Results of Tests on Vegetated Waterways, and Method of Field Application

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Results of Tests on Vegetated Waterways, and Method of Field Application

By MAURICE B. COX and VERNON J. PALMER*

THIS BULLETIN presents results of four years of research on the use of vegetation as a protective lining of farm waterways, such as pond spillways, terrace outlet channels, and natural watercourses. The protective ability and hydraulic characteristics of linings of alfalfa, Bermuda grass,

The use of vegetation as a lining to protect terrace outlet channels, pond spillways and other types of farm waterways from erosion is now a common practice. Field experience has yielded much information as to suitable vegetal covers, methods of establishment, and maintenance requirements. However, maximum velocities to which vegetal linings may be subjected and remain unharmed and the retardance offered to flow are factors difficult to evaluate in the field. The Oklahoma Agricultural Experiment Station, in cooperation with the Soil Conservation Service, conducted a series of vegetal channel experiments near Stillwater, Oklahoma, from 1940 to 1943 with the primary objective of evaluating these factors for certain vegetal covers adaptable as channel linings in Oklahoma and surrounding states. Contained herein is a final complete report of these studies. It includes the 1940 and 1941 results released as Technical Bulletin No. T-15 in September, 1942 (1).** These studies were conducted under the immediate direction and supervision of Maurice B. Cox.

The first attempt to study the stability and hydraulic behavior of vegetal lined channels was begun in 1935 near Spartanburg, S. C., by the Soil Conservation Service. This project, known as the Spartanburg Outdoor Hydraulic Laboratory, continued until 1941. A comprehensive report of its findings has been prepared by Ree and Palmer (5). In 1941 the site near Spartanburg was abondoned in favor of a much larger site and considerably greater water supply at Lake Carl Blackwell, near Stillwater, Oklahoma. This new location, renamed the Stillwater Outdoor Hydraulic Laboratory, surrounds blue grama grass, buffalo grass, weeping lovegrass, and a grass mixture native to Oklahoma were determined. The results are analyzed and presented in a manner such that engineers may apply them directly to the design of farm waterways.

the area in which the channel studies reported here were accomplished. Mutual cooperation and assistance benefited both State and Federal projects. Certain results from the studies by the Oklahoma Agricultural Experiment Station have ben used by Palmer in technical publications (2, 3, 4).

Seven different covers were tested. They were: Alfalfa (Medicago sativa), long and short Bermuda grass (Cynodon dactylon), blue grama (Bouteloua gracilis), buffalo grass (Buchloe dactyloides), weeping lovegrass (Eragrostis curvula), and a native grass mixture consisting of little bluestem (Andropogon scoparius), Indian grass (Sorghastrum nutans), switch grass (Panicum virgatum), blue grama, and side-oats grama (Bouteloua curtipendula).

Flow retardance results were analyzed and applied to field channels by procedures developed at the Stillwater Outdoor Hydraulic Laboratory on the basis of results obtained at both the Spartanburg and Stillwater laboratories (2, 3, 5).

DESCRIPTION OF LABORATORY

The experimental channels were constructed on a natural land slope, classified as Dougherty silt loam, below the dam of Lake Carl Blackwell, about six miles west of Stillwater, Oklahoma. The general arrangement of channels and facilities is shown in Figure 1. Water was drawn from the lake and pumped into the reservoir, then flowed by gravity through a rate measuring flume and suitable wooden connecting flumes into the channel being tested. The capacity of the system was 30 cubic feet per second.

The test channels were two feet wide and 100 feet long, with sheet iron separators between adjacent channels as shown in Figure 2. The top soil was removed from the slope where the channels were to be located and then the subsoil excavated to grade 12 inches below the finished grade. The sheet iron separators, 18 inches wide, were placed in position and brought to alignment by the use of planks (Figure 3). In channels where the vegetation was to be established from seed the top soil was then replaced and tamped to grade. Where sod was to be used, the channels were back-filled with top

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^{**}Italic numerals in parentheses refer to Literature Cited page 13.

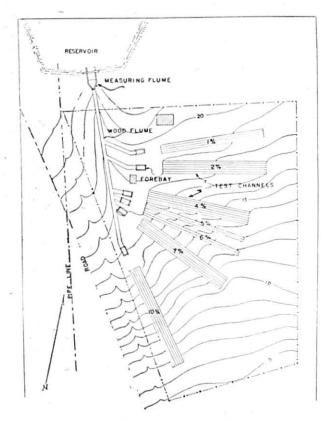


Fig. 1.—Arrangement of experimental area.

soil to within 4 inches of the final grade. Then sod, 4 inches thick, was placed carefully and rolled. The metal sidewall separators extended 6 inches above the finished channel bed. Extension sides 2 feet high were placed on top of the separators so that flows deeper than 6 inches could be obtained (Figure 4).

PROCEDURE

HYDRAULIC MEASUREMENTS

The test flows were measured by a threefoot type H flume (Figure 5). The desired rate of flow was established by adjustment of three control gates in a reservoir outlet structure upstream from the flume. A corrugated sheet metal baffle between the gate structure and flume resulted in satisfactory approach conditions to the flume.

For each run (discharge held constant or nearly so) the flow was allowed to become steady through the channel before water surface observations were begun. The duration of test flows ranged from 8 to 60 minutes. At the close of a run the flow was diverted from the test channel so that the effect of flow on the channel could be observed.

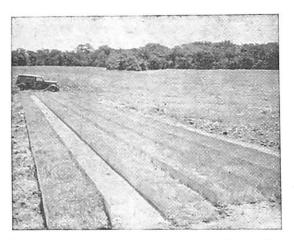


Fig. 2.—Completed test channels shortly after installation. The sheet iron separators extend six inches above the surface of the ground.

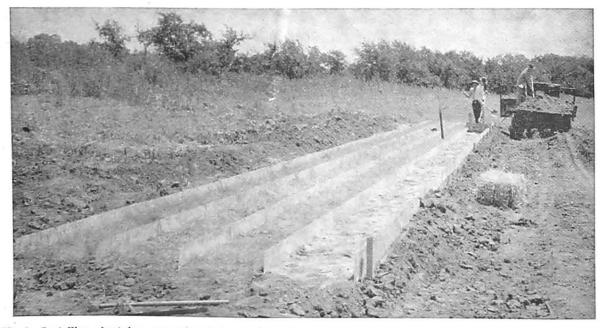


Fig. 3.—Installing sheet iron separators between channels. Strips of sheet iron 18 inches wide were placed 12 inches below finished grade and 6 inches above. Note $2'' \ge 12''$ boar ds used for maintaining alignment while soil is placed in channel.

McIntyre point gages held in riders operating on horizontal angle-iron supports (Figure 6) were used in making both bed and water surface measurements. Observations at 0.2 foot intervals across the channel were taken at four stations at 20-foot intervals along the channel, with the first station 20 feet from the channel entrance. Water surface measurements were taken simultaneously at the four stations. Two traverses of water surface were taken during each test run, using sharp points in the gages. For bed measurements, blunt points were used.

VEGETATIVE MEASUREMENTS.

During the first two seasons of testing (1940 and 1941) the vegetation was measured by a system yielding a volume of vegetation which was termed "forage cover." The grass was separated into small bunches or clumps and twisted to form a compact, round section. The diameter of this section and average length of stem were recorded. All the vegetation in an area 2 feet square was measured in this manner and the final results expressed in cubic inches of forage per square foot. For each channel, measurements were made at five selected loca-The air-dry weight of forage measured tions. in this manner was found from actual clippings to be 32.9 pounds per cubic foot. The variation in weight was very small for the different grasses studied. The advantage of this method was that the quantity of vegetation, incorporating number, size, and length of stems, was contained in a single figure.

During 1942 and 1943, a stand count method was used. This consisted of counting the number and determining the average length of

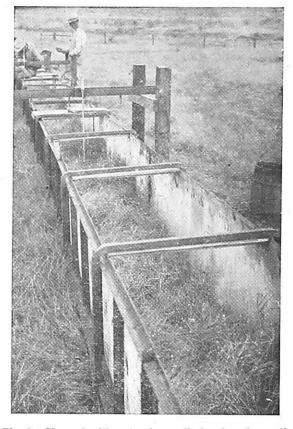


Fig. 4.—Channel with extension walls in place in readiness for testing. Point gage for making bed and water surface measurements is held in a rider operating on a horizontal steel angle. Photograph also shows a heavy growth of long Bermuda grass in Channel 7A, Experiment 1.

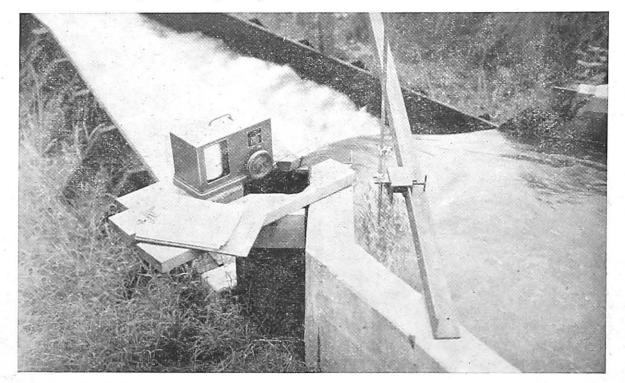


Fig. 5.-Three-foot, type H, rate measuring flume equipped with point gage and recorder,



Fig. 6.—Equipment and procedure used in making bed and water surface observations. Bermuda grass Channel 7A, Experiment 1, with vegetation about 80 percent submerged.

stems in a small area. The five areas counted in each channel were 6 inches square for the sod grasses and 24 inches square for alfalfa and the taller covers. The results are expressed in stems per square foot and average length of cover.

SCOUR MEASUREMENTS.

The rate of scour, expressed as surface inches of soil removed per hour of testing, was determined from the duration of flow and the difference between point gage readings taken across the channel bottom before and after each test run. With point gage measurements taken at only four stations, the computed scour rate is usually not an accurate evaluation of the erosion and damage to the channel. Visual observations of changes in the vegetation and channel bed are generally more significant. Scour rates as given in the included data should be considered as indications only, rather than absolute measurements.

VEGETATION SUBMERGENCE.

A visual observation of vegetation submergence was recorded for each test flow. Submergence was considered to occur only when plants were completely inundated, either by the flow being deep enough to overtop upright plants or by the velocity being great enough to bend the plants down into the flow. It is expressed as the percentage of the vegetation in a channel that was completely inundated. Figure 6 shows long, green Bermuda grass partially submerged. Submergence is an important action because the retardance to flow begins to decrease sharply after the vegetative cover is submerged.

HYDAULIC COMPUTATIONS.

The value of the coefficient n in the widely used Manning formula was evaluated for the various vegetal covers tested. The Manning formula to estimate velocity is

Where
$$V = \frac{1.486}{n} R^{2/3} S^{1/2}$$

or to determine capacity directly

$$Q = -----AR^{2/3} S^{1/2}$$

Where V=mean velocity in feet per second

- Q=discharge in cubic feet per second
- A=cross-sectional area of flow in square feet
- R—hydraulic radius in feet (the cross-sectional area divided by the wetted perimeter)
- S=slope of the energy line in feet per foot (slope of bed or water surface for uniform flow)
- n=a coefficient depending upon all the characteristics of a channel which produce retardation of the flow, such as roughness and irregularities of bed and sides, and irregularities in grade and crosssectional shape. In vegetal channels the effect of the area blocked out by the vegetation is included.

All the hydraulic elements except n in these expressions were determined from field measurements. The discharge, Q, was measured by the 3-foot H flume. The cross-sectional area was determined from the depth and width at the measuring stations. The mean velocity, V, at each station was computed from Q/A. The depth of flow, D, was used in place of the hydraulic radius, R, since tests on 3 percent slope channels at the Spartanburg Outdoor Hydraulic Laboratory (5) indicated the smooth sidewalls may have little effect when the bottom roughness is as great as it is in grass channels. Using depth of flow as the hydraulic radius has the effect of considering only the bed as the wetted perimeter. The slope of the energy line, S, was determined by slightly correcting the water surface slope to account for differences in velocityheads at the ends of the reach (since the flow was not always uniform). After these individual hydraulic elements were evaluated, the coefficient n was determined.

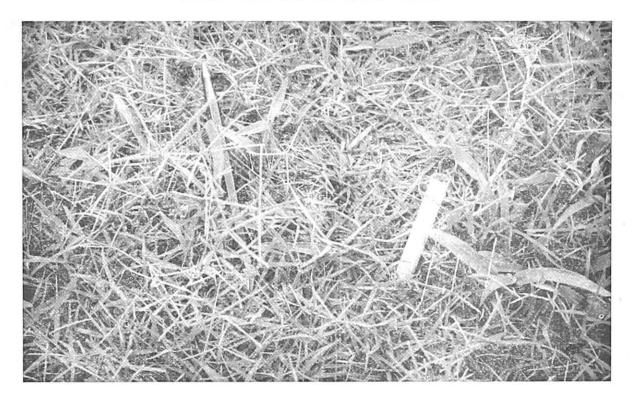


Fig. 7.—A very dense and uniform cover of short Bermuda grass with 939 stems per square foot and average length of 2.63 inches. Lower end of pencil and cigarette are in contact with the soil.

DESCRIPTION OF VEGETAL LININGS

ALFALFA.

The alfalfa channels were seeded during the spring of 1942 but poor stands were obtained. They were reseeded during the early spring of 1943 and good stands developed. The alfalfa made a good growth and the first crop was cut for hay. The tests were made during the late summer on new plants ten to thirteen inches tall.

BERMUDA GRASS (long).

The Bermuda grass channels were installed during the spring of 1940 by solid sodding. The grass was allowed to grow without clipping during the spring and most of the summer. A very vigorous top growth developed, with considerable dead material along the ground surface and most of the green leaves on the upper portion of the plants. This condition, Figure 4, prevailed when the tests were conducted in the fall of 1940. In the spring of 1941 the top growth of grass was removed completely and the channel beds given a light dressing of soil to replace that removed during the previous season's testing. For the second experiment (1941) the grass had attained a growth similar to that of the previous fall.

BERMUDA GRASS (short).

During the spring of 1942 the top growth of Bermuda grass on the channels installed in 1940 was again removed and the channel beds repaired. At this time additional channels were installed on 5 and 6 percent slopes. All the

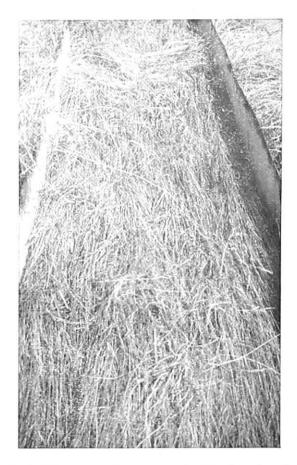


Fig. 8.—Blue grama lined Channel 10D after Experiment 1.



Fig. 9.—Buffalo grass lined Channel 10F before Experiment 1. The cover is 95 percent buffalo grass and 5 percent crabgrass.

Bermuda grass channels were mowed regularly during the 1942 growing season with a lawn mower set to cut as high as possible. A very dense, uniform cover of short grass developed in all channels (Figure 7). This condition was tested in the fall of 1942.

BLUE GRAMA GRASS.

The blue grama grass linings were installed by solid sodding in the spring of 1940. When tested in the fall, the channel: were covered with a very good stand of unmowed grass which included a small amount of crabgrass (Figure 8).

BUFFALO GRASS.

Buffalo grass was established in channels on 1, 2, 4, 7 and 10 percent slopes in the spring of 1940 by solid sodding. Covers on the 5 and 6 percent slopes were placed in the spring of 1942. This naturally short vegetation developed a fairly uniform cover (Figure 9) not quite as dense as that for the short Bermuda grass.

WEEPING LOVEGRASS.

The weeping lovegrass channels were seeded early in 1941. Although a generally good stand developed (Figure 10), the plants along the sides received more light and as a result grew more vigorously and tended to shade out plants in the center. This is believed to have caused the development of a narrow bare strip that existed along the centerline of the channel.

NATIVE GRASS MIXTURE.

The native grass channels were seeded in the spring of 1942 to a mixture of tall and short grasses consisting of little bluestem, Indian, switch, blue grama, and side-oats grama. Little bluestem was the most predominant (Figure 11). The tall grasses were clipped the next spring and the channels tested late in the summer.

PROTECTIVE ABILITY OF VEGETATIONS

The following paragraphs present observations on the ability of vegetal linings to reduce scour. These observations, of course, apply to the conditions of these experiments. The soil, Dougherty silt loam, is considered an erosionresistant soil. The covers were generally quite uniform and with densities considered good to excellent for field conditions. The channels were uniform in grade and had good alignment. The channel beds would be considered very smooth relative to field channels. As field conditions become more conducive to erosion, permissible velocities stated below should be decreased.



Fig. 10.—Weeping lovegrass in Channel 1B, Experiment 2. Maximum height approached 36 inches.

ALFALFA.

Permissible velocities for alfalfa should not exceed 3 feet per second and this cover should not be used as a channel lining on slopes steeper than 3 percent.

Visual observations of channels planted to alfalfa on the Wheatland Conservation Experiment Station near Cherokee, Oklahoma, show that good protection is offered to a channel with a 2 percent slope and that a protective cover developed more rapidly than for native grasses.

BERMUDA GRASS (long).

A permissible velocity of 7 ft. per sec. is a reasonable design value for slopes up to 10 percent where the soil is a silt or clay loam and a good, uniform cover will develop.

A tall, luxuriant growth of Bermuda grass does not necessarily provide the best channel protection. Extensive leaf growth may result in a thin stand of stems and inhibit the development of a dense growth near or on the ground surface. Runners will become very long without being rooted at the joints. The cover consists of a layer of live grass supported by bare stems and an accumulation of dead material. This condition existed for the Bermuda grass experiments conducted on long grass in 1940 and 1941. When subjected to deep, swift flows, the dead material lodged in drifts, forming a very irregular vegetal mat. Under this condition the flow became violently turbulent and excessive bed erosion was evident.

BERMUDA GRASS (short).

When Bermuda grass is mowed regularly or grazed reasonably, a dense stand tends to develop. The dense surface mat formed under such treatment provides excellent protection. In the experimental channels tested with short Bermuda grass only slight erosion was observed even after subjecting the linings to velocities as high as 12 ft. per sec. for 40-minute periods. A permissible velocity of 8 ft. per sec. for slopes up to 10 percent is recommended.

BLUE GRAMA GRASS.

The experiments show that with an excellent stand of blue grama grass a maximum design velocity of 7 ft. per sec. could be used on slopes up to 10 percent. Figure 8 shows the dense, tufted cover that developed in the experimental channels. Since blue grama is essentially a bunch grass and does not have stolons like Bermuda or buffalo grass, it generally will not develop as good a sod cover as these latter grasses. It is believed that permissible velocities under field conditions should be less for blue grama than for sod covers.

BUFFALO GRASS.

Buffalo grass is capable of forming a good, naturally short, sod cover. Only under favorable conditions, however, will it produce a cover providing the protection of clipped Bermuda grass. A permissible velocity of 7 ft. per sec. is recommended for good uniform covers on slopes not exceeding 10 percent.

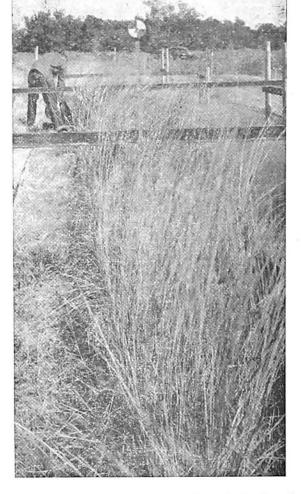


Fig. 11.—Native grass mixture in Channel 1D, Experiment 1. Little bluestem is the predominant grass, with growth as high as 48 inches.

WEEPING LOVEGRASS.

These experiments indicate that with good to excellent stands of weeping lovegrass the velocity should not exceed 3.5 ft. per sec. Use on slopes steeper than 5 percent is not desirable. Dense large bunches, high crowns, and much bare area characterizes a cover of weeping lovegrass. Deep, swift flows become very rough with this type of lining. The excessive turbulence and bare areas are factors very conducive to scour. When lovegrass is used as a lining the channel should be broadcast seeded to insure random location of plants.

NATIVE GRASS MIXTURE.

A native grass mixture consisting of little bluestem, Indian, switch, blue grama, and sideoats grama provides no more channel protection than weeping lovegrass. The bunch grasses, varying naturally in height, density, and size of clump, form a very irregular lining. As with weeping lovegrass, deep, swift flows become very rough and erosive. Velocities and slopes should be limited to 3.5 ft. per sec. and 5 percent respectively.

CAPACITY OF VEGETAL-LINED CHANNELS

LABORATORY RESULTS.

Appendix Tables 2 to 8 give a description of the cover, the hydraulic and scour results for each test flow, and observations of the hydraulic behavior. The hydraulic results are average values of three 20-foot reaches, whereas the scour rates are the averages of those determined at four cross-section stations. (See pages 6 and 8).

The capacity, Q, varies inversely as n in the Manning formula:

$$V = Q/A = \frac{1.486}{n} R^{2/3} S^{1/2}$$

An important consideration of the field technician in designing vegetal lined waterways is the estimation of the value of n. The hydraulic results of the experiments reported here will be presented in such a manner as to aid the technician in selecting a value for n. However, in the actual application, the design is accomplished through graphical means considering but not actually evaluating n.

The analysis of the results obtained will be confined to a presentation of the variation of the retardance coefficient, Manning's n, with depth and velocity of flow for the different covers studied, and to a method of field application. The method of analysis and application was developed at the Stillwater Outdoor Hydraulic Laboratory (3, 5). The product of mean velocity and hydraulic radius (approximately average depth) has been determined at this laboratory to be a satisfactory criterion for estimating n, and a graphical method of solving the Manning formula (considering an n variable with VR) has been developed to facilitate design. The presentation here will be on this basis with the exception that VD rather than VR will be used since side-wall friction has been considered negligible. Plots of n versus VD for the different covers tested are recorded in Figures 12 to 18, pages 14 to 20.

ALFALFA.—A single n—VD relationship applicable to a good uniform stand of green, uncut alfalfa is developed in Figure 12.

BERMUDA GRASS (long).—Figure 13 presents results from a great number of channels varying in bed slope from 1 to 10 percent and with considerable variation in length and density of Bermuda grass cover. The single curve indicated is considered to be an average relationship applicable to good uniform covers of tall Bermuda grass.

BERMUDA GRASS (short).—Figure 14 presents the n—VD results for a number of channels varying in bed slope from 1 to 10 percent. The covers of short Bermuda grass were fairly similar between channels, therefore Figure 14 shows only a single, average n—VD relationship that applies to good, uniform covers. BLUE GRAMA GRASS.—The length of cover in one channel of blue grama grass (channel 2-D) was considerably greater than that in any other channel. A division of the n—VD results into two classes, tall, and very tall, seems justifiable. These relationships are presented in Figure 15.

BUFFALO GRASS.—The n—VD results for fourteen experiments on unmowed buffalo grass are given in Figure 16. A single average n—VD relationship is shown that may be applied to good, uniform covers of this grass.

WEEPING LOVEGRASS.—The weeping lovegrass covers are divided into three groups dependent upon the length and age of cover. These are self-explanatory in Figure 17 for the three groups of plottings.

NATIVE GRASS MIXTURE.—Results from the three grass mixture channels are plotted in Figure 18. A single, average n-VD relationship is shown that is applicable to many channels with mixtures of tall and short grasses native to Oklahoma and surrounding region.

FIELD APPLICATION.

The average or selected n-VD relationships for all vegetal covers tested are presented in Figure 19 (page 21). This figure includes dashed lines indicating four basic n-VR relationships which will serve in applying the results of these experiments to field channels. These four basic relationships, designated as A, B, C, and D and shown separately in Figure 20, were developed from a review of all vegetal channel data prior to 1946. They were presented in the Handbook of Channel Design (2) prepared recently by the Stillwater Outdoor Hydraulic Laboratory for use of Soil Conservation Service Operations, and form the basis of the vegetal channel design method presented in that handbook.

Graphic solutions of the Manning formula for these four degrees of vegetal retardance are presented in Figures 21 to 24. The design procedure is to judge the degree of retardance (whether A, B, C, or D), select a value for V, and then determine the required R from one of the retardance diagrams A, B, C, or D, Figures 21 to 24. After R is determined, enter a diagram like Figure 25 and determine the dimensions of a suitable channel.

EXAMPLE

Given: Q=100 cubic feet per second S=3 percent Cover—weeping lovegrass

Find: Dimensions of a trapezoidal channel with 4:1 side slopes that will carry this flow.

Solution: Permissible velocity of weeping lovegrass is 3.5 ft. per second. Retardance B, Figure 19, applies to a good stand of weeping lovegrass at the end of the first growing season.

Enter diagram 22 with V=3.5, proceed right to the 3 percent slope line, then downward to the R scale and read R=0.99 ft. It is not necessary to determine n.

Compute the area, A, required from Q/V which is 100/3.5=28.6 sq. ft. Then enter diagram 25 with R= 0.99 and A=28.6 and determine b to be 18 feet. Proceed right at R=0.00 and determine depth of flow to be 1.25 feet.

The problem is solved unless b and d are not satisfactory. If so, change V slightly and proceed again through the two design diagrams.

The Handbook of Channel Design (2) contains a rather complete set of diagrams similar to Figure 25 for determining the dimensions of trapezoidal and triangular channels with many different side slopes, and for solving parabolic channels.

SUMMARY AND CONCLUSIONS

Results of rather extensive testing of the usefulness of a number of common vegetations in protecting waterways from esosion have been presented. Covers included alfalfa, Bermuda grass, blue grama grass, buffalo grass, weeping lovegrass, and a mixture of tall and short grasses native to Oklahoma. Channel slopes varied from 1 to 10 percent. The results are analyzed from the standpoint of (1) the protection offered, and (2) channel capacity.

- 1. Protection.
- a. Short Bermuda grass was superior over all other covers.
- b. Alfalfa, weeping lovegrass and the native grass mixture were the least effective in preventing bed erosion.
- c. Bermuda grass, both long and short, withstood more soil loss from around the roots than any of the other vegetations without serious damage to the channel.
- d. Under sustained high velocities, Bermuda grass was superior to all other grasses.
- e. Buffalo and blue grama grasses provided better channel protection than long Bermuda grass under light to moderate velocity tests but was unable to withstand prolonged high velocity flows as well as Bermuda grass.
- f. Bermuda grass provided more protection when clipped and maintained short than when allowed to grow tall and rank. Mowing produced a very dense, uniform cover that did not develop with the long cover.
- g. The permissible velocities to use in the design of field channels with good cover, good alignment, uniform slope, smooth beds, and with an erosion-resistant soil are suggested from these experiments to be:

| Cover | Permissible velocity (feet per second) | Slope limit* (percent) |
|-------------------------------|---|------------------------------|
| Bermuda grass; short | 8 | 10 |
| Bermuda grass; long | 7 | 10 |
| Blue grama grass; long | 7 | 10 |
| Buffalo grass | 7 | 10 |
| Native grass mixture; unmowed | 1 3.5 | 5 |
| Weeping lovegrass; long | 3.5 | 5 |
| Alfalfa; unmowed | 3 | 3 |

• For slopes steeper than these, permissible velocity is lower for the sod-type covers. For the bunch grasses and alfalfa these slopes are the maximum on which these covers should be used as a channel lining.

- 2. Channel capacity.
- a. The retardance or resistance coefficient, n, in the Manning formula, widely used to estimate velocity or channel capacity, has been evaluated for a number of vegetal linings.
- b. Manning's n, related to the depth and velocity of flow, is presented graphically in plottings of n versus VD.
- c. The results of these experiments are made directly applicable to the design of field channels by the inclusion of the four general n—VR design curves used in the Handbook of Channel Design (2).
 The graphical solution of the Manning formula for each of these general relationships as presented in this handbook is included here also. An example of the method of application is given.
- d. The complete hydraulic results including description of channels and notes on hydraulic behavior are tabulated in the appendix.

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- 5.—Ree, W. O., and Palmer, V. J.—Flow of Water in Small Channels Protected by Vegetal Linings. In process of publication as a U. S. D. A. technical bulletin.

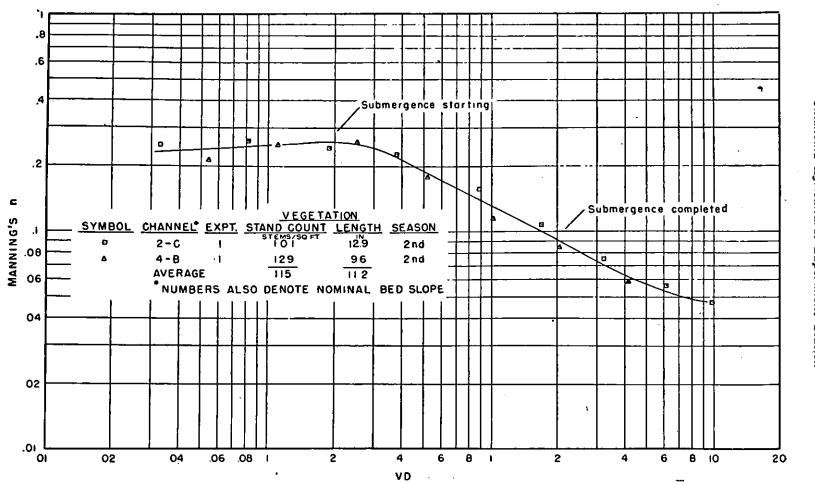
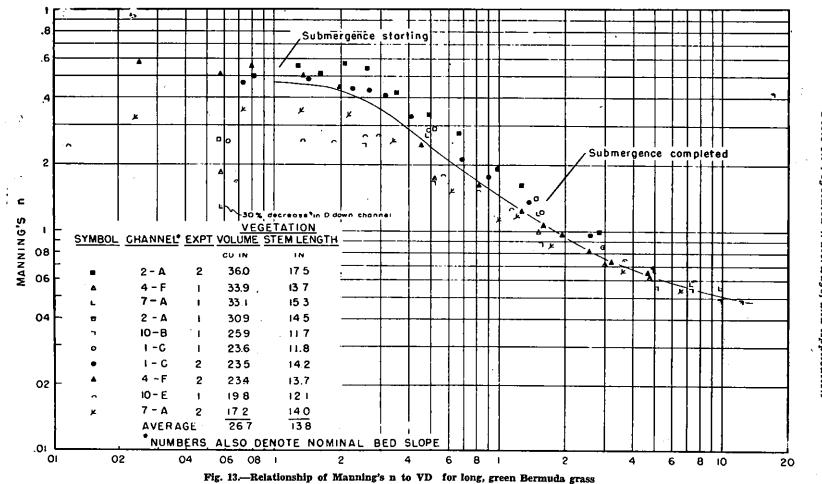


Fig. 12.-Relationship of Manning's n to VD for green, uncut alfalfa in good, uniform stands.



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Tests on Vegetated Waterways, and Application

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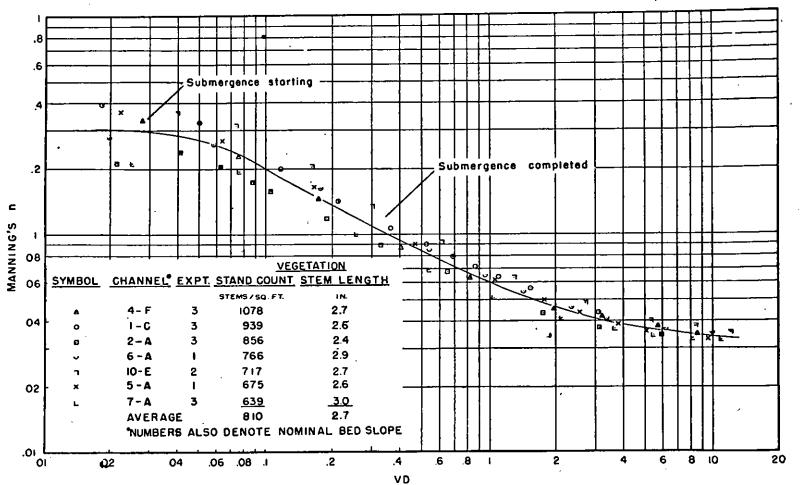
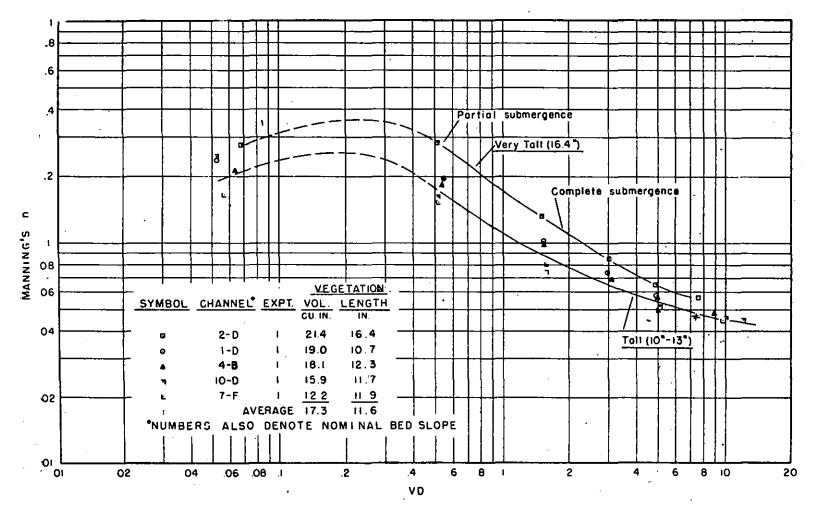
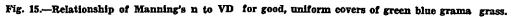
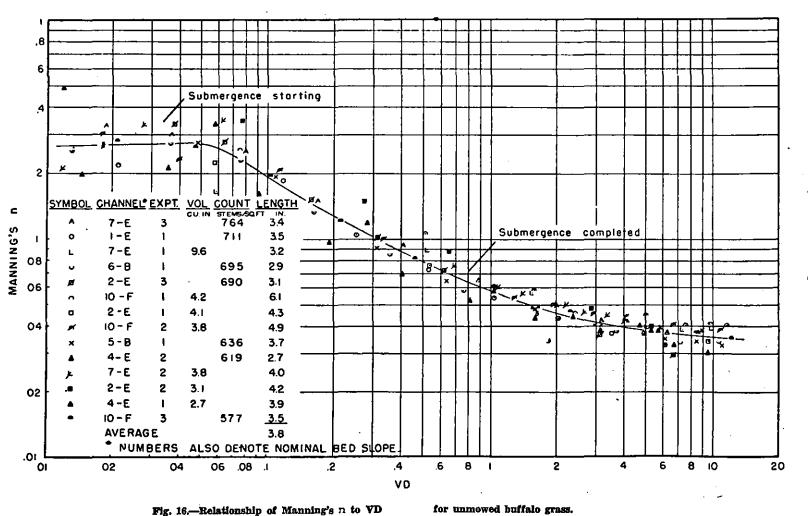


Fig. 14.-Relationship of Manning's n to VD for short, green Bermuda grass.





Tests on Vegetated Waterways, and Application





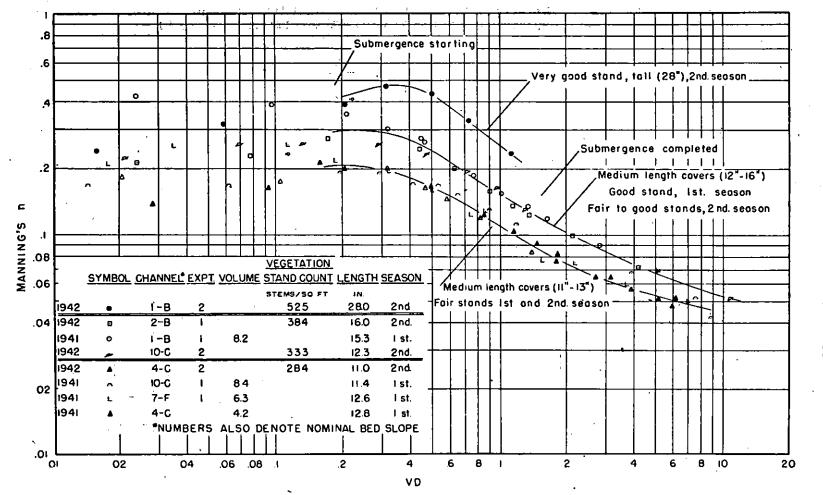
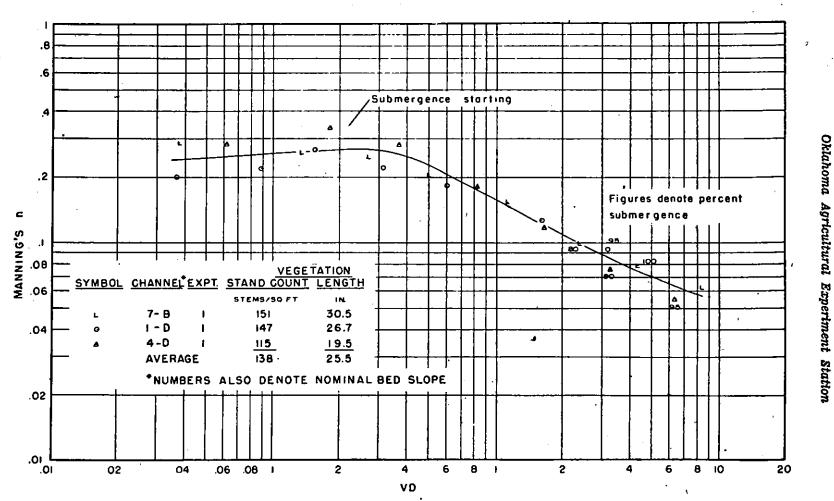
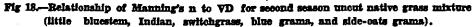


Fig. 17.-Relationship of Manning's n to VD for various conditions of green weeping love-grass.

Tests on Vegetated Waterways, and Application





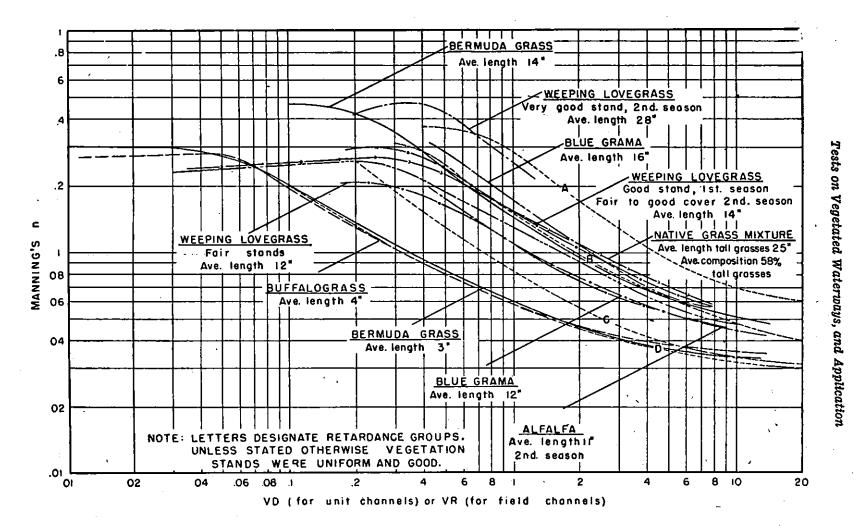


Fig. 19.-Experimental n-VD results as related to the general vegetal retardance curves A, B, C, and D.

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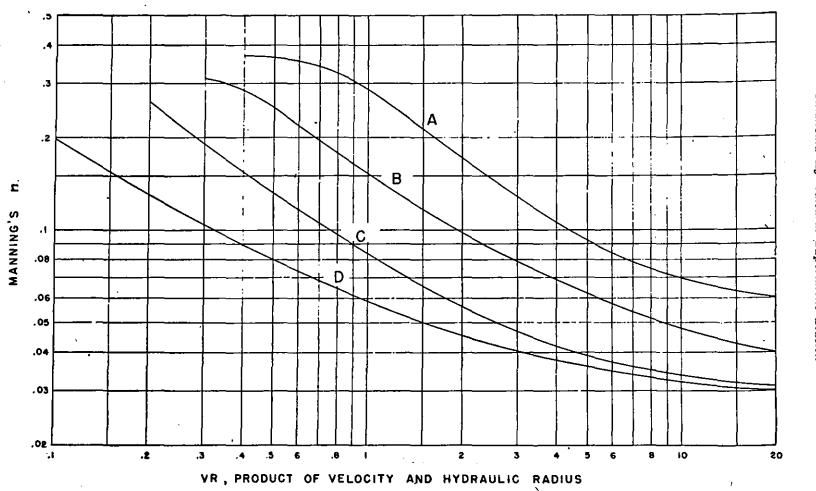
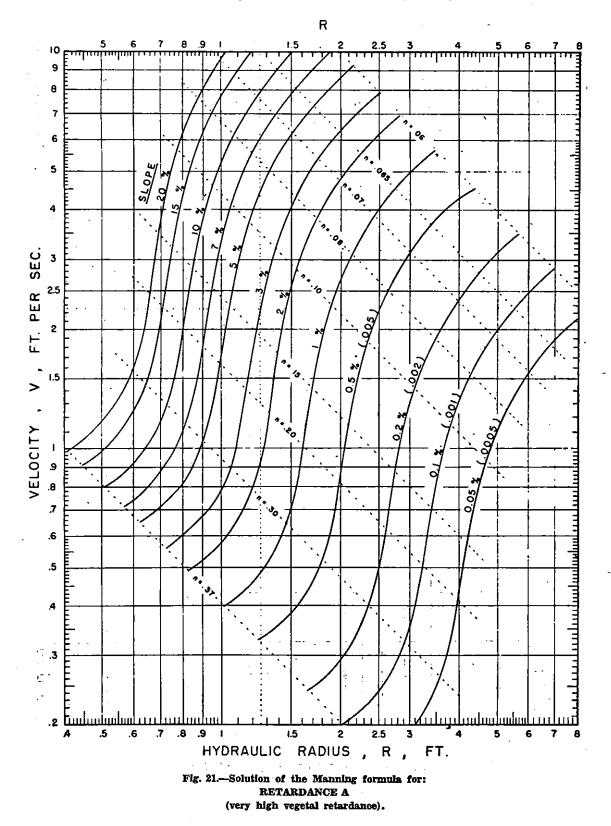


Fig. 20.-Degrees of vegetal retardance for which graphical solutions of the Manning formula have been prepared

Oklahoma Agricultural Experiment Station



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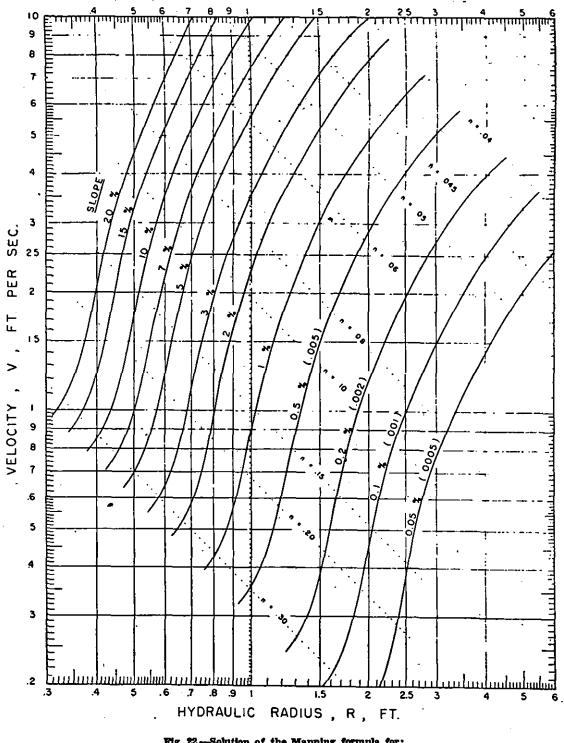
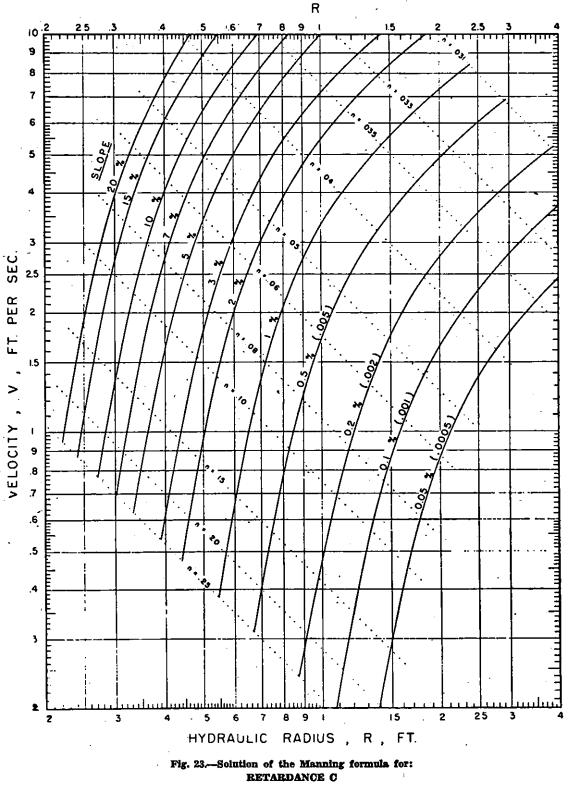


Fig. 22.—Solution of the Manning formula for: BETARDANCE B (high vegetal retardance). .



(moderate vegetal retardance).

