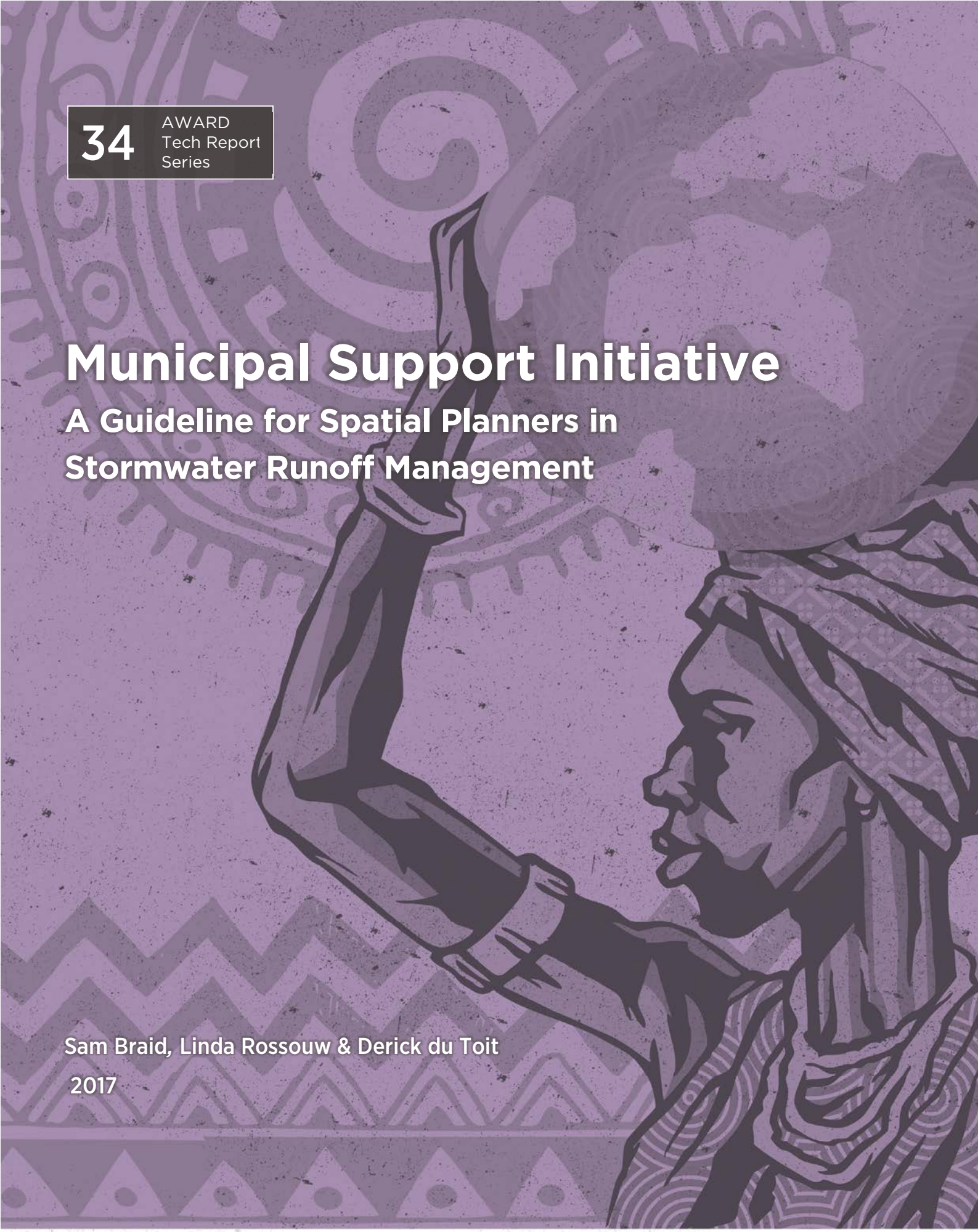
34 AWARD Tech Report Series

Municipal Support Initiative

A Guideline for Spatial Planners in Stormwater Runoff Management



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Acknowledgements

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1 Local government & stormwater management

It is a requirement of municipalities to compile and gazette a stormwater management by-law (s). It is recommended that this by-law be developed-law and must include provision for addressing water quantity and water quality reaching the receiving water resource bodies. A search of SABINet provided no gazetted by-laws for Mopani DM, nor Maruleng or BaPhalaborwa local municipality for stormwater regulation.

The RESILIM O project recommends that Sustainable Urban Drainage Systems (SUDS) be considered towards stormwater management.

1.1 Sustainable Urban Drainage Systems (SUDS)

SUDS promote more natural drainage through the use of a number of key unit processes. These unit processes are linked to the four elementary focal points of the binding philosophy of SUDS, namely:

A] Quantity (flow and volume)
B] Quality
C] Amenity
D] Biodiversity

A] Management of Quantity

The principle of quantity management is to reduce the concentrated volume of runoff to the receiving river. Stormwater flow quantity can be managed through:

- Rainwater harvesting – the direct capture of stormwater runoff, typically from rooftops, for supplementary water uses on-site.
- Infiltration – the soaking of stormwater runoff into the ground thereby physically reducing the volume of stormwater runoff on the surface.
- Detention – the slowing down of stormwater runoff before subsequent transfer downstream.
- Conveyance – the transfer of stormwater runoff from one location to another.
- Long-term storage – the volumetric control of stormwater runoff in a specified infiltrating area that will drain very slowly.
- Extended attenuation storage – the retention of stormwater runoff to protect receiving watercourses in the event of flooding if long-term storage and additional infiltration are not feasible on site.

B] Management of Quality

The principle of quality management is to ensure that the quality of the runoff waters does not contaminate the receiving river. Stormwater quality can be managed through:

- Sedimentation – the removal of sediment particles attached to pollution in stormwater runoff by reducing flow velocities to ensure sediment particles fall out of suspension.

- Filtration and biofiltration – the filtering of stormwater runoff pollutants that are conveyed with sediment by trapping these constituents on vegetative species, in the soil matrix or on geotextiles.
- Adsorption – the process whereby stormwater runoff pollutants bind to the surface of aggregate particles. Types of adsorption include cat-ion exchange, chemisorption and absorption.
- Biodegradation – the degradation of organic pollutants in stormwater runoff by microbes.
- Volatilisation – the conversion of stormwater runoff compounds to gas or vapour typically as a result of heat, chemical reaction, a reduction of pressure or a combination of these.
- Precipitation – the removal of soluble metals in stormwater runoff through chemical reactions between pollutant constituents and aggregate in the control structure to form a suspension of insoluble precipitates.
- Plant-uptake – the removal of stormwater runoff nutrients and metals through uptake by plants.
- Nitrification – the oxidisation of ammonia and ammonium ions in stormwater runoff by microbial factions to form nitrite and nitrate.
- Photosynthesis – the breakdown of organic pollutants in stormwater runoff through extended exposure to ultra-violet light.

C] Amenity Management

The principle of amenity management is to integrate stormwater management into the character and operating of a place rather than hidden infrastructure. The amenity value of SUDS can be managed through:

- Health and safety – the planning and implementation of control measures to prevent the injury or death of people including, inter alia, safe design practices, alert medical aid teams, and cooperative communities.
- Environmental risk assessment and management – the assessment and management of the various environmental sub-components to ensure their longevity.
- Recreation and aesthetics – the provision of interactive and attractive structural and non-structural components by protecting, shaping and creating open spaces and enhancing the visual appearances of the specified systems.
- Education and awareness – the dissemination of knowledge about stormwater management amongst interested and affected parties, through proactive campaigns, field trips and interactive stakeholder agreements.

D] Biodiversity Management

The principle of biodiversity management is to use the runoff management mechanisms to promote biodiversity habitat. The biodiversity of SUDS can be managed through:

- Protection – the identification and preservation of indigenous flora and associated fauna.
- Maintenance of habitat – the removal of invasive species.
- Monitoring – the monitoring of the fauna and flora, to ensure early intervention when problems arise.

1.2 SUDS Selection

SUDS generally embrace a number of options that are arranged in a treatment trains/process. In other words, stormwater is managed through a series of unit processes in much the same way as, for example, wastewater is treated in a treatment works. Twelve families of SUDS options are presented here. They each incorporate a variety of treatment processes with considerable overlap. The selection of any particular option/s is/are determined by the unique characteristics of the site.

It is unlikely that all options will be applicable and/or effective on any one site. It is thus important that the advantages and limitations of each option should be identified during the planning and design phases.

Seven basic selection criteria have been identified (Armitage *et al.*, 2013*)*:

A] Current and future landuse characteristics,
B] Site characteristics and utilisation requirements,
C] Catchment characteristics,
D] Stormwater runoff quantity (peak flow and flood volume) requirements,
E] Stormwater quality requirements,
F] Amenity requirements, and
G] Biodiversity requirements.

