The Oxbow

FROM THE NORTH DAKOTA STATE WATER COMMISSION

Flood Retention: Not Always the Silver Bullet

By James T. Fay and Patrick Fridgen

Approximately 400,000 acre-feet of floodwater storage above Fargo might have reduced the peak there during the 2009 flood by 1.5 feet.

For as long as people have inhabited land within the current borders of the state, flooding has had a profound impact on lives and property in North Dakota. And today, perhaps more so than anytime in the last half century, there is a renewed interest in identifying and developing permanent flood solutions - particularly in those communities that were flooded in 2009, and in those that are concerned about flooding again this spring.

To answer that call, officials at all levels of government are asked to go to their flood control toolboxes, so to speak, and identify a host of solutions that will provide protection, and will reduce future flood-related damages. Because the factors that contribute to flooding from one community to the next are all unique, it stands to reason that the alternatives for protection in different areas would also have to be unique. For example, in one community, a series of levees might do the trick. In another, the answer may lie in a diversion, upstream retention, buyouts/relocations, or some combination of the aforementioned. What is certain, is that there is no single solution to flood damage reduction in every one of North Dakota's communities that need help.

Despite this fact, there is one type of flood control project that somehow keeps popping up in discussions as the save-all silver bullet – no matter the location of the community or flood-prone property. And that type of project is floodwater retention.

To be fair, there's no question that dams and floodwater retention can be extremely effective in protecting loss of lives and property from flood damages. But, the best retention efforts aren't always 100 percent effective, 100 percent of the time - even if they're large-scale, and ideally located. With massive dams directly upstream of Valley City, Jamestown, and Bismarck, there were very few residents in those communities that gave flooding a second thought. After the spring of 2009, that has all changed.

For the Fargo-Moorhead (F-M) area, the U.S. Army Corps has received criticism for not including retention as much of a viable alternative to the metro area's flooding problems. But, consider the fact that the Corps estimates 200,000 to 400,000 acre-feet[1] of floodwater storage above the F-M area would only reduce the peak of a 100-year flood on the Red River by 1.6 feet.

To put that amount of storage into perspective, lets assume we're going to go after 400,000 acre-feet of storage. Some of that storage might be in larger, and deeper dry-dam projects like Maple River Dam, and some of it could be in much smaller and shallower projects. If the average depth of all that storage were about 5 feet, the surface area of that storage would be at least 80,000 acres. (Although, the incorporation of take land for all of the projects would substantially increase the necessary acreage.) Those 80,000 acres of floodwater storage would represent at least 125 square miles. As a comparison, the entire developed footprint of the F-M metro area (Fargo, West Fargo, Moorhead, and Dilworth) only covers about 51 square miles. So, the geographic extent of that amount of storage is one obstacle. And, that's not even getting into the costs associated with purchasing that much farmland – especially if it's located in the Red River Valley.

Another issue is that retention projects aren't located on just any land; they have to be located on someone's land. As in, someone's farm or pasture land that has probably been in the family for generations. So to go out and seek land to store floodwater, one has to make the case to landowners that - we would like to protect a community from flooding downstream, by flooding your land. Obviously, that's a very difficult case to make, regardless of the monetary compensation that's offered.

Other obstacles to overcome in developing and operating effective floodwater retention are timing and ice. Even if hundreds of thousands of acre-feet of floodwater storage projects could be built in every watershed that needs them, it is still necessary to capture water at the right time, or they do little or no good. When ice, and ice jams are added into the equation, things get even more unpredictable.

With regard to the timing issue, lets examine what it would have taken to lower the level of flooding at Fargo in 2009 by 1.5 feet. To start off, lets have a look at the flow and stage hydrographs (Figures 1 and 2) at Fargo for March through May 2009 to get a sense of what the flood looked like, and its magnitude. The shapes of the two hydrographs are similar, but one shows discharge in cubic feet per second, the other shows stage in feet.

To reduce the peak stage by 1.5 feet, we must control all of the water that caused this stage. We can't just take the water in the peak stage, because we don't know what water to store. Natural storage basins will begin to fill as soon as runoff begins. Once they're full, they begin to spill. Constructed storage sites suffer from the same problem. Outlets can be left open for the beginning of the runoff, but they must be closed at exactly the right time. If they're closed too late, (assuming they can be closed, since disasters make their own rules) control of the runoff is lost. If they're closed too soon, available storage is filled by the rising limb of the hydrograph, and the peak flows must be spilled to save the structure. It may even be possible to release a small base flow from each site, however this would have to be a trivial amount to avoid it aggregating into a much greater flow downstream. The only solution is to store it all.

