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Effects of P.L. 566 Stream Channelization on Wetlands in the Prairie Pothole Region

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EFFECTS OF P.L. 566 STREAM CHANNELIZATION ON WETLANDS IN THE PRAIRIE POTHOLE REGION

By

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ON WETLANDS IN THE
PRAIRIE POTHOLE REGION

This thesis is approved as a creditable and independent investigation by a candidate for the degree, Master of Science, and is acceptable as meeting the thesis requirements for this degree, but without implying that the conclusions reached by the candidate are necessarily the conclusions of the major department.

Head, Department of Wildlife and Fisheries Sciences — Date

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[1]The South Dakota Department of Game, Fish and Parks, South Dakota State University, U.S. Fish and Wildlife Service, and Wildlife Management Institute cooperating.

LIST OF APPENDICES

EFFECTS OF P.L. 566 STREAM CHANNELIZATION ON WETLANDS IN THE PRAIRIE POTHOLE REGION

Abstract

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The Wild Rice Creek Watershed project, in North and South Dakota, was constructed under authority of the Small Watershed Protection and Flood Prevention Act (P.L. 83-566 as amended). Structural measures included 24.7 miles of channelization and four floodwater retarding dams.

To measure the degree that channelization influenced drainage of prairie wetlands, drainage rates in a channelized tributary were compared to rates in an unchannelized tributary of Wild Rice Creek. Channelization had a direct impact on wetlands by channel drainage, reduction of overbank flows, and by providing drainage outlets. Indirect (secondary) wetland losses are believed to have occurred outside of the channelized areas. Almost three times more wetland basins and seven times more acres of wetlands were drained in the channelized area than in the unchannelized area before construction (1952-60). Most of that drainage occurred after approval of the Watershed Work Plan. During the years of channel construction and the years following construction (1961-72) more than seven times as many wetlands were drained in the channelized area than the unchannelized area and more than ten times as many acres. Drainage was

3.5 and 6.5 times higher for the wetland basins and acres, respectively, in the channelized area versus the unchannelized during the 1952-72 period.

When drainage of wetlands on two soil types was compared, rates were significantly higher ($P<.05$) on the soil types in the channelized area than in the unchannelized area. Drainage rate of number of wetlands in the 1/4 sections adjacent to the channel was the same as in the 1/4 sections one mile from the channel. Evidently, depth of channel in relation to wetland basin elevation was the major influence on drainage of surface water.

General conclusions concerning drainage in the Wild Rice Creek Watershed were: (1) drainage feasibility increased; (2) not only did the constructed channel stimulate drainage, but anticipation of the channel also had an effect; and (3) presence of the adequate drainage outlet was the major factor influencing decision by the landowner to drain.

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INTRODUCTION

Channelization involves straightening meanders, deepening and widening stream beds, and clearing streams or rivers and their banks of obstructing vegetation for flood control, water conveyance, navigation and/or increasing arable lands. Public concern over the adverse effects of channelization began to rise in the 1960's. In response to such concern, Congressional hearings were held in the early 1970's on channelization related to Federal policies for water resources development (U.S. House of Representatives 1971, U.S. House of Representatives 1973a, U.S. House of Representatives 1973b, and U.S. Senate 1971).

The principal Federal agencies involved in channelization are the Soil Conservation Service (SCS) of the U.S. Department of Agriculture (USDA), the Army Corps of Engineers (C of E) of the U.S. Department of Defense (USDD), the Bureau of Reclamation (Bur. Rec.) of the U.S. Department of the Interior (USDI), and the Tennessee Valley Authority (TVA). The Small Watershed Protection and Flood Prevention Act (P.L. 83-566 as amended), administered by SCS (Appendix A), was passed in 1954 and authorized channelization as a project feature.

The purpose of this study was to measure the degree to which channelization in a P.L. 566 project influenced wetland drainage in the Prairie Pothole Region. The approach was to compare drainage rates in channelized and unchannelized tributaries of a completed watershed project. The project selected was the Wild Rice Creek Watershed located in southeastern North Dakota and northeastern

South Dakota (Fig. 1). Wild Rice Creek is one of 38 SCS watershed projects in various stages of development east of the Missouri River in North Dakota (Soil Conservation Service 1974). In these projects, 320.5 miles of channelization (includes floodways, channel diversions, and channel improvements) have been completed, 27.8 miles are under construction, and 327.4 additional miles are presently planned for installation.

The Wild Rice Creek Watershed was the subject of a special report by the U.S. Fish and Wildlife Service (U.S. Fish and Wildlife Service 1965). One of 42 projects studied for the Council on Environmental Quality (CEQ) by Arthur D. Little, Inc. (Little 1973); it was the only project in which prairie potholes were an issue. Little (1973) recommended further on-site investigations and scientific studies, particularly regarding wetland drainage.

The project area contains 233,522 acres; 158,182 acres in North Dakota and 75,340 acres in South Dakota (Fig. 1). Local project sponsors were the Wild Rice, Sargent County (North Dakota), and Marshall County (South Dakota) Soil Conservation Districts and the Sargent County Water Conservation and Flood Control District (U.S. Department of Agriculture 1957). Technical and financial assistance was provided by the SCS.

The sponsors submitted a project application on 17 March 1955 with planning subsequently authorized 19 April 1956. A Watershed Work Plan was then completed in 1957 and construction authorized on 19 June 1958. Four supplements were added to the original plan

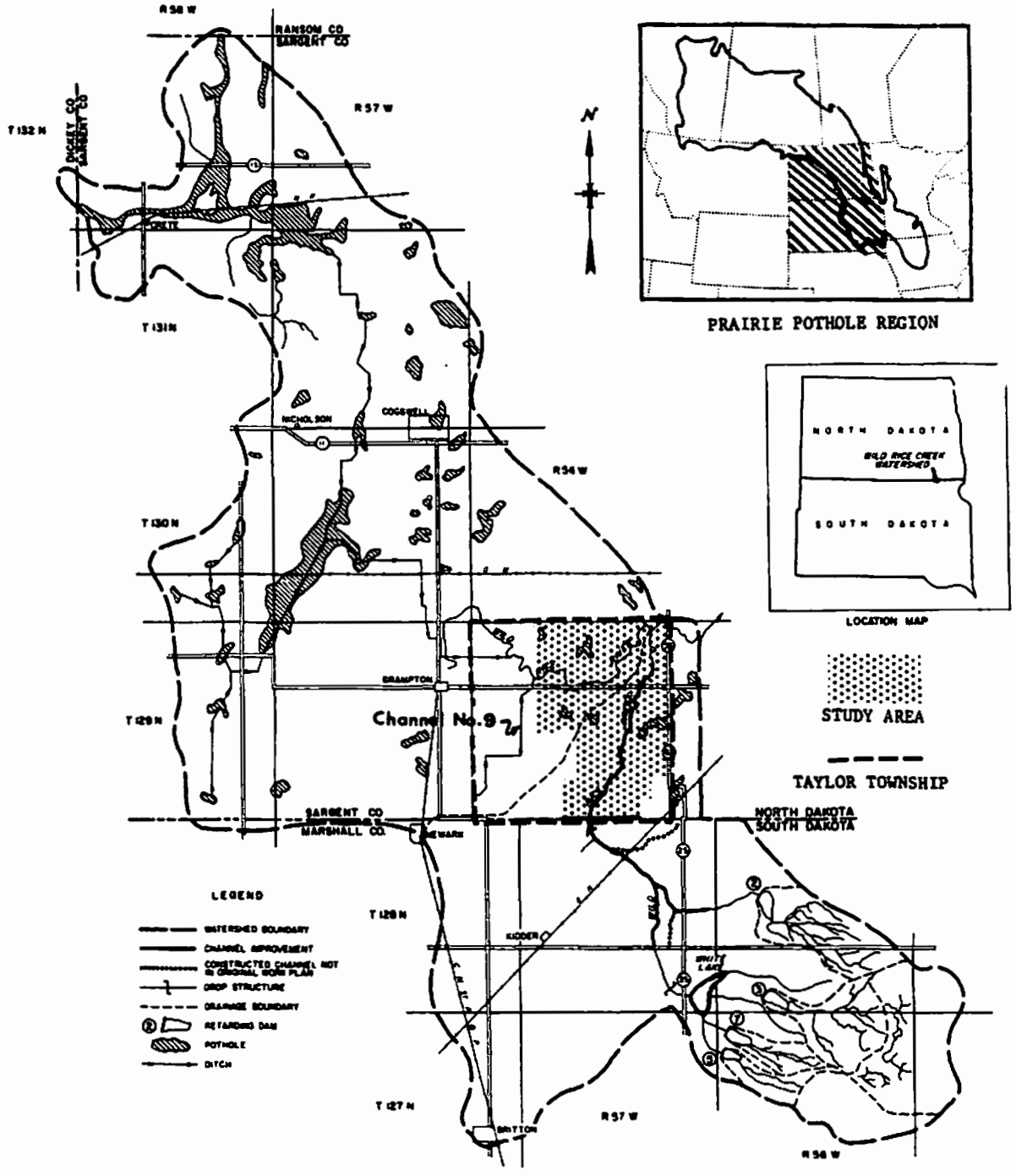

Fig. 1. Location of the study area in the Wild Rice Creek Watershed

between 1959 and 1971. Only Supplement No. III (Appendix B) received interagency review. The project was certified complete on 23 March 1971. A detailed description of the Wild Rice Creek Watershed is included in Appendix B.

Purposes of the project were watershed protection and flood control (U.S. Department of Agriculture 1957). Structural measures included four floodwater retarding dams with 2,001 acre-feet of floodwater storage and 24.7 miles of channelization. Construction of the main channel began in South Dakota in 1961 and was completed in North Dakota in 1963. Bottom widths varied from 10 to 34 feet, flow depth from 6.5 to 7.9 feet, velocity from 2.55 to 2.76 fps and side slopes of 2.5:1.

THE STUDY AREA

The Study Area consisted of 10,310 acres in Taylor Township, Sargent County, North Dakota and contained segments of the south and west tributaries of Wild Rice Creek (Fig. 1). These tributaries join, form the Wild Rice River, and then enter the Red River of the North near Fargo, North Dakota. Nearly one thousand wetland basins containing 1,742 wetland acres were in the Study Area in 1952.

Channeled and Unchanneled Tributaries

Channeled Area. -- The south tributary of Wild Rice Creek originates in the glacial moraine uplands of the Sisseton Hills in Marshall County, South Dakota, and flows in a northerly direction. The North Dakota portion of this tributary was the 6,756 acre channelized portion of the Study Area (Fig. 2). Channelized in 1962-63 as a project feature, it was originally a natural intermittent stream. Construction ended about 1 mile above its confluence with the west tributary (Section 12, T. 129 N., R. 56 W.).

The South Dakota portion of the south tributary, upstream from the Study Area, had been straightened and deepened during drainage efforts dating back to the First World War. These piecemeal efforts only aggravated problems downstream and the channel was apparently still inadequate for drainage or flood protection purposes (Little 1973: 23-7 and U.S. Department of Agriculture 1957:7).

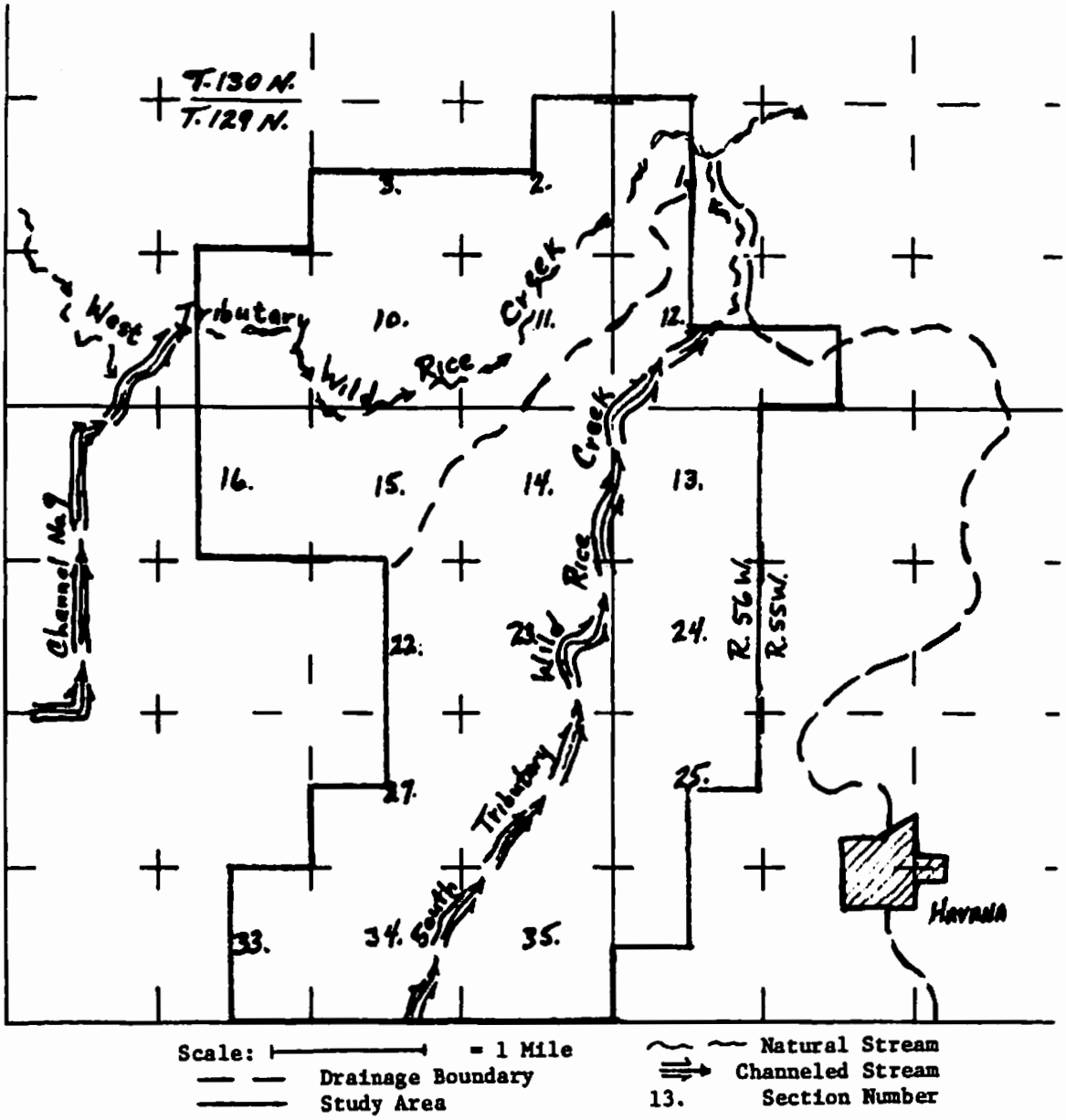

Fig. 2. Channelized south tributary and natural west tributary of the Wild Rice Creek Watershed.

Unchanneled Area. -- The west tributary originates near Brampton, North Dakota, and then flows easterly. Portions of this tributary also had been altered (Channel No. 9) during drainage activities dating back to 1918 (Fig. 1). Channel No. 9, an old legal drain added to the work plan by Supplement III in 1965, modified the west tributary for a short distance (Fig. 2). The natural west tributary, from the entrance of Channel No. 9 to near its confluence with the south tributary, served as the 3,554 acre unchannelized portion of the Study Area (Fig. 2).

Geology

The geology of the Study Area is characterized by the Dead-ice Moraine landform (Bluemle 1972). This moraine was deposited by the Wisconsin stage of the continental ice sheets.