There are four key intervention points in the treatment process, each having slightly different combinations of SUDS options to control the stormwater:

A] Good housekeeping – to ensure that as much as possible is done to minimise the release of pollutants, such as solid waste, into the environment where it may subsequently be transported by stormwater.
B] Source controls - manage stormwater runoff as close to its source as possible, usually on site. Typical SUDS options include: green roofs, rainwater harvesting, permeable pavements, retention ponds and soakaways.
C] Local controls - manage stormwater runoff in the local area, typically within road reserves. Typical SUDS options include bio-retention areas, filter strips, infiltration trenches, sand filters and swales.
D] Regional controls - manage the combined stormwater runoff from several developments. Typical SUDS options include constructed wetlands, detention ponds and retention ponds.

SUDS treatment processes should prioritise water quality treatment for low flows and attenuation and volume control for high flows. Furthermore, the number and size of the SUDS treatment components depends on 1) the sensitivity of receiving watercourses or other environments, 2) the size of contributing catchments upstream and 3) the expected pollution concentrations in stormwater runoff inflows. While the different SUDS options tend to be associated with a particular point in the treatment train, it is often possible to utilise them elsewhere depending on the site. For example, constructed wetlands are generally regarded as a regional control but they may also be used as an effective source control, as in the form of a pocket wetland in a residential complex.

SUDS are grouped as follows:

A] Source Controls are used to manage stormwater runoff as close to its source as possible – generally within the boundaries of a property.

These include:

- Green roofs - vegetated roofs.
- Rainwater Harvesting - temporary storage and reuse of rooftop and/or surface runoff.
- Soakaways - usually excavated pits that are packed with course aggregate and other porous media that are used to detain and infiltrate stormwater runoff from a single source.
- Permeable pavements - load-bearing, durable and pervious surfaces such as concrete block pavers (CBPs) laid on top of granular or stone base that can temporarily store stormwater runoff.

B] Local Controls are used to manage stormwater runoff as a second 'line of defence' typically in public areas such as roadway reserves and parks.

These include:

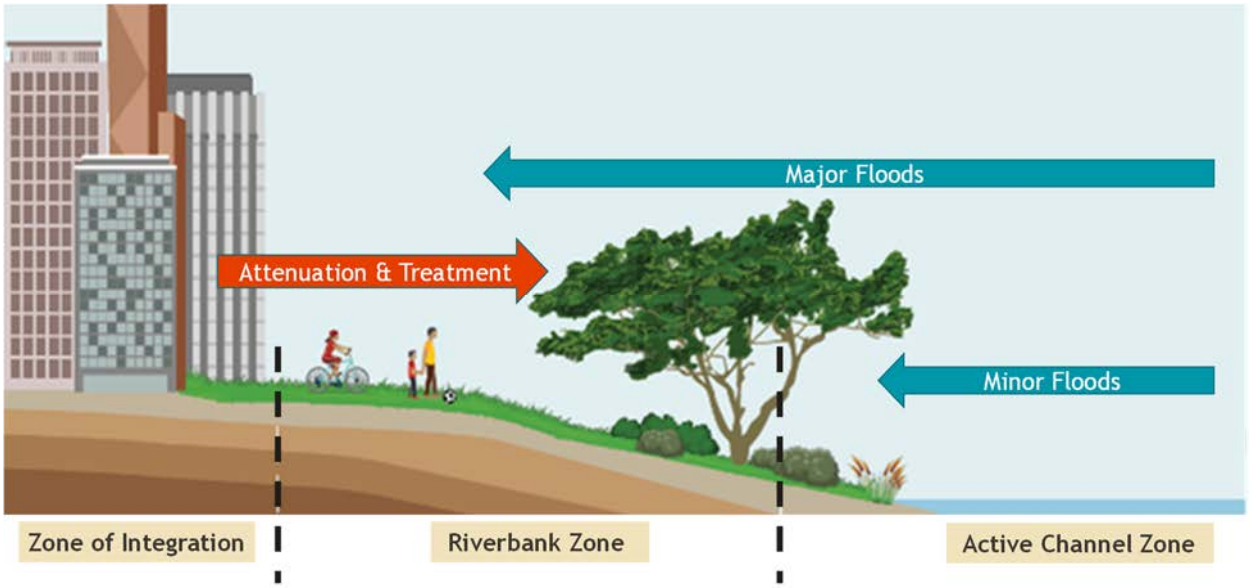
- Filter strips - vegetated areas of land that are used to manage shallow overland stormwater runoff through filtration.
- Swales - shallow grass-lined channels with flat and sloped sides that are used to convey stormwater from one place to another. They typically remain dry between rainfall events.
- Infiltration trenches - excavated trenches which are lined with a geotextile and backfilled with rock or other relatively large granular material. They are typically designed to receive stormwater runoff from adjoining residential properties.
- Bio-retention areas - landscaped depressions used to manage stormwater runoff through several natural processes such as filtration, adsorption, biological uptake and sedimentation.
- Sand filters – these usually comprise of an underground sedimentation chamber connected to a filtration chamber in which stormwater runoff is temporarily stored before being filtered through a sand filter.

C] Regional Controls are used to manage stormwater runoff as a last 'line of defence'. They are generally large-scale interventions which are constructed on municipal land.

These include:

- Detention ponds - relatively large depressions that temporarily store stormwater runoff in order to reduce the downstream flood peak.
- Retention ponds also known as 'retention basins' –formed by excavating below the natural ground water level and/or lining the base to retain stormwater runoff.
- Constructed wetlands- these attempt to mimic the characteristics of natural wetlands through the use of marshy areas and aquatic-resilient plants. They can be aesthetically pleasing and provide a vibrant wildlife habitat.

For more detail on implementing SUDS refer to Armitage *et al* (2013).



LAND USE PLANNING TO ADAPT FOR IMPACTS TO AND FROM THE RIVER

The Zone of Integration (The Light Development Zone)

The zone of integration is the area adjacent to, and on the land side of, the riverbank zone. The Zone of Integration is the area where renovation, redevelopment, or new development will occur. Such development may be commercial, residential, institutional, or any other use proposed within this guideline; however, all developments permitted in this zone should be light development. All development must include on-site attenuation, where this is not possible e.g. existing development, the riverbank zone can be used for this attenuation and natural treatment.

The Riverbank Zone

The Riverbank zone (1:100 year floodline), also known as the ecological zone, is the area stretching inland from the edge of the active channel. This zone should ideally be treated with indigenous vegetation planting and recreational mixed uses (e.g. foot paths, recreational open spaces). Exceptions to this principle include development or construction required by river dependent uses, and existing formal buildings or structures. Undesirable uses i.e. uses that pose a risk to life from flooding, must be removed from this area and must consequently be rehabilitated. This zone falls within the 30 - 50 metre setback

The Active Channel Zone

The Active Channel Zone (1:2 year floodline) consists of the actual river up to the water's edge, with the addition of a 5-meter buffer from the water's edge inland. The actual river plus the 5-meter buffer then makes up the Active Channel Zone. Strictly, no development or related (development) activities should be permitted in this zone. This zone will make allowance for 1:2 year floods and must thus remain in its natural state. The water's edge must be determined in wet months (rainy season) when the river is at its normal annual peak flow.

2 Mitigation of impacts

2.1 Landuse mitigation

2.1.1 Interventions for suitable landuses in buffer areas

The diagrams below, taken from H. van den Berg and S. Braid (2017), provide public and private sector development practitioners with a scenario based decision matrix on assessing site level urban riverine environments and determining appropriate interventions. These scenarios and the associated interventions are based on international best practice principles in terms of river setback zones, nature based infrastructure solutions, planning based interventions, traditional infrastructure solutions as well as socially just participatory planning practices. Accordingly, the overarching purpose of the diagram is to integrate the concepts and strategies presented within the preceding sections of the report into a practical decision flow that will assist with on the ground decision making and implementation.

1] Intervention A: Promote Integrated Site Planning

The first step is an understanding of the current reality. The factors that have driven the demand for the development in question, as well as all *status quo* conditions must be understood as clearly as possible. This understanding must also include highlighting who the relevant stakeholders are for the development. The development of a municipal Spatial Development Framework is a form of Integrated Site Level Planning.

Once this has been determined, a future aspiration and vision for the development can be determined via stakeholder engagement processes. The visioning exercise will form part of the Concept Development.