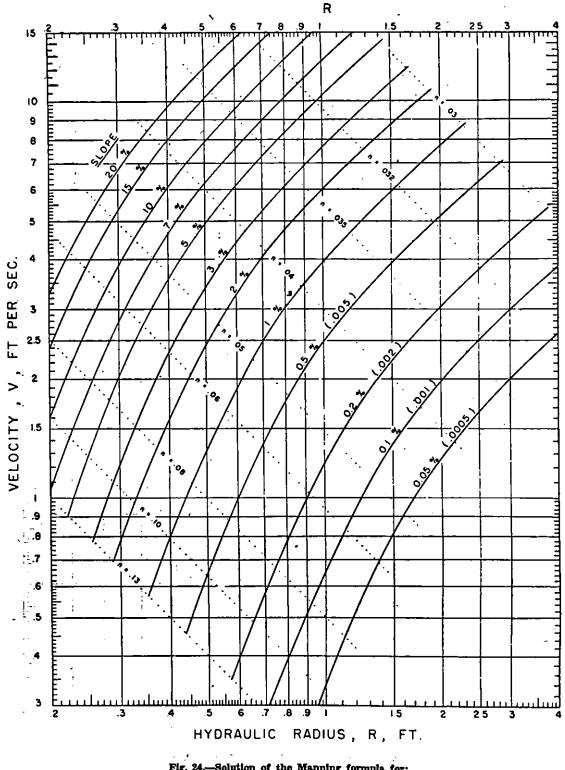
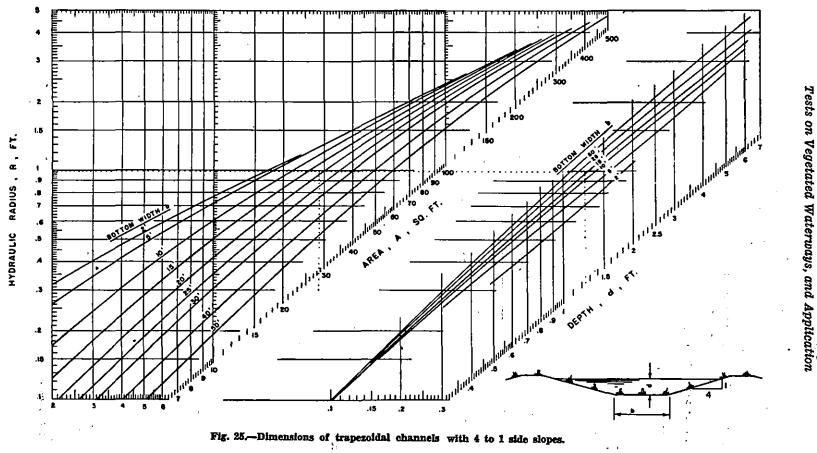


Fig. 24.—Solution of the Manning formula for: RETARDANCE D (low vegetal retardance).



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APPENDIX

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| Table | 1.—Experiments | Conducted, Bed | Slopes of Channels, and | Vegetation Measurements. |
|-------|----------------|----------------|-------------------------|--------------------------|
| | | | | |

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| | Channel | Experi | ment | - Bed | Vegeta | tion measu | rements |
|---|---------------|--------|------|---------|---------------------------------------|----------------|---------------------------|
| Vegstal cover and condition | Citeriner - | No. | Date | alope | Volume | Stand count | Average stem length |
| | | | - | Percent | 1 | 3 | Inches |
| Malfa | 2C | 1 | 9/43 | 2.05 | | 101 | 12.9 |
| uncut, green | 4B | ī | 9/43 | 3.86 | | 129 | 9.6 |
| Bermuda grass | 10 | 1 | 9/40 | 1.20 | 23.6 | | 11.8 |
| long, green | | 2 | 7/41 | .89 | 23.5 | | 14.2 |
| 10-6, 8100- | 2A | 1 | 9/40 | 2.03 | 30.9 | | 14,5 |
| 1 | | 2 | 8/41 | 1.97 | 36.0 | • | 17.5 |
| | 4F | ī | 9/40 | 4.06 | 33.9 | | 13.7 |
| | | 2 | 8/41 | 3.84 | 23.4 | | 13.7 |
| | 7A | 1. | 9/40 | 7.01 | 33.1 | | 15.3 |
| • | · · | . 2 | 8/41 | 7.01 | 17.2 | | 14.0 |
| | 10B | `ī | 8/40 | 10.19 | 25.9 | | 11.7 |
| • | 10E | ī | 8/41 | 10.14 | 19.8 | · | 12.1 |
| Sermuda grass | 10 | 3 | 8/42 | .96 | · · · · · · · · · · · · · · · · · · · | 939 | 2.6 |
| short, green | 2A | 3 | 8/42 | 2.00 | | 856 | 2.4 |
| · · · · · · · · · · · · · · · · · · · | 4 F | 3 | 8/42 | 3.86 | | 1078 | 2.7 |
| | . 5A | 1 | 8/42 | 5.19 | | 675 | 2.6 |
| | 6A | 1 | 8/42 | 6.10 | | 766 | 2.9 |
| - | 7A | 3 | 8/42 | 7.06 | | 639 | 3.0 |
| | 10E | 2 | 8/42 | 10.22 | | 717 | 2.7 |
| Blue graina graes | 1D | 1 | 9/40 | 1.01 | 19.0 | | 10.7 |
| uncut, green | 2D | 1 - | 9/40 | 1.95 | 21.4 | • | 16.4 |
| | 4B | 1 | 9/40 | 4.11 | 18.1 | | 12.3 |
| | 7F | 1 | 9/40 | 7.11 | 12.2 | | 11.9 |
| 1 | 10 D - | 1 | 8/40 | 10.31 | 15.9 | - | 11.7 |
| Buffalo grass | 1E | 1 | 9/42 | .97 | | 711 | 3.5 |
| uncut, green | 2 E | 1 | 9/40 | 1.89 | 4.1 | | 4.3 |
| | • | 2 | 7/41 | 2.01 | `3.1 | | 4.2 |
| | | 3 | 9/42 | 2.05 | | 690 | 3.1 |
| _ | 4 E | 1 | 8/41 | 3.87 | 2.7 | | 3.9 |
| | | 2 | 8/42 | 3.83 | | 619_ | 2.7 |
| | 5 B | 1 | 8/42 | 5.18 | | 636 | 3.7 |
| • | 6B | 1 | 8/42 | 6.01 | | 695 | 2.9 |
| | 7E | 1 | 9/40 | 7.14 | 9.6 | | 3.2 |
| | | 2 | 8/41 | 6.99 | 3.8 | | 4.0 |
| · | | 3 | 8/42 | 6.89 | | 764 | 3.4 |
| | 10F | 1 | 9/40 | 10.16 | 4.2 | | 6.1 |
| | | · 2 | 8/41 | 10.07 | 3.8 | | 4.9 |
| | | 3 | 8/42 | 10.12 | | 577 | 3.5 |
| Weeping lovegrass | _ 1 B | 1 | 7/41 | .98 | 8.2 | | 15.3 |
| long, green | ~~ | 2 | 9/42 | .99 | | 525 | 28.0 |
| | 2B | . 1 | 9/42 | 2.11 | | 384 | 16.0 |
| · · · · · · · · · · · · · · · · · · · | 4C | 1 | 8/41 | 3.91 | 4.2 | | 12.8 |
| | | 2 | 9/42 | 3.87 | | 284 | 11.0 |
| | 7F | 1 | 8/41 | 7.04 | 6.3 | | 12.6 |
| • | 100 | 1 | 8/41 | 10.10 | 8.4 | | 11.4 |
| | | 2 | 9/42 | 9.83 | | 333 | 12.3 |
| Native grass mixture tall and short, green | ID (D | 1 | 9/43 | .87 | | 147 | 26.7 |
| watt aller allows, BICCH | 4D | 1 | 9/43 | 3.85 | | 115 | 19.5 |
| | 7B | 1 | 9/43 | 7.14 | | 151 | 30.5 |

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² Cubic inches of vegetation per square foot of channel surface (See text for explanation). ² Number of stems per square foot.

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| | • | | | | | | • | | Coeffic | ients |
|-----------|------|---------------------------------------|----------|-----------------------------|----------------------------|---------------------------|---------------------|------------------------------|-----------|------------|
| Bun | Date | Discharge per loot of width, VD | Depth, D | Mean velocit y, Y | Effecti re slope | Vegetation submargence | Duration of flow | Av. r sto od scour | cheaty, O | Manning, n |
| 1 | 3 | 8 | ° 4 | 5 | 6 | 7 | 8 | 9 | 10 | 1 |
| · · · · · | | Ou. 11. per sec. | Feet | Ft. per | Ft. per ft. | Percent | Min, | In. per hr. | <u>-</u> | |

ALFALFA

Description of vegetation: Good uniform stand of green, uncut alfalfa with 101 stems per square foot; average length 12.9 inches; composition 95 percent alfalfa; 5 percent crabgrass. Vegetation upright at start of testing. Channel established from seed in spring 1942. Cut for hay fall 1942 and spring 1943. Hydranlic behavlor: Flow uniform through stand for runs 1, 2, 3 and 4, surface smooth. Surface of flow slightly rough for runs 5 and 6 and increased in roughness with each following run. All vegetation submerged for runs 8 and 9.

| Channel 4B | | | | Bed Slope | 3.86 Perc | ent | | E | vperiment (| 1, 1943 |
|------------|-----|-------|------|-----------|----------------------|-------------|----|-------|-------------|---------|
| 9 | 9-8 | 9.96 | 1.63 | 6.11 | .0201 | 100 | 18 | 1.080 | 34.3 | .0474 |
| 8 | 9-8 | 6.06 | 1.34 | 4.52 | .0202 | 100 | 20 | .662 | 27.7 | .056 |
| 7 | 9-8 | 3.19 | 1.09 | 2.93 | .0196 | 100 | 25 | .106 | 20.2 | .074 |
| 6 | 9-8 | 1.66 | .899 | 1.85 | .0204 | 95 · | 21 | .086 | 13.7 | .106 |
| 5 | 9-8 | .887 | .785 | 1.13 | .0200 | 50 | 20 | .000 | 9.06 | .157 |
| 4 | 9-8 | .372 | .583 | .639 | .0191 | 10 | 25 | .000 | 6.07 | .225 |
| 3 | 9-8 | .188 | .403 | .466 | .01 9 1 (| 0 | 20 | .036 | 5.31 | .241 |
| 2 | 9-8 | .0811 | .251 | .323 | .0197 | 0 | 23 | .016 | 4.61 | .257 |
| 1 | 9-8 | .0325 | .142 | .229 | .0200 | 0 | 40 | .000 | 4.30 | .250 |

Description of vegetation: Good uniform stand of green, uncut alfalfa with 129 stems per square foot; average length 9.6 inches; composition 97 percent alfalfa; upright at start of testing. Channel established from seed in spring 1942. Cut for hay fall 1942 and spring 1943. Hydraulic behavior: Flow uniform through stand for runs 1, 2 and 3, surface smooth. Surface of flow slightly rough for runs 4 and 5 and rough for run 6 and very rough for run 7.

| • 1 | 9-9 | .0533 | .143 | .373 | .0381 | 0 | 50 | .000 | 5.07 | .214 |
|-----|-----|-------|------|------|-------|-----|----|------|------|-------|
| 2 | 9-9 | .110 | .243 | .452 | .0379 | 0 | 15 | .000 | 4.73 | .251 |
| 3 | 9-9 | .250 | .404 | .619 | .0372 | 30 | 21 | .024 | 5.09 | 257 |
| 4 | 9-9 | .521 | .506 | 1.03 | .0370 | 50 | 30 | .012 | 7.65 | .178 |
| 5 | 9-9 | 1.02 | .583 | 1.75 | .0379 | 80 | 39 | .022 | 11.8 | .115 |
| . 6 | 9-9 | 2.04 | .728 | 2.81 | .0385 | 100 | 25 | .071 | 16.8 | .0843 |
| . 7 | 9-9 | 4.17 | .903 | 4.62 | .0385 | 100 | 30 | .077 | 24.8 | .0590 |

BERMUDA GRASS, LONG

Table 3.—Results of Tests of Channels Lined with Long Bermuda Grass.

| Channel 1C | | | | Bed Slope | 1.20 Per | rcent | | E | xperiment | 1, 1940 |
|--|---|--|---|--|---|---|---|---|--|--|
| Description of ve green grass with foot; average ler Bermuda; uprigh by solid sodding | 23.6 cut ngth 11.8 nt at star | ic inches (inches; con- t of testing | of forage mposition : | per square 98 percent | and c center merge run 3 | aulic behaviour over about ² r of the ch ed for rema causing of the flow | & of the s annel for dining run aly slight | rass down run 2. G s but stan ripples o | n a stream rass compl nding up in n the surf | along the etely sub- 1 flow for ace. Sur- |
| 1 | 9-12 | .0622 | .251 | .248 | .0112 | 0 | 36 | .000 | 4.69 | |
| 2 | 9-12 | .498 | .915 | .544 | .0125 ' | 25 | 14 | .000 | 5.10 | .287 |
| 3 | 9-12 | 1.56 | 1.10 | 1.42 | .0122 | 100 | 33 | .164 | 12.3 | .123 |
| 4 | 9-12 | 2.99 | 1.31 | 2.28 | .0118 | 100 | 27 | .247 | 18.3 | .0851 |
| 5 | 9-12 | 4.93 | 1.56 | 3.16 | .0123 | 100 | 33 | .098 | 23.1 | .0696 |
| Channel 1C | | | | Bed Slope | 0.89 Per | cent | • | · E | periment 2 | , 1941 , |
| Description of ve green grass with foot; average len Bermuda; uprig tablished by soli tenance, remove caused by erosio | 23.5 cut ogth 14.2 ht at be d sodding d old g | ole inches (inches; con ginning of g in the sp rass and | of forage nposition 1 testing. ring of 194 filled lar | per square 00 percent Grass es- 40. Main- | all ru for ru very wavin bottor | aulic behavious from 1 t ins from 1 t ins 1, 2 and smooth thr ig in the flo in as velocit ce of the flo | o 10 with d 3. The oughout a ow. Run by appeare | little or n surface o all these 11 appare d to be n | o effect on f the flow runs with ntly pressed | the grass remained the grass i grass to |

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| | nt. | | | | | | | _ | Coeffici | ents |
|--|--|--|---|--|--|--|---|--|---|--|
| Ħ | Date | Discharge per foot of width, VD | Depth, D | Mean velooity, V | Effective Blope | Vegetation submergence | uration 1 flow | Av. rate of scour | Chezy, O | Manning, n |
| | | | <u>A</u> | <u>8</u> \$ | 14120 | <u> </u> | ្ត្រីទ ខ | | | · · · |
| 1 | | 3 | • | Pt. per | Pt. per | | 0 | Jn. per | 10 | . 11 |
| <u> </u> | | per sec. | Feet | sec. | <u> </u> | Percent | Min, | hr. | | |
| 2 | 7-12 7-12 | .0735 .142 | .404 .606 | .182 .234 | .0110 .0117 | 0 0 | 45 35 | .000 .093 | 2.76 2.83 | .468 .488 |
| 3 4 | 7-12 | .224 | .743 | .301 | .0122 | 20 | 30 | .000 | 3.23 | .441 |
| 5 | 7-12 | .267 | .821 | .325 | .0124 | 30 | 27 | .000 | 3.30 | .439 |
| 6 | 7-12 | .314 | .861 | .365 | .0126 | 50 | 23 | .000 | 3.64 | .404 |
| 7 | 7-12 | .407 | .889 | .458 | .0127 | 75 | 22 | .087 | 4.46 | .330 |
| 8. | 7-12 | .691 | .939 | .736 | .0124 | 90 | 26 | .000 | 7.01 | .211 |
| 9 | 7-12 | .899 | .991 | .907 | .0124 | 100 | 31 | .161 | 8.36 | .179 |
| 10 11 | 7-12 7-12 | 1.36 2.56 | 1.08 1.28 | 1,26 2.00 | .0123 .0124 | 100 100 | 21 31 | .000 .035 | . 11,1 16.1 | .137 .0964 |
| Channel 2A | | | | Bed Slo | pe 2.03 Per | rcent | | _ | periment] | |
| reen grass wi pot; average 1 ermuda; upri y solid soddin | ength 14.5 i Ight at star | inches; con t of testing | position 1 | 00 percent | of ch the c about smoo | affecting gra annel that o channel widt t 40 percent th for both nel during r | overed th h, and ru of chani last two | e grass for n 3, stream tel width, runs. Was | about 20 p n width inc surface of sh-out und | creased flow water side |
| 1 | 9-10 | .0565 | .199 | .284 | .0207 | 0 | 40 | .000 | 4.46 | .258 |
| 2 3 | 9-10 9-10 | .516 1.46 | .803 .974 | .642 1.50 | .0215 .0213 | 20 40 | 18 30 | .000 .090 | 4.91 10.5 | .202 .141 |
| | | ; | | Bed Slop | | | | | | |
| Channel | 41 | | _ | Det Stop | | | | | periment 2 | - |
| Description of recen grass wi oot; average ent Bermuda stablished by | ith 36.0 cub length 17.5 ; upright a y solid soc | oic inches of inches; c it beginnin iding in t | of forage p omposition g of testing the spring | 100 per- ng. Grass of 1940. | throu Runs more wavi: | aulie behav igh 5 with v 6 to 10 is 9 grass beca ng in the fl r surfaces | very little acreased me subm .ows. All | effect on in depth erged but these run | the stems with each remained s had fair | or leave run an erect an ly smoot |
| reen grass wi oot; average ent Bermuda; stablished by faintenance, 3 | ith 36.0 cub length 17.5 ; upright a v solid soc removed old | ic inches of inches; c it beginnin iding in t d grass an | of forage p omposition g of testin he spring d filled la | 100 per- ng. Grass of 1940. | throu Runs more wavi: wate: | igh 5 with 1 6 to 10 in 9 grass beca | very little acreased me subm ows. All For runs | effect on in depth erged but these run | the stems with each remained s had fair | or leave run ar erect ar ly smoot |
| reen grass wi oot; average ent Bermuda stablished by faintenance, : aused by eros | th 36.0 cub length 17.5 ; upright a v solid soc removed ob- sion of pre- 8-6 | oic inches; c i inches; c at beginnin iding in t d grass an vious testin | of forage 1 omposition g of testin the spring d filled la g. | 100 per- ng. Grass of 1940. rger holes | throu Runs more wavi: wate: flow .0209 | ugh 5 with v 6 to 10 i: 9 grass beca ng in the fi r surfaces. were rough 0 | very little acreased me subm ows. All For runs 26 | effect on in depth erged but these run 11 and 12 .000 | the stems with each remained s had fair the surfa- 2.51 | or leave run an erect an ly smoo ces of th |
| reen grass wi oot; average ent Bermuda stablished by faintenance, : aused by eros 2 3 | th 36.0 cub length 17.5 ; upright a v solid soc removed ok sion of pre- 8-6 8-6 | oic inches; c i inches; c it beginnin ding in t d grass an vious testin .0803 .128 | of forage] omposition g of testin he spring d filled la g. .366 .517 | 100 per- ng. Grass of 1940. rger holes .219 .247 | throu Runs more wavi: wate: flow .0209 .0211 | ugh 5 with v 6 fo 10 if 9 grass beca ng in the fl r surfaces. were rough 0 0 | very little acreased me subm ows. All For runs 26 14 | effect on in depth erged but these run 11 and 12 .000 .000 | the stems with each remained s had fair the surfa- 2.51 2.36 | or leave run ar erect ar ly smoot ces of th .503 .566 |
| reen grass wi oot; average ent Bermuda, stablished by faintenance, : aused by eros 2 3 4 | th 36.0 cub length 17.5 ; upright a solid soc removed ob- sion of pre- 8-6 8-6 8-6 8-6 | ic inches; c i inches; c it beginnin lding in t d grass an vious testin .0802 .128 .160 | of forage] omposition g of testin he spring d filled la g. .366 .517 .561 | 219 247 286 | throu Runs more wavie flow .0209 .0211 .0211 | igh 5 with v 6 6 to 10 if 9 grass beca ng in the fl r surfaces. were rough 0 0 0 | very little acreased me subm ows. All For runs 26 14 26 | effect on in depth erged but these run 11 and 12 .000 .000 .000 | the stems with each remained s had fair the surface 2.51 2.36 2.62 | or leave run ar erect ar ly smoot ces of th .503 .566 .516 |
| reen grass wi oot; average ent Bermude stablished by faintenance, aused by eros 2 3 4 5 | th 36.0 cub length 17.5 ; upright a v solid soci removed ob sion of pre- | bic inches; c inches; c at beginnin ding in t d grass an vious testin .0803 .128 .128 .160 .206 | of forage p omposition g of testin he spring d filled la g. | 219 247 286 298 | throu Runs more wavi: wate: flow .0209 .0211 .0211 .0215 | igh 5 with v s 6 to 10 ii e grass beca ng in the fi r surfaces. were rough 0 0 0 | very little acreased me subm ows. All For runs 26 14 26 10 | effect on in depth erged but these run 11 and 12 .000 .000 .000 .000 .070 | the stems with each remained s had fair the surfat 2.51 2.36 2.62 2.44 | or leave run an erect an ly smoo ces of th .503 .566 .516 .574 |
| reen grass wi oot; average ent Bermuda. stablished by faintenance, : aused by eros 2 3 4 5 6 | th 36.0 cub length 17.5 ; upright a r solid soci removed ob sion of pre- 8-6 8-6 8-6 8-6 8-6 8-6 8-6 | ic inches c inches; c at beginnin Iding in t d grass an vious testin .0802 .128 .160 .206 .259 | of forage p omposition g of testih he spring d filled la g. .366 .517 .561 .693 .771 | 219 247 247 286 298 336 | throu Runs more wavi wate flow .0209 .0211 .0211 .0211 .0215 .0214 | ugh 5 with v s 6 to 10 i: e grass beca ng in the fi r surfaces. were rough 0 0 0 10 25 | very little acreased me subm ows. All For runs 26 14 26 10 11 | effect on in depth erged but these run 11 and 12 .000 .000 .000 .000 .070 .000 | the stems with each remained s had fair the surfact 2.51 2.36 2.62 2.44 2.61 | or leave run ar erect ar ly smoo ces of th .503 .566 .516 .574 .545 |
| reen grass wi oot; average ent Bermuda, stablished by faintenance, aused by eros 2 3 4 5 | th 36.0 cub length 17.5 ; upright a v solid soci removed ob sion of pre- | bic inches; c inches; c at beginnin ding in t d grass an vious testin .0803 .128 .128 .160 .206 | of forage p omposition g of testin he spring d filled la g. | 219 247 286 298 | throu Runs more wavi: tlow .0209 .0211 .0211 .0215 | igh 5 with v s 6 to 10 ii e grass beca ng in the fi r surfaces. were rough 0 0 0 | very little acreased me subm ows. All For runs 26 14 26 10 | effect on in depth erged but these run 11 and 12 .000 .000 .000 .000 .070 | the stems with each remained s had fair t the surface 2.51 2.36 2.62 2.44 2.61 3.41 | or leave run an erect an ly smoo ces of th .503 .566 .516 .574 .545 .423 |
| reen grass wi oot; average ent Bermuda. stablished by faintenance, : aused by eros 2 3 4 5 6 7 | th 36.0 cub length 17.5 ; upright a v solid soci removed ob slon of prev 8-6 8-6 8-6 8-6 8-6 8-6 8-6 8-6 8-6 | ic inches; c inches; c at beginnin Iding in t d grass an vious testin .0802 .128 .160 .206 .259 .350 | of forage p omposition g of testih he spring d filled la g. | 219 247 247 247 247 286 298 336 426 555 | throu Runs more wavii wate: flow .0209 .0211 .0211 .0215 .0214 .0190 | ugh 5 with v s 6 to 10 i: e grass beca ng in the fl r surfaces. were rough 0 0 10 25 50 | very little acreased me subm ows. All For runs 26 14 26 10 11 27 12 | effect on in depth erged but these run 11 and 12 .000 .000 .000 .000 .000 .000 .000 .0 | the stems with each remained s had fair t the surface 2.51 2.36 2.62 2.44 2.61 3.41 4.32 | or leave run ar erect ar ly smoo ces of th .503 .566 .516 .574 .545 .423 .338 |
| reen grass wi oot; average ent Bermuda. stablished by faintenance, : aused by eros 2 3 4 5 6 7 8 | th 36.0 cub length 17.5 ; upright a v solid soci removed ob slon of prev 8-6 8-6 8-6 8-6 8-6 8-6 8-6 8-6 8-6 | ic inches; c i inches; c at beginnin Iding in t d grass an vious testin .0802 .128 .160 .206 .259 .350 .492 | of forage p omposition g of testih he spring d filled la g. | 2007 square 100 per- ng. Grass of 1940. rger holes 219 247 286 298 336 426 | throu Runs more wavii wate: flow .0209 .0211 .0215 .0214 .0190 .0187 | ugh 5 with v s 6 to 10 ii e grass beca ng in the fl r surfaces. were rough 0 0 10 25 50 70 | very little accreased me subm ows. All For runs 26 14 26 10 11 27 | effect on in depth erged but these run 11 and 12 .000 .000 .000 .000 .000 .000 .000 | the stems with each remained s had fair the surface 2.51 2.36 2.62 2.44 2.61 3.41 4.32 5.29 | or leave run an erect an ly smoo ces of ti .503 .566 .516 .574 .545 .423 .338 .278 |
| reen grass wi pot; average ent Bermuda stablished by faintenance, : aused by eros 2 3 4 5 6 7 8 9 | th 36.0 cub length 17.5 ; upright a v solid soc removed ob sion of pre- | ic inches c inches; c t beginnin d grass an vious testin .0802 .128 .160 .206 .259 .350 .492 .664 | of forage 1 omposition g of testih he spring d filled la g. | 219 247 247 247 286 298 336 426 555 709 | throu Runs more wavi: wate: flow .0209 .0211 .0211 .0215 .0214 .0190 .0187 .0191 | igh 5 with v_i 6 fo 10 it 9 grass beca ng in the fl r surfaces. were rough 0 0 0 0 10 25 50 70 90 | very little ncreased ows. All For runs 26 14 26 10 11 27 12 13 | effect on in depth erged but these run 11 and 12 .000 .000 .000 .000 .000 .000 .000 .0 | the stems with each remained s had fair t the surface 2.51 2.36 2.62 2.44 2.61 3.41 4.32 | or leave run ar erect ar ly smoo ces of th .568 .516 .574 .545 .338 .278 .195 |
| reen grass wi pot; average ent Bermude stablished by faintenance, : aused by eros 2 3 4 5 6 7 7 8 9 10 | th 36.0 cub length 17.5 ; upright a v solid soci removed ob sion of pre- | bic inches; c inches; c at beginnin ding in t d grass an vious testin .0802 .128 .160 .206 .259 .350 .492 .664 .990 | of forage 1 omposition g of testih he spring d filled la g. | 2007 square 100 per- ng. Grass of 1940. rger holes 219 247 286 298 336 426 555 709 1.03 | throu Runs more wavi wate flow .0209 .0211 .0211 .0215 .0214 .0190 .0187 .0191 .0193 | igh 5 with v if igh 5 to 10 if if grass beca ng in the fl r surfaces. were rough 0 0 0 0 10 25 50 70 90 100 | very little ncreased me subm ows. All For runs 26 14 26 10 11 27 12 13 27 | effect on in depth erged but these run 11 and 12 .000 .000 .000 .000 .000 .000 .000 .0 | the stems with each remained s had fair the surfact 2.51 2.36 2.62 2.44 2.61 3.41 4.32 5.29 7.59 | or leave run ar erect ar ly smoo ces of th .503 .566 .516 .574 .423 .338 .278 .195 .164 |
| reen grass wi oot; average ent Bermuda. stablished by daintenance, : aused by eros 2 3 4 5 6 7 8 9 10 11 12 Channel | th 36.0 cub length 17.5 ; upright a v solid soc removed ob sion of prev 8-6 8-6 8-6 8-6 8-6 8-6 8-6 8-6 8-6 8-6 | bic inches; c inches; c it beginnin ding in t d grass an vious testin .0802 .128 .160 .208 .259 .350 .492 .664 .990 1.28 .280 | of forage 1 omposition g of testif the spring d filled la g. .366 .517 .561 .693 .771 .822 .887 .937 .961 .998 1.19 | ber square 100 per- ng. Grass of 1940. rger holes 247 286 298 336 426 555 709 1.03 1.26 2.35 Bed | throu Runs more wavi: wate: flow .0209 .0211 .0211 .0215 .0214 .0190 .0187 .0191 .0193 .0193 .0194 .0199 Slope 4.06 | ligh 5 with v is 6 to 10 ii is 6 to 10 ii is grass beca ng in the fl r surfaces. were rough 0 0 0 0 0 10 25 50 70 90 100 100 100 100 100 | very little ncreased me subm ows. All For runs 26 14 26 14 26 10 11 27 12 13 27 30 | effect on in depth erged but these run 11 and 12 .000 .000 .000 .000 .000 .000 .000 .0 | the stems with each remained s had fair the surfa 2.51 2.36 2.62 2.44 2.61 3.41 4.32 5.29 7.59 9.07 15.3 xperiment | or leave run ar erect ar ly smoot 503 566 516 574 423 338 278 195 164 099 |
| reen grass wi oot; average ent Bermuda: stablished by Maintenance, : aused by eros 2 3 4 5 6 7 8 9 10 11 12 Channel Description of green grass w foot; average cent Bermuda | th 36.0 cub length 17.5 ; upright a v solid soc removed ob sion of prev 8-6 8-6 8-6 8-6 8-6 8-6 8-6 8-6 8-6 8-6 | ic inches; c inches; c it beginnin ding in t d grass an vious testin .0802 .128 .160 .208 .259 .350 .492 .664 .990 1.28 2.80 : Heavy u bic inches; t start of | of forage 1 omposition g of testin the spring d filled la g. .366 .517 .561 .693 .771 .822 .887 .937 .961 .998 1.19 niform sta of forage testing; gi | ber square 100 per- ng. Grass of 1940. rger holes 219 247 286 298 .336 .426 .555 .709 1.03 1.26 2.35 Bed nd of long per square a 100 per- | throu Runs more wavi: wate: flow .0209 .0211 .0211 .0215 .0214 .0190 .0187 .0191 .0193 .0193 .0194 .0199 Slope 4.06 Hyda run abou smoo flow, | Igh 5 with v 6 f to 10 ii 9 grass beca ng in the fl r surfaces. were rough 0 0 0 10 25 50 70 90 100 100 100 | very little ncreased me subm ows. All For runs 26 14 26 10 11 27 12 13 27 30 dor: Flow i the gra nnel widd all of g water s | effect on in depth erged but these run 11 and 12 .000 .000 .000 .000 .000 .000 .000 .0 | the stems with each remained s had fair the surfa 2.51 2.36 2.62 2.44 2.61 3.41 4.32 5.29 7.59 9.07 15.3 xperiment grass for enter of chese erged but uns 4 and | or leave run ar erect ar ly smoot ces of th .503 .566 .516 .574 .423 .338 .278 .195 .164 .099 I, 1940 run 1 b hannel f flows w waving 5. all |
| reen grass wi oot; average ent Bermuda: stablished by daintenance, : aused by eros 2 3 4 5 6 7 8 9 10 11 12 Channel Description of green grass w foot; average cent Bermuda lished by solid | th 36.0 cub length 17.5 ; upright a volid soci removed ob- sion of pre- 8-6 8-6 8-6 8-6 8-6 8-6 8-6 8-6 8-6 8- | ic inches; c inches; c it beginnin ding in t d grass an vious testin .0802 .128 .160 .208 .259 .350 .492 .664 .990 1.26 2.80 : Heavy u bic inches; t start of n spring o .0572 | of forage p omposition g of testih he spring d filled la g. | ber square 100 per- ng. Grass of 1940. rger holes 219 247 286 298 .336 .426 .555 .709 1.03 1.26 2.35 Bed nd of long per square a 100 per- rass estab- .430 | throu Runs more wavi wate flow .0209 .0211 .0215 .0214 .0190 .0187 .0191 .0193 .0194 .0199 Slope 4.06 Hyda run abou smoo flow, grass .0402 | ligh 5 with v s 6 to 10 iv grass beca ng in the fl r surfaces. were rough 0 0 0 10 25 50 70 90 100 100 100 100 100 100 25 50 70 90 100 100 100 100 100 100 100 | very little nereased me subm ows. All For runs 26 14 26 10 11 27 27 27 30 lor: Flom i the gra nnel wid all of g water s , surface 31 | effect on in depth erged but these run 11 and 12 .000 .000 .000 .000 .000 .000 .000 .0 | the stems with each remained s had fair 2.51 2.36 2.62 2.44 2.61 3.41 4.32 5.29 7.59 9.07 15.3 xperiment grass for enter of ch erged but uns 4 and fairly roup 5.94 | or leave run ar erect ar ly smoot 503 566 516 574 423 338 278 195 164 0999 1, 1940 run 1 b hannel f flows w waving 5, all |
| reen grass wi oot; average ent Bermuda; stablished by daintenance; aused by eros 2 3 4 5 6 7 8 9 10 11 12 Channel Description of green grass w foot; average cent Bermuda lished by solid | th 36.0 cub length 17.5 ; upright a , solid soc removed ob- sion of pre- 8-6 8-6 8-6 8-6 8-6 8-6 8-6 8-6 8-6 8- | ic inches; c inches; c it beginnin ding in t d grass an vious testin .0802 .128 .160 .208 .208 .259 .350 .492 .664 .990 1.28 2.80 : Heavy u bic inches; 7 inches; d t start of n spring o .0572 .516 | of forage 1 omposition g of testin he spring d filled la g. | 2007 square 100 per- ng. Grass of 1940. rger holes 219 247 286 298 336 426 555 709 1.03 1.26 2.35 Bed nd of long per square a 100 per- rass estab- 430 1.06 | throu Runs more wavi: wate: flow .0209 .0211 .0211 .0211 .0215 .0214 .0190 .0187 .0191 .0193 .0193 Slope 4.06 Hyda run abou smoo flow, grass .0402 .0399 | Igh 5 with y 6 6 to 10 it 9 grass beca ng in the fi r surfaces. were rough 0 0 0 10 25 50 70 90 100 100 100 100 100 100 100 | very little ncreased me subm ows. All For runs 26 14 26 10 11 27 12 13 27 27 30 lor: Flon l the gra nnel wid all of g water s , surface 31 10 | effect on in depth erged but these run 11 and 12 .000 .000 .000 .000 .000 .000 .000 .0 | the stems with each remained s had fairi the surfact 2.51 2.36 2.62 2.44 2.61 3.41 4.32 5.29 9.07 15.3 xperiment grass for enter of ch erged but uns 4 and fairly roug 5.94 7.64 | or leave run ar erect ar ly smoot ces of th .503 .566 .516 .574 .545 .423 .338 .278 .195 .164 .0998 1, 1940 run 1 b hannel f flows w waving 5, all gh. .182 .173 |
| reen grass wi oot; average ent Bermuda stablished by faintenance, : aused by eros 2 3 4 5 6 7 8 9 10 11 12 Channel Description of green grass w loot; average cent Bermuda lished by solid | th 36.0 cub length 17.5 ; upright a v solid soc removed ob- sion of pre- 8-6 8-6 8-6 8-6 8-6 8-6 8-6 8-6 8-6 8- | ic inches; c inches; c it beginnin digrass an vious testin .0802 .128 .160 .206 .259 .350 .492 .664 .990 1.26 2.80 : Heavy u bic inches; c it start of n spring o .0572 .516 1.52 | of forage 1 omposition g of testin he spring d filled la g. | 219 247 286 298 336 426 555 709 1.03 1.26 2.35 Bed nd of long per square a 100 per- rass estab- 430 1.06 2.28 | throu Runs more wavi: wate: flow .0209 .0211 .0215 .0214 .0215 .0214 .0191 .0193 .0194 .0193 .0194 .0193 Slope 4.06 Hyda run abou smoc flow, grass .0399 .0400 | Igh 5 with y 6 6 to 10 it 9 grass beca ng in the fi r surfaces. were rough 0 0 0 10 25 50 70 90 100 100 100 100 100 Percent raulic behav 2 submerged t X of cha ath. Run 3, , surface of s submerged 0 75 100 | very little ncreased me subm ows. All For runs 26 14 26 10 11 27 12 13 27 30 itr: Flon i the gra nnel widd all of g water s , surface 31 10 29 | effect on in depth erged but these run 11 and 12 .000 .000 .000 .000 .000 .000 .000 .0 | the stems with each remained s had fair the surfa 2.51 2.36 2.62 2.44 2.61 3.41 4.32 5.29 7.59 9.07 15.3 xperiment grass for enter of ch see erged but uns 4 and fairly roun 5.94 7.64 14.0 | or leave run ar erect an ly smoot 568 516 574 .545 .423 .338 278 .195 .164 .0998 1, 1940 run 1 b hannel f flows w waving 5, all gh. .182 .193 .0994 |
| reen grass wi oot; average ent Bermuda stablished by faintenance; aused by eros 2 3 4 5 6 7 8 9 10 11 12 Channel Description of preen grass w toot; average ent Bermuda ished by solid | th 36.0 cub length 17.5 ; upright a , solid soc removed ob- sion of pre- 8-6 8-6 8-6 8-6 8-6 8-6 8-6 8-6 8-6 8- | ic inches; c inches; c it beginnin ding in t d grass an vious testin .0802 .128 .160 .208 .208 .259 .350 .492 .664 .990 1.28 2.80 : Heavy u bic inches; 7 inches; d t start of n spring o .0572 .516 | of forage 1 omposition g of testin he spring d filled la g. | 2007 square 100 per- ng. Grass of 1940. rger holes 219 247 286 298 336 426 555 709 1.03 1.26 2.35 Bed nd of long per square a 100 per- rass estab- 430 1.06 | throu Runs more wavi: wate: flow .0209 .0211 .0211 .0211 .0215 .0214 .0190 .0187 .0191 .0193 .0193 Slope 4.06 Hyda run abou smoo flow, grass .0402 .0399 | Igh 5 with y 6 6 to 10 it 9 grass beca ng in the fi r surfaces. were rough 0 0 0 10 25 50 70 90 100 100 100 100 100 100 100 | very little ncreased me subm ows. All For runs 26 14 26 10 11 27 12 13 27 27 30 lor: Flon l the gra nnel wid all of g water s , surface 31 10 | effect on in depth erged but these run 11 and 12 .000 .000 .000 .000 .000 .000 .000 .0 | the stems with each remained s had fairi the surfact 2.51 2.36 2.62 2.44 2.61 3.41 4.32 5.29 9.07 15.3 xperiment grass for enter of ch erged but uns 4 and fairly roug 5.94 7.64 | or leave run ar erect ar ly smoot ces of th .503 .566 .516 .574 .545 .423 .338 .278 .195 .164 .0994 1, 1940 run 1 b hannel f flows w waving 5, all gh. .182 .173 |
| reen grass wi oot; average eent Bermuda, stabilshed by Maintenance, : aused by eros 2 3 4 5 6 7 8 9 10 11 12 Channel Description of green grass w foot; average cent Bermuda lished by solid | th 36.0 cub length 17.5 ; upright a solid soc removed ob- sion of prev- 8-6 8-6 8-6 8-6 8-6 8-6 8-6 8-6 8-6 8- | ic inches; c inches; c it beginnin digrass an vious testin .0802 .128 .160 .208 .259 .350 .492 .664 .990 1.26 2.80 : Heavy u bic inches; 7 inches; 6 at start of n spring o .0572 .516 1.52 3.00 | of forage 1 omposition g of testin he spring d filled la g. | er square 100 per- ng. Grass of 1940. rger holes 219 247 286 298 .336 .428 .555 .709 1.03 1.26 2.35 Bed nd of long per square n 100 per- rass estab- .430 1.06 2.28 3.67 4.79 | throu Runs more wavi: wate: flow .0209 .0211 .0215 .0214 .0190 .0193 .0194 .0193 .0194 .0193 Slope 4.06 Hydu run abou smoo flow, grass .0399 .0400 .0401 | Igh 5 with y is 6 to 10 it grass beca ng in the fl r surfaces. were rough 0 0 0 10 25 50 70 90 100 100 100 100 100 100 100 | very little ncreased me subm ows. All For runs 26 14 26 10 11 27 30 27 30 dor: Flon 1 the gra nnel wid all of g water s , surface 31 10 29 33 | effect on in depth erged but these run 11 and 12 .000 .000 .000 .000 .000 .000 .000 .0 | the stems with each remained s had fair the surfa 2.51 2.36 2.62 2.44 2.61 3.41 4.32 5.29 7.59 9.07 15.3 xperiment grass for enter of ch sof these erged but uns 4 and fairly rout 5.94 7.64 14.0 20.0 | or leave run ar erect ar ly smood ces of th .503 .566 .574 .545 .423 .338 .278 .195 .164 .0999 I, 1940 run 1 b tannel f flows w waving 5, all gh. .182 .173 .0994 .0015 |

Table 3.—Results of Tests of Channels Lined with Long Bermuda Grass—(Continued).

| Run Date Discharge per foot of width, VD Depth, D Mean, VD Mean, VD Effective alope alope submergence submergence flow Chery, C | ents |
|---|-----------------------------------|
| Run Date Discharge per foot of width, VD Depth, D Depth, D Mean velocity, V Vegetationn submergende submergende flow Chezy, C | Manning, n |
| 1 2 3 4 5 6 7 8 9 10 | 11 |
| Cu. ft. Ft. per Ft. per In per per sec. Feet sec. ft. Percent Min. hr. | |
| 1 8-9 .0245 .161 .152 .0377 0 40 .000 1.98 | .57 |
| 2 8-9 .0579 .253 .229 .0374 0 32 .000 2.38 | .50 |
| 3 8-9 .0794 .324 .245 .0382 0 25 .000 2.22 | .56 |
| 4 8-9 .135 .416 .324 .0384 10 18 .000 2.59 | .50 |
| 5 8-9 .196 .490 .400 .0374 25 11 .000 2.96 | .44 |
| 6 8-9 452 .568 .796 .0366 50 16 .000 5.54 | .24 |
| 7 8-9 .815 .627 1.30 .0370 80 17 .000 8.54 | .16 |
| 8 8-9 1.25 .694 1.80 .0364 95 10 .000 11.4 | .12 |
| 9 8-9 1.59 .733 2.17 .0368 100 10 .000 13.3 | .10 |
| 10 8-9 1.95 .777 2.51 .0368 100 10 .000 14.9 | .096 |
| 11 8-9 2.56 .827 3.09 .0369 100 26 .089 17.8 | .08 |
| 12 8-9 3.19 .877 3.64 .0373 100 24 .075 20.2 | .07 |
| 13 8-9 4.62 1.02 4.53 .0374 100 24 .051 23.3 | .06 |
| nannel 7A Bed Slope 7.01 Percent Experiment 1, | 1940 |
| iption of vegetation: Heavy uniform stand of long grass with 33.1 cubic inches of forage per square average length 15.3 inches; composition 100 percent ida; upright at start of testing. Grass established id sodding in spring 1940. Hydraulic behavior: Flow through grass for run 2, stream down center of channel that had grass su for over half of channel width, surface of water Run 3, grass submerged, surface of flow slight Runs 4 and 5, surface of flow rough with wav large. Runs 6 and 7, apparently high surface surface of flow very rough. | bmerg smoo y roug es fai |
| 1 9-2 .0578 .091 .635 .0707 0 30 .000 7.99 | .128 |
| 2 9-2 .480 .513 .936 .0707 50 12 .000 4.93 | .271 |
| 3 9-2 1.50 .628 2.39 .0700 90 12 .342 11.4 | .121 |
| 4 9-2 5.02 .897 5.60 .0716 100 31 .208 22.0 | .066 |
| U44 004, 16 001 0110, 0010 <u>4-0</u> z | .057 |
| | |
| | .054 |

Table 3.—Results of Tests of Channels Lined with Long Bermuda Grass—(Continued).

Description of vegetation: Good uniform stand of long green grass with 17.2 cubic inches of forage per square foot; average length 14.0 inches; composition 100 percent Bermuda; upright at beginning of testing. Grass established by solid sodding in spring of 1940. Maintenance, removed old grass and filled larger holes caused by érosion of previous testing. Hydraulic behavior: Flow entirely through grass for runs 2 through 4. Grass started bending under flow with run 5 and continued being submerged by runs 6 and 7 with stems remaining erect or waving in the flow; flow surfaces fairly smooth. Runs 8 and 9 submerged most of the grass; surfaces of flows fairly rough. Runs 10, 11 and 12, surface of flows rough to very rough.

| Channel 10B | | | | Bed Slo | pe 10.2 Per | cent | | Ex | periment l | , 1940 |
|-------------|------|-------|------|---------|-------------|------|----|------|------------|--------|
| 12 | 8-16 | 6.49 | .936 | 6.93 | .0697 | 100 | 26 | .112 | 27.1 | .054 |
| 11 | 8-16 | 3.61 | .746 | 4.84 | .0702 | 100 | 22 | .039 | 21.2 | .067 |
| 10 | 8-16 | 1.74 | .561 | 3.10 | .0703 | 100 | 23 | .038 | 15.6 | .086 |
| 9 | 8-16 | 1.22 | .543 | 2.24 | .0706 | 98 | 12 | .000 | 11.5 | .119 |
| 8 | 8-16 | 1.00 | .477 | 2.10 | .0706 | 90 | 10 | .000 | 11.5 | .115 |
| 7 | 8-16 | .623 | .427 | 1.46 | .0704 | 75 | 18 | .000 | 8.44 | .153 |
| 6 | 8-15 | .345 | .408 | .846 | .0713 | 50 | 19 | .000 | 4.99 | .260 |
| 5 | 8-15 | .216 | .360 | .601 | .0708 | 25 | 19 | .037 | 3.78 | .335 |
| 4 | 8-15 | .134 | .278 | .482 | .0708 | 10 | 24 | .000 | 3.45 | .352 |
| 3 | 8-15 | .0737 | .197 | .374 | .0705 | 0 | 20 | .000 | 3.19 | .358 |
| 2 | 8-15 | .0237 | .094 | .252 | .0700 | 0 | 20 | .000 | 3.10 | .324 |

Description of vegetation: Heavy uniform stand of long green grass with 25.9 cubic inches of forage per square foot; average length 11.7 inches; composition 100 percent Bermuda; upright at beginning of testing. Grass established by solid sodding in spring of 1940.

