Turbidity monitoring: reducing sediment loading in Redside Dace habitat

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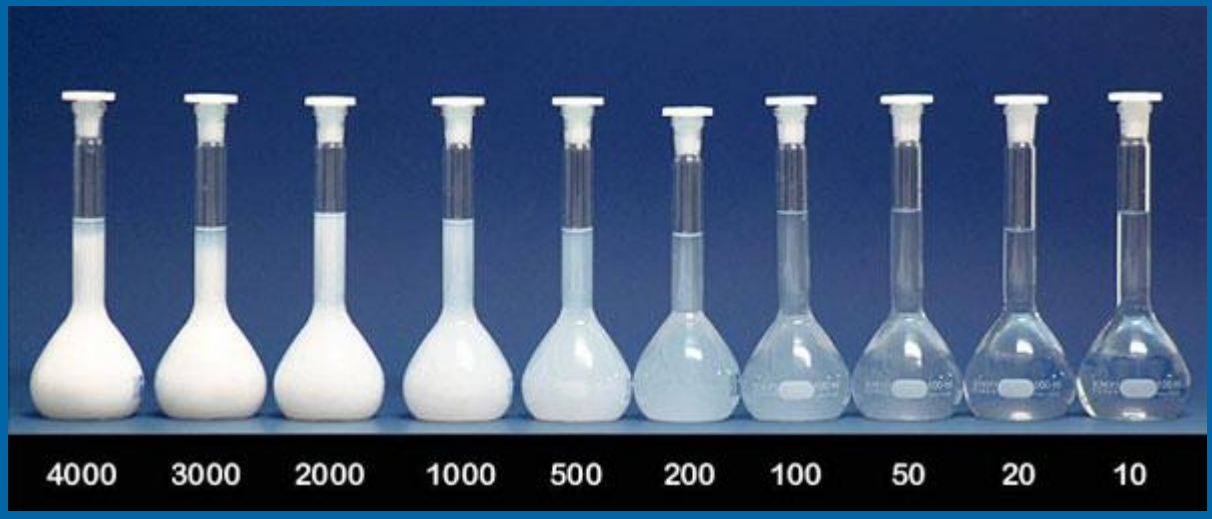
Thanks

Thanks to Block 5 Landowners Group for allowing us to present these materials.

Spoiler

- Turbidity vs. TSS
- Impacts of turbidity and TSS
  - sensitivity of the fish community (e.g. salmonids or Redside Dace)
- The role of sediment and erosion control in the mitigation of sediment loading from construction activities
- Case study: monitoring and communication regime employed at Block 5 (a large-scale community development project in Brampton, Ontario)

Turbidity is a measure of the clarity of a fluid and is an important component of water quality.



Typical series of turbidity standards (Optek, 2012)

What is turbidity?

The turbidity of a fluid varies with the volume of suspended particles, the size, colour, and shape of the particles, their refractive indices, light wavelengths, and the presence of air bubbles in the fluid.

Some solid material is too heavy to remain suspended and settles out of the fluid when it is not flowing. It is the presence of very small particles (usually not visible to the naked eye) that causes a fluid to be turbid because they settle very slowly or not at all if the flows are turbulent.

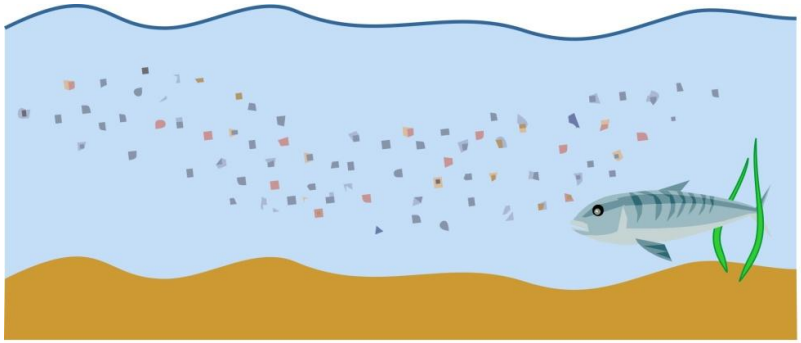
How are turbidity and TSS different?

The distinction between turbidity and TSS is apparent in the way each one is quantified.

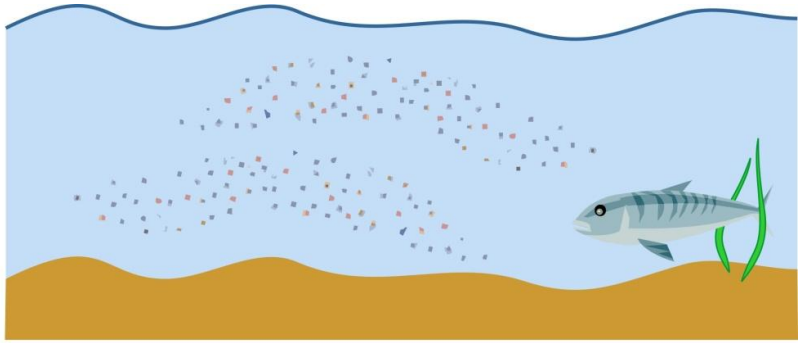
Turbidity is an *optical* property, measured by observing the ability of light to be transmitted through a sample of fluid, without being scattered or absorbed.

Total suspended solids (TSS) is a *gravimetric* or *volumetric* property, measured as the total mass or volume of material in a fluid sample.

How are turbidity and TSS different?



100 particles, 1 mg each
Concentration = 100 mg/L



200 particles, 0.5 mg each
Concentration = 100 mg/L

Turbidity	<	Turbidity
TSS	=	TSS

Currently, the federal *Fisheries Act* declares:

no one may carry out any work or undertaking that results in the harmful alteration, disruption or destruction of fish habitat (HADD)

no one is permitted to deposit a deleterious (harmful) substance, including sediment, into water containing fish

Potentially, the federal *Fisheries Act will declare*:

no one may carry on any work, undertaking or activity, other than fishing, that results in an adverse effect on a fish of economic, cultural or ecological value

Though the definition may change,

fish cannot be harmed!

Potential effects of turbidity and TSS on aquatic life

The degree of exposure and impacts are dependent on *concentration* and *duration*.

