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ARTIFICIALLY CONSTRUCTED BACKWATERS AND THEIR IMPACT ON GROUNDWATER LEVELS BENEATH AN ADJACENT WET MEADOW ON THE PLATTE RIVER IN CENTRAL NEBRASKA

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Summary -- Three backwater areas were constructed along a small channel of the Platte River using temporary, inflatable plastic dams. Two dams impounded water for most of the summer, but the third dam was removed early because of potential impacts on local fish populations. The sandy soils on the streambed prevented the dams from sealing completely and water seeped beneath them. In addition, discharge into the channel declined during the study. As a consequence, the dams created relatively small impoundments. They supported fish and aquatic insects found in other Platte River backwaters and were characterized by shallow, slow-moving water, fine organic sediments, abundant emergent vegetation, and filamentous algal mats. Western mosquitofish were the dominant species behind the dams, except in one area where large numbers of plains topminnow were found. Several fish species sampled before impoundment (channel catfish, central stoneroller, common carp, speckled chub) were completely absent after the dams were in place. Groundwater levels in the adjacent wet meadow showed little response to the dams. Monitoring wells showed similar fluctuations and were highly correlated with river stage except during the summer of 1992. This variation appeared to be due to high precipitation. Further monitoring would have been informative, but structural failure of the dams necessitated conclusion of the study in the Fall of 1992. Ground and surface water management is discussed in light of the study findings.

INTRODUCTION

Wet meadows, backwaters, and small channels provide some of the most important migratory feeding and nesting habitat for wildlife found along the Platte River in central Nebraska (Krapu 1981). Nearly 300 species of birds are found in the Platte River valley, including half a million sandhill cranes, 7 to 9 million ducks and geese, and federally listed whooping cranes, eskimo curlews, and peregrine falcons (Currier et al. 1985, Faanes and Lingle in press). Over half of these species use wet meadows and their associated wetlands to obtain plant and animal foods, including small fish, frogs, crayfish, grasshoppers, crickets, beetles, earthworms, insect larvae, egg masses, aquatic invertebrates, roots, seeds, fruits, and tubers (Krapu 1981). As many of these forage species are dependent upon moist soils or standing water for all or part of their life cycle, they are primarily confined to wetlands and wetland margins. Such wetlands are provided by the swales, sloughs and backwater areas found in the meadows.

Wet meadows typically consist of a series of linear wetlands and elevated sand ridges. Their hydrology is characterized by water level fluctuations caused by changes in river stage, precipitation, and freezing and thawing (Henszey & Wesche 1993, Currier unpublished data). Hurr (1983) found that major fluctuations in river discharge were reflected in groundwater levels beneath the meadows within a few hours. Henszey & Wesche (1993), likewise, found a direct correspondence between river stage and groundwater levels, but they identified precipitation as an important additional short-term influence on groundwater.

In spring and early summer, snowmelt in the Rocky Mountains and along tributaries of the Platte contributes to a high river discharge (O'Brien & Currier 1987). These inflows are normally reflected in correspondingly high groundwater levels in the adjacent meadows (Currier 1989, Henszey and Wesche 1993), and are thought to play an important role in sustaining wet meadow flora and fauna (Currier 1989, Savidge & Seibert 1992). As a result of poor drainage and high soil saturation in the meadows, spring precipitation often pools and ponds before seeping into the ground. By July, however, river flows and groundwater levels have usually declined, and surface water has mostly drained or evaporated from the meadows. Under these conditions, mid-summer precipitation is able to seep rapidly into the porous soils, and ponding rarely occurs.

Studies by Hurr (1983) and Henszey & Wesche (1993) have examined the relationship between river stage and groundwater levels under naturally-occurring hydrologic fluctuations. In this study, we attempted to artificially manipulate river stage and to examine the resulting impact on groundwater levels. The primary purposes of the study were 1) to investigate the viability of locally raising the river stage by constructing a backwater , 2) to determine the resulting effects on groundwater levels in an adjacent wet meadow, and 3) to examine the ecological impacts of creating a backwater and its effects on fish and aquatic organisms.

STUDY AREA

The study site is located at the east end of Clark Island (sec 32 and 33, T9N R13W, Buffalo County), in the Platte River near Gibbon, Nebraska (Figure 1). The Platte River Trust owns and manages the 40-ha meadow and adjacent riparian area (the "Dippel Tract") as migratory bird habitat. Three dams were constructed along a narrow channel of the river that flowed between Clark Island and an adjacent 80-ha area of wooded accretion. The channel formed as a branch of the main river approximately 0.8 km upstream of the west dam, and averaged 1-5 meters in width and 0-20 cm in depth (with a few deeper areas of 50 cm or more). A few kilometers downstream of Dam #1, the channel rejoined the main river. During this study, the channel had a year-round discharge, except at very low river stages, when there appeared to be no surface flow. Low-head beaver dams were built in several places along the stream, creating some deep pools, and flooding portions of the channel.

The channel was bordered by wetland emergents (e.g., bulrushes, cattails), small trees, and shrub thickets. Herbaceous species included cattail (*Typha spp.*), burreed (*Sparganium eurycarpum*), bulrushes (*Scirpus validus, S. americanus*), sedges (*Carex spp.*), giant reed (*Phragmites australis*), cordgrass (*Spartina pectinata*), barnyard grass (*Echinochloa crus-galli*), and common weedy species. Woodland species along the channel and on the river accretion were dominated by 40 to 50 year old cottonwood (*Populus deltoides*) and diamond willow (*Salix rigida*) trees with an understory of green ash (*Fraxinus pennsylvanica*), catalpa (*Catalpa speciosa*), boxelder (*Acer negundo*), russian olive (*Eleagnus angustifolia*), sandbar willow (*Salix exigua*), and rough-leaf dogwood (*Cornus drummondii*).

A natural levee (3.0-4.5 m in height) on the north edge of the stream created an abrupt break that divided the riparian woodlands from the wet meadow. The north side of the meadow was delineated by another intermittently flowing river channel surrounded by woodlands. The meadow itself was somewhat bowl-shaped, with lower elevations in the center and higher elevations along the levees at the margins. Although the ridge and swale topography typical of wet meadows was present on the site, few of the swales actually held standing water during the study. Moderate grazing over the last five years, has allowed a gradual improvement in range condition and expansion of native species, including big bluestem (*Andropogon gerardii*), switchgrass (*Panicum virgatum*), and a number of sedges (*Carex spp.*). Weedy and invader species such as smooth brome (*Bromus inermis*), bluegrass (*Poa pratensis*), ragweed (*Ambrosia artemisiifolia*), and red cedar (*Juniperus virginiana*) were also widespread. About 14 ha of cropland on the site (SE ¼ Sec 32) was reseeded to native grasses in the fall of 1990.

