Stable streams are defined to be in a state of dynamic equilibrium. The natural processes of a stream will result in a channel that is not set in place but has a natural adjustment, bank migration rates, erosion and deposition. Changes in the flow regime, sediment supply, slope and substrate can cause local channel instabilities that can lead to systematic reach wide instability and possible channel evolutions. Many urban stream restoration projects can be good examples and experimentations of the effect of changes in flow regimes that affect sedimentation and erosion rates.

Urban Streams are always being adjusted by backwater, changes in sediment supply, increased runoff, canalization, removal of vegetation and bed armoring. Any stream restoration should evaluate the causes of channel instability and the potential for the channel to recover and return to a dynamic equilibrium. Urban streams systems typically have channel instability and enlargement that can result in risk to structures, lose of land, and increase flood stage. Urban channels have also been widened with the goal of increased flood conveyance, which can lead to long term aggradation and channel instability.

The major goal of urban stream restoration projects are usually trying to create a stable restored channel with unstable and conflicting boundary conditions. Other goals of urban stream restoration projects include limiting flood risk, increase public use, increase habitat, property protection, mitigation and aesthetics. The dynamic equilibrium of a stable stream is not accepted in goals and objectives of many stream restoration projects. A process focused design for urban stream restoration will evaluate risk on multiple design flows that are at and above a bankfull stage. Natural channel design has eight sequential phases. Each phase is adjusted below to describe work in urban channels and watersheds.

Phase I: Restoration Goal/Objectives – Urban channels have specific restoration objectives associated with many processes and stakeholders. It is critical to obtain clear and concise statements of restoration objectives in order to appropriately design to meet the solutions of an urban project. The uncertainty and risk associated with the all phases needs to be communicated to the stakeholders.

Phase II: Regional and Local relations – To understand the existing conditions a design team needs to develop regional and localized specific information on geomorphologic characterization, hydrology and hydraulics. In many urbanized channels there are not active deposition features that can be identified as a bankfull feature. The degree of instability and the change in flow regime in urban channels may also produce features that have multiple depositional surfaces after varying stages. These urban depositional stages are due to the frequency of flooding as well as due to increased impervious area within the watershed. A local regional relationship can be developed that relates multiple depositional surfaces to a drainage area. These relationships should also be related to a risk level or to a return interval. Development of an urban regional curve is a tool that comes from the applied fluvial geomorphology that can be useful in urban channel design. This tool should used with other hydraulic tools to define a design channel dimension.

Phase III: Watershed/River Assessment – On all urban projects there is a need to conduct an urban watershed/river assessment to determine and identify instability in both the reach and the watershed. A watershed assessment is a tool to guide the practitioner in quantifying the consequences of change in the watershed as related to the project reach. Phase III, watershed/river assessment, is an important procedural step in a sound restoration plan because it identifies the causes and consequences associated with the loss of physical and biological river function (Rosgen 2006). The phase III assessment should provide the practitioner with knowledge of the river and highlight uncertainties and potential risk of failure. In urban settings this data needs to be communicated to stakeholders to update and modify goals and objectives that are confliction or not achievable. An assessment tool for predicting streambank erosion Rosgen (2001a), uses a classification of the Bank Erodibility Hazard Index and Near-Bank Stress calculations. Bank erosion prediction should be used to display the failure risk of infrastructure due to bank
erosion to project stakeholders. Bank erosion prediction can also be adjusted in urban reaches to predict bank erosion and property loss at storms with a less frequent recurrence interval.

**Phase IV:** Change overall management (Passive restoration) – Consider passive restoration recommendations based on land use prior to considering mechanical restoration. While there should be a priority in restoration is to seek a natural recovery solution; based on changes in the controlling variables many of the urban projects have goals and objectives that limit the application of passive restoration. Rivers will do more work where there is more available energy and less work where there is less available energy. Therefore rivers are always working in a trajectory toward a uniform dissipation of energy. Multi-dimensional modeling can be used with the planning for a passive restoration strategy to indentify potential locals of risk due to un-uniformities in the dissipation of energy. Stormwater BMPs and flood control methods within the watershed can be used as a tool to management the flow regime of the channel that may allow for a passive channel restoration in an urban setting.

