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## Rhine Cities - Urban Flood Integration (UFI)

German and Dutch Adaptation and Mitigation Strategies

Cornelia Redecker



# Rhine Cities - Urban Flood Integration (UFI)

**German and Dutch Adaptation and Mitigation Strategies**

Cornelia Redeker

*Delft University of Technology, Faculty of Architecture and The Built Environment,  
Department of Urbanism*



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# Rhine Cities - Urban Flood Integration (UFI)

**German and Dutch Adaptation and Mitigation Strategies**

Proefschrift  
ter verkrijging van de graad van doctor  
aan de Technische Universiteit Delft,  
op gezag van de Rector Magnificus prof. ir. K.C.A.M. Luyben,  
voorzitter van het College voor Promoties,  
in het openbaar te verdedigen op maandag 21 januari 2013 om 15:00 uur  
door Cornelia REDEKER  
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geboren te Braunschweig, Duitsland

Dit proefschrift is goedgekeurd door de promotor:  
# (Prof. Dr. Ir. V.J. Meyer)

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For millennia, monumentality took in all the following aspects of spatiality...  
the perceived, the conceived and the lived; representations of space  
and representational spaces, the spaces proper to each faculty,  
from the sense of smell to speech; the gestural and the symbolic.

*Henri Lefebvre*



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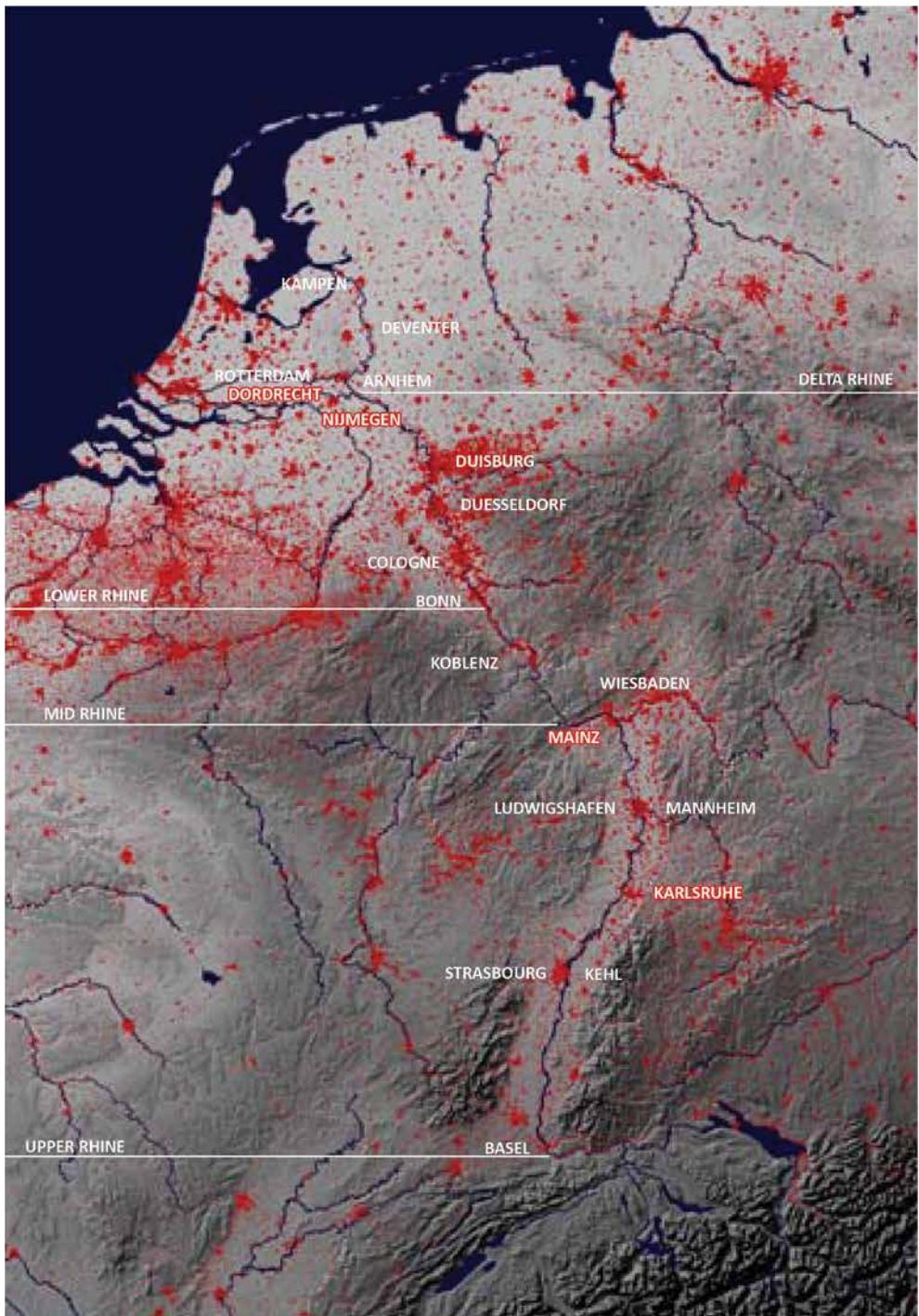


Figure 1

River Systems and Urban Fabric (Steffen Nijhuis, TU Delft, 2008 adapted by authour)

# Summary

While agglomerations along the Rhine are confronted with the uncertainties of an increasing flood risk due to climate change, different programs are claiming urban river front sites. Simultaneously, urban development, flood management, as well as navigation and environmental protection are negotiating the border between the river and the urban realm. This produces complex spatial constellations between the river system and the urban realm with a diverse set of interdependencies, where programs have to synergize while adapting to dynamic water levels. Based on an expanding area at risk and the reliance on flood levels to remain within an acceptable spectrum for adaptive measures to be effective, Urban Flood Integration (UFI) involves border negotiations between the river and the urban realm where adaptation and mitigation ideally synergize.

Instead of a scientific approach that reduces complexity in order to reach a verifiable question, a post-normal science approach is chosen as an evaluation and working method applied within this research. The working method relies on literature studies, semi-structured interviews and empirical research through repeated site visits. The general heterogeneity of the case studies regarding their planning structure, status and time scales, data availability and the willingness by the agencies involved to provide usable information shapes the formal research structure.

Part I serves as a narrative for the case study analysis and for the final conclusions and recommendations in Part II. It is made up of three chapters, where Urban Flood Integration is framed historically, theoretically and strategically within the specific geographic context of the navigable Rhine:

Anthropogenic transformations of the Rhine flood plains in the 19th and 20th century have turned formerly wide, often meandering or bifurcating river beds into urbanized embankments along straight, channelled rivers. The perception of the river changed from being dynamic to being controllable. This produced the spatial backdrop for modernist and therefore sectoral developments based on a dialectical relationship between the urban realm and the (river) landscape. Yet, as conversions of former harbours are turning sites outside the flood defence into inner city living quarters, as retention polders are positioned in flood plains with enough damage potential to threaten regional economies, and flood mitigating measures are more viable/effective on site in the middle of the city than in a rural area, site specific negotiations between simultaneous programmatic claims are producing new urban typologies/ecologies that in turn demand and rely on a new methodological approach. Within this research design is considered not only a spatial, but also a strategic tool capable of not only linking different programs, but also different disciplines.

Flood Risk Management along the Rhine today combines river expanding measures and adaptive strategies with the existing defensive system to cope with the risk increase as a consequence of previous interventions and developments and fluctuations in water levels due to climate change. Differences in landscapes and urgencies and differences in planning cultures between the Upper and Lower Rhine and the Delta have also led to different strategic approaches. Within this research the innovative capacity of the adaptive and anticipatory water-based approach in the Netherlands provides lessons to be learned specifically regarding spatial quality as a strategic component of water-related projects.

In Part II, the investigation of two Dutch and two German urbanized water front developments along different river segments of the Rhine according to their synergetic potential, but also regarding the temporal and spatial interdependencies between the river system as a whole, the regional context as well as the actual water front as the project site, aims to examine the following questions: Between adaptive and mitigative strategies, what is the spectrum of spatial constellations between urban development and flood management within the constraints set by navigation and a (partial) restoration of the dynamic river landscape? How are temporal and spatial interdependencies shaping these projects? Relational diagrams show the reciprocations between urban development and river dynamics of each investigated case study and the respective agencies and processes involved. The case study analysis serves as a basis for recommendations for the architectural and programmatic scope of flood-resilient projects dealing with expansive flood management strategies and respectively a strategic design approach addressing multiple scales and programs. Embedded in an exemplary atlas of the respective typology along the different Rhine segments, the four case studies from south to north are:

- Karlsruhe Rappenwört, a steered retention polder along the meandering Upper Rhine
- Mainz Zollhafen, a port conversion with flood adaptive housing along the bifurcating Upper Rhine
- Nijmegen Lent, a bypass and urban extension based on a dike set back along the Waal
- Dordrecht Stadswerven, an urban development outside the dikes in the Delta

In summary, differences in landscape, threat and political structures have produced different planning cultures in Germany and the Netherlands in terms of flood management. Both Dutch and German mitigation measures remain path dependent on the defensive system. Yet, whereas the Dutch approach to flood mitigation is holistic in an extended ecological sense and specifically includes spatial quality, in Germany, planning flood-related issues remains part of a sectoral approach where spatial quality is not initially included, but remains an additional layer towards the end of the project. Confronted with a strong ecological lobby, the focus is to restore the former

alluvial forest in niches. Of the six programs defined in the ICPR Atlas, forestry seems the only one capable of taking on river dynamics and transforming accordingly over time. All other programs (settlements, industries, traffic infrastructure, and to some degree agriculture, specifically when ecological flooding is taken into account) remain reliant on defensive measures, and in case of their failure, infrastructural support and adaptation measures. They are, however, not included in a design strategy that explores potentialities.

In the light of long-term strategies and programs, the Dutch approach offers a more iterative planning practice that is capable of evolving with the experience gained. Dutch experience and corresponding policy adaptation has further shown that a more permissive planning approach to allow additional programs within Room for the River measures can raise local acceptance and thus reduce negative effects. In Germany, water management agencies avoid projects that could become precedence cases and thus enable repetition. This restrictive approach is a hindrance on the way to larger-scale strategies that rely on pilot projects as testing grounds. The Dutch approach seems to aim for incentives and actually provides them, as the trade-off in the Nijmegen case shows. Moving from a restrictive to a responsive planning approach that includes incentives produces a breeding ground and should always be a central component of any strategy. One of the main findings of this research is, specifically in Germany, the limited availability of information, as well as lacking visualization layers of ongoing programs and projects (which may be an additional indication of the lacking involvement of designers in German spatial flood risk management projects). This research contributes to a broader understanding by providing an atlas of selected flood-adaptation and flood-mitigation typologies along the Rhine between Basel and Rotterdam.

Directly addressing the design practice, this research proposes to move from a spatial to a strategic design approach by

- involving architects, landscape architects, urban designers from the initial stage to enable their engagement also in the strategic design of a project;
- enabling design to become part of a systemic approach that aims for capacity building and therefore includes ecological, economic and cultural conditions through a transdisciplinary approach;
- making the invisible layers visible: Visualize systems/expert information to make them accessible and to enable communication between disciplines;
- hosting design competitions in cooperation with local stakeholders bringing people and ideas together to trigger emergence;

- applying back-casting strategies to move beyond existing conceptions: design may thus becomes “telescopic” and allow a challenge of existing givens, the visualization of concepts again playing a central role.

Two follow-up research projects are proposed:

Development of Design Guidelines for a river segments approach: Evaluation of ongoing or recent mitigation and adaptation projects, but also other river-related developments (e.g. navigation) in an academic research project to define potential emergent capacities between systemic and qualitative elements. In collaboration with the practice, smaller scale pilots as part of existing mitigation programs on a river segment scale could aim to substantiate the findings.

Cost-Benefit-Analysis Spatial Quality: To substantiate the qualitatively developed argument towards Urban Flood Integration (UFI), a cost-benefit analysis of a transdisciplinary layer that is comparable to the measures defined by the Dutch Quality Team for the German Room for the River, which focus today on ecological rejuvenation vs. spatial quality as a secondary aim.

The final outcome of the following multiple case-study investigation and the typological atlas provided is seen to be valuable for a number of different organizations, such as governmental and educational institutions dealing with the geospecific context and spatial development along the Rhine, representatives from the building sector and venture capitalists, as well as people with a personal interest in ecological urbanism in the context of the Rhine.

# Samenvatting

Terwijl stedelijke agglomeraties langs de Rijn worden geconfronteerd met de onzekerheden van een steeds groter wordend overstromingsrisico als gevolg van klimaatverandering, zijn diverse stedelijke bouwprojecten gericht op het ontwikkelen van locaties langs de rivier. Stadsontwikkeling, hoogwaterbeheer en rivierverkeer en milieubescherming verkennen tegelijkertijd de grenzen tussen de rivier en het stedelijk domein. Dat leidt tot complexe ruimtelijke constellaties waarbij sprake is van een reeks afhankelijkheden van uiteenlopende aard. Projecten moeten op elkaar worden afgestemd en tevens rekening houden met aanpassing aan dynamische waterstanden. Het stedelijke hoogwaterintegratieconcept UFI (Urban Flood Integration) gaat ervan uit dat het risicogebied groter wordt en de waterstanden binnen aanvaardbare grenzen blijven om effectieve aanpassingsmaatregelen te kunnen nemen en stemt de rivier en het stedelijke domein op elkaar af, waarbij idealiter synergie optreedt tussen adaptieve en beschermende maatregelen.

In plaats van een wetenschappelijke aanpak die complexiteit beperkt om tot een verifieerbare vraagstelling te kunnen komen, wordt de voorkeur gegeven aan een postnormale wetenschappelijke benadering als beoordelings- en werkmethode voor dit onderzoek. De werkmethode is gebaseerd op literatuurstudie, min of meer gestructureerde vraaggesprekken en empirisch onderzoek middels herhaalde bezoeken aan locaties. De formele onderzoeksstructuur krijgt vorm door het globaal heterogene karakter van deze casestudy's met betrekking tot planningsstructuur, status en tijdschema's, beschikbaarheid van gegevens en de bereidheid van betrokken instanties om bruikbare informatie te leveren.

Deel I bevat een verhalende beschrijving ten behoeve van de analyse van de casestudy en van de eindconclusies en aanbevelingen in Deel II. Het bestaat uit drie hoofdstukken, die de stedelijke hoogwaterintegratie in historisch, theoretisch en strategisch perspectief plaatsen binnen de specifieke geografische context van de bevaarbare Rijn:

Menselijke ingrepen in de overstromingsgebieden van de Rijn in de 19de en 20de eeuw hebben ervoor gezorgd dat voorheen brede, vaak meanderende of zich vertakkende rivierbeddingen verstedelijkte oevers werden langs rechtgetrokken, gekanaliseerde rivieren. De perceptie van de rivier is daarbij veranderd van dynamisch naar beheersbaar. Dit maakte de weg vrij voor modernistische en daardoor ook sectorgebonden ruimtelijke ontwikkelingen op basis van een dialectische relatie tussen het stedelijk domein en het (rivier)landschap. Inmiddels worden voormalige havens echter getransformeerd van gebieden buiten de waterkering tot woonwijken die in de stadskern zijn opgenomen. Uiterwaarden maken nu deel uit van

overstromingsgebieden met een schadepotentieel dat regionale economieën zou kunnen ontwrichten, overstromingsbeperkende maatregelen zijn nu levensvatbaarder/ effectiever in een stadskern dan in een landelijk gebied. Verschillende projecten onderhandelen nu over dezelfde locatie waar ze beslag op willen leggen, wat leidt tot nieuwe stedelijke typologieën/ecologieën die om een nieuwe methodologische aanpak vragen. Binnen dit onderzoek wordt ontwerpen niet alleen gezien als een ruimtelijk maar ook als een strategisch middel dat in staat is een brug te slaan tussen verschillende projecten én tussen verschillende disciplines. De huidige vorm van hoogwaterbeheer langs de Rijn omvat een combinatie van rivierverbredende maatregelen en aanpassingsstrategieën in samenhang met bestaande waterkeringen, om zo het hoofd te kunnen bieden aan toegenomen risico's die het gevolg zijn van eerdere ingrepen en ontwikkelingen, en van fluctuaties in de waterstand veroorzaakt door klimaatverandering. Verschillen in de landschappen en de planologische culturen van de Boven- en Benedenrijn en de Rijndelta hebben eveneens tot verschillen in strategische benadering geleid. In het kader van dit onderzoek kan het innovatieve karakter van de adaptieve en proactieve watergeoriënteerde aanpak in Nederland nuttige en gerichte informatie verschaffen met betrekking tot de ruimtelijke kwaliteit als strategisch component van watergerelateerde projecten.

In Deel II onderzoeken we twee Nederlandse en twee Duitse stedelijke bouwprojecten langs de rivieroever op verschillende locaties langs de Rijn op basis van de volgende vragen: rekening houdend met enerzijds adaptieve en anderzijds risicobeperkende strategieën, welke ruimtelijke constellaties zijn er denkbaar in het spectrum tussen stadsontwikkeling en hoogwaterbeheer, binnen de grenzen die worden opgelegd door het vaarverkeer en het (gedeeltelijk) herstel van het dynamische rivierlandschap? Hoe geven tijden ruimtegebonden onderlinge afhankelijkheden vorm aan deze projecten? Hierbij is rekening gehouden met het synergetisch potentieel, maar ook met de tijd- en ruimtegerelateerde onderlinge afhankelijkheden tussen het rivierstelsel in zijn totaliteit, de lokale en regionale context en de feitelijke ligging langs de rivier als ontwikkellocatie. Relationale diagrammen laten de onderlinge afhankelijkheid zien tussen stedelijke ontwikkelingen en het dynamische karakter van de rivier, voor ieder onderzochte casestudy en voor de betreffende instanties en processen. De vier casestudy's zijn opgenomen in een representatieve atlas van de betreffende typologieën langs de diverse Rijnsegmenten. Het betreft de volgende vier casestudy's, van zuid naar noord:

- Karlsruhe Rappenwört, een gestuurde uiterwaard langs de meanderende Bovenrijn
- Mainz Zollhafen, een project waarbij een havengebied is getransformeerd tot een woonwijk met amfibische woningen ter hoogte van de splitsing van de Bovenrijn
- Nijmegen Lent, het uitgraven van een geul en een stedelijke uitbreiding met teruglegging van een bestaande dijk langs de Waal
- Dordrecht Stadswerven, een buitendijs stadsontwikkelingsgebied in de Rijndelta

Samenvattend: verschillen in landschap, bedreigingen en politieke structuren hebben geleid tot verschillen in planologische cultuur tussen Duitsland en Nederland op het gebied van hoogwaterbeheer. De fasering van risicobeperkende maatregelen in zowel Nederland als Duitsland blijft niettemin afhankelijk van de waterkering. Waar in Nederland de aanpak van hoogwater evenwel ecologisch gezien holistisch van aard is en specifiek rekening houdt met de ruimtelijke kwaliteiten, vormt de Duitse benadering van hoogwatergerelateerde problemen onderdeel van een sectorgerichte aanpak waarbij ruimtelijke kwaliteit in eerste instantie geen rol speelt, maar pas tegen het eind van het project als extra laag wordt toegevoegd. Onder druk van een krachtige ecologische lobby is de nadruk inmiddels verschoven naar herstel van het voormalige alluviale bosgebied in niches. Van de zes programma's die in de ICPR-atlas zijn gedefinieerd, lijkt bosbouw het enige programma te zijn dat rekening kan houden met het dynamische karakter van de rivier en mettertijd een daarop afgestemd transformatieproces kan doorlopen. Alle andere programma's (bebouwing, industrie, verkeersinfrastructuur, en in beperkte mate landbouw, met name wanneer rekening wordt gehouden met ecologische overstromingen) blijven afhankelijk van waterkerende maatregelen en, mochten deze ontoereikend blijken, van infrastructurele ondersteunings- en aanpassingsmaatregelen. Ze maken echter geen deel uit van een ontwerpster die mogelijkheden onderzoekt.

In het licht van langetermijnstrategieën en -projecten weerspiegelt de Nederlandse aanpak een meer iteratief gerichte planningspraktijk die in staat is met de verworven ervaring mee te groeien. In Nederland is gebleken dat een minder rigide aanpak van planning, met beleidsaanpassingen om aanvullende projecten binnen de maatregelen in het kader van 'Ruimte voor de Rivier' mogelijk te maken, tot snellere acceptatie door de lokale bevolking en dus ook tot beperking van de negatieve gevolgen leidt. In Duitsland mijden waterbeheerinstanties doorgaans projecten die een precedentrol zouden kunnen vervullen, teneinde herhaling te voorkomen. Deze restrictieve benadering vormt een obstakel voor het ontwikkelen van grootschaligere strategieën die pilotprojecten vereisen als testcase. De Nederlandse aanpak lijkt te zijn gericht op prikkels en biedt die feitelijk ook, zoals het bereikte compromis in de Nijmegen-casus laat zien. Het afstand nemen van een restrictieve ten gunste van een responsieve planologische benadering met ingebouwde prikkels schept een voedingsbodem voor creativiteit en zou een wezenlijk onderdeel van iedere strategie moeten vormen. Een van de belangrijkste bevindingen van dit onderzoek, met name in Duitsland, is de beperkte beschikbaarheid van informatie, naast het ontbreken van visualisatielagen voor lopende programma's en projecten (wat soms een extra indicatie vormt van de geringe betrokkenheid van ontwerpers in de ruimtelijke beheersprojecten van overstromingsrisico's in Duitsland). Dit onderzoek draagt bij tot een beter begrip van de verschillende maatregelen via haar atlas van geselecteerde typologieën voor aanpassende en beperkende maatregelen bij hoogwater langs de Rijn tussen Basel en Rotterdam.

De casestudy-analyse is de basis van aanbevelingen voor de architecturale en programmatische reikwijdte van overstromingsbestendige projecten die zich richten op strategieën voor expansief hoogwaterbeheer. Dit onderzoek richt zich rechtstreeks op de ontwerppraktijk en doet dan ook voorstellen om over te stappen van een ruimtelijke naar een strategische ontwerpenbenadering, namelijk door vanaf de beginfase architecten, landschapsarchitecten en stedelijk ontwerpers te betrekken, zodat ook zij een bijdrage kunnen leveren aan de strategische opzet van een project;

ontwerpen te integreren in een systeemomvattende benadering die gericht is op het ontwikkelen van capaciteit en daarom ook ecologische, economische en culturele voorwaarden omvat, op basis van een discipline-overschrijdende aanpak;

onzichtbare lagen zichtbaar te maken: visualiseer systeemgerichte informatie/expertise zodat deze toegankelijk wordt en interdisciplinaire communicatie mogelijk wordt;

ontwerpwedstrijden in samenwerking met lokale belanghebbenden uit te schrijven, om zo mensen en ideeën bijeen te brengen en initiatieven van de grond te krijgen;

backcasting-strategieën toe te passen om los te komen van gevestigde ideeën. Dit kan het ontwerpproces “telescopisch” maken waardoor het vastgeroeste ideeën ter discussie stelt. Ook hierbij speelt de visualisatie van concepten een essentiële rol.

Er wordt een voorstel voor twee vervolgonderzoeksprojecten gedaan:

De ontwikkeling van ontwerprichtlijnen voor een riviergegmentgerichte benadering: beoordeling van reeds lopende of recent uitgevoerde risicobeperkende en adaptieve projecten, naast andere riviergerelateerde ontwikkelingen (bijvoorbeeld m.b.t. rivierverkeer) in een academisch onderzoeksproject om potentiële nieuwe mogelijkheden te definiëren door het samenbrengen van systeem- en kwaliteitsgerichte elementen. In samenwerking met het veld kan worden getracht deze bevindingen te staven door middel van kleinschaligere pilotprojecten, als onderdeel van bestaande risicobeperkende projecten op riviergegmentschaal.

Kosten-/batenanalyse van ruimtelijke kwaliteit: de ontwikkeling van een kosten-/batenanalyse van een discipline-overschrijdende laag die vergelijkbaar is met de maatregelen zoals die zijn vastgelegd door het Nederlandse kwaliteitsteam voor het Duitse ‘Ruimte voor de Rivier’-programma, waarbij momenteel de nadruk ligt op ecologische verjonging tegenover ruimtelijke kwaliteit als secundair doel. Deze analyse is gericht op het staven van het kwalitatief ontwikkelde argument voor UFI (Urban Flood Integration).

Het eindresultaat van het meerdere casestudy's omvattende onderzoeksprogramma en de daaruit voortgekomen typologische atlas wordt als waardevol beschouwd voor organisaties van uiteenlopende aard, zoals overheidinstellingen en educatieve instellingen die zich bezighouden met de geospecifieke context en ruimtelijke ontwikkeling langs de Rijn, vertegenwoordigende partijen uit de bouwwereld en durfkapitalisten, naast mensen die een persoonlijk belang hebben bij het ecologisch urbanisme binnen de context van de Rijn.

**1. INTRODUCTION**

**PART I / NARRATIVE**

**3. EVOLUTION**

PRE-INDUSTRIAL

INDUSTRIAL

TRANS-INDUSTRIAL

**4. FLOOD RISK MANAGEMENT  
TODAY**

**PART II / CASE STUDY EVALUATION**

**6. KARLSRUHE**

ATLAS RETENTION POLDERS

**MITIGATION**

**7. MAINZ**

ATLAS HARBOUR CONVERSIONS

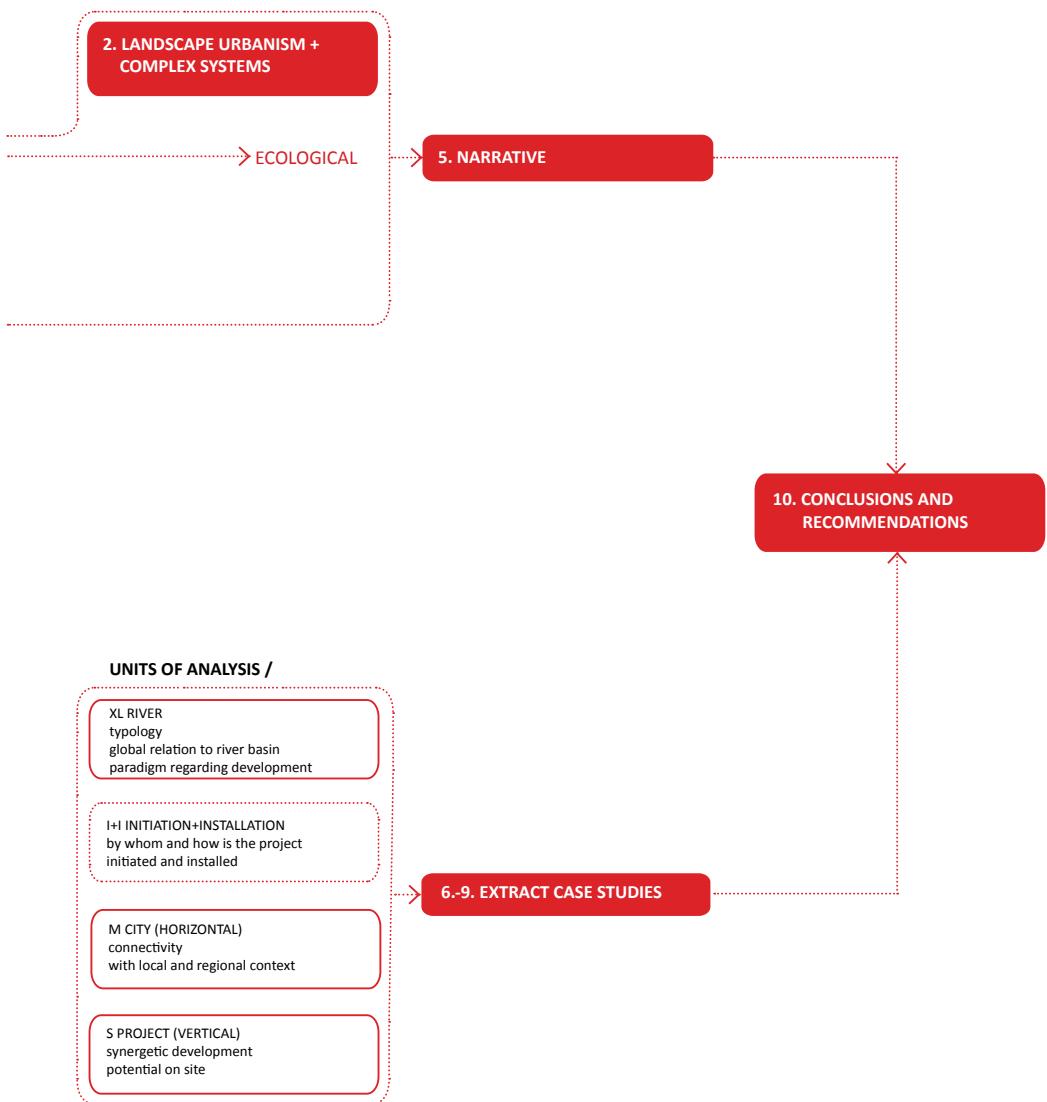
**8. DORDRECHT**

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**MITIGATION+ADAPTATION**





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## PART 1 **Narrative**



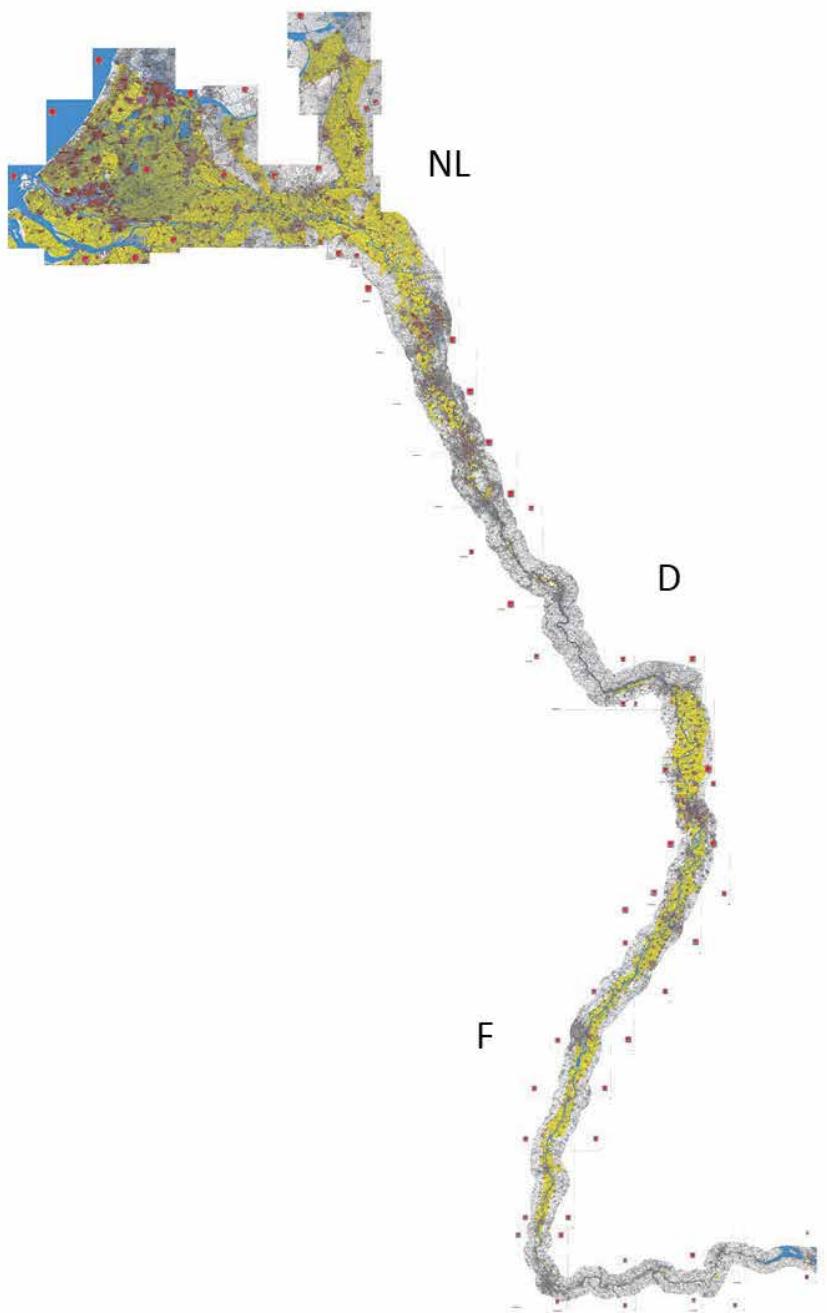
# 1 Introduction

## § 1.1 Problem Definition and Approach

Urban Flood Integration (UFI) along the Rhine – Spatial Strategies is an investigation of flood resilient urban development. Is it possible to combine urban river front renewal with spatial flood management strategies and vice versa? Could these programs be capable of producing urban qualities and reducing the vulnerability to floods according to a new risk awareness while respecting the constraints set by the river as a navigation channel and a dynamic landscape? Between adaptive and mitigative strategies, what is the spectrum of spatial constellations between urban development and flood management within the constraints set by navigation and a (partial) restoration of the dynamic river landscape? How are temporal and spatial interdependencies shaping these projects? The inherent parameters involved are studied and visualized as a knowledge base for further design strategies for the flood prone urban realm.

### Problem Definition

Between the Alps and the North Sea, between Basel and Rotterdam, since Roman times, the Rhine has been subject to severe anthropogenic manipulations as an economic development corridor. Only in the phase of declining production have considerations of its role as a public realm and as a host to the iconographic found their way back into the arena of river front developments. Trans-industrial Central European agglomerations are challenged by their spatial legacy of industrial transformations and the competition with other cities often more privileged in terms of topography, climate and therefore life style. In this context, river cities are privileged. The interaction between the urbanized landscape and the specific river segment it frames catalyses the kind of urban development capable of responding to these challenges. Yet in this regard, spatial quality is often reduced to an aesthetic conception of space focussing on the image. In the urban realm this often finds its expression in Mediterranean B-side analogies in the temporal sphere as well as tendencies towards musealizing, not only its aligning medieval cities but also former inner city harbours on their way to becoming new urban quarters (Koolhaas, 1994). Applied to our landscape conception, bucolic and conservationist approaches seem to prevail. This may be rooted in our approach to projects. The systemic rarely finds consideration as the spatial design of projects for the urban realm and for landscapes is often preceded by the technical versus initially designing the project together spatially and technically.



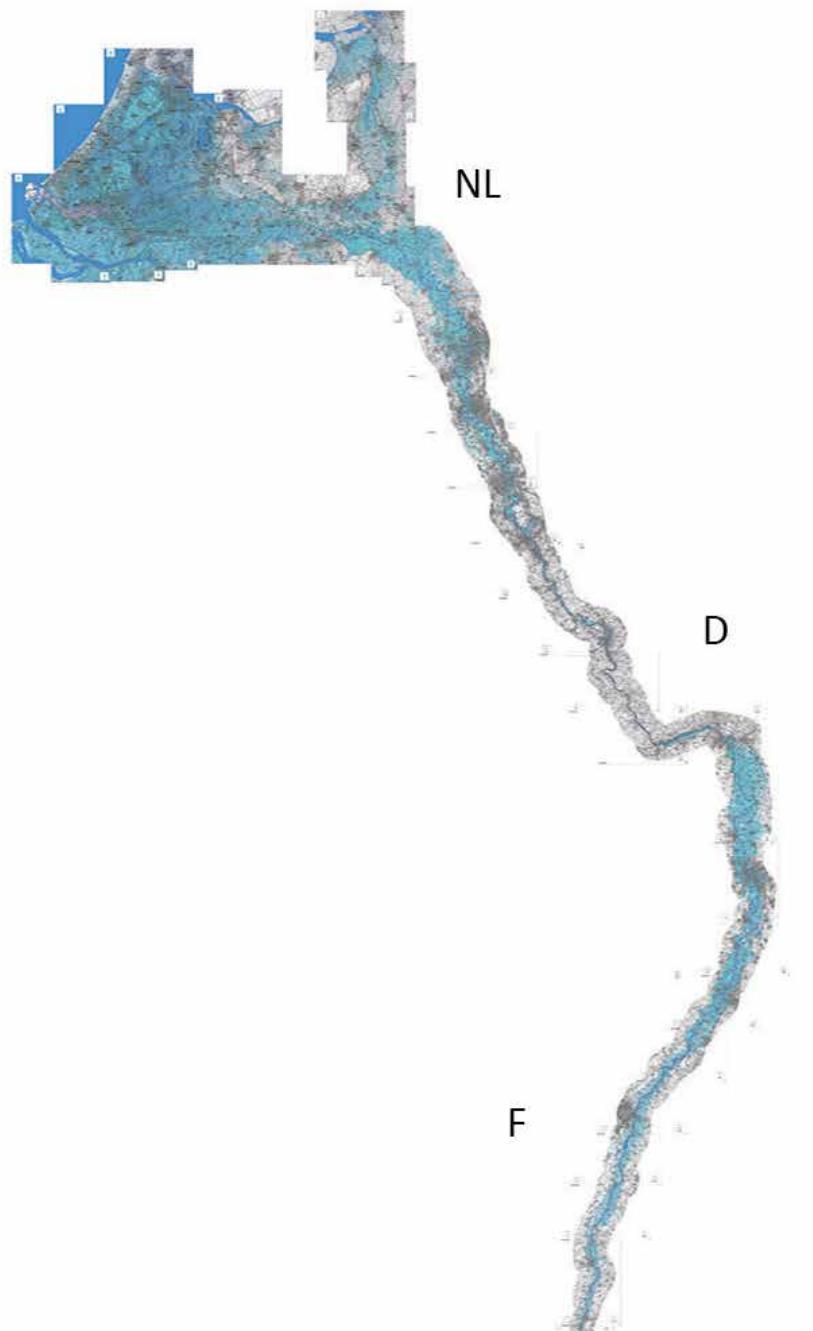


Figure 2

Flood risk along the Rhine according to economic damage potential and water depths (ICPR Rhine Atlas, 2001).

While struggling with spatial quality, agglomerations along the Rhine are threatened by an increasing risk of river floods, combined with other flood risks. Due to climate change, the frequency of inundations and expected water levels are increasing, affecting a previously industrialized and urbanized landscape outside of the defense line and thus not laid out for the inherent risks of failure or exceedance. Border negotiations therefore always involve the area inside and outside of the flood defense and the defense line itself.

Developments in the flood-prone areas of compact cities and urbanized landscapes along the Rhine are only beginning to combine urban programs with the inherent dynamics of the river landscape based on the specific parameters of the site and its infrastructure in a productive way. Synergetic developments may be capable of reintroducing a spatial complexity more resilient to floods, which is missing in the modernist entities these agglomerations are largely composed of. The apparent contradiction between the eternal desire to live and work in the direct vicinity of the river shows in 'the investments in the flood plain' as 'an index for the profitability' (Hartmann, 2011:16) vs. the increasing risk of flooding.

While beauty is a main argument for settling along waterfronts (Hartmann, 2011), flood plains provide fertile farmland, resources for economic development and drinking water while functioning as corridors of transport (Petrow et al, 2006). This demands synergetic spatial strategies for two reasons. Heterogeneous programs stake claims on the waterfront while an increasing flood probability demands an accommodation of varying water levels within the urban fabric. This may offer the chance of adding new qualities to the trans-industrial condition while lessening the economic damage potential of seasonal floods from the river. In this context, spatial quality expands beyond its rediscovery and instrumentalization by the real estate market. It is linked to ecological, social, technical and cultural conceptions of space. Its capacity is only beginning to be perceived beyond its limited aesthetic application. The capacity of architectural characteristics "stands in a stress ratio between substance and contingency. This stress ratio touches on the point at issue, it defines capacity. Substance includes articulated space, dense atmosphere, form and material, architectural repertoire, conciseness. Contingency adheres to the performative, openness, variability in use, shift of meaning, space for appropriation and occupancy." (Janson, Wolfrum, 2006, translated by author). While a more holistic approach to space is present in all agendas, the instruments to explicitly address spatial quality in a non-sectoral approach are not.

Between urban development and flood management, as well as navigation and renaturalization processes involved in flood-alleviating and flood-adaptive measures - what programmatic constellations are evolving in current projects and how do these relate to their local/regional context and the river as a whole?

The geopolitical differences in planning culture between Germany and the Netherlands are strongly linked to the different topographical conditions and the character of the respective flood risk (see fig. 1-2). The linear character of the German river landscape and the comprehensive water system of the Dutch Delta are reflected in the planning structure. The Dutch system is centralized and flood management and navigation are in the responsibility of one agency (Rijkswaterstaat), yet the governance approach is adaptive and anticipatory (e.g. area based approach). This highly dynamic planning culture is historically rooted in the polder system. Due to the urgencies of climate change functioning 'as a trend-breaker' (Verbeek and Zevenbergen, 2008a:8), this system is constantly developed further and even partially abandoned (depoldering). It always addresses multiple spatial layers and programs. On the other hand, in the German system, water management is organized federally and the planning culture is highly sectoral. The Rhine functions as a national, federal and often municipal border for large parts of the German Rhine. As a result, conceptual thinking on a local scale ends at the border. To think beyond the middle of the river is hindered by maps which end at the borders, and in general information is not easily accessible due to the numerous agencies involved, which are, in many cases, organized differently in the different states and municipalities.

Beyond the reliance of the defensive system for all flood related developments, path dependencies linked to the specific landscape show in the different perceptions of nature. The 'former flood plain' as a spatial category is not found in the context of the Dutch polder system. In Germany, it outlines clearly defined boundaries of the flood endangered areas also behind the dikes. Whereas in the Dutch planning context 'nature is made' just as other programs are integrated in a man-made context, in Germany it is the aim to partially reinstall qualities of the original river typology, yet without considering a remediation with other programs (described in chapter 4).

The aesthetics of spatial design are instrumentalized in Dutch planning with the repeatedly stated aim of creating an attractive country to live in (Nijhoff, 2008 a. o.). In Germany, design strategies are not part of mitigation projects. This may be rooted in the difference in the perception of man-made vs. natural landscapes and possibly in the different degrees of density and land consumption. In the Netherlands, land consumption is directly linked with economic growth (see chapter 3). This may also explain the lack of local acceptance being one of the key hindrances to German Room for the River projects.

### **Border Negotiations – Between Mitigation and Adaptation**

In general, it is possible to state that expansive spatial flood management is divided into two strategies: The mitigation of floods by river-expanding measures to lower water tables and damage reduction by adaptation. Non-defensive development along the Rhine happens in both directions. The city expands via flood-adapted urban developments outside of the defense line and contracts as flood-mitigating

developments give space back to the river. While river-expanding measures generally imply morphological transformations of the flood plain to reduce water levels, urban adaptations strategies involve spatial measures primarily on the building scale to reduce the vulnerability of the area at risk. At the same time, the expected rise in water levels and in the frequency of occurring floods is not only endangering the area outside of the dikes, but also the area behind it – to what degree depending on the specific topography.

These two givens demand a closer look at the spatial and temporal interdependencies of non-defensive developments between river and city. Thus, in terms of context, it is possible to say that measures can ideally be divided into a rural approach (river expansion) and an urban approach (urban adaptation) as river expansion demands large-scale measures while urban density is directly related to the damage potential on site. Both of these developments stake claims in the flood plain. However, as our capacity to adapt to varying water levels today is limited and the topographical and urban conditions delimitate expansive measures, defensive and expansive measures function interdependently.

Collective defense systems are linear installations, most prominently dikes, but also walls, stop-logs, gates, etc. which are implemented as a border between the river bed and the areas at risk. Both mitigation and adaptation projects, functioning in direct relation with the flood defense, are located on the riverside, which is often transformed by the project, as is the area behind the defense line. The according differences between Dutch and German flood plains is explained in detail in chapter 4.

### **Adaptation Outside the Flood Defense**

Locally, the increasing flood risk demands adaptations focusing on the object scale. Today, adaptive projects are exceptional/singular developments in the flood plain made possible by the post-industrial vacancies of previously developed areas. They are market driven, local initiatives and therefore focus on the project scale. It is important to say that today, developments outside of the flood defense are exceptional and involve a high degree of adaptation. As water levels are predicted to rise and planning laws are becoming more restrictive, the current method of flood management for building developments outside of the existing defense system has changed. Since industrial conversion sites and harbours are traditionally positioned outside of the flood defense, a strictly defensive approach for the collective area at risk is not an option as it would imply further reducing the discharge area of the river. Therefore, developments outside of the defense area are reducing flood-damage potential by applying adaptive measures on the scale of individual buildings and raising infrastructure networks as well as developing evacuation measures which in turn rely on a situation behind the defense to provide refuge.

## Flood Prone Areas Inside the Flood Defense

As the exceedance and failure of defensive structures are taken into account, a new awareness for the flood risk of the area within the defense line becomes part of current strategies (EU Flood Directive). This not only enlarges the considered area at risk, but is changing the perception of safety behind the defense line. Areas outside the defense line are not only developed with a high degree of adaptation, but are 'only' exposed to fluvial floods including surface waters and rising ground water levels (and in the delta region storm surges). The area within the defense is additionally exposed to pluvial floods. Due to the multiple flood risks involved, the lack of risk awareness inside of the defense, as well as the scale of the protected areas at risk, realistic strategies demand a systemic approach. Since they are more interdisciplinary, and, depending on the strategy chosen, demand much longer time frames, they also assume a much higher public acceptance.

## Mitigation

Flood mitigation measures generally imply transformations of the former flood plain morphology. By enlarging existing profiles to expand the discharge capacity of the river, water levels of extreme floods are ideally lowered not only locally, but flood levels up and down river are reduced as part of accumulative strategies. Mitigation measures and their river scale approach demand for geopolitical cooperation (i.e. Upper Rhine High Water Action Plan or Room for the River for the Dutch Rhine Branches all coordinate under the International Commission for the Protection of the Rhine). Flood mitigation is therefore a strategy implemented top-down. As the negative effects of individual measures prevail, the local contextualization of flood mitigating projects proves to be challenging. Flood mitigation measures to lower flood levels are realized on agricultural land or forest within the rural and peri-urban context. In Germany, they are combined with nature development programs, and possibly recreational concepts. Yet, as engineering works to decrease their degree of flood exposure, designs generally do not go beyond technical measures to manage negative side effects such as seepage or rising ground water levels, which are not considered beyond technical resolution. In the Dutch Room for the River projects, spatial quality is a clearly defined aim of the project that is ensured by the respective agencies (e.g. Quality Team). For exceptional projects such as the Dike setback in Nijmegen Lent, expansive measures are also integrated in the urban realm. Of course, further factors play a significant role for the development of agglomerations along the Rhine in the light of an increasing flood risk:

- the expanse of the urbanized landscape blurring the border between city and landscape and increasing the complexity of flood management strategies;
- simultaneous and often conflicting claims on urbanized river fronts by different agencies, such as restrictions set by navigation and nature (re-)development, further confine urban development and flood management measures within flood-prone areas;

- urbanized landscapes as palimpsests of their pre-industrial / industrial / trans-industrial state can be considered as hybrid landscapes obeying to conflicting logics;
- a new risk awareness demanding an involvement of the public which in turn demands for a public realm capable of conveying the changed risk situation;
- increasingly limited public economic means.

### **From Flood Resilience to UFI**

A new, more permissive approach revolving around adaptation measures is defined as flood-resilient<sup>1</sup>, the ability to recover quickly and easily. It involves social, cultural, ecological and economic issues and may be capable of offering new solutions ideally by producing emergent qualities between the diverse water front developments with the necessary degree of adversity protection. Based on an expanding area at risk and the reliance on flood levels remaining within an acceptable spectrum for adaptive measures to be effective, within this research, pro-active measures to reduce water levels (mitigation measures) are explicitly included within the scope of flood resilience. This expanded definition of flood resilience is termed urban flood integration (UFI). Shaving peak floods and applying adaptive design strategies according to the principle of living with water are both part of this expansive strategy. UFI involves border negotiations between the river and the urban realm where adaptation and mitigation ideally synergize. This coheres with the IPCC advice to react to probability and damage potential by mitigating the event itself and adapting to the threat so as to become more resilient in terms of damage (IPCC, 2001). It may also provide links for larger areas reserved for emergency floods. By applying a systemic perspective on the river, UFI explicitly includes the urban dimension of mitigation measures and ideally aims for an urban fabric that is capable of at least partially flooding frequently. 'The urban fabric' is seen as 'a vital and dynamic feature in reducing flood losses, instead of being a sole and inert receiver of flood impacts.' This is attempted 'by developing a flood damage model

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1

The term resilience originates in economics. In the flood management context see UFM Dordrecht: "New approaches on urban design need to be developed to adapt the urban environment to flood risk by enhancing the resilience of the urban environment to floods and thus reducing its vulnerability. In many cases accepting and preparing for some degree of flooding will be a more sensible solution, not only from a technical and financial perspective, but also from a social and environmental perspective." (UFM WP 201, 1:2008), the Scottish Governments Initiative: "Sustainable Flood Management provides the maximum possible social and economic resilience against flooding by protecting and working with the environment in a way which is fair and affordable both now and in the future. In this context 'resilience' means: 'ability to recover quickly and easily', and Ecological Urbanism: "(...) resilience and therefore sustainability must not be limited to merely 'surviving' in an ecological context. Indeed, resilient, adaptive and thus sustainable design means 'thriving', and therefore must necessarily include economic and ecological health and cultural vitality as planning and design goals." (Lister, 539:2010)

that treats' urban landscapes of different densities 'as a complex adaptive systems' (Verbeek and Zevenbergen, 18:2011 referring to Holland, 1995).

Whereas mitigation and adaptation projects have previously been treated sectorally, UFI proposes to consider them together. It includes morphological transformations of the river bed (flood mitigation) and transformations on the object scale (flood adaptation) and in that way manifests spatial and temporal interdependencies between the river regime and the local and regional context. Ideally, UFI projects not only contribute to a reduced vulnerability to risk, but also aim for ecological and economic capacity while producing spatial qualities on a local scale. UFI demands laboratory conditions in order to apply an iterative, long-term approach. In this context, projects do not only require a spatial, but also a strategic design layer.

### **Approach**

As not only the flood regime, but also ecological rejuvenation (Habitat2000, Water Framework Directive) and economic drivers (navigation, fresh water supply) address the river scale, neither mitigation nor adaptation strategies for individual cities can be separated from the knowledge and strategies concerning the river system as a whole. It is therefore necessary to develop an understanding for the individual river segments in relation to strategies affecting individual projects. This involves an understanding of the river's original typology as well as its channeled form. At the same time, riverfront developments pivot around the local scale. While mitigation projects rely on local acceptance to be implemented within due time frames, adapted urban development projects outside of the defense are frontrunners for the future adaptation of the endangered areas behind the defense as demanded by the EU-Flood Directive. Based on an understanding of the river as a complex open system, this research aims to analyze different urban river-front projects in terms of their negotiable border between city/urban landscape and river. The case studies, a selection of the most recent German and Dutch spatial flood management projects between fluvial flood mitigation and flood adaptation, cover a spectrum of city-river-project constellations. Beyond the conflict between urban development and flood management, navigation (per se demanding for a channelled river) and nature development (demanding the opposite) add additional spatial parameters. To investigate the state of the projects today, scalar time and space relations are visualized and investigated in order to show:

- how and by whom along the river such measures are initiated and installed;
- how developments today evolve in relation to theories of path dependency and the specific spatial constellations/heritage on site;
- how they perform with regards to the periods before, during and after a flooding;
- how contingent they are within their local/regional context;
- as a sum, what urban typologies they produce.

The case studies investigated are two Dutch and two German projects including mitigation (Karlsruhe), adaptation (Mainz and Dordrecht) as well as combined measures (Nijmegen). From south to north, they are:

Karlsruhe - a retention polder in the urbanized flood plain of the meandering Upper Rhine;

Mainz - an inner city harbour conversion project along the bifurcating Upper Rhine;

Nijmegen - an urban extension project coupled with a dike set back and the installation of a bypass to relieve a bottleneck along the Waal;

Dordrecht - a harbour conversion project for the island of Dordrecht within the context of the Rhine Delta (see fig. 3 on the following pages).

## § 1.2 Aim

There are many misconceptions related to flood mitigation and adaptation and a large degree of indeterminacy regarding expected flood events and demographic and socio-economic developments. The visualization and reflection of current German and Dutch mitigation and adaptation projects along the Rhine on the local / regional scale aims to enable a better understanding of the relationship between the respective agglomeration and the river regime as well as the inherent temporal and spatial interdependencies with accumulative mitigation measures and conversely their strategically eminent effect on the local context. As a contribution to the development of emergent strategies, this research aims to exemplify the synergetic, and thus transdisciplinary potential and limitations of the following case studies and - as a consequence - evolving design strategies. By rethinking traditional boundaries between, for example, city and landscape as well as between disciplines, different programs may happen on one site. The more permissive focus here lies on the question "how" instead of "if." This approach also coheres with the insights of the Dutch Room for the River program where restrictive land use planning to prohibit all developments

in the flood plain has been revised (BGR, 2006) and with the German planning system where restrictive flood management (spatial reservation) is always weighed on the municipal level against other programs with attention to common welfare (Hartmann, 2011). Striving for an ecological urbanism, this approach also strives for an ecological economy. The investigation of the synergetic development potential is based on two hypotheses:



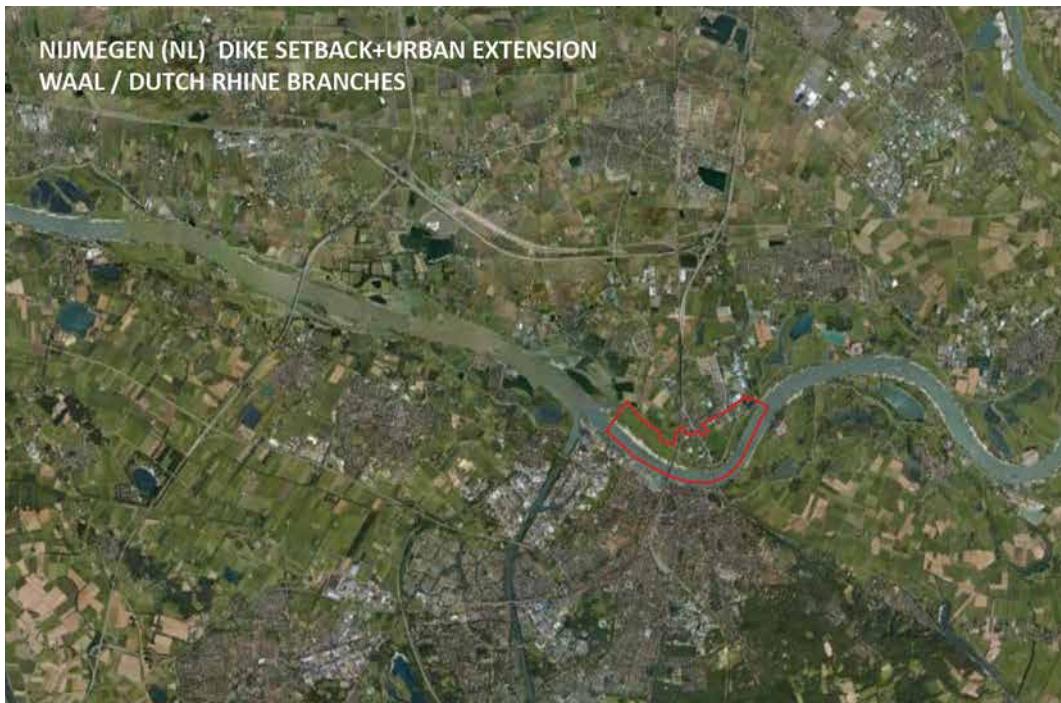


Figure 3

Case studies from south to north Karlsruhe, Mainz, Nijmegen, Dordrecht.

**H1.** UFI relies on the integration of the local/regional scale. Based on the idea that synergetic solutions between flood management and urban development offer qualities for both, the analysis and visualization of the case studies seeks to qualify these two assumptions.

**H2.** River channelling leaves us with the challenge of how to restore the dynamic qualities of the flood plain while providing a functioning economic and urban development corridor. Previously zoned and thus separated programs are therefore beginning to overlap. As a result, flood plain developments are most of all a question of remediating conflicting programs to produce emergent qualities between them. This research considers this a design task, both strategically and spatially. As increasing risk demands back-casting and uncertainty<sup>2</sup> demands iteration, strategy and design are no longer analogue developments.

In times of uncertainty the urban realm becomes a laboratory and strategic design relies on spatial design to adapt the environment to cope with future events as well as to mitigate their impact iteratively. At the same time, depending on who is asked, stakeholders involved in integrated flood risk management vary and are tendentially increasing in numbers (Hartmann, 2011), among German experts, they do not include designers.

### Learning from...

Urgencies in the Netherlands are triggering innovation, where spatial quality is key to an 'area-based approach to water' (see chapter 4). The inherent systems approach relies on anticipatory and adaptive management strategies based on scenarios (back-casting), the investigation of alternatives, iteration (pilots), and monitoring. Although flood risk damage potential in Germany is lower than in the Netherlands and therefore less prioritized, it remains systems-relevant. To gain additional momentum, flood adaptation measures could be linked to other climate-related urban redevelopments, for example energy-efficient refurbishment. In any case, a paradigm change towards an iterative approach in German planning culture from simply avoiding precedences to creating pilots relies on a transdisciplinary approach to planning so as to overcome sectoral developments.

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2

Uncertainty as 'the information required to perform a task and the amount of information already possessed' (Galbraith, 1973)

## § 1.3 State of the Art

Regardless of the discipline, only very few studies have dealt with the Rhine corridor as a whole. Lucien Febvre, historian and founder of the École d'Annales, wrote the essay 'The History of the Rhine' in 1935. He was the first to introduce the European dimension of the Rhine beyond national borders by considering two thousand years of this specific geographic regions socio-economic and cultural development. By visualizing and analyzing the multiple claims on urban river fronts along the Rhine, this research aims to follow his approach.

Documentations such as 'The Rhine under the influence of man- river engineering works, shipping, water management' by the CHR in 1993, but also the flood maps (2001) and the typological atlas (2004) by the ICPR as a frontrunner of the EU Flood Directive have greatly contributed to knowledge production on the river scale.

Further authors have treated national developments regarding individual river segments. David Blackbourn has taken the 19th century Channeling of the Upper Rhine as a case study for his work, 'The Conquest of Nature- Water, Landscape and the Making of Modern Germany'. He describes "the reshaping of the German Landscape" to show "how modern Germany itself was shaped in the process." The Dutch 'Battle over the Rivers, 200 Years of River Policy' by Alex van Heezik illustrates 200 years of debate over and implementation of anthropogenic river transformations in the Netherlands. Earlier works on the making of the Dutch polder landscape and cities such as 'The Making of Dutch Towns' by Gerald L. Burke and 'Leefbare Laagland' by G.P. van de Veen or William TeBrake's 'Medieval Frontier: Culture and Ecology in Rijnland' and more recently the 'Atlas of Dutch Water Cities' by Fransje Hooijmeier and Han Meyer have given insight on the specific interdependencies between the Dutch systems of rivers and land reclamation, and, consequently, of city building.

The severe floods of 1993 and 1995 produced the urgent need to rethink flood management along the Rhine and to intensify cross-border collaborations between Germany and the Netherlands, and to deal with retention along the Upper Rhine, also in France. Numerous study projects evolved. However, only a few - such as the IRMA Sponge project, dealt with multiple projects for a specified region, such as in this case the Rhine and Maas. Others, such as SDI, Freude am Fluss, those concerned with developments in the flood plain, and adaptation projects such as UFM (Urban Flood Management 2005-2008) and FloodResilienCity (2008-2013) and MARE (2009-2012) are based on an exchange of knowledge among similar projects along different rivers and within different planning contexts.

Further, the legal framework was adapted to promote a new approach to flood management. The EU Water Framework Directive (2000/60/EC) dealing with the ecological qualities of surface waters was followed by the EU Flood Directive (2007/60/EC) on the assessment and management of flood risk. Additionally, changes in national law followed the major flood events, the Federal Water Act in Germany (2005) to improve preventive flood protection, the Beleidslijn Grote Rivieren in the Netherlands to define possible developments in the river bed (1997/2006) and the Water Act (2009), a framework legislation containing provisions on integrated water management based on the 'water systems approach'.

Although the Rhine basin remains one of the most densely populated corridors in Europe, in the past, urban studies have focussed on individual cities or water fronts without contextualizing specific urban landscapes within the river system on a transdisciplinary scale. Due to urgencies produced by climate change and the ongoing transformation from a production-based to a knowledge-intensive industry/society, this is changing. More or less radical approaches towards incorporating water and its inherent risks into future urban developments are illustrated in Kelly Shannon's (KU Leuven) invention of the term Water Urbanism, the focus of the European Master in Urbanism at TU Delft on Delta Urbanism directed by Han Meyer as well as the recent Harvard GSD studio run by Pierre Bélanger and Nina-Marie Lister on a possible reinvention of the Dutch polder landscape. Related research may also be found for other rivers such as the Mississippi by Anuradha Mathur, Dilip da Cunha, Mississippi Floods: Designing a Shifting Landscape (2001) or ongoing studies for the Elbe or the Danube in the European context. However, the understanding of (urban) design is often limited to the city core, the restoration of the European city model, excluding its capacity to remediate the dynamics of the landscape with its role as an economic development corridor.

At the beginning of this PhD research in 2006, I visited eleven municipalities and conducted interviews to understand the consideration of climate change in the planning and the cooperation between urban planning and water management. Although all eleven cities were developing riverfront projects, in 9 out of the 11 cities, the two departments did not (pro-)actively cooperate in the urban riverfront renewal projects nor take climate change into account. The two cities where this was not the case were Dutch. From this quick scan of the status quo at the time, it is clear that although more than a decade had passed since the major floods along the Rhine and a number of measures had been initiated to reduce flood impacts, on the local scale, sectoral boundaries between technical water management measures and urban development had prevailed (see Appendix A for an overview of the cities visited).

## § 1.4 Outline of the Evaluation and Working Method

Urban Flood Integration (UFI) is part of an interdisciplinary PhD research project at TU Delft. All three PhD studies deal with different aspects of urban flood management for the Dutch and/or German Rhine. Bianca Stalenberg at the Chair of Hydraulic Engineering has developed a tool for the design of flood-proof urban riverfronts. Miriam Cuppen (Technical Management) is studying the issue of legitimacy within urban flood management projects. The common case study of all three studies is the city of Nijmegen (see Appendix B for a summary of the other two PhD-research projects).

The evaluation and working method applied here is based on the understanding that the Rhine as a complex system with a diverse set of interdependencies (as described in the IRMA Sponge project) demands a systemic approach. This implies that not all parts of the system can run optimally. Therefore, instead of a scientific approach that reduces complexity in order to reach a verifiable question, a post-normal science approach was applied. A relational framework outlines the potentials and limitations of border negotiation projects between the river and the urban realm. Part I is made up of three chapters, where Urban Flood Integration is framed theoretically, historically and strategically within the specific geographic context of the navigable Rhine. It serves as a narrative for Part II, composed of the case study analysis and of the final conclusions and recommendations. The working method relies on literature studies, semi-structured interviews and empirical research through repeated site visits. The general heterogeneity of the case study documentation in terms of their planning structure, status and time scales, the data availability and the willingness by the agencies involved to provide usable information shapes the formal research structure.

### PART I

#### Chapter 2: Complex Systems and Landscape Urbanism (Theory)

elaborates a counter model to the modernist approach of urban planning based on an extended ecological perspective. Cities and landscapes are understood as relational frameworks defined by processual developments based on the layer approach (landscape/infrastructure/urban development). Landscape urbanism defines a non-sectoral, processual planning practice with the aim of triggering emergence between the different programs on site (vs. avoiding conflict). It therefore focusses less on the optimal performance of one explicit program and aims instead for an interplay of ecological, economic and cultural programs based on a definition of ecology that includes the urban realm. In terms of design, this involves a transdisciplinary approach based on an extended definition of ecology. As landscape and urbanism are no longer clearly separable entities, but states of varying densities, impervious surfaces, etc., ecologies become pluralistic, processual and always involve human cohabitation.

### **Chapter 3: Evolution (Spatial heritage)**

investigates simultaneous claims made by urbanization, navigation, flood management and nature development in the context of trans-industrialization. Although cultural, political, social, ecological and economical aspects weave through all of these, the focus lies on their path-dependent spatial manifestations and their transformative capacities. It also includes an overview of pre-industrial, industrial and trans-industrial city-landscape-river constellations and the programmatic and spatial interdependencies relevant for ongoing border negotiations between the urbanized landscape and the industrially altered river today.

### **Chapter 4: Flood Risk Management Today (Strategy)**

Room for the River projects today are reliant on defensive measures. Conversely, to meet design-safety levels, defensive measures demand an increase of discharge capacities via expansive measures. A changing risk perception has led from a strictly protective strategy to flood-risk management and explicitly includes failure and exceedance of the given measures. This gives way for adaptive strategies focussing on the object scale to complement the primarily morphological interventions of defensive and expansive measures. The previously linear boundary between river and urban development is therefore, also programmatically, expanding and diversifying. Current German and Dutch strategies and frameworks are outlined to show the approaches taken before evaluating individual projects.

### **Chapter 5: Narrative (Resumé)**

summarizes the main conclusions of PART I:

- The need for a transdisciplinary layer to operate in complex systems; Design as a discipline no longer functions as a result of previous decisions, but strategic design and spatial design become an iterative process (anticipatory and adaptive management) where the city is considered a laboratory.
- The spatial heritage which is shaping decision-making processes today, and
- the differences in flood management strategies applied in the Netherlands and Germany in relation to topography, threat, planning culture and policies.

## **Part II**

### **Chapter 6: Multiple Case Study Analysis**

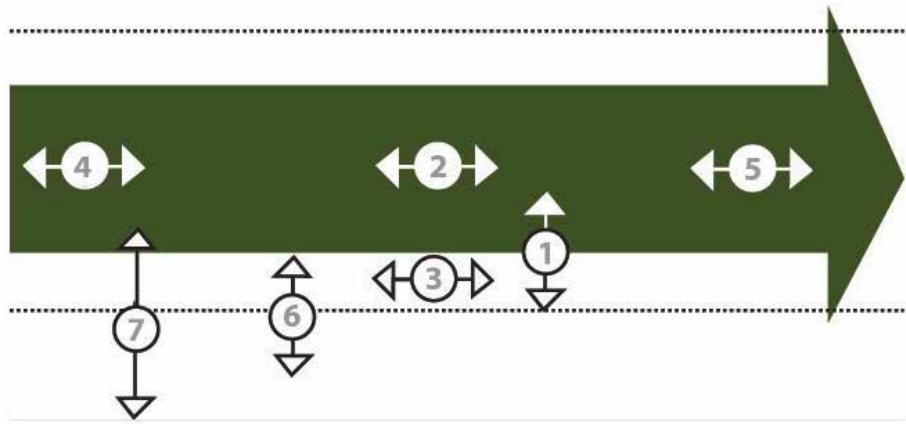
We chose four case studies Karlsruhe, Mainz, Nijmegen and Dordrecht based on the spectrum of city-river-flood management constellations they present. All are current developments or projects in the flood plain on different segments along the Rhine. Embedded in a Rhine atlas of their respective typology (retention polders, bypasses and harbour conversions), they are not comparable, but represent to varying degrees the mitigative and/or adaptive typologies for a number of other sites along the river. The case study analysis is an investigation of the temporal and spatial relationships

between the four main claims on site: urban development, flood management, navigation and nature development and the respective scales and thus hierarchies that shape the project. All four case studies are located in the flood plain and were chosen based on the presuppositions that:

- the urban river front developments are all allowing water on site, they follow an expansive (vs. a defensive) approach and are thus transformative;
- it is the stated aim to minimize economic damage potential by flood adaptive or mitigating measures;
- urbanity is not limited to the compact city, but understood as a gradient of varying densities and scales;
- programmatic complexity is an inherent / potential quality that demands a transdisciplinary layer to become operative;
- navigation is not to be confined by the proposed measures.

The relations between the catchment and the local scale are described in the IRMA Sponge project as follows (see fig. 4):

1. The direct relation between river and flood plain with river water levels determining opportunities for (...) flood protection in the flood plain, flood plain land use, activities influencing high/low river water levels
2. Measures in the river bed influencing high/low water levels, sedimentation, stability of the river channel, navigation
3. Competing interest for land use in the flood plain
4. The relation with upstream river stretches, such as discharges, and the demand for navigation
5. The relation with downstream river stretches, such as water levels and discharges, and the demand for navigation
6. Demand from adjacent areas and regional and national authorities for certain land use and activities in the flood plain
7. Demand from adjacent areas and regional and national authorities for certain river functions and safety from flooding



**Figure 4**

*Relations between the catchment and the local scale (IRMA Sponge, 2002).*

For this research the relations defined by the IRMA Sponge project are subsumed in four layers: the river, the agencies and time frames involved in the project, the local/regional scale and the project scale. The following aspects are investigated and visualized in order to further extract their interdependencies and their limitations and potentials regarding Urban Flood Integration. Questions of ground water, current and sedimentation will only be incorporated where data is available.

#### **X-Large (the river scale)**

The selected projects are evaluated in terms of their global relation to the Rhine catchment as the decisive scale for flood events (Hartmann, 2011) and the respective river segment. An atlas framing the occurrence and context of the typology along the Rhine will mirror path dependencies and paradigms concerning specific project typologies (steered retention polders, bypasses and harbour conversions). In terms of flood management, this layer serves as a basis to understand the current interdependencies of the different river segments and the paradigms and strategies applied. For the first time the respective typologies along the Rhine are presented coherently. Specifically for the steered retention polders of the High Water Action Plan along the Upper and Lower Rhine, where the project implementation is executed by France and three different German federal states, this is an approach providing knowledge beyond political borders. For example, steered retention polders have been

very difficult to implement due to their scale and negative local side effects, as well as their sectoral qualities. Instead of showing the projects according to programs, the aim of the atlas is to provide the basis for an open classification system for different river front typologies.

#### **I+I (initiation and installation)**

investigates by whom and how projects are initiated and how they are being installed in order to show how the realization process influences the actual result (within the specific local/regional context of relevant developments). In a brief description of the initiation and installation process, the main non-spatial parameters of the specific project will be defined. This is not a central part of the research, but aims to include the major political, economic and socio-cultural factors shaping the project. This will be visualized on a timeline based on the four main programs and their according agencies to frame the project in terms of short- and long term developments and the degree of iteration involved.

#### **Medium (local and regional context, horizontal programming)**

Based on the preceding chapters on the evolutionary development of the Rhine and related urbanization processes, the site's border between river and city and its sequential capacities and limitations will be analyzed. Conflicting interests within the local context produce synergetic development potential. A discussion of the alternatives considered investigates if and how this becomes operative for the local context.

#### **Small (project scale - vertical programming)**

The waterfront is the actual site for possible developments based on the supposed conflict of urban development and flood threat, predominantly its economic damage potential. The physical site is defined by spatial capacities on site, claims as well as existing programs (urban and flood related), expected water levels and the scale. The sites of the different projects and the programs on site will be analyzed accordingly. An adaptation of the systems engineering approach, as applied in the further development of the Nijmegen Lent project both by the hydraulic engineers and by the urban designers, will serve to visualize the different system components of the project development according to the available data.

#### **Extraction (as a synthesis of the four layers)**

We will illustrate the layers of temporal and spatial interdependencies. Relational diagrams show the reciprocations between urban development and river dynamics of each investigated case study and the respective agencies and processes involved. The extracts aim to show how strategic and spatial design are capable of producing synergetic qualities within the given context while conforming to the given boundary conditions of the river.

## § 1.5 Expected Results

This research sets out to investigate a selection of ongoing projects within different urban contexts along the Rhine and their inherent interdisciplinary parameters. It will give an overview of programmatic constellations evolving in current flood mitigation and flood adaptation projects on site and show how these relate to their local and regional context and the river as a whole. It will result in an open inventory of current and ongoing developments of mitigation and adaptation measures in the form of an atlas. An analysis of the projects' challenges and potentials for urban development and conversely for flood management aims to formulate a new adaptive approach for mitigation measures that strategically involves design. In conclusion, the research aims to show the breadth of measures and spatial constellations already present in current flood management projects along the Rhine – as part of a top-down plan, a self-generating process or even historical coincidence - and to speculate on their operative potential for the contemporary urban river landscape.

Based on the hypothesis that synergetic solutions between flood management and urban development offer qualities for both, the analysis and visualization of the case studies aims to qualify this assumption. The extract of the spatial and temporal interdependencies between project scale, context, river and the agencies involved will serve as a basis for the conclusion. It focusses on the architectural scope (this includes architecture, urban design and landscape architecture) of flood management projects on one hand and how flood management influences design at the border between city and river on the other. The research aims to answer how project scales can be expanded or redefined in order to enhance the relationship between urban design and water management in both directions.

PART I provides the theoretical, historical and strategic framework as a narrative for the case study evaluation in PART II. "Complex Systems and Landscape Urbanism" frames the perspective applied to define the "ecological approach" as a future time frame and long-term strategy demanding for a transdisciplinary layer. The historical overview in the chapter evolution is organized according to the specific geographic context and the relevant time frames (pre-industrial / industrial / trans-industrial) to show path dependencies relevant for the mediation of the named programs. "Flood Risk Management Today" elaborates strategies and differences in Dutch and German flood-related planning. The research in PART II will quantify and embed the typologies 'retention polder,' 'bypass' and 'harbour conversion' exemplarily within their topographical, urban and programmatic context.

The mediation between different programs and disciplines with the aim of generating emergence between conflicting claims at the border between city and river as a new field of interest for urban designers demands an understanding of the local and

regional scale and of flood risk management. The research offers visualisations of possible programmatic constellations today (horizontally beyond the project scale and vertically on site of the project) in relation to the respective original and transformed river typology. The illustrated interdependencies between the projects and their local and regional context will outline future design tasks for urban design in the context of German and Dutch flood management under uncertainty and give a brief recommendation on future research topics. The format of the research is a text that includes maps, aerial photos and graphic representations.

As a contribution to knowledge, UFI provides an overview of different flood mitigating measures, specifically bypasses and retention polders along the Rhine, as well as harbour conversions as new flood-adapted urban developments on a local scale. The aim is to show the inherent and multiple border negotiations between the urban landscape and the river.

The UFI research provides the design disciplines with knowledge about the current state of riverfront developments between mitigation and adaptation and formulates recommendations for designers involved in flood-related projects and for those flood-related projects where designers should get involved. Its approach aims not only to organize multiple agencies and programs, but also to produce differences by anticipating emergent qualities between them.

Apart from recommendations directly addressing the design practice, two follow-up research projects are proposed:

**Cost-Benefit-Analysis Spatial Quality:** To substantiate the qualitatively developed argument towards Urban Flood Integration (UFI), a cost-benefit analysis of a transdisciplinary layer to advise on and ensure spatial quality in German Room for the River projects, which today mainly focus on ecological rejuvenation as a secondary aim, is recommended.

**Development of Design Guidelines for a River Segments Approach:** Evaluation of ongoing or recent mitigation and adaptation projects, but also other river-related developments (e.g. navigation) in an academic research project to define potential emergent capacities between systemic and qualitative elements. In collaboration with the practice, smaller scale pilots as part of existing mitigation programs on a river segment scale could aim to substantiate the findings.



## 2 Complex Systems and Landscape Urbanism

elaborates a counter-model to the modernist approach of urban planning based on an extended ecological perspective. Cities and landscapes are understood as relational frameworks defined by processual developments based on the layer approach (landscape/infrastructure/urban development). Landscape urbanism defines a non-sectoral, processual planning practice with the aim of triggering emergence among the different programs on site (vs. avoiding conflict). Therefore it focuses less on the optimal performance of one explicit program. Instead it aims at an interplay of ecological, economic and cultural programs based on a definition of ecology that includes the urban realm.



## § 2.1 Temporal and Spatial Interdependencies

As modernist and thus industrial heritage, previous developments in the flood plain or in flood-endangered areas along the Rhine today embody a land-use pattern based on separated functions. However, recent experience and a new understanding are challenging this approach, which is rooted in the ideal of order and control. As a consequence, sustainable development demands reduced land consumption, a new, less dialectic understanding of urbanity (city and landscape as notions providing clear spatial entities no longer suffice) and an integrated approach to planning with the aim of creating emergent qualities between different programs. Ideally this approach coheres with the economic and ecological principles of multiple use.<sup>3</sup>

In this context, sites along the river demand a synergetic approach to often conflicting, but simultaneous claims, combined with the accommodation of varying water levels - as an inherent part of a flood plain development, or, in preparation of a failure or exceedance of the flood defense. The Dutch government implemented a new spatial planning approach in 2005. It not only involved a decentralized steering strategy, but also introduced the three-layer approach (Nota Ruimte, 2005). The layered strategy defined a new approach to spatial planning by differentiating three spatial entities and their temporal patterns of renewal:

- Landscape including the ground quality, the water system and the topography that takes centuries to transform;
- Networks such as infrastructure, waterways and roads renewed every 20-30 years;
- Land occupation where forms of land use may change every 10 years or longer (van Buuren, ed., 2002).

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"Densifying cities can reduce energy consumption, but may have negative effects on adaptation as the urban climate effect is intensified and the heat island effect and therefore the need for cooling increases. A diligent design of the remaining open spaces, reducing impermeability, building isolation and planting trees for more green and shade can mitigate the negative effects of densification." (Deutsche Anpassungsstrategie an den Klimawandel, 2008)

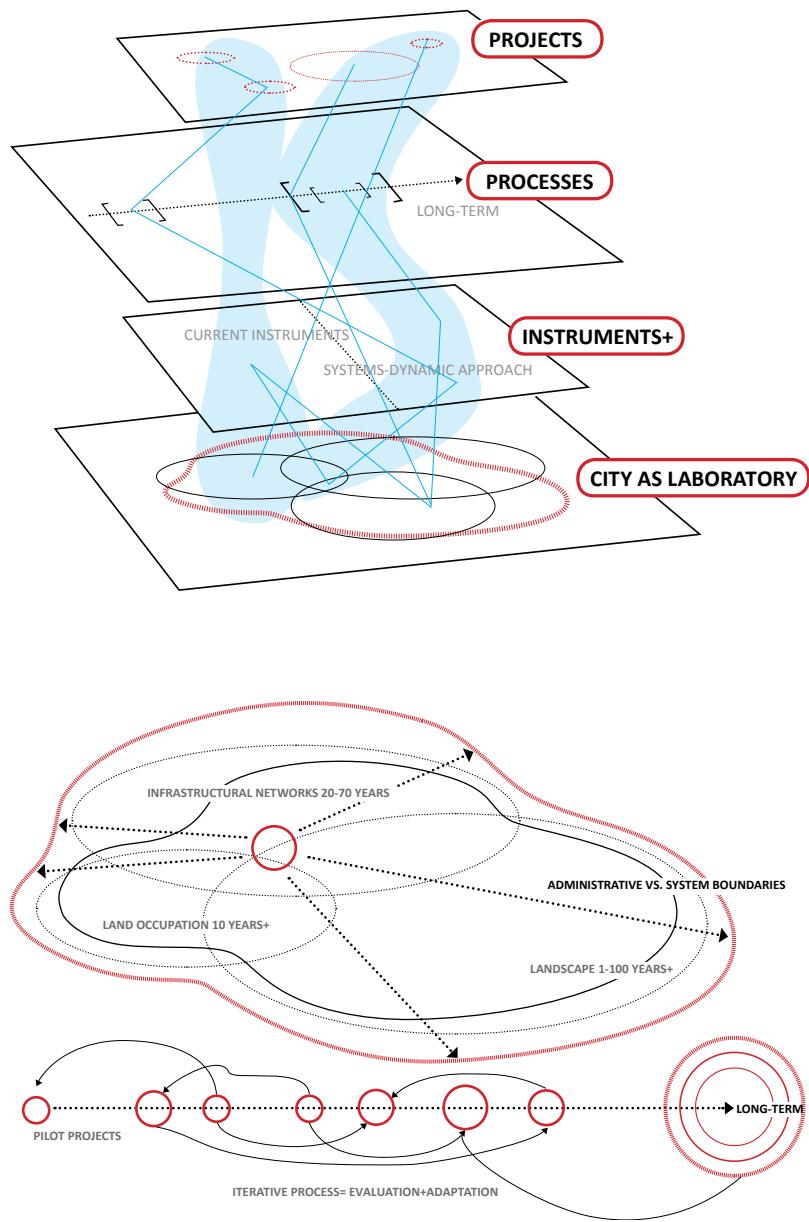


Figure 5

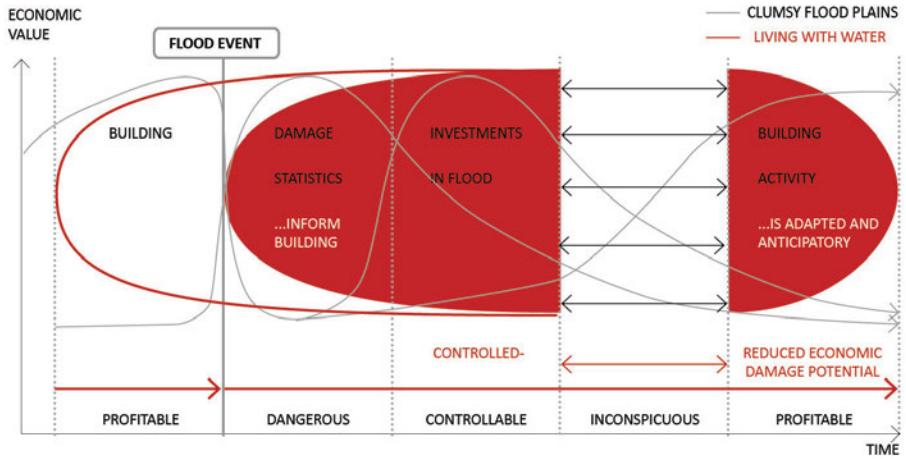
Expanding time and project scales demands for a strategic design approach (graphic TU Munich Chair for Spatial Development adapted by authour)

The temporal and spatial interdependencies categorized in the layer approach can partly be related to the time frames in Fernand Braudel's theory of the longue durée differentiating between structure, cycle and event. While social, political and economic structures or geographic parameters may change very slowly or not at all, economic

cycles and fluctuations take several years or decades (i.e. Kondratieff cycle), as opposed to events such as the change of laws, governments, etc. taking on weeks, days or even hours and, for example in the case of an extreme flood event, are capable of affecting all three spatial layers. As stated in the ecosystems approach, "Moving towards sustainable development involves long enough time lines for the actors and the context of the ecosystem to change." (Kay 2009:11). This involves a new understanding of planning, moving away from the "discrete zones of practice" (Lister, 2010:537) of the industrial era towards a much more processual, interdisciplinary and iterative strategy (fig. 5). This requires the development of a fitting administrative approach that allows for a dynamic development process. It therefore demands a different steering philosophy from government to governance. Systems changes require preparatory analyses and a phased decision-making, for example to reserve areas in the short-term for future uses (Pelt et al, 2011).

For urban planning in times of uncertainty, this demands a long-term, integrated, area-based approach. Verbeek and Zevenbergen (2008:9) specify a systems approach for urban planners, water managers and designers that "addresses resiliency as an ongoing goal in every aspect of urban planning and urban system investment." The tools to weigh decisions for long-term urban planning being environmental and social impact assessments, cost-benefit analyses, life-cycle costs, and risk analyses. Further, they argue that the continuous redevelopment of cities offers ample possibilities to improve the resilience of areas at risk. While the typical life cycle of buildings in Europe is about 50 years, within the next 30 years an estimated one third of the European building stock will be renewed (European Construction Technology Platform, 2005 in Verbeek and Zevenbergen, 2008a:17). The decision if buildings should be left as they are, adapted, replaced or not rebuilt at all in this strategy not only involves a long-term planning perspective, but also requires a differentiated strategy according to the existing site conditions, the respective building stock, and property rights. Design therefore becomes strategic, not only to enable architectural capacity building in terms of substance and contingency (Janson, Wolfrum, 2006), but also in its incorporation of parametric strategies.

Values in flood plains have been accumulated, destroyed, rebuilt and continually expanded. During the different phases, a number of stakeholders are involved who perceive the flood plain according to different logics (Hartmann, 2011, see fig. 6). To overcome the "inconspicuous phase," the phases of investments in flood protection and building activity are combined towards a strategy which is ideally also iterative. Currently this approach serves as a counter model for developments in the flood plain by proactively aiming for 'living with water' strategies.



**Figure 6**

*Perception of Floodplains (Hartmann, 2011, adapted by author in red).*

Specifically in the western world, in the decline of its industrial self-understanding, this change in paradigm produces anxiety and disbelief as such time scales today rarely cohere with legislations or economic cycles. Producing spatial qualities in parallel with following long-term strategies is seen within this research as a key to create a supportive environment for long-term developments. Therefore spatial design is more than a produced quality. It is essential in remediating programs and therefore disciplines and to produce a positive and supportive environment for change.

## § 2.2 Landscape Urbanism - The Role of Design within Complex Systems

### Complex Systems

From a systems approach, the Rhine - and here this includes the Rhine as a highly dynamic ecological system, as a development corridor, a transport route and an urbanized landscape - can be defined as a complex open system, demanding a plurality of perspectives when negotiating its borders. Due to the high degree of uncertainty inherent to any complex system, emergence opposed to zoning seems to be the more adequate strategy for a sustainable / resilient development.

While zoning aims for the maximum efficiency of isolated entities without producing conflict, a systemic approach aims for emergence through “recursive procedures” (Allen, 1999). The idea of emergence is based on the understanding that a system behaves as

a whole. If one part of a system is optimized in isolation, another part will move further from its optimum to accommodate the change. This implies, that generally, when a system is optimal, its components are themselves run in a suboptimal way (Kay, 2009). In this context, resilience reflects the capacity of complex adaptive systems to cope with disturbance (for example, floods) and to reorganize while undergoing change (for example, climate and socio-economic change) (Gersonius et al, 2008:81 referring to Walker, B., Holling, C.S., Carpenter, S.R., Kinzig, A., 2004).

Post-normal science as a framework approach (as opposed to normal science where a clearly framed question demands a single answer) searches for paradigms instead of moving within the one already specified. The interrelations between the different territories (i.e. river segments), agencies and ecologies require a transdisciplinary approach which "invokes emergence between the different disciplines over merely working with them" (Kay 2009:11). For the design disciplines, this implies a practice that engages in the parametric constellations of the site and the multi-faceted relationships with its environment in a much more open way where it is not the final outcome as a static condition, but the processual capacity of the project to continuously transform, that is essential. This approach makes spatial design more than the aim to produce spatial qualities. Design becomes strategic and responsive with the goal of increasing the overall resilience of the respective site.

### **Landscape Urbanism / Ecological Urbanism / Infrastructure Urbanism**

Landscape Urbanism revolves around the three spatial layers of ecology, landscape and infrastructure and is thus, depending on the focus, also defined as Ecological Urbanism (Mostavasi et al, 2010) or Infrastructure Urbanism (Allen, 1999, Bélanger, 2009). Through an extended definition of ecology, as a fourth layer, including not only human species, but also artificial ecologies, such as, for example, waste (Allen, 1999), the differentiation between landscape and city becomes unproductive. Landscapes and cities as "loosely structured frameworks" are the fields of landscape urbanism or ecological urbanism.

Based on the transferential definitions of landscape, urbanism, and ecology, land use patterns and zoning are replaced by the field condition where infrastructure provides a framework and process unbonds designation: The "(...) boundaries contingent on a particular geography and topography, reterritorialized by any of various patterns, some of which are inscribed on the ground, many of which may lie beneath the thin occupiable surface, insensible, yet controlling infrastructural points and lines of force." (Hays, 2000:114).

In the past, infrastructure as "the underlying foundation (of a system or organization)" has been understood as a spatial category "somehow exempt from having to function socially, aesthetically, or ecologically" (Paul, 2010). Thus, while "forming the basis for later urbanization" (Viganò in Shane, 2004:6) infrastructure has remained a

mono-functional, superordinate network that is for the most part invisible, either physically as it is located beneath the ground or as we are blind to recognize its spatial manifestations. Infrastructure is rarely a performative design element.

Stan Allen describes landscape as important to architecture and urbanism as a model of process. Landscapes, perhaps with the exception of the Netherlands, can therefore not be designed and controlled to the degree that architecture is. Allen defines landscapes and cities as loosely-structured frameworks that grow and change over time: "Cities, like natural ecologies, emerge through recursive procedures. They are the cumulative result of countless individual operations repeated over time with slight variation. Difference is produced incrementally, as an effect of repetition and feedback. As an urbanistic model, an artificial ecology implies a complex interplay of agents, objects and process, where time is a key variable."

The evaluation of the case studies in Part II aims to define four different urban models at the border between 'city' and river. Beyond the spatial design on the project scale and its local context, this will include the link to the landscape system of the Rhine and the initiation and installation process applied. The concept of an 'artificial ecology' may be applied as all projects, however controlled, aim to integrate the dynamics of the river in different ways.

### **Design**

Nina-Marie Lister elaborates the advancing understanding of ecology and its impact on the design practice: "As the shape and form of our physical, constructed environment changes with the political-economic and the social-cultural forces of globalization, decentralization and post-industrialization, the ground plane of the contemporary metropolitan region has reshaped the paradigm of ecology. This coupled and reinforcing relationship between ecology and landscape hinges around design. All of our ecologies - multiple, layered, complex, and insurgent - collectively inform the design of our urban and urbanizing landscapes. And these emergent landscapes, in turn, continue to shape the ecologies that define us" (Lister, 2010:536).

Interestingly enough, landscape urbanism evolved from landscape ecology rooted in German and Dutch land planning after WW2. Landscape ecology did not reach the United States until the 1980s. Shane elaborates the emergence of landscape urbanism in the 1990s as "European land management principles merged with post-Darwinian research on island biogeography and diversity to create a systematic methodology for studying ecological flows, local biospheres, and plant and species migrations conditioned by shifting climatic and environmental factors (including human settlements). Computer modeling, GIS, and satellite photography formed a part of this

research into the patches of order and patterns of 'disturbances' (hurricanes, droughts, floods, fires, ice ages) that help create the heterogeneity of the landscape."<sup>4</sup>

As a design discipline, landscape urbanism evolved in the 1990s in Europe and the United States as an approach to the multi-faceted and indeterminable developments of the post-industrial era. The scope of methodologies is wide. In the academic context, landscape urbanism has been coined by computer-based parametric design projects at the AA around Mohsen Mostafavi and Patrick Schuhmacher, inspired by Barcelona-like, large-scale infrastructure projects. In practice, there are exemplary conversions of former industrial sites such as the Duisburg Nord project for the IBA Emscher Park by Peter Latz Landscape Architects, where a highly polluted, former coal and steel production plant was turned into a public park by the use of phytoremediation. Paola Viganò (IUAV Venice) and Kelly Shannon (KU Leuven) have done further research in the field within different European contexts. In the United States, projects by Charles Waldheim and also by Field Operations (James Corner and Stan Allen) in the 1990s draw on landscape ecology.<sup>5</sup> Their projects focus on processual developments of predominantly interstitial spaces. Currently, commission-based research at Harvard GSD is being done in the academic realm by Christian Werthmann (landscape urbanism) working on informal cities, and Pierre Bélanger (infrastructure urbanism) together with Nina-Marie Lister (ecological urbanism) with a commission to investigate alternative futures of the Dutch polder model (see case study Dordrecht).

As a counter model to New Urbanism and to the Generic City (Shane, 2004), landscape urbanism, based on the cause-effect network, searches for patterns within these frameworks that may function as breeding grounds for self-organization and adaptation as part of a dynamic field.

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4 Shane refers to Monica G. Turner, Robert H. Gardner, Robert V. O'Neill, eds. *Landscape Ecology in Theory and Practice: Pattern and Process*, p.10, Springer, New York, 2001; also Richard T.T. Forman, Michael Godron, *Landscape Ecology*, p. 619, Wiley, NY, 1986; also *Landscape Mosaics: The Ecology of Landscapes and Regions*, Cambridge University Press, 1996).

5 an Mc Harg, *Design with Nature*, 1968 added layering capacity of computer graphics to help isolate the "no build" voids based on aesthetic, ecological, and agricultural values. Corner also draws on landscape ecology tradition that defines the landscape very broadly as a mosaic of "the total spatial and visual entity of human living space" that integrates the environment, living systems, and the man-made. (James Corner, *Eidetic Operations and New Landscapes*, in: *Recovering Landscape: Essays in Contemporary Landscape Architecture*, p. 153-169, ed. James Corner, Princeton Architectural Press, New York, 1999 in: Shane, 2004) In the landscape urbanism exhibit in 1997 by Charles Waldheim, he turns the landscape ecology approach towards the city. Waldheim defined Landscape Urbanism as a branch of landscape ecology, concentrating on the organization of human activities in the natural landscape. (..) interstitial design discipline operating in the scapes between buildings, infrastructural systems, and natural ecologies. (Shane, 2004)

"The implications of landscape urbanism are principally concerned with engaging processes that facilitate design in the context of complex and dynamic cultural-natural systems. In this respect, landscape urbanism is necessarily more than just another 'new' urbanism; it is concerned with more than merely urban form, and centers on a more complex problematic; it is a multi-scaled and multi-layered urbanism involving cultural, social, political, economic, infrastructural, and ecological conditions that are layered, tangled, and mutually dependent" (Lister, 2010: 538).

The notion of creating difference can explain how design as part of an aesthetic paradigm (vs. planning) can be linked to the context of complex and dynamic cultural-natural systems. Guattari describes the role of architects and urban planners as those who "cannot hide behind a so-called transversal neutrality. An ethical paradigm has to be complemented with an aesthetic paradigm that will help prevent processes from getting fixated in deadly repetitions. In the case of the latter, each concrete performance introduces openings that cannot be assured by theoretical foundations or an authority but that are always work in progress" (Guattari, 1989 in: Andermatt Conley, 2010:139). Systems change needs to be instigated as a processual development involving different time scales and involving people, as cohabitation demands for niches for the individual to unfold. It demands for a process-driven aesthetic practice. Design is capable of addressing different time and project scales when linking the project scale to larger scale transformations. "As a dualized practice, design can be strategically deployed between two different scales: short, immediate periods of time with large geographic effects over long periods of time. Design, and the research that preconditions it, therefore becomes telescopic, capable of integrating multiple scales of interventions at once" (Bélanger, 2009:91 referring to Cosgrove, 2003).

