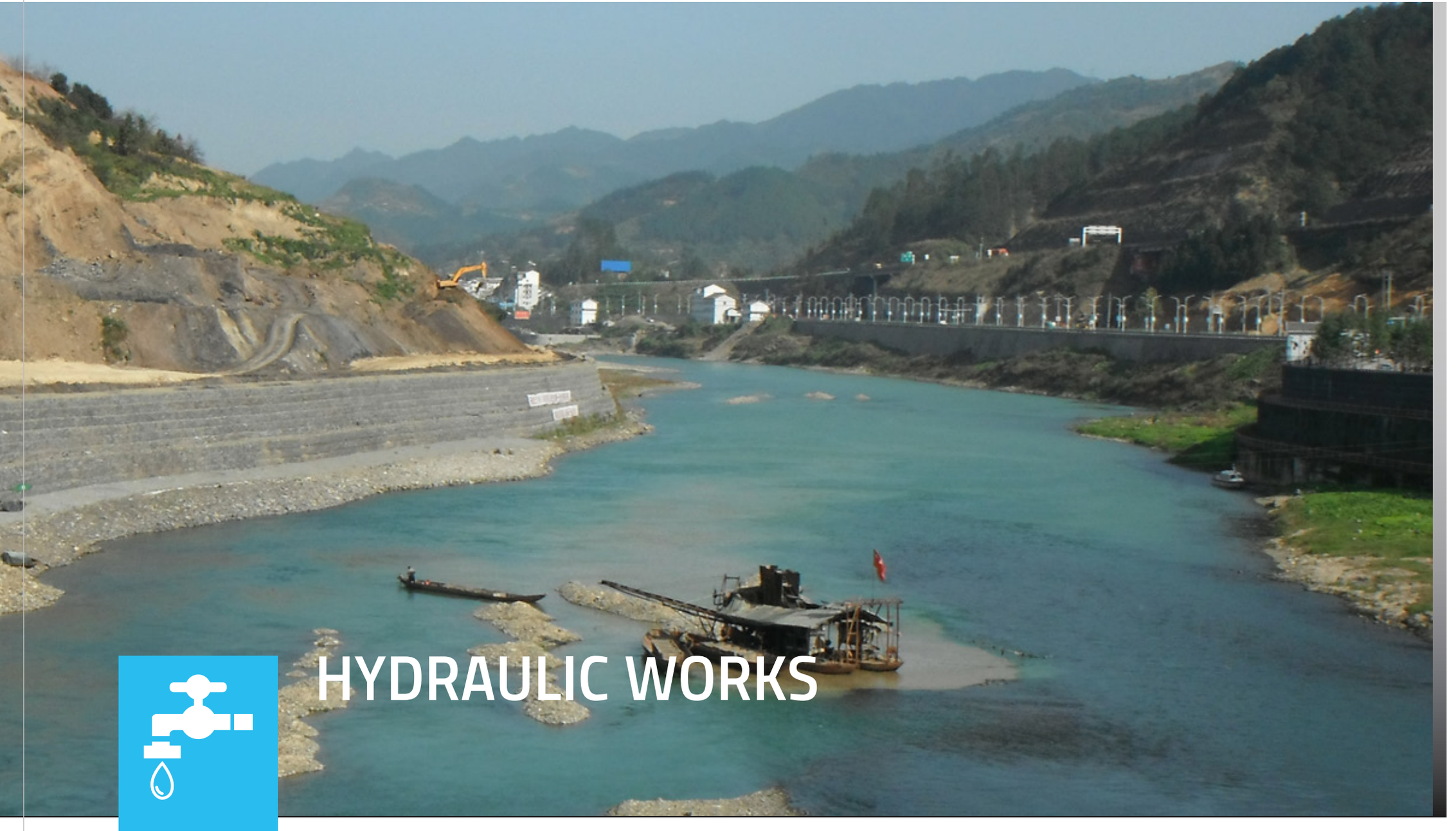
MACCAFERRI



HYDRAULIC WORKS

INTRODUCTION:
RIVERS - A LIVING ENTITY

Man has always used watercourses whether for food, transportation or commerce.

Today, our understanding of hydraulic engineering and river ecosystems enables us to find a better balance between the demands of our societies and environmental equilibrium.

OUR SOLUTIONS:
OUR CAPABILITY

Our experience in hydraulic works started in the 1890's when we provided the emergency repairs to a breach in the dam at Casalecchio di Reno; the dam controlled the water supply which powered the industries of Bologna which were totally reliant upon it.

Since then our capability has grown and today, we possess particular expertise in the protection and training of watercourses throughout their life-cycle.

With our specialist knowledge and comprehensive product range, we offer clients a graded, logical range of hydraulic erosion protection techniques from soil bioengineering solutions through to robust high-energy capacity structures.

Wherever your hydraulic erosion problem exists, the level of intervention should be appropriate to the erosion risk you face.

Our Hydraulic works solutions:

- Channeling works
- Longitudinal structures
- Transverse structures:
  - Weirs & drop structures
  - Culverts
  - Dams
- Groynes
- Bridge protection
- Waterproofing

River Tevere, Italy

CONCEPTS

As watercourses are an integral part of our survival, a balance has to be found between control and ecology.

