2012 UMSRS Oral Abstract Guide (arranged by session number)

Session 1: Stream Restoration Design Guidance

Stream Restoration Prioritization Criteria: A Systems Approach

Amanda Hillman *MN Department of Natural Resources*

The Stream Habitat Program is committed to enhancing and restoring the biology, hydrology, geomorphology, water quality and connectivity of Minnesota's streams through stream restoration. The purpose of the Stream Restoration Prioritization Criteria is to identify and prioritize projects that best address this systems approach. These criteria concentrate on projects that will result in systemic outcomes. High priority projects will: 1) relax human constraints on the stream to a greater degree, 2) have a greater level of resource potential, 3) have larger-scale targets and 4) restore or reconnect habitat critical to aquatic or riparian species that are federally listed, state listed or are rare to the major watershed. Projects score higher when more than one species or life stages benefits and when various or key habitat (i.e. spawning areas) is restored or reconnected. Restoration projects are designed using Natural Channel Design, where the restoration will restore natural channel function and will be self-sustaining. This approach considers socio-economic aspects including: cost, timing, technical feasibility and social acceptance. A judgment criterion is in place for unique projects that may affect regional policy changes by serving as a flagship project and/or projects that will provide for a unique monitoring opportunity. The fundamental goals of this approach are to spend restoration funding efficiently and produce projects with far reaching impacts.

The Stream Project: Decision analysis and design guidance for stream restoration

Dan Baker *Johns Hopkins University,* Peter Wilcock *Johns Hopkins University*

We present the framework of a stream restoration decision analysis and design guidance product that defines and implements a rational, objectives-driven approach to evaluating and designing stream restoration projects. The Stream Project is a collaboration among scientists, engineers, and decision analysts at the National Center for Earth-surface Dynamics (NCED), the Intermountain Center for River Rehabilitation and Restoration (ICRRR) and the US Army Corps of Engineers (USACE). Two key challenges define the intent of the Stream Project and its contribution to existing decision and design guidance in stream restoration. The first is an essential and pervasive interaction among science, engineering, decision analysis, and practice. None of these perspectives are sufficient on their own but must be explicitly combined in developing a framework that supports project assessment and design decisions. The second key challenge is to develop an approach that is both objectives-driven and predictive. Our goal is a methodology in which specific, quantifiable objectives are explicitly linked to design choices in a way that supports tradeoff analysis, adaptive management, and more effective learning by doing. This framework will allow benefits and costs to be determined and tradeoffs to be defined and evaluated. This presentation will present the Stream Project organization and describe the decision and design tools used.

Modeling in-stream structures and a low-head dam retrofit with a 2D hydraulic model

Jeff Weiss *Barr Engineering,* Jessica Kozarek *St Anthony Falls Laboratory*

Adaptive Hydraulics (AdH) is a 2-dimensional model developed by the US Army Corps of Engineers. It was used to model two projects with extremely detailed topographic information in order to gain a better understanding of how this model can be used in the design process. The first project was a series of experiments run at the Outdoor Stream Laboratory at the St. Anthony Falls Laboratory that examined the impacts of rock vanes, j-hook vanes, and bendway weirs on flow patterns and sediment scour and deposition. Detailed bathymetric and water surface elevation data made it possible to calibrate the AdH model to a degree that is rarely possible. The second project was a low-head dam retrofit project in which boulders were used to create a step-pool sequence that allows fish passage. Detailed bathymetry data was taken during a dry period. AdH was used to model the existing retrofit project and compared to HEC-RAS results. In addition, various boulder spacings were modeled to determine impacts on velocities that could be used to target various fish species in future designs.

