Chapter Twenty-eight

AGRICULTURAL WATER MANAGEMENT BY STREAM WATER LEVEL CONTROL

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INTRODUCTION

In the past ten years, irrigated land in the South Atlantic Coastal Plains has increased from 216,500 ha to 759,200 ha (Anonymous, 1985a). As elsewhere, southeastern agriculture must compete with industry and municipalities for water. Use of deep ground-water for irrigation will probably continue to increase by 13-25 per cent per year unless alternative sources such as stream water-level control (SWLC) are developed. An estimated 1,110 km (18,000 miles) of channels on 4.8 million ha (12 million acres) of land in the southeast and on 15-20 million ha in the humid region can benefit from the addition of water-level control structures to conserve water resources through stream water-level management.

Water resources may become critical in the Southeast as well as in other sections of the US. For example, in North Carolina, water levels in the Yorktown, Castle Hayne and Cretacens aquifers have dropped 3 m, 24 m and 30 m, respectively, since 1965. In South Carolina, the water levels in the Black Creek and Middendorf aquifers have dropped 9 m since 1965 (US Geological Survey, 1985). The drawdown of these aquifers are not the only problem. Flood control requires the use of stream channelization. Benefits of channelization on flood control were observed after 1967 in the Conetoe Drainage District in North Carolina. In 1967, a Public Law 566 drainage project drained 25,000 ha of land using 153 km (95 miles) of channels. Several thousand ha of cropland that were once flooded several times a year, washing out bridges, flooding homes and damaging crops, became protected. Channelization corrected the flooding problem but caused overdrainage near these deep channels, increasing drought stress to crops and reducing yields. This watershed needs both drainage and water conservation in the same system.

A portion of the Conetoe Drainage District, the Mitchell Creek Watershed, in Edgecombe and Pitt Counties, North Carolina, was selected for the study of drainage and water resource conservation by maintaining stream water levels with only 0.6 m freeboard in dry weather but allowing the stream to flow unrestricted during times of flooding. This chapter describes the effects of SWLC on the field water-table, the water stored for irrigation water supply, flood control, water quality, and crop yield response.

METHODS AND MATERIALS

The 800 ha (2,000 acre) area along Mitchell Creek is flat to gently rolling with a maximum elevation difference of 1.5 m (5 feet). Nine soils series - Altavista, Augusta, Cape Fear, Conetoe, Portsmouth, Roanoke, State, Tarboro and Wahee - were mapped and rechecked for yield sample sites by Soil Conservation Service personnel. Water-table observation wells were installed 5.5 m (18 feet) deep, in six lines perpendicular to and on both sides of Mitchell Creek. Hydraulic conductivity was measured randomly over the area using the auger hole method (Luthin, 1957) and the open-end pipe test method (Anonymous, 1974). A Fabridam (Doty, Thayer and Jessup, 1984b)(a water-inflatable structure made of 2-ply nylon rubber-coated fabric bolted to a concrete pad in the shape of the stream channel) was installed in 1982 across Mitchell Creek about midway along the study area to control stream water-level elevations (Figure 28.1).

Crop yields were determined from hand-harvested samples near the water-table observation wells (Doty, Parsons, Nasehzadeh-Tabrizi, Skaggs and Badr, 1984a). Regressed yields are averages of samples taken over the area where crops were grown. Yields for 1980 and 1981 were averaged for the entire area. Beginning in 1982, the area was divided into two sections; above (control) and below (no control) the dam, with irrigated and non-irrigated fields in both areas.