Left uncontrolled, watercourses can have a detrimental impact on society. Therefore, the hydraulic solution selected should follow key principles:

- Balance erosion and sedimentation
- Make efficient use of natural materials
- Provide appropriate irrigation
- Deliver effective conveyance
- Prevent flooding

PHILOSOPHY

Follow the 'minimum level of energy' approach; select hydraulic erosion protection materials commensurate with the shear forces or loads expected to preserve delicate ecosystems.

Consider the watercourse as part of a catchment area, not in isolation.

Limit the generation and transportation of soil particles as this can cause:

- Loss of land
- Stagnation of watercourses

Use locally available materials wherever possible.

ENVIRONMENT

The river is a dynamic environment.

Integrate soil bio-engineering at the earliest stage to absorb the solution back into the environment.

Consider the durability of the solution and the environment as complementary entities; select products that will integrate so well that they coexist with vegetation to mutually strengthen the solution.

Use locally available materials to reduce carbon footprint.

EVOLUTION

Understand the evolution of the watercourse:

- Mountainous
- Mid-slope
- Valley

Select solutions appropriate to the location with an awareness of the impact of the intervention up or down-stream.

Plan the river works to prevent flooding.

Maintain the river to ensure required conveyance.

TECHNICAL

Design criteria should be based on risk assessments.

Satisfy geotechnical and hydraulic stability:

- Structural stability of the banks
- Active shear stress applied by the water vs serviceability limit of the solution

Check the performance of the solution:

- Throughout the duration of the storm event
- At the focus points; toe of slope, scour pockets
- With and without vegetation as the shear resistance changes

Use our MacRA design software to rapidly balance project demands.

PRODUCT

Selected solutions should:

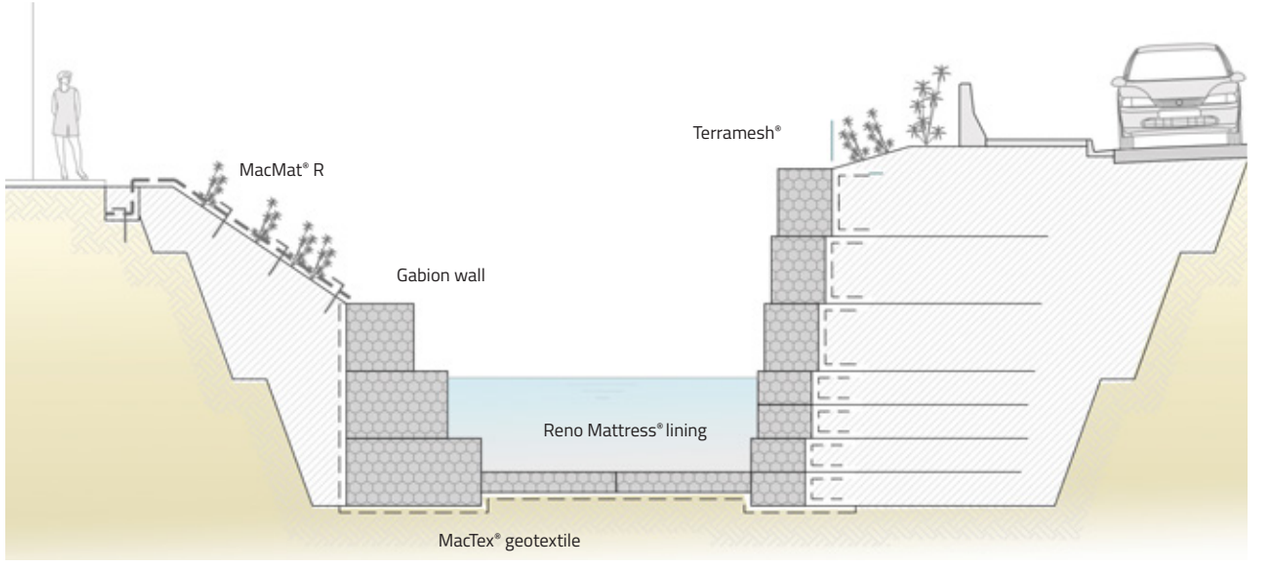
- Be flexible yet structurally continuous
- Be durable yet permeable
- Embrace natural materials
- Offer required design life
- Filter suspended materials
- Be simple to construct
- Use local labour - community engagement
- Follow Corporate Social Responsibility

CHANNELLING WORKS

Where appropriate, confining a watercourse within a defined channel has clear benefits; the consequences of uncontrolled water can be devastating.

This is particularly relevant within urban areas, adjacent to infrastructure or precious agricultural lands.

These river training works protect the channel banks and bed to limit the effect of the hydraulic shear forces, preventing erosion, scour, land-loss and sediment transport.



The channel banks may also be unstable and require structural support; our retaining walls and soil reinforcement solutions, appropriately designed and specified for use in a fluvial environment are ideal.


Mexico


Brazil

The cross section of the channel is fundamental to the performance of the conveyance capacity of the watercourse.

River training works typically require both banks and the channel bed to be protected, thereby maintaining the position of the watercourse.

Incorporating soil bioengineering techniques within the solution rapidly promotes vegetation and re-colonisation of the banks.

