Flood Damage Assessment and Survey of Mitigation Efforts at Stump Lake, North Dakota: A Study of a Closed-basin Lake Flood

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Abstract

Since 1993, Devils Lake, a terminal lake in northeastern North Dakota, has risen 7.3 m in response to an unprecedented ten-year regional wet cycle. Lake area has nearly tripled, resulting in more than $400 million dollars in direct flood damages. Beginning in 1999 Devils Lake began to overflow into Stump Lake, a smaller closed lake sub-basin located in Nelson County. Outflow from Devils Lake has combined with local runoff to produce a 1.5-m rise in Stump Lake over the past three years. Extensive rural flooding marked by an increase in the number, size, and permanence of wetlands has also occurred within both lake basins over the same period.

The authors document the flood history of Stump Lake and rural Nelson County, assess the flood damages resulting from the rise of Stump Lake and the growth of rural wetlands in Nelson County, and survey the flood mitigation efforts associated with this closed-basin flood hazard. Remote sensing image interpretation, field work, personal interviews and compilation of data from private, county, state, and federal agencies are used to quantify the direct, indirect, and secondary damages associated with terminal lake and rural wetland flooding in Nelson County. Results document the comparative magnitudes of direct, indirect, and secondary flood damages, as well as the relative contribution of rural wetland and terminal lake flood damages. The study provides a case history of a pervasive, chronic flood hazard not routinely addressed by federal flood mitigation programs.

Introduction

Closed-basin lakes are one of the most dynamic hydrological systems in the world, and have been shown to be exhibit rapid and significant water surface elevation changes in response to both to climatic fluctuations and human impacts (Williams 1996). Closed basins lack a natural surface outlet to the sea and drain to a closed-basin lake (also called a terminal lake or saline lake). Although researchers have proposed that closed-basin lake levels provide an excellent natural monitor of climate change, their use for such purposes is hindered by the fact that they are also very sensitive to human modification of basin hydrologic conditions (Williams 1996).

Indigenous cultures have adapted to the non-equilibrium environment around closed-basins by developing human use systems and flexible livelihood strategies that are adjusted to the fluctuating lake levels (Evans and Mohieldeen 2002). In the United States, by contrast, resource managers normally view closed-basins through a stability bias lens that fails to recognize the natural variability of these systems (Morrisette 1988). Rigid and inflexible human use systems are forced onto a natural system that is characterized by non-equilibrium conditions. This assumption of climatic and hydrologic stability has led to the development of rigid human use systems for these variable natural systems, and has contributed to a growing national closed-basin lake flood hazard (Association of State Floodplain Managers 1986).

The most recent closed-basin lake natural disaster in the United States is the Devils Lake of North Dakota, where the direct damages for infrastructure repairs, residential and commercial relocations, utility lines, sewage facilities, and recreational facilities has approached $400 million. The water surface elevation time series for Devils Lake since European contact is given in Figure 1. Lake levels in Devils Lake dropped steadily until reaching a minimum of 427.0 m in 1940, when the lake was less than 1 m deep. A long-term wetting trend followed that produced a significant though erratic rise in the lake's water surface elevation through the 1980s. The torrential rains that occurred in the summer of 1993 initiated a dramatic shift to a rapid and steep rise in water surface elevation that has continued through 2001. Since 1993 the water surface elevation at Devils Lake has risen more than 7.0 m.

In July of 1999 Devils Lake reached an elevation of 440.89 m (Figure 1), and water began to spill from East Devils Lake into Stump Lake through the Jerusalem Outlet for the first time in approximately 700 years (Murphy et al. 1997). Stump Lake is a closed-basin lake located within the Stump Lake sub-basin to the east of the Devils Lake basin. Because of its lower WSE (approximately 429.2 m at the time of spillover from Devils Lake) and smaller potential lake volume Stump Lake provides an excellent opportunity to examine the full range of flood damages and flood mitigation efforts associated with a closed-basin lake natural hazard. Because the lake-rise flood hazard is fundamentally different from that experienced with riverine or coastal environments, their flood mitigation approaches will be unique and may be transferable to other closed-basin lake environments (Association of State Floodplain Managers 1986). Furthermore, the entire drought to deluge cycle that has taken more than 60 years to complete at Devils Lake (Figure 1) may be compressed into a much smaller number of years at Stump Lake, making the research problem more amenable to study.

We posed several specific research questions: (1) What is the nature and extent of flood damages due to the rising levels of Stump Lake?; (2) What is the magnitude of flood damages arising from the closed-lake flooding in comparison to flood damages resulting from rural

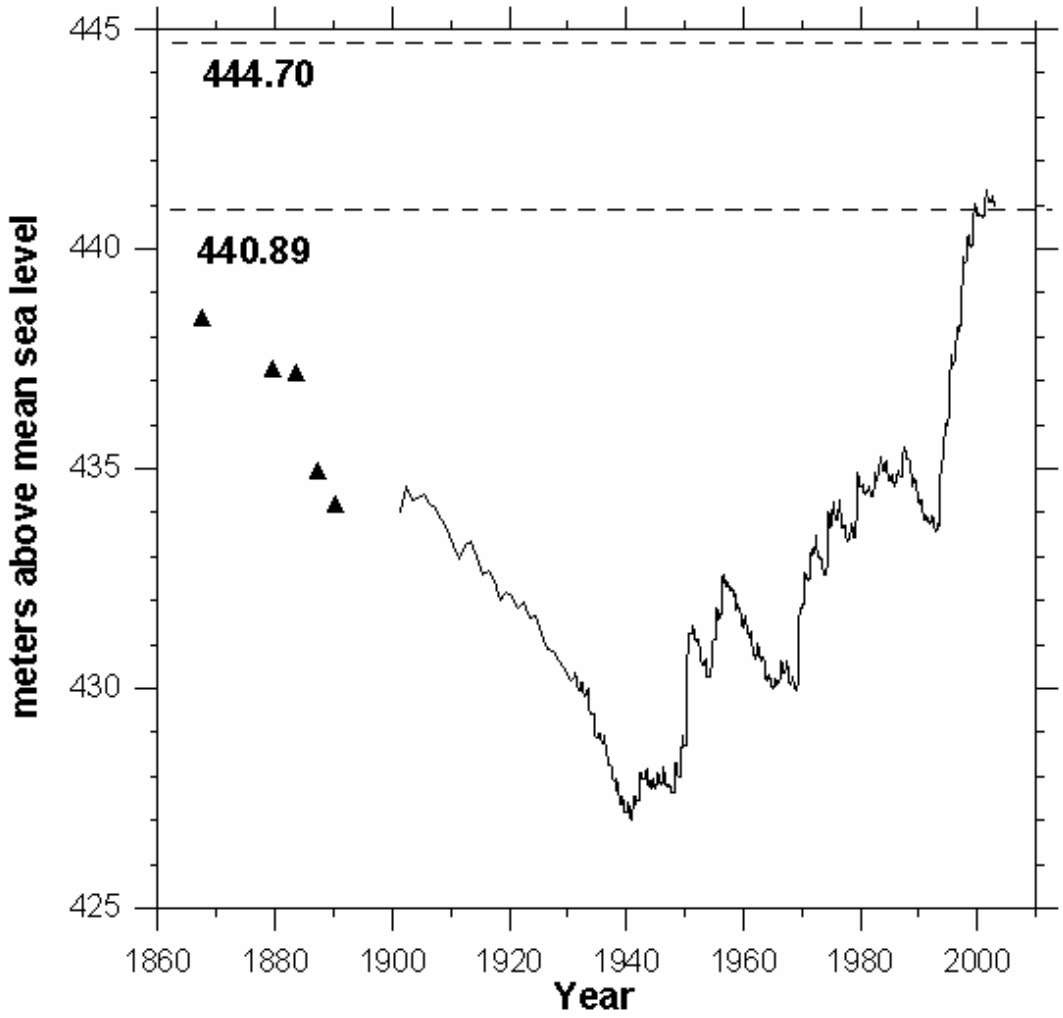

Figure 1: Water surface elevation (m) historical time series at Devils Lake, North Dakota (USGS gage #05056500) through 2001. The spill elevation to Stump Lake is 440.89 m; the spill elevation to the Sheyenne River is 444.70 m. Source: USGS.

wetland flooding?; (3) What is the relative scale of direct, indirect, and secondary flood damages?; (4) How can GIS and remote sensing be used to assess closed-basin and rural wetland flooding?; (5) What mitigation efforts and programs have proven successful for closed-basin and rural wetland flooding?; (6) Are there any unmet needs and unmitigated flood damages arising from either closed-basin lake or rural wetland flooding? Because the flooding problems around Stump Lake and within Nelson County are so interwoven with similar problems at Devils Lake and within the Devils Lake Basin, it is anticipated that lessons learned from the Stump Lake case study will be useful in providing insights to the larger Devils Lake Basin flood disaster. The study also provides a case study of a unique form of climate hazard associated with slow and unidirectional environmental change that produces pervasive but spatially ill-defined adverse effects (Riebsame 1985).

Study Area and Flood Hazard

Nelson County is located in east-central North Dakota between Ramsey County to the west and Grand Forks County to the east (Figure 2). The native mixed grass ecosystem has been largely converted to an agricultural land cover that provides the economic base of the county and surrounding region (Dix and Smeins 1967). Small grains dominate the county agricultural land cover, although row crop acreage has increased substantially over the past two decades. Pasture and hay acreage has declined consistently over time as have livestock numbers. The regional economy has been largely bypassed by the economic boom of the 1990s, and has experienced economic stagnation and demographic decline. The county population declined from 4,178 in 1992 to 3,656 in 2000. Maintenance of a stable rural economy as the basis for preserving their rural way of life is the major priority for county residents.