Glacial sediment of the Dead-ice Moraine is mainly till but also includes gravel, sand, and lake silt and clay. Collapse of the Dead-ice deposited till about 100 feet thick in a rather rugged landscape with numerous wetlands of various sizes and shapes.

A more detailed description of the geology and land use is given in Appendix B.

Soils

Aastad loan and Forman-Aastad loam soil types (mapping units) of the Forman-Aastad Association are present in significant amounts in both the channeled (72.5 percent) and unchanneled (86.2 percent)

areas. These, along with two wetland soils, are described in the Sargent County Soil Survey (1964) as follows:

> Aastad loam soils, with a 0 to 3 percent slope, are nearly level on glacial till. Its surface layer contains less clay, but this soil is otherwise similar to Aastad clay loam. Both soils resist wind and water erosion. They are suited to the same crops, require the same management, and produce about the same yields. As much as 10 percent of any area of this mapping unit may consist of Hamerly, Tetonka, and Parnell soils (Capability Unit II c-6; Silty range site).
>
> Forman-Aastad loam soils, with a 3 to 6 percent slope, have been mapped together because they occur together in such a complex pattern that it is impractical to map them separately. The Forman soil is more extensive and better drained than the Aastad soil and is higher on the landscape. As much as 15 percent of this complex consists of the Hamerly, Tetonka, and Parnell soils. Forman-Aastad loams are deep, dark and fertile and well suited to small grains, alfalfa, and grasses. Yields are good except when there is not enough rain (Capability Unit II e-6; Silty range site.)
>
> Parnell (Pa) and Tetonka-Parnell (Tp) are soils indicative of wetland basins. Parnell soils are very poorly drained soils that occur in depressions and potholes of the glacial till plain. Parnell soils are generally too wet to cultivate. Marsh grasses, sedges, and bulrushes are the main vegetation. The depressions make good breeding places for ducks and also protect other wildlife (Sargent County Soil Survey 1964). Tetonka-Parnell soils also occur in depressions in the glacial till plain. They are imperfectly drained to poorly drained soils in shallow moderately wet depressions. Parnell and Tetonka-Parnell soils produce good yields of small grains, corn and alfalfa when drained.

Wetland Preservation

In the early 1960's, four wetland areas within the Study Area were delineated by the U.S. Fish and Wildlife Service (USFWS) for possible fee purchase under its Small Wetlands Acquisition Program (Public Law 87-585). All remaining wetlands qualified for wetland easements under that program.

A 160-acre tract (NW 1/4, Sec. 2, T. 129 N., R. 56 W.) was purchased in fee title in 1970 by the USFWS. In addition, the landowner's right to drain, fill, or burn wetlands in the N 1/2, Sec. 11 and the NE 1/4, Sec. 1, T. 129 N., R. 56 W. was purchased by USFWS easements in 1965 and 1968, respectively.

METHODS

Aerial Flights

Aerial observations were made throughout the watershed during the summer of 1972 to record new drainage ditches and land use changes on 1968 USDA aerial photographs (4 inches = 1 mile). Oblique aerial photographs also were taken in 1972 to depict the general landscape of the watershed.

Wetland Classification

To improve accuracy in identifying and typing wetlands in the Study Area, undisturbed wetland basins throughout Sargent County, North Dakota, were examined. These basins, determined from the Sargent County Soil Survey to be in the same soil types found in the Study Area, were in Cropland Adjustment Program lands, in native prairie, and on USFWS Waterfowl Production Areas and the Tewaukon National Wildlife Refuge. Wetland types (Shaw and Fredine 1956 and Stewart and Kantrud 1971), wetland soils, vicinity soils, dominant basin vegetation, estimated overflow levels, shape of basin cross section, land use, and photo distinctiveness were recorded for each wetland.

Wetland basins in the Study Area were classified according to Shaw and Fredine (1956) using wetland-soil type relationships, USDA (1952, 1960, and 1968) aerial photos, and observations in the

field. Data from drainage referrals were available for some of the wetlands in the Study Area. This provided an additional opportunity to evaluate wetland typing.

Since the Drainage Referral Act (P.L. 87-732) was passed in 1962, requests by landowners for USDA financial and technical assistance to drain wetlands in North and South Dakota and Minnesota are referred to the USFWS for determinations of wetland types and wildlife values. If significant wildlife values exist, the landowner is so notified and USDA assistance is restricted. Drainage, however, may be accomplished at the landowner's expense or with USDA assistance for Type I wetlands after a 5-year waiting period.

Engineering Survey

Elevations for the natural channel (where distinguishable), overflow levels, new channel depths, and strategically located wetland basins were established by a USFWS survey crew. These data provided information on the feasibility of wetland drainage and stream overflow levels before and after channelization.

Data Recording

Data were recorded by quarter sections to a distance of 1 mile on either side of the quarter section containing the channelized and unchannelized portions of Wild Rice Creek. Wetlands protected by USFWS fee purchase or easements in the unchanneled area were not included. There were no USFWS protected wetlands in the channeled area.

Acreages of soil types, wetlands, and land use were determined from 1952, 1960, and 1968 aerial photographs and from USDA soil maps (4 inches = 1 mile).

Field observations, watershed maps, and U.S. Geological Survey (USGS) topographic maps were used to determine the location of drainage boundaries between channelized and unchannelized portions of the Study Area. Floodplain locations were determined in a similar manner.

Land Use

The amount and location of drainage, drainage interest, and wetland types were determined from USDA cost-sharing and technical assistance data and USFWS files for the period 1955-62. Drainage referral data provided information after 1962.

Land retirement and current land use data were obtained for the period 1970-73 from ASCS records. Land use data also were obtained from aerial flights, USDA aerial photos, direct field observations, and interviews with farmers.

RESULTS

Wetland - Soil Type Relationships

Data from undisturbed wetland basins throughout Sargent County provided information on wetland-soil type relationships for basins which had been soil mapped and for aiding photo interpretation. For example, 87 wetland basins had been soil mapped as Parnell soils and all were at least Type III's (Table 1). Of 26 wetlands soil mapped as Tetonka-Parnell soils, 24 were Type III wetlands.

Streambed and Channel Elevations

Wild Rice Creek historically overflowed its banks, thereby supplying water to extensive floodplain wetlands. However, channelization lowered the creek's original bottom elevation at Station A (Fig. 3) by 6.3 feet (Table 2) thus preventing or reducing overflows from entering floodplain wetlands. In addition, lowering the natural creek bottom 3.7 feet at Station B provided an effective drainage outlet for floodplain wetlands such as those in Sections 13, 24, and vicinity (Fig. 3 and 4).

Excavations for the channel obliterated much of the original creek. However, oxbow elevations indicated that there had been a rise of 0.5 feet between Stations C and D and a fall of 1.2 feet from Station C to Station B prior to channelization.

Channelization increased the gradient for wetlands at Station C from 1.2 feet to 3.7 feet (Station B invert - Table 2), or a difference of 2.5 feet for this distance of approximately 1 mile. A profile

Table 1. Undisturbed wetland basins examined in Sargent County, North Dakota (Pa = Parnell, Tp = Tetonka-Parnell, ◊ = wetland but not soil typed, and NM = not mapped in soils survey).

Soils	Ephemeral[a]	Wetland Type[b]			Total
		I	III	IV	
Aastad Clay Loam					
Pa					0
Tp			1		1
◊		2	3		5
NM	1	1			2
Aastad Loam					
Pa			38		38
Tp		2	19		21
◊	2	29	34		65
NM	15	23	12		50
Forman-Aastad					
Pa			32	5	37
Tp			3		3
◊		4	22		26
NM	3	11	13		27
Forman-Buse					
Pa			4	2	6
Tp					0
◊			4		4
NM					0
Hamerly					
Pa			4		4
Tp					0
◊			2		2
NM		4	2		6
Hamerly-Aastad Loams					
Pa					0
Tp			1		1
◊			2		2
NM		1	1		2
Overly-Bearden					
Pa			1	1	2
Tp					0
◊					0
NM					0
TOTALS	21	77	198	8	304

[a] Ephemeral wetland according to Steward and Kantrud (1971)
[b] Wetland types according to Shaw and Fredine (1956)

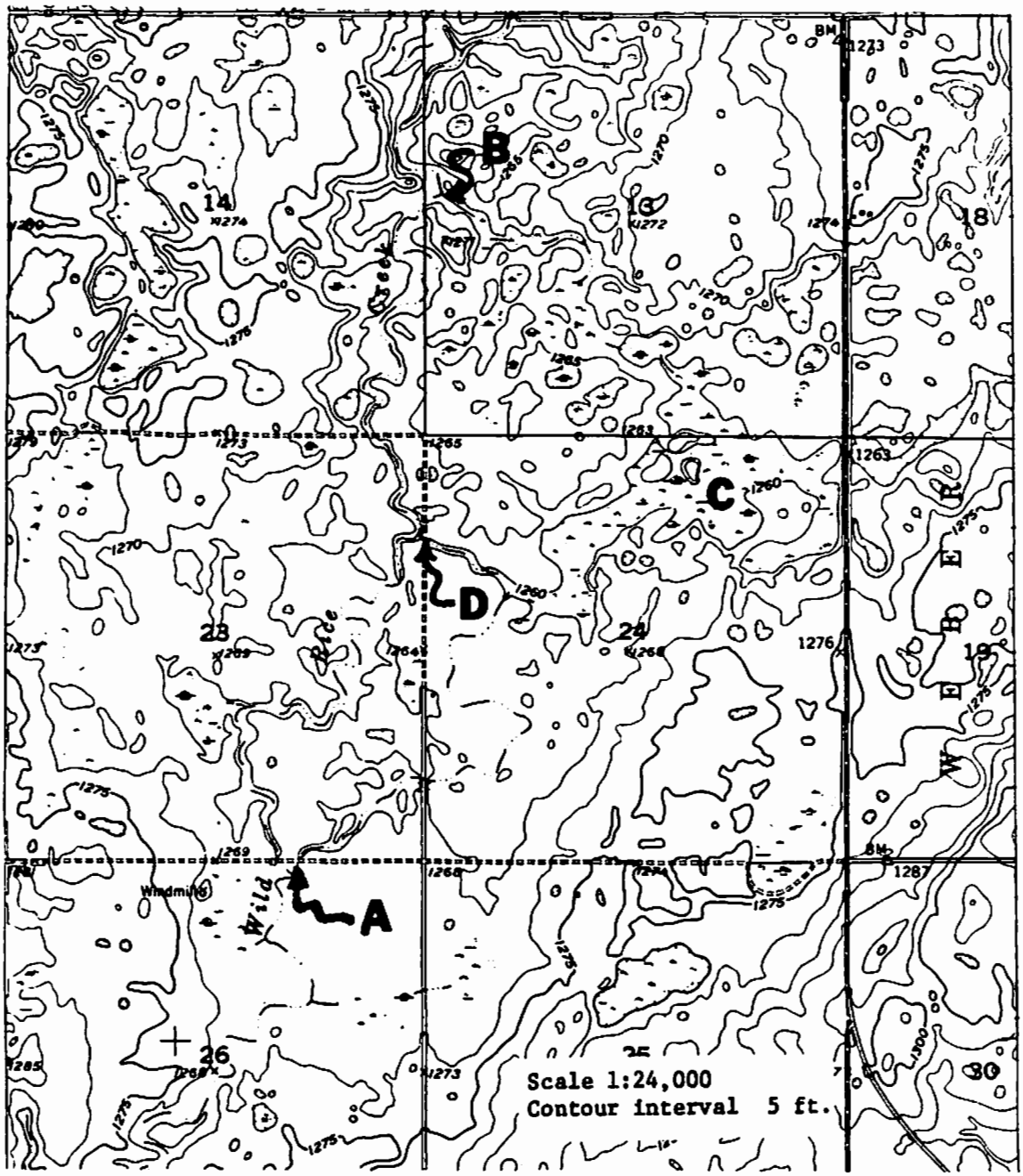

Fig. 3. U.S. Geological Survey Topography map (1953) of channeled portion of the study area showing locations (A, B, C, and D) that were surveyed.

Table 2. Relative changes in elevations at selected locations in the channeled portion of Wild Rice Creek. Stations A, B, C, and D are shown as locations on Figure 3.

Survey Station		Elevation (ft.)		
		Natural Sites	New Channel	Difference
A	Creek divide-overflow	100.0[a]	93.7	-6.3
B	Drainage outlet	100.0[a]	96.3[b]	-3.7
C	Wetland Basins	101.2	-	-4.9
D	Overflow	101.7[c]	-	-5.4

[a]Natural channel (oxbow) relative elevation = 100.0

[b]Culvert invert with flap gate at elevation 97.5

[c]Prairie trail culvert invert

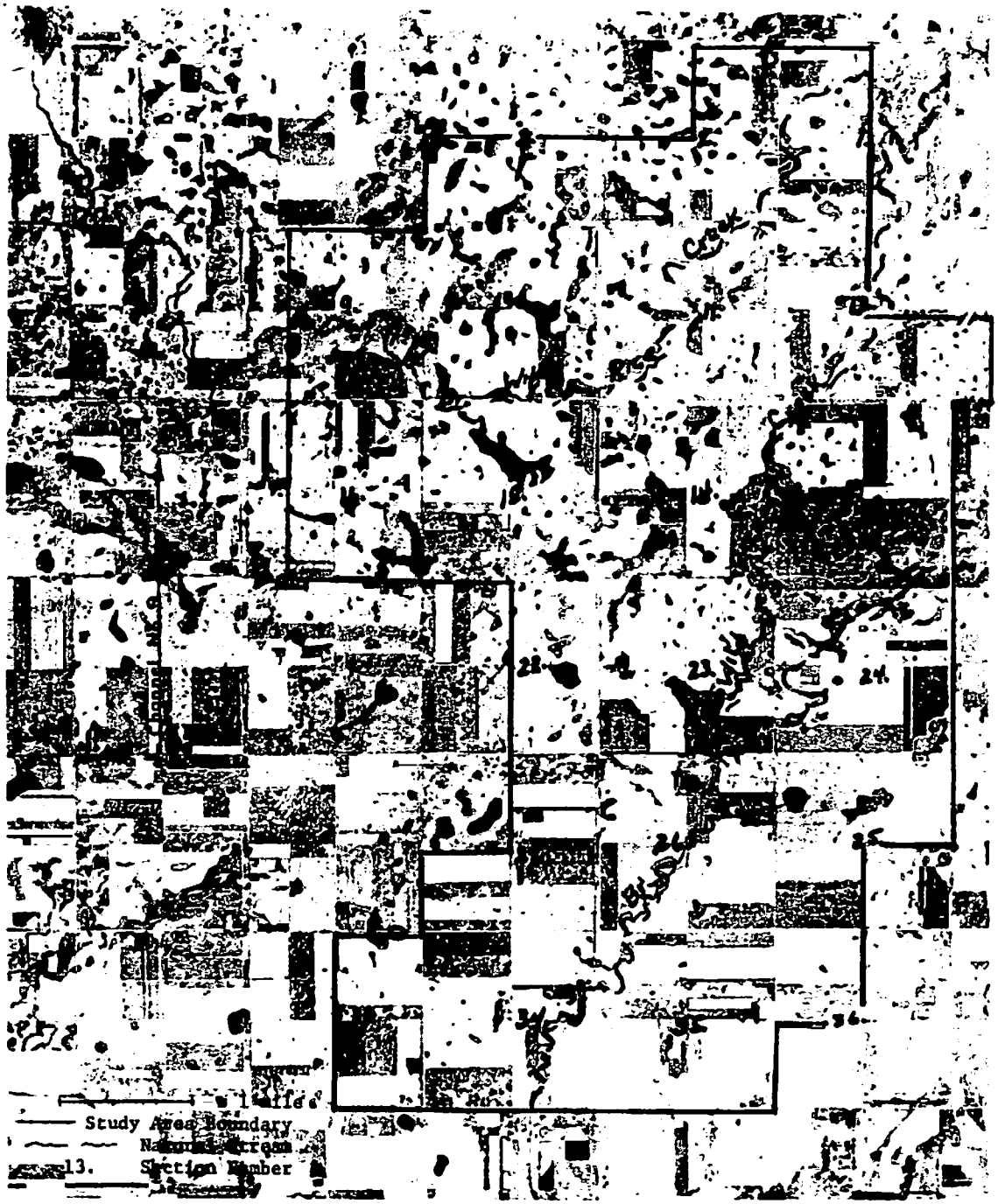

Fig. 4. Study area in 1952 showing the west and south tributaries of Wild Rice Creek with the associated wetland complexes.

view of natural and new channel elevations, with wetland drainage gradient changes for this location, is shown in Figure 5. Flap gates were installed on culverts at this and other drainage outlets along the new channel to prevent backwater flows.