Abrasion effect

The abrasion effect of the bedload is an important consideration when specifying the mesh and coating type. Structures within the watercourse must always feature high quality heavily galvanised mesh with an additional polymer coating that is highly resistant to abrasion; our innovative PoliMac™ coating meets these needs.

Italy

Costa Rica

Brazil

LONGITUDINAL STRUCTURES

When full canalisation is not necessary, river banks can be protected by longitudinal structures parallel to the watercourse. They are used for:

- Control of meanders
- Containment of normal flow
- Flood protection
- Hydraulic erosion control
- Reinstatement of eroded banks

Left unprotected, the watercourse erodes the bank resulting in instability.


China


Russia


India


Thailand

Revetments are suitable where the slope has localised shallow surface failures which do not affect the global stability.

Solutions include Reno Mattresses, MacMat® R and soil bioengineering incorporating GeoMac and Biomac, provide immediate erosion protection and the ability to revegetate.

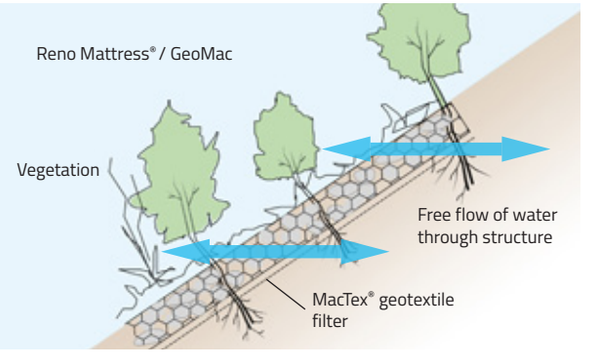
Where the river bank is structurally unstable and requires retaining, a variety of structures are suitable:

- Gabions: Double twist mesh units provide flexible mass-gravity retaining walls.
- Terramesh®: Unique soil reinforcement modular units featuring a gabion facing element with integral geogrid soil reinforcement.
- Green Terramesh®: As Terramesh® but with a sloping vegetated face.

Malaysia

Free draining structures:

Gabions and Reno Mattresses are naturally free-draining and form ideal bank protection systems. A build-up of water pressure beneath the revetment or behind a structure is dissipated rapidly through the Reno Mattress® or gabion; vital in tidal rivers, or within flood prone areas.

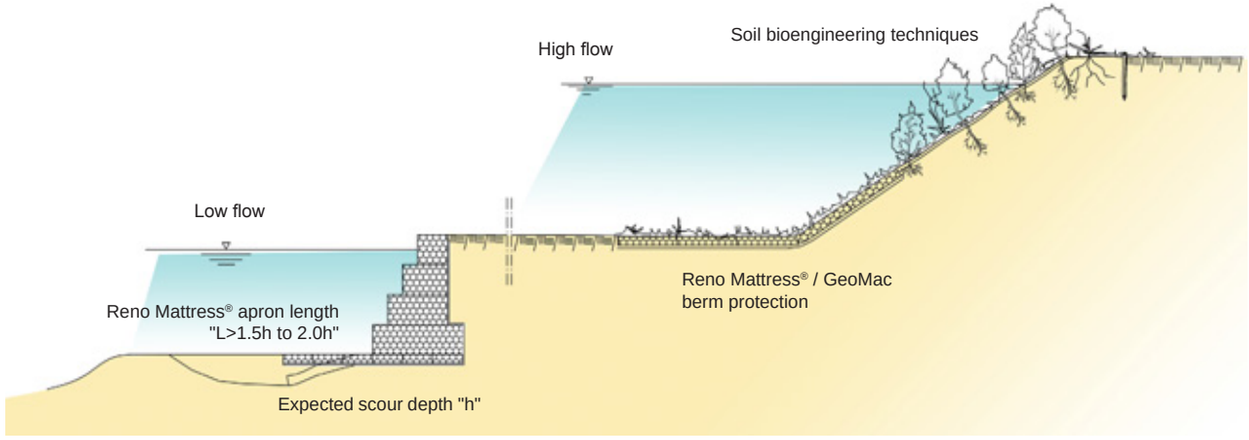


LONGITUDINAL STRUCTURES

A channel section may feature a combination of solutions to contain the flow:

- A low flow main channel with gabions and Reno Mattresses
- A high flow 'overtop' channel with MacMat® R for flood or storm conditions

Selecting an appropriate solution should consider the availability of materials at the project site. Re-using site-won materials, for example river cobbles, within the hydraulic works dramatically reduces the carbon footprint of the solution, yet can deliver equivalent performance.



Hard armour Vs Soft armour

Rigid hydraulic erosion protection methods such as concrete lining should only be used in exceptional circumstances;

- They cannot accommodate the differential settlement and local bed changes of dynamic fluvial environments
- They are not as environmentally compatible as a flexible, permeable structure that is able to sustain vegetation

Germany

The intended function of the watercourse strongly influences the design parameters and solutions selected. This may be to:

- Maintain navigation in canals
- Provide efficient irrigation for agricultural processes

Particular attention is required if river traffic will cause wave action, or other complex flow conditions, such as propeller currents.

