CATALOGUE OF NATURE-BASED SOLUTIONS FOR INFRASTRUCTURE PROJECTS

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EXECUTIVE SUMMARY

Nature-based solutions as infrastructure are not new. There are many examples of large public works projects and projects led by conservation organizations that integrate nature to deliver infrastructure services and bring environmental and community benefits. But what is new is the **thinking on how to translate that experience into the core operations of private companies** to leverage private finance and integrate nature-based solutions at scale into how we build future or retrofit existing infrastructure. It is estimated that emerging markets will need to invest $2 trillion per year in infrastructure for the next decade.[92] This is an opportunity to reimagine how infrastructure could be built with nature to reduce the footprint of traditional grey infrastructure and generate additional business, economic, climate, biodiversity and community benefits.

This catalogue provides examples of nature-based solutions that private infrastructure companies can integrate into their core business operations and articulates the business case for doing so. Many examples rely on ecosystem services, while others present opportunities to complement the design of gray infrastructure to benefit nature and people. In both cases, the intent of the catalogue is to **raise the awareness of the business benefits of nature-based solutions** and start the conversation with infrastructure companies to identify opportunities and possible projects. The catalogue will evolve over time as the market for nature-based solutions for infrastructure projects develops and matures.

In the meantime, please get in touch with us to share suggestions and case studies that demonstrate the business case for water, extractives and renewable energy companies to implement nature-based solutions at scale.

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PURPOSE OF CATALOGUE

This catalogue is a **companion resource** to IFC's Biodiversity Finance Reference Guide.[1]

RAISING AWARENESS

This catalogue intends to raise awareness about the use of nature-based solutions (NBS) in infrastructure sectors among IFC investment teams and private sector clients. It provides sector specific examples of **NBS investments** that **conserve, enhance, and restore ecosystems and biodiversity** within larger infrastructure projects.

> These NBS provide infrastructure-type services that are core to projects' operations and that can displace or complement grey (traditional engineered) infrastructure.

This catalogue supplements IFC's Biodiversity Finance Reference Guide, providing **sector-specific examples** where NBS are accepted use of proceeds. This catalogue is not an exhaustive list and other NBS that meet the criteria articulated could be considered. Some of the following NBS practices are also part of best practice risk management.

This catalogue is a result of a partnership between **IFC** and **Conservation International.**

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IFC'S BIODIVERSITY FINANCE REFERENCE GUIDE

Biodiversity finance is a new and fast-growing area of green finance to direct capital towards production practices and products that directly address the drivers of biodiversity loss and help avoid negative impact, conserve, or restore nature and ecosystem services.

IFC Biodiversity Finance Reference Guide identifies eligible investment activities that protect, maintain, or enhance biodiversity and ecosystem services. The Guide builds on the **Green Bond Principles** and the **Green Loan Principles** to provide eligible use of proceeds and aligns with the targets of the **Kunming-Montreal Global Biodiversity Framework**.

Investment activities listed in the Guide are organized in **three categories:**

Investments that generate biodiversity co-benefits

Financing that seeks **to address the key drivers of biodiversity loss** (land/sea use change; pollution; overexploitation of resources; and invasive species) in economic activity.

Investments in biodiversity conservation and restoration

Financing to support **nature conservation or restoration** and related services as a primary objective of investment.

Investments in nature-based solutions

Financing to support **integration of nature-based solutions into larger projects** to provide infrastructure services and displace or complement grey infrastructure.

This catalogue focuses on examples for the above category.

The Guide in its entirety addresses the finance mobilization target 19 of the Kunming-Montreal Global Biodiversity Framework and target 14 to integrate biodiversity across sectors. In addition, each investment activity listed in the Guide contributes to other targets. IFC consulted with the UN Secretariat of the Convention on Biological Diversity to map each investment activity to the relevant targets of the Global Biodiversity Framework.

BIODIVERSITY FINANCE & NATURE-BASED SOLUTIONS

This catalogue focuses on the third investment category of IFC's Biodiversity Finance Reference Guide: **Investments in Nature-Based Solutions.**

To be considered biodiversity finance, investment activities must meet **all** of the following criteria:

1. **BE CONSISTENT** with the Green Bond and Green Loan Principles and contribute to either SDG 14 (life under water) or SDG 15 (life on land)
2. **DO NOT INTRODUCE** material risks to other themes and priority environmental areas of the SDGs
3. **FOLLOW** internationally accepted sustainability standards
4. **ADDRESS** a key driver of biodiversity loss: land/sea use change, climate change*, pollution, resource overexploitation, and spread of invasive species (**the Guide does not include taxonomy for climate finance*)
5. **PROVIDE** metrics and data to report on impact

Eligible investments in nature-based solutions must:

Provide infrastructure-type or other services that are material to a project's operation

Displace or complement man-made structures

NATURE-BASED SOLUTIONS

The most accepted definition of 'nature-based solutions' comes from the United Nations Environment Programme (UNEP):

NATURE-BASED SOLUTIONS are actions to protect, conserve, restore, sustainably use and manage natural or modified terrestrial, freshwater, coastal and marine ecosystems which address social, economic and environmental challenges effectively and adaptively, while simultaneously providing human well-being, ecosystem services, resilience and biodiversity benefits.[2]

Nature-based solutions can accomplish a variety of project goals,[3, 4] such as:

CLEAN WATER:

- Improve water quality by reducing chemical, nutrient and sediment runoff
- Improve water quality by removing pollutants in wastewater such as solids and pathogens

FLOOD MANAGEMENT:

- Protect and increase the resilience of communities and assets from flooding
- Reduce peak flow (the maximum rate of flow water passing a given point following rainfall)[5]

WATER SECURITY:

- Improve water retention
- Contribute to water supply reliability

EROSION CONTROL:

- Stabilize steep slopes and degraded areas
- Reduce number of landslides in the surrounding environment of infrastructure

COASTAL PROTECTION:

- Protect coastal urban areas and assets from erosion, storm surges, damage from wave energy, and sea level rise

NATURE-BASED SOLUTIONS

Benefits

Depending upon the project and the setting, NBS offer many benefits when compared to traditional infrastructure:[3]

1. **Business Case:** Lower investment and operational/ maintenance costs for infrastructure services
2. **Climate Change Mitigation:** Lower carbon footprint when compared to conventional alternatives; carbon sequestration services
3. **Climate Change Adaptation:** Disaster risk reduction; infrastructure resilience[6]
4. **Biodiversity Benefits:** Higher plant and animal variety, improved ecosystem services
5. **Social:** Job creation, cultural and educational opportunities and improvement of human health and wellness

Challenges

Practitioners face challenges when constructing and utilizing NBS:[3]

1. **Location specific:** Requires location specific design which makes it challenging to have universal design guidelines and templates
2. **Specialized Knowledge:** Requires specialized engineering expertise in designing and operating nature-based solutions
3. **Performance Management:** Requires adaptive management and performance monitoring to complement long-term operations and maintenance
4. **Large footprint:** Requires large land area for implementation of some nature-based solutions
5. **Financing:** Lack of knowledge on how to finance NBS; absence of widely accepted methodologies for valuing ecosystem services
6. **Permitting:** Lack of guidance from governments and institutional bodies on permitting for NBS given it is a conceptually emerging area in infrastructure

NATURE-BASED SOLUTIONS: Water Supply

Example: Bishan-Ang Mo Kio Park, Singapore

Original concrete-lined canal

Restored sinuous stream channel (NBS)

CONTEXT: Despite plentiful rainfall, Singapore has little land to capture and store water. To meet its population demand for fresh water, Singapore imports 40% of its water at a significant cost. To reduce its reliance on water imports, Singapore undertook a project to increase available water catchment and storage area.[7, 8]

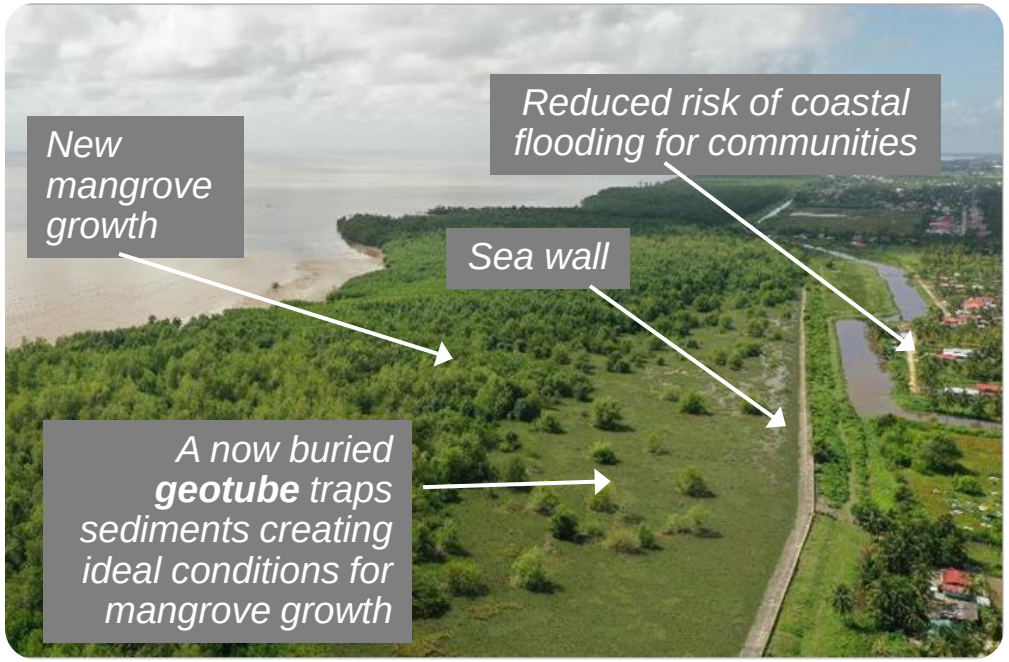
NBS: A three-kilometer-long sinuous stream channel was restored in place of a 2.7-kilometer-long concrete-lined drainage channel.

COST: Increasing the local water catchment is a cheaper alternative to importing water from neighboring countries. Singapore currently pays Malaysia 0.01 Singapore dollar for 1,000 gallons of raw water from the Johor river in Malaysia (for a daily maximum of 250,000,000 gallons of water).[11]

BENEFITS: The restoration of sinuous flow of the stream increased water storage capacity of the local river and floodplain system by 40%. Additional benefits of the NBS included improved water quality, a 30% increase in biodiversity and an increase of 12% in recreational space.[3]

NATURE-BASED SOLUTIONS: Coastal Flood Management

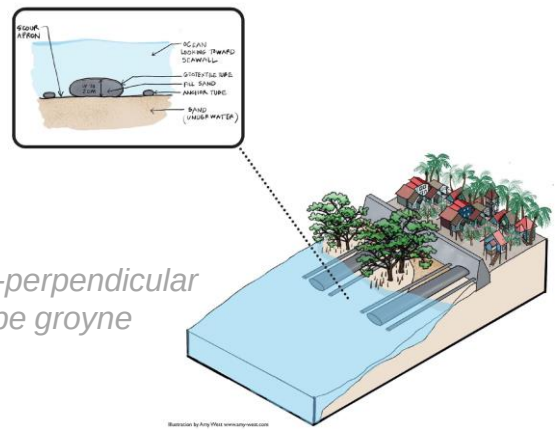
Example: Coastal Guyana



CONTEXT: In Guyana, **90%** of the population lives along the coast **below sea level** in areas vulnerable to sea rise and storm surge.

NBS: Planting mangroves next to a seawall provided **protection against sea level rise** and storm surge for coastal communities. To promote the growth of mangroves, a geotube was buried to trap sediments to create ideal growing conditions for mangroves.[9]

COST: Using a geotube to promote the growth of mangroves was **a cheaper alternative** compared to raising and strengthening the seawall. Materials of geotubes on average cost 6 to 12 less (about $200 to $400 a foot) than materials for seawalls (about $2000 a foot).[10]



Coast-perpendicular geotube groyne

BENEFITS: Mangroves offer coastal resilience to sea rise and storm surge. They reduce wave size and trap sediments in their roots, which allows the seabed level to rise. Mangroves create ideal environments for fish, offering benefits for local fisheries. Mangroves also offer climate mitigation services through carbon sequestration and can generate revenue through carbon credits.

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SECTOR-SPECIFIC NATURE-BASED SOLUTIONS FOR:

WATER UTILTIES

EXTRACTIVES

ENERGY

CATALOGUE OF NATURE-BASED SOLUTIONS

Water Utilities

Water Supply | Wastewater Treatment | Stormwater Management

*This section covers nature-based solutions that can be integrated into water utilities infrastructure investments, with a specific focus on **water supply, wastewater treatment** and **stormwater management**.*

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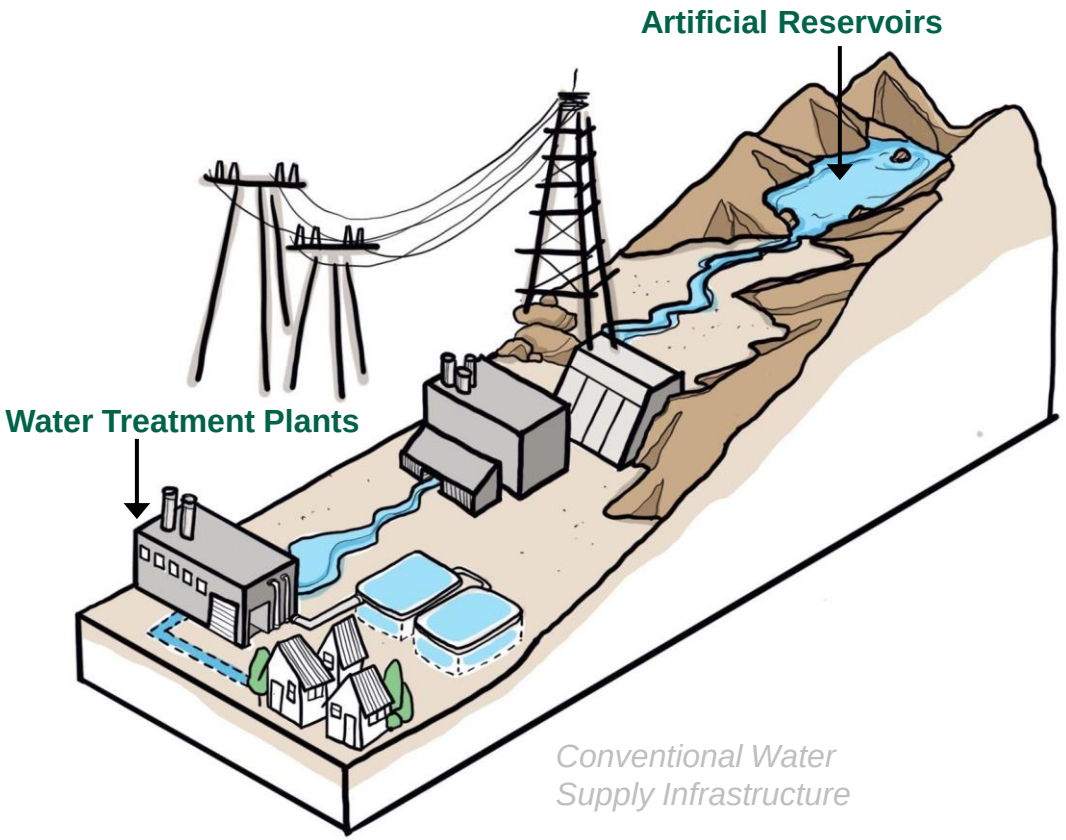
NATURE-BASED SOLUTIONS FOR **WATER UTILITIES**:
Water Supply Infrastructure

CATALOGUE OF NATURE-BASED SOLUTIONS FOR WATER UTILITIES

Nature-Based Solution	Infrastructure Service	Performance	Key Driver of Biodiversity Loss Addressed
Reforestation and forest conservation	Water supply	Reduce sedimentation; increase water storage capacity; improve water quality; reduce flood risk; carbon sequestration services	Land-use change; resource overexploitation; climate change
Infiltration and treatment-based landscape (small dams and/or terracing; infiltration channels)	Water supply; stormwater management	Increase infiltration; reduce sedimentation; reduce flood risk; increase water storage capacity; regulate flows to reservoir (location specific)	Land-use change; pollution
Rainwater harvesting	Water supply; stormwater management	Contribute to water supply reliability; reduce peak flows; less land area required compared to reservoir alternatives	Resource overexploitation; land-use change
Quarry lakes	Water supply	Improve local water storage capacity; reduce flood risk	Land-use change; resource overexploitation
Treatment wetlands	Wastewater treatment	Improve water quality; reduce chemical input, energy costs and quantity of water in treatment process; reduce flood risk; carbon sequestration services	Pollution; climate change
Horizontal levees	Hard structure to protect coastal assets; wastewater treatment	Reduce risk of damage from sea level rise and storm surge; reduce flood risk; improve water quality	Pollution; climate change
Interconnected networks of green stormwater infrastructure from site to regional scale	Stormwater management	Improve water quality; reduce flood risk; reduce peak flows; reduce heat island effect; improve air quality; carbon sequestration services	Pollution
Permeable pavement	Stormwater management	Improve water quality; reduce flood risk; reduce heat island effect	Pollution
Bioretention and biofiltration	Stormwater management	Improve water quality; reduce flood risk; carbon sequestration services; reduce heat island effect	Pollution; climate change

CONVENTIONAL WATER SUPPLY INFRASTRUCTURE



Conventional Water Supply Infrastructure

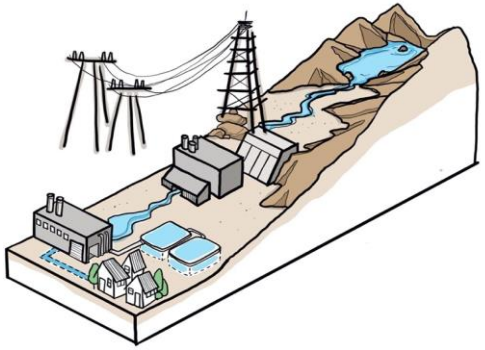
Conventional water supply infrastructure consists of man-made structures such as artificial reservoirs and water treatment plants. Such structures have **high construction and maintenance costs** and utilize high-emission building materials.