Attempts to drain the numerous wetlands in the vicinity of Station C, dating back many years, apparently were ineffective prior to channelization (Fig. 4). Lack of adequate differences in elevation (Table 2), bank overflow, and backwater effects from Wild Rice Creek (Fig. 3) limited drainage success. According to local farmers, this area of marshland was referred to as a "lake" in early times.

Drainage

Interest in drainage in the Study Area during various watershed activity periods was measured by USDA cost-shared and technically assisted drainage accomplishments between 1955-62 and from requests for USDA drainage assistance referred to the USFWS under authority of P. L. 87-732 between 1962-72. It should be noted that USDA cost-sharing and drainage referrals differ somewhat. USDA cost-share assistance data measure actual drainage accomplished while requests for such assistance referred to the USFWS are an indication of desire or intent to drain.

Aerial photos (1952, 1960, 1968) showed the loss of wetlands between these years. The 1968 photos were up-dated during aerial observations and field checks in 1972 and 1973 to show current drainage.

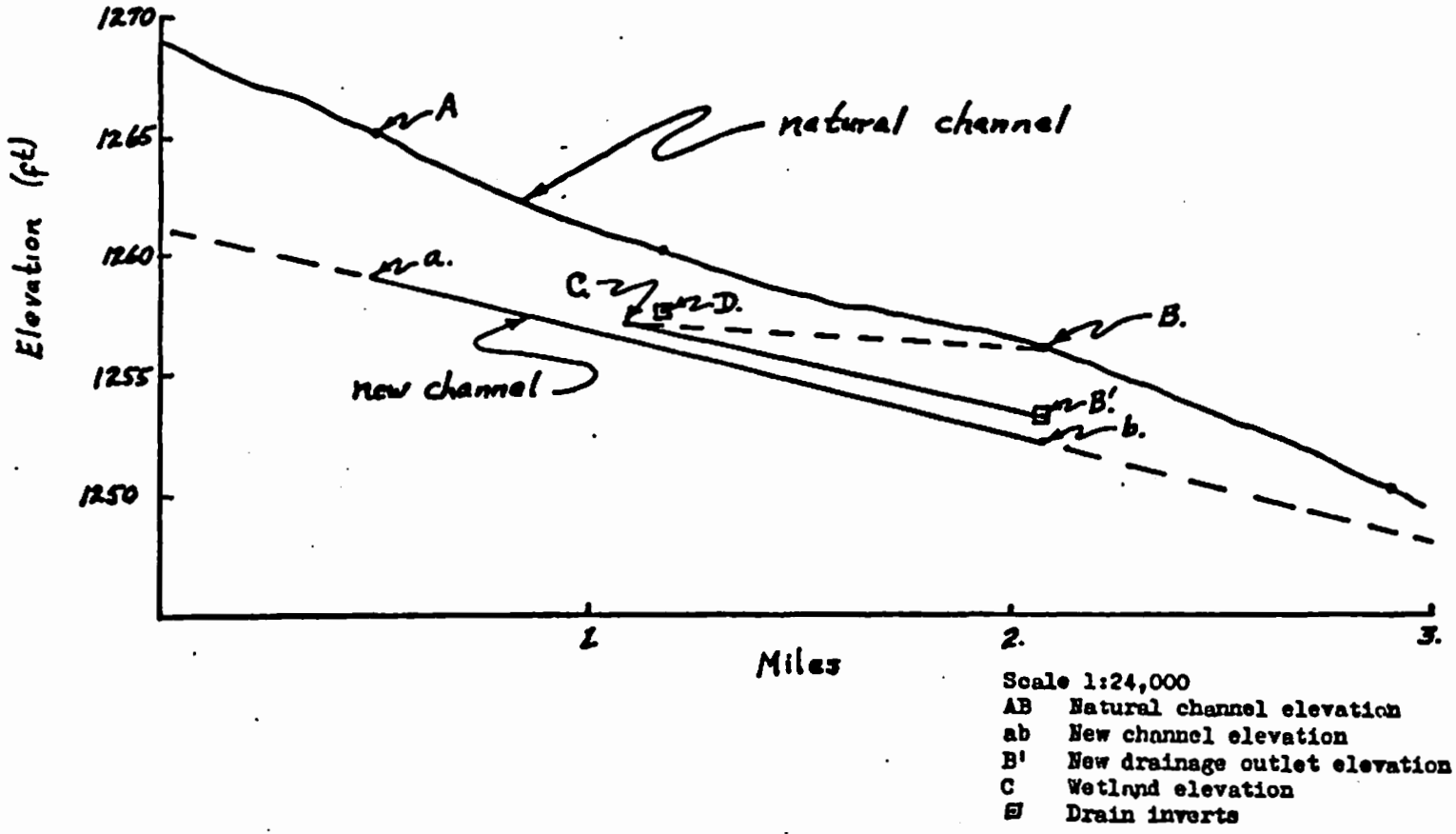

Fig. 5. Profile view of natural and new channel showing changes in gradient for wetland (C) drainage (from C-B to C-B'). Stations A, B, C, and D are shown on Figure 3 and in Table 2.

Pre-work plan, 1952-57. -- USDA data on drainage were not available prior to 1955. However, pre-work plan drainage interest was not high in Taylor Township which contained the Study Area. Three landowners in the township received USDA drainage assistance during the period 1955-57 (Table 3). Only 2.5 percent (16) of the 651 wetlands drained in Sargent County during that time were in Taylor Township, although the township represents 4.2 percent of the county.

Seven (43.8 percent) of the 16 wetlands drained in Taylor Township were in the Study Area (Table 4). This was considered normal in as much as the Study Area comprised 44.7 percent of the township. Six of the seven drained wetlands were in the channelized portion of the Study Area. No USDA drainage assistance was provided in the township in 1956 and 1957.

Post-work plan, 1958-60. -- The Wild Rice Watershed Work Plan was approved in December 1957. Drainage interest in Taylor Township subsequently increased in the three-year period (1958-60) following approval. While the number of landowners receiving USDA drainage assistance increased 23 percent for Sargent County, the increase was 967 percent for Taylor Township (Table 3).

During this post-work plan period, the number of wetlands drained with USDA assistance in Taylor Township increased 1,338 percent. The number drained in the rest of Sargent County increased only 65 percent. Eighteen percent of the USDA assisted drainage in Sargent County occurred in Taylor Township during these three years.

Table 3. USDA drainage assistance in Taylor Township (T129N, R56W) and in the remaining portion of Sargent County for 1955-57 and 1958-60[a].

	Taylor Township			Sargent County Minus Taylor Township		
	Pre-work Plan 1955-57	Post-work Plan 1958-60	Percent Change	1955-57	1958-60	Percent Change
Landowners assisted	3	32	+ 967	96	118	+23
Potholes Drained	16	230	+1338	635	1046	+65
Acres Drained	77	405	+ 426	374	209	-44

[a]Bureau of Sport Fisheries and Wildlife Memorandum dated October 6, 1964. (Ray St. Ores, Chief, Wetlands Section, RBS, Mpls. to Chief, Div. of Tech. Services, Mpls.)

Table 4. USDA drainage assistance in Taylor Township (T129N, R56W) and in the Study Area 1952-62.

Period and Year	Taylor Township[a]		Study Area					
			Channeled Area			Unchanneled Area		
	Number Wet-land Areas	Acres	Number Wet-land Areas	Percent of Township	Acres	Number Wet-land Areas	Percent of Township	Acres
Pre-work plan								
1955	16	77	6	37.5	2.4	1	6.3	0.2
1956	0	0	0	-	0	0	-	0
1957	0	0	0	-	0	0	-	0
Post-work plan								
1958[c]	70	161	58[b]	82.9	79.0	14[b]	20.0	14.7
1959	45	42	17	37.8	49.9[b]	5	11.1	2.7[b]
1960	115	202	8	7.0	5.9	26	22.6	17.3
Channel construction								
1961	10	8	0	-	0	0	-	0
1962[d]	26	3	0	-	0	0	-	0
TOTALS	282	493	89	31.6	137.2	46	16.3	34.9

[a] Data reproduced from U.S. House of Representatives 1971:2593.
[b] Slightly different calculation than published data.
[c] Watershed Work Plan approved December 1957.
[d] Drainage Referral Act, P.L. 87-732 passed October 2, 1962.

Of 282 wetlands drained with USDA assistance between 1955-62 in Taylor Township, 81.6 percent (230) were drained in the post-work plan period (Table 4). A drainage plan associated with Channel No. 9 (Fig. 1) was developed in 1960 and accounted for most of the USDA assisted drainage in Taylor Township outside of the Study Area in that year (USFWS files). Channel No. 9 was subsequently added to the Watershed Work Plan in 1965 by Supplement III (Appendix B).

In the channeled portion of the Study Area, 93.3 percent (83) of the 89 wetlands drained with USDA assistance between 1955-62 were eliminated in the three-year period (1958-60) following approval of the work plan but prior to channelization (Table 4).

Most USDA assisted drainage in the unchanneled area also occurred during the post-work plan period. That interest can be explained, in part, by the fact that landowners in the channelized area also owned land in the unchanneled area (Fig. 6).

Although federal cost-sharing was available during the post-work plan period, apparently a disproportionately small percentage of the wetlands drained in the channelized area (Table 5) was assisted by USDA as compared to the unchannelized area (Table 6). In the unchannelized area, 92.5 percent of the wetlands drained between 1952-60 were drained with USDA assistance. Conversely, USDA drainage assistance in the channelized area accounted for 37.7 percent of the wetlands drained during that time. Two possible explanations for these differences in USDA assistance are: (1) privately drained Type III wetlands averaged about one acre larger in size than wetlands drained with USDA assistance; thus the number of wetlands classified

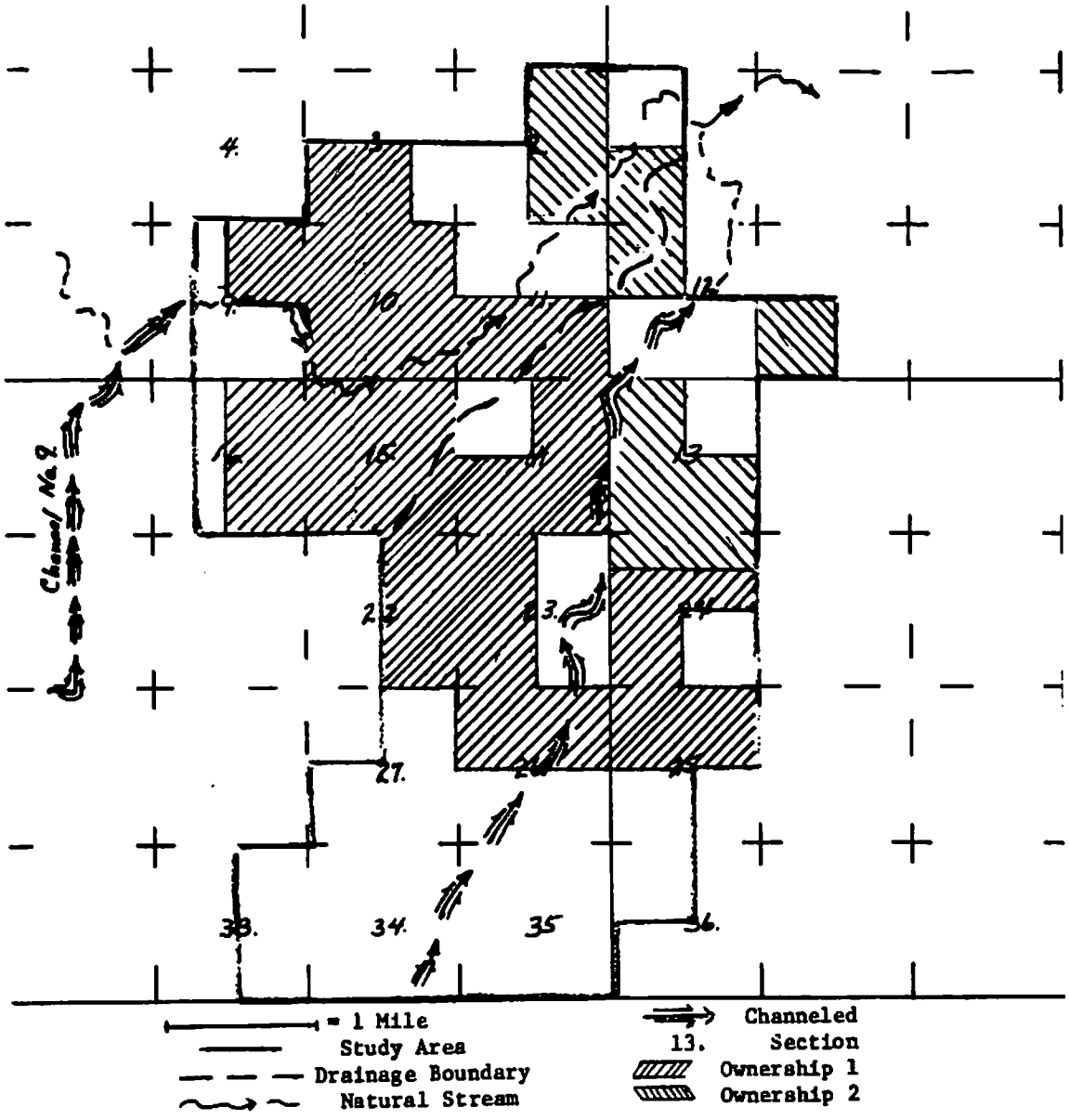

Fig. 6. Study area showing ownership overlap in channelized and unchannelized areas.

Table 5. Drainage by private and USDA assistance by wetland types and acres in channeled area from 1952-72.

	Wetland Type									
	Type I[a]		Type III		Type IV		Type V		Totals	
	Number	Acres	Number	Acres	Number	Acres	Number	Acres	Number	Acres
Wetlands in 1952	220	96.3	402	898.0	7	101.8	0	0	629	1096.1
Drained between 1952-60										
Private	45	25.4	101	295.3	1	9.6	0	0	147	330.3
USDA Assistance[b]	24	11.8	65	125.0	0	0	0	0	89	136.8
Total	69	37.2	166	420.3	1	9.6	0	0	236	467.1
Percent	31.4	38.6	41.3	46.8	14.3	9.4	0	0	37.5	42.6
Drained between 1961-72										
Private	109	42.5	136[c]	230.5	0	0	0	0	245	273.0
USDA Assistance[d]	0	0	3	9.4	0	0	0	0	3	9.4
Total	109	42.5	139	239.9	0	0	0	0	248	282.4
Percent	49.5	44.1	34.6	26.7	0	0	0	0	39.4	25.8
Drained between 1952-72										
Private	154	67.9	237	525.8	1	9.6	0	0	392	603.3
USDA Assistance[d]	24	11.8	68	134.4	0	0	0	0	92	146.2
Total	178	79.7	305	660.2	1	9.6	0	0	484	749.5
Percent of Total	80.9	82.7	75.9	73.5	14.3	9.4	0	0	76.9	68.4

[a]Minimal numbers and acres: some Type I's may have been overlooked

[b]USDA records prior to 1955 not available; drained wetlands assumed to be by private means

[c]Destroyed by channel

[d]Wetlands determined by USFWS to be low value are not included

Table 6. Drainage by private and USDA assistance by wetland types and acres in unchanneled area from 1952-72.

