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# The World is Running Out of Sand

Even desert city Dubai imports its sand. This is why

The little-known exploitation of this seemingly infinite resource could wreak political and environmental havoc

PERSPECTIVES

**ENVIRONMENT** 

# A looming tragedy of the sand commons

Increasing sand extraction, trade, and consumption pose global sustainability challenges

The Observer Coastlines

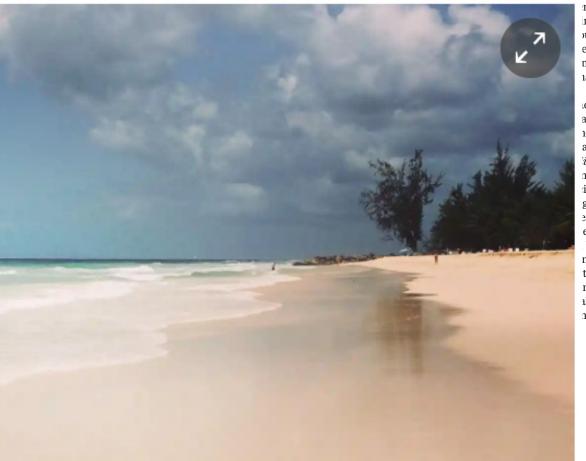
Is the world running out of sand? The truth

behind stolen beaches and dredged islands

BBC Sign in News Sport Weather Shop Earth Travel More - Search Q ball building addise islam tion industrial.

New Series: Discover: Level Up Bright Sparks

bal building boom has nd. Gangs are now stealing adise islands are being tion industry

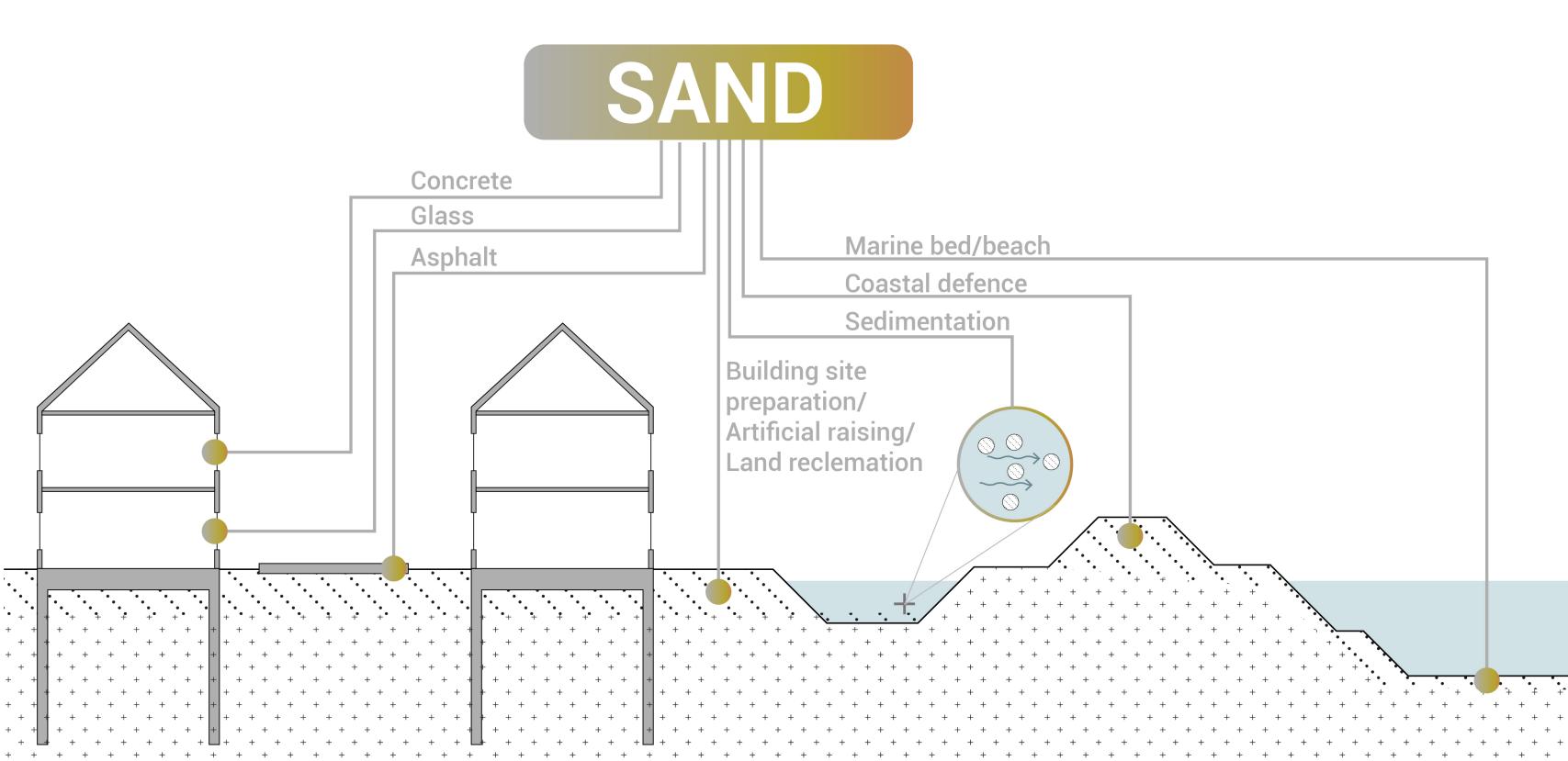


est Africa (13). trade, and po a" is considere



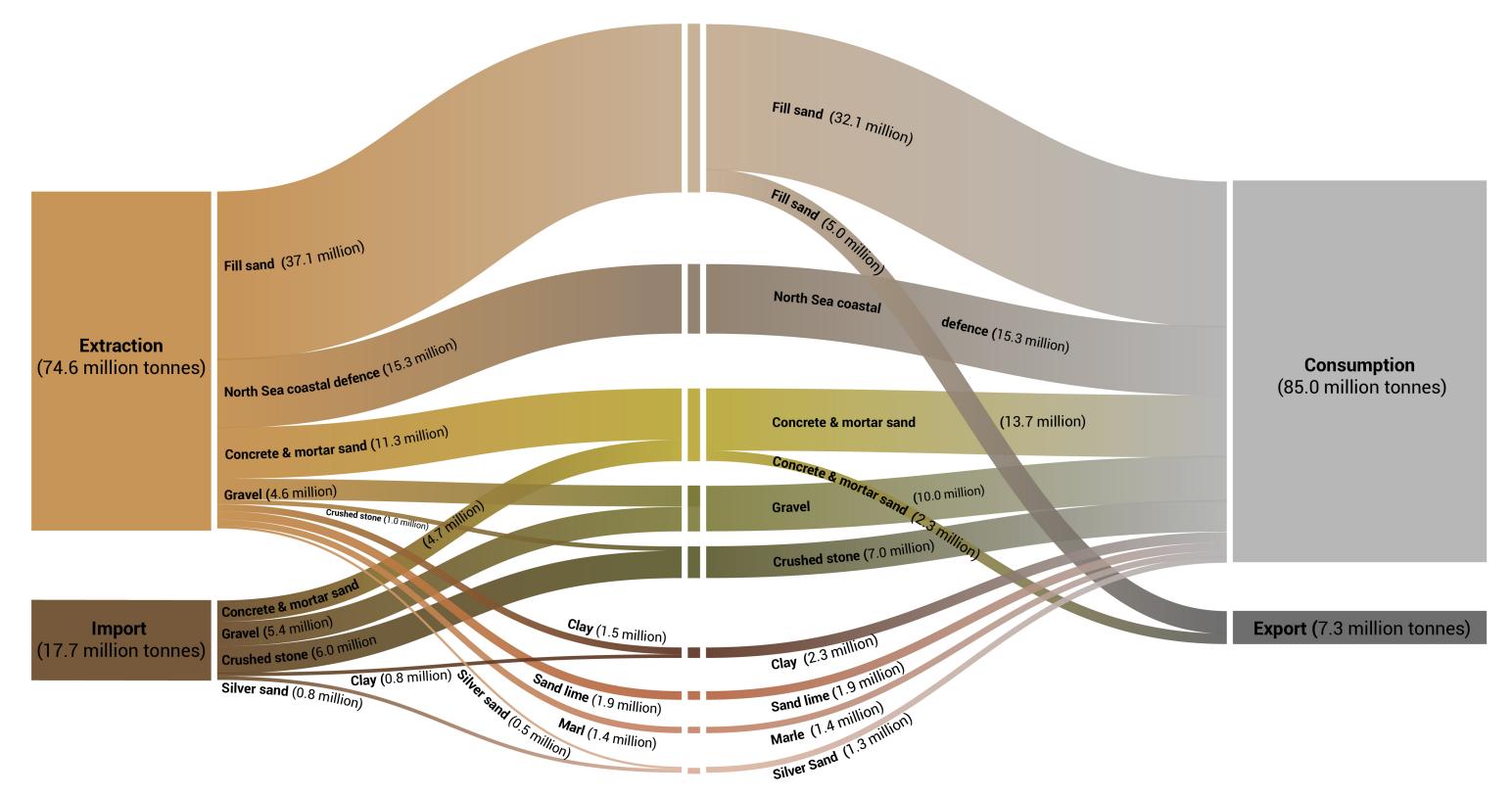
## Key ingredient of the urban environment





### Dutch extraction and consumption

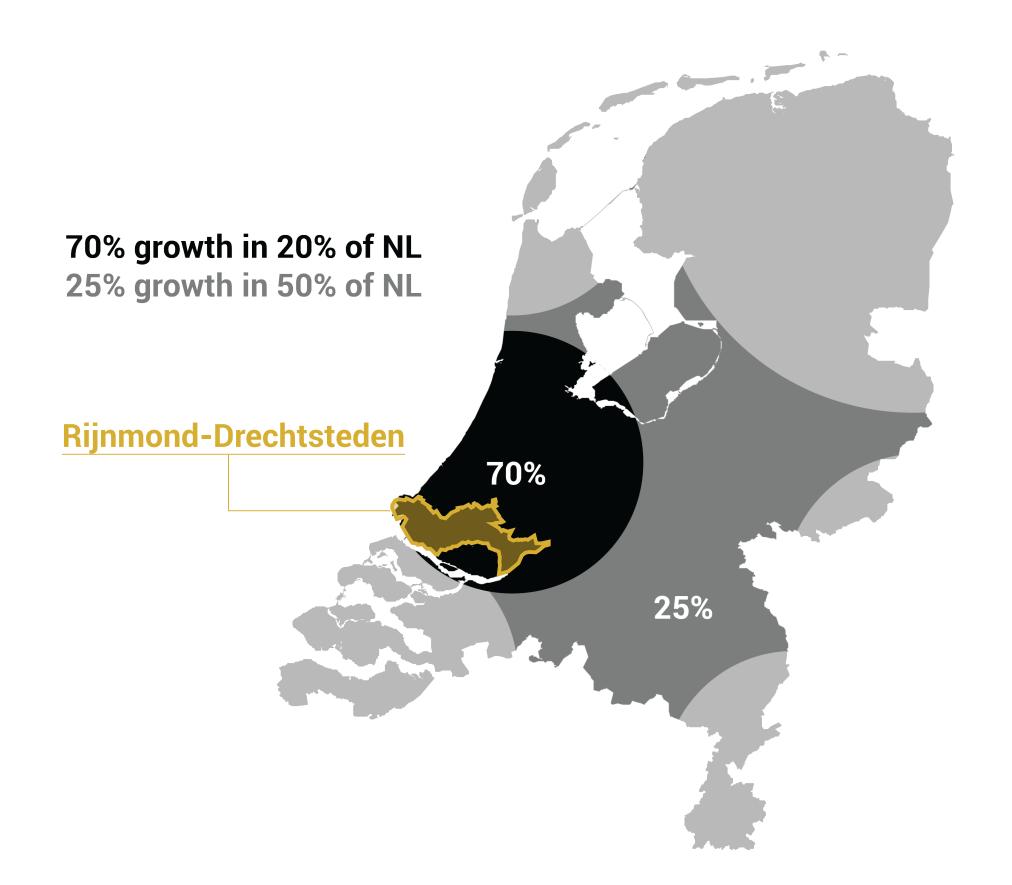






#### One million new houses in the Netherlands before 2040

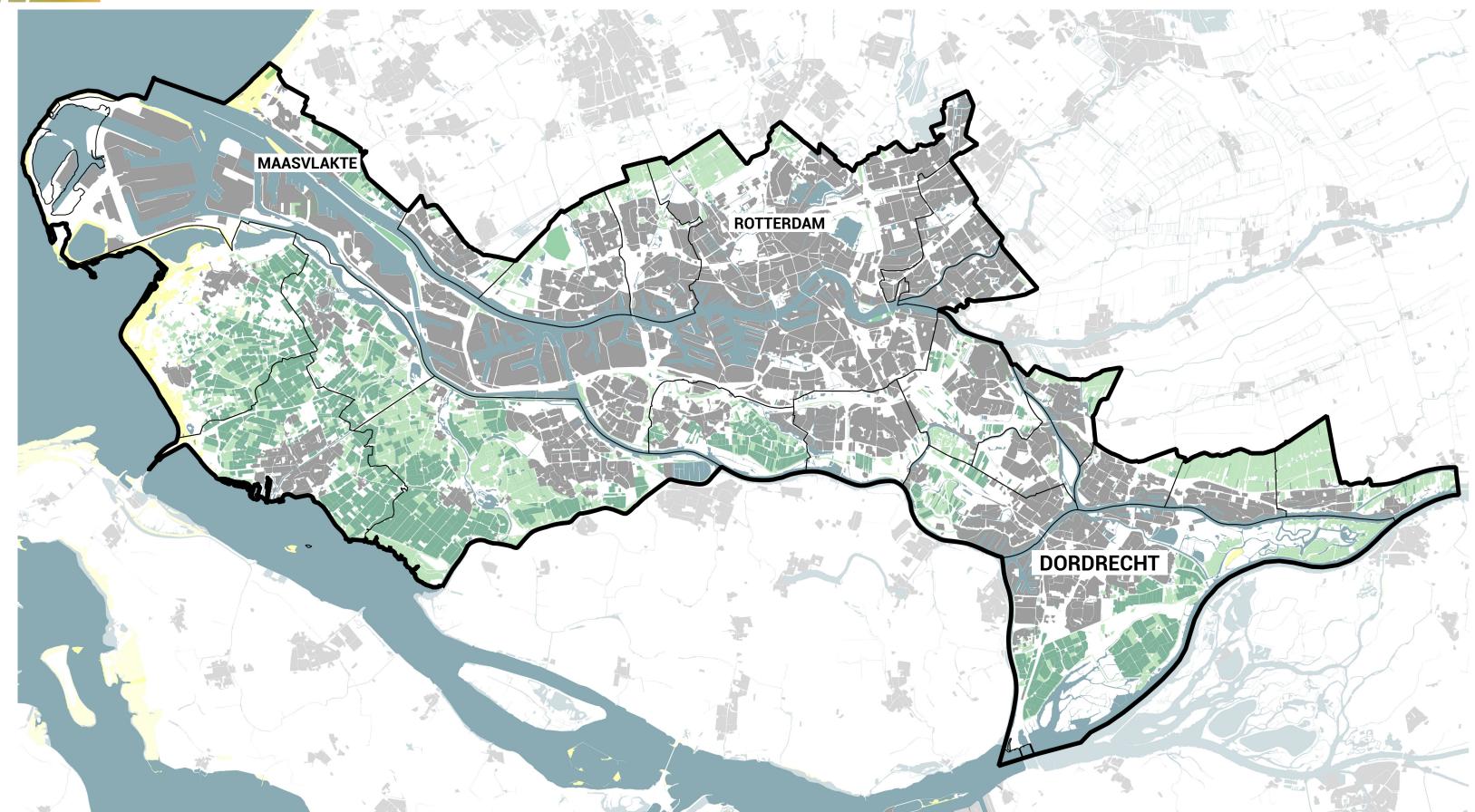






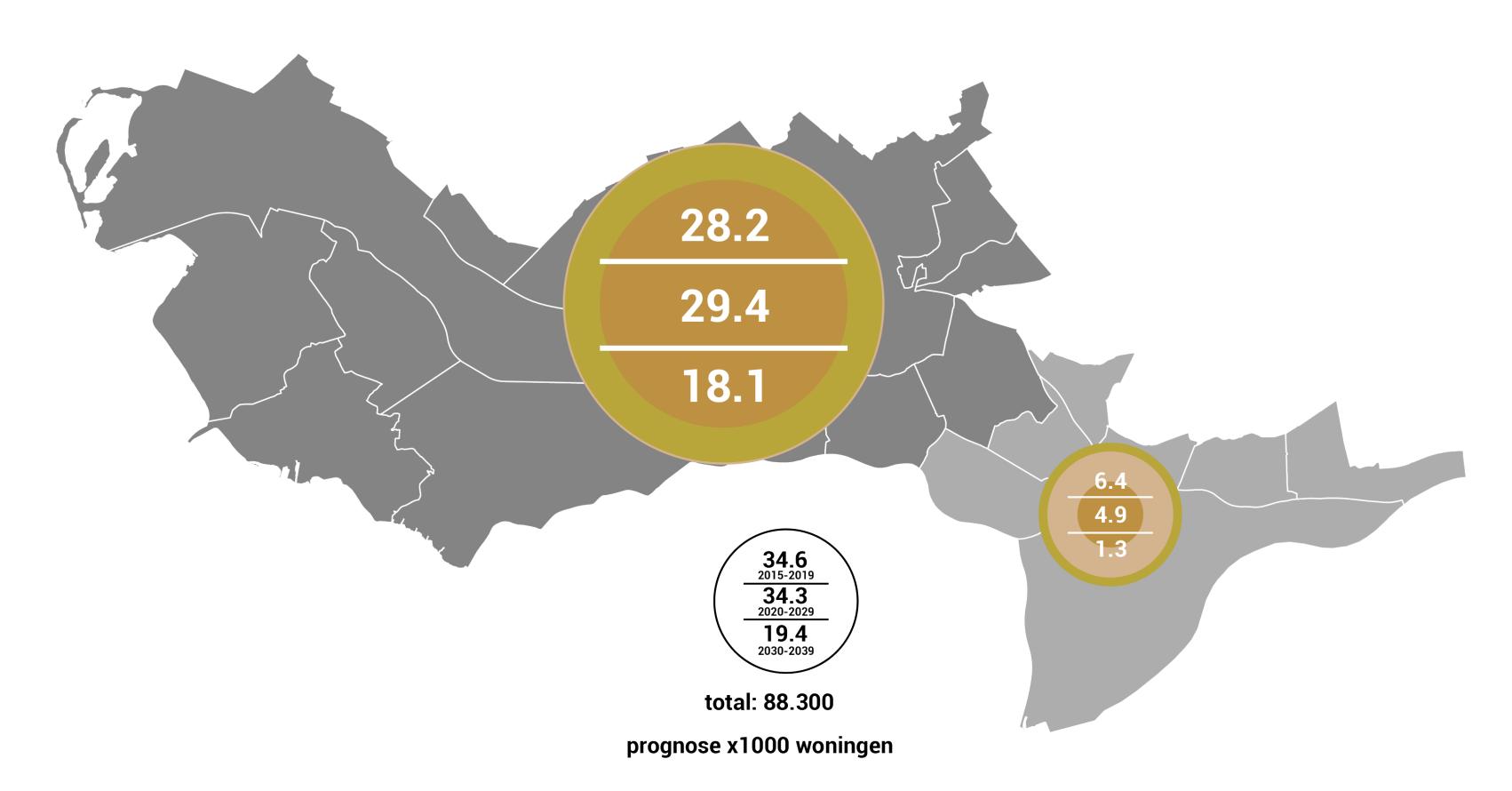
# Urbanised Delta regions: Rijnmond-Drechtsteden





## Almost 100.000 dwellings





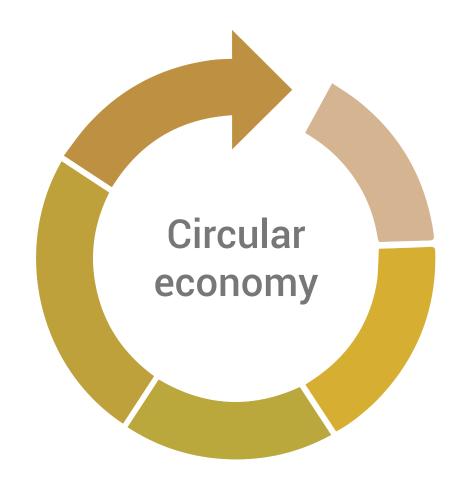


## Towards a circular Dutch economy in 2050



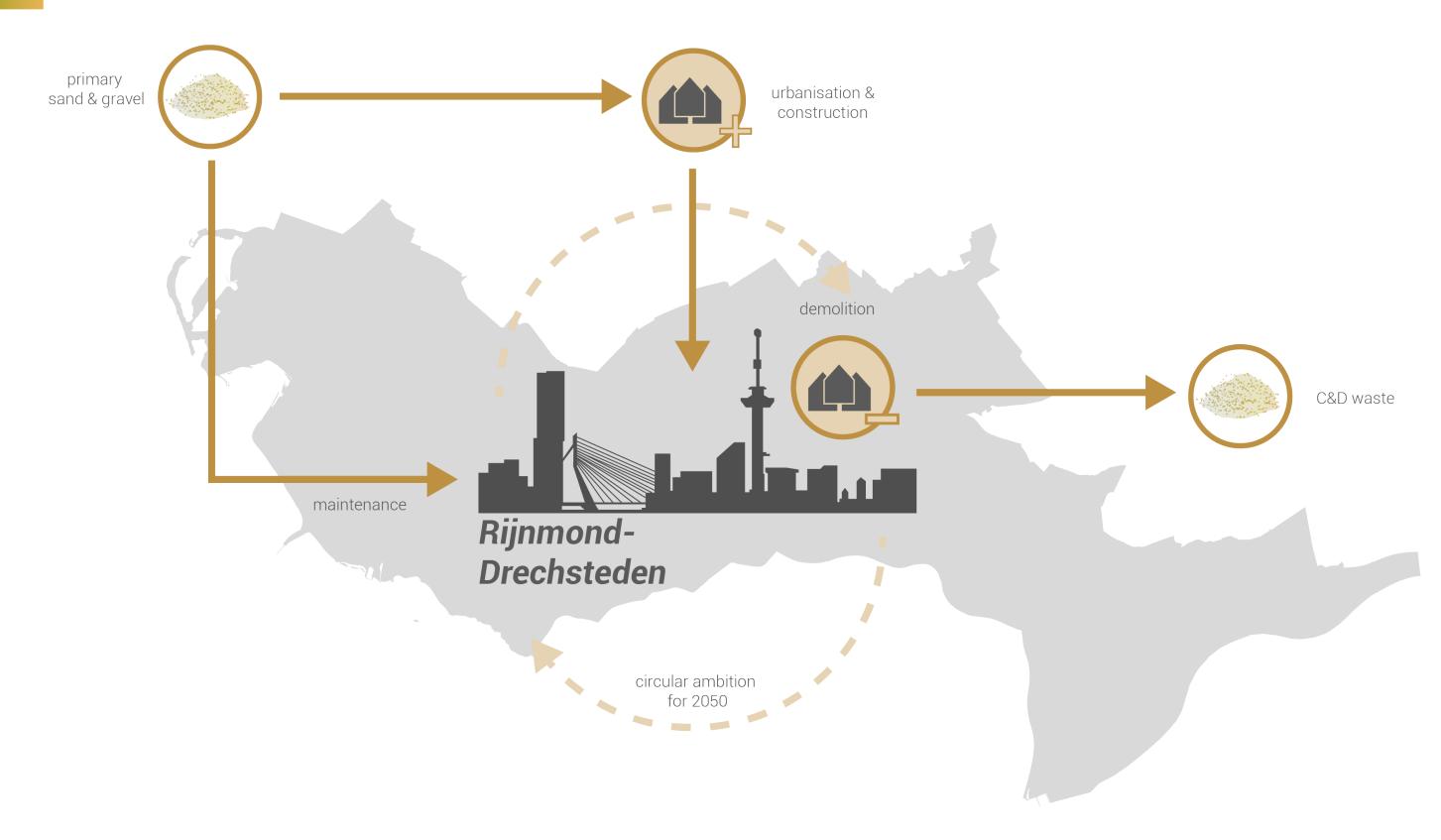


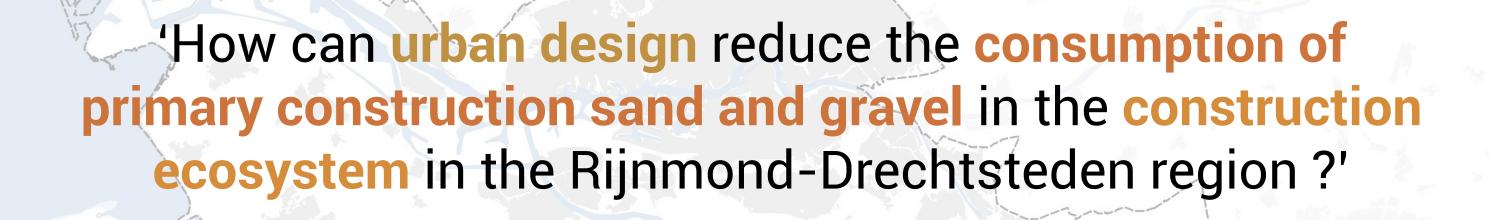




#### **Problem statement**









## Table of content/method



- 1) What is the constuction sand & gravel metabolism of RMDS region until 2040?
- 2) What is the impact of the construction sand & gravel metabolism of RMDS region until 2040?
- 3) How can urban design reduce the material consumption and impact of construction sand & gravel?
- **4)** How can the construction sand & gravel metabolism of RMDS region be improved?