Artificial Reservoirs are formed behind dams to store freshwater. Releases from the artificial reservoir through the dam supply water to downstream users and can provide flood control and energy generation co-benefits.

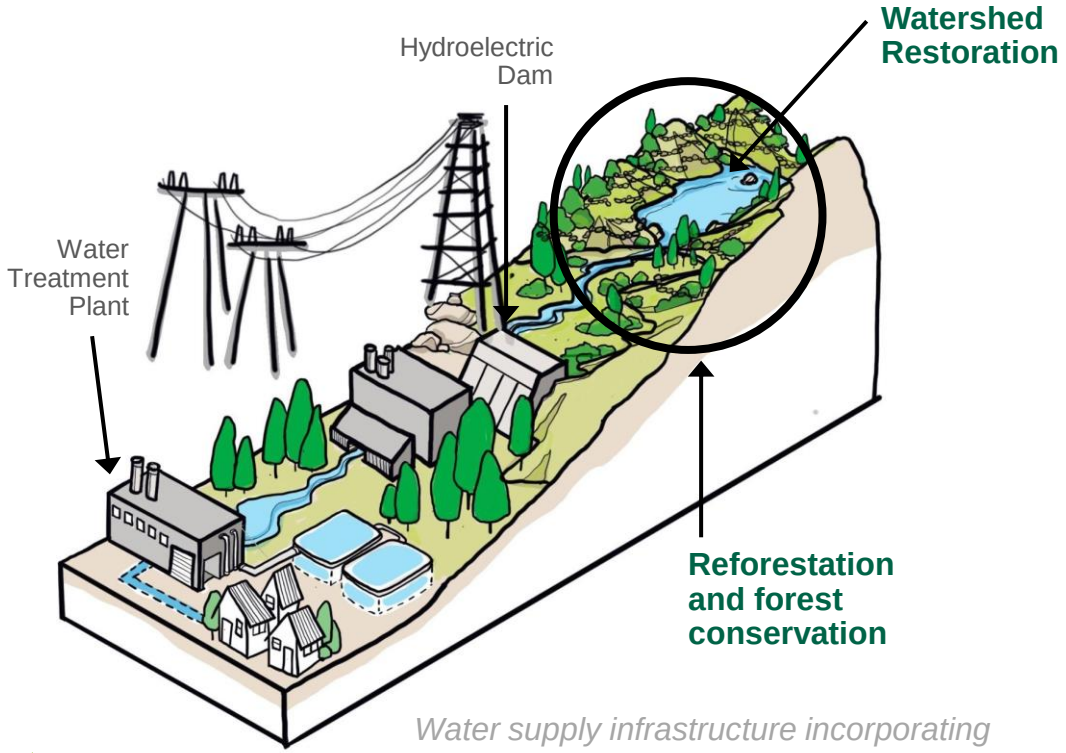
Water Treatment Plants remove contaminants and/or potentially harmful pathogens from raw water to produce water for human consumption.

WATER SUPPLY: **Reforestation & Forest Conservation**

NATURE-BASED SOLUTIONS



Conventional Water Supply Infrastructure



Water supply infrastructure incorporating reforestation and forest conservation

REFORESTATION: practices that restore ecologically suitable landscapes through replanting native or naturalized species.[1]

FOREST CONSERVATION: establishment of legally recognized protected areas.

FARM MANAGEMENT PRACTICES: incentivized, on-site practices, such as conservation easements and integration of trees into croplands or pasture, that provide mutual benefits to farmers and the local watershed.

BUSINESS RATIONALE

- Reduce sedimentation making water cleaner and cheaper for downstream water treatment plants to clean.
- Reduce sedimentation which prolongs the useful life of the reservoir.
- Regulate flows to reservoirs, which increases water storage capacity.
  - Where hydropower is present, regulation of flows increases energy production and reduces need for sediment flushing.
- Increase infiltration to shallow and deep groundwater supplies, improving their recharge and reducing flood risk.
- Carbon sequestration services.

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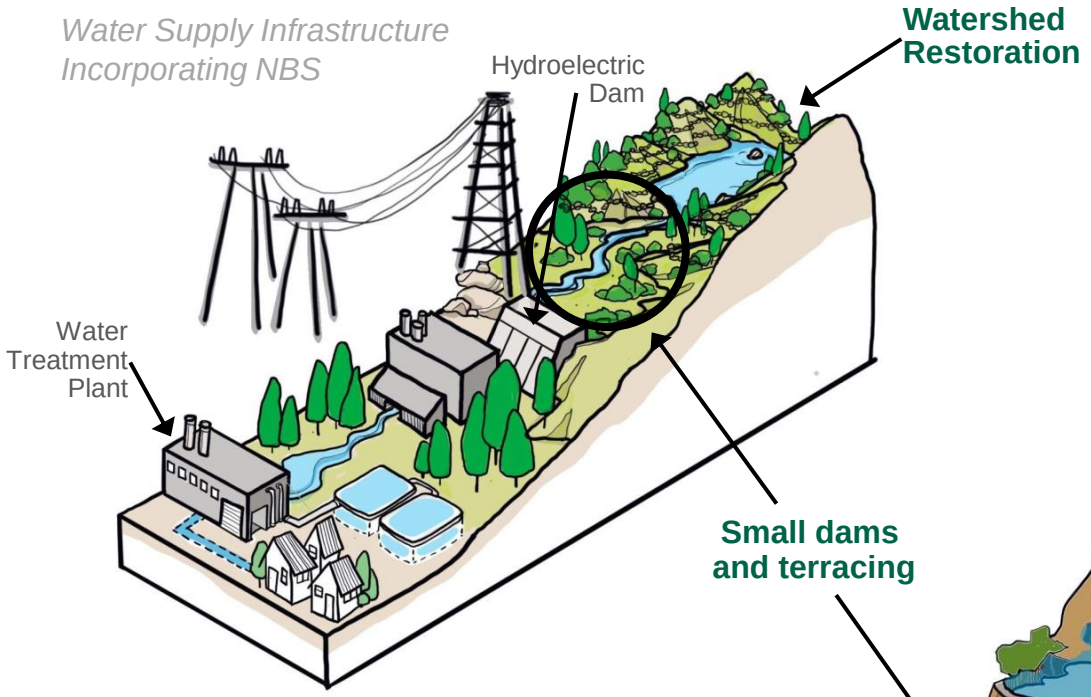
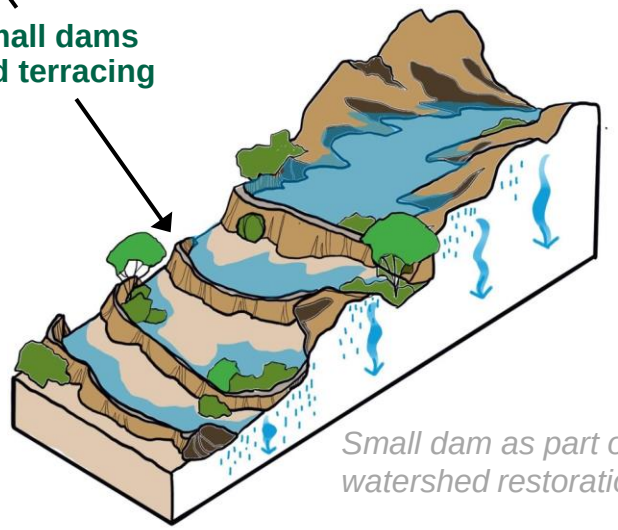
WATER SUPPLY & STORMWATER MANAGEMENT:
Infiltration and Treatment-based Landscapes – Dams & Terracing

NATURE-BASED SOLUTIONS

Water Supply Infrastructure Incorporating NBS



Small dams and/or terracing, which hold water and allow rainwater to absorb into the earth, are an example of a treatment-based landscape.



Small dam as part of watershed restoration

INFILTRATION AND TREATMENT-BASED LANDSCAPES: landscapes that integrate small dams and/or terracing that expand groundwater recharge areas and natural catchment regions to reduce the quantity of stormwater runoff.

BUSINESS RATIONALE

- Slow overland flow of water to help reduce local flood risk and soil erosion and protect built assets.
- Increase groundwater infiltration to recharge aquifers which results in increased water storage in the local area and increased water table during water scarce periods.

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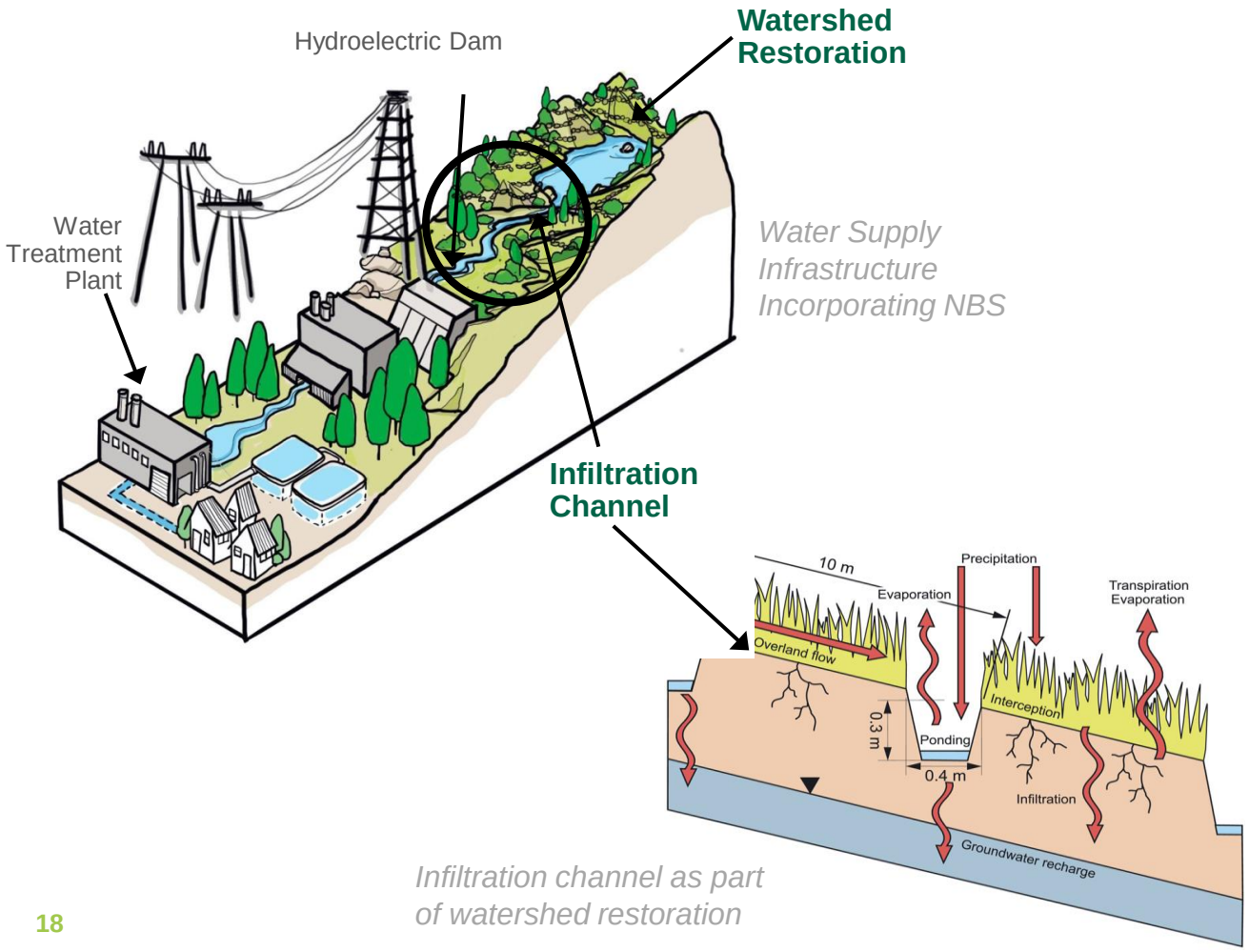
WATER SUPPLY & STORMWATER MANAGEMENT:
Infiltration and Treatment-based Landscapes – Infiltration Channels

NATURE-BASED SOLUTIONS



Water Supply Infrastructure Incorporating NBS

Infiltration channel as part of watershed restoration

8.4 km long infiltration channel in the Andes Mountains [12]

INFILTRATION CHANNELS

are trenches dug into the earth that collect and guide surface water.[13]

BUSINESS RATIONALE

- Slow overland flow of water to help reduce local flood risk and soil erosion and protect built assets.
- Increase groundwater infiltration to recharge aquifers which results in increased water storage in the local area and increased water table during water scarce periods.

