

**Agency Advisory Board Meeting
Energy & Environmental Research Center
June 23, 2005**

Agency Advisory Board (AAB) Members Present:

Don Elston
Randy Gjestvang
Damon Grabow
Scott Jutila
Linda Kingery
Ruth Lewis
Bill Schuh
Mike Vavricka
Esther Vogel
Jeff Volk
Dean Wieland

Energy & Environmental Research Center (EERC) Staff Present:

Beth Bolles
Lisa Botnen
Doug Davidson
Lynette de Silva
Kim Dickman
Heith Dokken
Sheila Hanson
John Harju
Jim Johnson
Marc Kurz
Corey Maki
Santa Pachhai
Xixi Wang
Kirk Williams

Beth Bolles called the meeting to order, welcomed everyone, and provided an update of Waffle[®] activities.

Update

Beth explained that the second field trial started this past spring and that an update would be given by Marc Kurz on the field trial; Corey Maki on the road stability testing results; Heith Dokken on further identification of storage areas, natural storage, and storage area volumes; Xixi Wang on the status of the ongoing modeling tasks; Lynette de Silva on the Web-based products that are complete and available online; and Eric DeVuyst of North Dakota State University (NDSU) on the economic analysis.

EERC staff would like input from AAB members on the final report layout and content. The goal is to provide a final report with the most useful and relevant information contained in a user-friendly format. Beth requested that board members review the final report layout in their folders at a later date and let her know of suggestions or changes they may have.

Field Trial Progress

Marc reported on the field trials. He stated that everyone should have received a summary report of last year's first field trial results and that comments are welcome. The water storage was completed on all four of the sites, three located in Minnesota and one in North Dakota. Storage volume, infiltration, and evaporation estimates were completed. Water quality sampling, analysis, and soil chemistry tests are under way for each site. After the sites dry out, core samples will be taken. The University of North Dakota (UND) will fly a plane with an infrared camera over all four sites to look at the health of the vegetation.

The Shelly, Minnesota, site is in the second year of testing. It is a full section of agricultural land, recently planted in spite of the heavy rainfall that occurred. Approximately 150 ac-ft of water was stored on the site for 14 days, reaching the maximum elevation of water storage. By monitoring the water that flowed through the culverts off the site, it was found that discharge was less than last year, likely due to debris from the former crop that was left on the field.

The Lake Bronson, Minnesota, site, located about 3 miles southwest of Lake Bronson, is a full section of Conservation Reserve Program (CRP) land, which stored approximately 150 ac-ft of water. Because of a leaking joint on the standpipe, water was stored about 5 days before water release was begun. Since this is the section for the road stability evaluation, the plan is to study it again next year to investigate the effects of a full 2 weeks of water storage. One of the landowners near this area reported that typically his land floods from the coulee but stayed dry this year, so the Waffle concept appeared to work on a local scale.

The Agassiz Wildlife Refuge site is northeast of Thief River Falls, Minnesota, near the southwest corner of the refuge, consisting of 400 acres of CRP coverage. The only water held at that site was due to precipitation. Between 120 and 130 ac-ft of water was held for 28 days because the adjacent judicial ditch was continuously full and, therefore, would not have drained the water from the site. Soil moisture and temperature readings were collected on approximately 40–50 acres where the water was 6–10 inches deep.

The Gilby, North Dakota, site is located 5 miles east of Gilby on John Scott's CRP land. The 140 ac-ft of water was contained by a constructed berm on the north and east side of his land. The water will not be released; John is trying to enroll his land in the Wetlands Reserve Program. Water storage varied on this section from 6 in. to 4 ft deep.

Future activities for the field trial include retrieving data from the soil moisture/soil temperature sensors as soon as it is dry enough to do so, completing the soil chemistry testing, conducting infiltrometer tests, and interpreting the results. A summary of the results will be sent prior to the next AAB meeting. The culvert modification will be reinstalled on the Lake Bronson site as soon as permits and landowner agreements are in place. The road stability analysis will be completed by holding water back at least 14 and up to 17 days.

Bill Schuh asked if any agricultural land was included in the field trials. Marc answered that the Shelly site is agricultural land.

