GUIDE

FOR

SELECTING ROUGHNESS COEFFICIENT

"n" VALUES FOR CHANNELS

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The purpose of this group of pictures, selected from Technical Bulletin No. 129, "Flow of Water in Drainage Channels" by C. E. Ramser, is to illustrate the wide range of the roughness coefficient "n" of Manning's formula for channel valocities related to actual channel conditions. Study of the pictures and information shown should assist in selecting realistic values of "n" for both present and future constructed channels.

The pictures usually were taken when the channels were at low flows so that the channel condition could be seen.

The tables show several measured values for the channels at different depths of flow. In most cases the pictures were not taken at the same time of the measurements.

The "n" values shown in the tables under the pictures were calculated by using the measured values of slope, hydraulic radius, and discharge in the Kutter formula for velocity. The calculated "n" values would have been slightly less had the measured values been substituted in the Manning formula. Many engineers use the same "n" value of either formula.

When the hydraulic radius "r" is 3.28, the same "n" value used in the two formulae will give the same value for the velocity. When "r" is less than 3.28, the velocity calculated by the Manning formula will be slightly greater than if calculated by the Kutter formula. When "r" is greater than 3.28, the velocity calculated by the Manning formula will be slightly less than if calculated by the Kutter formula.

For all practical purposes, the "n" values calculated by Kutter's formula may be considered to be the same for Manning's formula.

The velocity determined by Manning's formula varies inversely as the value of "n". This factor affects the velocity more than any other factor and its value depends entirely upon channel characteristics which are evaluated generally only by observation. Therefore, it is important that the observers who select these factors have some basis for evaluation. These pictures should aid in making a selection of the "n" value.

The following should be considered carefully in estimating the value of "n" for a channel:

1. The material through which the channel will be constructed, such as earth, rock, gravel, etc.

2. Surface irregularity of the sides and bottom of the channel.

3. Variations of successive cross sections in size and shape.

4. Obstructions which may remain in the channel and affect the channel flow.

5. Vegetation effects should be carefully assessed.

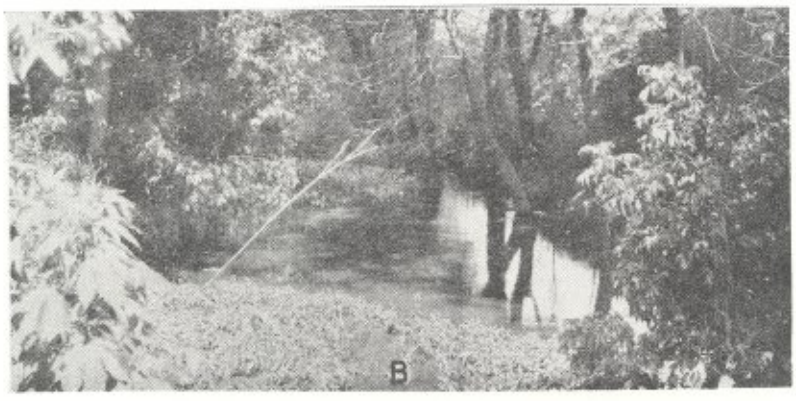
6. Channel meandering must also be considered.

For a discussion of the above points, please refer to Supplement B of the Engineering Handbook - Hydraulics - Section 5, attached.

Kaskaskia Mutual Dredged Channel near Bondville, Illinois. Approximate bottom width 10 feet. Picture taken April 1925.

Date of observation	Average maximum depth	Average surface width	Discharge	Average cross section	Mean velocity	Mean hydraulic radius	Slope of water surface	Coefficient of roughness n	Description of channel
Feb. 7, 1925	2.1	16.5	21.9	24.6	0.89	1.36	0.000473	0.040	*Course*, straight; 330 feet long. *Cross section*, some variation in shape; for variation in size, see Figure 20, G. *Side slopes*, rather irregular. *Bottom*, rather irregular. *Soil*, lower part, black clay; upper part, dark-gray silty clay loam. *Condition*, badly obstructed by trees 1 to 6 inches in diameter on side slopes and edges of bottom; some weeds but practically no grass; no foliage. *Constructed*, 1902; cleared, about 1910. (Pl. 27, C and fig. 19, G.)
Mar. 16, 1925	3.0	18.9	45.5	39.6	1.15	1.89	.000424	.039	
Mar. 29, 1924	5.3	27.6	106.7	92.8	1.15	3.00	.000367	.051	
Feb. 25, 1926	5.7	29.6	100.7	105.7	.95	3.19	.000394	.067	
Aug. 24, 1924	4.1	23.0	67.1	64.0	1.05	2.50	0.000494	0.056	*Condition*, as described above, but with summer foliage, and water weed on bottom along one-tenth of course.
June 6, 1924	4.4	24.1	72.2	71.9	1.00	2.66	.000409	.056	
do	5.0	26.8	85.6	88.1	.97	2.95	.000373	.060	
Aug. 21, 1924	6.1	30.9	120.4	116.6	1.03	3.36	.000427	.067	
Aug. 20, 1924	8.4	41.0	206.1	200.3	1.03	4.35	.000536	.094	

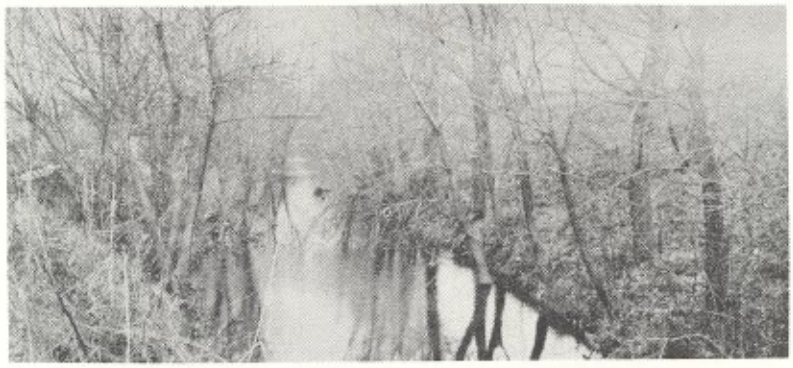
Kaskaskia Mutual Dredged Channel near Bondville, Illinois. Approximate bottom width 10 feet. Picture taken July 1927.



Date of observation	Average maximum depth	Average surface width	Discharge	Average cross section	Mean velocity	Mean hydraulic radius	Slope of water surface	Coefficient of roughness n	Description of channel
Sept. 28, 1926	4.3	23.8	48.0	68.8	0.70	2.58	0.000645	0.097	*Course*, nearly straight; 330 feet long. *Cross section*, some variation in shape; for variation in size, see Figure 20, F. *Side slopes*, irregular. *Bottom*, irregular. *Soil*, lower part, black clay; upper part, dark-gray silty clay loam. *Condition*, badly obstructed by trees 2 to 12 inches in diameter covering side slopes, except intervals aggregating half length of right bank occupied by large weeds and bushy willows; no foliage. *Constructed*, 1902; cleared, about 1910.
Sept. 9, 1926	7.5	34.3	111.5	157.8	.71	4.05	.000388	.110	
Oct. 2, 1926	8.0	36.6	132.3	176.4	.75	4.24	.000409	.111	
do	8.6	40.0	160.6	200.9	.80	4.43	.000421	.109	
	[1] 9.0								*Condition*, as in summer of 1924, but worse. (Pl. 27, B.)

[1] Average maximum depth at bankful stage.

Kaskaskia Mutual Dredged Channel near Bondville, Illinois. Approximate bottom width 10 feet. Picture taken April 1925.



Date of observation	Average maximum depth	Average surface width	Discharge	Average cross section	Mean velocity	Mean hydraulic radius	Slope of water surface	Coefficient of roughness n	Description of channel
Feb. 7, 1925	2.4	18.1	21.9	29.8	0.73	1.50	0.000527	0.064	*Course*, nearly straight; 330 feet long. *Cross section*, some variation in shape; for variation in size, see Figure 20, F. *Side slopes*, irregular. *Bottom*, irregular. *Soil*, lower part, black clay; upper part, dark-gray silty clay loam. *Condition*, badly obstructed by trees 2 to 12 inches in diameter covering side slopes, except intervals aggregating half length of right bank occupied by large weeds and bushy willows; no foliage. *Constructed*, 1902; cleared, about 1910. (Pl. 27, A and fig. 19, F.)
Mar. 16, 1925	3.3	19.8	45.5	46.1	.99	2.09	.000503	.052	
Feb. 25, 1926	6.1	29.3	100.7	114.5	.88	3.44	.000397	.077	
Aug. 8, 1924	4.4	24.0	67.1	71.0	0.95	2.60	0.000591	0.070	*Condition*, as described above, but with summer foliage, and three-fourths of length of bottom covered with short weeds.
June 6, 1924	4.8	25.1	72.2	79.9	.90	2.82	.000500	.072	
do	5.4	26.9	85.6	96.5	.89	3.15	.000424	.074	
Aug. 21, 1924	6.4	30.5	120.4	124.8	.96	3.60	.000473	.080	
Aug. 20, 1924	8.8	40.8	206.1	207.4	.99	4.49	.000503	.097	

Old Town Creek Dredged Channel near Tupelo, Mississippi. Approximate bottom width 10 feet. Picture taken 1914.

Date of observation	Average maximum depth	Average surface width	Discharge	Average cross section	Mean velocity	Mean hydraulic radius	Slope of water surface	Coefficient of roughness n	Description of channel
Mar. 5, 1914	4.0	19.5	45.0	50.0	0.90	2.28	0.000358	0.052	*Course*, straight; 1,224 feet long. *Cross section*, slight and gradual variations in shape; for variation in size, see fig. 2, A. *Side slopes*, right side irregular, left side very irregular. *Bottom*, irregular and uneven. *Soil*, varies from black waxy clay at top to yellow clay at bottom. *Condition*, right side slope and part of bottom practically covered with small saplings, brush, and cane; occasional growths of vegetation on other side slopes. *Constructed*, Dec. 1907.
Mar. 20, 1914	4.3	20.0	59.7	58.0	1.03	2.43	.000350	.047	
Apr. 17, 1914	4.65	21.0	77.9	60.4	1.29	2.55	.000377	.041	
Apr. 9, 1914	5.3	22.2	105.4	74.2	1.42	2.85	.000292	.035	
Apr. 3, 1914	5.4	23.0	120.0	80.0	1.50	2.90	.000312	.035	
Apr. 13, 1914	6.6	26.4	185.1	107.0	1.73	3.37	.000271	.032	
Mar. 26, 1914	6.7	26.5	218.2	110.2	1.98	3.42	.000305	.030	
Mar. 12, 1914	7.1	27.5	240.0	120.0	2.00	3.53	.000290	.029	
Mar. 26, 1914	7.1	27.6	242.4	120.0	2.02	3.58	.000279	.029	
do	7.4	28.0	260.4	127.0	2.05	3.69	.000267	.029	
Apr. 13, 1914	8.1	29.8	310.2	142.3	2.18	3.96	.000271	.028	Description of channel practically the same as the above, except for remarks under *Condition*. *Condition*, all brush, vegetation, and obstructions to flow were cleared from the course of channel and for 500 feet above the upper end of the course, and for the same distance below the lower end. (Pl. 1, B.)
May 5, 1914	11.6	37.5	710.2	265.0	2.68	5.70	.000346	.034	
Mar. 30, 1914	12.4	39.7	815.6	295.5	2.76	5.95	.000268	.030	
May 6, 1914	12.7	41.0	882.2	307.4	2.87	6.05	.000346	.033	
	[1] 13.0								

[1] Average maximum depth at bankful stage.

Mud Creek Dredged Channel near Tupelo, Mississippi. Approximate bottom width 10 feet. Picture taken 1913.

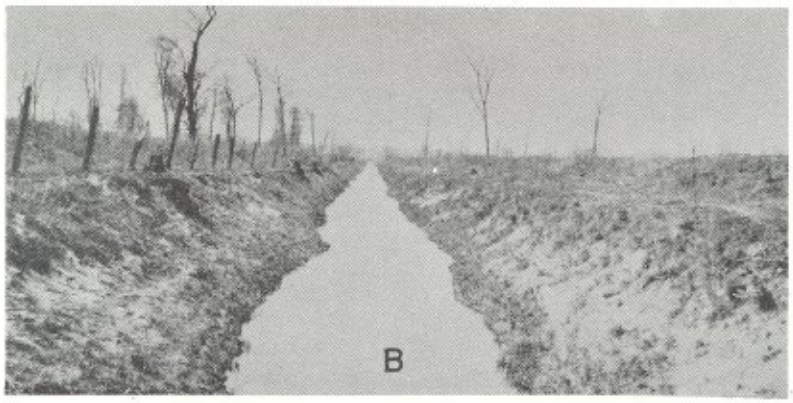
Date of observation	Average maximum depth	Average surface width	Discharge	Average cross section	Mean velocity	Mean hydraulic radius	Slope of water surface	Coefficient of roughness n	Description of channel
Apr. 11, 1914	2.6	18.5	54.8	40.0	1.37	1.8	0.000300	0.027	*Course*, straight; 1,194 feet long. *Cross section*, very little variation in shape; for variation in size see fig. 2, B. *Side slopes*, quite regular. *Bottom*, even and regular. *Soil*, sandy, waxlike clay. *Condition*, newly dredged channel; no vegetation or obstructions of any sort in channel. *Constructed*, January, 1913. (Pl. 1, C and fig. 1, B.)
do	2.8	19.3	61.9	43.0	1.44	1.9	.000305	.027	
Apr. 7, 1914	2.9	19.5	64.8	43.2	1.50	1.9	.000305	.026	
Apr. 9, 1914	3.2	20.5	74.9	47.7	1.57	2.1	.000310	.027	
Apr. 5, 1914	3.8	22.0	115.0	57.5	2.00	2.3	.000301	.022	
Mar. 28, 1914	4.0	22.6	125.0	61.0	2.05	2.5	.000349	.025	
Mar. 26, 1914	4.1	22.8	130.2	62.6	2.08	2.6	.000336	.025	
do	4.9	24.7	192.7	88.0	2.19	2.9	.000321	.025	
Mar. 27, 1914	4.95	24.8	199.1	88.5	2.25	2.9	.000349	.025	
Apr. 8, 1914	5.0	24.9	203.4	90.0	2.26	3.0	.000340	.025	
May 5, 1914	9.9	32.5	762.8	225.0	3.39	5.3	.000364	.026	
Mar. 29, 1914	10.65	34.5	904.0	252.5	3.58	5.6	.000378	.026	
do	10.70	34.5	914.4	254.0	3.60	5.6	.000393	.026	
	[1] 11.50								

[1] Average maximum depth at bankful stage.

Dredged Ditch No. 18 of Cypress Creek Drainage District near Arkansas City, Arkansas. Approximate bottom width 10 feet. Picture taken March 1925.

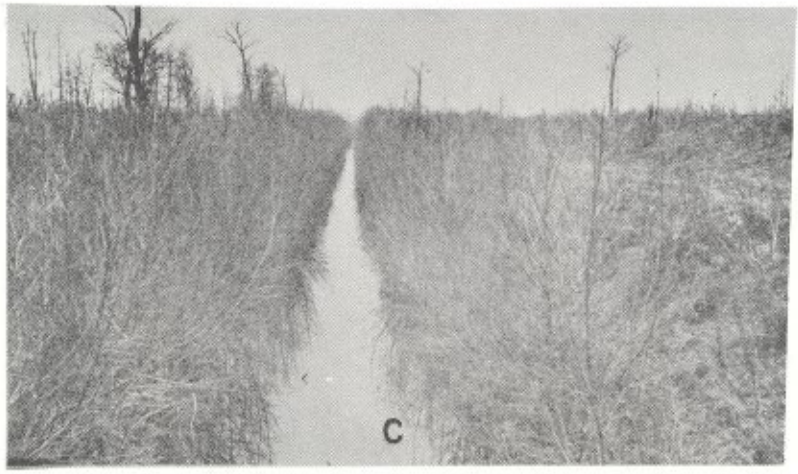
Date of observation	Average maximum depth	Average surface width	Discharge	Average cross section	Mean velocity	Mean hydraulic radius	Slope of water surface	Coefficient of roughness n	Description of channel
Feb. 21, 1925	3.0	22.7	22.0	46.5	0.47	1.91	0.000124	0.049	*Course*, straight; 810 feet long. *Cross section*, quite uniform in shape; for variation in size, see fig. 15, B. *Side slopes*, irregular and uneven. *Bottom*, irregular and uneven. *Soil*, heavy silty clay. *Condition*, practically entire section filled with large sized growth of trees consisting principally of willows and cottonwoods. *Constructed*, June, 1918. (Pl. 17, B and fig. 14, B.)
Mar. 15, 1925	4.5	30.4	55.2	85.0	.65	2.61	.000151	.051	
Feb. 19, 1926	4.7	31.4	61.1	93.0	.66	2.75	.000104	.044	
Mar. 22, 1926	5.5	34.4	86.7	118.0	.73	3.21	.000116	.048	
Jan. 23, 1926	6.5	39.3	125.1	156.7	.80	3.70	.000152	.056	
Jan. 27, 1926	6.7	40.1	108.6	162.5	.67	3.75	.000109	.057	
Mar. 17, 1925	7.8	44.5	230.6	214.5	1.08	4.42	.000317	.060	
Dec. 17, 1925	8.1	45.5	170.7	225.5	.75	4.55	.000179	.077	
Dec. 15, 1925	8.9	48.7	216.4	266.0	.81	4.99	.000290	.099	

Ditch No. 1 of Little River Drainage District near Chaffee, Missouri. Approximate bottom width 10 feet. Picture taken April 1923.