By addressing multiple scales, design can thus help bridge the gap between the long time periods required for a sustainable development and short-term political and economic cycles or events such as flooding. In this way spatial design becomes more than the realization of a project, it becomes a contributing part of a long-term transformation strategy.

Applied to the approach of river-expanding, landscape urbanism does not only comply with the multiple spatial scales that the various projects affect and are affected by. It takes the aspect of indeterminacy as a given by switching from a strategic practice to a tactical approach. "Not to be solved with one stroke, the introduction of tactical strategies to successfully operate with living organisms and systems, subject to constant change and great indeterminacy, has been applied by landscape architects for large scale projects such as brown-field remediation, large parks or complicated projects in the urban periphery. They require strategies that unfold over time and can survive uncertainty" (Wertmann, 2010).

In the light of deindustrialization and a reflexive modernization, the programs are simultaneously claiming ground on the border between river and city. Urbanization, flood management, nature development, navigation and to some degree production are undergoing a process where the central point is to find a new balance between the different claims. The concept of reintroducing mixed uses in urban planning is not new. One of the first apologetics for a mix of primary and secondary uses was Jane Jacobs (1961). Yet, in the light of an increasing demand for redevelopment based on conditions produced by deindustrialization and a reflexive modernization, it is not solely about aiming to combine uses so as to avoid, for example, vandalism. Sustainable design is not only about preservation of ecological niches. A systemic approach with the goal of producing resilience is not about the mere organization of survival in an ecological context, but about thriving (Lister, 2010). Consequently design goals must incorporate economic and ecological balance and cultural vitality.

### **Backcasting**

Cause-effect relationships within a process such as climate change are highly complex and therefore a high degree of uncertainty is immanent in modelling results and forecasts. This demands an iterative approach, capable of enduring long-term visions, but flexible enough to adjust to short term and often unforeseen events and changes. Backcasting therefore starts from a vision of the future and deduces information about the system components by using knowledge about the system and its behavior. This results in a set of strategies to address future uncertainties (Gret-Regamey and Brunner et al, 2011). Backcasting therefore not only identifies relevant parameters to enable, if necessary, fundamental changes. As a learning development triggered by conflict, it also assumes an iterative approach. Yet, current planning systems are not always fit to apply a backcasting strategy. They need to evolve to include: (1) participation, bottom-up processes and informal instruments (2) a regional perspective and responsibility by planners, while (3) sectoral measures should be combined and implemented integratively in system-oriented strategies to secure the multifunctionality of landscapes and reduce the vulnerability of our environment to climate changes. (Gret-Regamey and Brunner, 2011:43). The multifunctionality of landscapes and a reduced risk are seen as a combined goal of a systems-approach.

Further reasons why a methodological approach is challenging to apply here in regard to urban flood management, are a lacking understanding of current and future risks and implications (flood frequency is likely to increase during the lifetime of buildings), a lack of long-term, integrated and comprehensive planning; an inadequate steering role by local and regional authorities, and the conservative nature of the building sector (Szöllösi-Nagy and Zevenbergen, 2005 in: Gersonius et al, 2008).

A further hindrance is the often missing knowledge and/or accessibility of scientific data to those involved in the planning process. This has led to the development of model projects whose goal is to contribute to knowledge production while providing

site-specific data and iterative loops between designing and evaluating different proposals. Ideally, these model projects provide knowledge, methodologies and tools transferable to other situations.

## § 2.3 Flood Risk and the Regime of Risk Calculation

Three components determine flood risk: flood hazard, vulnerability and exposure. Hazard defines the threatening natural event, including its probability and magnitude of occurrence. Exposure specifies the values and humans that are present at the location involved, and vulnerability describes the lack or loss of resistance to damaging or destructive forces. Flood risk can be mathematically calculated as the product of hazard, exposure and vulnerability; and presently we are reliant on a defined flood risk to become operative. This approach, however, produces a number of parameters with a high degree of uncertainty. In flood protection, policies and actions rely predominantly on an approach that deals with the probability of floods. Future events, however, may exceed design flood levels. In addition, the increase of damage potential in areas at risk rises due to perceived safety. By reducing the probability of floods occurring, vulnerability therefore increases. There is a general consensus in water management that floods have to occur frequently to keep up flood risk awareness and operative knowledge (Hartmann, 2011:10). Thresholds that protect against frequent events and fail against rare extreme events therefore contradict the concept of thresholds (Voigt, 2005: 100). Urban development projects outside of dikes may be seen as frontrunners for adaptation processes also for the building stock behind the defense, a task addressed in the currently executed EU Flood Directive.

As risk cannot be entirely eliminated, risk management is an activity geared to the evaluation of schemes for reducing the overall risk. Flood risk management therefore requires a holistic approach, a multi-layer approach that addresses hydrological parameters as well as the human and socio-economic issues of planning, development and management in order to reduce the likelihood and/or the impact of floods. Flood risk management programs incorporate the following elements:

Prevention (Avoidance and Adaptation) - preventing flood damage by avoiding the construction of houses and industries in the present and future flood-prone areas and by adapting future developments to the risk of flooding, as well as promoting appropriate land-use, agricultural and forestry practices;

- Protection (Mitigation) - taking measures, both structural and non-structural, to reduce the likelihood of floods and/or the impact of floods in a specific location;
- Preparedness (Awareness) - informing the population about flood risks and what to do in case of an event;
- Emergency response - developing emergency response plans in the case of a flood;
- Recovery and lessons learned - returning to normal conditions as soon as possible and mitigating both the social and economic impacts on the affected population.

### **Calculated Risk and Uncertainty**

More than that, risk has also been considered as a motor for the exploration of new markets and a driver for development (Beck, 2007). According to Beck, risk can be described as social phenomenon evolving from the link between technical knowledge and calculated economic benefit. At the same time, risk calculation enables a de-individualization of risk as it is classified as a system-inherent event that requires political regulation. The industrialized system only becomes operative within its own uncertain future by determining a calculated risk.

However, recent events are undermining our established risk logic (Beck, 1988, 1999). With relation to climate change, Beck argues that extraordinary risk is endless both in terms of time and space, "an open-end festival of creeping, galloping and overlapping destructions" (Beck, 2007:52). In Europe, two historically opposing developments are currently colliding. While our high safety level is grounded on technocratic norms and control systems, we are simultaneously facing new risks that are neither legally, politically, nor technically graspable (Beck, 2007:65). While facing the self-inflicted occurrence of a catastrophe, our nation-based, technocratic order is therefore being questioned. At the same time, the threat remains unreal, as it may not occur at all.

A change to proactive management of natural disasters requires an identification of the risk, the development of strategies to reduce that risk, and the creation of policies and programs to put these strategies into effect. To do so, it seems prudent to link urban flood management strategies with other development processes, also those linked to climate change such as the urban water cycle, energy-efficient refurbishment of buildings, and all other developments which offer possibilities to reduce the vulnerability of our constructed environment. This, however, requires adequate management strategies on a local and regional level and the understanding that architectural design on all scales needs to incorporate a systemic approach. At the same time, spatial quality serves as a supportive layer to convey (awareness) and provide support (acceptance) of the urban transformation process.

Critique of a collective flood defense system: reducing the probability of floods by reinforcing collective protection works also reduces risk awareness and, if defense levels are exceeded, no one is prepared. An alternative approach aims to design the urban fabric in a flood resilient way. Supported by river expanding mitigation measures

that shave peak floods will ideally (there is always a residual risk that needs to be considered) produce an environment that is flooded frequently, yet at acceptable levels. In the current system of controlled-dynamic, the latter is applied to model developments outside the defense.

## § 2.4 Stewardship vs. Stakeholdership

Therefore, when taking individual involvement into account, there is a need to differentiate between the aim of reducing the probability of an extreme event and annual flooding with acceptable water levels as a possible way to keep up the awareness for the genius loci of the flood-prone area. A regular frequency of flood events contributes to risk awareness and consequently to a willingness to adapt.

Adaptive design, which Lister defines, in reference to C.S. Holling, as "an integrated, whole-system approach to the management of human-ecological interactions," would thus aim for frequent flooding with a manageable impact, producing environments which, rather than "failing to save," would be "safe-to-fail". This implies a continuous adaptation process whose goal is a model capable of taking on extreme events, such as floating cities that can adapt not only to all water levels, but also to currents and impacts as well as the replacement of buildings in areas at risk by open spaces. Possibly triggered by a high frequency of acceptable flood events supported by mitigation measures to reduce the probability of extreme discharges, this path demands not only an educated, but also a highly supportive environment.

As we move away from singular collective defense systems, we can define risk awareness as the degree of public realm/publicity a project produces both in terms of space and in terms of directly or indirectly affecting the general public or a specific stakeholder group. Awareness is therefore strongly linked to the spatial context and density and to the respective programs of the selected projects located either prominently in the city or as part of a landscape design. Further, the visibility of measures and frequency of flooding play a significant role in the level of awareness inherent to a project.

Within the UFM-Dordrecht project such an attempt is made by developing a flood damage model that treats cities as a complex adaptive system (Holland, 1995) instead of taking them as inert receivers of flood impacts (Verbeek and Zevenbergen, 2008a:18). This involves a change in responsibility. The change in scale from a singular local or regional collective defense system towards a combined solution that incorporates flood adaptations on the building scale involves house owners and

inhabitants as part of the local community in a much more active way. Extending the circle of those responsible requires more than a supportive environment. It needs to provide links for users and owners to abandon their passive role:

"The success of a project can not be judged solely by its degree of sustainability or integration with its natural setting: (...) interventions are always instigated by people for people, or at least the needs of people. Thus the emotional response to any new landscape plays an important role, next to meeting functional requirements and respecting site specific natural processes. Invoking the imagination and stewardship of its users and owners contributes greatly to the future survival of any work." (S+A Aronson, 2010:203)

Umberto Eco defines the aesthetic conception of an active receiver role, within epistemology and semiotics. It is based on the understanding that man does not understand the world by thinking alone, but by embodying his thoughts in actions, artefacts and signs. The work of art is seen as a product to which the reader, listener, or viewer responds through an act of interpretation. It therefore involves the analysis of processes including the conceptualization, reception, and consumption of the art work. Indeed, the work of art generates multi-coded messages whose actualization largely depends on the receivers' activity of interpretation. The receivers thereby lose their passive role (..) (Francios, 2011).

Applied to the urban landscape at risk, adaptation and mitigation projects not only demand the capacity of transforming the urban fabric accordingly. The role of the people also has to change - from being victimized to becoming contributors. As part of an area-based approach flood management therefore has to link with the socioeconomics of everyday life. Risk awareness demands a new sense of citizenship which moves away from the paternalistic structures of modernist planning. The consideration of effects on and potentials for the local scale and thus the acceptance and involvement of people become essential. This applies to the development of the strongly market-steered adaptation projects limited to the project scale as well as to mitigation projects that tend towards a top-down implementation. The potential and thus breeding ground the investigated projects offer in terms of "invoking the imagination and stewardship of its users and owners" depends strongly on their contingent capacities within their local context.

## § 2.5 Ecological Economics

As already pointed out by Lister, sustainable development relies on our economic capacity. Already in 1957, the landscape architect and founder of the rheinkolleg,<sup>6</sup> Walter Rossow, proclaimed that "the landscape has to become the law", arguing for a less compulsive land use:

*"Die Vorstellung von der Unerschöpflichkeit des Bodens, des Wassers, erzeugt ein antibiologisches Verhalten, bei dem jedes Handeln zu einem Handeln gegen alle natürlichen Kräfte wird. Dieses antibiologische Verhalten ist ein Lebenszustand, bei dem der verlorene Instinkt noch nicht durch ein an seine Stelle getretenes Bewusstsein ersetzt ist. Es ist daraus ein praktisches und wirtschaftliches Denken und Handeln entstanden, dessen Wertmaßstab der Augenblickserfolg ist und dessen Zeitmaß über das Heute nicht hinausgeht." (Rossow, Werkbund, 1959 in: Daldrop-Weidmann, 1991:45)*

"The conception of the inexhaustibility of ground and water produces an antibiological behaviour, where all actions become actions against natural forces. This antibiological behaviour is a state where the lost instinct has not been replaced by another sense of awareness. This has produced a pragmatic and economical school of thought and practice where value is measured by the momentary success and time frames are limited to the present."(translated by author)

Climate change is forcing us to move away from neo-liberal economic principles, where the economy (short-term) and the environment (long-term) are perceived as two separate systems towards ecological economics. Within ecological economics "the economy is seen as an open, growing, wholly dependent subsystem of a materially closed, non-growing and finite ecosphere" (Rees 1995, Daly 1992). This demands an expanded ecological understanding, that includes the urban realm and human enterprise as part of the finite ecosphere and rejects relegating their impacts as external to the market system (Rees, 2003). In turn, this implies that our economic drivers have to become green. This paradigm change involves a transformation

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6

"founded in 1988, the Rheinkolleg is an association that deals with the origins and future of the river system Rhine. The focus of activities, grounded on a generalist humanistic perspective, is communication. We promote knowledge about scientific interdependencies between areas up- and down river and show solutions. The Rheinkolleg has observer status at the International Commission for the protection of the Rhine (ICPR) and supports the ICPR Rhine program 2020 and the European Waterframework Directive for a sustainable development." ([www.rheinkolleg.de](http://www.rheinkolleg.de) (translated by author))

process that will vehemently challenge our infrastructural logic. Up until today our infrastructure is not, for the most part, self-organizing, but is reliant on constant maintenance and the availability of economic means. On the contrary, an ecological approach would thrive for systems that are multi-functional and ideally self-sufficient.

As Beck states in his elaboration of the regime of risk definitions, the relationship between the relations of production (Marx) and the relations of definitions (risk calculation) may not be determined. Yet, he sees them as being historically interwoven within the first, industrial and nation-state based modernity. He puts forth the hypothesis that 'green capitalism' is possible: while the relations of production are to remain constant, the relations of definition have to be reformed. Beyond growth and full employment, this implies an ecological approach as a third principle.

Based on an increasing flood risk and a transformation from a productive economy to a service-oriented economy, supported by sustainable technologies and a landscape perception of controlled-dynamic, infrastructural landscapes aim to instrumentalize the inherent conflict potential in order to be operative and performative at the same time (Paul, 2010).

In the following chapter, the major paradigm changes will illustrate our previous orders and their respective path dependencies so as to provide an understanding of the spatial heritage (palimpsest) and programmatic relationships we are dealing with in current developments at the border of city and river.

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## § 2.6

### Complex Systems and Landscape Urbanism – Demanding for a Transdisciplinary Layer (Extract)

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The Rhine may be defined as a complex system in need of timelines that are long enough for the actors and the ecosystem to change. It also implies that not all parts of the system can run optimally within the functioning of the system as a whole. This asks for a design practice that engages in the parametric constellations of the site and its multi-faceted relationships with its environment in a much more open way. In such a system, it is not the static condition of the final outcome, but the processual capacity for continuous transformation of the project that is essential. Landscape urbanism, based on the cause-effect network, searches for patterns within these frameworks which can function as breeding grounds for self-organization and adaptation as part of a dynamic field. In this context, back-casting is a long-term systems-dynamic and therefore iterative approach where the outcome is defined by shorter-term developments reliant on 'learning' strategies. Sectoral measures should be combined

to secure the multifunctionality of landscapes and their capacity to take on climate change. This is only possible if the emergent capacity between programs is triggered.

Since risk cannot be entirely eliminated, flood risk management relies on a holistic approach. Risk may be considered a driver for innovation also for a long-term perspective. Risk calculation is necessary for the industrialized system to become operative. However, not only the occurrence of extreme events, but also climate change as an "endless threat" (Beck, 2007) is currently questioning the established risk logic. This questioning can be interpreted as the advent of a systems change that also redefines the design task. It asks for the strategic design of environments which, rather than "failing to save" aim to be "safe-to-fail" (Lister, 2010), as the visibility of measures and a regular frequency of flood events contribute to an individualized risk awareness. Therefore, the consideration of effects on and potential for the local scale and thus the acceptance by and involvement of people becomes essential. The local factor applies to the development of predominantly market-steered adaptation projects that are limited to the project scale such as harbour conversion projects, as well as to large-scale mitigation projects along the Upper and Lower Rhine that tend to be implemented top-down and the Delta Rhine, where the steering philosophy is already linked to the local scale. The emergent potential between the different programs or activities on site and on the local scale rely on contingency to create a breeding ground for emergent behavior between programs.

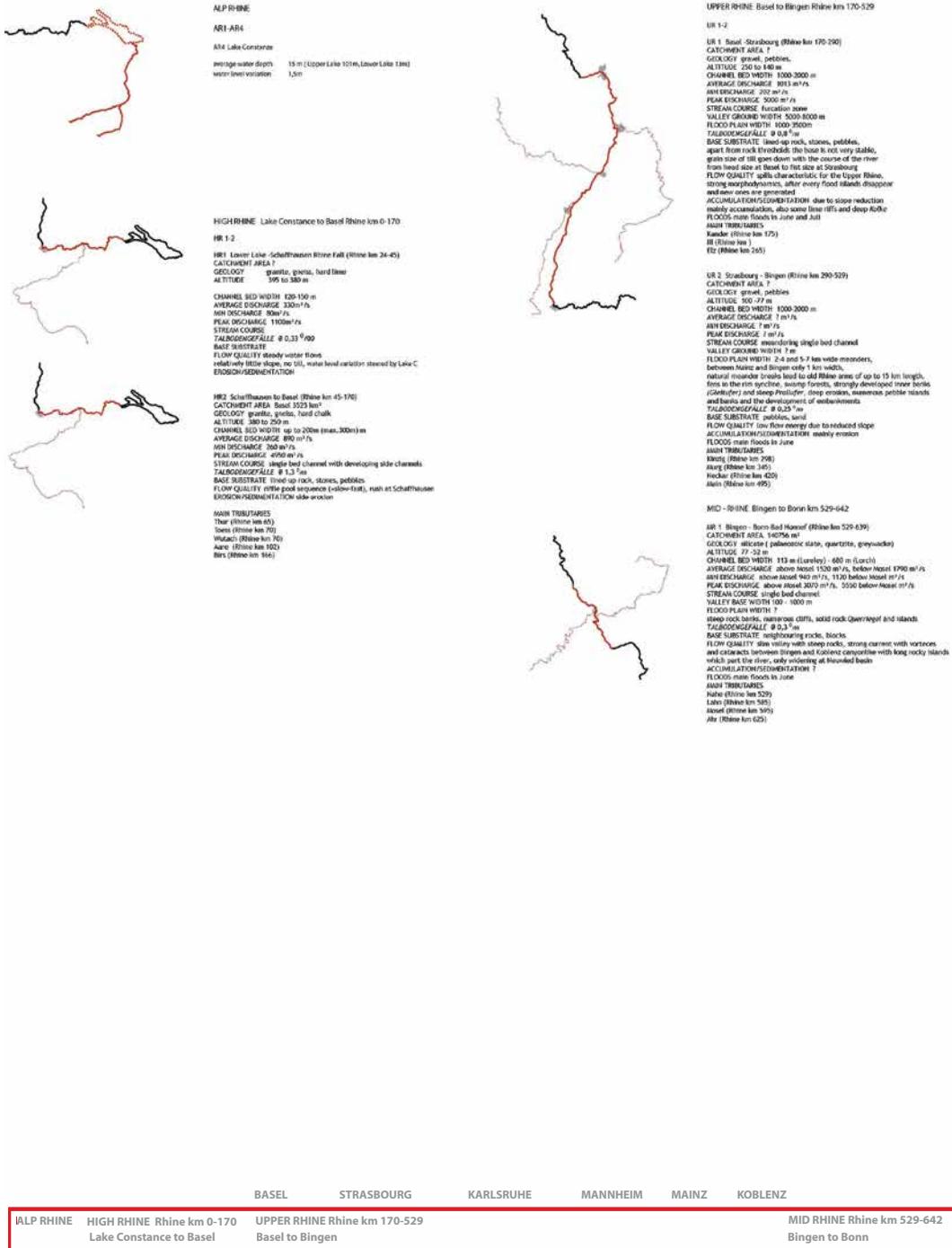
In this context, the environment and the economy can no longer be seen as two separate systems. Instead, the "economy is an open, growing, wholly dependent subsystem of a materially closed, non-growing and finite ecosphere" (Rees, 1995, Daly, 1992). Therefore our ecological understanding has to expand to include the human enterprise and the urban realm. To move beyond merely organizing the different claims on site towards evoking emergent capacities and spatial qualities between programs, also economically, a transdisciplinary layer is needed to moderate the process. In this research, this will be defined as an ecological approach reliant on strategic design.

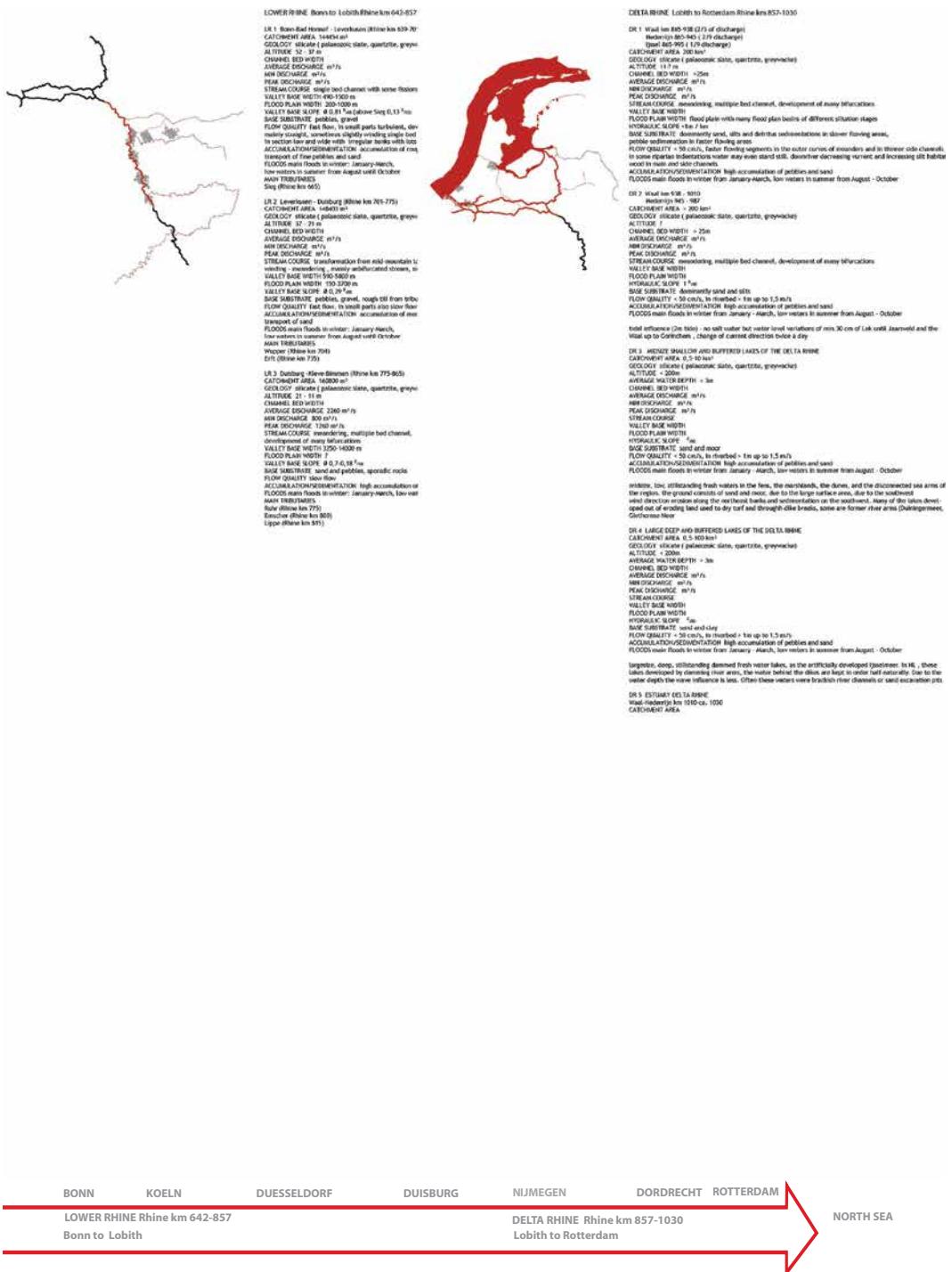


## 3 Evolution

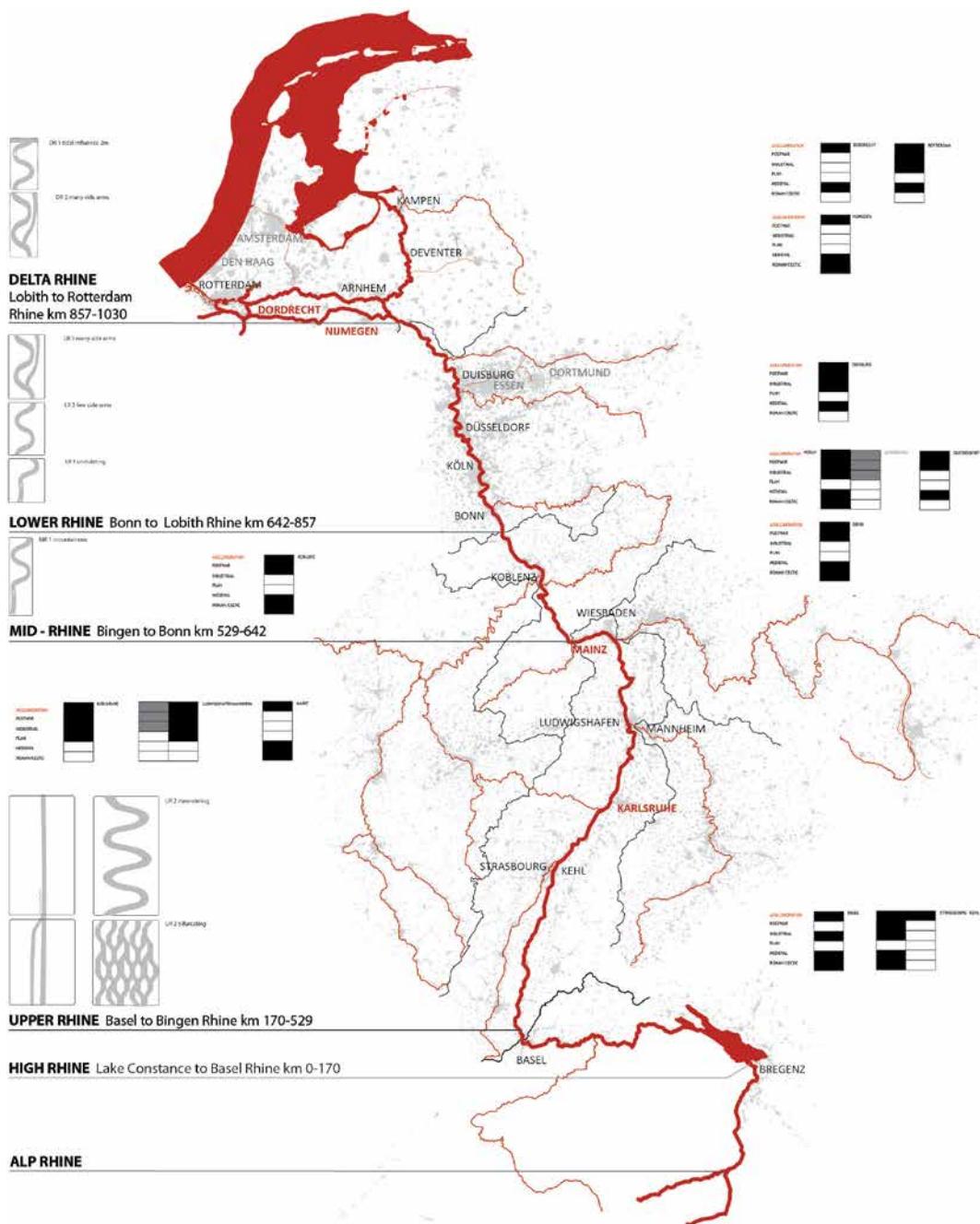
This chapter explores the evolution of the Rhine basin as a development corridor. It gives an overview of pre-industrial, industrial and trans-industrial city - landscape - river constellations and their programmatic and spatial interdependencies relevant for ongoing border negotiations between the urbanized landscape and the industrially altered river today. While ecology as a further agent has entered the arena of trans-industrial developments, path-dependencies from the industrial system limit our capacity to adapt.

3. EVOLUTION → PRE-INDUSTRIAL → INDUSTRIAL → TRANS-INDUSTRIAL

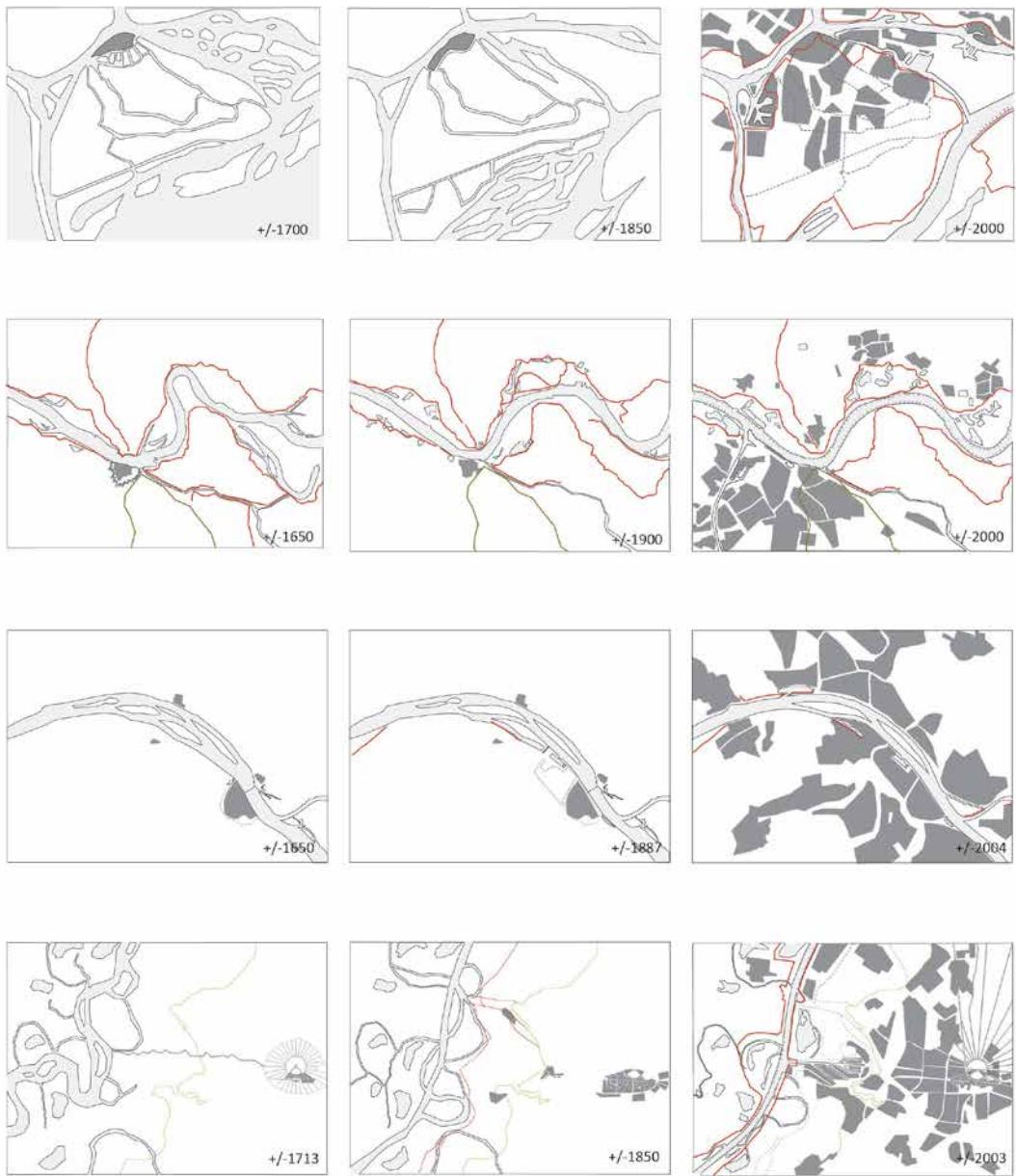




**Figure 7**  
River typologies along the Rhine (ICPR, 2004 adapted by author).



**Figure 8**  
*River typologies and urban foundations along the Rhine (graphic by author).*



**Figure 9**

*Pre-Industrial, Industrial and Trans-Industrial / Phasing of Dordrecht, Nijmegen, Mainz and Karlsruhe (graphic by author)*

## § 3.1 The Rhine Basin - A Development Corridor

An overview of pre-industrial, industrial and trans-industrial city / landscape / river constellations (or better states) in relation to the programs that are driving the development aims to outline their inherent interdependencies. Path dependencies evolving from previous developments are relevant for the mediation of different spatial entities today.

The Rhine basin, today with a population of 58 million (almost 12% of the European Union with 493 million), hosts six major trans-industrial conurbations including the Rhine-Ruhr Region with the Duisburg inland port and the Randstad with the Europorto in Rotterdam. Ocean-going vessels reach as far as Mannheim (190,000/a) and river barges as far as Basel (37,000/a). The Rhine-Main-Danube canal (completed in its current form in 1992, but with a history reaching back to the first century) allows barge traffic between the North Sea and the Black Sea (Irma Sponge project 13). With its 17 agglomerations between Basel and Rotterdam it can also be considered an urban development corridor. At the same time, cleansed via the bank filtrate and combined with ground water, it provides drinking water for the inhabitants along its banks. As a navigation channel with two main European harbours, the sea port of Rotterdam, the inland port of Duisburg and via the Main-Danube canal in direct connection to the Black Sea, the Rhine connects the European hinterland with the world. Since Roman times, it can be considered one of the most important European economic development corridors.

Taking the river as a topographical, political and military boundary, the channelling of the Upper Rhine by Tulla and its consequences downstream and the Sandoz accident in 1986 are only some examples that show the historical multitude of influences on the scale of the river. Their temporal and spatial effects on Rhine urbanization in direct relationship with its waterfront, as a palimpsest of larger scale political, infrastructural, industrial and cultural developments, raises the question of how we define the city and its boundaries in this context today.

In the rise of 19th and 20th century industrialization, the Rhine became subject to severe anthropogenic manipulations, predominantly channelling. Specifically the originally strongly meandering typology of the Upper Rhine was radically transformed. As a first initiative to protect and expand arable land and urban settlements, in a second phase to improve the navigability and later to accommodate barrages for energy production. This greatly influenced the hydrology and morphology of the river far beyond the site of intervention.

At the same time, the Rhine remains a dynamic landscape with different river typologies (see fig. 7). Both successful efforts towards ecologically restoring the industrially polluted and transformed river and a growing understanding of the cultural values of its dynamic landscape drive the ongoing paradigm change regarding developments along the Rhine. Yet, ecology is only starting to move beyond flora and fauna to include the human habitat and therefore economic capacity and the urban realm.

The Delta differs from the other Rhine segments in many ways, also in terms of its temporal organization: the management of water levels is an existential, vital and constant process due to the given topography and the man-made polder landscape. Thus, water management covers the range from a continuous draining activity, reliant on the polder system, to the handling of potentially extreme events posed by a combined threat of sea and river. In contrast, along the German river segments, although very diverse in terms of topography and landscape, the linear defensive systems have no vital functions on a day-to-day-basis, but remain infrastructures for events occurring in seasonal cycles. Also, due to an increase in pluvial floods, this is currently changing.

The inherent change of interdependencies between the economic and ecological aspects of the river as a development corridor have changed and are changing the originally dialectic relationship between river cities and landscapes. There are three paradigm changes, first from a productive to an industrial system, secondly, a sectoral ecological approach and ongoing, towards an understanding of ecology that strives to incorporate human cohabitation. To gain an understanding of the situation today, it is necessary to review the evolution of river-city constellations along the Rhine according to the two major historical paradigm changes.

City form along the Rhine, in particular the urbanized landscape aligning the contemporary version of the compact European city, has evolved according to the inherent economies between the river and the local/regional context and technological skill (see fig. 8-9). The following section elaborates the palimpsests and expansions of urban developments, and thus the major forces defining the relationship between city and landscape along the Rhine today. The economic drivers (navigation, production) related to landscape development and perception (nature>landscape>ecology) and reflected upon the urban evolution from the Roman city to the contemporary urban landscape give insight into the becoming of the major temporal and spatial interdependencies of these layers' historical development.

City/Landscape constellations are two-fold: the urban realm with regards to its surrounding landscape and its direct relationship to the river as a dynamic landscape. It is important to differentiate between the two, specifically because the different Dutch and German hinterland conditions shape their respective perceptions of the adjoining flood plains.

Paradigm shifts along the Rhine until the second half of the 20th century were mainly triggered by technical innovation, political changes and growth. Today, there is a necessity of reconsidering the capacity of river dynamics. We can therefore see a changing relationship between the natural and the human-constructed and, as a consequence, the impact on the previously sectoral system as a whole.

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### § 3.2 Pre-Industrial Evolution (Pre-Channelling)

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The term dynamic refers to a constant transformation of the flood plain due to varying surface and ground water levels (Ernstberger, 2010) as it applied to its pre-channelled state. Historically, urban developments were adapted to the topographic and hydromorphogenic parameters of the site with defensive measures on the local scale or as part of the fortified city. During these time periods extreme floods occurred (St. Elizabeth's flood destroying Dordrecht in 1421, Cologne record flood 13.55 metres in 1784). Although dramatic, they occurred less frequently and in most cases (Dordrecht remains historically exceptional) with a relatively smaller impact as economic damage potential in the flood plain was limited and organized in a more compact urban form. Shipping was organized according to the different river segments with changes from sea barge to river vessel, using toll points to profit from transshipment.

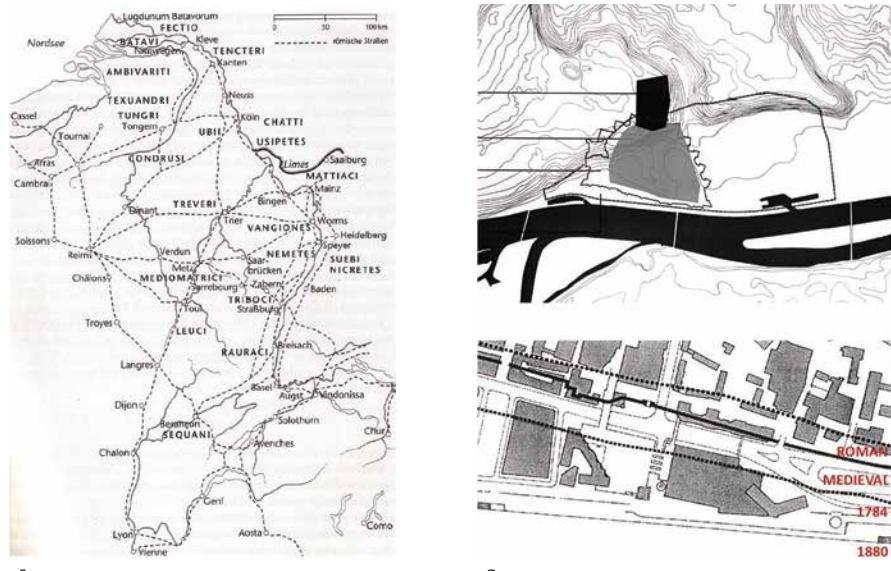
#### Roman Foundations

Twelve Roman foundations and a network of streets were erected along the Rhine (fig. 10.1). Whereas the river itself, with its inherent forces and unpredictabilities, was perceived as a 'deic concept' (Sieweke, 2010:80), the topographical qualities of its adjoining landscape were integrated in the intelligent layout of settlements and harbours with the Limes as a physical hindrance and a territorial boundary.

The strategic use of the given topography is inherent to Roman city landscape constellations along the Rhine as settlements were erected on raised terraces above the river. Looking at Mainz historically, shows its continuous development towards the Rhine. First pre-Roman settlements, but also the Roman fort 13 BC occupied the higher regions around today's inner city. With the rise of Roman civic urban development, the occupation of the Rhine plain begins. The series of walls on the Rhine side, starting with the Roman Wall (mid-third century) followed by different medieval fortifications, illustrate the continuous shift of the urban waterfront towards the river. Whereas urban expansions parallel to the river take up kilometers, developments towards the Rhine from Roman times up until the 20th century, triggered by military defense and trade, were laid out in dense layers of only a few hundred meters (Stadtplanungsamt Mainz, 1998) (fig. 10.2). Already in Roman times, two harbours

were installed: a military harbour on the site that today is the historical city and a trade harbour at the site of today's harbour. As capital of the Roman province and a transshipment station for commerce and navigation, Mainz participated in the wealth of the Roman Empire ([www.zollhafen-mainz.de](http://www.zollhafen-mainz.de)).

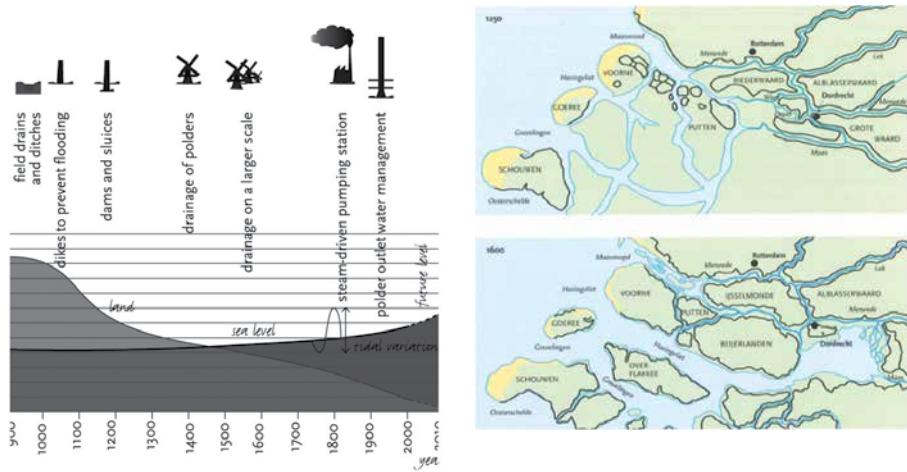
Also, the Oppidum Ubiorum that became Cologne, was erected on a gravel plateau flood safe about five meters above the level of the waterfront. The harbour was located in a natural side-channel and a creek defined the Northern border of the settlement (Blenck, 2001). This use of the landscape's given advantages is exemplary for the twelve Roman left-bank foundations along the Rhine. Also, the harbours in Basel and Mainz were established in bayous framed by natural islands. Nijmegen is the last Roman city foundation along the Rhine with such given topographic advantages.



**Figure 10**  
1. Late Roman streets (Le Febvre, 1934)  
2. Mainz - Expansion towards the river (Municipal Planning Department, 1998)

## The Dutch Lowlands

For the Dutch lowlands, other methods had to be developed to protect the cities against high water levels. Settlements were erected on sand dunes formed by natural sedimentation processes. As broad, linear elements parallel to the river, they enabled only some degree of flood safety (Boo de and Middelkoop, 1999). To protect settlements, the first dikes were erected in the Netherlands around the 10th century, but they were positioned upstream from the villages and orthogonal to the course of the river. Numerous floods along the Dutch Rhine branches in the thirteenth century led to the erection of the first closed dike ring system (Ven, van de and Driessen, 1995). Yet, this system was not capable of sufficiently protecting the areas inside of the dikes. Dike breaches and exceedances led to inundations of the hinterland every winter (Ven, van de and Driessen, 1995). Furthermore, for the adjoining areas inside the dike rings, the proceeding land subsidence demanded for drainage techniques to cope with rising ground water levels and excess water within the enclosed systems (see fig. 11.1). The Dutch landscape as an anthropogenically steered system arose from 'turning a natural landscape into a cultural landscape. Polders have long formed a blank canvas for experiments in urban and landscape design. Agricultural interests were a central concern initially, but the polders were in fact colonized from the cities. Accordingly, their designs reflect an urban perspective.'



**Figure 11**

1. Evolution of water management in the Netherlands (RWS)
2. Dordrecht - Loss and development of land in the Northern Delta 1250 and 1600 (Ven, van de, 1993)

The Rhine and the Maas branch and rejoin on the way to the North Sea. This river constellation holds a number of islands, one of them being Dordrecht. As a city at the transition from river to sea on the confluence of five rivers, the urban development of Dordrecht is reliant on adapting to the dynamics of its surrounding waters. The transformation of the landscape occurred in exchanges between tidal and fluvial dynamics and anthropogenic interventions. Land loss had previously taken place as a consequence of subsidence due exploitation of the peat landscape, salt production and peat digging. The final outcome was not that negative since the peat was replaced by fertile sea clay (Ven, van de, 2004). While sedimentation led to a rise of embankments, islands developed as land was washed up from the sea (see fig. 11.2). Already in the 14th century Dordrecht was part of an anthropogenically transformed landscape. Before the devastating St. Elizabeths flood of 1421, induced by dike failure, Dordrecht already made up part of the Grote Waard, a number of waarden protected against floods by a ring dike. In the Golden Age (1600s), large land reclamation measures took place, resulting in the island of Dordt. This allowed Dordrecht to become a strategically important city in the Delta. For centuries, timber trade was the city's main economic driver. Its waterfront was lined with wooden windmills (Hooijmeier et al, 2005).

After the catastrophic storm surge in 1421, Dordrecht remained an island. Dynamics in water levels led to sedimentation processes that allowed Dordrecht to grow and that formed small islands in the lake. The expansions to the southeast of the historical city were endikened in the 16th century. The different phases of this process are still visible in the fan-shaped dike structure of the island (see Bax et al, 2008).

Dordrecht was founded in 1220 on both sides of the Turedricht in the midst of peat swamps, with the main streets and embankments located both on the harbour and on the river. The navigability of the river Merwede – Old Meuse was the main motive for the foundation of Dordrecht and allowed it to become a successful trade city. As the settlement grew, better protection against fluvial floods became important. Riverbanks were heightened and transformed into dikes. However, due to an expansion of harbour activities, the city also grew towards the river, thus expanding the urban area unprotected by dikes. In the thirteenth century, the area between these dikes and the river Merwede - Old Meuse mainly contained a marshy area with sand banks. The harbour and wharf area to the northwest of the Voorstraat was washed up and raised in the 13th century (Bax et al, 2008). In 1410, the construction of a harbour marked the first expansion towards the river. More expansions were carried out in the following years. In the seventeenth century, the harbour area was transformed into a living area, simultaneously turning the Voorstraat into a flood defense and into a central street of the quarter. The houses along the waterside of the Turedricht make up part of the flood defense (Hooijmeyer et al, 2005). The harbour and housing area to the Northwest of the Voorstraat were not protected against floods. Dordrecht is one of the few trading cities that is protected not by city walls but by dikes (Stalenberg, 2010) and that has such large areas outside of the dikes.

The majority of the Dutch urban landscape constellations in the lowlands differed significantly from the German and also French settlements upriver as they required combined technical landscape interventions: dikes to protect against flood events and a continuous draining of the adjoining landscape to enable urban development. Within a polder, the formal space is primarily defined by the pattern of the water structure and its waterworks. This differentiation between the threat of singular flood events and the permanently capacious landscape model of the Dutch polder system explains the fundamental difference between German and Dutch water management. While in the Netherlands, all aspects of existence are related to the specific geography and the appropriate water management system necessary to stay dry, in Germany, flood events primarily affect the waterfronts by random events.

### **Dynamic Landscapes**

However, waterfronts along the Rhine have not always been as linear as they appear today. The regional river segments, although very different both in terms of their morphology as well as their materiality, were dynamic landscapes with a river bed that changed its course within the possible realm of the flood plain. The width of the flood plain varied depending on the river segment from over 15 kilometers along the Upper and Lower Rhine to only 300 meters within the steep valley of the Mid-Rhine. Extreme flood events occurred along the German Rhine in 674, 886, 1124, 1295, 1342, 1573, 1651, 1652, 1758, 1784, 1813, 1876 and 1882/3 (Hartmann, 2011). Although Dutch water management had already developed innovative technologies to prevent areas from being waterlogged along the Dutch Rhine branches from the 16th century onwards, storm surges still occurred in 1625, 1686, 1717, 1775-1776, and 1776-1777. Equally severe river floods occurred in 1608, 1651, 1725, 1741, 1757, 1784, and 1799 (Stive, Vrijling, 2011). Neither of these lists claims to be complete.

As a consequence of the changing riverbed, villages, as the only settlements in the flood plain along the Upper Rhine, were completely captured by the river or changed sides in the course of a flood event (Blackbourn, 2006:84). Ten meters below Karlsruhe, the few settlements in the flood plain of the Upper Rhine subsisted on hunting, fowling, fishing and gold sifting (see fig. 12.1). As the Rhine constantly changed its meandering bed, land was washed away with the floods. Repeatedly, the islands and parts of the high shore were eroded and broke off. Only small celtic groups and eremites settled here between 400 to 113 BC. The oldest village was located on the island Rappenwoert and washed away in the 7th century. Some settlers tried to develop dwellings in the trees to adapt - without success. On the upper shore, the village Daxlanden was founded located in a swale. This offered protection against wind while surrounding bushes and weeds offered protection against the cold. At this time (around 644), the Rhine bed was located on site of the Federbach, a small Rhine tributary, which today ends in an old Rhine arm. So, once more, the village with about 30 to 40 houses, directly adjoined the Rhine. Yet, as the swale was located on the high shore, they felt safe from the water.

Daxlanden provided the only ferry connection between Baden and Pfalz, profiting from tolls for all imported goods. In the 18th century, the village became an important trading point with guesthouses. Even the Dutch came to Daxlanden to import large amounts of wood from the surrounding mountain villages. The wood was brought to Daxlanden, tied together in rafts and sent down river. Due to tolls, this was very profitable for the little village. In this period, the construction work on Karlsruhe was underway.

Karlsruhe, also known as the fan-city (see fig.12.2), was laid out on the Upper Plateau of the Rhine at an elevation of 115 and 322 meters above sea level, with the villages on the high shore at 114 meters. Due to the meandering of the Northern Upper Rhine segment, the flood plain here has a width between 3000 and 9000 meters. After the latest ice age, large amounts of melting water from the mountains transported and deposited sand, stones, pebbles and boulder in the flood plain. The Rhine therefore developed its bed in meanders through the lower plains and produced a lot of islands. Karlsruhe, located on the Upper Plateau 10 meters above the flood plain, was not prone to flooding, but the villages in the flood plain, Daxlanden and Knielingen, were. In 1350, Daxlanden became part of the manors belonging to the Badense dynasty, who began building dikes and river regulations on a local scale in order to protect their lands.

The villages profited from their position in the flood plain, but were repeatedly flooded and equally affected by changing riverbeds and the repeated failure of dikes. In 1560, the Rhine was moved west and further dike and rectification measures were carried out. Preceded by one of the coldest winters recorded, the worst flood occurred in 1651. At the end of February, all tributaries carried so much water to the Rhine that the flood plain completely inundated. The unfortified shores were no longer capable of holding even though sacks, chains, beams and ropes were used to hold the weak segments of the shore. Due to its location in the swale without a discharge, Daxlanden remained flooded and buildings were destroyed. Still today, the height difference of the steep slope of the high shore to the Federbach is seven to eight meters. Repeatedly, large floods are mentioned. Also in 1590 Daxlanden is hit by a severe flood, which tore away the entire dike leading to Knielingen.

In 1652 rectification measures included the cut of the Fritschlach dike and the digging of a new main bed. As a consequence, three villages changed sides, becoming right bank settlements. Again, in 1673 and 1677 new dikes were erected around Daxlanden and Rappenwört. Between the late 18th century and 1830, 425 hectares of land had been lost to floods. Severe floods occurred in 1758, 1760, 1784, 1791, 1797 and 1802. Floods also occurred in all preceding centuries, often in several years in a row ([www.daxlanden.com](http://www.daxlanden.com)).



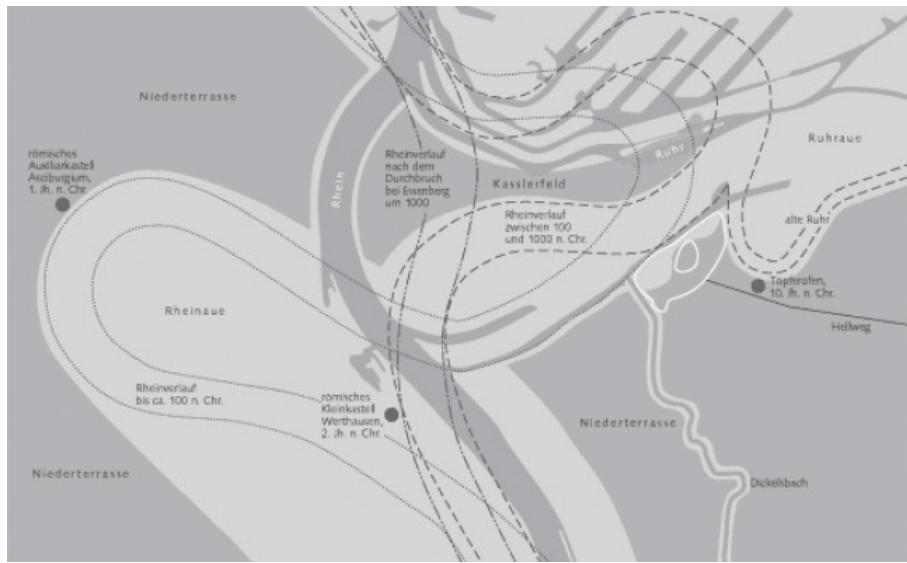
**Figure 12**

1. Karlsruhe - villages in the flood plain 1713 ([www.daxlanden.com](http://www.daxlanden.com)).
2. Projection of fan city etching, Heinrich Schwarz 1721 (City Archive Karlsruhe 8/PBS XVI 18.

The phenomenon of changing riverbeds affected cities all along the river (see fig. 13) and triggered continuous interventions in its course, at this stage on a local scale. For example in Zutphen along the IJssel in the fourteenth century, the river course was altered to reduce the flood risk of the Southern part of the city (Stalenberg, 2010).

Manipulations of the river bed, however, were not only executed to reduce flood impacts. The strategic role of the left bank foundations were just as vulnerable to river dynamics. The implementation of groynes in Cologne in the thirteenth century were meant to avoid current dynamics from changing the convex waterfront on the left bank of the main channel to a side-arm on the right bank, thus also changing political constellations in a fundamental way (Ahrends, 2007). Initially as a reaction to flood threat or in case of fortifications for geopolitical reasons, measures remained local. Although impressive efforts were made, there was no awareness of the river scale. Adapting to the naturally given conditions on an object scale often created solutions.

Adaptations on the object scale were taken by many Dutch farmers, who adjusted their farms or built new farms with a raised ground floor by 1.0-1.5 meters to prevent the inundation of social rooms (Ven van de, 1993). The area beneath the house became a cellar that could flood. Additionally, stables were elevated to keep cattle dry during flood conditions. In those days, floods were not unusual. Devastating dike-breaches occurred along the Dutch Rhine branches at least thirteen times in the eighteenth century. (Bosch and Ham van der, 1998 in Stalenberg, 2010:27)



**Figure 13**

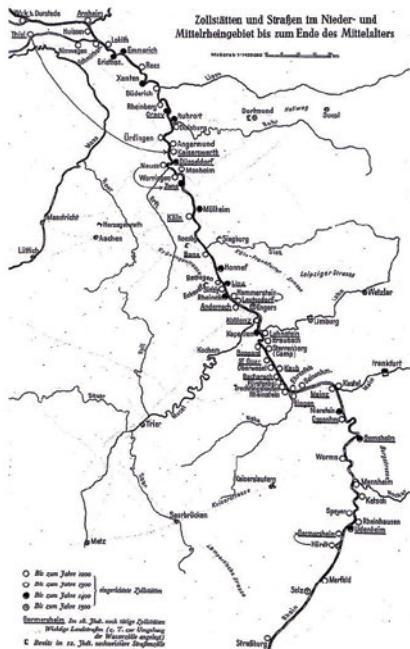
Duisburg, changing river bed until channelling in 19th century (Wasserwirtschaftsamt Duisburg).

### **Navigation and Urban Development in the Middle Ages**

The ability to adapt on the object scale also shows in the navigation system up until the nineteenth century. Changing barges according to the specific river systems' demands made Cologne and Mainz, for example, important harbours for the transshipment of goods. The river was not transformed, but boats were adapted to the conditions of different river segments, which in turn produced toll points (fig. 14). With the power of the Catholic Church in the Middle Ages, Mainz, like many other Rhine cities, developed into a global market place. Its wealth relied on the pile rights given in 1317. All goods that were transported on the river past Mainz had to be marketed for three days. Only goods that were not sold could be transported further up river ([www.zollhafen.de](http://www.zollhafen.de)).

Urban development expanded towards the river, filling the gap between the former Roman fortification and riverfront and expanding the fortification lines perpendicular to the river. Gradual profiles with wooden embankments defined waterfronts as the site for economic activities. After the decline of the Roman Empire and resulting from phases of migration, medieval city states began to rise, expanding on the plan of Roman left bank cities. Roman left bank foundations transformed into medieval commercial centres, and toll and transshipment points from sea to river barges, as in the case of Cologne and Mainz. Commercial agreements between cities were organized in the Hanseatic League. While city states began to be shaped by a civic society based on economic developments strongly linked to trade on the river, the area outside of the cities fortified boundaries remained rural (Febvre, 1934). The urban typology remained framed and dense. Along the Rhine, bulwarks protected medieval cities, and the

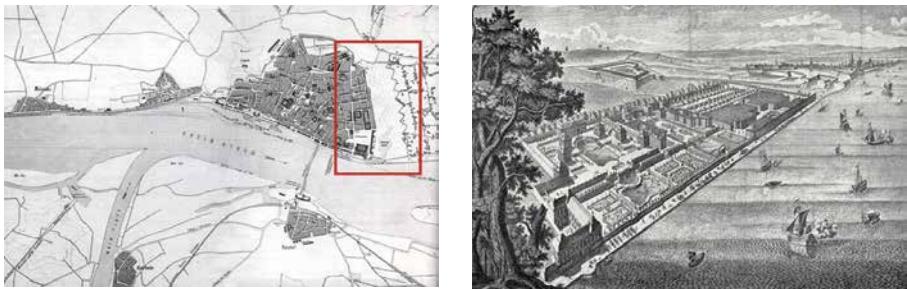
Roman outposts on the right bank were also further established. Yet, for the majority of the cities the right bank remained limited to this military function. The fortifications of many medieval cities also functioned as a protection against floods (Hooimeijer, Meyer et al, 2005). However, as the independent geometry of the bulwark shows, topographical qualities of the landscape no longer defined urban development. By expanding the city into the flood plain, its vulnerability to high water levels was taken into account as to accommodate economic activities related to the river.



**Figure 14**

Toll points and streets along the Lower and Mid Rhine until the end of the Middle Ages (Niessen, 1926).

As part of the Limes, Nijmegen is a Roman left bank foundation on the river Waal surrounded by the high ground of the lateral moraine and forests, the last Roman foundation with these privileges. The two castles are erected at a distance to the river as the given topography protects the upper city against fluvial floods. Only the lower medieval city laid out between the former castles is flood prone. The houses along the urban riverfront protected the lower city from floods, since it had no doorways facing the river (Van der Grinten, 1980 in Stalenberg, 2010:58). During the middle ages, the city became a successful trade city and was fortified. In the following period, also the lower city was fortified, simultaneously protecting the city from floods and from adversary attacks. Beyond using the fortification as a defensive system against floods, inundation trenches could be integrated in the bulwarks, as in the case of Mainz (see fig 14.1).



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**Figure 15**

1. Mainz - The inundation entrenchment to the northwest of the city on site of the future expansion plan. (*Stadtplanungsamt Mainz, 1998*)
2. Mainz - The Baroque Pleasure Palace Favorite built between 1700-1722 and destroyed during coalition wars in 1793 (etching by Salomon Kleiner, 1726).

### Baroque City Foundations

Ideals of enlightenment defined the two 17th century foundations along the Rhine, the residence cities of Karlsruhe and Mannheim. The two differed fundamentally in the way they were positioned in relation to the river. Karlsruhe was the latest city foundation along the Upper Rhine in 1715. As a residence city based on absolute principles and the ideals of enlightenment, it was laid out in the forest on the Upper Plateau ten meters above the flood plain. The geometric compass layout (at that point divided into 32 rays) with the castle at its centre embodies the idea of absolute reign. Nine boulevards are oriented south while the others give access to hunting grounds and connect Karlsruhe with the surrounding villages. The radiant layout of the city and its planned building-height development from the three-storey castle to the single-storey resident buildings are examples of the idealist city typology. In a second development phase, the absolutist principles of this radiant urban layout from the castle were complemented by classicistic elements, most prominently the axis from the castle to the Ettlinger Tor (Bräunche, Koch). While Karlsruhe was erected to be flood-safe on a high plateau ten meters above the vast river bed, Mannheim was planned as a fortified city protected by moats with the task of securing the confluence of the Neckar into the Rhine.

The formalist baroque pleasure palace Favorite along the waterfront of Mainz shows that not all developments of this era chose the distance to the river or a location within the fortified city (fig. 15.2). Erected at the beginning of the 17th century, the gardens were located outside of the fortification across from the Main confluence. This proved to be a mistake, as occupation led to the destruction of the garden ensemble during the coalition wars in 1793 (<http://deu.archinform.net/projekte/12355.htm>). It shows Mainz' predominantly military role up until the Treaty of Versailles in 1919.

### **Stalling Development and Geopolitics**

At the end of the 17th century, a number of problems primarily rooted in the limited scale of interventions challenged city-river constellations in Germany and in the Netherlands. Although great efforts were made on a local scale, the dynamics of the river did not cohere with the fragmented strategies (Blackbourn, 2005). This applied not only to the development of singular dikes and the abuse of groynes for land expansion, but also to urban river fronts. Embankments made of wood, often not necessarily maintained, a lack of depth of the riverbed and obstacles leading to the damming up of water are only a few aspects which illustrate the uncoordinated approach to water management. The common understanding that natural forces were not fully controllable increasingly began to conflict with the rise of enlightenment and the inherent belief of mastering nature.

While the digging of the Pannerdensch Channel in 1707 provided navigable Rhine branches throughout the year (Ven van de, 2007), rivers were generally in a very bad shape in the 18th century (Bosch and Ham van der, 1998). Although lower hinterlands were protected by partitioning dikes to prevent a flooding of the entire area, land reclamation lead to an increase in flood disasters in the 17th and 18th century. Narrow riverbeds were prone to dam water during the winter time due to ice (Ven van de, 2007) and groynes to protect dikes against erosion were often used by landowners to increase the size of their estates.

Changes in the scale of flood protection measures were not to occur until a centralization of political structures permitted large-scale interventions to be executed. In the Netherlands, the foundation of the Batavian Republic (1795) made the central government responsible for water management. The French occupation led to the unification of the micro states along the Upper Rhine (1806). Similarly, the Prussian state's enlisting of Westfalia and the Rhineland for support during the battle of Waterloo against the French (1815, Treaty of Vienna) were prerequisites for the large scale channelling and dike erections to follow (see Blackbourn, 2006, Heezik, 2008).

### § 3.3 The Channeling – Industrializing The River

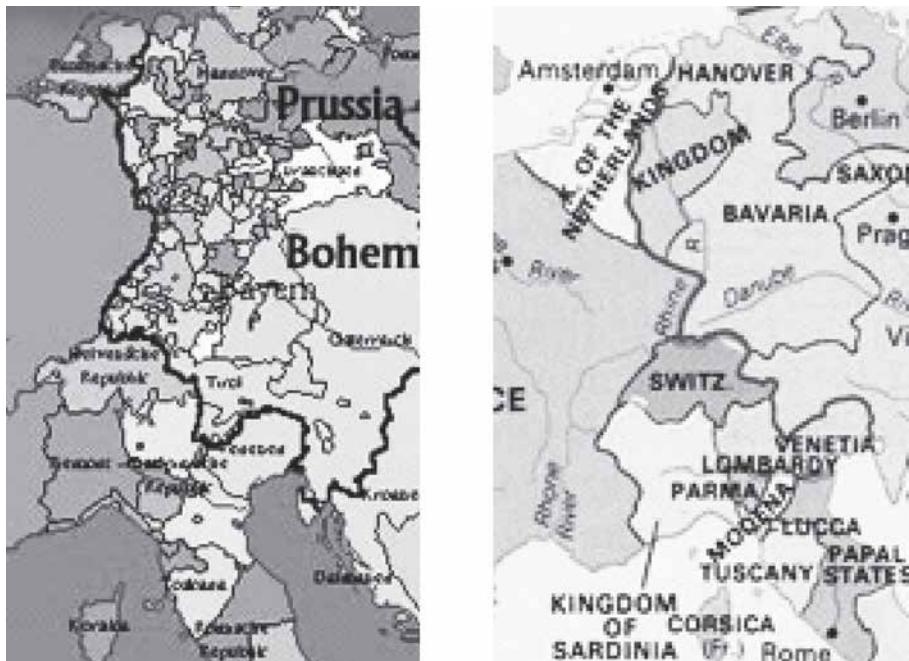
The term controlled may be applied to the phase of channelling in the 19th century that exemplifies the aims and understanding of a modernist approach to nature. Based on the belief that modern technologies were capable of outruling the forces of nature by superimposing infrastructural measures to appropriate the river, the demands of industrial production and navigation dominated. Urban development (land use) consequently followed this logic. It was no longer topographical criteria, but the efficiency of infrastructural hubs and nodes that predominated. Although palimpsests on previous transshipment sites in the flood plain, harbours became engineering works and, as such, alien to the natural conditions of the site. Navigation was no longer reliant on changing barges at different river segments. Instead engineering works enabled developments that were much more independent from local conditions. Large scale infrastructural measures were taken that allowed one type of ship to travel the river.

Long-term consequences were not considered, as the knowledge of the impacts of large-scale infrastructural measures on the water system did not exist at that time. They relied instead on trial and error, resulting in a regular raising and reinforcement of embankments after a flood event. There were some exceptions of course, for example Gottfried Tulla, initiator and engineer of the Upper Rhine-channelling project, who opposed a complete cut-off of old arms of the Rhine, foreseeing the negative influence on downstream communities (Blackbourn, 2006). While large-scale measures radically reorganized the system, awareness of and thus opposition to the consequences of the interventions only evolved over time. In order to manage and control the production and flows of goods, functions were eventually separated. Industrial zones as a third, highly restricted spatial entity grew to complement the previously dualistic relation between landscape and city.

In Germany, the first paradigmatic shift that implied a manipulation of the river beyond the local scale was the channelling of the Upper Rhine by Gottfried Tulla between 1817 and 1865. This new approach of channelling the river beyond the local scale can be considered as the true industrialization of the Rhine. Before a meandering river between Basel and Karlsruhe and from there on bifurcating until Bingen, the wild river became a deepened, narrowed stream, held in its partly new bed by dikes on both sides. The main aim of this intervention was the protection of 'riverside communities from flooding and allowing former marshland to be cultivated, as water tables fell' (Blackbourn, 2006:91). However, as efficient as they were for some causes, engineering measures had severe effects on the ecosystem. As ground water tables dropped, entire landscapes transformed.

Previous floods, but also political changes and technical innovation evoked the channelling of the Upper Rhine. At the beginning of the 19th century, on the right

bank of the Upper Rhine, Germany was fragmented into a multitude of micro-states (Blackbourn, 2006). The defense of the territories East of the Rhine occupied by the French led to a unification of these states, later enabling a clear boundary to form between France and Germany (see fig. 16). This development can be seen as the beginning of modern nation-building (Febvre, 1934). Without these political changes, the channelling of the Upper Rhine would hardly have been possible. Conversely, channelling was also favoured as it produced stable borders (Blackbourn, 2006). In the year 1800, the engineer Gottfried Tulla was commissioned by the Grand Duke to develop a coherent flood-protection strategy for the Upper Rhine. In 1819, the cutting of the new Rhine bed at the height of Daxlanden was carried out. As a consequence, Daxlanden became a right bank village, losing its left bank parishes and its position as a shipping and trading point.



**Figure 16**  
Nation States before Napoleon's conquests 1799 and after the Congress of Vienna 1815 ([www.cominganarchy.com](http://www.cominganarchy.com)).

Also, in the 19th century, severe floods occurred until the Rhine correction was completed. For weeks and months after the event, basements, barns and fields of the lower lying villages remained flooded. Houses remained humid and the surrounding

areas were swamps. Consequently, not only the inhabitants of the affected villages but also the settlements on the rim of the high shore suffered from malaria and typhus.

In the spring of 1817, the forest areas within the cuts were felled. This produced severe local resistance as land had to be given up to other villages that had changed river sides due to the rectification. Due to local resistance, it took months to start the digging of the main trench. Soldiers on vacation were hired to deal with the demonstrators. Even Tulla only came to the construction sites armed. However, since the land owners were compensated and the rectification measures produced a lot of work for the region, resistance eventually diminished. In Knielingen alone, 800 workers were working on the rectification project (10 workers were usually working on a 30-meter-long section of the main trench.)

As a cut picked up the thalweg of the current, it dug the new river bed with a width of 240 meters in the pebble sole. The future bank foundation was then fixed with weights. Later, the embankment below and above the water was constructed according to normed profiles. This process was not always easy.

Fowling, fishing and gold-sifting, the economies of the flood plain villages disappeared due to the increased velocity of the river. Yet, previous flood plains became agricultural land as swamps were laid dry. Mosquitoes no longer nested and the risk of fever diseases decreased. Also, previous border negotiations were no longer a problem as the fixed riverbed defined state boundaries. Although in 1882 a dike broke at Neuburgweier and flooded Fritschlach by two meters, the village center remained flood-free due to the rectification; only the brickworks at the Saum Lakes were severely affected. The main dike in the flood plain of Karlsruhe was not built until 1934.

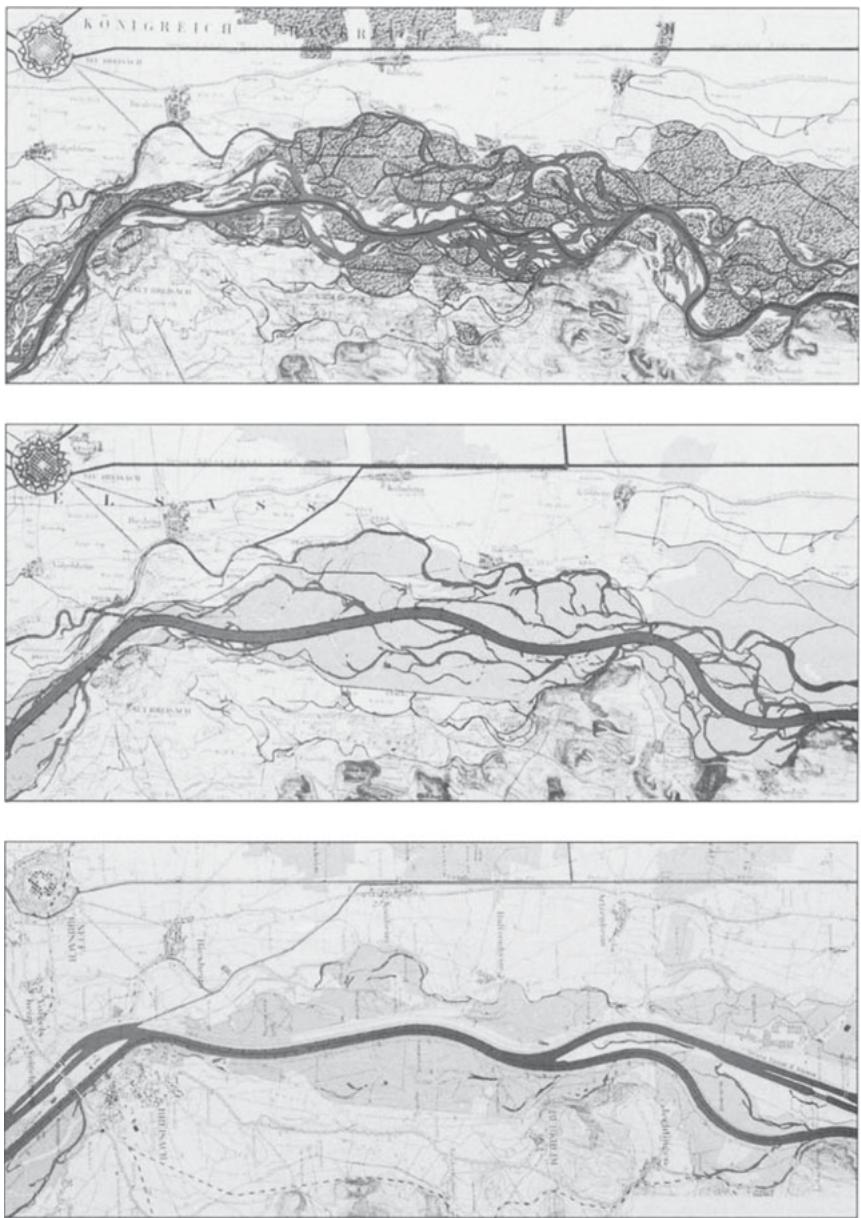
In 1818, the first plans were also developed for a harbour to connect Karlsruhe with the Rhine via a canal, by, amongst others, Johann Gottfried Tulla. He also planned a water pipeline from the former residence of Durlach to improve the drinking water situation in Karlsruhe (Bräunche, Koch). However, up until the founding of the German Empire in 1871, industrial investments in Karlsruhe as a location remained modest due to its position on the border with France. In 1902, the Rheinhafen opened, taking 440 hectares of land from the village of Daxlanden. Many day laborers began working in the harbour, loading and unloading goods such as coal. In 1910, Daxlanden became part of Karlsruhe part of the agreement being the installation of a tram connection to the city. In 1954, the Rheinhafen steam power plant was erected. Industrial development in the former flood plain peaked with the location of two oil refineries North of Maxau in the 1960s connecting with the pipeline Marseille-Ingolstadt ([www.daxlanden.com](http://www.daxlanden.com)).

The channelling shortened the course of the river between Basel and Worms from 350 to 270 kilometres (Blackbourn, 2006) and accelerated the flood wave between Basel and Maxau from 64 to 23 hours (Bismuth et al, 1998). Due to width of the

riverbed of the Upper Rhine, dikes now protected extensive lowlands. In 1817, the year the Tulla project began, the Rhine was enveloped in 2300 square kilometres of flood plain (Solmsdorf et al, 1975) varying in width from a few hundred meters to fifteen kilometres. By 1975, only 1/10th of this ecological corridor of forests, marshes, meadows and reeds remained, leaving only small patches unable to function as a continuous corridor. 'A riverscape otherwise dominated by human enterprise, the flood plain had lost its geographic breadth, biological diversity, its ecological dynamism and much of its self-cleansing capacity' (Cioc, 2002:16). Thirty years after Tulla began what he named the "Upper Rhine Correction," the Prussian navigation project of channelling the Lower and the Middle Rhine between Bingen and the Dutch-German border was carried out (Cioc, 2002). In the course, the Lower Rhine alone was shortened by 23 kilometres (Bismuth et al, 1998).

The channelling of the river itself changed the morphological and hydrological state of the basin from Basel onwards. This affected all areas of life. Sifting for gold, one of the oldest activities on the Upper Rhine, as well as fishing and fowling disappeared, as did the fish markets and fishing boats from the urban waterfronts. Cities also stopped serving as toll and transition points from sea to river barges. Instead, arable land and industrial production, thus urbanization, continually increased. Developments linked to the rectification of the Rhine produced a relationship between the occupants and the river that 'correlated to a lesser extent with natural circumstances' (Hooijmeier et al, 2004). While the first rectification phase of the Upper Rhine served flood protection and permitted side channels, the second phase, which lasted until the 1970s, also implied the amputation of side arms to further improve the navigation capacity of the main river. This was not favoured in Tulla's original plans, who rightly anticipated the consequences: an increase of floods down river (fig. 17).

The development of cities such as Mannheim at first profited from the new order of the river course. The river mouth of the Neckar was relocated in the 1860s and 1870s as part of finalizing the correction measures (Friesenheimer Durchschnitt), and the city built the Industriehafen. The new harbour in the former side arm of the Rhine immensely contributed to the economic prosperity of the city in the years to come. South of Mannheim, conditions for shipping remained extremely bad due to shifting pebble islands and a lack of depth in the shipping lane. In the next rectification phase, instigated by Max Honsell and Willgerodt (first name unknown), the erection of groynes and submerged dikes ensured the navigability of the Upper Rhine. Mannheim, as the main transshipment hub from river to tracks, lost its strategic position in the course of further regulation measures between 1907-1913 that enabled the navigability up until Strasbourg and in the coming decades, as far as Basel (Bernhardt, 2000). The case of Mannheim exemplifies how large-scale river transformations also resonated in the development of individual cities. While before, the original river typology defined navigability and thus related development, this change of path made geospecificity something that could be manipulated to produce corridors of industrial economic activity.



**Figure 17**

Topographical maps of Upper Rhine channelling (exemplary sections): 1828 - wild river with side arms, branches and gravel banks; 1872 - average width 200 m, doubling average discharge capacity, alluvial forest still flooded; 1963 - Rhine side channel, barrages, dikes directly aligning river bed, disconnection of alluvial forest. (Ministry of Environment Baden-Wuerttemberg, 2007).

The concept of navigation along the Rhine also changed with the second phase of rectification and the Act of Mannheim, an international agreement in 1868 that abolished staple rights and tolls. The shipping lane was channelled to a maximum of 450 meters between the Main confluence and Bingen, producing dike lines on both sides of the river and hard urban embankments along the cities' new riverfronts as they further expanded into the flood plain (Stadtplanungsamt Mainz, 1999). Harbours that were previously in the gradual flood plain, equipped with wooden embankments, now became excavations within the urban extensions into the river with hard orthogonal profiles (fig. 18). Transforming the natural flood plain into an orthogonal embankment expanding into the river served as the basis for further urban development.



Figure 18

Mainz 1887 - the Neustadt and the Zollhafen in the former side channel (City Archive Mainz).

### Netherlands

In the Netherlands, devastating dike breaches occurred at least 13 times in the 18th century (Bosch and Ham van der, 1998) and led to the foundation of the Ministry for Public Works and Water Management, Rijkswaterstaat, in 1798. From this point on large river works became feasible, such as the construction of channels, the deepening of existing rivers and the construction of groynes (Ven van de, 1993). Yet, the 'normalization' of the river was discussed with great controversy beforehand. Although, many were in favour of diverting river flows instead of normalizing the streambed, no one responsible on a local scale was willing to provide areas within their districts for emergency overflows voluntarily (Heezik van, 2008). It was not until 1850 that plans led to actual implementation, this time massive river works (Bosch and Ham van der, 1998), such as the channelling of the river Waal in a fixed bed aligned with groynes.

In the Netherlands, river dikes differed in height at the end of the 19th century. Extensive dredging created a system of channels to improve water discharge and to create shipping routes. As the natural Meuse and Rhine branches silted up, in 1870,

the New Rotterdam Waterway was constructed as an artificial mouth for the Rhine that kept the port of Rotterdam accessible for sea vessels. One of the main points of controversy was the optimal width and depth (through erosion or dredging) of the riverbed. Although channelling improved navigability, it also led to higher water levels. Especially during the construction of the Nieuwe Merwede, the adjoining areas flooded frequently (Heezik van 2008:32). While the Upper and the Lower Merwede were made suitable for shipping, the Nieuwe Merwede, completed in 1885, was designed to discharge water and ice. All three Merwede branches relied on continuous, large-scale dredging (Heezik van, 2008). After the discharge of the Maas was improved in the 19th century, a full separation of the Maas and the Waal was finalized in 1904, with the completion of the Bergsche Maas (Hooijmeier, 2005).

The 'normalizing' of Dutch river branches took place gradually through the construction of new groynes, training walls et cetera, as well as by getting rid of damaging river works. Various islands and sandbars in the rivers had to be linked to the banks, particularly on the river Waal. In this way the river would become a single channel, and this would considerably reduce the chance that ice barriers would form. In this context, a general norm needed to be determined for the heights of the dikes and the summer dikes. (Heezik, 2008). Navigation was the main motive for normalization, also due to the pressure from Germany's criticism of the state of Dutch rivers: 'the rivers constituted essential economic links with other countries - but especially the German hinterland, on which the Dutch economy grew increasingly dependent in the course of the 19th century' (Heezik, 2008:29). The channeling of the Waal was carried out in different phases, based on trial and error. The second rectification design implied a slightly meandering layout where groynes narrowed the navigation channel and dredging was increasingly applied to accommodate the water depths needed (Heezik, 2008).

Apart from differing safety concerns and the financial means of the water boards, this depended to some degree on the extent of buildings on and along the dikes. Along the Waal, houses, sometimes even entire villages, were positioned on both sides of the dikes (Heezik, 2008).

The Dutch Delta was affected by not only river floods but also storm surges, most devastatingly in 1916 and 1953. Large-scale reclamation projects followed. With the Delta Act, passed in 1958, the decision was made to close off the inlets that made the Netherlands so vulnerable to storm surges (Stive, Vrijling, 2011) by developing the Delta Works. They consist of dams, sluices, locks, dikes, levees, and storm surge barriers with the aim of shortening the Dutch coastline, thus reducing the flood risk from the sea. For the first time, measures were not based on a trial-and-error approach, but involved a probabilistic approach that was also applied to the Dutch dike ring system (see Chapter 4 Flood Risk Management).

### **Urban Expansions into the Floodplain**

The normalization and rectification developments no longer only induced trade activities, but in the course of industrialization, people from the rural areas came to the cities, eventually leading to further urban expansions. Between 1860 and 1865 rectification measures were taking place at the height of Mainz expanding the embankment into the river. New harbours were built in the former flood plain. With the simultaneous development of the train as a new mode of transport, Mainz became a modern trading place of the industrial age. In 1860, the Winterhafen was erected on the southern border of the left bank in connection with the first Central Station on the Rhine, erected between the waterfront fortification and the river, its dam also serving as a flood defence. The Winterhafen also served as an emergency harbour during floods. Ten years later, the train station was complemented by the first permanent bridge across the Rhine since Roman times. Due to the growing transport sector, an additional railway station for the transport of goods was erected, as part of the urban expansion plan of the Neustadt. A lack of space for additional tracks led to the relocation of the Rhine station to the south of the historical city in the 1880s.

In 1869, Mainz was the densest city along the Rhine with 89 persons to a quarter hectare (Berlin 28, Cologne 78). As a result of both the fortification and the ratio of military space (7 square kilometers) to civic space (1.2 square kilometers), urban development within the city walls was not possible. At the same time, stone houses were not allowed in the Gartenfeld to avoid their use by adversaries for defensive purposes. The remaining fortification prevented Mainz from becoming a major industrial city as it lacked space to accommodate large factories. Production included leather and textile processing, wood processing, food processing and construction and iron steel industries. All of these industrial activities were reliant on the harbours. Only after the agreement to expand the fortification beyond the rayon zone of the Gartenfeld to the northwest of the historical city did urban expansion plans really begin. At once, spatial capacities doubled. Development in the Neustadt relied on the expansion of the city into the river. The new embankment was also fortified ([http://de.wikipedia.org/wiki/Geschichte\\_der\\_Stadt\\_Mainz](http://de.wikipedia.org/wiki/Geschichte_der_Stadt_Mainz)).

The Neustadt of Mainz was developed on a symmetrical grid-layout. It was, structured by green boulevards and squares inspired by Haussmann's redevelopment of Paris. Three major axes from the northwest to the southeast connected the historical city with the Neustadt. Between 1880 and 1887, the Zollhafen and the new raft harbour in the banked up Ingelheimer Aue, the Ingelheim flood plain, later redeveloped into the Industriehafen, were erected in the former flood plain of the fortified Neustadt. As the area of the former Gartenfeld was very low, it flooded frequently. Plans entailed raising the entire area, also necessary for installing the canalization system. Due to the scale of the site and lacking funds, this was only realized partially and often after houses had already been erected. Therefore many of the buildings in the Neustadt have very low-lying plots or basements (<http://de.wikipedia.org/wiki/Mainz-Neustadt>).

The Act of Mannheim also declared shipping to be free for all, thus changing the geoconomics of toll points and staple rights, the source of economic prosperity for many cities along the Rhine. With the rise of industry, harbours and their adjoining production sites and open market places were no longer the centre of urban life, but became increasingly restrictive areas.

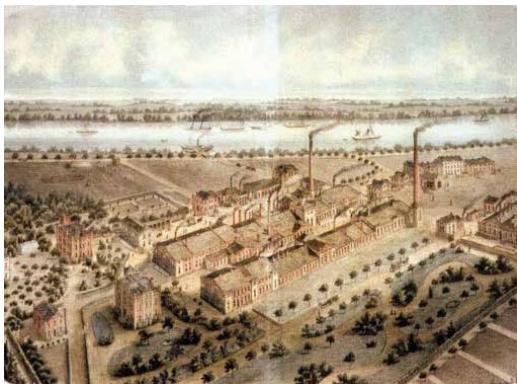
With the migration of harbour activities, new urban embankments created opportunities for promenades along the urban riverfront where, historically, only transshipment activities and trade had taken place. With the rise of leisure and the activity of flaneuring along urban riverfronts as a bourgeois phenomenon, transshipment activities and markets were gradually separated from the previously joint public sphere.

Anthropogenic transformations of the Upper Rhine between Basel and Bingen in the 19th century mainly served flood protection, the reclamation of agricultural land and the navigability of the Rhine until Basel. In the Treaty of Versailles in 1919, France was granted the right to develop hydro-energy plants along the Rhine. Between 1928 and 1977, ten barrages were erected as water power plants along the Upper Rhine between Basel and Iffezheim. With them, also sluices for navigation were built. Consequently, the loss of flood plains meant that flood protection down river from Iffezheim was no longer sufficient. In addition, due to an increased discharge velocity and the erosion of the riverbed, water could only flood the adjoining areas at very high flood levels (Ludwig, 2008).

### **The Rise of Leisure**

During industrialization, the river became a transport route where the now historical city faded to mirror its commercial activities. The channelling of the Upper Rhine made the centres of commerce and transshipment volatile, gradually evoking their musealization. The public rise of leisure, introduced by unions demanding 8 hours work - 8 hours sleep - 8 hours free time (Decaix, Redecker, 2001), made the riverbank into a site for leisure and labour that demanded a linear expansion of the city along the waterfront in order to accommodate both. Floating public swimming pools were installed at the waterfront within the city, for example in Basel and Cologne, while industrial plants began to expand on the rims of the cities (fig. 19.2).

Taking down the cities' fortifications to give way to horizontal expansion created the preconditions for modern urban planning. Triggered by the growing conflict induced by industrial production, programs began to separate. The transformation from a mercantile to an industrial economy led to scale enlargement and specialization of urban space and functions. Traffic infrastructure such as train dams were combined with flood defensive functions, for example with the erection of the first train station along the riverbank in Mainz (Stadt Mainz, 1999).



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**Figure 19**

1. Leverkusen, 1876, A. Eltzner (City Archive Leverkusen)
2. Ford plant parking newly built cars on sand in 1932 ([www.mediaford.com](http://www.mediaford.com))
3. Rheinstrandbad Rapenwörth in the flood plain of Karlsruhe, 1928 (Bundesanstalt für Wasserbau)

Also new industrial cities were founded that relied on the strategic waterfront positions for transshipment, cooling water and waste discharge. Ludwigshafen along the Upper Rhine, vis-à-vis Mannheim and Leverkusen along the Lower Rhine, founded in 1860, are two examples. The cities evolved around the chemical plants of two global companies, BASF and Bayer (see fig. 19.1).

At the same time, leisure activities were no longer bound to the local. Ferry stops for excursions on steamboats to the castles of the Mid-Rhine were installed. Romantic prose focussing on the landscape of the Mid-Rhine with its vineyards and castle ruins fed the subjective ideal of a bucolic landscape. Leisure became an institutionalized public good on different scales along the river. Already during medieval times, certain activities were located outside of the city walls to avoid, for example, fire. However, the compact medieval city was incrementally freed from its multifunctional structure as it no longer needed to be protected against military invasions and began to spread out into the region. The urbanized landscape began to rise.

In 1928, the Rheinstrandbad Rappenwört, a Rhine bath in a former side-arm, and an ornithological station were built in the former flood plain of Karlsruhe, introducing leisure to the flood plain (fig. 19.3). Thousands of visitors came to the opening. Plans were to make the island Rappenwört a beach hotel, to have a café with a dance floor, and to create sports fields and educational facilities for the ornithological station. The bath was built as summer leisure facilities for families of the impoverished middle class, workers and civil servants who did not have the possibility to travel. The Rheinstrandbad was part of Neues Bauen. Between 1936 and 1954, the housing project Rheinstrandsiedlung with allotment gardens was built.

### **Unintended Consequences**

The increasing dynamics in water levels also have negative consequences for navigation. During high water levels not only bridges may become too low, but at some point shipping has to terminate completely. Even more problematic are prolonged low water levels, for example along the Lower Rhine and the Waal as ships can transport less to reduce their depth, leading to an increase in the number of ships and queues at the Dutch sluices (Pelt et al, 2011).

As a consequence of channelling, sedimentation and erosion are producing challenging effects on a systems scale. Specifically in the Rhine-Meuse Delta they affect the stability of dikes, groynes and banks, the navigation channel, the safety level of cables and pipes dropping below the envisaged safety level, dropping ground water levels and the discharge distribution (Pelt et al, 2011). This requires dredging and sediment supplementation, for example in the Dordtse Kil.

The increasing industrial activity and associated pollution, as well as the increased velocity and current due to the channelling of the river, also eventually led to an

alienation process. The river was no longer capable of accommodating work and leisure activities along its urban river fronts. Cities began turning their backs on the waterfront. They were not rediscovered until the beginning industrial decline.

In the Netherlands, fishing lobbies founded the first environmental organizations, already at the beginning of the 20th century. Negative effects linked to channeling and salination had become an issue for farming and fishing since the 1850s, but increasing water pollution specifically affected the fishing sector (Heezik van, 2008). However, due to the economic strength of industrial production paired with a technocratic approach to river management, these voices remained more or less unheard until this era had passed its peak. First doubts about a technocratic approach to river management evolved in the 1960s with a general critique of modernism, pollution and damage to the natural environment (Heezik van, 2008).

Due to the long list of 'unintended consequences of hydraulic engineering (...): anti-flood measures that brought new flood risks, corrected rivers that unexpectedly scoured their beds, dams that had unanticipated side effects, water tables that fell catastrophically - all had a place in the catalogue of engineering own goals.' (Blackbourn, 2006:328). The negative consequences were very heterogeneous. For example, ground tables dropped dramatically only along the Southern bifurcating section of the Upper Rhine, while the negative effects of the polluted river water were a more severe problem for the remnant alluvial forests outside of the defense along the northern, meandering Upper Rhine, where the area behind the defence turned into botanically richer landscapes (Blackbourn, 2006). Specifically water quality, but also desertification stood in the focus of German, at this point conservationist, opposition rising at the beginning of the 1950s. In 1970 the newspaper Die Welt called the Rhine 'Germany's largest sewer,' a Federal office for the Environment was founded in 1974, and the Green Party was constituted at the end of the 1970s (Blackbourn, 2006:331). Alfred Töpfer, at that time minister of the environment, dove into the Rhine in 1984 to provide living proof of the improving water quality. Due to exceptional international efforts by the Rhine states, organized in the ICPR, the rejuvenation of the Rhine had already begun a historical development. With the ongoing implementation of the water framework directive, it still continues. Yet, the structural quality of the Rhine and the Rhine embankments as a consequence of engineering measures well up into the late 1970s to provide not only flood protection, but electricity, navigability and drinking water, remain a challenge.

While apologists of an ecological restoration of the river and its adjoining flood plain demand for a deconstruction of rectified solid river embankments, at the same time, engineering driven maintenance measures are manifold. Beyond the maintenance of dikes as described in the next chapter, for example dredging to provide for the depth of the shipping lane may be named as one of the economically

most evident. Although vulnerable to the dynamics in water levels, the navigability of the river is directly linked to economic growth/capacity, the restoration of the flood plain and maintenance of defensive structures are not.

On a regional scale the net city strategically positioned factory complexes and business units next to traffic nodes. Traffic infrastructures for trains began lining the river as the invention of the steam engine marked a key development of industrialization. Later automotive transport led to additional linear networks. The river played an increasingly subordinate role. After the war, the concept of the 'Autogerechte Stadt', the car-friendly city, was applied to the post-war developments of many cities. On the scale of the compact city, in many cases, this reorganization of the urban form in accordance with the automobile implied an orientation away from the river and led to a further decline of the urban waterfront, already in full swing due to the separation of functions and worsened by the industrial pollution of the river water. Later, in the 1980s and 1990s, the decision was made to relocate some of these infrastructures underground, specifically for prominent sites within the inner city, such as in Cologne and Duesseldorf. Road segments were tunnelled in order to re-establish the connection between the historical city and the river. Although limited to a conception of the urban riverfront as a site for leisure, these can be seen as a first step towards the rising awareness to urban waterfront potentials.

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### § 3.4 Trans-Industrial<sup>7</sup> Evolution (From Controlled to Controlled-Dynamic)

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As a consequence of increasing flood risk and damage potential, also for areas behind the defence line, paired with rising ecological awareness and declining industrial production, the threefold constellation of landscape, city and industrial zones in agglomerations along the Rhine is currently being redefined. For urban developments in areas at risk, the adaptation to varying water levels on site becomes an inherent part of planning, while on the scale of the river basin, large-scale mitigation measures aim to influence peak discharges. In terms of the ecological approach to these highly

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Given the spectrum of active industries along the Rhine such as BASF and Bayer, transforming industries such as Novartis and the general struggle to overcome industrial thinking, the term trans-industrial, coined by Rolf Peter Sieferle seems more suitable than post-industrial (coined by D. Bell, 1973).

complex landscapes both on a local scale as well as on the scale of the river segment, strategies can not solely imply a restoration of the original state. The original state here describes the dynamic state of the alluvial plain before channelling from a landscape perspective and the historical layout of the European city without considering the regional scale. Challenging the dualistic relationship between city and landscape demands a remediation (Lister, 2010) of the different layers and programs on site. At this point this implies dynamic niches in a regime defined by control while ideally aiming for a state of controlled-dynamic and a revival of adaptation measures on a project scale.