Road Stability Testing

Corey explained that the road stability profile analysis/monitoring was conducted at the Lake Bronson site. Two profiles, both located on County Road 19, approximately 1 mile apart, were monitored. The first profile was “wet,” and the second profile, the control, was “dry.” The first profile was instrumented with moisture sensors at eight locations, which were spaced 8 ft apart and symmetrical to the centerline of the road. The four individual capacitance probe sensors at each location were installed at 6-, 12-, 18-, and 24-in. depths.

Temperature sensors were placed in both profiles. The units were installed at eight locations spaced 8 ft apart, symmetrical to the centerline of the road. The individual sensors were placed at 4 in. and 1-, 2-, 3-, 4-, 5-, and 6-ft depths.

Thaw progression was documented. The sensor was limited to 6 ft, but the frost extended beyond that. The road asphalt allowed the ground to freeze and thaw faster. When full water capacity was achieved at the field trial site, the shoulder slopes at the site were still completely frozen.

The stored water from this site was released after 5 days and showed no adverse impact to the road surface or soil profile. However, the plan is to run the trial for the full 14 days to investigate those effects.

A question was raised about the unit used for the moisture profile. Corey answered that it is percentage, the volume of water divided by the volume of soil.

Another question regarded precipitation. As there was not much spring rain, would there be any effect if there had been rain? Corey answered yes and no. Unless rain surpassed snowmelt, then no effect on the ground would be seen. If that did happen, there would also be a balancing effect on the control, the dry side of the road.

Quantifying Storage

Heith presented the storage scenarios, explaining the statistical approach used with the National Elevation Dataset (NED) and how relief was utilized to determine storage by sections. A question raised by the AAB was how much natural storage occurs in a typical spring melt. According to Xixi, the standard for natural storage equates to 1.5 ac-ft per section of land. Another question was whether land that was flooded in 1997 was accounted for in the storage calculations. Heith indicated that the flooded areas were accounted for using the U.S. Army Corps of Engineers (USACE) outline. NED and topographic maps were used for the initial scenario. Then storage estimates were developed accounting for 1 ft of freeboard. An additional 5 ac-ft from each section was removed to account for natural storage. Sections of land along the river were also removed.

Using the light detection and ranging (Lidar) data was a similar approach to the NED data analysis. Topographic maps were used to find the lowest points on the land. To verify those results, a sink-fill method was used. Bridges, dams, and other structures were accounted for in

the analysis. Areas that were less than 27 in. deep or less than 10 acres in size were eliminated. Lakes, rivers, towns, etc., were removed, and then 1-ft freeboard was applied to the remaining sections. The main stem, tributaries, Devils Lake, and Red Lake were also removed.

Storage results from the Lidar and sink–fill methods for the entire Forest River Watershed totaled 44,700 ac-ft. The NED data analysis with 1-m horizontal accuracy and 6–12-cm vertical accuracy indicated more than 11,000 ac-ft of storage, accounting for the probability of storage and relief category (low vs. high). Using the model, storage was redistributed throughout the entire watershed.

Beth added that the approximate average volume of storage per area section of land was determined. The relief of the land was used to model storage and estimate viable storage areas. Areas with the lowest relief are more likely to store water. After determining average storage volumes, the redistribution over the entire watershed was based upon the likelihood of storage. Volumes represent percentages for the model and not necessarily the reality of actual storage.

Bill asked how it was determined that one-half of a section of land would be an acceptable natural storage amount. The number was determined by subtracting canopy storage. Beth added that storage distribution will not result in storing water across the whole 640 acres. It tends to be one-half of that or even one-third of the section.

Scott Jutila asked if we took out the flood plains, cities, etc. Beth answered affirmatively; all the major tributaries and areas that were flooded in 1997 were eliminated to be conservative and not overestimate storage capacity.

Modeling Progress and Preliminary Results

Xixi presented the preliminary results of modeling efforts, discussing SWAT and USACE Hydrologic Engineering Center (HEC)–River Analysis System (RAS) models for the Red River Basin (RRB). The models will be used to evaluate the effects of Waffle storage on mitigating a 1997-type or higher flood. Professor Howe Lim from UND is providing scenarios for floods of greater magnitude than 1997.