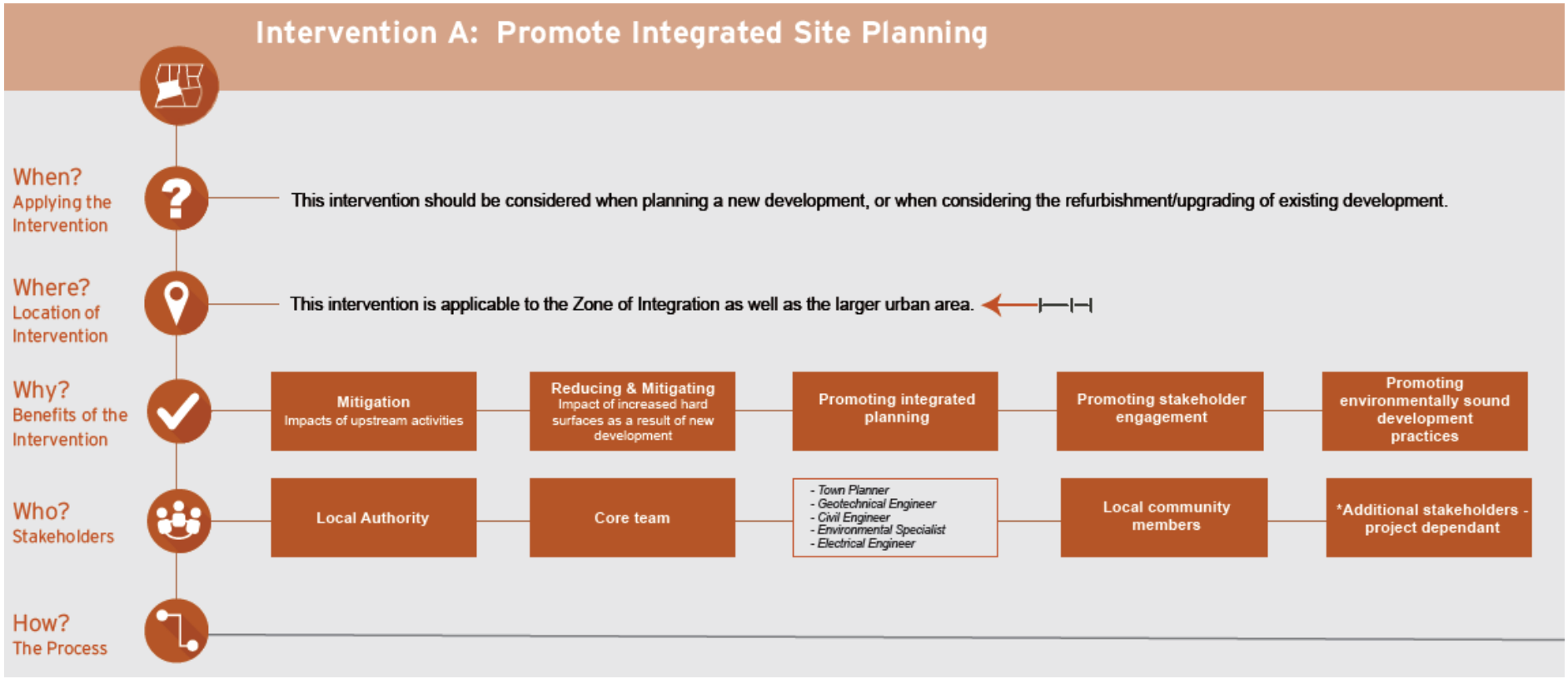


Figure 1: Intervention A: Integrated Site Level Planning (Source: H. van den Berg and S. Braid, 2017)

A feasibility study for the development must be undertaken, in order to ensure the highest and best use of the land, in line with local priorities, strategies and plans. This includes a land and legal, social, infrastructural and environmental assessment to determine the development informants linked to each of these themes. The outcomes are then fed into the Concept development process. The Concept development process is iterative and requires inputs from various stakeholders. The development of the concept should take into account the possibilities for the given site based in terms of the vision based on the site-specific findings of the feasibility study. Once this has been developed and approved through a participatory planning process, detailed design can commence, which will typically include detailed planning and statutory approvals, underpinned by detailed engineering designs. Once implementation has occurred, it is critical that Operation and Maintenance (O&M) be prioritised. The O&M plan should be part of the planning process from Inception, and the stakeholders should be identified in accordance with this principle.

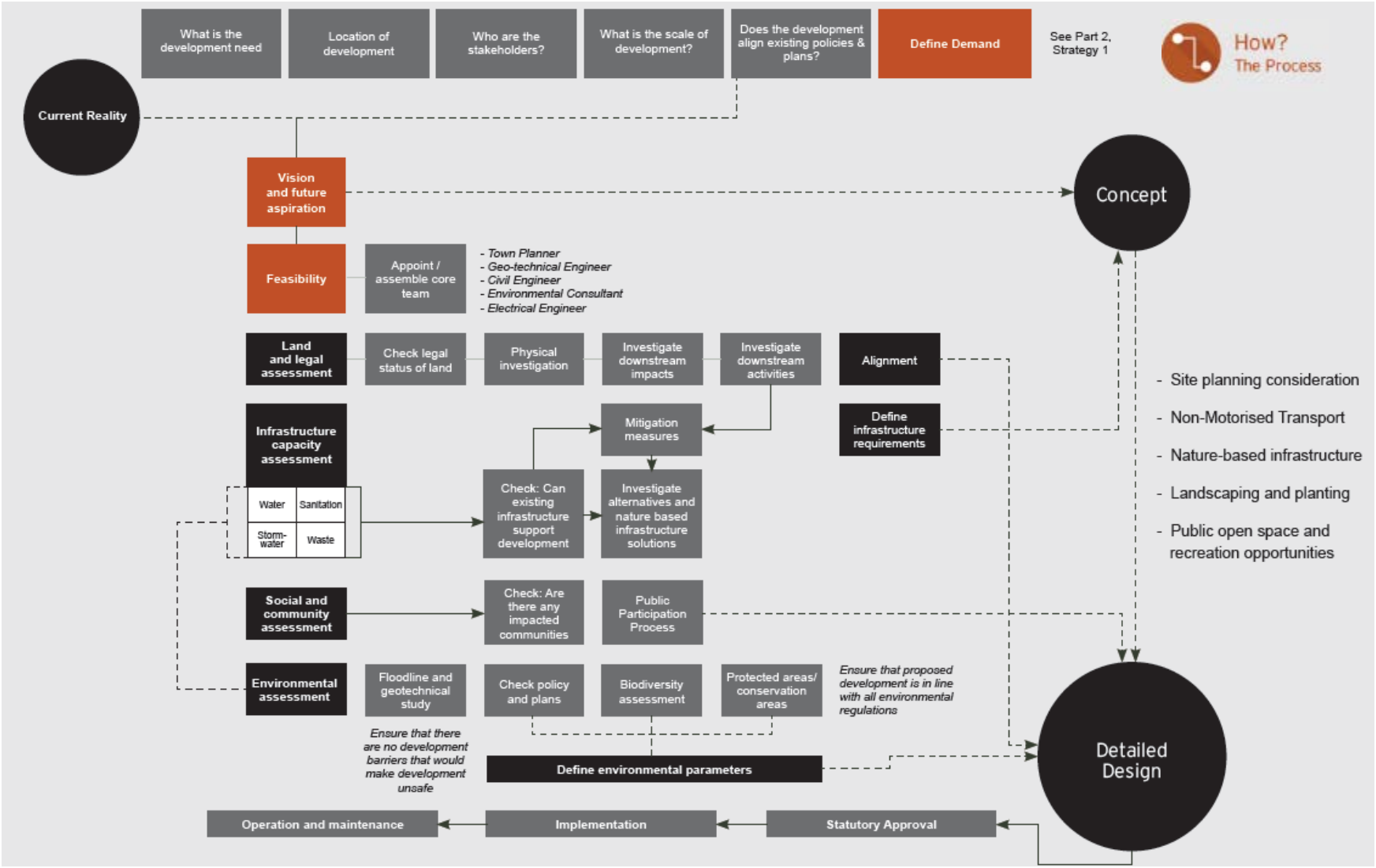


Figure 2: Promote integrated site planning to support river function (H. van den Berg and S. Braid, 2017)

2] Intervention B: Relocation Process to Ensure Participatory Planning and Community Buy-in