## Table of content/method



- 1) What is the constuction sand & gravel metabolism of RMDS region until 2040?
- → Analysis of the current system

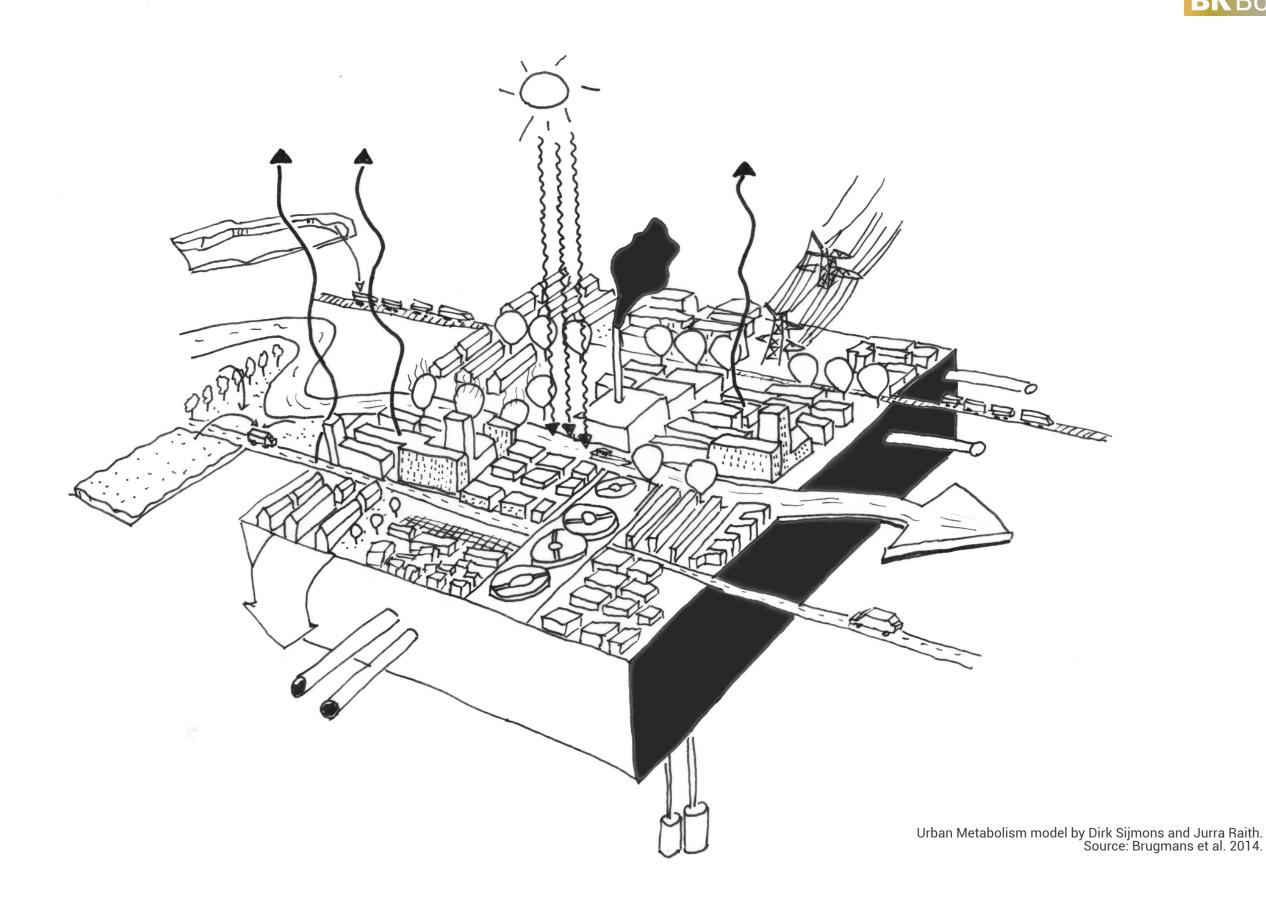
- **2)** What is the impact of the construction sand & gravel metabolism of RMDS region until 2040?
- → LCA evaluation

- 4) How can the construction sand & gravel metabolism of RMDS region be improved?



## Theory Urban Metabolism

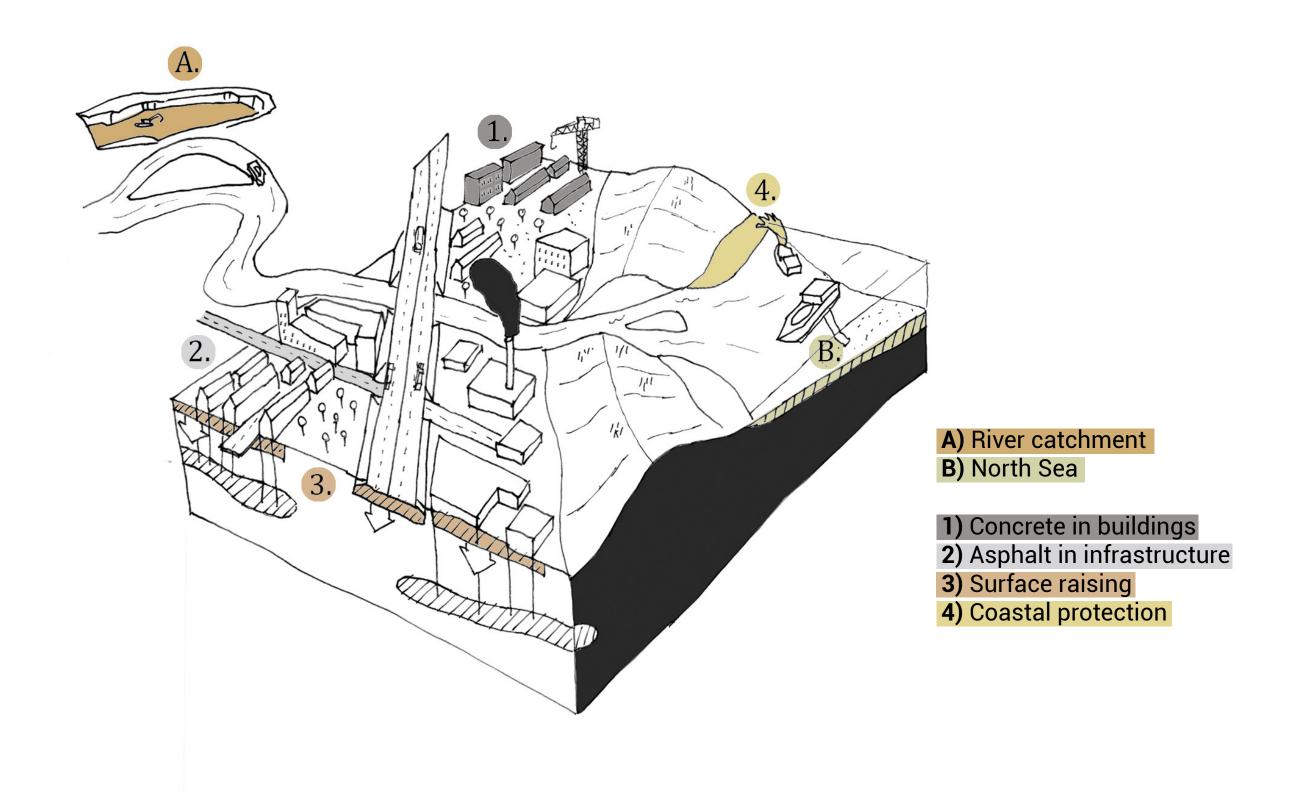






## Theory Sand and gravel metabolism

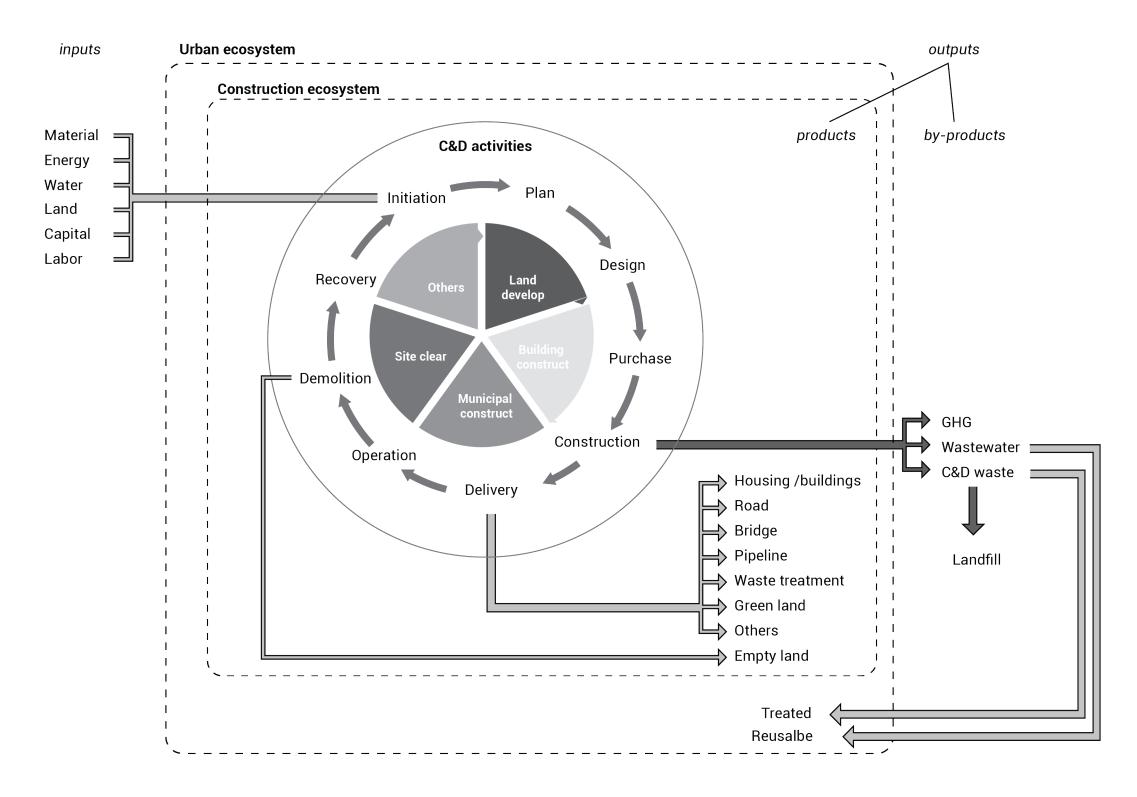






## Theory Construction Metabolism

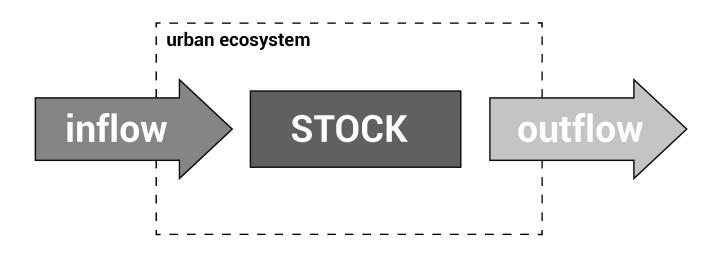






## Theory Metabolic framework

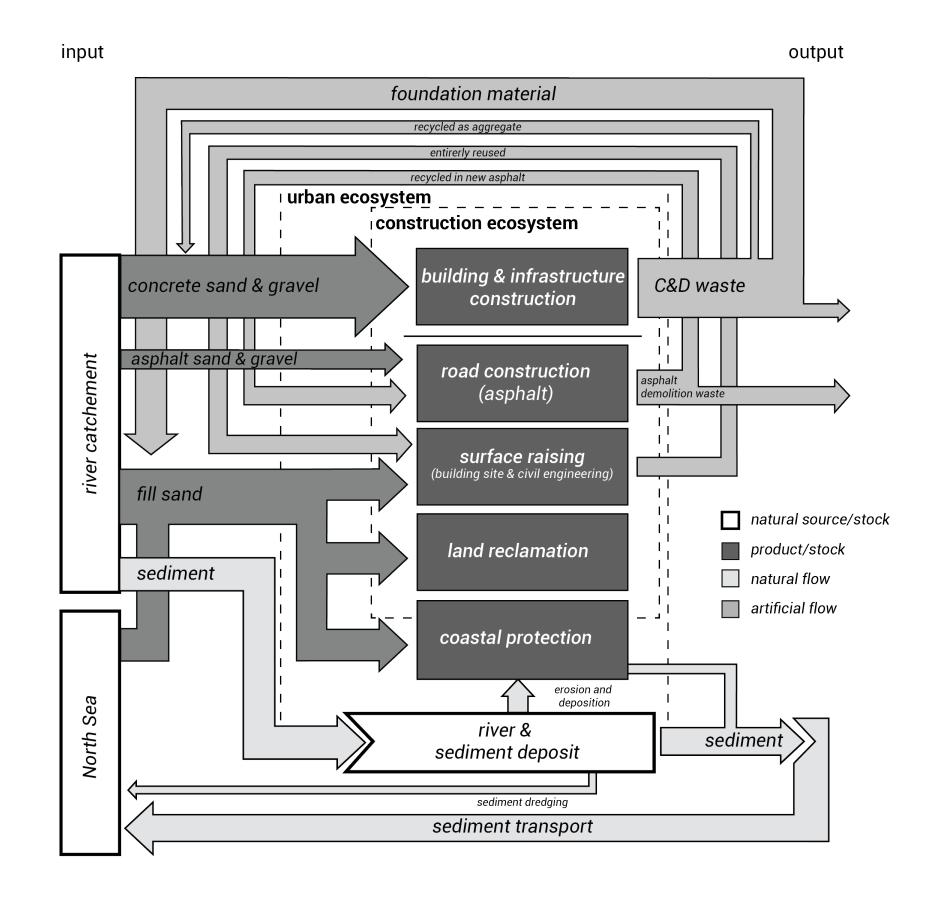






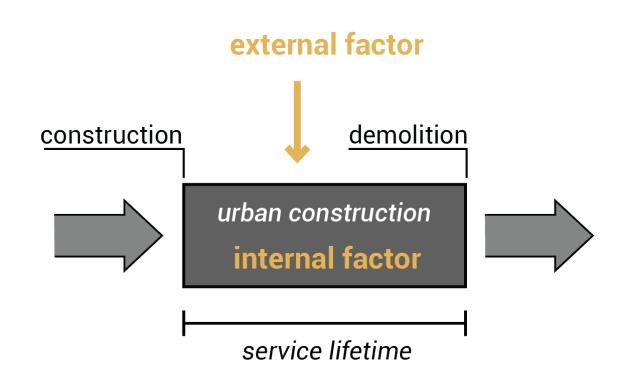
### Theory Sand and gravel metabolism (in the Dutch context)







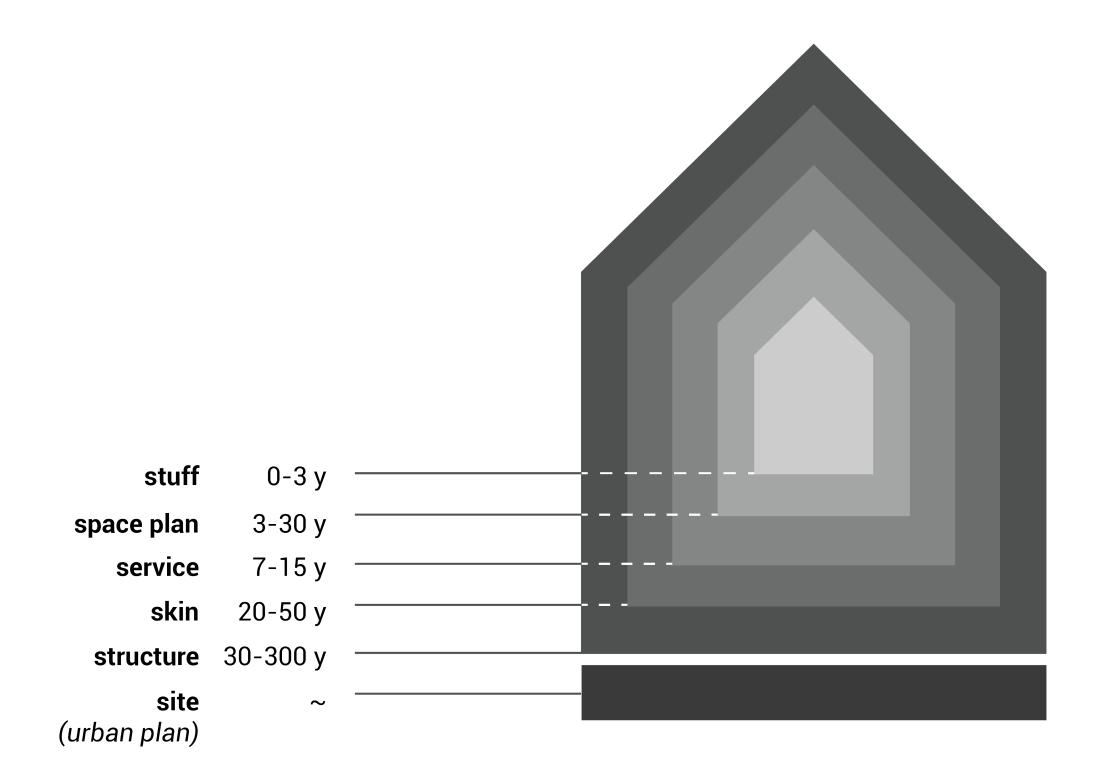
'Durability is the capability of a building or its part to **perform its required function** over a **specified period of time** under the **influence of the agents** anticipated in service' (ISO, 2011).