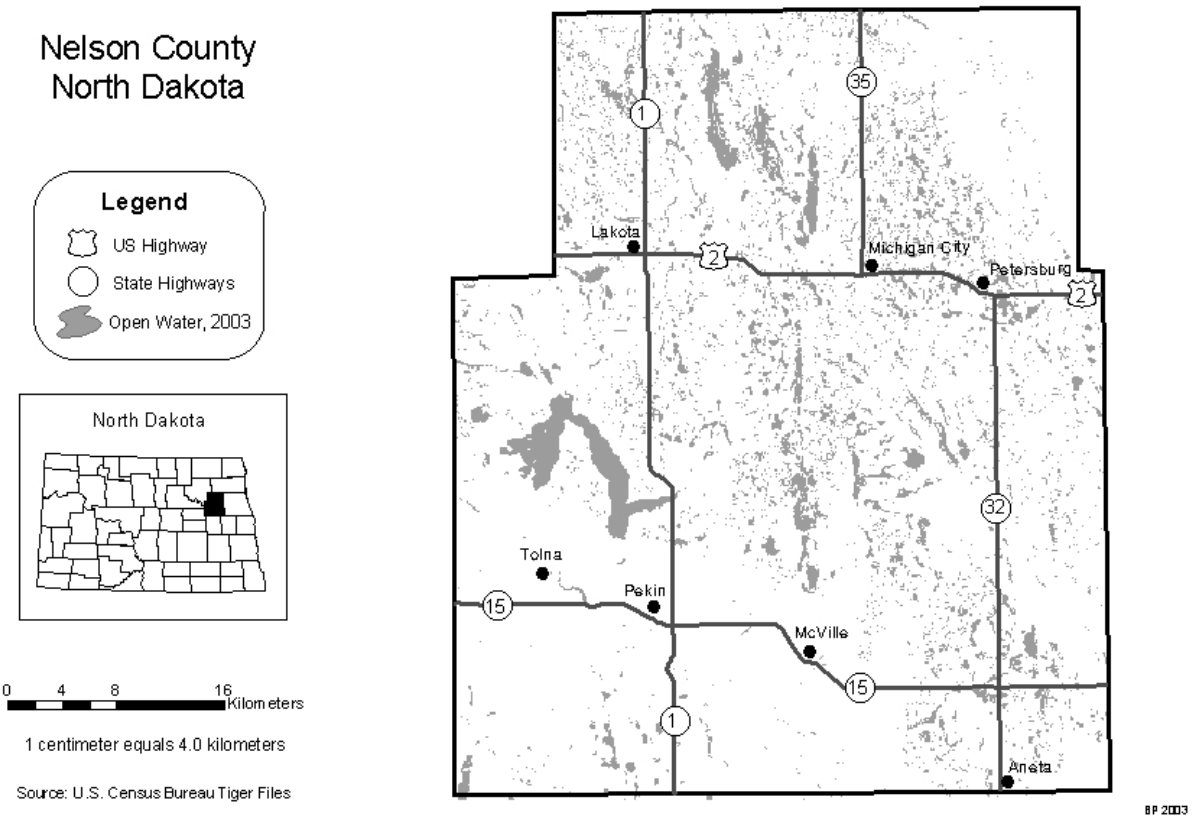

Figure 2: Base map of Nelson County, North Dakota.

The county is located within the Drift Prairie physiographic region and is dotted with innumerable shallow depressions that formed during alternating advances and retreats of the continental ice sheet during the last glacial period (Murphy et al. 1997). The eastern half of North Dakota has experienced an unprecedented wet spell since 1993 as shown in Figures 1 and

3. Normally the precipitation regime is characterized by a high degree of interannual variability. Over a multi-decadal to century time scale, however, clusters of consecutive years with below average or above average precipitation occur in sequence. The best-known example of this is the Dust Bowl Era of the 1930s that resulted in considerable environmental and socioeconomic impact to the region. Figure 3 indicates that between 1993 through 2001 the region experienced a run of years with above average precipitation. This wet spell that was still in process in 2001, has been comparable in magnitude but opposite in sign to the Dust Bowl Era that has achieved mythic proportion in the American environmental folklore. Although the devastation wrought to the region by the dry spell of the 1930s is widely recognized, the deleterious effects brought by the wet spell of the 1990s has largely eluded the national consciousness.

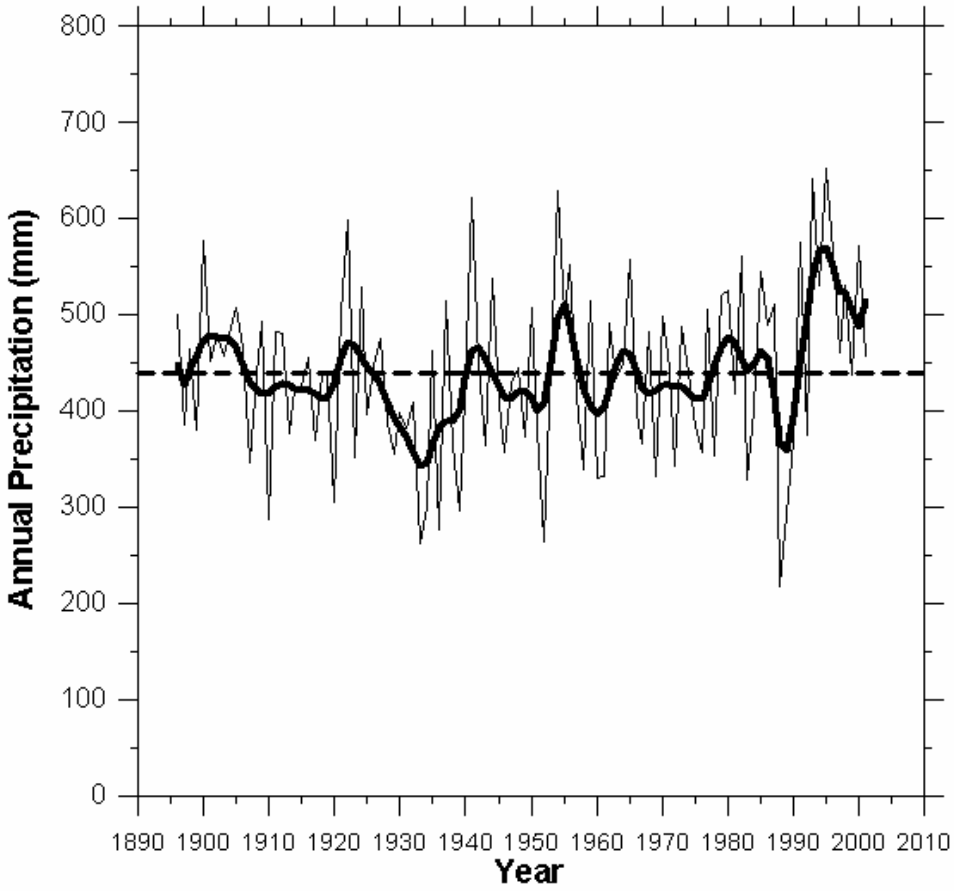

Figure 3: Time series of annual precipitation for Langdon Experiment Farm, North Dakota, 1896-2001. The dark curve is a 9-term binomial filter of the annual time series.

The wet spell has produced two environmental impacts in Nelson County. The first effect has been the growth of Stump Lake, which has created a closed-basin lake flood hazard. The growth of Stump Lake has been driven by three hydrologic factors: the direct precipitation onto the lake surface, the increase of surface runoff from the surrounding Stump Lake sub-basin, and the spillover of surface runoff from Devils Lake. The second environmental effect has been the

expansion in the number of rural wetlands (Figure 4). The fine-textured glacial till soils of the region have low vertical permeability and often develop concrete frosts during the winter (Woo and Rowsell 1993). The shallow wetland depressions also accumulate drifting snow during the winter. During the spring snowmelt season the wetland depressions temporarily collect surface runoff and snowmelt. Unlike other wetland types, northern prairie wetlands are a dynamic wetland resource that varies significantly in character depending upon the regional moisture conditions. During significant wet spells the prairie landscape will experience an explosion in pond abundance, an increase in average pond size and depth, and increased permanence of wetlands (Winter and Rosenberry 1998). Increasing regional groundwater levels also contribute to this effect (Schuh 1999). The complete Nelson County flood hazard, therefore, results from the combined effect of the closed-basin lake and rural wetland flood events. Assessment of the flood damages and evaluation of flood mitigation efforts in Nelson County will require separate consideration of both processes.