### The Agglomeration

Today, the urban condition along the Rhine is no longer that of clear urban entities, but a continuous development corridor with varying densities bound to the six major production and transportation hubs (see fig. 20): Basel/Mülhausen/Freiburg with chemical industries, food, textile and metal industries, Strasbourg with cellulose, food, textile and metal industries, Rhein-Neckar with Karlsruhe and Heidelberg, Mannheim, Ludwigshafen with chemical industries, the Rhein-Main with chemical industries, rubber industries, electro-, metal and service industries, the Rhine between Köln and the Ruhrgebiet with petrochemical industries, refineries, metal und car industries, and the service and trade centres in Köln, Düsseldorf and Duisburg and the Randstad with the Rotterdam-Europoort with refineries, chemical industries, metal and transport industries and European service industries (ICPR, 2001). As these six industrial regions have found themselves at least to some degree in a phase of declining production since the 1970s (oil crisis) that continued throughout the 1990s (global relocation of production sites), and in a spatial reorganization of transport logistics, they leave a palimpsest of structures and of programs behind. Although in this context tri-modal transportation includes river transshipment, many other commercial programs have historically found their way to the former flood plain that are not necessarily reliant on the closeness to the river (Herzog, 2008).

Along the banks of the Rhine today, there are 20 cities with 100.000 inhabitants or more. When adding up their peripheral settlements or taken together with an adjoining city, 17 of these are by the UN definition of 1997, urban agglomerations. Urban agglomerations comprise the compact city and its surrounding urbanized landscape and seem a productive categorization for the contemporary condition of formerly distinguishable entities along the Rhine. While some industries along the Rhine are still going strong, such as BASF in Ludwigshafen, or have managed to reinvent themselves, for example Novartis in Basel, certain regions are struggling to develop viable concepts for the vast industrial heritage of vacancies, specifically along the Cologne-Ruhrgebiet axis. At the same time the infrastructural landscape of the hinterland is defined by multi-modal transport connections between river ports and green hubs.

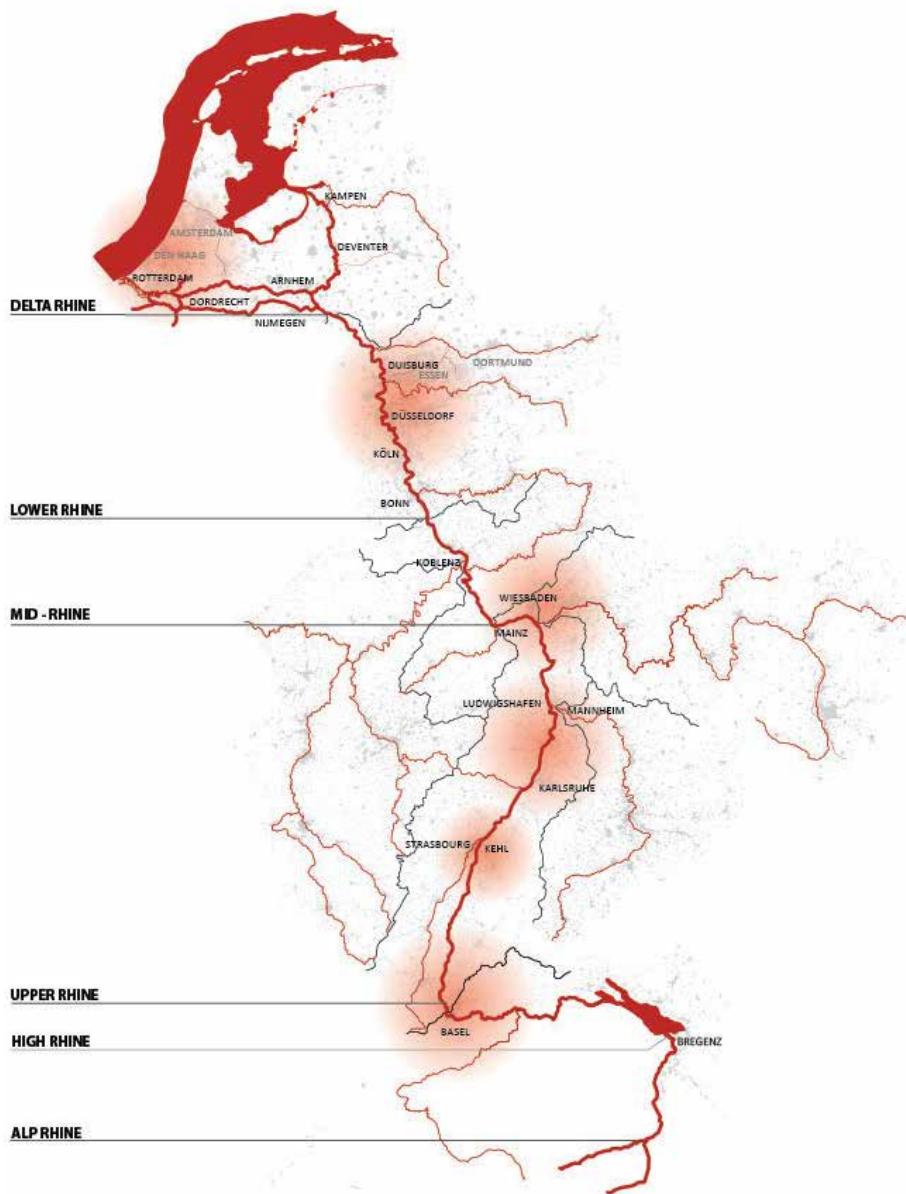


Figure 20

*The six major transportation and production hubs along the Rhine (ICPR, 2001, graphics by author)*

### The Compact European City

After the oil crisis, the compact city model came back on stage (DRO 1984). Decreasing energy consumption by lowering the amount of commuters and creating density became the incentive for urban redevelopment (Hoek, van den, 2008).

In the 1990s, often competing with cities more privileged in terms of topography and climate and also branding, city centers and their representative waterfronts were rediscovered. In many cases, the main actors were no longer omnipotent governments, but more and more market driven actors and combined public private partnerships (Meyer, 1999). Harbour conversions turned into privileged urban developments for dwellings and office space paired with the creation of a new public realm as the 19th century promenade, before limited to the historical city, now expanded along the full length of the compact cities' urban river front. However, a recognition of the original river typology or a remediation of its qualities are only marginal, as the 19th century embankments have left no links. In this context of positioning themselves in a global competition for location factors, cities along the Rhine today are increasingly confronted with two seemingly contradicting challenges. While the pressure of site value along their waterfronts demands redevelopment and restoration, the seasonal confrontation of their flooding increases.

Specifically the historical cities located along the river front are often flood prone, but in their structure and their status as monuments, they are also most difficult to adapt. This shows for Delta cities such as Dordrecht or Kampen, but also for the historical cities along the Mid-Rhine or the Lower Rhine, where historical cities directly adjoin the river. The integration of defensive elements remains a challenge and tends to involve high expenditures and long time frames while increasing risk may demand for height extensions.

As the lower city is flooded every year, the urban riverfront of Nijmegen was equipped with a flood defense in the 1980s that made reference to the fortification and was later supplemented by stop-logs for the individual buildings along the waterfront. This system was altered several times, most recently between 2007-2009, to meet the updated safety demands of the Dutch government. Existing quay walls were replaced with ones made of reinforced concrete with a brick cladding, and given added height through the use of stop-logs on top of the walls. Also, to the south of the bridge, stop-logs originally positioned within were moved to the front of buildings to make the support structure visible and accessible. In many cases they had been decorated or concealed while inside the restaurants (Stalenberg, 2010).

In the case of Dordrecht, there is no spatial capacity to install additional flood defences beyond ephemeral systems due to previous urban development. Flood prevention in Dordrecht therefore involves yearly flood simulation events organized by the water boards where the installation of stop-logs is practiced by the residents to raise

awareness for the inherent flood risk and to maintain operative knowledge regarding installation techniques .This is exemplary. Yet, during the last decades, an increase in river discharge and sea levels have demanded new solutions for flood risk management producing a conflict situation between the historical urban layout and required safety measures.

Harbour migration due to changes in transport logistics and industrial decline produced porosity. Inner city harbour conversions that followed, triggered a classical European city ideal with housing amenities, work and public space within walking distance to create urbanity. The conversion of these inner city waterfront sites not only revitalizes the compact European city model, but also pushes for flood-adapted developments. Since the 1980s until today and presumably the coming years, inner city harbours have been migrating to peripheral urban river fronts in order to accommodate the change from bulk transport to tri-modal container logistics. This again involves a horizontal expansion of the urban waterfront in the flood plain in order to accommodate required harbour basin depths, space and/or spatial constellations and traffic infrastructures and consequently additional impermeable surfaces.

Currently the negotiation between protecting flood plain habitat vs. the econometrics of harbour logistics is being debated, for example, in Cologne (see fig. 21.1). Due to the long plan approval procedure, the former harbour basin that was filled up has developed a rare flora and fauna within an otherwise industrial area and was therefore defined as a nature protection area in the 1970s. Nature compensation measures on other sites are now planned to enable the redevelopment as a harbour. While the expansion of transportation hubs along the riverfront continues to follow the industrial path of claiming more open spaces to accommodate current demands, environmental concerns, such as compensating for additionally consumed space, have to be met. More integrative concepts, where nature development and industrial uses are combined onsite have been proposed, for example MVRDV's proposal for the Maasvlakte 2 (Wall, 2004), but have not been developed.

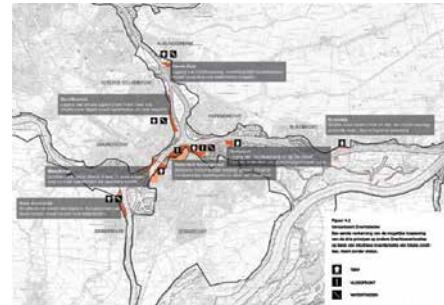
Also the Zollhafen in Mainz demanded for a new spatial organization, which is currently being implemented. With the relocation of trans-shipment activities further down river in the flood plain, the previous site of the Zollhafen can be transformed into a new living district. Continuous growth and modernization led to the decision for a new freight traffic centre and a relocation of the Zollhafen to the site of the Ingelheimer Aue, the Ingelheim flood plain, in 1993 ([www.mainzerhaefen.de](http://www.mainzerhaefen.de)). As in the case of Cologne, compensation measures were taken to attain permission to build in the flood plain, however in the case of Mainz, to compensate for lost retention volume.

Most harbour conversions, like Mainz, are limited to the project scale. Since Dordrecht is part of the Drechtsteden, the Stadswerven area was part of a regional concept, developed in the masterplan 'Drechtovers', Drecht embankments, in the 1990s.

Dordrecht is part of an archipelago of islands and forms together with the surrounding municipalities the Drechtsteden with a total population of 280.000 . The goal of the master plan was to create a regional identity for the adjoining cities via their waterfronts. At high tide, saltwater enters the New Waterway and moves up as far as Dordrecht when the levels of river discharge are low (Heezik, 2008). In Already in the 20th century, derelict harbour and wharf areas outside of the dikes were increasingly transformed into housing areas, but large areas remain. The area between the confluence of the Beneden Merwede, the Noord and Oude Maas makes up 30 hectares and forms a major conversion site within the city, but outside the dikes (Hooijmeier et al, 2005). Until today, these areas are not protected against floods (fig.21.2). The Drechtsteden development will not solve the question how Dordrecht will manage the combined threat of fluvial floods and storm surges. Instead, the way developments will adapt strongly relies on larger scale solutions for the Rijnmond area. The construction of a storm surge barrier in 1996 sought to bring a solution to the threat of storm surges and to protect the inlands from the influence of the sea during storm surge conditions. A solution for the increasing flood discharge of the river Merwede-Old Meuse has not yet been found (Stalenberg, 2010). The conversion of the Drechtsteden embankments into new living districts not only provides a regional approach to urban development and an awareness for the opposite banks. As these areas outside of the dikes are in many cases higher than the adjoining areas behind the defence, their development may turn the previous configuration of these water cities around.



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**Figure 21**

1. Compensation measures for the planned harbour expansion in Cologne - a new harbour on an old harbour site that has become a rare flora-fauna-habitat due to the long plan approval procedure. ([www.hafenerweiterung.de](http://www.hafenerweiterung.de))
2. Drechtsteden - map of possibilities where the three principles of raising, flooding and exchange as spatial strategies at the border between river and city can be applied (Bax et al, 2008).

### **The Urban Landscape**

Rising ecological activism in the 1970s had made the Rhine river, as other habitats, a self-organized public concern. The beginning decline of Western European industrial production in the 1970s (oil crisis) and throughout the 1990s (global relocation of production sites), paralleled by events such as the Sandoz accident in 1984, allowed the conflict between technical progress and growth and environmental damage to become a prevalent political issue. In the Netherlands, changes evoked from such visions as the Plan Ooievaar, the Stork Plan in 1987 (see fig. 22) and Stromenland Nederland 2030 and from the floods of 1993 and 1995. Social protests, especially from residents and organizations in the river-area were rising against plans by Rijkswaterstaat to enlarge and broaden the dikes in the river areas, which would destroy the typical river landscape. The government installed a commission to investigate the content of the complaints and to advise about the possibilities of alternative approaches.

"The Stork Plan, which was drafted on their own initiative by officials in the Ministries of Agriculture, Nature, and Food Quality, and of Transport, Public works, and Water Management, presented a new way of looking at spatial planning for the river system. On the basis of the insights and experiences that had already been gained before 1985 with the ecosystems approach in following and guiding the development of new nature, the 'Stork Plan' made a plea to allow the major rivers, especially the Waal, to return to a more natural state. Importantly, the drafters also declared that this did not have to do any harm to the socio-economic functions of the rivers. Although agriculture within the dykes had to make room for nature, it could be strengthened behind the dykes. Other socio-economic functions, such as excavations of sand and clay, and the extraction of water, could create conditions precisely for developments in nature and could thus in principle continue to be maintained. Because of its integral character - the union, after all, ecological and economic objectives, and of qualitative and quantitative aspects - the plan resonated considerably with the new generation of water policy-makers in Rijkswaterstaat. In the third Water Policy Document, ample attention was thus devoted to the new spatial planning for the river system." (Heezik van, 2008:75)

The 'Plan Ooievaar' can be seen as a professional expression of the resistance against the ongoing destruction of the ecological and cultural characteristics of the river landscape. Eventually, the Dutch strategy entitled 'Room For the River' was implemented and water management became a political topic involving not only engineers, but also ecologists, spatial planners, artists and the broader public to promote a more natural approach to river management.



**Figure 22**

*Fragment of the Plan Ooievaar, the Stork Plan by Dick Hamhuis, Lodewijk van Nieuwenhuijzen, Willem Overmars, Dirk Sijmons, and Frans Vera (Heezik, 2008).*

Along the Upper Rhine, like many cities, Karlsruhe continued to grow through the integration of numerous surrounding villages up until the 1970s, often much older than the city itself (Bräunche, Koch). At the same time, the beginnings of social and economical change at the end of the 1960s changed urban development strategies from the car-centered city model to 'city-friendly mobility.' Instead of further urban expansions into the periphery, urban restructuring of existing quarters, former industrial sites and the development of urban green spaces aimed to reduce land consumption. Improvement of the spatial quality within the city was geared to prevent further emigration of tax-paying residents beyond the municipal border to the periphery (Bräunche, Koch). However, these strategies did not incorporate the area in the flood plain. In terms of trade, the situation of Karlsruhe changed geopolitically with the European Unification. Its border location vis-à-vis France along the Rhine, once a disadvantage, now put Karlsruhe in a central position of European transport nets, a dynamic which reflects on activities in the former flood plain. Although flood damage potential has increased severely (Ludwig, 2008), which may be seen as proof of activity in the former flood plain, programs to incorporate the urbanized landscape in a design approach have been limited to a few studies (see Dieterle, 2002). The sectoral perception of the flood plain and the upper city, but also of the heterogeneity of programs in the flood plain shows in the limited integration of the planned retention polder, where, beyond conflict avoidance, ecological flooding to eventually restore the alluvial forest is the only additional program discussed.

The focus on landscape restoration in the context of flood mitigation projects in Germany may be ascribed to the sectoral planning tradition also enabled by a vast availability of space after channelling. In the Netherlands, nature development and other programs are treated less sectorally, as not only the 'Plan Ooievaar' and the

Room for the River program, but also the different dynamics in urban expansions and thus land consumption show. Specifically, along the Upper Rhine the alluvial forest is restored in niches. Whereas, the mitigation project in the urban landscape of Karlsruhe's former flood plain is one further sectoral development in a container of large scale programs, the central position of the dike set back in Nijmegen provides links to the urban development activated by the project.

The approach of combining flood prevention measures with urban development culminates today in projects such as the urban extension plan of the Waalsprong in combination with a dike setback and the creation of a new side channel across from the left bank of Nijmegen. After the rediscovery of the left bank urban riverfront in the 1980s, the Waalsprong, the urban expansion across the Waal, is framing Nijmegen's development. As a left-bank Roman foundation, Nijmegen developed expansion plans across the Waal in 1993 (development vision KAN). The parishes Elst, Valburg and Bemmel were suburbanized by Nijmegen to do so (total investment for ground acquisitions about 68 million Euro). Due to the curvature of the river at the height of the city, the Waalsprong completes the circle of the existing urban development, creating a vis-à-vis across the river. Instead of expanding into a third ring on the already urbanized left bank Waalfront, this decision generates a compact European city model. Interestingly, at the same time, the urban extension plans, known as the Waalsprong, are part of the regional development strategy Knooppunt Arnhem-Nijmegen (KAN) based on a traffic infrastructure development. As a development strategy, the Waalsprong simultaneously represents compactness while creating an orientation towards Arnhem. As part of the Vinex program, 10,000-12,000 dwellings and 50 ha of commercial area were originally planned. Within the Waalsprong development as an existing European city model, it is not typical, as most Vinex sites were planned much less as parts of existing cities, but mainly connected to strategic infrastructure hubs. Also, the new city centre planned at the heart of the Waalsprong and its mixed use as foreseen in the plans, contrasts with the average Vinex development. (see Mensink, Boeijenga, 2008).

### **Land Consumption And Economic Growth**

Land Consumption and the increase in impervious surfaces is one of the major anthropogenic drivers for an increase in run-off and therefore an increase of flood risk. At the same time, it increases infrastructure development and thus costs.

Newly claimed surfaces are predominantly developed imperviously or in some other way deprived of their infiltration capacity. This means they are built on asphalt and concrete, mechanically densified and often contaminated (UBA, 2004). Reducing land consumption offers space for water storage, enables a decelerated run-off, and provides space for the ecological restoration of the flood plain.

In Germany and the Netherlands, spatial expansion exceeds the dynamics of an increase in population by far. In the past, in German state subsidies such as the 'Eigenheimzuschlag', the house-building subsidy and the 'Pendlerpauschale', the commuter subsidy, or the Vinex housing program in the Netherlands, remnants of post-war housing demands, all supported a peripheral urban development. In both countries, the system of planning as well as law and property rights strive for building and growth (Hartmann, 2011). In the Netherlands, employment numbers and economic growth have a congruent dynamic to land coverage. That is not the case in Germany – here it shows that there is a disproportionate growth in land use in relation to economic growth (Siedentrop et al, 2009).<sup>8</sup> While the Netherlands are still under a lot of expansion pressure (see Nijmegen), Germany has a very limited demand for growth (Siedentrop et al, 2009). State programs have contributed to predominantly single-family housing developments in the periphery. Land consumption increased not only by building on previously green areas, but also by establishing necessary traffic connections. In Germany, new settlement areas make up 90% of land consumption. In comparison: one hectare, 10.000 square meters, is the size of a plot that a pedestrian can walk around in about five minutes. Depending on the typology chosen, this plot can accommodate ten single-family houses, 40 row houses or 250 multi-storey dwellings (UBA, 2004).

Relevant differences between the two countries are the Dutch competence on a national level for land use questions as opposed to greater freedom in the fixation of new settlement areas on a local or regional level in Germany (Siedentrop et al, 2009). The combination of previous state subsidies and the increase in tax income for the municipalities have led to a generous designation of new development areas within the communal boundaries. In Germany, these practically correlate with the increase of urban waste land (UBA, 2004). Currently, strategies aiming to reduce land consumption are focussing on urban development of derelict inner city areas and, even more challenging, the redevelopment of old commercial zones to prevent further

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The quoted study is mainly based on data of Corine Landcover (CLC). Corine defines 44 types of land cover mapped at a scale of 5 hectares. 37 are relevant for Germany. In Corine, built areas are an aggregate of urbanized areas, industrial, commercial and traffic areas, excavation areas, land fills, building sites and developed green areas, not used for agricultural uses.

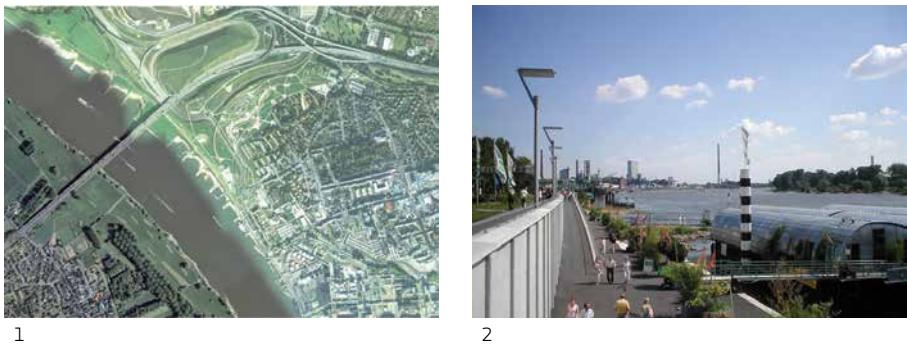
sprawl into the periphery.<sup>9</sup> At the same time, within the next 30 years an estimated one third of the building stock will be renewed (European Construction Technology Platform, 2005). This offers different options to raise urban resilience, from avoiding building development in flood-prone areas as the most obvious solution to, where this is not possible, a flood-adapted development. Again, this implies the need to consider flood risk not only, as already the case, in legislation, but to design new, intelligent urban models that include these considerations.

One strategy to develop such models according to the laboratory condition that uncertainty demands may be the instrumentalization of events in the urban realm such as horticulture exhibitions and international building exhibitions, et cetera. More than just temporal, these events have always been applied to trigger longer-term developments. Their temporal elements may also offer potential to monitor flood-adapted developments, an example being the Landesgartenschau, the federal horticulture exhibition in Leverkusen 2005 (fig. 23). Apart from a new park development on a former land-fill, two floating pavilions were installed between two groyne fields. This was an exceptional development that broke the taboo of the navigation channel as a zone banning development and suggesting the potential of these fields as development sites. Restrictions that apply for the multiple use of groynes are rooted in the risk of sedimentation and erosion. However, in Leverkusen, a marina installed in the 1970s in an adjoining groyne field has not caused problems (van Acken, 2008). It would have been interesting to monitor the two floating buildings at the time of the horticulture exhibition to break with the strict interdiction of the navigation channel and its aligning infrastructure as a potential waterfront site. Of course, this approach goes both ways, it could also imply that buildings are not only ephemeral due to the nature of the event, but temporal in response to hydrological and hydraulic parameters. Apart from floating houses, as of today our flood-adapted developments do not involve temporary buildings that can be moved or deconstructed not just in case of an event, but as a responsive strategy to a changing environment.

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Spatial planning policies in the Netherlands (status January 2010) include: the Order in the Council Spatial Planning (AMvB Ruimte), which reconfirms national aims to reduce urban sprawl and to establish a national ecological network to increase habitat connectivity, the Action Programme against landscape cluttering (Beautiful Netherlands) aiming to reduce the development of new commercial zones by redeveloping old ones, and a long-range programme to restore habitat defragmentation (Meerjarenprogramma Ontsnoeiing) (source: [http://www.eea.europa.eu/soer/countries/nl/soertopic\\_view?topic=land](http://www.eea.europa.eu/soer/countries/nl/soertopic_view?topic=land)). In Germany, the central government's sustainability aims include reducing land consumption to 30 hectares per day by 2020 (Deutsche Nachhaltigkeitsstrategie, update 2008). Among others, there are measures to reduce land consumption through the urban development promotion programs Stadtumbau West and Stadtumbau Ost.



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**Figure 23**

*Landesgartenschau Leverkusen 2005 with floating pavilions between groynes (Google Earth and Municipality Leverkusen).*

### § 3.5 Evolution (Extract)

The economic drivers (navigation, production) related to landscape development and perception (nature>landscape>ecology) and reflected upon the urban evolution from the Roman city to the contemporary urban landscape give insight into the major temporal and spatial interdependencies of the historical layers. From dynamic to controlled, to controlled-dynamic, the historical development of Rhine cities and landscapes are in all three phases related to the river as a navigation channel and as a river prone to flood. In terms of change, this is driven by economic capacity, technical innovation and political organization.

While the pre-channelled era enabled cities to profit from the change of barge and the related culture of trade along the urban waterfronts, it required vessels to adapt to the conditions of the river. This relationship between object and landscape was completely turned upside down by the channelling of the Rhine. What began as the infrastructural appropriation of the landscape in the 19th century eventually also allowed a continuous voyage on the river. Cities were no longer defined by their geographic position at the change of river segments. Instead their economic success was and is reliant on the infrastructure they could provide. Beyond the expansion into the river bed and the introduction of raised paved embankments, freed of fortifications, cities began to expand in parallel to the river and into the hinterland. The majority of the people considered channelling an improvement since floods seemed under control and land was won – arable land, land for urban expansions and for production sites.

Awareness of the negative effects of intensive land use and land consumption only became apparent over time when major transformations had already occurred.

Yet, just as the transition from dynamic to controlled was conceived as a 'great leap forward,' path dependencies of the defensive system define development in the trans-industrial period, which are defined here as controlled-dynamic. While flood preventive measures are once more in need of improvement, a new agency, ecology, has entered the arena, challenging previous givens. As we are undergoing a transitional change from a strictly static approach (as controlled) to a combined form (controlled-dynamic, yet still under the industrial regime), the remediation of the industrial river with the urbanized landscape in the former flood plain continues to demand for an armada of infrastructural measures. At the same time, economic damage potential behind the defence, which continues to increase due to the consistent need for growth and thus land consumption, necessitates a system of control. Furthermore, along the waterfront all profile changes have to comply with navigation - from orthogonal urban profiles to the 'normalized' waterfronts partly aligned with groynes in the urban landscape. At the same time, the success of cities along the Rhine is not only defined by their infrastructural capacity, but also in an increasingly competitive atmosphere between cities, also by spatial quality.

In the Delta, the management of varying water levels is an existential, vital and constant process due to the given topography and the man-made polder landscape. Thus, water management reaches from a continuous draining activity, reliant on the dike ring system, to the handling of potentially extreme events posed by a combined threat of sea and river. In contrast, along the German river segments, although very diverse in terms of topography, the linear defensive systems have no vital functions on a day-to-day-basis, but remain infrastructures for events occurring in seasonal cycles. Due to an increase in pluvial floods, this is currently changing. The difference in topography may also explain the focus on landscape restoration in the context of flood mitigation projects in Germany, where the alluvial forest is restored in niches, whereas in the Netherlands nature development and other programs are treated much less sectorally.

Land consumption and the increase in impervious surfaces is one of the major anthropogenic drivers for an increase in run-off and therefore an increase of flood risk. In Germany and the Netherlands, spatial expansion exceeds the dynamics of an increase in population by far, however, in the Netherlands there is a congruent dynamic to economic growth (Siedentrop et al, 2009). The conversion of inner city harbour areas into new living and working districts continues the legacy of urban development in the flood plain, reducing the original discharge capacity of the river. Yet, when taking a regional perspective, it is simultaneously a strategy for inner city rejuvenation. It may serve as a counter model to land consumption and therefore reducing run-off.

At the same time, the urbanized landscape that has evolved as a consequence of channelling may also have to adapt to cope with future flood risks proactively- in the form of emergency flooding.

Concluding, it may be said that the strategic positioning of a city region increasingly relies on its spatial quality. At the same time, flood adaptation as a consequence of an area-based risk landscape and area-based mitigative measures is no longer confined to the areas in the direct vicinity of the river. This in combination with the idea that 'the coupled and reinforcing relationship between ecology and landscape hinges around design' (Lister, 2010:536) provides the parameters for a spatial design that is no longer only technical in terms of infrastructure and much more systemic in its architectural conception.

# 4 Flood Risk Management

In this chapter, current flood risk along the Rhine and flood management strategies according to the different river segments and differing national strategies of defence and expansion (mitigation + adaptation) are mapped and elaborated in order to contextualize the challenges of flood management at the border between today's river and city.

PRE-INDUSTRIAL → INDUSTRIAL → TRANS-INDUSTRIAL

**4. FLOOD RISK MANAGEMENT  
TODAY**

## § 4.1 Flood Risk along the Rhine

Apart from being a body of cultural heritage, the Rhine is something else - a threat. This is true not only as a host to industrial plants along its water fronts and their potential emissions as well as the economic impact of their disappearance, but also as a river bound for extreme floods. Flood risk along the Rhine has increased in two ways: due to climate change the probability of extreme floods is rising. At the same time, levels of investments in areas at risk have doubled every three decades (parallel to mean economic growth), while room for rivers decreased due to urbanization, but also due to new agricultural land, brick factories, harbours and bridges. This also led to an increase of costs for future investments (van Os, et al, 2002). More than 85% of the natural flood plain surfaces of the Rhine were disconnected from the river to be urbanized and used as agricultural land. According to the Dartmouth Flood Observatory and other sources, the floods in 1993 and 1995 produced an estimated damage of 4 billion Euros (Engel, 1997; Glaser and Stangl, 2003; Brakenridge and Anderson, 2008 in: Bubeck, te Linde, 2011:459).

There are different forms of flood damage: extreme rainfalls, the rupture of a primary dam, the rupture of an antechamber or another regional dam. Also, the height exceedance of current defence systems and human failure have to be taken into account. Causes for flooding are often interconnected and can be influenced by a number of spatial conditions: the failure of drainage infrastructure and flood defence systems, the specific (artificial) topography, the degree of paved surface, et cetera (fig. 24).

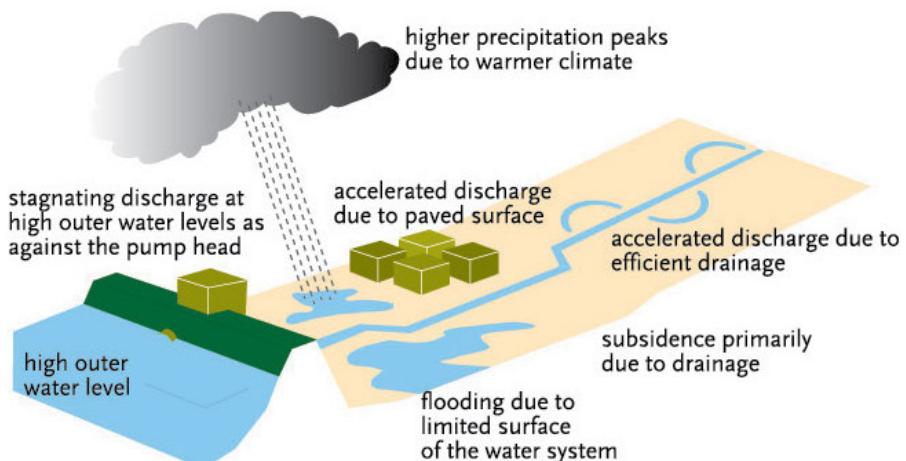


Figure 24  
Interconnected causes of flooding (RWS, 2011)

### **According to the Different Rhine Segments**

In terms of risk, the Rhine segments differ significantly. While the Upper Rhine has a much larger surface at risk, the number of persons affected is much lower. The Mid-Rhine settlements at risk are the highest with 34% (average 9-16%) due to the cities built in the middle ages on the narrow banks of the Rhine. In consequence, these medieval cities suffer from high abandonment rates (Koetter, 2006). The Lower Rhine surfaces at high risk (flood depth above 2 m) are mainly those protected by dikes, but the height and maintenance of dikes and the sense of security they engender in the inhabitants of the hinterland are currently being questioned. Most threatened by floods is the Delta Rhine Basin - 79% of this area (flood depth above 2 m) is at risk and large parts lie below sea level. The intensity of use of valley bottoms at risk is highest along the Lower Rhine and the Delta. 90% of the total area is endangered while only 74% of the surfaces along the Upper and Mid Rhine. While 75% of the surfaces affected today are used for agricultural purposes, 83% of all damages hit settlement areas that represent a mere 11% of the surface (ICPR, 2001).

Within the past 150 years, urbanization processes and river channelling have reduced the flood plain surfaces of the Dutch Rhine branches alone by 65% (Delft Hydraulics in IRMA Sponge, 2001). The Netherlands has become prosperous due to its favorable position in the delta of several large rivers. But without strong flood defences, two-thirds of the country would be under water - simultaneously threatened by storm surges from the sea and river floods. Nine million people live in this vulnerable area of the Netherlands where, ironically, 65% of the gross national product is earned (Transport and Water Management Inspectorate, 2006). During the flood event in 1995, the dikes in the Netherlands just barely withstood the water. As a precautionary matter, several hundreds of thousands of people were evacuated. Damages were estimated at several billion Euros (van Gelder, 1999).

Above the barrage of Iffezheim, the danger of dike breaches is much lower than for the following part of the Upper Rhine, with exception of the three remaining Rhine meanders. With a return period of 1/1000, the segment, developed with a series of water energy plants, is protected by barrage dams laid out for events of a much lesser frequency than the Rhine segment downstream (Ludwig, 2008).

Below the Iffezheim barrage, potential flood impact has severely increased, producing an economic damage potential of up to six billion Euros in case of breaches or exceedances of a 1/200 year event (Pfarr, 2010). The discharge increase as a consequence of the barrage constructions along the Upper Rhine between 1955 and 1977 led to a loss of natural flood plains. The flood protection level for the low lands along the Upper Rhine had, at its peak, decreased from 1/200 to 1/60 (MUFV RLP, 1997). Today, as part of the measures of the High Water Action Plan are installed, the Upper Rhine has reached a discharge capacity of 1/120, expanding with every further

measure completed. In 1980, only 2% of the natural flood plain between Basel and Karlsruhe were still intact (Hügin, 1980 in Pfarr, 2010:145).

In Rheinland-Pfalz, damage potential for settlements along the Rhine in case of a 1/100 year flood, without taking existing flood protection into account, would accumulate to more than 675 million Euros and affect nearly 40,000 inhabitants. 75 industrial plants<sup>10</sup> would potentially be affected (MUFV RLP, 2010). In Nordrhein-Westfalen, 1.5 million inhabitants live in the former flood plain behind the dikes, with a potential damage value of 20 billion Euros (Schmid-Breton, 2011).

Two temporal factors play an essential role in flood risk: the flood regime of the tributaries and the forecasting periods. Pluvial influences on the flood regime through the main tributaries of the Rhine are severe. In order to reduce this impact, rainwater harvesting within the river sheds of the tributaries is a possible strategy for reducing high-frequency floods. Procrastinating run-off through different kinds of storage on site can also produce spatial qualities. However, the adaptation of land use in small catchments leads to flood mitigation for high-frequency floods, as in the case of a five-year flood, yet with an increasing catchment scale and a less frequent flood, such as a 1/100 year event, the mitigating effect on the flood peak discharge is minimal (Bronstert et al, 2001).

From the Alps and for parts of the Upper Rhine Basin, the Rhine discharge is influenced by snow and snow melt. In the winter months, precipitation is stored as snow, leading to low water levels. In the early summer, these melt and water tables rise. As winter precipitation will increasingly fall as rain instead of snow and since there will generally be more rainfall, a rise in water levels also in the winter months is expected for this river segment. At the same time, more extreme dry periods are expected in the summer all along the Rhine.

The discharge of the Neckar, Main and Mosel as the main tributaries of the Rhine are all pluvial regimes, thus reaching their peak discharges in the winter months (Wiedmann, 2009). The changed flooding season of the Upper Rhine consequently produces the risk of flood waves from the Rhine and its tributaries meeting and accumulating in the main river bed. The mean discharge at Basel is 100 m<sup>3</sup>/s, at Mainz it is 1600 m<sup>3</sup>/s. Below the Neckar river, the influence of tributaries on the Mid-Rhine Valley becomes more evident with their discharge peaks in spring. Due to the channelling of the Upper

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according to the definition of the EU Framework Directive 96/61/EU

Rhine, the time the flood wave takes from Basel to Karlsruhe has decreased from 65 hours to 22 hours, and at Worms it is 62 hours instead of 98. As the peak wave of the Rhine below the 'Ausbaustrecke', the barrage stretch, moves closer to those of the tributaries, especially the Neckar, it could, in the worst case, overlap and lead to an uncontrollable event, which would severely affect Mannheim, located at the confluence of the Neckar and the Rhine (Stieghorst, 2009). For cities along the Lower Rhine, specifically for Cologne, the Mosel river significantly influences the flood regime.

The Dutch Rhine branches into the Waal, which carries 60% of the water, the Nederrijn and the IJssel. Upon completion of the Room for the River program the discharge will increase to 15000 m<sup>3</sup>/s at Lobith and the distribution will change slightly. Future measures aim for an accommodation of 18000 m<sup>3</sup>/s (see fig. 25). Flood risk in the Netherlands is not only fluvial, but also defined by rising sea levels. A storm surge in combination with a river flood affecting the Dutch Delta is the worst case scenario for the Netherlands.

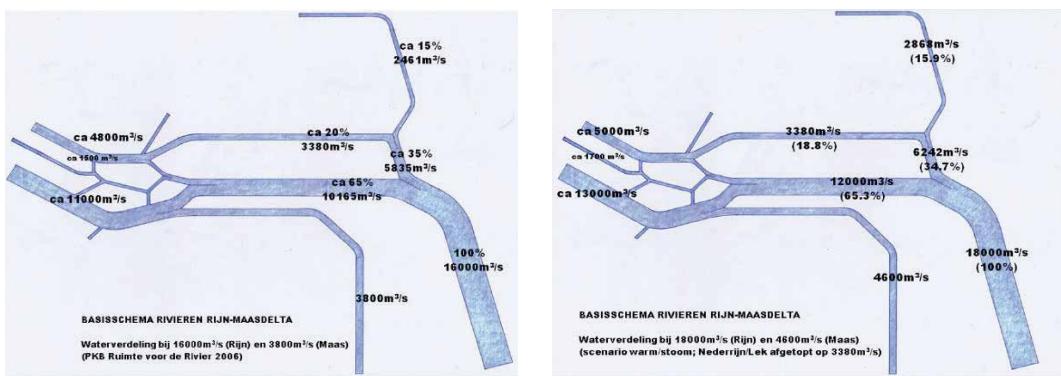


Figure 25

Distribution along Dutch Rhine branches upon completion of the Dutch Room for the River measures 2015 and according to Delta Scenario Stoorm/Warm (Pelt et al., 2011)

Refined forecasting technologies enable flood prediction for the Rhine of up to three days ahead of the actual occurrence at the Dutch-German border. This leads to a time-space detachment, giving the affected stakeholders up to 72 hours to prepare for the event. Apart from avoiding a threat to human life, this may reduce economic damage when flooding inhabited areas, presuming that architecture and technical infrastructure can be protected by previous measures. This demands, however, large scale transformations of existing building structures. Based on this, studies such as the 'Rampenbeheersungsstrategie Overstroming Rijn en Maas', the Catastrophe management strategy for Floods of The Rhine and Maas, proposes the improved compartmentalization

of the existing dike rings (53 in NL) for more strategic flooding through a system of cascading retention areas in order of damage potential (RWS, 2006).

Studies of the work group show the complexity of effects and the reliance on failure already taken into account. In terms of the cross border risk, flood-defence exceedances between Bonn and Krefeld already occur before the flood peak wave arrives. This exceedance enables the segment between Krefeld and Lobith not to be flooded with the exception of Emmerich, where, according to calculations in 2002, the flood wall will be exceeded. This problem will be solved by 2020. The planned dike reinforcements will lead to slightly higher water levels at Lobith, though only due to measures at the height of Emmerich. Upriver from Emmerich, the dike reinforcements will lead to a slight reduction in discharge. The highest discharge at Lobith is 15,944 m<sup>3</sup>/s. Cross border floods do not occur in the Ooij- and Duffeltpolder nor in the Niers catchment. On the right bank, floods in Emmerich occur consistent with the situation today, which in turn leads to floods in Achterhoek and Liemers (Guden, 2004).

### **Future Risk Scenarios**

The following pages illustrate the future risk scenarios for the Netherlands as summarized in the study 'Flood protection in the Netherlands: framing long-term challenges and options for a climate-resilient delta,' published by the Netherlands Environment Assessment Agency in 2009:

Climate change in the Netherlands will imply:

- a rise in sea level;
- an increase in peak drainage flows from rivers in the winter months;
- increased seepage pressure and salinization;
- flooding in rural and urban areas;
- aridity in rural areas and low river flows in the summer months;
- reduced water quality due to higher temperatures and water shortages.

(MNP, 2005; KNMI, 2006)

It is expected that climate change will result in an increase in both average rainfall and peak rainfall intensity in the summer and winter months. Only in the scenarios that assume a change in airflow pattern over northwest Europe, is it expected that average rainfall will significantly decrease in the summer and that it will be much drier than in the current situation (KNMI, 2006). In the Netherlands, therefore, the climate will become both wetter (in the winter) and dryer (in the summer) and, due to the expected increase in peak rainfall intensity, more uncertain, with larger regional and local differences (KNMI, 2006). As a result, there is an increased risk of both flooding and drought.

Along the Dutch coast, the sea level rose by about 20 centimeters over the last century. Satellite observations show that the rate of sea level rise has increased since

1993. Recently published scenarios from the Royal Netherlands Meteorological Institute (KNMI, 2006) predict a sea level rise in the 21st century between 35 and 85 centimeters. The Delta Committee (2008) estimates a ‘high-end’ range of sea level rise of 65 to 130 centimeters for the period up to 2100. Large variations are given due to a high degree of uncertainty for the climate system as a whole, the melting of the Greenland and West Antarctic Ice Sheets, and future greenhouse gas emissions.

Geological findings indicate that, in the past, an increase in temperature of over about 2 to 2.5° C in the Northern Hemisphere was accompanied by sea level rises totalling about 4 to 6 metres, and that there have been periods when sea levels rose at a rate of 1.5 metres a century. Based on climate scenarios, an increase in temperature of 2 to 2.5° C in the Northern Hemisphere could be reached by 2050. Based on currently available information, the Netherlands Environmental Assessment Agency assumes the following:

- The KNMI estimate of 35 to 85 centimeters/century is the most likely range of expected sea level rise for the Netherlands, this century. This estimate, contrary to that of the IPCC, takes into account a limited increase in the rate of melting of the ice caps and a relatively strong increase in temperature in the Northern Hemisphere.
- Given the large uncertainties and the small chance of a rapid increase in the melting and disintegration of the Greenland and Antarctic Ice Sheets in the next century, a sea level rise to a maximum of 1.5 metres, over the next 100 years, is considered the worst-case scenario.
- It is still very uncertain whether the global emission reduction of 50 - 60% required to stabilise the increase in temperature at 2° C, will be achieved in the foreseeable future. Should this global emission reduction not be achieved, the possible sea level rise is more likely to be at the higher end of the KNMI range than the lower.” (Ligtvoet et al, 2009:13)

The North Sea storms must be considered as well, since wind speeds and the power of storms increase with each degree in temperature (IPCC, 2007b). The current protection level is based on a storm surge with a return period of 1 in 10,000 years and a sea level of 5 metres above NAP (Amsterdam Ordinance Datum). A similar storm surge at higher temperatures could result in a higher water level than what is currently taken into account. There are large uncertainties regarding the expected change in both the frequency of storms and the force and direction of the wind. The frequency of storms in the North Sea has decreased over the last forty years, but it is not clear to what extent this corresponds to the rise in temperature. (see also KNMI, 2006).

The expected sea level rise, based on the KNMI scenarios, will not necessarily result in large amounts of flooding from the sea (WL | Delft Hydraulics, 2007a). However, as sea levels rise, the natural drainage capability of regional water systems and rivers due

to gravity is reduced, water levels rise in tidal rivers and estuaries, and the influence of tides and salt water is seen further inland. Rotterdam and Dordrecht will become increasingly vulnerable areas if sea levels continue to rise. Higher sea levels will also result in a greater upward pressure on groundwater. WL Delft | Hydraulics, TNO and Geodelft carried out further research for the report The Netherlands in the Future into whether this increasing seepage pressure would constitute a major problem. The study showed that the most important seepage problems will take place immediately behind the dunes and behind the dikes along the rivers and in the IJsselmeer polders (WL Delft | Hydraulics et al, 2007b). Yet, this is primarily a localized phenomenon and current models are not yet capable of simulating this in sufficient detail (Ligtvoet et al, 2009).

Apart from general projections such as increases in temperature as well as water in summer and in winter, ,along with generally increase in precipitation in winter and dryer summers (ICPR, 2011), future climate scenarios for the Rhine for 2050 and beyond are currently being developed in the International Commission for the Hydrology of the Rhine Basin (CHR) research project Rheinblick 2050. Joint climate and discharge projections for the international Rhine River catchments will be published in 2013. Baden-Wuerttemberg and Rheinland-Pfalz are already organized in KLIWA to investigate the impact of climate change on the river system and to formulate recommendations. A climate change factor is already being applied in Baden-Wuerttemberg. 15 to 25 % are added to the height of dikes and defensive elements (John-Koch et al, 2009). For the Rhine in Baden-Wuerttemberg this is 50 cm (ICPR, 2011).

All climate change projections involve a high degree of uncertainty, making it necessary to plan with different scenarios. One key aspect of planning under uncertainty is to avoid developments that could hinder future conditions and evolving measures. In any case, 'no- or low-regret measures' are recommended. These are measures that involve minor investments to avoid greater cost of future adaptation measures to enable a certain flexibility in adjustments (Maurer, 2011).

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## § 4.2 Flood Risk Management Beyond River Containment

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As defensive systems along the Rhine are no longer capable of fulfilling required safety norms, they are combined with large-scale river-expanding measures. Although often discussed as either/or strategies, both are mutually interdependent, the only alternative being avoidance, or to some degree, adaptation. As defensive and adaptive measures are limited in height, they require an increase in discharge capacity to lower water tables. Water levels have to be lowered, specifically peak discharges, in order to cohere with current design water levels and to enable a limitation of height for flood

defences. Room for the River projects can therefore be considered as supportive of the defensive system, while they themselves rely on defensive elements to be implemented within the former flood plains now hosting economic goods.

### **Mitigation**

By applying expansive strategies, mitigation measures aim to reduce magnitude (extreme water levels), and thus the probability of extreme events. Investigations for the Rhine have shown<sup>11</sup> that extreme events can only be mitigated by peak shave flooding upriver and thus by measures such as steered retention polders, bypasses, dike setbacks and other adaptations to the river infrastructure and the river profile such as the removal of obstructions in the river bed.

These measures are engineering works. As accumulative measures, they primarily address river management on the scale of a specific river segment - for the Upper Rhine program in Germany defined by its capacity before the 'Oberrheinausbau', the Upper Rhine development in the 20th century and for the Dutch Rhine branches by accommodating a discharge of 16,000 cubic m<sup>3</sup>/s at Lobith with the capacity to handle 18,000 m<sup>3</sup>/s in the future.

While the Room for the River program in the Netherlands explicitly aims for spatial quality as part of the river-expanding measures also within the urban realm, involving different integrative strategies and participation processes, the additional focus for the retention polders in Germany predominantly lies in the restoration process of the formerly dynamic landscape qualities within their now urbanized context. It is being developed by engineers and ecologists.

### **Adaptation**

Adapting buildings to flood risks implies developing an inherent resistance to damaging or destructive forces and thus a reduced vulnerability. However, based on path-dependent spatial and cultural patterns, as well as economic factors, our adaptive capacity today is limited. How can we increase it?

The degree of exposure to floods may be reduced by not building in or inhabiting the specific areas at risk, defined as avoidance. If the capacity to adapt does not comply with the risk on site, migration is the only alternative, thus practicing avoidance. As the risk on site is increasing, our adaptive capacity must as well.

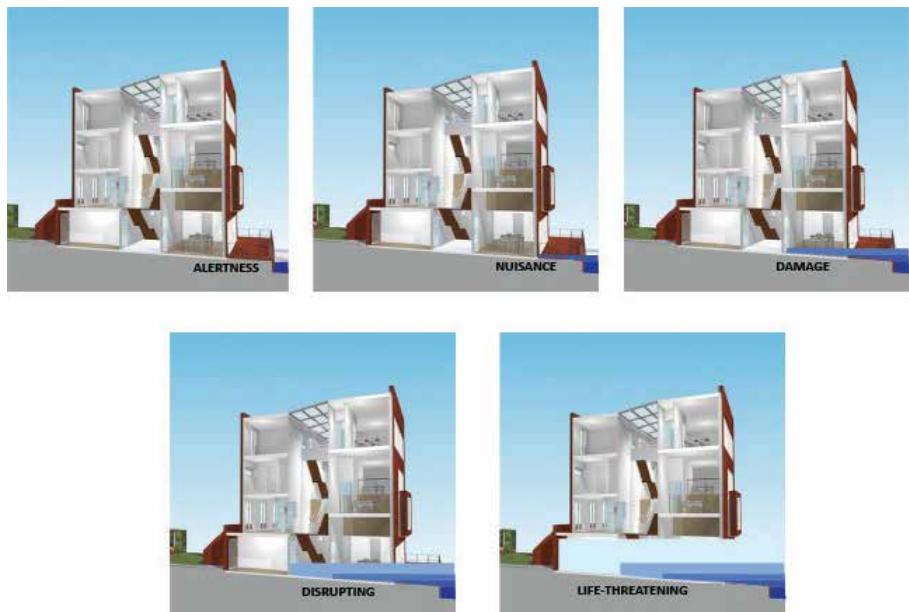
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IRMA Sponge and 'Grenzüberschreitende Auswirkungen von Hochwasser entlang des Niederrheins'

In parallel with the change in relationship between landscape and city from two separate entities to a vast continuum of urban, suburban and rural spaces, the former exclusively applied defensive strategy no longer holds. The Rhine basin between Basel and Rotterdam with the Ruhrgebiet and the Randstad is the most densely urbanized corridor in Europe (blue banana, etc.). The existing risk to already urbanized areas behind the defence in case of exceedance or breach, as well as the maintenance costs of defensive infrastructures have therefore led to the development of alternative strategies to structural flood management.

In line with the publishing of the flood hazard maps by 2013 demanded by the EU Flood Directive, apart from non-spatial measures, the question to what degree building development in urbanized areas can be adapted or built back will be central for future strategic developments. Some of the areas at risk, specifically in the direct vicinity of the river, are also the areas with the highest location factor, thus not necessarily the sites where development could be built back. This applies specifically for the exceptional urban development of former port and wharf sites in the flood plain currently being converted as Northwestern European cities become increasingly reliant on their central water front qualities (see PART II / case studies Mainz and Dordrecht).



**Figure 26**  
Definition of different risk gradients (Hilte, Waals, 2008)

The capacity to adapt spatially to floods is currently limited to designated water levels (fig. 26). Floating buildings are the only flood adaptive typology capable of withstanding height limitations. Yet, they are not implementable in most flood-endangered areas. To find solutions beyond design safety levels, adaptations to the built environment are complemented by operative measures (e.g. evacuations as the most prominent). Thus, it is not only the aim to reduce the impact of floods by reducing the vulnerability of the built environment, but also to reduce peak water levels during extreme events through flood alleviating measures that reduce their magnitude and probability.

Minimizing damage potential is the most cost-effective flood risk management measure. With awareness of the rising risk of extreme floods, total control is not only impossible, but also economically not feasible. This leads to the need to accept more risk and to develop more resilience and adaptability in the future. Recommended are measures and strategies which anticipate higher peak discharges, while preserving room for future measures.

In spatial terms there are three ways of managing flood risk: avoidance, resistance and resilience. These three strategies may be applied on a neighbourhood scale as well as for individual buildings. Avoidance implies moving out of the area at risk, horizontally for the urban scale and vertically for the object scale. Building up resistance against floods involves collective or individual defensive measures while resilient strategies aim to incorporate varying water levels within the project design in order to reduce the overall vulnerability and recovery period of the respective urban development or individual building. Except for floating houses, all adaptive strategies today are limited in height depending on the return period of applied design water levels. Therefore, in an awareness of rising water levels, mitigation measures become crucial for all three strategies.

These three (four including floating buildings) spatial strategies of flood management must be orchestrated according to the sites' potential and demands and their economic feasibility not only in terms of flood protection, but also in relation to the urban potential they are capable of producing.

Translating these recommendations onto the situation of the cities along the Rhine today implies efficiently protected or well adapted high density conurbations reserving the spaces in between urbanized areas for possible flood plain rejuvenation – perhaps a return to the traditional European city structure. All variations of that concept imply an additional set of parameters.

German and Dutch river containment and expansion systems and strategies are elaborated here to illustrate the differences in context and strategy.

## § 4.3 River Containment

River containment not only supports a defensive approach to flood management on a territorial scale, but, opting for a channelled riverbed, also coheres with the demands of navigation. Defensive elements can be applied on an object scale via stop-logs, etc., or on a territorial scale as a collective defence system via dikes, flood walls and mobile elements. If failure and exceedance were not taken into account this would be the most viable strategy to protect high density conurbations. When functioning as planned, collective systems allow large areas to remain unaffected by high water levels. However, maintenance costs, height limitations, exceedances, failures during a flood event and a collective feeling of safety 'behind the defence line' are the weak points of a strictly defensive approach. Collective flood defence systems along the Rhine differ significantly in terms of safety levels, section and as systemic structures in relation to their topographical context (fig. 27). This most evidently shows in the juxtaposition of the German and Dutch flood defence systems. For both systems, the maintenance and improvements of defensive infrastructures relies not only on engineering expertise and organization, but on national economies capable of providing the related financial means.

### River Containment D

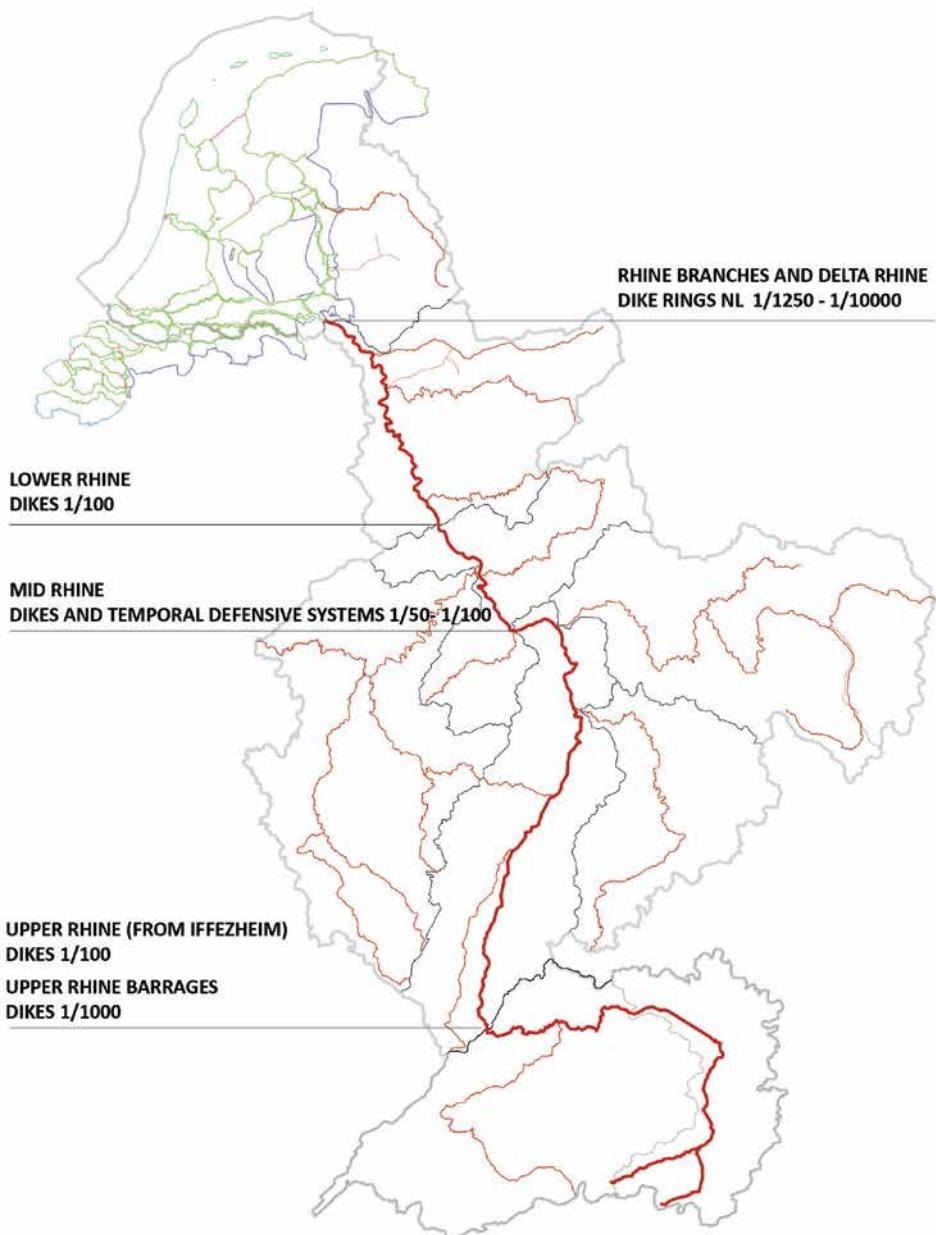
With the exception of the Upper Rhine segment that hosts water power plants between Iffezheim and Maerkt with safety levels today of 1:1000 (Ludwig, 2008), the design water level of defensive systems in Germany varies between a return period of 1:100 on average, 1:50 along the Mid-Rhine and 1:200 for highly exposed sites such as parts of the city of Cologne or the Zollhafen development in Mainz.

	total budget	river widening	dike reinforcement
Baden-Wuerttemberg	N.I.	> 1.0 (2011)	0.5 (2007)
Rheinland-Pfalz (1995- )	1.2	N.I.	0.23
Nordrhein-Westfalen (2007-2015)	1.2	N.I.	0.83
Hessen (2002-2007)	0.115	N.I.	N.I.

Table 1

*Cost of flood management investments for the different federal states in D (for sources see text)*

## DEFENSIVE SYSTEM



## EXPANSIVE SYSTEM

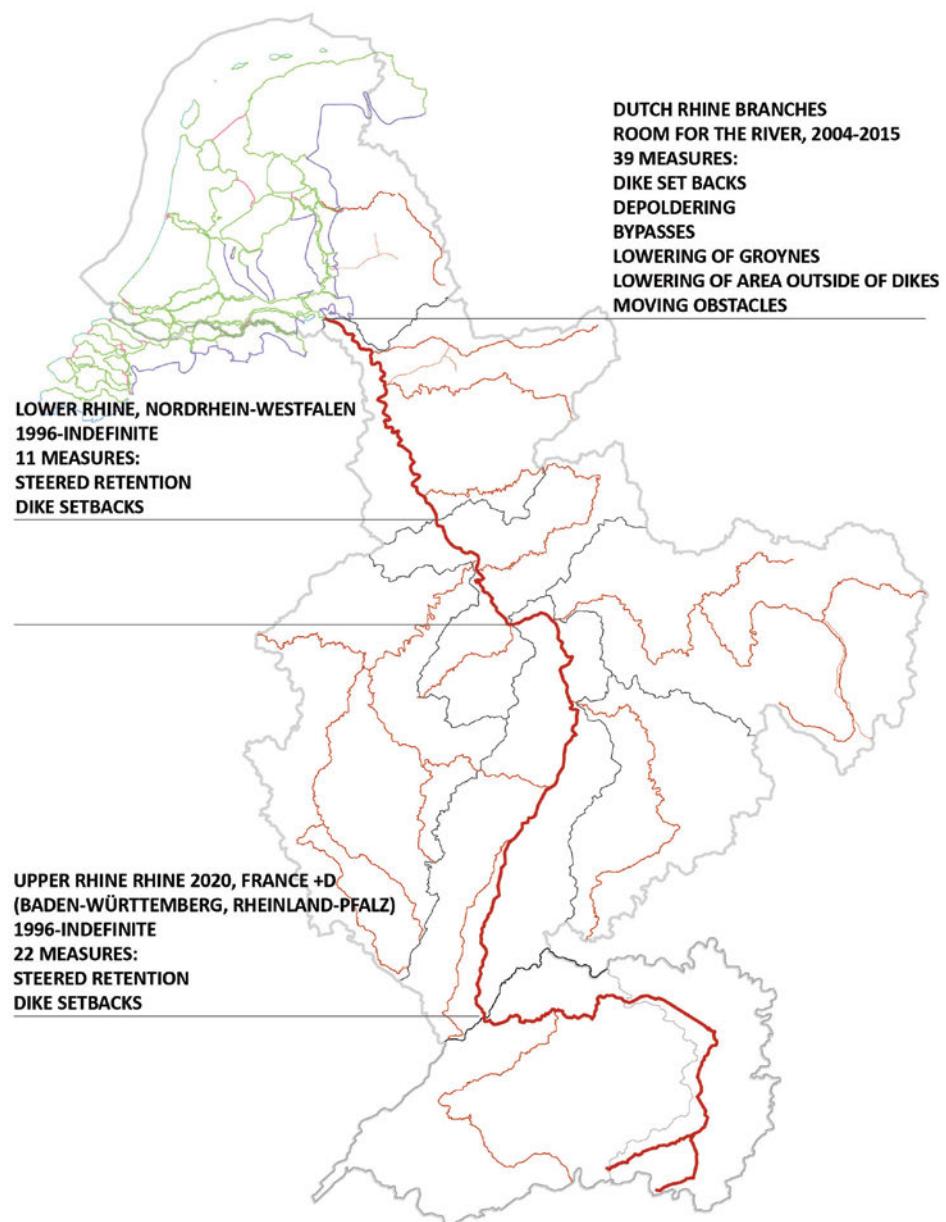


Figure 27

Defensive and expansive systems according to Rhine segments (RWS, ICPR, graphics by author).

The listed activities illustrate the economic dimensions of flood risk management, both in terms of improvement and maintenance costs. The state of Baden-Wuerttemberg has around 1050 km of dikes within its jurisdiction. At the end of 2007 more than 300 dike segments with a total length of about 500 km length had, to varying degrees, geotechnical deficits. For their maintenance and reinforcement a budget of 500 million Euros has been estimated (Waldner, 2011 and DS 14/5921, 2010). In 2005 the costs for the Integrated Rhine program were estimated 775 Mio, almost doubling the costs estimation from 2000 and costs have increased further since then (Kretschmann et al, 2010). The audit court expects costs to increase to more than 1 billion Euros (Waldner, 2011).

Flood risk protection and prevention in Rheinland-Pfalz is based on three pillars: natural retention, technical flood protection such as dikes, retention polders and local protection measures and additional measures. The program, which passed state parliament in 1995, has a total investment volume of 1.2 billion Euros of which, in 2010, 730 million had already been invested. This includes both defensive and expansive measures. Realized and future measures are part of flood risk management according to the Wasserhaushaltsgesetz 2010 Federal Water Act and the flood risk management plans according to the EU Flood Directive. 125 of 160 primary dikes between Lauterburg and Bingen have been reinforced. Every reinforcement measure is preceded by an evaluation to see if a dike setback would be possible on site. Investments in dike reinforcement and pumping stations along the Upper Rhine in Rheinland-Pfalz amount to 155 million Euros and will total 230 million Euros (MUFVRLP, 2011).

In Nordrhein-Westfalen the state government has issued a new flood management program until 2015. Since 2007, 1.2 billion Euros are being invested in the realization of steered retention polders, dike setbacks and dike reinforcements (MKULNV NRW, 2007). In Nordrhein-Westfalen alone, almost 300 km of dikes had to be improved, producing construction costs of 827 million Euros (May 2009). The flood management concept of the city of Cologne, issued in 1996, including 60 km of dikes, flood walls and mobile elements, was finalized in 2008. The total costs amounted to 260 million Euros (MUNLV NRW, 2009).

The state of Hessen made investments of 115 million Euros between 2002 and 2007 including flood prevention measures, communal defensive measures, maps of flood endangered areas, reinforcement of the dikes along the Rhine and Main rivers and the financial participation in the erection of dikes upriver south of the state border (MULRV Hessen, 2007).

### River Containment NL

The Dutch delta is divided into 53 dike rings with differing safety levels defined by population density and economic value. The coastal protection levels are higher

as storm surges happen with much less prediction time and flow channels are much deeper than in the river areas. A legal norm for boundary conditions in the Netherlands for a river dike lies at 1:1,250 while for sea dikes it is 1:10,000. The Delta Committee, established soon after the major flood of 1953, developed this alternative approach. The event in 1953 damaged 800 km of dikes and inundated an area of 2,000 square kilometers with mainly salt water. 72,000 people had to be evacuated and 1,835 people lost their lives. More than 3,000 houses were destroyed, 43,000 damaged. The flood produced a damage amounting to 14% of the Dutch Gross Domestic Product (Ven van de, 1993). Dike improvements were made until the 20th century by raising the dikes by 50 centimeters above the previous storm surge level (Ven van de, 1993). However, the severe dike improvements instigated by this strategy produced a lot of local resistance as houses located along the dikes had to be moved. Dike improvement stagnated even when safety levels were lowered (Stalenberg, 2010). The insufficiency of this approach also became apparent with the increasing sea level and subsidence of significant parts of the Dutch low lands. While before, natural subsidence was compensated by clay and sand deposited during the flooding of the major rivers, this was no longer possible once dikes were built.

The 20th century focussed on battling the North Sea after storm surges in 1894, 1916 and the disastrous storm surge flood in 1953. In 1958 The Delta Committee published the Delta Act in 1958 (Stive, Vrijling, 2011). It comprised a large set of engineering works to raise protection from the sea: the Delta Works. 2875 kilometres of dikes and dunes and dams and four large-scale defensive systems (Delta Works) make up the primary Dutch defensive system. It protects the land from water from the sea, from the major rivers and from the IJsselmeer and the Markermeer lakes. The secondary defensive system protects from floods indirectly.<sup>12</sup> The condition of the primary flood defences is particularly crucial and monitoring their condition absolutely vital to 'keep dry feet.'

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Flood defences in category a (a defences) include dikes, dunes, and hydraulic structures which provide direct protection against the sea, the major rivers, the IJsselmeer and the Markermeer lakes.  
Flood defences in category b (b defences) such as te Afsluitdijk or the Maeslant storm surge barrier, connect flood defences in either category a or c  
Flood defences in category c (c defences) are defences that provide indirect protection against flood water. An example is the flood defences along the Nordzeekanal (source: Assessment of primary flood defences in: The Netherlands National Report on...2006, Transport and Water Management Inspectorate Water Management, Lelystad, 2006)

In contrast to the former approach to flood management, which was based on the reactive principle of increasing the height of the existing flood defence according to the highest water level observed, probabilities of occurrence based on the current state of the rivers and coast defined the new approach (Van der Most, Wehrung, 2005). In this 'probabilistic approach' risk is defined as the probability of inundation times the value of investments:  $R = P \times V$  making it easy to determine the optimal dike height (Stive, Vrijling, 2011).

Only 44% of the 2875 kilometres of primary flood defences met the standard in 2006, while 24% did not meet the standard and 32% of the primary defence was not assessed due to lack of data (Assessment of primary flood defences in The Netherlands National Report 2006, Lelystad, 2006)

Using current techniques, the dikes (hard flood defences) and coastal defences (soft flood defences) can be sufficiently maintained, even in the case of a sea level rise of 1 to 1.5 metres a century. If, however, the rise in sea level were to increase to 1.5 metres a century (as a result of an increase in the melting rate of the ice sheets), then continued maintenance of the dikes and dunes would require considerably more effort. According to the Adviescommissie Financiering Waterkeringen (Advisory Committee for Primary Dike Financing, 2006), this could mean a doubling in the annual cost for maintenance of the dikes. Flood protection currently costs each inhabitant of the Netherlands about 40 to 45 Euros per year, equivalent to about 0.15% of the GNP. Therefore, even if these costs were to double, the effect on Dutch expenditure could remain limited. (Ligtvoet et al, 2009)

The 'Room for the River' measures account for a sea level rise of about 60 centimeters. However, a further rise in sea level combined with a reduction in natural downhill flow will require the construction of higher dikes on an increasingly larger area. In the area surrounding the lower reaches of the Rhine and Meuse rivers, these dikes will progressively take on the character of sea dikes rather than river dikes (WL Delft | Hydraulics, 2007a in: Ligtvoet et al, 2009:14).

	Scenario				
Year	2040	2100	2100	2100	far future
Sea level rise (cm)	24	60	85	150	500
Max. discharge Rhine river	16,700	18,000	18,000	18,000	18,000
Cost in billion					
River widening	2.7	5.5	5.5	5.5	5.5
Dike reinforcement*	0.2	1.8	2.6	6.1	36

\*including the Meuse river

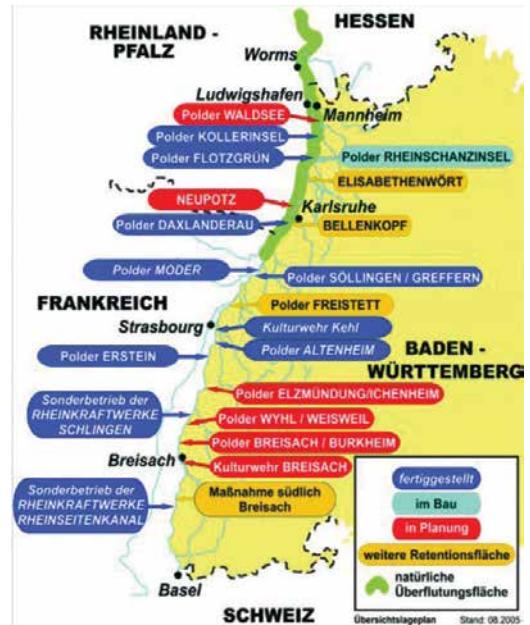
Table 2

Costs of flood management investments under different climate change scenarios excluding the costs of upgrading the current Dutch flood protection system (Aerts, 2009:37)

Table 2 shows potential costs for future flood protection measures under different climate change scenarios for 3500 km of dikes, the nourishment of 450 km of beaches and widening of main rivers. The costs are calculated for sea level rise in combination with maximum river discharges according to the KNMI scenario for 2040 and 2100 (85 cm) (Van den Hurk et al, 2006) and additionally for more extreme scenarios for the long term. Aerts points out that "apart from the projections of climate change, future projections show a gradual trend in house construction. In particular, by the year 2040 about 500,000 to 1,500,000 new houses will be constructed in the Netherlands. Even if future flood risk defined as probability times damage are maintained at a constant level by heightening the dikes, the potential damage of a flood is expected to increase." Beyond reducing the probability of floods, reducing the vulnerability of buildings to limit damage in case of a flood is one example in a wide range of adaptation measures, just as "financial arrangements, such as insurance, could be promoted to compensate flood victims and heighten risk awareness." Again we can see how additional building development will negatively influence the damage potential of a flood, an incentive for adaptive buildings and infrastructure.

## § 4.4 River Expansion - Between Mitigation+Adaptation

While the compact city may not be capable of hosting Room for the River projects per se due to lacking spatial capacities, the sites which can are not as rural as they may seem (see PART II / Karlsruhe XL ATLAS retention polders). Programmatically, flood mitigation via river expansion can principally be combined with nature development measures. Both opt for a widening of the river bed.



1

2

**Figure 28**

Overview of German and French Room for the River measures along the Upper Rhine (LUBW) and along the Lower Rhine (Umweltbericht NRW, 2009)

Room for the River as a flood mitigation strategy is applied to many rural areas in the Rhine catchment. The two main programs along the Rhine are the Rhine High Water Action Plan in Germany and France and the Room for the River program in the Netherlands. Within densely urbanized areas, local river expansion strategies towards flood mitigation are truly exceptional. Due to the lack of space, higher land prices and existing building structures, these strategies are only considered when local conditions exclusively require it while offering the necessary spatial capacity - as in the exceptional case of Nijmegen (see case study Nijmegen). However, the former flood plain sites, perceived as predominantly rural

landscapes due to their seemingly low density, have accommodated programs and thus increased economic damage potential that allows the categorization urban landscape. River expansions within compact city structures are not capable of mitigating high water levels (see Mainz and Dordrecht). Instead, they opt for adaptive strategies.

To shave peak floods, measures in the Netherlands aim for an increase in discharge capacity ( $m^3/s$ ) in the Rhine Delta. In Germany, mitigation measures are volumetric ( $m^3$ ) and strive for water storage (ICPR, 2005). River-expanding measures in the Netherlands include dike set backs, side channels, green rivers, removing of obstacles in the river bed and the lowering of groynes (fig. 29). The High Water Action Plan in Germany and France only foresees dike setbacks and/or the installation of retention polders (fig. 28).

### River Expansion D

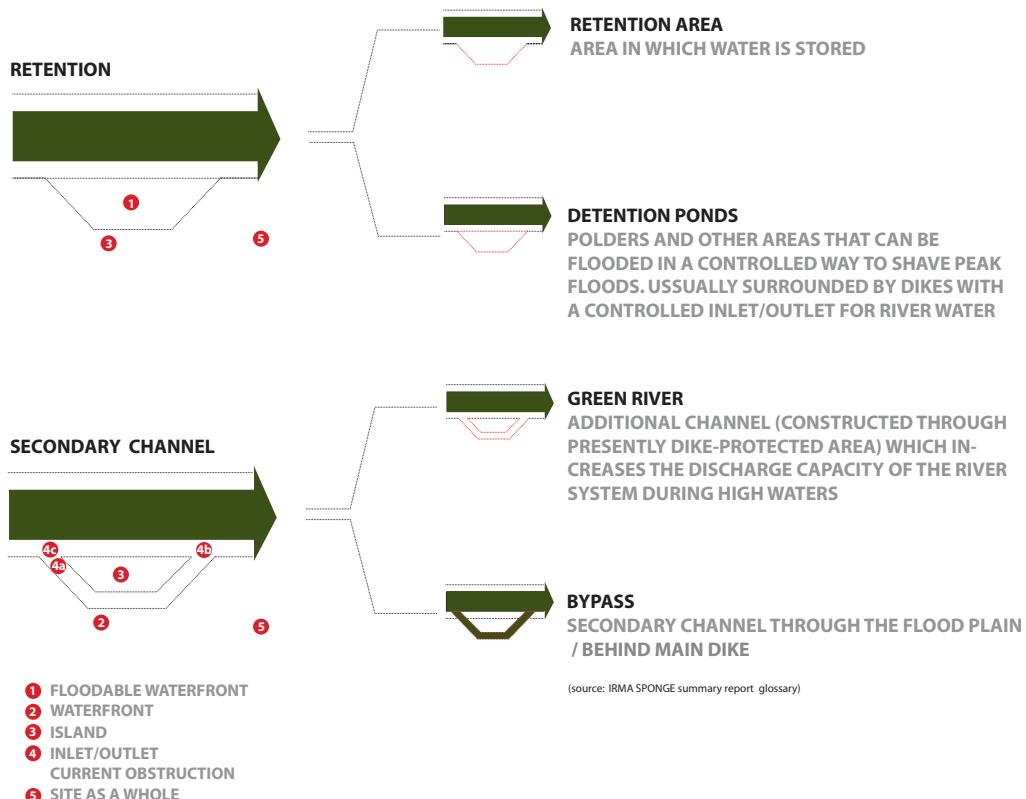
Already between 1968 and 1978, while barrages were still being erected, the International Flood Study Commission was founded and came to the conclusion that the reinstallation of the flood protection level as it was before barrage construction was mandatory. In 1982, France and Germany agreed on measures towards flood mitigation. In 1988, Baden-Wuerttemberg decided on a framework for the installation of the Integrated Rhine Program (IRP). Ecological issues and the need for additional measures to the previous agreement with France were included. In 1996 the state government passed a framework plan with the aim to reinstall discharge capacity as it was before the Upper Rhine barrage construction and a reinstallation of the flood plain. As a consequence of the floods of 1993 and 1995, the Rhine states developed a joint High Water Action Plan in 1998 with a budget volume of 12.5 billion Euros. Until 2005 total expenditure amounted to 4.45 billion Euros of which 1.7 billion were spent on dike reinforcements and local defensive measures.

The aim is to reduce high water levels by approximately 70 cm. Between 1995 and 2005, an additional 77,000,000  $m^3$  of retention volume were realized, amounting in total to 213,000,000  $m^3$ . For 2020, the ICPR's target is 296,000,000  $m^3$  (ICPR, 2005:8). In 2001, the plan was integrated in the project 'Rhine 2020'<sup>13</sup>. More space will once again be made available for the river and flood risks will be incorporated in planned programs/

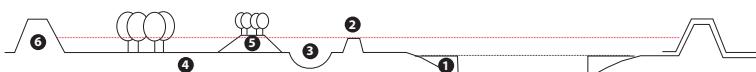
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13 The program 'Rhine 2020 – program on the sustainable development of the Rhine' succeeds the Rhine Action Program. The focal points of future Rhine protection policy are the further improvement of the Rhine ecosystem, the improvement of flood prevention and protection and groundwater protection. The continued monitoring of the state of the Rhine and the further improvement of water quality remain essential. The program is based on a holistic approach. The above mentioned fields of action are taken into account comprehensively and on an equal basis. In the lowlands of the Rhine risks of flood damage must be reduced by 25 % by 2020 (compared to 1995). Downstream the impounded section of the Upper Rhine (downstream of Baden-Baden) extreme flood peaks must be reduced by up to 70 cm (compared to 1995). (ICPR, 2001)

developments if the flood plain can not be made available to the river again. Also, risk awareness and individual flood-protection measures of those affected by floods should improve. However, already today, it is clear that these mitigation measures will not be able to accommodate extreme events. For example, the destructive part of the Mosel flood of 1993 had a volume of 630,000,000 m<sup>3</sup>. To retain this amount of water would have required a retention volume the size of Lake Constanze with a water depth of 1.2 meters (Kron, 2003). Capacities at this scale demand rethinking the relationship between adaptation and mitigation and their temporal and spatial interdependencies. The tributary flood wave of the Mosel joined the flood of the Rhine to cause the severe flood of 1993. Lowering flood risk and extreme water levels via expansive measures is reliant on political and financial support. Due to local resistance, this has not always been a given, leading to a slower implementation process (Rast, Geiger, 2007).



POSSIBLE MEASURES TO INCREASE THE DISCHARGE CAPACITY OF RIVERS:



- ① LOWERING OF GROYNE
- ② REMOVING SUMMER EMBANKMENT
- ③ SECONDARY CHANNEL
- ④ LOWERING OF FLOOD PLAIN (EXCAVATION CLAY/SAND)
- ⑤ REMOVING OF HIGH-WATER FREE AREAS
- ⑥ DIKE REPOSITIONING

Source: Freude Am Fluss

## POTENTIAL FOR URBAN DEVELOPMENT

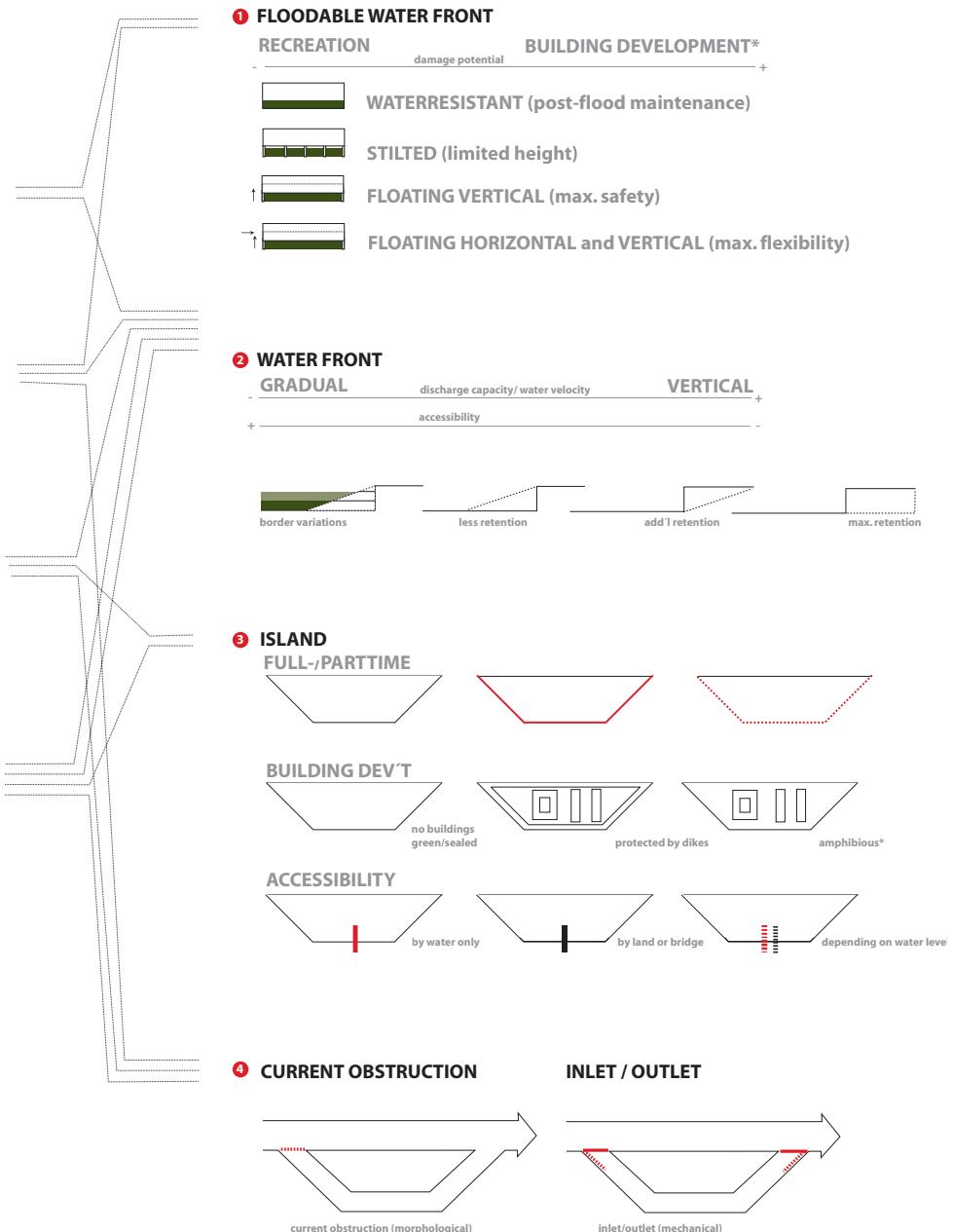


Figure 29

Generic catalogue of expansive flood managementstrategies and their urban development potential (graphic by authour)

Based on international and state contracts, flood risk due to the barrage development along the Upper Rhine is reduced by a system of retention measures with a total capacity of 226 million cubic meters (MUF RLP, 1997). With optimal steering, for flood events up to a probability of 1/200, they aim at limiting the discharge to a maximum of 5000 m<sup>3</sup>/s before the Neckar enters the Rhine and 6000 m<sup>3</sup>/s after (Homagk, Ludwig, 2009). The IRP program foresees 22 retention measures along the Rhine in Baden-Wuerttemberg and Rheinland-Pfalz. Between 1945-1975, 412 million cubic meters of retention volume were eliminated. 255 cubic meters are restorable. Yet, the remaining 157 are not, as they are on site of the barrage and sluices of the Upper Rhine water plant development between Iffezheim and Maerkt. To compensate for this missing capacity, steered retention polders after Iffezheim are being installed (Skublics, 2010:17). The Integrated Rhine Program in Baden-Wuerttemberg aims to reinstall a discharge capacity for a 200-year flood while conserving and redeveloping natural flood plains with a system of dike setbacks and steered retention polders for a volume of 226 million m<sup>3</sup>. The measures of the state of Rheinland-Pfalz (44 million cubic meters) are divided into 30 million m<sup>3</sup> before the Neckar tributary and 14 million after, in order to protect the steep valley of the Mid Rhine. Specifically for the protection of the Mid-Rhine settlements, the development of retention polders is prioritized before dike reinforcements.

The estimated total costs for the Integrated Rhine Program today amount to around 1 billion Euros (Waldner, 2011). In 2000, a budget was set for 483 million and by 2005 was increased to 775 million, expenditure almost doubling due to rising construction prices and the need for more extensive environmental studies due to conflicting programs (Splett, Gönner 2010). In the year 2000, a finalization of the implementation process was foreseen for 2015. Now state government is expecting a 2028 completion. Within ten years, the completion date was expanded by 13 years (Splett, Gönner 2010).

Four steered retention polders are only to be activated to mitigate extreme floods risking dike exceedances and/or breaches. They are statistically only flooded once in a hundred years, enabling a continued agricultural usage. Only one of the four polders, Köln-Langel, has been realized to date and Köln-Worringen is currently being developed. The two others, Bylerward and Ilvicher Bruch are facing a lot of local resistance and are therefore reserved for future measures upon demand, depending on an increase in discharge due to climate change. This is currently being investigated by the ICPR. Orsoy-Land has been added to the steered retention polders with broad support of the local inhabitants (MUNLV NRW, 2009).

Until 2015, dike setbacks and steered retention polders along the Lower Rhine can create an area of 3325 hectares with a total volume of 140 million cubic meters. The aim is to reduce flood levels in the long term at Lobith by 10 cm and to delay the arrival of the flood wave by 12 hours (MUNLV NRW, 2009:209).

Retention measures for large catchments require both steering to cut the flood wave at its vertex effectively and forecasting to prepare adequately. For a catchment as large as the Rhine, steered retention is as of today the only effective solution to reduce water levels. This only works if the retention polder is implemented in the vicinity of the area that demands protection (ICPR, 1999)

The main objectives of the German Room for the River measures are:

- the reinstallation of discharge capacity to pre-barrage levels
- the restoration of the alluvial plain as defined in the framework concept for the Integrated Rhine Program in Baden-Wuerttemberg, where most of the measures are taking place (Pfarr et al, 1996).

### River Expansion NL

Flood management in the Netherlands has always been developed in reaction to previous flood events. This was the case in the 1900s, 1953, 1990s, but also after Katrina in 2005, as it showed the vulnerability of an industrialized Delta Region. After the severe floods in 1993 and 1995, where dikes along the Dutch Rhine branches almost failed, the approach changed from fighting water to living with water (Immink, 2005). Also in 1998, large parts of the Western Netherlands were flooded due to heavy rainfall. To prevent the flooding of cities and villages, polders were deliberately inundated. The Committee Water Policy in the 21st century was founded and for the first time recommended flood management measures that not only focussed on defensive measures, but on river-expansion, arguing that room had to be given back to the river to mitigate floods. Building in the flood plain was to be forbidden so as to give more space to the river (Stalenberg, 2010). This restrictive approach proved to be a hindrance to the implementation of river-expanding measures.

Retaining, storing and discharging has been the Dutch national strategy since 2001. By increasing lateral space, rivers gain additional room for storage and discharge in areas of the alluvial plains currently protected by dikes (van Os, et al, 2002). This implies an end to strictly separating water and land. Instead, it promotes spatial planning with water. The approach involves the retention of rainwater in the soils, ponds and canals along the tributaries not only to reduce pluvial floods in the catchment, but also to limit the discharge of the tributaries into the main rivers. Furthermore, water should be stored outside the riverbed in detention areas in order to achieve a decrease in extreme water levels downstream of the measure. Thirdly, the discharge capacity of the river is increased by deepening the riverbed or by setting back dikes and digging side channels. Dike improvements are only to be executed where spatial measures are technically or financially not applicable.



Figure 30

Overview of Dutch Room for the River measures ([www.roomfortheriver.nl](http://www.roomfortheriver.nl))

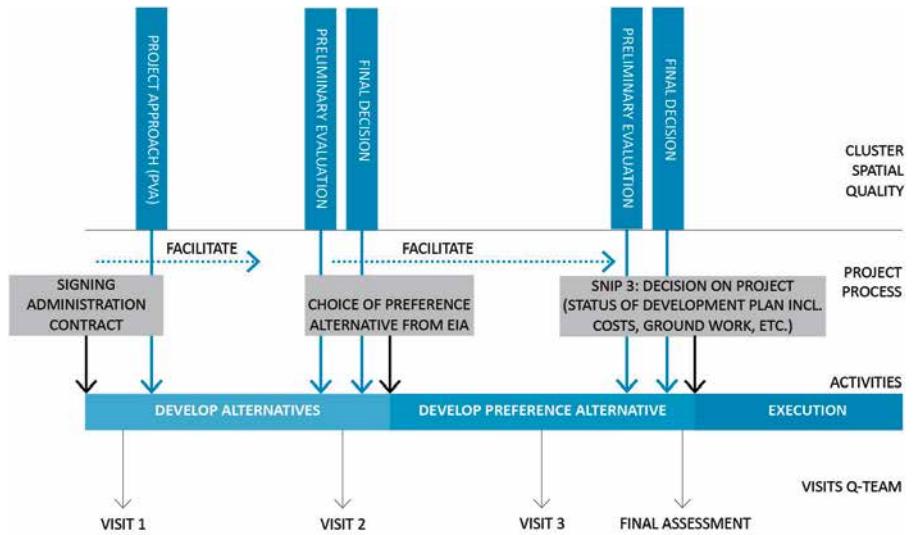
In addition, the committee asked for a sustainable policy in water management, expecting the government to anticipate events instead of reacting. Only solutions not hindering future measures were to be implemented, which implied reserving space for these future measures. The Room for the River program allows for the discharge of the river to increase without increasing water levels (PKB, 2005). In 2006, the Dutch Cabinet drew up the Spatial Planning Key Decision Room for the River (SPKD) Planologische Kernbeslissing Ruimte vor de Rivier), with three objectives:

- in 2015 the Rhine branches will safely cope with an outlet capacity of 16,000 m<sup>3</sup>/s
  - the measures implemented to achieve the above will also improve the quality of the environment of the river basin
  - the extra space that the rivers will need throughout the coming decades as a result of expected climate changes will remain available

A safety level of 1/1,250 and a design discharge of 16,000m<sup>3</sup>/s at Lobith is applied, an increase from previously 15,000m<sup>3</sup>/s. "Where possible and cost-effective, measures are already taken for discharging 18,000m<sup>3</sup>/s from the branches of the Rhine, for example, by establishing a link between the water task and spatial developments. To anticipate the safety tasks after 2015, space should be set aside and where necessary, purchased, outside and possibly also inside of the dikes. Future agreements will be made in the perspective of the flood risk perspective" (National Water Plan, 2008). 39 Room for the River measures with an estimated budget of more than 2.1 billion Euros for implementing the basic package are currently being planned and implemented (SPKD,

2006) (fig. 30). However, the Room for the River approach is not a long-term solution as the space available for water storage in the river area as a whole, the possibilities for diverting river flow to the Zeeland delta and/or the River IJssel and the IJsselmeer, and possible water storage options in these areas may not suffice. Other solutions will need to be found for normal and peak flows in the Rhine (Ligtvoet et al, 2009).

Besides achieving government safety levels, the Room for the River measures will enhance the spatial quality of the industrially transformed river. Although not the primary concern, spatial quality is a central element in the development of Room for the River measures which are considered "drivers for spatial development" (Q-Team, 2012:5). The 'Quality Team' supports the implementation of Room for the River projects. It supervises the projects and consults all those involved in the planning process. The team consists of five experts from the disciplines of landscape architecture, physical geography, river hydrology and biology and urban design. The Quality Team participates in the conceptual phase from the early beginnings, through the preliminary and towards the final designs on the 'architectural specifications' in the tender documents (Sijmons, 2011:66). The Quality Team advises the local and initiating agencies at four stages of the project, ending with the final approval of the project to the Minister before the budget is granted to the local government (see fig. 31). From the experience gained, Sijmons points out two effects of the Quality Team. Large firms tendering for work hire talented landscape architects and other designers knowing they will have to meet the standards of the Quality Team, as well as to boost the quality through collegial debate. As a model, the Dutch Quality Team exemplifies how design can be integrated in a predominantly technical domain at a very high qualitative level. It supports the transformative capacity of infrastructural landscapes to become more than just another part of the, to some degree, urbanized landscape they occupy. The mission of the Q-Team is "to ensure that attractive projects are developed to strengthen the quality of the different river branches" (Q-Team, 2009:4).



**Figure 31**

*Q-Team working scheme: from developing alternatives until project execution (Q-Team, 2012, translated by author)*

Improving spatial quality in the river areas involves:

- increasing spatial diversity along the different river branches
  - maintaining and strengthening the open character of the river area along with its
  - characteristic waterfronts
  - preservation and development of the landscape, ecological, geographic, and
  - historico-cultural qualities
  - improvement of the environment
  - increasing the use of the main inland waterways by the commercial and
  - recreational shipping
- (Q-Team, 2012)

The Q-Team does not only strive for image qualities. Spatial quality is defined by a threesome of hydrological effectiveness (functionality), ecological robustness, and rejuvenation in a meaningful, but sober design. Dynamic processes should drive the design studies. Setting the dynamic qualities into a strong contrast with the formally defined parts of the river can lead to beautiful results (Q-Team, 2012). In the Q-Team Jaarverslag 2009 2010 2012 further aspects how to improve the spatial quality are elaborated:

- Accessibility: minimizing isolation during flood periods and generally improving accessibility of the flood plain (today many sand beaches are not accessible).