METHODS

Locations for the dams were chosen where the stream could be impounded to create backwater areas using a minimum dam length. This was determined by surveying the streambed and cross-sections of the channel and adjacent banks. The dams ranged in length from 75-100 m, and were evenly spaced along the channel (see Figure 1). Before construction, a section 404 permit was received from the U.S. Army Corps of Engineers to place fill in a wetland. A permit to allow construction in a floodplain was also received from Buffalo County.

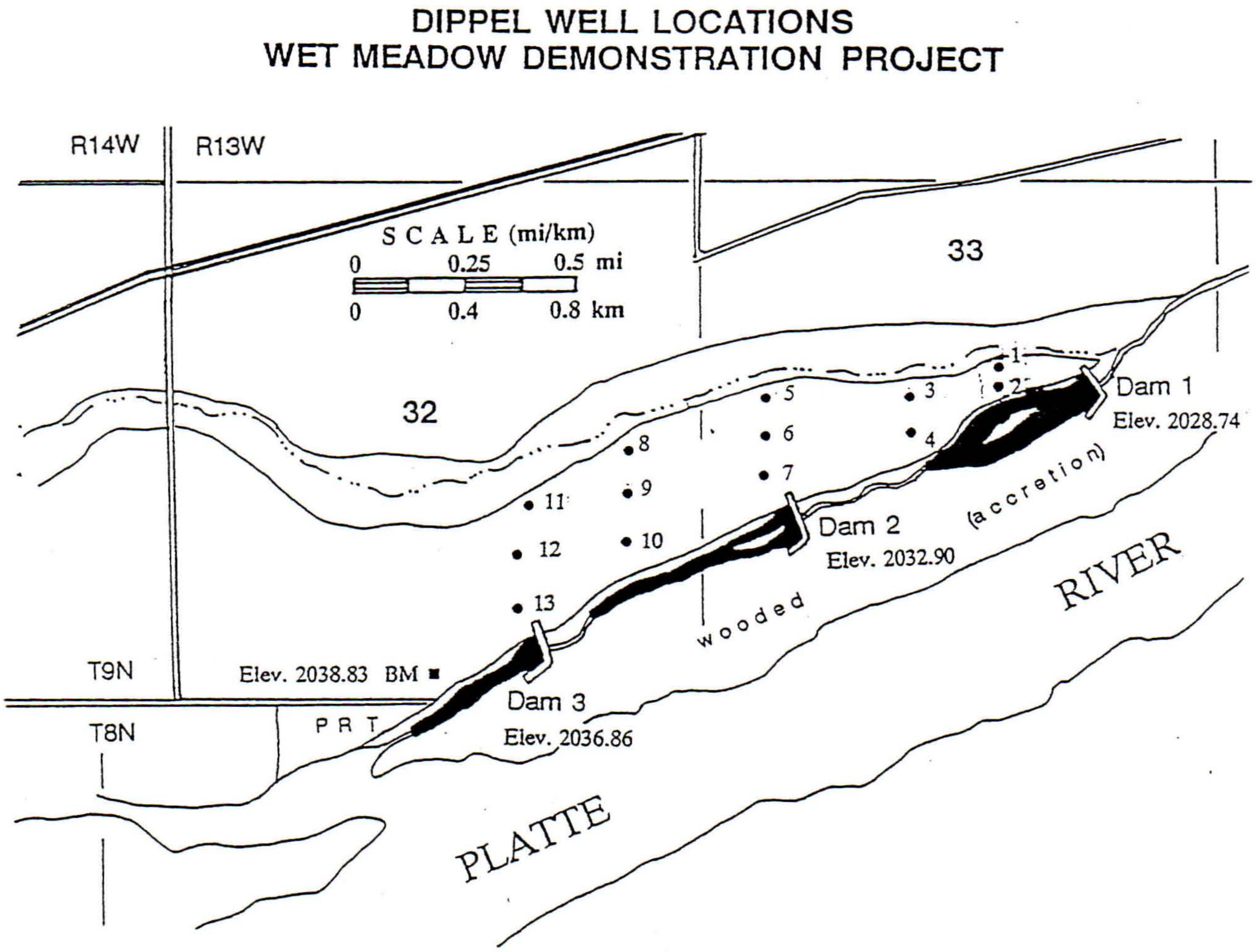


Figure 1. Map of the study area with the locations of the three temporary dams on a narrow side channel of the Platte River near Gibbon, Nebraska. Locations of monitoring wells are shown on the wet meadow to the north of the channel.