	Wetland Type									
	Type I[a]		Type III		Type IV		Type V		Totals	
	Number	Acres	Number	Acres	Number	Acres	Number	Acres	Number	Acres
Wetlands in 1952	81	28.1	266	462.5	14	85.2	3	70.4	364	646.2
Drained between 1952-60										
Private	1	0.1	3	6.3	0	0	0	0	4	6.4
USDA Assistance[b]	18	4.5	31	30.6	0	0	0	0	49	35.1
Total Drained	19	4.6	34	36.9	0	0	0	0	53	41.5
Percent Drained	23.5	16.4	12.8	8.0	0	0	0	0	14.6	6.4
Drained between 1961-72										
Private	7	2.3	20	24.4	0	0	0	0	27	26.7
USDA Assistance[c]	0	0	0	0	0	0	0	0	0	0
Total	7	2.3	20	24.4	0	0	0	0	27	26.7
Percent Drained	8.6	8.2	7.5	5.3	0	0	0	0	7.4	4.1
Drained between 1952-72										
Private	8	2.4	23	30.7	0	0	0	0	31	33.1
USDA Assistance[c]	18	4.5	31	30.6	0	0	0	0	49	35.1
Total	26	6.9	54	61.3	0	0	0	0	80	68.2
Percent of Total	32.0	24.5	20.3	13.3	0	0	0	0	22.0	10.6

[a]Minimal numbers and acres: some Type I's may have been overlooked.

[b]USDA records prior to 1955 not available; drained wetlands assumed to be by private means

[c]Wetlands determined by USFWS to be low value are not included

as noncropland by the ASCS and not eligible for assistance may have been disproportionately large and (2) USDA drainage records, not available prior to 1955, did not correspond to the time the wetland count was determined from 1952 aerial photographs. Drained wetlands for which no USDA records were available were assumed to have been drained privately. Therefore, USDA cost-share data are minimal. The USDA drainage policy established in 1957 is included as Appendix D.

In 1952, the channelized portion of the Study Area contained 629 individual, identifiable wetland basins consisting of 1,096 acres. By 1960, 236 (37.5 percent) wetlands consisting of 467.1 (42.6 percent) acres had been drained (Table 5).

The unchannelized area contained 646.2 acres of wetlands in 364 basins in 1952. Fifty-three (14.6 percent) of these wetland basins, containing 41.5 acres (6.4 percent), were drained by 1960 (Table 6). A large portion of the drainage in both the channelized and unchannelized areas occurred with USDA assistance in the years 1958-60, immediately following approval of the Watershed Work Plan.

Channel construction period, 1961-63. -- In 1961, construction of the 24.7 miles of channel began in the South Dakota portion of the watershed, upstream from the Study Area. USDA cost-shared drainage in Taylor Township, North Dakota in 1961 markedly declined compared to the 3 years (1958-60) following work plan approval (Table 4). Only 10 wetlands were drained with USDA assistance in the township in 1961, none of which were in the Study Area.

Total federal cost-shared drainage for North Dakota also decreased in 1961. From 1943 to 1960, USDA drainage assistance was provided for an average of 81,857 acres annually (U.S. Department of Agriculture 1971). However, in 1961, such assistance was provided for drainage of 13,683 acres. Thus, the observed reduction of USDA drainage assistance for 1961 in Taylor Township would be normal.

Drainage efforts again were intensified during the last two years (1962 and 1963) of channel construction in the Study Area. Nearly 56 percent of the 198 wetlands in the channeled area and 57 percent of the 42 wetlands in the unchanneled area requested for USDA drainage assistance between 1962 and 1972 were requested during the 1962-63 period (Table 7).

The number of wetlands in drainage referrals in the unchanneled area during the 1962-63 channel construction period again was, in part, stimulated by overlapping landownerships (Fig. 6). For example, of the 134 wetlands involved in drainage referrals in the Study Area in 1962 and 1963 (Table 7), 90 involved owners who requested wetland drainage assistance in both the channeled and unchanneled areas.

By comparison, 10.8 percent of the 443 wetlands in drainage referrals in Taylor Township, exclusive of the Study Area, occurred in 1962 and 1963 (Table 7). Additionally, the highest percentage (73.5 percent of township) of wetlands requested for USDA cost-sharing and technical drainage assistance between 1962-72 occurred in the channelized area in 1963 (the year the channel was completed), even though this area represented only 29.3 percent of the township.

Table 7. Wetland areas and acres of wetlands requested for USDA drainage assistance in drainage referrals (P.L. 87-732)[a] in Taylor Township (T129N, R56W) and in the channeled and unchanneled Study Area 1962-72.

Period and Year	Taylor Township		Study Area							
			Channeled Area				Unchanneled Area			
	Number of Areas Requested	Number of Acres Requested	Number of Areas Requested	Percent of Township	Number of Acres Requested	Percent of Township	Number of Areas Requested	Percent of Township	Number of Acres Requested	Percent of Township
Channel Construction										
1962[a]	84	106.2	38	45.2	60.4	56.9	11	13.1	12.1	11.4
1963[b]	98	58.2	72	73.5	48.5	83.3	13	13.3	8.2	14.1
Post Channel Construction										
1964	264	94.2	18	6.8	10.2	10.8	0	0	0	0
1965	75	48.0	25	33.3	16.5	34.4	18	24.0	12.0	25.0
1966	78	99.0	16	20.5	11.0	11.1	0	0	0	0
1967	31	32.0	11	35.5	6.0	18.8	0	0	0	0
1968	23	17.0	11	47.8	11.0	64.7	0	0	0	0
1969	18	53.5	7	38.9	40.4	75.5	0	0	0	0
1970	12	55.0	0	0	0	0	0	0	0	0
1971	0	0	0	0	0	0	0	0	0	0
1972	0	0	0	0	0	0	0	0	0	0
TOTALS	683	563.1	198	29.0	204.0	36.2	42	6.1	32.3	5.7

[a]P.L. 87-732 passed October 2, 1962

[b]Channel construction completed

Post-channel construction period, 1964-72. -- In 1960, 393 identifiable wetlands remained in the channelized area and 311 in the unchannelized area (Table 8). Excluding wetlands requested for USDA drainage assistance during the 1962-63 period (Table 7), 283 and 287 wetlands would have remained in the channelized and unchannelized areas, respectively, in 1964. During the post-channel period, 88 (31.1 percent) of the remaining wetlands in the channeled area and 18 (6.3 percent) in the unchannelized area were requested for USDA drainage assistance (Table 7). Thus, drainage interest, based on referrals, was five times higher in the channelized area than in the unchannelized for the years after channel construction. Also, while drainage referrals ceased in 1965 in the unchanneled area, they continued in the channeled area through 1969 (Table 7).

Drainage interest, based on referrals, also was influenced by overlapping ownerships during the post-channel construction period. For example, requests for USDA drainage assistance in the Study Area in 1965 involved 25 wetlands in the channelized area and 18 in the unchannelized -- all requested by a single landowner (Table 7).

Summary, 1952-72 period. -- Between 1952 and 1960, the number of wetlands drained was 2.6 times higher in the channelized area than in the unchannelized area (Table 5 and 6). From an acreage standpoint, drainage during that period was 6.7 times higher in the channelized area. The largest portion of the drainage between 1952 and 1960 occurred during the period 1958-60, immediately following approval of the Watershed Work Plan.

Table 8. Rate of drainage of wetlands on the channeled and unchanneled portions of the Study Area from 1961-72.

	Wetlands in Channeled Area						Wetlands in Unchanneled Area					
	Present in 1960		Drained from 1961-72				Present in 1960		Drained from 1961-72			
			Areas		Acres				Areas		Acres	
Type	Number	Acres	Number	Percent	Number	Percent	Number	Acres	Number	Percent	Number	Percent
I	151	59.1	109	72.2	42.5	71.9	62	23.5	7	11.3	2.3	9.8
III	236	477.7	139	58.9	239.9	50.2	232	425.6	20	8.6	24.4	5.7
IV	6	92.2	0		0		14	85.2	0		0	
V	0	0	0		0		3	70.4	0		0	
TOTALS	393	629.0	248	63.1	282.4	44.9	311	604.7	27	8.7	26.7	4.4

Drainage during the 1961-72 period, during and after channelization, destroyed 63.1 percent (248) of the 393 wetlands of all types remaining in the channelized area in 1960 (Table 8). By comparison, drainage in the unchannelized area eliminated 8.7 percent (27) of the 311 wetlands present in 1960 (Table 8). During this period, from an acreage standpoint, 44.9 percent of the wetland base remaining in 1960 was drained in the channelized area while only 4.4 percent was drained in the unchannelized area (Table 8). Thus, drainage rates were 7.3 times higher for wetland basins and 10.2 times higher for wetland acreages in the channelized versus the unchannelized area during and after channelization. Most of this drainage (56 and 57 percent in the channeled and unchanneled area, respectively) took place during the channel construction period (Table 7).

The channelized portion of the Study Area contained 629 individual, identifiable wetlands of all types in 1952 (Table 9). By 1972, 76.9 percent (484 wetlands) had been drained -- over 80 percent of the Type I's, 75 percent of the Type III's and 14 percent of the Type IV's (Table 9). The 629 original wetland basins contained 1,096 acres; 68.4 percent (749.5 acres) of which were drained.

Within the unchannelized portion of the Study Area, 364 wetland basins of all types existed in 1952 (Table 9). Twenty-two percent of these (80 wetlands) were drained by 1972. Involved in this drainage were 32 percent of the Type I's, 20 percent of the Type III's, and none of the Type IV's. The 364 wetlands, intact in 1952, contained 646.2 acres. By 1972, 10.6 percent (68.2 acres) had been drained (Table 9).

Table 9. Rate of drainage of wetlands on the channeled and unchanneled Study Area from 1952-72.

	Wetlands in Channeled Area						Wetlands in Unchanneled Area					
	Present in 1952		Drained from 1952-72				Present in 1952		Drained from 1952-72			
			Areas		Acres				Areas		Acres	
Type	Number	Acres	Number	Percent	Number	Percent	Number	Acres	Number	Percent	Number	Percent
I	220	96.3	178	80.9	79.7	82.8	81	28.1	26	32.1	6.9	24.6
III	402	898.0	305	75.9	660.2	73.5	266	462.5	54	20.3	61.3	13.3
IV	7	101.8	1	14.3	9.6	9.4	14	85.2	0		0	
V	0	0	0		0		3	70.4	0		0	
TOTALS	629	1096.1	484	76.9	749.5	68.4	364	646.2	80	22.0	68.2	10.6

Over the period 1952-72, wetland basins and acreage drained were 3.5 and 6.5 times higher, respectively, in the channelized area than in the unchannelized. From an acreage standpoint, Type III wetlands accounted for most losses -- 88.1 percent in the channelized area and 89.9 percent in the unchannelized area.

Drainage by Soil Types

Soils are formed by the interaction of factors such as parent material, climate, plant and animal life, relief and time (Omodt et al. 1968). Since soil types or mapping units are the same wherever they occur, a comparison of wetland drainage rates within the same soil type in the channeled and unchanneled areas was deemed to be an accurate measure of the influence of channelization.

Aastad loam and Forman-Aastad loam represent 77.2 percent of the land in the Study Area. Drainage rates in these two soil types were compared for the channeled and unchanneled areas. In the channeled area, 80.7 and 51.7 percent of the wetlands in Aastad loam and Forman-Aastad loam soil types, respectively, were drained (Table 10). In these same soil types 24.8 and 20.8 percent of the wetlands were drained in the unchannelized area. Combining these two soil types, 77.3 percent of the 503 wetlands in the channelized area were drained compared to 22.4 percent of the 330 wetlands in the unchannelized area (Table 10).

Chi-square analysis indicated that drainage of Type III's was significantly higher ($P<.01$) in the channelized area than the unchannelized for both soil types. Drainage also was significantly higher

Table 10. Drainage by two soil types occurring in channeled and unchanneled Study Area from 1952-72.

Soil and Wetland Types	Wetlands in Channeled Area						Wetlands in Unchanneled Area					
	Present in 1952		Drained 1952-72		Percent Drained 1952-72		Present in 1952		Drained 1952-72		Percent Drained 1952-72	
	Number	Acres	Number	Acres	Number	Acres	Number	Acres	Number	Acres	Number	Acres
Aastad loam (Ab)[a]												
I	162	73.6	133	59.5			49	16.0	15	4.7		
III	281	620.3	226	472.3			84	140.9	18	21.1		
IV	[illegible]	31.0	0	0			0	0	0	0		
V	0	0	0	0			0	0	0	0		
Subtotal	445	724.9	359	531.8	80.7	73.4	133	156.9	33	25.8	24.8	16.4
Forman-Aastad loam (FoB)[b]												
I	8	2.4	7	2.3			25	10.2	8	1.8		
III	47	89.9	23	26.4			160	261.8	33	35.4		
IV	3	55.2	0	0			9	57.9	0	0		
V	0	0	0	0			3	79.4	0	0		
Subtotal	58	147.5	30	28.7	51.7	19.5	197	400.3	41	[illegible]	20.8	[illegible]
TOTALS[c]	503	872.4	389	560.5	77.3	64.2	330	557.2	74	63.0	22.4	11.3

[a] 4,307 acres in channeled area; 1,236 acres in unchanneled area

[b] 593 acres in channeled area; 1,828 acres in unchanneled area

[c] 4,900 acres in channeled area; 3,064 in unchanneled area

for Type I wetlands in Aastad loam ($P<.01$) and Forman-Aastad loam ($P<.05$) in the channelized area.

Drainage by Distance from Channel and from Natural Stream

Rates of drainage also were measured as they related to distance from the channeled and unchanneled portions of Wild Rice Creek by quarter section (1/2 mile) intervals. This involved the quarter section (within) in which the natural or channelized creek lay plus two quarter sections on either side (1/2 mile and 1 mile).

Drainage rates were substantially higher in the channeled area than in the unchanneled at all distances measured (to 1 mile beyond "within" quarter section). On a percentage basis, wetland basin drainage rates in the channelized area were 3.4, 3.0, and 6.7 times greater than in the unchannelized area at the "within", 1/2 mile and 1 mile distances, respectively (Table 11). The rate of drainage of wetland acreages in the channelized area was 4.9, 7.3, and 8.7 times higher than that for the unchannelized area at these same distances.

The high rate of drainage (81.4 percent) at the 1/2 mile interval in the channeled area resulted from a large wetland complex being drained into the channel (Table 11). Wetland "consolidation" could explain the increase at the 1/2 mile interval over that of the "within" category in the unchanneled area (27.6 vs. 22.7 percent). The relatively high drainage rate of Type I wetland basins with a declining wetland acreage tends to support this view.

Table 11. Drainage of wetlands by distance[a] from channel in the channeled area and from the streambed in the unchanneled area.