- Creating connections, for example between urban peripheral developments and agriculture.
- Keeping a balance between intensive and extensive recreation and nature in the flood plain by good zoning.
- Involving citizens to incorporate their favorite spots in the flood plain in the design.
- Cultural history as source of inspiration based on a strategy of “not ‘back to’ but ‘further with’”).
- The dike is key as it outlives most other elements and dominates the landscape structure.
- A design project is only considered successful when designers and technical specialists work on projects together from the beginning.
- From demolition to reuse: investigate if derelict buildings may have second life for example by setting up an ideas competition.
- Infrastructure such as bridges, inlet constructions, pumping stations or mounds are proposed for many projects. The influence of these elements on the final image should be clear when presenting the implementation plans. The rule applied by the Q-Team: define the mandatory and offer freedom where possible.
- Consideration of different surface materials, for example for dikes to produce a variety of microreliefs and –milieus.

The definition of spatial quality criteria is organized in ‘Handrijkings’ (handbooks) according to the different river branches and segments. The ‘Handrijking Waal’, IJssel or Rijn (addressing the Nederrijn and Lek) provide site specific information and inspiration for initiators and designers to discuss the topic of spatial quality from the initial planning stage to the realization of the river landscape projects. Instigated by VROM and the Program Direction Room for the River (PDR), the ‘Handrijkings’ were developed by Terra Incognita landscape architects together with other consultants in workshops together with future users, decision makers and initiators of spatial developments. The ‘Handrijking Waal’ describes ‘core qualities’ of the Waal river landscape and provides tested design guidelines for assistance. The ‘Handrijkings’ were further discussed in various institutional contexts to provide for a supportive environment. The aim is to provide a link between the increase in discharge capacity and the spatial quality task formulated in the Spatial Memorandum Room for the River (Terra Incognita et al, 2009).

## § 4.5 Policy Frameworks And Strategies

The extreme events of 1993 and 1995 and the expected increase in flood risks due to climate change have not only led to new flood management strategies, but also to corresponding frameworks on a European level and on a national scale, both in Germany and the Netherlands. The following sub-chapter gives an overview of the different (legal) frameworks and strategies in order to point out some of the major differences in Dutch and German planning culture.

### EU

On a European level, in 2007, the EU Directive on Flood Risks came to complement the European Water Framework Directive (2000). The flood directive focuses on the coherent flood approach of member states. Its goal is to reduce and manage the risks that floods pose to human health, the environment, infrastructure and property. Member states need to carry out a preliminary assessment to identify the river basins and associated coastal areas at risk of flooding. For such zones flood risk maps have to be published by 2015 and then flood risk management plans focussing on prevention, protection and preparedness have to be developed by 2018 (EU Flood Directive 2007/60/EC). Flood risk maps differentiate between the flood prone areas outside of the dikes and the flood endangered areas behind the dikes in case of breach or exceedance. Preliminary assessments and pilot flood risk management plans are currently being developed.

The 2007 'Leipzig Charter on Sustainable European Cities' promotes an integrated approach that takes into account the various dimensions of sustainable development and coordinates the actions of multiple stakeholders. Economic, social and territorial cohesion are a key aspect of this strategy, in line with the integration of the urban dimension in the EU cohesion policy 2007-2013. The Leipzig Charter addresses recommendations for the sustainable urban development of European Cities. It is supported by all European Ministers responsible for urban development in their country. Three aspects relevant for UFI can be found here: an integrative planning approach, a plea for a compact settlement structure and the importance of public spaces: "An important basis for efficient and sustainable use of resources is a compact settlement structure. Spatial planning and urban planning can prevent urban sprawl by rigorously controlling land supplies and speculative development."

The key instrument to assess the effects of a project on its surrounding is the environmental impact assessment (EIA). The European Union has established a mix of mandatory and discretionary procedures to assess environmental impacts. The EIA

Directive<sup>14</sup> was first introduced in 1985 and later amended in 1997. The directive was further amended in 2003, following the 1998 Aarhus Convention. In 2001, the issue was enlarged to encompass the assessment of plans and programmes by the so-called Strategic Environmental Assessment (SEA) Directive,<sup>15</sup> which is now in force. Under the EU directive, an EIA must provide the following information to comply:

- A description of the project;
- Alternatives that have been considered;
- A description of the environment;
- A description of the significant effects on the environment
- Mitigation
- A non-technical summary (EIS) and
- Lack of know-how/technical difficulties

One of the main critiques of the environmental impact assessment with regard to climate change is its lack of challenging the given. While climate change requires back-casting strategies to define what we have to do today in order to reach future goals, the environmental impact assessment weighs only the current situation and data of the past (Gret-Regamey and Brunner, 2011). In addition, generally the affected municipalities define the scope of the EIA. This may not suit superordinate goals and time frames, as was the case for the dike setback in Nijmegen (see Chapter 9), part of the Dutch Room for the River program. In this specific case the EIA remained on a conceptual level. It was not brought into the procedure for a number of reasons (Cuppen, 2011). Also in the German planning context, where municipalities are legally in a position to weigh common welfare issues more heavily than flood plain protection, the EIA may show deficiencies. Whether an issue is more important than flood protection can not be derived from the law (Hartmann, 2011). Furthermore, the increasingly relevant participatory aspects that are part of the EIA are not always satisfactory within flood risk management projects (Cuppen, 2011).

Aim of the EIA is to assist in the decision making process. A further critique of the assessment procedure is its lack to incorporate spatial quality. Projects may evolve without a clear conception of its spatial design qualities unless this is explicitly part of the programmatic scope, as for example in the Dutch Room for the River projects. Here, the Netherlands Commission for the Environmental Assessment (CEA) specifically

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European Union Directive (85/337/EEC) on Environmental Impact Assessments

15

Strategic Environmental Assessment (SEA) Directive (2001/42/EC)

demands for the “elaboration of the objectives ‘high-water safety’ and ‘improvement of spatial quality’ and of their interrelationship” and asks to “indicate the role played by the spatial quality in the devising of variants and in the reviewing framework”. It refers to the “Spatial Quality memorandum drawn up specifically for the proposed undertaking” that “provides the building blocks for the development of variants.” In the EIA report the objective(s) for improving spatial quality within the framework of the proposed undertaking are to be investigated by distinguishing, where relevant, between objectives related to the Room for the River Key Planning Decision and other objectives, for example on the grounds of provincial policy or resulting from the area procedure (workshops involving stakeholders). The prioritising of the various perspectives or components of spatial quality, the interrelationships and the choices made with regard to the building blocks for the variants are to be described and indicated which preconditions and starting points for the variants this leads to. Further, how spatial quality will be deployed as a reviewing framework when further working out and designing variants (for example, whether spatial quality will be used to guide or to bind) (NCEA, 2009).

To conclude from the Dutch Room for the River approach to spatial quality: The inclusion of spatial quality in the EIA relies on its definition as a project goal. To be treated efficiently in the course of an EIA, a previous definition of what exactly spatial quality may involve is necessary.

### **Cooperation and Collaboration**

International coordination is handled in the International Commission for the Protection of the Rhine (ICPR). The ICPR first published flood risk maps for the entire Rhine in the Rhine Atlas in 2001. Flood management coordination between Nordrhein-Westfalen and the Netherlands led to the signing of a flood working group in 1997 and updated in 2007 until 2012, based on the ‘joint declaration for the cooperation in sustainable flood management’ between the German state of Nordrhein-Westfalen, the Dutch province of Gelderland and the Directorate-General for Public Works and Water Management (Rijkswaterstaat) for the Eastern Netherlands (MUNLV NRW, 2009). The group studied the effects of extremely high water in the border region between Germany and the Netherlands and estimated the volume of water that could eventually reach the Netherlands. As measures in Germany can not adequately maintain the required protection level in the Netherlands, the Room for the River program proves necessary (SPKD, 2006). The knowledge that upstream flood prevention measures can reduce extreme floods only on a local scale, leads to the recommendation that along the Lower Rhine and Meuse, decision makers should not look far upstream for solutions. Instead, it recommends a focus on measures in or near downstream areas, possibly via detention ponds. As space is limited in the Rhine-

Meuse basins, the aim should be to enable more than one function in areas at risk of flooding (see also recommendation legal framework).<sup>16</sup>

### National Strategies and Frameworks

Containment and expansion as spatial measures are embedded in broader strategies evolving since the 1990s. They are based on a cyclic approach to flood management involving operative flood risk management before, during and after the event.

#### Preventive Flood Risk Management in Germany

The German system for land use planning is highly complex, fragmented and decentralized and complexity is the most important obstacle in flood plain restoration (Moss and Mohnsted, 2008). Before the Federal Water Act was issued in 2005, there was no section in German law entitled flood protection (Hartmann, 2011). In Germany, Spatial planning (Raumordnung) and water legislation (Wasserrecht) offer instruments to define options for urban planning in terms of flood protection and prevention measures. To avoid further land consumption or looking at decentralized rain water management within a developed area, there is more tolerance than for building in flood endangered areas. For these areas, building permits remain exceptional.

Comprehensive spatial management (raumordnerisches Flächenmanagement) for a preventive flood management strategy in Germany involves:

- Securing and reclaiming natural flood plains ('Room for the River')
- Risk management in potentially flood endangered areas (behind dikes)
- Retaining water within the entire catchment area
- Reducing land consumption

The key vision for the task of spatial planning is a sustainable development that involves social and economic demands on space in coherence with its ecological functions. Urban land use planning is bound to the principles and aims of spatial planning at federal or federal state level. Preventive flood management (§2 Abs. 2 ROG) is part of these principles and goals (LAWA Arge Bau, 2010).

The EU Flood Directive is translated into national law in the update of the federal water act (2010). The German federal states (Länder) are committed to defining stretches of

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Also according to Dirk Sijmons, CEO of HNS and Rijksadviseur voor het landschap at the time, 30,000 ha of land should be reserved for water in the West of the Netherlands. An absolute prerequisite for the availability of land on such a scale is the incorporation of multifunctional land use (lecture UNESCO IHE, 2007).

water liable to flood damage and the respective flood prone areas. These plans have to be made public in the coming five to seven years, depending on the damage potential. By 2012, the states also have to set up flood risk management plans to coordinate preventive measures along the rivers where they do not already exist. These plans must be laid out for a 1/100 year flood. The 1/100 year flood, stipulated in the Act for Preventive Flood Protection (2005), is generally also the designated water level that defines flood prone areas. Beyond flood prone areas, flood endangered areas such as those behind the dikes have to be identified to show the flood threat in order to create awareness for the risk to inhabitants and the municipal planning authorities. One of the critiques is the doubt whether the Federal Water Act actually offers effective instruments to make room for rivers and that it lacks legal consequences in case of delays. Giving flood plains a legally binding status is a very "time consuming and complex administrative procedure" (Hartmann, 2011:23). It is much easier for water managers to maintain the system as it is (dike reinforcement and maintenance) than to declare areas as flood plains. The law does not give any incentive to change the system. While the declaration of flood plains demands a 'Raumordnungsbeschluss' (Spatial Plan Enactment), an EIA and a plan approval procedure, dike maintenance does not. At the same time weighing issues of flood plain designation against general welfare provides municipalities with a great amount of freedom in balancing local interests against superordinate, but sectoral interests of water management.

Priority areas as the goals and reserve areas as the principles of federal spatial planning for preventive flood management (see fig. 32) are defined in spatial plans for the federal state and in regional plans. They must be designated in the regional plans (state and regional scale executed by the Länder), municipal zoning plans and legally binding layout plans (in the responsibility of the municipality). Whereas goals are specified further on a municipal level, principles serve as parameters for consideration (see exceptional developments).

Environmental protection is also organized by the Länder, but specific aspects may be weighted on a municipal level. Ecological flooding is a prerequisite for the installation of steered retention polders to prepare plants and animals for flooding during the activation of retention polders in their function to mitigate water levels. They are statutory according to the German federal and state nature protection laws. However, they can also be sidestepped to ensure general welfare, as, for example, in the case for the Polder Langel in Cologne.<sup>17</sup> This would be a typical case of preferring public interests.

As a navigation channel, the Rhine is managed on a national level by the 'Wasserstraßenverwaltung des Bundes', the federal shipping administration. National shipping authorities must authorize all changes to the riverbed profile and all mooring sites. They are represented in regional offices. Currently, the environmental organization NABU is working on communication strategies between the WSB and the municipalities for revitalization projects of urban water fronts ([www.lebendiger-rhein.de](http://www.lebendiger-rhein.de)). For agricultural land, erosion and pollution should be avoided or reduced. In terms of specific projects even the farmers and often the landowners along the Rhine have to be involved.<sup>18</sup> The EIA precedes the plan approval procedure, which is mandatory for developments that influence the defence line. It also involves a public participation procedure that takes all objections to the project into account. The plan may also become effective for possible condemnation measure.

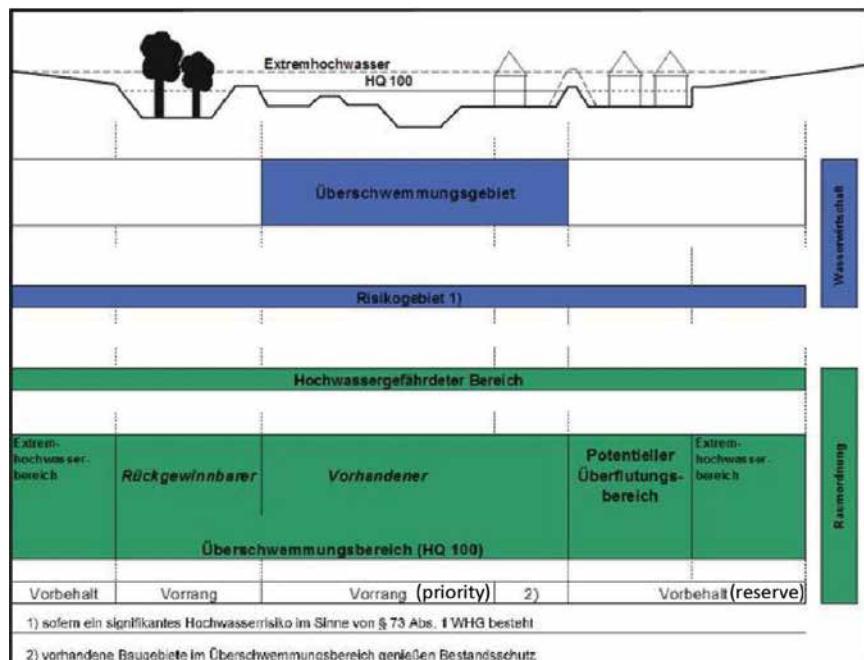


Figure 32

Section with priority areas and reserve areas in D (LAWA, 2011)

### **Dutch Layer Approach (National Water Plan)**

Research and strategy development in the Netherlands underlies a much higher dynamic. In the past ten years, the Fourth National Policy Document on Water Management (Vierde Nota Waterhuishouding), the Water Management in the 21st Century Advisory Committee (Commissie Waterbeheer 21e eeuw) and the National Administrative Agreement on Water (Nationale Bestuursakkoord Water) represented important impulses for water management. The first National Water Plan, a framework vision based on the new Water Act (Waterwet) and the Spatial Planning Act (Wet Ruimtelijk Ordening) and recommendations by the Delta Committee, drafted for the 2009-2015 planning period, define the current phase.

"On the basis of flood risk, standards are currently being redefined. They will be tested every six years against water levels and wave heights that are expected twelve years later. In 2011, the level of standards will be decided upon based on a cost-benefit analysis and an analysis of the potential number of casualties. The consequences of the safety standards increased by a factor 10 as proposed by the Delta Committee will also be shown. Further research will be conducted into robust and wide delta dikes" (Stumpe, 2009).

Current water policy in the Netherlands already takes the possible effects of climate change into account, in general with a time horizon of about 50 years, and, for coastal defences, a century. Most threatening are simultaneous floods from the sea and the river. In the long term, rising sea levels and the potentially corresponding reduction in free water flow in rivers determine the sustainability of the Netherlands (Ligtvoet et al, 2009).

Dutch Flood management is not only developed responsively to previous events in the Netherlands. Moreover, hurricane Katrina, which led to the devastating flood in New Orleans in 2005, gave the Dutch government reasons to rethink their policies on flood and water management. In 2007, the Delta Committee 2008 was founded to investigate how the Netherlands could be protected until 2100 and still remain a safe country to live in. As a result, the Delta Committee introduced a three-layer approach, which resulted in the National Water Plan at the end of 2008. Based on the safety-chain approach of pro-action, prevention and preparation, response and after-care, developed at the end of the 20th century, one of these layers or a combination are to be applied - depending on the local setting and type of flood (Stalenberg, 2010). The National Water Plan not only addresses preventive measures but also includes operative aspects in case of an event. This is a multi-layer approach to protection:

1. Prevention - prevention of floods by reducing probability as highest priority, implying the construction of flood retaining structures and preserving space for their future improvements.

2. Sustainable spatial layout - taking flood risk into account in spatial planning by adaptation, reducing the amount of damage and casualties. A second layer is important since the first layer is not capable of fully protecting the Netherlands.
3. Disaster mitigation - operative flood risk management including evacuation, information systems, et cetera. Even though flood risk can never be ruled out completely through defensive measures, these are and remain the main pillars of flood risk management. The second and third layers are therefore aimed at limiting the effects of flooding. The aim of the second layer is to create a sustainable spatial layout of the Netherlands and the third seeks to improve the organisational preparations for a potential flood (disaster mitigation).

### **Legal Framework NL**

Water levels are strongly interlinked with ground use and therefore with spatial planning. In the Netherlands, two new laws define the interaction between spatial planning and water management, the Federal Water Act (Waterwet, 2009) and the Federal Spatial Planning Act (Wet Ruimtelijk Ordening, 2008). The Water Act looks at integral water management from a water systems perspective, including all relations within water system: between water quality and quantity, surface water and ground water, but also the relations between water, land use and water users. As a result, it involves nature, environment and spatial planning. It is well connected with the new law on spatial planning (Wet ruimtelijke ordening Wro) intensifying the engagement with spatial issues (Ministerie van Verkeer en Waterstaat, 2008).

In the Netherlands, the state is responsible for state waterways and the water boards are responsible for all other waters. In contrast to Germany, flood management and navigation are both in the responsibility of one ministry, RWS. The municipalities and the provinces take on additional water management tasks involving specific ground water extraction and infiltration issues and the municipalities are those responsible for rain and ground water management. Provinces oversee water boards and municipalities and can give instructions and orders (Ministerie van Verkeer en Waterstaat, 2008).

The general river-related provisions for all developments are stated in the Dutch Policy Guidelines for Large Rivers (Beleidslijn Grote Rivieren). The main provisions are:

- a positioning and execution ensuring the safety of state water works
- no limitation to future measures for enlarging the discharge or storage capacity
- keeping of consequent water level rise or decrease of the storage capacities as minimal as possible
- ensuring the compensation of the remaining effects on the water levels and the storage capacity both financially and in due time (BGR, 2006:7).

The Federal Water Act can provide regulations to prevent floods, continuing the practice of defining design water levels, peilbesluiten, and target water levels, streefpeilen. It can set regulations for the storage and discharge capacity of regional water systems to store or discharge excess water during high water levels. The national and regional water plans' strategic vision statements define the framework for water management issues and measures for six years. These are also relevant for spatial planning and aim at strengthening the interaction between water management and spatial planning. The water boards and RWS set up operational water management plans specifying which measures are to be executed in the following period (Ministerie van Verkeer en Waterstaat, 2008).

Furthermore, inhabitants and businesses have to accept certain water management activities called toleration obligations, gedoog- en duldplichten. It is new that property owners have to store water on their land if it is situated within a designated water storage area, as defined in the leggers and in the municipal zoning plan. The water managers establish registers called leggers for the water management structures under their responsibility. These are registers that note which criteria the structures have to fulfill regarding their position, form, scale and construction as well as administrative boundaries and protection zones. Protection zones only allow activities according to very restrictive criteria in order to ensure the stability of the dike (Ministerie van Verkeer en Waterstaat, 2008).

The categories of projects that require an environmental impact assessment are summarized in Dutch legislation, the 'Wet milieubeheer'. The use of thresholds for activities makes sure that the EIA is mandatory for activities that may have considerable impacts on the environment. For projects and plans that fit these criteria, an EIA report is required.

A nature conservation impact assessment was performed for the 39 Room for the River measures to see whether the decisions the PKB takes are in accordance with the relevant regulations. The decision relating to each measure must comply with the Nature Conservancy Act 1998 and the Flora and Fauna Act. In each case, the nature conservation impact assessment must take on board the Strategic Framework for the Birds and Habitats Directives, Room for the River and Room for Natura 2000 (SPKD, 2007). Mitigation – preventing or reducing significant adverse impacts on the protected ecological values – is not always feasible within the area to which the measure applies. In such cases mitigation will be put into effect within the Natura 2000 site as a whole and if possible in an area affected by another measure by virtue of this PKB. Where mitigation proves impossible, compensatory measures will be taken outside the Natura 2000 site (SPKD, 2007).

The experience with ecological flooding in the German projects may be important for projects in the Netherlands as bypasses and 'green rivers' are foreseen in the national

program Room for the River (Menke, Nijland, 2008). However, they are not required and due to the differences in river landscapes may not be necessary in the Netherlands as there are no alluvial forests to be restored and in any case ground water levels are much higher. Ecological flooding is a key component of German retention polder development, demanding much more frequent floods than simply the shaving of peak floods, and it is therefore not popular among those who use the area for gravel excavation, agriculture and leisure. The Dutch Room for the River measures do not foresee ecological flooding. However, other reasons to raise the frequency of flood events on site play a role. For example, in the Nijmegen project, flood frequency is defined according to aspects of awareness rather than ecological considerations (see PART II Nijmegen).

## § 4.6 Exceptional Developments In The Flood Plain

D / For the first time, the approval of new building sites in the flood plain has been generally prohibited on a national scale. Exceptional building permissions, however, may be granted in case of nine very restricted cases, such as when the municipalities have no other possibilities to expand, and on the condition that new buildings have to be developed to adapt to flooding. According to the Federal Water Act, an exceptional permission to build in the legally designated flood plain can be acquired for the following cases:

1. due to technical or economical reasons, a business within or next to a designated flood plain can only expand into the flood plain
2. the newly-defined development area is directly adjacent to the existing building structure
3. lives are not endangered, severe damage or a health threat is not expected
4. the discharge and the water level will not be negatively influenced
5. flood retention will not be negatively influenced and the loss of reduced retention volume will be compensated accordingly.
6. existing flood protection will not be negatively influenced
7. no negative effects may be expected for the areas up- and down river

8. flood prevention measures are considered
9. the buildings have to be adapted according to the inherent flood risk as defined by the design water level which defines the flood endangered area.

There is no data available on the number of exceptional permits for building developments in the flood plain (not including harbours and wharfs)<sup>19</sup> that have been issued along the Rhine. Based on data provided by the regional governments since 2003, fourteen singular developments and 18 urban land-use plans have been granted in Baden-Wuerttemberg (DS, 2009).

**NL** / In the Netherlands, any activity in the riverbed requires two kinds of permits. A permit upholds the Act of Public Works and Water Management (Wet beheer rijkswaterstaatswerken; Wbr) and conforms with the spatial framework, the 'streekplannen' (regional plans) and 'bestemmingsplannen' (zoning plan). The zoning plan also provides information about fluctuations in water levels (Nillesen, 2011). The coordination of these two is organized in the BGR. The BGR applies for all primary rivers that play a role in flood management under the responsibility of the Dutch state.

The more process-oriented approach of the BGR aims to anticipate claims for indemnification. It offers a step-by-step weighting system to negotiate the spatial claims in the riverbed. The river bed is defined by the dike crown and the design water level 1:1250 for the endikened areas and the sectional topography for areas without dikes (see fig. 33).

The BGR differentiates between discharging and retaining river regimes, stromvoerend and bergend regimes. Regarding developments in the riverbed, within discharging river segments, principally all specified river-related activities are permitted according to the strategy 'yes, given that...' vs. non-river related activities which are forbidden, unless under certain circumstances where exceptions are possible 'no, unless...' Within the retaining regime all activities are permitted as long as they cohere with the river-related provisions 'yes, given that...' (BGR, 2006:21). River-related activities are activities and building measures related to river management and navigation and other functions that are specifically bound to the river (BGR, 2006:24).

Non-river related activities are:

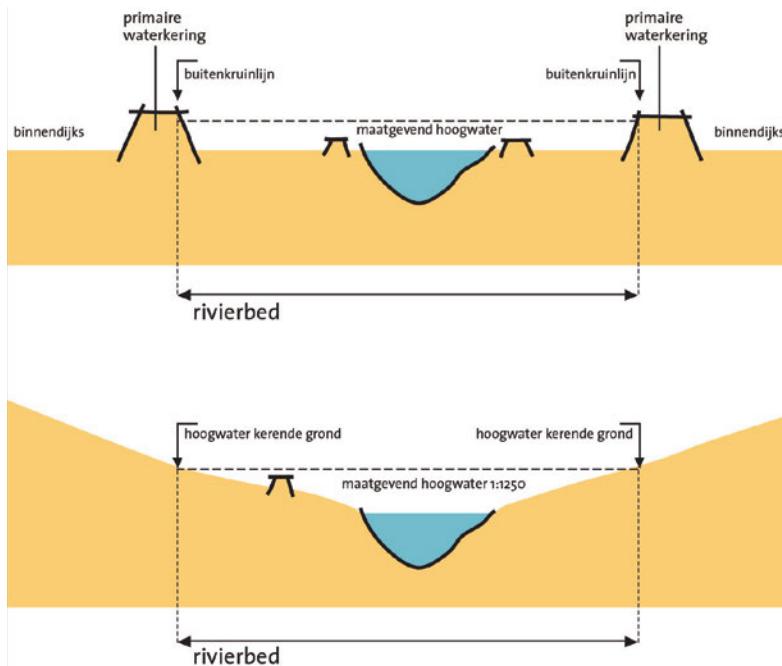
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according to the federal water act § 31 b Abs. 4 and § 78

- a. a great public concern which can not be realized outside of the riverbed;
- b. a grave economic concern for existing ground-related agricultural businesses where the activities can not be realized outside of the river bed;
- c. a change in program for existing buildings; or
- d. an activity which per saldo offers more room for the river than a location acceptable for river management. (BGR, 2006:24)

As not everything can be defined by general rules, the Waterwet introduces the integral water permit for activities in, on, under or over water systems. Six previous permits are now organized under one. It also includes, for example building on dikes.



**Figure 33**  
Schematic section of the riverbed as defined in the Wbr in a situation with and without dikes (BGR, 2006)

### Responsibilities

**NL / Risk and the inherent responsibility for protective measures against possible damage are in the hands of the initiator of an activity in the riverbed. The possibility for insurance**

against flood damage for building developments in the flood plain relies on adequate adaptation to the dynamics of the water, such as floating or stilted buildings. While the state is responsible for the safety behind the dikes and thus compensates for damage, there is no insurance against dike breaches or exceedances (ICPR, 2011). In the outer dike area, the responsibilities are organized differently and lie in the hands of the local authorities. In addition to existing law, layout plans (bestemmingsplans) and building codes have to include specifications to prevent the inherent risk. Evacuation plans may be an essential contribution to preventive measures during floods. The provinces, water boards and the central government are charting flooding risks jointly and these will be mapped out in zones by 2012 (Ministerie van Verkeer en Waterstaat, 2008).

**D** / The federal state and the Länder only compensate for damage behind the dikes in exceptional cases. This is determined on an individual event basis. German insurance companies have developed a zoning system for flooding, backwater and heavy rainfall (ZÜRS). ZÜRS enables an evaluation of a building's location according to its inherent flood risk as specified in four zones. A statistical flood risk with a probability of flooding less than once in 200 years applies for 86% of the buildings in Germany. Only 3% of all buildings are located in Zones 3 with a probability of flooding once in 10 to 50 years and Zone 4 (more often than once in 10 years). However, not all buildings are insurable against flood risk. If the probability of a regular flood risk is a given, for example in a legally defined flood plain, flood protection is only supplied with a high deduction or not supplied at all. At the same time, flood risk insurance can be declined when the building is not provided with corresponding protective measures. This also requires individual responsibility (source: [www.gdv.de](http://www.gdv.de)).

### **Compensation and Space for Future Measures**

**D** / The compensation of exceptional developments in the flood plain in Germany is organized in the Federal Water Act. If developments in the flood plain are permitted, a qualitatively equivalent area has to be compensated for in due time in order to provide the same retention volume as the development. The compensation measures must pay attention to avoid negative effects up and down river as well. Compensation measures for new developments are to be included in municipal zoning plans. Spatial reservation for future measures is at this point not foreseen in Germany.

**NL** / The PKB Ruimte voor de Rivier foresees measures for the short-term with 16000 m<sup>3</sup>/s at Lobith by 2015 and, unlike in Germany, also for the long term: 18000 m<sup>3</sup>/s and 60 cm sea level rise for 2100. This long-term perspective involves the location of where to set space aside for future river expansion measures in the inner and outer dike areas. Here the focus lies on reserving areas behind the dikes, as the outer dike areas should not be developed in a way that could hinder future measures (BGR, 2006:43). New developments in the riverbed should only be permitted with good reason, likewise in order to enable river-related activities and measures compensating for the effects of these activities (BGR, 2006:24). In areas where space is a 'rare good,' priority is given

to space for river expansions, for the compensation of nature developments, for river related activities and for future measures. To avoid water levels rising, a good location and execution have to be found before compensation is considered. The rise in water levels caused by an activity must be compensated for effectively (BGR, 2006:24).

## § 4.7 Differences In Planning Culture

### Landscape and Threat

When looking at projects in Germany and the Netherlands, it is essential to point out the differences in planning culture. The spatial preconditions lead to a very different risk perception and thus risk management, as the safety levels of the dikes in Germany (1:100) and the Netherlands (1:1,1250 for river dikes and 1:10,000 for coastal defence) illustrate.

The Delta differs from the other Rhine segments also regarding its temporal organization: The management of water levels is an existential, vital and constant process due to the given topography and the man-made polder landscape. Thus, water management extends from a continuous draining activity, reliant on the dike ring system, to handling the combined threat of sea and river that can create potentially extreme events. In contrast, along the German river segments, although very diverse in terms of topography, the linear defensive systems have no vital functions on a day-to-day-basis, but remain infrastructures for events occurring in seasonal cycles.

"The extent to which water is a defining factor in spatial developments depends on the nature, scope and urgency of the water task in relation to other tasks, existing functions and soil quality, as well as other area-specific features." (Stumpe, 2009:5)

### Political Structures

Political structures relevant for flood management also differ significantly. While centralized political structures in the Netherlands enable a top-down approach, in Germany the federal structure provides the Länder with their individually defined programs with a high degree of autonomy. A formulation such as "the central government encourages....", anticipating the proactive involvement of different stakeholders is not imaginable. The federal structure produces a high degree of complexity. Organizational structures may also differ between the states. Rooted in the federal organization of activities and a high degree of autonomy from centralized structures, project information is not easily accessible as it is handled not only more confidentially, but also more sectorally. To give an example: In Germany, flood management is handled on the state level by the Länder and navigation is managed

by the federal shipping authority, whereas in the Netherlands flood management and navigation are both in the responsibility of Rijkswaterstaat. Furthermore, the economic perspective in German flood management is not capable of producing a different dynamic and dissemination policy. The coherence of political entities within the dike ring system in the Netherlands, where each dike ring is also a separate administrative unit according to the Water embankment Act (1995), further shows the essential link between political and spatial organization in terms of flood management in the Netherlands (Aerts, 2009). Except for in Nordrhein-Westfalen, the German Rhine is a border for most of its length - between Baden-Wuerttemberg and France and between the adjoining federal states. At the same time, dikes as linear systems of course cross state borders, thus sharing responsibilities. This requires bilateral agreements.

### **Integration and Iteration**

NL / Two further aspects deserve mentioning in an understanding of the differences in planning culture. Although flood management in the NL is a top-down process, it aims for an integrative approach both programmatically as well as in terms of cooperation between the institutions and parties involved locally. In the National Waterplan this approach is defined as an area-based approach:

"An area-based approach is to become the standard for implementing measures, which means not only deciding what is needed from the perspective of the water system but, more specifically, working with all stakeholders to apply a development-gearred approach and seize opportunities. (...) the government wants to work on water policy: together with other authorities, water management bodies, citizens and businesses, using an area-based approach that requires customizing, with continuous investment in knowledge and innovation, with the willingness to learn, and aimed at adjustment to new developments through monitoring and evaluation." (Stumpe, 2009: 8,19)

This approach aims at making urban areas more livable by addressing different programs cohesively. This involves living, working, mobility and leisure, but also landscape, nature, water and the environment. Green spaces and water will be increased within urban developments to make urban water systems more robust and climate-resistant while offering opportunities for making the city more attractive. In this context, also living on water is encouraged.

This integrative strategy is developed iteratively. The learning approach is paired with a high degree of transparency, dissemination and exchange of data, both locally<sup>20</sup> and internationally, producing a productive environment for innovation, local experiment and marketability also internationally.<sup>21</sup> An interesting example is the first major zoning plan set up by the Westland region in 2009. It combines water storage and residential development into a dual-use category (Nillesen, Singelenberg, 2011).

A programmatic approach is already taken in the Room for the River project. It leaves space for other authorities and market parties to propose alternatives or supplementary plans “under the condition that the objectives of the SPKD Room for the River are realized on time and that the parties concerned can guarantee sufficient financing for the project. (...) For the application of new knowledge, techniques or technologies which allow the objectives to be met more effectively or in a more socially acceptable way. Important criteria are greater safety and spatial quality and/ or cost effectiveness. This approach is in accordance with the desires of the region itself.” (SPKD, 2007:13)

Water management can be integrated in all programs, such as leisure activities, nature and landscape, agriculture, renewable energy production and housing. An area-based approach is seen as a possible strategy towards “improving water management whilst reinforcing the economy and the living environment at the same time. And this should be done at a social cost that is as low as possible”. (Stumpe, 2009:5)

While spatial planning is a decentralized activity, water management is a centralized task in the responsibility of Rijkswaterstaat (Public Works and Water Management). A sustainable and climate-resistant water system necessitates that short- and long-term water management requirements be considered in spatial development. The iterative approach inherent to Dutch water management to achieve this shows in the flexibility applied. It is the aim to enable a successful implementation not only from a water management point of view, but also spatio-economically. This specifically entails a less sectoral approach by

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20 "Solutions and areas will be considered as a cohesive whole and the (spatial) consequences for regional systems and functions (drinking water, agriculture, nature and shipping) made transparent." (Stumpe, 2009)

21 Not only are international best practices for low-lying areas inventoried as one task within the water plan, but "...where opportunities arise and a demand for Dutch technology and knowledge is made known, the Cabinet is opting for an approach based on a global positioning of the water and delta technology sectors of industry. An international 'Water Sector Marketing Programme' (Marketing Programma Watersector) is to be developed in 2012." (RWS, 2008).

the water managers, who are asked to anticipate spatial and economic developments proactively and to involve themselves beyond their statutory obligations.

An example of the flexibility inherent to the approach is illustrated in the change of strategy after an evaluation of the Nota Ruimte 2005 showed that restrictive spatial reservations within the Room for the River Directive in 1997 produced conflicts on a local and regional scale. Permitting river-related activities in the riverbed and other activities only in case of a 'profound societal reason' led to conflicts primarily with the municipalities and the private businesses. Ironically, the Spatial Planning Memorandum study showed that activities not related to the river could actually contribute to the realization of the river-related aims. Some locations in the riverbed had declined with increasing vacancies and vandalism of vast areas resulting from the Room for the River policy. Therefore the Nota Ruimte started an experimental program for these sites: the Experiment with adapted building (Emab) for 15 locations. In connection with the PKB and the BGR, it enables owners to develop a project idea together with other stakeholders involved. Apart from compensating for any possible water level rise as a consequence of the development, an expansion of the riverbed is a precondition. As a result, the project should enable more room for the river in total. The project was set up to experiment with adapted building, such as swimming or stilted typologies in order to gain experience with 'water-neutral building' techniques. The 15 experimental projects are seen as an independent trajectory in order to stimulate adapted building and to encourage its development (BGR, 2006).

The current tasks illustrating the ongoing dynamics in Dutch flood risk management as an iterative approach are the following: further studies and work on the Room for the River program and the EU Flood Risk Management Directive along with a consideration of policy amendments based on these studies; and the continued quest for effective measures or means of keeping space for water available in the long term, supplementary to the tool of spatial reservation.

D / Due to the long bureaucratic procedures that precede plan approval as well as less pressure for action and integration of flood-related projects due to a smaller existential risk, projects are executed/managed less responsively to progressive experience. German planning practice opts for an integrated approach, which implies including flood-related issues in comprehensive spatial planning and involving all stakeholders to avoid conflicts and increase acceptance. As Hartmann points out, it is not always clear who the stakeholders are. In any case, landowners are often neglected (Hartmann, 2011) and designers are never considered as relevant agencies. Instead the focus lies on land use planners, water managers and insurance companies, environmental agencies, disaster management, and the population as a collective.

Although exceptional developments in the flood plain are possible upon local decision-making, they are not a coordinated effort for learning.

In Rheinland-Pfalz and Baden-Wuerttemberg flood partnerships between state environmental agencies and municipalities/project developers are also encouraged (see PART II / Mainz Zollhafen).

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## § 4.8 Flood Risk Management - Demanding for an Iterative Approach (Extract)

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The existing risk to already urbanized areas behind the defence in case of exceedance, breach or seepage, as well as the maintenance costs and height limitations of defensive infrastructures and the uncertainty of future scenarios have led to the quest for alternative flood management strategies.

Although often discussed as either/or strategies, defensive and mitigative measures are mutually interdependent, the only alternatives being avoidance or adaptation. Due to spatial and cultural patterns along with economic reasons, our capacities to adapt today are limited. River containment both supports a defensive approach to flood management on a territorial scale and, opting for a channelled river bed, coheres with the demands of navigation. Instead, river expansion measures encourage nature development, but may lead to an increase in sedimentation, which demands additional dredging measures of the river bed. Both strategies rely on adequate economic capacity to achieve and maintain the system.

Maintenance costs and height limitations, exceedance and failure during a flood event and a collective feeling of safety 'behind the defence line' are the weak points of a strictly defensive territorial approach. In D+NL, dike improvements are only to be executed where expansion measures are technically or financially not applicable. The Room for the River approach is not a long-term solution for the Netherlands: other solutions will need to be found for normal and peak flows in the Rhine. An important factor that limits the available solutions is the limited space available for water storage and diversion (Ligtvoet et al, 2009). A further rise in sea level and consequently a reduction in natural downhill flow will, in the long-term, require higher dikes to be built in an increasingly larger area of the south-western Netherlands (Ligtvoet et al, 2009). Due to the expected continuous building development in the Netherlands, the potential damage of a flood is expected to increase even once the dikes are heightened, corresponding to the increase in probability (Aerts, 2009).

In Germany and the Netherlands, spatial expansion exceeds the dynamics of an increase in population by far. However, in the Netherlands employment numbers and economic growth have a congruent dynamic to land coverage (Siedentrop et al, 2009).

In Germany, land consumption and the increase in impervious surfaces is also one of the major anthropogenic drivers for an increase in run-off and therefore an increase of flood risk. Reducing land consumption is seen as one of the key strategies to reducing this run-off. It may also reduce economic damage potential as well as infrastructural expenses while offering space for water storage.

Aside from differences in strategy between defence and expansion, topographical differences play a major role when looking at flood risk management strategies in Germany and the Netherlands. Moreover, differences in planning culture, which may again be linked to the landscape as a system, play a major role. The different time scales (finite D 2020 and NL alternative planning under uncertainty until 2100) are relevant for the spatial layout. In Germany, the time horizon is, at this point, limited to the next 10 years. Whereas Dutch climate scenarios involve time scales of 50 and 100 years, reservations for future measures in Germany are not scenario based. Beyond a climate buffer of adding 50 cm to current defence heights in Baden-Württemberg and the designation of emergency polders, future measures are included in current plans.

Flood risk management in the Netherlands is centrally organized and developed iteratively in a responsive process between the central government and local administrative bodies. German planning is organized in a federal system, with fewer possibilities to incorporate new insights along the way, due to long planning procedures and the given complexity of multiple agencies and differing levels of hierarchy. Projects are executed /managed less responsively to progressive experience due to long bureaucratic procedures preceding plan approval and less pressure for action and integration of flood related projects as a result of the smaller existential risk. It therefore offers fewer feedback loops between the local scale of implementation and the strategic planning scale. Conversely to the Netherlands, there is no economic perspective in flood management in Germany. Here, it may be important to point out that the Dutch economic perspective currently involves hydraulic engineering techniques and planning expertise. It does not pertain to the economic capacity of programs evolving from the dynamics of water levels on site.

Some examples to illustrate the differences in planning culture:  
Whereas the Room for the River program is mainly organized between the central and the local scale, the High Water Action Plan is developed across four states and two nations and a corresponding project scale. The coherence of political entities with the dike ring system in the Netherlands, where each dike ring is also a separate administrative unit according to the Water embankment Act (1995) further shows the essential link between political and spatial organization in terms of flood management in the Netherlands. In Germany, although the river itself serves as a border, the different river segments do not cohere with state boundaries.

Emab, the experimental building program for Room for The River sites in the Netherlands was developed as a direct response to previous experience. As a restrictive approach to flood plain development only allowing river-related programs, proved to be counterproductive, a more permissive and interactive approach was developed with the direct participation of local inhabitants including programs that showed contributions to the realization of river-related goals even though they were not related to the river. Also in Germany, local resistance has led to a decelerated implementation process for the retention polders in Germany, yet there is no transdisciplinary layer to coordinate alternative strategies.

On a local scale in Germany, exceptional developments in the floodplain are possible upon local decision-making, but they are not coordinated in any research effort for learning. Partnerships between the state level and the project developers are encouraged within individual projects, however, these are not reflected within a program structure. Also, the support of the Dutch Room for the River measures' local implementation process by the Quality Team as a continuous mentoring/consultancy provides a better knowledge exchange between the projects and enables a coordinated learning effect.

In contrast to Germany where flood management is organized on state level by the Länder and navigation is managed by the federal shipping authority, in the Netherlands flood management and navigation are both the responsibility of Rijkswaterstaat.

Rooted in the landscape: in Germany, beyond inner city sites, a restrictive ecological perception of flood plain prevails over urban development. While the majority of compact cities may not be capable of hosting Room for the River projects due to lacking spatial capacities, the sites which can are not as rural as they may seem when considering their economic damage potential. For example for the area behind the primary dike along the Upper Rhine in Baden-Württemberg, where settlements and industrial plants are located in the former flood plain without preparatory measures taken in case of an event and where a dike breach or exceedance could easily lead to regional supply shortages, massive large-scale traffic hindrances and a breakdown of supply lines (Ludwig, 2008).

In NL, the area-based approach (National Water Plan) encourages living on water and combining water and green zones in the urban realm. Taking an area-based approach is seen as a way of improving water management whilst reinforcing the economy and the living environment at the same time. This involves the short- and the long-term perspective and the anticipation of developments across disciplines. 'The extent to which water is a defining factor in spatial developments depends on the nature, scope and urgency of the water task in relation to other tasks, existing functions and soil quality, as well as other area-specific features.'(Stumpe, 2009:5).

Exceptional in this context is the specified demand for spatial quality as a secondary project goal within the Dutch Room for the River program. It not only formulates the need for spatial quality, but also provides a strategic design approach to ensure its consideration from the initial project stage to the implementation.

## 5 Resumé Part I / Narrative



ECONOMIC SYSTEM	PRE-INDUSTRIAL /	INDUSTRIAL /	TRANS-INDUSTRIAL /	ECOLOGICAL /
CITY / LANDSCAPE RELATION	DYNAMIC	CONTROLLED	CONTROLLED-DYNAMIC	ECOLOGICAL
SOCIETY	INSTINCT	NO AWARENESS	AWARENESS QUESTIONS SYSTEM	AWARENESS DEFINES STRATEGY
FLOOD MANAGEMENT STRATEGY	LOCAL DEFENSE	LARGE SCALE DEFENSE	DEFENSE AND MITIGATION	RESILIENCE

## **2. Complex Systems And Landscape Urbanism – Demanding For A Transdisciplinary Layer**

As Landscape Urbanism, based on the cause-effect network, takes the long term and therefore uncertainty into account, it demands for a transdisciplinary layer. By moving beyond a sectoral approach to coordinate the different programs and disciplines and to manage projects responsively to lessons learned- not only spatially, but also economically – the aim is to create capacity for emergent qualities between programs to arise. Whereas the trans-industrial logic does not provide economic capacity, but relies on resources reliant on industrial production, the ecological approach, based on an understanding of the economy as a subsystem of an endless ecosphere, thrives for solutions capable of providing for themselves.

## **3. Evolution – Path Dependencies**

In term of land consumption, we can speak of a paradigm shift from an expanding productive scale towards an expanding ecological scale. However, path dependencies today specifically involve the economic capacity needed to sustain the industrial system. The rise of the ecological movement in the 1960s and 70s and its further establishment have greatly contributed to the restoration of the river in terms of water quality. Yet, changes in the structural quality towards a more dynamic system are at this point only possible within niches supportive of the industrial regime. Whereas the long tradition in making and maintaining the Dutch anthropogenic landscape enables a less dialectic relationship between the urban realm and the landscape, German measures aim at restoring the original landscape as it was before channelling and are therefore focussed less on the remediation of all programs which have manifested themselves or are staking claims in the former flood plain. At the same time, adaptation strategies of inner city harbours in the flood plain offer a counter model to further land consumption. Instead they leave space for water storage and floodplain restoration, a decelerated run-off, and a reduction in infrastructural costs. This approach demands for a layering of programs and thus for the remediation of different spatial entities.

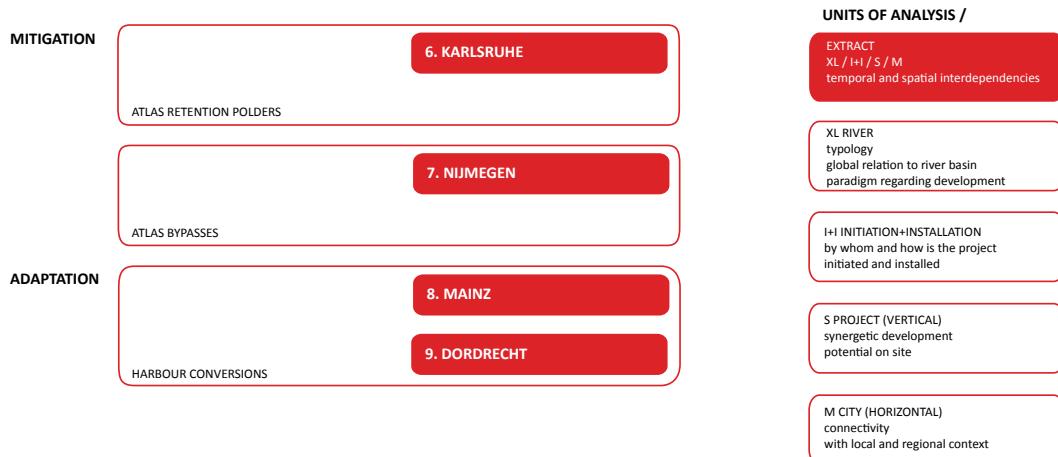
## **4. Flood Risk Management Today – Differences in Planning Culture**

The industrial system relies on the production of means to maintain its infrastructure. While an increasing flood risk demands for the accommodation of more dynamic fluctuations in water levels and industrial production along the Rhine is decreasing, our concept of growth is (once more or still) being questioned. Therefore, to challenge the given system, all changes towards a more dynamic system also demand for respective economic capacities - by reducing damage potential (adaptation) and by introducing new markets fit to perform within a dynamic river landscape. This systems change demands for different strategic components which we already find in Dutch flood risk management: an area-based approach based on long-term strategies, back-casting and iteration, the encouragement of proactive collaboration between agencies and a permissive approach to the integration of diverse programs.



## PART 2 Case Study Evaluation

The four case studies Karlsruhe, Mainz, Nijmegen and Dordrecht (see fig. 34) were chosen based on the spectrum of city-river-flood management constellations they present. All are current developments or projects in the flood plain on different segments along the Rhine. They are not comparable, but representative mitigative and/or adaptive typologies for a number of other sites along the river (see XL Atlas). They are an investigation of the temporal and spatial relationships between the five main claims on site: urban development, flood management, navigation, production and nature development and their respective scales and hierarchies shaping the project.



RIVER SEGMENT / CITY TYPOLOGY / PROJECT	SCALE / INITIATOR / STATUS
 <p>DORDRECHT (NL) HARBOUR CONVERSION BENEDEN MERWEDE / DELTA RHINE</p> <p>DELTA RHINE / DUTCH WATER CITY / COMPACT EUROPEAN CITY MODEL / INNER CITY HARBOUR CONVERSION TO FLOOD-ADAPTED HOUSING /</p>	<p>RHINE KM 975 / 30 HECTARES / LEVEN MET WATER + MUNICIPALITY OF DORDRECHT URBAN FLOOD MANAGEMENT / RESEARCH PROJECT 2005-2008</p>
 <p>NIJMEGEN (NL) DIKE SETBACK+URBAN EXTENSION WAAL / DUTCH RHINE BRANCHES</p> <p>WAAL / RIGHT BANK EXPANSION + RIVER BYPASS / COMPACT EUROPEAN CITY MODEL / URBAN LANDSCAPE / FLOOD MITIGATION AND ADAPTED URBAN DEVELOPMENT</p>	<p>RHINE KM 881,5-885,5 80 HECTARES / RIJKSWATERSTAAT MUNICIPALITY OF NIJMEGEN / INTERREG IVB FLOODRESILIENCY 2008-2011 FINAL DESIGN PHASE 2012-2015 IMPLEMENTATION</p>
 <p>MAINZ (D) HARBOUR CONVERSION BIFURCATING UPPER RHINE</p> <p>BIFURCATING UPPER RHINE / COMPACT EUROPEAN CITY MODEL / INNER CITY HARBOUR CONVERSION / FLOOD ADAPTED HOUSING /</p>	<p>RHINE KM 499,5-500,8 33 HA STADTWERKE MAINZ AG WITH RLP MINISTRY FOR THE ENVIRONMENT, INTERREG IVB FLOODRESILIENCY / 2012 PLAN APPROVAL 2012-2015 IMPLEMENTATION</p>
 <p>KARLSRUHE (D) STEERED RETENTION POLDER MEANDERING UPPER RHINE</p> <p>MEANDERING UPPER RHINE URBAN LANDSCAPE / INFRASTRUCTURAL LANDSCAPE: FLOOD MITIGATION AND ECOLOGICAL RESTORATION</p>	<p>RHINE KM 354,5-359,5 510 HA 14 MILLION M³ RETENTION VOLUME / UPPER RHINE HIGH WATER ACTION PLAN / 2011-2013 PLANNING APPROVAL PROCEDURE 2014 PLANNED COMPLETION</p>

**Figure 34**  
Case studies from north to south (Google Earth adapted by authour)

For this research the relations are subsumed in four layers: the river scale, the local / regional scale, the project scale and as a fourth layer the agencies initiating and installing the project. The temporal and spatial interdependencies are extracted and visualized. The following aspects are investigated and visualized in order to further extract their interdependencies and their limitations and potentials regarding UFI. Questions of ground water, current and sedimentation will only be incorporated where data is available.

#### X-LARGE (the river scale)

The selected projects are evaluated in terms of their global relation to the Rhine river. Paradigms regarding their development will be mirrored by an atlas of the specific typology along the Rhine. In terms of flood management, this layer serves as a basis to understand the current interdependencies of the different river segments and the paradigms and strategies applied.

#### I+I (initiation and installation)

illustrates by whom and how projects are initiated and installed to show how the realization process influences the actual result (within the specific local/regional context of relevant developments). This will be visualized on a timeline based on the four main programs and their according agencies.

#### MEDIUM (local/regional context)

Based on the preceding chapters on the evolutionary development of the Rhine and related urbanization processes, the sites border between river and city and the sites sequential capacities and limitations will be analyzed. Conflicting interests on site or within the local context produces synergetic development potential. If and how this becomes operative for the local context will be investigated.

#### SMALL (project scale)

The water front is the actual site for possible developments based on the supposed conflict of urban development and flood threat, predominantly its economic damage potential. The site is defined by spatial capacities on site, claims as well as existing programs (urban and flood related), expected water levels and the scale. The sites of the different projects and the objects on site will be analyzed accordingly. The systems engineering approach, as applied in the further development of the Nijmegen Lent project both by the hydraulic engineers and by the urban designers will be adapted. The different system components will be analyzed in relation to their interdisciplinary reciprocations produced by the different claims on site or within the site's immediate context to show how they influence the project design.

#### EXTRACTION / (synthesis of four layers)

The layers' scalar interdependencies will be illustrated. A relational diagram shows the reciprocations between urban development and river dynamics of each investigated case study and the respective agencies involved.



# 6 Karlsruhe

MITIGATION /

## 6. KARLSRUHE

ATLAS RETENTION POLDERS

UNITS OF ANALYSIS /

### EXTRACT

XL / I+I / S / M

### XL RIVER

typology

### I+I INITIATION+INSTALLATION

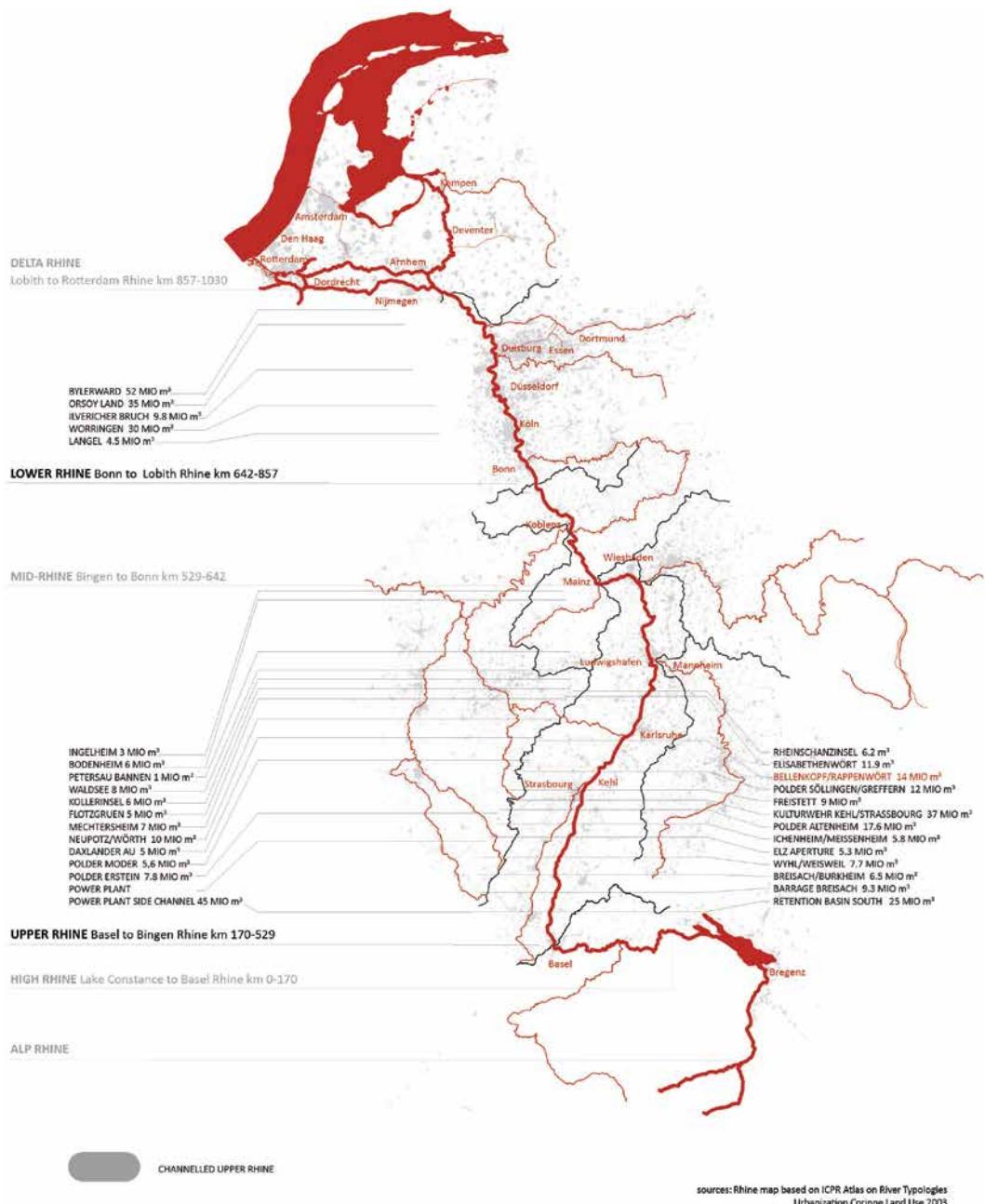
by whom and how is the project

### S PROJECT (VERTICAL)

synergetic development

### M CITY (HORIZONTAL)

connectivity



**Figure 35**

Overview of retention polders along the Upper and Lower Rhine (Rhine map based on ICPR Atlas of river typologies, urbanization Corine Land Cover 2003, map of retention areas from state water authorities)

**UPPER RHINE /**  
France  
Baden-Württemberg  
Rheinland-Pfalz

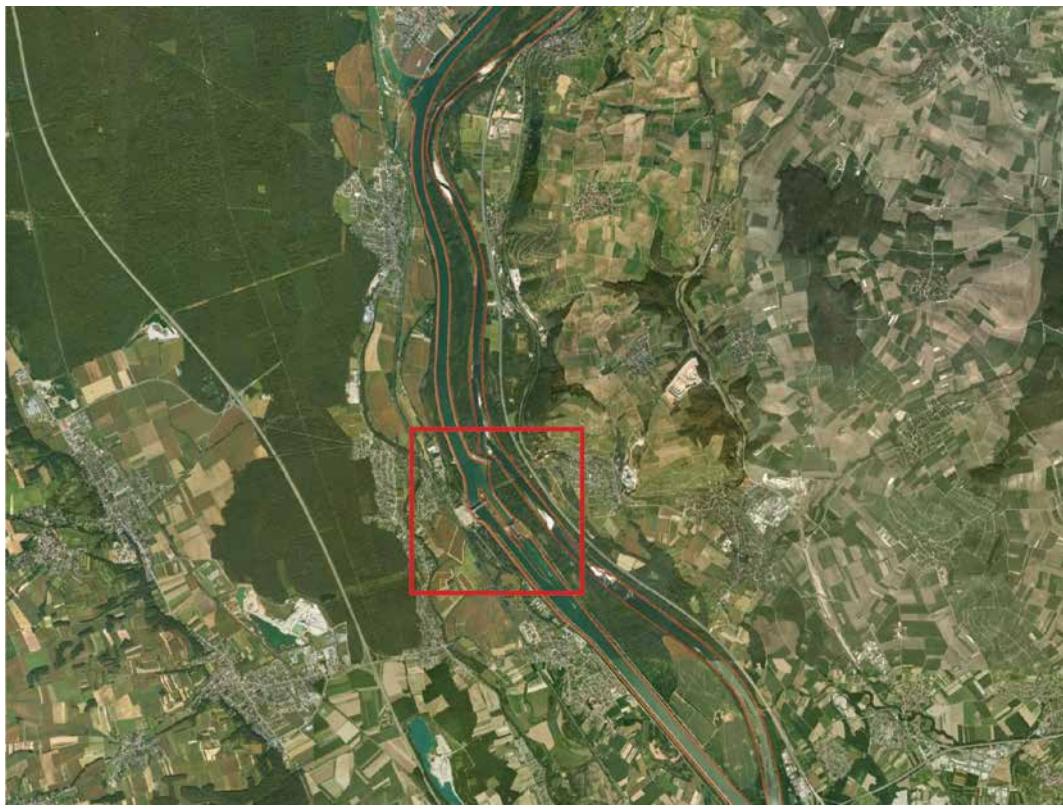


**LOWER RHINE /**  
Nordrhein-Westfalen



**Figure 36**

Atlas Of Retention Polders (Google Earth 2009-2012, viewing height 10 km, dike lines ICPR Atlas, 2001)

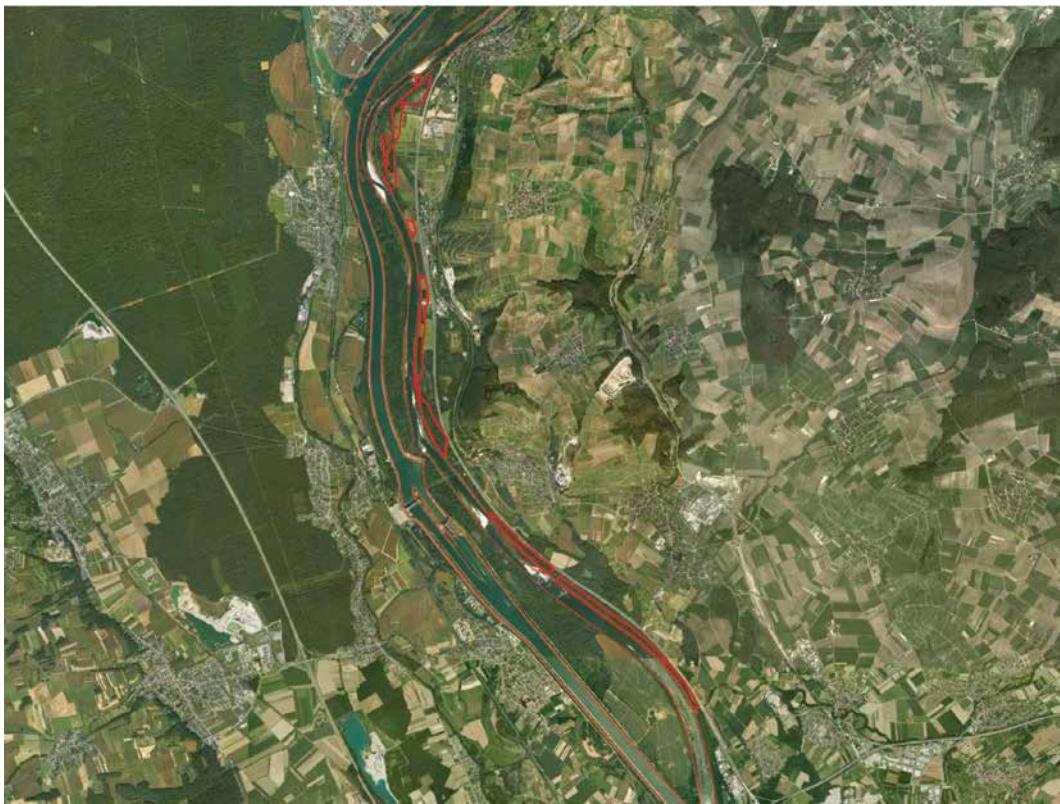


**Figure 37**  
*Hydro-Power Plant / Side Channel / Rhine km 174.*

Land use: hydro power plants / Conv volume: capacities of all hydro-power plants 45 million m<sup>3</sup> /

Building period: n.i. / Status: in use

Building costs: n.i. / ([www.rp.baden-wuerttemberg.de](http://www.rp.baden-wuerttemberg.de))



**Figure 38**  
*Weil Breisach Section 1+2 / Rhine km 174.3-218.8.*

Land use: free dev't of vegetation on gravel banks / Context: excavation of flood plain by 6 m / Flood frequency: 15 days /year / Floodable area: 596 hectares / Flood volume: 25 million m<sup>3</sup> / Building period: n.i. / Status: land use planning approval (Raumordnungsbeschluss) / divided into 4 sections: section 1 plan approval, section 3+4 plan-approval procedure / Building costs: n.i. / ([www.rp.baden-wuerttemberg.de](http://www.rp.baden-wuerttemberg.de))



Figure 39  
*Weil Breisach section 3 / Rhine km 174.3-218.8.*

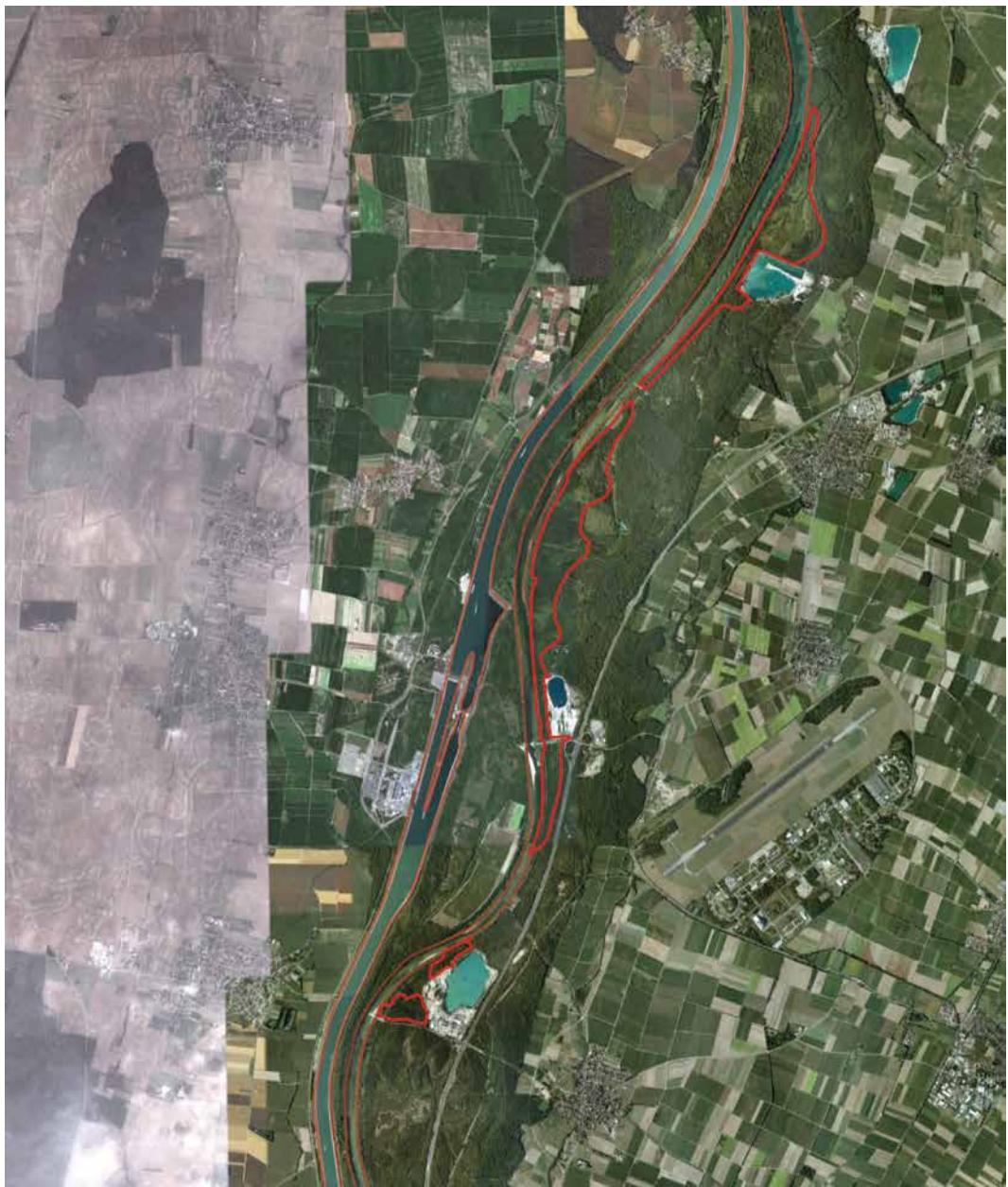
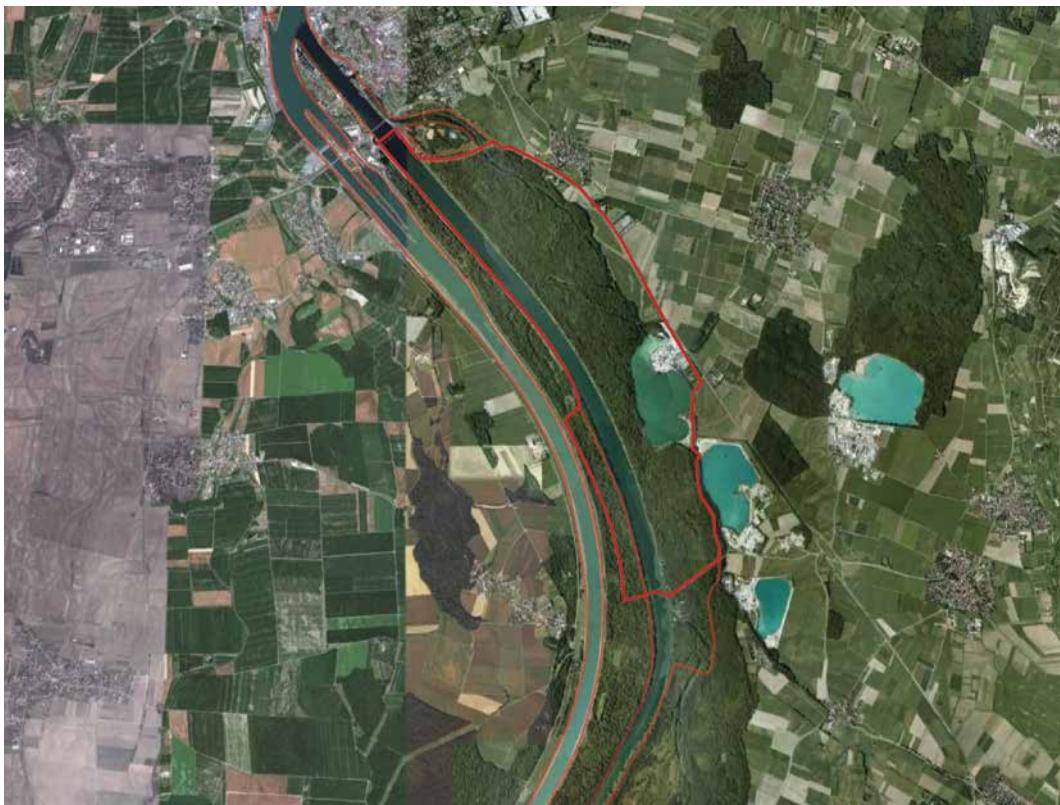


Figure 40  
*Weil* / *Breisach* section 4 / Rhine km 174.3-218.8



**Figure 41**  
*Kulturwehr Breisach / 1965 / Rhine km 242.8.*

Land use: mainly forestry, in small parts agriculture flooded until 1970, barrage erected to support ground water / Context: surrounded by Flügeldamm, main dike III and French dike and Franzosenweg Rhine km 219 to the South the retention polder matches the flood prone area / Flood frequency: n.i. / Floodable area: 505 hectares / Flood volume: 9.3 million m<sup>3</sup> / Building period: 1960-1965 / Status: in use since 1988 / Building costs: n.i. / ([www.rp.baden-wuerttemberg.de](http://www.rp.baden-wuerttemberg.de))

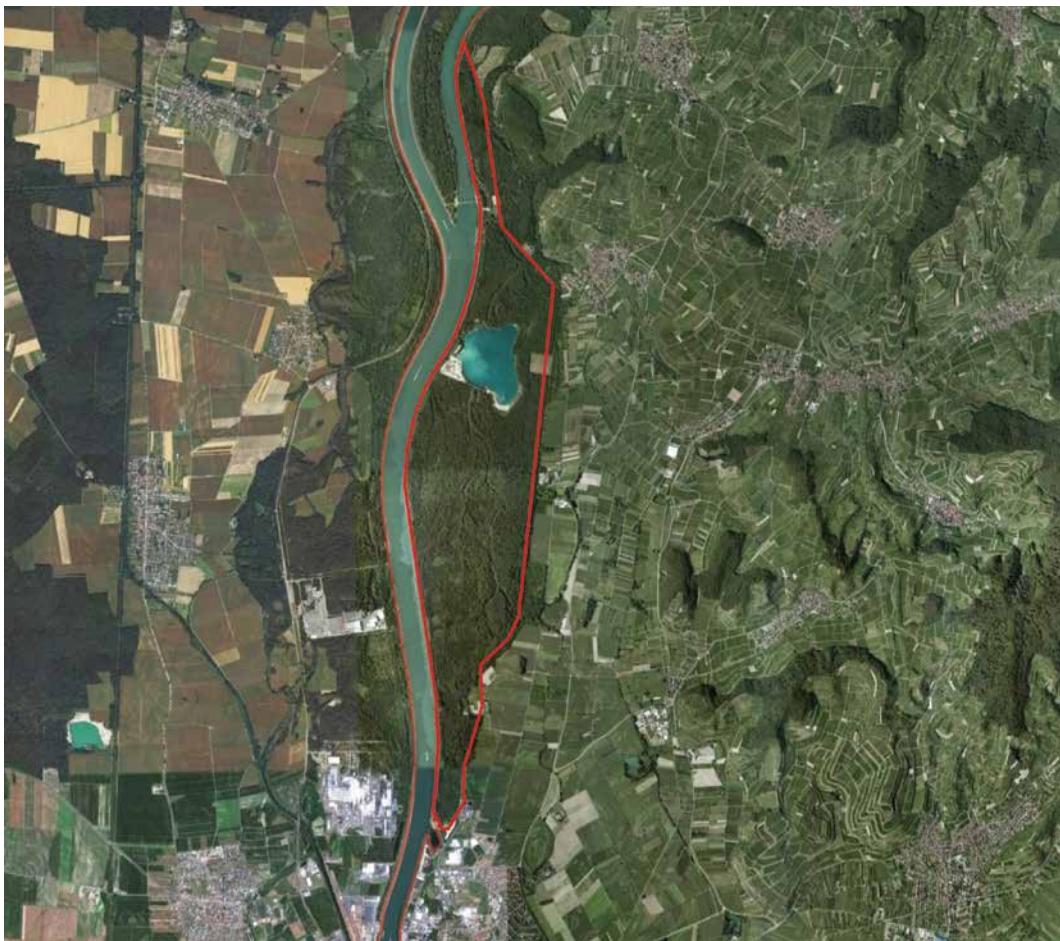


Figure 42

Breisach Burkheim / Rhine km 228.2-236.

Land use: mainly forestry / Context: barrage Markolsheim, main dike III, outflow area below main barrage / Flood frequency: n.i. / Floodable area: 605 hectares / Flood volume: 6.5 million m<sup>3</sup> / Building period: n.i. / Status: land use planning approval (Raumordnungsbeschluss) / Building costs: n.i. ([www.rp.baden-wuerttemberg.de](http://www.rp.baden-wuerttemberg.de))

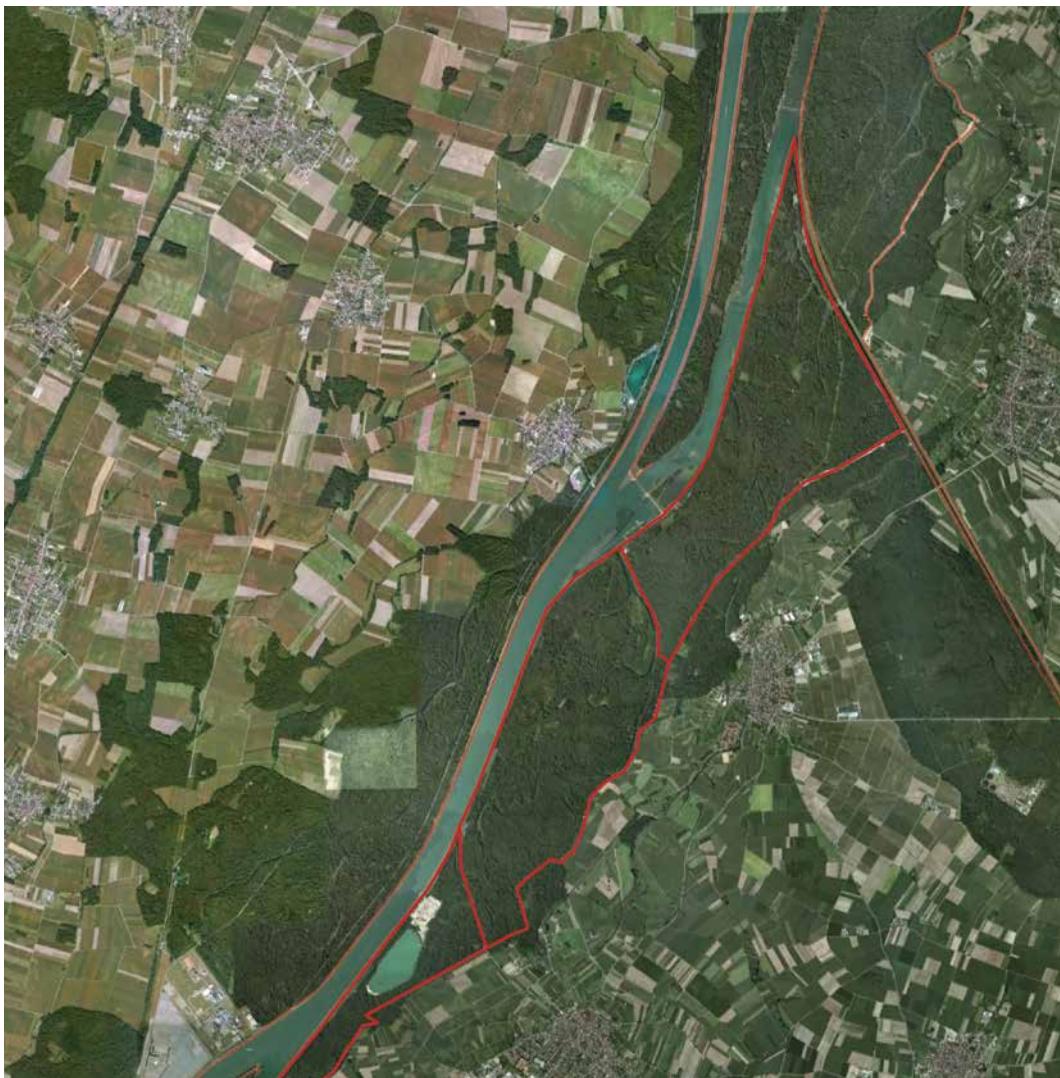


Figure 43

Wyhl Weisweil / Rhine km 241.5-253

Land use: mainly forestry context Rheinau, main dike IV, part of free-flooding area during special use of barrages south of canal / Flood frequency: n.i. / Floodable area: 595 hectares / Flood volume: 7.7 million m<sup>3</sup> / Building period: n.i. / Status: land use planning approval, preparation of plan approval procedure / Building costs: xx million Euro co-financed by EU Interreg Rhine-Meuse / ([www.rp.baden-wuerttemberg.de](http://www.rp.baden-wuerttemberg.de))

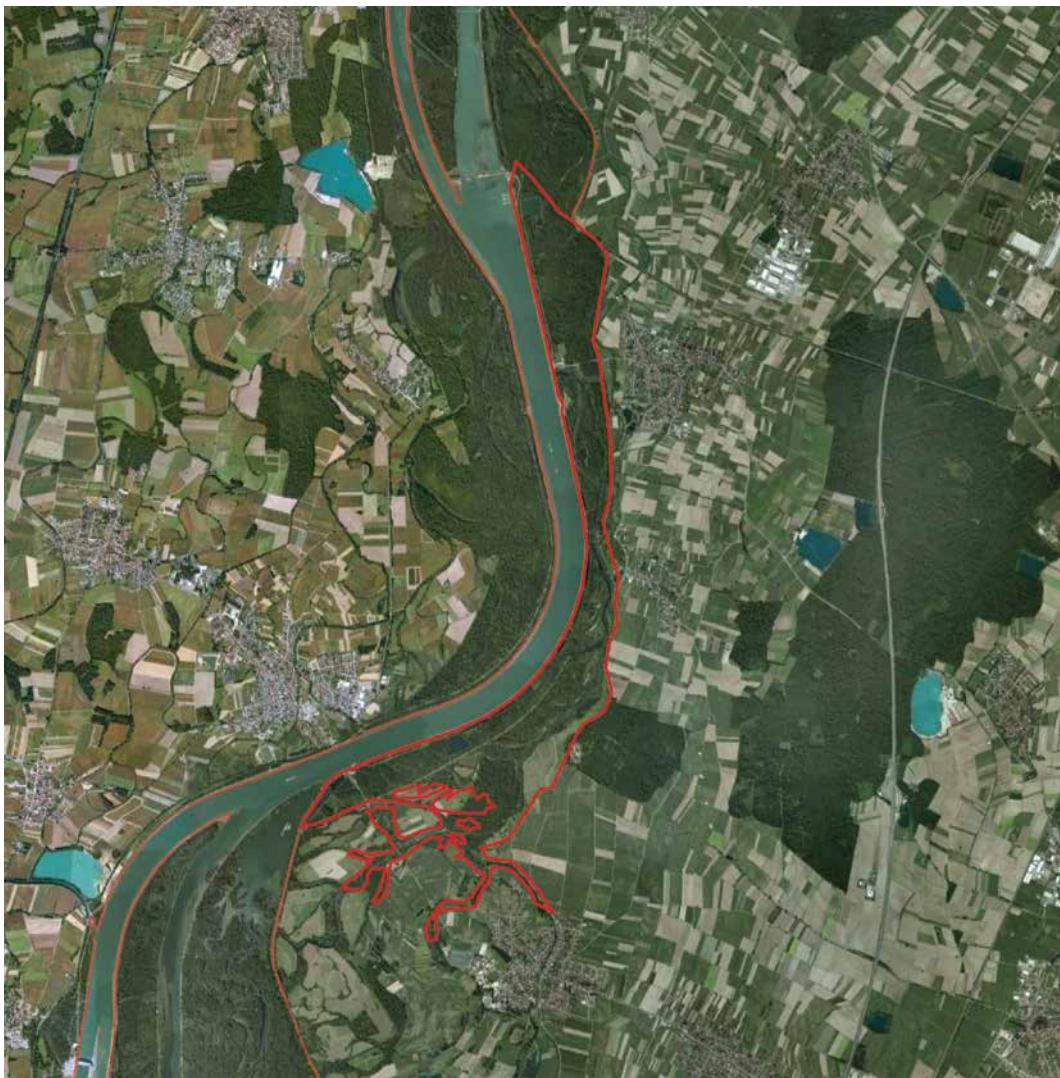


Figure 44

Elz Aperture Rhine km 260-268.5

Land use: forestry and agriculture, nature protection area / Context: barrage Gerstheim, main dikes VI and VII, below barrage Gerstheim free / Floodable area: n.i. Flood frequency: n.i. / Floodable area: 469 hectares / Flood volume: 5.3 million m<sup>3</sup> / Building period: n.i. / Status: plan approval procedure / project currently on hold by court decision until demanded improvements are made / Building costs: n.i. / ([www.rp.baden-wuerttemberg.de](http://www.rp.baden-wuerttemberg.de))



Figure 45

Ichenheim/Meissenheim/Ottenheim Rhine km 272-276.0

Land use: mainly forestry / area flooded unit 1970 / Context: barrage Strasbourg , main dike IX, retention polder Altenheim / Flood frequency: n.i. / Floodable area: 390 hectares / Flood volume: 5.8 million m<sup>3</sup> / Building period: n.i. / Status: preparation of plan approval procedure / Building costs: n.i. ([www.rp.baden-wuerttemberg.de](http://www.rp.baden-wuerttemberg.de))



Figure 46  
Erstein / Rhine km 276

Land use: forest / Context: n.i. / Flood frequency: 1/10 years (3600 m<sup>3</sup>/s) / floodable area: 600 hectares / Flood volume: 7.8 million m<sup>3</sup> / Building period: 10 years of planning 5 years realization / Status: ready for use / Building costs: 25 million Euro / (Guide pratique du risque d'inondation dans le schéma de cohérence territoriale de la région Strasbourg, 2002 and [http://www.vnf.fr/vnf/img/cms/Domaine\\_public\\_fluvial/hidden/dp\\_200411191502.pdf](http://www.vnf.fr/vnf/img/cms/Domaine_public_fluvial/hidden/dp_200411191502.pdf))



Figure 47

Altenheim 1+2 / Rhine km 278.3-284

Land use: forestry and agriculture flooded until 1970 supportive infrastructural measures to protect Altenheim, Goldscheuer und Marlen / Context: barrage Strasbourg, main dike X / Flood frequency: 1/x years (03/1988, 02/1990, 02/1999, 05/1999) / Floodable area: 520 hectares (350 hectares and 170 hectares) / Flood volume: 17.6 million m<sup>3</sup> / Building period: 1977-1985 / Status: in use since 1988, plan aproval in 1977, ecological floodings at 1550 m<sup>3</sup>/s since 1989 (by 8/2006 about 100 times) / Building costs: n.i. / ([www.rp.baden-wuerttemberg.de](http://www.rp.baden-wuerttemberg.de))

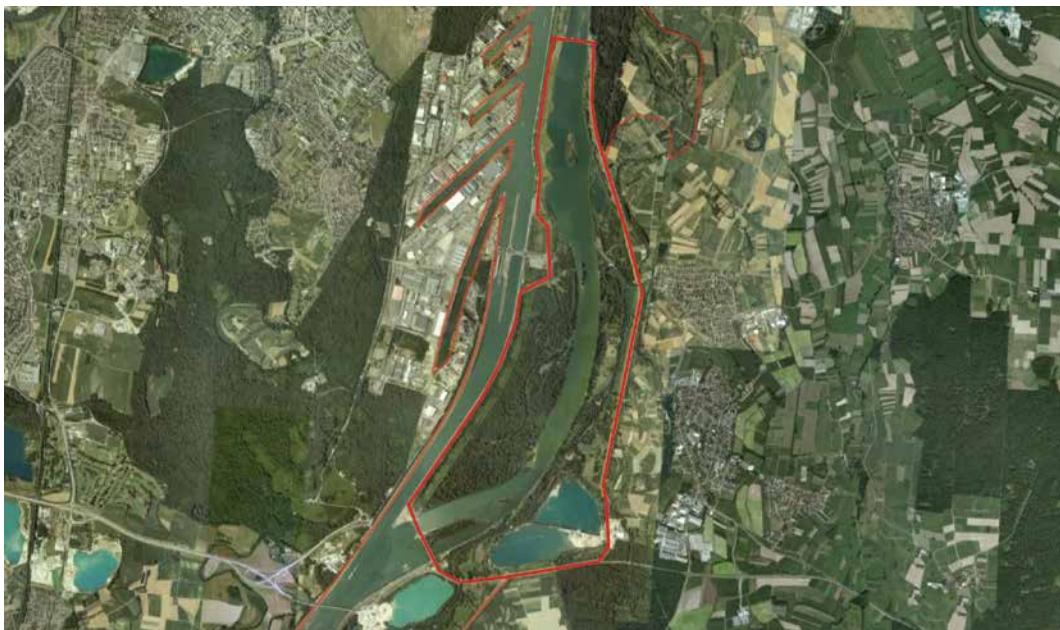


Figure 48

Kulturwehr Kehl/Strasbourg / Rhine km 284-290.2

Land use: permanent water storage to level ground water and retention, supportive infrastructural measures to protect Altenheim, Goldscheuer und Marlen / Context: in the area of the Strasbourg Rhine sling, barrage Gambsheim, main dikes XIII, XIV, XV / Flood frequency: n.i. / Floodable area: 700 hectares / Flood volume: 37 million m<sup>3</sup> / Building period: 1977-1985 / Status: in use as flood retention basin since 1985 / Building costs: n.i. / ([www.rp.baden-wuerttemberg.de](http://www.rp.baden-wuerttemberg.de))



Figure 49

Freistett / Rhine km 302-309

Land use: fluvial forest and retention, forestry and gravel excavation, agriculture, after the main dike was built in 1974 / Context: barrage Gamburg and main dikes XIII, XIV, XV / Flood frequency: n.i. / Floodable area: 475 hectares / Flood volume: 9 million m<sup>3</sup> / Building period: n.i. / Status: preparatory research completed / Building costs: n.i. / ([www.rp.baden-wuerttemberg.de](http://www.rp.baden-wuerttemberg.de))

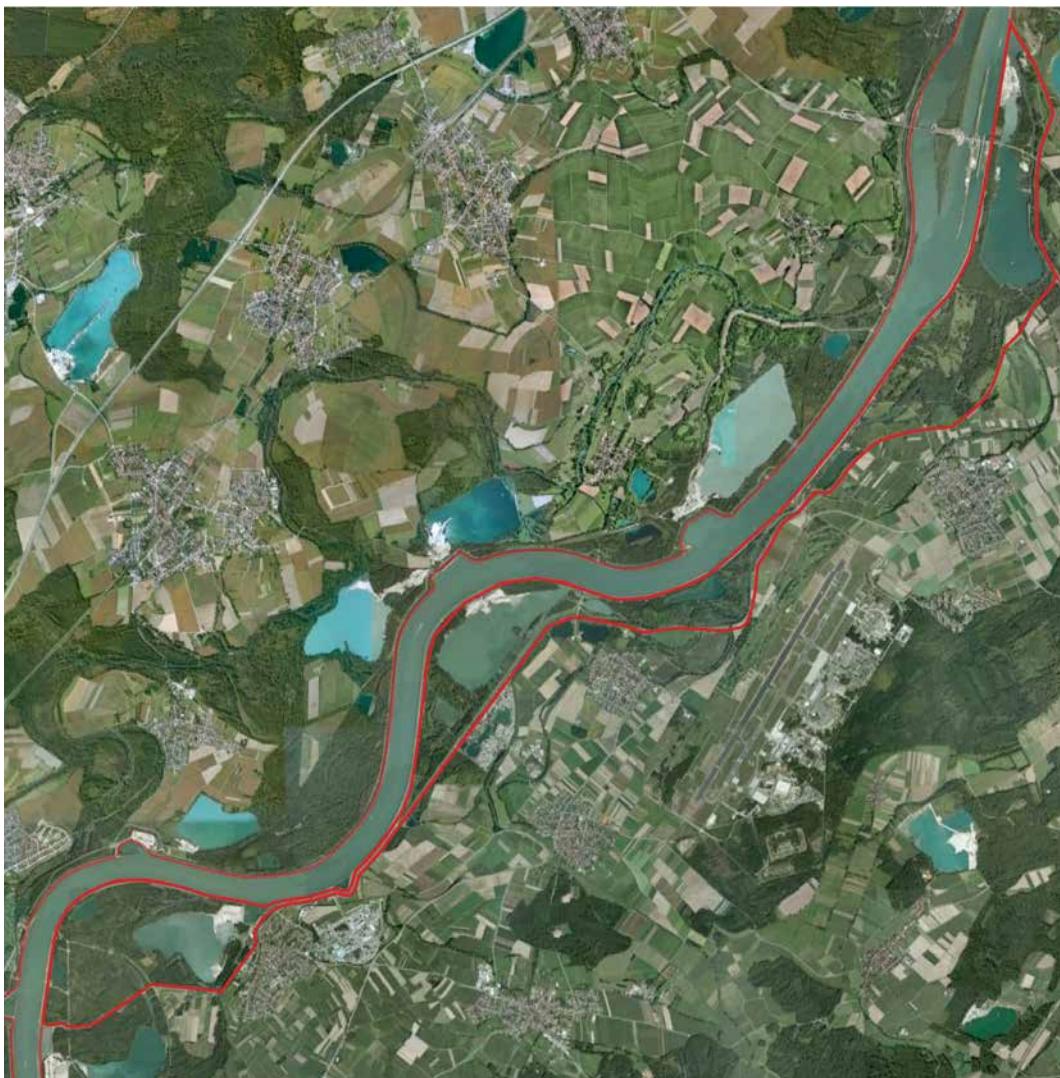


Figure 50

Söllingen/Greffern / Rhine km 317.4 - 329.5

Land use: former flood plain, cut off from the Rhine when the barrage Iffezheim was built in (1974-1978) / Flood frequency: 1/30 years / Floodable area: 580 hectares / Flood volume: 12 million m<sup>3</sup> Building period: 6 years / Plan approval procedure 1998, ready for use in 2006 / Building costs: 67.5 million Euro / (Gewässerdirektion Nördlicher Oberrhein / [www.4gwd.de/karlsruhe](http://www.4gwd.de/karlsruhe))



**Figure 51**  
Moder / Rhine km 330

Land use: n-i. / Context: former Moder Delta / Flood frequency: n.i. / Floodable area: 40 hectares  
Flood volume: 5.6 million m<sup>3</sup> / floods at 3500 m<sup>3</sup>/s / Building period: completed in 1992  
Status: built / Building costs: 16.7 million Euro / ([http://www.vnf.fr/vnf/img/cms/Domaine\\_public\\_fluvial/hidden/dp\\_200411191502.pdf](http://www.vnf.fr/vnf/img/cms/Domaine_public_fluvial/hidden/dp_200411191502.pdf))



Figure 52  
Bellenkopf Rappenwört / Rhine km 353.8-359.3

Land use: forest with fluvial remnants, agriculture and water, flood plain cut off from river in 1934/5  
Context: highly heterogeneous urbanized landscape / Flood frequency: 1/20 years / Floodable area: 510 hectares / Flood volume: 14 million m<sup>3</sup> / Max. speed of flooding: 445 m<sup>3</sup>/s / Elevation: 116-122 m above sea level / Max flood level: 2.5 meters / Building period: 6 years / Status: preparation of plan approval procedure / Building costs: 67.5 million Euro / ([www.rp.baden-wuerttemberg.de](http://www.rp.baden-wuerttemberg.de); <http://www.rp.baden-wuerttemberg.de/servlet/PB/menu/1158654/index.html>)

## § 6.1 XL / The River Scale

In the following section, retention polders along the Rhine (see fig. 35) are evaluated in terms of their global relationship to the river. The atlas will mirror the paradigms regarding their development. The atlas documents all retention polders, planned and realized, along the Rhine in Baden-Württemberg, Rheinland-Pfalz and Nordrhein-Westfalen. This has never been done before beyond the scale of the individual state programs of the federal states. A coherent overview with a focus on the specific typology aims to give information about the heterogeneous contexts and the sectoral development of this specific flood mitigation typology.

### Typology

Retention polders are installed by perforating and/or setting back the main dike and reinforcing old dike lines on the land side, many of which outline old Rhine meanders (see Atlas fig. 36-52 and 63-79). In steered versions, they are filled and emptied via in- and outlet gates. They are installed to lower water tables by 'shaving' the flood wave's peak. This is achieved by opening the gates directly when the peak flood reaches the height of the polder. As a steered measure, the impact on water levels is generally more effective than that of non-steered polders or dike set-backs, yet open measures are preferred by ecologists. In some cases, retention polders and dike setbacks are combined (see for example fig. 64 Neupotz-Wörth). Steered retention polders appear along the Upper Rhine and the Lower Rhine only. Along the Mid-Rhine, the steep and narrow valley does not provide the spatial capacities to accommodate polders.

