



Seneca Lake Guardian Comments on Seneca Dairy Systems, Phase 1 Galvanizing Plant

Comments to Seneca County IDA and Town of Romulus Board and Planning Board

Seneca Lake Guardian (SLG) has reached out to internationally known experts in hot dip galvanizing and industrial storm water management. Their CVs and analyses are attached. We have summarized their questions and comments below:

Hot Dip Galvanizing

JOHN F. MALONE, President (CV attached)
GALVANIZING CONSULTANTS INC.

Galvanizing Consultant, Inc. with more than 45 years of experience in plant design, construction, inspection, project management, on-site training, development and business process reengineering in the field of galvanizing.

<http://galvanizingconsultants.org/>

While Mr. Malone feels that in general, this facility is well-designed, he has some outstanding issues that SLG concurs should be considered and addressed.

Summary of questions and suggestions for optimal safety of the public, environment, and employees of the proposed facility:

1. Need additional details on the coating that is being proposed for the containment areas.
"It has been our experience that coating per se can be breached through wear, dropped items, etc. and we would request how this concern can be addressed. The best material for containment liners in our professional opinion is ½' -5/8" welded polypropylene."
2. The tanks are welded polypropylene (First stage containment), The coating is the Second Stage Containment, and the concrete floor is the Third Stage. "We would suggest a 50-100mm polypro lapped liner under the concrete for the Fourth Stage."
3. The listing of tanks does not show the Acid Recovery tank(s). How many and where located?
4. The application states that there will be no storage tanks. This is highly unusual. If one or more are required they should be double walled and surrounded by a containment structure of appropriate size.
5. Additional information is requested on the acid regeneration system.

We think that Mr. Malone would be happy to discuss these issues with Fisher Associates.



Stormwater management

Richard Horner, PhD (CV attached)
University of Washington: Emeritus Research Associate Professor,
Departments of Landscape Architecture and Civil and Environmental Engineering and

Summary of suggestions/ concerns:

- 1.) The earlier documents describe infiltration basin capacity sufficient to eliminate all surface stormwater discharge, at least up to and including the 100-year, 24-hour precipitation event. In contrast, the later ones replace infiltration with lined and underdrained bioretention.^[1] These management practices are not equivalent in their ability to control runoff water quantity and quality. A lined bioretention cell will reduce the volume and pollutant mass loading discharged much less than the originally planned infiltration basin; because, without infiltration, the water loss will be limited to what occurs by evapotranspiration alone. The change apparently occurred because it was recognized that the groundwater table is too high to permit an excavated infiltration basin. The confusion surrounding this point signifies carelessness.
- 2.) With the switch from infiltration to lined bioretention, the more recent documents do not present estimates of the probable performance of the modified system; *i.e.*, there is no statement equivalent to the original claim that the system would eliminate all surface stormwater discharge, at least up to and including the 100-year, 24-hour precipitation event. Those evaluating the project hence have no basis to judge its likely effectiveness. The proponent is obligated to assure reviewers that the situation has been comprehensively and carefully analyzed and to demonstrate with the best available evidence how well the proposed system is expected to work.
- 3.) Industrial plants working with large quantities of heavy metals, like zinc, have a way of releasing them to the outdoors through doors, gaps, track-out by vehicles, etc. There, they are not only air pollutants but can become stormwater pollutants toxic to aquatic life too when entrained in runoff. While this plan is quite impressive, it does not represent everything that could be done. The entire indoor manufacturing facility could be put under negative pressure. Special measures could be applied to interdict releases when doors open and vehicles transit, backed up by practices to recover as much of any release as possible.
- 4.) Legacy Contaminants from the Former Seneca Army Depot: The May 1 document lists approximately 15 categories of such pollutants, representing many individual chemicals and other substances. The documents are less complete in elucidating how they will be prevented from being mobilized into stormwater runoff. This is another area that requires detailed elaboration to inform proper judgments regarding the project.
- 5.) Please clarify the applicant's goals of having no off-site releases of sediments and other construction-related pollutants and then detail how the applicant intends to commit to the specific management practices capable of achieving these goals.



Seneca Lake Guardian's goal is to assure that the facility is designed in such a way that it minimizes all risk to the public, the environment, and the employees of the facility. We hope these comments help improve the plans.

Seneca Lake Guardian continues to have concerns about Phase 2 and 3; the mill/ weld facility. SLG will attempt to seek outside expert advice regarding this build out, as soon as information is provided.

Please contact Mary Anne Kowalski, Research Director, Seneca Lake Guardian if you have any questions.



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DOMESTIC AND INTERNATIONAL

www.galvanizingconsulting.com

JOHN F. MALONE, PRESIDENT

October 7, 2019

TO: Yvonne Taylor

FROM: John F. Malone – GCI

**RE: Proposed Hot
Dip Galvanizing Facility – Seneca NY**

Dear Yvonne,

Galvanizing Consultants Inc., a Nevada Corporation, conducting business from Whitsett, NC was asked to comment on the environmental risks on a proposed hot dip galvanizing facility in Seneca, NY. GCI has been in business for over 50 years and is considered to be the independent leader in galvanizing consulting. We have not charged for, nor been compensated for our opinions in this matter and have no prior or current business connections to any party to this matter.

We have reviewed the proposal in depth and, based on the submissions which we have reviewed our professional conclusions are as follows:

1. The proposed facility, by current galvanizing standards, is a very small facility with very limited potential for environmental impact.
2. The kettle/tank sizes, as submitted are approximately 11'1" x 7'7" x 3' 11" with each chemical tank holding approximately 5600 gallons of liquid each.
3. The average galvanizing facility today has tanks 50+' x 8' wide x 10' deep containing about 30,000 gallons of liquid.
4. There are five principal environmental concerns arising from today's hot dip galvanizing operations.
 - a. Air Pollution
 - b. Ground water pollution from accidental spillage
 - c. Discharge of chemical waste into private or municipal treatment facilities
 - d. Storm water discharge
 - e. Disposal of waste acid

5. Air Pollution is of two types. Acid/Caustic/Flux fumes emitted from the acid tanks and Particulate Emissions emitted from the galvanizing kettle. Both of these sources are addressed by sophisticated filtration systems and negative air containment devices that far exceed current regulations and pose no environmental impact.
6. Ground Water Pollution from accidental spillage/tank rupture is addressed by total containment of a size that is capable of holding the simultaneous rupture of all tanks. This far exceeds the normal standard of 1.5X -2X the volume of the largest tank. This is oversized and will pose no environmental impact.
7. Discharge of Chemical waste. There is no plan to discharge any chemical to the wastewater stream other than gray water from the lavatories and in the event of a spill there are no floor drains in the facility that could carry the spill. There is no anticipated environmental impact from this.
8. Storm Water Pollution. Based on the submitted plans the Storm Water System design is far more than is normally required with large rip rap check dams, infiltration basin, and grassed swales leading to an outlet to the creek. With the majority of the finished product being stored inside under cover, new galvanizing will not be subjected to environmental exposure. If it were, the amount of actual zinc, zinc oxide, zinc hydroxide, and/or zinc carbonate that would be contained in storm water would be far below threshold limits and will be totally contained prior to entry to the creek. There has been some concern regarding the toxicity of zinc to aquatic life but in our professional opinion this facility presents no adverse environmental impact. It should be noted that docks, piers, boat trailers, sheet pilings, etc are routinely utilized in lake and stream applications with no adverse effects from the zinc.
9. Waste Acid Disposal. In accordance with the submitted material, waste acid will be regenerated on site with only small amounts of waste acid being transported at extended intervals by licensed haulers to appropriate disposal areas.