Protection from wildlife

Animals, especially beavers, living in and around watercourses can inadvertently cause damage to the channels, weakening the banks.

Preventing these effects, or minimising and repairing them are important to maintain the bank integrity. Our MacMat® R is proven in these environments.

TRANSVERSE STRUCTURES: WEIRS

These transverse structures prevent erosion and contribute to the stabilisation of the river beds and water quality.

They dissipate the energy of the flow.

Gabion and Reno Mattress® weirs and drop structures are flexible and are simple to install in poor soils, mountainous regions and for flood control works.


Canada


UAE

These grade control structures limit hydraulic erosion in the watercourse by reducing the hydraulic gradient and hence the velocity of the water to a value at which it ceases to dislodge soil particles in the river bed and banks.

The benefit is that this reduces the bank erosion protection measures required outside of the weir zone as well.


South Africa

Once the flow passes over the weir, the water slows back down again. The location of the hydraulic jump has to be determined and suitable erosion protection measures deployed. Solutions could include a counter-weir or lined stilling basin.

The design of the drop structure and stilling basin can incorporate numerous features to improve the performance of the structure:

- Double layer of mesh
- Two layers of thinner Reno Mattress® rather than one thicker layer
- Concrete grout infill to the Reno Mattress® in the plunge pool area
- Rock fill selection to include larger boulders

Australia

Weir types

Vertical: Used in sequence, or in rivers with high sediment load.

Stepped: For small drops and low sediment transport.

Sloped: For high discharges and small river-bed material particles.

TRANSVERSE STRUCTURES: CULVERTS

Water control structures are required to guide and control flows into and out of the culvert to limit erosion. These structures often also have to retain steepened river-banks.

The design of the structure has to address the potential locations of scour risk and provide suitable hydraulic erosion protection.

Reno Mattress® aprons prevent scouring of the culvert foundation.

Canada

"Gabions and Terramesh® are often used as the culvert headwalls and can be designed to support roadways or other infrastructure above"

Culvert materials

Regardless of the culvert material (steel, concrete boxes) the flexibility of our solutions enables them to be successfully integrated into the project.

The culvert may also be part of a number of hydraulic structures working together to ensure stability of the watercourse; weirs, cascades, channels.

Flow regimes through culverts can be complex. Care is required at the edges of the protection works where the channel returns to natural materials.

The most effective solutions often combine products to optimise technical performance and cost.

USA

TRANSVERSE STRUCTURES: DAMS

These dam and dyke structures contain water behind them, releasing it in a controlled manner. These structures can form part of catchment-wide, flood alleviation schemes, containing excess water until there is sufficient downstream capacity.

Double twist mesh gabions and Reno Mattresses have been used on the up and downstream faces of dams for many years providing hydraulic erosion protection.

Spillways are also lined with Maccaferri systems depending on the expected shear force of the flow.

Albania

India

Philippines

GROYNES

Groynes and guide bunds are specifically designed and located within a watercourse to divert the flow away from the banks reducing hydraulic erosion damage.

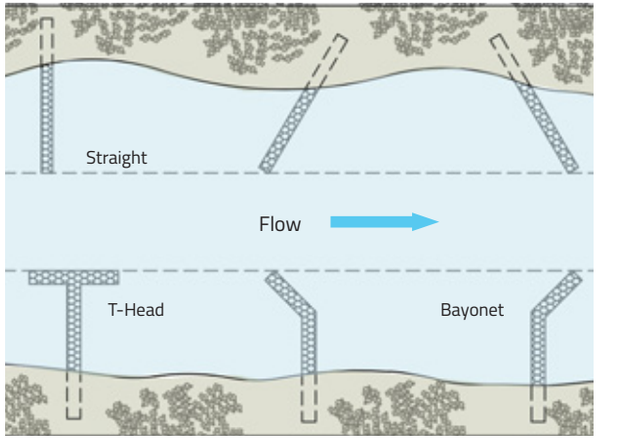
They are suitable when the river is wide enough and when the banks can be modified.

- They are active systems and influence sedimentation in the watercourse.
- The frequency and shape of groynes alters the deposition regime and erosion protection offered.
- The hydraulic regime is rapidly altered by groynes and great care is required in the design.

Groyne spacing:

The intensity and location of siltation depends on the ratio of the of the groyne spacing relative to its length. Our technical teams can support you with your hydraulic works problems.

Brazil



BRIDGE PROTECTION

Where vital and expensive infrastructure crosses watercourses, hydraulic erosion needs to be prevented.

Total scour has three primary causes;

- General degradation of the channel bed due to natural or man-made causes which can be remote from the bridge
- Contraction scour from increased flow velocity due to a reduction in flow area
- Local vortex-induced scour at the piers and abutments

Attention is also required on the river banks up and downstream of the bridge.

The changes in the flow regime may require hydraulic erosion protection measures on these banks and the channel bed.

Russia


Turkey


Mexico

Although certain design details will be specific to each structure, common attributes of the protection are:

- Prevent loss or movement of riverbed material by the use of a filter layer beneath the scour protection
- Detail the vulnerable perimeter of the scour protection
- Extent of the protection determined by design parameters, life of structure and return period of storm event

Our modular double twist mesh gabions, Reno Mattresses and sack gabions offer ideal scour protection as they are flexible, permeable and long-lasting.