For the Rhine branches in the Netherlands, retention polders were not included in the measures of the Ruimte voor de Rivier program, since they produced severe local resistance and were not considered the right strategy within the Dutch context. Noodoverloopgebieden (controlled flooding areas) were suggested in 'Anders omgaan met water' in 2000 as a possible emergency measure. If, during an extreme river flood, dike breaks would seem likely, it should be possible to control the flooding by directing it to previously designated areas (of course these would be less densely populated, and with less capital invested). The Commissie Noodoverloopgebieden also known as the Commissie-Luteijn was created in 2002 to advise this strategy, suggesting nine potential areas. Under normal circumstances, controlled flooding areas are considered to be as protected against floods as other areas. Yet, in case of an emergency (exceeding the 1250 year return level) they may be sacrificed to avoid worse floods elsewhere (Helpdesk Water, 2011). After some years of discussion, it was concluded that the costs of developing controlled flooding areas would be very high, and the benefits questionable. The idea was dropped altogether (Tussenbesluit Rampenbeheersingsstrategie overstromingen Rijn en Maas, 2005).

In expectance of a potential increase in extreme floods as a consequence of climate change, space for events beyond a 1/200 year flood have also been reserved along the German Rhine. Additional emergency retention polders are foreseen in Rheinland-Pfalz and Nordrhein-Westfalen. In Nordrhein-Westfalen the retention polders Islicher Bruch and Bylerward are part of the original Hochwasserschutzkonzept. Their realisation, however, depends on the results of the research currently conducted by the ICPR to assess the impact of climate change on water levels for the German Rhine. Results are expected in 2012 (Umweltbericht NRW, 2009). In Rheinland-Pfalz specific plans have been made for the emergency polders Hördt (max. 36 million cubic meters) and Eich-Guntersblum (max. 28 million cubic meters) as emergency polders for extreme events in addition to the planned measures (LUWG, 2011).

### **Locations**

The retention polders along the Upper Rhine were positioned in the former flood plains, the areas that were free to flood before the channelling of the Rhine in the 19th and 20th century. They were positioned according to the available land and the respective flood impact (Webler, 2009). For the most part they are projected on sites of the former alluvial forests and to a lesser degree on agricultural land. These sites are then empoldered and flooded to mitigate peak discharges, and more frequently flooded for ecological reasons. The aim of ecological flooding is to redevelop the flora and fauna of the alluvial forest. As water levels can not be stored at the same height, the decision to include the rejuvenation of the former flood plain implied an increase from 5 to 13 retention polders in Baden-Württemberg. Upon completion, the retention polders in Baden-Württemberg will total an area of 7000 hectares of which about 70% are forest, 12% are agricultural land and 15% are surface waters (old Rhine arms, gravel pits, fishing ponds, streams, etc.) The remaining three percent are roads and buildings (Pfarr, 2010:146).

### **Scale**

Retention polders require extensive capacities to be effective and considering their scale, the impact on water tables is very moderate - only decimetres. During the floods in February and May 1999 the activation of the installed polders, Kulturwehr Kehl and the polder Altenheim, lowered water tables by 33 and 24 cm at Maxau (Karlsruhe) with measures lasting four to five days (Homagk, 2010). Along the Upper Rhine, the storage capacity of these measures varies between 3.6 million cubic meters (Mechtersheim, fig. 48) and 37 million cubic meters (Kulturwehr Kehl, fig.67). The retention volume depends on the elevation of the site and the available area. For ecological reasons water levels in the retention polders will reach a max. level of 2.50 meters and have a continuous current during a flood event. During ecological flooding, due to topographical variation, not the entire area is flooded nor do water levels exceed the range of decimetres. (Pfarr, 2010)

## **Constructed Ecologies**

In- and outlet structures are needed to steer the retaining process through the main dike at the waterfront and the adaptation of a secondary dike on the land side. Supportive infrastructure is needed to manage seepage and rising ground water levels to avoid damage to the built environment in the vicinity of the polder. Until a critical water level is reached, the in- and outlet gates are kept open to enable ecological flooding. While space for flooding is reserved for events lasting several days (although the entire flood wave along the Rhine takes up to two to three weeks), other functions have fundamentally different time patterns, e.g. ecological flooding requires an annual occurrence. Annual flooding is necessary to redevelop an alluvial forest habitat while flood management will only involve flooding at a discharge beyond 5000 cubic meters for the retention polders before and 6000 cubic meters for those located after the Neckar tributary. Ecological flooding is initiated to recreate the alluvial forest and its inherent biodiversity. For agricultural land use it can be problematic. In Germany, most farmers accept the additional use of their fields as retention areas with a statistical risk of being flooded every 100 to 200 years. However, with the exception of corn, which in turn is too obstructive in the context of, for example, dike set backs, ecological flooding destroys crops (Ebner, 2010).

## **Seepage Problematic and Local Resistance**

By perforating or setting back the main dike, the polder and its inherent seepage problematic move closer to existing urban developments. Conflict potential and thus the pressure not to flood the designated polders during high water levels arises when measures to protect adjoining areas and to ensure other programs are not taken - escape mounds for animals (also demanded by hunters) or wells and drainage systems to reduce the negative impacts of the dammed up water for example. Therefore, to manage rising ground water tables and seepage in the vicinity of the polder, supportive measures are necessary. Ground water wells, drainage systems and pumping stations can be installed between the dike and the endangered developments to avoid the flooding of basements, etc. (RPK, 2008). Local resistance against the polders is rooted in their potentially negative effects for the adjoining areas. For the retention polder Langel in Cologne, 165 property-related objections against the plan decree were filed (Hartmann, 2011). Also against three polder projects along the Upper Rhine files were sued (Homagk, 2010). Homagk sees the cause in a lacking willingness by the municipalities upriver who are largely protected up to a flood level of 1/1000 to provide flood mitigation measures for areas downriver. But also a local threat can be part of the argument. Jürgen Jacob, mayor of Altrip, one of the municipalities that is taking their case to federal court is convinced: "Already today our municipality is affected by floods. From our point of view, the erection of the polder bears incalculable risks for our inhabitants. We hope that now the Federal Administrative Court will finally ensure safety for our municipality" (Baumann, 2010). Ironically, the negative effects rise with load increase. Enlarging retention areas to lower the stored water levels would reduce the effects on ground water levels and the inherent seepage issues. The area affected by the water pressure may be considered as

an amphibious zone with (re-)development potential. Steering water levels by expanding the retention area could provide an alternative approach.

### **Global Relation to River Basin**

The retention polders are part of "Rhine 2020," initiated by the International Commission for the Protection of the Rhine to recreate retention capacities. Specifically, the construction of barrages between the towns of Maerkt and Iffezheim from 1928 to 1977 has led to a reduction of wetlands and thus a reduced discharge capacity for floods - increasing the risk of dike exceedance and breaches (Homagk, 2010:38). Reduced to a discharge capacity of 1/60 as a consequence of the barrage-construction series, the aim of the High Water Action Plan as a binational agreement between France and Germany in 1982 was to reinstall retention capacities to the 1/200 level as they were before barrage construction (Griesbaum et al, 2007). The program was expanded to include the redevelopment of near-natural wetlands in the projects in the 1990s. This demanded a severe increase in the polders required as their water level was limited to 2.5 meters and required a constant current (Pfarr, 1996). At present, discharge capacities have reached a level of approximately 1/120 with 53% of the retention measures in place (Homagk, 2010). As an accumulative measure, the retention polders along the Upper Rhine aim to lower water tables by 70 cm in total upon completion. In the Treaty of Versailles, the use of water energy along the Upper Rhine was granted exclusively to France. However, when the Rhine discharge exceeds 1500 cubic meters (capacity of barrages) France and Germany are allowed to use excess water to equal terms. Within the Integrated Rhine program, this water is used for ecological flooding. (Pfarr, 2010).

### **Forms and Quantity of Appearance**

Although the agreement between France and Germany on the HWAP was signed in 1982, only three of thirteen measures have been realized along the Upper Rhine in Baden-Württemberg as the Integrated Rhine Program (IRP) (Pfarr, 2010) and in Rheinland-Pfalz it is five of ten (RLP, 2007). Hessen, as the third adjoining federal state along the Upper Rhine, is not realizing polders, but co-financing measures in Rheinland-Pfalz. Along the Lower Rhine, the first retention polder of eleven measures was completed in Cologne in 2009. In France, the two polders Erstein and Moder have long been realized, but so far only Erstein has been used once in August 2007, lowering flood levels by 7 cm at Karlsruhe (Homagk, 2010:40). One reason may be the missing infrastructural support to cope with seepage (Baumgärtner, 2011). In Germany, the difficulty of installing these measures is rooted in the extensive plan approval procedure (Homagk, 2010) and politically supported local opposition. Negative effects in the vicinity of the retention polder prevail and the flood threat remains abstract to the inhabitants, as they have been protected successfully by the installed flood defence system in the past. This 19th-century defensive system not only provided protection against floods, but also enabled land uses behind the defence line to generate growth and prosperity for this previously poor region.

### **Paradigm Regarding Development**

The restoration of the flood plain by steered retention as a concept of proactive flood mitigation is driven by two goals - flood protection (infrastructure) and wetland development (landscape). As a program to reinstall retention capacities as they were before the channelling of the Upper Rhine, the Integrated Rhine program does not involve urban development, but foresees the installation of a series of infrastructural landscapes. Between a highly technical approach to lower water tables and the idea of redeveloping the former wetlands on these sites, peak shaving and ecological flooding are combined with the sites' programs during the rest of the year (usually agriculture and/or forestry in combination with recreational concepts). German environmental law only permits flood retention measures in former flood plains cut off from the river. Ecological flooding is a precondition for a system of steered retention (Pfarr, 1996). Whereas a monofunctional approach shaped the border between river and land during industrialization (channelling), today the demanded efficiency of retaining measures and an ecological perception of the landscape are combined. This leads to a hybridization of the retention polder as an infrastructural measure to lower flood levels and to remediate the former flood plain with the dynamics of the river landscape. Yet, the synergetic approach is limited to the project scale and reaffirms the system introduced by channelling, which determines the flood plain as a flood-free area. Regarding the heterogeneous programs that have evolved in the former flood plain, neither emergent potentials between them nor those in combination with the polder are considered. The polder projections are therefore just as much sectoral developments. While infrastructural support measures manage potential negative side effects, further capacities of the polder in the context of the urban landscape are not taken into account. Even as expansive measures, retention polders both rely on and stabilize the defensive system.

**For their lack of innovation regarding sectoral development in the flood plain as well as their dependency on and support of the defensive system, retention polders may be considered path-dependent.**

## § 6.2 I+I / Initiation and Installation

### Initiation

The definition of goals by the ICPR to binational agreements between Germany and France, the coordination and co-financing by the state and the execution by regional administrative authorities make the installation of retention polders along the Rhine a top-down process. France and the participating German states assigned the sites using a top-down approach. Potential conflicts in land use make comprehensive regional planning, plan approval procedures and in most cases an EIA necessary. These instruments are applied to ensure a participatory approach (Splitt, 2009). State water boards as operators are responsible for compensations to private owners (Pfarr, 2010).

The federal state covers 41.5% of the installation costs. Baden-Württemberg co-finances and coordinates the polder program as a whole. The participating parties are the Ministry of the Environment and the Regierungspräsidium as the regional administrative authority of Karlsruhe. They prepare and carry out the plan approval procedure together with a wide range of engineering firms and ecological institutions. The retention polder Rappenwörth is within the jurisdictions of Karlsruhe, Rheinstetten and Au am Rhein. While the municipalities favour the steered solution, the nature preservation organisations prefer the open solution. The municipal utilities company that is planning a drinking water plant nearby is also affected.

### Installation

After a long and complex phase involving engineers who developed the plan and diverse sectoral studies, specifically regarding nature and environmental questions, the project is now being introduced to the public, the municipalities and technical authorities. The state institution for water will offer information events in Karlsruhe and Rheinstetten. The Landratsamt as the responsible lower water authority will conduct the plan approval procedure with its participation and explanation steps. After evaluating the expert suggestions and feedback generated by these public information events, the plan may be adapted where applicable. Next, the plans will be publicly displayed and everyone affected or interested can respond. The procedure is expected to take at least two years before the plan approval (RPK, 2011) (see fig. 53).

**Spatial quality is not a declared program goal of the Integrated Rhine Program. There is no transdisciplinary agency to consider spatial quality or emergence between programs as a development factor for the project on a local scale. The capacity of the public sector to initiate such programs locally is rarely given or else it is hindered by sectoral or hierarchical boundaries (Hartmann, 2011; Steinberg, 2012).**

1715	foundation of Karlsruhe at 8 km distance to the Rhine 10 m above the flood plain
1817	beginning of Upper Rhine rectification by Gottfried Tulla
1902	opening of port Rheinhafen Karlsruhe
1919	Treaty of Versailles granting France the exclusive right to install water power plants between Basel and Lauterbourg
1929	opening of Rhine pool Rheinstrandbad Rappenwörth
1934	erection of main dike, cutting remnant flood plain off from river
1922-1977	barrage construction on Upper Rhine between Iffezheim and Maerk
	reducing discharge capacities from 1/200 to 1/60
1962	opening of petrol harbour and refineries
1982	opening of container terminal
1982	agreement D+F on retention polders along Upper Rhine to reinstall discharge capacities for a 1/200 flood as before the barrage construction
19XX	preliminary assessment of available space to accommodate retention polders
1983	water levels at Maxau reach 8.59 meters - large parts of harbour flooded
1988	Baden-Württemberg launches Integrated Rhine Program (IRP) increasing the number of polders from 5 to 13 to lower storage level in polders to enable ecological restoration
1988	installation of harbour flood gate
1992	second logistics harbour expansion
1997	local refineries Esso und OMW merge to MiRO, Mineralöraffinerie Oberrhein GmbH & Co. KG
1999	water levels at Maxau reach 8.52 meters
	the harbour gate protects the harbour from flooding
2000	first planned but not realized Landesgartenschau/Bundesgartenschau
2002	study Stadtregion Karlsruhe 2030 –Grenzen überschreiten (Bava et al, 2002)
2007	Regierungspräsidium Karlsruhe, regional administrative authority and executing agency, decides on steered polder
2008	public events to inform and discuss alternatives and solutions
2011-2013	plan approval procedure retention polder Rappenwoert demanding exceptional approval by nature preservation law
2014	planned completion of retention polder Rappenwoert
2015	second planned but not realized Landesgartenschau/Bundesgartenschau
2015	originally planned completion of Integrated Rhine program
2028	planned completion of Integrated Rhine program

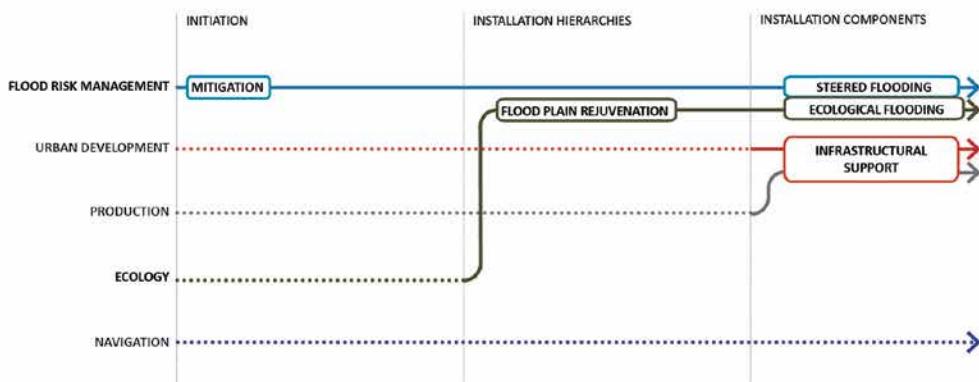


Figure 53  
Initiating program, installation hierarchies and installation components

## § 6.3 M / Local and Regional Context



**Figure 54**  
*Pre-Industrial / Industrial / Trans-Industrial Karlsruhe (graphic by author)*

To analyze the retention polder Rappenwoert in Karlsruhe, it is necessary to understand the interdependencies of the two main alternatives discussed within the context of the urban landscape of Karlsruhe and the Mid-Upper Rhine Region. The following text summarizes the different aspects that led to the steered solution for Rappenwoert. In terms of flood management the assessment of the risks and durability produced by the new situation and its capacity to fulfil ecological standards on a local scale as well as the status of the polder Daxlanden on a regional scale, were the decisive parameters by which the alternatives were weighed. In order to contextualize the alternatives described in the following section, before a brief description of the local and regional context with some of its defining programs today.

### The Mid-Upper Rhine Region

Although the Mid-Upper Rhine Region (see fig. 56) is economically driven by its industrial activity in the former flood plain, forest and agriculture make up about 40% of the surface. Only 20% is urban development including traffic (RVMO, 2008). Attempts to create spatial concepts for the larger context such as the PAMINA regional park, which also includes the regions of Palatinate and Northern Alsace on the opposite side across the river is limited to recreational paths in the former flood plain (see fig. 57.3). This is underlined by the impact of the political boundaries between federal (Rheinland-Pfalz and Baden-Wuerttemberg) and nation states (D-F) and the scale (total area 520 square kilometres). Since 2007, the region is connected to the TGV high-speed net between Paris and Budapest (RVMO, 2008). Nature protection areas make up about 4% of the region, and landscape protection areas around 30%, of which almost 30% are water protection areas (RVMO, 2008). About 25% of the region (556 km<sup>2</sup>) are part of 'Natura 2000.' Also large parts of the former flood plain are nature and landscape protection as well as Fauna-Flora-Habitat sites.

### Rappenwört in the Context of the Urban Landscape

Built in the Age of Enlightenment, the historical plan city of Karlsruhe was erected 10 m above the flood plain. It was positioned on the lower terrace of the Rhine at a safe distance from the highly dynamic, meandering Upper Rhine in a bed with a width of up to 15 km (see fig. 54, 55). After the final channelling of the Rhine at the height of Karlsruhe in 1934, the flood plain was completely cut off from the river. The original landscape qualities of the alluvial plain transformed as a result of the separation from the dynamics of the river. This allowed large parts of the former alluvial forest not only to become agricultural land. With rising industrialization, the cities' less representative, but often large-scale programs demanding space, and sometimes river logistics, were positioned in the flood plain.

The urban landscape in the meandering flood plain of Karlsruhe has therefore evolved as an archipelago characterized by a vast array of programs (Bava et al, 2003). Business parks, allotment gardens, the harbour, a land-fill, a steam-power plant, a paper factory, a wind-mill, refineries, the retention polder itself, old Tulla dikes aligning nature reservation areas around old Rhine arms, a modernist swimming pool in one of the numerous bayous, and a nature-information centre and a drinking water plant all illustrate the vast array of programs that the former flood plain has taken on after its cut off from the river. The two former fishing and gold sifting villages Daxlanden and Rheinstetten, had already existed.

Historically, their houses were erected on the upper shore, as the villages were used to flooding. After the erection of the main dike in 1934, houses were also built on the lower shore (Hartleb, 2008).

Today, the former flood plain is accommodating programs that are only in some cases dependent on the river, such as the steam power plant, which is cooled with river water and which also receives its mineral coal on the waterway (Hartleb, 2008). In many cases, programs have been located on site due to the available space for large-scale or less representative programs and a generally expansive land consumption policy. These programs include the land fill, business parks, etc.. Their supply chain is linked to the motorways instead of the river. The motorway, running perpendicularly through the urban landscape of the former flood plain, connects the two banks by a bridge. It also cuts through the landscape, hindering south-north connections for pedestrians and cyclists. Mercedes-Benz on the opposite side of the river is not reliant on river logistics, but instead produces an extremely high damage potential in the former flood plain. As a new business park is being planned on the opposite side of the river next to the Daimler plant, development in the former flood plain continues (Dieterle, 2011).

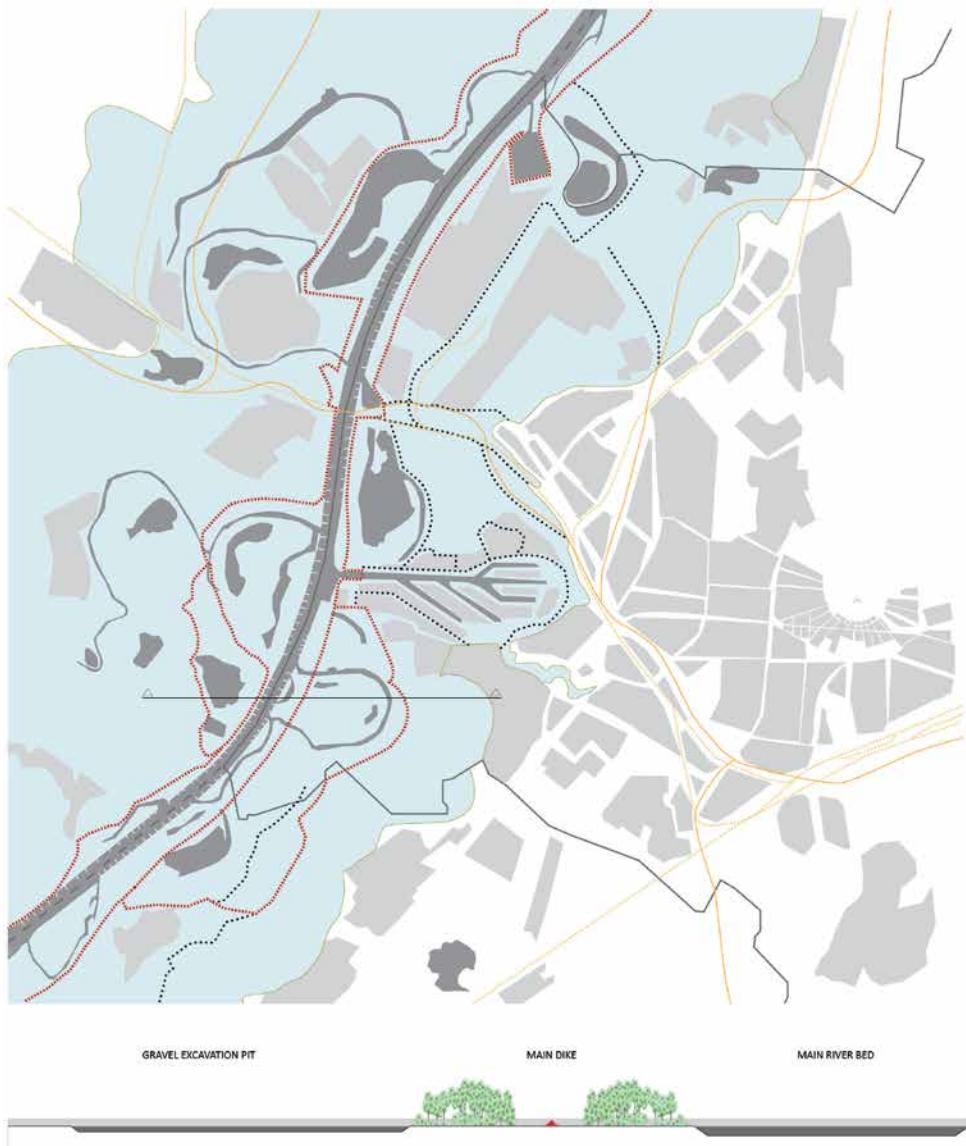
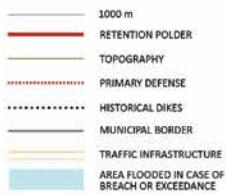
The planned polder lies within the jurisdiction of Karlsruhe and Rheinstetten (rural district Karlsruhe) and the municipality Au am Rhein (rural district Rastatt), facing France and the state of Rheinland-Pfalz.

### **Production/Navigation**

Preceded by the Maxau harbour, today a marina, the Rheinhafen was built in 1901. As the city centre is located 7 km away from the Rhine, it was not until this development that Karlsruhe actually became a Rhine city. In comparison to other cities along the Rhine, this is exceptional. After several expansions, the harbour today has six basins on a site of about 300 hectares. The facilities are accessed via a street and tracks. With transhipment activities of 6 million tons/year (mainly oil and mass goods), the Karlsruhe harbour is among Europe's largest. Additionally, the European oil pipeline Marseille-Karlsruhe-Ingolstadt feeds the "Oil Crossing SouthWest." After the construction of the oil harbour in 1962 and the pipeline, Karlsruhe has turned into a centre for petroleum refinery. The harbour offers work to 6000 people, making it one of the most important employers of the city. Due to traffic overload on state motorways and lacking track capacity, a further rise in container transhipment, specifically from the North Sea to the inland ports, is expected. One of the future expansion plans involves the development of the existing Rhine-Rhone-Canal to connect Karlsruhe with the Mediterranean (Hartleb, 2008). In 1988 a floodgate was installed to protect the harbour from fluvial floods.

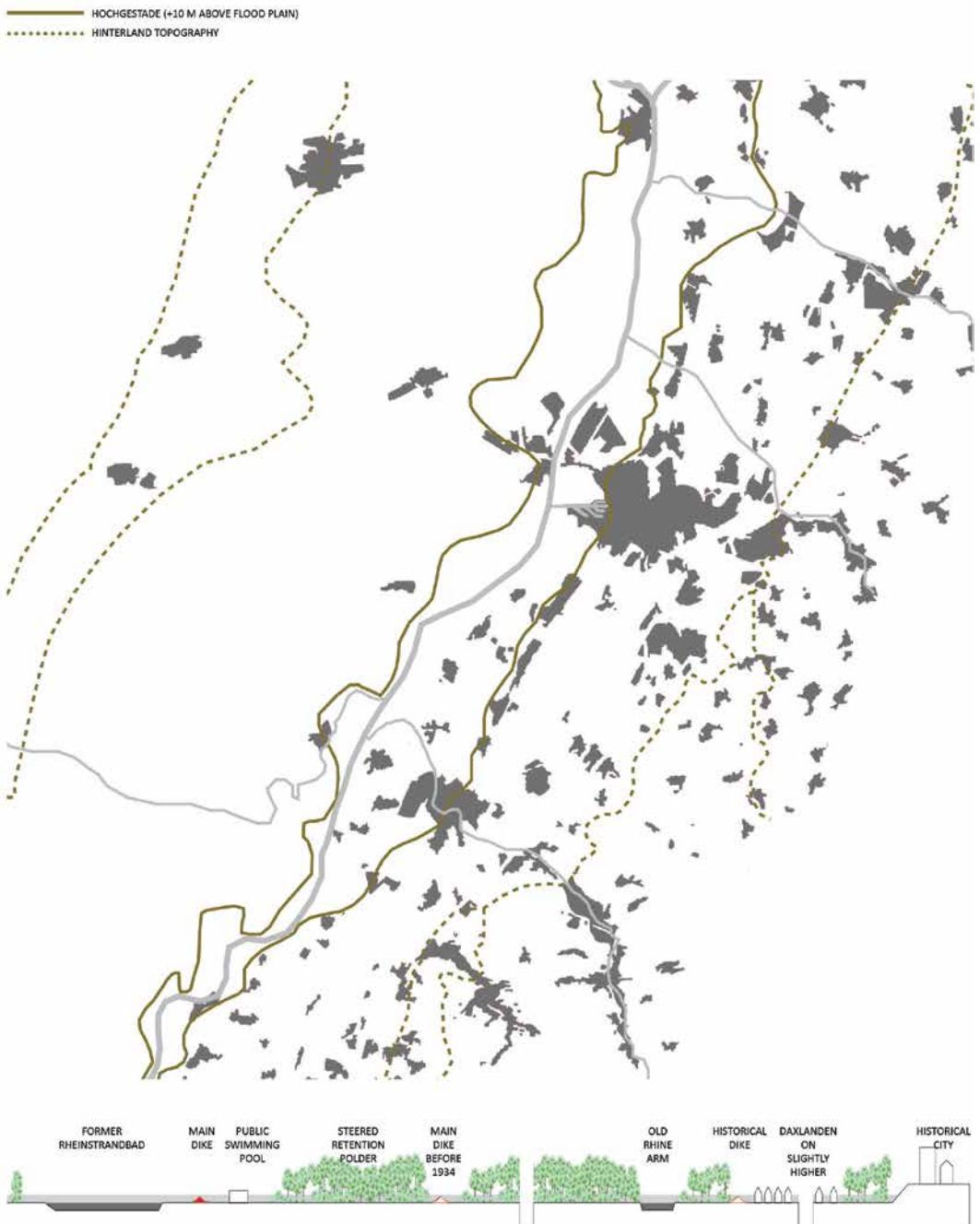
### **Urban Development**

In the last ten years, new urban development has been comparably low. The urban landscape of Karlsruhe is not only a site for industrial and commercial programs within remnants of the former alluvial forest and agricultural land. Former gold-sifting villages were located in the flood plain for centuries, later providing the work force for the harbour. The Rheinpark is a modernist recreational concept with a Rhine bath, sports fields and a nature education centre and is located on the site of the planned polder. The buildings are listed as examples of Neues Bauen (Heinze, 2012).



**Figure 55**

Rappenwört in the context of the city (based on topographical map and flood map Karlsruhe)



**Figure 56**

Left bank Mid-Upper Rhine region (based on map Regionalverband Mittlerer Oberrhein) and section with polder (based on topographical map Karlsruhe and Rhine Atlas, iCPR 2001)

The urban landscape has not been part of a coherent planning process in terms of urban landscape design. As part of the study 'Urban Region Karlsruhe 2030 –beyond boundaries' the heterogeneity of the former flood plain was interpreted as an archipelago of programs which could be interconnected to produce spatial qualities (see fig. 57.5) (Bava et al, 2002). Concepts were also developed to enable housing in the harbour with special privatization agreements to undermine legal hindrances with regard to noise emissions. However, this study was not followed up by the municipality (Dieterle, 2011).

Further attempts to develop a conceptual design for the urbanized flood plain were made by considering a participation in the national horticulture exhibition Bundesgartenschau (see fig. 57.4). In Germany, these function as triggers for urban development by landscape architectural means. Also, an application for the International Building Exhibition, IBA, was considered. However, the application for the Bundesgartenschau failed and the municipal planning departments were not able to create the necessary political support to finance these programs (Dieterle, 2011).

As part of the Integrated Rhine Program (IRP), the Ministry of the Environment of Baden-Württemberg developed a complementary recreational concept for the polders in 2008. Its goal is to enhance the existing facilities while developing strategies for times when access is restricted during ecological flooding or steered flooding. It also aims to raise the acceptance for flood mitigation measures among the inhabitants. The measures will partly be financed by funds of the IRP (Dürr, Pfarr, 2008). Central measures involve visitors centres and open areas as regional attractors. Decentralized measures include the improvement of information and educational facilities and an enhancement of the site-specific recreational infrastructure for local inhabitants. Further bike paths and canoe routes will be improved.

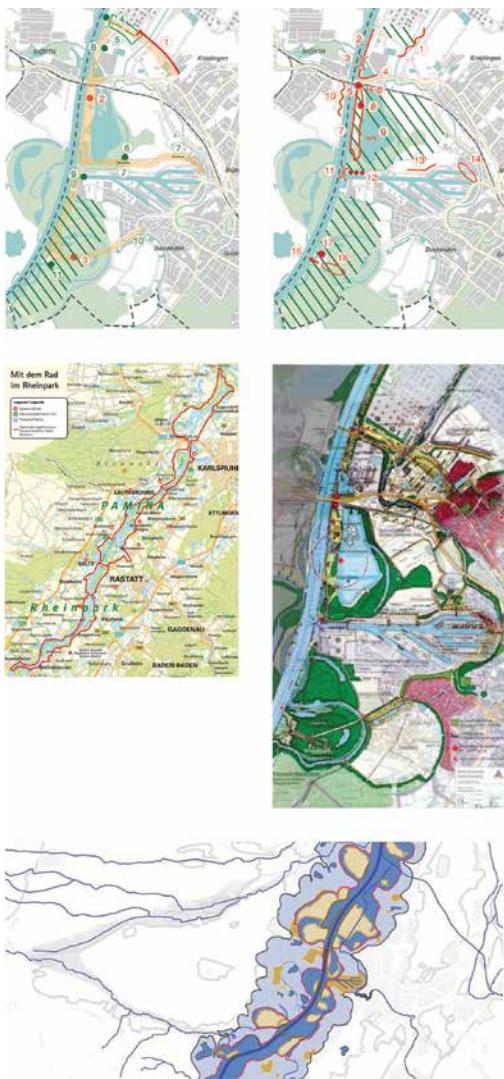
The local landscape department of the municipality is developing two park concepts: the Landschaftspark Rhein in Maxau to the north of the harbour as part of the regional PAMINA Rhine park project and the Rheinauenerlebnispark located on site of the polder (see fig. 56). The Landschaftspark Rhein is currently being implemented and foresees a continuous path along the Rhine as well as a bridge over the harbour entrance, a restaurant, playgrounds and a museum and nature observation stations (Karlsruhe Masterplan 2015). It strives to create stronger visual and physical links to the Rhine, but lacks the capacity to connect with other programs. The PAMINA park concept is based on a museal approach, trying to create a cross border park on 850 square kilometers with multiple stations, among them 10 museums and nature conservation centres accessible by bike (see fig. 57.3) ([www.pamina-rheinpark.org](http://www.pamina-rheinpark.org)). The plan is to implement the 'Rheinauenerlebnispark' on the polder itself in parallel with the polder development. It extends the concept of the existing nature education centre with experiential environmental facilities themed around the alluvial flood plain (fig. 57.1-2). Further infrastructural measures to raise the tram line and to install flood defence measures for the nature education centre and the 'Rheinstrandbad' aim to guarantee accessibility

even during flooding. Without the infrastructural measures for the adjoining area and without the raised tram line and defence measures, the budget for the park concept for Rappenwört amounts to 3,321,000 Euro and will only in part be financed by IRP (Dürr, Pfarr, 2008).

The urban landscape in the former flood plain of Karlsruhe does not underlie a design strategy adequate to the scale and heterogeneity of the site. As this is a wealthy region, the negation of the urban landscape as a design task is not a consequence of lacking funds. Spatially, the distance of the historical city and the lacking visual contextualization may be a reason. Furthermore, the large-scale infrastructure perpendicular to the river, such as the harbour and the motorway, pose a spatial challenge to creating a better connectivity. Yet it is most of all in terms of strategy that the project layers remain sectoral developments.

The project structure by the Ministry for the Environment lacks the involvement of urban designers and landscape architects. It is limited to the Gardening Department of the municipality that is developing the designs in consultation with other local agencies (Karlsruhe Masterplan 2015; Henze, 2012). The project developer is the Regierungspräsidium, a regional agency in charge of the steered polder project. Since the planning and installation costs are already very high and the plan approval procedure appears extremely complex, there is only limited capacity to integrate a more comprehensive design approach. This shows in the missing links among the infrastructural measures necessary to protect adjoining areas from seepage and rising ground water levels and the landscape design. It also shows in the lack of consideration given to the diverse programs of the flood plain and in the detached development of the two park concepts.

A further aspect that shows the lacking design strategy is the missing visualization layer that could communicate how the plans to design a park could be combined with the infrastructural layer and the foreseen flood pattern. Although the Park project is being developed since 2007, there are no plans of the current design available because individual measures are part of the ongoing plan approval procedure (Henze, 2012). To develop a plan that includes infrastructural, recreational and flood-related measures and the dynamics of redeveloping the alluvial forest could be a start to develop a more comprehensive design approach - beyond the technical realm of the project.



**Figure 57**

1-2. Landschaftspark Rhein (Landscape Park Rhine) and Rheinauenerlebnispark (Flood Plain Experience Park) developed by the Municipal Gardening Department remain subordinate concepts (Municipality Karlsruhe, Gardening Department, 2008). 3. Pamina Rhine Park, a regional and transnational park concept with bike paths and canoe routes connecting different educational and recreational facilities in the former flood plain on both sides of the river ([www.eurodistrict-regio-pamina.com](http://www.eurodistrict-regio-pamina.com), 2010) 4. Concept proposal for Bundesgartenschau 2015 (federal horticulture exhibition) serves as a basis for the further development of the two park concepts (Gartenbauamt Karlsruhe, 2007) 5. Rhine Archipelago, the conceptual study Karlsruhe 2030 proposed to consider the urban landscape in the former flood plain as an archipelago of different programs that could be connected (Bava et al., 2002).

### **Flood Threat/Management**

Today, the former flood plain has a high economic damage potential. In the areas behind the primary dikes along the Upper Rhine in Baden-Württemberg, settlements and industrial plants are located in the former flood plain without preparatory measures in case of a flood event. A dike breach or exceedance affecting these areas may lead to regional supply shortages, massive large-scale traffic hindrances and a breakdown of supply lines (Ludwig, 2008). The following scenario of a fictional dike breach thirteen kilometres upriver from Karlsruhe illustrates the impact scale of a possible dike breach. After about two days, the harbour, protected towards the river by a flood gate, would be inundated from the land side and the refineries, 15 to 18 km further down river, would be affected after three to four days. After about five days the water would flow back into the Rhine at a distance of 22 kilometres from the actual dike breach (Homagk, Ludwig, 2009).

One of the main challenges of flood risk management is uncertainty. Flood scenarios differ significantly depending on where the dike breach occurs. Therefore, operative flood risk management for the urban landscape of Karlsruhe relies on an intelligent grid that measures water levels at sensitive points in the former flood plain behind the defence in case of a breach. This allows a coordination of measures according to specific flood scenarios. In this way, operational flood management can be improved by adapting measures according to a dynamic calculation of the flood development and the actual discharge capacity of the dike breach (Homagk, Ludwig, 2009).

### **Alternatives Discussed for the Retention Polder Rappenwört**

The alternatives did not involve the consideration of other sites. Instead, local and regional interdependencies defined the parameters for the decision to implement a steered retention polder. As a dike setback would compromise the performance of the historical retention polder of Daxlander Au on the opposite side of the river, which has existed since the 19th century and is part of the retention stock of the Upper Rhine, the solutions discussed imply only perforations of the main dike. Three alternatives, a non-steered (Alternative 1) and steered solutions (Alternative 2+3) were discussed (RPK, 2007). Because of its lesser relevance, this research will not explore Alternative 3. A comparative analysis between the steered and non-steered solution included requirements for plan approval, flood mitigation, environmental impact and Flora-Fauna-Habitat compatibility, as well as costs, effects of an extreme event beyond a 200-year flood, and impacts in case of a contamination of the Rhine (Vogt et al, 2007).

### **Alternative 1 / Open System - Perforations in the Main Dike**

#### **Flood Mitigation**

The alternative model discussed and favoured by the ecologists suggested a non-steered system where openings would be cut into the main dike (fig. 58.2). This non-steered version does not differentiate between ecological flooding and flooding

to reduce peak discharges. Therefore, it does not fulfil the demands of the IRP in terms of flood relief for a 1/200 year flood (Harms, 2006). Due to environmental laws, the closed system needs an exceptional permit to be implemented in the former flood plain. This permit is only granted when the most ecological solution is chosen, which in turn would be the open version. In this way, many politicians have argued against the steered solution (see Vogt et al, 2007).

With Alternative 1, already at a discharge of 4080 m<sup>3</sup>/s in the Rhine, 400 m<sup>3</sup>/s are flowing into the retention polder and thus lowering water tables. As a consequence, the polder Daxlander Au would be activated at a later point in time than before. This would lessen its mitigative capacity, which is most effective for small and medium scale floods specifically for the regions Karlsruhe and Mannheim (fig. 58.1). The mitigation of small and medium scale floods are relevant as they may accumulate with the flood wave of the Neckar tributary downstream at the height of Mannheim. In case of an implementation of the non-steered polder, the Daxlander Au polder could not be filled before a discharge of 4480 m<sup>3</sup>/s. This would imply a decrease in peak shaving by about 50% with negative effects down river from Karlsruhe up until the Mid-Rhine (Vogt et al, 2007). Adjustments to the Polder Daxlander Au would imply lowering its summer dike or constructing an in- and outlet structure. Neither the state of Rheinland-Pfalz nor the ICPR supported these adjustments, as the additional costs and negative impacts on the FFH would only lead to a preservation of the status quo (RP Karlsruhe, 2007).

## **Alternative 2 / Steered System - In/Outlet Structures in the Main Dike**

### **Flood Mitigation**

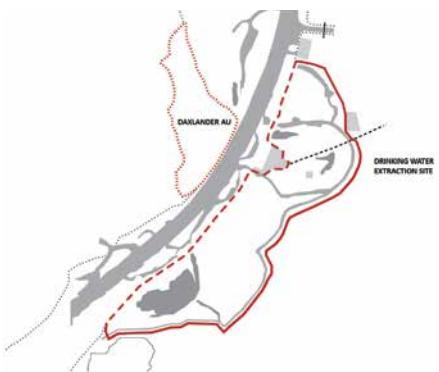
In contrast to the non-steered version, Alternative II does not influence the activation and therefore the mitigative impact of the historical polder Daxlander Au (fig. 58.3). Because the inlet structures are closed at a discharge of 4000 m<sup>3</sup>/s to 4500 m<sup>3</sup>/s in the Rhine, the polder on the opposite side can fill before Rappenwört is activated. In terms of flood mitigation, the investigation showed that the solution via non-steered openings in the main dike would be less effective for the cities Mannheim and Ludwigshafen down river. Infrastructural support measures do not differ between Alternative 1 and 2 (Vogt et al, 2007).

### **Landscape**

Although the Integrated Rhine Program aims for an ecological restoration of the flood plain, all alternatives have a negative impact on the Natura 2000 criteria and according to nature preservation law therefore demand for an exceptional permit. Yet, this is not seen as a hindrance since the flood risk means that public interests and safety are at stake (Vogt et al, 2007) and therefore prioritized.



1



2



3

**Figure 58**

1. Sphere of influence upriver - Lowering the effects of the retention polder Daxlander Au would imply negative effects for the Karlsruhe and Ludwigshafen/Mannheim region. The confluence of the Neckar with the Rhine is one of the neuralgic spots along the Rhine in case the flood waves of the two rivers accumulate.
2. Alternative 1 - open system / perforations in the main dike: The polder floods at  $4080 \text{ m}^3/\text{s}$  which reduces the capacity of the existing retention polder vis-à-vis Daxlander Au as it would be activated at a later point in time.
3. Alternative 2 - steered system - in/outlet structures in the main dike.: The polder Rappenwört is closed during a discharge of  $4000-4500 \text{ m}^3/\text{s}$  and therefore allows full activation of Daxlander Au. The polder itself floods at  $4500 \text{ m}^3/\text{s}$ .

### **Industries / Production**

A further factor that played a role was the planned municipal utilities drinking water plant of Karlsruhe with an extraction of 7.4 million cubic meters water per year. It is located in the Innere Kastenwört, directly adjoining the retention polder (see fig. 54). It is integrated in the development and it is possible to use the polder at the same time, depending on the version chosen. An increase of the drinking water plant's supply to a larger region would also increase the area of water extraction. This would increase Rhine infiltration when the polder is activated because of rising ground water levels that influence the water quality negatively. The ground water current comes from the Black Forest and has a very high water quality. However, if more water is extracted than the amount that arrives, bank filtrate from the Rhine fills this gap. With the planned amount of water extraction without the retention polder, 11-12% of bank filtrate is expected. With the polder the amount increases to 21% for the non-steered and 22% for the steered version during an extreme event. As the drinking water plant is planning on raising its extraction to provide drinking water beyond the municipal borders, the infiltration of Rhine water could increase and thus produces a conflict among flood management, ground water protection and the economic interests of the municipal supply company (Harms, 2006).

### **Non-Spatial aspects**

On a project scale, the open solution would cost about 20% less (Harms, 2006). The construction of the open polder would be more cost-effective with 51 million euros vs. the closed system with 61 million (Kaufmann, 2007). Also, the maintenance costs for the closed system are slightly higher with 0.73 - 0.9 million Euro/year. Whereas the non-steered solution is 10 million euro less expensive, the costs for the adjustments to the polder Daxlander Au would amount to approximately 5 million euro with additional costs for land expropriations and compensations (Vogt et al, 2007).

**To conclude: technical, economic and ecological parameters shaped the decision towards the steered alternative. Spatial considerations played no role.**

#### FLOOD FREQUENCY

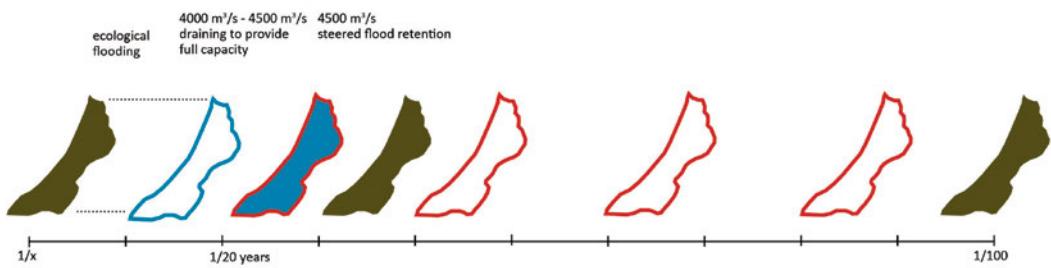


Figure 59

Flood frequencies of the retention polder: open ecological flooding (green), steered flood mitigation (blue)



Figure 60

Project site (Regierungspräsidium Karlsruhe, 2007)

## § 6.4 The Project Scale

On the project scale, the retention polder Rappenwoert is a flood mitigation measure and a landscape rejuvenation project but a threat to the adjoining programs (fig. 60). The following text elaborates the temporal organization and the infrastructural support demanded to enable installation.

### Flood Mitigation and Landscape Rejuvenation

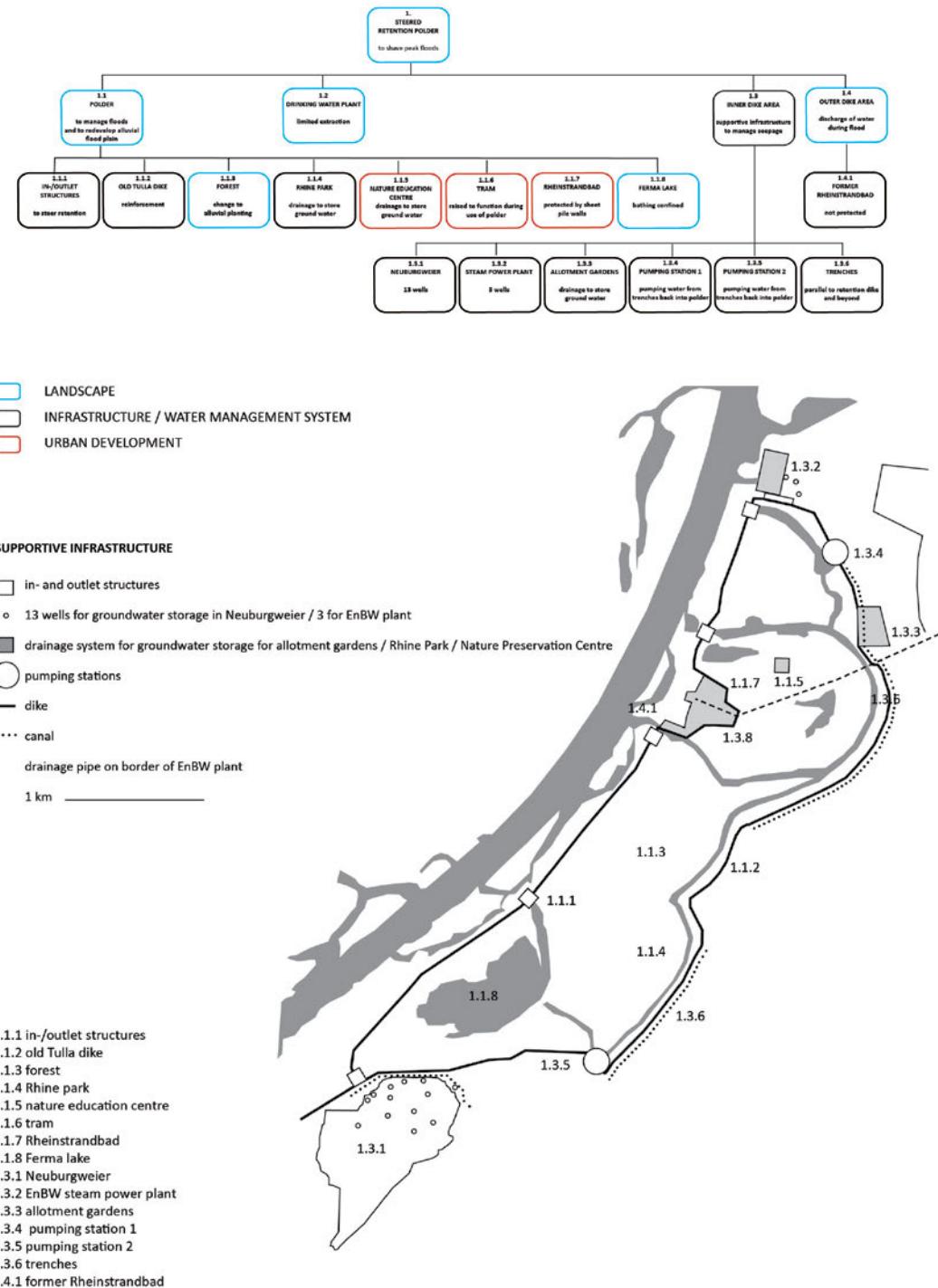
The retention polders along the Upper Rhine are positioned according to the land available in the former flood plain and their impact on the peak flood wave. The retention polder Karlsruhe Rappenwoert is positioned south of the harbour. Steered retention is the primary function in the hierarchical organization of the polder Rappenwoert. The retention area is flooded through five in- and outlet structures at a discharge of 4500 m<sup>3</sup>/s (Maxau gauge station). This is equivalent to a 1/50 year flood event. As part of the Integrated Rhine Program it aims to accumulatively raise the flood protection level after Iffezheim from the current flood-protection level of 1/120 years to 1/200. On an area of 510 hectares and with a retention volume of 14 million cubic meters, it is expected to lower flood levels on a local scale by 7 cm (Adomat, 2007) and as part of an accumulative measure for the Upper Rhine between Basel and Mannheim by 70 cm. Steered flooding will statistically take place every 20 years (RPK, 2008). The secondary program to restore the alluvial forest ecologically on site via non-steered flooding processes in direct exchange with the varying water levels of the Rhine stops at a discharge of 4000 m<sup>3</sup>/s (8.53 m). This ensures that essential volumetric capacities are available when the flood wave's peak reaches the height of Karlsruhe (see fig. 59). In order to enable a synergetic program on site, the project requirements are limited to defining the temporal organization between steered and non-steered flooding processes. Yet, fulfilling Habitat 2000 criteria remains problematic and requires exceptional approval.

### Morphological Transformations in Relation to the Programs on Site

The installation of the retention polder and the demanded ecological flooding only necessitates minor transformations of the existing morphology. In- and outlet structures are installed in the existing main dike erected only in 1934, while the land side is protected by an older reinforced dike outlining the old Rhine arm.

### Infrastructural Appropriation for Existing Programs

Avoiding damage to the aligning programs requires a number of support measures. This is to ensure the protection of the building development of Rheinstetten-Neuburgweier, the Rheinpark Rappenwört, the nature education centre Karlsruhe-Rappenwört, the allotment gardens north of Hermann-Schneider- Allee and the EnBW steam power plant when the polder is in use. Supportive infrastructure exists to regulate seepage and ground water levels (fig. 61). It includes:



**Figure 61**  
Elements of polder (map: Regierungspräsidium Karlsruhe, adapted by author).

- 13 wells for groundwater storage in Neuburgweier / 3 wells for EnBW
- Drainage for groundwater storage for allotment gardens / Rhine Park / Nature Preservation Centre
- Pumping stations
- Trenches
- Drainage pipe EnBW
- Extensive trench development and expansion
- Two large pumping stations

Within economically viable parameters, adjacent open areas are protected by a trench system along the retention dike. The collected water is pumped back into the polder via the two pumping stations. To the east of the polder a continuous path system between the Rheinhafen Karlsruhe and Rheinstetten- Neuburgweier is planned. Swimming in the Ferma lake will be confined (RPK, 2008).

### **Object Adaptation**

The city wants to protect the Rheinstrandbad swimming pool on the polder site with a sheet-pile wall and to raise the street and tram line onto a 2.5 meter high dam to enable access during high water levels. Also, the nature education centre will be flood-proofed, and accessible by boat or via a pier (Hustede, 2011). All together, the implementation of the retention polder will comprise 180 single measures (RPK, 2011).

### **Non-Spatial Aspects**

Regarding the seepage/ground water problem, an extra budget is set aside to compensate for potential damage that can not be foreseen at this stage of the project. This specifically applies for damage to the agricultural land protected by the trench system running in parallel to the retention dam.

**The project scale is focussed on the temporal and spatial organization of the two kinds of flooding, for flood mitigation and ecological rejuvenation, while managing negative effects on the surrounding developments.**

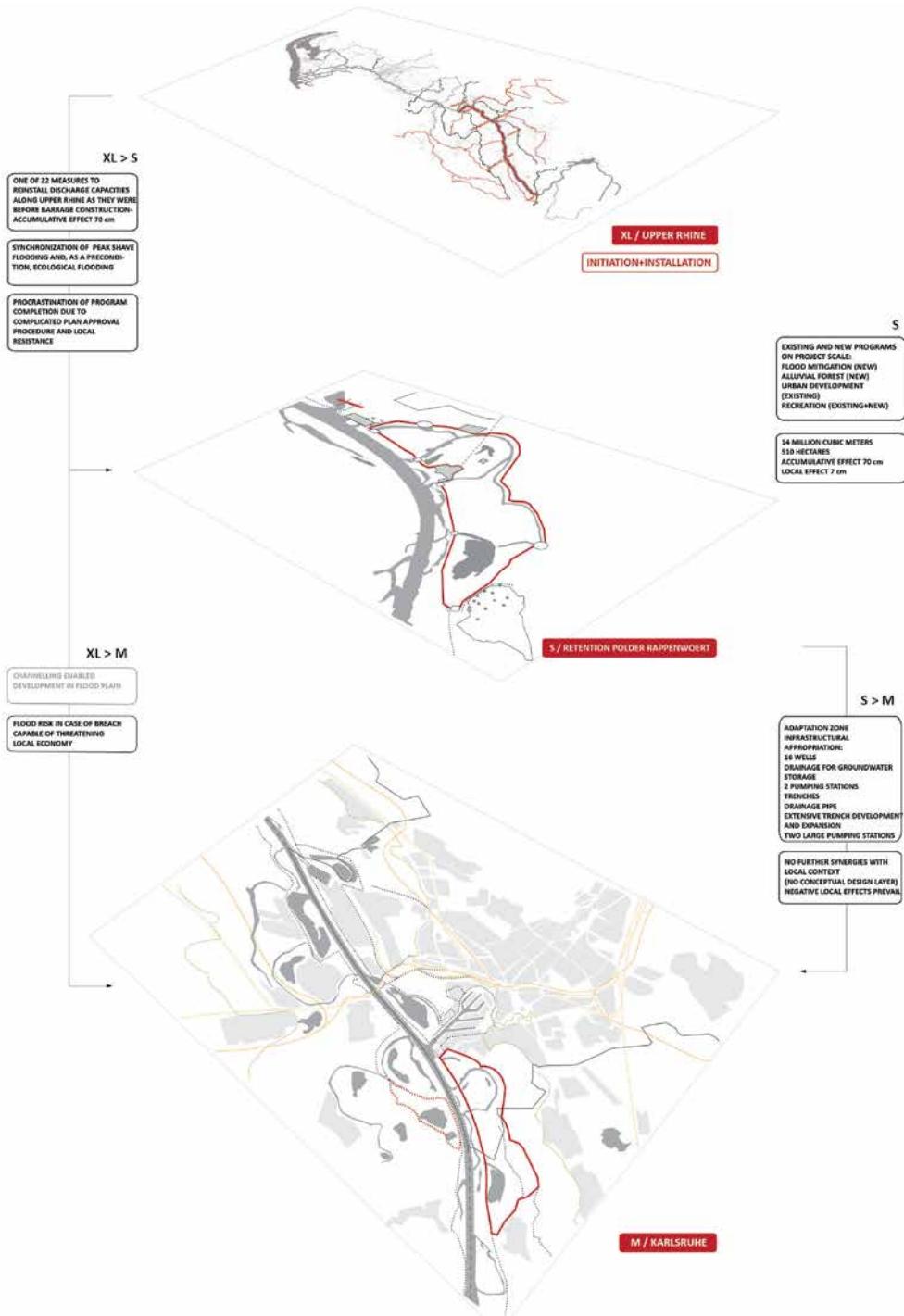


Figure 62

Extract diagram showing interdependencies between river-, project- and local scale.

## § 6.5 E / Extraction

**XL / TYPOLOGY** Steered retention polders are areas behind the main dike reserved for peak flood shaving and as a precondition for ecological flooding. In their direct vicinity negative effects due to seepage prevail. **GLOBAL RELATION TO RIVER BASIN** Steered retention polders are only implemented along the Upper and Lower Rhine. 36 retention polders and dike set backs have been or are being implemented in France and in Germany with the goal of accumulatively lowering water tables by 70 cm along the Upper Rhine and by 10 cm at Lobith along the Lower Rhine. In addition, emergency polders are designated to cope with extreme floods in the future. **PARADIGM** In terms of water management, the retention polders along the Upper Rhine aim to restore discharge capacities as they were before barrage construction. In terms of nature development, ecological flooding aims to re-establish riparian qualities lost in the course of rectification, a precondition for the polder installation. All of these measures – spatial reservation, nature development and infrastructural appropriation – remain technical. Apart from a subordinated recreational concept, they are developed without considering potential emergent qualities on a local and/or regional scale. For their lack of breaking with the sectoral development in the former flood plain and their dependency and support of the defensive system, retention polders may be considered path-dependent.

**I+I / INITIATION+INSTALLATION** The installation of the retention polders along the Rhine is a top-down process initiated by the ICPR and executed by regional agencies. In many cases, complex plan approval procedures and local resistance against the polders lead to a stagnation of the implementation process and an increase in cost. There is no transdisciplinary agency between the ICPR to support the local scale to consider spatial quality or emergence between programs as a development factor for the projects. Spatial quality is not a declared program goal of the Rhine 2020 program and the capacity of the public sector to initiate such programmatic links is, in many cases, hindered by sectoral or hierarchical boundaries. As there are no designers involved, there is no conceptual design layer to carry the project.

**S / PROJECT SCALE** The project scale is focussed on the temporal and spatial organization of ecological and peak shave flooding while managing the negative effects on the surrounding developments. Beyond infrastructural adaptation measures to deal with the seepage problem, damage to agricultural land due to the polder use will be individually remunerated. Apart from the installation of the in- and outlet structures in the main dike, the river front is not transformed morphologically.

**M / LOCAL AND REGIONAL CONTEXT** The urban landscape of Karlsruhe serves as a container for a heterogeneous set of programs evolving in the wide river bed of the meandering Upper Rhine at a distance from the city centre located 10 meters above the flood plain. The sectoral organization of its programs coheres with the modernist

approach that has lead to the rectification of the river in the 19th and 20th century. The impact of retention polders on their local context is defined by the potential flood risk they produce for existing villages, industries and infrastructure - not their positive effect on peak water levels. Technical, economic and ecological parameters shaped the decision towards the steered alternative in Karlsruhe. Spatial considerations did not play a role at the conceptual phase, but are an additional layer limited to recreation.

**LEARNING FROM...SPATIAL DESIGN** The surrounding area negatively affected by the water pressure is, at this point, excluded from any design strategy. It may, however, be considered as an amphibious zone with (re-)development potential. Reducing demanded water levels by expanding the retention area could provide an alternative approach and also a strategy for future measures. Lowering water storage levels would produce fewer negative side effects for the adjoining areas behind the defence. This would also expand the alluvial zone. ...**STRATEGIC DESIGN** In Karlsruhe all programs in the highly urbanized former flood plain are lacking a conceptual design capable of linking programs and enabling emergence. Specifically for the polder and its direct vicinity, the drinking water plant, the swimming bypass and its adjoining new basins, the nature education centre and the old Tulla dikes on site offer vast conceptual capacity for an area-based approach. The conceptual design of living with water would need to be applied to mitigation measures at the initial development stage.



Figure 63

Daxlander Au / Rhine km 357.5

Land use: n.i. / Context: n.i. / Flood frequency: n.i. / Floodable area: n.i. / Flood volume: 5.1 million m<sup>3</sup> / Building period: n.i. / Status: completed in 1997<sup>1</sup> / Building costs: n.i. / ([www.geoexplorer-wasser.rlp.de](http://www.geoexplorer-wasser.rlp.de), 1 MUFV RLP, Hochwasserschutz in Rheinland-Pfalz, Mainz, 2011)



Figure 64

Neupotz Wörth (Jockgrim) Retention polder and dike set back / Rhine km 368

Land use: 24% forestry, 70 % agriculture, 6% water+gravel excavation pits to be expanded on the agricultural land / new dike (6.5 km) and retention dam (2.5 km) separating free from steered polder

/ dike removed in area of free retention / Context: Bundesstrasse 9 between Neupotz and Woerth

Flood frequency: n.i. / Floodable area: 420 hectares in total, 145 flooded freely / Flood volume: 18 million m<sup>3</sup> / Building period: n.i. / Status: planned completion 2012<sup>1</sup> / Building costs: n.i. /

(Struktur- und Genehmigungsdirektion Süd, Neustadt, 2001, <sup>1</sup>MUFV RLP, Hochwasserschutz in

Rheinland-Pfalz, Mainz, 2011)



Figure 65

Elisabethenwört / Rhine km 380.8-383.4

Land use: forestry and agriculture / Context: island surrounded by Rhine and Russheimer Altrhein in the northeast and divided by the state border to Rheinland-Pfalz / Flood frequency: n.i. / Floodable area: 400 hectares / Flood volume: 12 million m<sup>3</sup> / Building period: n.i. / Status: preliminary studies and designs / Building costs: : n.i. / ([www.rp.baden-wuerttemberg.de](http://www.rp.baden-wuerttemberg.de))



Figure 66

Rheinschanzinsel / Rhine km 388.5-392.0

Land use: intensive agriculture / Context: Rhine, Phillipsburger Altrhein, main dike XXXIII

Flood frequency: statistically 1/20 years / Floodable area: 210 hectares / Flood volume: 6.2 million m<sup>3</sup> / Building period: 3 years / Status: plan approval 2004, currently under construction / Building costs: 20 million Euro / (Gewässerdirektion Nördlicher Oberrhein; [www.4gwd.de](http://www.4gwd.de))



Figure 67

Mechtersheim / Rhine km 388.4

Land use: n.i. / Context: n.i. / Flood frequency: 1/25 years / Floodable area: 145 hectares / Flood volume: 3.6 million m<sup>3</sup> / Building period: 2010 - 2012 / Status: plan approval 2010, currently under construction / Building costs: 20 million Euro / (<http://www.sgsued.rlp.de/Pressemitteilungen/broker.jsp?uMen=f3c705e6-8f8d-a8116d16bb102700266&uCon=b4050dfa-e34c-1721-0lad-b3d572e13d63&uTem=aaaaaaaaaaaa-aaaa-aaaa-00000000042>)



Figure 68

Plotzgrün / Rhine km 392.6

Land use: artificial island as a result of 19th cent. Rhine correction; agriculture; 85 hectares are an endiked landfills by BASF / Context: south of Speyer and Althausener Altrhein / Flood frequency: 1/20 years / Floodable area: 340 hectares / Flood volume: 5 million m<sup>3</sup> / Building period: 6 years Status: completed in 2002<sup>1</sup> / Building costs: 7.8 million Euro / (Struktur- und Genehmigungs-direktion Süd, Neustadt, 2001; <sup>1</sup>MUFV RLP, Hochwasserschutz in Rheinland-Pfalz, Mainz, 2011)

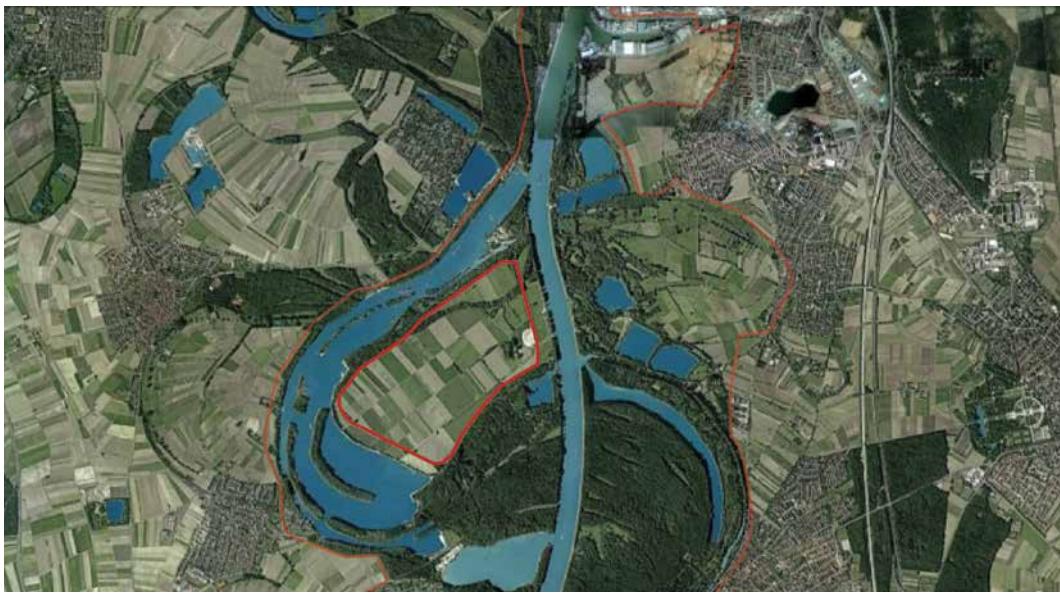


Figure 69

Kollerinsel / Rhine km 409.9

Land use: agriculture, recreation, nature development / Context: Otterstaedter Altrhein / Flood frequency: n.i. / Floodable area: 232 hectares / Flood volume: 6.1 million m<sup>3</sup> / Building period: 2000-2004 / Status: completed 2005<sup>1</sup> / Building costs: n.i. / (Struktur- und Genehmigungsdirektion Süd, Neustadt, 2001; <sup>1</sup>MUFV RLP, Hochwasserschutz in Rheinland-Pfalz, Mainz, 2011)



Figure 70

*Waldsee Altrip Neuhofen retention polder and dike setback / Rhine km 411.5*

Land use: forestry and agriculture / Context: n.i. / Flood frequency: n.i. / Floodable area: n.i. / Flood volume: max 9 million cubic meters<sup>1</sup> / Building period: : n.i. / Status: currently proceedings in contentious administrative matters at the Federal Administrative Court / Building costs: n.i. (Landtag RLP DS 16/359, 2011, [www.neuhofen.de](http://www.neuhofen.de) 4.2.2010; <sup>1</sup>MUFV RLP, Hochwasserschutz in Rheinland-Pfalz, Mainz, 2011)



Figure 71

Petersau Bannen retention polder and dike setback / Rhine km 436

Land use: forestry and agriculture / Context: n.i. / Flood frequency: n.i. / Floodable area: n.i.

Flood volume: 1.4 million m<sup>3</sup> / Building period: n.i. / Status: planned completion 20121 / Building costs: n.i. (Landtag RLP DS 16/359, 2011; MUFV RLP, Hochwasserschutz in Rheinland-Pfalz, Mainz, 2011)



Figure 72

Worms Mittlerer Busch / Rhine km 436

Land use: forestry and agriculture / Context: n.i. / Flood frequency: n.i. / Floodable area: n.i. / Flood volume: 2.1 million m<sup>3</sup> / Building period: n.i. / Status: completed in 2007<sup>1</sup> / Building costs: n.i.  
(Landtag RLP DS 16/359, 2011, <sup>1</sup>MUFV RLP, Hochwasserschutz in Rheinland-Pfalz, Mainz, 2011)



Figure 73

Bodenheim / Rhine km 488.6-491.2

Land use: mainly agriculture with a dense canal system, water cleansing plant on site built back , supportive infrastructural measures , 10 ha ecological compensation measures on site / Context: nature preservation area, B9 on former main dike, new polder dike with sealing wall

Flood frequency: 1/200 years / Floodable area: 212 hectares / Flood volume: 6.7 million m<sup>3</sup> /

Building period: n.i. / Status: completed in 2009<sup>1</sup> / Building costs: 27 million Euro

([http://wasser.rlp.de/servlet/is/7838/Bodenhm\\_%20Laubhm.pdf](http://wasser.rlp.de/servlet/is/7838/Bodenhm_%20Laubhm.pdf), <sup>1</sup>MUFV RLP,

Hochwasserschutz in Rheinland-Pfalz, Mainz, 2011)



Figure 74

Ingelheim / Rhine km 517

Land use: agriculture / flooded until 1970 / supportive infrastructural measures to protect Fein-Weinheim, hydro power plant Badweg, pump for IKA lake to protect surrounding buildings

Context: Selz dike (west), new dike east of land fill, main dike (north), protected via new polder dike (east) and motorway (south) / Flood frequency: 1/5-20 years / Floodable area: 162 hectares

Flood volume: 4.5 million m<sup>3</sup> / 30.000 m<sup>3</sup> for ecological flooding (1-3 years) / Building period: 2002-

2004 / Status: ready for use in 2006 / first use in 2011 / Building costs: 17 million Euro, co-funded

by SDF Interreg IIIb / (Flyer RLP Ingelheim)



**Figure 75**

Langel / Rhine km 669-672 Steered retention polder and dike setback

Land use: agriculture and nature redevelopment, supportive infrastructure (a. o. 16 wells) / Context: protection of Porz-Langel, Lülsdorf, Ranzel; compensation for dropped measures / Flood frequency: 1/100 years, flooded at 11.30 Cologne gauge / Floodable area: 158 hectares / Flood volume: 4.5 million m<sup>3</sup> / Building period: 2007-2009, preliminary study 1997, plan approval 2004 / Status: ready for use since 2009 / Building costs: around 30 million Euro / ([http://www.steb-koeln.de/baulicherhochwasserschutzzentral.html?detail\[uid\]=11&cHash=346962fa1cNRW\\_Umweltbericht\\_2009](http://www.steb-koeln.de/baulicherhochwasserschutzzentral.html?detail[uid]=11&cHash=346962fa1cNRW_Umweltbericht_2009), Feldmann, 2006)



**Figure 76**

*Worriener Bruch / Rhine km 706-708*

Land use: agriculture, nature+water protection area, individual buildings, B9 / Context: reconnection of old meander, protects northern city, cities down river, lowers water levels locally by max. 17 cm, if flood exceeds 11.90 m, time gain by 14 hours / Flood frequency: 1/200 years / Floodable area: 670 hectares / Flood volume: 30 million m<sup>3</sup> / Max. speed of flooding 330 m<sup>3</sup>/s / Building period: preliminary study 1999, plan approval+execution 2004-2011 / Status: n.i. / Building costs: around 40 million Euro / (<http://www.steb-koeln.de/retentionsraum-koeln-worringen.html>, NRW Umweltbericht 2009, Feldmann, 2006)



Figure 77

Ivericher Bruch / Rhine km 750-754.5

Land use: agriculture and nature protection area / Context: n.i. / Flood frequency: n.i. / Floodable area: 270 hectares / Flood volume: 9.8 million m<sup>3</sup> / Status: climate change related reserve area (activation depends on outcome of ICPR report expected for 2012) / Building costs: n.i. / ([ftp://ftp.cs.kun.nl/pub/TWM/academic%20year%202006%202007/TWM%20The%20course%202006%202007%20\(MM004\)/TWM%20excursions%202006%202007/5%2013-11-06%20excursion%20Province%20of%20Gelderland%2Bgroup%20work%20transnational%20Flood%20Management/Abschluss-%20und%20Teilberichte%20Niederrhein/4\\_Teilbericht%20Eingabedaten%20DSS/AnlageB\\_Eingabedaten%20DSS\\_D.pdf](ftp://ftp.cs.kun.nl/pub/TWM/academic%20year%202006%202007/TWM%20The%20course%202006%202007%20(MM004)/TWM%20excursions%202006%202007/5%2013-11-06%20excursion%20Province%20of%20Gelderland%2Bgroup%20work%20transnational%20Flood%20Management/Abschluss-%20und%20Teilberichte%20Niederrhein/4_Teilbericht%20Eingabedaten%20DSS/AnlageB_Eingabedaten%20DSS_D.pdf))



**Figure 78**

Orsoy Land / Rhine km 797.5-803.5 Retention polder and dike setback

Land use: agriculture / Context: study proposes polder east and polder west / Flood frequency: only during extreme events / Floodable area: 550 hectares / Flood volume: 35 million m<sup>3</sup> (lowering of water levels locally by 15 cm) / Building period: n.i. / Status: planning phase, local support, 2008 contract with dike association / Building costs: around 40 million Euro / (<http://www.urquellwasser.eu/news/wasserbelebung/kalkschutz/hochwasserschutz-umweltministerium-kauft-flaeche-in-orsoy-land-zum-hochwasserschutz/33330/>, NRW Umweltbericht 2009, Feldmann, 2006)



**Figure 79**  
*Bylerward (Version B3) / Rhine km 845.5 – 854.5*

Land use: agriculture / Context: n.i. / Flood frequency: n.i. / Floodable area: 1200 hectares / Flood volume: 52 million m<sup>3</sup> / Building period: n.i. / Status: preliminary study of 10 alternatives, strong local opposition, climate change related reserve area (further development depends on outcome of ICPR report expected 2012) / Building costs: n.i. / (NRW Umweltbericht 2009, Feldmann, 2006, AnlageB\_Eingabedaten DSS\_D)

# 7 Mainz

## ADAPTATION /

HARBOUR CONVERSIONS

7. MAINZ

8. DORDRECHT

## UNITS OF ANALYSIS /

EXTRACT

XL / I+I / S / M

XL RIVER

typology

I+I INITIATION+INSTALLATION

by whom and how is the project

S PROJECT (VERTICAL)

synergetic development

M CITY (HORIZONTAL)

connectivity

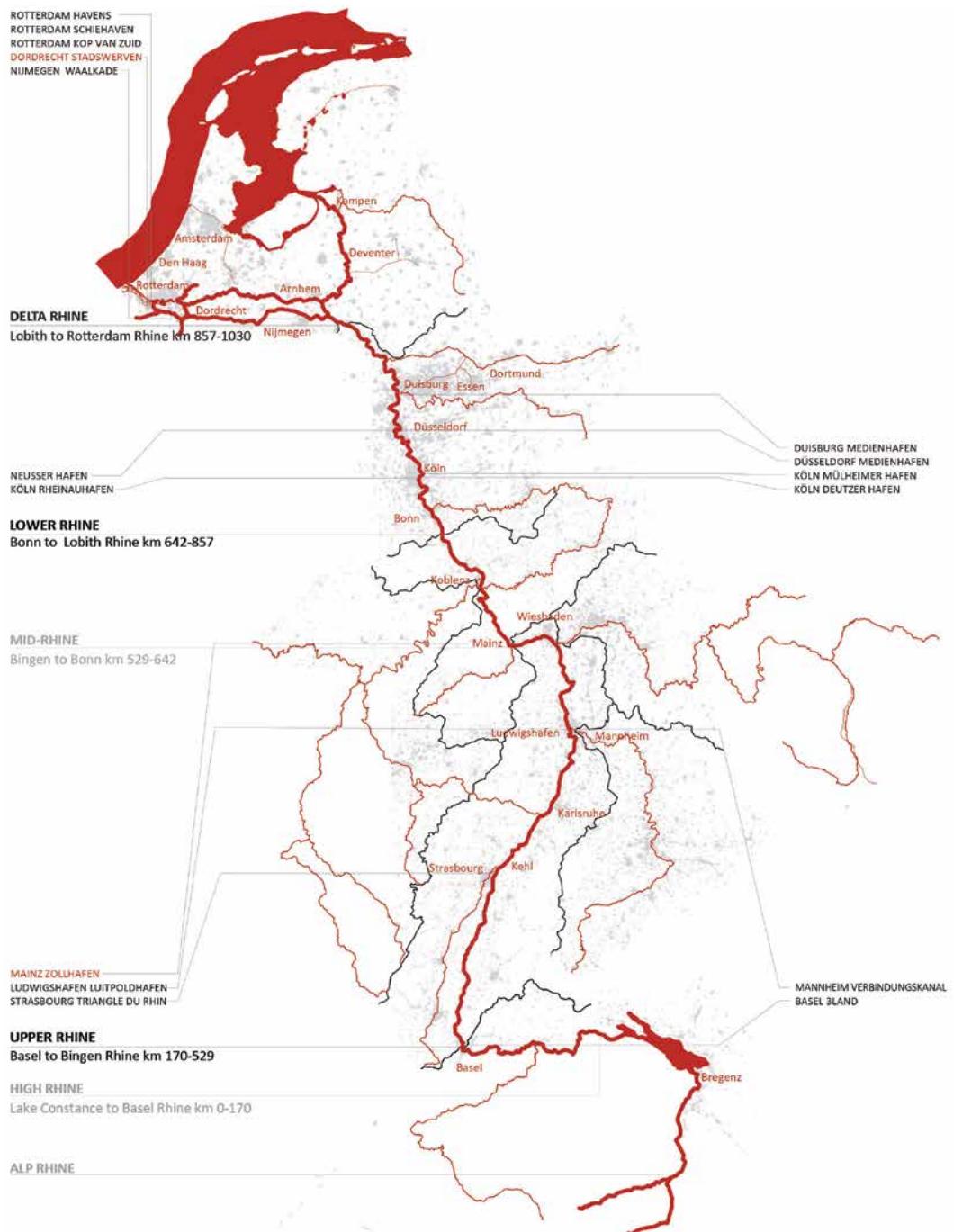


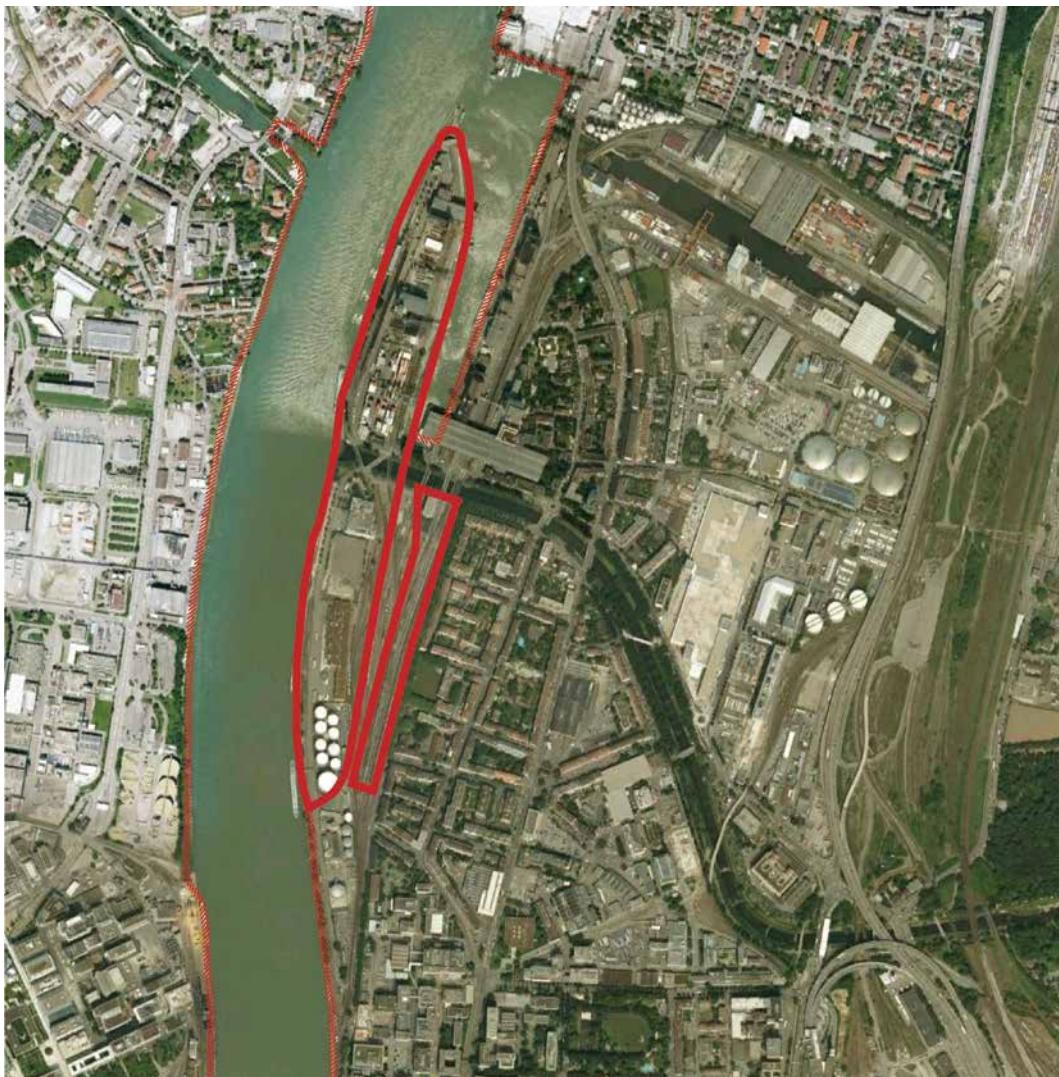
Figure 80

Overview of Harbour Conversions along the Rhine.  
(Rhine map based on ICPR Atlas of River Typologies, Urbanization Corine Land Cover 2003)



Figure 81

Atlas of Harbour Conversions (Google Earth 2009-2012, viewing height 2 km, dike lines ICPR Atlas, 2001)



**Figure 82**  
Basel 3Land Development Vision / Rhine km 168.3-169.8

Program: conversion of harbour/industrial site to an island with working, dwellings and leisure as part of a larger concept to connect the different river sides / Morphological transformation: former side channel reactivated to create island / Scale: 20 hectares / Flood risk: not considered relevant, both river sides above 1/100 year flood level (lines in plan indicate 1/100 year flood line\*) no flood defense system beyond quay walls and slopes currently being renewed to avoid erosion / Period: 2011 (MVRDV, 2011; Baudepartment Basel, 2008)

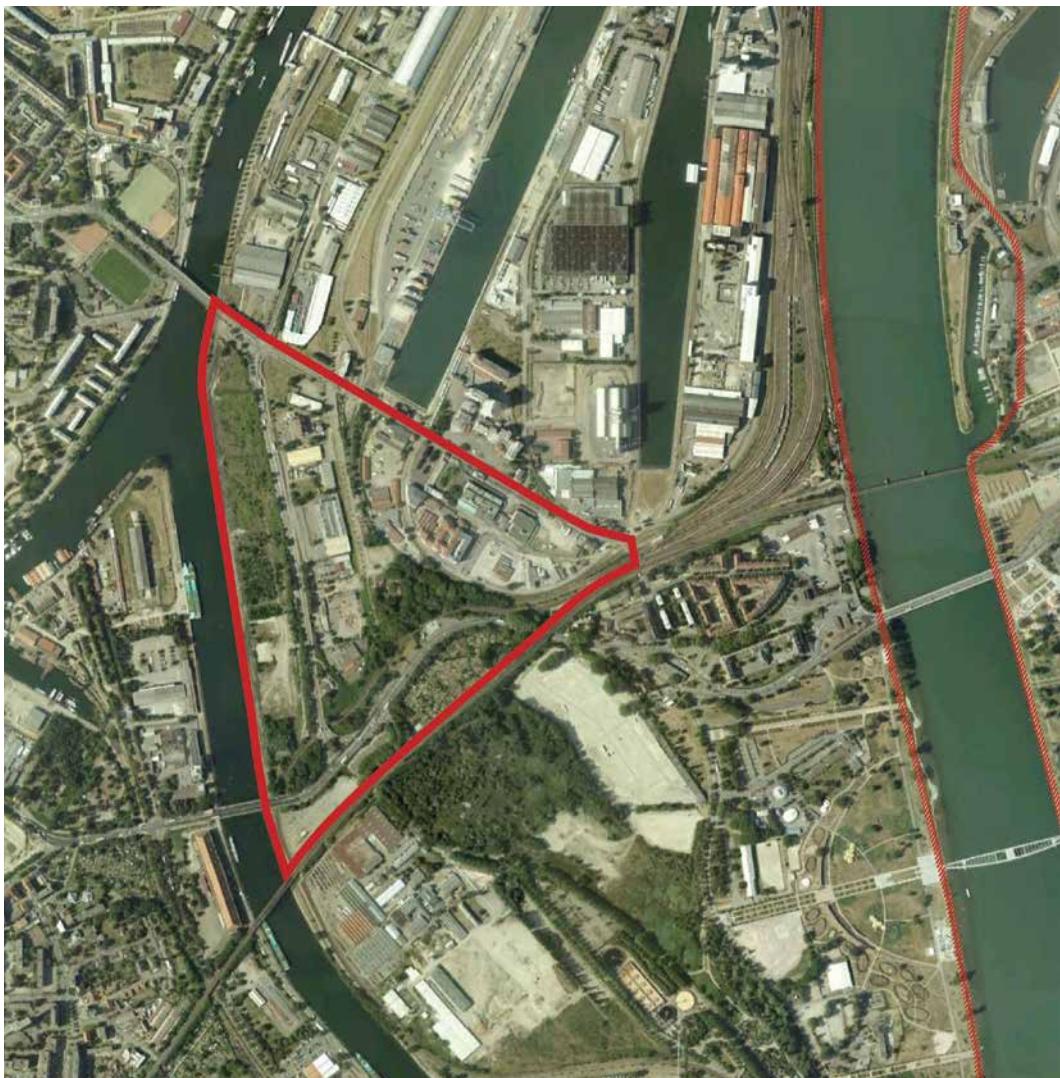


Figure 83  
Strasbourg Triangle Du Rhine / Rhine km 293-294

Program: Study of alternative uses / Morphological transformation: None / Scale: 42 Hectares / Flood risk: No information, lines in plan indicate 1/100 year flood line / Period: 200 (Triangle Du Rhin, Study, ADEUS, Strasbourg, 2007)

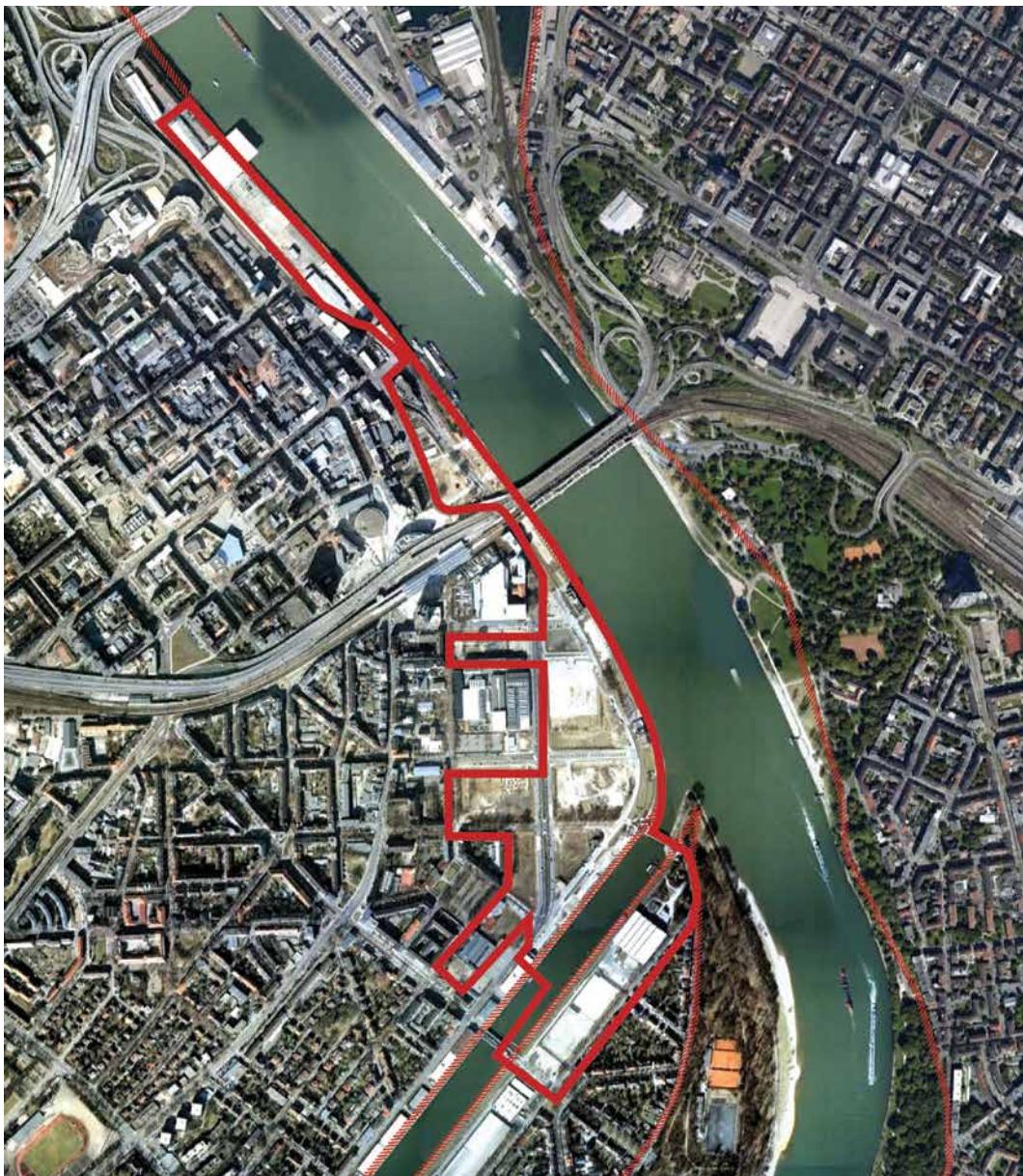
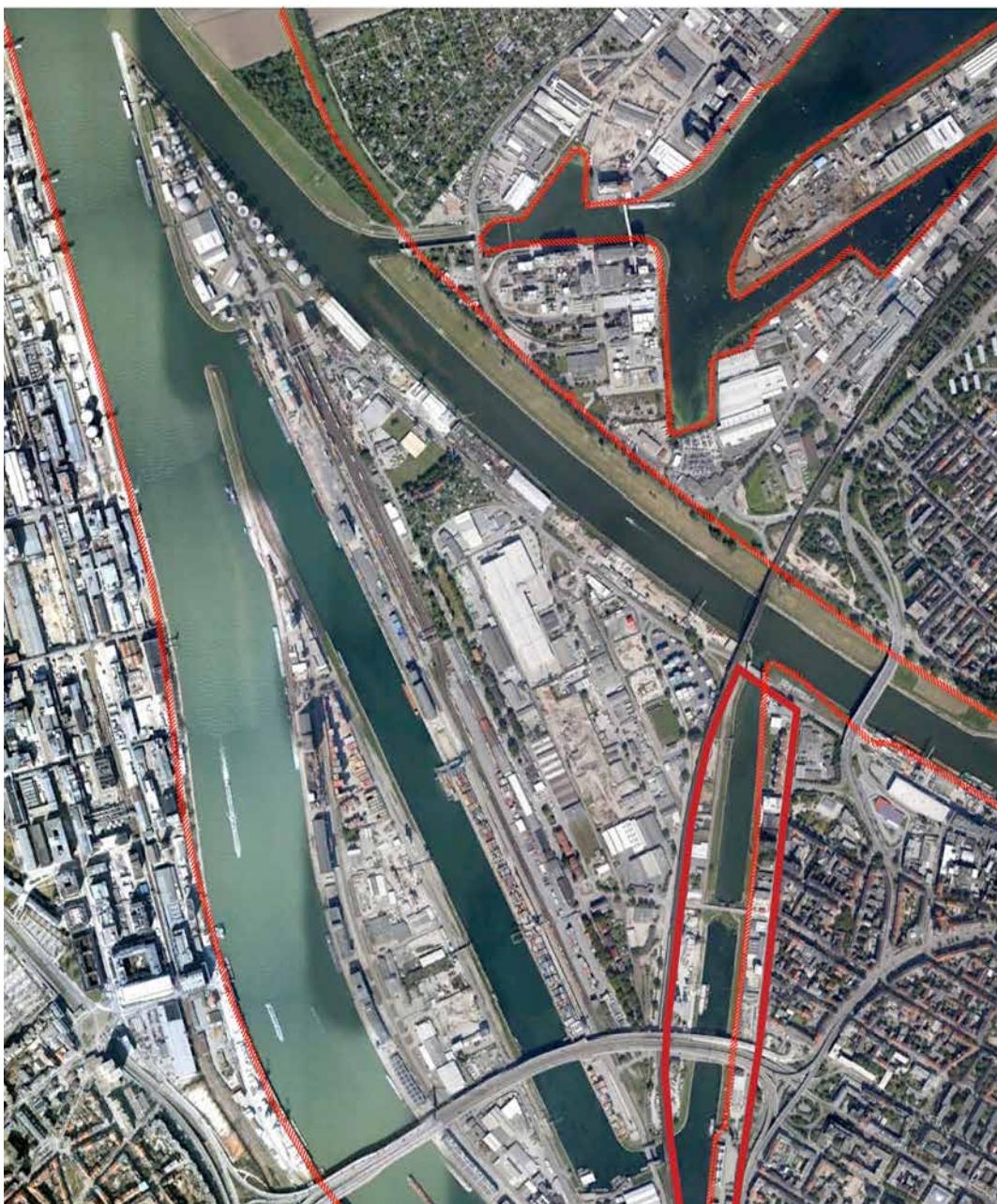


Figure 84  
Ludwigshafen Luitpoldafen / Rheinufer Süd / Rheingalerie / Rhine km 423.3-425.5

Program: harbour/industrial site conversions to dwellings, work spaces, recreation, shopping mall /  
Morphological transformation: None / Scale: 42 hectares / Flood risk: Redefinition of flood plainw,  
building development behind defense line 1/200, flood adapted against seepage / Period: 2011 ( [www.ludwigshafen.de/standort/umwelt/wasser/hochwasserschutz](http://www.ludwigshafen.de/standort/umwelt/wasser/hochwasserschutz) / [www.ludwigshafen.de/standort/1/](http://www.ludwigshafen.de/standort/1/) )



Program: Conversion of harbour/industrial site to Work spaces, dwellings, universities, open spaces and new walking, connection between Neckar and Rhine / Morphological transformation: None / Scale: 1:000000 / Hectares: 100 / Flood risk: Site protected by flood wall and topography / Period: Since 2001 (framework plan) / AVKM Verbindungskanal Mannheim, Stadt Mannheim, 2007, Hochwasserschutz, Stadt Mannheim, 2003

Figure 85  
Mannheim Verbindungskanal / Rhine km 426-427



Figure 86

Mainz Zollhafen / Rhine km 499.5-500.8

Program: Dwellings, commercial and open spaces / Morphological transformation: Gradual, green slope on northern quay, laying historical quay heads free, canal system to create harbour islands / Flood risk: Development outside of the flood defense statistically flooded 1/100 years / Scale: 22 hectares with water surfaces / 13 hectares / Period: 1993 (first feasibility study) - 2025 (estimated completion)

### **Harbour Conversions**

In the following section harbour conversions (see fig. 80, 81) are evaluated in terms of their global relation to the Rhine river. This chapter explores the paradigms of their development, which are reflected in an atlas documenting their appearance along the Rhine. This atlas documents all harbour conversions, planned and realized, along the Rhine to give a coherent overview of the specific typology. In terms of flood management, this layer serves as a basis for understanding the current adaptation strategies applied to urban development in the flood plain.

