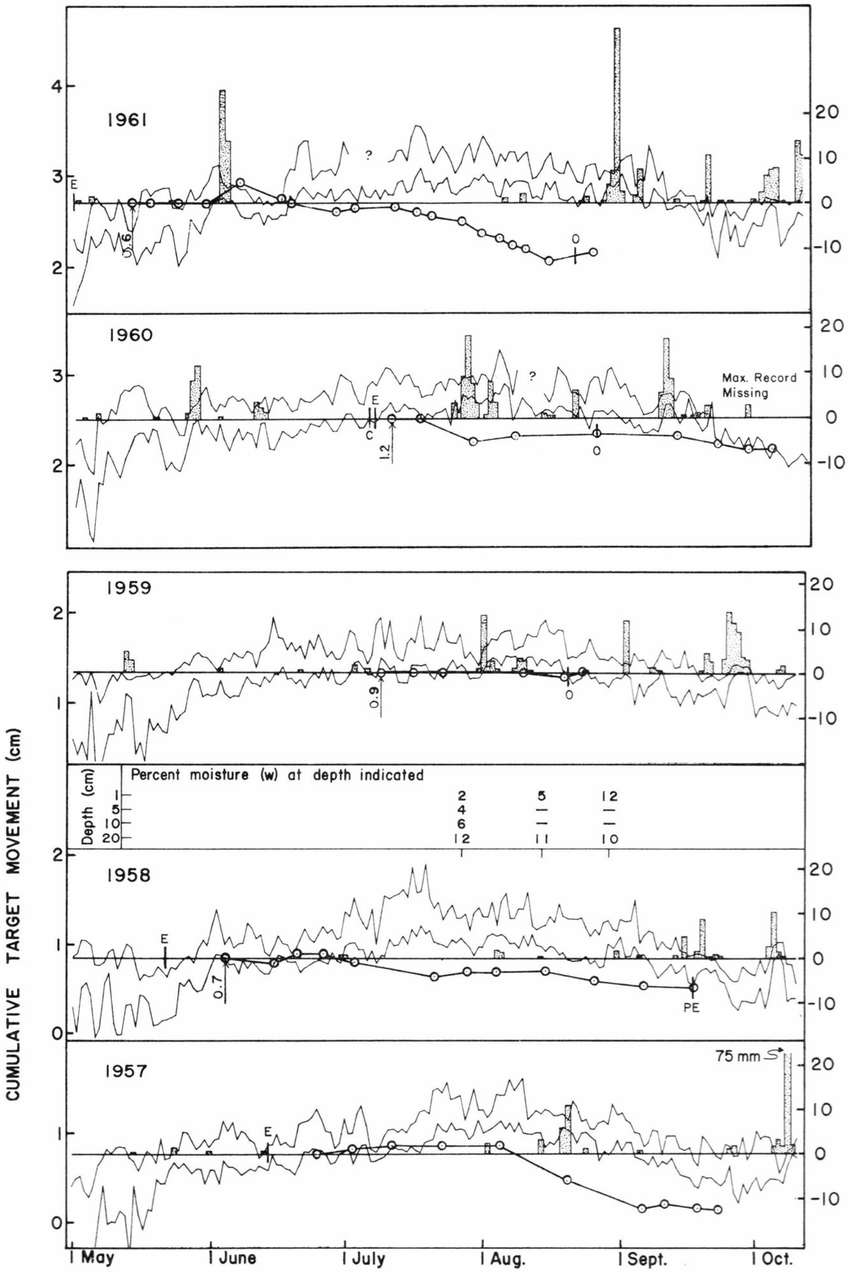
EXPERIMENTAL SITE 7 TARGET 35 (20 cm)

Plate C 2–30.



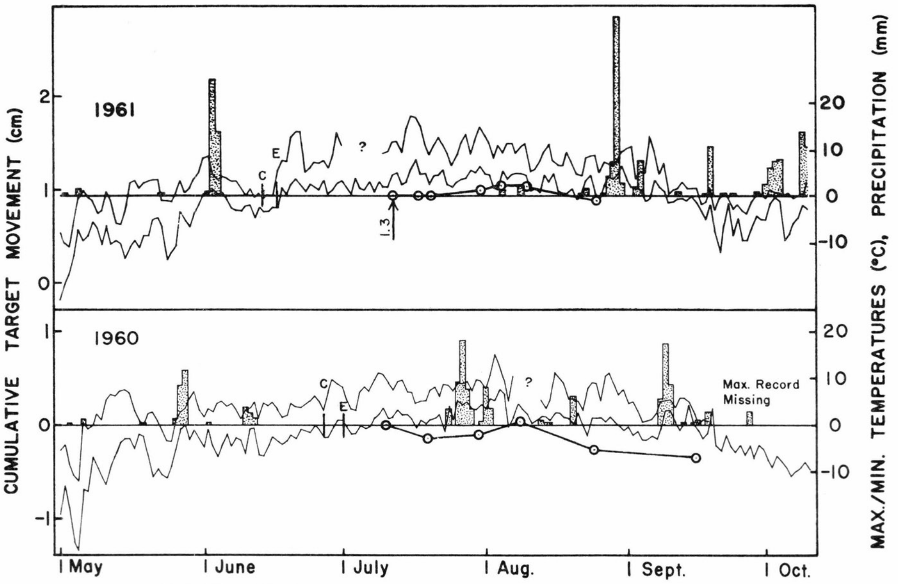
EXPERIMENTAL SITE 7 TARGET 36 (10 cm)

Plate C 2–31.

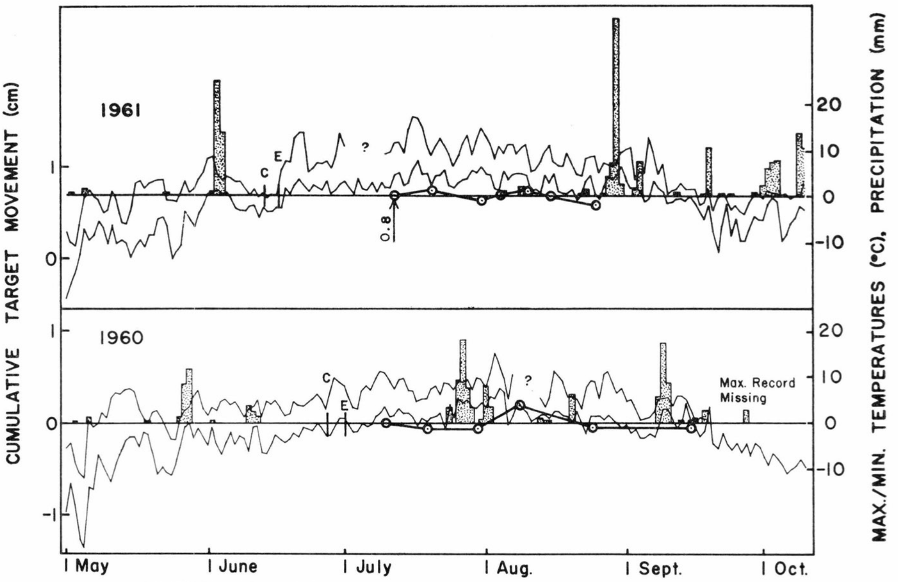


EXPERIMENTAL SITE 7 TARGET 38 (10 cm)

Plate C 2–32.

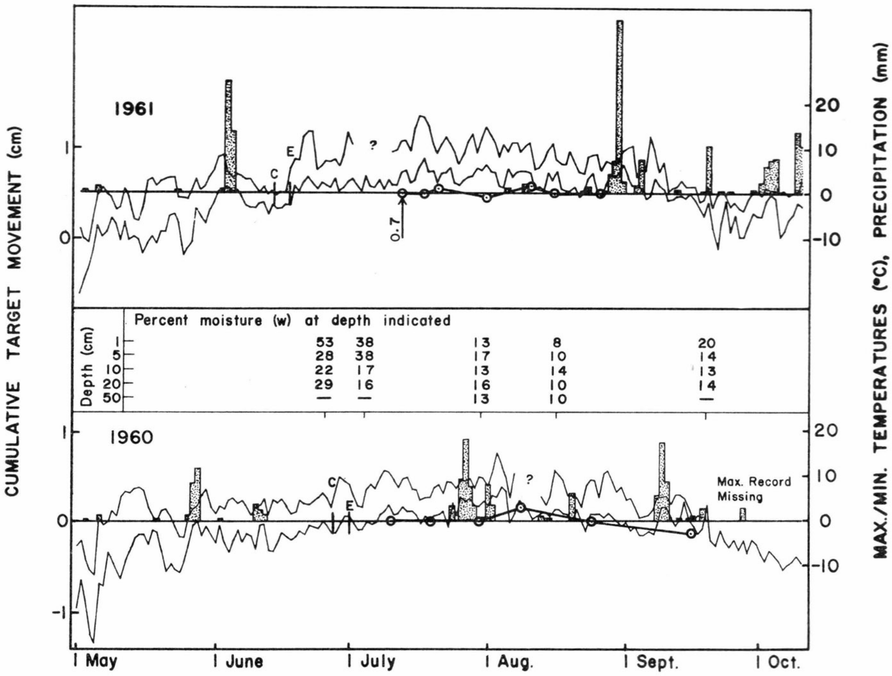


EXPERIMENTAL SITE 7 STONE TARGET I

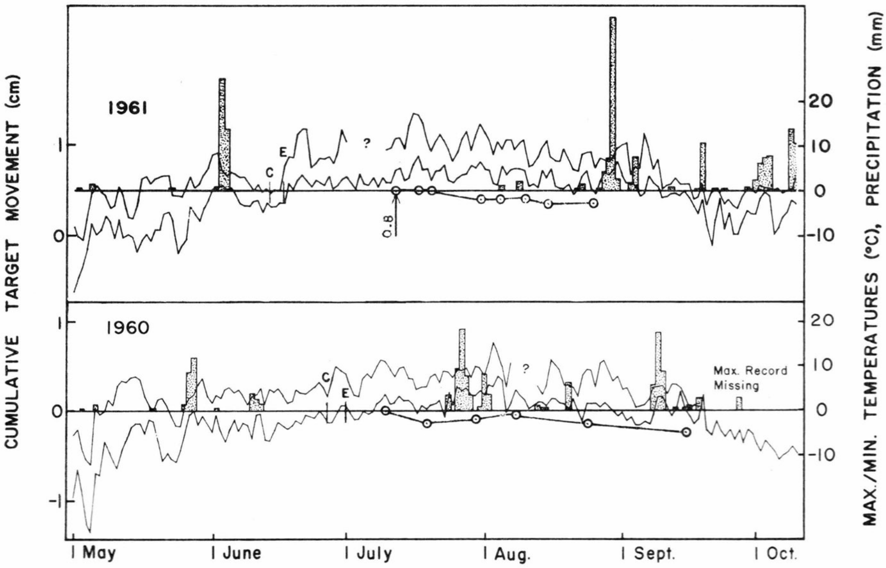


EXPERIMENTAL SITE 7 STONE TARGET 2

Plate C 2–33.

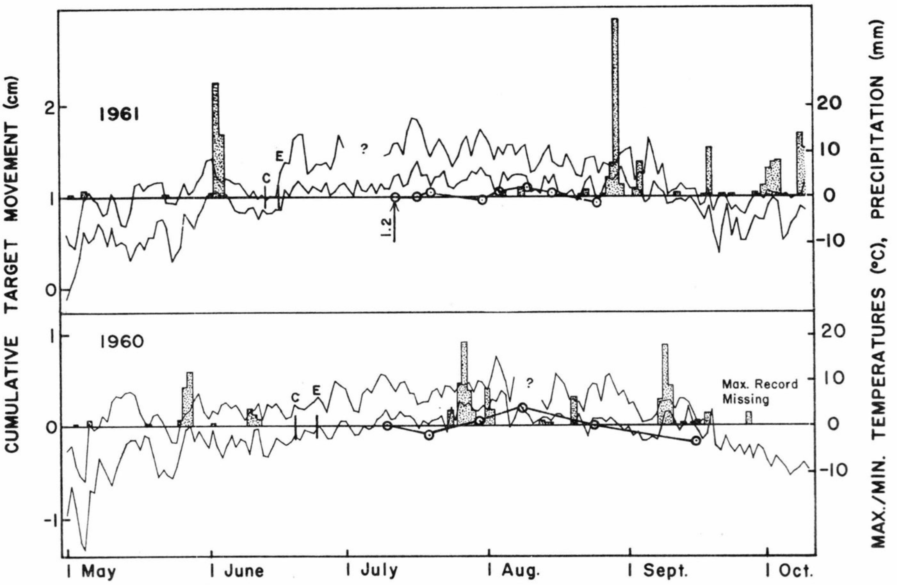


EXPERIMENTAL SITE 7 STONE TARGET 3

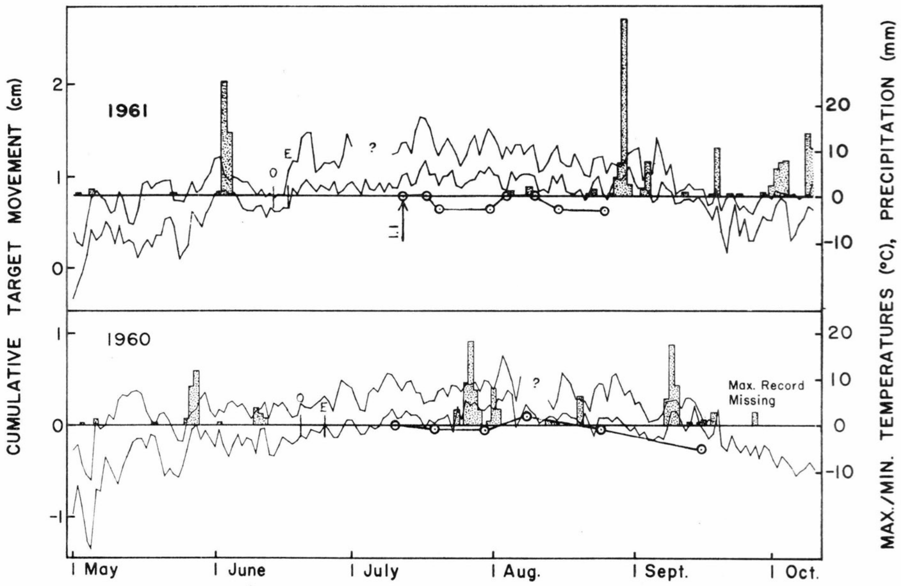


EXPERIMENTAL SITE 7 STONE TARGET 4

Plate C 2–34.

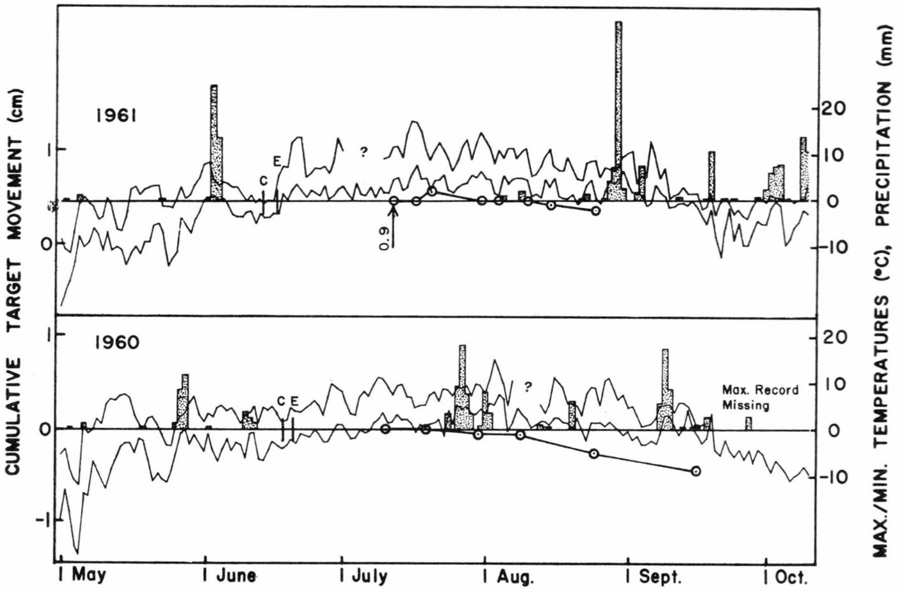


EXPERIMENTAL SITE 7 STONE TARGET 5

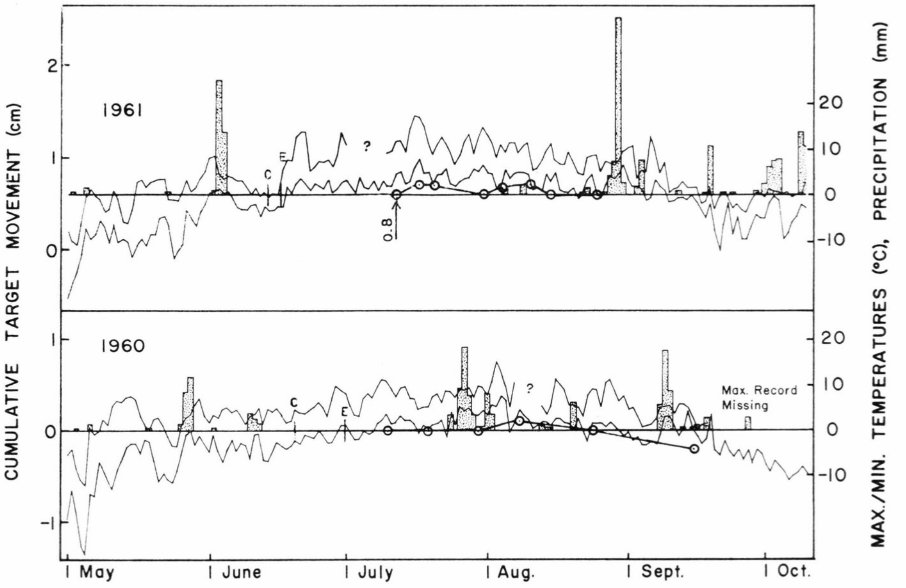


EXPERIMENTAL SITE 7 STONE TARGET 6

Plate C 2–35.

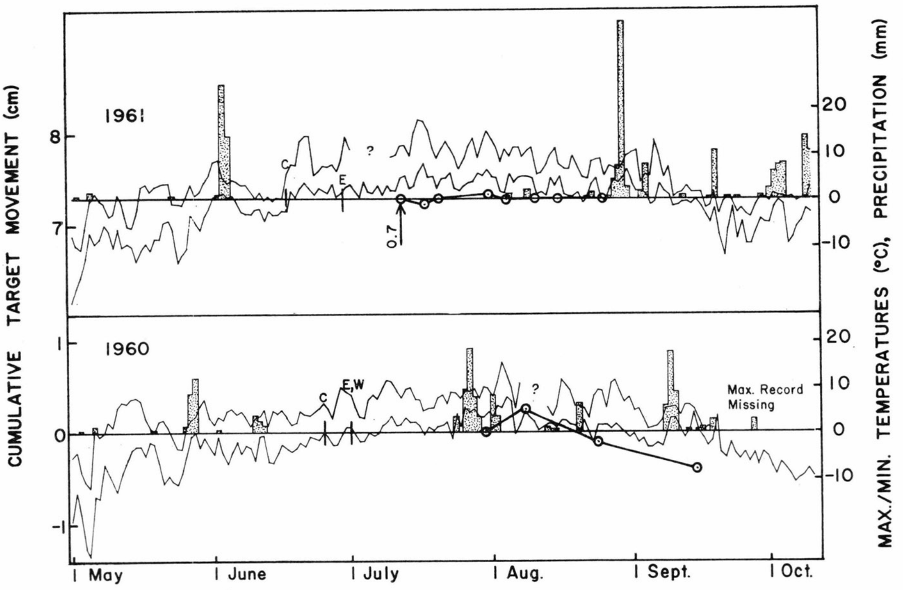


EXPERIMENTAL SITE 7 STONE TARGET 7

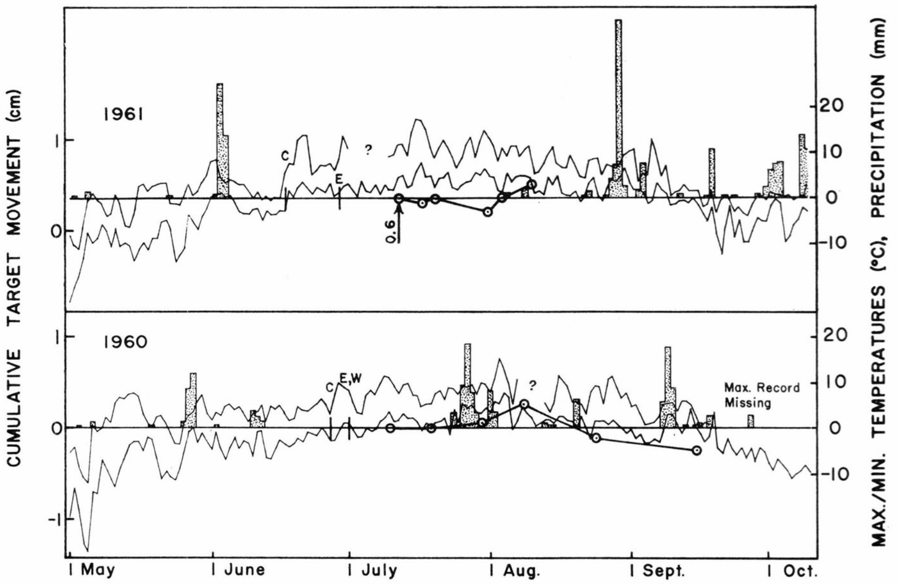


EXPERIMENTAL SITE 7 STONE TARGET 8

Plate C 2–36.

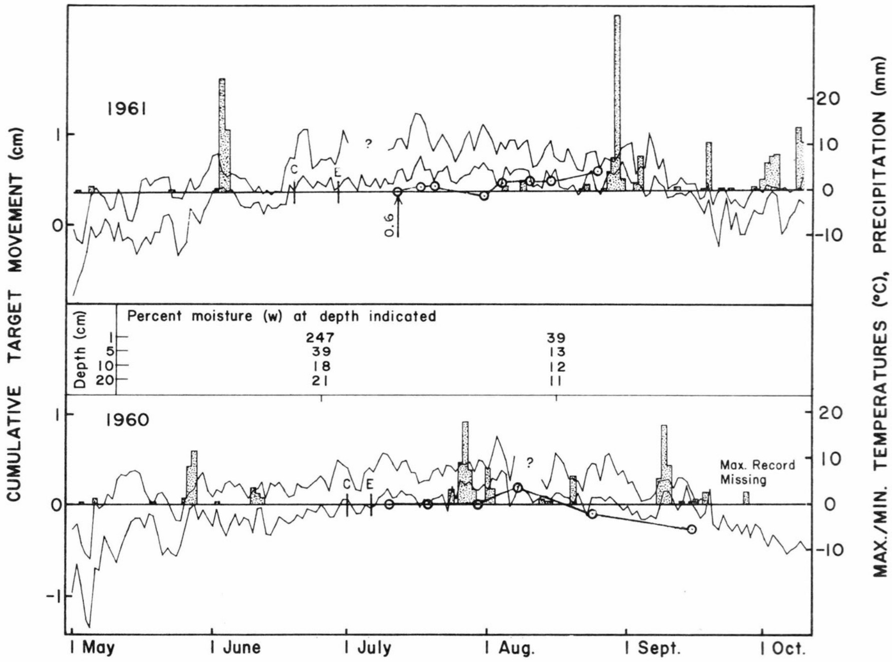


EXPERIMENTAL SITE 7 STONE TARGET 9

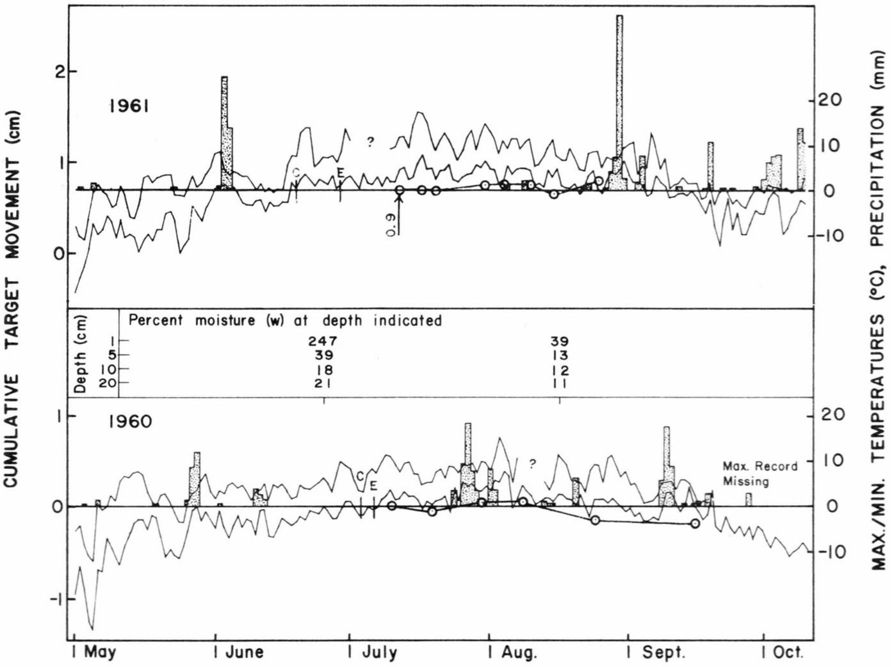


EXPERIMENTAL SITE 7 STONE TARGET 10

Plate C 2–37.

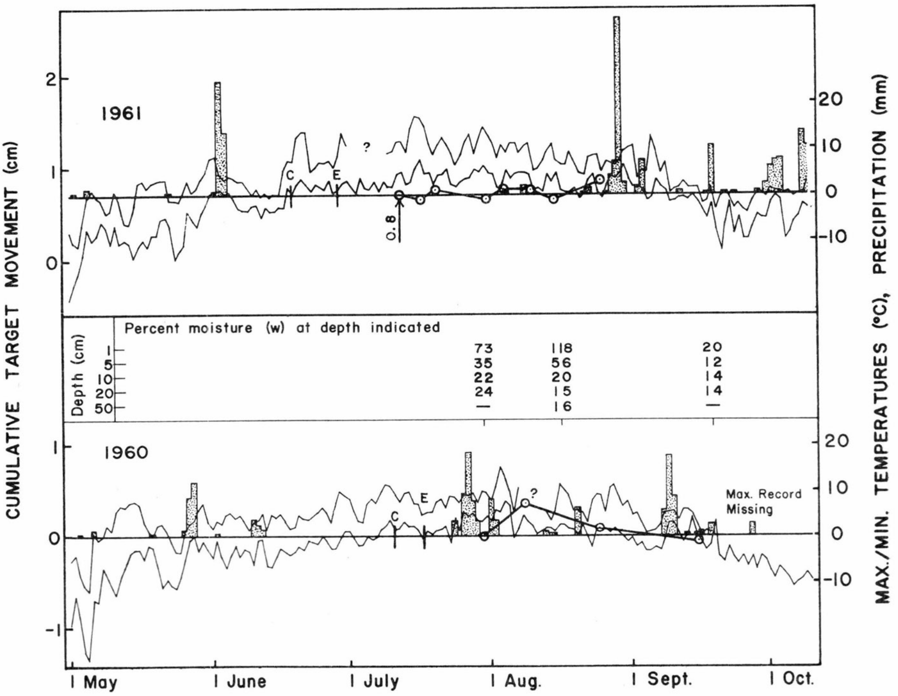


EXPERIMENTAL SITE 7 STONE TARGET 11

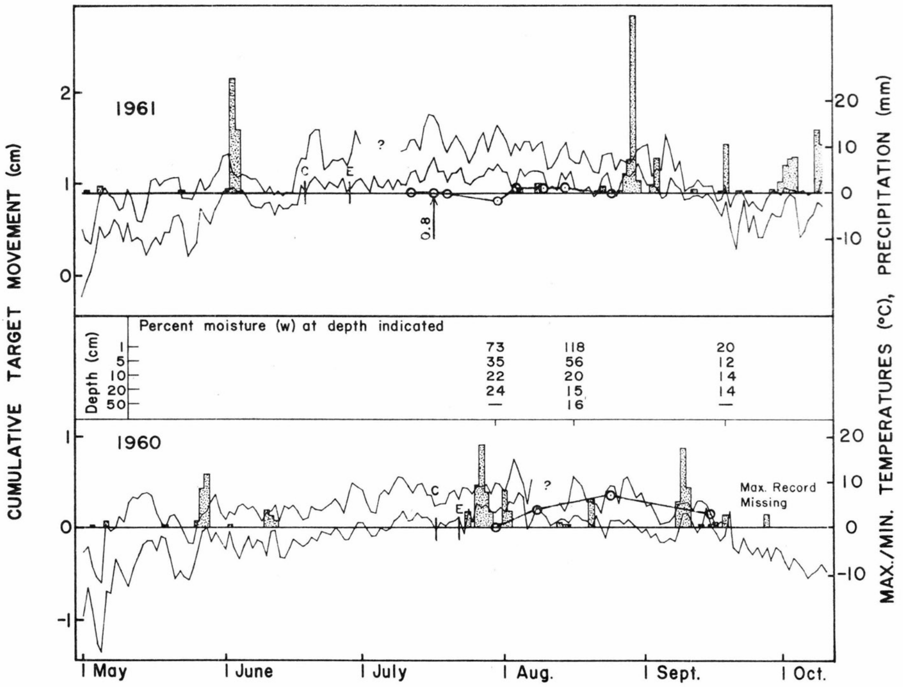


EXPERIMENTAL SITE 7 STONE TARGET 12

Plate C 2–38.

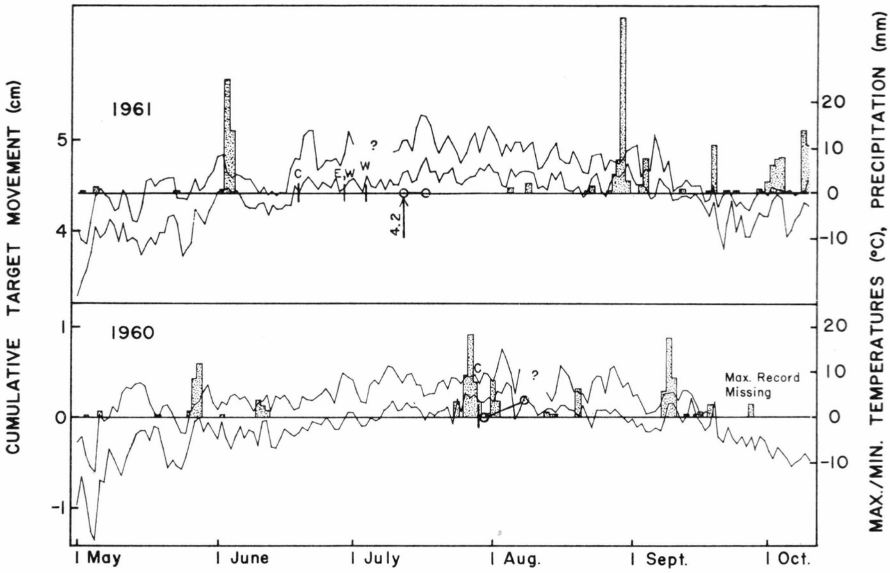


EXPERIMENTAL SITE 7 STONE TARGET 13

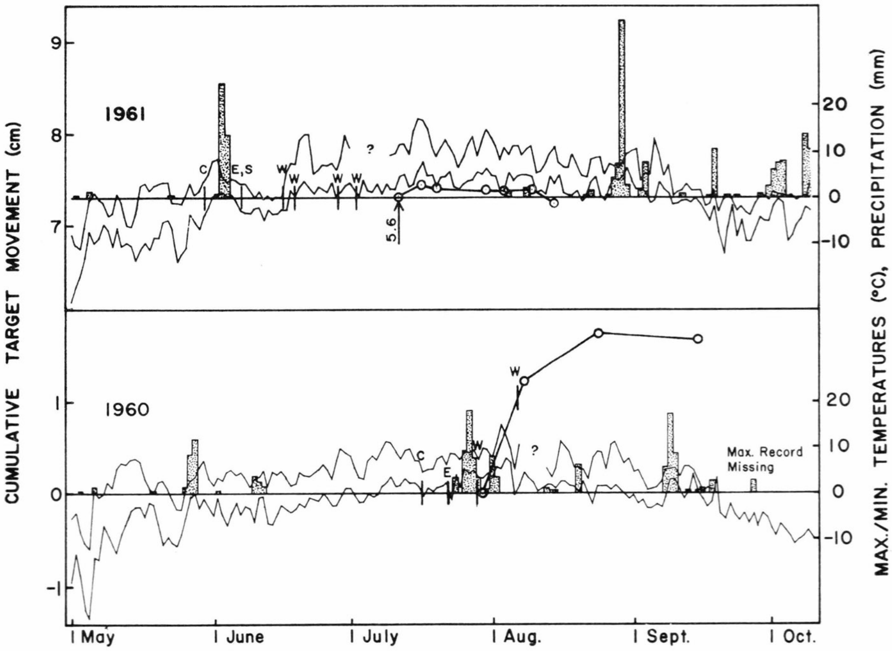


EXPERIMENTAL SITE 7 STONE TARGET 14

Plate C 2–39.

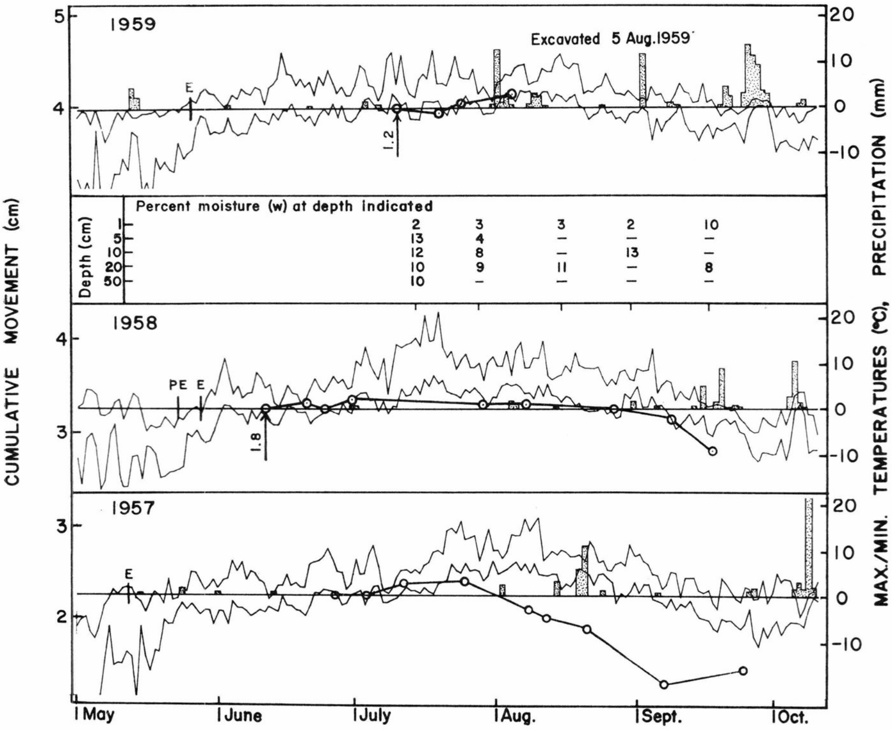


EXPERIMENTAL SITE 7 STONE TARGET 15



EXPERIMENTAL SITE 7 STONE TARGET 16

Plate C 2–40.



Percent moisture (w) at depth indicated

Depth (cm)					
1	2	3	3	2	10
5	13	4	–	–	–
10	12	8	–	13	–
20	10	9	11	–	8
50	10	–	–	–	–

EXPERIMENTAL SITE 8 MASS-WASTINGMETER 8 (at ground surface)

Plate C 3–1.

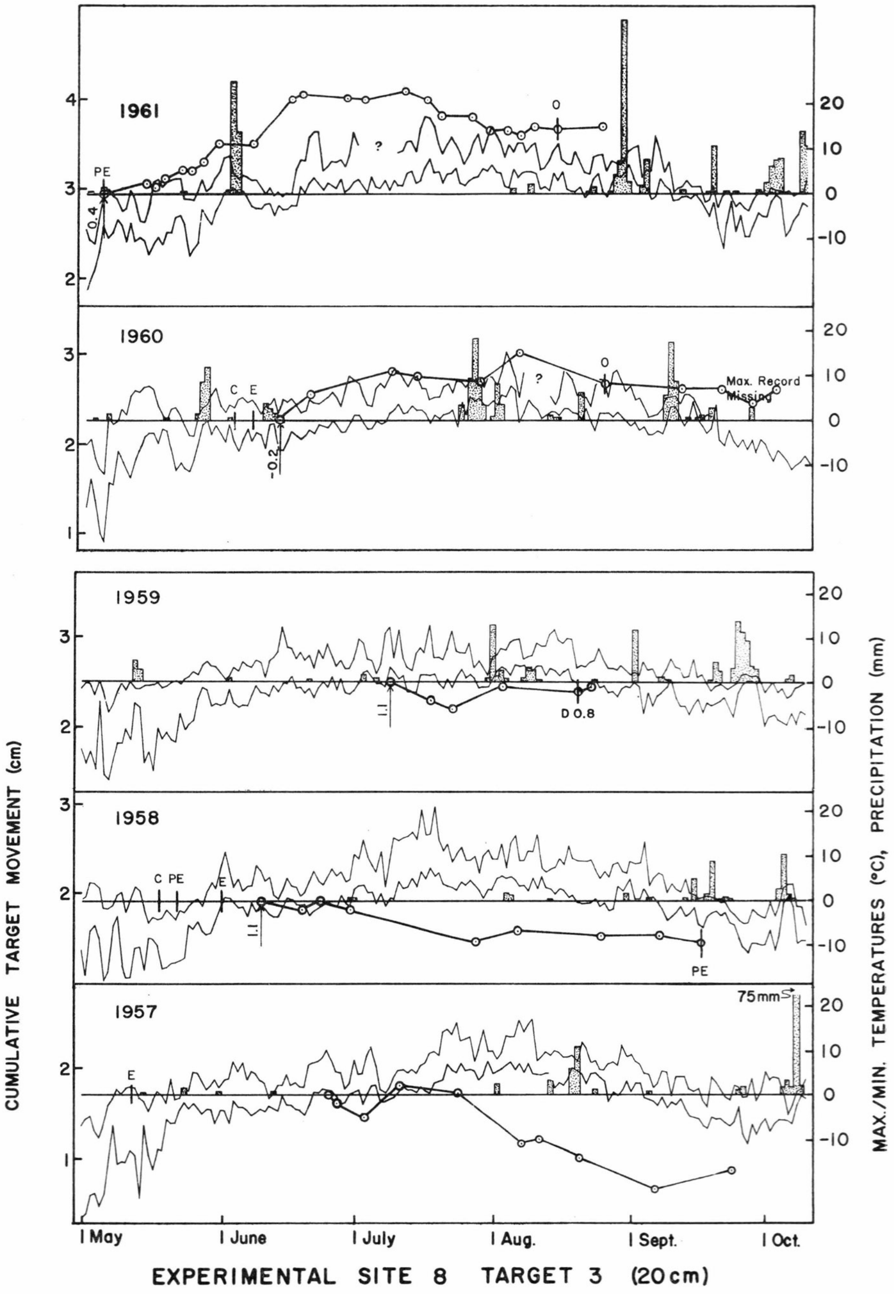
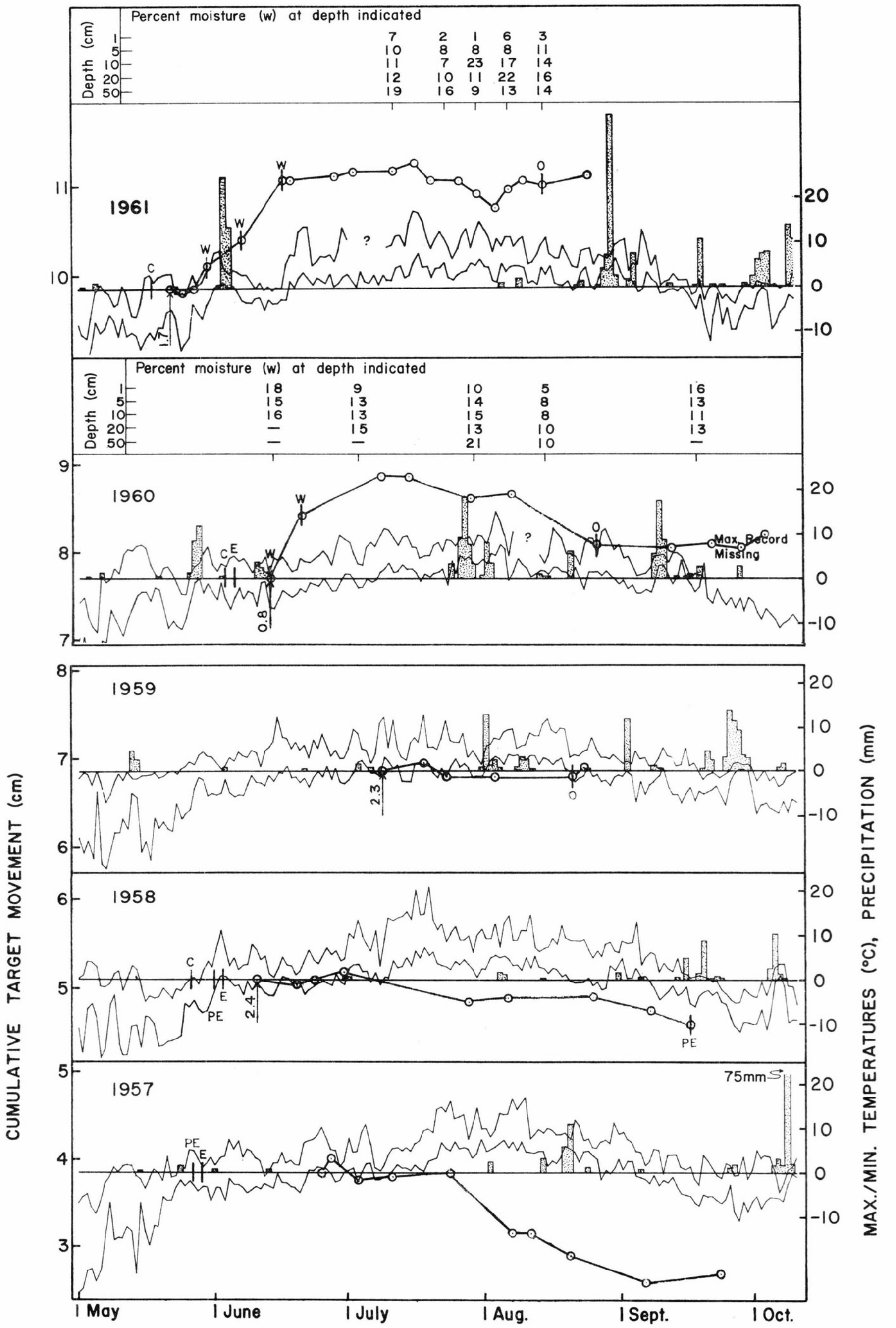
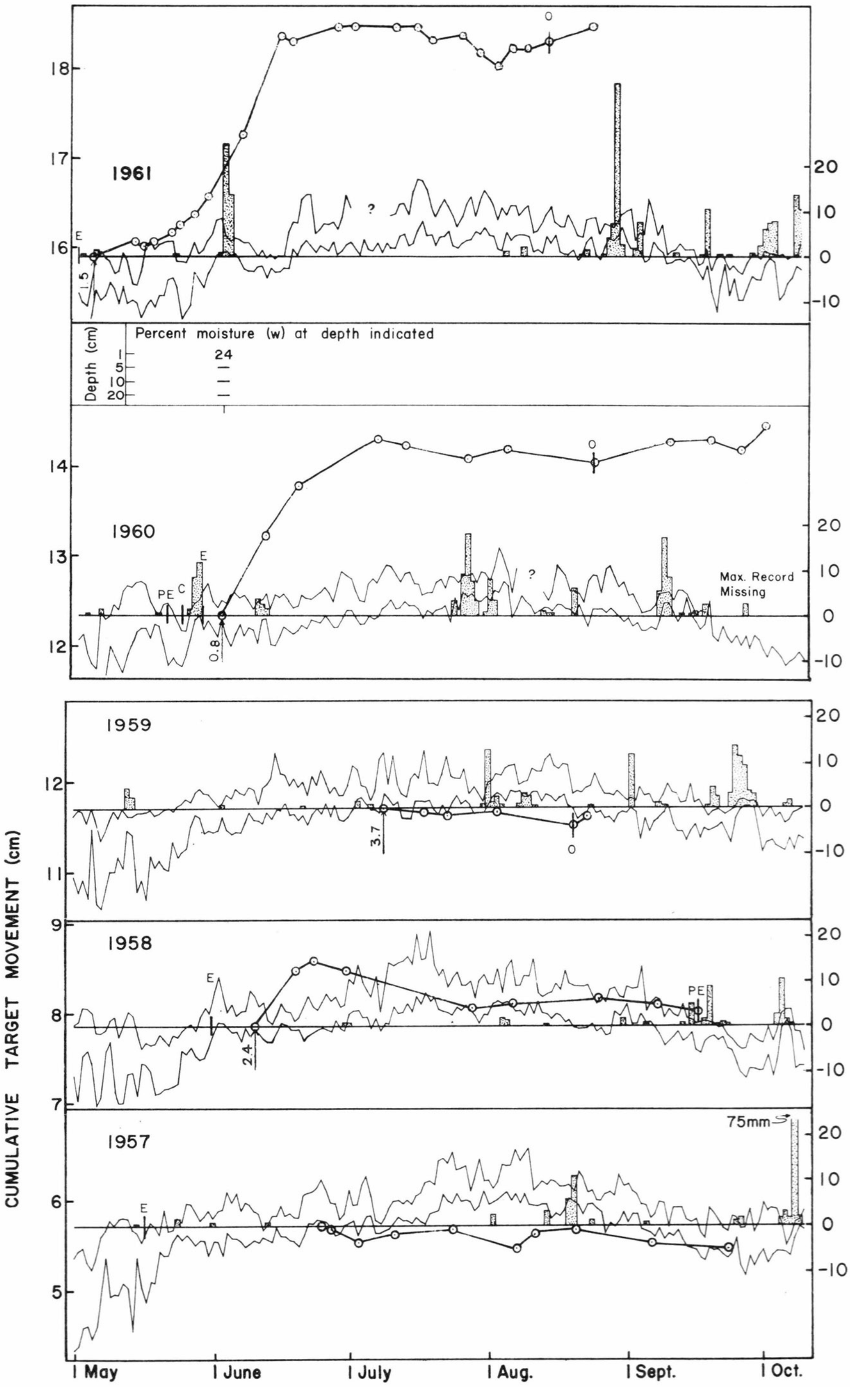

1961
1960
1959
1958
1957
CUMULATIVE TARGET MOVEMENT (cm)
MAX./MIN. TEMPERATURES (°C), PRECIPITATION (mm)
4
3
2
1
20
10
0
-10
PE
0.4
?
O
C
E
-0.2
Max. Record Missing
1.1
D 0.8
75mm
I May
I June
I July
I Aug.
I Sept.
I Oct.
EXPERIMENTAL SITE 8 TARGET 3 (20cm)

Plate C 3–2.



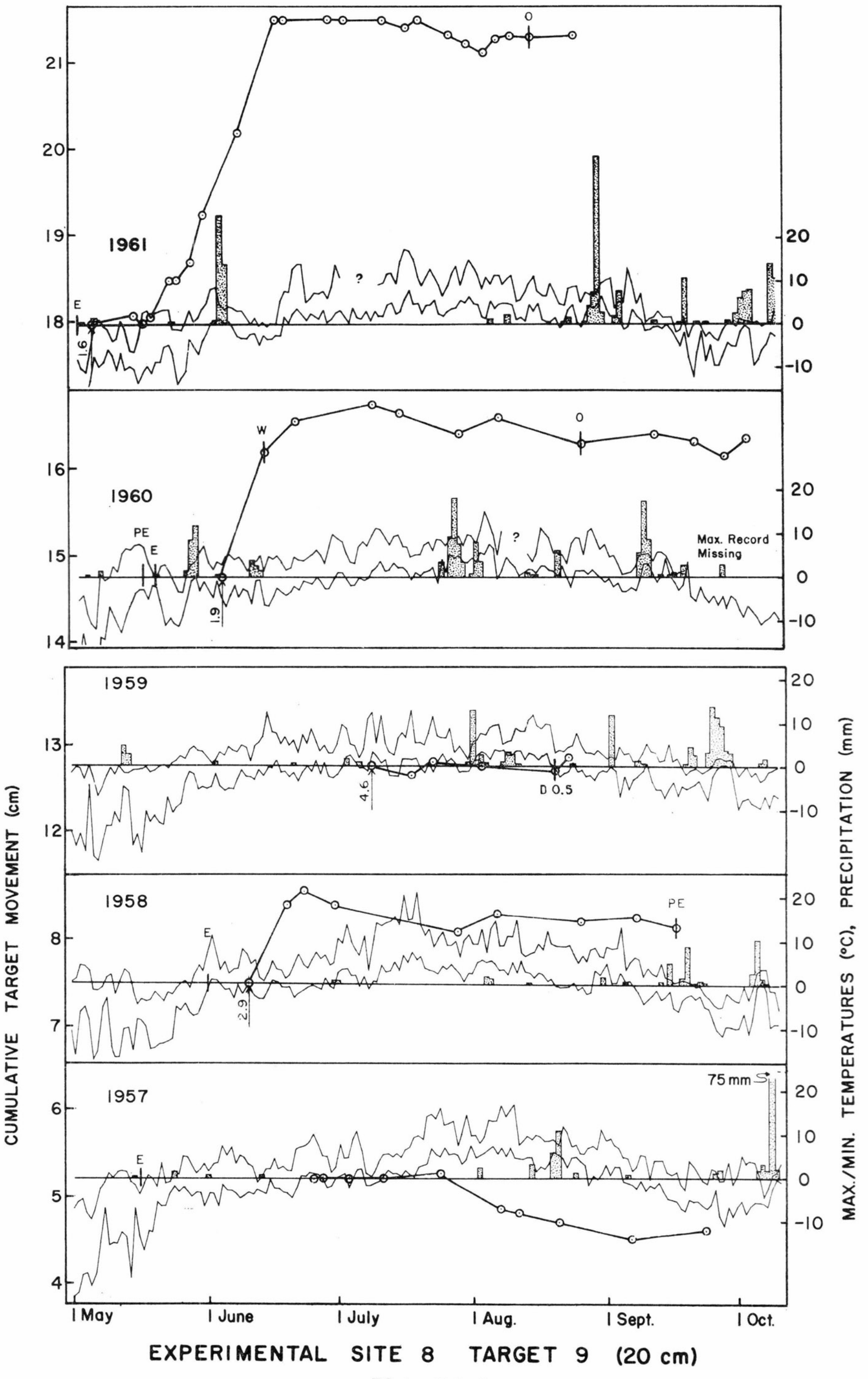
EXPERIMENTAL SITE 8 TARGET 6 (10 cm)

Plate C 3–3.



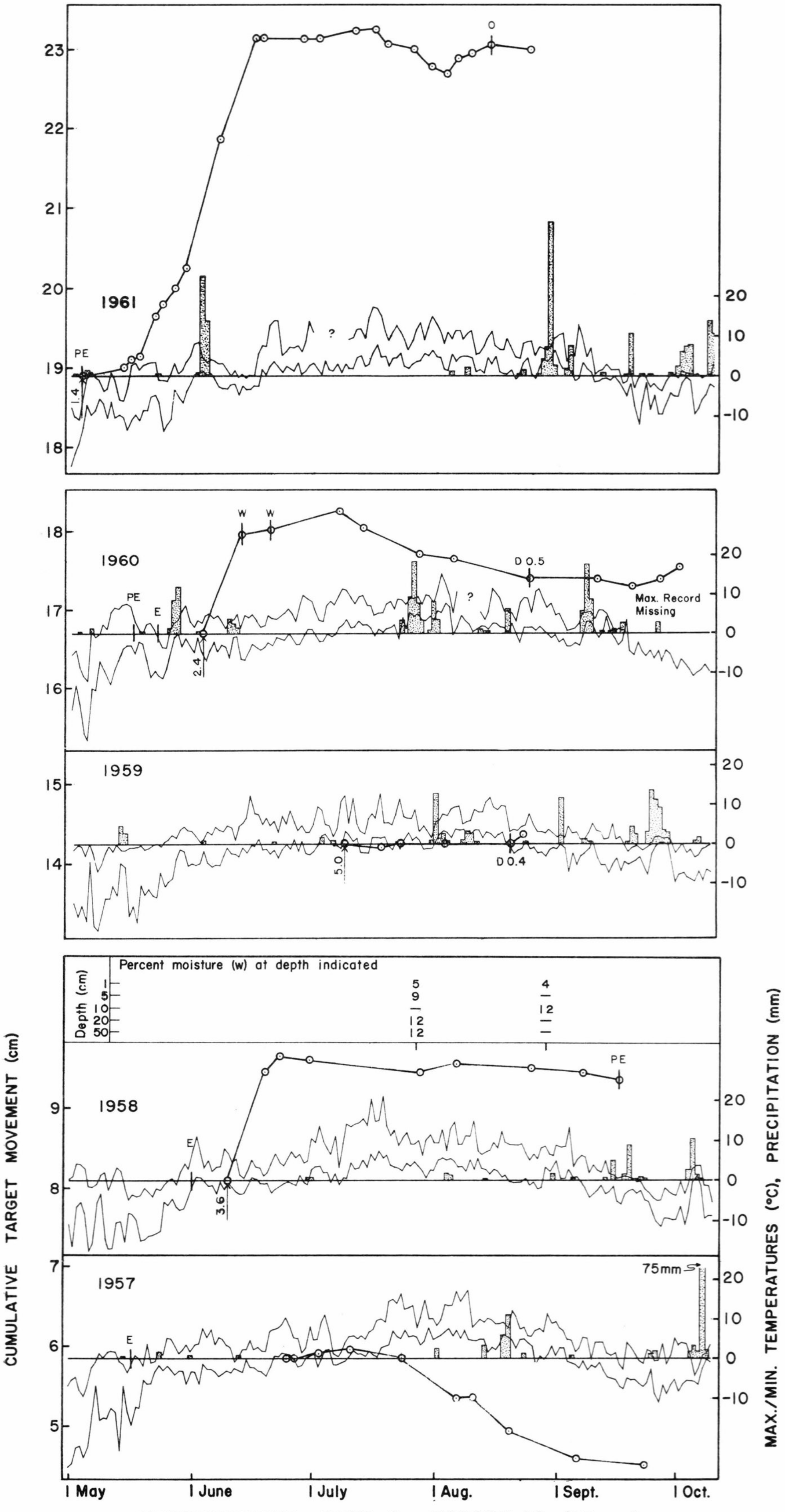
EXPERIMENTAL SITE 8 TARGET 8 (10 cm)

Plate C 3–4.



EXPERIMENTAL SITE 8 TARGET 9 (20 cm)

Plate C 3–5.



EXPERIMENTAL SITE 8 TARGET 10 (10cm)

Plate C 3–6.

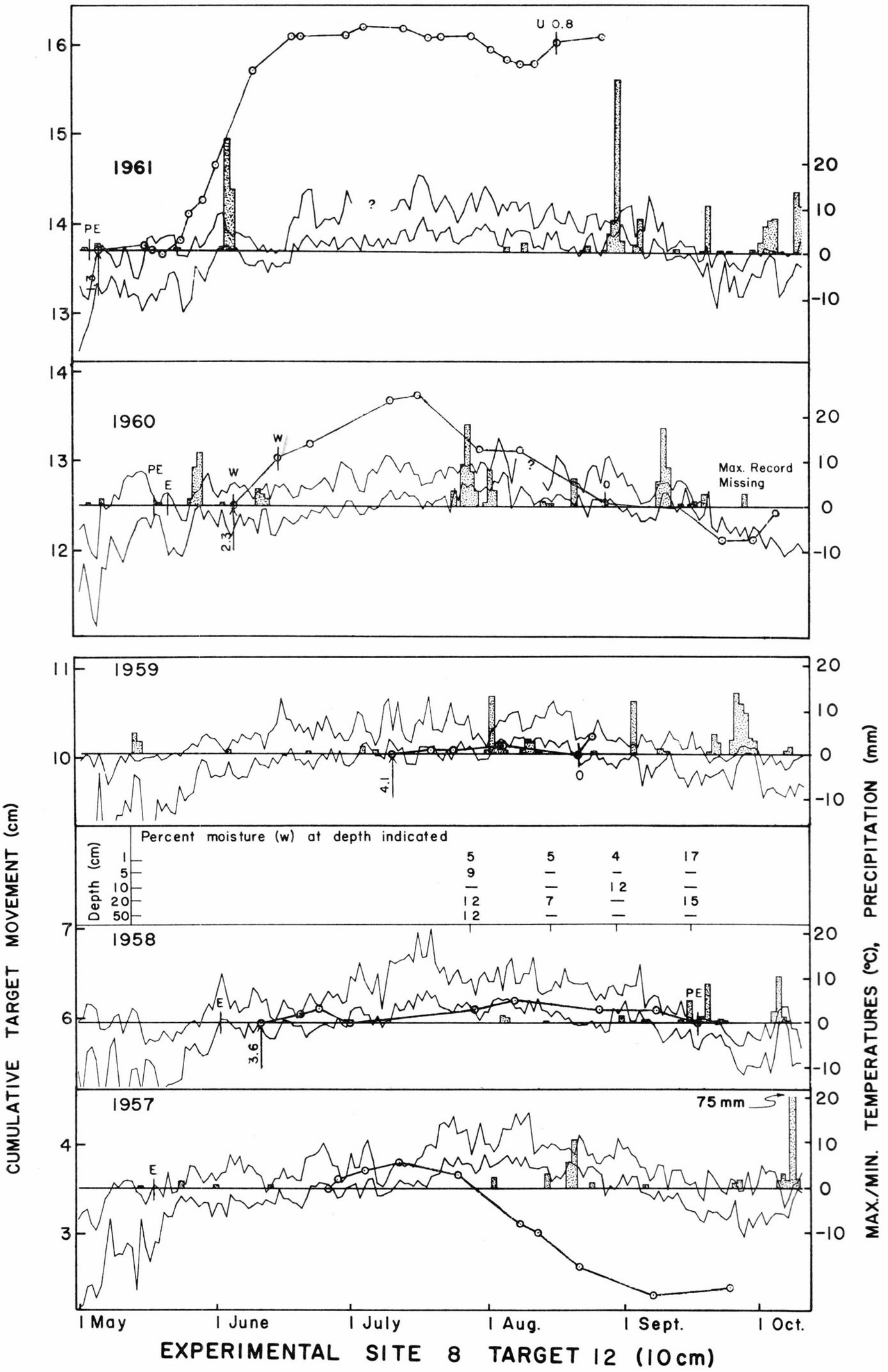
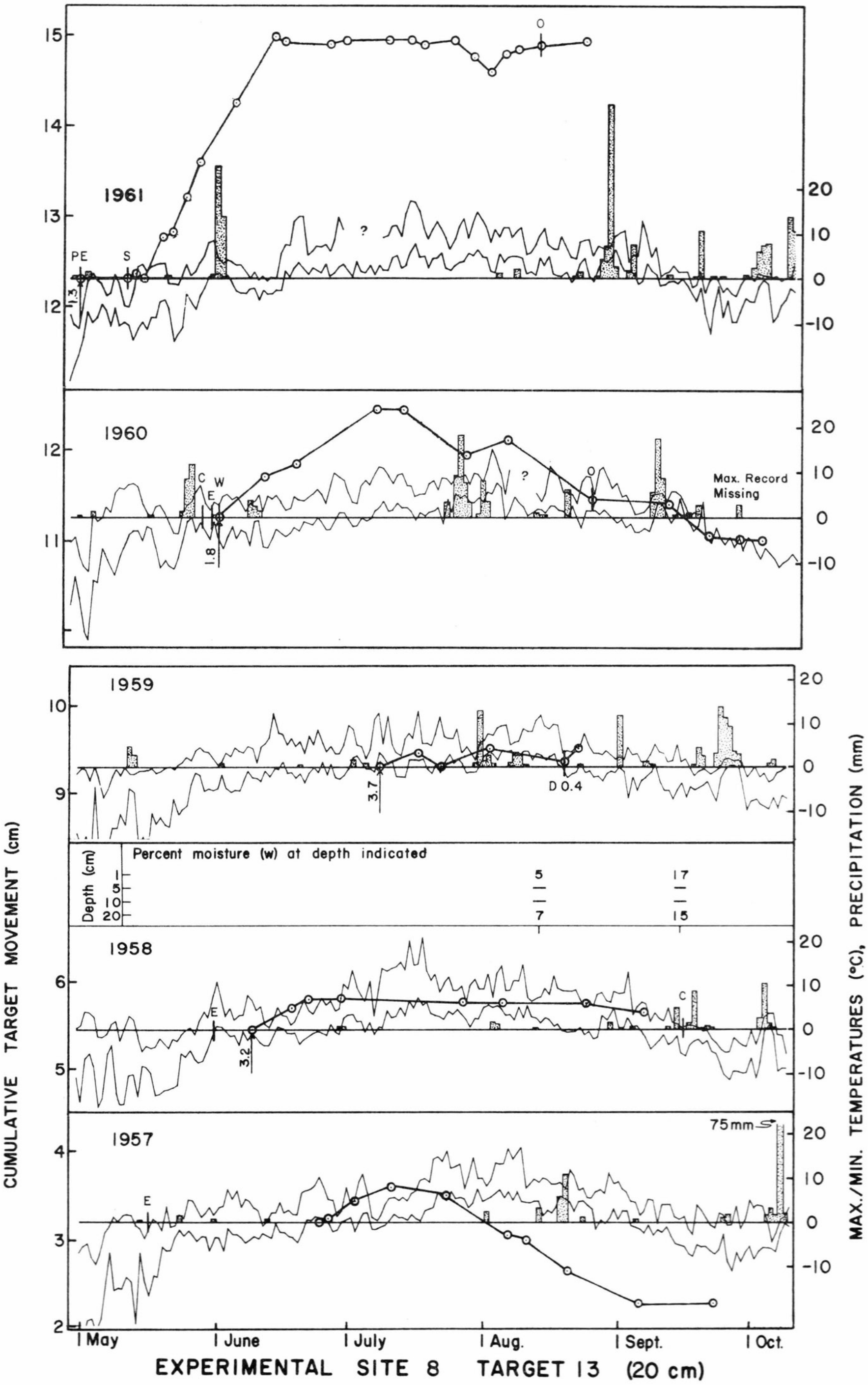

1961
1960
1959
1958
1957
U 0.8
PE
1.3
W
E
2.3
Max. Record Missing
0
?
4.1
Percent moisture (w) at depth indicated
Depth (cm)
1
5
10
20
50
5 9 — 12 12
5 — — 7 —
4 — 12 — —
17 — — 15 —
3.6
75 mm
CUMULATIVE TARGET MOVEMENT (cm)
MAX./MIN. TEMPERATURES (°C), PRECIPITATION (mm)
16
15
14
13
12
11
10
7
6
4
3
20
10
0
-10
1 May
1 June
1 July
1 Aug.
1 Sept.
1 Oct.
EXPERIMENTAL SITE 8 TARGET 12 (10cm)

Plate C 3–7.



EXPERIMENTAL SITE 8 TARGET 13 (20 cm)

Plate C 3–8.

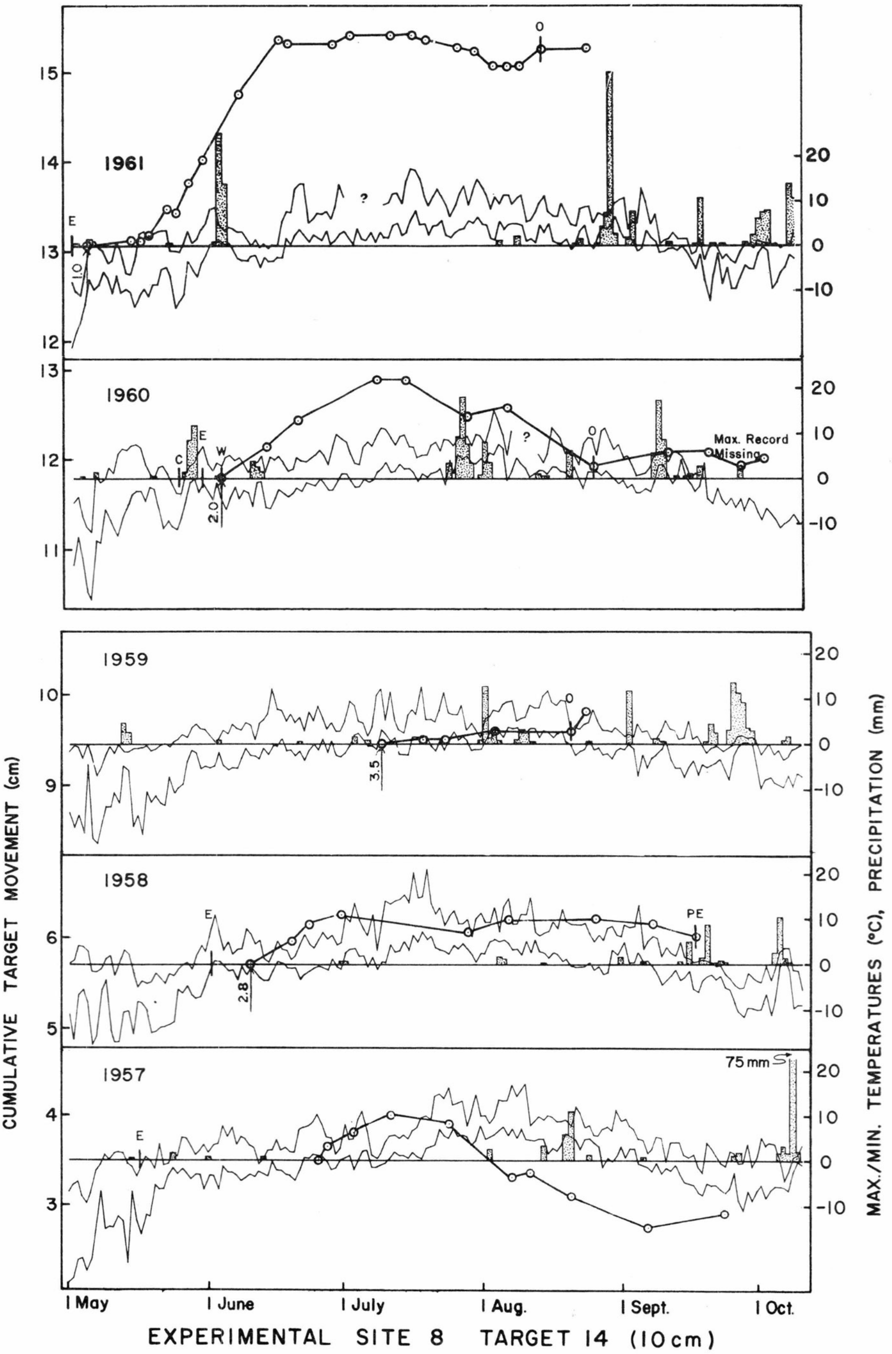
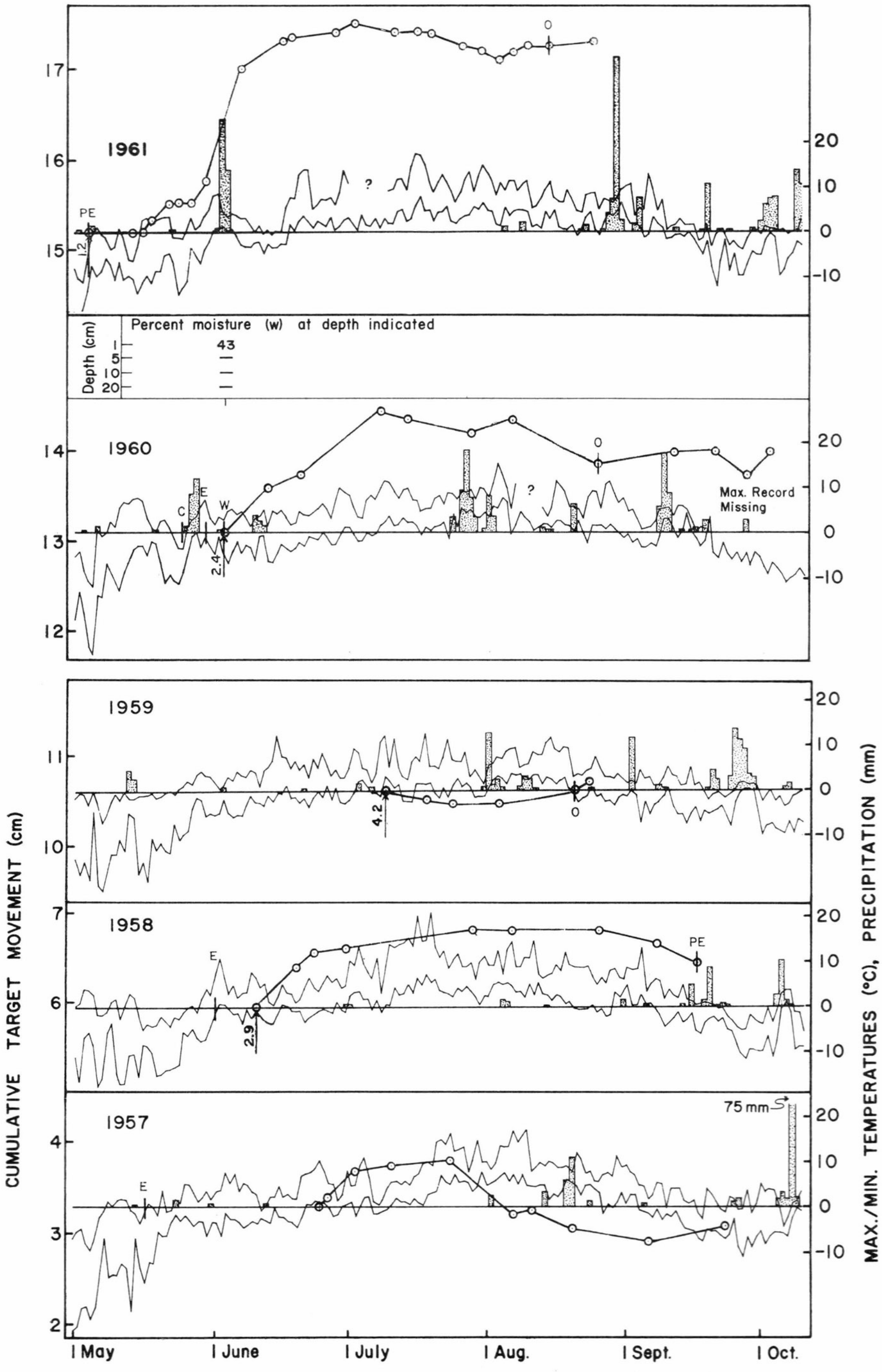
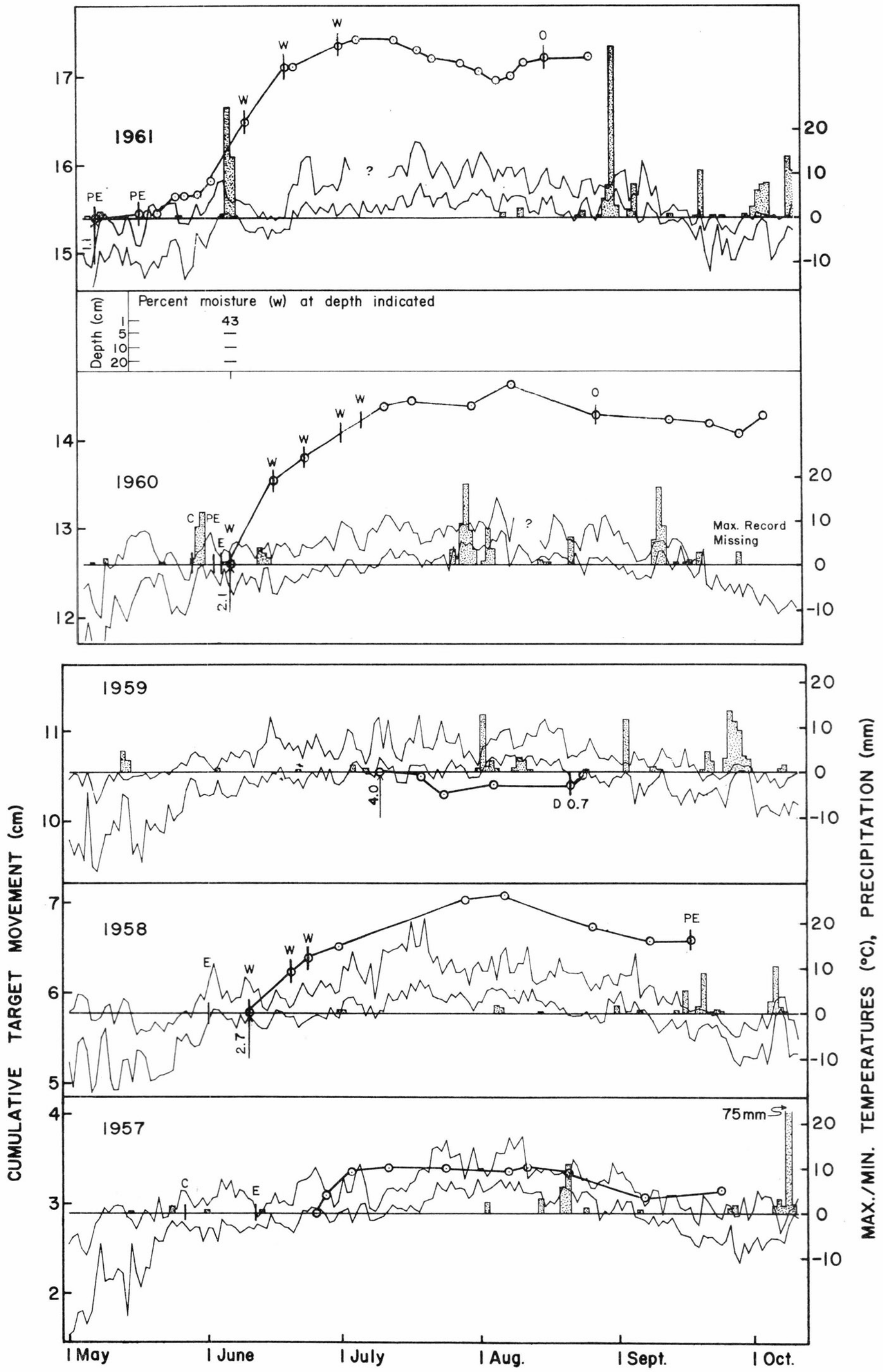

1961
1960
1959
1958
1957
E
1.0
?
O
C
E
W
2.0
Max. Record Missing
3.5
2.8
PE
75 mm
15
14
13
12
11
10
9
6
5
4
3
20
10
0
-10
CUMULATIVE TARGET MOVEMENT (cm)
MAX./MIN. TEMPERATURES (°C), PRECIPITATION (mm)
1 May
1 June
1 July
1 Aug.
1 Sept.
1 Oct.
EXPERIMENTAL SITE 8 TARGET 14 (10 cm)

Plate C 3–9.



EXPERIMENTAL SITE 8 TARGET 15 (20 cm)

Plate C 3–10.



EXPERIMENTAL SITE 8 TARGET 17 (20 cm)

Plate C 3–11.

