CONCLUSIONS

Degradation of urban water bodies and watersheds is, based on the definition embedded in the Clean Water Act (Section 502(19)), is pollution. It is a result of discharges of pollutants from diffuse and point sources, by hydraulic effects of increased flows, siltation by sediments, and by past activities of people residing in the watershed. Flood plain encroachment, stream channeling and various hydraulic structures called in past as stream improvements have caused degradation of the habitat and disappearance of many species.

Most of the projects stream modification projects, in the past and even today, are driven by flood control objectives. In the past, stream modifications to accommodate increased flows, were detrimental to the integrity of these water bodies. Today, ecological improvement and restoration of the integrity of the urban water bodies are required by the citizens and supported by the agencies. Furthermore, the *Antidegradation* rule prevents today further degradation of the nation's water bodies.

Degradation of urban water bodies is only partly caused by "pollutants." The definition of "pollutant" (CWA Section 502(6)) implies mostly discharges and loads of pollution causing compounds from the watershed. Because degradation of the urban water bodies is also caused by pollution that may not be a pollutant (e.g., stream lining by concrete) many degraded urban water bodies have not been included on the Section 303(d) listing and are not considered for the Total maximum Daily Load (TMDL) programs.

Diffuse pollution abatement and watershed protection and restoration is probably most impacted by Aldo Leopold's (*A Sand County Almanac with Essays on Conservation,* Oxford university Press, 2001) and Rachel Carson's (*Silent Spring,* Houghton Mifflin, Boston) writings and thoughts. The preservation and remediation activities in urban and urbanizing areas deal with land use and abuse of the land that causes pollution. In the broad sense, diffuse pollution (that also includes habitat, stream alteration, contaminated sediments, watershed spraying, deforestation, etc.) has also a problem that a significant part of the solution cannot be mandated. Only minimum government funding is available for water body restoration and the cost far exceeds the available funds governments made available for such projects. Most of the funding in other cases must come from local sources and from citizens' initiatives. On the other hand, most solutions to diffuse pollution are not costly, they represent common sense stewardship approaches to land use and sustainability of resources. Thus, the land ethic of the users of the water body and citizens of the watershed play an increasingly important role. Simply and bluntly said, watershed/water body preservation/restoration will not happen if citizens do not exercise their land (environmental and/or biocentric) ethic attitudes. In order to allocate public (and private) funds for stream restoration, decionmakers should be aware of citizens' attitudes toward preserving and protecting the integrity of urban water bodies and their willingness to pay (WTP) for water body preservation and restoration.

This research addressed the issues of urban water body management considering two objectives; (1) flood control and, (2) ecological preservation and restoration of integrity of the water bodies. In the past, these two objectives were conflicting. Today, they could go hand to hand because the most effective stewardship of the urban water bodies must consider both objectives in the same time and find solutions that would be complementary and achieve both objectives in the same time.

The research developed tools that will enable development of such programs. The research team further developed and advanced the methodology for flood and ecological risk determination for urban water bodies and advanced it in the Geographical Information System (GIS) environment. The socio economic team them

surveyed the attitudes and WTP of the citizens in the Menomonee River and Oak Creek watersheds in order to obtain information on possible levels of funding from the citizens for the two objectives and a weighting factor between the two risks. The citizens in the two watersheds support both objectives but not in the same level. Environmental objectives of ecological preservation and restoration of the urban water bodies were preferred by a ration of more than 2.5 to one over flood control. Thus, citizens have expressed the willingness to be stewards of the watersheds and support the ecological objectives.

Specific conclusions

Flood risk determination

The methodology developed in this research facilitates evaluation of risk due to flooding. Flood risk at any given location is related to local topography, the distribution of flows in the river, the distance to the river and the distance to the floodplain relative to the width of the floodplain. Urbanization of the watershed changes the flow distributions. Thus, flood risk changes over time and is not a constant value.

First, flood risk has been evaluated for present watershed conditions. This has been done in two different ways: (1) flood risk has been evaluated on a watershed wide basis, both for whole watershed and specific locations (properties); and (2) area flooded by flows of specified recurrence intervals floodplain has been delineated. Second, the effect of urbanization on flood risk has been assessed. Discharge-frequency curves for gage stations located within the watersheds has been adjusted to account for changes with watershed urbanization. Adjusted curves have been then used to evaluate flood risk for hypothetical development scenarios.

The methodology has been applied to both Oak Creek and Menomonee River watersheds, with the exception of floodplain delineation (Oak Creek watershed only). Results have been presented with more detail given in individual technical reports.

Ecological risks

The water and sediment quality of two investigated watersheds has been evaluated using risk assessment methodology. The acute and chronic toxicity risks due to water column contamination have been calculated using modified methodology developed by the water Environment Research Foundation. The release of pollutants from the contaminated sediment further affecting the biotic community was estimated separately.