Using instream wood characteristics to guide the restoration of agricultural headwater streams

Peter Smiley Jr. *USDA-ARS Soil Drainage Research Unit,* Eric Gates *Ohio State University*

We conducted a large scale assessment to determine if the presence and diversity of instream wood types differs among Scioto River Basin (Ohio) headwater streams exhibiting four channel types ranging from recently channelized to unchannnelized. Data on the presence of instream wood types within 118 headwater streams for the large scale assessment were obtained from the Ohio Environmental Protection Agency. We also conducted a small scale field study in twelve headwater streams within the Upper Big Walnut Creek watershed within the Scioto River basin to determine if the amounts and types of instream wood differ between channelized and unchannelized agricultural headwater streams. Our large scale assessment found the presence of rootwads, rootmats, and logs and the diversity of instream wood differed among channel types with unchannelized streams having the greatest values and recently channelized streams having the least values. Our small scale field study observed that the diversity of instream wood, density of instream wood, and density of large log jams was greater in unchannelized than channelized streams within the Upper Big Walnut Creek watershed. Channelized headwater streams within this watershed contained mostly small simple wood pieces, large simple wood pieces, and large overhanging vegetation. Unchannelized streams possessed mostly small simple wood pieces, large rootwads, and large log jams. Our preliminary results from these assessments indicate the amount and type of instream wood differs between channelized and unchannelized headwater agricultural streams within the Scioto River basin. These results highlight the importance of small instream wood for agricultural headwater streams and use of restoration practices that increase the amount of instream wood and alter the proportion of different types of instream wood within channelized agricultural headwater streams.

Session 2: Stream Restoration, Ecology, and Aquatic Management

Brook Trout Response to Stream Realignment in Wisconsin's Central Sands Region

John Wiater *Stantec*

Lost Creek, a tributary of the Plover River in Portage County Wisconsin, has been ditched and channelized to support agriculture production that make up most the watershed. Watershed degradation and groundwater manipulation through drainage and irrigation has severely altered native brook trout (Salvelinus fontinalis) habitat creating stream restoration opportunities.

In 2005, the Wisconsin Department of Transportation (WisDOT) acquired 350 acres of land from four property owners to restore wetland and stream habitat to offset impacts from highway development. Three years of extensive monitoring and modeling of hydrology and groundwater were completed in conjunction with aquatic and geomorphologic surveys to create a site design that would maximize wetland development. During this time, a naturally reproducing population of Brook Trout was discovered within several of the onsite ditches and pump ponds.

In order to preserve this unique stream resource on site, the final design included ditch filling and rerouting 7,250 linear feet of naturalized stream channel, 7 online ponds and approximately 20 acres of riparian wetlands adjacent to 200 acres of restored wetlands and 130 acres of native prairie. To re-create a native stream environment, two reference reach sections were chosen within the native Lost Creek channel to gather baseline geomorphological and aquatic data. This data was used to create a stream gradient and sinuosity to simulate natural and current stream flow data.

Construction of the new stream channel was completed in fall 2009 with oversight by the biological design team. Biological and geomorphological monitoring began in spring 2010. Fisheries surveys (electroshocking and hook and line surveys) in spring and fall 2011 indicated that the brook trout population inhabited the new stream channel. Over 350 young of the year (YOY) and 165 adult brook trout were sampled during the 2011 sampling. The YOY brook trout are concentrated in the south channel and represent a concentration of roughly 200 trout per mile. Adult brook trout were concentrated in the 7 constructed ponds on site and have an average length of 8.2 inches. Catch per unit effort totals within the ponds are approximately 33 trout per hour.

Future potential improvements within the stream channel include natural channel constriction in wide width areas of the channel, instream habitat structures natural instream grade control structures, and woody vegetation bank establishment.

Restoring Urban Streams Using Hand Labor and On-Site Material

Ed Matthiesen *Wenck Associates, Inc.,* Kristine Jenson *Vadnais Lakes Area WMO*

The Vadnais Lakes Area Watershed Management Organization (VLAWMO) is a joint powers citizen commission charged with protecting water resources in a 25 square mile area of suburban Ramsey County, Minnesota. Lambert Creek is a tributary that discharges to Vadnais Lake, a drinking water reservoir used by the city of St. Paul. A 1,660 reach of this stream, which flows through residential back yards in the city of Vadnais Heights, was experiencing erosion and downcutting, conveying sediment and nutrients downstream. VLAWMO estimated that the cost to stabilize this reach using traditional construction methods was over $200,000. Deterred by this high cost, VLAWMO decided to take an alternate approach. Hydraulic information showed shear stress and velocities were within a range that biorestoration could work, with brush bundles and grade control structures providing stabilization as live stakes took root and became the primary structural reinforcement. The project was redesigned to use only hand labor supplied by the Minnesota Conservation Corps and materials harvested on site. With a $45,000 grant to work with the Conservation Corps, VLAWMO's out-of-pocket cost was reduced to $22,000, about one-tenth the cost of traditional construction.