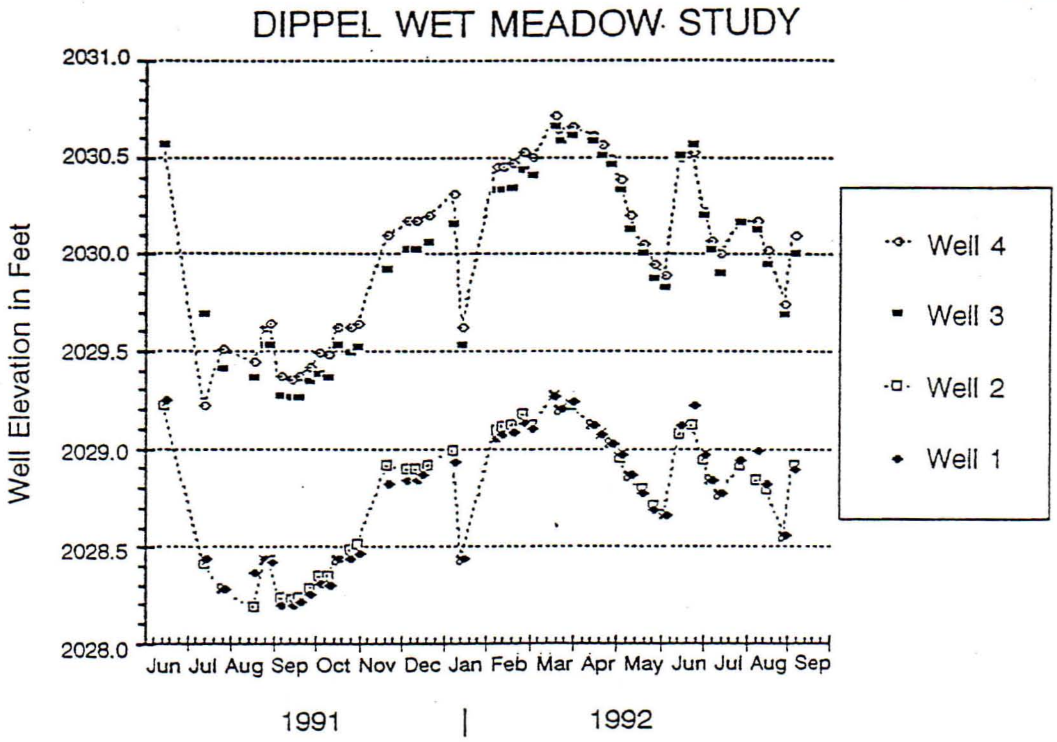
Water-inflated plastic tubing (manufactured by Water Structures Unlimited) was used to create the three temporary dams. The 10 mil clear plastic tubing consisted of two flexible "inner" tubes filled with water, and an "outer" master tube that confined and stabilized the inner tubes. When inflated, the tubes measured 90 x 170 cm (3 x 6 ft), and could be cut to any length needed to span the channel. The flexible tubing conformed to the stream bottom, creating a seal and allowing the tubes to act as low-head dams. When the impounded water reached the height of the tubes, it was allowed to flow over the top and on downstream. Site preparation included clearing an 8 m wide strip of woodland and shrub growth where the tube was to be placed, and backfilling with sand to create a bed that was free of stems and stumps that could puncture the tubes.

The three dams were inflated in April 1992. However, the downstream-most dam (#1) was deflated in mid-May because of concerns about potential impacts on a local population of brook stickleback (*Culaea inconstans*). The remaining two dams were kept inflated through August.

Groundwater levels in the wet meadow north of the channel were monitored over a 15-month period (June 1991 to September 1992) using a series of 13 groundwater observation wells placed in a grid pattern (Figure 1). The wells were constructed of 5.08 cm diameter PVC pipe that was driven 3 to 6 m into pre-dug bore holes in the ground. The bottom meter of each pipe was perforated to allow groundwater to enter. Wells were monitored on a weekly basis by measuring the distance from the top of the well casing to the groundwater surface with an electronic measuring device. Well measurements were converted to absolute elevation in tenths of feet (relative to National Geodetic Datum of 1929). Groundwater fluctuations were compared with daily river discharge data from the nearest U.S.G.S. gaging station located at Kearney, approximately 24 km upstream. Precipitation data was measured with a continuous recorder at the Audubon Lillian Annette Rowe Sanctuary, approximately 8 km upstream from the study area.

In the summer of 1991, before the dams were installed, we began surveying the fish, macroinvertebrates, and aquatic habitats in the experimental channel. The survey continued in 1992, following impoundment of the backwater areas. In 1991, we sampled a 100 m reach of stream at each of the dam sites. In 1992, we sampled the impoundments along with a 100 m stream reach immediately downstream of each dam. This design allowed us to compare habitat availability and faunal relative abundances before and after dam construction and to compare the artificial backwater areas to adjacent, unmanipulated reaches of the stream.

To describe the aquatic habitat, we measured physical habitat characteristics at regular intervals along transects across the stream channel. At each sample point, the habitat description included measurements of water depth, mean water column velocity, water temperature, substrate composition, and potential cover for fish. Water depth



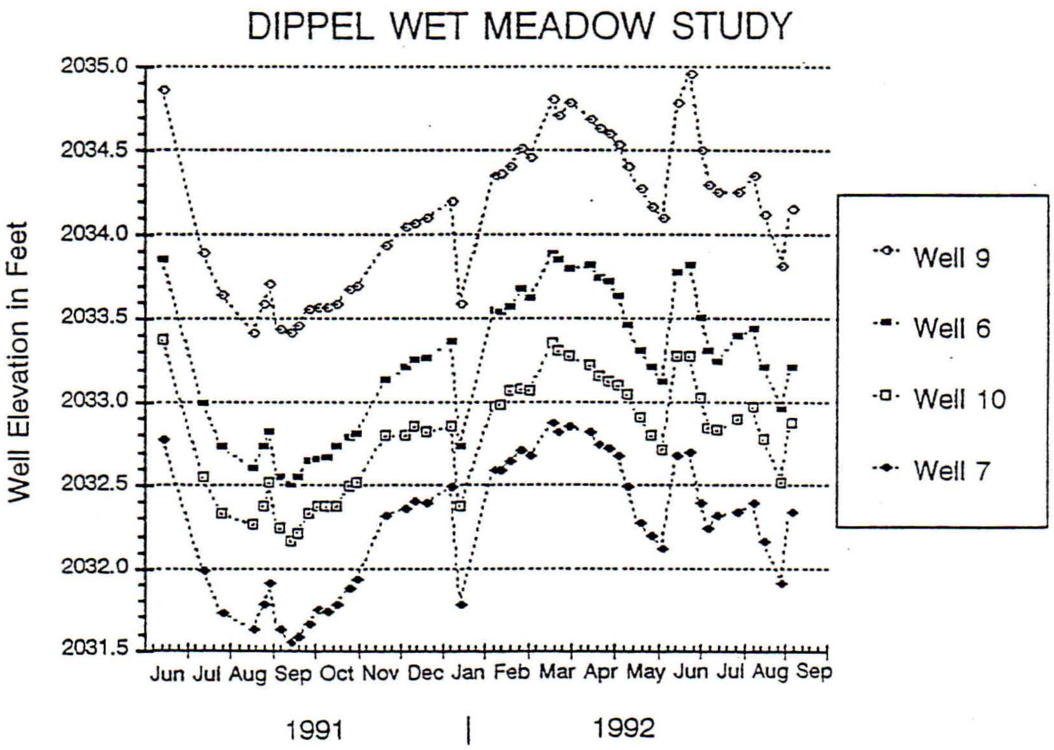


Figure 2. Well elevations during the study period. Lower numbers represent wells at the downstream (east) edge of the study area; higher numbers represent wells at the upstream (west) edge. Water levels show similar fluctuations in all the wells.