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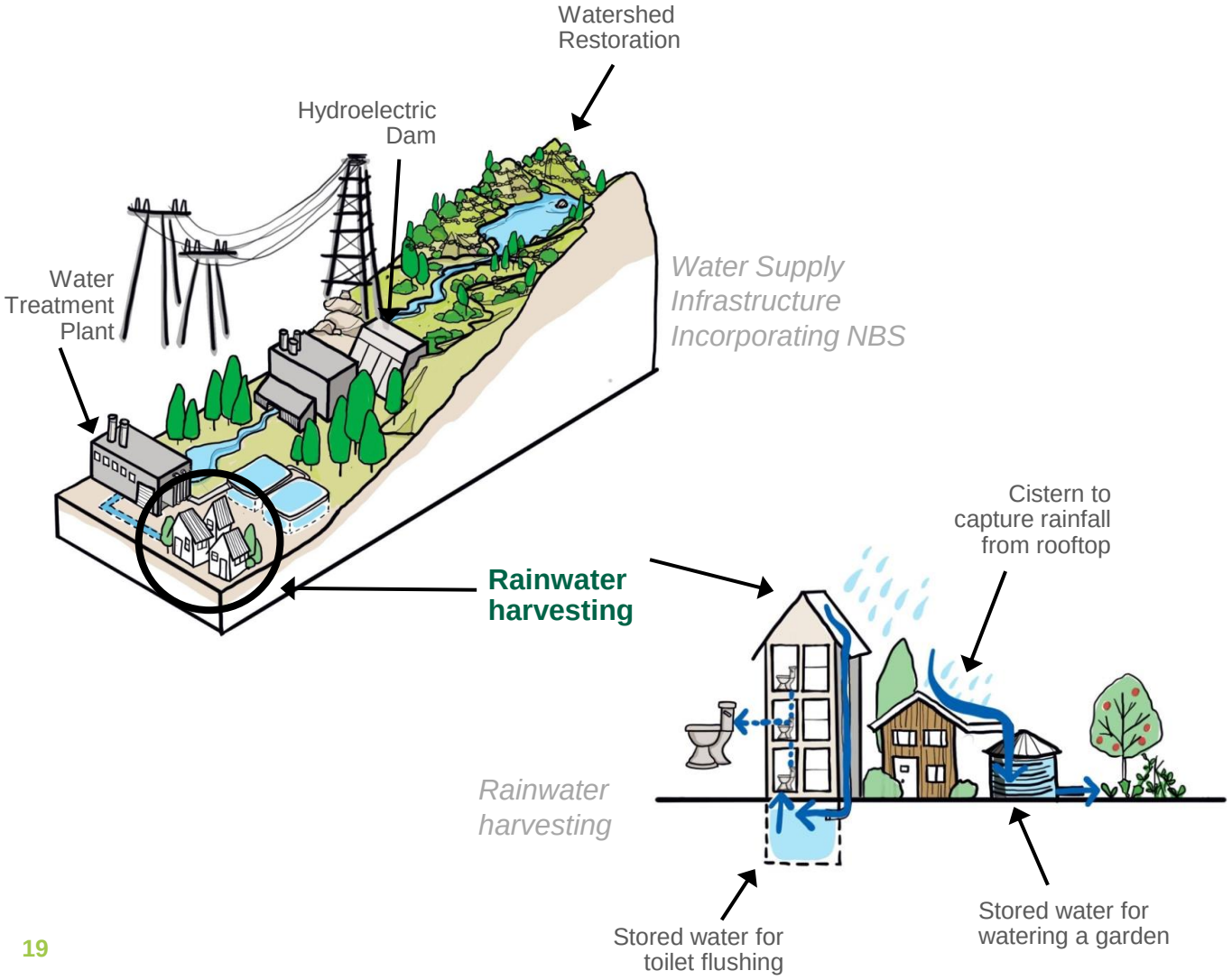
WATER SUPPLY & STORMWATER MANAGEMENT:
Rainwater Harvesting (Bioretention)

NATURE-BASED SOLUTIONS



RAINWATER HARVESTING: the practice of collecting and using rainwater from roofs and other artificial surfaces.

BUSINESS RATIONALE: UTILITIES

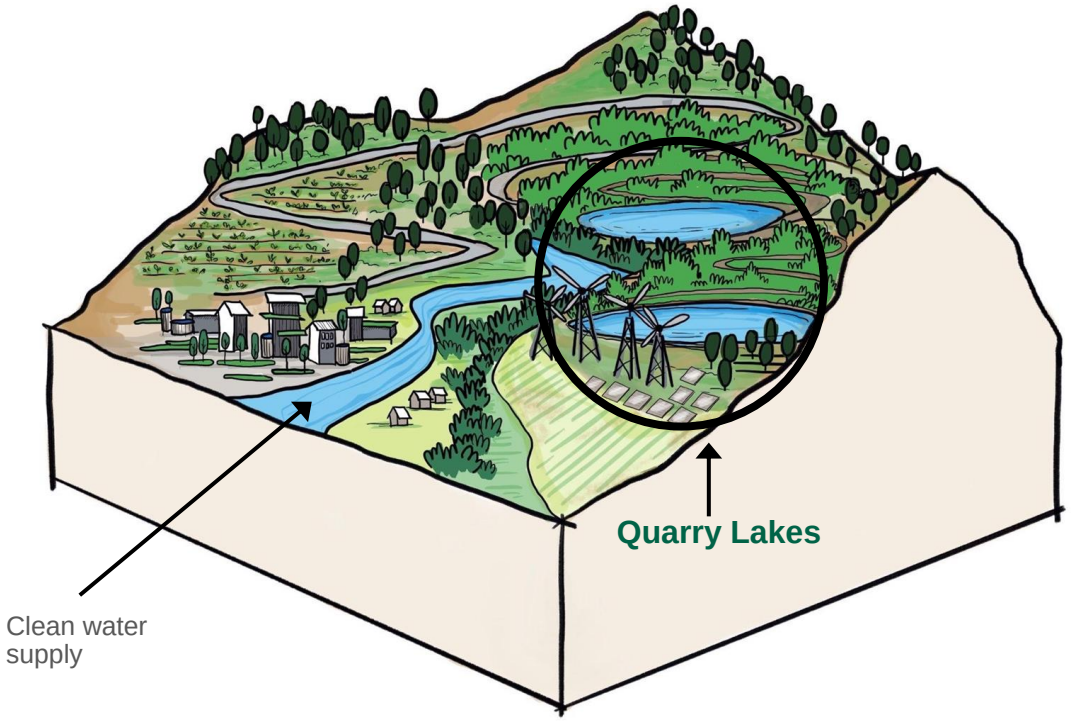
- Reduce flood risk through reducing peak flow of water.
- Contribute to water supply reliability.
- Less land required compared to reservoir alternatives.

BUSINESS RATIONALE: CONSUMERS

- Reduce flood risk through reducing peak flow of water (risk mitigation measure).
- Increase water storage lowering utilities cost.

WATER SUPPLY: **Quarry Lakes**

NATURE-BASED SOLUTIONS



Restored mine incorporating NBS, including quarry lakes

QUARRY LAKES are reservoirs created out of abandoned mining pits that, where suitable, can provide **critical recharge to groundwater aquifers or water storage** to manage water supplies for the local area.

BUSINESS RATIONALE

- Increase water storage for use during water scarce periods.
- Reduce flood risk.
- Utilize reclaimed land for reservoir which reduces pressure for land use change for water supply infrastructure in the local area.
- Utilize existing landscape at a lower cost than conventional infrastructure alternatives.

NATURE-BASED SOLUTIONS FOR **WATER UTILITIES:**
Wastewater Treatment Infrastructure

CONVENTIONAL WASTEWATER TREATMENT INFRASTRUCTURE

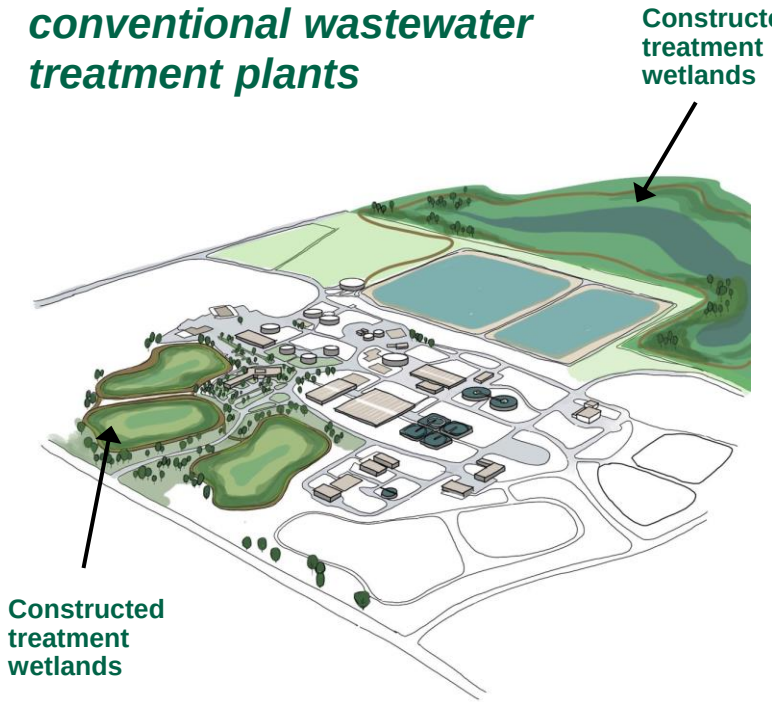
Conventional wastewater treatment infrastructure [91]

Conventional wastewater treatment plants **use numerous biological, physical, and chemical processes to clean the wastewater** collected from homes, businesses and industries so it can safely be reused or discharged back into the environment.

WASTEWATER TREATMENT: **Treatment Wetlands**

NATURE-BASED SOLUTIONS

Treatment wetlands typically increase the footprint of conventional wastewater treatment plants



Constructed treatment wetlands integrated into a wastewater treatment plant

Integration of treatment wetlands for wastewater treatment further cleans water before it is discharged into the environment.

Treatment wetlands utilize native plants, soil, porous media, and bacteria to remove pollutants in wastewater including solids, organics, nitrogen, phosphorus and pathogens.[14]

They are built by excavating, backfilling, grading, diking and installing water control structures to establish desired hydraulic flow patterns - before discharging to the environment.

Shallow treatment areas work best and must be hydrated to maintain effectiveness. Wetland plants, such as cattail, southern naiad and algae are suitable for water quality treatment.

BUSINESS RATIONALE

- Improve water quality by removing 75% to 90% of pollutants naturally.[15]
- Reduce chemical input, energy use costs and quantity of water in the treatment process.
- Reduce flood risk.
- Carbon sequestration services, supporting businesses' climate strategies.
- Increase biodiversity (benefits vary depending on project location).

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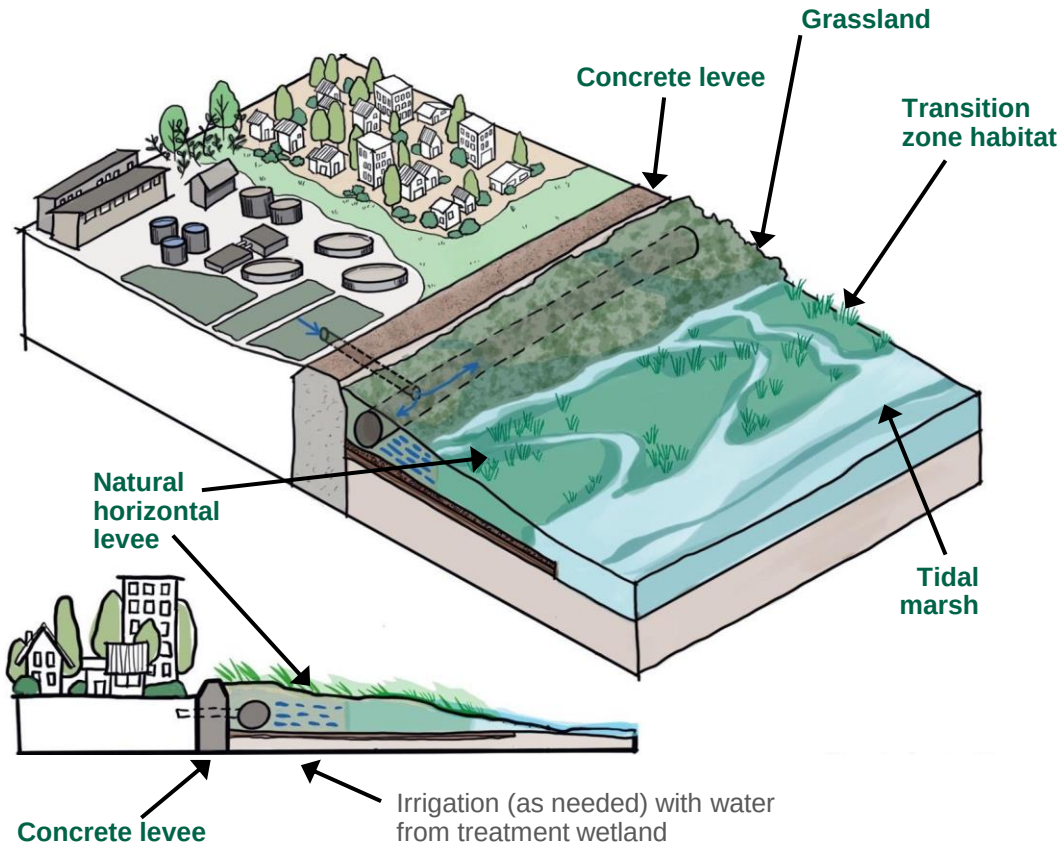
WASTEWATER TREATMENT & COASTAL RESILIENCE:
Horizontal Levees

NATURE-BASED SOLUTIONS



Treatment wetlands incorporated into horizontal levees

HORIZONTAL LEVEES: Wide, sloping, vegetated buffers of land constructed behind a hardened structure (levee) that prevent water from moving inland.

They are typically **designed for coastal protection**. In areas where horizontal levees happen to be located close to wastewater treatment plants, they can also perform an additional function of further cleaning water at the final stage of the treatment process before it is discharged into the environment.[17]

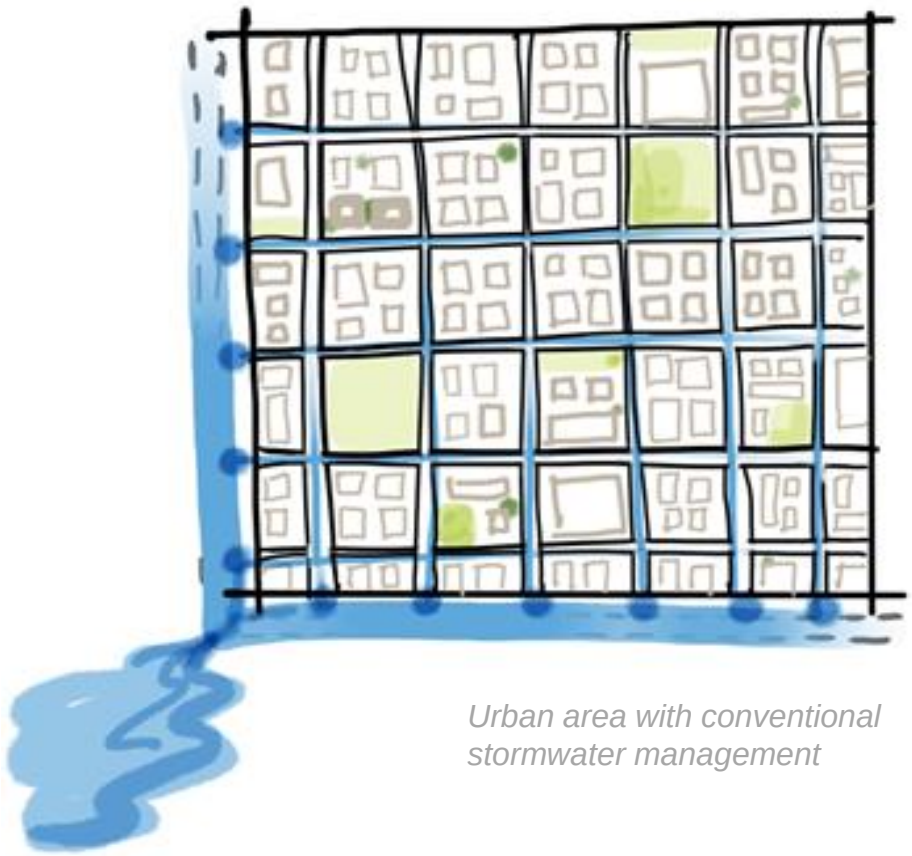
By protecting the coastal habitats and moving the hardened structure (levee) away from the coast, the natural habitat provides **a buffer to reduce the impacts of flooding**, storm surge and waves.[16] As a result, the hardened structure (levee) are reduced in size compared to levees which do not have a natural habitat buffer, lowering construction costs.