Where the contractor is not able to work in the dry, these units can also be pre-filled and conveniently lifted and placed into the works.


China

WATERPROOFING OF RESERVOIRS, LAKES & CHANNELS

Impermeable membranes are often used to contain water within hydraulic works.

To prevent the water from draining away, or cross-contaminating the ground water, a robust and reliable containment system is required.

Our package of geosynthetics includes MacLine® impermeable membranes and geosynthetic clay liners, MacTex® protection, filtration and separation geotextiles and MacDrain® drainage geocomposites, which are used in conjunction with our traditional materials to create protected lining systems for hydraulic works.

Uplift pressure on the membrane can be caused by the presence of a water table and must be considered in the design process.

Unlined structures within the catchment, such as attenuation ponds, are suitable where water draining into the natural soils is permissable.

Venezuela

Russia

Italy

France

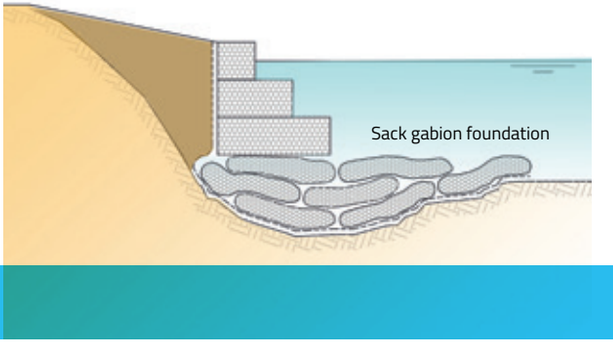
OTHER SOLUTIONS

The flexibility of our solutions, coupled with our innovative approach to problem solving, enables us to continually use our products in new ways.

Our pliable sack gabions form ideal foundations for riverbank retaining structures or to fill a breach in hydraulic defence structures.

Cubiroc prefilled gabion units are specifically designed to be lifted and placed directly into the river works, reducing the need for temporary works and coffer-dams. They incorporate unique features to simplify the installation process.

Gabion and Reno Mattresses have been successfully used as Fish Passes, enabling access for migrating fish around a man-made obstacle in the channel; a weir or dam.



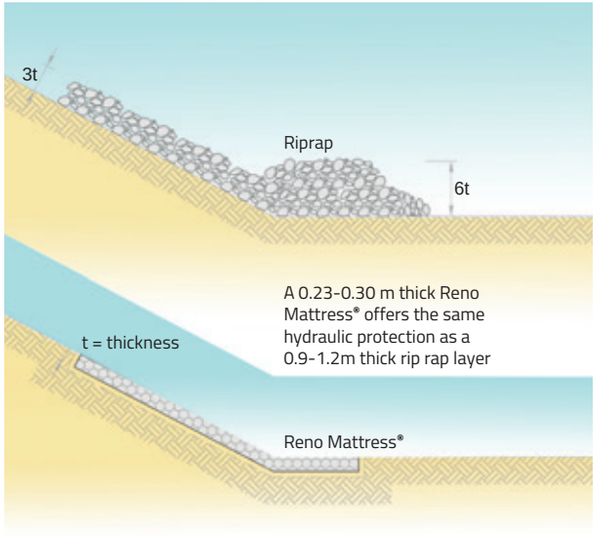
ENVIRONMENTAL SOLUTIONS: CARBON FOOTPRINT

We endeavour to reduce the environmental impact of our solutions wherever possible and achieving a balance with the technical performance and risk reduction.

We do this in a number of ways:

- The hydraulic resistance of confined rock within a Reno Mattress® or gabion is far greater than loose riprap, reducing the stone quantity needed
- Our solutions often enable the re-use of site-won materials within the structure
- Our products are transported flat-packed and assembled at the project site, reducing transportation volume
- Light-weight equipment needed for installation
- The permeability of our solutions encourages the growth of vegetation, producing large amounts of biomass which in turn captures atmospheric CO_2.

Focusing on our supply chain and manufacturing facilities, we have reduced our energy consumption and are installing solar p.v. power within our factories.



- A Reno Mattress® bank protection solution has 50% less CO_2 emissions than a riprap solution
- A gabion wall has 80% less CO_2 emissions than a concrete mass gravity wall

Further benefits can be gained if stone fill is locally available.

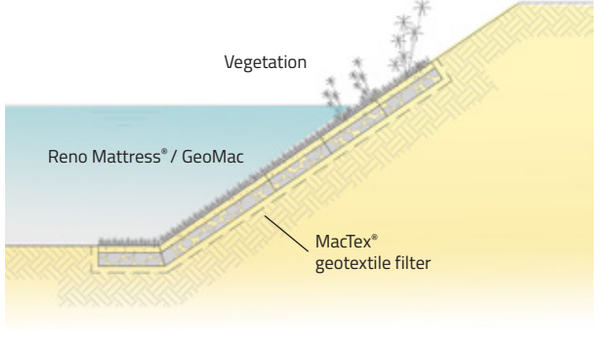
REVEGETATION GREEN SOLUTIONS & SOIL BIOENGINEERING

Naturalisation of our engineering structures is a positive environmental benefit.