Since the case studies of Mainz and Dordrecht both focus on harbour conversions, the following atlas is valid for both. Many of the issues are the same for urban development projects in the flood plain, e.g. flood adaptive building typologies, potential evacuation routes, etcetera. Yet, Mainz Zollhafen along the Upper Rhine and Dordrecht Stadswerven as part of the Rhine Delta differ significantly in terms of context and project ambition. Mainz is a model project delimited to the scale of the Zollhafen whereas Dordrecht Stadswerven is a site-specific study embedded within a larger strategy of flood-adapted urban development. Thus, apart from a shared atlas, the two case studies will therefore be documented individually in order of their location from south to north.

### **Typology**

Harbour conversion typologies evolve from a change of mass goods transshipment to a transport of goods predominantly based on container logistics. This leads to a change in spatial demands: no longer a harbour basin but a longitudinal quay is needed and the just-in-time trimodal transshipment of goods often requires additional space. This development along the Rhine, as elsewhere, has made harbours as they have evolved historically obsolete. Built in the flood plain and raised to ensure the necessary water depths (see fig. 86), harbour basins, in many cases, are remnants of natural side channels (see Atlas e.g. Basel Kleinhueningen, Mainz Zollhafen, Cologne Rheinauhafen). During the process of industrialization as a key stage in the evolution of the harbour sites that are being converted today, the urban waterfront was expanded into the riverbed to channel the river leaving a concave excavation of the basin. The plans for the Zollhafen development at Mainz projected on the landfill as part of the Upper Rhine rectification illustrate the procedure. What was formerly a gradual soft waterfront now became a hard orthogonal profile that not only provided additional space for harbour activities, but also improved the navigability of the river. In 1868, the Upper Rhine states agreed on the reduction of the river bed width to 450 meters downstream from the Main until Bingen, reducing the average width of 500-600 meters (Heidecker, Kuhn, 2007). Eduard Kreysig, the city architect of Mainz, integrated this decision in his concept to expand the city and plan for the Zollhafen (see fig. 88).

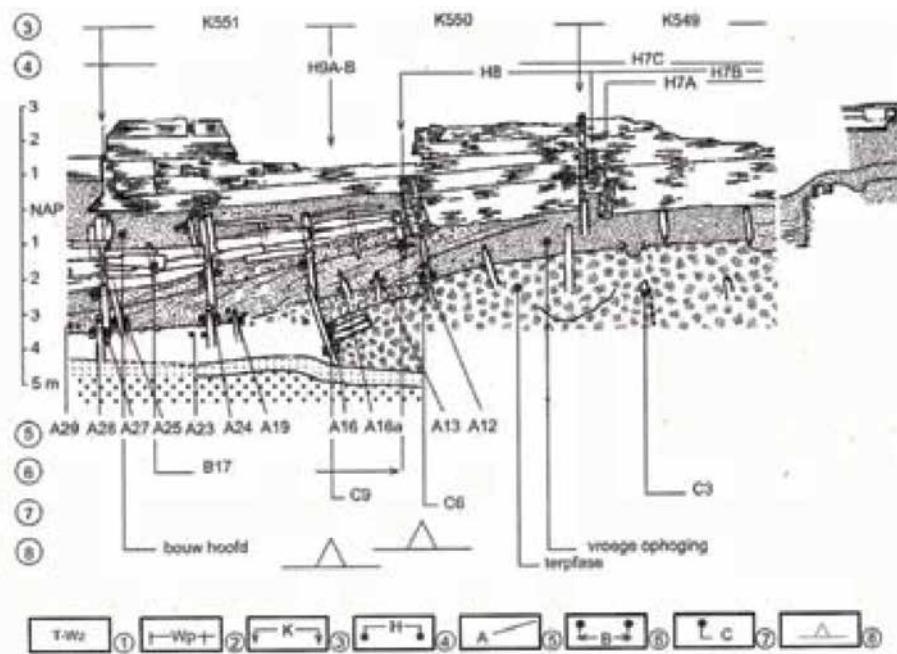


Figure 87

Dordrecht: archeological section of the underground in the flood plain (harbour area) with different phases of raising the site (Bax et al, 2008)



Figure 88

Mainz: harbour projection of Zollhafen and Industriehafen, 1856 (Stadtarchiv Mainz)

Because of their traditional position outside of the flood defence, today, these are one of the few exceptional sites where urban development is allowed in the flood plain in Germany. In the Netherlands, there is no longer a legislation that prohibits developments in the flood plain, but also in the Dutch context the flood plain is an exceptional development area where water-related activities are prioritized. In

Germany, the Hochwasserschutzgesetz (federal law on flood protection) 2005 generally prohibits new developments in the flood plain, though with certain exceptions, leaving a great amount of freedom to local decision makers (see Chapter 4.6 Exceptional Developments in the Flood Plain). As an urban typology, the exceptional site qualities of the meandering waterfront offers otherwise rarely available sites for dense inner city developments. The meandering of the harbour basin line increases the number of attractive waterfront locations and thus land value. Harbour conversion projects are driven by urban site development based on a local interest but are not actively part of a geographically specified larger scale flood management strategy , despite being affected by it. In Germany, however, the retention capacity of the river at the height of the project may not be reduced by new building developments (WHG § 78, 2010). Raising the area is per se only applicable in the downstream zone of a river. In the upstream zone of a river this concept will act as an obstruction causing water levels to rise during high river discharges. An exception can be made for areas that are already high but need to be elevated to comply with changing water levels due to climate change (Stone et al, 2008).

As a consequence to altered transshipment methods, which demand for a relocation of harbour activities, waste land is generated. It often needs containment measures to handle contaminated soils, and also restriction on uses/transformations of the harbour basin as a result of the contamination of the harbour bed, mainly due to paint residues from ships (Eberhardt, 2008). Yet, with a high urban development potential for the relevant city, the additional development costs for an appropriation of the site – including infrastructure, treating contamination, but also regarding flood adaptation – imply the construction of privileged dwellings and office spaces far from a mixed social structure. This is one of the two main critiques of these developments, the other being the lack of connectivity with adjoining parts of the city on the land side. The division between the former harbour sites and the adjoining city quarters on the land side can have different causes: the height difference between the areas, the defence line and also traffic infrastructures in parallel to the river that separate the adjoining cities from the harbours - as areas with previously restricted access. Yet, however well connected to the rest of the city on the land side, all harbour conversions do provide a continuous promenade and new public spaces along the water and tend to add cultural functions with restaurants and bars to create urban qualities on site. According to the Leipzig Charta on sustainable urban development, public spaces are a key to a sustainable urban development.

The sites do not need to be newly determined in order to add spatial capacities for the city, but instead appear as wasteland waiting to be developed. They are conversions of former industrial sites. Measures to give up these sites are initiated by transshipment institutions. In general, only then urban development in the flood plain and thus corresponding flood management strategies come into play as an increasingly necessary layer of development. The discussions in Basel for the Harbour

Kleinhueningen, initiated by Studio Basel and the municipality, represent an exception in this order of events along the Rhine. Here, the scarcity of inner city area available for essential housing development questions the use of such prominent sites for logistics activities. The conflict potential in combining the concurring programs on site, urban development and logistic-related harbour activities, is mainly based on noise emissions. The problem for transforming programs lies in ongoing long-term leases (Herzog et al, 2005). The Basel harbour conversion project Masterplan 3Land from 2011 is part of the IBA Basel 2020 with a design proposal by MVRDV.

### **Forms and Quantity of Appearance**

The acknowledgement of the former use as an industrial site for transshipment activities is kept present in all projects. A former crane, a storage building, some old cobble stone pavements, or tracks may serve as artefacts to convey this history. Collective identity is the key argument for this approach that is based on the preservation of singular elements (Koolhaas, Mau, 1998). What is not considered in the plans is the original river morphology on site, for example the pre-existent side channel. While the industrial past remains present, the severe transformations of the morphology during this era have erased any links to its original transformative landscape.

Logistics harbours are still on the rise. Today, water levels are reaching seasonal extreme lows during dry periods in the summer and high water levels in the winter months, thus bringing shipping activities to a halt during these phases. However, the further expansion of logistic harbours continues although their viability could be considered uncertain. Often supported by state funding and local politics that doubt climate predictions(extremely low water tables) and believe in potential economic growth (Bernau, 2009). Nevertheless, both navigation and urban development can only sustain a certain range of fluctuation in water levels and duration.

### **Global Relation To The River Basin / Flood Management**

Harbour conversions do not play a proactive role in the mitigation of high water levels. Instead, they demand for defensive measures on the object scale on site and often make up part of the city's defence line. They do not evolve as part of larger flood-alleviating measures, but as a local reaction to global changes in transport logistics. In the case of the Zollhafen project in Mainz, situated along the Upper Rhine, water levels and consequently safety levels are dependent on the Upper Rhine retention polders, which are still in the course of being installed in Germany, as opposed to France where they were already realized in the 1990s (see polders Moder and Erstein in atlas of retention polders). The design water level of 1/200 (86.53 meters) that is applied today, refers to the normative levels when the retention polders along the Upper Rhine are completed (Schernikau, 2012).

## **Paradigm Regarding Development**

Paradigms have changed with regard to flood and water management. In the Rheinhafen in Duisburg, one of the early harbour conversion projects (Foster Architects and Planners, 1992), water levels in the inner harbour basin were deliberately designed to remain constantly high to minimize the distance to the river front level. In the Rheinauhafen in Cologne, the defence line in corten steel became a central design element, contributing to flood risk awareness for the site. In the Zollhafen project, designated building plots should include water storage capacities not only to make buildings more flood resilient, but also to contribute to flood risk awareness by deliberately including the dynamics of water levels in the design itself. The Stadtwerke Mainz AG as the owner of the site in partnership with the Ministry for Ecology of the State Rheinland-Pfalz are working together with the aim of meeting the retention capacity as it was in the spatial constellation of the site as a harbour, and of developing a series of new prototypes for flood resilient building and landscaping. Their approach to flood resilient urban development is based on five guiding principles: 1. People have historically always settled by the water; this should also be possible in the future. 2. Absolute protection against floods is not feasible; flood risk management is therefore necessary for all possible scenarios. 3. Where technical protection is not possible or acceptable, inundation must be allowed. Living must be flood-adapted, even behind dikes and walls. For new plans and buildings, construction must be stable and resistant and the use must be adapted to the highest possible water levels (extreme flood) 4. Forecasting and precautionary behaviour must be developed optimally; this also applies for the existing building stock. 5. Flooding must be calculated: within long-term concepts, refurbishments must be flood-adapted. To implement these principles, the state of Rheinland-Pfalz has established a municipal "Information and Consultation Centre for Flood Precaution" and a "Competence Centre for Flood Management and Precautionary Building" in cooperation with the Technical University of Kaiserslautern (Theis, 2010).

As part of the EU-Interreg IVb North West Europe project Flood ResilienCity (2008-2013), Mainz Zollhafen is also involved in a theme-based partnership with related partner city projects in Brussels, Dublin, Paris, Orléans, Sheffield, Leuven and Nijmegen (see 9.4). The goal of the project is to "integrate the increasing demand for more houses and other buildings with the increasing need for more and better flood risk management measures in North West European cities along rivers." To achieve this goal, the themes of the project have been defined as awareness, avoidance, alleviation, adaptation, as well as strategy and capacity in order to engage in these four so-called A's. The exchange with the Northwest European partners aims to overcome "preconceived local and national solutions, stemming from historic needs and traditional approaches to managing these problems." Arguing that "the time has come to develop and implement plans for flood flows exceeding 'defences', with higher surface flows and urban area inundation," spatial solutions seek adaptive solutions that set up an urban spatial plan for infrastructural development as well as services and building regulations capable of withstanding the impact of possible future floods

([www.floodresiliency.eu](http://www.floodresiliency.eu)). In terms of non-spatial measures according to the EU Flood Directive (not part of this research), the city of Mainz is establishing a flood risk management plan on the scale of the entire city to deal with the obligatory issues of risk management such as information systems, evacuation and insurance.

Paradigms differ between urban and industrial site developments in the redevelopment of the Zoll- and Industriehafen. For the relocation and expansion of the logistics harbour upriver from its former site at Zollhafen, retention neutrality is not solved on site, but balanced by financing part of a retention polder along the Upper Rhine (Geiss, 2012). The new container terminal is actually built thirty meters into the river bed (Rohleder, 2010) - an obstruction to the discharge capacity of the river. Although the site is, as the name Ingelheimer Aue implies, in the physical flood plain, it is not located within the legally defined flood plain. This contrasts with the urban development of the Zollhafen, where the majority of the development is both physically and legally in the flood plain and demands that retention neutral development with corresponding water-retaining capacities be established on site. The opposite approach in the directly neighbouring projects also poses the question of how effective retention capacity on a site of this scale actually is. Perhaps the message conveyed by the Zollhafen as a sustainable inner city urban development should relate rather to the constructed density and centrality. It serves as a counter-model to further developments in the peri-urban context that not only produces a much higher degree of sealed ground for the development itself, but also for the required traffic infrastructure (see Chapter 3.4).

## § 7.2 I+I / Initiation and Installation

1860-1885	Channel rectification to improve the navigability of the river
1882	Raft harbour with 2.000 meters length and up to 150 m wide basins on site of the raised Ingelheimer Aue.
1880-1887	Construction of Zollhafen
1945	85% of Zoll- and Industriehafen destroyed
after 1945	Erection of Industriehafen
1973	Schnellumschlaganlage
1980s	Modern crane installations
1993	Site investigation for new cargo logistics centre suggests a relocation of harbour activities
2003	Decision by municipality on development of masterplan Zoll- and Industriehafen
2004	<b>Urban design workshop with four proposals</b>
2004	Preliminary plan approval of legally binding framework plan for the restructuring of Zoll- and Industriehafen with two subsequent plan approval procedures
2004-2005	Informal public hearing (Hafenforum I) followed by five cooperative planning workshops
2005	Municipal decision on framework plan and public plan presentation (Hafenforum II)
2006	<b>Flood partnership between State Environment Ministry and Stadtwerke Mainz AG to develop model project for flood adapted building</b>
2006	Start of infrastructure development plans
2007	Update of framework plan
2007-2013	<b>Interreg IVb Flood ResilienCity: Awareness, Avoidance, Assistance</b> Co-financing of flood related planning and engineering tasks <b>Co-financing deconstruction southern quay</b>
2008	Opening of the Kunsthalle at Zollhafen
2008	Early public participation (according to § 3 /1 BauGB)
2009/10	EU-wide tender for strategic partnership for the development and marketing
2010	Founding of Mainzer Hafen GmbH and Zollhafen GmbH+Co KG
2010	Development of Project Management Guide and Flood Risk Management Guide (preliminary versions)
2011-12	Deconstruction southern quay head and development southern quay
2012	Planned plan aproval Bebauungsplan (legally binding layout plan) and parallel update of zoning plan
2012-2025	Planned realization

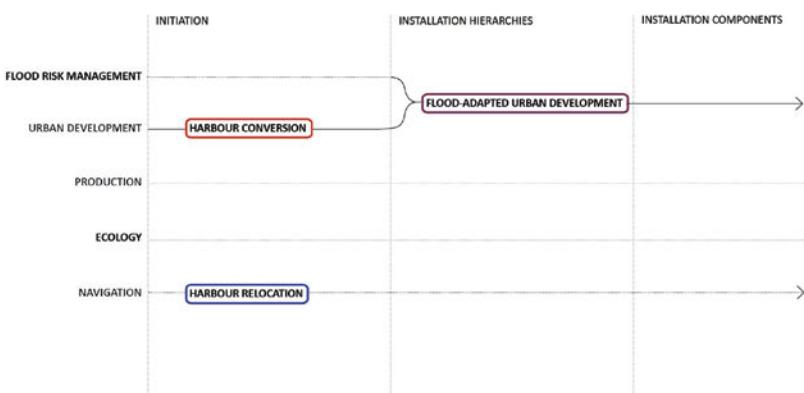


Figure 89  
Initiating program, installation hierarchies and components

## **Initiation**

Stadtwerke Mainz AG, Department for Water management (owner)  
Municipality of Mainz  
Ministry of the Environment Rheinland-Pfalz

## **Participating Disciplines / Agencies**

Stadtwerke Mainz AG  
Ministry for Environment  
City of Mainz partnership on flood adaptive development  
SGD Sued water authority to approve proposal  
Site development (Stadtwerke with Schüssler Plan engineers)  
Interreg IVb Flood ResilienCity project partners  
External experts (engineering, architecture, hydrology)  
CA Immo real estate development  
Project developers for individual sites

## **Installation**

A master plan for Zollhafen evolved from several planning workshops with urban designers and architects. The flood issue was developed iteratively in collaboration with the water managers and the Ministry for Environment. From the first framework plan in 2005, retention-neutral development was taken into account namely by redesigning the profile of the northern quay and developing the harbour islands (Geiss, 2012).

To inform developers on the additional conditions created by its position in the flood plain, the Stadtwerke are developing two handbooks. Prior to building activities, a manual on the additional requirements, but also of the possibilities for the development of the individual plots in terms of flood-adapted building in the context of Zollhafen is being developed. It serves as a medium to communicate the specific site parameters to project developers (Redeker, forthcoming). Furthermore, a guide to living and working in the Zollhafen – a manual on maintenance and behaviour before during and after floods – gives information on how to prepare and behave (Webler, forthcoming). This manual raises questions that can not be answered solely on the scale of the Zollhafen, but that demand an emergency plan on the scale of the city. This plan is being developed simultaneously.

The plan is being developed in three sections starting with the southern quay. All changes to the morphology of the site necessitate individual plan-approval procedures. The legally binding layout plan is currently underway. Hindrances for its stipulation are not flood-related issues, but noise emissions from the adjoining industries. The layout plan for the urban development also includes parameters for flood-adapted building. For example, all dwellings have to be 1.2 or 1.4 meters above the 1/100 year flood level. To obtain a building permit for the individual building plots being sold by the Stadtwerke Mainz AG, the municipal utilities company and owner of the

site, both a building permit as well a water legislation permit are mandatory (Redeker, forthcoming).

## § 7.3 Local And Regional Context

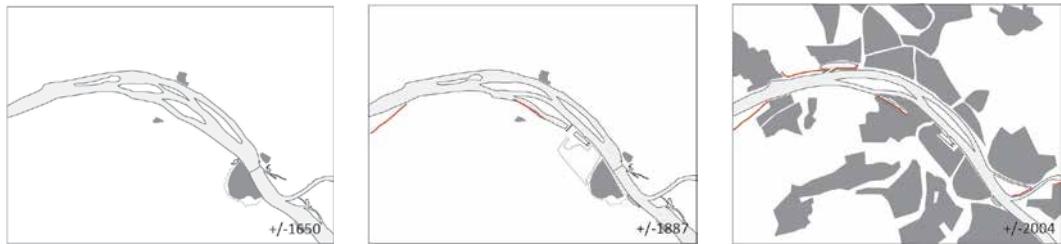


Figure 90  
Pre-Industrial / Industrial / Trans-Industrial Mainz (graphic by author)

To gain an understanding of the Zollhafen conversion project, this section analyses the political, topographical, regional and flood-related aspects of the project with a focus on the scale of the city and its regional context. Subsequently, it presents alternatives for the redevelopment of the Zollhafen for new urban development and of the adjoining Industriehafen for the cargo logistics centre (installation 2010) in light of their respective approaches to flood management and the implications on site and beyond.

### The Zollhafen In The Context of the City and the Region

As the maps of Mainz illustrate (fig. 91, 92), the political borders of the states and of the municipality run through the middle of the river. While flood impacts are considered on the scale of the river, measures themselves focus on the political borders of the state of Rheinland-Pfalz. They are executed by the SGD Süd, the regional approval institution under the authority of the Ministry for the Environment and on a municipal scale by the local water management agency. Although the political layers of the system are not the main focus of this research, it is important to understand the political borders as a major influential factor on project development as they often define the perspective. On a larger scale, the inner city location of this conversion project is part of the Rhine-Main region, one of the five main agglomerations along the Rhine, at a strategic position to the Frankfurt airport and exposition grounds, yet within the political borders of Mainz. Wiesbaden, the city across the river, is the capital of the state of Hessen. There are no urban development projects between Wiesbaden and Mainz. Solely the small enclave of Mainz on the opposite Rhine bank, the former

outpost of the fortified city, relates to the right bank. The bifurcating river typology with its islands and the political borders running through the middle of the river may both be considered a hindrance to a cross-river perspective. At the same time, the island condition could become the basis for a spatial design concept beyond the river.

Topographically, the Zollhafen site is located on a former side-arm of the bifurcating Northern Upper Rhine (see fig. 89). With a relatively high altitude, at an average height of about 86,20 meters +NN, the Zollhafen site was raised in the course of the river rectification in the 19th century. Also, the Industriehafen, the site of the relocation project, is part of that former side-arm of the river. It has already served transshipment purposes since Roman times (Stadtplanungsamt Mainz, 1997). It subsequently became reclaimed land in the course of channelling, only leaving the harbour basins as remnants. The convex water front with the very reduced curvature at the height of a side arm framing the remaining islands is characteristic for this part of the Upper Rhine after the tributary of the Main river.

As a development in the flood plain, the Zollhafen is part of the 1/200 defence line of the city of Mainz. In the course of this development, the defence level of the city is being raised from 1/100 (86.20 meters +NN at Zollhafen) to 1/200 (86.53 meters +NN). Large parts of the adjoining, densely developed, Hausmannian-inspired Neustadt, the 19th century urban expansion, as the Zollhafen designed by the city architect Eduard Kreysig, would be flooded in case of exceedance or breach of the defence line (see fig. 85 and fig. 90, 91 on the following pages).

### **Alternatives**

The harbour relocation/conversion project in Mainz was never considered beyond the scale of the sites of Zoll- and Industriehafen, as the spatial reorganisation of programs enabled the expansion of the logistics harbour to the adjoining site. The urban development of the Zollhafen has to be understood as a possibility generated by these relocation measures. The following text explains the alternative presented for the logistics expansion and, after its rejection, the evolution of the urban development within the different paradigms of flood management mentioned (XL). The layers of analysis will be landscape/water system, infrastructure, urban development and non-spatial parameters.

#### **Landfill - Expansion of Logistics Harbour on Site**

The first alternative considered at the beginning of the nineties involved filling in the northern part of the harbour basin to create additional ground for container storage and trans-shipment (Geiss, 2012). This would have implied a major transformation of the existing morphology of the site leading to reduced retention capacity and additional sealed surface. While, infrastructural adjustments would have been kept at a minimum, traffic-related conflicts and noise emissions would have remained an issue for the adjoining Neustadt. Urban development could not have taken place on

the Zollhafen site. The authorities would not have approved this solution, as it does not comply with federal law forbidding the reduction of existing retention capacities of rivers. Also, noise emission from the harbour posed a problem for the Neustadt.

### **Conversion / Relocation**

In 2003, the municipality agreed on the development of a masterplan for Zoll- and Industriehafen based on the relocation of the logistics harbour and the urban development of the former Zollhafen, which would define the different zones ([www.zollhafen.de](http://www.zollhafen.de)). A first version of the urban design for the Zollhafen, based on this masterplan, was developed in 2005. It already included a retention neutral concept. Based on economical and spatial parameters, the framework plan was adapted and approved in 2007. One of the streets perpendicular to the river received a new curvature to avoid B-side locations and, in terms of architecture, some sites were redesigned and densified (see fig. 92). All other flood-related issues, such as the definition of the defence line and the rise in emergency routes and height specifications for dwellings, were developed iteratively in collaboration with the water management agencies involved (Geiss, 2012).

### **Infrastructure**

The new infrastructural appropriation of the Zollhafen site involves street development, district heating, canalization, gas, electricity, media and water supply. Except for the streets, all infrastructure is raised or adapted to cope with a 1/200 year flood. The owner of the site, the Stadtwerke Mainz, the municipal utilities company is carrying out the site development. Conflicts may involve height differences between the lower lying city and the Zollhafen. This may apply for example to electricity (Geiss, 2012).

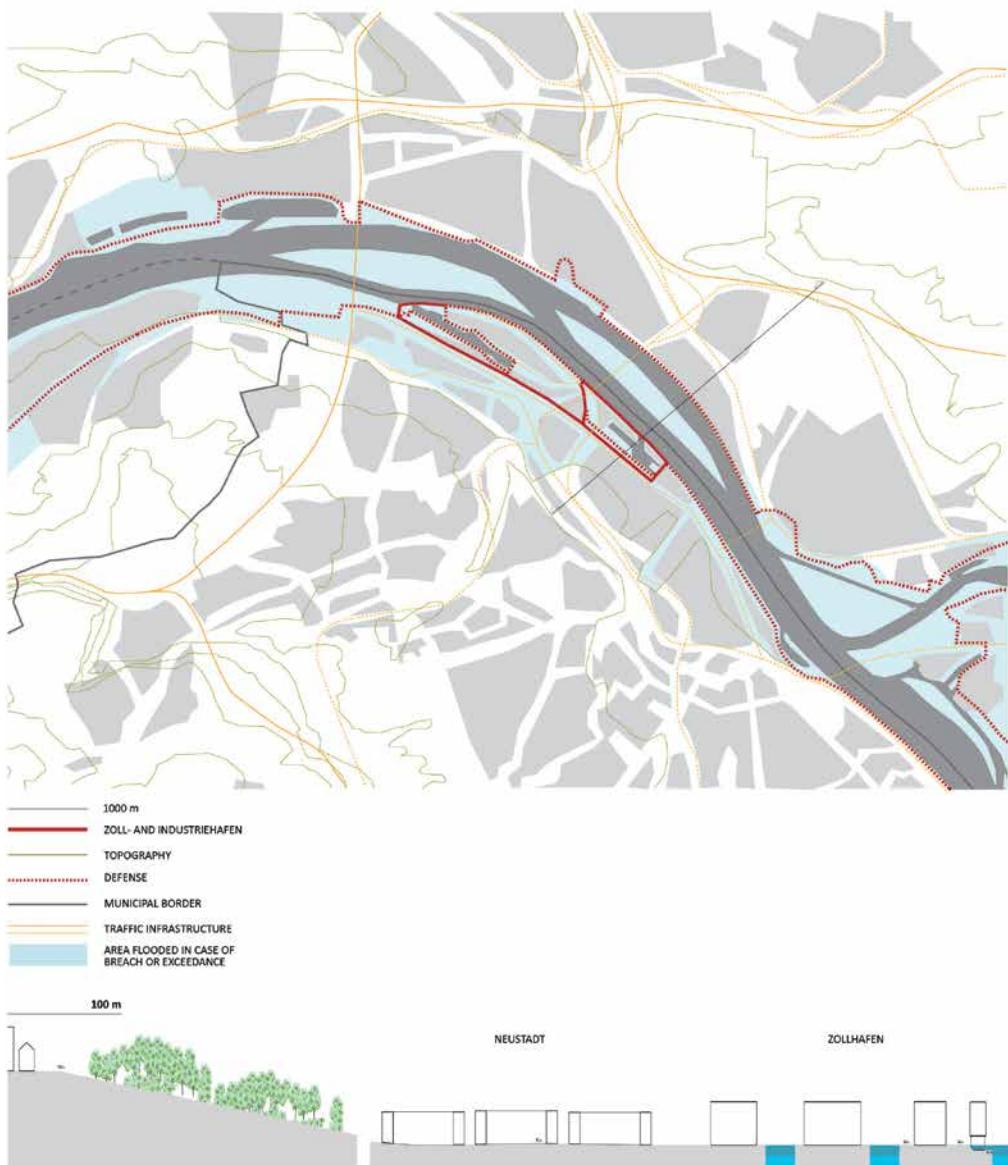


Figure 91

Zollhafen and Industriehafen in the context of the city (based on topographical map and master plan 2003)

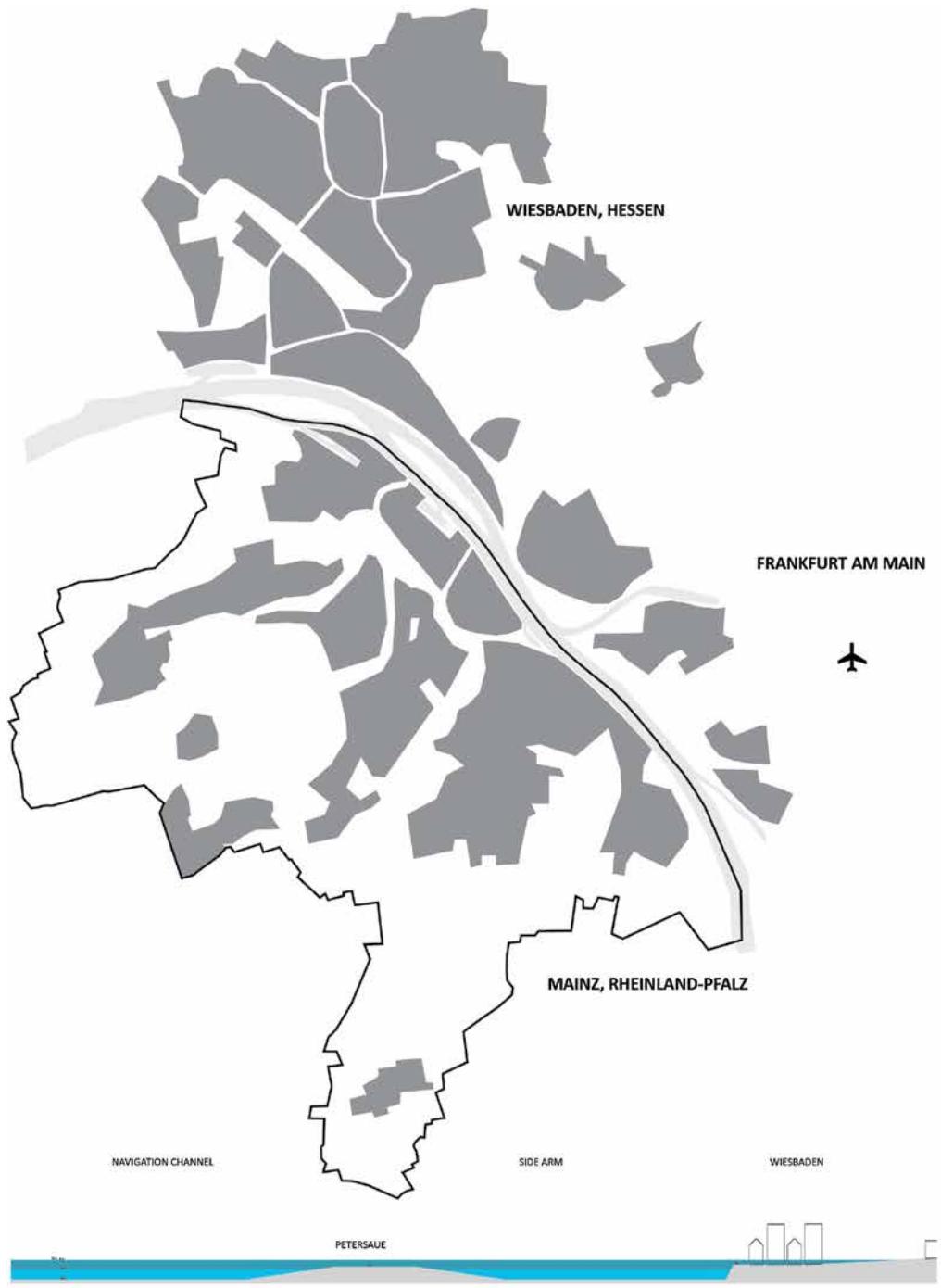


Figure 92

Rhine-Main Region (based on Google maps) and section with projected harbour conversion and 1/200 year flood (based on topographical map, Rhine Atlas, 2001 and sections Schüssler Plan).

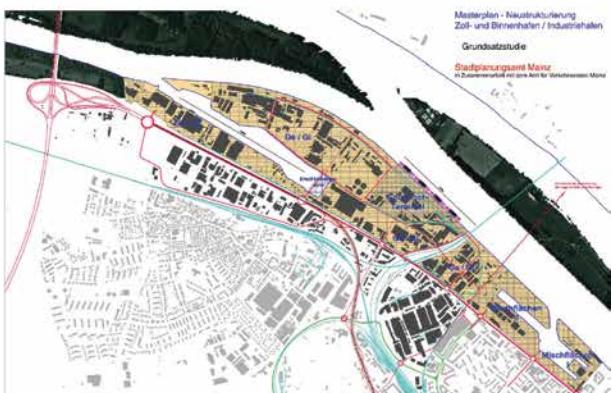


Figure 93

1. **Frameworkplan 2011** with flood defense and raised emergency routes (Schüssler Plan, 2011) 2. **Framework plan2007** adapted to improve economic capacity and to reduce noise emissions (Stadtplanungsamt Mainz) 3. **Framework plan 2005** Initial design: retention neutrality via development of harbour islands and green embankment on northern quay (Stadtplanungsamt Mainz) 4. **Masterplan 2003** Concept Study for harbour redevelopment of Zollhafen, Binnenhafen, Industriehafen (Stadtplanungsamt Mainz).

## § 7.4 S / The Project Scale

On the project scale, the Zollhafen as an inner city harbour conversion is an adapted urban development in the flood plain and part of the urban flood defence line. The following text explores the spatial and temporal organisation and the infrastructural support this demands.

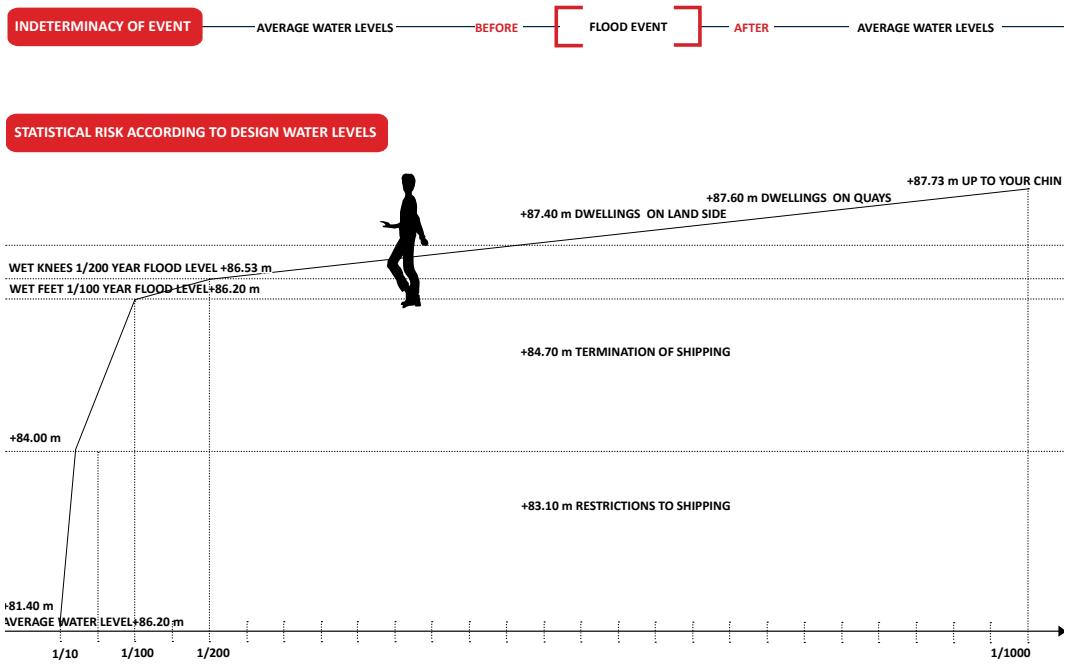
### Model Project For Flood-Adapted Building

#### Urban Development

The new urban development is comparable to other harbour conversions with a programmatic mix of commercial spaces, dwellings and prominent public spaces along the water. On the 13 hectares available for building development (see fig. 93), the average floor space index is 2.8, the total floor area 355,000 m<sup>2</sup>, equally distributed between commercial use and housing ([www.zollhafen-mainz.de](http://www.zollhafen-mainz.de)).

#### Water Storage on Site

Based on the framework plan (Rahmenplan) of 2007 and as part of the Interreg IVb project Flood ResilienCity, sites were defined as model projects for flood-adapted buildings. For selected building plots, a degree of water will be stored on site. The volume of approximately 20-40% of the water between the 1/100 and the 1/200 flood must be accommodated within the building plot perimeters. This is not necessary to achieve retention neutrality for the Zollhafen area. The designated plots aim to serve as sites for the development of new building typologies, capable of being partially flooded. Although in the case of certain buildings, flooding to avoid buoyancy could be considered, this idea conveys a less technical approach. By storing water within the plot as an architectural element, wet-proof construction reduces the damage potential of the building. Only one building, today the site of the Rhenushalle 11, is located on the lower embankment and directly affected by currents. This building therefore has to be constructed in a way that can withstand currents and objects and does not influence discharge capacity negatively. Possible collisions with ships during floods are not a threat since shipping is terminated before water levels are high enough to allow for them to actually reach the site (DIN EN 1991-1-7).



**Figure 94**  
Flood frequencies (graphic by authour) and project site (Stadtwerke Mainz AG).

### **Raised Dwellings and Flood Protection on the Building Scale**

Beyond the water storage capacity, defensive elements are integrated to protect the buildings in the flood plain from flooding uncontrollably. As an additional safety measure, depending on their location, dwellings are only permitted at a level of 1.2 and 1.4 meters above the 1/100 year flood level (see fig. 94). Architecturally, this offers a synergetic solution in terms of producing the privacy desired in a highly frequented public sphere. For the ground floor, solutions remain a challenging design task, as adjoining street levels vary and split levels always imply a more complex flooding situation.

### **Municipal Defence Line**

The 1/200 year flood defence line of Mainz runs along the southwestern border of the Zollhafen site. While sections of the defense line are accommodated in the street development or integrated in the building plots, a mobile system provides for small parts. This implies that defensive elements must be integrated on site and need to connect with the parts of the defence line under municipal authority. Specifically in terms of mobile elements, pre-defined arrangements about maintenance and operation responsibilities are necessary.

### **Emergency Routes**

The Zollhafen is laid out in a way that enables inhabitants to stay up to a minimum of a 1/200 year flood. The foreseen dwelling heights in combination with emergency routes that are accessible up to a 1/200 year flood aim to make the Zollhafen flood safe for dwellers (Redeker, forthcoming). Emergency routes are therefore not called evacuation routes since their primary function is to supply inhabitants with goods in case of a flood, or to reach the buildings in case of an emergency such as a fire. It is one of the key measures that enables inhabitants to stay in their homes during a flood event. The infrastructural supply that is often linked to municipal networks that might not accommodate a 1/200 year flood proves to be challenging in this context. This specifically applies to electricity, but also to back-water levels.

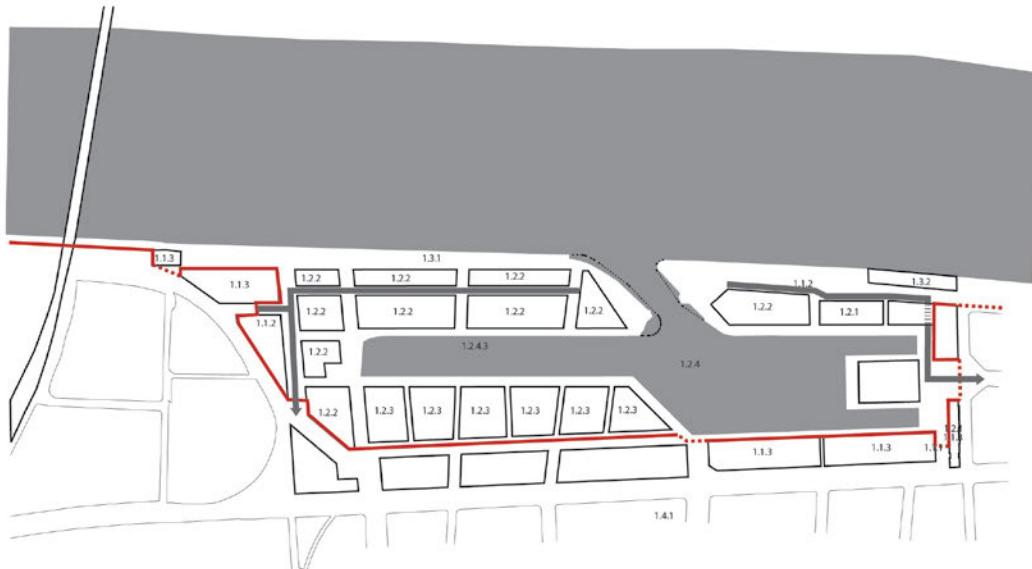
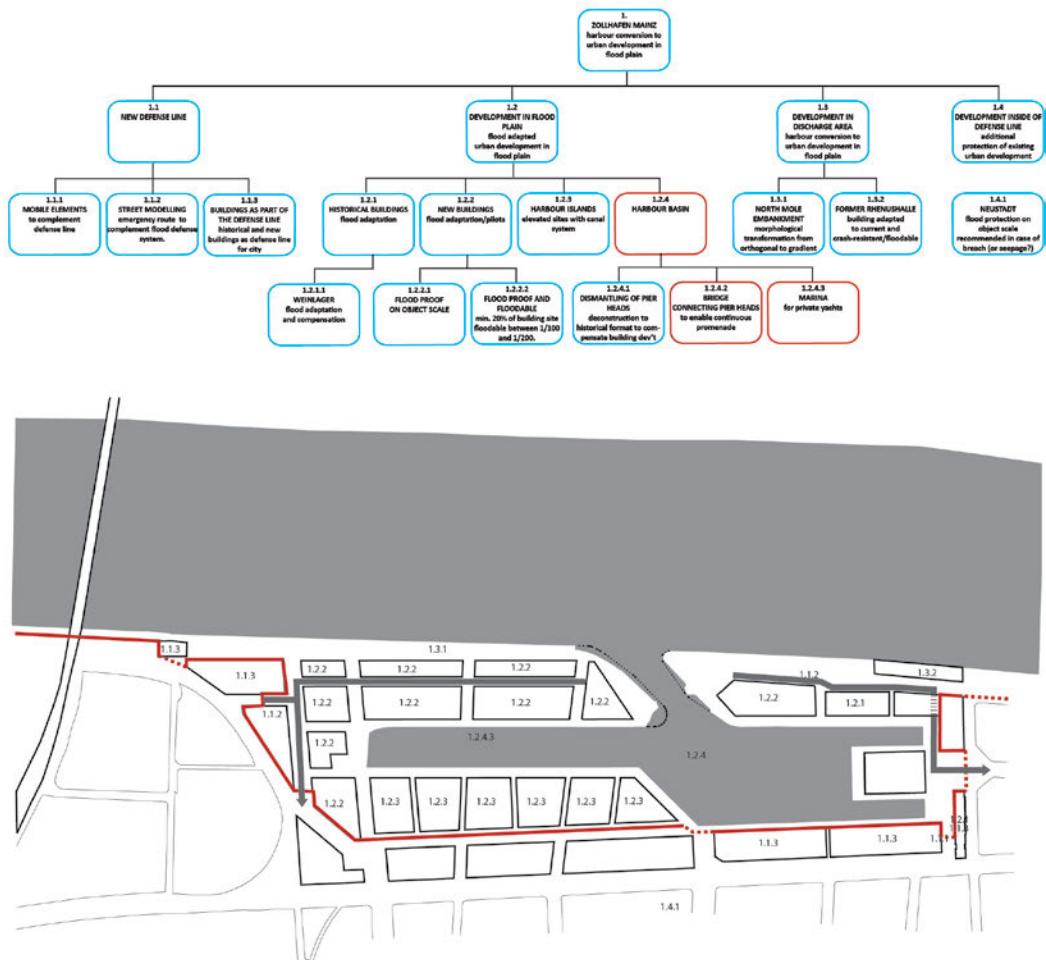
### **Landscaping**

The project evolves from urban and infrastructural layers focussing on the object scale (see fig. 94). The morphology of the site and the river at the height of the project play a limited role for the Zollhafen development. While parts of the embankment are remodelled in order to attain the required retention balance, and since design water levels are affected by Upper Rhine mitigation measures, the overall geometry of the harbour remains unchanged. The project only calculates for the degree of compensation on site. The roads and open spaces compensate development fully. The required retention volume is calculated volumetrically. The retention capacity is calculated as the volume defined vertically by the existing harbour morphology and the 1/100 year flood line and horizontally by the border to the river during average water levels and the boundary of the site defined by the existing fence. Only minor

adjustments to the morphology are being made. In the first stage a new modelling of the streets and open spaces to adhere to required retention capacity on site. The 2005 plan created additional retention capacity by planning a deconstruction of the quay heads and by creating a gradual slope for the embankment of the northern quay (Geiss, 2012). To ensure a safe evacuation up to a flood of 1/200 on the longitudinal streets of the quays, a decision was made to raise the streets. The flood model further informed the design of the emergency streets as it showed the generation of currents in the streets orthogonal to the emergency routes during flooding from the harbour basin (Sydroconsult, 2009).

### **Non-Spatial Measures**

Including such adaptation measures from the beginning reduces extra costs for flood-adapted development to a minimum. Individual sites will be sold off to project developers. The development costs of the site as a whole are expected to return through the sell-off of the individual plots. (Geiss, 2009). Arrangements between project developers or future owners of the buildings are necessary to ensure the installation of defensive elements, evacuation exercises and general maintenance of integrated flood-protective elements (Webler, forthcoming).



#### UPDATE!

- 1.1.1 mobile elements
- 1.1.2 street modeling / evacuation route
- 1.1.3 buildings as part of defense line
- 1.2.1 historical buildings
- 1.2.2 flood adapted building / storage capacity on site
- 1.2.3 harbour islands
- 1.2.4 harbour basin
- 1.3.1 northern quay embankment
- 1.3.2 building in the discharge area / storage capacity on site
- 1.3.3 deconstruction of quay heads
- 1.4.1 Neustadt

- |  |
|--|
| <span style="color: blue;">□</span> LANDSCAPE / WATER MANAGEMENT SYSTEM<br><span style="color: grey;">□</span> INFRASTRUCTURE<br><span style="color: orange;">□</span> URBAN DEVELOPMENT |
|--|

Figure 95

Elements of harbour conversion (based on Frameworkplan 2011).

## § 7.5 E / Extract

**XL / TYPOLOGY** Harbour conversion sites are traditionally positioned in the flood plain outside of the flood defence. As they have been raised, they are generally less at risk from floods than the area behind the defence. Expanding on the 19th-century river front promenade, the conversion from an industrial program to inner city dwellings and commercial spaces produces new public domains on previously non-accessible sites.

**GLOBAL RELATION TO RIVER BASIN** Due to changing demands to accommodate container logistics, harbour conversions are appearing all along the navigable Rhine. They are generally not linked to larger-scale programs. In the case of Mainz, the completion of mitigation measures along the Upper Rhine may influence design water levels formally, but have no relevant effect on the development. PARADIGM As exceptional developments in the flood plain, "living with water" has evolved as a design strategy for these sites with the goal of developing flood-resilient urban typologies. As medium- to high-density inner city developments, they adhere to a compact European city model. In the case of Mainz, we can find opposing paradigms of the retention-neutral development of the Zollhafen as a new urban quarter and the Industriehafen as an industrial site where financing mitigation measures along the Upper Rhine must compensate for the added volumetric development (Geiß, 2012). This illustrates the current programmatic limitations of retention neutral development.

**I+I / INITIATION** The project is initiated on a local scale. A flood partnership between Stadtwerke Mainz, the municipal utilities company that owns the harbour, and the Federal Ministry for the Environment creates this model project for flood-adapted building, as does the involvement in the FloodResilienCity Interreg IVb program.

**INSTALLATION** The project scope is limited to the scale of the Zoll- and Industriehafen. On the Zollhafen site, this involves flood-adapted design, infrastructural development and the sell-off of the individual building plots. Since it is completely redeveloped, flood-adaptation proves to be less challenging in obtaining a building permit than, for example, existing noise emissions, which are too high for the residential program. Although some flood-related issues related to the municipal scale are also relevant for the EU Flood Directive, the Zollhafen development is not embedded in any strategic, larger-scale urban development programs on a local or regional scale.

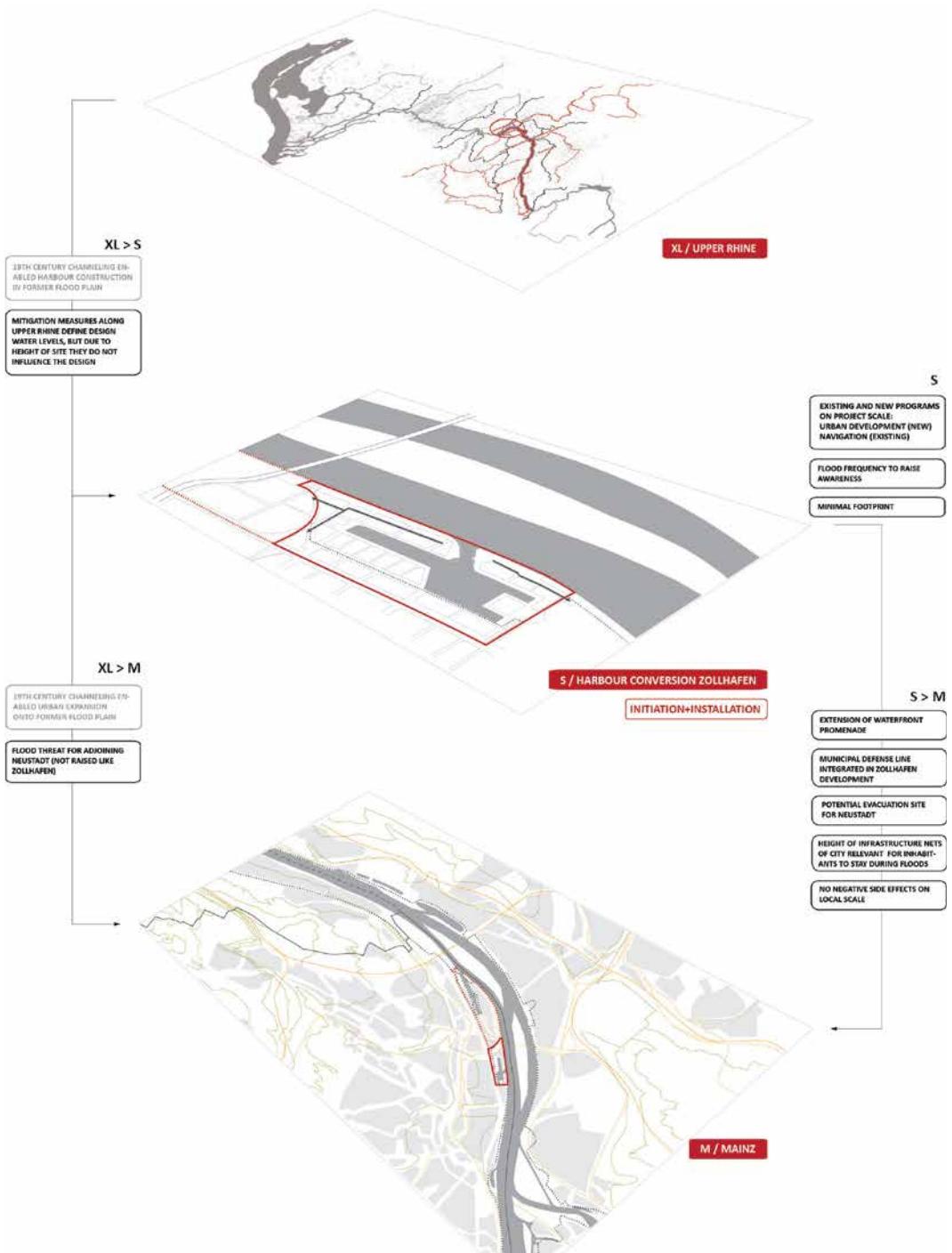


Figure 96

Extract diagram showing interdependencies between river-, project- and local scale.

**SMALL / PROJECT SCALE** Combining morphological transformations and adaptations on the object scale, the Zollhafen is designed as a retention-neutral development with safe havens to enable inhabitants to stay during floods. Special building typologies as part of the municipal defence line or buildings in the flood-plain and therefore wet-proof align raised emergency routes. They are combined with an open space design that aims to convey dynamics in water levels to raise the awareness of otherwise rare flood events. **RESPONSIBILITIES** As a result of this combined strategy, operative responsibilities must be negotiated/defined.

**MEDIUM / LOCAL AND REGIONAL CONTEXT** The Zoll- and Industriehafen development is a linear expansion. It produces new public spaces along the water by expanding the waterfront promenade of the historical city into a former no-go area while extending harbour functions upriver and into the flood plain. **FLOOD RISK** More flood-endangered than the Zollhafen is the area behind the defence because it was not raised during the urban extension in the 19th century. **MISSING LINKS** There are no links to the opposite river bank for many reasons: Mainz is traditionally a left-bank city, the municipal and state border runs through the middle of the river, there is a bifurcating river typology.

**LEARNING FROM... SPATIAL DESIGN** In contrast to mitigation measures, flood adaptation projects have no negative side effects for the adjoining areas. Instead, the flood protection level in Mainz has risen to a 1/200 year level in the course of developments. **STRATEGIC DESIGN** As an urban typology, harbour conversions adhere to a compact European city model. This is specifically relevant as expansions into the periphery increase run-off and may become a hindrance to future areas needed for emergency flooding. In this context, flood-adapted inner city developments may become strategically relevant for future mitigation strategies.

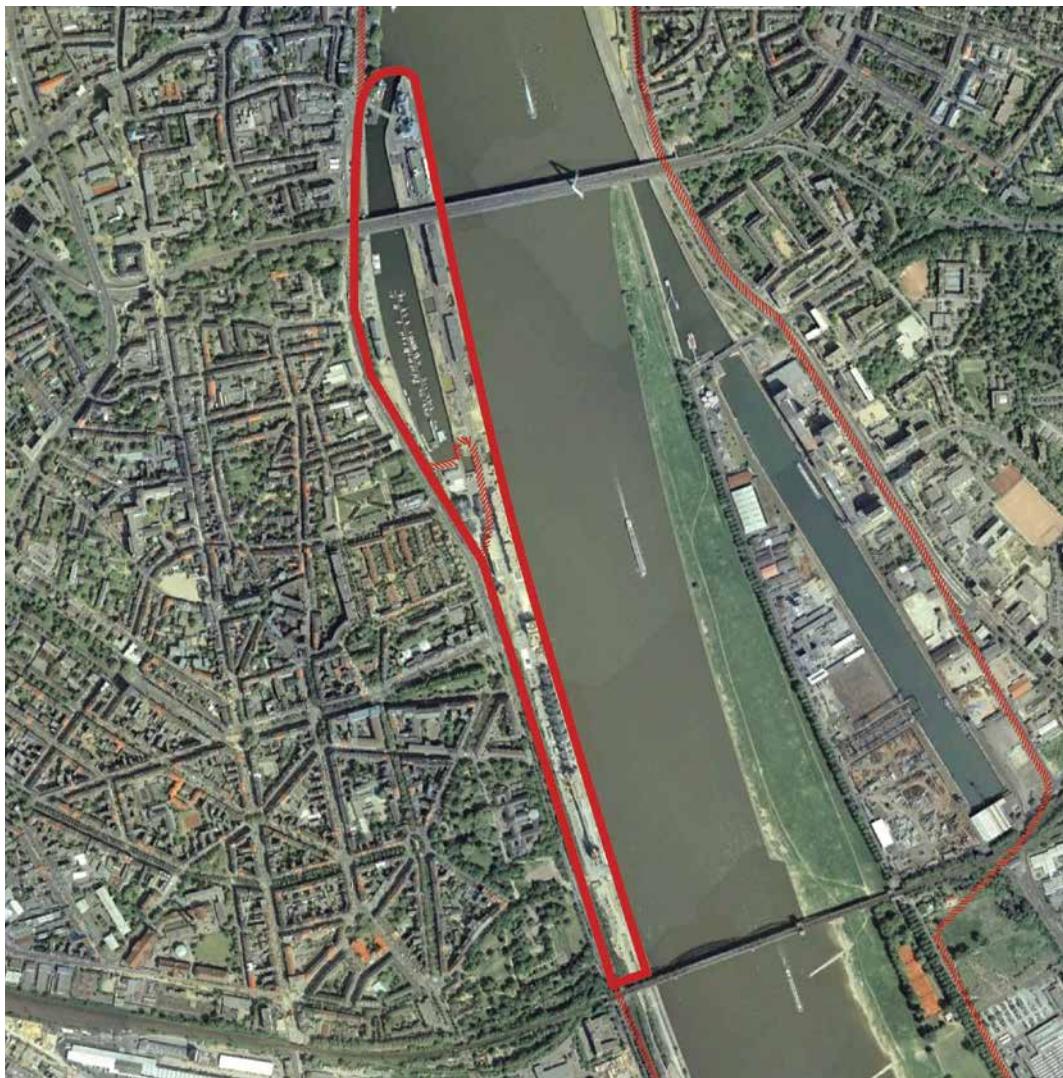


Figure 97

Koeln Rheinauhafen / Rhine km 685.9-687.5

Program: conversion of harbour/industrial site to dwellings, work spaces, and cultural facilities /  
Morphological transformation: none / Scale: 15.4 hectares / Flood risk: large parts of development outside flood defense, large parts flooded at 11.30 Cologne gauge (1/100), buildings protected up until a 1/100 year flood event, temporarily raised pedestrian routes in case of flood / Period: 1992-201 / ([www.rheinauhafen-koeln.de](http://www.rheinauhafen-koeln.de), telephone interview HKC, Mr. Fuchs March 8, 2012)

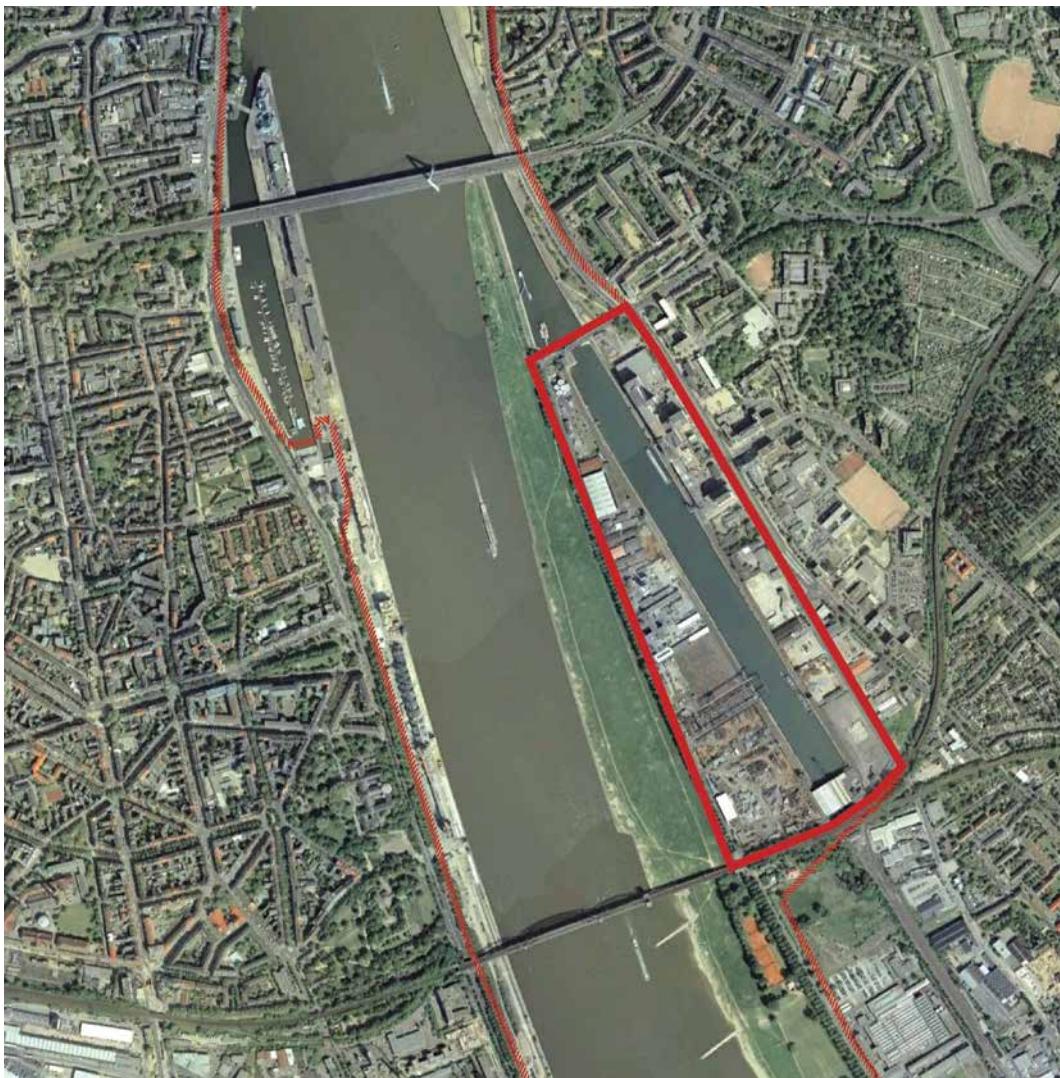


Figure 98  
Koeln Deutzer Hafen / Rhine km 685.5-686.90.8

Program: conversion of harbour/industrial site to dwellings and / or work spaces / Morphological transformation: not planned as of yet / Scale: 35 hectares / Flood risk: large parts of development outside of flood defense, large parts flooded at 11.30 Cologne gauge / Period: feasibility study 2008, (development long-term perspective for the city, problematic: existing leases until 2023 of businesses reliant on water access) / ([www.hw-karten.de](http://www.hw-karten.de); Stadt Köln, Standortuntersuchung Deutzer Hafen, 2008)

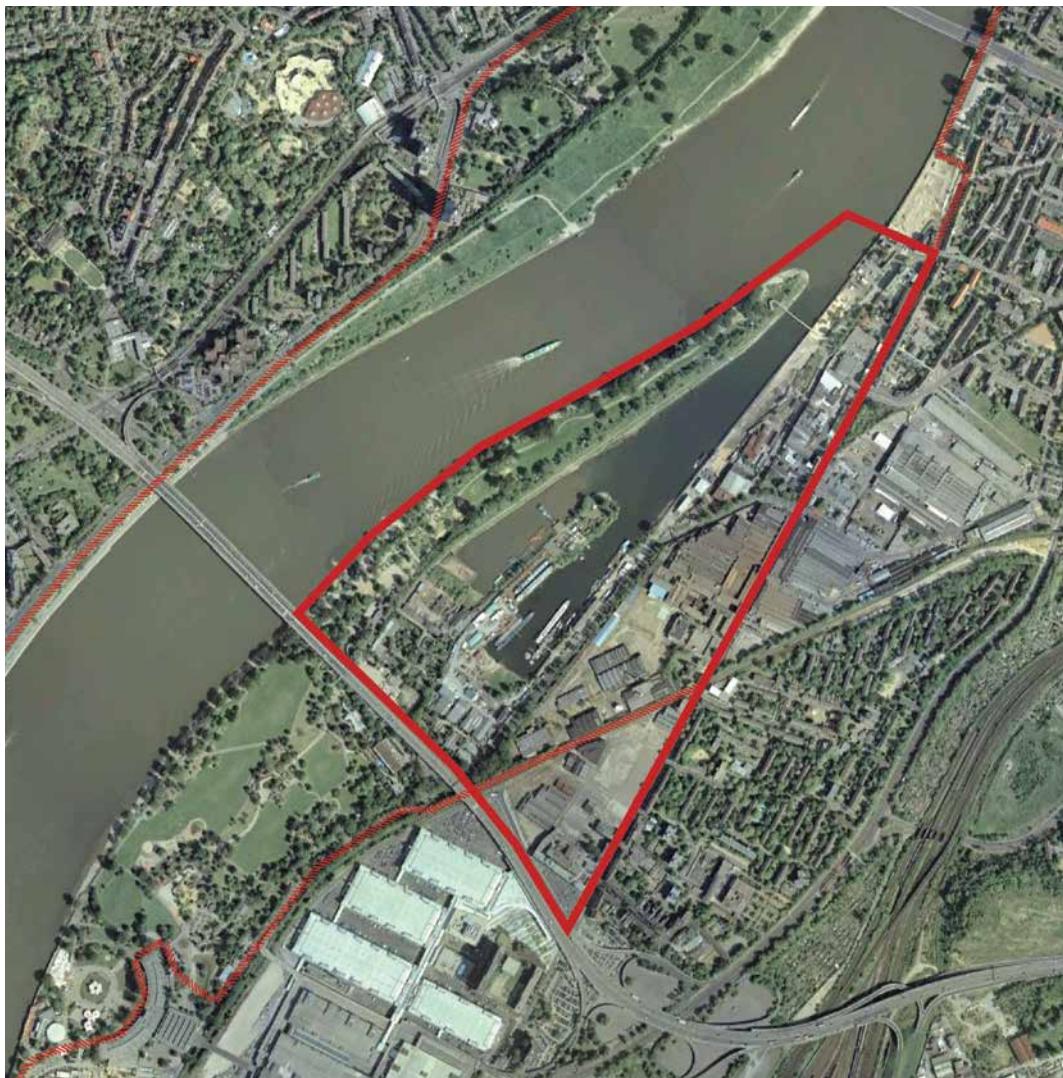


Figure 99  
Koeln Muelheimer Hafen / Rhine km 690.2-691.7.

Program: conversion of harbour/industrial site to dwellings, work spaces and recreation /  
Morphological transformation: not planned as of yet / Scale: 41.5 hectares / Flood risk: large parts of site are outside of the flood defense, large parts flooded at 11.30 Cologne gauge, the area is flooded at 9.50 meters Cologne Gauge / Period: since 1992 (first competition, 1. prize O.M. Ungers)  
(Masterplan Köln, AS+P, 2009, Rechtsrheinisches Entwicklungskonzept Teilraum Nord, 2009)

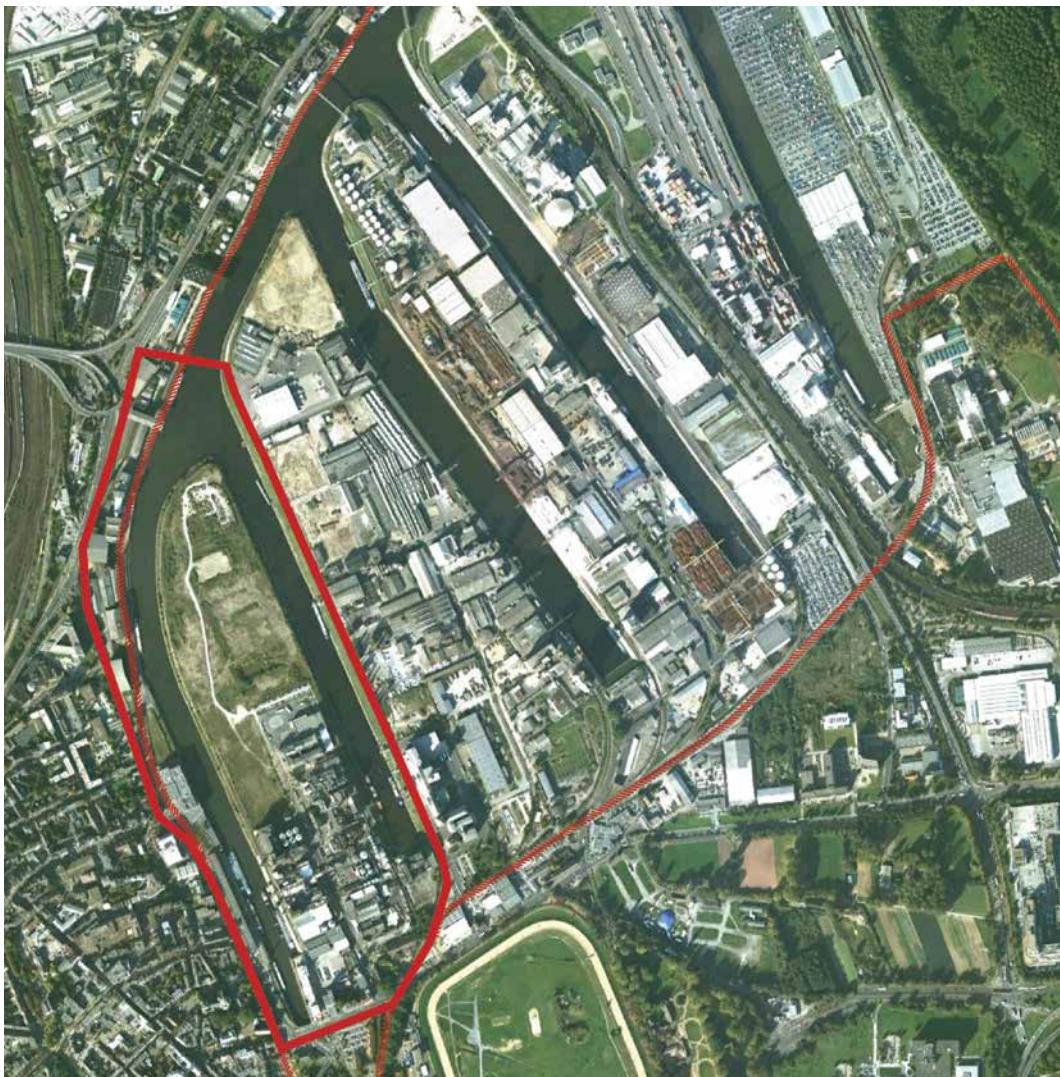


Figure 100

Neusser Hafen Basin 1 / Rhine km 738-739

Program: conversion of harbour/industrial site to dwellings, work spaces and new park /  
Morphological transformation: n.i. / Scale: 20 hectares / Flood risk: development in flood plain /  
Period: competition 2005 / (opposition by harbour company as they fear lacking capacity to expand in future) / ([www.duesseldorf.de/medienhafen/geschichte/index.shtml](http://www.duesseldorf.de/medienhafen/geschichte/index.shtml))



Figure 101  
Duesseldorf Medienhafen / Rhine km 742-743.7

Program: conversion of harbour/industrial site to dwellings and work spaces / Morphological transformation: none / Scale: 30 hectares / Flood risk: development in flood plain, flood protection measures only since 2006, reinforced concrete wall on dike / Period: feasibility study 1974 that proposed to combine the harbour functions with other programs, 1985 beginning of urban development / ([www.duesseldorf.de/medienhafen/geschichte/index.shtml](http://www.duesseldorf.de/medienhafen/geschichte/index.shtml); [www.duesseldorf.de/wasserbau/hochwasserschutz/ausbau/08hafen.shtml](http://www.duesseldorf.de/wasserbau/hochwasserschutz/ausbau/08hafen.shtml))

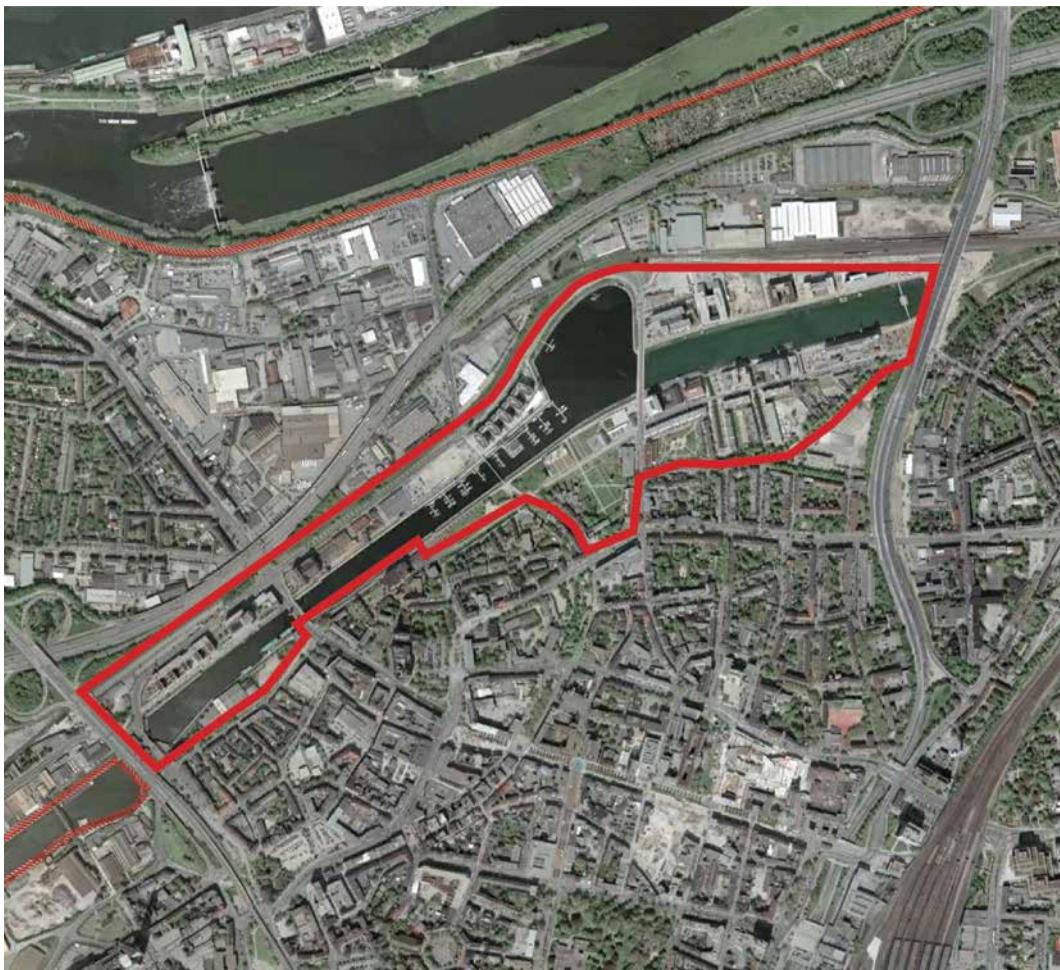


Figure 102  
Duisburg Medienhafen / Rhine km 778-779

Program: conversion of harbour/industrial site to dwellings and work spaces / Morphological transformation: canal system orthogonally to the basin and constantly high water levels in final basin to produce spatial quality / Scale: 89 hectares / Flood risk: harbour shut off by flood gate installed in 1908 / Period: 1991 (competition masterplan)-2003 / ([www.innenhafen-portal.de/standort/html/rundgang.html](http://www.innenhafen-portal.de/standort/html/rundgang.html))

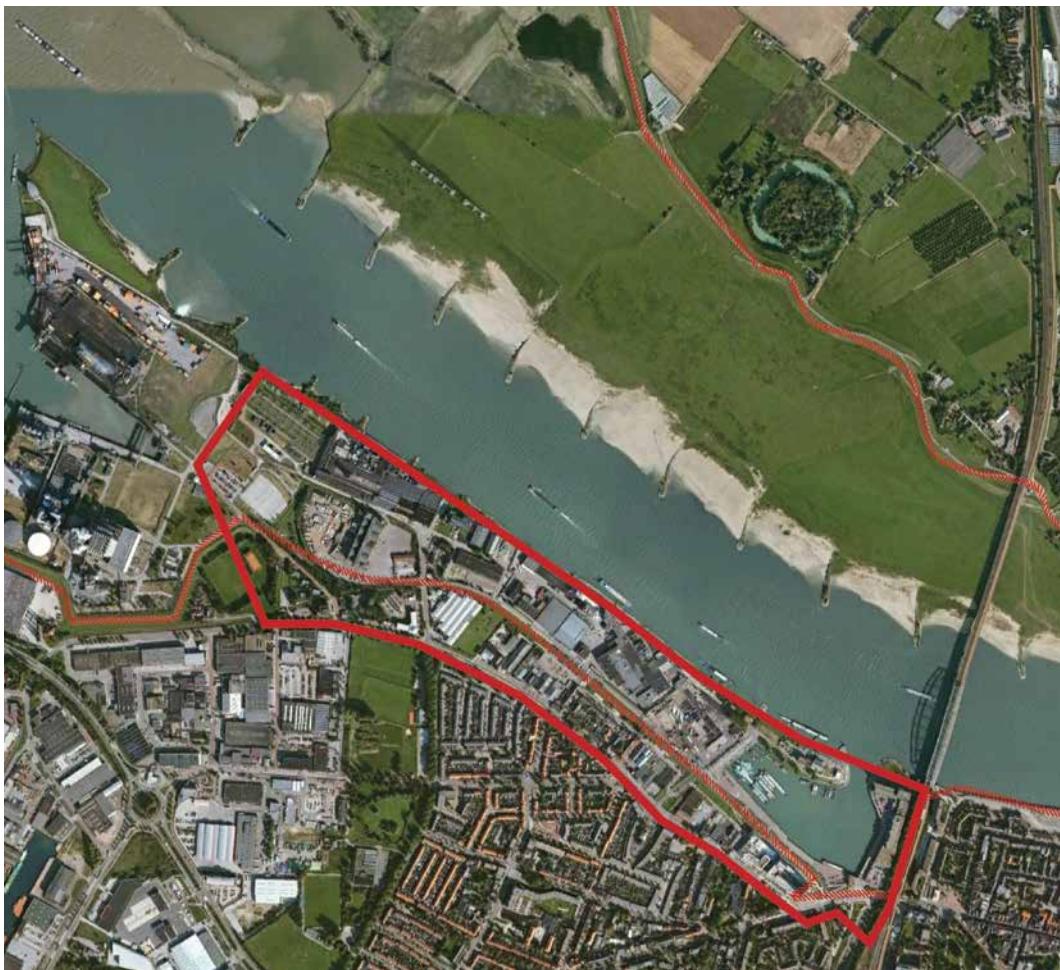


Figure 103

Nijmegen Waalfront / Waal / Rhine km 883.5-884.5

Program: conversion of harbour/industrial site to dwellings and work spaces / Morphological transformation: enhancing historical development to allow dynamics of water to become part of design strategy / Scale: 43 hectares / Flood risk: large parts of the development outside of dike / Period: masterplan stipulated 2003, realization since 2007 / ([www.waalfrontnijmegen.nl/hetplan.php](http://www.waalfrontnijmegen.nl/hetplan.php))



Figure 104

Dordrecht Stadswerven / Lower Merwede / Rhine km 975

Program: conversion of harbour/industrial site to dwellings / Morphological transformation: partial raise of area / Scale: 70 hectares including water surfaces / Flood risk: development outside of flood defense / Period: 2004-2024 / ([http://geo.zuid-holland.nl/geo-loket/kaart\\_overstromingsrisico.html](http://geo.zuid-holland.nl/geo-loket/kaart_overstromingsrisico.html)) / Urban Flood Management Project (Leven Met Water))

# 8 Dordrecht

## § 8.1 Global Relation To The River Basin / Flood Management

### Intro Rhine-Meuse Delta

On a systems scale, the Drechtsteden and the Rijnmond region, along with the Rivers and the Southwestern Delta, are part of the Rhine-Meuse Delta. Different solutions to cope with an increasing flood risk are currently under consideration for the Rhine-Meuse Delta system. The main interdependencies between flood risk and fresh water supply as well as the inherent economic and ecological implications are summarized below, based on preliminary results from the Problem analysis Rhine-Meuse Delta, 2011 at its concept stage.

Raising barriers between the sea and the river will influence not only the Rotterdam and Dordrecht (dike heights and water levels) but also the area further upriver. At the same time, redistributing the discharge over the main rivers will greatly influence the areas downriver (Pelt et al, 2011). The regional water system of the Rhine-Maas Delta is linked with the main water system of the Delta. Therefore, local and regional development may influence decisions on the aforementioned systems scale and conversely, different development scenarios on a systems scale must be anticipated in order to enable a sustainable development locally. As urban development projects outside of the dikes are considered relevant on a national scale (Pelt et al, 2011), the Stadswerven project is nested within a larger system - more so than comparable urban conversion projects in the outer dike area upriver (see Chapter 7 Mainz).

Further Room for the River measures and dike reinforcements may mitigate risks. Yet, the current approach has its limitations: the slack underground and existing buildings on site challenge dike reinforcements while the possibilities of water storage and river widening are often limited because of physical hindrances and existing settlements. Further options involve the large-scale measures already described in the Chapter Flood Risk Management, such as redirecting water differently through the rivers and making new rivers and green rivers with extra discharge to the IJsselmeer. At the same time, in terms of river discharge, the Rhine-Maas Delta is linked not only to the Dutch Rhine branches, but also to Belgium and Germany (Pelt et al, 2011).

In the case of Dordrecht, its location in the transition zone between the sea- and the river-dominated delta implies an exposure to the changing discharge of the Rhine

and the Maas as well as tidal influences from the North Sea via the Maas aperture. On a day-to-day basis, water levels vary on average by 70 cm as a result of tidal influences. Extreme floods can occur when river and sea water rise simultaneously. Flood risk is thus defined by expected river and sea water levels. The risk is further influenced by winds and the performance and operability of the Maeslant- and Hartel and the Haringvliet locks (Stone, Beckers and Penailillo, 2008). The functioning of the Maeslantkering is crucial for the protection of the western part of the Netherlands during storms on the North Sea. River-widening measures at this height of the river would not influence water levels, yet high water levels at Dordrecht are further influenced by the ongoing Room for the River measures as well as by the Delta Plan. The 'afsluitbaar open' Rijnmond concept is one to be further investigated (Delta Committee, 2008). It proposes locks to the west and east of the urbanized area between Rotterdam and Dordrecht, leading peak discharge from the Rhine and Maas rivers away through the Southwestern Delta (see fig.105). The flow direction depends on the discharge of the Rhine and (to a lesser extent) of the Meuse. Water flows towards and into the sea via the Nieuwe Waterweg (Maasmonding) and through the locks in the Haringvliet. The Maas aperture is an open outlet. The discharge at the Haringvliet locks depends on the Rhine discharge at Lobith. The locks are shut when the river discharge is low (< 1200 m<sup>3</sup>/s). The locks are fully open at a Rhine discharge of 10,000 m<sup>3</sup>/s. The water flows in opposite direction during high tides up to a Rhine discharge at Lobith of 4000 m<sup>3</sup>/s. The flow direction changes when the Rhine discharge at Lobith is larger than 4000 m<sup>3</sup>/s. From this point onwards the river discharge starts to dominate the incoming tide flow (Stone, Beckers and Penailillo, 2008).

### **Further Interdependencies**

Interdependencies between eastern and western sections frame the systemic developments of the Rhine Maas Delta. For example, low water levels will lead to a shortage of fresh water. At the same time, rising sea levels will lead to a silting up of the Nieuwe Waterweg, the New Waterway, with effects far inland. The faster the economy and the population grow, the larger the damage potential in- and outside the dikes. Flood risk for this region is expected to be 2-5 times as high by 2050. For Dordrecht, flood risk may become 100 times as high by 2100. For the Rijnmond-Drechtsteden area, a sea level rise of 35 centimetres would imply that 30% of the dikes would not comply with current safety norms. Depending on the Deltascenario, this number could increase to 50% by 2100. Sediment management is becoming increasingly relevant as the erosion of the riverbed might also lead to an instability of the dikes. Only recently sediment has thus been added to the Dordtse Kil (Pelt et al, 2011).

### **Delta Agreement 2014 - Flood Protection and Fresh Water Supply**

The Delta Agreement Rhine-Meuse Delta (Deltabeslissing Rijn-Maas Delta) planned for 2014 deals with flood protection and fresh water supply in 2100, in synergy with ecological and socioeconomic development ([www.rijksoverheid.nl](http://www.rijksoverheid.nl)). It is necessary to investigate how long current policies can be effective before reaching so-called policy

transition points (beleidsomslagepunten). In preparation of the Delta Agreement, the corresponding system components of the Rhine-Meuse Delta are being analysed to define relevant elements for short- and long-term strategies, along with intermediary policies on the way to fundamental decisions for the long-term (Pelt et al, 2011). Here are the preliminary results in summary to show what components are interdependent:

Interdependencies between flood protection and fresh water supply are key for the future development of the Delta. Policies for the two must therefore be coordinated. The decision to allow more salt water to enter the system can affect the safety of the dikes and the fresh water inlet points. The more openly the solution allows sea water to enter the system, the further inland the effects will be felt. A new distribution scheme among the river branches will influence both issues of flood protection and fresh water supply. At this point the decision of the hierarchical organization is not clear. Whether a solution on the systems scale is more effective and efficient than many local and regional measures (here these are raising dikes, storing water and more room for the river) is crucial for the long term (Pelt et al, 2011).

An open connection to the North Sea will imply a reinforcement of dikes and significantly affect spatial quality. A closed system would protect more spatial developments outside of the dikes (Pelt et al, 2011).

If the defensive strategy is continued, fresh water consumption must decrease. If there is a paradigm change towards a strategy of 'function follows water' vs. 'water follows function', specifically with water from the sea, this will lead to further salination. This change in safety strategy would strengthen the ecological system and thus also strongly influence the Biesbosch (Pelt et al, 2011). Yet ecological developments would conflict with regional water supply.

Decisions on flood protection and fresh water supply on the systems scale of the Rhine-Mass Delta are strongly interlinked with the ecological and economic issues of shipping, living quality in the outer dike area of Rotterdam and the Drechtsteden, estuarine dynamics, tourism and recreation. Therefore the impact of decisions on a systems scale on these issues needs to be investigated. Recommendations include the combined consideration of short- and long-term decisions. The financial situation suggests that only urgent measures should be realized in the short-term and further expenditures should be moved to the future where possible. However, measures should be flexible enough to deal with the actual climate development to avoid path dependencies (Pelt et al, 2011).

### **Paradigm Regarding Development**

Dordrecht is a Delta city, an island surrounded by the rivers Beneden Merwede and Oude Maas in the north, Nieuwe Merwede and the Hollands Diep to the south and the Dordtsche Kil in the west. Water has therefore shaped its economy (as a mercantile

city), its ecology (Biesbosch) and its identity. Like all urban areas in the low lands, Dordrecht is protected by a dike system. Yet, due to its island condition, it is one of the smallest polders in the Netherlands. The dike rings have evolved in tandem with the growth of the city and today provide a fabric that spreads across the city island. Partially because of its history as a mercantile city, parts of the urban development, including a part of the historical city centre, industrial areas, the Biesbosch natural reserve and regeneration projects such as Stadswerven, are located outside of the dikes. Flood management is thus an omnipresent and continuous task that makes the island of Dordrecht a laboratory for dealing with the multi-faceted challenges of being an attractive and safe city. According to the United Nations, two thirds of the world population are expected to live in flood-prone delta-regions by the middle of the 21st century. The municipality of Dordrecht is seeking to position itself as a frontrunner in the discourse on cities and climate change (Belanger, Lister, 2010).

Dordrecht is working on this role through a number of different projects in very different constellations. Apart from international projects and studies, the city is active in the regional collaboration 'Dordrecht werkt aan water,' together with the water board Hollandse Delta. Climate change is key for the Waterplan Dordrecht 2009 - 2015. In the plan of measures for water safety, water quantity, water quality and use, and water perception, it states what needs to be done and defines further ambitions regarding climate adaptation. The most important projects in that regard are MARE (Managing Adaptive Responses to changing flood risks), the 'Wielwijk Klimaatbestendig', the 'Voorstraat', the Water Framework Directive and the intensive interaction with the inhabitants, businesses, research institutions and other governments. The execution of the new water plan demands extra input from all water partners, both physically and financially (Arcadis et al, 2009). The long-term vision statement (2050) is stated as follows:

"The island of Dordrecht has a climate-proof, safe, beautiful and healthy water system. It is capable of accommodating both extreme rainfall as it can withstand long heat and dry periods. Maintenance measures of the water system and the flood defences take sea level rise and an increase in peak discharges into account. On the entire Island, the water system is clean and ecologically sound. Water contributes to the spatial quality of the urban public spaces and the rural public areas. The water structure is an attractive continuous route that connects the city with the rural landscape and that has a high nature value. The citizens of Dordrecht live consciously with water, make full use of it and enjoy the open water. Water and space, nature and culture promote each other and contribute to the vitality and sustainability of the island of Dordrecht."

MARE, as the UFM follow-up project, focuses on the area inside and outside of the dikes and addresses two issues: rain water management in the city and the "multi-level safety approach" for urban areas threatened by river and sea floods. Aim of the project is to enable a widespread implementation of local adaptive measures to reduce and

adapt to flood risk. The project is set up with three different platforms. First, 'Learning and Action Alliances' aim to enable collaborative learning and to avoid adverse-impact solutions. They include local, regional or national level authorities, knowledge institutes and private enterprises. Second, a 'Climate Proofing Toolbox and Guidance (CPT)' for the climate-proofing of responses identified in Flood Risk Management Plans helps to answer the questions of if, how and when to adapt to climate change. Third, the Learning and Action Alliances will demonstrate and evaluate the Climate Proofing Toolbox and Guidance by applying it to real flood risk management demonstration projects ([www.mare-project.eu](http://www.mare-project.eu)).

The academic design research project 'Depoldering Dordrecht' by GSD Harvard challenges previous paradigms by developing prototypical designs that capitalize on an ecological approach to the future delta development, arguing for a counter model to the predominant engineering approach. With the understanding that the Netherlands having long been the world's most sophisticated laboratory for deltaic infrastructural experimentation, the recent studio looked at potential futures for the region around the city of Dordrecht in the Rhine-Meuse Delta. "Proposing a series of ecological interventions for the Delta Region, the ultimate objective of the studio is to develop contemporary design methods that go far beyond flood mitigation or passive adaptation, and in effect, capitalize on the climate conundrum of the future" (Belanger, Lister, 2010).

The key question that framed Urban Flood Management (UFM) as an interdisciplinary design project, addressing a number of scales for the short- and the long-term, was how to make the Netherlands a safe and attractive place to live not only today, but also in 50 or even 100 years (Nijhoff in van Herk, 2008). The results of the research project address questions of urban design, risk and damage assessment, as well as legal instruments and communication tools. It sought to provide a method for integral solutions for excess water, water quality and other tasks. UFM provides an interdisciplinary design approach and contributes to policy development on different scales (Nijhoff in van Herk, 2008). This approach focuses on the Stadswerven conversion area as a pilot for outer dike development, where "the urban fabric" is seen "as a vital and dynamic feature in reducing flood losses, instead of being a sole and inert receiver of flood impacts." This is attempted "by developing a flood damage model that treats cities as a complex adaptive system" (Verbeek, Zevenbergen, 2008a:18 referring to Holland, 1995). Moreover, by teaming up with venture capitalist Bax & Willems from Spain, the municipality of Dordrecht seeks to develop not only new urban models, but also new urban economies for areas outside of the dikes.

Different temporal and spatial interdependencies that need to be considered in the decision-making process have led to a systems approach addressing different scales and agencies. Beyond the Stadswerven area as the focus of the Urban Flood Management project, a number of other water-related projects are often simultaneously dealing with water quality, quantity and safety inside and outside of the dikes. Being an attractive country, region and city to live in is explicitly included in all aim formulations. This research will focus on the revision of the original masterplan and the methodology of the UFM project that enabled it.



**Figure 105**

'Afsluitbaar Open'- Concept for the Rijnmond Island (Ties Rijcken, TU Delft, source: Deltacommissie, 2008) and Dordrecht's location in the transition zone between the sea-dominated and river-dominated delta with Room for the River measures and locks and potential sites for future RvR measures (original graphic: Bax et al, 2008, Pelt et al, 2011:11,29 adapted by author).