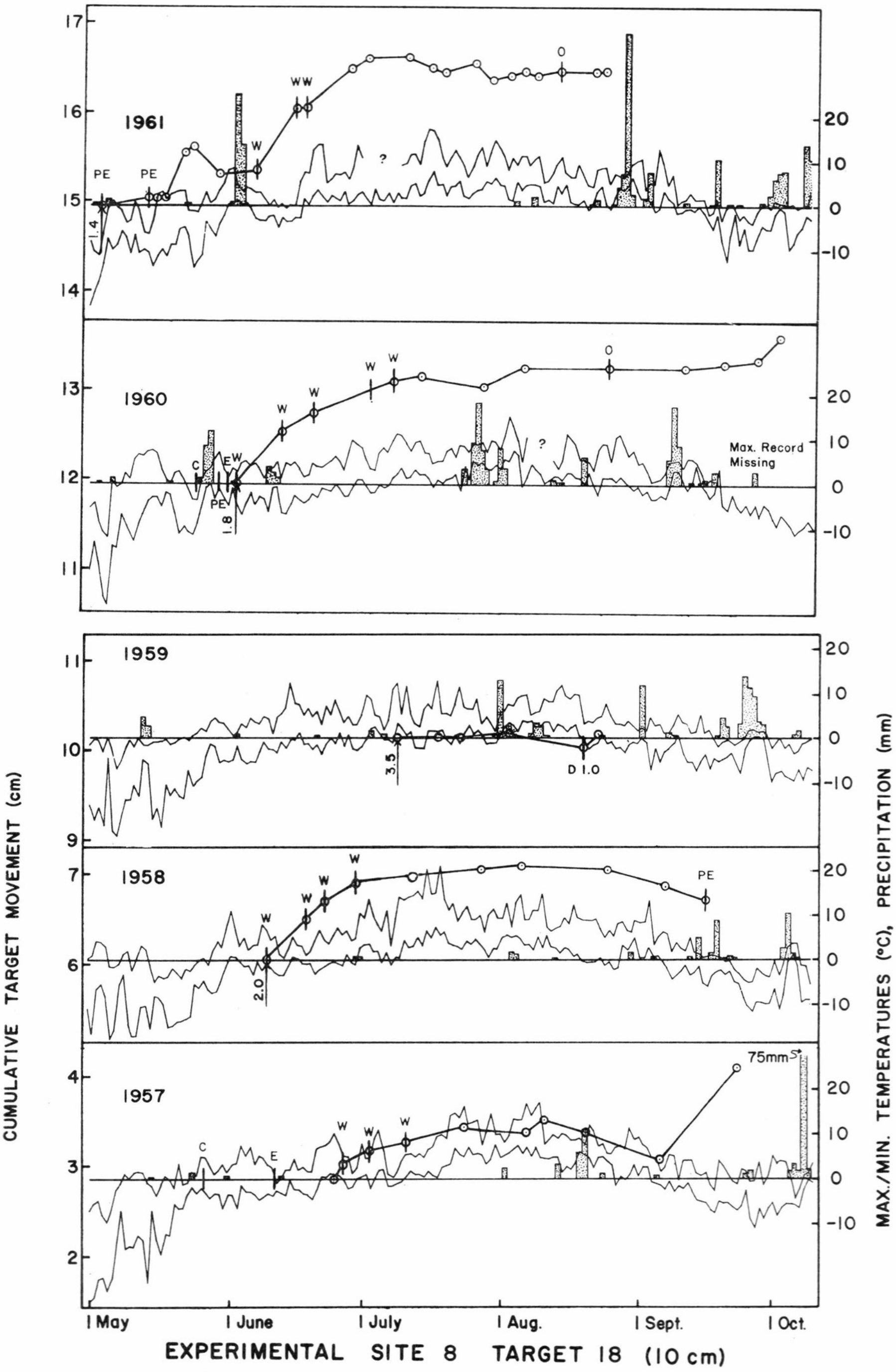
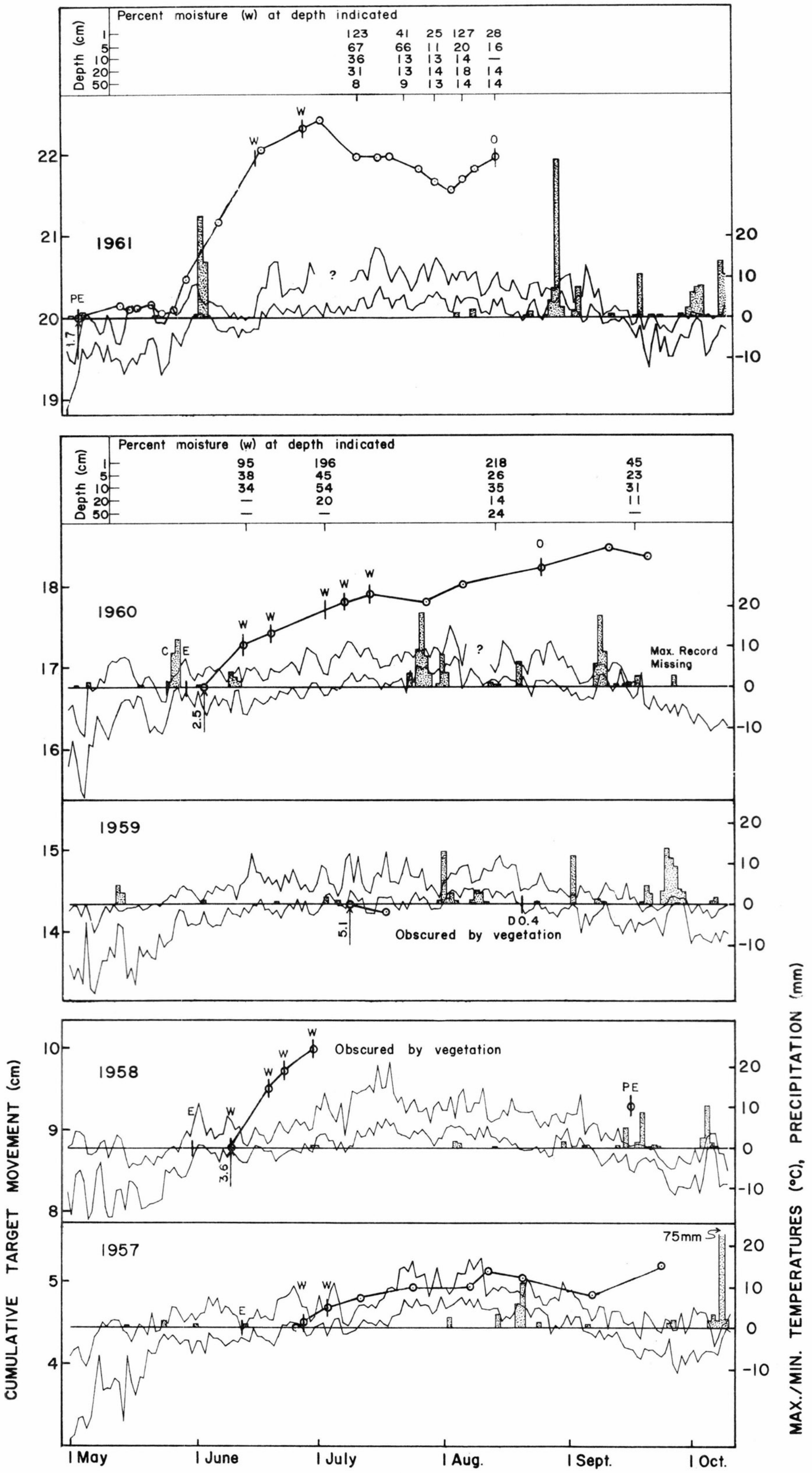
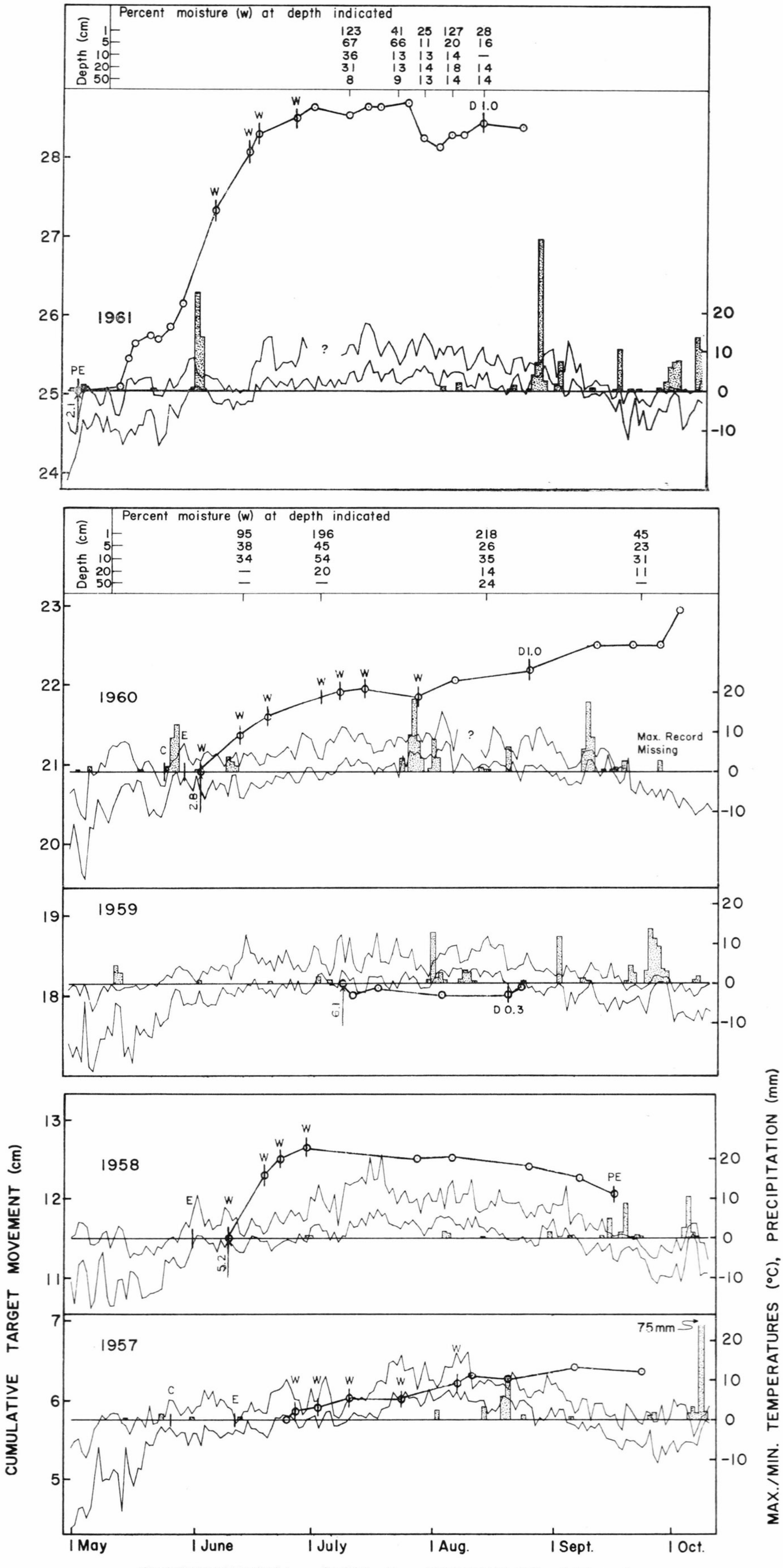

1961
1960
1959
1958
1957
PE
W
WW
O
C
E
D 1.0
1.4
1.8
2.0
3.5
?
Max. Record Missing
75mm S+
CUMULATIVE TARGET MOVEMENT (cm)
MAX./MIN. TEMPERATURES (°C), PRECIPITATION (mm)
17
16
15
14
13
12
11
10
9
7
6
4
3
2
20
10
0
-10
1 May
1 June
1 July
1 Aug.
1 Sept.
1 Oct.
EXPERIMENTAL SITE 8 TARGET 18 (10 cm)

Plate C 3–12.



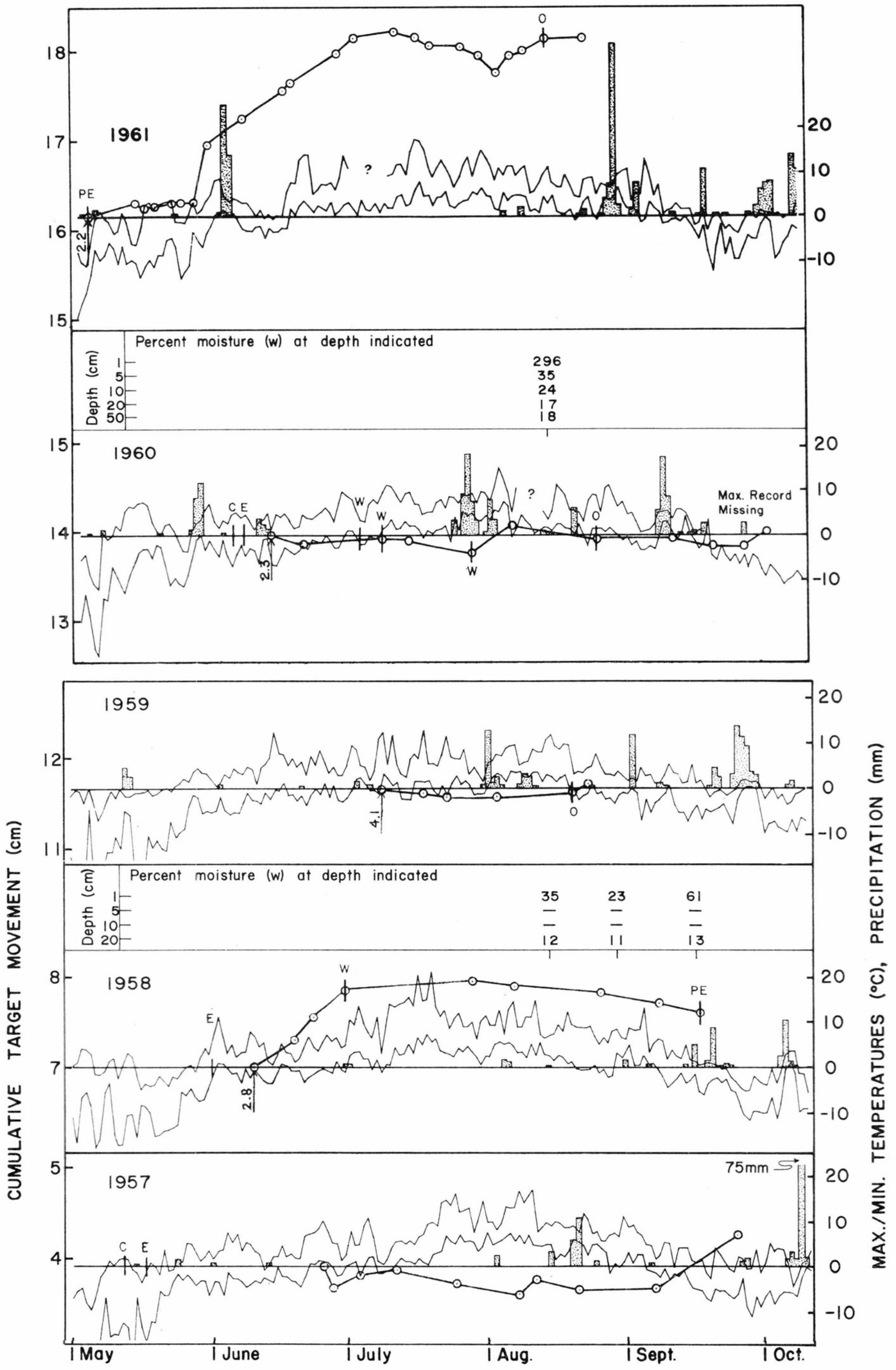
EXPERIMENTAL SITE 8 TARGET 19 (10 cm)

Plate C 3–13.



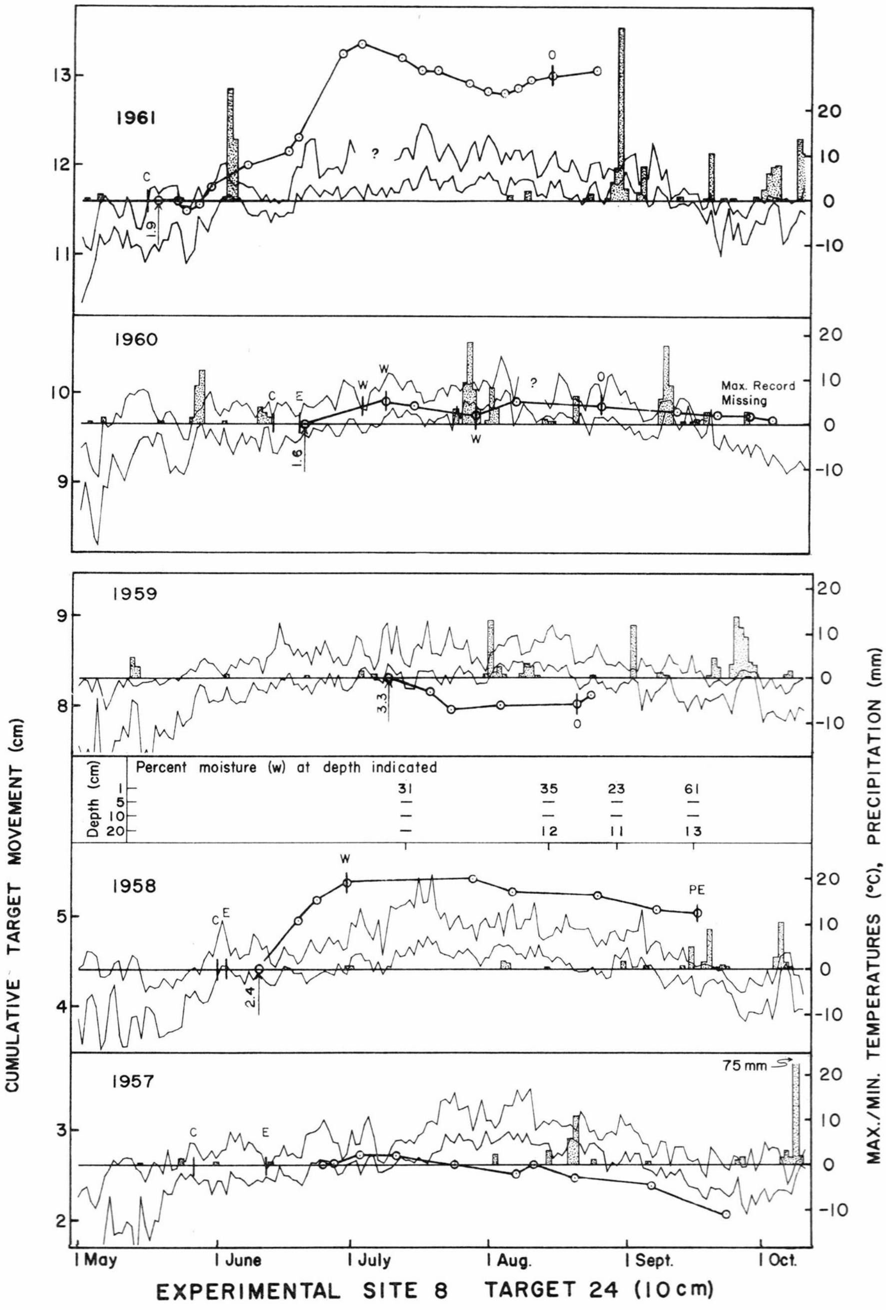
EXPERIMENTAL SITE 8 TARGET 20 (10 cm)

Plate C 3–14.



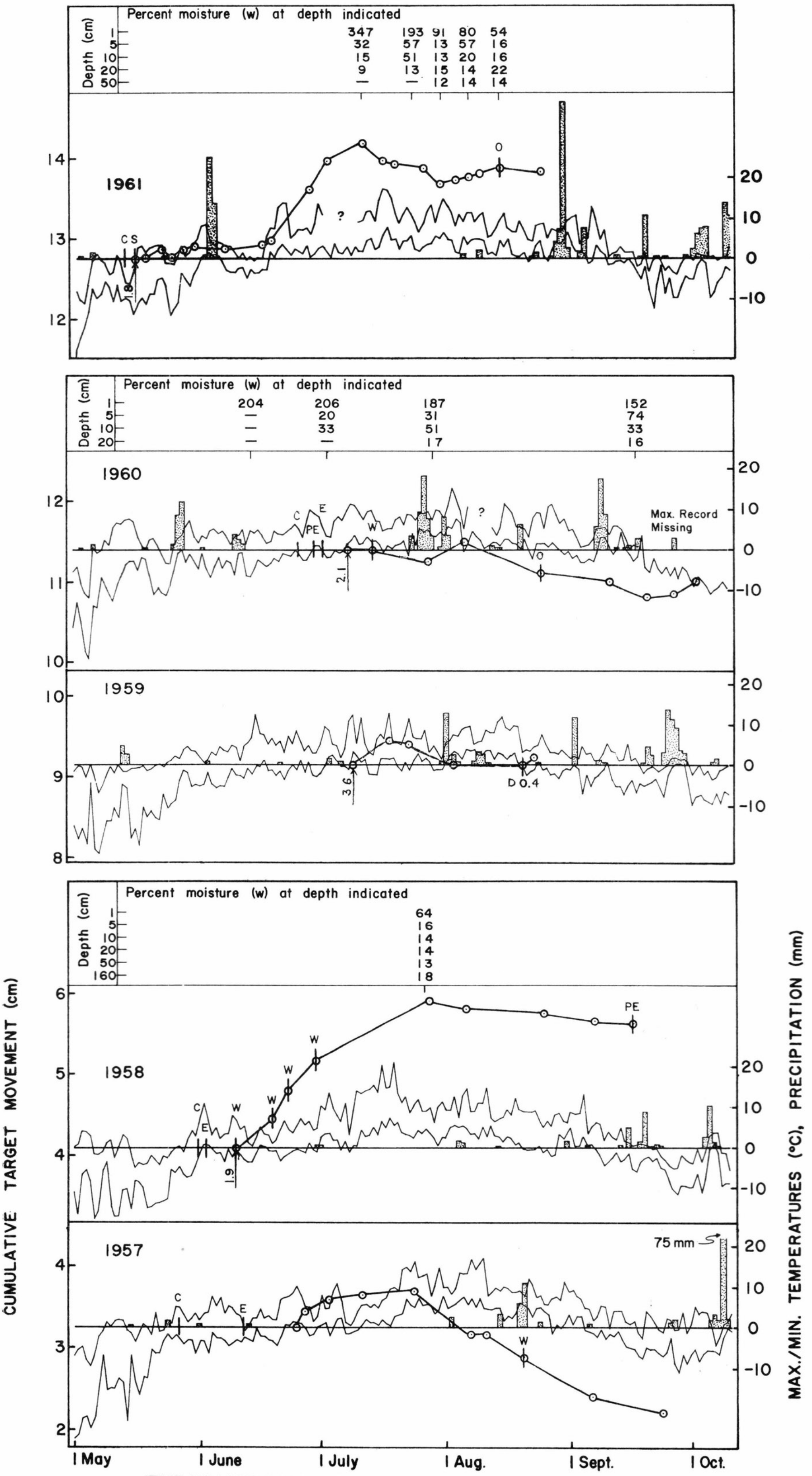
EXPERIMENTAL SITE 8 TARGET 23 (20cm)

Plate C3–15.



EXPERIMENTAL SITE 8 TARGET 24 (10 cm)

Plate C 3-16.



EXPERIMENTAL SITE 8 TARGET 28 (10 cm)

Plate C 3–17.

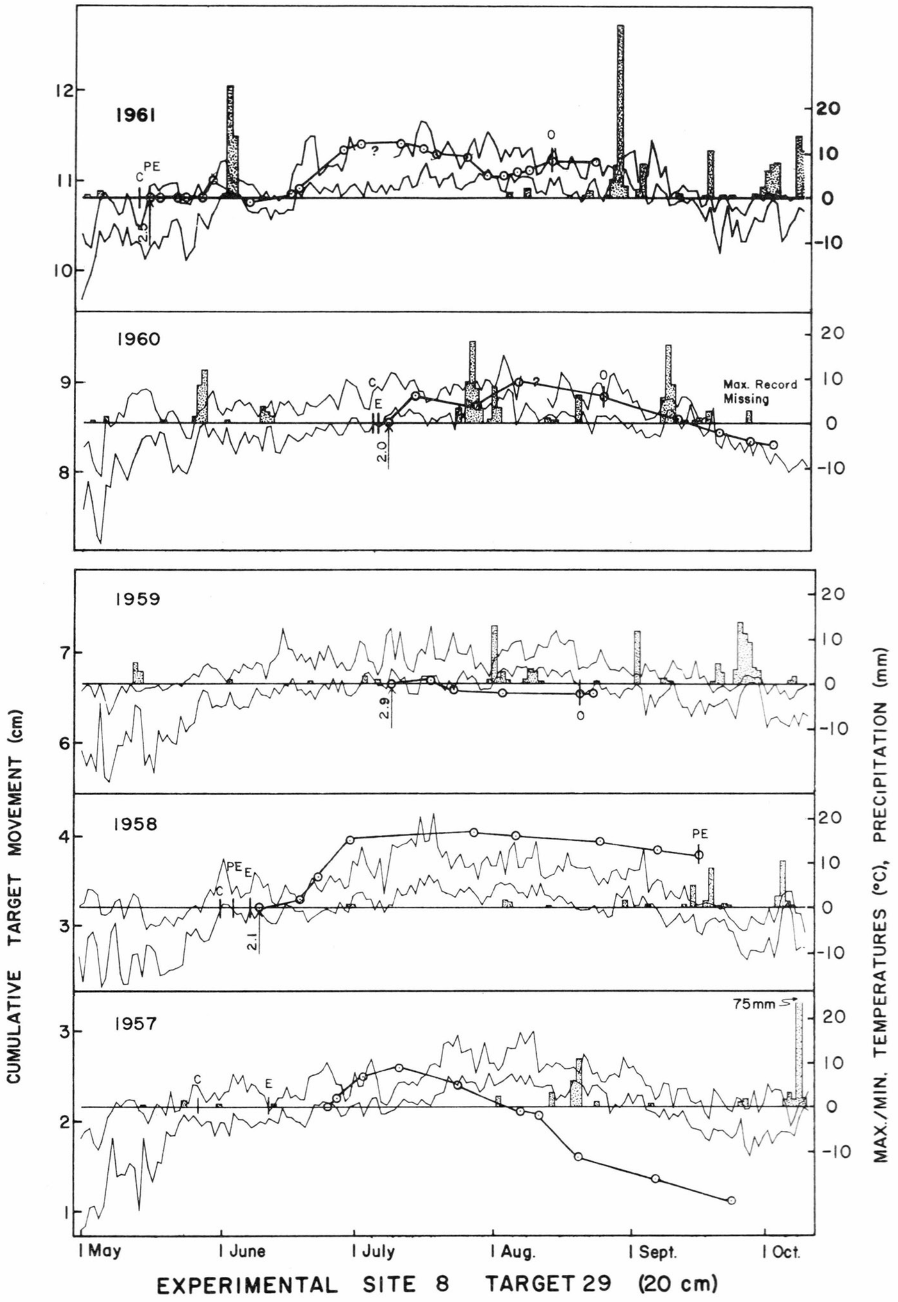
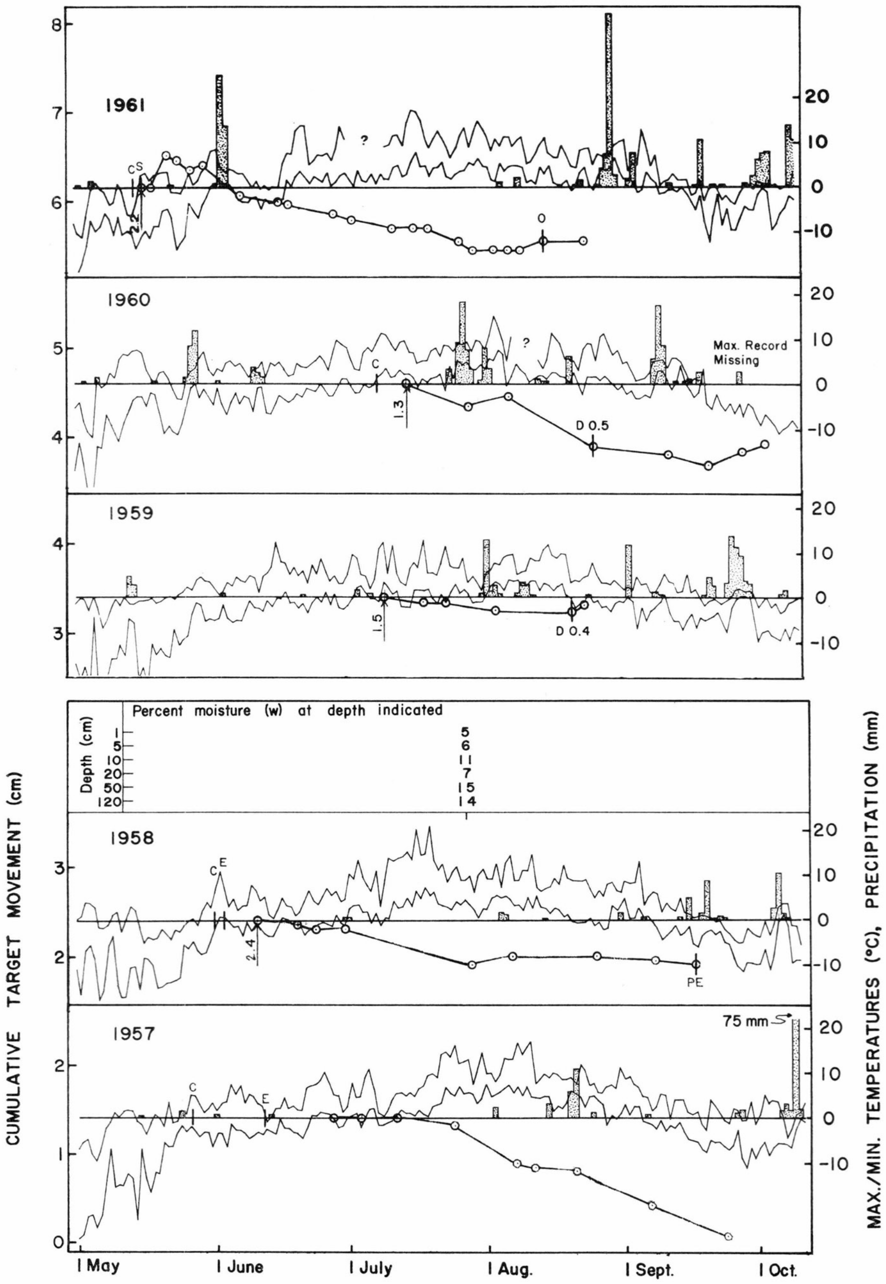

1961
C PE
2.5
?
O
1960
C
E
2.0
?
O
Max. Record Missing
1959
2.9
O
1958
PE E
C
2.1
PE
1957
C
E
75mm
CUMULATIVE TARGET MOVEMENT (cm)
MAX./MIN. TEMPERATURES (°C), PRECIPITATION (mm)
12
11
10
9
8
7
6
4
3
2
1
20
10
0
-10
1 May
1 June
1 July
1 Aug.
1 Sept.
1 Oct.
EXPERIMENTAL SITE 8 TARGET 29 (20 cm)

Plate C 3–18.



EXPERIMENTAL SITE 8 TARGET 31 (20 cm)

Plate C 3–19.

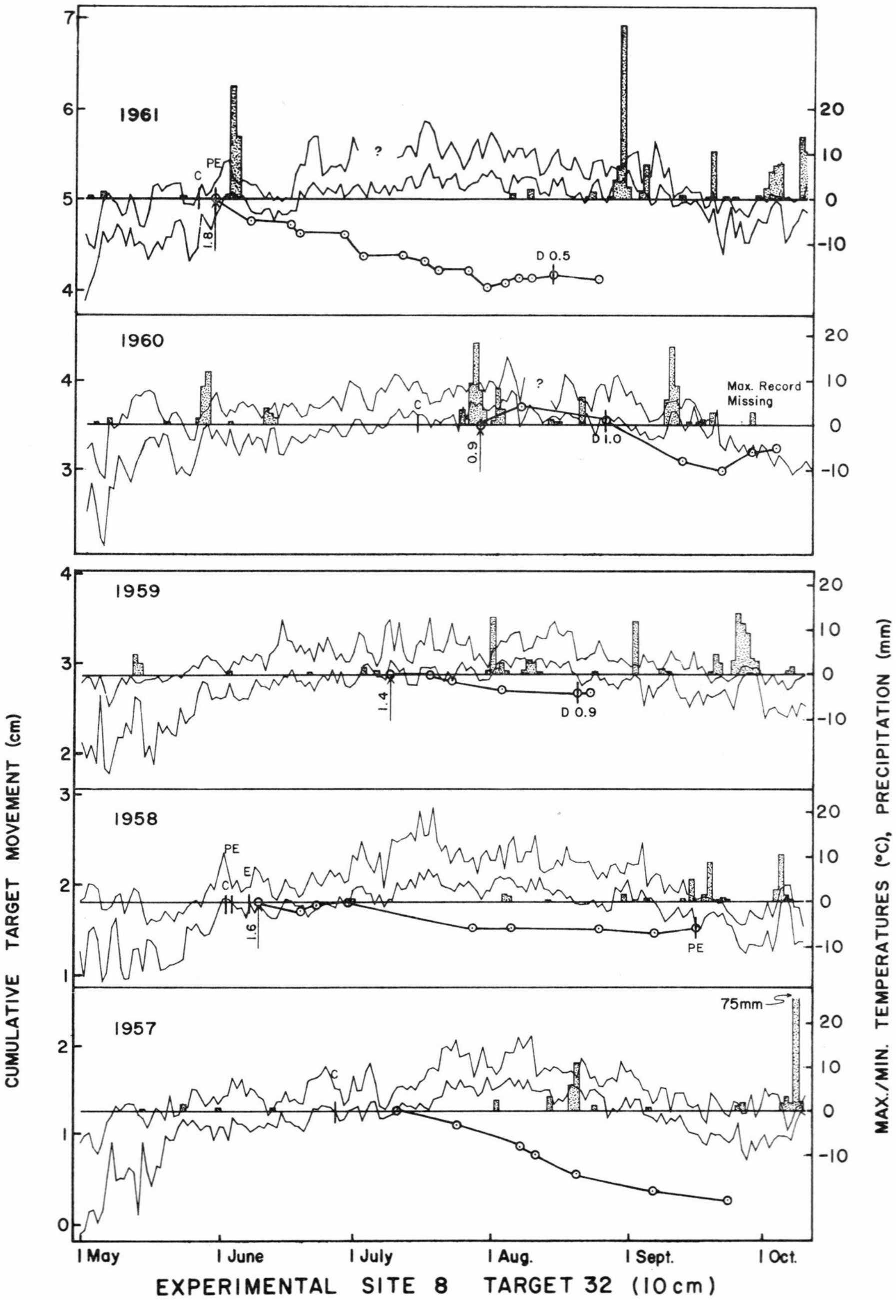
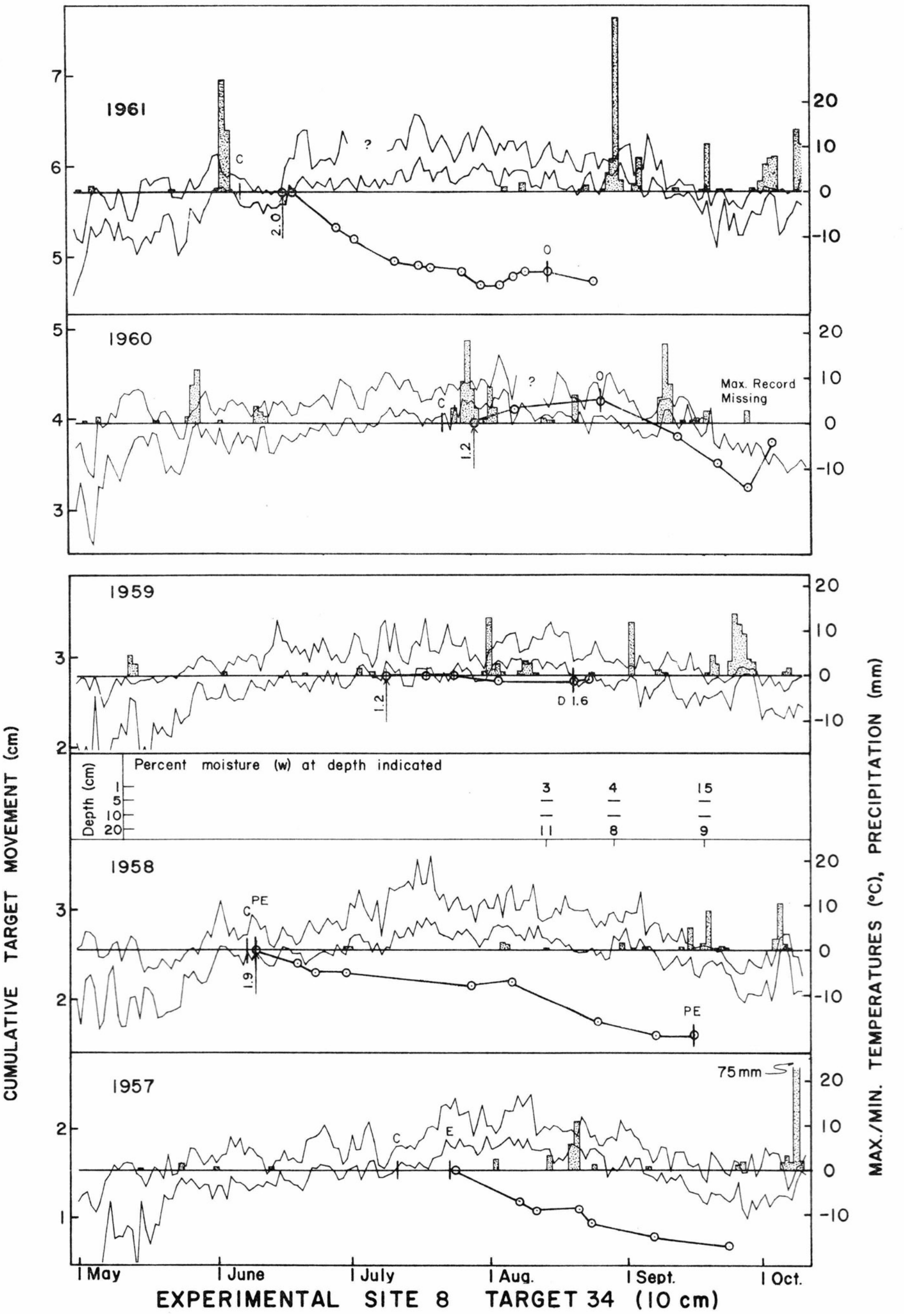

1961
1960
1959
1958
1957
C
PE
E
D 0.5
D 1.0
D 0.9
1.8
0.9
1.4
1.6
?
Max. Record Missing
75mm
CUMULATIVE TARGET MOVEMENT (cm)
MAX./MIN. TEMPERATURES (°C), PRECIPITATION (mm)
7
6
5
4
3
2
1
0
20
10
0
-10
I May
I June
I July
I Aug.
I Sept.
I Oct.
EXPERIMENTAL SITE 8 TARGET 32 (10 cm)

Plate C 3–20.



EXPERIMENTAL SITE 8 TARGET 34 (10 cm)

Plate C 3–21.

APPENDIX D.

GRAIN-SIZE AND RELATED ANALYSIES

CONTENTS

General

The grain-size and Atterberg-limit analyses were made in part by Mr. JAMES ALLISON at the Thayer Scool of Engineering at Dartmouth College in part by Mr. JOSEPH KRAVITZ and assistants, under the supervision of Dr. JOHN SANDERS, at the Sedimentology Laboratory of the Department of Geology at Yale University, and later by Mr. TIMOTHY

LaFarge, Mr. Christopher Reichert, and Mr. Henry Froehlich. At Dartmouth the method involved sieving and hydrometer analysis, at Yale, separation of sand from smaller sizes by a rising-water current elutriator, and then pipette analysis of the silt and clay sizes. In view of the different procedures, most of the analyses by the first method were checked against the second to assure comparable data. It was found that the elutriator and pipette techniques gave an average increase of about 5 percent in the fines, and grain comparisons under the microscope showed that the reason lay in the tendency for silt and clay sizes to cling to larger particles in spite of routine washing during sieving. Therefore, the analyses reported in the following tables and grain-size curves are those corresponding to elutriation (or thorough washing when the elutriator became inoperative) and pipetting. The nomenclature of the sediments follows Washburn, Sanders, and Flint (1963).

The specific-gravity analyses were made by Mr. Allison. They show a tendency for the lowest values to be nearest the ground surface, probably mainly because of organic matter. However, there is the possibility of sorting effects related to specific gravity, perhaps indirectly through particle size and shape of different soil particles (Corte, 1962, 1963a, 1963b). The relatively high specific gravities at ES 16 as compared with the other experimental sites probably reflects both the absence of vegetation and the dominance of trap particles at ES 16.

The *in-situ* density determinations were made by John Scully at the school of Civil Engineering at Purdue University. The collecting method involved driving a pipe into the ground, so that the determinations are subject to any errors resulting from compaction. Consequently the results represent maximum *in-situ* values only. The increase in density with depth, shown by the results, may reflect such errors, although natural compaction is presumably also involved.

The summary tables of grain-size analyses give all analyses relating to the mass-wasting experimental sites. Specimens from along the target lines were taken after the lines were discontinued. The other specimens, which were collected and analysed earlier in the program, are for the most part less pertinent but are included as supplementary data. The grain-size curves are confined to the target-line specimens. In the corresponding triangular diagrams (Pls. D2, D6–D7), gravel sizes are omitted and the sand, silt, and clay-size percentages are readjusted accordingly.

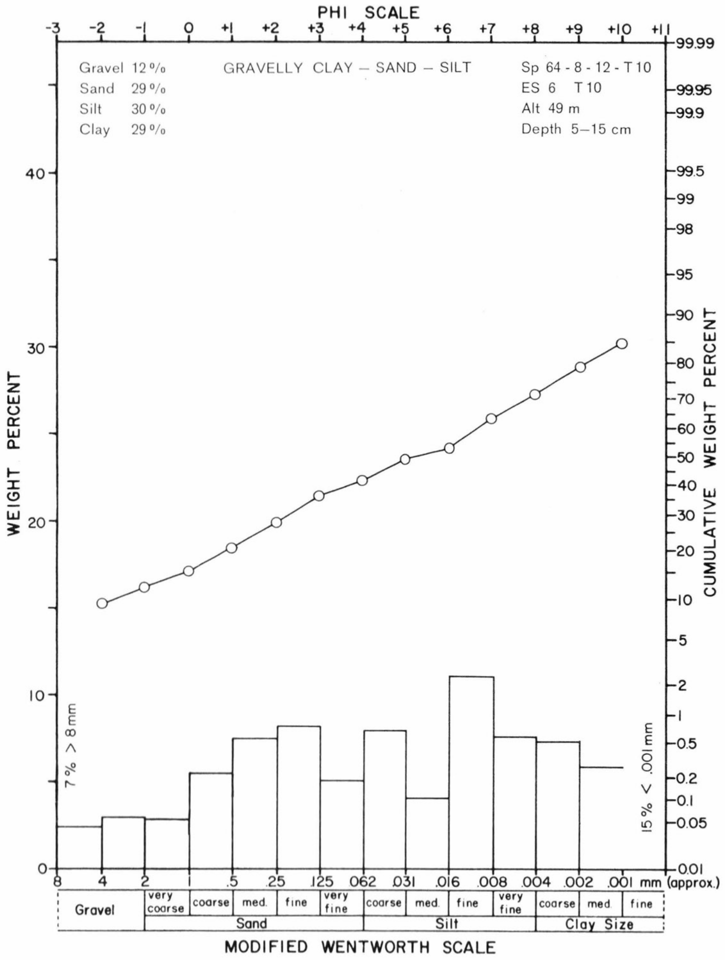


Plate D 1–1.

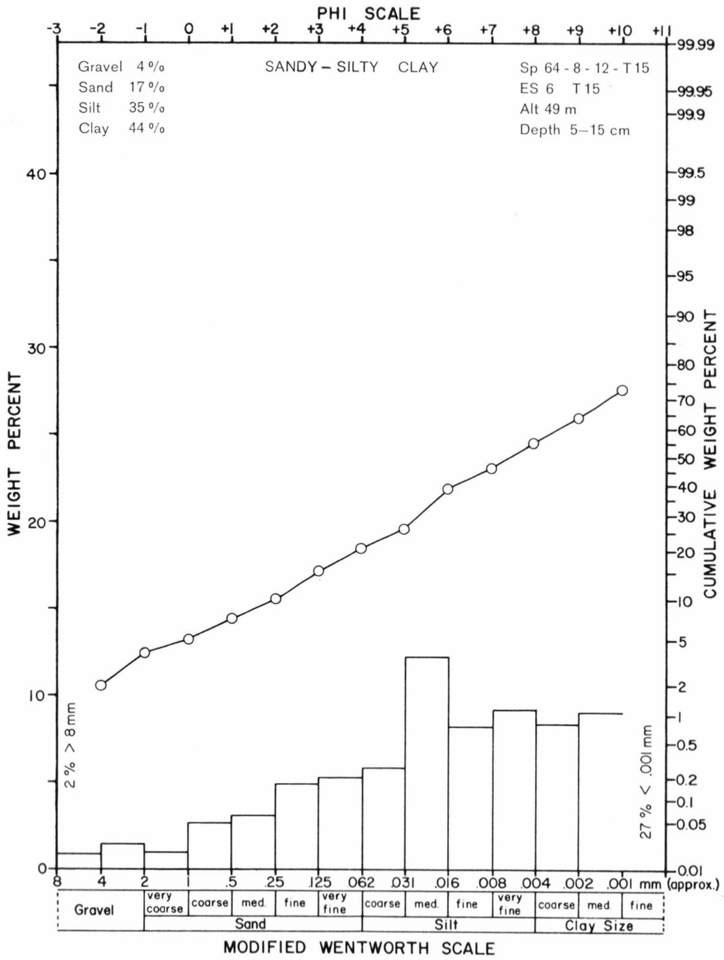


Plate D 1–2.

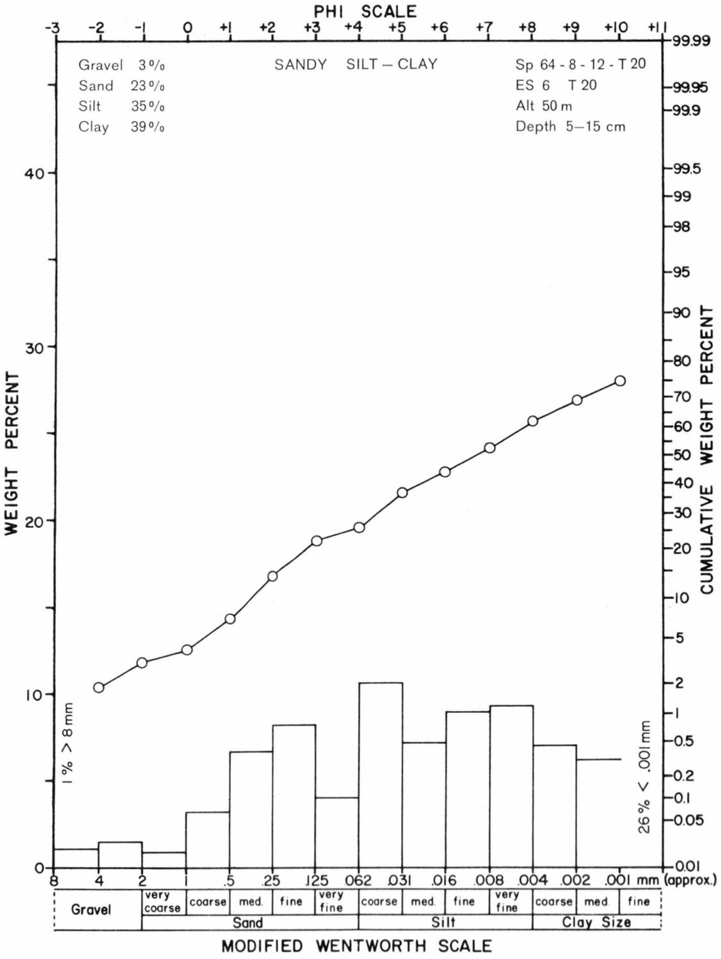


Plate D 1–3.

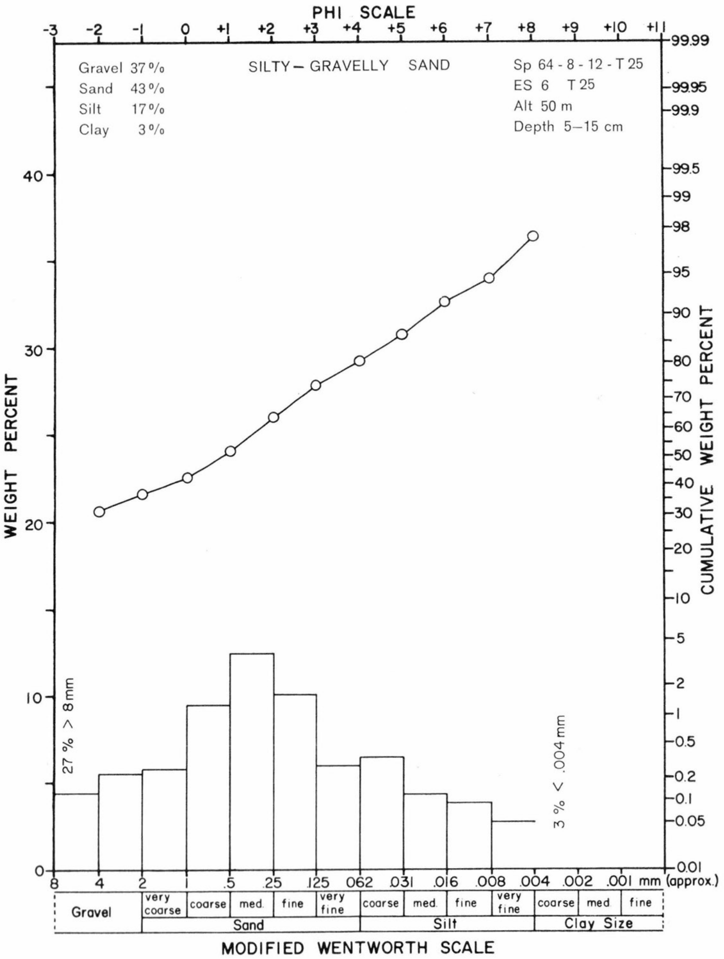


Plate D 1–4.

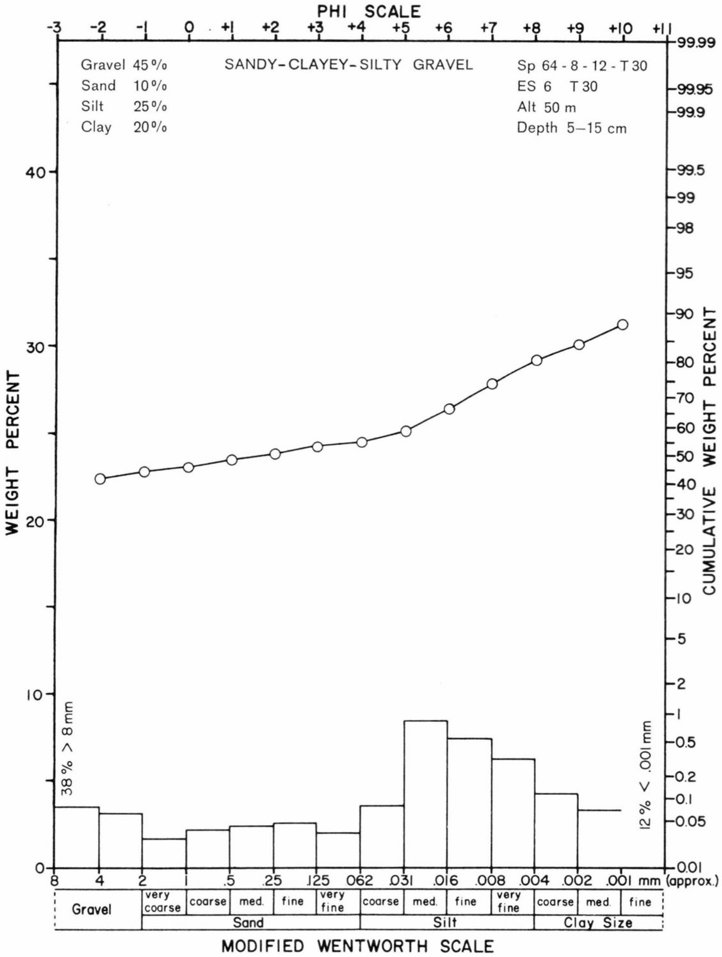

PHI SCALE
-3 -2 -1 0 +1 +2 +3 +4 +5 +6 +7 +8 +9 +10 +11
Gravel 45 %
Sand 10 %
Silt 25 %
Clay 20 %
SANDY-CLAYEY-SILTY GRAVEL
Sp 64 - 8 - 12 - T 30
ES 6 T 30
Alt 50 m
Depth 5–15 cm
WEIGHT PERCENT
0 10 20 30 40
CUMULATIVE WEIGHT PERCENT
99.99 99.95 99.9 99.5 99 98 95 90 80 70 60 50 40 30 20 10 5 2 1 0.5 0.2 0.1 0.05 0.01
38 % > 8 mm
12 % < .001 mm
8 4 2 1 .5 .25 .125 .062 .031 .016 .008 .004 .002 .001 mm (approx.)
Gravel
very coarse
coarse
med.
fine
very fine
Sand
coarse
med.
fine
very fine
Silt
coarse
med.
fine
Clay Size
MODIFIED WENTWORTH SCALE

Plate D 1–5.

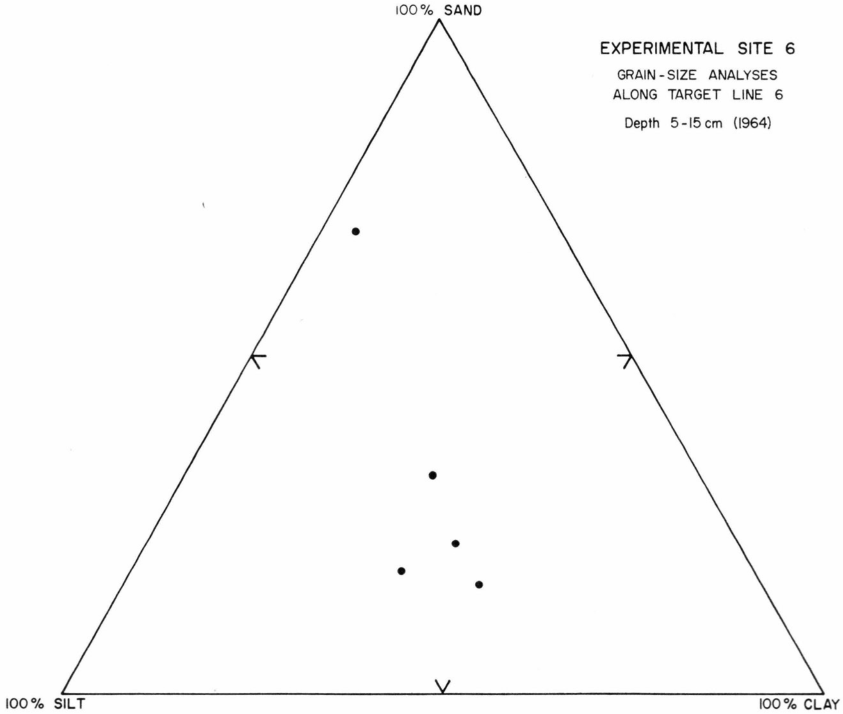

100% SAND
EXPERIMENTAL SITE 6
GRAIN-SIZE ANALYSES
ALONG TARGET LINE 6
Depth 5-15 cm (1964)
100% SILT
100% CLAY

Plate D 2.

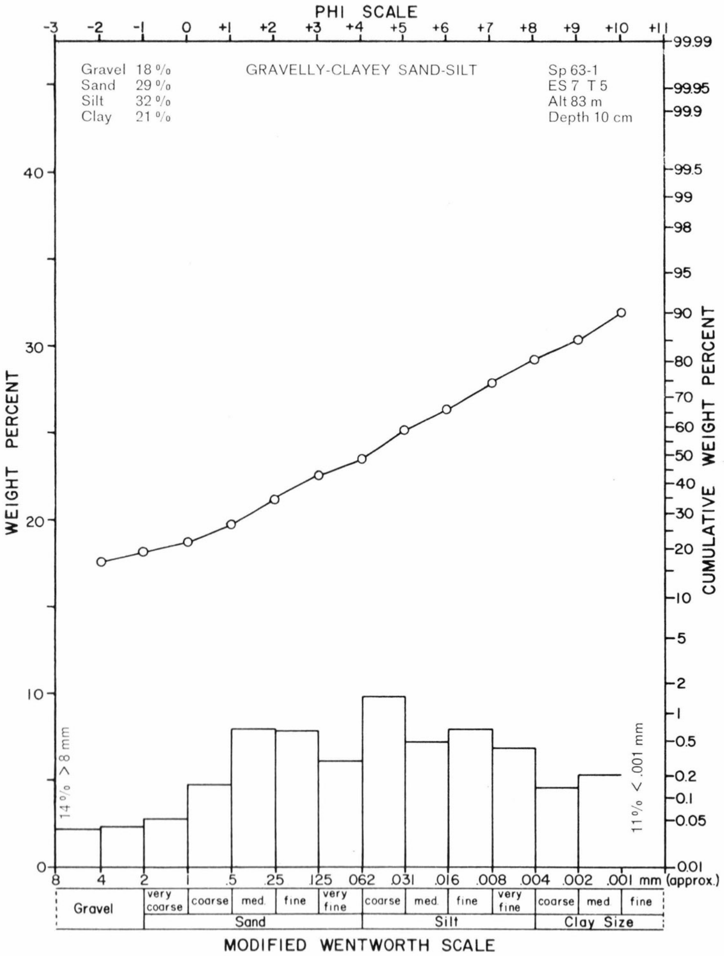


Plate D 3–1.

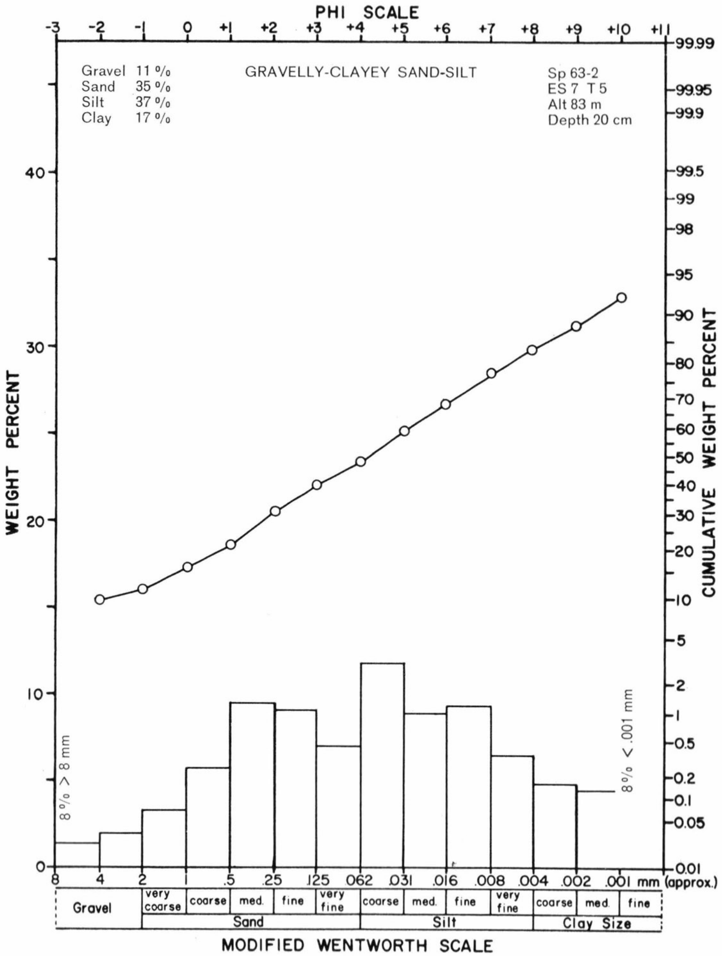


Plate D 3–2.

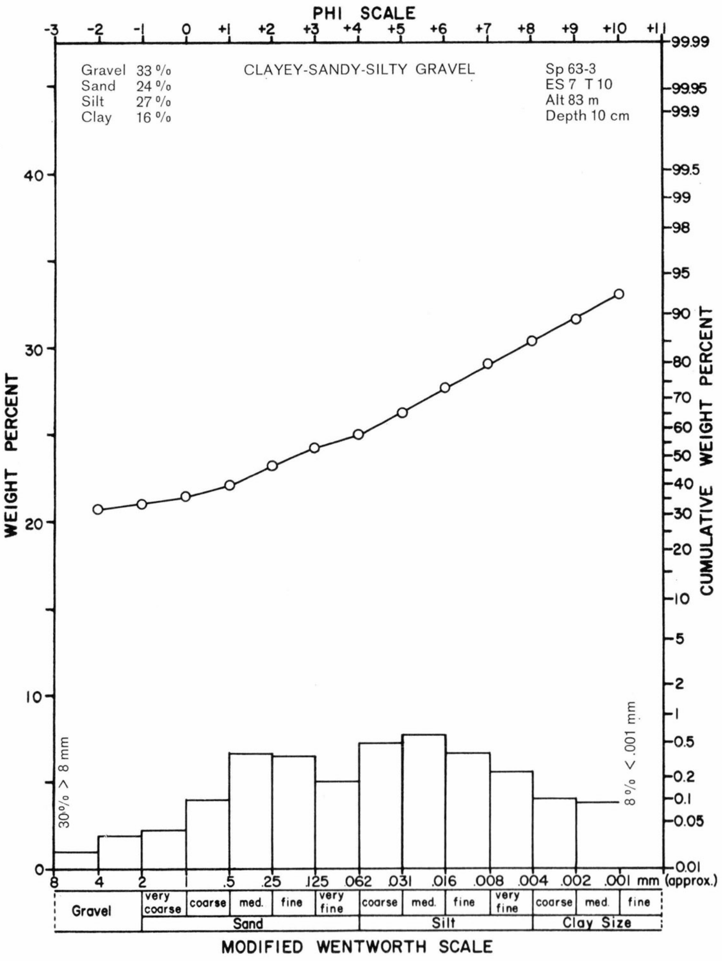


Plate D 3–3.

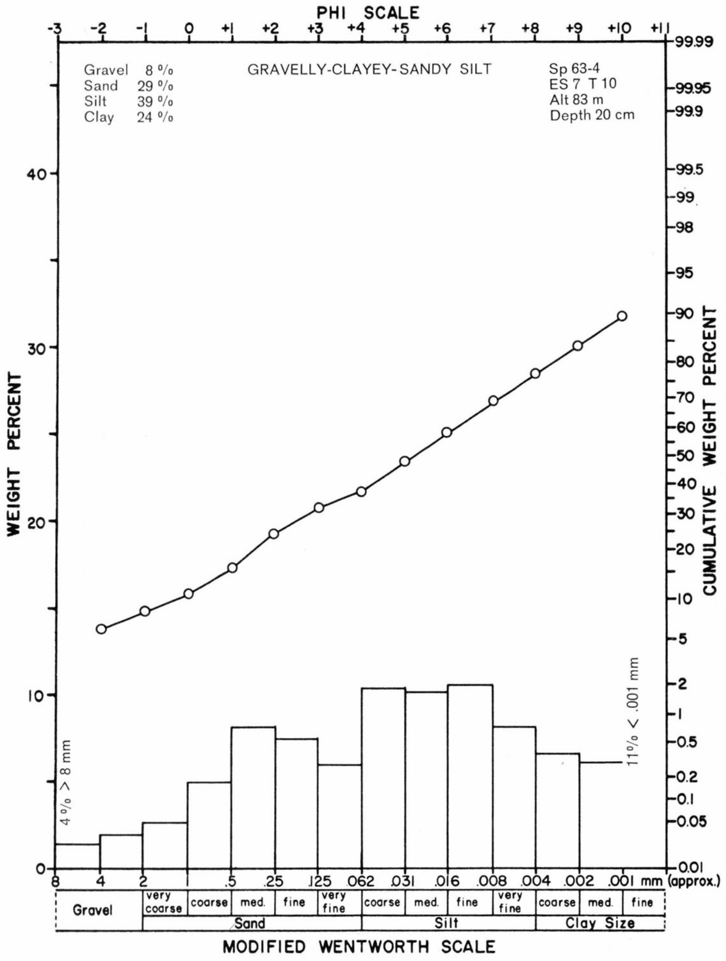


Plate D 3–4.

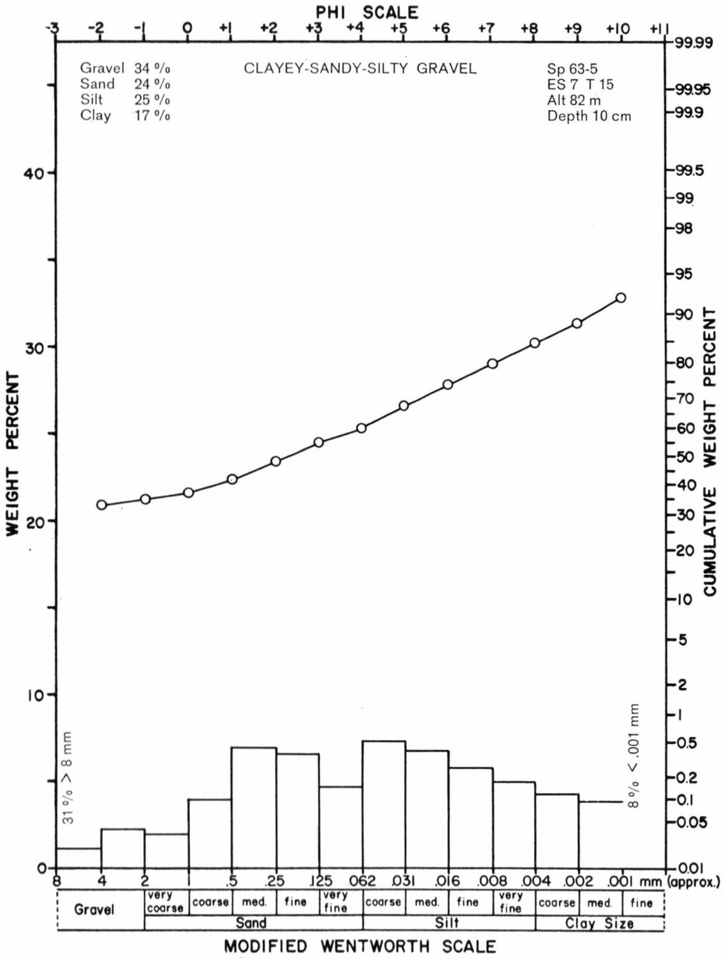


Plate D 3–5.

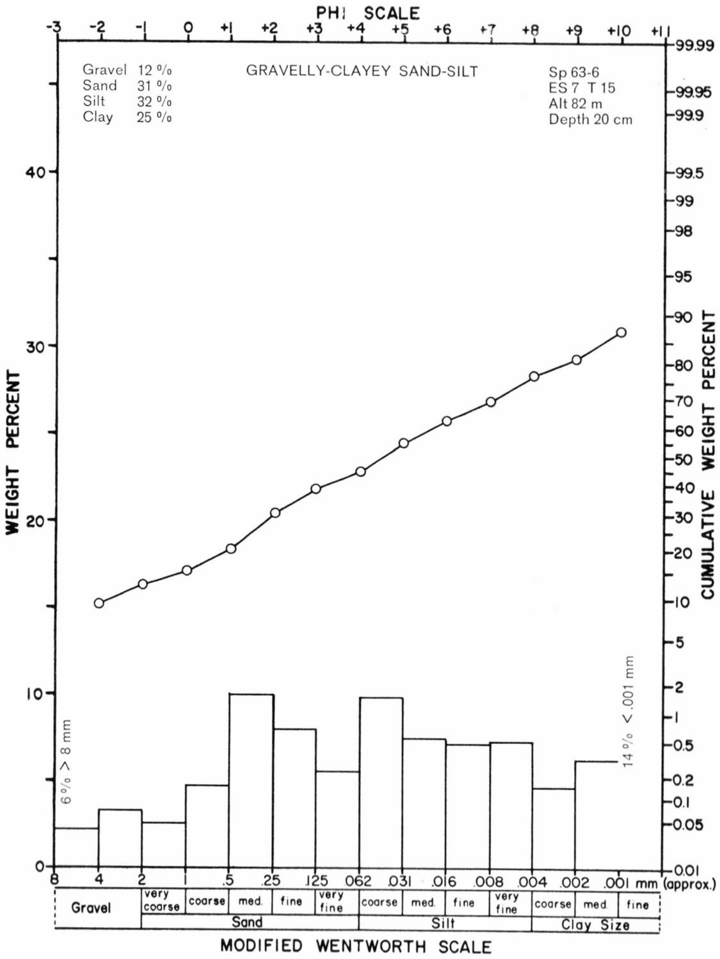


Plate D 3–6.

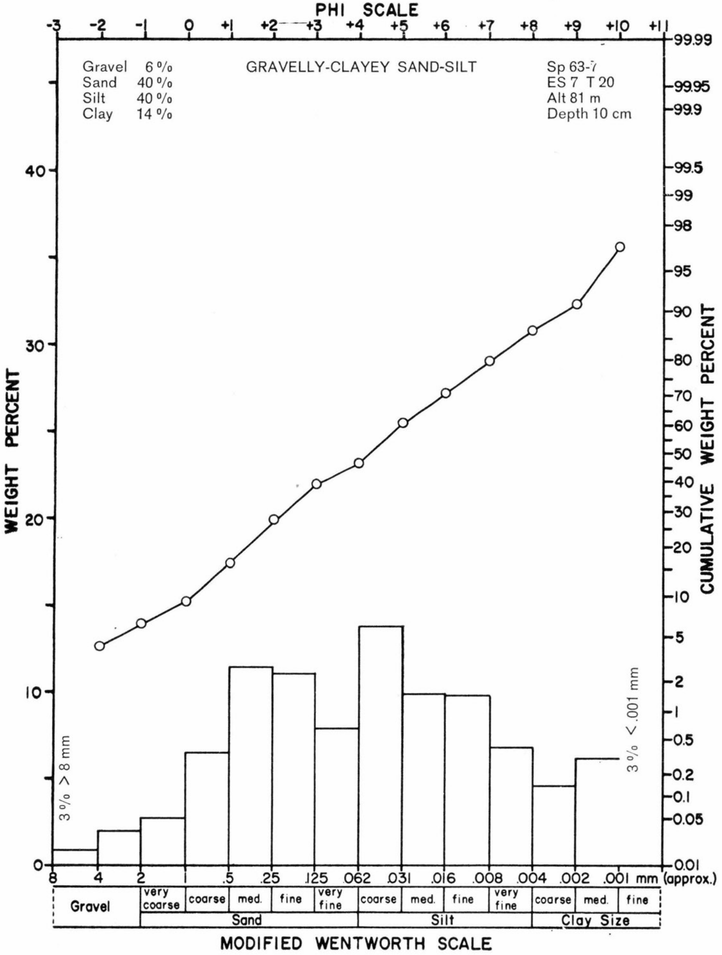


Plate D 3–7.

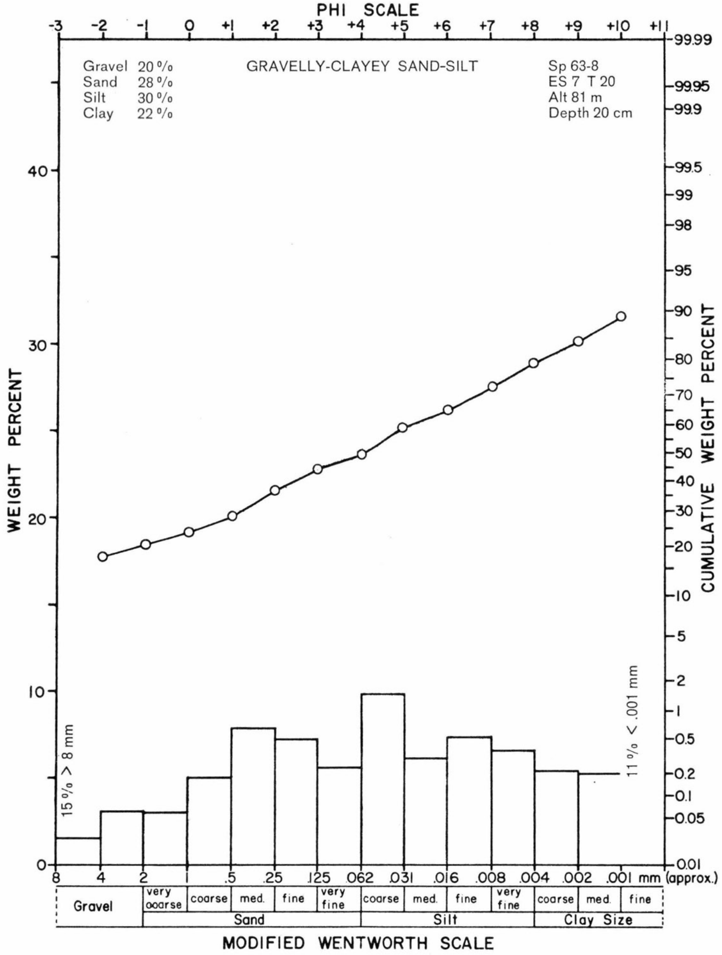


Plate D 3–8.

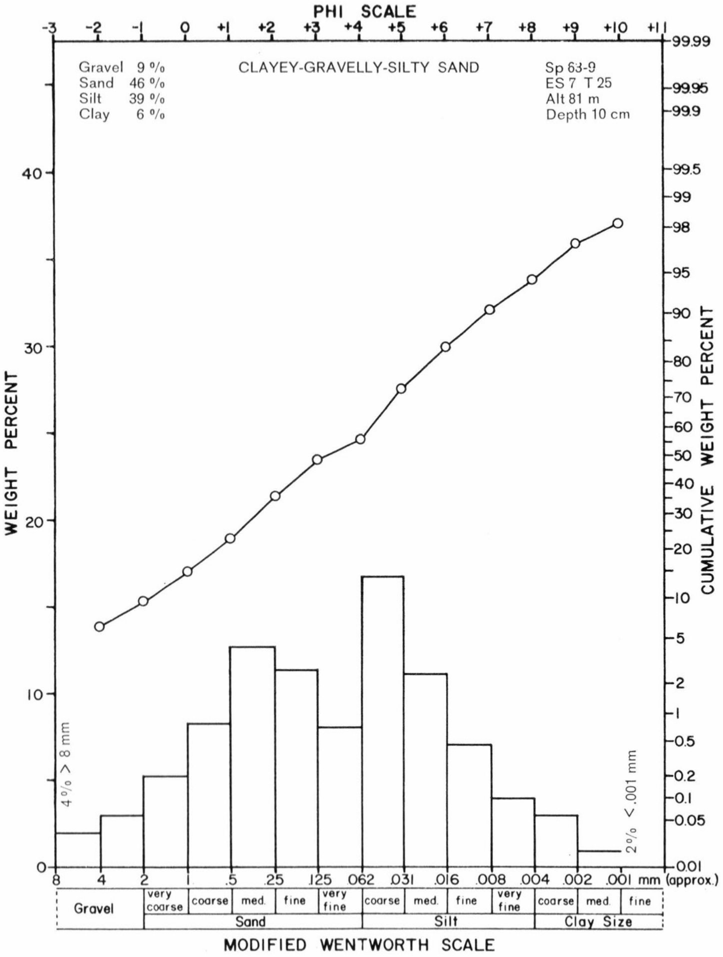


Plate D 3–9.

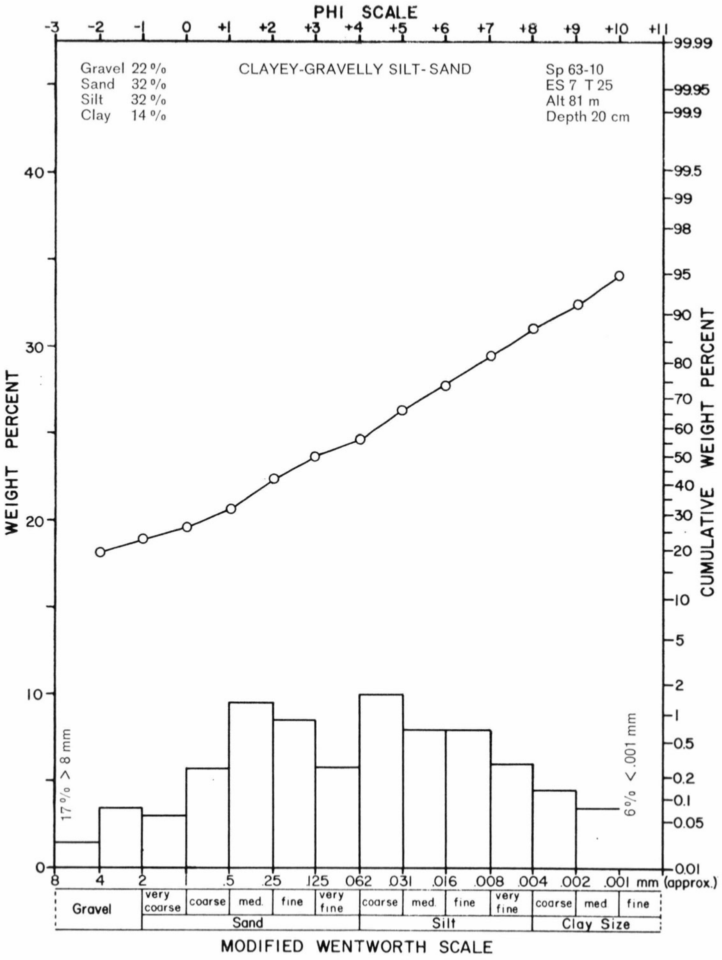


Plate D 3–10.

