Aquatic Ecology
Learning Objectives

This document sets out the learning objectives for **Envirothon NB Aquatic Ecology**. Teams should be ready to be able to demonstrate knowledge within the objectives listed below.

KEY POINT 1 — Abiotic Factors

Understanding the physical and chemical conditions that govern aquatic ecosystems.

MODULE 1 Watersheds & the Water Cycle

1. Know the processes and phases of the water cycle and understand its role in moving water, nutrients, and pollutants through a watershed.

- Name and describe all six stages: evaporation, transpiration, condensation, precipitation, surface runoff, infiltration
- Explain how climate change is intensifying the water cycle in NB (more intense precipitation, longer summer droughts)
- Connect water cycle stages to nonpoint source pollution (NPS) transport pathways ● NPS

2. Understand the concept and components of a watershed and be able to identify watershed boundaries, stream order, and drainage patterns.

- Define: watershed, catchment, ridgeline, headwaters, tributary, floodplain, estuary
- Apply the Strahler stream order system — including the rule about same-order joins
- Identify dendritic, meandering, and braided drainage patterns and match each to NB examples
- Name NB's three major watersheds (Wolastoq | Saint John, Miramichi, Petitcodiac) and a key ecological fact about each
- Explain what makes the Bay of Fundy unique and why it matters ecologically

3. Describe fluvial processes and explain how they shape NB river systems.

- Explain erosion, transport, and deposition and why meander bends erode on the outside
- Connect riparian clearing to accelerated bank erosion and increased turbidity ● NPS

MODULE 3 Water Quality & Monitoring

4. Know how to perform and interpret chemical water quality tests and understand why aquatic organisms are affected by physical, chemical, and biological water conditions.

- State CCME guidelines for: temperature, dissolved oxygen (at least 3 threshold levels), pH, turbidity, phosphate, nitrate, conductivity, and E. coli
- Explain the daily dissolved oxygen cycle in a eutrophic water body and why fish kills happen overnight
- Describe the complete eutrophication chain from nutrient input to fish kill (8 steps) ● NPS
- Interpret a water quality data table: flag problems, identify causes, predict ecological impacts

5. Understand biological oxygen demand (BOD), chemical oxygen demand (COD), and their use in assessing organic pollution.

- Distinguish BOD from COD and explain what high values indicate
- State typical BOD values for healthy water vs. raw sewage

6. Know how to conduct field water quality monitoring using standard instruments and protocols.

- Identify the instruments used: YSI multi-probe, Secchi disk, turbidity tube, YSI Photometer 9500, Quanti-tray (E. coli)
- Describe the CABIN biomonitoring approach and explain why biological monitoring complements chemical testing
- Explain what EPT richness and the EPT:Chironomidae ratio indicate about stream health
- Describe cyanobacteria bloom types (surface and benthic) in NB; explain health risks and the correct public response

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KEY POINT 2 — Biotic Factors

Understanding the living components of aquatic ecosystems — organisms, food webs, population dynamics, and species identification.

MODULE 4 Benthic Macroinvertebrates

7. Understand the dependence of aquatic organisms on one another and explain how energy and matter flow through freshwater food webs.

- Trace energy flow from leaf litter and algae through macroinvertebrates to fish and terrestrial predators
- Explain the River Continuum Concept and how dominant energy sources shift from headwaters to large rivers (CPOM → FPOM)
- Describe five functional feeding groups and explain where each dominates

8. Identify common freshwater macroinvertebrates using guides and keys, assign them to pollution tolerance groups, and use the data to assess water quality.

- Rapidly identify to order or group: mayfly (3 tails), stonefly (2 tails), caddisfly (case or rear hooks), water penny, dobsonfly, dragonfly, damselfly, crayfish, midge larva, aquatic worm, leech, rat-tailed maggot
- Assign each organism to Group 1 (sensitive), 2 (somewhat tolerant), or 3 (tolerant)
- Calculate a weighted water quality score (Group 1 × 3, Group 2 × 2, Group 3 × 1) and interpret the result
- Use a dichotomous key accurately to identify an unfamiliar specimen
- Explain why macroinvertebrates are better long-term bioindicators than a single chemical water quality test

9. Understand the ecology and conservation significance of native freshwater mussels in NB.

- Explain the mussel-host fish relationship (glochidia → host fish gills → juvenile mussel) ● SAR
- Name NB's key mussel species: Brook Floater (Special Concern), Yellow Lampmussel (Special Concern), Dwarf Wedgemussel (Extirpated)
- Explain why the Dwarf Wedgemussel disappeared from the Petitcodiac River after 1968
- Describe the arrival of Zebra Mussels in NB (2023, Madawaska River) and their threat to native species

MODULE 5 Fish Identification & Ecology

10. Identify common, rare, threatened, and endangered freshwater fish species as well as Aquatic Invasive Species (AIS) using guides and keys.