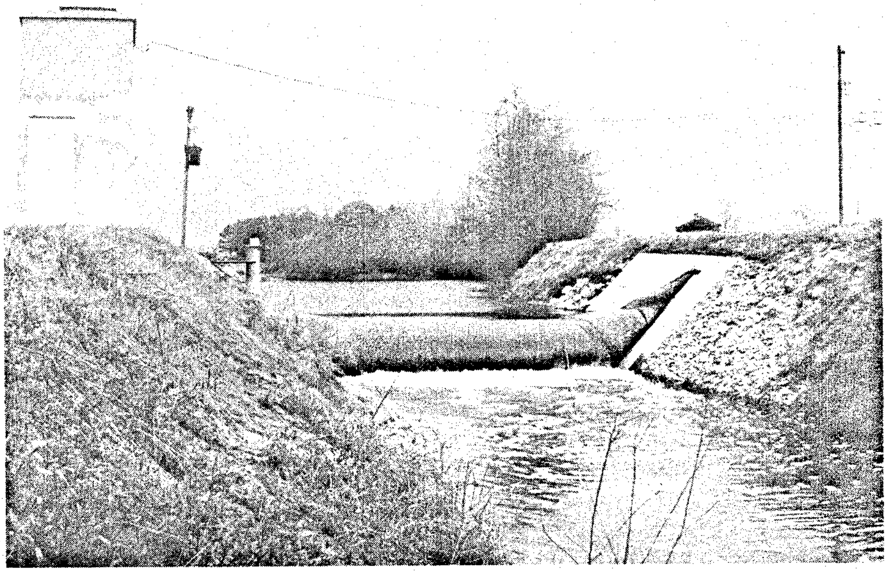
RESULTS AND DISCUSSION

Stream water-level control (SWLC) raised the water-table levels and increased the soil water storage underground as depicted in Figure 28.2 (Doty, Parsons, Skaggs and Nasehzadeh-Tabrizi, 1984c). The soil water storage decreased as distance away from the dam increased both perpendicular to the stream and upstream from the dam reaching approximate equilibrium with the non-controlled levels at more than 3,005 m upstream and 650 m perpendicular to the stream. This additional storage is estimated to be about 820,000 m^3, an underground lake 1 m deep covering 82 ha, or the average yearly irrigation requirement of 385 mm for about 213 ha.

Water, stored in the soil profile, flows to the channel in response to hydraulic gradients where it can be pumped from the creek. More than four times as much land area was irrigated in 1985 as in 1980 before SWLC (Table 28.1). In 1983, 352,840 m^3 (168 mm on 210 ha) of water was pumped from Mitchell Creek (Table 28.1) and more than 10 times that amount remained in storage at the end of the drought in 1983 (Doty, Moore and Foutz, 1986). Irrigation water pumped from Mitchell Creek with SWLC will sustain irrigation for about 50 per cent of the land area in the watershed and increase crop yields.

In 1980 and 1981 without SWLC, corn yields in the Mitchell Creek watershed increased as the distance of the sample site from the creek increased (Figure 28.3). Corn grain yields (corrected to 15.5 per cent moisture) of 4.8 t/ha were measured at 25 m from Mitchell Creek and 9.0 t/ha at a distance of 852 m from the creek,

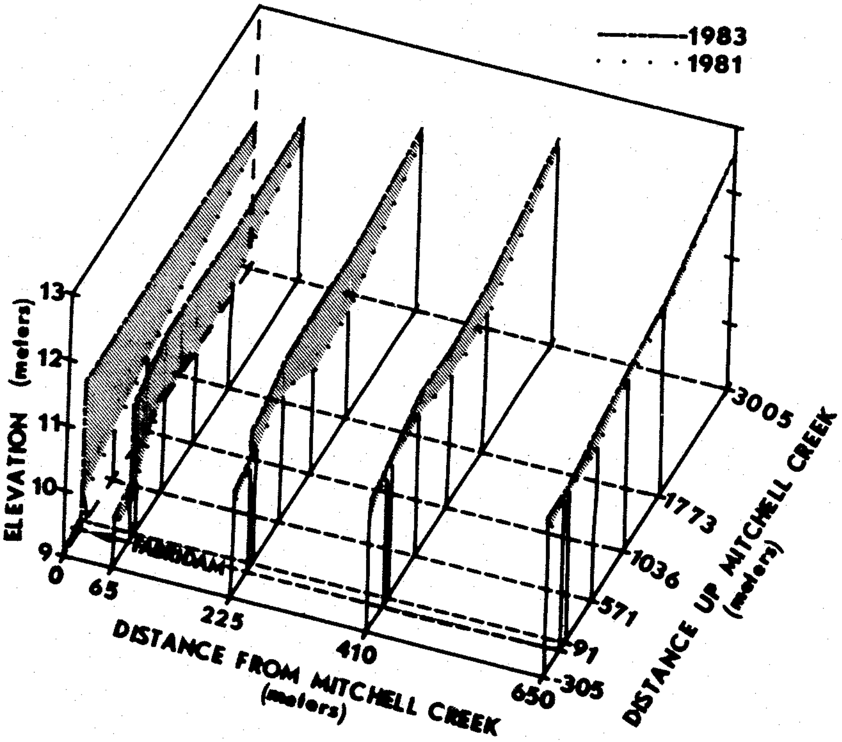
Figure 28.1: The water-inflatable fabric dam on Mitchell Creek near Tarboro, North Carolina