Excessive suspended sediment and turbidity can result in:

- Clogging or abrasion of gills of fish and other organisms
- Increase susceptibility to disease and parasites
- Limitations to visibility and movement
  - Interference with movement and migration
  - Disruption of social behaviours, foraging, and predator avoidance

* *Reduced quality of fish habitat and spawning areas*

  - *lack of plant growth to provide cover from predators when light is limited by turbidity in the photic zone*
  - *lack of suitable substrata for laying eggs*

* *Destruction of habitat for benthic organisms*

* These are related to *settlement* of TSS

Fish responses to suspended sediment

Excerpts from a *Dose-Response Database*[1] for fishes exposed to suspended sediment in varying degrees:

Adult salmonids - freshwater

Species	Sediment Dose / Exposure Concentration (mg/L)	Duration (h)	Fish Response	Reference
Salmon	210	24	Traditional spawning habitat abandoned	Hamilton (1961)
Salmon (sockeye)	270,000	1	Mortality rate 100%	Newcomb and Flagg (1983)
Trout	270	312	Gill tissue damaged	Herbert and Merkens (1961)
Trout (rainbow)	160,000	24	Mortality rate 100%	Alabaster and Lloyd (1980)

[1] Database compiled by Newcombe & Jensen (1996)

Fish responses to suspended sediment

Excerpts from a *Dose-Response Database*[1] for fishes exposed to suspended sediment in varying degrees:

Adult nonsalmonids - freshwater

Species	Sediment Dose / Exposure Concentration (mg/L)	Duration (h)	Fish Response	Reference
Carp	25,000	336	Some mortality	Wallen (1951)
Goldfish	25,000	336	Some mortality	Wallen (1951)
Sunfish	9,600	1	Rate of ventilation increased	Horkel and Pearson (1976)

[1] Database compiled by Newcombe & Jensen (1996)

Fish responses to suspended sediment

Excerpts from a *Dose-Response Database*[1] for fishes exposed to suspended sediment in varying degrees:

Adult nonsalmonids – estuarine or riverine-estuarine

Species	Sediment Dose / Exposure Concentration (mg/L)	Duration (h)	Fish Response	Reference
Stickleback	10,000	24	No mortality (10-12°C)	Rogers (1969)
Stickleback	330,000	24	Mortality rate 50% (9.0-9.5°C)	Rogers (1969)
Minnow	200,000	24	Mortality rate 10% (15°C)	Rogers (1969)
Minnow	300,000	24	Mortality rate 30% (10°C)	Rogers (1969)

[1] Database compiled by Newcombe & Jensen (1996)

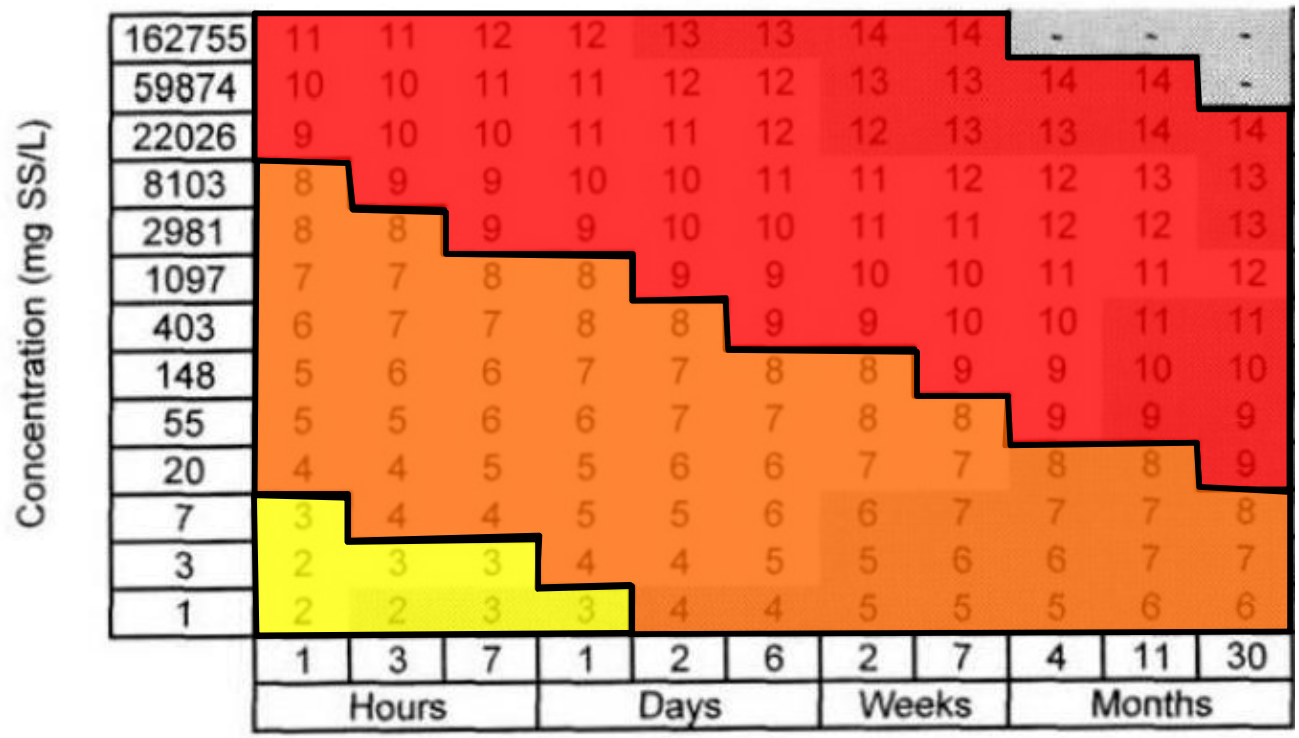
Potential effects of turbidity and TSS on fish

Fish responses to suspended sediment can be categorized as follows:

- *Behavioural effects* (lowest degree of severity)
  - Alarm reaction, abandonment of cover, avoidance response
- *Sublethal effects* (intermediate degree of severity)
  - Reduction in feeding rates and success
  - Physiological stress such as increased respiration rate
  - Habitat degradation and impaired homing
- *Lethal and paralethal effects* (highest degree of severity)
  - Reduced growth rate and delayed hatching
  - Mortality