There are several areas that we would like some additional information regarding:

1. Additional details on the coating that is being proposed for the containment areas. It has been our experience that coating per se can be breached through wear, dropped items, etc. and we would request how this concern can be addressed. The best material for containment liners in our professional opinion is ½' -5/8" welded polypropylene .
2. The tanks are welded polypropylene (First stage containment), The coating is the Second Stage Containment, and the concrete floor is the Third Stage. We would suggest a 50-100mm polypropylene lined liner under the concrete for the Fourth Stage.
3. The listing of tanks does not show the Acid Recovery tank(s). How many and where located?
4. The application states that there will be no storage tanks. This is highly unusual. If one or more are required they should be double walled and surrounded by a containment structure of appropriate size.
5. Additional information is requested on the acid regeneration system.

In conclusion, if constructed in accordance with the submitted proposals, it is our professional

opinion that this facility is a well-designed environmentally friendly facility that poses no environmental risks to the area or the area's water supply.

Respectfully submitted,

John F. Malone -GCI

JOHN F. MALONE
GALVANIZING CONSULTANTS INC.
687 Winners Choice Drive
Whitsett, NC 27377
336-603-4218

PROFESSIONAL CV

EDUCATION - Graduate 1961 - NY State Institute of Applied Arts & Sciences - A.A.S. .Civil Engineering

Graduate 1972 - Institute of Applied Technology - Certified Nuclear Coatings Technician

Graduate National Association of Corrosion Engineers Resident Courses I, II, & IV Corrosion 1972, Corrosion Control by Protective Coatings 1974, Cathodic Protection

EXPERIENCE - **GALVANIZING CONSULTANTS INC. - 1987-Pres. President.** Provide consulting services to the engineering, galvanizing, and manufacturing industries regarding all phases of hot dip galvanizing. Work includes, expert witness testimony, QA/QC procedures, marketing studies, failure analysis, implementation of marketing strategies, sales and marketing training, educational seminars, technical research, plant design and layouts, project management, duplex facility design and construction, field investigations, etc.

VICE PRESIDENT/CHIEF ENGINEER - Duncan Galvanizing Corp. - 1973-1987. Was responsible for operation, research, QA/QC, and marketing strategies for a highly successful major New England Galvanizer producing in excess of 20,000,000 lbs. per year. Developer of the Colorgalv duplex process.

ASSOC. PROFESSOR- ADJUNCT FACULTY -University of Mass. - 1986-2006 - Have taught Construction Materials, Building Code Compliance, and Industrial and Commercial Construction Courses in Continuing Education curriculum 2 semesters per year. Department chairman 2003-2006.

VP/GENERAL SUPT. - Arco Steel Erection - 1971-73. Was responsible for turn key construction of hot dip galvanized framed buildings throughout New England. Total project responsibility for this period exceeded \$35 million.

PROJECT ENGINEER - Armco Steel Corporation – Middletown, Ohio – 1966-71. Responsible for design and installation of galvanized sheet steel construction products, bridges, pilings, bin type retaining walls, etc.

CHIEF INSPECTOR – Andrews & Clark, Volmer Associates, NYC – 1964-1966 – Served as Chief Construction Inspector on \$30 million bridge and highway construction project.

SGT/SP 5 – US Army Combat Engineers– 1962-1964

**CERTIFICATIONS/
LICENSES -**

Licensed Construction Supervisor (MA), Certified Nuclear Coatings Technician
Registered Arbitrator - American Registry of Arbitrators, Voting Member ASTM.

OTHER -

Noted author/speaker for matters related to Hot Dip Galvanizing. Has conducted over 1,000 seminars for Federal, State, and private engineers relating to specifying, producing, and inspecting hot dip galvanized steel. Mr. Malone is a long time member of the National Education Association and the Mass. Teacher's Assoc. He has conducted

intensive seminars on behalf for the American Galvanizers Association on a regular basis for their members. Recently served as one of 60 experts recruited from around the world to serve on a two year Delphi study of the industry. Taught graduate courses in hot dip galvanizing at the University of Wisconsin in 1974-1978, and MIT in 1977. Mr. Malone is considered to be the leading expert on duplex coatings (Paint and powder over HDG) in the United States and one of the leading international authorities on hot dip galvanizing.

PERSONAL

Married, 8 children, 11 grandchildren

SENECA DAIRY SYSTEMS GALVANIZING PLANT PROPOSAL

Preliminary Assessment

By Richard Horner
October 3, 2019

Main Issue for My Consideration—the Stormwater Management System

The documents dated May 1, 2019 and July 9, 2019 versus those issued on August 3, 2019 and September 9, 2019 present two different elements as the principal components of the stormwater management system. The earlier documents describe infiltration basin capacity sufficient to eliminate all surface stormwater discharge, at least up to and including the 100-year, 24-hour precipitation event. In contrast, the later ones replace infiltration with lined and underdrained bioretention.¹ These management practices are not equivalent in their ability to control runoff water quantity and quality. A lined bioretention cell will reduce the volume and pollutant mass loading discharged much less than the originally planned infiltration basin; because, without infiltration, the water loss will be limited to what occurs by evapotranspiration alone.

The change apparently occurred because it was recognized that the groundwater table is too high to permit an excavated infiltration basin. The bioretention cell that replaces it is excavated too, and must be separated from the water table by a liner and fitted with underdrains to convey the water on to the pond. It is beyond my understanding how this fundamental characteristic (high groundwater), if true, escaped attention much earlier. The May 1 document describes 50 percolation tests performed in the vicinity of the prospective infiltration basin, showing acceptable infiltration rates and separation to bedrock, with no mention of encountering groundwater.

The confusion surrounding this point signifies carelessness, of which it is not the only example. The June 18, 2019 letter from Fisher, contained in the July 9 document, questioned a huge inconsistency in the purported size of the originally planned infiltration basin: is it to be 600,000 or 60,000 cubic feet in volume? The response was that the former number is correct.

