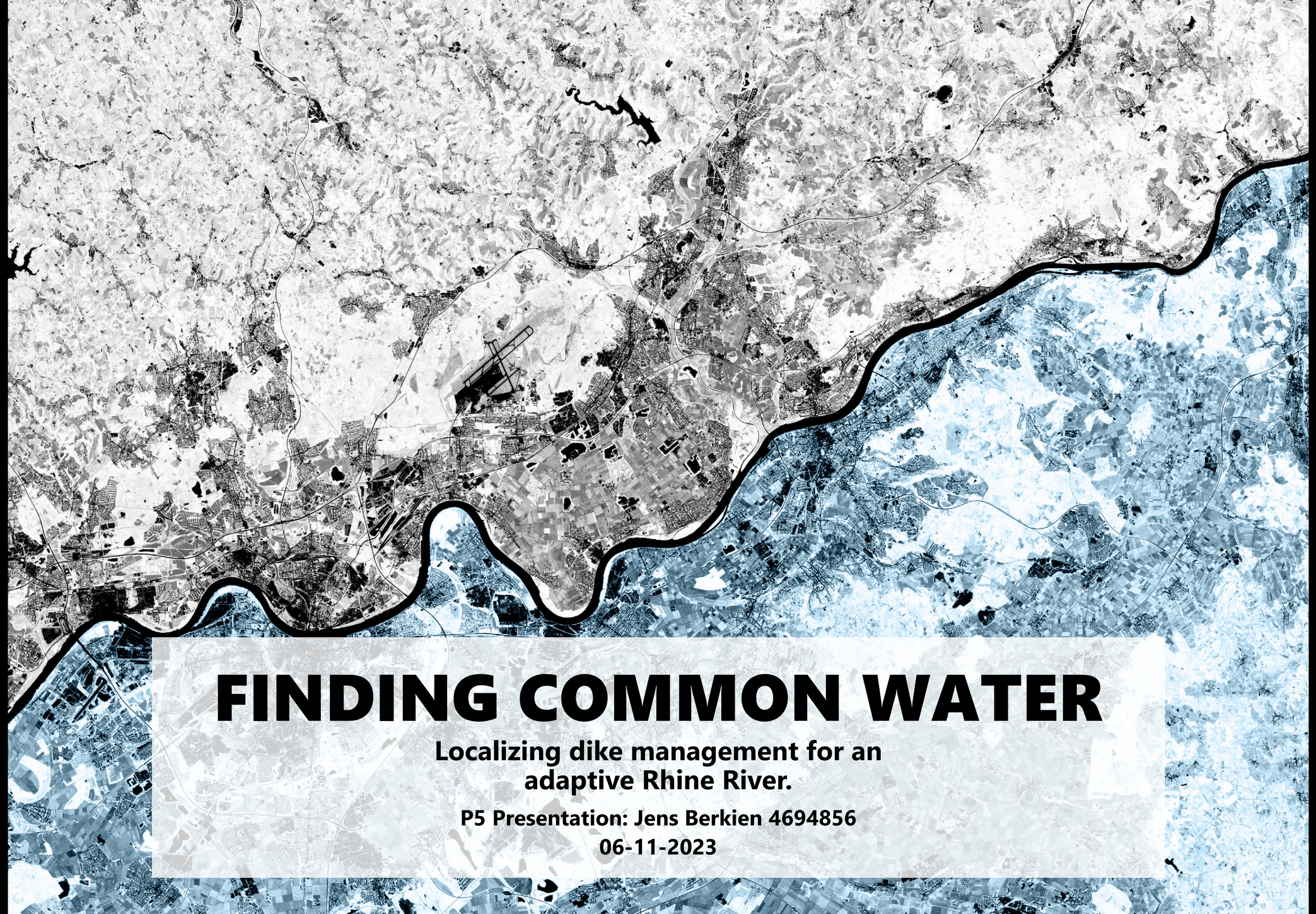
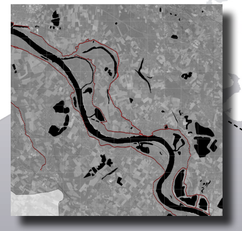


FINDING COMMON WATER

Localizing dike management for an adaptive Rhine River.

P5 Presentation: Jens Berkien 4694856

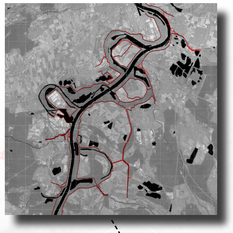
06-11-2023



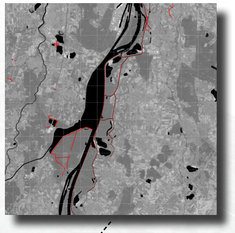
Rees: ***Delta Rhine (NL-DE)***



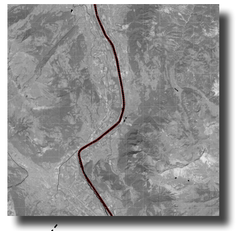
Meerbusch: ***Lower Rhine (DE)***



Germersheim: ***Upper Rhine (FF)***



Altenheim: ***Upper Rhine (FR-DE)***



Vaduz: ***Alpine Rhine (CH-AT-LI)***

Started: July 2023

Planned: March 2024

Planned: June 2024

Initiated: November 2023

Dikes per Rhine Regions

Dikes of the Rhine

THE RHINE CONNECTS

Building further on the Interreg Program of 2023

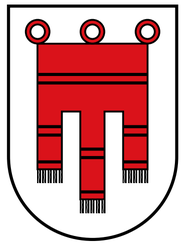
Localizing dike management for an adaptive Rhine River.

INTRODUCTION
WHAT HAVE WE DONE?

COLLABORATION OF THE **IKSR** (RHINE AUTOHORITY), **CHR** (RHINE RESEARCH INSTITUTION), **RIJKSWATERSTAAT** (THE NETHERLANDS) **CANTON ST GALL** (SWITZERLAND) **BUNDESLÄNDE VORALBERG** (AUSTRIA)

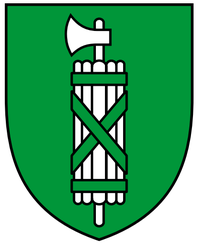








Rijkswaterstaat
Ministerie van Infrastructuur en Milieu



***(1)*. Introduction of the Program**
Enthousiastic people caring for their environment

***(2)*. Why have we done this?**
Seeing the problem of the Rhine River

***(3)*. What have we done?**
Seeing the Rhine as a key to the relation between man and river

***(4)*. How have we done this?**
Building a central model for the river

***(5)*. What are the first results?**
Testing the notion within the Alpine Rhine

***(6.)* How are we moving forward?**
Design of a Roadmap towards local dike autonomy







EXTENDING EXISTING PROJECT TO THE LARGER RHINE SCALE

(1). **Introduction of the Program**
Enthousiastic people caring for their environment

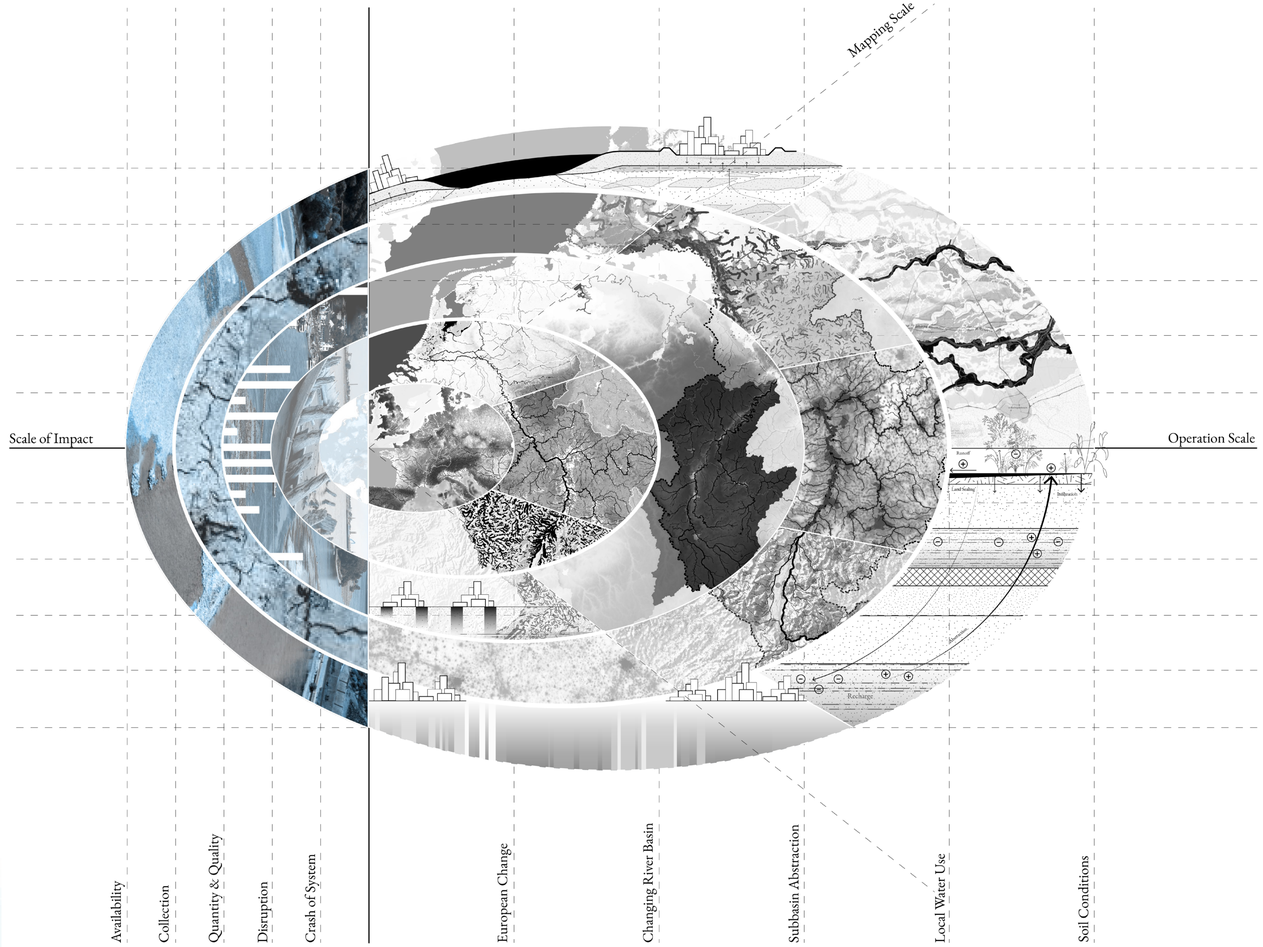
(2). **Why have we done this?**
Seeing the problem of the Rhine River

(3). **What have we done?**
Seeing the Rhine as a key to the relation between man and river

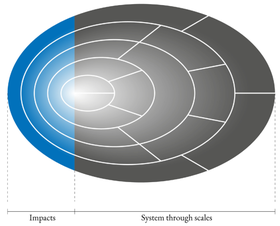
(4). **How have we done this?**
Building a central model for the river

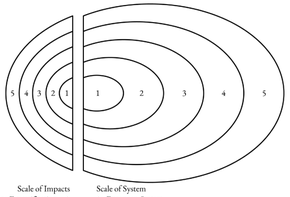
(5). **What are the first results?**
Testing the notion within the Alpine Rhine

(6.) **How are we moving forward?**
Design of a Roadmap towards local dike autonomy



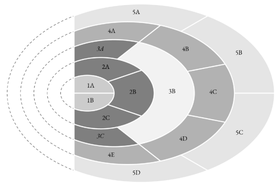
Legend





Scale of Impacts
Climate Change Desertification 1
Increase of periods of Floods & Drought 1
Changing Water Quantity & Quality 1
Land Sealing 1
Water Loss 1

Scale of System
1 European System
1 Rhine River Basin
1 Rhine River Subbasins
1 Local Water Relations
1 Capacity of the Soil



1A Effective Precipitation
1B Sea Temperature
2A Elevation Profile
2B Groundwater Recharge
2C River Discharge

3A Continuation Elevation
3B Water Exploitation Index
3C Water Abstraction
4A Flooding Coastal
4B Flooding Riverine

4C Protection against Water
4D Water Intensive Economies
4E Built Density
5A Subsidence
5B River Sedimentation patterns

5C Groundwater Recharge
5D Hydrologic Conductivity

ARISING ISSUES OF THE RHINE RIVER LANDSCAPE

(1). **Introduction of the Program**
Enthousiastic people caring for their environment

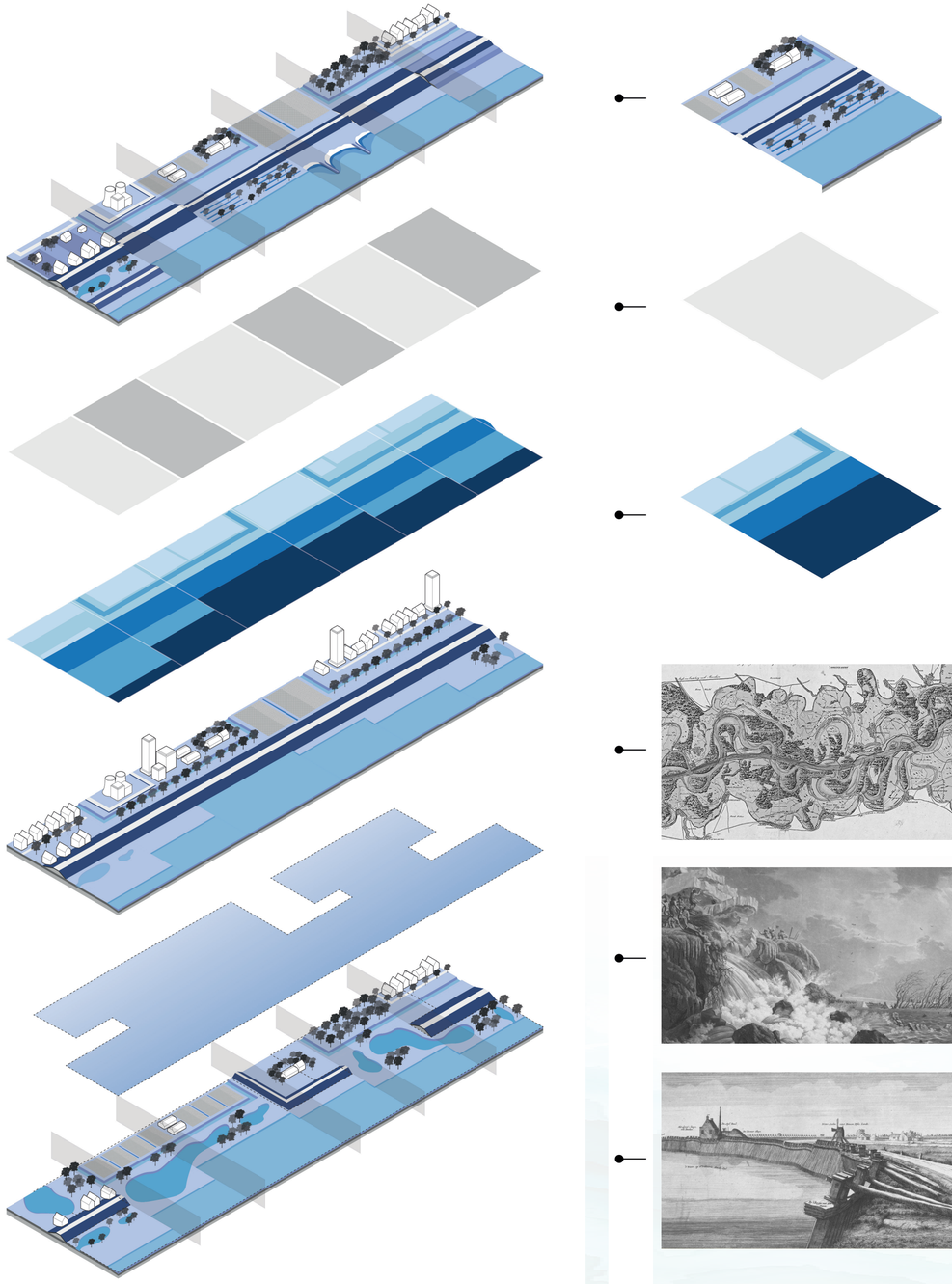
(2). **Why have we done this?**
Seeing the problem of the Rhine River

(3). **What have we done?**
Seeing the Rhine as a key to the relation between man and river

(4). **How have we done this?**
Building a central model for the river

(5). **What are the first results?**
Testing the notion within the Alpine Rhine

(6.) **How are we moving forward?**
Design of a Roadmap towards local dike autonomy



RE-ESTABLISHING THE LOST RELATION BETWEEN MAN & RIVER

(1). Introduction of the Program
Enthousiastic people caring for their environment

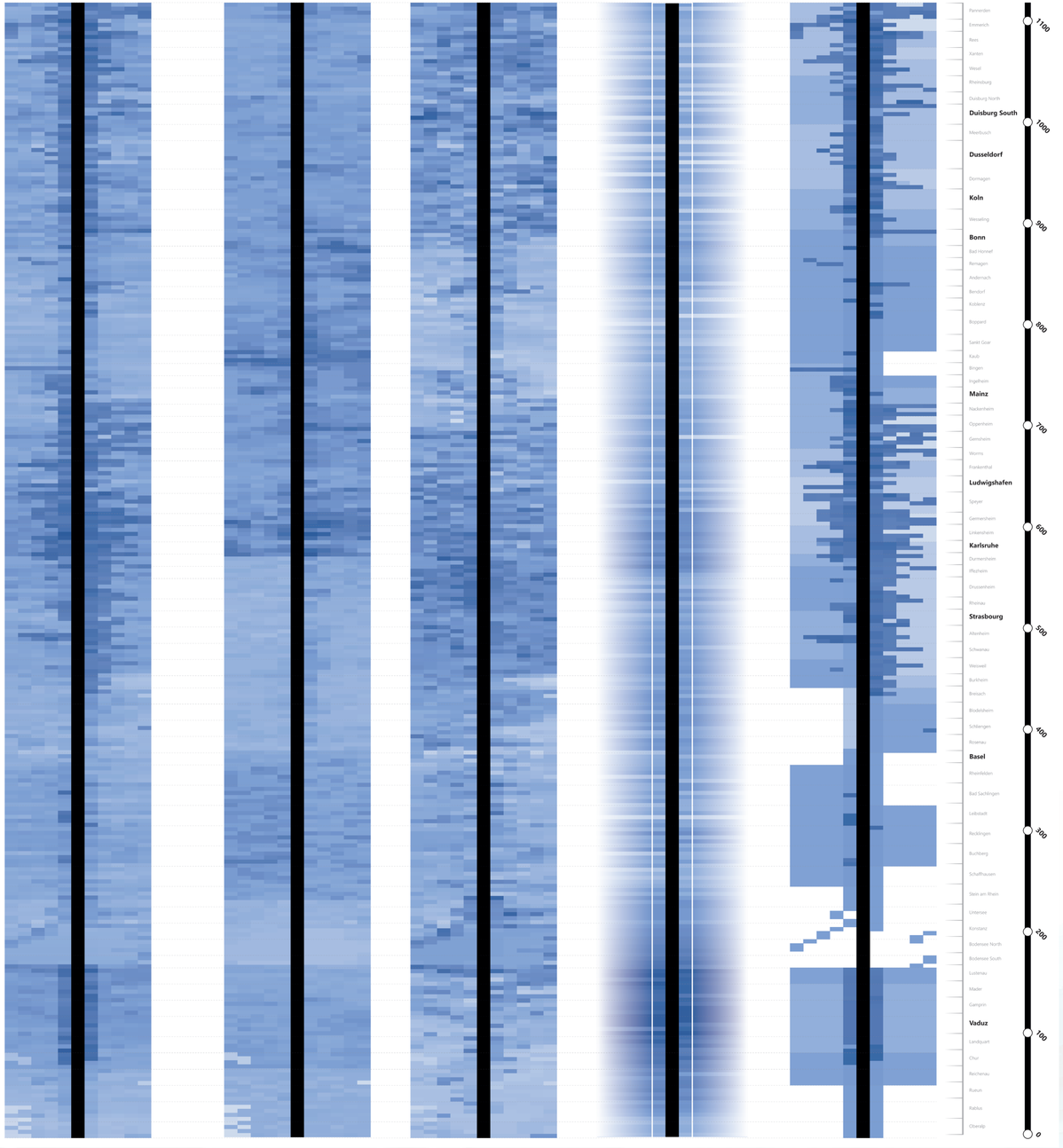
(2). Why have we done this?
Seeing the problem of the Rhine River

(3). What have we done?
Seeing the Rhine as a key to the relation between man and river

(4). How have we done this?
Building a central model for the river

(5). What are the first results?
Testing the notion within the Alpine Rhine

(6.) How are we moving forward?
Design of a Roadmap towards local dike autonomy



CALCULATIONS TO ESTABLISH LOCAL POSSIBILITIES

(1). **Introduction of the Program**
Enthousiastic people caring for their environment

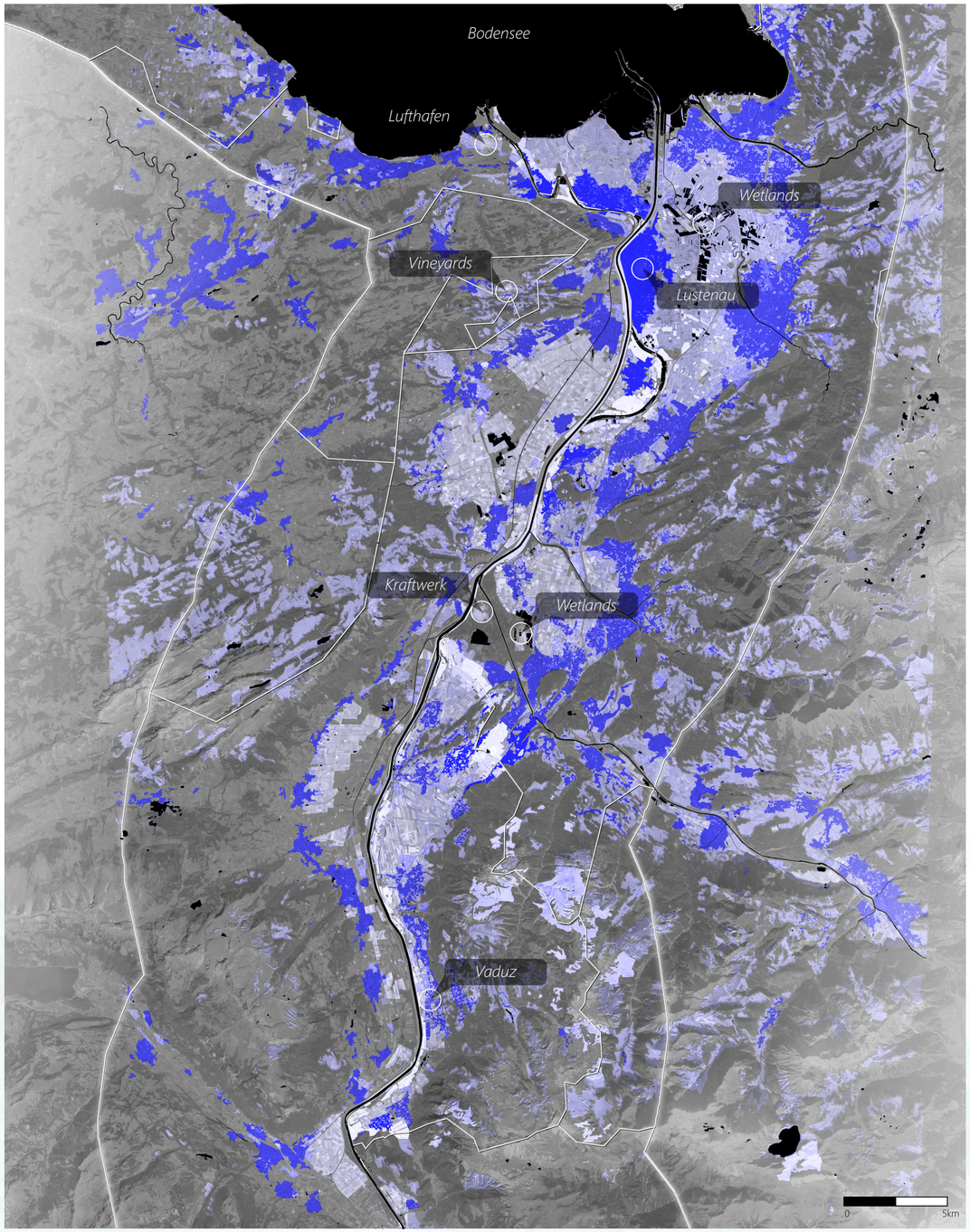
(2). **Why have we done this?**
Seeing the problem of the Rhine River

(3). **What have we done?**
Seeing the Rhine as a key to the relation between man and river

(4). **How have we done this?**
Building a central model for the river

(5). **What are the first results?**
Testing the notion within the Alpine Rhine

(6.) **How are we moving forward?**
Design of a Roadmap towards local dike autonomy



TESTING THE METHOD ON A SET LOCAITON (ALPINE RHINE)

(1). **Introduction of the Program**
Enthousiastic people caring for their environment

(2). **Why have we done this?**
Seeing the problem of the Rhine River

(3). **What have we done?**
Seeing the Rhine as a key to the relation between man and river

(4). **How have we done this?**
Building a central model for the river

(5). **What are the first results?**
Testing the notion within the Alpine Rhine

(6.) **How are we moving forward?**
Design of a Roadmap towards local dike autonomy



ESTABLISHING A ROADMAP FOR LOCALIZED DIKE AUTONOMY

(1). **Introduction of the Program**
Enthousiastic people caring for their environment

(2). **Why have we done this?**
Seeing the problem of the Rhine River

(3). **What have we done?**
Seeing the Rhine as a key to the relation between man and river

(4). **How have we done this?**
Building a central model for the river

(5). **What are the first results?**
Testing the notion within the Alpine Rhine

(6.) **How are we moving forward?**
Design of a Roadmap towards local dike autonomy

INTRODUCTION

INTERREG: THE RHINE CONNECTS

***(1)*. The Healthy Rhine**

Change plastic intake of the Rhine
Restoration of migratory fish
Citizen Science Oude Ijssel

***(2)*. The Green Rhine**

Expansion of riverine forests
Living Dikes
Ecological corridor Niederrhein

***(3)*. The Living Rhine**

Communcitation, Education & Parcticipation
3D online visitor centre
Interactive lectures & Exhibitions

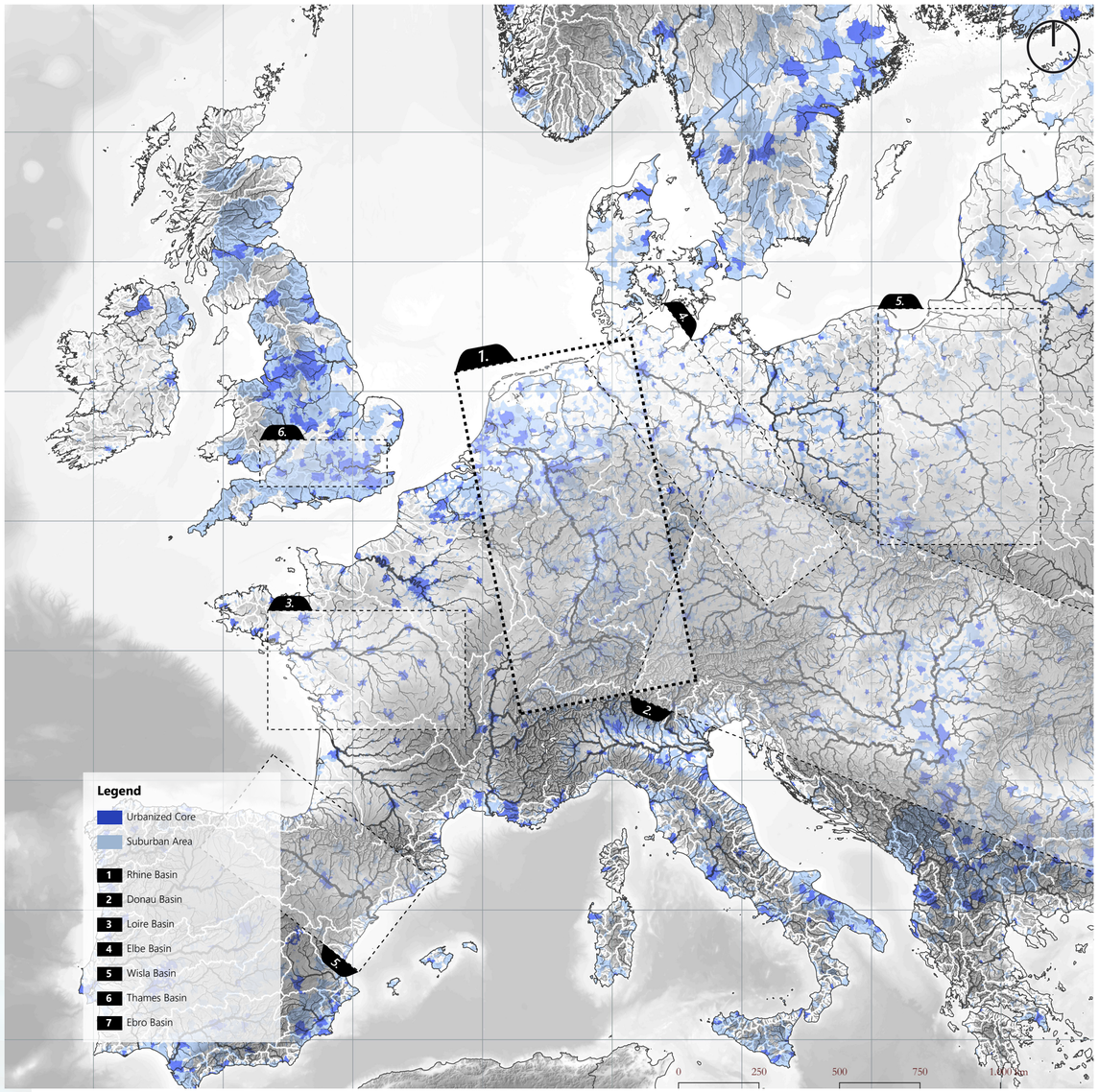
Localizing Dike Management



WHY HAVE WE DONE THIS?

SEEING THE PROBLEM OF THE RHINE RIVER

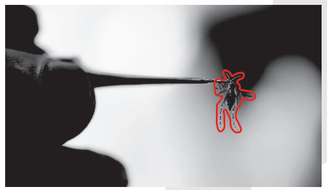
Rhine River Basin




Why have we done this?
The Age of the Anthropocene
GLOBAÏA
WORLD MAPPER
www.worldmapper.org

Effects on Hydrological Systems

Unpredictability of the Climate Extremes along the Rhine



Increase of diseases



Increasing sensitiviy of forrest fires



Increasing danger of subsidence & erosion



Loss of biodiversity



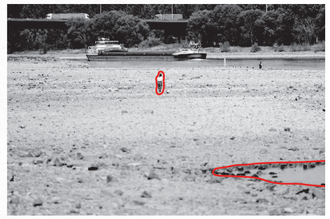
Unpredictability of flash floods



Decrease in future water quality



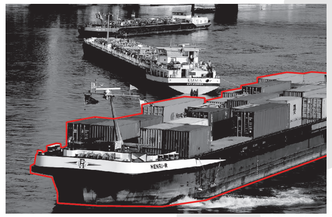
Drying out and sealing of topsoil



Dyring out and sealing of river beds

Effects on Human Systems

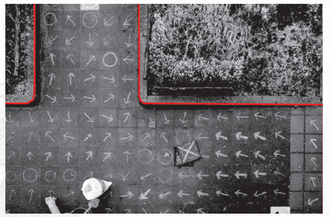
Risking urbanized systems that makes facilitates the Rhine Identity



Delays and decrease inland shipping



Loss of agricultural production



Change of waterflow due to land sealing



Decay of industrial practices



Protection of current dike structures



Strengthening of dike structures



Loss of unique ‘Rhine‘ practices



Changing intensity of river flow

Changing the look of our land



Cologne: August 2021



Cologne: August 2022

The European Union



United Nations Framework Convention on Climate Change (1993)

European Climate Change Program (2000)

International Carbon Action Partnership (2007)

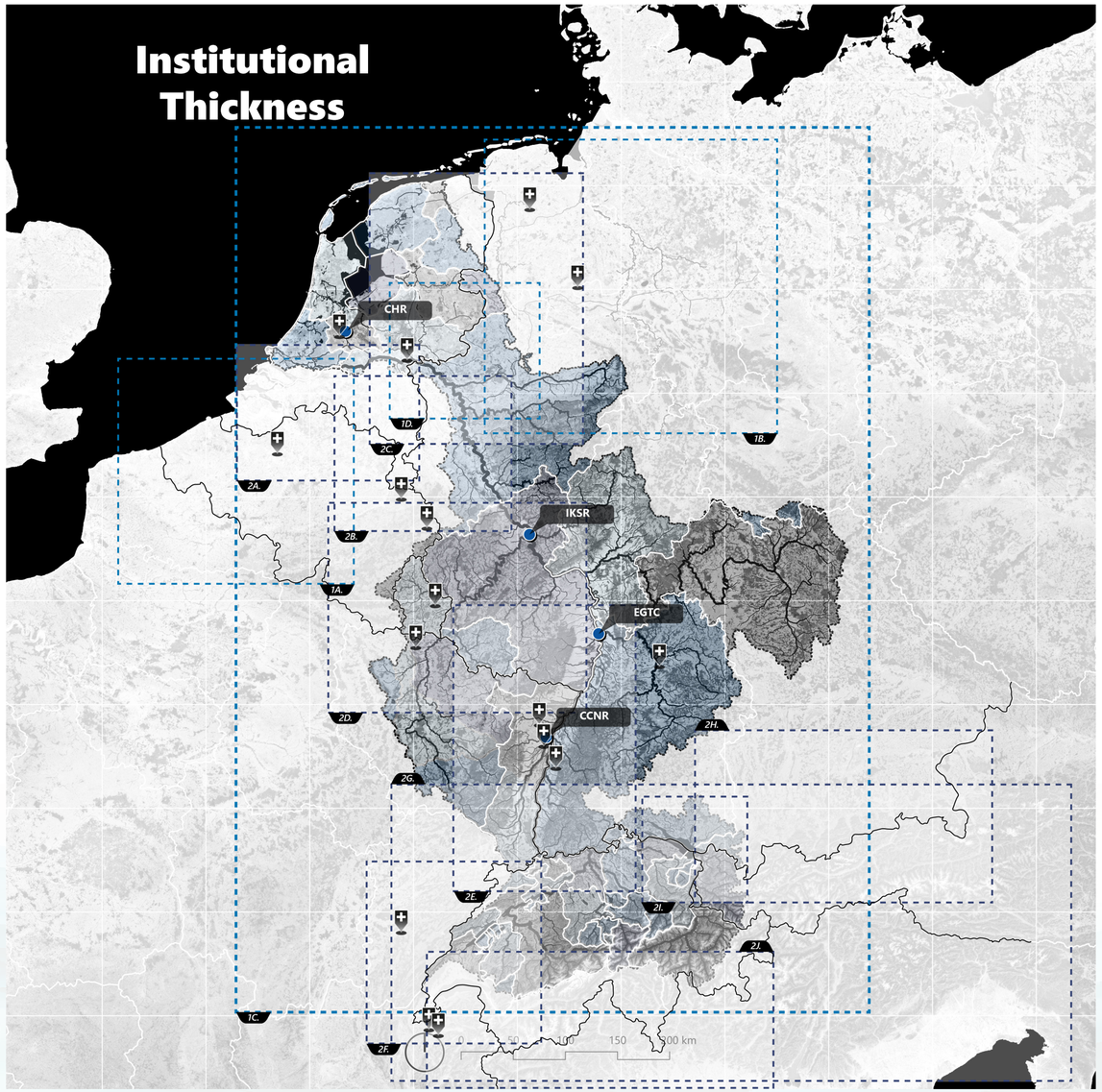
European Climate Change Initiative (2010)

Paris Climate Agreements (2015)

European Climate Initiative (2017)

European Green Deal (2019)

Rhine Problems
=
European Problems



Legend

Adminastrative Water Management Authority

Rhine Basin Authority

River Committees/Programs

- **1A** International Scheldt Committee
- **1B** International Ems Committee
- **1C** International Rhine Commission (IKSR)
- **1D** Europarc Netherlands-Germany

Interregional Programs EU

- **2A** Interreg VL-NED
- **2B** Interreg Maas-Rijn
- **2C** Interreg DE-NED
- **2D** Interreg GroBregion
- **2E** Interreg Rhin-Oberrhein
- **2F** Interreg FR-CH
- **2G** Interreg Alpine Space
- **2H** Interreg Bayern-Austria
- **2I** Interreg Alphenrhein Bodensee
- **2J** Interreg IT-CH

Problems of Integration of Policies

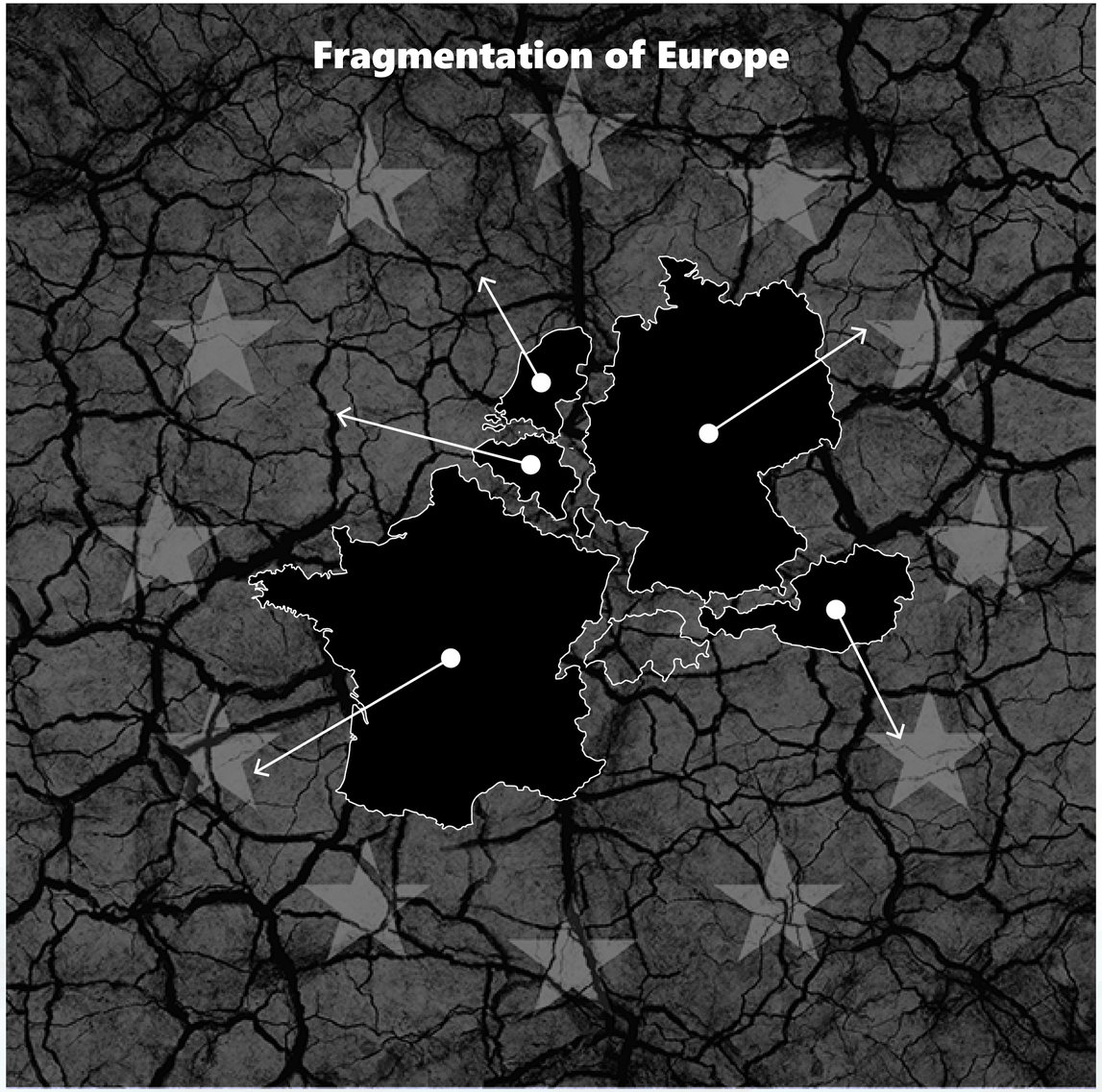
↓

Institutional Thickness

↓

Lack of Territorial Policy Implementation

↓



Problems of Integration of Policies

↓

Over dominant National Authorities

↓

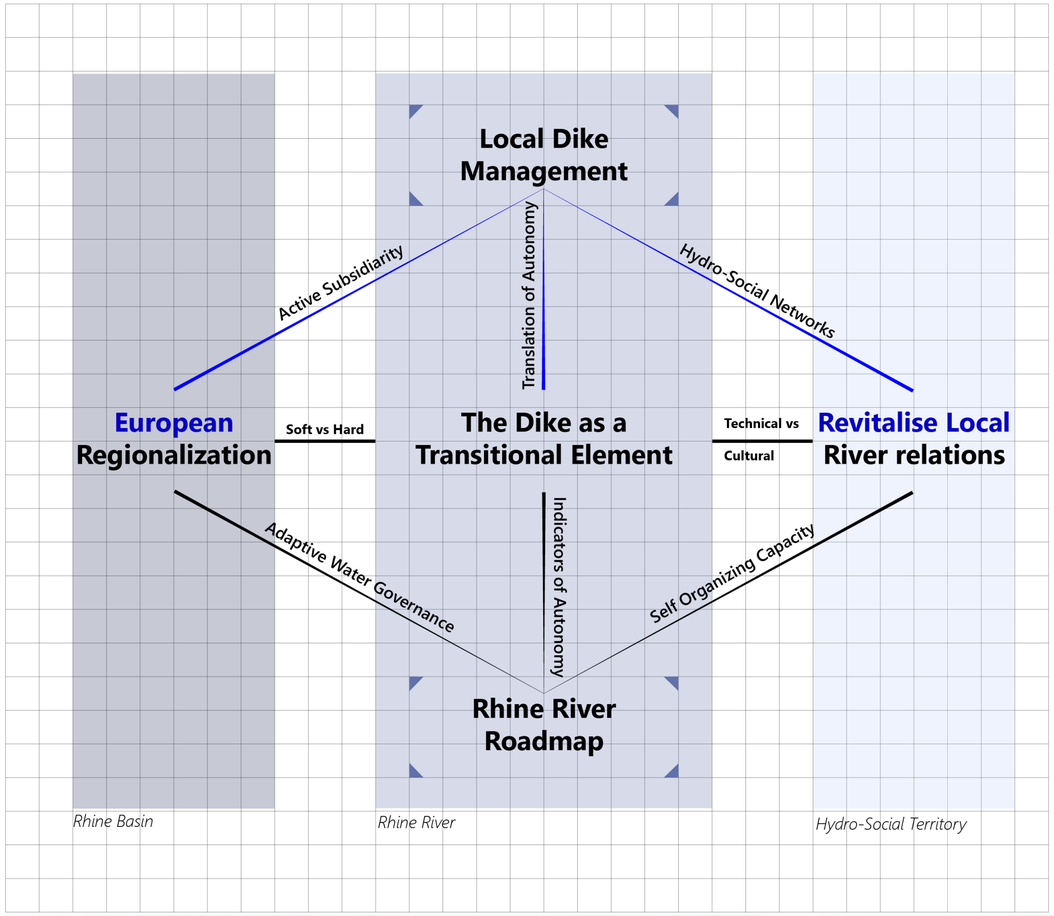
Large Cultural Differences in Spatial Planning Discourse

↓

Increasing the Gap between Europe and its Citizens

WHAT HAVE WE DONE?

WE HAVE CHANGED THE ATTITUDE TOWARD DIKES



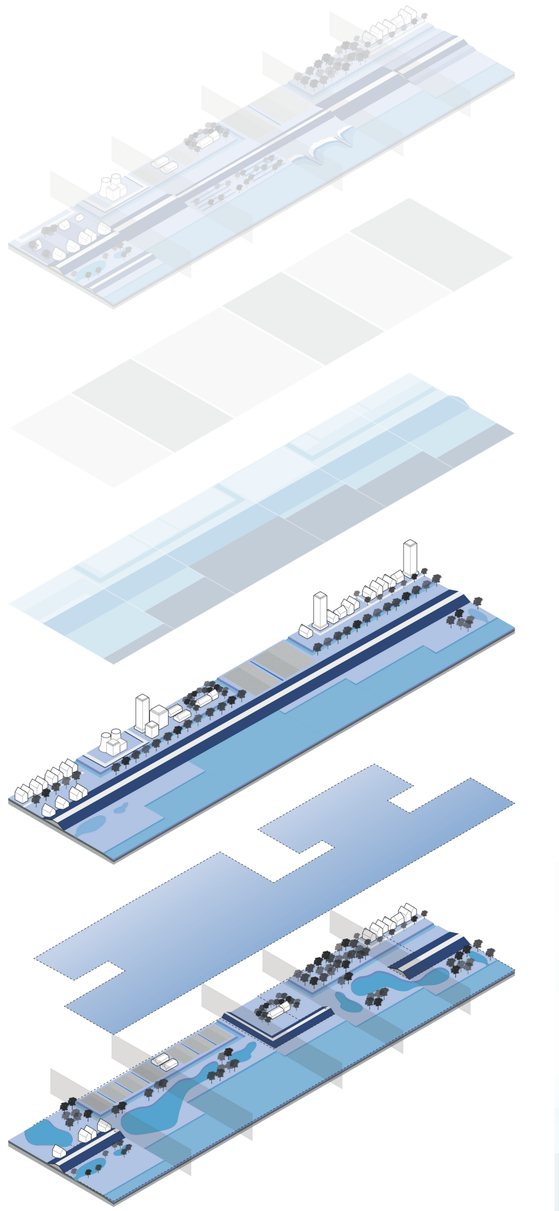
*The project focuses on the spatial element of the **dike** as a **Transitional element** between the process of **European Regionalization** and **Revitalizing local river relations**, through the creation of a **roadmap towards local dike management**.*

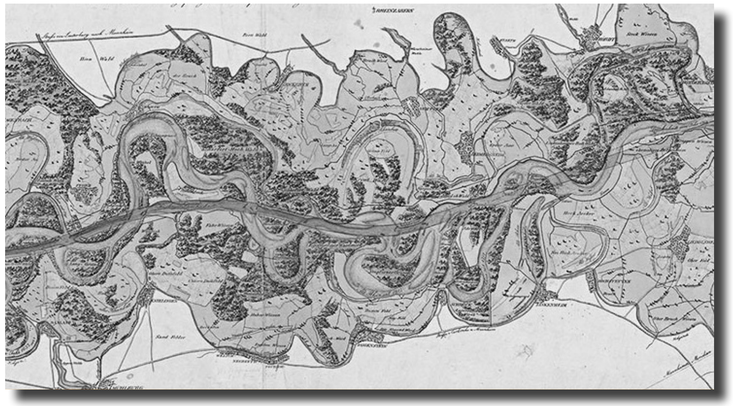
History of Dike Management

Simple element to protect local farms

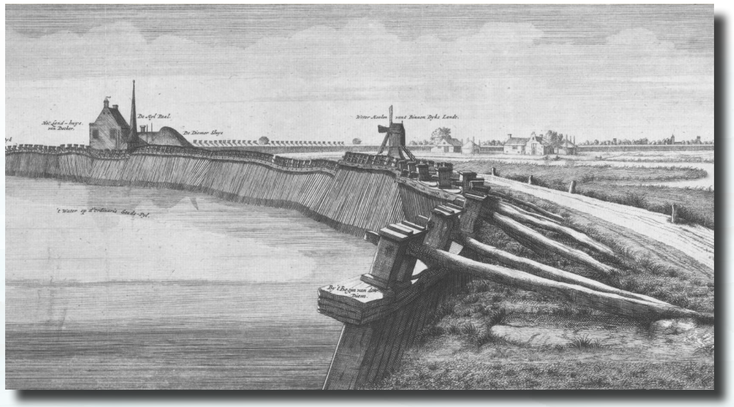
High urbanization rates towards the Rivers Edge

Control of the River by large National Authorities







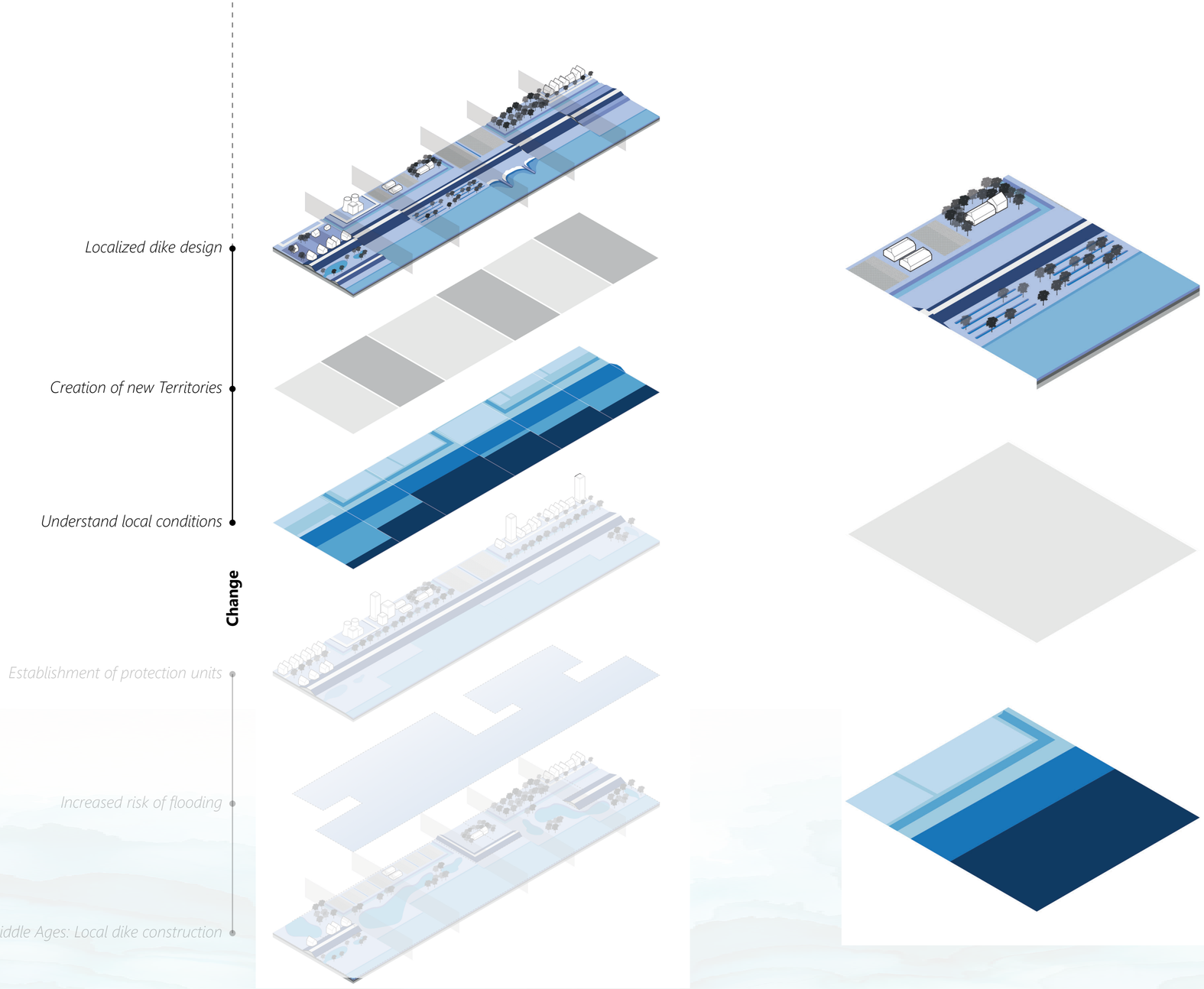


Future of Dike Management

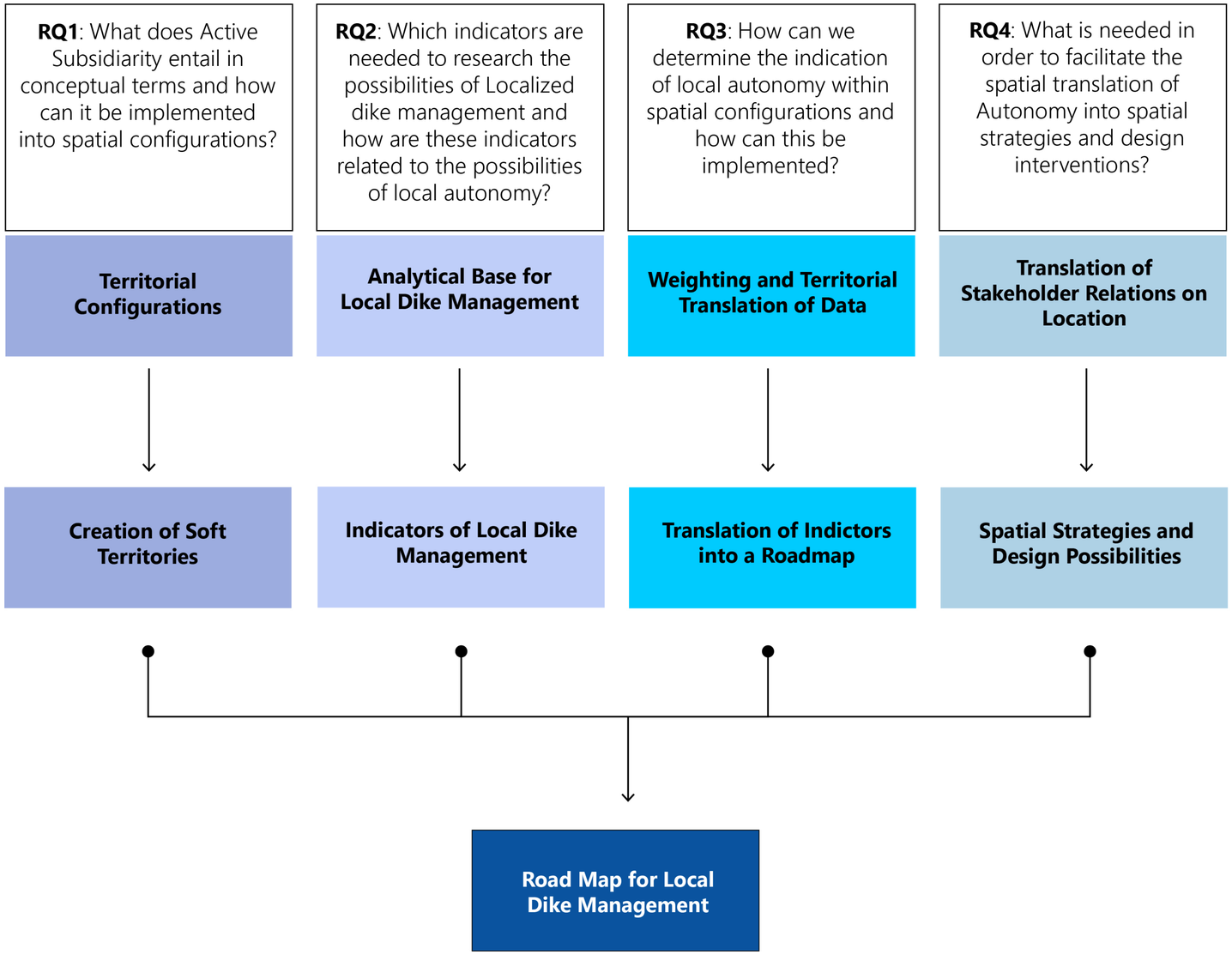
Understanding local context differences

Establishing new spatial areas of interaction

Localized dike construction



How can Active Subsidiarity empower localized autonomy of dike management, facilitating a new ‘line of defense’ & awareness of climate extremes regarding the Rhine River?



