Training Water Science Technicians for the Future –
A National Online Curriculum Using Advanced Technologies and Real-time Data

Length: 1 year, 4-6 credits per semester or quarter
Each module includes one week of instruction including:
- 3 lectures per week (50 minutes each)
- 1-2 laboratories (or field sessions) per week (2 hours each)

Audience: 2 or 4 year programs focused on Water Resources; Water Science; Water Pollution, Wastewater; Environmental Science; Fisheries and Wildlife, Ecology, Natural Resource Management, Conservation Biology, Limnology, Biology, Forestry, Aquatic Science

Objective: Provide hands on training in technical, analytical, and presentation skills necessary in the fields listed above using a variety of real-time lake and stream data from the Internet, including the Water-on-the-Web data.

Format: Course is divided into six major units totaling up to 27 curriculum modules. Course can be used in its entirety or can be used to supplement existing lectures in pre-existing related courses (text or lecture-note based) as well as field and lab studies.

UNIT 1 WATERSHED AND AQUATIC SCIENCE FUNDAMENTALS

MODULE 1 WATERSHED SCIENCE AND SOCIETY
- Beneficial uses of water (including discussion of pollution)
- Lakes and streams: Human impacts
  - Point sources (conventional, toxics)
  - Non point source (land use practices, atmospheric deposition, wildlife practices, climate change, etc.)
- Hydrologic cycle
- Groundwater
- Climatic influences (light, temperature, precipitation, wind)
- Land-water interactions
- Ecoregions

MODULE 2-3 LAKE ECOLOGY (LIMNOLOGY)
- Introduction: Lakes are a reflection of their watersheds and climates and lakes are *patchy*
- Food web dynamics
- Organism and metabolism overview
  - Plants, animals, bacteria/fungi (within habitat context, e.g., pelagic, littoral, benthic)
  - Productivity (1^{o}, 2^{o}, respiration, microbial loop)
  - Food webs (including bottom up, top down concepts)
- Basins (types and origins, including reservoirs)
- Morphometry (shapes, parameters)

- "Structure" and patchiness (habitat context)
  - Physical and chemical factors
    - Horizonal (advection)
    - Vertical (light, temp, density; O_2; stratification; mixing)
  - Biological distributions of organisms
  - Temporal variations (physical, chemical, biological)
- Biogeochemistry (applied limnology context)
  - Major ions
  - Nitrogen cycling
  - Phosphorus cycling
  - Iron and sulfur cycling
  - Sediment-water interactions (nutrients/metals release vs DO, Fe, S)
- Eutrophication
  - Management of shallow versus deep lakes
  - Case studies (e.g., Lakes Washington, Tahoe, Mead, Shagawa, Onondaga, Minnetonka)
- Zooplankton and fish issues (management context)
- Paleolimnology overview
- Reservoir issues
- Other issues (e.g., acid rain, exotic species, Hg, PCBs)

MODULE 4-5 STREAM ECOLOGY

- geomorphology
- hydrology (flow, temperature, light)
- stream chemistry
- organisms (algae, higher plants, invertebrates, fish)
- sediments and sediment-water interactions
- patch origin and characteristics

UNIT 2 EXPERIMENTAL DESIGN

MODULE 6 PROBLEM AND OBJECTIVE FORMULATION

- Posing the question – formulating testable hypotheses
- Understanding risk – real v. perceived water resource issues
- Introduction to principles of experimental designs
  - Selecting frequency of sampling
  - Pre/post; upstream/downstream reference sites
- Establishing goals
- Survey of typical lake and stream water resource issues

UNIT 3 DATA COLLECTION AND RETRIEVAL

MODULE 7 WATERSHED AND LANDUSE SURVEYS

- Introduction to Watershed Assessment (check out www.watershednet.com/manual.html)
  - Public surveys—question formulation, survey instruments and design
  - Identification of watershed issues
  - Historical conditions assessment

- Landscape characterization
- Channel habitat type classification
- Hydrology and water use
- Riparian/wetlands assessment
- Sediment sources assessment
- Channel modification assessment
- Watershed characterization of temperature
- Watershed condition evaluation

MODULE 8-9 LAKE SURVEYS

Field

- Lake morphometry
  - graphical (planimetry, count the squares, cut and weigh)
  - software (GIS and simpler programs)
  - manual and acoustic depth sounding
- Water quality assessment
- Physical and chemical field profiling
  - Temperature, DO, pH, EC (including calibration and maintenance)
  - *In-situ* instruments (data logger calibration and maintenance – SEE MODULE 12)
  - Light (Secchi; radiometers)
- Water sampling – manual
  - Conventional (Van Dorn, Niskin, bottles, pumps)
  - Contaminants (clean techniques)
  - Microbes (sterile technique)
- Water sampling – automated
- Zooplankton (e.g., nets, traps)
- Benthos and sediments (e.g., cores, dredges, traps)
- Aquatic vegetation (e.g., visual; grabs; census transects; wetland delineation)
- Fish and fish habitat assessment (e.g., seines; traps; acoustic)
- QA/QC

Laboratory

- Bottle preparation
- Water quality analyses (basic)
  - Alkalinity, hardness
  - TDS, salinity, EC, color
  - TSS, turbidity
  - Nutrients (N and P – principles of colorimetry)
- Water chemistry kits
- Microbiology (e.g., fecal coliform. *E.coli*)
- Specific ion probes (e.g., chloride, ammonium)
- Ions (IC, AAS overviews)
- Chlorophyll-a (extractions; spectrophotometric and fluorometric methods)
- Phytoplankton assessment (rapid scans; quantitative microscopy)
- QA/QC