Fish responses to suspended sediment

Adult salmonids



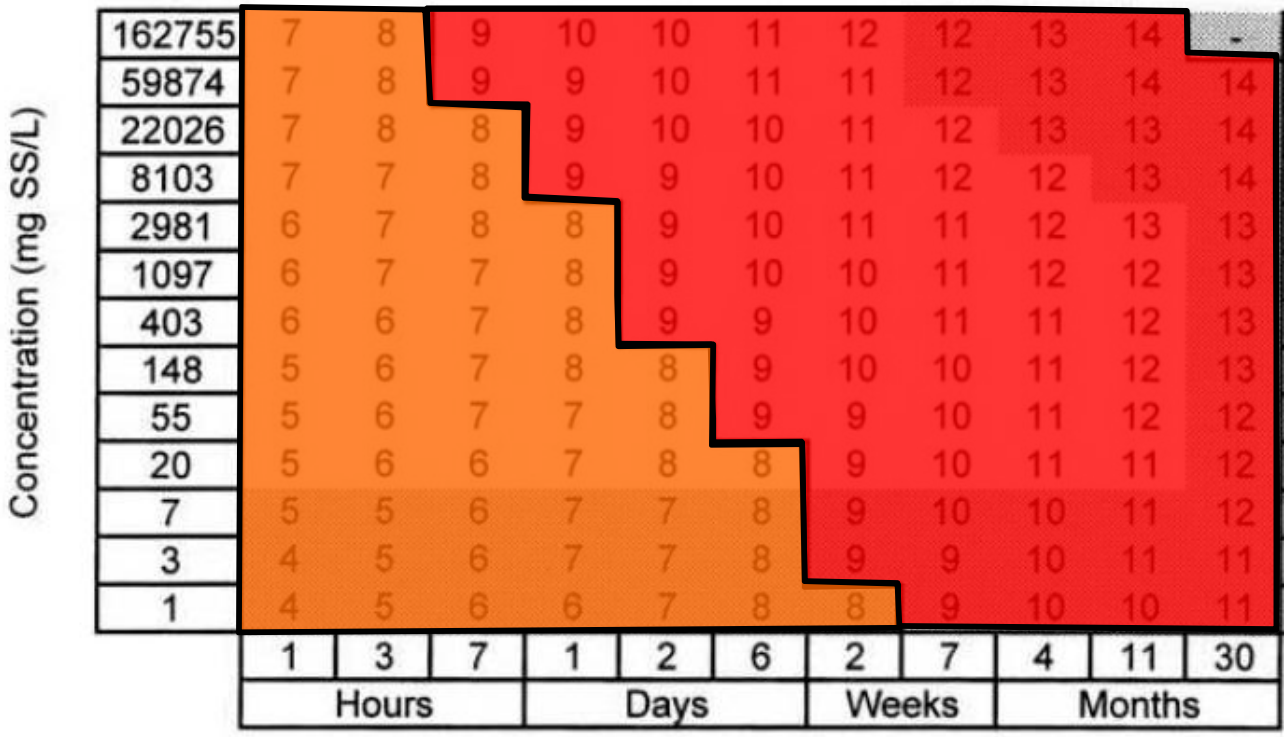
Severity of ill effect

Behavioural **Sublethal** **Lethal and paralethal**

Newcombe & Jensen (1996)

Fish responses to suspended sediment

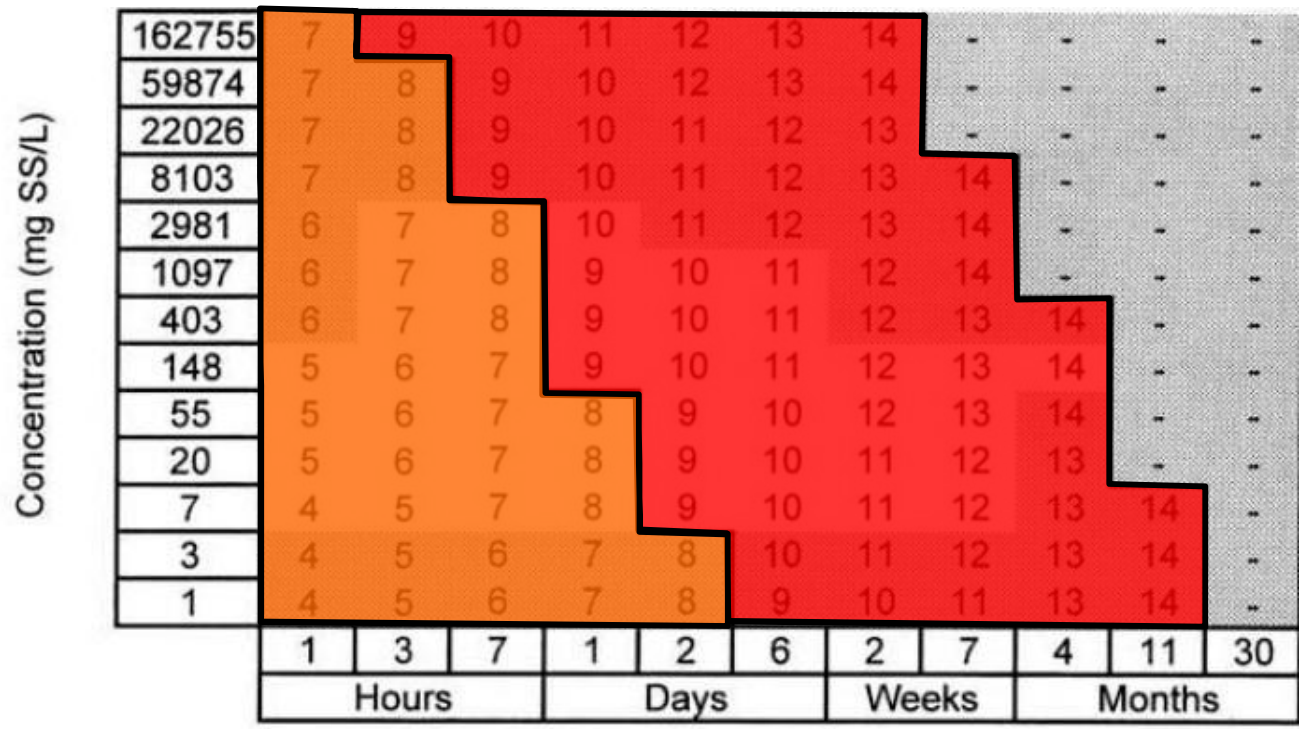
Adult nonsalmonids



Newcombe & Jensen (1996)