BUSINESS RATIONALE

- Reduce the risk of damage from sea level rise and storm surge to both the community (and if located close by, the water treatment plant).
- Reduce flood risk.
- When used for wastewater treatment, could improve water quality. [15]
- Construction and maintenance costs for a natural horizontal levee are 40% less than a traditional waterfront concrete levee.[17]

NATURE-BASED SOLUTIONS FOR **WATER UTILITIES:** **Stormwater Management Infrastructure**

CONVENTIONAL STORMWATER MANAGEMENT



Urban area with conventional stormwater management

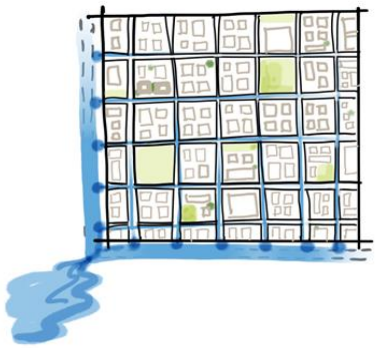
STORMWATER MANAGEMENT aims to prevent pollution from entering waterways from rainwater that runs off the landscape.

CONVENTIONAL STORMWATER MANAGEMENT relies on curbs, gutters, and buried storm drains to quickly and efficiently prevent flooding away from built, mostly impervious, infrastructure.

Stormwater pollution results from materials and chemicals washed into storm drains from the streets, gutters, industrial sites, homes and parking lots.[18]

STORMWATER MANAGEMENT: **Green Stormwater Infrastructure**

NATURE-BASED SOLUTIONS



Community with conventional stormwater management

Community with green stormwater infrastructure

GREEN STORMWATER INFRASTRUCTURE: mimics natural systems by supporting adsorption into the ground, which reduces water volume, pollutant loads, stream bank erosion, and sedimentation.[19]

Can range in scale from site design approaches to regional planning such as conservation of large tracts of open land.

Interconnected networks of green stormwater infrastructure, along with gray infrastructure, enhance urban resiliency by increasing water supply, reducing flooding, combating urban heat island effect, and improving water quality of nearby bodies of water.[18]

BUSINESS RATIONALE: CITIES

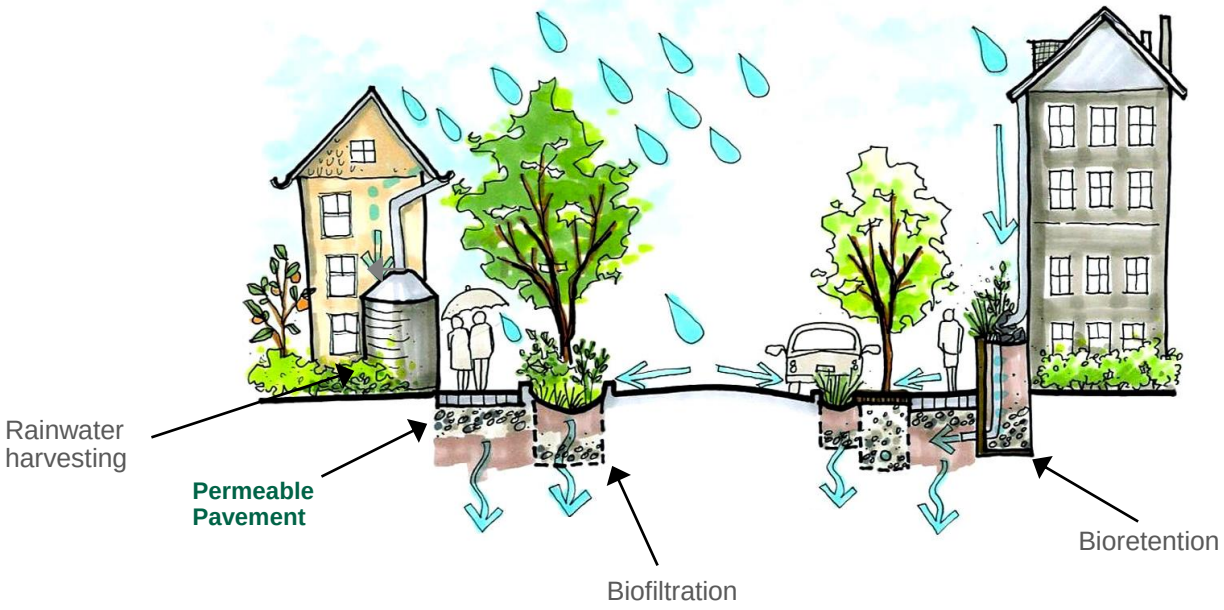
- Increase property values.
- Reduce heat island lowering energy use for cooling.
- Contribute to cleaner air.
- Create recreational spaces.
- Increase biodiversity (benefits vary depending on project location).
- Carbon sequestration services.

BUSINESS RATIONALE: UTILITIES

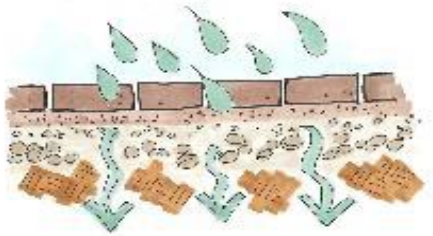
- Reduce flood risk.
- Decrease pollutant discharges, up to 80% pollutant removal, saving costs of water treatment at wastewater treatment plants.

STORMWATER MANAGEMENT: **Permeable Pavement**

NATURE-BASED SOLUTIONS



Community with green stormwater infrastructure



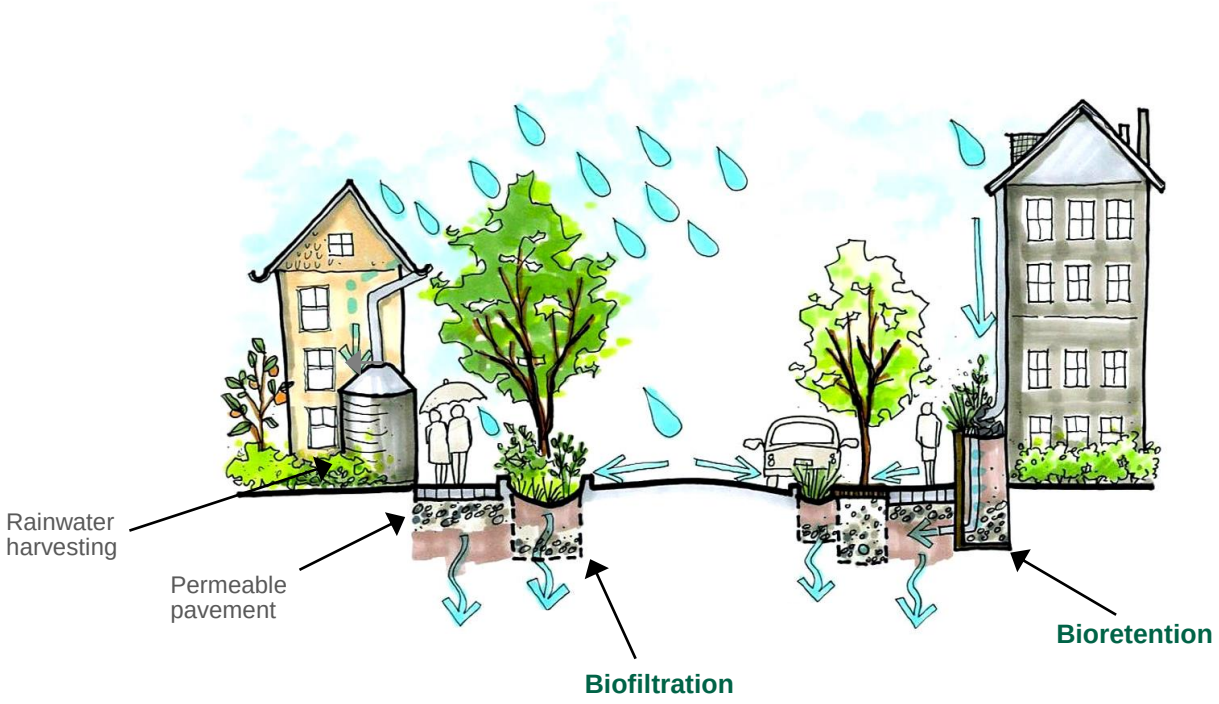
PERMEABLE PAVEMENT: structure that uses **natural materials** to create a **durable, pervious surface** overlaying a crushed stone base that allows stormwater to easily infiltrate into the underlying soil.[20]

BUSINESS RATIONALE

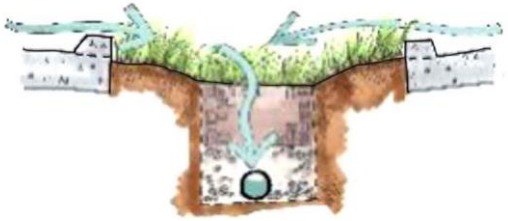
- Decrease pollutant discharges, saving costs to treat wastewater.
- Reduce flood risk.
- Reduce heat island effect lowering costs for utilities.

STORMWATER MANAGEMENT: **Bioretention & Biofiltration**

NATURE-BASED SOLUTIONS



Community with green stormwater infrastructure



BIORETENTION AND BIOFILTRATION:

processes that allow for **filtration** through a **specialized soil media** and **infiltration into subsurface soils**. The processes can be constructed with or without an underdrain (perforated) pipe.

BUSINESS RATIONALE

- Decrease pollutant discharges, saving costs to treat water at wastewater treatment plants.
- Reduce flood risk.
- Carbon sequestration services, supporting businesses' strategies.
- Reduce heat island effect, lowering costs for utilities.
- Increase urban biodiversity.

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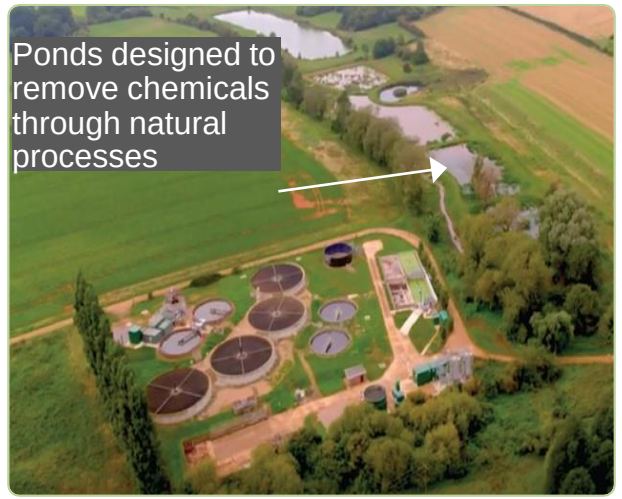
NATURE-BASED SOLUTIONS FOR **WATER UTILITIES:**
Case Studies

CASE STUDY: Anglian Water (UK)

Example of an investment with a nature-based solution component

SECTOR	• **Water supply** (provision of clean water)
INVESTMENT	• Part of **£250 million** green bond by Anglian Water
NBS & COST	• **1 ha constructed water** treatment wetland, planting 25,000 native wetland species that remove acutely toxic ammonia, phosphorus and other chemicals, planting 1,400 native trees in connecting river channel. • **£600,000** for NBS (vs £11 million for traditional chemical-based purification).
RATIONALE FOR NBS	• **Lower cost** of water filtration. • Increase **resilience to floods**. [21]
IMPACT OF NBS	• Savings of **£10.4 million** over traditional chemical stripping solution. • **53%** water consumption savings. • **89%** reduction in CO2e emissions (lower energy use and lower levels of dissolved organic carbon). • Resilience benefits (flood risk reduction). • Biodiversity co-benefits. • **59** new similar projects are in preparation by Anglian Water.



Anglian Water's wastewater treatment wetland and plant

Anglian Water's NBS treatment wetland

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CASE STUDY: Water Utilities (Peru)

Example of an investment with a nature-based solution component

SECTOR

- **Water supply**

INVESTMENT

- **$25 million** committed by Peru's largest water utility.
- 43 out of Peru's 50 water utilities added a small fee to monthly water utility bills to collectively raise **$50 million** over the last 15 years. [22]

NBS & COST

NBS **vary depending on geographic location**, but include:

- Reforestation or afforestation
- Infiltration ditches
- Rustic water and soil conservation practices (often known as water sowing and harvesting)
- Construction of permeable micro-reservoirs.[23]

Water reservoir constructed for water security in the Andes

RATIONALE FOR NBS

- NBS for improving water security are **cost competitive** with conventional alternatives (within a $0.25/m3 price point).[24]
- Use of NBS **avoids negative environmental trade-offs** like deforestation and increased energy demand (resulting in increased emissions).

IMPACT OF NBS

- **Increased water supply** to support water security. Following the restoration efforts, local springs provided more water during the dry season, supporting local businesses.[25]
- **Improved water quality** through increased infiltration/reduced sedimentation, reducing water treatment costs.
- **Increased moisture** in the hillside facilitates the growth of vegetation that helps control erosion on the steep slopes.

Ditches constructed for water infiltration

CASE STUDY: Catskills Mountains, New York City Watershed (United States)

Example of an investment with a nature-based solution component

SECTOR	• **Water treatment** (reforestation & forest conservation)
INVESTMENT	• **$1.5 billion** toward 1) payments for environmental services to farmers for changes in farm management practices, 2) purchase of land, and 3) improvement of the wastewater system in the watershed area. • **$167 million** in annual maintenance fees of the forested watershed in the Catskills mountains.
NBS	**Forest conservation activities** including: • Payments to **farmers** to incentivize sustained changes to farm management practices in effort to reduce pollution to the watershed area, such as building fences to keep cattle from waterways.[26] • Purchase of **70,000 acres** of land for conservation purposes in the New York City (NYC) watershed. • Payments to **landowners** to keep forests undeveloped.
RATIONALE FOR NBS	• Without the forest conservation activities reducing the pollution levels in the watershed, NYC would need to spend **$6 billion** to build filtration plants that would then cost $250 million per year to maintain.
IMPACT OF NBS	• **Improved water quality by reducing non-point source pollution and sedimentation**, making water cleaner and cheaper for downstream water treatment plants to clean. • $100 million increase into local economy each year.[25]

Farm management practices in action in the Catskills to reduce non-point source pollution into the water supply [27]

Rondout Reservoir, part of the New York City's water supply network [26]

CATALOGUE OF NATURE-BASED SOLUTIONS

Extractives

Roads | Water Management | Waste Management
Air Pollution Management | Reclamation

*This section covers nature-based solutions that can be integrated into extractives-linked infrastructure investments, with a specific focus on **roads, water management, waste management, air pollution management** and **reclamation.***

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CATALOGUE OF NATURE-BASED SOLUTIONS FOR EXTRACTIVES

Nature-based Solution	Infrastructure Service	Performance	Key Driver of Biodiversity Loss Addressed
Bioengineering for roads	Roads	Stabilize slope; reduce erosion and landslides; reduce flood risk and protect local built assets; carbon sequestration services	Land use change
Road routing	Roads	Reduce number of wildlife collisions and car accidents; reduce air pollution; avoid local communities	Land use change; pollution
Road decommissioning	Roads	Improve water supply quality through increased infiltration; reduce flood risk; reduce erosion; improve biodiversity through increasing native and naturalized species	Land use change; pollution
Forest conservation and/or restoration	Water Management	Reduce flood risk; reduce peak flows; improve water quality; reduce erosion; improve water supply to mine and local communities	Land use change; resource overexploitation; climate change
Treatment wetlands	Water Management	Improve water quality through filtering and adsorbing pollutants; improve water supply to mine and local communities; reduce flood risk; carbon sequestration services	Land use change; pollution
Floodplain restoration	Water Management	Reduce flood risk; improve water supply to mine and local communities; improve water quality; improve biodiversity through provision of undisturbed habitat for species	Land use change; pollution