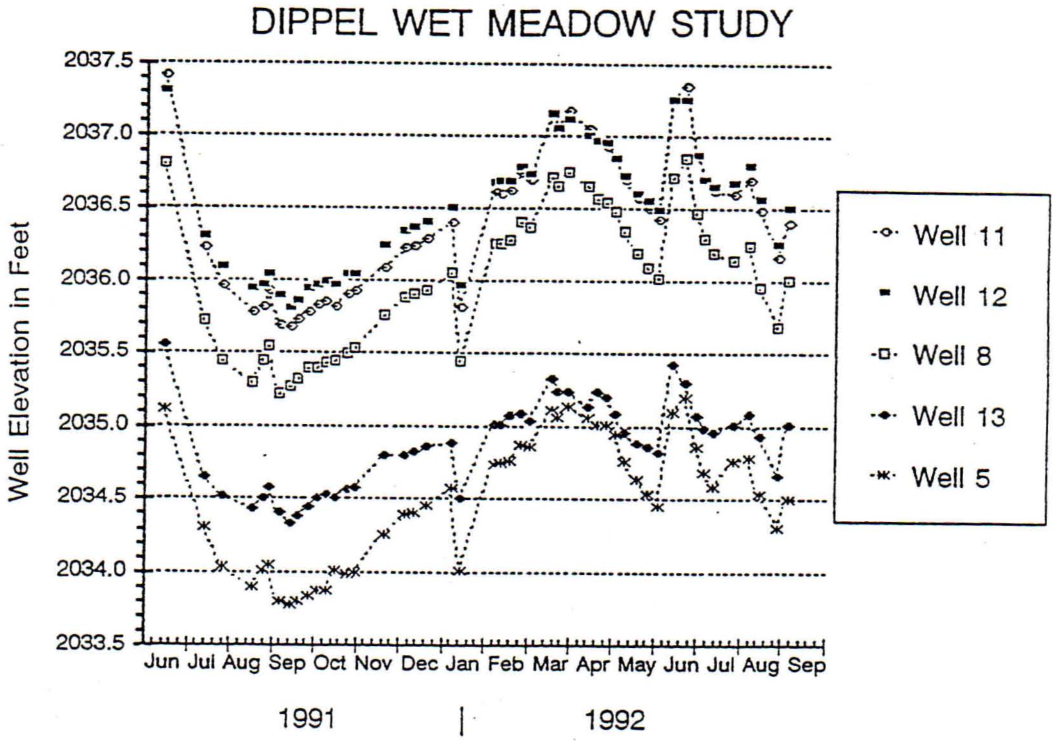


Figure 2. (Continued)

and mean column velocity were measured with an electronic flow meter (Marsh-McBirney Model 201 or Model 2000 Flo-Mate) attached to a top-setting wading rod. We measured water temperature with a hand-held mercury thermometer, and substrate composition was based on a visual estimate of a 0.1 m^2 area around each sample point. Finally, we characterized objects or topographic features that afforded potential cover for fish. Comparisons are based on mean values of the habitat variables within each 100 m sample reach (except for cover, which is a categorical variable).

We collected fish using a combination of seining (3/16" mesh), electrofishing (Coffelt Model Mark X), and dip netting. Fish were identified, measured, and usually released at the point of capture. (Occasional reference specimens were preserved in 10% formalin and stored in the laboratory.) We collected macroinvertebrates using a combination of dip netting and kick netting. Invertebrates were preserved in 50% isopropanol and brought to the laboratory for identification. Comparisons of the fish and invertebrate fauna are based on the relative abundances of species in our samples.

RESULTS

Ground Water Monitoring

The 13 monitoring wells generally followed the same groundwater patterns throughout the study (Figure 2). Median groundwater levels in 1992 were about 20 cm (0.6 ft) higher than during the last half of 1991. This appeared to be a response to both higher river discharge and to more abundant rainfall during the summer months in 1992 (Figure 3). There was a high correlation (R-square = 0.76) between groundwater levels and river discharge except during May-August 1992, when over 30% of the total precipitation during the study period occurred (Figures 4 and 5). On a relative basis, median river discharge in May-August was only 12% of the peak discharge during the study, while median groundwater levels were 66% of their maximum levels during the same period (see Figure 5). There were abrupt fluctuations in groundwater in mid-January 1991 and again between May and June 1992. The mid-January change was apparently in response to a short-term (48 hour) decline in river stage (compare Figures 2 and 3). The substantial groundwater increase in May-June, however, occurred during a period when river discharge was relatively uniform, but shortly after a 74 mm (3 inch) rainfall event. A similar response occurred in mid- to late July 1992, when 125 mm (5 inches) of precipitation was recorded. The groundwater response during that period, however, is complicated by a fluctuating river discharge. Even after river discharge declined during August 1992, groundwater levels remained relatively high.

As illustrated in Figure 5, there was no apparent response in groundwater level to the three dams and their associated backwater areas. In the figure, Well 13 represents an upstream monitoring station, while well 2 is located at the downstream end of the study area. Neither well shows a direct response to installation of the dams. In fact, immediately following inflation of the dams, groundwater levels declined. As discussed above, much of the groundwater rise during the time the dams were in place appears to be related to rainfall events. Throughout the study, standing water averaged only 40 to 60 cm behind the dams and only rarely did the impoundments reach their maximum height of 90 cm (point of overfow). The dams were not very effective at storing water, and the backwaters created were relatively small and shallow. Most likely, the impounded areas did not elevate stage levels significantly enough to influence adjacent groundwater levels.