## Theory Durability

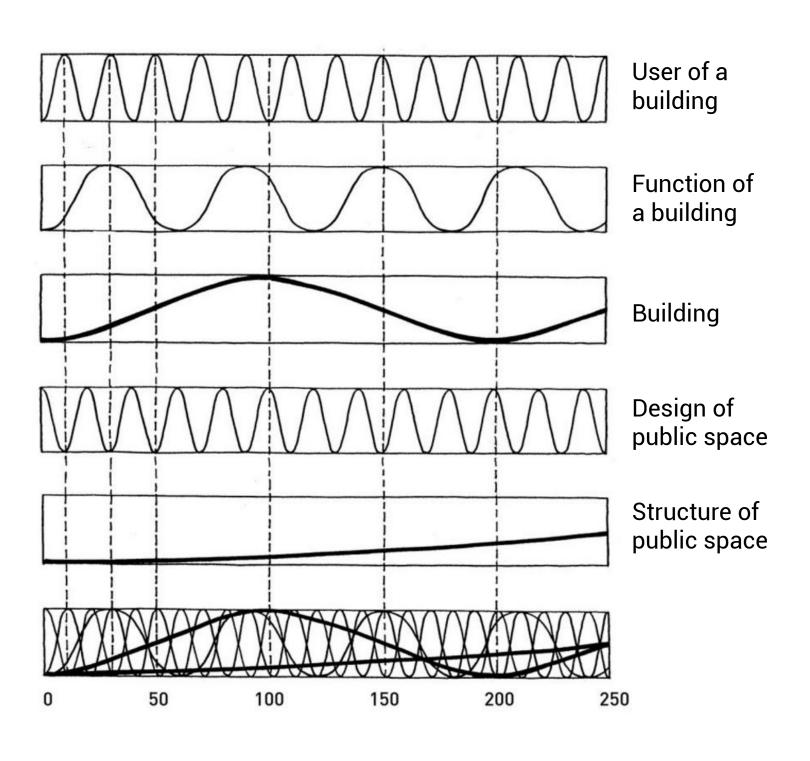






## Theory Rhythm of a city

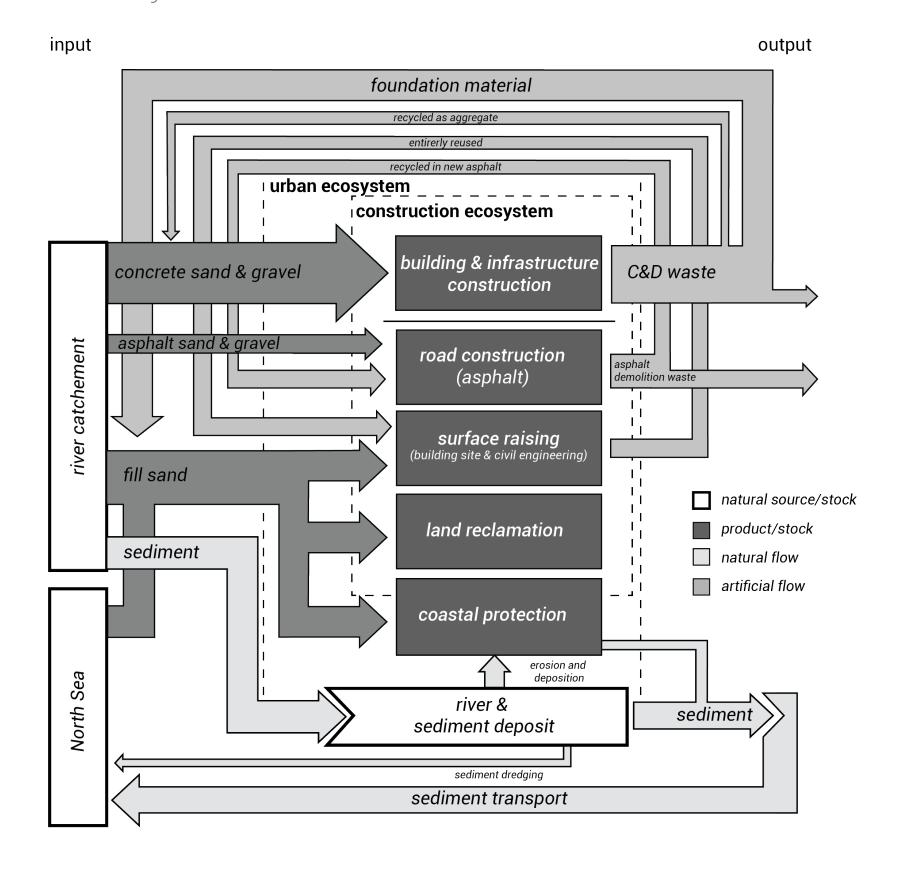






## Analysis Metabolic system until 2040

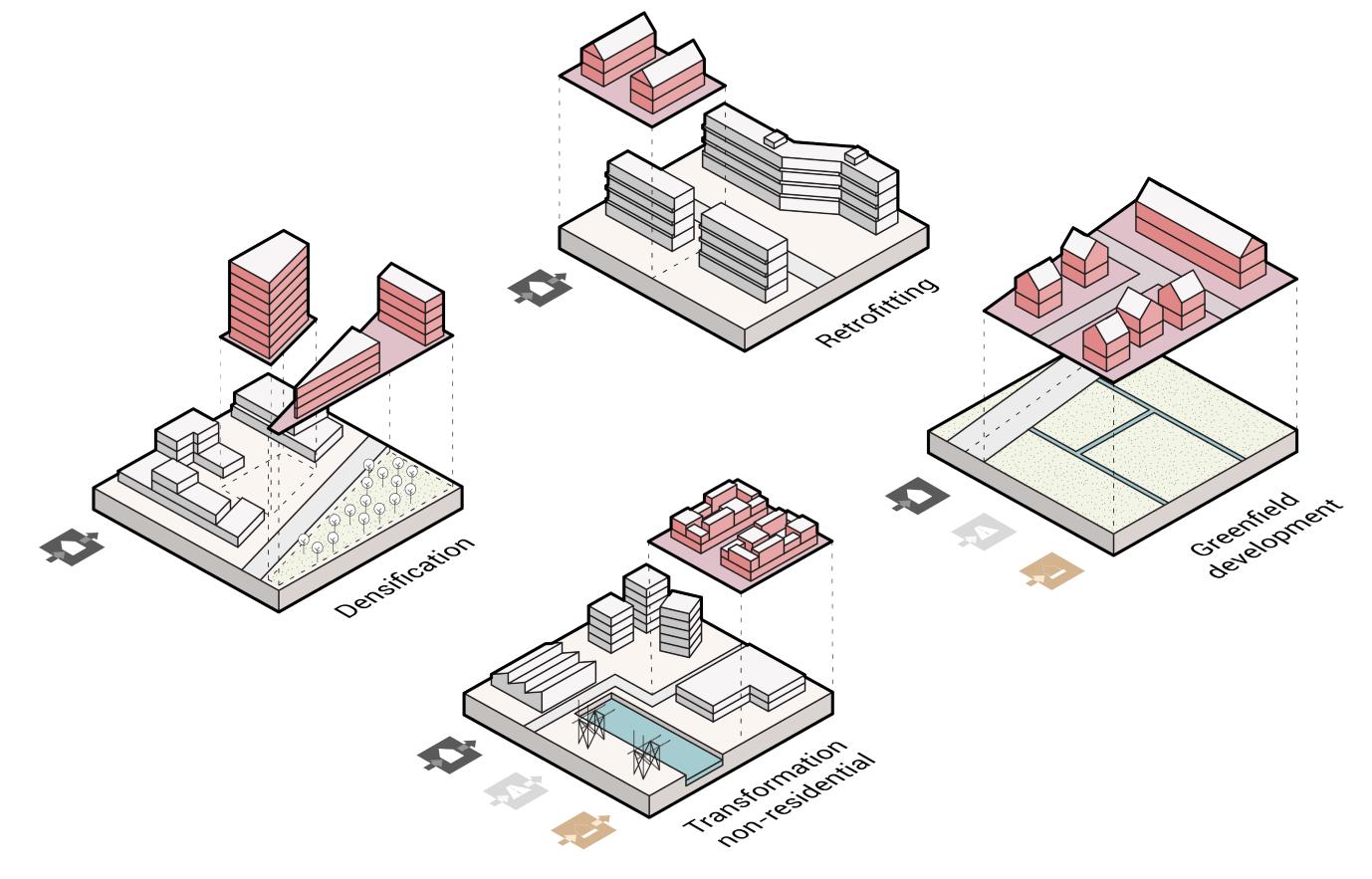






## Analysis Conditions of urban development

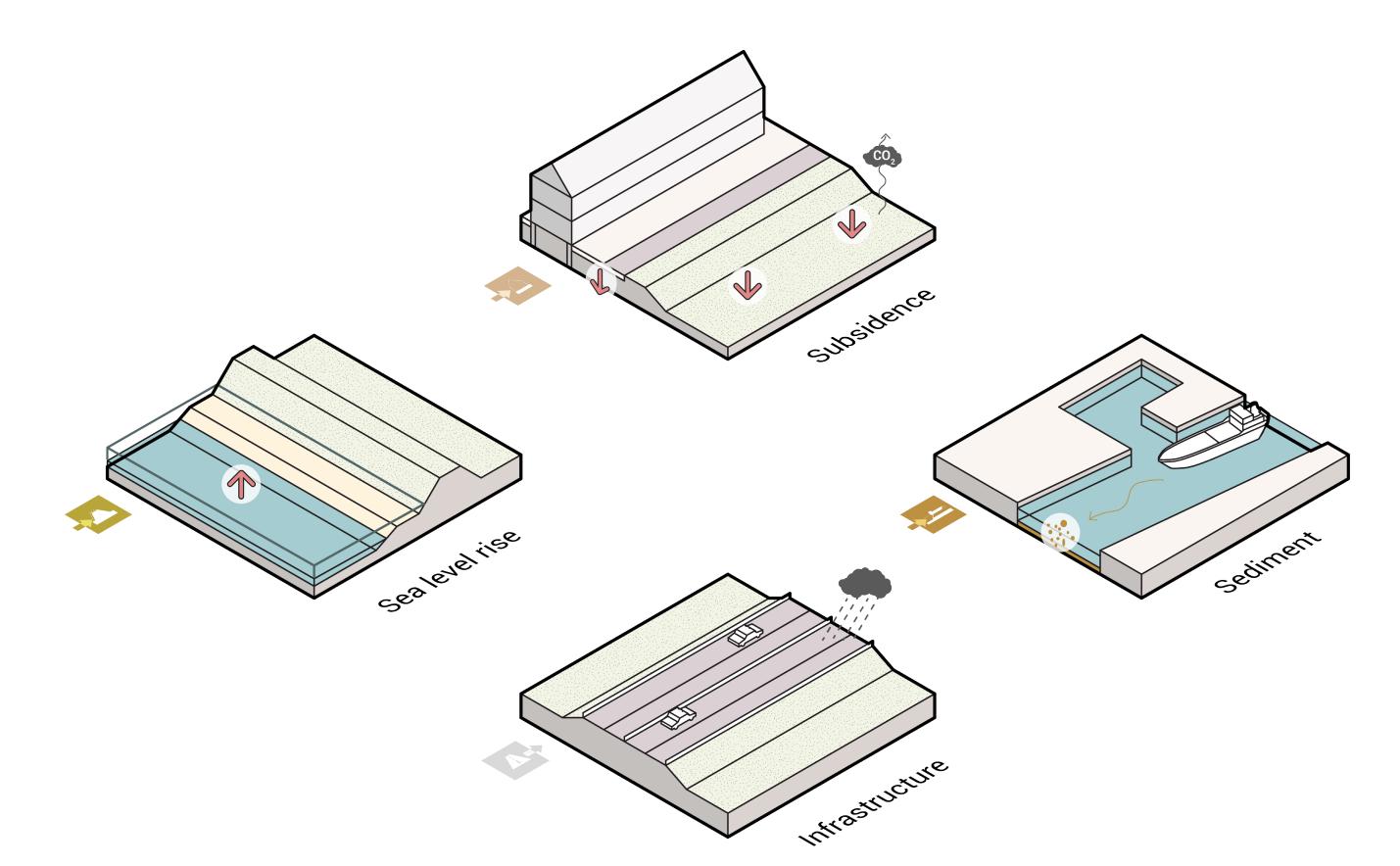






## **Analysis** Conditions of maintenance

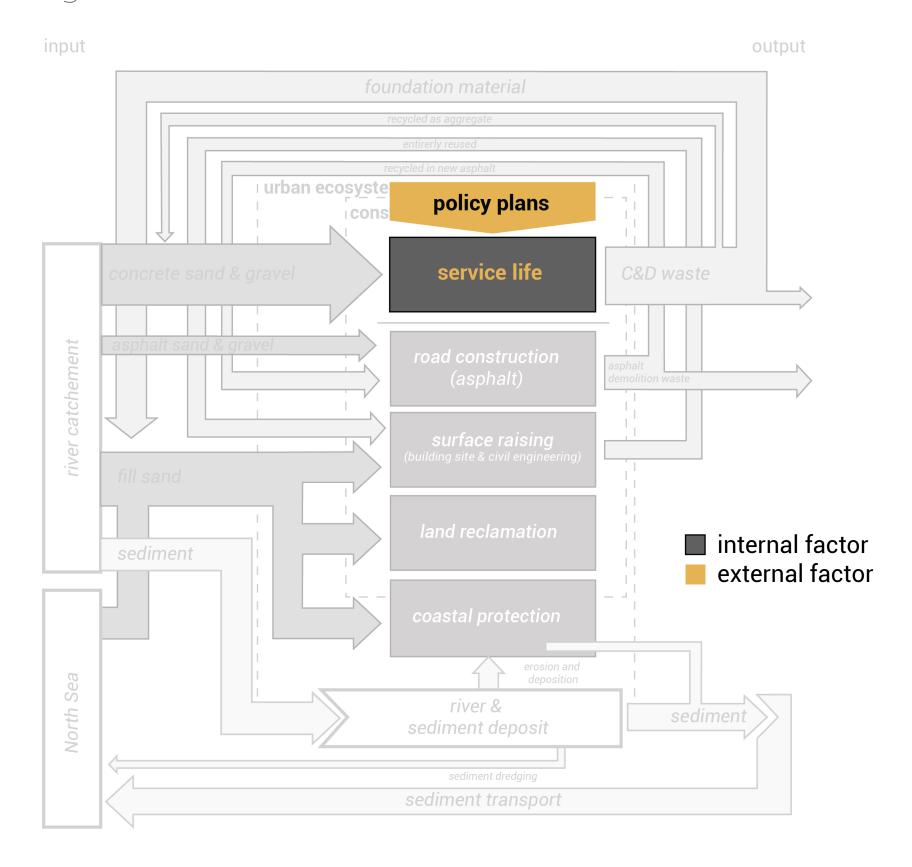






## Analysis Building stock

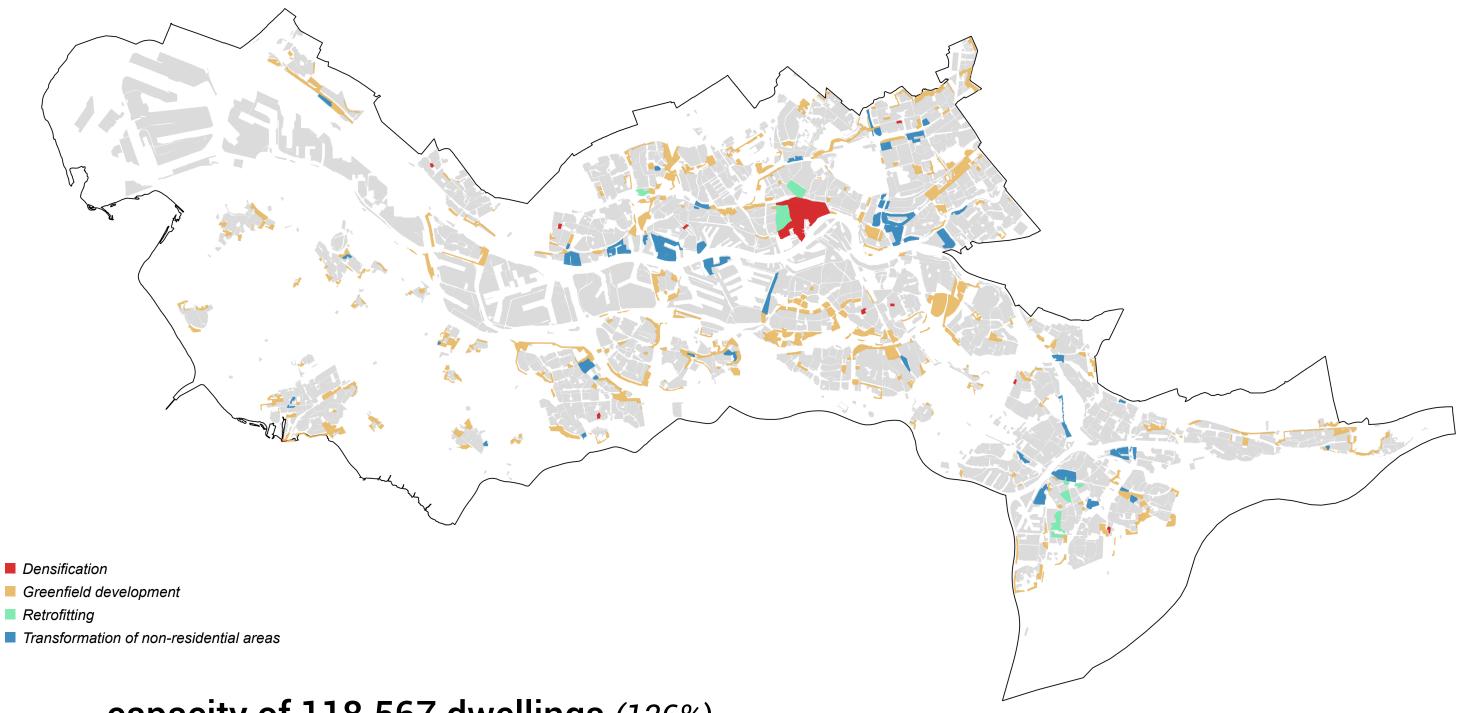






## **Building** Capacity for urbanisation within the BE





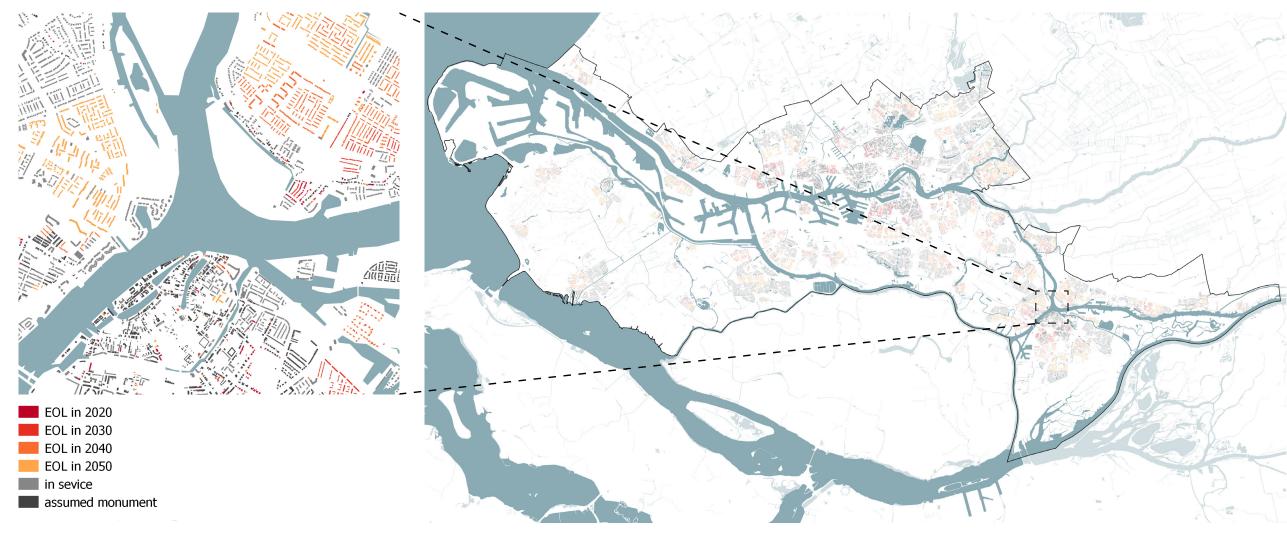
capacity of 118.567 dwellings (126%)

+/- 11,7 mln tonnes concrete



## Building End-of-life scenario (75 years)







- 105.433 dwellings
- +/- 22 mln tonnes concrete



- + 105.433 dwellings
- +/- 14 mln tonnes concrete

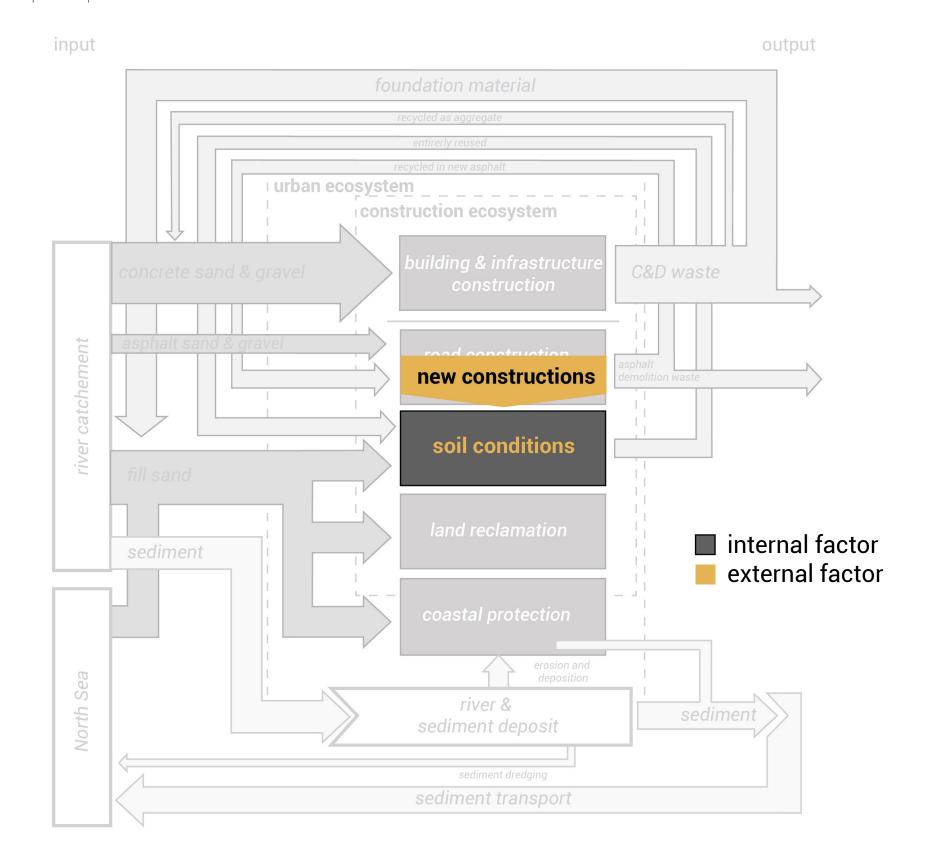
EOL residential stock	in 2020	in 2030	in 2040	in 2050
amount	13.494	14.912	36.472	46.020
cumulative	13.494	28.406	64.878	110.898