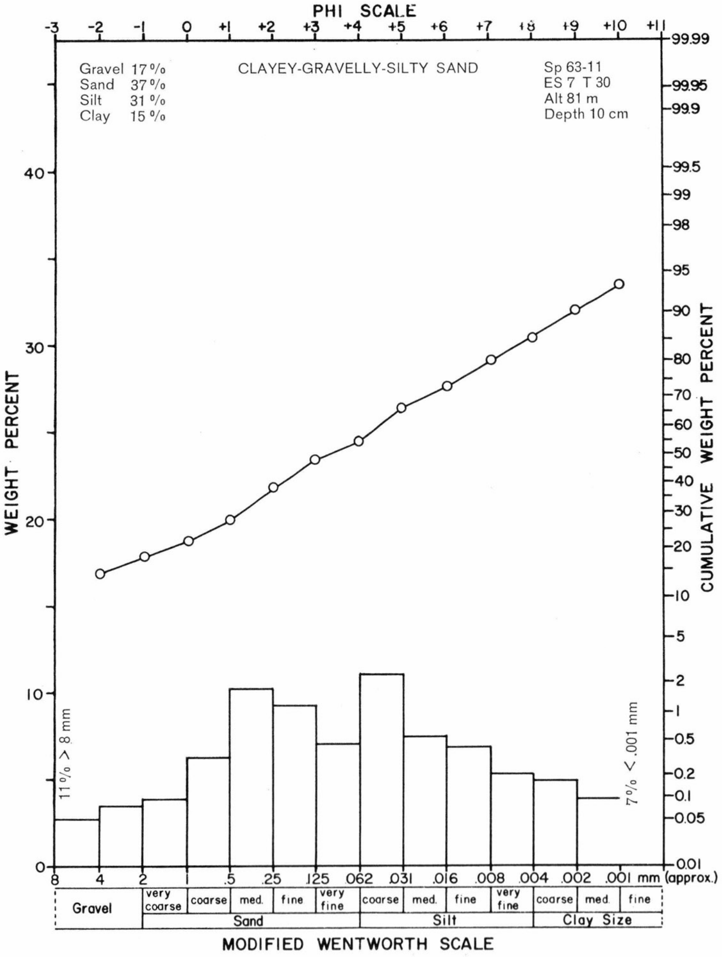


Plate D 3–11.

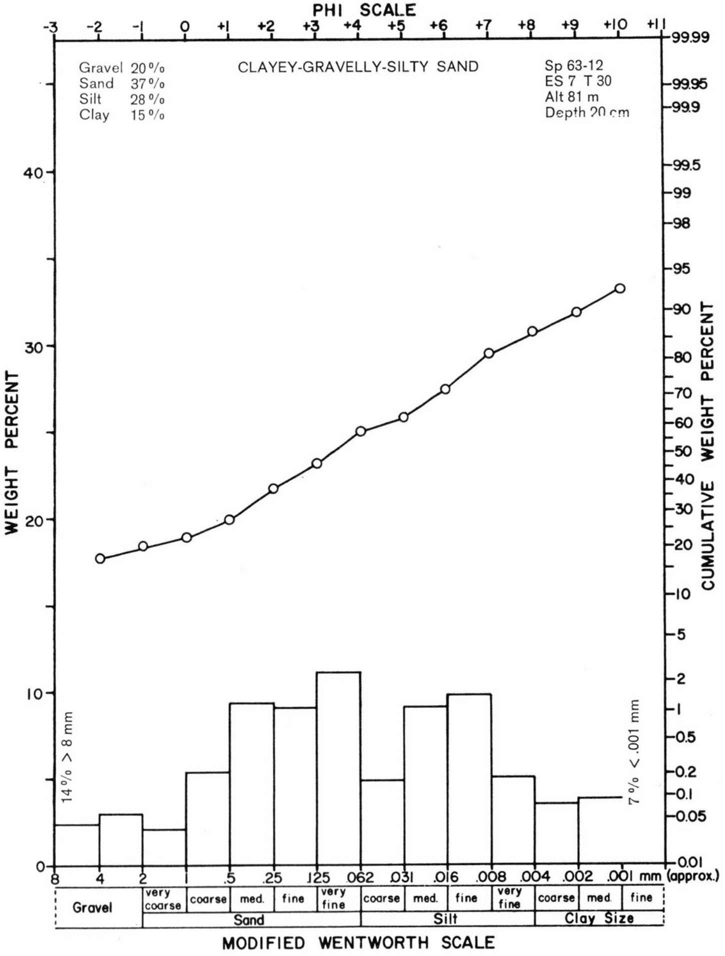


Plate D 3–12.

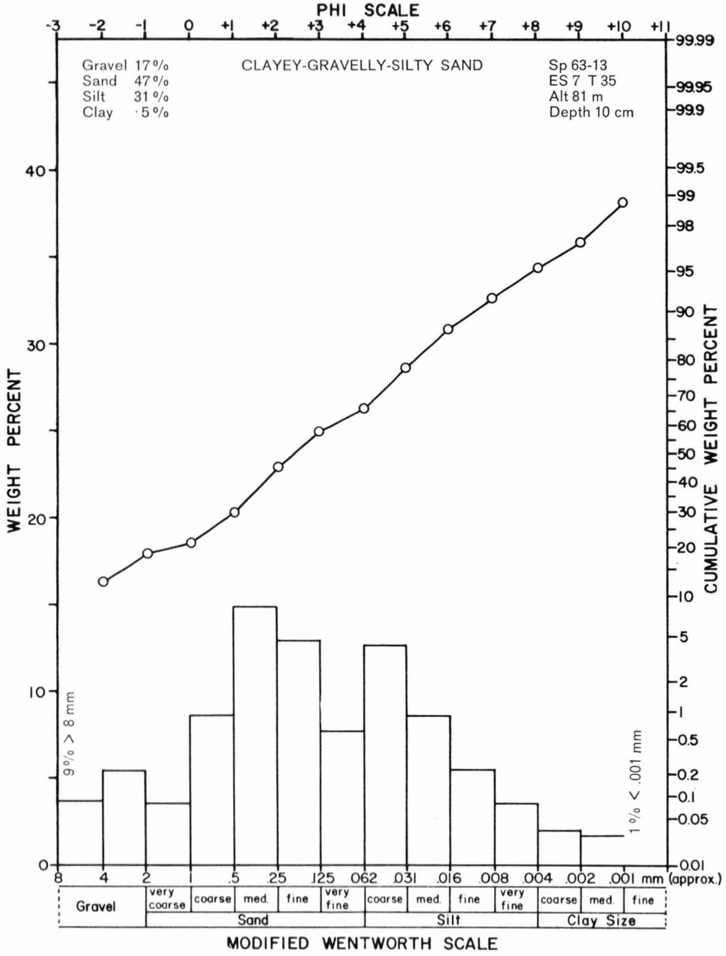


Plate D 3–13.

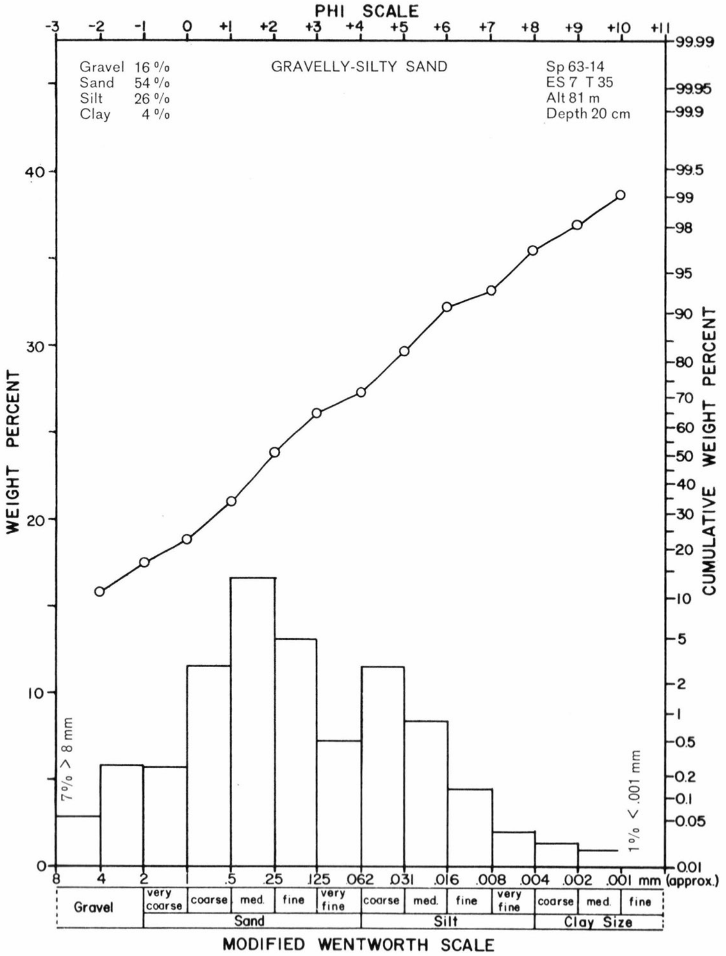


Plate D 3–14.

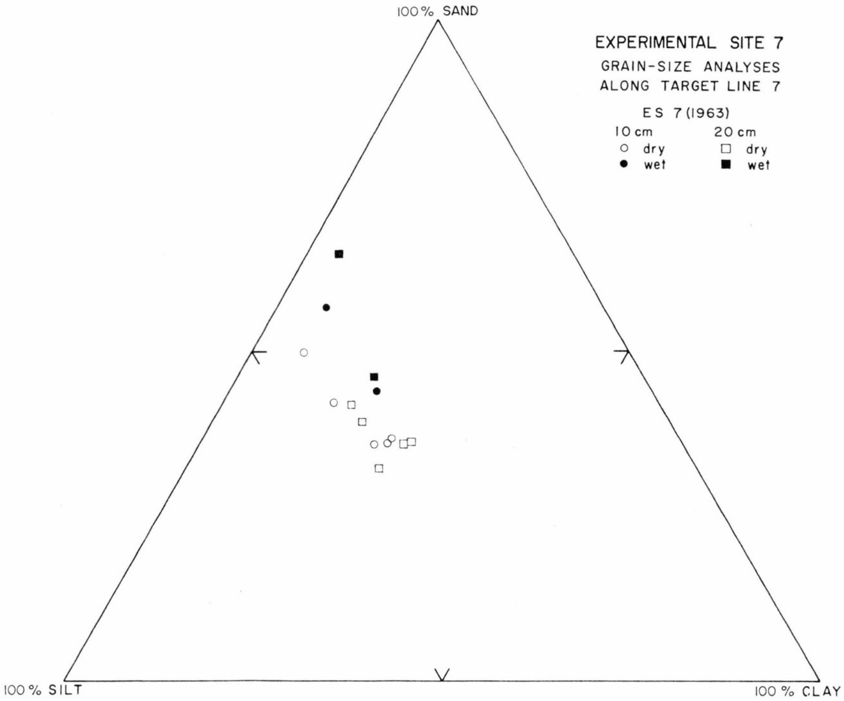

100% SAND
100% SILT
100% CLAY
EXPERIMENTAL SITE 7
GRAIN-SIZE ANALYSES
ALONG TARGET LINE 7
ES 7 (1963)
10 cm
20 cm
○ dry
● wet
□ dry
■ wet

Plate D 4.

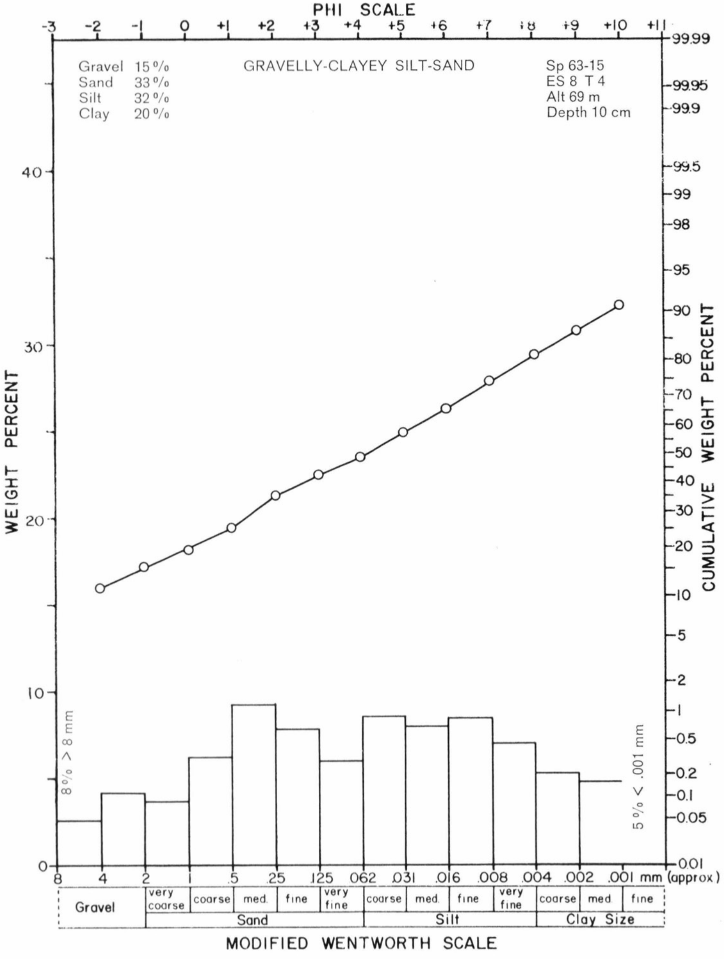


Plate D 5–1.

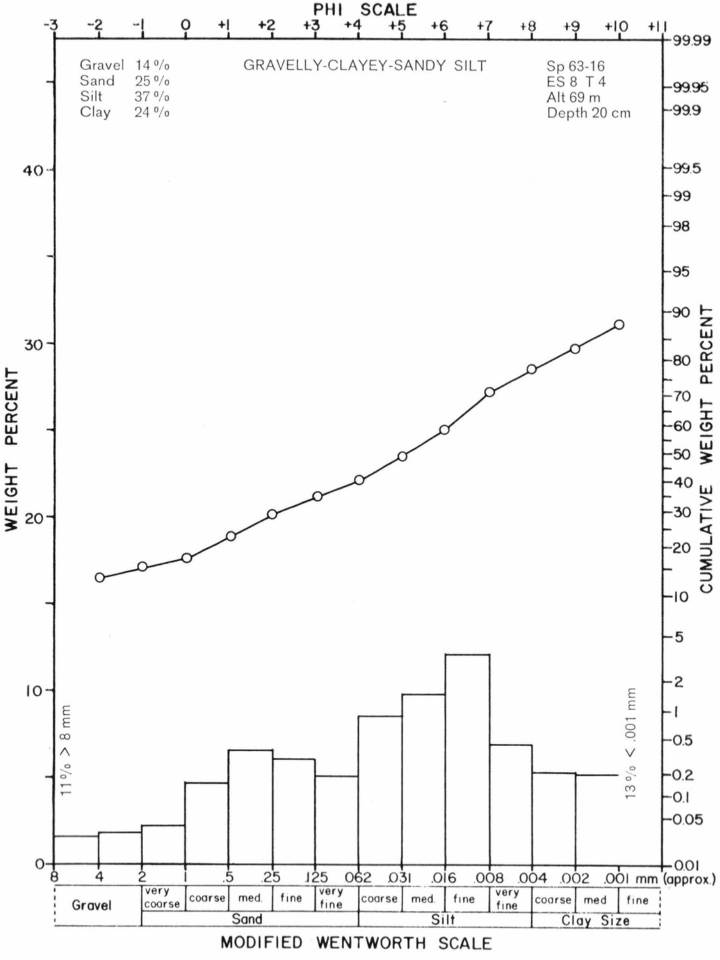


Plate D 5–2.

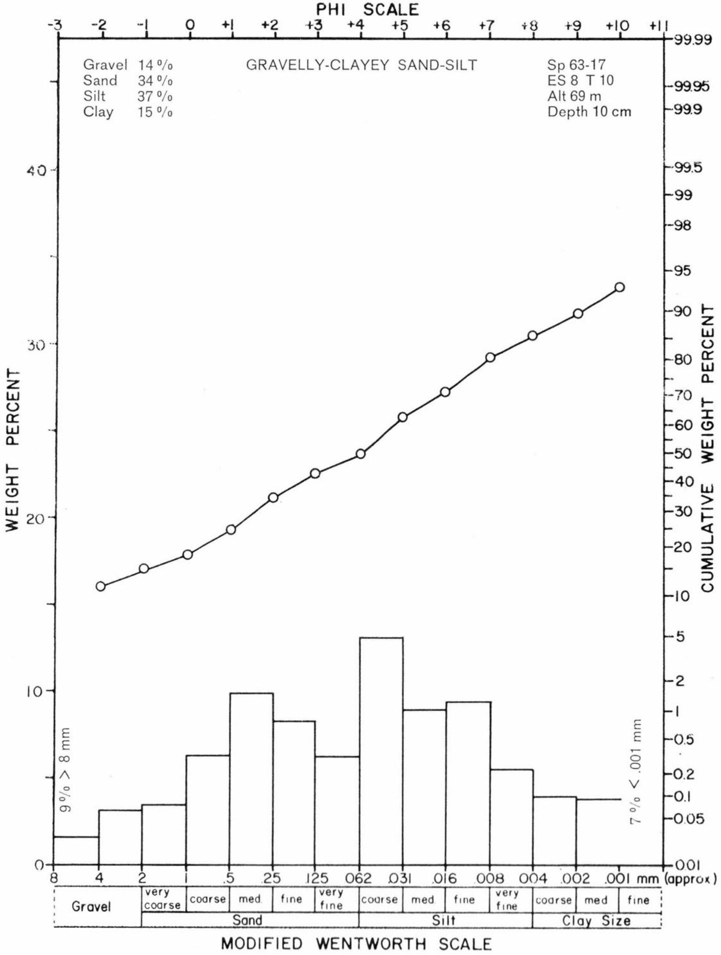


Plate D 5–3

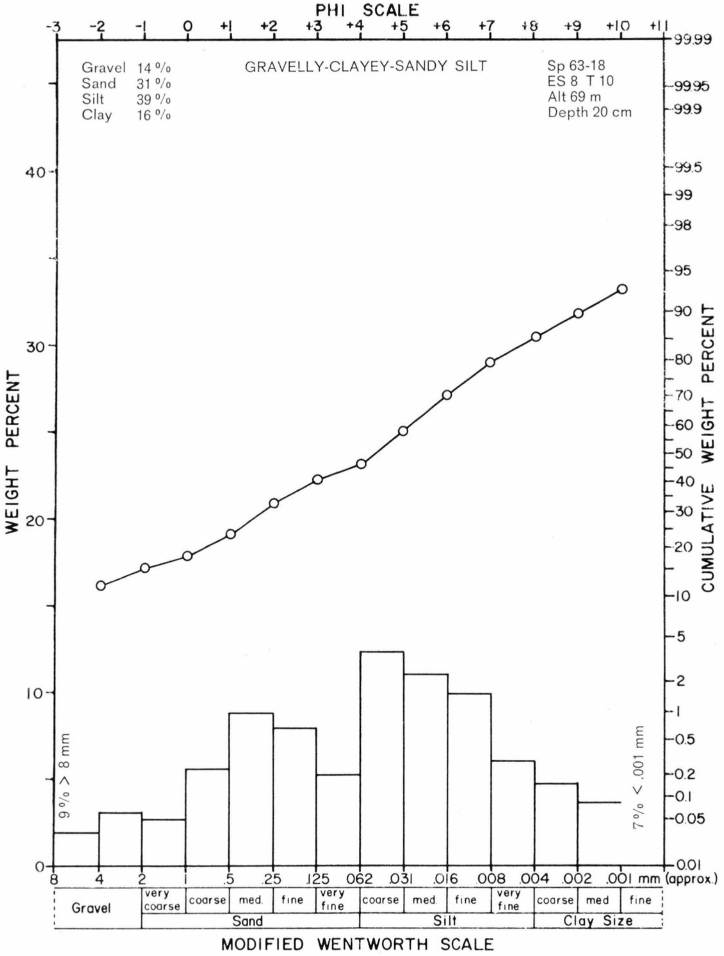


Plate D 5–4.

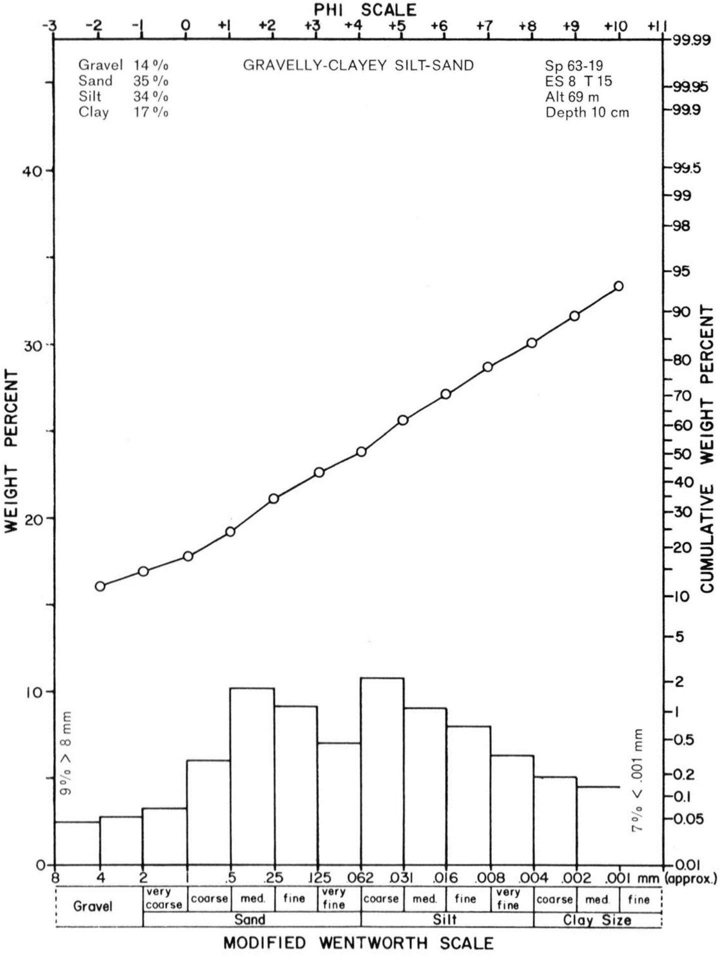


Plate D 5–5.

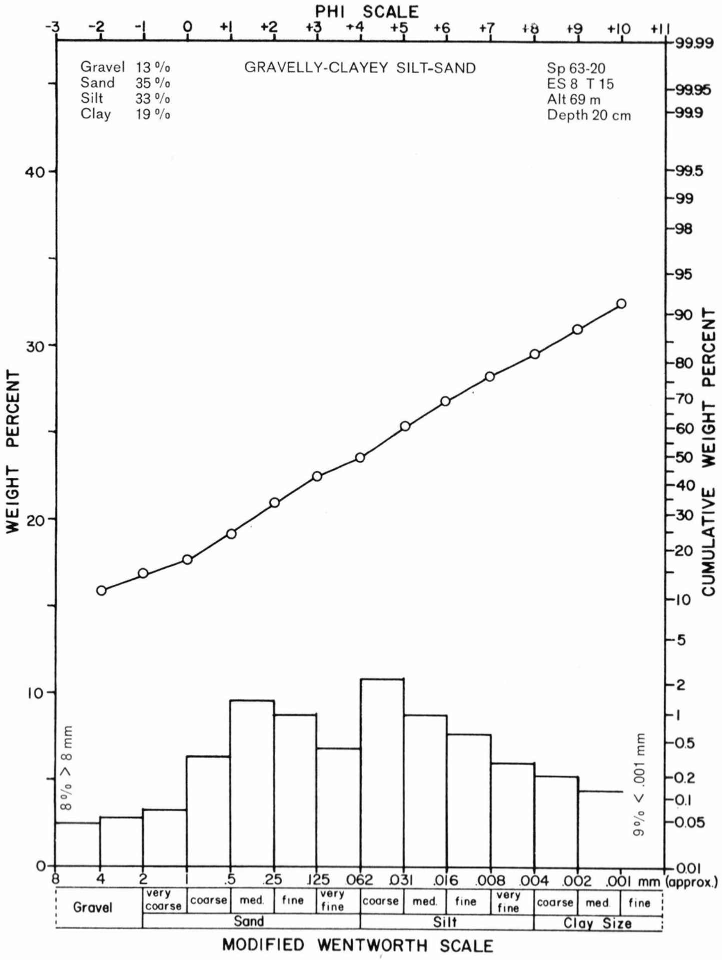


Plate D 5–6.

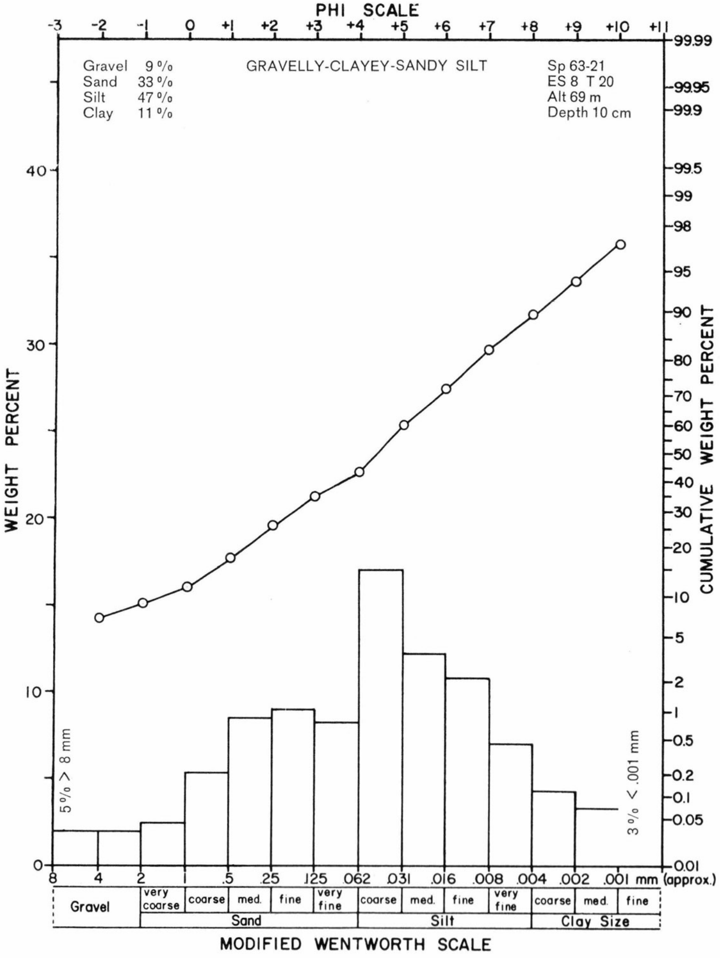


Plate D 5–7.

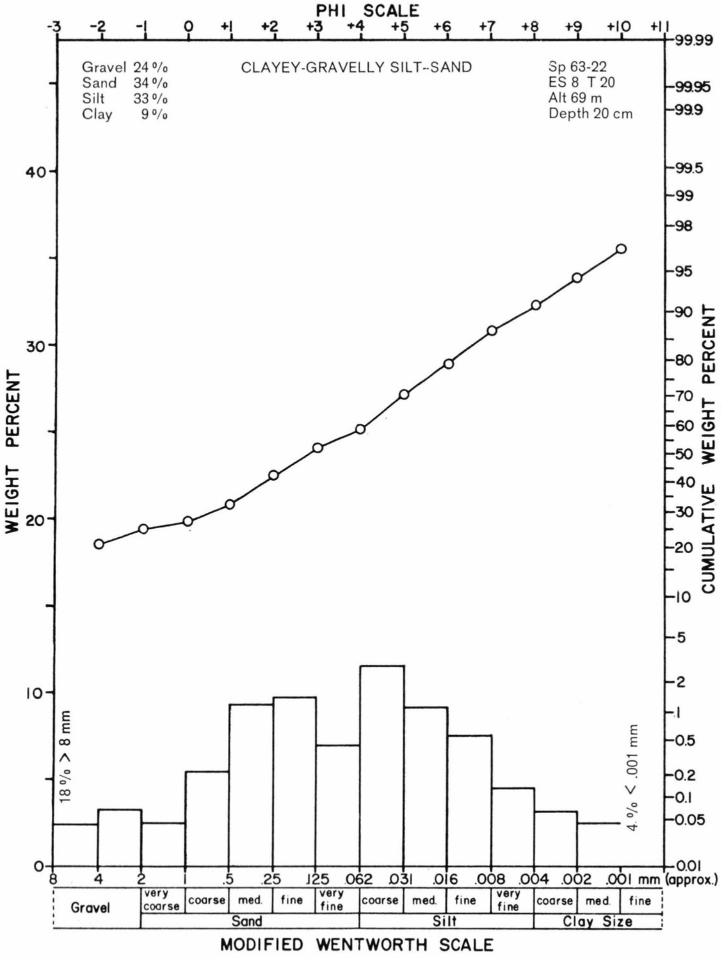


Plate D 5–8.

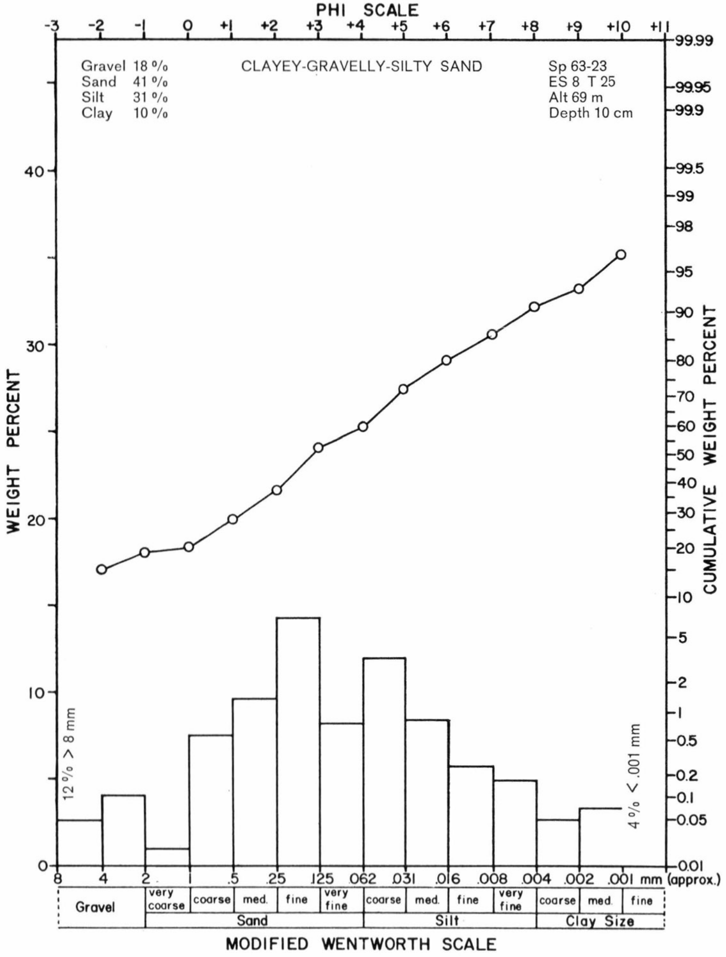


Plate D 5–9.

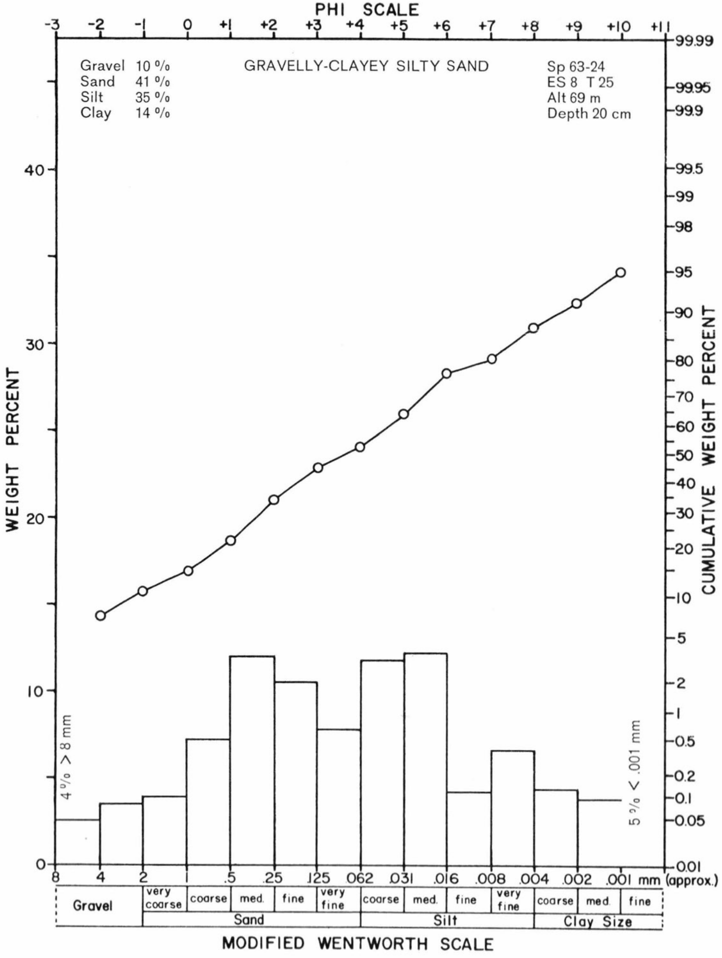


Plate D 5–10.

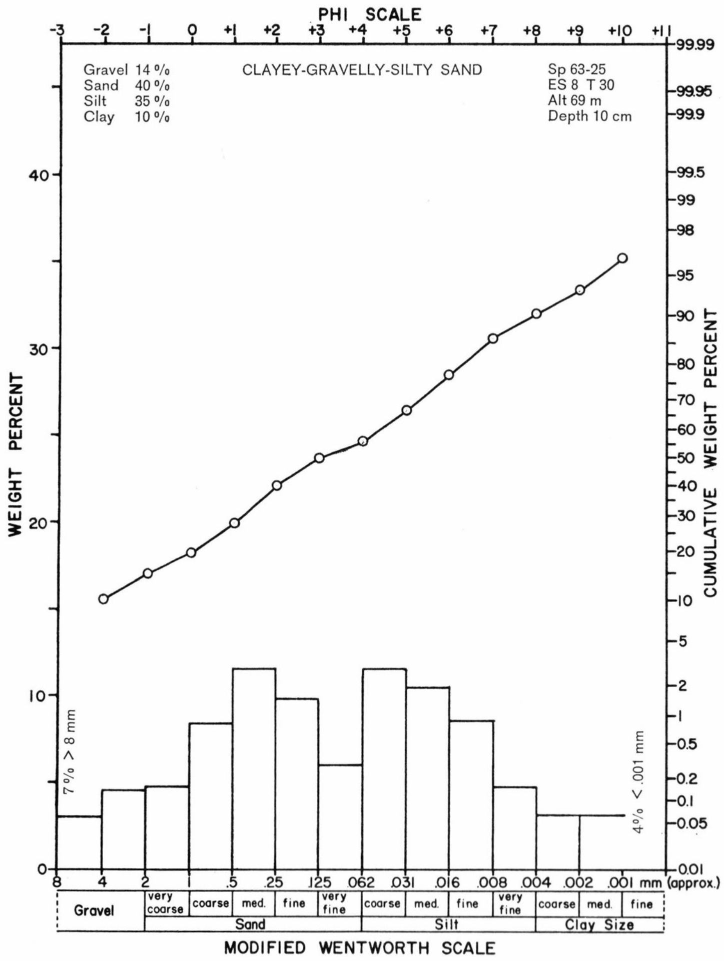


Plate D 5–11.

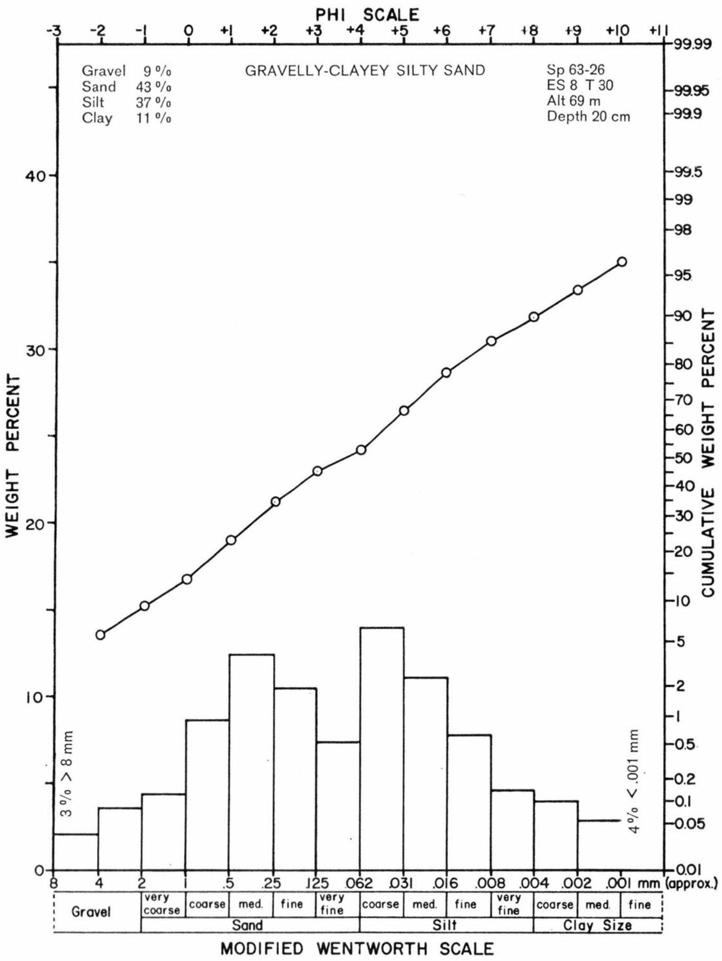


Plate D 5–12.

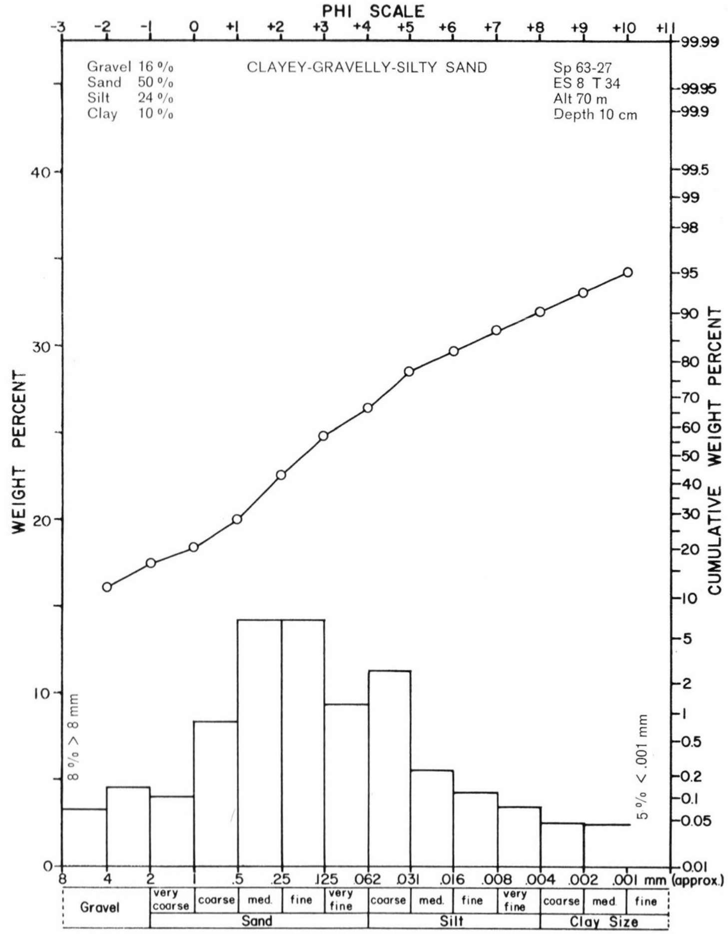


Plate D 5–13.

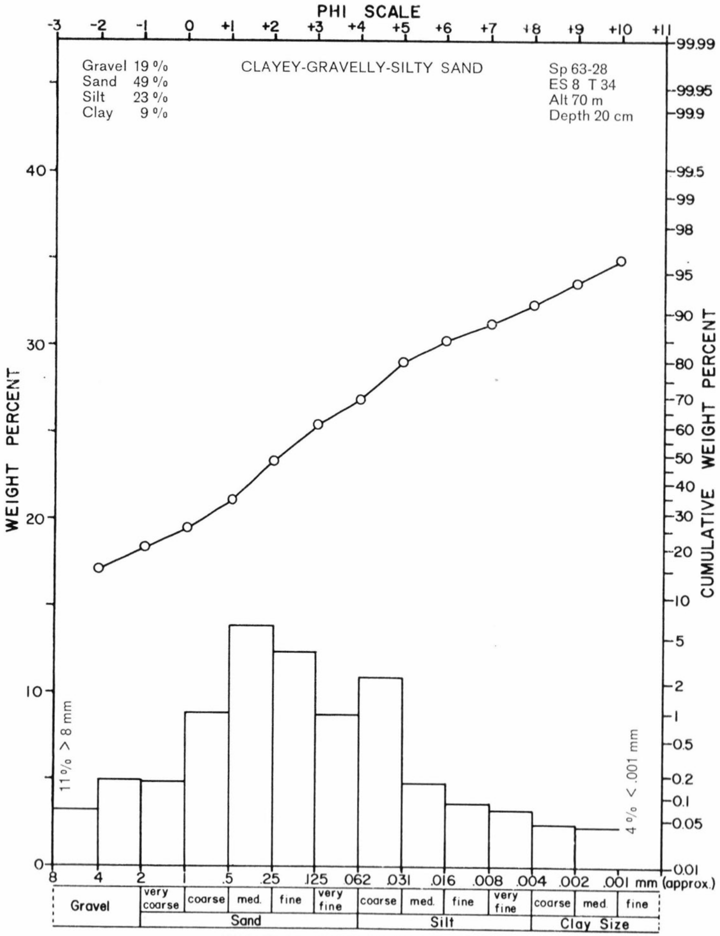


Plate D 5–14.

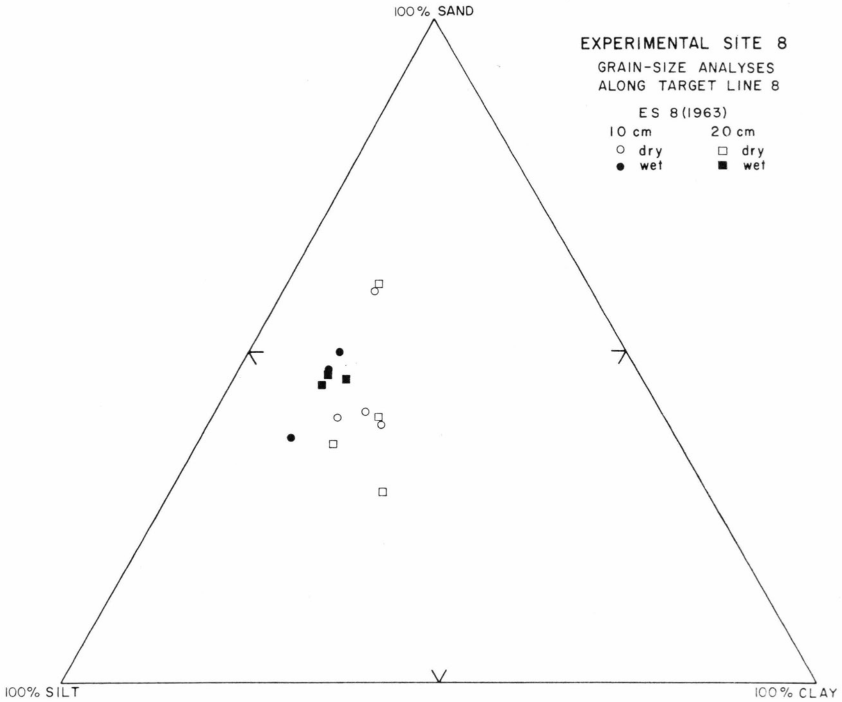

100% SAND
100% SILT
100% CLAY
EXPERIMENTAL SITE 8
GRAIN-SIZE ANALYSES
ALONG TARGET LINE 8
ES 8 (1963)
10 cm
20 cm
○ dry
● wet
□ dry
■ wet

Plate D 6.

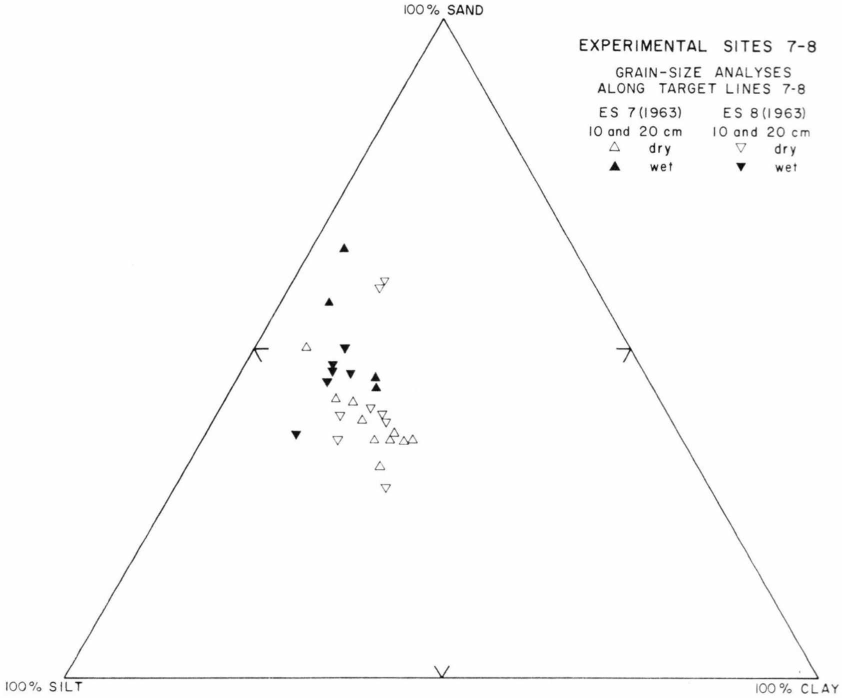

100 % SAND
100% SILT
100% CLAY
EXPERIMENTAL SITES 7-8
GRAIN-SIZE ANALYSES
ALONG TARGET LINES 7-8
ES 7 (1963)
10 and 20 cm
△ dry
▲ wet
ES 8 (1963)
10 and 20 cm
▽ dry
▼ wet

Plate D 7.

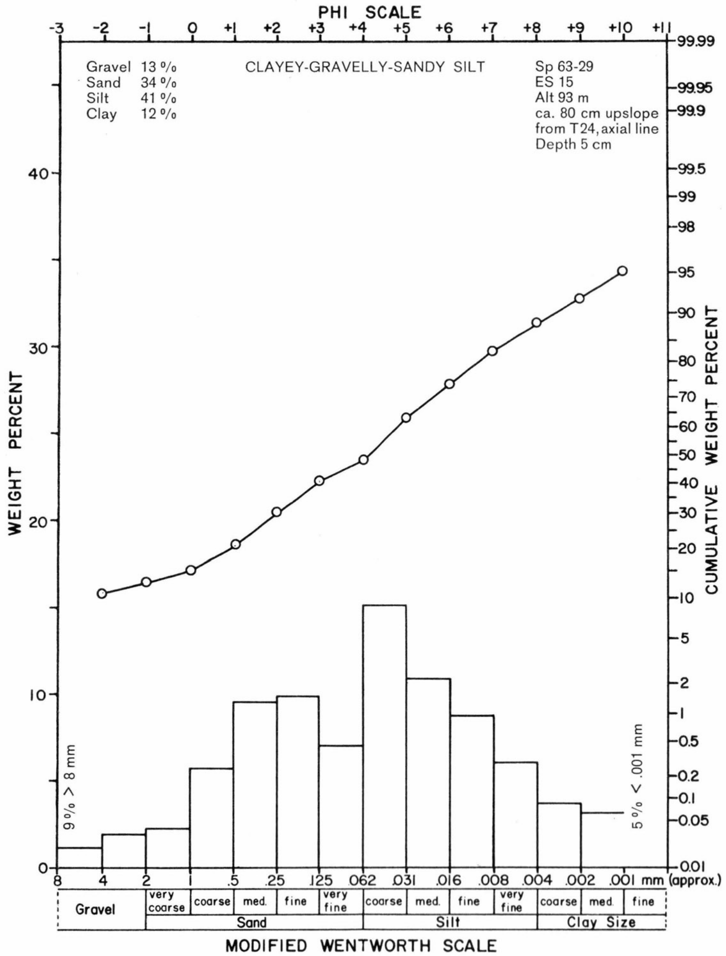


Plate D 8–1.

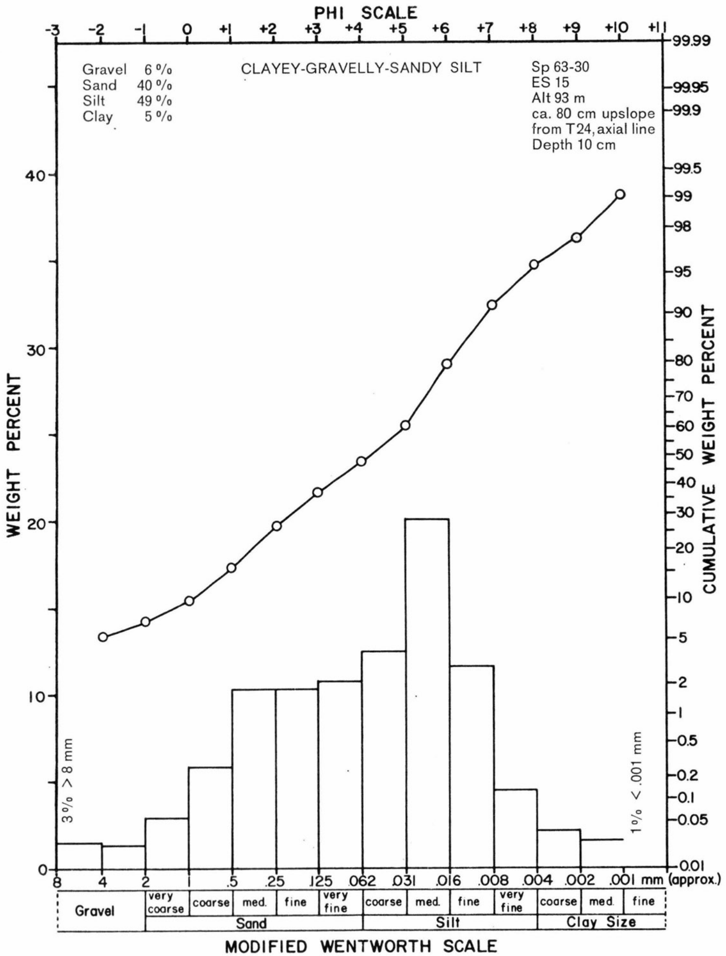


Plate D 8–2.

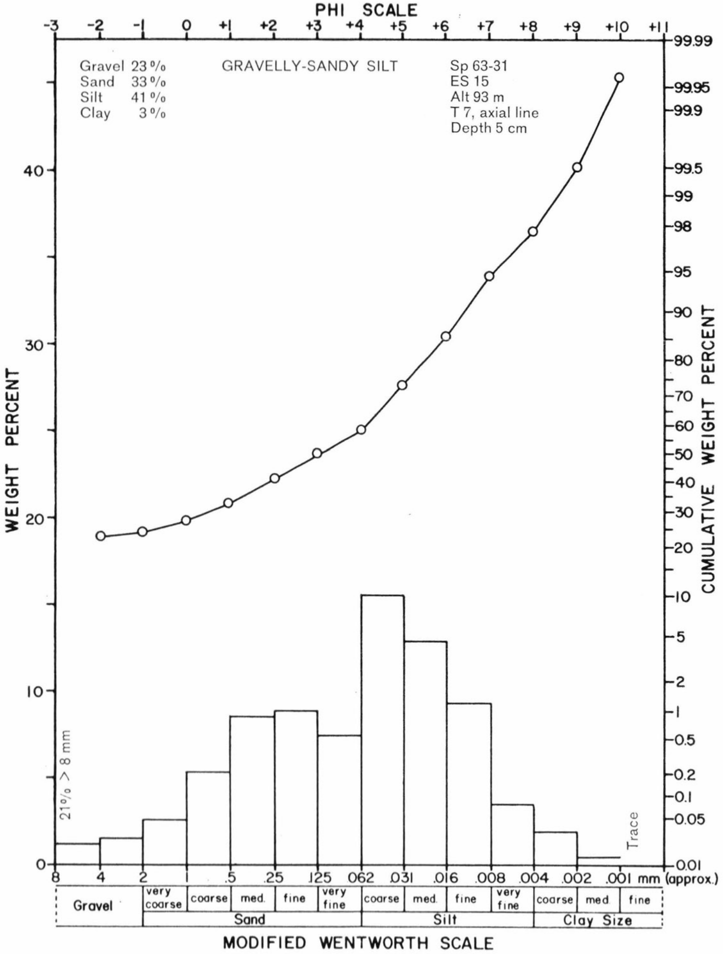


Plate D 8–3.

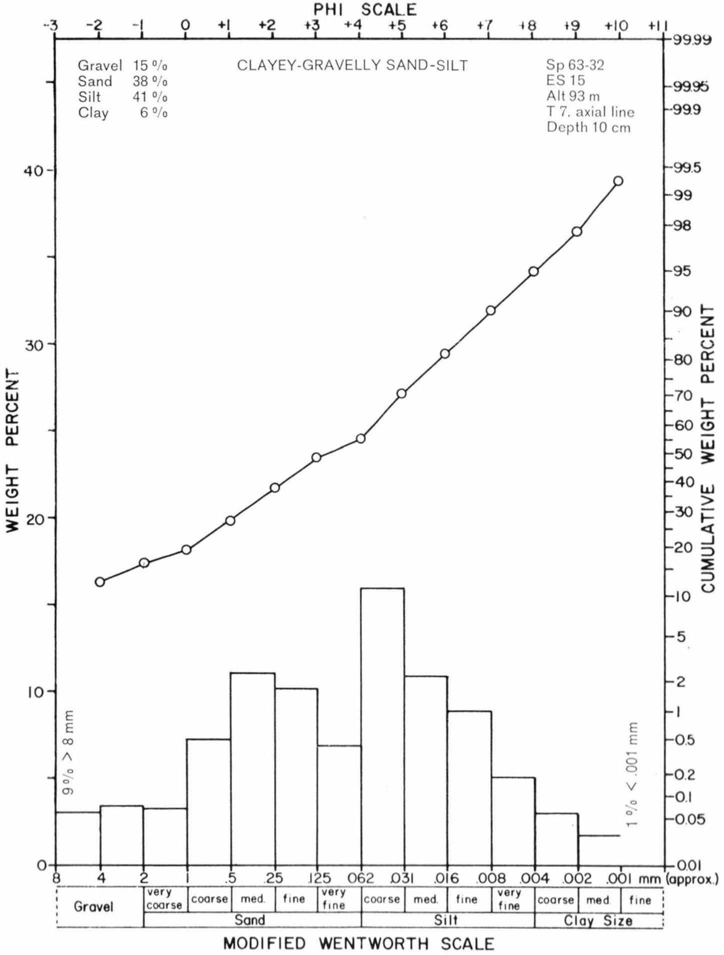


Plate D 8–4.

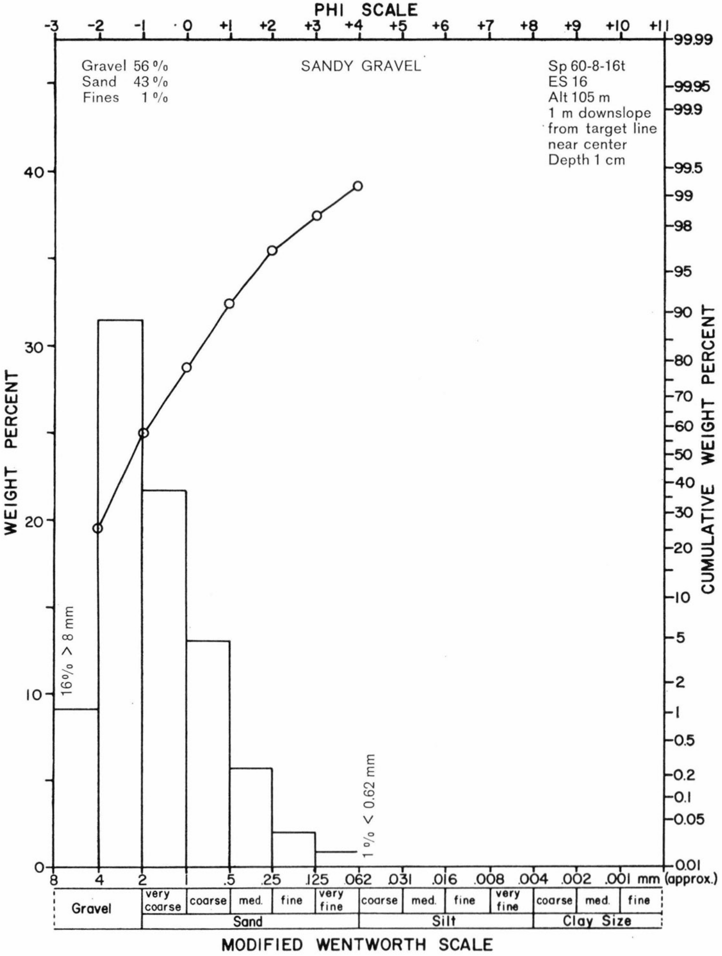
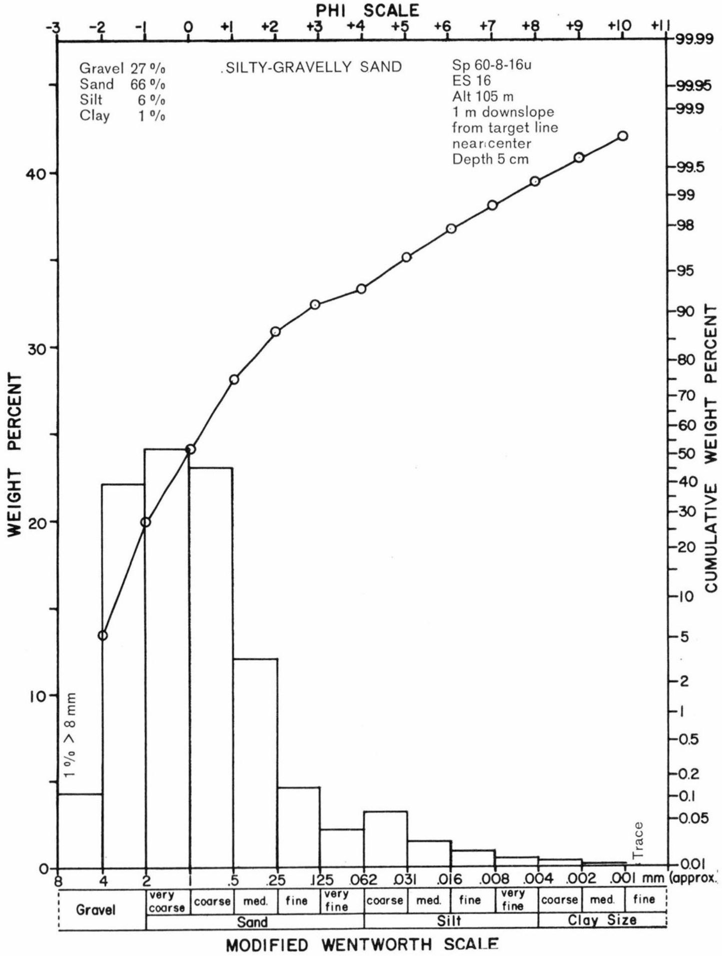


Plate D 9–1.



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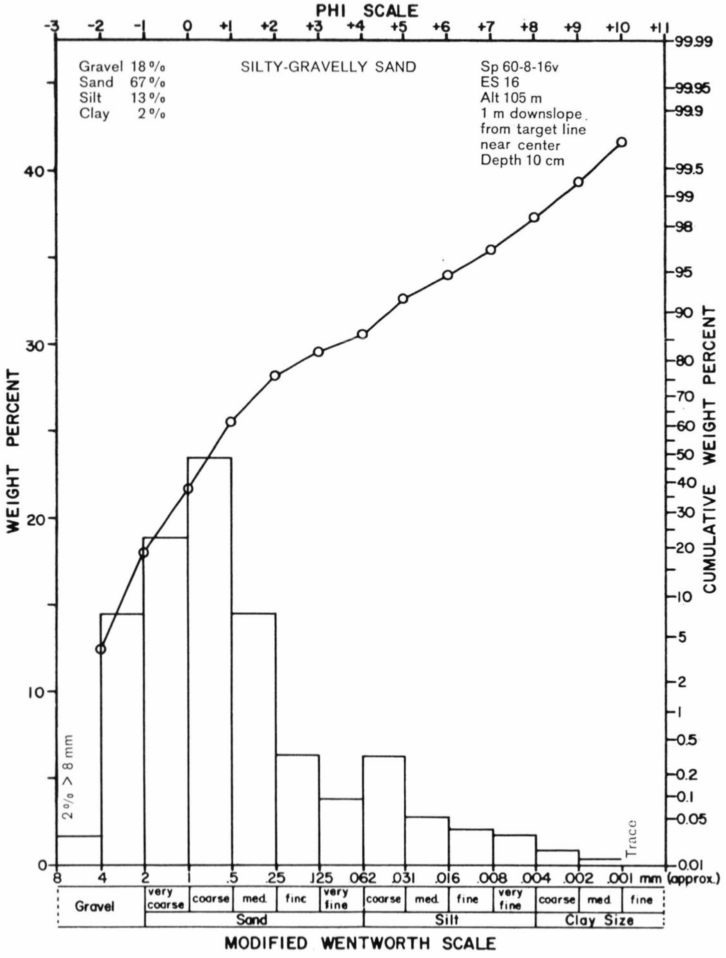

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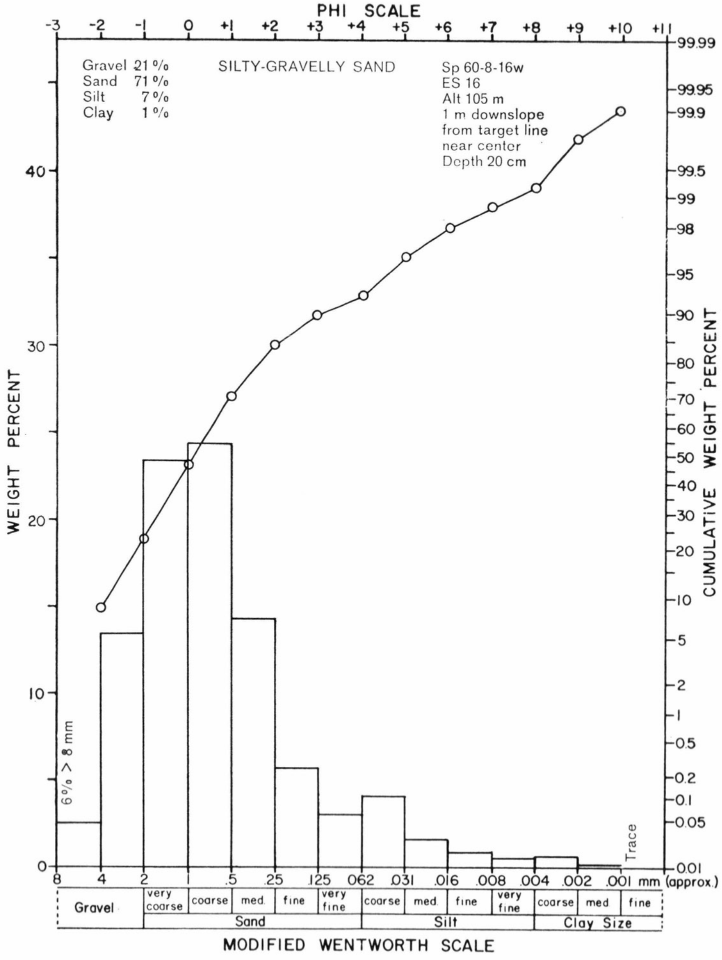


Plate D 9-4.

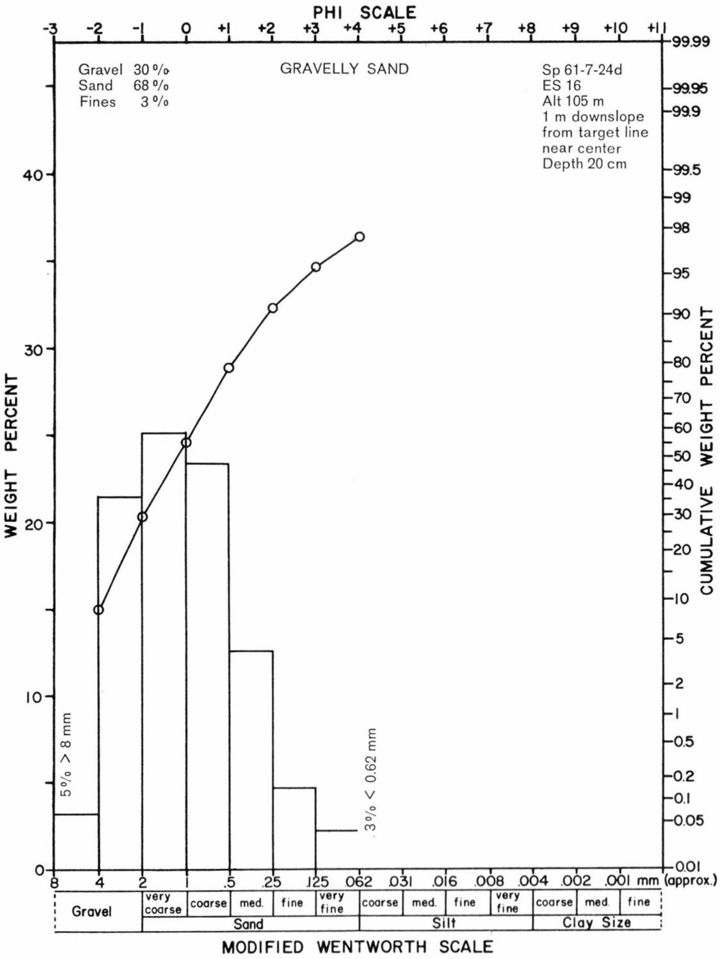


Plate D 9–5.

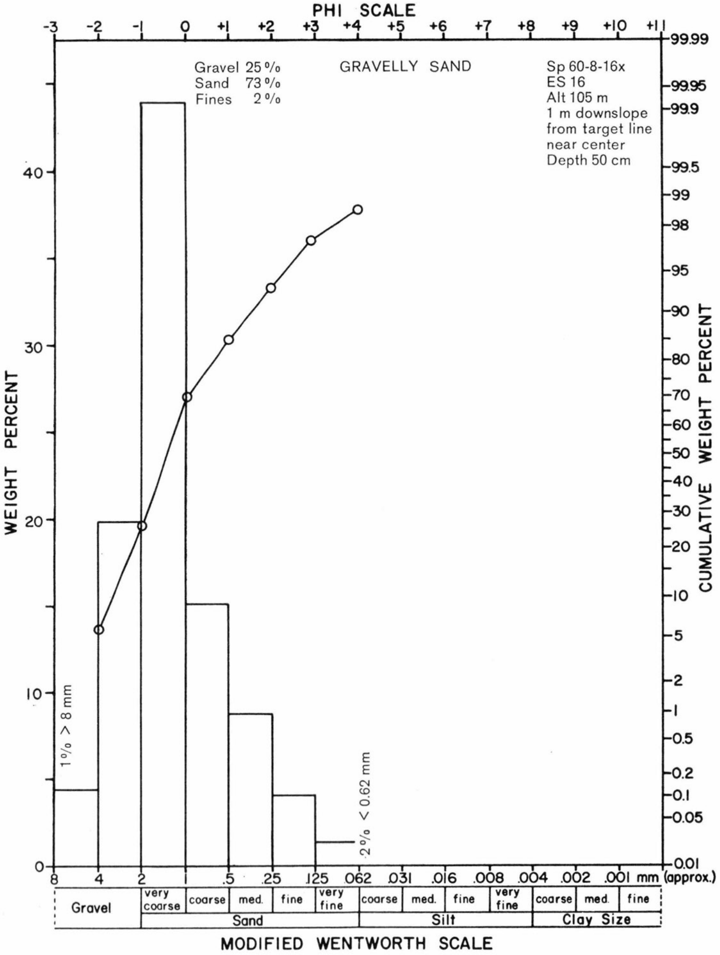


Plate D 9–6.

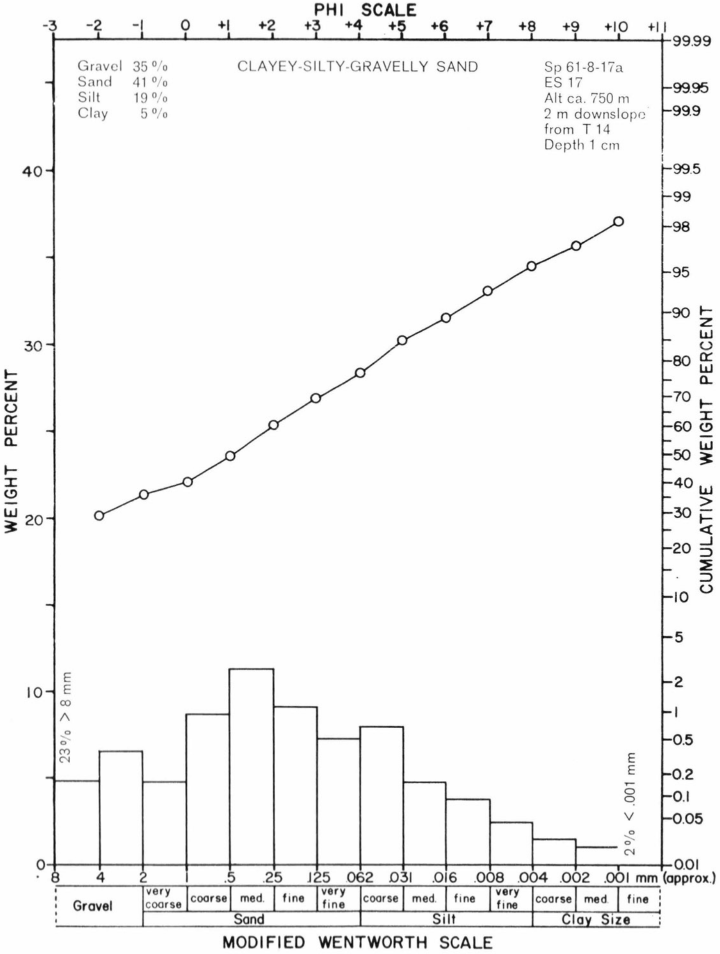


Plate D 10–1.

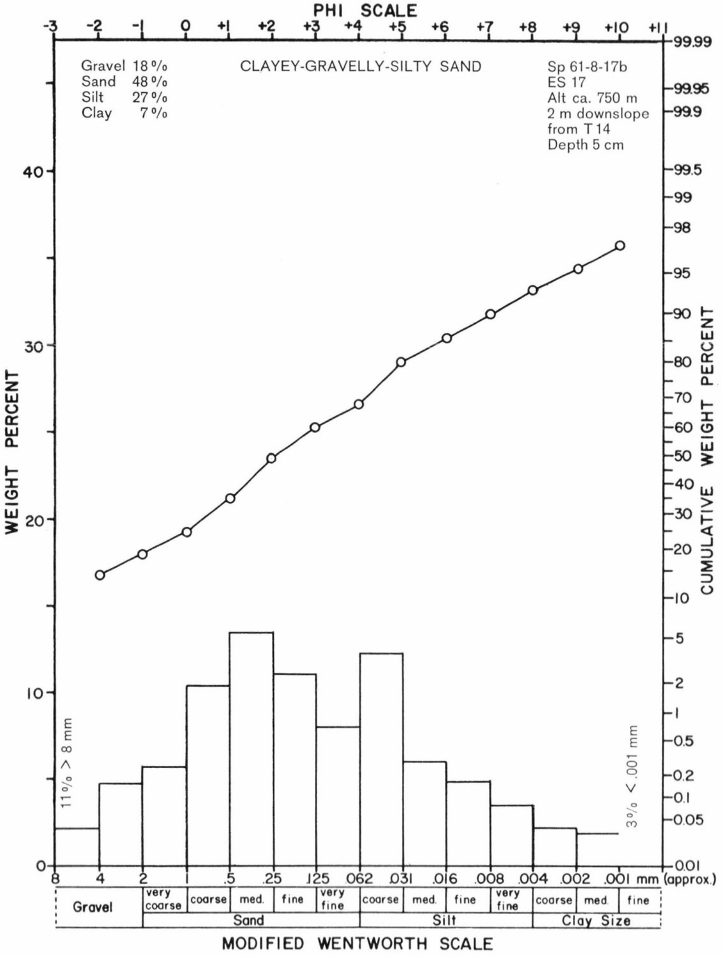


Plate D 10–2.

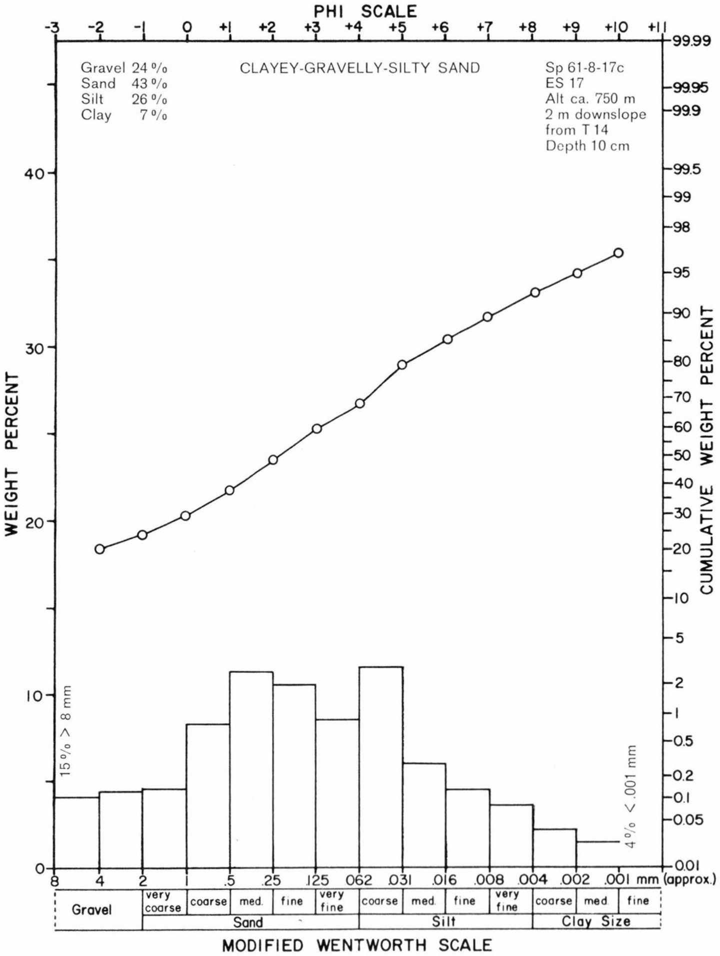


Plate D 10–3.