Fish and Aquatic Community Changes

During 1991, before construction of the dams, the narrow branch channel was composed of alternating runs or riffles and pools along with occasional ponds created by beaver dams. Except in beaver ponds, the channel was narrow (1-5 m wetted width), shallow (average water depth 11 cm; range 0-20 cm), and had a moderate flow (average mean column velocity 2 cm/s [range 0-11 cm/s] near Dam #1, and 8.6 cm/s [range 0-22

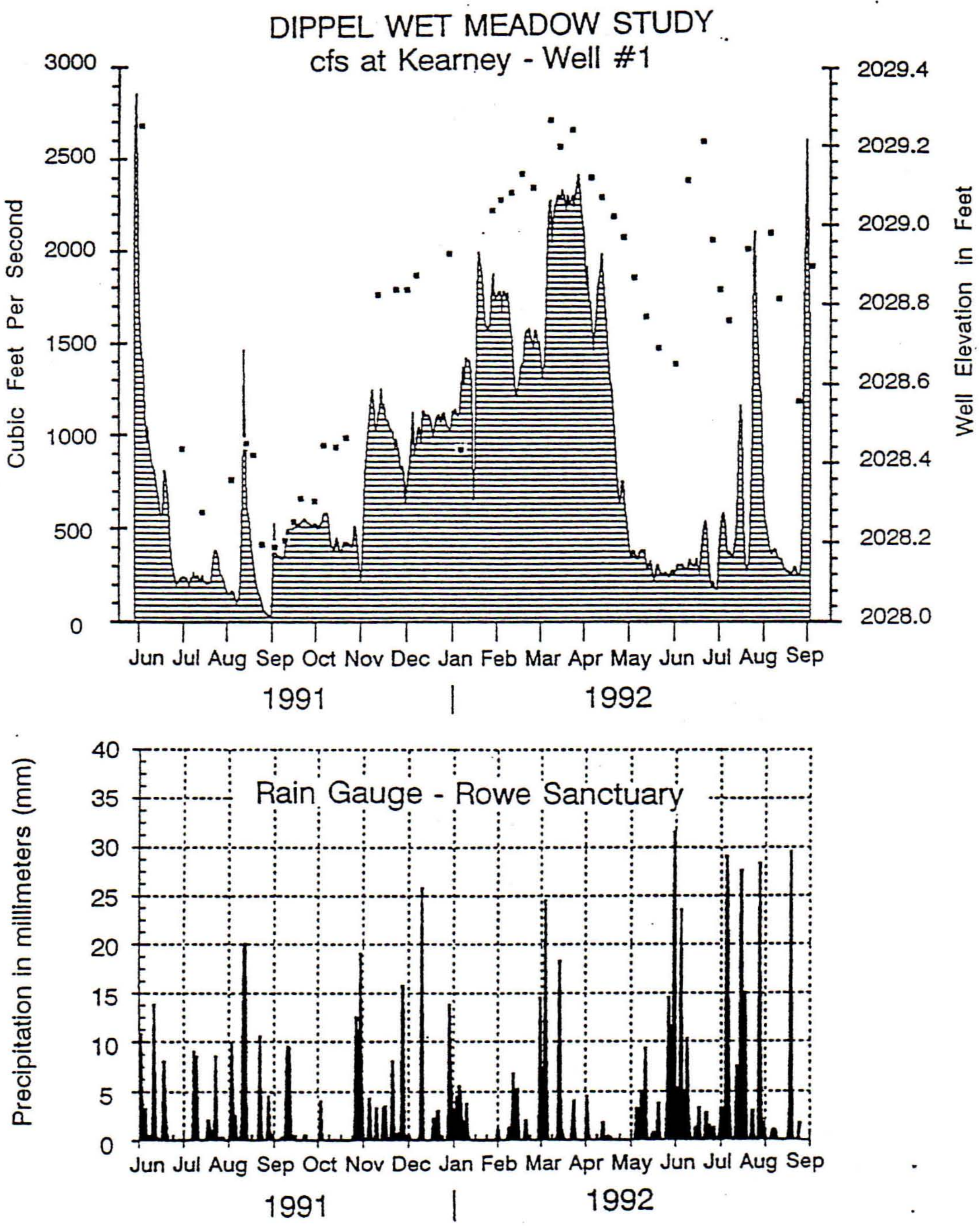
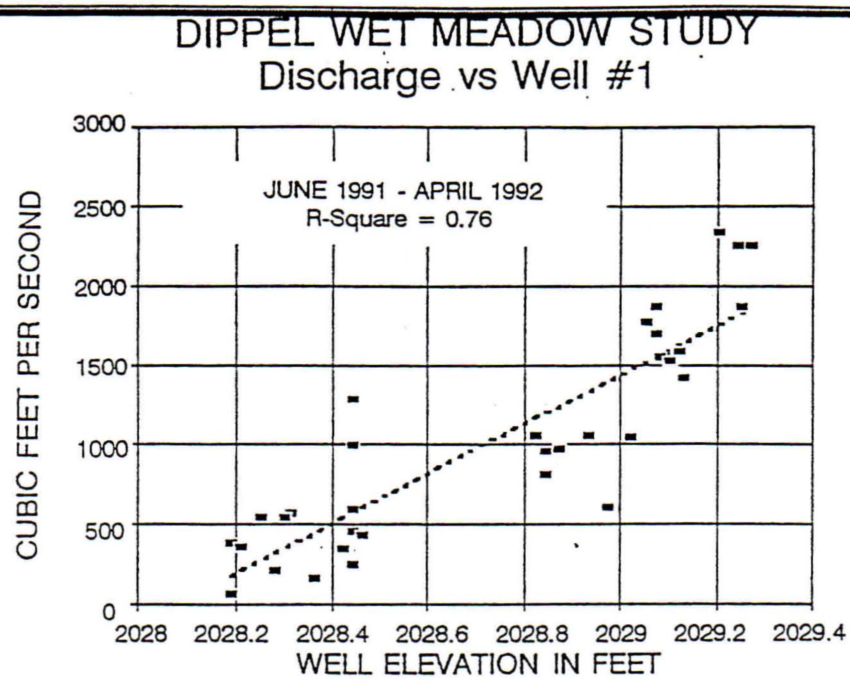


Figure 3. Groundwater elevations (well 1) superimposed over a hydrograph of the daily discharge in the Platte River at Kearney (gaged 24 km upstream of the study location). Groundwater fluctuations closely followed river stage fluctuations, except during the May-August period in 1992. Daily precipitation in mm is shown in the bottom diagram.