Fish responses to suspended sediment

Eggs and larvae of salmonids and nonsalmonids



Newcombe & Jensen (1996)

Impacts of turbidity and TSS

Impacts of turbidity and TSS

Case study:

Springbrook Creek and Tributary 8B
Block 5, City of Brampton

Large scale development

- Large scale land clearing to facilitate development
- Clearing destabilizes sediment within the developable landscape
  - Large scale removal of vegetation decreases resistance and increases velocity of overland flows
  - Increases opportunity for splash entrainment and allows materials to be
  - Exposes materials that would not normally be exposed in a natural context
  - In southern Ontario the exposed material is often clay and till
  - Clay and till are easy to entrain and difficult to get out of suspension
- Mobile sediment increases turbidity in affected watercourses
- Turbidity effects are mitigated using Sediment and Erosion Control measures and Compliance Monitoring

Large scale development

Ontario Regulation 293/11 under the *Endangered Species Act*, 2007 requires:

a description of the steps the person shall take to monitor the effectiveness of the actions taken to minimize effects on Redside Dace, including details and timelines of inspections of sediment and erosion control measures

Block 5 monitoring protocols

- *Proactive*
  - Site visits before, during, and after storm events
  - Monumented photographs collected at each visit
  - Monitoring of loading to settling basins and direction for emptying/cleaning
  - Measurements of water clarity (e.g., using a Secchi disk)
  - Documentation of water clarity and sediment plume dimensions
  - Assessment and reinforcement of sediment and erosion controls
  - Correspondence with agencies for events resulting in sediment release

This approach to monitoring can only be successful with good communication between clients, monitors, contractors, project engineers and agencies.

Sediment and erosion control measures

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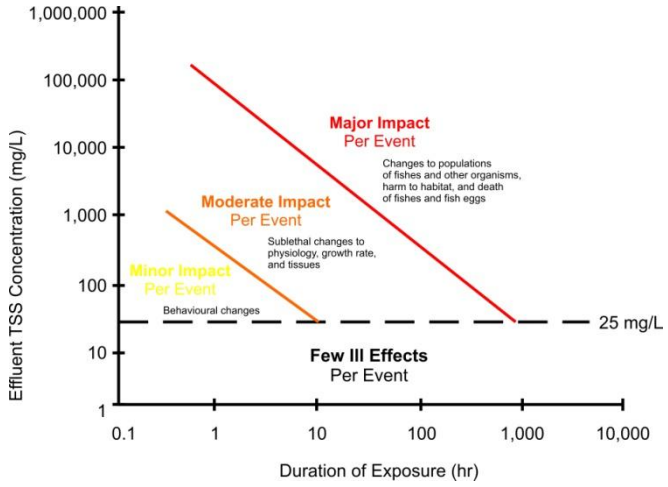
Sediment and erosion control measures

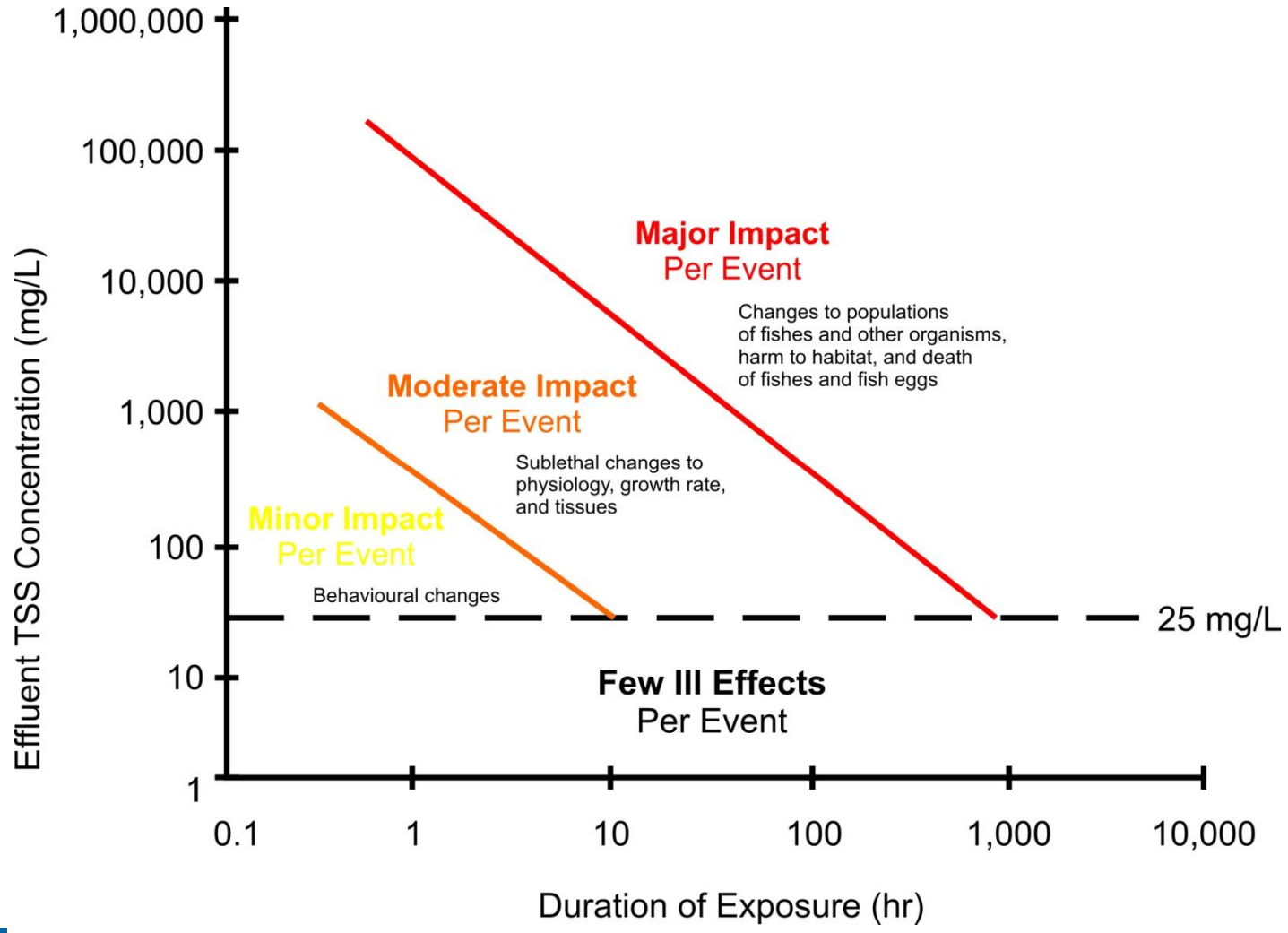
Block 5 monitoring protocols

- *Reactive*
  - Silt Smart
  - Monitoring through telemetry-based instruments
  - Notification of issues as they arise
  - Notification of project team, client, and agencies
  - Response to issues documented
  - Quantification with regards to concentration and duration