A SWAT model was developed for each of the 27 U.S. Geological Survey (USGS) eight-digit hydrologic unit codes (HUCs). Inputs included NED, soil data, State Soil Geographic Database/Soil Survey Geographic Database (STATSGO/SSURGO), the National Hydrography Dataset (NHD), National Weather Service (NWS) data, and USGS flow data. Flow data were used to calibrate and validate the model. A HEC–RAS hydrodynamic model was then set up for the Red River main stem and the geometric data from the USACE steady-state model of the main stem. Major bridges and culverts were also included.

Each HUC outlet simulates the pre- and post-Waffle hydrographs. First, the simulation is implemented for 100% of the identified Waffle storage areas. This helps to identify what areas can store water first. It was then assumed that 100% of the storage areas identified could be used to store water. If the simulation indicates a large reduction (say, about 10% or 13% reduction), additional simulations of 75%, 50%, 20%, or even 10% are considered. Various factors will be considered to get a conservative range, and then the pre-Waffle water surface elevations along

the main stem are simulated using the HEC-RAS model with the pre-Waffle hydrographs as inputs. This simulation provides a current water surface profile. For the second simulation, the post-Waffle hydrographs simulated by SWAT and the current flow hydrographs used in the HEC-RAS model are used, which will provide the water surface profile after using the Waffle storage.

For each individual watershed, the effects will be measured based on peak discharge reductions over each watershed; evaluation points such as towns, major highways, etc, are available. Simulated peak reductions on a postmodel situation are also available. The crest will determine the final difference on the postmodel and premodel peaks. From this, the effects of implementing the Waffle on a local scale can be evaluated.

For the main stem, the water surface elevation reductions from implementing the Waffle will be reviewed. Three local crests have been simulated. The SWAT model is almost completed; some adjustments had to be made to calibrate the model. The SWAT model simulated the effects of local storage areas.

Models were calibrated using USGS observed-flow hydrographs in 1997 and validated with the 1979, 1978, 1975, 1969, and 1966 floods. Most of the models were calibrated using these hydrographs. Where hydrographs were not available for some watersheds, observed peaks were used. For a few watersheds that have no information available, parameters from adjacent watersheds were used.

Situations were encountered where the model underestimated a second peak. Sometimes, this is because when the snow melts, the temperature falls, and the melting process may have stopped. Sometimes, models do not catch these quick responses. The model overestimated some of those outlets to melt.

A mainstem HEC-RAS model from White Rock Dam to Halstad is being developed by USACE. The EERC will extend this model from Halstad to Emerson, Manitoba. SWAT model outputs have already been successfully coupled with the HEC-RAS model upstream of Halstad. Once the complete mainstem HEC-RAS model is completed, it will be used to run pre- and post-Waffle conditions to determine flood stage reductions.

We have already started running Waffle storage scenarios using the SWAT models. Some results are available from those simulations. Initially the SWAT models were run to determine pre-Waffle flows at selected evaluation locations. The next step was to run the SWAT models with Waffle storage areas included. As previously mentioned, each SWAT watershed model is divided into a number of small subbasins. In order to model Waffle storage, the distributed storage areas were lumped together within each smaller subbasin and treated as ponds. The SWAT models were then rerun to determine the post-Waffle flows at the evaluation sites. The flow reductions can then be compared, and pre- and postmodel hydrographs will be available.

The Bois de Sioux Watershed in Minnesota has a total Waffle storage of 22,785 ac-ft. The map shows the Waffle storage areas. Beth added that the ponds were figured into the model. The reduction was determined from this model. Pre-Waffle, the model indicated 6135 cfs; post-

Waffle was 5030 cfs. Almost an 18% reduction in peak flows can be achieved. When flow reductions were reviewed, we found that they vary with flood events. Generally, the reduction percentage decreased with bigger floods.

Results from the Buffalo-Red Watershed show much lower reductions in peak flows. This is due to the fact that there were very few storage areas upland; most storage areas were very close to the outlet. Even though flow reductions were relatively small along this tributary, the cumulative impact of Waffle storage on the Red River may be much higher. This will be evaluated once the HEC-RAS model is complete probably by the end of October.

To summarize, preliminary simulations indicated that the effects of Waffle storage might vary depending on watershed characteristics and distribution of storage. Two different examples resulted in different reductions. Generally, flood reduction percentages decrease with flood magnitude. For example, the bigger the flood, the smaller the reduction will be.