- Classify NB fish by thermal preference — cold-water: Atlantic salmon, brook trout, lake trout, arctic char; cool-water: striped bass, yellow perch, white perch, chain pickerel; warm-water: largemouth and smallmouth bass, pumpkinseed, brown bullhead
- Identify key NB native species from photos or descriptions using diagnostic features:
- Atlantic salmon: parr marks (8–11 dark vertical bars with red spots), kype on spawning males, forked tail
- Brook trout: vermiculations on back, red spots with blue halos, square caudal fin, white-edged lower fins
- Atlantic sturgeon: five rows of bony scutes, long pointed snout, mouth < 50% of head width
- Shortnose sturgeon: short blunt snout, mouth > 60% of head width — key distinction from Atlantic Sturgeon
- American eel: jaw present, continuous dorsal/caudal/anal fin, snakelike — distinguish from sea lamprey (no jaw, oral disc, 7 gill slits)
- Striped bass: 6–9 horizontal dark lateral stripes, two separate dorsal fins
- Chain pickerel: distinctive dark chain-like pattern on olive-green sides, long snout, dorsal fin far back
- Yellow perch: 6–9 vertical green-brown bars on yellow sides, amber pectoral fins
- Sea lamprey: circular toothed oral disc, no jaw, no pectoral/pelvic fins, 7 separate gill slits
- White sucker: subterminal mouth, lower lip wider than tall, olive-dusky back
- American shad: silvery with blue-green metallic back, row of dark spots behind operculum
- Distinguish anadromous (Atlantic salmon, shad, sturgeon), catadromous (American eel), and resident fish life histories with NB examples
- Know the conservation status of NB fish species at risk (SAR) ● SAR: Atlantic salmon inner Bay of Fundy (Endangered SARA), Atlantic sturgeon (Threatened COSEWIC), shortnose sturgeon (Special Concern SARA), American eel (Threatened COSEWIC), striped bass Bay of Fundy (Endangered COSEWIC), Lake Utopia rainbow smelt — both populations (Endangered COSEWIC / Threatened SARA)
- Know key fish anatomy terms: parr marks, alevin, smolt, kype, adipose fin, vermiculations, scutes, operculum, opercular flap, lateral line, barbel, caudal peduncle, glochidia

11. Understand the ecological role of fish in NB freshwater food webs and their connections to other species.

- Explain why cold-water fish (salmon, brook trout) are sensitive indicators of cumulative watershed health, connecting temperature, DO, turbidity, EPT richness, and NPS pollution ● NPS
- Explain how anadromous fish transport marine-derived nutrients into freshwater systems
- Identify which fish species are suspected hosts for NB native mussels: Blacknose Dace, Golden Shiner, Ninespine Stickleback, and Yellow Perch (Brook Floater hosts); White Perch (Yellow Lampmussel host) ● SAR
- Explain the carrying capacity concept and how competing water uses (fisheries, drinking water, agriculture, recreation, hydropower, navigation) affect aquatic ecosystem health

12. Identify Aquatic Invasive Species (AIS) of fish in NB and understand prevention and control.

- Identify NB invasive fish species from photos or descriptions: chain pickerel (introduced 19th c.), smallmouth bass (introduced late 19th c.), largemouth bass (first NB capture 2006), muskellunge (first NB capture 1988)
- Explain the specific ecological harm of smallmouth bass: predation on juvenile salmon and trout, dramatic reduction of EPT macroinvertebrate communities in invaded lakes

- Explain the ‘clean, drain, dry’ principle for preventing AIS spread between water bodies
- Know the role of the NB Invasive Species Council and eDNA surveillance in AIS monitoring and response