Chronic effects of lead represent the highest risk to aquatic biota in both watersheds (10^{-3}). Copper is also a pollutant of concern (chronic toxicity risk of 10^{-4}) in Menomonee River. Both acute and chronic risks from copper calculated for the Menomonee River are two orders of magnitude higher than those for the Oak Creek. Potential risk (10^{-5}) is caused by copper (acute toxicity, Menomonee River) and zinc (chronic toxicity, both watersheds). The risks from lead and zinc are at the same level for both watersheds, with the exception of acute risk from lead after 1987 which is one order of magnitude higher for Oak Creek than for Menomonee River. The risk methodology has been revised and modified for assessment of risk due to contaminated sediments. Copper and lead are of concern in evaluated watersheds with risk values reaching 10^{-4} to 10^{-2}.

The pollutant load model was developed and implemented in ArcView GIS. The model has been calibrated and verified for present land use conditions and practices.

Impact of urbanization on ecological integrity

The fish and macroinvertebrates sampling have been used to evaluate biotic integrity of investigated water bodies. The ecological integrity has been then evaluated in its three components: chemical integrity of a water column, chemical integrity of sediment, and habitat integrity. The risk-based methodology has been developed to evaluate the effect of physical habitat.

The effect of individual risk components of chemical integrity has been assessed. For the sites investigated, the sediment risk appears to have the most important single effect. This shows the importance of evaluating the sediment contamination together with water column contamination.

The variation in biotic integrity is caused by toxicity of investigated contaminants in the water column and sediment, but also toxicity of other contaminants, habitat degradation and/or combination of all these factors. The combined evaluation accounts for 99.5% of variability in IBI. The combined model represents significant improvement when compared to individual effect models.

Contingent Valuation Method and WTP for flood control and ecological preservation/restoration

Following the development of the theory of the Contingent Valuation Method and a discussion of the survey development, WTP functions were estimated for both flood control and ecological risk reduction using a censored regression approach. The findings suggest that both goods depend on demographic, psychological and risk related measures. Hence, both goods have both private good and public good attributes. Since the risk level faced by the respondent does appear to influence WTP, the goods can be characterized as having attributes of local public (i.e., partially excludible) goods. WTP is higher when the individual resides in the 101 to 1000 year floodplain, which implies that those respondents strategically consider how future urbanization of the watershed may influence their flood risk. In addition, as the recurrence rate increases (within the 1000 year floodplain), WTP falls. However, the fact that those respondents well outside the range of reasonable risk of flooding still have positive WTP that varies with demographic and other psychological drivers suggests that the flooding good also has community-wide effects. Likewise, given that WTP for ecological risk reduction depends on more than just proxies for the ecological risk in the vicinity of the respondent also suggests community-wide effects of environmental improvement. A test of the embedding effect reveals the possibility that embedding may be a problem since there is no significant difference between the value placed on more and less expansively defined projects. However, the problem of potential biases from misspecification reduces the power of the test.

Simulations for the Menomonee River and Oak Creek watersheds reveal that ecological risk reduction generates benefits that are between 2.4 (Menomonee) and 3.3 (Oak Creek) times higher than those of a comparable project devoted solely to flood control. Treating the two goods as separable and additive, total benefits for the Menomonee River watershed would from a project that combined environmental improvement and additional flood control would generate annual benefits of $2.1 million and benefits over the lifetime of the project of $31.5 million. So long as the cost of such a project don't exceed $31.5 implies that the project would generate net societal benefits. A much smaller level of benefits is found in the Oak Creek watershed, with annual benefits equal to $210 thousand and total project benefits at $3.2 million.

Finally, the models were used for simulating WTP in an adjacent watershed, and the findings revealed environmental benefits more than 10 times those of flood control benefits. Annual benefits for the Root River watershed were $533 thousand and they were $8.1 million over the life of the project. However, the findings associated with flood control should be interpreted with caution given that flood risks were assumed to be zero throughout the watershed, and other non-demographic variables that vary spatially were assumed constant in the simulation.

Survey of Attitudes

It was recognized that until recently, WTP studies had focused heavily on the demographic determinants and have given little attention to psychological variables that could affect valuation levels for environmentally related projects. The key finding here is that an explicitly psychological approach increases the explanatory power of more conventional WTP models. Psychological variables based on the Theory of Planned Behavior, especially in the form of subjective norms and cognitive structure, could have a major impact on the level of WTP for a project to hold the line on flooding in one major Milwaukee area watershed and to improve two urban watersheds. Of particular importance is in this study is that residents' perceptions of the actual efficacy of the project in bringing about its physical goals were among the most important considerations in their WTP judgments, especially if the projects were expected to produce enduring benefits. It is also noteworthy that residents' feelings of "doing something for the environment" seemed to weigh into their willingness to pay not only for the ecological improvement project but, significantly, also for the flood control project. Perceptions of economic costs played a relatively little role in the results, although factors such as the relatively good economic times that existed at the time of the survey may have led many respondents to minimize consideration of possible effects of project funding on their pocketbooks. Since these beliefs are most likely informed by mass mediated communication about flooding and environmental quality issues in watersheds, further examination of the extent to which individuals rely on such communication sources for relevant information, as well as how they seek, encounter, and process that information, is warranted.