Bill Schuh commented that the results are interesting. Based on the study, he wondered if there are certain areas in the upper basin that have a higher probability for storage. Will the model be used to target high-probability areas in the subbasins? Will these areas be tested? Beth answered that Xixi will develop a code for the model, which is called optimization, whereby the model is coded for specific areas to target for storage. It can go back by a reverse process and identify the best areas for storage. Bill added that there are areas that should be explored. Beth agreed.

Bill asked if a pilot watershed will be used to assess flood effects. Beth answered yes.

Someone asked if each red dot on the map represents a section identified for potential storage areas. Xixi answered that it was a count of how many actual Waffle storage volumes are available in a particular subbasin. Waffle storage areas are then grouped together. Each red dot represents a section of land for Waffle storage. For each subwatershed, there would be one pond included in the model. The smallest size of a subwatershed is 1 mi². Each watershed is then subdivided into a smaller subbasin.

Jeff Volk asked if specific details on storage can be identified for a township. Beth indicated that there is a general idea within a township, but further evaluation would have to take place on a site-by-site basis. There is a general idea of where potential storage areas are and approximately how much storage is available, but the information is not specific enough to start implementation.

Jeff wondered if potential storage is being overutilized. There may be a situation in which all the potential storage for a subwatershed sits at the head of the subwatershed and physically cannot fill an area if it is assumed that it is all available at the bottom of the watershed. He asked if it would affect the model if there were several small dams rather than Waffle storage. He stated that if can be factored out, it is somewhat of a comfort. However, the fact that it's accumulated, all available, and all in one spot, is a concern. Doug added that the SWAT model will look at each subbasin that will have flow in and out. Xixi added that we can specify a pond within a subbasin, which intercepts water generated from this subbasin. Water coming from the subbasins upstream of this subbasin does not flow into this pond.

Bill expressed concern that the upper basin is overestimated.

Jeff compared it to modeling a bunch of little dams and not Waffle storage. The upper basin does not recognize model potential. Xixi added that, at this stage, ponds were used; they intercept or store. The ponds are not responsible for the flows upstream, only for a specific basin. Beth asked Xixi if, in the case of precipitation, the pond would be considered completely full. It does not automatically consider that it is higher volume, or does it take into account precipitation and what can actually run off it? Xixi answered that it considers that the water draining from the subbasin is not the water coming from upstream areas. It does not automatically assume it is at full capacity.

Bill commented that Jeff's objection has to do with the point at which quantities are deemed negligible or too small for redistribution. Bill asked about the variability of the model. Beth asked Xixi if he could combine the hydrologic response unit into larger units. Xixi stated that the hydrology has not changed—begin with the subbasin concept then subdivide; for this, the topography is relied upon.

Jeff commented that the Maple Watershed has a huge breakout problem and asked how the model analyzes overland flow from the river through another hydrologic system. He asked if the model was tweaked with enough variables to make the hydrograph match or if there are enough data in that watershed to accurately show what is truly happening. Xixi said that he looks at the USGS hydrographs; each of the hydrographs has two peaks. There was a huge ice jam that occurred at the two peak stages. There were two stages which caused these timing issues.

Jeff asked how the SWAT model handles one channel that turns into a river and probably two or three systems of water flowing overland miles away and then eventually coming back. Xixi answered that some assumptions must be made to model these. Some water losses were considered using a temporary "retention" to mimic the ice jam, as it warmed up, then the water flowing again.

Jeff asked how the model can be accurate for a change in a watershed. Xixi answered that everything in the 1997 flood was assumed. Jeff added that USACE has been studying that area for many years. Beth added that breakouts are treated as retention. Xixi added that every factor that affects grouping together retention ponds has already been considered. He tried to adjust for some complexities along with breakout flows and ice jams in the model calibration. To keep this meeting's agenda on schedule, Beth suggested that Jeff and Xixi meet after the meeting to continue discussing this issue.

Economic Analysis Update

Eric DeVuyst discussed the economic analysis under way with Larry Leistriz and Dean Bangsund at NDSU. The first objective is to look at the cost-effectiveness of the Waffle as an initial basinwide assessment. Estimates are being developed of potential mitigated flood damages; it would be beneficial if those damages could be prevented. Since it is not known how the Waffle will be implemented, some cost estimates are made based on assumptions.