13. Know how to perform or describe fish monitoring methods used in NB.

- Describe the purpose, procedure, and appropriate use of: backpack electrofishing, seine fishing, smolt wheel (rotary screw trap), trap net monitoring, and eDNA sampling
- Know that electrofishing and handling species at risk require a scientific licence
- Know the Inner Bay of Fundy Atlantic salmon Live Gene Bank (LGB) and smolt wheel monitoring by Fort Folly Habitat Recovery on the Petitcodiac

MODULE 2 Aquatic Environments & Wetlands

14. Identify aquatic and wetland environments based on their physical, chemical, and biological characteristics.

- Name and describe the four lake zones (littoral, limnetic, profundal, benthic) and the characteristics of each
- Compare oligotrophic and eutrophic lakes across at least five parameters
- Explain thermal stratification (epilimnion, thermocline, hypolimnion) and seasonal turnover
- Distinguish lotic from lentic systems and describe key ecological differences
- Identify and distinguish the six NB wetland types: bog, fen, marsh, swamp, shallow water/aquatic bed, coastal marsh — with key plant indicators for each
- Explain the three conditions that define a wetland in NB (hydric soils, water at or near surface, hydrophytic vegetation)

15. Understand societal benefits and ecological functions of wetlands.

- Explain at least six wetland ecosystem services: flood control, water filtration, groundwater recharge, wildlife habitat, carbon storage, shoreline stability
- State the $24,000/hectare ecosystem service value of NB wetlands and the significance of 65% salt marsh loss
- Explain the blue carbon concept for salt marshes and its climate relevance

16. Understand the functions and values of riparian zones and be able to identify them.

- Explain six riparian zone functions: stream temperature control, CPOM input, bank stabilization, nutrient filtration, wildlife corridor, large woody debris
- Connect riparian zone loss to EPT richness decline, stream temperature increase, and NPS loading ● NPS
- Know NB’s 30 m buffer requirement under WAWA and the activities it regulates

KEY POINT 3 — Aquatic Environments

Understanding the physical environments where aquatic life exists, including groundwater and coastal habitats.

MODULE 2 Aquatic Environments & Wetlands (continued)

17. Know the characteristics of groundwater systems and understand threats to groundwater quantity and quality.

- Define: aquifer, groundwater recharge, baseflow, water table
- Explain how wetlands and riparian zones contribute to groundwater recharge
- Identify NPS threats to groundwater: nitrate leaching, pesticide infiltration, failing septic systems ● NPS
- Know that NB's Potable Water Regulation (1993) and Water Well Regulation (2002) protect groundwater drinking supplies

18. Describe coastal and estuarine environments and explain their ecological significance in NB.

- Define estuary and explain how freshwater-saltwater mixing creates unique productive habitat
- Describe the Bay of Fundy salt marsh significance: semipalmated sandpiper staging (up to 75% of global population), *Corophium volutator* as food source, blue carbon storage
- Know the Musquash Estuary as Atlantic Canada's first marine protected area (2006) ● SAR
- Describe the ecological difference between the Bay of Fundy coast (macrotidal) and the Northumberland Strait coast (microtidal)

KEY POINT 4 — Water Protection and Conservation

Understanding the laws, agencies, and management practices that protect aquatic ecosystems.

MODULE 6 Non-Point Source Pollution (NPS) ★ 2026 Focus

19. Identify global and local sources of point and non-point source pollution and discuss methods to reduce each. ● NPS

- Define and contrast point source and non-point source pollution with NB examples of each
- Describe the three main NPS transport pathways: surface runoff, leaching/infiltration, atmospheric deposition
- Explain the first flush effect and its significance for aquatic life
- Explain how impervious surfaces increase NPS loading and identify green infrastructure solutions
- Know that Atlantic Canada has the highest pesticide runoff risk in Canada (42 runoff days per year) and explain why

20. Describe agricultural, forestry, and urban NPS pollutants and propose appropriate best management practices (BMPs). ● NPS

- Name primary agricultural NPS pollutants: excess N, excess P, sediment, pesticides, livestock waste (E. coli)
- Name and explain at least six agricultural BMPs with effectiveness data (e.g. riparian buffers remove 50–80% of sediment)
- Name and explain at least four urban green infrastructure BMPs: rain gardens, permeable pavement, bioswales, stormwater retention ponds
- Explain how road salt acts as a NPS pollutant and its emerging link to cyanobacteria dominance
- Know the Wolastoq/Saint John River federal investment ($2.3M, 14 projects, February 2026) as a current NPS management example

21. Understand the interaction of competing uses of water and why water conservation matters.

- Identify at least five competing water uses and explain how each can conflict with ecosystem health
- Explain why water conservation matters at the individual, community, and watershed scale

MODULE 7 Legislation & Water Governance

22. Interpret major provincial and federal laws used to protect water quality and propose management decisions to improve water quality.