Moving through the Rhine scales

Creation of a Roadmap showing the steps from:

Rhine River Autonomy Indicators

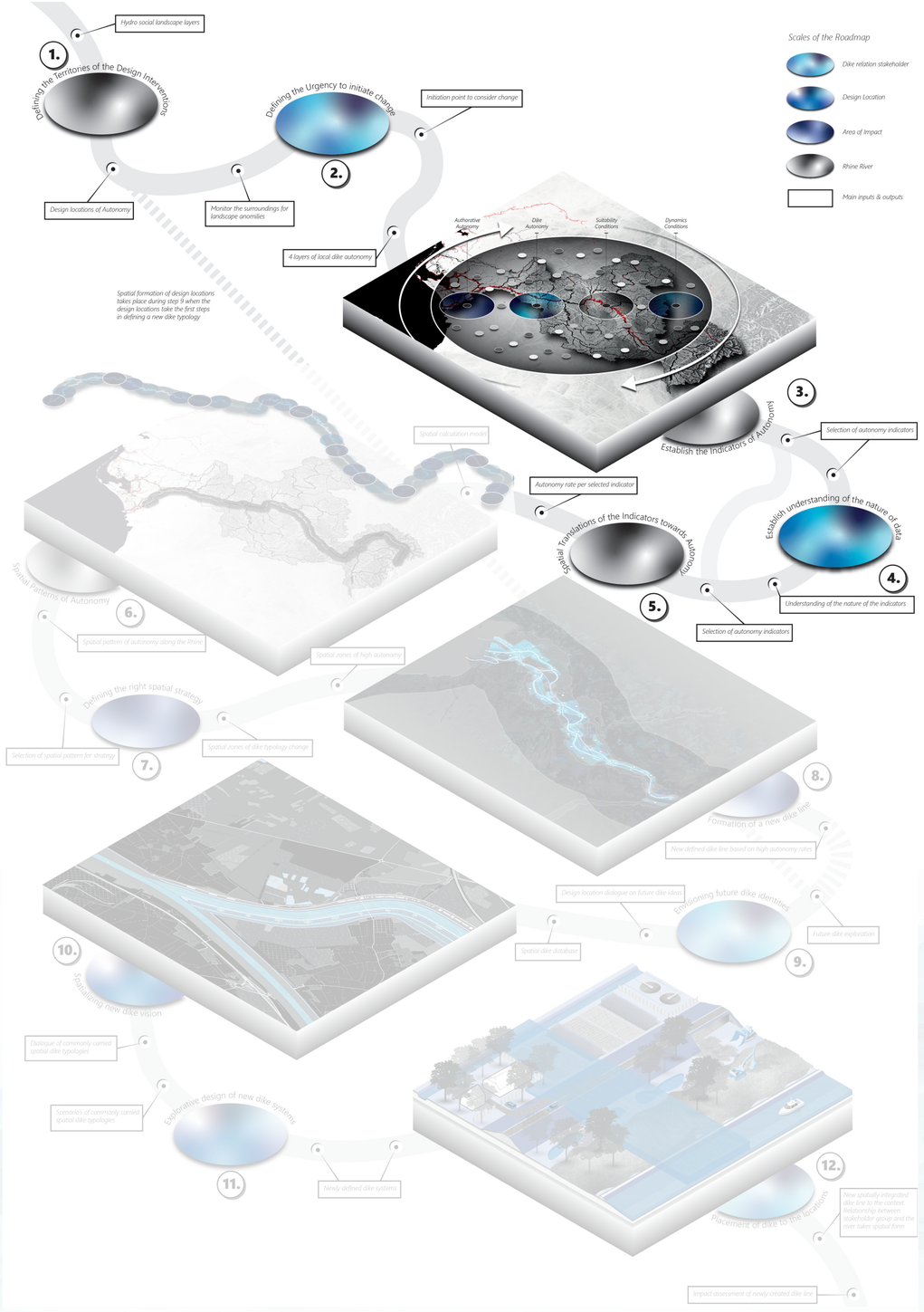
↓

Localized potentials for Dike Autonomy



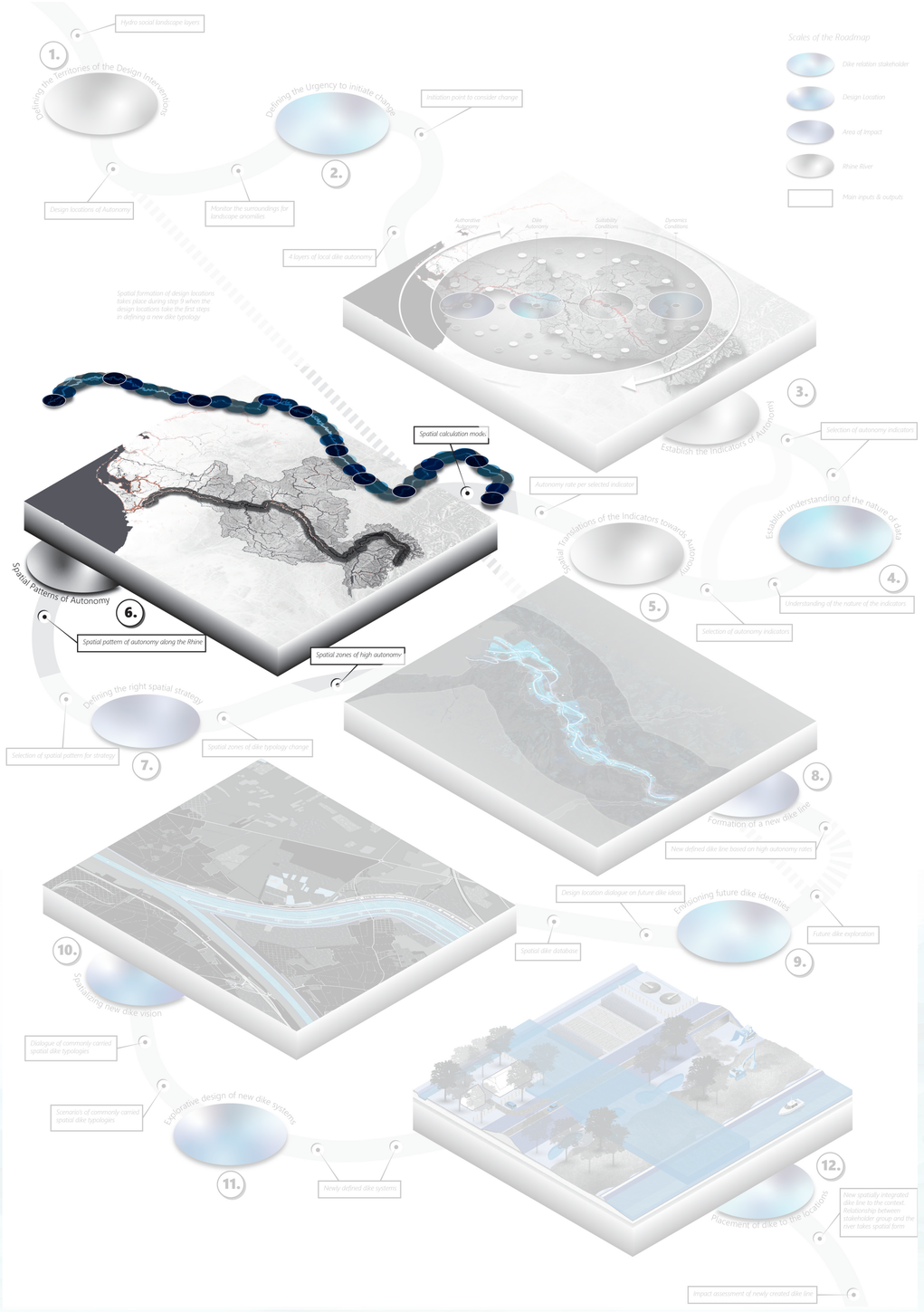
Moving through the Rhine scales

(1). *Understanding the conditions that are created within the Rhine Basin*



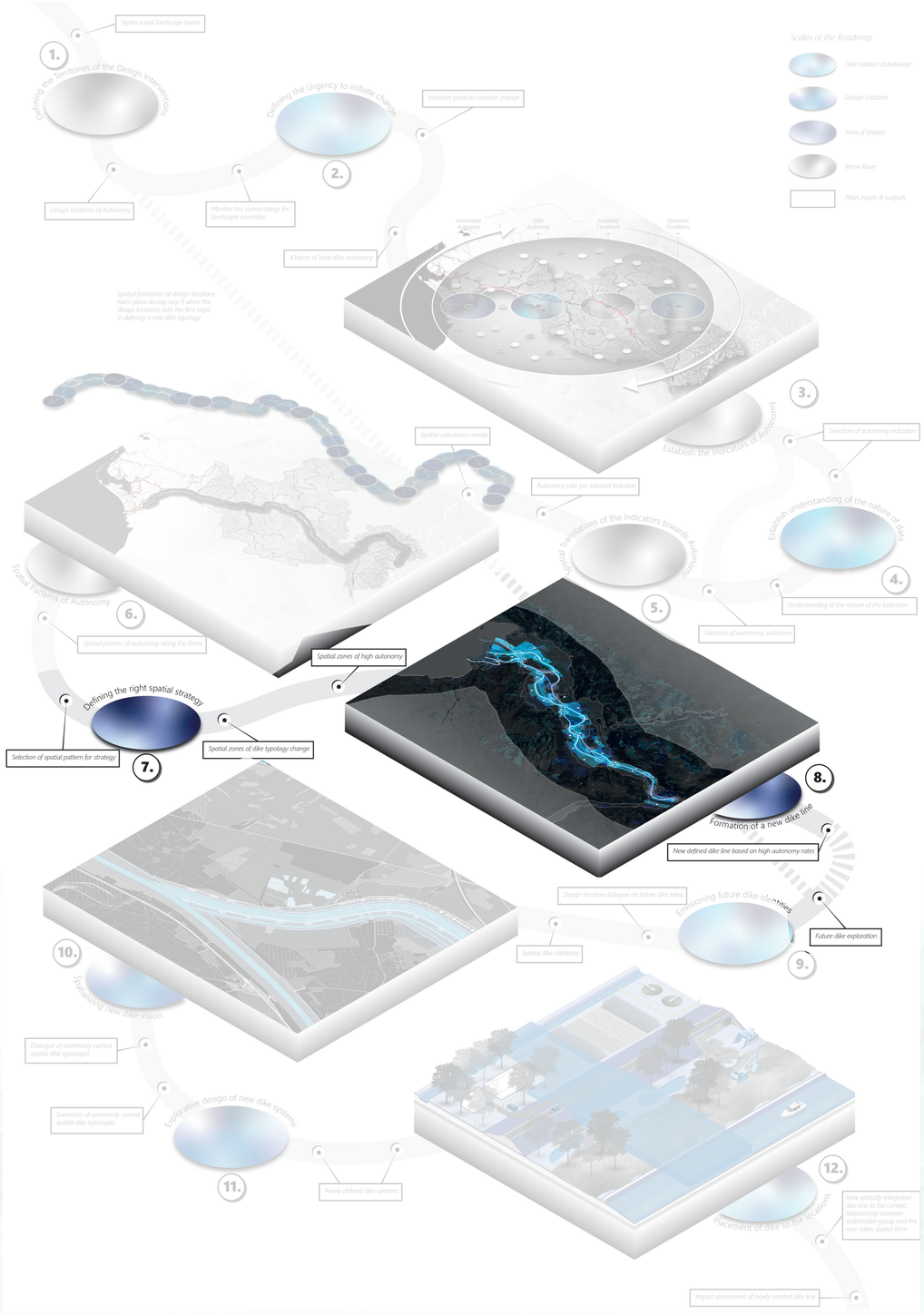
Moving through the Rhine scales

(2). *Spatialization of the Rhine indicators to determine areas of Autonomy potentials*



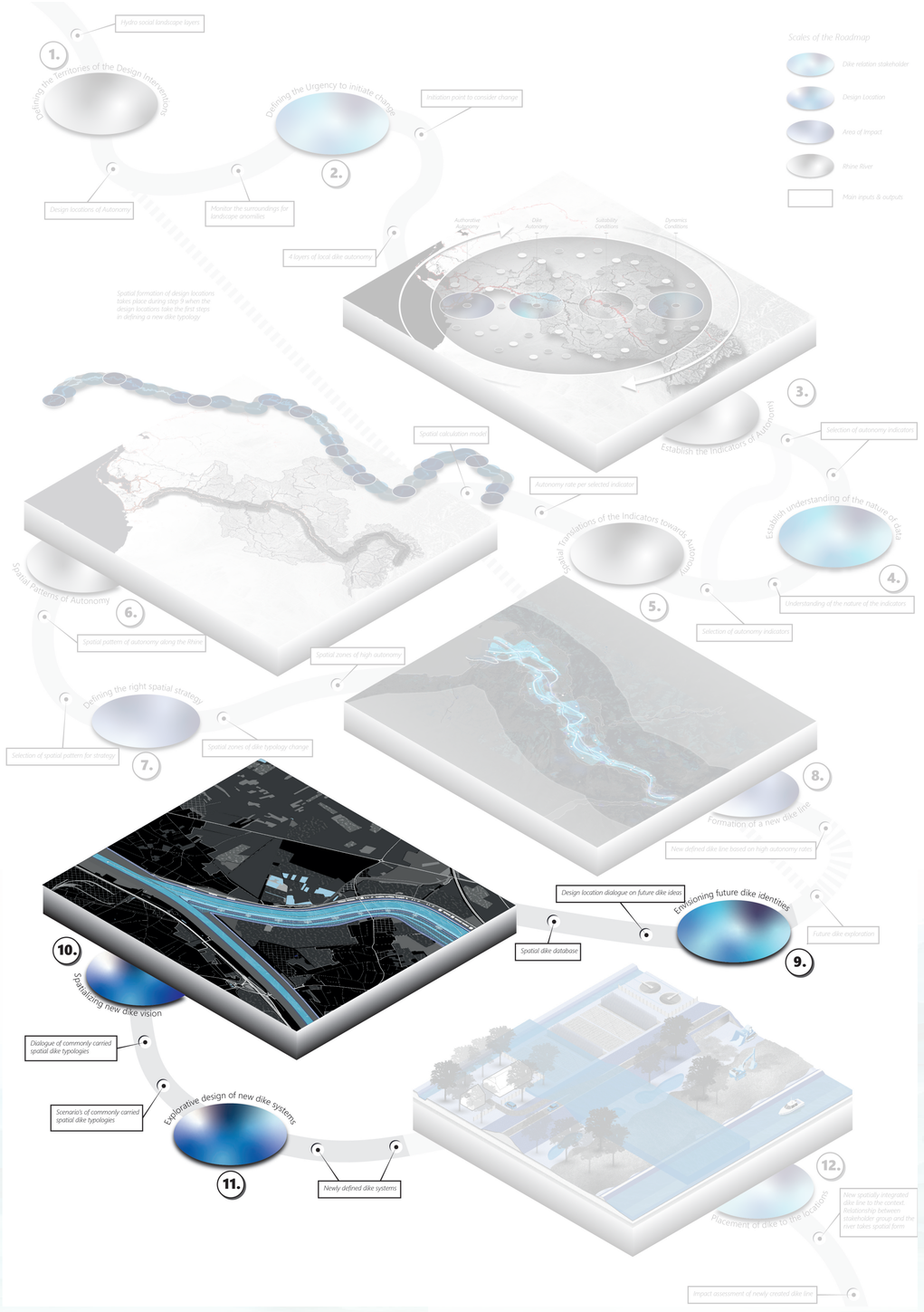
Moving through the Rhine scales

(3). *Data designates potential locations for autonomous dike lines.*



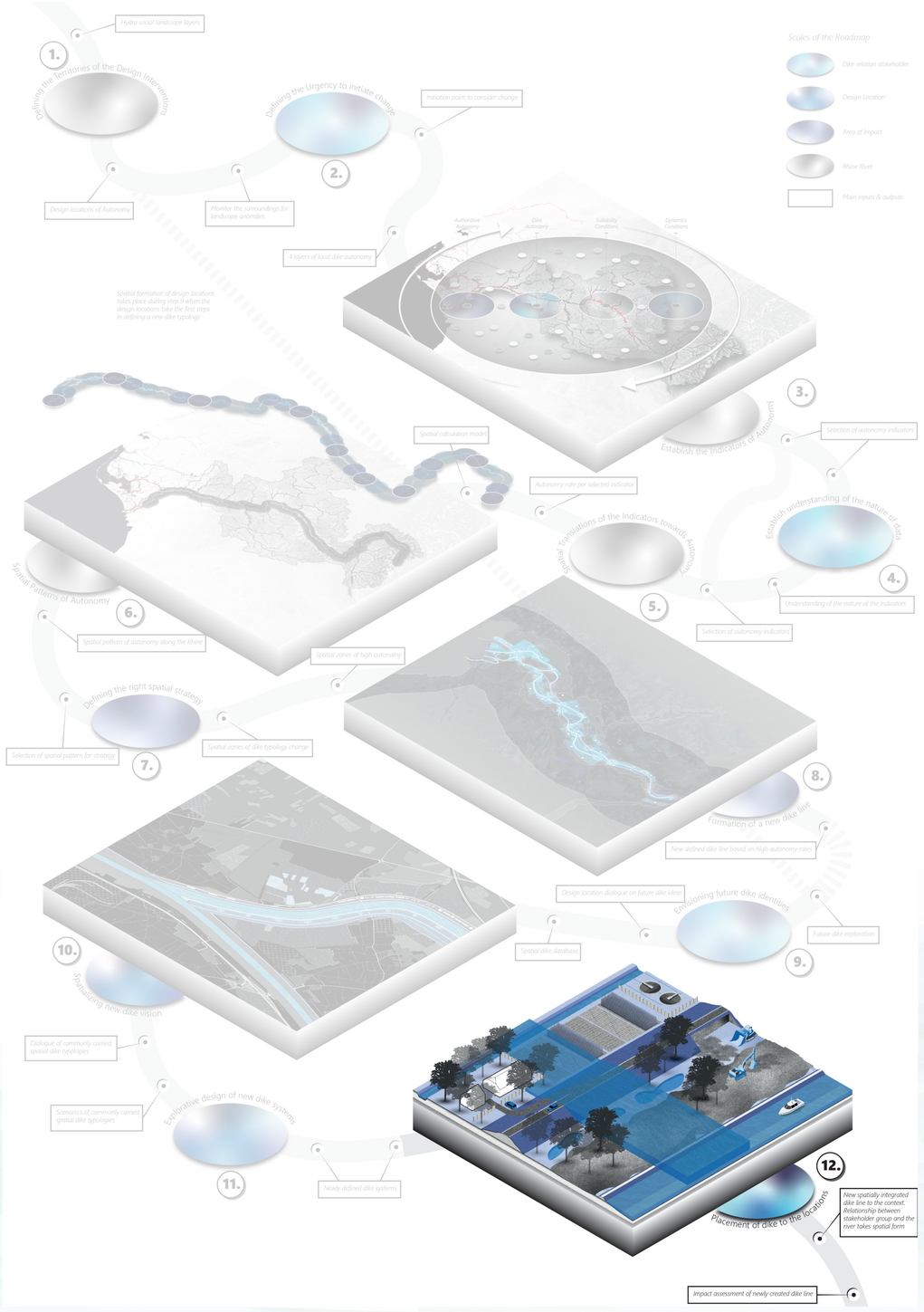
Moving through the Rhine scales

(4). *Establishment of Design Locations based on a shared relations between Man & River*



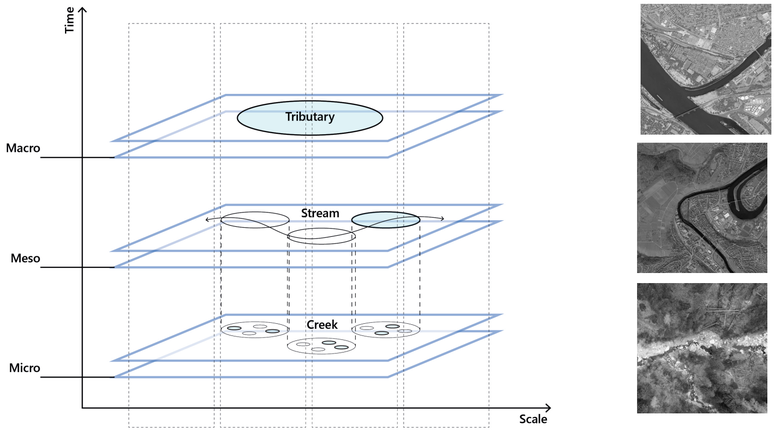
Moving through the Rhine scales

(5). *Spatialization of local dike relations into new spatial dike systems.*



WHAT HAVE WE DONE?

RESPATIALIZE THE AREA OF INTERACTION



Extent

Every water body can be classified based on a certain scale

Content

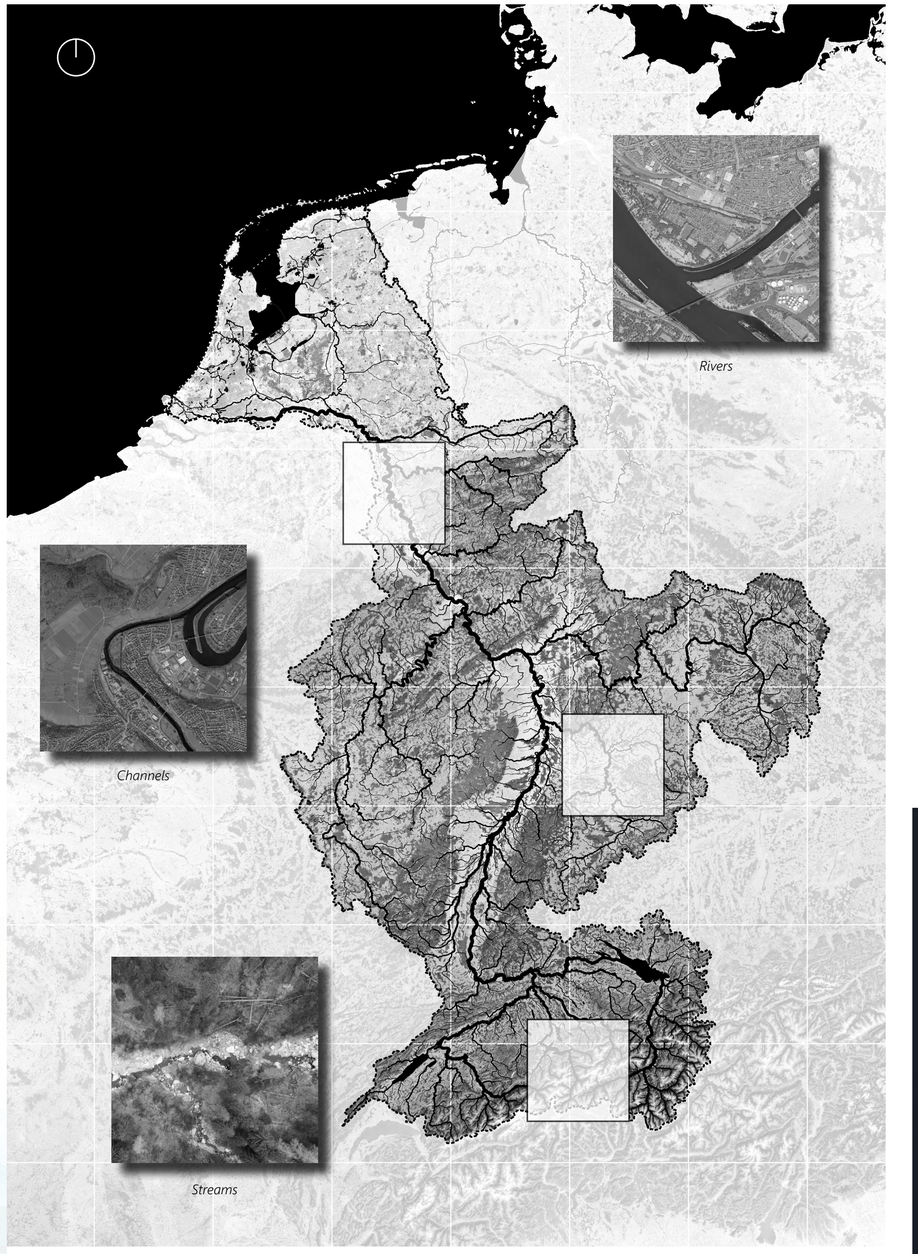
Every water body has to deal with different spatial contexts

Importance

Water bodies on different scales have different importances

Interrelations

Throughout history, water bodies have had different impacts on society

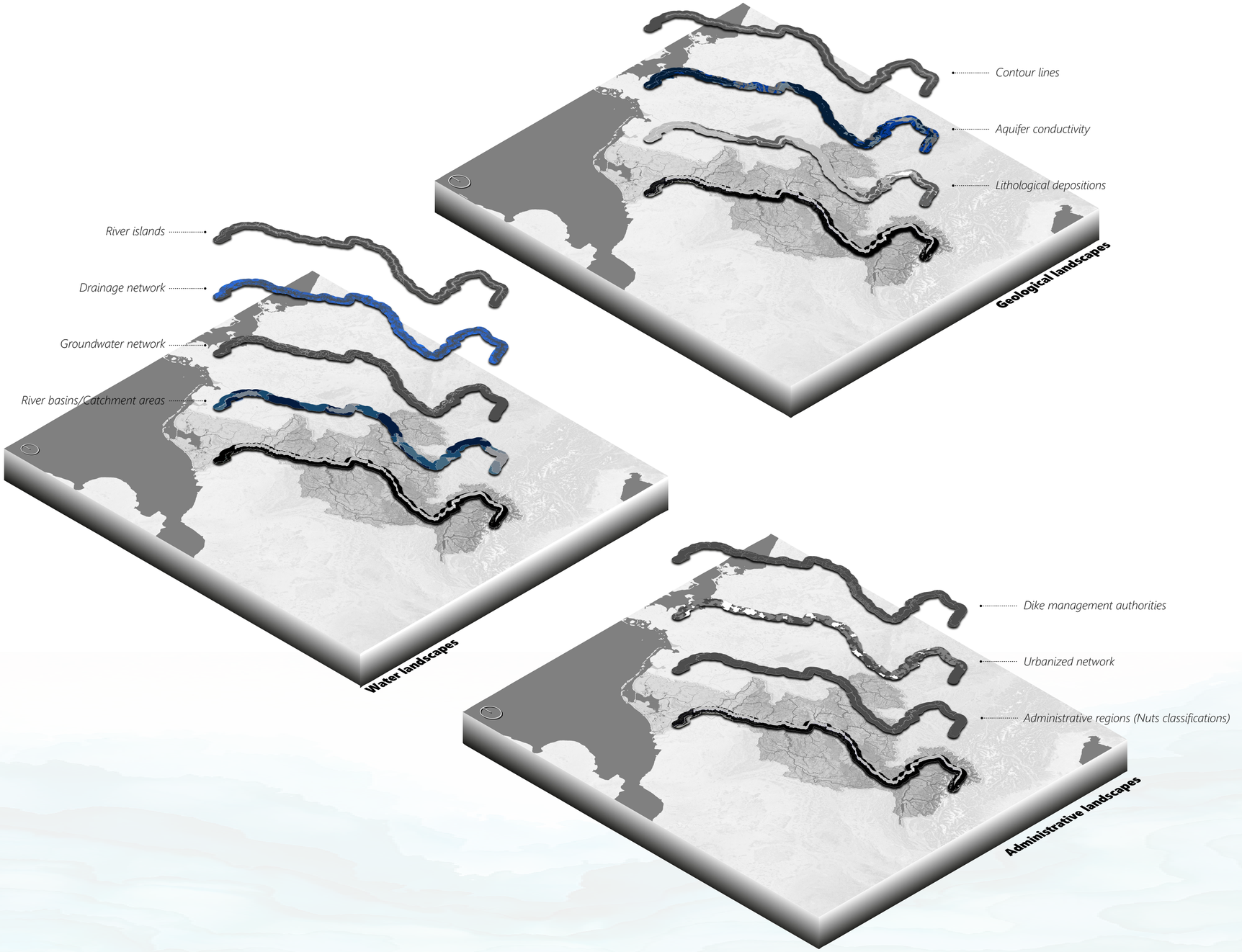


3 Layers of Hydro-Social Territories

Geological Landscapes

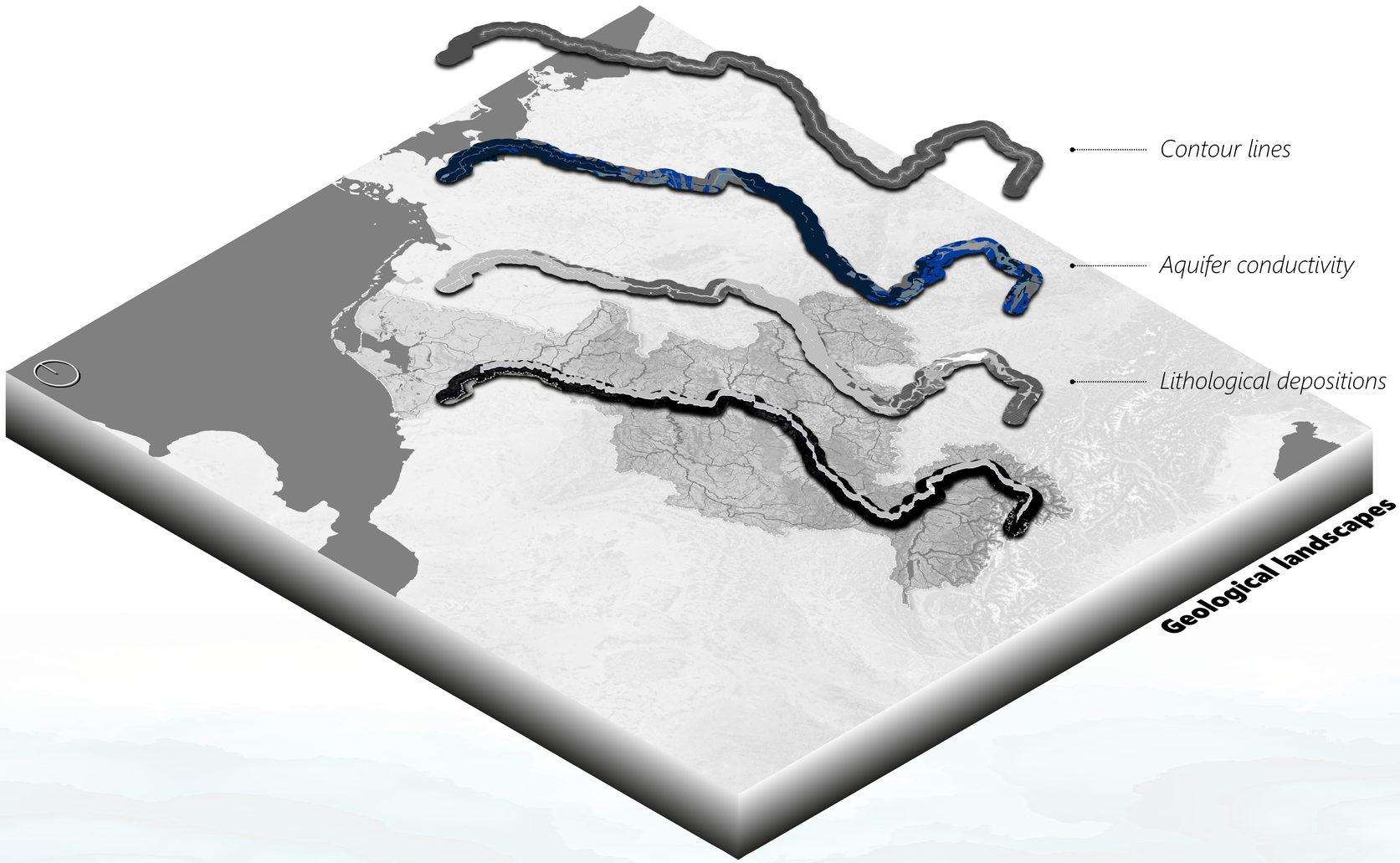
Water Landscapes

Adiminstrative Landscapes



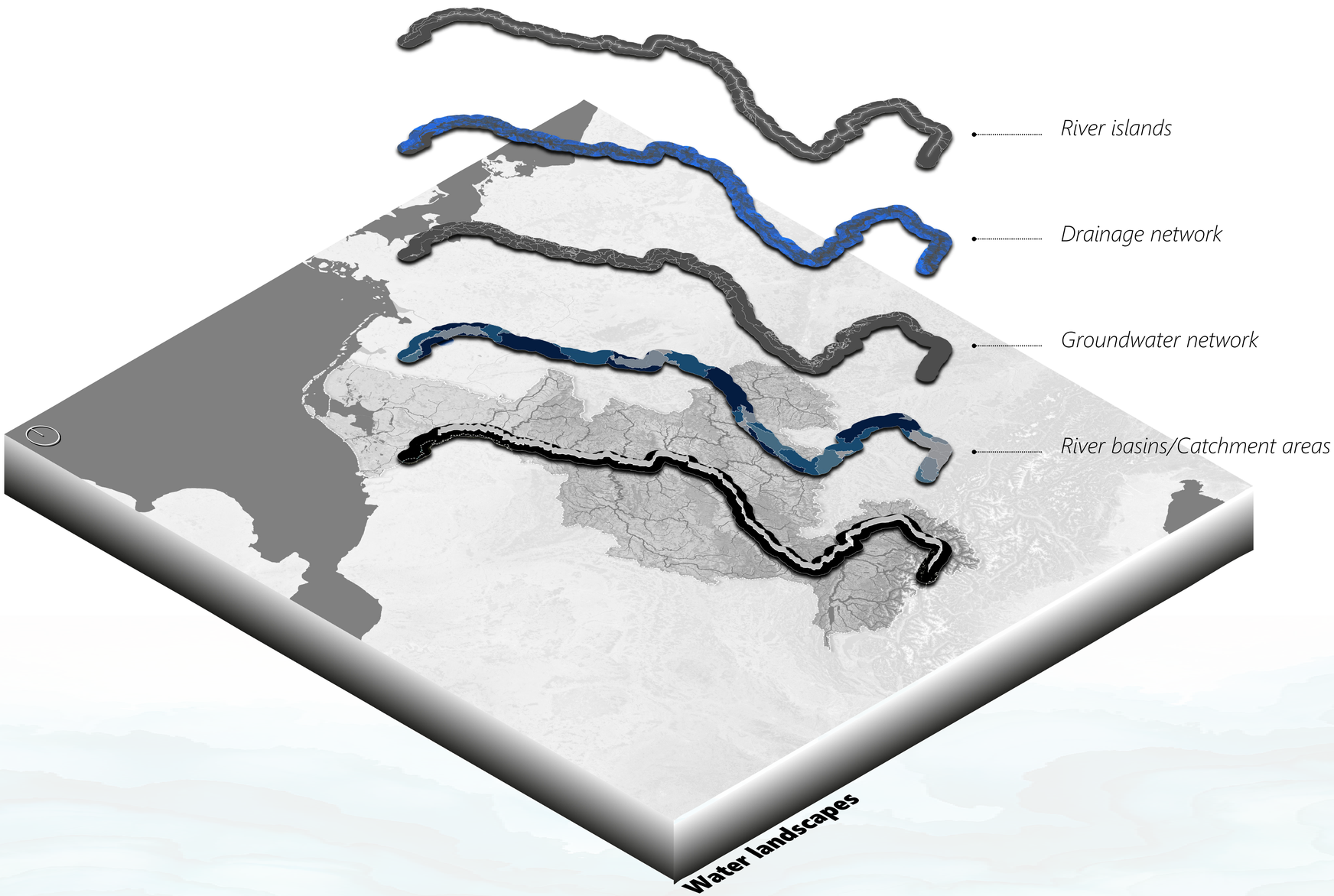
Geological Landscapes

The underlying soil formations that establish the foundation of the relationship on the surface



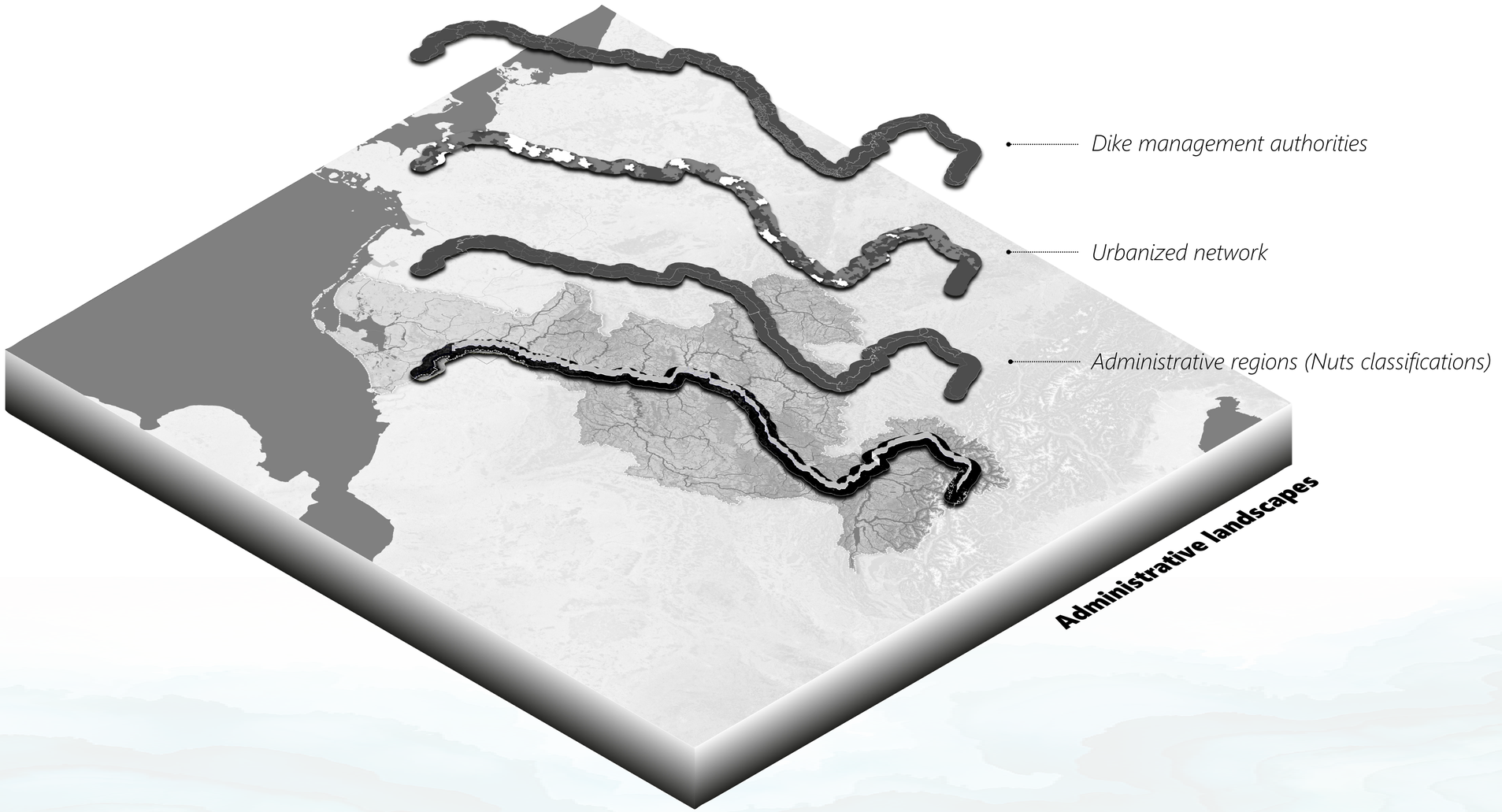
Water Landscapes

The spatial translation of the existing Hydrological System



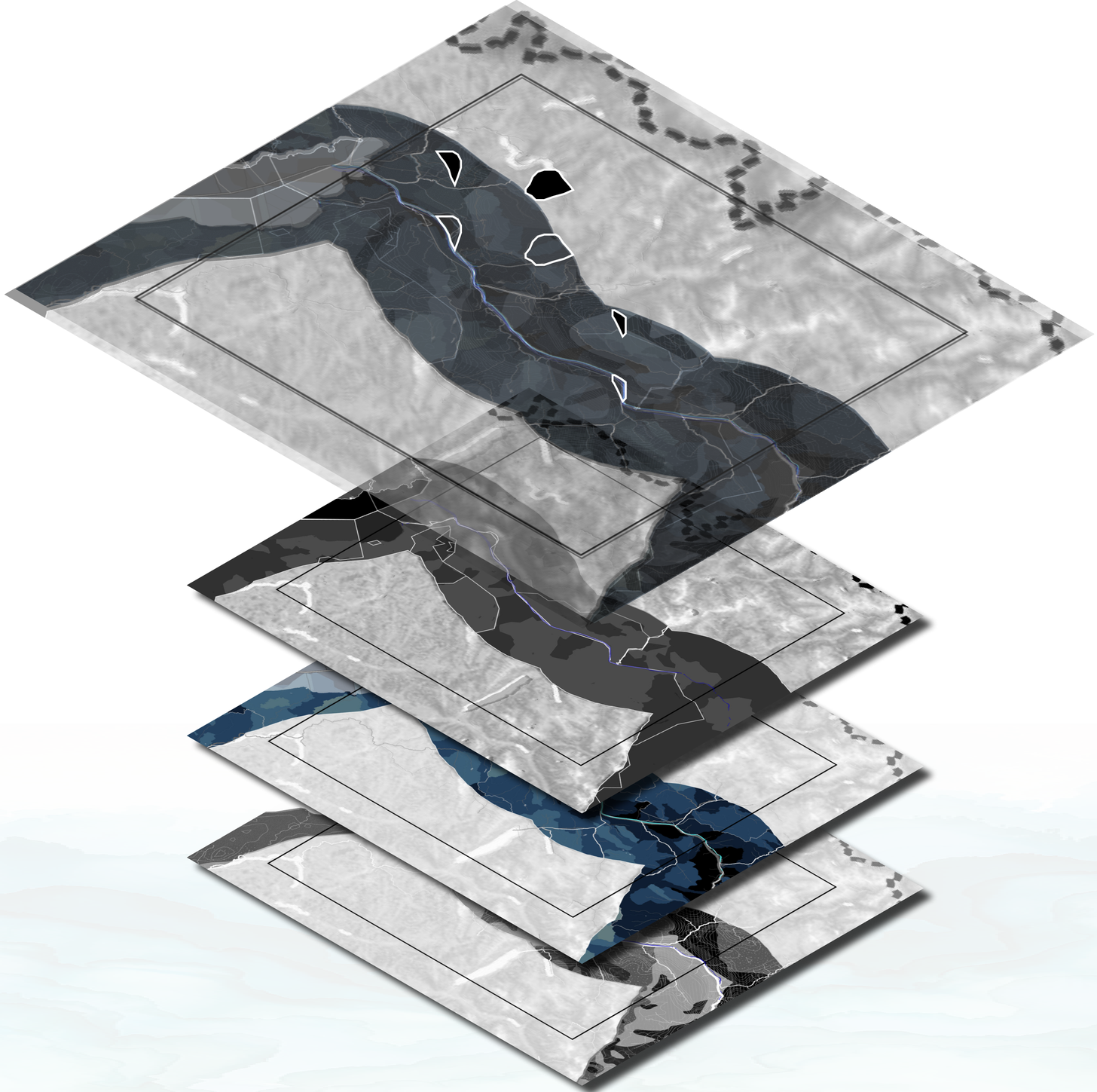
Administrative Landscapes

The spatial translation of the existing areas where mutual regulations and practices form Administrative units



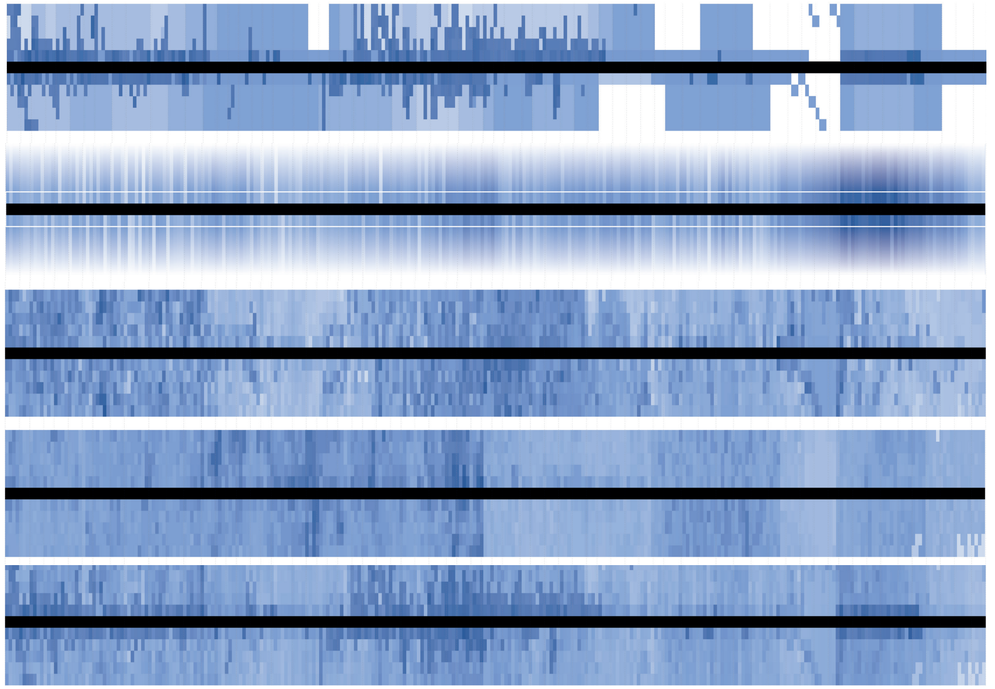
Establish new Territories

Formation of newly defined areas where a mutual relation is formed between River & Man



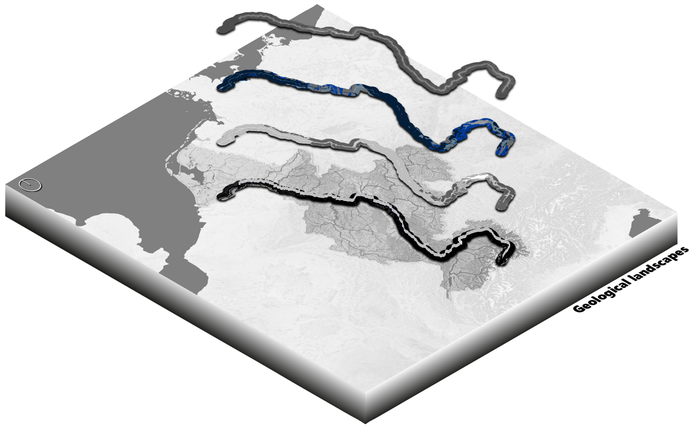
HOW HAVE WE DONE THIS?

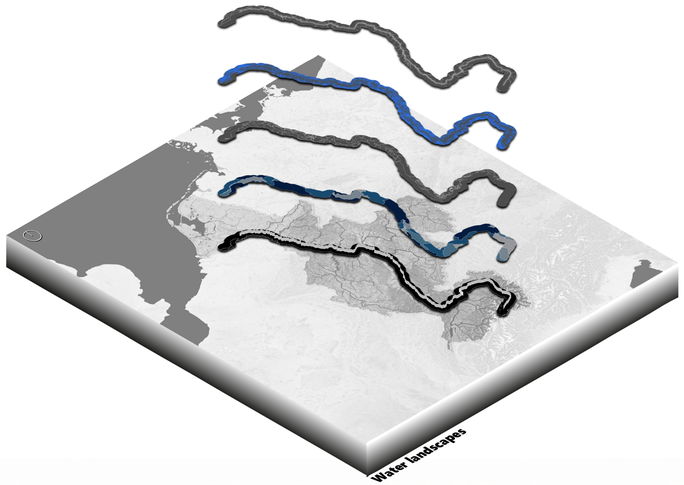
BUILDING A CENTRAL MODEL FOR THE RIVER

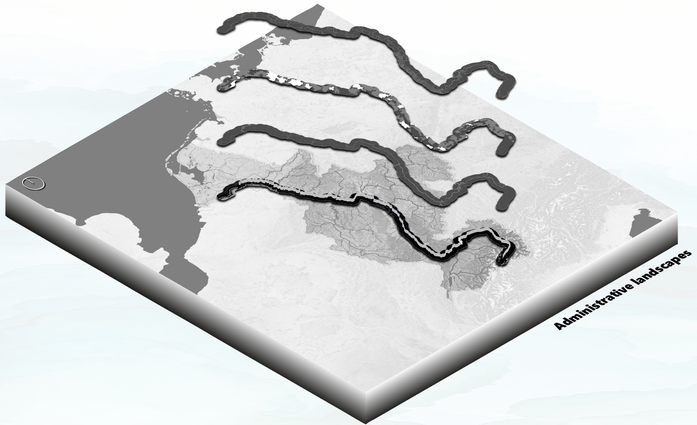


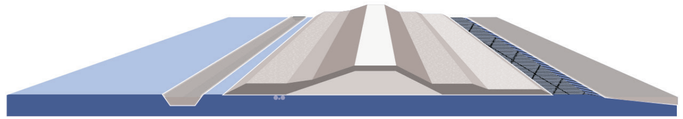
Establishing a Set of Indicator Groups

Determining the conditions for Localized Dike Autonomy to gain foothold along the Rhine

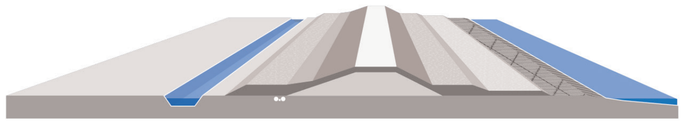




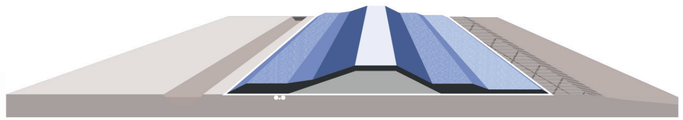




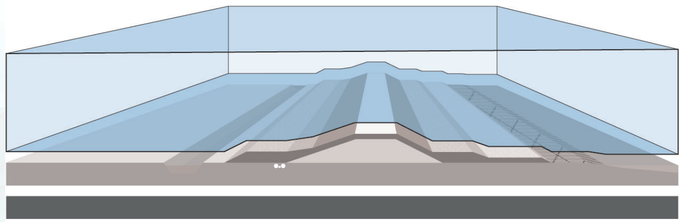
Suitability Indicators



River Indicators



Dike Indicators

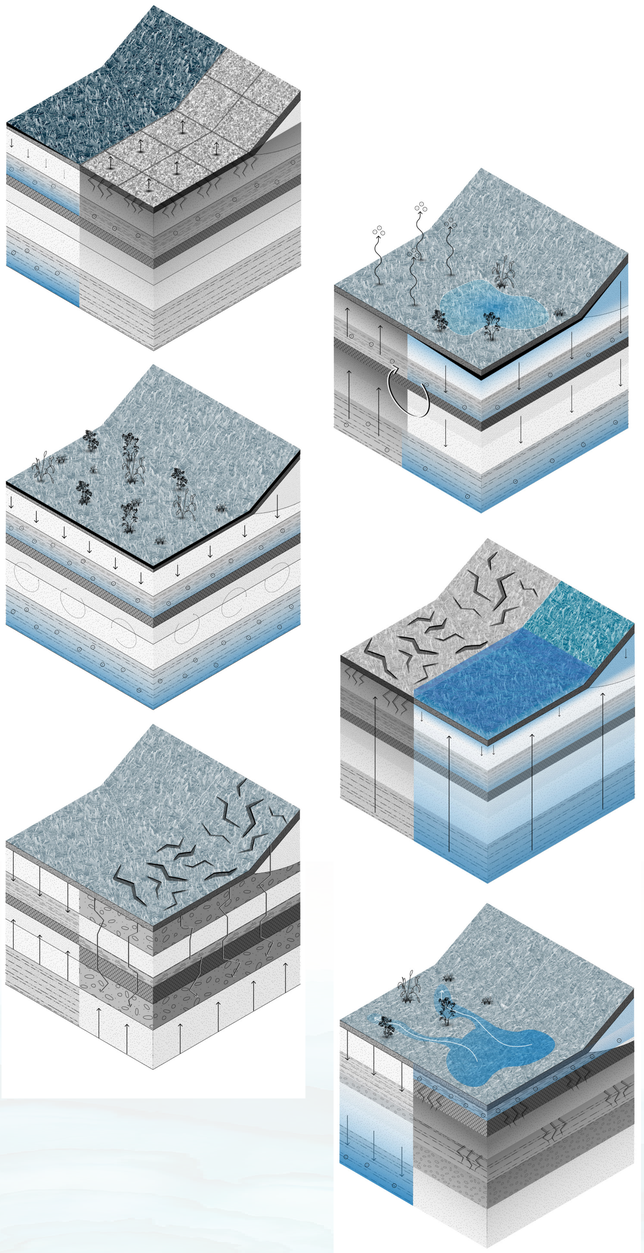


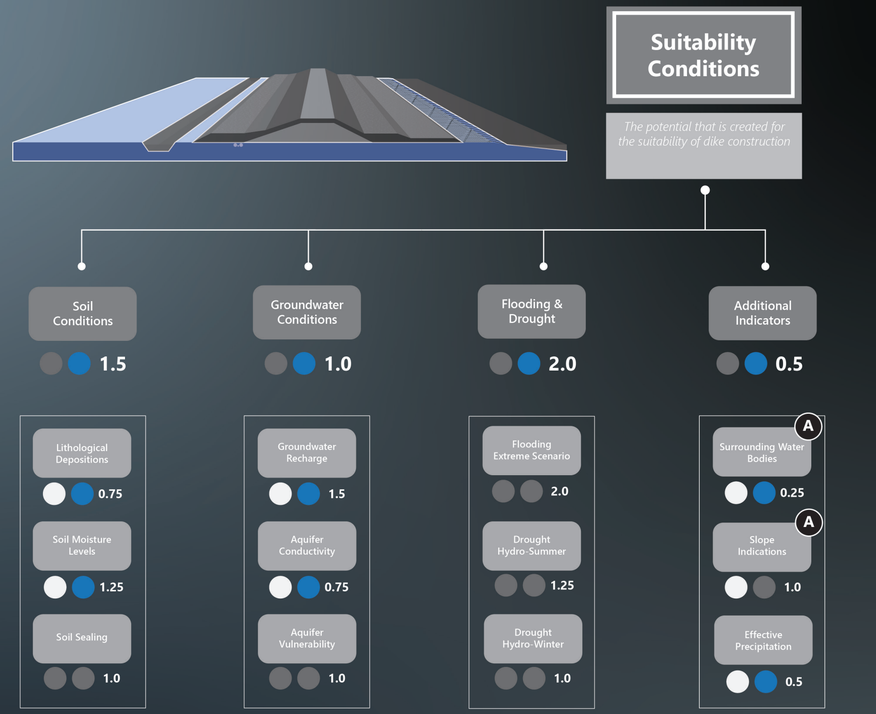
Authoritative Indicators

Establishing a Set of Indicator Groups

(1). Suitability Conditions

Surrounds the question of whether a dike can be placed on a particular location.

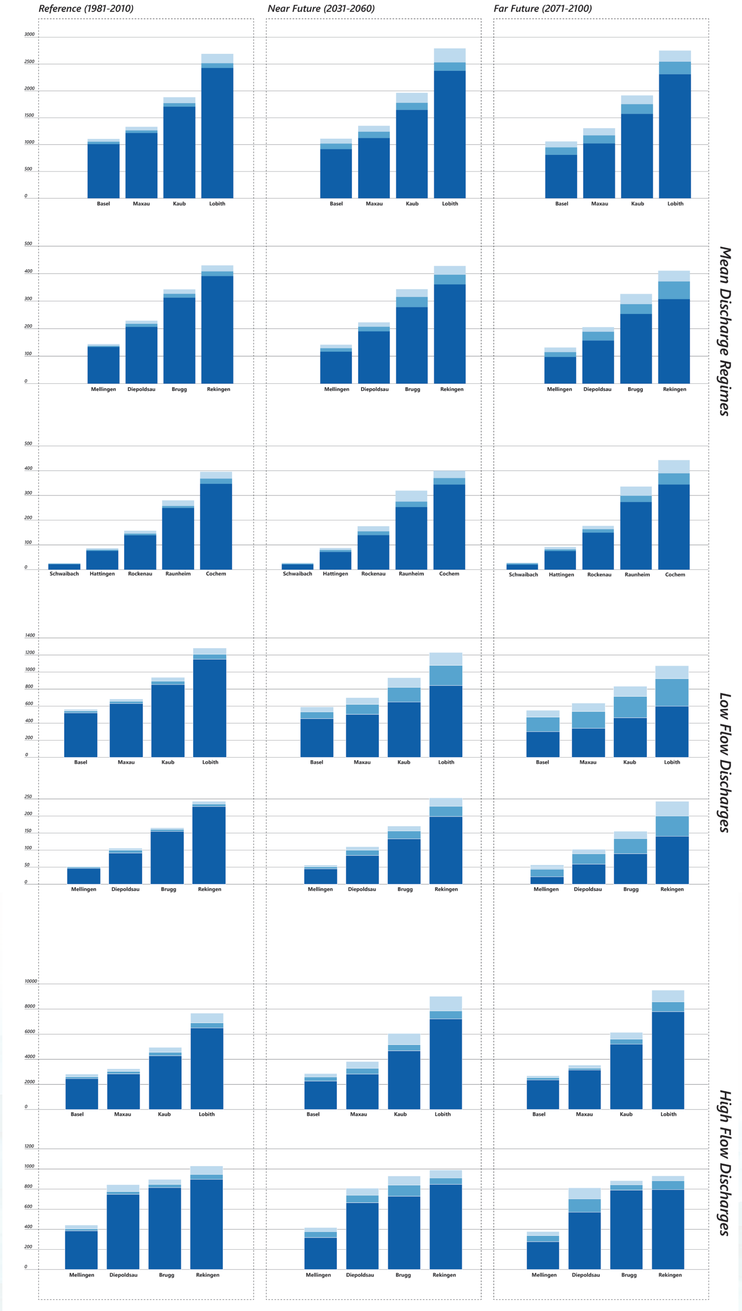


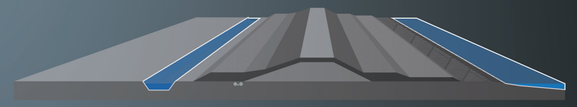


Establishing a Set of Indicator Groups

(2). Dynamics Conditions

Based on the natural conditions that are provided by the Rhine river itself





Dynamics Conditions

Concerning the conditions that are influencing the stability and/or location of a dike body

- River Discharge — 1.5
  - Change in High-Low Flow (2050) — 1.5
  - Uncertainty High-Low Flow (2050-2100) — 1.0
  - Low Flow Drought — 1.25
  - *Quantitative Water Discharge* — 1.0
  - Total Discharge of the River — 1.0
  - Rate of Discharge Change — 1.25
  - Tributaries of the Rhine — 0.25
- Dike System Interruptions — 0.75
  - Water Distribution Mechanisms — 1.0
  - Groins of the Rhine — 1.0 (A)
  - Water Nodes — 0.75
  - River Measures (Width) — 0.5
- Sedimentation Patterns — 1.25
  - Sedimentation Material — 1.25
  - River Angles & Erosion — 1.5

Relation to Created Autonomy · Relation to Dike Suitability · Weight given in calculation · Used as an Addition to Autonomy

A

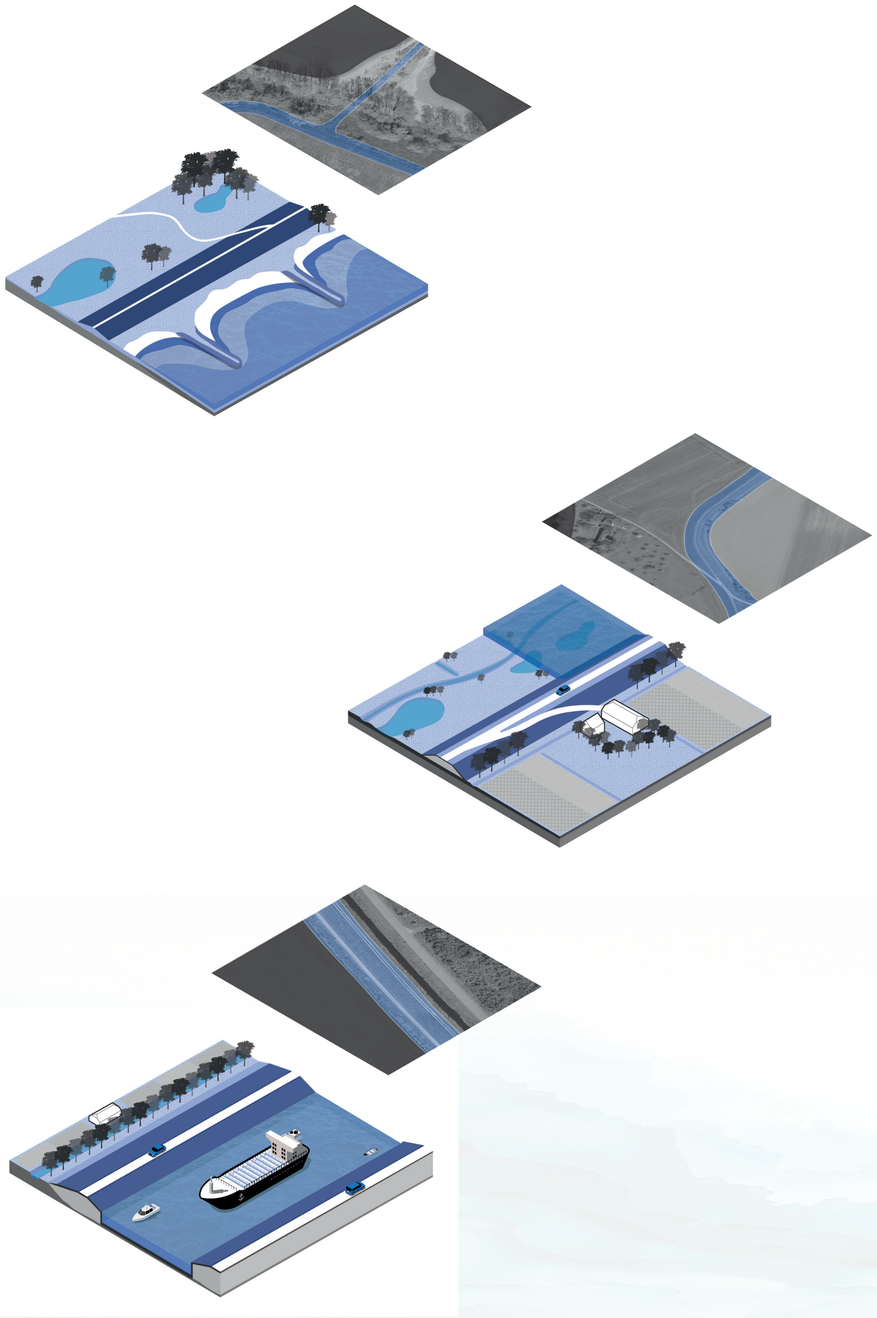
Positive · Negative · Neutral

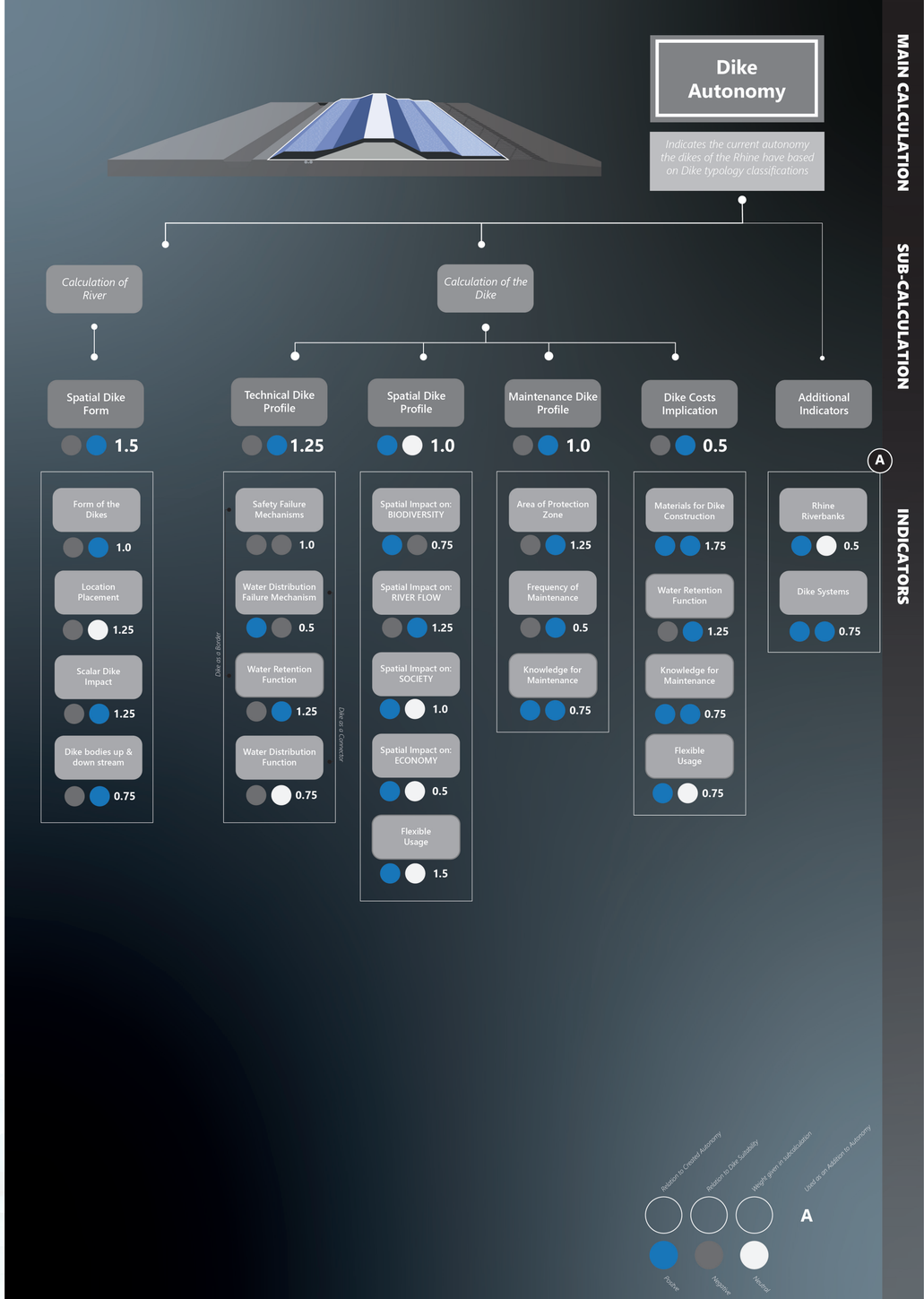
MAIN CALCULATION · SUB-CALCULATION · INDICATORS

Establishing a Set of Indicator Groups

(3). Dike Autonomy

Surround the central character of the dike as a transitional element within the landscape

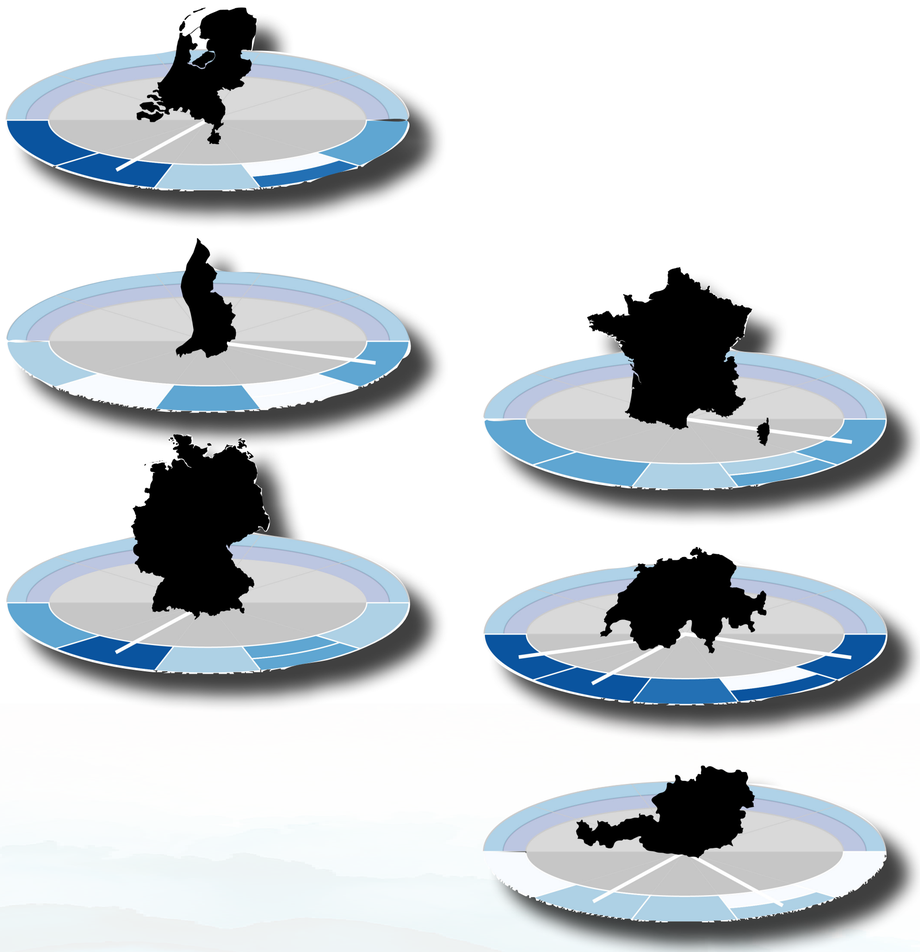


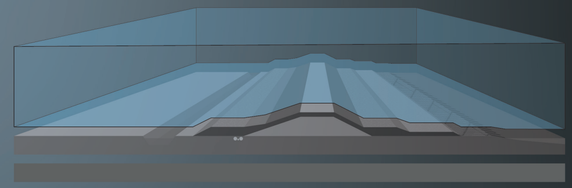


Establishing a Set of Indicator Groups

(4). Authoritative Regions

Based on the on spatial configurations where certain rules, regulations, practices and management systems take place





Authorative Regions

Indicates the potential to self-govern within the decision-making process of dike management

MAIN CALCULATION

SUB-CALCULATION

INDICATORS

- **(Flood) Safety Regions** — *Chance of Flooding as to future projections (moderate + extreme)* — 1.0
  - Future Prediction (Moderate) 1.0
  - Future Prediction (Extreme) 1.0
- **Decision Making Autonomy** — *Available IWM qualities according to existing landuse classification* — 2.0
  - Available Knowledge 2.0
  - Available Funds 1.75
  - Available Space 1.5
  - Self-Organizing Capacity 1.0
  - Total Stakeholder Involvement 0.75
  - Dealing with Uncertainties 0.5
  - A
    - Existing Projects IKSR 0.75
    - Spread of Project Influence 0.5
- **Autonomy of the Adminstration** — *Administrative layers of complexity that (dis)allow autonomy* — 1.5
  - *Socio-Economic Conditions* 1.75
    - GDP as per purchasing power standard 1.0
    - Urbanized Regions 0.75
  - *Political Landscape* 4.5
    - Water Management Powers 1.0
    - Dike Management Powers 1.5
    - Trust in Governance 0.25
    - Trends in Adaptiveness 0.5
    - Trends in Citizen Engagement 0.5
    - Water Management Integration 0.5
    - Spatial Planning Discourse 0.25
- **Water Use Distribution** — *Autonomy as based on the Efficiency of Water Use per land use classification* — 1.25
  - *Economic Water Use Efficiency* 1.5
    - Water Use 0.75
    - Water Efficiency 0.25
  - *Quantitative Water Use* 0.25
    - Power Plant Water Use 1.5
    - Waste Water Points 1.0
    - Water Dependent Regions 2.0
  - A

Relation to Created Autonomy · Relation to Dike Suitability · Weight given in calculation · Used as an Addition to Autonomy