Date of observation	Average maximum depth	Average surface width	Discharge	Average cross section	Mean velocity	Mean hydraulic radius	Slope of water surface	Coefficient of roughness n	Description of channel
Jan. 26, 1923	3.2	17.7	26.6	39.0	0.68	2.00	0.000058	0.025	*Course*, straight; 800 feet long. *Cross section*, very little variation in shape; for variation in size, see figure 18, D. *Side slopes*, quite regular. *Bottom*, fairly regular. *Soil*, dark, heavy, tenacious clay. *Condition*, newly cleared channel, practically no vegetation. *Constructed*, December, 1914. (Pl. 21, B and fig. 17, D.)
Jan. 25, 1923	3.5	18.4	34.9	45.1	.77	2.18	.000070	.026	
Mar. 6, 1923	3.8	19.2	43.9	50.7	.87	2.34	.000086	.027	
Jan. 24, 1923	4.5	21.0	57.9	62.6	.92	2.64	.000080	.027	
Apr. 13, 1923	5.2	23.2	91.6	78.8	1.16	3.01	.000108	.028	
Jan. 23, 1923	5.8	25.2	91.9	93.8	.98	3.28	.000069	.028	
Jan. 31, 1923	6.4	26.7	140.9	107.8	1.31	3.67	.000110	.029	
Mar. 13, 1923	6.8	28.2	148.2	121.6	1.22	3.77	.000096	.029	
Feb. 3, 1923	7.6	30.2	184.2	143.3	1.29	4.06	.000109	.031	
Jan. 22, 1923	7.7	30.4	182.1	146.3	1.24	4.10	.000099	.031	
Mar. 12, 1923	7.8	30.5	220.1	148.2	1.49	4.13	.000144	.031	
Feb. 1, 1923	7.9	30.8	230.8	152.8	1.51	4.21	.000139	.031	
Jan. 21, 1923	8.0	31.0	228.0	155.5	1.47	4.26	.000128	.031	

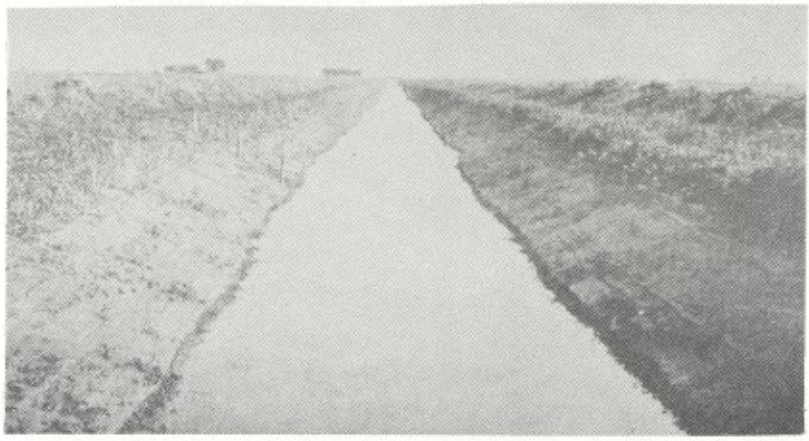
Ditch No. 1 of Little River Drainage District near Chaffee, Missouri. Approximate bottom width 10 feet. Picture taken December 1925.



Date of observation	Average maximum depth	Average surface width	Discharge	Average cross section	Mean velocity	Mean hydraulic radius	Slope of water surface	Coefficient of roughness n	Description of channel
									Course, straight; 800 feet long. *Cross section*, very little variation in shape; for variation in size, see figure 18, D. *Side slopes*, quite regular. *Bottom*, fairly regular. *Soil*, dark, heavy, tenacious clay. *Condition*, newly cleared channel, practically no vegetation. *Constructed*, December, 1914.
Nov. 29, 1925	6.6	27.4	81.7	115.0	0.71	3.66	27.2	0.069	Same channel as above with about 2 years' growth of willows. (Pl. 21, C.)
Nov. 28, 1925	7.4	29.7	99.6	136.5	.73	3.98	26.4	.073	
	[1] 8.0								

[1] Average maximum depth at bankful stage.

Allen Creek Dredged Channel near Missouri Valley, Iowa. Approximate bottom width 15 feet. Picture taken 1917.



Date of observation	Average maximum depth	Average surface width	Discharge	Average cross section	Mean velocity	Mean hydraulic radius	Slope of water surface	Coefficient of roughness n	Description of channel
	Feet	*Feet*	*Second-feet*	*Sq. ft.*	*Ft. per sec.*	*Feet*			
June 4, 1917	7.1	42.3	930.8	196.2	4.74	4.30	0.0002807	0.014	*Course*, straight; 794 feet long. *Cross section*, practically no variation in shape; for variation in size, see fig. 9, A. *Side slopes*, smooth and regular. *Bottom*, even and regular. *Soil*, heavy, dark, silty loam. *Condition*, practically no vegetation in channel; bottom covered with ½ to 1 foot of mud; sides covered with silt of slimy and slippery nature which was no doubt principally responsible for low value of *n*. *Constructed*, summer of 1916. (Pl. 11, A and fig. 8, A.)
do	7.15	42.4	837.1	197.4	4.24	4.32	.0002392	.014	
	[1] 8.00								

[1] Average maximum depth at bankful stage.

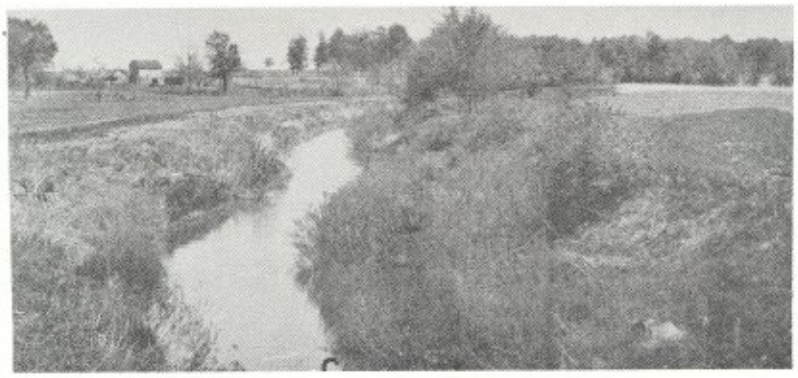
The perimeter of the channel was coated with slippery mud.

Pigeon Creek Dredged Channel near Cresent, Iowa. Approximate bottom width 15 feet. Picture taken in 1917.

Date of observation	Average maximum depth	Average surface width	Discharge	Average cross section	Mean velocity	Mean hydraulic radius	Slope of water surface	Coefficient of roughness n	Description of channel
June 6, 1917	11.7	48.5	1,685.1	329.8	5.11	6.18	0.000642	0.025	*Course*, straight; 858 feet long. *Cross section*, slight variation in shape; for variation in size, see fig. 9, D. *Side slopes*, left side fairly regular; right side rough and irregular. *Bottom*, slightly irregular. *Soil*, heavy, dark, silty loam. *Condition*, very little vegetation in channel. bottom covered with ½ to 1 foot of mud; sides coated with slippery silt. *Constructed*, 1907. (Pl. 12, A and Fig. 8, D.)
June 6, 1917	[1] 12.0	53.8	2,047.1	363.7	5.63	6.12	.000621	.022	
	12.4								

[1] Average maximum depth at bankful stage.

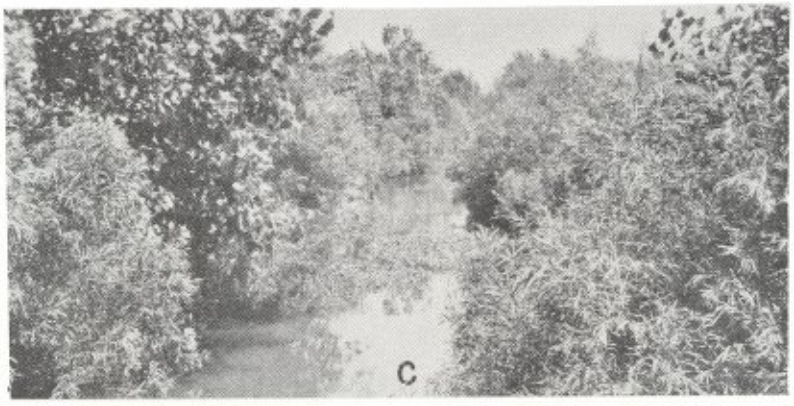
Kaskaskia River Dredged Channel near Sadorus, Illinois. Approximate bottom width 15 feet. Picture taken May 1926.



Date of observation	Average maximum depth	Average surface width	Discharge	Average cross section	Mean velocity	Mean hydraulic radius	Slope of water surface	Coefficient of roughness n	Description of channel
Jan. 18, 1926	5.2	37.6	249.1	130.6	1.91	3.15	0.000383	0.033	*Course*, crooked; 600 feet long. *Cross section*, considerable variation in shape; for variation in size, see fig. 20, H. *Side slopes*, very irregular and uneven. *Bottom*, fairly even and regular. *Soil*, lower part, light bluish gray clay, which is hard, waxy, and slippery at the bottom; upper part, gray silt loam. *Condition*, very young growth and stubble on upper part of slopes, none on lower part; channel cleared in September, 1925. *Constructed*, 1907; vegetation cut about every 2 years. (Pl. 26, C and fig 19, H.)
Feb. 26, 1926	6.2	43.0	321.0	169.5	1.89	3.58	.000485	.041	
Feb. 25, 1926	7.1	47.1	415.6	210.0	1.98	4.04	.000515	.044	
Apr. 7, 1926	7.6	49.2	454.4	236.8	1.92	4.35	.000463	.046	
June 12, 1926	2.8	25.6	70.7	56.2	1.26	2.02	53.6	0.030	*Condition*, left slope covered with weeds, right slope with willows, except near bottom.
Sept. 17, 1926	3.2	26.8	69.8	66.8	1.04	2.28	44.4	.037	
Sept. 7, 1926	4.2	31.5	99.3	95.1	1.04	2.74	38.7	.044	
Sept. 13, 1926	4.9	36.2	138.4	120.5	1.15	3.04	39.1	.045	
Sept. 6, 1926	6.4	43.8	197.1	177.5	1.11	3.68	35.2	.053	
Sept. 5, 1926	7.4	48.3	260.2	225.4	1.15	4.22	28.9	.068	
Sept. 11, 1926	8.4	51.6	320.8	273.2	1.17	4.76	28.3	.072	
	[1] 9.0								

[1] Average maximum depth at bankful stage.

Camp Creek Dredged Channel near Seymore, Illinois. Approximate bottom width 15 feet. Picture taken July 1927.



Date of observation	Average maximum depth	Average surface width	Discharge	Average cross section	Mean velocity	Mean hydraulic radius	Slope of water surface	Coefficient of roughness n	Description of channel
	Feet	*Feet*	*Second-feet*	*Sq. ft.*	*Ft. per sec.*	*Feet*			*Course*, straight; 661 feet long. *Cross section*, very little variation in shape; for variation in size, see fig. 20, J. *Side slopes*, fairly regular. *Bottom*, uneven and irregular. *Soil*, lower part, yellowish gray clay; upper part, light gray silty clay loam. *Condition*, in 1924, newly cleaned leaving weeds and stubble on side slopes; in 1926, sides covered with trees and vines without foliage. *Constructed*, 1906; cleaned, winter of 1923–24.
Sept. 10, 1926	4.6	28.6	60.9	87.9	0.69	2.84	0.000516	0.095	
Oct. 2, 1926	7.3	36.0	164.9	175.7	.94	4.37	.000546	.104	
	[1] 8.5								

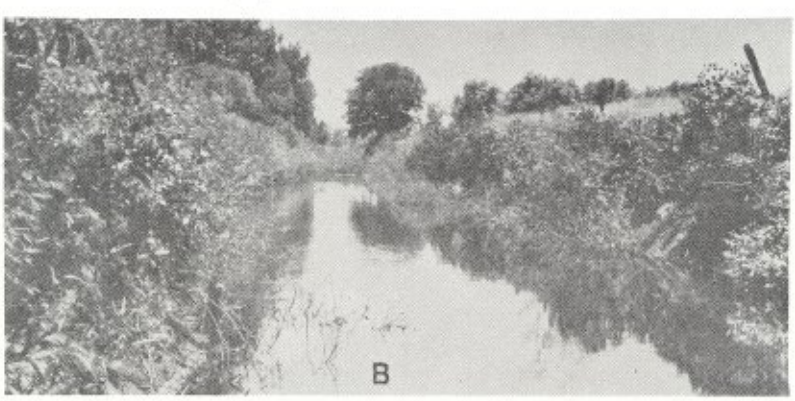
[1] Average maximum depth at bank-full stage.

Condition, side slopes covered with heavy growth of poplar trees 2 to 3 inches in diameter, large willows, and climbing vines; thick growth of water weed on bottom. (Pl. 29, C.)

Two Mile Slough Dredged Channel near Sadorus, Illinois. Approximate bottom width 15 feet. Picture taken April 1925.

Date of observation	Average maximum depth	Average surface width	Discharge	Average cross section	Mean velocity	Mean hydraulic radius	Slope of water surface	Coefficient of roughness n	Description of channel
Mar. 13, 1925	2.7	18.3	25.6	32.6	0.79	1.64	0.000558	0.056	*Course*, straight; 360 feet long. *Cross section*, considerable variation in shape; for variation in size, see fig. 20, I. *Side slopes*, irregular. *Bottom*, very irregular. *Soil*, lower part, black slippery clay; upper part, gray silty clay loam. *Condition*, about 100 feet of course covered with dense growth of bushy willows, some in bottom; remainder of both slopes covered with weeds and a scattering growth of willows and poplars 1 to 6 inches in diameter; no foliage; some silting in bottom. *Constructed*, redredged 1906; cleared, 1921. (Pl. 28, A and fig. 19, I.)
Jan. 19, 1926	4.0	22.3	44.2	59.7	.74	2.43	.000550	.081	
Mar. 14, 1925	5.6	27.2	86.4	99.2	.87	3.25	.000464	.081	
Feb. 25, 1926	5.8	27.9	101.4	107.0	.95	3.41	.000447	.076	
Mar. 19, 1925	5.8	28.1	105.1	106.6	.99	3.38	.000422	.070	
Jan. 18, 1926	6.0	28.4	92.7	111.4	.83	3.49	.000531	.096	
Apr. 7, 1926	7.5	32.7	159.5	158.7	1.01	4.24	.000500	.091	

East Lake Fork Dredged Channel near Ivesdale, Illinois. Approximate bottom width 15 feet. Picture taken July 1927.

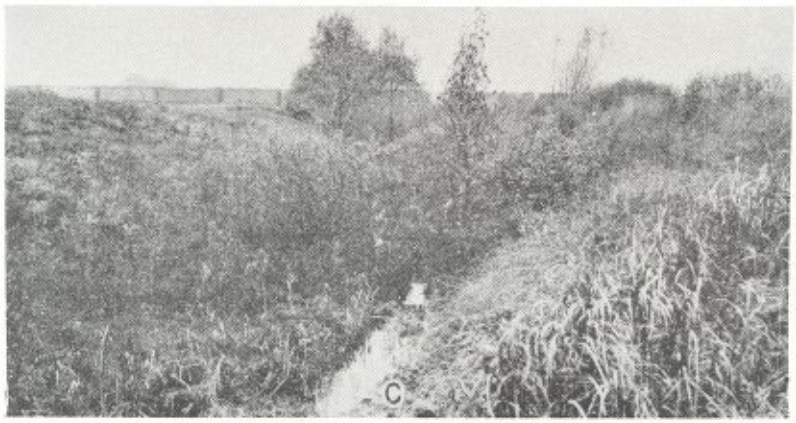


Date of observation	Average maximum depth	Average surface width	Discharge	Average cross section	Mean velocity	Mean hydraulic radius	Slope of water surface	Coefficient of roughness n	Description of channel
Sept. 7, 1926	5.2	28.4	64.0	101.6	0.63	3.24	0.000326	0.093	*Course*, straight; 800 feet long. *Cross section*, very little variation in shape; for variation in size, see Figure 20, E. *Side slopes*, rather irregular. *Bottom*, uneven and rather irregular. *Soil*, lower part, yellowish gray clay; upper part dark-gray silt loam. *Condition*, dead weeds and stubble on side slopes; channel had been cleared shortly before March, 1925. *Constructed*, 1885; redredged about 1904.
Sept. 5, 1926	6.1	30.5	77.2	126.8	.61	3.70	.000279	.100	
Sept. 13, 1926	7.2	33.5	124.6	162.1	.77	4.25	.000330	.097	
Sept. 11, 1926	8.8	41.3	170.8	222.2	.77	4.75	.000308	.103	
	[1] 9.5								

[1] Average maximum depth at bankful stage.

Condition, left side rather steep, showing some tendency to cave; brush larger on side slopes; foliage on all vegetation. (Pl. 26, B.)

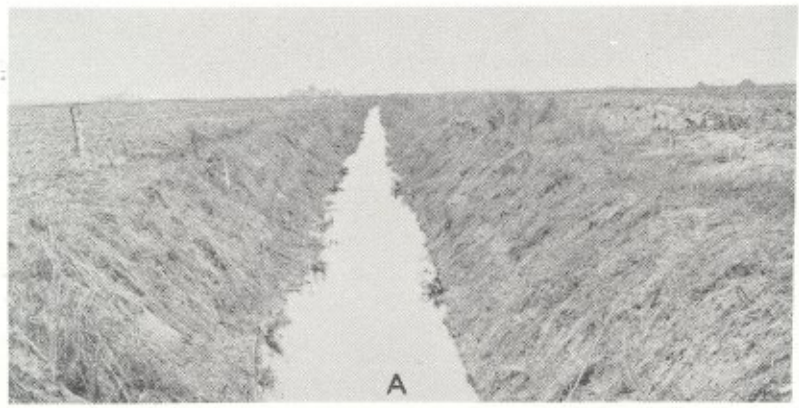
Stewart Branch Dredged Channel near Champaign, Illinois. Approximate bottom width 15 feet. Picture taken October 1926.