During the summer of 2010 trees were thinned to 20' on either side of the creek and the branches used to construct brush bundles and logs used for grade control structures. The disturbed areas were then seeded and covered with erosion control blanket. In the spring of 2011 live stakes of willow and dogwood cuttings were planted.

An educational component was included in this project for the Conservation Control workers and the adjacent neighbors with the design engineer explaining the purpose and design behind toe protection and grade control structures. Additionally, a water resources graduate student conducted a pre-project macroinvertebrate assessments, with a post-construction assessment scheduled for 2012 to measure changes in species diversity and abundance as a result of adding coarse woody debris to the channel.

The unique role of winter invertebrate communities in trout streams of southeastern Minnesota

Jane Mazack *University of Minnesota,* William French *University of Minnesota,* Patrick Sherman *University of Minnesota,* Jennifer Biederman *University of Minnesota,* Lori Krider *University of Minnesota,* Bruce Vondracek *USGS, Minnesota Cooperative Fish and Wildlife Research Unit,* Jim Perry *University of Minnesota,* Leonard C. Ferrington, Jr. *University of Minnesota*

Groundwater-fed streams, which remain cold in summer but ice-free in winter, provide ideal habitat for ultra-cold stenotherm insects and brown trout. Previous studies on these insects have focused on their thermal tolerance limits; however, their role within the broader ecosystem context is not well-established. Thus, the goals of our study were to document winter invertebrate emergence and community composition, while investigating their relationships to thermal regime and trout growth. We assessed 12 trout streams in southeastern Minnesota on three occasions throughout the winter using invertebrate bioassessment protocols. Invertebrate sampling dates were paired with trout diet analyses to determine invertebrate influence on trout diet and growth. Surface-floating pupal exuviae collection and Hess samples were used to study the emergence patterns of cold-adapted insects in relationship to water temperature and evaluate winter invertebrate community composition. Both community composition and winter emergence patterns varied among streams with different thermal regimes and geospatial contexts. Additionally, winter brown trout diet and condition were significantly related to invertebrate community characteristics. We plan to use these results to model the vulnerability of southeastern Minnesota trout streams to climate change, in order to allow for better prioritization of preventative and restorative stream management plans.

Assessment of culverts designed to meet stream simulation requirements

Bradley Hansen *University of Minnesota ,* Sara Mielke *St. Anthony Falls Laboratory, University of Minnesota,* John Nieber *University of Minnesota Department of Bioproducts and Biosystems Engineering,* Jeff Marr *St. Anthony Falls Laboratory, University of Minnesota*

The stream simulation approach to culvert design requires that a culvert not substantially change the functioning of the stream. This means that a culvert is required to perform similarly to the natural stream in passing sediment, woody debris, maintaining channel form and profile, and facilitating the migration of fish and aquatic organisms. In this study 19 culverts originally designed to meet some or all stream simulation requirements were surveyed to assess how well they met the requirements. The main criterion used to evaluate this was the presence or absence of adequate sediment in the culvert. Of the 19 culverts surveyed, thirteen sites had recessed culverts. Six of theses recessed culverts did not meet the criteria. A likely reason that these culverts lack sediment was improper sizing relative to bankfull channel width. Other possible reasons were also identified and will be presented along with recommendations for improving culvert design to meet stream simulation requirements.