With the switch from infiltration to lined bioretention, the more recent documents do not present estimates of the probable performance of the modified system; *i.e.*, there is no statement equivalent to the original claim that the system would eliminate all surface stormwater discharge, at least up to and including the 100-year, 24-hour precipitation event. Those evaluating the project hence have no basis to judge its likely effectiveness.

With these criticisms stated, it is my opinion that the system is at least potentially protective of aquatic resources. While not as effective as infiltration or unlined bioretention, lined bioretention does capture pollutants as they pass through the approximately 30-inch soil column. It does reduce both the volume of water (by roughly 30 percent overall) and the concentrations

¹ Both proposals follow the major element with a wet extended-detention pond and grass swale before discharge to Reeder Creek.

and total mass loadings of pollutants. Moreover, the system is conceived as a treatment train, with a wet pond and grass swale adding pollutant attenuation (and some additional volume reduction). The key point, though, is that the proponent is obligated to assure reviewers that the situation has been comprehensively and carefully analyzed and to demonstrate with the best available evidence how well the proposed system is expected to work.

Other Points

Industrial plants working with large quantities of heavy metals, like zinc, have a way of releasing them to the outdoors through doors, gaps, track-out by vehicles, etc. There, they are not only air pollutants but can become stormwater pollutants toxic to aquatic life too when entrained in runoff. The proponent exhibits a fair degree of recognition of this potential and offers measures to counteract it. Proposed controls include acid tanks under negative pressure, fume scrubber, bag house, HEPA filters, and carbon filters. While this plan is quite impressive, it does not represent everything that could be done. The entire indoor manufacturing facility could be put under negative pressure. Special measures could be applied to interdict releases when doors open and vehicles transit, backed up by practices to recover as much of any release as possible.

A former military base has high potential to present problems of legacy contaminants. The May 1 document lists approximately 15 categories of such pollutants, representing many individual chemicals and other substances. The documents are less complete in elucidating how they will be prevented from being mobilized into stormwater runoff. This is another area that requires detailed elaboration to inform proper judgments regarding the project.

The construction phase presents potential water pollution problems while the facility is being built and before it goes into operation. While the Preliminary Stormwater Management Plan in the May 1 document is more complete than other plans I have seen at the same stage of project development, it should be further detailed to aid in making a confident evaluation. One way to do so would be to state goals of having no off-site releases of sediments and other construction-related pollutants and then committing to the specific management practices capable of achieving these goals.

Curriculum Vitae

HORNER, Richard Ray

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University of Washington:
Emeritus Research Associate Professor,
Departments of Landscape Architecture and Civil
and Environmental Engineering and
Sole Proprietor Consultant

EDUCATION

- 1976 - 1978 University of Washington, Seattle, Washington; Ph.D. (Civil Engineering)
- 1965 - 1966 University of Pennsylvania, Philadelphia, Pennsylvania; M.S. (Mechanical Engineering)
- 1961 - 1965 University of Pennsylvania, Philadelphia, Pennsylvania; B.S. *Cum Laude* (Mechanical Engineering)

HONORS AND AWARDS

Augustus Trask Ashton Scholarship, University of Pennsylvania, 1961 - 65
Annual Academic Honors, University of Pennsylvania, 1961 - 65
Tau Beta Pi National Engineering Honor Society
National Science Foundation Traineeship, University of Pennsylvania, 1965 - 66

EMPLOYMENT

- 1986 - Present Richard R. Horner, Sole Proprietor (offering services in environmental engineering and science)
- 2011 - Present University of Washington, Seattle, Washington
Emeritus Research Associate Professor
- 1981 - 2011 University of Washington, Seattle, Washington
Research Associate Professor
- 1986 - 1990 King County, Seattle, Washington
Coordinator of Puget Sound Wetland and Stormwater Management Research Program (part-time; continued under contract to University of Washington)
- 1969 - 1981 Northampton Community College, Bethlehem, Pennsylvania
Engineering Department (Coordinator, 1971 - 73 and 1978 - 79)
Environmental Studies Department (Co-coordinator, 1973 - 76 and 1978 - 1981)
Professor, 1978 - 1981; Associate Professor, 1973 - 78;
Assistant Professor, 1969 - 73,
Leave of Absence, 1977 - 78; Sabbatical Leave, 1976 - 77
- 1977 - 1978 University of Washington, Seattle, Washington

Department of Civil Engineering
 Research Engineer, Highway Runoff Water Quality Project

1976 - 1977 University of Washington, Seattle, Washington
 Department of Civil Engineering and Institute for Environmental Studies
 Research Assistant and Teaching Assistant

1966 - 1969 Exxon Research and Engineering Company, Florham Park, New Jersey;
 Project Engineer

1965 - 1966 University of Pennsylvania, Philadelphia Pennsylvania
 Department of Mechanical Engineering; Research Assistant

NATIONAL COMMITTEES

National Academy of Sciences Panel on Reducing Stormwater Discharge Contributions to Water Pollution, 2007-2008.

Technical Advisory Panel for Water Environment Federation projects on Decentralized Stormwater Controls for Urban Retrofit and Combined Sewer Overflow Reduction, 2005-2007.

Co-chair, Engineering Foundation Conference on Effects of Watershed Development and Management on Aquatic Ecosystems, 1996.

National Academy of Sciences Panel on Costs of Damage by Highway Ice Control, 1990-91.

U.S. Environmental Protection Agency National Wetland Research Planning Panel, 1988, 1991.

RESEARCH PROJECTS

* Principal Investigator.

** Co-Principal Investigator. (Where undesignated, I was a member of the faculty investigation team without principal investigator status).

Effects of Waterfront Stormwater Solutions Prototypes on Water Quality Runoff in Puget Sound near Pomeroy Park - Manchester Beach; Washington Sea Grant; \$148,838; 2015-17.

Development of a Stormwater Retrofit Plan for Water Resources Inventory Area (WRIA) 9 and Estimation of Costs for Retrofitting all Developed Lands of Puget Sound; U.S. Environmental Protection Agency and King County (WA); \$243,619; 2010-13.

Ultra-Urban Stormwater Management; Seattle Public Utilities; \$1,130,000; 1999-2008.*

Roadside Vegetation Management Study; Washington State Department of Transportation; \$50,000; 2004-05.

The Ecological Response of Small Streams to Stormwater and Stormwater Controls; U. S. Environmental Protection Agency, cooperating with Watershed Management Institute (Crawfordsville, FL); \$579,117; 1995-2003.*

Vegetated Stormwater Facility Maintenance; Washington State Department of Transportation; \$86,000; 1998-2000.*

Roadside Drainage System Management for Water Quality Improvement; King and Snohomish (WA) Counties; \$70,000; 1997-2000.*

Standardization of Wet Weather Protocols for Stream Impact and Treatment Technology Performance Assessments; Water Environment Research Foundation, cooperating with Water Research Center (Huntington Valley, Pennsylvania) and University of Illinois; \$125,000; 1996-97.

