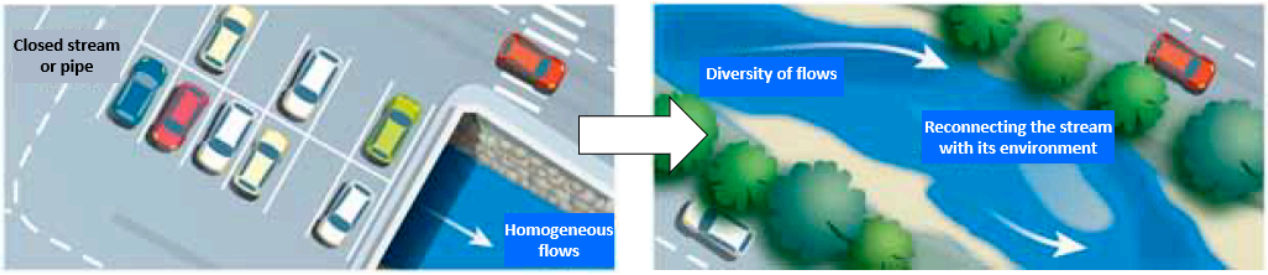
I/ General description and characterization of the NBS entity

I.1 Definition and different variants existing

Definition	The complete coverage of a watercourse is undoubtedly the most traumatic human intervention that a river system can undergo since it results in the complete disappearance of the latter. It leads to the complete disappearance of the habitats, the riparian forest, the relations between the aquifer and the banks, etc., but also to a major ecological discontinuity of the fluvial network. Whenever the socio-political context allows it, the reopening of the stream should be realized. The opening of streams is necessarily accompanied by heavy demolition work and reconstruction of a new bed.

There are **different levels of restoration**:
1) The most radical method is to fully discover the watercourse and to "recreate" it completely in its natural thalweg respecting its original morphology
2) If the land area of the old route is not available, the watercourse can still be opened, and natural banks recreated (softening slopes, vegetation, etc.), with a low flow bed with a more adequate morphology
3) If, for various technical and financial reasons, discovering the stream is not possible, mitigation measures of the impacts can be implemented, such as the creation of wells of light on the covered linear (if it is not too long), the establishment of an alluvial substrate at the bottom of the bed, or the positioning of physical elements to facilitate fish movement.



Schematic representation of a reopened stream @ONEMA (adapted)

Some practical illustrations are provided below.

Before restoration (left image) – 6 months after restoration (right image)
© Photo: Vincent MIquel - CARG

Before restoration (left image) – 2 years after restoration (right image)
© SYMASOL

Before restoration in 1999 (top image) – After restoration in 2006 (bottom image)
© Photo Alain Cadou

I.2 Urban challenges and sub-challenges related + impacts		
Main challenges and sub-challenges targeted by the NBS	02| Water management and quality > 02-1 Urban water management > 02-2 Flood management 04| Biodiversity and urban space > 04-1 Biodiversity > 04-2 Urban space development and regeneration > 04-3 Urban space management	- Improvement of the hydromorphological functioning of the watercourse - Potential improvement of flood control by improving stormwater management - Restore the aquatic habitats of the watercourse and increase the faunistic and floristic biodiversity - Ensure ecological continuity and improve the free movement of aquatic species
Co-benefits and challenges foreseen	01| Climate issues > 01-2 Climate adaptation 07| Public Health and Well-being > 07-1 Quality of life 09| Urban planning and governance	- Create cool areas - Enhance the landscape and recreational activities around and in the riverbed. - Revitalize the image of the river and offer residents a green space of quality - Diversify planning actions and stakeholders
Possible negative effects	07| Public Health and Well-being > 07-2 Health	-Possible pests such as mosquitos, frog cries…

II/ More detailed information on the NBS entity

II.1 Description and implication at different spatial scales	
Scale at which the NBS is implemented	In an anthropized sector, reopening a stream is often carried out on few linear meters (neighbourhood scale).
Impacted scales	While the local ecological effect is appreciable, river-wide gains remain limited (more continuity has to be achieved to affect this scale).
II.2 Temporal perspective (including management issues)	
Expected time for the NBS to become fully effective after its implementation	The NBS is rapidly effective after its implementation: it only needs time for the reopened stream to stabilize and for the new vegetation to grow.
Life time	Life time of the stream
Sustainability and life cycle	A priori, no major impact associated with the life cycle of the NBS. The implementation phase is the phase most likely to generate impacts.
Management aspects (kind of interventions + intensity)	Occasional grass cutting
II.3 Stakeholders involved / social aspects	
Stakeholders involved in the decision process	Landowner (private or public)
Technical stakeholders & networks	Resort to a qualified contractor who has the needed equipment and experience is recommended.
Social aspects	No particular social bottleneck