Session 3: Characterizing Sediment Transport in Fluvial Systems

Sediment Transport In Stream Restoration

Peter Wilcock *Johns Hopkins University,* Dan Baker *Johns Hopkins University*

It is commonly acknowledged that sediment transport is not effectively incorporated in typical stream restoration design. Yet many projects seem to perform acceptably. But some do fail, sometimes spectacularly. Is stream restoration design simply a game of chance, best left to those with a strong nerve or a deep faith? Can we predict sediment supply and transport capacity with enough accuracy that we can confidently forecast channel behavior? Uncertainty clearly plays a role (whether explicitly considered or not), because it is not possible to precisely forecast future future water and sediment supply. What tools are available to a designer? Can we identify conditions under which sediment supply is a significant design issue? What options exist to finesse or accommodate uncertainties in both sediment supply and transport capacity? This paper presents tools from recent sediment transport research that can help a channel designer incorporate sediment transport and its uncertainty in stream channel design.

Quantifying Stored Sediment In Southwest Wisconsin Stream Channels

Robert Hansis *R Hansis Consulting,* Faith Fitzpatrick*, US Geological Survey*

Given the role of sediment as a major pollutant across many spatial scales, it is important to determine sediment sources, and relative contribution of each source, in the determining where in a watershed or stream system to focus restoration efforts.

We looked at the sediment budgets of two watersheds in southwest Wisconsin to determine where to target management efforts and how to best measure the outcomes of intensive soil conservation and stream rehabiliation approaches. While significant sources of upland erosion were identified, we found that in-place sediment volumes were equal to years to decades of loads coming from upland sources. These findings led us to explore approaches to deal with the sediment that is already present to complement management actiivites that are reducing upland sources. The presentation will include the methods we used to quantify the in-place sediment as well as a discussion of methods to remediate the habitat losses due to sedimentation.

Developing a comprehensive approach for prioritizing stream restoration sites in the Minnesota River Basin

Christian Lenhart *University of Minnesota,* John Nieber *University of Minnesota,* Ann Lewandowski *University of Minnesota*

Research now indicates that the majority of sediment exported from the Minnesota River is derived from near-channels sources, amplified by recent streamflow increases. With the Minnesota River turbidity TMDL nearing completion and other initiatives ongoing to reduce river sedimentation and eutrophication there is a need to develop a more comprehensive approach to reduce channel erosion. Therefore, the McKnight Foundation funded a project to develop an approach for prioritizing channel erosion reduction strategies over the expansive Minnesota River Basin (MRB). It will be necessary to develop a strategic framework for action rather than doing restoration on a case-by-case basis, opportunistically at sites with willing landowners or funding availability. A second major goal is to develop strategies for control of ravine, bluff and streambank (RBS) erosion that are specific to each channel type and viable from an economic standpoint to apply across this 17,000 mi^2 watershed. While numerous technical approaches exist for stabilizing ravines, bluffs and streambanks, most are too costly for widespread application because of design, materials and mobilization costs. A third related goal is to address economic needs of landowning farmers by identifying agroecosystems that are sustainable from an economic and ecological standpoint. These multi-use strategies must enhance ecological services in the entire riparian corridor while providing some economic benefit to increase adoption by landowners. The use of alternative perennial crops, rotational grazing, controlled drainage and direct stream restoration practices may all be appropriate in different riparian settings. Building on previous work, the areas with the highest near channel sediment yield will be mapped in GIS. Existing data on channel erodibility, bank erosion hazard, derived geomorphic metrics and cost-benefit data will be used to assess the relative costs and benefits of different stream, bluff and ravine restoration and stabilizations practices. The erosion and sediment delivery data in combination with economic and social factors will be used to rank the priority for channel stabilization and/or ecological restoration. The most cost-effective sediment reduction strategies for ravines, bluffs and streambanks will be identified from the existing toolbox of strategies such as streambank bioengineering and rock vanes. Three case studies of sediment reduction projects will provide insight into practical siting, cost, social and implementation issues in a ravine-dominated setting, a bluff project threatening public infrastructure, and a small upland watershed. Our strategies will be informed by public feedback in three public meetings to be held at Fairmont, a site in western Minnesota and Mankato.