Road Shoulder Treatments for Water Quality Protection; Washington State Department of Transportation and King County Roads Division; \$90,000; 1995-96.**

Control of Nuisance Filamentous Algae in Streams by Invertebrate Grazing; National Science Foundation; \$193,691; 1994-96.

Criteria for Protection of Urban Stream Ecosystems; Washington Department of Ecology; \$230,000; 1994-96.

Region-Specific Time-Scale Toxicity in Aquatic Ecosystems; Water Environment Research Foundation, cooperating with Water Research Center (Huntington Valley, Pennsylvania) and University of Illinois; \$670,000; 1994-96.

Establishing Reference Conditions for Freshwater Wetlands Restoration; U. S. Environmental Protection Agency; \$75,000; 1993-97.

Stormwater Management Technical Assistance to Local Governments; Washington Department of Ecology; \$115,000; 1992-93.*

Center for Urban Water Resources Management; Washington Department of Ecology; \$336,490; plus \$157,400 matching support from seven local governments; 1990-93.*

University of Washington Cooperative Unit for Wetlands and Water Quality Research; King County, Washington; amount varied by year; 1987-95.*

Assessment of Portage Bay Combined Sewer Overflows; City of Seattle; \$132,676; 1990-91.*

Velocity-Related Critical Phosphorus Concentrations in Flowing Water, Phase 3; National Science Foundation; \$108,332; 1988-90.**

Design of Monitoring Programs for Determining Shellfish Bed Bacterial Contamination Problems; Washington Department of Ecology; \$12,000; 1988-89.*

Puget Sound Protocols Development; Tetra Tech, Inc. and Puget Sound Estuary Program; \$10,144; 1988.*

Improving the Cost Effectiveness of Highway Construction Site Erosion/Pollution Control, Phase 2; Washington State Department of Transportation; \$97,000; 1987-89.*

Wetland Mitigation Project Analysis; Washington State Department of Transportation; \$74,985; 1987-89.*

Lake Chelan Water Quality Assessment; Harper-Owes, consultant to Washington State Department of Ecology; \$42,977; 1986-88.

Quality of Management of Silver Lake; City of Everett; \$67,463; 1986-88.

Effectiveness of WSDOT Wetlands Creation Projects; Washington State Department of Transportation; \$42,308; 1986-87.*

Improving the Cost Effectiveness of Highway Construction Site Erosion/Pollution Control; Washington State Department of Transportation; \$41,608; 1986-87.*

Management Significance of Bioavailable Phosphorus in Urban Runoff; State of Washington Water Research Center and Municipality of Metropolitan Seattle; \$32,738; 1986-87.**

Environmental Monitoring and Evaluation of Calcium Magnesium Acetate (CMA); Transportation Research Board of National Academy of Sciences; \$199,943; 1985-87.*

Conceptual Design of Monitoring Programs for Determination of Water Quality and Ecological Change Resulting from Nonpoint Source Discharges; Washington State Department of Ecology; \$49,994; 1985-86.**

Development of an Integrated Land Treatment Approach for Improving the Quality of Metalliferous Mining Wastewaters; Washington Mining and Mineral Resources Research Institute; \$4,000; 1985-86.*

Preliminary Investigation of Sewage Sludge Utilization on Roadsides; Washington State Department of Transportation; \$6,664; 1984-85.*

Source Control of Transit Base Runoff Pollutants; Municipality of Metropolitan Seattle; \$26,867; 1984-85.**

Lake Sammamish Future Water Quality; Municipality of Metropolitan Seattle; \$28,500; 1984-85.

Implementation of Highway Runoff Water Quality Research Results; Washington State Department of Transportation; \$13,998; 1984-85.*

Performance Evaluation of a Detention Basin and Coalescing Plate Oil Separator for Treating Urban stormwater Runoff; Washington State Water Research Center; 1984-85; \$11,724.**

Velocity-Related Critical Phosphorus Concentrations in Flowing Water, Phase 2; National Science Foundation; \$99,088; 1983-85.**

Development of a Biological Overland Flow System for Treating Mining Wastewaters; Washington Mining and Mineral Resources Research Institute; \$6,030; 1983-84.*

Nutrient Contributions of Agricultural Sites to the Moses Lake System; Moses Lake Conservation District; \$15,039; 1982-84.*

Planning Implementation of Runoff Water Quality Research Findings; Washington State Department of Transportation; \$12,735; 1982-83.**

Transport of Agricultural Nutrients to Moses Lake; Brown and Caldwell Engineers; \$22,725; 1982-83.**

Investigation of Toxicant Concentration and Loading Effects on Aquatic Macroinvertebrates; University of Washington Graduate School Research Fund; \$3,788; 1982.*

Sampling Design for Aquatic Ecological Monitoring; Electric Power Research Institute; \$542,008; 1981-86.

Velocity-Related Critical Phosphorus Concentrations in Flowing Water; National Science Foundation; \$70,310; 1980-82.

Highway Runoff Water Quality; Washington State Department of Transportation; \$461,176; 1977-82.

BOOKS

Shaver, E., R. Horner, J. Skupien, C. May, and G. Ridley. *Fundamentals of Urban Runoff Management: Technical and Institutional Issues*, 2nd Edition. U.S. Environmental Protection Agency, Washington, D.C., 2007.

Azous, A. L. and R. R. Horner. *Wetlands and Urbanization: Implications for the Future*. Lewis Publishers, Boca Raton, FL, 2000.

Horner, R. R., J. J. Skupien, E. H. Livingston, and H. E. Shaver. *Fundamentals of Urban Runoff Management: Technical and Institutional Issues*. Terrene Institute, Washington, D. C., 1994.

REFEREED JOURNAL PUBLICATIONS AND BOOK CHAPTERS

Wright, O.M., E. Istanbuloglu, R.R. Horner, C.L. DeGasperi, and J. Simmonds. 2018. Is There a Limit to Bioretention Effectiveness? Evaluation of Stormwater Bioretention Treatment Using a Lumped Ecohydrologic Watershed Model and Ecologically-Based Design Criteria. *Hydrological Processes* 2018:1-17.

Chapman, C. and R.R. Horner. Performance Assessment of a Street-Drainage Bioretention System. *Water Environment Research* 82(2): 109-119, 2010.

Horner, R. R. et al. Structural and Non-Structural Best Management Practices (BMPs) for Protecting Streams. In *Linking Stormwater BMP Designs and Performance to Receiving Water Impact Mitigation*, B. K. Urbonas (ed.), American Society of Civil Engineers, New York, pp. 60-77, 2002.

Comings, K. J., D. B. Booth, and R. R. Horner. Storm Water Pollutant Removal by Two Wet Ponds in Bellevue, Washington. *Journal of Environmental Engineering* 126(4):321-330, 2000.