.

Hydraulic behavior: Flow through grass for run 1. Run 2, stream down center of channed had grass submerged for over half of channel width, surface of water smooth. Run 3, grass submerged, surface of flow slightly rough. Runs 4 and 5, surface of flow rough with waves fairly large. Runs 6 and 7, apparently high surface velocity, surface of flow very rough.

| Channel 1 | 0B, cont. | | | | | | | | Coeffic | ients |
|-----------|-----------|---------------------------------------|----------|---------------------|--------------------|---------------------------|---------------------|----------------------|----------|--------------|
| Run | Date | Discharge per foot of width, VD | Depth, D | Mean velocity, V | Effective slope | Vegetation aubmergence | Duration of flow | Av. rate of scour | Chezy, C | Manning, n . |
| 1 | 2 | 8 | 4 | 5 | 6 | 7. | 8 | 9 | 10 | ц |
| | | Cu. ft. per sec. | Feet | Pt. per sec. | Pt. per ft. | Percent | Min. | In. per hr. | | |
| 1 | 8-30 | .253 | ,295 | .858 | .101 | 0 | 26 | .000 | 4.98 | .244 |
| 2 | 8-30 | .517 | .359 | 1,44 | .102 | 60 | 14 | .000 | 7.54 | .166 |
| 3 | 8-30 | 1.55 | .471 | 3.30 | .102 | 100 | 33 | .044 | 15.1 | .087 |
| 4 | 8-30 | 5.06 | .730 | 6.93 | .102 | 100 | 33 | .251 | 25.5 | .055 |
| 5 | 8-30 | 7.27 | .893 | 8.14 | .102 | 100 | 34 | .383 | 27.0 | .054 |
| 6 | 8-30 | 9.72 | 1.00 | 9.72 | .100 | 100 | 35 | .290 | 30.7 | .048 |
| 7 | 8-30 | 12.2 | 1.15 | 10.6 | .102 | 100 | 27 | .280 | 31.1 | .049 |
| Channel 3 | 10E · | | | Bed Slo | pe 10.1 Pe | rcent | | Ex | periment | l, 1941 |

Table 3.—Results of Tests of Channels Lined with Long Bermuda Grass—(Continued).

Description of vegetation: Good uniform stand of long green grass with 19.8 cubic inches of forage per square foot; average length 12.1 inches; composition 100 percent Bermuda; upright at beginning of testing. Grass established by solid sodding in the spring of 1940. Maintenance, removed old grass and filled larger holes caused by erosion of previous preliminary testing. Hydraulic behavior: Flow through grass for runs 1 through 4 causing very little effect on the grass. Runs 5 and 6, stream flowed along center of channel, submerged part of grass which remained partially erect. under the flow. Runs 7, 8 and 9 submerged grass along center line, the surface of the flows was rough. Runs 10 and 11 submerged all grass and surfaces of flows were very rough with some foam riding the surface.

| 8-23 | .0118 | .046 | .256 | .101 | 0 | 50 | .000 | 3.76 | .240 |
|------|--|--|---|--|---|---|---|---|---|
| 8-23 | .0683 | .106 | .644 | .102 | 0 | 18 | .000 | 6.26 | .166 |
| 8-23 | .135 | .205 | .657 | .102 | 0 | 12 | .162 | 4.58 | .255 |
| 8-23 | .186 | .246 | .756 | .102 | 10 | 20 | .054 | 4.81 | .250 |
| 8-23 | .247 | .306 | .807 | .102 | 20 | 12 | .120 | 4.61 | .272 |
| 8-23 | .293 | .332 | .883 | .103 | 30 | 14 | .000 | 4.82 | .266 |
| 8-23 | .570 | .393 | 1.45 | .103 | 50 | 10 | .085 | 7.26 | .178 |
| 8-23 | .817 | .444 | 1.84 | .102 | 75 | 9 | .120 | 8.69 | .152 |
| 8-23 | 1.15 | .488 | 2.35 | | | 9 | .000 | 10.5 | .127 |
| 8-23 | 3.65 | .713 | 5.12 | | 100 | | .169 | 19.1 | .0740 |
| 8-23 | 7.42 | .969 | 7.66 | .0988 | 100 | 27 | .320 | 24.8 | .0599 |
| | 8-23 8-23 8-23 8-23 8-23 8-23 8-23 8-23 | 8-23 .0683 8-23 .135 8-23 .186 8-23 .247 8-23 .293 8-23 .570 8-23 .817 8-23 1.15 8-23 3.65 | 8-23 .0683 .106 8-23 .135 .205 8-23 .186 .246 8-23 .247 .306 8-23 .293 .332 8-23 .570 .393 8-23 .817 .444 8-23 1.15 .488 8-23 3.65 .713 | 8-23 .0683 .106 .644 8-23 .135 .205 .657 8-23 .186 .246 .756 8-23 .247 .306 .807 8-23 .293 .332 .883 8-23 .570 .393 1.45 8-23 .817 .444 1.84 8-23 1.15 .488 2.35 8-23 3.65 .713 5.12 | $\begin{array}{c ccccccccccccccccccccccccccccccccccc$ | 8-23 .0683 .106 .644 .102 0 8-23 .135 .205 .657 .102 0 8-23 .136 .246 .756 .102 10 8-23 .247 .306 .807 .102 20 8-23 .293 .332 .883 .103 30 8-23 .570 .393 1.45 .103 50 8-23 .817 .444 1.84 .102 75 8-23 1.15 .488 2.35 .102 98 8-23 3.65 .713 5.12 .101 100 | $\begin{array}{c ccccccccccccccccccccccccccccccccccc$ | $\begin{array}{c ccccccccccccccccccccccccccccccccccc$ | $\begin{array}{c ccccccccccccccccccccccccccccccccccc$ |

BERMUDA GRASS, SHORT

Table 4.—Results of Tests of Channels Lined with Short Bermuda Grass.

| Channel 1C | | | | Bed Sl | ope 0.96 Per | rcent | | Ex | periment S | 3, 1942 |
|------------|------|---------------------------------------|----------|---------------------|--------------------|---------------------------|---------------------|----------------------|------------|------------|
| _ | | _ | | | | | | | Coeffic | lents |
| Run | Date | Discharge per foot of width, VD | Depth, D | Mean velocity, V | Effective slope | Vegetation submergence | Duration of flow | Av. rate of scour | Chezy, C | Manning, n |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
| | | Cu. ft. per sec. | Peet | Ft. per sec. | Ft. per ft. | Percent | Min, | In. per hr. | | |
| 1 | 8-5 | .0180 | .161 | .112 | .0099 | 30 | 40 | .000 | 2.80 | .394 |
| 2 | 8-5 | .0495 | .262 | .189 | .0101 | 70 | 8 | .046 | 3.71 | .325 |
| 3 | 8-5 | .116 | .325 | .357 | .0102 | 90 | 8 | .046 | 6.28 | .198 |
| 4 | 8-5 | .208 | .374 | .555 | .0103 | 95 | 13 | .136 | 9.01 | .141 |
| 5 | 8-5 | .360 | .440 | .819 | .0103 | 100 | 10 | .120 | 12.2 | .107 |
| 6 | 8-5 | 526 | .496 | 1.06 | .0102 | 100 | 11 | .000 | 14.8 | .089 |
| 7 | 8-5 | .686 | .540 | 1.27 | .0102 | 100 | 12 | .000 | 17.2 | .078 |
| 8 | 8-5 | .866 | .585 | 1.48 | .0102 | 100 | 11 | .033 | 19.1 | .070 |
| 9 | 8-5 | 1.10 | .633 | 1.73 | .0102 | 100 | 11 | .080 | 21.6 | .063 |
| 10 | 8-5 | 1.54 | .720 | 2.14 | .0102 | 100 | 12 | .042 | 25,0 | .056 |
| 11 | 8-5 | 3.11 | .946 | 3.29 | .0101 | 100 | 15 | .154 | .23.8 | .043 |

Description of vegetation: Good uniform stand of short green grass with 939 stems per square foot; average length 2.63 inches; composition 100 percent Bermuda; upright at start of testing. Grass established by solid sodding in spring 1940. Old grass removed and channel grade reestablished by filling low places with soll. Hydraulic behavior: Flow well up on grass for runs 1, 2 and 3 but grass remained erect causing only small ripples on surface. Runs 4, 5, 6 and 7, surface of flow increased in roughness but surface very steady. Surface of flow rough for runs 8, 9, 10 and 11.

| | L | | | Bed Slop | pe 2.00 Per | rcent | • | E | xperiment | 3, 1942 |
|---|--|--|---|--|---|--|--|---|---|--|
| | | | | | | | | | Coeffi | cients |
| | · · | 2 | | > | | Vegetätion submergence | | 5 | | 4 |
| | | Discharge per foot o width, VD | A | ~ | 0 | 10 I I OI | E > | | Ö | b ú |
| | | ਵੈੱਟ ਜ | ส์ | 4 <u>5</u> | ÷. | a a | a te | Ĕ. | N | - Te |
| Run | Date | is is the second s | Depth, | Mean velocity, | Effective slope | . agu | Duration of flow | Av. rate scour | Chezy, | Manning. |
| - | | | | | | | | < <u>2</u> | ច | <u>×</u> |
| 1 | 2 | 3 Cu. ft. | 4 | 5 Ft. per | 6 | 7 | 8 | 9 | 10 | 11 |
| _ | | per sec. | Feet | 50C. | Ft. per ft. | Percent | Min. | In. per hr. | | |
| escription of nort green gr ge length 2.42 pright at sta odding in sp nannel grade pil. | ass with 85 inches; count of testing ring of 19 | 6 stems pe nposition I ng. Grass 940. Old | er square f 00 percent establishe grass rem | oot; aver- Bermuda; d by solid loved and | and 3 on su grass | aulic behavi 3 over all gra 11 over all gra 11 over all gra 11 over all grand 11 ove | ass for ru of grass but surfa | ns 4, 5 and erect in | 16 with sm flow. Run | uall ripple is 7 to 1 |
| | 8-6 | .0208 | .0948 | .219 | .0207 | 50 | 20 | 000 | <u> </u> | 910 |
| 1 2 | 8-6 | .0208 | .155 | .210 | .0207 | 50 75 | 10 | .000 .035 | 5.08 4.65 | .212 |
| | | .0403 | .135 | .340 | .0204 | 15 80 | 10 | | 4.65 | .239 |
| 3 | 8-6 | | .202 | | .0204 | | | .070 | 5.64 | .202 |
| 4 [′] | 8-6 | .0873 | | .432 | .0205 | 95 100 | 11 | .080 | 6.77 | .171 |
| 5 | 8-6 | .104 | .213 | .487 | | 100 | 10 | .035 | 7.43 | .156 |
| 6 | 8-6 | .186 | .255 | .730 | .0204 | 100 | 18 | .140 | 10.2 | .118 |
| 7 | 8-6 | .326 | .302 | 1.08 | .0205 | 100 | 10 | .035 | 13.8 | .0893 |
| 8 | 8-6 | .645 | .384 | 1.68 | .0205 | 100 | 11 | .067 | 19.1 | 0670 |
| 9. | 8-6 | 1.76 | .548 | 3.21 | .0198 | 100 | 13 | .000 | 31.0 | .0437 |
| 10 | 8-6 | 3.12 | .704 | 4.44 | .0198 | 100 | 11 | .033 | 37.8 | .0372 |
| 11 | 8-6 | 5.94 | .986 | 6.02 | .0199 | 100 | 12 | .000 | 43.1 | .0345 |
| Channel 4H | 7 | | • | Bed Sloj | pe 3.86 Per | rcent | | E | xperiment | 3, 1942 |
| pright at sta odding in sp nannel grade | nt of testing oring of 1 | ng. Grass 940. Old | establishe grass rem | loved and | Surfa | over grass uce of flow e in depth u | increased | i in rough | hness with | each in |
| oright at sta odding in sy nannel grade il. | nt of testin pring of 1 reestablish | ng. Grass 940. Old ned by fill | establishe grass rem ing low p | d by solid loved and laces with | Surfa crease | e in depth | increased until runs | i in roug 8 and 9 | hness with were very | each ir rough. |
| bright at sta dding in sy nannel grade il. 1 | nt of testin pring of 1 reestablish 8-12 | ng. Grass 940. Old hed by fill | establishe grass rem ing low p .124 | d by solid loved and laces with .221 | Surfa crease .0382- | e in depth t | increased until runs 35 | i in roug 8 and 9 .000 | hness with were very 3.24 | each ir rough. |
| oright at sta oright at sta sinannel grade il. 1 2 | nt of testin pring of 1 reestablish 8-12 8-12 | ng. Grass 940. Old Led by fill .0274 .0738 | establishe grass rem ing low p .124 .180 | d by solid loved and laces with .221 .410 | Surfa creas .0382- .0379 | e in depth of flow | increased until runs 35 16 | l in roug 8 and 9 .000 .000 | hness with were very 3.24 5.01 | each ir rough. .333 .228 |
| right at sta dding in sg annel grade il. 1 2 3 | nt of testin pring of 1 reestablish 8-12 8-12 8-12 | ng. Grass 940. Old hed by fill | establishe grass rem ing low p .124 .180 .226 | d by solid loved and laces with .221 .410 .756 | Surfa creas .0382- .0379 .0377 | uce of flow e in depth t 0 50 90 | increased until runs 35 16 16 | l in roug 8 and 9 .000 .000 .022 | hness with were very 3.24 5.01 8.29 | each ir rough. .333 .228 .144 |
| right at sta dding in sp annel grade ll. 1 2 3 4 | nt of testin pring of 1 reestablish 8-12 8-12 8-12 8-12 8-12 | ng. Grass 940. Old 1ed by fill .0274 .0738 .171 .403 | establishe grass rem ing low p .124 .180 .226 .282 | d by solid noved and laces with .221 .410 .756 1.43 | Surfa crease .0382- .0379 .0377 .0379 | 0 50 90 100 | increased until runs 35 16 16 32 | l in roug 8 and 9 .000 .000 .022 .034 | hness with were very - 3.24 5.01 8.29 14.0 | each ir rough. 333 .228 .144 .0878 |
| pright at sta dding in sp annel grade il. 1 2 3 4 5 | nt of testin pring of 1 reestablish 8-12 8-12 8-12 8-12 8-12 8-12 | ng. Grass 940. Old 1ed by fill .0274 .0738 .171 .403 .821 | establishe grass rem ing low p .124 .180 .226 .282 .354 | d by solid noved and laces with .221 .410 .756 1.43 2.32 | Surfa crease .0382- .0379 .0377 .0379 .0379 .0382 | 0 50 90 100 100 | increased until runs 35 16 16 16 32 29 | l in roug 8 and 9 .000 .000 .022 .034 .012 | hness with were very - 3.24 5.01 8.29 14.0 20.1 | each ir rough. .333 .228 .144 .0878 .0631 |
| pright at sta dding in sr iannel grade il. 1 2 3 4 5 6 | nt of testin pring of 1 reestablish 8-12 8-12 8-12 8-12 8-12 8-12 | ng. Grass 940. Old hed by fill .0274 .0738 .171 .403 .821 1.94 | establishe grass rem ing low p .124 .180 .226 .282 .354 .490 | d by solid loved and laces with .221 .410 .756 1.43 2.32 3.97 | Surfa crease .0382- .0379 .0377 .0379 .0382 .0382 | 0 50 90 100 100 100 | increased until runs 35 16 16 32 29 30 | i in rougi 8 and 9 .000 .000 .022 .034 .012 .029 | hness with were very 3.24 5.01 8.29 14.0 20.1 28.9 | each ir rough. .333 .228 .144 .0878 .0631 .0458 |
| right at sta dding in sr annel grade 11. 1 2 3 4 5 6 7 | nt of testin pring of 1 reestablish 8-12 8-12 8-12 8-12 8-12 8-12 8-12 8-12 | ng. Grass 940. Old Led by fill .0274 .0738 .171 .403 .821 1.94 3.22 | establishe grass rem ing low p .124 .180 .226 .282 .354 .490 .623 | d by solid loved and laces with .221 .410 .756 1.43 2.32 3.97 5.17 | Surfa crease .0382- .0379 .0377 .0379 .0382 .0382 .0387 .0390 | 0 50 90 100 100 100 100 | increased intil runs 35 16 16 16 32 29 30 29 | l in rougi 8 and 9 .000 .022 .034 .012 .029 .000 | hness with were very 3.24 5.01 8.29 14.0 20.1 28.9 33.2 | each ir rough. .333 .228 .144 .0878 .0631 .0458 .0413 |
| right at sta dding in sr annel grade 11. 1 2 3 4 5 6 | nt of testin pring of 1 reestablish 8-12 8-12 8-12 8-12 8-12 8-12 | ng. Grass 940. Old hed by fill .0274 .0738 .171 .403 .821 1.94 | establishe grass rem ing low p .124 .180 .226 .282 .354 .490 | d by solid loved and laces with .221 .410 .756 1.43 2.32 3.97 | Surfa crease .0382- .0379 .0377 .0379 .0382 .0382 | 0 50 90 100 100 100 | increased until runs 35 16 16 32 29 30 | i in rougi 8 and 9 .000 .000 .022 .034 .012 .029 | hness with were very 3.24 5.01 8.29 14.0 20.1 28.9 | each ir rough. |
| right at sta dding in sr annel grade 11. 1 2 3 4 5 6 7 8 9 | nt of testin pring of 1 reestablish 8-12 8-12 8-12 8-12 8-12 8-12 8-12 8-12 | ng. Grass 940. Old by fill .0738 .171 .403 .821 1.94 3.22 5.73 | establishe grass rem ing low p .124 .180 .226 .282 .354 .490 .623 .826 | d by solid loved and laces with .221 .410 .756 1.43 2.32 3.97 5.17 6.94 8.52 | Surfa crease .0382- .0379 .0377 .0379 .0382 .0387 .0390 .0392 .0391 | 0 50 90 100 100 100 100 100 100 | increased intil runs 35 16 16 16 32 29 30 29 30 29 35 | l in rougi 8 and 9 .000 .000 .022 .034 .012 .029 .000 .056 .062 | hness with were very - 3.24 5.01 8.29 14.0 20.1 28.9 33.2 38.6 43.0 | each in rough. |
| bright at sta dding in sp nannel grade il. 1 2 3 4 5 6 7 8 9 Channel 5A | nt of testin pring of 1 reestablish 8-12 8-12 8-12 8-12 8-12 8-12 8-12 8-12 8-12 8-12 8-12 8-12 | ng. Grass 940. Old hed by fill .0738 .171 .403 .821 1.94 3.22 5.73 8.60 | establishe grass rem ing low p .124 .180 .226 .282 .354 .490 .623 .826 1.01 | d by solid loved and laces with .221 .410 .756 1.43 2.32 3.97 5.17 6.94 8.52 Bed Slop | Surfa crease .0382- .0379 .0379 .0379 .0382 .0387 .0390 .0390 .0391 pe 5.19 Pei | 0 50 90 100 100 100 100 100 100 100 100 | increased until runs 35 16 16 32 29 30 29 30 29 35 35 | l in rougi 8 and 9 .000 .000 .022 .034 .012 .029 .000 .056 .062 E: | hness with were very 3.24 5.01 8.29 14.0 20.1 28.9 33.2 38.6 43.0 xperiment | each ir rough. .333 .228 .144 .0878 .0631 .0458 .0413 .0413 .0373 .0347 1, 1942 |
| right at sta dding in sp annel grade il. 1 2 3 4 5 6 7 8 9 Channel 5A escription of een grass w ngth 2.62 in vright at sta | nt of testin pring of 1 reestablish 8-12 8-1 | 1g. Grass 940. Old .ed by fill .0274 .0738 .171 .403 .821 1.94 3.22 5.73 8.60 Good un ems per s position 100 ng. Grass | establishe grass rem ing low p .124 .180 .226 .282 .354 .490 .623 .826 1.01 iform stan quare foot 0 percent | d by solid loved and laces with .221 .410 .756 1.43 2.32 3.97 5.17 6.94 8.52 Bed Slop d of short ; average Bermuda; | Surfa crease .0382- .0379 .0379 .0379 .0382 .0390 .0390 .0392 .0391 pe 5.19 Per Hydra runs Rippl surfae | 0 50 90 100 100 100 100 100 100 | increased until runs 35 16 16 16 32 29 30 29 35 35 35 ior: Flow 4 with 1 ge for run | d in rougi 8 and 9 .000 .000 .022 .034 .012 .029 .000 .056 .062 E: 7 through miform st as 5 and 6. | hness with were very - 3.24 5.01 8.29 14.0 20.1 28.9 33.2 38.6 43.0 xperiment and over urface, sma Runs 7 to | each ir rough. |
| right at sta dding in sg annel grade il. 1 2 3 4 5 6 7 8 9 Channel 5A escription of een grass w ngth 2.62 in oright at sta dding in the | A vegetation: vring of 1 reestablish 8-12 8- | 1g. Grass 940. Old 1ed by fill .0274 .0738 .171 .403 .821 1.94 3.22 5.73 8.60 Good un ems per s tostion 100 ng. Grass 1942. .0217 | establishe grass rem ing low p .124 .180 .226 .282 .354 .490 .623 .826 1.01 .01 .101 .104 | d by solid laces with .221 .410 .756 1.43 2.32 3.97 5.17 6.94 8.52 Bed Slop d of short ; average Bermuda; d by solid | Surfa crease .0382- .0379 .0377 .0379 .0382 .0387 .0390 .0392 .0391 pe 5.19 Pei Hydra runs Rippl surfa runs .0518 | 0 50 90 100 100 100 100 100 100 100 100 100 | increased intil runs 35 16 16 32 29 30 29 35 35 35 ior: Flow 4 with t ge for run th appare 35 | d in rougi 8 and 9 .000 .000 .022 .022 .029 .000 .056 .062 E: 7 through miform st us 5 and 6. ently high .000 | hness with were very - 3.24 5.01 8.29 14.0 20.1 28.9 33.2 38.6 43.0 xperiment and over urface, sma Runs 7 to surface very | each ir rough. .333 .228 .144 .0878 .0631 .0458 .0413 .0373 .0347 1, 1942 grass fo .11 ripples > 10, wate elocity fo .360 |
| right at sta dding in sp annel grade il. 1 2 3 4 5 6 7 8 9 Channel 5A scription of een grass w ngth 2.62 in nright at sta dding in the 1 2 | A spring of testing of 1 reestablish 8-12 8-12 8-12 8-12 8-12 8-12 8-12 8-12 | 1g. Grass 940. Old 1ed by fill .0274 .0738 .171 .403 .821 1.94 3.22 5.73 8.60 Good un ems per s position 100 1g. Grass 1942. .0217 .0625 | establishe grass rem ing low p .124 .180 .226 .282 .354 .490 .623 .826 1.01 .101 .101 .101 .104 .165 | d by solid laces with .221 .410 .756 1.43 2.32 3.97 5.17 6.94 8.52 Bed Slop d of short ; average Bermuda; d by solid .209 .379 | Surfa crease .0382- .0379 .0379 .0379 .0382 .0390 .0390 .0390 .0391 pe 5.19 Per Hydra runs Rippl surfa runs Rippl Surfa surfa runs .0518 .0517 | uce of flow e in depth 0 50 90 101 0 75 | increased until runs 35 16 16 16 32 29 30 29 35 35 35 35 4 with u ge for run th appare 35 20 | l in rougi 8 and 9 .000 .000 .022 .034 .012 .029 .000 .056 .062 E: 7 through miform su is 5 and 6. ently high .000 .000 | hness with were very 3.24 5.01 8.29 14.0 20.1 28.9 33.2 38.6 43.0 xperiment and over urface, sma Runs 7 to surface very 2.84 4.10 | each ir rough. 333 .228 .144 .0878 .0631 .0458 .0413 .0373 .0347 1, 1942 grass for .10, wate elocity for .360 .269 |
| right at sta dding in sp annel grade il. 1 2 3 4 5 6 7 8 9 Channel 5 A escription of een grass w ngth 2.62 in right at sta dding in the 1 2 3 | nt of testin pring of 1 reestablish 8-12 8-17 8-17 8-17 8-17 8-17 8-17 8-17 8-17 8-17 8-17 8-17 | 1g. Grass 940. Old 1ed by fill .0738 .171 .403 .821 1.94 3.22 5.73 8.60 Good un ems per s position 100 1g. Grass 1942. .0217 .0625 .162 | establishe grass rem ing low p .124 .180 .226 .282 .354 .490 .623 .826 1.01 iform stan quare food 0 percent establishe .104 .165 .216 | d by solid noved and laces with .221 .410 .756 1.43 2.32 3.97 5.17 6.94 8.52 Bed Slop d of short ; average Bermuda; d by solid .209 .379 .752 | Surfa crease .0382- .0379 .0379 .0379 .0382 .0390 .0390 .0390 .0390 .0391 pe 5.19 Pei Hydra runs Rippl surfae runs .0518 .0517 .0515 | uce of flow e in depth 0 50 90 10 0 | increased until runs 35 16 16 32 29 30 29 30 29 35 35 35 35 ior: Flow 4 with t ge for run th appare 35 20 18 | d in rougi 8 and 9 .000 .002 .022 .034 .012 .029 .000 .056 .062 E: through miform su is 5 and 6. ently high .000 .000 .000 .000 .000 .000 .000 .020 | hness with were very • 3.24 5.01 8.29 14.0 20.1 28.9 33.2 38.6 43.0 xperiment and over urface, sma Runs 7 to surface very 2.84 4.10 7.15 | each ir rough. .333 .228 .144 .0631 .0458 .0413 .0373 .0347 1, 1942 grass fo .10, wate elocity fo .360 .269 .162 |
| right at sta iding in sp annel grade 1. 1 2 3 4 5 6 7 8 9 Channel 5A escription of een grass w agth 2.62 in right at sta idding in the 1 2 3 4 | nt of testin pring of 1 reestablish 8-12 8-17 8-17 8-17 8-17 8-17 8-17 8-17 | ng. Grass 940. Old hed by fill .0274 .0738 .171 .403 .821 1.94 3.22 5.73 8.60 Good un ems per s sosition 100 ng. Grass 1942. .0217 .0625 .162 1.06 | establishe grass rem ing low p .124 .180 .282 .282 .354 .490 .623 .826 1.01 .01 .01 .01 .01 .01 .01 .04 .165 .216 .372 | d by solid loved and laces with .221 .410 .756 1.43 2.32 3.97 5.17 6.94 8.52 Bed Slop d of short ; average Bermuda; d by solid .209 .379 .752 2.84 | Surfa crease .0382- .0379 .0379 .0379 .0382 .0387 .0390 .0390 .0390 .0391 pe 5.19 Pei Hydra runs Rippl surfa runs .0518 .0515 .0516 | 0 50 90 100 100 100 100 100 100 100 100 100 100 100 100 100 100 100 100 100 100 100 100 100 100 100 100 100 rcent | increased intil runs 35 16 16 32 29 30 29 30 29 35 35 35 ior: Flow 4 with t ge for run th appare 35 20 18 30 | d in rougi 8 and 9 .000 .000 .022 .034 .012 .029 .000 .056 .062 E: through inform st inform st inform st .000 .000 .000 .000 .000 .000 .000 .020 .017 | hness with were very 3.24 5.01 8.29 14.0 20.1 28.9 33.2 38.6 43.0 xperiment and over irface, sma Runs 7 to surface very 2.84 4.10 7.15 13.6 | each ir rough. .333 .228 .144 .0878 .0631 .0458 .0413 .0373 .0347 1, 1942 grass fo .11 ripple > 10, wate elocity fo .269 .162 .0891 |
| right at sta dding in sr annel grade il. 1 2 3 4 5 6 7 8 9 Channel 5A scription of een grass w ngth 2.62 in right at sta dding in the 1 2 3 4 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 | nt of testin pring of 1 reestablish 8-12 8-17 8-17 8-17 8-17 8-17 8-17 8-17 8-17 8-17 8-17 8-17 8-17 8-17 | 1g. Grass 940. Old 1ed by fill .0274 .0738 .171 .403 .821 1.94 3.22 5.73 8.60 Good un ems per s 1005; 101 1g. Grass 1942. .0217 .0625 .162 1.06 1.06 | establishe grass rem ing low p .124 .180 .226 .282 .354 .490 .623 .826 1.01 .01 .01 .01 .01 .01 .01 .01 .01 .0 | d by solid laces with .221 .410 .756 1.43 2.32 3.97 5.17 6.94 8.52 Bed Sloj d of short ; average Bermuda; d by solid .209 .379 .752 2.84 2.84 | Surfa crease .0382- .0379 .0379 .0382 .0387 .0390 .0390 .0390 .0391 pe 5.19 Pee Hydra runs Rippl surfa runs .0518 .0515 .0516 .0519 | ce of flow e in depth of 50 90 100 100 100 100 100 100 100 100 rcent 1, 2, 3 and es fairly lar ce rough wi 9 and 10. 0 75 95 100 100 | increased intil runs 35 16 16 32 29 30 29 35 35 35 4 with 1 ge for run th appare 35 20 18 30 30 30 | d in rougi 8 and 9 .000 .000 .022 .034 .012 .029 .000 .056 .062 E: 7 through miform su is 5 and 6. ently high .000 .000 .000 .022 .034 | hness with were very 3.24 5.01 8.29 14.0 20.1 28.9 33.2 38.6 43.0 xperiment and over urface, sma Runs 7 to surface very 2.84 4.10 7.15 13.6 20.5 | each ir rough. |
| right at sta dding in sp annel grade il. 1 2 3 4 5 6 7 8 9 Channel 5 A Scription of een grass whogh 2.62 in right at sta dding in the 1 2 3 4 5 6 6 7 8 9 | nt of testin pring of 1 reestablish 8-12 8-17 8-17 8-17 8-17 8-17 8-17 8-17 8-17 8-17 8-17 8-17 8-17 8-17 8-17 8-17 8-17 8-17 8-17 | ng. Grass 940. Old 1.ed by fill .0274 .0738 .171 .403 .821 1.94 3.22 5.73 8.60 Good un ems per s position 100 ng. Grass 1942. .0217 .0625 .162 1.06 1.78 | establishe grass rem ing low p .124 .180 .226 .282 .354 .490 .623 .826 1.01 | d by solid laces with .221 .410 .756 1.43 2.32 3.97 5.17 6.94 8.52 Bed Slop d of short ; average Bermuda; d by solid .209 .379 .752 2.84 2.84 3.99 | Surfa crease .0382- .0379 .0379 .0379 .0382 .0390 .0390 .0392 .0391 pe 5.19 Pet Rippl surfa runs Rippl surfa runs .0518 .0518 .0515 .0516 .0519 .0521 | uce of flow e in depth 0 50 90 100 100 100 100 100 100 100 100 100 100 100 100 100 100 100 100 0 75 95 100 100 100 100 | increased until runs 35 16 16 32 29 30 29 35 35 35 35 4 with 1 ge for run th appart 35 20 18 30 30 30 30 | d in rougi 8 and 9 .000 .000 .022 .034 .012 .029 .000 .056 .062 E: through iniform st is 5 and 6. ently high .000 .020 .020 .021 .029 .022 .000 .020 .020 .000 .029 .029 | hness with were very 3.24 5.01 8.29 14.0 20.1 28.9 33.2 38.6 43.0 xperiment and over urface, sma Runs 7 tc surface very 2.84 4.10 7.15 13.6 20.5 26.1 | each ir rough. 333 .228 .144 .0878 .0631 .0458 .0413 .0373 .0347 1, 1942 grass fo ill ripples > 10, wate elocity fo .360 .269 .162 .0891 .0619 .0498 |
| right at sta dding in sp annel grade il. 1 2 3 4 5 6 7 8 9 Channel 5A 5 5 6 7 8 9 Channel 5A 2 2 3 4 4 5 5 4 dding in sp 3 4 5 5 6 7 8 9 1 2 2 3 4 5 5 6 7 8 9 1 2 2 3 4 5 7 8 9 1 2 2 3 4 5 7 8 9 1 2 2 3 4 5 7 7 8 9 1 2 2 3 4 5 7 7 8 9 1 Channel grade i 1 3 4 5 7 7 8 9 1 Channel grade i 1 3 4 5 7 7 8 9 1 Channel grade i 1 3 4 5 7 7 8 9 1 Channel 5 7 8 9 1 Channel 5 7 8 9 1 Channel 5 7 8 9 1 Channel 5 7 8 9 1 Channel 5 7 8 9 1 Channel 5 7 1 1 2 2 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 | A state of testing of 1 reestablish 8-12 8-12 8-12 8-12 8-12 8-12 8-12 8-12 | 1g. Grass 940. Old 1ed by fill .0274 .0738 .171 .403 .821 1.94 3.22 5.73 8.60 Good un ems per s 1942. .0217 .0625 .162 1.06 1.78 2.56 | establishe grass rem ing low p .124 .180 .226 .282 .354 .490 .623 .826 1.01 .01 .101 .101 .101 .105 .216 .372 .372 .447 .512 | d by solid laces with .221 .410 .756 1.43 2.32 3.97 5.17 6.94 8.52 Bed Slop d of short ; average Bermuda; d by solid .209 .379 .752 2.84 3.99 5.01 | Surfa crease .0382- .0379 .0379 .0379 .0382 .0390 .0390 .0390 .0391 pe 5.19 Per Hydra runs Rippl surfa runs .0518 .0516 .0516 .0519 .0521 .0522 | uce of flow e in depth 0 50 90 100 100 100 100 100 100 100 100 100 100 100 100 100 100 100 100 0 75 95 100 100 100 100 100 100 100 100 | increased until runs 35 16 16 32 29 30 29 35 35 35 35 35 35 35 35 35 35 35 20 18 30 30 30 30 30 32 | l in rougi 8 and 9 .000 .000 .022 .034 .012 .029 .000 .056 .062 E: 7 through miform su is 5 and 6. ently high .000 .020 .000 .022 .034 .012 .029 .029 .000 .020 .029 .029 .029 .029 .029 .029 .029 | hness with were very 3.24 5.01 8.29 14.0 20.1 28.9 33.2 38.6 43.0 xperiment and over urface, sma Runs 7 to surface very 2.84 4.10 7.15 13.6 20.5 28.1 30.7 | each ir rough. |
| pright at sta dding in sp annel grade il. 1 2 3 4 5 6 7 8 9 Channel 5A escription of een grass w oright at sta dding in the 1 2 3 4 5 6 7 8 9 Channel 5 4 5 6 7 8 9 Channel 5 4 5 6 7 8 9 Channel 5 4 5 6 7 8 9 Channel 5 4 5 6 7 8 9 Channel 5 7 8 9 Channel 5 7 8 9 Channel 5 7 8 9 Channel 5 7 8 9 Channel 5 7 8 9 Channel 5 7 8 9 Channel 5 7 8 9 Channel 5 7 8 9 Channel 5 7 8 8 9 Channel 5 7 8 8 9 Channel 5 7 8 8 9 Channel 5 7 8 8 9 Channel 5 7 8 8 9 Channel 5 7 8 8 9 Channel 5 7 8 8 9 Channel 5 8 8 9 Channel 5 8 8 9 Channel 5 8 8 8 9 Channel 5 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 | nt of testin pring of 1 reestablish 8-12 8-17 | Ig. Grass 940. Old 1ed by fill .0274 .0738 .171 .403 .821 1.94 3.22 5.73 8.60 Good un ems per s position 100 ng. Grass 1942. .0217 .0625 .162 1.06 1.06 1.78 2.56 3.83 | establishe grass rem ing low p .124 .180 .226 .282 .354 .490 .623 .826 1.01 | d by solid noved and laces with .221 .410 .756 1.43 2.32 3.97 5.17 6.94 8.52 Bed Slop d of short ; average Bermuda; d by solid .209 .379 .752 2.84 2.84 2.84 3.99 5.01 6.28 | Surfa crease .0382- .0379 .0379 .0379 .0382 .0387 .0390 .0390 .0390 .0391 pe 5.19 Pei Hydra runs Rippl surfa runs .0518 .0517 .0515 .0516 .0519 .0521 .0522 .0521 | uce of flow e in depth 0 50 90 100 100 100 100 100 100 100 100 100 100 100 100 100 100 100 100 0 75 95 100 100 100 100 100 100 100 100 100 100 | increased until runs 35 16 16 32 29 30 29 30 29 30 29 35 35 35 35 tor: Flow 4 with t ge for run th appare 35 20 18 30 30 30 30 30 32 33 | d in rougi 8 and 9 .000 .002 .022 .034 .012 .029 .000 .056 .062 E: through miform su is 5 and 6. ently high .000 .000 .020 .020 .020 .020 .020 .020 .020 .020 .020 .020 .020 .020 .020 .020 .020 .020 .020 .022 .023 | hness with were very - 3.24 5.01 8.29 14.0 20.1 28.9 33.2 38.6 43.0 xperiment and over urface, sma Runs 7 to surface very - 2.84 4.10 7.15 13.6 20.5 26.1 30.7 85.3 | each ir rough. .333 .228 .144 .0878 .0631 .0458 .0413 .0373 .0347 1, 1942 grass fo .10, wate elocity fo .360 .269 .162 .0891 .0498 .0434 .0388 |
| pright at sta dding in sp nannel grade il. 1 2 3 4 5 6 7 8 9 Channel 5A escription of een grass w ngth 2.62 in pright at sta dding in the 1 2 3 4 5 6 7 8 9 S | nt of testin pring of 1 reestablish 8-12 8-17 | ng. Grass 940. Old hed by fill .0274 .0738 .171 .403 .821 1.94 3.22 5.73 8.60 Good un ems per s sosition 100 ng. Grass 1942. .0217 .0625 .162 1.06 1.06 1.78 2.56 3.83 5.12 | establishe grass rem ing low p .124 .180 .282 .282 .354 .490 .623 .826 1.01 .01 .01 .01 .01 .01 .01 .01 .01 .0 | d by solid laces with .221 .410 .756 1.43 2.32 3.97 5.17 6.94 8.52 Bed Slop d of short ; average Bermuda; d by solid .209 .379 .752 2.84 2.84 3.99 5.01 6.28 7.38 | Surfa crease .0382- .0379 .0379 .0379 .0382 .0387 .0390 .0390 .0390 .0391 pe 5.19 Pei Hydra runs Rippl surfa runs .0518 .0517 .0516 .0516 .0521 .0521 .0521 .0517 | uce of flow 0 50 90 100 100 100 100 100 100 100 100 100 100 100 100 100 100 100 100 100 100 0 75 95 100 100 100 100 100 100 100 100 100 | increased increased intil runs 35 16 16 32 29 30 29 30 29 35 35 35 ior: Flow 4 with t ge for run th appard 35 20 18 30 30 30 30 30 35 35 29 35 35 29 35 35 35 35 35 35 35 35 35 35 | d in rougi 8 and 9 .000 .000 .022 .034 .012 .029 .000 .056 .062 E: through iniform st iniform st iniform st .000 .000 .000 .000 .000 .000 .000 .020 .017 .029 .029 .029 .029 .026 .052 | hness with were very 3.24 5.01 8.29 14.0 20.1 28.9 33.2 38.6 43.0 xperiment and over irface, sma Runs 7 to 5.84 4.10 7.15 13.6 20.5 26.1 30.7 85.3 39.0 | each ir rough. .333 .228 .144 .0878 .0631 .0458 .0413 .0373 .0347 1, 1942 grass fc .11 ripple > 10, wate elocity fc .360 .269 .162 .0891 .0434 .0388 .0358 |
| pright at sta dding in sp nannel grade il. 1 2 3 4 5 6 7 8 9 Channel 5A escription of een grass w ngth 2.62 in oright at sta dding in the 1 2 3 4 5 6 7 8 9 9 Channel 5A escription of een grass w | nt of testin pring of 1 reestablish 8-12 8-17 8-1 | Ig. Grass 940. Old 1ed by fill .0274 .0738 .171 .403 .821 1.94 3.22 5.73 8.60 Good un ems per s position 100 ng. Grass 1942. .0217 .0625 .162 1.06 1.06 1.78 2.56 3.83 | establishe grass rem ing low p .124 .180 .226 .282 .354 .490 .623 .826 1.01 | d by solid loved and laces with .221 .410 .756 1.43 2.32 3.97 5.17 6.94 8.52 Bed Slop d of short ; average Bermuda; d by solid .209 .379 .752 2.84 2.84 3.99 5.01 6.28 7.38 9.96 | Surfa crease .0382- .0379 .0379 .0379 .0382 .0390 .0390 .0390 .0390 .0390 .0390 .0391 pe 5.19 Pei Hydra runs Rippl surfa runs .0518 .0517 .0515 .0516 .0519 .0521 .0522 .0521 .0521 .0521 .0527 | uce of flow e in depth 0 50 90 100 100 100 100 100 100 100 100 100 100 100 100 100 100 100 100 0 75 95 100 100 100 100 100 100 100 100 100 100 100 100 100 | increased until runs 35 16 16 32 29 30 29 30 29 30 29 35 35 35 35 tor: Flow 4 with t ge for run th appare 35 20 18 30 30 30 30 30 32 33 | d in rougi | hness with were very 3.24 5.01 8.29 14.0 20.1 28.9 33.2 38.6 43.0 xperiment and over urface, sma Runs 7 to surface very 2.84 4.10 7.15 13.6 20.5 28.1 30.7 35.3 39.0 45.0 | each in rough. .333 .228 .144 .0878 .0631 .0458 .0413 .0373 .0347 1, 1942 grass fc .010, wata elocity fc .360 .269 .162 .0891 .0498 .0434 .0388 .0328 .0328 |
| pright at sta dding in sp nannel grade il. 1 2 3 4 5 6 7 8 9 Channel 5A escription of reen grass w ngth 2.62 in pright at sta dding in the 1 2 3 4 5 6 7 8 9 9 | nt of testin pring of 1 reestablish 8-12 8-17 8-1 | 1g. Grass 940. Old 1ed by fill .0274 .0738 .171 .403 .821 1.94 3.22 5.73 8.60 Good un ems per s position 100 ng. Grass 1942. .0217 .0625 .162 1.06 1.06 1.78 2.56 3.83 5.12 9.71 | establishe grass rem ing low p .124 .180 .226 .282 .354 .490 .623 .826 1.01 | d by solid loved and laces with .221 .410 .756 1.43 2.32 3.97 5.17 6.94 8.52 Bed Slop .752 2.84 2.84 3.99 .752 2.84 2.84 3.99 5.01 6.28 7.38 9.96 Bed Slop | Surfa crease .0382- .0379 .0379 .0379 .0382 .0390 .0390 .0391 pe 5.19 Per Hydra runs .0518 .0517 .0515 .0516 .0519 .0521 .0522 .0521 .0521 .0521 .0521 .0527 .0507 pe 6.10 Per | uce of flow e in depth 0 50 90 100 100 100 100 100 100 100 100 100 100 100 100 100 100 100 100 0 75 95 100 100 100 100 100 100 100 100 100 100 100 100 100 | increased until runs 35 16 16 16 32 29 30 29 35 35 35 35 4 with 1 29 35 35 35 20 18 30 30 30 30 32 33 39 | d in rougi 8 and 9 .000 .000 .022 .034 .012 .029 .000 .056 .062 E: r through miform st .062 E: r through miform st .000 .020 .017 .029 .016 .022 .016 .026 .052 .166 E: E: | hness with were very 3.24 5.01 8.29 14.0 20.1 28.9 33.2 38.6 43.0 xperiment and over inface, sma Runs 7 to surface very 2.84 4.10 7.15 13.6 20.5 28.1 30.7 85.3 39.0 45.0 xperiment | each in rough. .333 .228 .144 .0878 .0631 .0458 .0413 .0373 .0347 1, 1942 grass fc .0413 grass fc .0413 .0347 1, 1942 grass fc .0619 .0498 .0434 .0388 .0329 1, 1942 |

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Table 4.—Results of Tests of Channels Lined with Short Bermuda Grass—(Continued).