Session 4: Integrated Design and Evaluation

Combining Restoration & Hazard Mitigation: The case for dam removal in flood damage reduction

Tom MacDonald *Barr Engineering,* Sara Strassman *American Rivers,* Rita Weaver *Barr Engineering,* Nathan Campeau *Barr Engineering*

Dams can affect riverine flooding in two primary ways: 1) potential dam failures causing releases of impounded water & sediment and 2) exacerbated localized flooding due to reduce channel and floodplain storage and modifications to hydraulics and riverine processes. For several years, American Rivers has been collecting qualitative and quantitative data on the relationship between dam removal projects and local flood damage reduction. We recently completed an analysis of the benefits of a system-wide dam removal campaign that was conducted on the Baraboo River in Wisconsin between the 1970s and the early 2000s. In this presentation, we will discuss:

A) The characteristics of dams and dam sites that, upon removal, tend to yield flood damage reduction benefits,
B) Results from hydraulic modeling showing reduced occurrence of flooding for select locations, and
C) The opportunity for partnership between hazard mitigation and environmental restoration professionals.

Natural Channel Design in a Legal Ditch: Lawndale Creek

Luther Aadland *Minnesota Dept. of Natural Resources,* Neil Haugerud *Minnesota Dept. of Natural Resources*

A large proportion of headwater streams across the Midwest have been straightened, dredged, “improved” and designated as legal ditches. This paper will walk through the application of natural channel design and construction in a legal ditch system. Lawndale Creek was channelized in 1895 with a state ditch, and in 1960 with a separate county ditch. Natural segments of meandering prairie stream retained a diverse fauna of headwater species. Reference channels from these natural segments coupled with morphology data from other similar streams in the region were used to develop the restoration design. The project presented numerous challenges associated with ditch law, water appropriation, permitting and environmental assessment, and construction. The channel was excavated in the winter of 2010-2011 and flows were diverted into it in August, 2011. The restoration will be monitored in terms of hydrology, water quality, riparian vegetation, sediment transport, geomorphology and channel migration rates, fish and invertebrate communities and ecology.

Assessment and Monitoring of a Restoration: Lawndale Creek

Neil Haugerud *Minnesota Dept. of Natural Resources,* Luther Aadland *Minnesota Dept. of Natural Resources*

Many monitoring designs look at single aspects of a stream restoration over short time periods, but few evaluate the all components of a stream for a long period of time. This paper will discuss the long term monitoring plan for a restored segment of Lawndale Creek. This creek is a unique cold-water, prairie stream located in Wilkin County. A restoration project was completed in August of 2011 which replaced 2.3 miles of ditch with 3.5 miles of stream channel in the Atherton Wildlife Management Area. It has a unique fish community that includes brook trout as well as headwater species, such as finescale dace, pearl dace and river darters that are becoming increasingly uncommon in the Red River basin. A long term monitoring plan has been designed and implemented to evaluate water chemistry, hydrology, biology, and geomorphology changes that occur in the restored stream channel. Biological components that are being evaluated are the fish community changes, macroinvertebrate community colonization and riparian vegetation responses. Discussion will include the methods used to monitor the project and show preliminary pre-construction and post-construction monitoring results.

A Historic Tale-Restoring and Reconnecting Shadybrook Creek

Jessica Hickey *Davey Resource Group,* Ken Christensen *Davey Resource Group*

Davey Resource Group was contracted by Holden Arboretum in Kirtland, Ohio to restore and re-route a portion of Shadybrook Creek; a coldwater tributary to the East Branch of the Chagrin River. Davey teamed with a local Ohio construction contractor and engineering firm to develop a plan to restore the stream to what was believed its historic pathway. This presentation will discuss the obstacles faced during the development of the restoration plans, how the ultimate design was selected, the construction and riparian planting process, and the ultimate results of the stream restoration. During a storm event in 2006, a large portion of the streambank upstream of the project area collapsed, causing unconsolidated glacial tills to fill the project area, which was a former swimming pond. Approximately 1,500 cubic feet of sediment is now present in this former pond area. A degraded concrete dam/spillway prevents the sediment from washing downstream.