Anderson, E. L., E. B. Welch, J. M. Jacoby, G. M. Schimek, and R. R. Horner. Periphyton Removal Related to Phosphorus and Grazer Biomass Level. *Freshwater Biology* 41:633-651, 1999.

- Horner, R. R., D. B. Booth, A. Azous, and C. W. May. Watershed Determinants of Ecosystem Functioning. In *Effects of Watershed Development and Management on Aquatic Ecosystems*, L. A. Roesner (ed.), American Society of Civil Engineers, New York, pp. 251-274, 1997.
- Horner, R.R. Toward Ecologically Based Urban Runoff Management. In *Urban Runoff and Receiving Systems*, E.E. Herricks (ed.), Lewis Publishers, Boca Raton, Florida, pp. 365-378, 1995.
- Walton, S. P., E. B. Welch, and R. R. Horner. Stream Periphyton Response to Grazing and Changes in Phosphorus Concentration. *Hydrobiologia* 302:31-46, 1994.
- Reinelt, L. E. and R. R. Horner. Pollutant Removal from Stormwater Runoff by Palustrine Wetlands Based on a Comprehensive Budget. *Ecological Engineering* 4:77-97, 1995.
- Horner, R.R. and M.V. Brenner. Environmental Evaluation of Calcium Magnesium Acetate for Highway Deicing Applications. *Resources, Conservation and Recycling* 7:213-237, 1992.
- Brenner, M.V. and R.R. Horner. Effects of Calcium Magnesium Acetate on Dissolved Oxygen in Water. *Resources, Conservation and Recycling* 7:239-265, 1992.
- Reinelt, L.E., R.R. Horner, and R. Castensson. Nonpoint Source Water Quality Management: Improving Decision-Making Information through Water Quality Monitoring. *Journal of Environmental Management* 34:15-30, 1992.
- Horner, R.R., M.V. Brenner, R.B. Walker, and R.H. Wagner. Environmental Evaluation of Calcium Magnesium Acetate. In *Calcium Magnesium Acetate (CMA): An Emerging Bulk Chemical for Multi-purpose Environmental Applications*, D.L. Wise, Y.A. Lavendis, and M. Metghalchi (eds.), Elsevier Science Publishers B.V., The Netherlands, pp. 57-102, 1991.
- Horner, R.R., E.B. Welch, M.R. Seeley, and J.M. Jacoby. Responses of Periphyton to Changes in Current Velocity, Suspended Sediments and Phosphorus Concentration. *Freshwater Biology* 24:215-232, 1990.
- Horner, R.R. Long-Term Effects of Urban Stormwater on Wetlands. In *Design of Urban Runoff Quality Controls*, L.A. Roesner, B. Urbonas, and M.B. Sonnen (eds.), American Society of Civil Engineers, New York, pp. 451-466, 1989.
- Welch, E.B., R.R. Horner, and C.R. Patmont. Phosphorus Levels That Cause Nuisance Periphyton: A Management Approach. *Water Research* 23(4):401-405, 1989.
- Butkus, S.R., E.B. Welch, R.R. Horner, and D.E. Spyridakis. Lake Response Modeling Using Biologically Available Phosphorus. *Journal of the Water Pollution Control Federation* 60(9):1663-1669, 1988.
- Reinelt, L.E., R.R. Horner, and B.W. Mar. Nonpoint Source Pollution Monitoring Program Design. *Journal of Water Resources Planning and Management* 114(3):335-352, 1988.
- Welch, E.B., J.M. Jacoby, R.R. Horner, and M.R. Seeley. Nuisance Biomass Levels of Periphytic Algae in Streams. *Hydrobiologia*, 157:161-168, 1988.

- Reinelt, L.E., R. Castensson, and R.R. Horner. Modification of an Existing Monitoring Program to Address Nonpoint Source Pollution, A Case Study of the Svarta River Basin, Sweden. *Vatten* 43:199-208, 1987.
- Mar, B.W., R.R. Horner, J.S. Richey, D.P. Lettenmaier, and R.N. Palmer. Data Acquisition, Cost-Effective Methods for Obtaining Data on Water Quality. *Environmental Science and Technology* 20(6):545-551, 1986.
- Horner, R.R., J.S. Richey, and G.L. Thomas. A Conceptual Framework to Guide Aquatic Monitoring Program Design for Thermal Electric Power Plants. *Rationale for Sampling and Interpretation of Ecological Data in the Assessment of Freshwater Ecosystems*, Special Technical Publication 894 of the American Society for Testing and Materials, Philadelphia, Pennsylvania, pp. 86-100, 1986.
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PRESENTATIONS AND DISCUSSIONS

*Presented by a co-author. In all other cases, I presented the paper.

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An Overview of Storm Runoff Water Quality Control. Invited presentation at the American Water Resources Association Workshop on Forest Conversion; LaGrande, Washington; November 1988.

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Long-Term Effects of Urban Stormwater on Wetlands. Invited presentation at the Engineering Foundation Conference on Urban Stormwater; Potosi, Missouri; July 1988.

Highway Construction Site Erosion and Pollution Control: Recent Research Results. Invited presentation at the 39th Annual Road Builders' Clinic; Moscow, Idaho; March 1988.

Urban Stormwater and Puget Trough Wetlands. Presented at the 1st Annual Puget Sound Water Quality Authority Research Meeting; Seattle, Washington; March 1988 (prepared with F.B. Gutermuth, L.L. Conquest, and A.W. Johnson).

Preliminary Comparative Risk Assessment for Hanford Waste Sites. Presented at Waste Management 88; Tucson, Arizona; February 1988 (prepared with R.F. Weiner and J. Kettman).*

What Goes on at the Hanford Nuclear Reservation? Invited presentation at the Northwest Association for Environmental Studies Annual Meeting; Western Washington University, Bellingham, WA; November 1987.

The Puget Sound Wetlands and Stormwater Management Research Program. Invited presentation at the Pacific Northwest Pollution Control Association Annual Meeting; Spokane, Washington; October 1987.

Design of Cost-Effective Monitoring Programs for Nonpoint Source Water Pollution Problems. Invited presentation at the American Water Resources Association, Puget Sound Chapter, Annual Meeting; Bellevue, Washington; November 1986.

A Review of Wetland Water Quality Functions. Invited plenary presentation at the Conference on Wetland Functions, Rehabilitation, and Creation in the Pacific Northwest: The State of Our Understanding; Port Townsend, Washington; May 1986.