Date of observation	Average maximum depth	Average surface width	Discharge	Average cross section	Mean velocity	Mean hydraulic radius	Slope of water surface	Coefficient of roughness n	Description of channel
Sept. 30, 1926	2.3	17.0	12.4	19.2	0.65	1.06	0.003169	0.106	*Course*, crooked; 360 feet long. *Cross section*, considerable variation in shape; for variation in size, see fig. 20, M. *Side slopes*, irregular. *Bottom*, very irregular. *Soil*, lower part, dark gray clay with some sand and pebbles; upper part, dark gray silty clay loam. *Condition*, slopes covered with dense growth of tall weeds, bushes, and wiry grass; occasional bushy willows, and trees 6 to 9 inches in diameter; bottom very grassy, except narrow winding strip. *Constructed*, about 1890. (Pl. 28, C and fig. 19, M.)
Oct. 3, 1925	2.5	17.8	16.7	23.6	.71	1.23	.003406	.114	
Sept. 13, 1925	2.8	18.6	21.1	28.4	.74	1.41	.003422	.122	
Sept. 4, 1926	3.6	20.5	34.4	44.2	.78	1.96	.003131	.149	
Sept. 9, 1926	3.7	20.8	43.2	46.5	.93	2.02	.002956	.125	
	[1] 7.5								

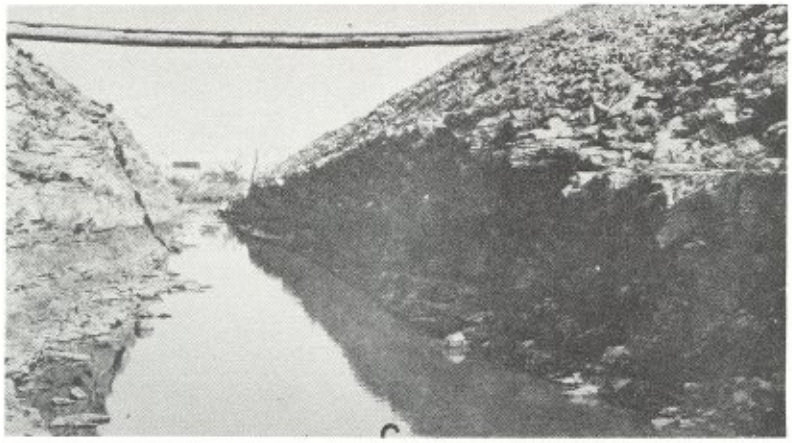
[1] Average maximum depth at bankful stage.

Lateral Ditch No. 15 near Bement, Illinois. Approximate bottom width 15 feet. Picture taken April 1925.



Date of observation	Average maximum depth	Average surface width	Discharge	Average cross section	Mean velocity	Mean hydraulic radius	Slope of water surface	Coefficient of roughness n	Description of channel
Mar. 26, 1925	1.8	15.0	17.8	18.0	0.99	1.16	0.000512	0.034	*Course*, straight; 1,000 feet long. *Cross section*, practically no variation in shape; for variation in size, see fig. 20, K. *Side slopes*, quite regular. *Bottom*, somewhat irregular. *Soil*, lower part, slippery gray clay; upper part, grayish tan silty clay loam. *Condition*, good; dead weeds practically flat on side slopes. *Constructed*, 1886; redredged, 1922. (Pl. 30, A and fig. 19, K.)
Mar. 16, 1925	2.6	17.3	28.7	30.5	.94	1.65	.000384	.040	
Mar. 14, 1925	3.8	20.0	77.7	53.4	1.46	2.39	.000237	.028	
Mar. 19, 1925	4.4	21.3	82.0	67.0	1.22	2.78	.000175	.031	

Sals Creek Rock Channel near Ancell, Missouri. Approximate bottom width 15 feet. Picture taken March 1924.



Date of observation	Average maximum depth	Average surface width	Discharge	Average cross section	Mean velocity	Mean hydraulic radius	Slope of water surface	Coefficient of roughness n	Description of channel
July 12, 1924	2.5	15.4	115.0	35.6	3.23	1.93	0.001898	0.030	*Course*, straight; 250 feet long. *Cross section*, very little variation in shape; for variation in size, see fig. 18, F. *Side slopes*, fairly regular. *Bottom*, quite even and regular. *Soil*, limestone rock. *Condition*, same channel as above, enlarged and smoothed by hand. *Constructed*, December, 1922. (Pl. 23, C and fig. 17, F.)
July 10, 1924	2.9	15.6	146.2	42.0	3.48	2.19	.001898	.031	
Jan. 30, 1923	3.1	15.8	156.9	45.0	3.49	2.30	.001750	.030	
Mar. 18, 1927	3.8	16.1	230.3	56.6	4.07	2.68	.002872	.037	
Feb. 1, 1923	4.3	16.3	265.2	63.3	4.19	2.88	.002690	.037	
Mar. 18, 1927	4.3	16.3	280.8	64.1	4.38	2.91	.002913	.037	
----do----	4.7	16.6	353.5	71.5	4.94	3.10	.003142	.036	
Mar. 31, 1927	7.2	17.7	810.6	112.8	7.19	4.01	.003721	.032	
June 13, 1927	7.4	17.8	884.5	116.4	7.60	4.08	.003529	.030	
Mar. 31, 1927	7.5	17.9	901.2	119.0	7.57	4.13	.004198	.033	
June 13, 1927	7.8	18.0	957.5	123.9	7.73	4.21	.004129	.033	
----do----	7.8	18.0	995.7	124.1	8.02	4.22	.004937	.034	
----do----	7.9	18.1	1,020.8	127.0	8.04	4.28	.005018	.035	
----do----	8.0	18.2	1,008.5	128.8	7.83	4.31	.004659	.035	
----do----	8.1	18.2	1,077.0	130.4	8.26	4.33	.004957	.034	

Cypress Creek Dredged Channel near Bethel Springs, Tennessee. Approximate bottom width 15 feet. Picture taken 1917.

Date of observation	Average maximum depth	Average surface width	Discharge	Average cross section	Mean velocity	Mean hydraulic radius	Slope of water surface	Coefficient of roughness n	Description of channel
Feb. 15, 1917	0.7	12.5	7.9	8.9	0.89	0.67	0.002080	0.047	*Course*, straight; 308 feet long. *Cross section*, abrupt variations in shape; for variation in size, see fig. 6, J. *Side slopes*, very irregular and rough. *Bottom*, uneven; subject to variation due to sand deposits. *Soil*, clay loam. *Condition*, exposed perimeter above low water practically covered with grass and weeds. *Constructed*, December, 1915. (Pl. 9, A and fig. 5, J.)
July 23, 1917	2.3	17.3	72.4	33.8	2.14	1.76	.002435	.047	
----do----	2.9	18.8	103.7	42.1	2.46	1.99	.001915	.040	
	[1] 5.5								

[1] Average maximum depth at bankful stage.

Sugar Creek Dredged Channel near Henderson, Tennessee. Approximate bottom width 15 feet. Picture taken 1917.

Date of observation	Average maximum depth	Average surface width	Discharge	Average cross section	Mean velocity	Mean hydraulic radius	Slope of water surface	Coefficient of roughness n	Description of channel
Mar. 29, 1917	1.9	17.3	23.1	25.4	0.91	1.37	0.000729	0.050	*Course*, 669 feet long; first half straight, last half curved. *Cross section*, very little variation in shape; for variations in size, see fig. 6, I. *Slide slopes*, upper part, smooth and regular; lower part, rather rough. *Bottom*, very rough and irregular with numerous holes. *Soil*, stiff clay loam; does not wash easily. *Condition*, some roots extending from sides of channel; very little vegetation in channel. *Constructed*, Dec., 1915. *Remarks*, very rough condition of bottom is mainly responsible for high values of n obtained. (Pl. 8, B and fig. 5, I.)
Mar. 27, 1917	2.1	17.5	29.8	29.2	1.02	1.53	.000825	.050	
Jan. 4, 1917	2.6	18.2	63.6	39.9	1.59	1.96	.000970	.044	
Feb. 15, 1917	3.5	19.4	148.0	57.8	2.56	2.57	.001232	.038	
Dec. 28, 1917	6.3	27.2	322.0	116.0	2.78	3.41	.000936	.037	
Jan. 29, 1917	6.4	27.4	376.2	117.5	3.20	3.42	.001111	.036	
Jan. 22, 1917	6.6	28.2	355.2	121.9	2.92	3.44	.000920	.036	
July 26, 1917	6.9	29.2	347.2	128.0	2.71	3.49	.000738	.034	
Jan. 5, 1917	[1] 7.1	29.9	406.5	132.2	3.08	3.51	.000855	.033	

[1] Average maximum depth at bankful stage.

Huggins Creek Dredged Channel near Finger, Tennessee. Approximate bottom width 15 feet. Picture taken 1917.

Date of observation	Average maximum depth	Average surface width	Discharge	Average cross section	Mean velocity	Mean hydraulic radius	Slope of water surface	Coefficient of roughness n	Description of channel
Dec. 8, 1916	2.0	18.9	49.1	35.4	1.39	1.72	0.000738	0.040	*Course*, straight; 618 feet long; part of 1916 course. *Condition*, channel in considerably worse condition than when first series of measurements were made; more irregular and rough due to caving banks and a great deal more vegetation in channel. (Pl. 8, A and fig. 6, H.)
do	2.3	19.6	63.2	40.5	1.56	1.87	.000713	.037	
Dec. 28, 1916	2.55	20.1	88.2	46.0	1.92	2.06	.000888	.037	
Feb. 15, 1917	2.60	20.2	88.4	47.0	1.88	2.09	.000834	.036	
Dec. 28, 1916	3.0	20.8	115.2	55.9	2.06	2.34	.000835	.036	
Jan. 18, 1917	3.2	21.1	123.6	58.8	2.10	2.42	.000832	.036	
Mar. 3, 1917	3.5	22.2	143.6	64.3	2.23	2.55	.000877	.036	
	[1] 6.3								

[1] Average maximum depth at bankful stage.

Back Swamp Dredged Channel near Lumberton, North Carolina. Approximate bottom width 15 feet. Picture taken in 1915.

Date of observation	Average maximum depth	Average surface width	Discharge	Average cross section	Mean velocity	Mean hydraulic radius	Slope of water surface	Coefficient of roughness n	Description of channel
Apr. 22, 1915	2.5	22.5	28.5	25.3	1.13	1.22	0.000792	0.038	*Course*, straight; 250 feet long. *Cross section*, abrupt variations in shape; for variation in size, see fig. 11, B. *Side slopes*, fairly regular. *Bottom*, fairly regular, some holes. *Soil*, sandy clay. *Condition*, mat of overhanging ragged roots on both side slopes; no weeds or grass in channel; some roots in bottom. *Constructed*, winter 1913. (Pl. 13, C and fig. 10, B.)
Feb. 10, 1915	2.9	23.1	40.0	32.0	1.25	1.45	.000880	.042	
May 17, 1915	3.1	23.3	58.6	35.6	1.65	1.57	.000880	.034	
Feb. 3, 1915	4.4	24.6	129.6	66.0	1.96	2.51	.000624	.034	
Jan. 20, 1915	5.1	25.2	171.9	83.1	2.07	2.98	.000600	.036	
May 13, 1915	5.7	25.8	232.5	98.8	2.35	3.34	.000730	.038	
Jan. 25, 1915	5.75	26.0	235.1	99.3	2.37	3.34	.000640	.036	
	[1] 6.5								

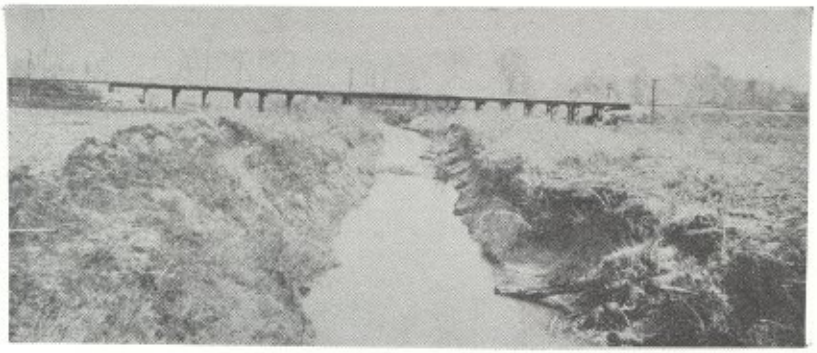
[1] Average maximum depth at bankful stage.

Chawappah Creek Dredged Channel near Shannon, Mississippi. Approximate bottom width 15 feet. Picture taken 1913.

Date of observation	Average maximum depth	Average surface width	Discharge	Average cross section	Mean velocity	Mean hydraulic radius	Slope of water surface	Coefficient of roughness n	Description of channel
Feb. 5, 1913	2.8	18.7	75.0	41.0	1.83	1.95	0.000850	0.036	*Course*, straight; 320 feet long. *Cross section*, very little variation in shape; for variation in size, see fig. 2, D. *Side slopes*, quite regular except near top and along edge of bottom. *Bottom*, quite regular. *Soil* varies from a sandy loam at top to a waxy clay at bottom. *Condition*, very little vegetation in channel; irregularity of upper part of channel due to erosion. *Constructed*, May, 1911. (Pl. 2, B and fig. 1, D.)
Apr. 5, 1913	7.3	31.2	368.1	156.0	2.36	4.20	.000406	.034	
Feb. 28, 1913	11.1	36.4	1,152.6	282.5	4.08	6.05	.000935	.038	
	[1] 12.0								

[1] Average maximum depth at bankful stage.

Coonewah Creek Dredged Channel near Shannon, Mississippi. Approximate bottom width 15 feet. Picture taken in 1913.



Date of observation	Average maximum depth	Average surface width	Discharge	Average cross section	Mean velocity	Mean hydraulic radius	Slope of water surface	Coefficient of roughness n	Description of channel
Apr. 4, 1913	10.6 [1] 12.0	36.7	850.0	286.2	2.97	5.95	0.000620	0.043	*Course*, straight; 450 feet long. *Cross section*, rather gradual variations in shape; for variations in size, see fig. 2, E. *Side slopes*, very irregular. *Bottom*, irregular and uneven. *Soil*, clay loam. *Condition*, some grass and other vegetation on side slopes; bottom free from growth. *Constructed*, May, 1909. (Pl. 2, C and fig. 1, E.)

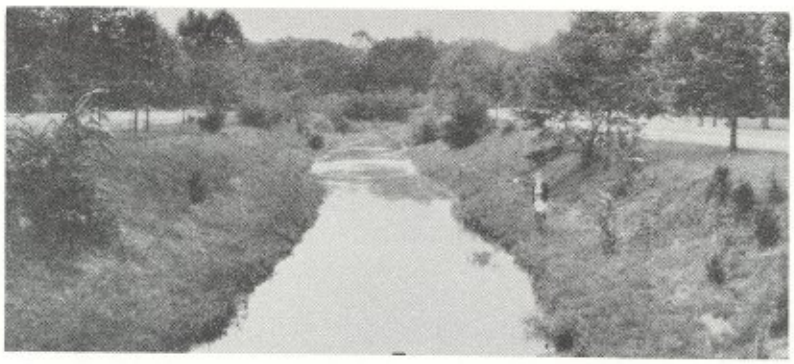
[1] Average maximum depth at bankful stage.

West Branch of Salt Fork Dredged Channel near Urbana, Illinois. Approximate bottom width 20 feet. Picture taken April 1925.

Date of observation	Average maximum depth	Average surface width	Discharge	Average cross section	Mean velocity	Mean hydraulic radius	Slope of water surface	Coefficient of roughness n	Description of channel
May. 1, 1924	3.4	29.4	148.4	80.4	1.85	2.50	0.001118	0.048	*Course*, straight; 550 feet long. *Cross section*, some variation in shape; for variation in size, see fig. 20, D. *Side slopes*, irregular. *Bottom*, rather irregular. *Soil*, lower part, probably clay originally but now mixed with a large percentage of sand; upper part, bowlder clay, quite stony. *Condition*, side slopes covered with rather thick growth of small trees and sprouts of maple, elm, poplar, box elder, and some willow, from ½ inch to 8 inches in diameter; no grass; stones on bottom up to 1 foot in diameter; no appreciable silting. *Constructed*, about 1908. (Pl. 24, C and fig. 19, D.)
Apr. 26, 1924	3.6	31.0	151.2	89.6	1.69	2.65	.001216	.057	
Sept. 14, 1925	3.9	32.3	153.1	97.9	1.56	2.77	.000838	.053	
Sept. 28, 1926	4.2	34.4	226.3	109.1	2.07	2.92	.000924	.044	
Jan. 18, 1926	4.4	35.6	202.8	114.5	1.77	2.95	.001087	.056	
Mar. 20, 1925	4.5	36.7	286.1	119.3	2.40	3.01	.001111	.043	
Feb. 9, 1925	4.8	38.6	301.1	129.4	2.33	3.09	.001240	.047	
Mar. 29, 1924	5.1	41.1	392.6	142.5	2.76	3.20	.001587	.047	
Sept. 13, 1925	5.3	42.4	370.6	149.8	2.47	3.25	.001220	.046	
Mar. 19, 1925	5.7	44.5	481.5	165.9	2.90	3.43	.001427	.044	
Oct. 1, 1925	5.9	45.7	462.3	176.1	2.66	3.56	.001284	.047	
Mar. 14, 1925	6.1	46.4	483.1	185.8	2.60	3.69	.001435	.052	
Feb. 25, 1926	6.5	48.1	625.0	208.0	3.00	3.91	.001825	.053	
Apr. 8, 1926	6.6	48.2	666.7	208.5	3.20	3.92	.001531	.046	
Dec. 19, 1924	6.9	49.8	699.7	225.7	3.10	4.10	.001733	.052	
Sept. 4, 1926	7.0	50.0	696.1	227.8	3.06	4.12	.001282	.046	
Oct. 2, 1926	8.3	54.5	993.0	297.5	3.34	4.91	.001385	.050	
Apr. 7, 1926	10.2 [1] 10.0	60.5	1,402.0	405.2	3.46	5.99	.001885	.066	

[1] Average maximum depth at bankful stage.