= total deomolished



## **Analysis** Site preparation

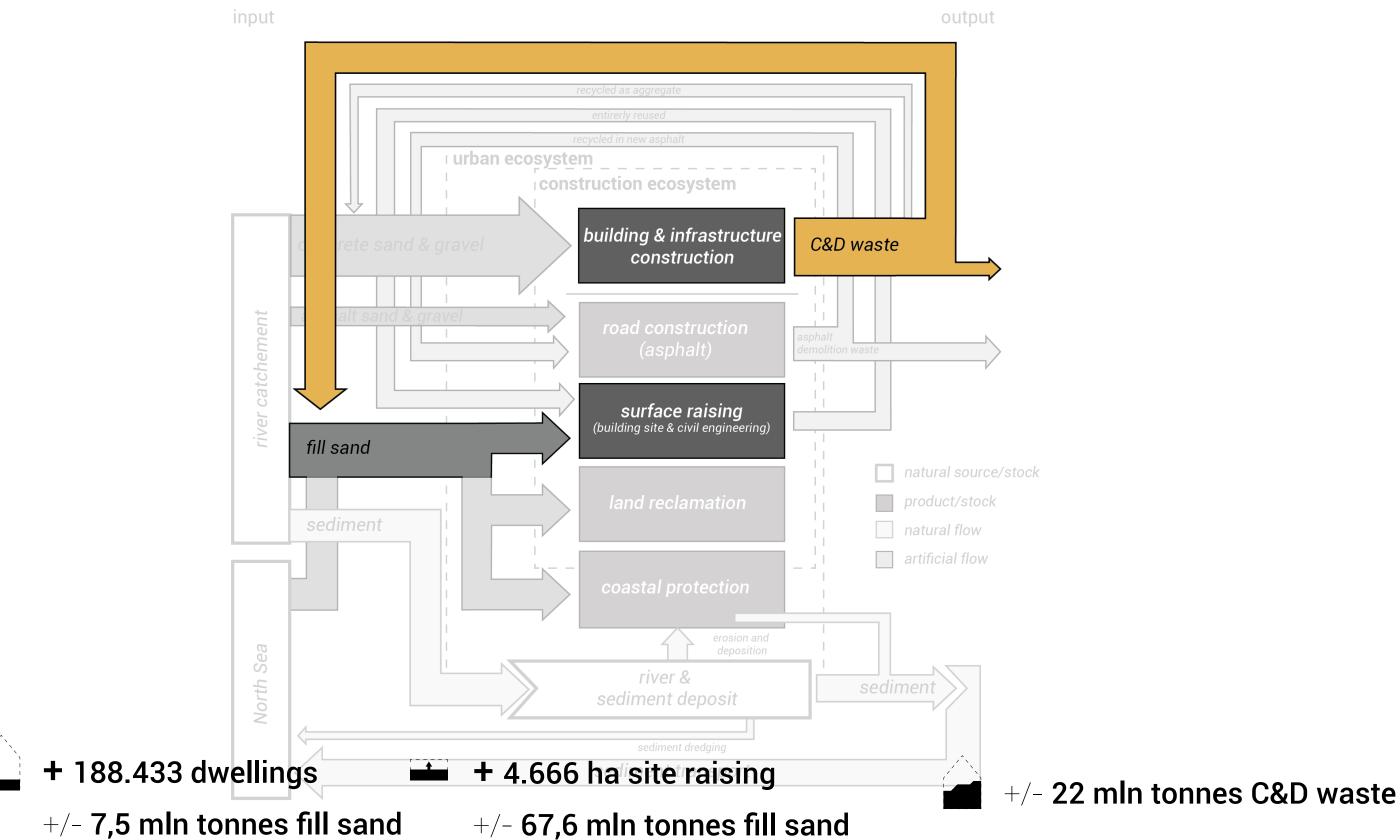






#### Site preparation New construction and C&D return flux



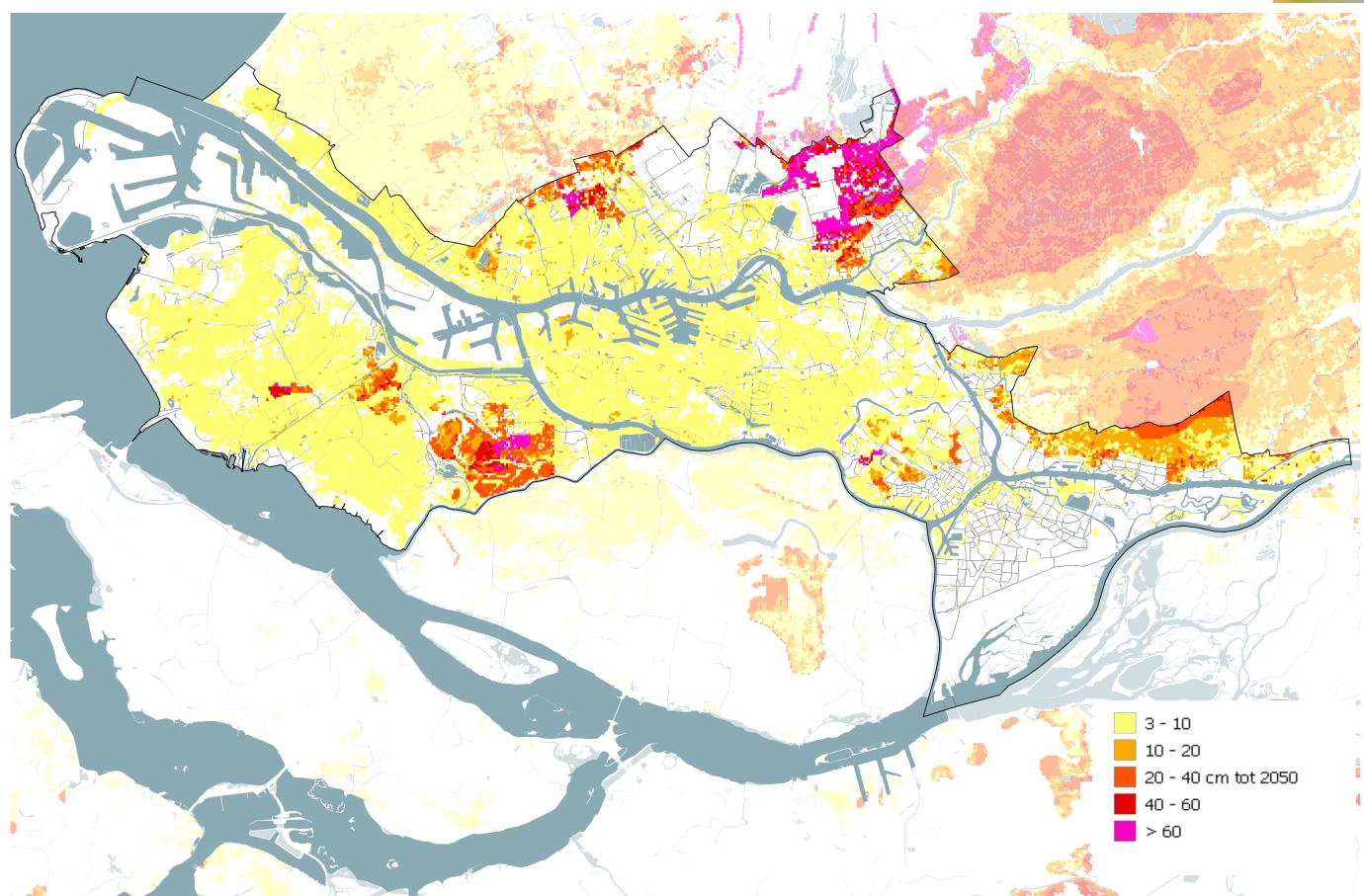


+/- 67,6 mln tonnes fill sand



# Site preparation Soil condition

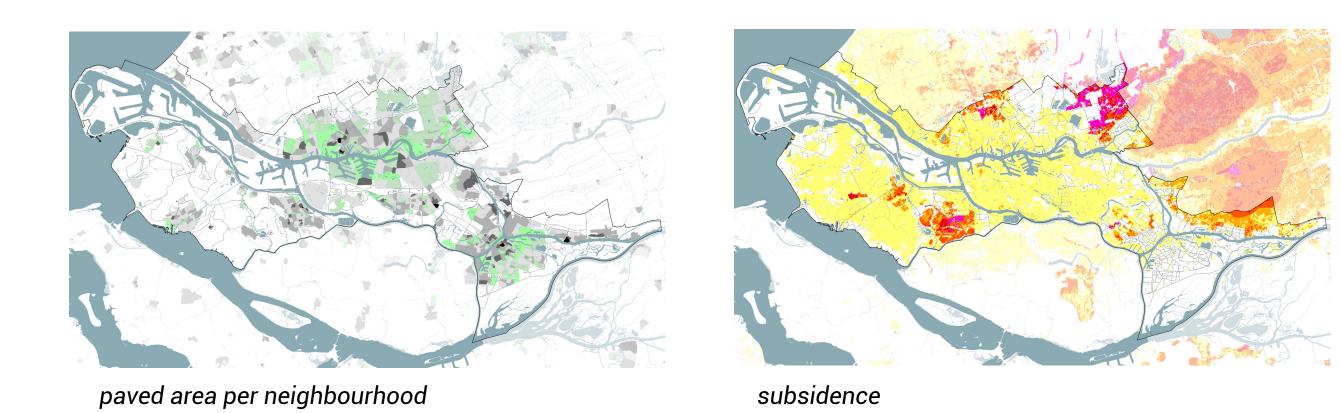






## Site preparation Maintenance calculation





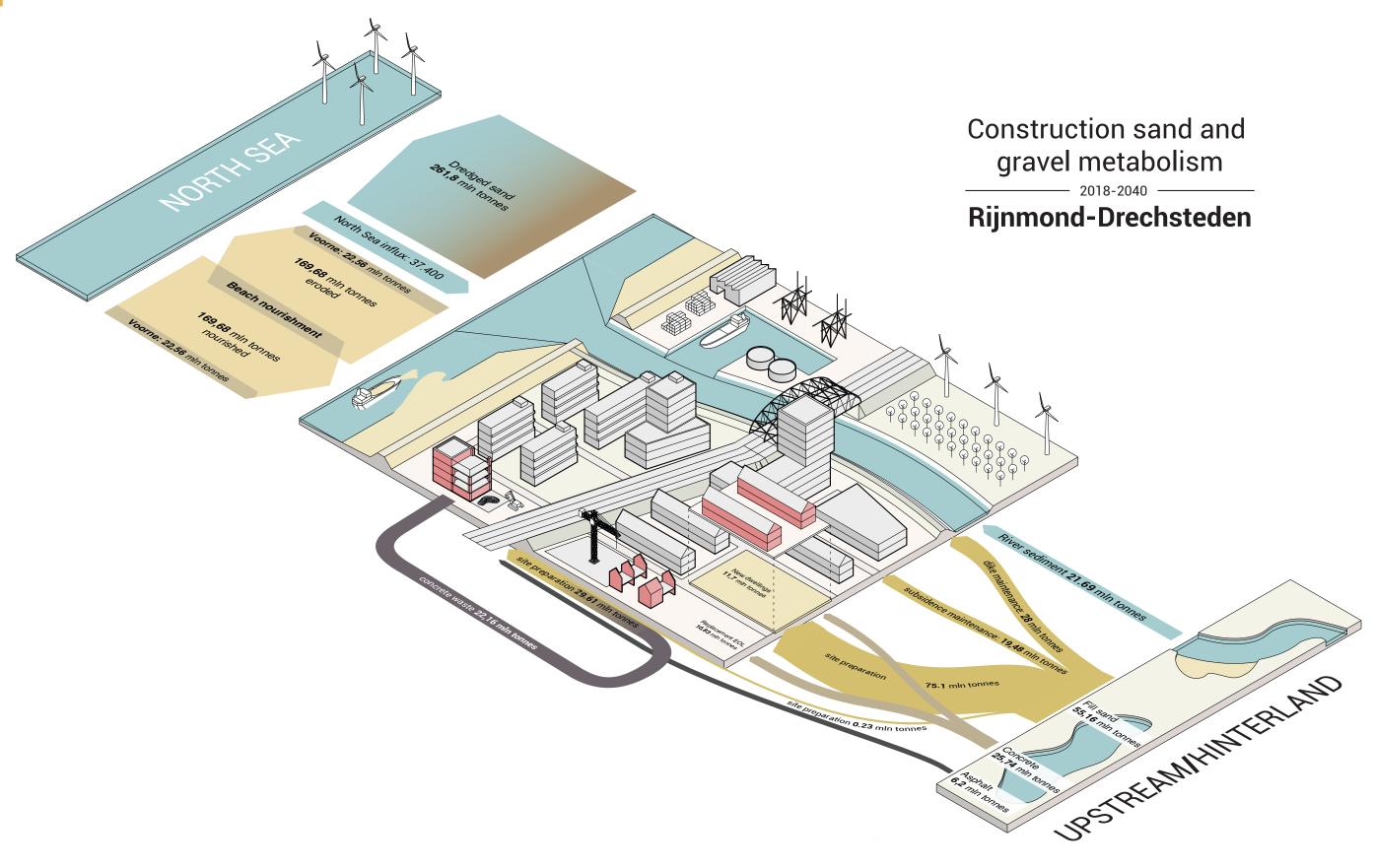
Amount of fill sand = ((Area neighbourhood × percentage paved area)-built area) × subsidence pace



+/- 20 mln tonnes fill sand

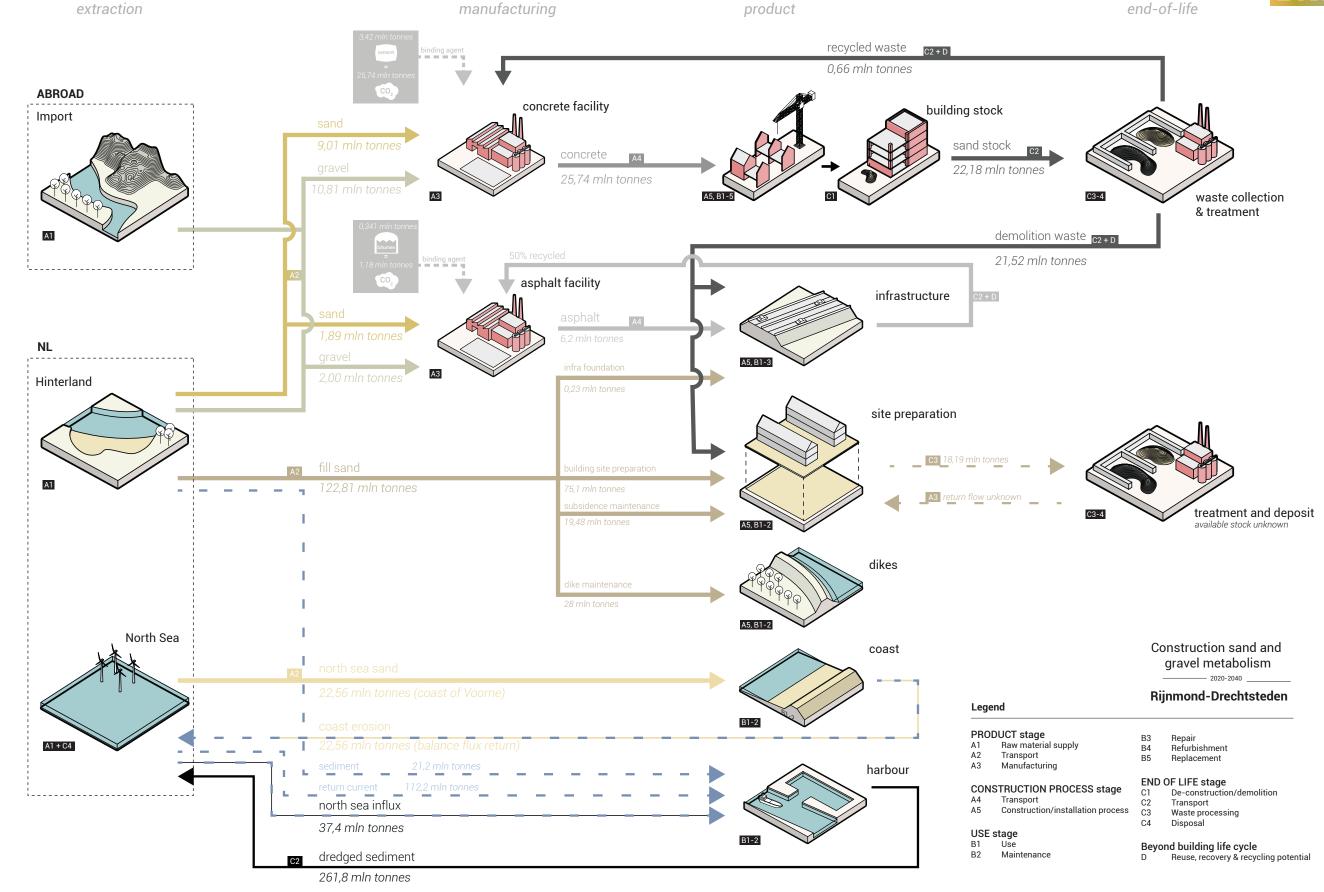
## Analysis Metabolic model result





## LCA Systematic and spatial





# LCA Building Life Cycle Information

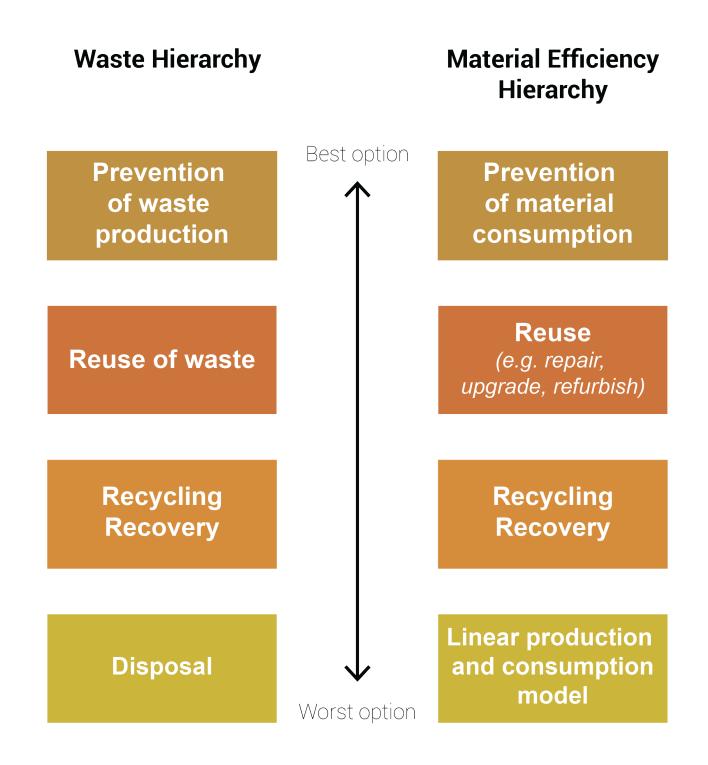


PRODUCT stage		CONSTRUCTION PROCESS stage		N	USE stage			END OF LIFE stage			E	Benefits and loads		
<b>A1</b>	<b>A2</b>	<b>A</b> 3	<b>A4</b>	A5	B1	B2	В3	B4	B5	C1	C2	<b>C</b> 3	C4	D
Raw material supply	Transport	Manufactering	Transport	Construction / installation aprocess	Use	Maintenance	Repair	Refurbishment	Replacement	Deconstruction/demolition	Transport	Waste processing	Disposal	Reuse, recovery & recycling potential
					В6	operational energy use								
			В7		ationa er use									



## Waste and material efficiency hierarchies







## Bijhouwer's situation consciousness



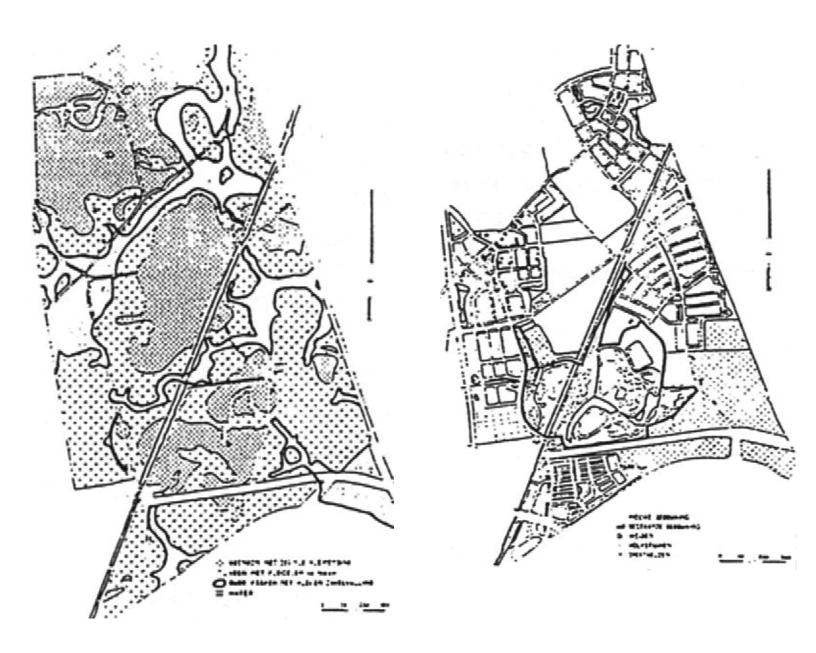
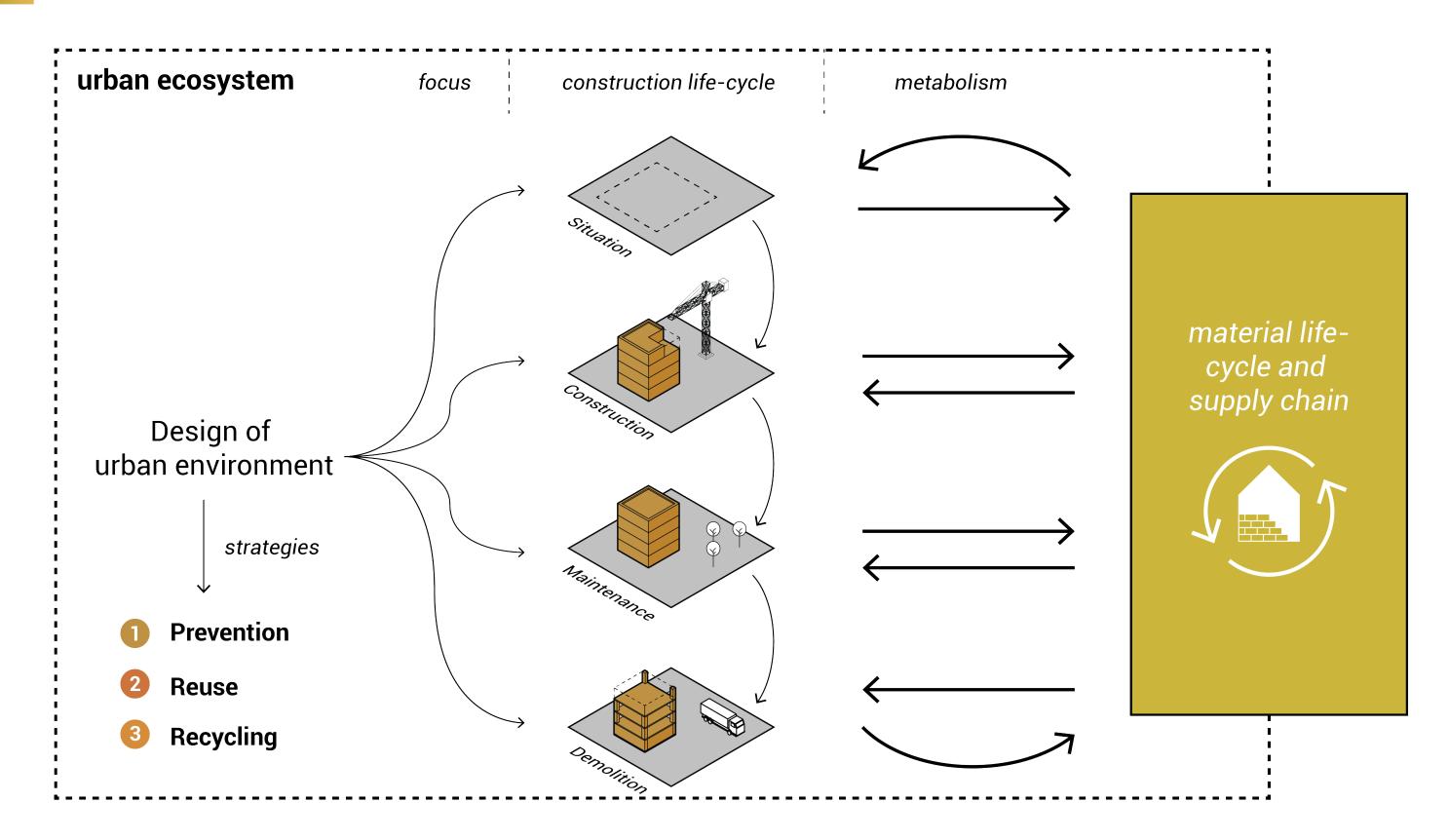


Fig. 662 Bijhouwer, soil map of Kethel and surroundings

Fig. 663 Bijhouwer, development plan of Kethel and surroundings

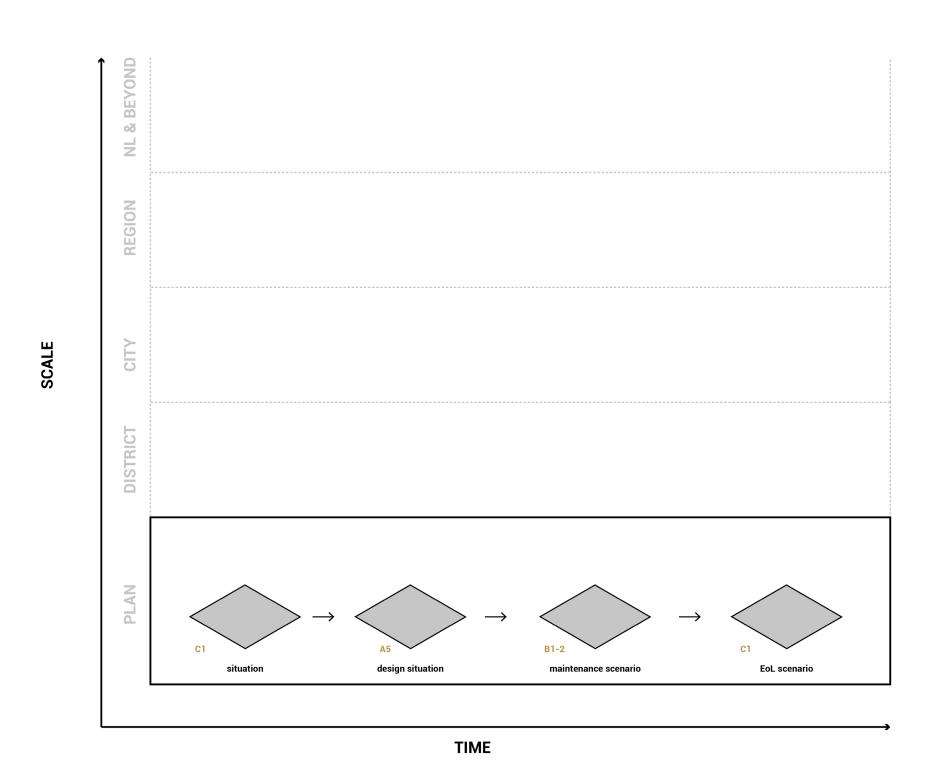
## Material conscious approach





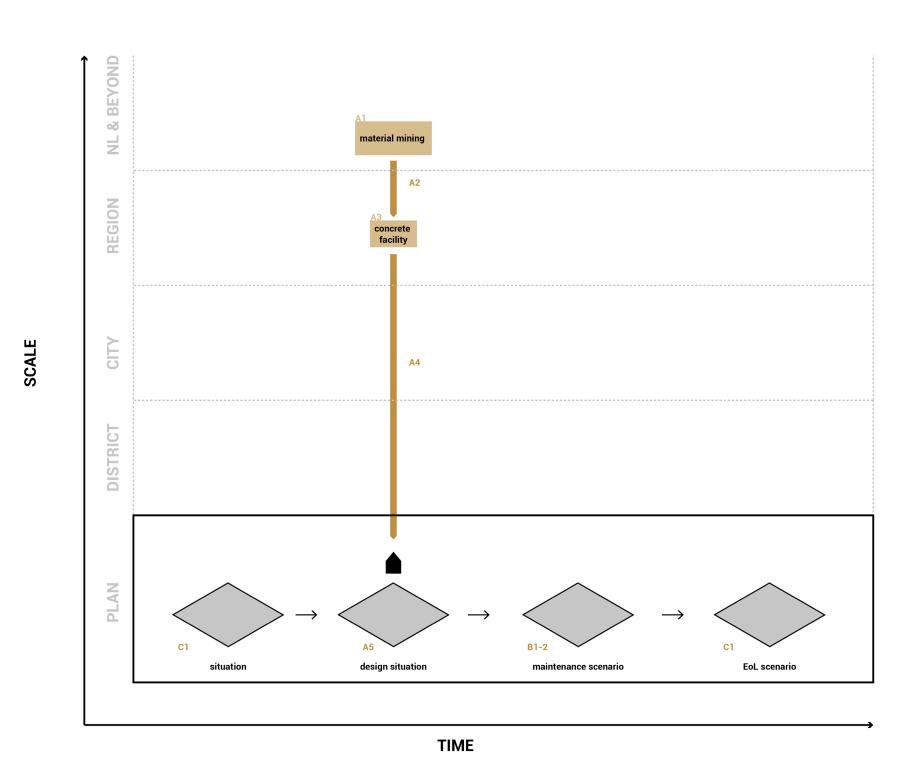
## Tools for a material conscious approach





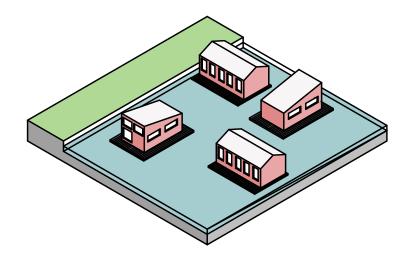
# Tools for a material conscious approach