- Explain the constitutional division of water jurisdiction between federal and provincial governments
- Know the NB Clean Water Act (1989) and its key regulations: WAWA 30 m buffer rule, Watershed Protected Areas Designation Orders, Water Classification Regulation, Potable Water Regulation
- Explain who needs a WAWA permit and name at least five activities that require one; distinguish provisional from standard permits
- Know the NB Wetlands Conservation Policy: no net loss of PSW; all wetlands protected by presence since 2020
- Know the NB Water Strategy 2018–2028 and its five goals
- Explain Fisheries Act sections 35 (HADD) and 36 (deleterious substances) and apply each to a realistic NB scenario
- Explain SARA: COSEWIC assessment, Schedule 1 listing, general prohibitions, critical habitat protection ● SAR
- Know that the Canada Water Agency Act came into force October 15, 2024, with the Wolastoq/Saint John River as a priority waterbody

23. Be familiar with the federal, provincial, and Indigenous governance actors for water resources in NB.

- Identify the roles of: NB DELG, DFO, ECCC, Canada Water Agency, watershed groups, and First Nations
- Explain s.35 Constitution Act recognition of Aboriginal and treaty rights related to water
- Explain the UNDRIP Act (2021) and its relevance to water governance in NB
- Know the significance of the Wolastoqey Nation’s relationship with the Wolastoq

24. Understand how education programs and enforcement agencies work together to prevent the spread of Aquatic Invasive Species (AIS).

- Explain the ‘clean, drain, dry’ principle for preventing AIS transport between water bodies
- Know the 2023 Zebra Mussel confirmation in NB (Madawaska River) and the eDNA monitoring and boat decontamination response
- Identify the NB Invasive Species Council as the key AIS coordination body in NB

MODULE 8 Field Skills & NB Exam Preparation

25. Demonstrate field skills and exam readiness for the NB Envirothon aquatic ecology station.

- Rapidly identify macroinvertebrate specimens to order/group and assign to the correct pollution tolerance group
- Calculate a weighted water quality score from a macroinvertebrate sample and interpret the result
- Identify NB fish species from photos using diagnostic features (parr marks, vermiculations, scutes, chain pattern, lateral stripes, etc.)
- Interpret a multi-parameter water quality data table: identify problems, explain ecological impacts, recommend BMPs ● NPS
- Delineate a watershed boundary on a topographic map and assign stream order at labelled points
- Identify NPS pollution sources on a land-use map and propose layered BMP solutions ● NPS
- Apply the DIAG–LINK–SOLVE oral presentation framework to a watershed NPS scenario
- Integrate all five Envirothon subject areas (aquatic ecology, forestry, soils, wildlife, current issue) in the oral presentation

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Module — Learning Objective alignment at a glance

Mod.	Title	Key Point(s)	Objectives covered
1	Watersheds & the Water Cycle	KP1	1–3: Water cycle, watershed concepts, stream order, fluvial processes
2	Aquatic Environments & Wetlands	KP2, KP3	14–18: Lake/wetland classification, ecosystem services, riparian zones, groundwater, coastal environments
3	Water Quality & Monitoring	KP1	4–6: CCME water quality parameters, BOD/COD, CABIN biomonitoring, cyanobacteria
4	Benthic Macroinvertebrates	KP2	7–9: Food webs, macroinvertebrate ID & scoring, freshwater mussels, AIS mussels
5	Fish Identification & Ecology	KP2	10–13: Fish ID using keys, thermal classification, species at risk, AIS fish, host-fish relationships, fish monitoring methods
6	Non-Point Source Pollution ★	KP4	19–21: NPS sources & pathways, BMPs, competing water uses, water conservation
7	Legislation & Water Governance	KP4	22–24: NB & federal water law, governance actors, AIS prevention
8	Field Skills & NB Exam Preparation	All KPs	25: Integrated field skills, species ID, data interpretation, oral presentation

● SAR = Species at Risk connection ● NPS = Non-point source pollution connection (2026 Current Environmental Issue focus)