IDRAIM: A Methodological Framework for Hydromorphological Analysis and Integrated River Management of Streams

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ISPRA: Italian National Institute for Environmental Protection and Research

- National Public Body supporting the Ministry of Environment (MoE)
- Research Institute + National Environment Agency
- National coordinator of Regional EA federation
- National WISE node

  - Support policies implementation

  ✓Produce standards + methodologies for monitoring + evaluation of env. status, flood hazard etc…

  ✓Make methodologies applicable

  ✓Training activity

Italian context

• Densely populated country and high levels of risk related to fluvial processes

Magra River catchment

EU Directives: conflicting objectives…?

Water Framework Directive (WFD)

Floods Directive (FD)

Potentially conflicting objectives:

- Quality
- Safety

Motivation

Need of geomorphological tools: Italian Environmental Agency (ISPRA) (2008) promoted research

Objectives

(1) To develop a method for **morphological assessment** (WFD) (2009-2010);
(2) To develop a **comprehensive methodological framework** to support integrated management of **geomorphological river processes** (2010 – 2013)

Novelties

The framework stems from existing methods but **accounts for the specific Italian context and the European Directives (WFD & FD)**, explicitly including consideration of **fluvial hazard** (FD)

IDRAIM: key characteristics

(1) **Catchment-wide** spatially hierarchical framework;

(2) **Temporal component** explicitly accounted;

(3) Consideration of **channel dynamics** in terms of fluvial hazards explicitly accounted;

(4) Framework designed to comply with WFD and FD requirements, but could be used for **other purposes in river management**;

(5) Method designed to be used by **environmental or water agencies**

(6) Based on **GIS-remote sensing** analysis and **field survey**

Overall structure

Spatial context

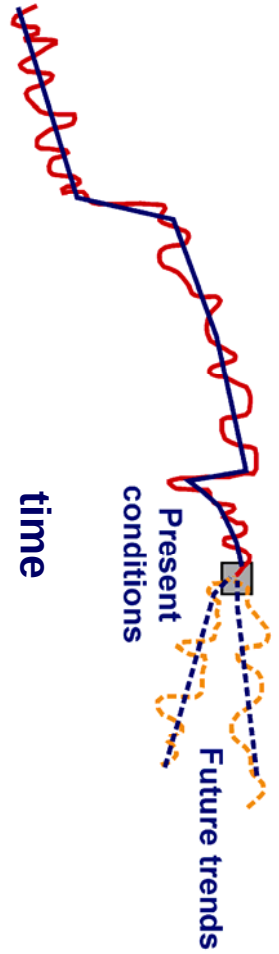
Temporal context

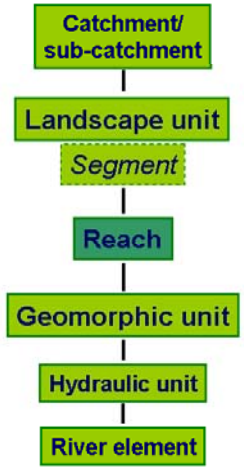
Phase 2: Past evolution and present river conditions

Present state

Phase 1: Characterization of the fluvial system

Phase 3: Future trends





Phase 4: Management

Phase II: Past evolution and present river conditions

Reconstruction of evolutionary trajectories and interpretation of causes of changes

Assessment of morphological quality:

- **Morphological Quality Index** (*MQI*)

Assessment of channel dynamics (hazards):

- **Morphological Dynamics Index** (*MDI*)
- **Event Dynamics Classification** (*EDC*)
- **Morphological river dynamics corridors** (*MDC, EDCo*)