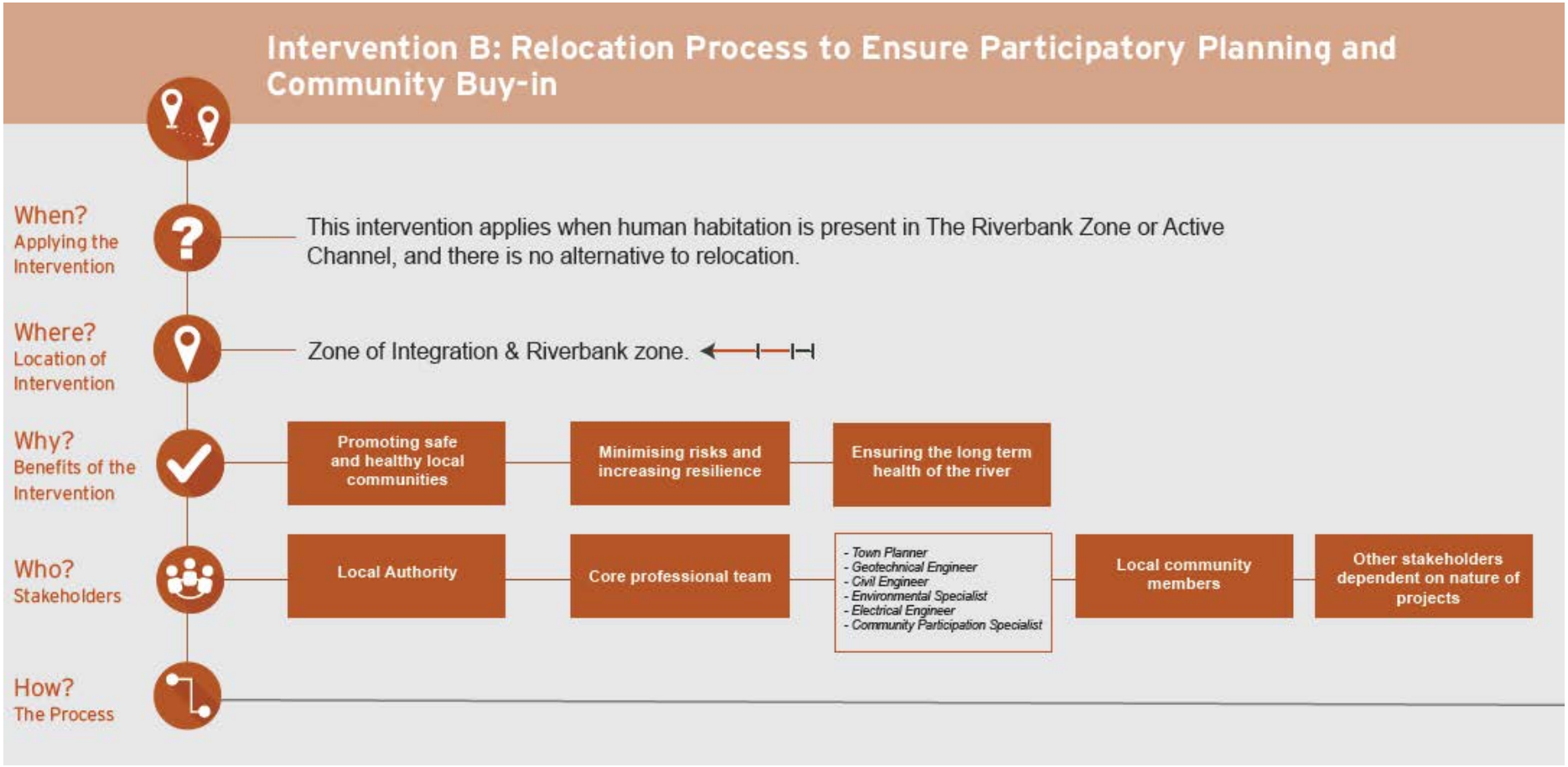


Figure 3: Intervention B: Relocation Process to Ensure Participatory Planning and Community Buy-in

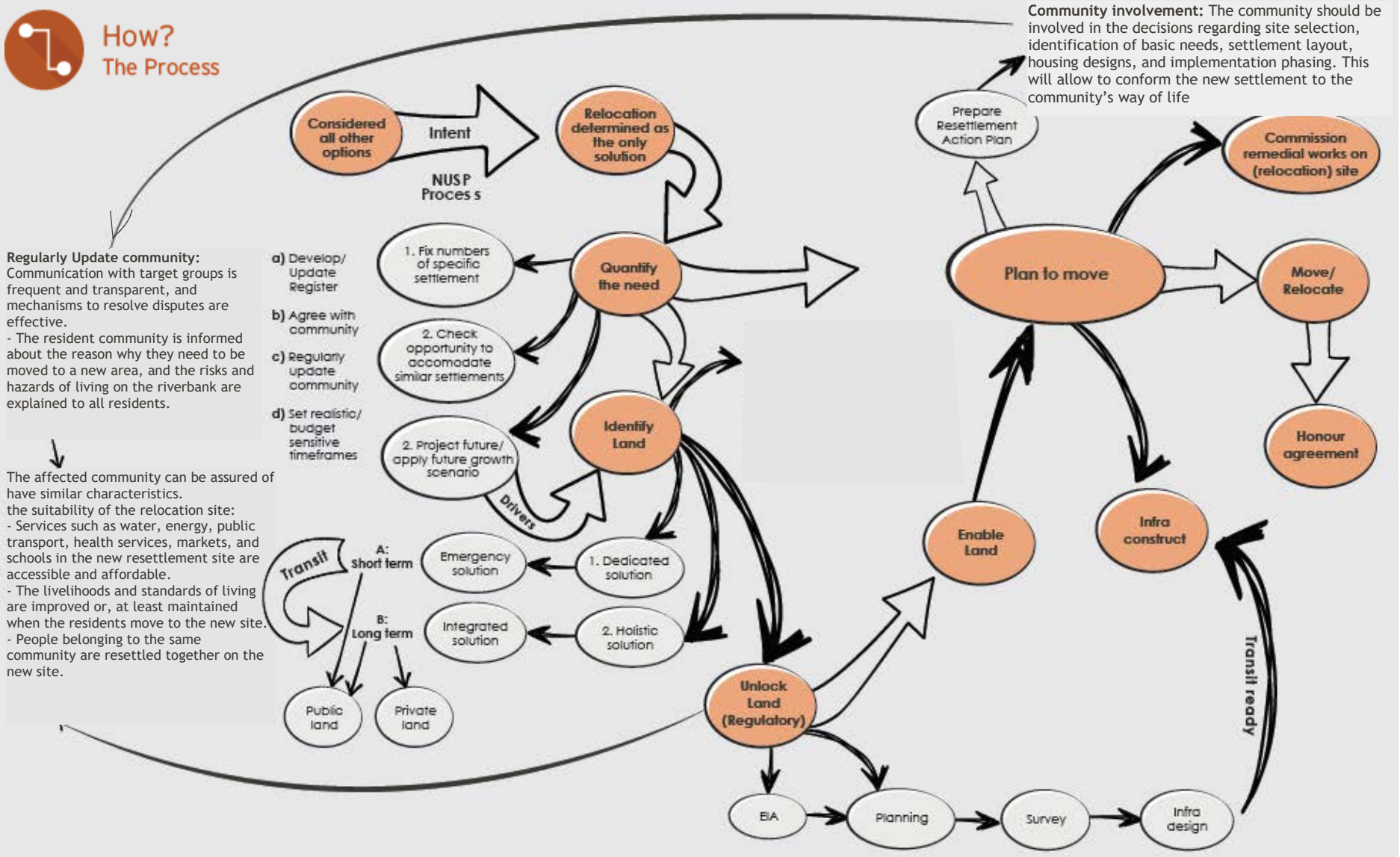


Figure 4: The process for Intervention B (H. van den Berg and S. Braid, 2017)

3] Intervention C: Promote Nature-Based Solutions & Ecologically Sensitive Development & Interventions