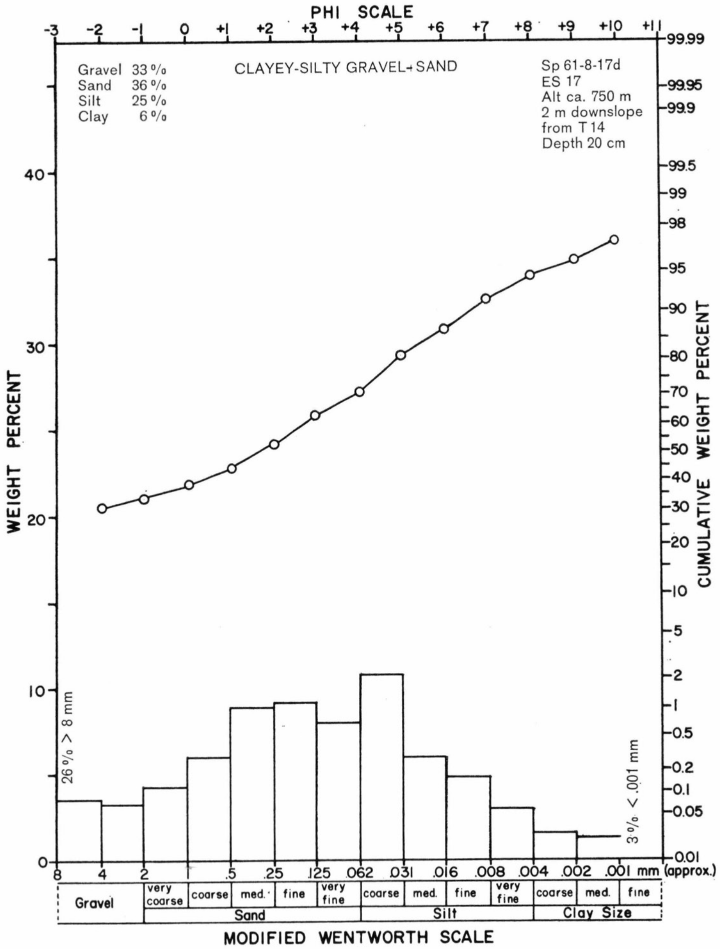


Plate D 10–4.

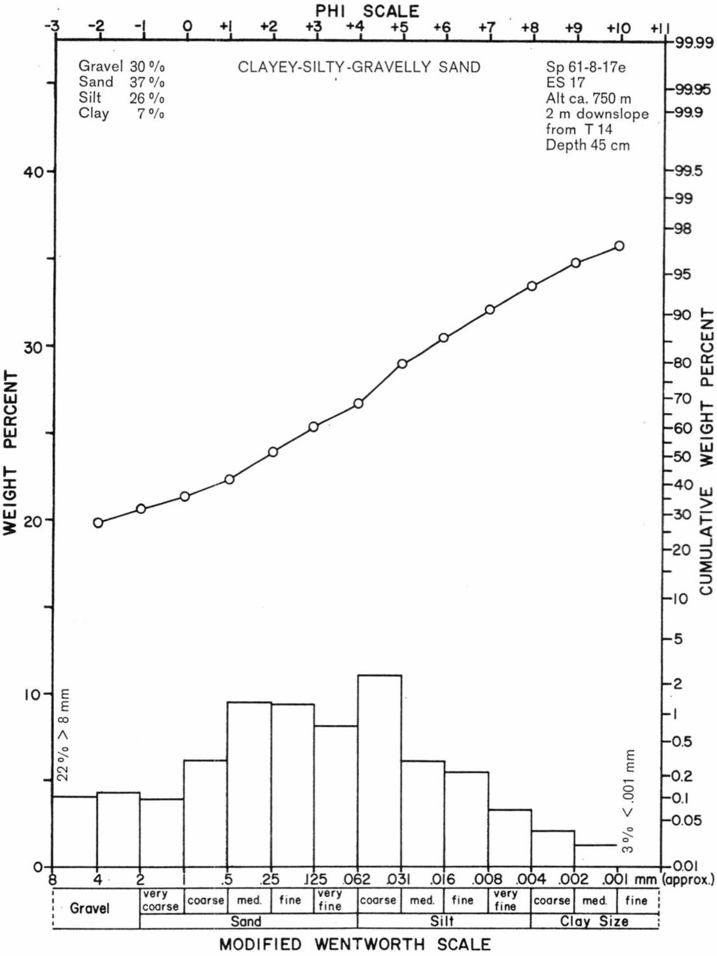

PHI SCALE
-3 -2 -1 0 +1 +2 +3 +4 +5 +6 +7 +8 +9 +10 +11
Gravel 30 %
Sand 37 %
Silt 26 %
Clay 7 %
CLAYEY-SILTY-GRAVELLY SAND
Sp 61-8-17e
ES 17
Alt ca. 750 m
2 m downslope from T 14
Depth 45 cm
WEIGHT PERCENT
0
10
20
30
40
CUMULATIVE WEIGHT PERCENT
99.99
99.95
99.9
99.5
99
98
95
90
80
70
60
50
40
30
20
10
5
2
1
0.5
0.2
0.1
0.05
0.01
22 % > 8 mm
3 % < .001 mm
8 4 2 1 .5 .25 .125 .062 .031 .016 .008 .004 .002 .001 mm (approx.)
Gravel
very coarse
coarse
med.
fine
very fine
coarse
med.
fine
very fine
coarse
med.
fine
Sand
Silt
Clay Size
MODIFIED WENTWORTH SCALE

Plate D 10–5.

Table D I. *Experimental site 6. Summary of grain-size analyses, Atterberg limits, and specific gravity determinations*

Specimen Number and Location	Designation (and Silt + Clay Percentage)	Liquid Limit (LL) Plastic Limit (PL) Plasticity Index (PI = LL-PL) In percent moisture (w)	Specific Gravity
	Along Target Line 6		
64-8-12 T 10	Gravelly$_{12}$-clay$_{29}$sand$_{29}$-silt$_{30}$	LL 26	
ES 6	Si + cl = 59	PL 20	
T 10, depth 5-15 cm		PI 6	
64-8-12 T 15	Sandy$_{17}$-silty$_{35}$-clay$_{44}$	LL 36	
ES 6	Si + cl = 79	PL 21	
T 15, depth 5–15 cm		PI 15	
64-8-12 T 20	Sandy$_{23}$-silt$_{35}$-clay$_{39}$	LL 32	
ES 6	Si + cl = 74	PL 26	
T 20, depth 5–15 cm		PI 6	
64-8-12 T 25 cm	Silty$_{17}$-gravelly$_{37}$ sand$_{43}$	LL 36	
ES 6	Si + cl = 20	PL 29	
T 25, depth 5–15 cm		PI 7	
64-8-12 T 30	Sandy$_{10}$-clayey$_{20}$-silty$_{25}$gravel$_{45}$	LL 70	
ES 6	Si + cl = 45	PL 65	
T 30, depth 5–15 cm		PI 5	
	Near Target Line 6		
61-8-18h	Sandy$_{15}$-clayey$_{18}$-silty$_{23}$ gravel$_{44}$	LL 57	2.53
ES 6. 10 m downslope		PL 48	
T 16, depth 10 cm	Si + cl = 41	PI 9	
TCS 6A			
61-8-18i	Gravelly$_{5}$-clayey$_{17}$-silty$_{35}$ sand$_{43}$	LL 17	2.71
ES 6. 10 m downslope		PL 13	
T 16, depth 20 cm	Si + cl = 52	PI 4	
TCS 6A			
61-8-18j	Gravelly$_{5}$-clayey$_{14}$-silty$_{36}$ sand$_{45}$	LL 16	2.70
ES 6. 10 m downslope		PL 13	
T 16, depth 45–50 cm	Si + cl = 50	PI 3	
TCS 6A			
61-8-18k	Gravelly$_{5}$-clayey$_{28}$ sand$_{32}$-silt$_{35}$	LL 23	2.72
ES 6. 10 m downslope		PL 16	
T 16, depth 80–85 cm	Si + cl = 63	PI 7	
TCS 6A			
61-8-18 l	Sandy$_{11}$-silty$_{30}$ clay$_{55}$	LL 33	2.76
ES 6. 10 m downslope		PL 22	
T 16, depth ca. 85–90 cm		PI 11	
TCS 6A	Si + cl = 85		

Table D II. *Experimental site 7. Summary of grain-size analyses, Atterberg limits, and specific gravity determinations*

Specimen Number and Location	Designation (and Silt + Clay Percentage)	Liquid Limit (LL) Plastic Limit (PL) Plasticity Index (PI = LL-PL) In percent moisture (w)	Specific Gravity
	Along Target Line 7		
63-1	Gravelly$_{18}$-clayey$_{21}$ sand$_{29}$-silt$_{32}$	LL 14	
ES 7		PL 13	
T 5, depth 10 cm	Si + cl = 53	PI 1	
63-2	Gravelly$_{11}$-clayey$_{17}$ sand$_{35}$-silt$_{37}$	LL 14	
ES 7		PL 12	
T 5, depth 20 cm	Si + cl = 54	PI 2	
63-3	Clayey$_{16}$-sandy$_{24}$-silty$_{27}$ gravel$_{33}$	LL 18	
ES 7		PL 14	
T 10, depth 10 cm	Si + cl = 43	PI 4	
63-4	Gravelly$_{8}$-clayey$_{24}$-sandy$_{29}$ silt$_{39}$	LL 17	
ES 7		PL 14	
T 10, depth 20 cm	Si + cl = 63	PI 3	
63-5	clayey$_{17}$-sandy$_{24}$-silty$_{25}$ gravel$_{34}$	LL 18	
ES 7		PL 15	
T 15, depth 10 cm	Si + cl = 42	PI 3	
63-6	Gravelly$_{12}$-clayey$_{25}$ sand$_{31}$-silt$_{32}$	LL 18	
ES 7		PL 13	
T 15, depth 20 cm	Si + cl = 57	PI 5	
63-7	Gravelly$_{6}$-clayey$_{14}$ sand$_{40}$-silt$_{40}$	LL 16	
ES 7		PL 15	
T 20, depth 10 cm	Si + cl = 54	PI 1	
	(A few sand-size shell fragments)		
63-8	Gravelly$_{20}$-clayey$_{22}$ sand$_{28}$-silt$_{30}$	LL 19	
ES 7		PL 13	
T 20, depth 20 cm	Si + cl = 52	PI 6	
63-9	Clayey$_{6}$-gravelly$_{9}$-silty$_{39}$ sand$_{46}$	LL 27	
ES 7		PL 21	
T 25, depth 10 cm	Si + cl = 45	PI 6	
63-10	Clayey$_{14}$-gravelly$_{22}$ silt$_{32}$-sand$_{32}$	LL 17	
ES 7		PL 15	
T 25, depth 20 cm	Si + cl = 46	PI 2	

(continued)

Experimental site 7 (continued)

Specimen Number and Location	Designation (and Silt + Clay Percentage)	Liquid Limit (LL) Plastic Limit (PL) Plasticity Index (PI = LL-PL) In percent moisture (w)	Specific Gravity
63-11 ES 7 T 30, depth 10 cm	Clayey$_{15}$-gravelly$_{17}$-silty$_{31}$ sand$_{37}$ Si + cl = 46	LL 20 PL 17 PI 3	
63-12 ES 7 T 30, depth 20 cm	Clayey$_{15}$-gravelly$_{20}$-silty$_{28}$ sand$_{37}$ Si + cl = 43	LL 16 PL 14 PI 2	
63-13 ES 7 T 35, depth 10 cm	Clayey$_{5}$-gravelly$_{17}$-silty$_{31}$ sand$_{47}$ Si + cl = 36	LL 19 PL 17 PI 2	
63-14 ES 7 T 35, depth 20 cm	Gravelly$_{16}$-silty$_{26}$ sand$_{54}$ Si + cl = 30	LL 20 PL 16 PI 4	
	Near Target Line 7		
60-8-16a ES 7. 10 m downslope T 6-7, depth 1 cm	Silty$_{12}$-sandy$_{24}$ gravel$_{60}$ Si + cl = 16	Nonplastic	2.57
60-8-16b ES 7. 10 m downslope T 6-7, depth 5 m	Clayey$_{16}$-silty$_{23}$-sandy$_{27}$ gravel$_{34}$ Si + cl = 39	LL 21 PL 16 PI 5	2.68
60-8-16c ES 7. 10 m downslope T 6-7, depth 10 cm	Gravelly$_{23}$-clayey$_{24}$ sand$_{25}$-silt$_{28}$ Si + cl = 52	LL 22 PL 14 PI 6	2.70
61-7-24e ES 7. 10 m downslope T 6-7, depth 20 cm	Clayey$_{15}$-sandy$_{21}$-silty$_{24}$ gravel$_{40}$ Si + cl = 39	LL 18 PL 14 PI 4	2.71
61-8-4j ES 7. 10 m downslope T 8, depth 0–3 cm TCS 7A	Clayey$_{5}$-silty$_{17}$-sandy$_{34}$ gravel$_{44}$ Si + cl = 22	LL 27 PL 20 PI 7	2.65
61-8-4k ES 7. 10 m downslope T 8, depth 15–25 cm TCS 7A	Sandy$_{22}$-clayey$_{23}$ gravel$_{27}$-silt$_{28}$ Si + cl = 51	LL 20 PL 14 PI 6	2.73

(continued)

Experimental site 7 (continued)

Specimen Number and Location	Designation (and Silt + Clay Percentage)	Liquid Limit (LL) Plastic Limit (PL) Plasticity Index (PI = LL-PL) In percent moisture (w)	Specific Gravity
61-8-4l ES 7. 10 m downslope T 8, depth 35–45 cm TCS 7A	Clayey$_{15}$-sandy$_{26}$-gravelly$_{26}$ silt$_{33}$ Si + cl = 48	LL 16 PL 11 PI 5	2.71
61-8-4m ES 7. 10 m downslope T 8, depth 55–65 cm TCS 7A	Gravelly$_{12}$-clayey$_{20}$-sandy$_{30}$ silt$_{38}$ Si + cl = 58 (Sand-size shell ? fragment)	LL 16 PL 13 PI 3	2.72
61-8-4n ES 7. 10 m downslope T 8, depth 75–85 cm TCS 7A	Clayey$_{15}$-gravelly$_{19}$ silt$_{32}$-sand$_{34}$ Si + cl = 47	LL 15 PL 11 PI 4	2.71
61-8-4o ES 7. 10 m downslope T 8, depth 95–105 cm TCS 7A	Clayey$_{18}$-gravelly$_{20}$ sand$_{31}$-silt$_{31}$ Si + cl = 49 (3 large pebbles excl.) Clayey$_{12}$-sandy$_{19}$-silty$_{20}$ gravel$_{49}$ Si + cl = 32 (3 large pebbles incl.)	LL 16 PL 12 PI 4	2.72
61-8-4p ES 7. 10 m downslope T 8, depth 115–125 cm TCS 7A	Gravelly$_{16}$-clayey$_{20}$ silt$_{32}$-sand$_{32}$ Si + cl = 52	LL 16 PL 12 PI 4	2.72
61-8-4q ES 7. 10 m downslope T 8, depth 135–140 cm TCS 7A	Clayey$_{17}$-silty$_{24}$-sandy$_{26}$ gravel$_{33}$ Si + cl = 41	LL 17 PL 12 PI 5	2.71
60-8-16p ES 7. 8 m downslope T 23-24, depth 1 cm	Clayey$_{12}$-gravelly$_{14}$-silty$_{27}$ sand$_{47}$ Si + cl = 39	LL 26 PL 22 PI 4	2.63
60-8-16q ES 7. 8 m downslope T 23-24, depth 5 cm	Gravelly$_{14}$-clayey$_{15}$ sand$_{35}$-silt$_{36}$ Si + cl = 51	LL 20 PL 15 PI 5	2.70
60-8-16r ES 7. 8 m downslope T 23-24, depth 10 cm	Gravelly$_{14}$-clayey$_{21}$ silt$_{31}$-sand$_{34}$ Si + cl = 52	LL 22 PL 13 PI 9	2.71

(continued)

Experimental site 7 (continued)

Specimen Number and Location	Designation (and Silt + Clay Percentage)	Liquid Limit (LL) Plastic Limit (PL) Plasticity Index (IP = LL-PL) In percent moisture (w)	Specific Gravity
60-8-16s ES 7. 8 m downslope T 23-24, depth 20 cm	Clayey$_{15}$-gravelly$_{18}$ sand$_{33}$-silt$_{34}$ Si + cl = 49	LL 16 PL 12 PI 4	2.71
60-8-16f ES 7. 5 m downslope T 27-29, depth 1 cm	Gravelly$_{20}$-silty$_{29}$ sand$_{49}$ Si + cl = 31	Nonplastic	2.55
60-8-16g ES 7. 5 m downslope T 27-29, depth 5 cm	Clayey$_{5}$-silty$_{18}$-sandy$_{30}$ gravel$_{47}$ Si + cl = 23	LL 19 PL 16 PI 3	2.67
60-8-16h ES 7. 5 m downslope T 27–29, depth 10 cm	Clayey$_{6}$-silty$_{25}$-gravelly$_{30}$ sand$_{39}$ Si + cl = 31	LL 18 PL 14 PI 4	2.66
60-8-16i ES 7. 5 m downslope T 27-29, depth 20 cm	Clayey$_{7}$-silty$_{19}$-sandy$_{23}$ gravel$_{51}$ Si + cl = 26	LL 19 PL 16 PI 3	2.67
60-8-16j ES 7. 5 m downslope T 27-29, depth 40 cm	Clayey$_{14}$-gravelly$_{18}$-silty$_{31}$ sand$_{38}$ Si + cl = 45	LL 16 PL 13 PI 3	2.69
61-7-24f ES 7. 5 m downslope T 27-29, depth 45–50 cm	Clayey$_{13}$-gravelly$_{19}$ silt$_{32}$-sand$_{36}$ Si + cl = 45	LL 16 PL 13 PI 3	2.70
61-8-7a ES 7. 28 m downslope T 31, depth 0–3 cm TCS 7B	Clayey$_{6}$-sandy$_{43}$ silt$_{51}$ Si + cl = 57	High organic content	
61-8-7b ES 7. 28 m downslope T 31, depth 15–25 cm TCS 7B	Clayey$_{8}$-gravelly$_{28}$-silty$_{28}$ sand$_{36}$ Si + cl = 36	LL 20 PL 15 PI 5	2.68
61-8-7c ES 7. 28 m downslope T 31, depth 35–45 cm TCS 7B	Clayey$_{12}$-gravelly$_{24}$ silt$_{31}$-sand$_{33}$ Si + cl = 43	LL 15 PL 10 PI 5	2.71

(continued)

Experimental site 7 (continued)

Specimen Number and Location	Designation (and Silt + Clay Percentage)	Liquid Limit (LL) Plastic Limit (PL) Plasticity Index (PI = LL-PL) In percent moisture (w)	Specific Gravity
61-8-7 d ES 7. 28 m downslope T 31, depth 55–65 cm TCS 7 B	Clayey$_{10}$-sandy$_{28}$ gravel$_{31}$-silt$_{31}$ Si + cl = 41	LL 15 PL 11 PI 4	2.71
61-8-7 e ES 7. 28 m downslope T 31, depth 75–85 cm TCS 7 B	Clayey$_{8}$-gravelly$_{26}$ sand$_{32}$-silt$_{34}$ Si + cl = 42	LL 14 PL 11 PI 3	2.71
61-8-7 f ES 7. 28 m downslope T 31, depth 95–105 cm TCS 7 B	Clayey$_{8}$-gravelly$_{14}$ silt$_{38}$-sand$_{40}$ Si + cl = 46	LL 16 PL 11 PI 5	2.70
61-8-7 g ES 7. 28 m downslope T 31, depth 115–125 cm TCS 7 B	Clayey$_{12}$-gravelly$_{19}$ silt$_{34}$-sand$_{35}$ Si + cl = 46	LL 15 PL 12 PI 3	2.71
60-8-16 k ES 7. 5 m downslope T 34-35, depth 1 cm	Sandy$_{40}$ silt$_{56}$ Si + cl = 60	Nonplastic (Organic matter)	2.63 ?
60-8-16 l ES 7. 5 m downslope T 34–35, depth 5 cm	Gravelly$_{10}$-clayey$_{18}$-sandy$_{20}$ silt$_{51}$ Si + cl = 69	LL 39 PL 32 PI 7	2.62
60-8-22 a ES 7. 5 m downslope T 34-35, depth 10 cm	Clayey$_{12}$-sandy$_{30}$ silt$_{58}$ Si + cl = 70	Nonplastic	2.66
60-8-22 b ES 7. 5 m downslope T 34-35, depth 20 cm	Sandy$_{10}$-silty$_{35}$ clay$_{55}$ Si + cl = 90	LL 39 PL 26 PI 13	2.63
60-8-22 c ES 7. 5 m downslope T 34-35, depth 40 cm	Clayey$_{5}$-silty$_{24}$-gravelly$_{32}$ sand$_{39}$ Si + cl = 29	LL 16 PL 15 PI 1	2.69
61-7-24 g ES 7. 5 m downslope T 34-35, depth 50 cm	Clayey$_{6}$-gravelly$_{22}$-silty$_{26}$ sand$_{46}$ Si + cl = 32	LL 17 PL 15 PI 2	2.63

Table D III. *Experimental site 8. Summary of grain-size analyses, Atterberg limits, and specific gravity determinations*

Specimen Number and Location	Designation (and Silt + Clay Percentage)	Liquid Limit (LL) Plastic Limit (PL) Plasticity Index (PI = LL-PL) In percent moisture (w)	Specific Gravity
	Along Target Line 8		
63-15 ES 8 T 4, depth 10 cm	Gravelly$_{15}$-clayey$_{20}$ silt$_{32}$-sand$_{33}$ Si + cl = 52	LL 20 PL 16 PI 4	
63-16 ES 8 T 4, depth 20 cm	Gravelly$_{14}$-clayey$_{24}$-sandy$_{25}$ silt$_{37}$ Si + cl = 61	LL 18 PL 13 PI 5	
63-17 ES 8 T 10, depth 10 cm	Gravelly$_{14}$-clayey$_{15}$ sand$_{34}$-silt$_{37}$ Si + cl = 52	LL 15 PL 13 PI 2	
63-18 ES 8 T 10, depth 20 cm	Gravelly$_{14}$-clayey$_{16}$-sandy$_{31}$ silt$_{39}$ Si + cl = 55	LL 15 PL 14 PI 1	
63-19 ES 8 T 15, depth 10 cm	Gravelly$_{14}$-clayey$_{17}$ silt$_{34}$-sand$_{35}$ Si + cl = 51	LL 20 PL 15 PI 5	
63-20 ES 8 T 15, depth 20 cm	Gravelly$_{13}$-clayey$_{19}$ silt$_{33}$-sand$_{35}$ Si + cl = 52	LL 17 PL 12 PI 5	
63-21 ES 8 T 20, depth 10 cm	Gravelly$_{9}$-clayey$_{11}$-sandy$_{33}$ silt$_{47}$ Si + cl = 58	LL 20 PL 16 PI 4	
63-22 ES 8 T 20, depth 20 cm	Clayey$_{9}$-gravelly$_{24}$ silt$_{33}$-sand$_{34}$ Si + cl = 42	LL 18 PL 14 PI 4	
63-23 ES 8 T 25, depth 10 cm	Clayey$_{10}$-gravelly$_{18}$-silty$_{31}$ sand$_{41}$ Si + cl = 41	LL 32 PL 25 PI 7	
63-24 ES 8 T 25, depth 20 cm	Gravelly$_{10}$-clayey$_{14}$-silty$_{35}$ sand$_{41}$ Si + cl = 49	LL 17 PL 13 PI 4	

(continued)

Experimental site 8 (continued)

Specimen Number and Location	Designation (and Silt + Clay Percentage)	Liquid Limit (LL) Plastic Limit (PL) Plasticity Index (PI = LL-PL) In percent moisture (w)	Specific Gravity
63-25 ES 8 T 30, depth 10 cm	Clayey$_{10}$-gravelly$_{14}$-silty$_{35}$ sand$_{40}$ Si + cl = 45	LL 17 PL 16 PI 1	
63–26 ES 8 T 30, depth 20 cm	Gravelly$_{9}$-clayey$_{11}$-silty$_{37}$ sand$_{43}$ Si + cl = 48	LL 22 PL 19 PI 3	
63-27 ES 8 T 34, depth 10 cm	Clayey$_{10}$-gravelly$_{16}$-silty$_{24}$ sand$_{50}$ Si + cl = 34	LL 13 PL 13 PI 0	
63-28 ES 8 T 34, depth 20 cm	Clayey$_{9}$-gravelly$_{19}$-silty$_{23}$ sand$_{49}$ Si + cl = 32	LL 12 PL 11 PI 1	
	Near Target Line 8		
60-8-21 a ES 8. 1 m downslope T 3, depth 1–20 cm TG 8 B	Clayey$_{17}$-sandy$_{23}$-silty$_{24}$ gravel$_{36}$ Si + cl = 41	LL 20 PL 15 PI 5	2.68
60-8-15 a ES 8. 5 m downslope T 4-6, depth 1 cm	Silty$_{13}$-sandy$_{20}$ gravel$_{62}$ Si + cl = 18	LL 17 PL 13 PI 4	2.69
60-8-15 b ES 8. 5 m downslope T 4-6, depth 5 cm	Clayey$_{16}$-gravelly$_{19}$-silty$_{28}$ sand$_{37}$ Si + cl = 44	LL 21 PL 14 PI 7	2.70
60-8-15 c ES 8. 5 m downslope T 4-6, depth 10 cm	Clayey$_{13}$-gravelly$_{26}$ silt$_{29}$-sand$_{33}$ Si + cl = 42	LL 16 PL 12 PI 4	2.71
60-8-15 d ES 8. 5 m downslope T 4-6, depth 20 cm	Clayey$_{12}$-silty$_{27}$ gravel$_{31}$-sand$_{31}$ Si + cl = 39	LL 15 PL 12 PI 3	2.65
61-7-24 a ES 8. 5 m downslope T 4-6, depth 20 cm	Clayey$_{17}$-gravelly$_{22}$ sand$_{29}$-silt$_{32}$ Si + cl = 49	LL 17 PL 12 PI 5	2.71

(continued)

Experimental site 8 (continued)

Specimen Number and Location	Designation (and Silt + Clay Percentage)	Liquid Limit (LL) Plastic Limit (PL) Plasticity Index (PI = LL-PL) In percent moisture (w)	Specific Gravity
60-8-15 e ES 8. 5 m downslope T 4-6, depth 50 cm	Clayey$_{17}$-gravelly$_{19}$ silt$_{30}$-sand$_{34}$ Si + cl = 47	LL 17 PL 11 PI 6	2.71
61-8-2 a ES 8. 10 m downslope T 6, depth 1 cm TCS 8 A	Clayey$_{9}$-silty$_{23}$-sandy$_{26}$ gravel$_{42}$ Si + cl = 32	LL 18 PL 13 PI 5	2.70
61-8-2 b ES 8. 10 m downslope T 6, depth 15–25 cm TCS 8 A	Clayey$_{13}$-sandy$_{27}$ silt$_{28}$-gravel$_{32}$ Si + cl = 41	LL 17 PL 13 PI 4	2.71
4-9-61 a ES 8. 10 m downslope T 6, depth 0–16 cm TCS 8 A	Cf. 61-8-2 a and 61-8-2 b	*In-situ* dry density 1.78 gm/cm^3	
4-9-61 f ES 8. 10 m downslope T 6, depth 16–33 cm TCS 8 A	Cf. 61-8-2 b	*In-situ* dry density 1.84 gm/cm^3	
61-8-2 c ES 8. 10 m downslope T 6, depth 35–45 cm TCS 8 A	Gravelly$_{15}$-clayey$_{18}$ sand$_{33}$-silt$_{34}$ Si + cl = 52	LL 19 PL 14 PI 5	2.71
4-9-61 g ES 8. 10 m downslope T 6, depth 38–55 cm TCS 8 A	Cf. 61-8-2 c	*In-situ* dry density 1.87 gm/cm^3	
61-8-2 d ES 8. 10 m downslope T 6, depth 75–85 cm TCS 8 A	Clayey$_{20}$-gravelly$_{21}$-sandy$_{25}$ silt$_{34}$ Si + cl = 54	LL 19 PL 15 PI 4	2.72
61-8-2 e ES 8. 10 m downslope T 6, depth 95–102 cm TCS 8 A	Sandy$_{7}$-silty$_{41}$ clay$_{48}$ Si + cl = 89	LL 25 PL 20 PI 5	2.75

(continued)

Experimental site 8 (continued)

Specimen Number and Location	Designation (and Silt + Clay Percentage)	Liquid Limit (LL) Plastic Limit (PL) Plasticity Index (PI = LL-PL) In percent moisture (w)	Specific Gravity
61-8-2f ES 8. 10 m downslope T 6, depth 115–125 cm TCS 8A	Sandy$_{12}$-silty$_{39}$ clay$_{45}$ Si + cl = 84	LL 26 PL 19 PI 7	2.74
61-8-2g ES 8. 10 m downslope T 6, depth 135–145 cm TCS 8A	Sandy$_{14}$-clayey$_{25}$ silt$_{58}$ Si + cl = 83	LL 20 PL 15 PI 5	2.73
61-8-2h ES 8. 10 m downslope T 6, depth 155–165 cm TCS 8A	Gravelly$_{10}$-sandy$_{21}$-clayey$_{25}$ silt$_{44}$ Si + cl = 69	LL 19 PL 15 PI 4	2.73
61-8-2i ES 8. 10 m downslope T 6, depth 170–180 cm TCS 8A	Clayey$_{17}$-silty$_{25}$ gravel$_{27}$-sand$_{31}$ Si + cl = 42	LL 18 PL 14 PI 4	2.73
61-8-2j ES 8. 10 m downslope T 6, "Silty streaks" depth 80–120 cm TCS 8A	Sandy$_{22}$-clayey$_{24}$ silt$_{50}$ Si + cl = 74	LL 19 PL 14 PI 5	2.73
60-8-15f ES 8. 5 m downslope T 19-22, depth 1 cm	Silty$_{23}$-gravelly$_{35}$ sand$_{40}$ Si + cl = 25	Nonplastic	2.53
60-8-15g ES 8. 5 m downslope T 19-22, depth 5 cm	Silty$_{44}$ sand$_{49}$ Si + cl = 48	Nonplastic	2.54
60-8-15h ES 8. 5 m downslope T 19-22, depth 10 cm	Gravelly$_{8}$-clayey$_{8}$-sand$_{36}$ silt$_{48}$ Si + cl = 56	LL 18 PL 18 PI 0	2.62
60-8-15j ES 8. 5 m downslope T 19-22, depth 50 cm	Clayey$_{11}$-gravelly$_{20}$-silty$_{30}$ sand$_{39}$ Si + cl = 41	LL 14 PL 10 PI 4	2.69

(continued)

Experimental site 8 (continued)

Specimen Number and Location	Designation (and Silt + Clay Percentage)	Liquid Limit (LL) Plastic Limit (PL) Plasticity Index (PI = LL-PL) In percent moisture (w)	Specific Gravity
60-8-15k ES 8. 5 m downslope T 24, depth 1 cm	Largely matted vegetation		
61-7-24b ES 8. 5 m downslope T 24, depth 5 cm	Gravelly$_8$-clayey$_8$-sandy$_{36}$ silt$_{48}$ Si + cl = 56. "Organic silt"	LL 51	2.57
60-8-15m ES 8. 5 m downslope T 24, depth 10 cm	Clayey$_{10}$-gravelly$_{22}$-silty$_{30}$ sand$_{38}$ Si + cl = 40		
61-7-24c ES 8. 5 m downslope T 24, depth 10 cm	Clayey$_9$-gravelly$_{22}$ silt$_{33}$-sand$_{36}$ Si + cl = 42	LL 22 PL 18 PI 4	2.66
60-8-15n ES 8. 5 m downslope T 24, depth 20 cm	Clayey$_9$-silty$_{17}$-sandy$_{23}$ gravel$_{51}$ Si + cl = 26	LL 17 PL 13 PI 4	2.68
60-8-15o ES 8. 5 m downslope T 24, depth 50 cm	Clayey$_{14}$-gravelly$_{22}$ sand$_{32}$-silt$_{32}$ Si + cl = 46	LL 16 PL 13 PI 3	2.70
61-8-4a ES 8, 13 m downslope T 27, depth 1 cm TCS 8B	Clayey$_8$-gravelly$_{18}$-silty$_{29}$ sand$_{45}$ Si + cl = 37	High organic content	
61-8-4b ES 8, 13 m downslope T 27, depth 15–25 cm TCS 8B	Gravelly$_{12}$-clayey$_{19}$ silt$_{33}$-sand$_{36}$ Si + cl = 52	LL 17 PL 13 PI 4	2.71
4-9-61b ES 8, 13 m downslope T 27, depth 0–23 cm TCS 8B	Cf. 61-8-4a and 61-8-4b	*In-situ* dry density 1.54 gm/cm^3	
61-8-4c ES 8. 13 m downslope T 27, depth 35–45 cm TCS 8B	Clayey$_{13}$-silty$_{29}$ gravel$_{29}$-sand$_{29}$ Si + cl = 42	LL 17 PL 13 PI 4	2.71

(continued)

Experimental site 8 (continued)

Specimen Number and Location	Designation (and Silt + Clay Percentage)	Liquid Limit (LL) Plastic Limit (PL) Plasticity Index (PI = LL-PL) In percent moisture (w)	Specific Gravity
4-9-61 c ES 8. 13 m downslope T 27, depth 25–41 cm TCS 8 B	Cf. 4-9-61 b and 61-8-4 c	*In-situ* dry density 2.0 gm/cm^3	
61-8-4 d ES 8. 13 m downslope T 27, depth 55–65 cm TCS 8 B	Clayey$_{15}$-gravelly$_{21}$ silt$_{32}$-sand$_{32}$ Si + cl = 47	LL 16 PL 13 PI 3	2.71
4-9-61 d ES 8. 13 m downslope T 27, depth 46–61 cm TCS 8 B	Cf. 61-8-4 c and 61-8-4 d	*In-situ* dry density 2.0 gm/cm^3	
61-8-4 e ES 8. 13 m downslope T 27, depth 75–85 cm TCS 8 B	Clayey$_{11}$-silty$_{27}$-gravelly$_{28}$ sand$_{34}$ Si + cl = 38	LL 15 PL 12 PI 3	2.71
4-9-61 e ES 8, 13 m downslope T 27, depth 65–81 cm TCS 8 B	Cf. 61-8-4 d and 61-8-4 e	*In-situ* dry density 2.14 gm/cm^3	
61-8-4 f ES 8. 13 m downslope T 27, depth 95–105 cm TCS 8 B	Clayey$_{12}$-gravelly$_{14}$ silt$_{37}$-sand$_{37}$ Si + cl = 49	LL 17 PL 13 PI 4	2.70
61-8-4 g ES 8. 13 m downslope T 27, depth 100 cm TCS 8 B	Gravelly$_{7}$-sandy$_{27}$ clay$_{31}$-silt$_{35}$ Si + cl = 66	LL 21 PL 16 PI 5	2.73
61-8-4 h ES 8. 13 m downslope T 27, depth 115–125 cm TCS 8 B	Clayey$_{12}$-gravelly$_{13}$ sand$_{37}$-silt$_{38}$ Si + cl = 50	LL 17 PL 13 PI 4	2.70
61-8-4 i ES 8. 13 m downslope T 27, depth 130–140 cm TCS 8 B	Clayey$_{15}$-gravelly$_{21}$ silt$_{30}$-sand$_{34}$ Si + cl = 45	LL 16 PL 12 PI 4	2.71

Table D IV. *Experimental site 15. Summary of grain-size analyses, Atterberg limits, and specific gravity determinations*

Specimen Number and Location	Designation (and Silt + Clay Percentage)	Liquid Limit (LL) Plastic Limit (PL) Plasticity Index (PI = LL-PL) In percent moisture (w)	Specific Gravity
63-29	Clayey$_{12}$-gravelly$_{13}$-sandy$_{34}$ silt$_{41}$	LL 17	
ES 15		PL 11	
Central area of tread, depth 5 cm	Si + cl = 53	PI 6	
63-30	Clayey$_{5}$-gravelly$_{6}$-sandy$_{40}$ silt$_{49}$	LL 15	
ES 15		PL 12	
Central area of tread, depth 10 cm	Si + cl = 54	PI 3	
63-31	Gravelly$_{23}$-sandy$_{33}$ silt$_{41}$	LL 17	
ES 15		PL 12	
Central area of front, depth 5 cm	Si + cl = 44	PI 5	
63-32	Clayey$_{6}$-gravelly$_{15}$ sand$_{38}$-silt$_{41}$	LL 15	
ES 15		PL 11	
Central area of front, depth 10 cm	Si + cl = 47	PI 4	

Table D V. *Experimental site 16. Summary of grain-size analyses, Atterberg limits, and specific gravity determinations*

Specimen Number and Location	Designation (and Silt + Clay Percentage)	Liquid Limit (LL) Plastic Limit (PL) Plasticity Index (PI = LL-PL) In percent moisture (w)	Specific Gravity
60-8-16 t ES 16. 1 m downslope target line near center, depth 1 cm	Sandy$_{43}$ gravel$_{56}$ Si + cl = 1	Nonplastic	
60-8-16 u ES 16. 1 m downslope target line near center, depth 5 cm	Silty$_{6}$-gravelly$_{27}$ sand$_{66}$ Si + cl = 7	Nonplastic	2.96
60-8-16 v ES 16. 1 m downslope target line near center, depth 10 cm	Silty$_{13}$-gravelly$_{18}$ sand$_{67}$ Si + cl = 15	Nonplastic	2.88 ?
60-8-16 w ES 16. 1 m downslope target line near center, depth 20 cm	Silty$_{7}$-gravelly$_{21}$ sand$_{71}$ Si + cl = 8	Nonplastic	2.95
61-7-24 d ES 16. 1 m downslope target line near center, depth 20 cm	Gravelly$_{30}$ sand$_{68}$ Si + cl = 2	Nonplastic	3.03 ?
60-8-16 x ES 16. 1 m downslope target line near center, depth 50 cm	Gravelly$_{25}$ sand$_{73}$ Si + cl = 2	Nonplastic	
60-5-26 b ES 16. Vicinity Needle-ice-fluffed grus surface within ca. 50 m of ES 16, depth 0–5 cm	Silty$_{12}$-gravelly$_{19}$ sand$_{66}$ Si + cl = 15		

Table D VI. *Experimental site 17. Summary of grain-size analyses, Atterberg limits, and specific gravity determinations*

Specimen Number and Location	Designation (and Silt + Clay Percentage)	Liquid Limit (LL) Plastic Limit (PL) Plasticity Index (PI = LL-PL) In percent moisture (w)	Specific Gravity
61-8-17a ES 17. 2 m downslope T 14, depth 1 cm	Clayey$_5$-silty$_{19}$-gravelly$_{35}$ sand$_{41}$ Si + cl = 24	LL 19 PL 15 PI 4	2.74
61-8-17b ES 17. 2 m downslope T 14, depth 5 cm	Clayey$_7$-gravelly$_{18}$-silty$_{27}$ sand$_{48}$ Si + cl = 34	LL 19 PL 14 PI 5	2.74
61-8-17c ES 17. 2 m downslope T 14, depth 10 cm	Clayey$_7$-gravelly$_{24}$-silty$_{26}$ sand$_{43}$ Si + cl = 33	LL 20 PL 16 PI 4	2.74
61-8-17d ES 17. 2 m downslope T 14, depth 20 cm	Clayey$_6$-silty$_{25}$ gravel$_{33}$-sand$_{36}$ Si + cl = 31	LL 19 PL 15 PI 4	2.76
61-8-17e ES 17. 2 m downslope T 14, depth 40–45 cm	Clayey$_7$-silty$_{26}$-gravelly$_{30}$ sand$_{37}$ Si + cl = 33	LL 19 PL 15 PI 4	2.76

Appendix E.

TEMPERATURE AND RELATED OBSERVATIONS

CONTENTS

General

Meteorological data for Mesters Vig, based on observations of the Danish Government station, are given in Washburn (1965, tables 1–2, p. 46–53). The precipitation values and daily temperature extremes for May to October, 1956–61, are plotted as background information on the target movement graphs (app. C).

The instrumentation used for supplementary temperature observations at the experimental sites (tables E I–E IV) is described below.

Thermocouple Strings and Pyrometer-Potentiometer

The thermocouple strings and pyrometer-potentiometer were manufactured by the Thermo Electric Co., Inc. of Saddle Brook, New Jersey. The strings consisted of copper-constantan thermocouples incased in plastic and generally spaced every 10 cm except for a 5-cm interval near the surface in some strings. Several strings showed a slight departure from the 10-cm spacing and several had to be joined to reach the bottom of augur holes; as a result there was a variation in thermocouple spacing in some strings. Spacings as measured in the field are indicated in connection with the thermocouple observations (tables E I–E IV). All strings were confined to the active layer and most reached nearly to the permafrost table. An unanticipated difficulty was that a number of thermocouple leads were broken, probably by geese that were apparently attracted by the grasslike aspect of the leads or by their plastic covering. Destruction of leads accounts for the omission of readings at certain depths in some strings.

The pyrometer-potentiometer used in 1956 and early in 1957 was a specially developed, compact and lightweight unit designed to read temperature directly to 0.2°, with estimates to 0.1°, over a temperature range of $-20°$ to $+20°$. A thermistor was used as a temperature compensator in a compensating network, and the instrument was zeroed by means of a galvanometer light beam; this arrangement was sensitive to tilt and turned out to be unsatisfactory for field use. In order to assure acceptable results, repeated series of readings were made, generally with check readings against two laboratory mercury thermometers having 0.2° divisions and permitting estimates to 0.1°.

A much-improved model of similar size but much less sensitive to tilt was used during most of the 1957 season. It was powered by mercury cells, could be read directly to 0.1°, and was adapted for use either with or without an ice bath as a reference junction. After minor modifications by the Thermo Electric Co., the same instrument was used during the subsequent program years. In the field all readings with the 1957 model were referenced to an ice bath.

Accepted thermocouple readings are shown in tables E I–E IV. Many are based on successive series of readings of the same string within a few tens of minutes of each other, the series reproducing readings to within 0.1°–0.2°. Where the series seemed equally reliable and showed discrepancies of this order of magnitude, the series were averaged. Where a series showed a difference of 0.1° to 0.2° between initial and final check readings, the difference was distributed between the thermocouples of that string. In general any readings that checks indicated might be in error by more than 0.2° were eliminated. Thus, all tabulated thermocouple readings are believed to be accurate to $\pm 0.2°$ and many of them to $\pm 0.1°$. The temperature difference between successive thermocouples in any one string is probably reliable to 0.1°, since the determination of differences of temperature between thermocouples is subject to less error than the determination of the actual temperature.

Some thermocouple strings were frost heaved with time, as determined by excavation 5 years after their installation, and the changes have been allowed for in discussing the data. The greatest discrepancies were at TCS 7 B and TCS 8 B where they were up to 17.5 cm and 14.0 cm, respectively. TCS 6 B and TCS 7 C–7 E were not excavated, but at least the earliest readings at TCS 6 B are regarded as meaningful. Since the readings at TCS 7 C–7 E were made in the same year that the strings were installed, they are also believed to be reasonably representative for the indicated depths.

Thermographs

The air thermograph used was a Casella model conforming to British weather service standards. It was operated by an 8-day clock mechanism and the charts could be read directly to 2° and estimated to 0.5°. The instrument was calibrated in the field by comparison with laboratory thermometers reading to 0.2°.

Soil (or "distance") thermographs of two types were employed, both manufactured by the Belfort Instrument Company of Baltimore, Maryland, and differing mainly in having either one sensing bulb and recording pen (cat. no. 5–1100) or two bulbs and pens (cat. no. 5–1135). The sensing bulbs, buried at different depths in the ground, were tubes 37 cm long and 2.5 cm in diameter; they were filled with a liquid hydrocarbon and connected to the recorder by a 3-m long capillary element armored with flexible wire mesh. Units were temperature-compensated so that only the bulb temperature controlled the pen. The recorder was similar to that of the air thermograph in being an 8-day clock mechanism. The charts, scaled in degrees Fahrenheit, could be read directly to about 0.5° (1°F) and estimated to 0.3° (0.5°F). Calibration was carried out by inserting the tubes in an ice bath. Initially this was done at "Camp Tahoe" but experience showed that jarring of the instruments during transport to the site of installation could affect the calibration. They were therefore recalibrated at the sites, and in all cases of continued operation at the same location the tubes were replaced in their identical former positions. Adjustments to temperature records as the result of such recalibration could be commonly confirmed by the near constant temperature curve at about 0° during certain intervals of freezing or thawing. The observational data are given in tables B I and B II.

APPENDIX F.

MOISTURE DETERMINATIONS

CONTENTS

General

The moisture determinations, except those indicated in parentheses, were made by Mr. JAMES ALLISON at the School of Engineering at Dartmouth College and by Mr. JOHN SCULLY at the School of Civil Engineering at Purdue University. The specimens were collected in water-tight vials and weighed within a matter of hours. The subsequent laboratory work was then carried out at leisure according to normal procedures. The determinations in parentheses are regarded as less precise than the others; some of them were made in the field by desiccating the specimens in burning alcohol. Determinations marked with an asterisk refer to specimens that were still frozen when collected.

The observations suffer from discontinuity in time and space. Aside from being time consuming and having to compete with other investigations, the sampling procedure, because of disturbance, precluded observations very close to target lines or at exactly the same locations. The availability of *in-situ* recording equipment would have greatly facilitated the program.

Table F I. *Experimental site 6. Moisture determinations*

Percent Water Expressed as $w = \frac{\text{Wt of Water}}{\text{Wt of Solids}}$ and $m = \frac{\text{Wt of Water}}{\text{Wt of Water and Solids}}$

	1958 30 July		1961 13 July		7 Aug	
	w	m	w	m	w	m
10 m downslope						
T 15–17						
Vicinity TCS 7 A						
Surface	..	..	252	72	38	28
Depth 5 cm.......	..	..	240	71	29	22
10	..	..	36	27	18	15
20	..	..	13	12	32	25
50	..	..	7	6	8	8
5 m downslope						
T 17–18						
Surface	(353)	(78)	..	..	..	..
Depth 10 cm.......	(18)	(15)	..	..	..	..
20	(20)	(16)	..	..	..	..
5 m downslope						
T 36–37						
Surface	(244)	(72)	..	..	..	..
Depth 10 cm.......	(23)	(19)	..	..	..	..
20	(27)	(21)	..	..	..	..

Table F II. *Experimental site 7. Moisture determinations*

Percent Water Expressed as $w = \frac{\text{Wt of Water}}{\text{Wt of Solids}}$ and $m = \frac{\text{Wt of Water}}{\text{Wt of Water and Solids}}$

	1957					
	4 July		29 July		2 Sept	
	w	m	w	m	w	m
10 m downslope						
T 6–8						
Vicinity TCS 7A						
Surface	(4)	(4)	(4)	(4)	..	..
Depth 5 cm	..	..	..	..	..	..
10	..	..	..	..	..	..
20	..	..	..	..	..	..
50	..	..	..	..	..	..
5–10 downslope						
T 13						
Surface	(19)	(16)	(4)	(4)	..	..
Depth 5 cm	..	..	..	..	..	..
10	..	..	..	..	..	..
20	..	..	..	..	..	..
50	..	..	..	..	..	..
28 m downslope						
T 31						
MW 7						
Depth 0– 20 cm	..	..	..	..	(34)	(25)
20– 40	..	..	..	..	(19)	(16)
40– 60	..	..	..	..	(18)	(15)
60– 80	..	..	..	..	(17)	(15)
80–100	..	..	..	..	(17)	(14)
100–120	..	..	..	..	(17)	(14)
120–140	..	..	..	..	(15)	(13)
5–10 m downslope						
T 34–35						
Surface	(137)	(58)	(96)	(49)	..	..
Depth 5 cm	—	—	—	—	..	..
10	—	—	—	—	..	..
20	—	—	—	—	..	..
50	—	—	—	—	..	..

(continued)

Experimental site 7 (continued)

	1958									
	13 July		28 July		15 Aug		30 Aug		19 Sept	
	w	m	w	m	w	m	w	m	w	m
5 m east rod										
Surface	1	1	..	..	..	..	..	..	..	..
Depth 10 cm	10	9	..	..	..	..	..	..	..	..
20	11	10	..	..	..	..	..	..	..	..
50	13	11	..	..	..	..	..	..	..	..
100	11	10	..	..	..	..	..	..	..	..
5 m downslope rod										
Surface	..	..	2	2	2	2	3	2	(18)	(15)
Depth 5 cm	..	..	(8)	(8)	—	—	—	—	—	—
10	..	..	(10)	(9)	—	—	—	—	—	—
20	..	..	11	10	11	10	10	9	10	9
50	..	..	(13)	(11)	—	—	—	—	—	—
5–10 m downslope T 13										
Surface	..	..	7	6	..	..	3	3	—	—
Depth 5 cm	..	..	(10)	(9)	..	..	—	—	—	—
10	..	..	9	8	..	..	—	—	—	—
20	..	..	(9)	(9)	..	..	8	7	9	8
50	..	..	(14)	(12)	..	..	—	—	—	—
5 m downslope T 17										
Surface	..	..	..	..	5	5	..	..	..	..
Depth 20 cm	..	..	..	..	10	9	..	..	..	..
5–10 m downslope T 23–25										
Surface	..	..	(86)	(47)	..	..	..	..	..	..
Depth 5 cm	..	..	(48)	(34)	..	..	..	..	..	..
10	..	..	(17)	(15)	..	..	..	..	..	..
20	..	..	(17)	(15)	..	..	..	..	..	..
50	..	..	(17)	(14)	..	..	..	..	..	..
5 m downslope T 27–30										
Surface	20	17	..	..	16	14	21	17	19	16
Depth 5 cm	..	..	..	..	—	—	—	—	—	—
10	..	..	..	..	—	—	—	—	—	—
20	..	..	..	..	(12)	(11)	15	13	(13)	(12)
40–50	..	..	..	..	—	—	—	—	—	—

(continued)

Experimental site 7 (continued)

	1958									
	13 July		28 July		15 Aug		30 Aug		19 Sept	
	w	m	w	m	w	m	w	m	w	m
5–10 m downslope										
T 34–35										
Surface	..	..	..	..	..	..	2	2	..	..
Depth 5 cm.	..	..	..	..	..	..	—	—	..	..
10 .	..	..	..	..	..	..	—	—	..	..
20 .	..	..	..	..	..	..	5	5	..	..
50 .	..	..	..	..	..	..	—	—	..	..
5 m downslope										
T 37										
Surface	..	..	2	2	(5)	(5)	12	11	..	..
Depth 5 cm.	..	..	4	4	—	—	—	—	..	..
10 .	..	..	(6)	(6)	—		—	—	..	..
20 .	..	..	(12)	(11)	11	10	(10)	(9)	..	..

	1960									
	25 June		4 July		30 July		16 Aug		18 Sept	
	w	m	w	m	w	m	w	m	w	m
10 m downslope										
T 6–8										
Vicinity TCS 7A										
Surface	53*	34*	38	27	13	12	8	7	20	16
Depth 5 cm.	28*	21*	38	27	17	15	9	9	14	13
10 .	22*	17*	17	14	13	11	13	12	13	11
20 .	29*	22*	15	13	16	14	10	9	14	13
50 .	—	—	—	—	13	12	10	9	—	—
5–10 m downslope										
T 23–25										
Surface	247*	71*	..	..	..	..	39	28	..	..
Depth 5 cm.	39*	28*	..	..	..	..	13	12	..	..
10 .	18*	15*	..	..	..	..	12	11	..	..
20 .	21*	17*	..	..	..	..	11	10	..	..
50 .	..	..	..	..	..	..	..	..	..	..
5–10 m downslope										
T 34–35										
Surface	84*	46*	..	..	59	37	200	67	61	38
Depth 5 cm.	81*	45*	..	..	37	27	163	62	55	36
10 .	73*	42*	..	..	24	19	50	33	29	22
20 .	67*	40*	..	..	—	—	17	15	22	18
50 .	—	—	..	..	—	—	19	16	—	—

(continued)

Experimental site 7 (continued)

	1961											
	10 June		12 July		24 July		31 July		7 Aug		15 Aug	
	w	m	w	m	w	m	w	m	w	m	w	m
10 m downslope												
T 6–8												
Vicinity TCS 7A												
Surface	37*	27*	3	3	2	2	1	1	7	7	7	6
Depth 5 cm.	21*	17*	11	10	24	20	9	9	5	4	—	—
10 .	16*	14*	10	9	8	8	9	9	12	11	14	13
20 .	16*	14*	11	10	10	9	10	9	10	10	14	13
50 .	—	—	12	11	10	9	13	11	10	9	15	13
5 m downslope												
T 27–30												
Surface	67*	40*	28	22	9	8	5	5	57	36	15	13
Depth 5 cm.	—	—	13	12	12	11	11	10	18	16	14	12
10 .	49*	33*	15	13	12	11	11	10	15	13	15	13
20 .	25*	20*	14	12	9	9	12	11	19	16	15	13
40–50.	—	—	14	13	12	10	7	7	17	15	13	11
5–10 m downslope												
T 34–35												
Surface	106*	91*	174	74	367	79	144	59	—	—	112	53
Depth 5 cm.	70*	41*	46	31	145	59	69	41	52	34	59	37
10 .	65*	39*	50	33	42	29	33	25	15	13	29	22
20 .	86*	46*	18	16	—	—	23	19	33	25	15	13
50 .	—	—	—	—	17	14	6	6	10	9	15	13

Table F III. *Experimental site 8. Moisture determinations*

Percent Water Expressed as $w = \dfrac{\text{Wt of Water}}{\text{Wt of Solids}}$ and $m = \dfrac{\text{Wt of Water}}{\text{Wt of Water and Solids}}$

	1957											
	30 May		31 May		2 June		6 June		4 July		29 July	
	w	m	w	m	w	m	w	m	w	m	w	m
17 m upslope T 2 (beneath 19 cm snow and ice)												
Surface	..	..	..	..	..	..	(16)*	(14)*	..	..	..	..
13 m upslope T 2 (thawed 6 cm, downslope edge snow patch)												
Surface	..	..	..	..	..	..	(27)	(21)	..	..	..	..
23 m upslope T 6 (beneath 22 cm snow and ice)												
Surface	..	..	..	..	..	..	(29)*	(23)*	..	..	..	..
19 m upslope T 6 (thawed 7 cm, downslope edge snow patch)												
Surface	..	..	..	..	..	..	(22)	(18)	..	..	..	..
13 m upslope T 6 (beneath 15 cm snow and ice)												
Surface	..	..	..	..	(34)*	(25)*	..	..	..	..	..	..
11 m upslope T 6 (thawed 3 cm, downslope edge snow patch)												
Surface	..	..	..	..	(32)	(24)	..	..	..	..	..	..
4–5 m downslope T 6												
Surface	(22)	..	(25)	..	..	..	..	..	..	..	..	..

(continued)

Experimental site 8 (continued)

	1957											
	30 May		31 May		2 June		6 June		4 July		29 July	
	w	m	w	m	w	m	w	m	w	m	w	m
26 m upslope T 7 (beneath 22 cm snow and ice)												
Surface	..	..	..	..	..	..	(26)*	(21)*	..	..	..	..
22 m upslope T 7 (thawed 6 cm, downslope edge snow patch)												
Surface	..	..	..	..	..	..	(20)	(17)	..	..	..	..
4–5 m downslope T 7												
Surface	(28)	(22)	(29)	(22)	..	..	..	..	..	..	..	..
11 m downslope T 7 (1 m west TCS 8 A)												
Surface	..	..	..	..	..	..	..	..	(7)	(6)	(6)	(5)
20 m downslope T 7 (beneath 15 cm snow and ice)												
Surface	..	..	(15)	(13)	..	..	..	..	..	..	..	..
21 m downslope T 7 (thawed 5 cm, downslope edge snow patch)												
Surface	..	..	(20)	(16)	..	..	..	..	..	..	..	..
18 m upslope T 8 (beneath 18 cm snow and ice)												
Surface	..	..	..	..	(26)*	(21)*	..	..	..	..	..	..
14 m upslope T 8 (thawed 11 cm, 15 cm downslope from edge snow patch)												
Surface	..	..	..	..	(19)	(16)	..	..	..	..	..	..

(continued)

Experimental site 8 (continued)

	1957											
	30 May		31 May		2 June		6 June		4 July		29 July	
	w	m	w	m	w	m	w	m	w	m	w	m
20 m upslope T 9 (beneath 16 cm snow and ice)												
Surface	..	..	..	..	(44)*	(30)*	..	..	..	..	..	..
16 m upslope T 9 (thawed 11 cm, 10 cm downslope from edge snow patch)												
Surface	..	..	..	..	(25)	(20)	..	..	..	..	..	..
11 m downslope T 11 (10 m west TCS 8A)												
Surface	..	..	..	..	..	..	..	..	(9)	(8)	(6)	(5)
13 m downslope T 28 (1 m west TCS 8B)												
Surface	..	..	..	..	..	..	..	..	(282)	(74)	(39)	(28)

	1958											
	14 July		28 July		15 Aug		30 Aug		16 Sept		19 Sept	
	w	m	w	m	w	m	w	m	w	m	w	m
5 m east MW 8												
Surface	2	2	..	..	..	..	..	..	..	..	..	..
Depth 5 cm	13	12	..	..	..	..	..	..	..	..	..	..
10	12	10	..	..	..	..	..	..	..	..	..	..
20	10	9	..	..	..	..	..	..	..	..	..	..
50	10	9	..	..	..	..	..	..	..	..	..	..
5 m downslope T 1												
Surface	..	..	2	3	3	3	2	2	10	9	..	..
Depth 5 cm	..	..	4	4	—	—	—	—	—	—	..	..
10	..	..	(8)	(7)	—	—	13	11	—	—	..	..
20	..	..	(9)	(8)	11	10	—	—	8	8	..	..
5 m downslope T 11–12												
Surface	..	..	(5)	(4)	5	5	4	4	(17)	(15)	..	..
Depth 5 cm	..	..	9	8	—	—	—	—	—	—	..	..
10	..	..	—	—	—	—	12	11	—	—	..	..
20	..	..	(12)	(11)	7	7	—	—	15	13	..	..
50	..	..	(12)	(11)	—	—	—	—	—	—	..	..

(continued)

Experimental site 8 (continued)

	1958											
	14 July		28 July		15 Aug		30 Aug		16 Sept		19 Sept	
	w	m	w	m	w	m	w	m	w	m	w	m
5 m downslope												
T 23–24												
Surface	..	..	..	..	35	26	23	19	61	38	..	..
Depth 5 cm.	..	..	..	..	—	—	—	—	—	—	..	..
10 .	..	..	..	..	—	—	—	—	—	—	..	..
20 .	..	..	..	..	12	11	11	10	13	11	..	..
50 .	..	..	..	..	—	—	—	—	—	—	..	..
5 m downslope												
T 26–28												
Surface	..	..	(64)	(39)	..	..	..	..	..	..	..	..
Depth 5 cm.	..	..	(16)	(14)	..	..	..	..	..	..	..	..
10 .	..	..	(14)	(12)	..	..	..	..	..	..	..	..
20 .	..	..	(14)	(12)	..	..	..	..	..	..	..	..
50 .	..	..	(13)	(12)	..	..	..	..	..	..	..	..
160 .	..	..	(18)	(15)	..	..	..	..	..	..	..	..
5 m downslope												
T 31–34												
Surface	..	..	5	5	3	3	4	4	..	..	15	13
Depth 5 cm.	..	..	6	6	—	—	—	—	..	..	—	—
10 .	..	..	(11)	(10)	—	—	—	—	..	..	—	—
20 .	..	..	(7)	(7)	11	10	8	8	..	..	9	8
50 .	..	..	15	13	—	—	—	—	..	..	—	—
120 .	..	..	(14)	(12)	—	—	—	—	..	..	—	—

	1960											
	15 June		4 July		30 July		15 Aug		15 Sept		18 Sept	
	w	m	w	m	w	m	w	m	w	m	w	m
5 m downslope												
T 4–6												
Surface	18	15	9	8	10	9	5	5	10	..	16	14
Depth 5 cm.	15	13	13	11	14	13	8	8	10	..	13	11
10 .	16	14	13	11	15	13	8	8	10	..	11	10
20 .	—	—	15	13	13	11	10	9	10	..	13	12
50 .	—	—	—	—	21	18	10	9	—	..	—	—
5 m downslope												
T 19–22												
Surface	95	49	196	66	..	..	218	69	..	..	45	31
Depth 5 cm.	38	28	45	31	..	..	26	20	..	..	23	19
10 .	34	24	54	35	..	..	35	26	..	..	31	24
20 .	—	—	20	17	..	..	14	12	..	..	11	10
50 .	—	—	—	—	..	..	24	19	..	..	—	—

(continued)

Experimental site 8 (continued)

	1960											
	15 June		4 July		30 July		15 Aug		15 sept.		18 Sept	
	w	m	w	m	w	m	w	m	w	m	w	m
5 m downslope T 23–24												
Surface	..	..	..	..	..	..	296	75	..	..	..	..
Depth 5 cm.	..	..	..	..	..	..	35	26	..	..	..	..
10 .	..	..	..	..	..	..	24	19	..	..	..	..
20 .	..	..	..	..	..	..	17	15	..	..	..	..
50 .	..	..	..	..	..	..	18	16	..	..	..	..
5 m downslope T 26–28												
Surface	204	67	206	67	187	65	..	..	..	..	152	60
Depth 5 cm.	—	—	20	17	31	24	..	..	..	..	74	43
10 .	—	—	33	25	51	34	..	..	..	..	33	25
20 .	—	—	—	—	17	15	..	..	..	..	16	13
50 .	—	—	—	—	—	—	..	..	..	..	—	—

	1961									
	12 July		24 July		31 July		7 Aug		15 Aug	
	w	m	w	m	w	m	w	m	w	m
5 m downslope T 4–5										
Surface	7	6	2	2	1	1	6	6	3	2
Depth 5 cm.	10	9	8	7	8	7	8	8	11	10
10 .	11	10	7	7	23	19	17	15	14	13
20 .	12	11	10	9	11	10	22	18	16	14
50 .	19	16	16	14	9	8	13	12	14	12
5 m downslope T 19–22										
Surface	123	55	41	29	25	20	127	56	28	22
Depth 5 cm.	67	40	66	40	11	10	20	17	16	14
10 .	36	26	13	11	13	11	14	12	—	—
20 .	31	23	13	12	14	12	18	16	14	13
50 .	8	7	9	8	13	12	14	12	14	13
5 m downslope T 26–28										
Surface	347	78	193	66	91	48	80	44	54	35
Depth 5 cm.	32	24	57	36	13	12	57	37	16	14
10 .	15	13	51	34	13	11	20	17	16	14
20 .	9	8	13	12	15	13	14	12	22	18
50 .	—	—	—	—	12	10	14	12	14	12
160 .	—	—	—	—	—	—	—	—	—	—

Table F IV. *Experimental site 15. Moisture determinations*

Percent Water Expressed as $w = \frac{\text{Wt of Water}}{\text{Wt of Solids}}$ and $m = \frac{\text{Wt of Water}}{\text{Wt of Water and Solids}}$

	1958								1960			
	9 July		28 July		30 Aug		19 Sept		23 June		10 Aug	
	w	m	w	m	w	m	w	m	w	m	w	m
0.5 m east												
T 23												
Target line 20°												
Surface	15	13	..	..	..	..	..	..	..	..	..	..
2.5 m upslope												
T 24												
Target line 20°												
Surface	..	..	..	..	..	..	..	..	34	25	28	22
1 m downslope												
T 14												
Target line 110°												
Surface	..	..	..	..	..	..	..	..	70	41	169	56
1.5 m upslope												
T 16												
Target line 110°												
Surface	20	17	..	..	..	..	..	..	..	..	..	..
0.5 m upslope												
T 17												
Target line 110°												
Surface	..	..	(21)	(17)	17	15	30	23	..	..	..	..

Table F V. *Experimental site 16. Moisture determinations*

Percent Water Expressed as $w = \frac{\text{Wt of Water}}{\text{Wt of Solids}}$ and $m = \frac{\text{Wt of Water}}{\text{Wt of Water and Solids}}$

	1957		1958		1960					
	15 Aug		9 July		23 June		10 Aug		18 Sept	
	w	m	w	m	w	m	w	m	w	m
Excavation for MW 16										
Depth 0– 3cm	(14)	(12)	..	..	..	..	..	..	..	..
18–22	(3)	(3)	..	..	..	..	..	..	..	..
38–42	(2)	(2)	..	..	..	..	..	..	..	..
69–73	(5)	(5)	..	..	..	..	..	..	..	..
0.5 m west TCS 16										
Surface	..	..	2	1	..	..	..	..	..	..
1–1.5 m downslope MW 16										
Surface	..	..	..	..	0	0	2	2	4	4
Depth 5 cm..	..	..	..	..	0	0	4	4	4	4
10 ..	..	..	..	..	0	0	4	4	3	3
20 ..	..	..	..	..	—	—	—	—	5	5

	1961			
	13 July		24 July	
	w	m	w	m
1–1.5 m downslope MW 16				
Surface	2	2	1	1
Depth 5 cm.....	2	2	1	1
10	3	3	1	1
20	6	6	3	3
50	5	5	4	4

Table F VI. *Experimental site 17. Moisture determinations*

Percent Water Expressed as $w = \frac{\text{Wt of Water}}{\text{Wt of Solids}}$ and $m = \frac{\text{Wt of Water}}{\text{Wt of Water and Solids}}$

	1958 16 July		1960 27 Aug		1961 17 Aug	
	w	m	w	m	w	m
North end post						
Target line 17						
Surface	9	9	..	..	..	..
0.5 m south						
T 2						
Surface	..	..	56	36	..	..
Depth 5 cm	..	..	31	24	..	..
10	..	..	25	20	..	..
8 m downslope						
T 5–6						
Surface	20	17	..	..	..	..
7.5 m upslope						
T 7						
Surface	25	20	..	..	..	..
Depth 10 cm	25	20	..	..	..	..
2 m downslope						
T 13–14						
Surface	8	7	14	12	13	11
Depth 5 cm	—	—	14	12	13	11
10	—	—	16	14	15	13
20	14	12	2	2	18	15
40	—	—	—	—	16	14

Appendix G.
PENETROMETER READINGS

CONTENTS

General

Through the courtesy of the U. S. Air Force Cambridge Research Center and Carlton E. Molineux of that organization, a cone penetrometer was used to measure shear strength of the ground at ES 6–8, 15. The instrument was a standard Vicksburg cone penetrometer having a 30° cone with base area of 0.5 in^2, and equipped with a 150-lb capacity proving ring and dial indicator (Molineux, 1955, p. 11–12; figs. 5–6, p. 13). The dial indicator on the model used was indexed to read penetration resistance in lb/in^2, and it is this resistance (in both kg/cm^2 and lb/in^2) that is given as a measure of shear strength in tables G I–G IV. The unconfined compressive strength in cohesive regolith is about 4 times the penetration resistance, but this correlation is only very rough for material with a plasticity index less than 13 (Waterways Experiment Station, 1948, p. 20; cf. Molineux, 1955, fig. 4, p. 9). Although the Mesters Vig data are essentially restricted to cohesive materials, the plasticity index is characteristically low, ranging from 0 to 13 (app. D), and conversion of penetration resistances to unconfined compressive strengths is therefore omitted in tables G I–G IV.

Table G I. *Experimental site 6. Penetrometer readings*

Location	kg/cm²	lb/in²	1961 12 July Comments and Moisture Determinations w (percent)	
10 m downslope				
T 16				
Depth 0–50 cm	4–7	60–100	Some adjacent places have zones up to 11–14 kg/cm² (150–200 lb/in²) because of gravel	
50–80	3–6	40– 80	Depth to frost 80–90 cm	
			13 July	
			Depth	w
			1– 5 cm	240–352
			10	36
			20	13
			50	7
10 m? downslope				
T 30–35				
Depth 0–50 cm	ca. 3	40	Water covered	
50–90	4–7	60–100	Depth to frost 85–95 cm	

Table G II. *Experimental site 7. Penetrometer readings*

	1960					
	1 Aug			10 Aug		
Location	kg/cm^2	lb/in^2	Comments and Moisture Determinations w (percent)	kg/cm^2	lb/in^2	Comments and Moisture Determinations w (percent)
10 m downslope						
T 6–8						
Depth 0– 5 cm	4	50		7– 11	100– 150	
25	4–6	60– 80		8– 14	120– 200	
50	6–8	80–120		13–> 14	180–> 200	
			30 July			16 Aug
			Depth w			Depth w
			1–5 cm 13–17			1–5 cm 8– 9
			10 13			10 13
			20 16			20 10
			50 13			50 10
5 m downslope						
T 27–30						
Depth 0–5 cm	1	10		1–3	20– 40	
25	3	40		4–6	60– 80	
50	3–4	40–60		7	100	
			30 July			16 Aug
			Depth w			Depth w
			1–5 cm 35–73			1–5 cm 56–118
			10 22			10 20
			20 24			20 15
						50 16
			Gelifluction			
			T 27–28 (10 cm)			
5 m downslope						
T 34–35						
Depth 0–5 cm	1	10		3–4	40–60	
25	6	90		4–6	60–80	
50	5	70		6	80	
			30 July			16 Aug
			Depth w			Depth w
			1–5 cm 17–59			1–5 cm 163–200
			10 24			10 50
						20 17
						50 19
			Gelifluction			
			T 35 (20 cm)			
						Gelifluction
						T35 (20 cm)

(continued)

Experimental site 7 (continued)

Location	1960 20 Aug kg/cm^2	lb/in^2	12 Sept kg/cm^2	lb/in^2
10 m downslope T 6–8				
Depth 0–5 cm	>14	>200	>14	>200
5 m downslope T 27–30				
Depth 0–5 cm	3	40	1– 3	20– 40
25	6– 7	90–100	6– 8	80–120
50	8–10	120–140	10	140
5 m downslope T 34–35				
Depth 0–5 cm	4– 5	50– 70	3– 4	40– 60
25	4– 6	60– 80	4– 6	60– 80
50	6	80– 90	6– 7	80–100

Location	1961 17 June Comments and Moisture Determinations w (percent)	12 July kg/cm^2	lb/in^2	Comments and Moisture Determinations w (percent)	24 July kg/cm^2	lb/in^2	Comments and Moisture Determinations w (percent)
10 m downslope T 6–8							
Depth 0– 5 cm	Snow covered and frozen				>17	>240	Ground too hard to penetrate
0–90		7–14	100–200	Readings >14 kg/cm^2 (>200 lb/in^2) in places because of gravel. Depth to frost 90 cm			
				12 July Depth w 1–5 cm 3–11 10 10 20 11 50 12			24 July Depth w 1–5 cm 2–24 10 8 20 10 50 10

(continued)

Experimental site 7 (continued)

	1961						
	17 June		12 July			24 July	
Location	Comments and Moisture Determinations w (percent)	kg/cm²	lb/in²	Comments and Moisture Determinations w (percent)	kg/cm²	lb/in²	Comments and Moisture Determinations w (percent)
5 m downslope T 27–30							
Depth 0–30 cm	Snow covered and frozen	4– 8	60–120	Gravelly	> 17	> 240	Ground too hard to penetrate
30–80		1	10– 20	Depth to frost 80 cm			
				12 July			24 July
				Depth w			Depth w
				1– 5 cm 13–28			1– 5 cm 9–12
				10 15			10 12
				20 14			20 9
				40–50 14			40–50 12
5 m downslope T 34–35							
Depth 0–20 cm		4	50– 60				
20–40		4–14	60–200				
40–90		3– ?	40– ?	Depth to frost 90–110 cm			
				12 July			
				Depth w			
				1–5 cm 46–174			
				10 50			
				20 18			

Table G III. *Experimental site 8. Penetrometer readings*

	1960					
	1 Aug			10 Aug		
Location	kg/cm^2	lb/in^2	Comments and Moisture Determinations w (percent)	kg/cm^2	lb/in^2	Comments and Moisture Determinations w (percent)
5 m downslope						
T 4–6						
Depth 0–5 cm (veg.)	4	50		6	90	
0–5 (no veg.)	3	40		>14	>200	
25 (veg.)	6–8	90–110				
25 (no veg.)	5	70		8–14	120–200	
50 (veg.)	9–13	130–190				
50 (no veg.)	13	180		>14	>200	
			30 July			15 Aug
			Depth w			Depth w
			1–5 cm 10–14			1–5 cm 5–8
			10 15			10 8
			20 13			20 10
			50 21			50 10
5 m downslope						
T 19–22						
Depth 0–5 cm	1	20		3	40	
25	3–6	40–80		6	80	
50	6	80		6	80	
			Gelifluction			15 Aug
			T 19–20, 22			Depth w
			(10 cm)			1–5 cm 26–218
						10 35
						20 14
						50 24
						Gelifluction T 19–20 (10 cm)
5 m downslope						
T 26–28						
Depth 0–5 cm	1	20		1	20	
25	3–4	40–60		6–11	80–160	Gravelly
50	4–6	60–80		4	60	
			30 July			
			Depth w			
			1–5 cm 31–187			
			10 51			
			20 17			
			Gelifluction T 28 (10 cm)			

(continued)

Experimental site 8 (continued)

Location	1960 20 Aug kg/cm^2	lb/in^2	Comments and Moisture Determinations w (percent)	12 Sept kg/cm^2	lb/in^2
5 m downslope					
T 4–6					
Depth 0–5 cm (no veg.)	> 14	> 200		> 14	> 200
5 m downslope					
T 19–22					
Depth 0–5 cm	4	60		5	70
25	6–8	80–120		5– 8	70–120
50	6–9	90–130		6–11	80–150
5 m downslope					
T 26–28					
Depth 0–5 cm	3	40		3	40
25	6–11	90–150	Gravelly	7	100
50	6	80		6	85

Location	1961 17 June kg/cm^2	lb/in^2	Comments and Moisture Determinations w (percent)	12 July kg/cm^2	lb/in^2	Comments and Moisture Determinations w (percent)
5 m downslope						
T 4–6						
Depth 0–10 cm	3–4	40–60		6–8	80–120	
10–40	2	30	Depth to frost 50 cm			
10–50				4–7	60–100	
50–(70?)				8	120	Depth to frost 70 cm?
			Gelifluction T 6 (10 cm)			12 July Depth w 1–5 cm 7–10 10 11 20 12 50 19

(continued)

Experimental site 8 (continued)

	1961					
	17 June			12 July		
Location	kg/cm²	lb/in²	Comments and Moisture Determinations w (percent)	kg/cm²	lb/in²	Comments and Moisture Determinations w (percent)
5 m downslope T 19–22						
Depth 0– 5 cm				4–7	60–100	
0–40	1–3	20–40	Depth to frost 45 cm			
5–20				3–7	40–100	Gravelly
20–50				3–4	40– 60	
50–80				3–5	40– 70	Depth to frost 70–80 cm
			Gelifluction T 19–20, 22 (10 cm) T 21 (20 cm)			12 July Depth w 1– 5 cm 67–123 10 36 20 31 50 8
5 m downslope T 26–28						
Depth 0– 5 cm	3–4	40–60				
0–20				3–8	40–120	
5–20	3	40				
20–45	2	30	Depth to frost 43 cm			
20–100				3–4	40– 60	Very wet. Depth to frost 80?–100 cm
			Gelifluction T 28 (10 cm)			12 July Depth w 1–5 cm 32–347 10 15 20 9

(continued)

Experimental site 8 (continued)

Location	kg/cm^2	lb/in^2	1961 24 July Comments and Moisture Determinations w (percent)	
5 m downslope				
T 4–6				
Depth 0–5 cm (no veg.)	>17	>240	Surface "hard baked"	
5 m downslope				
T 19–22				
Depth 0– 5 cm	4–11	60–150	Surface dry	
5–50	7–14	100–200		
50–90	4– 7	60–100	Depth to frost 100 cm	
			24 July	
			Depth	w
			1– 5 cm	41–66
			10	13
			20	13
			50	9
5 m downslope				
T 26–28				
Depth 0– 5 cm	4– 5	60– 70		
5–50	6–14	80–200	Gravelly	
50–90	4– 7	60–100		
			24 July	
			Depth	w
			1– 5 cm	57–193
			10	51
			20	13

Table G IV. *Experimental site 15. Penetrometer readings*

	1960				
	1 Aug		10 Aug		
Location	kg/cm^2	lb/in^2	kg/cm^2	lb/in^2	Comments and Moisture Determinations w (percent)
2.5 m upslope					
T 24					
Target line 20°					
Depth 0– 5 cm	1	10	3	40	
25	5	75	4–13	60–180	
50	7	95	> 14	> 200	
					10 Aug Depth w 1 cm 28
1 m downslope					
T 14					
Target line 110°					
Depth 0– 5 cm	1	10	1– 3	20– 40	
25	13	180	4– 6	60– 80	
50	6	80	6–> 14	80–> 200	
					10 Aug Depth w 1 cm 169

	1960			
	20 Aug		12 Sept	
Location	kg/cm^2	lb/in^2	kg/cm^2	lb/in^2
2.5 m upslope				
T 24				
Target line 20°				
Depth 0– 5 cm	4	50	4	50
25	4–> 14	60–> 200	4–> 14	80–> 200
50	> 14	> 200	> 14	> 200
1 m downslope				
T 14				
Target line 110°				
Depth 0– 5 cm	1– 3	20– 40	1– 3	20– 40
25	4– 7	60– 100	4– 8	60– 120
50	10–> 14	140–> 200	13–> 14	180–> 200

Færdig fra trykkeriet den 15. juli 1967.