- Nonpoint Discharge and Runoff session leader. American Society of Civil Engineers Spring Convention; Seattle, Washington; April 1986.
- Prevention of Lake Sammamish Degradation from Future Development. Invited presentation at the American Society of Civil Engineers Spring Convention; Seattle, Washington; April 1986.
- Design of Monitoring Programs for Nonpoint Source Water Pollution Problems. Invited presentation at the American Society of Civil Engineers Spring Convention; Seattle, Washington, April 1986 (prepared with L.E. Reinelt, B.W. Mar, and J.S. Richey).*
- Nonpoint Pollution Control Strategies for Moses Lake, Washington. Presented at the Fifth Annual Meeting of the North American Lake Management Society; Lake Geneva, Wisconsin; November 1985 (prepared with R.C. Bain, Jr., and L. Nelson).
- Response of Lake Sammamish to Urban Runoff Control. Presented at the Fifth Annual Meeting of the North American Lake Management Society; Lake Geneva, Wisconsin; November 1985 (prepared with J.I. Shuster, E.B. Welch, and D.E. Spyridakis).*
- A General Approach to Designing Environmental Monitoring Programs. Invited presentation at the Pacific Section AAAS Symposium on Biomonitors, Bioindicators, and Bioassays of Environmental Quality; Missoula, Montana; June 1985 (prepared with J.S. Richey and B.W. Mar).
- Panel Discussion on the Planning Process for Non-point Pollution Abatement Programs. Non-point Pollution Abatement Symposium; Milwaukee, Wisconsin; April 1985.
- Nutrient Transport Processes in an Agricultural Watershed. Presented at the Fourth Annual Meeting of the North American Lake Management Society; McAfee, New Jersey; October 1984 (prepared with E.B. Welch, M.M. Wineman, M.J. Adolfson, and R.C. Bain Jr.).*
- Nutrient Transport Processes in an Agricultural Watershed. Presented at the American Society of Limnology and Oceanography Annual Meeting; Vancouver, British Columbia; June 1984 (prepared with M.M. Wineman, M.J. Adolfson, and R.C. Bain, Jr.).
- Factors Affecting Periphytic Algal Biomass in Six Swedish Streams. Presented at the American Society of Limnology and Oceanography Annual Meeting; Vancouver, British Columbia; June 1984 (prepared with J.M. Jacoby and E.B. Welch).*
- A Conceptual Framework to Guide Aquatic Monitoring Program Design for Thermal Electric Power Plants. Presented at the American Society for Testing and Materials Symposium on Rationale for Sampling and Interpretation of Ecological Data in the Assessment of Freshwater Ecosystems; Philadelphia, Pennsylvania; November 1983 (prepared with J.S. Richey, and G.L. Thomas).
- Panel Discussion. Public Forum: Perspectives on Cumulative Effects; Institute for Environmental Studies; University of Washington; Seattle, Washington; August 1983.
- A Guide for Assessing the Water Quality Impacts of Highway Operations and Maintenance. Presented at the Transportation Research Board Annual Meeting; Washington, D.C.; January 1983 (prepared with B.W. Mar).

Assessment of Pollutant Loadings and Concentrations in Highway Stormwater Runoff. Presented at the Pacific Northwest Pollution Control Association Annual Meeting; Vancouver, British Columbia; November 1982 (prepared with B.W. Mar and L.M. Little).

Phosphorus and Velocity as Determinants of Nuisance Periphytic Biomass. Presented at the International Workshop on Freshwater Periphyton (SIL); Vaxjo, Sweden; September 1982 (prepared with E.B. Welch and R.B. Veenstra).*

The Development of Nuisance Periphytic Algae in Laboratory Streams in Relation to Enrichment and Velocity. Presented at the American Society of Limnology and Oceanography Annual Meeting; Raleigh, North Carolina; June 1982 (prepared with R.B. Veenstra and E.B. Welch).

A Predictive Model for Highway Runoff Pollutant Concentrations and Loadings. Presented at the Stormwater and Water Quality Model Users' Group Meeting; Alexandria, Virginia; March 1982 (prepared with B.W. Mar).

Stream Periphyton Development in Relation to Current Velocity and Nutrients. Presented at American Society of Limnology and Oceanography Winter Meeting; Corpus Christi, Texas; January 1979 (prepared with E.B. Welch).

A Comparison of Discrete Versus Composite Sampling of Storm Runoff. Presented at the Northwest Pollution Control Association Annual Meeting; Victoria, British Columbia; October 1978 (prepared with B.W. Mar and J.F. Ferguson).*

A Method of Defining Urban Ecosystem Relationships Through Consideration of Water Resources. Presented at UNESCO International Man and the Biosphere Project 11 Conference; Poznan, Poland; September 1977.

GRADUATE AND UNDERGRADUATE COURSES TAUGHT (University of Washington)

Civil and Environmental Engineering 552, Environmental Regulations; 8 quarters.

Landscape Architecture 590, Urban Water Resources Seminar; 3 quarters.

Landscape Architecture 522/523, Watershed Analysis and Design; 15 quarters.

Engineering 260, Thermodynamics; 1 quarter.

Engineering 210, Engineering Statics; 2 quarters.

Civil Engineering/Water and Air Resources 453, Water and Wastewater Treatment; 1 quarter.

Civil Engineering/Water and Air Resources 599, Analyzing Urbanizing Watersheds; 1 quarter.

CONTINUING EDUCATION SHORT COURSES TAUGHT (University of Washington; multiple offerings)

Infiltration Facilities for Stormwater Quality Control

Wetlands Ecology, Protection, and Restoration

Storm and Surface Water Monitoring

Fundamentals of Urban Surface Water Management

Applied Stormwater Pollution Prevention Planning Techniques

Construction Site Erosion and Pollution Control Problems and Planning

Construction Site Erosion and Pollution Control Practices

Construction Site Erosion and Sediment Control Inspector Training

Inspection and Maintenance of Permanent Stormwater Management Facilities

Biofiltration for Stormwater Runoff Quality Control

Constructed Wetlands for Stormwater Runoff Quality Control

LOCAL COMMITTEES

Stormwater Panel advising Puget Sound Partnership, 2007.

Technical Advisory Committee, City of Seattle Environmental Priorities Project, 1990-91.

Environmental Toxicology Graduate Program Planning Committee, University of Washington, 1990.

Habitat Modification Technical Work Group, Puget Sound Water Quality Authority, 1987.

Underground Injection Control of Stormwater Work Group, Washington State Department of Ecology, 1987.

Nonpoint Source Pollution Conference Advisory Committee, 1986-87.

Puget Sound Wetlands and Stormwater Management Research Committee, 1986-90.

Accreditation Review, University of Washington Department of Landscape Architecture, 1986.

Planning Committee for University of Washington Institute for Environmental Studies Forum on Perspectives on Cumulative Environmental Effects, 1983.

CONSULTING

Salmon-Safe, Inc.; assessment of sites for possible certification representing practices that protect salmon; 2004-present.

Puget Soundkeeper Alliance and Smith and Lowney, PLC, Seattle, Washington; Technical assistance in Clean Water Act legal cases; 1996, 2002-present.