Wetland Type	Channeled Area: Wetlands Present in 1952 Number	Channeled Area: Wetlands Present in 1952 Acres	Channeled Area: Avg. Size	Channeled Area: Drained Total Number	Channeled Area: Drained Total Acres	Channeled Area: Drained Percent of Total Number	Channeled Area: Drained Percent of Total Acres	Channeled Area: Drained Avg. Size	Unchanneled Area: Wetlands Present in 1952 Number	Unchanneled Area: Wetlands Present in 1952 Acres	Unchanneled Area: Avg. Size	Unchanneled Area: Drained Total Number	Unchanneled Area: Drained Total Acres	Unchanneled Area: Drained Percent of Total Number	Unchanneled Area: Drained Percent of Total Acres	Unchanneled Area: Drained Avg. Size
Within																
I	37	13.5		31	12.6				14	5.9		0	0			
III	79	184.8		58	134.4				76	100.1		22	21.9			
IV	1	6.0		0	0				5	16.8		0	0			
V	0	0		0	0				2	26.4		0	0			
Total	117	204.3	1.75	89	147.0	76.1	72.0	1.65	97	149.2	1.54	22	21.9	22.7	14.7	1.00
1/2 Mile																
I	87	38.4		74	33.4				39	17.5		22	5.9			
III	173	480.4		139	372.1				129	261.1		26	32.1			
IV	3	25.8		1	9.6				5	40.4		0	0			
V	0	0		0	0				1	44.0		0	0			
Total	263	544.6	2.07	214	415.1	81.4	76.2	1.94	174	363.0	2.09	48	38.0	27.6	10.5	0.95
1 Mile																
I	96	44.4		73	33.7				28	4.7		4	1.0			
III	150	232.8		108	153.7				61	101.3		6	7.3			
IV	3	70.0		0	0				4	28.0		0	0			
V	0	0		0	0				0	0		0	0			
Total	249	347.2	1.39	181	187.4	72.7	54.0	1.04	93	134.0	1.44	10	8.3	10.8	6.2	0.83
Totals																
I	220	96.3		178	79.7	80.9	82.8		81	28.1		26	6.9	32.1	24.6	
III	402	898.0		305	660.2	75.9	73.5		266	462.5		54	61.3	20.3	13.3	
IV	7	101.8		1	9.6	14.3	9.4		14	85.2		0	0	0	0	
V	0	0		0	0	0	0		3	70.4		0	0	0	0	
TOTAL	629	1096.1	1.74	484	749.5	76.9	68.4	1.55	364	646.2	1.77	80	68.2	22.0	10.6	0.85

[a]By 160 acre Quarter Section (one-half mile) increments: "within" = quarter section containing channel or streambed; 1/2 mile = adjacent quarter section to "within" quarter; 1 mile = quarter section lying 1 mile from "within" quarter.

In the channeled area, the percentage of wetland basins drained at the furthest distance measured (1 mile) did not decline markedly from the average percentage of drained basins closer to the channel (72.7 vs. 78.8 percent). However, the percentage of acres drained (54.0 vs. 74.1 percent) declined markedly at that distance (Table 11).

The average wetland size in both the channeled and unchanneled areas was nearly identical (1.74 and 1.77 acres, respectively). However, the average size of drained wetlands was nearly twice as large in the channeled than the unchanneled area (Table 11). Landowners, evidently, are more likely to drain all sizes of wetlands when an adequate drainage outlet is provided.

The size of wetlands drained at each interval in the channeled area tended to be close to the average size of the wetlands in that distance category (Table 11). The greatest difference was at the 1 mile distance where average wetland size was 1.39 acres while the drained wetland size averaged 1.04 acres. However, in the unchanneled area, the average size of drained wetlands at all intervals was substantially less than the average size of the wetlands at that distance (1.00 vs. 1.54; 0.95 vs. 2.09; and 0.83 vs. 1.44 for the "within", 1/2 mile, and 1 mile distances, respectively) (Table 11).

Drainage of Floodplain and Non-floodplain Wetlands in the Channeled Area

The Wild Rice Creek floodplain width varied with maximum widths of over 2 miles (U.S. Department of Agriculture 1957). Within that portion of the floodplain lying in the channelized area were 277

wetland basins containing 565.9 acres in 1952 (Table 12). These floodplain wetlands accounted for 44 percent of the wetland basins (629) and 51.6 percent of the wetland acreage (1,096.1) in the channelized portion of the Study Area.

Floodplain wetlands were drained at a somewhat higher rate than non-floodplain wetlands over the 1952-72 period. Drainage eliminated 83.9, 80.9, and 50.0 percent of the Type I, III, and IV wetlands, respectively, in the floodplain compared to 78.9, 71.5, and 0 percent outside the floodplain (Tables 5 and 12). For all types, drainage destroyed 81.6 percent of the 277 floodplain wetlands and 73.3 percent of the 352 non-floodplain wetlands in the channelized portion of the Study Area. It is not known how many wetlands in the floodplain were not drained because of inadequate channel depths.

Wetlands in USDA Land Retirement Programs

Land retired from crop production under USDA wheat (Title IV) and feed grain (Title V) programs authorized by P. L. 91-524 (1970) for the years 1970-73 in the channelized area was plotted on USDA aerial photographs. Wetlands, ineligible due to being classified as noncropland by the ASCS under the land retirement program, also were noted.

Differences in climate, geology, topography, ground water, and land use create wide variations in pothole hydrology (Sloan 1970). Type I wetlands are generally farmed during normal farming operations or seeded separately once dry. Because of these factors plus others such as size, abundance, and cropping history, some

Table 12. Fate of floodplain wetlands in the channeled area.

	Floodplain Wetlands 1952		Wetlands Drained						Wetlands Not Drained	
			1952-60		1961-72		Total[a] 1952-72			
Type	Number	Acres	Number	Acres	Number	Acres	Number	Acres	Number	Acres
I	87	40.7	38	20.5	35	14.5	73(84)	35.0(86)	14	5.7
III	188	509.6	105	327.6	47	126.9	152(81)	454.5(89)	36	55.1
IV	2	15.6	1	9.6	0	0	1(50)	9.6(62)	1	6.0
TOTALS[a]	277	565.9	144(52)	357.7(63)	82(30)	141.4(25)	226(82)	499.1(88)	51	66.8

[a]Percent of 1952 floodplain wetlands shown in parenthesis

Type III wetlands also are classified as cropland by the ASCS. In certain years, some Type III wetlands may be cultivated (Stewart and Kantrud 1973). However, Type III wetlands in the Study Area contain Parnell and Tetonka-Parnell soils that are described as "poorly or very poorly drained" and generally would be too wet to cultivate in the spring (Sargent County Soil Survey 1964).

Drained and undrained Type I and III wetlands in the channeled portion of the Study Area that were included in land retirement programs for the period 1970-73 were recorded (Table 13). Over the 4-year period, an average of 9.7 percent of the 96.3 acres of drained and undrained Type I wetlands was included in land retirement each year. Similarly, a yearly average of 9.6 percent of the 660.2 acres of drained Type III wetlands was in land retirement. By comparison, an average of 1.2 percent of the 237.8 acres of undrained Type III wetlands was included each year in retirement programs.

The average size of undrained Type III wetlands in land retirement was smaller than that for all undrained Type III wetlands in the channelized area; 0.6 vs. 2.5 acres, respectively (Table 9 and 13). The smaller undrained Type III wetlands in land retirement suggest that the ASCS tended to disqualify the larger Type III wetland for cropland retirement.

These data indicate that drained Type III wetlands were included in 1970-73 land retirement programs eight times more frequently than undrained Type III wetlands. The Watershed Work Plan (U.S. Department of Agriculture 1957:16) states, "For the period of three years from May 28, 1956, surplus crops grown on any lands reclaimed shall be ineligible for any benefits under the soil bank provision

Table 13. Drained and undrained wetlands in the channeled portion of the Study Area placed in USDA land retirement programs from 1970-73.

	Drained										Undrained		Total	
	1952-60				1961-72				Total					
	Private		USDA Assistance		Private		USDA Assistance							
Type	Number	Acres	Number	Acres	Number	Acres	Number	Acres	Number	Acres	Number	Acres	Number	Acres
I	14	5.8	5	1.2	62	21.4	0	0	81	28.4	20	8.8	101	37.2
III	45	70.3	23	84.9	68	97.5	0	0	136	252.7	19	11.1	155	263.8
Totals	59	76.1	28	86.1	130	118.9	0	0	217	281.1	39	19.9	256	301.0

of the Soil Bank Act and under price support legislation." Therefore, wetlands converted to cropland by drainage began qualifying for land retirement programs in 1959, 2 years before the start of channel construction. However, records of drained land coming into production and subsequently qualifying for land retirement programs relative to channelization are scarce (U.S. House of Representatives 1971:536).

DISCUSSIONS AND CONCLUSIONS

In a letter dated 1 July 1957, the USFWS commented on the proposed Wild Rice Creek Watershed. The conclusion was that the project would benefit fish and wildlife resources, even though channelization was a project feature.

Following construction of the channel, the USFWS made a follow-up inspection of the watershed. In a report dated August 1965, the statement was made, "However, recent investigations have shown our general conclusion that fish and wildlife resources would benefit from the project to have been greatly in error." The report goes on to say, "Probably the main cause for this erroneous conclusion was an underestimation of the number and quality of wetlands along the floodplain of Wild Rice Creek coupled with the unfortunate assumption that these wetlands would not be drained by surface field ditches once an outlet was provided."

Under contract with the Council on Environmental Quality, A. D. Little (1973) made a field survey of the Wild Rice Creek Watershed. The conclusions differed from those of the USFWS. Little (1973) stated, "channel modifications have not served as an inducement to on-farm pothole drainage or to hastening the process that continues largely as a result of landowners individual actions."

It is obvious that significant differences of opinion exist relative to the impact of channelization on prairie wetlands. Part of this can be explained by a lack of comprehensive follow-up studies

on projects that include channelization. This shortcoming is illustrated by Nathaniel P. Reed's (Assistant Secretary for Fish, Wildlife, and Parks, USDI) comments before the Conservation and Natural Resources Subcommittee of the Committee on Government Operations (U.S. House of Representatives 1971:409). He said, "The specific impact of channel alterations on the quantity and quality of bottomland wildlife and waterfowl populations has not been the subject of intensive study." Although the reference was to bottomland hardwood habitat in the southeast, it is equally true for the Prairie Pothole Region.

Channelization in the Wild Rice Creek Watershed did in fact accelerate the loss of prairie wetlands. This wetland loss occurred by channel drainage, reduction or elimination of stream overbank and backflows, and providing outlets for ancillary drainage.

The overall impact of the channel was a drainage rate, based on number of wetlands, nearly 3.5 times higher in the vicinity of the channel as compared to the unchanneled natural stream. In terms of wetland acreages, the rate was almost 6.5 times higher. Most of this acreage was Type III wetlands.

The influence of the P.L. 566 Wild Rice Creek Watershed proposal on drainage began long before channel construction started. This was evident from observed drainage rates during various stages of the project -- pre-work plan, post-work plan, channel construction and post-channel construction.

Based on USDA cost-sharing and technical assistance data, interest in drainage in the Study Area and in Taylor Township before approval

of the Watershed Work Plan was about equal to that for Sargent County. Following Work Plan approval in December 1957, a large increase occurred in drainage interest in the Study Area. In the post-work plan period (1958-60) -- following construction authorization, but prior to construction -- the number of landowners receiving drainage assistance in Sargent County increased 23 percent, while such assistance increased 967 percent in Taylor Township. Relative to the number of wetlands drained, assistance increased 65 percent for the county and 1,338 percent for the township.

Of the wetlands drained with USDA assistance in Taylor Township (282) between 1955 and 1962, over 81 percent was drained during the post-work plan period 1958-60. Approximately 30 percent of the wetlands drained in the township were in the channelized area and 93.3 percent of those were drained in the post-work plan period.

Interest in drainage, although only half that for the channeled area, increased in the unchanneled area as well during the post-work plan period. However, that drainage also was influenced by the pending channel. Most drainage in the unchanneled area was conducted by landowners who also owned land in the channelized area.

Based on aerial photos, drainage of wetland basins and acres before (1952-60) channel construction began was 2.6 and 6.7 times higher in the channelized area than in the unchannelized area, respectively. As indicated, the largest portion of this drainage occurred immediately following Work Plan approval. Anticipation of using the publicly financed channel as a drainage outlet, therefore, provided an impetus to wetland drainage.

Increased wetland drainage resulting from the anticipation of a project is a common occurrence. Southwick (1969:29) indicated that "several hundred acres ... were actually drained of surface water during watershed proceedings" in a Minnesota project.

Interest in drainage, measured by USDA assistance, was reduced in the Study Area during the first year (1961) of channel construction. This reduction appears to have been normal and can be explained, in part, by an overall statewide reduction of USDA drainage activity in North Dakota. In 1961, the acreage drained in the state was 84 percent below the annual average for the preceding 17 years (U.S. Department of Agriculture 1971).

There then followed an increase in emphasis on wetland drainage during the last 2 years of channel construction in the Study Area (1962 and 1963). Over half of the wetlands in drainage referrals between 1962 and 1972 were submitted in the last 2 years of channel construction. Referral wetlands averaged 55 per year during those 2 years compared to 10 per year for the period 1964-72.

The same trend was found in the unchanneled area where drainage referral rates were six times higher during the construction period than in the years that followed. This was again influenced by landownership. Over two-thirds of the wetlands requested for USDA drainage assistance involved landowners with land in both the channeled and unchanneled area. Thus, the channel stimulated wetland drainage well beyond the confines of its physical location and use.

The further impact of the channel on prairie wetlands can be seen during the post-construction period. During that period, drainage assistance was requested and referred to the USFWS for 31 percent of remaining wetlands in the channeled area compared to 6.3 percent in the unchanneled area. Drainage, on a percentage basis, was 7.3 and 10.2 times higher for wetland basins and acres, respectively, in the channelized area than in the unchannelized.

The rate of drainage in the unchanneled area was considered to be approximately normal for the 1961-72 period; the rate of drainage in the channeled area was accelerated. Haddock and DeBates (1969) reported drainage rates in North Dakota of approximately 5 percent for Type III, IV, and V wetlands for the 4-year period 1965-68. Similarily, a 5-square mile area sampled by the USFWS in Sargent County (outside the Wild Rice Creek Watershed) showed only 3 (1.9 percent) of 161 wetlands of Types III, IV, and V drained between 1965 and 1973 (USFWS files).

The impact of the channel on wetlands was further confirmed by looking at soils. Wetland drainage in two soil types, representing 77.2 percent of the Study Area, was significantly ($P<.05$) higher for Type I and Type III wetlands in the channelized versus the unchannelized area. Because of various inherent characteristics, soil types are believed to be an accurate parameter for comparing drainage rates in different areas.

The percentage of wetland basins drained in the channelized area did not decline markedly up to a distance of 1 mile from the

quarter section in which the channel was located; however, the percentage of wetland acres did decline. Channel depths in relation to wetland basin elevations (drainage feasibility), rather than distances to the channel were probably the major influence on drainage of surface water.

Floodplain wetlands were drained at a slightly higher rate than were non-floodplain wetlands (81.6 percent versus 73.3 percent, respectively). The higher drainage rate for floodplain wetlands was probably related to the greater intensity of agriculture, increased land values, higher inherent fertility, proximity of the channel, and topography of the floodplain.

Acreages of drained and undrained wetlands in the channeled and unchanneled areas showed that landowners used less size discrimination for drainage when adequate outlets were provided by channelization. The average size of drained wetlands was nearly twice as large in the channelized area as in the unchannelized area.