West Branch of Salt Fork Dredged Channel near Urbana, Illinois. Approximate bottom width 20 feet. Picture taken July 1924.



Date of observation	Average maximum depth	Average surface width	Discharge	Average cross section	Mean velocity	Mean hydraulic radius	Slope of water surface	Coefficient of roughness n	Description of channel
May 1, 1924	2.7	29.2	148.4	57.5	2.58	1.84	0.000644	0.025	*Course*, straight; 480 feet long. *Cross section*, very little variation in shape; for variation in size, see fig. 20, C. *Side slopes*, fairly regular. *Bottom*, quite flat but somewhat irregular in places. *Soil*, bottom covered with stones and gravel; upper part, bowlder clay with oxidized iron. *Condition*, some small sprouts, bushes and dead grass on side slopes, without foliage; bottom covered with mossy stones at lower end of course, but mostly with gravel at upper end. *Constructed*, about 1908 (Pl. 24, B and fig. 19, C.)
Apr. 26, 1924	2.9	30.6	151.2	65.4	2.31	2.01	.000898	.030	
Mar. 20, 1925	3.9	35.5	286.1	91.5	3.13	2.42	.000933	.026	
Feb. 9, 1925	4.1	39.4	301.1	105.7	2.85	2.53	.001085	.031	
Mar. 19, 1925	4.9	45.5	481.5	141.4	3.41	2.93	.000806	.025	
Mar. 14, 1925	5.3	47.7	483.1	161.7	2.99	3.20	.000744	.029	
Apr. 8, 1926	5.8	49.8	666.7	185.3	3.60	3.52	.000958	.030	
Feb. 25, 1926	5.9	49.8	625.0	186.2	3.36	3.53	.000854	.030	
Dec. 19, 1924	6.1	51.0	699.7	201.3	3.48	3.72	.000704	.027	
----do----	6.8	53.4	806.4	237.1	3.40	4.14	.000704	.030	
Apr. 7, 1926	9.5	63.6	1,402.0	392.5	3.57	5.71	.000552	.032	

Monona-Harrison Dredged Channel near Onawa, Iowa. Approximate bottom width 20 feet. Picture taken in 1916.

Date of observation	Average maximum depth	Average surface width	Discharge	Average cross section	Mean velocity	Mean hydraulic radius	Slope of water surface	Coefficient of roughness n	Description of channel
June 2, 1916	4.4	37.2	221.0	131.3	1.68	2.60	0.000267	0.027	*Course*, straight; 948 feet long. *Cross section*, slight variations in shape, abrupt variations in size. *Side slopes*, quite irregular, particularly upper part. *Bottom*, fairly regular. *Soil*, dark silty loam. *Condition*, considerable growth in upper portion of channel, none in lower; silty material deposited on bed and sides of channel. *Constructed*, 1910. (Pl. 13, A and fig. 8, E.
May 22, 1916	6.9	47.2	614.0	270.8	2.27	4.19	.000261	.028	
	[1] 10.0								
June 8, 1917	8.5	59.8	499.0	308.0	1.62	4.82	0.000178	0.036	Practically no change in channel since measurements were made in 1916.
June 9, 1917	8.8	61.5	546.5	322.1	1.70	4.92	.0001475	.032	
	[1] 10.0								

[1] Average maximum depth at bankful stage.

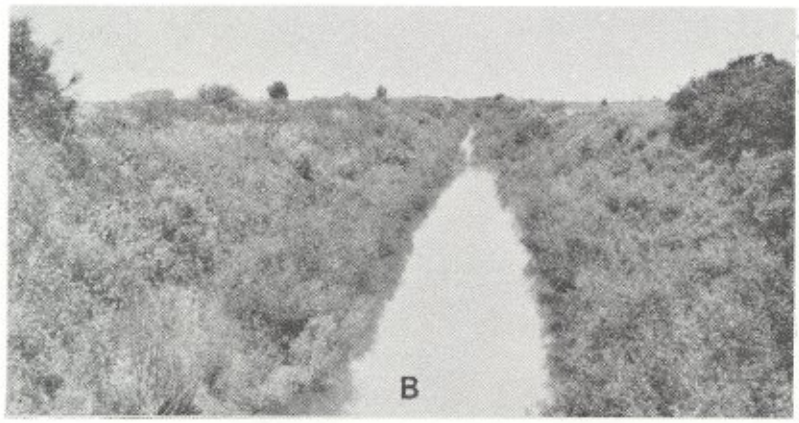
Sides of channel slightly coated with mud. Bed and flat portions of the channel sides was coated with silt.

South Forked Deer River Dredged Channel near Henderson, Tennessee. Approximate bottom width 20 feet. Picture taken in 1916.

Date of observation	Average maximum depth	Average surface width	Discharge	Average cross section	Mean velocity	Mean hydraulic radius	Slope of water surface	Coefficient of roughness n	Description of channel
Mar. 30, 1916	3.2	26.1	115.2	73.3	1.57	2.46	0.000257	0.028	*Course*, straight; 624 feet long. *Cross section*, very little variation in shape; for variation in size, see Fig. 6, C. *Side slopes*, slightly irregular. *Bottom*, fairly regular; uneven in places with small depressions. *Soil*, heavy clay near bottom; clay loam near top. *Condition*, practically no vegetation in channel. *Constructed*, November, 1914. (Pl. 7, B and fig. 5, C.)
Mar. 1, 1916	3.8	27.1	169.4	89.0	1.90	2.81	.000393	.031	
May 16, 1916	3.9	27.4	193.2	91.5	2.11	2.87	.000305	.025	
May 22, 1916	5.8	30.4	358.0	147.0	2.43	3.96	.000361	.029	
May 3, 1916	6.4	31.5	434.6	168.3	2.58	4.34	.000345	.029	
	[1] 9.3								

[1] Average maximum depth at bankful stage.

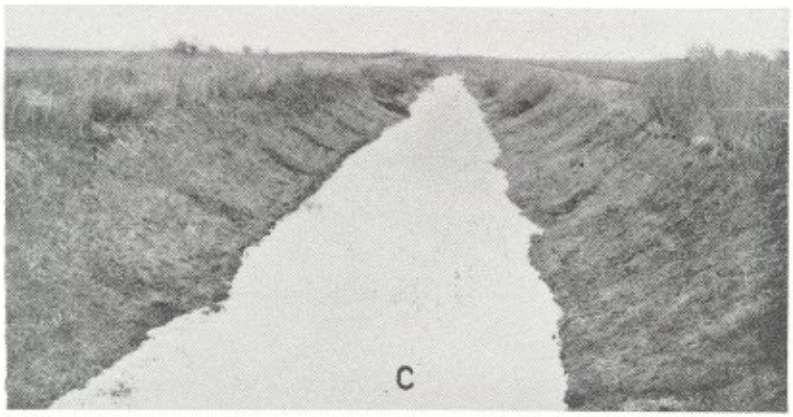
Lake Fork Special Dredged Channel near Bement, Illinois. Approximate bottom width 25 feet. Picture taken July 1924.



Date of observation	Average maximum depth	Average surface width	Discharge	Average cross section	Mean velocity	Mean hydraulic radius	Slope of water surface	Coefficient of roughness n	Description of channel
	Feet	*Feet*	*Second-feet*	*Sq. ft.*	*Ft. per sec.*	*Feet*			*Course*, straight; 816 feet long. *Cross section*, very little variation in shape; for variation in size, see fig. 20, B. *Side slopes*, fairly regular. *Bottom*, uneven and irregular. *Soil*, lower part, light gray clay; upper part, yellowish gray clay. *Condition*, side slopes covered with dense growth of bushy willows, except near bottom; some small poplar saplings at intervals along course; one silt bar about middle of course, otherwise bottom in quite good condition. *Constructed*, 1885; redredged, 1909.
Sept. 17, 1926	6.8	48.8	185.1	221.4	0.84	4.20	0.000241	0.075	
Sept. 7, 1926	7.4	50.8	192.2	253.7	.76	4.60	.000244	.090	
Aug. 25, 1924	8.0	52.3	259.7	282.3	.92	4.94	.000286	.085	
Sept. 6, 1926	8.5	53.6	244.4	309.6	.79	5.27	.000239	.096	
Sept. 5, 1926	9.2	55.2	282.5	347.7	.81	5.71	.000228	.098	
Sept. 13, 1926	9.6	56.1	319.7	372.2	.86	5.96	.000214	.093	
Sept. 10, 1926	12.0	61.6	495.2	511.0	.97	7.33	.000236	.104	

Condition, about the same as for above measurements, except that growth was covered with foliage. This channel was cleared during fall of 1925, but there appeared to be as much growth in channel by the fall of 1926 as previous to clearing. (Pl. 25, B.)

Lake Fork special Dredged Channel near Bement, Illinois. Approximate bottom width 25 feet. Picture taken November 1925.



Date of observation	Average maximum depth	Average surface width	Discharge	Average cross section	Mean velocity	Mean hydraulic radius	Slope of water surface	Coefficient of roughness n
Jan. 19, 1926	4.5	40.8	158.0	120.4	1.31	2.78	0.000186	0.030
Feb. 26, 1926	6.1	46.8	296.1	189.7	1.56	3.79	.000169	.030
Apr. 9, 1926	6.8	48.8	332.0	220.7	1.50	4.19	.000146	.032
Apr. 8, 1926	7.9	52.2	461.1	279.6	1.65	4.91	.000142	.032
	[1] 13.0							

[1] Average maximum depth at bankful stage.

Description of channel

Course, straight; 816 feet long. *Cross section*, very little variation in shape; for variation in size, see fig. 20, B. *Side slopes*, fairly regular. *Bottom*, uneven and irregular. *Soil*, lower part, light gray clay; upper part, yellowish gray clay. *Condition*, side slopes covered with dense growth of bushy willows, except near bottom; some small poplar saplings at intervals along course; one silt bar about middle of course, otherwise bottom in quite good condition. *Constructed*, 1885; redredged, 1909.

Condition, practically no growth in channel; cleared during fall of 1925. (Pl. 25, C.)

Bogue Hasty Dredged Channel near Shaw, Mississippi. Approximate bottom width 25 feet. Picture taken in 1915.

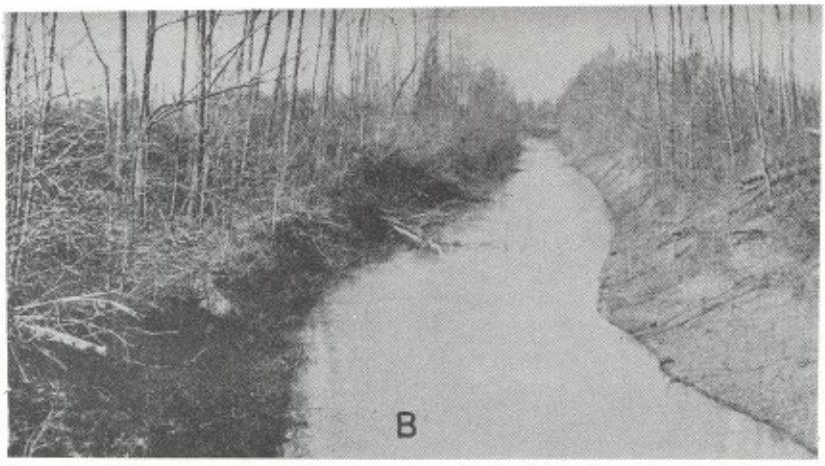
Date of observation	Average maximum depth	Average surface width	Discharge	Average cross section	Mean velocity	Mean hydraulic radius	Slope of water surface	Coefficient of roughness n
Jan. 5, 1915	2.55	38.1	50.1	74.8	0.67	1.85	0.000152	0.038
Jan. 20, 1915	4.05	42.3	183.6	137.0	1.34	3.01	.000183	.031
Feb. 25, 1915	5.60	47.2	275.9	209.0	1.32	4.08	.000119	.032
Feb. 22, 1915	5.75	47.3	366.8	210.8	1.74	4.10	.000166	.028
Feb. 23, 1915	7.80	53.3	650.0	314.0	2.07	5.30	.000169	.029
Jan. 25, 1915	[1] 9.50	58.2	786.6	414.0	1.90	6.31	.000157	.035

[1] Average maximum depth at bankful stage.

Description of channel

Course, straight; 1,039 feet long. *Cross section*, slight and gradual variations in shape; for variations in size, see fig. 4, C. *Side slopes*, right side very irregular and caving badly; left side quite regular. *Bottom*, rather irregular. *Soil*, upper part, dark silty loam; lower part, light yellow clay. *Condition*, upper part right side slope covered with weeds and small tree sprouts; left side slope practically free from vegetation. *Constructed* September, 1911. (Pl. 4, A and fig. 3, C.)

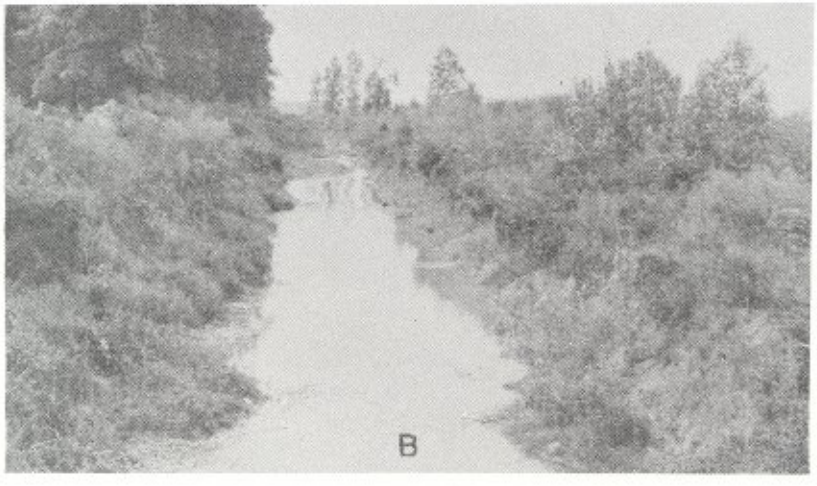
Bogue Hasty Dredged Channel near Shaw, Mississippi. Approximate bottom width 25 feet. Picture taken March 1926.



Date of observation	Average maximum depth	Average surface width	Discharge	Average cross section	Mean velocity	Mean hydraulic radius	Slope of water surface	Coefficient of roughness n	Description of channel
	Feet	*Feet*	*Second-feet*	*Sq. ft.*	*Ft. per sec.*	*Feet*			
Mar. 13, 1926	4.2	40.4	134	117	1.15	2.77	0.000130	0.029	*Course*, straight, 1,000 feet long, nearly same as above. *Cross section*, slight variation in shape; for variation in size, see fig. 4, D. *Side slopes*, fairly even and regular. *Bottom*, rather irregular. *Soil*, same as above. *Condition*, banks fairly clean and free from vegetation. *Constructed*, September, 1911. (Pl. 4, B and fig. 3, D.)
Mar. 9, 1926	5.4	44.5	204	169	1.21	3.59	.000114	.031	
Apr. 17, 1924	5.9	45.7	319	184	1.73	3.79	.000147	.026	
Dec. 17, 1925	7.7	52.0	391	286	1.37	5.14	.000099	.034	
Mar. 8, 1926	7.7	52.0	465	287	1.62	5.15	.000140	.034	
May 28, 1924	8.4	54.2	586	323	1.81	5.55	.000120	.029	
Feb. 25, 1924	9.4	56.5	710	373	1.90	6.06	.000135	.032	
	[1] 9.5								

[1] Average maximum depth at bankful stage.

West Bogue Hasty Dredged Channel near Shaw, Mississippi. Approximate bottom width 25 feet. Picture taken August 1924.