Initially, The Holden Arboretum defined the project to include the removal of a dam impoundment, outlet, concrete inlet channel and associated sidewalls, and approximately 1,500 cubic yards of sediment. Following analysis by the Davey team, it was determined that these activities would cause excessive damage to surrounding areas. Not only would the mature trees that have established adjacent to the dam be destroyed, but the expense to remove, transport, and dispose of the excess sediment would be cost-prohibitive. The Davey team provided a stream design to The Holden Arboretum that would re-route Shadybrook Creek around the dam, using what is likely the stream's historic pathway to the west. This final design was approved. Intensive topographic surveys and hydrologic modeling were performed to establish baseline conditions. Several natural channel design features were incorporated as appropriate for stream gradient. These features mimic natural conditions present upstream of the project site. Construction began in April, 2009 and was completed in June, 2009.

Session 5: Restoration in the Built Environment: Urban Stream Restoration

Trillium Site Stream Corridor Restoration Project, St. Paul, Minnesota

Bob Fossum *Capitol Region Watershed District,* Kathleen Anglo *City of St. Paul Parks and Recreation,* M. Beth Wentzel *Inter-Fluve, Inc.*

The City of St. Paul, over the next several years, plans to develop a new Trillium Nature Sanctuary. The new park will be developed in an approximately 41 acre brownfield that has been acquired by the City. The Trillium Site Master Plan calls for recreating a new stream segment running the length of the park along with some associated wetlands/ponds. The new stream segment will approximate the location of the original Trout Brook which was placed in a storm sewer below grade in the late 1800s. Longer term plans call for expansion of the stream segment to north to Lake McCarrons and south to the Mississippi River.

Capitol Region Watershed District (CRWD), in partnership with the City of St. Paul, has completed a feasibility study and preliminary engineering of the stream segment and wetlands/ponds for the Trillium Site. The stream segment will be approximately 3,000 feet and 3-6 wetland/pond features will be included on site to treat and deliver water to the channel. Additionally, CRWD analyzed up to 12 different water sources for the water features on the Trillium Site, including harvesting stormwater from adjacent properties, pumping water out of the storm sewers and ponds, and gravity flow options from storm sewers and ponds. The preferred water source option was determined to be a combination of harvesting stormwater from an adjacent residential neighborhood and construction of a gravity flow pipe from an upstream pond and Trout Brook Storm Sewer.

The Trillium Site water features will process the incoming source water to a condition more conducive to natural ecology. The completed system will provide critical functions for biological habitat for water-dependent flora and fauna as well as supporting wildlife habitat. It is the intent of the City and CRWD to utilize these facilities as educational and wildlife appreciation activities. Upon completion, the Trillium Stream Segment will represent the largest open channel stream segment in the City of St. Paul. The project will accomplish the multiple goals of stormwater management, habitat creation, demonstration, education to effectively “Bring Water Back to St. Paul,” a major theme of the CRWD Watershed Management Plan.

Kinnickinnic River Watercourse Rehabilitation - Early Out Project

Thomas Sear *Short Elliott Hendrickson, Inc.,* Patrick Elliott *Milwaukee Metropolitan Sewerage District (MMSD)*

The Kinnickinnic River (KKR) Watershed is an approximately 25 square mile, highly urbanized drainage area, located in south central Milwaukee County and tributary to the Milwaukee River Estuary. Approximately 4.5 square miles of the watershed (18.0%) is contained within the City of Milwaukee - Combined Sewer Service Area (CSSA). The KKR has undergone considerable alteration in the past, including channel widening and realignment, and the installation of concrete lining. The Milwaukee Metropolitan Sewerage District (MMSD) has initiated a series of flood management projects within the KKR Watershed that address watercourse rehabilitation, neighborhood revitalization, and the provision of community and recreational benefits. Interests being promoted by a range of municipal, agency and community stakeholders include: improved channel and estuary water quality conditions; aquatic and fisheries habitat development; improvements to public safety, river access, and recreational facilities; and the maintenance or replacement of aging infrastructure.

MMSD is completing an “early out” final design and construction project that includes the rehabilitation of approximately 1,000 feet of watercourse, located between the South 6th Street and I-94 bridges. Watercourse rehabilitation improvements include: (1) removal of 500 feet of concrete lined channel; (2) development of 1,000 feet of stone-lined main channel, with riffle and pool sequences, that enhance aquatic habitat and fish passage; (3) maintenance of appropriate 100-year flood management; (4) establishment of stable embankment side slopes, while protecting existing infrastructure; (5) promoting the development of wetland areas and upslope native vegetated communities; and (6) providing enhancements that facilitate maintenance and community access to the river.