  - Used to improve response, not for enforcement



Fish responses to suspended sediment



Newcombe (1986)

Effectiveness monitoring protocol

- For large-scale projects, Silt Smart guidelines state:
- Where there is potential for *significant* impacts due to the nature of the proposed works and/or site conditions and sites in the vicinity of sensitive stream:
    - Monitoring protocol is designed to provide *continuous* monitoring of site conditions through the use of turbidity sensors and grab samples to facilitate a *rapid response* to sediment release to a receiving watercourse

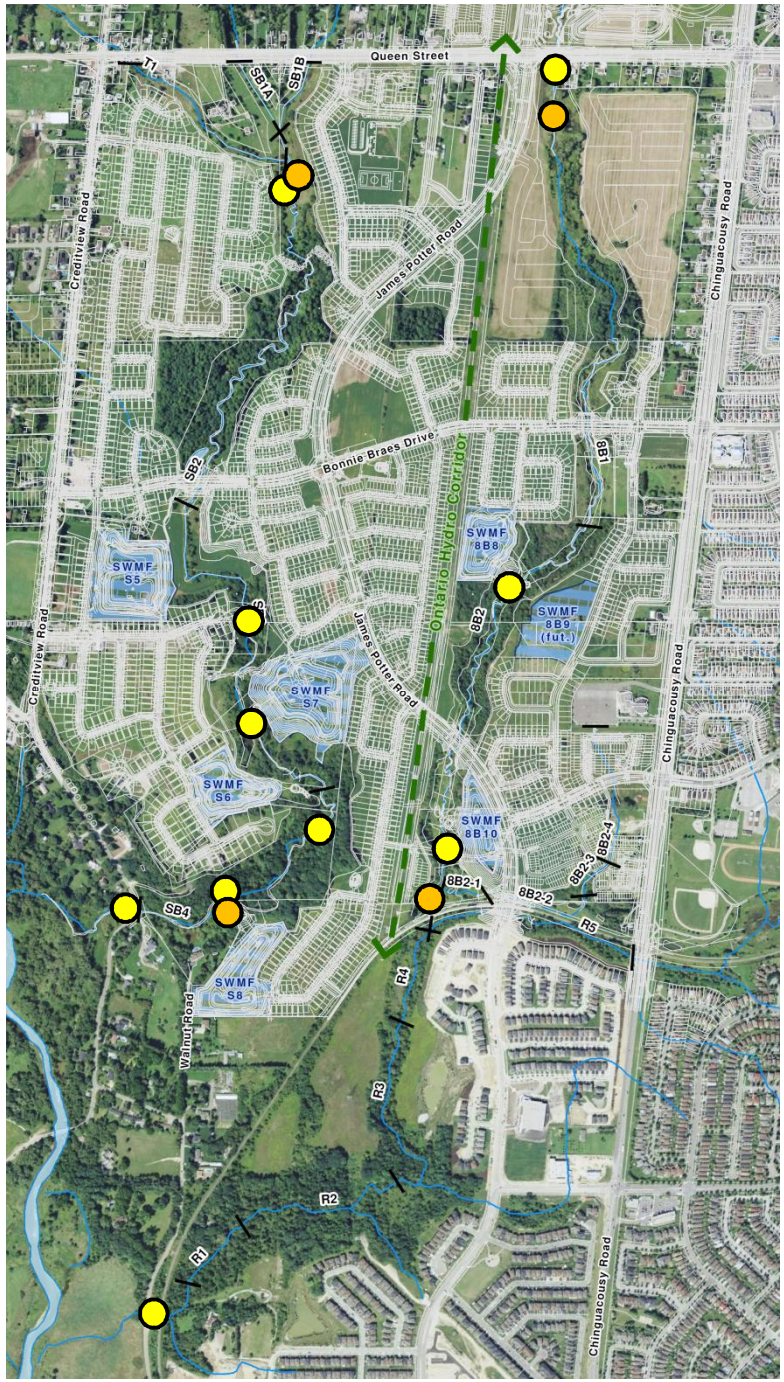
Effectiveness monitoring protocol

	Occurrence Scenario 1	Occurrence Scenario 2	Occurrence Scenario 3
Occurrence	Two consecutive turbidity measurements of 8 NTUs above background	Turbidity is 8 NTUs above background for 10 hours or more	Two consecutive turbidity measurements greater than 330 NTUs above background
Alert	Alert is sent to Contact Group 1 & repeated every 2 hours until turbidity decreases below target	Alert is sent to Contact Group 2 and repeated every 2 hours until turbidity decreases to below target	Alert is sent to Contact Group 3 and repeated every 2 hours until turbidity decreases to below target
Contact Group Members	Landowners Group GHD CVC	Landowners Group GHD CVC MOE MNR	Landowners Group GHD CVC MOE MNR DFO

Block 5 data logger and Silt Smart monitoring stations

Legend

- R1 — Reach Break and ID
- Silt Smart Monitoring Station
- Temperature and Water Level Logger
- Development Fabric
- Watercourse
- Proposed Stormwater Management Pond
- Waterbody



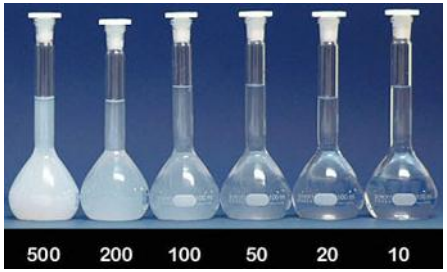
Measuring turbidity

Turbidity is quantified using a *nephelometer*, which measures the amount of light that is scattered from a light source by suspended particles in the water. The greater the scattering, the higher the turbidity.