12th century	founding of Dordrecht
1421	St Elizabeth's Flood
1953	North Sea flood of 1953
1994	Projectbureau Drechtsovers (1994) Masterplan Drechtsovers. Een kwaliteitssprong. Den Haag, SDU
1995	Drechtsteden agreement
1999	Doordtse Wand multifunctional flood defence
2020	Dordrecht 2020: declaring vision statement Dordrecht Dutch water city
1999	installation of water taxi between Drechtsteden and Rotterdam
2003-2007	Stedelijk Waterplan Dordrecht
2004	Palmboom & VandenBout Stedenbouwkundigen De Stadswerven. Stedenbouwkundig plan.
2007	Europen Stadswerven and workshop for the development of outer dike areas
2005-2008	Urban Flood Management Dordrecht Hamburg London together with London and Hamburg financed by Leven met Water and BMBF-RIMAX expert monitoring by COST C22 (EU)
2009-2015	Waterplan Dordrecht
2009-2012	MARE Managing Adaptive Responses to changing flood risks
2010	Harvard GSD Depoldering Dordrecht, design research project
2014	Delta Agreement on the five issues: Fresh Water Supply Flood Protection Rhine-Maas Delta Spatial Adaptation Water level management IJsselmeer
2011-2024	realisation Stadswerven

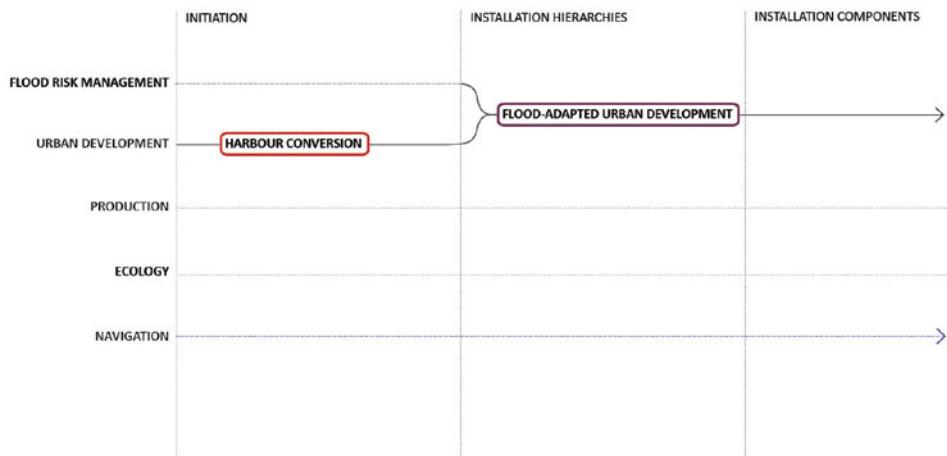


Figure 106  
Initiating program, installation hierarchies and installation components

## § 8.2 I+I / Initiation and Installation

### Initiation / Methodology

The Urban Flood Management project (UFM) is part of the national initiative Leven met Water, a program to generate operative knowledge for new water management strategies. For UFM, Dordrecht, Hamburg and London worked together in one project for three testing sites. The Dordrecht consortium was comprised of public, private, local and national parties from the municipality of Dordrecht, the waterboard Hollandse Delta, Rijkswaterstaat, the Ministry of Infrastructure and Environment, the Province of Zuid-Holland, the construction firm Dura Vermeer, the research institute Deltares, the local housing corporation Progrez and the UNESCO-IHE Institute for water education. It was further supported by Bax & Willems consultants. The parties worked together on a holistic approach linking flood management, planning and policy-making with methodologies for the assessment and management of residual flood risk in the urban environment, including financial, socio-economic and technical aspects in order to evaluate, compare and disseminate the results (Verbeek and Zevenbergen, 2008).

The Stadswerven area functions as a pilot project for the further (re)development of the area outside the main ring dike. Therefore the Delta river scale as well as interdependencies with the local and regional context framed or were framed by the project. As part of the iterative design methodology, Deltares developed a risk model and Dura Vermeer developed a flood damage assessment model. These models, which included events resulting from WB21 climate change scenarios, provided first design parameters for the initial urban design of the Stadswerven study area. The design proposals were then again assessed using risk and damage assessment models and further considered questions of communication and policy and governance. Furthermore, the recommendations from the different work packages of the UFM defined follow-up research questions. These include, for example, examining innovative concepts or including pluvial floods, etc. (Stone, Beckers and Penailillo, 2008) as in the follow-up project MARE, laying out information for a cost-benefit analysis regarding retrofitting measures for individual buildings (Verbeek and Zevenbergen, 2008a) or linking the polder city and the Stadswerven area (Bax et al, 2009).

### Installation

The first masterplan for Stadswerven, issued in 2005, foresaw raising the complete area of Stadswerven to 4.00 m+ NAP to avoid any risk of flooding (Dordrecht, 2009). In proposing a more differentiated concept, the UFM project approach and results challenged this design. Within the UFM project, damage impact reduction methods and vulnerability indicators for specific areas outside of the dikes were assessed and developed, and a cost-benefit analysis that juxtaposed economic value with expected annual damages provided site-specific parameters for urban design (Verbeek and Zevenbergen, 2008a). Two of the three design proposals, the Integrated Floodfront

and the Watersteps design, were then again assessed to evaluate their respective flood impact. These iterative loops allowed an analysis of the Stadswerven design embedded in the context of the outer dike area and the empoldered city (see fig. 106). The UFM project was completed in 2008. The knowledge it produced informed the second Delta Committee (Commissie Veerman, 2008) and the National Waterplan concept (2008). Also the Province Zuid-Holland used the project for its provincial outer dike flood protection policy (waterveiligheidsbeleid) (Dordrecht, 2009). In 2009, a revised masterplan informed by the insights produced by the iterative approach of the UFM design research was presented. It will be implemented in phases according to individual neighbourhoods (Stadswerven Masterplan, 2009) (see fig. 106).

### § 8.3 M / Local and Regional Context

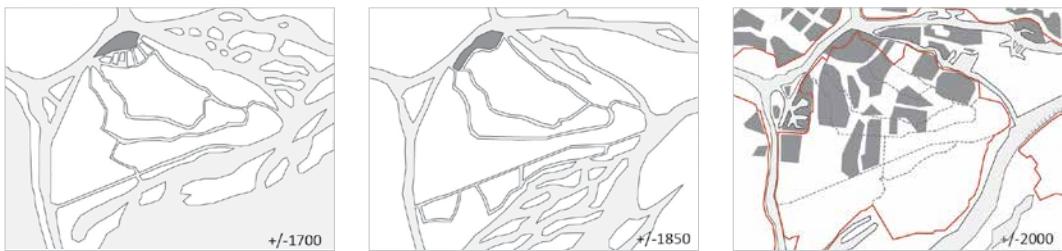


Figure 107  
Pre-Industrial / Industrial / Trans-Industrial Dordrecht (graphic by author)

#### Stadswerven in the Context of the City / of the Region

The following section describes Dordrecht's urban system inside and outside of the dikes and as part of the Drechtsteden region, before setting the Stadswerven development in the context of previous and current development strategies. As a summary of the project conclusions of the Urban Flood Management Project, the mixed design strategy chosen for the site will be illustrated in terms of its potential for the outer dike area of Dordrecht and how it could be linked to the polder city and the Drechtsteden regional waterfronts (Drechtsteden, 1994).

#### Dordrecht Inside and Outside of the Dikes

Under the influence of daily tidal dynamics, Dordrecht is a deltaic polder city. Throughout history, Dordrecht has been confronted with flood events, most severely in 1421. The Saint Elisabet's flood killed over 100,000 people and created the island of

Dordrecht as it is today. Dordrecht is the only city along the Rhine whose genesis as an island, but also its most destructive moment are linked to a flood (see fig. 107).

Dordrecht is an island at the crossing of the main water and traffic arteries of the south wing of the Randstad, and is enclosed by four rivers. The city of Dordrecht, on the Northwestern part of the island, is the oldest city of Holland (dating back to the 12th century) and large parts are located outside of the dikes (see fig. 109). The Stadswerven area and the adjoining historical city to the west are framed by industrial areas and ports and by the Biesbosch further to the east and south. The area between the confluence of the Beneden Merwede, and the Noord and Oude Maas makes up 30 hectares and forms a major conversion site within the city but outside of the dikes (Hooijmeier et al, 2005). Until today, these areas are not protected against floods collectively, but rely on individual flood-proofing measures on the building scale. Urban development has left no spatial capacity to install additional flood defences, producing a conflict situation between the urban layout and required safety measures. The building stock of the outer dike area is heterogeneous. It consists of 'historical' buildings, mainly from the 19th century, as well as post-war developments (Verbeek and Zevenbergen, 2008a).

### **Landscape**

Dordrecht is an island that formed during the flood of 1421. The Southern area is part of the Biesbosch, a unique fresh water tidal area. The Biesbosch is a combined ecosystem of freshwater tides and river bound nature. The rivers form important connections between diverse large- and small-scale nature areas. Many of these areas are internationally managed by the water framework directive and Natura2000 (Pelt et al, 2011).

### **Water System**

Although the main navigation channels runs south of Dordrecht in the Nieuwe Merwede, the Beneden Merwede also serves as a shipping channel. The water system of the island itself includes rivers, harbours, ring ditches (singels), channels, kills, locks, puddle pools and reservoir basins. Plungers, dams, sluices and mills regulate the water and the defence, sea and polder dikes around the inner dike areas protect against floods from the rivers (Arcadis et al, 2009).

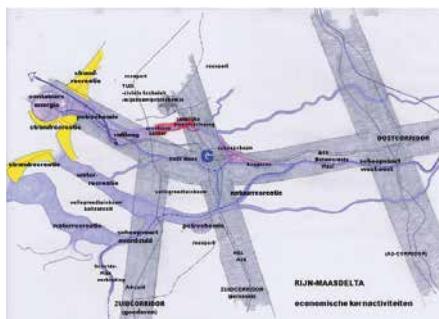
The city itself can be divided into a northern part located in the outer marshes, hosting the historical centre, and the main residential part of the city, located in a polder area (Verbeek and Zevenbergen, 2008a). The outer dike area of the island of Dordrecht includes parts of the historical city, the harbours, de Start and the Biesbosch. It is influenced by tidal and seasonally varying river water levels (both high and low) (Arcadis, 2009). Due to its relatively high altitude (caused by a long process of sedimentation) the outer dike area is not protected against river floods by any man-made structures other than quays. The Southern area, which hosts the majority of post-war built residential districts, consists of reclaimed land and is protected by a dike ring based on a 1:2000 year design flood.

The average elevation of Dordrecht inside the dikes is 1 meter above sea level (Dordrecht, 2009). In the inner dike area water levels are therefore permanently regulated. The water levels within the polders are defined by the respective spatial program. Excess water is pumped out by eight mills (four land mills and four city mills) and discharged to the North Sea via the rivers. During dry periods, water is let in from the surrounding river system to remain on level. The quality of the inlet water is generally better than the water quality in Dordrecht, with the exception of the Biesbosch polder with its clean springs. The city disposes of high and low groundwater levels where the wooden foundations of the buildings can stand in the dry (Arcadis et al, 2009).

## The Drechtsteden at the Transition Zone between River and Sea

Dordrecht is part of an archipelago of islands and forms, together with the surrounding municipalities, the Drechtsteden, whose total population is 280.000 (fig. 110). Apart from coordinating activities, it expands the focus of the adjoining municipalities by developing a Drechtovers masterplan (fig. 111). It foresees a regional waterfront concept with a focus on the areas outside of the dikes. Derelict industrial sites on the riverfront, for the most part outside of the dikes, are redeveloped into new urban neighbourhoods. The water taxi connecting Dordrecht with Papendrecht and Zwijndrecht being one of its first strategic features ([www.waterbus.nl](http://www.waterbus.nl)).

The regional economy is dependent on water: some sectors need fresh water (agriculture, industries, green ports), others use fresh water (shipping, fishing, recreation). Ground water management, the cleansing of water infrastructure and drinking water supply are also dependent on the availability of sufficient fresh water supply. Water shortage or drops in quality immediately create economic damage (Pelt et al, 2011) (see fig. 108).



**Figure 108**  
*Water related Economies (Pelt et al, 2011)*

## Flood Risk

In terms of flood risk, a combined medium storm surge and a medium river flood are decisive for Dordrecht (Pelt et al, 2011). On a daily basis, water levels today vary between 0.20 to 0.90 meters +NAP. The Flood Management legislation foresees the dikes around Dordrecht to be able to withstand the maximum water level of the kind of flood expected to occur every 2000 years. This implies that the dikes around the island of Dordrecht are designed to avert floods up to a design water level of 3.01 meters +NAP. As applied for the UFM project, according to the medium WB21 scenario with a return period of 2000 years, the water level of 3.01 meters in 2008 will rise to 3.41 meters in the year 2100 (Stone, Beckers and Penailillo, 2008).

The Deltascenario Warm en Stroom (Warm and Flow) for the year 2100 indicates that 'maatgevende hoogwaterstanden' (MHWs), normative flood levels, will increase by an average of 0.5 to 1 meter in the area of Rotterdam and Dordrecht (Pelt et al, 2011). As described in section XL, the development of future water levels depends on larger scale developments such as the 'afsluitbaar open'-concept for the Rijnmond island. The situation therefore remains uncertain, in terms of climate change and the effects of future measures to cope with it.

The last major flood event that Dordrecht witnessed was the 1953 flood. Even if the impact on Dordrecht of the recent flood events in 1993 and 1995 was minimal, the historical city centre outside of the dikes in particular, due to its height between 2 and 2.5 meters + NAP, remains continuously susceptible to flood risk. Therefore, large areas in the northern part of the city are adapted to handle design floods up to 1/10 years with flood-proof shutters and other temporal defence measures (Verbeek and Zevenbergen, 2008a). The floor level in many of these houses lies 0.2 – 0.4 m above the ground level. They are floored with tiles and built to withstand water flowing along the outer walls (Stone, Beckers, Penailillo, 2008). The Stadswerven area, directly adjoins the main dike and its average elevation is approximately NAP +3 m or higher. Today, flood prevention in Dordrecht involves yearly flood simulation events organized by the water board. The installation of stop-logs is practiced by the residents to raise awareness for the inherent flood risk and to maintain operative knowledge regarding installation techniques (Stalenberg, 2010).

## Alternative Designs For Stadswerven in the Context of the City

### Iterative Design Process leading to a Revision of the Masterplan

The Stadswerven area, although already developed to the stage of a stipulated masterplan, served as a pilot for the UFM project to develop iterative strategies for areas outside of dikes. The results of the design research challenged the existing masterplan and eventually led to its revision. While the first plan foresaw to raise the entire area to 4.01 m +NAP, the concepts developed as part of the UFM project studied more differentiated solutions in terms of topography and building development. After

an in-depth assessment of the inherent damage potential for different exceedance probabilities, the UFM project produced results that opt for a combined solution. It involves adaptations on the object scale and a morphological modelling of the site. The incorporation of varying water levels into the design produces spatial qualities and raises flood risk awareness.

### **Relation to Polder City**

The comparison of floods for protected and outer dike areas by Stone, Beckers and Penailillo (2008), summarized in table 3, is a real eye-opener. It shows that flood impact on the Stadswerven area is of a completely different nature than on areas inside the dikes, and surprisingly it proves more resilient on many levels. The negative aspects in case of a dike breach: a flood results in an uncontrolled flowing of water and the flooding of a low area causes respective water depths, which means that draining the area can take a long time. The strategic advantage in terms of flooding for the area outside of the dikes is its predictability. During extreme water levels , the Stadswerven will certainly flood and can thus be prepared. For dike protected areas, it remains uncertain if a dike will breach and if it does, it remains unclear when and where it will do so. Stone thus concludes that the flooding of a dike protected area is a catastrophe while a flooding of the Stadswerven will only cause an inconvenience (Stone, Beckers and Penailillo, 2008).

Dike protected area	Stadswerven
large water depth velocities	small water depth relatively large water relatively small water velocities
long flood duration	short flood duration
unpredictable	predictable
catastrophe	inconvenience

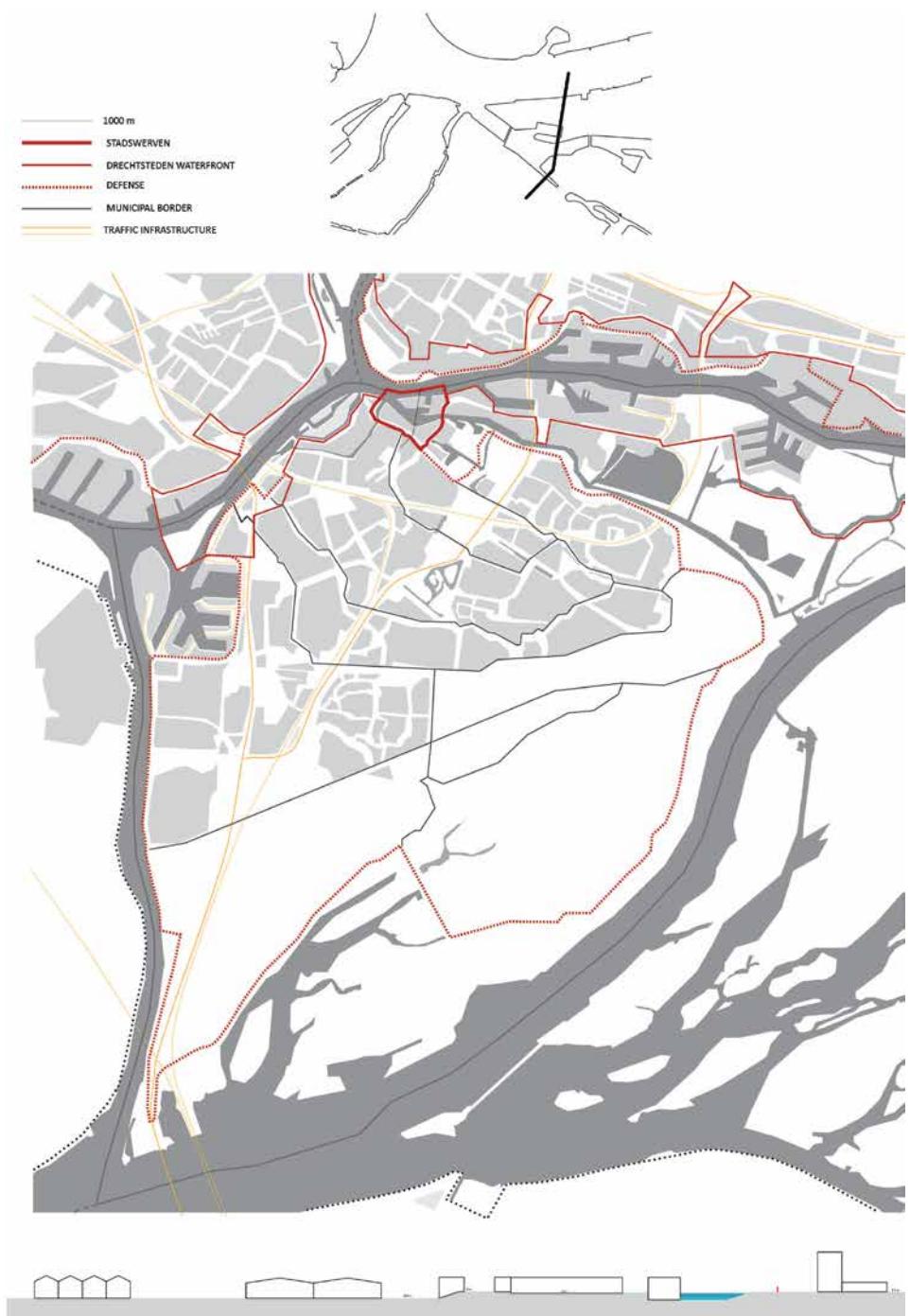
Tab. 3 Comparison of the flood impact for a dike-protected area and for Stadswerven (Stone, Beckers and Penailillo, 2008)

Further factors that enable a flood-resilient urban development in the floodplain are low water heights in case of expected floods (0.5 meters) and also low water velocities (0,25 m/s). In accordance with a storm surge, the duration of a flood will be 8 hours on average with a preliminary lead time of at least 12 hours to prepare or evacuate (Stone, Beckers and Penailillo, 2008).

Due to the height of the area outside of the dikes, the possibilities of evacuating inhabitants of the polder city to Stadswerven were also discussed. Raised rescue routes from the lower-lying polder city (Bax et al, 2008) would enable an evacuation to the outer dike area, which may remain flood-free in case of a dike breach (see fig. 108, 109 and 111). This emergency plan would imply the need for a new design of raised routes.

#### **Findings of the Damage Assessment Model applied to the Outer Dike Area**

For the benefit of prospective cases, spatio-temporal patterns of expected flood damage distribution were brought together in a model identifying spatial damage clusters. Future design responses would then be able to use the information provided by the identification of these patterns. The choice between retrofitting individual buildings or large scale implementation of flood barriers in particular is informed by such spatio-temporal patterns (Verbeek and Zevenbergen, 2008a). The flood damage model that was developed for the UFM project was applied on an area outside of the dikes of the northern part of Dordrecht, covering about 2096 hectares and hosting over 5600 individual buildings. The damage assessment model applied a cluster approach. The number of buildings flooded and their economic damage potential defined the cluster scales. This approach shows damage clusters of different scales. The resulting cluster map produces a site-specific "risk landscape" (Verbeek and Zevenbergen, 2008a), which in turn enables differentiated design strategies to be applied depending, among other parameters, on the scale of the cluster. In general, it can be said that in most cases each additional measure is less cost-efficient. As the flood risk becomes smaller, so does the absolute risk reduction through an additional measure (Verbeek and Zevenbergen, 2008b, and Hoss, Jonkmann, Maaskant, 2011).



**Figure 109**

Stadswerven in the context of the city (based on Overstromingskaart NL) and section according to ufm design (Bax et al, 2008).

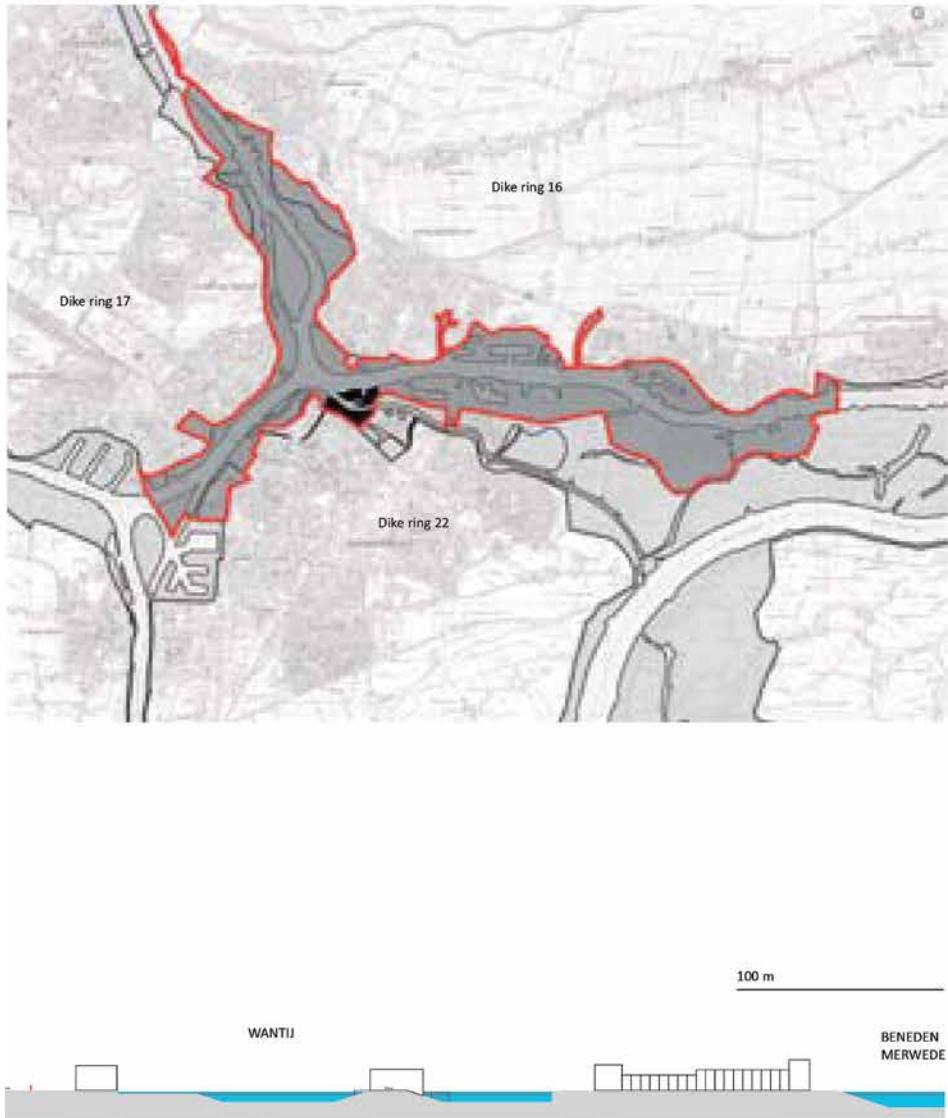


Figure 110  
Drechtsteden (red) with Stadswerven Area (black)(Bax et al, 2008).

Some of the key findings of the UFM damage model:

1. Due to their density and even distribution, the susceptibility of infrastructural works<sup>22</sup> to flood impacts in the case study area is higher for the developed land than for buildings (Verbeek and Zevenbergen, 2008a).
2. The patterns observed in the cluster distribution show a clearly defined global maximum, surrounded by a large amount of small local peak. Large scale protection measures may therefore be oversized and a combined strategy considered: retrofitting individual buildings for smaller damage clusters and more collective flood defence measures for the historical centre Although the basis for these results does not take economic viability into account, it does provide information that could be used for a cost-benefit analysis (Verbeek and Zevenbergen, 2008a).
3. The age distribution of the building stock in relation to expected damages provides a useful planning tool regarding life-cycle management, the application of retrofitting measures and urban renewal schemes. Results for the Stadswerven area showed flooding at lower exceedance probabilities and during extreme events in only around 25% of the historical buildings (constructed before 1904) compared with 50% of Post-WW2 buildings (Verbeek, Zevenbergen, 2008a). **Design Alternatives**

The three design principles studied within the UFM project cover the spectrum from a strictly morphological approach (Mound), through a collective solution on the building scale (Floodwall), to the adaptation of individual buildings on the object scale (Watersteps). Based on the UFM documentation of the work packages 2, 3 and 4, they are described briefly and their estimation in terms of flood risk, damage potential and spatial quality as part of the iterative design process are summarized below.

#### **Mound**

Mounting Stadswerven: The main strategy for this design concept is comparable to the existing plan. The elevation of the site is raised to 4m + NAP by adding a sand body to create a mound covering the entire area. This level would ensure protection from flood impacts up to an exceedance probability of 1/20,000 and is therefore in line with the design water level predicted for 2100 according to the WB21 climate scenarios (Stone, Beckers and Penailillo, 2008). Yet, the applied level is also far beyond the safety levels used for the main river dikes in the Netherlands and would only be exceeded by floods

causing a national catastrophe, e.g. a tsunami (Verbeek and Zevenbergen, 2008b). The concept provides a safe environment up to the design water level. No other measures, such as adjusted building concepts or infrastructure, are taken. Therefore, if design water levels are exceeded, the area would be flooded without further protection (Stone, Beckers and Penailillo, 2008). Apart from the obvious distance produced between average water levels and the waterfront even when considering daily fluctuations, the critique of this design are the extended resources it demands for and the impossibility of its application on a larger scale (Verbeek and Zevenbergen, 2008b). Costs for raising land are estimated at 20 Euro/ square meter (Gersonius, Zevenbergen, Puyan and Billah, 2008). Except for areas which are already high but need to be elevated to comply with changing water levels due to climate change, the Mound concept is only applicable in the downstream zone of a river. Raising areas upstream will act as an obstruction, causing water levels to rise during high river discharges. (Stone, Beckers and Penailillo, 2008). Further, "fewer possibilities to brand Dordrecht as a 'water city' and the lack of innovative possibilities for integrated UFM (which has strong support by local politics)" (Verbeek and Zevenbergen, 2008b). For former industrial areas with contaminated soils, the Mound concept may offer a durable solution (Bax et al, 2008).

### **Integrated Floodwall**

The Integrated Floodwall integrates buildings and infrastructure into a ring-dike surrounding the area that withstands floods up to the design water level (fig. 111). Examples of such defences are houses with raised floor levels or elevated open spaces sometimes in combination with other functions, such as a car park. Accessibility is ensured by a raised 'lifeline' that also accommodates the area's main infrastructure and utility lifelines, e.g. gas, electricity, water (Verbeek and Zevenbergen, 2008b). A large part of the Stadswerven area would be protected by the Floodwall. The areas not enclosed by the defence are designed to cope with flooding. A possible failure of the Floodwall should, however, be considered (Stone, Beckers and Penailillo, 2008). Anticipating such a failure, optional and additional measures for the area can be taken, such as wet-proof housing. Expected damages exclusively affect the infrastructural elements; no buildings are affected by inundation because of the integrated ring dike system (Verbeek and Zevenbergen, 2008b). Yet, in case the integrated ring dike system breaches, expected damages increase significantly. A differentiated result in case of failure depends on the structure of the planned area, which can be divided into two zones. Each zone can be designed as a flood-proof compartment. In case of a breach, however, a compartmentalization might increase the negative results through higher flow velocities, structural damage and thus higher damage levels (Verbeek and Zevenbergen, 2008b).

### **Watersteps**

The Watersteps design adapts to floods on the individual building scale. It combines floating, amphibious and raised buildings as well as other wet- and dry proof solutions to overcome potential inundation (Verbeek and Zevenbergen, 2008b). Instead of moving away from the water, the river becomes part of the design and enhances the

quality of the urban environment. For the Stadswerven, Watersteps measures are applied along the Wantij river. The gradual slope of the riverfront terrain rising towards the landside provides different floodable environments that make it possible to implement several flood-proof building concepts ranging from wet-proof to floating. Parts of the area are raised since the Watersteps concept relies on adjoining higher grounds “to accommodate more vulnerable functions and as a safe haven when needed” (Stone, Beckers and Penailillo, 2008:34). It is therefore only applicable as a combined concept (see fig. 111). The damage assessment of the design proposals shows significant differences. Although also for the Watersteps approach, expected damages mainly affect the infrastructure, a much more gradual increase in damages for lower exceedance probabilities can be expected than in the Floodwall design, despite covering a much larger affected surface. Since infrastructure covers a much smaller area in the Watersteps design than in the Floodwall design, damage levels are lower, also for extreme events. Also in case of failure, the maximum expected damages are relatively low as the shift is much more gradual; failure leads to ‘graceful degradation’ (Verbeek and Zevenbergen, 2008b:54).

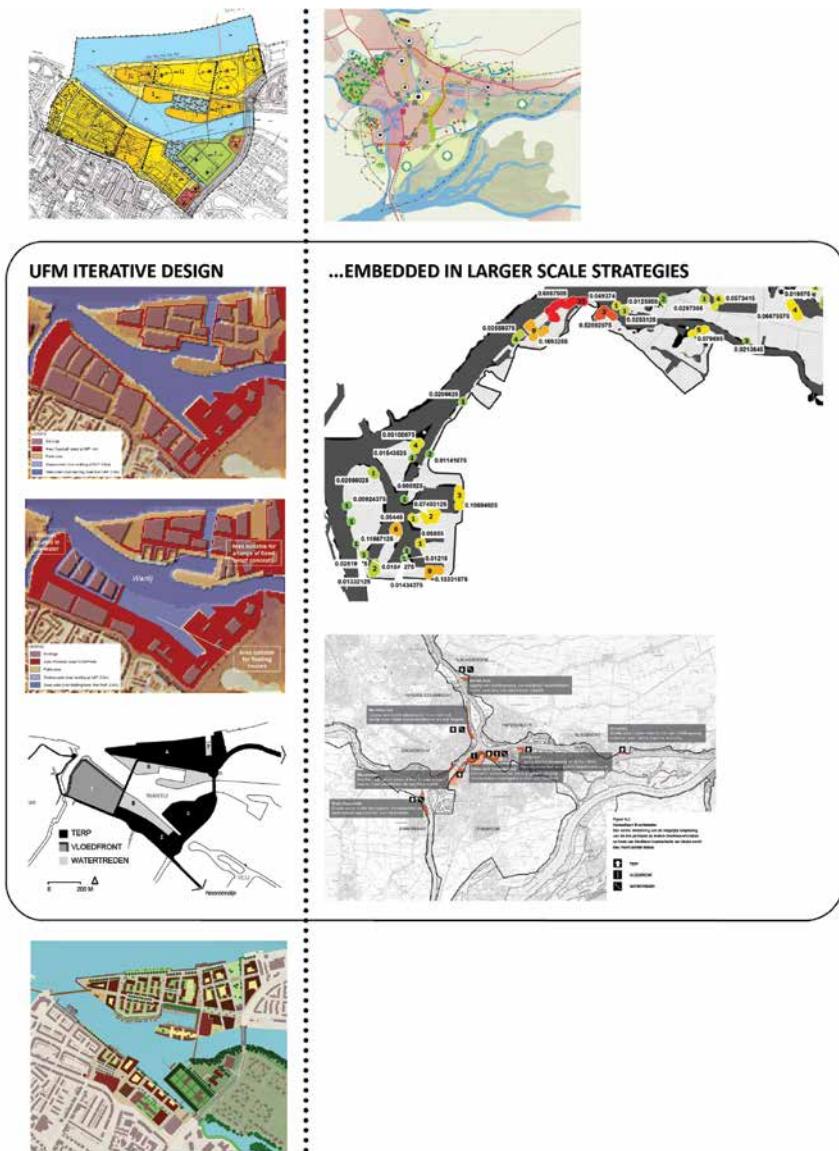
The evaluation of the three design concepts for a water level of 3.4 m + NAP shows that the Integrated Floodwall is the only approach that does not provide a raised area. Therefore the Integrated Floodwall has to include further measures such as wet-proofing to cope with failure, to enable controlled flooding and to avoid buoyancy. Ultimately, the design research led to the proposal of a mixed strategy in which low mean annual damages are combined with acceptable potential damage levels in case of failure, with the recommendation to protect infrastructure as the major object of damage in frequent floods (Verbeek and Zevenbergen, 2008b).

### **Responsibilities**

For the three design principles applied to the pilot area of Stadswerven, there are no modifications in legislation necessary. For the mound concept, a raising of the entire area, legislation can remain as it is. For the Integrated Floodwall design, a concept already being applied in different water cities all over the Netherlands, buildings and open spaces are used as defensive elements. Here it is necessary to specify by whom and how norms are defined. This demands for a high degree of negotiation/communication, not only in the phase of development, but also in terms of management. The same applies for the Watersteps design (van den Bergh et al, 2008).

### **Application on other Drechtsteden Waterfronts**

The direct applicability on a regional scale of the design solutions developed relies on the existing masterplan for the Drechtsovers. It proposes a number of outer dike developments. As part of the UFM design research, the different design concepts were projected onto the different sites according to the specificities that define the adjoining waterfront profiles.



**Figure 111**

Left from top to bottom: *MASTERPLAN STADSWERVEN 2005: raising the entire area to 4.01 meters NAP (ruimtelijkplannen.nl) / THE INTEGRATED FLOODWALL DESIGN* incorporates a ring dike into the building blocks based on a design flood of about 1/4000 years. The red area illustrated the location of the barrier and areas already elevated to a level of NAP + 4m in the present situation (Stone, Beckers and Penailillo, 2008) / *THE WATERSTEPS DESIGN* incorporates flood risk reduction by using retrofitting schemes on individual buildings. The red area is elevated to a safe level of NAP +4m. Around the Wantij, areas are designated for floating houses and houses located in the water and for different types of wet and dry proof building concepts (Stone, Beckers and Penailillo, 2008) / *PROPOSAL FOR A COMBINED SOLUTION* (Bax, et al, 2008) / *REVISED MASTERPLAN FOR STADSWERVEN 2009 informed by UFM design research* (Dordrecht, 2009) / Right from top to bottom: *DRECHTSTEDEN MASTERPLAN 1994*: with the aim to link the adjoining cities via their waterfronts (Projectbureau Drechtsovers) / *DAMAGE CLUSTER DISTRIBUTION* (Verbeek, Zevenbergen, 2008a) / *UFM DESIGN PRINCIPLES* applied on Drechtsovers (Bax et al, 2008)

	 Mount	 Integrated floodwall	 Watersteps
Safety level	+	+	+
Maximum reached velocities and depths are within safety limits	+	+	+
Anticipation on climate change	+	+	+
Safety river under average conditions	+	+	+
Safe havens within areas	+	-	+
Anticipation on possible failure of floodwall		+	
Incorporation of flood proof infrastructure		-	+
Controlled flooding	-		+

-  **not applicable for design concept**
-  **complies**
-  **does not comply**

**Figure 112**

Evaluation of the Stadswerven concepts for a water level up to 3.4+NAP, the foreseen design water level for 2100 according to the WB21 scenario (Stone, Beckers and Penailillo, 2008).

### Revising the Stadswerven Masterplan

The existing masterplan 'de Stadswerven,' strictly adhering to a mound concept, was already stipulated in 2005. To adapt this plan to a more complex topography, as proposed in the UFM project, implies a revision. Without significantly changing the spatial and programmatic development (Dordrecht, 2009), the new Stadswerven masterplan 2009 (see fig. 114) was informed by the UFM research design results (fig. 112). This implied designing with water instead of moving away from it and involves all three design principles.

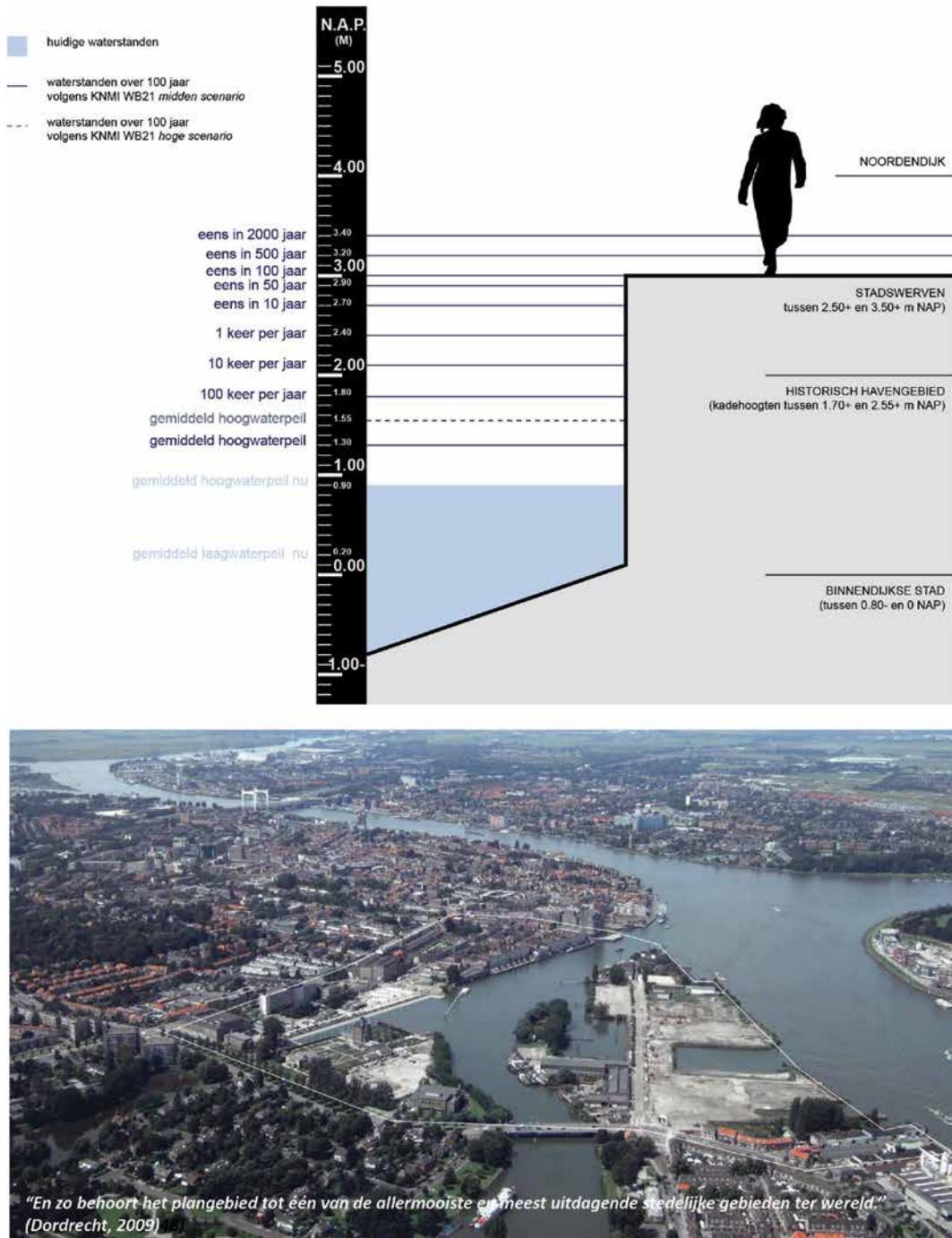
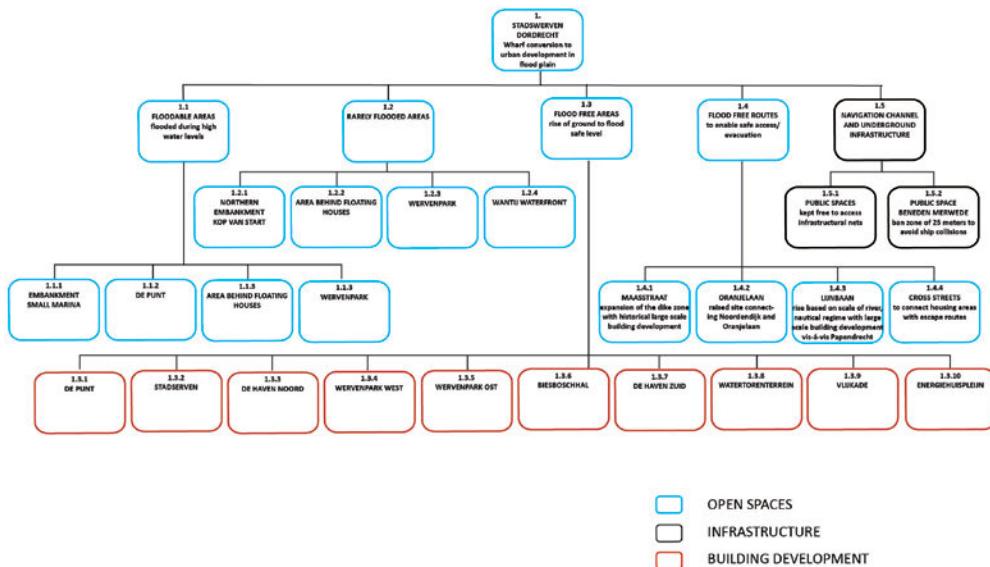


Figure 113  
Flood frequencies Stadswerven and project site Stadswerven (both Bax et al, 2008)



**Figure 114**  
Elements of harbour conversion (based on Masterplan Dordrecht 2009).

## § 8.4 Small / The Project Scale

On the project scale, Stadswerven as an inner city conversion is an adapted urban development in the flood plain directly adjoining the main dike. The revised Masterplan based on the UFM findings was designed by using varying water levels as a design parameter with the goal of creating a close experience of the fluctuating water levels on a daily and seasonal basis while providing safe havens and evacuation during extreme events (see fig. 113). The following text expands on the spatial and temporal organization of these demands.

### Morphological Transformations in Relation to the Programs on Site

The majority of the 70 hectares of development area are water. Apart from a long embankment along the southern riverfront of the Wantij, the meandering waterfront and the adjacent rivers turn the land into peninsulas. Land reduction in favour of expanding the water basin and the length of the waterfront further amplifies this phenomenon, for example via additional marinas. As a starting point, the relief design of the land uses the average ground level of 3.01+ NAP. It is developed to allow gradual access to the water from a number of embankment squares and parks, to manage run-off, and to provide flood-free routes (Dordrecht, 2009) and flood-free open spaces serving as escape mounds in case of an emergency event. Building development includes parking garages starting from the 3 meter-height level. Each sub-area has an interior raised flood-free area.

### Reciprocations between Spatial Design and Designing for Safety

#### Building Typologies

In addition, the layout aims to integrate the 19th-century structure of the area (Dordrecht, 2009) while implementing a broad range of typologies: from buildings that directly stand in the water to small scale floating houses and row houses in the inner areas, in combination with large scale blocks and solitary structures aligning the waterfronts. As in the Watersteps concept, individual buildings can take on flood defensive functions.

#### Waterfront Profiles

The water front profiles cover the entire bandwidth from hard orthogonal profiles, in the form of buildings or aligned with piers, to gradual slopes of different depths and material qualities (green, rubble, etc.). Furthermore, marinas and bridges make up part of the meandering water front.

#### Emergency Routes

The main emergency routes are the Maasstraat, the Oranjelaan on the polder dike and the Lijnbaan. The modelling of the landscape also foresees gradual slopes away from the Maasstraat of up to 3 meters height difference in the orthogonal streets towards the water (Dordrecht, 2009).

**Appropriating the Urban Development with Regard to Existing Infrastructure**

Navigation: In its function as a navigation channel, the Merwede produces restrictions for the development of the adjoining embankment. Rijkswaterstaat requires a 25-meter ban zone from the river with no building development making this one of the many public spaces, yet in this case an obligatory one (Dordrecht, 2009). Existing Infrastructure on site: Regional energy supply plants on site and the givens of the historical layout mean that existing infrastructural networks, cables and a pipeline also influence the building layout (Dordrecht, 2009).

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## § 8.5 E / Extract

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**XL / GLOBAL RELATION TO RIVER BASIN** Dordrecht is a small polder city with large areas outside of the dikes simultaneously influenced by sea and river. As a deltaic city it is therefore embedded in systemic, long-term developments/decisions where urban development becomes an issue of national relevance also to avoid future path dependencies. The Delta Agreement foresees short-, intermediate- and long-term decisions. As of yet, it is not clear whether the flood management strategy should be an extra-large scale solution or an accumulative solution of storing, widening and reinforcing. **PARADIGM** Upcoming systems scale decisions regarding flood management (water follows function (economic) vs. function follows water (ecological) (Pelt et al, 2011) are key, also the project scale development. Dordrecht is developed as a model for other Delta cities worldwide. Yet, along the Rhine, it remains a unique case.

**I+I / INITIATION** The Stadswerven area functions as a pilot project for the further (re-)development of the area outside the main ring dike. Therefore not only the Delta river scale, but also interdependencies with the local and regional context were framed by or framed the project scope of the UFM project. The Dordrecht consortium was a collective of public, private, local and national parties. **INSTALLATION** They worked together to develop a holistic approach by linking flood management, planning and policy-making and methodologies for the assessment and management of residual flood risk in the urban environment. This included financial, socio-economic and technical aspects. The results were evaluated, compared and disseminated. As part of the iterative design methodology, a risk model and a flood damage assessment model were developed. Based on these models, urban designers implemented hydraulic information as design parameters for the spatial plan. The design proposals were then reassessed and eventually led to a redesigning of the existing masterplan, which had strictly suggested to raise the area. The project results further included follow-up research questions. The development of Dordrecht as a prototypical Delta city relies on a strong municipality. The Stadswerven project is embedded in a number of

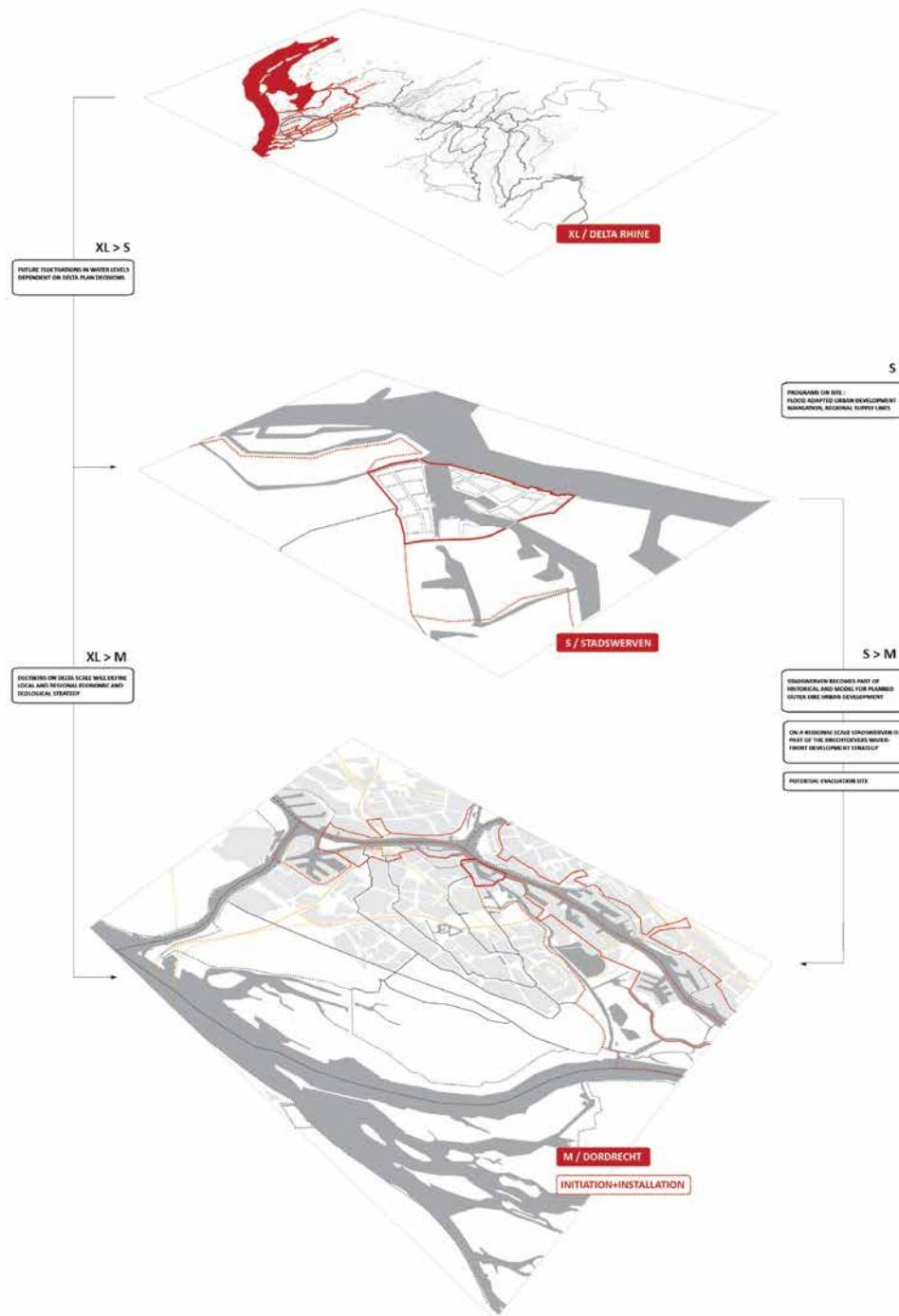
other research and development projects on different scales where water and flood adaptation are central themes.

**SMALL / THE PROJECT SCALE** In the masterplan, varying water levels are applied as a design parameter with the aim of allowing a close experience of the fluctuating water levels on a daily and seasonal basis and to provide a safe haven and escape during extreme events. Morphological measures and object adaptation are combined. While the central areas of the individual neighbourhoods are raised, a broad variety of flood-adapted building typologies are suggested for the other areas. The public spaces are designed to enhance the experience of varying water levels and also to create a link with the site-specific fresh water tidal vegetation. This links the Stadswerven also with the adjoining Biesbosch. **CONSTRAINTS** The restrictions that apply due to shipping and existing underground infrastructure also influence the design. **RESPONSIBILITIES** All solutions rely on safe havens and emergency routes at given heights (Stone, Beckers and Penailillo, 2008) while demanding additional management/negotiation of responsibilities (van den Bergh et al, 2008).

**MEDIUM / LOCAL AND REGIONAL CONTEXT** Dordrecht is the only city along the Rhine whose genesis as an island as well as its most destructive moment are linked to a flood. The situation remains uncertain, in terms of climate change and the effectiveness of future measures in dealing with it. The Urban Flood Management design research successfully challenged the existing "De Stadswerven" masterplan because it showed that designing with water may be more flood resilient than merely moving away from it. The research-by-design approach led to the proposal of a mixed-strategy in which low mean annual damages are combined with acceptable potential damage levels in case of failure (Verbeek and Zevenbergen, 2008b). In the qualitative comparison of a flood inside and outside the dikes, a number of arguments showed that the outer dike area might be safer than the polder city, e.g. flooding outside of the defence is less intense in terms of current, etc. due to altitude and direct back-flow into river, while polders flood faster and have to be pumped empty after the event (Stone, Beckers and Penailillo, 2008). Due to the given height of the Stadswerven area, it may have the operative potential as an evacuation site for the polder city. This would require 'raised routes' (Bax et al, 2008). The applicability of the design solutions developed on a regional scale for the Drechtsteden waterfront areas outside of the dikes (Bax et al, 2008) relies on the existing masterplan for the Drechtsovers, a regional strategy that links the Drecht cities by crossing the river.

**LEARNING FROM...SPATIAL DESIGN** Although the design results are very comparable to the Zollhafen project, the design strategies developed for the UFM project, their documentation and the link to other systems and time scales provide exemplary strategic design lessons. The design strategy that was developed and applied within the UFM project is applicable to other urban development projects outside of the dikes, and partially also inside them (damage assessment according to clusters, cost-benefit

according to age of building stock, etc.). The applied damage assessment of Verbeek and Zevenbergen defines risk landscapes where damage clusters may, for example, define the scale of the adaptive solution (e.g. larger clusters need collective solutions; smaller clusters require the retrofitting of individual buildings). This may sound very logical, but should not be underestimated as it enables a completely new design approach on a neighbourhood or local scale. On a building scale, the life cycle of the building stock is taken into account. Both approaches provide additional parameters to enable a differentiated decision-making process beyond the neighbourhood scale, in this context primarily an administrative boundary. **STRATEGIC DESIGN** The Stadswerven project further shows how important continuity is in terms of linking the project to the local and regional scale. By challenging the given masterplan, the Urban Flood Management project provided innovative, generic tools and design methods applicable on a number of scales: from the building scale, through a project application, to a juxtaposition with local conditions and a regional projection.



**Figure 115**  
Extract diagram showing interdependencies between river-, project- and local scale



Figure 116

Rotterdam Kop Van Zuid / Rhine km 1000-1001.3

Program: conversion of harbour/industrial site to dwellings and work spaces / Morphological transformation: n. i. / Scale: 125 hectares / Flood risk: development in flood plain / Period: 1986-today / ([http://geo.zuid-holland.nl/geo-loket/kaart\\_overstromingsrisico.html](http://geo.zuid-holland.nl/geo-loket/kaart_overstromingsrisico.html); Masterplan Kop Van Zuid; In: Cities And Ports, 1999)

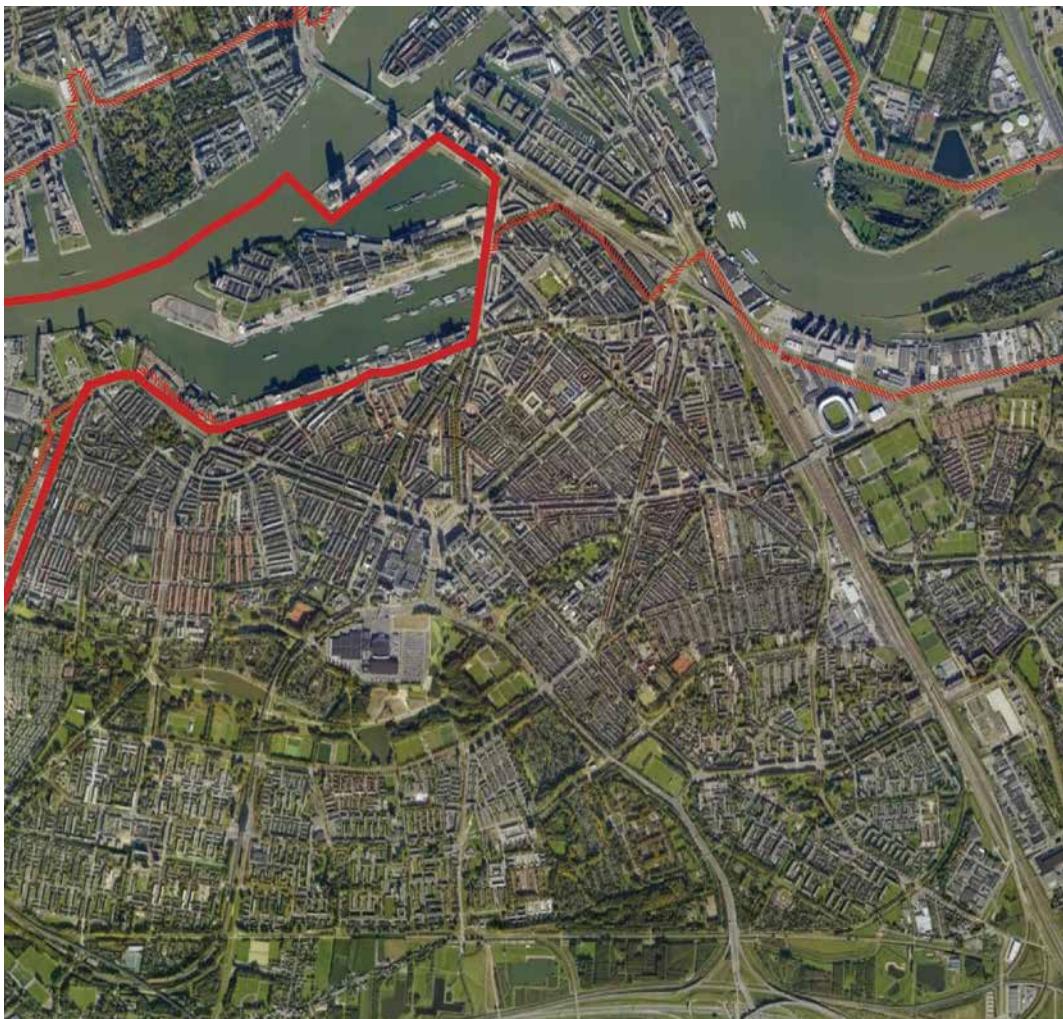


Figure 117

Rotterdam / Muller+Lloydspier / Schiehaven / Rhine km 1002.2-1004

Program: conversion of harbour/industrial site to dwellings, work spaces, universities, etc. /  
Morphological transformation: Mullerpier terrain raised by 15 cm / Scale: 20 hectares / Flood risk:  
development outside of dikes, dwellings raised / Period: 1997-2013 / ([http://geo.zuid-holland.nl/geo-loket/kaart\\_overstromingsrisico.html](http://geo.zuid-holland.nl/geo-loket/kaart_overstromingsrisico.html); [www.lloydkwartier.nl](http://www.lloydkwartier.nl))





**Figure 118**  
*Stadshavens / Rhine km 1001-1008*

Program: structure vision of converting port/industrial sites to dwellings and work spaces with the aim to connect the city and the port / Morphological transformation: n.i. / Scale: 1600 hectares including water surfaces / Flood risk: development in flood plain / Period: 2011-2015 (flexible -2025-2040)



# 9 Nijmegen

## MITIGATION AND ADAPTATION /

### 7. NIJMEGEN

ATLAS BYPASSES

## UNITS OF ANALYSIS /

EXTRACT

XL / I+I / S / M

XL RIVER

typology

I+I INITIATION+INSTALLATION

by whom and how is the project

S PROJECT (VERTICAL)

synergetic development

M CITY (HORIZONTAL)

connectivity

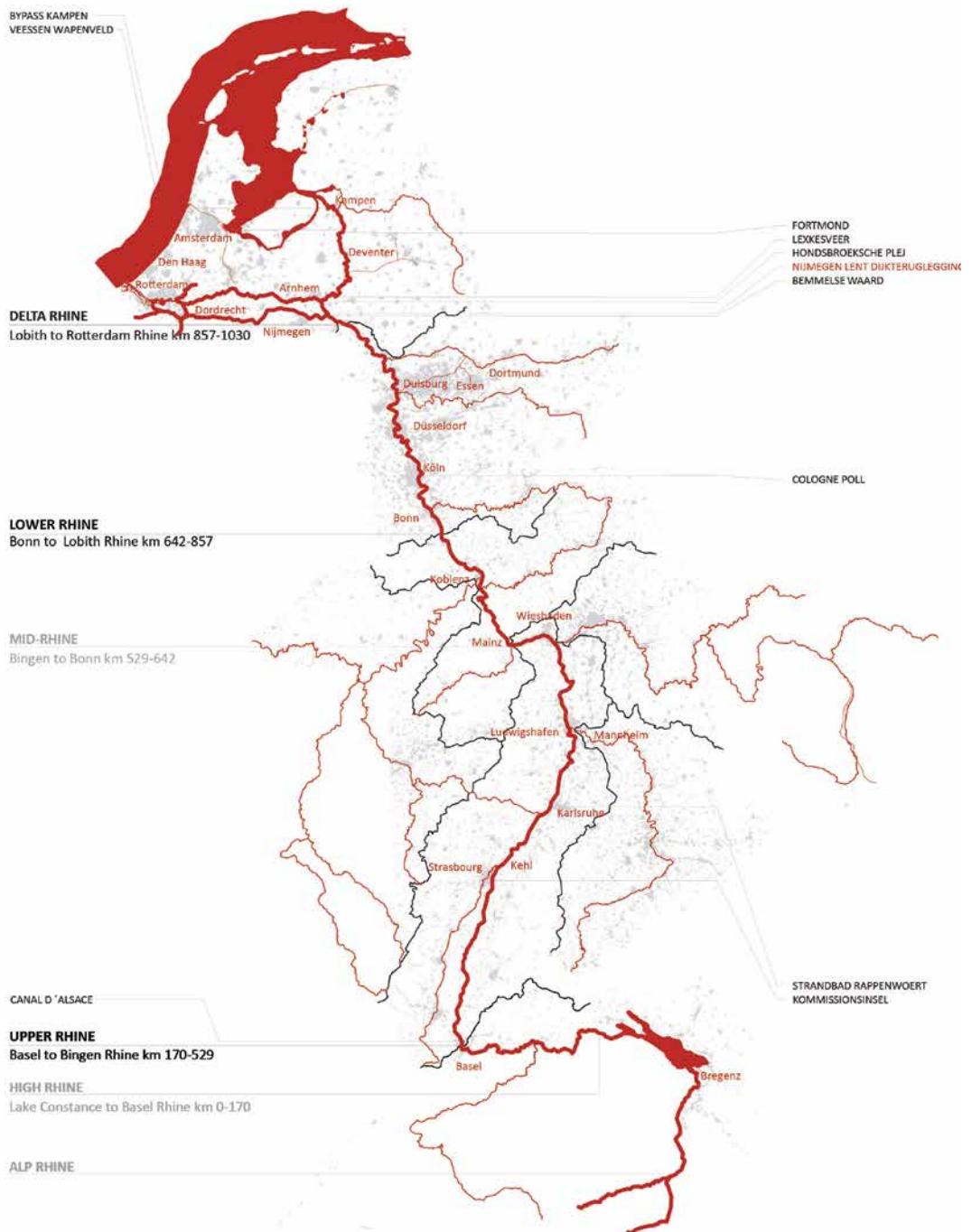


Figure 119

Overview of bypasses along the Rhine (Rhine map based on ICPW Atlas of river typologies, urbanization Corine Land Cover 2003).

### DUTCH RHINE BRANCHES

#### UPPER RHINE



#### LOWER RHINE



Figure 120

Elements Atlas Of Bypasses (aerials 2009-2012, viewing height 10 km, dike lines based on ICPR Atlas, 2001)

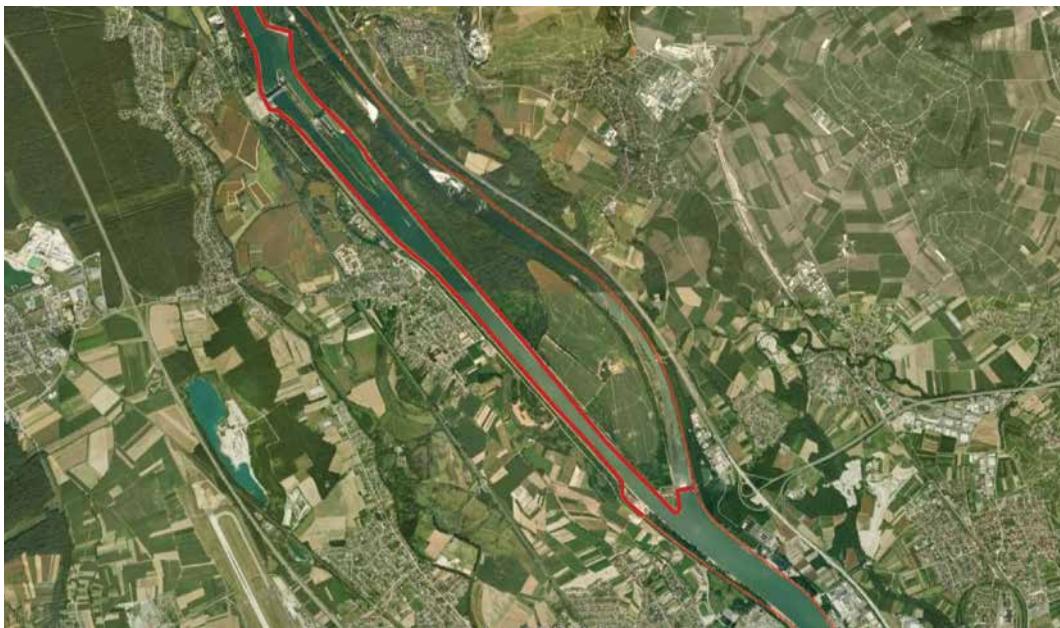
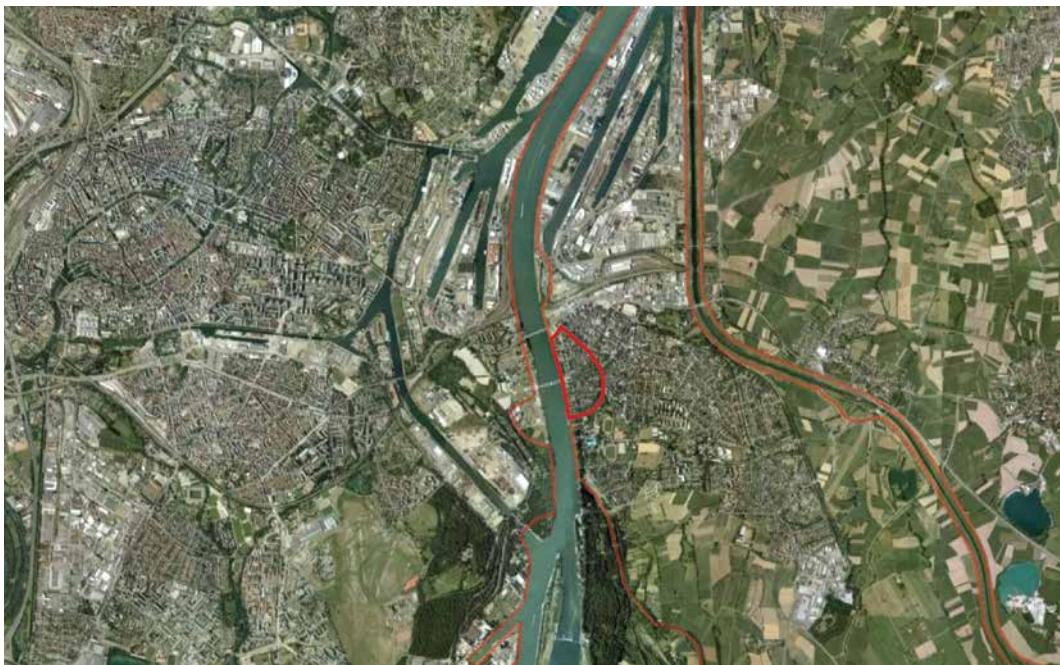


Figure 121

Canal D' Alsace / / Rhine km 174 -225

Program: Manmade channel left of Rhine between Kembs and Neubreisach erected for shipping and energy production; Barrages with water power plants and sluices at Kembs, Ottmarsheim, Fessenheim and Vogelgrün / Period: 1932-1970 / Scale: 50 km length, 6 m depth, width 130 m / width of riverbed 80 m / Originally planned over a length of 112 km until Strasbourg. After first building sections were completed ground water tables dropped severely. After the Saar negotiations (1956) between D and F and the agreement on the channelling of the Mosel (completed in 1964) the limited length of the channel today and a channelling of a minimum discharge into the original river bed was agreed on. ([www.wissen.de](http://www.wissen.de), [www.buergerimstaat.de/2\\_00/rhein03.htm](http://www.buergerimstaat.de/2_00/rhein03.htm))



**Figure 122**  
*Kommissionsinsel Kehl / Rhine km 292*

Program: developed in the years before the First World War as a privileged housing area on former island formed by the disconnected Rhine arm. Also a prison is located on the island / Period: 1911-1940s / Scale: 19 hectares / Marie Antoinette was officially handed over by Austria to France on this island on the Rhine near Kehl in 1770 and therefore it became known as Kommissionsinsel after the commission that took over Marie Antoinette. Adjoining the former island today is the Parc des deux Rives (2004), the only cross border development linking the German and the French river sides. To the south and the west, the former island is separated from the adjoining quarters by an old Rhine arm. (Architecture Guide Strasbourg)



Figure 123

Karlsruhe Rheinstrandbad Public Bath / Rhine km 358

Program: Rhine swimming bypass (man made) in flood plain and beach with sports fields / Period: 1924-1929 as part of the Generalbebauungsplan / Scale: 10 hectares / The bypass was closed for swimming in the 1960s due to an increasingly bad water quality. This was compensated by the building of new pool basins in the direct vicinity. Today, the Rheinstrandbad and the nearby Nature Education Centre are listed as exemplary for Neues Bauen. On site of the new retention polder Rappenwört (see Chapter 6 Karlsruhe), they will be protected from floods by sheet pile walls and access will be enabled also during (ecological) flooding. (Karlsruhe Stadtwiki)

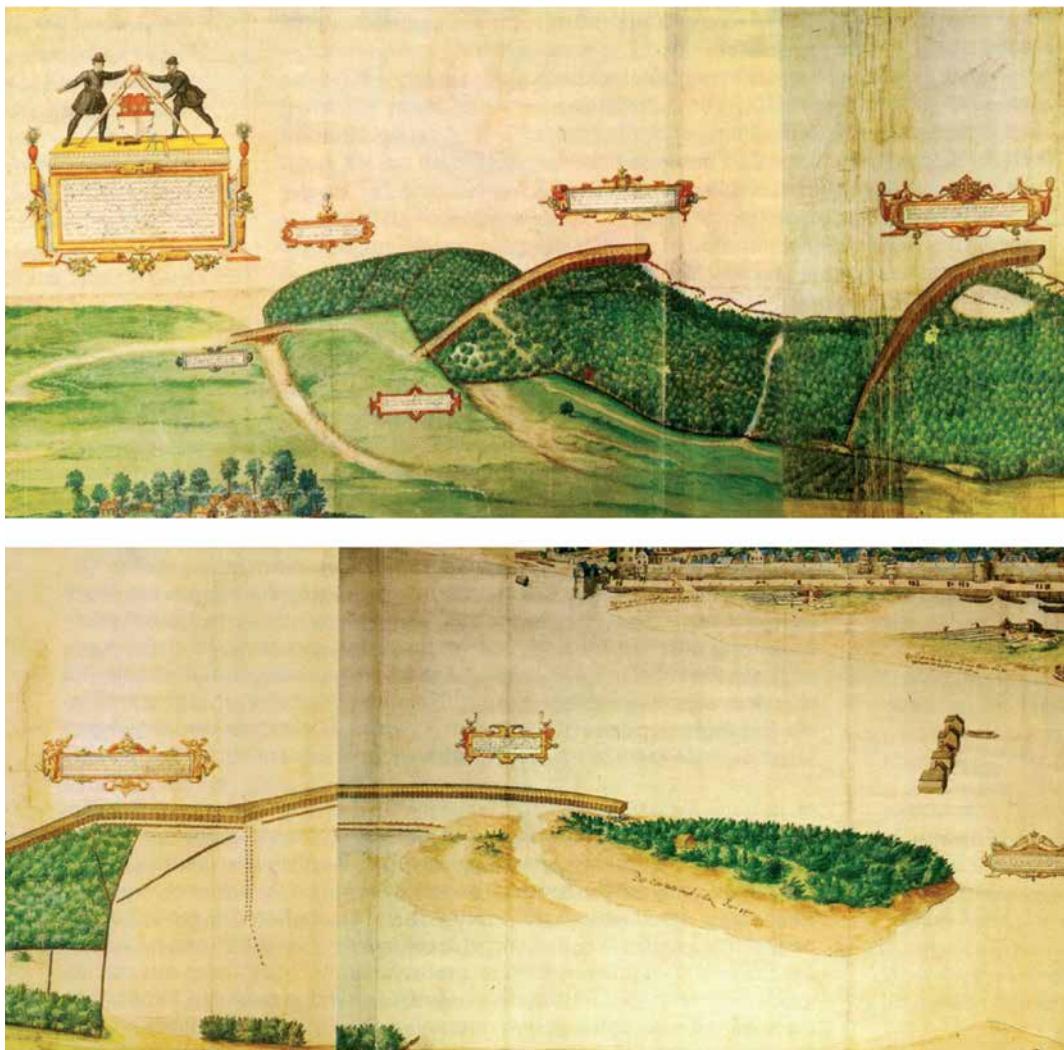


Figure 124

Flotzgrün / Reconnection Of Old Rhine Arm / Rhine km 392.6

Program: artificial island, agricultural area serves as steered retention area, landfill by BASF / Period: decades (gravel excavation), 6 years (polder construction) / Scale: 500 hectares / Flotzgrün is an artificial island as a result of 19th cent. 'Rhine correction'.

On the island an agricultural area serves as steered retention area, and an additional 85 hectares are an endikened landfill by BASF. The former Rhine meander was reconnected when the dike was set back to frame the steered retention polder and as a long-term consequence of gravel excavation. (Struktur- und Genehmigungsdirektion Süd, Neustadt, 2001)



**Figure 125**  
Cologne Poll / Rhine km 672

Program: Strategic development / Period: 12th century / Scale: no information / The river was redirected to avoid a right bank side arm of the Rhine to become the main channel bed as it would have implied a change of centres. This enabled the Roman left bank foundation to remain a location along the main channel and consequently the centre of transshipment activities. (Historical Archive Cologne; Ahrends, Der Strom und die Warenströme, 2007)



Figure 126

Bemmelse Ward / Rhine km 877-881

Program: Increase discharge capacity of the Rhine and create room for the river to improve flood protection, nature-oriented recreation / Period: 2003-2008 (SDF) / Scale: 400 hectares / The Bemmelse Waard is a floodplain on the northern bank of the river Waal, just east of Nijmegen. It is part of the Ooijpolder Land Consolidation Project and the Gelderse Poort Strategic Landscaping Project (Strategisch Groen Project). The area is characterised by a large brickyard and big lakes created by excavating sand. An old channel runs along the dike. The old course of the river Waal will be made visible by linking together and reducing existing clay and sand pits Constructing channels in the floodplain. (SDF Project Brochure 2005, [www.risicokaart.nl](http://www.risicokaart.nl))



Figure 127

Nijmegen / Dike Setback / Waal / Rhine km 883-885

Program: Room for the River project involving a dike setback and bypass in combination with urban extension plans and ecological and recreational program

Period: 2004-2015 / Scale: 80 hectares ([www.risicokaart.nl](http://www.risicokaart.nl), [www.ruimtevoorderivier.nl](http://www.ruimtevoorderivier.nl))

## § 9.1 Nijmegen XI / The River Scale

In the following section bypasses along the Rhine are evaluated in terms of their global relation to the river. Paradigms regarding their development will be mirrored by an atlas. The atlas documents bypasses, planned and realized, along the Rhine. A coherent overview with a focus on the specific typology aims to inform about the flexibility of this flood mitigation typology. Bypasses have been adapted by heterogeneous programs and contexts. This layer also shows where along the Rhine this typology is implemented in terms of flood management, and the paradigms and strategies applied.

### Typology

Along the Rhine, the bypass appears in different roles and contexts. As a natural element of the meandering and bifurcating Upper Rhine, it has been adapted to functions such as an 'island creator' for privileged housing (Kehl) or as a river swimming pool profiting from the reduced current velocity (Karlsruhe). Measures to reconnect old Rhine arms along the Upper Rhine seek to rejuvenate the alluvial plain. As a fully anthropogenic measure, the Canal d'Alsace was constructed to enable shipping and energy production at Kembs, Ottmarsheim and Fessenheim along the Upper Rhine. A historic example shows how side channeling the main current in Cologne can redefine power in relation to space. As a strategic measure for flood channelling, the bypass is being implemented along the Dutch Rhine branches in the Room for the River program. It takes on different forms – as a side channel in the flood plain implying a dike set back, as a conveyance channel within a dike ring demanding for an adaptation of the primary defence line and as a green river also behind the dikes. Its form and scale depends on local conditions. As a flood mitigation measure, it reduces the need for other measures upstream. In the Dutch Room for the River measures, bypasses lower water levels by approximately 30 to 70 cm ([www.ruimtevoorderivier.nl/veessenwapenveld.aspx](http://www.ruimtevoorderivier.nl/veessenwapenveld.aspx)).

### Global Relation to River Basin

As an accumulative strategy, Ruimte voor de Rivier aims to increase discharge capacity along the Dutch Rhine branches. This additional capacity is defined at Lobith. The discharge capacity at the height of the Dutch-German border will increase from 15,000 m<sup>3</sup>/s to 16,000 m<sup>3</sup>/s by 2015 and to 18,000 m<sup>3</sup>/s for the long term, while strategies anticipating long-term capacities are given priority. For the Dutch Rhine branches, the amount of water carried is divided among the different branches. To accommodate future discharge capacities along the Dutch Rhine branches, the Waal has to carry 2/3 of that discharge – about 10,165 m<sup>3</sup>/s for the short term (RWS, 2005).

According to the quick scan study, without clearing the bottle neck at Nijmegen to accommodate the additional 1200m<sup>3</sup>/s along the Waal, large scale dike set backs would be necessary: Beuningen (ca. 3 km, 130 ha), Ooij (ca. 6 km, 550 ha) and further

downstream. Also intensive excavation measures in the flood plain between Lobith and past Thiel would be essential. Estimated costs without plan compensation would amount to approximately 450 million Euro.<sup>23</sup> Measures such as large scale dike setbacks upriver can be avoided when the dissolution of the bottleneck at the height of Nijmegen is capable of lowering water tables 20 to 50 cm. Such a measure could also increase effects of measures down river (10-20cm) and provide capacities for the future within the system (Quickscan, 2000).

### **Forms and Quantity of Appearance**

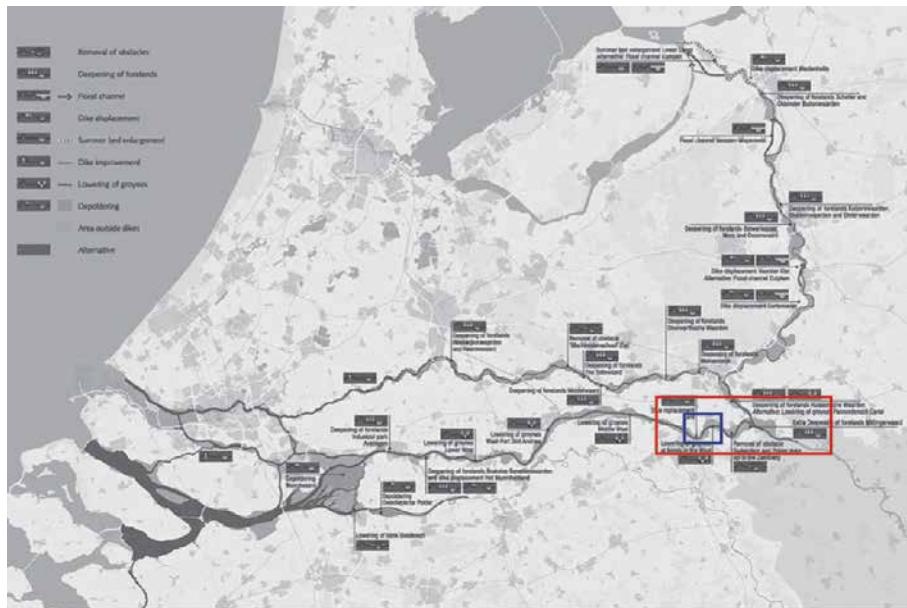
Within the now 39 projected Dutch Room for the River measures, a bypass is applied in five cases for flood channeling of which only three are directly linked to urban development (Nijmegen, Zutphen+Deventer, Kampen, see Atlas).

The bottleneck at Nijmegen plays a special role within this task, as it is not only part of the accumulative measures of the Room for the River program, where the discharge capacity of the flood plain is increased by setting back the dike, lowering the flood plain, installing a side channel or lowering groynes. At Nijmegen, the strongly meandering curvature of the Waal produces a bottleneck leading to a water pile-up. This produces severe effects up river even into Germany (RWS, 2005). Thus, a solution is needed on site at the height of the city itself; the space created would not only add to overall capacity, but also produce relief on the site of the pile up itself (see fig. 128). Due to the topography and previous urban development on the South bank, only the North bank - where the Waalsprong, the planned urban expansion across the river, is projected - offers spatial capacities to host such measures. As a consequence, all possible solutions carry the inherent conflict between river expansion and urban development and involve different political institutions and stakeholders – from state and municipality to the citizens affected.

---

23

1 billion Guilders



**Figure 128**  
*'40 Measures and Alternatives'; (source PKB, 2006) with scale of alternatives (red) and impact of Dike setback Lent (blue)*

### Paradigm Regarding Development

As part of the Room for the River program, the bottleneck at Nijmegen also plays a special role because of the conflict between the existing urban context and the necessary river expanding measures. The flood management measures to cope with the bottleneck must therefore not only adhere to the usual spatial qualities taken into account by RvR measures, but must also synergize with existing urban development plans on site for the right bank of the Waal. Thus, spatial quality is not only a parameter in relation to existing developments, but a pro-active factor in combining large scale transformations of the river with projected developments. This implies a layering of different demands on the same site – flood management in combination with the enhancement of spatial qualities (Nijmegen, 2007) as well as an arrangement with preexisting urban development plans and the existing rural context. The restrictions on site due to navigation provide another layer, which can be considered a precondition for any development.

In relation to the layer approach, this project shows the overlapping of functions and the different reciprocations in development between landscape, infrastructure and urban development resulting from parallel claims (see S). The Dike setback Lent is a rare example where an urban expansion plan and a large-scale morphological transformation of the river on site are planned almost simultaneously. Yet, as stated in

the environmental impact assessment MER of the two alternatives of the dike setback (RWS, 2005), in the hierarchy of this truly synergetic development, spatial quality will always be subordinate to river management in the decision making hierarchy – this also includes the Waalsprong development.

**As a combined measure, the scale of Nijmegen remains exceptional. The Waalsprong as part of the Vinex program is an urban expansion plan that would rarely be developed today on account of a decrease in growth and a change in strategy regarding land consumption (see Chapter 3 / Evolution). However, bypasses remain attractive flood-mitigating solutions for cities as they produce secondary water fronts.**

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## § 9.2 I+I / Initiation And Installation

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### **Initiation**

Rijkswaterstaat  
(Municipality of Nijmegen)

### **Installation**

In its initial analysis of the situation in 2000, the Quick Scan evaluated three possible solutions with their impact not only on the mitigation of water levels, but also on the existing urban extension plans. The Ministry of Traffic and Water (RWS), the municipality of Nijmegen, the polder district Betuwe and the province Gelderland conducted this analysis. In the end, its only feasible proposal was a dike setback in the direct vicinity of the main riverbed.

When RWS introduced the need to dissolve the bottleneck of the Waal at Nijmegen, the municipality agreed under a number of conditions: full state guarantees for eventual damage claims from project developers, the construction of a second bridge across the Waal, the setup of an EIA to consider other alternatives and that local stakeholders would have a voice (Cuppen, 2012). This trade-off between larger scale mitigation aims and local interests shows how incentives for the local scale may trigger acceptance and may serve as a further basis to enable local emergence.

1993	Development vision KAN (urban development KAN region including Waalsprong)
1996	Structuurplan Land over de Waal Spatial vision of the municipality for the main plan of the Waalsprong
1996-98	Grenscorrecties The adjoining parishes Elst, Valburg and Bemmel are suburbanized by Nijmegen
1999	building development starts – first houses in Oosterhout
2000-02	Discussion Note Room for the River by RWS
2000	Quick scan conducted by the ministry of traffic and water (RWS), the municipality of Nijmegen, the polder district Betuwe and the province Gelderland
2001	building stop – a new environmental impact assessment is demanded by the state council
2003	Voorkeursmodel – college of Nijmegen presents an updated version of spatial vision plan
2003	housing developments in Visveld and Oosterhout begin after results of MER
2004	Nota 'De weg naar Bestemmingsplannen', report 'The Way to the Zoning Plan' GEM Waalsprong and Ontwikkelingsbedrijf present a Vorkeurmodel with special focus on the qualities of the river for the urban development
2006	Dike set back (based on Plan Brokx version) passed by first and second chamber as part of the Planologische Kernbeslissing 'Ruimte voor de Rivier' (PKB RvR)
2007	Hoofdlijnen by RWS with Royal Haskoning, Alterra, Oranjewoud
2007	Spatial Plan - Dike Set Back Lent by the municipality of Nijmegen
2007	Main traffic structure is approved by the city council
2009-11	Final design phase: EIA report, zoning plan, dike setback, plan for waterboard
2012-15	Realization phase: dike construction, digging of side channel, bridge construction

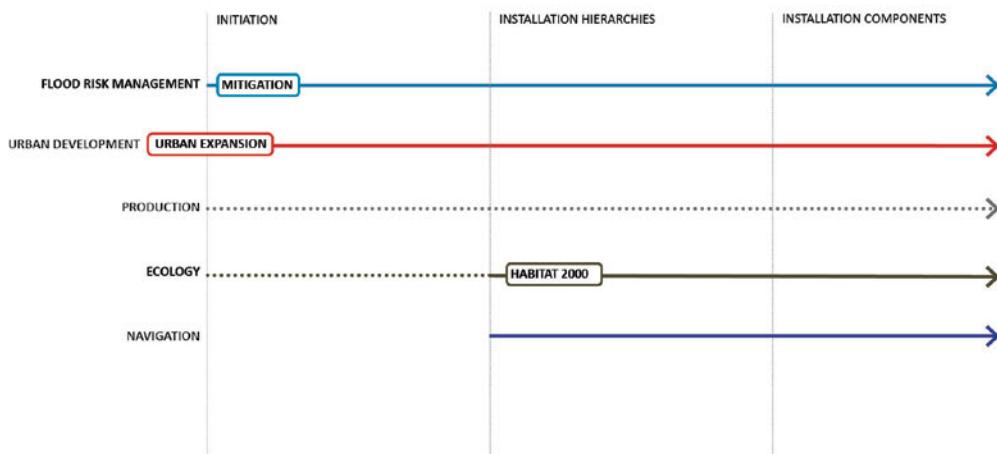


Figure 129  
Initiating program, installation hierarchies and installation components (data sources: Nijmegen 2003, 2007, Cuppen, 2012).

There were two alternatives of this plan in the direct vicinity of the main riverbed: a dike setback by 350 m with the excavation of a side channel in the flood plain to reduce water levels (known as Plan Brokx) or the version known as the Lentse Warande, developed by inhabitants together with Prof. van Ellen as a reaction to the proposal by Rijkswaterstaat. These were the content of further discussion and were also evaluated in the Environmental Impact Assessment in 2005. Planning approval was given for the Dike set back Lent (an update of the initial Plan Brokx) as part of the 40 measures in the Room for the River program in the Planologische Kernbeslissing Ruimte voor de Rivier (PKB) by the Dutch government's first and second chamber in 2006.

In 2007, the urban development vision Ontwikkelingsbeeld was a follow-up to the Vorkeursmodel and passed on the municipal level as an informal planning tool. It incorporates a much greater diversification of the housing development with a mix of other programs. In January 2007, the Ministry of Traffic and Water set up the main design guidelines Ontwerp op Hoofdlijnen for the dike setback; it included all the hydraulic and project-engineering measures until 2015 based on a systems-engineering approach. These guidelines together with the systems engineering approach served as the basis for the spatial plan Ruimtelijk Plan Dijkteruglegging Lent, the Spatial Plan that the municipality developed and finalized in December 2007. The project is currently in planning and will start to be implemented in 2013. 2008-2011 were projected for the final design phase, an ecological impact assessment, the zoning plan, and the dike relocation plan for the waterboard (see fig. 129).

### § 9.3 M / Local And Regional Context

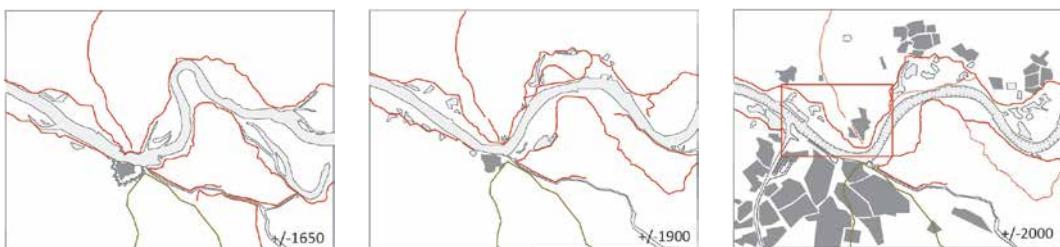


Figure 130  
Pre-Industrial / Industrial / Trans-Industrial Nijmegen (graphic by author)

To analyze the project of resolving the bottleneck within the urban context of the Nijmegen / KAN region, it is necessary to understand the impact of the different

alternatives evaluated by the different institutions /stakeholders involved. The following text summarizes the different aspects that led to the solution in the flood plain that will be implemented. In terms of flood management, the decisive parameters to weigh the alternatives were the assessment of both the risk and durability produced by the new situation and the infrastructural impact on the Waalsprong's urban expansion plan's water system, as well as previous investments made.

### **The Waalsprong in the Context of the City**

#### **Region**

The region Arnhem-Nijmegen has a relatively modest water-bound economy (container transshipment). Research and development activities of the Wageningen University are strongly linked with the green ports. Apart from flood protection, the economy of the east of the Netherlands is not as strongly linked to water as the Rhine-Maas Delta (Pelt et al, 2011).

As a left-bank Roman foundation (see fig. 130), Nijmegen developed first expansion plans across the Waal in 1993 (development vision KAN) which led to the plan 'Het Land over de Waal' in 1996 (see fig. 133). The parishes Elst, Valburg and Bemmel were suburbanized by Nijmegen to do so (total investment of ground acquisitions 150 million Gilders being about 68 million Euro). Due to the curvature of the river at the height of the city, the Waalsprong completes the circle of the existing urban development, creating a cross-river development. Instead of expanding into a third ring on the already urbanized left bank Waalfront, this decision provides a compact European city model. Interestingly, the urban extension plans, known as the Waalsprong, are simultaneously part of the regional development strategy Knooppunt Arnhem-Nijmegen (KAN), based on a traffic infrastructure development. As a development strategy, the Waalsprong thus represents compactness while creating an orientation towards Arnhem (see fig. 131-2). As part of the Vinex program, there were originally to be 10,000-12,000 dwellings and 50 ha of commercial area. Within the Waalsprong development as an existing European city model, this is not typical, since the planning of most Vinex sites was mainly connected to strategic infrastructure hubs rather than as parts of existing cities. The plans for both the new city centre at the heart of the Waalsprong and its mixed use contrasted the average Vinex development, although in a relatively modest form (see Mensink, Boeijenga, 2008).

The Waalsprong is part of the dike ring 43 with a safety level of 1/1250 per year based on the exceedance possibility of the mean water level (MHW). The planned water management system for the Waalsprong includes a retention channel behind the dike to take up seepage and rain water that will be cleaned and collected in two retention basins supplying surface waters in the ring ditches (water singels) of the Stadseiland and the Dorpzone during dry periods (RWS, 2007).