We can find the amount we need to store by adding up the water that passes the gage location up to, and including the peak. It is a simple

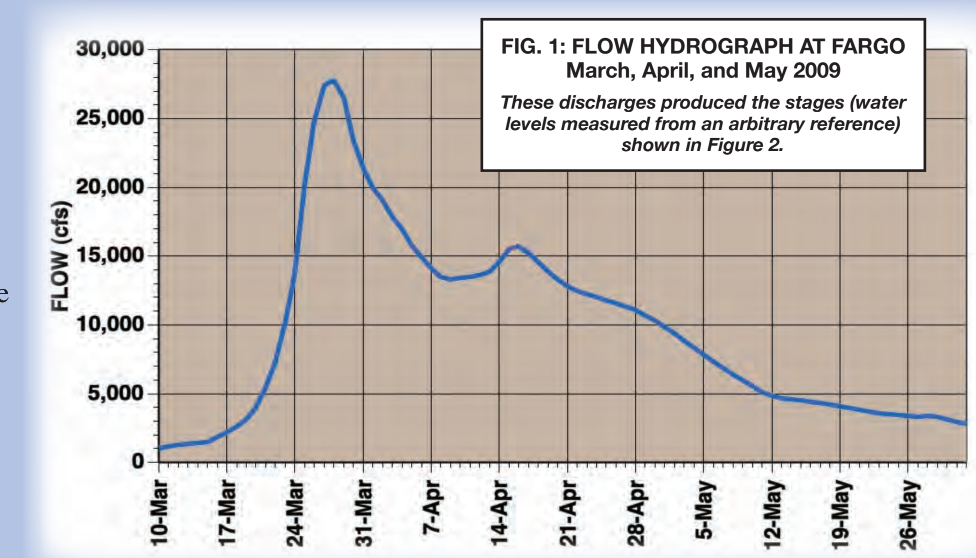

FIG. 1: FLOW HYDROGRAPH AT FARGO
March, April, and May 2009
These discharges produced the stages (water levels measured from an arbitrary reference) shown in Figure 2.

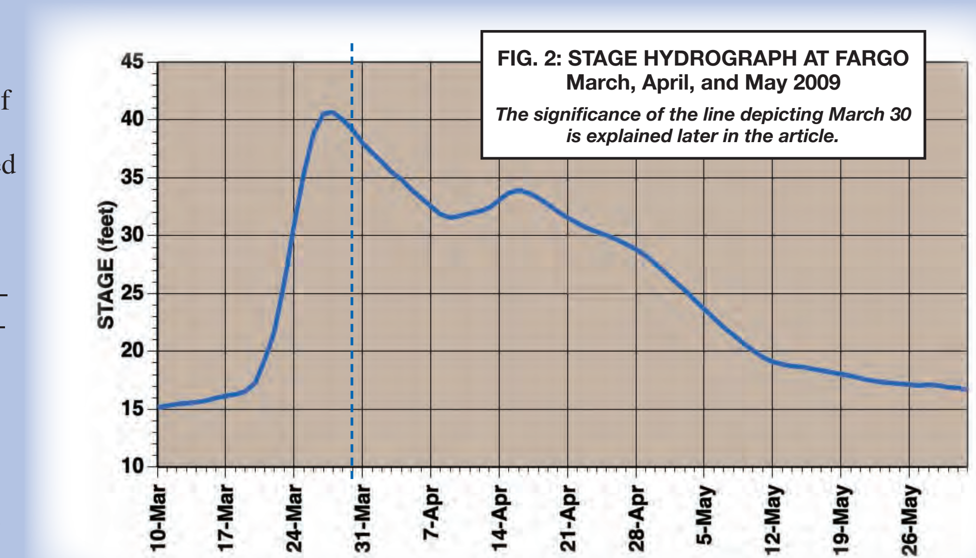

FIG. 2: STAGE HYDROGRAPH AT FARGO
March, April, and May 2009
The significance of the line depicting March 30 is explained later in the article.

[1] *One acre-foot is equal to one acre of land, covered by one foot of water.*

matter (since the flows are given as mean daily flows) to compute the volumes. This is shown in the volume hydrograph in Figure 3.

With the time sequence of volumes we can add up the total amount of water that has passed the gage at any given time, as shown in Figure 4.

If we re-examine Figure 2 for the day the stage drops 1.5 feet from the peak level, we find it is March 30. And then, if we look at Figure 4 again on that same date, we find the volume that has passed the gage as of March 30 is approximately 400,000 acre-feet.

Therefore, if we could store 400,000 acre-feet, theoretically we could lower the stage at Fargo by 1.5 feet. However, we would also have a major city at flood stage located downstream from 400,000 acre-feet of stored water. And, this water will not disappear. It must be released at some point or it will release itself. One of the difficulties in the flood of 2009 at Fargo and elsewhere was the vast amounts of water stored as ice in the basins above. The blizzards added greatly to this uncertainty, but water stored above a city at risk is a serious threat. A quick glance back at Figure 1 shows that by the first of April, Fargo was still in danger.