Positive · Negative · Neutral · A

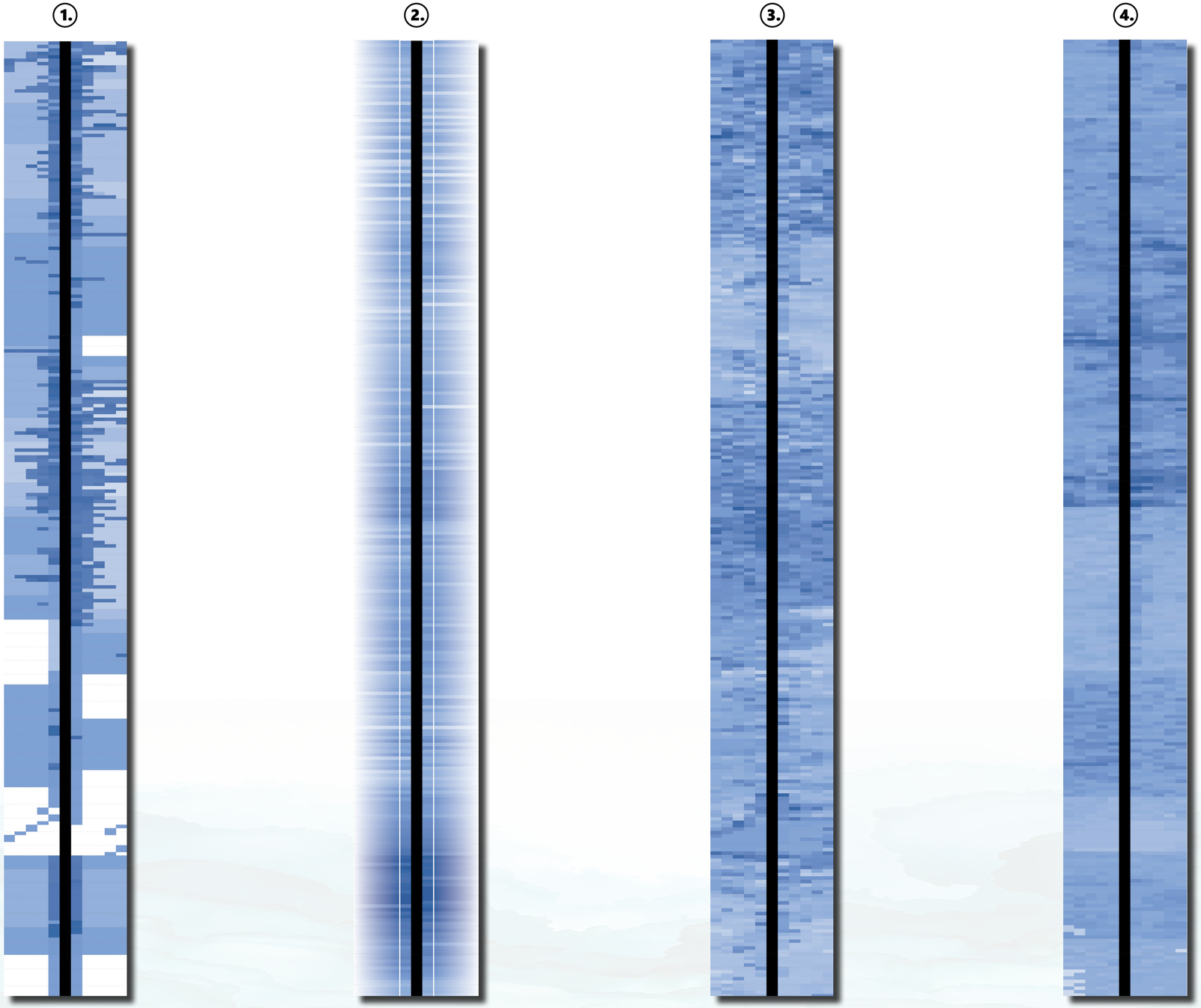
Autonomy Lines of the Rhine

(1). *Dike Autonomy*

(2). *River Dynamics*

(3). *Suitability Conditions*

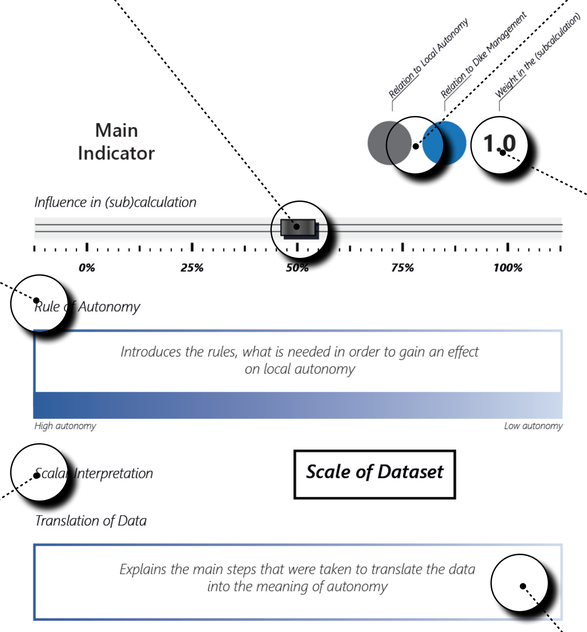
(4). *Authoritative Regions*



Influence of the Indicator within the calculation, represent the indicators importance

Does it have a positive or negative relation to Dike Management & Local Autonomy

The main Rule of Autonomy explaining the relation between the Indicator & the potential of local autonomy



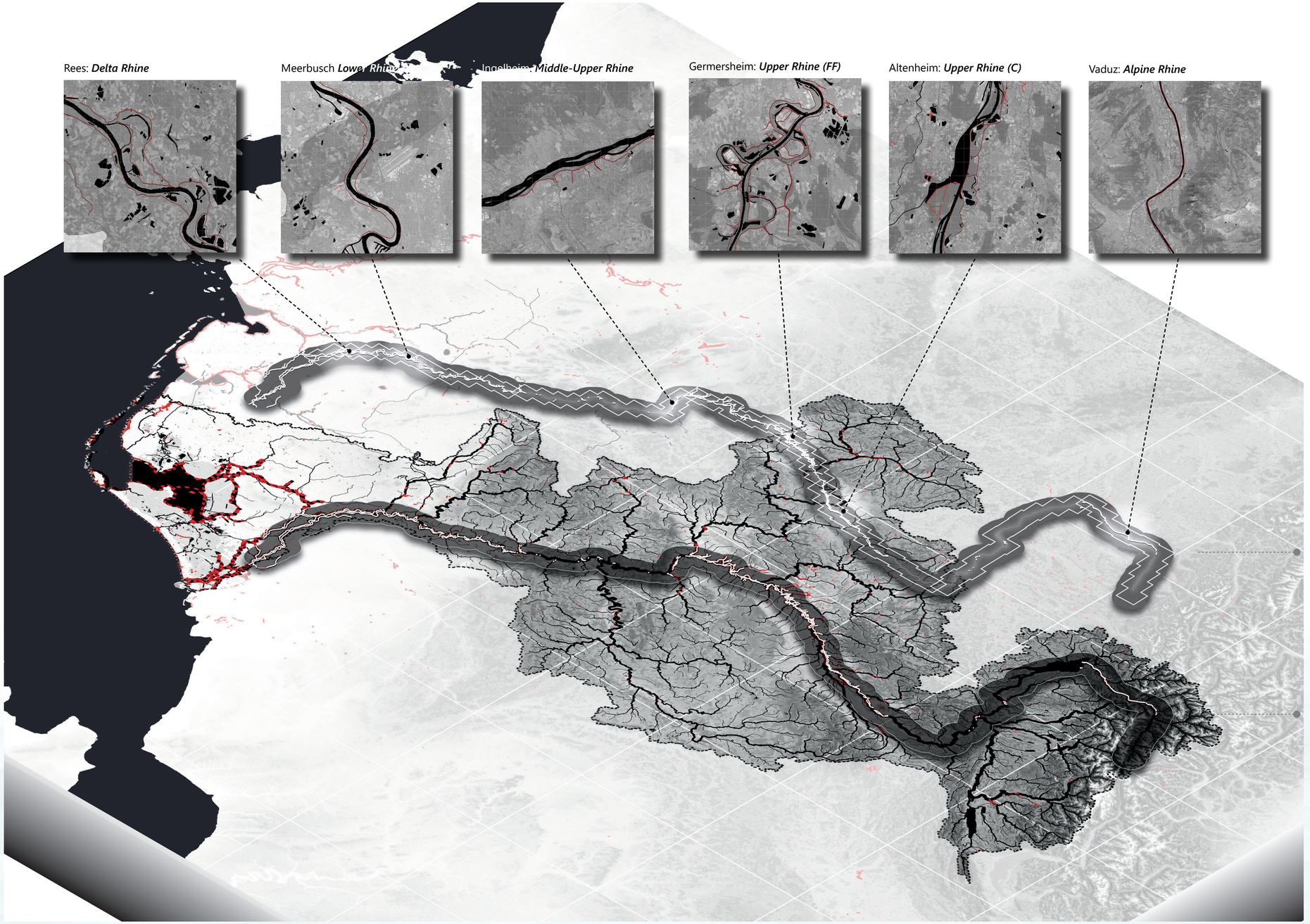
Weight of the Indicator per calculation

The scalar impact of the data used within the calculation

The translation of the used data towards the meaning of Autonomy

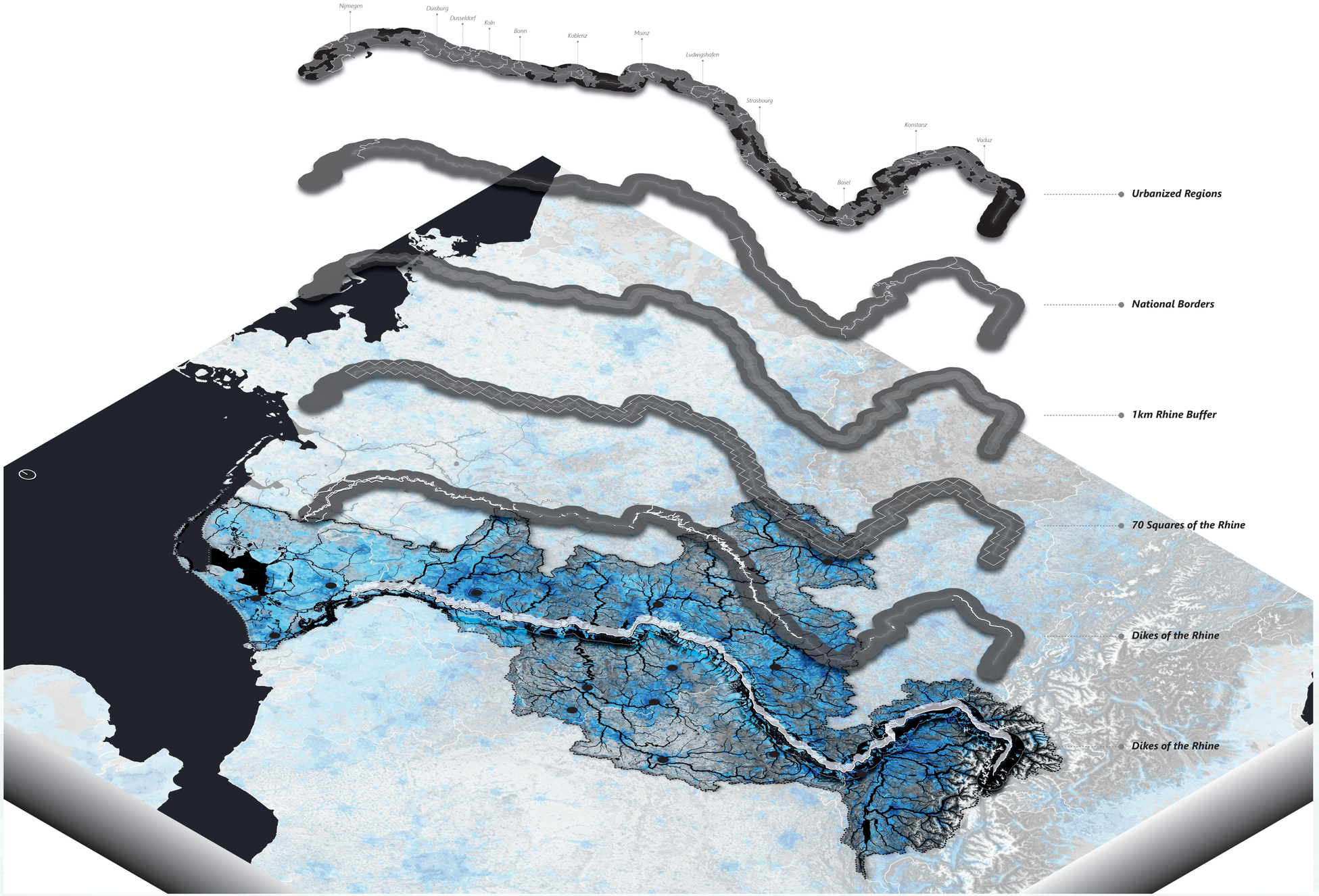
How to move through the scales?

The need to establishe a 'Model' that translates the Rhine into localized autonomous regions



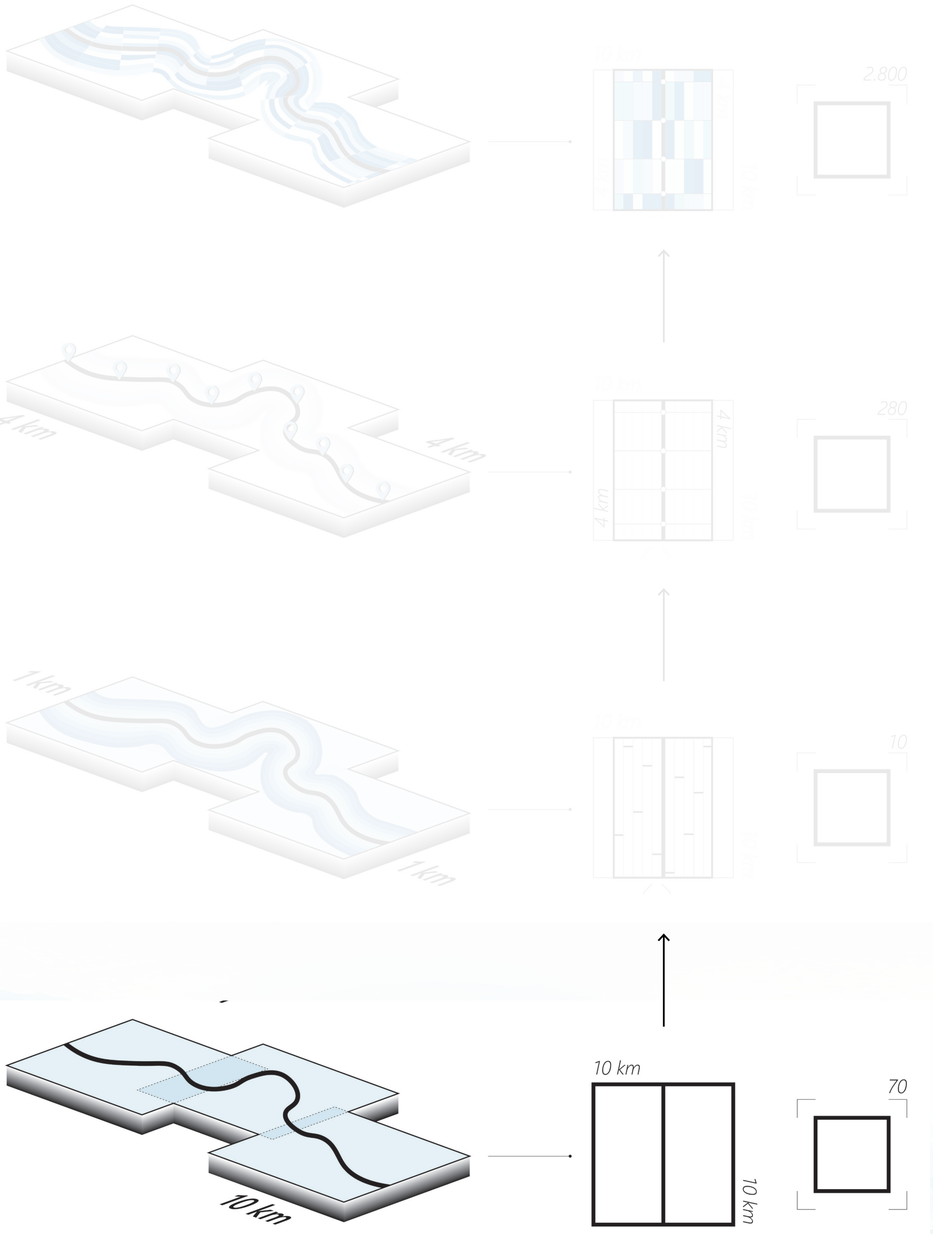
Spatialization of the RHINE LINE

The creation of a 'Model' based around the flow of the Rhine River.



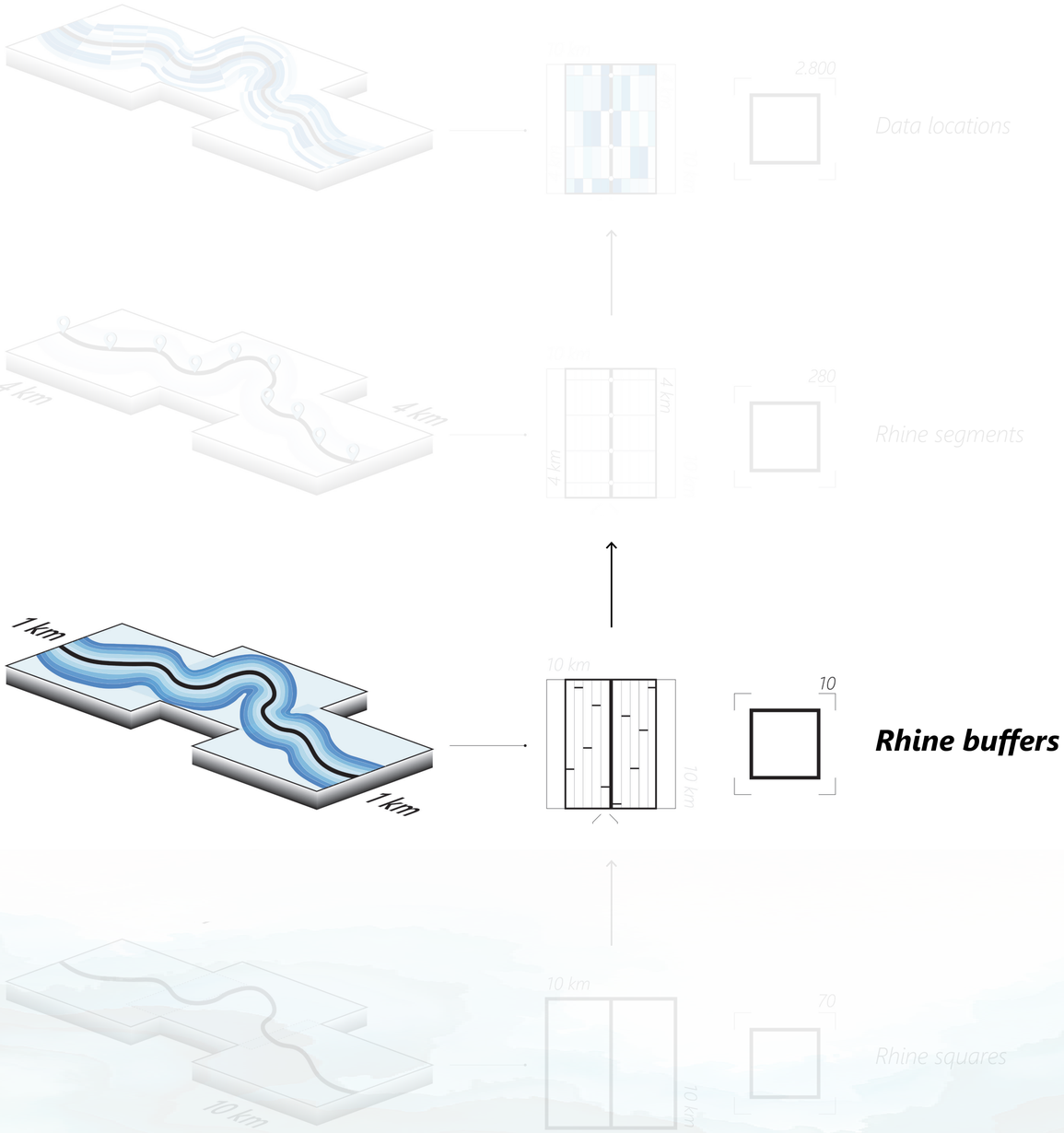
Creating the RHINE LINE

(1). *Division of the Rhine in 70 squares of 10x10 km*



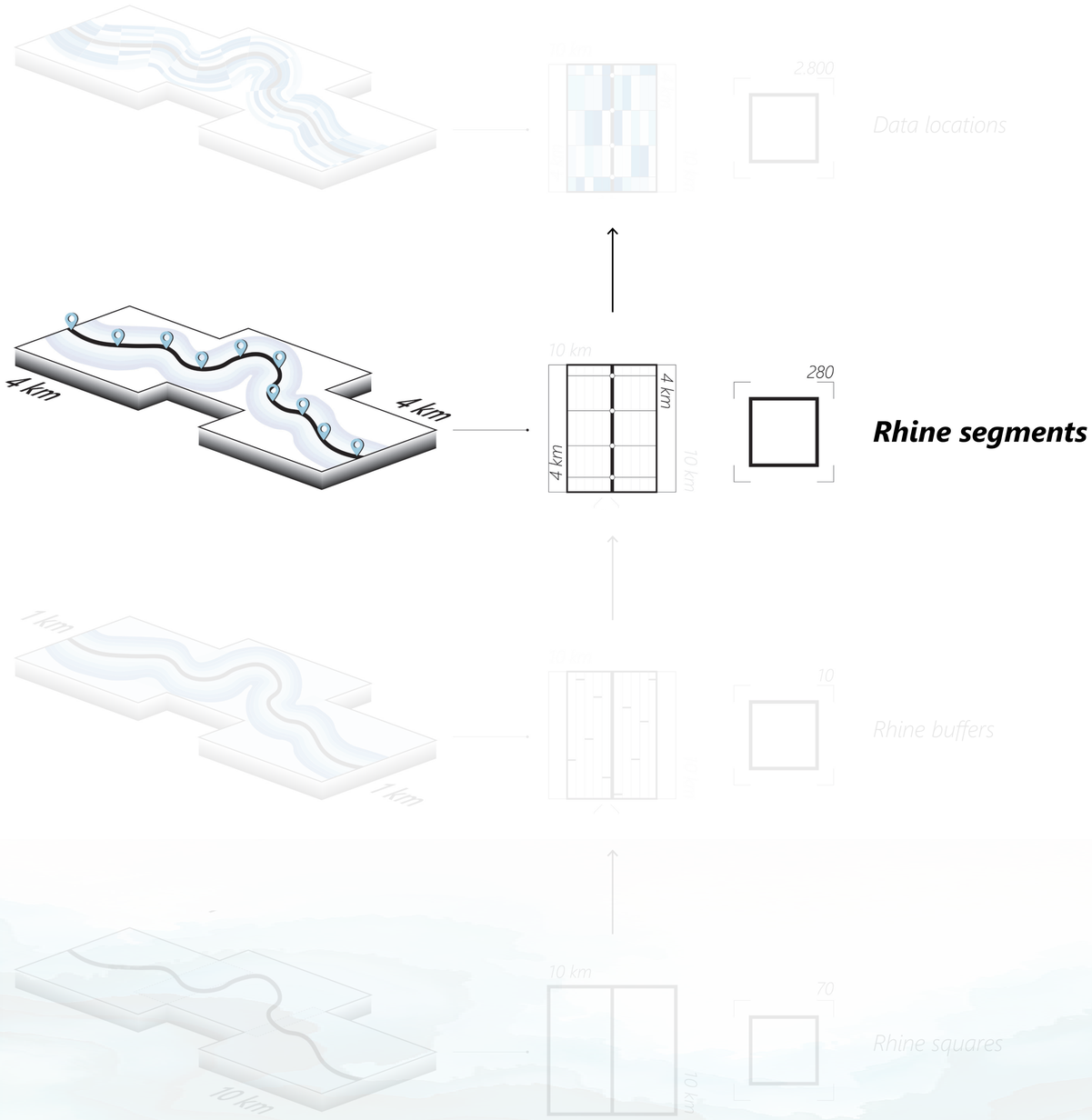
Creating the RHINE LINE

(2). *Buffering of the Rhine at a distance of 1km*



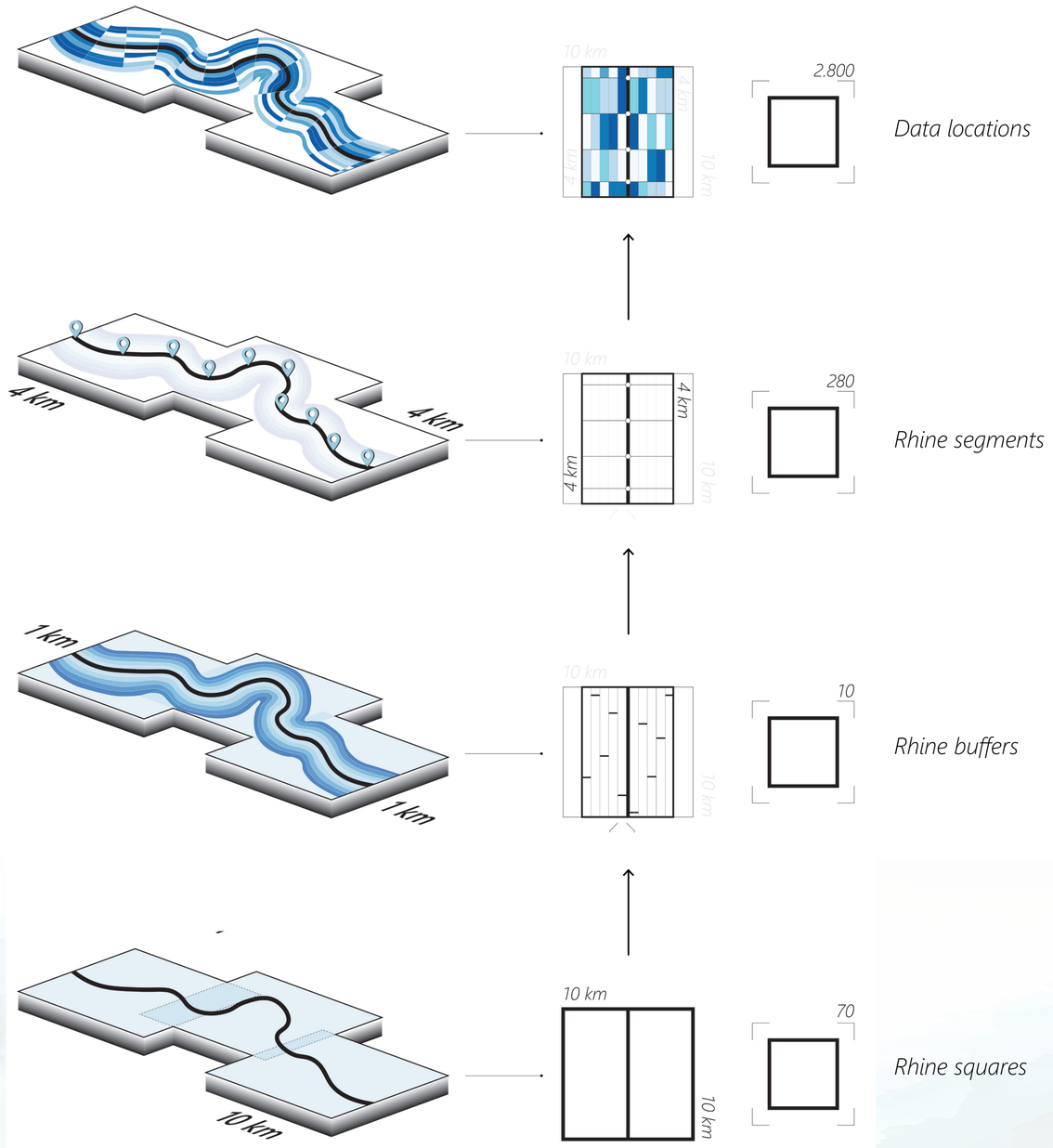
Creating the RHINE LINE

(3). *Dividing the length of the Rhine in segments of 4 km*



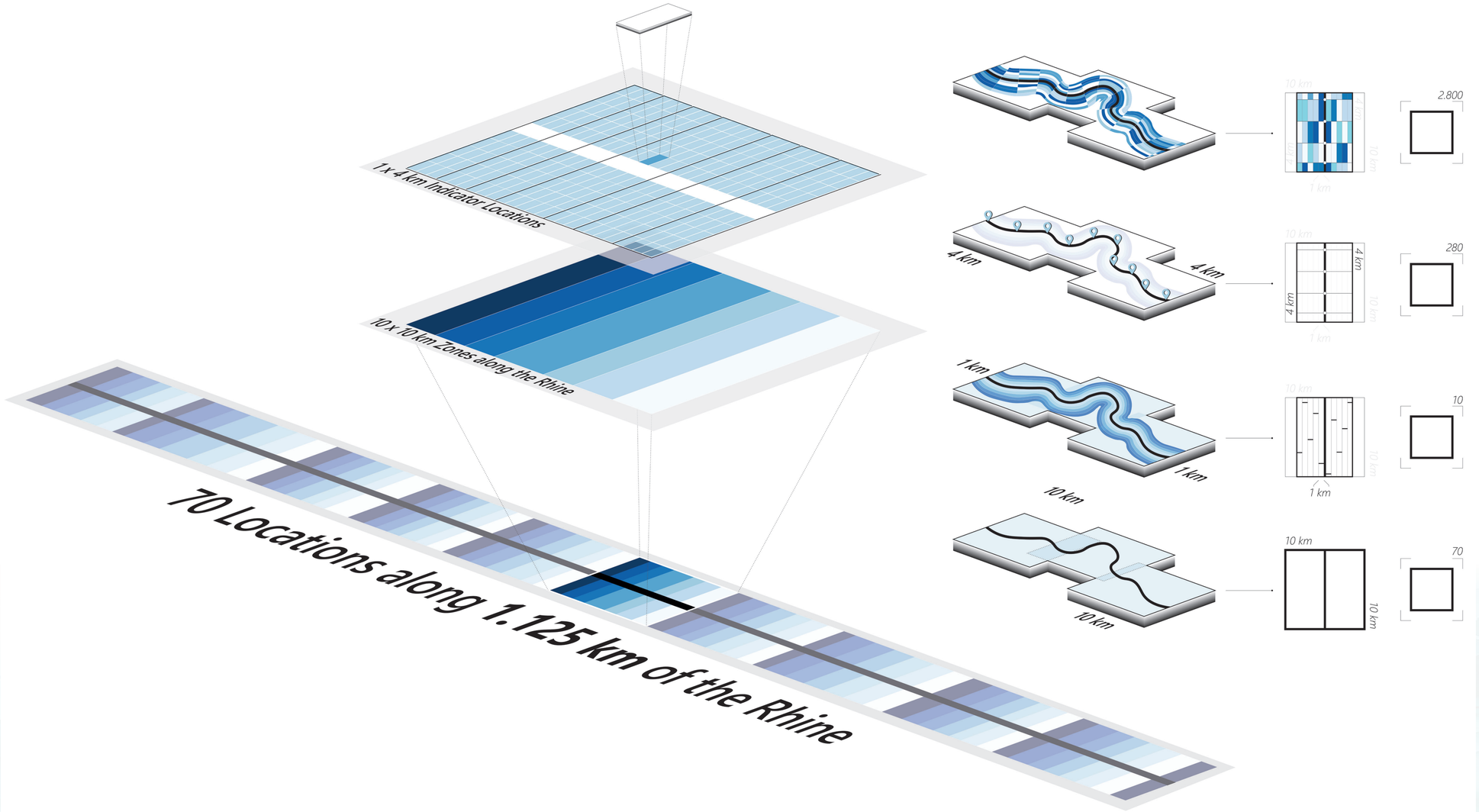
Creating the RHINE LINE

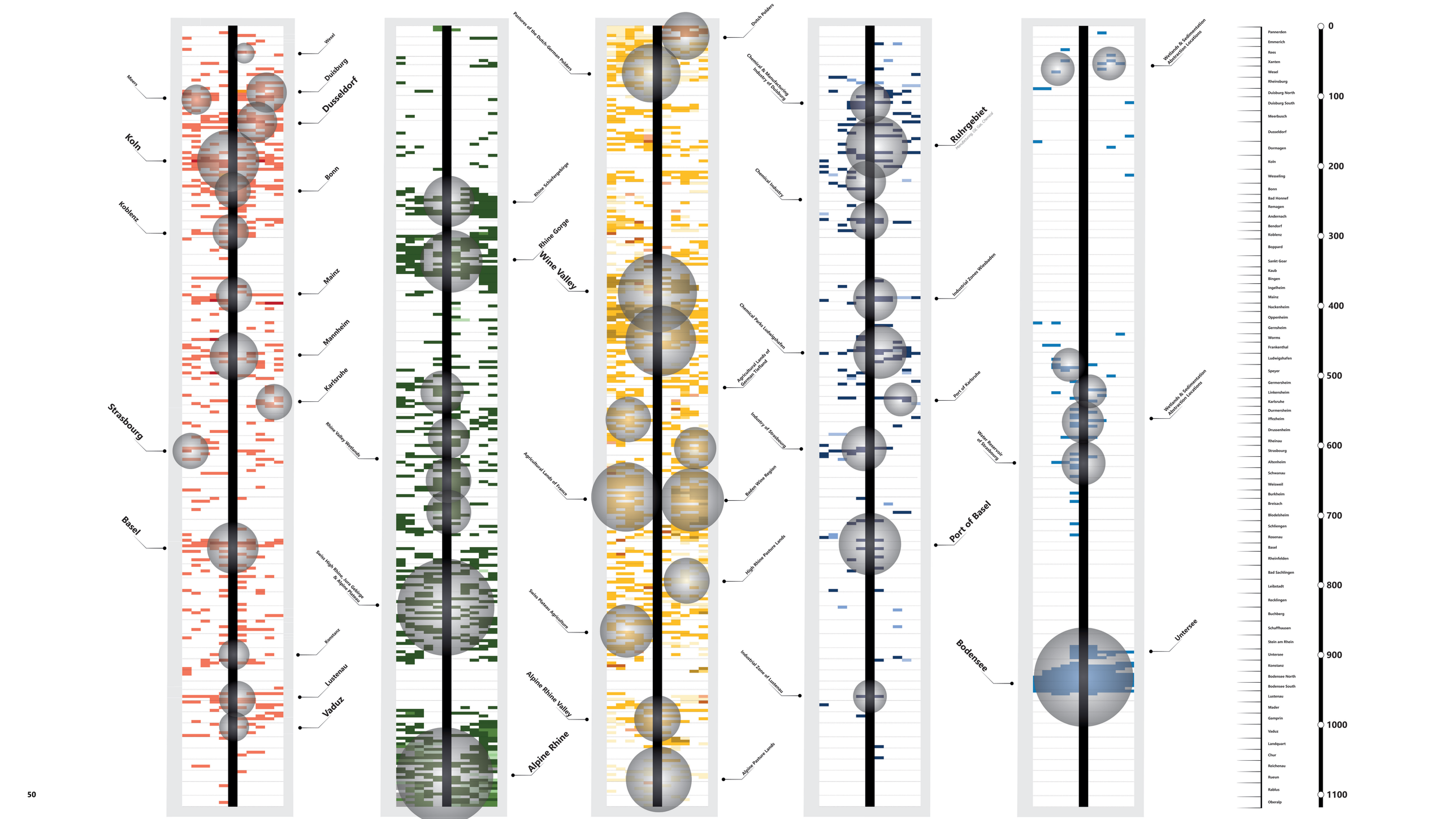
(4). *The creation of 2.800 data points that represent a zone of 1x4 km*

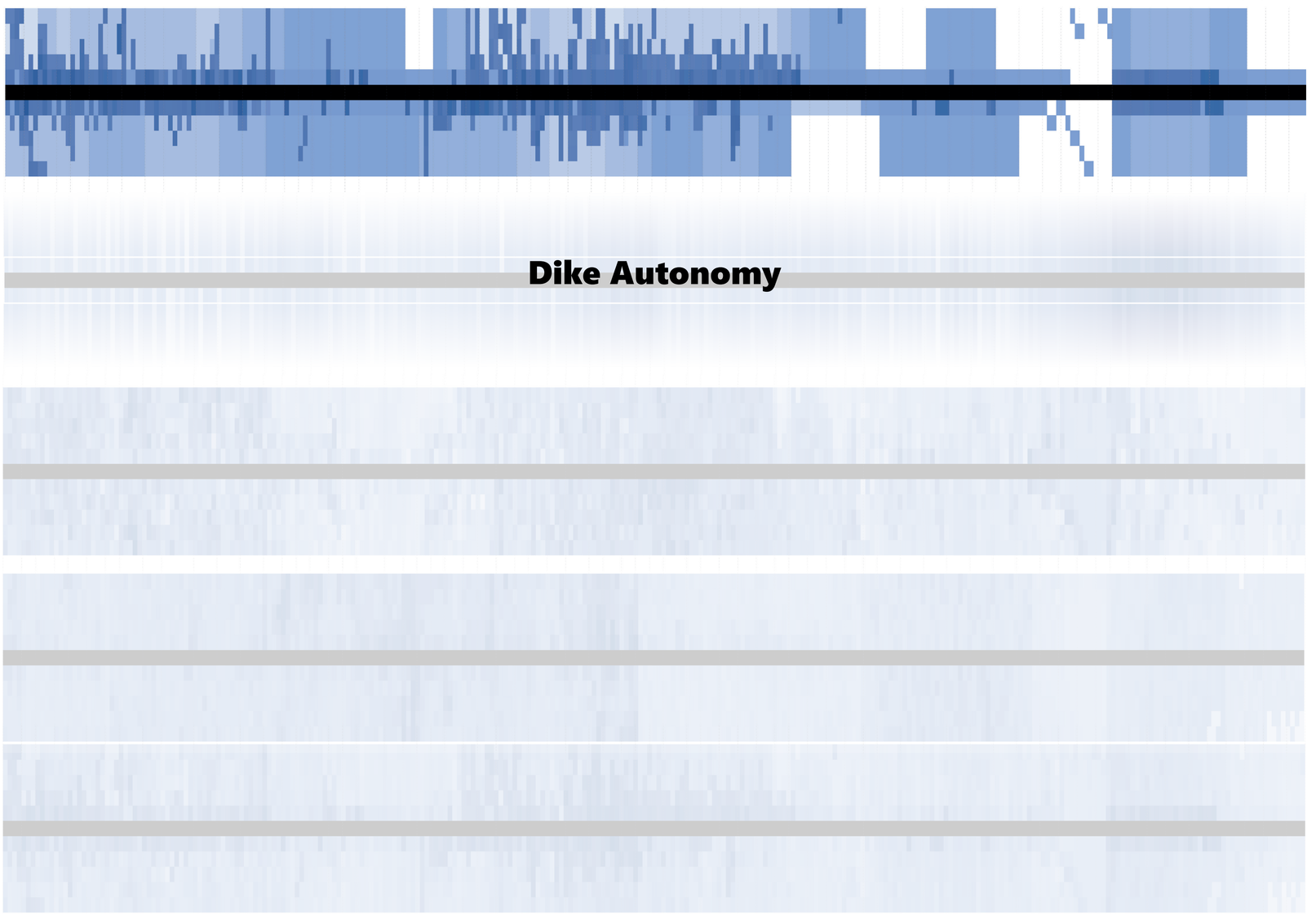


Creating the RHINE LINE

Establishing a spatial data 'Model' that can be used to translate information of a Rhine scale to the localized units




Moers
Koln
Koblenz
Strasbourg
Basel
Wesel
Duisburg
Dusseldorf
Bonn
Mainz
Mannheim
Karlsruhe
Rhine Valley Wetlands
Swiss High Rhine, Jura Gebirge & Alpine Plateau
Konstanz
Lustenau
Vaduz
Pastures of the Dutch-German Polders
Rhine Schiefergebirge
Rhine Gorge
Wine Valley
Agricultural Lands of France
Swiss Plateau Agriculture
Alpine Rhine Valley
Alpine Rhine
Dutch Polders
Chemical & Manufacturing Industry of Duisburg
Chemical Industry
Chemical Parks Ludwigshafen
Agricultural Lands of German Hinterland
Industry of Strasbourg
Baden Wine Region
High Rhine Pasture Lands
Industrial Zone of Lustenau
Alpine Pasture Lands
Ruhrgebiet
Manufacturing Oil, Gas, Chemical
Industrial Zones Wiesbaden
Port of Karlsruhe
Water Reservoir of Strasbourg
Port of Basel
Bodensee
Wetlands & Sedimentation Abstraction Locations
Wetlands & Sedimentation Abstraction Locations
Untersee
Pannerden
Emmerich
Rees
Xanten
Wesel
Rheinsburg
Duisburg North
Duisburg South
Meerbusch
Dusseldorf
Dormagen
Koln
Wesseling
Bonn
Bad Honnef
Remagen
Andernach
Bendorf
Koblenz
Boppard
Sankt Goar
Kaub
Bingen
Ingelheim
Mainz
Nackenheim
Oppenheim
Gernsheim
Worms
Frankenthal
Ludwigshafen
Speyer
Germersheim
Linkenheim
Karlsruhe
Durmersheim
Iffezheim
Drussenheim
Rheinau
Strasbourg
Altenheim
Schwanau
Weisweil
Burkheim
Breisach
Blodelsheim
Schliengen
Rosenau
Basel
Rheinfelden
Bad Sachlingen
Leibstadt
Recklingen
Buchberg
Schaffhausen
Stein am Rhein
Untersee
Konstanz
Bodensee North
Bodensee South
Lustenau
Mader
Gamprin
Vaduz
Landquart
Chur
Reichenau
Rueun
Rablus
Oberalp
0
100
200
300
400
500
600
700
800
900
1000
1100


Dike Autonomy

Establishing Dike Autonomy

(1). *Spatial Dike Form*

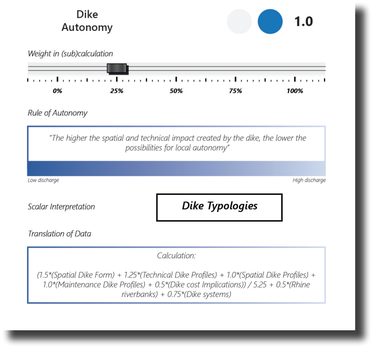
(2). *Technical Dike Profiles*

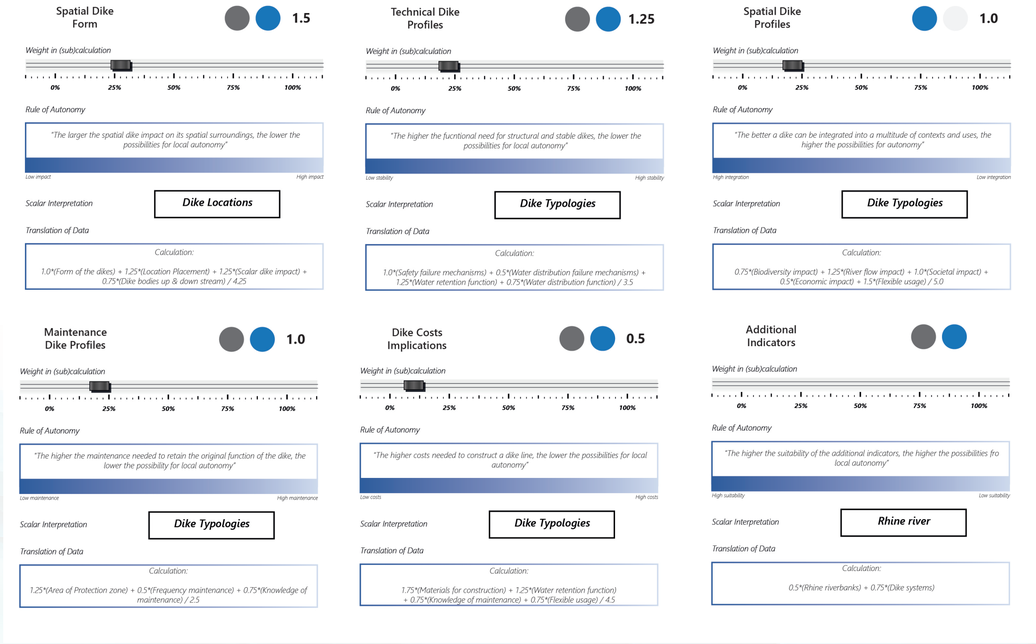
(3). *Spatial Dike Profiles*

(4). *Maintenance Dike Profiles*

(5). *Dike Construction*

(6). *Additional Indicators*



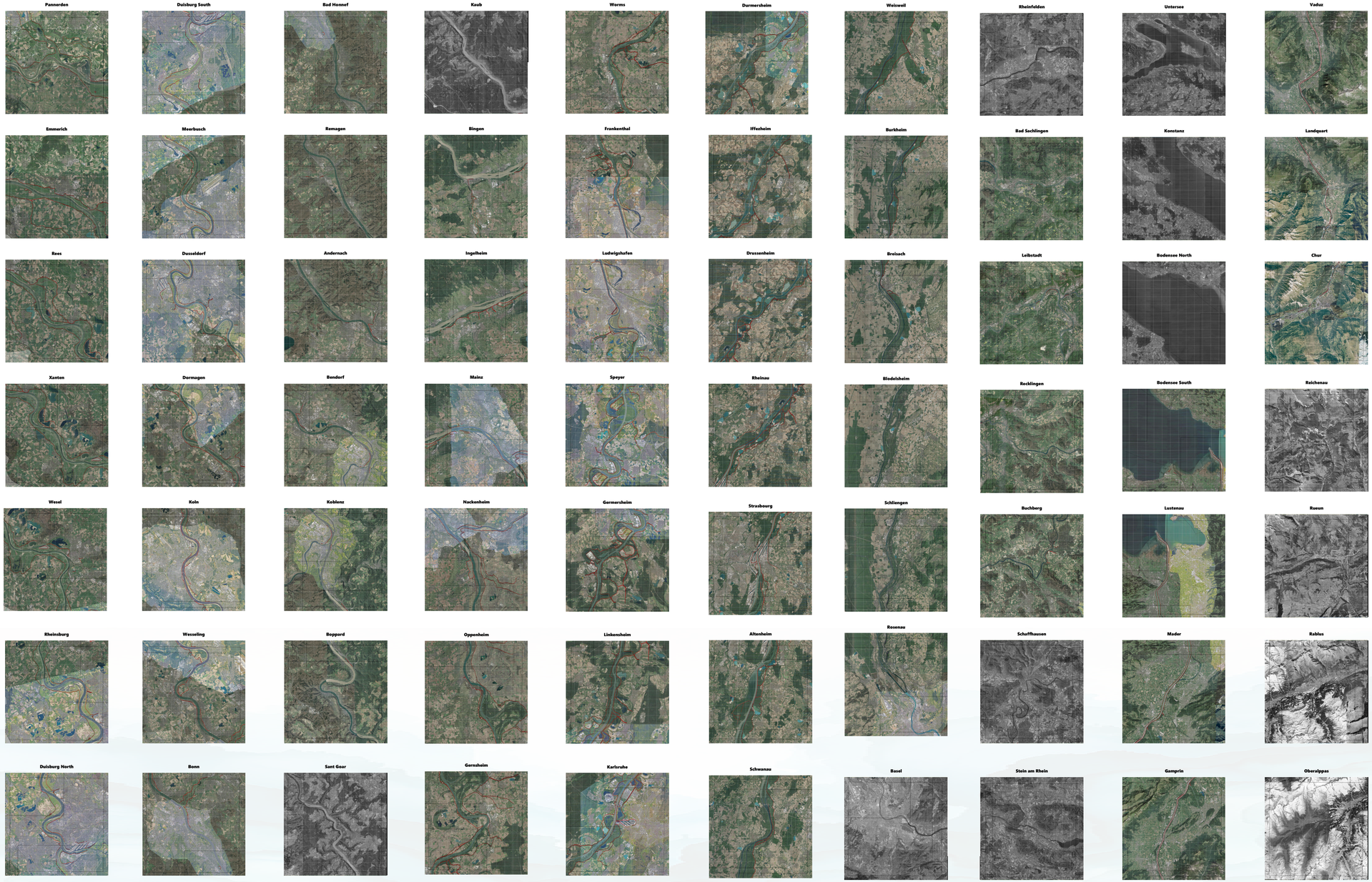


Dikes of the Rhine

Out of the 70 defined locations along the Rhine, all but 13 have classified dike lines

↓

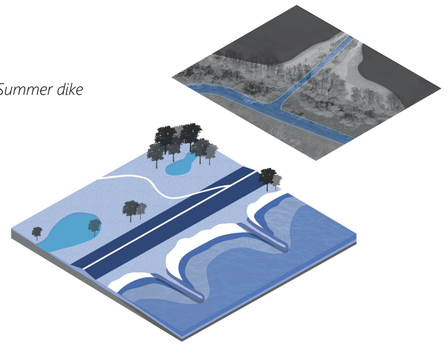
Simplification of the Dikes of the Rhine



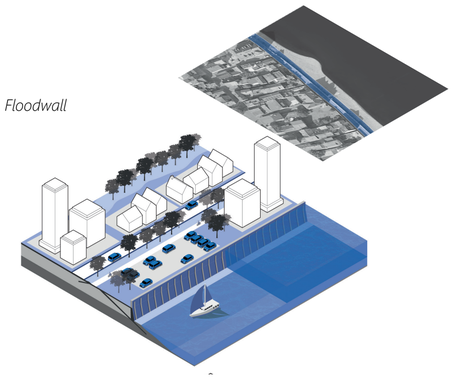
Creation of Dike Typologies

Simplification of the Dikes along the Rhine River.

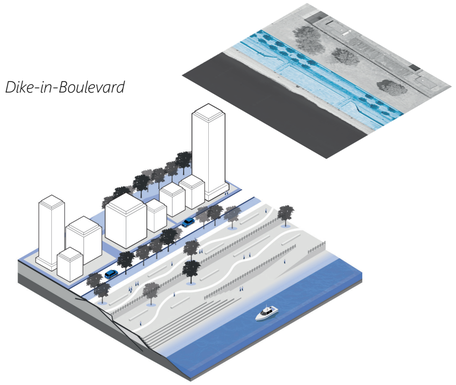
Summer dike



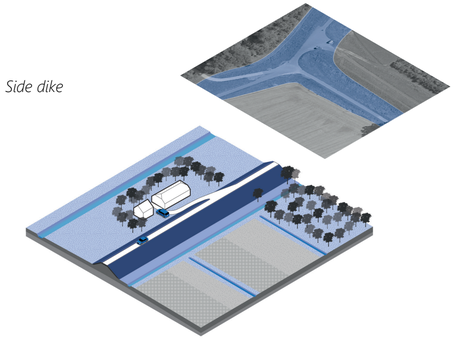
Floodwall



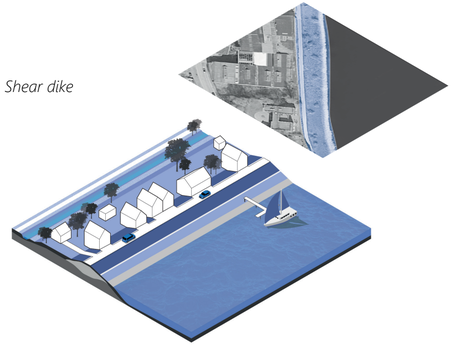
Dike-in-Boulevard



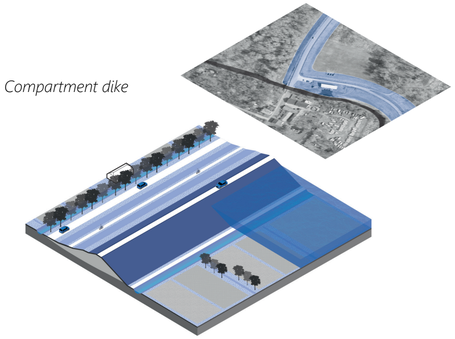
Side dike



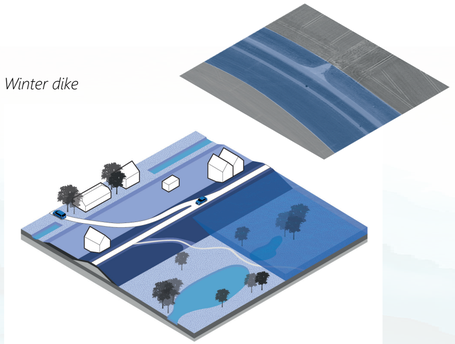
Shear dike



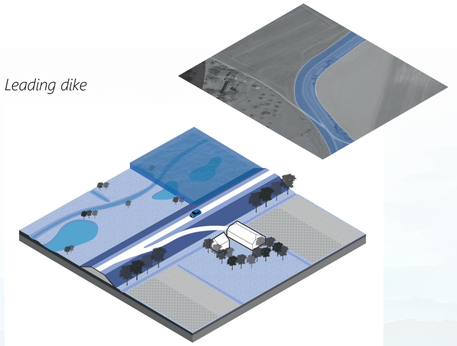
Compartment dike



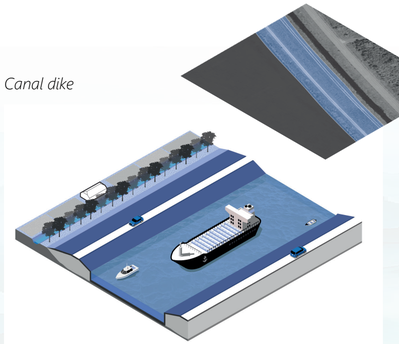
Winter dike



Leading dike

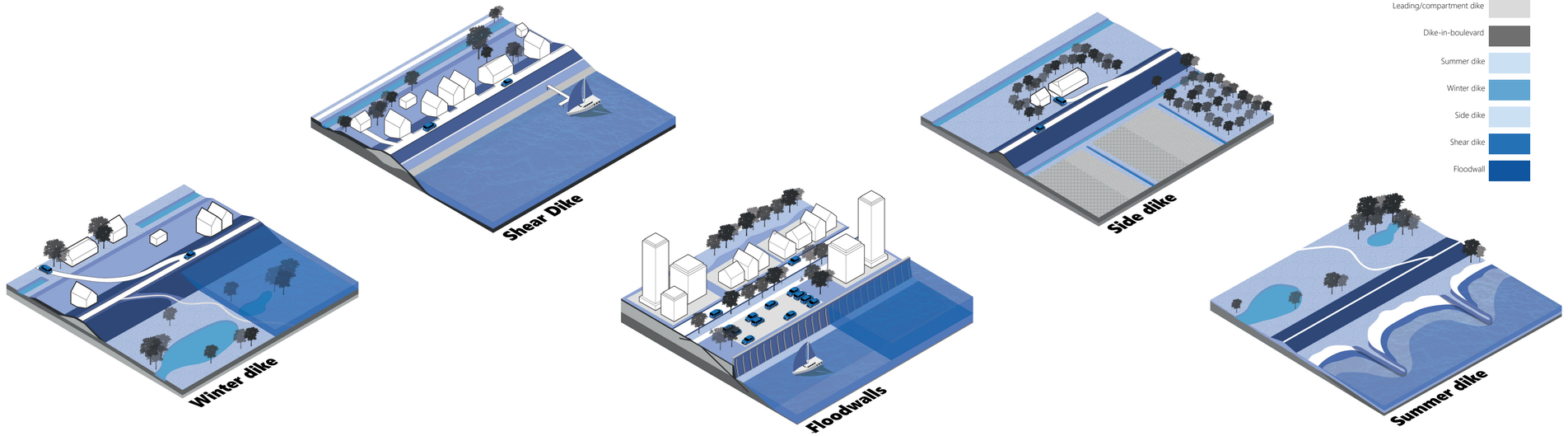


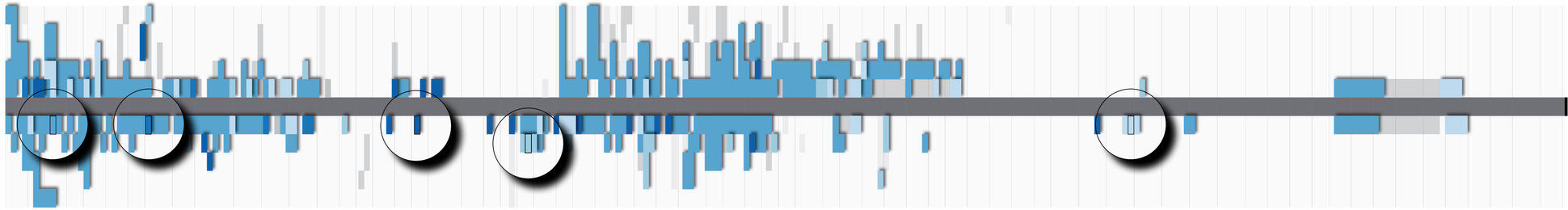
Canal dike



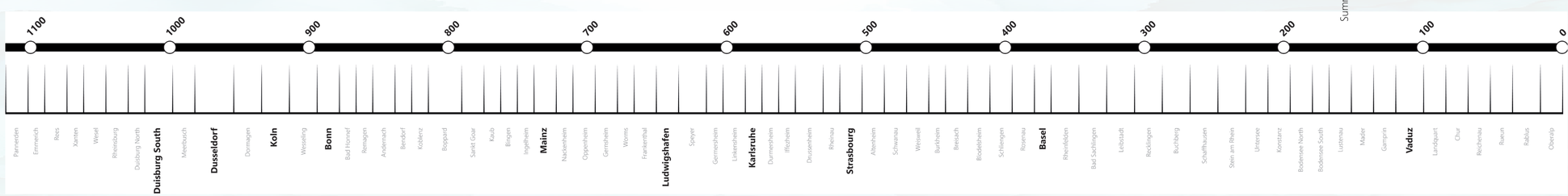
Creation of Dike Typologies

Protective dikes:
Dikes with its main function to protect an area from the river



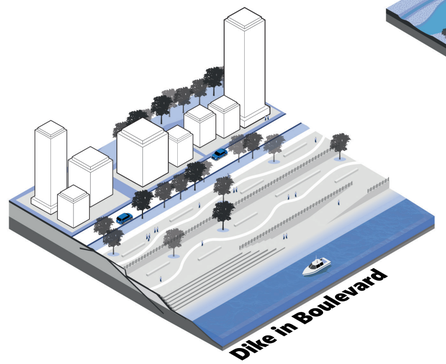


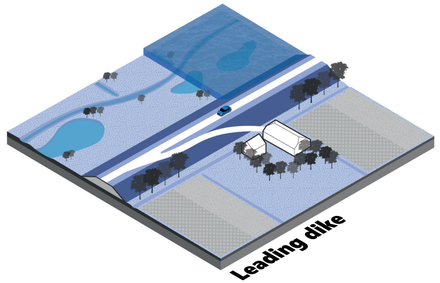


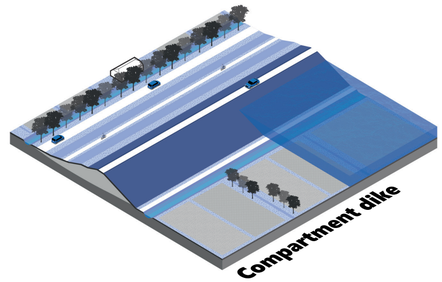


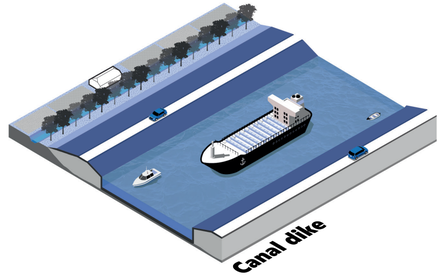
Creation of Dike Typologies

Distributive dikes: *Dikes with its main function to distribute water away from the river or to a specific location*

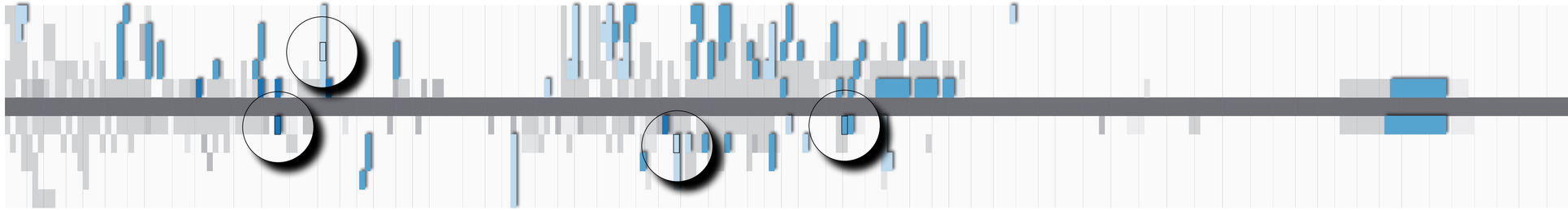


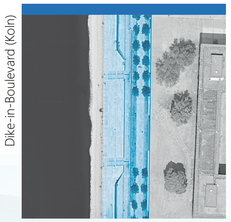


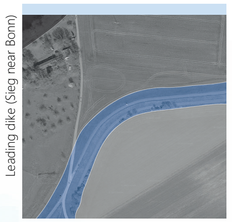




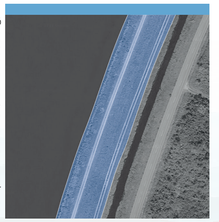
Canal dike
Leading/compartment dike
Dike-in-boulevard
Summer dike
Winter dike
Side dike
Shear dike
Floodwall

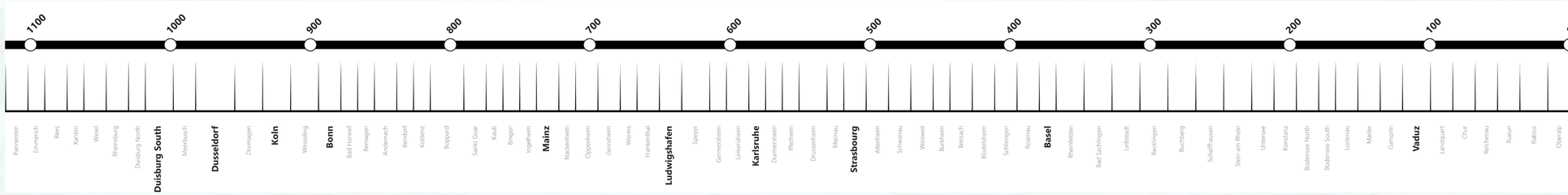



Dike-in-Boulevard (Köln)


Leading dike (Sieg near Bonn)

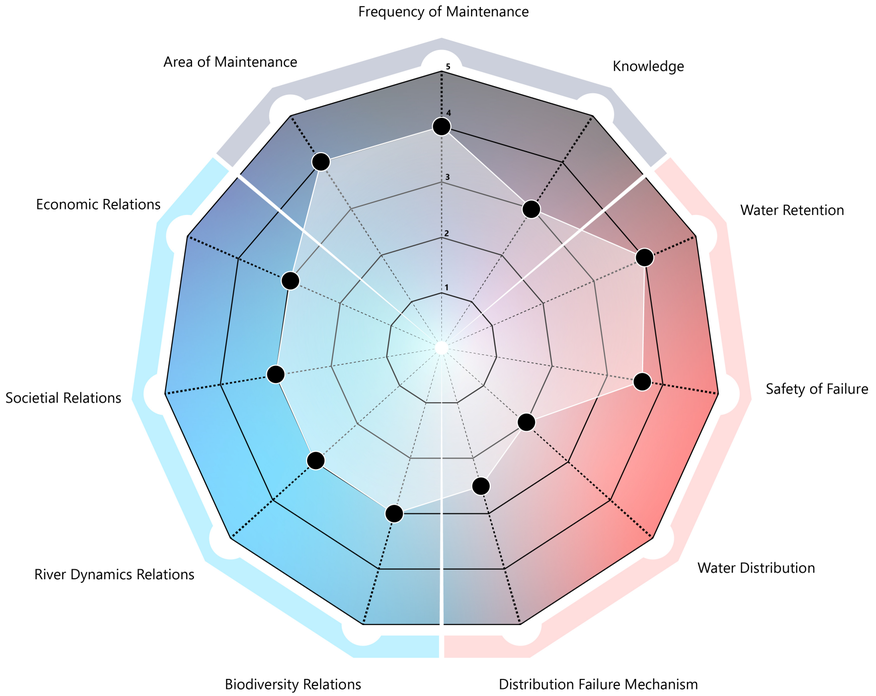

Compartment dike (Ludwigshafen)

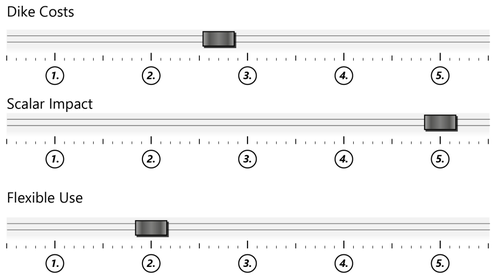

Compartment dike (near Strasbourg)

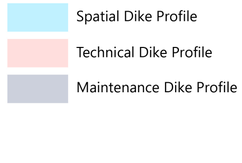


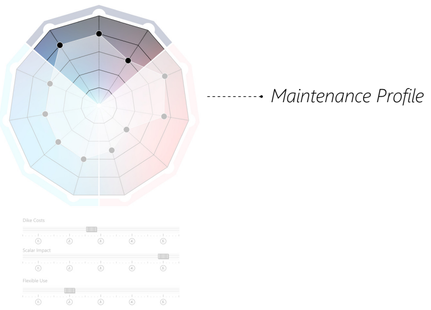
Ranking of Dike Typologies

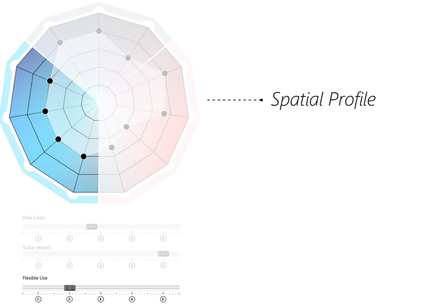
When a dike is considered important in the protection of a vulnerable location, autonomy is considered to be low