Drained Type III wetlands were likely to be included in USDA land retirement programs eight times more readily than were undrained Type III wetlands.

The engineering data show that drainage feasibility was increased. Not only did the constructed channel stimulate drainage, but the fact that the channel was forthcoming also influenced landowner's decision to drain. Soil types, distance from the channel, and location relative to the floodplain played a minor role in influencing drainage rates. Thus, the overriding consideration by the landowner was the presence of an adequate outlet. Even though legislation and/or

policies currently prohibit the use of public funds for the drainage of Type III, IV, and V wetlands in the Prairie Pothole Region, drainage can and is easily accomplished privately once public funds are used for channelization.

Drainage of wetlands stimulated by the presence of a newly constructed ditch is not unique to the Wild Rice Creek Watershed. In recent years, similar results have been observed in other areas of the Prairie Pothole Region. Choate (1972) found 54 percent of the wetland acres drained in the channeled area compared to 6 percent in the unchanneled area in the SCS's Hawk Creek Watershed project in west-central Minnesota. Bonnema (1972) also found a loss of 82 percent of the wetland acres following construction of a private channelization project in south-western Minnesota. Most of that wetland loss occurred during the 3-year period following channel construction. And, Vannote (1973) pointed out that channelization contributed to loss of wetlands by preventing or reducing bank overflow and by providing the opportunity for establishment of secondary drainage of both permanent and ephemeral wetlands.

Perhaps the main "selling point" of a watershed project is increased income for the landowners. This is accomplished by a reduction of annual flooding and/or increases in drainage. Several reasons are apparent for drainage increases. First of all, it permits the landowner to increase agricultural output; thereby increasing net income. Secondly, under P.L. 566, the taxpayer assumes most or all of the construction costs (risk). Following construction, the local sponsors assume all responsibilities for operation and

maintenance of the channel. Consequently, the public has no legal means of protecting its interest in wetlands once an adequate drainage outlet is in place.

That landowner's objective is increased income also can be seen in the Rural Environmental Assistance Program (formerly the Agricultural Conservation Program) which provides cost-sharing to landowners for various practices. Within that program, two broad categories exist -- conservation and income producing. Harmon (1974) reported that $31.00 of cost-sharing was used for drainage, liming and irrigation practices for every $1.00 spent on wildlife practices in six midwestern states (Illinois, Indiana, Iowa, Michigan, Minnesota, and Ohio) in 1971.

The objective of increasing income is further illustrated in a post-construction study of the SCS's Crane Creek Watershed project in southern Minnesota. That project provided 26.2 miles of channel. In addition, certain soil conservation practices were proposed. At the time the project was certified complete by the SCS, landowners had failed to apply most of the recommended conservation practices but exceeded the proposed drainage by 34 percent (Bonnema and Zschomler 1974).

SCS Memorandum 118, dated February 14, 1972, establishes a stream classification system. This system includes, 1) natural streams having perennial flows, 2) manmade ditches or previously modified channels having perennial flows, 3) natural or man-modified streams or channels having intermittent flows, and 4) natural or man-modified streams or channels having flows only during periods

of surface runoff. Most streams in the Prairie Pothole Region have intermittent flows as did Wild Rice Creek and, therefore, would be placed in category 3. But, regardless of stream category, the end results with respect to drainage of wetlands would have been the same. Thus, placing streams to be channelized in various administrative categories bears no relationship to the potential environmental impacts.

Even though drainage was not a project purpose in the Wild Rice Creek Watershed, the amount of drainage that resulted from the project is consistent with a USDA economic study of the Small Watershed Program over its 18 year history (U.S. Department of Agriculture 1974). That report indicated that "drainage and irrigation have comprised a very significant part of the program in regions where they are needed and adaptable." Drainage still remained the third highest cost, by project purpose (after flood control and recreation) of 205 P.L. 566 projects approved during 1969-72, while miles of channelization per project has experienced an almost linear increase over the 18 years.

RECOMMENDATIONS

Channelization in the Prairie Pothole Region, with its attendant impacts on floodplains and prairie wetlands, is a classic example of Federal (and state) agencies and programs in conflict with each other over finite resources. The conflict takes on even more serious consequences in that region because of the relatively high agricultural productivity and the national and international importance of wetland habitat for migratory birds. Significantly, the loss of this natural production habitat cannot be adequately mitigated or replaced by structural or other means (Harmon 1974).

Channelization in the Prairie Pothole Region is primarily associated with and stimulated by the economic desire for enhancing agricultural production. Channelization accomplishes this by locally removing water from land more rapidly than under natural conditions and by lowering or removing surface and ground water resources which inhibit farming operations and/or optimum crop production. In as much as natural ecosystems develop inherent flood control mechanisms, channelization which destroys these mechanisms can be counter-productive from the standpoint of natural flood control.

When used for the intensification of agriculture, whether expressed or implied, channelization is an indication of an economic or social system out of balance with available natural resources. Thus, we have an engineering technique that attempts to treat a symptom rather than the cause. The end result may well be trading one set of problems

for another. From this base the following specific recommendations are made (general recommendations are in Appendix E).

1. Critical ecosystems, such as wetlands, should be defined and delineated at the national level for each of the Water Resources Council's 18 water resource regions. Appropriate wetland maintenance policies and guidelines should then be implemented to provide pre-project criteria for water development agencies.

2. Special guidelines and environmental constraints are needed for channelization activities in the Prairie Pothole Region.

Although some resources in P.L. 566 projects can be institutionalized and thereby increase some forms of recreation and public use such as fishing and occasionally waterfowl harvest opportunities (Dillon and Marriage 1973), little can be done to mitigate the loss of natural waterfowl production habitat. For example, engineering techniques such as multipurpose reservoirs for flood control are compatible with some forms of recreation such as fishing. However, this is seldom the case with wildlife habitat. Additionally, the relatively low density nature of hunting associated with the pothole region will bias project analysis against such production habitat.

The lack of project sponsor response to the 1958 and 1962 amendments to P.L. 566 which authorized Federal cost-sharing for recreation (U.S. Department of Agriculture 1974), and the lumping of "fish and wildlife" for cost/benefit analysis can place wildlife habitat in general and production habitat in particular at a severe disadvantage.

3. Due to the multiple public values of wetlands (Jahn and Trefethen 1973, and Sprypek 1972) and the negative impacts of channelization on these values, numerous nonstructural alternatives to channelization should be made available at competitive cost-sharing rates.

These alternatives could include combinations of the following: (1) tax adjustments, (2) flood insurance, (3) reduced harvest subsidies, (4) shifts to multiple use and less intensive agriculture, (5) land retirement, (6) zoning, (7) fee purchase, (8) flooding easements, (9) environmental easements, (10) negative sanctions, (11) wetland preservation for flood control, (12) wetland development, (13) retention dams, and (14) diversions into natural storage areas.

Fee purchase of the flood plain appears to be a feasible solution, particularily where damages do not involve public health and safety. In the Wild Rice Creek Watershed, structural measures cost $1,092,830 to protect the 12,490 acre flood plain from summer rainstorm flood damages in 9 out of 10 years. Assuming that the 9,865 acres of spring snowmelt damages also were the same acres inundated by summer rains, structural costs averaged $87.50 per acre at the time floodplain land values were $75-$85 per acre (U.S. Department of Agriculture 1957).

Similarily, wetland preservation for flood control purposes appears to be at least a partial solution. For example, the water budget for potholes (Shjeflo 1968:35 and personal communication 1975) given as:

$$\Delta H = ET+S-P-R$$

where

ΔH = decrease in storage, as measured by the stage of pond,

ET = evapotranspiration,

S = net seepage outflow,

P = precipitation, and

R = runoff

can be modified to obtain net storage values (NSV) of potholes. Assuming the runoff (R) as being included in storage, the following net storage value of undrained potholes, exclusive of precipitation, can be given as follows[1]

$$\Delta H+R = ET+S-P \text{ or}$$

$$NSV = ET+S-P$$

There were 1,096 wetland acres in 629 basins in the channelized portion of the Study Area in 1952. Drainage destroyed 749.5 of these acres by 1972, and continues to eliminate the remainder. Assuming Shjeflo's net seepage outflow for vegetated ponds (S = 1.08'), evapotranspiration rates of 2.75' (Kohler et al. 1959) and average annual precipitation in the Study Area of 1.58 feet, each acre of wetland would have a net storage value (NSV) of 2.25 acre-feet of water.

As expected, this is somewhat below the gross (included precipitation) average annual 2.53 feet of water received by potholes studied

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[1]Total storage values of potholes will vary considerably, depending on topography. The U.S. Geological Survey presently still considers 33 percent of the south tributary and 50 percent of the west tributary of the Wild Rice Creek drainage areas as "non-contributing" (personal communication 1975).

in North Dakota by Shjeflo (1968). Considering the above assumptions, the net storage value (NSV) of 2.25 feet for the original 1,096 acres in wetland basins would have amounted to 2,466 acre-feet of water. This amount of storage would have exceeded by 465 acre-feet the floodwater retention achieved by constructing the watershed projects' four retarding dams (Appendix B). Similarily, the drainage of the entire 1,096 wetland acres, with subsequent loss of their storage values, would more than nullify the flood control benefits of these four reservoirs. At 1957 estimated construction costs of $203.16 per acre-foot for floodwater detention structures (U.S. Department of Agriculture 1957) the 2,466 acre-feet of net storage of wetlands in the channeled portion of the Study Area would have been worth about $500,000 or $457.00 per acre of natural wetland for only this single wetland value.

Encouragingly, some existing Federal programs already tangentially touch on many of these alternatives, for example, P.L. 93-234 (floodplain insurance), P.L. 93-86 (reduced harvest payments due to flooding or late seeding and perpetual easements for floodplains and aquatic areas), P.L. 91-559 (water bank program), and P.L. 87-585 (USFWS wetland program). Specific programs, however, are lacking or not funded for adequately meeting the environmental quality objectives and alternatives under the new Principles and Standards for Water and Related Land Resources (Federal Register Vol. 38, No. 174, Part III).

4. Water development agencies should recognize private wetland drainage as being project induced.

The data are clear that channels constructed in the vicinity of wetlands in the Prairie Pothole Region stimulate and accelerate drainage.

5. The SCS should recognize that relative to drainage the environmental impacts of channelization are unrelated to its stream classification system.

Where wetlands are involved, deepening an intermittent or perennial natural or manmade channel, or constructing a ditch where no channel existed, the end result is the same -- increased drainage. In the Prairie Pothole Region the new SCS stream classification system has no relevance from a wetland drainage standpoint.

6. Clear definitions and/or policies are needed by regions from the Water Resources Council on the following:

A. Flooding and flood control -- what is a flood and how does it relate to the functional floodplain during years and seasons of high precipitation.

B. Flood dangers or damages and "excess water" -- floods should be classified according to their potential impacts on life, health, and property. Allocations of public funds for control should be prioritized on a nationwide basis.

C. Flooding vs. drainage -- distinctions should be based on soil profiles, topographic maps with narrow contours, remote sensing, vegetative types and growth patterns, and historical land use data.

D. "Non-contributing" areas -- should be defined by runoff rates and frequency of overflow. Areas having natural water storage values should be protected so as to remain non-contributing.

E. "Fish and wildlife habitat" -- should be defined and separated by categories and subcategories in order to evaluate environmental impacts, mitigation, and benefits.

F. "New land into production" and "primary purpose" -- should be recognized as relative phrases. The first phrase has little agricultural basis. The numerical ranking of the purpose, if even a purpose at all, is largely academic from an environmental standpoint.

G. "Poorly drained and "very poorly drained" -- are environmentally negative and should be replaced by terms such as "submerged" and "aquatic" soils.

7. More detailed pre-project inventories and investigations should be made in channelization projects in the Prairie Pothole Region in order to more clearly define potential impacts on wetlands and other resources.

8. Resource managers should inventory and obtain elevation data on all aquatic resources in the watershed and relate these to elevations of natural and proposed channels.

In the Prairie Pothole Region, the economic feasibility of wetland drainage normally exists; but not always the physical feasibility. Any excavation below the natural terrain for any purpose which conveys water, therefore, can fulfill the physical constraint.

9. Soil type and soil formation should be used, where appropriate, to specifically separate natural wetlands and cropland with a water problem.

The distinction between drainage and flooding in channelization projects is an important issue. Wetland-soil type relationships appear to be a possible future aid in resolving this issue. Soil surveys, therefore, should define and code all distinguishable wetland basins.

Soil mapping units may also exhibit certain characteristics such as wetland densities, inherent fertility, biological productivity, and ease of drainage, which are important in evaluating environmental impacts of water resource projects.

10. Post-project evaluations should be made at intervals.

Project induced (secondary) environmental impacts can and do result many years after completion. Post-project analysis should be based on automatic data gathering techniques and modeling originally developed for baseline pre-project assessments.

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Appendix A. Water Development

Various water development activities are occurring throughout the United States. The principal Federal agencies involved in water development are the Soil Conservation Service (USDA), the Corps of Engineers (USDD), the Bureau of Reclamation (USDI), and the Tennessee Valley Authority (TVA). The Soil Conservation Service (SCS) and the Corps of Engineers are the primary agencies concerned with flood control. Dams, levees, and channelization have been the principal structural measures used for flood control.

Flood Control Legislation - Soil Conservation Service

The Soil Conservation Service received its authority for flood control activities from the following sources[1]:

(1) The Act of April 27, 1935 (Public Law 74-46), as amended) established the SCS to carry out the "policy of Congress to provide permanently for the control and prevention of soil erosion and thereby to preserve natural resources, control floods, prevent impairment of reservoirs and maintain the navigability of rivers and harbors, protect public health, public lands and to relieve unemployment." The Act authorized the Secretary of Agriculture (a) to conduct surveys and investigations; (b) to carry out "preventive measures, including, but not limited to, engineering

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[1] Stream Channelization: What Federally Financed Draglines and Bulldozers Do To Our Nation's Streams. Fifth Report by the Committee on Government Operations, U.S. Government Printing Office, Sept. 27, 1973.

APPENDIX

operations, methods of cultivation, the growing of vegetation, and changes in use of land;" (c) to furnish financial or other aid to any agency, governmental or otherwise, or any person, subject to such conditions as he may deem necessary, for purposes of the Act, and (d) to acquire lands "whenever necessary for the purposes" of the Act.

(2) Title III of the Bankhead-Jones Farm Tenant Act of July 22, 1937 as amended, authorized and directed the Secretary ... "to develop a program of land conservation and land utilization, in order thereby to correct maladjustments in land use, and thus assist in controlling soil erosion, reforestation, developing and protecting recreational facilities, mitigating floods, preventing impairment of dams and reservoirs, conserving surface and subsurface moisture, protecting the watersheds of navigable streams, and protecting the public lands, health, safety, and welfare, but not to build industrial parks or establish private industrial or commercial enterprises."

(3) Section 13 of the Flood Control Act of 1944 (Public Law 78-534) authorized the Secretary of Agriculture "to prosecute works of improvement for runoff and water retardation and soil prevention in 11 watersheds".

(4) The Act of August 7, 1956 (Public Law 84-1021) as amended in 1969 (by Public Law 91-118) authorized SCS " ... to enter into contracts ... with owners and operators of land

in the Great Plains area ... to assist farm, ranch, or other landowners or operators to make, in orderly progression over a period of years, changes in their cropping systems or land uses which are needed to conserve, develop, protect, and utilize the soil and water resources of their farms, ranches, and other lands and to install the soil and water conservation measures and carry out the practices needed under such changed systems and uses."