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| • | ont. | | • | | | | | | Coeffic | lents |
|--|--|---|--|---|---|---|--|--|--|--|
| | Date | Discharge per foot of width, VD | Depth, D | Mean velocity, V | Effective Lope | Vegetation submergence | Duration of flow | Av. rate of scour | Chezy, C | Manning, n |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | `п |
| , | | Cu. ft. per sec. | Feet | Ft. per sec. | Ft. per ft. | Percent | Min. | In. per hr. | | |
| 1 | 8-18 | .0196 | .079 | .248 | .0613 | 0 | 42 | .000 | 3.56 | .276 |
| 2. | 8-18 | .0577 | .146 | .395 | .0610 | 50 | 19 | .026 | 4.20 | .258 |
| 3 | 8-18 | .173 | .212 | .815 | .0610 | 80 | 21 | .092 | 7.16 | .160 |
| 4 | 8-18 | .536 | .285 | 1.88 | .0610 | 100 | 30 | .041 | 14.2 | .084 |
| 5 | 8-18 | .960 | .344 | 2.79 | .0609 | 100 | 30 | .024 | 19.3 | .064 |
| 6 | 8-18 | 1.44 | .395 | 3.64 | .0608 | 100 | 32 | .000 | 23.5 | .054 |
| 7 | 8-18 | 2.34 | .481 | 4.87 | .0606 | 100 | 32 | .057 | 28.5 | .046 |
| 8 | 8-18 | 3.33 | .554 | 6.01 | .0605 | 100 | 32 | .084 | 32.9 | .041 |
| 9 | 8-18 | 6.18 | .750 | 8.24 | .0595 | 100 | 34 | .221 | 39.0 | .036 |
| 10 | 8-18 | 10.0 | .986 | 10.2 | .0579 | 100 | 32 | .061 | 42.6 | .034 |
| Channel 7A | | | | | pe 7.06 Pe | | | | periment : | |
| 0 inches; con start of test | nposition ing. Gra | 100 percen ss establish | t Bermud | lid sodding | 3. V mere | Vater surfac ged by flows | e smooth | with small | | Irass su |
| 0 inches; con start of test: spring of 1940 established by | nposition ing. Gra). Old gr | 100 percen ss establish ass remove | t Bermuc led by so d and cha | ia; upright lid sodding | 3. V merg roug | Water surfac | e smooth of run 4 6. High | with small to 10. Su surface v | ripples. (rface start velocity inc | Grass su ed getti |
| start of test | nposition ing. Gra). Old gr | 100 percen ss establish ass remove w places w .0246 | ed by so d and cha tith soil. | ia; upright lid sodding annel grade .332 | 3. V merg roug | Water surface ged by flows h after run e foam on s | e smooth of run 4 6. High | with small to 10. Su surface v | ripples. (rface start velocity inc | Grass su ed getti licated |
| start of test spring of 1940 established by | nposition ing. Gra). Old gr filling lo | 100 percen ss establish ass remove w places w .0246 .0749 | t Bermuc hed by so d and cha rith soil. | ia; upright lid sodding annel grade | 3. V merg roug whit | Water surface ged by flows th after run te foam on s | e smooth of run 4 6. High surface du | with small to 10. Su surface v ring runs | ripples. (rface start velocity ind 9 and 10. | Grass st ed gett: licated .211 |
| start of test spring of 1946 established by 1 | nposition ing. Gra). Old gr filling lo 8-19 | 100 percen ss establish ass remove w places w .0246 | ed by so d and cha tith soil. | ia; upright lid sodding annel grade .332 | 3. W merg roug whit .0702 | Water surface ged by flows h after run e foam on s | e smooth of run 4 6. High surface du 30 | with small to 10. Su surface v ring runs .000 | ripples. C rface start relocity inc 9 and 10. 4.63 | Jrass st ed gett: licated .211 .192 |
| start of test spring of 1940 established by 1 2 | nposition ing. Gra). Old gr filling lo 8-19 8-19 | 100 percen ss establish ass remove w places w .0246 .0749 | at Bermuc and by so d and cha rith soil. .074 .137 | ia; upright lid sodding annel grade .332 .547 | 3. V merg roug whit .0702 .0698 | Water surface ged by flows th after run e foam on s 0 75 | e smooth of run 4 6. High surface du 30 19 | with small to 10. Su surface w ring runs .000 .000 | ripples. C rface start velocity inc 9 and 10. 4.63 5.64 | Grass st ed getti licated .211 .192 .099 |
| start of test spring of 1946 established by 1 2 3 | nposition ing. Gra). Old gr filling lo 8-19 8-19 8-19 8-19 | 100 percen ss establish cass remove w places w .0246 .0749 .255 | at Bermuc hed by so d and cha rith soil. .074 .137 .192 | da; upright lid sodding annel grade .332 .547 1.33 | 3. V merg roug whit .0702 .0698 .0699 | Water surface ged by flows th after run e foam on s 0 75 95 | e smooth of run 4 6. High surface du 30 19 17 | with small to 10. Su surface v ring runs .000 .000 .021 | ripples. (rface start relocity ind 9 and 10. 4.63 5.64 11.5 17.2 | Frass such as the second secon |
| start of test spring of 1946 established by 1 2 3 4 | nposition ing. Gra). Old gr filling lo 8-19 8-19 8-19 8-19 8-19 | 100 percen ss establish ass remove w places w .0246 .0749 .255 .535 | at Bermuc hed by so d and cha rith soil. .074 .137 .192 .240 | da; upright lid sodding annel grade .332 .547 1.33 2.23 | 3. T merg roug whit .0702 .0698 .0699 .0702 .0707 | Water surfac ged by flows th after run e foam on s 0 75 95 100 100 | e smooth of run 4 6. High surface du 30 19 17 37 | with small to 10. Su surface v ring runs .000 .000 .021 .010 | ripples. 0 rface start relocity ind 9 and 10. 4.63 5.64 11.5 17.2 23.9 | 27855 51 ed getti licated .211 .192 .099 .068 .050 |
| start of test spring of 1946 established by 1 2 3 4 5 | nposition ing. Gra 0. Old gr filling lo 8-19 8-19 8-19 8-19 8-19 8-19 8-19 | 100 percen ss establish ass remove w places w .0246 .0749 .255 .535 1.03 | at Bermud and by so d and cha- rith soil. .074 .137 .192 .240 .298 | da; upright lid sodding annel grade .332 .547 1.33 2.23 3.47 | 3. W merg roug whit .0702 .0698 .0699 .0702 .0707 .0715 | Water surfac ged by flows h after run e foam on s 0 75 95 100 | e smooth of run 4 6. High surface du 30 19 17 37 34 | with small to 10. Su surface v ring runs .000 .000 .021 .010 .025 | ripples. (rface start relocity ind 9 and 10. 4.63 5.64 11.5 17.2 23.9 31.6 | 2rass su ed gett: licated .211 .192 .099 .068 .050 .040 |
| start of test spring of 1946 established by 1 2 3 4 5 6 7 | nposition ing. Gra 0. Old gr filling lo 8-19 8-19 8-19 8-19 8-19 8-19 8-19 | 100 percen ss establish ass remove w places w .0246 .0749 .255 .535 1.03 2.10 | t Bermud hed by so d and cha ith soil. .074 .137 .192 .240 .298 .396 | da; upright lid sodding annel grade .332 .547 1.33 2.23 3.47 5.31 | 3. V merg roug whit .0702 .0698 .0699 .0702 .0702 .0707 .0715 .0719 | Water surfact ged by flows h after run e foam on s 0 75 95 100 100 100 100 | e smooth of run 4 6. High surface du 30 19 17 37 37 34 33 36 | with small to 10. Su surface v ring runs .000 .000 .021 .010 .025 .054 .060 | ripples. (rface start relocity inc 9 and 10. 4.63 5.64 11.5 17.2 23.9 31.6 36.2 | 3rass st ed gett: licated .211 .192 .099 .068 .050 .040 .036 |
| start of test spring of 1946 established by 1 2 3 4 5 6 7 8 | nposition ing. Gra). Old gr filling lo 8-19 8-19 8-19 8-19 8-19 8-19 8-19 8-19 | 100 percen ss establish cass remove w places w .0246 .0749 .255 .535 1.03 2.10 3.68 5.50 | t Bermud ted by so d and char tith soil. .074 .137 .192 .240 .298 .396 .524 .636 | da; upright lid sodding annel grade .332 .547 1.33 2.23 3.47 5.31 7.02 8.64 | 3. V merg roug whit .0702 .0698 .0699 .0702 .0707 .0715 .0719 .0720 | Water surface ged by flows h after run e foam on s 0 75 95 100 100 100 100 100 | 20 smooth 3 of run 4 4 6. High surface du 30 19 17 37 34 33 36 31 | with small to 10. Su surface v ring runs .000 .021 .010 .025 .054 .060 .058 | ripples. (rface start relocity inc 9 and 10. 4.63 5.64 11.5 17.2 23.9 31.6 36.2 40.5 | 3rass st ed gett: licated .211 .192 .099 .066 .050 .040 .036 |
| start of test spring of 1946 established by 1 2 3 4 5 5 6 7 | nposition ing. Gra 0. Old gr filling lo 8-19 8-19 8-19 8-19 8-19 8-19 8-19 8-19 | 100 percen ss establish ass remove w places w .0246 .0749 255 .535 1.03 2.10 3.68 | t Bermud ted by so d and char rith soil. .074 .137 .192 .240 .298 .396 .524 | da; upright lid sodding annel grade .332 .547 1.33 2.23 3.47 5.31 7.02 | 3. V merg roug whit .0702 .0698 .0699 .0702 .0702 .0707 .0715 .0719 | Water surfact ged by flows h after run e foam on s 0 75 95 100 100 100 100 | e smooth of run 4 6. High surface du 30 19 17 37 37 34 33 36 | with small to 10. Su surface v ring runs .000 .000 .021 .010 .025 .054 .060 | ripples. (rface start relocity inc 9 and 10. 4.63 5.64 11.5 17.2 23.9 31.6 36.2 | 3rass st ed gett: licated .211 .192 .095 .066 .056 .046 .034 .036 |
| start of test spring of 1944 stabilished by 1 2 3 4 5 6 7 8 9 10 Channel 10E | nposition ing. Gra Old gr filling lo 8-19 8-19 8-19 8-19 8-19 8-19 8-19 8-19 | 100 percen ss establish vass remove w places w .0246 .0749 .255 .535 1.03 2.10 3.68 5.50 8.23 11.0 | tt Bermud ted by so d and char rith soil. .074 .137 .192 .240 .298 .396 .524 .524 .636 .799 .957 | da; upright lid sodding annel grade .332 .547 1.33 2.23 3.47 5.31 7.02 8.64 10.3 11.5 Bed SI | 3. V merg roug whit .0698 .0699 .0702 .0707 .0715 .0709 .0720 .0720 .0720 .0720 .0720 .0720 .0720 .0720 .0720 .0720 .0720 .0720 .0720 .0720 .0720 .0720 .0720 .0720 .0720 .0722 .0725 .0722 .0725 .0722 .0722 .0722 .0722 .0722 .0725 .0722 .072 | Water surface ged by flows h after run e foam on s 0 75 95 100 100 100 100 100 100 100 100 100 | ze smooth 5 of run 4 4 6. High surface du 30 19 17 37 34 33 36 31 33 40 | with small to 10. Su surface v ring runs .000 .000 .000 .021 .010 .025 .054 .060 .058 .146 .116 | ripples. 0 rface start relocity ind 9 and 10. 4.63 5.64 11.5 17.2 23.9 31.6 36.2 40.5 43.5 45.2 xperiment | 3rass sued getti licated 211 .192 .099 .068 .050 .040 .036 .033 .032 2, 1942 |
| start of test spring of 1944 established by 1 2 3 4 5 6 7 7 8 9 10 Channel 10E escription of v een grass wil ngth 2.71 incl rright at star dding in sprin el grade reeste 1 | nposition ing. Gra Old gr filling lo 8-19 8-19 8-19 8-19 8-19 8-19 8-19 8-19 | 100 percen ss establish cass remove w places w .0246 .0749 .255 .535 1.03 2.10 3.68 5.50 8.23 11.0 : Good un tems per s position 10 ng. Grass . Old grass . Old grass . Old grass . 0396 | tt Bermud led by so d and char rith soil. .074 .137 .192 .240 .298 .396 .524 .636 .799 .957 .107 .257 | ia; upright lid sodding annel grade .332 .547 1.33 2.23 3.47 5.31 7.02 8.64 10.3 11.5 Bed SI nd of short of; average ; Bermuda; ed by solid and chan- with soll. .325 | 3. V merg roug whit .0702 .0698 .0699 .0702 .0707 .0715 .0719 .0720 .0701 .0678 ope 10.2 Pe Hyda runs to b fairl in r 9 an .102 | Water surfact ged by flows in after run e foam on s 0 75 95 100 100 100 100 100 100 100 | te smooth of run 4 6. High surface du 30 19 17 37 34 33 36 31 33 40 Flow for Runs 6 to | with small to 10. Su surface v ring runs .000 .000 .021 .010 .025 .054 .060 .058 .146 .116 E v through ostly subm runs 4 an 0 10, surfa | ripples. (rface start relocity ind 9 and 10. 4.63 5.64 11.5 17.2 23.9 31.6 36.2 40.5 43.5 45.2 xperiment and over erged and 4.5. Wat ce of flow | Jrass su ed getti licated 211 .192 .099 .068 .050 .046 .034 .032 2, 1942 grass : beginni er surfa increas |
| start of test spring of 1944 established by 1 2 3 4 5 6 7 7 8 9 10 Channel 10E escription of v een grass with ngth 2.71 incl rright at star dding in sprin 4 grade reests | nposition ing. Gra Old gr filling lo 8-19 8-19 8-19 8-19 8-19 8-19 8-19 8-19 | 100 percen ss establish cass remove w places w .0246 .0749 .255 .535 1.03 2.10 3.68 5.50 8.23 11.0 : Good un tems per s position 10 ing. Grass . Old grass by filling lo | ti Bermuc led by so d and char rith soil. .074 .192 .240 .298 .396 .524 .636 .799 .957 | ia; upright lid sodding annel grade .332 .547 1.33 2.23 3.47 5.31 7.02 8.64 10.3 11.5 Bed SI nd of short of; average ; Bermuda; ed by solid and chan- with soll. | 3. V merg roug whit .0702 .0698 .0699 .0702 .0707 .0715 .0719 .0720 .0701 .0678 ope 10.2 Pe Hydu runs to b fairl in r 9 an | Water surface ged by flows th after run e foam on s 0 75 95 100 100 100 100 100 100 100 10 | e smooth of run 4 a 6. High surface du 30 19 17 37 34 33 36 31 33 40 | with small to 10. Su surface v ring runs .000 .000 .021 .010 .025 .054 .060 .058 .146 .116 E v through ostly subm runs 4 an 0 10, surfa .010, surfa | ripples. (rface start relocity ind 9 and 10. 4.63 5.64 11.5 17.2 23.9 31.6 36.2 40.5 43.5 45.2 xperiment and over erged and d 5. Wat ce of flow velocity f | Frass s ed gett licated .211 .192 .064 .055 .054 .054 .055 .054 .055 .055 .05 |
| start of test spring of 1946 established by 1 2 3 4 5 6 7 8 9 10 Channel 10E escription of v een grass win ngth 2.71 incl rright at star dding in sprin el grade reesta | nposition ing. Gra Old gr filling lo 8-19 8-19 8-19 8-19 8-19 8-19 8-19 8-19 | 100 percen ss establish cass remove w places w .0246 .0749 .255 .535 1.03 2.10 3.68 5.50 8.23 11.0 : Good un tems per s position 10 ng. Grass . Old grass . Old grass . Old grass . 0396 | tt Bermud led by so d and char rith soil. .074 .137 .192 .240 .298 .396 .524 .636 .799 .957 .107 .257 | ia; upright lid sodding annel grade .332 .547 1.33 2.23 3.47 5.31 7.02 8.64 10.3 11.5 Bed SI nd of short ot; average ; Bermuda; ed by solid and chan- with soll. .325 | 3. V merg roug whit .0702 .0698 .0699 .0702 .0707 .0715 .0719 .0720 .0701 .0678 ope 10.2 Pe Hyda runs to b fairl in r 9 an .102 | Water surface ged by flows h after run e foam on s 0 75 95 100 100 100 100 100 100 100 10 | te smooth of run 4 a 6. High surface du 30 19 17 37 34 33 36 31 33 40 whor: Flow Grass m flow for Runs 6 to ith appare 40 | with small to 10. Su surface v ring runs .000 .021 .010 .025 .054 .060 .058 .146 .116 E v through ostly subm runs 4 an 0 10, surfa ently high .000 | ripples. Orface start relocity ino 9 and 10. 4.63 5.64 11.5 17.2 23.9 31.6 36.2 40.5 43.5 45.2 xperiment and over erged and d 5. Wat ce of flow velocity for | Frass si ed gett licated .211 .099 .066 .054 .054 .035 .035 .033 .033 .033 .033 .033 .033 |

Table 4.—Results of Tests of Channels Lined with Short Bermuda Grass—(Continued).

| | | • • | | | | | | | | |
|----|------|-------|------|------|-------|-----|----|------|------|-------|
| 1 | 8-20 | .0396 | .122 | .325 | .102 | 0 | 40 | .000 | 2.92 | .360 |
| 2 | 8-20 | .0732 | .162 | .452 | .102 | 30 | 18 | .000 | 3.52 | .313 |
| 3 | 8-20 | .162 | .201 | .806 | .102 | 75 | 17 | .000 | 5.63 | .203 |
| 4 | 8-20 | .300 | .227 | 1.32 | .102 | 95 | 40 | .018 | 8.68 | .134 |
| 5 | 8-20 | .610 | .276 | 2.21 | .102 | 100 | 32 | .000 | 13.2 | .0910 |
| 6 | 8-20 | 1.29 | .349 | 3.70 | .102 | 100 | 34 | .031 | 19.6 | .0638 |
| 7 | 8-20 | 2.71 | .462 | 5.86 | .103 | 100 | 31 | .035 | 26.9 | .0487 |
| 8 | 8-20 | 5.32 | .617 | 8.63 | .102 | 100 | 32 | .038 | 34.4 | .0399 |
| 9 | 8-20 | 8.55 | .792 | 10.8 | .0996 | 100 | 31 | .058 | 38.4 | .0372 |
| 10 | 8-20 | 12,1 | .951 | 12.7 | .0959 | 100 | 37 | .048 | 42.3 | .0348 |
| | | | | | | | | | | |

BLUE GRAMA GRASS

| Table 5.—Results of | Tests of | Channels | Lined | with | Blue | Grama | Grass. |
|---------------------|----------|----------|-------|------|------|-------|--------|
|---------------------|----------|----------|-------|------|------|-------|--------|

| Channel 4 | В | | | Bed Slop | e 4.11 Perc | ent | | E | xperiment | 1, 1940 |
|---|--|--|--|-------------------------------------|---|--|---|---|---|-----------------------|
| ipped green er square fo on 70 percer | vegetation grass with oot; average ht blue gran | h 18.1 cub length 13 na, 30 perc | oic inches 2.3 inches; cent crab i | of forage composi- and needle | and o grass of wat | ver part o remained ter smooth | of all of erect or v for all t | grass for waving in these runs | n grass for runs 2 a the flows Run 4 s | nd 3 bu Surfac |
| | ing in sprin | | g. Grass | established | runs 4 | 5 and 6 apparent e | surface o | f flows s | slightly rou lightly rou s. | ugh. Fo gh. Ver |
| | | | | .413 | runs 4 | 5 and 6 | surface o | f flows s test flow: | lightly rou s. | gh. Vei |
| | ing in sprin | ng of 1940. | • • | | little a | 5 and 6 apparent e | surface o rosion by | f flows s test flow: .000 | lightly rou s. 5.23 | gh. Ven 210 |
| | ing in sprin 9-5 | ng of 1940. | .152 | .413 | little s | 5 and 6 apparent e 0 | surface o rosion by | f flows s test flow: .000 .000 | lightly rou s. 5.23 7.36 | .210 .181 |
| | 9-5 9-5 | g of 1940. .0628 .533 | .152 .503 | .413 1.06 | .0412 .0415 | 5 and 6 apparent e 0 80 95 | surface o rosion by 15 9 | f flows s test flow: .000 .000 .249 | lightly rou s. 5.23 7.36 14.1 | .210 .181 .0990 |
| | 9-5 9-5 9-5 9-5 | .0628 .533 1.53 | .152 .503 .661 | .413 1.06 2.31 | runs 4 little s .0412 .0415 .0409 | 5 and 6 apparent e 0 80 | surface o rosion by 15 9 32 | f flows s test flow: .000 .000 | lightly rou s. 5.23 7.36 | gh. Ver 210 |

.

.

| Channel 7F | | | | Bed Slop | æ 7.11 Pe | ercent | | E | xperiment | 1, 1940 | | |
|---|--|--|--|--|---|--|--|--|---|--|--|--|
| · . | | | | | | | | | Coeffic | ients | | |
| | | م ^و . | _ | ⊳ | | Vegetation submergence | | ş | | u | | |
| | | Action | 9 | | \$ | | 5₽ | 3 | D | å, | | |
| - | n) | ਵ ੇ ਜ | ੜੂ | 43 | ÷. | eta Del | Do at | .ដ _អ | 5 | a la | | |
| Run | Date | Discharge per foot of width, VD | Depth, | Mean velocity, | Effective slope | Veg | Duration of flow | Av. rate scour | Chezy, | Manulog, | | |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | <u>u</u> | | |
| | | Cu. ft. per sec. | Fest | Ft. per sec. | Ft. per ft. | Percent | Min. | In. per hr. | | | | |
| Description of v | egetation | | | | | aulic behav | | | grass for 1 | י <u>.</u> חוד חוד | | |
| clipped green gr | | | | | | over part or | | | | | | |
| quare foot; ave | | | | | erect | or waving | in the fl | ows, surfa | ice of wate | r smooth | | |
| percent blue gra | | | | | | 4, surface | | | | | | |
| pright at start | | | establishe | ed by solid | | ice of flow | s rough. | Very slig | ht apparer | it erosio | | |
| odding in sprin | g of 1940 |). | | | by te | sts. | <u>.</u> | <u> </u> | | | | |
| 1 | 9-4 | .0568 | J105 | .541 | .0713 | 0 | 33 | .000 | 6.27 | .163 | | |
| 2 | 9-4 9-4 | .516 1.57 | .377 .500 | 1.37 3.14 | .0717 .0714 | 50 100 | 11 | .033 | 8.34 | .152 | | |
| 3 4 | 9-4 9-5 | 1.57 5.02 | .500 | 5.1 4 6.68 | .0714 | 100 | 29 30 | .030 .120 | 16.6 28.8 | .0797 .0494 | | |
| 5 | 9-5 9-5 | 5.02 7.43 | .926 | 8.02 | .0707 | 100 | 30 | .120 | 28.6 31.5 | .0494 | | |
| 6 | 9-5 | 9.83 | 1.06 | 9.27 | .0704 | 100 | 34 | .053 | 34.1 | .0441 | | |
| Channel 10 | | | _ | Bed Slop | e 1.01 Per | rcent | | E | xperiment 1 | l, 1940 | | |
| Description of v | egetation | : Good u | niform sta | and of un- | | aulic behav | | | | | | |
| clipped green gr | ass with | 19.0 cubic | inches of | forage per | over | part of gra | ss in run | 2, and all | for run 3 | with gras | | |
| square foot; ave | | | | | wavii | ng in the f | low, surfa | ce smooth | i; runs 4 a | nd 5, the | | |
| percent blue gra upright at start | ma, 20 p | ercent crat | and need | ile grasses; | SULLA | ce of the fl | ows was s | lightly rou | lgn. | | | |
| | | ux. criass | COMMINSIN | cu by somu | | | | | | | | |
| | | | | | | | | | | | | |
| sodding in spring | g 1940. | | | | 0100 | | · | 000 | 4.05 | 002 | | |
| odding in spring | g 1940. 9-14 | .0523 | .218 | .240 | .0109 | 0 | 45 | .000 | 4.95 | .235 | | |
| 1 2 | g 1940. 9-14 9-14 | .0523 .543 | .778 | .698 | .0122 | 30 | 20 | .218 | 7.24 | .198 | | |
| 1 2 3 | g 1940. 9-14 9-14 9-14 | .0523 .543 1.53 | .778 .982 | | | | | | | | | |
| 1 2 | g 1940. 9-14 9-14 | .0523 .543 | .778 | .698 1.56 | .0122 .0116 | 30 100 | 20 29 | . 218 .192 | 7.24 14.7 | .198 .101 | | |
| sodding in spring 1 2 3 4 | g 1940. 9-14 9-14 9-14 9-14 9-14 | .0523 .543 1.53 2.96 | .778 .982 1.21 | .698 1.56 2.45 8.43 | .0122 .0116 .0114 | 30 100 100 100 | 20 29 32 | .218 .192 .050 .011 | 7.24 14.7 21.0 | .198 .101 .0734 .0578 | | |
| 1 2 3 4 5 Channel 2D Description of v | 9-14 9-14 9-14 9-14 9-14 9-14 9-14 | .0523 .543 1.53 2.96 4.90 | .778 .982 1.21 1.43 | .698 1.56 2.45 8.43 Bed Slop | .0122 .0116 .0114 .0111 pe 1.95 Pe Hydr | 30 100 100 100 rcent aulic behav | 20 29 32 31 ior: Flow | .218 .192 .050 .011 E 7 through | 7.24 14.7 21.0 27.4 xperiment : grass for r | .198 .101 .0734 .0578 I, 1940 un 1 and | | |
| 1 2 3 4 5 Channel 2D Description of v | g 1940. 9-14 9-14 9-14 9-14 9-14 9-14 9-14 | .0523 .543 1.53 2.96 4.90 : Good u 21.4 cubic | .778 .982 1.21 1.43 miform sta inches of | .698 1.56 2.45 8.43 Bed Slop and of un- forage per | .0122 .0116 .0114 .0111 pe 1.95 Pe Hydr over | 30 100 100 100 rcent raulic behav grass for r | 20 29 32 31 for: Flow un 2 and | .218 .192 .050 .011 E y through 3, slight t | 7.24 14.7 21.0 27.4 xperiment : grass for r pending of | .198 .101 .0734 .0578 1, 1940 un 1 and the stem | | |
| sodding in spring 1 2 3 4 5 Channel 2D Description of w clipped green gr | g 1940. 9-14 9-14 9-14 9-14 9-14 9-14 9-14 vegetation ass with rrage leng | .0523 .543 1.53 2.96 4.90 :: Good U 21.4 cubic ;th 16.4 in | .778 .982 1.21 1.43 niform sta inches of ches; com | .698 1.56 2.45 8.43 Bed Slop and of un- forage per pact; com- | .0122 .0116 .0114 .0111 we 1.95 Pe Hydr over for r | 30 100 100 100 rcent aulic behav grass for r un 3, surfa | 20 29 32 31 for: Flow un 2 and ce of flow | .218 .192 .050 .011 F 7 through 3, slight k 7 smooth. | 7.24 14.7 21.0 27.4 xperiment : grass for r pending of Runs 4 an | .198 .101 .0734 .0578 1, 1940 un 1 and the stem d 5 com | | |
| sodding in spring 1 2 3 4 5 Channel 2D Description of w clipped green gr square foot; ave position 50 per | g 1940. 9-14 9-14 9-14 9-14 9-14 9-14 9-14 9-14 | .0523 .543 1.53 2.96 4.90 :: Good u 21.4 cubic 3th 16.4 in e grama, 1 | .778 .982 1.21 1.43 miform sta inches of ches; com 70 percen | .698 1.56 2.45 8.43 Bed Slop and of un- forage per pact; com- t crab and | .0122 .0116 .0114 .0111 we 1.95 Pe Hydr over for r plete | 30 100 100 100 rcent aulic behav grass for r un 3, surfa- ly submerge | 20 29 32 31 for: Flow un 2 and ce of flow ed, surface | 218 .192 .050 .011 F 7 through 3, slight k 7 smooth. e of flow | 7.24 14.7 21.0 27.4 grass for r pending of Runs 4 an slightly rou | .198 .101 .0734 .0578 1, 1940 un 1 and the stem. d 5 com. gh. Run | | |
| sodding in spring 1 2 3 4 5 | g 1940. 9-14 9-14 9-14 9-14 9-14 9-14 9-14 9-14 | .0523 .543 1.53 2.96 4.90 :: Good u 21.4 cubic 3th 16.4 in e grama, 1 at start o | .778 .982 1.21 1.43 miform statinches of ches; com 70 percen f testing. | .698 1.56 2.45 8.43 Bed Slop and of un- forage per pact; com- t crab and | .0122 .0116 .0114 .0111 pe 1.95 Pe Hydr over for r plete 6, su | 30 100 100 100 rcent aulic behav grass for r un 3, surfa | 20 29 32 31 for: Flow un 2 and ce of flow ed, surface low rough | 218 .192 .050 .011 F 7 through 3, slight k 5 smooth. 5 of flow 1. Wash-0 | 7.24 14.7 21.0 27.4 grass for r pending of Runs 4 an slightly rou | .198 .101 .0734 .0578 1, 1940 un 1 and the stem d 5 com- gh. Rur | | |
| sodding in spring 1 2 3 4 5 Channel 2D Description of v clipped green gr square foot; ave position \$0 per hoedle grasses; tablished by solid | g 1940. 9-14 9-14 9-14 9-14 9-14 9-14 9-14 9-14 | .0523 .543 1.53 2.96 4.90 :: Good u 21.4 cubic 3th 16.4 in e grama, 1 at start o | .778 .982 1.21 1.43 miform statinches of ches; com 70 percen f testing. | .698 1.56 2.45 8.43 Bed Slop and of un- forage per pact; com- t crab and | .0122 .0116 .0114 .0111 pe 1.95 Pe Hydr over for r plete 6, su | 30 100 100 rcent aulic behav grass for r un 3, surfa ly submerge irface of f | 20 29 32 31 for: Flow un 2 and ce of flow ed, surface low rough | 218 .192 .050 .011 F 7 through 3, slight k 5 smooth. 5 of flow 1. Wash-0 | 7.24 14.7 21.0 27.4 grass for r pending of Runs 4 an slightly rou | .198 .101 .0734 .0578 1, 1940 un 1 and the stem d 5 com- gh. Rur | | |
| sodding in spring 1 2 3 4 5 Channel 2D Description of w clipped green gr square foot; ave position \$0 per needle grasses; tablished by solid 1 2 | g 1940. 9-14 9-14 9-14 9-14 9-14 9-14 9-14 9-14 | .0523 .543 1.53 2.96 4.90 21.4 cubic 3th 16.4 in e grama, 1 at start o in spring .0682 .510 | .778 .982 1.21 1.43 niform sta inches of ches; com 70 percen f testing of 1940. 232 .788 | .698 1.56 2.45 8.43 Bed Slop and of un- forage per pact; com- t crab and Grass es- .294 .647 | .0122 .0116 .0114 .0111 pe 1.95 Pe Hydr over for r plete 6, su cause .0201 .0214 | 30 100 100 rcent aulic behav grass for r un 3, surfa- ly submerge irface of f ed run to be 0 95 | 20 29 32 31 Hor: Flow un 2 and ce of flow ed, surface low rough e very sho 27 12 | 218 .192 .050 .011 7 through 3, slight k smooth. e of flow h. Wash-o rt. .000 .000 | 7.24 14.7 21.0 27.4 xperiment : grass for r pending of Runs 4 an slightly rou but under 4.31 5.01 | .198 .101 .0734 .0578 1, 1940 un 1 and the stem d 5 com gh. Run side wal .271 .285 | | |
| sodding in spring 1 2 3 4 5 Channel 2D Description of we clipped green gr square foot; ave position 50 per nucedle grasses; tablished by solit 1 2 3 | g 1940. 9-14 9-14 9-14 9-14 9-14 9-14 9-14 0-14 0-14 0-11 9-11 9-11 | .0523 .543 1.53 2.96 4.90 :: Good u 21.4 cubic 3th 16.4 in e grama, 1 at start o in spring .0682 .510 1.50 | .778 .982 1.21 1.43 niform sta inches of ches; com f testing. of 1940. .232 .788 .953 | .698 1.56 2.45 8.43 Bed Slop and of un- forage per pact; com- t crab and Grass es- .294 .647 1.57 | .0122 .0116 .0114 .0111 be 1.95 Pe Hydr over for r plete 6, su cause .0201 .0214 .0213 | 30 100 100 100 rcent aulic behav grass for r un 3, surfac ly submerge trface of f ed run to b 0 95 100 | 20 29 32 31 for: Flow un 2 and ce of flow ed, surface low rough e very sho 27 12 29 | 218 .192 .050 .011 E v through 3, slight k smooth. e of flow h. Wash-0 ort. .000 .130 | 7.24 14.7 21.0 27.4 grass for r pending of Runs 4 an slightly rou put under 4.31 5.01 11.1 | .198 .101 .0734 .0578 1, 1940 un 1 and the stem d 5 com. gh. Run side wal .271 .285 .132 | | |
| sodding in spring 1 2 3 4 5 Channel 2D Description of v clipped green gr square foot; ave position \$9 per model grasses; tablished by solid 1 2 3 4 | g 1940. 9-14 9-14 9-14 9-14 9-14 9-14 9-14 9-14 9-14 9-14 pregetation rass with trage lengt cent blue upright d sodding 9-11 9-11 9-11 | .0523 .543 1.53 2.96 4.90 :: Good u 21.4 cubic 3th 16.4 in 9 grama, 1 at start o in spring .0682 .510 1.50 3.00 | .778 .982 1.21 1.43 | .698 1.56 2.45 8.43 Bed Slop and of un- forage per pact; com- t crab and Grass es- .294 .647 1.57 2.73 | .0122 .0116 .0114 .0111 be 1.95 Pe Hydr over for r plete 6, su cause .0201 .0214 .0213 .0207 | 30 100 100 100 rcent aulic behav grass for r un 3, surfa ly submerge urface of f ed run to be 0 95 100 100 | 20 29 32 31 for: Flow un 2 and ce of flow ed, surface low rough e very sho 27 12 29 32 | 218 .192 .050 .011 7 through 3, slight k 5 smooth. 2 of flow 1. Wash-0 ort. .000 .130 .079 | 7.24 14.7 21.0 27.4 xperiment : grass for r bending of Runs 4 an slightly rou but under 4.31 5.01 11.1 17.9 | .198 .101 .0734 .0578 1, 1940 un 1 and the stem d 5 com- gh. Run side wal .271 .285 .132 .0844 | | |
| sodding in spring 1 2 3 4 5 Channel 2D Description of v clipped green gr square foot; ave position 50 per huedle grasses; tablished by solid 1 2 3 4 5 | g 1940. 9-14 9-11 9-11 9-11 9-11 9-11 9-11 9-11 9-11 9-11 9-11 | .0523 .543 1.53 2.96 4.90 :: Good U 21.4 cubic gth 16.4 in e grama, 1 at start o in spring .0682 .510 1.50 3.00 4.86 | .778 .982 1.21 1.43 | .698 1.56 2.45 8.43 Bed Slop and of un- forage per pact; com- t crab and Grass es- .294 .647 1.57 2.73 3.83 | .0122 .0116 .0114 .0111 pe 1.95 Pe Hydr over for r plete 6, su cause .0201 .0214 .0213 .0207 .0202 | 30 100 100 rcent aulic behav grass for r un 3, surfa- ly submerge rrface of f ed run to be 0 95 100 100 100 | 20 29 32 31 Hor: Flow un 2 and ce of flow ed, surface low rough e very sho 27 12 29 32 32 32 | 218 .192 .050 .011 7 through 3, slight k 7 smooth. 2 of flow 1. Wash-0 ort. .000 .130 .079 .034 | 7.24 14.7 21.0 27.4 xperiment : grass for r bending of Runs 4 an slightly rou but under 4.31 5.01 11.1 17.9 24.1 | .198 .101 .0734 .0578 1, 1940 un 1 and the stem d 5 com- gh. Run side wal .271 .285 .132 .0844 .0643 | | |
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Run run 7 the h surface</td></td> | <td>g 1940. 9-14 9-14 9-14 9-14 9-14 9-14 9-14 9-14 regetation rass with rrage leng cent blue upright d sodding 9-11 9-1</td> <td>.0523 .543 1.53 2.96 4.90 : Good u 21.4 cubic th 16.4 in e grama, 1 in spring .0682 .510 1.50 3.00 4.86 7.54 : Good u h 15.9 cut ge length grama, 3 at start o in the spr .0523 .516 1.59</td> <td>.778 .982 1.21 1.43 </td> <td>.698 1.56 2.45 8.43 Bed Slop and of un- forage per pact; com- t crab and Grass es- .294 .647 1.57 2.73 3.83 4.93 Bed Slop and of un- of forage hes; com- crab and Grass es- 0. .264 1.48 3.70</td> <td>.0122 .0116 .0114 .0111 De 1.95 Pe Hydr over for r plete 6, su cause .0201 .0214 .0213 .0207 .0202 .0200 De 10.3 Pe Hydr 1 and Runs 5 and surfa veloc .103 .102</td> <td>30 100 100 100 rcent aulic behav grass for r un 3, surfa- ly submerge rrface of f ed run to be 0 95 100 100 100 100 100 100 100 100 100 10</td> <td>20 29 32 31 for: Flow un 2 and ce of flow ed, surface d, surface tow rough e very sho 27 12 29 32 32 32 10 ior: Flow iss remaine urface of of the flow very rough ittle appa 40 36 29</td> <td>218 .192 .050 .011 E 7 through 3, slight k 5 smooth. 2 of flow 5 of flow .130 .000 .130 .079 .034 .106 E 7 over part d erect or the flow s 5 ow were 10 m with app rent erosi .000 .060 .067</td> <td>7.24 14.7 21.0 27.4 xperiment : grass for r bending of Runs 4 an slightly rou but under 4.31 5.01 11.1 17.9 24.1 28.5 xperiment : cor all grass waving in slightly roug pough and r barently hig on. 4.74</td> <td>.198 .101 .0734 .0578 I, 1940 un 1 and the stem d 5 com- gh. Run side wal .271 .285 .132 .0844 .0643 .0563 I, 1940 s for run: the flows gh. Run run 7 the h surface</td> | | g 1940. 9-14 9-14 9-14 9-14 9-14 9-14 9-14 9-14 regetation rass with rrage leng cent blue upright d sodding 9-11 9-1 | .0523 .543 1.53 2.96 4.90 : Good u 21.4 cubic th 16.4 in e grama, 1 in spring .0682 .510 1.50 3.00 4.86 7.54 : Good u h 15.9 cut ge length grama, 3 at start o in the spr .0523 .516 1.59 | .778 .982 1.21 1.43 | .698 1.56 2.45 8.43 Bed Slop and of un- forage per pact; com- t crab and Grass es- .294 .647 1.57 2.73 3.83 4.93 Bed Slop and of un- of forage hes; com- crab and Grass es- 0. .264 1.48 3.70 | .0122 .0116 .0114 .0111 De 1.95 Pe Hydr over for r plete 6, su cause .0201 .0214 .0213 .0207 .0202 .0200 De 10.3 Pe Hydr 1 and Runs 5 and surfa veloc .103 .102 | 30 100 100 100 rcent aulic behav grass for r un 3, surfa- ly submerge rrface of f ed run to be 0 95 100 100 100 100 100 100 100 100 100 10 | 20 29 32 31 for: Flow un 2 and ce of flow ed, surface d, surface tow rough e very sho 27 12 29 32 32 32 10 ior: Flow iss remaine urface of of the flow very rough ittle appa 40 36 29 | 218 .192 .050 .011 E 7 through 3, slight k 5 smooth. 2 of flow 5 of flow .130 .000 .130 .079 .034 .106 E 7 over part d erect or the flow s 5 ow were 10 m with app rent erosi .000 .060 .067 | 7.24 14.7 21.0 27.4 xperiment : grass for r bending of Runs 4 an slightly rou but under 4.31 5.01 11.1 17.9 24.1 28.5 xperiment : cor all grass waving in slightly roug pough and r barently hig on. 4.74 | .198 .101 .0734 .0578 I, 1940 un 1 and the stem d 5 com- gh. Run side wal .271 .285 .132 .0844 .0643 .0563 I, 1940 s for run: the flows gh. Run run 7 the h surface |
| sodding in spring 1 2 3 4 5 Channel 2D Description of v clipped green gr square foot; ave position 50 per needle grasses; tablished by solid 1 2 3 4 5 6 Channel 10D Description of v clipped green g per square foo poslibion 70 pero needle grasses; tablished by solid 1 2 3 4 5 6 Channel 10D Description of v clipped green g per square foo poslibion 70 pero needle grasses; tablished by solid | g 1940. 9-14 9-14 9-14 9-14 9-14 9-14 9-14 regetation rass with rrage leng cent blue upright d sodding 9-11 9-1 | .0523 .543 1.53 2.96 4.90 21.4 cubic th 16.4 in e grama, 1 at start of in spring .0682 .510 1.50 3.00 4.86 7.54 Good u h 15.9 cub ge length at start of in the spr .0523 .516 | .778 .982 1.21 1.43 | .698 1.56 2.45 8.43 Bed Slop and of un- forage per pact; com- t crab and Grass es- .294 .647 1.57 2.73 3.83 4.93 Bed Slop and of un- of forage hes; com- trab and Grass es- 0. .264 1.48 | .0122 .0116 .0114 .0111 e 1.95 Pe Hydr over for r plete 6, su cause .0201 .0214 .0213 .0207 .0200 e 10.3 Pe Hydr 1 and Runs 5 and surfa veloc .103 .102 | 30 100 100 100 rcent aulic behav grass for r un 3, surfact ly submerge trface of f ed run to be 0 95 100 100 100 100 100 100 rcent aulic behav d 2 but grass d 6, surface ce became ity. Very 1 60 100 100 100 | 20 29 32 31 for: Flow un 2 and ce of flow ed, surface dow rough e very sho 27 12 29 32 32 32 10 ior: Flow is remaine urface of of the flu very rough ittle appa 40 36 | 218 .192 .050 .011 E 7 through 3, slight k smooth. e of flow of flow .1 Wash-6 ort. .000 .130 .079 .034 .106 E 7 over part d erect or the flow s with app rent erosi .000 .000 .034 | 7.24 14.7 21.0 27.4 grass for r bending of Runs 4 an slightly rou under 4.31 5.01 11.1 17.9 24.1 28.5 xperiment 2 or all grass waving in slightly roug rough and r barently hig on. 4.74 7.84 17.6 | .198 .101 .0734 .0578 I, 1940 un 1 and the stem: d 5 com. gh. Run side wal .271 .285 .132 .0844 .0643 .0563 I, 1940 s for runs the flows gh. Runs run 7 the h surface .240 .159 .0733 | | |
| sodding in spring 1 2 3 4 5 Channel 2D Description of v clipped green gr square foot; ave position S0 per noedle grasses; tablished by solid 1 2 3 4 5 6 Channel 10D Description of v clipped green g per square foo position 70 perc needle grasses; tablished by solid 1 2 3 4 5 6 | g 1940. 9-14 9-14 9-14 9-14 9-14 9-14 9-14 9-14 regetation rass with trage leng cent blue upright 9-11 9- | .0523 .543 1.53 2.96 4.90 :: Good u 21.4 cubic 3th 16.4 in e grama, 1 at start o in spring .0682 .510 1.50 3.00 4.86 7.54 :: Good u h 15.9 cul ge length grama, 3 at start o in the spr .0523 .516 1.59 5.02 | .778 .982 1.21 1.43 | .698 1.56 2.45 8.43 Bed Slop and of un- forage per pact; com- t crab and Grass es- .294 .647 1.57 2.73 3.83 4.93 Bed Slop and of un- of forage thes; com- crab and Grass es- 0. .264 1.48 3.70 7.28 | .0122 .0116 .0114 .0111 pe 1.95 Pe Hydr over for r plete 6, su cause .0201 .0214 .0213 .0207 .0200 pe 10.3 Pe Hydr 1 and Runs 5 and surfa veloc .103 .102 .101 | 30 100 100 100 rcent aulic behav grass for r un 3, surfa- ly submerge trface of f ed run to b 0 95 100 100 100 100 100 100 rcent aulic behav d 6, surface ce became ce became ty. Very 1 60 100 100 100 | 20 29 32 31 for: Flow un 2 and ce of flow ed, surface low rough e very sho 27 12 29 32 32 32 32 32 10 ior: Flow is remaine urface of of the flow very rough ittle appa 40 36 29 31 | 218 .192 .050 .011 E 7 through 3, slight k 5 smooth. 2 of flow 1 smooth. 2 of flow 1 smooth. 2 of flow 1 smooth. 2 of flow 1 smooth. 2 of 0 wash-0 .000 .130 .079 .034 .106 E 7 over part d erect or the flow s ows were 1 a with appr rent erosi .000 .060 .060 .0667 .155 | 7.24 14.7 21.0 27.4 grass for r bending of Runs 4 an slightly rou out under 4.31 5.01 11.1 17.9 24.1 28.5 xperiment 2 or all grass waving in slightly roug rough and r barently hig on. 4.74 7.84 17.6 27.6 | .198 .101 .0734 .0578 I, 1940 un 1 and the stem: d 5 com- gh. Run side wal .271 .285 .132 .0844 .0643 .0563 I, 1940 s for rum the flows gh. Runs run 7 the h surface 240 .159 .0733 .0507 | | |

Table 5.—Results of Tests of Channels Lined with Blue Grama Grass.—(Continued).

