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
  o Point sources (conventional, toxics)
  o 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
  o Plants, animals, bacteria/fungi (within habitat context, e.g., pelagic, littoral, benthic)
  o Productivity (1°, 2°, respiration, microbial loop)
  o Food webs (including bottom up, top down concepts)
• Basins (types and origins, including reservoirs)
• Morphometry (shapes, parameters)
• “Structure” and patchiness (habitat context)
  o Physical and chemical factors
    ▪ Horizontal (advection)
    ▪ Vertical (light, temp, density; O2; stratification; mixing)
  o Biological distributions of organisms
  o Temporal variations (physical, chemical, biological)
• Biogeochemistry (applied limnology context)
  o Major ions
  o Nitrogen cycling
  o Phosphorus cycling
  o Iron and sulfur cycling
  o Sediment-water interactions (nutrients/metals release vs DO, Fe, S)
• Eutrophication
  o Management of shallow versus deep lakes
  o 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
  o Selecting frequency of sampling
  o 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)
  o Public surveys—question formulation, survey instruments and design
  o Identification of watershed issues
  o Historical conditions assessment
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
  o 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
  o 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)
  o Traditional EDA techniques
  o Emerging EDA techniques
  o 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
  o Pollutant loads (e.g., TMDLs)
  o Lake water quality (e.g., WILMS and other spreadsheet models)
  o Streams (e.g., In-stream Flow Incremental Methodology – IFIM)
  o Stormwater, urban runoff

UNIT 6 MANAGEMENT POLICY, OUTREACH, AND EXTENSION

MODULE 22 REGULATIONS AND COMPLIANCE MONITORING
- Introduction to risk management
  o Health-based risks
  o Ecological risks
  o Risk assessment process (hazard ID, exposure, dose-response, risk characterization, risk management and communication)
• Clean Water Act (CWA)
  o Regulating point sources (e.g., NPDES, receiving water nutrient criteria)
  o Regulating nonpoint sources (e.g., TMDL process)
• Safe Drinking Water Act (SDWA)
• Clean Air Act (e.g., acid rain, Hg)
• Hazardous Waste
  o CERCLA (Superfund)
  o SARA (Superfund amendments and reauthorization)
  o Toxic Substances Control Act (TSCA)
  o Resource Conservation & Recovery Act (RCRA: solid and hazardous wastes)
  o 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
  o Conflict resolution
  o Volunteer monitoring
• Typical issues
  o Shoreland development
  o Water extraction/quantity
  o Water diversion
  o Water reuse
  o Wetland draining
  o Flood plain management
  o TMDL process

MODULE 24  LAKE RESTORATION
• Lake restoration techniques and case studies
  o Physical and chemical methods (e.g., nutrient inactivation, dredging, aeration/circulation)
  o Biological methods (e.g., biomanipulation, macrophyte management)

MODULE 25  STREAM RESTORATION
• Stream restoration techniques and case studies
  o Physical and chemical methods (e.g., channelization, gradient, flow, cover, dam removal)
  o 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
  o Nonpoint Education for Municipal Officials (NEMO)
  o EPA EMPACT
  o Case Studies
• Comprehensive land use planning
• Effective presentation skills
  o Oral and poster techniques
  o Presentation software