Unlike TSS, which is described as a concentration, turbidity is described using *NTU values*.

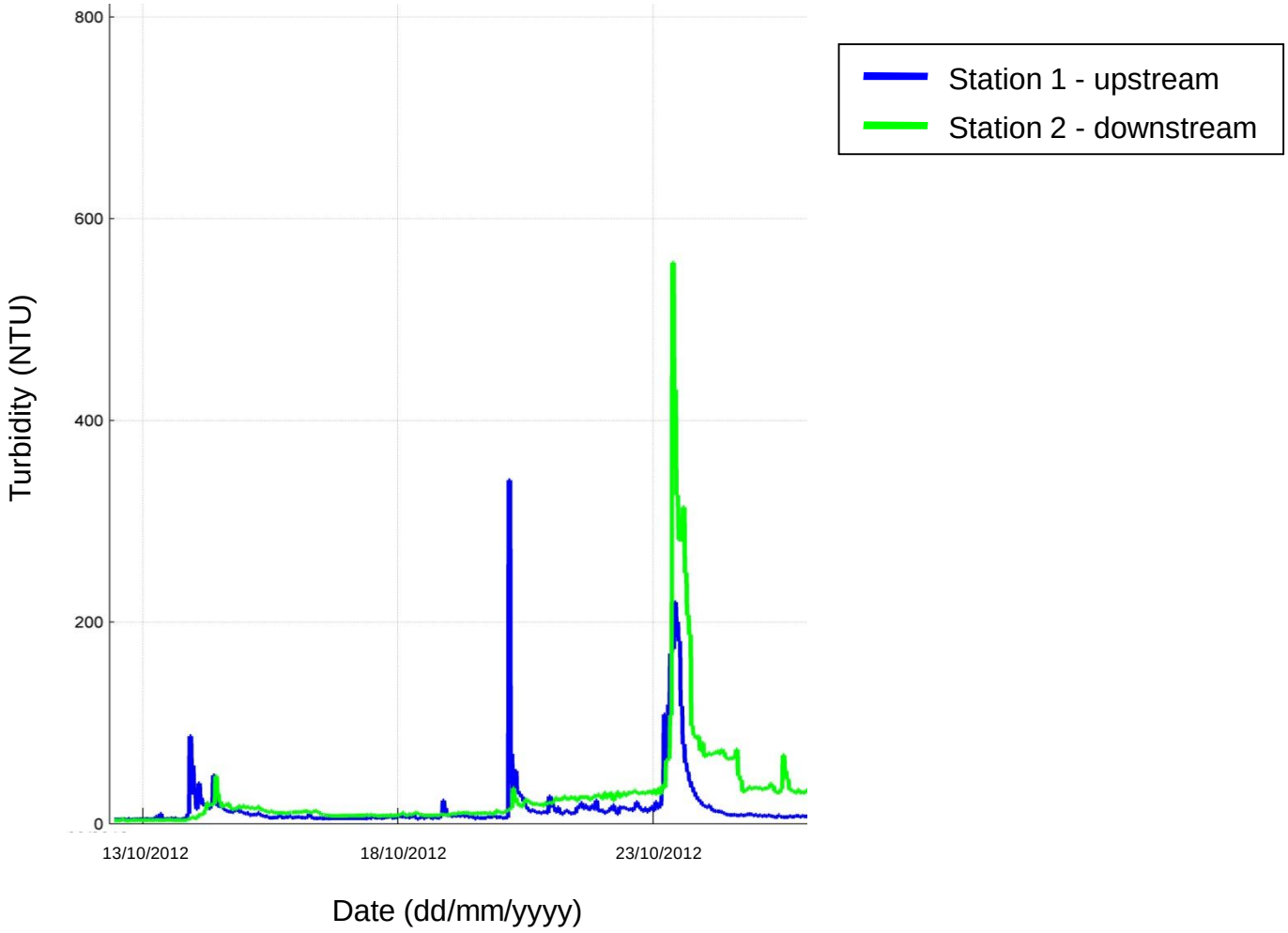
Low NTU values → high water clarity

High NTU values → low water clarity



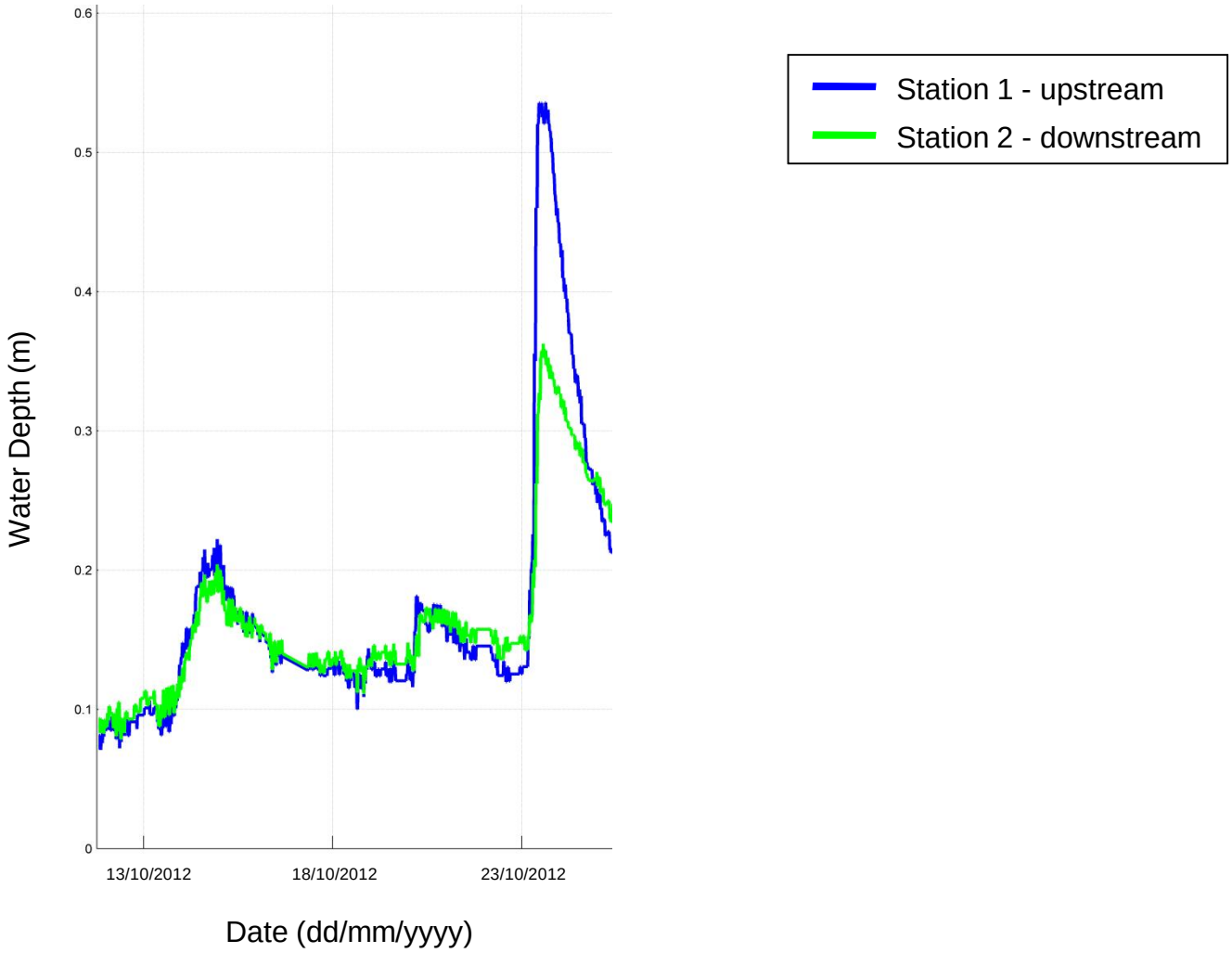
Block 5 monitoring results – Springbrook Creek