••

| Channel 1E | | | · | Bed Slop | e 0.97 Per | cent | | E | xperiment 1 | , 1942 |
|---|--|--|---|---|---|--|--|---|--|--|
| | | | | <u> </u> | | | · | | Coeffici | ents |
| | - | 2 | | ₽ | • | | | | | 5 |
| | | 8,JB | Α. | | 2 | gen | g . | 3 5 | , D | 30 |
| | | a s | ų. | d B | ÷. | ner | low | rate | Az - | ti i |
| Run | Date | Discharge per foot of width, VD | , Depth. | Mean yelocity, | Effective slope | Vegetation submergence | Duration of flow | ٩. م | Chezy, | Mannin |
| | 3 | | 4 | 5 | 6 | 7 | 8 | <u> </u> | 10 | 11 |
| | | Cu. ft. per sec. | Feet - | Pt. per sec. | Ft. per | Percent | Min. | In. per hr. | | |
| escription of v | egetation: | | | | | | | | and over | grass for |
| linned green gr | ass with | 111 stems 1 | per square | foot; av- | runs | 1 and 3. | Grass bega | n bending | under flow | of run 4 |
| rage length 3.5 | inches: c | omposition | 100 perce | ent buffalo | | | | | rface of flo | |
| rass; upright a | t start of | testing. (| Frass esta | blished by | | | | | flow becam | |
| olid sodding in | spring 194 | ю | | | with | each incre | ase in dept | h but did | not get ver | y rough. |
| 1 | 9-2 | .0212 | .123 | .172 | .0107 | . 0 | 50 | 000 | 4.80 | .219 |
| 3 | 9-2 | .117 | .321 | .364 | .0093 | 75 | 25 | .000 | 6.72 | .185 |
| 4 | 9-2 | .251 | .361 | .695 | .0094 | 95 | 35 | .014 | 11.9 | .105 |
| 5 | 9-2 | .534 | .453 | 1.18 | .0096 | 100 | 40 | .030 | 18.0 | .0728 |
| 6 | 9-2 | 1.05 | .571 | 1.84 | .0096 | 100 | 38 | .019 | 24.8 | .0547 |
| 7 | 9-2 | 2.03 | .747 | 2.72 | .0096 | 100 | 24 | .036 | 32.1 | .0441 |
| 8 | 9-2 | 3.57 | .937 | 3.81 5.09 | .0101 .0102 | 100 100 | 30 35 | .053 .000 | 39.4 47.8 | .0376 |
| 9 | · 9-2 | 6.16 | 1.21 | | | | | | | .0330 |
| Channel 2E | | | | | pe 1.89 Pe | | | | xperiment 1 | |
| Description of v | regetation | Good u | morm sta | nd of un- | | | | | of grass wit | |
| lipped green gr quare foot; ave | ass with | 4.1 CUDIC I | heres of | noisige per | | | | | Runs 3 ar | |
| quare 1001; ave percent buffalo | arage leng | sen 4.3 inc | nes; cont | or annual | | | | | lightly roug | |
| rasses; upright | , it per | of testing | Grace | established | | | | | nd grass r | |
| by solid sodding | in spring | 1940. | . (11465 | 630601101104 | | of flow rou | | | 1111 BL002 1 | |
| | <u>_</u> | | | | · · | · · · · · | | | | <u> </u> |
| 1 | 9-15 | .0571 | .180 | .317 1.41 | .0197 .0188 | 0 95 | 30 | .000 | 5.06 | .225 |
| 2 | 9-15 9-15 | .532 1.56 | .377 .554 | 2.81 | .0186 | 95 100 | 12 30 | .000 | 16.8 | .0757 |
| 3 4 | 9-15 9-15 | 3.00 | .736 | 4.08 | .0188 | 100 | 27 | .144 .245 | 28.0 35.0 | .0490 |
| 5 | 9-15 | 4.99 | .946 | 5.28 | .0191 | 100 | 31 | .166 | 89.5 | .0409 .0375 |
| 6 | 9-15 | 9.62 | 1.33 | 7.23 | .0191 | 100 | 32 | .084 | 45.4 | .0344 |
| Channel 2E | - | | | Bed Slo | pe 2.01 Pe | rcent | | | Experiment | |
| | | Tlain an | dermo etc | nd of un- | | | | | | · |
| | | : Fair un | norm sta | forsee per | Hyar | aune bena | vior: Run | 6, grass | submerged | partiall |
| Description of v | egetation: | | menes or | notition 100 | Duil | 7 apparent | ereot in the | 110W. St | urface of flo | w smootl |
| clipped green g | rass with | th An ind | hee comt | | nun | 7 apparen | uy maicau | es a chang | ge in flow a | as surfac |
| clipped green g square foot; av | rass with erage leng | th 4.2 inc | hes; comj f testing | Grass AS- | hoon | mo foisle i | own Dw | | | |
| Description of w clipped green g square foot; av percent buffalo; tablished in spr | rass with erage leng : upright | th 4.2 inc at start o | f testing. | Grass es- | beca | me fairly : condition | ough. Ru | ns 8, 9 ar wht incre | nd 10 simila | ir in sur |
| clipped green g square foot; av percent buffalo; tablished in spr | rass with erage leng ; upright ing 1940. | th 4.2 inc at start o Maintena | f testing. nce consis | Grass es- ted of con- | beca: face | condition | ough. Ru except sli | ns 8, 9 ar ght incre | nd 10 simila ase in rou | ar in sui ghness a |
| clipped green g square foot; av | rass with erage leng ; upright ing 1940. | th 4.2 inc at start o Maintena | f testing. nce consis | Grass es- ted of con- | beca: face | me fairly condition h increased | ough. Ru except sli | ns 8, 9 ar ght incre | nd 10 simila | ar in sur ghness a |
| clipped green g square foot; av percent buffalo tablished in spr trolling weeds a vious testing. | rass with erage leng ; upright ing 1940. nd filling | th 4.2 inc at start o Maintenan damaged p | f testing. nce consis places cau | Grass es- ted of con- sed by pre- | becar face depti | condition h increased | except sli | ght incre | nd 10 simila ase in roug | ghness a |
| clipped green g square foot; av- percent buffalo; tablished in spr trolling weeds a vious testing. 6 | rass with erage leng ; upright ing 1940. nd filling 7-18 | th 4.2 inc at start o Maintenan damaged 1 .0763 | f testing. nce consis places cau | Grass es- ted of con- sed by pre- .263 | beca face depti | condition h increased 80 | except sli | ght incre | nd 10 simila ase in roup | ghness a 348 |
| clipped green g square foot; av percent buffalo ablished in spr rolling weeds a vious testing. 6 .7 | rass with erage leng ; upright ing 1940. nd filling 7-18 7-18 | th 4.2 inc at start o Maintenan damaged 1 .0763 .270 | f testing. nce consis places cau .290 .373 | Grass es- ted of con- sed by pre- .263 .725 | beca face depti .0196 0196 | condition h increased 80 100 | except sli 23 12 | 9ht incre .000 .000 | nd 10 simila ase in roug 8.50 8.52 | 348 .149 |
| clipped green g square foot; av percent buffalo tablished in spr trolling weeds a vious testing. 6 7 8 | rass with erage leng ; upright ing 1940. nd filling 7-18 7-18 7-19 | th 4.2 inc at start o Maintenan damaged 1 .0763 .270 .655 | f testing. nce consis places cau .290 .373 .461 | Grass es- ted of con- sed by pre- .263 | beca: face depti .0196 0196 .0199 | condition h increased 80 100 100 | ough. Ru except sli 23 12 45 | .000 .000 .043 | nd 10 simila ase in roug 8.50 8.52 14.8 | 348 .149 .0881 |
| clipped green g square foot; av bercent buffalo ablished in spr rolling weeds a rious testing. 6 .7 | rass with erage leng ; upright ing 1940. nd filling 7-18 7-18 | th 4.2 inc at start o Maintenan damaged 1 .0763 .270 | f testing. nce consis places cau .290 .373 | Grass es- ted of con- sed by pre- .263 .725 1.42 | beca face depti .0196 0196 | condition h increased 80 100 | except sli 23 12 | 000 .000 .043 .082 | nd 10 simila ase in roug 3.50 8.52 14.8 29.5 | 348 .149 .0881 .0485 |
| clipped green g square foot; av percent buffalo ablished in spr rolling weeds a vious testing. 6 7 8 9 10 | rass with erage leng ; upright ing 1940. nd filling 7-18 7-18 7-18 7-19 7-19 | th 4.2 inc at start o Maintenau damaged y .0763 .270 .655 2.85 | f testing. nce consis places cau .290 .373 .461 .780 | Grass es- ted of con- sed by pre- .263 .725 1.42 3.66 5.29 | beca: face depti .0196 0196 .0199 .0199 | condition h increased 80 100 100 100 100 | rough. Ru except sli 23 12 45 50 | 000 .000 .043 .082 .128 | ad 10 simila ase in rou 8.50 8.52 14.8 29.5 37.3 | 348 .149 .0881 .0485 .0399 |
| clipped green g square foot; av percent buffalo tablished in spr trolling weeds a vious testing. 6 7 8 9 10 Channel 2E | rass with erage leng ; upright ing 1940. nd filling 7-18 7-18 7-19 7-19 7-19 | th 4.2 inc at start o Maintenaa damaged y .0763 .270 .655 2.85 5.28 | f testing. nee consis blaces cau 290 373 .461 .780 .999 | Grass es- ted of con- sed by pre- 263 .725 1.42 3.66 5.29 Bed Slo | beca: face deptl .0196 .0199 .0199 .0202 ope 2.05 Pc | 80 100 100 100 100 ercent | rough. Ru except sli 23 12 45 50 38 | 000 .000 .043 .082 .128 | nd 10 simila ase in roup 8.50 8.52 14.8 29.5 37.3 Experiment | 348 .149 .0881 .0485 .0399 3, 1942 |
| clipped green g square foot; av percent buffalo tablished in spr trolling weeds a vious testing. 6 7 8 9 10 Channel 2E Description of | rass with erage leng ; upright ing 1940. nd filling 7-18 7-18 7-18 7-19 7-19 7-19 7-19 | th 4.2 inc at start o Maintenaa damaged j .0763 .270 .655 2.85 5.28 5.28 | f testing. nee consis blaces cau .290 .373 .461 .780 .999 niform st | Grass es- ted of con- sed by pre- 263 .725 1.42 3.66 5.29 Bed Slo and of un- | beca face depti .0196 .0196 .0199 .0199 .0202 ope 2.05 Pc Hyd | condition h increased 80 100 100 100 100 ercent raulic beha | rough. Ru except sli 23 12 45 50 38 | .000 .000 .043 .082 .128 | ad 10 simils ase in roug 3.50 6.52 14.8 29.5 37.3 Experiment and over | 348 .149 .0881 .0485 .0399 3, 1942 |
| clipped green g square foot; av percent buffalo ablished in spr rolling weeds a vious testing. 6 7 8 9 10 Channel 2E Description of clipped green g | rass with erage leng ; upright ing 1940. nd filling 7-18 7-18 7-19 7-19 7-19 7-19 7-19 | th 4.2 inc at start o Maintenaa damaged y .0763 .270 .655 2.85 5.28 5.28 : Good u 690 stems y | f testing. nce consis places cau .290 .373 .461 .780 .999 niform st per square | Grass es- ted of con- sed by pre- 263 .725 1.42 3.66 5.29 Bed Slo and of un- foot; aver- | beca: face deptl .0196 0196 .0199 .0202 ope 2.05 Pc Hyda runs | 80 100 100 100 100 2FCENT Fraulic beha 1, 2 and 3 | except sli 23 12 45 50 38 evior: Flor 3, very smo | .000 .000 .043 .082 .128 | ad 10 simila ase in roug 8.50 8.52 14.8 29.5 37.3 Experiment and over | 348 .149 .0881 .0485 .0399 3, 1942 grass fo |
| clipped green g square foot; av percent buffalo cablished in spr rolling weeds a vious testing. 6 7 8 9 10 Channel 2E Description of clipped green g age length 3.1 | rass with erage leng ; upright ing 1940. nd filling 7-18 7-18 7-19 7-19 7-19 7-19 7-19 vegetation rass with inches; c | th 4.2 inc at start o Maintenan damaged y .0763 .270 .655 2.85 5.28 5.28 5.28 i: Good u 690 stems y omposition | f testing. nee consis places cau .290 .373 .461 .780 .999 niform st per square 100 perc | Grass es- ted of con- sed by pre- 263 .725 1.42 3.66 5.29 Bed Slo and of un- foot; aver- ent buffalo | beca: face deptl .0196 0199 .0199 .0202 ope 2.05 Pc Hyd runs stan | condition h increased 100 100 100 100 ercent raulic behr 1, 2 and 3 ding in flo | except sli 23 12 45 50 38 evior: Flo 8, very smc | 000 .000 .043 .082 .128 .128 .082 .128 .082 .128 .015 .015 .015 .015 .015 .015 .015 .015 | ad 10 simila ase in roug 8.50 8.52 14.8 29.5 37.3 Experiment a and over ce. Grass s Surface smo | 348 .149 .0881 .0485 .0399 3, 1942 grass for submerge |
| clipped green g square foot; av- percent buffalo ablished in spr rolling weeds a rous testing. 6 7 8 9 10 Channel 2E Description of clipped green g age length 3.1 grass; upright | rass with erage leng ; upright ing 1940. nd filling 7-18 7-18 7-19 7-19 7-19 7-19 7-19 7-19 cass with inches; c at start o | th 4.2 inc at start o Maintenan damaged y .0763 .270 .655 2.85 5.28 5.28 5:28 5:28 5:28 5:28 5:28 5:28 5:28 5: | f testing. nee consis places cau 290 373 461 .780 .999 niform st per square 100 perc Grass est | Grass es- ted of con- sed by pre- 263 .725 1.42 3.66 5.29 Bed Slo and of un- foot; aver- ent buffalo ablished by | becal face depti .0196 0199 .0199 .0202 ope 2.05 Pc Hyd runs stan face | condition h increased 100 100 100 100 ercent raulic behr 1, 2 and 3 ding in flo | except sli 23 12 45 50 38 evior: Flo 8, very smc | 000 .000 .043 .082 .128 .128 .082 .128 .082 .128 .015 .015 .015 .015 .015 .015 .015 .015 | ad 10 simila ase in roug 8.50 8.52 14.8 29.5 37.3 Experiment and over | 348 .149 .0881 .0485 .0399 3, 1942 grass for submerge |
| clipped green g square foot; av bercent buffalo ablished in spr rolling weeds a rlous testing. 6 7 8 9 10 Channel 2E Description of clipped green g age length 3.1 grass; upright solid sodding in | rass with erage leng ; upright ing 1940. nd filling 7-18 7-18 7-19 7-19 7-19 7-19 7-19 vegetation rass with inches; c at start o n spring 1 | th 4.2 inc at start o Maintenan damaged y .0763 .270 .655 2.85 5.28 : Good u 690 stems y oomposition f testing. 1940. Main | f testing. nee consis places cau 290 373 .461 .780 .999 niform st per square 100 perc Grass est itenance | Grass es- ted of con- sed by pre- 263 .725 1.42 3.66 5.29 Bed Slo and of un- foot; aver- ent buffalo ablished by consisted of | becal face depti .0196 0199 .0199 .0202 ope 2.05 Pc Hyd runs stan face | condition h increased 100 100 100 100 ercent raulic behn 1, 2 and 3 ding in flo of flow f | except sli 23 12 45 50 38 evior: Flo 8, very smc | 000 .000 .043 .082 .128 .128 .082 .128 .082 .128 .015 .015 .015 .015 .015 .015 .015 .015 | ad 10 simila ase in roug 8.50 8.52 14.8 29.5 37.3 Experiment a and over ce. Grass s Surface smo | 348 .149 .0881 .0485 .0399 3, 1942 grass for submerge |
| clipped green g square foot; av percent buffalo :ablished in spr rolling weeds a dious testing. | rass with erage leng ; upright ing 1940. nd filling 7-18 7-18 7-19 7-19 7-19 7-19 7-19 7-19 at start o and filling | th 4.2 inc at start o Maintenaa damaged y .0763 .270 .655 2.85 5.28 : Good u 690 stems y composition f testing. 1940. Main ag damage | f testing. nee consis places cau 290 373 .461 .780 .999 niform st per square 100 perc Grass est itenance | Grass es- ted of con- sed by pre- 263 .725 1.42 3.66 5.29 Bed Slo and of un- foot; aver- ent buffalo ablished by consisted of | becal face depti .0196 0199 .0199 .0202 ope 2.05 Pc Hyd runs stan face | condition h increased 100 100 100 100 ercent raulic behn 1, 2 and 3 ding in flo of flow f | except sli 23 12 45 50 38 evior: Flo 8, very smc | 000 .000 .043 .082 .128 .128 .082 .128 .082 .128 .015 .015 .015 .015 .015 .015 .015 .015 | ad 10 simila ase in roug 8.50 8.52 14.8 29.5 37.3 Experiment a and over ce. Grass s Surface smo | 348 .149 .0881 .0485 .0399 3, 1942 grass for submerge |
| clipped green g square foot; av percent buffalo cablished in spr rrolling weeds a vious testing. 6 7 8 9 10 Channel 2E Description of clipped green g age length 3.1 grass; upright solid sodding in cutting weeds erosion of previ | rass with erage leng ; upright ing 1940. nd filling 7-18 7-18 7-19 7-19 7-19 7-19 7-19 7-19 at start o and filling | th 4.2 inc at start o Maintenaa damaged y .0763 .270 .655 2.85 5.28 : Good u 690 stems y composition f testing. 1940. Main ag damage | f testing. nee consis places cau 290 373 .461 .780 .999 niform st per square 100 perc Grass est itenance | Grass es- ted of con- sed by pre- 263 .725 1.42 3.66 5.29 Bed Slo and of un- foot; aver- ent buffalo ablished by consisted of | becal face depti .0196 0199 .0199 .0202 ope 2.05 Pc Hyd runs stan face | condition h increased 100 100 100 100 ercent raulic behn 1, 2 and 3 ding in flo of flow f | except sli 23 12 45 50 38 evior: Flo 3, very smo w for runs airly rough | 000 000 043 082 128 1 w through oth surfa 4 and 5; for runs | ad 10 simila ase in roug 8.50 8.52 14.8 29.5 37.3 Experiment a and over ce. Grass s surface smo 6 and 7 a | 348 .149 .0881 .0485 .0399 3, 1942 grass for submerge poth; sur and roug |
| clipped green g square foot; av bercent buffalo ablished in spr rolling weeds a dous testing. | rass with erage leng ; upright ing 1940. nd filling 7-18 7-18 7-19 7-19 7-19 7-19 7-19 7-19 7-19 a filling vegetation rass with inches; c at start o n spring 1 and filling | th 4.2 inc at start o Maintenan damaged y .0763 .270 .655 2.85 5.28 :: Good u 690 stems y omposition f testing. 1940. Main g damage | f testing. nee consis places cau .290 .373 .461 .780 .999 niform st per square 100 perc Grass est thenance of d places | Grass es- ted of con- sed by pre- 263 .725 1.42 3.66 5.29 Bed Slo and of un- foot; aver- ent buffalo ablished by consisted of caused by | beca face deptil .0196 0199 .0199 .0202 .0 | so and s. | except sli 23 12 45 50 38 evior: Flo 3, very smo w for runs airly rough 47 | 000 .000 .043 .043 .043 .082 .128 .082 .128 .082 .082 .082 .082 .082 .000 | ad 10 simila ase in roug 8.50 8.52 14.8 29.5 37.3 Experiment and over ce. Grass s surface smo 6 and 7 a 3.81 | 348 .149 .0881 .0495 .0399 3, 1942 grass f submerge poth; su and roug |
| clipped green g square foot; av percent buffalo :ablished in spr rolling weeds a dous testing. | rass with erage leng ; upright ing 1940. nd filling 7-18 7-18 7-19 7-19 7-19 7-19 7-19 7-19 vegetation rass with inches; cc at start o n spring 1 and fillin ous testin. 9-1 | th 4.2 inc at start o Maintenan damaged 1 .0763 .270 .655 2.85 5.28 :: Good u 690 stems 1 oomposition f testing. 1940. Main ng damage g. | f testing. nee consis places cau 290 373 .461 .780 .999 niform st per square 100 perc Grass est itenance d places .103 | Grass es- ted of con- sed by pre- 263 .725 1.42 3.66 5.29 Bed Slo and of un- foot; aver- ent buffalo ablished by consisted of caused by .175 | beca: face dept1 .0196 .0199 .0202 .0202 .0202 Hyd runs stand face for { | condition h increased 80 100 100 100 100 100 ercent raulic behr 1, 2 and 3 ding in flo of flow f 3 and 9. | except sli 23 12 45 50 38 evior: Flor 8, very smo w for runs airly rough 47 31 | 000 .000 .043 .082 .128 .128 .128 .027 .027 .027 .020 .000 .000 | ad 10 simila ase in roug 8.50 8.52 14.8 29.5 37.3 Experiment and over ce. Grass s surface smo 6 and 7 a 3.81 3.36 | 348 .149 .0881 .0485 .0399 3, 1942 grass fo submerge poth; sup and roug 267 .334 |
| clipped green g square foot; av- bercent buffalo ablished in spr rolling weeds a rous testing. 6 7 8 9 10 Channel 2E Description of clipped green g age length 3.1 grass; upright solid sodding in cutting weeds erosion of previ | rass with erage leng ; upright ing 1940. nd filling 7-18 7-18 7-19 7-19 7-19 7-19 7-19 7-19 vegetation rass with inches; c at start o and fillin ous testin. 9-1 9-1 | th 4.2 inc at start of Maintenan damaged y .0763 .270 .655 2.85 5.28 : Good u 690 stems y composition f testing. 1940. Mair ng damage g. .0180 .0379 | f testing. nee consis places cau 290 373 .461 .780 .999 niform st per square 100 perc Grass est tenance of places .103 .185 | Grass es- ted of con- sed by pre- 263 .725 1.42 3.66 5.29 Bed Slo and of un- foot; aver- ent buffalo ablished by consisted of caused by .176 .205 .280 .579 | beca: face dept1 .0196 .0199 .0202 .0202 .0202 .0202 Hyd runs stand face for { .0206 .0203 | condition h increased 80 100 100 100 100 100 ercent raulic beh; 1, 2 and 3 ding in flo of flow f 8 and 9. 0 10 | except sli 23 12 45 50 38 evior: Flo 3, very smo w for runs airly rough 47 | 9ht incre .000 .000 .043 .082 .128 I w through oth surfa 4 and 5; for runs .000 .000 .025 | ad 10 simila ase in roug 8.50 8.52 14.8 29.5 37.3 Experiment 1 and over ce. Grass s surface smo 5 6 and 7 a 3.81 3.36 4.19 | 348 .149 .0881 .0485 .0399 3, 1942 grass for submerge poth; sup and roug 267 .334 .277 |
| clipped green g square foot; av- bercent buffalo ablished in spr rolling weeds a rous testing. 6 7 8 9 10 Channel 2E Description of clipped green g age length 3.1 grass; upright solid sodding in cutting weeds erosion of previ | rass with erage leng ; upright ing 1940. nd filling 7-18 7-18 7-19 7-19 7-19 7-19 7-19 vegetation rass with inches; c at start o n spring 1 ous testin. 9-1 9-1 9-1 | th 4.2 inc at start o Maintena) damaged p .0763 .270 .655 2.85 5.28 : Good u 690 stems p composition f testing. 1940. Main ng damage g. .0180 .0379 .0630 | f testing. nce consis places cau .290 .373 .461 .780 .999 niform st ner square 100 perc Grass est tenance of .103 .185 .225 | Grass es- ted of con- sed by pre- 263 .725 1.42 3.66 5.29 Bed Slo and of un- foot; aver- ent buffalo ablished by consisted of caused by .175 .205 .280 | beca: face deptl .0196 0199 .0199 .0202 ope 2.05 Pc Hyda runs stand face for { .0206 .0203 .0199 | condition h increased 80 100 100 100 100 ercent raulic behn 1, 2 and 3 ding in flo of flow f 3 and 9. 0 10 50 | except sli 23 12 45 50 38 evior: Flor 5, very smo w for runs airly rough 47 31 20 | 000 .000 .043 .082 .128 1 w through oth surfa. 4 and 5; for runs .000 .000 .000 .025 .029 | ad 10 simila ase in roug 8.50 8.52 14.8 29.5 37.3 Experiment and over ce. Grass s surface smo 6 and 7 a 3.81 3.36 4.19 7.91 | 348 .149 .0881 .0485 .0399 3, 1942 grass f. submerge poth; sur and roug 267 .334 .277 .151 |
| clipped green g square foot; av bercent buffalo ablished in spr rolling weeds a rous testing. 6 7 8 9 10 Channel 2E Description of clipped green g age length 3.1 grass; upright solid sodding in cutting weeds erosion of previ 1 2 3 4 5 6 | rass with erage leng : upright ing 1940. nd filling 7-18 7-18 7-19 7-19 7-19 7-19 7-19 7-19 7-19 7-19 | th 4.2 inc at start o Maintenan damaged 1 .0763 .270 .655 2.85 5.28 .055 2.85 5.28 .000 out .059 stems 1 .000 out .000 out .0180 .0379 .0630 .156 .311 .622 | f testing. nee consis places cau .290 .373 .461 .780 .999 miform st ber square 100 perc Grass est tenance of .103 .185 .225 .270 | Grass es- ted of con- sed by pre- 263 .725 1.42 3.66 5.29 Bed Slo and of un- foot; aver- ent buffalo ablished by consisted of caused by .176 .205 .280 .579 | beca: face deptl .0196 0199 .0202 ope 2.05 Pc Hyd face for 8 .0206 .0206 .0203 .0199 .0200 | condition h increased 80 100 100 100 100 ercent raulic behn 1, 2 and 3 ding in flo of flow f 3 and 9. 0 10 50 90 | except sli 23 12 45 50 38 evior: Flo 3, very smo w for runs airly rough 47 31 20 30 | 9ht incre .000 .000 .043 .082 .128 I w through oth surfa 4 and 5; for runs .000 .000 .025 | ad 10 simila ase in roug 8.50 8.52 14.8 29.5 37.3 Experiment a and over ce. Grass 5 surface smo 6 and 7 a 3.81 3.36 4.19 7.91 12.2 | 348 .149 .0881 .0485 .0399 3, 1942 grass for submerge both; sun and roug 267 .334 .277 .151 .101 |
| clipped green g square foot; avpercent buffalo iablished in spr rolling weeds a vious testing. 6 7 8 9 10 Channel 2E Description of clipped green g age length 3.1 grass; upright solid sodding in cutting weeds erosion of previ 1 2 3 4 5 6 7 | rass with erage leng ; upright ing 1940. nd filling 7-18 7-18 7-19 7-19 7-19 7-19 7-19 7-19 7-19 7-19 | th 4.2 inc at start o Maintena) damaged j .0763 .270 .655 2.85 5.28 | f testing. nee consis places cau .290 .373 .461 .780 .999 niform st per square 100 perc Grass est tenance of .103 .185 .225 .270 .320 | Grass es- ted of con- sed by pre- 263 .725 1.42 3.66 5.29 Bed Slo and of un- foot; aver- ent buffalo ablished by consisted of caused by .176 .205 .280 .579 .971 | beca: face deptl .0196 0199 .0202 ope 2.05 Pc Hyd runs stand face for 8 .0206 .0203 .0199 .0200 .0199 .0200 .0201 | condition h increased 80 100 100 100 100 100 ercent 1, 2 and 3 ding in flo of flow f 3 and 9. 0 10 50 90 100 | airly rough 47 30 30 30 30 30 30 50 47 47 31 20 30 | 9ht incre .000 .043 .043 .043 .043 .043 .043 .043 | ad 10 simila ase in roug 8.50 8.52 14.8 29.5 37.3 Experiment and over ce. Grass s surface smo 6 and 7 a 3.81 3.36 4.19 7.91 12.2 17.6 | 348 .149 .0881 .0495 .0399 3, 1942 grass f submerge poth; su and roug 267 .334 .277 .151 .101 .072; |
| clipped green g square foot; av percent buffalo tablished in spr trolling weeds a vious testing. 6 7 8 9 10 Channel 2E Description of clipped green g age length 3.1 grass; upright solid sodding ii cutting weeds erosion of previ 1 2 3 4 5 6 | rass with erage leng ; upright ing 1940. nd filling 7-18 7-18 7-19 7-19 7-19 7-19 7-19 7-19 7-19 7-19 | th 4.2 inc at start o Maintenan damaged 1 .0763 .270 .655 2.85 5.28 .055 2.85 5.28 .000 out .059 stems 1 .000 out .000 out .0180 .0379 .0630 .156 .311 .622 | f testing. nee consis places cau .290 .373 .461 .780 .999 niform st per square 100 perc Grass est itenance of .103 .185 .225 .270 .320 .396 | Grass es- ted of con- sed by pre- 263 .725 1.42 3.66 5.29 Bed Sto able Sto ablished by consisted of caused by .175 .205 .280 .579 .971 1.57 | beca: face dept1 .0196 .0199 .0199 .0202 .0202 .0202 Hyd face for { .0206 .0203 .0199 .0200 .0199 .0200 | condition h increased 80 100 100 100 100 100 100 100 100 100 100 100 100 100 101 11, 2 and 3 11, 3 and 9. 110 100 100 100 100 100 | except sli except sli 23 12 45 50 38 evior: Flo 3, very smo w for runs airly rough 47 31 20 30 30 29 | 9ht incre .000 .000 .043 .082 .128 .082 .128 .082 .128 .082 .017 .000 .025 .029 .017 .042 | ad 10 simila ase in roug 8.50 8.52 14.8 29.5 37.3 Experiment a and over ce. Grass 5 surface smo 6 and 7 a 3.81 3.36 4.19 7.91 12.2 | 348 .149 .0881 .0485 .0399 3, 1942 grass f. submerge both; sup and roug 267 .334 .277 .151 |

Table 6.—Results of Tests of Channels Lined with Buffalo Grass.

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| Channel 4E | | | | | | · · · · · · · · · · · · · · · · · · · | | | | |
|--|--|--|--|--|---|---|---|---|--|---|
| | | | • | | | _ | | | Coeffi | |
| | | ្ដុំខ្ល | A | • | | Vegetation submergence | _ | | _ | я - |
| | ı | Discharge per foot o width, VD | | Mean velocity, | Effective slope | atic at the second s | Duration of flow | rate cour | D J | Manning, |
| d | 3 | 8-3 | Depth, | E SO | ដីខ្ល | 10.4 | 12 C | E S | Chezy, | 8 |
| Run | Data | | ā | 97 | 12.0 | Veg | 8× | ٩. ۲ | đ | μ, |
| | | 3 | 4 | 5 | | 7 | | . 9 | 10 | <u></u> - |
| <u> </u> | | Ou. it. | | Ft. per | Pt. per | • | <u> </u> | In. per | 10 | ** |
| | | per sec. | Feet | sec. | | Percent | <u>Min.</u> | hr. | | |
| scription of pped green g lare foot; av rcent buffalo blished in spr | grass with verage leng o; upright | 2.7 cubic th 3.9 inc | inches of hes; com | forage per position 100 | fore for re grass flow maine 10, 11 | testing but uns 1 and submerged rough for 1 der of runs | in good 2 with su 1 but we uns 4, 5, . Erosion ; not enou | condition. mooth sur- aving in t 6 and 7, a 1 Was appa | by rain of Flow thro face. Run he flow. S nd very rou irent for ea the chann | ough gra 3 most Surface gh for r ch of ru |
| | 0 19 | .0118 | .096 | .123 | | | | 000 | 0.00 | 400 |
| 1 | 8-12 | | | | .0386 | 0 | 29 | .000 | 2.03 | .496 |
| 2 | 8-12 | .0575 | .197 | .292 | .0380 | 10 | 22 | .000 | 3.39 | .338 |
| 3 | 8-12 | .279 | .271 | 1.03 | .0383 | 80 | 16 | .053 | 10.2 | .118 |
| 4 | 8-12 | 1.05 | .393 - | 2.67 | .0381 | 100 | 18 | .000 | 21.8 | .0584 |
| 5 | 8-12 | 1.67 | .467 | 3.58 | .0388 | 100 | 10 | .000 | 26.7 | .049 |
| 6 | 8-12 | 2.39 | .543 | 4.40 | .0391 | 100 | 11 | .033 | 30.2 | .044 |
| 7 | 8-12 | 3.20 | .630 | 5.08 | .0389 | 100 | 11 | .167 | 32.4 | .042 |
| 8 | 8-12 | 4.06 | .722 | 5.63 | .0392 | 100 | 10 | .000 | 33.5 | .042 |
| . 9 | 8-12 | 4.74 | .775 | 6.12 | .0392 | 100 | 8 | .231 | 35.1 | .040 |
| 10 | 8-12 | 5.30 | .810 | 6.54 | .0388 | 100 | 12 | .042 | 36.9 | .038 |
| ĩi | 8-12 | 5.74 | .840 | 6.83 | .0389 | 100 | 24 | .126 | 37.8 | .038 |
| | Q10 | | .877 | 7.16 | .0389 | 100 | 23 | .079 | 38.8 | .0375 |
| 12 | 8-12 | 6.28 | | | | | | | 00.0 | |
| 12 | 8-12 | 6.28 | | | | 4 | | | | |
| Channel 4E escription of ipped green g ge length. 2.7 | vegetation grass with 6 inches; C at start of | : Good u il9 stems j omposition testing. | niform st per square 100 pero Grass est | Bed Slo tand of un- foot; aver- cent buffalo tablished by | pe 3.83 Per Hydra ing ru 5 and right | aulic behav uns 1, 2, 3 a i 6 most or in flow, | nd 4 with all gras surface | w through a surface o s submerge vavy. Sur | Experiment and over f flow smoo ed but rema face of flo | grass du th. Ru aining u w becar |
| Channel 4E escription of | vegetation grass with 6 inches; C at start of in spring 1 and fillin | : Good u il9 stems p omposition testing. 940. Main ng damaga | iniform st per square 100 pero Grass est ntenance | Bed Slo tand of un- foot; aver- cent buffalo tablished by consisted of | Hydra Hydra ing ri 5 and right rough | aulic behav uns 1, 2, 3 a i 6 most or in flow, | nd 4 with all gras surface th increas | w through a surface o s submerge vavy. Sur | and over a f flow smoo | grass du th. Ru aining u w becar |
| Channel 4E escription of ipped green g re length.2.7 ass; upright lid sodding i tting weeds osion of prev | vegetation grass with 6 inches; C at start of in spring 1 and fillin vious testing | : Good u i19 stems] omposition; testing, 940. Main ig damag 5. | iniform st per square 100 pero Grass est ntenance ed places | Bed Slo and of un- foot; aver- cent buffalo tablished by consisted of caused by | ppe 3.83 Per Hydring ru 5 and right rough face | aulic behave uns 1, 2, 3 and d 6 most or in flow, her with each of flow rou | and 4 with all grass surface with th increase igh. | w through a surface o s submerge wavy. Sur se in depth | and over a f flow smoo ed but rema face of flo i. Runs 9 a | grass du th. Ru aining u w becar nd 10 su |
| Channel 4E scription of pped green g e length 2.7 ass; upright id sodding tting weeds osion of prev | vegetation grass with 6 inches; C at start of in spring 1 and fillin vious testing 8-31 | : Good to i19 stems pomposition testing. 940. Main g damago 5. .0144 | iniform st per square 100 pero Grass est ntenance ed places .062 | Bed Slo tand of un- e foot; aver- cent buffalo tablished by consisted of caused by .233 | Hydra Hydra ing r 5 and right face .0383 | aulic behave uns 1, 2, 3 a d 6 most or in flow, her with each of flow rout | and 4 with all grass surface with the increase igh. 40 | w through n surface o s submerge wavy. Sur se in depth .000 | and over a f flow smoo ed but rema face of flo i. Runs 9 a 4.79 | grass du th. Ru aining u w becar nd 10 su .198 |
| Channel 4E escription of pped green g e length_2.7 ass; upright id sodding tting weeds osion of prev | vegetation grass with 6 inches; C at start of in spring 1 and fillin dious testing 8-31 8-31 | : Good u i19 stems j omposition t testing. 940. Mali g damage | iniform stoper square 100 pero Grass esti- nitenance ed places .062 .111 | Bed Slo tand of un- e foot; aver- cent buffalo tablished by consisted of caused by .233 .318 | hype 3.83 Per Hydra ing ru 5 and right rough face o .0383 .0384 | aulic behav uns 1, 2, 3 g d 6 most on in flow, her with eac of flow rou 0 20 | and 4 with all grass surface we th increase ogh. 40 22 | w through n surface o s submerge wavy. Sur se in depth .000 .000 | and over f flow smoo ed but rema face of flo a. Runs 9 a 4.79 4.87 | grass du th. Ru aining u w becar nd 10 su .198 .213 |
| Channel 4E escription of pped green g e length.2.7 ass; upright id sodding : ting weeds basion of prev | vegetation grass with 6 inches; C at start of in spring 1 and fillin vious testing 8-31 8-31 8-31 | : Good u i19 stems j omposition t testing. 940. Main g damage 5. .0144 .0353 .0917 | iniform st per square 1 100 per Grass est ntenance ed places .062 .111 .165 | Bed Slo tand of un- e foot; aver- cent buffalo tablished by consisted of caused by 233 .318 .556 | Ppe 3.83 Per Hydri ing ru 5 and right face of .0383 .0384 .0386 | aulic behav uns 1, 2, 3 g 1 6 most on in flow, ier with each of flow rou 0 20 50 | and 4 with all grass surface with the increase gh. 40 22 20 | w through 1 surface o s submerge wavy. Sur 5e in depth .000 .000 .036 | and over i f flow smoo ed but rema face of flo i. Runs 9 a 4.79 4.87 7.00 | grass du th. Ru aining u w becar nd 10 su .198 .213 .159 |
| Channel 4E escription of pped green g e length.2.7 ass; upright tild sodding : tting weeds belon of prev | vegetation grass with 6 inches; C at start of in spring 1 and fillin rlous testing 8-31 8-31 8-31 8-31 8-31 | : Good u i19 stems j omposition (testing. 940. Main ag damag 5. .0144 .0353 .0917 .191 | iniform st per square 100 per Grass est intenance ed places .062 .111 .165 .191 | Bed Slo tand of un- e foot; aver- cent buffalo tablished by consisted of caused by 233 .318 .556 1.00 | Ope 3.83 Per Hydrring rr 5 and right rough face .0383 .0384 .0386 .0385 .0385 .0385 | aulic behav uns 1, 2, 3 g 1 6 most on in flow, ter with eac of flow rou 0 20 50 75 | and 4 with all grass surface with th increase gh. 40 22 20 33 | w through 1 surface o s submerge wavy. Sur 5e in depth .000 .000 .036 .000 | and over if f flow smoo ed but rema face of flo . Runs 9 a 4.79 4.87 7.00 11.7 | grass du th. Ru aining u w becar nd 10 su .198 .213 .159 .097 |
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| Channel 4E escription of pped green g e length.2.7 ass; upright itid sodding tting weeds osion of prev 1 2 3 4 5 6 7 8 9 10 Channel 5E escription of pped green erage length lo grass; up hed by solid | vegetation grass with 6 inches; C at start of in spring 1 and fillin flous testing 8-31 8-31 8-31 8-31 8-31 8-31 8-31 8-31 | : Good u il9 stems) omposition f testing. 940. Main ag damage 3. .0144 .0353 .0917 .191 .402 .818 1.60 3.16 6.72 9.60 : Good u h 636 ste ; composi start of t h spring 1 | iniform st per square h 100 perd Grass esi ntenance ed places .062 .111 .165 .191 .245 .317 .424 .583 .849 1.01 iniform st ms per s tion 100 p resting. G 942. | Bed Slo tand of un- foot; aver- cent buffalo tablished by consisted of caused by 233 .318 .556 1.00 1.64 2.58 3.78 5.43 7.92 9.51 Bed Slo tand of un- quare foot; percent buf- irass estab- 232 | Ppe 3.83 Per Hydra ing r ing r 5 and right rough rough 383 .0383 .0384 .0383 .0385 .0383 .0385 .0380 .0379 .0383 .0384 .0384 .0373 Dpe 5. 18 Hydr runs in th ripph and incre .0515 .0515 | aulic behav uns 1, 2, 3 a 1 6 most on in flow, her with easy of flow rou 0 20 50 50 50 50 100 100 100 100 1 | vior: Fild vior: Fild for and 5. flow increase increase gh. 40 22 20 33 37 28 35 33 29 32 | w through a surface o s submerge wavy. Sur- se in depth .000 .000 .036 .000 .048 .043 .043 .043 .043 .045 .015 .000 .061 I partially s ' flow reg Runs 6 t reasing in | and over if f flow smoo ed but remains face of flo . Runs 9 a 4.79 4.87 7.00 11.7 17.1 23.6 29.6 36.1 43.9 49.0 Experiment n and over ubmerged bular except 0 10, grass roughness | grass du th. Ru aining u w becar nd 10 su .198 .213 .159 .097 .069 .052 .043 .037 .032 .030 1, 1942 grass 1 .030 1, 1942 grass 1 .030 grass 1 .030 1, 1942 grass 2 .030 1, 1942 grass 2 .030 1, 1942 grass 1 .030 grass 1 .030 gras 1 .030 gras 1 .030 gras 1 .030 gras 1 .030 gras 1 .030 gras 1 .030 gras 1 .0300 gras 1 |
| Channel 4E scription of pped green g e length 2.7 ass; upright tid sodding tting weeds bsion of prev 1 2 3 4 5 6 7 8 9 10 Channel 5E erage length lo grass; up hed by solid 1 2 3 3 4 5 6 7 8 9 10 Channel 5E 2 3 4 5 6 7 8 9 10 Channel 5E 2 3 10 Channel 5E 2 3 3 10 Channel 5E 2 3 3 10 Channel 5E 2 3 3 2 3 3 | vegetation grass with 6 inches; C at start of in spring 1 and fillin vious testing 8-31 8-31 8-31 8-31 8-31 8-31 8-31 8-31 | : Good u 19 stems) omposition ? testing. 940. Main ag damage .0144 .0353 .0917 .191 .402 .818 1.60 3.16 6.72 9.60 : Good u n 636 ste ; composi start of t n spring 1 | iniform st per square h 100 pero Grass est intenance ed places .062 .111 .165 .191 .245 .317 .424 .583 .849 1.01 iniform st ms per s tion 100 p testing. G 942. .077 .143 .187 | Bed Slo tand of un- e foot; aver- cent buffalo tablished by consisted of caused by 233 318 .556 1.00 1.64 2.58 3.78 5.43 7.92 9.51 Bed Slo tand of un- quare foot; percent buf- trass estab- 232 .334 | Ppe 3.83 Per Hydr: ing r ing r 5 and right rough rough 383 .0383 .0384 .0383 .0385 .0383 .0385 .0383 .0384 .0383 .0384 .0383 .0384 .0384 .0373 Ope 5. 18 Hydr runs in th rippla and incree .0515 .0513 .0515 | aulic behav ims 1, 2, 3 a 1 6 most or in flow, her with easy of flow row 0 20 50 75 95 100 100 100 100 100 100 100 ercent 1, 2 and 3 her flow. S es for runs surface of ase in dep 0 10 50 | und 4 with all grass surface v surface v ch increase gh. 40 22 20 33 37 28 35 33 29 32 vior: Flow flow inc: th. . 60 21 18 | w through a surface o s submerge wavy. Sur- se in depth .000 .036 .000 .048 .043 .043 .043 .043 .043 .043 .045 .000 .061 I w through partially s flow reg Runs 6 t reasing in .000 .034 .100 | and over f flow smoo ed but rema face of flo . Runs 9 a 4.79 4.87 7.00 11.7 17.1 23.6 29.6 36.1 43.9 49.0 Experiment n and over ubmerged b ular except o 10, grass roughness 3.71 3.91 5.94 | grass du th. Ru aining u w becan nd 10 su .199 .213 .159 .069 .052 .043 .037 .032 .032 .032 .032 .032 .032 .032 .032 |
| Channel 4E scription of pped green g e length 2.7 ass; upright ting weeds bsion of prev 1 2 3 4 5 6 7 8 9 10 Channel 5E escription of pped green erage length to grass; up hed by solid | vegetation grass with 6 inches; C at start of in spring 1 and fillir dious testing 8-31 8-31 8-31 8-31 8-31 8-31 8-31 8-31 | : Good u 19 stems) omposition { testing. 940. Main ag damage .0144 .0353 .0917 .191 .402 .818 1.60 3.16 6.72 9.60 : Good u n 636 ste ; composi start of t n spring 1 .0179 .0478 .108 .310 | iniform st per square h 100 perc Grass est ntenance ed places .062 .111 .165 .191 .245 .317 .424 .583 .849 1.01 iniform st ms per s tion 100 p testing. G 942. .077 .143 .187 .225 | Bed Slo tand of un- e foot; aver- cent buffalo tablished by consisted of caused by 233 318 .556 1.00 1.64 2.58 3.78 5.43 7.92 9.51 Bed Slo tand of un- quare foot; percent buf- irass estab- 232 .334 .577 1.38 | Ppe 3.83 Per Hydr: ing r 5 and right rough face .0383 .0384 .0386 .0383 .0384 .0383 .0384 .0383 .0384 .0384 .0384 .0385 .0384 .0384 .0373 Ope 5 18 Hydr runs in tr in tr rippl .0515 .0515 .0513 .0513 | aulic behav ins 1, 2, 3 a 1 6 most on in flow, her with easy of flow row 0 20 50 75 95 100 100 100 100 100 100 100 10 | und 4 with all grass surface with ch increase gh. 40 22 20 33 37 28 35 33 29 32 vior: Fide Grass urface of 4 and 5. flow inc: th. 21 18 32 | w through a surface o s submerge wavy. Sur- se in depth .000 .036 .000 .036 .000 .048 .043 .035 .015 .000 .048 .043 .035 .015 .000 .061 I partially s flow regi Runs 6 t reasing in .000 .034 .000 .034 .000 .034 | and over f flow smoo ed but rema face of flo . Runs 9 a 4.79 4.87 7.00 11.7 17.1 23.6 29.6 36.1 43.9 49.0 Experiment n and over ubmerged b ular except o 10, grass roughness 3.71 3.91 5.94 12.9 | grass du th. Ru aining u w becan nd 10 su .198 .213 .159 .097 .052 .043 .037 .032 .030 1, 1942 grass 1 .030 for sm submerg with ea .268 .277 .192 .090 |
| Channel 4E scription of pped green g e length 2.7 ass; upright tid sodding ting weeds basion of prev 1 2 3 4 5 6 7 8 9 10 Channel 5H escription of pped green erage length lo grass; up hed by solid 1 2 3 4 5 5 5 5 5 5 5 5 5 5 5 5 5 | vegetation grass with 6 inches; C at start of in spring 1 and fillin vious testing 8-31 8-31 8-31 8-31 8-31 8-31 8-31 8-31 | : Good u i19 stems) omposition (testing. 940. Main ig damago .0144 .0353 .0917 .191 .402 .818 1.60 3.16 6.72 9.60 : Good u h 636 ste ; composi start of t h spring 1 .0179 .0478 .108 .310 .646 | iniform st per square 1 100 perc Grass esi ntenance ed places .062 .111 .165 .191 .245 .317 .424 .583 .849 1.01 iniform st ms per s tion 100 p testing. G 942. .077 .143 .187 .225 .286 | Bed Slo tand of un- e foot; aver- cent buffalo tablished by consisted of caused by 233 318 .556 1.00 1.64 2.58 3.78 5.43 7.92 9.51 Bed Slo tand of un- quare foot; percent buf- trass estab- 232 .334 .577 1.38 2.26 | Ppe 3.83 Per Hydr: ing r 5 and right rough Jace | aulic behav ins 1, 2, 3 a 1 6 most on in flow, her with eac of flow rou 0 20 50 75 95 100 100 100 100 100 100 100 10 | nd 4 with all grass surface when the increase gh. 40 22 20 33 37 28 35 33 29 32 vior: Fld . Grass urface of 4 and 5. flow incr th. 60 21 18 32 23 | w through a surface o s submerge wavy. Sur- se in depth .000 .000 .036 .000 .043 .043 .043 .043 .043 .043 .043 .045 .015 .000 .061 I partially s flow reg Runs 6 t reasing in .000 .034 .000 .048 .040 .048 .040 .041 .040 .045 .046 | and over f flow smoo ed but rema face of flo . Runs 9 a 4.79 4.87 7.00 11.7 17.1 23.6 29.6 36.1 43.9 49.0 Experiment n and over ubmerged b ular except o 10, grass roughness 3.71 3.91 5.94 12.9 18.6 | grass du th. Ru aining u w becar nd 10 su .198 .213 .159 .097 .069 .052 .043 .037 .032 .030 1, 1942 grass 1 out wavi for sm submerg with ea .268 .277 .192 .090 .065 |
| Channel 4E escription of pped green g e length_2.7 ass; upright id sodding tting weeds osion of prev 1 2 3 4 5 6 7 8 9 10 Channel 5E escription of pped green erage length hed by solid 1 2 3 4 5 6 7 8 9 10 | vegetation grass with 6 inches; C at start of in spring 1 and fillin vious testing 8-31 8-31 8-31 8-31 8-31 8-31 8-31 8-31 | : Good u il9 stems) omposition f testing. 940. Main ag damage .0144 .0353 .0917 .191 .402 .818 1.60 3.16 6.72 9.60 : Good u h 636 ste ; composi start of t h spring 1 .0179 .0478 .108 .310 .646 1.64 | iniform st per square h 100 perds Grass est intenance ed places .062 .111 .165 .191 .245 .317 .424 .583 .849 1.01 iniform st ms per s tion 100 p g42. .077 .143 .187 .225 .286 .414 | Bed Slo tand of un- e foot; aver- cent buffale by consisted of caused by 233 318 .556 1.00 1.64 2.58 3.78 5.43 7.92 9.51 Bed Slo tand of un- quare foot; percent buf- trass estab- 232 .334 .577 1.38 2.26 3.95 | Ppe 3.83 Per Hydr: ing r ing r 5 and right rough rough 383 .0383 .0384 .0383 .0385 .0383 .0384 .0373 .0383 .0384 .0373 Def 5.18 Hydr runs in th rhydr runs in th .0515 .0513 .0515 .0515 .0515 .0515 .0515 .0515 .0520 .0520 | aulic behav ins 1, 2, 3 a 1 6 most on in flow, her with easy of flow rou 0 20 50 50 75 95 100 100 100 100 100 100 100 10 | nd 4 with all grass surface with ch increase gh. 40 22 20 33 37 28 35 33 29 32 vior: Fild 4 and 5. flow incr th. 60 21 18 32 23 20 | w through a surface o s submerge wavy. Sur- se in depth .000 .000 .036 .000 .048 .043 .043 .043 .043 .043 .045 .015 .000 .061 I partially s flow regr Runs 6 t reasing in .000 .034 .016 .073 | and over if f flow smoo ed but remains face of flo . Runs 9 a 4.79 4.87 7.00 11.7 17.1 23.6 29.6 36.1 43.9 49.0 Experiment n and over ubmerged tular except 0 10. grass roughness 3.71 3.91 5.94 12.9 18.6 26.9 | grass du th. Ru alning u w becar nd 10 su .198 .213 .159 .097 .069 .052 .043 .037 .0322 .0304 1, 1942 grass b out wavi for sm submerg with ea .268 .277 .192 .090 .065 .047 |
| Channel 4E escription of pped green g e length 2.7 ass; upright tid sodding tting weeds osion of prev 1 2 3 4 5 6 7 8 9 10 Channel 5E escription of pped green erage length ho grass; up hed by solid 1 2 3 4 5 6 7 7 8 9 10 | vegetation grass with 6 inches; C at start of in spring 1 and fillin vious testing 8-31 8-31 8-31 8-31 8-31 8-31 8-31 8-31 | : Good u i19 stems) omposition { testing. 940. Main ag damage .0144 .0353 .0917 .191 .402 .818 1.60 3.16 6.72 9.60 : Good u h 636 ste ; composi start of t h spring 1 .0179 .0478 .108 .310 .646 1.64 3.17 | niform st per square h 100 perd Grass esintenance ed places .062 .111 .165 .191 .245 .317 .424 .583 .849 1.01 | Bed Slo tand of un- foot; aver- cent buffalo tablished by consisted of caused by 233 318 .556 1.00 1.64 2.58 3.78 5.43 7.92 9.51 Bed Slo tand of un- quare foot; percent buf- trass estab- 232 .334 .577 1.38 2.26 3.95 5.67 | Ppe 3.83 Per Hydr: ing r ing r 5 and right rough dasa .0383 .0384 .0385 .0380 .0383 .0384 .0383 .0385 .0388 .0385 .0388 .0388 .0386 .0383 .0384 .0373 .0384 .0373 Ope 5 18 P Hydr runs in tr rippid .0515 .0513 .0515 .0513 .0515 .0513 .0515 .0519 .0520 .0524 .0524 | aulic behav ims 1, 2, 3 a 1 6 most on in flow, her with easy of flow row 0 20 50 75 95 100 100 100 100 100 100 100 10 | and 4 with all grass surface v ch increase gh. 40 22 20 33 37 28 35 33 37 28 35 33 37 28 35 33 37 28 35 33 37 28 35 33 37 28 35 32 29 32 20 4 and 5. flow increase urface v flow increase urface v flow increase 21 4 and 5. flow increase 21 4 and 5. flow increase 22 20 32 20 20 32 20 32 20 20 32 20 20 32 20 20 20 20 20 20 20 20 20 20 20 20 20 | w through h surface o s submerge wavy. Sur- se in depth .000 .000 .036 .000 .048 .043 .043 .043 .043 .043 .043 .043 .043 .043 .048 .043 .048 .043 .051 .000 .061 I w through partially s flow regin Runs 6 t reasing in .000 .034 .000 .034 .000 .034 .015 .000 .034 .000 .034 .000 .034 .000 .034 .000 .034 .000 .034 .000 .034 .000 .034 .000 .034 .000 .034 .000 .034 .000 .034 .000 .034 .000 .034 .000 .034 .000 .034 .000 .034 .000 .034 .000 .035 .000 .036 .000 .005 .000 .000 .000 .000 .005 .000 .000 .005 .000 | and over if f flow smoo ed but remains face of flo . Runs 9 a 4.79 4.87 7.00 11.7 17.1 23.6 29.6 36.1 43.9 49.0 Experiment n and over ubmerged t ular except o 10, grass roughness 3.71 3.91 5.94 12.9 18.6 26.9 33.2 | grass du th. Ru aining u w becar nd 10 su .198 .213 .159 .097 .069 .052 .043 .037 .037 .030 1, 1942 grass 1 for sm submerg with ea .268 .277 .192 .090 .065 .047 .040 |
| Channel 4E escription of pped green g e length 2.7 ass; upright itid sodding tting weeds osion of prev 1 2 3 4 5 6 7 8 9 10 Channel 5E escription of ipped green erage length lo grass; up hed by solid 1 2 3 4 5 5 6 7 8 9 10 Channel 5E 5 6 7 8 9 10 Channel 5E 5 6 7 8 9 10 Channel 5E 7 8 8 9 10 Channel 5E 7 8 8 9 10 Channel 5E 7 8 8 8 8 7 8 8 8 7 8 8 8 8 7 8 8 8 8 | vegetation grass with 6 inches; C at start of in spring 1 and fillin vious testing 8-31 8-31 8-31 8-31 8-31 8-31 8-31 8-31 | : Good u i19 stems) omposition ? testing. 940. Main ag damage .0144 .0353 .0917 .191 .402 .818 1.60 3.16 6.72 9.60 | niform st per square h 100 pero Grass est ditenance ed places .062 .111 .165 .191 .245 .317 .424 .583 .849 1.01 | Bed Slo tand of un- e foot; aver- cent buffalo tablished by consisted of caused by 233 318 .556 1.00 1.64 2.58 3.78 5.43 7.92 9.51 Bed Slo tand of un- quare foot; percent buf- trass estab- 232 .334 .577 1.38 2.26 3.95 5.67 8.03 | Ppe 3.83 Per Hydr: ing ri 5 and right rough face 4 .0383 .0384 .0385 .0380 .0385 .0380 .0379 .0383 .0388 .0384 .0373 .0384 .0373 .0384 .0373 .0384 .0373 .0384 .0373 .0515 .0513 .0515 .0519 .0520 .0524 .0522 | aulic behav ims 1, 2, 3 a 1 6 most on in flow, her with easy of flow row 0 20 50 75 95 100 100 100 100 100 ercent aulic beha 1, 2 and 3 her flow. S surface of ase in dep 0 10 100 100 100 100 100 100 | und 4 with all grass surface w sh increase gh. 40 22 20 33 37 28 35 33 29 32 vior: Flow flow increase flow increase flow increase 18 32 20 20 20 20 20 20 20 20 20 20 20 20 20 20 25 | w through n surface o s submerge wavy. Sur- se in depth .000 .000 .036 .000 .043 .044 .043 .044 .043 .044 .044 .044 .044 .046 .044 .046 .044 .046 .044 .046 .046 .046 .046 .046 .046 .046 .046 .046 .046 .047 .046 .047 .046 .047 .047 .054 .071 .071 | and over if f flow smoo ed but remains face of flo . Runs 9 a 4.79 4.87 7.00 11.7 17.1 23.6 29.6 36.1 43.9 49.0 Experiment n and over ubmerged bular except o 10, grass roughness 3.71 3.91 5.94 12.9 18.6 26.9 33.2 40.3 | grass du th. Ru alning u w becar nd 10 su .198 .213 .159 .097 .052 .043 .037 .0322 .0330 .037 .0322 .0330 .037 .0322 .0330 .043 .037 .0322 .0320 .043 .037 .0322 .0320 .043 .037 .0322 .0320 .045 .277 .192 .268 .277 .192 .090 .065 .047 .0400 .045 |
| Channel 4E escription of pped green g e length.2.7 ass; upright lid sodding tting weeds osion of prev 1 2 3 4 5 6 7 8 9 10 Channel 5E escription of ipped green rerage length lo grass; up hed by solid 1 2 3 4 5 6 7 7 8 9 10 | vegetation grass with 6 inches; C at start of in spring 1 and fillin vious testing 8-31 8-31 8-31 8-31 8-31 8-31 8-31 8-31 | : Good u i19 stems) omposition { testing. 940. Main ag damage .0144 .0353 .0917 .191 .402 .818 1.60 3.16 6.72 9.60 : Good u h 636 ste ; composi start of t h spring 1 .0179 .0478 .108 .310 .646 1.64 3.17 | niform st per square h 100 perd Grass esintenance ed places .062 .111 .165 .191 .245 .317 .424 .583 .849 1.01 | Bed Slo tand of un- foot; aver- cent buffalo tablished by consisted of caused by 233 318 .556 1.00 1.64 2.58 3.78 5.43 7.92 9.51 Bed Slo tand of un- quare foot; percent buf- trass estab- 232 .334 .577 1.38 2.26 3.95 5.67 | Ppe 3.83 Per Hydr: ing r ing r 5 and right rough dasa .0383 .0384 .0385 .0380 .0383 .0384 .0383 .0385 .0388 .0385 .0388 .0388 .0386 .0383 .0384 .0373 .0384 .0373 Ope 5 18 P Hydr runs in tr rippid .0515 .0513 .0515 .0513 .0515 .0513 .0515 .0519 .0520 .0524 .0524 | aulic behav ims 1, 2, 3 a 1 6 most on in flow, her with easy of flow row 0 20 50 75 95 100 100 100 100 100 100 100 10 | and 4 with all grass surface v ch increase gh. 40 22 20 33 37 28 35 33 37 28 35 33 37 28 35 33 37 28 35 33 37 28 35 33 37 28 35 32 29 32 20 4 and 5. flow increase urface v flow increase urface v flow increase 21 4 and 5. flow increase 21 4 and 5. flow increase 22 20 32 20 20 32 20 32 20 20 32 20 20 32 20 20 20 20 20 20 20 20 20 20 20 20 20 | w through a surface o s submerge wavy. Sur- se in depth .000 .036 .000 .036 .000 .048 .043 .043 .043 .043 .043 .043 .043 .048 .043 .054 .000 .061 I .000 .061 I .000 .034 .000 .034 .000 .034 .000 .034 .000 .034 .000 .048 .054 .057 | and over if f flow smoo ed but remains face of flo . Runs 9 a 4.79 4.87 7.00 11.7 17.1 23.6 29.6 36.1 43.9 49.0 Experiment n and over ubmerged t ular except o 10, grass roughness 3.71 3.91 5.94 12.9 18.6 26.9 33.2 | grass du th. Ru alning u w becar nd 10 su .198 .213 .159 .097 .069 .052 .043 .0374 .0322 .0304 1, 1942 grass fu ut wavi for sm submerg |