Table V.

EXPERIMENTAL SITES 6-8, 15-17 SUMMARY OF MEAN TARGET MOVEMENTS > 0.2 CM

	JUMP CM			GELIFLUCTION CM							RETROGRADE MOVEMENT CM			SEPTEMBER MOVEMENT CM			TOTAL MOVEMENT (1) CM			ANNUAL RATE (1) CM/YR						
	GEN GROUP ADJ	DRY	WET	GEN GROUP ADJ	DRY	WET	TARGET DEPTH DRY 10 CM	TARGET DEPTH DRY 20 CM	TARGET DEPTH WET 10 CM	TARGET DEPTH WET 20 CM	GEN GROUP ADJ	DRY	WET	GEN GROUP ADJ	DRY	WET	GEN GROUP ADJ	DRY	WET	GEN GROUP ADJ	DRY	WET	TARGET DEPTH DRY 10 CM	TARGET DEPTH DRY 20 CM	TARGET DEPTH WET 10 CM	TARGET DEPTH WET 20 CM
EXPERIMENTAL SITE 6																										
MW6 (1956-59)																	3.3		3.3	1.2		1.2				
CONE TARGETS (1956-61)	6.0		6.0	1.4		1.4			1.5	1.3	3.6		3.6	0.5		0.5	4.9		4.9	1.0		1.0			1.0	0.9
MOVEMENTS EXCEEDING GROUP MEAN																										
CONE TARGETS																										
PROPORTION	9/19		9/19	10/19		10/19					9/18		9/18	7/18		7/18	9/19		9/19	8/19		8/19				
PROPORTION EXPRESSED AS PERCENT	47		47	53		53					50		50	39		39	47		47	42		42				
EXPERIMENTAL SITE 7																										
MW7 (1957-59)																	8.1		8.1	4.3		4.3				
ROD (1956-61)	3.5	3.3		1.0	1.0						1.7	1.7		0.3	0.3		3.8	3.8		0.8	0.8					
CONE TARGETS (1956-61)	5.3	4.2	10.8	2.0	1.1	6.4	1.0	1.2	3.9	8.9	1.8	2.0	0.7	0.5	0.5	0.4	6.6	4.4	17.0	1.3	0.9	3.4	1.0	0.8	2.6	4.2
STONE TARGETS (1960-61)	1.4	0.9	5.1	0.3	0.2	0.9					0.3	0.4	0.	0.	0.	0.	1.3	0.7	5.1	1.3	0.7	5.1				
MOVEMENTS EXCEEDING GROUP MEAN																										
CONE TARGETS																										
PROPORTION	11/35	5/29	6/ 6	8/35	3/29	5/ 6					21/35	21/29	0/ 6	16/35	14/29	2/ 6	9/35	3/29	6/ 6	9/35	3/29	6/ 6				
PROPORTION EXPRESSED AS PERCENT	31	17	100	23	10	83					60	72	0	46	48	33	26	10	100	26	10	100				
STONE TARGETS (1960-61)																										
PROPORTION	2/16	0/14	2/ 2	5/16	4/14	1/ 2					9/16	9/14	0/ 2	0/16	0/14	0/ 2	2/16	0/14	2/ 2	2/16	0/14	2/ 2				
PROPORTION EXPRESSED AS PERCENT	13	0	100	31	29	50					56	64	0	0	0	0	13	0	100	13	0	100				
EXPERIMENTAL SITE 8																										
MW8 (1956-59)																	4.2	4.2		1.4	1.4					
CONE TARGETS (1956-61)	13.3	12.2	15.1	4.3	4.1	4.6	4.0	4.3	4.7	4.3	2.6	2.9	2.0	0.3	0.2	0.4	15.9	14.3	18.5	3.2	2.9	3.7	2.9	2.9	3.7	3.7
MOVEMENTS EXCEEDING GROUP MEAN																										
CONE TARGETS																										
PROPORTION	13/29	7/18	6/11	17/29	11/18	6/11					14/29	11/18	3/11	9/29	4/18	5/11	15/29	8/18	7/11	15/29	8/18	7/11				
PROPORTION EXPRESSED AS PERCENT	45	39	55	59	61	55					48	61	27	31	22	45	52	44	64	52	44	64				
EXPERIMENTAL SITE 15 (1957-60)																										
AXIAL LINE (20° TARGET LINE)																	8.9			3.1						
TRANSVERSE LINE (113° TARGET LINE)																	2.9			1.0						
EXPERIMENTAL SITE 16 (1957-59)																	3.1			1.1						
EXPERIMENTAL SITE 17 (1957-59)																										
AXIAL POINT (T7) ON TRANSVERSE LINE																	23.5			12.4						
TRANSVERSE LINE																	14.5			7.6						

(1) TOTAL MOVEMENT AND ANNUAL RATE TAKEN DIRECTLY FROM OBSERVATION TOTALS RATHER THAN FROM SUMMATION OF COMPONENT MOVEMENTS, SINCE AMOUNT CALCULATED FROM COMPONENTS DISREGARDS ALL MOVEMENTS ≤ 0.2 CM

Table VI.1.

EXPERIMENTAL SITE 7 FROST CREEP - GELIFLUCTION - RETROGRADE PROPORTIONS FOR TARGET MOVEMENTS > 0.2 CM
24 AUG 1959 - 25 AUG 1960

TARGETS READ WITHIN 4 DAYS OF BEING SUBJECT TO GELIFLUCTION
DOWNSLOPE OR UPSLOPE ATTITUDE CHANGE PROBABLY ≤ 0.2 CM
ADJUSTED MOVEMENTS

TARGET NO	DRY OR WET	POTENTIAL FROST CREEP CM SEPT MOVET (1)	POTENTIAL FROST CREEP CM JUMP	POTENTIAL FROST CREEP CM TOTAL	RETROGRADE MOVET AFTER JUMP CM	TRUE FROST CREEP CM	GELIFLUCTION CM	ANNUAL MOVEMENT CM CAL	ANNUAL MOVEMENT CM ADJ	ANNUAL MOVEMENT CM DIFF BETWEEN CAL AND ADJ
2	D		0.	0.	0.	0.	0.50	0.50	0.55	-0.05
3	D		0.	0.	0.	0.	0.40	0.40	0.50	-0.10
5	D		0.25	0.25	0.	0.25	0.30	0.55	0.35	0.20
6	D		0.85	0.85	0.	0.85	0.	0.85	0.85	0.
7	D		0.	0.	0.	0.	0.40	0.40	0.40	0.
10	D		0.40	0.40	0.	0.40	0.	0.40	0.35	0.05
15	D		0.	0.	0.30	-0.30 (2)	0.85	0.85	0.65	0.20
24	D		0.95	0.95	0.40	0.55	0.	0.55	0.65	-0.10
25	D		1.05	1.05	0.35	0.70	0.	0.70	0.85	-0.15
26	D		1.10	1.10	0.40	0.70	0.	0.70	0.80	-0.10
27	D		1.00	1.00	0.30	0.70	0.25	0.95	1.00	-0.05
35	W		2.30	2.30	0.	2.30	2.20	4.50	4.75	-0.25
36	W		1.20	1.20	0.	1.20	1.35	2.55	2.90	-0.35
TOTAL										
DRY AND WET			9.1	9.1	1.8	7.7	6.3	13.9	14.6	-0.7
DRY			5.6	5.6	1.8	4.2	2.7	6.9	7.0	-0.1
WET			3.5	3.5	0.	3.5	3.6	7.1	7.7	-0.6
MEAN (WITH STANDARD ERROR)										
DRY AND WET			0.7	0.7	0.1	0.6	0.5	1.1	1.1	-0.1
			(0.2)	(0.2)	(0.1)	(0.2)	(0.2)	(0.3)	(0.4)	(0.0)
DRY			0.5	0.5	0.2	0.4	0.3	0.6	0.6	0.
			(0.1)	(0.1)	(0.1)	(0.1)	(0.1)	(0.1)	(0.1)	(0.0)
WET			1.8	1.8	0.	1.8	1.8	3.5	3.8	-0.3
			(0.6)	(0.6)	(0.0)	(0.6)	(0.5)	(1.0)	(1.0)	(0.1)

PROPORTIONS

	POTENTIAL FROST CREEP/ RETROGRADE MOVET CM	TRUE FROST CREEP/ POTENTIAL FROST CREEP CM	TRUE FROST CREEP/ GELIFLUCTION CM
TOTAL			
DRY AND WET	9.10/ 1.75	7.65/ 9.10	7.65/ 6.25
DRY	5.60/ 1.75	4.15/ 5.60	4.15/ 2.70
WET	3.50/ 0.	3.50/ 3.50	3.50/ 3.55
REDUCED MEAN			
DRY AND WET	5.20/ 1.00	0.84/ 1.00	1.22/ 1.00
DRY	3.20/ 1.00	0.74/ 1.00	1.54/ 1.00
WET		1.00/ 1.00	0.99/ 1.00

CAL CALCULATED MOVEMENT. CALCULATED FROM PRECEDING COLUMNS

ADJ ADJUSTED MOVEMENT. OBSERVED MOVEMENT ADJUSTED FOR ANGLE OF VIEW, GRADIENT AND TARGET ATTITUDE CHANGE

(1) NO SEPTEMBER OBSERVATIONS IN 1959

(2) NEGATIVE VALUES OF FROST CREEP REGARDED AS 0 IN COMPUTING TOTAL AND MEAN FROST CREEP. THE BASIS FOR THIS PROCEDURE IS DISCUSSED IN THE TEXT

Table VI.2.

EXPERIMENTAL SITE 7 FROST CREEP – GELIFLUCTION – RETROGRADE PROPORTIONS FOR TARGET MOVEMENTS > 0.2 CM
25 AUG 1960 – 25 AUG 1961

TARGETS READ WITHIN 4 DAYS OF BEING SUBJECT TO GELIFLUCTION
DOWNSLOPE OR UPSLOPE ATTITUDE CHANGE PROBABLY ≤ 0.2 CM
ADJUSTED MOVEMENTS

TARGET NO	DRY OR WET	POTENTIAL FROST CREEP CM			RETROGRADE MOVET AFTER JUMP CM	TRUE FROST CREEP CM	GELIFLUCTION CM	ANNUAL MOVEMENT CM		
		SEPT MOVET	JUMP	TOTAL				CAL	ADJ	DIFF BETWEEN CAL AND ADJ
3	D	0.	0.55	0.55	0.30	0.25	0.30	0.55	0.55	0.
5	D	0.50	0.45	0.95	0.35	0.60	0.	0.60	0.90	−0.30
6	D	0.25	0.55	0.80	0.40	0.40	0.25	0.65	0.85	−0.20
7	D	0.	0.70	0.70	0.30	0.40	0.	0.40	0.65	−0.25
9	D	0.	0.90	0.90	0.35	0.55	0.30	0.85	0.90	−0.05
10	D	0.	0.50	0.50	0.25	0.25	0.	0.25	0.60	−0.35
11	D	0.	0.80	0.80	0.25	0.55	0.	0.55	0.70	−0.15
12	D	0.	0.80	0.80	0.	0.80	0.	0.85	0.70	0.15
13	D	0.30	0.50	0.80	0.	0.80	0.	0.80	0.65	0.15
14	D	0.95	0.35	1.30	0.40	0.90	0.25	1.15	1.25	−0.10
15	D	0.	0.65	0.65	0.30	0.35	0.	0.35	0.70	−0.35
16	D	0.30	0.90	1.20	0.	1.20	0.30	1.50	1.45	0.05
17	D	0.	0.45	0.45	0.35	0.	0.	0.10	0.60	−0.50
18	D	0.45	0.75	1.20	0.60	0.60	0.25	0.85	0.80	0.05
19	D	0.	0.95	0.95	0.50	0.45	0.	0.45	0.60	−0.15
20	D	0.	0.90	0.90	0.25	0.65	0.	0.65	0.95	−0.30
33	W	0.	1.85	1.85	0.	1.85	3.10	4.95	4.75	0.20
36	W	0.	1.55	1.55	0.90	0.65	2.00	2.65	2.35	0.30
TOTAL										
DRY AND WET		2.8	14.2	16.9	5.5	11.3	6.8	18.2	20.	−1.8
DRY		2.8	10.8	13.5	4.6	8.8	1.7	10.6	12.9	−2.3
WET		0.	3.4	3.4	0.9	2.5	5.1	7.6	7.1	0.5
MEAN (WITH STANDARD ERROR) (1)										
DRY AND WET		0.2	0.8	0.9	0.3	0.6	0.4	1.0	1.1	−0.1
		(0.1)	(0.1)	(0.1)	(0.1)	(0.1)	(0.2)	(0.3)	(0.2)	(0.1)
DRY		0.2	0.7	0.8	0.3	0.6	0.1	0.7	0.8	−0.1
		(0.1)	(0.1)	(0.1)	(0.0)	(0.1)	(0.0)	(0.1)	(0.1)	(0.1)
WET		0.	1.7	1.7	0.5	1.3	2.6	3.8	3.6	0.3
		(0.0)	(0.2)	(0.2)	(0.5)	(0.6)	(0.6)	(1.2)	(1.2)	(0.1)

PROPORTIONS

	POTENTIAL FROST CREEP/ RETROGRADE MOVET CM	TRUE FROST CREEP/ POTENTIAL FROST CREEP CM	TRUE FROST CREEP/ GELIFLUCTION CM
TOTAL			
DRY AND WET	16.85/ 5.50	11.25/16.85	11.25/ 6.75
DRY	13.45/ 4.60	8.75/13.45	8.75/ 1.65
WET	3.40/ 0.90	2.50/ 3.40	2.50/ 5.10
REDUCED MEAN			
DRY AND WET	3.06/ 1.00	0.67/ 1.00	1.67/ 1.00
DRY	2.92/ 1.00	0.65/ 1.00	5.30/ 1.00
WET	3.78/ 1.00	0.74/ 1.00	0.49/ 1.00

CAL CALCULATED MOVEMENT. CALCULATED FROM PRECEDING COLUMNS

ADJ ADJUSTED MOVEMENT. OBSERVED MOVEMENT ADJUSTED FOR ANGLE OF VIEW, GRADIENT AND TARGET ATTITUDE CHANGE

(1) STANDARD ERROR BASED ON UNROUNDED COMPUTER MEAN

Table VII.

EXPERIMENTAL SITE 8 FROST CREEP – GELIFLUCTION – RETROGRADE PROPORTIONS FOR TARGET MOVEMENTS > 0.2 CM
26 AUG 1960 – 25 AUG 1961

TARGETS READ WITHIN 4 DAYS OF BEING SUBJECT TO GELIFLUCTION
DOWNSLOPE OR UPSLOPE ATTITUDE CHANGE PROBABLY ≤ 0.2 CM
ADJUSTED MOVEMENTS

TARGET NO	DRY OR WET	POTENTIAL FROST CREEP CM			RETROGRADE MOVET AFTER JUMP CM	TRUE FROST CREEP CM	GELIFLUCTION CM	ANNUAL MOVEMENT CM		
		SEPT MOVET	JUMP	TOTAL				CAL	ADJ	DIFF BETWEEN CAL AND ADJ
3	D	0.	0.40	0.40	0.55	−0.15 (1)	1.30	1.30	1.20	0.10
6	D	0.	1.70	1.70	0.50	1.20	1.85	3.05	3.15	−0.10
8	D	0.40	1.50	1.90	0.45	1.45	3.05	4.50	4.65	−0.15
9	D	0.	1.65	1.65	0.40	1.25	3.55	4.80	5.20	−0.40
13	D	0.	1.30	1.30	0.40	0.90	3.05	3.95	3.55	0.40
14	D	0.	1.00	1.00	0.35	0.65	2.35	3.00	3.40	−0.40
15	D	0.25	1.25	1.50	0.40	1.10	2.35	3.45	3.70	−0.25
17	D	0.	1.10	1.10	0.45	0.65	2.30	2.95	3.00	−0.05
18	W	0.35	1.35	1.70	0.55	1.15	1.95	3.10	3.30	−0.20
19	W	0.25	1.65	1.90	0.85	1.05	2.80	3.85	3.85	0.
20	W	0.75	2.10	2.85	0.55	2.30	3.95	6.25	6.35	−0.10
23	W	0.	2.15	2.15	0.45	1.70	2.45	4.15	4.30	−0.15
24	W	0.	1.95	1.95	0.55	1.40	2.15	3.55	3.35	0.20
28	W	0.	1.85	1.85	0.50	1.35	1.45	2.80	2.80	0.
29	W	0.	2.60	2.60	0.60	2.00	0.65	2.65	2.50	0.15
TOTAL										
DRY AND WET		2.	23.6	25.6	7.6	18.2	35.2	53.4	54.3	1.
DRY		0.7	9.9	10.6	3.5	7.2	19.8	27.	27.9	−0.9
WET		1.4	13.7	15.	4.1	11.0	15.4	26.4	26.5	−0.1
MEAN (WITH STANDARD ERROR) (2)										
DRY AND WET		0.1	1.6	1.7	0.5	1.2	2.4	3.6	3.6	−0.1
		(0.1)	(0.1)	(0.2)	(0.0)	(0.1)	(0.2)	(0.3)	(0.3)	(0.1)
DRY		0.1	1.2	1.3	0.4	0.9	2.5	3.4	3.5	−0.1
		(0.1)	(0.2)	(0.2)	(0.0)	(0.2)	(0.3)	(0.4)	(0.4)	(0.1)
WET		0.2	2.	2.1	0.6	1.6	2.2	3.8	3.8	0.
		(0.1)	(0.2)	(0.2)	(0.1)	(0.2)	(0.4)	(0.5)	(0.5)	(0.1)

PROPORTIONS

	POTENTIAL FROST CREEP/ RETROGRADE MOVET CM	TRUE FROST CREEP/ POTENTIAL FROST CREEP CM	TRUE FROST CREEP/ GELIFLUCTION CM
TOTAL			
DRY AND WET	25.55/ 7.55	18.15/25.55	18.15/35.20
DRY	10.55/ 3.50	7.20/10.55	7.20/19.80
WET	15.00/ 4.05	10.95/15.00	10.95/15.40
REDUCED MEAN			
DRY AND WET	3.38/ 1.00	0.71/ 1.00	0.52/ 1.00
DRY	3.01/ 1.00	0.68/ 1.00	0.36/ 1.00
WET	3.70/ 1.00	0.73/ 1.00	0.71/ 1.00

CAL CALCULATED MOVEMENT. CALCULATED FROM PRECEDING COLUMNS

ADJ ADJUSTED MOVEMENT. OBSERVED MOVEMENT ADJUSTED FOR ANGLE OF VIEW, GRADIENT AND TARGET ATTITUDE CHANGE

(1) NEGATIVE VALUES OF FROST CREEP REGARDED AS 0 IN COMPUTING TOTAL AND MEAN FROST CREEP. THE BASIS FOR THIS PROCEDURE IS DISCUSSED IN THE TEXT

(2) STANDARD ERROR BASED ON UNROUNDED COMPUTER MEAN

Table A I.

EXPERIMENTAL SITE 6 TARGET ATTITUDES

TARGET NO(1)	EXCLUDED TARGETS (E)	8 AUG 1956			1957				1958			
		DEPTH CM	DIST FROM PREV TARGET CM	REMARKS	HEAVE CM	TILT (OFFSET OF TIP FROM VERT AT INSERT PT) CM		REMARKS	HEAVE CM	TILT (OFFSET OF TIP FROM VERT AT INSERT PT) CM		REMARKS
						DOWN	UP			DOWN	UP	
MW6		103.5		* 4 SEPT	? ?	?	?	*	?	?	?	*
1	E	20.0									X	
2	E	10.0	200						X		X	
3	E	20.0	200	AT E EDGE OF HUMMOCK			X					
4	E	10.0	200		X		X	CHANNELING?			X	
5	E	20.0	200		X				X		X	
6	E	10.0	200			X		CHANNELING?	X	X		CHANNELING?
7	E	20.0	200		X		X	CHANNELING?	X		X	CHANNELING?
8	E	10.0	200		X	X		CHANNELING?		X		CHANNELING?
9	E	20.0	400		X		X		X		X	
10		10.0	200			X			X	X		
11	E	20.0	200		X		X		X	X	X	
12		10.0	200	AT TOP OF HUMMOCK						?		
13		20.0	200		X				X	X		
14		10.0	200	AT TOP OF HUMMOCK			X				X	
15		20.0	200								X	
16		10.0	200				X				X	
17		20.0	200						X			
18		10.0	200				X				X	
19		20.0	200							X		
20		10.0	200							X		
21		20.0	200				X				X	
22		10.0	200			X						
23	E	20.0	200		X				X	X		
24		10.0	200			X				?		
25		20.0	200							X		
26		10.0	200									
27	E	20.0	200	INSERTED AT ANGLE	X		X	ORIG AT ANGLE			X	ORIG AT ANGLE
28		10.0	200			X						
29	E	20.0	200		X				X	X		
30		10.0	200									
31		20.0	200							X		
32	E	10.0	200						X	X		
33	E	20.0	200		X				X			
34		10.0	200									
35	E	20.0	200		X				X			
36	E	10.0	200		X							
37	E	20.0	200		X		X		X	X	X	
38	E	10.0	200					SNOW COVERED		X		
39	E	20.0	200	INSERTED AT ANGLE				SNOW COVERED		X		ORIG AT ANGLE
40	E	10.0	200	STONE REMOVED				SNOW COVERED				
41	E	20.0	200	STONE REMOVED				SNOW COVERED	X			
42	E	10.0	200					SNOW COVERED				
43	E	20.0	200					SNOW COVERED			X	
MEAN (MW6, E TARGETS, AND QUESTIONED OCCURRENCES EXCL)												
10-CM TARGETS												
20-CM TARGETS												
PROPORTION AND PERCENT OF TARGETS SHOWING HEAVE OR TILT (MW6, E TARGETS, AND QUESTIONED OCCURRENCES EXCL)												
10-CM TARGETS					0/12	4/12	3/12		1/12	2/10	3/12	
					0	33	25		8	20	25	
20-CM TARGETS					1/ 7	0/ 7	1/ 7		2/ 7	4/ 7	2/ 7	
					14	0	14		29	57	29	

TARGET NO(1)	22 AUG 1959				
	HEAVE CM	TILT (OFFSET OF TIP FROM VERT AT INSERT PT) CM		DIST FROM PREV TARGET CM	REMARKS
		DOWN	UP		
MW6	14.5	?	?		* EXCAVATED 6 AUG
1	0.5	0.0	(2)		
2	1.0	(2)	(2)	201.5	
3	0.5	0.0	0.0	196.0	
4	5.5	(2)	(2)	211.0	CHANNELING?
5	4.5	0.0	(2)	188.0	
6	0.5	1.2	0.0	205.0	CHANNELING?
7	6.5	0.0	(2)	198.0	CHANNELING?
8	2.5	0.3	0.0	198.0	CHANNELING?
9	0.9	0.0	0.5	407.0	
10	1.0	0.0	0.0	199.0	
11	6.5	0.3	0.0	202.0	
12	0.0?	0.0	0.0	200.0	VEG UP TO 4 CM HIGH
13	3.5	0.3	0.0	198.5	
14	0.5	0.0	0.0	201.0	
15	4.5	0.0	0.0	202.5	
16	1.0	0.0	(2)	199.5	
17	4.5	0.0	0.0	202.0	
18	0.0	0.0	(2)	201.0	
19	3.5	0.0	0.0	201.0	
20	0.0?	0.6	0.0	199.0	
21	?	0.0	(2)	201.5	
22	?	0.5	0.0	199.5	
23	7.0	0.5	0.0	203.0	
24	1.0	0.6	0.0	197.0	
25	4.0	0.4	0.0	200.5	
26	0.5	0.0	0.0	200.0	
27	4.5	0.0	3.3	197.5	ORIG AT ANGLE
28	0.5?	0.3	0.0	204.0	
29	8.0	0.5	0.0	200.0	
30	0.0?	0.0	0.0	200.0	
31	1.5	0.3	0.0	202.0	
32	2.0	0.8	0.0	196.5	
33	8.5	(2)	0.0	204.0	
34	0.5?	0.0	0.0	197.0	
35	6.0	0.0	(2)	202.5	
36	5.5	0.0	9.5	401.0	CHANNELING. FALLEN OVER
37	7.0	0.0	(2)		
38	1.0	0.3	0.0	200.5	
39	2.5	0.4	(2)	201.5	ORIG AT ANGLE
40	2.0	2.5	0.0	198.0	DISTURBED
41	3.5	0.0	0.0	200.0	CHANNELING?
42	3.0	5.5	0.0	191.0	RESTING ON EDGE
43	1.0	0.0	0.3	210.0	
MEAN (MW6, E TARGETS, AND QUESTIONED OCCURRENCES EXCL)					
10-CM TARGETS	0.7	0.2	0.0		
20-CM TARGETS	3.6	0.1	0.0		
PROPORTION AND PERCENT OF TARGETS SHOWING HEAVE OR TILT (MW6, E TARGETS, AND QUESTIONED OCCURRENCES EXCL)					
10-CM TARGETS	5/ 6	4/12	0/12		
	83	33	0		
20-CM TARGETS	6/ 6	3/ 7	0/ 7		
	100	43	0		

TARGET NO(1)	25 AUG 1960					21 AUG 1961			
	HEAVE CM	TILT (OFFSET OF TIP FROM VERT AT INSERT PT) CM		DIST FROM PREV TARGET CM	REMARKS	HEAVE CM	TILT (OFFSET OF TIP FROM VERT AT INSERT PT) CM		REMARKS
		DOWN	UP				DOWN	UP	
MW6									
1	1.0	0.0	1.0			1.0	0.0	0.5	
2	1.0	0.0	(2)	203.5		1.5	0.0	0.7	
3	1.5	0.0	0.0	195.0		1.0	0.0	0.0	
4	2.5	0.0	1.5	397.5	CHANNELING?	3.5	0.0	1.0	RESTING ON EDGE
5	6.0	0.0	1.5			7.0	0.0	2.5	CHANNELING. RESTING ON EDGE
6				402.5	WASHED OUT				WASHED OUT
7	4.5	0.0	1.0		CHANNELING?	8.0	0.0	1.0	
8	3.5	4.0	0.0	191.0	CHANNELING. RESTING ON EDGE	4.5	14.0	0.0	CHANNELING. RESTING ON EDGE
9	7.5	0.0	3.0	408.0		9.0	0.0	4.5	
10	1.0	0.0	1.0	200.0		2.5	0.0	0.8	*
11	6.5	0.0	0.5	203.5		11.0	2.0	0.0	
12	?	0.0	0.0	199.5	*	?	0.0	0.0	* VEG UP TO 3 CM HIGH
13	4.5	0.0	0.0	198.5		7.5	0.0	(2)	*
14	0.0	0.0		200.5	*	1.0	0.0	0.0	*
15	5.5	0.0	0.0	201.0	*	6.0	0.0	1.0	
16	1.0	0.0	0.5	196.5		1.5	0.0	1.0	
17	4.5	0.5	0.0	202.0		5.5	0.0	0.0	
18	?	0.0	0.0	202.0	*	0.0	0.0	0.5	
19	2.0	0.0	0.0	200.5	*	4.0	0.0	1.0	
20	?	1.0	0.0	199.5		?	1.0	0.0	* VEG UP TO 4 CM HIGH
21	?	0.0	0.5	201.5		0.5	0.0	(2)	
22	?	0.0	0.0	200.0		0.0?	0.0	0.0	*
23	0.5	1.5	0.0	201.5	DISTURBED?	3.5	1.2	0.0	
24	0.5	2.0	0.0	199.0		1.5	2.0	0.0	*
25	5.0	1.0	0.0	200.5		6.0	1.3	0.0	
26	1.0?	0.0	0.0	199.5	*	0.5	0.0	0.0	*
27	2.0	0.0	3.0	198.5	ORIG AT ANGLE. RESTING ON EDGE	3.0	0.0	2.5	ORIG AT ANGLE
28	0.5	0.0	0.0	203.0		0.5	0.0	0.0	*
29	8.0	3.5	0.0	200.0		9.0	2.0	0.0	
30	0.5	0.0	0.0	199.5	*	0.5?	0.0	0.0	*
31	2.0	0.5	0.0	202.5	*	2.5	0.5	0.0	*
32	2.0	1.0	0.0	194.5		3.0	1.2	0.0	RESTING ON EDGE
33	6.5	4.5	0.0	201.0	DISTURBED	5.5	7.5	0.0	RESTING ON EDGE
34	?	0.0	(2)	194.5	*	1.0	0.0	0.0	*
35	2.5	0.0	0.0	202.5	DISTURBED	6.5	0.5	0.0	
36					FALLEN OVER				FALLEN OVER
37					SNOW COVERED	13.0	0.0	12.0	CHANNELING. RESTING ON EDGE
38					SNOW COVERED	1.0	0.8	0.0	
39					SNOW COVERED	3.5	0.5	0.0	ORIG AT ANGLE
40					SNOW COVERED	3.0	8.0	0.0	
41					SNOW COVERED	4.5	0.0	0.0	
42					SNOW COVERED				FALLEN OVER
43					SNOW COVERED	1.0	0.0	0.0	
MEAN (MW6, E TARGETS, AND QUESTIONED OCCURRENCES EXCL)									
10-CM TARGETS	0.6	0.3	0.2			1.1	0.3	0.2	
20-CM TARGETS	3.9	0.3	0.1			4.6	0.3	0.4	
PROPORTION AND PERCENT OF TARGETS SHOWING HEAVE OR TILT (MW6, E TARGETS, AND QUESTIONED OCCURRENCES EXCL)									
10-CM TARGETS	5/ 6	2/12	2/12			7/ 8	2/12	3/12	
	83	17	17			88	17	25	
20-CM TARGETS	6/ 6	3/ 7	1/ 7			7/ 7	2/ 7	2/ 7	
	100	43	14			100	29	29	

* SELECT TARGETS – THOSE WITH PROBABLY ≤ 0.2 CM DOWNSLOPE OR UPSLOPE ATTITUDE CHANGE DUE TO TILTING AND/OR TARGET HEAVING SINCE PREVIOUS ATTITUDE CHECK (E TARGETS EXCL)

(1) E TARGETS ARE EXCLUDED FROM MOVEMENT TABLES FOR REASONS CITED UNDER REMARKS AND/OR STATED IN TEXT

(2) THEODOLITE RECORD OF TILT DURING YEAR BUT PROBABLY ≤ 0.2 CM. TARGET OMITTED FROM MEAN

Table A II.

EXPERIMENTAL SITE 7 TARGET ATTITUDES

TARGET NO	EXCLUDED TARGETS (E)(1)	13 AUG 1956			1957				1958				21 AUG 1959					25 AUG 1960					21 AUG 1961			
		DEPTH CM	DIST FROM PREV TARGET CM	REMARKS	HEAVE CM	TILT (OFFSET OF TIP FROM VERT AT INSERT PT) CM		REMARKS	HEAVE CM	TILT (OFFSET OF TIP FROM VERT AT INSERT PT) CM		REMARKS 1958 HEAVES ESTIMATED	HEAVE CM	TILT (OFFSET OF TIP FROM VERT AT INSERT PT) CM		DIST FROM PREV TARGET CM	REMARKS	HEAVE CM	TILT (OFFSET OF TIP FROM VERT AT INSERT PT) CM		DIST FROM PREV TARGET CM	REMARKS	HEAVE CM	TILT (OFFSET OF TIP FROM VERT AT INSERT PT) CM		REMARKS
						DOWN	UP			DOWN	UP			DOWN	UP				DOWN	UP				DOWN	UP	
MW7		92.0		*	?	X		*	?	1.5	0.0	*	2.0	2.8	0.0		* AS OF 5 AUG WHEN EXCAVATED									
ROD		137.0		*	?	7.9	0.0	*	?	8.9	0.0	*	?	9.4	0.0		*	?	10.0	0.0		*	-2.0.	10.8	0.0	* HEAVE AS OF 25 AUG
1		20.0	200						3.0		X		1.0	0.0	0.4	190.0 ?		1.5	0.0	0.0	200.0		2.0	0.0	0.5	
2		10.0	200				X		2.5		X		1.5	0.0	0.0	202.0		1.0	0.0		200.0	*	1.0	0.0	0.3	
3		20.0	200						0.5				1.0 ?	0.0	0.0	200.0		2.0 ?	0.0	0.0	200.0	*	2.0 ?	0.0	0.0	*
4		10.0	200		X				1.0	X			0.5	0.5	0.0	200.5		0.5	1.0	0.0	200.5		1.0	0.5	0.0	
5		20.0	200		X				1.0		?		0.5	0.0	(2)	200.5		1.0	0.0	0.0	200.5	*	1.5	0.0	0.0	*
6		10.0	200						0.0				1.0 ?	0.0	0.0	200.0		1.5	0.0	0.0	200.0	*	0.5 ?	0.0	0.0	*
7		20.0	200						1.0				0.5	0.0	(2)	200.5		1.0	0.0	0.0	200.0	*	1.0	0.0	(2)	*
8		10.0	200			X			0.5	X			0.0	0.0	0.0	200.0		0.0	0.5	0.0	200.0		0.5	(2)	0.0	
9		20.0	200			X			0.5	X			0.5 ?	0.3	0.0	200.0		0.5 ?	0.0	0.0	200.0		1.0 ?	0.0	0.0	*
10		10.0	200	STONE REMOVED		X	X		1.5				0.5	0.0	0.0	200.5		1.0	0.0	0.0	200.0	*	1.0	0.0	0.0	*
11		20.0	200						0.0		X		0.5 ?	0.0	0.0	200.0		0.5 ?	0.0	1.0	200.5		0.5 ?	0.0	1.0	*
12		10.0	200	STONE REMOVED		X			1.5	X			1.0 ?	0.0	0.0	201.5		2.0 ?	0.0	0.0	201.5	*	1.5 ?	0.0	0.0	*
13		20.0	200		X		X		3.0				1.5	0.0	0.0	201.0		1.0	0.0	0.0	201.0	*	1.5	0.0	0.0	*
14		10.0	200			X			0.5	X			0.5	0.0	0.0	200.0		1.0	0.5	0.0	200.0		1.0	0.5	0.0	*
15		20.0	200						0.5				0.5	0.0	0.0	199.0		0.5	0.0	0.0	198.5	*	0.5	0.0	0.0	*
16		10.0	200				X		0.0				0.5 ?	0.0	0.0	200.0		0.0	0.0	0.0	200.0	*	0.0	0.0	0.0	*
17		20.0	200		X		X		1.5		X		0.5	0.0	0.0	201.5		1.5	0.0	1.0	202.0		1.5	0.0	1.1	*
18		10.0	200			X			1.0				0.5	0.0	0.0	200.5		0.5	0.0	0.0	200.5	*	0.5	0.0	0.0	*
19		10.0	200	STONE AT DEPTH					0.0				?	0.0	0.0	201.0		0.0	0.0	0.0	200.5	*	0.0	0.0	0.0	*
20		10.0	200						0.0				0.0	0.3	0.0	201.0		0.0	0.0	0.0	200.5		0.0	0.0	0.0	*
21		20.0	200				X		0.5		X		0.5	0.0	0.0	200.5		0.5	0.0	1.0	200.5		1.0	0.0	0.5	
22		10.0	200			X			1.0	X			0.5	0.3	0.0	200.5		0.5	0.0	0.0	201.0		0.5	0.0	(2)	*
23		20.0	200		X	X			2.0				2.0	0.4	0.0	199.5		2.0	0.0	0.0	199.0		1.5	0.0	0.0	*
24		10.0	200			?	?		1.5				0.5	(2)	0.0	201.0		0.5	0.0	0.0	201.0	*	0.5	0.0	0.0	*
25		20.0	200						0.5				0.5	0.0	0.0	200.5		0.5	0.0	0.0	200.5	*	1.0	0.0	0.0	*
26		10.0	200						1.0		X		0.5	0.0	0.0	201.5		0.5	0.0	0.0	201.0	*	1.0	0.0	0.0	*
27		10.0	200	STONE AT DEPTH			X		0.5				0.5	0.0	0.0	198.5		0.5	0.0	0.0	199.5	*	0.5	0.0	0.0	*
28		10.0	200			X			0.5	X			0.0	0.5	0.0	200.5		0.0	0.0	0.0	200.5		0.5	0.0	(2)	*
29	E	20.0	200	STONE REMOVED	X				2.5	X			4.0	0.7	0.0	201.0	HOLE IMMED UPSLOPE. DISTURBED	6.5	3.0	0.0	202.0		9.0	8.5	0.0	RESTS AGAINST DEPRESSION
30		10.0	200	STONE REMOVED					0.0				?	0.0	0.0	198.5		?	0.0	0.0	199.0	*	?	0.0	0.0	*
31		20.0	200		X				3.0				1.5	0.3	0.0	201.0		0.0	1.0	0.0	198.5		2.5	1.3	0.0	
32		10.0	400	INSERTED AT ANGLE			X		1.5		X	ORIG AT ANGLE	1.0	0.0	0.3	400.0	ORIG AT ANGLE. VEG UP TO 3 CM HIGH	1.5 ?	0.0	0.0	401.5	ORIG AT ANGLE. VEG UP TO 3 CM HIGH	1.0	(2)	0.8	ORIG AT ANGLE
33		20.0	400	INSERTED AT ANGLE. STONE REMOVED			X		0.0		X	ORIG AT ANGLE	1.0 ?	0.0	0.4	401.0	ORIG AT ANGLE	?	0.0	(2)	401.5	ORIG AT ANGLE. VEG UP TO 3 CM HIGH	1.0 ?	(2)	(2)	* ORIG AT ANGLE
34	E	10.0	200						2.0		X		0.5 ?	0.0	0.0	196.5	CHANNELING ?	0.0	0.0	1.0	191.0		0.0	(2)	0.7	
35		20.0	200		X		X		3.0				3.0	0.0	0.4	198.5		3.0	0.0	0.5	203.0	*	4.0	0.0	0.0	
36		10.0	200			?			0.0				0.5 ?	0.0	0.0	205.5		0.0	0.0	0.0	205.0	*	0.5	0.0	0.0	*
37	E	20.0	200						2.0				1.0	0.0	0.0	202.0	DISTURBED ?	1.5	0.0	0.0	198.5		4.0	0.0	0.0	
38		10.0	200						0.0				?	0.0	0.0	199.5		0.0 ?	0.0	0.0	199.0	*	?	0.0	0.0	*
39	E	20.0	200				X		0.0		X		?	0.0	0.3	200.0		?	0.0	1.0	200.0		?	0.0	0.8	
40	E	10.0	200			X			0.0	X			?	0.3	0.0	200.0		?	2.0	0.0	200.0		0.0 ?	0.8	0.0	
MEAN (MW7, E TARGETS, AND QUESTIONED OCCURRENCES EXCL)																										
10-CM TARGETS									0.7				0.5	0.1	0.0			0.5	0.1	0.0			0.6	0.1	0.1	
20-CM TARGETS									1.3				1.1	0.1	0.1			1.1	0.1	0.3			1.6	0.1	0.2	
PROPORTION AND PERCENT OF TARGETS SHOWING HEAVE OR TILT (MW7, E TARGETS, AND QUESTIONED OCCURRENCES EXCL)																										
10-CM TARGETS					1/20	7/18	5/19		13/20	6/20	3/20		10/13	4/20	1/20			10/16	3/20	0/20			13/16	2/20	2/20	
					5	39	26		65	30	15		77	20	5			63	15	0			81	10	10	
20-CM TARGETS					6/15	2/15	5/15		13/15	1/15	5/14		11/11	3/15	3/15			10/11	1/15	4/15			11/11	1/15	4/15	
					40	13	33		87	7	36		100	20	20			91	7	27			100	7	27	

* SELECT TARGETS – THOSE WITH PROBABLY ≤ 0.2 CM DOWNSLOPE OR UPSLOPE ATTITUDE CHANGE DUE TO TILTING AND/OR TARGET HEAVING SINCE PREVIOUS ATTITUDE CHECK (E TARGETS EXCL)

(1) E TARGETS ARE EXCLUDED FROM MOVEMENT TABLES FOR REASONS CITED UNDER REMARKS AND/OR STATED IN TEXT

(2) THEODOLITE RECORD OF TILT DURING YEAR BUT PROBABLY ≤ 0.2 CM. TARGET OMITTED FROM MEAN

Table A III.

EXPERIMENTAL SITE 8 TARGET ATTITUDES

TARGET NO	EXCLUDED TARGETS (E)(1)	22 AUG 1956			1957				1958			
		DEPTH CM	DIST FROM PREV TARGET CM	REMARKS	HEAVE CM	TILT (OFFSET OF TIP FROM VERT AT INSERT PT) CM DOWN	UP	REMARKS	HEAVE CM	TILT (OFFSET OF TIP FROM VERT AT INSERT PT) CM DOWN	UP	REMARKS 1958 HEAVE ESTIMATED
MW8		100.0		* DEPTH AS OF 17 AUG	?	X		*	?	X		*
1	E	20.0	200		X	X			1.0	X		
2	E	10.0	400	COMMONLY OBSCURED					0.0			
3		20.0	200						0.0			
4		10.0	200	STONES REMOVED	X				0.5	X		
5	E	20.0	400		X				2.0		X	DEPRESSION DOWNSLOPE SIDE
6		10.0	200		X		X		0.5			
7		20.0	200	STONE REMOVED					0.0	?		
8		10.0	200						0.5	X		
9		20.0	200	STONE REMOVED	X				1.0			
10		10.0	200			X			0.5	X		
11		20.0	200						1.0			
12		10.0	200				X		0.5		X	
13		20.0	200						0.0		X	
14		10.0	200	STONE REMOVED					0.5		X	
15		20.0	200				X		0.0		X	
16		10.0	200			X			0.0	X		
17		20.0	200						2.0		X	
18		10.0	200						0.0			
19		10.0	200	STONE AT DEPTH					0.0			
20		10.0	200						0.0	X		
21		20.0	200						3.5	?		
22		10.0	200			X			1.5	X		
23		20.0	200						2.0			
24		10.0	200			X			0.0	X		
25		20.0	200						5.0	X		
26	E	10.0	200			X			1.0	X		
27	E	20.0	200	STONE REMOVED	X				2.0			
28		10.0	400			?			0.0			
29		20.0	200						2.5		X	
30		10.0	200			X			0.0	X		
31		20.0	200	STONE REMOVED					0.0			
32		10.0	400			X			0.0	X		
33		20.0	200						1.0			
34		10.0	200						0.0			
MEAN (MW8, E TARGETS, AND QUESTIONED OCCURRENCES EXCL)												
10-CM TARGETS									0.3			
20-CM TARGETS									1.4			
PROPORTION AND PERCENT OF TARGETS SHOWING HEAVE OR TILT (MW8, E TARGETS, AND QUESTIONED OCCURRENCES EXCL)												
10-CM TARGETS					2/16	6/13	2/16		7/16	9/16	2/16	
					13	46	13		44	56	13	
20-CM TARGETS					1/13	0/13	1/13		8/13	1/11	4/13	
					8	0	8		62	9	31	

TARGET NO	21 AUG 1959					26 AUG 1960					15 AUG 1961			
	HEAVE CM	TILT (OFFSET OF TIP FROM VERT AT INSERT PT) DOWN	UP	DIST FROM PREV TARGET CM	REMARKS	HEAVE CM	TILT (OFFSET OF TIP FROM VERT AT INSERT PT) CM DOWN	UP	DIST FROM PREV TARGET CM	REMARKS	HEAVE CM	TILT (OFFSET OF TIP FROM VERT AT INSERT PT) CM DOWN	UP	REMARKS
MW8	7.0	?	?		* EXCAVATED 5 AUG									
1	0.5	1.5	0.0			0.5	1.5	0.0			2.0	3.2	0.0	DISTURBED?
2	?	1.0	0.0	400.0		?	0.0	0.0	400.0		?	0.0	0.0	
3	0.0?	0.8	0.0	201.0		0.0?	0.0	0.0	200.0		0.5	0.0	0.0	*
4	1.0	(2)	0.0	200.0		1.5	1.5	0.0	200.0		1.5	1.8	0.0	
5	2.5	0.0	0.0	400.5		3.0	0.0	(2)	401.5	DEPRESSION DOWNSLOPE SIDE	4.0	(2)	(2)	DEPRESSION DOWNSLOPE SIDE
6	0.5	(2)	0.0	200.0		1.0	0.0	(2)	199.0	*	1.0	0.0	0.0	*
7	0.0	0.3	0.0	199.5		0.5	1.5	0.0	200.0		2.5	1.0	0.0	
8	0.5	(2)	0.0	199.5		1.5	0.0	(2)	199.5	*	0.5	0.0	0.0	*
9	0.0	0.5	0.0	201.5		1.0	0.0	0.0	202.0		1.5	0.0	0.0	*
10	0.5	0.4	0.0	200.0		0.5	0.5	0.0	200.5	*	0.5	(2)	0.0	
11	1.0	0.3	0.0	198.5		1.0	1.0	0.0	197.5		2.5	0.6	0.0	
12	0.0	0.0	0.0	200.5		0.5	0.0	0.0	200.5	*	0.5	0.0	0.8	
13	?	0.4	0.0	201.0		?	0.0	0.0	201.0		?	0.0	(2)	*
14	0.0?	0.0	0.0	201.0		0.5?	0.0	(2)	201.5	*	0.5?	0.0	0.0	*
15	0.5?	0.0	0.0	201.0		0.5?	0.0	(2)	201.5	* VEG UP TO 3 CM HIGH	1.0?	0.0	0.0	*
16	0.5?	0.4	0.0	199.5		0.5?	1.0	0.0	199.5		0.0?	0.5	0.0	
17	1.5	0.7	0.0	200.5		1.5	0.0	0.0	200.5		2.0	0.0	0.0	*
18	0.0?	1.0	0.0	198.5	VEG UP TO 3 CM HIGH	0.5	0.0	0.0	198.5		1.0	0.0	(2)	*
19	?	0.4	0.0	200.5		?	0.0	0.0	199.5		?	0.0	0.0	* VEG UP TO 3 CM HIGH
20	0.0	0.3	0.0	203.0		?	1.0	0.0	203.0		0.5	1.0	0.0	*
21	3.0	1.1	0.0	199.0		4.5	2.0	0.0	200.0		7.0	1.5	0.0	
22	0.5	1.5	0.0	197.0		1.0	1.0	0.0	196.5		2.5	2.3	0.0	
23	3.5	0.0	0.0	201.0		3.5	0.0	0.0	201.5	*	7.0	(2)	0.0	* 5 CM FROM BOULDER
24	?	0.0	0.0	198.0		?	0.0	0.0	198.0	*	?	0.0	0.0	* VEG UP TO 2.5 CM HIGH
25	4.5?	0.3	0.0	201.0		2.5	1.5	0.0	201.5		7.0	0.5	0.0	
26	0.5	0.8	0.0	199.0		?	0.0	0.0	197.0	CHANNELING?	2.0	2.0	0.0	CHANNELING?
27	2.0	0.6	0.0	202.0		1.0	0.0	0.0	204.0	CHANNELING?	2.5	(2)	0.0	DEPRESSION UPSLOPE SIDE
28	?	0.4	0.0	400.5	VEG UP TO 4 CM HIGH	?	0.0	0.0	400.0		?	0.0	0.0	* VEG UP TO 3 CM HIGH
29	1.5	0.0	0.0	200.0		1.5	0.0	(2)	200.5	*	2.0	0.0	0.0	*
30	0.5	1.0	0.0	200.5		1.0?	2.0	0.0	200.5		1.0	1.5	0.0	
31	0.5	0.4	0.0	200.0		0.5	0.5	0.0	200.0	*	1.0	(2)	0.0	
32	0.0?	0.9	0.0	401.0		0.0?	1.0	0.0	402.0	*	0.0	0.5	0.0	
33	0.5	0.8	0.0	200.5		2.0	0.5	0.0	200.5		2.0	0.0	0.0	
34	0.0	1.6	0.0	200.0		0.0	0.0	0.0	200.5		0.0	0.0	0.0	*
MEAN (MW8, E TARGETS, AND QUESTIONED OCCURRENCES EXCL)														
10-CM TARGETS	0.4	0.6	0.0			0.8	0.5	0.0			0.9	0.5	0.1	
20-CM TARGETS	1.2	0.6	0.0			1.9	0.5	0.0			3.2	0.3	0.0	
PROPORTION AND PERCENT OF TARGETS SHOWING HEAVE OR TILT (MW8, E TARGETS, AND QUESTIONED OCCURRENCES EXCL)														
10-CM TARGETS	6/ 9	10/16	0/16			7/ 8	7/16	0/16			8/10	6/16	1/16	
	67	63	0			88	44	0			80	38	6	
20-CM TARGETS	7/ 9	10/13	0/13			10/10	6/13	0/13			11/11	4/13	0/13	
	78	77	0			100	46	0			100	31	0	

* SELECT TARGETS - THOSE WITH PROBABLY ≤ 0.2 CM DOWNSLOPE OR UPSLOPE ATTITUDE CHANGE DUE TO TILTING AND/OR TARGET HEAVING SINCE PREVIOUS ATTITUDE CHECK (E TARGETS EXCL)

(1) E TARGETS ARE EXCLUDED FROM MOVEMENT TABLES FOR REASONS CITED UNDER REMARKS AND/OR STATED IN TEXT

(2) THEODOLITE RECORD OF TILT DURING YEAR BUT PROBABLY ≤ 0.2 CM. TARGET OMITTED FROM MEAN

Table A IV.

EXPERIMENTAL SITE 6 ANALYSIS OF 1959-61 TARGET MOVEMENTS > 0.2 CM

TARGET NO (1)	DEPTH CM	TARGET ATTITUDES TILT > 0.2 CM (OFFSET OF TIP FROM VERT AT INSERT PT)						EFFECT OF ATTITUDE CHANGE (TILTING AND/OR HEAVING)				J U M P				G E L I F L U C T I O N				R E T R O G R A D E M O V E M E N T				SEPT MOVEMENT		A N N U A L M O V E M E N T TO LATE AUGUST (2)			
		22 AUG 1959		25 AUG 1960		21 AUG 1961		1959-60		1960-61		1959-60		1960-61		1960		1961		1960		1961		1960		1959-60		1960-61	
		DOWN	UP	DOWN	UP	DOWN	UP	DOWN	UP	DOWN	UP	OBS	ADJ	OBS	ADJ	OBS	ADJ	OBS	ADJ	OBS	ADJ	OBS	ADJ	OBS	ADJ	OBS	ADJ	OBS	ADJ
		CM		CM		CM		CM		CM		CM		CM		CM		CM		CM		CM		CM		CM		CM	
10	10.0	0.	0.	0.	1.00	0.	0.80	0.	1.00	0.20 *	0. *	0.	0.	0.35 *	0.35 *	0.75	0.75	1.15 *	1.15 *	0.55	0.	0.50 *	0.50 *	0. *	0. *	0.	0.80	1.05 *	1.05 *
12	10.0	0.	0.	0.	0.	0.	0.	0. *	0. *	0. *	0. *	0.45	0.	0.85	0.55	0.65	0.	1.55	1.25	0.30 0	0.30	0.65	0.65	0.30	0.	0.80	-0.70	2.00	1.70
13	20.0	0.30	0.	0.	0.	0.	0.	0.	0.30	0. *	0. *	0.80 *	0.80 *	1.65 *	1.65 *	1.15 *	1.15 *	1.80 *	1.80 *	0.80 *	0.80 *	0.50 *	0.50 *	0. *	0. *	1.20 *	1.20 *	3.00 *	3.00 *
14	10.0	0.	0.	0.	0.	0.	0.	0. *	0. *	0. *	0. *	1.10	0.	1.20	1.20	1.35	0.	3.00	3.00	0.40	0.40	0.45	0.	0.25	0.25	2.10	0.90	3.95	4.45
15	20.0	0.	0.	0.	0.	0.	1.00	0. *	0. *	0.	1.00	0.75 *	0.75 *	1.45 *	1.45 *	1.95 *	1.95 *	3.00 *	3.00 *	0.25 *	0.25 *	0.45 *	0.45 *	0.40 *	0.40 *	2.45 *	2.45 *	4.40 *	4.40 *
16	10.0	0.	0.	0.	0.50	0.	1.00	0.	0.50	0.	0.50	1.90	1.90	1.60 *	1.60 *	2.00	2.00	3.50 *	3.50 *	0.60	0.	0.40 *	0.40 *	0. *	0. *	3.45	3.95	4.95 *	4.95 *
17	20.0	0.	0.	0.50	0.	0.	0.	0.50	0.	0.	0.50	2.35 *	2.25 *	1.35	1.35	1.55 *	1.45 *	4.70	4.70	0.95 *	0.95 *	0.55	0.05	0.25	0.25	3.05 *	2.95 *	5.60	6.10
18	10.0	0.	0.	0.	0.	0.	0.50	0. *	0. *	0.	0.50	3.70	3.00	1.10	1.10	1.25	0.55	4.75	4.75	1.70	1.70	0.60	0.20	0.	0.	3.35	2.65	5.25	5.65
19	20.0	0.	0.	0.	0.	0.	1.00	0. *	0. *	0.	1.00	2.25 *	2.25 *	1.25	1.25	1.25 *	1.25 *	2.85	2.85	1.60 *	1.60 *	0.40	0.	0.30	0.30	2.30 *	2.30 *	3.55	4.35
20	10.0	0.60	0.	1.00	0.	1.00	0.	0.40	0.	0. *	0. *	1.75	1.75	1.30 *	1.30 *	1.20	1.20	3.05 *	3.05 *	1.45	1.05	0.40 *	0.40 *	0. *	0. *	1.95	2.35	3.50 *	3.50 *
21	20.0	0.	0.	0.	0.50	0.	0.	0.	0.50	0.50	0.	2.00 *	2.00 *	1.00 *	1.00 *	1.10 *	1.10 *	2.35 *	2.35 *	1.10 *	1.10 *	0.35 *	0.35 *	0. *	0. *	2.15 *	2.15 *	3.30 *	3.30 *
22	10.0	0.50	0.	0.	0.	0.	0.	0.	0.50	0. *	0. *	2.40 *	2.40 *	1.20 *	1.20 *	1.35 *	1.35 *	2.30 *	2.30 *	0.70 *	0.70 *	0.40 *	0.40 *	0.25 *	0.25 *	3.15 *	3.15 *	3.50 *	3.50 *
24	10.0	0.60	0.	2.00	0.	2.00	0.	1.40	0.	0. *	0. *	2.40	1.80	1.00	1.00	1.60	1.00	2.95	2.95	0.50	0.50	0.25	0.	0.	0.	3.60	3.00	3.70	4.20
25	20.0	0.40	0.	1.00	0.	1.30	0.	0.60	0.	0.30	0.	2.10	2.10	1.10 *	1.10 *	2.05	1.00	2.25 *	2.25 *	0.55	0.	0.45 *	0.45 *	0. *	0. *	3.85	4.55	2.90 *	2.90 *
26	10.0	0.	0.	0.	0.	0.	0.	0. *	0. *	0. *	0. *	1.75	1.75	1.35 *	1.35 *	1.30	1.30	1.95 *	1.95 *	0.	0.	0.55 *	0.55 *	0.35 *	0.35 *	3.05	4.05	3.20 *	3.20 *
28	10.0	0.30	0.	0.	0.	0.	0.	0.	0.30	0. *	0. *	2.50	2.50	1.65 *	1.65 *	1.45	1.45	2.80 *	2.80 *	0.	0.	0.85 *	0.85 *	0.25 *	0.25 *	0. +	0. +	3.75 *(3)	3.75 *(3)
30	10.0	0.	0.	0.	0.	0.	0.	0. *	0. *	0. *	0. *	2.80	2.10	2.10 *	2.10 *	1.30	0.60	3.95 *	3.95 *	0.	0.	0.55 *	0.55 *	0.75 *	0.75 *	4.10	3.40	6.20 *	6.20 *
31	20.0	0.30	0.	0.50	0.	0.50	0.	0.20 *	0. *	0. *	0. *	2.25	1.25	2.10	2.10	1.40	0.20	4.35	4.35	0.	0.	0.40	0.	0.	0.	3.65	2.75	6.30	6.80
34	10.0	0.	0.	0.	0.	0.	0.	0. *	0. *	0. *	0. *	2.05	2.05	1.90	0.60	0.80	0.80	4.35	3.05	0.	0.	0.65	0.65	0.30	0.	2.80	3.30	5.85	4.55
												2.25 *	2.25 *	2.15 *	2.15 *	0.30 *	0.30 *	2.45 *	2.45 *	0. *	0. *	0.45 *	0.45 *	0. *	0. *	2.20 *	2.20 *	4.20 *	4.20 *
												1.55 *	1.55 *	1.90 *	1.90 *	0.25 *	0.25 *	2.10 *	2.10 *	0. *	0. *	0.55 *	0.55 *	0. *	0. *	1.80 *	1.80 *	3.20 *	3.20 *
												2.80	1.60	2.10	2.10	0.	0.	2.65	2.65	0.25	0.25	0.60	0.	0.	0.	2.70	1.50	4.25	5.25
												2.15	2.15	1.75 *	1.75 *	0.25	0.25	1.40 *	1.40 *	0.70	0.30	0.50 *	0.50 *	0. *	0. *	1.95	2.35	2.60 *	2.60 *
												2.00 *	2.00 *	2.50 *	2.50 *	0.45 *	0.45 *	0.65 *	0.65 *	0.70 *	0.70 *	0.60 *	0.60 *	0. *	0. *	2.30 *	2.30 *	2.35 *	2.35 *
												2.05	1.05	2.25	2.25	0.	0.	0.35	0.35	0.75	0.75	0.25	0.	0.	0.	1.65	0.65	2.35	2.85
												1.40 *	1.30 *	2.20	2.20	0. *	0. *	0.35	0.35	0.90 *	0.90 *	1.05	0.55	0.25	0.25	0.65 *	0.55 *	1.65	2.15
												0.85 *	0.75 *	1.75	1.75	0. *	0. *	0.	0.	0.70 *	0.70 *	1.00	0.50	0.25	0.25	0.85 *	0.75 *	0.60	1.10
												1.30	1.30	1.60	1.60	0.	0.	0.	0.	0.55	0.25	1.05	0.55	0.	0.	1.45	1.75	0.	0.50
												1.20	1.20	1.95 *	1.95 *	0.25	0.25	0. *	0. *	0.95	0.	1.00 *	1.00 *	0.50 *	0.50 *	1.45	3.05	0.55 *	0.55 *

PROPORTION AND PERCENT OF TARGETS SHOWING A GIVEN CATEGORY OF MOVEMENT > 0.2 CM

	EFFECT OF ATTITUDE CHANGE 1959-60 DOWN	1959-60 UP	1960-61 DOWN	1960-61 UP
GENERAL GROUP	4/19	6/19	2/19	5/19
	21	32	11	26
SELECT GROUP	0/ 9	0/ 9	0/12	0/12
	0	0	0	0

MEAN TARGET ATTITUDE CHANGE (WITH STANDARD ERROR)

	EFFECT OF ATTITUDE CHANGE 1959-60 DOWN	1959-60 UP	1960-61 DOWN	1960-61 UP
GENERAL GROUP	0.1	0.1	0.	0.1
	(0.3)	(0.2)	(0.1)	(0.3)
SELECT GROUP	0.	0.	0.	0.
	(0.0)	(0.0)	(0.0)	(0.0)

JUMP 1959-60 OBS	JUMP 1959-60 ADJ	JUMP 1960-61 OBS	JUMP 1960-61 ADJ	GELIFLUCTION 1960 OBS	GELIFLUCTION 1960 ADJ	GELIFLUCTION 1961 OBS	GELIFLUCTION 1961 ADJ	RETROGRADE 1960 OBS	RETROGRADE 1960 ADJ	RETROGRADE 1961 OBS	RETROGRADE 1961 ADJ	SEPT 1960 OBS	SEPT 1960 ADJ	ANNUAL 1959-60 OBS	ANNUAL 1959-60 ADJ	ANNUAL 1960-61 OBS	ANNUAL 1960-61 ADJ
28/29	26/29	29/29	29/29	24/29	21/29	26/29	26/29	22/29	18/29	29/29	21/29	13/29	11/29	27/28	27/28	28/29	29/29
97	90	100	100	83	72	90	90	76	62	100	72	45	38	96	96	97	100
17/18	15/18	18/18	18/18	15/18	13/18	15/18	15/18	18/18	14/18	18/18	13/18	9/18	8/18	17/18	17/18	17/18	18/18
94	83	100	100	83	72	83	83	100	78	100	72	50	44	94	94	94	100
11/11	11/11	11/11	11/11	9/11	8/11	11/11	11/11	4/11	4/11	11/11	8/11	4/11	3/11	10/10	10/10	11/11	11/11
100	100	100	100	82	73	100	100	36	36	100	73	36	27	100	100	100	100
11/11	11/11	16/16	16/16	9/11	9/11	15/16	15/16	9/11	9/11	16/16	16/16	6/16	6/16	11/11	11/11	16/16	16/16
100	100	100	100	82	82	94	94	82	82	100	100	38	38	100	100	100	100
8/ 8	8/ 8	9/ 9	9/ 9	6/ 8	6/ 8	8/ 9	8/ 9	8/ 8	8/ 8	9/ 9	9/ 9	3/ 9	3/ 9	8/ 8	8/ 8	9/ 9	9/ 9
100	100	100	100	75	75	89	89	100	100	100	100	33	33	100	100	100	100
3/ 3	3/ 3	7/ 7	7/ 7	3/ 3	3/ 3	7/ 7	7/ 7	1/ 3	1/ 3	7/ 7	7/ 7	3/ 7	3/ 7	3/ 3	3/ 3	7/ 7	7/ 7
100	100	100	100	100	100	100	100	33	33	100	100	43	43	100	100	100	100

* SELECT TARGETS - THOSE WITH PROBABLY ≤ 0.2 CM DOWNSLOPE OR UPSLOPE ATTITUDE CHANGE DUE TO TILTING AND/OR TARGET HEAVING IN PERIOD INDICATED

OBS OBSERVED MOVEMENT. HORIZONTAL COMPONENT NORMAL TO TARGET LINE

ADJ ADJUSTED MOVEMENT. OBSERVED MOVEMENT ADJUSTED FOR TARGET ATTITUDE CHANGE ONLY, AS FOLLOWS.
JUMP, GELIFLUCTION, AND SEPT MOVEMENT FOR DOWN CHANGE,
RETROGRADE MOVEMENT FOR UP CHANGE,
ANNUAL MOVEMENT FOR BOTH DOWN- AND UP CHANGES

(1) OMITTED TARGETS ARE EXCLUDED FOR REASONS CITED IN TABLE OF TARGET ATTITUDES AND/OR CITED IN TEXT

(2) ANNUAL MOVEMENT TAKEN DIRECTLY FROM OBSERVATION TOTALS RATHER THAN FROM SUMMATION OF COMPONENT MOVEMENTS SINCE AMOUNT CALCULATED FROM COMPONENTS DISREGARDS ALL MOVEMENTS ≤ 0.2 CM

(3) LATE AUGUST READING LACKING, MID-AUGUST READING SUBSTITUTED

Table A V.

EXPERIMENTAL SITE 7 ANALYSIS OF 1959–61 TARGET MOVEMENTS > 0.2 CM

TARGET NO(1)	DEPTH CM	DRY OR WET	TARGET ATTITUDES TILT > 0.2 CM (OFFSET OF TIP FROM VERT AT INSERT PT)					
			21 AUG 1959		25 AUG 1960		25 AUG 1961	
			DOWN CM	UP	DOWN CM	UP	DOWN CM	UP
1	20.0	D	0.	0.40	0.	0.	0.	0.50
2	10.0	D	0.	0.	0.	0.	0.	0.30
3	20.0	D	0.	0.	0.	0.	0.	0.
4	10.0	D	0.50	0.	1.00	0.	0.50	0.
5	20.0	D	0.	0.	0.	0.	0.	0.
6	10.0	D	0.	0.	0.	0.	0.	0.
7	20.0	D	0.	0.	0.	0.	0.	0.
8	10.0	D	0.	0.	0.50	0.	0.	0.
9	20.0	D	0.30	0.	0.	0.	0.	0.
10	10.0	D	0.	0.	0.	0.	0.	0.
11	20.0	D	0.	0.	0.	1.00	0.	1.00
12	10.0	D	0.	0.	0.	0.	0.	0.
13	20.0	D	0.	0.	0.	0.	0.	0.
14	10.0	D	0.	0.	0.50	0.	0.50	0.
15	20.0	D	0.	0.	0.	0.	0.	0.
16	10.0	D	0.	0.	0.	0.	0.	0.
17	20.0	D	0.	0.	0.	1.00	0.	1.10
18	10.0	D	0.	0.	0.	0.	0.	0.
19	10.0	D	0.	0.	0.	0.	0.	0.
20	10.0	D	0.30	0.	0.	0.	0.	0.
21	20.0	D	0.	0.	0.	1.00	0.	0.50
22	10.0	D	0.30	0.	0.	0.	0.	0.
23	20.0	D	0.40	0.	0.	0.	0.	0.
24	10.0	D	0.	0.	0.	0.	0.	0.
25	20.0	D	0.	0.	0.	0.	0.	0.
26	10.0	D	0.	0.	0.	0.	0.	0.
27	10.0	D	0.	0.	0.	0.	0.	0.
28	10.0	D	0.50	0.	0.	0.	0.	0.
30	10.0	W	0.	0.	0.	0.	0.	0.
31	20.0	W	0.30	0.	1.00	0.	1.30	0.
32	10.0	W	0.	0.30	0.	0.	0.	0.80
33	20.0	W	0.	0.40	0.	0.	0.	0.
35	20.0	W	0.	0.40	0.	0.50	0.	0.
36	10.0	W	0.	0.	0.	0.	0.	0.
38	10.0	D	0.	0.	0.	0.	0.	0.

TARGET NO(1)	EFFECT OF ATTITUDE CHANGE (TILTING AND/OR HEAVING)				JUMP			
	1959–60		1960–61		1959–60		1960–61	
	DOWN CM	UP	DOWN CM	UP	OBS CM	ADJ	OBS CM	ADJ
1	0.40	0.	0.	0.50	0.	0.	0.45	0.45
2	0. *	0. *	0.	0.30	0. *	0. *	0.45	0.45
3	0. *	0. *	0. *	0. *	0. *	0. *	0.55 *	0.55 *
4	0.50	0.	0.	0.50	0.35	0.	0.75	0.75
5	0. *	0. *	0. *	0. *	0.25 *	0.25 *	0.45 *	0.45 *
6	0. *	0. *	0. *	0. *	0.70 *	0.70 *	0.55 *	0.55 *
7	0. *	0. *	0. *	0. *	0. *	0. *	0.70 *	0.70 *
8	0.50	0.	0.	0.50	0.35	0.	0.85	0.85
9	0.	0.30	0. *	0. *	0.25	0.25	0.90 *	0.90 *
10	0. *	0. *	0. *	0. *	0.40 *	0.40 *	0.50 *	0.50 *
11	0.	1.00	0. *	0. *	0.	0.	0.80 *	0.80 *
12	0. *	0. *	0. *	0. *	0. *	0. *	0.75 *	0.75 *
13	0. *	0. *	0. *	0. *	0.55 *	0.55 *	0.45 *	0.45 *
14	0.50	0.	0. *	0. *	0.25	0.	0.40 *	0.40 *
15	0. *	0. *	0. *	0. *	0. *	0. *	0.60 *	0.60 *
16	0. *	0. *	0. *	0. *	0.40 *	0.40 *	0.80 *	0.80 *
17	0.	1.00	0. *	0.10 *	0.70	0.70	0.40 *	0.40 *
18	0. *	0. *	0. *	0. *	0.60 *	0.60 *	0.70 *	0.70 *
19	0. *	0. *	0. *	0. *	0.75 *	0.75 *	0.90 *	0.90 *
20	0.	0.30	0. *	0. *	0.95	0.95	0.85 *	0.85 *
21	0.	1.00	0.50	0.	0.70	0.70	0.60	0.10
22	0.	0.30	0. *	0. *	0.75	0.75	0.65 *	0.65 *
23	0.	0.40	0. *	0. *	0.65	0.65	0.65 *	0.65 *
24	0. *	0. *	0. *	0. *	0.95 *	0.95 *	0.80 *	0.80 *
25	0. *	0. *	0. *	0. *	1.05 *	1.05 *	0.95 *	0.95 *
26	0. *	0. *	0. *	0. *	1.10 *	1.10 *	0.75 *	0.75 *
27	0. *	0. *	0. *	0. *	1.00 *	1.00 *	0.55 *	0.55 *
28	0.	0.50	0. *	0. *	0.90	0.90	0.75 *	0.75 *
30	0. *	0. *	0. *	0. *	1.65 *	1.65 *	1.25 *	1.25 *
31	0.70	0.	0.30	0.	4.75	4.00	1.35	1.05
32	0.30	0.	0.	0.80	2.25	1.95	1.75	1.75
33	0.40	0.	0. *	0. *	0.50	0.10	1.75 *	1.75 *
35	0. *	0.10 *	0.50	0.	2.30 *	2.30 *	2.10	1.60
36	0. *	0. *	0. *	0. *	1.20 *	1.20 *	1.30 *	1.30 *
38	0. *	0. *	0. *	0. *	1.15 *	1.15 *	0.55 *	0.55 *
PROPORTION AND PERCENT OF TARGETS SHOWING A GIVEN CATEGORY OF MOVEMENT > 0.2 CM								
GENERAL GROUP	7/35	8/35	3/35	5/35	28/35	24/35	35/35	34/35
	20	23	9	14	80	69	100	97
DRY	4/29	8/29	1/29	4/29	22/29	19/29	29/29	28/29
	14	28	3	14	76	66	100	97
WET	3/ 6	0/ 6	2/ 6	1/ 6	6/ 6	5/ 6	6/ 6	6/ 6
	50	0	33	17	100	83	100	100
SELECT GROUP	0/20	0/20	0/27	0/27	15/20	15/20	27/27	27/27
	0	0	0	0	75	75	100	100
DRY	0/17	0/17	0/24	0/24	12/17	12/17	24/24	24/24
	0	0	0	0	71	71	100	100
WET	0/ 3	0/ 3	0/ 3	0/ 3	3/ 3	3/ 3	3/ 3	3/ 3
	0	0	0	0	100	100	100	100
MEAN TARGET ATTITUDE CHANGE (WITH STANDARD ERROR)								
GENERAL GROUP	0.1	0.1	0.	0.1				
	(0.2)	(0.3)	(0.1)	(0.2)				
DRY	0.1	0.2	0.	0.1				
	(0.2)	(0.3)	(0.1)	(0.2)				
WET	0.2	0.	0.1	0.1				
	(0.3)	(0.0)	(0.2)	(0.3)				
SELECT GROUP	0.	0.	0.	0.				
	(0.0)	(0.0)	(0.0)	(0.0)				
DRY	0.	0.	0.	0.				
	(0.0)	(0.0)	(0.0)	(0.0)				
WET	0.	0.	0.	0.				
	(0.0)	(0.1)	(0.0)	(0.0)				

TARGET NO(1)	GELIFLUCTION				RETROGRADE MOVEMENT			
	1960		1961		1960		1961	
	OBS CM	ADJ	OBS CM	ADJ	OBS CM	ADJ	OBS CM	ADJ
1	0.30	0.	0.	0.	0.25	0.25	0.	0.
2	0.50 *	0.50 *	0.	0.	0. *	0. *	0.30	0.
3	0.40 *	0.40 *	0.30 *	0.30 *	0. *	0. *	0.30 *	0.30 *
4	0.25	0.	0.	0.	0.	0.	0.30	0.
5	0.30 *	0.30 *	0. *	0. *	0. *	0. *	0.35 *	0.35 *
6	0. *	0. *	0.25 *	0.25 *	0. *	0. *	0.40 *	0.40 *
7	0.40 *	0.40 *	0. *	0. *	0.25 *	0.25 *	0.30 *	0.30 *
8	0.	0.	0.	0.	0.	0.	0.55	0.05
9	0.	0.	0.30 *	0.30 *	0.30	0.	0.35 *	0.35 *
10	0. *	0. *	0. *	0. *	0. *	0. *	0.25 *	0.25 *
11	0.45	0.45	0. *	0. *	0.45	0.	0.25 *	0.25 *
12	0.30 *	0.30 *	0. *	0. *	0.55 *	0.55 *	0. *	0. *
13	0.40 *	0.40 *	0. *	0. *	0.60 *	0.60 *	0. *	0. *
14	0.95	0.45	0.30 *	0.30 *	0.65	0.65	0.40 *	0.40 *
15	0.80 *	0.80 *	0. *	0. *	0.50 *	0.50 *	0.30 *	0.30 *
16	0.50 *	0.50 *	0.25 *	0.25 *	0.25 *	0.25 *	0. *	0. *
17	0.	0.	0. *	0. *	0.25	0.	0.30 *	0.30 *
18	0. *	0. *	0.25 *	0.25 *	0.35 *	0.35 *	0.55 *	0.55 *
19	0. *	0. *	0. *	0. *	0.55 *	0.55 *	0.50 *	0.50 *
20	0.	0.	0. *	0. *	0.65	0.35	0.25 *	0.25 *
21	0.	0.	0.	0.	0.55	0.	0.40	0.40
22	0.	0.	0. *	0. *	0.45	0.15	0.35 *	0.35 *
23	0.25	0.25	0. *	0. *	0.40	0.	0.30 *	0.30 *
24	0. *	0. *	0. *	0. *	0.40 *	0.40 *	0.45 *	0.45 *
25	0. *	0. *	0. *	0. *	0.35 *	0.35 *	0.50 *	0.50 *
26	0. *	0. *	0. *	0. *	0.40 *	0.40 *	0.25 *	0.25 *
27	0.25 *	0.25 *	0. *	0. *	0.30 *	0.30 *	0.40 *	0.40 *
28	0.25	0.25	0. *	0. *	0.25	0.	0.50 *	0.50 *
30	0. *	0. *	0.80 *	0.80 *	0.35 *	0.35 *	0.25 *	0.25 *
31	0.	0.	2.00	1.70	0.	0.	0.	0.
32	0.	0.	1.20	1.20	0.	0.	0.30	0.
33	1.15	0.75	2.90 *	2.90 *	0.40	0.40	0. *	0. *
35	2.10 *	2.10 *	4.75	4.25	0.30 *	0.20 *	0.35	0.35
36	1.15 *	1.15 *	1.70 *	1.70 *	0. *	0. *	0.75 *	0.75 *
38	0. *	0. *	0.25 *	0.25 *	0.35 *	0.35 *	0.90 *	0.90 *
PROPORTION AND PERCENT OF TARGETS SHOWING A GIVEN CATEGORY OF MOVEMENT > 0.2 CM								
GENERAL GROUP	18/35	16/35	13/35	13/35	25/35	17/35	29/35	25/35
	51	46	37	37	71	49	83	71
DRY	15/29	13/29	7/29	7/29	22/29	15/29	25/29	22/29
	52	45	24	24	76	52	86	76
WET	3/ 6	3/ 6	6/ 6	6/ 6	3/ 6	2/ 6	4/ 6	3/ 6
	50	50	100	100	50	33	67	50
SELECT GROUP	11/20	11/20	10/27	10/27	14/20	13/20	23/27	23/27
	55	55	37	37	70	65	85	85
DRY	9/17	9/17	7/24	7/24	12/17	12/17	21/24	21/24
	53	53	29	29	71	71	88	88
WET	2/ 3	2/ 3	3/ 3	3/ 3	2/ 3	1/ 3	2/ 3	2/ 3
	67	67	100	100	67	33	67	67

TARGET NO(1)	SEPT MOVEMENT		ANNUAL MOVEMENT TO LATE AUGUST (2)			
	1960		1959–60		1960–61	
	OBS CM	ADJ	OBS CM	ADJ	OBS CM	ADJ
1	0.30	0.30	0.30	-0.10	0.60	1.10
2	0.65	0.65	0.55 *	0.55 *	0.85	1.15
3	0. *	0. *	0.50 *	0.50 *	0.55 *	0.55 *
4	0.	0.	0.55	0.05	0.80	1.30
5	0.50 *	0.50 *	0.35 *	0.35 *	0.90 *	0.90 *
6	0.25 *	0.25 *	0.85 *	0.85 *	0.85 *	0.85 *
7	0. *	0. *	0.40 *	0.40 *	0.65 *	0.65 *
8	0.	0.	0.30	-0.20	0.90	1.40
9	0. *	0. *	0.25	0.55	0.90 *	0.90 *
10	0. *	0. *	0.35 *	0.35 *	0.60 *	0.60 *
11	0. *	0. *	0.30	1.30	0.65 *	0.65 *
12	0. *	0. *	0. *	0. *	0.65 *	0.65 *
13	0.30 *	0.30 *	0.40 *	0.40 *	0.60 *	0.60 *
14	0.90 *	0.90 *	0.70	0.20	1.15 *	1.15 *
15	0. *	0. *	0.60 *	0.60 *	0.65 *	0.65 *
16	0.25 *	0.25 *	0.65 *	0.65 *	1.25 *	1.25 *
17	0. *	0. *	0.50	1.50	0.40 *	0.50 *
18	0.40 *	0.40 *	0.45 *	0.45 *	0.70 *	0.70 *
19	0. *	0. *	0.30 *	0.30 *	0.55 *	0.55 *
20	0. *	0. *	0.40	0.70	0.90 *	0.90 *
21	0.30	0.	0.35	1.35	0.65	0.15
22	0.45 *	0.45 *	0.45	0.75	0.85 *	0.85 *
23	0. *	0. *	0.50	0.90	0.70 *	0.70 *
24	0.55 *	0.55 *	0.65 *	0.65 *	1.10 *	1.10 *
25	0.40 *	0.40 *	0.85 *	0.85 *	0.95 *	0.95 *
26	1.00 *	1.00 *	0.75 *	0.75 *	1.70 *	1.70 *
27	0.80 *	0.80 *	0.95 *	0.95 *	1.15 *	1.15 *
28	0.50 *	0.50 *	1.10	1.60	0.75 *	0.75 *
30	0. *	0. *	1.75 *	1.75 *	1.55 *	1.55 *
31	0.40	0.10	4.85	4.15	3.70	3.40
32	0.60	0.60	2.35	2.05	3.45	4.25
33	0. *	0. *	1.70	1.30	4.40 *	4.40 *
35	0.	0.	4.35 *	4.45 *	6.20	5.70
36	0. *	0. *	2.40 *	2.40 *	1.95 *	1.95 *
38	0. *	0. *	1.00 *	1.00 *	0. *	0. *
PROPORTION AND PERCENT OF TARGETS SHOWING A GIVEN CATEGORY OF MOVEMENT > 0.2 CM						
GENERAL GROUP	17/35	15/35	34/35	30/35	34/35	33/35
	49	43	97	86	97	94
DRY	15/29	14/29	28/29	24/29	28/29	27/29
	52	48	97	83	97	93
WET	2/ 6	1/ 6	6/ 6	6/ 6	6/ 6	6/ 6
	33	17	100	100	100	100
SELECT GROUP	12/27	12/27	19/20	19/20	26/27	26/27
	44	44	95	95	96	96
DRY	12/24	12/24	16/17	16/17	23/24	23/24
	50	50	94	94	96	96
WET	0/ 3	0/ 3	3/ 3	3/ 3	3/ 3	3/ 3
	0	0	100	100	100	100

* SELECT TARGETS – THOSE WITH PROBABLY ≤ 0.2 CM DOWNSLOPE OR UPSLOPE ATTITUDE CHANGE DUE TO TILTING AND/OR TARGET HEAVING IN PERIOD INDICATED

OBS OBSERVED MOVEMENT. HORIZONTAL COMPONENT NORMAL TO TARGET LINE

ADJ ADJUSTED MOVEMENT. OBSERVED MOVEMENT ADJUSTED FOR TARGET ATTITUDE CHANGE ONLY, AS FOLLOWS.
JUMP, GELIFLUCTION, AND SEPT MOVEMENT FOR DOWN CHANGE,
RETROGRADE MOVEMENT FOR UP CHANGE,
ANNUAL MOVEMENT FOR BOTH DOWN- AND UP CHANGES

(1) OMITTED TARGETS ARE EXCLUDED FOR REASONS CITED IN TABLE OF TARGET ATTITUDES AND/OR CITED IN TEXT

(2) ANNUAL MOVEMENT TAKEN DIRECTLY FROM OBSERVATION TOTALS RATHER THAN FROM SUMMATION OF COMPONENT MOVEMENTS SINCE AMOUNT CALCULATED FROM COMPONENTS DISREGARDS ALL MOVEMENTS ≤ 0.2 CM

Table A VI.