This additional ecological value can be achieved with a low-cost by integrating vegetation and planting techniques at the design stage.

Research on our existing installations has shown these structures harbour large populations of mammals and macrobiotic fauna, indicating the quality of the ecosystems regenerated there.

The careful selection of solutions can support vegetation either naturally, e.g. siltation of the void volume within gabions and Reno Mattress®, or during installation, e.g. GeoMac, live-staking and planting.

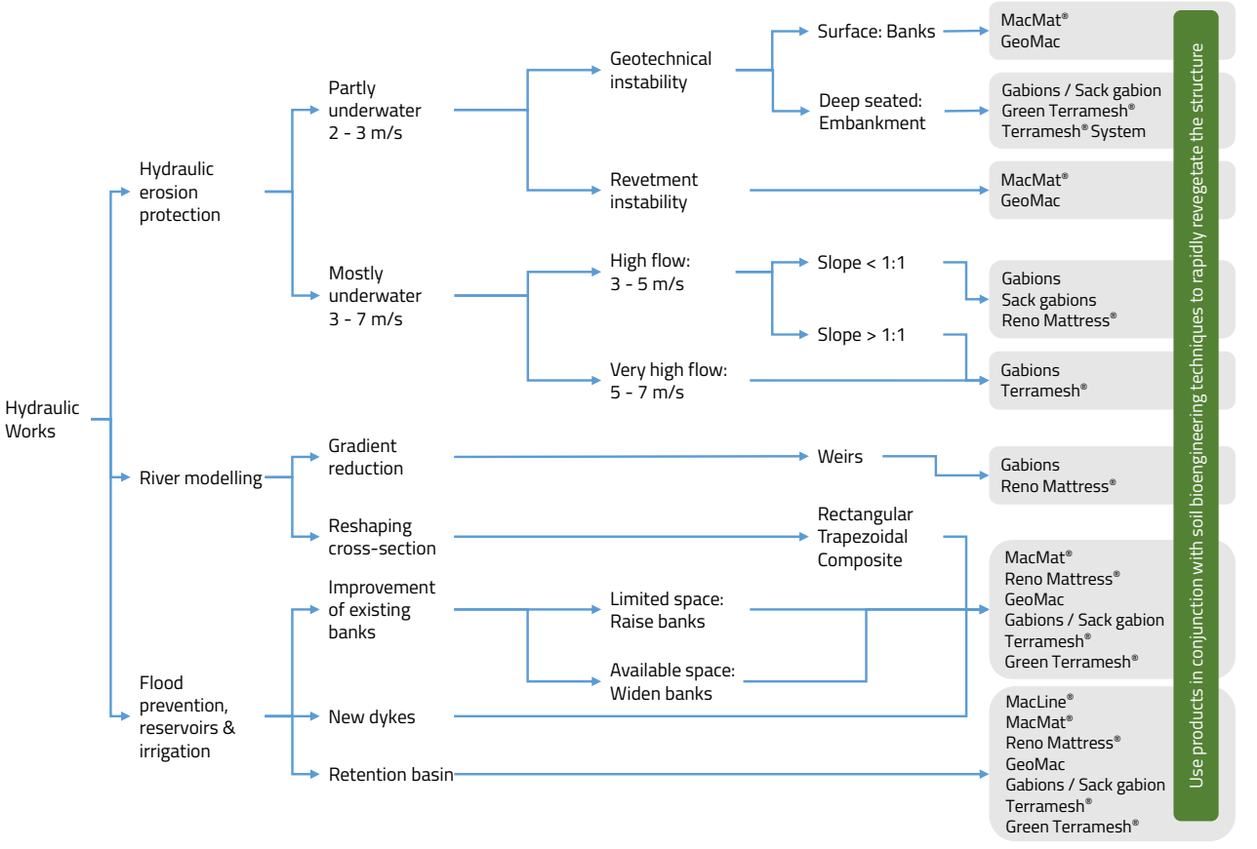


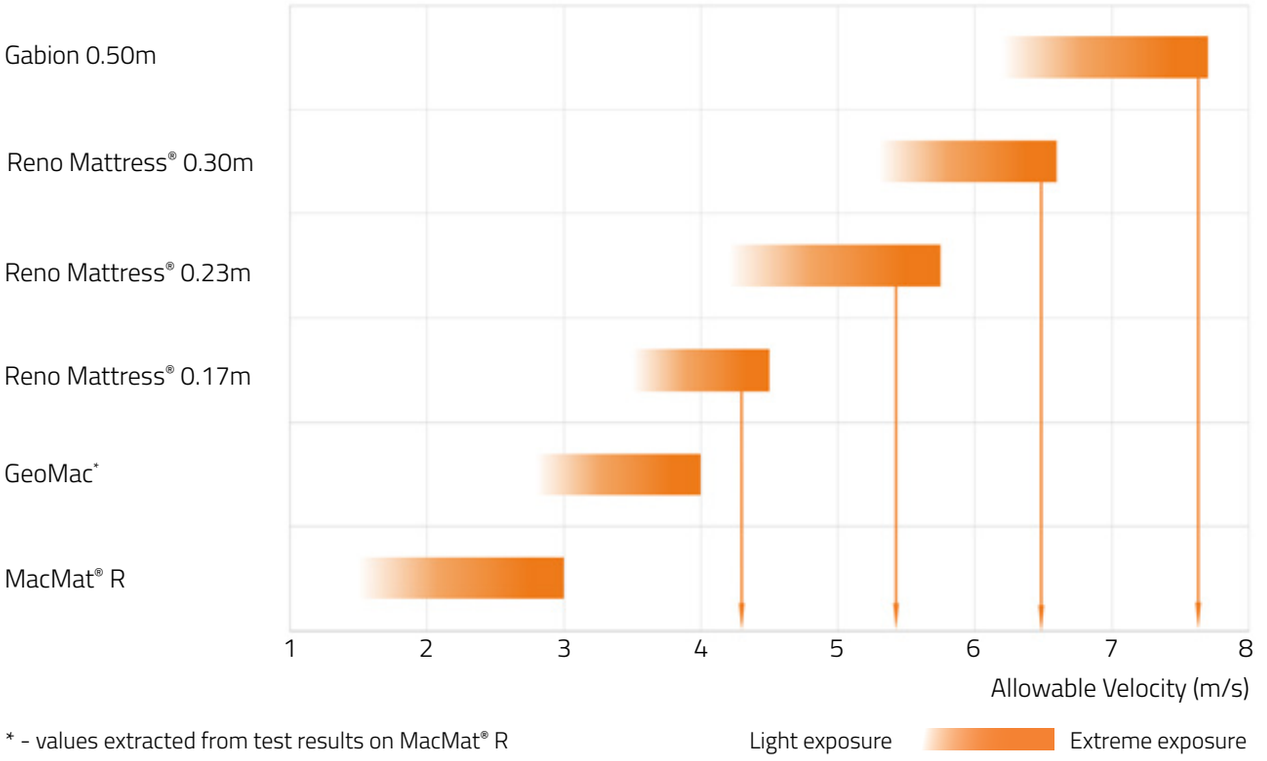
SOLUTION SELECTION & DESIGN

Our experience accumulated since1879, forms the core of our knowledge which we share with our clients to deliver durable, environmentally compatible hydraulic works solutions.

The frequency and severity of extreme events and natural hazards, including pollution, seem to be increasing, leading to greater exposure conditions than previously considered. These changes have to be accounted for within the solution selection and design process.

Why risk the integrity of your structure and the infrastructure that relies upon it?

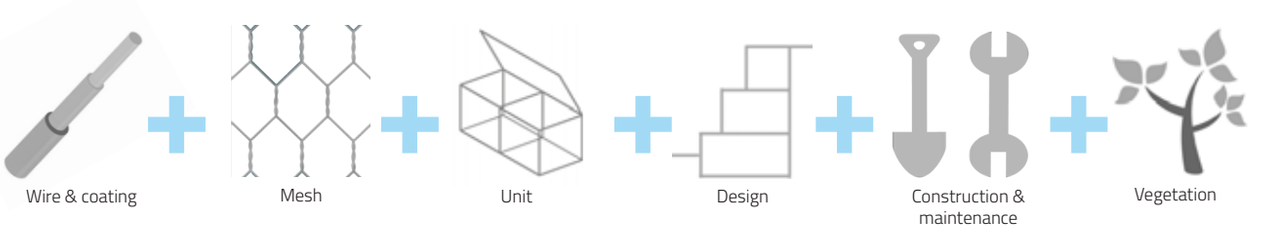




* - values extracted from test results on MacMat® R

Light exposure — Extreme exposure

The **functionality and design life** of a structure is not dependent on a single component but many working in harmony:



Durability

The durability of the solution starts with an accurate assessment of the problem, good design using appropriate parameters and finally, high quality products manufactured in a quality controlled factory and certified in accordance with recognised standards.

Although our double twist steel wire mesh has been tried and tested for over 70 years, it has been kept up to date with R & D into wire coating and mesh manufacturing technology. This has led to the development of advanced metallic and polymeric coatings;

- GalMac® - Zn/Al alloy galvanising
- PoliMac™ - High abrasion resistant polymer coating

Protection:

Wire mesh structures that are used within watercourses, adjacent to them or exposed to occasional wetting, must always have a polymer coating to a heavily galvanised wire coating.
Our innovative PoliMac™ provides longevity and excellent abrasion resistance.

Consult our engineers for further guidance.

DESIGN

Our experience, learned over nearly 140 years, forms the core of our knowledge which we share with our clients to select durable, environmentally compatible hydraulic works solutions.