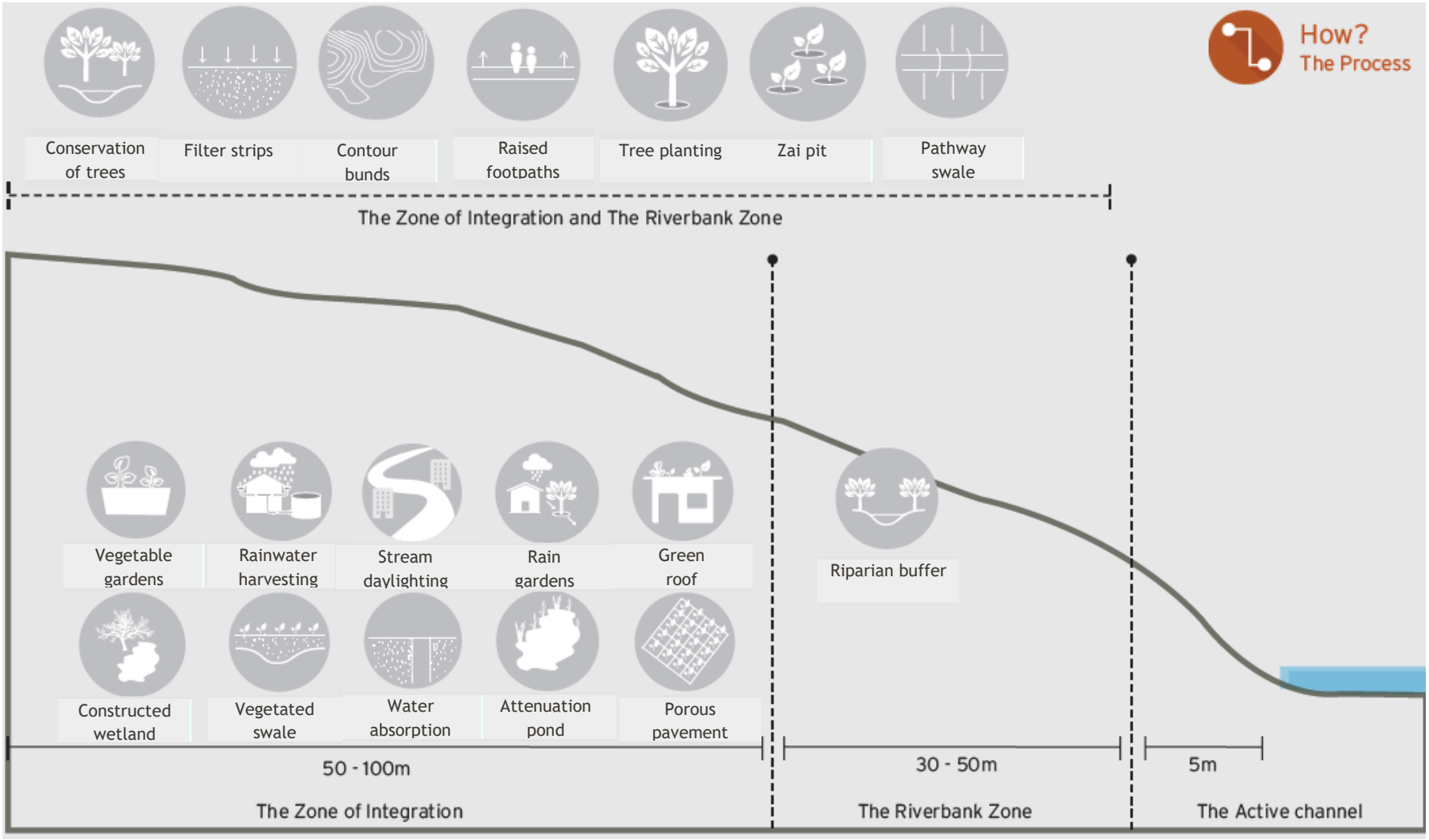


Figure 5: Promote nature based sollutions & ecologically sensitive development & interventions

4] Intervention C1: Runoff Reduction through Nature-based Interventions

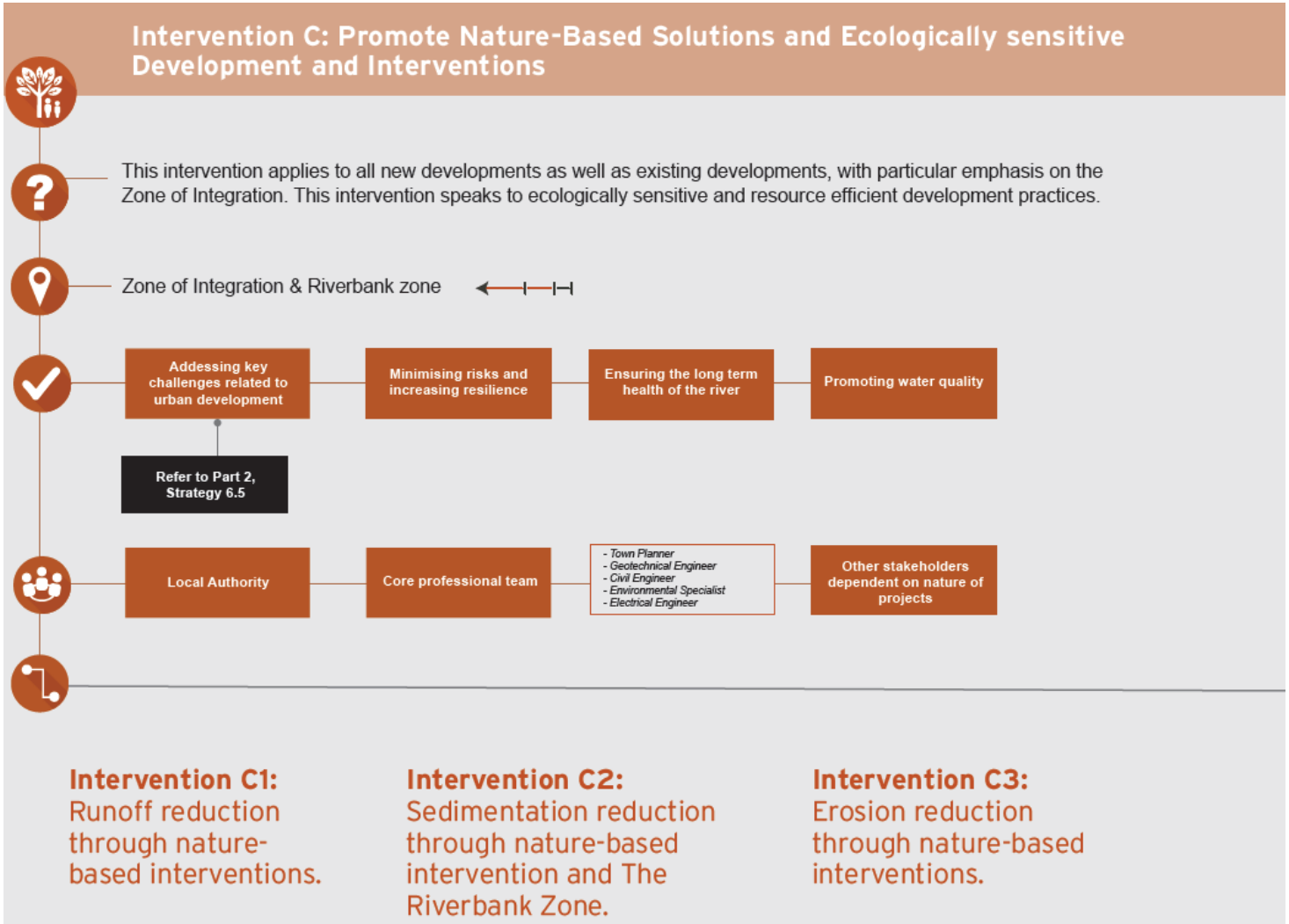
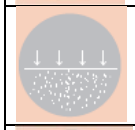
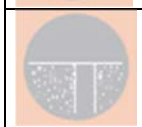


Figure 6: Runoff reduction through nature-based interventions (H. van den Berg and S. Braid, 2017)

TABLE 1: RUNOFF REDUCTION THROUGH NATURE-BASED INTERVENTIONS TO ADDRESS THE CHALLENGE OF EXCESS RUNOFF (H. VAN DEN BERG & S. BRAID, 2017)

Nature Based Preventative Infrastructural Interventions		Description	Area of Intervention
	Conservation of natural areas / urban park / urban woodland	Retain the pre-development hydrological and water quality characteristics of undisturbed natural areas, stream and wetland buffers by restoring and/or permanently conserving these areas, including ecologically sensitive areas. Urban parks and/or urban woodlands bring the forest to the city and connects residents with nature. It also helps cities and towns to build their urban forest and to achieve their outdoor recreation goals.	Riverbank Zone Zone of Integration (Green spaces; Agricultural / Rural)
	Riparian buffer	Riparian buffers can be used to treat and control stormwater runoff from some areas of a development project.	Riverbank Zone
	Filter strips / groundcover	Covering exposed soils with growing vegetation e.g. ground covers or mulching to reduce runoff from exposed soil	Riverbank Zone Zone of Integration (Green spaces; Agricultural / Rural)
	Vegetated swale	The natural drainage paths, or properly designed vegetated channels, can be used instead of constructing underground storm sewers or concrete open channels to increase time of concentration, reduce the peak discharge, and provide infiltration.	Zone of Integration (Residential; Business / Commercial; Industrial; Green spaces
	Water Absorption trench/pit	Shallow excavations that create temporary subsurface storage of runoff, the trench catches open runoff and allows for infiltration.	Zone of Integration (Residential; Business / Commercial; Industrial; Green spaces)
	Contour bunds	Semi-permeable barrier along contours to retain runoff and sheet wash from fields and open land.	Riverbank Zone Zone of Integration (Green spaces; Agricultural / Rural)
	Raised footpath	Increase height of footpath to adjacent land, so runoff does not flow down footpath but rather into adjacent lands.	Riverbank Zone Zone of Integration (Green spaces)
	Pathway swale	A small bund at regular intervals along paths to disperse runoff into adjacent fields or contour bunds.	Riverbank Zone Zone of Integration (Green spaces; Agricultural / Rural)
	Tree planting / tree pit / green corridor / urban tree canopy	Plant or conserve trees to reduce stormwater runoff, increase nutrient uptake, and provide bank stabilization. Trees can be used for applications such as landscaping, stormwater management practice areas, conservation areas and erosion and sediment control.	Riverbank Zone Zone of Integration (Residential; Business /