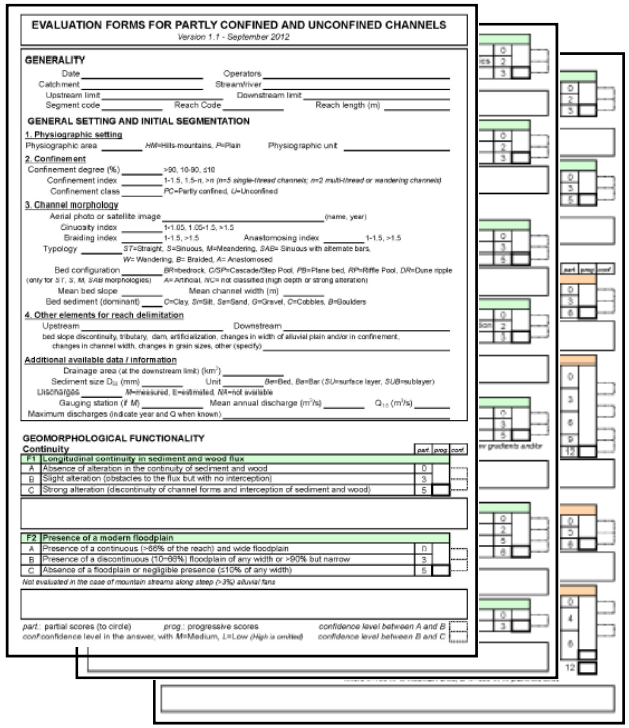
Morphological Quality Index (MQI)

- Aim: classification of current state of a river reach

Geomorphological functionality
F1: Longitudinal continuity
…
F13: Linear extension of functional vegetation

Artificiality
A1: Upstream alteration of flows
…
A12: Vegetation management

Channel Adjustments
CA1: Adjustments in channel pattern
CA2: Adjustments in channel width
CA3: Bed level adjustments


EVALUATION FORMS FOR PARTLY CONFINED AND UNCONFINED CHANNELS
Version 1.1 - September 2012

GENERALITY
Date
Operators
Catchment
Stream/river
Upstream limit
Downstream limit
Segment code
Reach Code
Reach length (m)

GENERAL SETTING AND INITIAL SEGMENTATION
1. Physiographic setting
Physiographic area — HM=Hills-mountains, P=Plain
Physiographic unit
2. Confinement
Confinement degree (%) — >90, 10-90, ≤10
Confinement index — 1-1.5, 1.5–h, >h (h=5 single-thread channels; h=2 multi-thread or wandering channels)
Confinement class — PC=Partly confined, U=Unconfined
3. Channel morphology
Aerial photo or satellite image (name, year)
Sinuosity index — 1=1.05, 1.05=1.5, >1.5
Braiding index — 1-1.5, >1.5
Anastomosing index — 1-1.5, >1.5
Typology — ST=Straight, S=Sinuous, M=Meandering, SAB= Sinuous with alternate bars, W= Wandering, B= Braided, A= Anastomosed
Bed configuration — BR=bedrock, CSP=Cascade/Step Pool, PB=Plane bed, RP=Riffle Pool, DR=Dune ripple (only for ST, S, M, SAB morphologies) — AR=Artificial, NC= not classified (high depth or strong alteration)
Mean bed slope
Mean channel width (m)
Bed sediment (dominant) — C=Clay, Si=Silt, Sa=Sand, G=Gravel, C=Cobbles, B=Boulders
4. Other elements for reach delimitation
Upstream
Downstream
bed slope discontinuity, tributary, dam, artificialization, changes in width of alluvial plain and/or in confinement, changes in channel width, changes in grain sizes, other (specify)
Additional available data / information
Drainage area (at the downstream limit) (km²)
Sediment size D_{50} (mm)
Unit — Be=Bed, Ba=Bar (SU=surface layer, SUB=sublayer)
Uncertainties — M=measured, E=estimated, NA=not available
Gauging station (if M)
Mean annual discharge (m^3/s)
$Q_{1.5}$ (m^3/s)
Maximum discharges (indicate year and Q when known)

GEOMORPHOLOGICAL FUNCTIONALITY
Continuity — part. | prog. | conf.
F1 Longitudinal continuity in sediment and wood flux
A — Absence of alteration in the continuity of sediment and wood — 0
B — Slight alteration (obstacles to the flux but with no interception) — 3
C — Strong alteration (discontinuity of channel forms and interception of sediment and wood) — 5
F2 Presence of a modern floodplain
A — Presence of a continuous (>66% of the reach) and wide floodplain — 0
B — Presence of a discontinuous (10÷66%) floodplain of any width or >90% but narrow — 3
C — Absence of a floodplain or negligible presence (≤10% of any width) — 5
Not evaluated in the case of mountain streams along steep (>3%) alluvial fans
part.: partial scores (to circle) prog.: progressive scores confidence level between A and B
conf.:confidence level in the answer, with M=Medium, L=Low (High is omitted) confidence level between B and C

2 sets of evaluation forms: confined, partly confined-unconfined

RINALDI M., SURIAN N., COMITI F., BUSSETTINI M. (2013) – *A method for the assessment and analysis of the hydromorphological condition of Italian streams: the Morphological Quality Index (MQI).* Geomorphology, 180-181, 96-108.