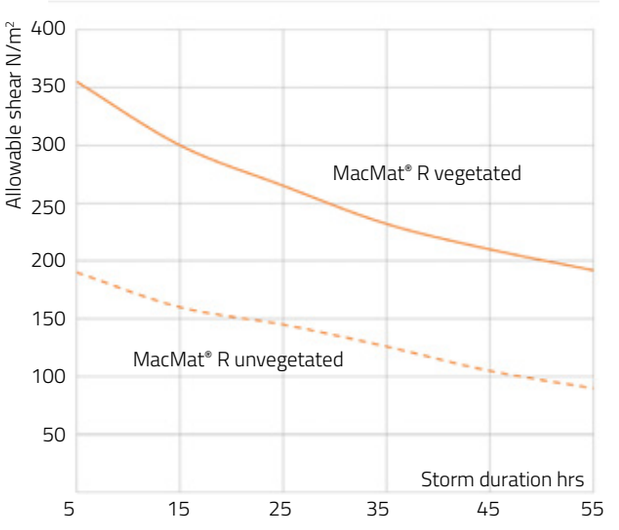
Numerous factors have to be considered and balanced within the design:

- Level of risk
- Environmental impact
- Design life
- Technical performance
- Cost of intervention
- Cost of the impact of not carrying out works, e.g. land loss, damage to infrastructure.

The tractive force theory design process is dependent on the location of the intervention within the catchment, its exposure conditions and how the structure will change over time.

	Thickness	Stone fill	Allowable velocity	Shear resistance	
		D_{50} (m)	(m/s)	Unvegetated (N/m²)	Vegetated (N/m²)
MacMat® R	Blanket	-	1.5-3.0 (<60 hrs)	190 / 80*	350 / 200*
GeoMac	0.30	Soil / rock	3.0-4.0 (<60hrs)	250 / 120*	400 / 250*
Reno Mattress®	0.17	75-100	4.2	190-200	400
	0.23	75-125	5.5	224-250	450
	0.30	100-150	6.4	260-300	450
Gabion	0.50	100-250	7.6	450	500

* = 5hrs / 60hrs



Storm duration

The expected duration of the flood event is critical to the success of the hydraulic erosion protection selected. Typical durations:

- Small rivers/drainage channels: 10 hrs
- Mid-sized rivers: 10-24 hrs
- Large rivers: 24-120 hrs

Critical considerations within the design of hydraulic works solutions must include the effects of:

- Vegetation
- Storm event duration

Over time, **vegetation** will establish within the watercourse, changing the watercourse roughness characteristics. The design should verify both conditions;

- Shear critical design - at end of construction
- Conveyance critical design - after vegetation establishment

The shear resistance benefits of vegetation deteriorate throughout the storm event; select solutions that will offer the required performance for the entire duration of the design storm event.

Working together with the project team, our engineers can add value in the design, detailing and installation techniques of the solution.

MACRA SOFTWARE

The MacRA design software supports engineers in the design of hydraulic protection within channels.

Bespoke cross-sections can be modelled in conjunction with the hydraulic erosion protection selected.

The performance of the channel can be checked for unvegetated and vegetated conditions alerting the designer to a potential lack of conveyance capacity and overtopping.

A library of channel soil types, natural materials, soil bioengineering techniques and erosion protection materials are included within the software database.

The design criteria are based on scale and full-size model tests.

The Maccaferri Innovation Centre, based in Bolzano, Italy is the hub of our R & D, enabling us to advance our solutions to the benefit of our clients and the populations they serve.

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Gruppo Industriale Maccaferri

Engineering a Better Solution

Maccaferri's motto is **'Engineering a Better Solution'**; We do not merely supply products, but work in partnership with our clients, offering technical expertise to deliver versatile, cost effective and environmentally sound solutions. We aim to build mutually beneficial relationships with clients through the quality of our service and solutions.

OFFICINE MACCAFERRI GROUP PROFILE

Founded in 1879, Officine Maccaferri soon became a technical reference in the design and development of solutions for hydraulic works and retaining structures.

Since then, through technological innovation, geographical expansion and focussed diversification, Maccaferri now offers solutions at a global level for a wide range of civil, geotechnical and environmental engineering applications.

ORGANISATIONAL STRUCTURE

Officine Maccaferri is at the heart of the Maccaferri Industrial Group, a corporation with revenues of €1.2B, operating in mechanical engineering, real estate & construction, energy, food & agro-industry and tobacco.

Officine Maccaferri's vision is to become a leading international provider of advanced solutions to the civil engineering and construction market. With nearly 3000 employees, over 30 manufacturing facilities and local operations in 100 countries around the world, Maccaferri can truly claim to have a global presence with local focus.

MACCAFERRI APPLICATIONS

- RETAINING WALLS & SOIL REINFORCEMENT
- HYDRAULIC WORKS
- ROCKFALL PROTECTION & SNOW BARRIERS
- EROSION CONTROL
- SOIL STABILISATION & PAVEMENTS
- BASAL REINFORCEMENT
- COASTAL PROTECTION, MARINE STRUCTURES & PIPELINE PROTECTION
- ENVIRONMENT, DEWATERING & LANDFILLS
- DRAINAGE OF STRUCTURES
- TUNNELLING*
- LANDSCAPE & ARCHITECTURE
- SAFETY & NOISE BARRIERS
- FENCING & WIRE
- AQUACULTURE NETS/CAGES
- CONCRETE FLOORING, PRECAST & OTHER USES*

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+ In 2014, Maccaferri and Bekaert entered a global sales and distribution joint venture. Bekaert Maccaferri Underground Solutions serves all markets except China, Hong Kong, Argentina, Brazil, Paraguay, Peru and Uruguay. In these countries the companies act independently.

MACCAFERRI