Table 6.—Results of Tests of Channels Lined with Buffalo Grass.—(Continued)

| Channel 6B | | _ | | Bed Slag | e 6.01 Pe | rcent | | E | xperiment | 1, 1942 |
|--|--|---|--|--|---|---|---|--|--|--|
| | | | | | | | · · · · · | | Coeffic | clents |
| | | Discharge per foot of width, VD | Ť D | Mean velocity, V | Effective slope | Vegetation | flow | , rate scour | z3, O | Manning, n |
| Run | Date | 210 Pin | Depth | Mer | Eff | Veg | and a | AV. | Chezy, | Mai |
| 1 | 2 | 3 - | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
| | | Cu. ft. per sec. | Feet | Ft. per sec. | Ft. per ft. | Percent | Min. | In. per hr. | | |
| Description of ve clipped green gra age length 2.9 in grass; upright at solid sodding in s | ss with 6 nches; c start of | 95 stems pe omposition testing. (| er square 1 100 perce | nt buffalo | and surfa 7 to incre | aulic beha 3 and over ace of flow 10, grass p asing in r ace of wate | part of s smooth e ressed to t oughness | tand for r except for the bottom with each | uns 4, 5 a small ripp and surfa increase | nd 6 wi les. Ru ce of flo in dep |
| 1 | 8-27 | .0130 | .059 | .221 | .0604 | 0 | 40 | .000 | 3.74 | .253 |
| 2 | 8-27 | .0362 | .115 | .315 | .0606 | 10 | 13 | .054 | 3.79 | .276 |
| 3 | 8-27 | .0750 | .159 | .472 | .0606 | 30 | 17 | .064 | 4.82 | .228 |
| 4 | 8-27 | .162 | .183 .224 | .885 1.58 | .0605 .0603 | 60 90 | 29 30 | .050 | 8.43 | .133 |
| 5 · 6 | 8-27 8-27 | .354 .772 | .224 .287 | 2.69 | .0603 | 100 | 30 33 | .017 .011 | 13.6 20.5 | .085 |
| 7 | 8-27 | 1.64 | .387 | 4.23 | .0604 | 100 | 31 | .074 | 27.7 | .045 |
| 8 | 8-27 | 3.76 | .573 | 6.57 | .0604 | 100 | 32 | .084 | 35.3 | .038 |
| 9 | 8-27 | 7.17 | .791 | 9.06 | .0588 | 100 | 30 | .144 | 42.1 | .033 |
| 10 | 8-27 | 10.9 | 1.02 | 10.7 | .0576 | 100 | 34 | .120 | 44.2 | .033 |
| Channel 7E | | | | Bed Slop | ю 7.14 Ре | rcent | | Ex | periment l | l, 19 <mark>40</mark> |
| Description of ve clipped green gra- quare foot; ave percent buffalo, cight at start of | ass with rage leng 15 percer | 9.6 cubic i gth 3.2 inc it crab and | nches of hes; comp needle gr | forage per position 85 casses; up- | cupie All o: Surfa for r | ed by strea f grass subm ace of wate uns 3 and 4 | m that su nerged by er smoth. l and roug | run 2 but ; Surface o h for runs | he grass f grass wavin of flow fai 5 and 6 wi | or run ng in flo rly rou |
| elipped green gre equare foot; ave bercent buffalo, i light at start of sodding in spring | ass with rage leng 15 percer of testing 1940. | 9.6 cubic i gth 3.2 inc it crab and g. Grass (| nches of hes; comp needle gr established | forage per position 85 casses; up- by solid | cupie All o: Surfa for ri ently | d by strea f grass sub ace of wat uns 3 and 4 very high | m that su nerged by er smoth. and roug surface ve | Ibmerged t run 2 but g Surface o h for runs locities for | he grass f grass wavin of flow fai 5 and 6 wi run 6. | or run ng in flo rly rou ith apps |
| clipped green gra square foot; aver bercent buffalo, light at start of sodding in spring 1 | ass with rage leng 15 percer of testing 1940. 9-5 | 9.6 cubic i gth 3.2 inc it crab and g. Grass e | nches of hes; comp needle gr established .107 | forage per position 85 casses; up- by solid | cupie All o: Surfa for r | d by strea f grass subi ace of wate uns 3 and 4 very high 50 | m that su nerged by er smoth. and roug surface ve 30 | Ibmerged t run 2 but g Surface o h for runs locities for .000 | he grass f grass wavir of flow fai 5 and 6 wi run 6. 6.25 | or run ig in flo rly rou ith apps .165 |
| clipped green green square foot; ave percent buffalo, light at start of sodding in spring | ass with rage leng 15 percer of testing 1940. | 9.6 cubic i gth 3.2 inc it crab and g. Grass (| nches of hes; comp needle gr established | forage per position 85 casses; up- by solid | cupie All o: Surfa for ri ently .0709 | d by strea f grass sub ace of wat uns 3 and 4 very high | m that su nerged by er smoth. and roug surface ve | Ibmerged t run 2 but g Surface o h for runs locities for | he grass f grass wavir of flow fai 5 and 6 wi run 6. 6.25 13.5 | for run ng in flo rly rou ith apps .165 .088 |
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| clipped green gre quare foot; ave bercent buffalo, ight at start of sodding in spring 1 2 3 4 5 6 Channel 7E Description of v clipped green gre quare foot; aver bercent buffalo; cablished in spr controlling weed by previous test 1 2 3 4 5 5 6 7 8 | ass with rage leng 15 percer of testing 1940. 9-5 9-5 9-6 9-6 9-6 9-6 9-6 9-6 9-6 9-6 9-6 9-6 | 9.6 cubic 1 gth 3.2 inc tt crab and g. Grass 4 .518 1.53 5.04 7.36 9.96 : Fair un 3.8 cubic 1 th 4.0 inch at start of 0. Mainter illing dam .0118 .0274 .0625 .696 1.10 1.42 2.42 2.71 | nches of hes; comy needle gr established .107 .274 .403 .665 .822 1.00 .665 .822 1.00 .00 .00 .822 1.00 .822 .822 1.00 .822 1.00 .822 1.00 .822 .822 .822 .822 .822 .822 .822 | forage per position 85 rasses; up- by solid .540 1.89 3.80 7.58 8.96 9.06 Bed Slop Md of un- forage per position 100 Grass es- nsisted of res caused .246 .259 .353 2.32 .318 3.64 4.73 5.30 | cupie All o Surfa for r ently .0709 .0714 .0715 .0718 .0711 .0896 be 6.99 Pe: Hydr 2 wit subm grass to ge rough rough .0699 .0699 .0699 .0699 .0698 .0698 .0698 .0701 .0701 | d by strea f grass subn ace of watu uns 3 and 4 very high 50 100 100 100 100 100 100 100 rcent aulic behav h slight be terged for a submerged strongh. I hness until a with foar 0 10 10 10 10 10 100 100 100 100 100 1 | m that su nerged by er smoth. 30 11 32 31 33 32 rior: Flow nding of s run 3. 1 by run 4 Remainder runs 10, n riding ti 25 16 18 23 12 | Ibmerged t run 2 but a Surface of h for runs locities for .000 .231 .404 .185 .321 E7 / through a stems for r Surface of 4 and surf of runs ti 11 and 2 he surface .000 .120 .000 .324 | he grass f grass wavir of flow fai 5 and 6 wi run 6. 6.25 13.5 22.4 34.7 37.1 37.7 greiment 2 grass for r un 2. Par f flow si ace of flow the flow 4.24 3.01 3.18 16.0 20.5 22.1 26.1 | for run ig in fic rly rou ith apps .165 .088 .057 .0400 .039 2, 1941 uns 1 a t of gra- noth w starti creased xcceding w. |
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| blipped green gre quare foot; ave bercent buffalo, ight at start of sodding in spring 1 2 3 4 5 6 Channel 7E Description of w lipped green gri controlling weed by previous test 1 2 3 4 5 5 6 7 8 9 10 | ass with rage leng rage leng 15 percent 1940. 9-5 9-5 9-6 9-6 9-6 9-6 9-6 9-6 9-7 9-8 9-9 9-9 9-6 9-6 9-7 9-8 9-9 9-6 9-6 9-6 9-7 9-6 9-6 9-6 9-6 9-6 9-7 9-6 9-6 9-7 9-6 9-6 9-6 9-7 9-8 9-8 9-9 9-8 9-9 9-10 194 8-14 8-14 8-14 8-14 8-14 8-14 | 9.6 cubic i gth 3.2 inc th crab and g. Grass 4 .0578 .518 1.53 5.04 7.36 9.96 Fair un 3.8 cubic i th 4.0 inct at start of 0. Mainter illing dam .0118 .0274 .0625 .696 1.10 1.42 2.42 2.71 3.41 4.04 | nches of hes; comp needle gr established .107 .274 .403 .665 .822 1.00 .665 .822 1.00 .005 .822 1.00 .005 .822 1.00 .005 .822 1.00 .005 .822 1.00 .005 .822 1.00 .005 .822 1.00 .005 .822 1.00 .005 .822 1.00 .005 .822 1.00 .005 .822 1.00 .005 .822 1.00 .005 .822 1.00 .005 .822 1.00 .005 .822 1.00 .005 .822 1.00 .005 .822 1.00 .005 .822 .822 .005 .822 .005 .822 .005 .822 .005 .822 .005 .822 .005 .822 .006 .005 .822 .006 .005 .822 .000 .005 .822 .000 .005 .822 .000 .005 .822 .000 .005 .822 .000 .005 .822 .000 .005 .822 .000 .005 .822 .000 .005 .822 .000 .005 .822 .000 .005 .825 .825 .825 .000 .005 .825 .825 .825 .000 .005 .825 .825 .825 .825 .825 .825 .825 .82 | forage per position 85 rasses; up- by solid .540 1.89 3.80 7.58 8.96 9.06 Bed Slop md of un- forage per position 100 Grass es- nsisted of ces caused .246 .259 .353 2.32 .318 3.64 4.73 5.30 5.97 6.66 | cupie All o: Surfa for r ently .0709 .0714 .0715 .0718 .0711 .0596 pe 6.99 Pe: Hydr 2 wit subm grass to ge rougi rougi .0699 .0699 .0699 .0700 .0698 .0701 .0698 .0701 | d by strea f grass subn ace of watt uns 3 and 4 very high 50 100 100 100 100 100 100 100 100 100 | m that su nerged by er smoth. and roug surface ve 11 32 31 33 32 7 for: Flow nding of s run 3. by run Remainder runs 10, n riding ti 25 16 18 23 12 10 16 9 9 | bmerged t run 2 but a Surface of h for runs locities for .000 .231 .404 .185 .321 E7 / through a stems for r Surface of 4 and surf of runs ti 11 and 5 he surface .000 .120 .000 .324 .000 .416 .000 .141 | he grass f grass wavin of flow fai 5 and 6 wi run 6. 6.25 13.5 22.4 34.7 37.1 37.7 grass for r un 2. Par f flow si ace of flow is ace of flow i | for run ig in flo rly rou ith apps .165 .088 .057 .040 .039 .039 .039 .039 .039 .040 .038 .039 .040 .057 .040 .057 .040 .057 .040 .057 .040 .057 .040 .057 .040 .057 .040 .057 .040 .057 .040 .057 .040 .057 .040 .057 .056 .057 .056 .057 .056 .057 .056 .057 .056 .057 .056 .057 .056 .057 .056 .057 .056 .057 .056 .057 .056 .057 .056 .045 .057 .056 .057 .057 .057 .056 .057 .05 |
| clipped green gre quare foot; ave bercent buffalo, ight at start of odding in spring 1 2 3 4 5 6 Channel 7E Description of w clipped green gre quare foot; aven bercent buffalo; cablished in spr controlling weed by previous test 1 2 3 4 5 6 7 8 9 | ass with rage leng 15 percer of testin 1940. 9-5 9-5 9-6 9-6 9-6 9-6 9-6 9-6 9-6 9-6 9-6 9-6 | 9.6 cubic 1 gth 3.2 inc the crab and g. Grass 4 .518 1.53 5.04 7.36 9.96 : Fair un 3.8 cubic 1 th 4.0 inch at start of 0. Mainter illing dam .0118 .0274 .0625 .696 1.10 1.42 2.42 2.71 3.41 | nches of hes; comy needle gr established .107 .274 .403 .665 .822 1.00 | forage per position 85 rasses; up- by solid .540 1.89 3.80 7.58 8.96 9.06 Bed Slop md of un- forage per position 100 Grass es- nsisted of wes caused .246 .259 .353 2.32 .318 3.64 4.73 5.30 5.97 | cupie All o Surfa for r ently .0709 .0714 .0715 .0718 .0711 .0596 e 6.99 Pe: Hydr 2 wit subm grass to ge rough .0699 .0699 .0699 .0699 .0698 .0701 .0698 | d by strea f grass subn ace of watu uns 3 and 4 very high 50 100 100 100 100 100 100 100 rcent aulic behav h slight be terged for s submerged t rough. J hness until h with foar 0 100 100 100 100 100 100 100 100 100 | m that su nerged by er smoth. 30 11 32 31 33 32 7 ior: Flow nding of s run 3. 1 by run 4. 25 16 18 23 12 10 16 9 9 24 24 | bmerged t run 2 but a Surface of h for runs locities for .000 .231 .404 .185 .321 En 7 through a stems for r Surface of 4 and surf of runs ti 11 and 2 he surface .000 .000 .120 .000 .324 .000 .416 .000 .141 .162 | he grass f grass wavin of flow fai 5 and 6 wi run 6. 6.25 13.5 22.4 34.7 37.1 37.7 speriment : grass for r un 2. Par f flow sin 12 were e: of the flo 4.24 3.01 3.18 16.0 20.5 22.1 26.1 28.0 29.9 32.3 35.6 | for run ig in flo rly rou ith apps .165 .088 .057 .0400 .039 2, 1941 uns 1 a t of gra- moth w startic creased xcceding w. .212 .339 .351 .075 .050 .047 .045 .057 .045 .042 .048 .057 .050 .047 .050 .057 .050 .047 .050 .057 .050 .057 .050 .057 .040 .057 .050 .057 .050 .057 .050 .057 .050 .057 .050 .057 .050 .057 .050 .057 .050 .057 .050 .047 .045 .057 .045 .047 .045 .047 .045 .057 .045 .047 .047 |
| lipped green gre quare foot; ave bercent buffalo, i ight at start of odding in spring 1 2 3 4 5 6 Channel 7E Description of we bercent buffalo; ablished in spr controlling weed by previous test 1 2 3 4 5 6 7 8 9 10 11 | ass with rage leng 15 percen- of testing 1940. 9-5 9-5 9-6 9-6 9-6 9-6 9-6 9-6 9-6 9-6 9-6 9-6 | 9.6 cubic 1 gth 3.2 inc tt crab and g. Grass 4 .0578 .518 1.53 5.04 7.36 9.96 | nches of hes; comp needle gr established . 107 .274 .403 .665 .822 1.00 .00 .00 .00 .00 .00 .048 .106 .177 .300 .346 .107 .346 .107 .300 .346 .107 .346 .107 .300 .346 .391 .471 .572 .607 .735 | forage per position 85 rasses; up- by solid .540 1.89 3.80 7.58 8.96 9.06 Bed Slop nd of un- forage per position 100 Grass es- nsisted of wes caused .246 .259 .353 2.32 .318 3.64 4.73 5.30 5.97 6.66 8.05 9.64 | cupie All o Surfa for r ently .0709 .0714 .0715 .0718 .0715 .0718 .0715 .0718 .0717 .0596 Pe 6.99 Pe: Hydr 2 wit subm grass to ge rougi rougi .0699 .0699 .0699 .0699 .0699 .0698 .0700 .0698 .0701 .0698 .0701 .0698 | d by strea f grass subn ace of watt uns 3 and 4 very high 50 100 100 100 100 100 100 100 100 rcent aulic behav h slight be terged for s submerged trough. 1 hness until a with foar 0 100 100 100 100 100 100 100 100 100 | m that su nerged by er smoth. and roug surface ve 11 32 31 33 32 7 for: Flow nding of s run 3. by run Remainder runs 10, n riding ti 25 16 18 23 12 10 16 9 9 | bmerged t run 2 but a Surface of h for runs locities for .000 .231 .404 .185 .321 E7 / through a stems for r Surface of 4 and surf of runs th 11 and 2 he surface .000 .324 .000 .324 .000 .416 .000 .141 .162 .272 | he grass f grass wavir of flow fai 5 and 6 wi run 6. 6.25 13.5 22.4 34.7 37.1 37.7 grass for r un 2. Par f flow si acc of flow in 12 were e: of the flo 4.24 3.01 3.18 16.0 29.5 22.1 26.1 28.0 29.9 32.3 | for run ig in flo rly rou ith appr .165 .088 .057 .040 .038 .039 2, 1941 uns 1 at t of gr: moth. |

Description of vegetation: Good uniform stand of unclipped green grass with 764 stems per square foot; average length 3.4 inches; composition 100 percent buffalo grass; upright at start of testing. Grass established by solid sodding in spring 1940. Maintenance consisted of cutting weeds and filling damaged places caused by. erosion of previous testing.

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Hydraulic behavior: Flow through and over grass for runs 1, 2, 3 and 4 with surface of flow smooth. Surface of flow rough for runs 5 to 10 increasing in roughness with each increase in depth. Apparent high surface velocity for runs 8 and 9 with some fcam on the surface.