River Hydromorphology

Training activity on hymo monitoring and assessment all over Italy

5 day-courses (theory and field) for institutional operators all over the country

Phase II: Past evolution and present river conditions

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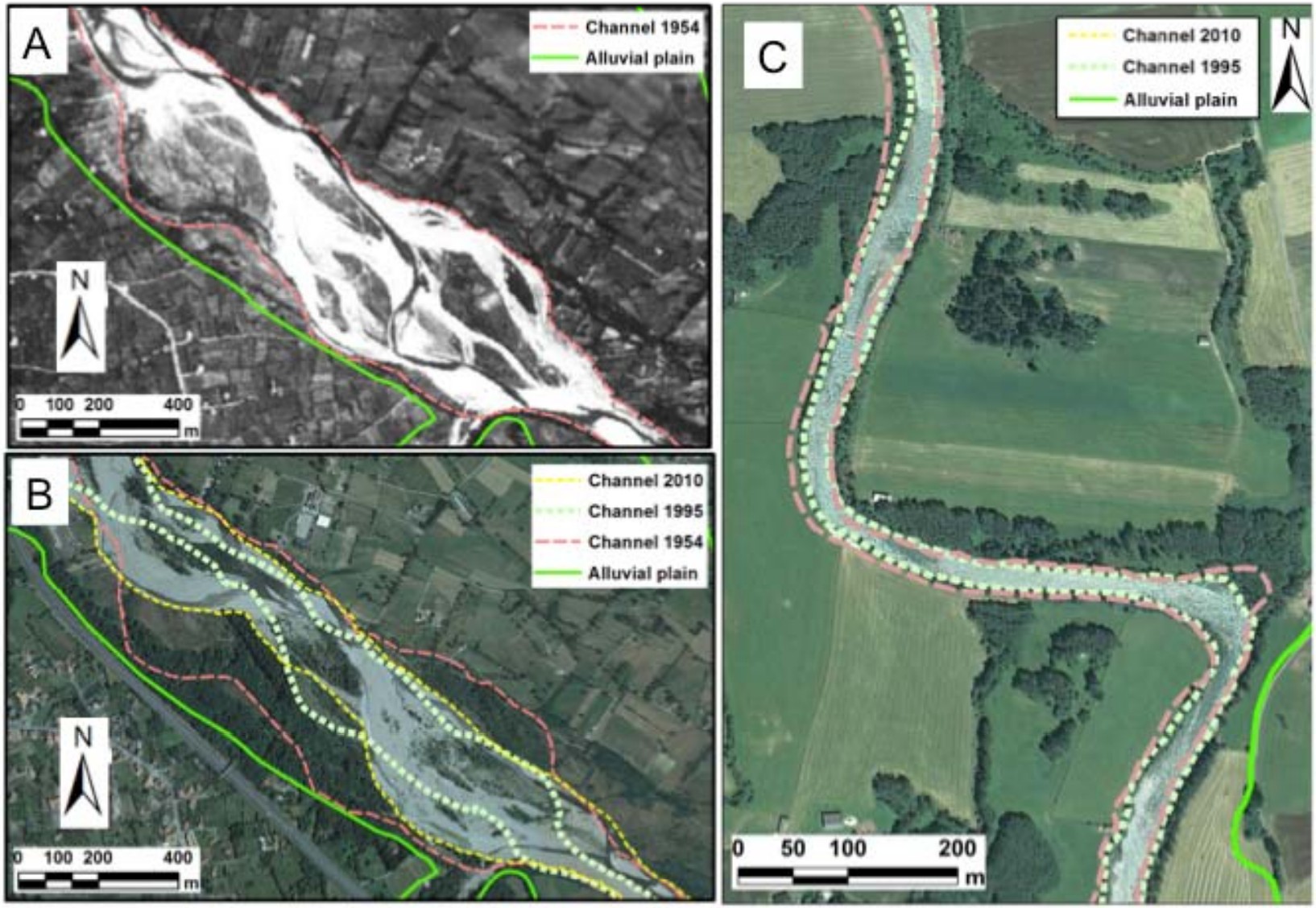
- **Morphological river dynamics corridors** (*MDC, EDCo*)