CATALOGUE OF NATURE-BASED SOLUTIONS FOR EXTRACTIVES

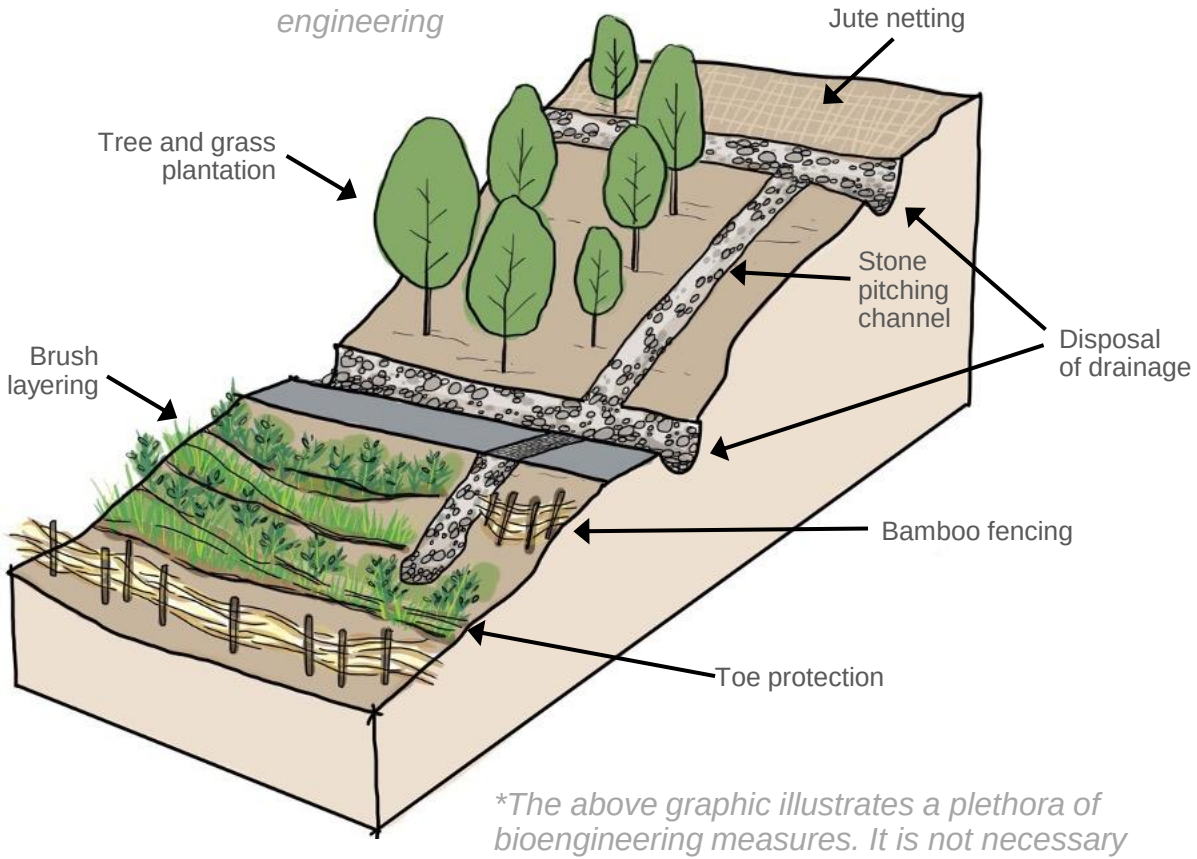
Nature-based Solution	Infrastructure Service	Performance	Key Driver of Biodiversity Loss Addressed
Phytocapping	Waste Management	Improve water quality; improve water management through increased infiltration; reduce windblow erosion; improve biodiversity through increasing native and naturalized species	Pollution
Reforestation and revegetation	Air Pollution Management	Reduce impact of windblown erosion and dust; carbon sequestration services; muffle noise	Pollution; climate change
Natural fiber matting	Air Pollution Management	Reduce impact of windblown erosion and dust; reduce erosion	Pollution
Assisted natural regeneration	Reclamation	Enhance natural recovery of forests; increase infiltration to shallow and deep groundwater supplies; carbon sequestration services	Climate change; invasive species
Applied nucleation	Reclamation	Enhance natural recovery of forests; increase infiltration to shallow and deep groundwater supplies; carbon sequestration services	Climate change; invasive species
Quarry lakes	Reclamation	Improve local water supply; reduce flood risk	Land use change; resource overexploitation
Establishment of sustainable agriculture production	Reclamation	Improve soil quality; reduce flood risk; reduce erosion; carbon sequestration services; improve biodiversity through increasing native and naturalized specie; additional revenue stream for local communities and farmers	Land use change

NATURE-BASED SOLUTIONS FOR **EXTRACTIVES**: **Road Infrastructure**

ROAD INFRASTRUCTURE: **Bio-engineering for Roads**

NATURE-BASED SOLUTIONS

Road infrastructure incorporating bio-engineering



**The above graphic illustrates a plethora of bioengineering measures. It is not necessary to implement all the measures in the graphic to successfully stabilize slopes surrounding road infrastructure.*

BIO-ENGINEERING FOR ROADS: practices that utilize **living vegetation** to provide high quality and low environmental impact methods **for slope stabilization**.

Bio-engineering can be implemented alone or combined with conventional road infrastructure.

BUSINESS RATIONALE

- Stabilizes slopes surrounding road infrastructure to reduce erosion and landslides.[28]
- Slow overland flow of water to help reduce local flood risk and protect built assets.
- Reduce air pollution.
- Carbon sequestration services.
- Lower cost when compared to conventional measures such as stone pitching, gabions and placement of soil cement layers.[29]
    - Where available, bioengineering can further lower costs by utilizing local or onsite materials for construction such as on-site soil, rocks, tree stumps, downed trees, live vegetation, and leaf litter.[29]

ROAD INFRASTRUCTURE: **Road Routing**

NATURE-BASED SOLUTIONS

Road infrastructures incorporating wildlife crossing

ROAD ROUTING TO PROTECT WILDLIFE:

infrastructure practices, such as locating and installing **wildlife crossings** across roads or **protected biodiversity corridors** for wildlife that maintain species access to their habitats and minimize infrastructure's encroachment to undeveloped areas. An assessment to inform routing and the placement of fauna passages is key.*

ROAD ROUTING TO AVOID COMMUNITIES: selecting

routes to minimize noise, dust and pollution to local communities.

BUSINESS RATIONALE

- Reduce number of animal strikes, vehicle damage, and injury to people.
  - An average cost of a wildlife crossing ranges from $500,000 to $6.2 million, depending on the length, materials and geographic complexity of the project.[34]
  - A study looked at crashes within 10 miles of 13 wildlife crossings and found each crossing generated an annual benefit of $235,000 to $443,000.[34]
- Avoid local communities to minimize noise and dust.

**These practices are also considered mitigation of project-related impacts per Good International Industry Practices and lender E&S standards.*

ROAD INFRASTRUCTURE: **Road Decommissioning**

NATURE-BASED SOLUTIONS

Removal of culverts on an unused road

Seeding and mulching (suing a straw blower) of an exposed area from a decommissioned road

ROAD DECOMMISSIONING: formal closure of any road that is not regularly inspected and maintained.*

Closure of a road includes:

- Decommissioning stream crossings.
- Removing culverts to avoid erosion that pollutes the downstream environment.
- Seeding and mulching exposed areas.
- Planting areas with native and/or naturalized species.[28]

BUSINESS RATIONALE

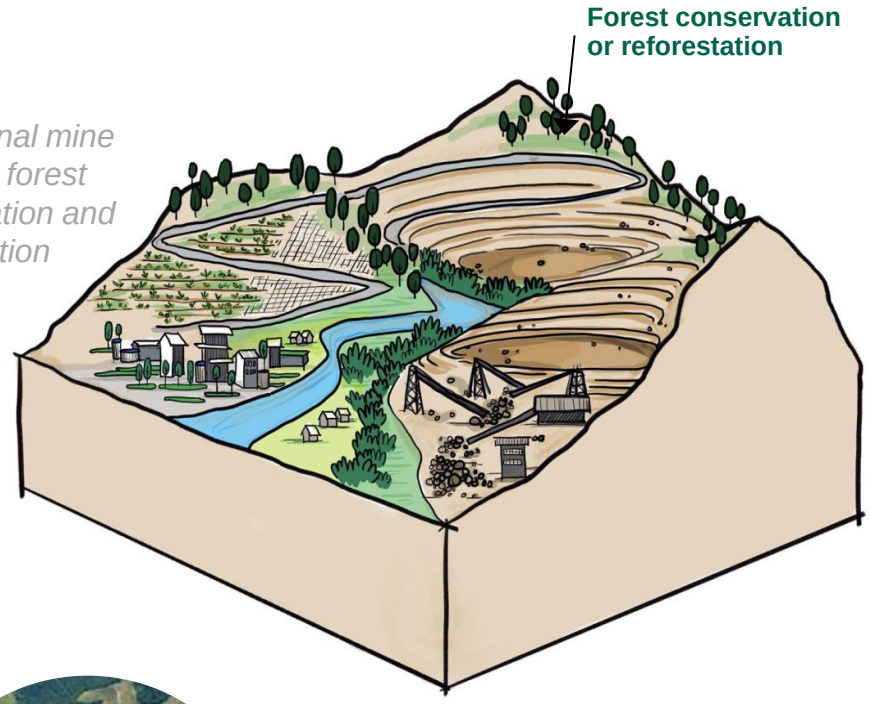
- Slow overland flow of water to help reduce local flood risk and soil erosion and protect built assets.
- Increase infiltration to shallow and deep groundwater supplies, improving their recharge.
- Improve water quality.
- Reduce erosion.
- Improve biodiversity through increasing native and naturalized species.

**These practices are also considered restoration per the mitigation hierarchy and are aligned with Good International Industry Practices and lender E&S standards.*

NATURE-BASED SOLUTIONS FOR **EXTRACTIVES**: **Water Management Infrastructure**

WATER MANAGEMENT: **Reforestation & Forest Conservation**

NATURE-BASED SOLUTIONS



Operational mine including forest conservation and reforestation

A mine in West Virginia incorporating reforestation practices [49]

REFORESTATION: water management practices in mining operations that restore ecologically suitable landscapes through replanting native or naturalized species.[1]

FOREST CONSERVATION: establishment of legally recognized protected areas for water management practices in mining operations.*

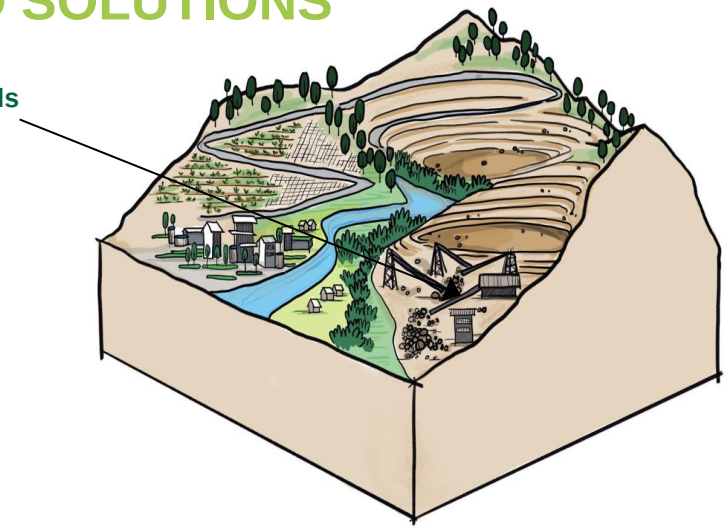
BUSINESS RATIONALE

- Reduce runoff and peak flows to reduce flood risk around the mine.
- Protect aquifers and borehole water supplies from contamination.
- Reduce erosion to improve water quality.
- Recharge groundwater supplies.
- Improve water supply for mine and local communities.

WATER MANAGEMENT: **Constructed Treatment Wetlands**

NATURE-BASED SOLUTIONS

Silver Creek aerobic wetlands treatment system used to treat acid mine drainage in the United States[33]



Operational mine indicating the area of potential inclusion for treatment wetlands

ACID MINE DRAINAGE is a common byproduct of mining that is harmful to local environment. The standard method to remove contaminants from the water is through expensive chemical treatment.

CONSTRUCTED TREATMENT WETLANDS are an NBS alternative to chemical treatment that utilize the naturally occurring processes of plants in wetlands to reduce or eliminate waterborne contaminants in mine-drainage.[30, 31]

These wetlands have a higher upfront cost compared to chemical treatment but are a cost-effective alternative for long-term operations and deliver additional climate mitigation benefits.[32] These wetlands typically require a larger footprint than conventional alternatives as well as maintenance to manage sequestered materials.[31]

CASE STUDY

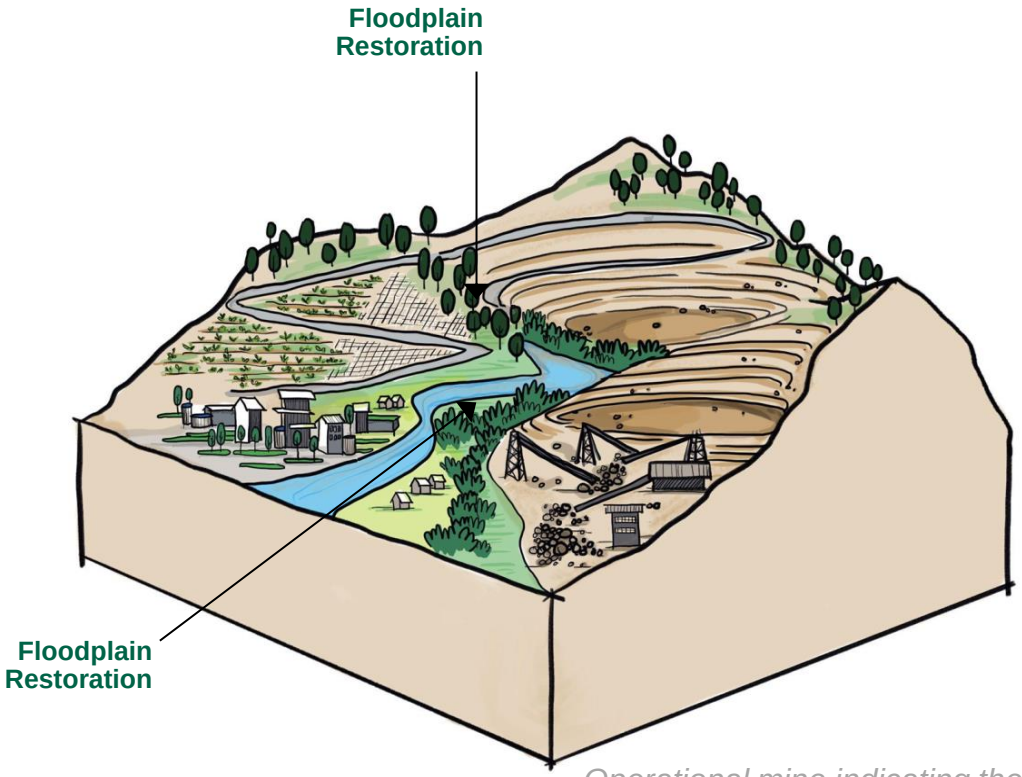
- A treatment wetland in Forwardstown, PA, built to treat acid mine drainage, has 13-acre settlement ponds, which cost around $500,000 to build. This cost was **offset in 2 years of operation**.
- When contrasted against the costs of chemical treatment which start at $20,000 a month, it was calculated that the total savings of these treatment wetlands were around **$250,000 annually**.[32]

BUSINESS RATIONALE

- Improve water quality through filtering and adsorbing pollutants in acid-mine drainage.
- Improve water supply for mine and local community.
- Reduce flood risks through increasing infiltration and area for water storage.
- Carbon sequestration services.