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| Channel 7 | E, cont. | | | | , | | | • | Coaff | cients |
|--|---|--|---|---|--|--|--|--|--|---|
| | | | | | | | | | | |
| • | | Discharge per foot of width VD | A | 4 | ¢ | Vegetation submergence | đ | | Ð | |
| | - | Sec. 1 | 4 | Mean Velocity, | Effective slope | erg | iration flow | . rate scour | | Mannulg, |
| Run | Date | 222 | Depth, | loc | ope | 1986 | 2 C | 2 | | ĝ |
| Ř | ă | | Á | WA N | <u>6</u> 3 | A | ឝី៩ | <u>م</u> | <u> </u> | <u> </u> |
| 1 | 2 | 3 | 4 | 5 | 6 | 7. | 8 | 9 | 10 | 11 |
| | | Cu. ft. per sec. | Feet | Ft. per sec. | Pt. per ft. | Percent | Min. | In. per hr. | | |
| 1 | 8-26 | .0184 | .082 | ,225 | .0689 | 0 | 35 | .000 | 3.00 | .329 |
| 2 | 8-26 | .0367 | .118 | .311 | .0688 | ŏ | 14 | .036 | 3.46 | .302 |
| 3 | 8-26 | .0790 | .167 | .473 | .0689 | 30 | 17 | .086 | 4.43 | .251 |
| 4 | 8-26 | .166 | .191 | .872 | .0690 | 50 | 35 | .025 | 7.62 | .149 |
| 5 | 8-26 | .408 | .246 | 1.66 2.80 | .0690 | 85 | 30 | .065 | 12.8 | .0925 |
| 6 | 8-26 8-26 | .893 2.02 | .319 | 2.80 4.54 | .0690 .0691 | 100 100 | 32 30 | .034 .096 | 19,0 25,9 | .0649 .0502 |
| . 8 | 8-26 | 4.18 | .621 | 6.74 | .0693 | 100 | 30 | .113 | 32.5 | .0302 |
| 9 | 8-26 | 8.62 | .893 | 9.65 | .0678 | 100 | 31 | .108 | 39.3 | .0372 |
| Channel 10 | F | | | Bed Slo | pe 10.2 Pe | rcent | | E | xperiment | 1, 1940 |
| escription of | vegetation | : Good u | niform sta | and of un- | Hydr | aulic behav | vior: Flo | w through | 1 grass w | ith stem |
| ipped green | grass with | 4.25 cubic | inches of | forage per | bendi | ng slightly | by force | of the wa | ter for run | n 1. Mos |
| quare foot: a | verage len | gth 6.1 inc | ches; com | position 95 | ofgr | ass submer | ged by ru | n 2 and a | all by run | 3 but re |
| ercent buffal | o, 5 percen | t crabgrass | ; upright | at start of | main | ing erect an ce of flows | na wavinj | f in the L | lows. Run | s 4 and |
| esting. Grass 940. | s establishe | a by some | i souumg | m spring | roots | . Runs 6 a | and 7, sur | e erosion face of fl | caused aro | una gras |
| 31 0. | | | | | consi | derable eros | sion but o | channel st | ill in fair | condition |
| | 0.1 | .0745 | .146 | .510 | .101 | 0 | 18 | .000 | 4.21 | |
| 1 2 | 9-1 9-1 | .512 | .140 | 1.87 | .101 | 90 | 12 | .102 | 11.2 | 258 .107 |
| 3 | 9-1 9-1 | 1.58 | .379 | 4.17 | .101 | 100 | 30 | .125 | 21.3 | .0595 |
| 4 | 9-1 | 5.07 | .653 | 7.77 | .0997 | 100 | 31 | .443 | 30.5 | .0455 |
| 5 | 9-1 | 7.60 | .783 | 9.70 | .0978 | 100 | 32 | .215 | 35.1 | .0407 |
| | | | | | | | | | | 0410 |
| 6 | 9-1 | 9.84 11.7 | .928 | 10.6 11.5 | .0976 0948 | 100 | 33 27 | .196 259 | 35.6 | 0413 |
| 6 7 | 9-1 | 9.84 11.7 | .928 1.02 | 11.5 | .0948 | 100 | 27 | .259 | 36.9 | .0405 |
| 6 7 Channel 10 | 9-1 0F | 11.7 | 1.02 | 11.5 Bed Slo | .0948 pe 10.1 Pe | 100 rcent | 27 | .259 E | 36.9 Experiment | .0405 2, 1941 |
| 6 7 Channel 10 Description of | 9-1 0F vegetation | 11.7 | 1.02 | 11.5 Bed Slo and of un- | .0948 pe 10.1 Pe Hydr | 100 rcent aulic behav | 27 | .259 E | 36.9 Experiment | .0405 2, 1941 uns 1 and |
| 6 7 Channel 10 Description of | 9-1 OF vegetation grass with | 11.7 : Good uu 3.8 cubic | 1.02 niform sta | 11.5 Bed Slo and of un- forage per | .0948 pe 10.1 Pe Hydr 2 wit | 100 rcent aulic behav h apparent | 27 ior: Flow ly high v | .259 E through elocity for | 36.9 Experiment grass for r depth. R | .0405 2, 1941 uns 1 an- |
| 6 7 Channel 10 Description of Supped green square foot: a | 9-1 OF grass with verage lens | 11.7 : Good un 3.8 cubic : 3.8 jincl | 1.02 niform sta inches of hes; comp | 11.5 Bed Slo and of un- forage per position 100 | .0948 pe 10.1 Pe Hydr 2 wit 4, pa | 100 rcent aulic behav h apparent rt of grass | 27 ior: Flow ly high v submerge | .259 E through elocity for d with sur | 36.9 Experiment grass for r depth. R: face of flo | .0405 2, 1941 uns 1 an uns 3 an ow slightl |
| 6 7 Channel 10 Description of Hipped green square foot; a bercent buffal ablished in sr | 9-1 Vegetation grass with verage leng o; upright pring 1940. | 11.7 : Good un 3.8 cubic gth 4.9 incl at start o Maintenar | 1.02 niform sta inches of hes; comp f testing. nce consist | 11.5 Bed Slo and of un- forage per position 100 Grass es- ted of con- | .0948 pe 10.1 Pe Hydr 2 wit 4, pa rough surfa | 100 rcent aulic behave th apparent rt of grass n. Remaind ce of flow i | 27 ior: Flow ly high v submerge ier of run ncreasing | 259 E through elocity for d with sum ns complet in roughn | 36.9 grass for r depth. R face of flo tely over g ess to runs | .0405 2, 1941 uns 1 an uns 3 an w slightl grass wit 9, 10, an |
| 6 7 Channel 10 Description of | 9-1 Vegetation grass with verage leng o; upright pring 1940. | 11.7 : Good un 3.8 cubic gth 4.9 incl at start o Maintenar | 1.02 niform sta inches of hes; comp f testing. nce consist | 11.5 Bed Slo and of un- forage per position 100 Grass es- ted of con- | .0948 pe 10.1 Pe Hydr 2 wit 4, pa rougi surfa 11 wi | 100 rcent aulic behave th apparent rt of grass n. Remaind ce of flow i hen surface | 27 ior: Flow ly high v submerge ler of run ncreasing of flow h | .259 E through elocity for d with sur ns completin roughn became exe | 36.9 grass for r depth. R face of flo tely over g ess to runs ceedingly r | .0405 2, 1941 uns 1 an uns 3 an w slightl grass wit 9, 10, an ough wit |
| 6 7 Channel 10 Description of elipped green quare foot; a bercent buffal ablished in sp rolling weeds | 9-1 Vegetation grass with verage leng o; upright pring 1940. | 11.7 : Good un 3.8 cubic gth 4.9 incl at start o Maintenar | 1.02 niform sta inches of hes; comp f testing. nce consist | 11.5 Bed Slo and of un- forage per position 100 Grass es- ted of con- | .0948 pe 10.1 Pe Hydr 2 wil 4, pa rougi surfa 11 wi foam | 100 rcent aulic behave th apparent rt of grass n. Remaind ce of flow i hen surface on the su | 27 ior: Flow ly high v. submerge ier of run ncreasing of flow h rface. En | 259 Through elocity for d with sur his completion roughn became extra osion was | 36.9 grass for r depth. R face of flo tely over g ess to runs ceedingly r | .0405 2, 1941 uns 1 an uns 3 an w slightl grass wit 9, 10, an ough wit |
| 6 7 Channel 10 Description of hipped green quare foot; a percent buffal ablished in sp rolling weeds | 9-1 Vegetation grass with verage leng o; upright pring 1940. | 11.7 : Good w 3.8 cubic gth 4.9 incl at start o Maintenar damaged p | 1.02 Inform statinches of hes; comp f testing. hee consist places caus | 11.5 Bed Slo and of un- forage per position 100 Grass es- ted of con- sed by pre- | .0948 pe 10.1 Pe Hydr 2 wil 4, pa rougi surfa 11 wi foam | 100 rcent aulic behav th apparent rt of grass n. Remaind ce of flow i hen surface on the su nel still in t | 27 ior: Flow ly high v. submerge ier of run ncreasing of flow h rface. En | 259 Through elocity for d with sur his completion roughn became extra osion was | 36.9 grass for r depth. R face of flo tely over g ess to runs ceedingly r | .0405 2, 1941 uns 1 an uns 3 an w slightl grass wit 9, 10, an ough wit |
| 6 7 Channel 10 Description of clipped green quare foot; a percent buffal ablished in sp rolling weeds rious testing. | 9-1 OF vegetation grass with verage leng to; upright oring 1940. and filling 8-2 | 11.7 : Good un 3.8 cubic at start o Maintenar damaged p .0178 | 1.02 niform statinches of hes; comp f testing. ice consist blaces caus .068 | 11.5 Bed Slo and of un- forage per position 100 Grass es- ted of con- sed by pre- .262 | .0948 pe 10.1 Pe Hydr 2 wit 4, pa rougi surfa 11 wi foam chan .101 | 100 rcent aulic behav th apparent rt of grass n. Remaind ce of flow i hen surface on the su nel still in t | 27 ior: Flow ly high v submerge ier of run ncreasing of flow 1 rface. En fair condi 43 | 259 F 7 through elocity for d with sur in roughn became exc osion was tion. | 36.9 grass for r depth. R face of flo eest to runs beedingly r quite app 3.16 | .0405 2, 1941 uns 1 an uns 3 an w slightl grass wit 9, 10, an ough wit parent bu .304 |
| 6 7 Channel 10 Description of hilpped green quare foot; a bercent buffal ablished in sp rolling weeds rious testing. | 9-1 OF vegetation grass with verage leng (o; upright oring 1940. and filling 8-2 8-2 | 11.7 : Good un 3.8 cubic i gth 4.9 incl at start o Maintenar damaged p .0178 .0395 | 1.02 niform sta inches of hes; comp f testing. ce consist blaces caus .068 .094 | 11.5 Bed Slo and of un- forage per position 100 Grass es- ied of con- sed by pre- .262 .420 | .0948 pe 10.1 Pe Hydr 2 wit 4, pa rougi surfa 11 wi foam chan .101 .101 | 100 rcent aulic behavion in apparent rt of grass n. Remaind ce of flow i hen surface on the su nel still in t 0 5 | 27 lor: Flow ly high y submerge ler of run ncreasing of flow h rface. En fair condi 43 20 | 259 F through elocity for d with sum ns complet in roughn became exc osion was tion. 000 .000 | 36.9 Experiment grass for r depth. R face of flo tely over g ess to runs ceedingly r quite app 3.16 4.31 | .0405 2, 1941 uns 1 an uns 3 an w slightl grass wit grass wit arent bu .304 .232 |
| 6 7 Channel 10 Description of lipped green quare foot; a bercent buffal ablished in sp rolling weeds ious testing. | 9-1 OF vegetation grass with verage leng o; upright pring 1940. and filling 8-2 8-2 8-2 8-2 | 11.7 : Good un 3.8 cubic 1 3.8 cubic 1 3.8 cubic 1 at start o Maintenar damaged p .0178 .0395 .113 | 1.02 niform sta inches of hes; comp f testing. nee consist places caus .068 .094 .165 | 11.5 Bed Slo and of un- forage per oosition 100 Grass es- ted of con- sed by pre- .262 .420 .685 | .0948 pe 10.1 Pe Hydr 2 wit 4, pa rougi surfa 11 wi foam chan .101 .101 | 100 rcent aulic behave th apparent rt of grass n. Remaind ce of flow i hen surface on the su nel still in t 0 5 30 | 27 lor: Flow ly high v submerge ler of run ncreasing of flow 1 rface. En fair condi 43 20 12 | 259 F Through elocity for d with sur ns complet in roughn became exa vosion was tion. | 36.9 Experiment grass for r depth. R face of flo tely over g ess to runs seedingly r quite app 3.16 4.31 5.30 | .0405 2, 1941 uns 1 an uns 3 an w slightl grass wit 9, 10, an ough wit arent bu .304 .232 .208 |
| 6 7 Channel 10 Description of lipped green quare foot; a quare foot; a q | 9-1 oF vegetation grass with verage leng o; upright pring 1940. and filling 8-2 8-2 8-2 8-2 8-2 8-2 | 11.7 : Good uu 3.8 cubic : sth 4.9 incl at start o Maintenar damaged p .0178 .0395 .113 .331 | 1.02 hlform sta inches of hes; comp f testing. hce consist blaces caus .068 .094 .165 .203 | 11.5 Bed Slo and of un- forage per position 100 Grass es- ted of con- sed by pre- .262 .420 .685 1.63 | .0948 pr 10.1 Pe Hydr 2 wili 4, pa rougl surfa 11 wi foam chan .101 .101 .101 | 100 rcent aulic behavy th apparent th of grass n. Remaind ce of flow i hen surface on the su nel still in t 0 5 30 80 | 27 ior: Flow ly high v, submerge ler of run ncreasing of flow h rface. En fair condi 43 20 12 15 | 259 F through elocity for in roughn became exc tion. 000 000 000 000 | 36.9 xperiment grass for r depth. R: face of flo tely over g ess to runs seedingly r quite app 3.16 4.31 5.30 11.4 | .0405 2, 1941 uns 1 an uns 3 an w slightl grass wit 9, 10, an ough wit arent bu .304 .232 _208 .100 |
| 6 7 Channel 10 Description of lipped green quare foot; a vercent buffal ablished in sp rolling weeds ious testing. | 9-1 OF vegetation grass with verage leng o; upright pring 1940. and filling 8-2 8-2 8-2 8-2 | 11.7 : Good un 3.8 cubic 1 3.8 cubic 1 3.8 cubic 1 at start o Maintenar damaged p .0178 .0395 .113 | 1.02 niform statinches of hes; comp f testing. tee consist blaces caus .068 .094 .165 .203 .320 .393 | 11.5 Bed Slo and of un- forage per oosition 100 Grass es- ted of con- sed by pre- .262 .420 .685 | .0948 pe 10.1 Pe Hydr 2 wit 4, pa rougi surfa 11 wi foam chan .101 .101 | 100 rcent aulic behave th apparent rt of grass n. Remaind ce of flow i hen surface on the su nel still in t 0 5 30 | 27 lor: Flow ly high v submerge ler of run ncreasing of flow 1 rface. En fair condi 43 20 12 | 259 F Through elocity for d with sur ns complet in roughn became exa vosion was tion. | 36.9 Experiment grass for r depth. R face of flo tely over g ess to runs seedingly r quite app 3.16 4.31 5.30 | .0405 2, 1941 uns 1 an uns 3 an w slightl grass wit 9, 10, an ough wit arent bu .304 .232 .208 |
| 6 7 Channel 10 Description of lipped green quare foot; a bercent buffal ablished in sp rolling weeds ious testing. 1 2 3 4 5 6 7 | 9-1 vegetation grass with verage leng lo; upright pring 1940. and filling 8-2 8-2 8-2 8-2 8-2 8-2 8-2 8-2 | 11.7 : Good un 3.8 cubic : gth 4.9 incl at start o Maintenar damaged p .0178 .0395 .113 .331 1.30 1.97 2.44 | 1.02 niform sta inches of hes; comp f testing. ice consist blaces caus .068 .094 .165 .203 .320 .393 .425 | 11.5 Bed Slo and of un- forage per position 100 Grass es- ted of con- sed by pre- 262 .420 .685 1.63 4.06 5.02 5.73 | .0948 Pe 10.1 Pe Hydr 2 wil 4, pa rougi surfa 11 wi foam chan .101 .101 .101 .101 .101 .101 .102 .102 | 100 rcent aulic behave th apparent rt of grass h. Remaind ce of flow i hen surface on the su nel still in t 0 5 30 80 100 100 100 | 27 lor: Flow ly high v submerge ler of run ncreasing of flow 1 rface. En fair condi 43 20 12 15 14 12 10 | 259 F Through elocity for d with sum in roughn became exe osion was tion. .000 .000 .000 .000 .000 .000 .000 .000 .000 | 36.9 grass for r depth. R face of flo tely over g ess to runs ceedingly r quite app 3.16 4.31 5.30 11.4 22.6 25.2 27.6 | .0405 2, 1941 uns 1 an uns 3 an ww slightl grass wit 9, 10, an ough wit varent bu .304 .232 .208 .100 .0547 .0507 .0468 |
| 6 7 Channel 10 Description of lipped green quare foot; a bercent buffal ablished in sp rolling weeds ious testing. 1 2 3 4 5 6 7 8 | 9-1 vegetation grass with verage leng o; upright pring 1940. and filling 8-2 8-2 8-2 8-2 8-2 8-2 8-2 8-2 | 11.7 : Good uu 3.8 cubic : 3th 4.9 incl at start o Maintenar damaged p .0178 .0395 .113 .331 1.30 1.97 2.44 2.95 | 1.02 hiform statinches of hes; comp f testing. hee consist places caus .068 .094 .165 .203 .320 .320 .393 .425 .471 | 11.5 Bed Slo and of un- forage per position 100 Grass es- ted of con- sed by pre- 262 .420 .685 1.63 4.06 5.02 5.73 6.25 | .0948 pe 10.1 Pe Hydr 2 wit 4, pa rougi surfa 11 wi foam chan .101 .101 .101 .101 .101 .101 .102 .102 .102 | 100 rcent aulic behave th apparent rt of grass h. Remaind ce of flow i hen surface on the su nel still in t 0 5 30 80 100 100 100 | 27 lior: Flow ly high vi submerge ler of run ncreasing of flow h rface. Er fair condi 43 20 12 12 15 14 12 10 9 | 259 F through elocity for in roughn became exc osion was tion. 000 .000 | 36.9 xperiment grass for r depth. R: face of flo tely over g ess to runs reedingly r quite app 3.16 4.31 5.30 11.4 22.6 25.2 27.6 28.5 | .0405 2, 1941 uns 1 an uns 3 an ow slightl grass wit 9, 10, an ough wit parent bu .304 .232 .208 .100 .0507 .0468 .0462 |
| 6 7 Channel 10 Description of lipped green quare foot; a hercent buffal ablished in sp rolling weeds tous testing. 1 2 3 4 5 6 7 8 9 | 9-1 vegetation grass with verage leng o; upright pring 1940. and filling 8-2 8-2 8-2 8-2 8-2 8-2 8-2 8-2 | 11.7 : Good uu 3.8 cubic 3 gth 4.9 incl at start o Maintenar damaged p .0178 .0395 .113 .331 1.30 1.97 2.44 2.95 4.16 | 1.02 hlform statinches of hes; comp f testing. hce consist blaces caus .068 .094 .165 .203 .320 .320 .320 .320 .471 .564 | 11.5 Bed Slo and of un- forage per oosition 100 Grass es- ted of con- sed by pre- 262 .420 .685 1.63 4.06 5.02 5.73 6.25 7.38 | .0948 Pr 10.1 Pe Hydr 2 wit 4, pa rougi surfa 11 wi foam chan .101 .101 .101 .101 .101 .102 .102 .102 .103 | 100 rcent aulic behav th apparent tr of grass 1. Remaind ce of flow i hen surface on the su nel still in t 0 5 30 80 100 100 100 100 100 | 27 ior: Flow ly high v, submerge ler of run ncreasing of flow h rface. En fair condi 43 20 12 15 14 12 15 14 12 10 9 9 | 259 F through elocity for in roughn became exe vosion was tion. 000 .000 | 36.9 xperiment grass for r depth. R: face of floo tely over g ess to runs ceedingly r quite app 3.16 4.31 5.30 11.4 22.6 25.2 27.6 28.5 30.7 | .0405 2, 1941 uns 1 an uns 3 an ow slightly trass wit 9, 10, an ough wit arent bu .304 .232 .208 .100 .0547 .0507 .0462 .0462 .0442 |
| 6 7 Channel 10 Description of dipped green quare foot; a percent buffal ablished in sp rolling weeds tious testing. 1 2 3 4 5 6 7 8 9 10 | 9-1 oF vegetation grass with verage leng o; upright pring 1940. and filling 8-2 8-2 8-2 8-2 8-2 8-2 8-2 8-2 | 11.7 : Good m 3.8 cubic gth 4.9 incl at start o Maintenar damaged p .0178 .0395 .113 .331 1.30 1.97 2.44 2.95 4.16 6.77 | 1.02 hiform statinches of hes; comp f testing. hee consist places caus .068 .094 .165 .203 .320 .320 .393 .425 .471 | 11.5 Bed Slo and of un- forage per position 100 Grass es- ted of con- sed by pre- 262 .420 .685 1.63 4.06 5.02 5.73 6.25 | .0948 pe 10.1 Pe Hydr 2 wit 4, pa rougi surfa 11 wi foam chan .101 .101 .101 .101 .101 .101 .102 .102 .102 | 100 rcent aulic behav th apparent rt of grass n. Remaind ce of flow i hen surface on the su nel still in t 0 5 30 80 100 100 100 100 100 | 27 ior: Flow ly high v submerge ler of rum ncreasing of flow h rface. Er fair condi 43 20 12 15 14 12 15 14 12 10 9 9 23 | 259 F through elocity for d with sum ns completing in roughn became exect osion was tion. 000 .000 | 36.9 grass for r depth. R fface of floo tely over g ess to runs seedingly r quite app 3.16 4.31 5.30 11.4 22.6 25.2 27.6 28.5 30.7 34.5 | .0405 2, 1941 uns 1 an uns 3 an w slight] grass wit 9, 10, an ough wit arent bu .304 .232 .208 .100 .0547 .0507 .0468 .0462 .0462 .0469 |
| 6 7 Channel 10 Description of lilipped green quare foot; a bercent buffal ablished in sp rolling weeds tious testing. 1 2 3 4 5 6 7 8 9 10 11 | 9-1 vegetation grass with verage leng o; upright pring 1940. and filling 8-2 8-2 8-2 8-2 8-2 8-2 8-2 8-2 | 11.7 : Good uu 3.8 cubic 3 gth 4.9 incl at start o Maintenar damaged p .0178 .0395 .113 .331 1.30 1.97 2.44 2.95 4.16 | 1.02 | 11.5 Bed Slo and of un- forage per oosition 100 Grass es- ted of con- sed by pre- 262 420 .685 1.63 4.06 5.02 5.73 6.25 7.38 9.32 11.5 | .0948 Pe 10.1 Pe Hydr 2 wili 4, pa rougl surfa 11 wi foam chan .101 .101 .101 .101 .101 .101 .102 .102 .102 .103 .101 .0960 | 100 rcent aulic behave th apparent rt of grass h. Remaind ce of flow i hen surface on the su nel still in t 0 5 30 80 100 100 100 100 100 100 | 27 ior: Flow ly high v, submerge ler of run ncreasing of flow h rface. En fair condi 43 20 12 15 14 12 15 14 12 10 9 9 | 259 7 through elocity for in roughn became exc tion. 000 000 000 000 000 000 000 0 | 36.9 xperiment grass for r depth. R: face of flo tely over g ess to runs seedingly r quite app 3.16 4.31 5.30 11.4 22.6 25.2 27.6 28.5 30.7 34.5 33.1 | .0405 2, 1941 uns 1 an uns 3 an w slightly grass wit 9, 10, an ough wit arent bu .304 .232 .208 .100 .0547 .0468 .0462 .0462 .0469 .0387 |
| 6 7 Channel 10 Description of lipped green quare foot; a bercent buffal ablished in sp rolling weeds ious testing. 1 2 3 4 5 6 7 7 8 9 10 11 Channel 10 | 9-1 vegetation grass with verage leng o; upright pring 1940. and filling 8-2 8-2 8-2 8-2 8-2 8-2 8-2 8-2 | 11.7 : Good un 3.8 cubic 1 3.8 cubic 1 at start o Maintenar damaged p .0178 .0395 .113 .331 1.30 1.97 2.44 2.95 4.16 6.77 10.9 | 1.02 | 11.5 Bed Slo and of un- forage per- oosition 100 Grass es- ted of con- sed by pre- 262 .420 .685 1.63 4.06 5.02 5.73 6.25 7.38 9.32 11.5 Bed Slo | .0948 Pe 10.1 Pe Hydr 2 wil 4, pa rougi surfa 11 wi foam chan .101 .101 .101 .101 .101 .102 .102 .102 .102 .103 .101 .0960 pe 10.1 Pe | 100 rcent aulic behavion the apparent rt of grass n. Remain ce of flow i hen surface on the surface surface on the surface on the s | 27 ior: Flow ly high v submerge ler of rum ncreasing of flow 1 rface. En fair condi 43 20 12 15 14 12 10 9 9 23 33 | 259 through elocity for in roughn became exe cosion was tion. 000 .0000 .000 .000 .00 | 36.9 xperiment grass for r depth. R: face of flo tely over g ess to runs reedingly r quite app 3.16 4.31 5.30 11.4 22.6 25.2 27.6 28.5 30.7 34.5 33.1 xperiment | .0405 2, 1941 uns 1 an uns 3 an w slightl grass wit 9, 10, an ough wit parent bu .232 .208 .100 .0547 .0468 .0462 .0442 .0409 .0387 3, 1942 |
| 6 7 Channel 10 Description of Ilipped green quare foot; a bercent buffal ablished in sp rolling weeds tious testing. 1 2 3 4 5 6 7 8 9 10 11 Channel 10 Description of lipped green | 9-1 vegetation grass with verage leng o; upright pring 1940. and filling 8-2 8-2 8-2 8-2 8-2 8-2 8-2 8-2 | 11.7 : Good uu 3.8 cubic : 2th 4.9 incl at start o Maintenar damaged p .0178 .0395 .113 .331 1.30 1.97 2.44 2.95 4.16 6.77 10.9 :: Fair un 577 stems | 1.02 hiform sta inches of testing. hes; comp f testing. hes; comp f testing. hes; comp hes; comp f testing. hes; comp hes; comp he | 11.5 Bed Slo and of un- forage per oosition 100 Grass es- ted of con- sed by pre- 262 .420 .685 1.63 4.06 5.02 5.73 6.25 7.38 9.32 11.5 Bed Slop nd of un- e foct; av- | .0948 Pe 10.1 Pe Hydr 2 wii 4, pa rougi surfa 11 wi foam chan .101 .101 .101 .101 .101 .102 .102 .102 .103 .101 .0960 pe 10.1 Pee Hydr | 100 rcent aulic behav. ch apparent rt of grass n. Remaind ce of flow i hen surface on the su nel still in f 0 5 30 80 100 100 100 100 100 100 100 | 27 ior: Flow ly high v, submerge ler of run ncreasing of flow h rface. En fair condi 43 20 12 15 14 12 15 14 12 10 9 9 23 33 | 259 F through elocity for in roughn became exe osion was tion. 000 000 000 000 000 000 000 0 | 36.9 xperiment grass for r depth. R: face of flo tely over g ess to runs seedingly r quite app 3.16 4.31 5.30 11.4 22.6 25.2 27.6 28.5 30.7 34.5 33.1 xperiment and over Flow over | .0405 2, 1941 uns 1 an uns 3 an ow slight grass wit arent bu .304 .232 .208 .100 .0547 .0507 .0462 .0442 .0409 .0387 3, 1942 grass fo most o |
| 6 7 Channel 10 Description of lipped green quare foot; a bercent buffal ablished in sp rolling weeds ious testing. 1 2 3 4 5 6 7 8 9 10 11 Channel 10 Description of lipped green race length 3 | 9-1 vegetation grass with verage leng o; upright pring 1940. and filling 8-2 8-2 8-2 8-2 8-2 8-2 8-2 8-2 | 11.7 : Good uu 3.8 cubic: gth 4.9 incl at start o Maintenar damaged p .0178 .0395 .113 .331 1.30 1.97 2.44 2.95 4.16 6.77 10.9 1: Fair un 577 stems .000000000000000000000000000000000000 | 1.02 hlform statinches of hes; comp f testing. hee consist blaces caus 068 .094 .165 .203 .320 .393 .425 .471 .564 .726 .950 hlform stating per squard .100 percent | 11.5 Bed Slo and of un- forage per- position 100 Grass es- ted of con- sed by pre- 262 .420 .685 1.63 4.06 5.02 5.73 6.25 7.38 9.32 11.5 Bed Slop nd of un- e foot; av- ent buffalo | .0948 Pe 10.1 Pe Hydr 2 wii 4, pa rougj surfa 11 wj foam chan .101 .101 .101 .101 .101 .101 .102 .102 .102 .102 .103 .101 .0960 Pe 10.1 Pec Hydr | 100 rcent aulic behav th apparent rt of grass n. Remaind ce of flow i hen surface on the su nel still in f 0 5 30 80 100 100 100 100 100 100 100 | 27 ior: Flow ly high v submerge ler of rum ncreasing of flow h rface. Er fair condi 43 20 12 15 14 12 15 14 12 10 9 9 23 33 ior: Flow 4 and 5 t | 259 F Through elocity for d with sum in roughn became exc osion was tion. 000 000 000 000 000 000 000 0 | 36.9 xperiment grass for r depth. R face of flo tely over g ess to runs ceedingly r quite app 3.16 4.31 5.30 11.4 22.6 25.2 27.6 28.5 30.7 34.5 33.1 xperiment and over Flow over saving in f | .0405 2, 1941 uns 1 an uns 3 an w slight] grass wit 9, 10, an ough wit arent bu .304 .232 .208 .100 .0547 .0507 .0468 .0462 .0409 .0387 3, 1942 grass for most o ow. Sur |
| 6 7 Channel 10 Description of lipped green quare foot; a bercent buffal ablished in sp rolling weeds ious testing. 1 2 3 4 5 6 6 7 8 9 10 11 Channel 10 Description of lipped green rage length 3 rass, upright | 9-1 vegetation grass with verage leng o; upright pring 1940. and filling 8-2 8-2 8-2 8-2 8-2 8-2 8-2 8-2 | 11.7 : Good up 3.8 cubic : gth 4.9 incl at start o Maintenar damaged p .0178 .0395 .113 .331 1.30 1.97 2.44 2.95 4.16 6.77 10.9 x: Fair up 577 stems composition (testing. (| 1.02 hlform statinches of hes; comp f testing. hce consist blaces caus 068 .094 .165 .203 .320 .393 .425 .471 .564 .726 .950 hlform stat per squark 100 perci Grass esta | 11.5 Bed Slo and of un- forage per- bosition 100 Grass es- ted of con- sed by pre- 262 .420 .685 1.63 4.06 5.02 5.73 6.25 7.38 9.32 11.5 Bed Slop nd of un- e foct; av- ent buffalo ablished by | .0948 Pe 10.1 Pe Hydr 2 wii 4, pa rougj surfa 11 wj foam chan .101 .101 .101 .101 .101 .101 .102 .102 .102 .102 .102 .103 .101 .0960 Pe 10.1 Pec Hydr runs grass face | 100 rcent aulic behav. th apparent rt of grass n. Remaind ce of flow i hen surface on the su nel still in f 0 5 30 80 100 100 100 100 100 100 100 | 27 ior: Flow submerge ler of rum ncreasing of flow h rface. Er fair condi 43 20 12 15 14 12 10 9 9 23 33 ior: Flow 4 and 5 t little rou | 259 F Through elocity for d with sum in roughn became exc osion was tion. 000 000 000 000 000 000 000 0 | 36.9 xperiment grass for r depth. R face of flo tely over g ess to runs ceedingly r quite app 3.16 4.31 5.30 11.4 22.6 25.2 27.6 28.5 30.7 34.5 33.1 xperiment and over Flow over Flow over for over run 6. S | .0405 2, 1941 uns 1 an uns 3 an w slight] grass wit 9, 10, an ough wit arent bu .304 .232 .208 .100 .0547 .0507 .0468 .0462 .0409 .0387 3, 1942 grass for most o low. Sur |
| 6 7 Channel 10 Description of lipped green quare foot; a bercent buffal ablished in sp rolling weeds ious testing. 1 2 3 4 5 6 6 7 7 8 9 10 11 Channel 10 Description of lipped green rage length 3 rass, upright olid sodding | 9-1 vegetation grass with verage leng o; upright pring 1940. and filling 8-2 8-2 8-2 8-2 8-2 8-2 8-2 8-2 | 11.7 : Good un 3.8 cubic fi tat start o Maintenar damaged p .0178 .0395 .113 .331 .331 .331 .331 .97 2.44 2.95 4.16 6.77 10.9 a: Fair un 577 stems composition f testing. G 940. Maintenar | 1.02 hiform statistics of testing, f testing, f te | 11.5 Bed Slo and of un- forage per- oosition 100 Grass es- ted of con- sed by pre- 262 .420 .685 1.63 4.06 5.02 5.73 6.25 7.38 9.32 11.5 Bed Slop nd of un- e foot; av- ent buffalo bblished by onsisted of | .0948 Pe 10.1 Pe Hydr 2 wii 4, pa rougl surfa 11 wi foam chan .101 .101 .101 .101 .101 .102 .102 .102 .102 .102 .102 .103 .101 .0960 Pe 10.1 Pe | 100 rcent aulic behav. th apparent rt of grass h. Remaind ce of flow i hen surface on the su nel still in the 0 5 30 80 100 100 100 100 100 100 100 | 27 ior: Flow submerge ler of rum ncreasing of flow h rface. Er fair condi 43 20 12 15 14 12 10 9 9 23 33 ior: Flow 4 and 5 t little rou | 259 F Through elocity for d with sum in roughn became exc osion was tion. 000 000 000 000 000 000 000 0 | 36.9 xperiment grass for r depth. R face of flo tely over g ess to runs ceedingly r quite app 3.16 4.31 5.30 11.4 22.6 25.2 27.6 28.5 30.7 34.5 33.1 xperiment and over Flow over Flow over for over run 6. S | .0405 2, 1941 uns 1 an uns 3 an w slight] grass wit 9, 10, an ough wit arent bu .304 .232 .208 .100 .0547 .0507 .0468 .0462 .0409 .0387 3, 1942 grass for most o low. Sur |
| 6 7 Channel 10 Description of lipped green quare foot; a bercent buffal ablished in sp rolling weeds ious testing. 1 2 3 4 5 6 7 7 8 9 10 11 Channel 10 Description of lipped green rage length 3 rass, upright olid sodding utting weeds | 9-1 vegetation grass with verage leng o; upright pring 1940. and filling 8-2 8-2 8-2 8-2 8-2 8-2 8-2 8-2 | 11.7 : Good un 3.8 cubic : 3th 4.9 incl at start o Maintenar damaged p .0178 .0395 .113 .331 1.30 1.97 2.44 2.95 4.16 6.77 10.9 : Fair un 577 stems composition t testing. 0 940. Main damaged | 1.02 hiform statistics of testing, f testing, f te | 11.5 Bed Slo and of un- forage per- oosition 100 Grass es- ted of con- sed by pre- 262 .420 .685 1.63 4.06 5.02 5.73 6.25 7.38 9.32 11.5 Bed Slop nd of un- e foot; av- ent buffalo bblished by onsisted of | .0948 Pe 10.1 Pe Hydr 2 wii 4, pa rougl surfa 11 wi foam chan .101 .101 .101 .101 .101 .102 .102 .102 .102 .102 .102 .103 .101 .0960 Pe 10.1 Pe | 100 rcent aulic behav. th apparent rt of grass n. Remaind ce of flow i hen surface on the su nel still in f 0 5 30 80 100 100 100 100 100 100 100 | 27 ior: Flow submerge ler of rum ncreasing of flow h rface. Er fair condi 43 20 12 15 14 12 10 9 9 23 33 ior: Flow 4 and 5 t little rou | 259 F Through elocity for d with sum in roughn became exc osion was tion. 000 000 000 000 000 000 000 0 | 36.9 xperiment grass for r depth. R face of flo tely over g ess to runs ceedingly r quite app 3.16 4.31 5.30 11.4 22.6 25.2 27.6 28.5 30.7 34.5 33.1 xperiment and over Flow over Flow over for over run 6. S | .0405 2, 1941 uns 1 an uns 3 an w slight grass wif 9, 10, an ough wit arent bu .304 .232 .208 .100 .0547 .0507 .0468 .0462 .0449 .0387 3, 1942 grass for most of unst |
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| 6 7 Channel 10 Description of lipped green quare foot; a bercent buffal ablished in sp rolling weeds ious testing. 1 2 3 4 5 6 6 7 7 8 9 10 11 Channel 10 Description of lipped green rage length 3 rass, upright olid sodding utting weeds rosion of pre- | 9-1 vegetation grass with verage leng o; upright pring 1940. and filling 8-2 8-2 8-2 8-2 8-2 8-2 8-2 8-2 | 11.7 : Good un 3.8 cubic : 2th 4.9 incl at start o Maintenar damaged p .0178 .0395 .113 .331 1.30 1.97 2.44 2.95 4.16 6.77 10.9 a: Fair un 577 stems composition t testing. C 940. Main damaged g. .0206 | 1.02 I.02 I.02 I.02 I.02 I.02 I.02 I.02 I.05 I.05 I.03 I.05 I.05 I.03 I.05 I.05 I.03 I.05 I.05 I.03 I.05 I | 11.5 Bed Slo and of un- forage per- oosition 100 Grass es- ted of con- sed by pre- 262 .420 .685 1.63 4.06 5.02 5.73 6.25 7.38 9.32 11.5 Bed Slop nd of un- e foot; av- ent buffalo ublished by onsisted of caused by | .0948 Pe 10.1 Pe Hydr 2 wili 4, pa rougl surfa 11 wi foam chan .101 .101 .101 .101 .101 .101 .101 .102 .102 .102 .103 .101 .0960 Pe 10.1 Pec Hydr runs grass face flcw durin | 100 rcent aulic behavy th apparent th apparent th apparent th apparent th apparent then surface on the surface on the surface on the surface on the surface on the surface on the surface all in the o 5 30 80 100 100 100 100 100 100 100 | 27 ior: Flow ly high v, submerge ier of run ncreasing of flow h rface. Er fair condi 43 20 12 15 14 12 12 15 14 12 10 9 9 23 33 ior: Flow , uniform 4 and 5 t little rou for runs | 259 F through elocity for in roughn became exc osion was tion. 000 .0000 | 36.9 xperiment grass for r depth. R: face of flot tely over g ess to runs reedingly r quite app 3.16 4.31 5.30 11.4 22.6 25.2 27.6 28.5 30.7 34.5 33.1 xperiment and over Flow over raving in f. run 6. S ith foam o | .0405 2, 1941 uns 1 an uns 3 an ow slight grass wit 9, 10, an ough wit sarent bu .232 .208 .100 .0547 .0468 .0462 .0442 .0469 .0387 3, 1942 grass for burface o n surface .286 |
| 6 7 Channel 10 Description of lipped green quare foot; a bercent buffal ablished in sp rolling weeds ious testing. 1 2 3 4 5 6 7 8 9 10 11 Channel 10 Description of lipped green rage length 3 rass, upright olid sodding utting weeds rosion of pre- | 9-1 vegetation grass with verage leng o; upright pring 1940. and filling 8-2 8-2 8-2 8-2 8-2 8-2 8-2 8-2 | 11.7 : Good u 3.8 cubic gth 4.9 incl at start o Maintenar damaged p .0178 .0395 .113 .331 1.30 1.97 2.44 2.95 4.16 6.77 10.9 x: Fair un 577 stems 577 stems .0192, 100 (940. Maintenar damaged g. | 1.02 hlform statinches of hes; comp f testing. hee consist blaces caus 068 .094 .165 .203 .320 .393 .425 .471 .564 .726 .950 hlform station per squark 100 perci Grass estates of places of places of | 11.5 Bed Slo and of un- forage per oosition 100 Grass es- ted of con- sed by pre- 262 .420 .685 1.63 4.06 5.02 5.73 6.25 7.38 9.32 11.5 Bed Slop nd of un- e foot; av- ent buffalo ablished by onsisted of caused by .286 .414 | .0948 Pe 10.1 Pe Hydr 2 wili 4, pa rougl surfa 11 wi foam chan .101 .101 .101 .101 .102 .102 .102 .102 .103 .101 .0960 Pe 10.1 Pec Hydr runs grazs face flew durin | 100 rcent aulic behav. ch apparent rt of grass h. Remaind ce of flow i hen surface on the su nel still in the o 5 30 80 100 100 100 100 100 100 100 | 27 ior: Flow ly high v, submerge ier of run ncreasing of flow h rface. En fair condi 43 20 12 15 14 12 15 14 12 10 9 9 23 33 33 ior: Flow , uniform 4 and 5 k little rou for runs 30 20 | 259 F through elocity for in roughn became exc osion was tion. 000 000 000 000 000 000 000 0 | 36.9 xperiment grass for r depth. R: face of flo tely over g ess to runs seedingly r quite app 3.16 4.31 5.30 11.4 22.6 27.6 28.5 30.7 34.5 33.1 xperiment and over Flow over raving in f. run 6. S ith foam o | .0405 2, 1941 uns 1 an uns 3 am ow slight grass wif 9, 10, an ough wif arent bu .232 .208 .100 .0547 .0468 .0462 .0442 .0469 .0387 3, 1942 grass for burface on surface .286 .268 |
| 6 7 Channel 10 Description of lipped green quare foot; a bercent buffal ablished in sp rolling weeds ious testing. 1 2 3 4 5 6 6 7 7 8 9 10 11 Channel 10 Description of lipped green rage length 3 rass, upright olid sodding utting weeds rosion of pre- | 9-1 vegetation grass with verage leng o; upright pring 1940. and filling 8-2 8-2 8-2 8-2 8-2 8-2 8-2 8-2 | 11.7 : Good un 3.8 cubic 3 2th 4.9 incl at start o Maintenar damaged p .0178 .0395 .113 .331 1.30 1.97 2.44 2.95 4.16 6.77 10.9 : Fair un 577 stems composition t testing. (940. Main- damaged g. .0206 .0468 | 1.02 | 11.5 Bed Slo and of un- forage per- oosition 100 Grass es- ted of con- sed by pre- 262 .420 .685 1.63 4.06 5.02 5.73 6.25 7.38 9.32 11.5 Bed Slop nd of un- e foot; av- ent buffalo ublished by onsisted of caused by | .0948 Pe 10.1 Pe Hydr 2 wili 4, pa rougl surfa 11 wi foam chan .101 .101 .101 .101 .101 .101 .101 .102 .102 .102 .103 .101 .0960 Pe 10.1 Pec Hydr runs grass face flcw durin | 100 rcent aulic behavy th apparent th apparent th apparent th apparent th apparent then surface on the surface on the surface on the surface on the surface on the surface on the surface all in the o 5 30 80 100 100 100 100 100 100 100 | 27 ior: Flow ly high v, submerge ier of run ncreasing of flow h rface. Er fair condi 43 20 12 15 14 12 12 15 14 12 10 9 9 23 33 ior: Flow , uniform 4 and 5 t little rou for runs | 259 F through elocity for in roughn became exc osion was tion. 000 .0000 | 36.9 xperiment grass for r depth. R: face of flo tely over g ess to runs seedingly r quite app 3.16 4.31 5.30 11.4 22.6 25.2 27.6 28.5 30.7 34.5 33.1 xperiment and over Flow over vaving in f. run 6. S ith foam o 3.35 3.88 5.52 | .0405 2, 1941 uns 1 an uns 3 an ow slight; trass wif 9, 10, an ough wit aarent bu .304 .232 .208 .100 .0547 .0507 .0462 |
| 6 7 Channel 10 Description of lipped green quare foot; a ercent buffal ablished in sp rolling weeds ious testing. 1 2 3 4 5 6 6 7 8 9 10 11 Channel 10 Description of lipped green rage length 3 rass, upright olid sodding utting weeds rosion of pre- | 9-1 vegetation grass with verage leng lo; upright pring 1940. and filling 8-2 8-2 8-2 8-2 8-2 8-2 8-2 8-2 | 11.7 : Good un 3.8 cubic 3 2.1 4.9 incl at start o Maintenar damaged p .0178 .0395 .113 .331 1.30 1.97 2.44 2.95 4.16 6.77 10.9 | 1.02 1.03 1.02 1.03 1.03 1.03 1.03 1.03 1.03 1.03 1.03 1.03 1.13 1.173 1.173 1.217 | 11.5 Bed Slo and of un- forage per- oosition 100 Grass es- ted of con- sed by pre- 262 .420 .685 1.63 4.06 5.02 5.73 6.25 7.38 9.32 11.5 Bed Slop nd of un- e foot; av- ent buffalo bilshed by onsisted of caused by .286 .414 .684 1.22 2.10 | .0948 Pe 10.1 Pe Hydr 2 wii 4, pa rougj surfa 11 wj foam chan .101 .101 .101 .101 .102 .102 .102 .102 .103 .101 .0960 Pe 10.1 Pec Hydr runs grass face flew durin .102 | 100 rcent aulic behav. th apparent rt of grass h. Remaind ce of flow i hen surface on the su nel still in f 0 5 30 80 100 100 100 100 100 100 100 | 27 ior: Flow ly high v submerge ler of rum ncreasing of flow h rface. Er fair condi 43 20 12 15 14 12 10 9 9 23 33 ior: Flow , uniform 4 and 5 k little rou for runs 30 20 18 36 38 | 259 F Through elocity for in roughn became exc osion was tion. .000 | 36.9 xperiment grass for r depth. R: face of flo tely over g ess to runs seedingly r quite app 3.16 4.31 5.30 11.4 22.6 27.6 28.5 30.7 34.5 33.1 xperiment and over Flow over raving in f. run 6. S ith foam o | .0405 2, 1941 uns 1 an uns 3 am ow slight grass wif 9, 10, an ough wif arent bu .232 .208 .100 .0547 .0468 .0462 .0442 .0469 .0387 3, 1942 grass for burface on surface .286 .268 |
| 6 7 Channel 10 Description of lipped green quare foot; a ercent buffal ablished in sp rolling weeds ious testing. 1 2 3 4 5 6 7 7 8 9 10 11 Channel 10 Description of lipped green rage length 3 rass, upright 0 10 2 3 7 8 9 10 11 Channel 10 10 2 3 3 4 5 6 6 7 7 8 9 10 11 Channel 10 10 2 3 3 4 5 5 6 6 7 7 8 9 10 11 Channel 10 5 10 11 Channel 10 10 2 3 7 8 9 10 11 Channel 10 10 2 3 7 8 9 10 11 Channel 10 10 2 3 7 8 9 10 11 Channel 10 10 2 7 8 9 10 11 Channel 10 10 2 7 8 9 10 11 Channel 10 10 2 7 8 9 10 11 Channel 10 10 12 7 7 8 9 10 11 Channel 10 10 12 7 7 8 9 10 11 Channel 10 12 7 7 8 9 10 11 Channel 10 12 7 7 8 9 10 11 Channel 10 12 7 7 8 9 10 11 Channel 10 12 7 7 8 8 9 10 11 Channel 10 12 7 7 8 7 8 8 9 10 11 Channel 10 12 7 8 8 9 10 11 7 8 8 9 10 11 7 8 8 9 10 11 7 8 8 8 9 10 11 7 8 8 8 8 9 10 11 12 7 8 8 8 8 9 10 11 12 7 8 8 9 10 11 12 8 8 10 10 10 10 10 10 10 10 10 10 10 10 10 | 9-1 vegetation grass with verage leng o; upright pring 1940. and filling 8-2 8-2 8-2 8-2 8-2 8-2 8-2 8-2 | 11.7 : Good uu 3.8 cubic : 3.8 cubic : 3.8 cubic : 3.8 cubic : 3.8 cubic : 4.16 : 6.77 : 10.9 :: Fair un 577 stems composition t testing. 0 940. Main: damaged g. .0206 .0468 .103 .211 .456 1.06 | 1.02 1.02 1.02 1.02 1.02 1.02 1.02 1.02 1.02 1.02 1.02 1.02 1.02 1.02 1.02 1.02 1.03 1.05 1.03 1.05 1.03 1.05 1.03 1.05 1.03 1.05 1.03 1.05 1.03 1.05 1.03 1.05 1.03 1.05 1.05 1.05 1.03 1.05 1.13 1.151 1.173 1.304 | 11.5 Bed Slo and of un- forage per- oosition 100 Grass es- ted of con- sed by pre- 262 .420 .685 1.63 4.06 5.02 5.73 6.25 7.38 9.32 11.5 Bed Slop nd of un- e foot; av- ent buffalo caused by .286 .414 .684 1.22 2.10 3.50 | .0948 Pe 10.1 Pe Hydr 2 wili 4, pa rougl surfa 11 wi foam chan .101 .101 .101 .101 .101 .101 .102 .102 .102 .102 .103 .101 .0960 Pe 10.1 Pec flcw durin .101 .102 .103 .101 .101 .101 .101 .101 .101 .101 .102 .102 .102 .102 .102 .103 .101 .101 .101 .102 .102 .102 .102 .102 .103 .101 .101 .101 .102 .102 .102 .102 .102 .102 .102 .103 .101 .101 .101 .102 .102 .102 .102 .102 .103 .101 .102 .102 .102 .103 .101 .102 .102 .102 .102 .102 .102 .102 .102 .102 .102 .103 .101 .102 .102 .102 .102 .102 .102 .102 .102 .102 .102 .103 .101 .102 | 100 rcent aulic behav. h apparent rt of grass h. Remaind ce of flow i hen surface on the su nel still in 1 0 5 30 80 100 100 100 100 100 100 100 | 27 ior: Flow ly high v, submerge ier of run ncreasing of flow h rface. En fair condi 43 20 12 15 14 12 10 9 9 23 33 ior: Flow , uniform 4 and 5 t little rou for runs 30 20 18 36 38 33 | 259 F through elocity for in roughn became exc osion was tion. 000 .000 | 36.9 xperiment grass for r depth. R: face of flot tely over g ess to runs zeedingly r quite app 3.16 4.31 5.30 11.4 22.6 27.6 28.5 30.7 34.5 33.1 xperiment and over Flow over run 6. S ith foam o 3.35 3.88 5.52 9.26 14.1 20.0 | .0405 2, 1941 uns 1 an uns 3 an uns 3 an ow slight grass wif 9, 10, an ough wif parent bu .232 .208 .100 .0547 .0468 .0462 .0442 .0409 .0387 3, 1942 grass for most con surface con surface .286 .268 .197 .122 .0821 .0610 |
| 6 7 Channel 10 Description of lipped green quare foot; a bercent buffal ablished in sp rolling weeds ious testing. 1 2 3 4 5 6 7 8 9 10 11 Channel 10 Description of lipped green rage length 3 rass, upright olid sodding utting weeds rosion of pre- 1 2 3 4 5 5 6 7 7 | 9-1 vegetation grass with verage leng o; upright pring 1940. and filling 8-2 8-2 8-2 8-2 8-2 8-2 8-2 8-2 | 11.7 : Good uu 3.8 cubic : 2th 4.9 incl at start o Maintenar damaged p .0178 .0395 .113 .331 1.30 1.97 2.44 2.95 4.16 6.77 10.9 | 1.02 hiform statistics of testing. hes; comp f testing. hes; comp hes; comp f testing. hes; comp f testing. hes; comp hes; comp h | 11.5 Bed Slo and of un- forage per oosition 100 Grass es- ted of con- sed by pre- 262 .420 .685 1.63 4.06 5.02 5.73 6.25 7.38 9.32 11.5 Bed Slop nd of un- e foct; av- ent buffalo iblished by onsisted of caused by .286 .414 .684 1.22 2.10 3.50 5.57 | .0948 Pe 10.1 Pe Hydr 2 wii 4, pa rougi surfa 11 wi foam chan .101 .101 .101 .101 .102 .102 .102 .103 .101 .0960 pe 10.1 Pee Hydr runs grass face flew durin .101 .102 .102 .102 .103 .101 .101 .101 .101 .102 .102 .102 .103 .101 .101 .102 .102 .102 .102 .102 .102 .102 .102 .103 .101 .101 .101 .101 .102 .102 .102 .102 .102 .102 .102 .102 .102 .103 .101 .101 .101 .102 .102 .102 .102 .102 .103 .101 .101 .101 .102 .102 .102 .102 .103 .101 .101 .102 .102 .102 .103 .101 .102 .102 .102 .103 .101 .102 .102 .102 .103 .101 .102 .102 .102 .102 .103 .101 .102 .102 .102 .102 .102 .103 .101 .102 .101 .101 .101 .102 | 100 rcent aulic behav. ch apparent rt of grass h. Remaind ce of flow i hen surface on the su nel still in the 0 5 30 80 100 100 100 100 100 100 100 | 27 ior: Flow ly high v, submerge- ter of run ncreasing of flow h rface. En fair condi 43 20 12 15 14 12 10 9 9 23 33 ior: Flow , uniform 4 and 5 t little rou for runs 30 20 18 36 38 33 38 | 259 F through elocity for in roughn became exc vosion was tion. 000 000 000 000 000 000 000 0 | 36.9 xperiment grass for r depth. R: face of flo tely over g ess to runs seedingly r quite app 3.16 4.31 5.30 11.4 22.6 27.6 28.5 30.7 34.5 33.1 xperiment and over Flow over raving in f. run 6. S ith foam o 3.35 3.88 5.52 9.26 14.1 20.0 27.2 | .0405 2, 1941 uns 1 an uns 3 am ow slight; grass wif 9, 10, an ough wit arent bu .232 208 .100 .0547 .0507 .0468 .0462 .0442 .0469 .0387 3, 1942 grass for most of bow. Sur urface on surface .0821 .0821 .0610 .0473 |
| 6 7 Channel 10 Description of hilipped green quare foot; a bercent buffal ablished in sp rolling weeds ious testing. 1 2 3 4 5 6 7 7 8 9 10 11 Channel 10 Description of hipped green rage length 3 rass, upright olid sodding tutting weeds resion of pre- 1 2 3 4 5 6 6 7 7 8 9 10 | 9-1 vegetation grass with verage leng o; upright pring 1940. and filling 8-2 8-2 8-2 8-2 8-2 8-2 8-2 8-2 | 11.7 : Good uu 3.8 cubic : 3.8 cubic : 3.8 cubic : 3.8 cubic : 3.8 cubic : 4.16 : 6.77 : 10.9 :: Fair un 577 stems composition t testing. 0 940. Main: damaged g. .0206 .0468 .103 .211 .456 1.06 | 1.02 1.02 1.02 1.02 1.02 1.02 1.02 1.02 1.02 1.02 1.02 1.02 1.02 1.02 1.02 1.02 1.03 1.05 1.03 1.05 1.03 1.05 1.03 1.05 1.03 1.05 1.03 1.05 1.03 1.05 1.03 1.05 1.03 1.05 1.05 1.05 1.03 1.05 1.13 1.151 1.173 1.304 | 11.5 Bed Slo and of un- forage per- oosition 100 Grass es- ted of con- sed by pre- 262 .420 .685 1.63 4.06 5.02 5.73 6.25 7.38 9.32 11.5 Bed Slop nd of un- e foot; av- ent buffalo caused by .286 .414 .684 1.22 2.10 3.50 | .0948 Pe 10.1 Pe Hydr 2 wili 4, pa rougl surfa 11 wi foam chan .101 .101 .101 .101 .101 .101 .102 .102 .102 .102 .103 .101 .0960 Pe 10.1 Pec flcw durin .101 .102 .103 .101 .101 .101 .101 .102 .102 .102 .102 .102 .103 .101 .101 .101 .101 .102 .102 .102 .102 .102 .102 .102 .102 .102 .103 .101 .101 .101 .102 .102 .102 .103 .101 .101 .101 .102 .102 .102 .102 .102 .102 .103 .101 .102 .102 .102 .102 .102 .102 .102 .102 .102 .102 .102 .103 .101 .102 | 100 rcent aulic behav. h apparent rt of grass h. Remaind ce of flow i hen surface on the su nel still in 1 0 5 30 80 100 100 100 100 100 100 100 | 27 ior: Flow ly high v, submerge ier of run ncreasing of flow h rface. En fair condi 43 20 12 15 14 12 10 9 9 23 33 ior: Flow , uniform 4 and 5 t little rou for runs 30 20 18 36 38 33 | 259 F through elocity for in roughn became exc osion was tion. 000 .000 | 36.9 xperiment grass for r depth. R: face of flot tely over g ess to runs zeedingly r quite app 3.16 4.31 5.30 11.4 22.6 27.6 28.5 30.7 34.5 33.1 xperiment and over Flow over run 6. S ith foam o 3.35 3.88 5.52 9.26 14.1 20.0 | .0405 2, 1941 uns 1 an uns 3 an uns 3 an ow slight grass wif 9, 10, an ough wif parent bu .232 .208 .100 .0547 .0468 .0462 .0442 .0409 .0387 3, 1942 grass for most con surface con surface .286 .268 .197 .122 .0821 .0610 |

