Working Paper #8

Implementation of a Flood Damage Reduction Strategy in the Red River Basin

Prepared by:
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Introduction

A watershed and ecological systems approach should be fundamental to an implementation strategy for flood damage reduction within the Red River basin. The purpose of this paper is to aid in the selection of appropriate flood control methods. The general criteria by which projects should be evaluated are as follows:

- Flood control effectiveness (including both local and downstream);
- Environmental impacts (positive or negative); and
- Affordability.

Flood control effectiveness requires identifying both the local effectiveness and the downstream effectiveness of the project. Timing of the storage as well as the volume of storage provided by a project is especially critical when using the project for downstream flood control

Environmental impacts of any potential project must be considered.

Affordability depends not only on the value of the benefits but also on the availability of funding sources. This paper includes a summary of programs available to fund certain aspects of multipurpose projects.

Defining and quantifying the Flooding Problem

Flooding periodically causes substantial property damage and risk to human life and health. The flood of 1997 that inundated much of the Red River basin, extensively damaging Grand Forks and other basin communities as well as agricultural lands, illustrated the severity of the problem.

Individual watersheds within the Red River basin may have distinctly different flooding characteristics and different landscape features. Therefore optimum flood control strategies will be unique to each area. On the other hand, the entire basin shares a common flood problem along the main stem of the Red River. Understanding that flood problem and the potential downstream impacts of various upstream flood damage reduction strategies is essential.

The Red River main stem flood is characterized by long duration and widespread flooded areas. The channel capacity of the most flood prone lower reaches of the Red River is about equivalent to a 2-year return period spring flood. Agricultural levees on portions of the Minnesota side provide spring flood protection equivalent to about a 5-year event. These levees provide a greater degree of protection against a summer flood event - probably about 25-year protection. The long duration of the spring flood commonly causes crop production losses due to delayed planting.

All communities along the Red River are subject to flooding. These communities have installed levee systems that provide varying degrees of flood protection, generally from 25- to 100-year protection. Emergency flood fight activities are often required to augment the protection provided by levees. Many farmsteads are also protected by levees.

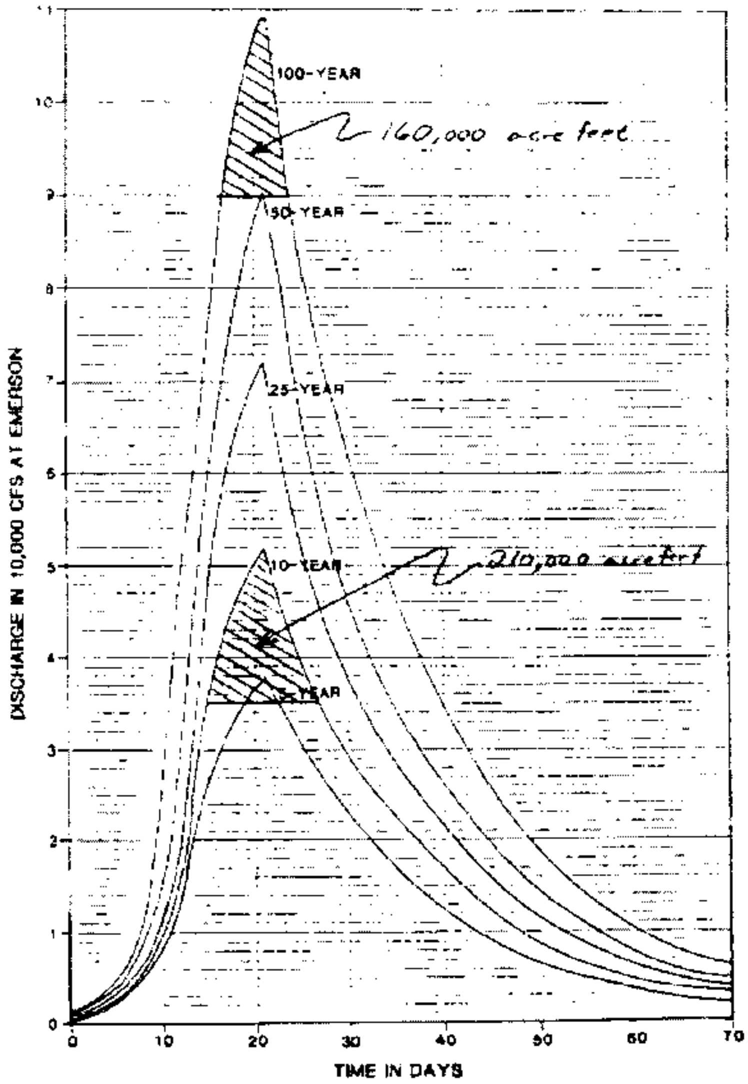
Flood damages to farmstead and urban areas are primarily related to peak flow. Agricultural damages are related to both peak flow and flood duration. Peak flow defines the depth and areal extent of the flooding while duration influences the degree of damage caused by the flooding.