## Reduce Building on water





A)
PRODUCT 
stage

A)
construction
stage

B) USE stage

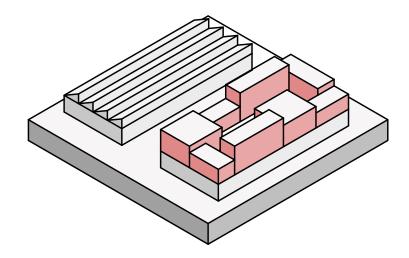
C) EoL stage

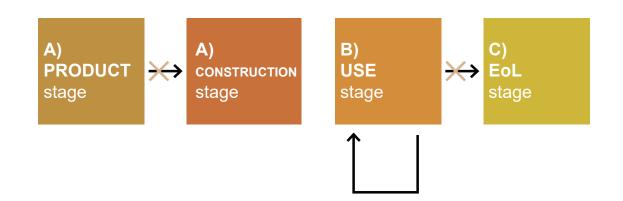


Steigereiland, Amsterdam

## Reuse Building transformation





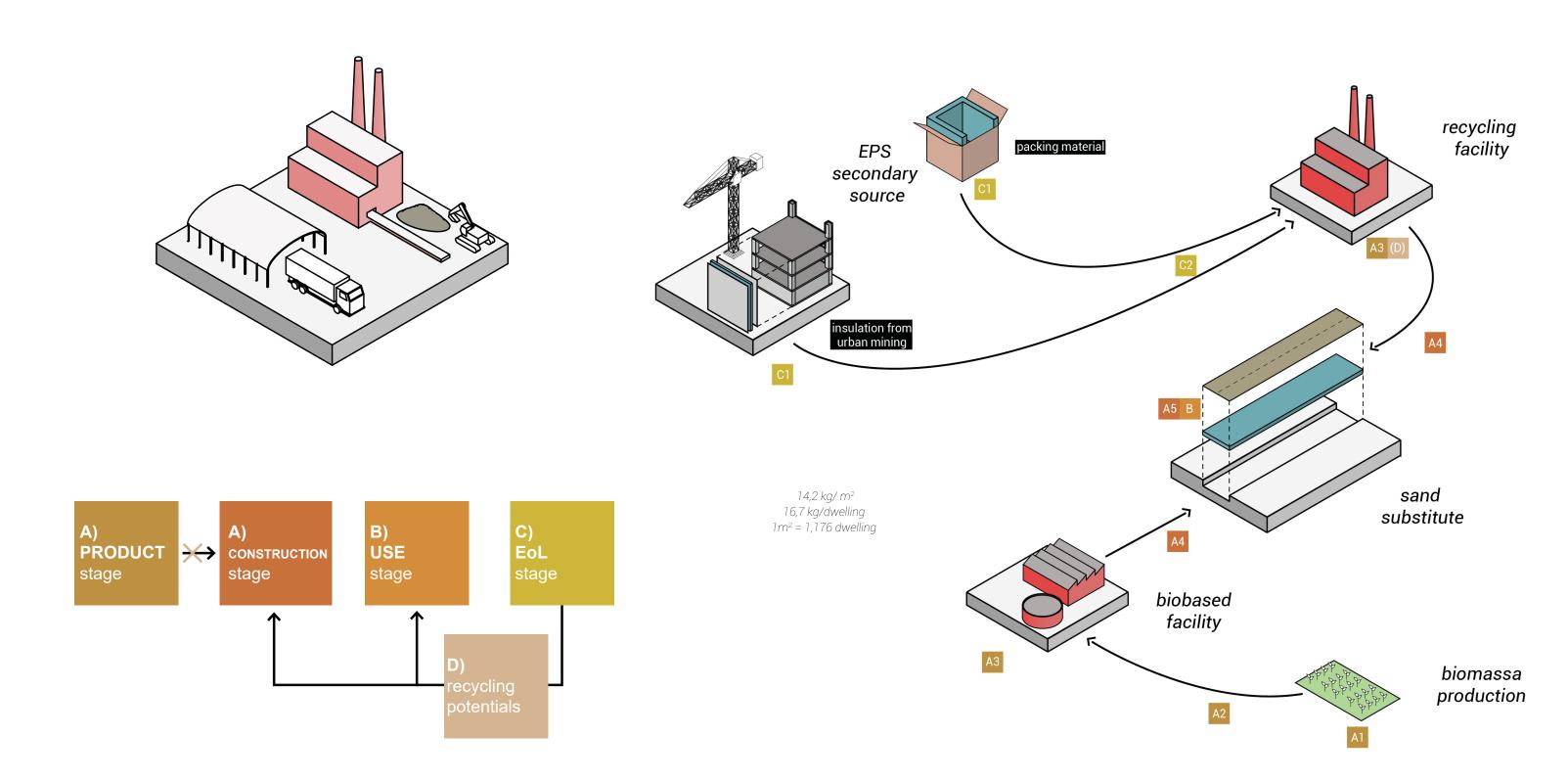




Former Philips Factory Gerard, Eindhoven

#### Recycling Secondary sources and facility

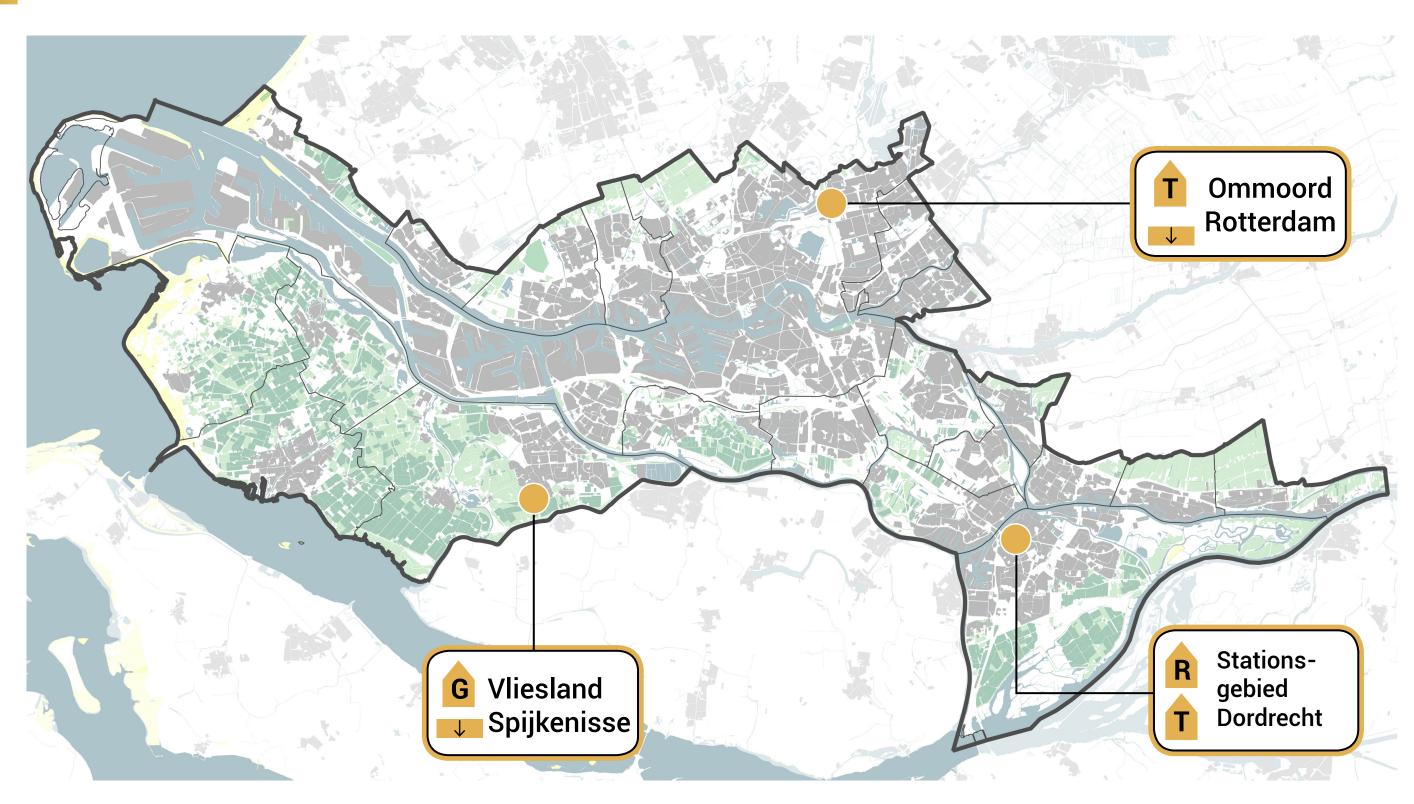






#### **Focus locations**



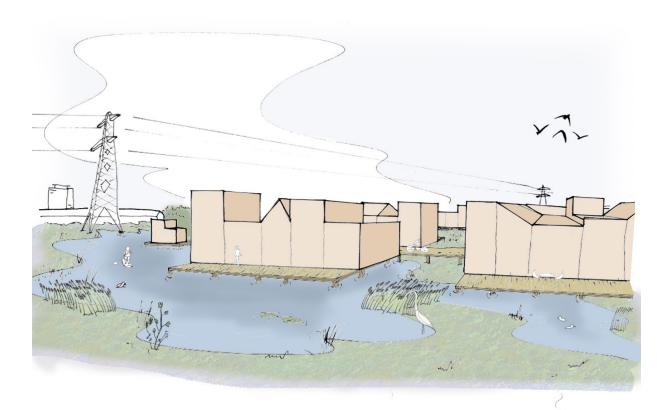


#### Focus locations





Ommoord - Vlambloem



Spijkenisse - Vliesland



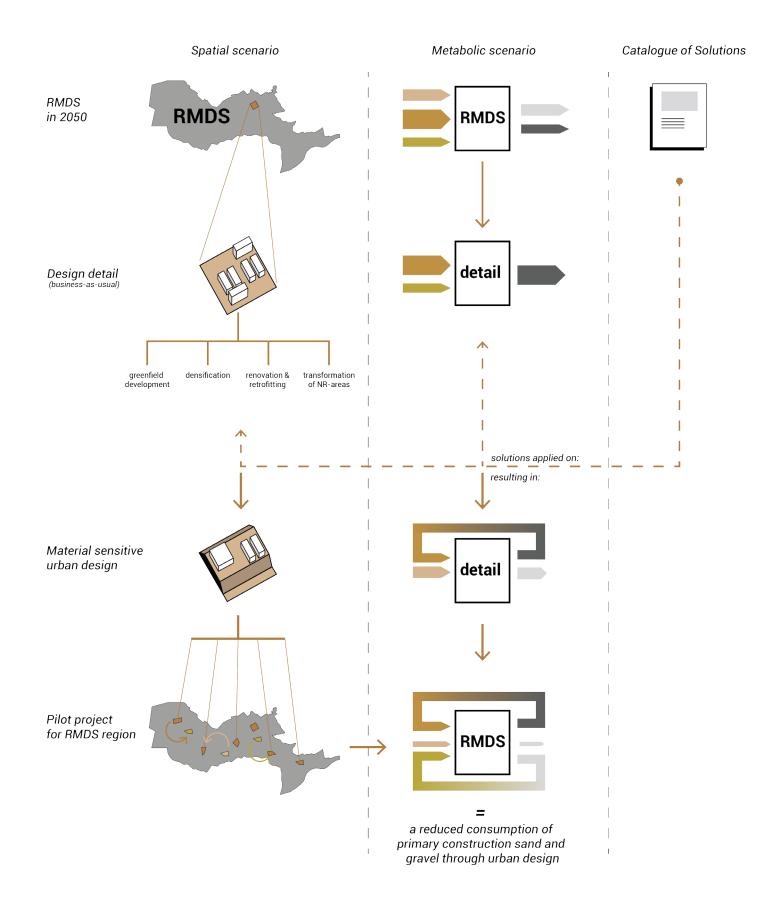
Ommoord - Roosbuurt



Dordrecht - Spoorzone

#### Design method

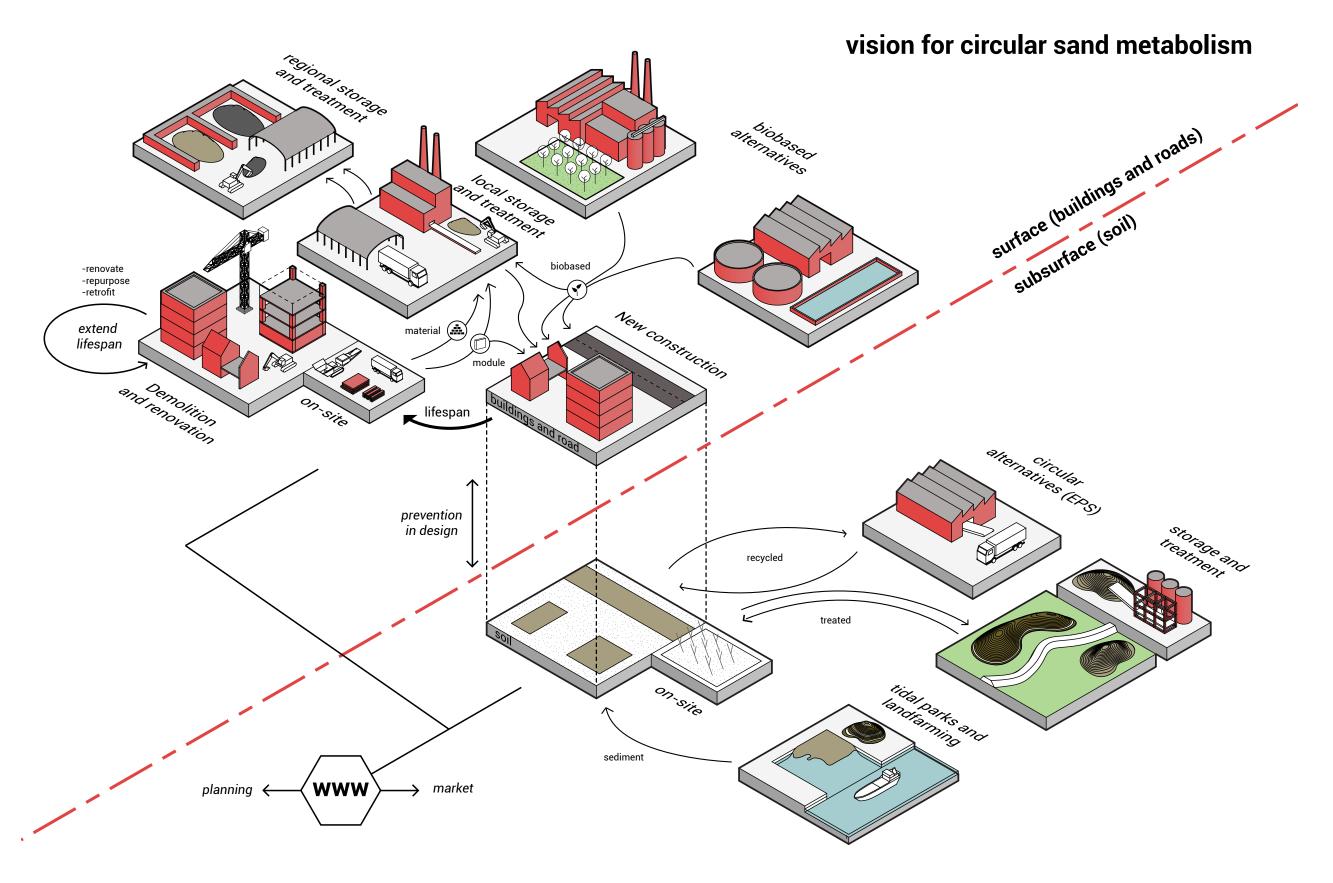






#### Regional sand metabolism





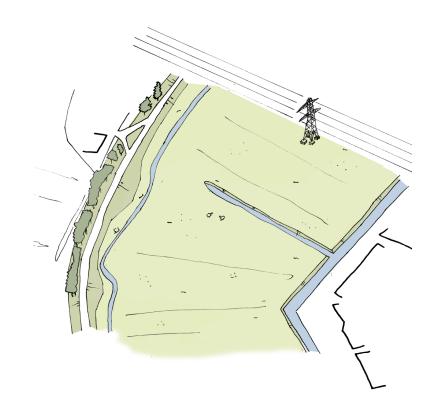
## Focus location Spijkenisse - Vliesland