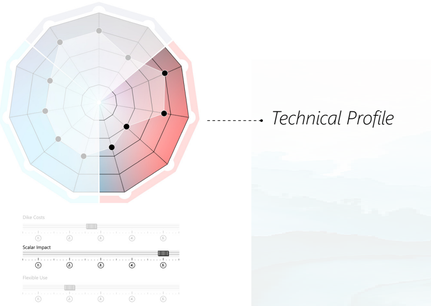












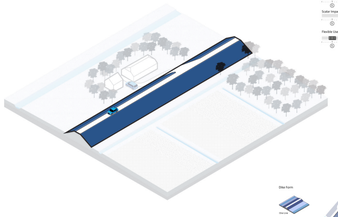
Ranking of Dike Typologies

Summer dike



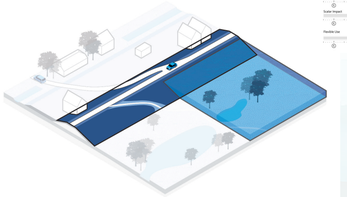


Side dike

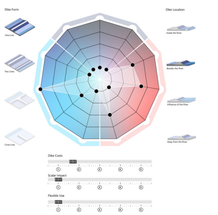


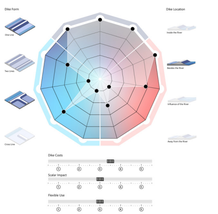


Winter dike

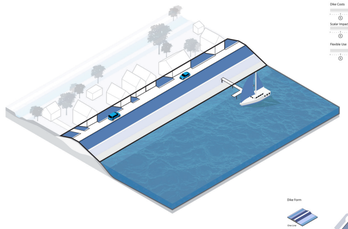


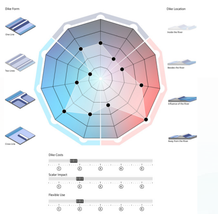
Floodwall



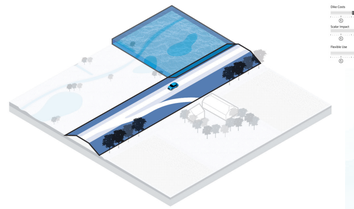


Shear dike

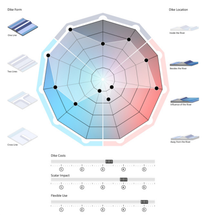


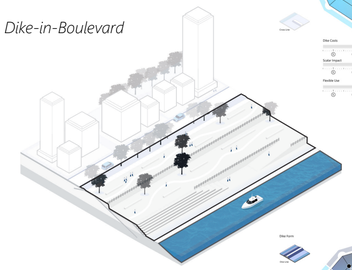


Leading dike

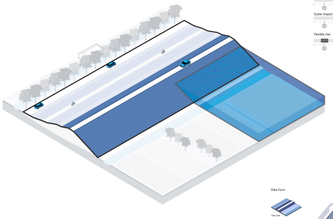


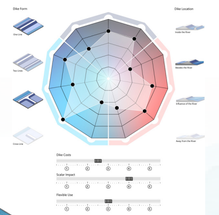
Dike-in-Boulevard



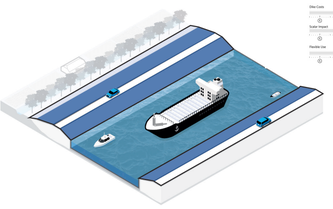


Compartment dike





Canal dike



Forming the Lines of the Rhine: Dike Autonomy



Dike Autonomy

1.0

Weight in (sub)calculation

0% 25% 50% 75% 100%

Rule of Autonomy

"The higher the spatial and technical impact created by the dike, the lower the possibilities for local autonomy"

Low discharge — *High discharge*

Scalar Interpretation

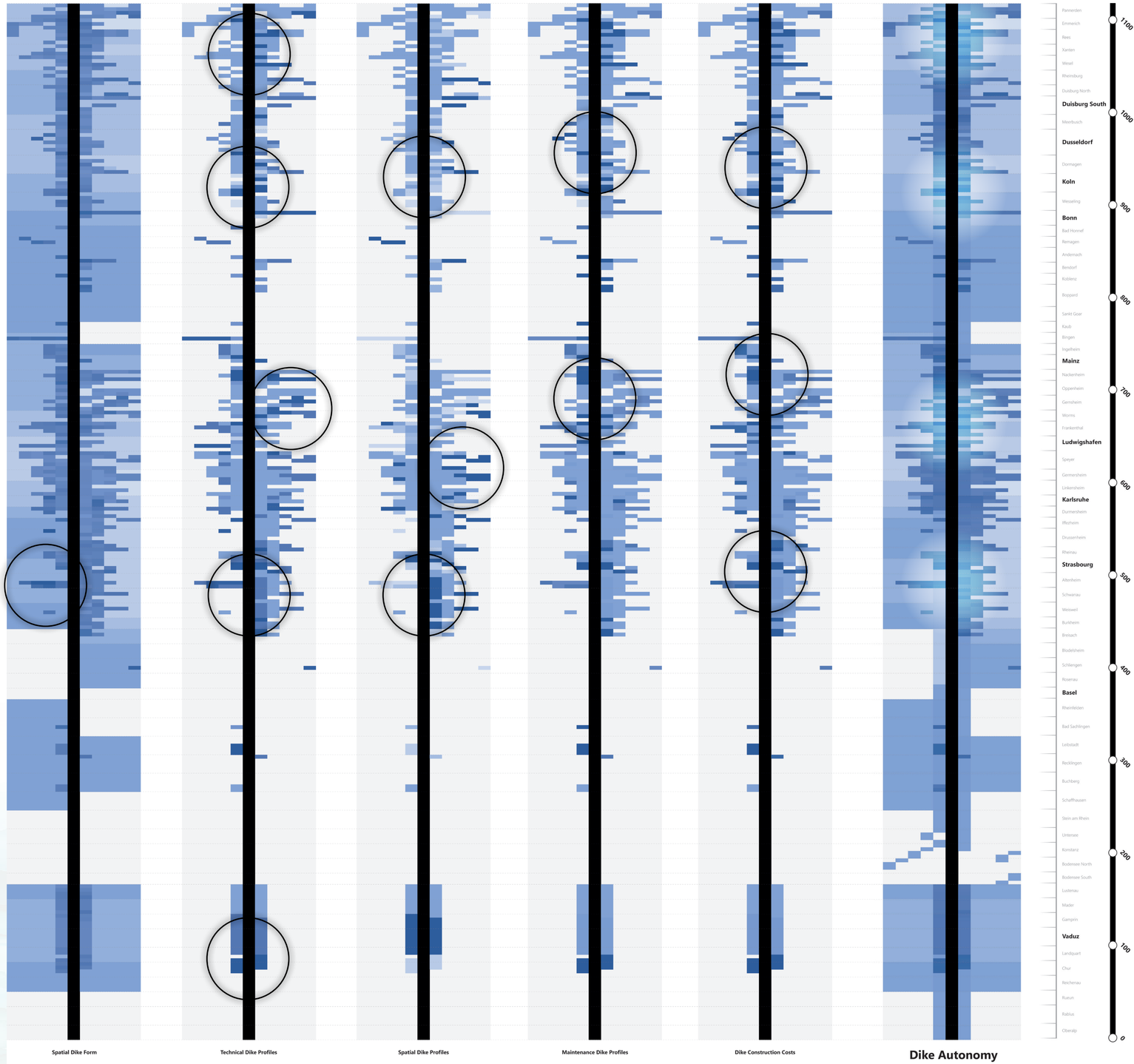
Dike Typologies

Translation of Data

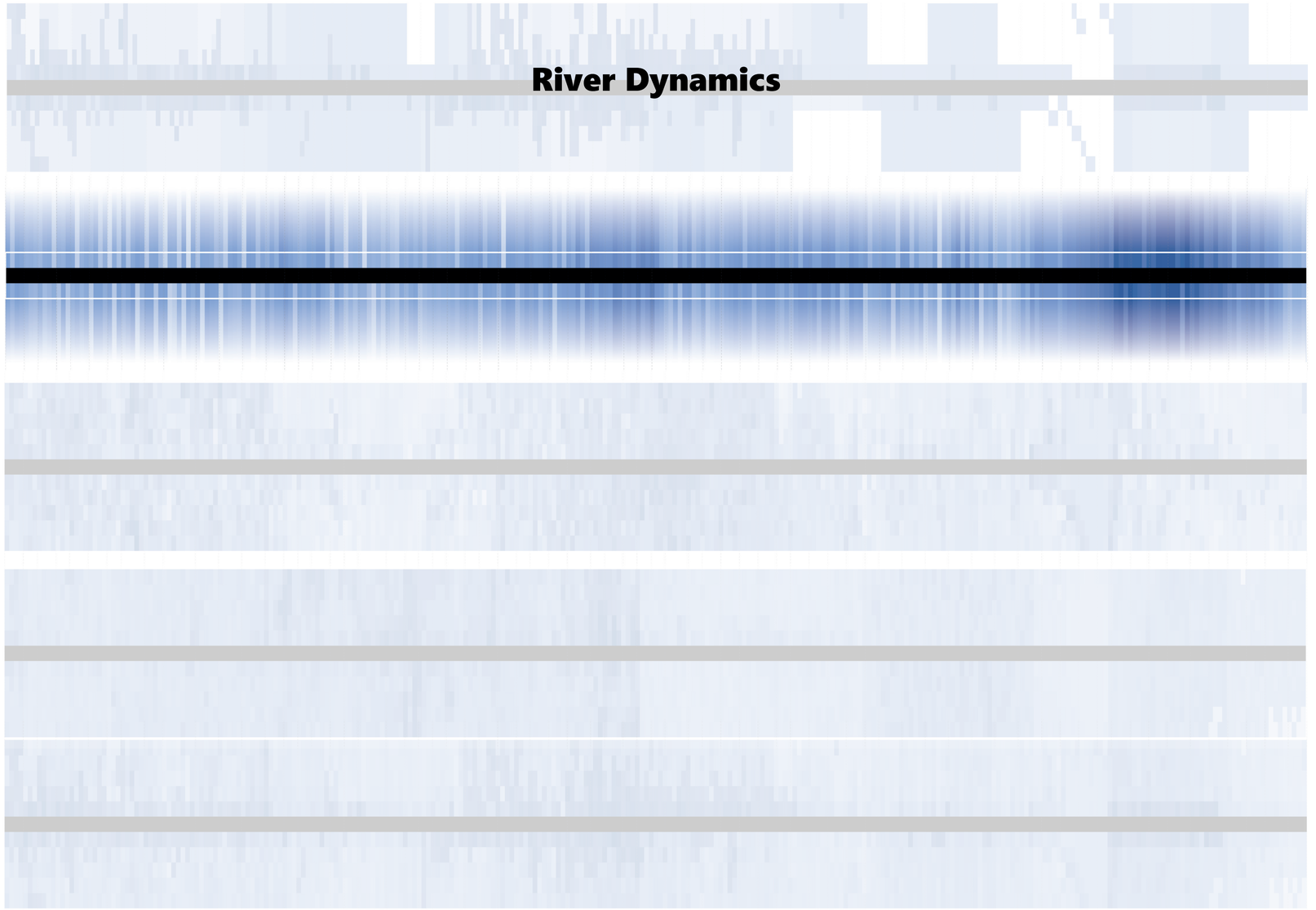
Calculation:

(1.5(Spatial Dike Form) + 1.25*(Technical Dike Profiles) + 1.0*(Spatial Dike Profiles) + 1.0*(Maintenance Dike Profiles) + 0.5*(Dike cost Implications)) / 5.25 + 0.5*(Rhine riverbanks) + 0.75*(Dike systems)*

High Autonomy indicates a high potential for maintaining a local dike line



River Dynamics



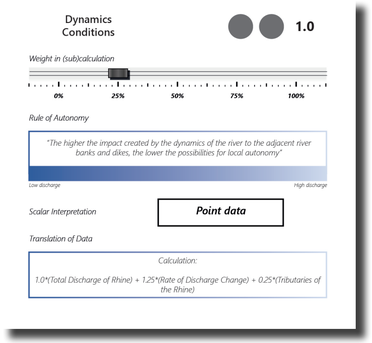
Establishing River Dynamics

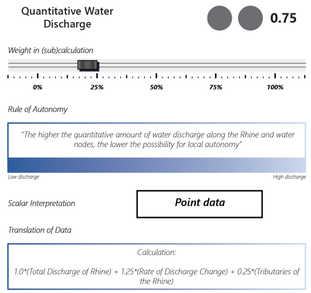
(1). *River Discharge*

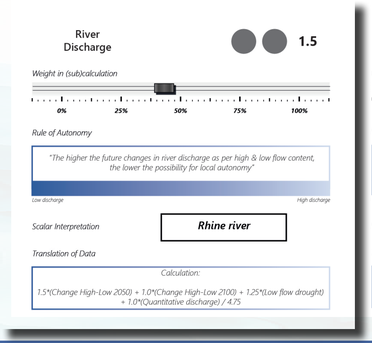
(2). *Dike System Interruptions*

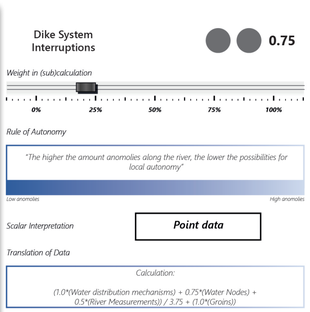
(3). *Sedimentation Patterns*

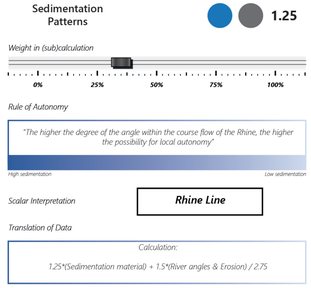
(4). *Quantitative Water Discharge*











RIVER DISCHARGE
CURRENT & FUTURE DISCHARGE REGIMES



River Discharge

1.5

Weight in (sub)calculation

0% 25% 50% 75% 100%

Rule of Autonomy

"The higher the future changes in river discharge as per high & low flow content, the lower the possibility for local autonomy"

Low discharge *High discharge*

Scalar Interpretation

Rhine river

Translation of Data

Calculation:

1.5(Change High-Low 2050) + 1.0*(Change High-Low 2100) + 1.25*(Low flow drought) + 1.0*(Quantitative discharge) / 4.75*

Establishing the Lines of Autonomy

(1). *Prediction of Future Discharge Regimes*

(2). *Effects on Low Flow Droughts*

(3). *Rhine River discharge classifications*

A. *Change in High-Low Flow (Now-2050)*

Change in High-Low Flow (2050) — 1.5

Weight in (sub)calculation

0% 25% 50% 75% 100%

Rule of Autonomy

"The higher the change in high-low flow of the river discharge of the Rhine, the lower the possibility for local autonomy"

Low change rate — *High change rate*

Scalar Interpretation — ***Rhine Line***

Translation of Data

Translation of the research provided by the Stahl et al., (2022) surrounding projections of river discharge of the Rhine till 2050. Calculation was made to conduct the change rate of high (W=1) & low flow (W=1) from 2020 till 2050. Additional indictions were provided based on the relations between the change of high and low flow to each other (W=0,25). Calculation was run as per 1x4 km location along the Rhine.

B. *Change in High-Low Flow Uncertainty*

Change in High-Low Flow (2100) — 1.0

Weight in (sub)calculation

0% 25% 50% 75% 100%

Rule of Autonomy

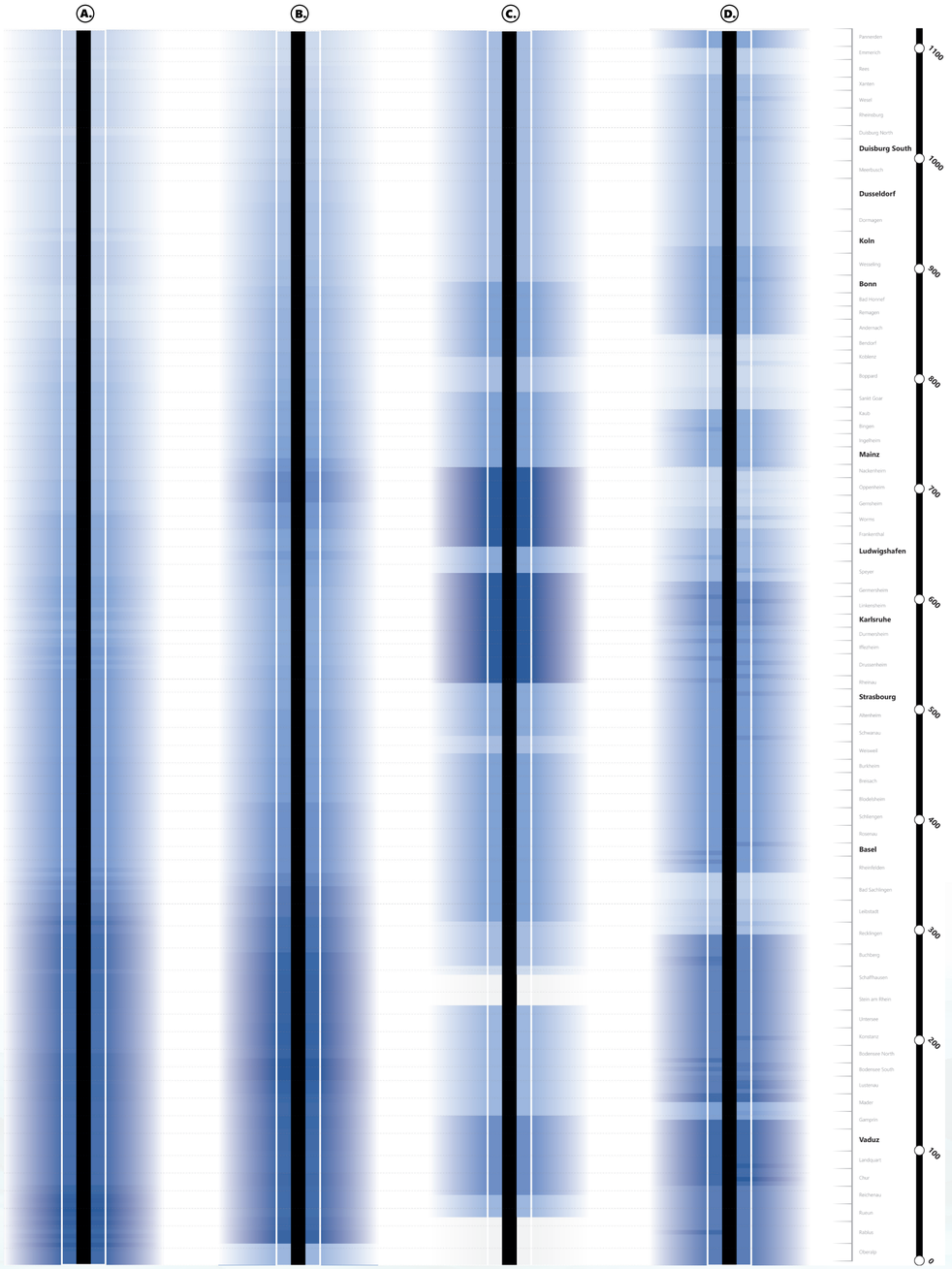
"The higher the change in high-low flow of the river discharge of the Rhine, the lower the possibility for local autonomy"

Low change rate — *High change rate*

Scalar Interpretation — ***Rhine Line***

Translation of Data

Translation of the research provided by the Stahl et al., (2022) surrounding projections of river discharge of the Rhine till 2050. Calculation was made to conduct the change rate of high (W=1) & low flow (W=1) from 2050 till 2100. Additional indictions were provided based on the relations between the change of high and low flow to each other (W=0,25). Calculation was run as per 1x4 km location along the Rhine.



C. *Low Flow Drought Issues*

Low Flow Drought — 1.25

Weight in (sub)calculation

0% 25% 50% 75% 100%

Rule of Autonomy

"The higher the degree of low flow from the year of 2022, the lower the possibility for local autonomy"

Low degree — *High degree*

Scalar Interpretation — ***Rhine river***

Translation of Data

Translation of the information provided by the European Drought Observatory for the recent drought year of 2022 (Cammaller et al., 2021). Translated based on the difference in hydrological seasons: Winter (W=1) & Summer (W=1,25). Low flow indirectly destabilizes the structural integrity of the dike line as a constant moisture level is needed.

D. *Total Water Discharge of the Rhine*

Quantitative Water Discharge — 0.75

Weight in (sub)calculation

0% 25% 50% 75% 100%

Rule of Autonomy

"The higher the quantitative amount of water discharge along the Rhine and water nodes, the lower the possibility for local autonomy"

Low discharge — *High discharge*

Scalar Interpretation — ***Point data***

Translation of Data

Calculation:

1.0(Total Discharge of Rhine) + 1.25*(Rate of Discharge Change) + 0.25*(Tributaries of the Rhine)*

Establishing the Lines of Autonomy



River Discharge

1.5

Weight in (sub)calculation

0% 25% 50% 75% 100%

Rule of Autonomy

"The higher the future changes in river discharge as per high & low flow content, the lower the possibility for local autonomy"

Low discharge — High discharge

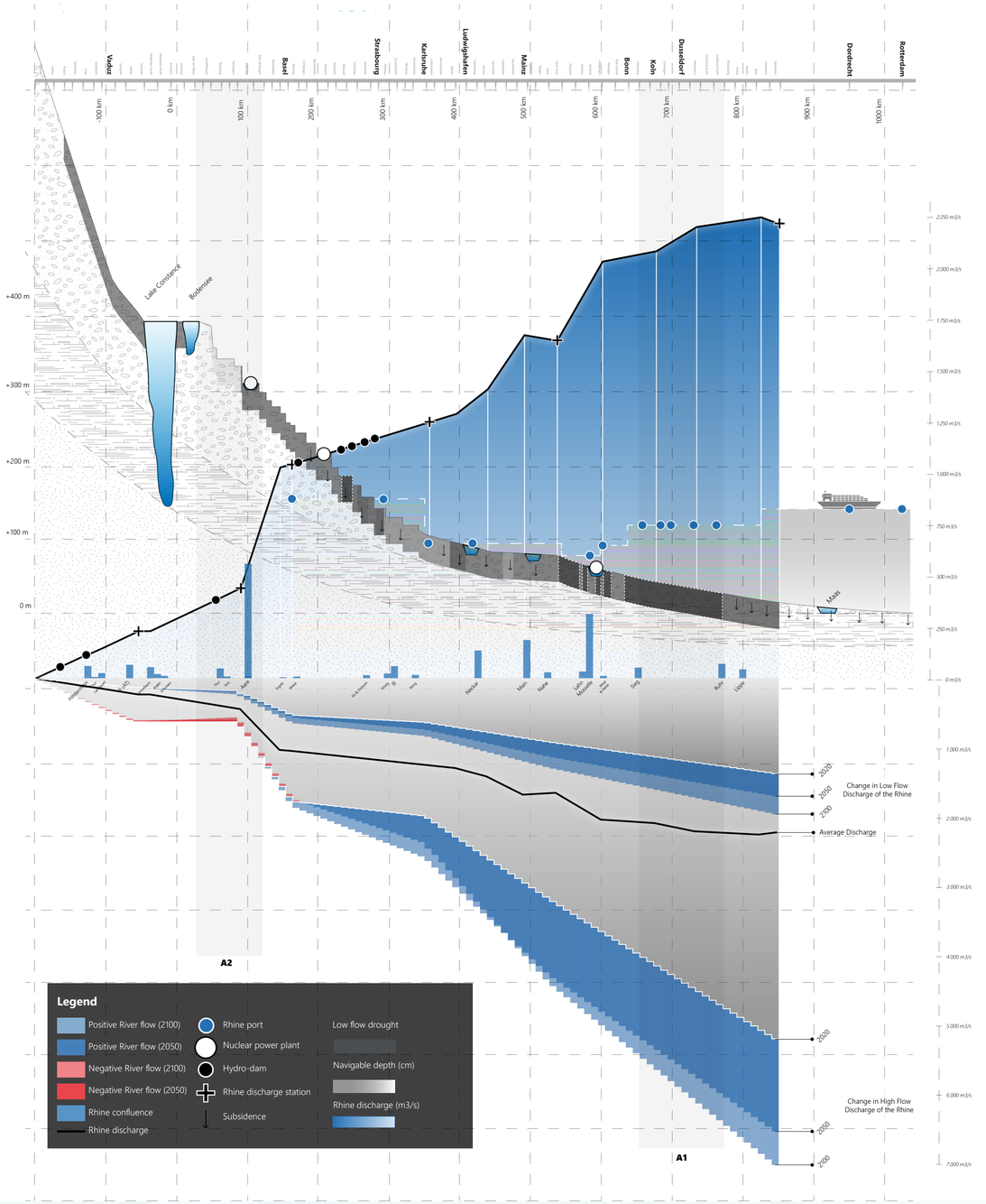
Scalar Interpretation

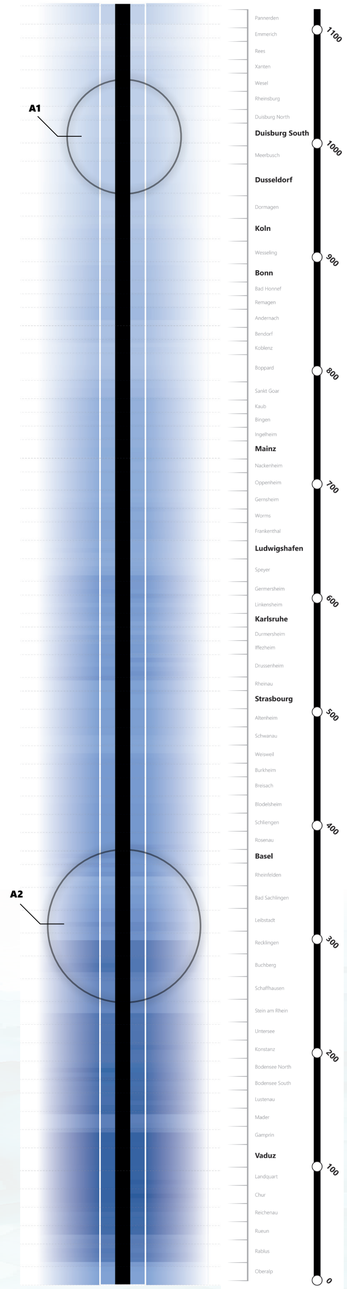
Rhine river

Translation of Data

Calculation:

1.5(Change High-Low 2050) + 1.0*(Change High-Low 2100) + 1.25*(Low flow drought) + 1.0*(Quantitative discharge) / 4.75*





Forming the Lines of the Rhine: Dike Autonomy



Dynamics Conditions

1.0

Weight in (sub)calculation

0% 25% 50% 75% 100%

Rule of Autonomy

"The higher the impact created by the dynamics of the river to the adjacent river banks and dikes, the lower the possibilities for local autonomy"

Low discharge — *High discharge*

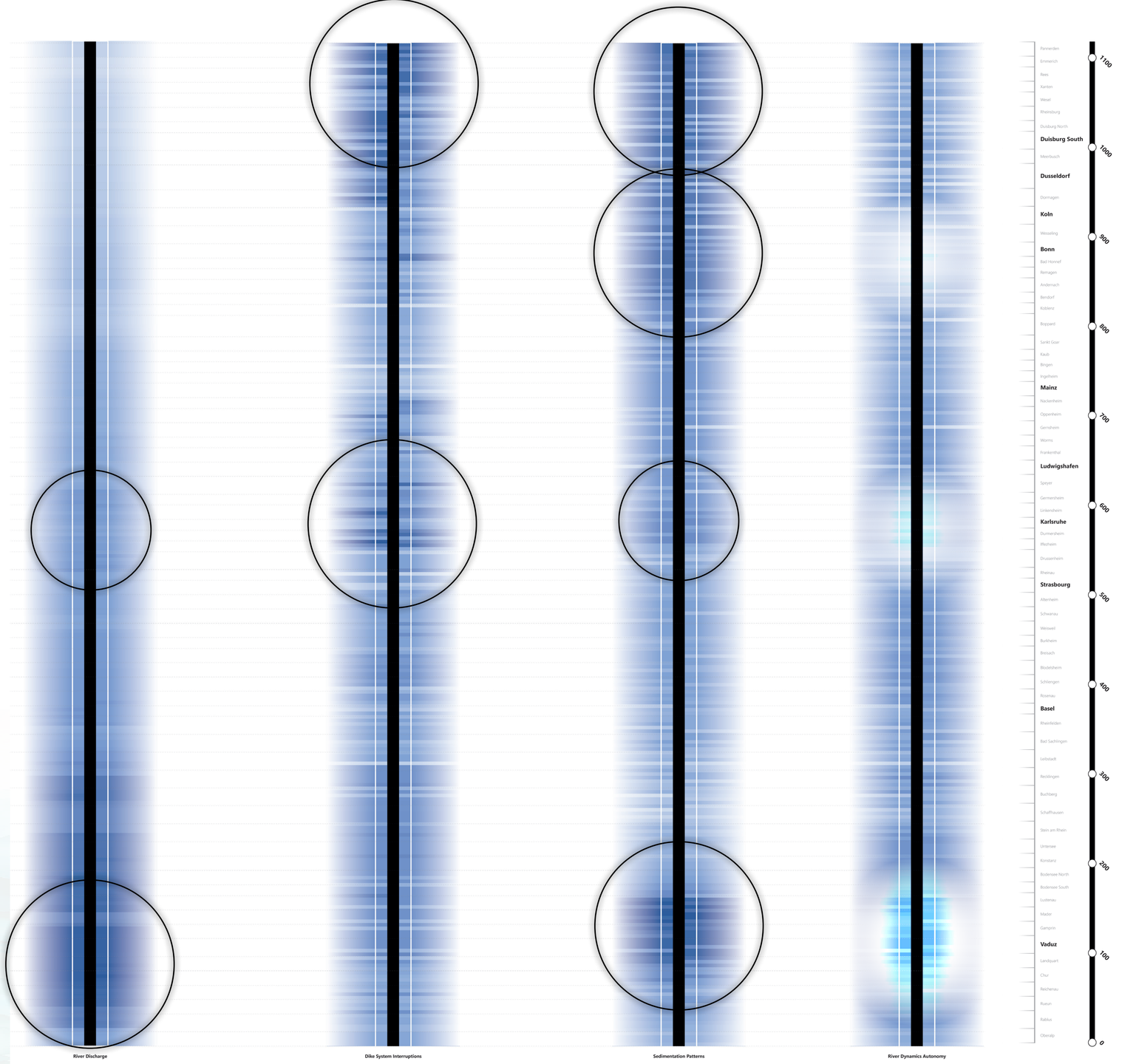
Scalar Interpretation **Point data**

Translation of Data

Calculation:

1.0(Total Discharge of Rhine) + 1.25*(Rate of Discharge Change) + 0.25*(Tributaries of the Rhine)*

High Autonomy indicates a low pressure from the Rhine River



Suitability Conditions

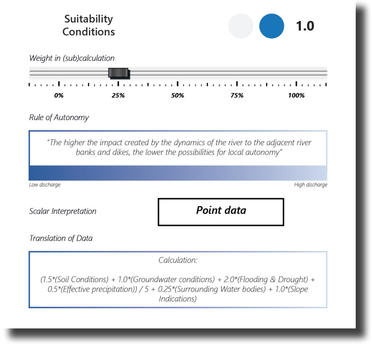
Establishing Suitability Conditions

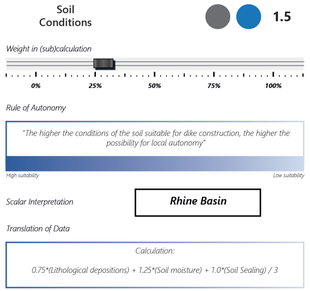
(1). *Soil Conditions*

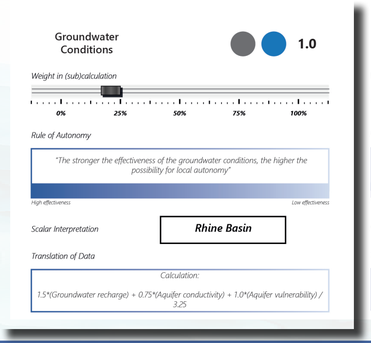
(2). *Groundwater Conditions*

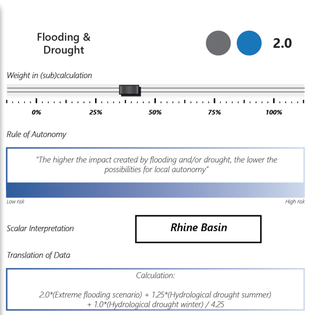
(3). *Flooding & Drought*

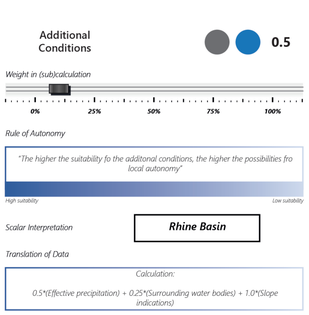
(4). *Additional Conditions*





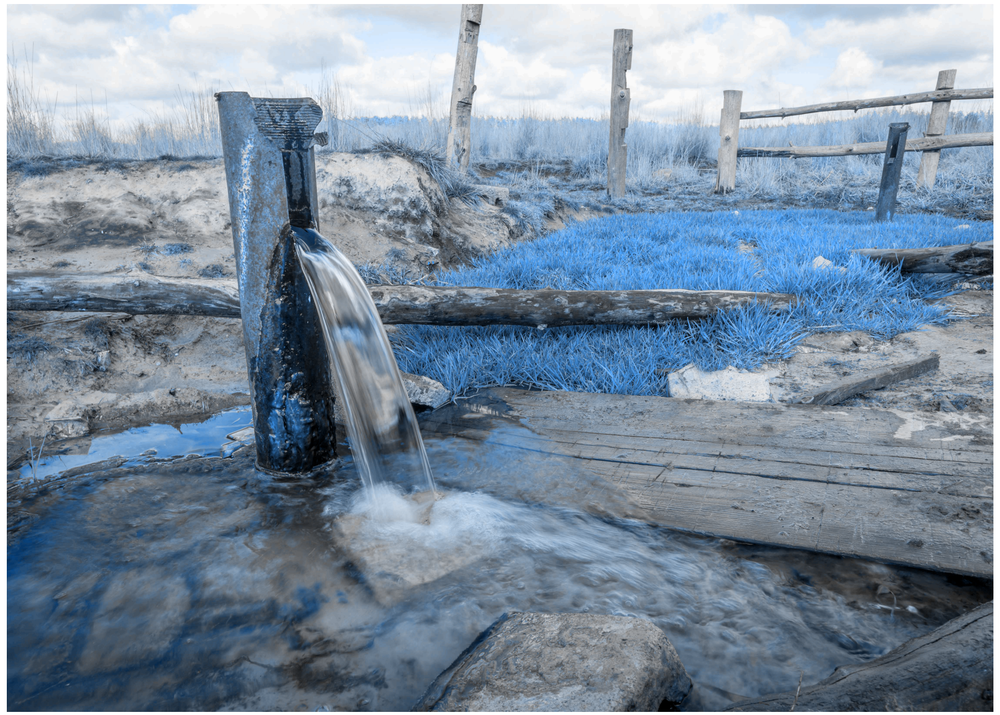






GROUNDWATER

WATER FLOWS WITHIN THE DIKE LINE



Groundwater Conditions 1.0

Weight in (sub)calculation

0% 25% 50% 75% 100%

Rule of Autonomy

"The stronger the effectiveness of the groundwater conditions, the higher the possibility for local autonomy"

High effectiveness *Low effectiveness*

Scalar Interpretation ***Rhine Basin***

Translation of Data

Calculation:

1.5(Groundwater recharge) + 0.75*(Aquifer conductivity) + 1.0*(Aquifer vulnerability) / 3.25*

Establishing the Lines of Autonomy

(1). Groundwater Recharge

(2). Aquifer Characteristics

A. *Groundwater Recharge*

Groundwater Recharge

1.5

Weight in (sub)calculation

0% 25% 50% 75% 100%

Rule of Autonomy

"The higher the amount of groundwater to be recharged within the underlying aquifers (mm/year), the higher the possibility for autonomy"

High recharge *Low recharge*

Scalar Interpretation ***Raster (1x1 km)***

Translation of Data

Translation of the data provided by GEUS (2021) on the potential groundwater recharge from 1960-2010. A high degree of recharge indicates the suitability of the soils to collect and transport water flows increasing the drainage capacity and saturation levels needed for dikes

B. *Aquifer Conductivity*

Aquifer Conductivity

0.75

Weight in (sub)calculation

0% 25% 50% 75% 100%

Rule of Autonomy

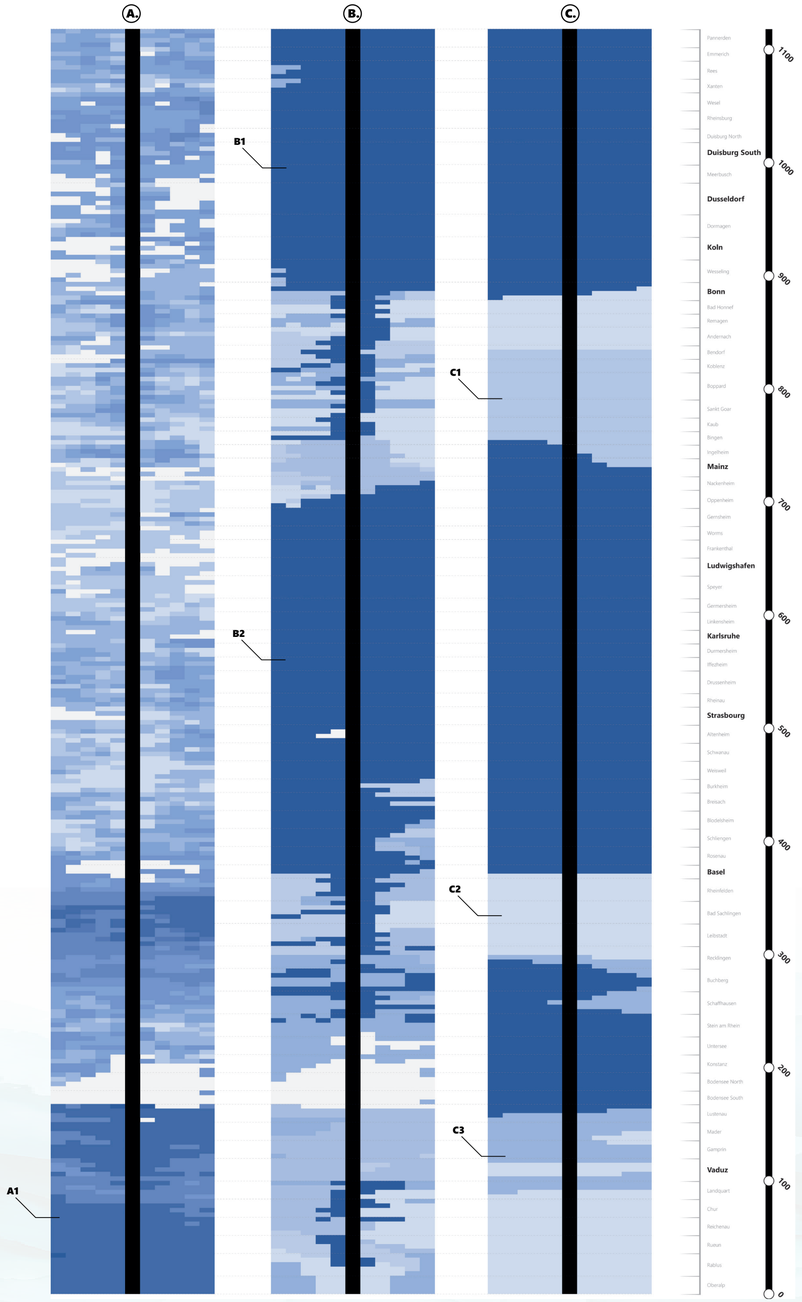
"The higher the conductivity of the underlying aquifers, the higher the possibility for local autonomy"

High conductivity *Low conductivity*

Scalar Interpretation ***Shapefile Areas***

Translation of Data

Translation of the information provided by the BGR (2019) on the aquiferal conductivity of Europe. High conductivity rates increase the rate for water to be infiltrated by the subsoil water tables, increasing the drainage and saturation rates needed for dikes



C. *Aquifer Vulnerability*

Aquifer Vulnerability

1.0

Weight in (sub)calculation

0% 25% 50% 75% 100%

Rule of Autonomy

"The higher the vulernability of the aquifers of the Rhine, the lower the possibility for local autonomy"

Low vulnerabilities *High vulnerabilities*

Scalar Interpretation ***Shapefile Areas***

Translation of Data

Translation of the information provided by BGR (2015) on the vulnerabilities of the aquifers of Europe. Calculation is provided based on the risk evaluation on the potentials of flooding and drought of aquifers (High (1), Moderate (3), Low (5))

Establishing the Lines of Autonomy



Groundwater Conditions

1.0

Weight in (sub)calculation

0% 25% 50% 75% 100%

Rule of Autonomy

"The stronger the effectiveness of the groundwater conditions, the higher the possibility for local autonomy"

High effectiveness — *Low effectiveness*

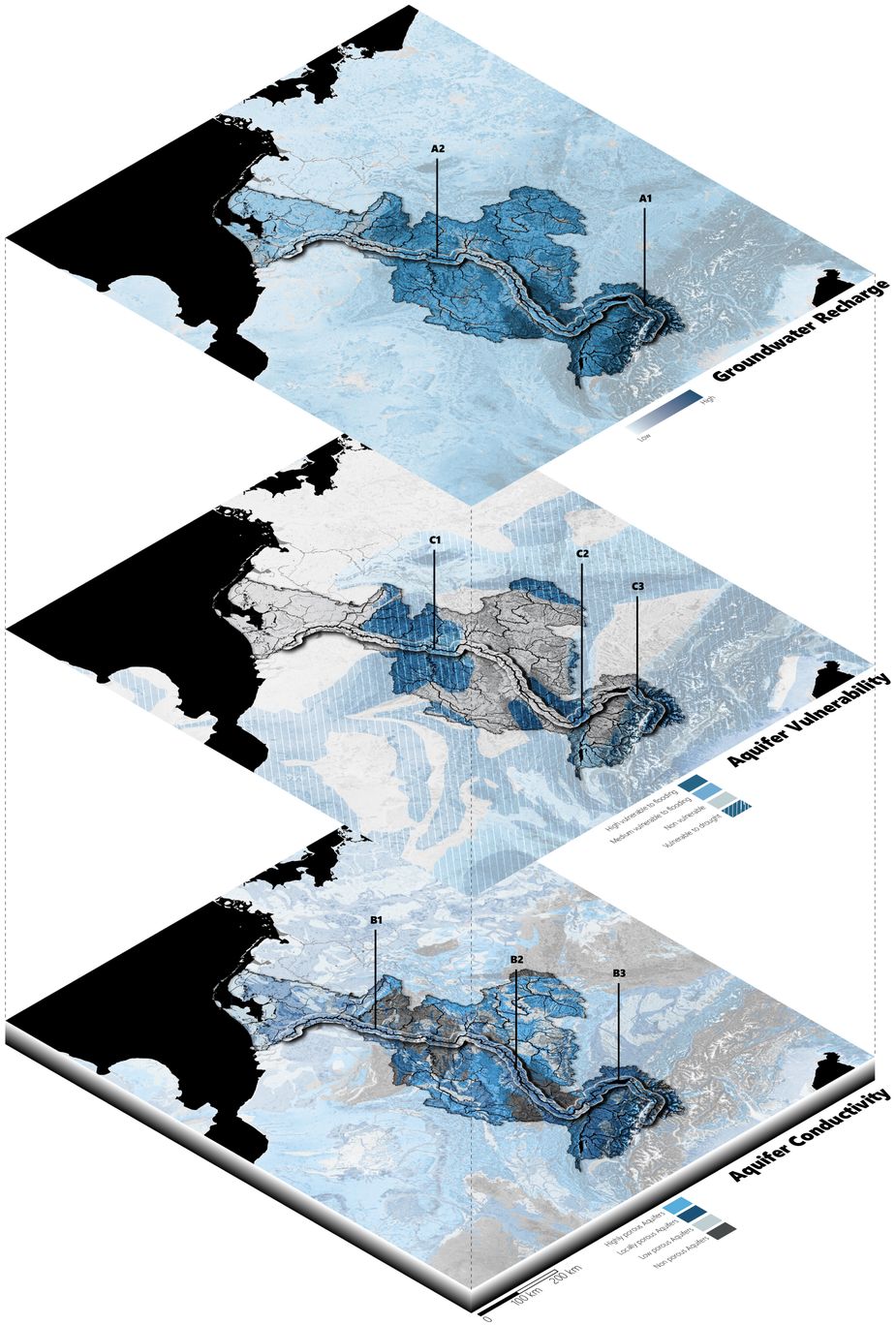
Scalar Interpretation

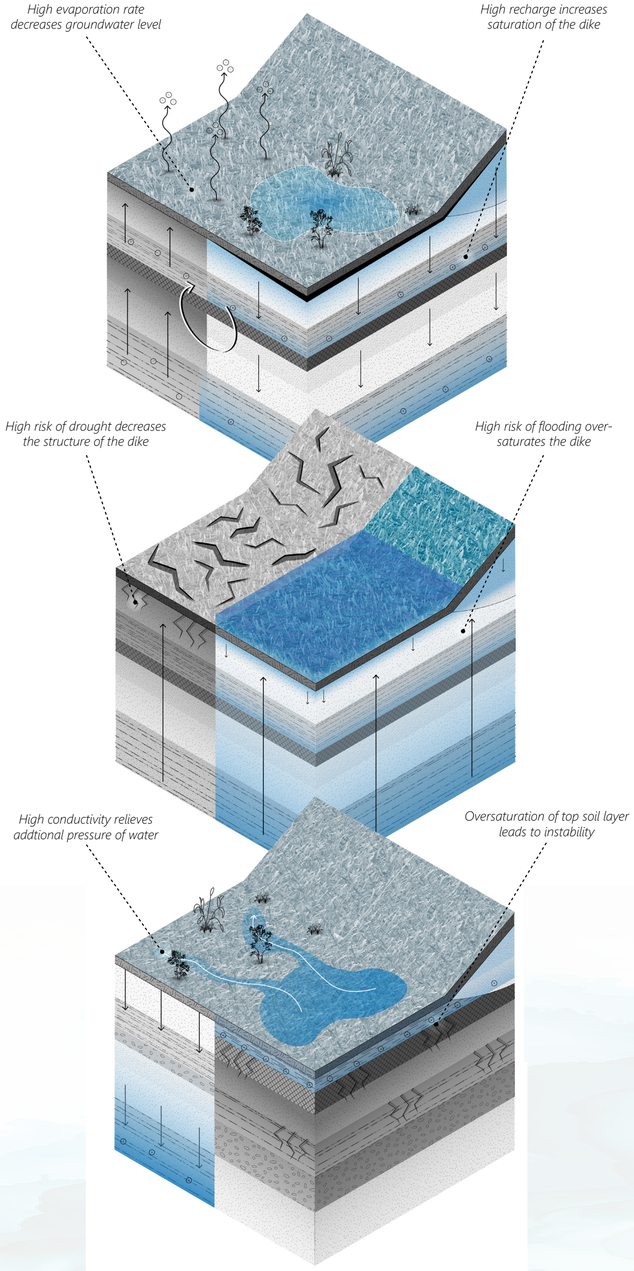
Rhine Basin

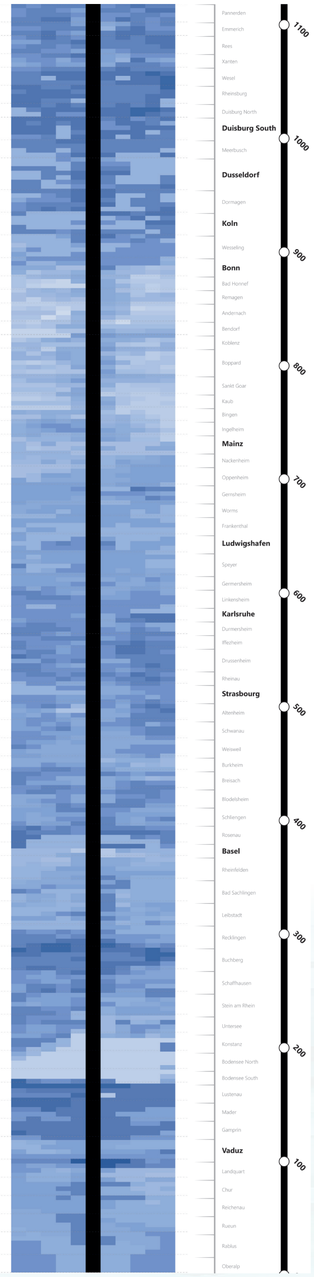
Translation of Data

Calculation:

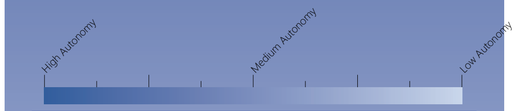
1.5(Groundwater recharge) + 0.75*(Aquifer conductivity) + 1.0*(Aquifer vulnerability) / 3.25*







Forming the Lines of the Rhine: Suitability Conditions



Suitability Conditions

1.0

Weight in (sub)calculation

0% 25% 50% 75% 100%

Rule of Autonomy

"The higher the impact created by the dynamics of the river to the adjacent river banks and dikes, the lower the possibilities for local autonomy"

Low discharge — *High discharge*

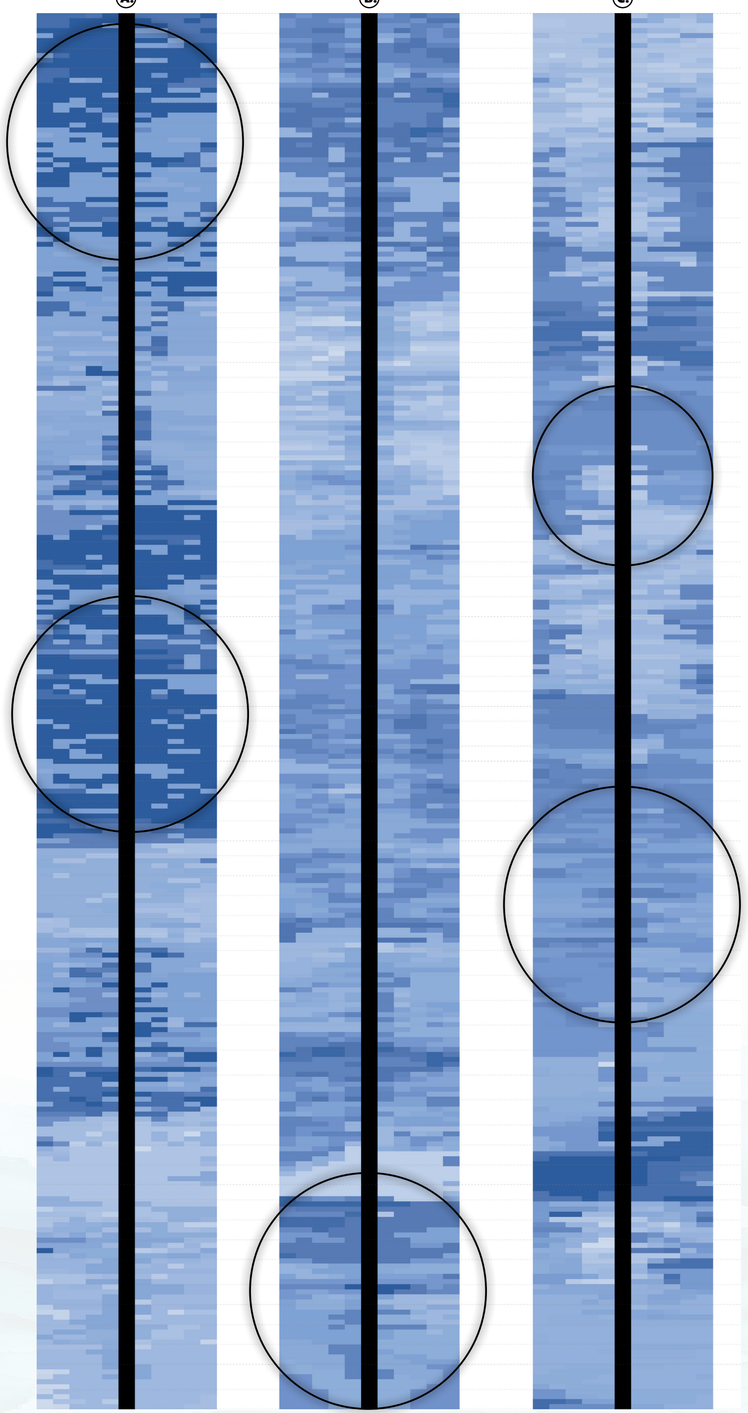
Scalar Interpretation **Rhine Basin**

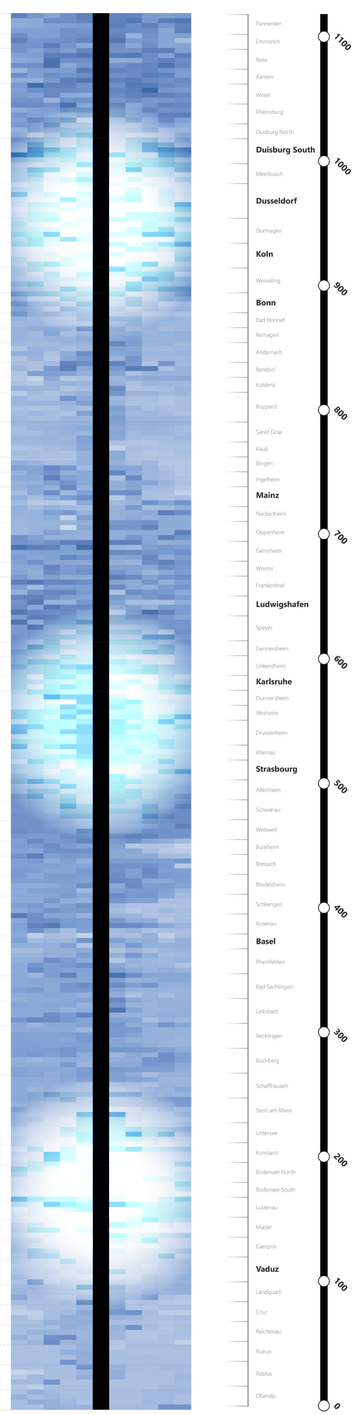
Translation of Data

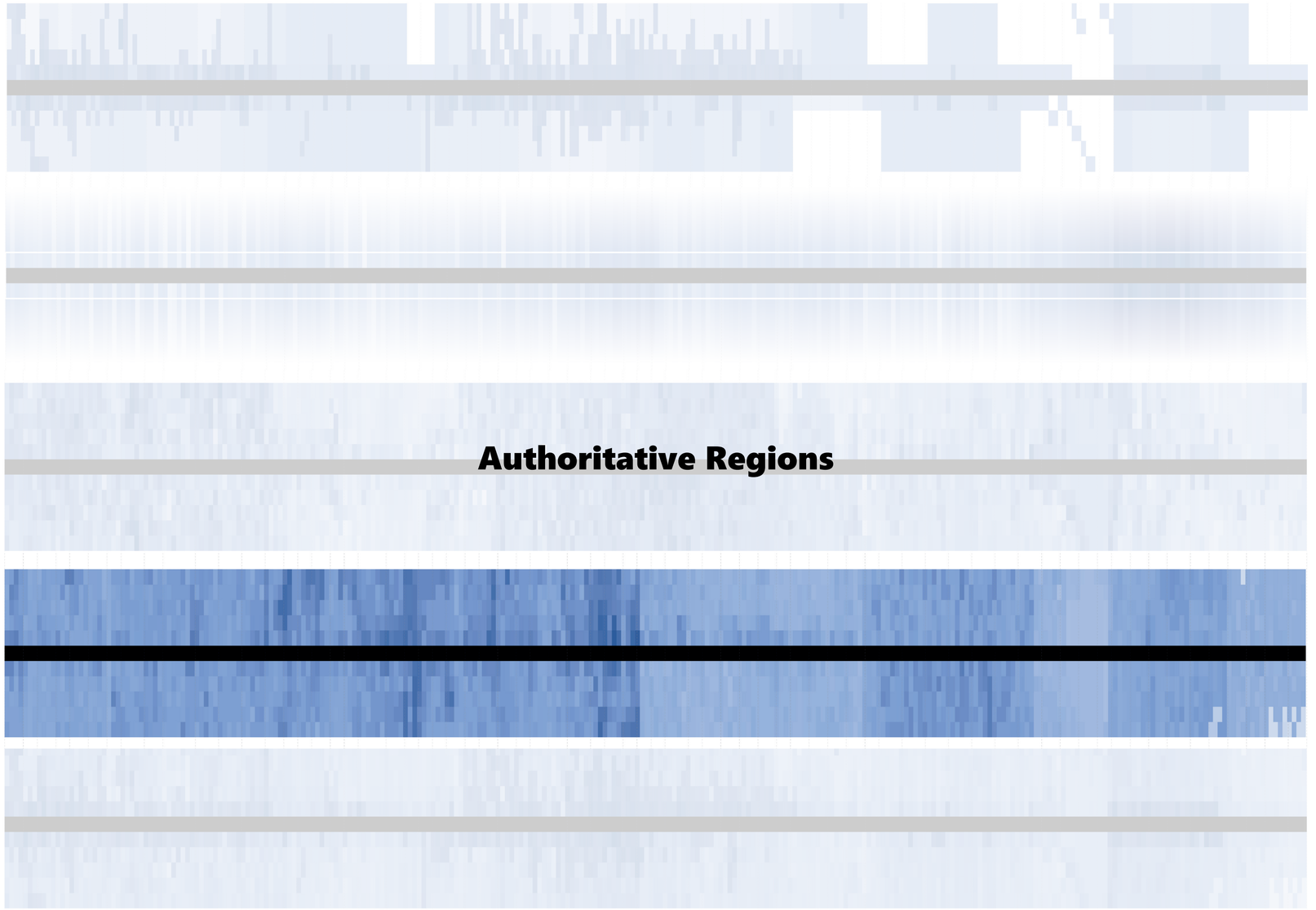
Calculation:

(1.5(Soil Conditions) + 1.0*(Groundwater conditions) + 2.0*(Flooding & Drought) + 0.5*(Effective precipitation)) / 5 + 0.25*(Surrounding Water bodies) + 1.0*(Slope Indications)*

High Autonomy indicates a high suitable location for dike construction






Authoritative Regions

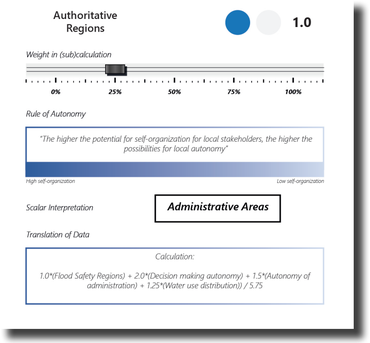
Establishing Authoritative Autonomy

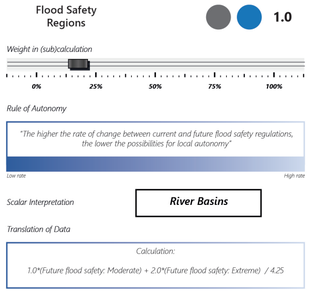
(1). *Flood Safety Regions*

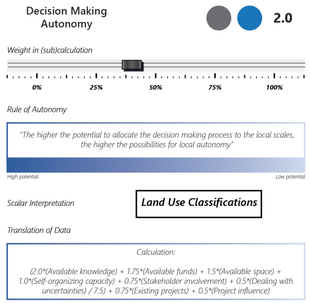
(2). *Decision-Making Autonomy*

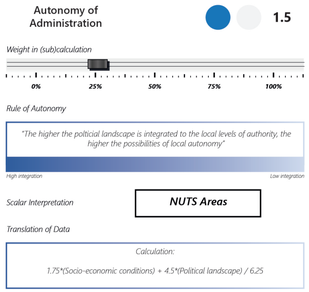
(3). *Administrative Autonomy*

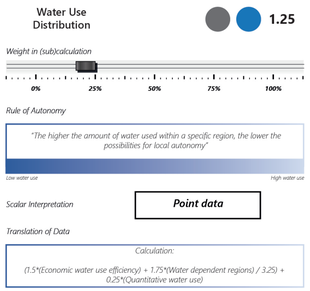
(4). *Water Use Distribution*











DECISION MAKING
SELF ORGANIZING CAPACITY OF THE LAND



Decision Making Autonomy 2.0

Weight in (sub)calculation

0% 25% 50% 75% 100%

Rule of Autonomy

"The higher the potential to allocate the decision making process to the local scales, the higher the possibilities for local autonomy"

High potential *Low potential*

Scalar Interpretation ***Land Use Classifications***

Translation of Data

Calculation:

(2.0(Available knowledge) + 1.75*(Available funds) + 1.5*(Available space) + 1.0*(Self-organizing capacity) + 0.75*(Stakeholder involvement) + 0.5*(Dealing with uncertainties) / 7.5) + 0.75*(Existing projects) + 0.5*(Project influence)*

Establishing the Lines of Autonomy

(1). *Available Space*

(2). *Available Funds*

(3). *Stakeholder Involvement*

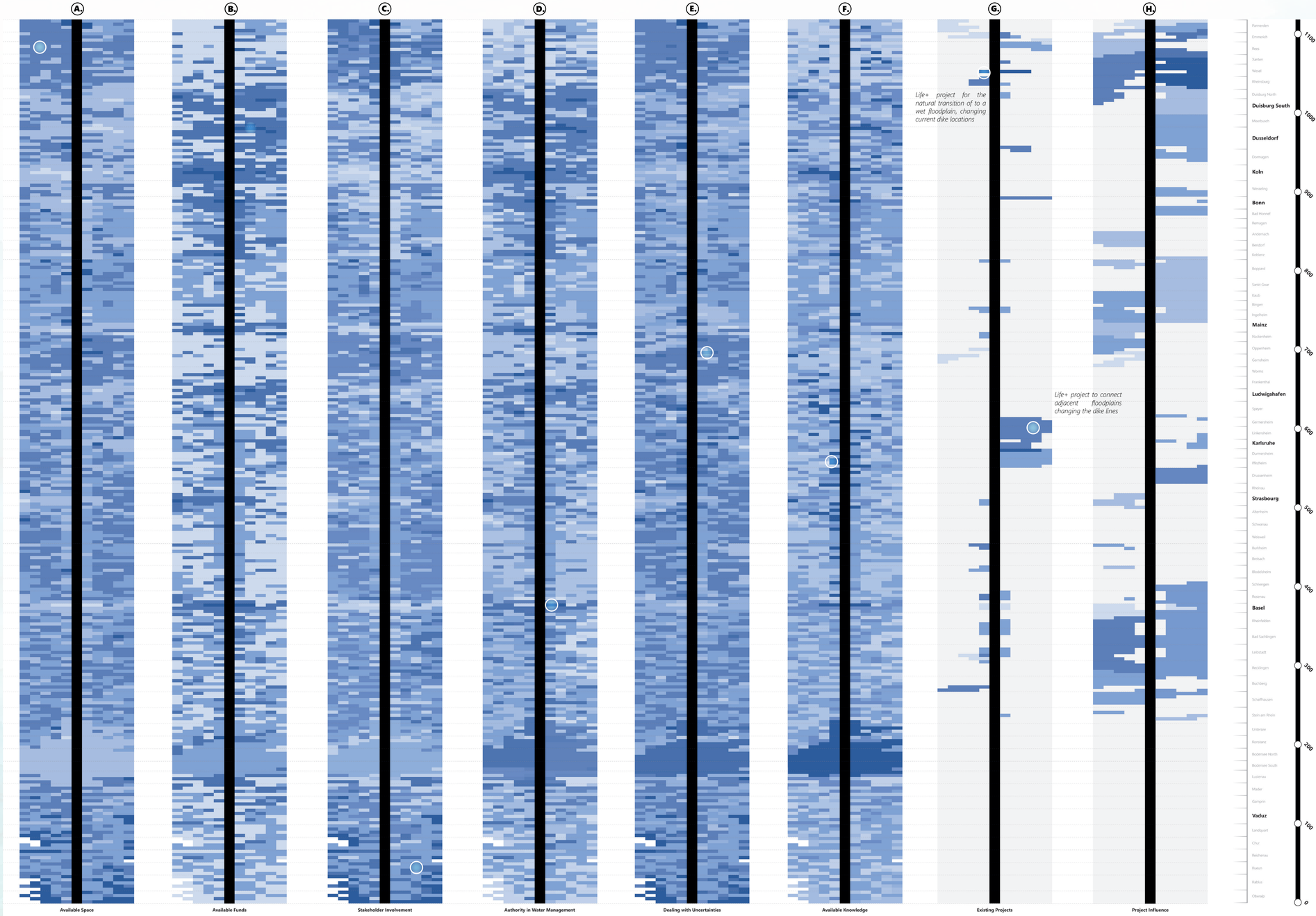
(4). *Autority in W. Management*

(5). *Dealing with Uncertainties*

(6). *Available Knowledge*

(7). *Existing Projects*

(8). *Project Influence*



Establishing the Lines of Autonomy



Decision Making Autonomy

2.0

Weight in (sub)calculation

0% 25% 50% 75% 100%

Rule of Autonomy

"The higher the potential to allocate the decision making process to the local scales, the higher the possibilities for local autonomy"