Most flood control measures are aimed at either decreasing the flow or increasing the tolerance to flood flows. In either case, it is necessary to determine how much flow can (or could) be safely carried and the volume of runoff in excess of that flow for the flood being considered. This is illustrated by looking at typical flood hydrographs of the Red River at Emerson as shown in the figure on the next page.

The capacity of the Red River at Emerson is about 35,000 cfs. The 10-year flood peak discharge is 51,500 cfs. The volume of the 10-year flood above 35,000 cfs is about 210,000 acre feet. The duration of flooding is about 12 days. Elimination of the flood would require ideally timed storage of 210,000 acre feet with an average detention time of about 14 days. Of course, removing 210,000 acre feet from the peak would require substantially larger storage capacity. This is because not all of the storage capacity would be ideally utilized. The efficiency of the storage for peak flow reduction depends on location, design, and operation.

The same volume reduction from a 100-year flood peak on the Red River would reduce the flow to less than a 50-year flood. Estimated flood damages of a 50-year flood on the Red River are about half that of a 100-year flood. This suggests that the same volume of storage required to control the 10-year flood on the Red River would also substantially reduce damages associated with major floods.

The relationship between watershed runoff and downstream flooding is defined by volume and timing. Those subwatersheds that produce the highest unit volume of runoff and/or deliver it during the height of the downstream flood are the major contributors. Collecting stream flow data during actual flood events can identify these subwatersheds.



Data Source: Middle River Snake River Watershed District, Warren, Minnesota

McCOMBS-KNUTSON ASSOCIATES, INC.

MINNEAPOLIS and HUTCHINSON, MINNESOTA

FIGURE 21

BALANCED HYDROGRAPHS

RED RIVER OF THE NORTH AT EMERSC

Computer modeling of the watershed can also identify major runoff contributing areas and can be used to optimize timing of proposed project storage with respect to downstream flooding (Working Paper #6). Modeling allows flood simulation based on hydrologic parameters that can be estimated based on physical landscape features. This provides an immediate basis for planning and design. However, the model should be calibrated based on observed data obtained during flood events. Therefore, a combination of stream gaging and hydrologic modeling is strongly recommended, particularly in smaller subwatersheds where data are lacking. Various flood control alternatives and combinations of alternatives can be reliably tested with the resultant model (Working Paper #6).

Flood Damage Reduction Goals

The Working Group has established flood protection goals for the Red River Basin. Preventing loss of life and damage to homes, farm structures, and communities requires protection against, or control of major floods typified by the 100-year spring flood. Reducing damages to transportation facilities also requires a focus on major floods.

Reducing flood damage to farmland, water quality, and natural resource systems requires control of the smaller, but more frequent floods that occur during the growing season. The level of protection for intensively farmed land adopted by the Working Group is control of the 10-year rainfall flood event.

Flood Damage Reduction Methods

Flood damage reduction methods that have historically been used throughout the Red River basin, as well as newer strategies can be placed in four broad categories as outlined below.