No artificial sand stock

Surrounded neighbourhoods

Concrete (Building) 641.790 tonnes





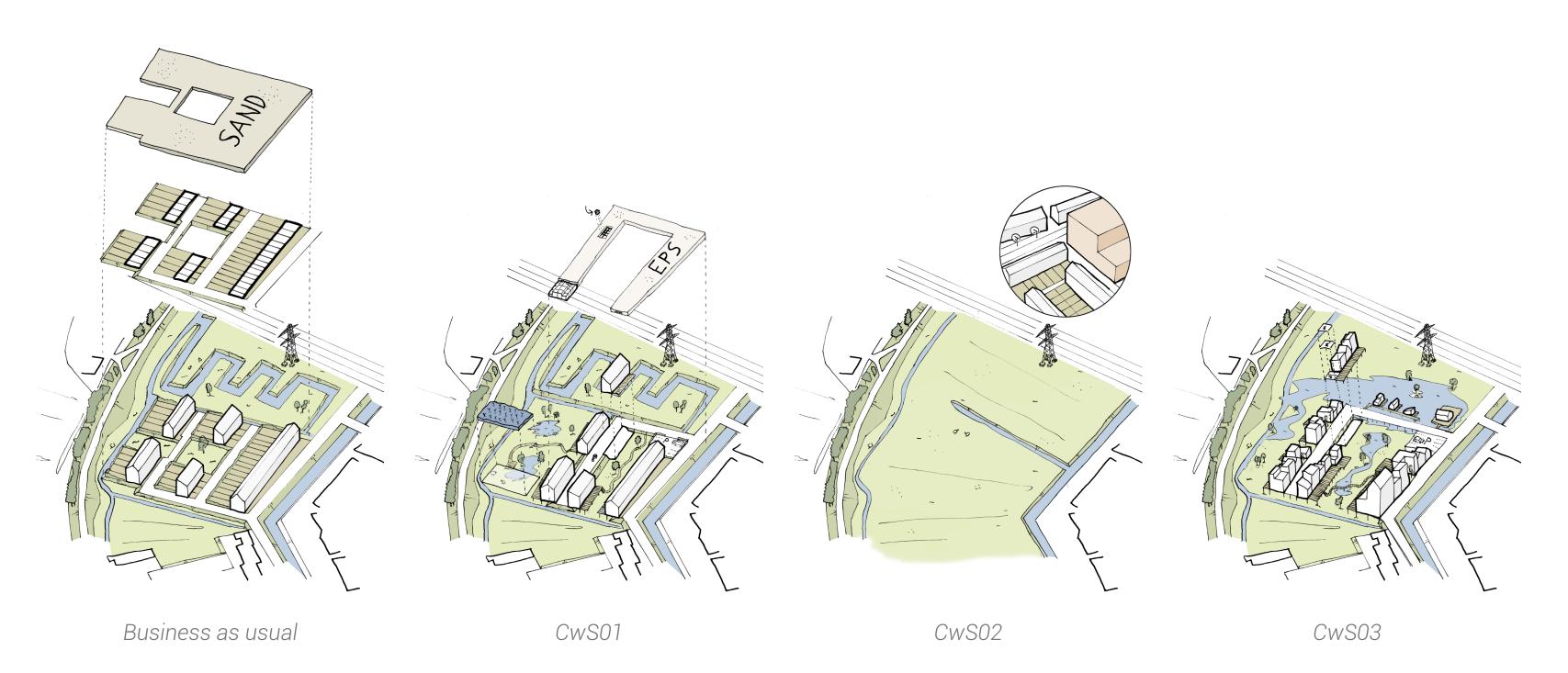






## Design options Spijkenisse - Vliesland

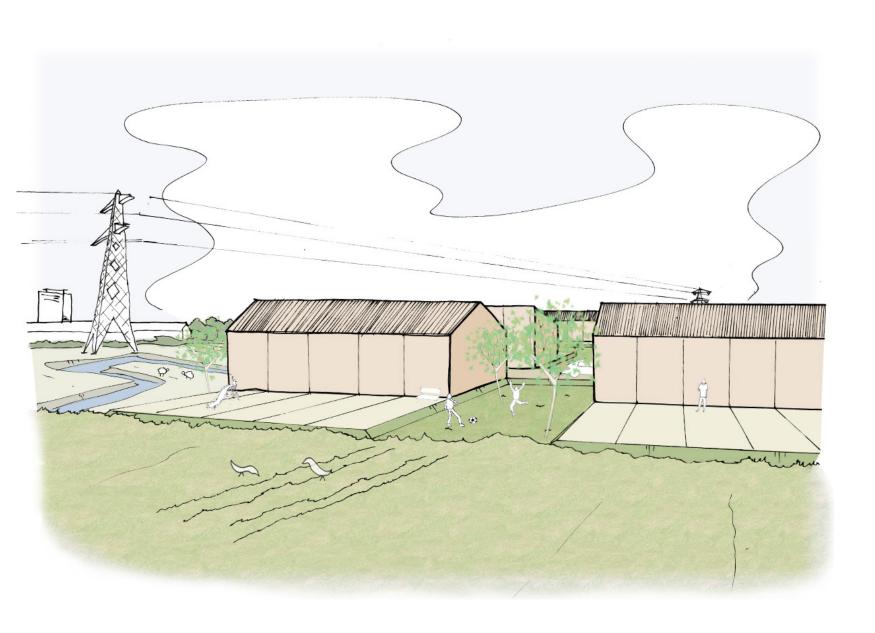


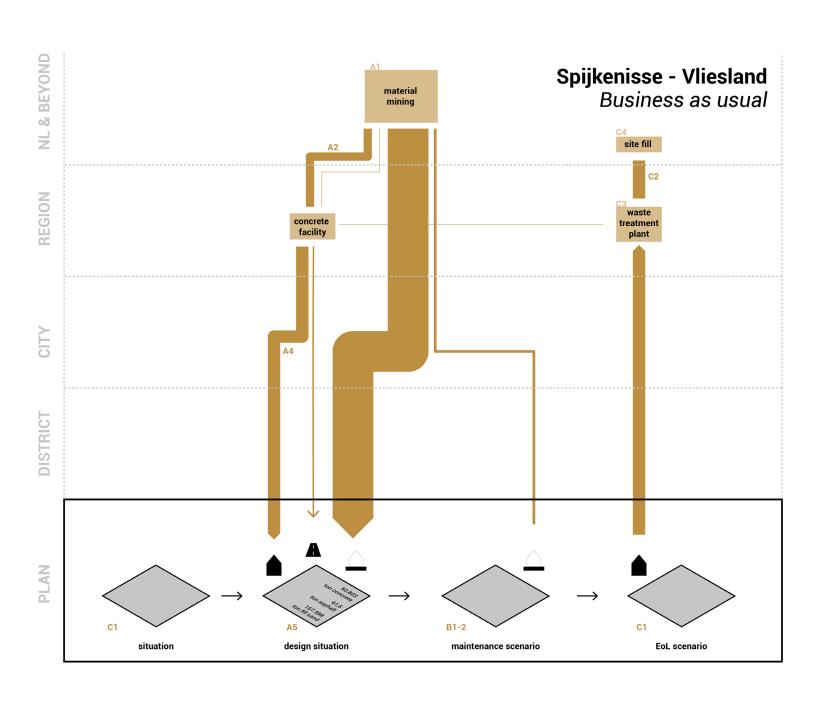




## Spijkenisse - Vliesland Business as usual



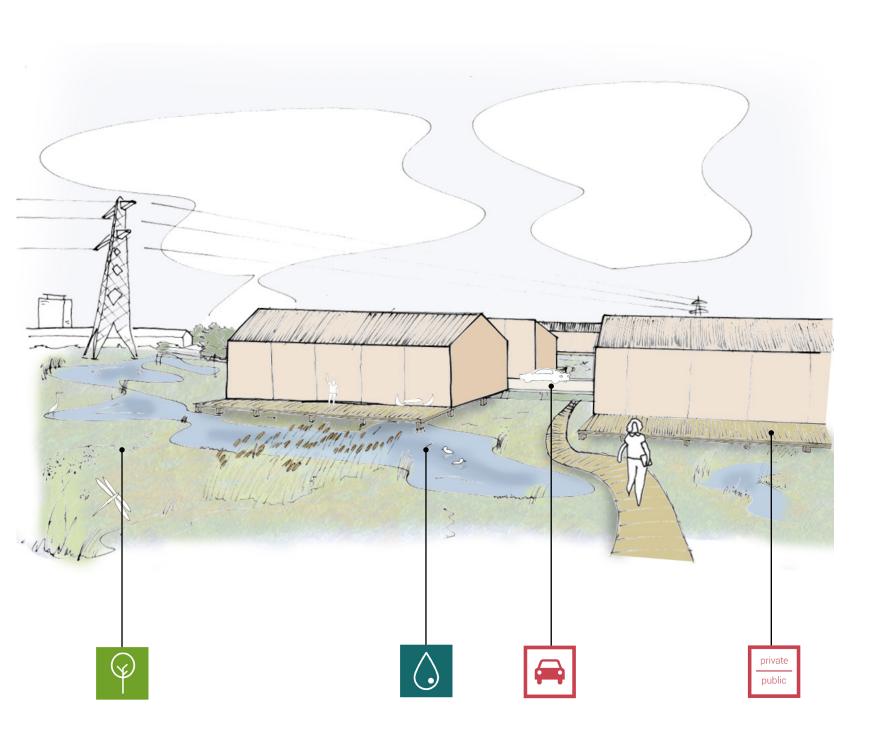


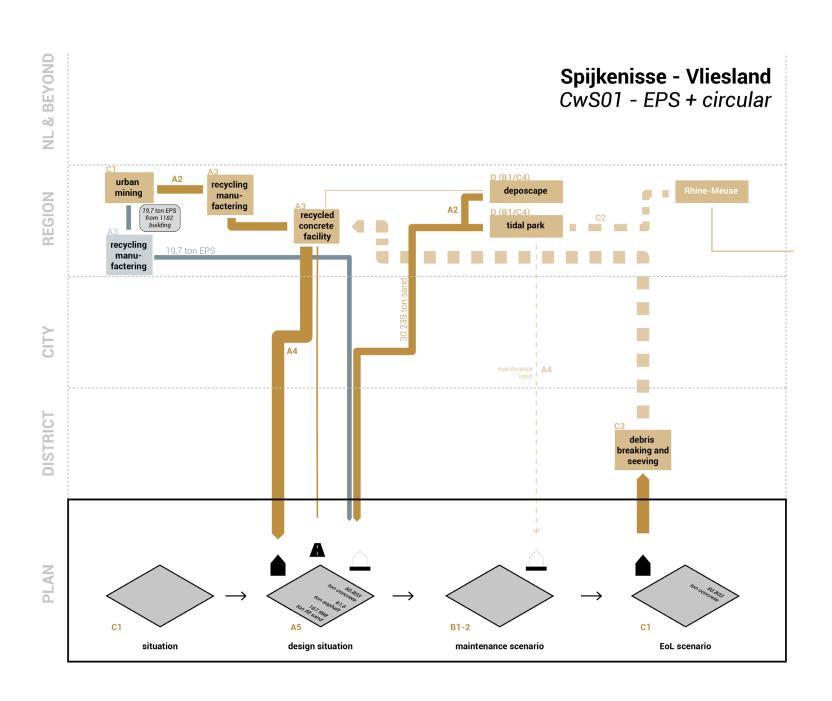




#### Spijkenisse - Vliesland CwS01

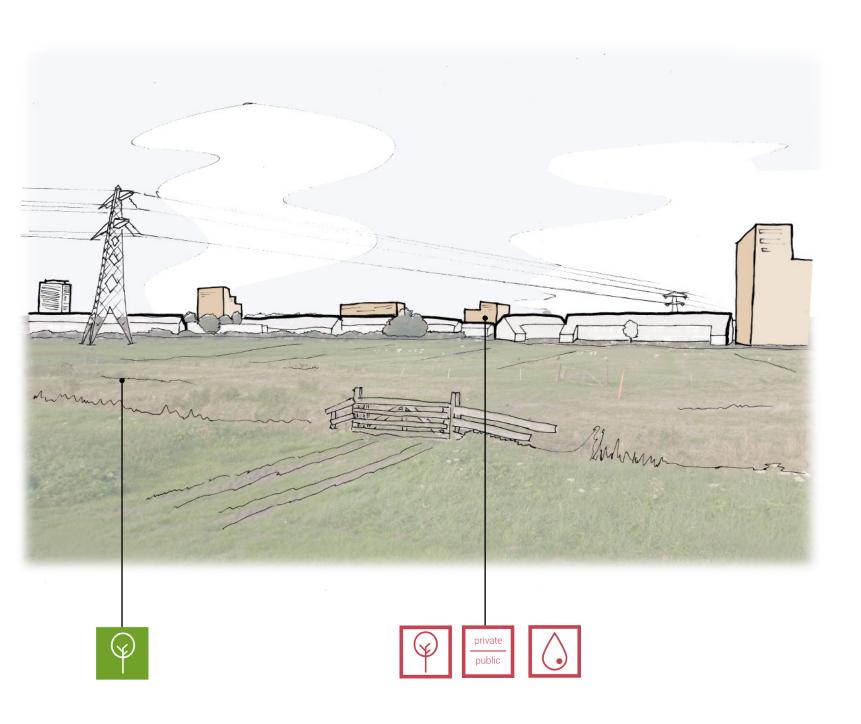


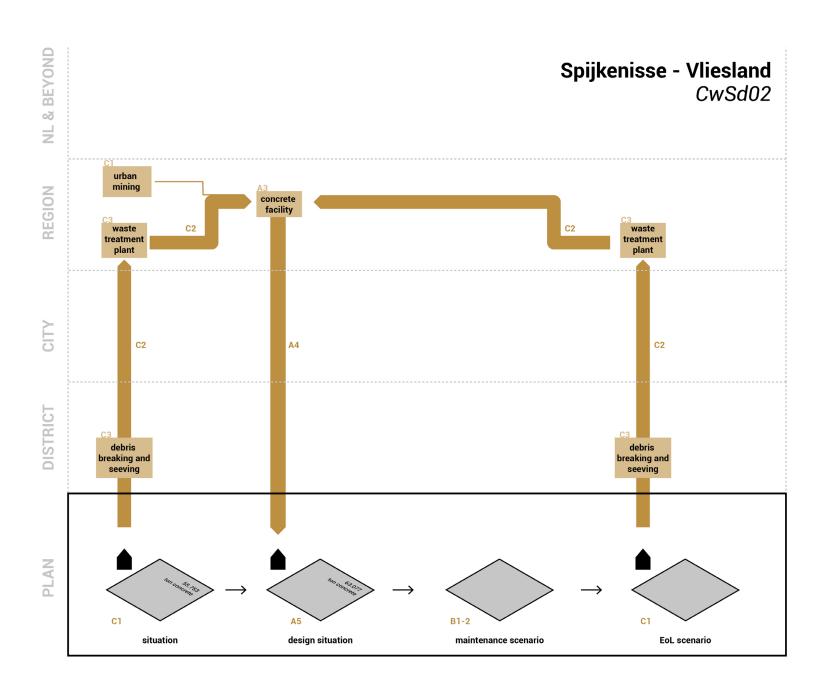




## Spijkenisse - Vliesland CwS02



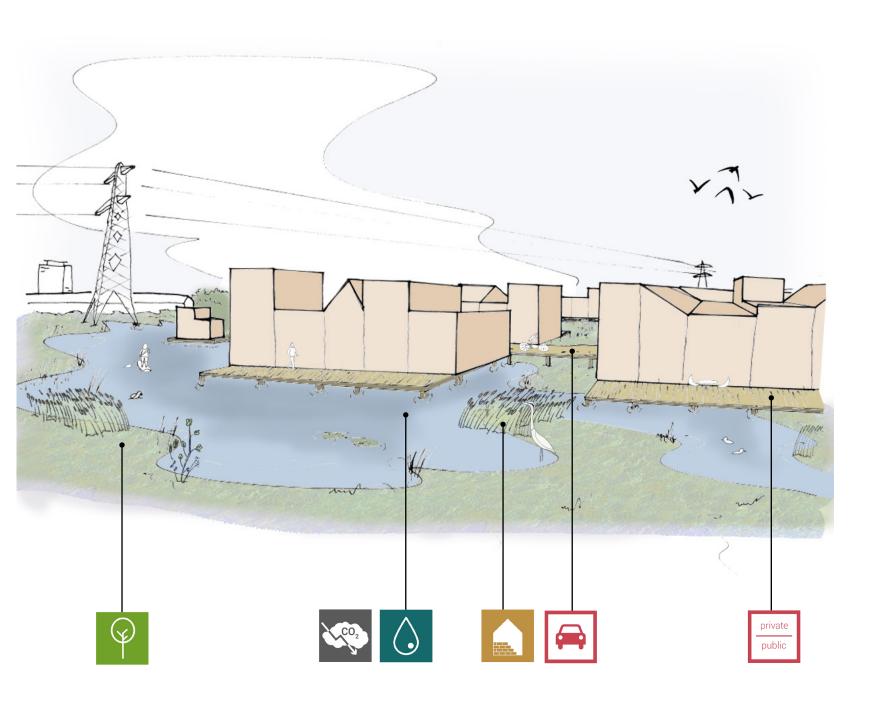


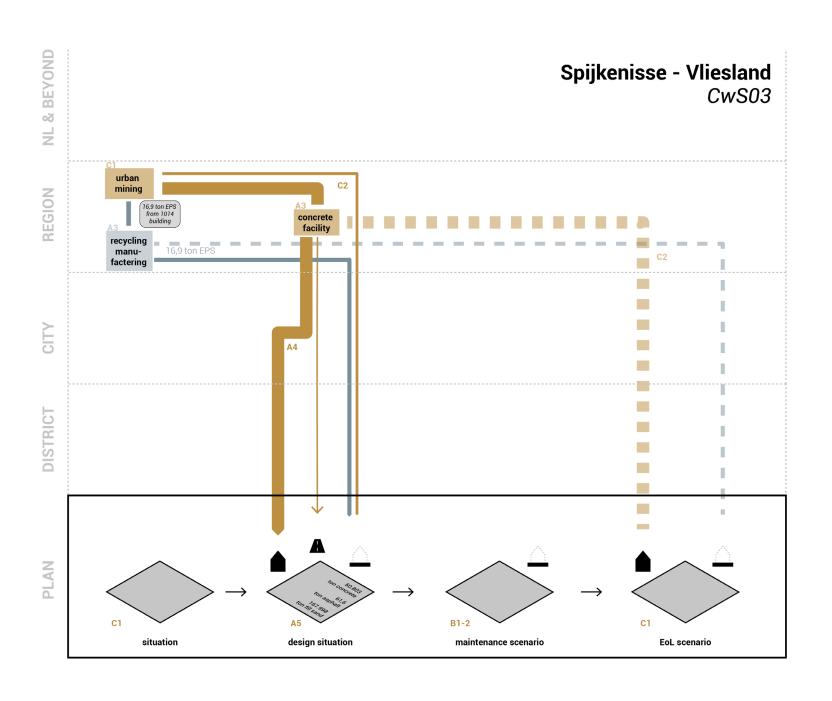




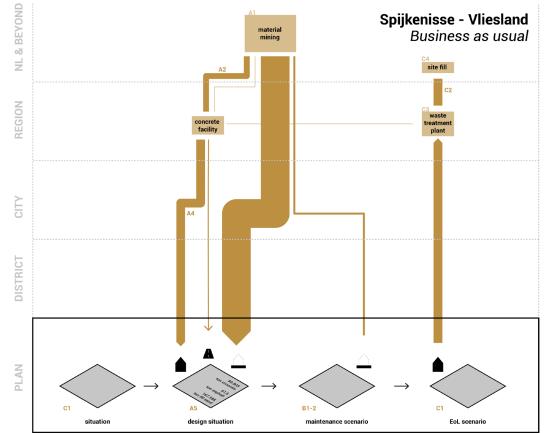
## Spijkenisse - Vliesland CwS03

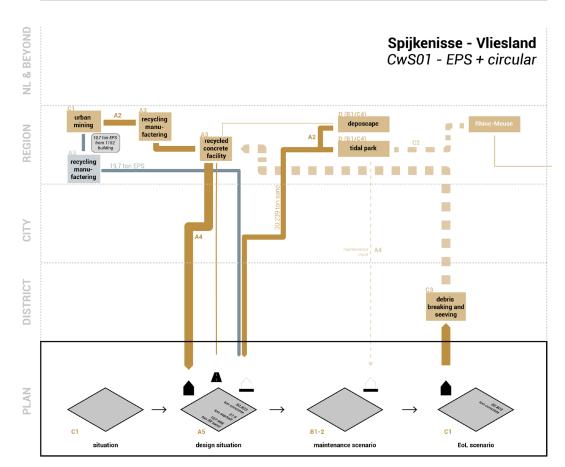




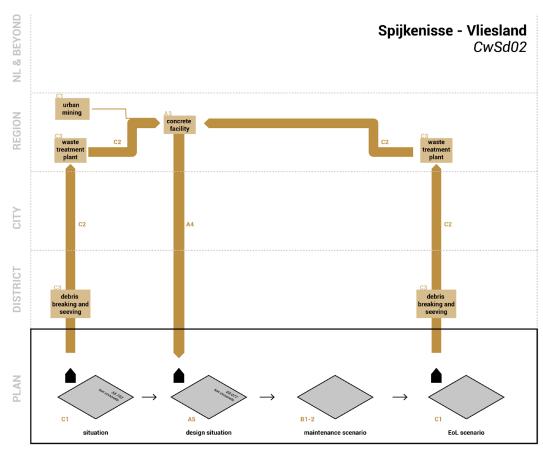


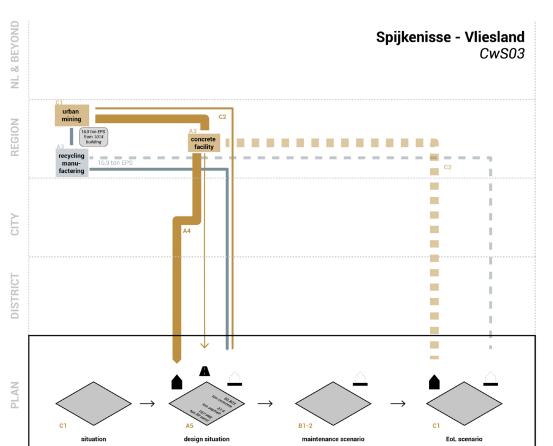






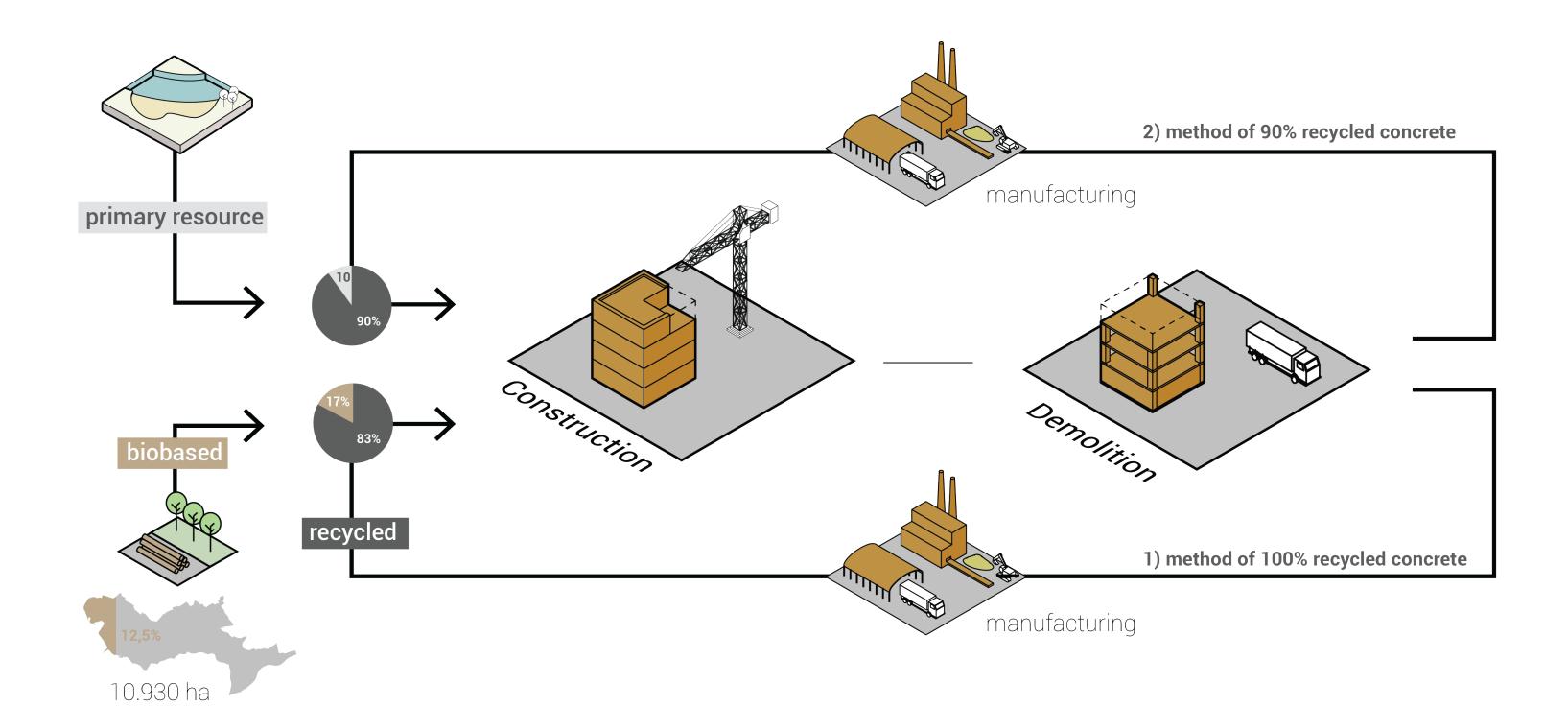






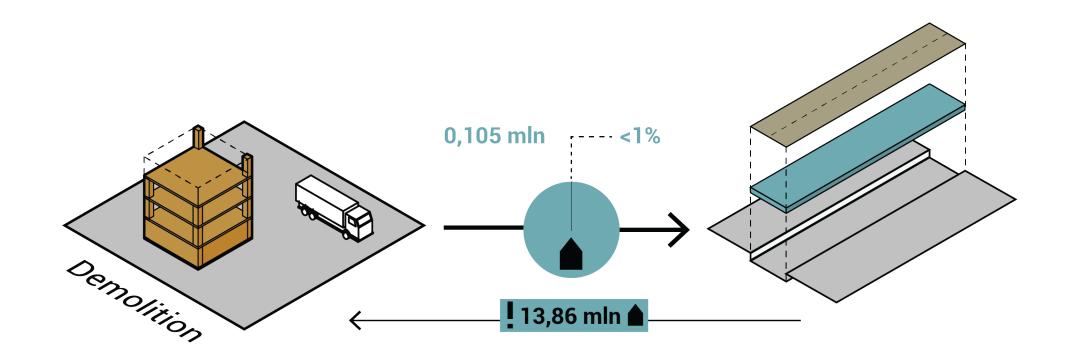
#### Impact on region Concrete





## Impact on region EPS





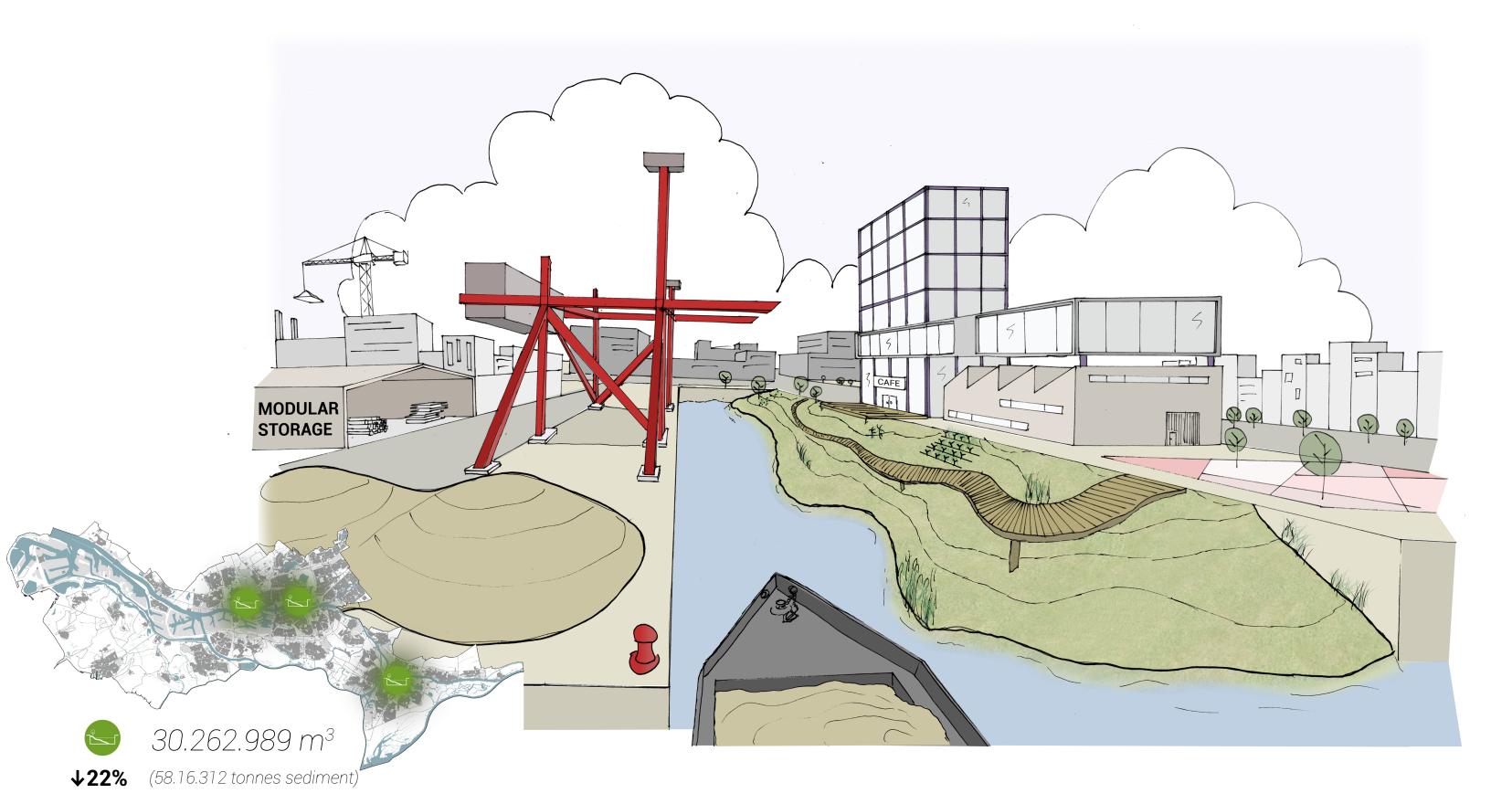
#### Regional productive scape: Soil treatment