EXPERIMENTAL SITE 8 ANALYSIS OF 1959-61 TARGET MOVEMENTS > 0.2 CM

TARGET NO(1)	DEPTH CM	DRY OR WET	TARGET ATTITUDES TILT > 0.2 CM (OFFSET OF TIP FROM VERT AT INSERT PT)						EFFECT OF ATTITUDE CHANGE (TILTING AND/OR HEAVING)				JUMP				GELIFLUCTION				RETROGRADE MOVEMENT				SEPT MOVEMENT		ANNUAL MOVEMENT TO LATE AUGUST(2)			
			21 AUG 1959		25 AUG 1960		15 AUG 1961		1959-60		1960-61		1959-60		1960-61		1960		1961		1960		1961		1960		1959-60		1960-61	
			DOWN	UP	DOWN	UP	DOWN	UP	DOWN	UP	DOWN	UP	OBS	ADJ	OBS	ADJ	OBS	ADJ	OBS	ADJ	OBS	ADJ	OBS	ADJ	OBS	ADJ	OBS	ADJ	OBS	ADJ
			CM		CM		CM		CM		CM		CM		CM		CM		CM		CM		CM		CM		CM		CM	
3	20.0	D	0.80	0.	0.	0.	0.	0.	0.	0.80	0. *	0. *	1.15	1.15	0. *	0. *	0.	0.	0.55 *	0.35 *	1.05	0.05	0.60 *	0.60 *	0. *	0. *	0.50	1.50	-0.30 *	-0.50 *
4	10.0	D	0.	0.	1.50	0.	1.80	0.	1.50	0.	0.30	0.	1.35 *	1.35 *	1.05 *	1.05 *	0. *	0. *	0. *	0. *	1.00 *	1.00 *	0.65 *	0.65 *	0. *	0. *	0.90 *	0.90 *	0. *	0. *
6	10.0	D	0.	0.	0.	0.	0.	0.	0. *	0. *	0. *	0. *	0.55	0.55	1.10 *	1.10 *	0.	0.	0. *	0. *	0.50	0.20	1.05 *	1.05 *	0. *	0. *	0.	0.30	0.45 *	0.45 *
7	20.0	D	0.30	0.	1.50	0.	1.00	0.	1.20	0.	0.	0.50	0.65 *	0.65 *	0.85 *	0.85 *	0. *	0. *	0.25 *	0.25 *	1.00 *	1.00 *	0.50 *	0.50 *	0. *	0. *	0. *	0. *	0.45 *	0.45 *
8	10.0	D	0.	0.	0.	0.	0.	0.	0. *	0. *	0. *	0. *	1.45 *	1.45 *	0.65	0.65	0. *	0. *	0.	0.	0.70 *	0.70 *	0.75	0.	0.	0.	0.80 *	0.80 *	0.	1.00
9	20.0	D	0.50	0.	0.	0.	0.	0.	0.	0.50	0. *	0. *	0.40	0.40	0.80	0.80	0.	0.	0.	0.	1.20	0.70	0.40	0.	0.	0.	-0.25	0.25	0.	0.50
10	10.0	D	0.40	0.	0.50	0.	0.	0.	0.10 *	0. *	0.	0.50	0.65	0.15	1.45	1.45	0.	0.	0.	0.	1.10	1.10	0.35	0.	0.	0.	0.	-0.50	0.60	1.10
11	20.0	D	0.30	0.	1.00	0.	0.60	0.	0.70	0.	0.	0.40	0.60 *	0.60 *	0.50	0.50	0. *	0. *	0.	0.	0.85 *	0.85 *	0.90	0.40	0.80	0.30	0. *	0. *	0.25	0.75
12	10.0	D	0.	0.	0.	0.	0.	0.80	0. *	0. *	0.	0.80	0.50 *	0.50 *	0.45	0.45	0. *	0. *	0.	0.	0.65 *	0.65 *	0.50	0.	0.	0.	0. *	0. *	0.	1.00
13	20.0	D	0.40	0.	0.	0.	0.	0.	0.	0.40	0. *	0. *	0.25	0.	0.90 *	0.90 *	0.	0.	0. *	0. *	0.55	0.55	0.55 *	0.55 *	0.50 *	0.50 *	0.	-0.40	0.75 *(3)	0.75 *(3)
14	10.0	D	0.	0.	0.	0.	0.	0.	0. *	0. *	0. *	0. *	0.85	0.85	1.05	0.55	0.	0.	0.	0.	1.00	0.50	0.70	0.70	0.	0.	0.30	0.80	0.	-0.50
15	20.0	D	0.	0.	0.	0.	0.	0.	0. *	0. *	0. *	0. *	0.55	0.55	0.80 *	0.80 *	0.	0.	0.25 *	0.25 *	0.90	0.40	0.35 *	0.35 *	0.35 *	0.35 *	0.	0.50	0.90 *	0.90 *
16	10.0	D	0.40	0.	1.00	0.	0.50	0.	0.60	0.	0.	0.50	1.00	0.	2.20 *	2.20 *	0.	0.	0.25 *	0.25 *	0.65	0.65	0.60 *	0.60 *	0.35 *	0.35 *	0.75	-0.65	1.90 *	1.90 *
17	20.0	D	0.70	0.	0.	0.	0.	0.	0.	0.70	0. *	0. *	0.	0.	1.10	0.80	0.35	0.	0.30	0.	0.50	0.50	0.45	0.45	0.30	0.	0.	-0.60	1.10	0.80
18	10.0	W	1.00	0.	0.	0.	0.	0.	0.	1.00	0. *	0. *	0.50 *	0.50 *	1.20 *	1.20 *	0.30 *	0.30 *	0. *	0. *	0.70 *	0.70 *	0.50 *	0.50 *	0. *	0. *	0.40 *	0.40 *	0.50 *	0.50 *
19	10.0	W	0.40	0.	0.	0.	0.	0.	0.	0.40	0. *	0. *	-0.30	-0.30	1.10 *	1.10 *	0.85	0.85	0. *	0. *	0.25	0.	0.50 *	0.50 *	0. *	0. *	0.55	0.85	0.55 *	0.55 *
20	10.0	W	0.30	0.	1.00	0.	1.00	0.	0.70	0.	0. *	0. *	0.35 *	0.35 *	0.70 *	0.70 *	0.60 *	0.60 *	0. *	0. *	0. *	0. *	0.45 *	0.45 *	0. *	0. *	1.00 *	1.00 *	0.25 *	0.25 *
21	20.0	W	1.10	0.	2.00	0.	1.50	0.	0.90	0.	0.	0.50	0.50 *	0.30 *	1.05 *	1.05 *	0.25 *	0.05 *	0. *	0. *	0. *	0. *	0.40 *	0.40 *	0. *	0. *	0.65 *	0.45 *	0.65 *	0.65 *
22	10.0	W	1.50	0.	1.00	0.	2.30	0.	0.	0.50	1.30	0.	0. *	0. *	0.60 *	0.60 *	0. *	0. *	0.25 *	0.25 *	0. *	0. *	0.40 *	0.40 *	0. *	0. *	0. *	0. *	0.55 *	0.55 *
23	20.0	W	0.	0.	0.	0.	0.	0.	0. *	0. *	0. *	0. *																		
24	10.0	W	0.	0.	0.	0.	0.	0.	0. *	0. *	0. *	0. *																		
25	20.0	W	0.30	0.	1.50	0.	0.50	0.	1.20	0.	0.	1.00																		
28	10.0	W	0.40	0.	0.	0.	0.	0.	0.	0.40	0. *	0. *																		
29	20.0	W	0.	0.	0.	0.	0.	0.	0. *	0. *	0. *	0. *																		
30	10.0	W	1.00	0.	2.00	0.	1.50	0.	1.00	0.	0.	0.50																		
31	20.0	D	0.40	0.	0.50	0.	0.	0.	0.10 *	0. *	0.	0.50																		
32	10.0	D	0.90	0.	1.00	0.	0.50	0.	0.10 *	0. *	0.	0.50																		
33	20.0	D	0.80	0.	0.50	0.	0.	0.	0.	0.30	0.	0.50																		
34	10.0	D	1.60	0.	0.	0.	0.	0.	0.	1.60	0. *	0. *																		
PROPORTION AND PERCENT OF TARGETS SHOWING A GIVEN CATEGORY OF MOVEMENT > 0.2 CM																														
GENERAL GROUP									8/29 28	10/29 34	2/29 7	11/29 38	16/19 84	13/19 68	18/19 95	18/19 95	5/19 26	3/19 16	6/19 32	5/19 26	16/19 84	13/19 68	19/19 100	15/19 79	5/19 26	4/19 21	9/19 47	11/19 58	13/19 68	16/19 84
DRY									4/18 22	6/18 33	1/18 6	8/18 44																		
WET									4/11 36	4/11 36	1/11 9	3/11 27																		
SELECT GROUP									0/11 0	0/11 0	0/16 0	0/16 0	8/ 9 89	8/ 9 89	11/12 92	11/12 92	3/ 9 33	2/ 9 22	5/12 42	5/12 42	6/ 9 67	6/ 9 67	12/12 100	12/12 100	3/12 25	3/12 25	5/ 9 56	5/ 9 56	10/12 83	10/12 83
DRY									0/ 8 0	0/ 8 0	0/ 9 0	0/ 9 0																		
WET									0/ 3 0	0/ 3 0	0/ 7 0	0/ 7 0																		
MEAN TARGET ATTITUDE CHANGE (WITH STANDARD ERROR)																														
GENERAL GROUP									0.3 (0.5)	0.2 (0.4)	0.1 (0.3)	0.2 (0.3)																		
DRY									0.2 (0.5)	0.2 (0.4)	0. (0.1)	0.2 (0.3)																		
WET									0.4 (0.5)	0.2 (0.3)	0.1 (0.4)	0.2 (0.3)																		
SELECT GROUP									0. (0.1)	0. (0.0)	0. (0.0)	0. (0.0)																		
DRY									0. (0.1)	0. (0.0)	0. (0.0)	0. (0.0)																		
WET									0. (0.0)	0. (0.0)	0. (0.0)	0. (0.0)																		

* SELECT TARGETS - THOSE WITH PROBABLY ≤ 0.2 CM DOWNSLOPE OR UPSLOPE ATTITUDE CHANGE DUE TO TILTING AND/OR TARGET HEAVING IN PERIOD INDICATED

+ 0. HERE INDICATES LACK OF DATA

OBS OBSERVED MOVEMENT. HORIZONTAL COMPONENT NORMAL TO TARGET LINE

ADJ ADJUSTED MOVEMENT. OBSERVED MOVEMENT ADJUSTED FOR TARGET ATTITUDE CHANGE ONLY, AS FOLLOWS.
JUMP, GELIFLUCTION, AND SEPT MOVEMENT FOR DOWN CHANGE,
RETROGRADE MOVEMENT FOR UP CHANGE,
ANNUAL MOVEMENT FOR BOTH DOWN- AND UP CHANGES

(1) OMITTED TARGETS ARE EXCLUDED FOR REASONS CITED IN TABLE OF TARGET ATTITUDES AND/OR CITED IN TEXT

(2) ANNUAL MOVEMENT TAKEN DIRECTLY FROM OBSERVATION TOTALS RATHER THAN FROM SUMMATION OF COMPONENT MOVEMENTS SINCE AMOUNT CALCULATED FROM COMPONENTS DISREGARDS ALL MOVEMENTS ≦ 0.2 CM

(3) LATE AUGUST READING LACKING, MID-AUGUST READING SUBSTITUTED

Table A VII.

EXPERIMENTAL SITES 6 - 8 SUMMARY OF 1960 AND 1961 PROPORTIONS FOR RETROGRADE MOVEMENTS >0.2 CM (1)

	1960										
	TOTAL NUMBER TARGETS CONSIDERED	OBS		ADJ FOR AND EXCEEDING ATTITUDE CHANGE		ADJ				COINCIDENCE BETWEEN DOWN ATTITUDE, NO CHANGE OF ATTITUDE, AND RETROGRADE MOVEMENT	
						DRY		WET			
		PROPORTION	PERCENT	PROPORTION	PERCENT	PROPORTION	PERCENT	PROPORTION	PERCENT	PROPORTION	PERCENT
EXPERIMENTAL SITE 6											
GENERAL GROUP	19	16/19	84	13/19	68			13/19	68	0/19	0
SELECT GROUP	9	6/ 9	67	6/ 9	67			6/ 9	67		
EXPERIMENTAL SITE 7											
GENERAL GROUP	35	25/35	71	17/35	49	15/29	52	2/ 6	33	0/35	0
SELECT GROUP	20	14/20	70	13/20	65	12/17	71	1/ 3	33		
STONE TARGETS	16			13/16	81	13/14	93	0/ 2	0		
EXPERIMENTAL SITE 8											
GENERAL GROUP	29	22/29	76	18/29	62	14/18	78	4/11	36	3/29	10
SELECT GROUP	11	9/11	82	9/11	82	8/ 8	100	1/ 3	33		
SUMMARY											
GENERAL GROUP	83	63/83	76	48/83	58	29/47	62	19/36	53	3/83	4
SELECT GROUP	40	29/40	73	28/40	70	20/25	80	8/15	53		
STONE TARGETS	16	13/16	81	13/16	81	13/14	93	0/ 2	0		

	1961											MEAN ATTITUDE CHANGE OF TARGETS SHOWING RETROGRADE MOVEMENT			
	TOTAL NUMBER TARGETS CONSIDERED	OBS		ADJ FOR AND EXCEEDING ATTITUDE CHANGE		ADJ				COINCIDENCE BETWEEN DOWN ATTITUDE, NO CHANGE OF ATTITUDE, AND RETROGRADE MOVEMENT		OBS			
						DRY		WET				1959 - 1960		1960 - 1961	
		PROPORTION	PERCENT	PROPORTION	PERCENT	PROPORTION	PERCENT	PROPORTION	PERCENT	PROPORTION	PERCENT	DOWN	UP	DOWN	UP
												CM			
EXPERIMENTAL SITE 6															
GENERAL GROUP	19	19/19	100	15/19	79			15/19	79	3/19	16	0.3	0.2	0.1	0.3
SELECT GROUP	12	12/12	100	12/12	100			12/12	100						
EXPERIMENTAL SITE 7															
GENERAL GROUP	35	29/35	83	25/35	71	22/29	76	3/ 6	50	1/35	3	0.1	0.1	0.0	0.1
SELECT GROUP	27	23/27	85	23/27	85	21/24	88	2/ 3	67						
STONE TARGETS															
EXPERIMENTAL SITE 8															
GENERAL GROUP	29	29/29	100	21/29	72	13/18	72	8/11	73	1/29	3	0.3	0.2	0.1	0.2
SELECT GROUP	16	16/16	100	16/16	100	9/ 9	100	7/ 7	100						
SUMMARY															
GENERAL GROUP	83	77/83	93	61/83	74	35/47	74	26/36	72	5/83	6	0.2	0.2	0.1	0.2
SELECT GROUP	55	51/55	93	51/55	93	30/33	91	21/22	95						
STONE TARGETS															

OBS OBSERVED MOVEMENT. HORIZONTAL COMPONENT NORMAL TO TARGET LINE

ADJ ADJUSTED MOVEMENT. OBSERVED MOVEMENT ADJUSTED FOR TARGET ATTITUDE CHANGE

(1) BASED ON TABLES FOR EXPERIMENTAL SITES 6 - 8, ANALYSES OF 1959 - 61 TARGET MOVEMENTS >0.2 CM

Table B I.

AIR-AND-GROUND ZERO-DEGREE CYCLES - OBSERVATIONS

ZERO-DEGREE CYCLES (TEMPERATURE CHANGES TO OR THROUGH 0° C) ARE LISTED FOR CYCLES PASSING 0° C WITH AMPLITUDES ≥ 0 AND (TO NEAREST DEGREE) ≥1 ,≥2 ,≥3 ,≥4

1 9 5 8

DATES AND AMPLITUDE	AIR CYCLES GOVT STATION	AIR CYCLES ES 8	GROUND CYCLES FOR THERMOGRAPHS 8A (12 CM)	8B (5)	8B (12)	8C (6)	8D (5)	8E (0)	MAXIMUM PROPORTION AND PERCENT OF EXPOSED TARGETS	PROPORTION	PERCENT
AUG									AUG		
≥ 0	8		0								
≥ 1	3		0						ES 6	19/19	100
≥ 2	2		0						ES 7	35/35	100
≥ 3	0		0						ES 8	29/29	100
≥ 4	0		0								
SEPT 1-15									SEPT 1-15		
≥ 0	9		0						ES 6	19/19	100
≥ 1	8		0						ES 7	35/35	100
≥ 2	6		0						ES 8	29/29	100
≥ 3	2		0								
≥ 4	0		0								
SEPT 16-18									SEPT 16-18		
≥ 0	3		0						ES 6	19/19	100
≥ 1	2		0						ES 7	31/35	89
≥ 2	0		0						ES 8	27/29	93
≥ 3	0		0								
≥ 4	0		0								

1 9 5 9

DATES AND AMPLITUDE	AIR CYCLES GOVT STATION	AIR CYCLES ES 8	GROUND CYCLES FOR THERMOGRAPHS 8A (12 CM)	8B (5)	8B (12)	8C (6)	8D (5)	8E (0)	MAXIMUM PROPORTION AND PERCENT OF EXPOSED TARGETS	PROPORTION	PERCENT
MAY 1-15									MAY 1-15		
≥ 0	1		0						ES 6	0/19 ?	0 ?
≥ 1	0		0						ES 7	0/35 ?	0 ?
≥ 2	0		0						ES 8		
≥ 3	0		0								
≥ 4	0		0								
MAY 16-31									MAY 16-31		
≥ 0	9		0						ES 6		
≥ 1	8		0						ES 7		
≥ 2	6		0						ES 8		
≥ 3	2		0								
≥ 4	1		0								
JUNE 1-15									JUNE 1-15		
≥ 0	15		3						ES 6		
≥ 1	14		2						ES 7		
≥ 2	9		0						ES 8		
≥ 3	6		0								
≥ 4	2		0								
JUNE 16-30									JUNE 16-30		
≥ 0	12		0						ES 6	19/19	100
≥ 1	10		0						ES 7	35/35	100
≥ 2	8		0						ES 8	29/29	100
≥ 3	3		0								
≥ 4	0		0								
JULY									JULY		
≥ 0	14		0								
≥ 1	10		0						ES 6	19/19	100
≥ 2	4		0						ES 7	35/35	100
≥ 3	0		0						ES 8	29/29	100
≥ 4	0		0								
AUG 1-23									AUG 1-23		
≥ 0	4		0						ES 6	19/19	100
≥ 1	3		0						ES 7	35/35	100
≥ 2	2		0						ES 8	29/29	100
≥ 3	0		0								
≥ 4	0		0								

1 9 6 0

DATES AND AMPLITUDE	AIR CYCLES GOVT STATION	AIR CYCLES ES 8	GROUND CYCLES FOR THERMOGRAPHS 8A (12 CM)	8B (5)	8B (12)	8C (6)	8D (5)	8E (0)	MAXIMUM PROPORTION AND PERCENT OF EXPOSED TARGETS	PROPORTION	PERCENT
MAY 18-31									MAY 18-31		
≥ 0	11					6	8	13	ES 6	0/19	0
≥ 1	9					2	0		ES 7	0/51	0
≥ 2	4					0	0		ES 8	9/29	31
≥ 3	3					0	0				
≥ 4	0					0	0				
JUNE 1-15									JUNE 1-15		
≥ 0	15					0	0	0	ES 6	14/19	74
≥ 1	15					0	0	0	ES 7	0/51	0
≥ 2	11					0	0	0	ES 8	22/29	76
≥ 3	8					0	0	0			
≥ 4	5					0	0	0			
JUNE 16-30									JUNE 16-30		
≥ 0	14					0	0	0	ES 6	14/19	74
≥ 1	12					0	0	0	ES 7	29/51	57
≥ 2	8					0	0	0	ES 8	22/29	76
≥ 3	4					0	0	0			
≥ 4	0					0	0	0			
JULY									JULY		
≥ 0	8					0	0	0			
≥ 1	4					0	0	0	ES 6	18/19	95
≥ 2	2					0	0	0	ES 7	51/51	100
≥ 3	0					0	0	0	ES 8	29/29	100
≥ 4	0					0	0	0			
AUG									AUG		
≥ 0	5					0	0	0			
≥ 1	2					0	0	0	ES 6	19/19	100
≥ 2	1					0	0	0	ES 7	51/51	100
≥ 3	0					0	0	0	ES 8	29/29	100
≥ 4	0					0	0	0			
SEPT 1-15									SEPT 1-15		
≥ 0	9	10		3	0	0	0	2	ES 6	19/19	100
≥ 1	7	7		1	0	0	0	0	ES 7	51/51	100
≥ 2	3	5		0	0	0	0	0	ES 8	29/29	100
≥ 3	0	0		0	0	0	0	0			
≥ 4	0	0		0	0	0	0	0			
SEPT 16-30									SEPT 16-30		
≥ 0	3	7		6	2	0	5	15	ES 6	19/19	100
≥ 1	2	4		2	0	0	1	3	ES 7	35/35	100
≥ 2	1	0		0	0	0	0	0	ES 8	29/29	100
≥ 3	0	0		0	0	0	0	0			
≥ 4	0	0		0	0	0	0	0			

1 9 6 1

DATES AND AMPLITUDE	AIR CYCLES GOVT STATION	AIR CYCLES ES 8	GROUND CYCLES FOR THERMOGRAPHS 8A (12 CM)	8B (5)	8B (12)	8C (6)	8D (5)	8E (0)	MAXIMUM PROPORTION AND PERCENT OF EXPOSED TARGETS	PROPORTION	PERCENT
MAY 1-15									MAY 1-15		
≥ 0	2	2		4	0	0	2	5	ES 6	0/19 ?	0 ?
≥ 1	2	2		1	0	0	1	5	ES 7	1/51	2
≥ 2	0	1		0	0	0	0	2	ES 8	16/29	55
≥ 3	0	1		0	0	0	0	1			
≥ 4	0	1		0	0	0	0	0			
MAY 16-31									MAY 16-31		
≥ 0	13	11		15	13	15	15	15	ES 6		
≥ 1	12	10		12	9	8	7	9	ES 7	3/51	6
≥ 2	11	6		2	7	0	0	1	ES 8	26/29	90
≥ 3	6	3		0	4	0	0	0			
≥ 4	0	1		0	0	0	0	0			
JUNE 1-15									JUNE 1-15		
≥ 0	8	5		0	7	0	2	3	ES 6		
≥ 1	5	5		0	3	0	0	0	ES 7	30/51	58
≥ 2	4	2		0	0	0	0	0	ES 8	29/29	100
≥ 3	2	0		0	0	0	0	0			
≥ 4	0	0		0	0	0	0	0			
JUNE 16-30									JUNE 16-30		
≥ 0	2	2		0	0	0	0	0	ES 6	19/19	100
≥ 1	1	2		0	0	0	0	0	ES 7	51/51	100
≥ 2	1	1		0	0	0	0	0	ES 8	29/29	100
≥ 3	1	0		0	0	0	0	0			
≥ 4	0	0		0	0	0	0	0			
JULY									JULY		
≥ 0	0	0		0	0	0	0	0			
≥ 1	0	0		0	0	0	0	0	ES 6	19/19	100
≥ 2	0	0		0	0	0	0	0	ES 7	51/51	100
≥ 3	0	0		0	0	0	0	0	ES 8	29/29	100
≥ 4	0	0		0	0	0	0	0			
AUG									AUG		
≥ 0	2	3		0	2	0	0	0			
≥ 1	1	3		0	1	0	0	0	ES 6	19/19	100
≥ 2	0	0		0	0	0	0	0	ES 7	51/51	100
≥ 3	0	0		0	0	0	0	0	ES 8	29/29	100
≥ 4	0	0		0	0	0	0	0			

(1) 16-18 SEPT FOR GOVERNMENT STATION. GAP IN PRECEDING RECORD

(2) CONE TARGETS. DATA LACKING FOR STONE TARGETS

Table B II.

AIR-AND-GROUND ZERO-DEGREE CYCLES - CORRELATION

AIR CYCLES FOR MAY AND SECOND HALF SEPTEMBER HAVE AMPLITUDE ≥ 0 C, FOR OTHER MONTHS ≥ 4
GROUND CYCLES ARE FOR DEPTH CA 5 CM AND HAVE AMPLITUDE ≥ 0

	MAY						JUNE						JULY			AUG			SEPT					
	1-15			16-31			1-15			16-30									1-15			16-30		
	CYCLES		MAX PERCENT EXPOSED TARGETS AND	CYCLES		MAX PERCENT EXPOSED TARGETS AND	CYCLES		MAX PERCENT EXPOSED TARGETS AND	CYCLES		MAX PERCENT EXPOSED TARGETS AND	CYCLES		MAX PERCENT EXPOSED TARGETS AND	CYCLES		MAX PERCENT EXPOSED TARGETS AND	CYCLES		MAX PERCENT EXPOSED TARGETS AND	CYCLES		MAX PERCENT EXPOSED TARGETS AND
	AIR	GROUND	COMMENTS	AIR	GROUND	COMMENTS	AIR	GROUND	COMMENTS	AIR	GROUND	COMMENTS	AIR	GROUND	COMMENTS	AIR	GROUND	COMMENTS	AIR	GROUND	COMMENTS	AIR	GROUND	COMMENTS
1957																								
GOVT STATION	5			10			4			0			0			0			0			2		
ES 6			0 ?			0 ?			47			63			95			100			100			100
ES 7			0 ?			0 ?			20			63			100			100						
ES 8			41			90			90			93			100			100			100			100
1958																								16-18 SEPT
GOVT STATION	10			5			0			0			0			0			0			3		
ES 6			0			0			21			79			100			100			100			100
ES 7			0			14			60			77			100			100			100			90
ES 8			0			72			100			100			100		0	100		0	100		0	95
1959																		1-23 AUG						
GOVT STATION	1			9			2			0			0			0			3			5		
ES 6			0 ?												100			100			0			0
ES 7			0 ?												100			100			0			0
ES 8															100			100			0			0
1960						18-31 MAY																		
GOVT STATION	8			11			5			0			0			0			0			3		
ES 6			0			0			74			74			95			100			100			100
ES 7			0			0			0			57			100			100			100			100
ES 8			0 ?		6-8	31		0	76		0	76		0	100		0	100	0	0-3	100	3-7	0-6	100
1961																		1-27 AUG						19-30 SEPT
GOVT STATION	2			13			0			0			0			0			0			5		
ES 6			0 ?									100			100			100			100			0
ES M			2			6			58			100			100			100			100			0
ES 8	2	0-4	55	11	15	90	0	0-2	100	0	0	100	0	0	100	0	0	100			100			0

Table B III.

EXPERIMENTAL SITE 6 TARGET EXPOSURE DATES

TARGET NO	1957				1958				1959				1960				1961			
	COV	PART EXP	EXP	FIRST READING	COV	PART EXP	EXP	FIRST READING	COV	PART EXP	EXP	FIRST READING	COV	PART EXP	EXP	FIRST READING	COV	PART EXP	EXP	'FIRST READING
10	?		25/6	27/6	11/6	18/6	20/6	20/6	?		9/7	9/7	14/6		6/7	11/7	?		28/6	28/6
12	?		25/6	27/6	11/6		18/6	20/6	?		9/7	9/7	14/6		6/7	11/7	?		28/6	28/6
13	?		25/6	27/6	11/6	18/6	20/6	20/6	?		9/7	9/7	6/7		11/7	11/7	?		28/6	28/6
14	?		25/6	27/6	11/6		18/6	20/6	?		9/7	9/7	14/6		6/7	11/7	?		28/6	28/6
15	?		25/6	27/6	11/6	18/6	20/6	20/6	?		9/7	9/7	14/6		6/7	11/7	?		28/6	28/6
16	?		25/6	27/6	18/6		20/6	20/6	?		9/7	9/7	14/6		6/7	11/7	?		28/6	28/6
17	?		25/6	27/6	11/6		18/6	20/6	?		9/7	9/7	14/6		6/7	11/7	?		28/6	28/6
18	?		25/6	27/6	11/6		18/6	20/6	?		9/7	9/7	14/6		6/7	11/7	?		28/6	28/6
19	?		25/6	27/6	20/6		25/6	26/6	?		9/7	9/7	14/6		6/7	11/7	?		28/6	28/6
20	25/6		27/6	27/6	20/6		25/6	26/6	?		9/7	9/7	14/6		6/7	11/7	?		28/6	28/6
21	27/6		3/7	3/7	20/6		25/6	26/6	?		9/7	9/7	14/6		6/7	11/7	?		28/6	28/6
22	27/6		3/7	3/7	20/6		25/6	26/6	?		9/7	9/7	14/6		6/7	11/7	?		28/6	28/6
24	11/7		14/7	14/7	26/6		5/7	8/7	?		9/7	9/7	14/6		6/7	11/7	?		28/6	28/6
25	14/7	15/7	25/7	25/7	26/6		5/7	8/7	?		9/7	9/7	14/6		6/7	11/7	?		28/6	28/6
26	14/7		25/7	25/7	26/6		5/7	8/7	?		9/7	9/7	14/6		6/7	11/7	?		28/6	28/6
28	14/7		25/7	25/7	6/7		8/7	8/7	?		9/7	9/7	6/7		11/7	11/7	?		28/6	28/6
30	25/7		7/8	8/8	8/7		13/7	15/7	?		9/7	9/7	13/7	19/7	29/7	19/7	?		28/6	28/6
31	25/7		7/8	8/8	8/7	13/7	14/7	14/7	?		9/7	9/7	19/7		29/7	29/7	?		28/6	28/6
34	8/8		20/8	20/8	15/7	20/7	22/7	22/7	?		9/7	9/7	8/8		21/8	21/8	?		28/6	28/6
38	21/9		(1)	(1)	22/7		30/7	30/7	?		9/7	9/7	29/9		(1)	(1)	28/6		13/7	13/7
39	21/9		(1)	(1`	30/7		31/7	2/8	?		9/7	9/7	29/9		(1)	(1)	28/6		13/7	13/7
43	21/9		(1)	(1)	8/8		13/8	13/8	9/7		19/7	19/7	29/9		(1)	(1)	21/7		3/8	3/8

EARLIEST POSSIBLE EXPOSURE
CUMULATIVE TOTALS(2)

	1957		1958		1960		1961	
	T10-34	T38-43	T10-34	T38-43	T10-34	T38-43	T10-34	T38-43
MAY								
1-15	0	0	0	0	0	0	0 ?	0
16-31	0 ?	0	0	0	0	0	0 ?	0
JUNE								
1-15	9 ?	0	4	0	14	0	19 ?	0
16-30	12	0	15	0	14	0	19	2
JULY								
1-15	16	0	18	0	17	0		2
16-31	18	0	19	2	18	0		3
AUG								
1-15	19	0		3	19	0		
16-31		0				0		
SEPT								
1-15		0				0		
16-30		0				0		

COV COVERED. TARGET SNOW COVERED

PART EXP PARTLY EXPOSED. TARGET PARTLY EXPOSED

EXP EXPOSED. TARGET EXPOSED ON OR BEFORE DATE INDICATED

(1) REMAINED SNOW COVERED

(2) DATA LACKING FOR 1959

Table B IV. 1.

EXPERIMENTAL SITE 7 TARGET EXPOSURE DATES

TARGET NO	1957				1958				1959				1960					1961				
	COV	PART EXP	EXP	FIRST READING	COV	PART EXP	EXP	FIRST READING	COV	PART EXP	EXP	FIRST READING	COV	PART EXP	EXP	FIRST READING	FC-G	COV	PART EXP	EXP	FIRST READING	FC-G
1	15/6		24/6	26/6	5/6		9/6	16/6	?		10/7	10/7	1/7		3/7	6/7		14/6		17/6	17/6	
2	?	15/6	24/6	26/6	2/6	4/6	5/6	5/6	?		10/7	10/7	27/6		1/7	1/7	X	14/6		17/6	17/6	
3	?		15/6	26/6	28/5	2/6	4/6	5/6	?		10/7	10/7	27/6		1/7	1/7	X	14/6		17/6	17/6	X
4	?		15/6	26/6	28/5	2/6	4/6	5/6	?		10/7	10/7	27/6		1/7	1/7		14/6		17/6	17/6	
5	?		15/6	26/6	28/5	2/6	4/6	5/6	?		10/7	10/7	27/6		1/7	1/7	X	14/6		17/6	17/6	X
6	?		15/6	26/6	28/5	2/6	4/6	5/6	?		10/7	10/7	27/6		1/7	1/7	X	14/6		17/6	17/6	X
7	?		15/6	26/6	28/5		2/6	5/6	?		10/7	10/7	27/6		1/7	1/7	X	14/6		17/6	17/6	X
8	?		15/6	26/6	28/5		2/6	5/6	?		10/7	10/7	25/6	27/6?	1/7	1/7		14/6		17/6	17/6	
9	15/6		24/6	26/6	28/5	2/6	4/6	5/6	?		10/7	10/7	27/6		1/7	1/7		14/6		17/6	17/6	X
10	15/6		24/6	26/6	28/5	2/6	4/6	5/6	?		10/7	10/7	25/6	27/6	1/7	1/7	X	14/6		17/6	17/6	X
11	15/6		24/6	26/6	28/5		2/6	5/6	?		10/7	10/7	20/6		25/6	25/6		14/6		17/6	17/6	X
12	15/6		24/6	26/6	28/5		2/6	5/6	?		10/7	10/7	20/6		25/6	25/6		14/6		17/6	17/6	X
13	15/6		24/6	26/6	28/5	2/6	4/6	5/6	?		10/7	10/7	20/6		25/6	25/6		14/6		17/6	17/6	X
14	15/6		24/6	26/6	28/5	2/6	4/6	5/6	?		10/7	10/7	18/6		20/6	20/6		14/6		17/6	17/6	X
15	15/6		24/6	26/6	28/5	2/6	4/6	5/6	?		10/7	10/7	18/6		20/6	20/6	X	14/6		17/6	17/6	X
16	15/6		24/6	26/6	2/6		4/6	5/6	?		10/7	10/7	20/6		25/6	25/6		14/6		17/6	17/6	X
17	24/6		26/6	26/6	4/6		5/6	5/6	?		10/7	10/7	25/6	27/6	1/7	1/7		14/6		17/6	17/6	X
18	28/6		4/7	13/7	13/6		16/6	16/6	?		10/7	10/7	1/7		3/7	6/7		17/6		19/6	19/6	X
19	28/6		4/7	13/7	16/6	18/6	21/6	21/6	?		10/7	10/7	25/6	27/6?	1/7	1/7		17/6	19/6	29/6	19/6	X
20	4/7		13/7	13/7	18/6		21/6	21/6	?		10/7	10/7	27/6		1/7	1/7		17/6	19/6	29/6	19/6	X
21	4/7		13/7	13/7	21/6		27/6	27/6	?		10/7	10/7	27/6		1/7	1/7		17/6	19/6	29/6	19/6	
22	13/7		24/7	24/7	27/6		1/7	4/7	?		10/7	10/7	1/7		3/7	6/7		19/6		29/6	29/6	
23	13/7		24/7	24/7	27/6	1/7	4/7	4/7	?		10/7	10/7	3/7		6/7	6/7		19/6		29/6	29/6	
24	13/7		24/7	24/7	27/6	4/7	9/7	4/7	?		10/7	10/7	3/7		6/7	6/7	X	19/6		29/6	29/6	
25	13/7		24/7	24/7	4/7		9/7	9/7	?		10/7	10/7	3/7		6/7	6/7	X	19/6		29/6	29/6	
26	13/7		24/7	24/7	9/7	11/7	16/7	22/7	?		10/7	10/7	10/7		11/7	11/7	X	19/6		29/6	29/6	
27	13/7		24/7	24/7	11/7		16/7	22/7	?		10/7	10/7	11/7	13/7	17/7	17/7	X	19/6		29/6	29/6	
28	13/7		24/7	24/7	11/7		16/7	22/7	?		10/7	10/7	17/7		22/7	29/7		19/6		29/6	29/6	
30	13/7		24/7	24/7	9/7		16/7	22/7	?		10/7	10/7	29/7		7/8	7/8		19/6		29/6	29/6	
31	13/7		24/7	24/7	4/7		9/7	9/7	?		10/7	10/7	29/7		7/8	7/8		19/6		29/6	29/6	
32	13/7		24/7	24/7	27/6		4/7	4/7	?		10/7	10/7	29/7		7/8	7/8		19/6		29/6	29/6	
33	13/7		24/7	24/7	21/6	25/6	27/6	27/6	?		10/7	10/7	23/7		29/7	29/7		14/6		17/6	17/6	X
35	24/6		28/6	13/7	9/6		13/6	16/6	?		10/7	10/7	13/7		17/7	17/7	X	28/5		31/5	31/5	
36	15/6		24/6	26/6	2/6	5/6	9/6	5/6	?		10/7	10/7	13/7		17/7	17/7	X	15/5		19/5	19/5	X
38	?		15/6	26/6	?		23/5	5/6	?		10/7	10/7	6/7		7/7	11/7		?		1/5	15/5	

EARLIEST POSSIBLE EXPOSURE CUMULATIVE TOTALS(1)

	1957	1958	1960	1961
MAY				
1-15	0	0?	0	0
16-31	0?	5?	0	1
JUNE				
1-15	7?	21	0	3
16-30	22	27	19	21
JULY				
1-15	35	35	30	35
16-31			35	

COV COVERED. TARGET SNOW COVERED

PART EXP PARTLY EXPOSED. TARGET PARTLY EXPOSED FROM SNOW

EXP EXPOSED. TARGET EXPOSED ON OR BEFORE DATE INDICATED

FC-G FROST CREEP - GELIFLUCTION. TARGET READ WITHIN 4 DAYS OF EXPOSURE AND HAVING PROBABLY ≤ 0.2 CM DOWNSLOPE OR UPSLOPE ATTITUDE CHANGE SINCE PREVIOUS AUGUST

(1) DATA LACKING FOR 1959

Table B IV. 2.

EXPERIMENTAL SITE 7 STONE-TARGET EXPOSURE DATES

TARGET NO	1960				1961			
	COV	PART EXP	EXP	FIRST READING	COV	PART EXP	EXP	FIRST READING
1	27/6		1/7	10/7	14/6		17/6	12/7
2	27/6		1/7	10/7	14/6		17/6	12/7
3	27/6		1/7	10/7	14/6		17/6	12/7
4	27/6		1/7	10/7	14/6		17/6	12/7
5	20/6		25/6	10/7	14/6		17/6	12/7
6	20/6		25/6	10/7	14/6		17/6	12/7
7	18/6		20/6	10/7	14/6		17/6	12/7
8	20/6		1/7	10/7	14/6		17/6	12/7
9	25/6		1/7	30/7	17/6		29/6	12/7
10	27/6		1/7	10/7	17/6		29/6	12/7
11	1/7		6/7	10/7	19/6		29/6	12/7
12	3/7		6/7	10/7	19/6		29/6	12/7
13	11/7		17/7	30/7	19/6		29/6	12/7
14	17/7		22/7	30/7	19/6		29/6	12/7
15	29/7		30/7	30/7	19/6		29/6	12/7
16	17/7		22/7	30/7	31/5		8/6	12/7

EARLIEST POSSIBLE EXPOSURE CUMULATIVE TOTALS

	1960	1961
MAY		
1-15	0	0
16-31	0	0
JUNE		
1-15	0	9
16-30	10	16
JULY		
1-15	13	
16-31	16	

COV COVERED. TARGET SNOW COVERED

PART EXP PARTLY EXPOSED. TARGET PARTLY EXPOSED FROM SNOW

EXP EXPOSED. TARGET EXPOSED ON OR BEFORE DATE INDICATED

Table B V.

EXPERIMENTAL SITE 8 TARGET EXPOSURE DATES

TARGET NO	1957				1958				1959				1960					1961				
	COV	PART EXP	EXP	FIRST READING	COV	PART EXP	EXP	FIRST READING	COV	PART EXP	EXP	FIRST READIN	COV	PART EXP	EXP	FIRST READING	FC-G	COV	PART EXP	EXP	FIRST READING	FC-G (2)
3	?		13/5	26/6	19/5	23/5	28/5	11/6	?		10/7	10/7	4/6		8/6	14/6		?	5/5	15/5	5/5	X
4	?		13/5	26/6	19/5		23/5	11/6	?		10/7	10/7	6/6		8/6	14/6		?		1/5	5/5	
6	?	28/5	30/5	26/6	28/5	2/6	4/6	11/6	?		10/7	10/7	4/6		6/6	14/6		19/5		23/5	23/5	X
7	?		18/5	26/6	28/5		2/6	11/6	?		10/7	10/7	4/6		6/6	14/6		15/5		17/5	17/5	
8	?		18/5	26/6	19/5?		2/6	11/6	?		10/7	10/7	26/5	23/5	31/5	4/6		?		1/5	5/5	X
9	?		18/5	26/6	19/5?		2/6	11/6	?		10/7	10/7	?	17/5	20/5	4/6		?		1/5	5/5	X
10	?		18/5	26/6	19/5?		2/6	11/6	?		10/7	10/7	?	17/5	23/5	4/6		?	5/5	15/5	5/5	
11	?		18/5	26/6	19/5?		2/6	11/6	?		10/7	10/7	?		23/5	4/6		?	5/5	17/5	5/5	
12	?		18/5	26/6	19/5?		2/6	11/6	?		10/7	10/7	?	17/5	20/5	4/6		?	5/5	15/5	5/5	
13	?		18/5	26/6	19/5?		2/6	11/6	?		10/7	10/7	31/5		2/6	4/6		?	5/5	15/5	5/5	X
14	?		18/5	26/6	19/5?		2/6	11/6	?		10/7	10/7	26/5		31/5	4/6		?		1/5	5/5	X
15	?		18/5	26/6	19/5?		2/6	11/6	?		10/7	10/7	26/5		31/5	4/6		?	5/5	15/5	5/5	X
16	18/5		28/5	26/6	19/5?		2/6	11/6	?		10/7	10/7	26/5	31/5	2/6	4/6		?	5/5	15/5	5/5	
17	28/5		13/6	26/6	19/5?		2/6	11/6	?		10/7	10/7	26/5	31/5	2/6	4/6		?	5/5	17/5	5/5	X
18	28/5		13/6	26/6	19/5?		2/6	11/6	?		10/7	10/7	26/5	31/5	2/6	4/6		?	5/5	17/5	5/5	X
19	28/5		13/6	26/6	19/5?		2/6	11/6	?		10/7	10/7	26/5		31/5	4/6		?	5/5	15/5	5/5	X
20	28/5		13/6	26/6	19/5?		2/6	11/6	?		10/7	10/7	26/5		31/5	4/6		?	5/5	15/5	5/5	X
21	28/5		13/6	26/6	19/5?		2/6	11/6	?		10/7	10/7	31/5		2/6	4/6		?	5/5	15/5	5/5	
22	18/5		28/5	26/6	19/5?		2/6	11/6	?		10/7	10/7	4/6		6/6	14/6		?	5/5	15/5	5/5	
23	13/5		18/5	26/6	19/5?		2/6	11/6	?		10/7	10/7	6/6		8/6	14/6		?	5/5	15/5	5/5	X
24	28/5		13/6	26/6	2/6		4/6	11/6	?		10/7	10/7	14/6		20/6	21/6		17/5		19/5	19/5	X
25	28/5		13/6	26/5	19/5?		2/6	11/6	?		10/7	10/7	12/6		13/6	21/6		?	5/5	17/5	5/5	
28	28/5		13/6	26/6	2/6		4/6	11/6	?		10/7	10/7	27/6	1/7	3/7	9/7		15/5		17/5	17/5	X
29	28/5		13/6	26/6	2/6	5/6	9/6	11/6	?		10/7	10/7	6/7		7/7	9/7	X	15/5	17/5	19/5	17/5	X
30	28/5		13/6	28/6	4/6	5/6	9/6	11/6	?		10/7	10/7	6/7		7/7	15/7		15/5		17/5	17/5	
31	28/5		13/6	28/6	2/6		4/6	11/6	?		10/7	10/7	9/7		15/7	15/7		15/5		17/5	17/5	
32	28/6		12/7	12/7	4/6	5/6	9/6	11/6	?		10/7	10/7	15/7		29/7	29/7		28/5	31/5	8/6	31/5	
33	12/7		24/7	25/7	4/6	5/6	9/6	11/6	?		10/7	10/7	15/7	22/7	29/7	29/7		31/5		8/6	8/6	
34	12/7		24/7	25/7	9/6	11/6	20/6	11/6	?		10/7	10/7	22/7		29/7	29/7		8/6		17/6	17/6	

EARLIEST POSSIBLE EXPOSURE CUMULATIVE TOTALS (1)

	1957	1958	1960	1961
APRIL				
1-15	0	0	0	0
16-30	0	0	0	4?
MAY				
1-15	12?	0	0	16
16-31	26	21?	9 ?	26
JUNE				
1-15	26	29	22	29
16-30	27		22	
JULY				
1-15	29		26	
16-31			29	

COV COVERED. TARGET SNOW COVERED

PART EXP PARTLY EXPOSED. TARGET PARTLY EXPOSED FROM SNOW

EXP EXPOSED. TARGET EXPOSED ON OR BEFORE DATE INDICATED

FC-G FROST CREEP - GELIFLUCTION. TARGET READ WITHIN 4 DAYS OF EXPOSURE AND HAVING PROBABLY ≤ 0.2 CM DOWNSLOPE OR UPSLOPE ATTITUDE CHANGE SINCE PREVIOUS AUGUST

(1) DATA LACKING FOR 1959

(2) GROUND SURFACE STILL FROZEN ON 5/5 AND EXPOSED TARGETS NOT YET SUBJECT TO MOVEMENT

Table C I.

EXPERIMENTAL SITE 6 TARGET MOVEMENTS > 0.2 CM 1956-61

J U M P

TARGET NO (1)	DEPTH CM	ANGLE OF VIEW	GRADIENT	1956-57 (INCL 1956 SEPT MOVET) CM		1957-58 CM		1958-59 CM		1959-60 CM		1960-61 CM		TOTAL CM	
				OBS	ADJ	OBS	ADJ	OBS	ADJ	OBS	ADJ	OBS	ADJ	OBS	ADJ
MW6	103.5	25	4.5												
10	10.0	58	3.0	1.70	3.20	0.40	0.75	1.20	2.25	1.15	2.15	0. *	0. *	4.45	8.35
12	10.0	50	2.5	1.00	1.55	1.40	2.20	0.85	1.30	1.35 *	2.10 *	1.05 *	1.65 *	5.65	8.80
13	20.0	46	2.5	1.30	1.85	0.85	1.20	1.65	2.40	0.55	0.80	1.60 *	2.30 *	5.95	8.55
14	10.0	43	2.5	0.85	1.15	1.05	1.45	1.50	2.05	0.65 *	0.90 *	0.85 *	1.15 *	4.90	6.70
15	20.0	43	2.5	1.50	2.05	0.60	0.80	1.25	1.70	1.45 *	2.00 *	0.65	0.90	5.45	7.45
16	10.0	43	2.5	1.05	1.45	0.55	0.75	1.00	1.35	0.40	0.55	0.80	1.10	3.80	5.20
17	20.0	43	2.5	1.10	1.50	0.55	0.75	1.35	1.85	0.65	0.90	1.45	2.00	5.10	7.00
18	10.0	43	2.5	0.75	1.05	0.60	0.80	1.15	1.55	0.60 *	0.80 *	0.50	0.70	3.60	4.90
19	20.0	43	2.5	1.05	1.45	0.55	0.75	0.90	1.25	0.50 *	0.70 *	0.45	0.60	3.45	4.75
20	10.0	43	2.5	1.15	1.55	0.60	0.80	1.05	1.45	0.25	0.35	0.90 *	1.25 *	3.95	5.40
21	20.0	43	2.5	0.40	0.55	0.60	0.80	0.85	1.15	0.85	1.15	1.05	1.45	3.75	5.10
22	10.0	43	2.5	0.80	1.10	0.	0.	1.20	1.65	0.55	0.75	0.80 *	1.10 *	3.35	4.60
24	10.0	42	2.5	0.80	1.10	0.70	0.95	1.75	2.35	1.00	1.35	2.20 *	2.95 *	6.45	8.70
25	20.0	42	2.5	1.55	2.10	0.60	0.80	1.90	2.55	0.	0.	1.10	1.50	5.15	6.95
26	10.0	40	2.5	1.65	2.15	0.45	0.60	0.95	1.25	0.50 *	0.65 *	1.20 *	1.55 *	4.75	6.20
28	10.0	33	2.5	0.80	0.95	0.	0.	1.05	1.25	-0.30	-0.35	1.10 *	1.30 *	2.65	3.15
30	10.0	26	2.5	1.70	1.90	0.35	0.40	0.75	0.85	0.35 *	0.40 *	0.70 *	0.80 *	3.85	4.35
31	20.0	26	2.5	1.35	1.50	0.	0.	1.15	1.30	0.50 *	0.55 *	1.05 *	1.15 *	4.05	4.50
34	10.0	24	2.5	1.70	1.85	0.	0.	1.10	1.20	0. *	0. *	0.60 *	0.65 *	3.40	3.70
MEAN (WITH STANDARD ERROR) MW6 EXCL GENERAL GROUP				1.2 (0.1)	1.6 (0.1)	0.5 (0.1)	0.7 (0.1)	1.2 (0.1)	1.6 (0.1)	0.6 (0.1)	0.8 (0.2)	1. (0.1)	1.3 (0.2)	4.4 (0.2)	6. (0.4)
SELECT GROUP										0.7 (0.2)	0.9 (0.2)	1. (0.2)	1.3 (0.2)		
PROPORTION (WITH STANDARD ERROR) AND PERCENT OF MOVEMENTS EXCEEDING GROUP MEAN BY AT LEAST 0.025 CM GENERAL GROUP				8/19 (0.1) 42.1	7/19 (0.1) 36.8	12/19 (0.1) 63.2	9/19 (0.1) 47.4	6/19 (0.1) 31.6	8/19 (0.1) 42.1	7/19 (0.1) 36.8	7/19 (0.1) 36.8	9/19 (0.1) 47.4	8/19 (0.1) 42.1	9/19 (0.1) 47.4	9/19 (0.1) 47.4
SELECT GROUP										2/ 9 (0.1) 22.2	2/ 9 (0.1) 22.2	6/12 (0.1) 50.	4/12 (0.1) 33.3		
MEAN (WITH STANDARD ERROR) FOR 10 CM T															
MEAN (WITH STANDARD ERROR) FOR 20 CM T															

G E L I F L U C T I O N

TARGET NO (1)	1957 CM		1958 CM		1959 CM		1960 CM		1961 CM		TOTAL CM	
	OBS	ADJ	OBS	ADJ	OBS	ADJ	OBS	ADJ	OBS	ADJ	OBS	ADJ
MW6												
10	0.35	0.65	0.	0.	0.	0.	0.	0.	0.55 *	1.05 *	0.90	1.70
12	0.80	1.25	0.	0.	0.	0.	0. *	0. *	0. *	0. *	0.80	1.25
13	0.60	0.85	0.70	1.00	0.	0.	0.	0.	0. *	0. *	1.30	1.85
14	0.65	0.90	0.	0.	0.	0.	0. *	0. *	0.25 *	0.35 *	0.90	1.25
15	0.60	0.80	0.	0.	0.	0.	0. *	0. *	0.	0.	0.60	0.80
16	0.	0.	0.75	1.05	0.	0.	0.	0.	0.	0.	0.75	1.05
17	0.	0.	0.65	0.90	0.	0.	0.	0.	0.	0.	0.65	0.90
18	0.25	0.35	0.	0.	0.	0.	0. *	0. *	0.	0.	0.25	0.35
19	0.35	0.50	0.	0.	0.	0.	0. *	0. *	0.	0.	0.35	0.50
20	1.15	1.55	0.95	1.30	0.	0.	0.	0.	0. *	0. *	2.10	2.85
21	0.90	1.25	0.	0.	0.25	0.35	0.	0.	0.	0.	1.15	1.60
22	0.35	0.50	0.75	1.05	0.	0.	0.	0.	0.25 *	0.35 *	1.35	1.90
24	0.85	1.15	0.	0.	0.	0.	0.	0.	0.25 *	0.35 *	1.10	1.50
25	0.35	0.45	0.35	0.45	0.	0.	0.35	0.45	0.30	0.40	1.35	1.75
26	0.30	0.40	0.60	0.80	0.	0.	0.30 *	0.40 *	0. *	0. *	1.20	1.60
28	0.60	0.70	0.45	0.55	0.	0.	0.85	1.00	0. *	0. *	1.90	2.25
30	0.	0.	0.40	0.45	0.	0.	0.60 *	0.65 *	0. *	0. *	1.00	1.10
31	0.30	0.35	0.65	0.70	0.	0.	0.25 *	0.30 *	0. *	0. *	1.20	1.35
34	0.	0.	1.15	1.25	0.	0.	0. *	0. *	0.25 *	0.25 *	1.40	1.50
MEAN (WITH STANDARD ERROR) MW6 EXCL GENERAL GROUP	0.4 (0.1)	0.6 (0.1)	0.4 (0.1)	0.5 (0.1)	0. (0.0)	0. (0.0)	0.1 (0.1)	0.2 (0.1)	0.1 (0.0)	0.1 (0.1)	1.1 (0.1)	1.4 (0.1)
SELECT GROUP							0.1 (0.1)	0.2 (0.1)	0.1 (0.1)	0.2 (0.1)		
PROPORTION (WITH STANDARD ERROR) AND PERCENT OF MOVEMENTS EXCEEDING GROUP MEAN BY AT LEAST 0.025 CM GENERAL GROUP	8/19 (0.1) 42.1	9/19 (0.1) 47.4	9/19 (0.1) 47.4	9/19 (0.1) 47.4	1/19 (0.1) 5.3	1/19 (0.1) 5.3	5/19 (0.1) 26.3	5/19 (0.1) 26.3	6/19 (0.1) 31.6	6/19 (0.1) 31.6	10/19 (0.1) 52.6	10/19 (0.1) 52.6
SELECT GROUP							3/ 9 (0.2) 33.3	3/ 9 (0.2) 33.3	5/12 (0.1) 41.7	5/12 (0.1) 41.7		
MEAN (WITH STANDARD ERROR) FOR 10 CM T											1.1 (0.1)	1.5 (0.2)
MEAN (WITH STANDARD ERROR) FOR 20 CM T											0.9 (0.2)	1.3 (0.2)

R E T R O G R A D E M O V E M E N T

TARGET NO (1)	1957 CM		1958 CM		1959 CM		1960 CM		1961 CM		TOTAL CM	
	OBS	ADJ	OBS	ADJ	OBS	ADJ	OBS	ADJ	OBS	ADJ	OBS	ADJ
MW6												
10	0.35	0.65	0.55	1.05	0.80	1.50	1.05	2.00	0.50 *	0.95 *	3.25	6.15
12	0.30	0.45	1.75	2.70	0.25	0.40	1.00 *	1.55 *	0.65 *	1.00 *	3.95	6.10
13	0.90	1.30	0.80	1.15	0.25	0.35	1.00	1.45	1.05 *	1.50 *	4.00	5.75
14	0.55	0.75	1.35	1.85	0.	0.	1.00 *	1.35 *	0.50 *	0.70 *	3.40	4.65
15	0.55	0.75	1.45	2.00	0.35	0.50	0.70 *	0.95 *	0.75	1.05	3.80	5.25
16	1.15	1.55	0.70	0.95	0.	0.	1.20	1.65	0.40	0.55	3.45	4.70
17	0.45	0.60	0.80	1.10	0.	0.	1.10	1.50	0.35	0.50	2.70	3.70
18	0.40	0.55	0.85	1.15	0.	0.	0.85 *	1.15 *	0.90	1.25	3.00	4.10
19	0.25	0.35	0.55	0.75	0.25	0.35	0.65 *	0.90 *	0.50	0.70	2.20	3.05
20	0.35	0.50	0. +	0. +	0.40	0.55	0.55	0.75	0.55 *	0.75 *	0. +	0.
21	0.60	0.80	0.55	0.75	0.25	0.35	1.00	1.35	0.70	0.95	3.10	4.20
22	0.30	0.40	0.45	0.60	0.30	0.40	0.90	1.25	0.35 *	0.50 *	2.30	3.15
24	0.	0.	0.40	0.55	0.40	0.55	0.65	0.90	0.60 *	0.80 *	2.05	2.80
25	0.25	0.35	0.60	0.80	0.	0.	0.50	0.65	0.45	0.60	1.80	2.40
26	0.	0.	0.50	0.65	0.	0.	0.70 *	0.90 *	0.50 *	0.65 *	1.70	2.20
28	0.	0.	0.95	1.15	0.40	0.50	0.25	0.30	0.50 *	0.60 *	2.10	2.55
30	0.35	0.40	0.25	0.30	0.40	0.45	0. *	0. *	0.45 *	0.50 *	1.45	1.65
31	0.	0.	0.	0.	0.	0.	0. *	0. *	0.40 *	0.45 *	0.40	0.45
34	0.55	0.60	0.	0.	0.	0.	0. *	0. *	0.40 *	0.45 *	0.95	1.05
MEAN (WITH STANDARD ERROR) MW6 EXCL GENERAL GROUP	0.4 (0.1)	0.5 (0.1)	0.7 (0.1)	1. (0.2)	0.2 (0.1)	0.3 (0.1)	0.7 (0.1)	1. (0.1)	0.6 (0.1)	0.8 (0.1)	2.5 (0.3)	3.6 (0.4)
SELECT GROUP							0.5 (0.1)	0.8 (0.2)	0.5 (0.1)	0.7 (0.1)		
PROPORTION (WITH STANDARD ERROR) AND PERCENT OF MOVEMENTS EXCEEDING GROUP MEAN BY AT LEAST 0.025 CM GENERAL GROUP	7/19 (0.1) 36.8	8/19 (0.1) 42.1	7/18 (0.1) 38.9	8/18 (0.1) 44.4	11/19 (0.1) 57.9	11/19 (0.1) 57.9	9/19 (0.1) 47.4	9/19 (0.1) 47.4	6/19 (0.1) 31.6	7/19 (0.1) 36.8	9/18 (0.1) 50.	9/18 (0.1) 50.
SELECT GROUP							6/ 9 (0.2) 66.7	6/ 9 (0.2) 66.7	3/12 (0.1) 25.	4/12 (0.1) 33.3		
MEAN (WITH STANDARD ERROR) FOR 10 CM T												
MEAN (WITH STANDARD ERROR) FOR 20 CM T												

S E P T E M B E R M O V E M E N T

TARGET NO (1)	1957 CM		1958 CM		1959+ CM		1960 CM		TOTAL CM	
	OBS	ADJ	OBS	ADJ	OBS	ADJ	OBS	ADJ	OBS	ADJ
MW6										
10	0.65	1.25	0.	0.	0.	0.	0. *	0. *	0.65	1.25
12	1.00	1.55	0.	0.	0. *	0. *	0. *	0. *	1.00	1.55
13	0.	0.	0.	0.	0.	0.	0. *	0. *	0.	0.
14	0.50	0.70	0.	0.	0. *	0. *	0. *	0. *	0.50	0.70
15	0.45	0.60	0.	0.	0. *	0. *	0.	0.	0.45	0.60
16	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
17	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
18	0.35	0.50	0.	0.	0. *	0. *	0.80	1.10	1.15	1.60
19	0.	0.	0.	0.	0. *	0. *	0.	0.	0.	0.
20	0.	0.	0. +	0. +	0.	0.	0.50 *	0.70 *	0. +	0. +
21	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
22	0.	0.	0.	0.	0.	0.	0.35 *	0.50 *	0.35	0.50
24	0.	0.	0.	0.	0.	0.	0.35 *	0.45 *	0.35	0.45
25	0.	0.	0.	0.	0.	0.	0.30	0.40	0.30	0.40
26	0.	0.	0.	0.	0. *	0. *	0. *	0. *	0.	0.
28	0.85	1.00	0.	0.	0.	0.	0. *	0. *	0.85	1.00
30	0.	0.	0.	0.	0. *	0. *	0. *	0. *	0.	0.
31	0.	0.	0.	0.	0. *	0. *	0. *	0. *	0.	0.
34	0.	0.	0.	0.	0. *	0. *	0. *	0. *	0.	0.
MEAN (WITH STANDARD ERROR) MW6 EXCL GENERAL GROUP	0.2 (0.1)	0.3 (0.1)	0. (0.0)	0. (0.0)	0. (0.0)	0. (0.0)	0.1 (0.1)	0.2 (0.1)	0.3 (0.1)	0.5 (0.1)
SELECT GROUP					0. (0.0)	0. (0.0)	0.1 (0.1)	0.1 (0.1)		
PROPORTION (WITH STANDARD ERROR) AND PERCENT OF MOVEMENTS EXCEEDING GROUP MEAN BY AT LEAST 0.025 CM GENERAL GROUP	6/19 (0.1) 31.6	6/19 (0.1) 31.6	0/18 (0.0) 0.	0/18 (0.0) 0.	0/19 (0.0) 0.	0/19 (0.0) 0.	5/19 (0.1) 26.3	5/19 (0.1) 26.3	8/18 (0.1) 44.4	7/18 (0.1) 38.9
SELECT GROUP					0/ 9 (0.0) 0.	0/ 9 (0.0) 0.	3/12 (0.1) 25.	3/12 (0.1) 25.		
MEAN (WITH STANDARD ERROR) FOR 10 CM T										
MEAN (WITH STANDARD ERROR) FOR 20 CM T										

A N N U A L M O V E M E N T T O L A T E A U G U S T 1 9 5 6 - 6 1 (2)

TARGET NO (1)	1956-57 (8 AUG 56- 8 AUG 57) CM		1957-58 (8 AUG 57- 27 AUG 58) CM		1958-59 (27 AUG 58- 27 AUG 59) CM		1959-60 (27 AUG 59- 25 AUG 60) CM		1960-61 (25 AUG 60- 21 AUG 61) CM	
	OBS	ADJ	OBS	ADJ	OBS	ADJ	OBS	ADJ	OBS	ADJ
MW6	1.15 *(3)	1.25 *(3)	1.10 *(3)	1.20 *(3)	0.70 *(3)	0.80 *(3)	EXCAVATED 6 AUG 59			
10	1.35	2.55	0.95	1.80	0.45	0.85	0.50	2.85	-0.30 *	-0.95 *
12	0.85	1.30	1.65	2.55	0.65	1.00	0.90 *	1.40 *	0. *	0. *
13	1.00	1.45	1.25	1.80	1.20	1.75	0.	0.45	0.45 *	0.65 *
14	0.45	0.60	0.85	1.15	1.35	1.85	0. *	0. *	0.45 *	0.60 *
15	1.05	1.45	0.35	0.50	0.75	1.05	0.80 *	1.10 *	0.	1.35
16	0.70	0.95	0.	0.	1.10	1.50	-0.25	0.35	0.	0.70
17	0.80	1.10	0.50	0.70	1.15	1.60	0.	-0.70	0.60	1.50
18	0.40	0.55	0.40	0.55	0.70	0.95	0. *	0. *	0.25	1.05
19	1.30	1.80	0.	0.	0.55	0.75	0. *	0. *	0.	1.35
20	2.15	2.95	0. +	0. +	0. +	0. +	0.	-0.55	0.75 *(4)	1.05 *(4)
21	1.30	1.80	-0.25	-0.35	0.70	0.95	0.30	1.10	0.	-0.70
22	1.10	1.50	0.35	0.50	0.90	1.25	0.	0.70	0.90 *	1.25 *
24	1.60	2.15	0.40	0.55	1.25	1.70	0.75	-0.90	1.90 *	2.55 *
25	1.75	2.35	0.35	0.45	1.70	2.30	0.	-0.80	1.10	1.10
26	1.95	2.55	0.40	0.50	0.75	1.00	0.40 *	0.50 *	0.50 *	0.65 *
28	1.15	1.35	0.70	0.85	0.55	0.65	0.55	1.00	0.55 *	0.65 *
30	1.70	1.90	0.25	0.30	0.35	0.40	1.00 *	1.10 *	0.25 *	0.30 *
31	1.35	1.50	0.95	1.05	1.05	1.15	0.65 *	0.50 *	0.65 *	0.70 *
34	1.70	1.85	0.60	0.65	1.05	1.15	0. *	0. *	0.55 *	0.60 *
MEAN (WITH STANDARD ERROR) MW6 EXCL GENERAL GROUP	1.2 (0.1)	1.7 (0.2)	0.5 (0.1)	0.8 (0.2)	0.9 (0.1)	1.2 (0.1)	0.3 (0.1)	0.4 (0.2)	0.5 (0.1)	0.8 (0.2)
SELECT GROUP							0.4 (0.1)	0.5 (0.2)	0.6 (0.2)	0.7 (0.2)
PROPORTION (WITH STANDARD ERROR) AND PERCENT OF MOVEMENTS EXCEEDING GROUP MEAN BY AT LEAST 0.025 CM GENERAL GROUP	10/19 (0.1) 52.6	9/19 (0.1) 47.4	7/18 (0.1) 38.9	6/18 (0.1) 33.3	8/18 (0.1) 44.4	7/18 (0.1) 38.9	8/19 (0.1) 42.1	9/19 (0.1) 47.4	9/19 (0.1) 47.4	8/19 (0.1) 42.1
SELECT GROUP							4/ 9 (0.2) 44.4	3/ 9 (0.2) 33.3	4/12 (0.1) 33.3	4/12 (0.1) 33.3
MEAN (WITH STANDARD ERROR) FOR 10 CM T										
MEAN (WITH STANDARD ERROR) FOR 20 CM T										

T O T A L M O V E M E N T A N D M E A N R A T E 1 9 5 6 - 6 1

TARGET NO (1)	TOTAL 1956-61 CM		RATE CM/YR	
	OBS	ADJ	OBS	ADJ
MW6	3.00 *(3)	3.30 *(3)	1.05	1.15
10	2.95	7.10	0.60	1.40
12	4.25	6.60	0.85	1.30
13	3.85	6.00	0.75	1.20
14	3.30	4.50	0.65	0.90
15	2.85	5.25	0.55	1.05
16	1.65	3.65	0.35	0.75
17	3.10	4.25	0.60	0.85
18	1.75	3.10	0.35	0.60
19	2.15	4.30	0.45	0.85
20	5.05	6.35	1.00	1.25
21	2.20	3.00	0.45	0.60
22	3.15	5.00	0.65	1.00
24	5.95	6.15	1.20	1.25
25	4.95	5.45	1.00	1.10
26	3.95	5.15	0.80	1.05
28	3.50	4.55	0.70	0.90
30	3.55	3.95	0.70	0.80
31	4.55	4.85	0.90	0.95
34	3.80	4.15	0.75	0.85
MEAN (WITH STANDARD ERROR) MW6 EXCL GENERAL GROUP	3.5 (0.3)	4.9 (0.3)	0.7 (0.1)	1. (0.1)
SELECT GROUP				
PROPORTION (WITH STANDARD ERROR) AND PERCENT OF MOVEMENTS EXCEEDING GROUP MEAN BY AT LEAST 0.025 CM GENERAL GROUP	9/19 (0.1) 47.4	9/19 (0.1) 47.4	8/19 (0.1) 42.1	8/19 (0.1) 42.1
SELECT GROUP				
MEAN (WITH STANDARD ERROR) FOR 10 CM T	3.6 (0.4)	5. (0.4)	0.7 (0.1)	1. (0.1)
MEAN (WITH STANDARD ERROR) FOR 20 CM T	3.4 (0.4)	4.7 (0.4)	0.7 (0.1)	0.9 (0.1)

TARGET NO	DEPTH CM	ANGLE OF VIEW	GRADIENT
MW6	103.5	25	4.5
10	10.0	58	3.0
12	10.0	50	2.5
13	20.0	46	2.5
14	10.0	43	2.5
15	20.0	43	2.5
16	10.0	43	2.5
17	20.0	43	2.5
18	10.0	43	2.5
19	20.0	43	2.5
20	10.0	43	2.5
21	20.0	43	2.5
22	10.0	43	2.5
24	10.0	42	2.5
25	20.0	42	2.5
26	10.0	40	2.5
28	10.0	33	2.5
30	10.0	26	2.5
31	20.0	26	2.5
34	10.0	24	2.5

MEAN (WITH STANDARD ERROR) MW6 EXCL
GENERAL GROUP

SELECT GROUP

PROPORTION (WITH STANDARD ERROR) AND PERCENT OF MOVEMENTS EXCEEDING GROUP MEAN BY AT LEAST 0.025 CM
GENERAL GROUP

SELECT GROUP

MEAN (WITH STANDARD ERROR) FOR 10 CM T

MEAN (WITH STANDARD ERROR) FOR 20 CM T

* SELECT TARGETS - THOSE WITH PROBABLY ≤ 0.2 CM DOWNSLOPE OR UPSLOPE ATTITUDE CHANGE DUE TO TILTING AND/OR TARGET HEAVING IN PERIOD INDICATED

\+ OMITTED FROM MEAN. 0. HERE INDICATES LACK OF DATA

OBS OBSERVED MOVEMENT. HORIZONTAL COMPONENT NORMAL TO TARGET LINE

ADJ ADJUSTED MOVEMENT. OBSERVED MOVEMENT ADJUSTED FOR ANGLE OF VIEW, GRADIENT AND, IN CASE OF ANNUAL MOVEMENT, FOR TARGET ATTITUDE CHANGE (1959-61)

(1) OMITTED TARGETS ARE EXCLUDED FOR REASONS CITED IN TABLE OF TARGET ATTITUDES AND/OR STATED IN TEXT

(2) ANNUAL MOVEMENT TAKEN DIRECTLY FROM OBSERVATION TOTALS RATHER THAN FROM SUMMATION OF COMPONENT MOVEMENTS, SINCE AMOUNT CALCULATED FROM COMPONENTS DISREGARDS ALL MOVEMENTS ≤ 0.2 CM

(3) ANNUAL MOVEMENTS OF MW6 ARE FOR 4 SEPT 1956 - 12 AUG 1957, 12 AUG 1957 - 30 JULY 1958, 30 JULY 1958 - 6 AUG 1959, AND TOTAL FOR PERIOD 1956-1959

(4) LATE AUGUST READING LACKING, EARLY AUGUST READING SUBSTITUTED

Table C II.