- Reduce runoff volume
  - Wetlands (providing infiltration and evapotranspiration);
  - Cropland BMPs (increase infiltration);
  - Conversion of cropland to perennial grassland (e.g., CRP);
  - Conversion of land use to forest (forested areas have the lowest runoff coefficients); and
  - Drainage (to lower antecedent moisture; but can also increase runoff by reducing residence time resulting in decreased infiltration or evaporation and by adding tributary area).
- Increase temporary flood storage
  - Impoundments[1];
  - Restored or Created Wetlands (functioning as impoundments);

[1] In this paper the term "impoundment" is a body of water temporarily confined within an enclosure. The enclosure may be a created or existing depressional basin and area enclosed by a dam. Water release may be permanently or temporarily controlled or uncontrolled. Future impoundments may include large wetland and riparian restorations and traditional dams and reservoirs.

- Setting back levees (to expand the floodplain area and the available storage for the more frequent flood events. Designing the levees to overtop during more severe flood events can measurably reduce downstream flooding by utilizing the flood storage landward of the levees at the most opportune time.); and
- Culvert sizing (to meter flood flows).

- Increase conveyance capacity
  - Channelization;
  - Drainage (creating new or improved channels);
  - Diversions; and
  - Set-back levees (to increase floodway capacity).

- Protection
  - Levees;
  - Flood proofing;
  - Flood warning and emergency response planning; and
  - Evacuation of flood plain (removing people and flood prone facilities and converting to flood compatible land uses.

Many projects will combine two or more of the above methods. Specific application of each method is highly dependent on their design and location.

- Reducing runoff volume is always beneficial, especially if done in the middle and upper parts of a watershed (Working Papers 2, 3 and 4).
- Increasing flood storage is most beneficially done in the middle and upper parts of a watershed (Working Papers 1, 2, 4, 5, 6).
- Increasing conveyance is most beneficially done in the lower parts of a watershed (Working Paper 5).
- Protection measures are most beneficially applied in the middle and lower parts of a watershed (Working Paper 3).

Many of the above methods have been used extensively throughout the basin. Most still have application as part of future flood damage reduction projects. The challenge for watershed district managers is to develop projects containing one or more of these methods while adhering to the flood damage and natural resource protection goals and principles established by the Working Group. Similarly, the challenge for natural resource managers, especially in the Red River basin, is to incorporate flood damage reduction goals, to the greatest extent possible in their development and operational plans.

Natural Resource Problems and Goals

The landscape throughout the Red River basin has been extensively altered, primarily to improve agricultural production. While the agricultural lands have been highly productive, much of the natural landscape values once present in the basin has been lost. Most of the original prairie landscape has been cultivated; many of the original wetlands have been drained. Many of the original streams have been channelized and riparian corridors have been diminished or lost. Dams and various land uses have fragmented both aquatic and terrestrial habitats. While loss of species of plants and animals dependent on the original landscape features is one effect, landscape alterations are also tied to variables such as water quality, soil erosion and sedimentation that have direct human impacts.

The Mediation Working Group has developed a comprehensive outline of natural resource goals to maintain biodiversity and a sustainable and beneficial ecosystem. These goals are incorporated by reference and acknowledged in this paper.

Multiple Objective Management Strategy

Any flood mitigation program first requires a clear and quantitative definition of the flooding problem. Identification of where, when, how long, and extent of the flood impacts are basic to beginning the development of a flood control program within any given watershed. A multiple objective management strategy additionally requires identification and integration of the natural resource goals with the flood management goals.

Multiple objective management strategies require that watershed and ecological systems approach must be used to a design and evaluate potential flood control projects since linked relationships between physical, biological and chemical processes controlling the natural resource environment can be disrupted or enhanced by changes resulting from a constructed project. A systems perspective is consequently imperative to address fully the integration of flood control and natural resource enhancement.