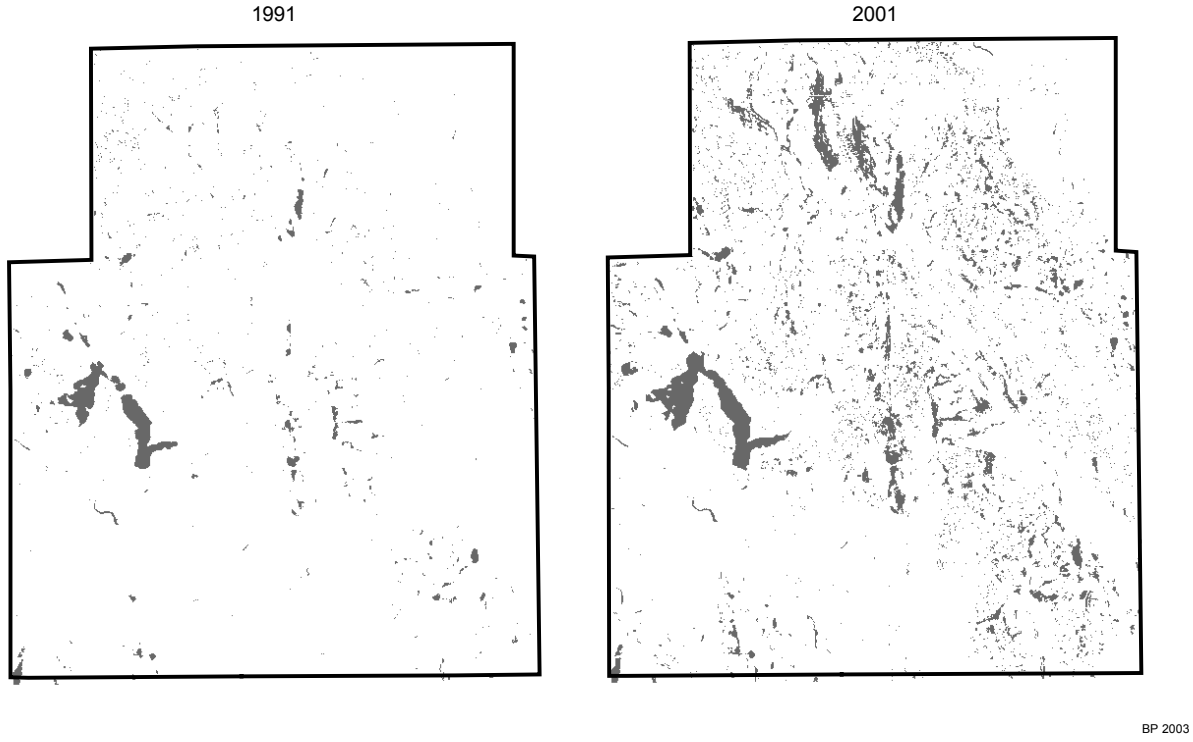

Figure 4: Extent of open water in Nelson County, North Dakota, derived from Landsat Thematic Mapper Imagery.

The details of the Stump Lake hydrology are shown in Figure 5 for the 2001 calendar year. Devils Lake began to rise from a pre-snowmelt WSE of 440.8 m (1446.2 ft) around day 100 (Figure 5c). The peak WSE for Devils Lake was reached on 22 July 2001 at 441.4 m (1,448.12 ft), when the lake area was 50,587 ha (125,000 acres), and the lake volume was 296,069 ha-m (2,400,000 acre-feet - AF). The lake then began a slow decline until winter freeze-up around day 285. Local snowmelt runoff around Stump Lake initiated a steep rise at a

somewhat earlier date than for Devils Lake (Figure 5b). The initial rapid rise in Stump Lake WSE was followed by a small but steady rise in WSE until it reached a peak WSE of 430.5 m (1,412.34 ft) on 8 August 2001 for a 0.55 m (1.8 ft) rise for the year. The approximate lake area was 3,157 ha (7,800 ac), and the lake volume was 15,297 ha-m (124,000 AF). This continued rise in Stump Lake WSE was driven by surface outflow from Devils Lake via the Jerusalem Outlet into the west end of Stump Lake (Figure 5a). The rate of outflow into Stump Lake from Devils Lake varied with the hydraulic head, and reached a peak of 1.42 cms (50 cfs) on 30 July 2001. Because Stump Lake hydrology is controlled by two sources of inflow – local snowmelt runoff around the lake and outflow from Devils Lake – it does not show a decline in WSE during the fall, and is expected to rise even more rapidly than has Devils Lake. Future WSE rises at Stump Lake will be primarily controlled by the future WSE of Devils Lake.

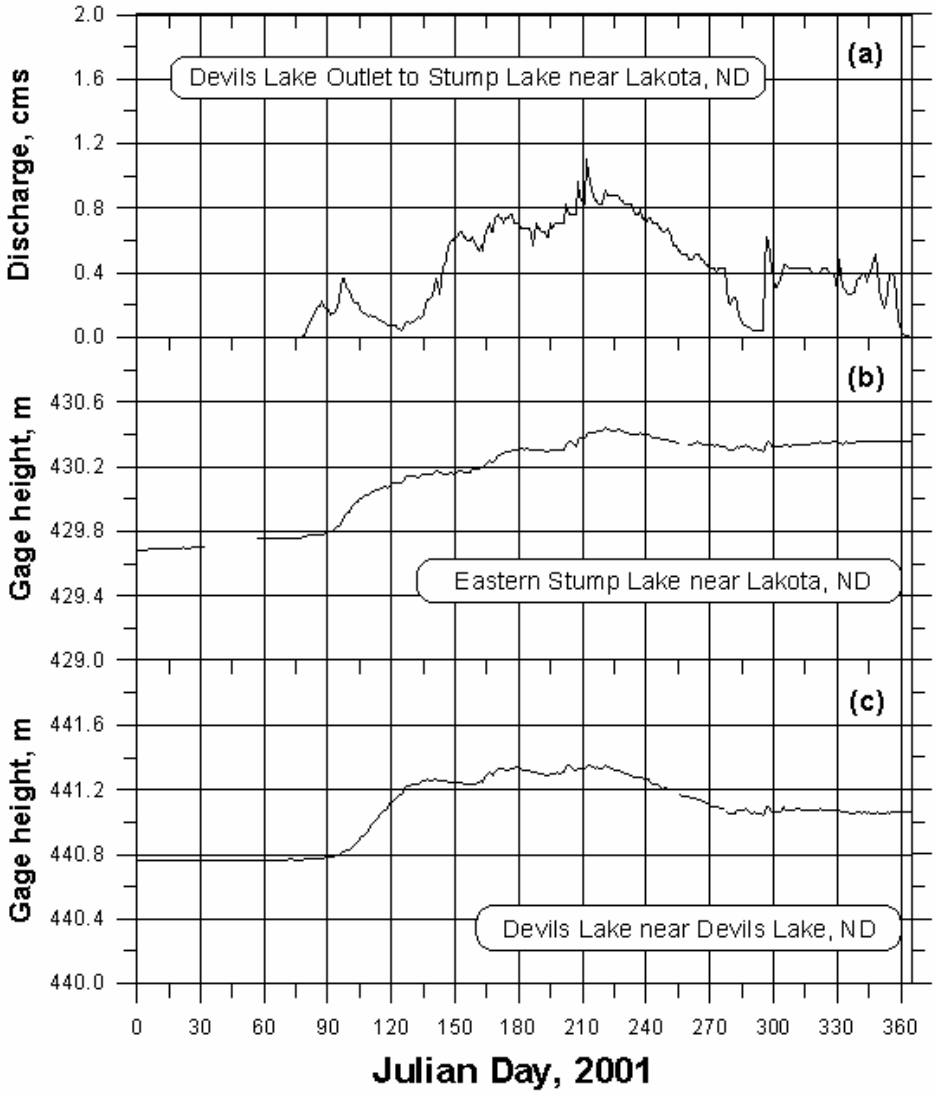

Figure 5: Outflow (cms) from Devils Lake to Stump Lake (USGS gage #05056636) for calendar year 2001 (a); Water surface elevation at Eastern Stump Lake (USGS gage

#05056665) for calendar year 2001 (b); Water surface elevation for Devils Lake (USGS gage #05056500) for calendar year 2001 (c). Source: USGS.

Methodology

The persons and agencies contacted during the study is given in Table 1. An effort was made to contact a key representative from all federal, state, county, and private agencies and organizations that were involved with mitigation of flood damages in Nelson County as a result of either closed-basin lake or wetland flooding. Local administrators and decision-makers were also interviewed. The methods of contact included on-site personal interviews, phone interviews, and e-mail contacts. The level of cooperation and assistance provided by federal, state, county and private representatives was exceptionally high, and all requests for information were fully responded to. Official documents, previously published research, and government web sites were also searched. Daily newspaper coverage from the local newspaper, *The Devils Lake Journal,* were routinely examined for relevant information. The primary regional newspaper (*The Grand Forks Herald*) and the regional ABC Television affiliate were also initially examined as sources of information, but not pursued due to their inconsistent and spotty coverage.

Table 1. Persons and Agencies Contacted.

Person/Organization	**Method of Contact**
Nelson County Emergency Management Coordinator	Interview
Public Officer, North Dakota Division of Emergency Management, (ND DEM)	Phone, e-mail
State Flood Coordination Center Meeting	Attended meeting
Fisheries Biologist, ND Game & Fish District	Phone
Nelson County Tax Equalization Director	Interview
Nelson County Road Superintendent	Interview, e-mail
HUD – Red River Regional Council	Phone, e-mail
Account Technician, Public Assistance Program, ND DEM	Phone
Field Representative, Eastern North Dakota, The Salvation Army	Phone
FEMA Region 8, Denver, CO	e-mail
Executive Director, Red River Valley Chapter, American Red Cross	Phone
Transition Coordinator, Lutheran Rural Response	Phone
Co-Executive Director, North Central Farm Services Agency	Interview, Phone, e-mail
District Conservationist, Nelson County Soil Conservation District	Phone
Regional Director, USDA Risk Management Agency	Phone, e-mail
Nelson County Extension Agent, NDSU Extension Service	Interview, Phone
Analyst/Special Projects Manager, ND DEM	Phone
Local Government Engineer, ND Department of Transportation	Phone, e-mail
Public Affairs, Small Business Administration	e-mail
Human Services Officer, Job Service North Dakota	e-mail

Flood Damage Assessment

On 21 May 2001, Governor John Hoeven requested a Presidential Disaster Declaration (PDD) for 27 counties and two reservations in eastern North Dakota. This included a preliminary damage estimate of $327,316 for the Public Assistance (PA) program for Nelson County. On 28 May 2001, FEMA authorized Presidential Disaster Declaration (PDD) FEMA-DR-1376-ND for damages that began on 1 March 2001. No Individual Assistance (IA) program mitigation request was submitted. This marked the 10th PDD for Nelson County during the nine-year period 1993-2001. The county was included in PDDs for nine consecutive years, with nine of the ten declarations being for flood-related damages. Indeed, the general Devils Lake region, of which Nelson County is a part, has experienced a chronic flood hazard that is unprecedented in modern times within the United States.