#### Regional productive scape: Tidal park

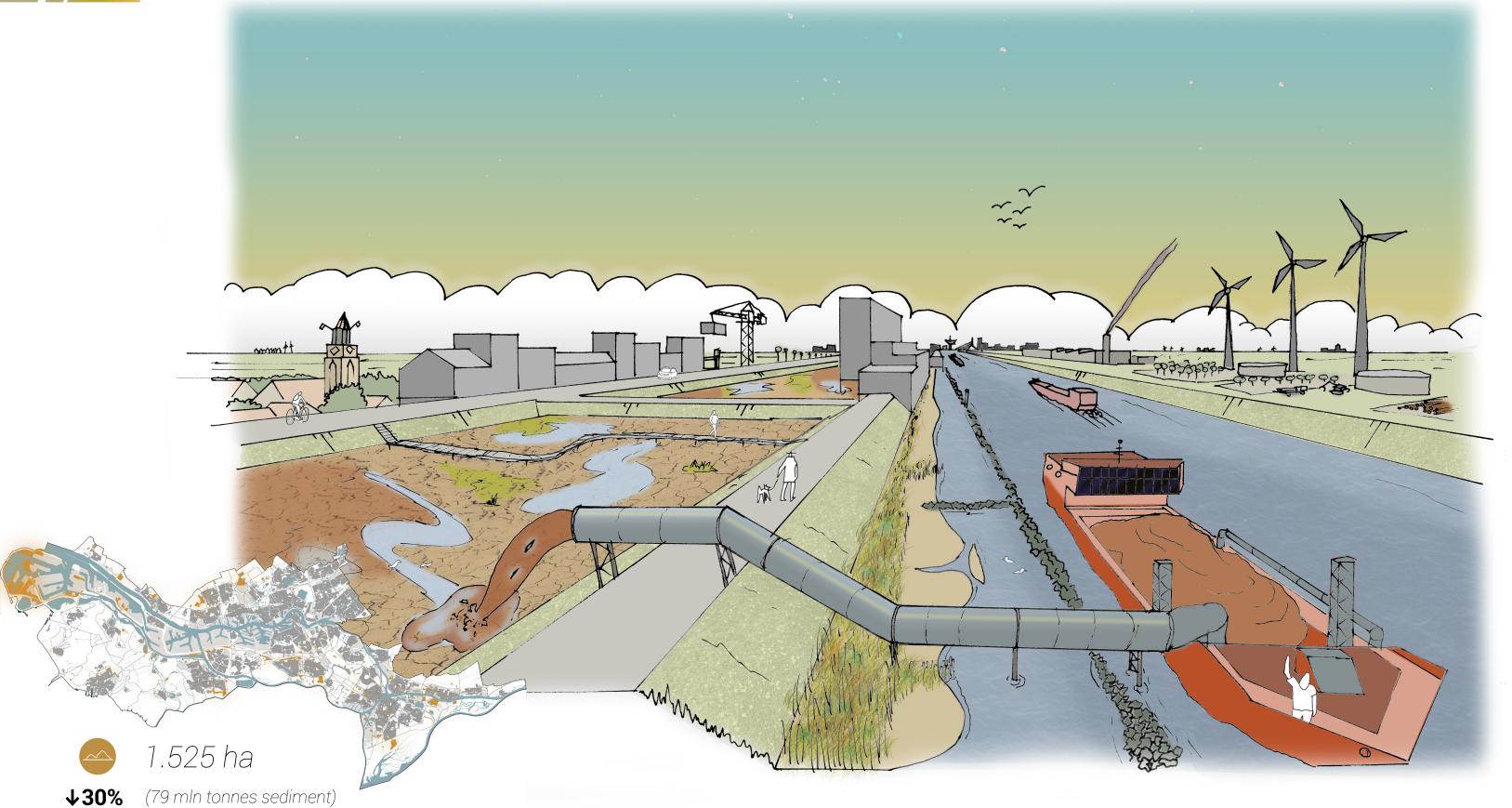




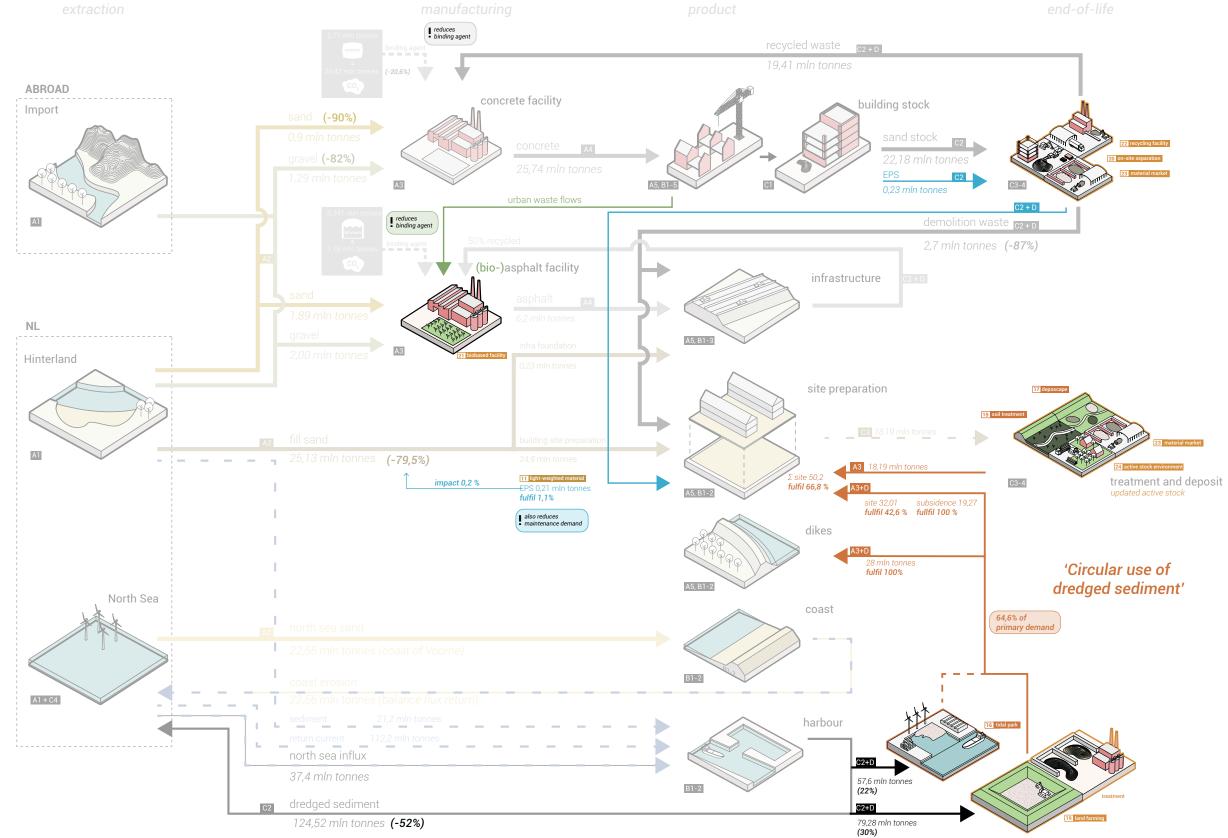


## Regional productive scape: Landfarming











#### Rijnmond-Drechtsteden: a sand-balanced region

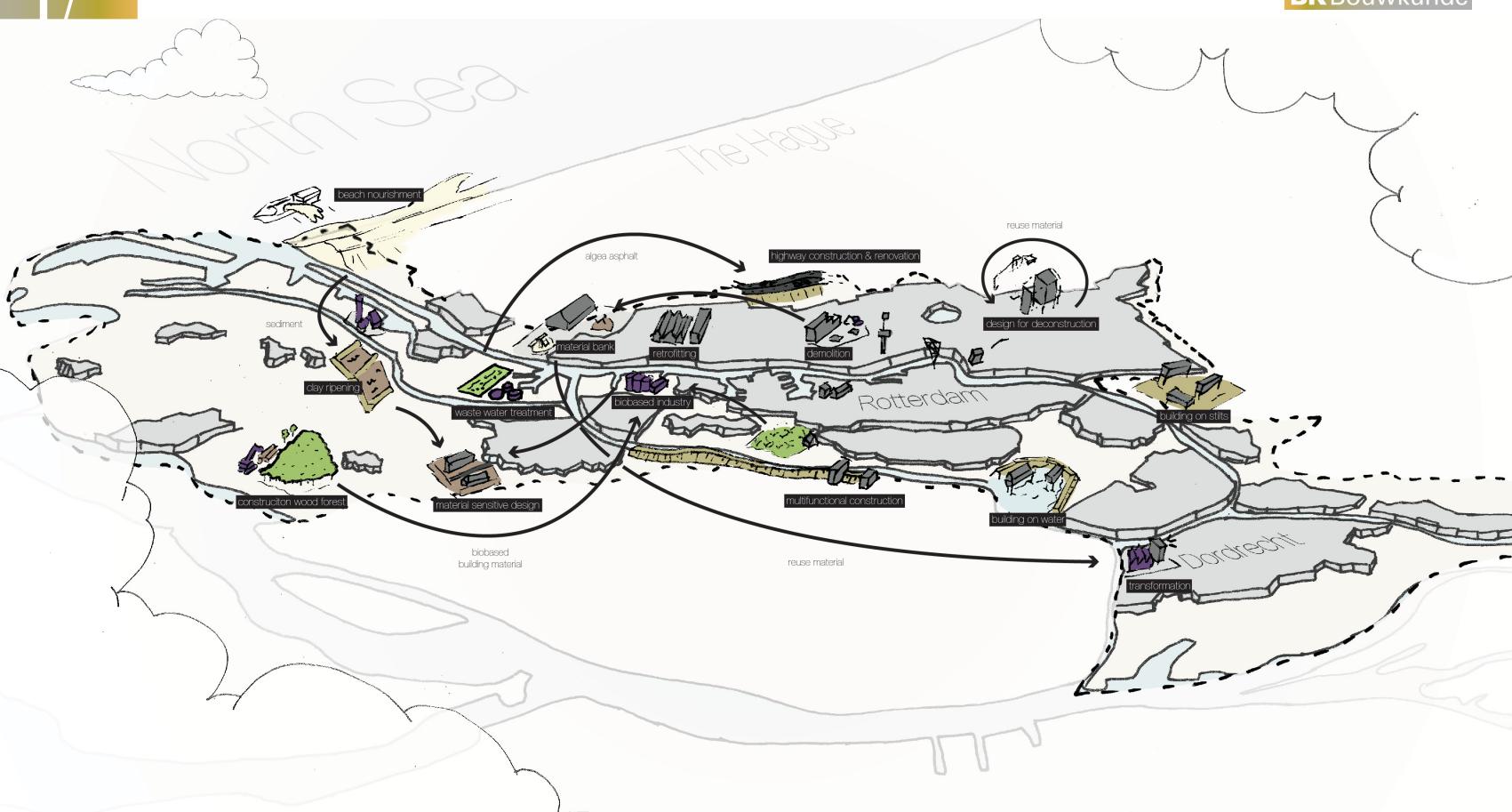


'How can urban design reduce the consumption of primary construction sand and gravel in the construction ecosystem in the Rijnmond-Drechtsteden region?'

- Applyng the material consciousness approach (in the life-cycle perspective and with material efficiency strategies) in the field of urban design
- Consumption can significantly be reduced through urban design in (inter-) relation to systematic metabolic changes and interventions on regional level
- This results in a multi-scalar approach between technical/local and planning/regional decisions
- In order to practically reduce the consumption and develop a circular construction, a more interdisciplinary process is needed between civil engineering and urbanism where environmental impact, technical feasibility and spatial quality are studied within the material consciousness approach