Date of observation	Average maximum depth	Average surface width	Discharge	Average cross section	Mean velocity	Mean hydraulic radius	Slope of water surface	Coefficient of roughness n	Description of channel
May 13, 1926	4.1	36.8	55.2	106	0.52	2.75	0.0001315	0.062	*Course*, straight; 897 feet long. *Cross section*, slight variation in shape; for variation in size, see fig. 4, G. *Side slopes*, very irregular and uneven. *Bottom*, very irregular. *Soil*, dark colored, waxy clay with thin layers of fine sand which causes slides. *Condition*, very poor, due to caving banks and weeds and grass. *Constructed*, May, 1911; redredged, April, 1923. (Pl. 5, B and fig. 3, G.)
May 12, 1926	5.7	42.4	121.0	172	.70	3.79	.0001003	.053	
do	6.2	44.0	141.0	190	.74	4.03	.0000914	.050	
May 11, 1926	8.2	47.9	258.0	284	.91	5.31	.0000670	.050	
May 28, 1924	8.8	49.0	313.0	316	.99	5.72	.0000726	.044	
Feb. 27, 1924	9.4	52.0	402.0	344	1.17	5.91	.0000713	.038	
	[1] 10.0								

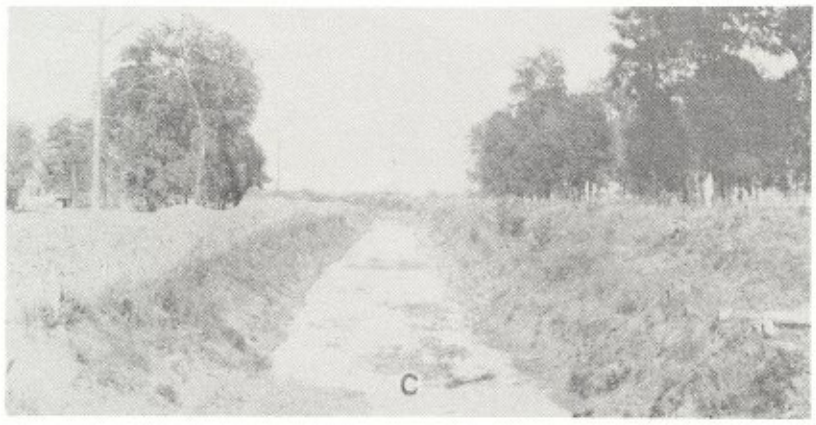
[1] Average maximum depth at bankful stage.

South Forked Deer River-Old Straight Channel-Jackson, Tennessee. Approximate bottom width 25 feet. Picture taken in 1916.

Date of observation	Average maximum depth	Average surface width	Discharge	Average cross section	Mean velocity	Mean hydraulic radius	Slope of water surface	Coefficient of roughness n	Description of channel
Mar. 20, 1916	7.0	40.0	395.2	196.2	2.01	4.44	0.000584	0.050	*Course*, fairly straight; 497 feet long. *Cross section*, considerable variation in shape; for variation in size, see fig. 6, L. *Side slopes*, irregular. *Bottom*, irregular with deep holes. *Soil*, sandy clay loam. *Condition*, sides of channel covered with trees, roots, and vines and subject to caving; logs, branches, and other drift on bottom of channel. (Pl. 10, A and fig. 5, L.)
Feb. 25, 1916	8.0	41.7	545.9	240.2	2.27	5.09	.000734	.055	
Mar. 20, 1916	8.8	43.2	735.7	275.0	2.68	5.56	.001088	.062	
Mar. 4, 1916	8.9	43.7	715.1	281.9	2.54	5.66	.000952	.062	
Feb. 3, 1916	11.5	48.8	1,066.6	403.2	2.64	7.19	.000501	.050	
	[1] 13.5								

[1] Average maximum depth at bankful stage.

Horseshoe Bayou Dredged Channel near Cleveland, Mississippi. Approximate bottom width 25 feet. Picture taken May 1924.



Date of observation	Average maximum depth	Average surface width	Discharge	Average cross section	Mean velocity	Mean hydraulic radius	Slope of water surface	Coefficient of roughness n	Description of channel
June 26, 1926	4.1	38.4	106.2	124.2	0.86	3.07	0.000218	0.053	*Course*, straight; 1,020 feet long. *Cross section*, slight variation in shape; for variation in size, see fig. 4, I. *Side slopes*, moderate irregularities caused by erosion and some caving of banks. *Bottom*, rather rough and irregular. *Soil*, stiff dark clay loam. *Condition*, a few short weeds in channel; 2 small bars in bottom where laterals enter. *Constructed*, December, 1921. (Pl. 5, C and fig. 3, I.)
May 11, 1926	4.0	38.2	120.4	120.6	1.00	3.00	.000130	.035	
do	4.8	40.1	178.0	153.0	1.16	3.58	.000131	.035	
Dec. 14, 1924	8.3	48.9	577.0	304.0	1.90	5.65	.000180	.035	
	[1] 9.0								

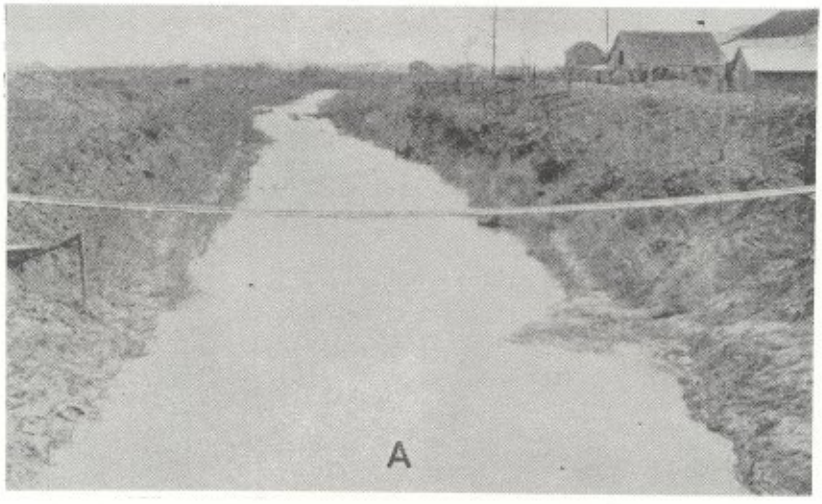
[1] Average maximum depth at bankful stage.

South Forked Deer River Dredged Channel at Cambells Levee - Jackson, Mississippi. Approximate bottom width 30 feet. Picture taken in 1916.

Date of observation	Average maximum depth	Average surface width	Discharge	Average cross section	Mean velocity	Mean hydraulic radius	Slope of water surface	Coefficient of roughness n	Description of channel
	Feet	*Feet*	*Second-feet*	*Sq. ft.*	*Ft. per sec.*	*Feet*			
Mar. 20, 1916	4.6	43.6	395.2	176.1	2.24	3.61	0.000571	0.038	*Course*, fairly straight; 534 feet long. *Cross section*, rather gradual variations in shape; for variation in size, see fig. 6, K. *Side-slopes*, very irregular. *Bottom*, very rough and uneven. *Soil*, sandy clay loam. *Condition*, very little vegetation; few obstructions in channel. *Constructed*, August, 1914. (Pl. 9, B and fig. 5, K.)
Feb. 25, 1916	6.1	46.9	545.9	249.0	2.19	4.65	.000552	.046	
Mar. 29, 1916	7.3	49.8	735.7	305.0	2.41	5.33	.000452	.041	
Mar. 4, 1916	7.5	50.3	715.1	315.6	2.27	5.45	.000300	.037	
	[1] 13.0								

[1] Average maximum depth at bankful stage.

Dredged Ditch No. 1 near Shaw, Mississippi. Approximate bottom width 30 feet. Picture taken March 1926.



Date of observation	Average maximum depth	Average surface width	Discharge	Average cross section	Mean velocity	Mean hydraulic radius	Slope of water surface	Coefficient of roughness n	Description of channel
Mar. 8, 1926	4.8	44.4	163.0	150.8	1.08	3.26	0.000184	0.041	*Course*, nearly straight; 995 feet long. *Cross section*, some variation in shape; for variation in size, see fig. 4, J. *Side slopes*, irregular, varying from steep to almost flat. *Bottom*, somewhat irregular. *Soil*, dark clay loam. *Condition*, growth of short grass and dead weeds in channel, perimeter rather rough. *Constructed*, February, 1922. (Pl. 6, A and fig. 3, J.)
Mar. 11, 1926	5.4	46.4	206.0	177.0	1.16	3.64	.000176	.041	
	[1] 8.0								

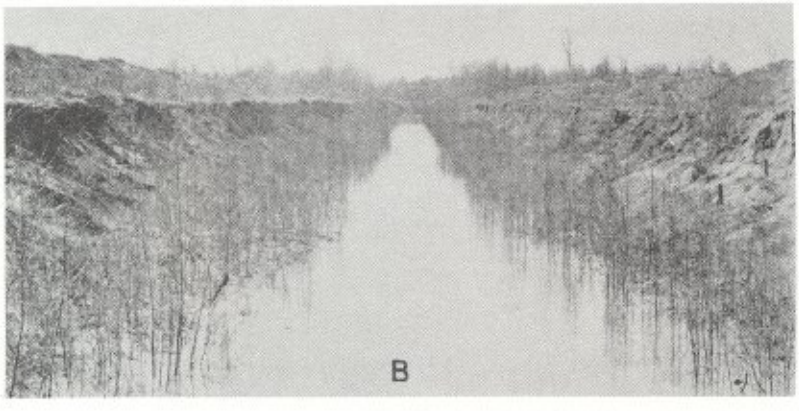
[1] Average maximum depth at bankful stage.

South Forked Deer River-Old Crooked Channel-Jackson, Tennessee. Approximate bottom width 30 feet. Picture taken 1916.

Date of observation	Average maximum depth	Average surface width	Discharge	Average cross section	Mean velocity	Mean hydraulic radius	Slope of water surface	Coefficient of roughness n	Description of channel
Mar. 20, 1916	5.1	46.5	395.2	241.2	1.64	4.15	0.003773	0.152	*Course*, very crooked, containing four distinct curves; 705 feet long at low water. *Cross section*, large variations in shape; for variation in size, see fig. 6, M. *Side slopes*, very irregular. *Bottom*, very irregular and full of holes. *Soil*, sandy clay loam. *Condition*, many roots, trees, and bushes on sides, and many logs, large trees, and other drift on bottom; trees are continually falling into channel, due to caving banks. (Pl. 10, B and fig. 5, M.)
Feb. 25, 1916	6.5	50.0	545.9	311.5	1.75	4.99	.003812	.162	
Mar. 29, 1916	7.6	54.0	735.7	366.0	2.01	5.56	.003450	.150	
Mar. 4, 1916	7.8	55.0	715.1	376.7	1.90	5.68	.002709	.146	
Feb. 3, 1916	11.1	64.5	1,066.6	575.8	1.85	7.60	.001486	.140	
	[1] 13.0								

[1] Average maximum depth at bank-full stage.

Cummins Lake Dredged Channel near Gould, Arkansas. Approximate bottom width 30 feet. Picture taken March 1926.



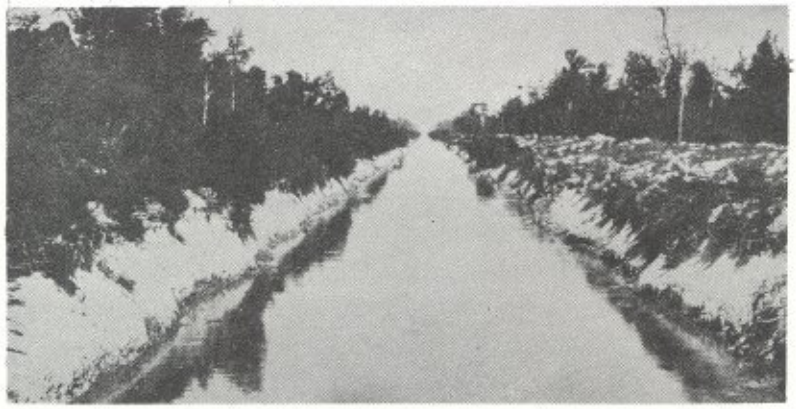
Date of observation	Average maximum depth	Average surface width	Discharge	Average cross section	Mean velocity	Mean hydraulic radius	Slope of water surface	Coefficient of roughness n	Description of channel
Feb. 18, 1926	4.2	44.1	128.5	115.8	1.11	2.51	0.000674	0.057	*Course*, straight; 710 feet long. *Cross section*, very little variation in shape; for variation in size, see fig. 15, E. *Side slopes*, fairly regular. *Bottom*, fairly regular. *Soil*, upper, sandy loam; lower, silty clay. *Condition*, growth of willows in channel 6 to 10 feet high except on upper part of side slopes and narrow strip of channel, willows about one year old. *Constructed* summer 1924 (Pl. 18, B and fig. 14, E.
Apr. 24, 1926	5.0	49.2	200.7	154.8	1.30	3.02	.000473	.051	
Dec. 14, 1926	6.0	53.7	245.9	202.0	1.22	3.61	.000448	.062	
Jan. 22, 1926	9.2	63.1	579.4	390.4	1.48	5.78	.000284	.059	
Jan. 21, 1926	9.9	64.3	764.1	432.8	1.77	6.22	.000304	.053	
do	9.9	64.3	787.4	433.5	1.82	6.23	.000309	.052	

Cummins Lake Dredged Channel near Gould, Arkansas. Approximate bottom width 30 feet. Picture taken June 1926.

Date of observation	Average maximum depth	Average surface width	Discharge	Average cross section	Mean velocity	Mean hydraulic radius	Slope of water surface	Coefficient of roughness n	Description of channel
May 12, 1926	4.0	41.8	55.9	104.5	0.53	2.41	0.000273	0.078	*Course*, straight; 710 feet long. *Cross section*, very little variation in shape; for variation in size, see fig. 15, E. *Side slopes*, fairly regular. *Bottom*, fairly regular. *Soil*, upper, sandy loam; lower, silty clay. *Condition*, growth of willows in channel 6 to 10 feet high except on upper part of side slopes and narrow strip of channel. willows about one year old. *Constructed* summer 1924
Nov. 11, 1926	7.1	57.8	314.1	262.6	1.20	4.34	.000390	.068	
Nov. 7, 1926	8.4	61.1	410.7	338.8	1.21	5.22	.000315	.070	
	[1] 13.5								*Course*, same as above. *Condition*, practically the same, except that willows and other vegetation are in full foliage. (Pl. 18, C.)

[1] Average maximum depth at bankful stage.

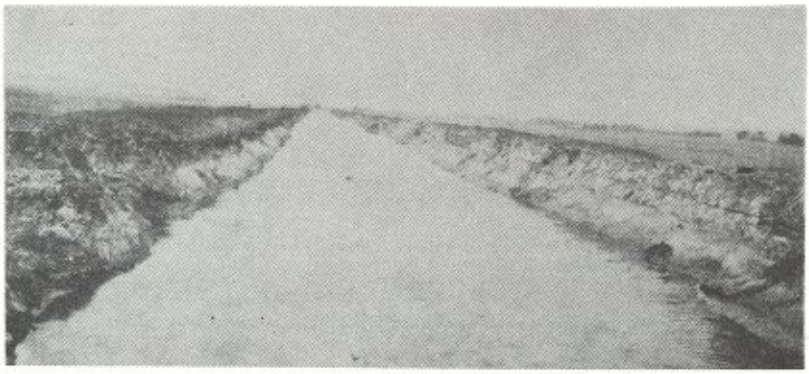
South Forked Deer River Dredged Channel near Roberts, Tennessee. Approximate bottom width 40 feet. Picture taken in 1916.



Date of observation	Average maximum depth	Average surface width	Discharge	Average cross section	Mean velocity	Mean hydraulic radius	Slope of water surface	Coefficient of roughness n	Description of channel
	Feet	*Feet*	*Second-feet*	*Sq. ft.*	*Ft. per sec.*	*Feet*			
Feb. 26, 1916	7.7	51.0	614.3	328.4	1.87	5.76	0.000094	0.026	*Course*, straight; 1,412 feet long. *Cross section*, very little variation in shape; for variation in size, see Fig. 6, A. *Side slopes*, regular and smooth. *Bottom*, even and fairly smooth. *Soil*, lower part, hard clay; upper part, clay loam. *Condition*, no vegetation or obstructions of any sort in channel. *Constructed*, October, 1915. (Pl. 6, C and fig. 5, A.)
Feb. 10, 1916	8.9	52.4	798.2	390.0	2.04	6.50	.000094	.025	
Mar. 29, 1916	9.5	53.4	919.4	421.8	2.18	6.84	.000096	.025	
Apr. 4, 1916	10.3	54.5	1,252.1	465.0	2.70	7.28	.000124	.024	
Mar. 4, 1916	10.8	55.2	1,502.6	494.0	3.04	7.55	.000166	.025	
	[1] 13.0								

[1] Average maximum depth at bankful stage.

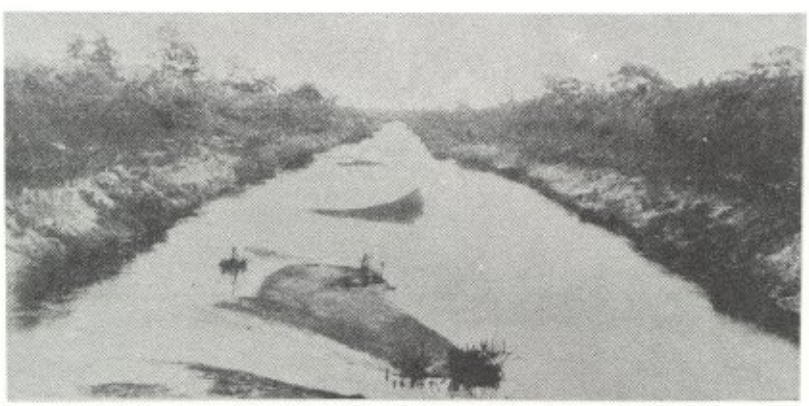
Boyer River Dredged Channel near Missouri Valley, Iowa. Approximate bottom width 40 feet. Picture taken in 1917.