WATER MANAGEMENT: **Floodplain Restoration**

NATURE-BASED SOLUTIONS



Operational mine indicating the area of potential inclusion for floodplain restoration

FLOODPLAIN RESTORATION:

the practice of dedicating low-lying land area in proximity to mines for the purpose of floodwater run-off from natural flowing water.

Incorporation of specific native species can increase percolation and aquifer recharge and reduce flood risk through storage of flood water.[35]

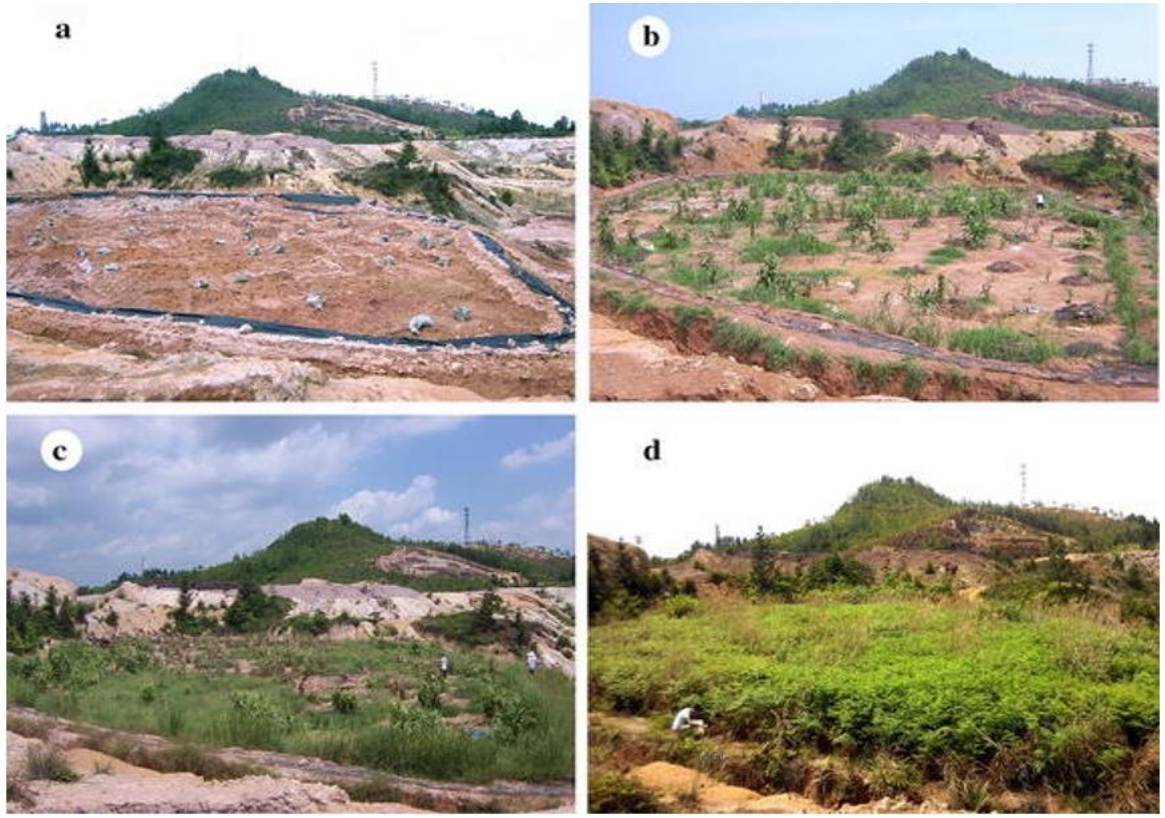
BUSINESS RATIONALE

- Reduce flood risk.
- Improve water supply for mine and local community.
- Improve water quality.
- Increase biodiversity through provision of undisturbed habitat for species.

NATURE-BASED SOLUTIONS FOR **EXTRACTIVES**: **Waste Management Infrastructure**

WASTE MANAGEMENT: **Phytocapping**

NATURE-BASED SOLUTIONS



The effects of phytocapping in a barren rare-earth mined site over time

PHYTOCAPPING: Planting native species as a vegetated cover over rock piles, tailings or bare-earth surfaces to reduce acid mine drainage. The vegetation adsorbs the infiltrating water and reduces the leaching of contaminants into the local water supply.*[52]

BUSINESS RATIONALE

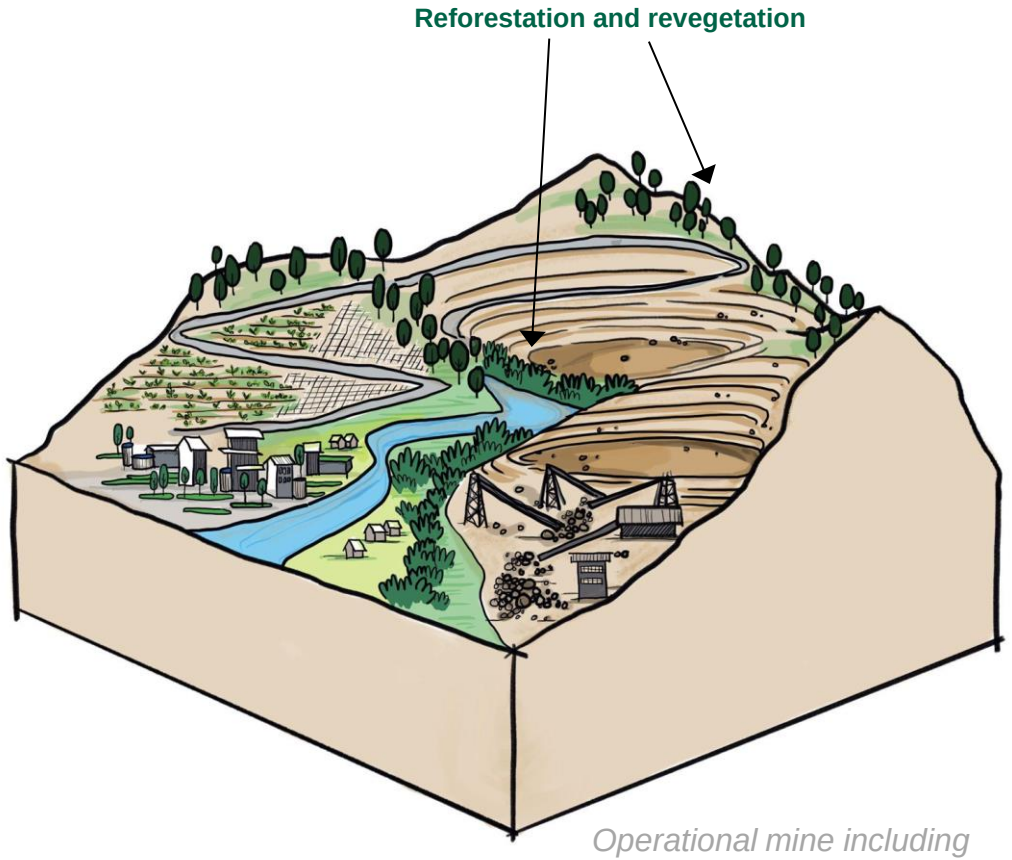
- Improves water quality by reducing leaching into the local water supply.
- Improve water management through increased infiltration.
- Reduce windblown erosion to lower air pollution.
- Improve biodiversity through increasing native and naturalized species.

**These practices are also considered restoration per the mitigation hierarchy and are aligned with Good International Industry Practices and lender E&S standards.*

NATURE-BASED SOLUTIONS FOR **EXTRACTIVES**: **Air Pollution Management**

AIR POLLUTION: **Reforestation and Revegetation**

NATURE-BASED SOLUTIONS



Operational mine including reforestation and revegetation

REFORESTATION AND REVEGETATION:

planting native species on banks and hillsides to **reduce windblown erosion.***

Sources of dust from mines and mine operations include blasting, handling, processing or transporting of the mined materials, and can also come from waste disposal facilities, such as waste rock and tailings, by wind erosion.[36]

Plant species best suited to reducing air pollution are trees with compact branches, broad leaves, shiny or waxy leaves and high proline content.[37]

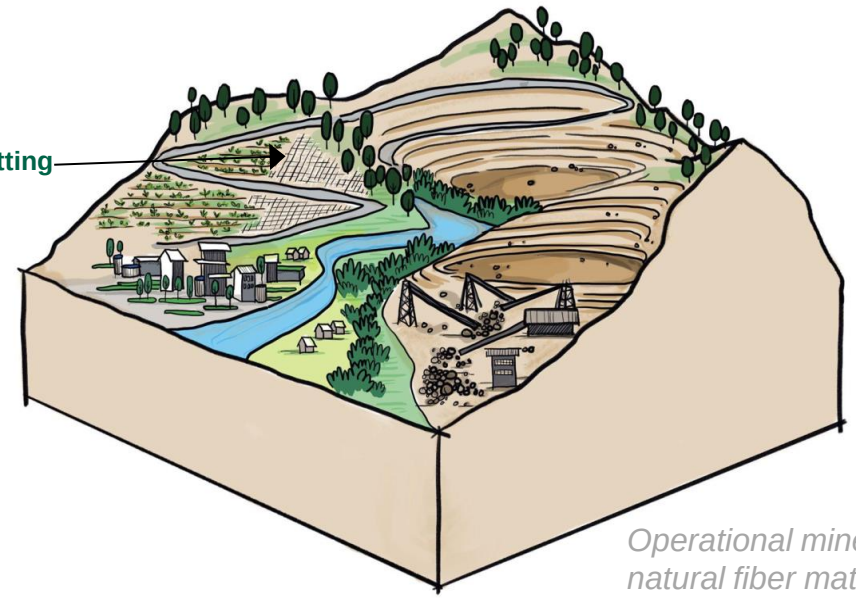
BUSINESS RATIONALE

- Reduce impact of windblown erosion and dust.
- Carbon sequestration services.
- Muffle noise, causing less disturbance to local communities and wildlife.

**These practices are also considered restoration per the mitigation hierarchy and are aligned with Good International Industry Practices and lender E&S standards.*

AIR POLLUTION: **Natural Fiber Matting**

NATURE-BASED SOLUTIONS



Operational mine natural fiber matting

Operational iron ore mine with coir matting to reduce dust impacts and contribute to slope stabilization [38]

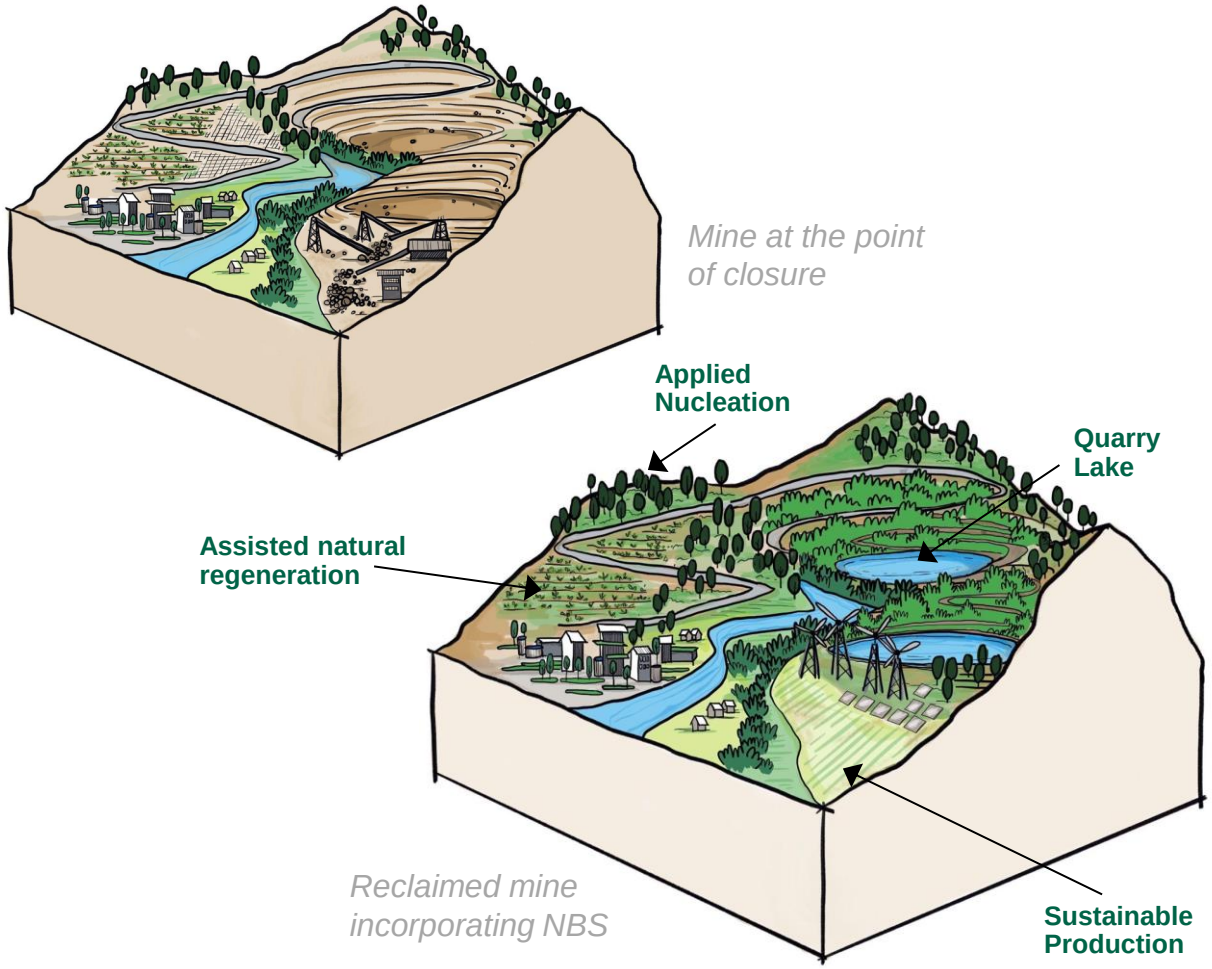
NATURAL FIBER MATTING: placement of **natural fibers**, such as rolled coir (husk of coconut), straw, or jute, on rock piles, tailings and bare-earth surfaces **to reduce soil erosion on banks** and reduce dust from sources such as transporting and processing materials that contribute to air pollution.

BUSINESS RATIONALE

- Reduce impact of windblown erosion and dust.
- Reduce erosion through contributing to slope stabilization efforts.[53]

NATURE-BASED SOLUTIONS FOR **EXTRACTIVES**: **Reclamation**

MINE CLOSURE AND RECLAMATION



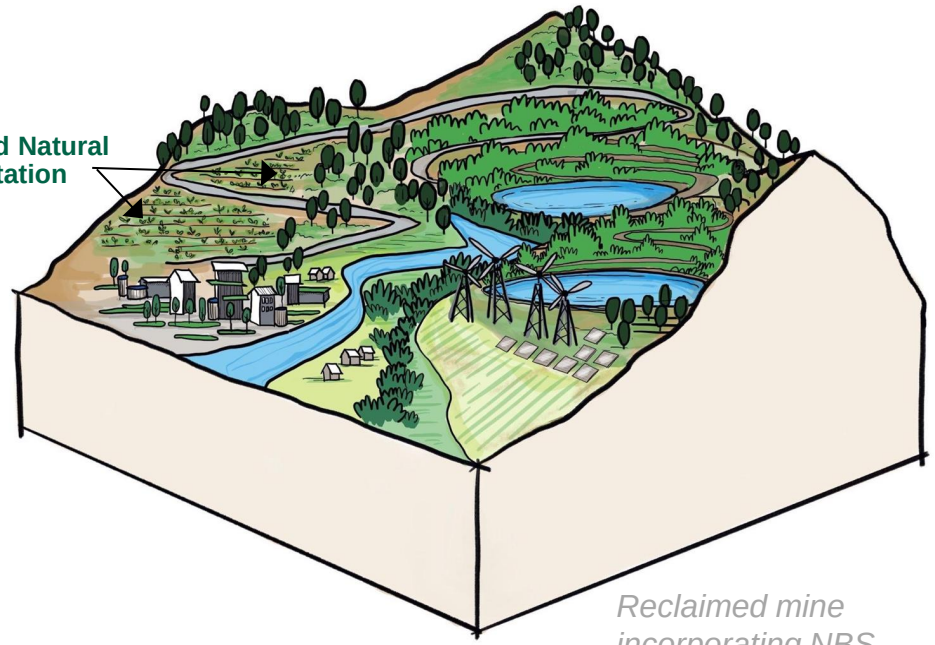
MINE CLOSURE: the process of **winding down operations at a mine site**, including planning, decommissioning, reclamation and monitoring.

