EXHIBIT A
SCOPE OF SERVICES

DESIGN CONSIDERATIONS FOR EMBANKMENT PROTECTION DURING ROAD OVERTOPPING EVENTS

BACKGROUND

Many roadways near the Red River watershed are prone to overtopping during flood events. Significant time and money are required to repair damaged roadway embankments post flooding. Soft scour prevention techniques, non-concrete techniques, have been shown to be effective at reducing scour in channels and outfalls. The goal of this research proposal is to evaluate the performance of several scour prevention methods during roadway overtopping flows with high tail water. Three embankment armoring techniques will be tested to stabilize the embankments: Scour Stop™, Enkamat®, and hydraulic soil stabilizer. Three flow modification techniques, reduced slopes, a water tube, and a water tube with apron, will be tested to reduce scour by modifying the flow and hydraulic jump. The first phase of the project will be conducted in a full-scale laboratory flume study. Later phases of the project will involve field monitoring of four field sites during flooding events. Preference will be given to sites that have employed soft scour prevention techniques. Post overtopping event inspections will be conducted to evaluate the effectiveness of the scour prevention techniques and corroborate the flow modeling. Flow modeling will be used to estimate impact of tested scour prevention techniques on the upstream flood stage

OBJECTIVE

The objective of this project is to develop protection of overtopping roads from scour is a major issue for the State of Minnesota. Flood events in the Red River watershed in recent years reinforce the need to protect overtopping roadways from scour. Some stretches of MnDOT highway that required repair after the 2011 Red River flood exceeded three miles in length. Repairing damaged roadways and embankments post flood is a significant time and monetary expense. Extensive repairs can prevent roads from being reopened to the public soon after flood water recede. Developing cost effective scour protection measures has the potential to greatly reduce this expense. This research will examine several soft design methods using an integrated approach of full-scale physical models, monitoring, and computational models. The research products will include a summary of findings and design guidelines that will help design and maintenance teams protect roadways during flood events.

SCOPE

The research approach used in this study will involve full-scale, physical model testing of three embankment armoring techniques (Scour Stop™, Enkamat®, and hydraulic soil stabilizer) and three flow modification techniques (reduced slopes, a water tube, and a water tube with apron) all aimed at protecting embankments during road overtopping events. Physical modeling results will be reinforced and further explored with field monitoring and hydrologic/hydraulic modeling of four sites.

The initial phase of the project will be a pre-experiment phase in which the University will review all available literature and work with the Technical Advisory Panel (TAP) to identify the highest priority design and implementation questions. Final design of experiments will be completed including determining the range of flow conditions and tail water elevations.

Physical model studies will be conducted over three tasks listed as Task 2-4. Tests will be conducted in the University's St. Anthony Falls Laboratory (SAFL) facilities. During Task 2 a three-foot wide prototype roadway embankment will be constructed and fitted with inflow and tail water controls. The research will involve data acquisition of the physical model using point gage scales, sonic range finders, and still images. An acoustic Doppler velocimeter (ADV) capable of measuring three components of velocity at 200Hz and characterizing shear stresses will be available. Baseline tests will be conducted on unprotected 4H:1V and 6H:1V embankments. The results of these baseline tests will be reviewed with the TAP to confirm that the tests are representative of the failure modes previously observed in FHWD-RD-88-181 and in the field.

The University's subcontractor, Wenck Engineering, Inc., will conduct site monitoring and inspection (Task 5) out of a field office located near the Red River watershed. Site monitoring will involve recording flood stage on both sides of the roadway. Inspections will be conducted post flood to evaluate the failure modes observed under natural conditions. Monitoring and inspection sites will be selected preferentially based on their use of scour protection systems and likelihood of overtopping.

Task 6, flow modeling, will be conducted by the subcontractor. Flow modeling is helpful to estimate the extent of the road overtopping, and the depth and velocity of the flow. It is assumed that data such as LiDAR topography, road profile, road cross sections, and bridge crossing information (if applicable) is available. Discharges will be determined by applying United States Geological Survey (USGS) regression equations, using stream gaging data (if available), and/or modeling. The 100-year flood discharge will be used unless a specific site has other available data. A hydraulic model such as HEC-RAS will be prepared for each site. It is anticipated that the effects of flow spreading out over a floodplain, such as break-out flows from an adjacent stream, may need to be computed. The results of the model will be used for the following information: flow elevation upstream and downstream of the road crossing, flow elevation as it passing over the road, flow velocity in the area of the concern (road shoulder), extent of roadway underwater and effect of various pavement protection alternatives (if any) on upstream flow elevations.

Each task will involve synthesizing the data from the literature survey, experimental testing, field monitoring, and computational modeling into a summary of design parameters/guidelines for use the tested scour prevention measures on Minnesota roadways. Task 7 and Task 8 will involve writing and review of a final project report on the effort.

ASSISTANCE

The University will require participation from hydraulic section of the MNDOT on this project as well as other local and county personnel with expertise in this topic. MnDOT assistance is assumed in providing road profile, cross sections, bridge plans (if applicable) and LiDAR data.