Since the variance accounted for by the TPB variables falls below the 40-50% reported as common in the meta-analysis of TPB studies, it is possible that the necessary measurement scheme (using Likert-type scaling in a telephone survey context) might have suppressed measurement reliabilities and therefore covariation among variables. Nonetheless, it appears that the Theory of Planned Behavior can be a significant tool to help explain Willingness to Pay for environmental and flood control projects such as these, even when the questions are administered in a telephone survey context.

Moreover, environmental perspectives can play a significant role in the determination cognitive structure and presumably, therefore, WTP. Not only is a broad measure of environmental beliefs, the Awareness of Consequences Scale, apparently an important influence on cognitive structure, but so is a measure of perceived taxpayer duty toward urban river cleanup as well. Thus, key theoretical concepts from environmental ethics seem to play an important role in the formulation of the public's WTP for urban watershed restoration. Because environmental attitudes may have ethical dimensions, more than a single broad measure of such attitudes is needed. (The true impact of the value-based attitude variables may have been suppressed in this analysis due to the need to further develop the measures.) Those who see the environment in ethical terms appear to have a greater WTP for environmental improvement, at least in the case of urban watersheds. Finally, because cognitive structure appears to directly affect WTP, and because environmental attitudes and values are a part of one's fundamental belief structure, environmental perspectives seem to affect WTP indirectly through cognitive structure.

Strictly demographic/economic variables, such as income, play a comparatively minor role in WTP regression equations relative to psychological variables such as cognitive structure and subjective norms. Decision making for public goods may well be much more intuitive and value oriented than the practitioners of contingent valuation studies previously thought. Thus, these psychological variables should prove to be valuable companions to the demographically related variables typically used to examine Willingness to Pay.

Results indicate that psychological perspectives derived from Ajzen's Theory of Planned Behavior TPB) and from communication do add significantly to the predictive power of contingent valuation

studies, at least when researchers examine public willingness to pay (WTP) for projects with environmental overtones such as flood control or the ecological improvement of a river or creek. In particular, the TPB variables of subjective norms (i.e., perceived social pressures) and cognitive structure (in this case, a subset of judgment dimensions based on beliefs and values about non-economic benefits) related significantly and positively to WTP, and did so in a replicated manner across two points in time and across the two projects. Also related to both WTP and to the non-economic aspects of cognitive structure was the respondent's attention to topical news (i.e., about Menomonee River flooding or about threats to the ecological health on the Menomonee River or Oak Creek, depending on the respondent's line of questioning). These results also replicated across time and across paths, although the relationships were stronger in the flood path as compared to the environmental path of questioning. It is possible that potential differences in news media coverage of events such as flooding, as compared to longer term issues such as the ecological quality of a river, might account in part for the stronger relationships found in the flood path. Further research into the potential impacts of mediated environmental communication and education on WTP are warranted, based on these results.

Of particular importance is in this study is that residents' perceptions of the actual efficacy of the project in bringing about its physical goals were among the most important considerations in their WTP judgments, especially if the projects were expected to produce enduring benefits.

In addition, a set of psychological "environmental perspective" variables representing ecologically-related beliefs and values also contributed, directly or indirectly, to respondents' willingness to pay for ecological improvements to the Menomonee River or Oak Creek. It is quite noteworthy that respondents' feelings of "doing something for the environment" seemed to weigh into their willingness to pay not only for the ecological improvement project but, significantly, also for the flood control project. In short, this means that the extent to which respondents believe that the natural world is valuable in its own right has a positive impact on WTP, even for a flood control project. To the extent that biocentric attitudes may be becoming more widespread, support for restoration of urban rivers in the form of willingness to pay will likely increase.

Strictly demographic/economic variables, such as income, and economically-oriented judgmental dimensions in cognitive structure, such as whether paying for the project would add significantly to taxes and how personally affordable the project would be, played a comparatively minor role in WTP regression equations relative to psychological variables above. It is possible, however, that fairly good economic times that existed at the time of the surveys might have reduced the effect of the economic variables on WTP decisions.

Although the challenges of measuring environmental perspectives and TPB variables in a survey context might have suppressed the strength of some relationships, these psychological variables should prove to be valuable companions to the demographically related variables typically used to examine Willingness to Pay.