Morphological Dynamics Index (MDI)

- Aim: evaluation of channel dynamics in the long time scale (100 years)

Indicators	Assessed parameters
Morphology and processes	
M1 – Channel typology	Definition of channel pattern based on sinuosity, braiding, and anastomosing indices
M2 – Bank erodibility	Type of banks (cohesive, non cohesive), percentage of protected banks and vegetation cover
M3 – Bed erodibility	Type of bed (alluvial, bedrock outcrops), percentage of bed revetments
M4 – Bank erosion processes	Length of retreating banks and rate of retreat
M5 – Channel width trend	Changes in channel width during the last 10-15 years
M6 – Bed-level trend	Bed-level changes during the last 10-15 years
Artificial elements	
A1 – Bank protection	Length of protected banks
A2 – Bed protection	Length of bed protected by revetments or ramps
Channel adjustments	
CA1 – Adjustments in channel pattern	Changes in channel pattern from 1950s based on changes in sinuosity, braiding, and anastomosing indices
CA2 – Adjustments in channel width	Changes in channel width from 1950s
CA3 – Bed-level adjustments	Bed-level changes over the last 100 years

Morphological Dynamics Index (MDI)



A and B: Magra R.: MDI “high”; C: Aurino R., MDI: “low”

Event Dynamics Classification (EDC)

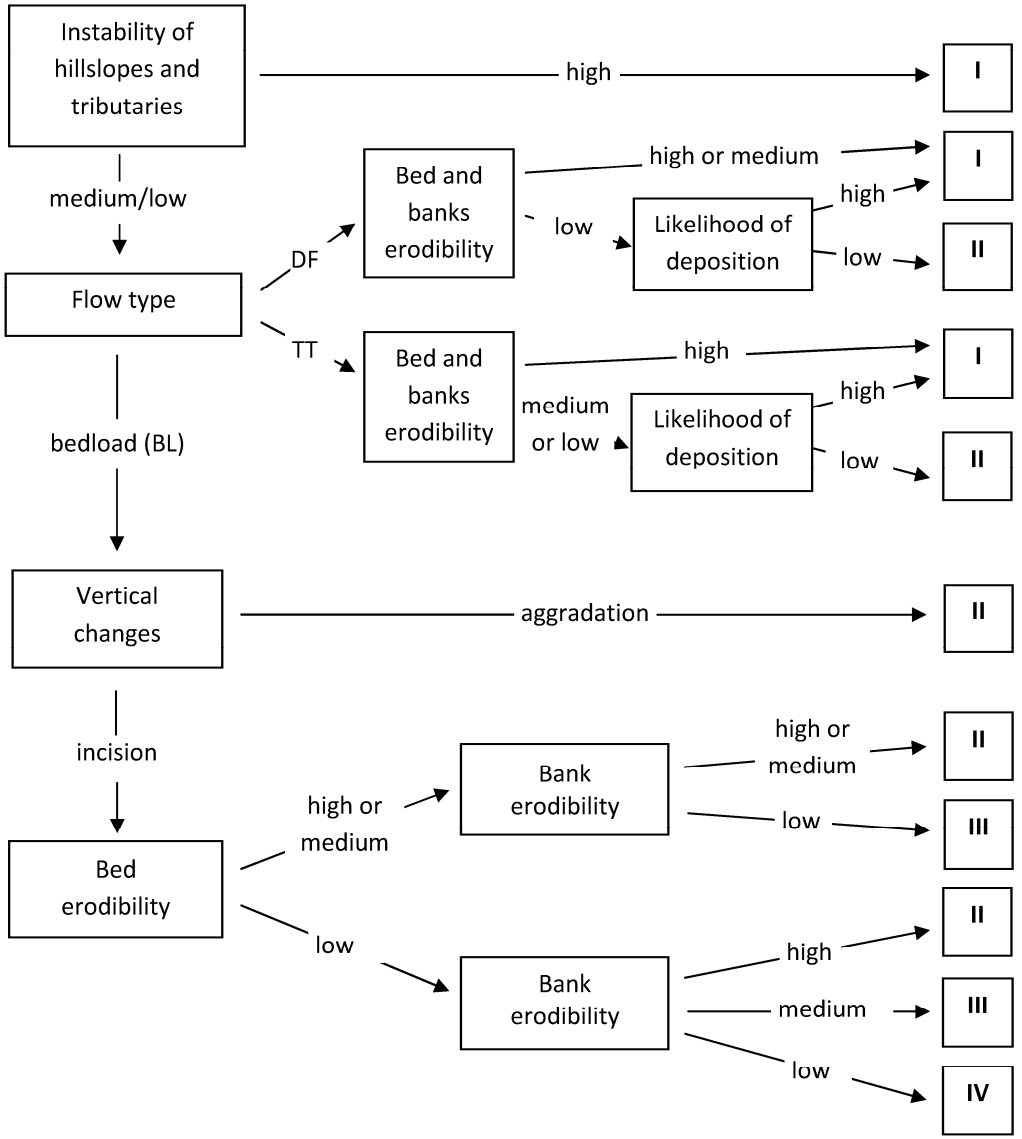
• Aim: assess the most likely channel responses to extreme flood events (-100 year return period).