Another issue is location. If the storage is in the wrong location, it does not control the flood. Furthermore, the farther it is above the damage center, the more of the basin that is left uncontrolled, so the storage must be close to the protected area. Without knowing which tributaries will cause the biggest part of the problem (and there is no way to know this) the only alternative is redundant storage. That means it is not out of the question that we would have to double or triple the amount of storage (and acres) indicated, which could put us around a million acre-feet.

Finally, this scenario is based on the 2009 flood in Fargo as it occurred. If the mid-flood blizzard had occurred earlier, or if the temperature had risen earlier, the peak flows (and stages) at Fargo would have been substantially higher. Even 400,000 acre-feet of storage would not have been much help. In fact, if the storage sites were spilling during the peak, things could have been much worse.

In addition, this scenario only addresses Fargo at the location of the stream gage. The level of protection rapidly diminishes as we move down the Red and encounter more flooding tributaries (for example, the Fargo scenario doesn't include the Sheyenne River). Thus, each site down the river faces the same challenges.

The point of all this is to convey the idea that retention may be part of the solution to reduce flood damages in various communities. But, it is very rarely the only solution. The other important issue to recognize is that retention projects are not without their problems – just like any other type of flood control project.

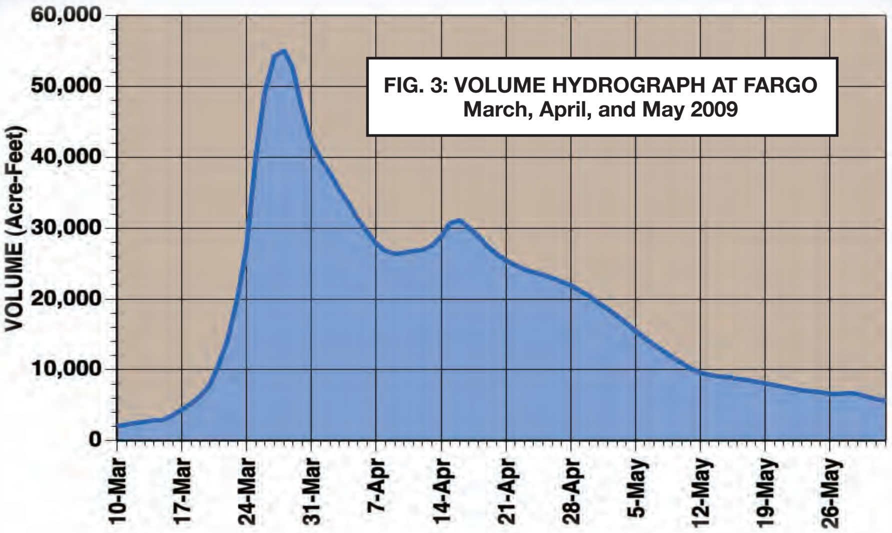

FIG. 3: VOLUME HYDROGRAPH AT FARGO
March, April, and May 2009

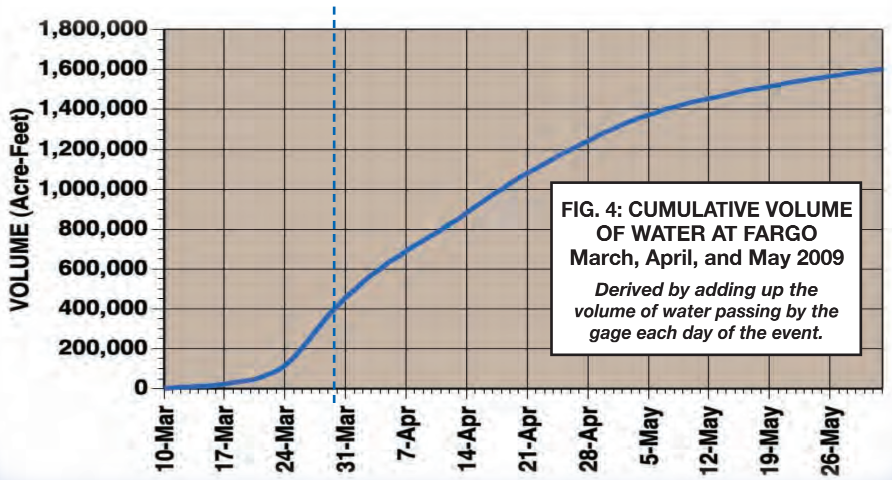

FIG. 4: CUMULATIVE VOLUME OF WATER AT FARGO
March, April, and May 2009
Derived by adding up the volume of water passing by the gage each day of the event.

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