Date of observation	Average maximum depth	Average surface width	Discharge	Average cross section	Mean velocity	Mean hydraulic radius	Slope of water surface	Coefficient of roughness n	Description of channel
June 8, 1917	5.3	64.0	904.5	288.0	3.14	4.29	0.0003340	0.023	*Course*, straight; 868 feet long. *Cross section*, considerable but gradual variations in shape; for variation in size, see fig. 9, C. *Side slopes*, fairly regular. *Bottom*, somewhat uneven and irregular. *Soil*, upper part, dark silty loam; lower part, hard yellow clay. *Condition*, practically no vegetation in channel; bottom and sides coated with layer of slippery silt. *Constructed*, 1910. (Pl. 11, C and Fig. 8, C.)
June 7, 1917	7.0	69.0	1,438.6	410.9	3.50	5.58	.0002525	.021	
June 6, 1917	10.5	76.0	2,707.4	663.7	4.08	7.80	.0001883	.020	
June 4, 1917	11.7	79.0	3,213.4	755.5	4.25	8.59	.0001278	.016	
do	12.2	80.0	3,756.0	799.0	4.70	8.99	.0001255	.015	
	[1] 15.0								

[1] Average maximum depth at bankful stage.

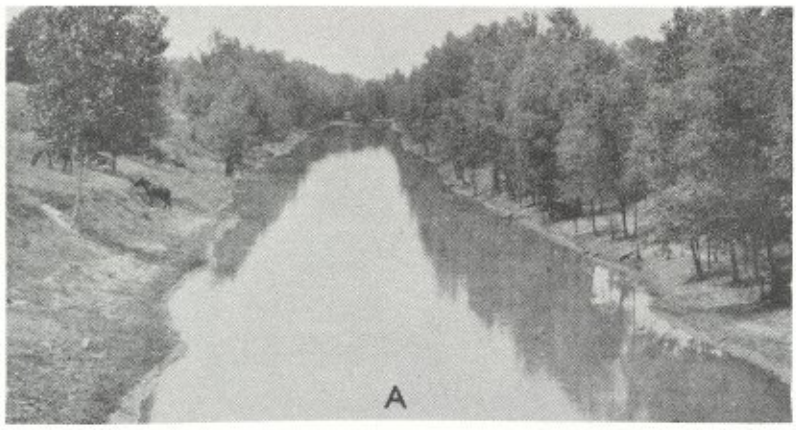
Main Dredged Channel near Vero, Florida. Approximate bottom width 40 feet. Picture taken in 1917.



Date of observation	Average maximum depth	Average surface width	Discharge	Average cross section	Mean velocity	Mean hydraulic radius	Slope of water surface	Coefficient of roughness n	Description of channel
Aug. 14, 1916	1.2	47.7	41.1	44.6	0.92	0.92	0.000625	0.034	*Course*, straight; 1,000 feet long. *Cross section*, slight variations in shape; for variation in size, see fig. 13, D. *Side slopes*, fairly uniform and regular for lowest three stages; rough and irregular for highest two. *Bottom*, fairly even and regular. *Soil*, sand on bottom, clay on sides. *Condition*, some vegetation in lower part of channel; flat sand bars. *Constructed*, December, 1912. (Pl. 16, A, and fig. 12, D.)
Nov. 21, 1916	2.2	52.8	131.2	91.4	1.44	1.70	.000478	.032	
Oct. 5, 1916	2.8	55.9	201.4	128.6	1.57	2.25	.000305	.028	
Oct. 28, 1916	5.3	67.2	569.5	285.7	1.99	4.11	.000479	.043	
Oct. 29, 1916	6.9	73.1	955.2	397.3	2.40	5.26	.000538	.046	
	[1] 10.0								
Sept. 12, 1917	3.2	57.9	290.2	136.9	2.12	2.33	0.000406	0.024	Condition of channel, about the same as for the 1916 measurements. For variation in size of channel see fig. 13, E.
Oct. 19, 1917	4.7	67.6	533.2	234.9	2.27	3.41	.000407	.030	
Sept. 27, 1917	5.1	68.9	577.2	260.0	2.22	3.68	.000416	.033	
Sept. 25, 1917	5.7	71.3	712.5	307.1	2.32	4.18	.000571	.040	
	[1] 10.0								

[1] Average maximum depth at bankful stage.

Ditch No. 19 near Winchester, Arkansas. Approximate bottom width 45 feet. Picture taken July 1926.



Date of observation	Average maximum depth	Average surface width	Discharge	Average cross section	Mean velocity	Mean hydraulic radius	Slope of water surface	Coefficient of roughness n	Description of channel
May 13, 1925	8.0	98.9	447.1	548.5	0.82	5.39	0.0000281	0.032	*Course*, straight; 1,600, feet long. *Cross section*, some variation in shape; for variation in size, see fig. 15, C. *Side slopes*, irregular. *Bottom*, rather irregular. *Soil*, upper, clay and sandy loam; lower, silty clay. *Condition*, some silting in channel; thick growth of willows and cottonwood trees cover most of left bank and about half of right bank; very little undergrowth, due to pasturing; grass on slopes; lower part of channel comparatively free from vegetation, except for some willows on small islands near upper end of course. *Constructed*, February, 1918. (Pl. 18, A and fig. 14, C.)
May 12, 1925	8.3	100.2	686.3	577.6	1.19	5.60	.0000597	.033	
Jan. 23, 1926	11.7	116.2	1,385.5	949.7	1.46	7.84	.0000937	.043	
Jan. 25, 1926	11.7	116.3	1,454.1	951.6	1.53	7.85	.0000944	.041	
Nov. 8, 1925	13.0	124.9	1,536.2	1,110.9	1.38	8.52	.0000962	.050	
	[1] 16.0								

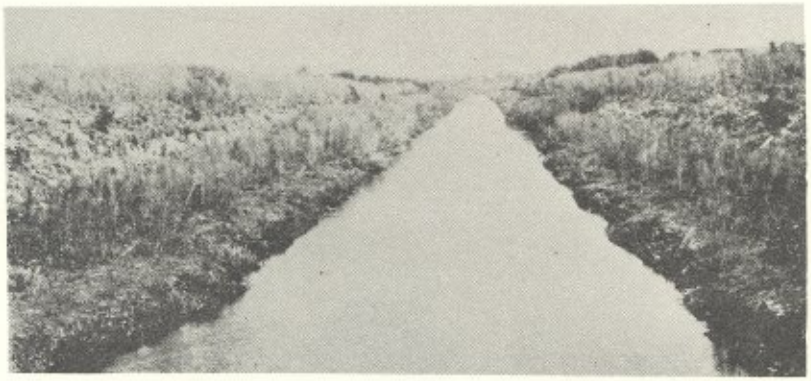
[1] Average maximum depth at bankful stage.

Bogue Phalia Dredged Channel near Helm, Mississippi. Approximate bottom width 45 feet. Picture taken in 1915.

Date of observation	Average maximum depth	Average surface width	Discharge	Average cross section	Mean velocity	Mean hydraulic radius	Slope of water surface	Coefficient of roughness n	Description of channel
	Feet	*Feet*	*Second-feet*	*Sq. ft.*	*Ft. per sec.*	*Feet*			
Jan. 14, 1915	4.20	57.5	468.5	192.0	2.44	3.11	0.000297	0.022	*Course*, straight; 1,003 feet long. *Cross section*, very little variation in shape; for variation in size, see fig. 4, A. *Side slopes*, left side, quite regular; right side, fairly regular. *Bottom*, smooth and even. *Soil*, lower part, sandy clay loam; upper part, clay loam of close texture. *Condition*, excellent, very little vegetation of any sort; lower part of channel more uniform and regular than upper part. *Constructed*, May, 1913. (Pl. 3, A and fig. 3, A.)
Feb. 13, 1915	6.20	63.3	678.4	320.0	2.12	4.61	.000159	.025	
Feb. 11, 1915	8.05	68.5	906.4	440.0	2.06	5.79	.000132	.028	
Feb. 10, 1915	9.45	72.5	1,102.1	535.0	2.06	6.65	.000118	.029	
Feb. 9, 1915	10.85	76.5	1,363.2	640.0	2.13	7.49	.000104	.029	
Jan. 27, 1915	11.10	77.3	1,635.9	657.0	2.49	7.67	.000127	.027	
Feb. 8, 1915	12.20	79.8	1,650.0	750.0	2.20	8.38	.000102	.030	
Feb. 2, 1915	14.80	86.1	3,142.8	970.0	3.24	10.00	.000195	.031	
Feb. 4, 1915	14.80	86.1	2,929.4	970.0	3.02	10.00	.000165	.031	
	[1] 18.00								

[1] Average maximum depth at bankful stage.

Main Dredged Channel near Fellsmere, Florida. Approximate bottom width 45 feet. Picture taken in 1917.



Date of observation	Average maximum depth	Average surface width	Discharge	Average cross section	Mean velocity	Mean hydraulic radius	Slope of water surface	Coefficient of roughness n	Description of channel
	Feet	*Feet*	*Second-feet*	*Sq. ft.*	*Ft. per sec.*	*Feet*			
Oct. 12, 1916	1.40	45.5	48.8	48.2	1.01	1.05	0.000328	0.025	*Course*, straight; 2,000 feet long. *Cross section*, slight variations in shape; for variation in size, see fig. 13, A. *Side slopes*, lower, fairly regular; upper, rather irregular. *Bottom*, regular and even. *Soil*, coarse sand on bottom, clay on sides. *Condition*, some vegetation, principally dog fennel, for higher stages; practically no vegetation for lower stages. *Constructed*, November, 1911. (Pl. 15, A.)
Dec. 5, 1916	1.7	46.4	64.7	63.1	1.02	1.32	.000260	.026	
Sept. 22, 1916	5.6	75.6	506.2	298.0	1.70	3.83	.000222	.032	
do	5.7	76.5	534.0	302.2	1.77	3.83	.000198	.029	
do	5.75	76.5	558.6	314.8	1.77	3.97	.000205	.030	
	[1] 15.9								
Feb. 10, 1917	1.6	45.6	44.2	48.1	0.92	1.05	0.000259	0.025	Condition of channel practically the same as during the 1916 measurements. For variation in size of channel see fig. 13, B. See fig. 12, B, for cross section.
July 12, 1917	2.3	49.3	94.7	83.1	1.14	1.66	.000235	.027	
Oct. 18, 1917	3.2	53.5	186.4	127.7	1.46	2.33	.000236	.027	
Sept. 29, 1917	5.0	68.8	403.1	241.4	1.67	3.15	.000200	.027	
do	7.6	88.5	746.8	441.9	1.69	4.86	.000185	.036	
	[1] 15.9								

[1] Average maximum depth at bankful stage.

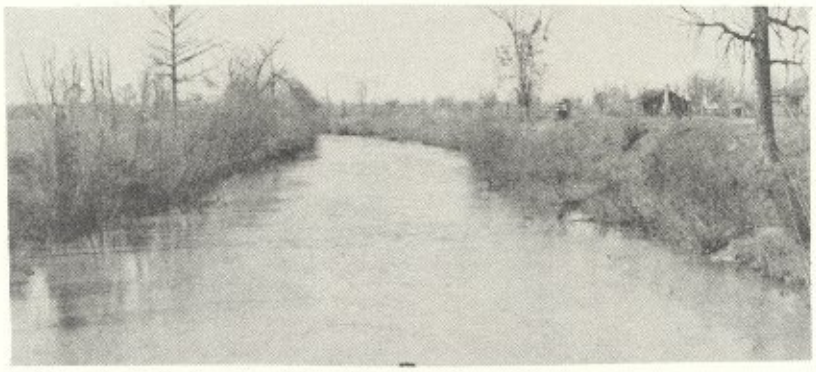
Dredged Ditch No. 43 of Cypress Creek Drainage District near Arkansas City, Arkansas. Approximate bottom width 55 feet. Picture taken July 1926.

A

Date of observation	Average maximum depth	Average surface width	Discharge	Average cross section	Mean velocity	Mean hydraulic radius	Slope of water surface	Coefficient of roughness n	Description of channel
	Feet	*Feet*	*Second-feet*	*Sq. ft.*	*Ft. per sec.*	*Feet*			
May 3, 1926	4.1	68.2	150.7	206.5	0.73	2.92	0.0000630	0.032	*Course*, straight; 1,710 feet long. *Cross section*, not much variation in shape; for variation in size, see fig. 15, A. *Side slopes*, somewhat irregular. *Bottom*, rather irregular and uneven. *Soil*, heavy silty clay. *Condition*, practically no vegetation or obstructions in channel; newly dredged. *Constructed*, September, 1924. (Pl. 17, A and fig. 14, A.)
Feb. 19, 1926	4.7	70.4	250.1	250.6	1.00	3.42	.0000807	.030	
May 11, 1926	6.0	74.4	371.2	336.2	1.10	4.34	.0000708	.031	
Mar. 7, 1926	9.9	85.0	1,178.2	660.0	1.78	7.18	.0000824	.030	
Jan. 26, 1926	10.1	85.1	900.6	670.2	1.34	7.27	.0000555	.034	
Jan. 23, 1926	10.3	86.0	1,401.2	693.9	2.02	7.47	.0001000	.030	
Mar. 7, 1926	10.9	87.1	1,648.7	743.0	2.22	7.87	.0000988	.028	
Mar. 9, 1926	11.2	87.7	1,374.0	766.3	1.79	8.06	.0000707	.031	
Dec. 16, 1925	12.6	90.4	1,788.5	896.9	1.99	8.99	.0000737	.030	
Nov. 5, 1925	16.2	98.6	3,460.8	1,255.9	2.75	11.27	.0000988	.029	
Nov. 13, 1925	16.8	99.7	3,063.1	1,314.3	2.33	11.61	.0000649	.029	
Nov. 9, 1925	17.2	100.8	3,386.5	1,348.0	2.51	11.77	.0000792	.030	
Nov. 10, 1925	17.2	100.8	3,407.5	1,346.7	2.53	11.76	.0000830	.030	
	[1] 18.0								

[1] Average maximum depth at bankful stage.

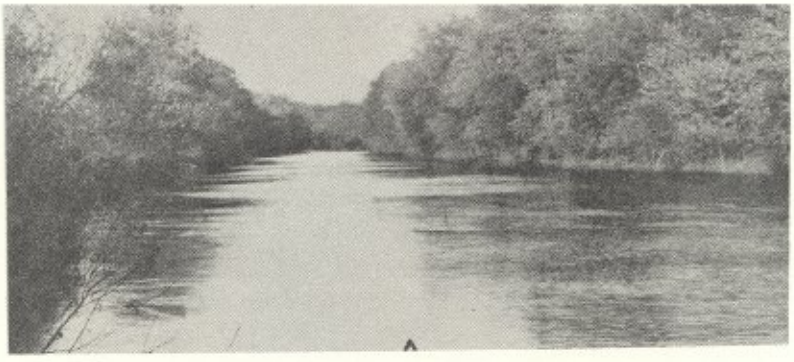
Bogue Phalia Natural Channel near Heads, Mississippi. Approximate bottom width 80 feet. Picture taken March 1926.



Date of observation	Average maximum depth	Average surface width	Discharge	Average cross section	Mean velocity	Mean hydraulic radius	Slope of water surface	Coefficient of roughness n	Description of channel
Mar. 15, 1926	8.8	121	944	756	1.25	6.09	0.000072	0.036	*Course*, nearly straight, slight curve at lower end; 1,554 feet long. *Cross section*, very little variation in shape; for variation in size, see fig. 4, B. *Side slopes*, very irregular. *Bottom*, irregular and uneven. *Soil*, clay loam, sandy bottom. *Condition*, weeds and small trees along banks; natural channel; was cleaned of all growth and obstructions in 1915. (Pl. 3, B and fig. 3, B.)
Nov. 17, 1925	10.4	132	1,080	965	1.12	7.10	.000056	.041	
Mar. 7, 1926	11.8	142	2,867	1,157	2.48	7.92	.000214	.037	
Mar. 9, 1926	12.5	147	2,383	1,260	1.89	8.32	.000106	.036	
Jan. 22, 1926	12.8	150	2,875	1,310	2.19	8.51	.000139	.036	
Mar. 8, 1926	13.5	154	3,064	1,405	2.18	8.84	.000132	.036	
Feb. 29, 1924	14.3	160	3,192	1,527	2.09	9.25	.000109	.036	
Dec. 17, 1925	14.5	162	3,000	1,550	1.94	9.32	.000112	.040	
Feb. 28, 1924	15.6	168	4,000	1,751	2.30	10.06	.000136	.038	
	[1] 20.0								

[1] Average maximum depth at bankful stage.

Natural Channel of Embarrass River near Charleston, Illinois. Approximate bottom width 100 feet. Picture taken in 1926.



Date of observation	Average maximum depth	Average surface width	Discharge	Average cross section	Mean velocity	Mean hydraulic radius	Slope of water surface	Coefficient of roughness n	Description of channel
	Feet	*Feet*	*Second-feet*	*Sq. ft.*	*Ft. per sec.*	*Feet*			
Apr. 13, 1926	8.7	139.3	1,974.9	945.3	2.09	6.52	0.000136	0.030	*Course*, straight; 1,000 feet long. *Cross section*, very little variation in shape; for variation in size, see fig. 20, A. *Side slopes*, somewhat irregular. *Bottom*, fairly even and regular. *Soil*, lower part, light gray silty clay; upper part, light tan silt loam. *Condition*, bottom comparatively clean and smooth, upper part of side slopes covered with large trees; natural channel. (Pl. 24, A and fig. 19, A.)
Feb. 27, 1926	9.9	146.4	2,500.7	1,119.2	2.23	7.32	.000128	.030	
Apr. 10, 1926	13.5	180.0	4,265.4	1,700.1	2.51	9.04	.000128	.031	
Sept. 14, 1926	13.7	182.1	4,318.9	1,740.7	2.48	9.15	.000128	.032	
Sept. 12, 1926	16.2	219.1	5,868.6	2,275.5	2.58	9.95	.000140	.034	
Sept. 9, 1926	17.6	237.4	6,237.4	2,605.8	2.39	10.45	.000087	.030	
Oct. 5, 1926	[1] 19.3	243.2	8,857.0	3,011.6	2.94	11.72	.000175	.038	

[1] Average maximum depth at bankful stage.