MODULE 10-11 STREAM SURVEYS

- Water quality assessment
- Field instrumentation (WQ meters, flow metering, data loggers)
- Water sampling (USGS Manual methods; pumps; remote samplers)
- Organism collection
- Biotic parameters
  - Rapid bioassessment protocols for wadeable streams (www.epa.gov/owow/monitoring/rbp; physical, chemical, and biotic characteristics)
- Fish and fish habitat assessment (e.g., seines, traps, acoustic)

MODULE 12 REMOTE SENSING AND INTERNET DATA SOURCES

- Satellite and aircraft imaging
- Satellite and aircraft sensors
- Automated *in situ* data loggers, samplers and modems (e.g., YSI, Hydrolab, RUSS)
- Sonar, hydroacoustics
- Radar
- Federal databases (e.g., STORET, BASINS, USGS)

UNIT 4 DATA MANAGEMENT

MODULE 13 QUALITY ASSURANCE AND QUALITY CONTROL

- Precision and accuracy (e.g., variance, spikes, data tracking and control charts, calibrations; Best Professional Judgment); closely linked to Module 17 Statistics
- Good Laboratory Practices
- Quality Assurance Project Plans (QAPPs)

MODULE 14 DATA TYPES, SOURCES AND RETRIEVAL

- Meta data
- Structuring spreadsheets and relational databases
- Essential information
- Spatial versus non-spatial data sets

MODULE 15 SPREADSHEETS AND NONSPATIAL DATABASES

- Software (e.g., Excel, Quattro Pro, Access)
- Using spreadsheets and databases to answer questions – case studies
  - Querying spreadsheets and databases
- Survey of RDMS software

MODULE 16 GEOGRAPHIC INFORMATION SYSTEMS (GIS)

- Maps as data (points, lines, polygons, objects)
- Polygon versus raster-based
- Software survey
- Data input (GPS, scanning) and data delivery
- Spatial data sets and analysis functions

UNIT 5 DATA ANALYSIS, INTERPRETATION, AND PRESENTATION

MODULE 17 ELEMENTARY STATISTICS

- Significant figures
- Measures of variation (e.g., mean, median, mode, skew, standard deviation, RPD, CV)
- Interpolation, extrapolation
- Hypothesis testing
- Principles of exploratory data analysis (EDA)
  - Traditional EDA techniques
  - Emerging EDA techniques
  - Survey of EDA software

MODULE 18 APPLICATIONS OF REGRESSION TO WATER QUALITY ANALYSIS

- Basic concepts and applications
- Basic linear regression
- Detecting and analyzing trends
- Curve fitting with Excel
- Assumptions and limitations of regression analysis
- Regression software survey

MODULE 19 GIS/SPATIAL ANALYSIS

- Vector analyses (e.g., unions, intersections, clipping, buffer analyses)
- Raster analyses (e.g., neighborhood statistics, interpolation, filtering)
- Patch statistics (e.g., survey, assumptions and use)

MODULE 20 DATA VISUALIZATION

- Basic graphical techniques and software
- Data visualization techniques

MODULE 21 INTRODUCTION TO MODELING

- Underlying assumptions of models
- Limitations of models
- Types of models (e.g., conceptual, empirical, mechanistic)
- Applications of models
  - Pollutant loads (e.g., TMDLs)
  - Lake water quality (e.g., WILMS and other spreadsheet models)
  - Streams (e.g., In-stream Flow Incremental Methodology – IFIM)
  - Stormwater, urban runoff

UNIT 6 MANAGEMENT POLICY, OUTREACH, AND EXTENSION

MODULE 22 REGULATIONS AND COMPLIANCE MONITORING

- Introduction to risk management
  - Health-based risks
  - Ecological risks
  - Risk assessment process (hazard ID, exposure, dose-response, risk characterization, risk management and communication)

- Clean Water Act (CWA)
  - Regulating point sources (e.g., NPDES, receiving water nutrient criteria)
  - Regulating nonpoint sources (e.g., TMDL process)
- Safe Drinking Water Act (SDWA)
- Clean Air Act (e.g., acid rain, Hg)
- Hazardous Waste
  - CERCLA (Superfund)
  - SARA (Superfund amendments and reauthorization)
  - Toxic Substances Control Act (TSCA)
  - Resource Conservation & Recovery Act (RCRA: solid and hazardous wastes)
  - Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA)
- State and local jurisdiction
- Where to go for information

MODULE 23 WATERSHED MANAGEMENT

- Organizational resources
- Comprehensive land use planning
- Involving stakeholders
  - Conflict resolution
  - Volunteer monitoring
- Typical issues
  - Shoreland development
  - Water extraction/quantity
  - Water diversion
  - Water reuse
  - Wetland draining
  - Flood plain management
  - TMDL process

MODULE 24 LAKE RESTORATION

- Lake restoration techniques and case studies
  - Physical and chemical methods (e.g., nutrient inactivation, dredging, aeration/circulation)
  - Biological methods (e.g., biomanipulation, macrophyte management)

MODULE 25 STREAM RESTORATION

- Stream restoration techniques and case studies
  - Physical and chemical methods (e.g., channelization, gradient, flow, cover, dam removal)
  - Biological methods (e.g., biomanipulation, riparian management)

MODULE 26 COMMUNITY EDUCATION AND INVOLVEMENT

- Risk communication
- Role in shoreland, coastal zone and watershed management

- Presenting technical information to non-technical audience
- Available resources (e.g., EPA EMPACT case studies, web resources, educational sources and organizations)
- Working with the media

MODULE 27 EDUCATING DECISION-MAKERS

- Risk communication
- Bringing data to decision-makers
  - Nonpoint Education for Municipal Officials (NEMO)
  - EPA EMPACT
  - Case Studies
- Comprehensive land use planning
- Effective presentation skills
  - Oral and poster techniques
  - Presentation software