Nature Based Preventative Infrastructural Interventions	Description	Area of Intervention
 Conservation agriculture and permaculture	Planned vegetable gardens/ Urban agriculture. Vegetable production in urban and peri-urban areas is mostly small scale and market oriented.	Zone of Integration (Residential; Green spaces; Agricultural / Rural)
 Zai pit	Series of off-set crescent-shaped pits facing upslope. Pits can be plant. Pits catch sheet flow runoff.	Riverbank Zone Zone of Integration (Green spaces; Agricultural / Rural)
 Rainwater harvesting	Direct runoff from rooftop areas to tanks and upland overland runoff flow to designate pervious areas to reduce runoff volumes and rates. Capture and store stormwater runoff to be used for irrigation systems or filtered and reused for non-contact activities.	Zone of Integration (Residential; Business / Commercial; Industrial; Agricultural / Rural)
 Stream Daylighting	Open previously-culverted/piped streams to restore natural habitats, better attenuate runoff by increasing the storage size, promoting infiltration, and help reduce pollutant loads.	Zone of Integration (Residential; Business / Commercial; Industrial; Green spaces)
 Rain Gardens / Absorption pond	Manage and treat small volumes of stormwater runoff using a conditioned planting soil bed and planting materials to filter runoff stored within a shallow depression.	Zone of Integration (Residential; Business / Commercial; Industrial; Green spaces)
 Vegetated (green) roof	Capture runoff by a layer of vegetation and soil installed on top of a conventional flat or sloped roof. The rooftop vegetation allows evaporation and evapotranspiration processes to reduce volume and discharge rate of runoff entering conveyance system.	Zone of Integration (Residential; Business / Commercial; Industrial)
 Constructed wetland	Small landscaped wetlands that can be designed as infiltration or filtering practices. Man-made (artificial) wetlands are designed to reduce, detain and treat wastewater and/ or stormwater runoff, to create or restore habitat for indigenous and migratory wildlife and for land reclamation in natural areas impacted by development. Water is stored in shallow vegetated pools that are designed to support wetland plants and simulate natural wetland ecosystems. Uses soil infiltration, reed rhizomes and biogeochemical processes to decrease stormwater quantity and improve water quality.	Zone of Integration (Residential; Business / Commercial; Industrial; Green spaces; Agricultural / Rural)
 Attenuation ponds (detention / retention)	Also known as detention/retention basins, are formed by excavating below the natural ground water level and/or lining the base to retain stormwater runoff. The maximum storage capacity of retention ponds is typically greater than their permanent pond volume which makes them effective in reducing downstream stormwater flood peaks. Retention ponds use a combination of sedimentation, filtration, infiltration and biological uptake processes to also remove pollutants from stormwater runoff	Zone of Integration (Green spaces; Agricultural / Rural)
 Porous Pavement	Pervious types of pavements that provide an alternative to conventional paved surfaces, designed to infiltrate rainfall through the surface, thereby reducing stormwater runoff from a site and providing some pollutant uptake in the underlying soils.	Zone of Integration (Residential; Business / Commercial; Industrial; Green spaces)

5] Intervention C2: Sedimentation Reduction Through Nature-based Interventions

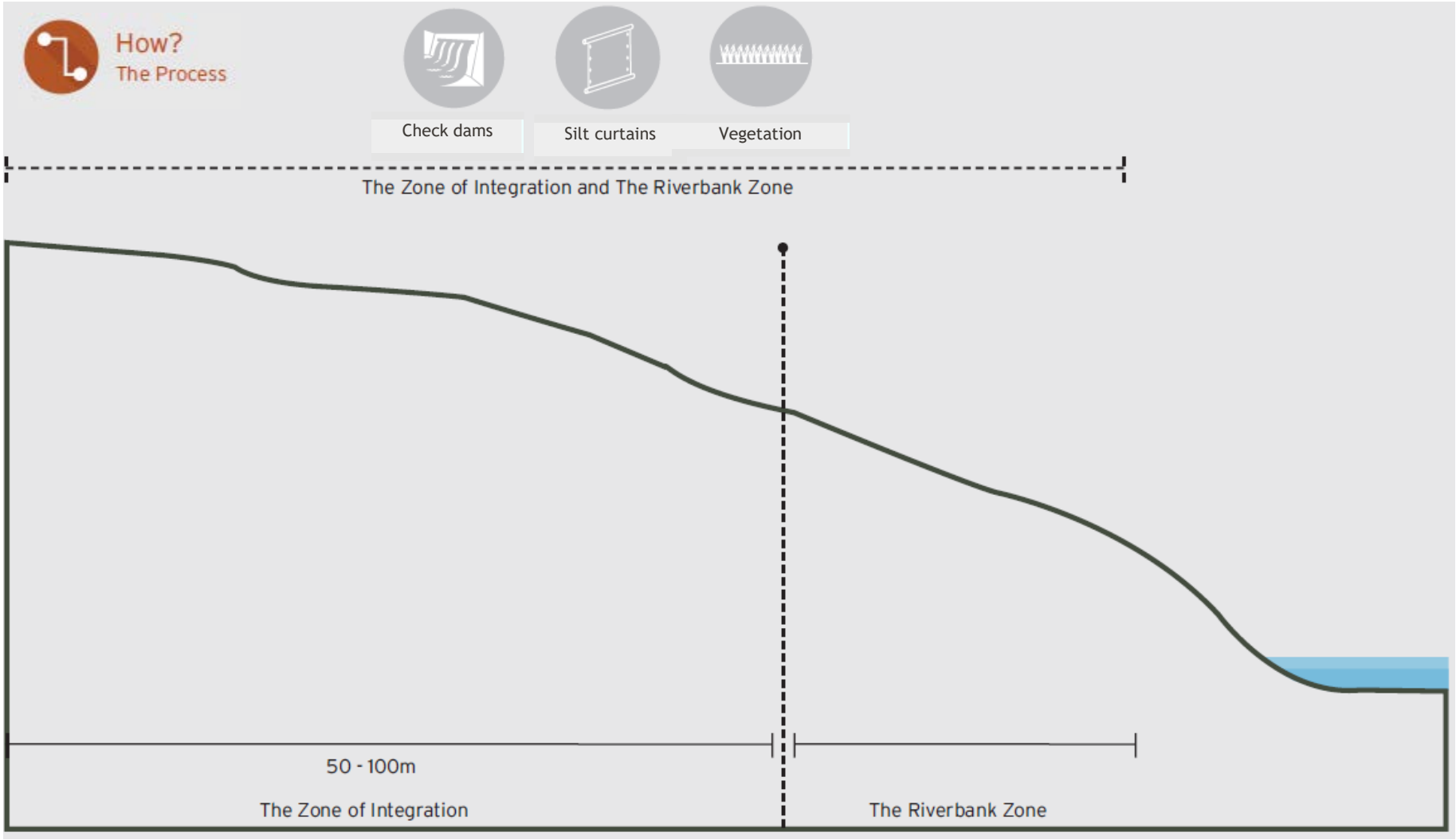
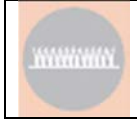


Figure 7: Sedimentation reduction through nature-based interventions (H. van den Berg and S. Braid, 2017)

TABLE 1: SEDIMENTATION REDUCTION THROUGH NATURE-BASED INTERVENTIONS (H. VAN DEN BERG AND S. BRAID, 2017)

Nature Based Preventative Infrastructural Interventions		Description	Area of Intervention
	Check dams	Covering exposed soils with growing vegetation e.g. ground covers or mulching to reduce runoff from exposed soil.	Riverbank Zone Zone of Integration (Green spaces; Agricultural / Rural)
	Silt curtains	Similar to check dams using geofabric across flow paths to trap sediment.	Riverbank Zone Zone of Integration (Agricultural / Rural)
	Vegetation barriers	Similar to contour bunds using dense vegetation such as vetiver grass to trap sediment and reduce runoff. Can be implement across a slope parallel with contours, or in riparian buffer area perpendicular to flow of water.	Riverbank Zone Zone of Integration