EXPERIMENTAL SITE 7 TARGET MOVEMENTS > 0.2 CM 1956-61

TARGET NO (1)	DEPTH CM	ANGLE OF VIEW	GRADIENT	DRY OR WET	JUMP											
					1956-57 (INCL 1956 SEPT MOVET)		1957-58		1958-59		1959-60		1960-61		TOTAL	
					OBS	ADJ	OBS	ADJ	OBS	ADJ	OBS	ADJ	OBS	ADJ	OBS	ADJ
					CM		CM		CM		CM		CM		CM	
MW7	100.0	4	10.0	W												
ROD	137.0	19	12.5	D	1.15 *	1.20 *	0.80 *	0.85 *	0.60 *	0.65 *	0.25 *	0.25 *	0.45 *	0.50 *	3.25 *	3.45 *
1	20.0	11	11.5	D	0.95	0.95	1.45	1.50	0.80	0.80	0.	0.	0.45	0.45	3.65	3.70
2	10.0	5	11.5	D	1.45	1.45	0.95	0.95	0.95	0.95	0. *	0. *	0.45	0.45	3.80	3.80
3	20.0	5	11.5	D	1.05	1.05	1.20	1.20	0.75	0.75	0. *	0. *	0.55 *	0.55 *	3.55	3.55
4	10.0	4	11.5	D	1.55	1.55	1.00	1.00	0.75	0.75	0.35	0.35	0.75	0.75	4.40	4.40
5	20.0	3	12.0	D	0.90	0.90	0.95	0.95	0.70	0.70	0.25 *	0.25 *	0.45 *	0.45 *	3.25	3.25
6	10.0	3	12.5	D	0.90	0.90	1.05	1.05	0.40	0.40	0.85 *	0.85 *	0.55 *	0.55 *	3.75	3.75
7	20.0	3	13.0	D	0.65	0.65	1.05	1.05	0.40	0.40	0. *	0. *	0.70 *	0.70 *	2.80	2.80
8	10.0	3	14.0	D	1.30	1.30	1.05	1.05	0.45	0.45	0.35	0.35	0.85	0.85	4.00	4.00
9	20.0	0	13.0	D	1.25	1.25	0.90	0.90	0.50	0.50	0.25	0.25	0.90 *	0.90 *	3.80	3.80
10	10.0	6	13.0	D	0.50	0.50	0.85	0.85	0.30	0.30	0.40 *	0.40 *	0.50 *	0.50 *	2.55	2.55
11	20.0	9	12.5	D	0.60	0.60	0.80	0.80	0.55	0.55	0.	0.	0.80 *	0.80 *	2.75	2.75
12	10.0	15	12.0	D	1.00	1.05	0.85	0.90	0.50	0.50	0. *	0. *	0.75 *	0.80 *	3.10	3.25
13	20.0	19	12.5	D	1.00	1.05	0.70	0.75	0.60	0.65	0.55 *	0.60 *	0.45 *	0.50 *	3.30	3.55
14	10.0	19	12.5	D	1.05	1.10	0.85	0.90	0.90	0.95	0.25	0.25	0.35 *	0.35 *	3.40	3.55
15	20.0	20	13.0	D	0.95	1.00	0.60	0.65	0.60	0.65	0. *	0. *	0.60 *	0.65 *	2.75	2.95
16	10.0	26	13.5	D	1.40	1.55	0.75	0.85	0.	0.	0.40 *	0.45 *	0.80 *	0.90 *	3.35	3.75
17	20.0	29	13.0	D	0.55	0.65	0.65	0.75	0.	0.	0.70	0.80	0.40 *	0.45 *	2.30	2.65
18	10.0	24	12.5	D	1.25	1.35	0.80	0.90	0.65	0.70	0.60 *	0.65 *	0.70 *	0.75 *	4.00	4.35
19	10.0	20	11.5	D	1.30	1.40	1.10	1.15	0.95	1.00	0.75 *	0.80 *	0.90 *	0.95 *	5.00	5.30
20	10.0	14	11.5	D	1.05	1.10	1.05	1.10	1.05	1.10	0.95	1.00	0.85 *	0.90 *	4.95	5.20
21	20.0	11	11.5	D	1.10	1.10	1.05	1.05	0.85	0.85	0.70	0.70	0.60	0.60	4.30	4.30
22	10.0	7	12.0	D	1.25	1.25	1.00	1.00	1.05	1.05	0.75	0.75	0.65 *	0.65 *	4.70	4.70
23	20.0	2	12.0	D	1.00	1.00	0.90	0.90	1.00	1.00	0.65	0.65	0.65 *	0.65 *	4.20	4.20
24	10.0	0	12.5	D	1.40	1.40	1.30	1.30	1.05	1.05	0.95 *	0.95 *	0.80 *	0.80 *	5.50	5.50
25	20.0	0	13.0	D	1.40	1.40	1.60	1.60	1.15	1.15	1.05 *	1.05 *	0.95 *	0.95 *	6.15	6.15
26	10.0	9	13.0	D	1.55	1.55	1.30	1.30	1.25	1.25	1.10 *	1.10 *	0.75 *	0.75 *	5.95	5.95
27	10.0	9	12.5	D	1.50	1.50	1.20	1.20	1.05	1.05	1.00 *	1.00 *	0.55 *	0.55 *	5.30	5.30
28	10.0	9	12.0	D	1.65	1.65	1.40	1.40	1.10	1.10	0.90	0.90	0.75 *	0.75 *	5.80	5.80
30	10.0	8	11.0	W	1.20	1.20	1.90	1.90	1.65	1.65	1.65 *	1.65 *	1.25 *	1.25 *	7.65	7.65
31	20.0	8	11.0	W	2.00	2.00	1.75	1.75	2.05	2.05	4.75	4.80	1.35	1.35	11.90	11.95
32	10.0	0	10.0	W	2.35	2.35	1.15	1.15	2.90	2.90	2.25	2.25	1.75	1.75	10.40	10.40
33	20.0	20	10.0	W	1.95	2.10	1.40	1.50	2.75	2.95	0.50	0.55	1.75 *	1.85 *	8.35	8.95
35	20.0	17	10.0	W	3.90	4.10	1.80	1.90	5.30	5.55	2.30 *	2.40 *	2.10	2.20	15.40	16.15
36	10.0	32	12.0	W	1.60	1.90	1.45	1.70	2.60	3.05	1.20 *	1.40 *	1.30 *	1.55 *	8.15	9.60
38	10.0	50	12.5	D	0.75	1.15	0.70	1.10	0.85	1.30	1.15 *	1.80 *	0.55 *	0.85 *	4.00	6.20
MEAN (WITH STANDARD ERROR) MW7 AND ROD EXCL GENERAL GROUP					1.3	1.3	1.1	1.1	1.1	1.1	0.8	0.8	0.8	0.9	5.1	5.3
					(0.1)	(0.1)	(0.1)	(0.1)	(0.2)	(0.2)	(0.2)	(0.2)	(0.1)	(0.1)	(0.5)	(0.5)
DRY					1.1	1.2	1.	1.	0.7	0.8	0.5	0.6	0.7	0.7	4.	4.2
					(0.1)	(0.1)	(0.1)	(0.0)	(0.1)	(0.1)	(0.1)	(0.1)	(0.0)	(0.0)	(0.2)	(0.2)
WET					2.2	2.3	1.6	1.7	2.9	3.	2.1	2.2	1.6	1.7	10.3	10.8
					(0.4)	(0.4)	(0.1)	(0.1)	(0.5)	(0.6)	(0.6)	(0.6)	(0.2)	(0.1)	(1.2)	(1.2)
SELECT GROUP											0.7	0.8	0.8	0.8		
											(0.1)	(0.2)	(0.1)	(0.1)		
DRY											0.5	0.6	0.7	0.7		
											(0.1)	(0.1)	(0.0)	(0.0)		
WET											1.7	1.8	1.4	1.6		
											(0.3)	(0.3)	(0.2)	(0.2)		
PROPORTION (WITH STANDARD ERROR) AND PERCENT OF MOVEMENTS EXCEEDING GROUP MEAN BY AT LEAST 0.025 CM GENERAL GROUP					13/35	14/35	13/35	12/35	8/35	8/35	13/35	12/35	11/35	11/35	11/35	11/35
					(0.1)	(0.1)	(0.1)	(0.1)	(0.1)	(0.1)	(0.1)	(0.1)	(0.1)	(0.1)	(0.1)	(0.1)
					37.1	40.	37.1	34.3	22.9	22.9	37.1	34.3	31.4	31.4	31.4	31.4
DRY					8/29	9/29	7/29	7/29	2/29	2/29	8/29	7/29	5/29	5/29	5/29	5/29
					(0.1)	(0.1)	(0.1)	(0.1)	(0.1)	(0.1)	(0.1)	(0.1)	(0.1)	(0.1)	(0.1)	(0.1)
					27.6	31.	24.1	24.1	6.9	6.9	27.6	24.1	17.2	17.2	17.2	17.2
WET					5/ 6	5/ 6	6/ 6	5/ 6	6/ 6	6/ 6	5/ 6	5/ 6	6/ 6	6/ 6	6/ 6	6/ 6
					(0.2)	(0.2)	(0.0)	(0.2)	(0.0)	(0.0)	(0.2)	(0.2)	(0.0)	(0.0)	(0.0)	(0.0)
					83.3	83.3	100.0	83.3	100.	100.	83.3	83.3	100.	100.	100.	100.
SELECT GROUP											10/20	10/20	10/27	9/27		
											(0.1)	(0.1)	(0.1)	(0.1)		
											50.	50.	37.	33.3		
DRY											7/17	7/17	7/24	6/24		
											(0.1)	(0.1)	(0.1)	(0.1)		
											41.2	41.2	29.2	25.		
WET											3/ 3	3/ 3	3/ 3	3/ 3		
											(0.0)	(0.0)	(0.0)	(0.0)		
											100.	100.	100.	100.		

TARGET NO (1)	GELIFLUCTION											
	1957		1958		1959		1960		1961		TOTAL	
	OBS	ADJ	OBS	ADJ	OBS	ADJ	OBS	ADJ	OBS	ADJ	OBS	ADJ
	CM		CM		CM		CM		CM		CM	
MW7												
ROD	0. *	0. *	0.35 *	0.35 *	0.35 *	0.35 *	0.25 *	0.25 *	0. *	0. *	0.95 *	0.95 *
1	0.	0.	0.30	0.30	0.	0.	0.30	0.30	0.	0.	0.60	0.60
2	0.25	0.25	0.65	0.65	0.	0.	0.50 *	0.50 *	0.	0.	1.40	1.40
3	0.50	0.50	1.00	1.00	0.30	0.30	0.40 *	0.40 *	0.30 *	0.30 *	2.50	2.50
4	0.30	0.30	1.10	1.10	0.25	0.25	0.25	0.25	0.	0.	1.90	1.90
5	0.	0.	0.70	0.70	0.25	0.25	0.30 *	0.30 *	0. *	0. *	1.25	1.25
6	0.55	0.55	0.55	0.55	0.35	0.35	0. *	0. *	0.25 *	0.25 *	1.70	1.70
7	0.25	0.25	0.45	0.45	0.30	0.30	0.40 *	0.40 *	0. *	0. *	1.40	1.40
8	0.	0.	0.70	0.70	0.25	0.25	0.	0.	0.	0.	0.95	0.95
9	0.40	0.40	0.55	0.55	0.25	0.25	0.	0.	0.30 *	0.30 *	1.50	1.50
10	0.45	0.45	0.55	0.55	0.25	0.25	0. *	0. *	0. *	0. *	1.25	1.25
11	0.	0.	0.45	0.45	0.25	0.25	0.45	0.45	0. *	0. *	1.15	1.15
12	0.	0.	0.40	0.40	0.35	0.35	0.30 *	0.30 *	0. *	0. *	1.05	1.05
13	0.	0.	0.55	0.60	0.40	0.40	0.40 *	0.40 *	0. *	0. *	1.35	1.40
14	0.	0.	0.70	0.75	0.40	0.40	0.95	1.00	0.25 *	0.25 *	2.30	2.40
15	0.	0.	0.45	0.50	0.30	0.30	0.80 *	0.85 *	0. *	0. *	1.55	1.65
16	0.	0.	0.35	0.40	0.75	0.85	0.50 *	0.55 *	0.25 *	0.30 *	1.85	2.10
17	0.	0.	0.40	0.45	0.30	0.35	0.	0.	0. *	0. *	0.70	0.80
18	0.	0.	0.35	0.40	0.40	0.45	0. *	0. *	0.25 *	0.25 *	1.00	1.10
19	0.	0.	0.	0.	0.35	0.35	0. *	0. *	0. *	0. *	0.35	0.35
20	0.	0.	0.	0.	0.35	0.35	0.	0.	0. *	0. *	0.35	0.35
21	0.	0.	0.	0.	0.50	0.50	0.	0.	0.	0.	0.50	0.50
22	0.	0.	0.	0.	0.45	0.45	0.	0.	0. *	0. *	0.45	0.45
23	0.	0.	0.	0.	0.45	0.45	0.25	0.25	0. *	0. *	0.70	0.70
24	0.	0.	0.	0.	0.30	0.30	0. *	0. *	0. *	0. *	0.30	0.30
25	0.	0.	0.	0.	0.35	0.35	0. *	0. *	0. *	0. *	0.35	0.35
26	0.	0.	0.	0.	0.35	0.35	0. *	0. *	0. *	0. *	0.35	0.35
27	0.	0.	0.	0.	0.40	0.40	0.25 *	0.25 *	0. *	0. *	0.65	0.65
28	0.35	0.35	0.	0.	0.25	0.25	0.25	0.25	0. *	0. *	0.85	0.85
30	0.55	0.55	0.	0.	0.35	0.35	0. *	0. *	0.80 *	0.80 *	1.70	1.70
31	0.75	0.75	0.55	0.55	0.40	0.40	0.	0.	2.00	2.00	3.70	3.70
32	0.80	0.80	1.25	1.25	0.25	0.25	0.	0.	1.20	1.20	3.50	3.50
33	0.95	1.00	2.00	2.15	0.80	0.85	1.15	1.20	2.90 *	3.10 *	7.80	8.30
35	1.95	2.05	4.55	4.75	0.70	0.75	2.10 *	2.20 *	4.75	4.95	14.05	14.70
36	1.10	1.30	1.30	1.55	0.25	0.30	1.15 *	1.35 *	1.70 *	2.00 *	5.50	6.50
38	0.	0.	0.	0.	0.	0.	0. *	0. *	0.25 *	0.40 *	0.25	0.40
MEAN (WITH STANDARD ERROR) MW7 AND ROD EXCL GENERAL GROUP	0.3	0.3	0.6	0.6	0.3	0.4	0.3	0.3	0.4	0.5	1.9	2.
	(0.1)	(0.1)	(0.1)	(0.2)	(0.0)	(0.0)	(0.1)	(0.1)	(0.2)	(0.2)	(0.4)	(0.5)
DRY	0.1	0.1	0.4	0.4	0.3	0.3	0.2	0.2	0.1	0.1	1.1	1.1
	(0.0)	(0.0)	(0.1)	(0.1)	(0.0)	(0.0)	(0.1)	(0.1)	(0.0)	(0.0)	(0.1)	(0.1)
WET	1.	1.1	1.6	1.7	0.5	0.5	0.7	0.8	2.2	2.3	6.	6.4
	(0.2)	(0.2)	(0.7)	(0.7)	(0.1)	(0.1)	(0.4)	(0.4)	(0.6)	(0.6)	(1.8	(1.9)
SELECT GROUP							0.4	0.4	0.3	0.3		
							(0.1)	(0.1)	(0.1)	(0.1)		
DRY							0.2	0.2	0.1	0.1		
							(0.1)	(0.1)	(0.0)	(0.0)		
WET							1.1	1.2	1.8	2.		
							(0.6)	(0.6)	(0.6)	(0.7)		
PROPORTION (WITH STANDARD ERROR) AND PERCENT OF MOVEMENTS EXCEEDING GROUP MEAN BY AT LEAST 0.025 CM GENERAL GROUP	12/35	12/35	10/35	10/35	11/35	11/35	11/35	11/35	6/35	6/35	7/35	8/35
	(0.1)	(0.1)	(0.1)	(0.1)	(0.1)	(0.1)	(0.1)	(0.1)	(0.1)	(0.1)	(0.1)	(0.1)
	34.3	34.3	28.6	28.6	31.4	31.4	31.4	31.4	17.1	17.1	20.	22.9
DRY	6/29	6/29	6/29	6/29	8/29	8/29	8/29	8/29	0/29	0/29	2/29	3/29
	(0.1)	(0.1)	(0.1)	(0.1)	(0.1)	(0.1)	(0.1)	(0.1)	(0.0)	(0.0)	(0.1)	(0.1)
	20.7	20.7	20.7	20.7	27.6	27.6	27.6	27.6	0.	0.	6.9	10.3
WET	6/ 6	6/ 6	4/ 6	4/ 6	3/ 6	3/ 6	3/ 6	3/ 6	6/ 6	6/ 6	5/ 6	5/ 6
	(0.0)	(0.0)	(0.1)	(0.1)	(0.2)	(0.2)	(0.2)	(0.2)	(0.0)	(0.0)	(0.2)	(0.2)
	100.	100.	66.6	66.6	50.	50.	50.	50.	100.	100.	83.3	83.3
SELECT GROUP							8/20	8/20	5/27	4/27		
							(0.1)	(0.1)	(0.1)	(0.1)		
							40.	40.	18.5	14.8		
DRY							6/17	6/17	2/24	1/24		
							(0.1)	(0.1)	(0.1)	(0.0)		
							35.3	35.3	8.3	4.2		
WET							2/ 3	2/ 3	3/ 3	3/ 3		
							(0.3)	(0.3)	(0.0)	(0.0)		
							66.7	66.7	100.	100.		
MEAN (WITH STANDARD ERROR) FOR 10 CM T DRY											1.	1.
											(0.2)	(0.2
WET											3.6	3.9
											(1.1)	(1.4
MEAN (WITH STANDARD ERROR) FOR 20 CM T DRY											1.1	1.2
											(0.2)	(0.2)
WET											8.5	8.9
											(3.0)	(3.2)

TARGET NO (1)	RETROGRADE MOVEMENT											
	1957		1958		1959		1960		1961		TOTAL	
	OBS	ADJ	OBS	ADJ	OBS	ADJ	OBS	ADJ	OBS	ADJ	OBS	ADJ
	CM		CM		CM		CM		CM		CM	
MW7												
ROD	0.80 *	0.85 *	0.30 *	0.30 *	0.25 *	0.25 *	0.30 *	0.30 *	0. *	0. *	1.65 *	1.70 *
1	0.95	0.95	0.60	0.60	0.	0.	0.25	0.25	0.	0.	1.80	1.80
2	1.05	1.05	0.65	0.65	0.	0.	0. *	0. *	0.30	0.30	2.00	2.00
3	1.00	1.00	0.60	0.60	0.	0.	0. *	0. *	0.30 *	0.30 *	1.90	1.90
4	1.05	1.05	0.60	0.60	0.	0.	0.	0.	0.30	0.30	1.95	1.95
5	0.95	0.95	0.60	0.60	0.	0.	0. *	0. *	0.35 *	0.35 *	1.90	1.90
6	1.00	1.00	0.55	0.55	0.	0.	0. *	0. *	0.40 *	0.40 *	1.95	1.95
7	1.10	1.10	0.45	0.45	0.	0.	0.25 *	0.25 *	0.30 *	0.30 *	2.10	2.10
8	1.15	1.15	0.60	0.60	0.	0.	0.	0.	0.55	0.55	2.30	2.30
9	1.00	1.00	0.55	0.55	0.	0.	0.30	0.30	0.35 *	0.35 *	2.20	2.20
10	0.85	0.85	0.55	0.55	0.	0.	0. *	0. *	0.25 *	0.25 *	1.65	1.65
11	0.70	0.70	0.60	0.60	0.	0.	0.45	0.45	0.25 *	0.25 *	2.00	2.00
12	0.60	0.60	0.55	0.55	0.	0.	0.55 *	0.55 *	0. *	0. *	1.70	1.70
13	0.65	0.70	0.75	0.80	0.	0.	0.60 *	0.65 *	0. *	0. *	2.00	2.15
14	0.70	0.75	1.10	1.15	0.	0.	0.65	0.70	0.40 *	0.40 *	2.85	3.00
15	0.65	0.70	0.55	0.60	0.	0.	0.50 *	0.55 *	0.30 *	0.30 *	2.00	2.15
16	0.65	0.70	0.45	0.50	0.	0.	0.25 *	0.30 *	0. *	0. *	1.35	1.50
17	0.70	0.80	0.60	0.70	0.	0.	0.25	0.30	0.30 *	0.35 *	1.85	2.15
18	0.60	0.65	0.95	1.05	0.	0.	0.35 *	0.40 *	0.55 *	0.60 *	2.45	2.70
19	0.45	0.50	0.85	0.90	0.	0.	0.55 *	0.60 *	0.45 *	0.50 *	2.30	2.50
20	0.45	0.45	0.90	0.95	0.	0.	0.65	0.65	0.25 *	0.25 *	2.25	2.30
21	0.55	0.55	0.65	0.65	0.	0.	0.55	0.55	0.40	0.40	2.15	2.15
22	0.35	0.35	0.70	0.70	0.	0.	0.45	0.45	0.35 *	0.35 *	1.85	1.85
23	0.25	0.25	0.75	0.75	0.	0.	0.40	0.40	0.30 *	0.30 *	1.70	1.70
24	0.	0.	0.70	0.70	0.	0.	0.40 *	0.40 *	0.45 *	0.45 *	1.55	1.55
25	0.	0.	0.95	0.95	0.	0.	0.35 *	0.35 *	0.50 *	0.50 *	1.80	1.80
26	0.	0.	0.60	0.60	0.	0.	0.40 *	0.40 *	0.25 *	0.25 *	1.25	1.25
27	0.	0.	0.30	0.30	0.	0.	0.30 *	0.30 *	0.40 *	0.40 *	1.00	1.00
28	0.	0.	0.	0.	0.	0.	0.25	0.25	0.50 *	0.50 *	0.75	0.75
30	0.30	0.30	0.	0.	0.	0.	0.35 *	0.35 *	0.25 *	0.25 *	0.90	0.90
31	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
32	0.	0.	0.40	0.40	0.	0.	0.	0.	0.30	0.30	0.70	0.70
33	0.	0.	0.	0.	0.	0.	0.40	0.45	0. *	0. *	0.40	0.45
35	0.	0.	0.40	0.40	0.	0.	0.30 *	0.30 *	0.35	0.35	1.05	1.05
36	0.	0.	0.40	0.45	0.	0.	0. *	0. *	0.75 *	0.90 *	1.15	1.35
38	0.70	1.10	0.40	0.60	0.	0.	0.35 *	0.55 *	0.90 *	1.40 *	2.35	3.65
MEAN (WITH STANDARD ERROR) MW7 AND ROD EXCL GENERAL GROUP	0.5	0.6	0.6	0.6	0.	0.	0.3	0.3	0.3	0.4	1.7	1.8
	(0.1)	(0.1)	(0.1)	(0.1)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.1)	(0.1)
DRY	0.6	0.7	0.6	0.7	0.	0.	0.3	0.3	0.3	0.4	1.9	2.
	(0.1)	(0.1)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.1)	(0.1)	(0.1)
WET	0.1	0.1	0.2	0.2	0.	0.	0.2	0.2	0.3	0.3	0.7	0.7
	(0.1)	(0.1)	(0.1)	(0.1)	(0.0)	(0.0)	(0.1)	(0.1)	(0.1)	(0.1)	(0.2)	(0.2)
SELECT GROUP							0.3	0.3	0.3	0.4		
							(0.1)	(0.1)	(0.0)	(0.1)		
DRY							0.3	0.3	0.3	0.4		
							(0.1)	(0.7)	(0.0)	(0.1)		
WET							0.2	0.2	0.3	0.4		
							(0.1)	(0.1)	(0.2)	(0.3)		
PROPORTION (WITH STANDARD ERROR) AND PERCENT OF MOVEMENTS EXCEEDING GROUP MEAN BY AT LEAST 0.025 CM GENERAL GROUP	19/35	19/35	19/35	21/35	0/35	0/35	17/35	17/35	16/35	12/35	21/35	21/35
	(0.1)	(0.1)	(0.1)	(0.1)	(0.0)	(0.0)	(0.1)	(0.1)	(0.1)	(0.1)	(0.1)	(0.1)
	54.3	54.3	54.3	60.	0.	0.	48.6	48.6	45.7	34.3	60.	60.
DRY	19/29	19/29	19/29	21/29	0/29	0/29	15/29	15/29	14/29	11/29	21/29	21/29
	(0.1)	(0.1)	(0.1)	(0.1)	(0.0)	(0.0)	(0.1)	(0.1)	(0.1)	(0.1)	(0.1)	(0.1)
	65.5	65.5	65.5	72.4	0.	0.	51.7	51.7	48.3	37.9	72.4	72.4
WET	0/ 6	0/ 6	0/ 6	0/ 6	0/ 6	0/ 6	2/ 6	2/ 6	2/ 6	1/ 6	0/ 6	0/ 6
	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.2)	(0.2)	(0.2)	(0.2)	(0.0)	(0.0)
	0.	0.	0.	0.	0.	0.	33.3	33.3	33.3	16.7	0.	0.
SELECT GROUP							12/20	10/20	10/27	10/27		
							(0.1)	(0.1)	(0.1)	(0.1)		
							60.	50.	37.	37.		
DRY							10/17	9/17	9/24	9/24		
							(0.1)	(0.1)	(0.1)	(0.1)		
							58.8	52.9	37.5	37.5		
WET							2/ 3	1/ 3	1/ 3	1/ 3		
							(0.3)	(0.3)	(0.3)	(0.3)		
							66.7	33.3	33.3	33.3		

TARGET NO (1)	SEPTEMBER MOVEMENT									
	1957		1958		1959+		1960		TOTAL	
	OBS	ADJ	OBS	ADJ	OBS	ADJ	OBS	ADJ	OBS	ADJ
	CM		CM		CM		CM		CM	
MW7										
ROD	0. *	0. *	0. *	0. *	0. *	0. *	0.30 *	0.30 *	0.30 *	0.30 *
1	0.	0.	0.	0.	0.	0.	0.30	0.30	0.30	0.30
2	0.	0.	0.	0.	0. *	0. *	0.65 *	0.65 *	0.65	0.65
3	0.	0.	0.	0.	0. *	0. *	0. *	0. *	0.	0.
4	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
5	0.25	0.25	0.	0.	0. *	0. *	0.50 *	0.50 *	0.75	0.75
6	0.	0.	0.	0.	0. *	0. *	0.25 *	0.25 *	0.25	0.25
7	0.	0.	0.	0.	0. *	0. *	0. *	0. *	0.	0.
8	0.40	0.40	0.	0.	0.	0.	0.	0.	0.40	0.40
9	0.	0.	0.	0.	0.	0.	0. *	0. *	0.	0.
10	0.	0.	0.	0.	0. *	0. *	0. *	0. *	0.	0.
11	0.	0.	0.	0.	0.	0.	0. *	0. *	0.	0.
12	0.30	0.30	0.	0.	0. *	0. *	0. *	0. *	0.30	0.30
13	0.25	0.25	0.	0.	0. *	0. *	0.30 *	0.30 *	0.55	0.55
14	0.30	0.30	0.	0.	0.	0.	0.90 *	0.95 *	1.20	1.25
15	0.30	0.30	0.	0.	0. *	0. *	0. *	0. *	0.30	0.30
16	0.35	0.40	0.	0.	0. *	0. *	0.25 *	0.30 *	0.60	0.70
17	0.30	0.35	0.35	0.40	0.	0.	0. *	0. *	0.65	0.75
18	0.30	0.35	0.	0.	0. *	0. *	0.40 *	0.45 *	0.70	0.80
19	0.35	0.35	0.	0.	0. *	0. *	0. *	0. *	0.35	0.35
20	0.30	0.30	0.	0.	0.	0.	0. *	0. *	0.30	0.30
21	0.25	0.25	0.	0.	0.	0.	0.30	0.30	0.55	0.55
22	0.55	0.55	0.	0.	0.	0.	0.45 *	0.45 *	1.00	1.00
23	0.35	0.35	0.	0.	0.	0.	0. *	0. *	0.35	0.35
24	0.35	0.35	0.	0.	0. *	0. *	0.55 *	0.55 *	0.90	0.90
25	0.25	0.25	0.	0.	0. *	0. *	0.40 *	0.40 *	0.65	0.65
26	0.45	0.45	0.	0.	0. *	0. *	1.00 *	1.00 *	1.45	1.45
27	0.65	0.65	0.	0.	0. *	0. *	0.80 *	0.80 *	1.45	1.45
28	0.50	0.50	0.	0.	0.	0.	0.50 *	0.50 *	1.00	1.00
30	0.25	0.25	0.	0.	0. *	0. *	0. *	0. *	0.25	0.25
31	0.40	0.40	0.	0.	0.	0.	0.40	0.40	0.80	0.80
32	0.50	0.50	0.	0.	0.	0.	0.60	0.60	1.10	1.10
33	0.45	0.50	0.	0.	0.	0.	0. *	0. *	0.45	0.50
35	0.	0.	0.	0.	0. *	0. *	0.	0.	0.	0.
36	0.	0.	0.	0.	0. *	0. *	0. *	0. *	0.	0.
38	0.	0.	0.	0.	0. *	0. *	0. *	0. *	0.	0.
MEAN (WITH STANDARD ERROR) MW7 AND ROD EXCL GENERAL GROUP	0.2	0.2	0.	0.	0.	0.	0.2	0.3	0.5	0.5
	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.1)	(0.1)	(0.1)	(0.1)
DRY	0.2	0.2	0.	0.	0.	0.	0.3	0.3	0.5	0.5
	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.1)	(0.1)	(0.1)	(0.1)
WET	0.3	0.3	0.	0.	0.	0.	0.2	0.2	0.4	0.4
	(0.1)	(0.1)	(0.0)	(0.0)	(0.0)	(0.0)	(0.1)	(0.1)	(0.2)	(0.2)
SELECT GROUP					0.	0.	0.3	0.3		
					(0.0)	(0.0)	(0.1)	(0.1)		
DRY					0.	0.	0.3	0.3		
					(0.0)	(0.0)	(0.1)	(0.1)		
WET					0.	0.	0.	0.		
					(0.0)	(0.0)	(0.0)	(0.0)		
PROPORTION (WITH STANDARD ERROR) AND PERCENT OF MOVEMENTS EXCEEDING GROUP MEAN BY AT LEAST 0.025 CM GENERAL GROUP	18/35	18/35	1/35	1/35	0/35	0/35	15/35	16/35	16/35	16/35
	(0.1)	(0.1)	(0.0)	(0.0)	(0.0)	(0.0)	(0.1)	(0.1)	(0.1)	(0.1)
	51.4	51.4	2.9	2.9	0.	0.	42.9	45.7	45.7	45.7
DRY	15/29	15/29	1/29	1/29	0/29	0/29	13/29	14/29	14/29	14/29
	(0.1)	(0.1)	(0.0)	(0.0)	(0.0)	(0.0)	(0.1)	(0.1)	(0.1)	(0.1)
	51.7	51.7	3.5	3.5	0.	0.	44.8	48.3	48.3	48.3
WET	3/ 6	3/ 6	0/ 6	0/ 6	0/ 6	0/ 6	2/ 6	2/ 6	2/ 6	2/ 6
	(0.2)	(0.2)	(0.0)	(0.0)	(0.0)	(0.0)	(0.2)	(0.2)	(0.2)	(0.2)
	50.	50.	0.	0.	0.	0.	33.3	33.3	33.3	33.3
SELECT GROUP					0/20	0/20	11/28	12/28		
					(0.0)	(0.0)	(0.1)	(0.1)		
					0.	0.	39.3	42.9		
DRY					0/17	0/17	11/25	12/25		
					(0.0)	(0.0)	(0.1)	(0.1)		
					0.	0.	44.	48.		
WET					0/ 3	0/ 3	0/ 3	0/ 3		
					(0.0)	(0.0)	(0.0)	(0.0)		
					0.	0.	0.	0.		

TARGET NO (1)	ANNUAL MOVEMENT TO LATE AUGUST 1956-61(2)									
	1956-57 (13 AUG 56- 21 AUG 57)		1957-58 (21 AUG 57- 27 AUG 58)		1958-59 (27 AUG 58- 24 AUG 59)		1959-60 (24 AUG 59- 25 AUG 60)		1960-61 (25 AUG 60- 25 AUG 61)	
	OBS	ADJ	OBS	ADJ	OBS	ADJ	OBS	ADJ	OBS	ADJ
	CM		CM		CM		CM		CM	
MW7			4.00 *(3)	4.05 *(3)	3.90 *(3)	3.95 *(3)	EXCAVATED 5 AUG 59			
ROD	1.00 *	1.10 *	0.65 *	0.70 *	0.75 *	0.80 *	0. *	0. *	0.80 *	0.85 *
1	0.50	0.50	0.90	0.95	0.90	0.95	0.30	0.	0.60	1.15
2	1.15	1.20	1.15	1.20	0.90	0.90	0.55 *	0.55 *	0.85	1.20
3	0.95	0.95	1.50	1.55	0.80	0.80	0.50 *	0.50 *	0.55 *	0.55 *
4	1.20	1.25	1.30	1.35	1.00	1.00	0.55	0.	0.80	1.35
5	0.50	0.50	1.00	1.00	0.85	0.85	0.35 *	0.35 *	0.90 *	0.90 *
6	0.65	0.65	0.85	0.85	0.60	0.60	0.85 *	0.85 *	0.85 *	0.85 *
7	0.	0.	0.95	1.00	0.70	0.70	0.40 *	0.40 *	0.65 *	0.65 *
8	0.60	0.60	1.30	1.35	0.60	0.60	0.30	0.	0.90	1.45
9	0.95	1.00	0.90	0.90	0.65	0.65	0.25	0.55	0.90 *	0.90 *
10	0.55	0.55	0.60	0.60	0.55	0.55	0.35 *	0.35 *	0.60 *	0.60 *
11	0.40	0.40	0.55	0.55	0.65	0.70	0.30	1.35	0.65 *	0.70 *
12	1.00	1.05	0.60	0.65	0.80	0.85	0. *	0. *	0.65 *	0.70 *
13	0.70	0.75	0.55	0.60	0.90	1.00	0.40 *	0.45 *	0.60 *	0.65 *
14	0.80	0.85	0.60	0.65	1.15	1.25	0.70	0.	1.15 *	1.25 *
15	0.60	0.65	0.45	0.50	0.85	0.95	0.60 *	0.65 *	0.65 *	0.70 *
16	1.15	1.30	0.75	0.85	0.70	0.80	0.65 *	0.75 *	1.25 *	1.45 *
17	0.35	0.40	0.40	0.45	0.70	0.80	0.50	1.75	0.40 *	0.60 *
18	1.00	1.10	0.40	0.45	0.75	0.85	0.45 *	0.50 *	0.70 *	0.80 *
19	1.15	1.25	0.60	0.65	1.10	1.20	0.30 *	0.35 *	0.55 *	0.60 *
20	0.90	0.95	0.65	0.70	1.20	1.25	0.40	0.75	0.90 *	0.95 *
21	0.95	1.00	0.35	0.35	1.20	1.25	0.35	1.40	0.65	0.
22	1.25	1.30	0.85	0.90	1.25	1.30	0.45	0.75	0.85 *	0.90 *
23	1.05	1.10	0.70	0.70	1.15	1.20	0.50	0.90	0.70 *	0.70 *
24	1.50	1.55	1.20	1.25	1.05	1.10	0.65 *	0.65 *	1.10 *	1.15 *
25	1.45	1.50	1.15	1.20	1.15	1.20	0.85 *	0.85 *	0.95 *	1.00 *
26	1.60	1.65	1.60	1.65	1.15	1.20	0.75 *	0.80 *	1.70 *	1.75 *
27	1.50	1.55	1.80	1.85	1.00	1.05	0.95 *	1.00 *	1.15 *	1.20 *
28	1.90	1.95	1.90	1.95	1.15	1.20	1.10	1.65	0.75 *	0.80 *
30	1.75	1.80	2.00	2.05	1.90	1.95	1.75 *	1.80 *	1.55 *	1.60 *
31	2.75	2.85	2.60	2.70	2.40	2.45	4.85	4.25	3.70	3.50
32	3.15	3.20	2.45	2.50	3.30	3.35	2.35	2.10	3.45	4.30
33	2.90	3.15	3.75	4.05	3.65	3.95	1.70	1.40	4.40 *	4.75 *
35	5.85	6.20	6.00	6.40	5.80	6.15	4.35 *	4.75 *	6.20	6.05
36	2.70	3.25	2.35	2.85	2.65	3.20	2.40 *	2.90 *	1.95 *	2.35 *
38	0.45	0.70	0.	0.	0.75	1.20	1.00 *	1.60 *	0. *	0. *
MEAN (WITH STANDARD ERROR) MW7 AND ROD EXCL GENERAL GROUP	1.3	1.4	1.3	1.4	1.3	1.4	0.9	1.1	1.3	1.4
	(0.2)	(0.2)	(0.2)	(0.2)	(0.2)	(0.2)	(0.2)	(0.2)	(0.2)	(0.2)
DRY	0.9	1.	0.9	0.9	0.9	1.	0.5	0.7	0.8	0.9
	(0.1)	(0.1)	(0.1)	(0.1)	(0.0)	(0.1)	(0.1)	(0.1)	(0.1)	(0.1)
WET	3.2	3.4	3.2	3.4	3.3	3.5	2.9	2.9	3.5	3.8
	(0.6)	(0.6)	(0.6)	(0.7)	(0.6)	(0.6)	(0.6)	(0.6)	(0.7)	(0.7)
SELECT GROUP							0.9	1.	1.	1.1
							(0.2)	(0.2)	(0.2)	(0.2)
DRY							0.6	0.6	0.8	0.9
							(0.1)	(0.1)	(0.1)	(0.1)
WET							2.8	3.2	2.6	2.9
							(0.8)	(0.9)	(0.9)	(1.0)
PROPORTION (WITH STANDARD ERROR) AND PERCENT OF MOVEMENTS EXCEEDING GROUP MEAN BY AT LEAST 0.025 CM GENERAL GROUP	11/35	11/35	10/35	10/35	6/35	6/35	8/35	11/35	7/35	9/35
	(0.1)	(0.1)	(0.1)	(0.1)	(0.1)	(0.1)	(0.1)	(0.1)	(0.1)	(0.1)
	31.4	31.4	28.6	28.6	17.1	17.1	22.9	31.4	20.	25.7
DRY	5/29	5/29	4/29	4/29	0/29	0/29	2/29	5/29	1/29	3/29
	(0.1)	(0.1)	(0.1)	(0.1)	(0.0)	(0.0)	(0.1)	(0.1)	(0.0)	(0.1)
	17.2	17.2	13.8	13.8	0.	0.	6.9	17.2	3.4	10.3
WET	6/ 6	6/ 6	6/ 6	6/ 6	6/ 6	6/ 6	6/ 6	6/ 6	6/ 6	6/ 6
	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)
	100.	100.	100.	100.	100.	100.	100.	100.	100.	100.
SELECT GROUP							5/20	4/20	8/27	8/27
							(0.1)	(0.1)	(0.1)	(0.1)
							25.	20.	29.6	29.6
DRY							2/17	1/17	5/24	5/24
							(0.1)	(0.1)	(0.1)	(0.1)
							11.8	5.9	20.8	20.8
WET							3/ 3	3/ 3	3/ 3	3/ 3
							(0.0)	(0.0)	(0.0)	(0.0)
							100.	100.	100.	100.

TARGET NO	TOTAL MOVEMENT AND MEAN RATE 1956-61				TARGET NO	DEPTH CM	ANGLE OF VIEW	GRADIENT	DRY OR WET
	TOTAL 1956-61		RATE						
	OBS	ADJ	OBS	ADJ					
	CM		CM/YR						
MW7	7.90 *(3)	8.05 *(3)	4.15	4.25	MW7	100.0	4	10.0	W
ROD	3.45 *	3.75 *	0.70	0.75	ROD	137.0	19	12.5	D
1	3.20	3.45	0.65	0.70	1	20.0	11	11.5	D
2	4.60	5.00	0.90	1.00	2	10.0	5	11.5	D
3	4.30	4.40	0.85	0.90	3	20.0	5	11.5	D
4	4.85	4.95	0.95	1.00	4	10.0	4	11.5	D
5	3.65	3.75	0.75	0.75	5	20.0	3	12.0	D
6	3.75	3.85	0.75	0.75	6	10.0	3	12.5	D
7	2.90	3.00	0.60	0.60	7	20.0	3	13.0	D
8	3.70	3.80	0.75	0.75	8	10.0	3	14.0	D
9	3.65	4.05	0.75	0.80	9	20.0	0	13.0	D
10	2.70	2.80	0.55	0.55	10	10.0	6	13.0	D
11	2.50	3.65	0.50	0.75	11	20.0	9	12.5	D
12	3.30	3.50	0.65	0.70	12	10.0	15	12.0	D
13	3.20	3.45	0.65	0.70	13	20.0	19	12.5	D
14	4.35	4.15	0.85	0.85	14	10.0	19	12.5	D
15	3.10	3.40	0.60	0.70	15	20.0	20	13.0	D
16	4.50	5.15	0.90	1.05	16	10.0	26	13.5	D
17	2.30	4.00	0.45	0.80	17	20.0	29	13.0	D
18	3.30	3.70	0.65	0.75	18	10.0	24	12.5	D
19	3.65	3.95	0.75	0.80	19	10.0	20	11.5	D
20	4.05	4.60	0.80	0.90	20	10.0	14	11.5	D
21	3.55	4.20	0.70	0.85	21	20.0	11	11.5	D
22	4.65	5.10	0.95	1.00	22	10.0	7	12.0	D
23	4.10	4.60	0.80	0.90	23	20.0	2	12.0	D
24	5.45	5.60	1.10	1.10	24	10.0	0	12.5	D
25	5.55	5.70	1.10	1.15	25	20.0	0	13.0	D
26	6.75	7.00	1.35	1.40	26	10.0	9	13.0	D
27	6.40	6.65	1.30	1.35	27	10.0	9	12.5	D
28	6.70	7.45	1.35	1.50	28	10.0	9	12.0	D
30	8.95	9.20	1.80	1.85	30	10.0	8	11.0	W
31	16.25	15.70	3.25	3.15	31	20.0	8	11.0	W
32	14.65	15.40	2.95	3.10	32	10.0	0	10.0	W
33	16.40	17.30	3.30	3.45	33	20.0	20	10.0	W
35	28.30	29.70	5.65	5.95	35	20.0	17	10.0	W
36	12.00	14.50	2.40	2.90	36	10.0	32	12.0	W
38	2.15	3.45	0.45	0.70	38	10.0	50	12.5	D
MEAN (WITH STANDARD ERROR) MW7 AND ROD EXCL GENERAL GROUP	6.1	6.6	1.2	1.3	MEAN (WITH STANDARD ERROR) MW7 AND ROD EXCL GENERAL GROUP				
	(0.9)	(0.9)	(0.2)	(0.2)					
DRY	4.	4.4	0.8	1.	DRY				
	(0.2)	(0.2)	(0.0)	(0.0)					
WET	16.1	17.	3.2	3.4	WET				
	(2.7)	(2.8)	(0.5)	(0.6)					
SELECT GROUP					SELECT GROUP				
DRY					DRY				
WET					WET				
PROPORTION (WITH STANDARD ERROR) AND PERCENT OF MOVEMENTS EXCEEDING GROUP MEAN BY AT LEAST 0.025 CM GENERAL GROUP	9/35	9/35	9/35	9/35	PROPORTION (WITH STANDARD ERROR) AND PERCENT OF MOVEMENTS EXCEEDING GROUP MEAN BY AT LEAST 0.025 CM GENERAL GROUP				
	(0.1)	(0.1)	(0.1)	(0.1)					
	25.7	25.7	25.7	25.7					
DRY	3/29	3/29	3/29	3/29	DRY				
	(0.1)	(0.1)	(0.1)	(0.1)					
	10.3	10.3	10.3	10.3					
WET	6/ 6	6/ 6	6/ 6	6/ 6	WET				
	(0.0)	(0.0)	(0.0)	(0.0)					
	100.	100.	100.	100.					
SELECT GROUP					SELECT GROUP				
DRY					DRY				
WET					WET				
MEAN (WITH STANDARD ERROR) FOR 10 CM T DRY	4.4	4.8	0.9	1.	MEAN (WITH STANDARD ERROR) FOR 10 CM T DRY				
	(0.3)	(0.3)	(0.1)	(0.1)					
WET	11.9	13.	2.4	2.6	WET				
	(1.6)	(2.0)	(0.3)	(0.4)					
MEAN (WITH STANDARD ERROR) FOR 20 CM T DRY	3.5	4.	0.7	0.8	MEAN (WITH STANDARD ERROR) FOR 20 CM T DRY				
	(0.3)	(0.2)	(0.1)	(0.0)					
WET	20.3	20.9	4.1	4.2	WET				
	(4.0)	(4.4)	(0.8)	(0.9)					

* SELECT TARGETS - THOSE WITH PROBABLY ≤ 0.2 CM DOWNSLOPE OR UPSLOPE ATTITUDE CHANGE DUE TO TILTING AND/OR TARGET HEAVING IN PERIOD INDICATED

\+ OMITTED FROM MEAN. 0. HERE INDICATES LACK OF DATA

OBS OBSERVED MOVEMENT. HORIZONTAL COMPONENT NORMAL TO TARGET LINE

ADJ ADJUSTED MOVEMENT. OBSERVED MOVEMENT ADJUSTED FOR ANGLE OF VIEW, GRADIENT AND, IN CASE OF ANNUAL MOVEMENT, FOR TARGET ATTITUDE CHANGE (1959-61)

(1) OMITTED TARGETS ARE EXCLUDED FOR REASONS CITED IN TABLE OF TARGET ATTITUDES AND/OR STATED IN TEXT

(2) ANNUAL MOVEMENT TAKEN DIRECTLY FROM OBSERVATION TOTALS RATHER THAN FROM SUMMATION OF COMPONENT MOVEMENTS, SINCE AMOUNT CALCULATED FROM COMPONENTS DISREGARDS ALL MOVEMENTS ≤ 0.2 CM

(3) ANNUAL MOVEMENTS OF MW7 ARE FOR 2 SEPT 1957 - 8 AUG 1958, 8 AUG 1958 - 4 AUG 1959, AND TOTAL FOR PERIOD 1957-1959

Table C III.

EXPERIMENTAL SITE 7 STONE-TARGET MOVEMENTS > 0.2 CM 1956-61

TARGET NO	NEAREST CONE TARGET	ANGLE OF VIEW	GRADIENT	DRY OR WET	JUMP		GELIFLUCTION						RETROGRADE MOVEMENT						SEPTEMBER MOVEMENT		ANNUAL MOVEMENT TO LATE AUGUST 1960-61 (1)		
					1960-61		1960		1961		TOTAL 1960-61		1960		1961		TOTAL 1960-61		1960		1960-61 (24 AUG 60 - 25 AUG 61)		DIFFERENCE FROM ASSOCIATED CONE TARGET
					OBS	ADJ	OBS	ADJ	OBS	ADJ	OBS	ADJ	OBS	ADJ	OBS	ADJ	OBS	ADJ	OBS	ADJ	OBS	ADJ	ADJ
					CM		CM		CM		CM		CM		CM		CM		CM		CM		CM
1	2	8	11.5	D	1.30	1.30	0.	0.	0.	0.	0.	0.	0.40	0.40	0.	0.	0.40	0.40	0.	0.	1.15	1.20	0.
2	3	5	11.5	D	0.75	0.75	0.25	0.25	0.	0.	0.25	0.25	0.25	0.25	0.	0.	0.25	0.25	0.	0.	0.65	0.65	0.10
3	6	3	13.0	D	0.65	0.65	0.	0.	0.	0.	0.	0.	0.30	0.30	0.	0.	0.30	0.30	0.	0.	0.55	0.55	-0.30
4	9	6	16.0	D	0.75	0.75	0.	0.	0.	0.	0.	0.	0.25	0.25	0.	0.	0.25	0.25	0.	0.	0.50	0.50	-0.40
5	11	9	12.5	D	1.15	1.15	0.30	0.30	0.	0.	0.30	0.30	0.35	0.35	0.	0.	0.35	0.35	0.	0.	1.00	1.05	0.4
6	12	10	12.5	D	1.05	1.05	0.	0.	0.	0.	0.	0.	0.35	0.35	0.	0.	0.35	0.35	0.	0.	0.65	0.70	0.
7	14	20	12.5	D	0.90	0.95	0.	0.	0.	0.	0.	0.	0.45	0.50	0.	0.	0.45	0.50	0.	0.	0.65	0.70	-0.6
8	17	35	13.0	D	0.80	1.00	0.	0.	0.	0.	0.	0.	0.30	0.35	0.	0.	0.30	0.35	0.	0.	0.55	0.70	0.10
9	20	18	11.5	D	0.70	0.75	0.25	0.25	0.	0.	0.25	0.25	0.65	0.70	0.	0.	0.65	0.70	0.	0.	0.45	0.50	-0.5
10	21	10	11.5	D	0.60	0.60	0.25	0.25	0.30	0.30	0.55	0.55	0.50	0.50	0.	0.	0.50	0.50	0.	0.	0.60 (2)	0.60 (2)	0.5
11	22	7	12.0	D	0.60	0.60	0.	0.	0.25	0.25	0.25	0.25	0.45	0.45	0.	0.	0.45	0.45	0.	0.	0.65	0.65	-0.25
12	25	0	13.0	D	0.90	0.90	0.	0.	0.	0.	0.	0.	0.25	0.25	0.	0.	0.25	0.25	0.	0.	0.95	1.00	0.
13	27	8	12.5	D	0.75	0.75	0.35	0.35	0.	0.	0.35	0.35	0.40	0.40	0.	0.	0.40	0.40	0.	0.	0.70	0.75	-0.45
14	28	5	12.0	D	0.75	0.75	0.35	0.35	0.	0.	0.35	0.35	0.	0.	0.	0.	0.	0.	0.	0.	0.55	0.55	-0.3
15	32	7	10.0	W	4.20	4.25	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	4.20 (2)	4.30 (2)	-0.1
16	35	17	10.0	W	5.60	5.85	1.75	1.85	0.	0.	1.75	1.85	0.	0.	0.	0.	0.	0.	0.	0.	5.55 (2)	5.90 (2)	-0.20
MEAN (WITH STANDARD ERROR)																							
GENERAL GROUP					1.3	1.4	0.2	0.2	0.	0.	0.3	0.3	0.3	0.3	0.	0.	0.3	0.3	0.	0.	1.2	1.3	-0.1
					(0.4)	(0.4)	(0.1)	(0.1)	(0.0)	(0.0)	(0.1)	(0.1)	(0.0)	(0.1)	(0.0)	(0.0)	(0.0)	(0.1)	(0.0)	(0.0)	(0.4	(0.4)	(0.1)
DRY					0.8	0.9	0.1	0.1	0.	0.	0.2	0.2	0.4	0.4	0.	0.	0.4	0.4	0.	0.	0.7	0.7	-0.1
					(0.1)	(0.1)	(0.0)	(0.0)	(0.0)	(0.0)	(0.1)	(0.1)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.1)	(0.1)	(0.1)
WET					4.9	5.1	0.9	0.9	0.	0.	0.9	0.9	0.	0.	0.	0.	0.	0.	0.	0.	4.9	5.1	-0.1
					(0.7)	(0.8)	(0.9)	(0.9)	(0.0)	(0.0)	(0.9)	(0.9)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.7)	(0.8)	(0.1)
PROPORTION (WITH STANDARD ERROR) AND PERCENT OF MOVEMENTS EXCEEDING GROUP MEAN BY AT LEAST 0.025 CM																							
GENERAL GROUP					2/16	2/16	7/16	7/16	2/16	2/16	5/16	5/16	8/16	9/16	0/16	0/16	8/16	9/16	0/16	0/16	2/16	2/16	
					(0.1)	(0.1)	(0.1)	(0.1)	(0.1)	(0.1)	(0.1)	(0.1)	(0.1)	(0.1)	(0.0)	(0.0)	(0.1)	(0.1)	(0.0)	(0.0)	(0.1)	(0.1)	
					12.5	12.5	43.8	43.8	12.5	12.5	31.3	31.3	50.	56.3	0.	0.	50.	56.3	0.	0.	12.5	12.5	
DRY					0/14	0/14	6/14	6/14	2/14	2/14	4/14	4/14	8/14	9/14	0/14	0/14	8/14	9/14	0/14	0/14	0/14	0/14	
					(0.0)	(0.0)	(0.1)	(0.1)	(0.1)	(0.1)	(0.1)	(0.1)	(0.1)	(0.1)	(0.0)	(0.0)	(0.1)	(0.1)	(0.0)	(0.0)	(0.0)	(0.0)	
					0.	0.	42.9	42.9	14.3	14.3	28.6	28.6	57.1	64.3	0.	0.	57.1	64.3	0.	0.	0.	0.	
WET					2/ 2	2/ 2	1/ 2	1/ 2	0/ 2	0/ 2	1/ 2	1/ 2	0/ 2	0/ 2	0/ 2	0/ 2	0/ 2	0/ 2	0/ 2	0/ 2	2/ 2	2/ 2	
					(0.0)	(0.0)	(0.4)	(0.4)	(0.0)	(0.0)	(0.4)	(0.4)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	
					100.	100.	50.	50.	0.	0.	50.	50.	0.	0.	0.	0.	0.	0.	0.	0.	100.	100.	

TARGET NO	NEAREST CONE TARGET	ANGLE OF VIEW	GRADIENT	DRY OR WET
1	2	8	11.5	D
2	3	5	11.5	D
3	6	3	13.0	D
4	9	6	16.0	D
5	11	9	12.5	D
6	12	10	12.5	D
7	14	20	12.5	D
8	17	35	13.0	D
9	20	18	11.5	D
10	21	10	11.5	D
11	22	7	12.0	D
12	25	0	13.0	D
13	27	8	12.5	D
14	28	5	12.0	D
15	32	7	10.0	W
16	35	17	10.0	W
MEAN (WITH STANDARD ERROR)				
GENERAL GROUP				
DRY				
WET				
PROPORTION (WITH STANDARD ERROR) AND PERCENT OF MOVEMENTS EXCEEDING GROUP MEAN BY AT LEAST 0.025 CM				
GENERAL GROUP				
DRY				
WET				

* ALL STONE TARGETS CONSIDERED SELECT

OBS OBSERVED MOVEMENT. HORIZONTAL COMPONENT NORMAL TO TARGET LINE

ADJ ADJUSTED MOVEMENT. OBSERVED MOVEMENT ADJUSTED FOR ANGLE OF VIEW AND GRADIENT

(1) ANNUAL MOVEMENT TAKEN DIRECTLY FROM OBSERVATION TOTALS RATHER THAN FROM SUMMATION OF COMPONENT MOVEMENTS, SINCE AMOUNT CALCULATED FROM COMPONENTS DISREGARDS ALL MOVEMENTS ≤ 0.2 CM

(2) LATE AUGUST 1960-61 COMPARISON IMPOSSIBLE BECAUSE OF LACK OF TARGET READINGS AT APPROPRIATE DATES, CLOSEST PRECEDING COMPARABLE DATES SELECTED INSTEAD AND DIFFERENCE FROM CONE TARGETS CALCULATED FROM SIMILAR CONE TARGET DATES

Table C IV.

EXPERIMENTAL SITE 8 TARGET MOVEMENTS ≥ 0.2 CM 1956-61

TARGET NO (1)	DEPTH CM	ANGLE OF VIEW	GRADI-ENT	DRY OR WET	JUMP 1956-57 (INCL 1956 SEPT MOVET)		1957-58		1958-59		1959-60		1960-61		TOTAL	
					OBS CM	ADJ	OBS CM	ADJ	OBS CM	ADJ	OBS CM	ADJ	OBS CM	ADJ	OBS CM	ADJ
MW8	100.0	6	11.0	D	2.25 *	2.25 *	1.80 *	1.80 *	1.15 *	1.15 *	EXCAVATED 5 AUG 59					
3	20.0	28	12.0	D	1.70	1.95	1.05	1.20	1.10	1.25	0.	0.	0.35 *	0.40 *	4.20	4.80
4	10.0	11	11.5	D	2.50	2.55	2.80	2.85	3.25	3.30	0.45	0.45	0.85	0.85	9.85	10.00
6	10.0	10	13.0	D	3.85	3.90	2.40	2.45	2.25	2.30	0.80 *	0.80 *	1.65 *	1.70 *	10.95	11.15
7	20.0	12	14.0	D	4.45	4.55	2.00	2.05	2.55	2.60	1.10	1.15	1.20	1.25	11.30	11.60
8	10.0	12	14.0	D	5.70	5.85	2.40	2.45	3.70	3.80	0.75 *	0.75 *	1.45 *	1.50 *	14.00	14.35
9	20.0	11	13.5	D	5.20	5.30	2.90	2.95	4.60	4.70	1.90	1.95	1.60 *	1.65 *	16.20	16.55
10	10.0	6	13.0	D	5.85	5.90	3.60	3.60	4.95	5.00	2.35 *	2.35 *	1.35	1.35	18.10	18.20
11	20.0	6	11.5	D	4.95	5.00	3.85	3.85	5.00	5.05	3.70	3.70	1.10	1.10	18.60	18.70
12	10.0	0	11.5	D	3.50	3.50	3.55	3.55	4.10	4.10	2.25 *	2.25 *	1.25	1.25	14.65	14.65
13	20.0	0	11.5	D	3.20	3.20	3.15	3.15	3.65	3.65	1.75	1.75	1.30 *	1.30 *	13.05	13.05
14	10.0	6	12.0	D	3.50	3.50	2.80	2.80	3.45	3.45	2.00 *	2.00 *	1.00 *	1.00 *	12.75	12.75
15	20.0	14	11.5	D	3.30	3.40	2.85	2.95	4.15	4.30	2.40 *	2.45 *	1.20 *	1.25 *	13.90	14.35
16	10.0	14	11.5	D	4.20	4.35	3.15	3.25	4.55	4.70	2.40	2.45	1.00	1.05	15.30	15.80
17	20.0	10	11.5	D	2.90	2.95	2.65	2.70	3.95	4.00	2.10	2.15	1.10 *	1.10 *	12.70	12.90
18	10.0	5	11.5	W	2.85	2.85	1.95	1.95	3.45	3.45	1.75	1.75	1.35 *	1.35 *	11.35	11.35
19	10.0	5	11.5	W	4.45	4.45	3.60	3.60	5.05	5.05	2.50	2.50	1.65 *	1.65 *	17.25	17.25
20	10.0	0	11.5	W	5.75	5.75	5.15	5.15	6.10	6.10	2.80	2.80	2.10 *	2.10 *	21.90	21.90
21	20.0	0	12.0	W	4.65	4.65	4.20	4.20	5.80	5.80	2.25	2.25	2.10	2.10	19.00	19.00
22	10.0	0	12.0	W	4.10	4.10	3.25	3.25	4.75	4.75	2.05	2.05	1.90	1.90	16.05	16.05
23	20.0	0	11.5	W	3.90	3.90	2.75	2.75	4.05	4.05	2.25 *	2.25 *	2.15 *	2.15 *	15.10	15.10
24	10.0	14	11.0	W	2.60	2.70	2.35	2.40	3.30	3.40	1.55 *	1.60 *	1.90 *	1.95 *	11.70	12.05
25	20.0	0	11.0	W	3.70	3.70	3.35	3.35	4.65	4.65	2.80	2.80	2.10	2.10	16.60	16.60
28	10.0	17	13.0	W	3.25	3.40	1.90	2.00	3.55	3.70	2.15	2.25	1.75 *	1.85 *	12.60	13.20
29	20.0	14	12.0	W	2.15	2.20	2.10	2.15	2.85	2.95	2.00 *	2.05 *	2.50 *	2.60 *	11.60	11.95
30	10.0	9	12.0	W	2.45	2.50	2.40	2.45	2.20	2.25	2.05	2.10	2.25	2.30	11.35	11.60
31	20.0	6	12.0	D	1.40	1.40	2.35	2.35	1.50	1.50	1.30 *	1.30 *	2.20	2.20	8.75	8.75
32	10.0	0	12.5	D	1.25	1.25	1.55	1.55	1.35	1.35	0.85 *	0.85 *	1.75	1.75	6.75	6.75
33	20.0	0	12.5	D	1.15	1.15	1.70	1.70	1.45	1.45	1.30	1.30	1.60	1.60	7.20	7.20
34	10.0	7	13.0	D	1.55	1.55	1.85	1.85	1.20	1.20	1.20	1.20	1.95 *	1.95 *	7.75	7.75
MEAN (WITH STANDARD ERROR) MW8 EXCL																
GENERAL GROUP					3.5 (0.3)	3.5 (0.3)	2.7 (0.2)	2.8 (0.2)	3.5 (0.3)	3.6 (0.3)	1.8 (0.2)	1.8 (0.2)	1.6 (0.1)	1.6 (0.1)	13.1 (0.8)	13.3 (0.7)
DRY					3.3 (0.4)	3.4 (0.4)	2.6 (0.2)	2.6 (0.2)	3.2 (0.3)	3.2 (0.3)	1.6 (0.2)	1.6 (0.2)	1.3 (0.1)	1.4 (0.1)	12. (0.9)	12.2 (1.0)
WET					3.6 (0.3)	3.7 (0.3)	3. (0.3)	3. (0.3)	4.2 (0.4)	4.2 (0.4)	2.2 (0.1)	2.2 (0.1)	2. (0.1)	2. (0.1)	15. (1.1)	15.1 (1.0)
SELECT GROUP											1.7 (0.2)	1.7 (0.2)	1.6 (0.1)	1.6 (0.1)		
DRY											1.6 (0.3)	1.6 (0.3)	1.3 (0.2)	1.3 (0.2)		
WET											1.9 (0.2)	2. (0.2)	1.9 (0.2)	2. (0.2)		
PROPORTION (WITH STANDARD ERROR) AND PERCENT OF MOVEMENTS EXCEEDING GROUP MEAN BY AT LEAST 0.025 CM																
GENERAL GROUP					15/29 (0.1) 51.7	13/29 (0.1) 44.8	14/29 (0.1) 48.3	13/29 (0.1) 44.8	15/29 (0.1) 51.7	16/29 (0.1) 55.1	17/29 (0.1) 58.6	17/29 (0.1) 58.6	16/29 (0.1) 55.1	15/29 (0.1) 51.7	13/29 (0.1) 44.8	13/29 (0.1) 44.8
DRY					9/18 (0.1) 50.	7/18 (0.1) 38.9	9/18 (0.1) 50.	8/18 (0.1) 44.4	9/18 (0.1) 50.	9/18 (0.1) 50.	8/18 (0.1) 44.4	8/18 (0.1) 44.4	6/18 (0.1) 33.3	5/18 (0.1) 27.8	7/18 (0.1) 38.9	7/18 (0.1) 38.9
WET					6/11 (0.2) 54.6	6/11 (0.2) 54.6	5/11 (0.2) 45.5	5/11 (0.2) 45.5	6/11 (0.2) 54.6	7/11 (0.2) 63.6	9/11 (0.1) 81.8	9/11 (0.1) 81.8	10/11 (0.1) 90.9	10/11 (0.1) 90.9	6/11 (0.2) 54.6	6/11 (0.2) 54.6
SELECT GROUP											6/11 (0.2) 54.6	6/11 (0.2) 54.6	9/16 (0.1) 56.3	9/16 (0.1) 56.3		
DRY											4/ 8 (0.2) 50.	4/ 8 (0.2) 50.	3/ 9 (0.2) 33.3	3/ 9 (0.2) 33.3		
WET											2/ 3 (0.3) 66.7	2/ 3 (0.3) 66.7	6/ 7 (0.1) 85.7	6/ 7 (0.1) 85.7		
MEAN (WITH STANDARD ERROR) FOR 10 CM T																
DRY																
WET																
MEAN (WITH STANDARD ERROR) FOR 20 CM T																
DRY																
WET																

TARGET NO	GELIFLUCTION 1957		1958		1959		1960		1961		TOTAL	
	OBS CM	ADJ	OBS CM	ADJ	OBS CM	ADJ	OBS CM	ADJ	OBS CM	ADJ	OBS CM	ADJ
MW8	0. *	0. *	0. *	0. *	0. *	0. *	EXCAVATED 5 AUG 59					
3	0.35	0.40	0.	0.	0.25	0.30	0.75	0.85	1.15 *	1.30 *	2.50	2.85
4	0.40	0.40	0.	0.	0.25	0.25	0.65	0.65	1.55	1.60	2.85	2.90
6	0.	0.	0.	0.	0.	0.	1.15 *	1.15 *	1.80 *	1.85 *	2.95	3.00
7	0.25	0.25	0.40	0.40	0.	0.	1.35	1.40	3.00	3.05	5.00	5.10
8	0.	0.	0.70	0.70	0.	0.	1.95 *	2.00 *	3.00 *	3.05 *	5.65	5.75
9	0.	0.	1.05	1.05	0.	0.	2.00	2.05	3.50 *	3.55 *	6.55	6.65
10	0.	0.	1.55	1.55	0.	0.	1.55 *	1.55 *	4.70	4.75	7.80	7.85
11	0.25	0.25	0.90	0.90	0.	0.	1.25	1.25	4.75	4.80	7.15	7.20
12	0.30	0.30	0.25	0.25	0.	0.	1.25 *	1.25 *	2.85	2.85	4.65	4.65
13	0.40	0.40	0.35	0.35	0.	0.	1.20	1.20	3.05 *	3.05 *	5.00	5.00
14	0.50	0.50	0.55	0.55	0.35	0.35	1.10 *	1.10 *	2.35 *	2.35 *	4.85	4.85
15	0.50	0.50	0.85	0.90	0.25	0.25	1.35 *	1.40 *	2.30 *	2.35 *	5.25	5.40
16	0.55	0.55	1.25	1.30	0.	0.	1.60	1.65	2.95	3.05	6.35	6.55
17	0.50	0.50	1.30	1.30	0.	0.	2.05	2.10	2.25 *	2.30 *	6.10	6.20
18	0.65	0.65	1.05	1.05	0.	0.	1.30	1.30	1.95 *	1.95 *	4.95	4.95
19	0.70	0.70	1.20	1.20	0.	0.	1.45	1.45	2.80 *	2.80 *	6.15	6.15
20	0.55	0.55	1.15	1.15	0.	0.	1.30	1.30	3.95 *	3.95 *	6.95	6.95
21	0.30	0.30	1.40	1.40	0.	0.	1.40	1.40	4.35	4.35	7.45	7.45
22	0.	0.	1.00	1.00	0.	0.	0.80	0.80	4.35	4.35	6.15	6.15
23	0.	0.	0.95	0.95	0.	0.	0.30 *	0.30 *	2.45 *	2.45 *	3.70	3.70
24	0.	0.	1.00	1.05	0.	0.	0.25 *	0.25 *	2.10 *	2.15 *	3.35	3.45
25	0.	0.	1.10	1.10	0.	0.	0.	0.	2.65	2.65	3.75	3.75
28	0.45	0.45	1.80	1.90	0.30	0.30	0.25	0.25	1.40 *	1.45 *	4.20	4.35
29	0.45	0.45	0.85	0.90	0.	0.	0.45 *	0.45 *	0.65 *	0.65 *	2.40	2.45
30	0.	0.	0.45	0.45	0.	0.	0.	0.	0.35	0.35	0.80	0.80
31	0.	0.	0.	0.	0.	0.	0. *	0. *	0.35	0.35	0.35	0.35
32	0.	0.	0.	0.	0.	0.	0. *	0. *	0.	0.	0.	0.
33	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
34	0.	0.	0.	0.	0.	0.	0.25	0.25	0. *	0. *	0.25	0.25
MEAN (WITH STANDARD ERROR) MW8 EXCL												
GENERAL GROUP	0.2 (0.1)	0.3 (0.1)	0.7 (0.1)	0.7 (0.1)	0.1 (0.0)	0.1 (0.0)	0.9 (0.1)	0.9 (0.1)	2.3 (0.3)	2.3 (0.3)	4.2 (0.4)	4.3 (0.4)
DRY	0.2 (0.1)	0.2 (0.1)	0.5 (0.1)	0.5 (0.1)	0.1 (0.0)	0.1 (0.0)	1.1 (0.2)	1.1 (0.2)	2.2 (0.4)	2.2 (0.4)	4.1 (0.6)	4.1 (0.6)
WET	0.3 (0.1)	0.3 (0.1)	1.1 (0.1)	1.1 (0.1)	0. (0.0)	0. (0.0)	0.7 (0.2)	0.7 (0.2)	2.5 (0.4)	2.5 (0.4)	4.5 (0.6)	4.6 (0.6)
SELECT GROUP							0.9 (0.2)	0.9 (0.2)	2.2 (0.3)	2.2 (0.3)		
DRY							1. (0.3)	1.1 (0.3)	2.2 (0.4)	2.2 (0.4)		
WET							0.3 (0.1)	0.3 (0.1)	2.2 (0.4)	2.2 (0.4)		
PROPORTION (WITH STANDARD ERROR) AND PERCENT OF MOVEMENTS EXCEEDING GROUP MEAN BY AT LEAST 0.025 CM												
GENERAL GROUP	14/29 (0.1) 48.2	14/29 (0.1) 48.2	16/29 (0.1) 55.1	16/29 (0.1) 55.1	5/29 (0.1) 17.2	5/29 (0.1) 17.2	16/29 (0.1) 55.2	16/29 (0.1) 55.2	15/29 (0.1) 51.7	16/29 (0.1) 55.2	16/29 (0.1) 55.2	17/29 (0.1) 58.6
DRY	8/18 (0.1) 44.4	8/18 (0.1) 44.4	6/18 (0.1) 33.3	6/18 (0.1) 33.3	4/18 (0.1) 22.2	4/18 (0.1) 22.2	12/18 (0.1) 66.7	12/18 (0.1) 66.7	9/18 (0.1) 50.	10/18 (0.1) 55.6	11/18 (0.1) 61.1	11/18 (0.1) 61.1
WET	6/11 (0.2) 54.6	6/11 (0.2) 54.6	10/11 (0.1) 90.9	10/11 (0.1) 90.9	1/11 (0.1) 9.1	1/11 (0.1) 9.1	4/11 (0.2) 36.4	4/11 (0.2) 36.4	6/11 (0.2) 54.6	6/11 (0.2) 54.6	5/11 (0.2) 45.5	6/11 (0.2) 54.6
SELECT GROUP							6/11 (0.2) 54.6	6/11 (0.2) 54.6	9/16 (0.1) 56.3	9/16 (0.1) 56.3		
DRY							6/ 8 (0.2) 75.	6/ 8 (0.2) 75.	6/ 9 (0.2) 66.7	6/ 9 (0.2) 66.7		
WET							0/ 3 (0.0) 0.	0/ 3 (0.0) 0.	3/ 7 (0.2) 42.9	3/ 7 (0.2) 42.9		
MEAN (WITH STANDARD ERROR) FOR 10 CM T												
DRY											3.9 (0.9)	4. (0.9)
WET											4.7 (0.8)	4.7 (0.8
MEAN (WITH STANDARD ERROR) FOR 20 CM T												
DRY											4.2 (0.9)	4.3 (0.9)
WET											4.3 (1.1)	4.3 (1.1)

TARGET NO	RETROGRADE MOVEMENT 1957		1958		1959		1960		1961		TOTAL	
	OBS CM	ADJ	OBS CM	ADJ	OBS CM	ADJ	OBS CM	ADJ	OBS CM	ADJ	OBS CM	ADJ
MW8	1.10 *	1.10 *	0.55 *	0.55 *	0. *	0. *	EXCAVATED 5 AUG 59					
3	1.40	1.60	0.50	0.55	0.30	0.35	0.55	0.60	0.50 *	0.55 *	3.25	3.65
4	0.85	0.85	0.60	0.60	0.	0.	0.30	0.30	0.65	0.65	2.40	2.40
6	1.40	1.40	0.60	0.60	0.	0.	0.80 *	0.80 *	0.50 *	0.50 *	3.30	3.30
7	0.40	0.40	0.40	0.40	0.25	0.25	0.40	0.40	0.45	0.45	1.90	1.90
8	0.25	0.25	0.55	0.55	0.	0.	0.25 *	0.25 *	0.45 *	0.45 *	1.50	1.50
9	0.75	0.75	0.45	0.45	0.	0.	0.60	0.60	0.40 *	0.40 *	2.20	2.20
10	1.45	1.45	0.30	0.30	0.	0.	0.95 *	0.95 *	0.55	0.55	3.25	3.25
11	1.85	1.85	0.	0.	0.	0.	1.70	1.70	0.60	0.60	4.15	4.15
12	1.50	1.50	0.25	0.25	0.	0.	1.60 *	1.60 *	0.40	0.40	3.75	3.75
13	1.30	1.30	0.	0.	0.	0.	1.45	1.45	0.40 *	0.40 *	3.15	3.15
14	1.25	1.25	0.25	0.25	0.	0.	1.10 *	1.10 *	0.35 *	0.35 *	2.95	2.95
15	0.90	0.95	0.35	0.35	0.	0.	0.70 *	0.70 *	0.40 *	0.40 *	2.35	2.40
16	0.55	0.55	0.50	0.50	0.	0.	0.50	0.50	0.25	0.25	1.80	1.80
17	0.35	0.35	0.50	0.50	0.25	0.25	0.55	0.55	0.45 *	0.45 *	2.10	2.10
18	0.45	0.45	0.40	0.40	0.	0.	0.	0.	0.55 *	0.55 *	1.40	1.40
19	0.30	0.30	0.70	0.70	0.	0.	0.	0.	0.85 *	0.85 *	1.85	1.85
20	0.	0.	0.60	0.60	0.	0.	0.	0.	0.55 *	0.55 *	1.15	1.15
21	0.25	0.25	0.80	0.80	0.	0.	0.	0.	0.40	0.40	1.45	1.45
22	0.25	0.25	0.60	0.60	0.	0.	0.	0.	0.65	0.65	1.50	1.50
23	0.30	0.30	0.35	0.35	0.	0.	0. *	0. *	0.45 *	0.45 *	1.10	1.10
24	0.65	0.65	0.40	0.40	0.35	0.35	0. *	0. *	0.55 *	0.55 *	1.95	1.95
25	0.55	0.55	0.70	0.70	0.30	0.30	0.25	0.25	0.60	0.60	2.40	2.40
28	1.50	1.55	0.30	0.30	0.30	0.30	0.70	0.75	0.50 *	0.50 *	3.30	3.40
29	1.50	1.55	0.25	0.25	0.	0.	0.70 *	0.70 *	0.60 *	0.60 *	3.05	3.10
30	1.30	1.30	0.30	0.30	0.	0.	0.75	0.75	0.25	0.25	2.60	2.60
31	1.35	1.35	0.50	0.50	0.	0.	1.00 *	1.00 *	1.05	1.05	3.90	3.90
32	1.00	1.00	0.35	0.35	0.	0.	0.70 *	0.70 *	1.00	1.00	3.05	3.05
33	0.95	0.95	0.60	0.60	0.25	0.25	0.55	0.55	1.05	1.05	3.40	3.40
34	0.85	0.85	0.95	0.95	0.	0.	0.95	0.95	1.00 *	1.00 *	3.75	3.75
MEAN (WITH STANDARD ERROR) MW8 EXCL												
GENERAL GROUP	0.9 (0.1)	0.9 (0.1)	0.5 (0.0)	0.5 (0.0)	0.1 (0.0)	0.1 (0.0)	0.6 (0.1)	0.6 (0.1)	0.6 (0.0)	0.6 (0.0)	2.6 (0.2)	2.6 (0.2)
DRY	1. (0.1)	1. (0.1)	0.4 (0.1)	0.4 (0.1)	0.1 (0.0)	0.1 (0.0)	0.8 (0.1)	0.8 (0.1)	0.6 (0.1)	0.6 (0.1)	2.9 (0.2)	2.9 (0.2)
WET	0.6 (0.2)	0.7 (0.2)	0.5 (0.1)	0.5 (0.1)	0.1 (0.0)	0.1 (0.0)	0.2 (0.1)	0.2 (0.1)	0.5 (0.1)	0.5 (0.1)	2. (0.2)	2. (0.2)
SELECT GROUP							0.7 (0.1)	0.7 (0.1)	0.5 (0.0)	0.5 (0.1)		
DRY							0.9 (0.1)	0.9 (0.1)	0.5 (0.1)	0.5 (0.1)		
WET							0.2 (0.2)	0.2 (0.2)	0.6 (0.1)	0.6 (0.1)		
PROPORTION (WITH STANDARD ERROR) AND PERCENT OF MOVEMENTS EXCEEDING GROUP MEAN BY AT LEAST 0.025 CM												
GENERAL GROUP	13/29 (0.1) 44.8	14/29 (0.1) 48.3	14/29 (0.1) 48.3	14/29 (0.1) 48.3	7/29 (0.1) 24.1	7/29 (0.1) 24.1	13/29 (0.1) 44.8	13/29 (0.1) 44.8	10/29 (0.1) 34.5	10/29 (0.1) 34.5	14/29 (0.1) 48.3	14/29 (0.1) 48.3
DRY	10/18 (0.1) 55.6	11/18 (0.1) 61.1	9/18 (0.1) 50.	9/18 (0.1) 50.0	4/18 (0.1) 22.2	4/18 (0.1) 22.2	10/18 (0.1) 55.6	10/18 (0.1) 55.6	6/18 (0.1) 33.3	6/18 (0.1) 33.3	11/18 (0.1) 61.1	11/18 (0.1) 61.1
WET	3/11 (0.1) 27.3	3/11 (0.1) 27.3	5/11 (0.2) 45.5	5/11 (0.2) 45.5	3/11 (0.1) 27.3	3/11 (0.1) 27.3	3/11 (0.1) 27.3	3/11 (0.1) 27.3	4/11 (0.2) 36.4	4/11 (0.2) 36.4	3/11 (0.1) 27.3	3/11 (0.1) 27.3
SELECT GROUP							5/11 (0.2) 45.5	5/11 (0.2) 45.5	3/16 (0.1) 18.8	3/16 (0.1) 18.8		
DRY							5/ 8 (0.2) 62.5	5/ 8 (0.2) 62.5	1/ 9 (0.1) 11.1	1/ 9 (0.1) 11.1		
WET							0/ 3 (0.0) 0.	0/ 3 (0.0) 0.	2/ 7 (0.2) 28.6	2/ 7 (0.2) 28.6		