Phase 1 of the work plan involves data collection to develop flood stage damage functions. Phase 2 will be driven by data collected in Phase 1. Data will be input from the EERC's technical models, such as culvert costs and planting delay time frames. Data on flood damage are available from USACE for 8–10 cities within the basin. USACE right now is working on updating the Fargo–Moorhead area. Phase 1 is nearly complete as far as getting the data needed to run an economic analysis.

Larry and Dean believe that the numbers they are getting from USACE will have values to approximately 90% of flood damage, which is very conservative because not everything is accounted for. Events might occur in rural areas, such as washed out roads or bridges as a result of flooding, and are not counted.

NDSU is kicking off Phase 2 in July. Once the data are compiled on the cost of implementing and maintaining the Waffle, further estimates will be made. The flood stage damage functions will be finalized and cost–benefit estimates produced. Then, a sensitivity analysis will be run that looks at various input values or parameters then compares them. How sensitive the model needs to be to address landowner payments will be determined.

For the benefits side, expected future flood damage will be computed for if the Waffle were in place versus if it were not. That relies on the probability of a flood occurring at different magnitudes such as 100- and 200-year floods. The dollars are also discounted so it is net present value of what might occur 50 years from now. The benefit would be a reduction in flood severity as a result of the Waffle. All of this would then be probability-weighted.

Beth added that Howe Lim, a civil engineer at UND, is conducting an analysis of the probability of various-magnitude floods occurring in the next 10, 20, 30, and up to 50 years from now. The question is, what are the chances of experiencing a flood like the one in 1997 in the next 20–50 years?

For Waffle implementation, there would be numerous cost variables, including the cost of implementing and maintaining the Waffle. Many of the costs are upfront infrastructure costs, like culverts, controlling culverts, road modifications, any other physical structure, and the installation, periodic maintenance, and repair of culverts.

An area of interest is land enrollment. This is where the social side of the project interacts with the economic components (land enrollment fee, payment to landowners/producers, etc.). Benefits and costs, losses, agriculture profits, and soil productivity will be investigated. There is also the overhead and administration of running a program, initially enrolling the landowners, maintaining the program over time, and dealing with all the paperwork. Eric also mentioned the survey of landowners in which they were asked what it would take to enroll in the Waffle. This was presented in a bid-type scenario, similar to when CRP first came out. It was a bid process initially; the cost develops into a formula over time. In the end, policy makers and other interested parties will be provided with the following types of information: conservative estimates of the cost-effectiveness of the Waffle – benefits vs. cost, the best- and worst-case scenarios of economic feasibility; the sensitivity of the cost-effectiveness to key parameters and

inputs, including estimating economic growth; and identifying areas/issues that warrant additional investigation or research.

Bill commented that pricing structure might be a base structure per year. Eric added that the following two extremes will provide scenarios:

1. The Waffle is not used because there is not enough water.
2. Situations in which there is too much water, like a flood crisis.

Web-Based Data Products

Lynette spoke about the Web-based products developed through this project. There are two databases developed to provide free public access to the resources gathered during the course of the Waffle project. Additionally, RRB flood protection resources are also provided.

Waffle Metadata is a geographic information system (GIS) metadata site that houses data sources. The sites are accessible from the Waffle home page (www.undeerc.org/Waffle). When the user clicks on the metadata site button at the bottom of the page, there is a map of the RRB to the right and an active layer to the left. Choices include watershed, county, or state. Then categories can be searched. Within each folder, there are subcategories to help define the search. Currently, there are about 90 data entries.

For example, to find soil moisture data in Polk County, select the active layer as the county and either scroll down and select county or click on the map itself. The information can be retrieved in a variety of forms. It can be exported and formatted or viewed as a list. Another method is to utilize the Advanced Search, in which either a specific watershed or county can be selected or what is available for the entire watershed can be viewed.

The other Waffle database is the Literature Resources site, which focuses on the bibliographic citations that have been primarily collected during this study. There is a brief explanation that leads into Reference Manager Publisher with as many as 15 databases available. The information can be exported in a variety of forms. There are over 500 entries at this point, but because of copyright issues, only 100 are posted on the Web site. Copyright permission is pending for the rest.

Beth asked if there were any general comments or questions with regard to the presentations. Participants were alerted to the latest Waffle newsletter. Beth concluded the meeting by saying that there are three key components to this study: the technical component, social aspects, and the economics. She reminded everyone to let EERC staff know if there are any comments on the final report outline. The meeting was adjourned.