6] Intervention C3: Erosion Reduction through Nature-based Interventions

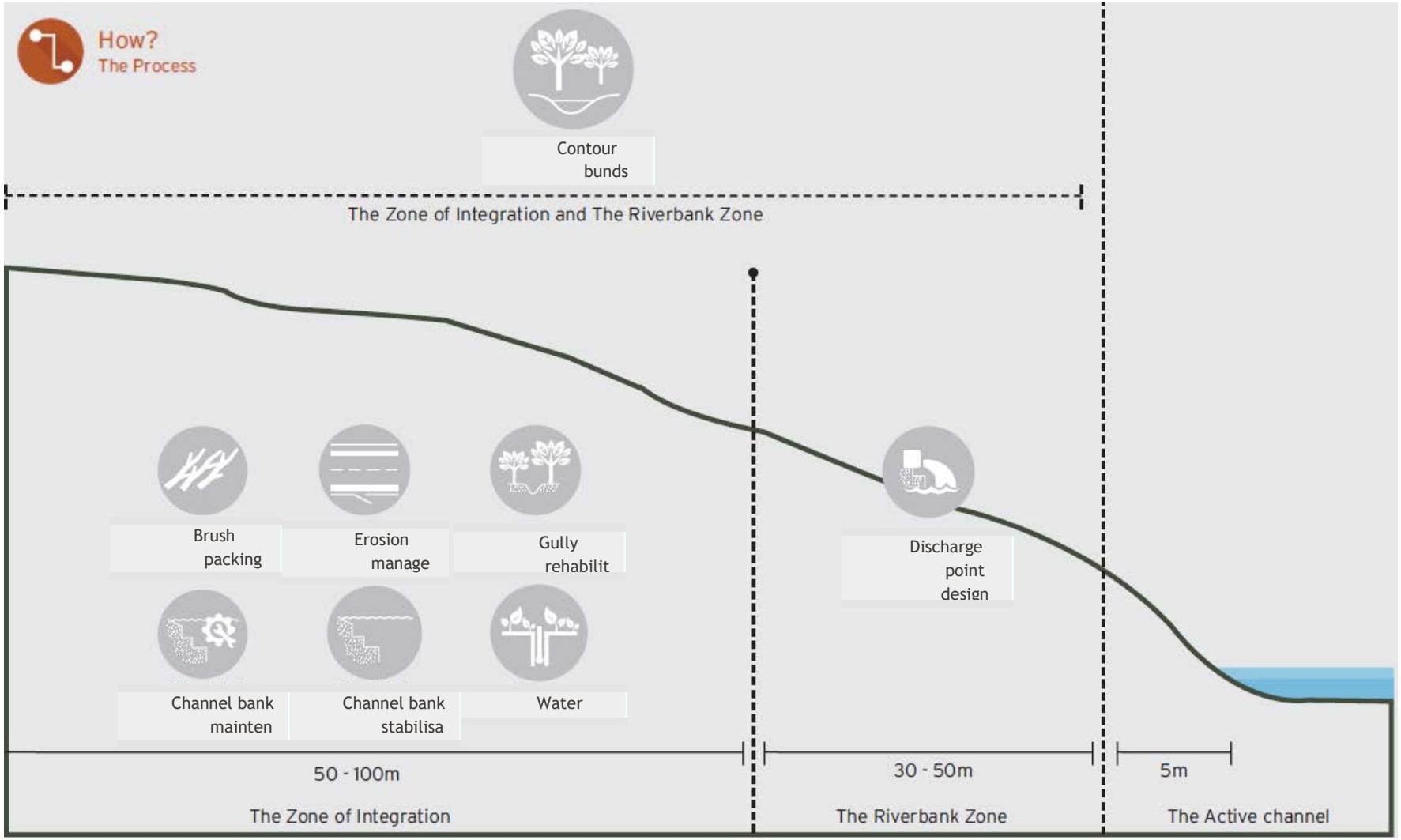


Figure 8: Erosion reduction through nature-based interventions (H. van den Berg and S. Braid, 2017)

TABLE 3: EROSION REDUCTION THROUGH NATURE-BASED INTERVENTIONS (H. VAN DEN BERG AND S. BRAID, 2017)

	Nature Based Preventative Infrastructural Interventions	Description	Area of Intervention
	Brush packing	Using branches of trees, especially thorn trees, to keep cattle out of overgrazed areas to allow these areas to re-establish vegetation and groundcover	Zone of Integration (Agricultural / Rural)
	Contour ridging / bunds	Constructed bunds or ridges at intervals along a slope to slow runoff and to prevent erosion.	Riverbank Zone Zone of Integration (Green spaces; Agricultural / Rural)
	Erosion management along roadsides	Mitre drains along road sides especially dirt roads to reduce channelling and erosion.	Zone of Integration (Green spaces; Agricultural / Rural)
	Gully rehabilitation	Grading of gullies (using interventions) to re-establish appropriate slope and prevent further erosion.	Zone of Integration (Green spaces; Agricultural / Rural)
	Channel bank maintenance	Bank contouring (physical contouring or reshaping) to re-establish appropriate slope and prevent further erosion	Zone of Integration (Green spaces; Agricultural / Rural)
	Channel bank stabilisation	Protect scouring and erosion of channel banks using gabion rock baskets, vegetated stepped terraces	Zone of Integration (Green spaces; Agricultural / Rural)
	Water efficiency	Reducing erosion at source by absorbing water or reducing runoff, e.g. planting water thirsty plants around boreholes or discharge points.	Zone of Integration (Residential; Business / Commercial; Industrial; Green spaces; Agricultural / Rural)
	Discharge point design	Where structures discharge to watercourses, structures should not be perpendicular to flow, but rather 45° facing downstream. Outlet should include erosion protection around the structure.	Riverbank Zone

7] Intervention D: Universal Best-Practice Interventions for Mitigation Development of Impacts within the Riverbank Zone and the Active Channel Zone

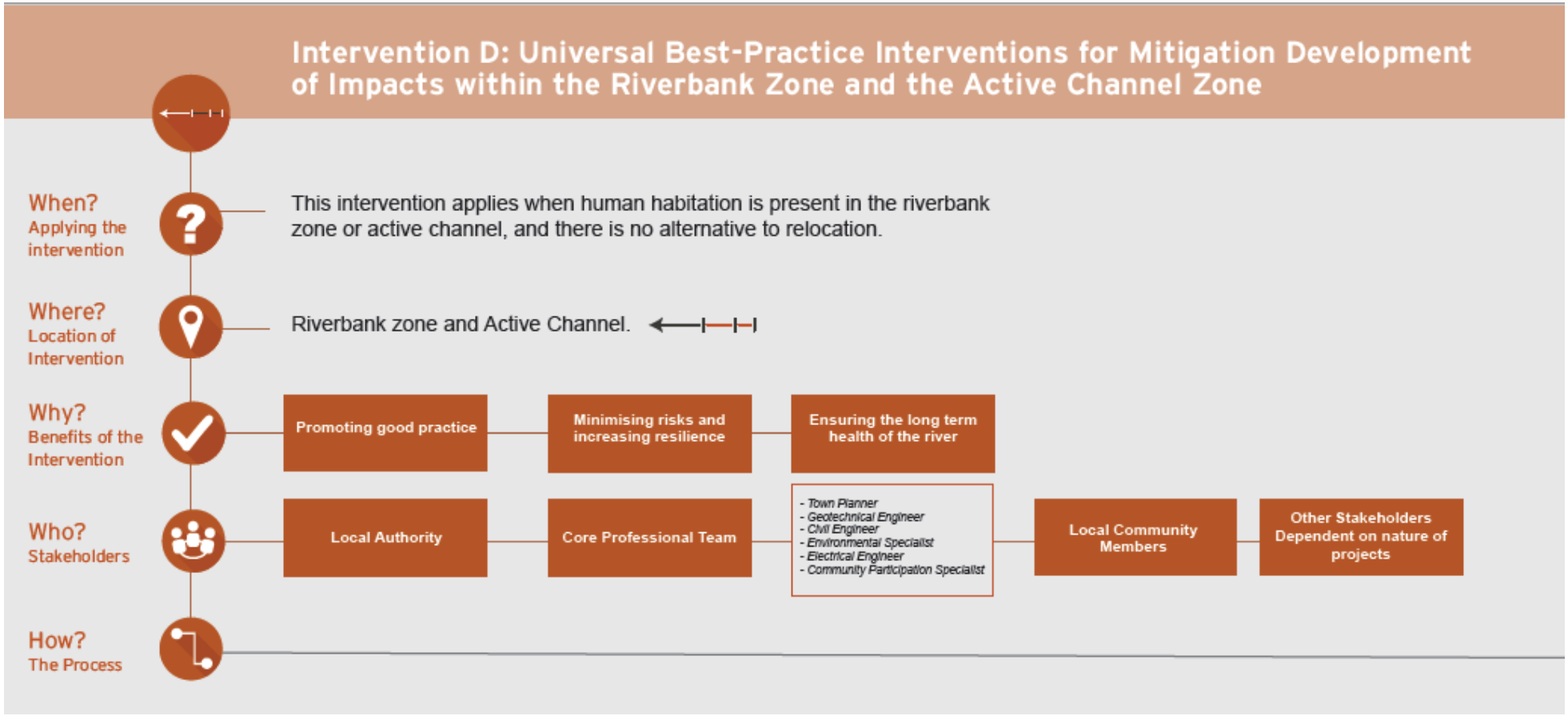


Figure 9: Universal best practice interventions for mitigation development of impacts within the active channel zone

TABLE 4: UNIVERSAL BEST-PRACTISE INTERVENTIONS FOR MITIGATION DEVELOPMENT IMPACTS WITHIN THE RIVERBANK ZONE AND THE ACTIVE CHANNEL ZONE (H. VAN DEN BERG AND S. BRAID, 2017)