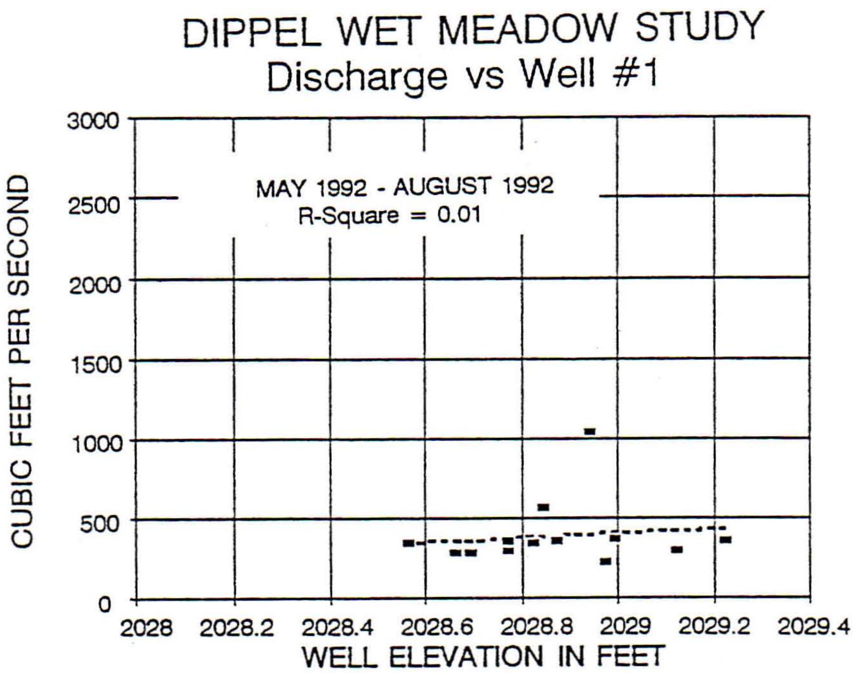


Figure 4. Simple regressions between river stage and groundwater levels in well 1. During the June 1991-April 1992 period, stage and well elevations were highly correlated (R-square = 0.76)(top of diagram). Later in the study period (May 1992-August 1992), however, there was little correlation (R-square = 0.01) between river stage and groundwater levels (bottom of diagram). Relatively high rainfall in the summer of 1992 is probably responsible for the low correlation during that period.

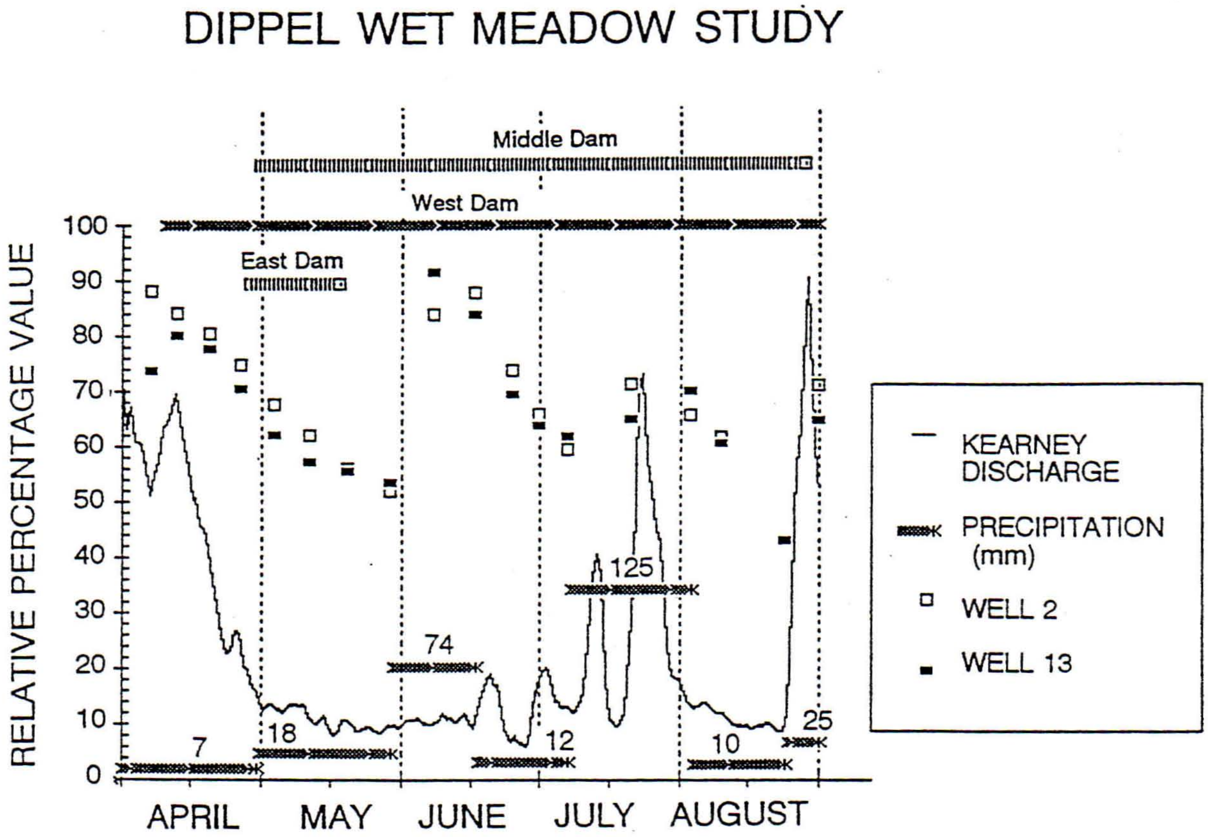


Figure 5. Groundwater elevations at the upstream (well 13) and downstream (well 2) portion of the study site in relation to river discharge, precipitation, and construction of the 3 temporary dams. Values are relative to maximum groundwater elevation and river discharge during the June 1991 to August 1992 period. Total precipitation (mm) for individual rainfall events is shown at the bottom of the diagram. Periods when the dams were in place are shown at the top of the diagram.

cm/s] near Dam #2). The substrate was primarily sand and gravel, except that ponds behind beaver dams also contained accumulations of particulate organic matter. Patches of filamentous green algae occurred throughout the channel. Clumps of emergents occurred in spots along the banks, except in beaver ponds where the emergents were more numerous and widely distributed.

The macroinvertebrate community contained a mixture of species from both erosional (i.e., flowing) and depositional (i.e., pool) habitats. Midges (Diptera: Chironomidae) were numerically dominant throughout the channel, and were especially abundant in clumps of filamentous algae. Swimming mayflies (Ephemeroptera: Baetidae, Oligoneuriidae, Siphloneuridae) and various bugs (Hemiptera), including water striders (Gerridae), water boatmen (Corixidae), and backswimmers (Notonectidae), were also widely distributed in the channel. The distribution of snails (Gastropoda) was patchy, but the areas where they occurred contained very dense aggregations. Leeches (Hirudinea) and crayfish (Decapoda) were also present in substantial numbers.