Responsible mine closure and reclamation considers **environmental, social and economic factors** from an early stage of mine development and throughout the life of the asset and can add value to shareholders and reduce long term environmental liability. [39, 40]

**These practices are also considered restoration per the mitigation hierarchy and are aligned with Good International Industry Practices and lender E&S standards.*

RECLAMATION: **Assisted Natural Regeneration**

NATURE-BASED SOLUTIONS



Reclaimed mine incorporating NBS

Reforested landscape created through assisted natural regeneration.[50]

ASSISTED NATURAL REGENERATION: a blend of active planting and passive restoration, where interventions focus on helping native trees and vegetation to naturally recover by removing barriers to their growth, such as **elimination of alien invasive species**.[41]

This form of restoration is typically the most cost-effective method as it utilizes limited labor-intensive activities, such as dispersing seed mixes, as well as locally available materials, such as using nearby trees as seed sources.[42]

BUSINESS RATIONALE

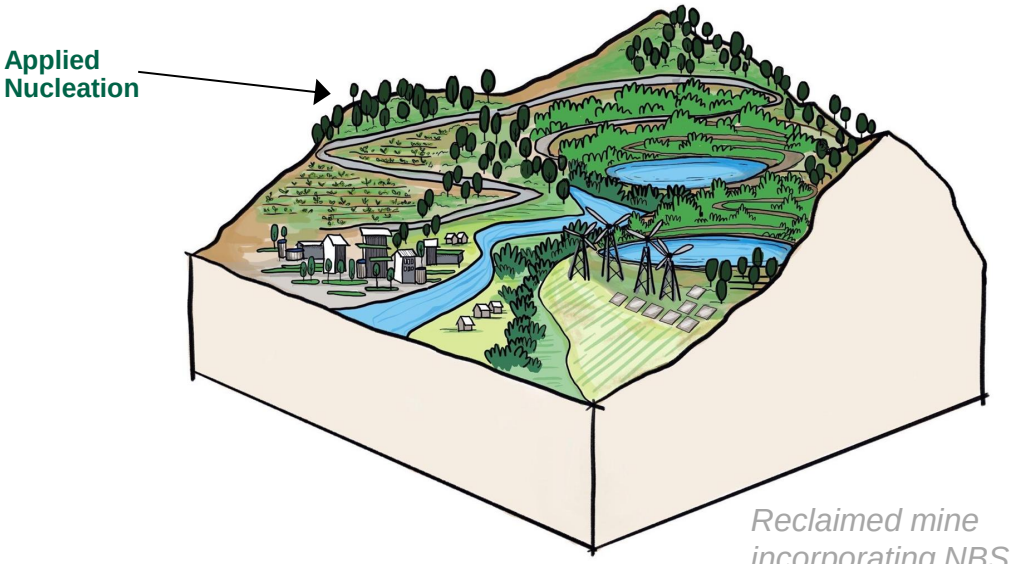
Enhance natural recovery of forests, leading to:

- Increase infiltration to shallow and deep groundwater supplies, improving their recharge.
- Carbon sequestration services.
- Improve biodiversity through increasing native and naturalized species.

**These practices are also considered restoration per the mitigation hierarchy and are aligned with Good International Industry Practices and lender E&S standards.*

RECLAMATION: **Applied Nucleation**

NATURE-BASED SOLUTIONS



Reclaimed mine incorporating NBS

Removal of invasive species to prepare land for planting native species [41]

APPLIED NUCLEATION: a technique that integrates **tree planting and natural succession** to restore and regrow forests. Trees are planted in clusters, rather than over the whole site, thereby reducing costs and labor.

Applied nucleation enhances natural forest recovery and relies on animal species to disperse native trees, which can create forests with high native biodiversity.[43]

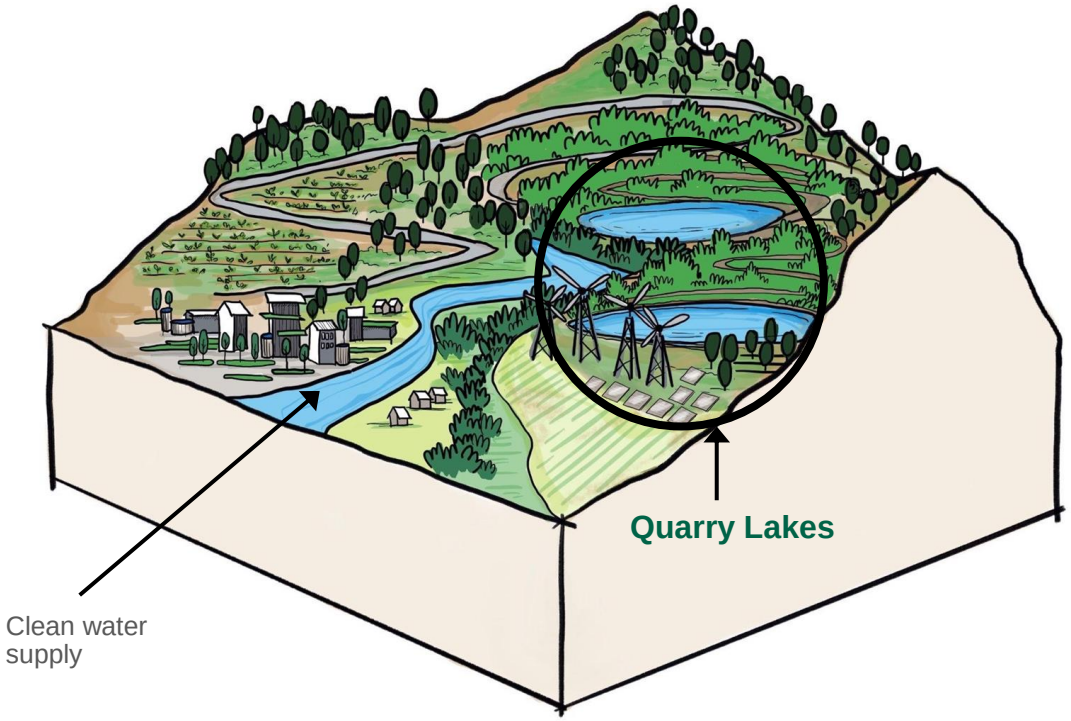
BUSINESS RATIONALE

Enhance natural recovery of forests, leading to:

- Increase infiltration to shallow and deep groundwater supplies, improving their recharge.
- Carbon sequestration services.
- Improve biodiversity through increasing native and naturalized species.

RECLAMATION: **Quarry Lakes**

NATURE-BASED SOLUTIONS



Restored mine incorporating NBS, including quarry lakes

QUARRY LAKES: reservoirs created out of **abandoned mining pits** that, where suitable, can provide critical recharge to groundwater aquifers or water storage to manage water supplies for the local area.

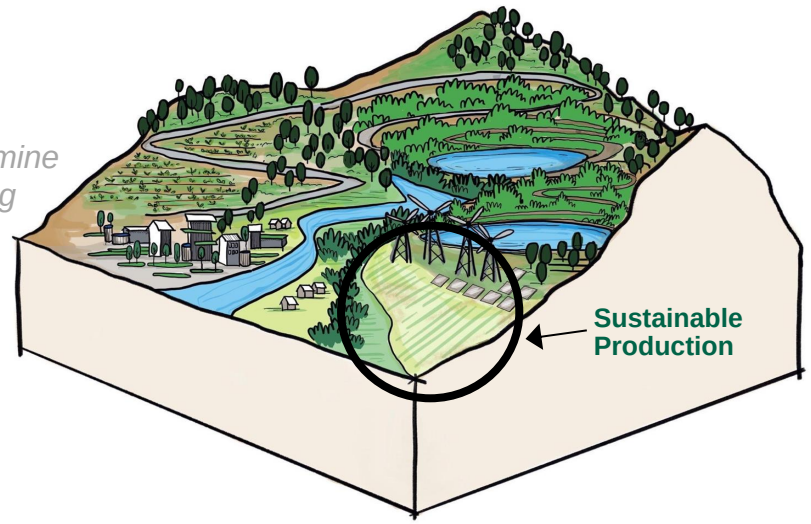
BUSINESS RATIONALE

- Increase water storage for use during water scarce periods.
- Reduce flood risk.
- Utilize reclaimed land for reservoir which reduces pressure for land use change for water supply infrastructure in the local area.
- Utilize existing landscape at a lower cost than conventional infrastructure alternatives.

RECLAMATION: **Establishment of Sustainable Agriculture Production**

NATURE-BASED SOLUTIONS

Reclaimed mine incorporating sustainable production practices



BUSINESS RATIONALE

Depending on the form of sustainable production:

- Improve soil quality on reclaimed land, reducing pressure for further conversion of forests.
- Reduce flood risk and erosion through increasing ground cover which promotes infiltration and stabilizes soil.
- Carbon sequestration services.
- Improve biodiversity through increasing native and naturalized species.
- Potentially provide an additional revenue stream for local communities and farmers.

Land used during the mining process can be reclaimed to be utilized for **sustainable production** such as:

- **Apiary**: planting native wildflowers to promote bee populations for honey production.[51]
- **Cover Crops**: planting crops, such as alfalfa, rye, and clover, to hold fragile soil in place to reduce erosion and to supply a food source for soil life to provide nutrients for future crops.[44]
- **Pastureland**: planting grasslands for livestock, such as cattle or sheep.[45]
- **Agroforestry**: integrating trees into croplands or pasture through windbreaks and buffers to shelter crops and animals as well as to reduce soil erosion.[1, 46]

Apiary in the land of a reclaimed mine in the Appalachian Mountains in the United States.[51]

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NATURE-BASED SOLUTIONS FOR **EXTRACTIVES:**
Case Study

CASE STUDY: Nimr Oil Fields (Oman)

Example of an investment with a nature-based solution component

SECTOR	• **Extractives** (water treatment wetland)
INVESTMENT	• N/A
NBS	• Water flows via gravity into **reed beds** where **periphyton** (algal and bacterial biofilms) attached to the submersed leaves and stems of the reeds trap the oil and break down hydrocarbon molecules, **cleansing the water**. • The oil in the process water is reduced from 400mg/l to less than **0.5mg/l** when leaving the water treatment wetland.[47]
RATIONALE FOR NBS	• **Lower cost** of water filtration than conventional methods.
IMPACT OF NBS	• **The 2.3 km²** Nimr water treatment plant purifies **115,000 m³** of oil-contaminated water daily.[48] • Reed bed reduces CO_2 emissions by **1,924,300 tons of CO_2**. (when compared to conventional water management method).[48] • **98%** reduction in energy costs.[47] • Creates a habitat for **130 species of migratory birds** and five different native reed species.[47]

Reed beds at Nimr Oil Fields

Aerial view of Nimr Oil Fields treatment wetlands

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CATALOGUE OF NATURE-BASED SOLUTIONS

Renewable Energy

Solar Power | Wind Power | Hydroelectric Power
Transmission & Distribution

*This section covers nature-based solutions that can be integrated into renewable energy infrastructure investments, with a specific focus on **solar power, wind power, hydroelectric power** and **transmission and distribution**.*

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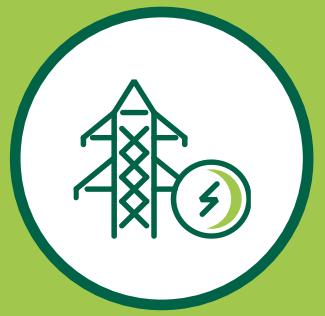
CATALOGUE OF NATURE-BASED SOLUTIONS FOR RENEWABLE ENERGY

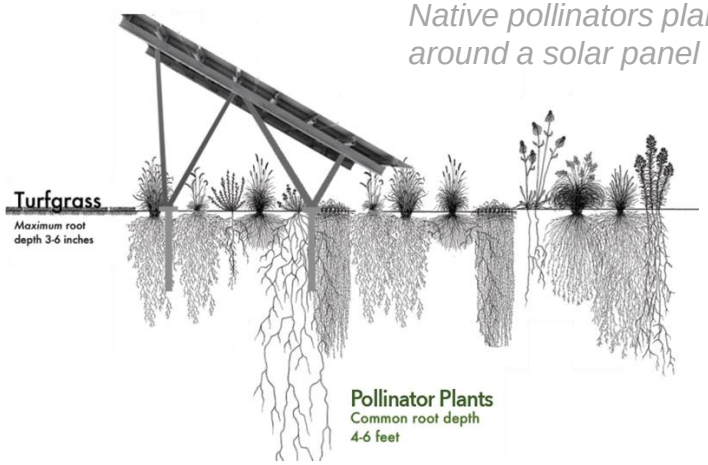
Nature-Based Solution	Infrastructure Service	Performance	Key Driver of Biodiversity Loss Addressed
Pollinator-friendly solar	Decreasing latent heat for solar power	Improve **energy production efficiency**; reduce costs for maintenance and mowing; improve infiltration of stormwater; carbon sequestration services	Land use change; climate change
Agrivoltaics (crops)	Decreasing latent heat for solar power	Improve energy production efficiency; **increase crop yield**; lower irrigation costs; improve infiltration of stormwater; carbon sequestration services	Land use change; overexploitation of resources; climate change
Agrivoltaics (livestock)	Decreasing latent heat for solar power	**Lower maintenance costs**; heat abatement for livestock; increase productivity of dairy cattle; improve soil quality; carbon sequestration services	Land use change; climate change
Alternative concrete mixes	Protection of coastal assets for wind power	**Increase durability of structure** & reduce maintenance costs from scouring [compared to regular concrete]; reduce regulatory compliance penalties; improve water quality; carbon sequestration services	Land and sea use change; pollution; climate change
Cable protection alternatives	Protection of coastal assets for wind power	**Lower installation costs**; less disruption in installation; reduce mitigation penalties for policy compliance; improve water quality; carbon sequestration services	Land and sea use change; pollution; climate change
Reforestation and forest conservation	Erosion control to increase water quality for hydroelectric power	**Decrease sedimentation in reservoir**, extending lifespan of power plant; lower maintenance costs; increase energy production	Land use change
Wetland, oyster and coral reef restoration	Protection of coastal assets for wind power and transmission/distribution lines	**Reduce damage on assets** and linear facilities; reduce maintenance costs; reduce erosion surrounding coastal infrastructure; carbon sequestration services	Land and sea use change; climate change

NATURE-BASED SOLUTIONS FOR **RENEWABLE ENERGY:** **Solar Power**



SOLAR POWER: **Pollinator-friendly Solar**

NATURE-BASED SOLUTIONS



Native pollinators planted around a solar panel

Pollinators planted at Carter Farms, United States[56]

POLLINATOR-FRIENDLY SOLAR: growing native grasses and wildflowers groundcover under solar panels.

Dense vegetation creates a **layer of shade on the ground**, absorbs latent heat, and **promotes lower ambient air temperature** through transpiration as a part of photosynthesis. This cooler, moderated microclimate can improve the energy production efficiency of solar panels.[54]

When preparing sites for solar installation, a pollinator friendly approach **skips the traditional step of removal of topsoil**, which reduces site preparation expenses and accelerates establishment of native plants.[55]

BUSINESS RATIONALE

- Improve energy production efficiency of solar panels.[54, 84]
- Reduce costs for maintenance and mowing – the maintenance of pollinator vegetation is 80% to 90% less expensive than turf over ten years for utility-scale developments.[54]
- Improve stormwater management through increased infiltration.
- Create habitat for pollinators, such as bees and butterflies.
- Increase pollination/crop yield by up to 6% for nearby crops (if located near agriculture).[86]
- Improve local bee populations to establish an additional source of income from honey production for local communities.