IN THE RIVERBANK ZONE	IN THE ACTIVE CHANNEL ZONE
Stormwater discharge set back from river with constructed wetland between active channel and outlet.	Stabilise bank with the planting of vegetation
Stormwater outlets at max 45° angle to flow of water.	Regular litter / solid waste clean-up
Clearing of alien and invasive vegetation and replace with indigenous vegetation	Litter traps at selected points in the river
Re-vegetation of riverbank zone if vegetation has been lost or removed	Clearing of alien and invasive vegetation and replace with indigenous vegetation
Include aeration of water with green infrastructure	Re-vegetation of Active Channel Zone if vegetation has been lost or removed
	Include aeration of water with green infrastructure

8] Intervention E: All New Developments as well as Existing Developments, with Particular Emphasis on the Zone of Integration

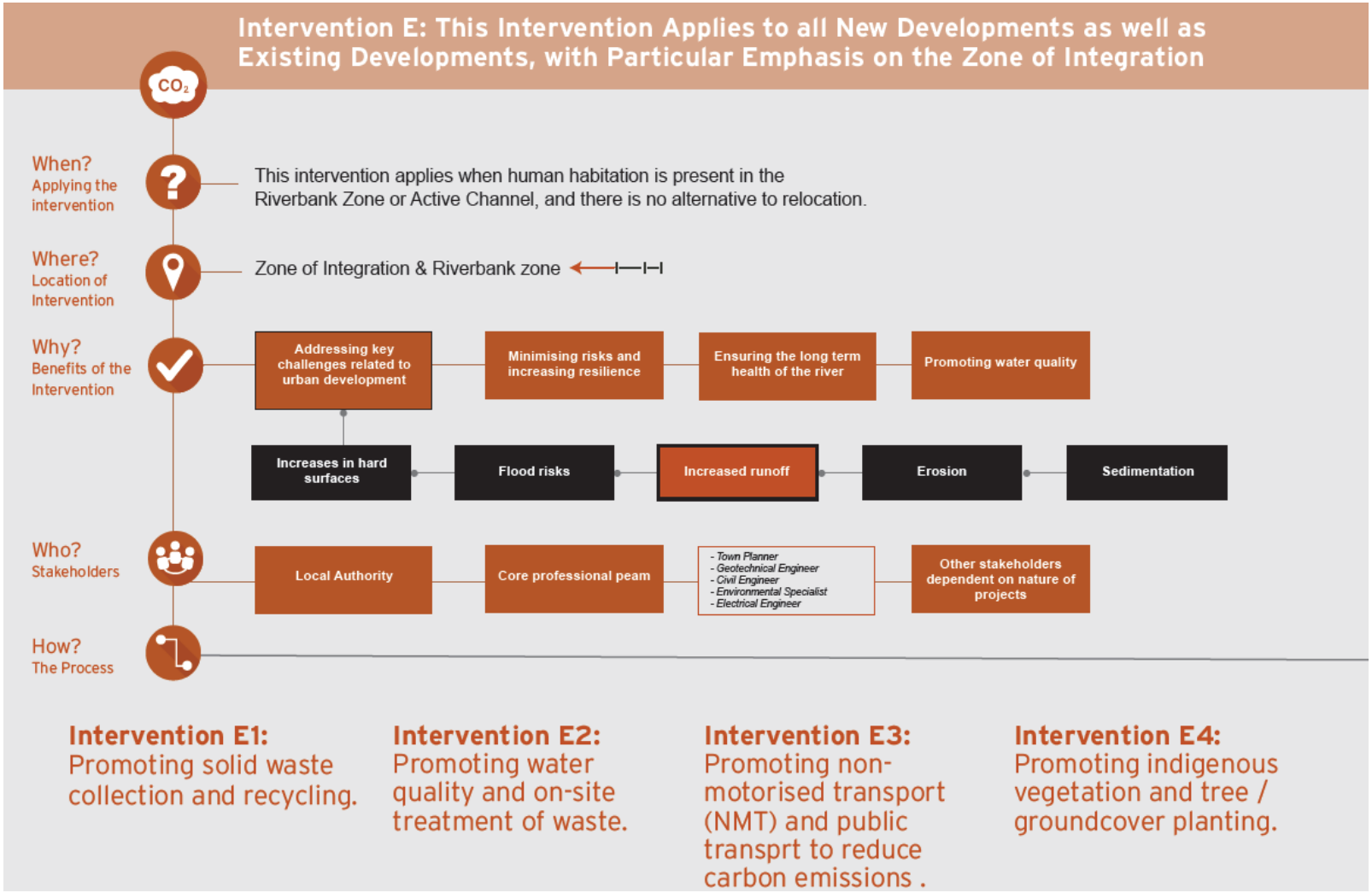


Figure 10: All new developments as well as existing developments, with particular emphasis on the zone of integration

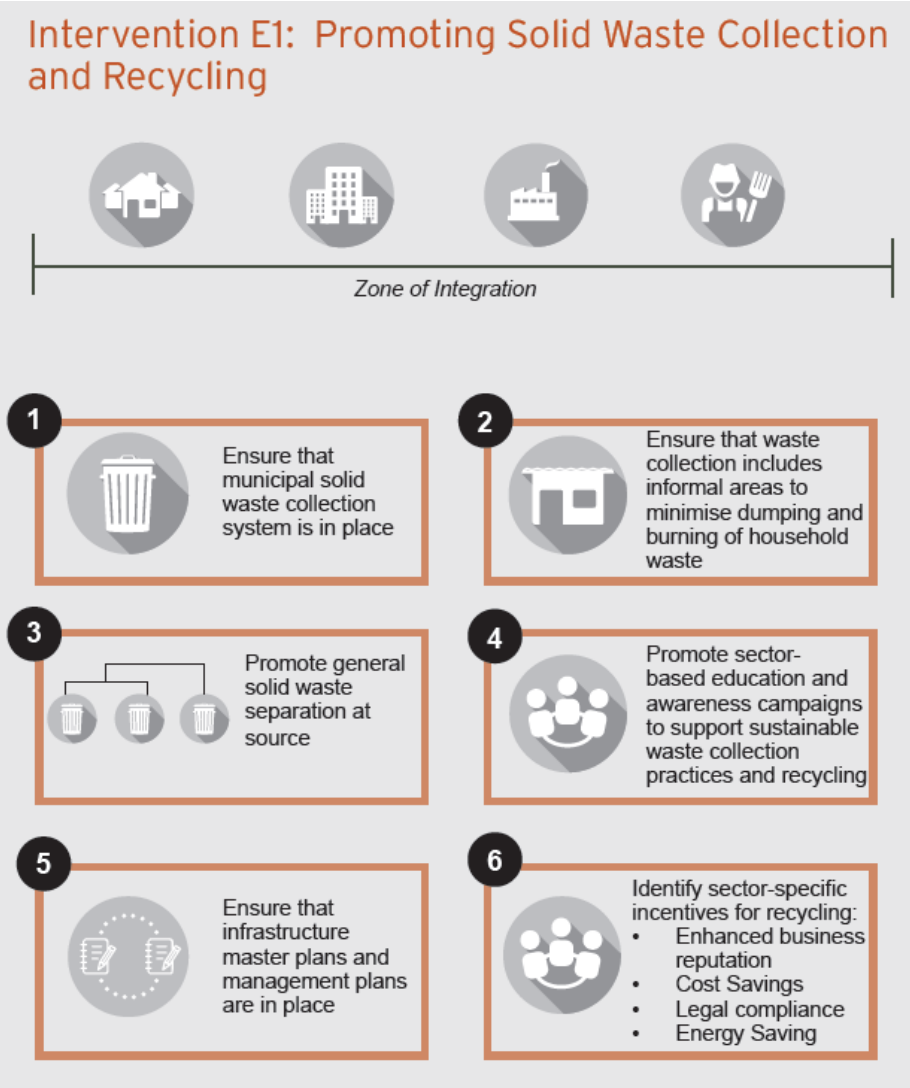


Figure 11: Promoting solid waste collection and recycling

Figure 12: Promoting water quality and osite treatment of waste

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The Association for Water and Rural Development

AWARD is a non-profit organisation specialising in participatory, research-based project implementation. Their work addresses issues of sustainability, inequity and poverty by building natural-resource management competence and supporting sustainable livelihoods. One of their current projects, supported by USAID, focuses on the Olifants River and the way in which people living in South Africa and Mozambique depend on the Olifants and its contributing waterways. It aims to improve water security and resource management in support of the healthy ecosystems to sustain livelihoods and resilient economic development in the catchment.

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About USAID: RESILIM-O

USAID: RESILIM-O focuses on the Olifants River Basin and the way in which people living in South Africa and Mozambique depend on the Olifants and its contributing waterways. It aims to improve water security and resource management in support of the healthy ecosystems that support livelihoods and resilient economic development in the catchment. The 5-year programme, involving the South African and Mozambican portions of the Olifants catchment, is being implemented by the Association for Water and Rural Development (AWARD) and is funded by USAID Southern Africa.

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