An estimate of "n" for this channel with no growth on the banks would be 0.025.

PREFACE

SUPPLEMENT B

HYDRAULICS

This supplement expands and augments subsection 4.4 of the Hydraulics Section of the Engineering Handbook.

The objective of Supplement B is to present a systematic procedure for the estimation of n values for use in hydraulic computations associated with natural streams, floodways and drainage channels.

This method of estimating roughness coefficients was developed by Woody L. Cowan. Mrs. Vivian Edwards typed the manuscript.

August 1, 1956

This supplement describes a method for estimating the roughness coefficient n for use in hydraulic computations associated with natural streams, floodways and similar streams. The procedure proposed applies to the estimation of n in Manning's formula. This formula is now widely used, it is simpler to apply than other widely recognized formulas and has been shown to be reliable.

Manning's formula is empirical. The roughness coefficient n is used to quantitatively express the degree of retardation of flow. The value of n indicates not only the roughness of the sides and bottom of the channel, but also all other types of irregularities of the channel and profile. In short, n is used to indicate the net effect of all factors causing retardation of flow in a reach of channel under consideration.

There seems to have developed a tendency to regard the selection of n for natural channels as either an arbitrary or an intuitive process. This probably results from the rather cursory treatment of the roughness coefficient in most of the more widely used hydraulic textbooks and handbooks. The fact is that the estimation of n requires the exercise of critical judgment in the evaluation of the primary factors affecting n. These factors are: irregularity of the surfaces of the channel sides and bottom; variations in shape and size of cross sections; obstructions; vegetation; meandering of the channel.

The need for realistic estimates of n justifies the adoption of a systematic procedure for making the estimates.

Procedure for estimating n. The general procedure for estimating n involves; first, the selection of a basic value of n for a straight, uniform, smooth channel in the natural materials involved; then, through critical consideration of the factors listed above, the selection of a modifying value associated with each factor. The modifying values are added to the basic value to obtain n for the channel under consideration.

In the selection of the modifying values associated with the 5 primary factors it is important that each factor be examined and considered independently. In considering each factor, it should be kept in mind that n represents a quantitative expression of retardation of flow. Turbulence of flow can, in a sense, be visualized as a measure or indicator of retardance. Therefore, in each case, more critical judgment may be exercised if it is recognized that as conditions associated with any factor change so as to induce greater turbulence, there should be an increase in the modifying value. A discussion and tabulated guide to the selection of modifying values for each factor is given under the following procedural steps.

1st step. Selection of basic n value. This step requires the selection of a basic n value for a straight, uniform, smooth channel in the natural materials involved. The selection involves consideration of what may be regarded as a hypothetical channel. The conditions of straight alignment, uniform cross section, and smooth side and bottom surfaces without vegetation should be kept in mind. Thus the basic n will be visualized as varying only with the materials forming the sides and bottom of the channel. The minimum values of n shown by reported test results for the best channels in earth are in the range from 0.016 to 0.018. Practical limitations associated with maintaining smooth and uniform channels in earth for any appreciable period indicate that 0.02 is a realistic basic n. The basic n, as it is intended for use in this procedure, for natural or excavated channels, may be selected from the table below. Where the bottom and sides of a channel are of different materials this fact may be recognized in selecting the basic n.

Character of channel	Basic n
Channels in earth	0.02
Channels cut into rock	0.025
Channels in fine gravel	0.024
Channels in coarse gravel	0.028

2nd step. Selection of modifying value for surface irregularity. The selection is to be based on the degree of roughness or irregularity of the surfaces of channel sides and bottom. Consider the actual surface irregularity; first, in relation to the degree of surface smoothness obtainable with the natural materials involved, and second, in relation to the depths of flow under consideration. Actual surface irregularity comparable to the best surface to be expected of the natural materials involved calls for a modifying value of zero. Higher degrees of irregularity induce turbulence and call for increased modifying values. The table below may be used as a guide to the selection.

Degree of irregularity	Surfaces comparable to	Modifying value
Smooth	The best obtainable for the materials involved.	0.000
Minor	Good dredged channels; slightly eroded or scoured side slopes of canals or drainage channels.	0.005
Moderate	Fair to poor dredged channels; moderately sloughed or eroded side slopes of canals or drainage channels.	0.010
Severe	Badly sloughed banks of natural channels; badly eroded or sloughed sides of canals or drainage channels; unshaped, jagged and irregular surfaces of channels excavated in rock.	0.020

3rd step. Selection of modifying value for variations in shape and size of cross sections. In considering changes in size of cross sections judge the approximate magnitude of increase and decrease in successive cross sections as compared to the average. Changes of considerable magnitude, if they are gradual and uniform, do not cause significant turbulence. The greater turbulence is associated with alternating large and small sections where the changes are abrupt. The degree of effect of size changes may be best visualized by considering it as depending primarily on the frequency with which large and small sections alternate and secondarily on the magnitude of the changes.

In the case of shape variations, consider the degree to which the changes cause the greatest depth of flow to move from side to side of the channel. Shape changes causing the greatest turbulence are those for which shifts of the main flow from side to side occur in distances short enough to produce eddies and upstream currents in the shallower portions of those sections where the maximum depth of flow is near either side. Selection of modifying values may be based on the following guide:

Character of variations in size and shape of cross sections	Modifying value
Changes in size or shape occurring gradually	0.000
Large and small sections alternating occasionally or shape changes causing occasional shifting of main flow from side to side	0.005
Large and small sections alternating frequently or shape changes causing frequent shifting of main flow from side to side	0.010 to 0.015

4th step. Selection of modifying value for obstructions. The selection is to be based on the presence and characteristics of obstructions such as debris deposits, stumps, exposed roots, boulders, fallen and lodged logs. Care should be taken that conditions considered in other steps are not re-evaluated or double-counted by this step.

In judging the relative effect of obstructions, consider: the degree to which the obstructions occupy or reduce the average cross sectional area at various stages; the character of obstructions, (sharp-edged or angular objects induce greater turbulence than curved, smooth-surfaced objects); the position and spacing of obstructions transversely and longitudinally in the reach under consideration. The following table may be used as a guide to the selection.

Relative effect of obstructions	Modifying value
Negligible	0.000
Minor	0.010 to 0.015
Appreciable	0.020 to 0.030
Severe	0.040 to 0.060

5th step. Selection of modifying value for vegetation. The retarding effect of vegetation is probably due primarily to the turbulence induced as the water flows around and between the limbs, stems and foliage, and secondarily to reduction in cross section. As depth and velocity increase, the force of the flowing water tends to bend the vegetation. Therefore, the ability of vegetation to cause turbulence is partly related to its resistance to bending force. Furthermore, the amount and character of foliage; that is, the growing season condition versus dormant season condition is important. In judging the retarding effect of vegetation, critical consideration should be given to the following: the height in relation to depth of flow; the capacity to resist bending; the degree to which the cross section is occupied or blocked out; the transverse and longitudinal distribution of vegetation of different types, densities and heights in the reach under consideration. The following table may be used as a guide to the selection:

Vegetation and flow conditions comparable to:	Degree of effect on n	Range in modifying value
Dense growths of flexible turf grasses or weeds, of which Bermuda and blue grasses are examples, where the average depth of flow is 2 to 3 times the height of vegetation.	Low	0.005 to 0.010
Supple seedling tree switches such as willow, cottonwood or salt cedar where the average depth of flow is 3 to 4 times the height of the vegetation.		
Turf grasses where the average depth of flow is 1 to 2 times the height of vegetation.		
Stemmy grasses, weeds or tree seedlings with moderate cover where the average depth of flow is 2 to 3 times the height of vegetation.	Medium	0.010 to 0.025
Brushy growths, moderately dense, similar to willows 1 to 2 years old, dormant season, along side slopes of channel with no significant vegetation along the channel bottom, where the hydraulic radius is greater than 2 feet.		

Turf grasses where the average depth of flow is about equal to the height of vegetation.		
Dormant season, willow or cottonwood trees 8 to 10 years old, intergrown with some weeds and brush, none of the vegetation in foliage, where the hydraulic radius is greater than 2 feet.	High	0.025 to 0.050
Growing season, bushy willows about 1 year old intergrown with some weeds in full foliage along side slopes, no significant vegetation along channel bottom, where hydraulic radius is greater than 2 feet.		
Turf grasses where the average depth of flow is less than one half the height of vegetation.		
Growing season, bushy willows about 1 year old, intergrown with weeds in full foliage along side slopes; dense growth of cattails along channel bottom; any value of hydraulic radius up to 10 or 15 feet.	Very high	0.050 to 0.100
Growing season; trees intergrown with weeds and brush, all in full foliage; any value of hydraulic radius up to 10 or 15 feet.		

A further basis for judgment in the selection of the modifying value for vegetation may be found in Table 1 which contains descriptions and data for actual cases where n has been determined. In each of the cases listed in Table 1 the data were such that the increase in n due to vegetation could be determined within reasonably close limits.

6th step. Determination of the modifying value for meandering of channel. The modifying value for meandering may be estimated as follows: Add the basic n for Step 1 and the modifying values of Steps 2 through 5 to obtain the subtotal of n_s.

Let ℓ_s = the straight length of the reach under consideration.

ℓ_m = the meander length of the channel in the reach.

Compute modifying value for meandering in accordance with the following table

Ratio ℓ_m/ℓ_s	Degree of meandering	Modifying value
1.0 to 1.2	Minor	0.000
1.2 to 1.5	Appreciable	0.15 n_s
1.5 and greater	Severe	0.30 n_s

Where lengths for computing the approximate value of ℓ_m/ℓ_s are not readily obtainable the degree of meandering can usually be judged reasonably well.

7th step. Computation of n for the reach. The value of n for the reach is obtained by adding the values determined in Steps 1 through 6. An illustration of the estimation of n is given in Example 1.

Dealing with cases where both channel and flood plain flow occurs.

Work with natural streams and floodways often requires consideration of a wide range of discharges. At the higher stages both channel and overbank or flood plain flow are involved. Usually the conditions are such that the channel and flood plain will have different degrees of retardance and, therefore, different n values. In such cases the hydraulic computations will be improved by dividing the cross sections into parts or subdivisions having different n values.

The reason for and effect of subdividing cross sections is to permit the composite n for the reach to vary with stage above the bankfull stage. This effect is illustrated by Example 2. The usual practice is to divide the cross section into two parts; one subdivision being the channel portion and the other the flood plain. More than two subdivisions may be made if conditions indicate wide variations of n. However, in view of the practical aspects of the problem, more than three subdivisions would not normally be justified.

In estimating n for the channel subdivision, all of the factors discussed above and all of the procedural steps would be considered. Although conditions might indicate some variation of n with stage in the channel, it is recommended that an average value of n be selected for use in the hydraulic computations for all stages.

In the case of flood plain subdivisions, the estimate of n would consider all factors except meandering. That is, the estimate would employ all of the procedural steps except Step 6. Flood plain n values will normally be somewhat greater than the channel values. Agricultural flood plain conditions are not likely to indicate an n less than 0.05 to 0.06. Many cases will justify values in the 0.07 to 0.09 range and cases calling for values as high as 0.15 to 0.20 may be encountered. These higher values apply primarily because of the relatively shallow depths of flow. The two

factors requiring most careful consideration are obstructions and vegetation. Many agricultural flood plains have fairly dense networks of fences to be evaluated as obstructions in Step 4. Vegetation probably would be judged on the basis of growing season conditions.

Field and office work.

It is suggested that field parties record adequate notes on field conditions pertinent to the five factors affecting n at the time cross section surveys are being made. The actual estimates of n may then be made in the office. This will require training of both field and office personnel. The conditions to be covered by field notes and considered in the estimate of n apply to a reach of channel and flood plain. It is not adequate to consider only those conditions in the immediate vicinity of a cross section. Note the sketch on Figure B.1. With cross sections located as shown, field notes should describe the channel and flood plain conditions through the reach indicated as a basis for estimating the n values (assuming subdivided sections) to be incorporated in the hydraulic computations at Section 2.

Figure B.2 shows a sample set of notes that illustrate the type of field information to be recorded as a basis for estimating n. Field men should be trained to recognize and record in brief statements those conditions that are necessary for realistic evaluation of the five factors discussed under procedural Steps 1 to 6.

Example 1. Estimation of n for a reach.

This example is based on a case where n has been determined so that comparison between the estimated and actual n can be shown.

Channel: Camp Creek dredged channel near Seymour, Illinois; see USDA Technical Bulletin No. 129, Plate 29-C for photograph and Table 9, page 86, for data.

Description: Course straight; 661 feet long. Cross section, very little variation in shape; variation in size moderate, but changes not abrupt. Side slopes fairly regular, bottom uneven and irregular. Soil, lower part yellowish gray clay; upper part, light gray silty clay loam. Condition, side slopes covered with heavy growth of poplar trees 2 to 3 inches in diameter, large willows and climbing vines; thick growth of water weed on bottom; summer condition with vegetation in full foliage.

Average cross section approximates a trapezoid with side slopes about 1.5 to 1 and bottom width about 10 feet. At bankfull stage, average depth and surface width are about 8.5 and 40 feet respectively.

Step	Remarks	Modifying values
1	Soil materials indicate minimum basic n.	0.02
2	Description indicates moderate irregularity.	0.01
3.	Changes in size and shape judged insignificant.	0.00
4.	No obstructions indicated.	0.00
5.	Description indicates very high effect of vegetation.	0.08
6.	Reach described as straight.	0.00
	Total estimated n	0.11

USDA Technical Bulletin No. 129, Table 9, page 96, gives the following determined values for n for this channel: for average depth of 4.6 feet n = 0.095; for average depth of 7.3 feet n = 0.104.

Example 2. Effect of subdividing cross sections.

The sole purpose of this example is to illustrate the effect of subdividing sections on the value of n for the complete section. It is not an illustration of hydraulic computations for determining water surface profiles or stage-discharge relationships.

This illustration is based on the following:

1. An actual stream cross section for which curves showing depth versus area and depth versus hydraulic radius for the channel and flood plain subdivisions and for the complete section are plotted on Figure B.3. Values of n are: for the channel subdivision 0.04; for the flood plain subdivision 0.08.

2. The conditions of uniform, steady flow are assumed.

   Manning's formula is handled in accordance with Leach's method. See Handbook of Hydraulics, McGraw-Hill Book Company, 3rd edition, page 534; 4th edition, page 8-65.

Notation:

Q = discharge - cfs

a = cross section area - $ft.^2$

r = hydraulic radius, ft.

p = wetted perimeter, ft.

s_o = channel slope, ft. per ft.

n = roughness coefficient

$$Q = \frac{1.486}{n} \; a \; r^{2/3} \; s_o^{1/2} \qquad (B.1)$$

Let $K_d = \frac{1.486}{n} \; a \; r^{2/3}$, then

$$Q = K_d \; s_o^{1/2} \qquad (B.2)$$

Assume the conditions are such that it is desirable to recognize more than one subdivision, each having a different n. Let subscripts 1, 2, and 3 refer to the section subdivisions and subscript t to the total section.

From equation B.2

$$Q = \left(K_{d1} + K_{d2} + K_{d3} - - - - + K_{dn}\right) s_o^{1/2} = \Sigma K_d \; s_o^{1/2} \qquad (B.3)$$

Also: $\frac{Q}{s_o^{1/2}} = \Sigma K_d = \frac{1.486}{n_t} \; a_t \; r_t^{2/3}$; therefore

$$n_t = \frac{1.486 \; a_t \; r_t^{2/3}}{\Sigma K_d} \qquad (B.4)$$

Table B.2 shows the computations for Example 2 and Figure B.3 shows a plot of roughness coefficient for the complete section versus depth.

In natural streams n normally shows a minor decrease as stage increases up to, or somewhat above, the bankfull stage, then appreciably increases as overbank stage increases. When n is significantly different for different parts of the cross section, subdivision of the cross section, as a basis for making the computations, automatically causes n_t to vary with stage above the bankfull stage. This is true although n_t is not computed in methods for determining water surface profiles. Note on Figure B.3 that n_t, which has been computed in Example 2 for illustrative purposes, shows considerable increase with stage above the 10-foot depth and that this increase is automatically recognized by subdivision of the cross section.

The plot of hydraulic radius on Figure B.3 illustrates a typical characteristic of natural streams. Note that the hydraulic radius for the complete section increases up to bankfull depth, then decreases through a limited range of depth, and again increases as depth of overbank flow increases.

This example also illustrates that recognition of high retardance for flood plain subdivisions by the use of relatively high n values does not cause n for the complete section, n_t, to be unreasonably high. In this case, the channel and flood plain are assigned n values of 0.04 and 0.08. The value of n_t ranges up to 0.072 as shown by Table B.2 and Figure B.3.