Some of the flood damage reduction measures listed in the TSAC Working Papers, such as wetland restorations, also address natural resource goals. Other measures, such as on-channel dams, may not. Some measures, such as set-back levees, while not directly addressing natural resource goals, may be less environmentally damaging than other alternatives and may be modified to include natural resource benefits. Some natural resource measures, such a prairie restoration, can also address flood control goals. Other measures, such as water level stabilization structures, may not.

It follows that a flood control strategy should account for and accommodate natural resource goals. Similarly, a natural resource program should account for and accommodate flood control goals. This suggests a hierarchical approach to flood damage reduction planning, beginning with the most environmentally beneficial practical alternatives.

Application specifics of a hierarchical strategy will necessarily depend on the characteristics of the watershed. However, a representative approach is outlined below which divides the watershed into three separate areas: upper, middle and lower. The primary distinguishing features of these three areas are the contributing drainage area, in combination with the location within the Red River basin.

First, runoff should be controlled as close as possible to the point where precipitation is changed to runoff. This control is important to establish throughout the watershed, but is particularly important in the *upper watershed area*, upstream from the first flooded area. Volume reduction or storage are the most appropriate types of measures to provide this localized flood control.

- Volume reduction may be accomplished by land use changes appropriate for the area such as:
  - Reforestation;
  - Prairie Restoration; and
  - Agricultural BMPs (Working Paper #3).
- The preferred storage alternative is wetland restoration as described in Working Papers 1 and 2. If restorable wetland areas do not exist or are not strategically located, they may be created. (Working Paper #2).
- Other storage alternatives appropriate to the upper watershed area include stormwater detention ponds and controlled detention on existing land through appropriate culvert sizing.
- Ditching or other conveyance improvements may be necessary to manage surface water in this area and to direct water to impoundment areas, but ditching should not be used to move the flooding problem downstream.

In the *middle watershed area*, the preferred alternative is installation of larger storage impoundments to alleviate the flooding problems persisting after upstream flood control options have been installed. The significant difference between these improvements and the upstream improvements is size. Siting of on-channel impoundments will determine impacts. Some areas such as drained basins may be beneficial for this type of practice (Working Paper #4).

- Large-scale wetlands that are designed to temporarily store excess runoff for up to 14 days for major summer events and longer during spring runoff.
- Gated control would increase the flood control benefit by allowing optimization of storage in conjunction with downstream flood flows. It should be recognized that gated impoundments have the potential to manage both rate and timing compared with ungated impoundments that can manage only rate.

- Off-channel impoundments generally cause less environmental impact than on-channel impoundments.
- On-channel impoundments on natural streams in the Red River basin may present major environmental concerns due to potential effects to flow and sediment regimes, aquatic habitat, sedimentation and erosion, fish passage, and riparian vegetation. While innovative designs and operation may reduce these impacts, location is a critical determinant of their extent and potential for remediation.

As in the upstream areas, conveyance improvements including channelization should be used only to route water in a controlled manner, and not to move the flooding problem downstream.

In *lower watershed* areas, conveyance improvements may be appropriate if the timing would move water ahead of the peak flood flows and would not contribute to increased peak flows farther downstream. Protection improvements are also applicable.

- Conveyance improvements could include:
  - Setback levees which may also provide ecologically beneficial stream restoration and riparian corridors (Working Paper #5); and
  - Compartmentalized off-channel impoundments to provide timely and efficient flood control storage.
- Protection alternatives include:
  - Agricultural levees which can be used to protect fields from frequent flooding (10-year design flood) while allowing for timely use of floodplain storage when the levees overtop during major (e.g., 100-year flood) events;
  - Community and property protection levees which protect property from both the frequent and major flood events; and
  - Abandonment of flood prone lands, including set-aside programs to remove land from agricultural production.