High potential *Low potential*

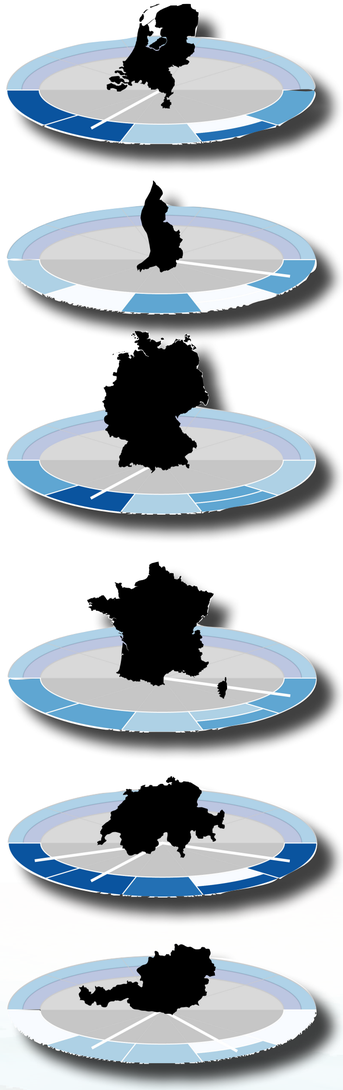
Scalar Interpretation

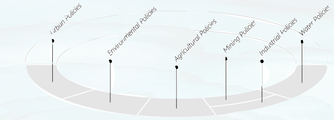
Land Use Classifications

Translation of Data

Calculation:

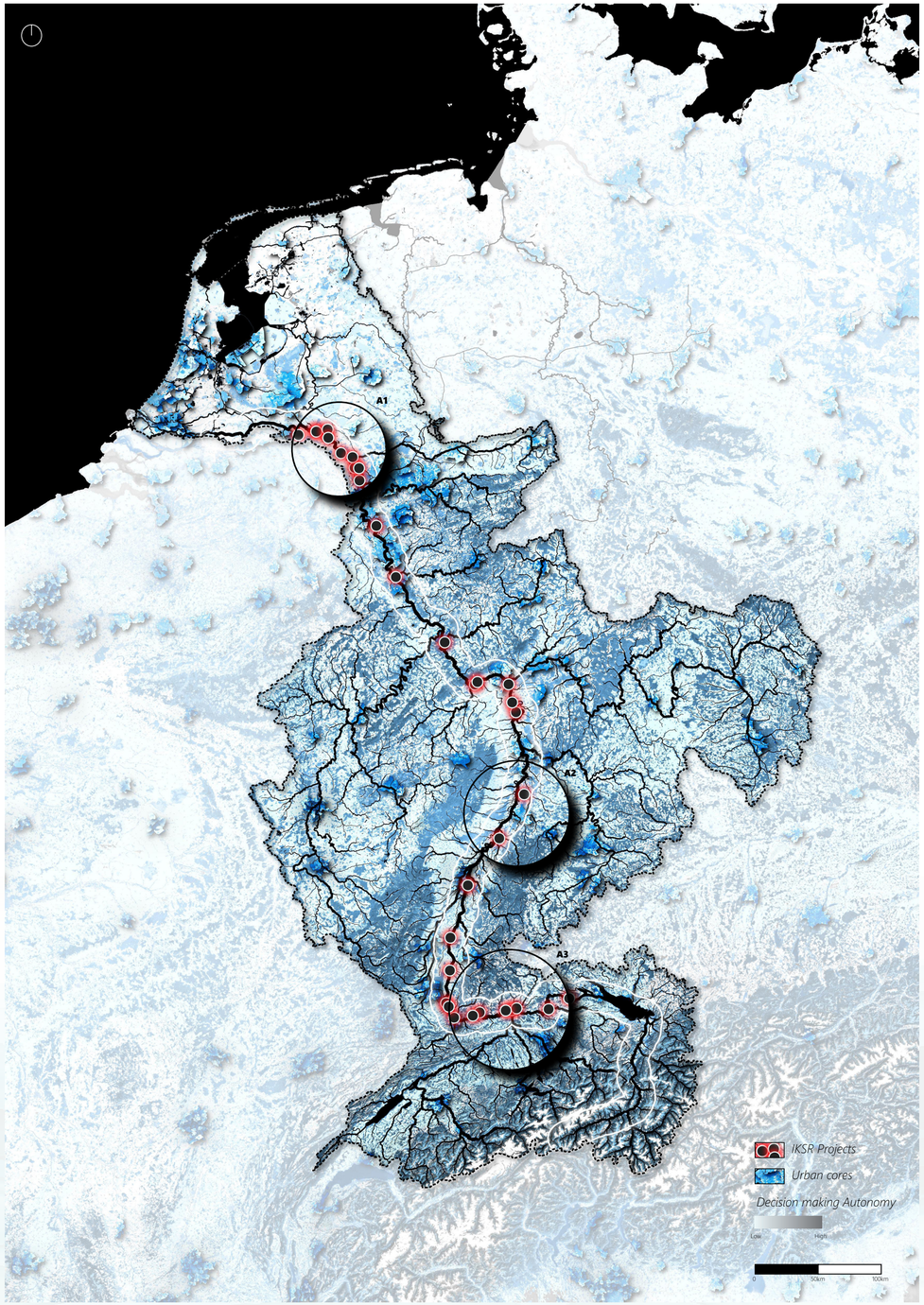
(2.0(Available knowledge) + 1.75*(Available funds) + 1.5*(Available space) + 1.0*(Self-organizing capacity) + 0.75*(Stakeholder involvement) + 0.5*(Dealing with uncertainties) / 7.5) + 0.75*(Existing projects) + 0.5*(Project influence)*

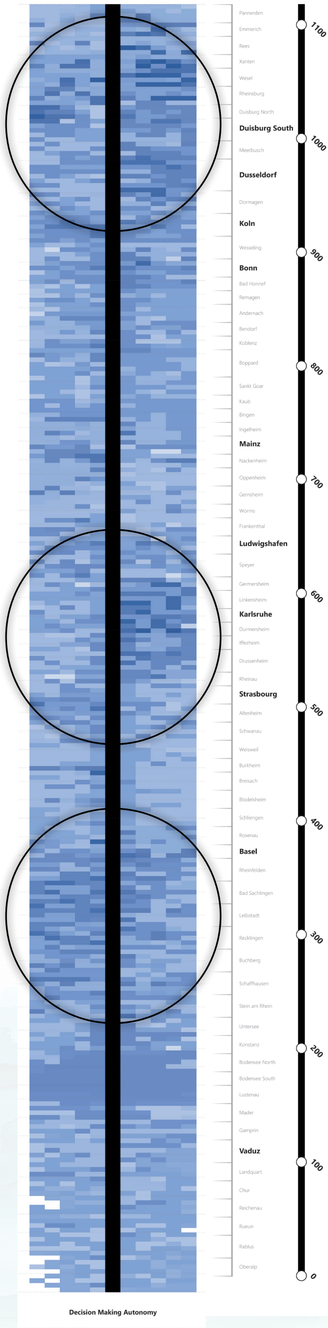




Integration rate of policies

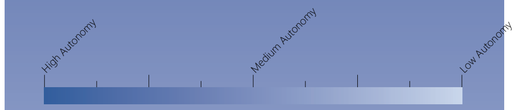
Low High





Decision Making Autonomy

Forming the Lines of the Rhine: Authoritative Regions



Authoritative Regions

1.0

Weight in (sub)calculation

0% 25% 50% 75% 100%

Rule of Autonomy

"The higher the potential for self-organization for local stakeholders, the higher the possibilities for local autonomy"

High self-organization — *Low self-organization*

Scalar Interpretation

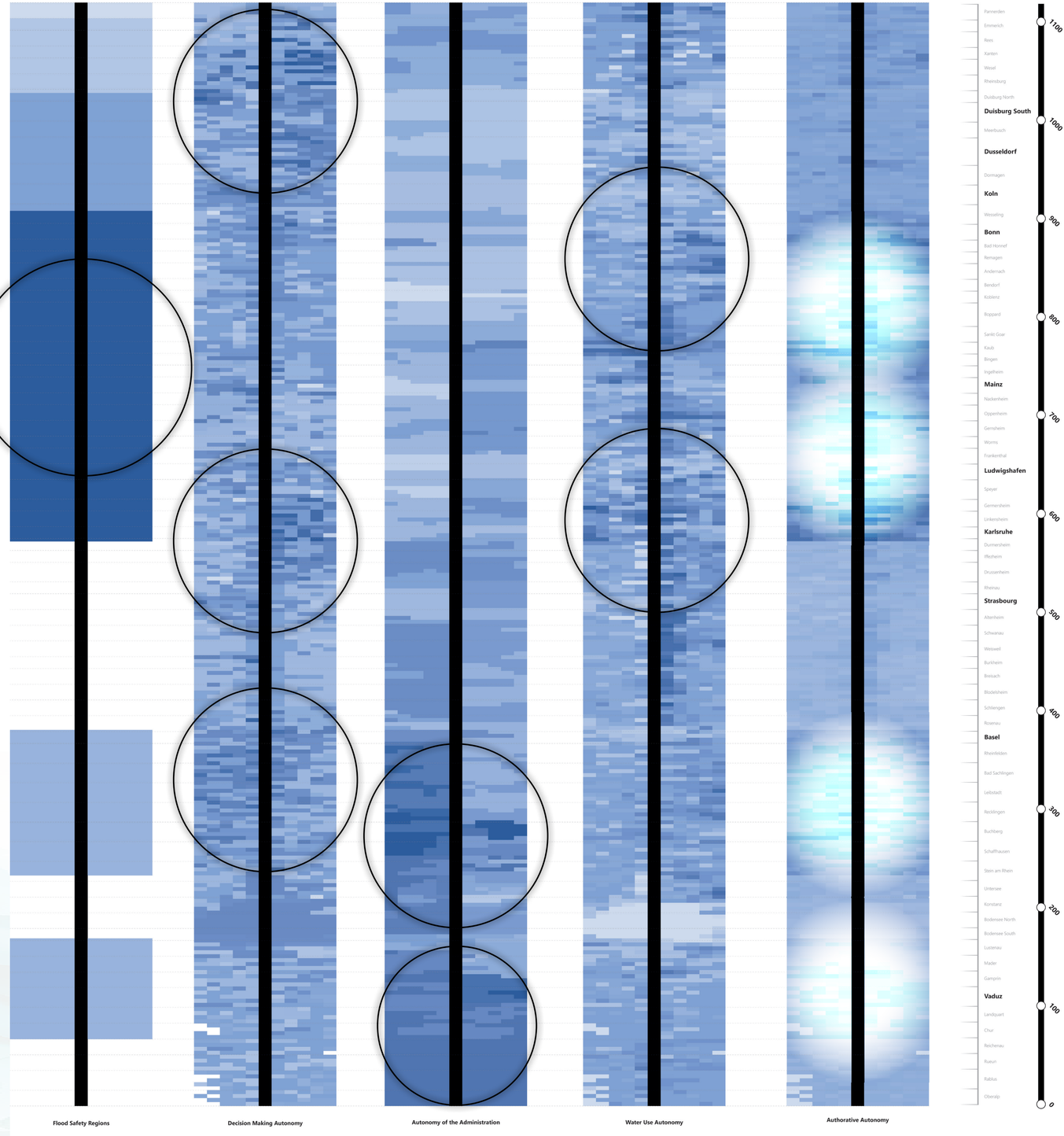
Administrative Areas

Translation of Data

Calculation:

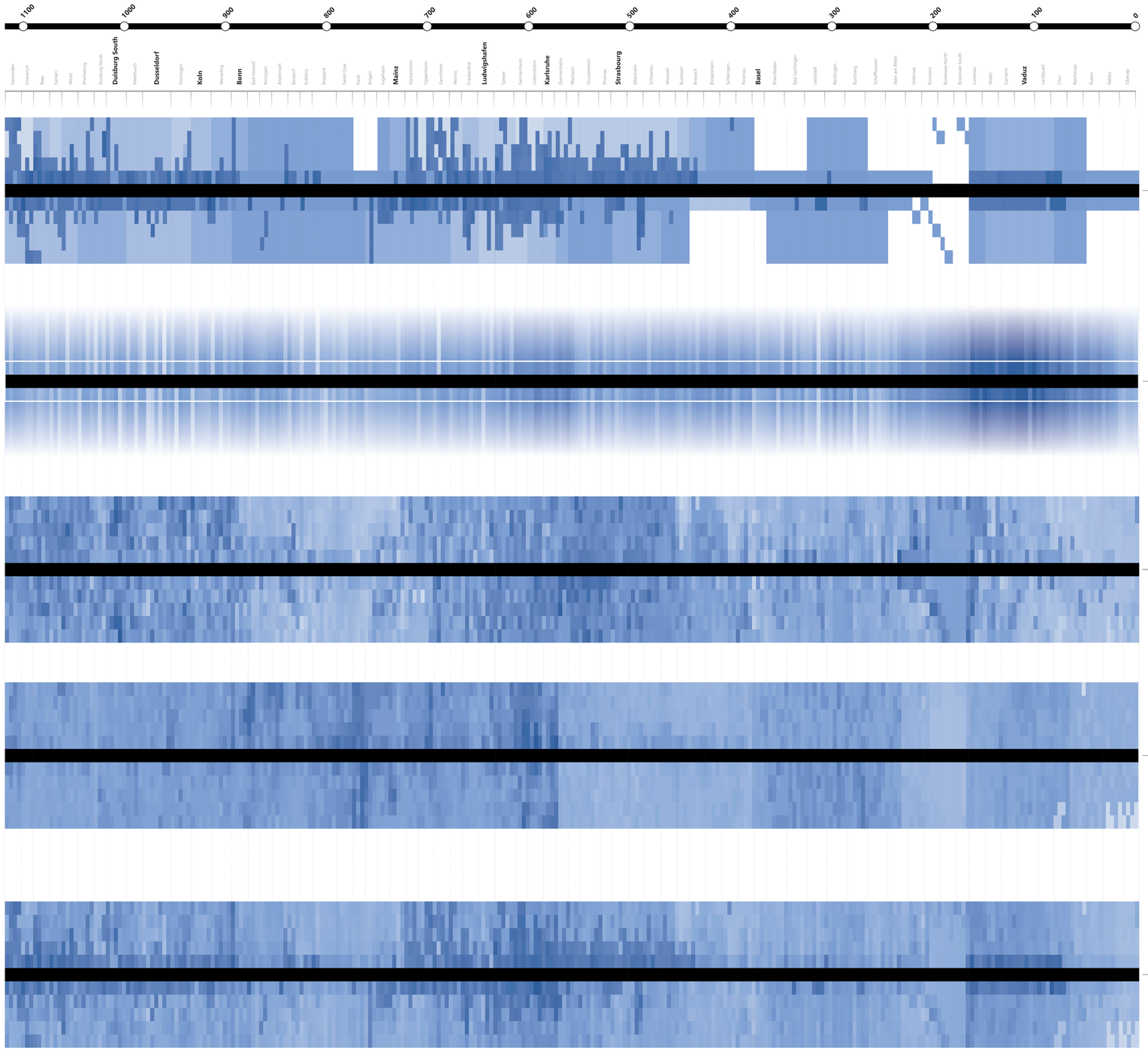
1.0(Flood Safety Regions) + 2.0*(Decision making autonomy) + 1.5*(Autonomy of administration) + 1.25*(Water use distribution)) / 5.75*

High Autonomy indicates a higher freedom in the decision making process



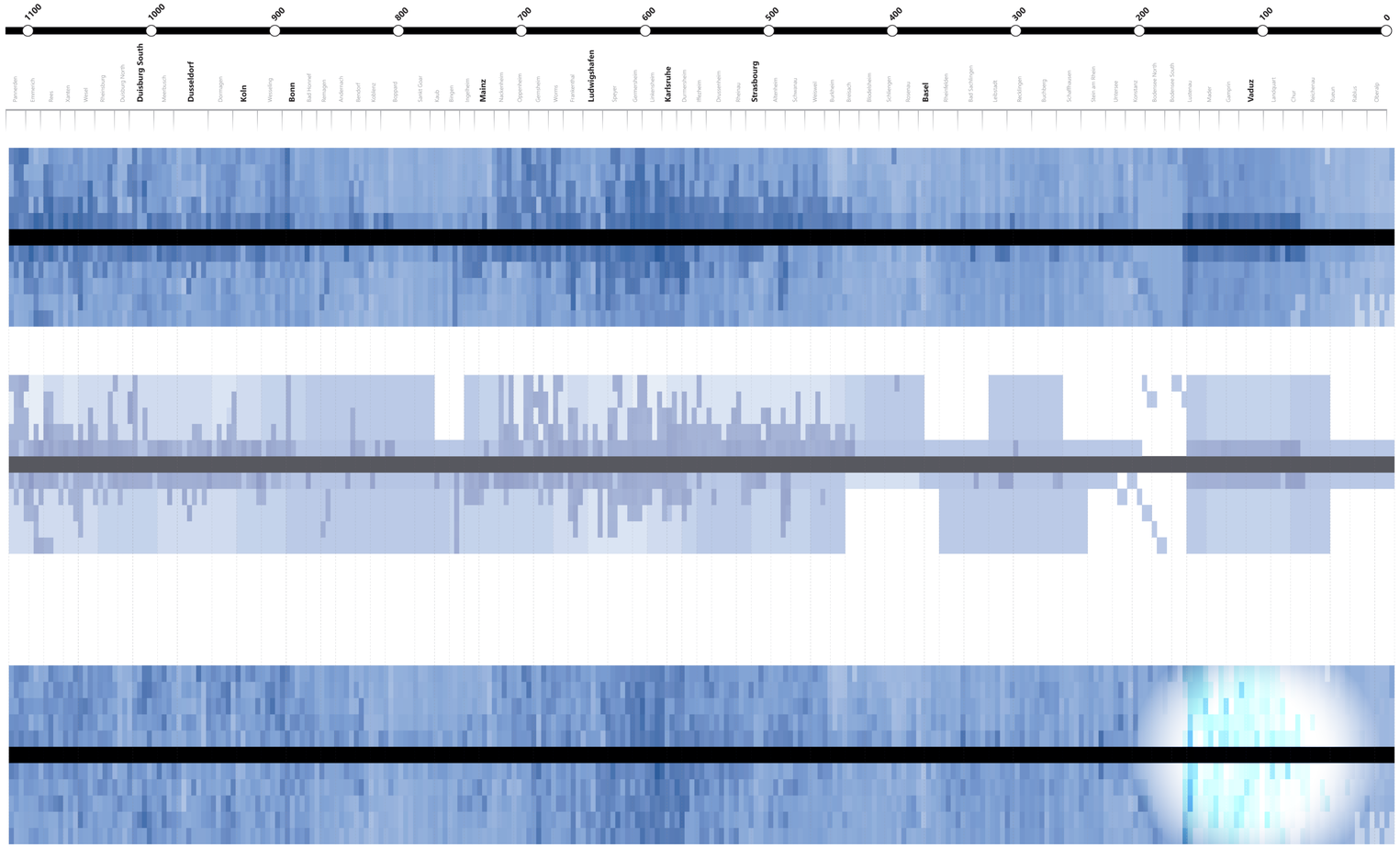
The Rhine Lines of Autonomy

Spatial Pattern



The Rhine Lines of Autonomy

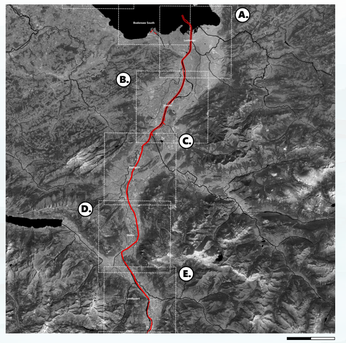
Spatial Pattern



Localized Dike Autonomy of the Rhine

Autonomy of the Dikes of the Rhine

Freedom of New Localized Dike Management



WHAT ARE THE FIRST RESULTS?

LOCAL DIKE DESIGN IN THE ALPINE RHINE



(1). The Alpine Rhine

(2). Results of the Calculations

(3). Formation of a new dike line

(4). Envision Future dike identities

(5). Dike Design Dialogues

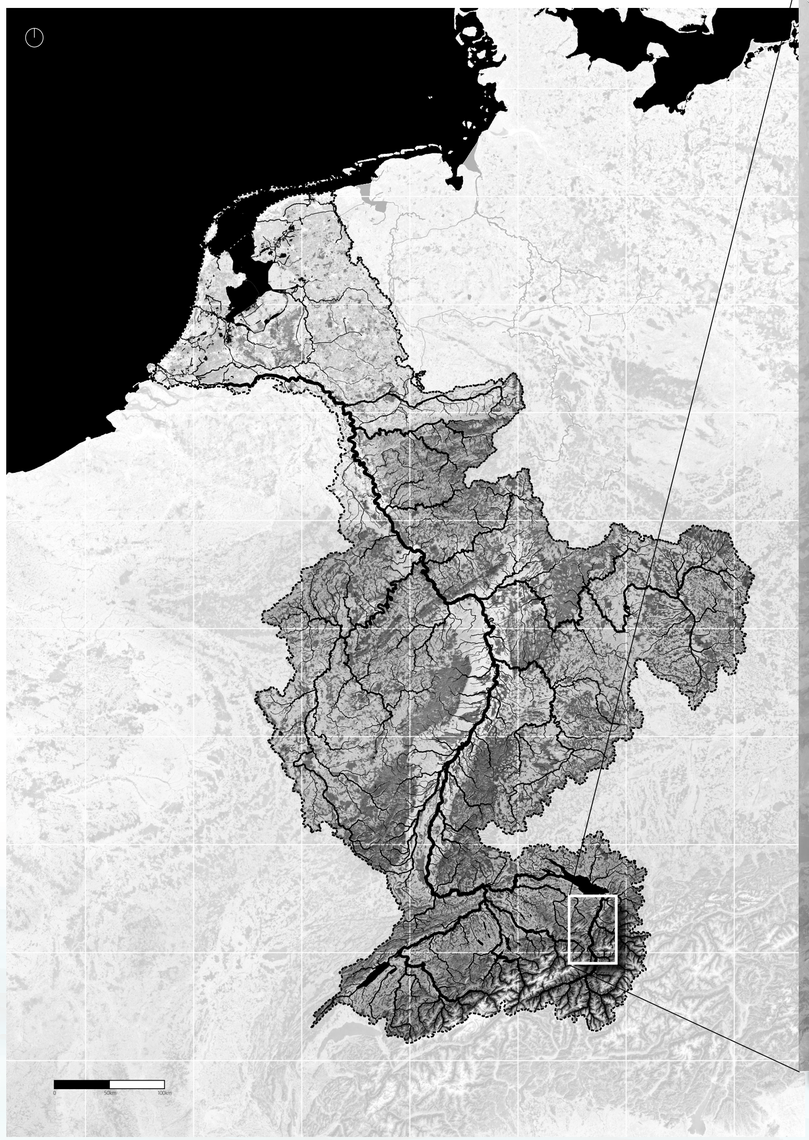
(6). Placement on Location & Impact Assessment

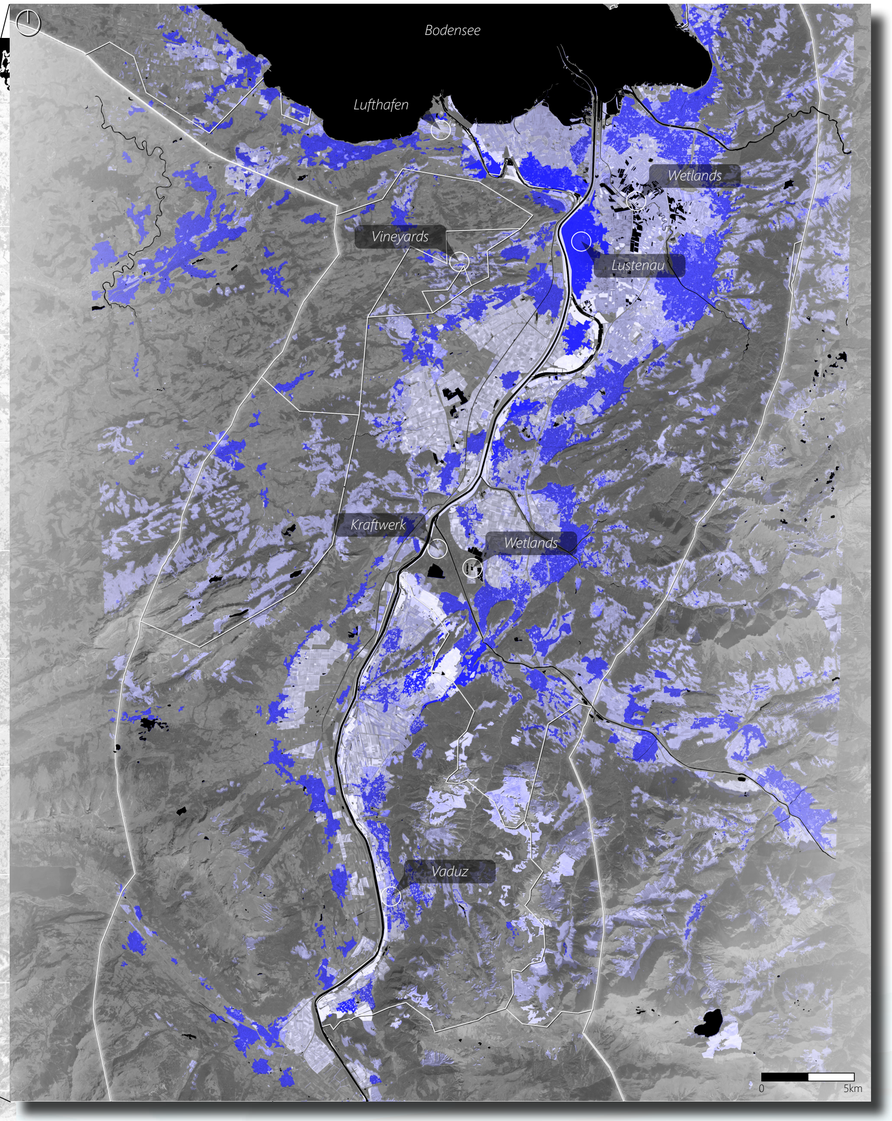
The Alpine Rhine

Urbanized Alpine river valley between Switzerzerland, Austria & Liechtenstein

Known for its 'Controlled' Rhine river before the Bodensee

Large sediment industries depending on Alpine sediments





Water bodies
Urban areas
Industrial zones (commericial & quarries)
Agricultural land
Natural grassland
Forests
Administrative regions (Nuts)
Elevation

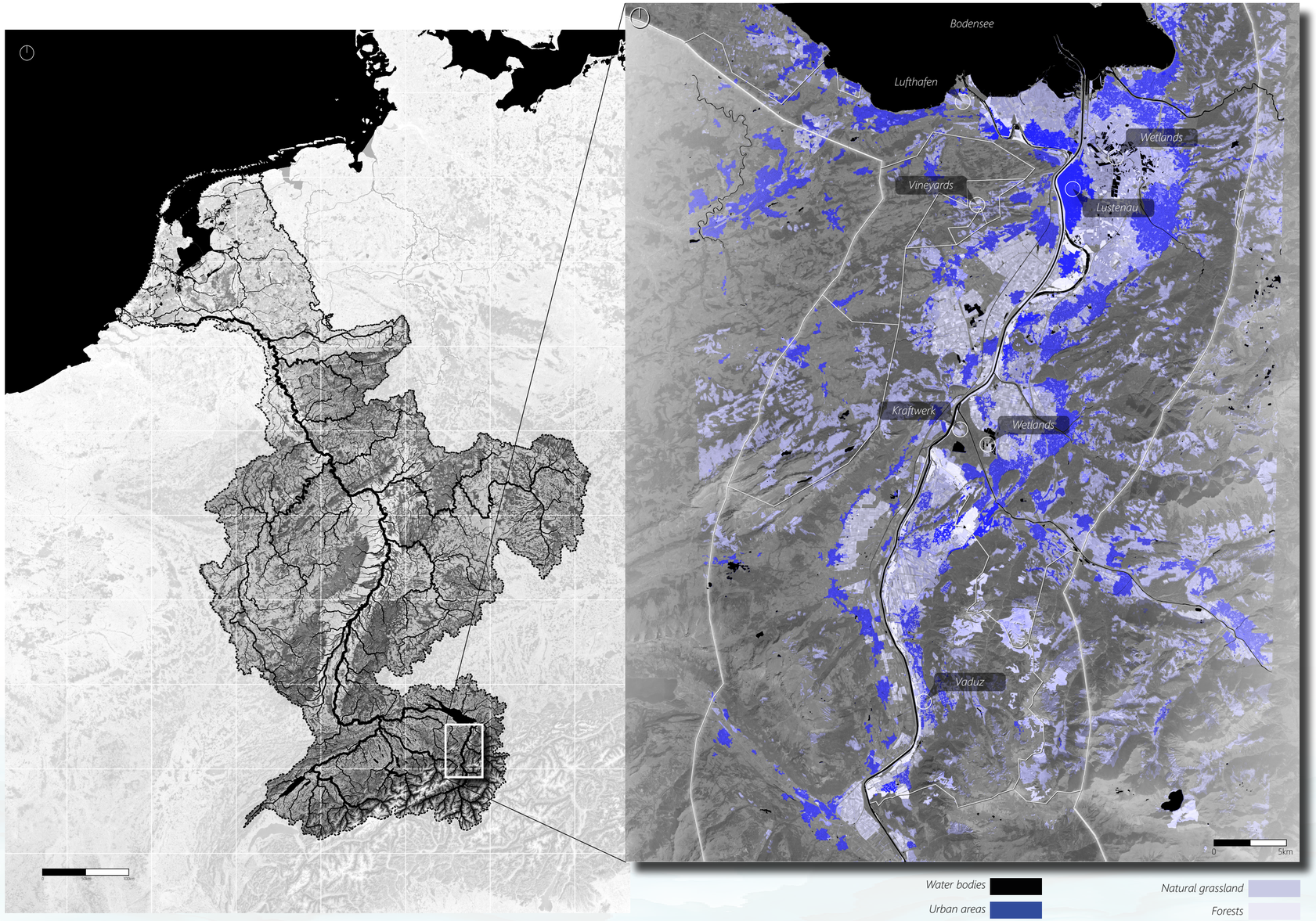


The Alpine Rhine

Urbanized Alpine river valley between Switzerzerland, Austria & Liechtenstein

Known for its 'Controlled' Rhine river before the Bodensee

Large sediment industries depending on Alpine sediments



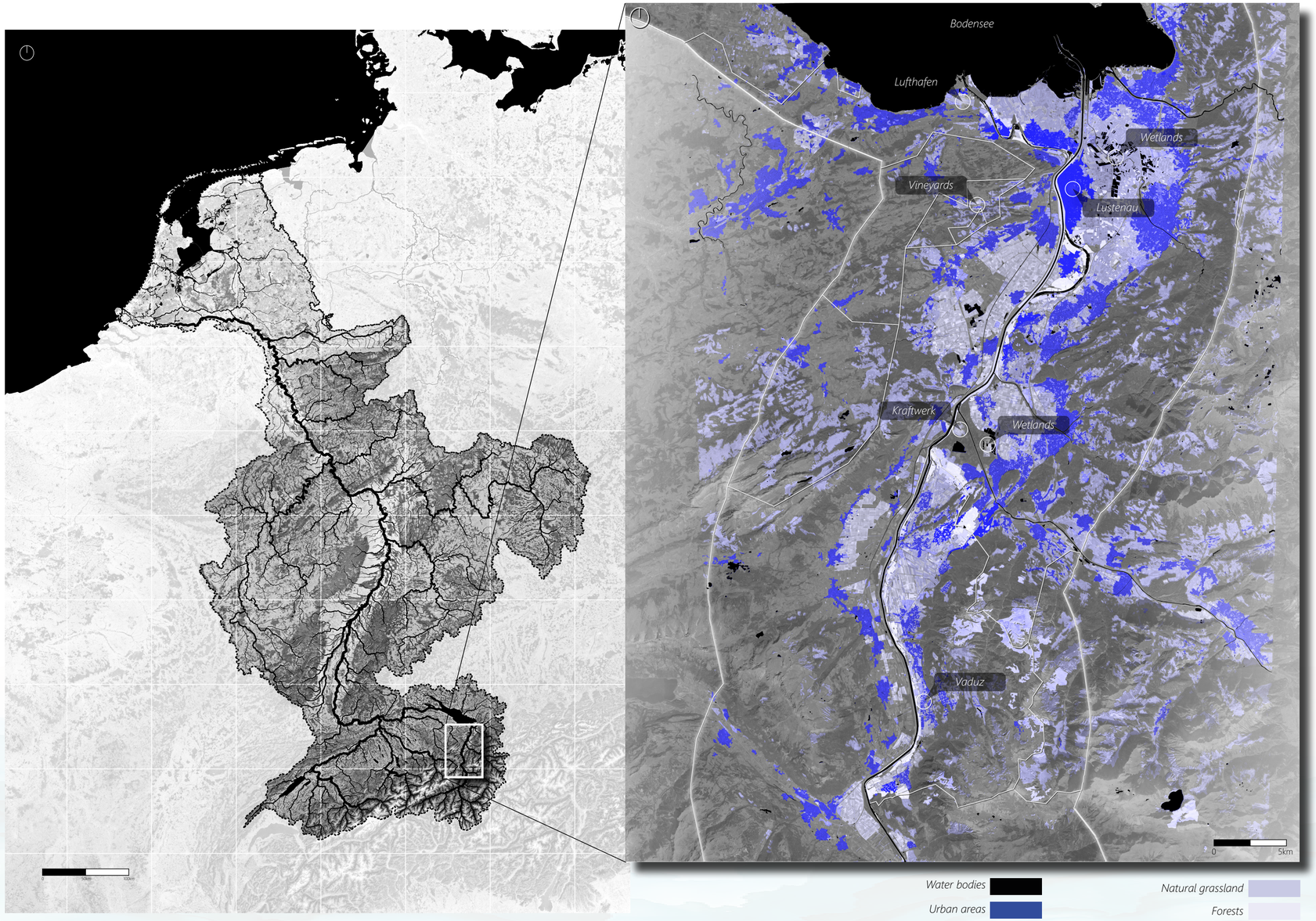


The Alpine Rhine

Urbanized Alpine river valley between Switzerzerland, Austria & Liechtenstein

Known for its 'Controlled' Rhine river before the Bodensee

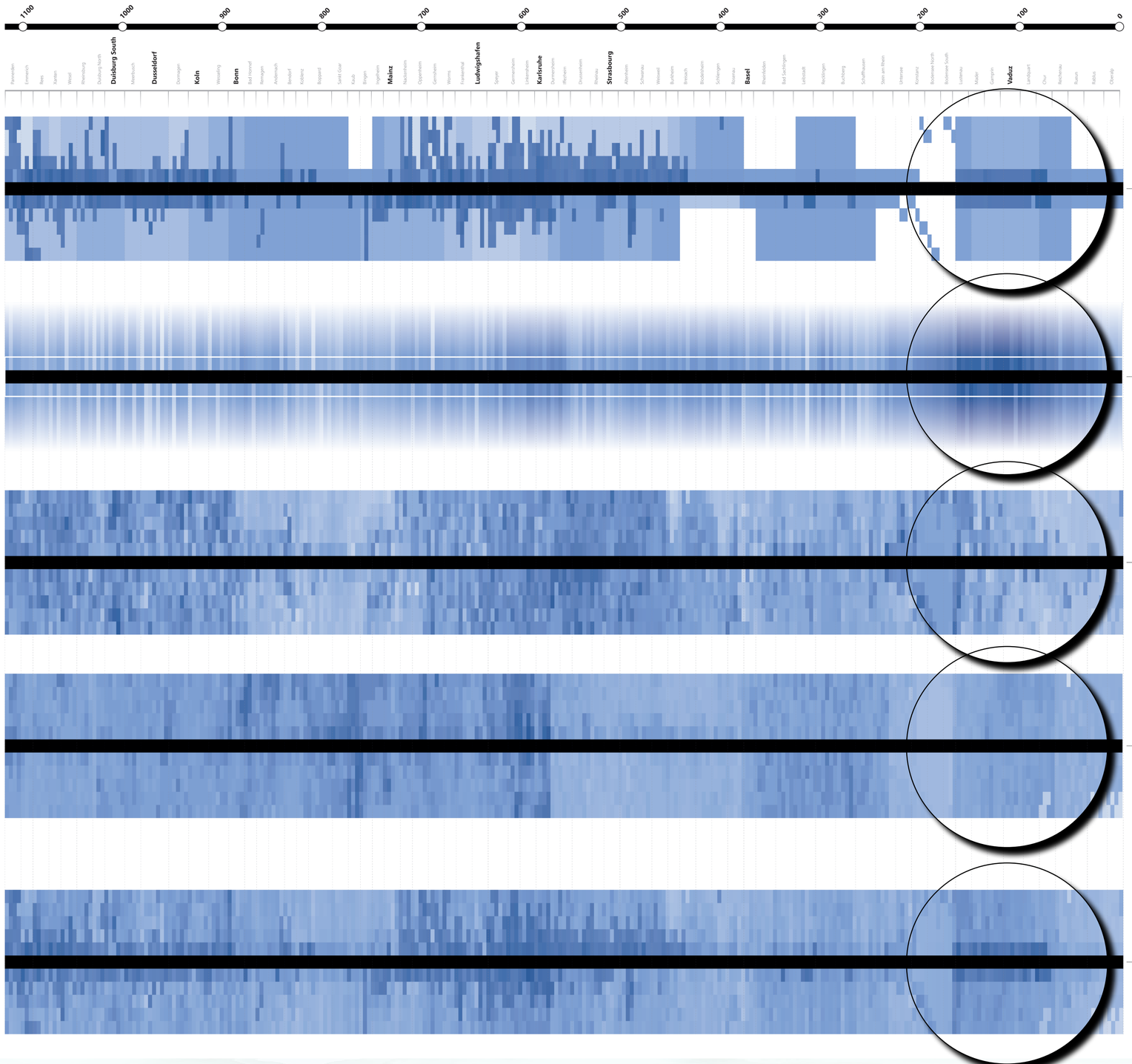
Large sediment industries depending on Alpine sediments





The Rhine Lines of Autonomy

Zooming in on the Alpine Rhine segment of the Rhine River

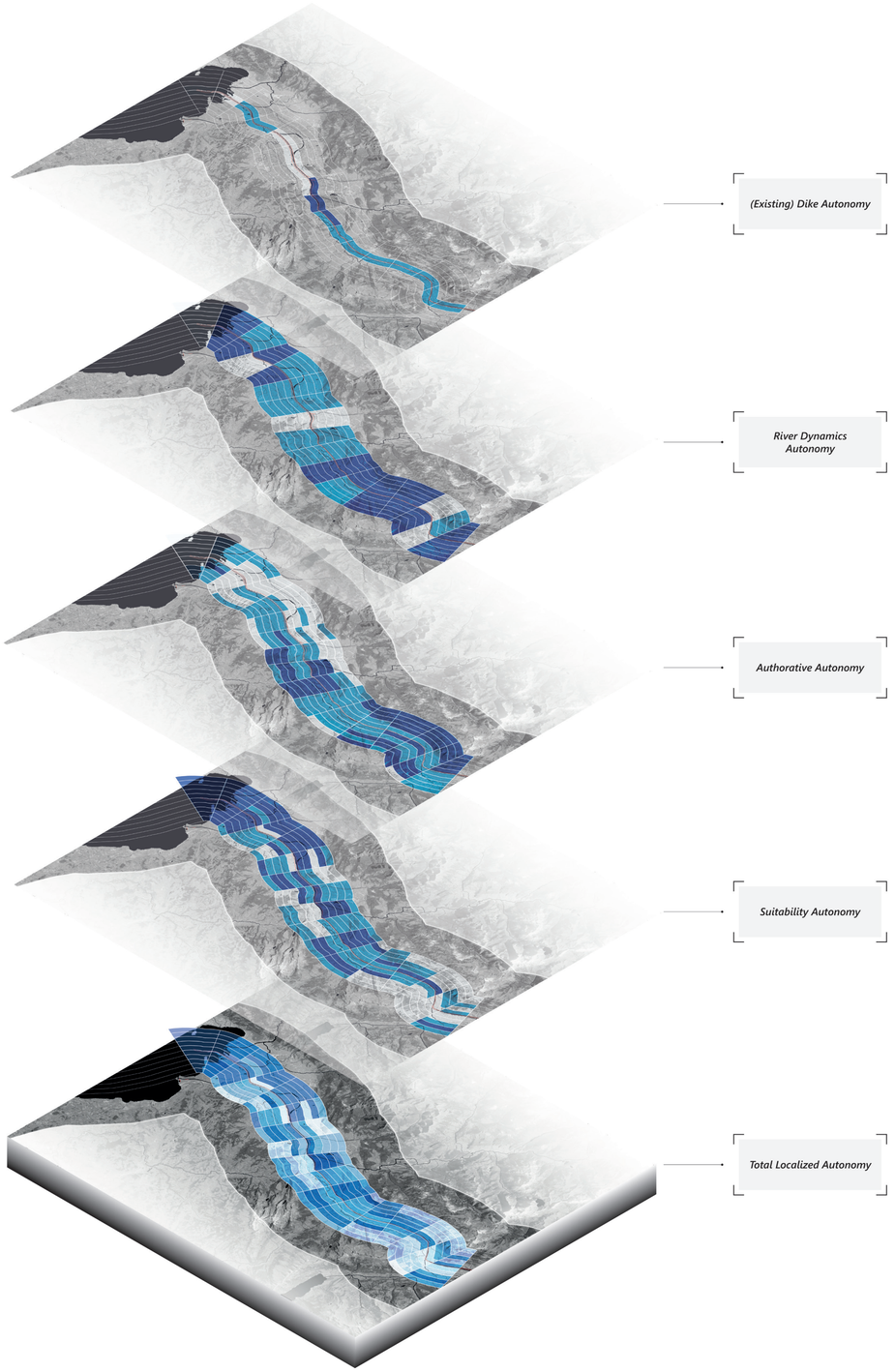


Alpine Rhine Autonomy

Spatial translation of the calculations on the Alpine Rhine

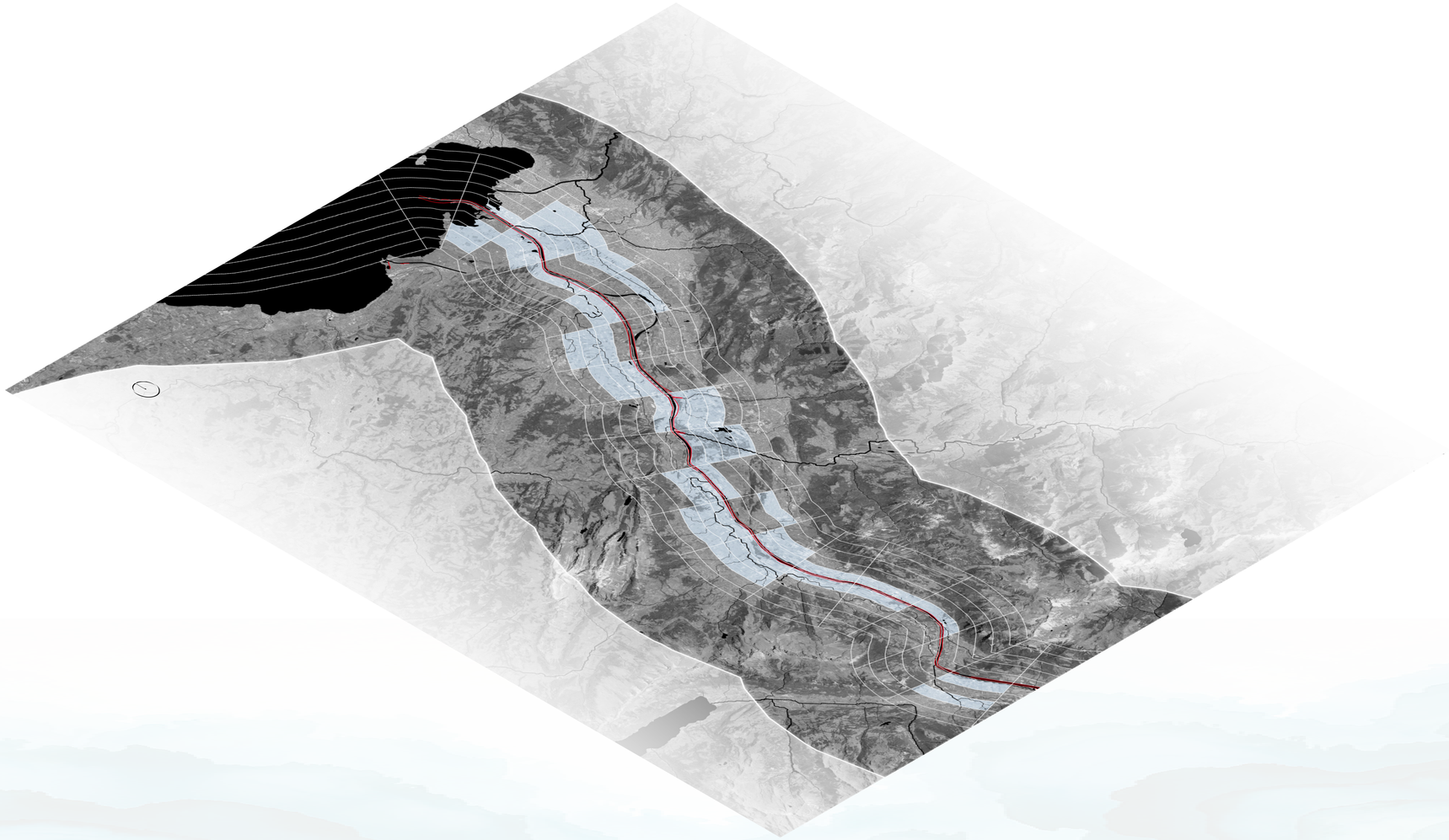
↓

Comparative autonomy translation only focussing on the relation between the Alpine Rhine results



Alpine Rhine Autonomy

Creation of Zones of Intervention, where localized dike Autonomy was considered as high



Alpine Rhine Autonomy

Elimate areas where dikes are not considered to be functional or suitable

Zones of potential



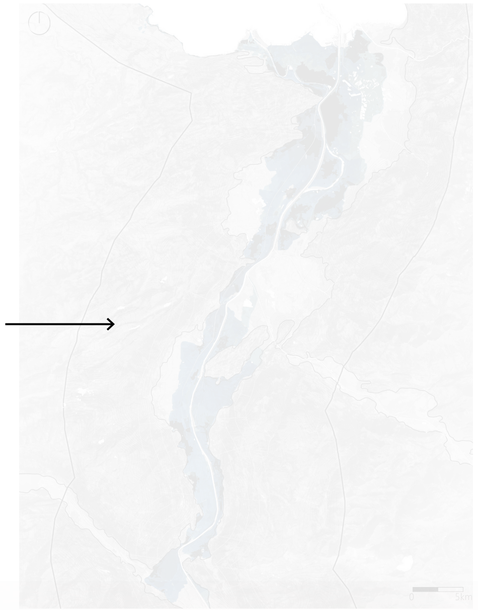
Rhine calculation model

Elevation

Degree of Autonomy

Low High

Freedom of Placement Indicators



Flooded Urban areas

Existing water bodies

Slope extend

Elevation

Flood extend

Extend of the new local dike line

Zones of intervention

Dike extention point

Area of newly defined dike line

Alpine Rhine Autonomy

Additional indicators to contextualize the future dike lines of the Alpine Rhine

(1). *Flood Extent*

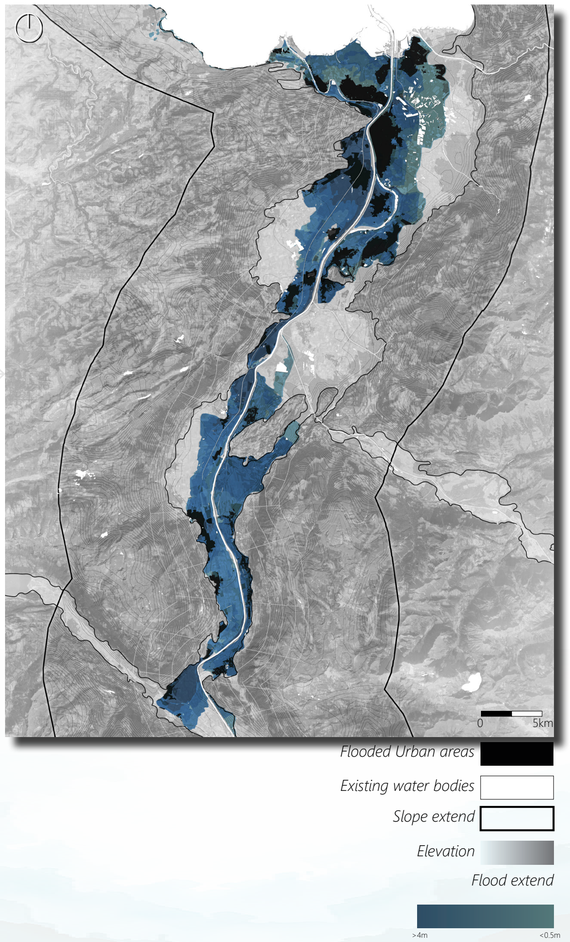
(2). *Slope Indications*

(3). *Existing Water Bodies*

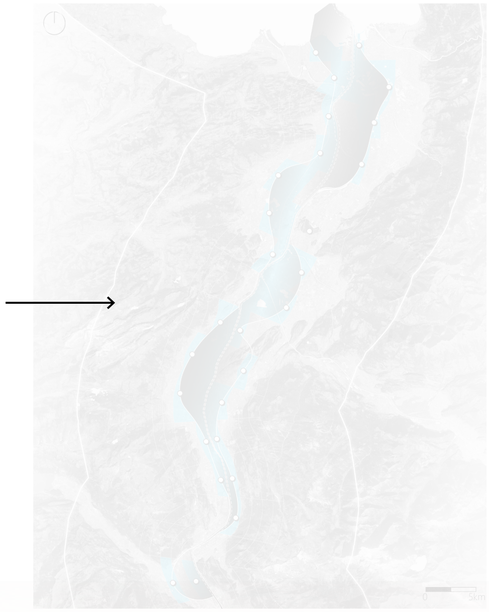
(4). *Lithological Depositions*

Zones of potential

Freedom of Placement Indicators



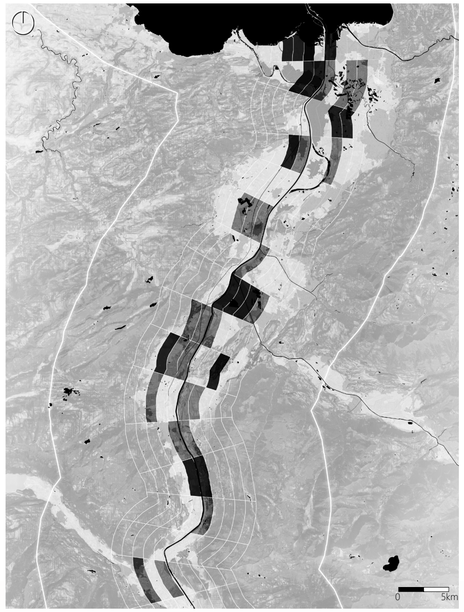
Extend of the new local dike line



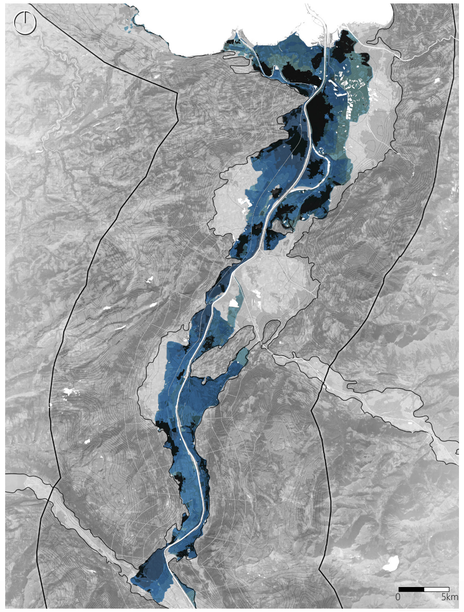
Alpine Rhine Autonomy

The new extent of the Dike lines along the Alpine Rhine.

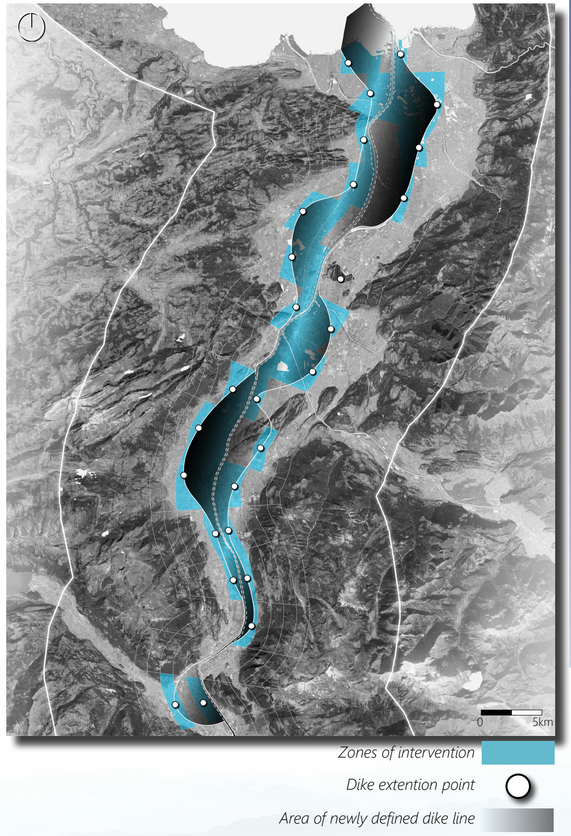
Zones of potential



Freedom of Placement Indicators



Extend of the new local dike line

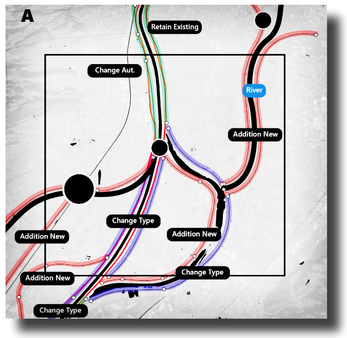


Dike Line Strategies

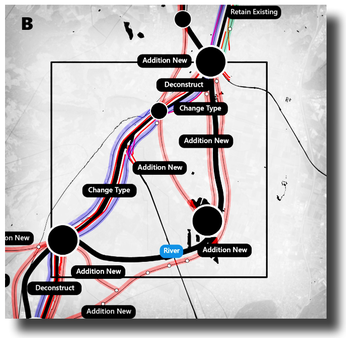
Contextualization of a new Dike line

Main premise: Allocate more space for the River, decreasing its pressure on the surroundings.

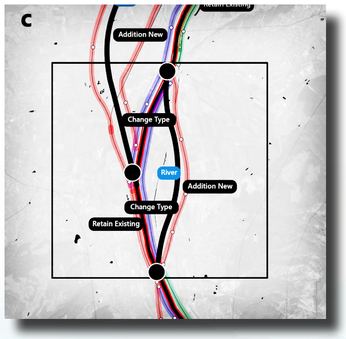
New defined river course of the Rhine



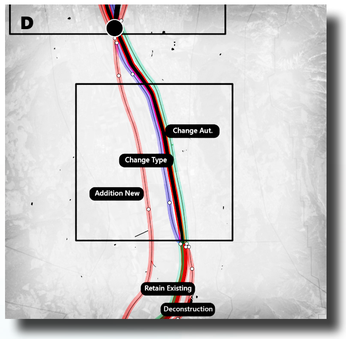
Additional side arm



Additional side arm



Additional space for the river

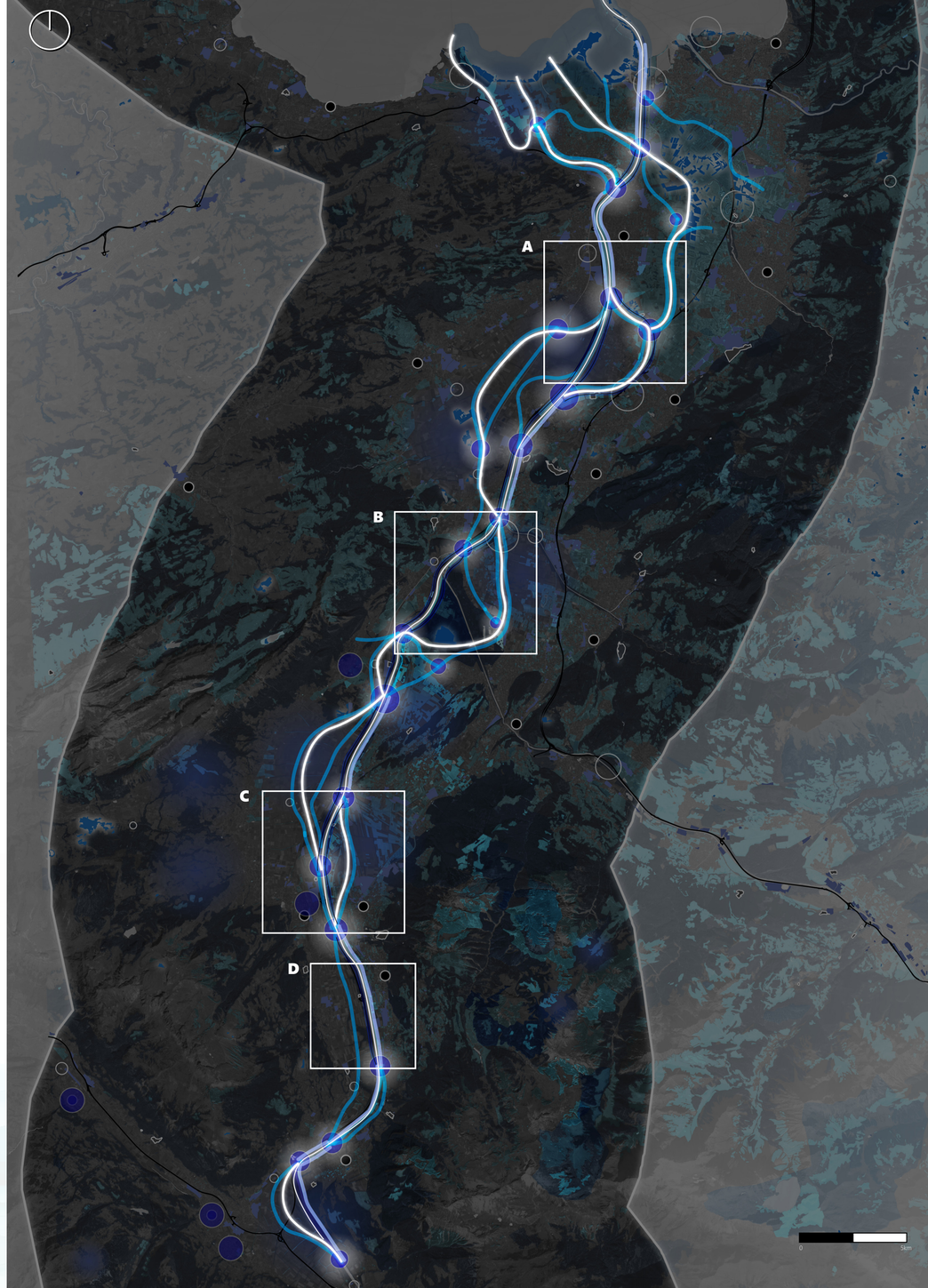


New dike additions

- Addition of new dike
- Retain existing dike line
- Change existing dike location

New dike line

- New water node
- New dike line
- New added waterway



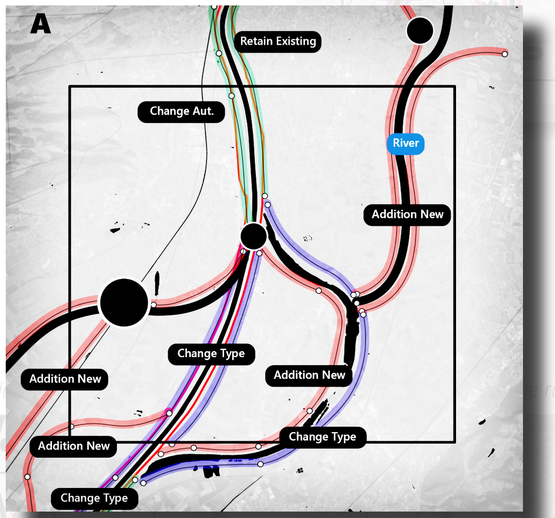
Dike Line Strategies

Contextualization of a new Dike line

Main Intervention: Re-instatement of the old Rhine side arm creates incentives for new dike lines.