a rate increase of about 0.1 t/ha for each 18.7 m (1 bu/38 ft) (Doty et al., 1984a). Plant stress, due to a lack of water, caused the lower corn yields near Mitchell Creek (Hardjoamidjojo and Skaggs, 1982; Doty et al., 1984a). In 1982-84 corn yields above the Fabridam with SWLC near Mitchell Creek were slightly more than they were away from the Creek. Corn yields at 25 m from the Creek were about 5 t/ha more after SWLC than before SWLC (Figure 28.3). This confirms that the overdrainage effects on crop yields were corrected by SWLC. Yields were increased by SWLC to a point about 500 m (1640 ft) on each side of Mitchell Creek.

Average yields of corn and soybeans on the study area are shown in Table 28.2. In 1982-5 under rainfed conditions with SWLC, there was a statistically significant 24 per cent increase in corn yields (1.5 t/ha) over that below the dam without SWLC. Under surface-irrigated conditions, there were no significant differences between corn yields with and without SWLC. Without SWLC, irrigation increased corn yields by 70 per cent in 1980 and 1981 and 79 per cent in 1982-5. This shows that additional water was needed and irrigation important during the later years. Irrigation and SWLC caused an increase in the average corn yields of 69 per cent (4.3 t/ha) during 1982-5 over those sites without SWLC or irrigation. Soybean yields under rainfed conditions were also increased slightly by SWLC, but not significantly, over those

Figure 28.2: Soil-water storage represented by water-table elevations for 1981 (before installation of Fabridam) and 1983 (after installation) in relation to distance from Mitchell Creek, above and below the dam



without SWLC (Table 28.2). However, under surface-irrigated conditions, soybean yields were 15 per cent less with SWLC than without SWLC. Corn and soybeans in the irrigated fields without SWLC were grown under a center pivot system, and those in the irrigated fields with SWLC were irrigated with a volume gun. Soybean competed with peanuts for irrigation with the volume gun in fields with SWLC. Stream water-level control was effective in increasing crop yields and storing water for irrigation.

In addition to yield increases, nutrient concentrations in the stream flow decreased by about 50 per cent after SWLC was implemented (Gilliam, Skaggs and Doty, 1986). This indicates less pollution of the stream water by agricultural activities with SWLC. Also, the farmers in the area report more and larger fish in the creek, more wood ducks nesting along the channels, and an increase in wildlife in general browsing at stream edges. The automatic operation of the Fabridam prevented flooding of the land area even with the shallow water-table provided by SWLC (Doty et al., 1986).

Table 28.1: Irrigation water pumped and land area surface irrigated

Year	No. of systems used[a] CP	VG	CDSI	Average annual irrig. appl. (mm)	Covered/ surface irrigation (ha)	Irrig. water pumped from Mitchell Creek (m^3)
1980	2	2	-	122	79	96,234
1983	2	2	-	168	210	352,840
1985	8	3	1	80	327	261,284

Note: a, CP = center pivot; VG = volume guns; CDSI = controlled-drainage/subirrigation system.

Table 28.2: Average crop yields for agricultural water management systems

	Average for years 1980 - 1981		1982 - 1985	
	1980 Soybean	1981 Corn	1982 Soybean	1985 Corn
	(t/ha)			
No control				
Rainfed	2.22	5.74b	2.09c	6.18c[a]
Irrigated	-	9.78a	3.47a	11.09a
Stream water level control				
Rainfed	-	-	2.17c	7.68b
Irrigated	-	-	2.96b	10.45a

Note: a, Data followed by a different letter within the same year and crop are significantly different at the 5% level.

Engineering design criteria must be established for future planning of water resource projects that will provide proper drainage and flood control during wet periods and still provide water storage in the soil profile and in stream channels. This stored water can supply water for crop needs either by capillary rise in the soil or by being applied as irrigation. Stream water-level control proved to be a satisfactory method of agricultural water management in this watershed, and there were numerous indications of positive impact on the local environment. Comparable results should apply in similar areas throughout the Southeast. The Soil Conservation Service is in the process of designing and