Fish Habitat Restoration Scenarios in an Urban Impaired Waterway

Phillip Rury *Bioengineering Group,* Wendi Goldsmith *Bioengineering Group*

Regulatory requirements to improve fish habitat were established for an industrial urban waterway that provided heavy commercial navigation as well as stormwater and treated wastewater conveyance. For more than 100 years the Chicago Area Waterway System (CAWS) was engineered and modified to serve the needs of the population. The challenge was to research internationally applied methods and to identify conceptual design measures that would establish physical fish habitat improvement without necessarily relying on their water quality improvement characteristics. Six restoration measures were identified that addressed habitat functional impairments and that would result in measureable changes in the fish habitat index scores. Restoration measures were used in alone and in tandem, adapted to several identified locations within the waterway.

The design was informed by an analysis of existing fish habitat and water quality research from around the world, as well as detailed supplemental habitat information such as bathymetry, bank features and commercial vessel traffic patterns. Designs identified provided simultaneously unique and ecologically productive aquatic habitat designs by employing an integrated approach based on creative implementation of proven technologies. The designs employed would improve public areas, allow continued commercial navigation, support the stormwater and wastewater functions of the river, and offer the needed durability to withstand the physical and biological stresses of the challenged setting. Port and river management entities often believe that the habitat value of a waterway is secondary to the value of that waterway to navigation and trade. However, keeping waterways healthy and functioning at multiple levels provides use of the waterway for recreational and aesthetic interests. Bioengineering Group successfully identified methods to balance the needs of environment, community and economics and presents these ideas herein for river managers/users to implement for “Greening” of the Ports in the United States.

Challenges of Multi-Goal Urban Stream Restoration Projects

Suzanne Hoehne *Biohabitats, Inc*

The Hudson High School Tributary (a tributary to Tinkers Creek) watershed in Northern Ohio has experienced significant land use changes in recent history, which has resulted in an altered hydrology. This altered hydrology, along with straightening the stream, has caused changes in the stream’s planform geometry and cross sectional shape. The unbalancing of the system has contributed a significant sediment load into Tinkers Creek, increased the risk of downstream flooding and reduced stream habitat. An urban stream restoration project has been undertaken by a collaboration of public entities to improve the Hudson High School Tributary and its surrounding environs. This design/build project is unique in that it has a wide range of goals, including: 1) enhance the existing high school Land Lab, 2) meet the city’s stormwater requirements for the site, 3) reconnect the stream with it surrounding floodplain, 4) improve water quality, 5) improve habitat, and 6) create an educational component linking the restoration to high school curricula. Biohabitats, Inc was awarded the contract for the design and construction of the project. Working with the high school students, the contractor, and the clients, a design has been developed that includes restoration of 2,000 linear feet of stream by reconnecting it to new and historical floodplains through the use of cobble weirs within a riparian area consisting of wet meadow, scrub/shrub wetlands, forested wetlands, riparian forest and emergent wetland habitat. The site also meets the city’s stormwater goals of reducing the 25 year flow to the 2 year flowand ultimately providing 6.35 acre feet of additional storage.

Session 6: Advanced Topics in Stream Restoration

Geomorphology of the Red River of the North and Tributaries and the Geomorphic Response of the Sheyenne River Diversion

Michelle Schneider *US Army Corps of Engineers,* Hans Hadley *WEST Consultants, Inc.,* Peter Hinck *Barr Engineering,* Miguel Wong *Barr Engineering*

This presentation will focus on the geomorphology of the Red River of the North, and its North Dakota tributaries near the Fargo-Moorhead metropolitan area, including the Wild Rice River, Sheyenne River, Maple River, Rush River and the Lower Rush River. All of the rivers in the study area lie within the old Glacial Lake Agassiz lake bed. In addition, the presentation will provide a discussion of the geomorphic changes happening in the "Horace to West Fargo" (HWF) and "West Fargo" (WF) channels diverting flood water from the Sheyenne River.