Table B.1 Examples of effect of vegetation on n. (Sheet 1 of 3)

Example No.	Names and Descriptions of Channels. Names, Plates and Tables Refer to USDA Technical Bulletin No. 129, November 1929	Range in mean velocity	Range in hydraulic radius	Average value n	Modifying value
1.	Fountain Head dredged channel near Champaign, Illinois; Plate 31-B and C, Table 9. Average cross section of channel resembles a parabola. At bankfull stage depth about 8 ft., top width about 30 feet.	2.09 to 2.59	1.73 to 2.42		
	a. Dormant season. Dry weeds on side slopes, no vegetation on bottom. Retarding effect of vegetation negligible.			0.031	
	b. Growing season, otherwise vegetation same as above. Heavy growth of weeds and grass in full foliage on side slopes.			0.037	0.006
2.	Cummins Lake dredged channel near Gould, Arkansas; Plate 18-B and C, Table 7. Average cross section of channel resembles a parabola. At bankfull stage depth about 13 ft., top width about 75 feet.	0.53 to 1.82	2.41 to 6.23		
	a. Side slopes moderately irregular from erosion and sloughing; estimated n for channel without vegetation 0.035.				
	b. Dormant season. Willows about one year old and 6 to 10 feet high continuous along side slopes except for about the upper third of sides. No growth in a strip about 20 feet wide along bottom. No foliage.			0.056	0.021
	c. Growing season, otherwise vegetation same as above. Willows and some weeds in full foliage. No vegetation along bottom.			0.072	0.037

Table B.1 Examples of effect of vegetation on n. (Sheet 2 of 3)

Example No.	Names and Descriptions of Channels. Names, Plates and Tables Refer to USDA Technical Bulletin No. 129, November 1929	Range in mean velocity	Range in hydraulic radius	Average value n	Modifying value
3.	Lateral Ditch No. 15 near Bement, Illinois; Plate 30-A, B and C, Table 9. Average cross section is practically a trapezoid with wide slopes about 1.1 and bottom width and depth each about 10 feet.	0.28 to 1.71	1.16 to 5.61		
	a. Dormant season. Dead weeds practically flat on side slopes; no dead growth in bottom.			0.033	
	b. Dormant season. Bushy willows about 1 year old and dead weeds on side slopes. No vegetation along bottom of channel. No foliage.			0.055	0.022
	c. Growing season. Vegetation same as b, above, except willows and weeds in full foliage. No vegetation on bottom.			0.072	0.039
	d. Growing season. Bushy willows and weeds in full foliage along side slopes. Dense growth of cattails along bottom.			0.119	0.086
	Ditch No. 18 of Cypress Creek drainage district near Arkansas City, Arkansas; Plate 17-B and C, Table 7. Average cross section is approximately triangular; at bankfull stage depth about 13 ft., top width about 70 feet.	0.47 to 1.08	1.91 to 6.23		
	a. Dredged channel about 8 years old. Side slopes moderately irregular. Estimated n for the channel without vegetation 0.035.				
	b. Dormant season. Practically the entire reach covered with trees, mostly willows and cottonwoods. Some dry weeds and brush. No foliage.			0.061	0.026

Table B.1 Examples of effect of vegetation on n. (Sheet 3 of 3)

Example No.	Names and Descriptions of Channels. Names, Plates and Tables Refer to USDA Technical Bulletin No. 129, November 1929.	Range in mean velocity	Range in hydraulic radius	Average value n	Modifying value
	c. Growing season. Vegetation described under b; in full foliage.			0.103	0.068
5.	Lake Fork special dredged channel near Bement, Illinois; Plate 25-A, B, and C, Table 9. Average cross section is approximately parabolic; at bankfull stage depth about 13 ft., top width about 65 to 70 feet.	0.79 to 1.65	3.55 to 7.33		
	a. Dormant season. Channel cleared; practically no vegetation of any type in channel.			0.031	
	b. Dormant season. Densely growing, bushy willows continuous along side slopes; some poplar saplings scattered among willows. No growth in a strip 20 to 30 feet wide along bottom. No foliage.			0.071	0.040
	c. Growing season. Vegetation described under b; in full foliage.			0.092	0.061
6.	Ditch No. 1 of Little River drainage district near Chafee, Missouri; Plate 21-B and C, Table 8. Average cross section trapezoidal, side slopes about 1.1, bottom width about 10 ft., depth about 8 feet.	0.68 to 1.51	2.00 to 4.26		
	a. Channel newly cleared, practically no vegetation			0.031	
	b. Dormant season. Dense, bushy willows continuous along side slopes; no foliage. No vegetation along bottom of channel.			0.071	0.040

Table B.2 Computations for Example 2.

Depth	a_1	r_1	$r_1^{2/3}$	K_{d1}	a_2	r_2	$r_2^{2/3}$	K_{d2}	ΣK_d	a_t	r_t	$r_t^{2/3}$	K	n_t
0.0	0	0.00	0.000	0	0	0.00	0.000	0	0	0	0.00	0.000	0	0.000
4.7	90	3.33	2.230	7450	0	0.00	0.000	0	7450	90	3.33	2.230	298	0.040
7.8	180	5.29	3.036	20250	0	0.00	0.000	0	20250	180	5.29	3.036	810	0.040
9.7	240	7.06	3.680	31900	750	1.06	1.040	14500	46400	990	1.31	1.197	1760	0.038
11.7	300	8.82	4.269	47500	2238	2.88	2.024	84000	131500	2538	3.14	2.144	8090	0.062
13.7	360	10.59	4.822	64400	3853	4.58	2.758	197000	261400	4213	4.82	2.854	17850	0.069
16.7	450	13.22	5.591	93400	6488	7.08	3.687	444000	537400	6938	7.30	3.763	38750	0.072

$$K_{d1} = \frac{1.486}{0.040} a_1 r_1^{2/3} = 37.15\, a_1 r_1^{2/3}$$

$$K_{d2} = \frac{1.486}{0.080} a_2 r_2^{2/3} = 18.58\, a_2 r_2^{2/3}$$

$$K = 1.486\, a_t r_t^{2/3}$$

$$n_t = \frac{K}{K_d}$$

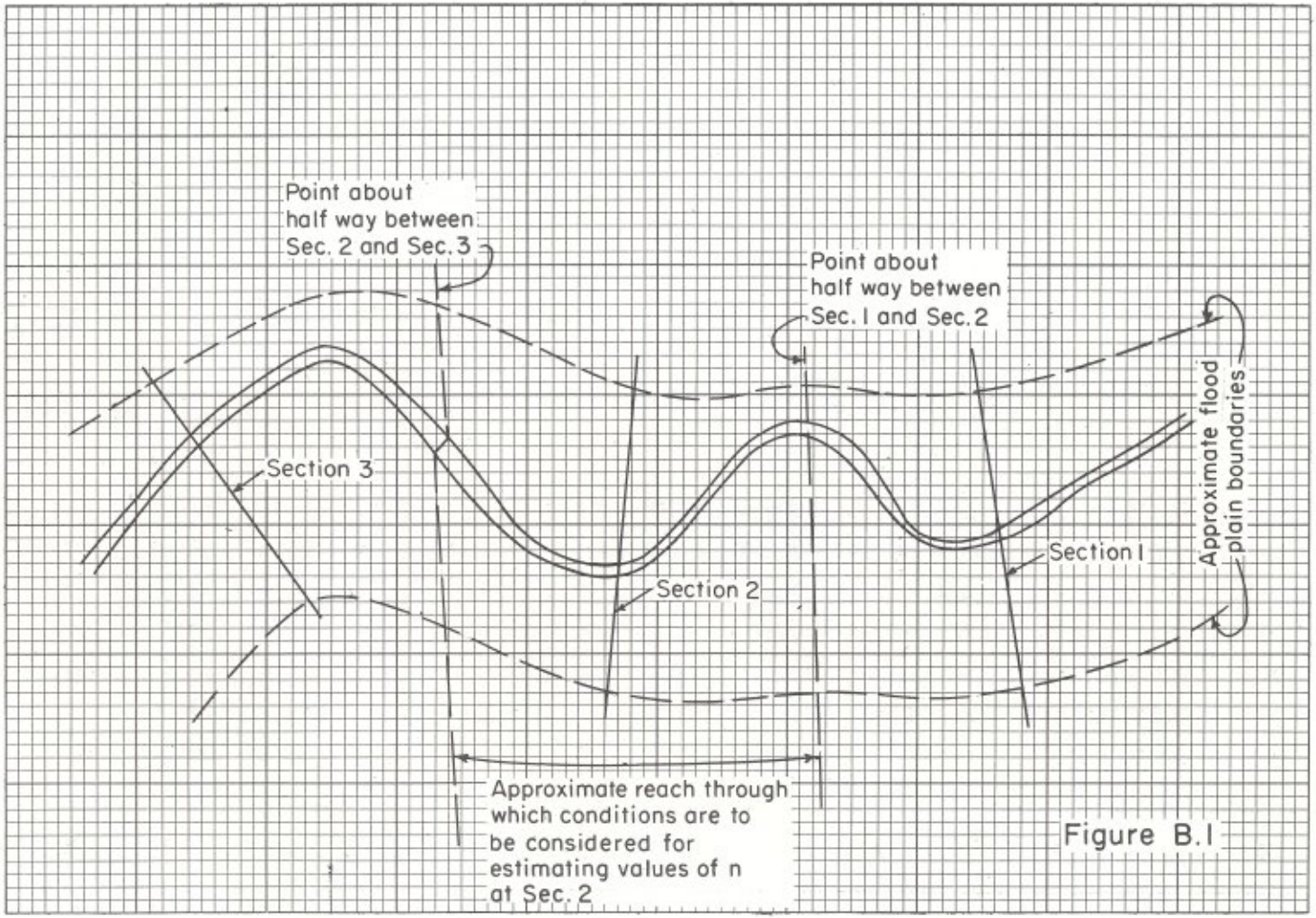
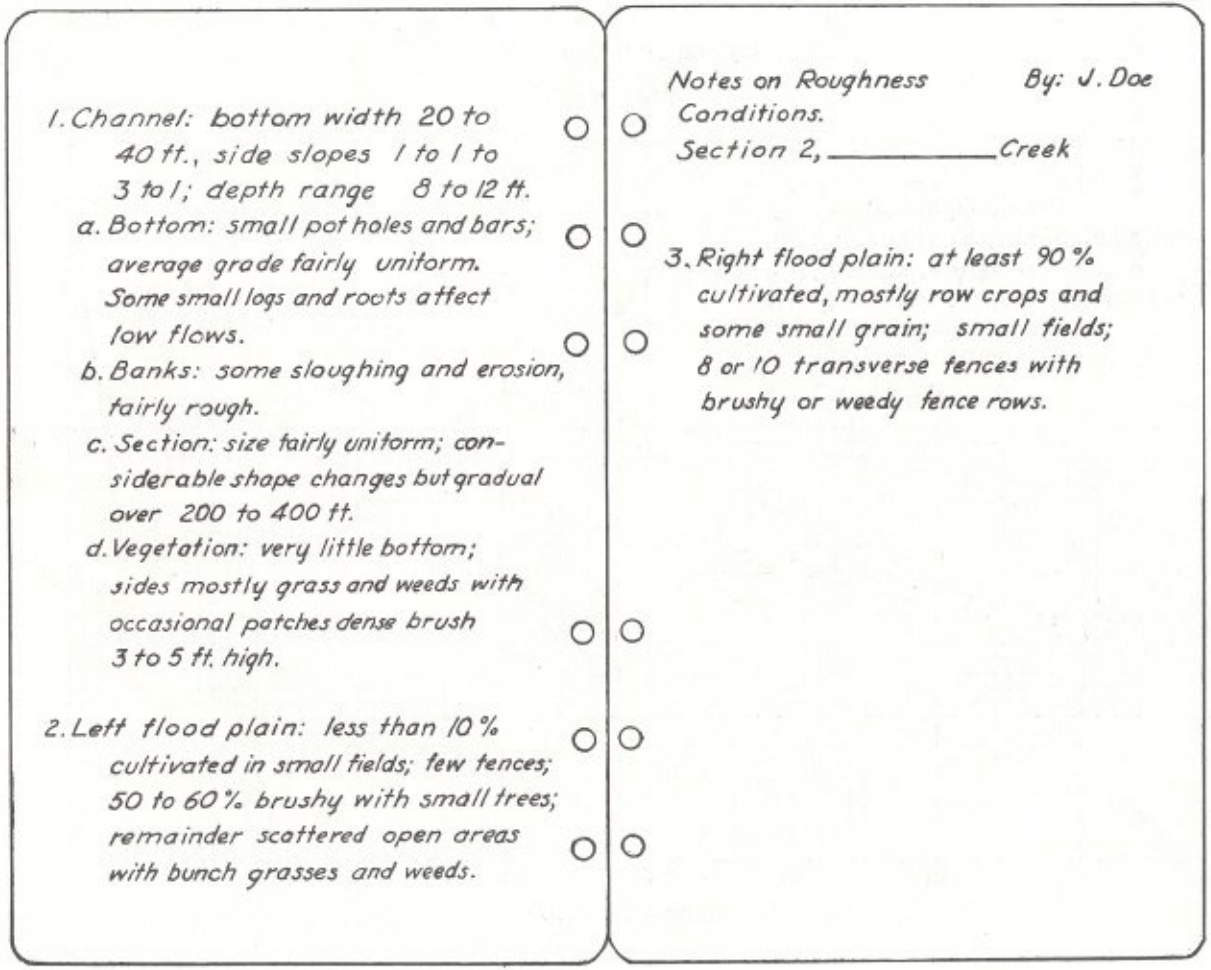

Point about
half way between
Sec. 2 and Sec. 3
Point about
half way between
Sec. 1 and Sec. 2
Section 3
Section 2
Section 1
Approximate flood
plain boundaries
Approximate reach through
which conditions are to
be considered for
estimating values of n
at Sec. 2

Figure B.1

Figure B.2 Sample notes on roughness conditions.



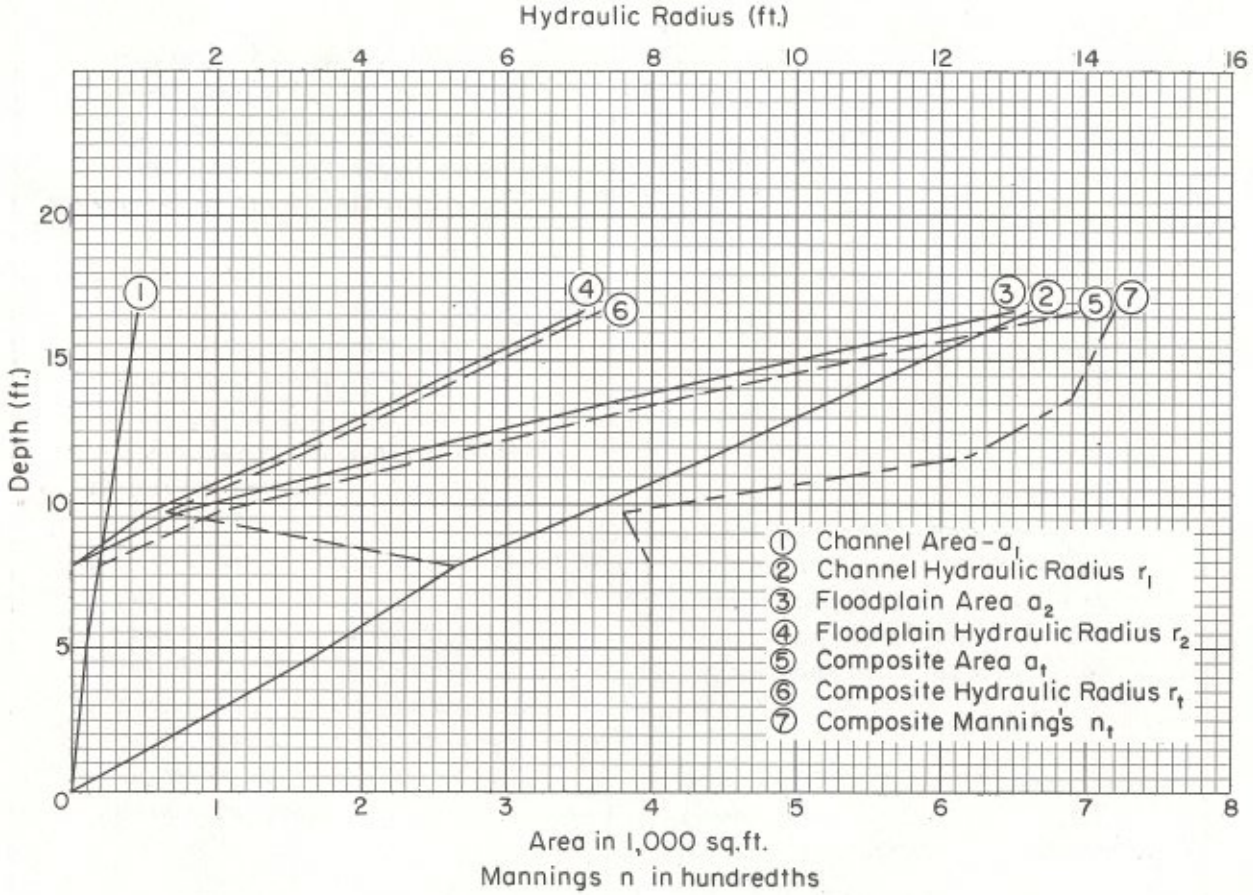

Hydraulic Radius (ft.)
2
4
6
8
10
12
14
16
Depth (ft.)
20
15
10
5
0
1
2
3
4
5
6
7
8
① Channel Area - a_1
② Channel Hydraulic Radius r_1
③ Floodplain Area a_2
④ Floodplain Hydraulic Radius r_2
⑤ Composite Area a_t
⑥ Composite Hydraulic Radius r_t
⑦ Composite Manning's n_t
Area in 1,000 sq.ft.
Mannings n in hundredths

Figure B.3