

A Diagnostic Approach for Identifying Biological Impairment and Dominant Stressors

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This project describes a novel, weight-of-evidence approach that is superior to traditional assessment methods because the exposures to stressors are more realistic and less subject to sampling and testing artifacts. The assessment methods employed range from sensitive molecular biomarkers to community level endpoints. In addition, the identification of dominant stressors is possible through a proven, effective, tiered approach that separates out stressor sources (e.g., surface water, suspended sediments, pore water, surficial sediment, deep sediment, groundwater upwelling, low flow, high flow) and stressor types (e.g., dissolved oxygen, flow and suspended solids, substrate type, persistent and non-persistent organic pollutants, ammonia, photo-toxicants, endocrine disruptors, and metals). Biological impairment is verified via assessments of benthic macroinvertebrate communities where impairment is based on realistic assessments of optimal watershed conditions considering hydrological characteristics and land uses.

The primary objective of this research is to demonstrate a novel, systematic, and accurate approach for identifying the dominant stressors at stream and river sites. Sub-objectives include showing:

- (1) how this approach adapts to widely differing ecoregions and fresh-water systems;
- (2) how significant biological impairment can be identified with a high degree of certainty; and
- (3) how the multiple lines of evidence utilized in the approach identify differing stressor classes where impairment is identified in a tiered assessment approach.

The approach systematically determines stressor responses during both low and high flow conditions and, if stress is observed, identifies the type of stressor and its relative magnitude. In Tier 1, an indication of stress is tested during short-term *in situ* exposures of four surrogate species (fish, cladoceran, amphipod, midge) or in the benthic communities. If Tier 1 tests indicate the presence of stressors, then the type of stressors and their relative magnitude are determined in Tier 2 with more in-depth stressor identification testing to discern effects from: suspended solids, flow, photo-induced toxicity, metals, ammonia, and non-polar organics. The *in situ* assays described in Tiers 1 and 2 determine if meaningful, adverse effects are occurring at the individual to community levels. Initial colonization studies will be conducted in contaminated and reference systems to better characterize existing benthic communities. In Tier 3, more precise stressor identification, exposure and bioaccumulation potential is assessed by hour, *in situ*, oligochaete (*Lumbriculus variegates*) and fish (*Omcorhynchus mykiss*) via biomarkers and tissue exposures of caged fish. The systems examined include a panel of three general stressor and three contaminant class-specific markers.

In summary, this tiered, weight-of-evidence approach will produce accurate conclusions on stream ecosystem quality by providing realistic exposures at multiple levels of organization. This will reduce the likelihood for sampling and laboratory-induced artifacts stemming from changes in contaminant bioavailability, stressor interactions, or organism exposures. The tiered approach is relatively simplistic, cost-effective, and can be adapted for routine use by regulatory and environmental consulting personnel. This approach will improve the ability of assessors to determine the true cause and magnitude of water quality impairment and improve total maximum daily load (TMDL) assessments.

Start and end date: January 2002 – January 2005.

Presentations:

Burton, G.A. Jr. (2003). Measuring toxicity and bioaccumulation: Linking exposure and effects. Sediment Chemical Stability Workshop, San Diego, CA. <http://www.sediments.org>

Burton, G.A. Jr. (2003). Assessment of ecological impairment associated with sediments: issues and approaches. Keynote presentation at Abstr. Annual Meeting of the Latin American Society of Environ. Toxicol. Chem. Buenos Aires, Argentina.

Burton, G.A. Jr., Nguyen, L.T., Janssen C., McWilliam R., Bossuyt B., Beltrami M., Baudo R., Green A. (2003). Sediment quality assessments: Strategically integrating multiple lines-of-evidence to improve decision making. Abstr. Annual Meeting of the Latin American Society of Environ. Toxicol. Chem. Buenos Aires, Argentina. (Invited)

Burton, G.A. Jr. (2003). Developing realistic assessment guidelines for sediment using benthic colonization and short term *in situ* responses. Abstr. Annual Meeting of the Latin American Society of Environ. Toxicol. Chem. Buenos Aires, Argentina. (Invited)

Custer, K.W., Burton, G.A. Jr. (2004). Use of indigenous species in field toxicity identification evaluation (TIE) chambers. Abstract presented at the Annual Meeting of the North American Benthological Society, Vancouver, British Columbia.

Roberts, A.P., Clements, W.H., Burton, G.A. Jr., and Oris, J.T. (2004). Gene expression in fish as an indicator of contaminant exposure. Poster presented at 2004 SETAC-NA Annual Meeting, Portland, OR.

Burton, G.A., Custer, K., Geyer, S., Nguyen, L.T., Janssen, C., McWilliam, R., Bossuyt, B., Beltrami, M., Baudo, R., Green, A. (2004). Identification of stressor effects using *in situ* exposures of species, populations and communities. Abstract presented at the Annual Meeting of Soc. Environ. Toxicol. Chem, Prague, Czechoslovakia.

Custer, K.W., Burton, G.A. (2004). Use of indigenous species in field toxicity identification evaluation (TIE) chambers. Abstract Presented at Annual Meeting World Congress, Soc. Environ. Toxicol. Chem. Portland, OR.

Geyer, S., Burton, G. A. (2004). Optimization of an *in situ* Toxicity Identification Evaluation device. Abstract presented at Annual Meeting World Congress, Soc. Environ. Toxicol. Chem. Portland, OR

Roberts, A.P., Oris, J.T., Clements, W.H., and Burton, G.A. Jr. (2005). Development and field-validation of a molecular biomarker approach to exposure assessment. Presentation at SETAC-Europe Meeting, Lille, France.

Peer-reviewed publication(s):

Burton, G.A Jr, Nordstrom, J.F. (2004). An *in situ* toxicity identification evaluation method. I. Lab Validation. *Environ Toxicol Chem* 23: 2844-2850.

Burton, G.A Jr, Nordstrom, J.F. (2004). An *in situ* toxicity identification evaluation method. II. Field Validation. *Environ Toxicol Chem* 23: 2851-2855.

Burton, G.A. Jr., Greenberg, M.S., Rowland, C.D., Irvine, C.A., Lavoie, D.R., Brooker, J.A., Eggert, L.M., Raymer, D.F.N., McWilliam, R.A. (2005). *In situ* exposures using caged organisms: a multi-compartment approach to detect aquatic toxicity and bioaccumulation. *Environ. Pollut.* 134(1): 133-144.

Other publication(s):

Publications in preparation:

Crane M, G. Allen Burton, Joseph Culp, Marc S. Greenberg, Kelly R. Munkittrick, Rui G.L.G. Ribeiro, Michael H. Salazar and Sylvie D. St-Jean. Role of *in situ* Approaches for Environmental Assessment and Management. Burton GA Jr, Baird D, Culp J, Maltby L. (eds.) *In situ* Based Effects Monitoring: Linkages to Ecological Consequences. Society of Environ Toxicol Chem. Publ., Pensacola, FL. (Submitted).

Roberts, A.P., Oris J.T., Burton G.A., Clement W.H.. Gene expression in caged fish as an indicator of contaminant exposure in stream. *Environ. Toxicol Chem.* (Submitted).

Sponsors in addition to the LRI: None.

Abstract revision date: January 2006.