(5) Watershed Protection and Flood Prevention Act (Public Law 83-566 as amended) was passed by the 83rd Congress in 1954. The Act permits applications for financial assistance in watersheds or subwatershed areas up to 250,000 acres. If the estimated Federal contribution to construction costs exceed $250,000, or any single flood control structure provides more than 2,500 acre-feet total capacity, the work plan must be approved by the appropriate committee on Congress. The Senate Agriculture and Forestry Committee and The House Agriculture Committee approve plans when a structure provides less than 4,000 acre-feet of capacity. The Senate and House Public Works Committee approve the plans when a structure provides more than 4,000 acre-feet of capacity. Other project plans may be approved by the SCS without approval of a congressional committee.

A watershed project under P.L. 83-566 begins when a local sponsor (water management, drainage, or soil and water conservation district) submits a request, through

the Governor of his designate, for SCS assistance. This assistance will typically include a feasibility study, drafting of a work plan, calculating benefits and costs, liaison with Federal and State agencies and Congress and preparing an environmental impact statement.

To be eligible for assistance (up to 100% for flood control), local sponsors must acquire land and water rights for the features and evidence that they will operate and maintain the improvements.

Public Law 83-566 Watershed projects approved by the SCS since July 1, 1960 involved the channelization of 16,400 miles of waterways at a total Federal cost of about $360 million as of May 1, 1971. Of this total, about 4,200 miles had been channelized by 1971 (U.S. House of Representatives 1973:24).

Drainage Policies - SCS

In the Prairie Pothole States, the SCS has had a policy since at least 1957 which discouraged their technical assistance for the drainage of wetlands if the primary purpose was to bring new land into cultivation (Appendix D). Since 1962 the SCS has been prohibited from providing technical assistance for on-farm drainage through Agriculture Conservation Practices (ACP and REAP) of wetland Types III, IV, and V. The "Reuss Amendment" to the Agriculture Appropriations Act has, since 1962 (P.L. 87-879), contained the following provision:

"provided further, that no portion of the funds for the 1963 program may be utilized to provide financial or technical

assistance for drainage on wetlands now designated as wetland Types 3 (III), 4 (IV), and 5 (V) in the United States Department of the Interior, Fish and Wildlife Circular 39, Wetlands of the United States, 1956."

Since 1967 the SCS has taken the position that it will not provide funds under the Small Watershed Protection and Flood Prevention Act for drainage of wetland Types III, IV, and V (SCS Watershed Protection Handbook, Section 106,041). However, this policy does not prevent the local sponsors or landowners from draining these wetlands, at their own expense, into watershed structures constructed with Federal funds.

Appenxix B. Description of the Wild Rice Creek Watershed

Drainage

The Wild Rice Creek Watershed is approximately 40 miles long and eight miles wide, encompassing 365 square miles, and consists of two tributaries. The south tributary arises in the glacial moraine uplands of the Sisseton Hills in Marshall County, South Dakota, and flows northerly. The source of the easterly flowing west tributary is near Brampton, North Dakota. Major drainage systems were installed in the early 1900's, adding considerably to the drainage area of these tributaries. The two tributaries join about 6 miles south of Forman, North Dakota, forming the headwaters of the Wild Rice River. The Wild Rice River enters the Red River of the North near Fargo, North Dakota.

Geology and Soils

The geology of the watershed consists of four distinct land forms: (1) Lake Plain - Glacial Lake Dakota; (2) Glacial Outwash; (3) Ground Moraine (till); and (4) Dead-ice Moraine (till) (Bluemle 1972). These land forms were deposited by the Wisconsin stage of the continental ice sheets.

The Dead-ice Moraine land form, of particular interest in this report, is glacial sediment that is mainly till, but may include gravel, sand and lake silt, and clay. Till in the area averages about 100 feet in thickness. The collapse of the dead-ice resulted in a rather rugged landscape with numerous marshes of various sizes and shapes.

Soil associations in the North Dakota portion of the watershed include the following: (1) Forman-Aastad, (2) Gardena-Glyndon, (3) Gardena-Spottswood-Wessington, and (4) Valentine-Hecla (Sargent County Soil Survey 1964). A description of these soil associations is listed in Table 1.

Table 1. Soil associations in the Wild Rice Creek Watershed (Sargent County Soil Survey 1964).

Soil Association	Description
1. Forman-Aastad	Well drained and moderately well drained nearly level and undulating soils in loamy glacial till; prismatic blocky subsoil.
2. Gardena-Glyndon	Moderately well drained soils in old silty lake sediments.
3. Gardena-Spottswood-Wessington	Well drained loamy soils underlain by sands and gravel.
4. Valentine-Hecla	Sand, soils in a choppy area where difference in elevation are generally less than 10 feet.

Land Use

Farms occupied 223,420 acres or 95.7 percent of the watershed in 1957 (U.S. Department of Agriculture 1957). The remainder of the acres were in towns, roads, and other miscellaneous uses. The average farm size in 1954 was 465 acres in Sargent County, North Dakota, and 505 acres in Marshall County, South Dakota.

Approximately 61.7 percent of the watershed was in cultivation when the watershed was proposed in 1957 (Table 2). Small grain accounted for 66.3 percent of the acres; row crops, 16.1 percent; tame hay, 14.5 percent; and summer fallow, 3.1 percent (U.S. Department of Agriculture 1957).

Eighty-four percent of the flood plain of the Wild Rice Creek Watershed was under cultivation, with wheat the major crop (Table 3).

Table 2. Land use in the Wild Rice Creek Watershed (U.S. Department of Agriculture 1957).

Land Use	Acres	Percent
Cropland	144,110	61.7
Grassland	70,157	30.0
Woodland	1,831	0.8
Misc.[a]	17,424	7.5
TOTAL	233,522	100.0

[a]Included roads, railroads, towns, and marshland.

Table 3. Crops grown in the floodplain of the Wild Rice Creek Watershed (U.S. Department of Agriculture 1957).

Crop	Percent of Cropland
Wheat	24.2
Barley	15.3
Oats	11.5
Corn	14.5
Flax	16.1
Alfalfa-brome	14.8
Summer Fallow	3.6
TOTAL	100.0

Climate

Climate in the watershed is typical of the eastern portion of the Northern Great Plains. Mean monthly temperatures vary from 71.4 F in the summer to 7.1°F in the winter. Maximum and minimum temperatures recorded were 110° and -45°F. Average annual precipitation is 20 inches, varying from 9 inches in 1936 to 35 inches in 1916. Mean snowfall is 31 inches. Average latest and earliest killing frosts are May 18 and September 23, respectively (U.S. Department of Agriculture 1957).

Flooding

Topography of the floodplain is relatively flat with grades as low as two feet per mile. Depths of flooding are not great and velocities are relatively low (U.S. Department of Agriculture 1957:7).

The Watershed Work Plan indicates that efforts were made in the South Dakota portion of the watershed to reduce floodwater damage and that "piecemeal approaches aggravated problems downstream."

Watershed flooding problems as described by the Watershed Work Plan are attributed to snowmelt and summer rainstorms. A 100-year frequency snowmelt was estimated to delay spring seeding by three weeks on 9,865 acres, causing an average damage of $26,744 or 31.6 percent of the total crop damage. A summer rainstorm at a 100-year frequency was estimated to damage 12,490 acres at an average value of $58,002 or 68.4 percent of the total damage to crops and pasture. Ninety-six percent of the direct flood damages were associated with crops and pasture. The remaining 4 percent were related to weed control, roads, bridges, and culverts. Indirect damages were estimated at 10 percent of the direct damages.

Erosion

Sediments transported by floods were reported to be low. Sediments from wind erosion on cultivated fields are frequently deposited in drainage ditches and waterways, requiring added maintenance (U.S. Department of Agriculture 1957). However, neither of these two types of deposition were considered to be measurable. Sheet erosion occurs

on the steeper slopes and in the moraine uplands. Damages from flood plain scour and stream bank erosion were negligible because of the low stream gradient and low velocities of the floodwater as it leaves the channel and spreads out across the land.

Other Water Problems

As indicated in the explanation of supplements to the Watershed Work Plan, there is a sizeable area proposed for irrigation by the Bureau of Reclamation in the western portion of the watershed. A portion of this area is underlain with a high water table that requires a system of water disposal ditches. The Bureau of Reclamation plans to channel the west tributary of Wild Rice Creek to accommodate increased flows from these drainage ditches and from irrigation return flows (Fig. 1).

Flood Control Measures

The Watershed Work Plan contained both structural (channelization, drop structures, and dams) and non-structural (land treatment) measures for flood control.

Land Treatment

Land treatment measures were to be applied to 47,766 acres within the watershed (Table 4). Annual land treatment practices involved 41,528 (86.9 percent) of these acres and permanent treatment was to be applied to 6,238 acres. In addition to those treatment practices,

16 miles of terracing and 25 stockwater ponds were to be installed. These land treatment measures were to reduce the floodwater damages by 4 percent (U.S. Department of Agriculture 1957).

Total land treatment costs were estimated at $322,351, of which $26,570 was to be from Public Law 83-566 funds. Private and Agriculture Conservation Program (ACP) funds were estimated at $295,781.

Structural Measures

Structural flood control measures in the Watershed Work Plan included four floodwater retarding dams and 24.7 miles of channel improvement. Floodwater structures were designed with a total capacity of 2,335 ac-ft., with floodwater detention of 2,001 ac-ft. At 1957 prices, estimated costs for the retarding structures amounted to $397,429.00 ($198.61/ac-ft.) Federal and $9,100.00 ($4.55 ac-ft.) local funds.

Federal costs for channel improvement were estimated at $247,930.00 ($10,037.65/mile) and local costs $271,480.00 ($10,991.09/mile). Local costs for all structural measures totaled $280,580 of which $269,480 was attributed to channel improvement easements and rights-of-way, including section line and private drive bridges (U.S. Department of Agriculture 1957).

Table 4. Land treatment measures to be applied to the Wild Rice Creek Watershed (U.S. Department of Agriculture 1957).

Land Treatment	Acres
Conservation Crop Rotation	17,840
Wind Strip Cropping	2,200
Stubble Mulching	500
Crop Residue Utilization	16,737
Contour Farming	948
Contour Strip Cropping	370
Proper Use	6,451
Contour Pasture Furrowing	761
Pasture Planting	1,331
Tree Planting	352
Wildlife Area Improvement	
Tree and Shrub Plantings	17
Wetland Improvement	210
Waterway Development	49

Supplements to Watershed Work Plan

Structural and land treatment measures were modified by four supplements between 1959 and 1971 (Table 5). According to Supplement II, the work plan needed amending because of factors discovered during the designing of the main channel. A new hydrologic procedure was developed to determine the channel size and capacity. It was determined that two grade stabilization structures would be required at the upper end of the main channel instead of the one prescribed in the work plan and that the main channel needed to be extended downstream. The original channel called for a capacity of 7.42 cfs/sq.mi. According to the supplement, if this criterion was used it would not give uniform protection along the entire flood plain.

The new hydrologic procedure provided for uniform protection and was based on removing a 10-year frequency summer flood from the flood plain within 24 hours. Channel laterals "A" and "B" were added "so that the benefits claimed in the original plan are realized." The benefit/cost analysis changed from the original 2.3:1 to 1.9:1 as a result of this supplement. Fig. 1 shows the location of laterals not in the original work plan. Estimated Federal costs for the channel rose from $247,930 to $398,196 and local costs from $276,580 to $293,205.

Supplement III in 1965 stated that "it has been found necessary to modify the Watershed Work Plan, as supplemented, by adding 6.09 miles of channel improvement to be known as Channel No. 9 and located entirely within North Dakota" (Fig. 1). The channel was added when it

was determined that it would not conflict with the Bureau of Reclamation's irrigation plans in the area.

Table 5. Supplements to the Wild Rice Creek Watershed Work Plan, 1959-71.

Supplement No. and Year		Changes
Supplement I	1959	Wild Rice Creek Watershed District becomes a co-sponsor.
Supplement II	1961	(a) Changed original channel design, increasing the capacity and extended main channel one mile downstream. Channel excavations increased from 592,584 cu. yds. to 901,100 cu. yds. (b) Added two channels (Lateral "A" of 1.1 miles and Lateral "B" of 1.3 miles, both in South Dakota). (c) Added a grade stabilization structure to the main channel in South Dakota.
Supplement III	1965	(a) Added 6.09 miles of channel improvement (Channel #9) in North Dakota, with wildlife habitat mitigation features. (b) Changes name of Sargent County Water Conservation and Flood Control District to Sargent County Water Management District.
Supplement IV	1971	Deleted 11.2 miles of channel improvement (Britton Channel) in South Dakota.

The Work Plan states that a plan proposed by the sponsors for a retarding reservoir on the west tributary for the reduction of flood damage, and for a series of equalizing ditches was determined not to be acceptable because of the irrigation plans of the Bureau of Reclamation. The reservoir would have acted as a drainage block, with a "backwater" effect on approximately 2,200 acres of irrigable lands.

The Bureau of Reclamation's plan involves an extensive system of water disposal ditches to accommodate internal drainage and irrigation water return flows. According to the Work Plan, sufficient capacity would be available from these drains to adequately control flood producing storms throughout the growing season. The increased out-flows resulting from the Bureau of Reclamation's development of this irrigation water disposal system would be recontrolled downstream in the Wild Rice "B" Watershed (planned downstream on the Wild Rice River). Structural measures were therefore abandoned in the western portion of the watershed (Fig. 1).

The local sponsors agreed in Supplement III to acquire the land, easements, or rights-of-way as needed for channel improvement and associated mitigation measures for Channel No. 9 (est. cost - $15,942). The local costs for administering contracts were estimated at $500. Federal construction costs for Channel No. 9 and wildlife mitigation measures were estimated at $96,515 and installation services (Federal) at $23,192.

Total local costs for the structural measures in the watershed project, after implementation of this supplement, were estimated at $313,647. Total Federal costs for structural measures amounted

to $859,555. The benefit/cost ratio returned to 2.3:1.

Supplement IV in 1971 deleted 11.12 miles of channel improvement (Britton Channel). This channel originated near the town of Britton, South Dakota, and joined the main channel of the south branch of the Wild Rice Creek about three-fourths of a mile south of the North Dakota - South Dakota border. The benefit/cost ratio dropped to 1.8:1 with this supplement. No explanation was given for deleting the Britton Channel.

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Sargent County Soil Survey. 1964. USDA Soil Conservation Service and North Dakota Agricultural Experiment Station. Series 1958. No. 28. January 1964.

U.S. Department of Agriculture 1957. Watershed Work Plan. USDA Soil Conservation Service. 25 pp plus tables.

APPENDIX C

Wetland Types, Densities and Drainage Rates Within Soil Types in Study Area, Sargent County, North Dakota, 1952-1972.