II.4 Design / techniques/ strategy	
Knowledge and know-how involved Or key points for success	Reopening a stream necessary implies civil engineering works, e.g. for the removal of concrete slabs or flow nozzles.
Materials involved	Civil engineering machines are needed.

II.5 Legal aspects related
- In France, this type of action fits in the regulatory framework (*Déclaration d'intérêt general*, and/or *Dossier de demande d'autorisation au titre de la loi sur l'eau*). - Unlike other restoration measures, the reopening of watercourses requires land acquisition, a measure to be achieved or at least to be negotiated, from the preliminary study.

II.6 Funding Economical aspects	
Range of cost	Examples of streams reopening measures give cost ranges between 900 and 2500 € excluding VAT per linear meter (Eau Seine Normandie, 2007).
Origin of the funds (public, private, public-private, other)	Depending of the owner of the land (can be public or private).

II.7 Possible combinations with other kinds of solutions (other environmental friendly solutions or conventional ones)
Reopened streams can be associated with complementary measures, e.g. disconnecting the rainwater and / or wastewater systems, creating a fording in an agricultural area, modifying the geometry of the streambed, vegetating the riverbanks or planting aquatic and semi-aquatic plants.

III/ Key elements and comparison with alternative solutions

III.1 Success and limiting factors	
Success factors	- Watercourse covering has very often disturbed the behaviour of the groundwater table, especially if it has been accompanied by piping, concreting of the bottom of the bed, deepening of the water lines, etc. Opening the watercourse must often be accompanied by a guarantee of tightness of the newly created bed, to avoid permanent losses of the watercourse after restoration works (by checking the natural bedrock (marls, clays, etc.) or, if necessary, by creating an artificial sealing under the new bed).
Limiting factors	- The coverage of a watercourse has often been linked to the urbanization of the areas initially occupied by the alluvial space or, in rural areas, to the more intensive use of these surfaces. This coverage has often been coupled with the "linearization" of the course of the watercourse as well as the "land consolidation" that accompanies it. As a result, opening a watercourse is inevitably a difficult restoration operation and a long-term "technical-administrative" procedure to put in place. It must necessarily be accompanied by the acquisition of land areas sufficient to restore the fluvial space. In addition, the initial route may often no longer be possible due to urbanization. - Putting under pipe or covering a watercourse is regularly coupled with a deepening of the stream, to favor its use as sewerage system. This deepening is sometimes very difficult, even impossible to recover, which then requires the realization of a watercourse "artificially" deeper than what would recommend the inspiration of natural models. - The water flow of the reopened stream must be sufficient

III.2 Comparison with alternative solutions	
Grey or conventional solutions counterpart	No alternative grey solution.
Close NBS	• Remeander rivers • Excavation of new waterbodies (ponds, lakes) • Infrastructures removed on rivers (ex. dams)

IV/ References

IV.1 Scientific and more operational references (presented jointly)

- RiverWiki is an interactive source of information on river restoration schemes from around Europe (up to now, 1026 river restoration case studies from 31 countries): https://restorerivers.eu/

IV.2 Sources used in this factsheet

- Eau Seine Normandie, Manuel de restauration hydromorphologique des cours d'eau – 3. Typologie des opérations de restauration et éléments techniques – Fiche 10 : Remise à ciel ouvert de cours d'eau, pp55-59, 2007 (in French)
- Agence Française pour la Biodiversité (ex. ONEMA) - La remise à ciel ouvert d'un cours d'eau http://www.onema.fr/recueil_restauration_hydromorphologie

V/ Author(s)

Name	Institution / company	Writer/ reviewer
Pyrène Larrey-Lassalle	Nobatek/INEF4	Writer
Patrice Cannavo	Agrocampus Ouest	Reviewer
Ryad Bouzouidja	Agrocampus Ouest	Reviewer
Marjorie Musy	Cerema	Reviewer