A complete loss accounting of the flood damages in Nelson County would examine the full range of loss associated with the flooding, including the tangible and intangible benefits and losses, and the direct and indirect benefits and losses (Tobin and Montz 1997). Of necessity our evaluation focused on the direct and indirect losses and costs of adjustment for the year 2001. A preliminary estimate of the flood damages due to closed basin and rural wetland flooding for 2001 is summarized in Table 2. The data are grouped into four categories: (1) direct federal payments for damages related to flooding that are not linked to a Presidential Disaster Declaration, (2) direct federal payments for flood damages tied to a Presidential Disaster Declaration, (3) indirect flood damages, and (4) secondary flood damages. The items are listed in descending order of total cost within each category. Total costs are further divided into the federal, state, and county portions according to the appropriate federal/state/county cost share. These damage totals should be viewed as minimal estimates since they are based upon disbursed damage payments rather than claimed or actual damage totals (Shultz and Kjelland 2002).

Direct Effects of Stump Lake Flooding

Roads and Infrastructure: Road and infrastructure impacts directly related to the rising level of Stump Lake consist of four items: (1) the relocation of State Highway 1, (2) the abandonment of Nelson County Road 4, (3) the construction of a bridge on Nelson County Road 27, and (4) the construction of new culverts on Nelson County Roads 15 and 23.

The rising WSE of Stump Lake has forced State Highway 1 to be raised two times in the past five years. In 1997 SH 1 was raised from 1408.0 ft to 1411.29 ft, and in 2001 work was begun to raise it to 1455.9 ft. The second phase involved rerouting SH 1 one mile to the east of its previous location. Work began on 11 June 2001 and was completed in the spring of 2002 at a total cost of $2,553,716. Had the work been completed within 180 days of the flooding, the costs would have been completely picked up by the federal government. Because this time frame was not feasible, the rerouting costs were picked up on an 80/20% federal/state cost share (Table 2), with the state costs provided by state highway funds (gas tax).

Prior to 2001, the rising waters of Stump Lake had inundated Nelson County Road 4, a road that had originally been part Nelson County's 171 mile County Motor Conveyance (CMC) allocation. Nelson County initiated paperwork to transfer CMC status from NC 4 to NC 24, and has abandoned the use of NC 4.

The increased flow of water from East Devils Lake to Stump Lake via the Jerusalem Outlet threatened to overwhelm the three 36 inch culverts along Nelson County Road 27, a major north-south road for the movement of people and goods and the provision of emergency services. In order to assure this vital flow of people, goods, and services the three culverts were replaced

with a new 162' bridge. The bridge is built to 1465' elevation, has a 50' wide channel, a 1000 cfs capacity, and was completed in November 2001 at a total cost of $896,989 (Table 2).

The increased discharge of surface waters through the Jerusalem Outlet to Stump Lake also threatened other county roads. In order to prevent inundation of these roads the existing undersized culverts at Nelson County Road 15 and Nelson County Road 23 were replaced with larger culverts at a total cost of about $12,000 (Table 2).

Table 2. Total Direct, Indirect, and Secondary Flood Damages ($) in Nelson County, 2001.

	Total Cost ($)	Federal Share ($)	State Share ($)	County Share ($)
Direct Flood Damages, Non-PDD-Based				
FCIC Indemnity (All water-related categories)	7,402,175	7,402,175	0	0
CRP Payments	4,477,466	4,477,466	0	0
State Highway 1 Road Work	2,553,716	2,042,973	510,743	0
Bridge Construction - ND 27	896,989	717,591	0	179,398
County Motor Conveyance System	607,710	497,071	0	110,639
Lost Calf Sales	187,600	0	0	187,600
Culvert Modifications	12,000	0	0	12,000
National Flood Insurance Program	10,838	10,838	0	0
Subtotal:	(16,148,494)			
Direct Flood Damages, PDD-Based				
Crop Disaster Programs	1,875,179	1,875,179	0	0
FEMA – Public Assistance	503,790	377,843	50,379	75,568
Subtotal:	(2,378,969)			
Indirect Flood Damages				
Lost Purchased Inputs – CRP Land	10,089,288	0	0	10,089,288
Lost Purchased Inputs – FCIC PP	6,764,868	0	0	6,764,868
'Lost Taxes'	13,208	0	0	13,208
Subtotal:	(16,867,364)			
Secondary Flood Damages				
CRP Purchased Inputs Multiplier	36,321,437	0	0	36,262,944
FCIC PP Purchased Inputs Multiplier	24,353,525	0	0	24,314,000
Lost Calf Sales Multiplier	562,800	0	0	562,800
Subtotal:	(61,237,762)			

Total:	96,632,589	17,401,136	561,122	78,572,313

Land Cover Change: Table 3 presents land inundation totals for specific land use categories. These figures are based upon an analysis of Landsat TM imagery obtained on 9 July 2001, 13 days before the peak WSE was reached for Stump Lake, and are based upon the 1992 USGS land cover classification dataset. The lake surface area increased by 1,048 hectares (ha) between 1992-9 July 2001, with the majority of the flooded land being forests surrounding the former lake shoreline, grasslands, pasture/hay land, and wetlands. Although this represents a 53% increase in the area of Stump Lake over the modern wet spell (Table 4), it accounts for only 8% of the total open water expansion over the period 1992-2001. Currently, Stump Lake accounts for about 16% of the open water in Nelson County.

Table 3. Land Inundation (ha) in Nelson County, 9 July 2001, WSE = 431.3 m (1415 ft).

Category	Nelson County, 1992	Stump Lake Flooding	Wetland Flooding	Total Flooding
Open Water	4,920	NA	NA	NA
Residential	351	0	15	15
Commercial/Transportation	645	1	14	15
Forest	3,281	238	128	366
Shrubland	330	5	0	5
Grasslands/Herbaceous	3,530	174	334	508
Pasture/Hay	31,071	268	1,080	1,347
Row Crops	167,867	8	3,593	3,601
Small Grains	30,067	0	902	902
Wetlands	19,319	354	6,976	7,330
Miscellaneous	3	0	0	0

Table 4. Total Open Water Area (ha), 1992 vs. 2001, Nelson County.

Category	USGS Land Cover, 1992	Landsat TM, 9 July 2001	Change 1992-2001	% Change, 1992-2001
Stump Lake	1,986	3,034	1,048	53%
Wetlands	2,934	15,424	12,490	426%
Total Open Water	4,920	18,458	13,538	275%

Fisheries and Wildlife: As the lake level in Stump Lake has risen, the quality of the lake habitat for fish has improved due to lower salinity levels, increased nutrient inputs, and the deeper lake that creates a greater source of O_2 and reduces the winter-kill of fish. At lower lake levels only brine shrimp were able to survive in the lake. For three years beginning in 1998 the North Dakota Game and Fish Department stocked the lake with yellow perch, a popular fish for winter ice fishing. Yellow perch stocked in 1998 (375,680) are now 8-10" long, while those stocked in 1999 are now 6-8" long. This is large for yellow perch, and has resulted in a sharp increase in the number of people fishing on the lake during the winter. The 2000 stocking (34,100) was smaller than requested due to a collapse of the fishery and inability to meet orders. There are no plans to stock the lake in 2001. The large perch arise from the lack of competition for nutrients

from other species. Stump Lake has seen significant recent growth in the number of anglers, especially winter ice fishing of perch, with up to 100 campers on selected weekends during the winter of 2001. There is concern that northern pike and walleye may be able to eventually enter Stump Lake via East Devils Lake. At present, salinity levels may be too high for them to reproduce, as younger pike and walleye are sensitive to the high salinity values. Continued freshening of the lake would improve the prospects for walleye and pike reproduction, but is not desired by locals since there is good pike fishing within 20 miles in most directions. Movement of pike from East Devils Lake or their natural propagation in Stump Lake would harm the ice fishing business since pike are predators that eat perch, and would degrade the quality of the ice-fishing. The positive economic impact of the fishery upon the Nelson County economy has been negligible, however.

Home Inundation: The land surrounding Stump Lake is very sparsely settled. Only eight National Flood Insurance Policy (NFIP) policies were active in 2001, totaling $415,200 in coverage. Six NFIP claims have been paid a total of $10,838 (Table 4).