Additional side arm

New defined river course of the Rhine

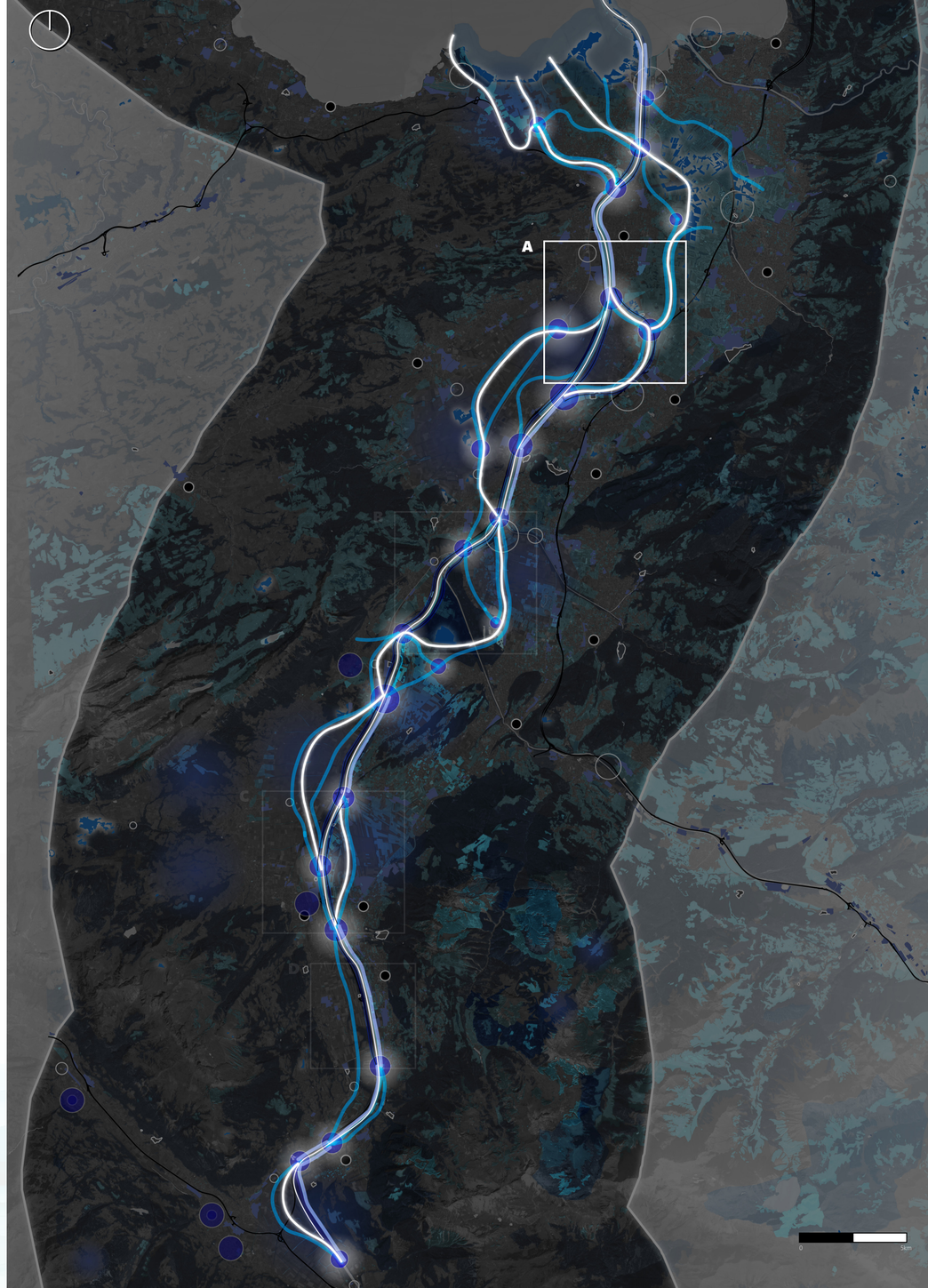


New dike additions

- Addition of new dike
- Retain existing dike line
- Change existing dike location

New dike line

- New water node
- New dike line
- New added waterway

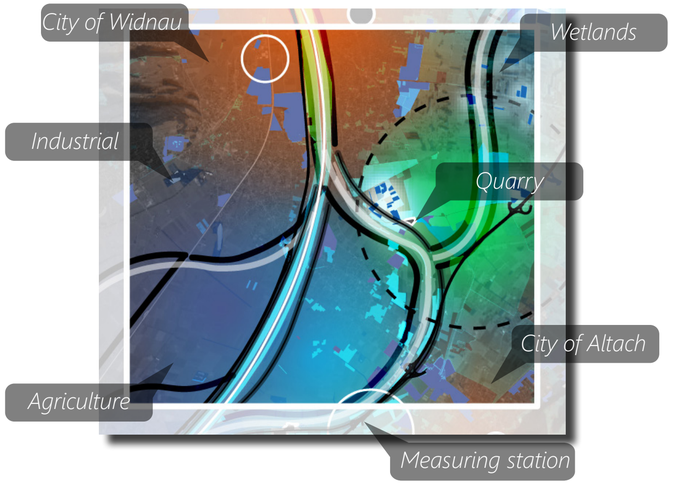


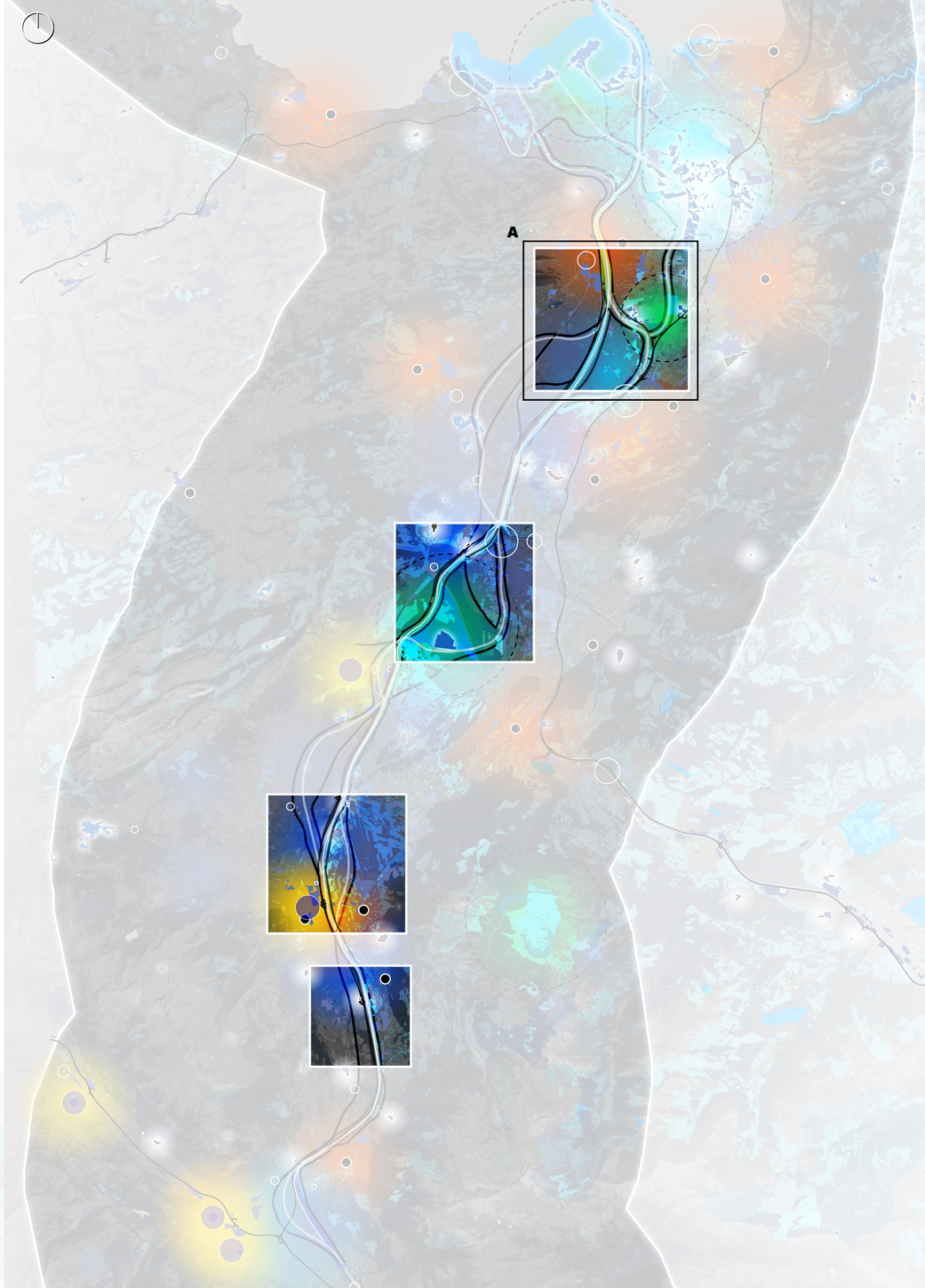
Dike Line Strategies

Understanding the interest of local stakeholders

↓

Increases the viability of later dike design dialogues

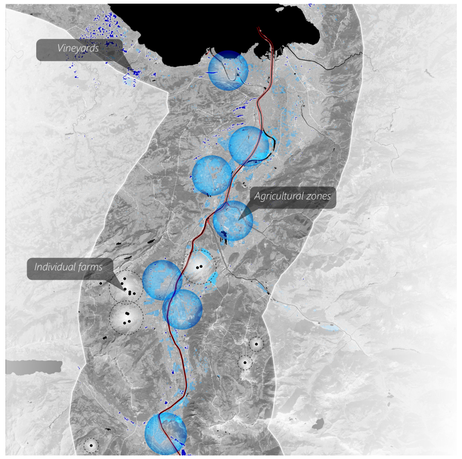




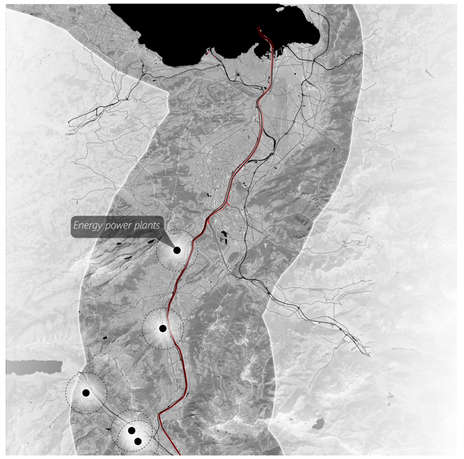
Dike Line Strategies

Understanding the interest of local stakeholders

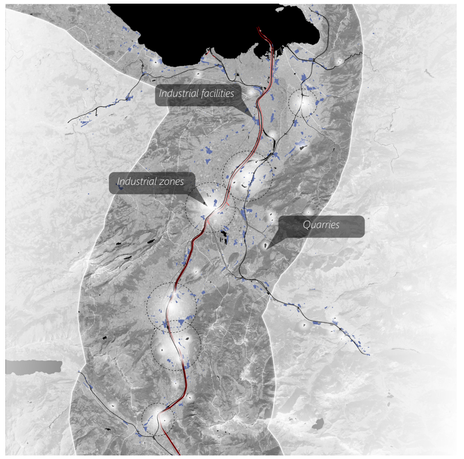
Agricultural Sector



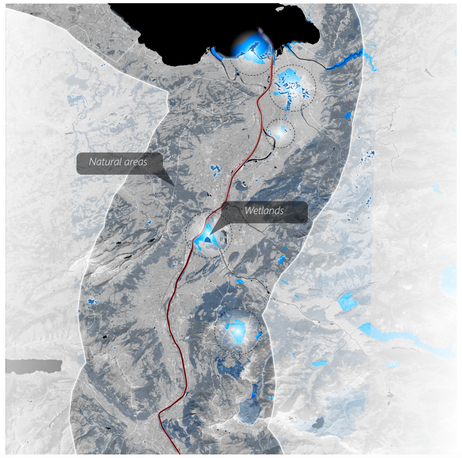
Energy Sector



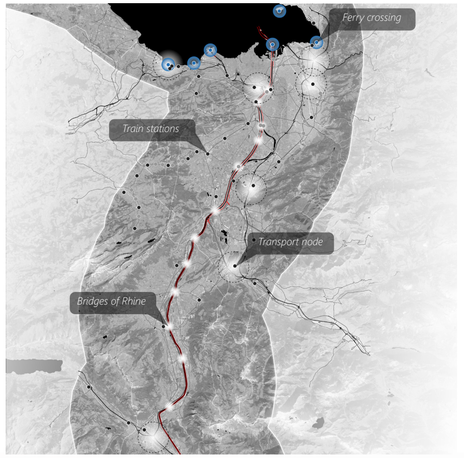
Industrial Sector



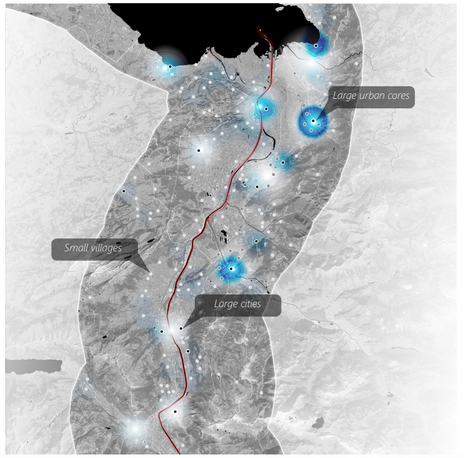
Soil and Water Organizations



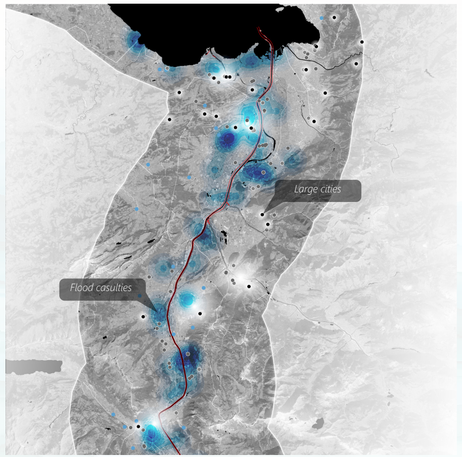
Transporation Sector



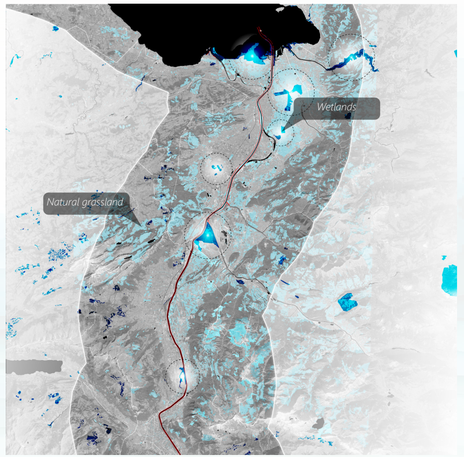
Urban development Sector



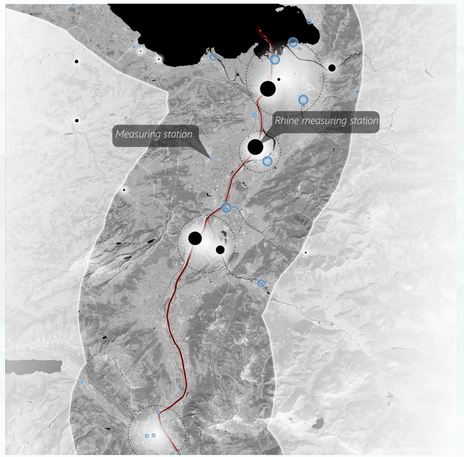
The residents



Nature and Ecology Organizations

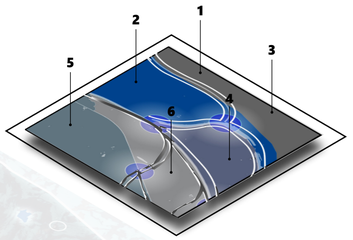


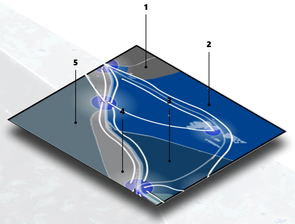
Waterworks Sector

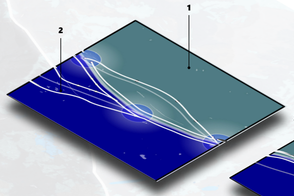


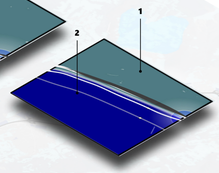
Dike Line Strategies

Formation of new design locations



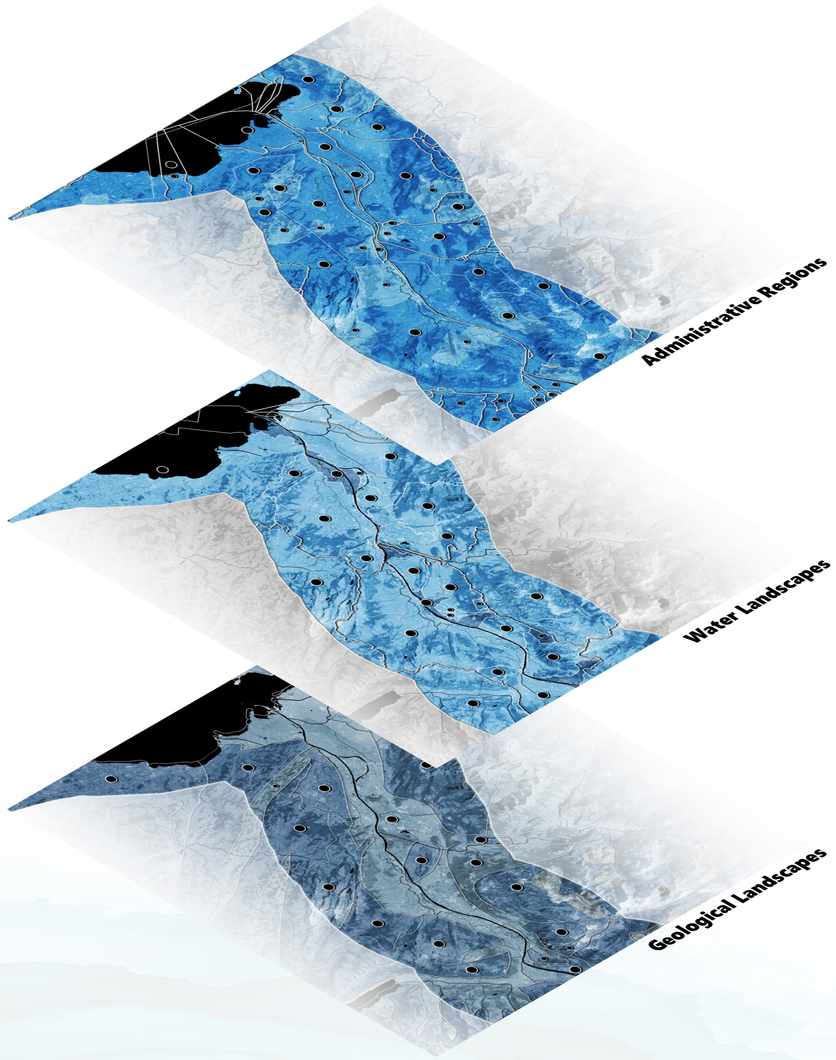


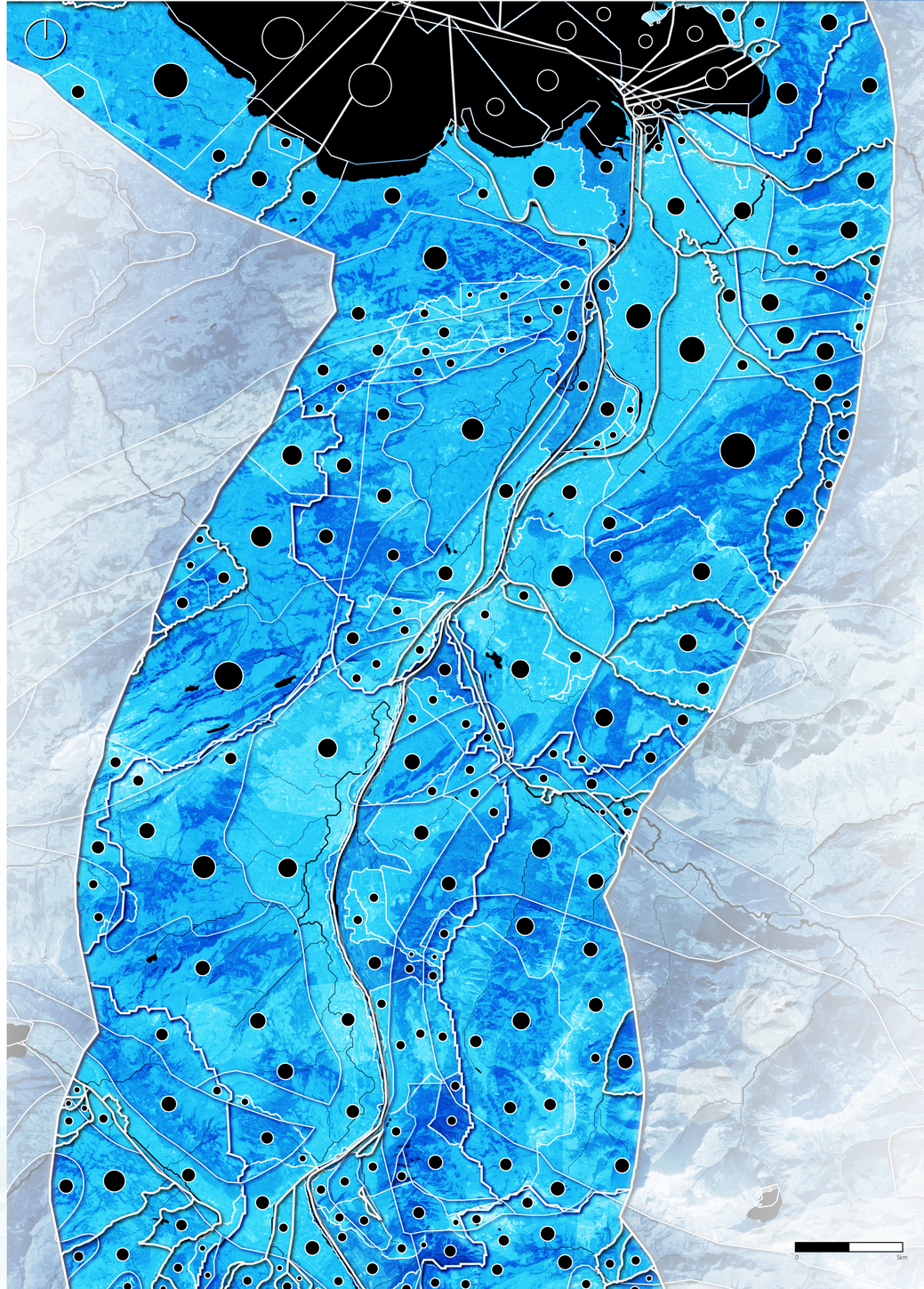




Dike Line Strategies

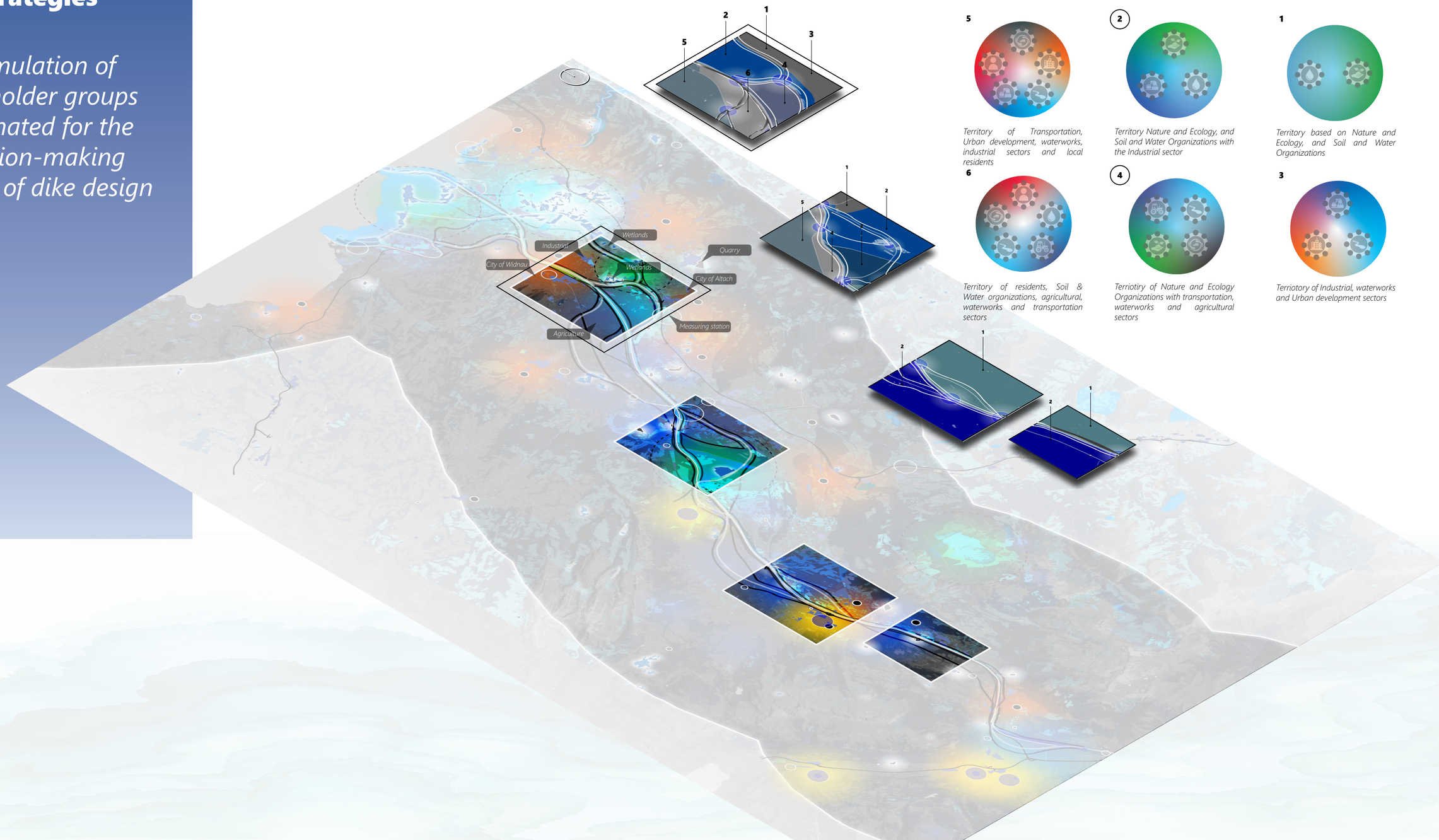
Contextualizing new Territories surrounding the mutual relation between man and river





Dike Line Strategies

Formulation of stakeholder groups designated for the decision-making process of dike design



5

Territory of Transportation, Urban development, waterworks, industrial sectors and local residents

2

Territory Nature and Ecology, and Soil and Water Organizations with the Industrial sector

1

Territory based on Nature and Ecology, and Soil and Water Organizations

6

Territory of residents, Soil & Water organizations, agricultural, waterworks and transportation sectors

4

Terriotiry of Nature and Ecology Organizations with transportation, waterworks and agricultural sectors

3

Terriotory of Industrial, waterworks and Urban development sectors

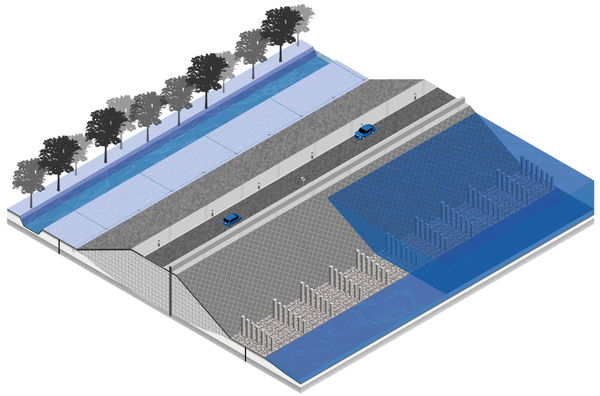
ESTABLISHING NEW MEANING OF DIKES

EXPLORATION OF DIKE IDENTITIES

What can a dike bring?
vs
What is needed from a dike?

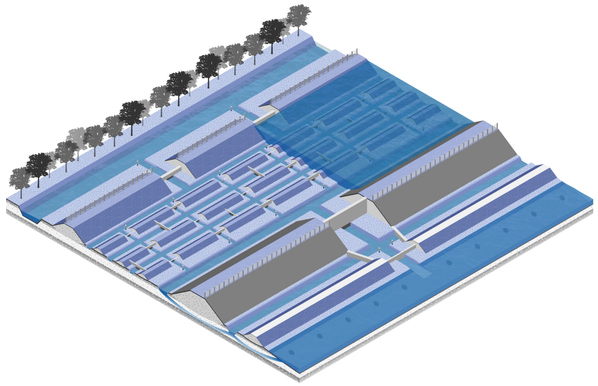


Protective dike



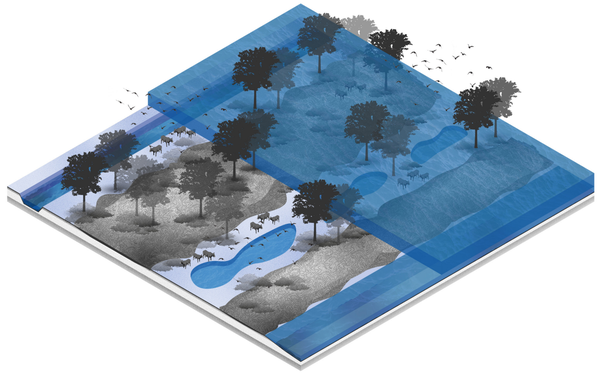
The border

Distributive dike



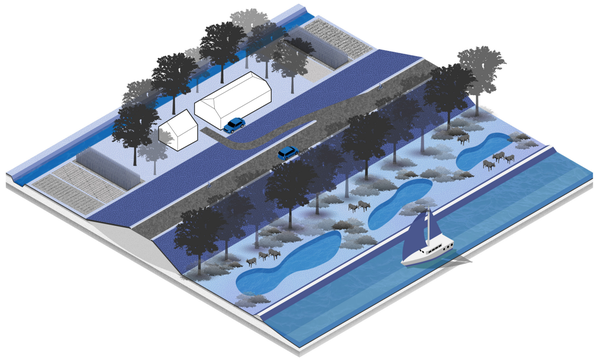
The resource

Natural dike



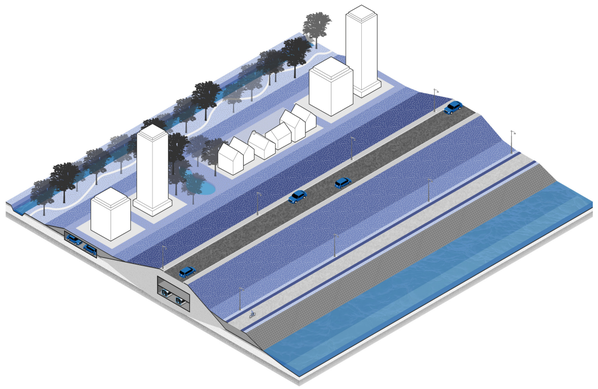
The source

Landscape dike



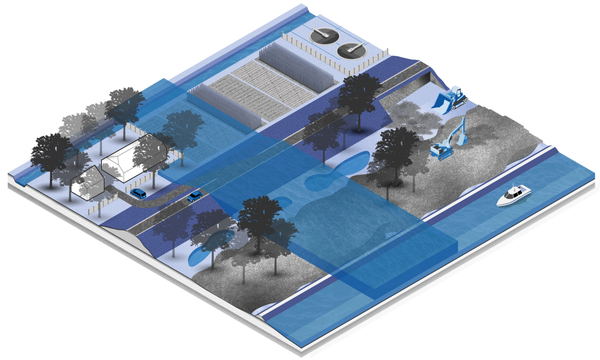
The place

Multifunctional dike



The user

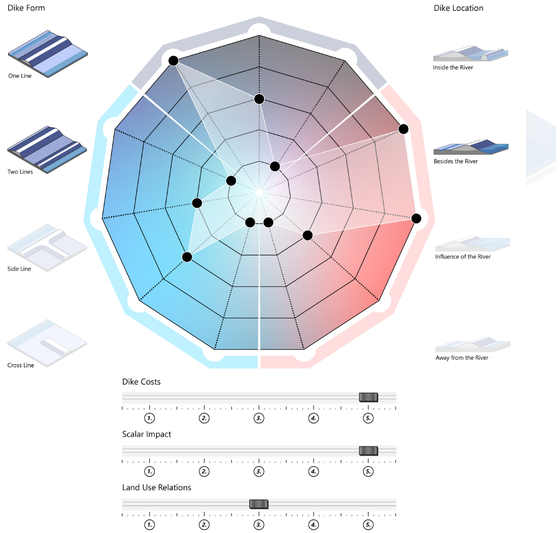
Locally managed dike



The balance

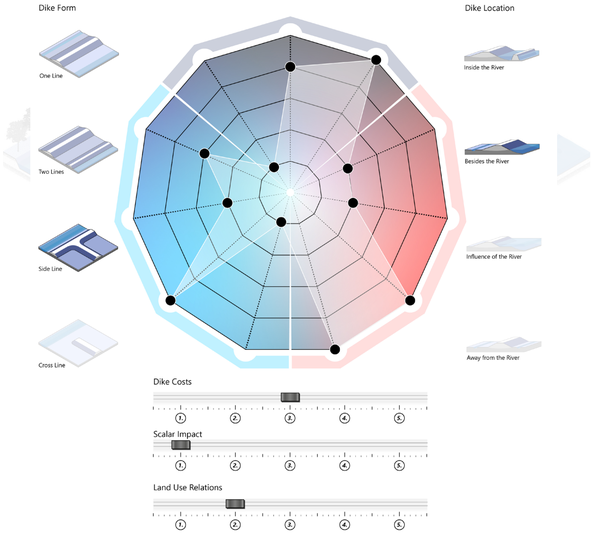
Protective dike

Protection *As based on their current and potential relationship to dikes*



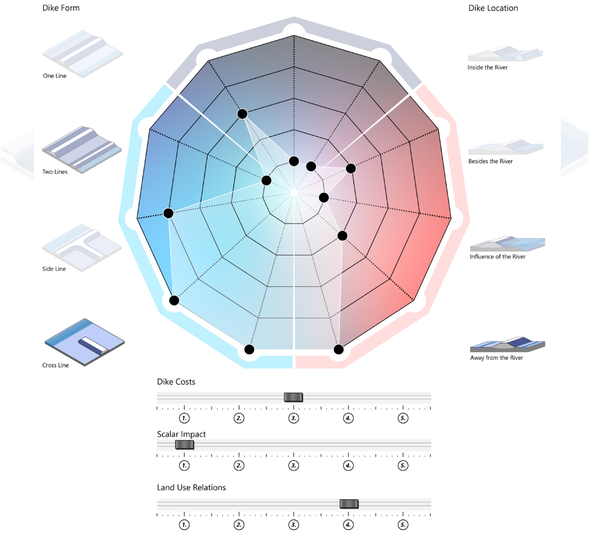
Distributive dike

Distributor *As based on their current and potential relationship to dikes*



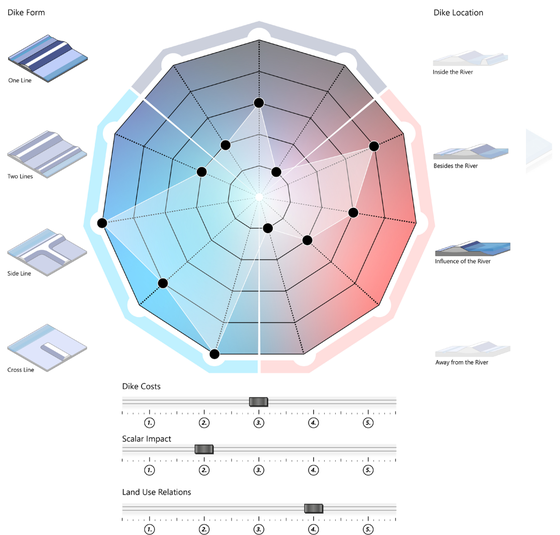
Natural dike

Natural Retention *As based on their current and potential relationship to dikes*



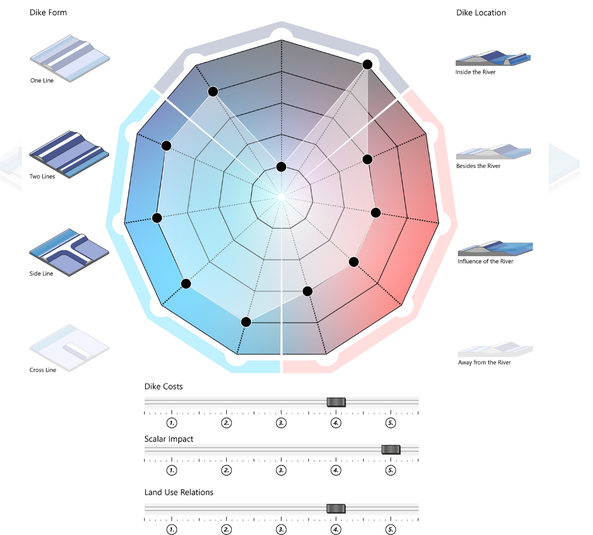
Landscape dike

Landscape Element *As based on their current and potential relationship to dikes*



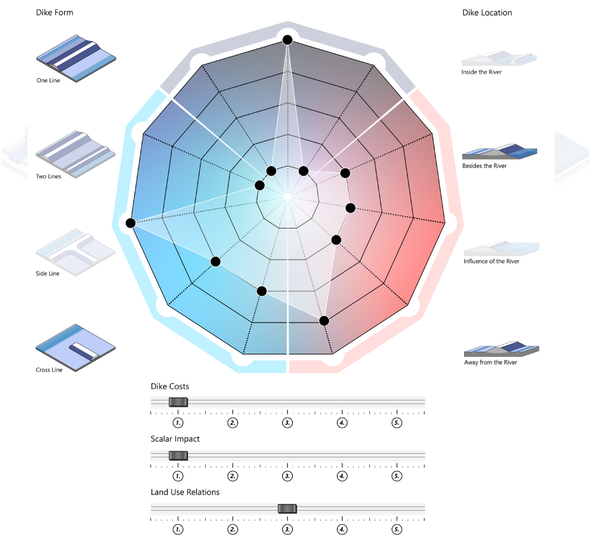
Multifunctional dike

Multifunctional Element *As based on their current and potential relationship to dikes*

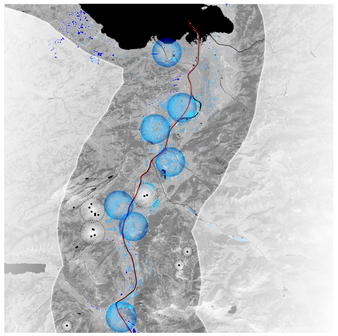


Locally managed dike

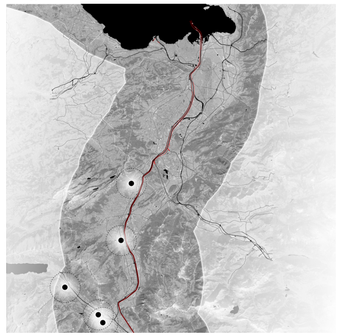
Local Management *As based on their current and potential relationship to dikes*



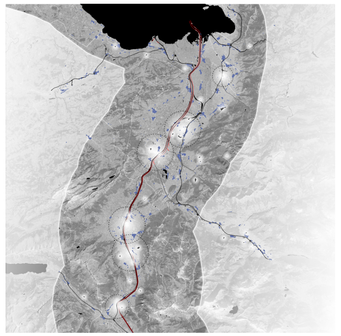
Agricultural Sector



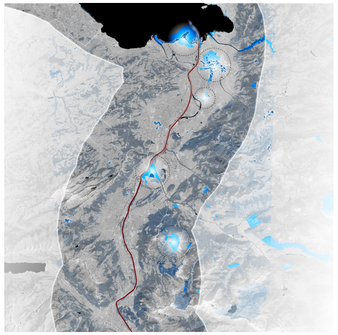
Energy Sector



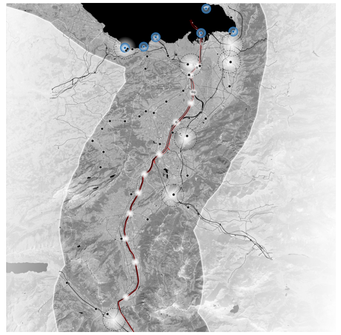
Industrial Sector



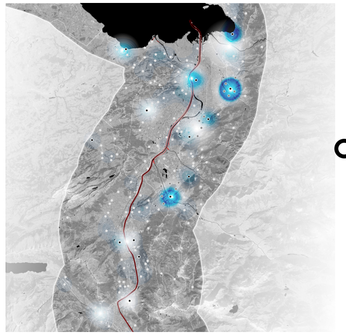
Soil and Water Organizations



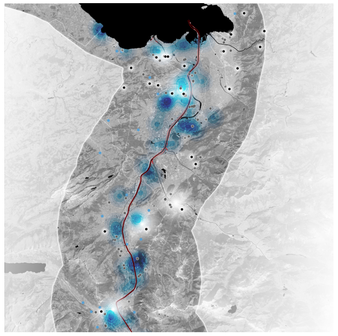
Transporation Sector



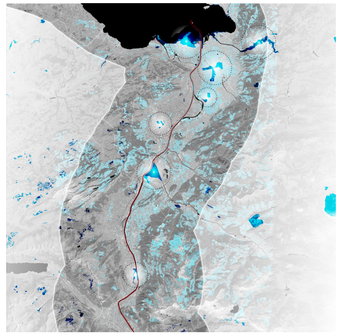
Urban development Sector



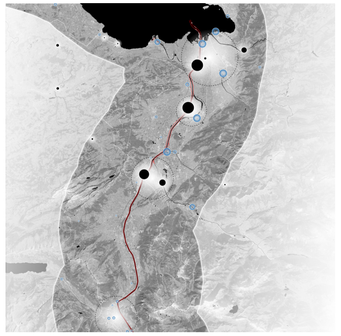
The residents



Nature and Ecology Organizations

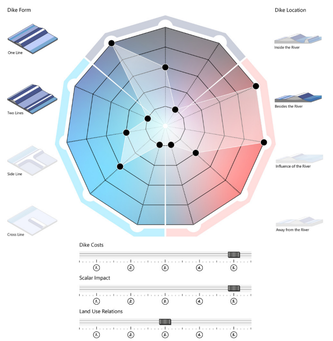


Waterworks Sector

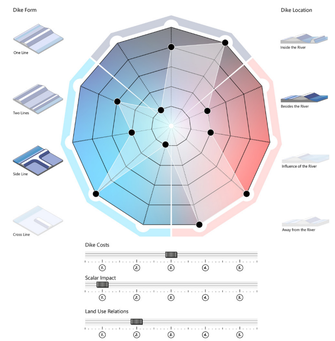


Stakeholder relations

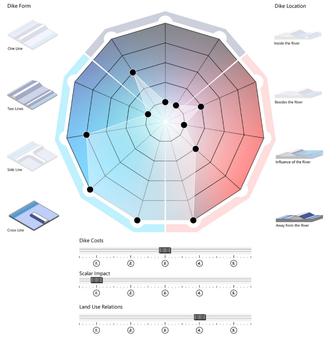
Protection *As based on their current and potential relationship to dikes*



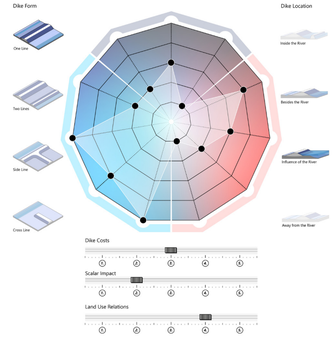
Distributor *As based on their current and potential relationship to dikes*



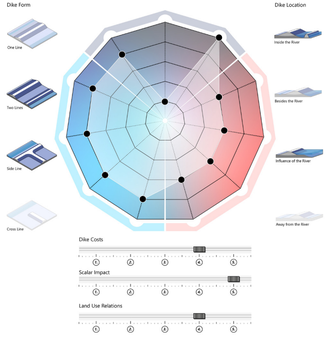
Natural Retention *As based on their current and potential relationship to dikes*



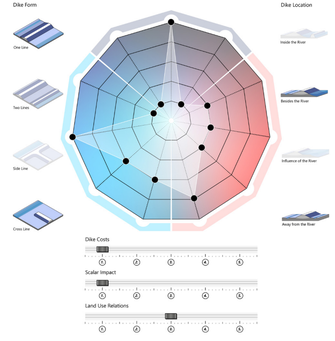
Landscape Element *As based on their current and potential relationship to dikes*



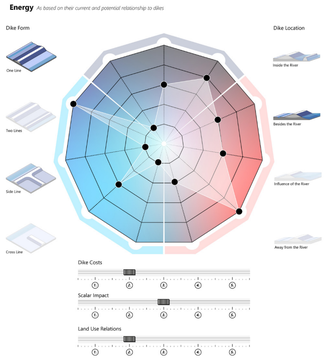
Multifunctional Element *As based on their current and potential relationship to dikes*

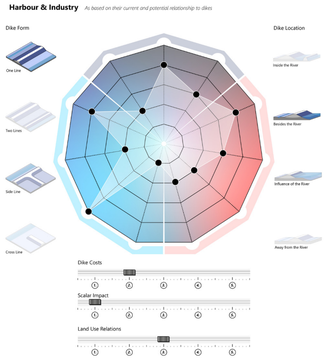


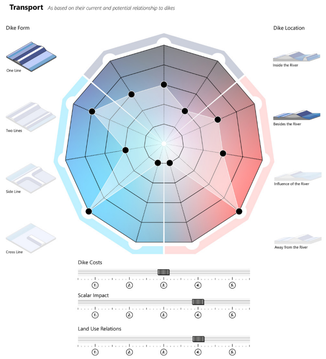
Local Management *As based on their current and potential relationship to dikes*

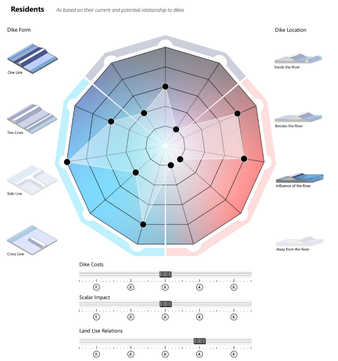


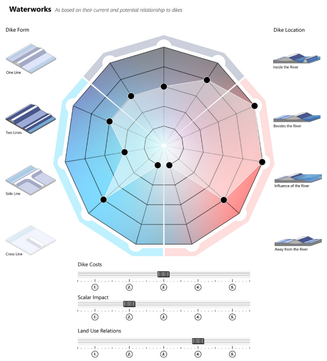
Future dike identities

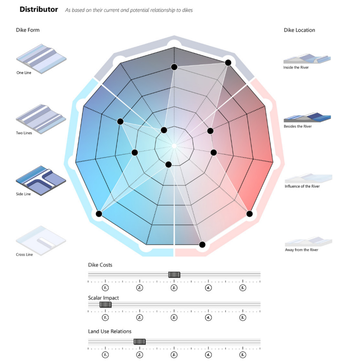


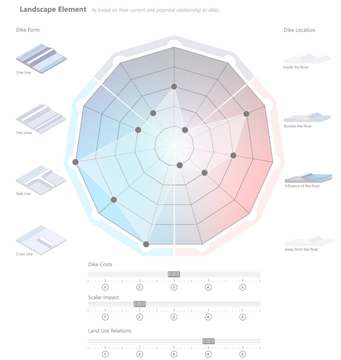


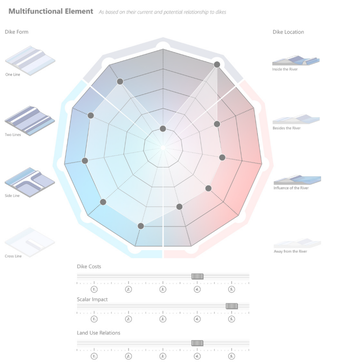


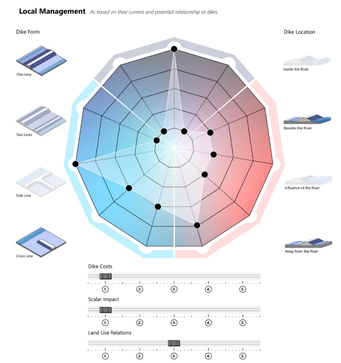










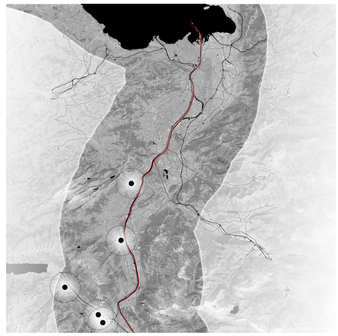


Stakeholder relations

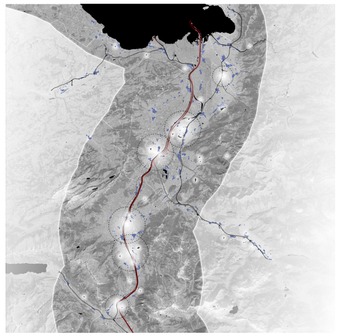
Future dike identities

Agricultural Sector

Energy Sector

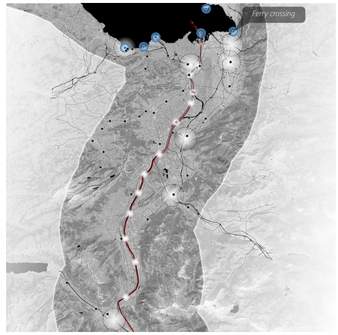


Industrial Sector



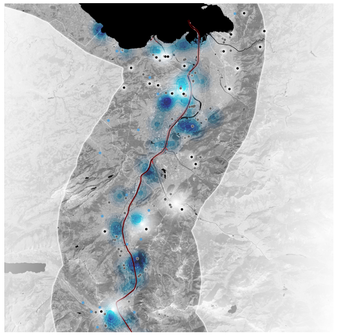
Soil and Water Organizations

Transporation Sector



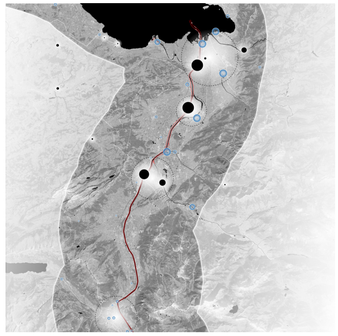
Urban development Sector

The residents

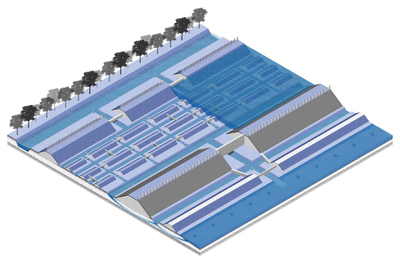


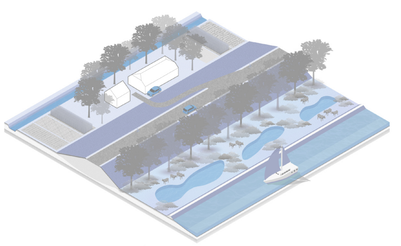
Nature and Ecology Organizations

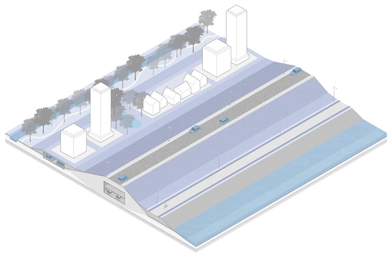
Waterworks Sector

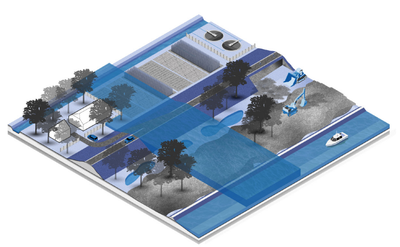


Stakeholder relations

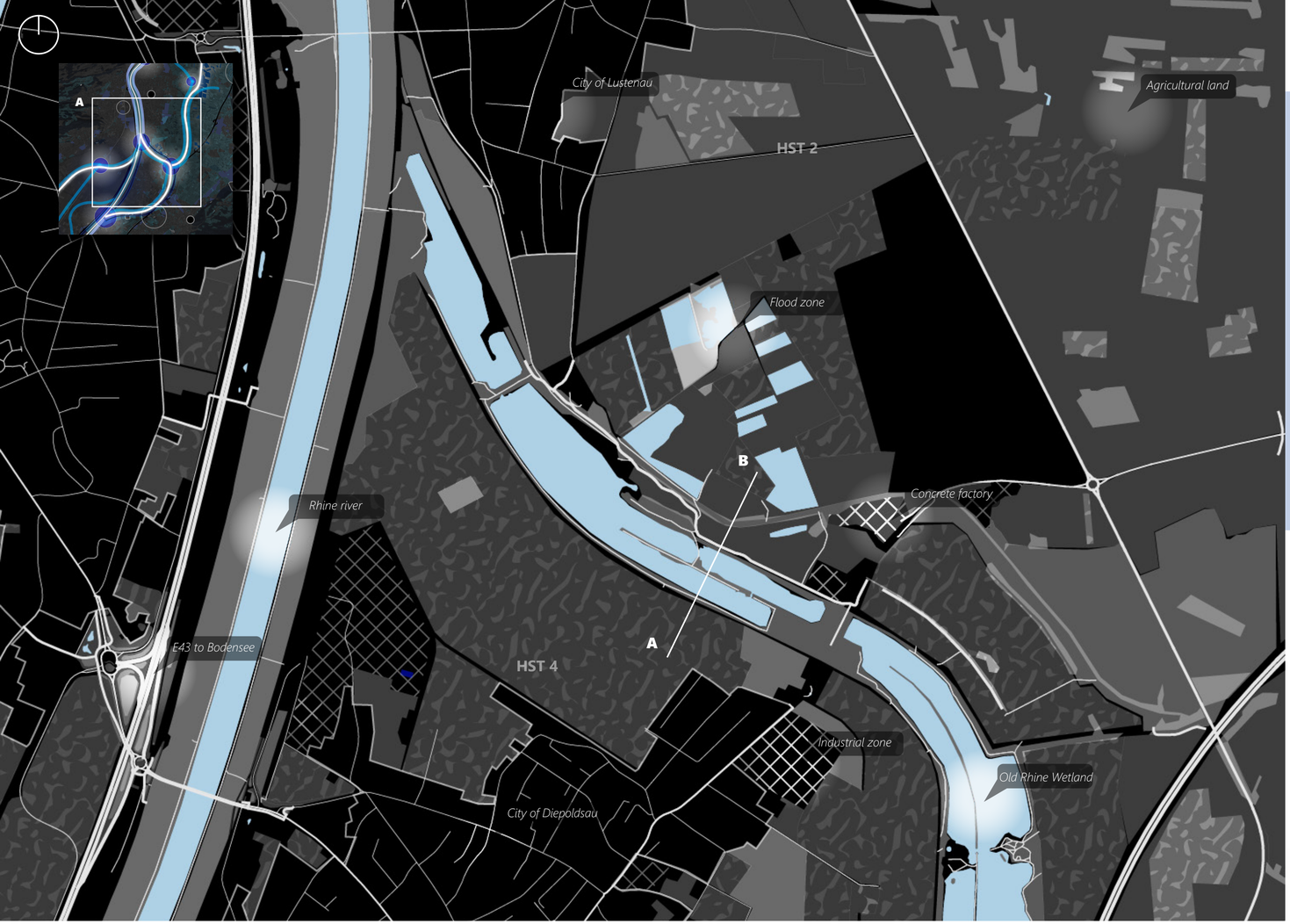








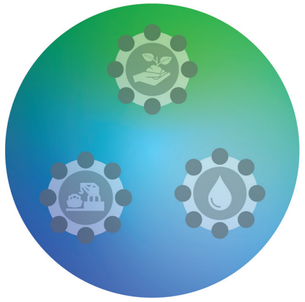
Future dike identities



DESIGN DIALOGUE OF FUTURE DIKES

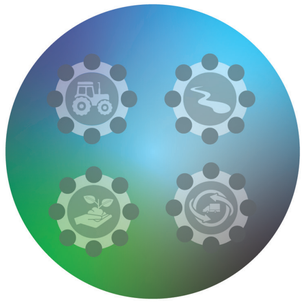
EXPLORATION OF DIKE TYPOLOGIES

HST 2



Territory Nature and Ecology, and Soil and Water Organizations with the Industrial sector

HST 4



Terriotiry of Nature and Ecology Organizations with transportation, waterworks and agricultural sectors

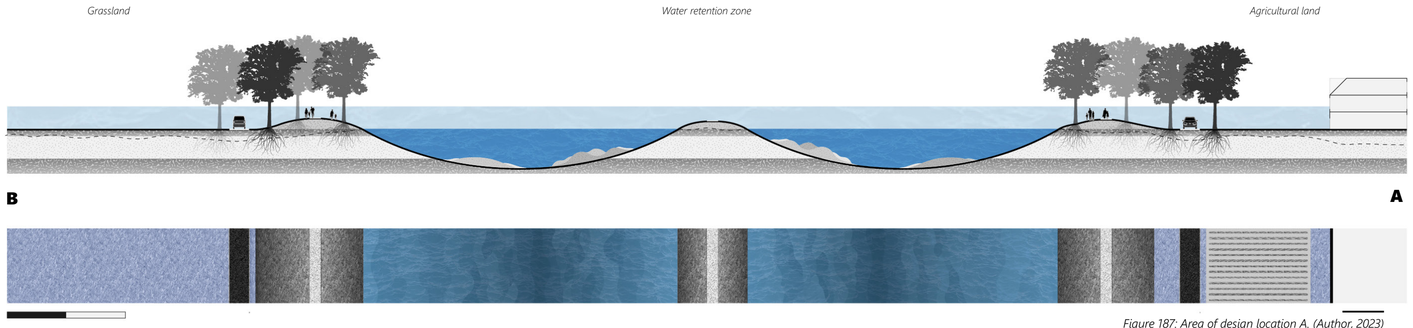
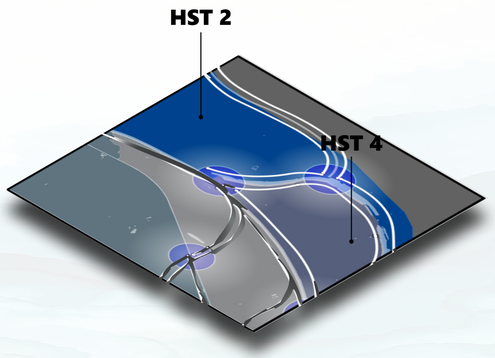


Figure 187: Area of design location A. (Author, 2023)

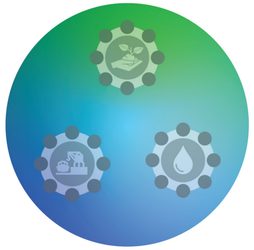
Figure 188: Existing section and top view of the border regions between HST 2 & 4. (Author, 2023)

Dike Design Dialogue

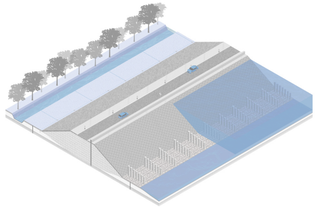
Relation scheme of current stakeholder groups & future dike identities



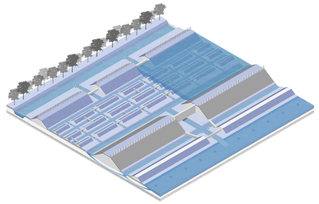
HST 2



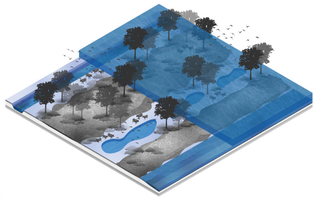
PRO **(16%)**



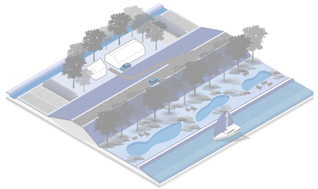
DIS **(19%)**



NAT **(25%)**

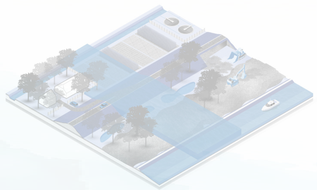


LAN **(15%)**

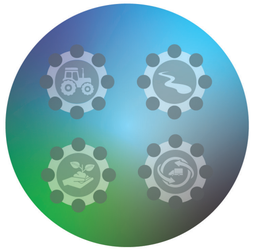


MUL **(11%)**

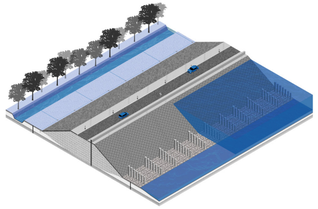
LOC **(13%)**



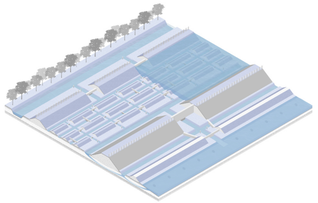
HST 4



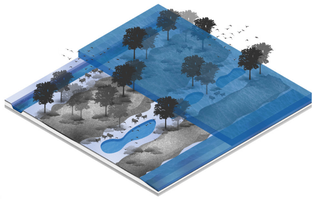
PRO **(21%)**



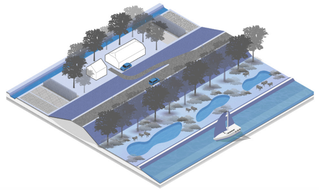
DIS **(15%)**



NAT **(21%)**

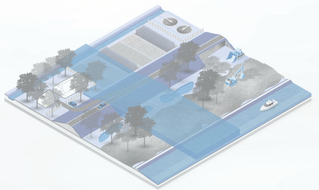


LAN **(19%)**



MUL **(10%)**

LOC **(15%)**



Dike Design Dialogue

Testing scenario's to underline the multitude of potential outcomes

Going for the Safe Option

The dike system that is mutually carried by both Design Locations

Going for the Radical Option

The dike system that is shows the options that are not directly carried by both Design Locations

Going for the Moderate Option

The dike system that is shows a moderate option for both Design Locations

HST 2



Floodwall **(30%)**



Bulkhead **(22%)**



Multifunctional dike **(21%)**



Stakeholder Groups

Allocated dike Typologies

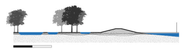
HST 4



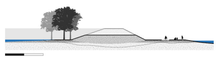
Leading dike **(22%)**



Summer dike **(31%)**



Spillover dike **(30%)**



GOING FOR THE SAFE OPTION

MULTIFUNCTIONAL - SPILLOVER SYSTEM



HST 2



Floodwall **(30%)**



Bulkhead **(22%)**



Multifunctional dike **(21%)**



Stakeholder Groups

Allocated dike Typologies

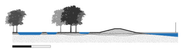
HST 4



Leading dike **(22%)**



Summer dike **(31%)**

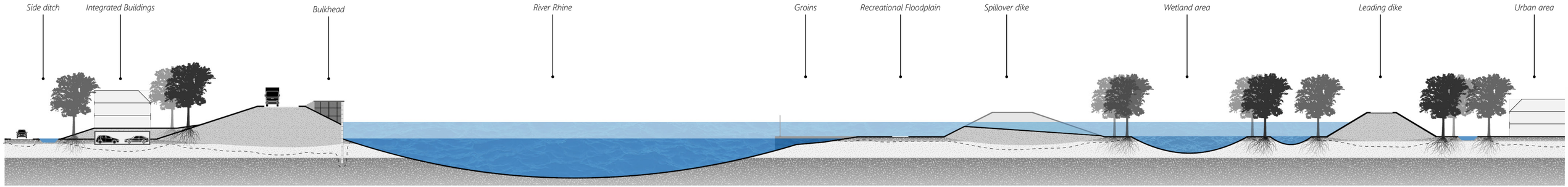


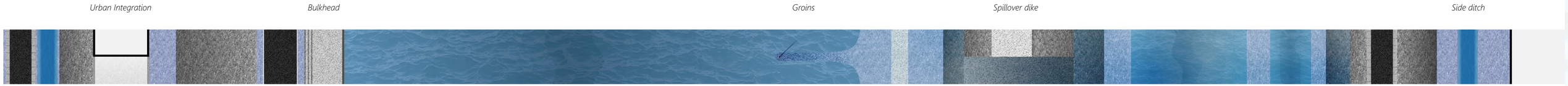
Spillover dike **(30%)**

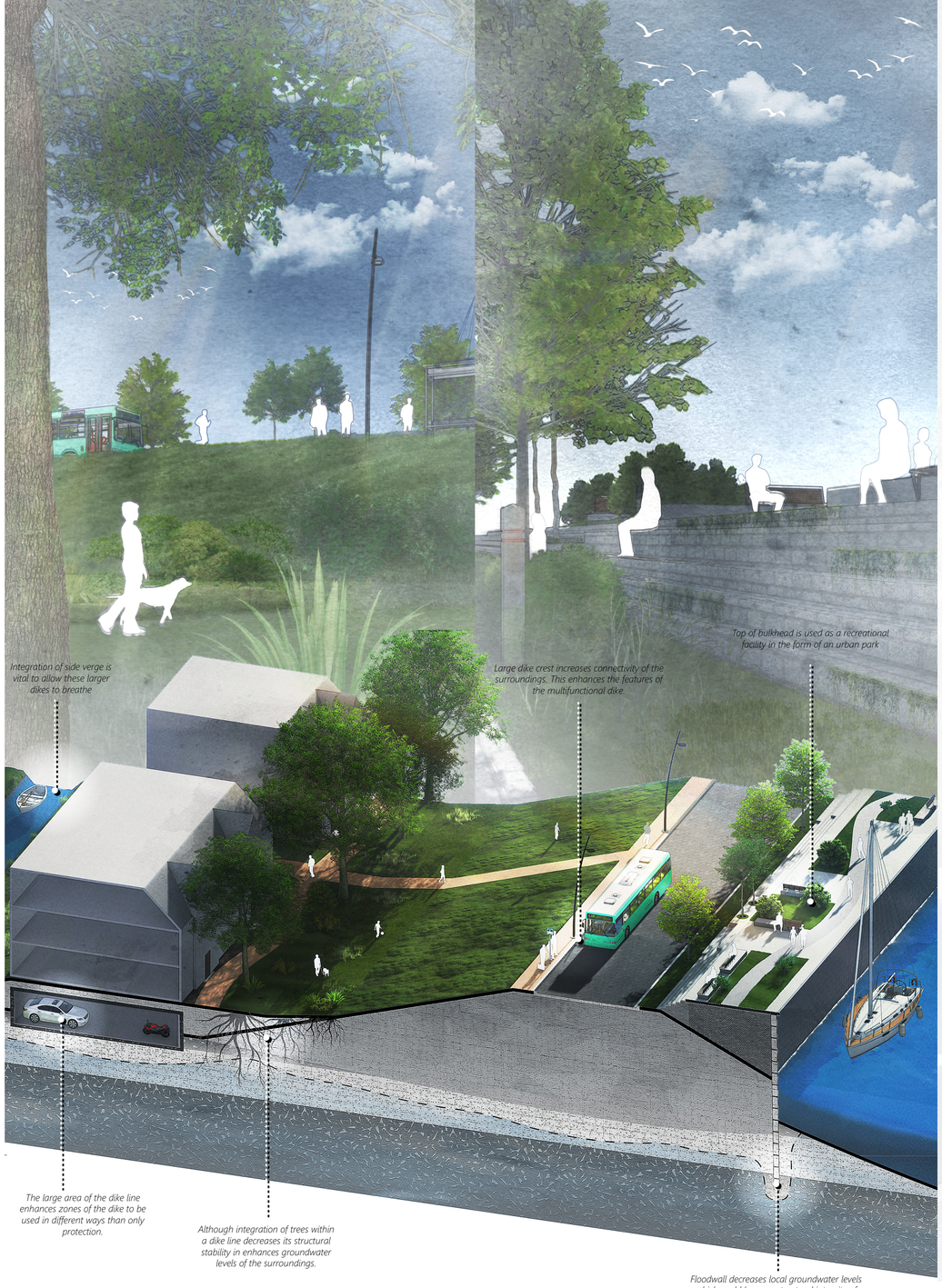


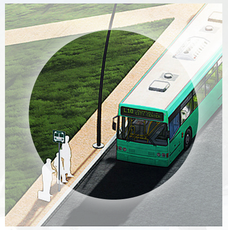
GOING FOR THE SAFE OPTION

MULTIFUNCTIONAL - SPILLOVER SYSTEM



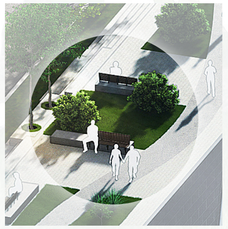






Multifunctional Dike

- *Enhancing connectivity with the direct surroundings*
- *Integrative use of the dike line*



Urban Riverfront Park

- *Enhancement of recreational facilities*
- *Establishes new connection between man & river*



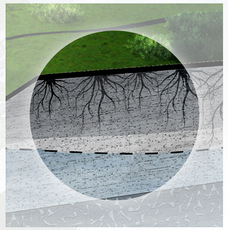
Floodwall

- *Forms a direct protective border*
- *Increases risks of groundwater droughts*

Spillover Dike

Enhances infiltration rate of the surroundings

Risks of groundwater floodings



Dike Maintenance

Subdued by direct forces of the river

Enhances natural retention function



Local Maintenance

Multifunctional dike line

Local grass maintenance by farm animals



Figure 196: Visualisation and Perspectives of the Spillover dike. (Author, 2023)

Due to flood capability of spillover dike, the dike is subdued by the forces of the river, allowing for water small pockets of water to be created

Adjacent waterways enhance the infiltration and distribution capacity of water.