A geomorphology study of the Red River of the North and it's tributaries in the vicinity of the Fargo, ND and Moorhead, MN metropolitan area has been underway since 2010. The study is documenting the geomorphic characteristics and processes of the rivers in the area to develop a better understanding of the potential effects of proposed flood risk management projects on the sediment transport and channel morphology of these rivers.

The study features the analysis of multiple sediment transport and geomorphologic datasets, including an intensive campaign to measure bedload and suspended sediment transport rates and sediment gradations during the spring floods of 2010 and 2011, as well as during the summer rainfall-runoff and baseflow events of 2011. These data are being used for sediment transport modeling of the HWF and WF diversion projects on the Sheyenne River in the study area.

Eastern North Dakota has been in a wet cycle since about 1993, which in combination with the operation of a Devil's Lake outlet pumping water almost continually into the Sheyenne River is causing the existing diversion channels to flow much more often than designed. In 2010 and 2011 the diversion channels had flow during a majority of the year. The WF diversion channel in particular has undergone major geomorphic changes, as a result of adjustments to its hydrology and sediment inputs with as much as 10 feet of deposition in the main channel, while having up to 4 feet of erosion in the low-flow channel. The observed geomorphic changes within the WF diversion channel appear to be the result of a progressive transformation of the cross section geometry similar to that of the "natural" Sheyenne River system. The transformation is likely occurring because the Sheyenne River waters are completely diverted into the WF diversion during large flood events during which most of the sand-sized riverine sediments are transported.

Eco-engineering on the Edge: Stream Restoration, Stabilization, and Evaluation of Risk

Dan Salas *Cardno JFNew*

Restoration, stabilization, and enhancement of streams is often undertaken in high risk environments. These considerations can impact the type of design and restoration practices implemented. Evaluation of risk is a critical component to understanding the types and degrees of risk involved in a project. Using a structured decision framework can help evaluate restoration options and help communicate selected approaches to regulators and the general public.

When protecting infrastructure such as gas pipelines, sewer lines, driveways, and property along streams, Cardno JFNew takes an ecologically-sensitive approach to creating solutions. In his presentation, Dan will compare traditional hard structure methods with alternative methods that have higher ecological value, discussing when and where an ecological approach will work best, limitations to this approach, evaluation of structural and environmental risk, as well as key considerations in design and implementation.

He will highlight examples of successful projects in northern Illinois, Indiana, southern Wisconsin and elsewhere that have implemented such alternatives, including using large woody structure and flow re-directive measures.

Combining Field And Laboratory Scale Stream Experiments With Numerical Simulations To Inform Stream Restoration Design

Jessica Kozarek *St. Anthony Falls Laboratory, University of Minnesota,* Craig Hill, Kris Guentzel, Miki Hondzo, Fotis Sotiropoulos*, St. Anthony Falls Laboratory, University of Minnesota*

Many stream restoration projects alter the physical structure of a stream channel structure by adding in-stream structures, constructed of rock, wood, or other materials, to direct the flow of water or add habitat complexity; yet, we lack a fundamental understanding of the interactions between turbulent three-dimensional (3D) flow around structures and the streambed, banks, and stream ecosystem. To develop predictive models of stream physical and ecological response to these restoration activities, a recent set of field scale experiments in the Outdoor StreamLab (OSL) at St. Anthony Falls Laboratory (SAFL) examined flow fields, sediment transport, and nutrient dynamics in the vicinity of in-stream rock structures. In addition to high-resolution topographic measurements (cm-scale), detailed local hydraulic and nutrient conditions were profiled at multiple cross sections using the following sensors: 3D ADV, NO3 biosensor, dissolved oxygen sensor, and temperature probe. In addition to OSL experiments, a series of small-scale physical model experiments were completed in the SAFL Tilting Bed Flume measuring 3D flow velocities and sediment scour patterns downstream of similar structures. These experimental results demonstrate the capability of full-scale experiments, coupled with indoor, field, and numerical investigations, to provide insight on the complex interactions between physical, chemical, and biological ecogeomorphic processes to inform restoration design.