TARGET NO	SEPTEMBER MOVEMENT 1957		1958		1959+		1960		TOTAL	
	OBS CM	ADJ	OBS CM	ADJ	OBS CM	ADJ	OBS CM	ADJ	OBS CM	ADJ
MW8	0. *	0. *	0. *	0. *	EXCAVATED 5 AUG 59					
3	0.	0.	0.	0.	0.	0.	0. *	0. *	0.	0.
4	0.	0.	0.	0.	0.	0.	0.30	0.30	0.30	0.30
6	0.	0.	0.	0.	0. *	0. *	0. *	0. *	0.	0.
7	0.	0.	0.	0.	0.	0.	0.25	0.25	0.25	0.25
8	0.	0.	0.	0.	0. *	0. *	0.40 *	0.40 *	0.40	0.40
9	0.	0.	0.	0.	0.	0.	0. *	0. *	0.	0.
10	0.	0.	0.	0.	0. *	0. *	0.25	0.25	0.25	0.25
11	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
12	0.	0.	0.	0.	0. *	0. *	0.30	0.30	0.30	0.30
13	0.	0.	0.	0.	0.	0.	0. *	0. *	0.	0.
14	0.	0.	0.	0.	0. *	0. *	0. *	0. *	0.	0.
15	0.	0.	0.	0.	0. *	0. *	0.25 *	0.25 *	0.25	0.25
16	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
17	0.	0.	0.	0.	0.	0.	0. *	0. *	0.	0.
18	1.05	1.05	0.	0.	0.	0.	0.35 *	0.35 *	1.40	1.40
19	0.35	0.35	0.	0.	0.	0.	0.25 *	0.25 *	0.60	0.60
20	0.	0.	0.	0.	0.	0.	0.75 *	0.75 *	0.75	0.75
21	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
22	0.75	0.75	0.	0.	0.	0.	0.30	0.30	1.05	1.05
23	0.60	0.60	0.	0.	0. *	0. *	0. *	0. *	0.60	0.60
24	0.	0.	0.	0.	0. *	0. *	0. *	0. *	0.	0.
25	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
28	0.	0.	0.	0.	0.	0.	0. *	0. *	0.	0.
29	0.	0.	0.	0.	0. *	0. *	0. *	0. *	0.	0.
30	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
31	0.	0.	0.	0.	0. *	0. *	0.25	0.25	0.25	0.25
32	0.	0.	0.	0.	0. *	0. *	0.25	0.25	0.25	0.25
33	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
34	0.	0.	0.	0.	0.	0.	0.50 *	0.50 *	0.50	0.50
MEAN (WITH STANDARD ERROR) MW8 EXCL										
GENERAL GROUP	0.1 (0.1)	0.1 (0.1)	0. (0.0)	0. (0.0)	0. (0.0)	0. (0.0)	0.2 (0.0)	0.2 (0.0)	0.3 (0.1)	0.3 (0.1)
DRY	0. (0.0)	0. (0.0)	0. (0.0)	0. (0.0)	0. (0.0)	0. (0.0)	0.2 (0.0)	0.2 (0.0)	0.2 (0.0)	0.2 (0.0)
WET	0.3 (0.1	0.3 (0.1)	0. (0.0)	0. (0.0)	0. (0.0)	0. (0.0)	0.2 (0.1)	0.2 (0.1)	0.4 (0.2)	0.4 (0.2)
SELECT GROUP					0. (0.0)	0. (0.0)	0.2 (0.1)	0.2 (0.1)		
DRY					0. (0.0)	0. (0.0)	0.1 (0.1)	0.1 (0.1)		
WET					0. (0.0)	0. (0.0)	0.2 (0.1)	0.2 (0.1)		
PROPORTION (WITH STANDARD ERROR) AND PERCENT OF MOVEMENTS EXCEEDING GROUP MEAN BY AT LEAST 0.025 CM										
GENERAL GROUP	4/29 (0.1) 13.8	4/29 (0.1) 13.8	0/29 (0.0) 0.	0/29 (0.0) 0.	0/29 (0.0) 0.	0/29 (0.0) 0.	13/29 (0.1) 44.8	13/29 (0.1) 44.8	9/29 (0.1) 31.	9/29 (0.1) 31.
DRY	0/18 (0.0) 0.	0/18 (0.0) 0.	0/18 (0.0) 0.	0/18 (0.0) 0.	0/18 (0.0) 0.	0/18 (0.0) 0.	9/18 (0.1) 50.	9/18 (0.1) 50.	4/18 (0.1) 22.2	4/18 (0.1) 22.2
WET	4/11 (0.2) 36.4	4/11 (0.2) 36.4	0/11 (0.0) 0.	0/11 (0.0) 0.	0/11 (0.0) 0.	0/11 (0.0) 0.	4/11 (0.2) 36.4	4/11 (0.2) 36.4	5/11 (0.2) 45.5	5/11 (0.2) 45.5
SELECT GROUP					0/11 (0.0) 0.	0/11 (0.0) 0.	6/16 (0.1) 37.5	6/16 (0.1) 37.5		
DRY					0/ 8 (0.0) 0.	0/ 8 (0.0) 0.	3/ 9 (0.2) 33.3	3/ 9 (0.2) 33.3		
WET					0/ 3 (0.0) 0.	0/ 3 (0.0) 0.	3/ 7 (0.2) 42.9	3/ 7 (0.2) 42.9		

TARGET NO	ANNUAL MOVEMENT TO LATE AUGUST 1956-61: 1956-57 (22 AUG 56-21 AUG 57)		1957-58 (21 AUG 57-26 AUG 58)		1958-59 (26 AUG 58-24 AUG 59)		1959-60 (24 AUG 59-26 AUG 60)		1960-61 (26 AUG 60-25 AUG 61)		TOTAL MOVEMENT AND MEAN RATE 1956-61: TOTAL 1956-61		RATE		TARGET NO	DEPTH CM	ANGLE OF VIEW	GRADI-ENT	DRY OR WET
	OBS CM	ADJ	OBS CM	ADJ	OBS CM	ADJ	OBS CM	ADJ	OBS CM	ADJ	OBS CM	ADJ	OBS CM/YR	ADJ					
MW8	1.90 *(3)	1.95 *(3)	1.35 *(3)	1.40 *(3)	0.85 *(3)	0.85 *(3)	EXCAVATED 5 AUG 59				4.10 *(3)	4.20 *(3)	1.35	1.40	MW8	100.0	6	11.0	D
3	1.00	1.15	0.50	0.60	0.95	1.10	0.	0.95	1.05 *	1.20 *	3.70	5.20	0.75	1.05	3	20.0	28	12.0	D
4	1.95	2.05	2.30	2.40	3.20	3.35	0.80	-0.75	2.00	1.75	10.25	8.80	2.05	1.75	4	10.0	11	11.5	D
6	2.90	3.00	2.00	2.10	2.05	2.15	1.20 *	1.25 *	3.00 *	3.15 *	11.10	11.55	2.20	2.30	6	10.0	10	13.0	D
7	4.35	4.60	2.25	2.35	2.30	2.40	2.10	0.95	3.95	4.70	14.90	14.95	3.00	3.00	7	20.0	12	14.0	D
8	5.65	5.95	2.50	2.65	3.45	3.65	2.45 *	2.60 *	4.40 *	4.65 *	18.45	19.45	3.70	3.90	8	10.0	12	14.0	D
9	4.70	4.95	3.50	3.65	4.60	4.80	3.45	4.15	4.95 *	5.20 *	21.25	22.80	4.25	4.55	9	20.0	11	13.5	D
10	4.95	5.10	4.55	4.70	4.85	5.00	3.05 *	3.05 *	5.60	6.30	23.00	24.15	4.60	4.85	10	10.0	6	13.0	D
11	3.85	3.95	4.40	4.50	4.95	5.10	3.35	2.70	5.25	5.80	21.80	22.05	4.35	4.40	11	20.0	6	11.5	D
12	2.60	2.65	3.50	3.55	4.10	4.20	2.30 *	2.35 *	3.55	4.45	16.10	17.25	3.20	3.45	12	10.0	0	11.5	D
13	2.65	2.70	3.10	3.15	3.80	3.90	1.95	2.40	3.50 *	3.55 *	14.95	15.65	3.00	3.15	13	20.0	0	11.5	D
14	3.10	3.20	3.10	3.20	3.60	3.70	2.15 *	2.20 *	3.30 *	3.40 *	15.25	15.70	3.05	3.15	14	10.0	6	12.0	D
15	3.05	3.20	3.80	4.00	3.90	4.10	3.15 *	3.30 *	3.50 *	3.70 *	17.30	18.20	3.45	3.65	15	20.0	14	11.5	D
16	4.50	4.75	3.95	4.15	4.35	4.60	3.60	3.15	3.70	4.40	20.10	21.05	4.00	4.20	16	10.0	14	11.5	D
17	3.35	3.45	3.45	3.60	3.70	3.85	3.85	4.70	2.90 *	3.00 *	17.20	18.55	3.45	3.70	17	20.0	10	11.5	D
18	3.35	3.45	3.70	3.80	3.15	3.25	3.05	4.15	3.20 *	3.30 *	16.50	17.95	3.30	3.60	18	10.0	5	11.5	W
19	5.05	5.15	0. +	0. +	0. +	0. +	0. +	0. +	3.75 *(4)	3.85 *(4)	21.95	22.90	4.40	4.60	19	10.0	5	11.5	W
20	6.25	6.40	6.15	6.30	5.70	5.80	4.10	3.45	6.20 *	6.35 *	28.40	28.25	5.70	5.65	20	10.0	0	11.5	W
21	4.75	4.85	5.25	5.35	5.55	5.65	3.65	2.80	6.30	6.95	25.50	25.65	5.10	5.15	21	20.0	0	12.0	W
22	4.00	4.10	4.60	4.70	4.40	4.50	2.80	3.35	5.85	4.65	21.70	21.35	4.35	4.25	22	10.0	0	12.0	W
23	3.65	3.75	4.15	4.25	3.90	4.00	2.20 *	2.25 *	4.20 *	4.30 *	18.15	18.50	3.65	3.70	23	20.0	0	11.5	W
24	2.45	2.55	2.80	2.95	2.85	3.00	1.80 *	1.90 *	3.20 *	3.35 *	13.05	13.70	2.60	2.75	24	10.0	14	11.0	W
25	3.45	3.50	4.05	4.15	4.05	4.15	2.70	1.55	4.25	5.35	18.50	18.65	3.70	3.75	25	20.0	0	11.0	W
28	2.90	3.10	2.90	3.10	3.50	3.75	1.95	2.50	2.60 *	2.80 *	13.80	15.25	2.75	3.05	28	10.0	17	13.0	W
29	1.60	1.70	2.30	2.40	2.65	2.80	2.30 *	2.40 *	2.35 *	2.50 *	11.20	11.80	2.25	2.35	29	20.0	14	12.0	W
30	1.90	1.95	2.00	2.05	2.05	2.10	1.65	0.65	2.35	2.95	9.95	9.80	2.00	1.95	30	10.0	9	12.0	W
31	0.80	0.80	1.20	1.25	1.30	1.35	0.65 *	0.55 *	1.65	2.20	5.55	6.10	1.10	1.20	31	20.0	6	12.0	D
32	0.55	0.55	0.95	0.95	1.15	1.20	0.85 *	0.75 *	0.60	1.15	4.10	4.60	0.80	0.90	32	10.0	0	12.5	D
33	0.70	0.70	0.70	0.70	1.15	1.20	1.45	1.80	0.	0.50	4.10	5.00	0.80	1.00	33	20.0	0	12.5	D
34	1.10	1.15	0.65	0.65	1.00	1.05	1.45	3.15	0.55 *	0.55 *	4.75	6.55	0.95	1.30	34	10.0	7	13.0	D
MEAN (WITH STANDARD ERROR) MW8 EXCL															MEAN (WITH STANDARD ERROR) MW8 EXCL				
GENERAL GROUP	3.1 (0.3)	3.3 (0.3)	3. (0.3)	3.1 (0.3)	3.3 (0.3)	3.4 (0.3)	2.3 (0.2)	2.3 (0.2)	3.4 (0.3)	3.7 (0.3)	15.3 (1.2)	15.9 (1.2)	3.1 (0.3)	3.2 (0.3)	GENERAL GROUP				
DRY	2.9 (0.4)	3. (0.4)	2.6 (0.3)	2.7 (0.3)	3. (0.3)	3.2 (0.4)	2.1 (0.3)	2.2 (0.3)	3.9 (0.4)	3.3 (0.4)	13.6 (1.6)	14.3 (1.3)	2.7 (0.3)	2.9 (0.3)	DRY				
WET	3.6 (0.4)	3.7 (0.4)	3.8 (0.4)	3.9 (0.4)	3.8 (0.4)	3.9 (0.4)	2.6 (0.3)	2.5 (0.3)	4. (0.5)	4.2 (0.5)	18.1 (1.8)	18.5 (1.7)	3.6 (0.4)	3.7 (0.4)	WET				
SELECT GROUP							2. (0.3)	2.1 (0.3)	3.3 (0.3)	3.4 (0.4)					SELECT GROUP				
DRY							2. (0.4)	2. (0.4)	3. (0.5)	3.2 (0.5)					DRY				
WET							2.1 (0.2)	2.2 (0.2)	3.6 (0.5)	3.8 (0.5)					WET				
PROPORTION (WITH STANDARD ERROR) AND PERCENT OF MOVEMENTS EXCEEDING GROUP MEAN BY AT LEAST 0.025 CM															PROPORTION (WITH STANDARD ERROR) AND PERCENT OF MOVEMENTS EXCEEDING GROUP MEAN BY AT LEAST 0.025 CM				
GENERAL GROUP	14/29 (0.1) 48.3	14/29 (0.1) 48.3	15/28 (0.1) 53.6	15/28 (0.1) 53.6	16/28 (0.1) 57.1	16/28 (0.1) 57.1	12/28 (0.1) 42.9	16/28 (0.1) 57.1	15/29 (0.1) 51.7	14/29 (0.1) 48.3	15/29 (0.1) 51.7	15/29 (0.1) 51.7	15/29 (0.1) 51.7	15/29 (0.1) 51.7	GENERAL GROUP				
DRY	7/18 (0.1) 38.9	7/18 (0.1) 38.9	9/18 (0.1) 50.	9/18 (0.1) 50.	10/18 (0.1) 55.6	10/18 (0.1) 55.6	7/18 (0.1) 38.9	10/18 (0.1) 55.6	9/18 (0.1) 50.	8/18 (0.1) 44.4	8/18 (0.1) 44.4	8/18 (0.1) 44.4	8/18 (0.1) 44.4	8/18 (0.1) 44.4	DRY				
WET	7/11 (0.2) 63.6	7/11 (0.2) 63.6	6/10 (0.2) 60.	6/10 (0.2) 60.	6/10 (0.2) 60.	6/10 (0.2) 60.	5/10 (0.2) 50.	6/10 (0.2) 60.	6/11 (0.2) 54.6	6/11 (0.2) 54.6	7/11 (0.2) 63.6	7/11 (0.2) 63.6	7/11 (0.2) 63.6	7/11 (0.2) 63.6	WET				
SELECT GROUP							7/11 (0.2) 63.6	7/11 (0.2) 63.6	7/16 (0.1) 43.8	7/16 (0.1) 43.8					SELECT GROUP				
DRY							5/ 8 (0.2) 62.5	5/ 8 (0.2) 62.5	4/ 9 (0.2) 44.4	4/ 9 (0.2) 44.4					DRY				
WET							2/ 3 (0.3) 66.7	2/ 3 (0.3) 66.7	3/ 7 (0.2) 42.9	3/ 7 (0.2) 42.9					WET				
MEAN (WITH STANDARD ERROR) FOR 10 CM T															MEAN (WITH STANDARD ERROR) FOR 10 CM T				
DRY											13.7 (2.2)	14.3 (2.3)	2.7 (0.4)	2.9 (0.5)	DRY				
WET											17.9 (2.4)	18.5 (2.4)	3.6 (0.5)	3.7 (0.5)	WET				
MEAN (WITH STANDARD ERROR) FOR 20 CM T															MEAN (WITH STANDARD ERROR) FOR 20 CM T				
DRY											13.4 (2.4)	14.3 (2.4)	2.7 (0.5)	2.9 (0.5)	DRY				
WET											18.3 (2.9)	18.7 (2.8)	3.7 (0.6)	3.7 (0.6)	WET				

* SELECT TARGETS – THOSE WITH PROBABLY ≤ 0.2 CM DOWNSLOPE OR UPSLOPE ATTITUDE CHANGE DUE TO TILTING AND/OR TARGET HEAVING IN PERIOD INDICATED

\+ OMITTED FROM MEAN. 0. HERE INDICATES LACK OF DATA

OBS OBSERVED MOVEMENT. HORIZONTAL COMPONENT NORMAL TO TARGET LINE

ADJ ADJUSTED MOVEMENT. OBSERVED MOVEMENT ADJUSTED FOR ANGLE OF VIEW, GRADIENT AND, IN CASE OF ANNUAL MOVEMENT, FOR TARGET ATTITUDE CHANGE (1959-61)

(1) OMITTED TARGETS ARE EXCLUDED FOR REASONS CITED IN TABLE OF TARGET ATTITUDES AND/OR STATED IN TEXT

(2) ANNUAL MOVEMENT TAKEN DIRECTLY FROM OBSERVATION TOTALS RATHER THAN FROM SUMMATION OF COMPONENT MOVEMENTS, SINCE AMOUNT CALCULATED FROM COMPONENTS DISREGARDS ALL MOVEMENTS ≤ 0.2 CM

(3) ANNUAL MOVEMENTS OF MW8 ARE FOR 17 AUG 1956 - 21 AUG 1957, 21 AUG 1957 - 26 AUG 1958, 26 AUG 1958 - 4 AUG 1959, AND TOTAL FOR PERIOD 1956-1959

(4) LATE AUGUST READING LACKING, MID-AUGUST READING SUBSTITUTED

Table C V.

EXPERIMENTAL SITE 8 TARGET MOVEMENTS, DOWEL LINE, 14 AUG 1958 - 14 JUNE 1960

DOWEL NO (1)	ANGLE OF VIEW	GRADI-ENT	MOVEMENT		ANNUAL RATE (1.8 YEAR PERIOD)	
			OBS	ADJ	OBS	ADJ
			CM		CM/YR	
4	12	17.0	0.8	0.9	0.4	0.5
5	12	17.0	1.1	1.2	0.6	0.7
7	10	17.0	1.2	1.3	0.7	0.7
11	8	18.5	2.2	2.3	1.2	1.3
13	7	18.5	2.6	2.8	1.4	1.6
15	6	18.5	2.2	2.3	1.2	1.3
16	5	18.5	1.6	1.7	0.9	0.9
MEAN (WITH STANDARD ERROR)			1.6 (0.3)	1.7 (0.3)	0.9 (0.1)	0.9 (0.2)

OBS OBSERVED MOVEMENT. HORIZONTAL COMPONENT NORMAL TO TARGET LINE

ADJ ADJUSTED MOVEMENT. OBSERVED MOVEMENT ADJUSTED FOR ANGLE OF VIEW AND GRADIENT

(1) OMITTED DOWELS MISSING JUNE 1960
DOWELS INSERTED TO DEPTH 10 CM EXCEPT T 15 WHICH WAS TO DEPTH 5 CM AND IS EXCLUDED FROM MEAN

Table C VI.

EXPERIMENTAL SITE 15 TARGET MOVEMENTS 28 JULY 1957 - 4 AND 20 JUNE 1960

20° LINE (AXIAL LINE)

DOWEL NO (1)	GRADI-ENT	MOVEMENT 28 JULY 1957 - 20 JUNE 1960		ANNUAL RATE (2.9 YEAR PERIOD)	
		OBS (2)	ADJ	OBS (2)	ADJ
		CM		CM/YR	
POST	4.0	7.9	7.9	2.7	2.7
1	4.0	8.1	8.1	2.8	2.8
2	4.0	8.1	8.1	2.8	2.8
3	4.0	8.2	8.2	2.8	2.8
4	12.0	8.2	8.4	2.8	2.9
6	12.0	8.3	8.5	2.9	2.9
7	3.0	8.3	8.3	2.9	2.9
8	3.0	8.4	8.4	2.9	2.9
13	3.0	8.8	8.8	3.0	3.0
14	3.0	8.9	8.9	3.1	3.1
15	3.0	9.0	9.0	3.1	3.1
17	3.0	9.2	9.2	3.2	3.2
18	3.0	9.3	9.3	3.2	3.2
20	3.0	9.3	9.3	3.2	3.2
21	3.0	9.6	9.6	3.3	3.3
23	3.0	10.0	10.0	3.4	3.4
24	3.0	10.1	10.1	3.5	3.5
MEAN (WITH STANDARD ERROR), POST EXCL(3)		8.8 (0.2)	8.9 (0.2)	3.0 (0.1)	3.1 (0.1)

113° LINE (TRANSVERSE LINE)

DOWEL NO	GRADI-ENT	MOVEMENT 28 JULY 1957 - 4 JUNE 1960		ANNUAL RATE (2.8 YEAR PERIOD)	
		OBS	ADJ	OBS	ADJ
		CM		CM/YR	
1	4.0	0.9	0.9	0.3	0.3
2	4.0	1.0	1.0	0.4	0.4
3	4.0	1.5	1.5	0.5	0.5
4	4.0	1.3	1.3	0.5	0.5
5	4.0	1.8	1.8	0.6	0.6
10	3.0	10.5	10.5	3.7	3.7
14	3.0	7.0	7.0	2.5	2.5
16	3.0	5.0	5.0	1.8	1.8
17	3.0	4.5	4.5	1.6	1.6
18	3.0	4.0	4.0	1.4	1.4
19	3.0	3.3	3.3	1.2	1.2
20	8.0	2.7	2.7	1.0	1.0
21	8.0	1.8	1.8	0.6	0.6
22	4.0	1.0	1.0	0.4	0.4
23	4.0	1.0	1.0	0.4	0.4
24	4.0	1.2	1.2	0.4	0.4
25	4.0	1.5	1.5	0.5	0.5
		2.9 (0.7)	2.9 (0.7)	1.0 (0.2)	1.0 (0.2)

OBS OBSERVED MOVEMENT. HORIZONTAL COMPONENT NORMAL TO TARGET LINE

ADJ ADJUSTED MOVEMENT. OBSERVED MOVEMENT ADJUSTED FOR GRADIENT

(1) OMITTED DOWELS MISSING JUNE 1960
DOWELS INSERTED TO DEPTH 10 CM EXCEPT T 19 (113 LINE) WHICH WAS TO DEPTH 5 CM AND IS EXCLUDED FROM MEAN

(2) BASED ON CALCULATED MOVEMENT OF T 13 AS DISCUSSED IN TEXT

(3) STANDARD ERROR BASED ON UNROUNDED COMPUTER MEAN

Table C VII.

EXPERIMENTAL SITE 16 TARGET MOVEMENTS, 17 AUG 1957 - 29 MAY 1960 AND 18 AUG 1961

DOWEL NO(1)	DEPTH CM	ANGLE OF VIEW	GRADIENT	MOVEMENT		MOVEMENT		ANNUAL RATE			
				17 AUG 1957 - 29 MAY 1960		17 AUG 1957 - 18 AUG 1961		(2.8 YEAR PERIOD)		(4.0 YEAR PERIOD)	
				OBS	ADJ	OBS	ADJ	OBS	ADJ	OBS	ADJ
				CM		CM		CM/YR		CM/YR	
2	5	5	24.0	4.1	4.5	5.0	5.5	1.5	1.6	1.2	1.4
3	10	18	23.5	3.0	3.4	3.5	4.0	1.1	1.2	0.9	1.0
4	5	18	23.5	4.0	4.6	4.5	5.2	1.4	1.6	1.1	1.3
6	5	18	23.5	3.5	4.0	4.0	4.6	1.2	1.4	1.0	1.1
7	10	18	23.5	2.0	2.3	2.2	2.5	0.7	0.8	0.5	0.6
8	5	2	22.0	3.4	3.7	0. (2)	0. (2)	1.2	1.3	0. (2)	0. (2)
11	10	2	22.0	1.2	1.3	1.8	1.9	0.4	0.5	0.4	0.5
13	10	2	22.0	0.8	0.9	1.3	1.4	0.3	0.3	0.3	0.3
15	10	2	22.0	1.0	1.1	1.8	1.9	0.4	0.4	0.4	0.5
16	5	5	22.0	1.5	1.6	2.5	2.7	0.5	0.6	0.6	0.7
17	10	5	22.0	1.0	1.1	2.4	2.6	0.4	0.4	0.6	0.6
18	5	5	22.0	1.7	1.8	3.2	3.5	0.6	0.6	0.8	0.9
19	10	2	22.0	1.0	1.1	2.7	2.9	0.4	0.4	0.7	0.7
20	5	2	22.0	2.5	2.7	0. (2)	0. (2)	0.9	1.0	0. (2)	0. (2)
21	10	2	22.0	1.0	1.1	2.0	2.2	0.4	0.4	0.5	0.5
22	5	2	22.0	3.2	3.5	0. (2)	0. (2)	1.1	1.2	0. (2)	0. (2)
23	5	5	22.0	2.0	2.2	3.3	3.6	0.7	0.8	0.8	0.9
24	10	10	22.0	1.5	1.6	3.0	3.3	0.5	0.6	0.7	0.8
26	10	10	22.0	1.5	1.6	3.5	3.8	0.5	0.6	0.9	0.9
28	10	10	22.0	1.3	1.4	3.1	3.4	0.5	0.5	0.8	0.8
31	10	10	22.0	2.7	3.0	2.5	2.7	1.0	1.1	0.6	0.7
36	5	5	23.5	3.9	4.3	4.0	4.4	1.4	1.5	1.0	1.1
37	5	0	24.0	1.6	1.8	2.4	2.6	0.6	0.6	0.6	0.6
38	10	0	24.5	2.3	2.5	3.0	3.3	0.8	0.9	0.7	0.8
39	5	0	24.5	3.3	3.6	3.5	3.8	1.2	1.3	0.9	0.9
40	10	0	24.5	2.5	2.7	3.5	3.8	0.9	1.0	0.9	0.9
41	5	0	24.5	4.0	4.4	4.5	4.9	1.4	1.6	1.1	1.2
42	10	0	25.5	2.5	2.8	0. (2)	0. (2)	0.9	1.0	0. (2)	0. (2)
43	5	0	25.5	3.5	3.9	0. (3)	0. (3)	1.2	1.4	0. (3)	0. (3)
44	10	0	26.5	2.5	2.8	0. (2)	0. (2)	0.9	1.0	0. (2)	0. (2)
46	10	0	27.0	2.2	2.5	0. (2)	0. (2)	0.8	0.9	0. (2)	0. (2)
48	10	0	28.0	2.1	2.4	0. (2)	0. (2)	0.7	0.9	0. (2)	0. (2)
49	10	6	29.0	2.0	2.3	0. (2)	0. (2)	0.7	0.8	0. (2)	0. (2)
50	5	6	29.0	2.5	2.9	0. (3)	0. (3)	0.9	1.0	0. (3)	0. (3)
51	10	6	29.0	2.4	2.8	0. (2)	0. (2)	0.9	1.0	0. (2)	0. (2)
53	10	8	29.0	2.4	2.8	0. (2)	0. (2)	0.9	1.0	0. (2)	0. (2)
55	10	10	29.0	2.8	3.3	0. (2)	0. (2)	1.0	1.2	0. (2)	0. (2)
56	5	10	29.0	4.5	5.3	5.0	5.8	1.6	1.9	1.2	1.4
57	10	10	29.0	2.2	2.6	2.5	2.9	0.8	0.9	0.6	0.7
60	10	10	29.0	7.0	8.2	8.5	10.0	2.5	2.9	2.1	2.5
62	10	12	29.0	5.5	6.5	6.0	7.1	2.0	2.3	1.5	1.8
64	10	12	29.0	6.0	7.2	6.0	7.2	2.1	2.6	1.5	1.8
66	10	12	28.5	5.5	6.6	5.5	6.6	2.0	2.4	1.4	1.6
67	5	12	28.0	6.0	7.2	0. (3)	0. (3)	2.1	2.6	0. (3)	0. (3)
68	10	12	28.0	2.0	2.4	2.0	2.4	0.7	0.9	0.5	0.6
MEAN (WITH STANDARD ERROR)(4)											
GENERAL GROUP				2.8 (0.3)	3.1 (0.3)	3.3 (0.3)	3.7 (0.4)	1.0 (0.1)	1.1 (0.1)	0.8 (0.1)	0.9 (0.1)
5 CM DOWELS				3.1 (0.3)	3.4 (0.3)	3.2 (0.5)	3.6 (0.5)	1.1 (0.1)	1.2 (0.1)	0.8 (0.1)	0.9 (0.1)
10 CM DOWELS				2.5 (0.4)	2.9 (0.5)	3.3 (0.4)	3.8 (0.5)	0.9 (0.2)	1.1 (0.2)	0.8 (0.1)	0.9 (0.1)

STANDING TARGETS 1961

	DEPTH INSERTED	
	5 CM	10 CM
PROPORTION	14/36	28/32
PERCENT	39	88

OBS OBSERVED MOVEMENT. HORIZONTAL COMPONENT NORMAL TO TARGET LINE

ADJ ADJUSTED MOVEMENT. OBSERVED MOVEMENT ADJUSTED FOR ANGLE OF VIEW AND GRADIENT

(1) OMITTED DOWELS MISSING 29 MAY 1960

(2) 1961 OBSERVATION OMITTED AS QUESTIONABLE

(3) DOWEL MISSING 18 AUG 1961

(4) STANDARD ERROR BASED ON UNROUNDED COMPUTER MEAN

Table C VIII.

EXPERIMENTAL SITE 17 TARGET MOVEMENTS, 5 AUG 1957 - 12 JULY 1959

TARGET NO(1)	GRADIENT	MOVEMENT		ANNUAL RATE	
				(1.9 YEAR PERIOD)	
		OBS	ADJ	OBS	ADJ
		CM		CM/YR	
1	12.0	-2.5(2)	-2.6(2)	-1.3(2)	-1.4(2)
2	12.0	9.0	9.2	4.7	4.8
3	12.0	16.0	16.4	8.4	8.6
4	12.0	15.0	15.3	7.9	8.1
5	12.0	20.0	20.4	10.5	10.7
6	12.0	19.0	19.4	10.0	10.2
7	12.0	23.0	23.5	12.1	12.4
8	12.0	19.5	19.9	10.3	10.5
9	12.0	15.5	15.8	8.2	8.3
10	12.0	13.0	13.3	6.8	7.0
11	12.0	16.0	16.4	8.4	8.6
12	12.0	10.5	10.7	5.5	5.6
13	12.0	5.0	5.1	2.6	2.7
14	12.0	2.5	2.6	1.3	1.4
15	12.0	-2.5(2)	-2.6(2)	-1.3(2)	-1.4(2)
MEAN (WITH STANDARD ERROR)		14.2 (1.6)	14.5 (1.7)	7.4 (0.9)	7.6 (0.9)

OBS OBSERVED MOVEMENT. HORIZONTAL COMPONENT NORMAL TO TARGET LINE

ADJ ADJUSTED MOVEMENT. OBSERVED MOVEMENT ADJUSTED FOR GRADIENT AND POSSIBLE TARGET ATTITUDE CHANGE

(1) CONE TARGETS INSERTED TO DEPTH 10 CM

(2) OMITTED FROM MEAN

Table E I.

EXPERIMENTAL SITE 6 THERMOCOUPLE OBSERVATIONS - STRINGS 6A-6B

READINGS °C
BLANKS INDICATE NO READINGS OR NONFUNCTIONING THERMOCOUPLES

THERMO COUPLE NO	ORIG DEPTH CM	1956		1957					1958																1959					1960							EXCAVATION 1961		
		SEPT	OCT	JULY	AUG		SEPT		JUNE		JULY						AUG					SEPT			JULY				AUG	JULY			AUG		SEPT		TC DEPTH	DIFF FROM ORIG DEPTH	COMMENTS
		27	4	25	7	21	8	14	18	26	5	14	22	25	28	30	2	5	8	15	27	7	13	22	9	13	20	27	15	11	19	29	8	22	12	27	CM		
TCS 6A																																							
SNOW DEPTH CM		17-18		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	PRESENT	0	0	0	0	0	0	0	0	0	0	0	0			EXCAVATED 6 AUG
12	0.0	-1.2	C	18.6	18.2	14.2	3.7																															-4.0	TC 12 4 CM ABOVE SURFACE
11	10.0±2	-0.6	A	9.3	9.3	7.6	2.3																														8.0	-2.0±2	
10	20.0±2	-0.6	T	7.8	7.6	5.3	1.5																														18.0	-2.0±2	
9	30.0±2	-0.6	A	7.1	6.8	4.2	1.3		-1.3	0.1	4.4	6.3	7.1	6.0	5.6	4.5	5.4	5.0	5.7	5.0	2.5	1.9	0.3	0.3	4.7	3.7	4.3	4.5	4.2	1.0	4.4	4.7	5.8	3.4	2.8	0.0	28.5	-1.5±2	
8	40.0±2	-0.6		6.2	6.2	3.7	1.2		-1.6	-0.5	2.5	4.8	6.3	5.4	4.9	4.0	4.8	4.6	5.1	4.5	2.5	1.8	0.4	0.3	2.6	2.5	3.6	3.8	3.5	0.3	3.4	3.9	4.6	3.1	2.7	0.0	38.0	-2.0±2	
7	50.0±2	-0.7	M	5.4	5.2	3.3	1.1		-2.0	-1.0	0.9	3.3	5.2	4.3	4.1	3.7	4.1	4.0	4.4	3.9	2.3	1.8	0.2	0.2	0.9	1.6	2.4	3.0	3.1	-0.2	1.9	3.1	3.2	2.8	2.3	-0.1	48.0	-2.0±2	
6	60.0±2	-0.7	I	4.3	4.4	2.7	1.0		-2.2	-1.5	-0.3	2.1	4.1	4.1	3.5	3.2	3.5	3.4	3.8	3.5	2.1	1.7	0.2	0.2	-0.2	0.5	1.6	2.2	2.2								?	?	SHEARED OFF. NOT OBSERVED IN EXCAVATION
5	70.0±2	-0.7	S	3.1	3.2	2.2	0.8		-2.6	-1.9	-0.9	0.5	2.5	2.7	2.7	2.4	2.7	2.7	3.0	2.9	1.7	1.4	0.2	0.0	-0.5	-0.6	0.6	1.5	1.5	-0.5	0.0	1.4	2.5	2.5	1.9	-0.1	67.0	-3.0±2	
4	80.0±2	-0.7	S	2.0	2.4	1.6	0.6																														76.0	-4.0±2	
3	90.0±2	-0.8	I	1.3	1.9	1.2	0.4		-3.2	-2.5	-1.7	-0.9	0.4	1.1	1.2	1.3	1.5	1.5	1.5	1.8	1.0	0.8	0.2	0.1	-1.4	-1.2	-0.5	-0.2	0.5	-0.6	-0.8	0.0	0.8	1.3	1.7	-0.2	83.0	-7.0±2	CLAYEY WITH SHELL FRAGMENTS AT 85 CM
2	100.0±2	-0.8	N	-0.2	0.7	0.5	0.2		-3.5	-2.8	-2.0	-1.5	-0.8	0.0	0.3	0.3	0.6	0.7	0.7	0.9	0.5	0.6	0.2	0.0	-1.8	-1.7	-0.8	-0.7	0.0								93.0	-7.0±2	
1	104.0±3	-0.9	G	-0.6	0.0	0.0	-0.1																														100.5	-3.5±3	DEPTH TO FROST 100 CM ICE AT LEAST 10 CM THICK AT 105 CM
TCS 6B																																							
SNOW DEPTH CM		13	12-13	(1)	(1)	21-26	0	0	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	0	0	0	0	0	0	0	8	0	0	0	0	0	(1)	(1)	(1)	(1)	(2)	0	1-2			NOT EXCAVATED WATER AT 10 CM
16	0.0	-1.2	-4.0			0.0	4.0	0.4									0.3	4.6	10.0	8.3	5.9	6.3	4.0	0.0	12.1	10.0	14.4	9.0	10.8					0.3	9.3	-0.8			
15	5.0	-0.7	-3.3			-0.1	3.2	-0.1																	12.1	9.6	14.4	8.9	11.0					1.7	9.3	-0.8			
14	15.0±2	-0.3	-2.5			-0.2	1.6	-0.2									-0.1	-0.2	5.3	8.3	1.3	2.9	0.3	0.3										0.0	5.5				
13	25.0±2	-0.3	-1.7			-0.3	0.4	-0.2									-0.4	-0.3	2.4	5.4	1.2	1.9	0.3	0.3	11.0	8.2	7.4	6.7	8.3					-0.4	1.9	-0.4			
12	35.0±2	-0.3	-1.1			-0.4	-0.2	-0.2									-0.5	-0.4	0.8	3.6	1.1	1.5	0.4	0.4	8.0	6.6	6.0	6.3	6.7										
11	45.0±2	-0.3	-1.1			-0.4	-0.3	-0.3									-0.6	-0.6	-0.2	2.2	1.4	1.7	0.3	0.4	6.1	5.7	5.7	5.9	5.6					-0.6	1.3	-0.4			
10	55.0±2	-0.3	-1.1			-0.5	-0.4	-0.4									-0.8	-0.6	-0.4	1.2	1.4	1.5	0.3	0.4	4.6	5.1	5.1	5.6	5.0					-0.6	1.0	-0.2			
9	65.0±2	-0.2	-1.1			-0.6	-0.5	-0.4									-0.9	-0.9	-0.7	0.4	0.7	1.4	0.3	0.3	3.5	4.3	4.6	4.8	4.5					-0.6	0.6	-0.2			
8	75.0±2	-0.1	-1.3			-0.7	-0.6	-0.5									-1.2	-1.1	-0.8	0.0	0.7	1.2	0.2	0.2	2.4	3.5	3.5	4.3	4.0					-0.8	0.2	-0.1			
7	85.0±2	-0.1	-1.3			-0.7	-0.7	-0.6									-1.2	-1.2	-1.0	-0.3	-0.5	1.1	0.2	0.3	1.5	2.5	2.8	3.5	3.3										
6	95.0±2	-0.1	-1.2			-0.8	-0.8	-0.7									-1.4	-1.3		-0.5					0.5	1.6	1.8	2.7											
5	105.0±2	-0.1	-1.1			-0.8	-0.9	-0.8									-1.5	-1.4	-1.3	-0.6	-1.5	0.3	0.2	0.3	-0.5	0.6	1.0	2.1	2.1										
4	115.0±2	-0.1	-1.0			-0.8	-1.0	-0.9									-1.6	-1.5	-1.5	-0.8					-0.9	-0.2													
3	125.0±2	-0.1	-0.9			-0.9	-1.0	-1.0									-1.7	-1.6	-1.6	-1.1	-2.0	-0.2	-0.1	-0.1	-1.3	-0.5	-0.8	0.6	1.5					-1.3	-0.6	-0.4			
2	135.0±2	-0.2	-0.9			-1.0	-1.2	-1.1									-1.9	-1.7	-1.7	-1.4	-2.0	-0.5	-0.3	-0.3	-1.7	-0.8	-1.0	-0.2	1.0					-1.3	-0.6	-0.8			
1	139.0±3	-0.3	-0.9			-1.0	-1.2	-1.1																															

(1) SNOW PRESENT. THERMOCOUPLE LEADS BURIED

(2) ICE PRESENT

Table E II.1.

EXPERIMENTAL SITE 7 THERMOCOUPLE OBSERVATIONS – STRINGS 7A–7B

READINGS °C
BLANKS INDICATE NO READINGS OR NONFUNCTIONING THERMOCOUPLES

THERMO COUPLE NO	ORIG DEPTH CM	1957							1958					
		JULY		AUG		SEPT			MAY	JUNE				
		11	24	6	22	8	12	19	23	4	9	13	18	27
TCS 7A														
SNOW DEPTH CM		0	0	0	0	0	0	0	25	0	0	0	0	0
16	0.0	18.1	>20.0	14.3	16.8	10.4	9.5	10.6	-3.4	4.7	>20.0	15.0	8.8	>20.0
15	5.0	14.5	19.7	15.3	10.2	3.5	0.4	1.0	-5.2	10.1	11.2	11.2	12.7	14.3
14	15.0±1	8.6	14.4	13.5	6.8	1.8	0.0	-0.6	-5.9	3.0	4.9	6.3	8.1	8.7
13	25.0±1	6.2	12.5	11.6	6.1	1.8	0.4	-0.4	-6.0	-0.6	2.5	4.3	6.0	7.1
12	35.0±1	5.0	11.6	10.1	6.1	2.0	0.7	-0.3	-6.0	-1.3	0.9	2.8	4.4	6.2
11	45.0±1	4.2	10.7	8.8	5.9	2.2	0.9	-0.1	-6.1	-2.0	0.0	1.9	3.2	5.6
10	55.0±1	3.6	9.6	8.0	5.7	2.3	1.0	-0.1	-6.3	-2.6	-0.8	0.6	2.1	4.5
9	65.0±1	3.0	8.5	7.2	5.3	2.3	1.1	0.2	-6.4	-3.2	-1.2	-0.3	1.1	3.6
8	75.0±1	2.3	7.4	6.5	4.8	2.2	1.1	0.1	-6.3	-3.5	-1.8	-0.9	0.1	2.4
7	85.0±1	1.6	6.1	5.6	4.3	2.1	1.1	0.0	-6.5	-4.0	-2.4	-1.4	-0.4	1.1
6	95.0±1	0.9	5.0	4.8	3.8	2.1	1.0	0.1	-7.5	-4.2	-2.9	-2.0	-1.2	0.1
5	105.0±1	0.0	3.9	4.0	3.3	1.9	0.9	0.1	-6.6	-4.3	-3.2	-2.5	-1.5	-0.5
4	115.0±1	-0.3	3.0	3.4	3.0	1.8	0.9	0.0	-6.9	-4.8	-3.8	-2.8	-2.0	-0.8
3	123.0±1	-0.6	2.2	2.8	2.6	1.6	0.7	0.1	-6.8	-5.0	-4.0	-3.1	-2.3	-1.1
2	133.0±1	-0.9	1.2	2.2	2.1	1.3	0.6	0.0		-5.2	-4.3	-3.5	-2.7	-1.4
1	139.0±2	-1.0	0.6	1.8	2.0	1.3	0.6	0.1						
TCS 7B														
SNOW DEPTH CM						0	0		PRESENT	0	0	0	0	0
16	5.0					2.8	0.8		-2.8		8.2	11.2	12.9	13.7
15	10.0					2.0	0.5		-2.5	0.9	3.4	5.0	7.6	7.5
14	20.0±1					1.7	0.8		-3.3	-0.3	0.8	1.6	3.6	3.7
13	30.0±1					2.1	0.9		-3.7	-0.8	0.2	0.4	1.9	2.7
12	40.0±1					2.1	0.9		-4.0	-1.3	0.1	0.2	1.1	2.1
11	50.0±1					2.1	0.9		-4.2	-1.4	-0.6	-0.5	0.2	1.5
10	60.0±1					2.1	0.9							
9	69.5±1					2.1	1.1		-4.6	-1.8	-1.2	-1.1	-0.6	0.1
8	79.5±1					2.0	0.9		-4.8	-2.4	-1.6	-1.5	-1.0	-0.2
7	89.5±1					1.8	1.0		-4.9	-2.8	-1.9	-1.7	-1.2	-0.6
6	99.5±1					1.5	0.8		-5.2	-2.9	-2.0	-2.0	-1.5	-0.8
5	109.5±1					1.4	0.8		-5.7	-3.4	-2.6	-2.3	-1.8	-1.2
4	120.0±1					1.1	0.6		-5.7	-3.6	-2.7	-2.6	-2.1	-1.3
3	130.0±1					0.9	0.5		-5.8	-3.9	-3.0	-2.7	-2.2	-1.6
2	140.0±1					0.7	0.3		-5.8	-4.2	-3.5	-2.8	-2.4	-1.8
1	BROKEN													

THERMO COUPLE NO	ORIG DEPTH CM	1958																
		JULY								AUG						SEPT		
		4	14	15	17	18	22	25	29	4	5	8	16	26	27	7	15	22
TCS 7A																		
SNOW DEPTH CM		0	0	0	0	0	0		0		0		0	0		0	1	PRESENT
16	0.0	11.6	>20.0	>20.0	>20.0	>20.0												
15	5.0	12.9	>20.0	>20.0	>20.0	>20.0	13.3		10.3		10.3		12.6	11.8		8.4	0.9	0.3
14	15.0±1	11.6	16.7	16.2	17.7	18.7	12.3		8.6		7.7		8.9	8.3		4.7	0.8	0.4
13	25.0±1	10.0	12.8	12.3	13.8	15.7	11.7		8.0		7.1		7.3	6.3		3.9	0.8	0.4
12	35.0±1	8.7	10.9	10.5	11.8	13.3	11.2		8.0		6.9		6.7	5.6		3.7	1.1	0.5
11	45.0±1	7.4	9.3	9.3	10.4	11.3	10.6		7.7		6.6		6.4	5.3		3.7	1.1	0.5
10	55.0±1	6.4	8.4	8.3	9.2	9.9	9.8		7.2		6.5		6.1	5.2		3.8	1.2	0.5
9	65.0±1	5.4	6.9	7.2	8.3	8.7	8.8		6.8		6.1		5.7	5.0		3.7	1.4	0.5
8	75.0±1	4.4	6.1	5.9	7.2	7.6	7.9		6.3		5.7		5.3	4.7		3.5	1.3	0.5
7	85.0±1	3.1	4.9	4.8	5.9	6.3	6.8		5.5		5.2		4.8	4.3		3.0	1.3	0.4
6	95.0±1	2.0	3.6	3.5	4.9	5.2	5.8		4.8		4.6		4.3	3.9		2.9	1.3	0.5
5	105.0±1	0.9	2.7	2.3	3.7	4.2	4.8		4.2		4.0		3.7	3.5		2.7	1.3	0.5
4	115.0±1	0.0	1.6	1.3	2.7	3.1	3.8		3.6		3.5		3.2	3.1		2.3	1.1	0.5
3	123.0±1	-0.4	1.2	0.5	2.1	2.6	3.0		3.1		3.0		2.8	2.8		2.1	0.9	0.5
2	133.0±1	-0.8	-0.5	-0.5	0.8	1.3	2.1		2.4		2.4		2.3	2.3		1.9	0.9	0.2
1	139.0±2																	
TCS 7B																		
SNOW DEPTH CM		0	0	0		0		0	0	0		0			0	0	6	15
16	5.0	10.2	>20.0	>20.0		13.7		>20.0	11.2	7.9		15.9			18.8	9.6	0.5	0.1
15	10.0	8.9	16.0	16.0		14.4		12.8	8.4	7.5		9.2			7.6	5.8	0.7	0.2
14	20.0±1	6.9	10.7	10.6		12.9		8.2	6.8	7.0		6.9			4.3	3.4	0.8	0.3
13	30.0±1	5.4	8.3	8.2		10.8		7.3	6.4	6.6		6.4			3.9	2.9	0.9	0.3
12	40.0±1	4.4	7.1	7.0		9.1		6.8	6.0	6.2		6.2			3.9	2.8	1.1	0.4
11	50.0±1	3.5	6.1	6.2		7.7		6.2	5.8	5.8		5.9			3.9	2.8	0.9	0.4
10	60.0±1																	
9	69.5±1	1.6	4.5	4.5		5.5		5.2	4.9	5.0		5.0			3.6	2.5	1.0	0.4
8	79.5±1	0.7	3.3	3.4		4.6		4.6	4.5	4.3		4.4			3.5	2.4	1.2	0.4
7	89.5±1	0.0	2.3	2.3		3.5		4.0	3.9	3.9		4.0			3.1	2.2	0.9	0.4
6	99.5±1	-0.4	1.3	1.3		2.5		3.2	3.4	3.3		3.4			2.8	2.1	1.1	0.3
5	109.5±1	-0.7	0.1	0.1		1.5		2.5	2.5	2.6		2.9			2.4	2.0	1.0	0.2
4	120.0±1	-1.0	-0.2	-0.6		0.5		1.8	2.0	2.1		2.3			2.1	1.5	1.0	0.2
3	130.0±1	-1.3	-0.5	-0.6		-0.2		1.1	1.4	1.6		1.8			1.8	1.1	0.8	0.2
2	140.0±1	-1.5	-1.0	-1.1		-0.5		0.5	0.9	1.1					1.4	1.0	0.8	0.1
1	BROKEN																	

THERMO COUPLE NO	ORIG DEPTH CM	1959						1960											TC DEPTH	DIFF FROM ORIG DEPTH	COMMENTS
		JULY				AUG		JUNE		JULY				AUG			SEPT	OCT			
		10	13	20	27	15	23	14	25	4	11	18	19	1	8	22	12	3	CM	CM	
TCS 7A																					
SNOW DEPTH CM		0	0	0	0	0			0	0	0		0	0	0	0	0	0			EXCAVATED 2 AUG
16	0.0																		0.0	0.0	
15	5.0																		5.5	0.5	
14	15.0±1																		15.0	0.0±1	
13	25.0±1	8.5	7.9	8.4	7.9	7.0			-0.3	6.6	8.5		7.0	6.2	8.6	4.3	3.2	-0.9	26.0	1.0±1	
12	35.0±1																		35.5	0.5±1	AUGER HOLE INCOMPLETELY BACKFILLED FROM 30–40 CM
11	45.0±1	6.5	6.1	7.0	7.0				-0.5	3.8	7.7		6.4	5.8	7.5	4.1	3.0	-0.6	45.0	0.0±1	
10	55.0±1	5.6	5.7	6.4	6.4	5.1			-0.7	2.9	6.6		6.0	5.5	6.9	4.1	2.9	-0.7	54.5	-0.5±1	
9	65.0±1	4.3	4.7	5.8	5.9	4.2			-0.8	1.8	5.5		5.2	5.3	6.3	3.7	2.8	-0.8	65.0	0.0±1	AUGER HOLE INCOMPLETELY BACKFILLED FROM 65–75 CM
8	75.0±1	3.4	3.8	4.8	5.0	3.7			-1.0	-0.6	4.5		4.9	4.7	5.7	3.1	2.5	-0.5	75.0	0.0±1	
7	85.0±1	2.2	2.6	3.5	4.5	3.2			-1.2	-0.4	3.3		4.8	4.2	5.1	3.1	2.5	0.0	85.0	0.0±1	
6	95.0±1	1.2	1.7	2.7	3.4	2.7			-1.3	-0.7	2.3		3.6	3.9	4.6	3.1	2.3	-0.2	95.0	0.0±1	
5	105.0±1	0.0	0.4	1.6	2.5	2.2			-1.5	-0.9	1.3		2.3	3.2	3.6	2.8	1.6	-0.2	104.5	-0.5±1	
4	115.0±1	-0.5	-0.2	1.1	1.7	2.0			-1.6	-1.0	0.0		2.0	2.8	2.9	2.2	1.6	-0.2	115.0	0.0±1	
3	123.0±1																		123.0	0.0±1	
2	133.0±1																		132.5	-0.5±1	
1	139.0±2																		138.0	-1.0±2	
TCS 7B																					
SNOW DEPTH CM		0	0	0	0	0	0	0		0	0	0		0	0	0	0	0			EXCAVATED 6 AUG (1)
16	5.0	9.9	13.5					0.2		12.6	18.7	13.1		9.1	20.0	9.5	11.2	2.6		-16.0	
15	10.0	10.5	13.5	18.8	9.7	13.4		-0.3		11.8	14.7	12.6		8.7	18.9					-16.0	
14	20.0±1	8.8	8.3	7.5	5.9	7.8	5.8	-0.4		5.2	8.9	6.9		6.3	13.7	6.7	3.0	-0.8	5.0	-15.0±1	SANDY 0–20 CM
13	30.0±1	6.5	6.1	6.0	5.2	5.8	4.1	-0.6		2.1	6.5	5.0		5.7	8.1	4.7	3.3	-0.6	15.5	-14.5±1	CLAYEY 20–120 CM
12	40.0±1																		25.0	-15.0±1	
11	50.0±1	4.4	4.5	4.5	4.4	4.4	3.3												34.0	-16.0±1	
10	60.0±1																		44.0	-16.0±1	
9	69.5±1																		54.0	-15.5±1	
8	79.5±1																		62.0	-17.5±1	
7	89.5±1																		72.5	-17.0±1	
6	99.5±1	-0.2	-0.1	1.2	1.9	2.1		-1.3		-0.5	-0.4	-0.1		2.4	3.0	2.8	2.0	-0.2	83.0	-16.5±1	
5	109.5±1	-0.6	-0.5	0.4	1.3	1.7	1.8												92.0	-17.5±1	
4	120.0±1	-0.8	-0.7	-0.4	0.7	1.4	1.0	-1.5		-0.8	-0.7	-0.5		2.0	0.7	2.2	2.0		103.0	-17.0±1	
3	130.0±1	-1.2	-0.9	-0.6	0.2	1.0	1.1	-1.4		-1.0	-1.0	-0.9		0.8	0.0	1.6	1.6	0.2	114.0	-16.0±1	
2	140.0±1																		?	?	LEADS BROKEN. CLAYEY AND SANDY WITH MANY
1	BROKEN																		?	?	COBBLES AND SMALL BOULDERS AT 120 CM

(1) TCS 7B TILTED DOWNSLOPE 8 CM WITH RESPECT TO BASE. 4-CM DEEP HOLE AT SURFACE, PROBABLY DUE TO COLLAPSE OF BACKFILL. DEPTHS ARE WITH RESPECT TO GENERAL SURFACE. TC 16 AND 15 ARE 11 CM AND 6 CM, RESPECTIVELY, ABOVE GENERAL SURFACE

Table E II.2.

EXPERIMENTAL SITE 7 THERMOCOUPLE OBSERVATIONS – STRINGS 7C–7E

READINGS °C
BLANKS INDICATE NO READINGS OR NONFUNCTIONING THERMOCOUPLES

THERMO COUPLE NO	ORIG DEPTH CM	1960								
		JULY				AUG			SEPT	OCT
		4	11	15	19	1	8	22	12	3
TCS 7C										
SNOW DEPTH CM		0	0	0	0	0	0	0	0	0
8	-2.0	13.3	18.3		13.4	7.9	18.0	9.9	7.4	-0.3
7	18.0±1	7.0	14.1		7.0	6.1	8.9	4.4	3.3	-0.5
6	38.0±1	4.3	8.2		6.1	5.5	7.2	4.2	3.3	-0.1
5	58.0±1	2.7	6.3		5.3	4.9	6.1	4.2	2.8	0.0
4	78.0±1	1.0	4.1		4.3	4.1	4.8	3.6	2.3	0.0
3	97.5±1	0.1	2.5		2.8	3.1	3.0	3.0	2.0	-0.2
2	117.5±1	-0.7	1.0		1.3	1.9	2.3	2.6	1.3	-0.5
1	130.0±1	-0.8	0.0		0.3	1.1	1.2	1.5	0.9	-0.2
TCS 7D										
SNOW DEPTH CM		0	0	0	0	0	0	0	0	0
8	-2.0	7.2	8.0		13.6	9.3	16.7	10.5	10.0	-0.6
7	18.0±1	3.1	6.5		7.7	6.6	11.7	6.2	2.8	-0.2
6	37.5±1	0.0	2.4		4.0	5.3	7.6	3.9	2.8	0.1
5	57.5±1	-0.4	0.5		2.4	4.6	5.7	3.2	2.8	0.2
4	77.0±1	-0.7	-0.1		1.0	3.6	4.8	2.9	2.5	0.2
3	97.0±1	-0.8	-0.4		0.0	2.4	3.4	2.2	1.8	0.5
2	117.0±1	-0.8	-0.6		-0.7	0.9	2.2	1.6	1.2	-0.2
1	130.0±1	-1.0	-0.9		-1.0	0.0	1.1	1.0	1.0	0.5
TCS 7E										
SNOW DEPTH CM		0	0	0	0	0	0	0	0	0
8	-2.5	11.2	18.0	13.0	11.7	9.0	19.8	13.2	8.9	2.8
7	18.0±1	5.5	4.3	4.1	3.7	5.6	8.3	6.3	4.0	0.0
6	37.5±1	0.9	0.8	0.5	0.7	2.8	6.2	4.0	3.8	-0.1
5	58.0±1	-0.1	0.0	-0.2	0.1	1.8	4.5	3.5	3.0	-0.2
4	78.5±1	-0.4	0.0	-0.3	-0.3	0.8	3.0	3.0	2.3	-0.2
3	98.5±1	-0.7	-0.2	-0.7	-0.5	0.1	0.9	2.0	2.0	-0.3
2	118.0±1	-0.6	0.1	-0.7	-0.6	-0.1	-0.2	0.6	1.6	-0.2
1	130.0±1	-0.3	0.1	-0.6	-0.7	-0.3	-0.6	-0.1	0.8	-0.2

Table E III.

EXPERIMENTAL SITE 8 THERMOCOUPLE OBSERVATIONS - STRINGS 8A-8B

READINGS °C
BLANKS INDICATE NO READINGS OR NONFUNCTIONING THERMOCOUPLES

THERMO COUPLE NO	ORIG DEPTH CM	1956		1957							1958																1959						1960									EXCAVATION 1961		
		SEPT	OCT	MAY	JULY		AUG		SEPT		JUNE					JULY					AUG			SEPT			JULY				AUG		JUNE	JULY			AUG			SEPT	OCT	TC DEPTH	DIFF FROM ORIG DEPTH	COMMENTS
		27	4	19	11	24	7	22	8	12	4	9	13	18	27	5	14	15	25	29	5	8	26	7	15	24	10	13	20	27	15	23	14	4	11	19	1	8	22	12	3	CM		
TCS 8A																																												
SNOW DEPTH CM		11-16	6-10	15		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6		0	0	0	0	0	0	0	0	0	0	0	0						EXCAVATED 1 AUG
21	0.0	-2.5	-5.8	-1.0		>20.0	>20.0	16.1	8.4	5.2	7.2	16.7	9.7	10.9	14.4	15.8	>20.0	>20.0	19.7	9.2	15.9	11.5	10.3	7.8	4.9																		- 3.0	TC 21 3 CM ABOVE SURFACE
20	10.0	-1.6	-3.7	-2.8		>20.0	16.4	11.6	5.7	4.6																																7.5	- 2.5	STONY AND CLAYEY 0-70 CM
19	18.0±1	-1.1	-3.2	-3.5		15.6	12.2	8.1	3.2	2.6	6.4	7.4	7.2	8.7	9.7	11.9	17.9	17.2	12.7	7.5	8.6	12.6	8.3	6.2	0.7																	15.5	- 2.5±1	
18	28.0±1	-0.7	-2.5	-4.2		13.2	10.3	6.6	2.3	1.5	1.4	4.1	4.8	5.9	7.1	9.1	13.5	13.3	9.9	7.6	7.4	9.7	6.3	4.5	0.9																	25.5	- 2.5±1	
17	36.0±1	-0.5	-2.1	-4.5		12.4	9.8	6.4	2.2	1.3																																32.5	- 3.5±1	
16	41.0±1	-0.4	-1.7	-4.6		12.1	9.6	6.4	2.4	1.5	-0.8	1.4	3.0	3.9	5.7	7.3	11.1	10.8	8.7	7.7	7.0	7.7	5.7	4.1	1.4		7.5	7.0	7.5	7.1	6.5	4.4	0.9	7.3	10.3	7.1	6.3	8.5				38.0	- 3.0±1	
15	46.0±1	-0.4	-1.5	-4.9		11.6	9.3	6.2	2.5	1.6	-1.1	0.7	2.3	3.3	5.3	6.8	10.1	9.7	8.3	7.4	6.8	7.5	5.7	4.0	1.5		6.9	6.5	7.2	7.0	6.0	4.5	0.4	6.9	9.8							42.5	- 3.5±1	
14	56.0±1	-0.4	-1.1	-5.2		10.7	8.7	6.1	2.5	1.7	-1.9	-0.3	1.2	2.3	4.4	6.1	8.8	8.3	7.8	7.1	6.5	6.9	5.5	3.8	1.6		6.3	6.1	6.7	6.6	5.5	4.4	0.3	6.8	8.9	6.8	6.2					52.5	- 3.5±1	
13	66.0±1	-0.4	-1.1	-5.5		10.0	8.1	5.8	2.6	1.8	-2.5	-0.9	0.0	1.2	3.3	5.1	7.6	7.7	7.1	6.6	6.6	6.6	5.4	3.7	1.8		5.3	5.3	5.7	5.8	5.0	4.2	0.0	6.1	8.0	6.4	6.0					62.0	- 4.0±1	
12	76.0±1	-0.4	-1.0	-5.9		8.8	7.5	5.2	2.5	1.9	-3.0	-1.7	-0.7	0.2	2.3	4.1	6.5	6.6	6.4	6.1	6.0	6.2	5.2	3.7	1.7		4.0	4.3	5.1	4.8	4.3	4.1	-0.2	5.4	7.5	5.7	5.5					72.0	- 4.0±1	CLAYEY WITH SOME SILTY
11	86.0±1	-0.4	-0.9	-6.3		7.3	6.6	4.6	2.5	1.9	-4.1	-2.4	-1.4	-0.6	1.0	2.9	5.0	5.1	5.4	5.4	5.3	5.4	4.8	3.3	1.6		3.1	3.1	3.9													81.5	- 4.5±1	LAYERS 70-120 CM
10	96.0±1	-0.4	-1.0	-6.6		6.2	5.8	4.0	2.4	1.8	-4.6	-3.0	-2.1	-1.3	-0.2	1.6	3.2	3.7	4.7	4.4	4.5	4.5	4.4	3.2	1.6		2.1	2.3	2.9	3.4	3.0	3.4	-0.8	3.4	4.5	4.7	4.5	5.3				91.0	- 5.0±1	
9	106.0±1	-0.4	-1.0	-6.9		4.9	5.0	3.6	2.3	1.7	-5.0	-3.5	-2.6	-1.8	-0.7	0.4	1.8	2.2	3.7	3.5	3.7	3.8	3.8	2.9	1.5																	101.0	- 5.0±1	
8	116.0±1	-0.4	-1.0	-7.1		4.0	4.1	3.2	2.1	1.6	-5.4	-3.9	-3.0	-2.3	-1.2	-0.4	0.8	1.0	2.7	2.8	3.5	2.9	3.2	2.5	1.6																	111.0	- 5.0±1	
7	126.0±1	-0.5	-1.0	-7.2		2.8	3.5	2.6	1.9	1.5	-5.7	-4.3	-3.4	-2.7	-1.6	-0.8	-0.4	-0.2	1.8	2.0	2.6	2.3	2.8	2.1	1.3																	121.0	- 5.0±1	CLAYEY WITH SOME SAND
6	136.0±1	-0.6	-1.0	-7.3		2.0	2.8	2.4	1.7	1.3	-5.9	-4.6	-3.7	-3.0	-1.9	-1.2	-1.0	-0.6	0.9	1.1	1.9	1.7	2.3	1.8	1.2		-0.8	-0.9	-0.6	-0.2	0.9	1.6										131.5	- 4.5±1	120-170 CM
5	146.0±1	-0.6	-1.0	-7.4		1.4	2.1	1.8	1.5	1.2	-6.1	-5.0	-4.1	-3.4	-2.2	-1.5	-1.1	-0.8	0.1	0.6	1.6	1.2	1.9																			139.0	- 7.0±1	
4	156.0±1	-0.6	-1.0	-7.5		0.6	1.6	1.5	1.3	1.0	-6.4	-5.3	-4.3	-3.7	-2.4	-1.8	-1.3	-1.2	-0.7	-0.2	1.0	0.7	1.4	1.1	1.0																	150.0	- 6.0±1	
3	164.0±1	-0.6	-1.0	-7.6		0.1	1.3	1.2	1.1	0.8																																158.0	- 6.0±1	
2	174.0±1	-0.7	-1.0	-7.7		-0.2	0.8	0.9	0.9	0.7	-6.8	-6.0	-4.7	-4.3	-3.1	-2.3	-1.7	-1.7	-1.2	-0.7	0.1	-0.1	0.6	0.8	0.8		-2.5	-2.3	-1.9	-1.2	-0.4	0.0	-2.8	-1.0	-0.3	-0.7?	0.7	0.2				165.5	- 8.5±1	DEPTH TO FROST 168 CM
1	180.0±2	-0.6	-1.0	-7.8		-0.4	0.4	0.5	0.6	0.6																																170.0	-10.0±2	INCREASINGLY SANDY 170-180 CM
TCS 8B																																												
SNOW DEPTH CM					0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	PRESENT	PRESENT	0	0	0	0	0	0	(1)	(1)	(1)	0	0	0	0	0	0			EXCAVATED 2 AUG
16	0.0																																											TC 16 MISSING
15	5.0																																										- 9.0	TC 15 4 CM ABOVE SURFACE
14	15.0±1				9.3	13.1	11.7	7.3	3.0	1.7		7.4	7.8	8.8	9.8	11.6	15.4	14.8	11.1	7.5		10.2	7.2	5.0	1.4	0.4																1.5	-13.5±1	TOP OF TC STRING (TC 14)
13	25.0±1																																									14.0	-11.0±1	TILTED DOWNSLOPE 11.5 CM
12	35.0±1				6.0	10.2	9.3	6.5	2.9	1.9		0.2	2.7	4.4	5.9	7.3	9.9	9.8	8.0	7.0		7.4	5.3	3.9	2.1	0.5																24.5	-10.5±1	WITH RESPECT TO BASE
11	45.0±1				5.5	9.5	8.8	6.4	3.2	2.1		-0.6	1.1	3.0	4.9	6.5	8.4	8.5	7.5	6.7		6.8	5.1	3.7	2.1	0.5	6.6															34.5	-10.5±1	
10	55.0±1				5.1	8.8	8.3	6.1	3.2	2.3		-1.1	-0.1	1.7	3.9	5.5	7.3	7.4	6.9	6.4		6.3	5.0	3.7	2.1	0.7																44.0	-11.0±1	
9	65.0±1				5.0	8.2	7.8	5.9	3.3	2.3		-1.6	-0.5	0.6	2.9	4.7	6.4	6.7	6.5	5.9		5.7	4.7	3.7	2.0	0.7	4.9	5.1	5.2	5.8	4.9	4.2				6.2	5.7	7.5	5.3	3.8	0.0	54.0	-11.0±1	
8	75.0±1				4.3	7.3	7.2	5.4	3.4			-2.0	-1.1	-0.2	1.8	3.7	5.6	6.0	5.9	5.7		5.7	4.5	3.5	1.9	0.7	3.8	4.4	4.6	5.6	4.4	3.9				5.6						64.0	-11.0±1	
7	85.0±1				3.7	6.4	6.6	5.0	3.4	2.4		-2.2	-1.5	-0.7	0.6	2.6	4.5	4.8	5.1	4.7		4.6	4.2	3.3	2.2	0.8	2.7	3.2	3.7	4.9	3.9	3.6				5.1	5.0	6.0	4.8	3.6	0.0	72.0	-13.0±1	INCREASINGLY SANDY BELOW 72 CM
6	95.0±1				3.1	5.7	5.9	4.4	3.2	2.3		-2.6	-1.8	-1.2	-0.2	1.5	3.3	3.6		4.0		4.2	3.8	3.0	2.1																	81.5	-13.5±1	
5	105.0±1				2.5	4.9	5.4	4.3	3.1	2.3		-3.0	-2.1	-1.5	-0.5	0.7	2.5	2.8	3.9	3.5		3.6	3.3	2.8	1.8	0.7	0.5	1.2	2.2	2.6	2.3	2.4				4.1	4.0	5.0	4.5	3.1	-0.2	91.0	-14.0±1	
4	115.0±1				1.8	4.2	4.7	3.9	3.0	2.2		-3.3	-2.4	-1.8	-0.7	-0.1	1.4	1.6	3.0	2.8		3.0	3.0	2.5	1.9	0.6																104.0	-11.0±1	
3	123.0±1				1.5	3.5	4.3	3.8	2.9	2.2		-3.4	-2.6	-2.0	-1.1	-0.5	0.7	0.8	2.3	2.5		2.8	2.6	2.4	1.9	0.5	-0.5	0.0	0.7	1.4	1.8	1.9				3.1	3.2	4.1	3.8	2.7	-0.5	114.0	- 9.0±1	
2	133.0±1				0.8	2.9	3.5	3.3	2.7	2.0		-3.7	-3.0	-2.3	-1.3	-0.7	0.1	0.1	1.6	1.7		2.2	2.3	2.1	1.8	0.5	-0.8	-0.5	-0.3	0.9	1.3	1.9				2.9	2.7	3.4	3.4	2.5	-0.3	122.0	-11.0±1	
1	139.0±2				0.5	2.3	3.1	3.0	2.5	2.0		-4.0	-3.4	-2.5	-1.5	-0.9	-0.4	-0.2	1.0	1.2		1.8	1.9	1.9	1.6	0.4	-0.9	-1.0	-0.8	0.4	1.1	1.6				2.1	2.3	3.0	3.2	2.2	-0.2	130.0	- 9.0±2	DEPTH TO FROST 179 CM

(1) SNOW PRESENT. THERMOCOUPLE LEADS BURIED

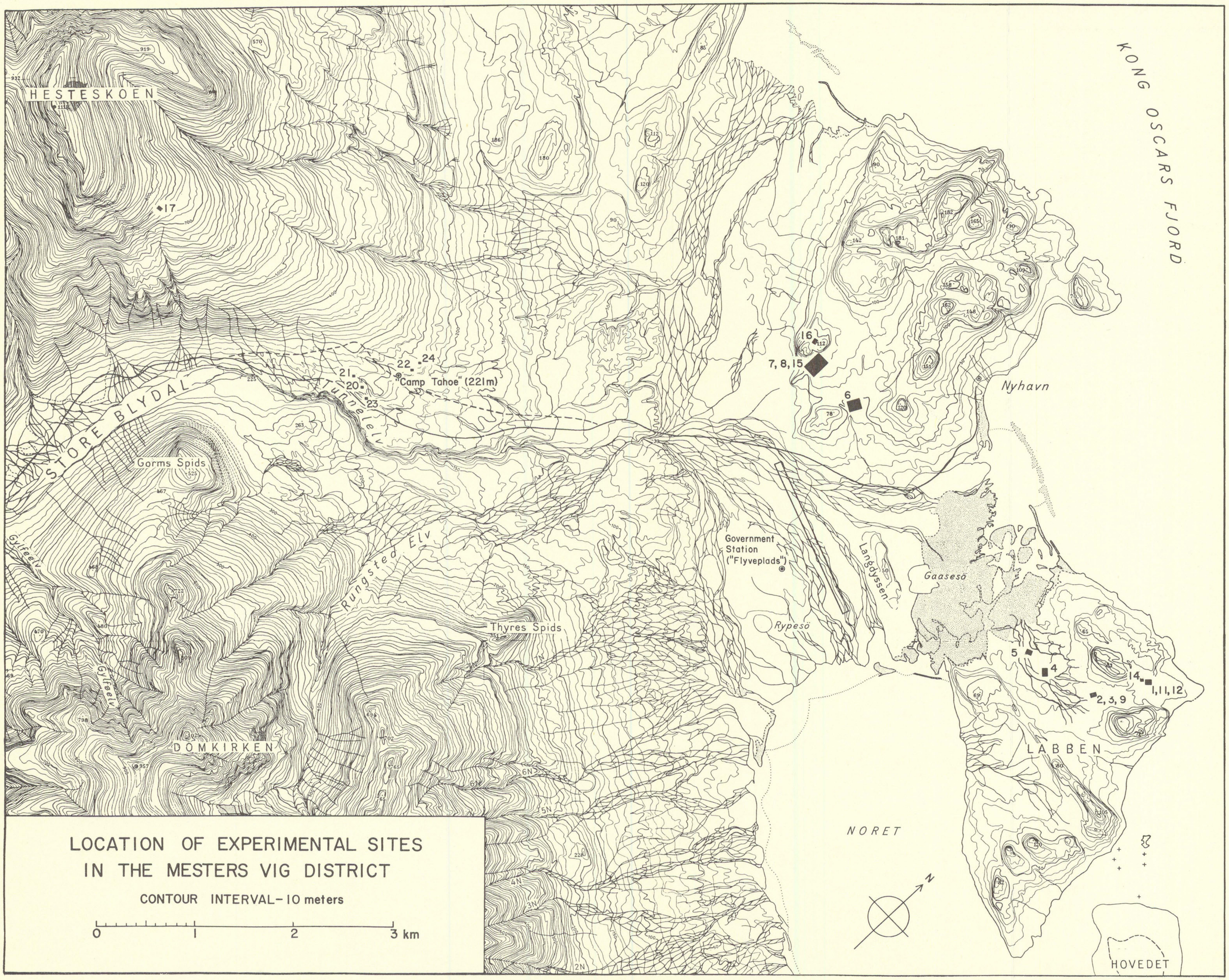
Table E IV.

EXPERIMENTAL SITE 16 THERMOCOUPLE AND THERMOMETER OBSERVATIONS

READINGS °C
BLANKS INDICATE NO READINGS OR NONFUNCTIONING THERMOCOUPLES

TCS 16

THERMO COUPLE NO	ORIG DEPTH CM	1957		1958																1959			EXCAVATION 1961		
		AUG	SEPT	MAY		JUNE				JULY							AUG	SEPT		JULY			TC DEPTH	DIFF FROM ORIG DEPTH	COMMENTS
		22	13	23	28	2	9	13	18	5	9 1 45 PM	9 3 15 PM	14	15	25	29	26	8	13	10	20	27	CM		
SNOW DEPTH CM		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			EXCAVATED 18 JULY
10	0		12.8																						TC 10 MISSING
9	10±1	10.8	3.3																				2.0	-8.0±1	
8	20±1	7.4	1.0																				13.0	-7.0±1	
7	30±1	7.7	1.8	0.1	0.6		6.8	8.4	8.9	10.9	8.4	8.5	14.6	14.9	12.7	10.7	7.1	4.7	3.2	10.4	11.0	13.2	23.0	-7.0±1	
6	40±1	7.7	2.4	0.0	0.0		4.1	6.5	7.1	9.8	8.3	8.3	12.9	13.2	12.2	10.4	7.4	4.8	3.1	9.1	9.5	8.7	33.0	-7.0±1	
5	50±1	7.2	2.8																				43.0	-7.0±1	
4	60±1	6.7	3.0	-1.3	-1.0		-0.2	1.2	3.1	7.4	7.0	7.0	9.2	9.8	10.1	9.0	6.9	4.9	3.7	5.7	6.6	6.8	53.0	-7.0±1	
3	70±1	6.1	3.1																				64.0	-6.0±1	
2	80±1	5.7	3.1																				73.0	-7.0±1	
1	90±1	5.3	3.0																				84.0	-6.0±1	
THERMOMETERS																									
THERMOMETER NO	DEPTH																								
SNOW DEPTH CM					0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
5	0						38.0	27.0	23.0	27.0	21.0	31.0								25.0	17.0	13.0			
4	5					24.4	24.0	18.8	19.0	21.2	16.0	20.2	23.4	23.6	18.0	13.8	11.8	10.0	7.0						
3	10				6.8	18.4	16.9	14.4	15.5	17.2	10.6	13.6	17.4	17.8	14.0	12.4	6.9	6.0	3.0	23.2	22.0	9.0			
2	20				1.2	10.6	10.0	10.6	11.4	12.5	8.4	9.0	14.8	15.0	12.7	10.8	6.0	4.0	0.6	16.8	18.2	10.2			
1	25				0.0	7.8	8.2	9.8	10.3	11.3	8.5	8.6	14.6	14.8	13.0	10.8	6.6	4.4	2.0	10.8	17.0	9.0			



LOCATION OF EXPERIMENTAL SITES IN THE MESTERS VIG DISTRICT

CONTOUR INTERVAL – 10 meters