Incorporation of groins allows for the water to be navigable during periods of low flow

Cattle of local farmers is allowed to roam the floodplains during periods of low river flow.

Low water retaining function of spillover dike allows for groundwater to be directly connected to the surface which enhances local biodiversity and stability of the soil.

Impact Assessment

Rhine Downstream:
Large risks of high water levels and flood occurrences

Rhine Upstream:
Medium risks of low water levels during low flow periods



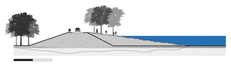
HST 2



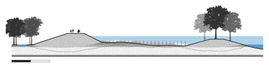
Compartment dike **(18%)**



Sawa dike **(18%)**



Sedimentation dike **(28%)**



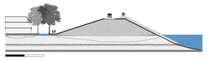
Stakeholder Groups

Allocated dike Typologies

HST 4



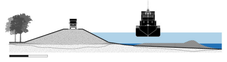
Revetment dike **(24%)**



Shear dike **(19%)**



Levee dam **(22%)**



GOING FOR THE RADICAL OPTION

SAWA - REVETMENT DIKE SYSTEM

Compartment dike *Sedimentation zone* *Dike crest* *Sawa dike + Recreation* *Rhine River* *Levee dam* *Shipping lane* *Concrete revetments* *Road infrastructure* *Side ditch*

Sedimentation zone *Smart dike system* *Recreational zones* *Levee dam* *Smart dike system* *Side ditch*

0 10m 20m

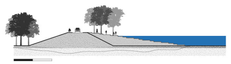
HST 2



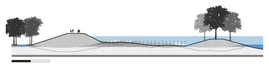
Compartment dike **(18%)**



Sawa dike **(18%)**



Sedimentation dike **(28%)**



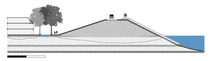
Stakeholder Groups

Allocated dike Typologies

HST 4



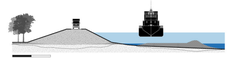
Revetment dike **(24%)**



Shear dike **(19%)**



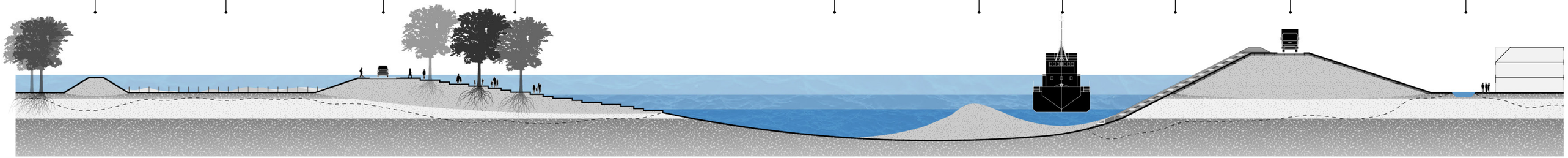
Levee dam **(22%)**



GOING FOR THE RADICAL OPTION

SAWA - REVETMENT DIKE SYSTEM

Compartment dike *Sedimentation zone* *Dike crest* *Sawa dike + Recreation* *Rhine River* *Levee dam* *Shipping lane* *Concrete revetments* *Road infrastructure* *Side ditch*



Sedimentation zone *Smart dike system* *Recreational zones* *Levee dam* *Smart dike system* *Side ditch*



0 10m 20m





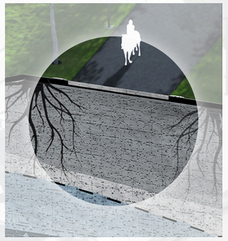
Floodable Recreation

- *Enhancement of recreational facilities*
- *Acception of the dynamics of the river*



Sedimentation zones

- *Local supply of sediment for maintenance & industries*
- *Providing from the river*



Sawa dike

- *Distribution of mass of the dike*
- *Increases risks of (groundwater) flooding*

Revetment protection

Enhances local protection

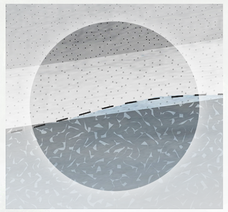
Integration of monitoring system



Groundwater levels

Intensive maintenance to retain large dike line

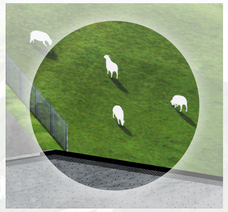
Risk of increase groundwater droughts

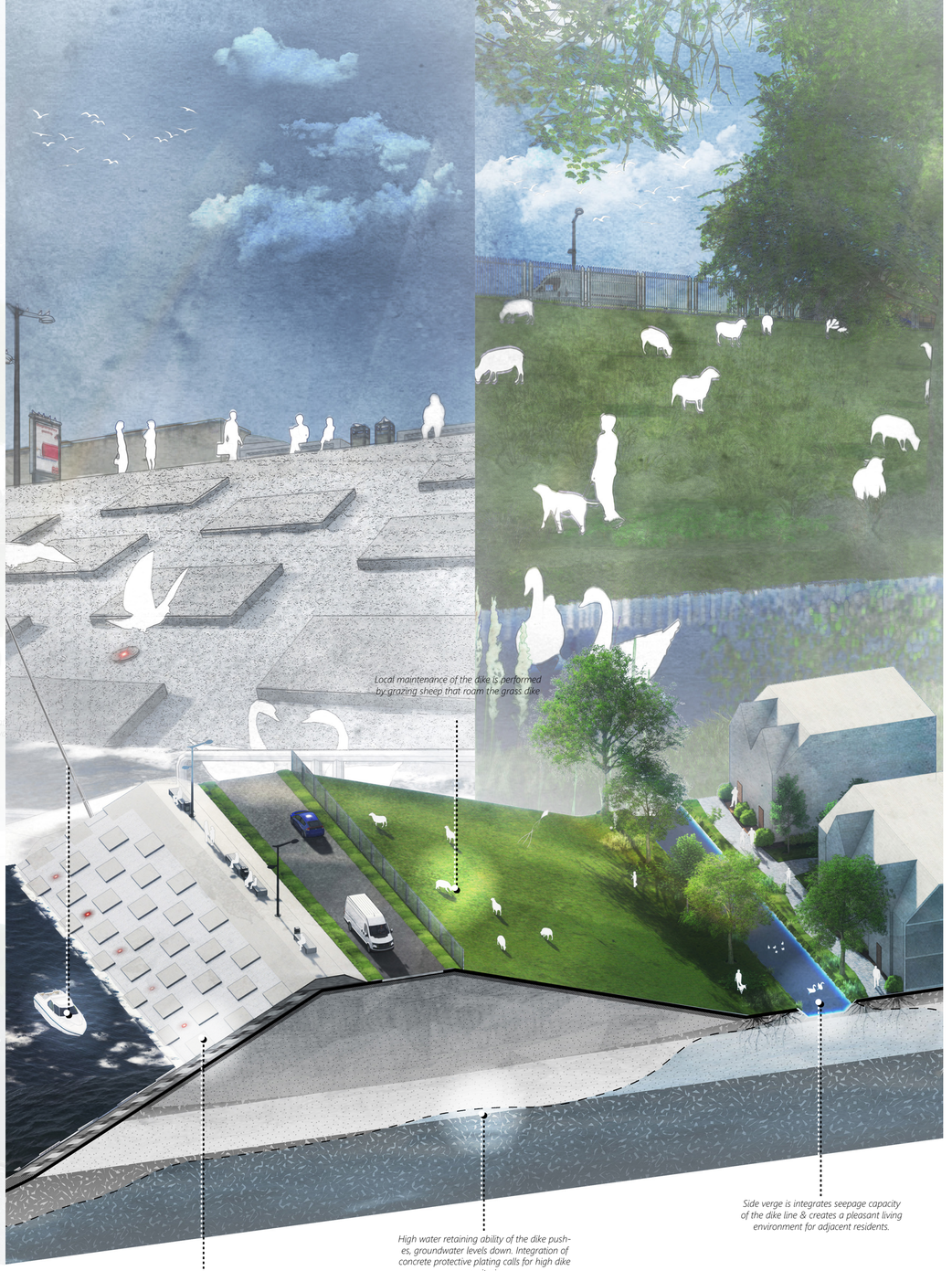


Local Maintenance

Multifunctional dike line

Local grass maintenance by farm animals





Impact Assessment

Rhine Downstream:
Medium risks of low flow droughts

Rhine Upstream:
Large risks of over-sedimentation and blockage of river.



HST 2



Winter dike **(22%)**



Side dike **(22%)**



Shear dike **(19%)**



Stakeholder Groups

Allocated dike Typologies

HST 4



Delta dike **(29%)**



Cistern dike **(20%)**



GOING FOR THE MODERATE OPTION

WINTER - CISTERN-DELTA DIKE SYSTEM

0 10m 20m

GOING FOR THE MODERATE OPTION

WINTER - CISTERN-DELTA DIKE SYSTEM

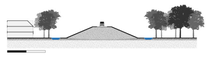
HST 2



Winter dike **(22%)**



Side dike **(22%)**



Shear dike **(19%)**



Stakeholder Groups

Allocated dike Typologies

HST 4

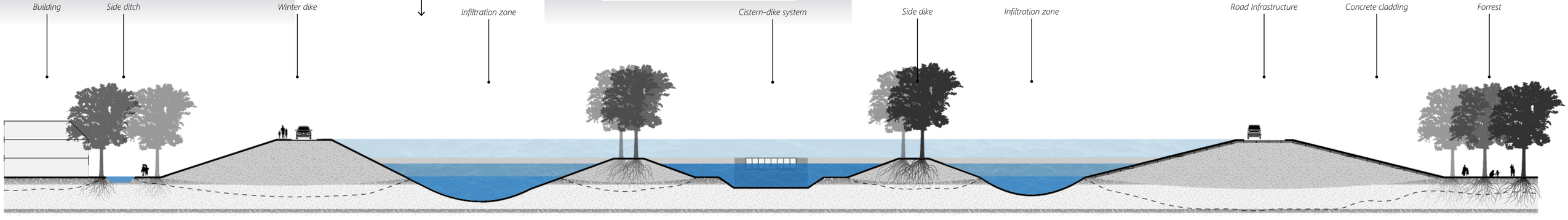


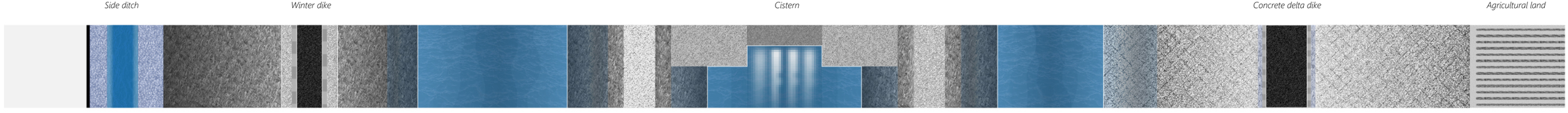
Delta dike **(29%)**



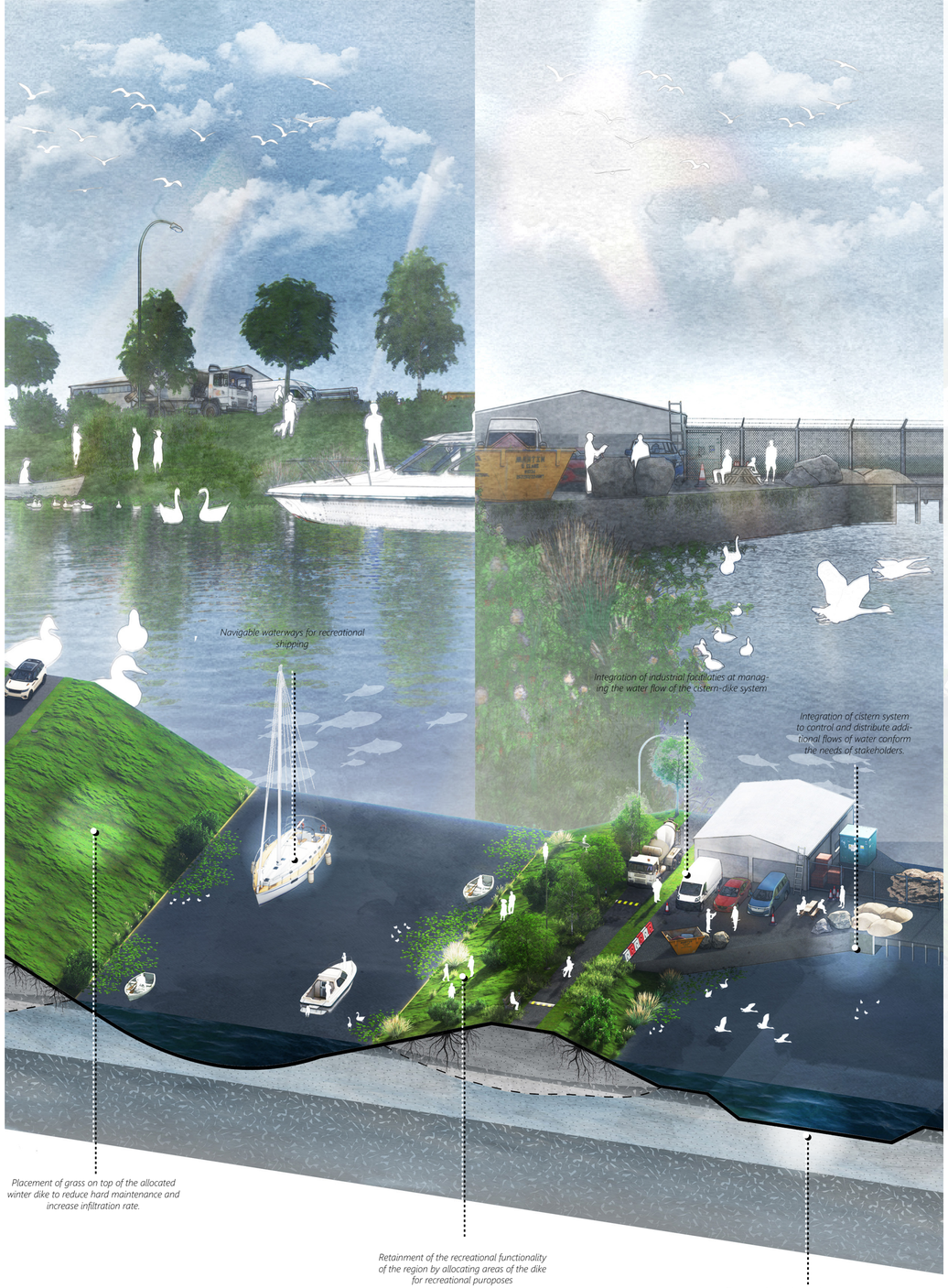
Cistern dike **(20%)**







0 10m 20m





Cistern System

- *Local control of water distribution*
- *Enhancing local industies*



Water distribution

- *Large concrete infrastructure*
- *Hampers natural river flow*



Local Industries

- *Reconnection of Industry and River*
- *Risks of over-exploitation of water resources*

Impact Assessment

Rhine Downstream:
Low risks of droughts in periods of low flow

Rhine Upstream:
Large risks of floods & drought occurances due to blockage and storage of water



HOW DO WE MOVE FORWARD?

DESIGN OF A ROADMAP

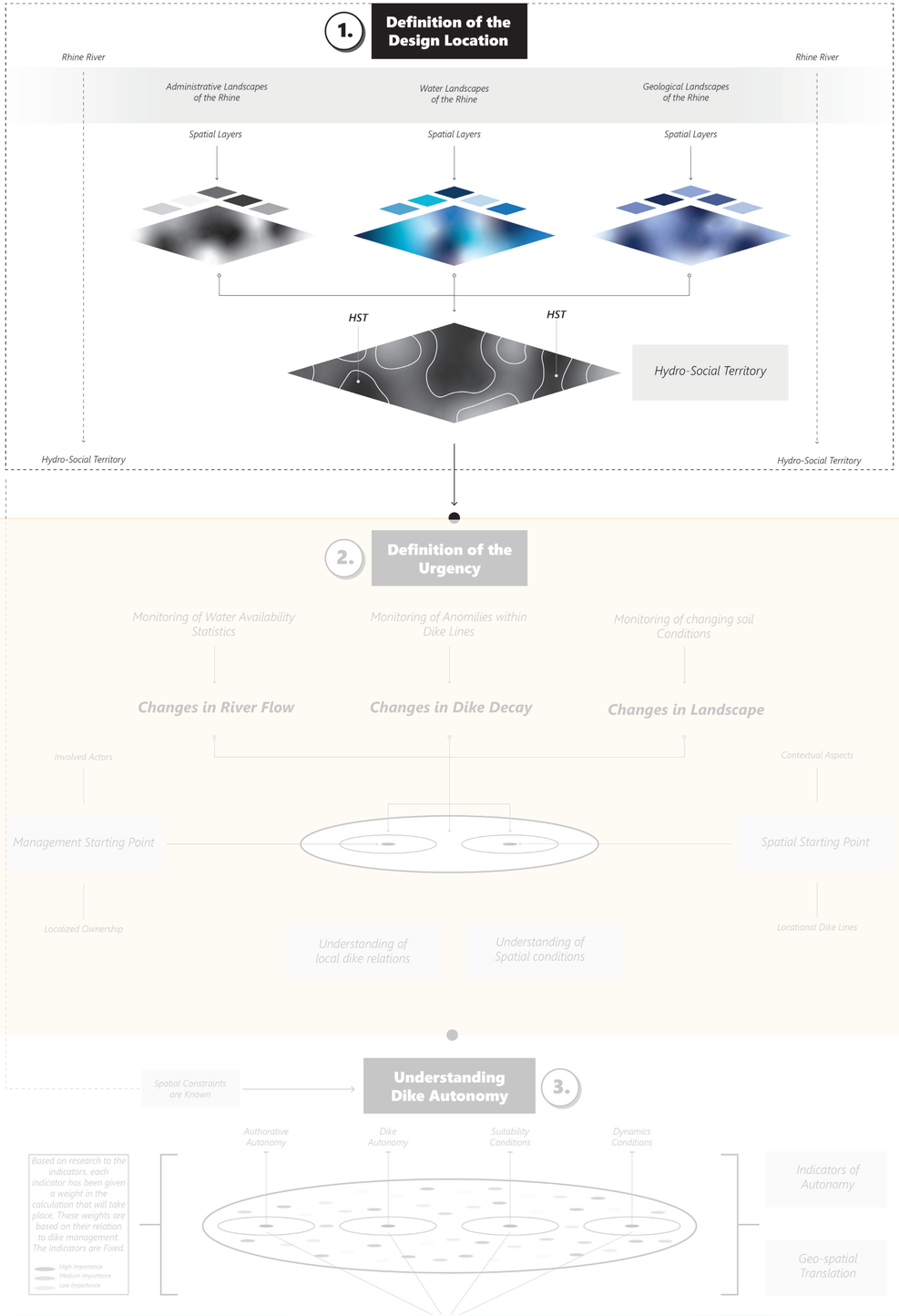
12 steps program *to distinguish the position of a local stakeholders in defining their* ***personal potential for local autonomy*** *within dike management*



The Design of the Roadmap

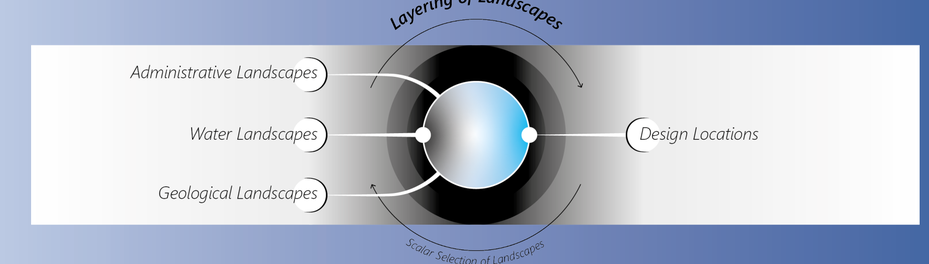
Understanding River based indicators for the establishment of localized dike autonomy

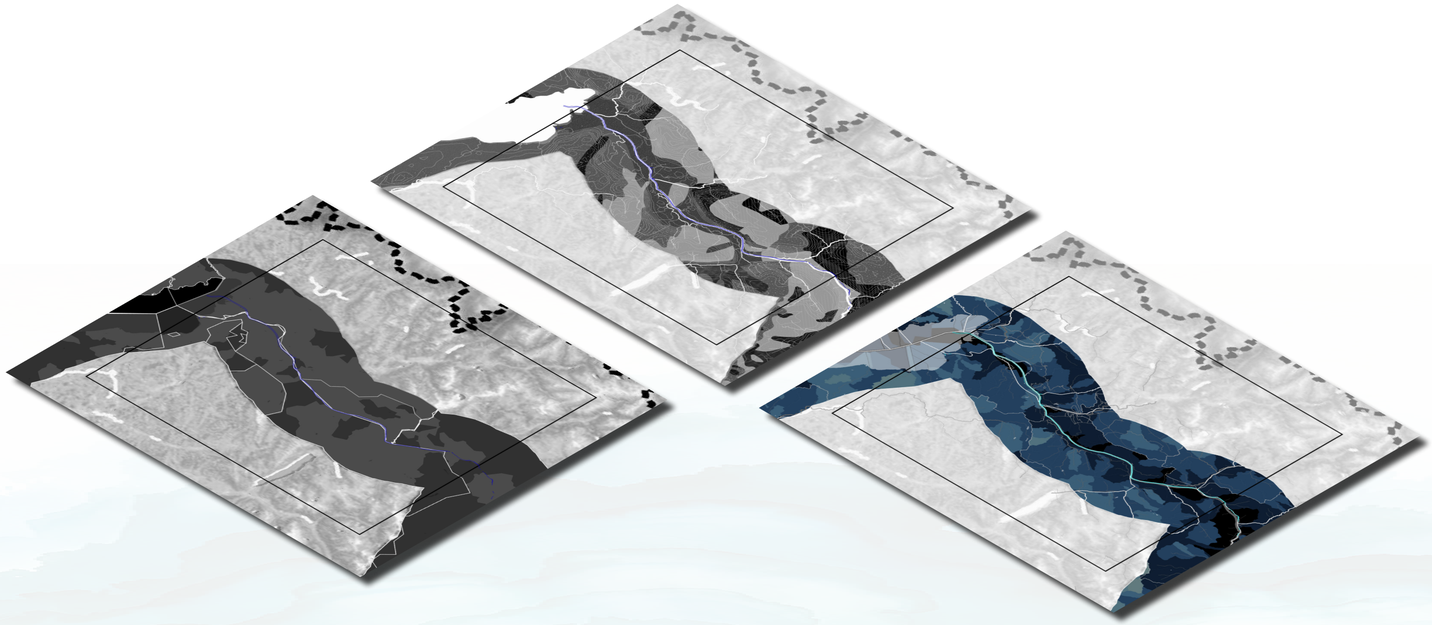


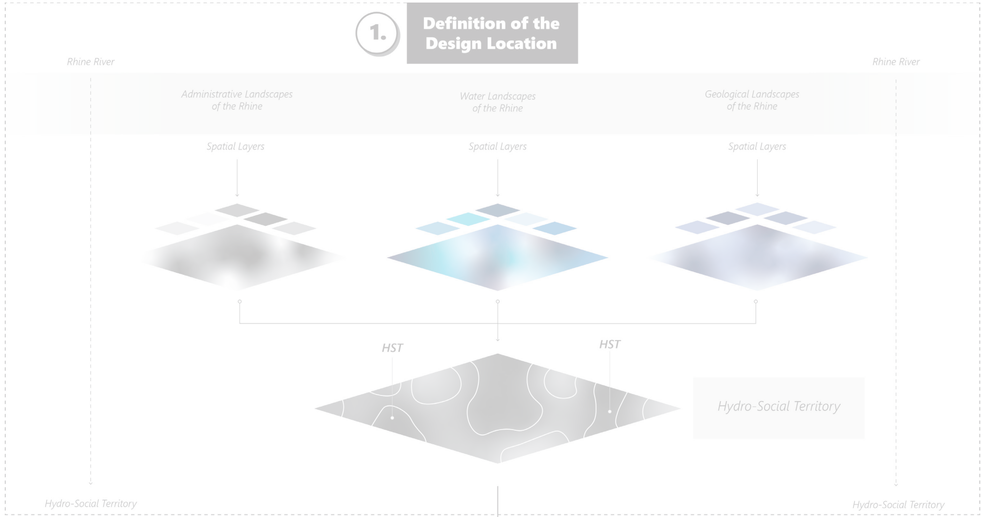


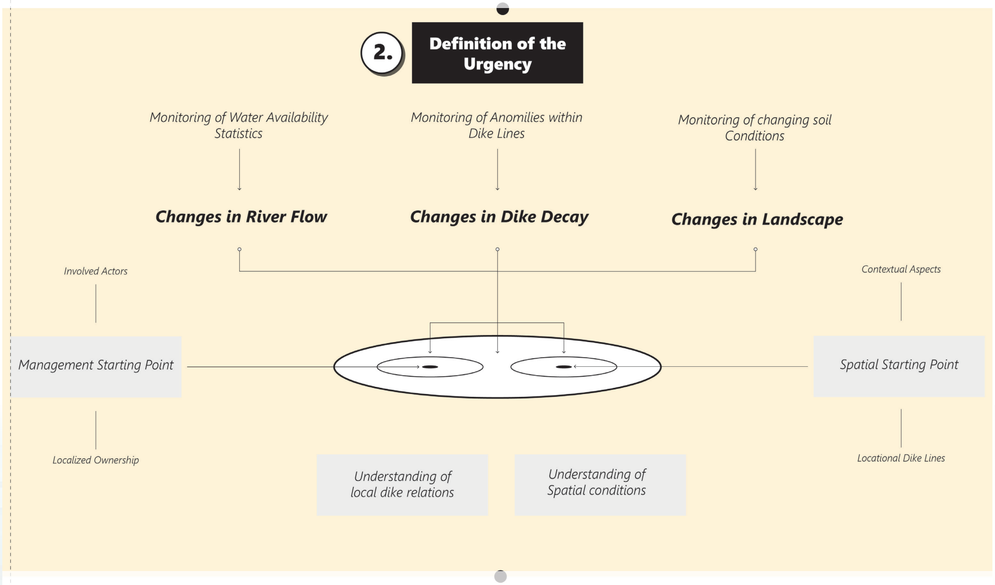
Step 1: Definition of the Design Locations

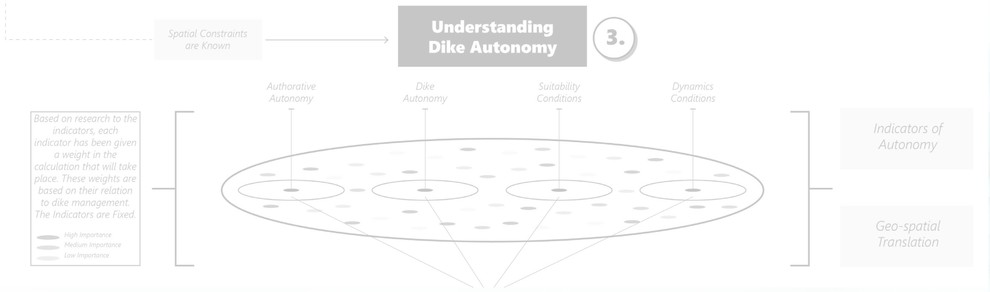
Creation of new Territories for localized dike design





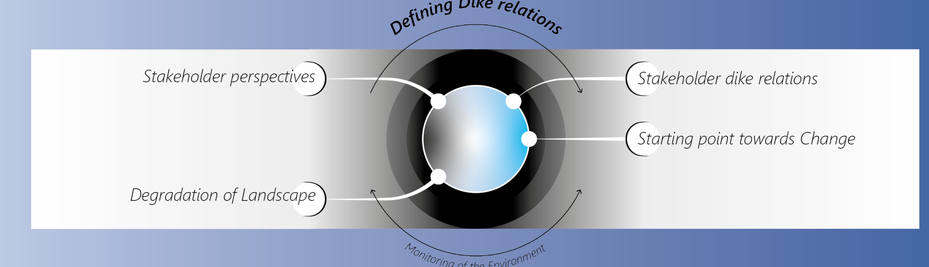






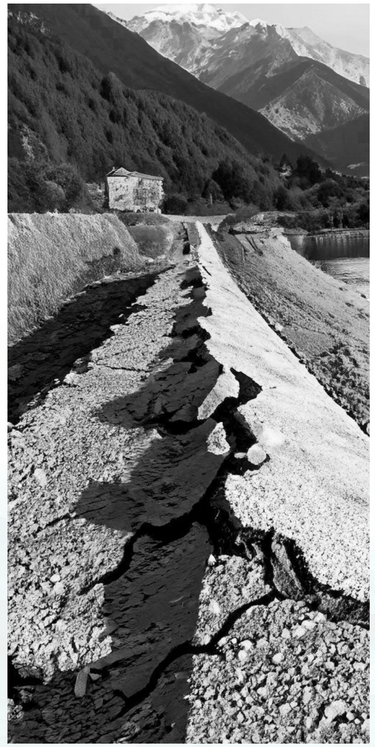
Step 2: Definition of the Urgency

Initiation of the Starting point towards change







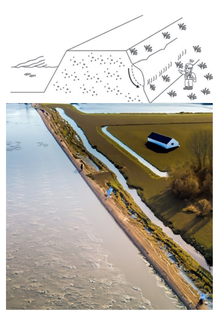


Definition of the Urgency

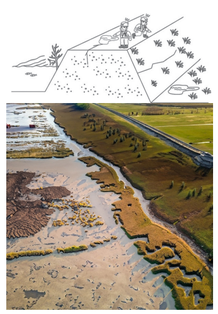
Change of the Landscape surrounding or on top of the dike line

↓

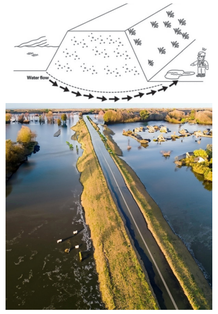
Does the local dike line protect me enough?



Sand boils alongside the dike



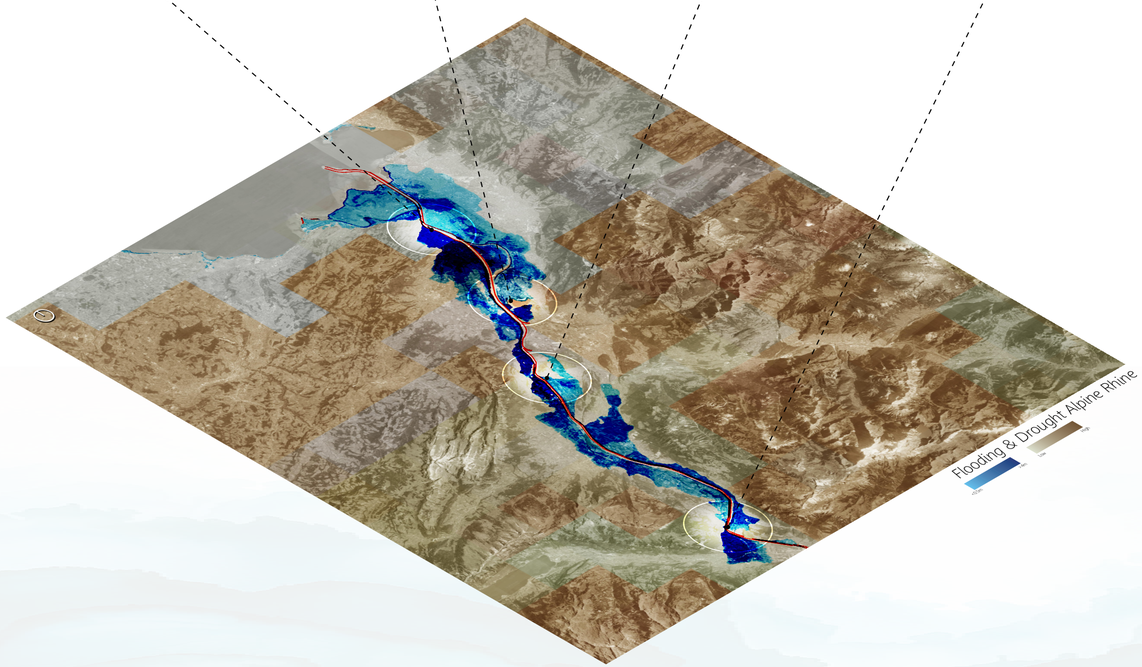
Cracks along the floodplain after flood

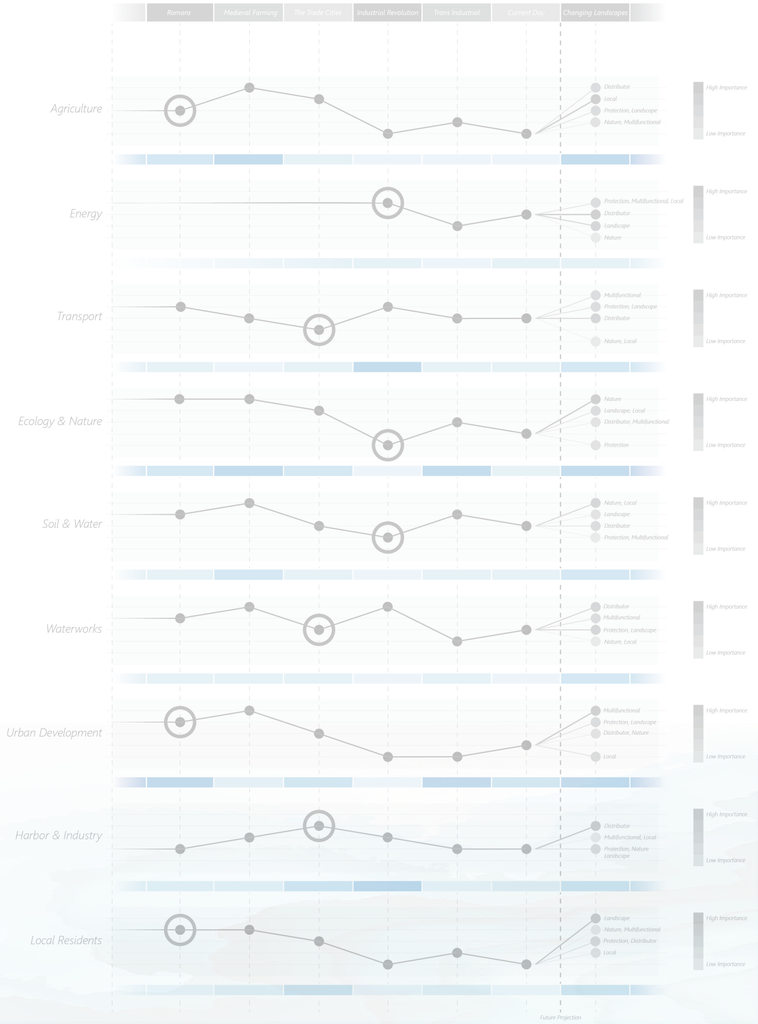


Uncontrolable seepage through the dike



Cracks inside the crest of the dike





Definition of the Urgency

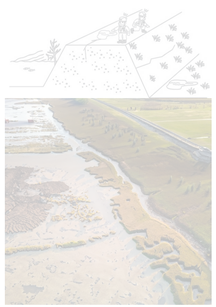
Understanding the relations between of the surrounding stakeholders in relation to dike managment

↓

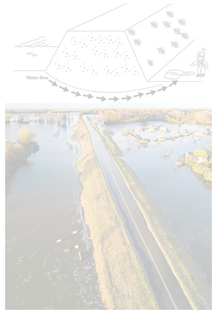
What is my position in relation toward dikes?



Sand boils alongside the dike



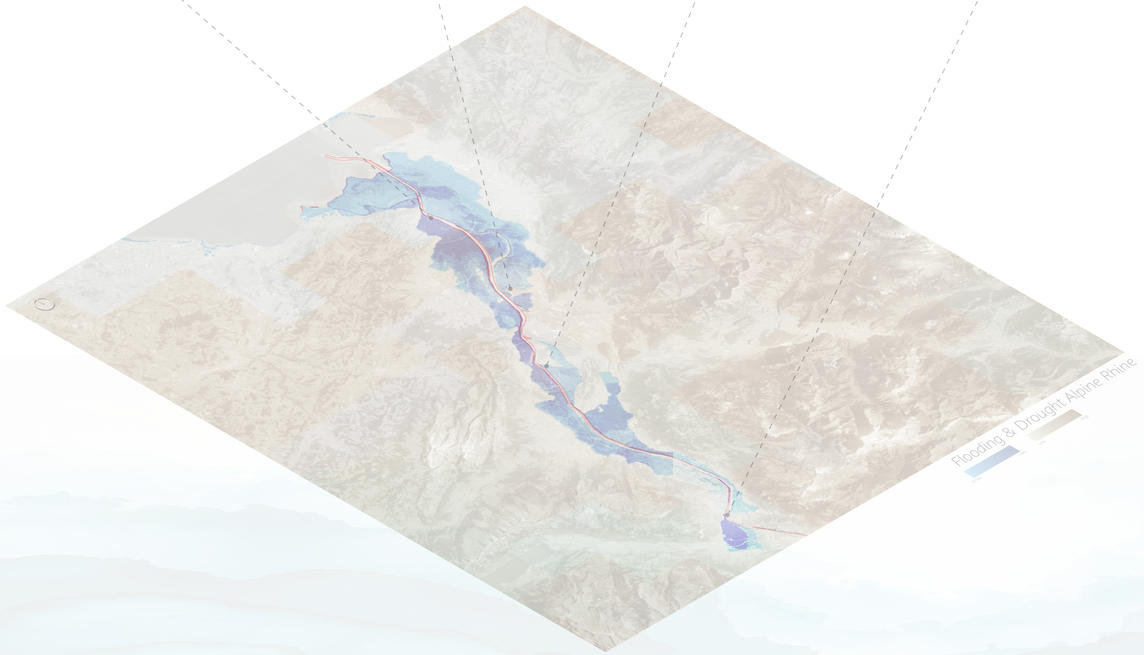
Cracks along the floodplain after flood

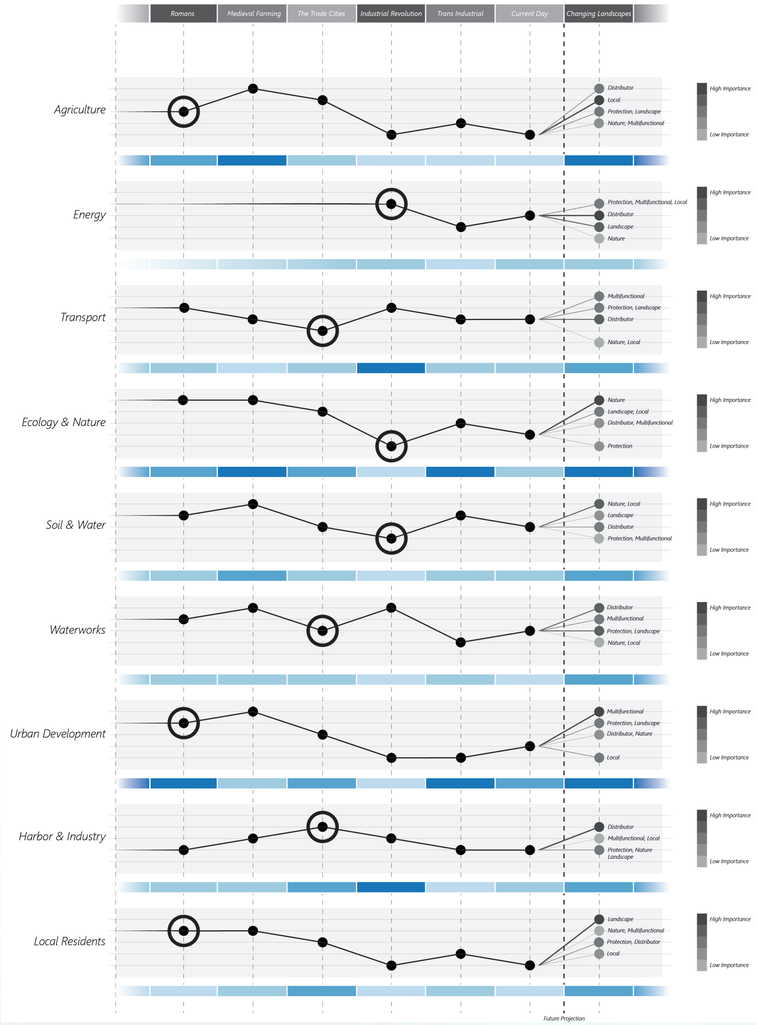


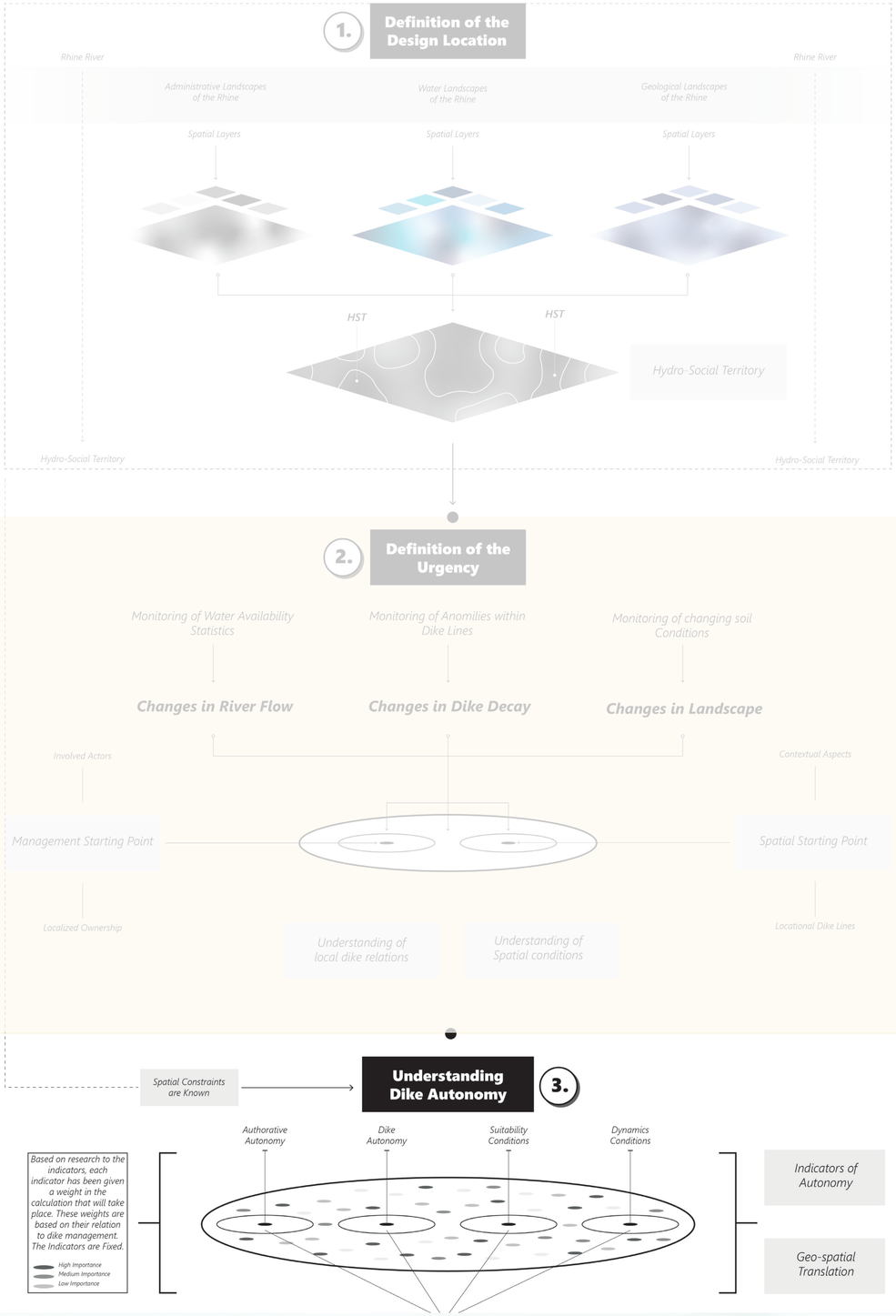
Uncontrolable seepage through the dike



Cracks inside the crest of the dike

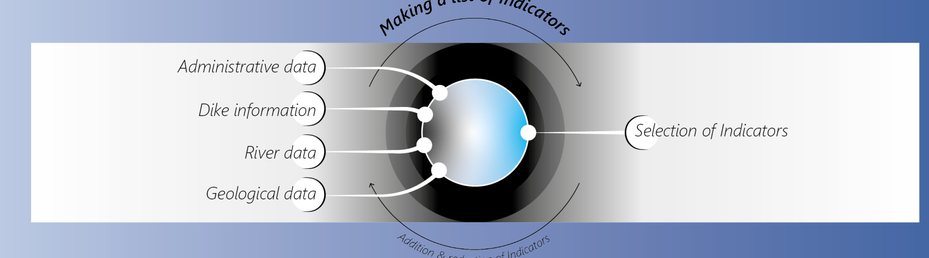




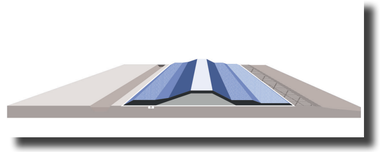


Step 3: Understanding the Autonomy Indicators

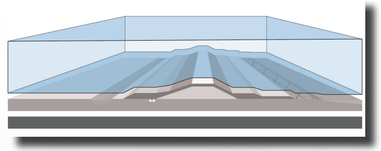
Collection of Indicators for establishing localized autonomy



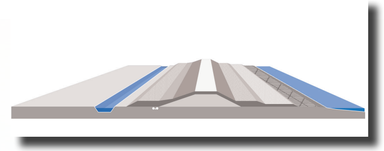
Dike Autonomy



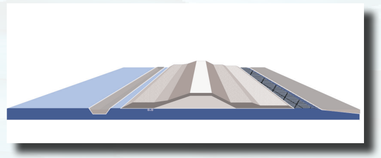
Authoritative Regions

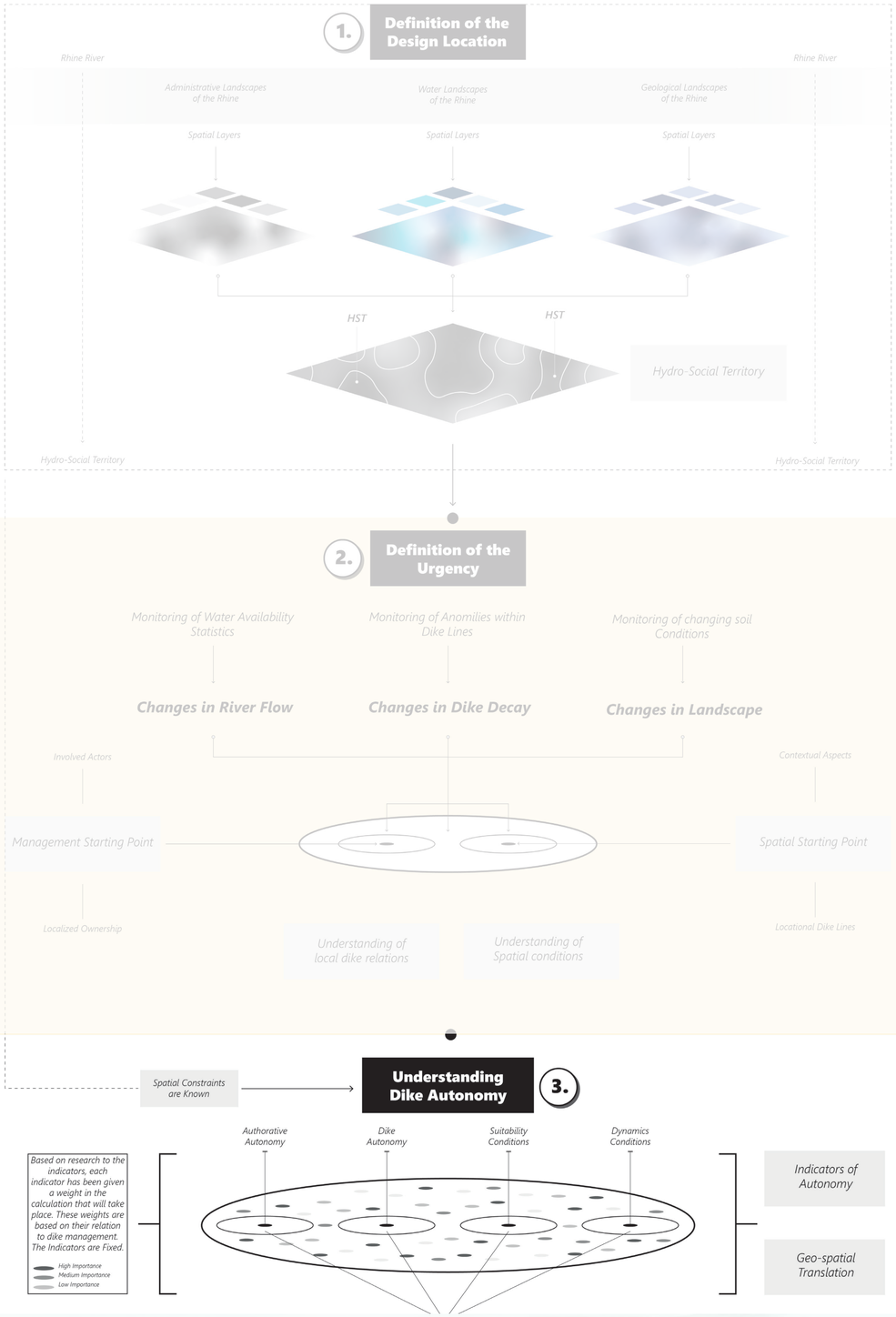


River Dynamics



Suitability Conditions





A: Flood Safety
- A1 Current Safety Regulations
- A2 Future Safety Regulations

B: Decision Making Autonomy
- B1 Available Knowledge
- B2 Available Funding
- B3 Availability of Space
- B4 Self-Organizing Capacity
- B5 Stakeholder Involvement
- B6 Levels of Uncertainty
- B7 Existing Projects

C: Socio-Economic Conditions
- C1 GDP, Purchasing Standard
- C2 Urbanized Regions

C: Management Relations
- C3 Water Management Power Relations
- C4 Dike Management Power Relations
- C5 Trust in Governance Structures
- C6 Adapativeness in Policy Making
- C7 Citizen Engagement

C: National Policy Indicators
- C8 Water Management Integration
- C9 Spatial Planning Discourse

D: Water Use
- D1 Economic Water Use Efficiency
- D2 Economic Water Efficiency
- D3 Power Plant Water Use
- D4 Waste Water Points
- D5 Water dependent Regions

O: River Discharge
- O1 High-Low Flow Differences
- O2 High-Low Flow Uncertainties
- O3 Low Flow Drought Conditions
- O4 Quantitative Discharge

P: Dike System
- P1 River Widths
- P2 Water Distribution Mechanisms
- P3 Groins
- P4 River Nodes

Q: Sedimentation Patterns
- Q1 Sedimentation Material
- Q2 Sedimentation & Erosion

E: Spatial Dike Formations
- E1 Form of Dikes
- E2 Location Placement
- E3 Dike Bodies Up & Down Stream
- E4 Scalar Impact of Dike System

F: Technical Dike Profile
- F1 Safety Failure Mechanisms
- F2 Water Distribution Failure Mechanisms
- F3 Water Retention Function
- F4 Water Distribution Function

G: Spatial Dike Profile
- G1 Dikes & Biodiversity
- G2 Dikes & River Flow
- G3 Dikes & Society
- G4 Dikes & Economy
- G5 Flexible Land Use

H: Maintenance Dike Profile
- H1 Area of Protection Zone
- H2 Frequency of Maintenance
- H3 Knowledge of Maintenance

I: Dike Construction Costs
- I1 Materials for Dike Construction

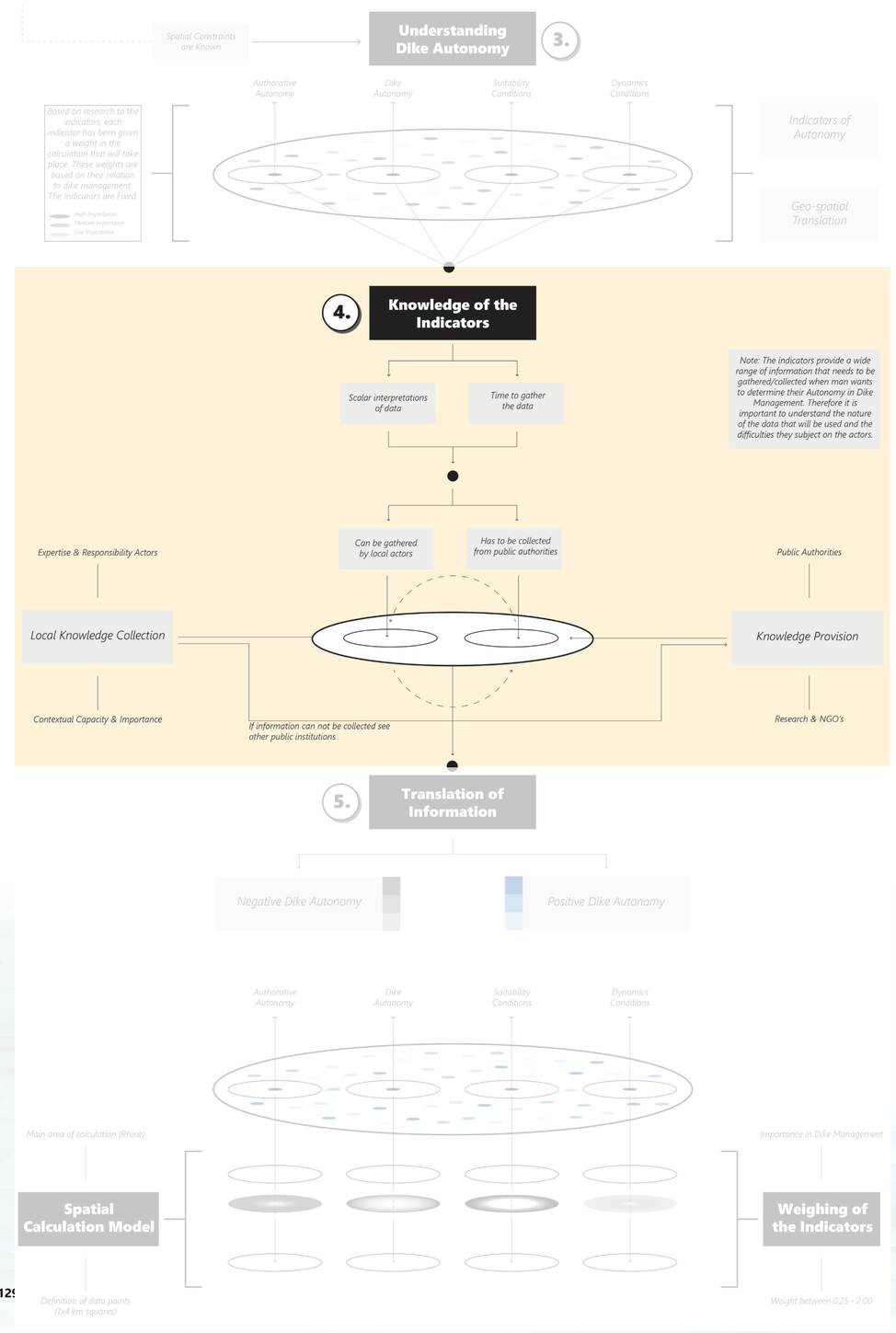
J: Additional Conditions
- J1 River Embankments
- J2 Local Dike Systems

K: Soil Conditions
- K1 Soil Sealing
- K2 Soil Moisture
- K3 Lithological Depositions

L: Groundwater Conditions
- L1 Groundwater Recharge
- L2 Aquifer Conductivity
- L3 Aquifer Vulnerability

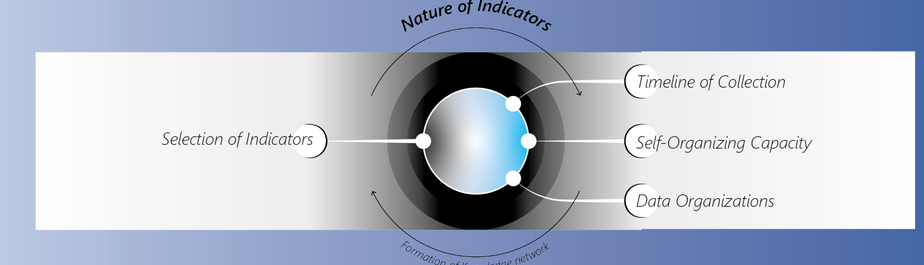
M: Flooding & Drought
- M1 Extreme Flooding Scenario
- M2 Hydrological Drought Seasons

N: Additional Conditions
- N1 Surrounding Water Bodies
- N2 Slope Indications
- N3 Effective Precipitation



Step 4: Understanding the Nature of Data

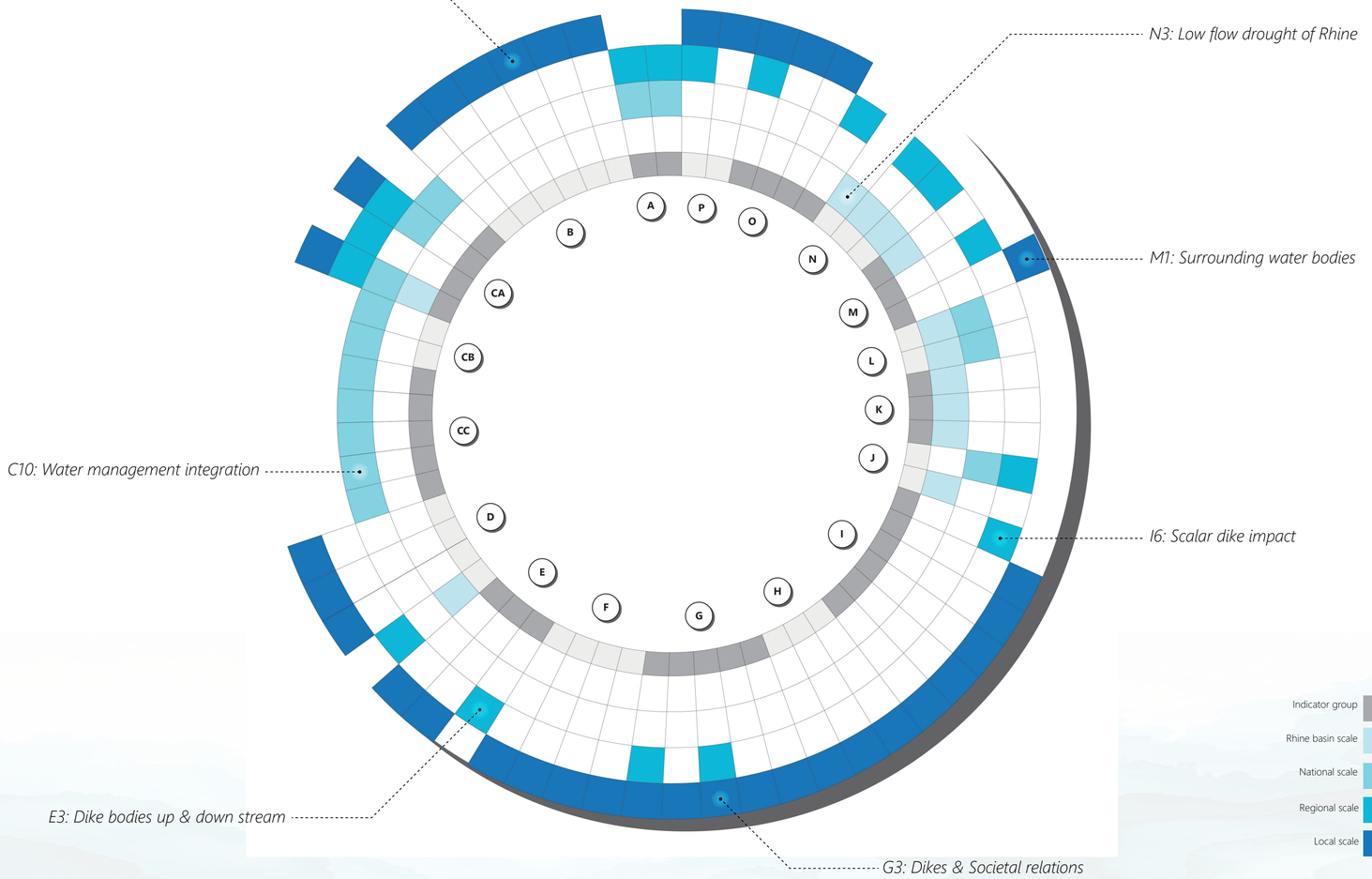
Where can I get the information from?



Nature of the Information

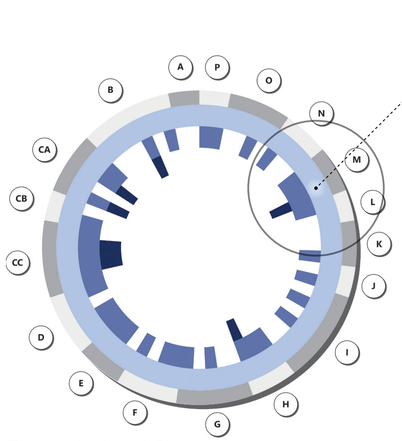
Each singular data usage has different components based on its scalar interpretation

Scalar Interpretation of Data

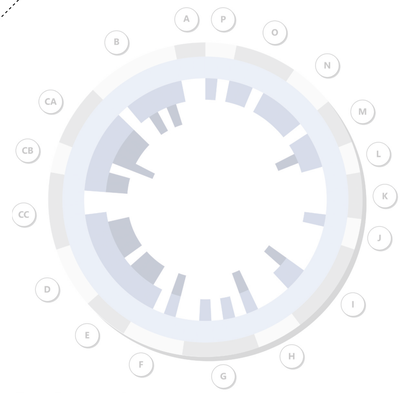


Nature of the Information

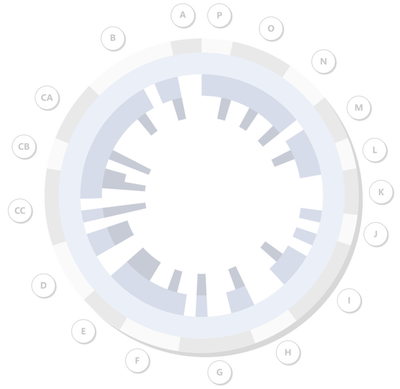
Ability of stakeholders to gather data themselves based on existing knowledge



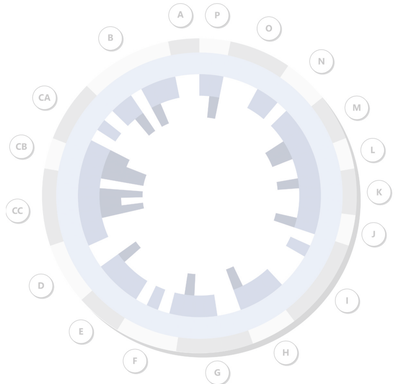
The Agricultural Sector



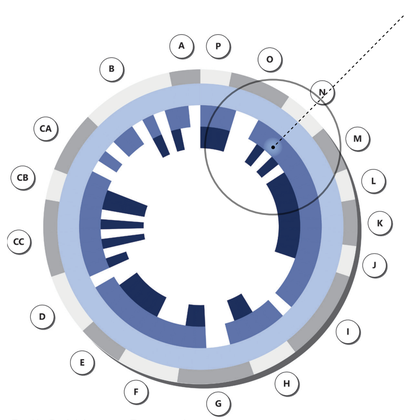
The Energy Sector



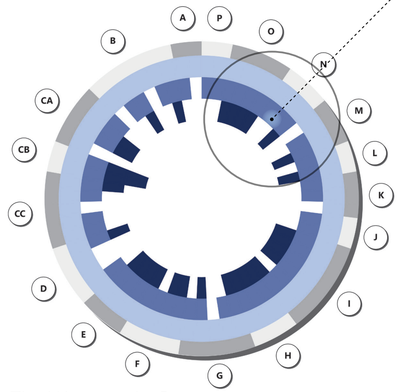
The Transportation Sector



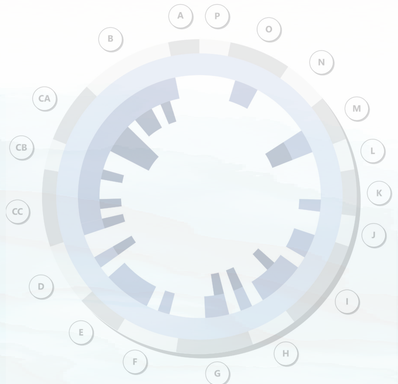
Nature & Ecology Organizations



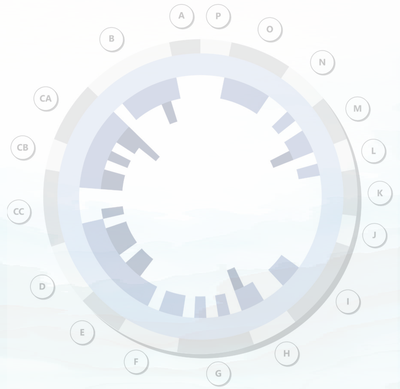
Soil & Water Organizations



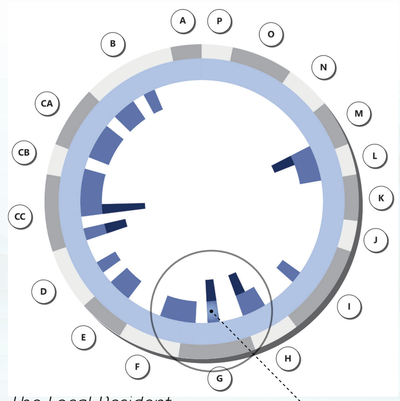
The Waterworks Sector



The Urban Development Sector



The Industrial Sector



The Local Resident

Can it be gathered?