Livestock Sales: The total number of livestock (all cattle, milk cows, sheep, hogs and pigs) has decreased significantly in recent years due to low cattle prices, management difficulties, and lack of reliable labor to assist in livestock operations. Currently, all cattle are by far the largest component of livestock in Nelson County, although it generally has not been a significant livestock county within the state. Analysis of satellite imagery summarized in Table 3 indicates that a total of 268 hectares of pasture and hay land has been inundated immediately surrounding Stump Lake. The average carrying capacity for pasturage in Nelson County is about 0.41 hectare per animal unit month. An animal unit month is one cow/calf pair per month, and it takes between 6-7 animal unit months (about 2.87 ha) to feed one animal unit for a year. Typically the calves are raised and sold while the cow is kept. Thus it takes about one growing season to raise a calf from purchased size to selling size. The 268 ha of lost pasture acres divided by 2.87 ha per animal unit equals 93 lost calf sales in 2001 due to the growth of Stump Lake. At approximately $400 per calf, this would be a total of $37,200 in lost livestock sales.

Direct Effects of Rural Wetland Flooding

Roads and Infrastructure: The explosive growth of wetlands has also greatly impacted the rural county and township road system. The growth of wetlands results in water abutting against roads, which softens the road shoulders, weakens their foundations, and encourages erosion by wave action. These impacts have been a major source of damages claimed under the FEMA Public Assistance (PA) program (Table 2). PA funds are available at a 75/10/15 federal/state/county cost share subject to adequate accumulated federal, state and county funds in the Bismarck Transportation Office that administers the gas tax monies. Because Nelson County has been a part of a PDD for the nine years from 1993-2001 there have been hundreds of project worksheets submitted under the PA program. These have mainly been for shoulder in slope repair work, culvert replacement, rip rap work along the sides of roads to protect against wave action, soft spot repairs for water abutting against the roads, and bridge debris clearance.

Land Cover Change: Wetland coverage on 9 July 2001 is reported by land cover category in Table 3, and summarized in Table 4. By 9 July 2001 open water associated with wetlands

covered approximately 15,424 ha, for a 426% increase over 1992. Most of the open water expansion occurred at the expense of wetlands and row crops, with significant additional totals coming from pasture/hay and small grains. Prairie pothole wetlands now comprise 84% of the total open water area in Nelson County, and has accounted for 92% of the open water expansion by 9 July 2001.

Livestock Sales: Wetland flooding has accounted for approximately 1,080 ha of lost pasture and hay acreage (Table 3). Repeating the analysis for income loss due to lost calf sales yields: 1,080 ha of lost pasture acres ÷ 2.87 ha per animal unit = 376 lost calf sales in 2001 due to wetland expansion. At approximately $400 per calf, this would be a total of $150,400 in lost livestock sales.

Fisheries and Wildlife: The unprecedented wet spell has resulted in an explosive growth in northern prairie wetlands and the many waterfowl that depend on those habitats for either nesting, feeding, or cover during migration. The North Dakota Game and Fish Department reports that the state water index is up 65% from 2000, and that there are about 4 million breeding ducks in the state (up from 700K in late 1980s). The state duck index is up 14% over 2000, and is the 2nd highest index value on record. This high index value is a result of the abundance of open surface water, nesting cover (natural and restored grasslands), and CRP acreage. Statewide this has led to a significant growth in the number of hunting and fishing licenses, and outdoor-based tourism and recreation opportunities over the past decade, although Nelson County lacks the infrastructure to take advantage of these new opportunities in a significant way.

Agriculture: The land inundation totals presented in Table 3 demonstrate that wetland flooding has been the cause of approximately 95% of the inundated agricultural land in Nelson County during 2001. Because government statistics are only available at the county level our analysis of the economic impact of flooding will be presented in this section. The imagery analysis results indicate that rural wetland flooding has been the primary cause of agricultural damages within the county.

Federal payments for flood-related agricultural damages derive from three separate sources. First, are the disaster payments that are part of the Crop Disaster Program segment of the Farm Bill and that are only available to counties that are included within a PDD. These payments are unrelated to crop insurance payments available through the Federal Crop Insurance Corporation (FCIC) and are based upon actual losses. They are also in addition to the basic production flexibility contracts and market loss assistance available through the Farm Bill. Totals for 2001 are shown below:

Year	Production Flexibility Contracts ($)	Market Loss Assistance ($)	Disaster Programs ($)	Total ($)
2001	3,663,638	4,049,341	1,875,179	9,588,158

Nearly 20% of the payments to Nelson County producers through the Farm Bill in 2001 were for disaster payments.

The second source of federal payments for flood-related losses derives from the crop insurance program available through the FCIC. The Farm Services Agency (FSA) considers the base agricultural acreage for Nelson County to be between 206.0-207.2 K ha [205.2 K ha in 2001]. The planted acreage in 2001 was about 141.6 K ha, representing about a 30% reduction in production acreage for the county. Producers are required to account for all of their base agricultural acreage each year. Summer fallow acreage (land not planted but left fallow for the year) accounted for only 2.4 K ha in 1998, but grew to 45.7 K ha in 2001. Most of this increase in summer fallow acreage is simply preventive planting (PP) acres, or land with a past cropping history that could not be planted due to rural flooding, and for which the producer decided to take crop insurance. If 205.2 K ha is the base agricultural acreage, and 45.7 K ha was in summer fallow, 22.3% of the base agricultural acreage was taken out of production in 2001 due to flooding.

The FCIC totals for Nelson County for all crop insurance claims are given below. These totals reflect the losses paid for all causes of loss that are eligible within the FCIC.

Year	Net Acres Insured (ha)	Total Premium ($)	Indemnity ($)	Loss Ratio
2001	136,815	4,135,412	8,568,847	2.07

The net insured acres were less than the base agricultural acreage because Conservation Reserve Program (CRP) acreage and selected other land categories do not have to be insured for participation within the Farm Bill. The totals for all flood-related crop insurance claims are given in Table 5 ($7,402,175 in 2001), and indicate that 86.4% of all crop insurance claims in Nelson County for 2001 were for flood-related losses.

These flood-related losses fall within three basic categories that are summarized in Table 5 for 2001.

Table 5. FCIC Indemnity ($) by Program Category, 2001.

FCIC Category	*Area (ha)*	*Indemnity ($)*
Preventive Planting (PP)	34,166	5,527,737
Excess Moisture (31)	10,344	1,326,754
Plant Disease (81)	3,811	547,684
Total:	48,321	7,402,175

(1) Preventive Planting: This category applies when the fields were too wet in the spring to prepare the seedbed, and the producer claims a lost crop due to early season moisture problems. Due to the short growing season in North Dakota, the FCIC specifies a closing date for spring planting, after which the producer assumes all risk of planting and is not eligible for FCIC payments. Preventive planting has been the leading cause of losses and acres affected, and was the cause of 64.5% of all FCIC losses, and 25.9% of all insured cropland in 2001.

(2) Excessive Moisture/Precipitation/Rain: This category applies when the producer claims that excessive moisture was a cause of loss, either because it was wet when the crop was planted or excessive rain occurred during the growing season. The moisture

caused loss and affected crop production, creating what local producers call 'drown-out'. Excess Moisture/Precipitation/Rain accounted for 15.5% of FCIC losses and 7.6% of all insured cropland in 2001.

(3) Plant Disease: The FCIC pays plant disease losses on many diseases that are caused by chronic wet conditions. Plant disease loss information is included because many of the plant disease losses that RMA has been paying (like scab, sclerotinia, etc.) are indirectly caused by wet conditions. Scab (*Fusarium* head blight) has affected wheat (durum and spring) and barley, while vomitoxin has affected barley (Peel 1998). Each disease decreases total yield, decreases the quality of the yield resulting in dockage charges at the grain elevators, and increases production costs due to chemical treatments and increased inputs arising from the decreased efficiency caused by the high soil wetness. Plant disease accounted for 6.4% of FCIC losses and 2.8% of all insured cropland in 2001.

The third source of federal funding that has helped mitigate the economic impact of rural wetland flooding has been payments for participation in the Conservation Reserve Program (CRP). There has been tremendous growth in CRP enrollment in Nelson County since 1998. In 1998 the National Resource Conservation Service (NRCS) changed the emphasis of the CRP criteria from highly erodible lands to wildlife benefits. National Conservation Priority Areas were established for the nation to set national conservation priorities. These changes were specifically designed to put wetland acreage into the program. Fortunately, for Nelson County producers, the entire county is within one such priority area - the Prairie Pothole Region. The timing of this change coincided with the explosion in the number of rural wetlands in Nelson County. From 1998 to 2001 Nelson County went from one of the least enrolled CRP counties in the state to the most heavily enrolled county in the state. The NRCS places a 25% cap on CRP acreage for each county. Nelson County has a current agricultural base of 205.2 K ha, thus limiting its CRP enrollment to 51.3 K ha. Nelson County is now at the cap (Table 6), so that new contracts can only be awarded as old contracted acres are taken out of the program.

Table 6. Conservation Reserve Program Enrollment (ha) by Land Eligibility Category, through 2001.

NRCS CRP Category	*hectares*
Cropped Wetland Associate	18,155
Cropped Wetland	3,527
Non-Cropped Wetland Associate	14,807
Non-Cropped Wetland	12,456
Water Bank Program	2,011
Total CRP Contracts	50,956

Table 6 provides the enrollments for various categories of land classes within the CRP program. The NRCS mission, however, is to increase wildlife benefits and not to mitigate agricultural losses due to rural wetland flooding. CRP contracts are awarded on a competitive basis based upon a closed bidding process. In order to secure a contract a producer must not only enroll their flooded wetlands that have a cropping history, but also the associated grasslands

and cropped lands that surround the wetlands. Table 6 indicates that in addition to the cropped wetland (non-permanent wetlands), non-cropped wetland (permanent wetlands), and water bank acres, a significant amount of associate grasslands surrounding the wetlands have also been enrolled. Although CRP enrollment has proven to be a popular inadvertent flood mitigation adaptation by local producers, the program results in significant amounts of farmland being taken out of production and has some undesired consequences (Leistritz et al. 2002). Current Nelson County CRP statistics are given below:

Year	Total Number Signed Contracts	Total CRP Enroll. (ha)	Avg. Rental Rate ($\$ ha^{-1}$)	Total CRP Income ($)
2001	1,105	50,956	887.82	4,477,466

Combining the CRP land totals with the preventive planting land totals indicates that 85,122 ha or nearly 42% of the agricultural base acreage of Nelson County has been taken out of production, either directly or indirectly, because of rural wetland flooding.