turbidity



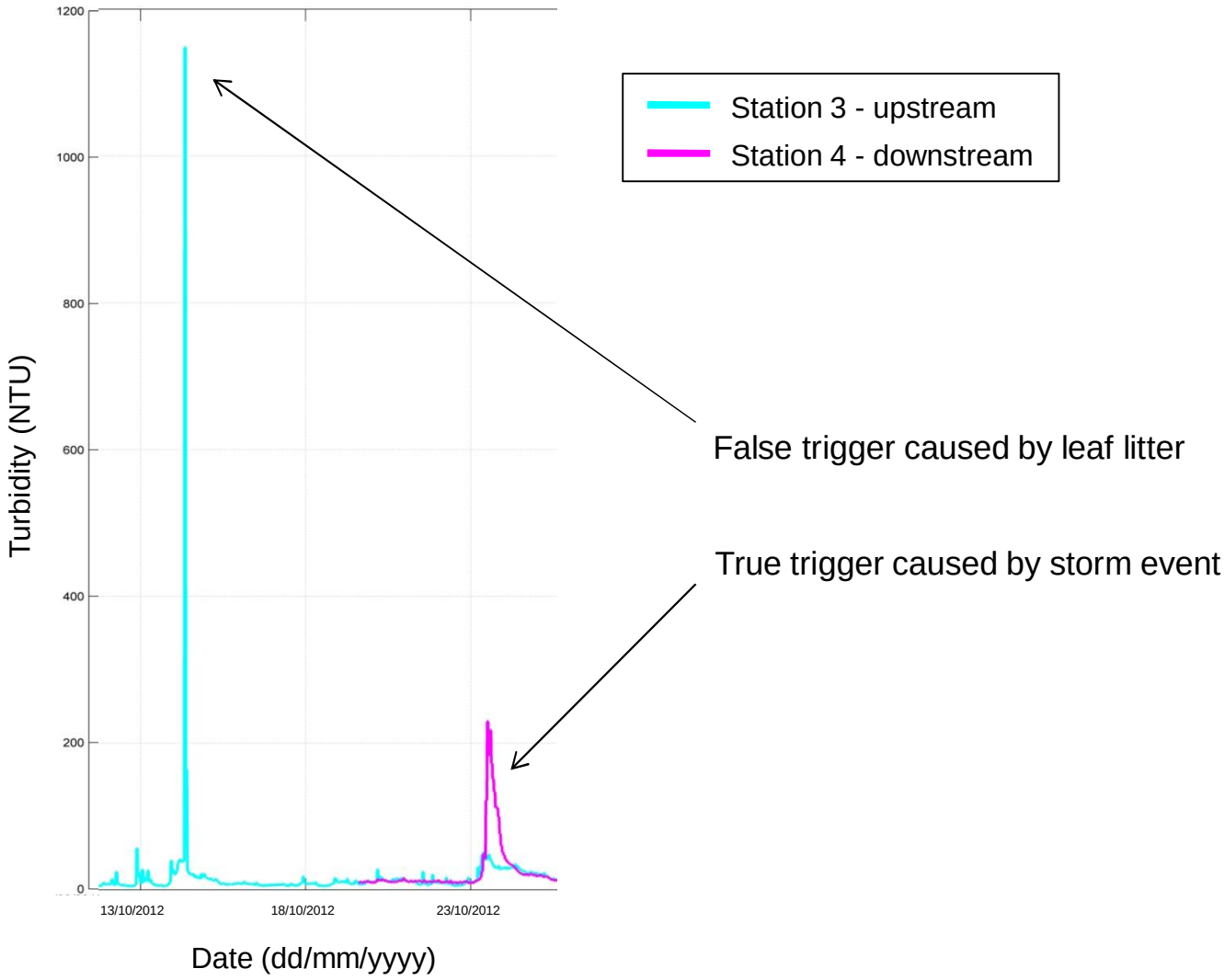
Block 5 monitoring results – Springbrook Creek