**Phase V:** Stream Restoration/Natural Channel Design – Initiate natural channel design with subsequent analytical testing of hydraulic and sediment transport (competence and capacity) relations. This phase combines the results from the prior phases, I through IV. It is important to remember that a successful urban restoration stems from a good assessment and clear and concise goals and objectives. This phase is not intended to repair and stabilize symptoms, but rather to provide restoration solutions that will offset the causes of the problem and allow the river be self-maintaining. Urban goals with many competing constraints; may not be able to have a self-maintaining restoration design. Natural channel design can be used in part as a design tool to repair and stabilize symptoms or urban channels. The process of natural channel design can also be used look at departure and risk analysis. A total of 40 analytical sequence steps generate and test restoration design specifications to determine dimension, pattern and profile relations as outlined in Chapter 11 of the NRCS (2007). Sediment competence is determined with methods described in Rosgen (2001b, 2006a). Sediment capacity is calculated using FLOWSED and POWERSED models (Rosgen, 2006a) based on dimensionless sediment rating curve relations (Troendle et al., 2001). Sediment transport analysis in urban channels should be assessed and routed through both the existing design cross-sections in a hydraulic model. The calculation of quantity sediment capacity transport is not as important as the ability to route a given sediment transport rate from a cross-section to a downstream cross-section. While bankfull flows and stage are important in urban projects require a design storms other than bankfull. A nested channel design approach is very important to accommodate multiple design storms. The energy state and potential for sediment transport needs to be analyzed at multiple flows and as a change between cross-sections. Transition zones in urban settings require a detailed analysis of flow expansion and contraction as it is related to specific energy and potential for sediment transport. Uniform energy dissipation in an upstream section to a lower energy state of a downstream section is important to minimize risk of project failure and locate placement of hardened structures.

**Phase VI:** Design Stabilization and Fisheries Enhancement Structures – In urban channels it is critical to design stabilization/enhancement/vegetative establishment measures and materials to maintain dimension, pattern and profile to meet stated objectives and manage risk. Whenever possible structures of native materials are used for energy dissipation, fish habitat enhancement, and nearbank stress reduction to extend time for vegetation response and establish bed pavement. Existing materials and infrastructure should be recycled and incorporated into the design of structures when possible. Selection of designs, materials and methods are critical to meet multiple objectives including aesthetics.

**Phase VII:** Implementation – Implement the proposed design and stabilization measures involving layout, sediment and erosion control and construction staging. Urban structures are designed to accomplish numerous functions based on the goals and objectives of the project. Urban projects require a detailed risk analysis of the structural integrity of the river restoration structures. The design storm of risk level needs to be accepted by the project stakeholders. The bankfull storm in generally a return interval between 1-2 yrs but, the risk level associated with a bankfull storm is not an acceptable risk level for most urban channel restoration and work. Urban projects should require a design storm other than bankfull.

**Phase VIII:** Monitoring and Maintenance Plan – Design a plan for effectiveness, validation and implementation monitoring to ensure stated objectives is met, prediction methods are appropriate and construction is implemented as designed. Stakeholders and designers should continually measuring data after restoration to understand and improve our prediction of sedimentological, hydrological, morphological and biological process relations within the restored river.
This presentation will discuss methods and tools of evaluating the geomorphic potential and departure analysis of a disturbed urban river system. The presentation will present a method of evaluating risk related to sediment transport and routing and evaluating the uncertainty of an urban stream restoration. Natural Channel Design is a tool and logical process that can be used to successfully restore urban water courses. The use of Natural Channel Design used solely with no additional design tools or considerations is not recommended for an urban system. While stand alone Natural Channel Design may produce some stable stream restoration projects, urban projects should at a minimal address uncertainties and risk analysis that is generally not associated with Natural Channel Design. Finally, the presentation will include a couple examples of urban stream restoration projects and techniques will be discussed and highlighted.