WORK PLAN

Task 1: Preliminary Analysis

The University will conduct a literature review to summarize and tabulate the findings of other studies regarding soft erosion control measures or roadway and embankment overtopping. For this task, other information, such as typical velocities and shear rates will be collected. Data will be used to identify the optimal installation techniques. Field visits to local roadways that have overtopped in recent years will be considered. The results will be presented to the TAP and modified after receiving feedback.

Deliverable(s): A PowerPoint Presentation, to the TAP; Annotated Report
Duration: 3 Months
Estimated Task Completion Date: December 31, 2012

Task 2: Construction and Baseline Testing

The University will construct a three-foot wide full-scale roadway embankment cross-section and flume will at the SAFL. The cross-section will include the road crest, downstream shoulder, and four vertical feet of the downstream embankment. The flume will be plumed into the SAFL supply channel and will be capable of a discharge of 20 cfs. The flume outlet will be outfitted with a tail water control structure. Baseline tests will be run on an unprotected embankment with 4H:1V and 6H:1V slopes. This will corroborate that our observed failure modes are similar to those observed in FHWD-RD-88-181 and by MnDOT.

Deliverable(s): A Two-Page Summary Report, on the experiments
Duration: 5 Months
Estimated Task Completion Date: April 30, 2013

Task 3: Flow Modification Testing

The University will evaluate the effectiveness of placing a water tube and a water tube with apron on the road shoulder at relocating the location of the hydraulic jump to the paved section of the road, and thereby reducing scour risks. Tests will be run for high and low tail water conditions. Each test will be run at increasing water discharges until the embankment fails.

Deliverable(s): A PowerPoint Presentation to the TAP; Annotated Report
Duration: 11 Months
Estimated Task Completion Date: May 31, 2014

Task 4: Embankment Stabilizing Testing
The University will evaluate the effectiveness of three techniques for stabilizing the embankment against scour. The three techniques will be determined with the guidance of the TAP. Tests will be run for high and low tail water conditions. Each test will be run at increasing water discharges until the embankment fails.

Deliverable(s): A Two-Page Summary Report, on the experiments
Duration: 11 Months
Estimated Task Completion Date: May 31, 2014

Task 5: Hydrologic and Hydraulic Modeling
The University's subcontractor will complete this task. Four typical sites will be selected under the guidance of the TAP. Discharges will be determined by applying USGS regression equations, using stream gaging data (if available), and/or modeling. The 100-year flood discharge will be used unless a specific site has other available data. A hydraulic model will be prepared for each site. Models will be used to estimate the following information: flow elevations upstream, downstream, and over the road crossing, flow velocity near the shoulder, the extent of submerged roadway, the effect of various scour prevention alternatives (if any) on upstream flow elevations.

Deliverable(s): A Four-Page Summary Report, on modeling efforts; A Copy of the Model
Duration: 6 Months
Estimated Task Completion Date: May 31, 2013

Task 6: Site Monitoring and Inspection
The University's subcontractor will complete this task. Four sites will be selected for monitoring and inspection. The sites will be selected under the guidance of the TAP based on their relevance to the laboratory studies and their likeliness to experience an overtopping event. Flood stage will be monitored upstream and downstream of the roadway. Post flood, site inspectors will evaluate the effectiveness of the in place revetment systems.

Deliverable(s): A Two-Page Summary Report, on the monitoring; Inspection Results
Duration: 6 Months
Estimated Task Completion Date: October 31, 2013

Task 7: Draft Final Report
The University will prepare a draft final report, following MnDOT's publication guidelines, to document project activities, findings and recommendations. This report will be submitted through the publication process for technical and editorial review. Draft design drawings will be developed in AutoCAD and converted to Microstation DGN. Draft design drawings will be baseline drawings of the optimum design and not formatted cut sheets. MnDOT will be able to format the drawing to MnDOT standards and use them to develop cut sheets.

Deliverable(s): Draft Final Report; Design Drawings
Duration: 4 Months
Estimated Task Completion Date: September 30, 2014

Task 8: Final Report Completion
During this task, the University will incorporate technical and editorial comments from the review process into the document, as appropriate. The University will consult reviewers for clarification or discussion of comments. The University will prepare a revised final report, and submit it for publication.

Deliverable(s): Final Report
Duration: 4 Months
Estimated Task Completion Date: January 31, 2015

PROJECT SCHEDULE

MONTHS

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Task 1	X	X	X											
Task 2			X	X	X	X	X							
Task 3										X	X	X	X	X
Task 4										X	X	X	X	X
Task 5			X	X	X	X	X	X						
Task 6								X	X	X	X	X	X	
Task 7														
Task 8														

	15	16	17	18	19	20	21	22	23	24	25	26	27	28
Task 1														
Task 2														
Task 3	X	X	X	X	X	X								
Task 4	X	X	X	X	X	X								
Task 5														
Task 6														
Task 7							X	X	X	X				
Task 8											X	X	X	X