water depth



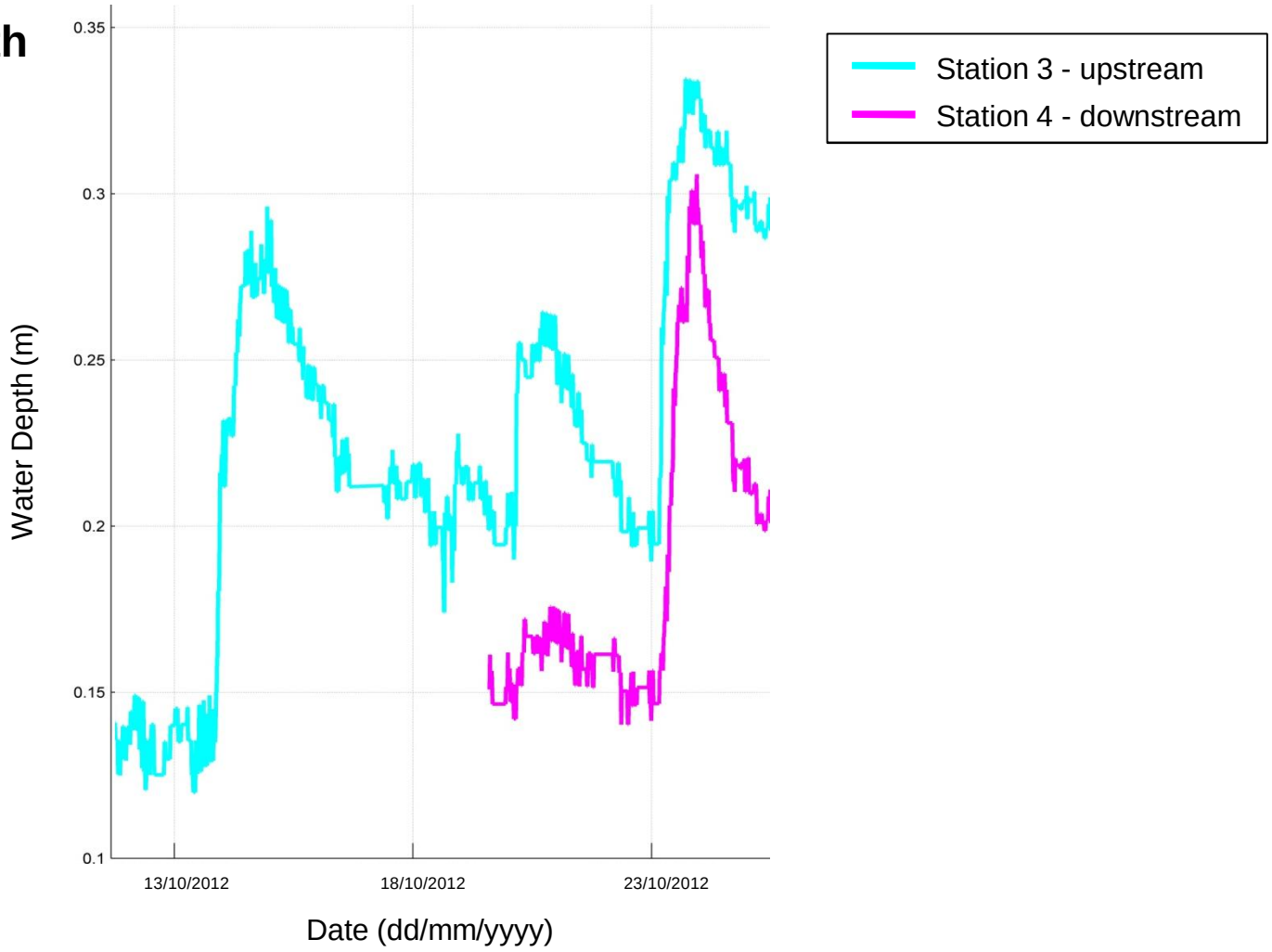
Block 5 monitoring results – Tributary 8B

turbidity



Block 5 monitoring results – Tributary 8B

water depth

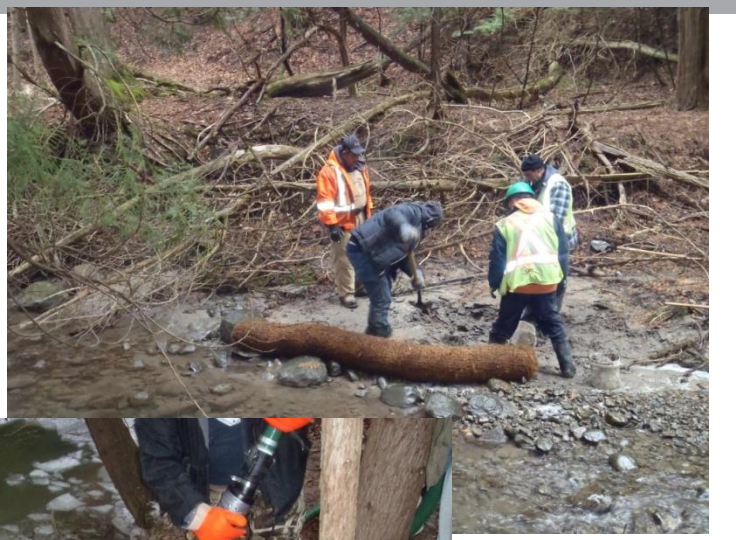


Block 5 erosion and sediment control measures

- > 20 km of sediment fencing, multiple barriers, and settling /siltation ponds
- Even minor fluctuations in sediment and erosion control result in impacts in water quality

Effectiveness monitoring protocol

- Protocol provide agencies with level of comfort
- Ensure *communication* between:
  - Contractors, consultants, owners *and agencies*
- Even with the best management on site, no site is perfect
  - Occasionally, an event will occur- protocols allow for a quicker response!
- Impact on fish is limited!

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Summary

- Turbidity and TSS can greatly affect aquatic life- degree of exposure and impacts are dependent on *concentration* and *duration*
  - There have been changes to the Fisheries Act, fish cannot be harmed!
- Turbidity effects are mitigated using Sediment and Erosion Control measures and Compliance Monitoring
- *Proactive* monitoring can only be successful with good communication between clients, monitors, contractors, project engineers and agencies
- *Reactive* monitoring is used to improve response, not for enforcement
- Even minor fluctuations in sediment and erosion control result in impacts in water quality

www.ghd.com

References

Newcombe, C.P. & Jorgen O.T. Jensen (1996): Channel Suspended Sediment and Fisheries: A Synthesis for Quantitative Assessment of Risk and Impact, North American Journal of Fisheries Management, 16:4, 693-727

Newcombe, C.P. 1986. Fisheries and the Problem of Turbidity and Inert Sediment in Water: A Synthesis for Environmental Impact Assessment. Waste Management Branch, Ministry of Environment, Victoria, B.C. 113 pp.