Two investigated aspects:

(1) assessment of the expected magnitude of morphological changes taking place during the event;

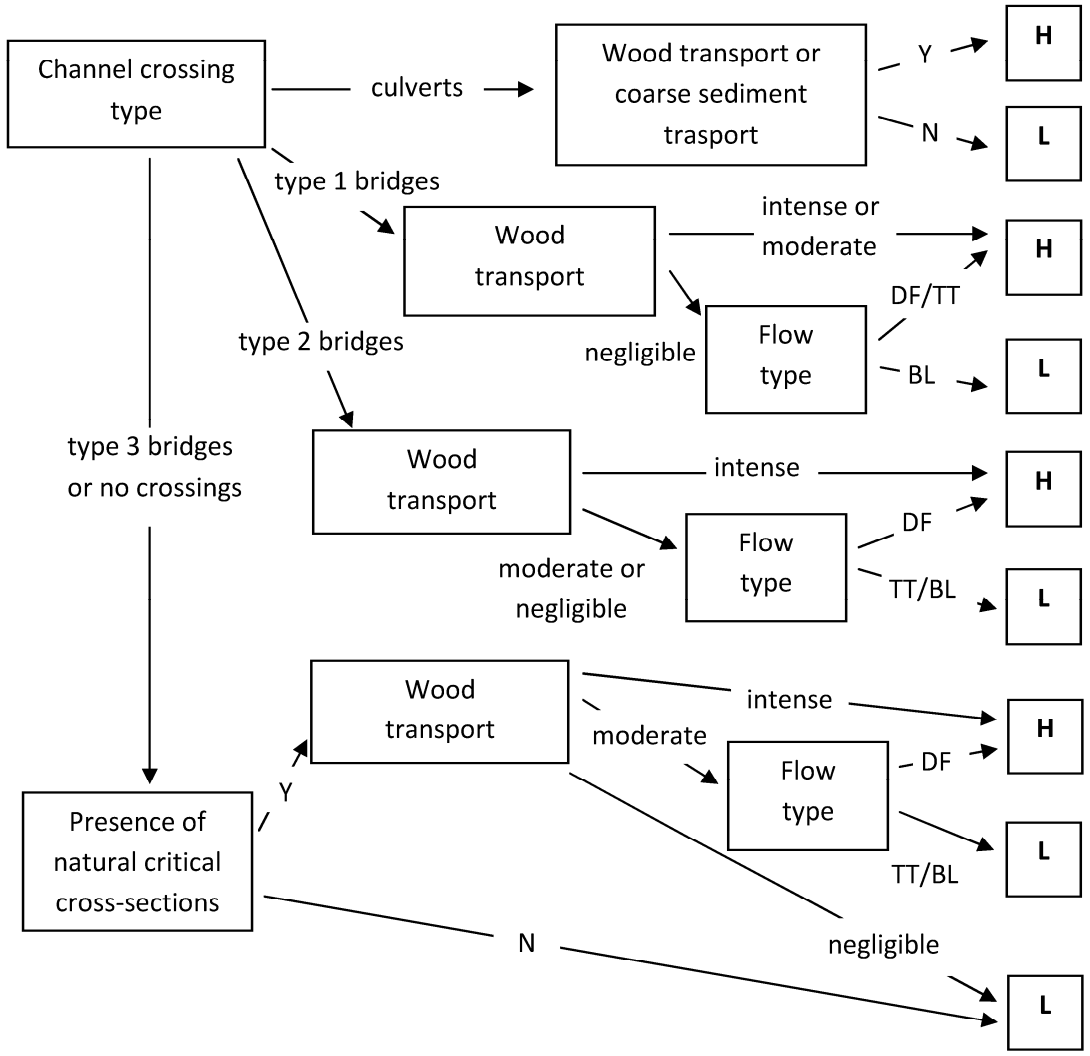
(2) assessment of the clogging conditions at critical cross-sections (e.g., bridges).