SOLAR POWER: **Agrivoltaics (Crops)**

NATURE-BASED SOLUTIONS

Agricultural crops growing in the shade of solar panels in the United States [60]

Aloe vera growing in the shelter of solar panels as part of study in Spain, Greece, and Italy [60, 61]

AGRIVOLTAICS: the use of land for both **agriculture (crops)** and **solar photovoltaic energy generation**.[57]

The crops with the solar panels overhead need less water and grow more efficiently, while creating a cooler, moderated microclimate to improve the energy production efficiency of solar panels.

BUSINESS RATIONALE

- Improve energy production efficiency of solar panels.
- Increase in crop yield from 20% to 60%.[58]
- Increase in habitat for pollinating insects (depending on crop variety).[58]
- Reduce water quantity used to irrigate crops by up to 15-20%[61] through:
  - Creation of ideal microclimate conditions that reduces water evaporation[91]
  - Partial and intermittent shading of crops by the solar panels.[58]
- Increased deep rooted vegetative ground cover can improve stormwater management through increased infiltration.[90]

SOLAR POWER: **Agrivoltaics (Livestock)**

NATURE-BASED SOLUTIONS

Sheep resting in the shape of solar panels in the United States [58]

Cows at a dairy farm utilizing the shade of solar panels in the United States [63]

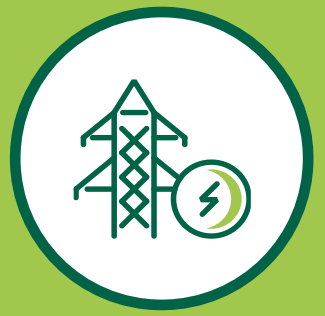
AGRIVOLTAICS: the use of land for both **agriculture (livestock)** and **solar photovoltaic energy generation.**

Livestock use solar panels for shade reducing heat stress during hot months.[57] Livestock in turn lower maintenance costs for mowing and can improve soil quality.

BUSINESS RATIONALE

- Lower mowing costs for solar power operators.[62]
- Heat abatement for livestock from the shade of the solar panels.[63]
- Increase productivity of dairy cattle due to lower levels of heat stress.[64]
- Improve soil quality due to increase organic matter (sheep & goats), leading to increased carbon sequestration services.[65]

NATURE-BASED SOLUTIONS FOR **RENEWABLE ENERGY:** **Wind Power**



WIND POWER: **Alternative Concrete Mixes**

NATURE-BASED SOLUTIONS

ECOncrete used in a coastal fortification structure [66]

$14 MILLION SAVED

In one U.S. project, including ECOncrete's technology in breakwaters **reduced regulatory penalties by approximately 80%,** or about **$14 million**. These savings equaled nearly 15% of overall project costs.[70]

Wind turbines installed with use of ECOncrete [67]

Pilot study of ECOncrete Coastalock armor units in the San Diego port [88]

ALTERNATIVE CONCRETE MIXES attract and promote the **colonization of organisms**, **further fortifying the structure**. These mixes can complement or replace standard concrete mixes in coastal fortifications and offshore wind structures.

ECOncrete is 2 to 7% more expensive than conventional concrete but offers returns on investment through **reduced maintenance costs** and **reduced regulatory penalties**.[89]

Other companies include alternative concrete are Reef Cells, Reef Innovations, & Roman Stone Construction Co.

BUSINESS RATIONALE

- 10x increase durability and strength of structure, with a longer lifespan than conventional concrete.[69]
- Reduce maintenance costs.
- Reduce regulatory compliance penalties [see example].
- Improve water quality.
- Enhance biodiversity through bio-enhancing concrete composition.
- 7x increase in carbon sequestration services versus conventional concrete.

WIND POWER: **Cable Protection**

NATURE-BASED SOLUTIONS

Roman Stone Construction Co. marine mattress being installed in the United Kingdom [75]

SubSea Specialist rock filter unit – pictured here on land, prior to installation [87]

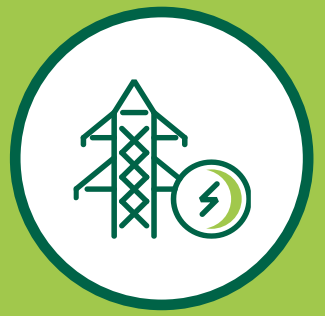
CABLE PROTECTION ALTERNATIVES, such as **rock filter units** and **marine mattresses** that utilize alternative concrete mixes, provide **protection for cables running from offshore wind turbines** to land.

Cables from offshore wind turbines are traditionally buried beneath the seabed, either through digging open trenches or horizontal directional drilling. While digging open trenches is the cheapest option, it poses significant negative environmental risks.[71] Horizontal directional drilling poses less environmental risks but is more expensive than the open trench method.[72]

BUSINESS RATIONALE

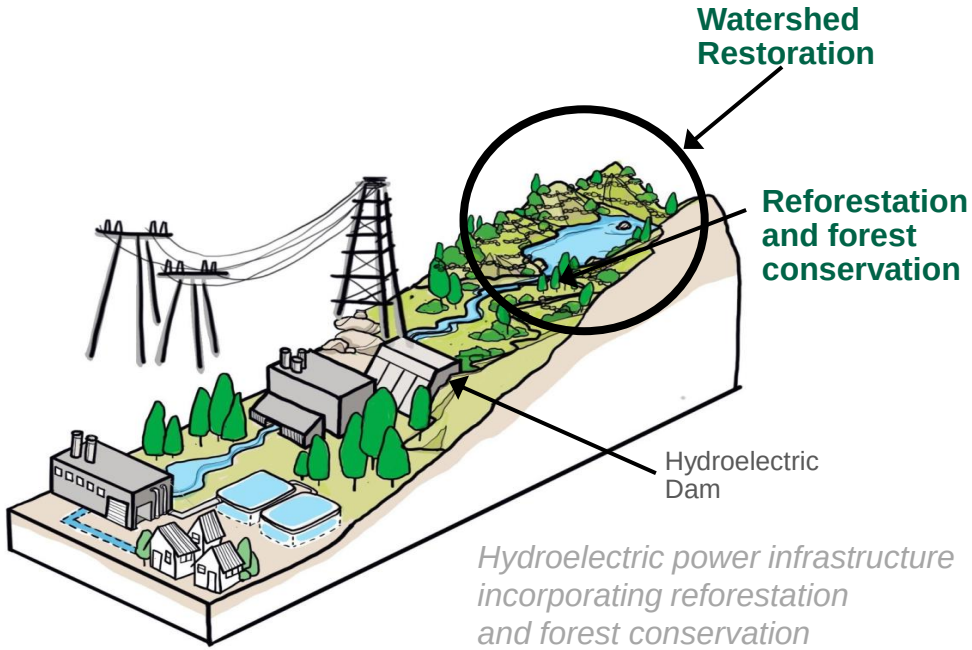
- Lower installation costs.
- Less disruption of the environment during installation.
- Reduce mitigation penalties for policy compliance [see slide 8 example] (depending on the material of the cable protection).
- Improve water quality (depending on the material of the cable protection).
- Enhance or create habitat for commercially important or sensitive species.
- Carbon sequestration services (depending on the material of the cable protection).[73]

NATURE-BASED SOLUTIONS FOR **RENEWABLE ENERGY:** **Hydroelectric Power**



HYDROELECTRIC POWER:
Reforestation and Forest Conservation

NATURE-BASED SOLUTIONS



Hydroelectric power infrastructure incorporating reforestation and forest conservation

Reforestation surrounding Fra ncisco Morazán Hydroelectric Power Station in Honduras[76]

REFORESTATION: practices that **restore ecologically suitable landscapes** through replanting native or naturalized species.[1]

FOREST CONSERVATION: establishment of **legally recognized protected areas**.*

Farm Management Practices: incentivized, on-site practices, such as conservation easements and integration of trees into croplands or pasture, can provide **simultaneous benefit to farmers** as well as the **watershed surrounding a reservoir**.

BUSINESS RATIONALE

Decreases sedimentation in reservoir behind the hydroelectric dam, extending lifespan of the asset through reducing wear and tear.

- Lower maintenance costs.
- Regulate flows to reservoirs, which increases energy production.
  - Reforesting 3% of the watershed surrounding a reservoir can increase annual energy generation by 5%.[76]

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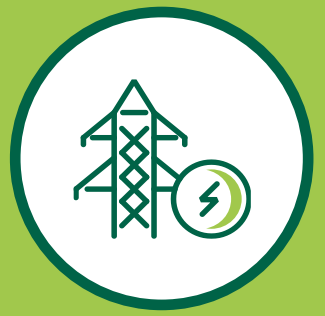
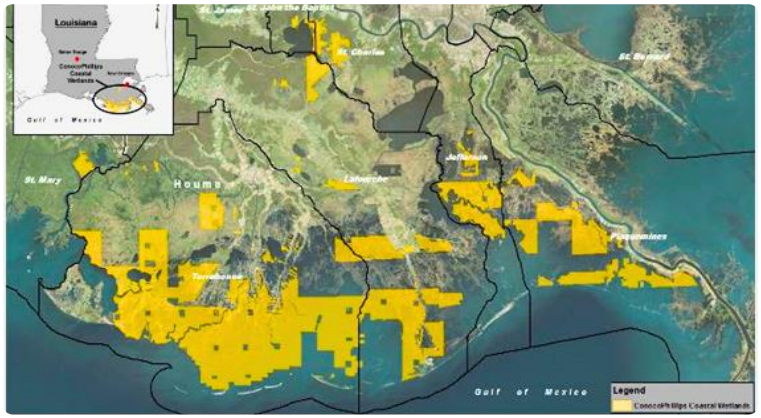
NATURE-BASED SOLUTIONS FOR **RENEWABLE ENERGY:** **Transmission & Distribution**



TRANSMISSION & DISTRIBUTION LINES; WIND POWER:
Wetland, Oyster and Coral Reef Habitat Creation

NATURE-BASED SOLUTIONS

Van Oord oyster reef restoration project to protect wind power infrastructure from scour and storm damage in the Netherlands [79]



Map showing (in yellow) protected coastal wetlands protecting gas pipes owned by Conoco Philips in the United States [78]

WETLANDS, OYSTER AND CORAL REEF HABITAT CREATION, RESTORATION AND CONSERVATION:

- Protect **offshore assets**, such as wind power infrastructure, and shoreline assets from scour, storm surge, sea level rise, and coastal erosion.
- Protect **offshore and coastal linear facilities**, such as pipelines or electrical power lines, from scour and storm surge

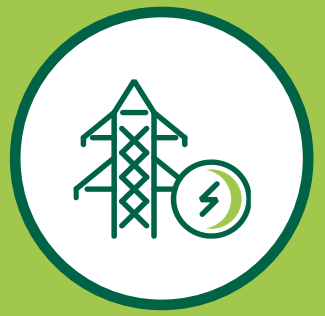
Conservation: establishment of legally protected areas.*[1]

Restoration: support the recovery of degraded, damaged or destroyed ecosystems.[77]

BUSINESS RATIONALE

- Reduce damages on wind power infrastructure (from storm surge and sea level rise) and on offshore and coastal linear facilities (from scour and storm surge).
- Reduced maintenance costs.
- Reduce erosion surrounding coastal wind power infrastructure and linear facilities.
- Carbon sequestration services.
- Community co-benefits such as creation of nurseries for local fisheries and enhanced tourism (e.g. recreational diving).

NATURE-BASED SOLUTIONS FOR **RENEWABLE ENERGY:** **Case Studies**



CASE STUDY: Itaipu Dam (Brazil)

Example of an investment with a nature-based solution component

SECTOR

- **Hydroelectric power** (reforestation/conservation)

INVESTMENT

- Total funds raised for construction, including financial rollovers, is **USD$27 billion** plus **USD$100 million** in paid-in capital.

NBS & COST

- **USD$9 million** for reforestation and restoration program.
- Protection of **101,000 hectares** of land upstream of the Itaipú dam.
- **44 million** trees planted in company-owned area around the dam.
- Restoration of 421 micro-watersheds.[80]

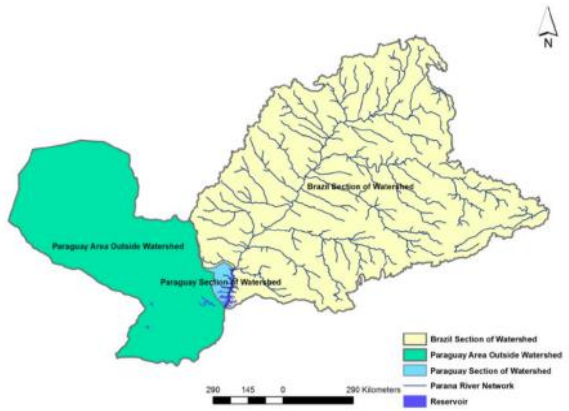
RATIONALE FOR NBS

- Prior deforestation and unsustainable land management practices upstream of the reservoir **reduced water quality**, creating unreliable flows and poor water quality for hydropower production.
- NBS practices were a **more cost-effective** and **environmentally-friendly solution** than traditional dredging practices, utilized to reduce sediment build up against the dam.

IMPACT OF NBS

- Itaipu Preserves program provides **USD$45 million** of direct financial benefits (avoided costs for dredging and reduced electricity generation capacity).[81]
- Provide a network of **biodiversity corridors** that link forested areas along the Parana River.
- Reforestation/conservation efforts capture **5.9 MT CO2e** per year.
- **1200 farms** converted to **organic production**; cooperatives organized to expand appropriate tilling and terracing techniques to reduce agriculture runoff.[80, 85]

Reforested strips of land surrounding the reservoir feeding into Itaipu Dam



Itaipu Dam watershed

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CASE STUDY: Zephyr Wind Farm (Pakistan)

Example of an investment with a nature-based solution component

SECTOR

- **Wind power** (mangrove restoration)

INVESTMENT

- **USD$41 million** (CDC Group); unknown amount from additional investors[83]

NBS & COST

- **USD$352,400** for the entire mangrove program, including initial costs for baseline studies, staff costs for monitoring growth for 25 years, and direct costs for **regeneration of 14 ha of mangroves**.[82]

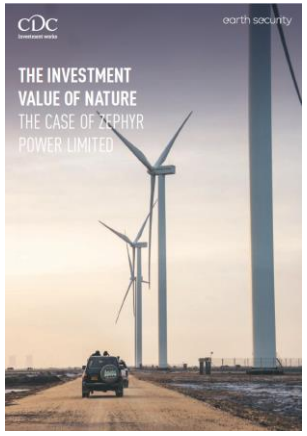
RATIONALE FOR NBS

- **Manage climate change impact** of sea level rise, leading to flooding and coastal erosion.
- Regular tidal water level fluctuation leading to wear and tear (scouring) on internal roads, turbine platforms, and power cables.

IMPACT OF NBS

- Mangrove restoration improved site stability, reduced soil erosion and built-up ecological assets, estimating to save the project developer and investors up to **USD$7 million** over the project's 25-year timeframe in maintenance and replacement costs.[82]
- Built up ecological assets resulted in substantial increase in fish, shrimp and crab population within a year, leading to doubling the income of local communities, with increased annual yield for **60 fisherman from USD$4,500 to USD$9,000.**[82]
- Enabled Zephyr to meet environmental requirements of international investors (in line with IFC Performance Standards).
- Project developer established a mangrove nursery to **re-plant 64 ha** – five times the originally planned area.

Mangroves regenerating at the Zephery Wind Farm project site



Earth Security report evaluating the effect of mangrove restoration at the project site

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