Flood-related agricultural losses have made area producers increasingly dependent upon government payments to remain economically viable. The table below shows the total farm marketings and government payments for 2000 (the most recent year for which data is available). Nearly 50% of all farm income derived from government payments in 2000, a significant increase from the 10-20% range observed over the earlier half of the 1990s.

Year	Crops ($1000s)	Livestock ($1000s)	Government Payments ($1000s)	Total ($1000s)	Govt. Payments (%)
2000	17,757	6,218	23,553	47,528	49.6

Indirect Effects of Stump Lake and Rural Wetland Flooding

Reduced Purchased Inputs: The current average costs for farming run about $297-309 per hectare ($120-125 per acre), and include all farm-related costs such as direct costs, land prices for rental/taxes, average return on investment, opportunity costs of money used, depreciation on equipment. About 67% of these total costs represent direct or purchased inputs, such as costs for seed, fertilizer, herbicide, fuel costs, fungicide, insecticide, repairs, crop insurance, operating interest, labor, harvesting costs, and other minor costs. Current purchased inputs average about $198-222 per hectare ($80-90 per acre), and are distributed as follows: seed costs (19%), fertilizer (20%), herbicide (11%), fuel (10%), and other (40%). When land is enrolled as CRP land or when preventive planting occurs there is a significant indirect economic impact upon the region in the form of reduced economic activity to the farm supply and service sector. Taking the preventive planting and CRP totals indicated in Tables 5 and 6 and multiplying them by the low end of the purchased inputs cost results in the indirect costs for 2001 shown in Table 2. The magnitude of the indirect economic impacts due to reduced purchased inputs due to retirement of land in the CRP program or the non-planting of viable cropland is comparable to the direct economic impacts given in Table 2. These costs are born completely by the regional farm supply and service sector of the economy with essentially no mitigation (Leistritz et al. 2002). This total

is a conservative estimate since much of the 10,344 ha experiencing excess moisture claims in Table 5 would also have experienced reduced purchased inputs. Because there is no way of knowing when during the growing cycle the excess moisture damage occurred, we have chosen to omit this indirect flood damage estimate.

Reduced Land Evaluation ('Lost Taxes'): Through Senate Bill 2068 producers can request a reduced land evaluation for flooded farmland that does not generate income. In 2001, 76 applications for reduced land evaluation were approved on a total of 2,870 acres (1,161 ha) totaling $13,208 in 'lost taxes' (Table 2). Because the financial needs of the county remain constant this is not a true loss of tax revenue, however, as mill rates are adjusted upwards on the remaining landowners. This reapportionment of the tax burden from county residents affected by flooding to those not affected by it is a form of sharing the loss among the county residents.

Secondary Effects of Stump Lake and Rural Wetland Flooding

The reduction in the number of planted acres and the reduced purchased inputs that result from the weakening of the primary agricultural sector also has secondary effects upon the regional economy. With decreased planting the local businesses experience decreased throughflow of locally-generated dollars. Multiplier-dependent businesses bear the brunt of this economic impact. The first businesses that are lost are the services that depend upon locally generated dollars that circulate within the community and region, although all businesses feel the effects of the weakened regional economy.

These secondary economic impacts can be estimated by using appropriate economic multipliers in combination with CRP and preventive planting acreages, and average purchased inputs costs. A multiplier of 3.0 is applied to livestock sales for the flow of dollars through the region/county, and a multiplier of 3.6 is applied to the economic turnover for all purchased inputs. The multipliers were obtained from the local county extension agent.

Because we are using economic multipliers the estimate of the secondary flood damages (Table 2) dwarfs the direct and indirect flood damage estimates. Because of economic leakage much or even most of the indirect and secondary flood damages presented in Table 2 are felt outside of Nelson County. Although our study focused upon Nelson County, the impact of the rural wetland flood hazard is experienced throughout the entire Devils Lake trade area.

Absentee landowners are also a controversial issue and add to the difficulty in maintaining a viable rural economy during a prolonged wet spell superimposed on a generally weak and troubled farm economy. Dollars paid to absentee landowners as a result of CRP contracts and crop insurance leave the community and do not circulate locally, adding to the problem of economic leakage.

Flood Mitigation Efforts

Federal

Agriculture: The majority of the $17,401,136 total federal costs during 2001 were for agriculture-related damages (79%), and most of these expenses (86%) were paid indirectly through the crop insurance and CRP programs. Crop damages specifically linked to a PDD accounted for only 14% of federal payments in 2001. The $1,875,170 crop disaster payments, in

fact, were a small percentage (20%) of the total payments made to Nelson County producers through the federal Farm Bill. With current average returns of between $105-120 per acre and average costs of between $120-125 per acre, the net return on farming is close to zero. Farming is not seen as a financially viable option for many farmers. Taking advantage of existing crop insurance and CRP opportunities provides producers with a short-term viable option for survival in the midst of an unprecedented wet spell. This 'cash-flowing' mode of operation, however, is not a viable long-term operation as the basic farm unit is not profitable under current national farm production economics.

Infrastructure: Similarly, the majority of the federal payments for infrastructure were made through programs not tied to a PDD. Nearly 90% of such federal expenses were for work related to the CMC system, emergency work on CMC roads, or for the relocation of a State Highway. Infrastructure-related work accounted for the majority of the remaining federal expenses. PA funding accounted for only 10% of infrastructure-related work. These funds have enabled Nelson County to maintain a basic core of primary roads. The county has been forced, however, to spend all of its local cost share funds matching federal and state funds to maintain the CMC system and other primary roads. Non-primary roads continue to suffer since primary roads are being maintained at their expense. This form of substitution hastens the deterioration of the already overextended county and township rural road systems.

Individual Homes: Rural out-migration has characterized Nelson County for the past 70 years. As a consequence, NFIP-related expenses for individual homes and structures have been less than 1% of federal costs. This lack of a significant direct human component to the closed-basin lake and rural wetland flooding hazards has hindered local and state efforts to communicate the severity of this flood disaster to the nation. This problem is compounded by the lack of an Individual Assistance (IA) component to the most recent PDD.

State

Property Tax Relief for Flooded Farmland: During the 2001 biennial state legislature meeting elected state officials passed Senate Bill 2068 that was a refinement of an earlier tax relief bill passed in 1999. This bill provided tax relief through reduced land evaluation for producers whose farmland was flooded and unable to produce income. The bill establishes a 10-acre minimum application, and producers must wait until the second year of inundation to request a reduced evaluation on their land. During the first year of inundation producers can only claim crop insurance for the land. All CRP/WB land is ineligible for a reduced evaluation, as is any land for which any income greater than $8.71 an acre was received in 2000 (the average Nelson County revenue per acre for non-cropland in 2000). This bill is intended as an option of last resort for producers who have no other means to derive income from their flooded land. The State legislation will have to renew the bill each, and producers must apply annually for reduced land evaluation.

Cost Share Assistance on Culverts: The North Dakota State Water Commission covered part of the local cost share for the replacement of three 36" culverts with three 60" culverts on NC 23 ($6,117). This was done so that the anticipated increased flow of water from Devils Lake via the Jerusalem Outlet would safely pass under the road and not back up behind it and weaken the

road. The construction of the new bridge at NC 27 is expected to increase the flow of water to Stump Lake, so this is a proactive measure to maintain the north-south flow of traffic as effectively and as long as possible.

Jerusalem Outlet Clearing: The North Dakota State Water Commission authorized funds to conduct a geologic study to determine the depth of wind-blown soil accumulation along the Jerusalem Outlet connecting East Devils Lake with Stump Lake (Murphy et al. 1997). In response to study results, the Governor authorized the ND National Guard to take farm equipment and lower the elevation of the Jerusalem Outlet from 1447.0' to 1446.5'. This effectively increased the flow of water from East Devils Lake to Stump Lake, and lessened backwater effects behind critical north-south roads.

Community Development Block Grant (CDBG) Funds: The state has used minor but unspecified amounts of CDBG funds to cover the local cost share of some PDD-based programs in Nelson County. This has been an attempt to lighten the enormous financial burden that Nelson County faces in meeting their cost share obligations.

Temporary Devils Lake Outlet: The state has lobbied strongly for the construction of an outlet from Devils Lake to the Sheyenne River as a major element of a comprehensive Devils Lake water management plan. Ongoing US Army Corps of Engineers studies have been so slow, however, that the ND State Water Commission has initiated plans for their own outlet that would be smaller in scope and shorter in duration than the USACE outlet. Both outlet plans, however, have been met with strong local, regional, and international opposition due to a variety of concerns. Many local officials seem resigned to the probable failure of the USACE outlet plan, and see the state outlet plan as a more likely means of providing structural assistance in reducing the flood threat ultimately tied to the rising of Devils Lake.