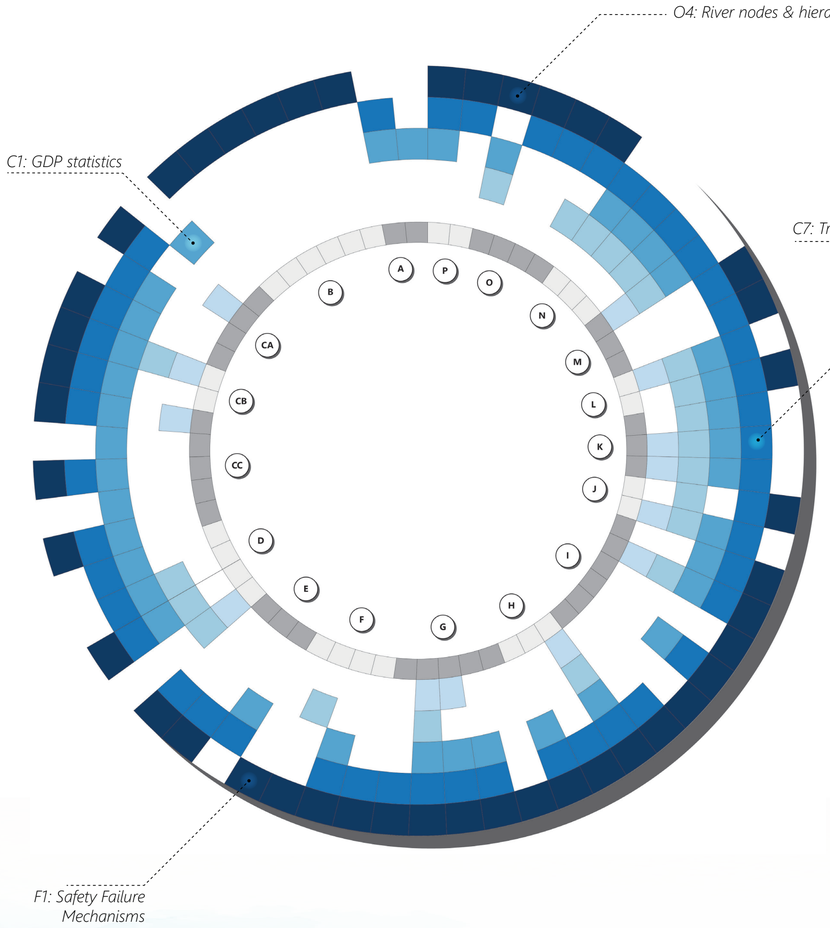
No

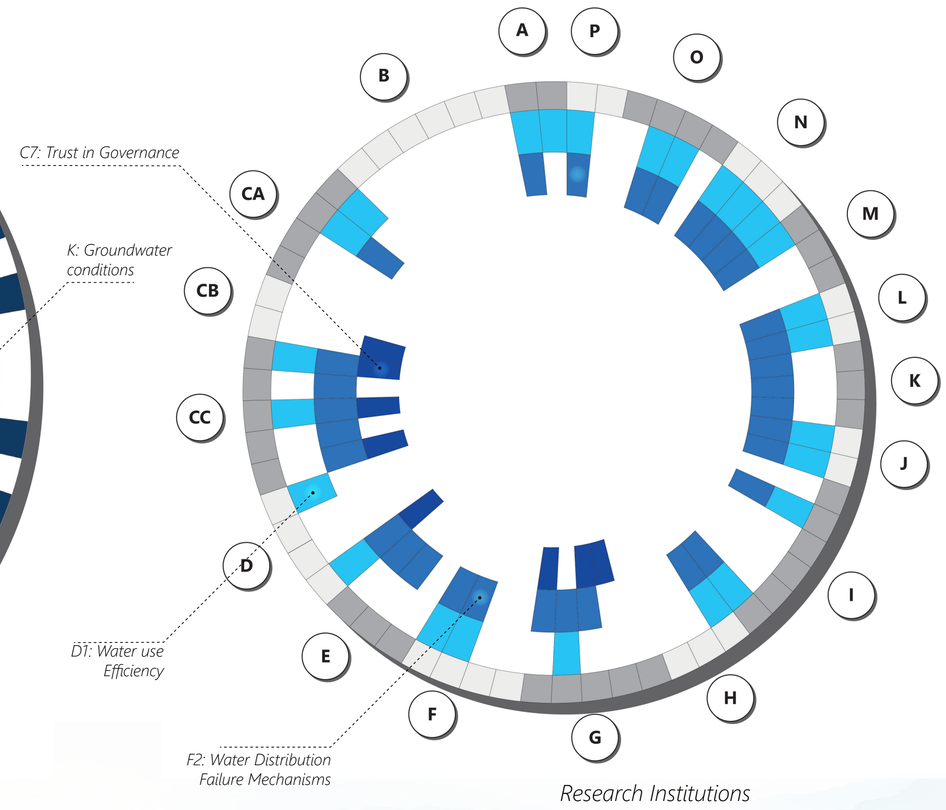
Maybe

Yes

Nature of the Information

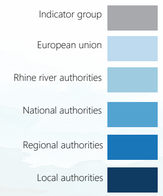
Responsible Authorities in data provision

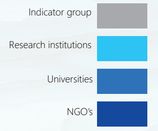




Responsible Authorities

Research Institutions





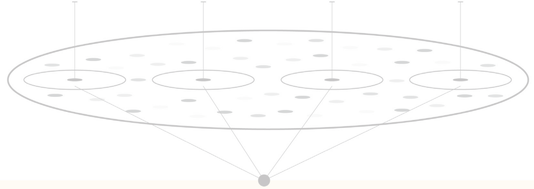
Spatial Constraints are Known

Understanding Dike Autonomy 3.

Authorative Autonomy | Dike Autonomy | Suitability Conditions | Dynamics Conditions

Based on research to the indicators, each indicator has been given a weight in the calculation that will take place. These weights are based on their relation to dike management. The Indicators are Fixed.

High Importance
Medium Importance
Low Importance



Indicators of Autonomy

Geo-spatial Translation

4. Knowledge of the Indicators

Scalar interpretations of data

Time to gather the data

Note: The indicators provide a wide range of information that needs to be gathered/collected when man wants to determine their Autonomy in Dike Management. Therefore it is important to understand the nature of the data that will be used and the difficulties they subject on the actors.

Can be gathered by local actors

Has to be collected from public authorities

Expertise & Responsibility Actors

Public Authorities

Local Knowledge Collection



Knowledge Provision

Contextual Capacity & Importance

If information can not be collected see other public institutions

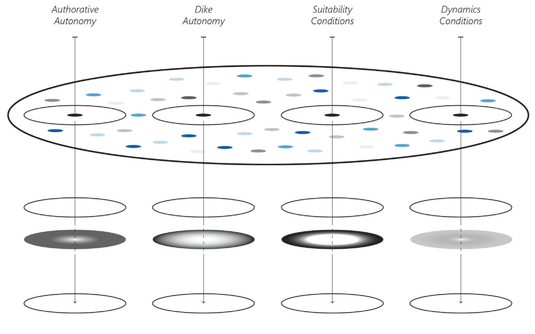
Research & NGO's

5. Translation of Information

Negative Dike Autonomy

Positive Dike Autonomy

Authorative Autonomy | Dike Autonomy | Suitability Conditions | Dynamics Conditions



Main area of calculation (Rhine)

Spatial Calculation Model

Definition of data points (1x4 km squares)

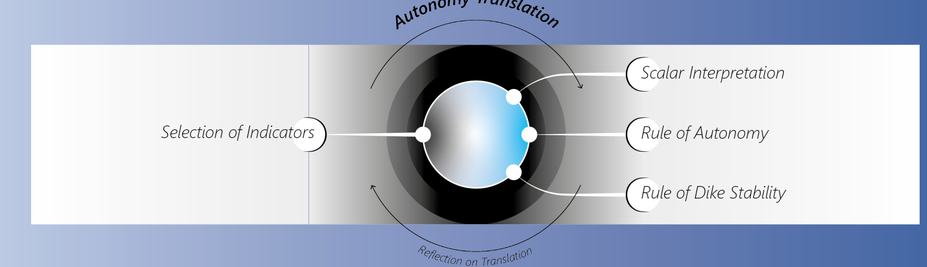
Importance in Dike Management

Weighing of the Indicators

Weight between 0.25 - 2.00

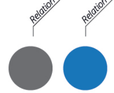
Step 5: Translation of the Information

Formulating the degree of Autonomy



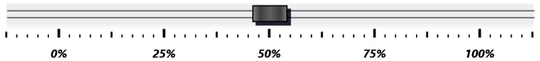
Relation to Local Autonomy | Relation to Dike Management | Weight in the (sub)calculation

Main Indicator



1.0

Influence in (sub)calculation



0% **25%** **50%** **75%** **100%**

Rule of Autonomy

Introduces the rules, what is needed in order to gain an effect on local autonomy

High autonomy — *Low autonomy*

Scalar Interpretation

Scale of Dataset

Translation of Data

Explains the main steps that were taken to translate the data into the meaning of autonomy

Spatial Constraints are Known

3. Understanding Dike Autonomy

Authorative Autonomy | Dike Autonomy | Suitability Conditions | Dynamics Conditions

Based on research to the indicators, each indicator has been given a weight in the calculation that will take place. These weights are based on their relation to dike management. The Indicators are Fixed.

High Importance
Medium Importance
Low Importance

Indicators of Autonomy

Geo-spatial Translation

4. Knowledge of the Indicators

Scalar interpretations of data

Time to gather the data

Note: The indicators provide a wide range of information that needs to be gathered/collected when man wants to determine their Autonomy in Dike Management. Therefore it is important to understand the nature of the data that will be used and the difficulties they subject on the actors.

Can be gathered by local actors

Has to be collected from public authorities

Expertise & Responsibility Actors

Public Authorities

Local Knowledge Collection

Knowledge Provision

Contextual Capacity & Importance

If information can not be collected see other public institutions

Research & NGO's

5. Translation of Information

Negative Dike Autonomy

Positive Dike Autonomy

Authorative Autonomy | Dike Autonomy | Suitability Conditions | Dynamics Conditions

Main area of calculation (Rhine)

Spatial Calculation Model

Definition of data points (1x4 km squares)

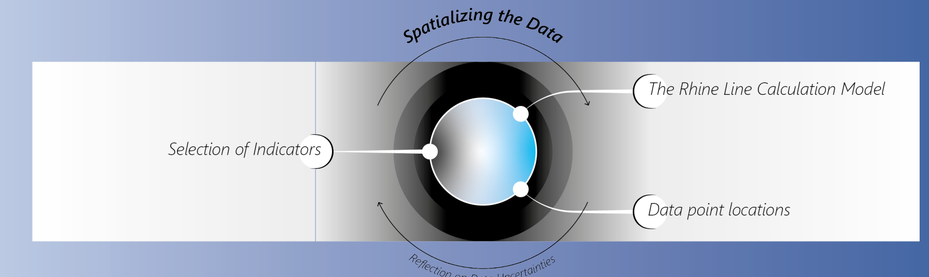
Importance in Dike Management

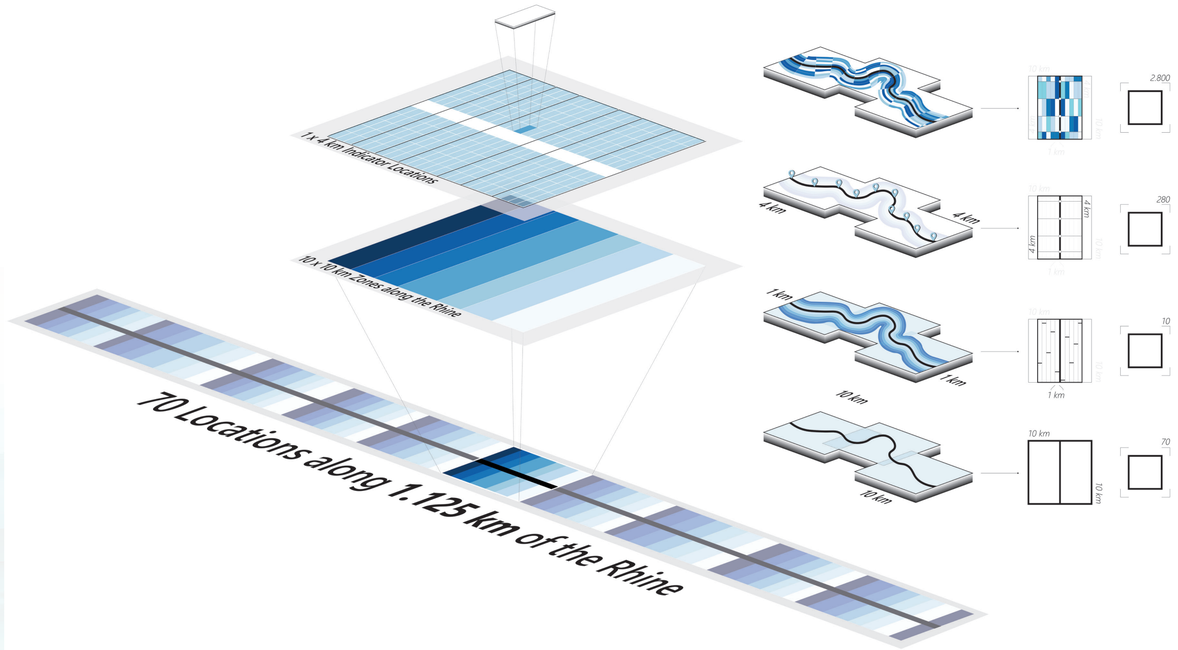
Weighing of the Indicators

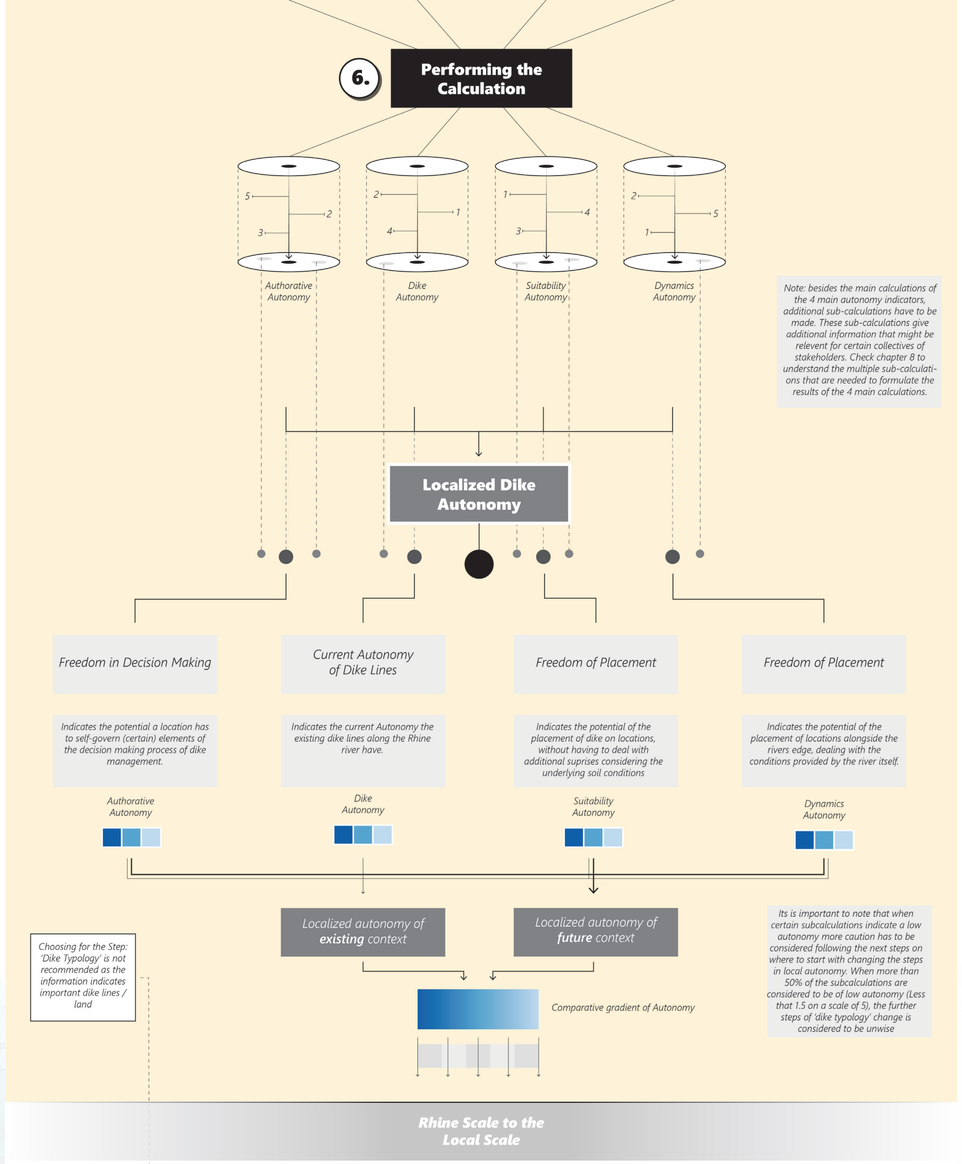
Weight between 0.25 - 2.00

Step 5.1: Spatialization of the Information

Spatializing the degree of Autonomy within my region

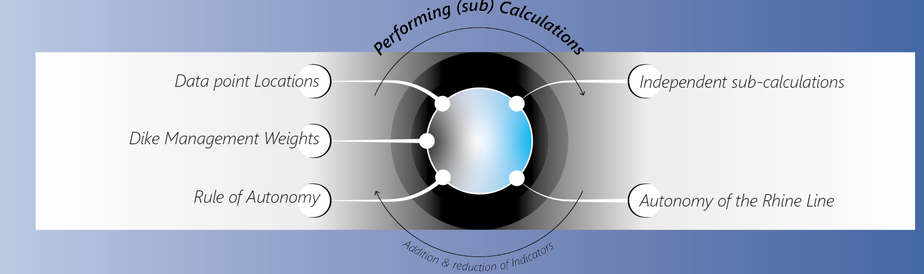


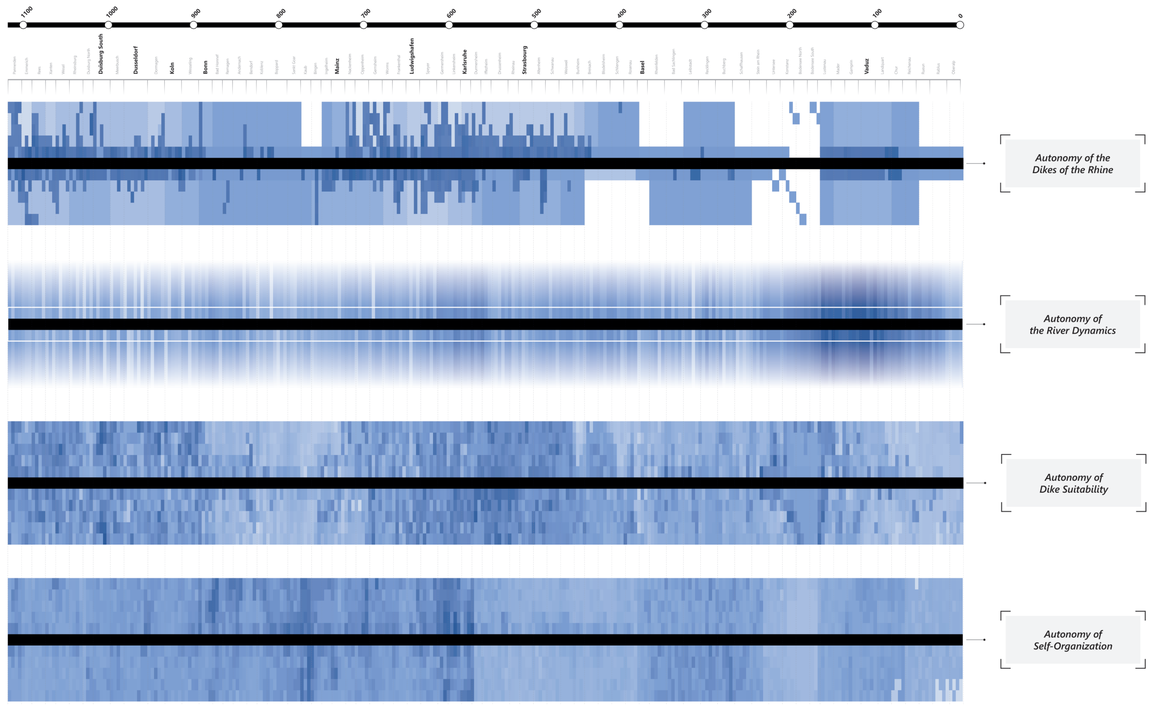


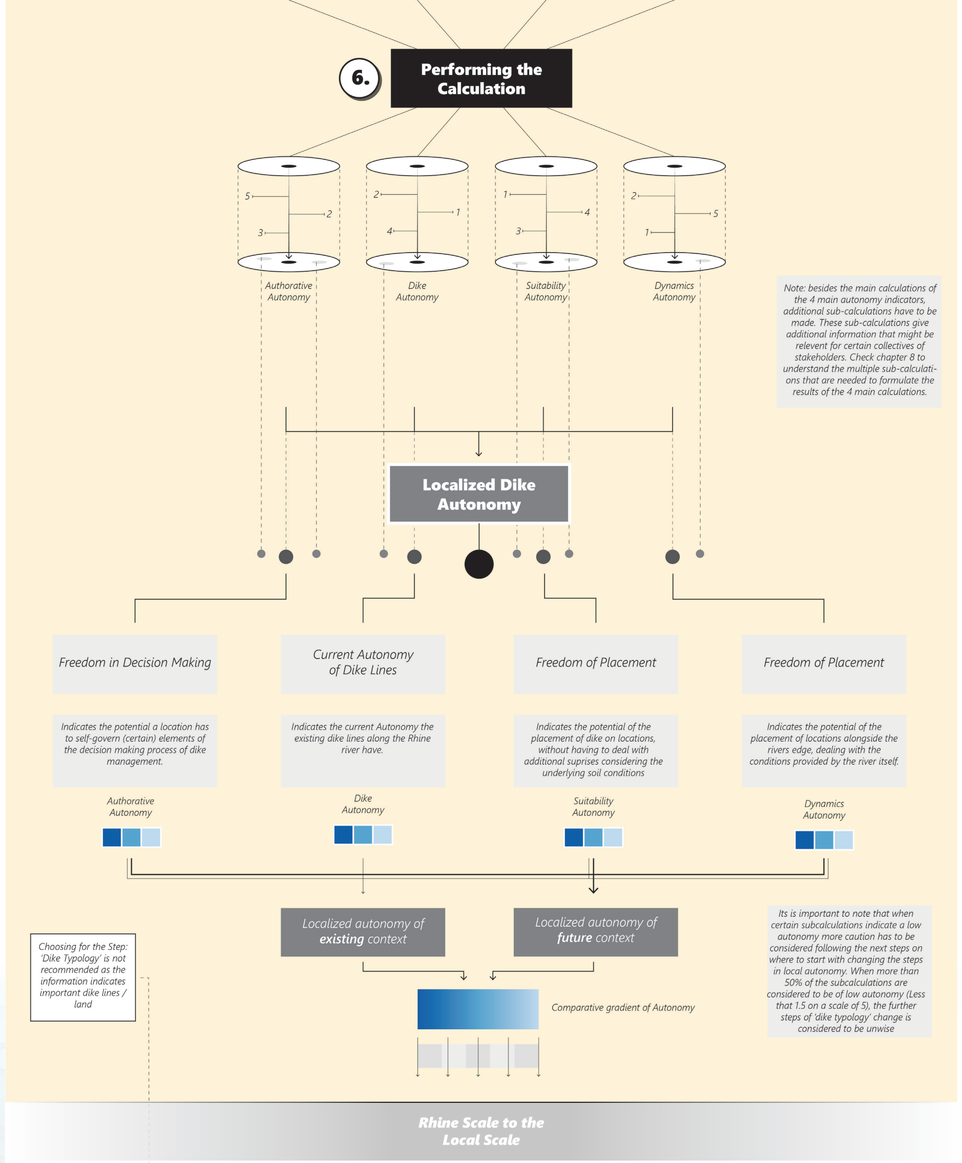


Step 6: Performing the Calculations

Creating a spatial pattern of Autonomy within my region

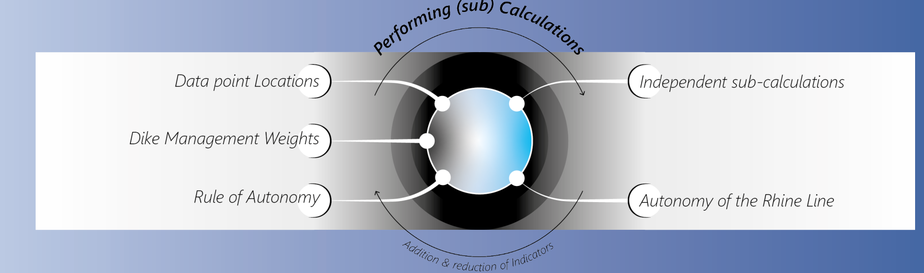




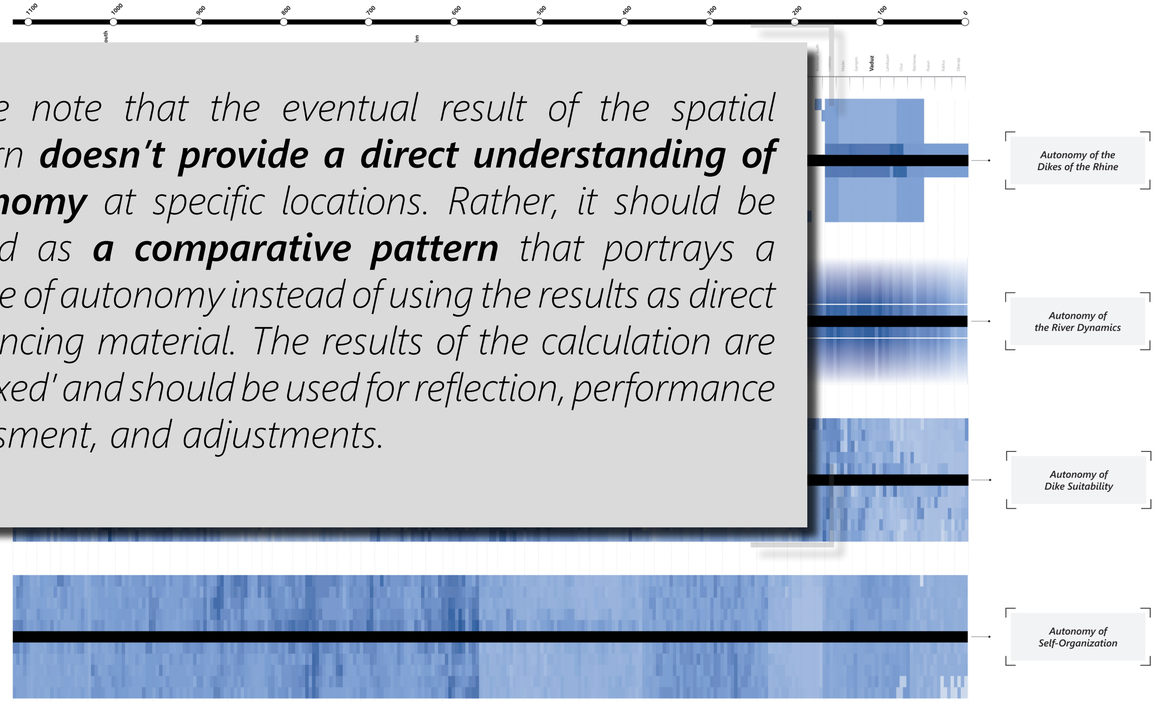


Step 6: Performing the Calculations

Creating a spatial pattern of Autonomy within my region



*Please note that the eventual result of the spatial pattern **doesn't provide a direct understanding of autonomy** at specific locations. Rather, it should be viewed as **a comparative pattern** that portrays a degree of autonomy instead of using the results as direct referencing material. The results of the calculation are not 'fixed' and should be used for reflection, performance assessment, and adjustments.*



7. **Choosing a Strategy**

Definition of strategy based on autonomy results

Spatial Change | *Management Change*

Dike Typology

Changing Existing Dike Structure

Construction of New Dike Structure

Deconstruction of Existing Dike Structure

Dike Location

Changing the Dike Location

Dike Stability

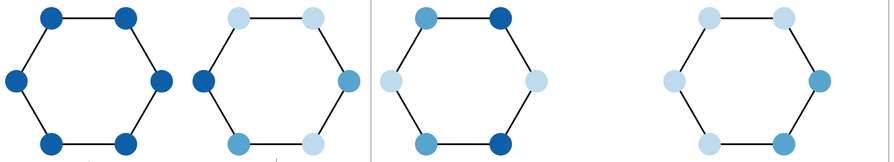
Increasing Dike Strength

Existing Dike

Changing Maintenance System

Note: Although the main indicators of change are related to the spatial element of the Dike, changes in the Maintenance System do have spatial impacts and should be taken into account.

Retain Existing Structure



Relation between the River and the landscape stays the same

Consideration of disregarding the current dike line

The location of the dike is fixed.

Freedom in Decision Making

Authorative Autonomy

Current Autonomy of Dike Lines

Dike Autonomy

Go Directly to the Addition of Other Spatial Dike Elements

Freedom in Placement

Suitability Autonomy

Freedom in Placement

Dynamics Autonomy

8. **Formation of a New Dike Line**

Formation of a New Dike Line Based on Autonomy

Freedom of Placement

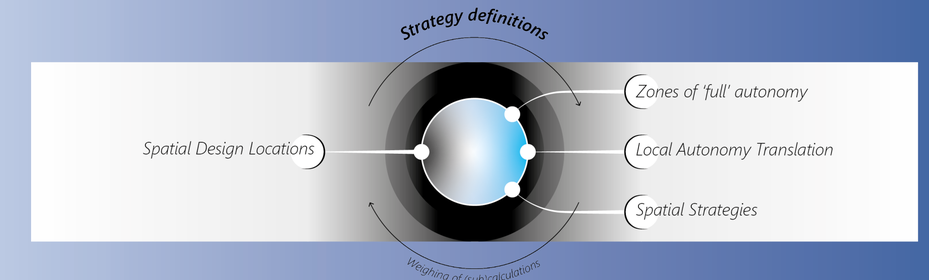
Extend Flood Line

Slope Indicators

Note: There are certain suitability conditions that have to be taken into account at the moment men decides to change the location of the new dike line. Large areas with a high

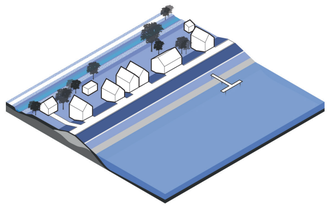
Step 7: Choosing a Strategy

Defining the strategies we can take based on calculation results



High autonomy

Low — *High*



Dike typology change

Medium autonomy

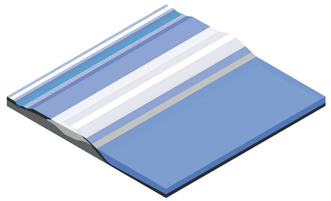
Low — *High*



Dike location change

Low autonomy

Low — *High*



Retain existing dike

8. **Formation of a New Dike Line**

Formation of a New Dike Line Based on Autonomy

Freedom of Placement

- ☐ *Extend Flood Line*
- ☐ *Slope Indicators*
- ☐ *Lithological Depositions*
- ☐ *Surrounding Water Bodies*

Note: There are certain suitability conditions that have to be taken into account at the moment men decides to change the location of the new dike line. Large areas with a high autonomy are not suited for dike due to their high elevation or other spatial characteristics.

9. **Envisioning Future Dikes**

Exploration of future dike scenarios based on each stakeholder group

- ☐ **Protective Dike**
- ☐ **Distributive Dike**
- ☐ **Tranisiton Dike**
- ☐ **Landscape Dike**
- ☐ **Multifunctional Dike**
- ☐ **Maintenance Dike**

Dike Database

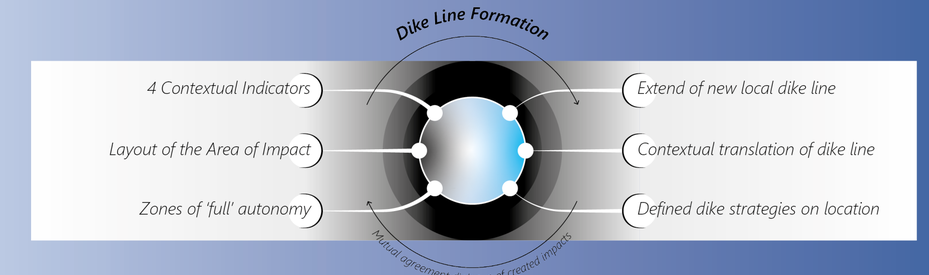
10. **Spatializing new Dike Typologies**

The moment the dike line is set out and the actor groups determine their ideologies in dike management, the further design process follows around the relations of actors at the direct vicinity of the dike line. Therefore a patchwork of dike building processes is set up that can take place as autonomous as needed.

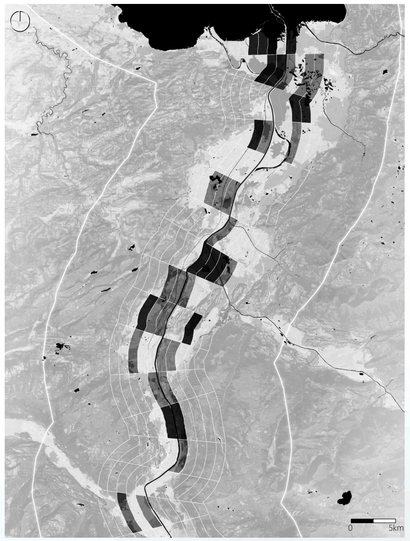
- **Protective Dike**
- **Distributive Dike**
- **Tranisiton Dike**
- **Landscape Dike**
- **Multifunctional Dike**
- **Maintenance Dike**

Step 8: Formation of a new Dike line

Where can we place a dike line within our region?

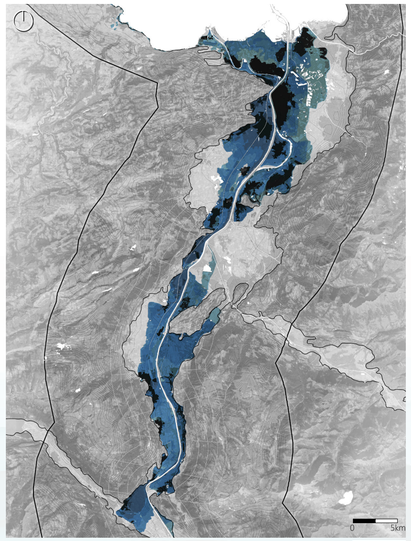


Zones of potential



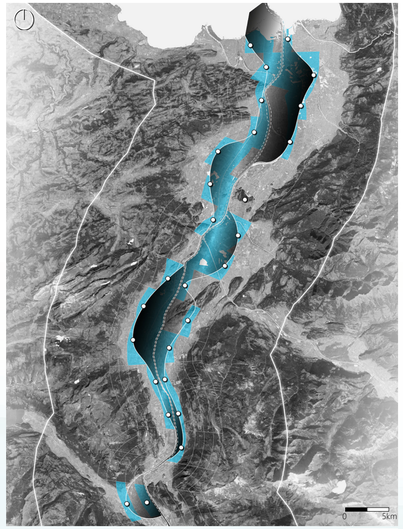
Rhine calculation model
Elevation
Degree of Autonomy
Low
High

Freedom of Placement Indicators



Flooded Urban areas
Existing water bodies
Slope extend
Elevation
Flood extend
>4m
<0.5m

Extend of the new local dike line



Zones of intervention
Dike extention point
Area of newly defined dike line

8. **Formation of a New Dike Line**

Formation of a New Dike Line Based on Autonomy

Freedom of Placement

- ☐ *Extend Flood Line*
- ☐ *Slope Indicators*
- ☐ *Lithological Depositions*
- ☐ *Surrounding Water Bodies*

Note: There are certain suitability conditions that have to be taken into account at the moment men decides to change the location of the new dike line. Large areas with a high autonomy are not suited for dike due to their high elevation or other spatial characteristics.

9. **Envisioning Future Dikes**

Exploration of future dike scenarios based on each stakeholder group

- ☐ **Protective Dike**
- ☐ **Distributive Dike**
- ☐ **Tranisiton Dike**
- ☐ **Landscape Dike**
- ☐ **Multifunctional Dike**
- ☐ **Maintenance Dike**

Dike Database

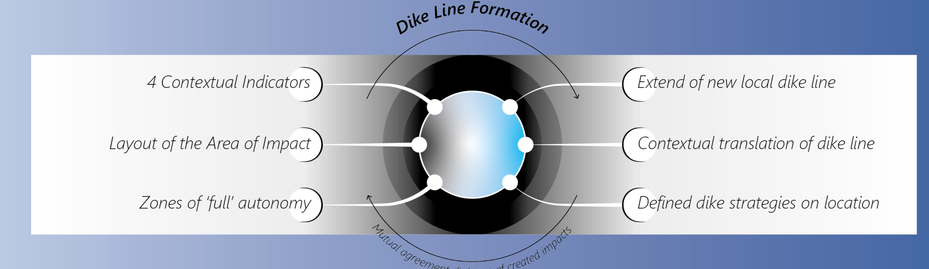
10. **Spatializing new Dike Typologies**

The moment the dike line is set out and the actor groups determine their ideologies in dike management, the further design process follows around the relations of actors at the direct vicinity of the dike line. Therefore a patchwork of dike building processes is set up that can take place as autonomous as needed.

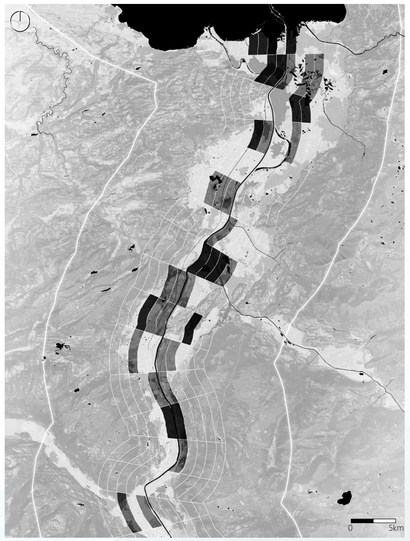
- **Protective Dike**
- **Distributive Dike**
- **Tranisiton Dike**
- **Landscape Dike**
- **Multifunctional Dike**
- **Maintenance Dike**

Step 8: Formation of a new Dike line

Where can we place a dike line within our region?



Zones of potential



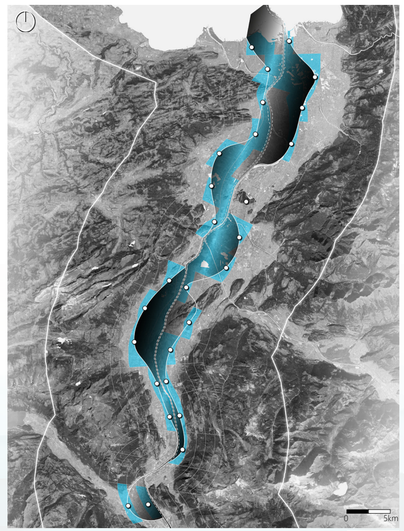
Rhine calculation model

Elevation

Degree of Autonomy

Low High

Extend of the new local dike line

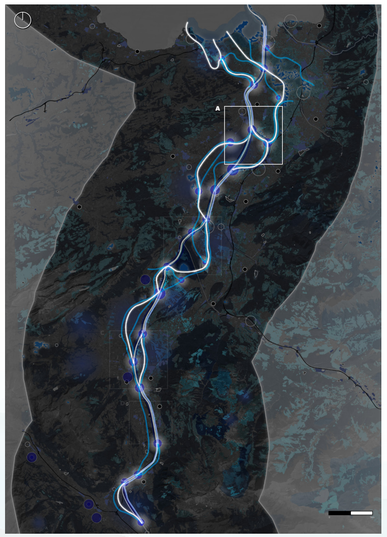


Zones of intervention

Dike extention point

Area of newly defined dike line

New defined dike line of along the river



8. **Formation of a New Dike Line**

Formation of a New Dike Line Based on Autonomy

Freedom of Placement

- *Extend Flood Line*
- *Slope Indicators*
- *Lithological Depositions*
- *Surrounding Water Bodies*

Note: There are certain suitability conditions that have to be taken into account at the moment men decides to change the location of the new dike line. Large areas with a high autonomy are not suited for dike due to their high elevation or other spatial characteristics.

9. **Envisioning Future Dikes**

Exploration of future dike scenarios based on each stakeholder group

- **Protective Dike**
- **Distributive Dike**
- **Tranisiton Dike**
- **Landscape Dike**
- **Multifunctional Dike**
- **Maintenance Dike**

Dike Database

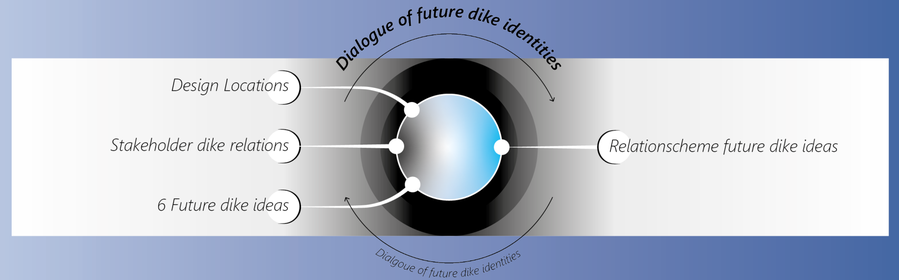
10. **Spatializing new Dike Typologies**

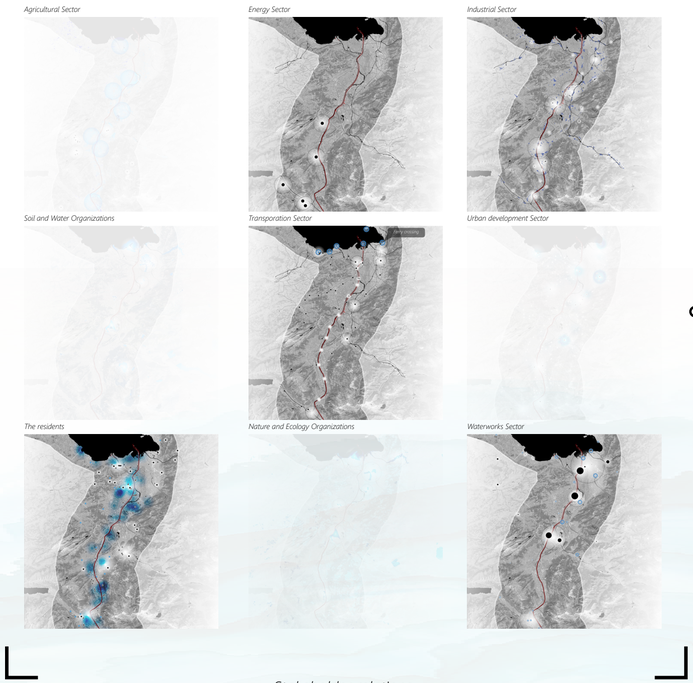
The moment the dike line is set out and the actor groups determine their ideologies in dike management, the further design process follows around the relations of actors at the direct vicinity of the dike line. Therefore a patchwork of dike building processes is set up that can take place as autonomous as needed.

- **Protective Dike**
- **Distributive Dike**
- **Tranisiton Dike**
- **Landscape Dike**
- **Multifunctional Dike**
- **Maintenance Dike**

Step 9: Envision Future Dikes

What is our position towards the relations with dikes?





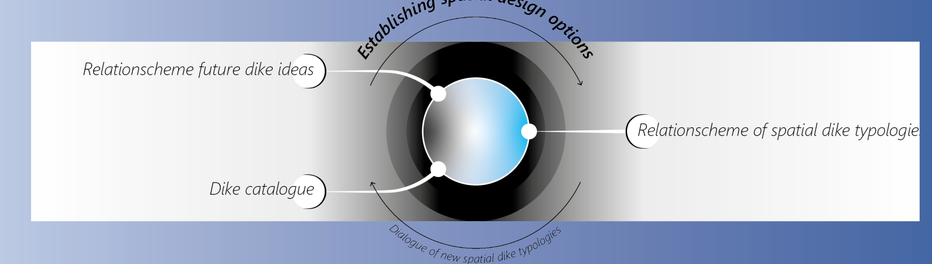
Stakeholder relations



Future dike identities

Step 10: Dike Design Dialogue

Formulation of relationschemes between dikes and our preferences



Dike Database → **Spatializing new Dike Typologies** **10.**

The moment the dike line is set out and the actor groups determine their ideologies in dike management, the further design process follows around the relations of actors at the direct vicinity of the dike line. Therefore a patchwork of dike building processes is set up that can take place as autonomous as needed.

- **Protective Dike**
- **Distributive Dike**
- **Tranisiton Dike**
- **Landscape Dike**
- **Multifunctional Dike**
- **Maintenance Dike**

11. **Creation of a new Dike System**

Safe option | *Moderate option* | *Extreme option*

Scenarios based on commonly carried spatial dike typologies

Contextual Filter

One Dike is selected

Multiple Dikes are selected

The dike selected in this part of the process are not the final results of the localization of dike management. These dikes function as the starting point of the spatiality the dike creates within its surrounding. The final steps of the process show additional spatial decision that can be made.

Dialogue to the formation of new spatial element

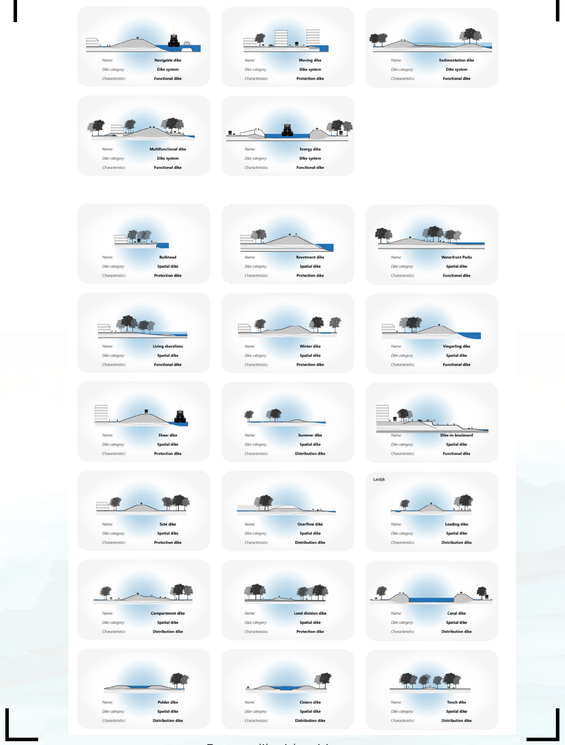
The main typology of the dike is chosen, indicating the main functional elements and spatial forms of the dike line. This does not indicate that this dike can be directly constructed. Later stages are in play to add additional spatial elements to the liking and needs of actors.

Note: these spatial elements do have impact on the overall autonomy of the dike line.

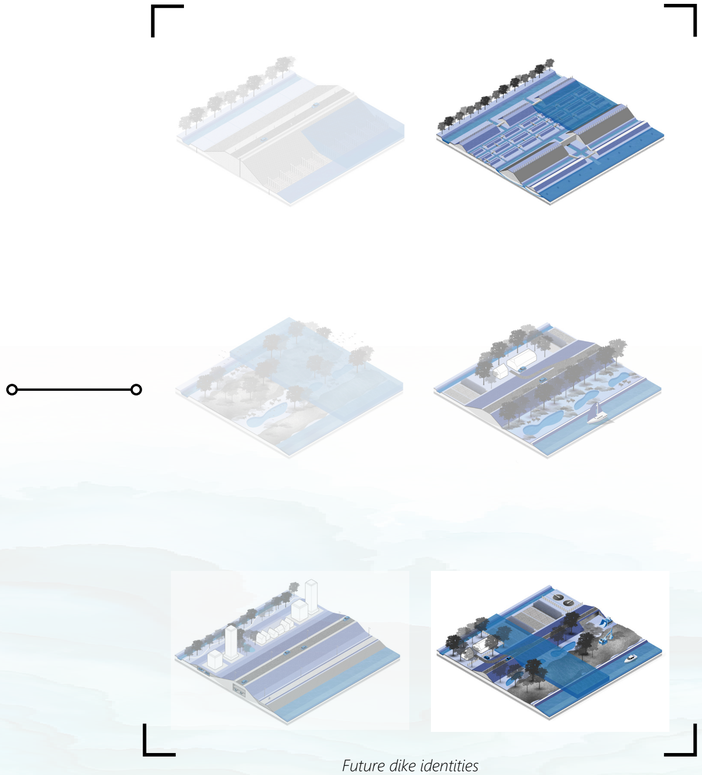
Based on the central notion that the stakeholders whom are related to the HST choice the dike that is commonly shared among each other (as based on preferences), does not mean that other possibilities are out of the question. HST have a free choice in the type of dike they want to construct. The downside is that existing knowledge and material issues might not be present, potentially harming further autonomy.

Freedom of choice by Design Location

12. **Placement on Location**



Future dike identities



Future dike identities

Dike Database

Spatializing new Dike Typologies

10.

The moment the dike line is set out and the actor groups determine their ideologies in dike management, the further design process follows around the relations of actors at the direct vicinity of the dike line. Therefore a patchwork of dike building processes is set up that can take place as autonomous as needed.

Protective Dike

Distributive Dike

Transiton Dike

Landscape Dike

Multifunctional Dike

Maintenance Dike

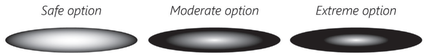


11. Creation of a new Dike System

Safe option

Moderate option

Extreme option

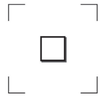


Scenarios based on commonly carried spatial dike typologies

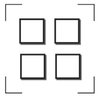


Contextual Filter

One Dike is selected

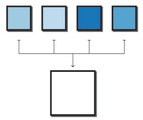


Multiple Dikes are selected



The dike selected in this part of the process are not the final results of the localization of dike management. These dikes function as the starting point of the spatiality the dike creates within its surrounding. The final steps of the process show additional spatial decision that can be made.

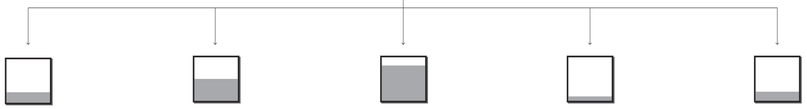
Dialogue to the formation of new spatial element



The main typology of the dike is chosen, indicating the main functional elements and spatial forms of the dike line. This does not indicate that this dike can be directly constructed. Later stages are in play to add additional spatial elements to the liking and needs of actors.

Note: these spatial elements do have impact on the overall autonomy of the dike line.

Based on the central notion that the stakeholders whom are related to the HST choice the dike that is commonly shared among each other (as based on preferences), does not mean that other possibilities are out of the question. HST have a free choice in the type of dike they want to construct. The downside is that existing knowledge and material issues might not be present, potentially harming further autonomy.

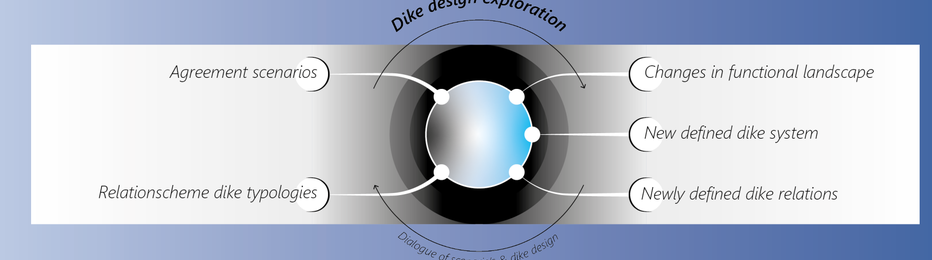


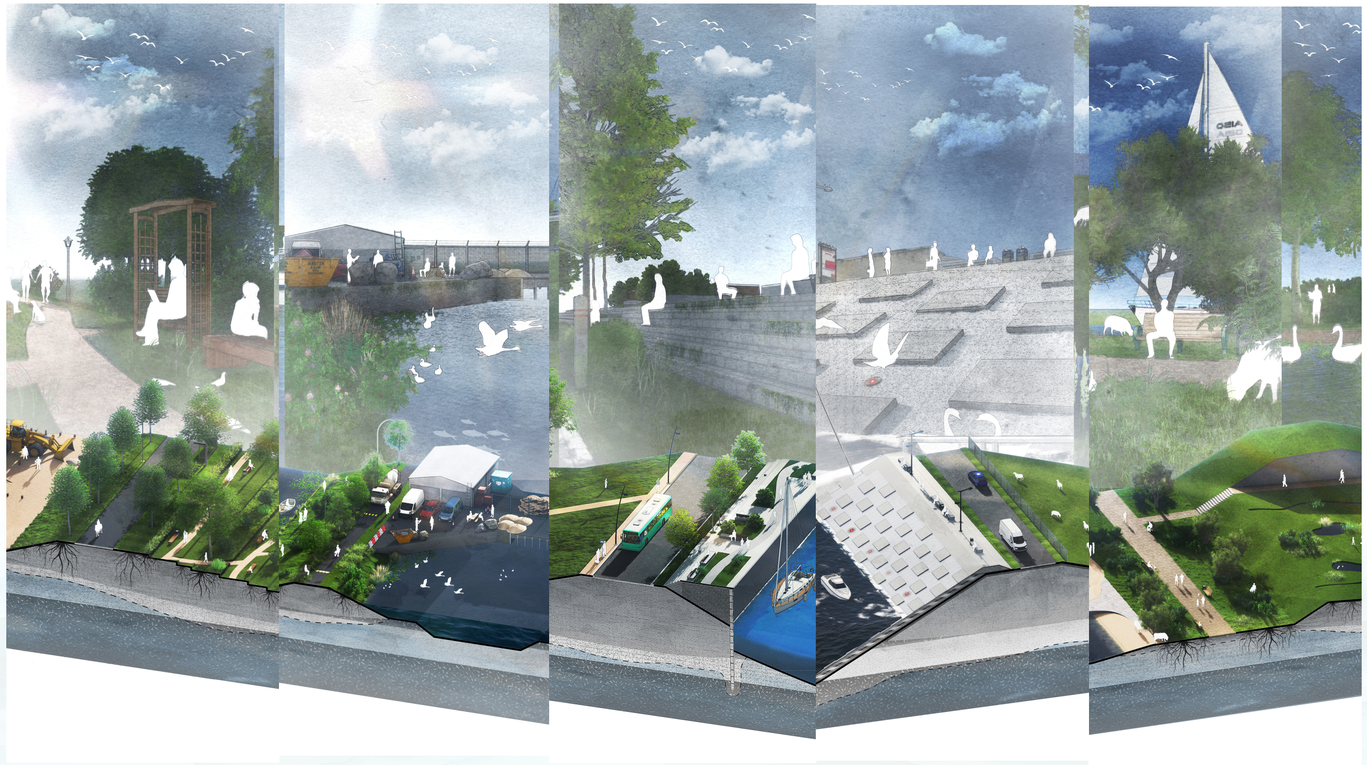
Freedom of choice by Design Location

12. Placement on Location

Step 11: Creating a new Dike System

Design dialogues of the multiple options





One Dike is selected

Multiple Dikes are selected

The dike selected in this part of the process are not the final results of the localization of dike management. These dikes function as the starting point of the spatiality the dike creates within its surrounding. The final steps of the process show additional spatial decision that can be made.

Dialogue to the formation of new spatial element

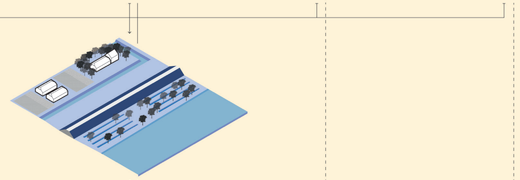
The main typology of the dike is chosen, indicating the main functional elements and spatial forms of the dike line. This does not indicate that this dike can be directly constructed. Later stages are in play to add additional spatial elements to the liking and needs of actors.

Note: these spatial elements do have impact on the overall autonomy of the dike line.

Based on the central notion that the stakeholders whom are related to the HST choice the dike that is commonly shared among each other (as based on preferences), does not mean that other possibilities are out of the question. HST have a free choice in the type of dike they want to construct. The downside is that existing knowledge and material issues might not be present, potentially harming further autonomy.

Freedom of choice by Design Location

12. Placement on Location



Recalculation of the Autonomy Performance

Localized Dike Autonomy has Decreased

Localized Dike Autonomy has Increased

Change Dike Typology or Change Additional Elements

Planning Phase of Dike Construction

Undergrond flows .(1)
Direct vicinity .(2)
Design location .(3)
River segment .(4)
Rhine River .(5)

Scalar Impact

Impact Assessment

Impact Time

(1). Direct Impact
(2). Monthly (Short term)
(3). Seasonal (Medium term)
(4). Multi-Seasonal (Long term)

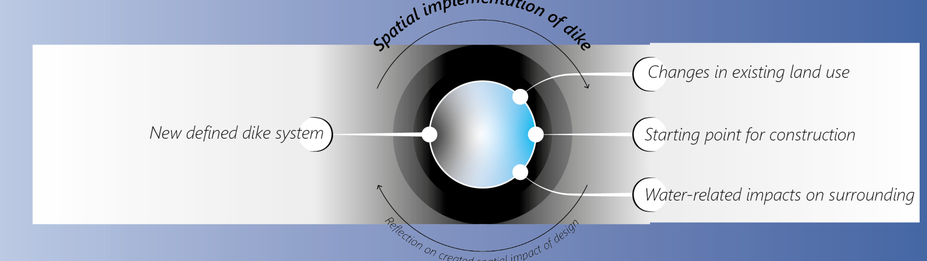
Dike functionality

River flow

Flooding & Drought

Step 12: Placement & Impact Assessment

What is the impact created once the dike is contextualized?



Dike Functionality

- Local maintenance
- Multifunctional use
- Connective use
- Enhance of biodiversity
- Local monitoring
- Prone to dike instability
- Prone to seepage

River flow

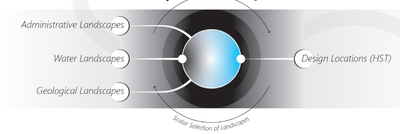
- Enhances sedimentation
- Stabilization of river flow
- Constant water available
- Increases water speed
- Over-sedimentation
- Increases high flow
- Increases low flow

Flooding & drought

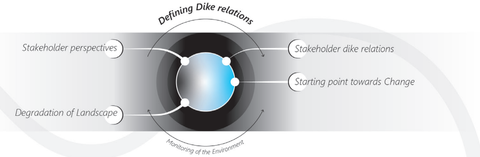
- Enhances infiltration rate
- Increases protection
- Increases awareness
- Prone to flooding
- Prone to drought



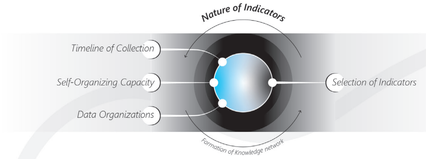
Step 1: *Design Locations (HST)*



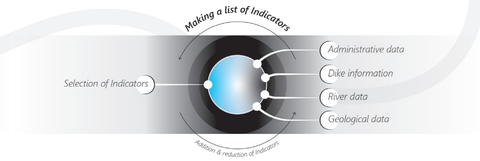
Step 2: *Urgencies*



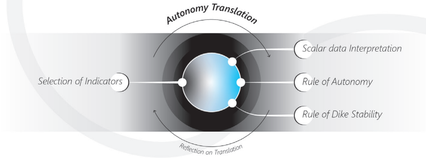
Step 4: *Knowledge Provision*



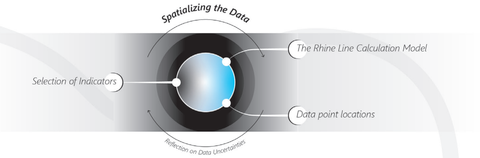
Step 3: *Indicators of Autonomy*



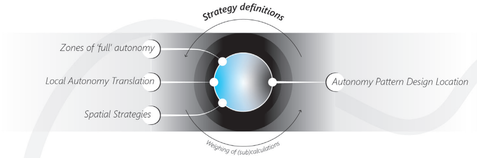
Step 5: *Translation of Indicators*



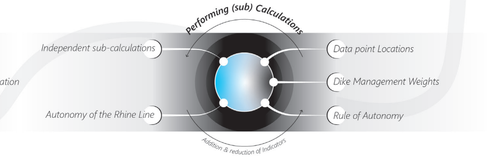
Step 5.1: *Spatialization Model*



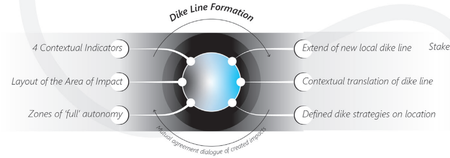
Step 7: *Defining Strategies*



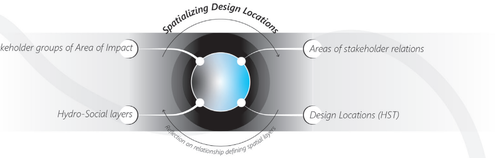
Step 6: *Calculation*



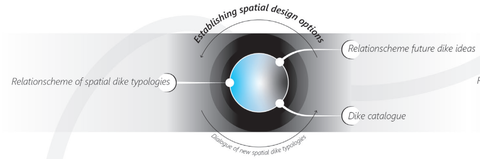
Step 8: *Dike Line Formation*



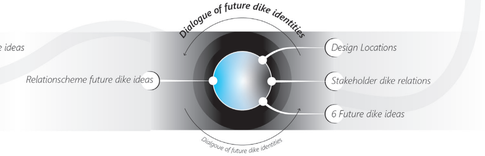
Step 8.1: *Design Locations (HST)*



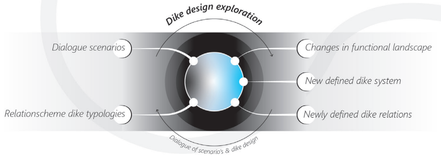
Step 10: *Spatial Dike Formation*



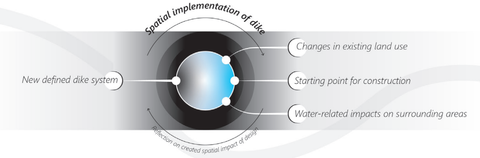
Step 9: *Future Dike Exploration*



Step 11: *Dike Systems*



Step 12: *Dike placement*





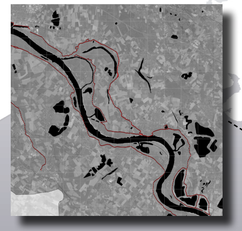
WHAT IS NEXT?
EXPLORATION OF NEW TEST LOCATIONS

Further development of the Roadmap on other Locations
Expanding the projects along the Rhine to further develop the Roadmap as a new method for Dike Management in the Rhine Basin





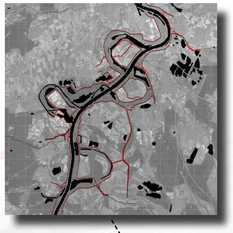




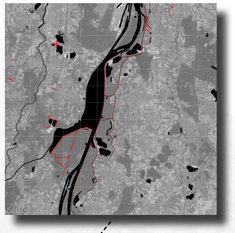
Rees: ***Delta Rhine (NL-DE)***



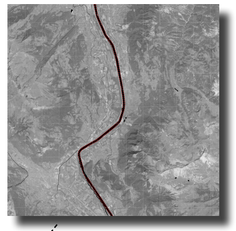
Meerbusch: ***Lower Rhine (DE)***



Germersheim: ***Upper Rhine (FF)***



Altenheim: ***Upper Rhine (FR-DE)***



Vaduz: ***Alpine Rhine (CH-AT-LI)***

Started: July 2023

Planned: March 2024

Planned: June 2024

Initiated: November 2023

Dikes per Rhine Regions

Dikes of the Rhine