The fish community in the pre-dam channel was dominated numerically by fathead minnow (*Pimephales promelas*), although plains killifish (*Fundulus zebrinus*) and western mosquitofish (*Gambusia affinis*) were also abundant. Mosquitofish is an exotic species that is rapidly expanding its distribution in the Platte, apparently to the detriment of some native fish species which have similar habitat requirements (Lynch 1988a). The channel was apparently a nursery area for young-of-year common carp (*Cyprinus carpio*) and a spawning area or summer refuge for several adult channel catfish (*Ictalurus punctatus*). Bluegill (*Lepomis macrochirus*) and small schools of sand shiner (*Notropis stramineus*) were also present throughout the study area.

The fish community also contained representatives of some less common species. There was a small population of brook stickleback, which had not previously been collected in this reach of the Platte River. In Nebraska, brook stickleback is at the extreme southwestern limit of its distribution; it is not common and occurs in small, disjunct populations (Madsen 1985). Brook stickleback were only present in the downstream reach of the channel (vicinity of Dam #1 and below). A large (approximately 1 m high), well-established beaver dam was apparently the upstream limit of their distribution at this site. Sticklebacks occupied deeper pools with undercut banks and/or overhanging vegetation and floating mats of filamentous algae. During June, the males in our samples displayed breeding coloration.

The shallower, faster flowing portions of the downstream reach had coarser, gravel substrate and open areas interspersed with patches of attached filamentous algae or macrophytes. In addition to some of the more common species, these areas contained small numbers of central stoneroller (*Campostoma anomalum*), the only algivorous species found in the central Platte, and speckled chub (*Macrhybopsis aestivalis*), a species that has virtually disappeared from the mainstem Platte River in this part of the state.

Composition of the fish community had changed by summer 1992, following construction of the tube-dams. Western mosquitofish had become the most abundant species throughout the channel, in fact, it was the *only* species in some reaches of the stream, including areas that were not affected by the tube-dams. Brook stickleback still occupied the lower reach of the channel and were, actually more abundant than the previous year, especially in the immediate vicinity of Dam #1, which had been removed in mid-May. Fathead minnow, although common, were far less numerous than before. The channel still contained some schools of shiners (sand shiner, bigmouth shiner [*Notropis dorsalis*], and river shiner [*Notropis blennius*]). We collected small numbers of red shiner (*Cyprinella lutrensis*) and creek chub (*Semotilus atromaculatus*), which we had not seen the previous year. Bluegill, however, were no longer present and apparently had been replaced by green sunfish (*Lepomis cyanellus*). Several additional species were absent from the 1992 samples, including central stoneroller, common carp, speckled chub, and channel catfish.

The composition of the macroinvertebrate community had also changed in 1992. Taxa characteristic of erosional habitats (e.g., mayflies) had disappeared from our samples. Midges were still the most abundant invertebrates, although backswimming bugs, amphipods, and leeches were also common. We collected small numbers of mussels (Bivalvia: Unionidae) in 1992. Large-bodied predatory invertebrates, especially dragonfly nymphs (Odonata) and giant water bugs (Hemiptera: Belostomatidae), seemed more abundant than the previous year.

These shifts in the aquatic fauna probably occurred because, between 1991 and 1992, the physical habitat in the channel changed markedly. By summer 1992, the stream had become a series of large pools interspersed with beaver ponds and the ponds behind the dams. The channel was wider (wetted width 2-10 m), but water flow had essentially ceased (average mean column velocity 0.02 cm/s [range 0-1 cm/s] near Dam #1, and 0.07 cm/s [range 0-1 cm/s] near Dam #3). The substrate had become covered with fine sand and mud, and particulate organic matter had accumulated over large areas. Extensive mats of tangled, filamentous green algae had developed, and marsh emergents including cattail, burreed and bulrush were much more abundant and widely distributed. These changes, especially the reduced water velocity, almost certainly favored mosquitofish and allowed it to become numerically dominant, at the expense of other species more characteristic of lotic habitats. Mosquitofish prefer calm habitats with fine substrates and aquatic vegetation (Lynch 1988b, Pflieger 1975).

It was difficult to attribute such dramatic hydrologic changes to the dams, because the tubes did not impound large volumes of water. Furthermore, the habitat changes persisted even after the dams were deflated and removed in late 1992. In 1993, we learned that a sandbar had been deposited at the origin of the branch channel, cutting it off from the main river and its source of surface water. Some pools continued to be maintained by groundwater seepage, but much of the channel, including a long reach where Dam #2 had been located, was completely dry by July 1993.

Experimental Backwater Areas

Generally, the impoundments created by the dams were similar to existing beaver ponds (see Figure 6). However, several of the beaver dams were higher than the tubes and thus created deeper pools. The impoundment on the north side of the channel behind Dam #2 was small, apparently because water kept seeping under the dam. Furthermore, the substrate in the pool remained sandy, with very little accumulation of particulate organic matter. Although marsh emergents developed along the wetland margin, there was little development of extensive algal mats. A similar area was created by the west dam (Dam #3), where a long, narrow, impoundment formed.

The conditions in these two pools apparently favored mosquitofish, which comprised 97% of the fish in our samples from these locations (fathead minnow was the only other species collected). A beaver pond immediately upstream of Dam #3 actually contained a higher diversity of fish species than the two artificial impoundments. In addition to mosquitofish, we collected sand shiner, fathead minnow, red shiner, plains killifish and creek chub in that pond, which was slightly larger than the artificial impoundments.

A somewhat different type of backwater formed behind the south side of Dam #2 (which was separated from the north side by a large island). The dam cut off water flow around the island and formed a backwater that was larger than the others. Substrate particle size was smaller than on the north side of the channel, substantial accumulations of fine particulate organic matter were deposited on the substrate, and abundant emergent vegetation developed along the pool margins. Extensive filamentous algal growth occurred in the large area of open water in the middle of the pool.

This area was particularly interesting because it contained a higher diversity of fish species than the other two impoundments, including one unusual species. The backwater contained mosquitofish, fathead minnow and green sunfish, but it also contained large schools of plains topminnow (*Fundulus sciadicus*) which, before the dam construction, had not been observed anywhere in this channel. In the Platte River drainage, plains topminnow characteristically inhabit clear, spring-fed pools and backwaters with extensive growths of aquatic and emergent vegetation (Cross 1967). Due to its specialized habitat requirements, this species usually occurs in isolated colonies within a river drainage (Pflieger 1975). Because its habitat preferences are similar to those of mosquitofish, there is some concern that mosquitofish may be displacing plains topminnow as it spreads through the Platte River drainage (Lynch, pers. comm.).