Natural Resources Defense Council, Los Angeles, California; Technical and program analysis and testimony on legal cases involving municipal and industrial stormwater NPDES permit compliance; 1993-2016.

Santa Monica Baykeeper (now Los Angeles Waterkeeper); Technical and program analysis and testimony on legal cases involving municipal and industrial stormwater NPDES permit compliance; 1993-present.

Orange County Coastkeeper; Assistance with legal cases involving industrial and construction site pollution control and monitoring; 2001-present.

Lawyers for Clean Water; Assistance with legal cases involving stormwater discharges; 2004-2018.

Earthjustice; Report and testimony regarding Washington state municipal stormwater permit before Pollution Control Hearing Board; 2008, 2013; assessment of Washington, DC combined sewer overflow control plan; 2015.

Tulane Environmental Law Clinic; Assessment and declaration on a legal case involving discharge under an industrial stormwater permit; 2015.

San Diego Coastkeeper, San Diego, California; Technical and program analysis and testimony on potential legal cases involving municipal and industrial stormwater NPDES permit compliance; liaison with City of San Diego; 1996-2011 and 2019.

Stillwater Science and Washington Department of Ecology; Water quality modeling for Puget Sound Characterization, Phase 2; 2010-2011.

City of Seattle Public Utilities; Analysis of technical aspects of stormwater management program; 2000-2008.

Ventura Coastkeeper; Technical and program analysis and testimony on legal cases involving municipal and industrial stormwater NPDES permit compliance; 2010-2015.

San Diego Airport Authority; Peer review of consultant products, training; 2004-2006.

U. S. Federal Court, Central District of California; Special master in Clean Water Act case; 2001-2002.

Storm Water Pollution Prevention Program, City of San Diego; Advising on response to municipal stormwater NPDES program; 2001-2002.

Kerr Wood Leidel, North Vancouver, B.C.; subconsultant for Stanley Park (Vancouver, B.C.) Stormwater Constructed Wetland Design; 1997-1998.

Clean South Bay, Palo Alto, California; Technical and program analysis and testimony on potential legal cases involving municipal and industrial stormwater NPDES permit compliance; 1996.

Resource Planning Associates, Seattle, Washington; Assistance with various aspects of monitoring under Seattle-Tacoma International Airport's stormwater NPDES permit; 1995-1997.

Watershed Management Institute, Crawfordville, Florida; Writing certain chapters of guides for stormwater program development and implementation and maintenance of stormwater facilities; 1995-2003.

King County Roads Division, Seattle, Washington; Teaching two courses on construction erosion and sediment control; 1995.

Snohomish County Roads Division, Seattle, Washington; Teaching a course on construction erosion and sediment control; 1995.

Alaska Marine Lines, Seattle, Washington; Performance test of a sand filter stormwater treatment system; 1994-95.

Economic and Engineering Services, Inc., Bellevue, Washington; Assessment of the potential for water quality benefits through modifying existing stormwater ponds; technical advice on remedying operating problems at infiltration ponds; 1994-96.

Washington State Department of Transportation, Olympia, Washington; Teaching courses on construction erosion and sediment control; 1994.

City of Bellevue, Washington; Peer review of documents on potential erosion associated with a road project; analysis of stormwater quality data; 1993-95.

City of Kelowna, B. C., Canada; Teaching short courses on constructed wetlands and erosion and sediment control; 1993.

Oregon Department of Environmental Quality, Portland, Oregon; Technical review of Willamette River Basin Water Quality Study reports; 1992-93.

Whatcom County, Bellingham, Washington; Mediation on lakeshore development moratorium among county, water district, and local community representatives; 1993.

Boeing Commercial Airplane Company, Renton, Washington and Sverdrup Corporation, Kirkland, Washington (at request of City of Renton); Review of stormwater control system design; design of performance monitoring study for system; 1992-94.

Golder Associates, Redmond, Washington; Technical advisor for study of stormwater infiltration; 1992.

Smith, Smart, Hancock, Tabler, and Schwensen Attorneys, Seattle, Washington; Technical advice on a legal case involving a stormwater detention pond; 1992.

PIPE, Inc., Tacoma, Washington; Teaching a course on the stormwater NPDES permit; 1992.

CH2M-Hill, Inc., Bellevue, Washington and Portland, Oregon; Technical seminar on constructing wetlands for wastewater treatment; literature review on toxicant cycling in arid-region wetlands constructed for wastewater treatment; literature and data review on lake nutrient input reduction; expert panel on TMDL analysis for Chehalis River; 1989-1995.

Kramer, Chin and Mayo, Inc., Seattle, Washington; Watershed analysis in Washington County and Lake Oswego, Oregon; literature review in preparation for stormwater infiltration system design; literature review and contribution to design of constructed wetland for municipal wastewater treatment; 1989-1995.

Woodward-Clyde Consultants, Portland, Oregon and Oakland, California; Analysis of wetland capabilities for receiving urban stormwater; design of a constructed wetland for urban

stormwater treatment; technical advisor on Washington Department of Ecology and City of Portland stormwater manual updates; 1989-1995.

R.W. Beck and Associates, Seattle, Washington; Assessment of pollutant loadings and their reduction for one master drainage planning and two watershed planning efforts; 1989-92.

Boeing Computer Services Corporation, Bellevue, Washington; mediation among Boeing, citizens' group, and City of Bellevue on stormwater control system design; 1990.

Parametrix, Inc., Bellevue, Washington; Review of Kitsap County Drainage Ordinance; 1990.

U.S. Environmental Protection Agency, Duluth Laboratory; Review of certain provisions of WET 2.0 wetland functional assessment model; 1989.

King County Council, Seattle, Washington; Review of King County Surface Water Design Manual; 1989.

Port of Tacoma, Washington; Assessment of stormwater control strategies; 1989.

Municipality of Metropolitan Seattle, Seattle, Washington; Assessment of land treatment systems for controlling urban storm runoff water quality; 1988-1992.

Impact Assessment, Inc., La Jolla, California (contractor to Washington State Department of Ecology); Socioeconomic impact assessment of the proposed high-level nuclear waste repository at Hanford, Washington; 1987.

Technical Resources, Inc., Rockville, Maryland (contractor to U. S. Environmental Protection Agency); assessment of water treatment waste disposal at pulp and paper plants; 1987-88.

Dames and Moore, Seattle, Washington; analysis of the consequences of a development to Martha Lake; 1987.

Harper-Owes, Seattle, Washington; project oversight, data analysis, and review of limnological aspects for Lake Chelan Water Quality Assessment Study; 1986-88.

URS Corporation, Seattle, Washington and Columbus, Ohio; presentation of a workshop on nonpoint source water pollution monitoring program design; analysis of innovative and alternative wastewater treatment for Columbus; development of a stormwater utility for Puyallup, Washington; watershed analysis for Edmonds, Washington; 1986-88.