## Rijnmond-Drechtsteden: a sand-balanced region



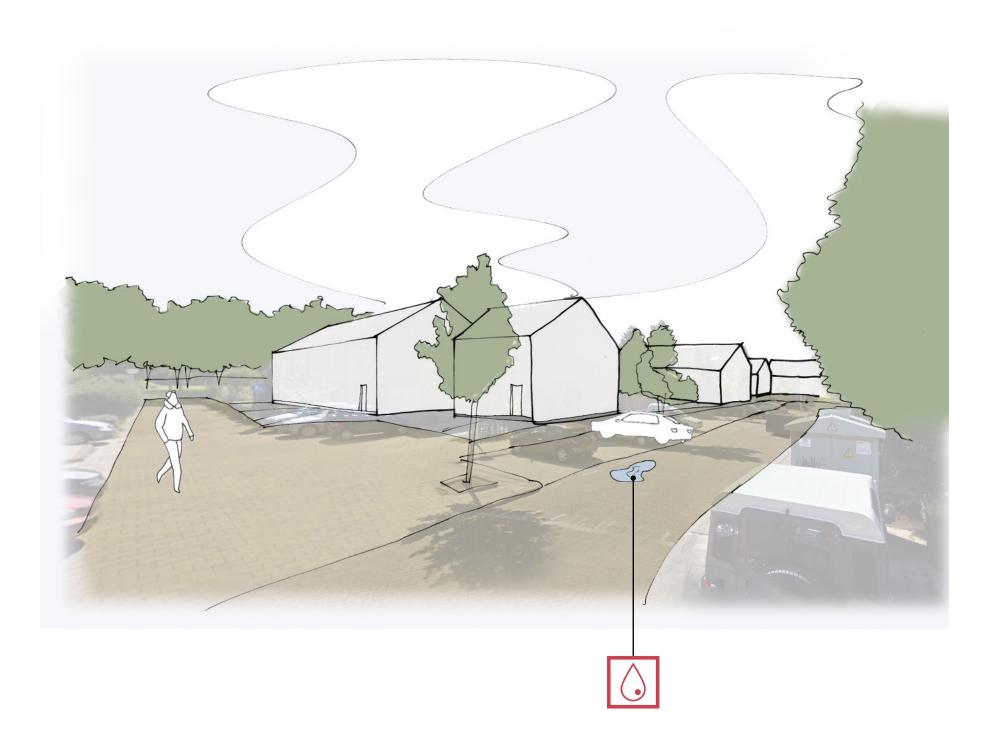


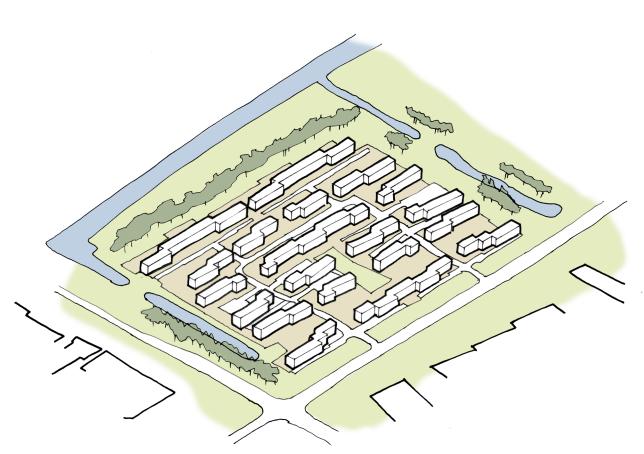




#### Rotterdam - Ommoord Situation

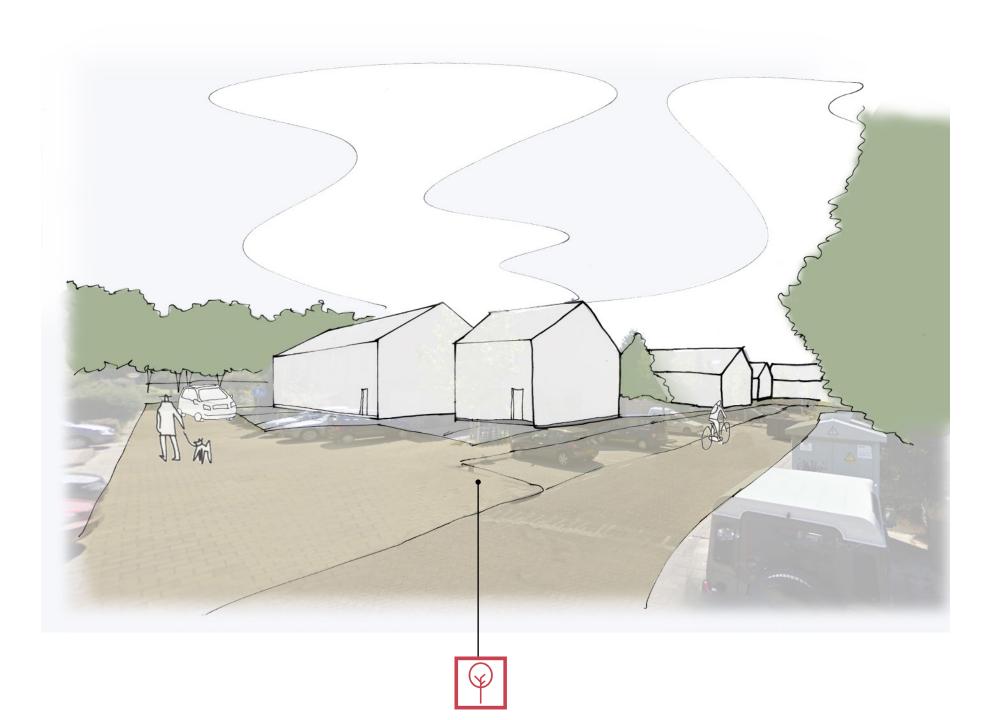


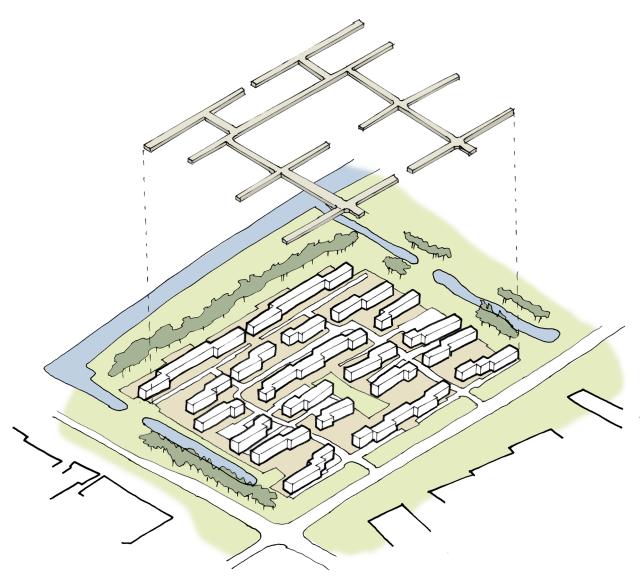




#### Rotterdam - Ommoord Business as usual

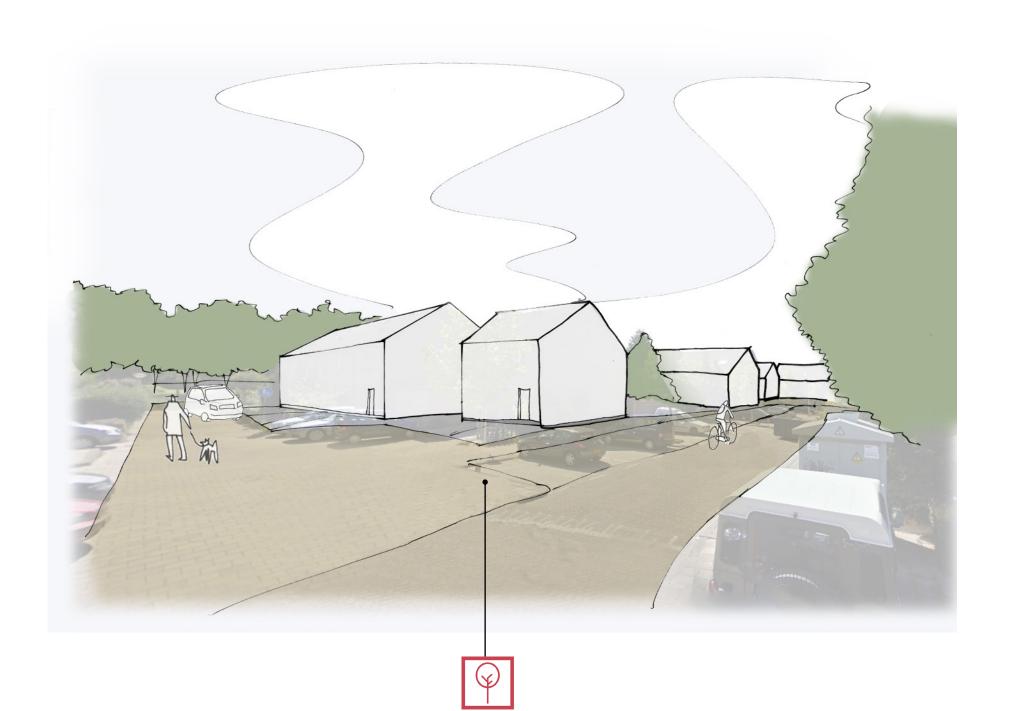


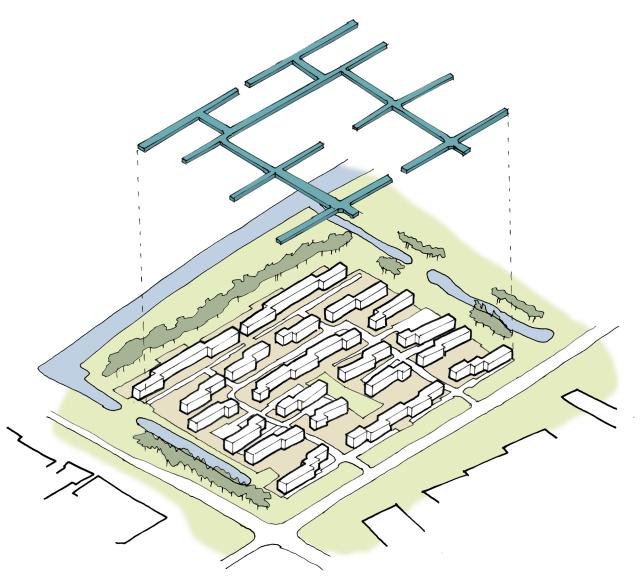




#### Rotterdam - Ommoord CwS01

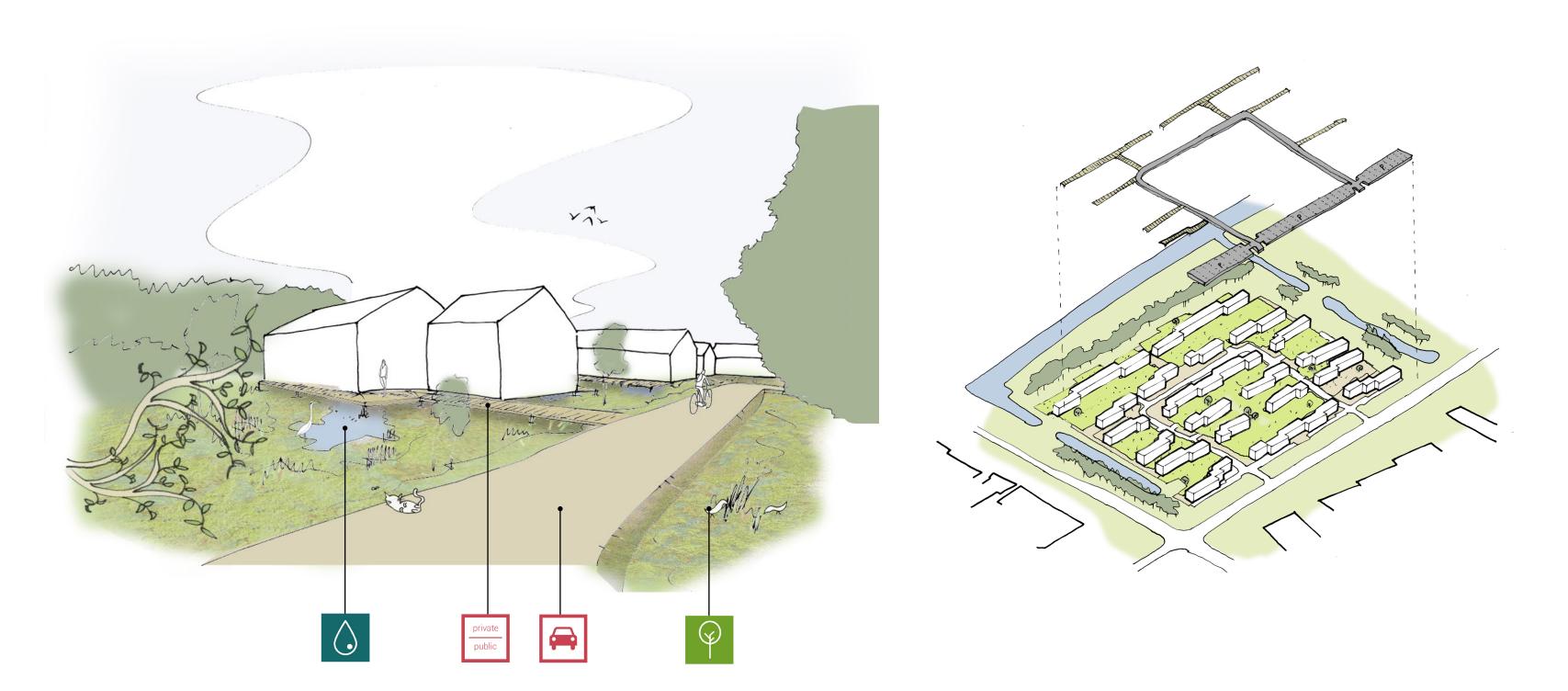






#### Rotterdam - Ommoord CwS02

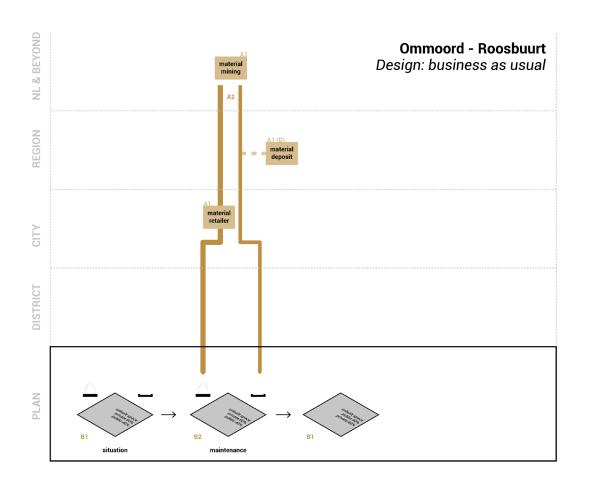


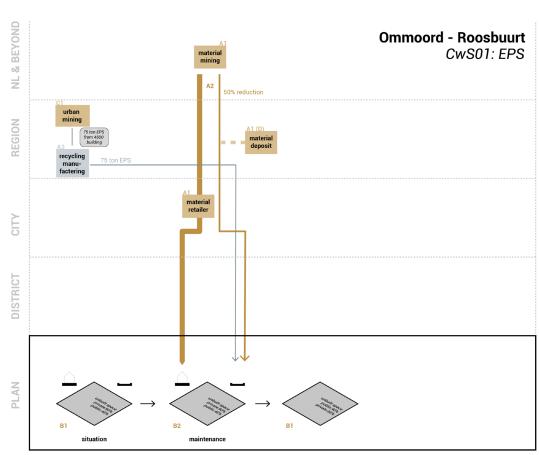


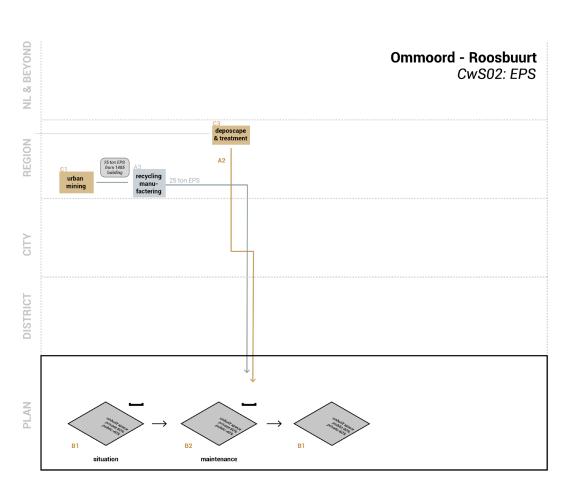


#### Rotterdam - Ommoord overview



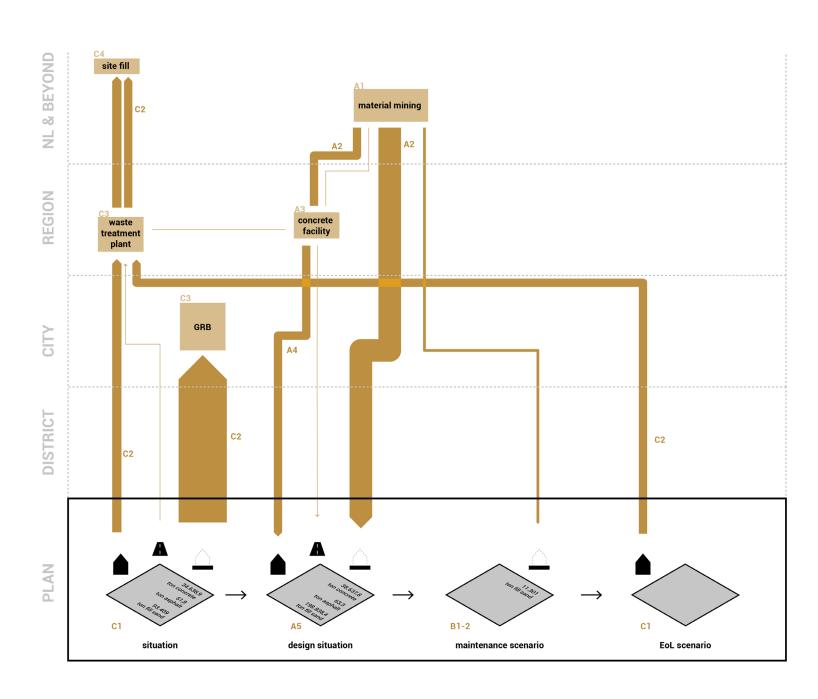






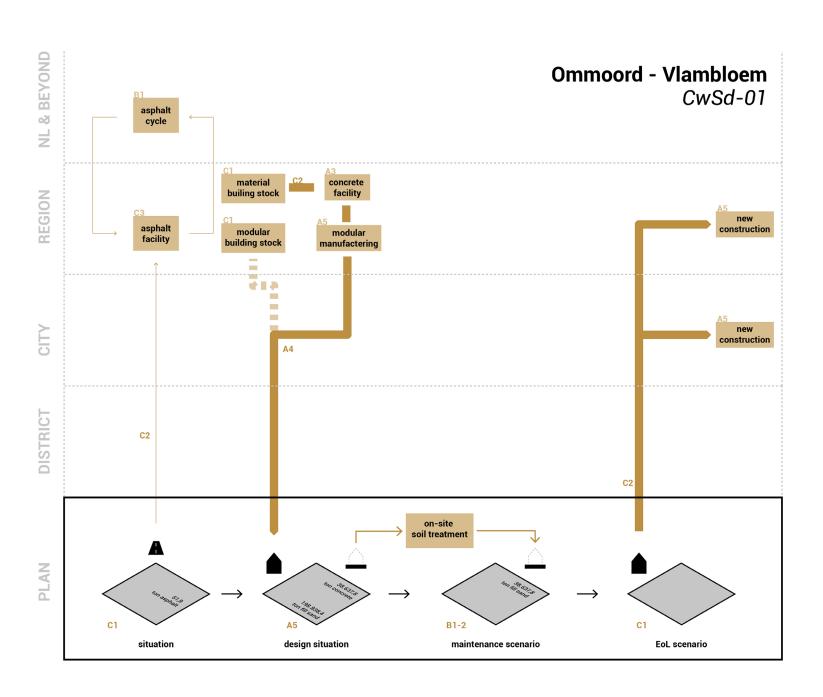






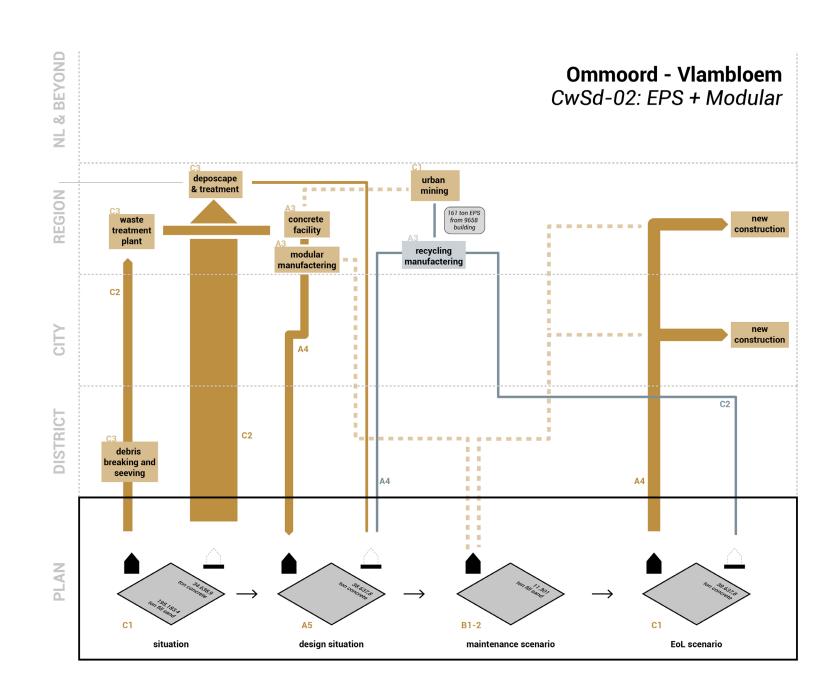






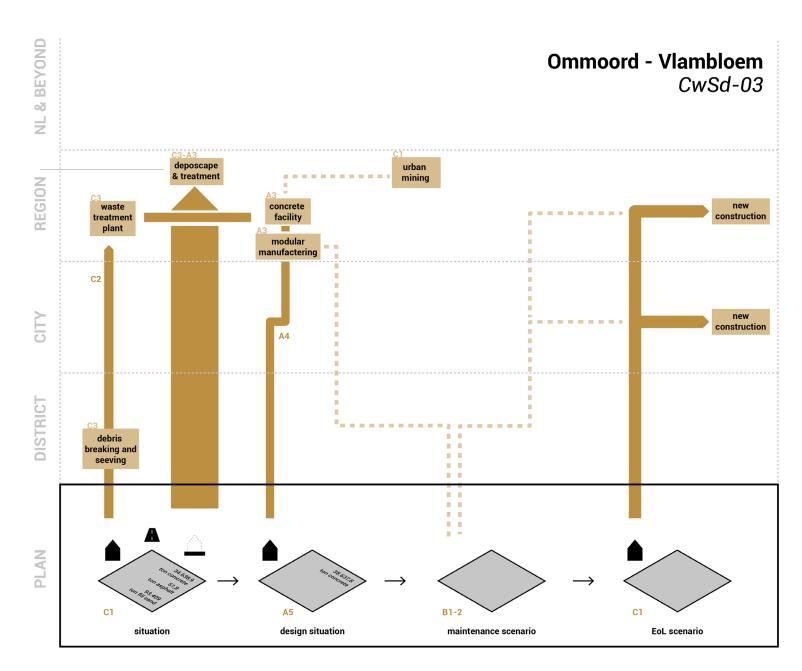








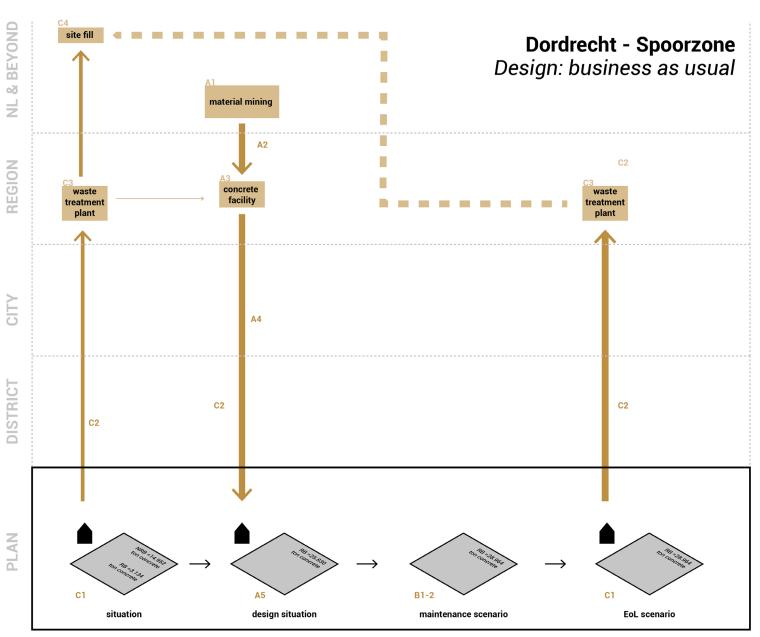








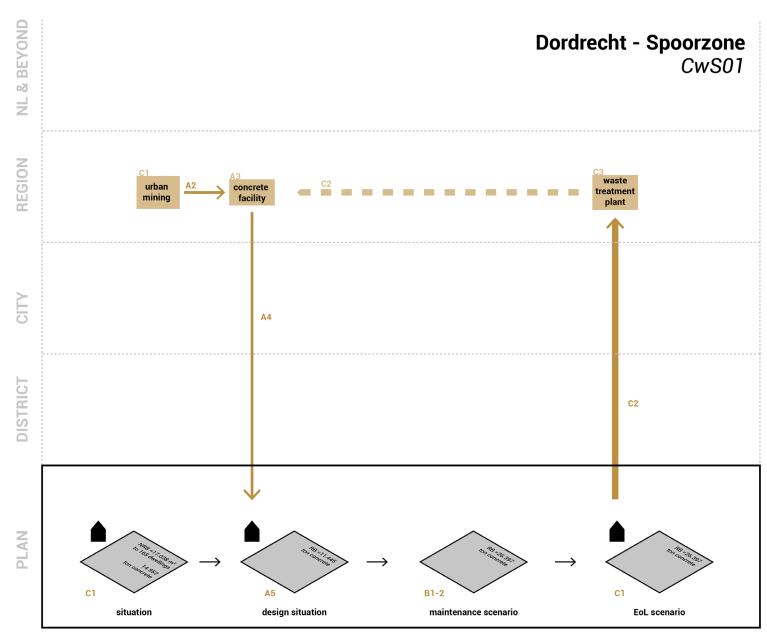








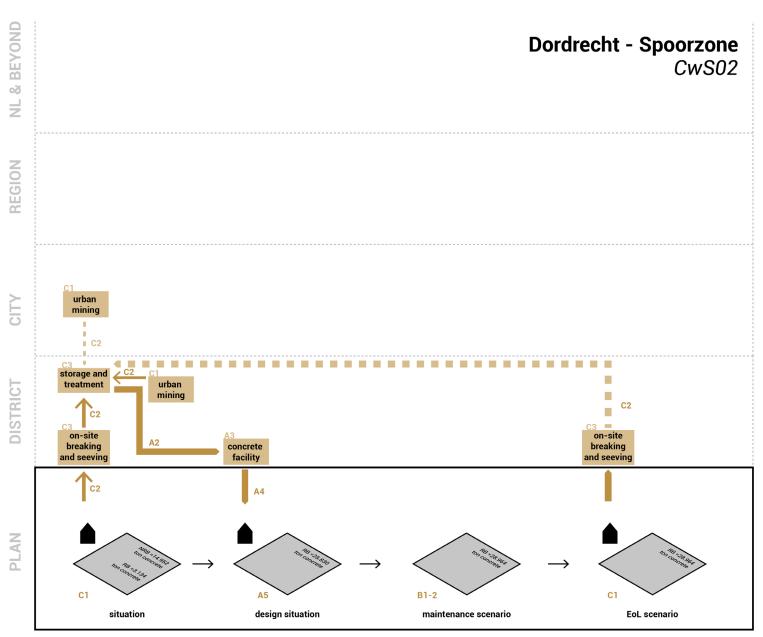






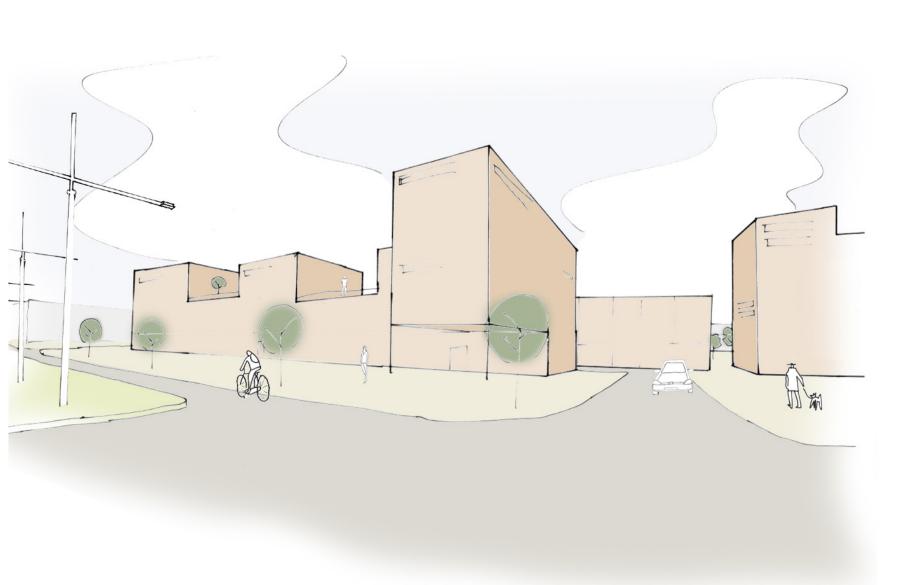


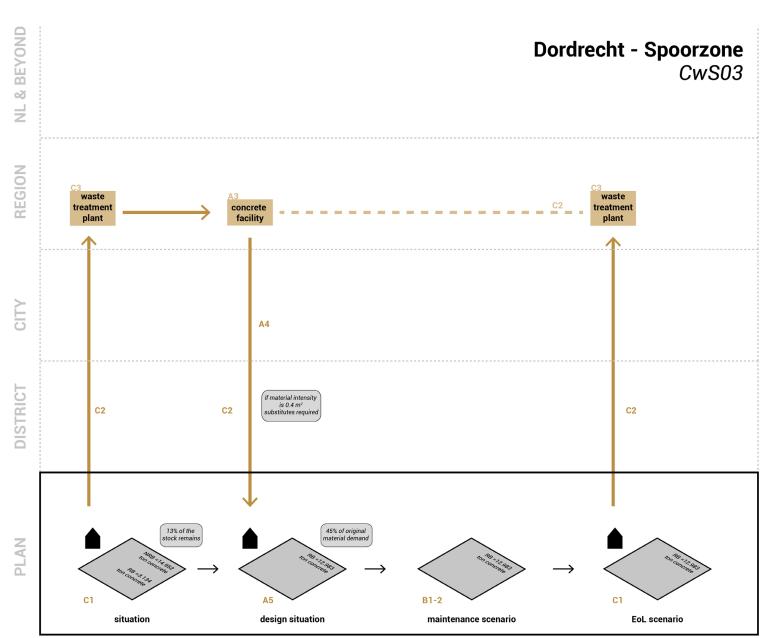






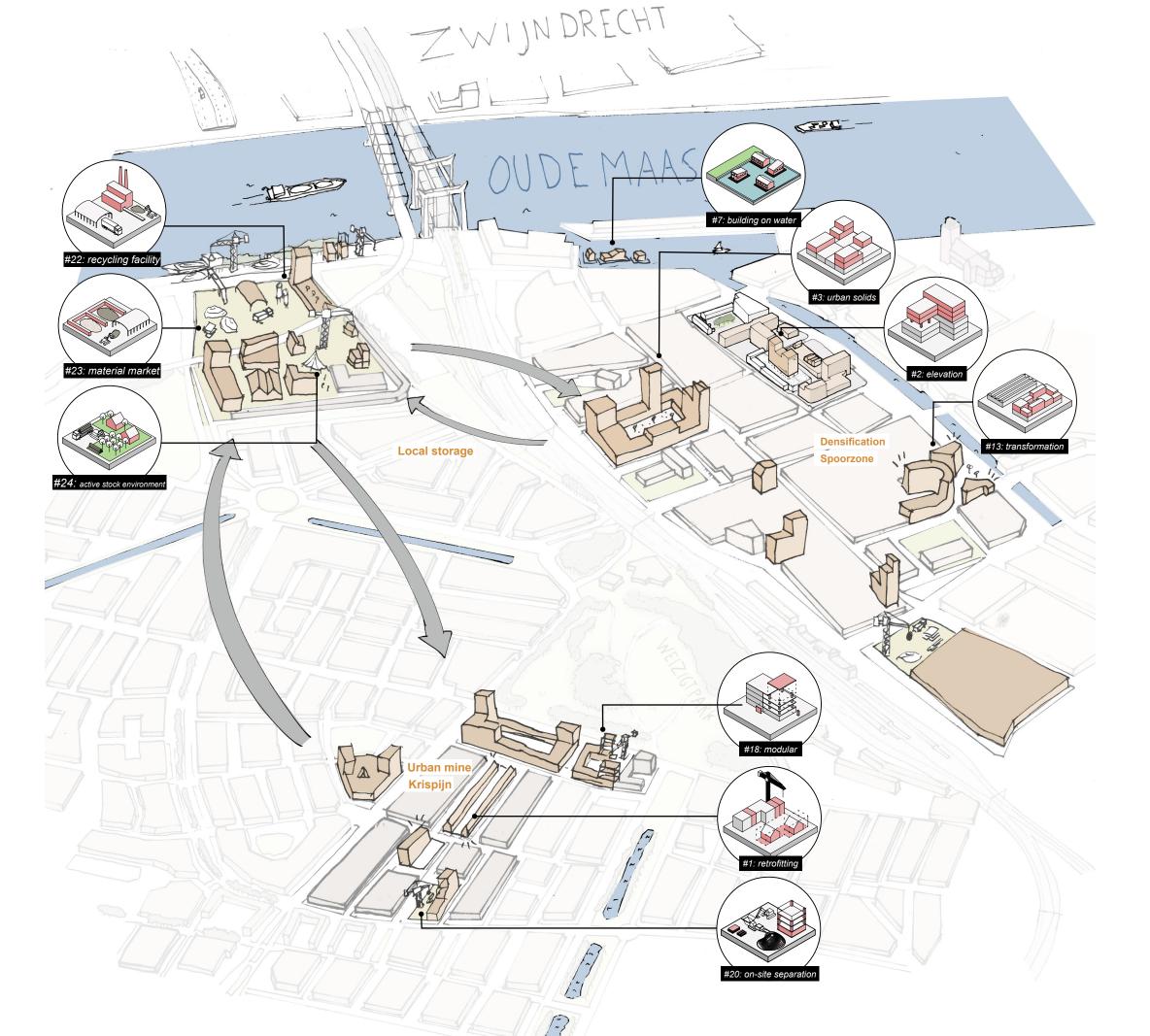








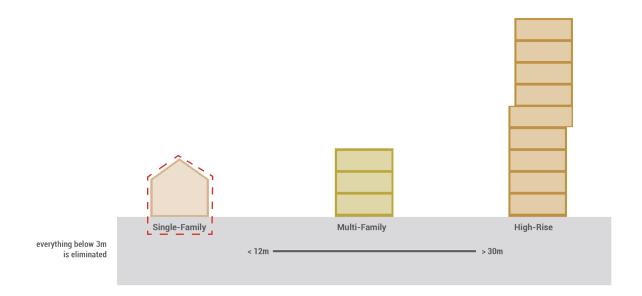


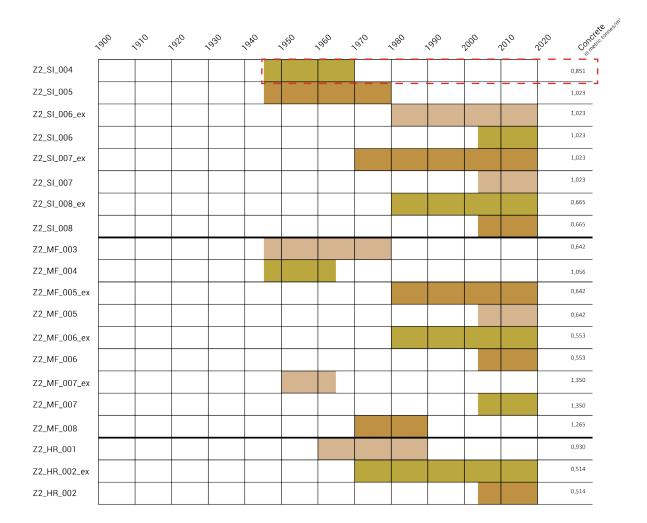




#### **Building database**







#### Example

**Building A** 

Function = residential (RB)

Year = 1960 Height = 9m Footprint =  $90m^2$ 

#### Database validation

RB < 12 so Single-Family Year = 1960 so MI<sub>concrete</sub> (material intensity)

= 0,85 metric tonnes /m<sup>2</sup>

#### Calculation

Total floorspace (GFA) is needed

GFA =  $(9/3)*90 = 270 \text{ m}^2$ Total material intensity of concrete:

GFA\*MI = 270\*0,85

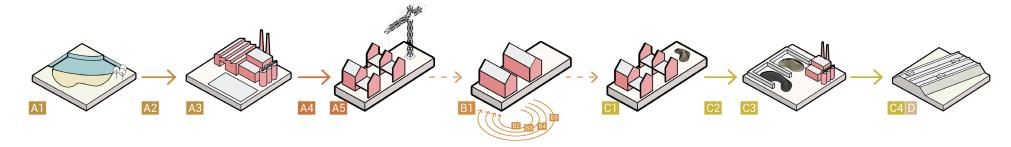
= 229,5 metric tonnes.



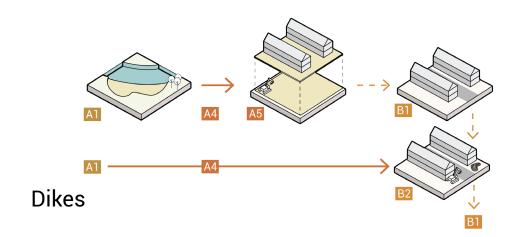
## LCA Systematic and spatial



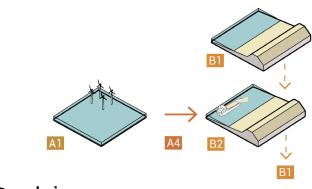
#### Buildings



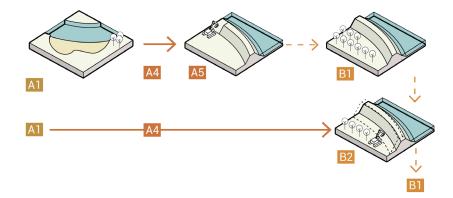
#### Site raising



#### Beach nourishment



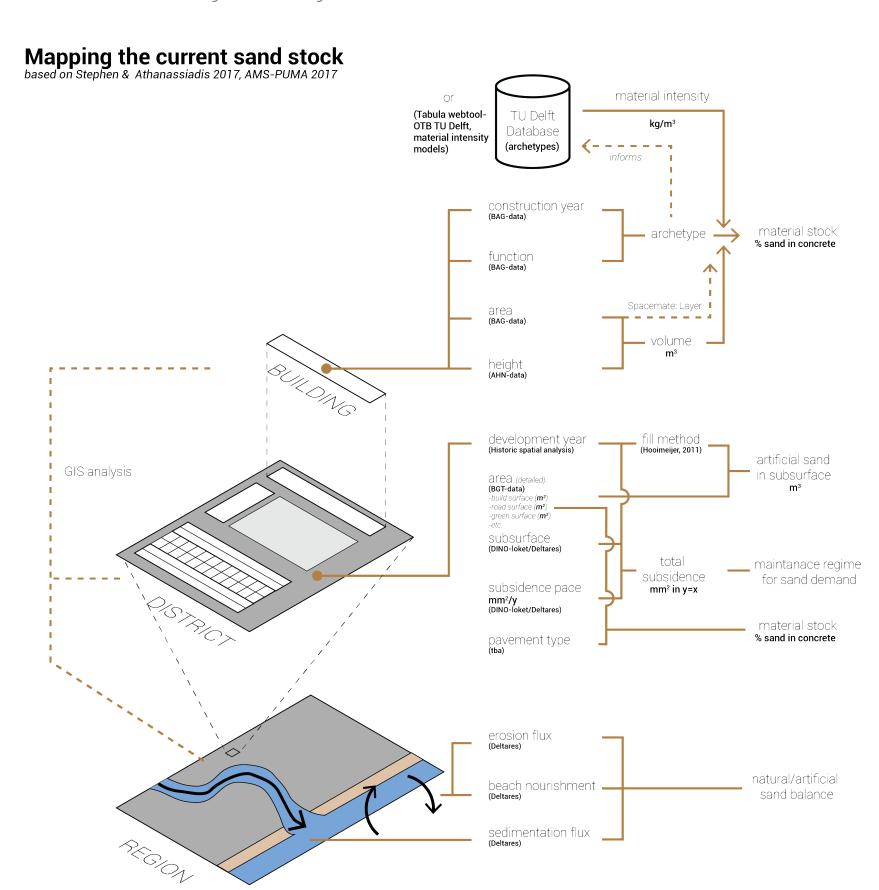
Dredging

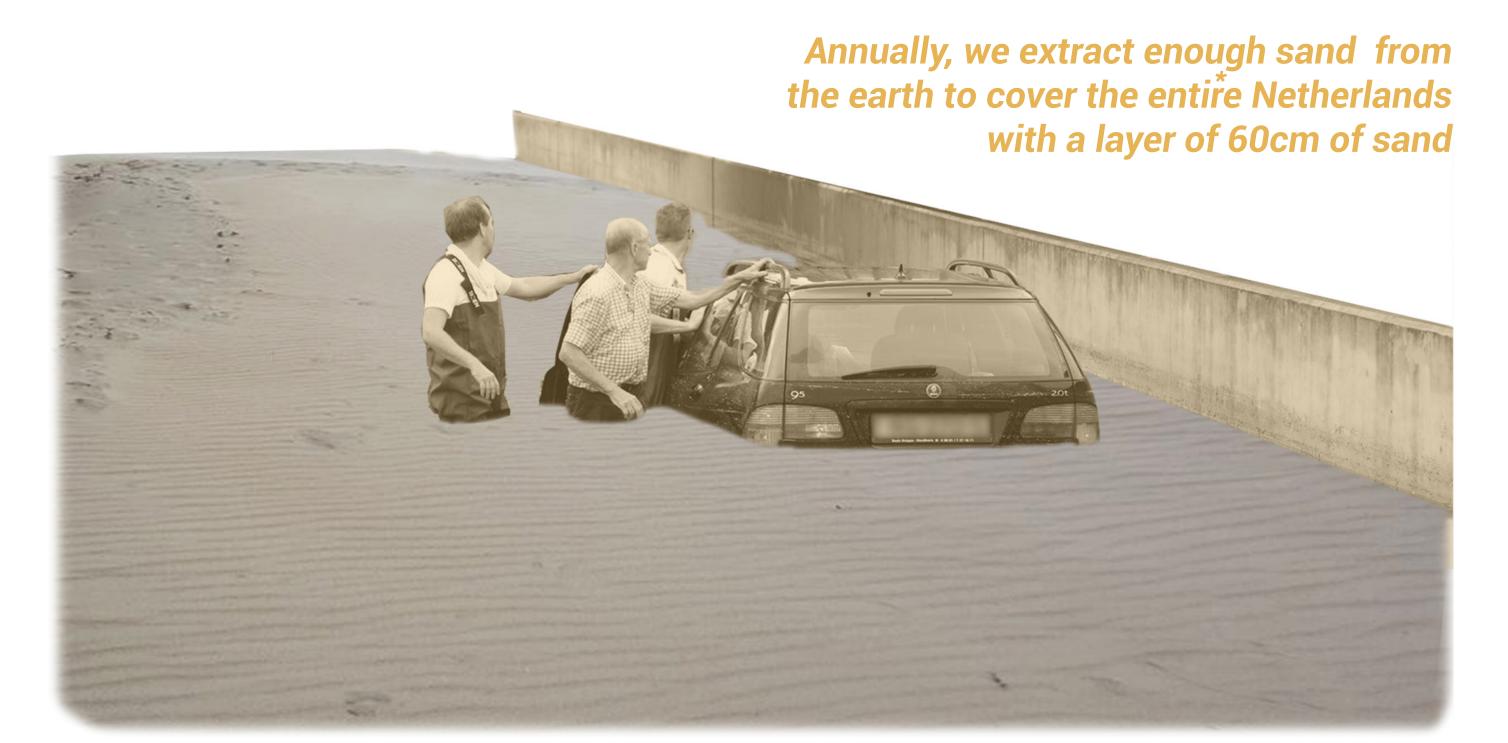




#### Analysis material intensity study







"Sand is, after water, the most used raw material on earth [...] and greatly exceeds their natural renewal rates"