County

Roads: The long lead time associated with the closed-basin lake rise and expansion of wetlands combined with the fixed nature of infrastructure has led to significant opportunities for mitigating the effects of flooding upon the county transportation network. The Nelson County Commission, Ramsey County Commission, and Nelson County Road Superintendent have been proactive in taking necessary efforts to maintain a critical transportation network for the flow of emergency services, farm products and equipment, and access to the major trade, medical, and service center in the City of Devils Lake. The table below lists the primary county roads that will be inundated as Stump Lake continues to rise (Figure 2).

Road	Approximate Lowest Roadway Elevation (ft)
Nelson County 4	1406.00'
Nelson County 23 (South)	1425.00'
Nelson County 15	1425.00'
Nelson County 23 (Middle)	1434.00'
Nelson County 23A	1435.00'
Nelson County 23 (North)	1448.50'

Nelson County 27	1451.50’

Nelson County officials have been effective at working through the federal County Motor Conveyance (CMC) system regulations to maintain critical transportation needs during this time of flooding. The CMC system is a federal program intended to help maintain the essential flow of people, goods, and services in rural communities. CMC roads are designated a priori with the federal government, and there are currently 171 miles of CMC roads in Nelson County. These roads are eligible for 80/20 federal/county cost share on repairs related to flooding irrespective of whether the county has been included in a PDD or not. Federal money for work on the CMC system is appropriated through transportation bills and the money is sent to state governments where it is dispersed to counties when the local cost share has accrued to an adequate level. The length of CMC roads for each county is based upon a federal formula. The 20% county share is paid for by a special mill rate established specifically for this purpose.

Nelson County Road 27 ("Border Road") was identified three years ago as the prioritized road to maintain as the lake levels rose. This decision was based upon conditions such as cost share expenses, current road integrity, road height, road width, location with respect to county populations, optimum provisions of provisions, etc. Ramsey, Nelson and Benson County Emergency Managers agreed jointly on this decision. A major concern was the ability to continue to provide emergency medical services to county residents as the road system became threatened and/or inundated. NC 27 is the only north-south road in the area between US Hwy 2 and Hwy 57 for a 30-40 mile stretch, and ambulances currently operate out of Lakota, Aneta, Michigan, and McVille.

Ramsey County dropped CMC status on Ramsey County RC 4, as it was flooded and considered nonessential, and had a transfer of function done to add Nelson County NC 27 to the CMC system. This resulted in Ramsey County losing CMC mileage, and Nelson County gaining an equal amount of CMC mileage, with the state total CMC mileage remained fixed. The Ramsey RC 4 / Nelson NC 27 transfer of function was completed in the summer of 2000. The federal government allows transfers of function for CMC roads, but there is about a 2-year lee period for work on CMC roads due to the paperwork and funding patterns. The long lead-time associated with closed-basin flooding, however, made this a viable mitigation tool. With NC 27 now a part of the CMC system it also qualified for emergency funding for construction of a bridge to prevent it from being inundated from surface waters flowing along the Jerusalem Outlet into Stump Lake.

A transfer of function is being undertaken to remove NC 4 from the CMC system for Nelson County and to transfer an equivalent mileage of CMC status to NC 24. Paperwork has to go through the State DOT Secondary Roads office that submits it to the federal office. The transfer of function process is an established routine that exists, subject to the transfer passing state and federal review. The paperwork takes 1-2 years, however.

Because Nelson County has been a part of ten PDDs in a nine-year period it also qualified for Public Assistance funding for road repairs due to flooding. The cost share percentages are fixed by FEMA for each PDD, with the most recent PDD [FEMA-DR-1376-ND] being designated at 75/10/15 (15% county share). The most anticipated significant future problem is the closing of some roads around Stump Lake as the waters continue to rise. NC feels that most/all of the paved county roads can be maintained if the wet spell continues, although annual maintenance will continue to be required. Several county roads around Stump Lake, however, will be lost that will complicate access and accessibility around the lake. Some

township roads also been closed, and more closures are anticipated in the future. This is seen as inevitable given the high level of infrastructure and low rural tax base to maintain the roads.

The greatest problem to date has been the persistent and growing number of sloughs in the county. They were formerly small potholes that would dry out as the summer progressed, but are now becoming larger, deeper, and more permanent. They have created a pervasive problem with softening of the road banks since the water does not go down. Nelson County has established an approach to try to keep the roads open as long as possible and hope that the wet spell subsides before the roads have to be abandoned.

Culverts and Bridges: The Nelson County Commission and Nelson County Road Superintendent were proactive in mitigating road problems by adding and enlarging culverts on several Nelson County roads. The purpose of these enhancements was to allow greater discharge (cfs) of water via the Jerusalem Outlet from East Devils Lake into Stump Lake. Although this policy would enhance the discharge of water into Stump Lake and hasten its rise, it would also significantly lengthen the time these roads could continue to serve as major transportation routes. NC 23 went from 3-36" culverts to 3-60" culverts as of September 2001 so that the anticipated increased flow of water from Ramsey County would pass under the road. This cost was covered by Nelson County (about $12K). A new bridge was built on NC 27 to replace the previous 3-36" culverts. The new bridge was completed November 2001 at a cost of approximately $897K, which was split on a 80/20 federal/county cost share (with Ramsey and Nelson Counties each paying 10% of the local cost share). The new bridge is also expected to increase the flow of water into Stump Lake, but was also deemed necessary to maintain the essential rural road infrastructure. The bridge construction and road repairs for NC 27 were also split on a 80/20 cost share, but the 80% federal share was paid through federal emergency funds that do not count toward the CMC federal pool of money, thus enabling Nelson County to make more effective use of their federal CMC allocation. Nelson County has more CMC projects to complete than it has CMC money to spend, and the funds are spent as soon as they build up to an adequate level in their account.

Municipal Water: The Lakota Water Line pipes water from a well south of Stump Lake to the Water Treatment Plant in the City of Lakota and provides drinking water for the county seat. The water line has become submerged as Stump Lake has risen. Because the water line was not designed to be submerged, and because of the high total dissolved solids (TDS) of Stump Lake water (TDS = 11,100 mg/l; dissolved sulfate = 6,300 mg/l) the Lakota drinking water is threatened. Should the seals on the submerged pipes develop a leak, the capacity of the Lakota Water Treatment Plant might be exceeded. Nelson County has been proactive and hired an engineering firm to examine the problem, although no specific plans have been agreed upon at present for this future contingency.

Stump Lake Park: Settlers Park (Stump Lake Park), the major county park, is supplied with water by a well behind a homestead south of Stump Lake. This water line has also become submerged and is threatened. No plans have been made for this possibility, however, other than the direct hauling of potable water to the park.

Floodplain Management: Nelson County joined the NFIP in March 1995. Recently, Nelson County has agreed to the FEMA mandated land-use ordinance restricting all new development below 1460' (the ordinary high water mark for Stump Lake). Previously Congress had to pass

an annual amendment to the NFIP. This NFIP endorsement allowed owners of insured structures threatened by rising closed lakes to file and collect a claim to move their structures before the structure was actually inundated. The new FEMA policy is a proactive measure to attempt to reduce future flood losses in closed basins by better floodplain management.

Private

The Salvation Army, American Red Cross, and Lutheran Rural Response have been the principle private agencies involved in flood mitigation in Nelson County. Such assistance is generated by direct contacts or referrals from law enforcement, county emergency management personnel, or some other service unit. Assistance can be in the form of vouchers or rapid drafts paid directly to various companies to cover necessary services, utilities, groceries, rent, or housing. Assistance has also been provided through the distribution of mold-cleaning kits for water-related mold growth and water in basements, assistance for basements experiencing cracks and collapsed walls, or ruined wells due to bacterial contamination from surface water flooding.

The total amount of such assistance has been relatively small in comparison to federal sources, and are generally in response to emergency situations where needs cannot be met by the individuals own resources. Private assistance focuses upon emergency needs requiring rapid turnaround time for basic human needs, and address individual needs that have fallen through the federal assistance gap. Private assistance also meets the needs of persons that may be unwilling to seek more routine federal assistance programs.

Individual Response

Individual producers have generally followed a decision chain in determining their response to the soil wetness problems in their fields. This decision chain has changed over time as the agricultural flood hazard has persisted. The chain consists of the following steps:

(1) Crop insurance claims: There have been an increased number of crop insurance claims filed as a result of the soil wetness. Producers can decide not to plant their fields, take crop insurance for that year, and hope to plant the next year.

(2) Assume risk: Producers can try to plant and hope that the wetness doesn't continue during the growing season. This was a more common approach taken by producers earlier in the wet cycle. They are now less likely to take the risk in these later stages of the wet cycle.

(3) CRP enrollment: CRP enrollment has increased significantly in an effort to stabilize income and make up for income lost due to flooding. CRP enrollment has increased in response to the wet cycle and unstable farm economy, but the program was not specifically designed for this type of problem.

(4) Chemical adjustments: Adoption of chemical fungicides to fight disease has not been fully adopted due to their cost, management problems, and imperfect results. Application costs about $15 per acre and is used for wheat but not barley, as it is ineffective on the latter. Adoption of fungicides has increased, and most farmers use it on some or all of their acres. Disease in barley is more difficult to combat, however, resulting in decreased barley acreage.

(5) Change crop patterns: Acreage for corn and soybeans has increased significantly during the wet cycle in an effort to increase yields, prices, and adapt to the increased soil wetness. Small grain acreage has correspondingly decreased.