Entranco Engineers, Bellevue, Washington; environmental impact assessment of proposed highway construction; technical review of Lake Sammamish watershed management project; technical review of Capital Lake wetland development; 1981-82; 1987-88; 1990.

Washington State Department of Ecology, Olympia, Washington; review of literature on wetland water quality, preparation of conference plenary paper, and leading discussion group at conference; analysis in preparation for a Shoreline Hearing Board case; 1986-87.

Richard C. Bain, Jr., Engineering Consultant, Vashon Island, Washington; analysis of watershed data and development of a policy for septic tank usage near Moses Lake, Washington; 1984-87.

University of Washington Friday Harbor Laboratory; analysis of adjacent port development and preparation of testimony for Shoreline Hearing Board; 1986.

Washington State Department of Transportation and Morrison-Knudsen Company, Inc./H.W. Lochner, Inc., Joint Venture, Mercer Island, Washington; environmental assessment of disposal of excavated material by capping a marine dredge spoil dumping site; 1984.

Foster, Pepper, and Riviera Attorneys, Seattle, Washington; analysis and testimony on provisions to reduce pollutants in stormwater runoff from a site proposed for development; 1983.

Williams, Lanza, Kastner, and Gibbs Attorneys, Seattle, Washington; collection and analysis of water quality data to support a legal case and preparation of testimony; 1982.

Herrera Environmental Consultants, Seattle, Washington; lake data analysis and report preparation; 1982-83.

Brown and Caldwell Engineers, Seattle, Washington; data collection and analysis for watershed study; 1982-83.

City of Marysville, Washington; environmental impact assessment of proposed bridge construction; 1982-83.

F.X. Browne Associates, Inc., Lansdale, Pennsylvania; contributions to manual on lake restoration for U.S. Environmental Protection Agency; preparation of funding proposals and permits for lake restoration; lake data analysis; literature reviews and analysis of septic tank contributions to lake nutrient loading and availability of different forms of nutrients; 1980-83.

Reston Division of Prentice-Hall, Inc., Reston, Virginia; review of and contributions to texts on environmental technology; 1978-79.

Butterfield, Joachim, Brodt, and Hemphill Attorneys, Bethlehem, Pennsylvania; analysis of environmental impact statements; expert witness; 1973.

RICHARD R. HORNER, PH.D.

BACKGROUND AND EXPERIENCE

I have 52 years of professional experience, 44 teaching and performing research at the college and university level. For the last 41 years I have specialized in research, teaching, and consulting in the area of storm water runoff and surface water management.

I received a Ph.D. in Civil and Environmental Engineering from the University of Washington in 1978, following two Mechanical Engineering degrees from the University of Pennsylvania in 1965 and 1966. Although my degrees are all in engineering, I have had substantial course work and practical experience in aquatic biology and chemistry.

For 12 years beginning in 1981, I was a full-time research professor in the University of Washington's Department of Civil and Environmental Engineering. From 1993 until 2011, I served half time in that position and had adjunct appointments in two additional departments (Landscape Architecture and the College of the Environment's Center for Urban Horticulture). I spent the remainder of my time in private consulting through a sole proprietorship. My appointment became emeritus in late 2011, but I continue university research and teaching at a reduced level while maintaining my consulting practice.

My research, teaching, and consulting embrace all aspects of stormwater management, including determination of pollutant sources; their transport and fate in the environment; physical, chemical, and ecological impacts; and solutions to these problems through better structural and non-structural management practices.

I have conducted numerous research investigations and consulting projects on these subjects. Serving as a principal or co-principal investigator on more than 40 research studies, my work has produced three books, approximately 30 papers in the peer-reviewed literature, and over 20 reviewed papers in conference proceedings. I have also authored or co-authored more than 80 scientific or technical reports.

In addition to graduate and undergraduate teaching, I have taught many continuing education short courses to professionals in practice. My consulting clients include federal, state, and local government agencies; citizens' environmental groups; and private firms that work for these entities, primarily on the West Coast of the United States and Canada but in some instances elsewhere in the nation.

Over a 17-year period beginning in 1986 I spent a major share of my time as the principal investigator on two extended research projects concerning the ecological responses of freshwater resources to urban conditions and the urbanization process. I led an interdisciplinary team for 11 years in studying the effects of human activities on freshwater wetlands of the Puget Sound lowlands. This work led to a comprehensive set of management guidelines to reduce negative effects and a published book detailing the study and its results. The second effort involved an analogous investigation over 10 years of human effects on Puget Sound's salmon spawning and

rearing streams. These two research programs have had broad sponsorship, including the U.S. Environmental Protection Agency, the Washington Department of Ecology, and a number of local governments.

I have helped to develop stormwater management programs in Washington State, California, and British Columbia and studied such programs around the nation. I was one of four principal participants in a U.S. Environmental Protection Agency-sponsored assessment of 32 state, regional, and local programs spread among 14 states in arid, semi-arid, and humid areas of the West and Southwest, as well as the Midwest, Northeast, and Southeast. This evaluation led to the 1997 publication of “Institutional Aspects of Urban Runoff Management: A Guide for Program Development and Implementation” (subtitled “A Comprehensive Review of the Institutional Framework of Successful Urban Runoff Management Programs”).

My background includes 25 years of work in California, where I have been a federal court-appointed overseer of stormwater program development and implementation at the city and county level and for two California Department of Transportation districts. I was directly involved in the process of developing the 13 volumes of Los Angeles County’s Stormwater Program Implementation Manual, working under the terms of a settlement agreement in federal court as the plaintiffs’ technical representative. My role was to provide quality-control review of multiple drafts of each volume and contribute to bringing the program and all of its elements to an adequate level. I have also evaluated the stormwater programs in San Diego, Orange, Riverside, San Bernardino, Ventura, Santa Barbara, San Luis Obispo, and Monterey Counties, as well as a regional program for the San Francisco Bay Area. At the recommendation of San Diego Baykeeper, I have been a consultant on stormwater issues to the City of San Diego, the San Diego Unified Port District, and the San Diego County Regional Airport Authority.

I was a member of the National Academy of Sciences-National Research Council (“NAS-NRC”) committee on Reducing Stormwater Discharge Contributions to Water Pollution. NAS-NRC committees bring together experts to address broad national issues and give unbiased advice to the federal government. The present panel was the first ever to be appointed on the subject of stormwater. Its broad goals were to understand better the links between stormwater discharges and impacts on water resources, to assess the state of the science of stormwater management, and to apply the findings to make policy recommendations to the U.S. Environmental Protection Agency relative to municipal, industrial, and construction stormwater permitting. My principal contribution to the committee’s final report, issued in October 2008, was the chapter presenting the committee’s recommendations for broadly revamping the nation’s stormwater program.