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Table 6.—Results of Tests of Channels Lined with Buffalo Grass.—(Continued)

| Channel 1B | | | - | Bed Slop | e 0.98 Pe | ercent | | · Exj | periment 1 | 1941 |
|---|--|--|--|--|--|---|--|---|--|--|
| | | | | | | | <u> </u> | | Coeffic | lents |
| | | Ma | | ₽ | | 8 | • | - | | đ |
| | | Discharge per foot of width, VD | A | | ę | Vegetation submergence | đ. | 2 1 | σ | <u>نو</u> |
| , | | ag 4 | Depth, | Mean velocity, | Effective slope | ber | Duration of flow | rate scour | 5 | Manning, |
| Run | Date | der der | Cepi | elo | 1 te | nd n | E. | AV. | Ohezy, | 147 |
| | | | | | | | | | | 11 |
| 1 | 2 | 3 Cu. ft. | <u></u> | 5 Ft. per | 6 Ft. per | 7 | 8 | 9 In. per | 10 | |
| | | per sec. | Feet | SCC. | ft. | Percent | Min. | hr, | | |
| escription of reen grass withot; average le ve grass, upri rom seed in sp | th 8.2 cubic ingth 15.3 in ght at star | ; inches o nches: con | of forage ; aposition 1 | per square | grass 3. Si part subm of su Surfa flows | aulic behavi- with no ap tream forma- of grass sub- erged for ru- bmerged for bmerged gra- tice of the f for runs 9 could be si | parent of ed down (merged fo in 6 and i uss waving lows fairly , 10 and | fect on gra center of or runs 4 as all for run g in the flo y smooth. 11 were sli | ss for run channel nd 5. Mos 7 and 8 w w for all t The surfa ghtly roug | s 1, 2 ar that ha it of gra- rith muc hree run ce of th |
| 1 | 7-15 | .0235 | .193 | .122 | .0107 | 0 | 30 | .000 | 2.71 | .426 |
| 2 | 7-15 | .0961 | .418 | .230 | .0116 | 0 | 22 | .000 | 3.32 | .391 |
| - 3 | 7-15 | .219 | .640 | .342 | .0121 | 0 | 16 | .187 | 3.92 | .356 |
| 4 | 7-16 | .318 .448 | .724 .829 | .440 .540 | 0124 .0128 | 20 50 | 19 15 | 000. 000. | 4.66 5.28 | .303 .274 |
| 5 6 | 、7-16 7-16 | .462 | .826 | .560 | .0128 | 50. 80 | 9 | .056 | 5.45 | .265 |
| 7 | 7-16 | .767 | .913 | .840 | .0126 | 100 | 15 | .000 | 7.84 | .187 |
| 8 | 7-16 | 1.02 | .967 | 1.06 | .0127 | 100 | 15 | .130 | 9.59 | .154 |
| 9 | 7-16 | 1.34 | 1.05 | 1.28 | .0126 | 100 | 9 | .496 | 11.1 | .135 |
| 10 | 7-17 | 1.64 | 1.10 | 1.49 | .0126 | 100 | 35 | .010 | 12.7 | .119 |
| 11 | 7-17 | 2.81 | 1.29 | 2.18 | .0126 | 100 | 35 | .014 | 17.3 | .089 |
| | | | | | | | | | | |
| Channel 1E escription of ong green gra | vegetation: ss with 525 | i stems pe | er square | n stand of foot; aver- | and 3 | aulic behav | h surface. | through Runs 4 and | i 5 submer | runs 1, ged part |
| Channel 1E escription of | vegetation: ss with 525 inches; con ight at star Grass clip i soil replace | i stems per inposition t of testin oped 4 inc | er square 100 percen g. Grass thes above | a stand of foot; aver- at weeping established ground in | Hydr and 3 grass of gr the f of th | aulic behav | h surface. e of flow omerged t submerge ms that i | v through Runs 4 and remained i by run 6 w ed all of th | stand for 15 submerg airly smoo ith grass e grass exce | runs 1, ged part oth. Mo waving cept a fo |
| Channel 1E escription of ing green gra- ge length 28 we grass; upr a spring 1941. oring 1942 and | vegetation: ss with 525 inches; con ight at star Grass clip i soil replace | i stems per inposition t of testin oped 4 inc | er square 100 percen g. Grass thes above erosion ha .110 | a stand of foot; aver- at weeping established ground in | Hydr and 3 grass of gr the f of th | aulic behav with smoot but surface ass was sul low. Run 7 he taller ste | h surface. e of flow omerged t submerge ms that i | v through Runs 4 and remained i by run 6 w ed all of th | stand for 15 submerg airly smoo ith grass e grass exce | runs 1 ged part oth. M waving cept a f |
| Channel 1E escription of ing green gra- ge length 28 ve grass; upr i spring 1941. pring 1942 and y previous tex- 1 2 | vegetation: ss with 52t inches; con ight at star Grass clip i soil replac sting. 9-3 9-3 | s stems per nposition t of testin pped 4 inconced where .0158 .0586 | er square 100 percen g. Grass thes above erosion ha .110 .279 | n stand of foot; aver- nt weeping established ground in id occurred .144 .210 | Hydr and 3 grass of gr the f of th face .0107 .0111 | aulic behav with smoot is but surface rass was sul low. Run 7 te taller ste of the flow 0 0 | h surface. e of flow omerged & submerged ms that p | v through Runs 4 and remained b by run 6 w ed all of th remained a .000 .021 | stand for i 5 submerg fairly smoo e grass exec t or above 4.80 4.15 | runs 1 ged part oth. M waving cept a f e the su .243 .317 |
| Channel 1E escription of ng green gra e length 28 ve grass; upr spring 1941. oring 1942 and y previous te: 1 2 3 | vegetation: ss with 522 inches; con ight at star Grass clil i soil replat sting. 9-3 9-3 9-3 | s stems per nposition t of testin oped 4 inc ced where .0158 .0586 .204 | er square 100 percen g. Grass thes above erosion ha .110 .279 .631 | n stand of foot; aver- nt weeping established ground in nd occurred .144 .210 .323 | Hydr and 3 grass of gr the f of th face .0107 .0111 .0131 | aulic behav with smoot but surface ass was sul low. Run 7 le taller ste of the flow 0 0 10 | h surface. e of flow omerged h submerged ms that n 60 24 24 24 | v through Runs 4 and remained i by run 6 w ed all of th remained a .000 .021 .030 | stand for 1 5 submerg (airly smooth fairly smooth th grass e grass exect t or above 4.80 4.15 3.74 | runs 1 ged part oth. M waving cept a f e the st .243 .317 .393 |
| Channel 1E escription of ng green gras te length 28 ve grass; upr spring 1941. rring 1942 and y previous tex 1 2 3 4 | vegetation: .ss with 52t inches; con ight at star Grass clip d soil replac sting. 9-3 9-3 9-3 9-3 | o stems per nposition t of testin oped 4 inc ced where 0158 .0586 .204 .311 | er square 100 percen g. Grass thes above erosion he .110 .279 .631 .889 | n stand of foot; aver- nt weeping established ground in ad occurred .144 .210 .323 .350 | Hydr and 3 grass of gr the f of th face .0107 .0111 .0131 .0143 | aulic behav with smoot but surface ass was sul low. Run 7 le taller ste of the flow 0 10 20 | h surface. e of flow omerged h ' submerge ms that i | v through Runs 4 and remained 1 by run 6 w ed all of th remained a .000 .021 .030 .060 | stand for 15 submerg fairly smoothing grass e grass exect t or above 4.80 4.15 3.74 3.25 | runs 1 ged parl oth. M waving cept a f e the si .243 .317 .393 .476 |
| Channel 1E escription of ng green gra- te length 28 ve grass; upr spring 1941. ring 1942 and previous te: 1 2 3 4 5 | vegetation: ss with 52t inches: coi ight at star Grass clip i soil replac sting. 9-3 9-3 9-3 9-3 9-3 9-3 | o stems per nposition t of testin oped 4 inc ced where 0158 .0586 .204 .311 .503 | er square 100 percen g. Grass thes above erosion ha .110 .279 .631 | n stand of foot; aver- nt weeping established ground in nd occurred .144 .210 .323 | Hydr and 3 grass of gr the f of th face .0107 .0111 .0131 .0143 .0146 | aulic behav with smoot but surface rass was sul low. Run 7 he taller ste of the flow 0 10 20 50 | h surface. e of flow omerged & submerge ms that p | v through Runs 4 and remained 1 by run 6 w ed all of th remained a .000 .021 .030 .060 .039 | stand for 15 submergiatry smoothing rass e grass ext or above 4.80 4.15 3.74 3.25 3.65 | runs 1 ged par th. M waving cept a f e the s .243 .317 .393 .476 .435 |
| Channel 1E scription of ng green gras e length 28 ve grass; upr spring 1941. ring 1942 and v previous tex 1 2 3 4 | vegetation: .ss with 52t inches; con ight at star Grass clip d soil replac sting. 9-3 9-3 9-3 9-3 | o stems per nposition t of testin oped 4 inc ced where 0158 .0586 .204 .311 | er square 100 percen g. Grass thes above erosion he .110 .279 .631 .889 1.13 | n stand of foot; aver- nt weeping established ground in id occurred .144 .210 .323 .350 .445 | Hydr and 3 grass of gr the f of th face .0107 .0111 .0131 .0143 | aulic behav with smoot but surface ass was sul low. Run 7 le taller ste of the flow 0 10 20 | h surface. e of flow omerged h ' submerge ms that i | v through Runs 4 and remained 1 by run 6 w ed all of th remained a .000 .021 .030 .060 | stand for 15 submerg fairly smoothing grass e grass exect t or above 4.80 4.15 3.74 3.25 | runs I ged par pth. M waving cept a f e the s .243 .317 .393 .476 .435 .331 |
| Channel 1E escription of ng green gra te length 28 ve grass; upr spring 1942 noring 1942 and y previous tes 1 2 3 4 5 6 | vegetation: .ss with 52t inches; con ight at star Grass clip i soil replac sting. 9-3 9-3 9-3 9-3 9-3 9-3 9-3 9-3 9-3 | o stems per nposition t of testin pped 4 inc ced where 0158 .0586 .204 .311 .503 .733 | er square 100 percei g. Grass iches above erosion ha .110 .279 .631 .889 1.13 1.22 | n stand of foot; aver- nt weeping established ground in id occurred .144 .210 .323 .350 .445 .601 .866 | Hydr and 3 grass of gr the f of th face .0107 .0111 .0131 .0143 .0146 .0138 | aulic behav with smoot but surface rass was sul low. Run 7 he taller ste of the flow 0 10 20 50 80 98 | h surface. e of flow omerged k submerge ms that r | v through Runs 4 and remained 1 by run 6 w ed all of th remained a .000 .021 .030 .060 .039 .036 .128 | stand for i 5 submerg fairly smoo ith grass e grass exet t or above 4.80 4.15 3.74 3.25 3.65 4.98 | runs 1 ged part oth. M waving cept a f e the su .243 .317 .393 .476 .439 .331 .234 |
| Channel 1E escription of ong green gra ge length 28 we grass; upr a spring 1941. oring 1942 and y previous te: 1 2 3 4 5 6 7 | vegetation: ss with 52t inches; con ight at star Grass clij d soil replace sting. 9-3 9-3 9-3 9-3 9-3 9-3 9-3 9-3 9-3 9-3 | of stems per ste | er square 100 percen g. Grass ches above erosion ha .110 .279 .631 .889 1.13 1.22 1.31 | a stand of foot; aver- nt weeping established ground in id occurred .144 .210 .323 .350 .445 .601 .866 Bed Slo pt; average eeping love established | Hydr and 3 grass of gr the f of th face .0107 .0111 .0131 .0143 .0146 .0138 .0132 ppe 2.11 Pc Hydr and roug came | aulic behav with smoot but surface rass was sul low. Run 7 he taller ste of the flow 0 10 20 50 80 98 | h surface. e of flow omerged 4 'submerged ms that 1 | v through Runs 4 and remained i by run 6 w ed all of th remained a .000 .021 .030 .060 .039 .036 .128 Ep w through th. Runs t in flow. | stand for 15 submergialry smoothing ith grass e grass exect t or above 4.80 4.15 3.74 3.25 3.65 4.98 7.07 cperiment stand for 5 and 6, flo | runs 1 ged part th. M waving cept a f the su 243 .317 .393 .476 .439 .331 .234 1, 1942 runs 1 bw sligh flow |
| Channel 1E escription of ng green gras te length 28 ve grass; upr 1 spring 1942 and y previous te: 1 2 3 4 5 6 7 Channel 2E escription of reen grass w might 16 inch rass; upright h spring 1942. 1 | vegetation: ss with 522 inches; con ight at star Grass clij d soil replace sting. 9-3 9-3 9-3 9-3 9-3 9-3 9-3 9-3 9-3 9-3 | i stems pr nposition t of testim pped 4 inc ced where 0158 .0586 .204 .311 .503 .733 1.13 : Good u ms per s iltion 100 t of testim pped 4 inc .0240 | er square 100 percen g. Grass ches above erosion ha .110 .279 .631 .889 1.13 1.22 1.31 | n stand of foot; aver- nt weeping established ground in ad occurred .144 .210 .323 .350 .445 .601 .866 Bed Slo Dt; average eeping love established ground in .229 | Hydr and 3 grass of gr the f of th face .0107 .0111 .0131 .0143 .0143 .0143 .0138 .0132 .0138 .0132 ppe 2.11 Pe Hydr and rougi came throu | aulic behav with smoot but surface ass was sul low. Run 7 le taller ste of the flow 0 0 10 20 50 80 98 ercent aulic behav h with grass e more roug ugh runs 7 t | h surface. e of flow omerged 4 submerged ms that 1 60 24 24 24 24 24 22 20 18 for: Flow face smoo s waving gh and to 10. 32 | v through Runs 4 and remained i by run 6 w ed all of th remained a .000 .021 .030 .060 .039 .036 .128 Ex v through th. Runs 5 in flow. turbulent | stand for 15 submerginal submerginal starty smoothing grass executed for the second start of the second start of the start | runs 1 ged part th. M waving cept a f e the su 243 .317 .393 .476 .4399 .331 .234 1, 1942 runs 1 w sligh increas |
| Channel 1E escription of ng green gras te length 28 ve grass; upr spring 1941. pring 1942 and previous tex 1 2 3 4 5 6 7 Channel 2F escription of reen grass w ngth 16 inch rass; upright a spring 1941. pring 1942. | vegetation: ss with 52 inches; con ight at star Grass clin is soil replace sting. 9-3 9-3 9-3 9-3 9-3 9-3 9-3 9-3 9-3 9-3 | i stems per mposition to f testim oped 4 inco- ced where .0158 .0586 .204 .311 .503 .733 1.13 : Good u ms per s .0158 .0586 .204 .311 .503 .733 1.13 : Good u ms per 4 inco- t of testin pped 4 inco- co- t of testin .0240 .0764 | er square 100 percen g. Grass ches above erosion ha 110 279 631 .889 1.13 1.22 1.31 | a stand of foot; aver- at weeping established ground in ad occurred .144 .210 .323 .350 .445 .601 .866 Bed Slo und of long bt; average established e ground in .229 .349 | Hydr and 3 grass of gr the f of th face .0107 .0111 .0131 .0143 .0143 .0143 .0132 .0132 ppe 2.11 Pc Hydr and roug came throu | aulic behav with smoot but surface ass was sul low. Run 7 le taller site of the flow 0 0 10 20 50 80 98 ercent raulic behav 3, water sur h with grass more roug ugh runs 7 t | h surface. e of flow omerged 4 'submerged ms that 1 60 24 24 24 24 20 18 ior: Flow face smoo s waving gh and to 10. 32 24 | v through Runs 4 and remained a oy run 6 w ed all of th remained a .000 .021 .030 .030 .039 .036 .128 Ex v through th. Runs 5 in flow. turbulent | stand for 15 submerg fairly smoo ith grass e grass exe t or above 4.80 4.80 4.80 4.15 3.74 3.25 3.65 4.98 7.07 stand for 5 and 6, flo Surface of as depth 4.88 5.11 | runs 1 ged part oth. M waving cept a f e the su .243 .317 .393 .476 .439 .331 .234 1, 1942 runs 1 pw sligh flow increa: .211 .221 |
| Channel 1E escription of ng green gra te length 28 ve grass; upr spring 1941. ring 1942 and y previous te: 1 2 3 4 5 6 7 Channel 2E escription of reen grass w ngth 16 inch rass; uprigh 1941 ring 1942. 1 2 3 | vegetation: ss with 522 inches; con ight at star Grass clip d soil replace sting. 9-3 9-3 9-3 9-3 9-3 9-3 9-3 9-3 9-3 9-3 | i stems per position to f testim poed 4 incored where | er square 100 percei g. Grass ches above erosion ha 110 279 631 .889 1.13 1.22 1.31 | a stand of foot; aver- nt weeping established ground in ad occurred .144 .210 .323 .350 .445 .601 .866 Bed Slo md of long pt; average eeping love established e ground in .229 .349 .436 | Hydr and 3 grass of gr the f of th face .0107 .0111 .0131 .0143 .0143 .0143 .0143 .0143 .0132 .0132 Hydr and rougi came throu | aulic behav with smoot but surface ass was sul- low. Run 7 le taller site of the flow 0 10 20 50 80 98 rccent raulic behav 3, water sur h with grass more roug ugh runs 7 to 0 0 0 0 0 | h surface. e of flow omerged 4 'submerged 4 'submerged ms that 1 | v through Runs 4 and remained for y run 6 we ed all of the remained a .000 .021 .030 .060 .039 .036 .128 Est w through th. Runs 5 in flow. turbulent | stand for 15 submerginates tairly smoothing rass e grass exection 4.80 4.15 3.74 3.25 3.65 4.98 7.07 cperiment stand for 5 and 6, flo Surface of as depth 4.88 5.11 4.72 | runs 1 ged part oth. M waving 2ept a f 243 317 393 476 439 331 234 1, 1942 runs 1 ow slight flow 1 increas 221 222 272 |
| Channel 1E escription of ng green gras te length 28 ve grass; upr spring 1942 and y previous te: 1 2 3 4 5 6 7 Channel 2E escription of rescription of ress; upright a spring 1941 pring 1942. 1 2 3 4 4 | vegetation: ss with 522 inches; con ight at star Grass clip d soil replaces sting. 9-3 9-3 9-3 9-3 9-3 9-3 9-3 9-3 9-3 9-3 | i stems pr mposition t of testim pped 4 inc ed where 0158 .0586 .204 .311 .503 .733 1.13 : Good u ms per s sition 100 t of testir pped 4 inc .0240 .0764 .171 .437 | er square 100 percei g. Grass thes above erosion he .110 .279 .631 .889 1.13 1.22 1.31 | n stand of foot; aver- nt weeping established ground in ad occurred .144 .210 .323 .350 .445 .601 .866 Bed Slo nd of long ot; average eeping love established ground in .229 .349 .436 .673 | Hydr and 3 grass of gr the f of th face .0107 .0111 .0131 .0143 .0146 .0138 .0132 .0146 .0132 .0146 .0132 .0147 .0147 .0147 .0148 .0132 .0148 .0132 .0148 .0132 .0148 .0132 .0149 .0121 .0211 .0221 .0222 | aulic behav with smoot but surface rass was sul low. Run 7 le taller ste of the flow 0 10 20 50 80 98 ercent raulic behav 3, water sur h with grass more roug ugh runs 7 t 0 0 0 25 | h surface. e of flow omerged 4 ' submerged 4 ' submerged ms that 1 | v through Runs 4 and remained i by run 6 w ed all of th remained a .000 .021 .030 .060 .039 .036 .128 Ex v through th. Runs 5 in flow. turbulent | stand for 1 5 submerg- airly smoothing ith grass e grass exect t or above 4.80 4.15 3.74 3.25 3.65 4.98 7.07 reperiment stand for b and 6, flo Surface of as depth 4.88 5.11 4.72 5.64 | runs 1 ged part tith. M waving cept a f e the su 243 .317 .393 .476 .439 .331 .234 1, 1942 runs 1 bw sligh flow increa: .21: .221 .221 .221 |
| Channel 1E escription of ng green gra- te length 28 ve grass; upr spring 1941. ring 1942 and previous te: 1 2 3 4 5 6 7 Channel 21 escription of reen grass w ngth 16 inch ass; uprigh 1941 ring 1942. 1 2 3 | vegetation: ss with 522 inches; con ight at star Grass clip d soil replace sting. 9-3 9-3 9-3 9-3 9-3 9-3 9-3 9-3 9-3 9-3 | i stems per position to f testim poed 4 incored where | er square 100 percei g. Grass ches above erosion ha 110 279 631 .889 1.13 1.22 1.31 | a stand of foot; aver- nt weeping established ground in ad occurred .144 .210 .323 .350 .445 .601 .866 Bed Slo md of long pt; average eeping love established e ground in .229 .349 .436 | Hydr and 3 grass of gr the f of th face .0107 .0111 .0143 .0146 .0138 .0132 .0146 .0138 .0132 .0146 .0138 .0132 .0146 .0132 .0146 .0132 .0121 .0211 .0221 .0222 .0225 | aulic behav with smoot but surface ass was sul- low. Run 7 le taller site of the flow 0 10 20 50 80 98 rccent raulic behav 3, water sur h with grass more roug ugh runs 7 to 0 0 0 0 0 | h surface. e of flow omerged 4 'submerged 4 'submerged ms that 1 | v through Runs 4 and remained for y run 6 we ed all of the remained a .000 .021 .030 .060 .039 .036 .128 Est w through th. Runs 5 in flow. turbulent | stand for 1 5 submerg airly smoo ith grass e grass exc t or above 4.80 4.15 3.74 3.25 3.65 4.98 7.07 cperiment stand for 5 and 6, flo Surface of as depth 4.88 5.11 4.72 5.64 7.00 | runs 1 ged part th. M waving cept a f the st 243 .317 .393 .476 .435 .331 .234 1, 1942 runs 1 bw slight flow increa .211 .227 .244 .201 |
| Channel 1E escription of ng green grave te length 28 ve grass; upr spring 1942 and y previous te: 1 2 3 4 5 6 7 Channel 22 escription of reen grass w ngth 16 inch ass; uprigh 16 inch aspring 1942. 1 2 3 4 5 6 7 | vegetation: ss with 52t inches; con ight at star Grass clij d soil replac sting. 9-3 9-3 9-3 9-3 9-3 9-3 9-3 9-3 9-3 9-3 | 5 stems pr mposition t of testim pped 4 inc ced where 0158 0586 204 .311 .503 .733 1.13 : Good u ms per s ition 100 t of testim pped 4 inc .0240 .0764 .171 .437 .632 | er square 100 percen g. Grass ches above erosion ha erosion ha 110 279 631 .889 1.13 1.22 1.31 | n stand of foot; aver- nt weeping established ground in ad occurred .144 .210 .323 .350 .445 .601 .866 Bed Slo md of long pt; average eeping love established ground in .229 .349 .436 .673 .884 | Hydr and 3 grass of gr the f of th face .0107 .0111 .0131 .0143 .0146 .0138 .0132 .0146 .0132 .0146 .0132 .0147 .0147 .0147 .0148 .0132 .0148 .0132 .0148 .0132 .0148 .0132 .0149 .0121 .0211 .0221 .0222 | aulic behav with smoot but surface rass was sul low. Run 7 te taller ste of the flow 0 10 20 50 80 98 ercent raulic behav 3, water sur h with grass more roug ugh runs 7 to 0 0 0 25 50 | h surface. e of flow omerged 4 'submerged ms that 1 | v through Runs 4 and remained i by run 6 w ed all of th remained a .000 .021 .030 .030 .039 .036 .128 Ex v through th. Runs 5 in flow. turbulent | stand for 1 5 submerg- airly smoothing ith grass e grass exect t or above 4.80 4.15 3.74 3.25 3.65 4.98 7.07 reperiment stand for b and 6, flo Surface of as depth 4.88 5.11 4.72 5.64 | runs 1 ged part tith. M waving cept a f e the si 243 .317 .393 .476 .435 .331 .234 1, 1942 runs 1 bw sligh flow increa .21: .227 .247 |
| Channel 1E escription of ng green gra- te length 28 ve grass; upr spring 1942 and previous tex 1 2 3 4 5 6 7 Channel 2F escription of reen grass w ngth 16 inch ass; upright 1 pring 1942. 1 2 3 4 5 6 7 8 | vegetation: ss with 522 inches; con ight at star Grass clip d soil replaces sting. 9-3 9-3 9-3 9-3 9-3 9-3 9-3 9-3 9-3 9-3 | 5 stems per mposition t of testim oped 4 inc. ced where .0158 .0586 .204 .311 .503 .733 .1.13 | er square 100 percei g. Grass ches above erosion ha 110 279 631 .889 1.13 1.22 1.31 miform sta square for percent w ng. Grass ches above .105 .219 .398 .650 .715 .766 .811 .850 | a stand of foot; aver- nt weeping established ground in ad occurred .144 .210 .323 .350 .445 .601 .866 Bed Sla ind of long pt; average eeping love established e ground in .229 .349 .436 .673 .884 1.19 1.42 1.61 | Hydr and 3 grass of gr the f of th face .0107 .0111 .0131 .0143 .0143 .0143 .0143 .0143 .0143 .0143 .0132 Ppe 2.11 Pc Hydr and rougi came throw .0211 .0216 .0221 .0225 .0226 .0226 | aulic behav with smoot but surface ass was sul- low. Run 7 le taller site of the flow 0 10 20 50 80 98 rccent aulic behav 3, water sur h with grass more roug ugh runs 7 t 0 0 0 0 0 0 0 0 0 50 80 98 rccent | h surface. e of flow omerged 4 'submerged ms that 1 60 24 24 24 24 24 20 18 rior: Floy face smoo s waving gh and to 10. 32 24 22 20 14 17 17 24 | v through Runs 4 and remained i by run 6 w ed all of th remained a .000 .021 .030 .039 .036 .128 Ex v through th. Runs 5 in flow. turbulent .000 .000 .000 .000 .000 .000 .000 .0 | stand for 15 submerging 15 submerging 15 submerging 15 submerging 16 submerging 17 stands 18 stand for 19 stand for 10 surface of 18 stand for 19 stand for 10 surface of 18 stand for 19 stand for 10 stand for 1 | runs 1 ged par oth. M waving cept a f e the su 243 337 393 476 438 331 234 1, 1942 runs 1 pw slight flow increa 222 277 .244 200 .15 |
| Channel 1E escription of ng green grave te length 28 ve grass; upr spring 1942 and y previous te: 1 2 3 4 5 6 7 Channel 22 escription of reen grass w ngth 16 inch ass; uprigh 16 inch aspring 1942. 1 2 3 4 5 6 7 | vegetation: ss with 522 inches; con ight at star Grass clil i soil replace sting. 9-3 9-3 9-3 9-3 9-3 9-3 9-3 9-3 9-3 9-3 | 5 stems per mposition t of testim oped 4 inc. .0158 .0586 | er square 100 percen g. Grass ches above erosion ha 110 279 631 .889 1.13 1.22 1.31 niform sta square for percent w I. Grass ches above .105 .219 .398 .650 .715 .766 .811 | a stand of foot; aver- nt weeping established ground in ad occurred .144 .210 .323 .350 .445 .601 .866 Bed Slo und of long bt; average established ground in .229 .349 .436 .673 .884 .1.19 1.42 | Hydr and 3 grass of gr the f of th face .0107 .0111 .0131 .0143 .0143 .0143 .0143 .0143 .0132 pe 2.11 Pc Hydr and roug came throw .0211 .0216 .0221 .0225 .0226 | aulic behav with smoot but surface ass was sul low. Run 7 le taller site of the flow 0 10 20 50 80 98 rccent raulic behav 3, water sur h with gras more roug ugh runs 7 to 0 0 25 50 80 95 | h surface. e of flow omerged 4 'submerged ms that 1 60 24 24 24 24 24 20 18 rior: Flow face smoo s waving ch and .o 10. 32 24 24 22 20 18 32 24 22 20 14 17 17 | v through Runs 4 and remained a oy run 6 w ed all of th remained a .000 .021 .030 .060 .039 .036 .128 Ex v through th. Runs 5 in flow. turbulent .000 .000 .000 .000 .000 .000 .000 .0 | stand for 15 submerging tairly smoothing tairly smoothing tairly smoothing tairly smoothing e grass exect 4.80 4.15 3.74 3.25 3.65 4.98 7.07 stand for 5 and 6, flow Surface of as depthing 4.88 5.11 4.72 5.64 7.00 9.10 10.5 | runs 1 ged par oth. M waving cept a f e the su 243 317 .393 .476 .438 .337 .234 1, 1942 runs 1 pw sligh flow increa .21 .222 .277 .244 .20 .15 .13 |

green grass with 4.2 cubic inches of forage per square foot; average length 12.8 inches; composition 100 percent love grass; upright at start of testing. Grass established by seed in spring 1941.

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Hydraulic behavior: Flow through and around grass for runs 1 through 4. Stream formed down center of channel for runs 5 and 6 and all of grass under flow for runs 8 and 9 but grass waving in the flow. Runs 10 through 13 pressed the grass fairly well down with the surface of the flow increasing in roughness with each run. Runs 12 and 13 caused some erosion between bunches of grass.

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| | | | | · · | | | | | Coeffi | cients |
|--|---------------------------------------|---------------------------------------|--------------------------|---------------------------|--|--|--|---|---|--|
| × . | | Discharge per foot of width, VD | A | ty. V | Bifecti ve slope | Vegetation | Duration of flow | arte scour | 0 | a ,8a |
| Run | Dete | sch dth | Depth, | Mean velocity, | feet | bme | 19 19 | 18 39 19 19 | Cheay, | Manning, |
| | | | | | | | | ₹Å. | 6 | Wa |
| 1 | 2 | 8 | 4 | | 6 | 7 | 8 | 9 | 10 | 11 |
| | | Cu. ft. per sec. | Feet | Ft. per sec | Ft. per ft. | Percent | Min. | In. per hr. | | |
| ` 1 | 8-28 | .0205 | .073 | .281 | .0390 | 0 | 30 | .000 | 5.25 | .183 |
| 2 | 8-28 | .105 | .190 | .553 | .0393 | 0 | 17 | .000 | 6.40 | .176 |
| 3 4 | 8-28 8-28 | .158 .315 | .272 .393 | .58 3 .801 | .0396 .0402 | 0 10 | 10 10 | .049 .000 | 5.64 6.40 | .213 .201 |
| 5 | 8-28 | .467 | .441 | 1.06 | .0399 | 50 | 10 | .000 | 8.01 | .163 |
| 6 | 8-28 | .584 | .471 | 1,24 | .0401 | 75 | 10 | .070 | 9.07 | .146 |
| • 7 | 8-28 | .816 | .510 | 1.60 | .0401 | 98 | 10 | .000 | 11.3 | .119 |
| 8 | 8-29 | 1.39 | .572 | 2.43 | .0394 | 100 | 11 | .000 | 16.2 | .083 |
| 9 | 8-29 | 1.79 | .631 | 2.84 | .0394 | 100 | 10 | .070 | 18.1 | .076 |
| 10 | 8-29 | 2.72 | .733 | 3.71 | .0393 | 100 | 10 | .070 | 21.9 | .064 |
| 11 | 8-29 | 3.90 | .847 | 4.60 | .0388 | 100 | 21 | .110 | 25,4 | .057 |
| 12 | 8-29 | 5.13 | .941 | 5.45 | 0388 | 100 | 23 | .133 | 28.5 | .051 |
| 13 | 8-29 | 5.92 | .981 | 6.04 | 0387 | 100 | 120 | .048 | 31.0 | 047 |
| Channel 4C | | | | Bed Slop | e 3.87 Pe | rcent | | J | Sxperiment | 2, 1942 |
| escription of | | | | | Hydr | aulic beha | vior: Flo | w through | n stand fo | r runs |
| reen grass wi | | | | | | d 3, surfac | | | | |
| ngth 11 incl | nes; com | position 10 | o percen | t weeping | grass | waving in | n flow, s | urface fai | rly rough. | Runs |
| ve grass: upr | ight at ti | he start of | testing. | Grass es- | 9 an | d 10, surfa | ce of flow | w increase | d in rough | ness wi |
| blished in spi | ing 1941. | Grass clip | pped 4 ind | ches above | | increase in | | | | |
| round in sprin | ng 1942 a | nd soil rep | laced wh | en erosion | | | - | | | - |
| ad occurred b | | | | | | | | | | |
| 1 | 9-5 | .0280 | .074 | .378 | .0387 | 0 | 22 | .000 | 7.08 | .138 |
| 2 | 9-5 | .0924 | .167 | 553 | .0393 | Õ | 22. | .000 | 6.83 | .163 |
| 3 | 8-5 | .202 | .296 | .682 | .0401 | 10 | 20 | .018 | 6.33 | .197 |
| 4 | 9-5 | .492 | .451 | 1.09 | .0407 | 30 | 20 | .036 | 8.16 | .164 |
| 5 | 9-5 | .850 | .528 | 1.61 | .0405 | 60 | 19 | .019 | .11.1 | .123 |
| 6 | 9-5 | 1.16 | .577 | 2.02 | .0402 | 90 | 18 | .040 | 13.3 | .104 |
| 7 | 9-5 | 1.47 | .621 | 2.37 | .0398 | 100 | 15 | .000 | 15.1 | .091 |
| 8 | 9-5 | 1.82 | .661 | 2.75 | .0398 | 100 | 18 | .028 | 17.0 | .0820 |
| 9 | 9-5 | 3.14 | .794 | 3.96 | .0396 | 100 | 14 | .000 | 22.4 | .064 |
| 10 | 9-5 - | 6.05 | 1.04 | . 5.82 | .0387 | 100 | 23 | .016 | 29.0 | .051 |
| Channel 7F | | | | Bed Slop | e 7.04 Pe | ercent | | E | xperiment : | l, 1941 |
| escription of reen grass wit oot; average le ove grass; upri y seed in sprin | h 6.3 cub ngth 12.6 ght at star | ic inches o inches; con | f forage ; position 1 | per square 100 percent | 1, 2 a of ch runs flow wavin still grass | aulic behav nd 3 but hi annel. Str 4, 5 and 6 for run 7, ng in flow. standing in below surf ity for runs | ghest velo eam form with a few surface o Runs 8 the flow ace of flow | city appear ed down of w bunches of the flow and 9, all v. Runs 10 w with app | red to be do enter of ch remaining v smooth v grass subm 0, 11 and 1 | wn cent annel fo above th vith gra- erged bi 2 presse |
| 1 | 8-27 | .0178 | .061 | .292 | .0705 | 0 | 22 | .000 | 4.47 | .210 |
| 2 | 8-27 | .0350 | .102 | .343 | .0707 | Ō | 16 | .000 | 4.03 | 254 |
| 3 | 8-27 | .113 | .207 | .546 | .0713 | 10 | 26 | .033 | 4.52 | .256 |
| - 4 | 8-27 | .186 | .254 | .734 | .0711 | 40 | 12 | .000 | 5.46 | .217 |
| 5. | 8-27 | .317 | .330 | .960 | .0710 | 60 | 9 | .120 | 6.26 | .198 |
| 6 | 8-27 | .504 | .385 | 1.31 | .0717 | 75 | 12 | .162 | 7.92 | .161 |
| 7 | 8-27 | .745 | .416 | 1.79 | .0715 | 95 | 10 | .049 | 10.4 | .124 |
| 8 | 8-27 | .870 | .465 | 1.87 | .0714 | 100 | 9 | .096 | 10.3 | .128 |
| 9 | 8-27 | 1.56 | .492 | 3.16 | .0713 | 100 | 9 | .256 | 17.0 | .0779 |
| 10 | 8-27 | 2.18 | .588 | 3.71 | .0708 | 100 | 22 | .152 | 18.2 | .0750 |
| 11 | 8-27 | 3.75 | .713 | 5.26 | .0710 | 100 | . 23 | .196 | 23.4 | .0601 |
| 12 | 8-27 | 6.96 | .939 | 7.41 | .0690 | 100 | 26 | .265 | 29.2 | .0506 |
| Channel 100 | y . | | | Bed Slop | e 10.1 Pe | | | | periment 1 | <u> </u> |
| escription of ong green gra quare foot; av | ss with 8 erage leng | 1.4 cubic ir th 11.4 incl | iches of t nes; comp | forage per | throu cente | aulic behav gh 4 with r line wher l down cen | very little e stand i | e effect or s thin. R | grass exc uns 5 and | ept alon 6. streau |

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Table 7.—Results of Tests of Channels Lined with Weeping Lovegrass.—(Continued)

| Channel 10 | C, cont. | | | | | | | | Coeffic | lents |
|------------|----------|---------------------------------------|----------|---------------------|--------------------|---------------------------|---------------------|----------------------|-----------|------------|
| Run | Date | Discharge per foot of width, VD | Depth, D | Mean velocity, V | Effective slope | Vegetation submergence | Duration of flow | AV. rate of scour | Chery, C. | Manning, n |
| . 1 | 2 | 3 | 4 | | Ft. per | 7 | 8 | 9 | 10 | 11 |
| | | Ou. ft. per sec. | Peet | Ft. per sec. | ít. Ø | Percent | Min, | In. per hr. | | |
| 1 | 8-26 | .0144 | .042 | .344 | .101 | 0 | 25 | .000 | 5.31 | .167 |
| 2 | 8-26 | .0019 | .100 | .619 | .102 | 0 | 12 | .102 | 6.16 | .167 |
| 3 | 8-26 | .195 | .215 | .906 | .103 | 0 | 12 | .162 | 6.16 | .191 |
| 4 | 8-26 | .293 | .274 | 1.07 | .103 | 10 | 11 | .067 | 6.45 | .190 |
| 5 | 8-26 | .411 | .314 | 1.31 | .103 | 25 | 12 | .090 | 7.34 | .170 |
| 6 | 8-26 | .534 | .366 | 1.46 | .103 | 75 | 10 | .247 | 7.58 | .168 |
| 7 | 8-26 | .657 | .391 | 1.68 | .102 | 90 | 10 | .070 | 8.41 | .152 |
| 8 | 8-26 | .895 | .426 | 2.10 | .102 | 98 | 9 | .136 | 10,1 | .129 |
| 9 | 8-28 | 1.19 | .465 | 2.56 | .102 | 100 | 11 | .233 | 11.8 | .112 |
| 10 | 8-26 | 3.90 | .704 | 5.54 | .101 | 100 | 25 | .348 | 20.8 | .0676 |
| 11 | 8-26 | 7.48 | .895 | 8.36 | .0989 | 100 | 30 | .269 | 28.1 | .0519 |

Table 7.—Results of Tests of Channels Lined with Weeping Lovegrass.—(Continued)

Description of vegetation: Fair uniform stand of long green grass with 333 stems per square foot; average length 12.3 inches; composition 100 percent weeping love grass; upright at start of testing. Grass established in spring of 1941. Grass clipped 4 inches above ground in spring 1942 and soil replaced where erosion had occurred by previous testing.

Hydraulic behavior: Flow through grass with smooth surface for runs 1, 2 and 3. Grass bending under flow for runs 4, 5, 6 and 7, and waving in current. Run 8 most of grass submerged but waving in flow causing rough surface. Runs 9 and 10 very rough surface.

| 1 | 9-8 | .0212 | .063 | .336 | .0987 | 0 | | 55 | .000 | 4.28 | .222 |
|----|------|-------|------|------|-------|-----|---|-----|------|------|------|
| 2 | 9-8 | .0694 | .141 | .492 | .0989 | 0 | | 23 | .032 | 4.17 | .257 |
| 3 | 9-8 | .132 | .208 | .637 | .0990 | 0 | | 20 | .062 | 4.44 | .258 |
| 4 | 9-8 | .289 | .331 | .874 | .0987 | 20 | | 19 | .026 | 4.84 | .256 |
| 5 | 9-8 | .476 | .421 | 1.13 | .0985 | 40 | | 14 | .052 | 5.57 | .232 |
| 6 | 9-18 | .720 | .483 | 1.49 | .0982 | 50 | | 18 | .020 | 6.87 | .194 |
| 7 | 9-8 | .985 | .524 | 1.88 | .0978 | 70 | | 11- | .067 | 8.32 | .162 |
| 8 | 9-8 | 1.32 | .550 | 2.40 | .0983 | 90 | | 33 | .037 | 10.4 | .131 |
| 9 | 9-8 | 5.12 | .843 | 6.08 | .0987 | 98 | 1 | 29 | .055 | 21.1 | .068 |
| 10 | 9-8 | 10.8 | 1.12 | 9.64 | .0978 | 100 | | 41 | .115 | 29.3 | .051 |

NATIVE GRASS MIXTURE

Table 8.—Results of Tests of Channels Lined with a Native Grass Mixture.

| Channel 1 | D | | | Bed Slop | e 0.87 Per | 0.87 Percent | | | Experiment 1, 1943 | | |
|---|---|--------------------------------|---|------------------------------|----------------------------------|-------------------|----------------------|----------------------|----------------------|----------------------------------|--|
| Description of vegetation: Good stand of tall and short rrasses, uncut with 147 stems per square foot; the ong grasses averaged 26.7 inches in length with 97 tems per square foot. Composition 66 percent tall rrasses, 34 percent crab and grama grasses; upright at tart of testing. Channel established from seed in pring 1942. Tall grasses cut in spring 1943. | | | | | | | | | | as largely 5 and grass sub | |
| | | | | seed in | sugni | lly rough | L. | | | | |
| | | | | .219 | | uy rougn | 80 | .000 | 5.71 | | |
| | Tall grasses | s cut in spr | ing 1943. | | | lly rougn | | .000 | | _200 _218 | |
| | Tall grasses 9-7 | ; cut in spr .0366 | ing 1943. .167 | .219 | .0095 | 11y rougn | 80 | | 5.71 5.71 5.16 | .218 | |
| | Tall grasses 9-7 9-7 | .0366 .0876 | ing 1943. .167 .293 | .219 .299 | .0095 | 0 | 80 30 | .029 .060 | 5.71 5.16 | .218 .265 | |
| | Tall grasses 9-7 9-7 9-7 9-7 | .0366 .0876 .153 | ing 1943. .167 .293 .447 | .219 .299 .342 | .0095 .0100 .0107 | 0 | 80 30 30 | .029 | 5.71 | .218 .265 .220 | |
| | Tall grasses 9-7 9-7 9-7 9-7 9-7 | .0366 .0876 .153 .309 | ing 1943. .167 .293 .447 .600 | .219 .299 .342 .515 | .0095 .0100 .0107 .0112 | 0 0 0 20 | 80 30 30 36 | .029 .060 .040 | 5.71 5.16 6.59 | · .218 .265 | |

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Tests on Vegetated Waterways, and Application

| Channel 4D | | | | Bed Slope | 3.85 Perc | ent | | Ex | periment | 1, 1943 |
|--|--|--|---|--|------------------------|---|-------------------------------------|----------------------------------|-------------------------------------|-------------------------------------|
| | | | | | | | | <u>_`</u> | Coeffi | cients |
| | | , S G S G | | 4 | | 3 | | - | | ra R |
| | | 40.18 | A | ห้ | Ø. | | 5 a | rate | Ð | ä |
| a | ę | ⁸ 84 | đ | 1 2 | 2 ECF | E E | 끓음 | # <u>8</u> | ĥ | i a |
| Run | Date | Discharge per foot o width, VD | Depth, | Mean velocity, | Effective slope | Vegetation submergence | Duration of flow | Å, | Chesy, | Manning, |
| 1 | 2 | 3 | 4 | 6 | 8 | 7 | 8 | 9 | 10 | 31 |
| | | Ou. ft. per sec. | Feet | Ft. per sec. | Ft. per ft. | Percent | Min. | In. per hr, | | |
| Description of grasses, green, Fhe tall grasse is stems per tall grasses, 57 at start of te spring 1942. Ta | uncut wi es average square percent c sting. Of | ith 115 ster ed 19.5 inc foot. Comp rab and gra- nannel esta | ms per so hes in le position é uma grasse blished b | uare foot. ength with 43 percent es; upright | 2 and and 5 Runs | ilic behavi 3 with su was rough 6 and 7 submerged | rface fair with sti were very | ly smooth If grass v rough | L. Flow f vaving in with prac | or runs (the flow tically al |
| | | .0609 | .183 | .333 | .0375 | 0 | 60 | .000 | 4.05 | .281 |
| 1 | 9-11 9-11 | .0009 | .185 | .457 | .0368 | 0 | 20 | .000 | 3.83 | .337 |
| 2 | 9-11 | .365 | .542 | .674 | .0368 | 10 | 20 | .000 | 3.83 4.79 | .337 |
| 3 | | | | | .0379 | 40 | 21 | | | |
| 4 | 9-11 | .815 1.64 | .668 | 1.22 2.09 | .0374 | 60 | 13 | .017 .093 | 7.73 | .180 |
| 5 | 9-11 | | .783 | | | | | | 12.2 | .117 |
| 6 7 | 9-11 9-11 | 3,22 6,23 | .900 1.10 | 3.58 5.66 | .0376 .0381 | 90 95 | 15 19 | .082 .101 | 19.5 27.6 | .0750 .05 47 |
| Channel 7B | | | · · | Bed Slope | 7.14 Perc | ent | | Ex | periment | |
| Description of grasses, green, The tall grasse stems per squ grasses, 36 pero start of testing 1942 and tall g | uncut wi s averaged are foot. cent crab , Channe | th 151 ster d 30.5 inche Compositi and grama el establishe | ms per se es in leng on 64 pe grasses; ed by seed | quare foot. th with 97 ercent tall upright at | and 3 slightly | ulic behavi with fairly rough fo bugh for ru | y smooth r runs 4 | surface. and 5, ro | Surface | of flow |
| 1 | 9-10 | .0376 | .113 | .333 | .0717 | 0 | 50 | .000 | 3.76 | .287 |
| 2 | 9–10 | .134 | .232 | .580 | .0716 | 0 | 29 | .067 | 4.52 | .260 |
| 3 | 9-10 | .265 | .341 | .777 | .0713 | 20 | 23 | .189 | 5.00 | .249 |
| 4 ` | 9-10 | .495 | .438 | 1.13 | .0713 | 30 | 37 | .043 | 6.40 | .203 |
| | 9-10 | 1.11 | .598 | 1.86 | .0721 | 50 | 27 | .112 | 8.99 | .153 |
| 5 | | | | | | | 01. | 050 | 140 | |
| 5 6 | 9-10 | 2.34 | .721 | 3.24 | .0716 | 80 | 31 ' | .058 | 14.3 | .0985 |
| | 9-10 9-10 | 2.34 4.22 | .721 .891 | 3.24 4.74 | .0716 0718 | 80 100 | 31 24 | .058 | 14.3 | .0985 .0777 |

Table 8.—Results of Tests of Channels Lined with a Native Grass Mixture.—(Continued)