(6) Alternative income from land: Some producers are beginning to post their land and charge hunting fees for ducks, geese, and deer. There has been a shift to off-farm income to offset the lost agricultural income. Producers are taking seasonal employment and more spouses are working to provide supplemental income. Producers now often farm because they want to, and work off-farm because they have to. More young producers are getting out of farming, and older farmers comprise a larger percent of all remaining farmers.

Unmet Needs

Because of the unique nature of closed-basin and rural wetland flooding, their uncommon occurrence throughout the United States, and the fact that national flood mitigation policy is written with riverine and coastal flood hazards in mind, it is not surprising that numerous needs and impacts were identified by local representatives that were not specifically met by an existing mitigation program.

Some of these unmet needs include the following issues:

(1) Many homes throughout the Stump Lake region are high enough to avoid flooding and are unlikely to result in an NFIP claim. The access roads and driveways to numerous homes, grain bins, and farm equipment barns and huts, however, have been inundated or will be threatened in the future. The responsibility for maintaining driveways and access roads usually falls to the township or homeowner, and is not eligible for PA assistance. Because of the small and declining rural tax base most townships are currently tapped out maintaining their existing roads and are unable to address this problem.

(2) Management of weeds becomes more problematic during an extensive wet spell. For example, Canadian thistle is becoming a greater problem due to the wet conditions. The thistle gets a foothold during wet spells and spreads throughout fields, propagating both by seed and by rhizominous roots. Thistle is a perennial weed that becomes a bigger problem each year after it becomes established. Leafy spurge has also significantly increased in acreage during the wet cycle, and is an especially difficult weed to control. Weed control spraying from the ground is very difficult or impossible during wet conditions. Aerial spraying is the only alternative, but it is costly, and not completely effective under certain wind conditions. Weed control increases the costs of production during a time when crop production is suffering. One producer remarked that it is much more difficult to manage a farm operation under chronic moist field conditions than it is under chronic dry field conditions.

(3) Chronic wet field conditions result in poorer soil structure due to compaction by farm equipment. The soils in Nelson County are generally on the fine soil end of the moderate-fine soil texture end, and are susceptible to increased soil compaction.

(4) Wet soil conditions also make it harder to seal up the wet trenches after fertilizer applications. The wet soil does not seal up as well, resulting in loss of anhydrous ammonia (fertilizer) due to volatilization. Anhydrous is lost before it has a chance to bind with the soil water to form nitrate. If, after anhydrous application, soil wetness continues, more nitrogen is leached out of the soil as well. Increased volatilization means that yield goals are not reached,

resulting in reduced income. Fixed anhydrous applications combined with reduced effectiveness of anhydrous in reaching yield goals results in decreased profitability.

(5) Accessibility to fields because of soil wetness and reduced trafficability of access roads has become a big issue for producers. Farm fields take on a patchier spatial pattern as opposed to their normal rectangular pattern. The patchy fields not only result in a reduction in the number of acres planted but results in an increase in the per unit time and fuel costs for farm operations due to the more irregular farm patterns. There is less than a 1:1 reduction in fuel and time inputs relative to the number of acres planted. This affects profitability as production is down but costs reductions do not keep pace.

(6) PA funding for rip-rap is only available after road damages have occurred. The county road superintendent cited the need for additional rip rap funding as well as the proactive use of rip rap for more roads. The use of rip rap as a mitigation method to reduce future damages is recommended, otherwise roads continue to suffer damage due to wave action associated with strong winds, long fetch distances, and shallow sloughs.

(7) Concern was expressed over the explosive growth in vectors associated with wet conditions and the high number of sloughs. Mosquitoes and wood ticks reduce weight gain of livestock, reduce livestock immune system efficiency, enhance the spread of disease, and increase livestock mortality – all of which translate into reduced producer income.

(8) Problems associated with basement mold are difficult to identify, document, and identify, and until recently were not recognized by FEMA as a flood hazard. Wet basements are an ideal breeding ground for molds. They are cool and damp and, when disturbed, the molds easily become airborne due to their small size. Infants, children at risk, elderly, pregnant women, people with respiratory conditions, and people with impaired immune systems are especially at risk. Mold symptoms include: nasal or sinus congestion that won't go away, sore throat, skin irritations, shortness of breath, constant headaches, aches and pains.

(9) The major road and infrastructure problem not covered by federal programs is associated with muskrat and beaver populations. Muskrats burrow into the sides of the roads and weaken and destabilize the banks of the roads. Beavers build ponds, resulting in rising waters that weaken and soften the roadsides. These problem spots often cannot be identified until an accident occurs. Because muskrats/beavers are natural biological agents, road problems associated with them are considered to be part of normal maintenance and are not covered by the PA program and must be paid for from Nelson County funds. Muskrat and beaver population are exploding, however, due to the increased habitat that is a direct result of the rural flooding.

(10) Once CRP contracts have been awarded, producers have a 12-month period to get their land into the native grass or dense nesting cover specified in the accepted offer sheet. Extensions up to three years are allowed if the land is too wet to plant into the specified cover type or the specified seed is not available. If they do not meet this deadline they can be put out of the program. The rapid growth of wetlands in Nelson County has resulted in the inundation of much associate land surrounding cropped wetlands or non-cropped wetlands that were designated in CRP awards. The standing water has prevented the planting of the native grass seed or dense

nesting cover seed specified in the awarded contract. Until the potholes reduce in size producers cannot meet the specific terms of their contracts. The amount of contracted CRP land approaching or surpassing the time limit is considerable, since many new contracts were awarded in 1998. Some Nelson County CRP land has gone beyond the 3-year limit and is still not in the stated cover. To date, no Nelson County producers have been excluded from the program who have been prevented from meeting the terms of their awards due to the expansion of wetlands. The congressional delegation is currently lobbying the issue to the National FSA.

(11) In a similar manner FCIC preventive planting losses are supposed to be limited to two consecutive years, at which time the land is supposed to be removed from the county's agricultural base acreage, and producers can no longer file a FCIC claim for preventive planting. Some producers have probably experienced two such consecutive losses, but no one has been excluded from the FCIC program as yet. FCIC payments are still being received on land claiming multiple consecutive losses due to preventive planting.

Conclusions

We return to the research questions posed in the Introduction. First, the primary flood damages resulting from the rising levels of Stump Lake are related to infrastructure, specifically maintaining the transportation network around the lake to provide for the movement of goods, peoples and services from areas south of the lake to the regional trade center northwest of the lake. Funds available through the CMC and PA programs have been adequate to this task, although they have consumed all available local cost share funds, resulting in the more rapid deterioration of the remaining county infrastructure. The lack of prime farmland immediately surrounding the lake has resulted in little direct agricultural damages due to the rising lake levels.

Second, the total flood-related damages for the county has been dominated by those resulting from the pervasive rural wetland flooding, as compared to the more intensive closed-basin flood hazard. Although closed-basin flooding is more likely to be communicated outside the region, rural wetland flooding dominates the Nelson County flood damage profile.

Third, direct flood damages are dominated by government payments for crop insurance claims, land enrolled in the CRP program, and the crop disaster program available through the Presidential Disaster Declaration process. Infrastucture costs are also a significant percentage of the total damages. Indirect costs associated with reduced purchased inputs arising from the large amount of land taken out of production are nearly as large as the direct federal payments. Secondary costs associated with economic multiplier effects resulting from the indirect damages are even larger. Although the majority (approximately 80%) of the direct damages are born by the federal government, all of the indirect and secondary damages are borne by the county or region. The reduced county tax base and income, and reduced flow of dollars through the regional economy, combined with the declining rural population and increased local cost share on infrastructure projects has placed an enormous strain upon the county and regional economy. How can the county and region maintain a viable rural economy when the primary agricultural economic sector is so devastated by pervasive flooding?

Fourth, GIS and remote sensing were found to be useful techniques in the analysis of both closed-basin and rural wetland flooding. In particular, they were helpful in determining the relative magnitude of closed-basin vs. wetland flooding, in establishing the land cover types that

were inundated by each flood type, and in determining the future damages due to continued lake rise.

Fifth, the existing CRP, FCIC and PDD programs have proved successful in providing funds to the producers who are the base of the regional economy. Although not primarily intended as a primary flood-mitigation program, the CRP program has helped producers maintain their farm operations. At some point, however, this 'cash-flowing' approach will not be sustainable, particularly if the competition for federal dollars were to significantly change the structure of the Farm Bill, FCIC or CRP programs.

Riebsame (1985) hypothesized that slow onset hazards, such as closed-basin floods, would provide a wider range of mitigation alternatives than other hazard events with more rapid speed of onset, and would allow for more efficient loss mitigation. With the exception of the proactive culvert modifications, the bridge construction, and the reallocation of roads within the CMC system, however, this was generally not found to be the case. Because all of the infrastructure work tied to the CMC program requires a local cost share, work can only be done as the federal funding accrues in an account, and as Nelson County comes up with adequate local cost share matching funds. Similarly, infrastructure work tied to the PA program can only be expended once a PDD has been approved by FEMA, and as local cost share funds become available. The PA program, in particular, lacks a proactive component.

Sixth, the unusual nature of closed-basin floods and wetland expansion flooding, combined with the fact that FEMA flood policy is normally written with riverine or coastal flooding in mind, resulted in a wide number of unmet needs that fall outside of existing federal flood mitigation programs.

We anticipate that many of our findings for Stump Lake-Nelson County are also true for the larger flood event occurring at Devil Lake and the surrounding multi-county sub-basin. Many of the mitigation techniques may also be transferable to other closed-basin flood hazard environments.

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