EDC: magnitude of changes



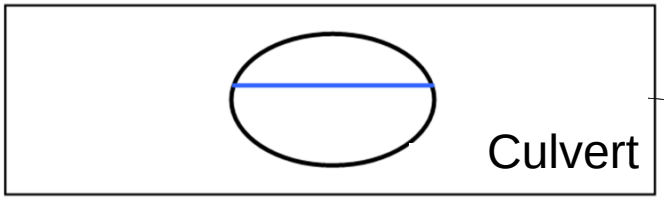
Channel dynamics: I: very high; II: high; III: medium; IV: low

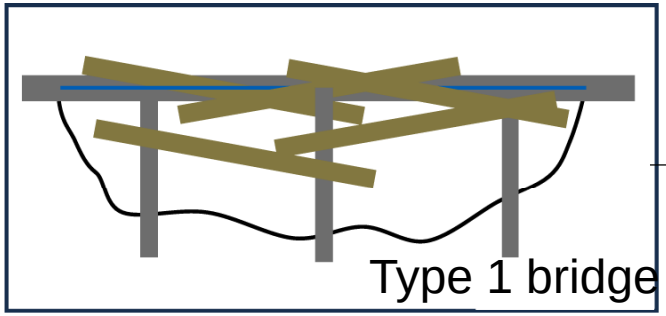
EDC: clogging at critical sections

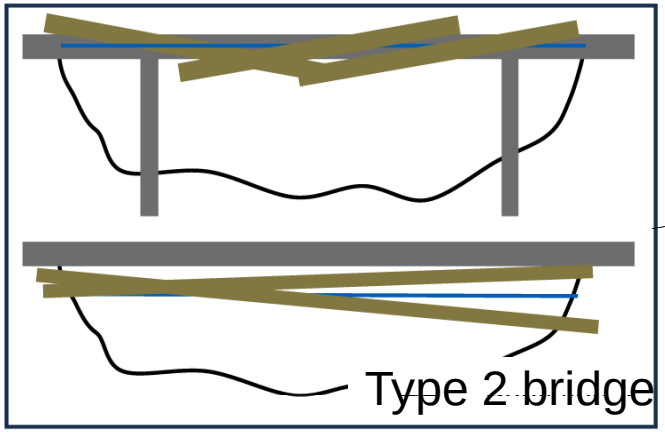


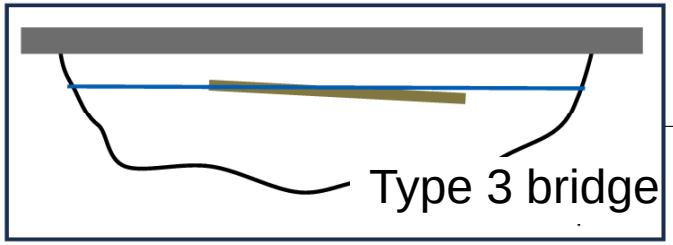