Funding and Partnership Opportunities

Success of this innovative approach to flood control is obviously dependent upon funding. Watershed district funding is generally applied to management of the watershed for efficient agricultural production and flood control. The watershed districts generally cannot fund, by themselves, the multiple benefits approach being proposed. This approach will require involvement by additional participants who must bring their values, expertise, and funding capabilities into the process in a timely and mutually beneficial manner.

Possible funding sources include existing programs and those that could be developed or expanded with additional targeted funding.

There are many programs currently funded and functional which offer immediate opportunities. Most are administered through state and federal governments. Following is a summary of the best-known entities and their most applicable existing programs that support wetland restorations, BMP's and other recommended conservation practices.

BOARD OF SOIL AND WATER RESOURCES (BWSR)

With local SWCD's, BWSR administers Reinvest in Minnesota (RIM), Permanent Wetland Preserve (PWP), Wetland Preservation Areas and state cost shared special projects. Wetland restorations, living snow fences, buffers and special designated projects are key components of their programs.

UNITED STATES DEPARTMENT OF AGRICULTURE (USDA)

In cooperation with many other agencies the USDA, through the NRCS, FSA and FmHA administers the Conservation Reserve Program (CRP), Wetland Reserve Program (WRP), FmHA Conservation Easements, and many other programs for implementation of BMP's. Many practices which result in buffers, wetland restorations, filter strips, tree plantings, and similar practices are funded through CRP payments or cost share programs. Because of the large budget and many acres covered by their programs the USDA is probably one of the best potential partners for accomplishing BMP practices.

UNITED STATES FISH & WILDLIFE SERVICE (USFWS)

The USFWS administers several programs with emphasis on wetland restoration and management. They have active acquisition programs for purchase of Waterfowl Production Areas. They also offer an easement payment for wetland protection rights on private lands. Also offered are free wetland restorations done under a 10-year agreement. Rights to restore the drainage facility to its former condition remain with the landowner. An evolving program targeting tall grass prairie preservation is underway and could offer compensation to protect fragile unbroken soils in the vulnerable beach ridge and similar areas of the Red River watershed.

MINNESOTA DEPARTMENT OF NATURAL RESOURCES (DNR)

Similar to the USFWS, the DNR has a land acquisition program. Generally they place greater emphasis upon management for resident wildlife species. DNR also helps administer RIM, WHIP, Protected Waters and Waterways, Game Lakes, Flood Damage Reduction and similar programs.

MINNESOTA POLLUTION CONTROL AGENCY (MPCA)

The MPCA has the Clean Water Partnership and Clean Lakes cost share programs which target water quality projects. They are also the lead agency compiling water quality monitoring data and may be a key player when it comes to monitoring success of flood control and water quality improvement efforts.

U.S. ARMY CORPS OF ENGINEERS (CORPS)

The CORPS has several funding authorities to address flood damage reduction and environmental restoration. They include Section 205 small flood control projects, Section 1135 – environmental restoration and Section 22.

Other potential partners include lake associations, counties and conservation organizations, such as Ducks Unlimited, MN Deer Hunters, MN Waterfowl Association and sport enthusiasts clubs.

There are numerous interested parties willing to put forth dollars where they are assured of a reasonable return for their investment. Bringing them and their funds into the picture and being able to develop projects that are fair and beneficial to all is essential. Public demand for recreational opportunities and a clean environment could help this become a primary source of partnership funds.

Future funding sources also merits discussion. A long term and dynamic plan such as this one needs to change and grow in a constructive manner. It makes sense to identify and fund existing programs that work well and to fund new initiatives such as outlined in the Clean Water Action Plan by Vice President Gore. Vice President Gore established a goal of restoring 100,000 wetland acres annually by the year 2004. Gaining a fair share of this national initiative could significantly support the overall flood control efforts within the Red River basin. It could be delivered by target funding through continuous sign up CRP, a Corps of Engineers program, or some other functioning delivery system.

Innovation and long term vision and planning are critical to the future of this effort. Hopefully, the proposed program of managing for multiple objectives will result in greater benefits for all involved.