Figure 6. Examples of backwater areas created behind the tube dams in 1992.

DISCUSSION

The dams constructed in this study were not very efficient at impounding water and had no discernible impact on groundwater levels in the adjacent meadow. There were problems in both the construction and maintenance of the dams and in their ability to store water (Figure 7). By the time the dams were in place in early 1992, flow into the branch channel was already probably reduced as a result of sediment deposition near its origin. The porous soils beneath the dams also probably contributed to reduced storage, as was evidenced by the resurfacing of flows a short distance downstream of the dams. In addition, there were maintenance problems in keeping the dams inflated and functional. Two of the dams were punctured during the study (probably by deer or other animals) and began to deflate and lose water. Although the punctures were patched, only the middle dam (Dam #2) functioned well throughout most of the study. Higher flows caused a problem at the upstream dam (Dam #3), because the tube rolled and twisted as water overtopped it, causing the center section to deflate. The tubes worked well in diverting flow, but they were not well suited as over-flow structures.

Most of the water entering the stream by the summer of 1992 was probably groundwater seepage from both the main channel and the adjacent wet meadow. Instead of the small channel contributing to recharge of the adjacent meadow, groundwater may actually have been discharging to the stream. Reversing this groundwater movement and recharging the adjacent meadow would probably have required impounding much larger and deeper backwater areas than those created by the tubes.

Studies by Hurr (1983) and Henszey & Wesche (1993) have documented rapid groundwater responses to changes in river stage. Under historic natural flow conditions, river stage changes have been detected within a matter of hours or days in wells near the river channel. Because lateral movement in the water table is rather slow, such responses would require mass movement of groundwater in response to stage fluctuations. Most likely, the volume of water stored in the impoundments in this study was far less than what would be needed to effect such a mass flow.

Although the portion of the study designed to examine the impacts of backwater areas on groundwater levels was rather disappointing, we were able to collect some valuable information about the Platte ecosystem and its function during the monitoring phase of the study. Well and precipitation data collected tended to confirm the findings of previous wet meadow groundwater investigations (Hurr 1983, Henszey & Wesche 1993). The over-riding factor influencing groundwater fluctuations appeared to be river stage, although episodic rainfall was also identified as a contributing factor in maintaining groundwater levels. As Henszey and Wesche (1993) noted, isolated precipitation events are usually associated with a temporary elevation of the groundwater table, followed by a gradual decline over periods as long as two weeks. In this study, the repeated precipitation events between May and September 1992 probably

Figure 7. Construction of one of the tube dams across the narrow branch channel of the Platte River. Water seepage below the dams can be seen in each photo.

masked the temporary impact of each event, and resulted in a nearly continuous elevation of groundwater levels during that period. These elevated groundwater levels also complicated the interpretation of any potential affects from the impoundment of water behind the tube-dams. The lack of any groundwater response shortly after the dams were constructed, indicates that they probably had little impact on groundwater levels beneath the meadows.

The two dams left in place until August 1992 created small impoundments which supported fish and aquatic insects characteristic of other backwater habitats on the Platte. Based on the backwaters created in this study and observations of existing beaver ponds on the same channel, it appears that several environmental factors probably influence backwater characteristics. These factors include 1) the quantity and source of inflow, 2) the morphological development and shape and roughness of the existing river channel, 3) the location and functioning of the water control structure, 4) access to colonizing species, 5) organic matter production and inflow, and 6) existing sediment characteristics. Such variability makes it difficult to predict the exact type of wetland that would arise as a result of attempts to manipulate and direct habitat "creation" of backwaters.

This study has helped to identify the diversity in backwater habitats along the Platte, and the diversity of organisms that they support. Several uncommon fish species were observed during the study, including brook stickleback, which was found on a segment of the existing channel, and plains topminnow, which was found in one of the experimental backwaters. One of the alarming findings in the study was the expansion and subsequent dominance of mosquitofish in the narrow channel. The reduction in water velocity that occurred after the channel was cut-off from its connection to the main river obviously created habitat conditions which were very favorable for development of a large mosquitofish population. (These conditions occurred in areas affected by the tube-dams as well as in areas that were not manipulated.) It is possible that some fish species were eliminated from the study reach due to lack of suitable habitat, but there is also concern that mosquitofish may eventually displace native species with similar habitat preferences, including the plains topminnow (Lynch, pers. comm.). Such changes in species composition need to be considered in the long-term management of backwater areas and small channels along the Platte, especially if artificial impoundments are contemplated as part of a management plan.

It would have been useful to monitor the backwater areas and the groundwater levels in the adjacent meadow for an extended period of time following the construction of the tube-dams. A longer study may have answered questions about habitat and species changes over the long-term in the created backwaters, and may have led to a better understanding of the relationship between stage levels in the channel and groundwater levels in the adjacent meadow. However, because of their structural failure, it was not feasible to maintain the dams beyond the end of the summer. The dams were deflated and dismantled in September and the study was terminated.

Although the tubes were a convenient way to manipulate the flow in the river channel and to examine changes in habitat conditions in newly created backwaters, they were not very durable, and were not very effective in impounding water. It appears that a much larger impoundment would most likely be necessary to investigate the relationship between river stage and groundwater levels in adjacent meadows. Some type of earthen dam or permanent structure would probably be required to create a larger and deeper impoundment. At the same time, development of a larger structure would necessarily have altered more of the existing channel, and may have precluded the development of the kinds of backwaters created during the study.

The construction of sills or low head dams along the Platte as a permanent solution to the maintenance of groundwater hydrology in wet meadows does not appear to be very practical. There was no apparent impact on groundwater levels from the dams constructed in this study. Larger dams, as noted above, might result in environmental trade-offs where meadows are maintained, but aquatic habitats and other important areas are severely altered or eliminated. Recent investigations (Henszey and Wesche 1993 and U.S. Fish & Wildlife Service 1993) also suggest that, in addition to the maintenance of high groundwater levels, it is also important to maintain the hydrological variability associated with wet meadows, including high spring peak flows and lower flow periods later in the year. It is difficult to imagine any practical way to maintain these hydrologic variations short of management of river flows. Artificial sills might be able to maintain a portion of the hydrologic baseline, but they are probably not capable of meeting all the hydrologic criteria needed for long-term sustainability of wet meadows.

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