Soil Type	Acres In Chan. Area	Acres In Unchan. Area	Wetland Density (% Acres 1952)	Wetland Types[a] I #	I Ac.	III #	III Ac.	IV #	IV Ac.	V #	V Ac.	Total All Types #	Total All Types Ac.
Aastad, clay loam (Aa)	659	02	18.5	25	8.5	35	113.5	0	0	0	0	60	122.0
Drained				19	7.4	31	109.8					50	117.2
Aastad, loam (Ab)	4307	1236	15.9	211	89.6	365	761.2	2	31.0	0	0	578	881.8
Drained				148	64.2	244	493.4	0	0			392	557.6
Aastad-Cresbard, loams (Ac)	92	0		2	2.2	4	7.2	0	0	0	0	6	9.4
Drained				2	2.2	2	5.2					4	7.4
Buse-Lerner, loams (BvD)	6	68		1	0.1	4	2.6	2	12.8	0	0	7	15.5
Drained				1	0.1	0	0	0	0			1	0.1
Forman-Aastad loams (FoB)	593	1828	22.6	31	12.6	207	351.7	12	113.1	3	70.4	255	547.8
Drained				15	4.1	56	61.8	0	0	0	0	71	65.9
Forman-Buse, loams (FvC)	19	227	29.8	5	1.7	18	57.2	3	14.5	0	0	26	73.4
Drained				2	0.3	3	4.8	0	0	0		5	5.1
Gardena-Glyndon, silt loams (GnA)	261	0	4.7	8	3.7	4	8.6	0	0	0	0	12	12.3
Drained				6	3.4	2	4.0					8	7.4
Hamerly Complex (Hb)	20	7		0	0	4	7.6	0	0	0	0	4	7.6
Drained						4	7.6					4	7.6
La Moure, silty clay loam (La)	168	171	3.6	1	0.1	6	12.2	0	0	0	0	7	12.3
Drained				0	0	4	11.6					4	11.6
La Prairie, silt loam (Lp)	61	5		0	0	3	1.9	0	0	0	0	3	1.9
Drained						2	1.1					2	1.1
Overly-Rearden, silty clay loam (OyA)	502	0	10.2	15	5.9	17	29.6	2	15.6	0	0	34	51.1
Drained				11	4.9	11	22.2	1	9.6			23	36.7
Renville Soils (Re)	68	10		0	0	1	7.2	0	0	0	0	1	7.2
Drained						0	0					0	0
Total Acres	6,736	3,554		301	124.4	668	1,360.5	21	187.0	3	70.4	993	1,742.3
Drained (1952-1972)[b]				204	86.6	359	721.5	1	9.6	0	0	564	817.7

[a]Types according to Shaw and Fredine (1956)
[b]Drainage rates vary in channeled and unchannaled areas.

Appendix D. USDA Drainage Policy in 1957

UNITED STATES DEPARTMENT OF AGRICULTURE
Washington 25, D. C.

Date: February 21, 1957

TO: SCS State Conservationists, Minnesota, South Dakota and North Dakota
Chairmen, ASC State Committees

FROM: D. A. Williams, Administrator, SCS
P. M. Koger, Administrator, ACPS

SUBJECT: Guidelines for Applying Policies in Drainage and Biology in the Pothole Section of Minnesota, North Dakota and South Dakota

This memorandum is applicable in those soil conservation districts and counties of Minnesota and the Dakotas in which potholes occur. It establishes guidelines for use by SCS Work Unit and Area personnel in making decisions regarding extending assistance in drainage under SCS Administrator's Memorandums 98 and 102, and provides information for State and County ASC Committees since in some cases they may ultimately be called on to make decisions in some of these cases. In using the guidelines, close cooperation must be maintained between SCS, the ASC County Committee and the supervisors of the Soil Conservation District.

Background Information

The following background information is important to the understanding and application of the guidelines:

1. Work Unit and Area personnel of SCS are required to decide in accordance with applicable Department policy, whether requested assistance should or should not be extended in the drainage of particular wetland sites. Among the problems arising in making such decisions are:

   a. How to appraise the primary purpose in draining the site.

   b. How to discharge Service objectives and policies in regard to wildlife as stated in Administrator's Memorandums 98 and 102.

c. How to discharge Service responsibilities in the Conservation Reserve Program.

2. The policy of the Department with respect to drainage is essentially this: Federal funds will not be used to assist in draining lands for the purpose of developing new farms nor for the primary purpose of bringing new land into agricultural production.

a. SCS Administrator's Memorandum 102 states: "In accord with the current policy of the Department of Agriculture, the Service will not provide assistance to cooperators in drainage, the primary purpose of which is to bring additional land into agricultural production."

b. Descriptions of drainage practices in the ACP National Bulletin include the limitations: "No Federal cost-sharing will be allowed for ditches (systems), the primary purpose of which is to bring additional land into agricultural production . . . . . In the installation of drainage systems, due consideration shall be given to the maintenance of wildlife habitat."

3. The Department does assist farmers in improving their operating efficiency by helping them to apply improved farming practices, including drainage of existing crop and pastureland whenever such drainage will contribute to improvement of efficiency on individual farms. In such cases, the Department provides technical assistance from the Soil Conservation Service and cost-sharing assistance is available under the Agricultural Conservation Program.

a. The Soil Conservation Service has several responsibilities in regard to the Agricultural Conservation Program. Among these is the responsibility for the technical phases of the drainage practices. This responsibility includes determining whether the proposed drainage is needed and practical. It also includes determining whether the primary purpose of the drainage is to bring additional land into agricultural production (see paragraph 134 of the ACPS Handbook).

b. The ACP National Bulletin lists seven general principles which are the basis upon which the program is developed and carried out. Principle 6 states: "The purpose of the program is to help achieve additional conservation on land now in agricultural production rather than to bring more land into agricultural production. The program is not applicable to the development of new or additional

"In the installation of drainage systems, due consideration shall be given to the maintenance of wildlife habitat."

6. The landowner or operator makes the decision as to how he will use and treat his land including whether he will apply drainage or other conservation practices.

Guidelines for Considering Individual Requests

The guidelines which follow apply to Soil Conservation Service technical help, whether the request is one referred from the Soil Conservation District, is an application for ACP cost-sharing, or is both. They are not intended as inflexible rules but as aids in judging the merits of each case, in making sound decisions as to whether the requested assistance will or will not be extended, and in planning for the maintenance or improvement of wildlife habitat.

In judging the merits of each case of an area proposed for drainage, the following circumstances should be considered:

a. Is the area located in a cultivated field or is it in a field of permanent or native vegetation?

b. Is the area a permanently wet one?

c. In what manner and how seriously does the area interfere with the efficiency of farming operations or with the establishment of conservation measures.

d. If the area can be cultivated after drainage, what will be the relationship of cost of drainage to early return from crops?

e. What is the proportional relationship of the area to the total cultivated acreage of the farm?

It is rather obvious that in many cases where the drainage of potholes and permanently wet areas would contribute importantly to the total acreage of cultivated land on the farm or for which the cost of drainage would likely be quickly amortized by returns from cultivated crops, they would be interpreted as being primarily for the purpose of bringing additional land into production.

Generally, assistance will not be provided for drainage of the following kinds of potholes and wet areas since ordinarily such drainage will be primarily for the purpose of bringing additional land into agricultural production:

farmland as a result of drainage . . . . . ."

c. In the ACPS Handbook (paragraph 78) the limitation regarding the bringing of additional land into agricultural production is interpreted as follows: "General program principle 6 and the wording of some practices deal with bringing additional land into agricultural production. It probably could be said that practically all land in farms and ranches is in agricultural production to some limited extent. However, the application of such an interpretation would permit the approval of practices C-9, C-10, C-13, and C-14 on woodland, swampland, open native range, desert land and similar land entirely unproductive except in the most limited sense. Such an approach would make the provision meaningless. The drainage of such land or the bringing of such land under irrigation would be, in practical effect, the bringing of additional land into agricultural production. No inflexible rule would likely achieve conformity with the spirit of the sixth general program principle in the National Bulletin and the wording of the practices. Accordingly, in approving or disapproving requests for cost-sharing for practices to which the limitation applies, county committees should proceed on the basis of sound judgment applied to the individual cases. As a general rule, cultivated cropland would be eligible as would land devoted to the production of tame hay crops. As to swampland, desert land and open rangeland producing only the natural growth of native forage, it is believed that such land which has been farmed at some time in the past, but which has not been farmed in recent years . . . . . generally would not qualify."

4. The Conservation Reserve Program provides economic returns and cost-sharing for retirement from cultivation of lands eligible for this program. Practice C-2, "Water and marsh management to benefit fish and wildlife," includes "The development of shallow-water areas to improve habitat for waterfowl, fur animals and other wildlife as well as restoration of drained areas (formerly marshland) by installing earth plugs or water control structures in drainage ditches." (When accepting assistance on Practice C-2, the landowner is responsible for conformity with applicable State laws relating to obstructing drainage ditches."

5. The SCS and the ACPS recognize wildlife to be a resource of national importance. One of the stated policies in biology of the SCS is: "To safeguard the habitat of valued wildlife and to offset or reduce damage to such habitat resulting from changes in land use or installation of soil and water conservation practices." The ACP National Bulletin sets up the qualification:

1. Potholes and wet areas in fields of permanent or native vegetation.

2. Potholes, marshes, sloughs, swales and swamps characterized by such vegetation as rushes, sedges, cattails, reed grasses, aquatic trees and shrubs, and associated aquatic plants.

3. Potholes and wet areas that do not seriously interfere with farming operations or with the establishment of conservation practices other than drainage.

Requests for assistance in draining the above kinds of wet areas may, in some cases, represent conditions where (a) the wet area is in the line of a ditch that will serve cropland at a higher elevation, or (b) the presence of the wet area prevents the adoption of needed conservation practices. Where such conditions exist, there may be some question as to whether the primary purpose of the proposed drainage is to bring additional land into agricultural production. If the WUC of SCS is in doubt as to whether furnishing the assistance would be proper, he will take one of the following actions:

1. If the request is an ACP 247 referral and the applicant is a SCD Cooperator, the WUC will consider the case with both the ASC County Committee and the SCD Board of Supervisors.

If such consultation indicates agreement of the Committee, the Board, and the WUC that the assistance is justified, the ACP 247 referral should be properly executed and the assistance extended.

If such consultation indicates less than agreement as to the assistance being justified, the ACP referral should be handled in conformity with paragraph 134 of the ACPS Handbook which, as to such doubtful cases, reads: "In the final analysis, judgment decisions in the doubtful cases are the responsibility of the county committee." In making decisions in these cases, the ASC County Committee should endeavor to abide by the guidelines set forth in the memorandum to the fullest extent consistent with the facts in the individual case.

2. If the request is an ACP 247 referral but the applicant is not a SCD Cooperator, the WUC will consider the case with the ASC County Committee. If consultation does not result in agreement as to appropriate action, the referral will be handled in conformity with paragraph 134 of the ACPS Handbook.

3. If the applicant is a SCD Cooperator but ACP cost-sharing is not involved, the WUC will consider the case with the SCD Board of Supervisors. If such consultation erases any doubt as to whether the assistance is justified, the assistance should be extended.

Group Drainage Enterprises

Requests for assistance in drainage enterprises organized under State laws will be evaluated in accordance with the same criteria used for judging the merits of requests by individual farmers. Where the request does not involve ACP cost-sharing and there is some doubt whether assistance should be provided, it will be referred to the SCS State Office for consideration.

Safeguarding the Habitat of Wildlife

Migratory waterfowl are an important wildlife resource of the pothole country. They are produced primarily upon privately-owned farm and ranch lands and their continued production in this area necessitates that landowners and operators have an appreciation of the values and importance of this resource, and that the retention and improvement of waterfowl habitat becomes a recognized part of conservation farming and ranching. It also requires the cooperative effort of private and public wildlife interests to enhance the opportunities for habitat improvement.

It is not solely the problem of landowners and operators. Wildlife interests must come to recognize and respect the farmer's choice to do with his land as he determines.

With these facts in mind, the WUC is responsible for taking the following actions even in those cases where the proposed drainage is clearly eligible within the policies of SCS and ACPS.

1. Encourage the soil conservation district governing body to develop positive wildlife conservation activities and to establish policies which will encourage habitat improvement for waterfowl and other wildlife.

2. Inform the farmer about the significant wildlife values of the wetland involved and call to his attention the alternative opportunities of improving the site for wildlife, including practices under the Conservation Reserve Program.

3. Consider with the farmer ways of replacing the significant habitat values that will be lost by drainage through: (a) improving permanent potholes left on the farm, or (b) developing ponds, pits, or dugouts, or (c) restoring previously-drained areas through the Conservation Reserve Program or other private or public effort.

4. If the farmer's decision to drain the area is not altered, and if the pothole is a permanent one and of apparent significant wildlife value, inform the farrer (and Soil Conservation District if he is a cooperator) that the SCS cannot give him further drainage

Appendix E. General Recommendations

1. The interrelationships of international balance of payments, export markets, market prices, target prices, energy inputs and margins of profit need to be evaluated in terms of rural stability, environmental tradeoffs, and environmental quality objectives.

2. Institutional constraints (zoning, tax relief, etc.) to exclude agriculture from certain critical habitats are needed at the national level to avoid bringing these habitat types into intensive production.

These constraints also should provide economic and social stability in rural areas. At present, some programs -- for example, the Rural Development Act and revenue sharing -- are available for rural economic and social stability, without the necessary accompanying environmental quality constraints. Environmental quality objectives should be associated with and become an incentive for this stability.

3. Hydrological and economic analysis of flooding and the proposed solutions involving the Federal Government should be conducted by its non-construction agencies, such as the U.S. Geological Survey and the Economic Research Service.

4. All wetland values should be researched more fully to determine their role in ecosystems.

Quantifications are needed on wetland values such as those described in the Water Bank Act (16 U.S.C. 1301-1311) which are: "to preserve and improve habitat for migratory waterfowl and other

wildlife resources; to reduce runoff, soil and wind erosion; and contribute to flood control; to contribute to improved water quality and reduce stream sedimentation; to contribute to improved subsurface moisture; to reduce acres of new land coming into production and to retire lands now in agricultural production; to enhance the natural beauty of the landscape; and to promote comprehensive and total water management planning."

Considerable emphasis has been placed on biological research relative to wetlands; however, more is needed from an ecological, social and economic standpoint. Engineering solutions for flood control predominate due to the lack of ecological, social and economic data on wetlands.

The values of wetlands for flood control, for example, needs to be fully established. Utilization of wetland storage appears to be a partial alternative, both physically and economically, to channelization for flood control.

Conversely, the cause and effect relationship of wetland drainage and downstream flooding also needs to be quantified. In the Wild Rice Creek Watershed, wetland drainage into an old legal drain (Channel No. 9) may have created a self-imposed flooding problem and thus the necessity for redigging this artificial tributary as an addition to the watershed project.

Similiarly, the Watershed Work Plan (U.S. Department of Agriculture 1957) states that earlier "piecemeal approaches (straightening and deepening the south tributary of Wild Rice Creek) aggravated problems downstream." The Work Plan also states, "Structures (retarding

reservoirs and channel improvements) are interdependent because the reservoir control will offset the otherwise increased flows downstream caused by the Britton branch of the channel improvements" and "This plan provides for floodwater storage capacity sufficient to compensate for the increased outflows from channel improvement."

5. All wetland preservation and/or maintenance programs should be expanded and modified to incorporate all social, economic and ecological benefits.

Even in the unchannelized area, wetlands are being lost. This same problem exists throughout much of the Prairie Pothole Region, in spite of the alternatives available with P.L. 93-585 (Wetlands Acquisition Act) and P.L. 91-559 (Water Bank Act).

6. The Water Resources Council should explore the concept of "low hazard" flooding in agricultural floodplains.

7. Channelization and its impacts should be studied by interdisciplinary teams on an ecosystem basis.

8. Funds for environmental analysis should at least equal the funds for engineering services.

9. Project sponsors should be informed at the outset of the policies regarding environmentally critical resources, including aquatic and terrestrial habitats.

10. One foot contour intervals of the floodplain and wetland basins should be used in determining flood damage areas and wetland elevations.

11. Land use changes and land treatment measures specifically designed to retain runoff and increase infiltration should be researched to the fullest extent.

Only 4 percent of the flood control benefits were attributed to land treatment in the Wild Rice Creek Watershed (U.S. Department of Agriculture 1957). However, Linsley and Franzini (1964) report that water infiltration can be increased up to 7 times by vegetative cover.