Clogging probability: H: high; L: low

Channel crossing types

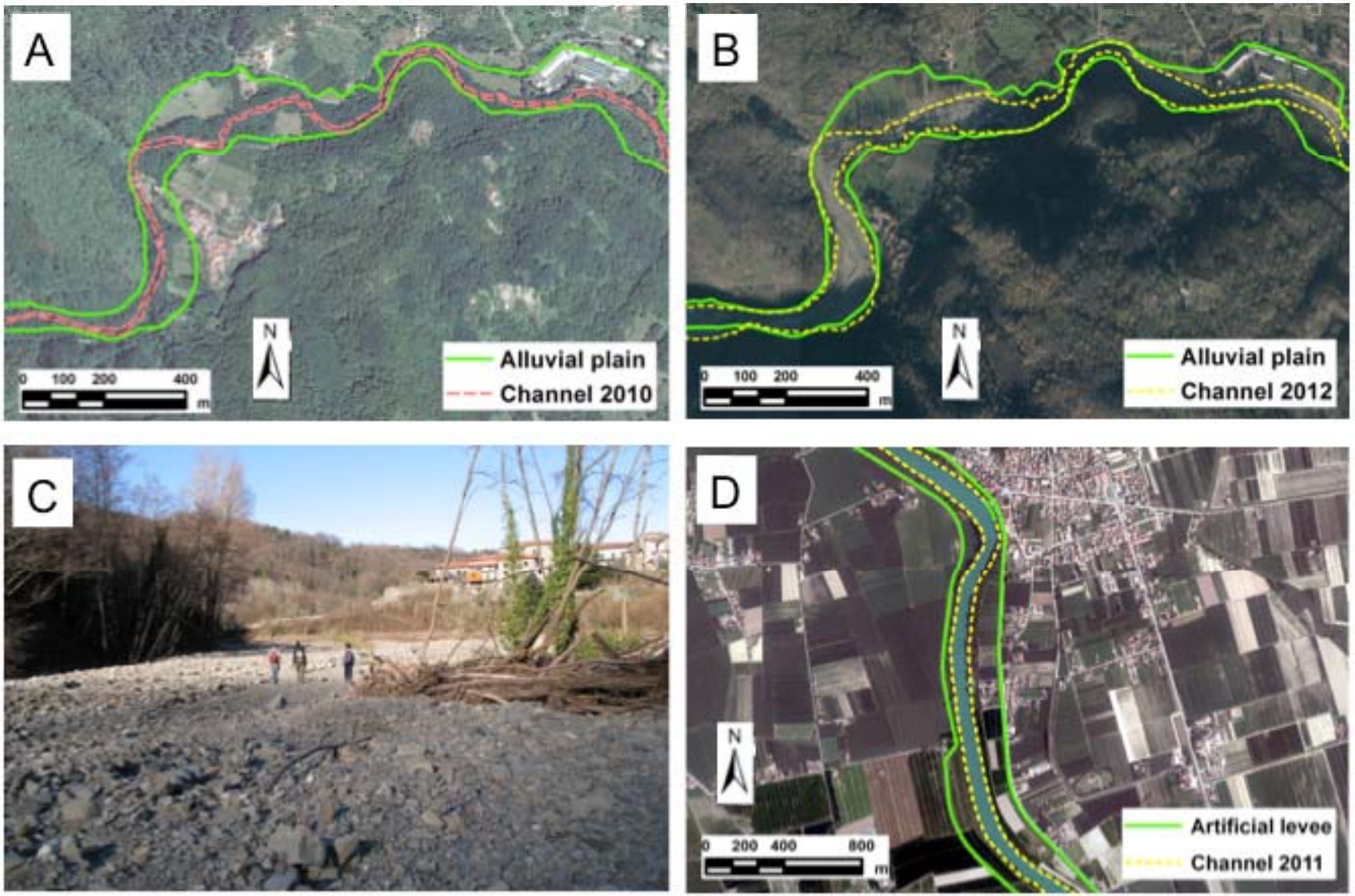








Event Dynamics Classification (EDC)



A, B and C: Teglia R.: EDC “very high”; D: Tagliamento R., EDC: “medium”

Morphological river dynamics corridors

Delineation of 2 corridors:

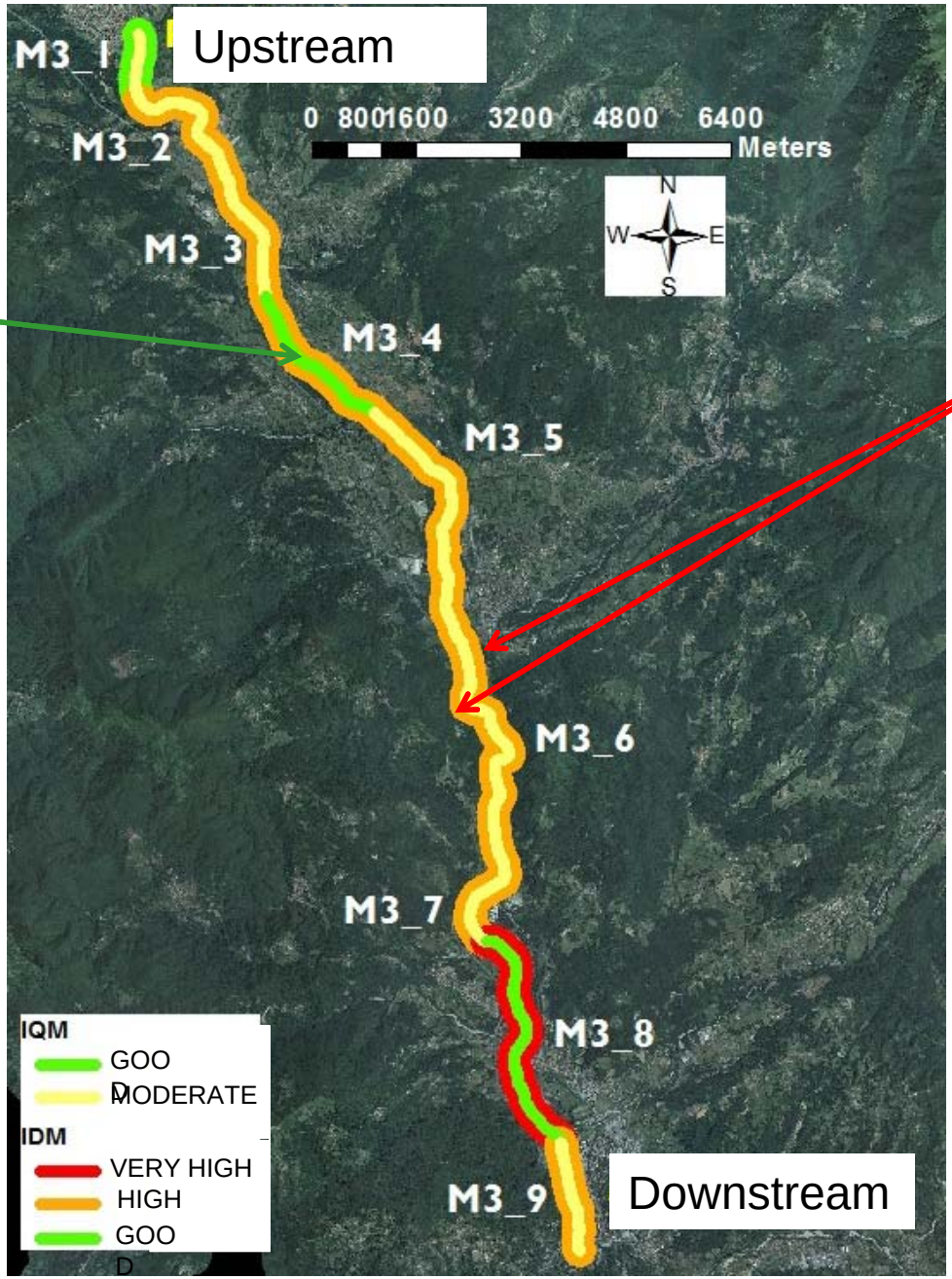
Morphological Dynamics Corridor (MDC): progressive changes

Event Dynamics Corridor (EDCo): changes associated to extreme event (>100 years RP)

	Historical evolution	**Potential future erosion**	**Natural elements of confinement**	**Bank protection and other artificial elements**
MDC	Since 1950s of XX century	50 years	No priority	Priority
EDCo	Since end XIX century / beginning XX century	50 or 100 years	Priority	No priority

Priority indicates those elements that are essential for the identification of the corridor, whereas no priority indicates those elements that need to be considered but do not determine the final delimitation of the corridor which depends on other elements.

Morphological Quality



Morphological Dynamics

Phase IV: Management

- General decision-making framework to manage geomorphological processes

Objective

Scenarios

Evaluation of effects

Best management action

IDRAIM: handbook + xls sheets

IDRAIM – sistema di valutazione idromorfologica, analisi e monitoraggio dei corsi d'acqua – Versione 0 (2014)

http://www.isprambiente.it/it/pubblicazioni/manuali-e-linee-guida/


Apologize for
flooding you!