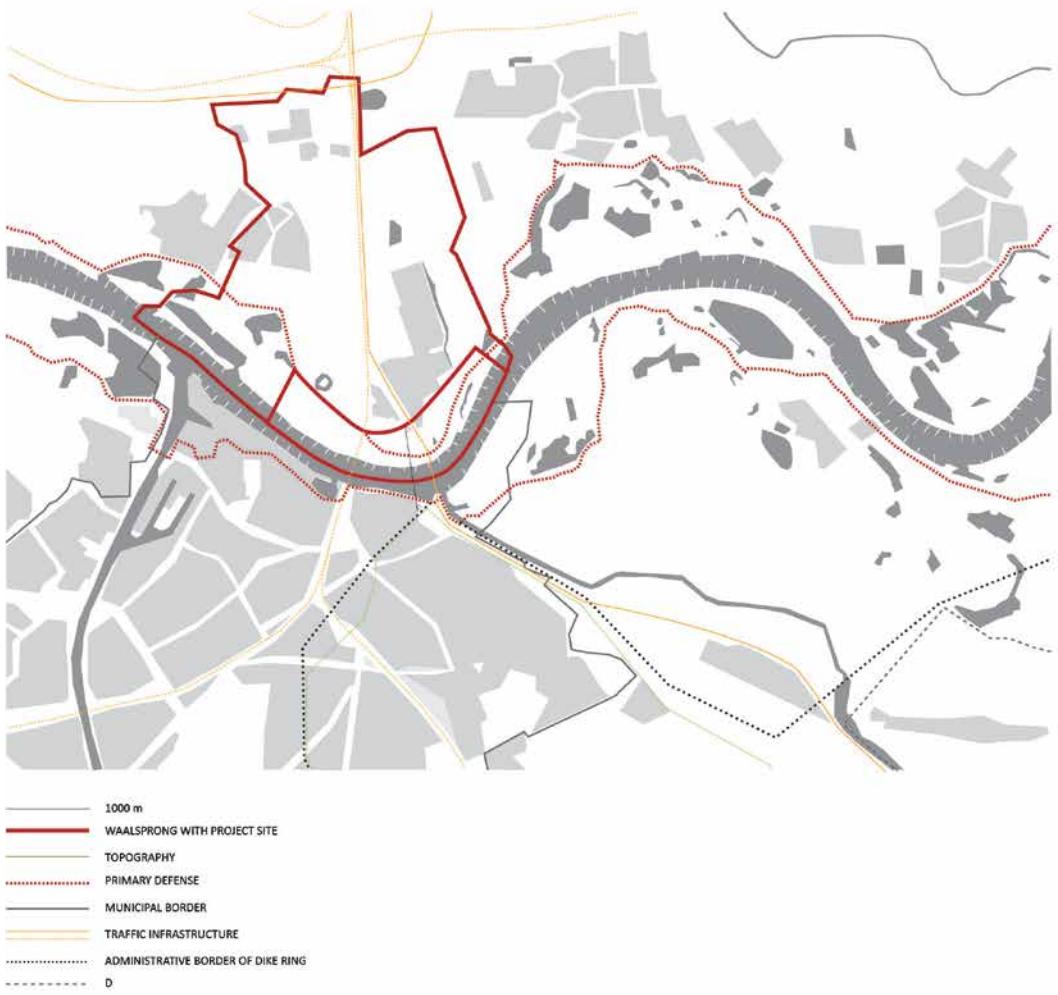


Figure 131

Nijmegen with project sites Waalsprong and Dike Setback Veur-Lent Section Dike Setback with new side channel (based on Spatial Plan, 2007; Limes Atlas, 2008)

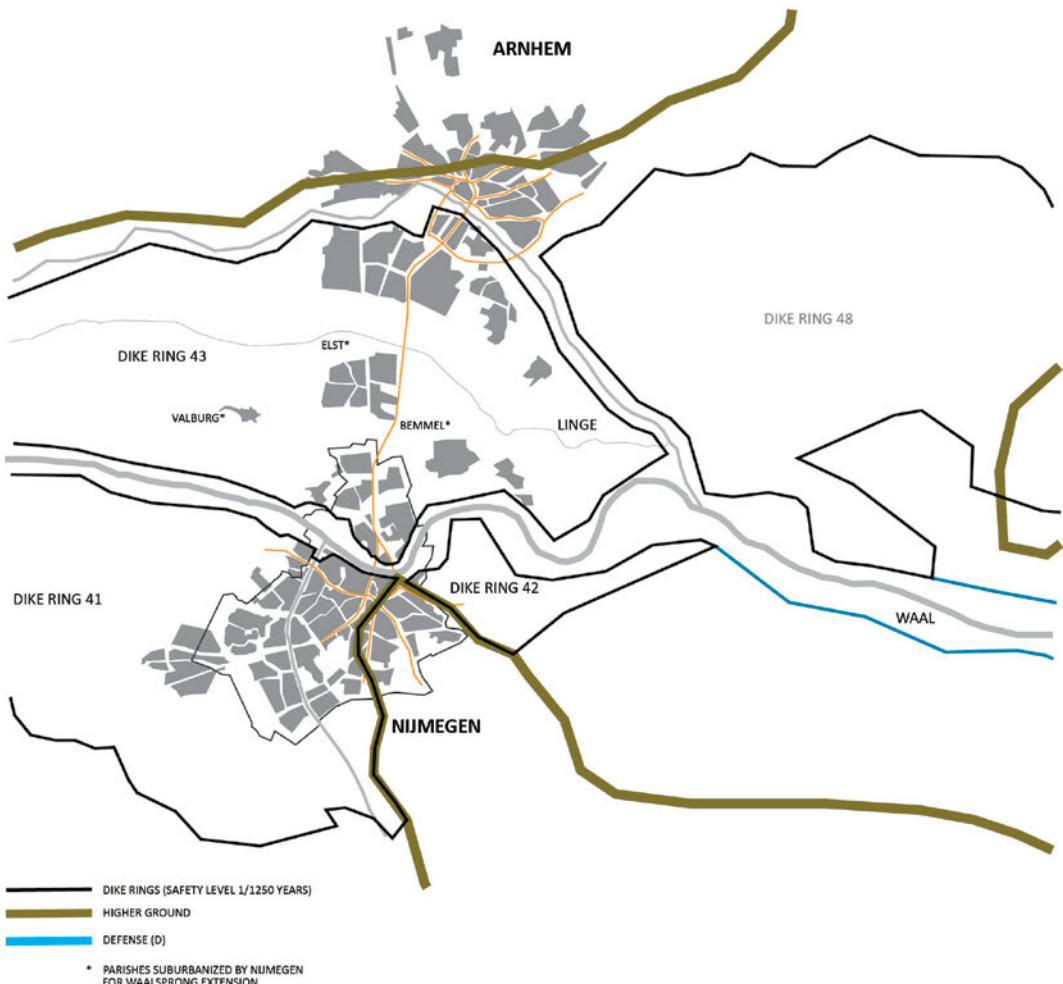


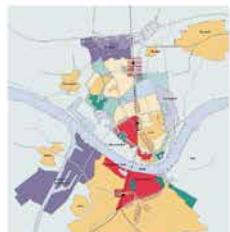
Figure 132

Urban Network KAN Region (based on VNK Dikering gebieden kaart 10, dike ring map, RWS; Urbanization and political border The big KAN Atlas, 2003)

## URBAN EXPANSION PLAN



STRUCTUURPLAN HET LAND OVER DE WAAL 1996<sup>1</sup>



VOORKEURSMODEL WITH  
A NEW CITY CENTRE WITH-  
OUT DIKE SETBACK 2003<sup>2</sup>



VOORKEURSMODEL WITH A  
NEW CITY CENTRE WITH  
DIKE SETBACK 2003<sup>2</sup>



ONTWIKELINGSBEELD 2007 development plan with elongated side channel and self-supporting water system for rain and seepage water harvesting in the Plassen (the rain water reservoirs)<sup>4</sup>

## RIVER EXPANSION PLAN



Three alternatives QUICKSCAN 2000<sup>2</sup>



Dike setback now based on PLAN BROKK 2005<sup>2</sup>



Dike setback later  
based on LENTSE WARANDE 2005<sup>2</sup>



DIKE SETBACK NOW - optimized  
based on PLAN BROKK 2005<sup>2</sup>  
also used for HOOFDLIJNEN 2007<sup>1</sup>

**Figure 133**  
Urban Expansion and River Expansion (sources: RWS, et al, Quickscan, 2000; RWS, Projectnota / MER Dijkteruglegging Lent, 2005; RWS, Ontwerp op Hoofdlijnen, 2007; Municipality Nijmegen, Spatial Plan, 2007)

## **Alternatives for the Dissolution of the Bottleneck**

To dissolve a bottleneck in the river, three measures are possible: a widening of the cross profile, a deepening of the cross profile or a bypass through the inner dike area can mitigate water levels (RWS, 2000). For the Dike set back Lent, five main alternatives have been investigated. Two larger scale solutions through the inner dike area, the Bypass Landschapszone and the Bypass Noord, abandoned at an early stage in the project, and two solutions which aimed at solving the problem in the flood plain of the main river bed, Plan Brokx and the Lentse Warande. The Lentse Warande was developed as an alternative to Plan Brokx by citizens advised by Prof. van Ellen, a retired hydraulic engineer. The fifth and final version in the Spatial Plan Dike Setback Lent in 2007 shows a solution based on a further development of Plan Brokx (see fig. 133).

The following section describes the Nijmegen case study's four alternatives and the further evolution of the Lent dike setback, specifically regarding their impact on the existing plans of the Waalsprong in the context of the city and region as a whole (see fig. 134-5). It includes an analysis of their inherent conflict potential, dissected according to the layers landscape, including the water system and the morphological transformation, infrastructure and urban development, and non-spatial aspects such as economical and political factors. The reciprocations between layers illustrate the temporal and scalar interdependencies of this approach towards flood mitigation and how this relates to the negotiation of the border between city and river. In the first study of possible solutions in 2000 (Quickscan), the following aspects were analyzed: the direct influence on water levels, the durability of the measure, spatial consequences and financial consequences. The results are summarized below.

### **Bypass Noord**

The bypass Noord was planned as a green river from the flood plain Bemmel to the flood plain Oosterhout through the Northern zone of the Waalsprong area planned to inundate during every flood. Altogether, three new polders will evolve from this plan: Stadseiland Lent, Landschapszone and Waalspronggebied. The 'Bypass Noord' was investigated with a width of 300-500 meters, with and without further excavating the conveyance channel created by the aligning dikes. The different solutions could have lowered water tables by 35-85 cm. It was discarded for various reasons.

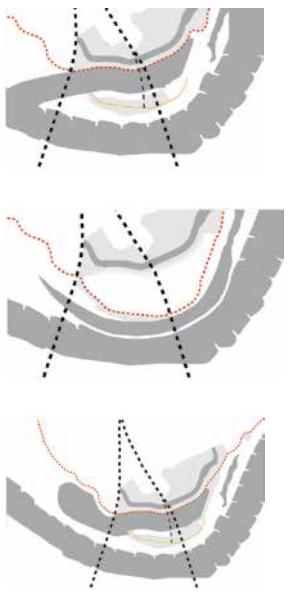
### **Landscape**

The bypass Noord would create a new, low-lying island with a large-scale housing development would be created between the main river with the primary dike and the conveyance channel with its aligning dikes also with eight-metre height in the landscape. In case of inundation, water levels would rise very quickly in these polders – two meters after only a few hours and five to six meters, the maximum inundation depth, after only 14 hours.



Figure 134

Alternatives investigated in Quick Scan Study (original graphic: Quick Scan, RWS, 2000; Urbanization, political border The big KAN Atlas, 2003)



**Figure 135**

*Lentse Warande vs. Plan Brokx as the two solutions in the direct vicinity of the river (original graphic: Quick Scan, RWS, 2000, Spatial Plan, Nijmegen, 2007 adapted by author). Plan Brokx - set back of primary dike and side channel in the flood plain. Lentse Warande - side channel in the flood plain and space reservation for future measures behind the primary dike. Dike Setback Lent - improvement of Plan Brokx with urban island and side channel expansion in favour of flood management and navigation*

It would have no larger influence on the planned water management system for the Waalsprong. The area to the North of the green river would remain part of the polder annex Lingesystem and could become part of the water system for the future commercial development of MTC Valkenburg. However, as a consequence of the greater dike length, seepage problems would increase for the stadsdeelpolder. In case the bypass would disconnect the water management system from the Linge, an independent discharge system would have to be developed. It would ensure that the seepage problematic would not have a negative effect on the Linge system. The existing village Oosterhout and Woonpark Oosterhout would become part of the new polder Waalspronggebied. As a green river would likely inundate at every flood, the bypass would also contribute to the awareness of its primary function as a flood conveyance channel.

## **Infrastructure**

The existing infrastructure would be heavily affected by the considered development due to the direct vicinity of the A15 freeway and the train tracks. Heavy adaptations of the infrastructure would become necessary involving a large part of overall costs: a junction between the new dikes lining the bypass and the A15 and train tracks. The train tracks and the A325 (Prins Mauritssingel), the Griftdijk and the Zandestraat and Dorpsingel would also need adjustment. For local infrastructure, such adjustments would be smaller. As an additional physical border, the bypass with its aligning dikes would only affect the spatial connection of the Waalsprong with the Overbetuwe region (Arnhem, Bemmel and Elst).

## **Urban Development**

In terms of composition, the bypass Noord could round off the Waalsprong development, creating a physical border between Nijmegen's right bank development and the surrounding KAN area. As the bypass would have to be realized in a zone reserved for future developments (post-2005), it would not interfere with projects currently executed, but would offer the possibility of adapting existing plans. It would therefore not affect the VINEX development: its goal of building 6500 dwellings could be met by 2005. However, the demolition of 50-75 existing dwellings and businesses would be inevitable. In terms of plan adaptations, the zoning plan for the Waalsprong would remain intact except for the MTC and de Grift along the A15.

## **Non-Spatial Parameters**

With an equivalent of 900 million Euros, the Northern bypass would be the most costly solution of the three alternatives evaluated in the Quick Scan in 2000. Limited ground is owned by municipality on site of the bypass as parts of the site are located in the parishes of Bemmel and Valburg. In the future, not only the risk but also the maintenance costs would increase because additional dikes aligning the bypass to both sides would expand the overall length of the dikes. Also, the commercial site MTC planned on site would imply negotiations as to where and how business units could be realized in the future.

## **Summary**

All together, this measure sustains the spatial coherence of the Waalsprong plans. However, it is not durable in terms of newly produced risk and costs.

## **Bypass Landschapszone**

The 'Bypass Landschapszone' was also planned as a green river from the flood plain of Bemmel, through the landscape zone, to the flood plain of the village of Oosterhout. The 'Bypass Landschapszone' would create three new polders - the city island Lent, also called the Dorpspolder, the Oosterhout housing park and Ressen park. The bypass was investigated with a width of 300-500 meters, with and without further excavating the conveyance channel created by the aligning dikes. The different solutions could have

lowered water tables by 40 to 60 cm. The 'Bypass Landschapszone' was discarded for similar reasons as the 'Bypass Noord'.

### **Landscape**

As a green river planned to inundate at every flood, the bypass would also contribute to the awareness of its primary function as a flood conveyance channel. Yet, due to the creation of three polders, the risk would increase as small polders flood at a faster rate. The newly created Dorpspolder would be fully inundated after only 10 hours. In addition, the water management system of the Waalsprong would no longer function, as the originally foreseen space for the retention basins were projected on the site of the planned bypass. A whole new water management system would have to be developed for the Waalsprong. As there is no compensation space available for the retention basins, this would imply a loss of supply water of 1 million m<sup>3</sup>/year. The village polder Lent would be cut off from the water management system of the Linge, making an independent drainage system necessary. In that way, the seepage level on the Linge water management system would not increase either. The polder-annex Linge system could be realized according to the original Waalsprong plans. Water for the village polder would have to be supplied via the large polder.

### **Infrastructure**

Infrastructure (sewerage, etc.) of the Waalsprong plans would demand for a high degree of adaptation in this version of the conveyance channel. Traffic infrastructures would be affected, specifically the train tracks, the A325 and the Dorpensingel, Griftdijk and Zandestraat; the same holds true for local traffic structures Leimate, Oosterhoutse and Bemmelse Dijk.

### **Urban development**

This proposal undermines the planned spatial coherence of the Waalsprong by creating three new polders - the city island Lent, Oosterhout housing park and Ressen park, also influencing commercial development. Existing urban expansion plans including the VINEX development would be more severely affected. The compensation space would be affected as well. About 30-45 dwellings and businesses would have to be demolished. Also housing development meant to achieve a higher degree of diversity would simply end up a reproduction of housing behind dikes with views of the dike. The 6,500 VINEX dwellings to be built by 2005 could not be realized.

### **Non-Spatial Measures**

Part of the 'Bypass Landschapszone' would be on the ground of the parish Bemmel. The municipality would have to acquire the Northern zone of the Stadseiland and de Woerdt (parish Bemmel) and demolish existing buildings. There would also have to be a number of plan adaptations and juridical adjustments.

## **Summary**

All together, this measure does not sustain the spatial coherence of the Waalsprong plans. Also, in terms of newly produced risk and costs, the solution is not durable.

## **Dike Setback Veur-Lent**

The Dike Setback Veur-Lent implies a dike set back of a minimum of 200 m over a length of 2 km, between the train bridge and the Waal bridge, with an option to excavate a side channel in the outer dike area. This would reduce water levels by 20-50 cm. The concept of a dike set back in the direct vicinity of the main riverbed was the only proposal that appeared feasible from the Quickscan study.

## **Landscape**

The set back of the dike would lead to the creation of one or two islands as bridge heads for the two existing bridges. The ring-ditch (watersingel) envisaged in the water management system of the Waalsprong would have to be given up because it was on the site of the projected new dike. To provide dike stability, the ring-ditch would be positioned about 80 m away from the dike. This distance could only be reduced if the seepage way length was guaranteed through the implementation of alternative measures. In any case, ground water levels would rise inside of the dikes. Large parts of the retention necessary for the Stadseiland were in the dike zone. The ring-ditch would contain 12,5 ha for retention purposes, taking into account future sealed surfaces in the village for Lent.<sup>24</sup> It was undesirable to have the dike setback prevent this development, and neither was splitting the singel in two. The exchange and renewal of surface water would become impossible leading to a negative impact on water quality.

## **Infrastructure**

In terms of large-scale infrastructure, the project would significantly affect only the Waal Bridge and the train tracks. It would also mean adapting the local routes: Griftdijk Noord, Past van Laakstraat, the dikes of Oosterhout and Bemmel.

## **Urban Development**

50 to 100 dwellings and businesses would have to be demolished. The newly created island would need to be developed in a way that would connect it to the centre. The VINEX goal of 6500 dwellings would not be met by 2005 as 2475 dwellings could no longer be realized. Vossenpels, today a green house area, would need to serve as

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24. According to the Regional Plan KAN 2005-2020 9% of the gross space coverage should be surface water or as agreed upon with the waterboard. In plans where the sealing of ground is more than 75% a higher degree of surface water is needed.

a compensation site for the planned housing development in order to provide short distances to the Waalsprong to guarantee the viability of businesses.

### **Non-Spatial Measures**

The estimated costs would amount to about 25% of the Bypass Noord. This would include the acquisition and demolition of parts of Veur-Lent and de Schans as well as the area around A325

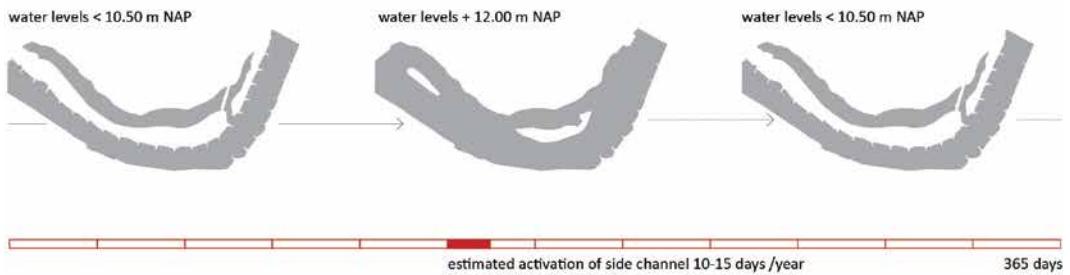
### **Summary**

The Dikes setback Veur-Lent proves to be more feasible in terms of producing new risk and also in terms of costs. The impact on the Waalsprong development is also quite high, but infrastructural conflicts are not as severe as in the other two cases.

### **Two Alternatives in The Direct Vicinity of the Riverbed – Plan Brokx and Lentse Warande**

The Environmental Impact Assessment in 2005 further discussed and evaluated two alternatives to Plan Brokx in the direct vicinity of the main riverbed: either a dike setback by 350 m with the excavation of a side channel in the flood plain to reduce water levels (known as Plan Brokx), or the version known as the Lentse Warande, developed by inhabitants together with Prof. van Ellen in reaction to the Rijkswaterstaat proposal.

While Plan Brokx produces a robust water level reduction of 27 cm to the east of Nijmegen (Koridon et al, 2007) and proves capable of accommodating the long-term discharge capacities already by 2015, the Lentse Warande proposes an implementation of the short term of 16,000 m<sup>3</sup>/s until 2015 with space reservations for possible future measures.



**Figure 136**

*Discharge Capacity and Flood Frequency: Average number of days when side channel is activated and increase of the discharge capacity of the Waal river by about 1/3 when the discharge at Lobith reaches 16000 m<sup>3</sup>/s (10.165 m<sup>3</sup>/s along Waal) (based on Spatial Plan, Nijmegen, 2007) and Project Site (Photo: Siebe Swart)*

For the short-term, the Lentse Warande proposes a channel in the outer dike area. Inside the dikes, space would be reserved for a future dike set back, serving as a park until then. This measure is capable of accommodating 16,700 m<sup>3</sup>/s without a raise in water tables today, but would require reserving space in order to set the dike back to provide discharge capacities of 18,000 m<sup>3</sup>/s at Lobith as a long-term solution (RWS, 2005). By extending the flood plain expansion of Plan Brokx towards the Oosterhoutse plain, water tables up river could also be lowered in the long term (RWS, 2005). One of the main arguments by those in favour of the Lentse Warande is that only seven instead of 50 buildings would have to be demolished.

### **Effects on the Waalsprong**

The reaction to the environmental impact assessment of the Waalsprong, the already existing urban expansion plan for the city of Nijmegen, provoked the development of a Vorkeursmodel or model of preferences. It suggested moving the new city centre to the riverfront further west from its previous position in the centre of the Waalsprong in order to create greater coherence with the city as a whole. A new city bridge would connect this new city centre (Koridon et al, 2007). The space for the side channel would be integrated in this plan, creating the island of Veur-Lent, which would also be connected to the dike Bommel via a new bridge. Overall, the previous urban expansion plan in the Fourth Nota Spatial Planning Extra (VINEX), with up to 12,000 dwellings and 50 ha commercial area, would be carried out with a reduced number of dwellings but a secondary water front, creating a more diversified border situation for this new neighbourhood. In 2007, the Ontwikkelingsbeeld, the urban development vision of the Waalsprong as a follow-up of the Vorkeursmodel was passed on the municipal level as an informal planning tool. It incorporated a much greater diversification of the housing development with a mix of other programs.

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## **§ 9.4 Small - The Project Scale**

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On the project scale, the dike setback and side channel Veur-Lent is a flood mitigation measure, an urban development and a landscape rejuvenation project. The following text elaborates the morphological interventions, the temporal organization and the infrastructural support demanded to enable installation.

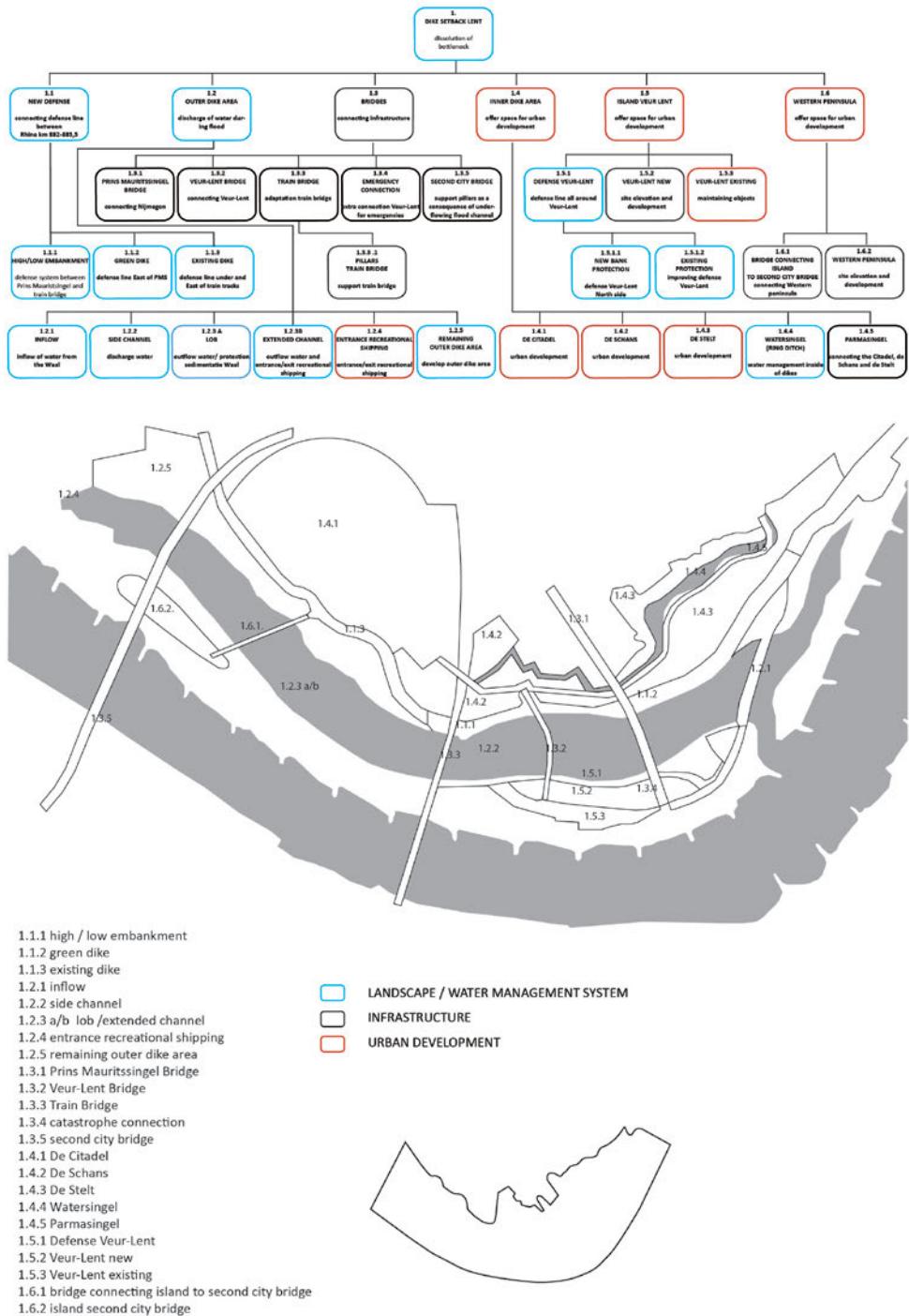


Figure 137

Elements of Dike setback Lent (Spatial Plan Dijkteruglegging Lent, Municipality of Nijmegen, 2007).

In the project 'Dijkteruglegging Lent' the river dike will be relocated by about 350 metres. The dike setback in combination with the excavation of a side channel will give the river Waal (see fig. 136) more space. The side channel is constantly carrying water, but will only be exposed to the current when the inlet sill is exceeded, which is foreseen for about 10 to 15 days per year. All together, fifty houses will have to be demolished, but most of the existing houses on the riverside of the existing Oosterhoutse dike can remain. The plan integrates the new dike as an urban embankment to be built on. Dwellings, commercial uses and restaurants. This creates a vis-à-vis to the existing city and transforms the formerly convex rural riverfront of the existing flood plain with a gradual slope into a hard, orthogonal, very urban waterfront. This will become the most prominent public space of the development. This waterfront, positioned between the bridges is designed as a terraced quay in order to overcome the height difference between average water levels of 6 meters NAP and the upper level of the quay of 16,25 meters. This hard quay ends with floating piers that serve as a marina. The newly created quay will continue below the bridges to enable a good connection with the sides of the dikes. Furthermore, an island, created in the flood plain, will be partly urbanized - three hectares have been negotiated by the municipality as space reserved to become a representative part of the Waalsprong. This part of the island will be elevated. The existing Oosterhoutse Waarden pastures will become a central park for the city of Nijmegen. Together with the area of the dike set back, they provide a nature area connecting the Gelderse Poort and the Biesbosch. The development concept for the park assumes a continuous side channel flowing into the Waal in the West between two groyne fields (Koridon et al, 2007).

It is necessary to differentiate between the primary requirements for the flood mitigating system of the bypass and the additional morphological transformations, infrastructural appropriations and object adaptations that enable the other programs on site: flood-resilient urban development and the navigability of the Waal. The amended systems-engineering diagram of the Main Design Guidelines illustrates which elements of the systems tree primarily relate to flood mitigation and the inherent defensive system and which elements serve urban development and navigation (fig. 137). Nevertheless, neither the outlet that serves as an entrance for recreational shipping and urban development nor the required raising of the Veur-Lent island are considered fundamental to the dike setback plan. However, they are included in the main design guidelines (RWS, 2007).

### **Morphological Transformations in Relation to the Programs on Site**

The dike set back and the excavation of the side channel imply a massive transformation of the existing morphology. To withstand erosion during flooding, the sensitive parts of the side channel must be lined (Koridon et al, 2007). In terms of analysing the project requirements, it becomes clear that not only flood-mitigating measures, but consequently urban development and navigation necessitate morphological appropriations in order to create a synergetic program. At the same

time, a large part of the site remains unchanged. As the navigation channel in the main riverbed needs to be preserved in its function, the northern waterfront, with its existing groyne structure on the main riverbed, remains unaffected. The site on the island that is reserved for urban development as well as the planned urban embankment need to be raised in order to provide the adequate flood-safety level outside or as part of the primary defence line. At the height of Prins Mauritssingel, the street connecting Nijmegen and Arnhem, the flood level to be considered is NAP +15.25 meters with a safety level of 1/1250. The height requirement of the island is up to the new developer. A height of NAP +15.25 would meet the required depth (ontwateringsdiepte) (RWS, 2007). A ring ditch and a dam wall in the new dike will provide the infrastructure necessary to avoid expected seepage inside of the dikes. The opening for recreational shipping is planned between groyne number 369 and 368, but another position is also possible. However, the outlet may produce sedimentation in the main riverbed. The side channel itself therefore needs to be extended beyond the opening, producing a languet in the Oosterhoutse Waard (RWS, 2007). The level of the languet bed is 2 meters + NAP and over a length of 400 meters it slopes gradually to a height of NAP +10m. The groynes at the height of the languet will stay in place, but must be reinforced. (RWS, 2007)

### **Reciprocations between the Main Design Guidelines and the Spatial Plan**

The adaptations of the Spatial Plan also further optimize the Hoofdlijnen plan, in terms of its hydraulic impact. As the side channel is expanded further to the pond in the Oosterhoutse Waarden, pile up is avoided in the side channel, improving the aspired water table reduction of 27 cm (according to PKB) to 35 cm. The opening between the groyne fields for private yachts remains. Also the land tongue is raised and protected by a summer dike and the inner slope to the North is made less steep. In addition, the bridge pillars, based on reference designs, are integrated in the hydraulic model to calculate their effects. Another effect of the dike setback is the influence on the water system for the inner dike area, specifically for the village Lent. It extends the already established design of a seepage barrier beyond the clay layer to the first water-carrying sand layer in the new dike. In the Hoofdlijnen, a budget is reserved for unforeseeable future measures to manage ground and surface water levels. In order to avoid extra seepage behind the new defence line, there is a new water connection in de Schans and in de Schelt that connects the Rietgraaf with the watercourse along the Turennensingel.

### **Infrastructural Appropriation Concerning Urban Development**

Urban development within the bypass development but outside the primary flood defence demands a degree of infrastructural appropriation to ensure accessibility, even during high water levels, and a possible evacuation of the island. Apart from the links created by the extended Waalbridge, the train bridge to the Veur-Lent peninsula/ island and a new city bridge as part of the project agreement with RWS, two smaller bridges will connect Veur-Lent directly with the northern waterfront of the Waalsprong.

The inlet sill will also accommodate the necessary technical infrastructure, while functioning as an additional connection between the Bemmelse dike and the island.

### **Object Adaptation (Urban Development)**

It is expected that seepage and a rise of ground water levels will significantly affect the neighbouring sites. Although a projected dam wall will reduce additional ground water levels in comparison to the 1993 flood, there is no dam wall in the area to the West where ground water levels will increase by about 20 cm (RWS, 2007). Without additional measures, the inner dike water system will be affected during high water levels (RWS, 2007). This will most likely necessitate more adaptations on the building scale. Furthermore, flood protection on an object scale for existing buildings on the island with a cultural value worth preserving is required.

### **Non-Spatial Aspects**

**Change in responsibilities:** Due to its position outside of the primary defence system, a primary flood defence no longer protects the urban development on the island. Thus the waterboard is no longer responsible. Instead the responsibility lies in the hands of the project developer, which in this case is expected to be the city. This implies that flood resilient site development – taking high water levels and strong currents in the main river bed and in the side channel during floods into account – is in the responsibility of those developing the site. The waterboard, however, has to make sure that the municipality is taking the necessary measures on the island. The project developer has to define safety levels and organise accessibility, evacuation and the management of supplies. According to the Main Design Guidelines, the situation for the inhabitants of the island is comparable with those in the Maas area that is not endikened (RWS, 2007). In terms of seepage, an extra budget is set aside by Rijkswaterstaat to compensate for future measures which can not be foreseen at this state of the project.

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## **§ 9.5 E / Extract**

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**XL / TYPOLOGY** As a typology, bypasses are instrumental for all programs (navigation, urban development, ecological rejuvenation, energy production, geopolitics, etc.). As a flood mitigation measure, they are part of the Dutch Room for the River program.

**GLOBAL RELATION TO RIVER BASIN** In the case of Nijmegen, a local solution is needed. The dike setback and bypass not only add to an overall capacity as part of an accumulative measure, they also produce relief for the bottleneck of the Waal on site. Alternative solutions would have required transnational large-scale mitigation measures (RWS, 2000). **PARADIGM** Spatial quality is not only a parameter in relation to existing developments, but in a pro-active way as large scale transformations of

the river are combined with projected urban developments – however, always as a secondary aim. In relation to the layer approach, this project shows the overlapping of programs and the different reciprocations in developments between landscape, infrastructure, and urban development, as a consequence of parallel claims between urban development, flood management and navigation.

**I+I / INITIATION** Rijkswaterstaat initiated the dissolution of the bottleneck as a top-down decision. The measure competed with previously initiated urban expansion plans by the municipality but was resolved through a negotiation process where the city could formulate demands (Cuppen, 2012 forthcoming). **INSTALLATION** The planning process was accompanied by different public participation procedures that culminated in an alternative plan. A systems-engineering approach was chosen to coordinate hydraulic and spatial measures. The Quality Team supports local agencies in carrying the measures out to ensure the secondary program goal of spatial quality.

**SMALL / PROJECT SCALE...MORPHOLOGY** Apart from the primary morphological transformations of the dike set back and channel installation, additional morphological adaptations are mandatory to accommodate urban development and ensure the navigability of the Waal. Furthermore, the complete river side of the island is not transformed to maintain its primary function as part of the shipping lane morphology.

**RESPONSIBILITIES** Development in the flood plain implies a change in responsibilities. The urban development of the Veur-Lent island is no longer the responsibility of the water board, but in the hands of the project developer (RWS, 2007). **CONSTRAINTS** The expected seepage problematic creates uncertainty for the urban development behind the primary defence. Due to the construction of the dike as an embankment with building development, future defensive measures will be difficult to realize. (Stalenberg, 2009)

**MEDIUM / LOCAL AND REGIONAL CONTEXT...ECONOMETRICS** The dike setback provides a reduced dike line to the status quo, reducing both risk and maintenance costs and influencing the Waalkade positively (Stalenberg, 2009) **LINKING PROGRAMS** The secondary waterfront and island add spatial qualities and offer additional waterfront sites. **LAND VALUE** While the land surface will decrease, land value may partially (have to) increase due to the vicinity of the water and the views created for the first and possibly second row of housing and also for the Citadel, as the new centre, raised to the height of the dike crest to enable views onto the river.

**LEARNING FROM...** The **STRATEGIC DESIGN** (spatial quality as a vital program component of the Dutch Room for River Measures, supported by the transdisciplinary Quality Team that links the river scale with local potential) and the spatial design (combining flood management, urban development, nature development and navigation on site) as part of a compact European City model are exemplary for urban flood integration.

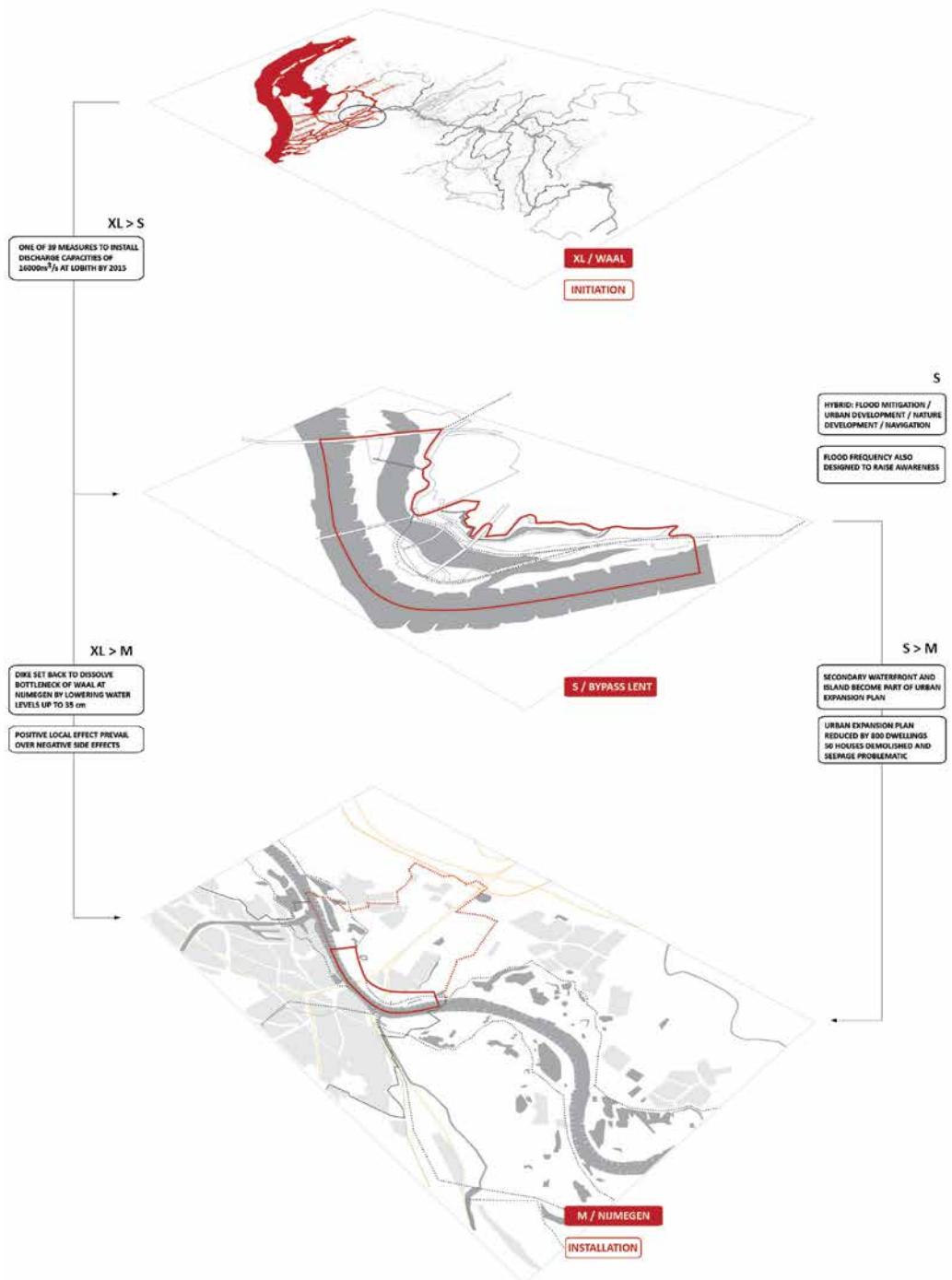


Figure 138

Extract diagram showing interdependencies between river-, project- and local scale.



Figure 139

Hondsbroeksche Pleij / Rhine km 878-879.5

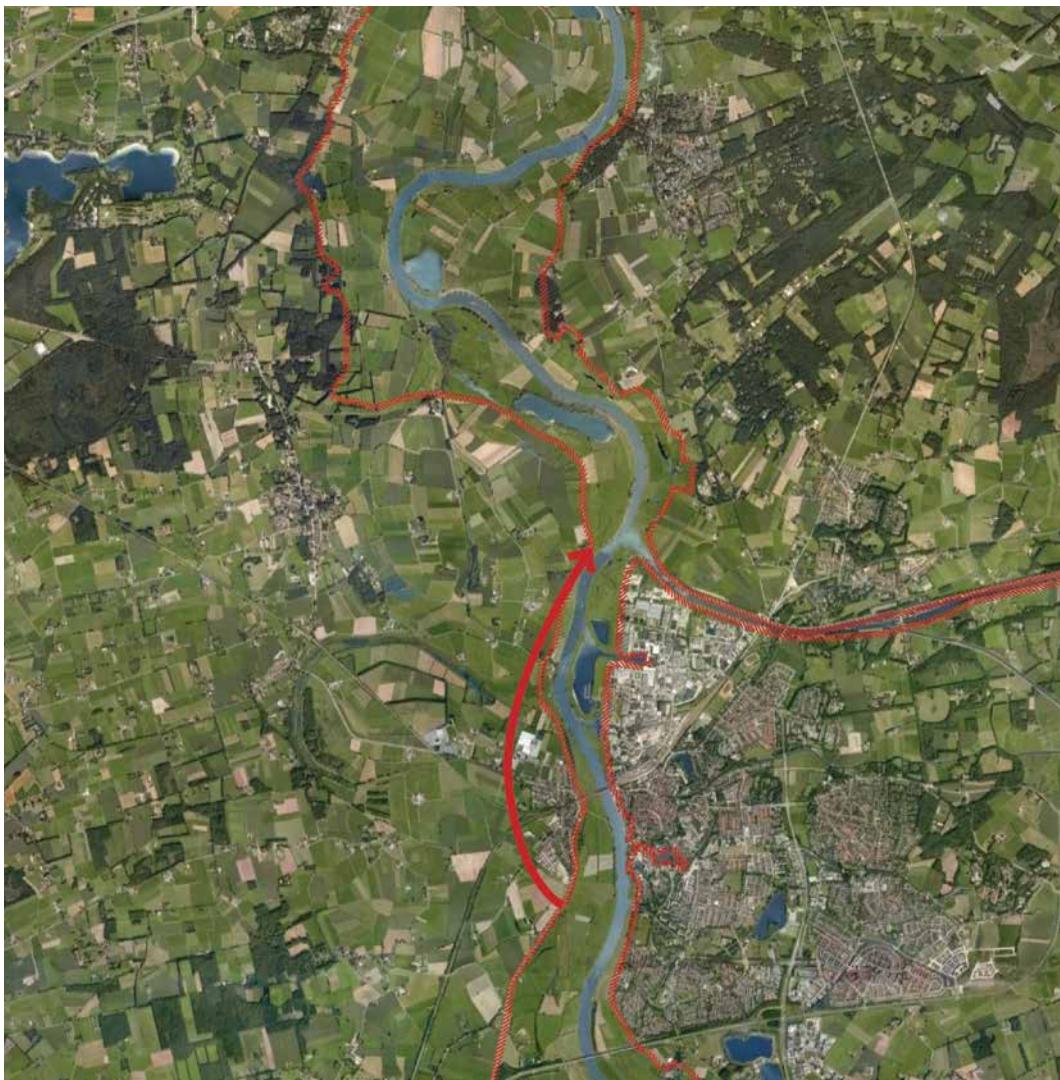
Program: Flood mitigation and nature development by linking areas along the Lower Rhine and the IJssel / Period: 2003-2008 (SDF) / Scale: 120 hectares / The Hondsbroeksche Pleij is a former floodplain on the right bank at the bifurcation of the rivers Lower Rhine and IJssel and is completely surrounded by dikes. The dikes are relocated, along the IJssel by approximately 250 metres and along the Lower Rhine by about 150 metres inland. The newly created floodplain will be lowered to allow natural features to develop and a channel will be constructed in the floodplain with an adjustable weir at the inlet to the channel. A large composting plant is removed from the floodplain to realize the measures. ([www.risicokaart.nl](http://www.risicokaart.nl), SDF project brochure 2005, [www.ruimtevoorderivier.nl/hondsbroekschepleij.aspx](http://www.ruimtevoorderivier.nl/hondsbroekschepleij.aspx))



Figure 140

Lexkesveer / Rhine km 901-903

Program: Flood mitigation and nature development / Period: 2003-2008 (SDF) / Scale: 380 hectares / The Lexkesveer floodplain lies on both sides of the Rhine within the municipalities of Renkum, Heteren and Wageningen that are connected by the Lexkesveer ferry link. The southern floodplains are part of a cross-border strategic nature development project. On the southern bank, the emphasis lies on combining safety and nature development. The ferry causeway located here will be partially replaced by a bridge, combined with the excavation of three summer embankments. Furthermore, a secondary channel will be excavated and extended under the bridge. Part of the floodplain will be lowered. The northern floodplain is part of the Noordoever Nederrijn development plan. (SDF PROJECT BROCHURE 2005, [www.rws.nl](http://www.rws.nl))



**Figure 141**  
Bypass Zutphen Stedendriehoek 2030 / IJssel / Rhine km 927.5-931



Figure 142

Bypass Deventer Stedendriehoek 2030 / IJssel / Rhine km 943-945

Program: see below / Period: 2004 / Scale: no information / "The task for the Apeldoorn-Deventer-Zutphen urban network is to strengthen the relationship and variation in housing and business areas with the simultaneous development of new qualities in water, nature, landscape and agriculture. Based on the layer approach and using an intensive, interactive planning process the involved municipalities arrived at a number of strategic choices for the spatial development of the region. A consensus was reached about the elaboration of a number of regional projects such as two bypasses in the IJssel at Deventer and Zutphen. Increasing the drainage capacity of the IJssel is combined with new urban expansions." [www.risicokaart.nl](http://www.risicokaart.nl), [www.landscape-architects.eu/projects/master-plan/bypass-landscape-for-stedendriehoek-2030.html](http://www.landscape-architects.eu/projects/master-plan/bypass-landscape-for-stedendriehoek-2030.html) (03292012)



Figure 143

Fortmond IJssel / Rhine km 959-962

Program: Flood mitigation, nature development, recreation / Period: 1989, 2003-2008 (SDF) / Scale: 200 hectares / By constructing side channels and lowering the floodplain the discharge capacity of the river IJssel is increased. The first nature development project in the area, Duursche Waarden, was implemented in 1989. In Enk, two deep secondary channels will be excavated that will both flow into the existing secondary channel in the Duursche Waarden. In De Zaaij / Roetwaard, a deep, isolated body of open water is being created. In Roetwaard, the existing open body of water will be connected to the river IJssel by excavating a secondary channel. ([www.risicokaart.nl](http://www.risicokaart.nl), SDF project brochure 2005)



Figure 144

Veessen Wapenveld IJssel / Rhine km 962-972

Program: Flood mitigation, nature development, recreation and agriculture / Period: 2004-2015 (RvR) / Scale: 8 km length / A flood bypass is installed between Veessen and Wapenveld. During extreme floods, 45% of the discharge of the IJssel can be redirected, temporarily reducing water levels by 63 cm with effects for Deventer and Zutphen. The bypass is installed by building two dikes. The side channel is expected to only be flooded during extreme events. The rest of the time it remains agricultural land. ([www.risicokaart.nl](http://www.risicokaart.nl), [www.ruimtevoorderivier.nl/veessenwapenveld.aspx](http://www.ruimtevoorderivier.nl/veessenwapenveld.aspx), [www.veluwe.nl/ruimte\\_voor\\_de\\_hoogwatergeul/project/casco](http://www.veluwe.nl/ruimte_voor_de_hoogwatergeul/project/casco))



Figure 145

Kampen IJssel / Rhine km 991-992

Program: Flood mitigation and nature development / Period: 2004-2015 (RvR) / Scale: 500 hectares, length 5 km / Bypass between IJssel and Vossemeer to manage excess water from IJssel and a new river front for Kampen over the same length with development potential for nature, recreation and buildings. The historical city will be disconnected from the land side to become a delta city. The plan includes the new settlement area De Oksel with the option of receiving a climate dike, a robust and heavy dike that can take on additional functions apart from being a water barrier. Installations for the functioning of the bypass will be constructed in a second phase starting 2020. ([www.risicokaart.nl](http://www.risicokaart.nl); project site according to masterplan by H+N+S landscape architects, 2006; [www.nederlandleeftmetwater.nl/wat\\_gebeurt\\_waar/projecten/258/een\\_bypass\\_in\\_kampen](http://www.nederlandleeftmetwater.nl/wat_gebeurt_waar/projecten/258/een_bypass_in_kampen))

# 10 Conclusions and Recommendations

This research investigated four representative city-river constellations between mitigation and adaptation along the Rhine.

- the retention polder Rappenwört in Karlsruhe on the Upper Rhine
- the Zollhafen harbour conversion in Mainz on the Upper Rhine
- the bypass in Nijmegen-Lent on the Rhine branch Waal
- the Stadswerven wharf conversion in Dordrecht along the Delta Rhine

Both flood-mitigating and flood-adapted developments produce additional damage potential, either on the local scale through seepage or on the project scale through new building development. In combination, the infrastructural adaptation necessary to manage the seepage problem that accompanies mitigation measures in the urban landscape and the architectural appropriation of the urban development exposed to flooding, offer possible design strategies on how to approach the hinterland - the flood endangered area behind the defence line.

UFI is based on the assumption that mitigation and adaptation are no longer separate strategies of spatial flood management, but ideally synergize to cope with frequent floods while lowering water tables. Applied on a vaster surface, this strategy could eventually lead to lower storage levels and thus an adaptation process on a regional scale. Concluding, it can be said that the closer mitigation and adaptation move together, the higher the flood risk awareness. To reflect on the case study qualities regarding UFI, the following synthesis responds to the two hypotheses:

H1. UFI relies on the integration of the local/regional scale. Based on the idea that synergetic solutions between flood management and urban development offer qualities for both, the analysis and visualization of the case studies seeks to qualify these two assumptions.

H2. River channelling leaves us with the challenge of how to restore the dynamic qualities of the flood plain while providing a functioning economic and urban development corridor. Previously zoned and thus separated programs are therefore beginning to overlap. As a result, flood plain developments are most of all a question of remediating conflicting programs to produce emergent qualities between them. This research considers this a design task, both strategically and spatially.

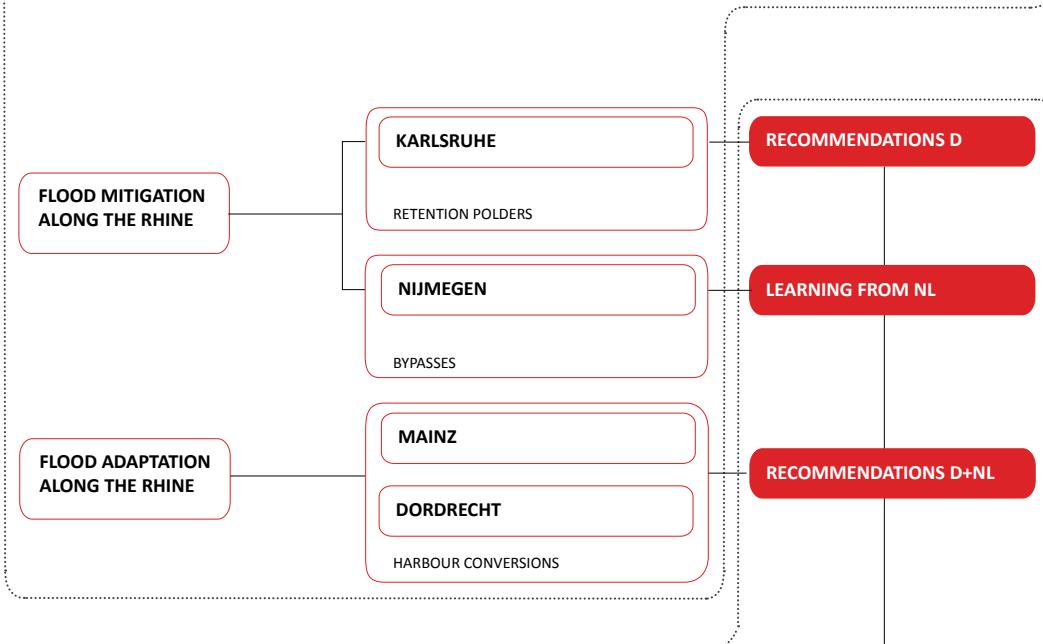
The response to Hypothesis 1 is a summary of the capacity of the projects' inherent city-river-landscape constellations to contribute to UFI as an extended ecological approach that includes the urban realm.

The response to Hypothesis 2 is an exploration of the role of strategic design in addressing the demand for an aesthetic practice, as part of an ecological and therefore iterative and anticipatory approach involving multiple scales, programs and agencies.

Based on the research results, recommendations are made. They address the role of design for the practice and define two research proposals to further substantiate the results.

## CONCLUSIONS

### 10.1 TOWARDS UFI - CITY-RIVER LANDSCAPE CONSTELLATIONS BETWEEN MITIGATION AND ADAPTATION TODAY



## RECOMMENDATIONS

### 10.2 TOWARDS URBAN FLOOD INTEGRATION

- STARTING FROM A RIVER SEGMENTS APPROACH
- A TRANSDISCIPLINARY LAYER THAT INCLUDES DESIGN
- OUTLINE OF A TRANSDISCIPLINARY LAYER
- EXPANDED ROLE OF DESIGN(ERS)

### 10.3 FUTURE RESEARCH

- RIVER SEGMENT APPROACH - DEVELOPMENT OF DESIGN GUIDELINES
- STRATEGIC DESIGN - COST-BENEFIT ANALYSIS

### 10.4 REFLECTING ON THE RESEARCH METHOD OF UFI

## § 10.1 Towards UFI - City-River-Landscape Constellations Between Mitigation And Adaptation Today

### Flood Mitigation Along The Rhine

#### Conflicts

Flood mitigation projects along the Rhine are accumulative large-scale measures implemented top-down, in Germany by the federal states, in the Netherlands by Rijkswaterstaat. Aside from the general complexity and extensive plan approval procedures (Homagk, 2010:41), conflicting programs as well as an increase in construction costs (Kretschmann et al, 2010), these mitigation measures often produce severe local resistance for two other reasons. The effect of lowering water tables is not considered relevant for the local situation (Hartmann, 2011) and the negative consequences expected, primarily seepage, but also the deconstruction of individual buildings, poses a threat to the inhabitants. Local resistance therefore often produces a delay in the execution of respective projects. In the case of the Integrated Rhine Program in Baden-Wuerttemberg, we can see that the original time frame is expected to expand by 13 years to 2028 (Splett, 2010) and the original budget increases accordingly. In Cologne, 165 property-related objections against the plan decree were filed against the polder Langel (Hartmann, 2011:63). The Altrip polder and dike setback is currently handled in the Federal Administrative Court (Baumann, 2010). Specifically the seepage problematic produces the need for extensive infrastructural support measures to cope with the risks and uncertainties of rising ground water levels during the activation of a polder or bypass in the vicinity of the site.

#### Potentials

Living with water as a chance for local development is, specifically in German mitigation projects, not yet commencing to make its way to the periphery. It may, however, be the key for future strategies. Assuming an expected increase in floods due to climate change due to climate change also for the German Rhine,<sup>25</sup> additionally emergency polders, as already reserved in Rheinland-Pfalz and Nordrhein-Westfalen, may be needed. Potential emergency polders are always urbanized landscapes. With less damage potential, they aim to prevent areas downriver that may not be capable of taking on water as well, such as historical cities. Emergency polders may

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Their further development depends on the outcome of the ICPR study on the effects of climate change for the German Rhine expected for 2012 (interview Andre-Breton, ICPR, 2011)

be temporarily flooded in case of an extreme event. Their scale depends on the effect needed and the availability of land. Ideally, flooding emergency polders at water levels lower than current mitigation polders (2.5 meters) could not only improve ecological, but in response to our limited adaptive capacity (see Chapter 4 FRM), also urban resilience. The lower the stored water levels, the more adaptation takes place above ground and therefore becomes an architectural task. All mitigation strategies rely on the development of an iterative and holistic long-term approach. Corresponding risk models and damage assessment tools, as those developed in the UFM project, may also be applied on a regional scale to define risk landscapes and to develop according design strategies.

#### **D+NL / Path Dependent on the Defensive System**

Mitigation measures are reliant on and supportive of the defensive system. Towards the land side, defensive measures are needed to protect adjoining programs. In the case of Karlsruhe, the secondary dike line of the first rectification phase by Tulla could be reinforced to replace the main dike for the length of the retention polder. On the river side, the defence line is needed to steer the retaining process. In synchronization with other measures, openings in the main dike such as steered in- and outlet-structures or jetties activate the filling of the polder or the bypass function to lower extreme water tables. In the case of Nijmegen, the scale and positioning of the bypass in the direct vicinity of the river is framed by the parameters of the existing polder system and its inherent flood risk, dike length and the economic viability of measures. In both cases, lowering extreme water tables takes pressure off the dikes and reduces the chance of exceedance.

#### **D / Retention Polders**

##### **City-River-Landscape Constellations - Between Engineering and Ecology**

Beyond peak flood shaving, the programmatic focus of the German retention polders as a precondition to their realization lies on the rejuvenation of the former alluvial forest on site. This illustrates the ideal of returning the former flood plain to its 'original condition,' a landscape as it was before the channelling of the Upper and Lower Rhine. Peak-flood shaving combined with the realization of ecological niches on site of the polder therefore requires a temporal organization of the two kinds of flooding.

Due to the urban development in the former flood plain in the past 150 years, this can only happen in niches. The dynamics inherent to the 'original condition' of the riparian landscape are not compatible with the activities that have evolved in the area behind the anthropogenic borders of the rectified river. Yet, as of today, these programs are in many cases the economic motor for the respective regions. Of the six programs defined in the ICPR Atlas, forestry seems the only one capable of taking on river dynamics and transforming accordingly over time. All other programs (settlements, industry, traffic infrastructure, and to some degree agriculture, specifically when ecological flooding is

taken into account) remain reliant on defensive measures, and in case of their failure, infrastructural support and adaptation measures.

### **Path Dependency on Sectoral Organization**

Secondly, the modernist organization of programs in the former flood plain of Karlsruhe does not provide for contingencies between programs. The flood plain serves as a container for a vast array of programs, arranged to avoid potential conflicts. The program of the retention polder is unique in its capacity to function as an infrastructural landscape and an ecological niche. And yet, it is planned in the modernist tradition of merely organizing programs on site. City-landscape constellations that have evolved in the former flood plain along the Upper Rhine lack a reading of the urban landscape beyond its operative capacities and as a performative realm. In Karlsruhe, first attempts to enhancing the spatial qualities of the former flood plain are made by creating visual connections to the opposite river front as part of the Landscape park Rhine and by developing a pedestrian network which integrates educational facilities as well as concepts such as the PAMINA park, a regional initiative that seeks to connect the three adjoining regions Palatinate, Mid-Upper Rhine and North Alsace. Yet these two park concepts, one a regional park, the other on the project site itself, remain additional layers. They are limited to providing recreational facilities based on current demands (see Chapter 6 KARLSRUHE). Although the recreational conception for the retention polders of the Integrated Rhine Program does include bike paths, educational facilities and other recreational infrastructure, these layers do not involve an emergent approach or involve designers outside of the municipal institutions, nor is their involvement strategic. In the case of Karlsruhe, the heterogeneous existing programs on site such as the Rheinstrandbad, the existing villages, and the energy plant, are merely appropriated to cope with the negative effects of the polder. Their elements are not proactively included in the park concepts, but remain a separate layer. Since building in the flood plain is generally not allowed, it is not an option considered in the context of the polder in Karlsruhe (RP Karlsruhe, 2011). In Germany, water management remains sectoral, whereas land use planning weighs different interests (Hartmann, 2011). This leads to the conclusion that the development of the retention polder follows the path of sectoral developments in the former flood plain of Karlsruhe (Dieterle et al, 2003) as landscape, infrastructure and urban development, and here this includes recreation, are not considered collectively.

In summary, German mitigation projects are, due to their spatial organization, but also due to current policies, path-dependent on a defensive approach and a sectoral planning culture. In the light of their long-term planning and implementation process, it becomes obvious that there is a justified need to update current mitigation strategies. Even more so, if the, at this point assumed, need to define further emergency polders as a potential concept next to super levees, will be verified. Needless to say, it would be a lost opportunity if such large-scale, costly projects offer so little potential locally. In the light of additional space for emergency flooding

needed in the future, strategies need to create local incentives to become more readily implementable and economically feasible. The underlying question is how retention and emergency polders become something that municipalities want rather than something they oppose? The following recommendations aim to offer spatial and strategic design proposals to adapt current German mitigation strategies towards a more emergent practice.

### **Recommendations - Expanding the Scale and Scope of German Mitigation Projects**

#### **R1 (Re-)mediating Programs and Designing an Amphibious Zone**

Versus only solving locally expected negative effects, the retention polder typology and the general flood risk behind the defence could be seen as an opportunity to enhance the urban landscape. Programs could be linked and expanded by breaking with the linear and sectoral demands in exchange for more gradual zones of adaptation and emergence. In the case of Karlsruhe, integrating the redevelopment of the former swimming bypass of the Rheinstrandbad directly aligning the polder on the river side or developing a landscape concept involving the old Tulla dikes could be ways to remediate programs both in an operative and in a performative way (see fig. 123). Furthermore, the infrastructural measures necessary to manage the negative side effects of the retention polder define the zone around its land side. Evaluating more gradual scalar alternatives for the polder itself and a programmatic conception beyond merely diminishing negative side effects could make this zone truly resilient. As such, an 'amphibious zone,' the area currently taken up by infrastructural measures, would have to be highly flood-adapted to cope with the different kinds of floods, but could at the same time gain qualities from its border position to this exceptional landscape. The idea of expanding the adaptation zone translates to the other Rhine 2020 retention polder projects currently being developed, and may serve as a pilot for the flood-adapted design of further emergency polders.

#### **R2 Data Accessibility and Visualization**

Currently, urban designers and landscape architects are not involved in the planning process of steered retention polders. Mitigation measures, although a severe intervention due to their scale and potentially negative impact, are first of all not considered a design task. The lack of available and accessible information enabling different agencies involvement further hinders a design approach (Verbeek and Zevenbergen, 2008; Stokmann, 2010). Information policy is slowly changing in Germany (see Chapter 4 FRM), making it difficult to trigger involvement and to develop concept proposals. This not only applies for detailed site information, but also for the large scale. As the accessibility of data (e.g. sections et cetera) preconditioning any design is not available, the design of the urbanized context of these infrastructural landscapes is rarely considered. Up until now, there are individual visualisations for the retention polders made by the federal states and the regional water management agencies, or by the corresponding French agencies for the two polders Erstein and

Moder. A coherent overview of all retention polders along the Upper and Lower Rhine did not exist before the atlas produced for this research. It serves as a small first step to enable a spatial understanding of the retention polder typology along the Rhine beyond administrative boundaries. As part of this research, all retention polders along the Rhine have been mapped sequentially for the first time. The atlas provides an overview of their scale, location and context, which is in most cases far from rural.

### R3 Design as a Strategy for the Implementation of Retention Polders

Design strategies that thrive on a synergy of mitigative and adaptive strategies for the existing program of Rhine 2020 (and possibly for additional emergency polders in the future) requires the urban dimension of mitigation measures to become part of an expanded ecological perspective. It calls for projects capable of synergizing adaptation and mitigation measures in a way that produces local support and participation not just in the design process, but by triggering "local spin-offs" (Sijmons, 2009:64). UFI therefore aims to develop economies that are not threatened by river dynamics, but ideally make use of them (see Chapter 3 Ecological Economics). It is therefore not about merely adding a recreational layer, which is itself a modernist invention, but to raise acceptance and awareness by creating spatial qualities and breeding grounds for local stewardship (Aronson, 2011). Landscape urbanism as a tactical design practice could contribute by linking mitigation measures with the programs of their corresponding heterogeneous urban landscapes. In addition to flood mitigation and alluvial flood plain rejuvenation, a third goal for the Integrated Rhine Program as part of Rhine 2020 could be to produce spatial qualities and link more programs. Stimulating local emergence in the context of the polder development could be a key to accelerate the installation process, but also to see the retention polders as a potential for development. By drawing public attention away from the negative side-effects of the retention measures, local support and involvement could rise, making possibilities for future measures more open.

## NL / Bypasses

### Bypasses as a Hybrid Typology

As the typological atlas (fig. 120-127) shows, in contrast to the retention polder, the bypass is a typology that has been instrumentalized throughout history at the border between city and river. It is much more versatile in terms of programming. It is not only implemented to mitigate floods, but has, over the centuries, been adapted for a diverse set of programs or intentions. In terms of flood mitigation along the Rhine, bypasses are so far mainly implemented in the Dutch context, although some of the open retention polders (Fliesspolder) along the Upper Rhine may also be considered bypasses.

In terms of city-landscape constellations, bypasses are capable of producing a secondary riverfront freed from the constraints of navigation. This produces a specific and rare (urban) quality for the otherwise rectified riverfront. Gradual slopes and a reduced velocity make the river water accessible. These provide an experience unusual in the urban context as river front profiles are for the most part orthogonal and average water levels and quays are often meters apart. Economically, the extended waterfront generally provides valuable building sites. In the case of Nijmegen Lent, previous development plans had to give way to the bypass, leading to a reduced number of possible dwellings (Spatial Plan, 2007) and increasing economic development pressure on the new island (FRC Workshop Nijmegen, 2011). In terms of navigation, the example of Nijmegen Lent shows how the groyne profile of the river side of the island remains untouched to ensure the navigability of the Waal while the bypass profiles are defined by the mitigative function of the side channel and the urban quality they are capable of producing.

#### **City-River Constellation of Nijmegen and Strategy Chosen**

The city-river constellation of the Nijmegen project is specific, historical coincidence. While the municipality planned its expansion across the river, the need to take pressure off the bottleneck produced by the Waal at the height of the city was recognized. This produced a rare situation where flood mitigation and urban development are combined into a flood-adapted urban development. Nature development and navigation are further programs that shape the project.

#### **NL / Path-Dependency on the Polder Model, but Area-Based Approach**

In the Dutch Room for the River projects, development is linked less to the original flood plain condition, but, as the investigated alternatives for Nijmegen Lent show, to the path-dependency of the polder model (see Nijmegen M) and adhere to a probabilistic approach to flood risk management. As a result, the increasing dike line, the risk of polder flooding as well as the costs generally make solutions in the direct vicinity of the river more viable.

The area-based approach and implementation strategy enabling top-down programs to be developed locally, allows Dutch Room for the River projects to develop synergies with ongoing developments as well as trigger new programmatic constellations in the context of the mitigation project. Although Dutch flood-mitigation projects are existentially reliant on the defensive system, the strategic design of the projects enables more positive feedback loops with the local realm. This responsive approach opens perspectives for long-term transformations.

#### **Recommendations NL - Learning from the Nijmegen Case**

##### **R1 Spatial Quality**

Synergies between flood management and other programs are based on spatial quality

as the second key goal of the Dutch Room for the River project, after safety. Spatial Quality as “the consistency between hydrological effectiveness, ecological robustness and aesthetic soundness with possibilities for recreational and urban development” (Sijmons, 2009:66) explicitly includes the urban realm in the conception of flood-mitigation projects. This approach enables local emergence. It could also be applied to German flood-mitigation projects to expand the project horizon in a positive way.

### R2 Incentives

When Rijkswaterstaat introduced the need to dissolve the bottleneck of the Waal at Nijmegen, the municipality agreed with a number of conditions: full state guarantees for eventual damage claims from project developers, the construction of a second bridge across the Waal and the start of an EIA to consider other alternatives and give local stakeholders a voice (Cuppen, 2012:101). This trade-off between larger-scale mitigation targets and local interests shows how incentives for the local scale may trigger acceptance and serve as a further basis to enable local emergence. Instead of opposing the project, it may be more gratifying for all involved to arrange deals. This especially applies for municipalities suffering from increasingly reduced economic means.

### R3 A Transdisciplinary Layer - the Quality Team

The Quality Team is involved in the conceptual phase from the initial start, through the preliminary and up to the final designs on the “architectural specifications” in the tender documents (Sijmons, 2011:66). It is made up of a landscape architect, a river specialist, a physical geographer, an urban designer and a biologist. The quality team advises the local and the initiating agencies at four stages, ending with a final approval of the project to the Minister before the budget is granted to the local government.

From the experience gained, Sijmons points out two effects of the Quality Team. Large firms tendering for work hire talented landscape architects and other designers as they know that they will have to meet the Quality Team standards and because of course collegial debate will boost quality.

As a model, the Dutch Quality Team exemplifies how spatial design can be strategically integrated in a predominantly technical domain at a very high qualitative level. It supports the capacity of infrastructural landscapes to transform into more than just another part of the, to different degrees, urbanized landscape they occupy. Spatial flood risk management is often lacking incentives or consequences (see also Hartmann, 2011). The Quality Team approach shows how both solicited and unsolicited strategies can be applied to ensure the synergetic development of spatial qualities.

### Flood Adaptation Along The Rhine

Spatial flood management today involves two strategies: mitigating floods by giving more space to the river and adapting to floods by (re-)developing areas at risk to become more flood-resilient. In contrast to the mitigation projects, which are

accumulative, adaptation projects are singular developments, which, depending on the height of the site, do not necessarily cohere with a larger-scale strategy. Converting the inner city harbour Zollhafen in Mainz on the Upper Rhine and the Stadswerven area in Dordrecht on the Lower Merwede, both traditionally positioned outside of the flood defence, into new living districts are typical flood adaptation measures. Yet, our capacity to adapt to varying water levels remains limited, not only on the building scale (see Chapter 4 UFM), but also regarding links with the municipal infrastructural networks, for example in Mainz. Therefore, additional layers are needed to cope with a remnant risk. Again, this demands for a new risk awareness by all involved.

### **Building in the Former Flood Plain / Raised Area and Evacuation / Awareness**

Harbours are usually erected on the riverbanks that were raised in the course of river rectifications and are therefore less flood-endangered than the area behind the flood defence line. This makes the question of evacuation an interesting one. The UFM project considered evacuating from the city to the higher lying Stadswerven area. In Mainz, evacuation is only considered an emergency option. Dwelling heights and emergency routes in the Zollhafen aim to enable inhabitants to stay in their apartments up to a flood level of at least a 1/200 year flood (Redeker, forthcoming).

Yet the raised solution poses a challenge to flood-risk awareness. As these riverfronts are only flooded in case of extreme events, flood-risk awareness becomes a major concern. In the evolution of harbour conversions along the Rhine, there has been a development regarding the design with fluctuating water levels. Earlier conversion projects such as the Rheinhafen in Duisburg were designed to produce a constantly high water line close to the quay level by regulating water levels for the inner harbour basin (Foster, 1991). We can see in the two case-study projects that the integration of varying water levels has become key to the design strategies applied. The paradigm has moved away from considering water as a controlled spatial quality to living with water as a spatial quality. The conveyance of dynamic water levels becomes a design goal that both increases flood risk awareness and reduces damage potential. Dordrecht and Mainz illustrate the combined solution of three basic design concepts: partially raising areas, including the defence on the building scale and allowing water on site.

### **Retention Neutrality**

As developments outside of the municipal flood defence, harbour conversions require a flood-adapted construction. Although the two projects investigated produce similar architectural approaches, parameters differ in relation to the river typology. Raising the area is per se only applicable in the downstream zone of a river. Upstream, it will act as an obstruction causing water levels to rise during high river discharges. An exception can be made for areas that are already high, but need to be elevated to comply with changing water levels due to climate change (Stone et al, 2008:32). This is the case for Mainz.

In Germany, harbour conversions demand for 'retention-neutral' development to comply with German water legislation (WHG § 78, 2010). This implies that no additional volume is built in the flood plain compared with the previous development situation. The morphology of the site and its further design therefore become an additional layer in the infrastructural appropriation and the flood-proofing of the individual buildings. In addition to raising or lowering areas partially, considering currents and obstructions in the morphological design and dealing with the often contaminated ground of harbour conversion areas, landscaping in Germany is also a quantitative task.

### **City-River-Landscape Constellations and Spatial Design Scales**

The city-river constellation may not necessarily promote difference on the project scale: the development of the site morphology and the building typologies remains quite comparable between Dordrecht and Mainz. Yet, their positions along the river and the city-landscape relationships, together with political borders do have an impact on the expanded project scale.

The island of Dordrecht, positioned in the river delta and thus affected by the rivers and the North Sea, is surrounded by water from all sides. Dordrecht, as a polder city, but with a historical city outside of the flood defence follows a multiplicity of approaches and projects on the island. Mainz is a left-bank development with a rising topography in the hinterland. Apart from the historical outpost on the right bank, it is geopolitically framed by the state border, which runs through the middle of the river. The city across from the Zollhafen is Wiesbaden, the capital of Hessen.

These differences have two implications for the larger scale perspective. As part of the Drechtsteden program, Dordrecht follows a regional waterfront strategy. The availability of the Drechtovers masterplan as a regional design strategy being an advantage. Even more crucial are the consequences for Dordrecht regarding decisions on the future flood management in the Rhine-Maas-Delta (e.g. discussed Open-Closed Rijnmond) as part of the forthcoming Deltaplan. It may therefore be considered a laboratory for flood-adapted building on the local and regional scale, where Stadswerven is embedded as a pilot project to develop tools and study a number of relevant issues for flood adapted design strategies. Apart from providing part of the municipal defence line of Mainz, the Zollhafen project is focussed on the project scale. On a regional scale, Wiesbaden and Mainz do not exchange or follow a common development strategy across the river that could serve as an entry point. The two cities are separated not only by political borders in the middle of the river, but also by the bifurcating river typology defined by islands and multiple channels at the height of the city even after channelling. Further, the Upper Rhine retention measures, although their completion will change the discharge capacity for Mainz from 1/120 to 1/200 (Webler, forthcoming), are only considered a marginal change that has no effect on the design strategy.

### **The Strategic Design of Adaptation Projects**

As frontrunners in the redevelopment of flood-endangered areas also behind the defence (one of the tasks of the EU Flood Directive), current flood-adapted urban developments provide valuable tools. In terms of the strategic design of Zollhafen and Stadswerven, we can differentiate between the Urban Flood Management program conception and the Interreg IVb FloodResilienCity project, but more crucial are the local conditions. In terms of typological development on the project scale, Mainz and Dordrecht as model projects propose similar solutions. Both put forth revised designs of master plans where spatial flood management had previously played a marginal role. The two projects differ regarding their scope.

The Zollhafen project is primarily a practice model that focuses on the development of model typologies for flood-adapted building and on the development of communication tools with potential developers and inhabitants. In contrast, the Dordrecht project is not only multiscalar, but also serves as a study case for the development of new tools and methodologies for damage assessment, iterative design, as well as economic and ecological issues, et cetera. The transdisciplinary layer of the UFM Dordrecht project enables a projection onto the regional scale (Drechtsteden, Rhine-Maas Delta) and a broader focus on the local scale (i.e. outer dike area, relation to polder city), while taking the existing building stock into account.

These differences may be rooted in the different landscape conditions but also depend on differences in planning cultures and of course political foci. Considering climate change, the area-based approach and the long-term perspective is a given for the Delta region. For harbour conversion sites such as the Zollhafen in Mainz along the Upper Rhine, this is not the case to the same degree. The systemic scope of the tools developed as part of the UFM project may provide useful also for new adaptation strategies of mitigation projects.

### **Recommendations D+NL - Adaptation**

#### **R1 Risk Landscapes**

Flood-adapted design in the light of climate change is still in its beginning phase: small-scale conversions in the flood plain and decentralized pilot projects like floating houses. Current flood-adapted urban developments provide valuable tools, such as harbour conversions as frontrunners for the redevelopment of areas at risk behind the defence (task of EU Flood Directive) and as a strategy to raise the local capacity of large-scale mitigation projects. Mapping and developing risk landscapes, such as the UFM project proposes, can be an approach that changes the boundaries currently defined by administrative borders, defense lines and property questions.

#### **R2 Iteration**

Beyond developing an iterative design practice that involves multiple disciplines, iteration

could also become a building strategy. Flood adapted building typologies cover the spectrum from defensive to floating. However, along the Rhine, temporary and mobile strategies are, as of yet, not considered for the building scale. Temporary strategies are limited to the application of defensive elements either to protect individual existing buildings or as part of municipal defence lines. Mobile buildings that can be moved from the flood-endangered area in case of an event or an increasing threat, can contribute to currently available options. Also with the expanded perspective of the flood-risk management plans for the flood-endangered areas behind the dikes this could become a relevant strategy. Also, building and horticulture exhibitions along the Rhine could be instrumentalized not only to renew urban waterfronts, but also to study prototypes, such as floating houses between groynes (see Chapter 3 EVOLUTION, Leverkusen).

### R3 Compact European City Model

#### Harbour Conversions - Advocating for a Compact City Model

Beyond the project scale, inner city harbour conversions are part of a compact European city model as they promote density, short distances, and a public realm. As an alternative to further expansions into the periphery, redeveloping urban waste lands contributes to a decrease in land consumption. In this way, creating new dwellings on inner city sites coheres with the Aalborg Commitments 2004 and the Leipzig Charter on Sustainable European Cities 2007, as well as the ambitious aims of the German government to reduce land consumption from today's 113 hectares to 30 hectares per day by 2020 (BBR, 2002). By redeveloping inner city sites, the creation of additional impervious surfaces and thus a further increase in run-off is avoided (see Bronstert et al, 2001 and Haase, Nuissl, 2006). Taking the regional scale into account, inner city harbour conversions may therefore also indirectly contribute to flood mitigation. As our capacity to adapt to floods remains limited, all measures that contribute to a reduction in run-off and an increase in water storage capacity should be considered.

## § 10.2 Towards Urban Flood Integration

### Starting From A River Segments Approach

#### Linking Spatial Quality to the Systemic

By choosing a river segments approach to spatial quality, landscape perception and design can be linked to the landscape system. Functioning as a systems scale, the strongly varying Upper-, Lower- and Mid Rhine and the different Delta Rhine branches have been subjected to numerous anthropogenic transformation strategies - channeling, widening, ecological rejuvenation. At the same time, their differing

typologies also offer unique landscape qualities - both in their original state as well as in regard to their anthropogenic transformations. By developing a river-segments approach to spatial quality with the aim to capitalize on river dynamics, the unique landscape qualities can be linked to the system's defining ecological, economic and cultural parameters.

The Dutch 'Handrijkings' (see Chapter 4) give an example of how specific landscape characteristics can serve as a basis for design guidelines. The underlying task to develop river-related projects interdisciplinarily from the beginning make these spatial quality specifications a source not only for designers, but for all involved in the project development. By further linking spatial quality to the systemic, tabus and no-go areas as a heritage of modernist planning culture may be overcome. This could be key to remediating the different claims on site. By starting from a spatially comprehensive landscape scale such as the river segment, the bucolic and the systemic may be combined towards an ecological approach that includes the economic and the urban realm. It further offers a method how to

- overcome political borders to create a new river culture: while 19th century river works relied on nation building, the situation today demands for a river-systems approach;
- in the light of increasingly recessive economic capacities: ideally reduce costs by developing integrative solutions instead of developing economies with a high damage potential in need of a costly infrastructural apparatus

### **Landscape Urbanism - From Spatial Design to Strategic Design**

In reference to the theoretical framework (Chapter 2), the case studies show that we are only at the advent of a systems change that is simultaneously driven by the need to increase resilience and challenged by the uncertainties as to how and how far. The telescopic quality needed to enable a systems change ('taking long enough time lines for the actors and the ecosystem to change' (Kays, 2009:11) therefore asks for responsive developments. Ba starting from the river segments scale, landscape urbanism may serve as a design methodology to do so. It does not aim for representational spaces where, in a neo-liberal sense of spatial quality, the image is prioritized. Instead, in landscape urbanism, design fosters the relationship between the landscape and a new ecological understanding (Lister, 2010). Therefore, in the discourse, the term strategy is actually replaced by tactics (Allen, 1999, Werthmann, 2010). Tactics implicitly underlines the responsive quality of interventions as part of an iterative and anticipatory long-term strategy.

### **Multiple Disciplines**

As an integrative approach to spatial quality involves multiple disciplines to work together from the initial conceptual phase onwards (Q-Team, 2012). This produces the need for an additional organizational, or transdisciplinary layer to ensure

multidisciplinarity. Again, the river systems approach offers a scale that overcomes political boundaries and offers a comprehensive spatial scale to different disciplines and stakeholders. To trigger emergent qualities between flood infrastructure and the areas to be protected continuously relies on new spatial solutions that can not be developed within singular fields of expertise. Yet, not only hydrologists, engineers, landscape architects, urban planners and designers to develop spatial solutions, but also policy makers, political scientists and other agents are needed to develop organizational and economic structures that enable their implementation within a given time frame and that continuously produce a fertile ground for long-term change. Again, also the strategic design of a project therefore relies on multidisciplinarity beyond the design and planning disciplines. Today, we generally find the analogous approach of scientific expertise leading decision makers to define primarily technical goals which are in turn developed by engineers according to strict environmental conditions (e.g. Karlsruhe). Spatial design generally remains the last layer added. Only when making its way to the initial project agenda as in the Dutch Room for the River measures, thus involving designers from the beginning, does spatial quality become meaningful in the sense of capacity building between substance and contingency. While substance provides articulated spaces, contingency adheres to openness, space for appropriation and occupancy (see Chapter 1+2 / Janson, Wolfrum, 2006). In this sense capacity as a concept of spatial quality ideally coincides with a telescopic approach by providing articulation and openness at the same time.

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### § 10.3 Recommendations for a Transdisciplinary Layer that includes Design

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#### Developing Local Potentials

A transdisciplinary layer on a program scale that explicitly includes spatial design is specifically needed to trigger more positive responses to German mitigation projects locally while enabling a learning process through experience. Surplus qualities for the Upper and Lower Rhine retention polders could be developed and investigated. Between the international project goals and not only local execution, but the development of local potential and “spin-offs” (Sijmons, 2009) feedback loops are needed to enable a learning development among stakeholders. Beyond emergent ecological qualities fostered on site, steered retention polders today remain infrastructural landscapes and sectoral developments. Locally integrating “clumsy polders” (Hartmann, 2011), beyond infrastructural measures and recreational facilities by using their given parameters to trigger emergence between adjoining programs and stakeholders, could raise local acceptance and participation. This could be key to speeding up the installation process of ongoing and future projects and to develop a

planning culture that seeks a telescopic, area-based adaptation process rather than an exhaustion of capacities on the project scale.

### **Urgencies**

As stated by Beck and proven in the Dutch approach, urgencies produce innovation (see Chapter 2 Complex Systems and Landscape Urbanism). Along the German Rhine, flood risk is not as present and therefore the focus on the negative effects of mitigation measures often prevail. Risk awareness in the two Dutch cases takes a regional (Rhine-Maas Delta) and a local (Nijmegen) perspective. Risk awareness remains relatively abstract due to the rare flood frequency, in Mainz due to the given height and in Karlsruhe as developments are located behind the defense. Although urgencies may seem less prevalent than in the River Delta, scenarios along the Upper Rhine have shown the impact of failure and exceedance of the defence (Ludwig, 2009:14). Paired with an overall recessive economic capacity not just coping with floods on an operative level and to recover, but also maintaining the infrastructural system itself, requires adaptation processes on multiple scales and time frames and a laboratory condition to investigate emergent capacities between programs on site. To move beyond the political and sectoral structures of the projects, a transdisciplinary agency is needed that is capable of addressing the issues involved spatially. The difficulties of linking sectoral water management goals with spatial interests in D (Hartmann, 2011) demands support. Neither the ICPR where project goals are defined on a supra-national level, nor the federal states in charge, nor the local and regional agencies responsible for executing the respective projects currently consider the production of emergent qualities between programs to be a programmatic component.

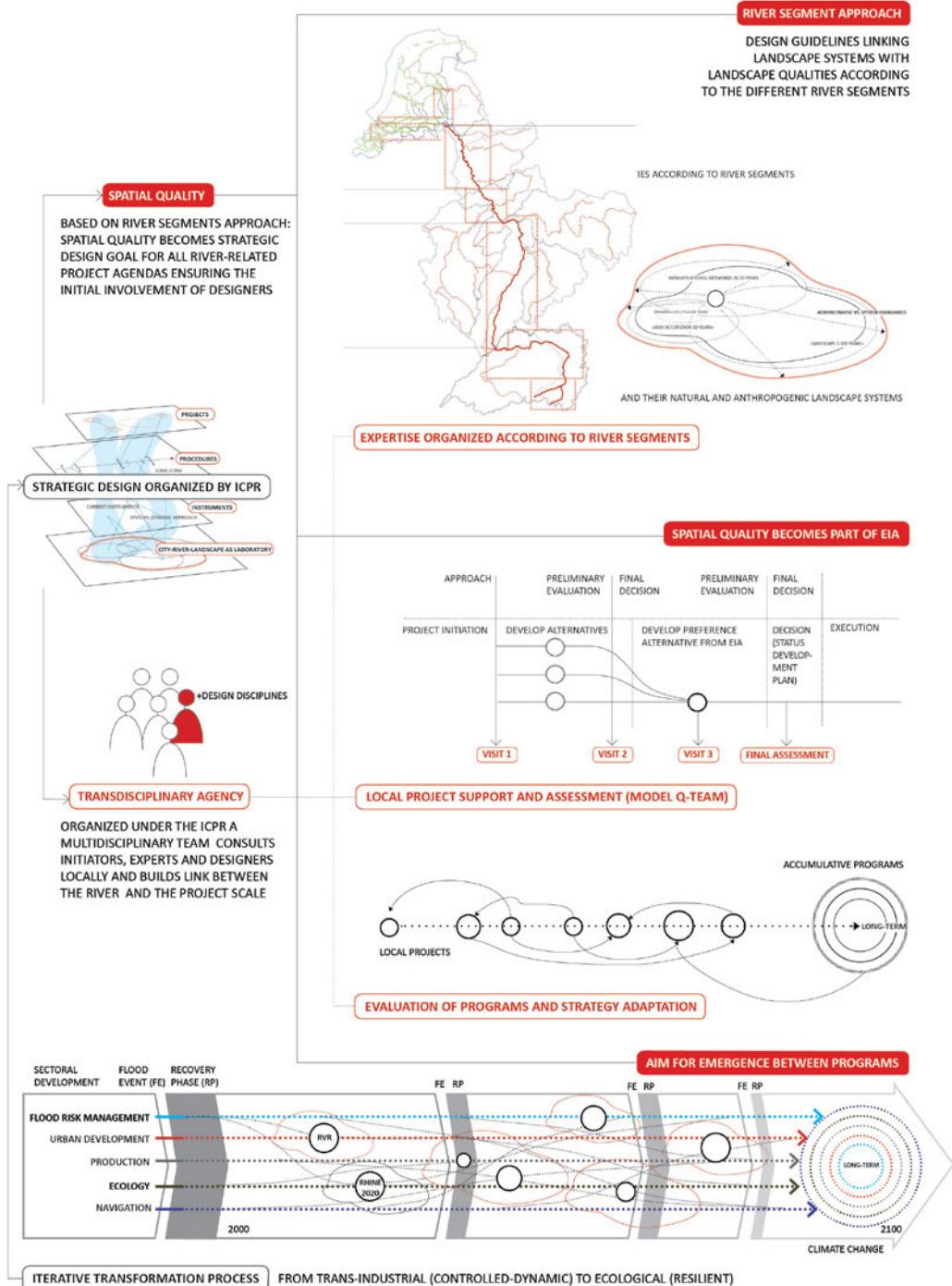


Figure 146

Strategic design of river-related projects based on a river segments approach to spatial quality (graphic by author).

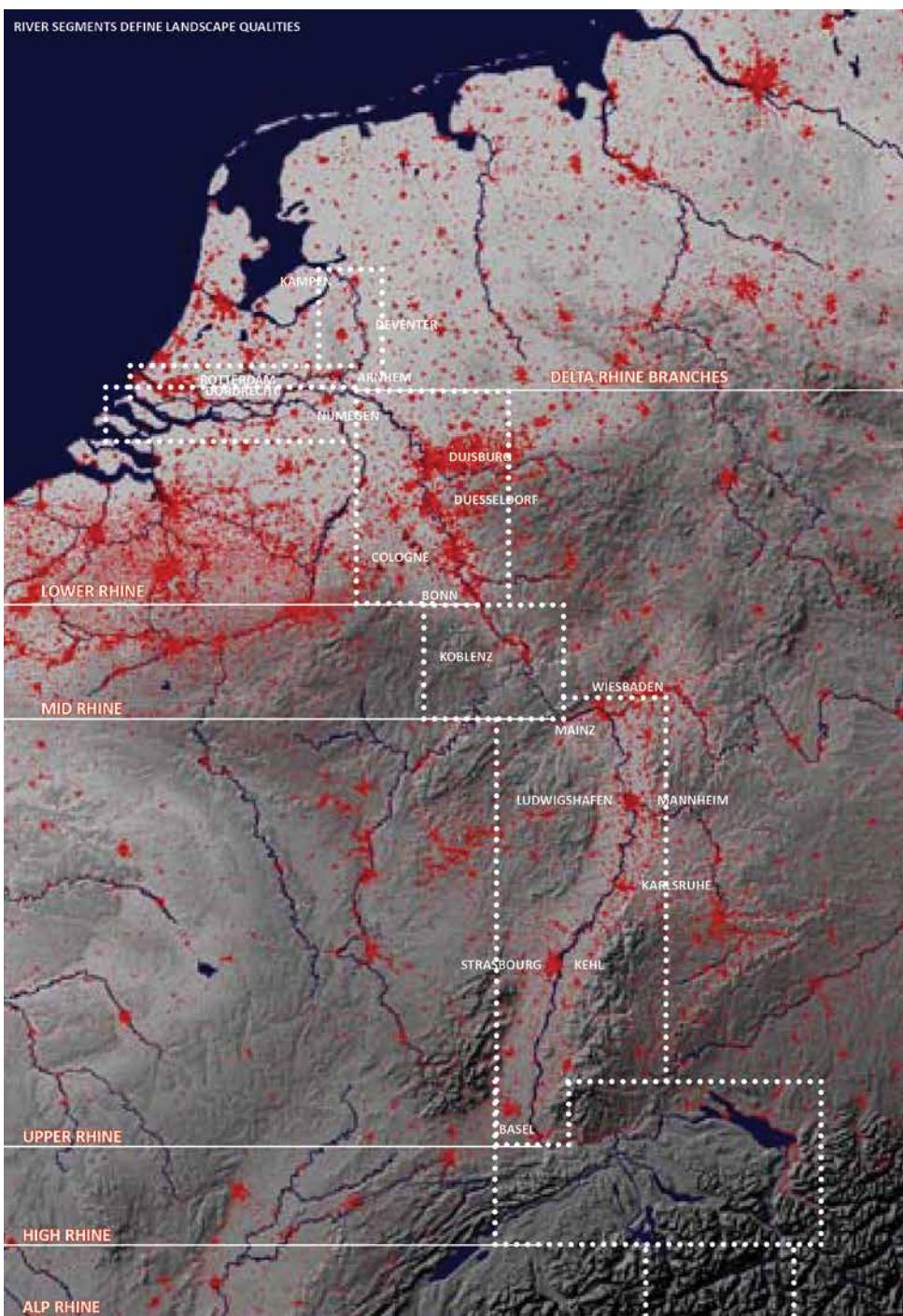


Figure 147

River segments define landscape qualities (Stephen Nijhuis, TU Delft, 2008 adapted by author).

## Expanding Scales

A further argument for a transdisciplinary layer is the perspective. Today, political borders frame projects and jurisdictions define perspectives. Furthermore, the visualization and accessible data of a project is organized according to administrative borders, unfortunately this is for the entire Upper Rhine the middle of the river. This hinders cross-river projects. Karlsruhe and Mainz are framed by the Rhine as a political border while Nijmegen and Dordrecht are embedded in an effort to develop spatial concepts involving the opposite bank(s). With the PAMINA park concept, also the flood plain in Karlsruhe is part of a regional strategy, yet again this strategy focusses on a museal approach (see Chapter 6.3 / KARLSRUHE). Across from Karlsruhe, more commercial developments are currently planned in the former flood plain. It is of course helpful when plans across the river with a regional approach already exist that are capable of not just organizing programs, but to consider their spatial capacity. By installing a support layer which addresses all projects of the program, the specific spatial parameters of the different river segments such as the meandering or bifurcating typology of the Upper Rhine and the urban agglomerations on both sides of the river become more vital than political borders. Local agencies could be supported proactively in developing durable concepts that expand the local scale and limited programmatic focus. In terms of the solidarity between up- and downstream areas, an even broader scale perspective is needed, again combined with corresponding incentives. This specifically applies for new models of implementing emergency polders (Hartmann, 2011). A further task would involve developing design links between riverfront developments and the superordinate parameters of navigation, which are for the most part not negotiated.

The same accounts for the time scale aspect of project horizons. Whereas the perspective of German projects ends with their finalization and are finished in exhaustion, Dutch projects are anticipatory by explicitly including recommendations/ proposals for further research and development potentials and by opting for no-regret solutions to avoid hindrances for future measures. Different time scales involve the short-, intermediate- and long-term: Urban Flood Integration requires embedded experimental developments and their monitoring and evaluation as part of an adaptive and anticipatory larger-scale strategy. Transdisciplinary agencies are needed to support local decision makers and project developers to make their projects part of an iterative process with a clearly defined long-term perspective. This not only involves deconstruction and spatial reservation, but also the flood-adapted redevelopment of the existing building stock which could be linked to other programs such as energetic refurbishment. Other urgencies do exist in Germany, such as the aim to lower space consumption from 130 to 30 hectares by 2020 or, energetic refurbishment. They provide ample opportunities for synergies with Urban Flood Integration measures. The typical life cycle of a building is 50 years (Zevenbergen et al, 2008). Continuous urban redevelopment and the renewal of 1/3 of the building stock within the next 30 years (European Construction Technology Platform, 2005) offers vast opportunities

to develop more resilient concepts as part of adaptive and mitigative anticipatory strategies. This will only happen if local decision makers can define corresponding potentials. They therefore need to be supported in solicited and unsolicited ways. Again, the Quality Team may serve as a model.

### **Learning Capacity**

Throughout the extended thirty years duration of the Upper Rhine retention program, only one adjustment has been made to the programmatic conception of the project. The secondary aim of the program since 1986 is to restore the biotope qualities of the former flood plain. Yet, although the retention measures have experienced such resistance, no strategies to further trigger "spin-offs" (Sijmons, 2009) on the local scale were considered beyond the recreational concept developed by the state of Baden-Wurttemberg in 2008. In the light of the duration until the program will be completed in 2028, there is still ample time to change this.

### **Outline of a Transdisciplinary Layer**

A transdisciplinary layer could proactively link flood-related issues with other programs as they are interlinked anyway. Enabling an adaptive and anticipatory approach means creating spatial as well as economic and ecological models for settlement, agriculture, industry, traffic infrastructure, and other programs capable of profiting from the dynamics of varying water levels. Beyond being flood resilient, these models ideally provide economic capacities to relieve costs.

Organized under the ICPR, an interdisciplinary team could support project managers, urban planners, politicians and all others involved in the local planning and design process in developing collective programmatic links. The different river segment typologies could play a key role in developing such a different focus. The Quality Team of the Room for the River program in the Netherlands may serve as an example of how a transdisciplinary agency can be organized and set together in terms of expertise. This consulting team can ensure communication between the project and the river scale (i.e. river segment/accumulative program), provide exchange and consulting for local agencies, and oversee the progress of the projects. The experience of the Dutch Quality Team could serve as an example to develop similar teams for other large-scale mitigation projects (see fig. 146-147).

### **Expanded Role Of Design(ers)**

#### **From Spatial Design to Strategic Design**

To enable an iterative strategy that aims for emergence between often conflicting claims on site, UFI strategies must integrate design as a strategic practice from the beginning. To include the administrative realm in this context, strategic design involves more than spatial design, but the design of processes. As communal budgets are low,

projects are generally understaffed. This makes it even more necessary to redesign the processes. Architects are used to thinking interdisciplinarily and working on different scales. They are trained to think systematically, to understand how problems are interconnected and to visualize them. This is very valuable in an increasingly complex world. Visualizing expert information and interdependencies can be an important first step towards understanding and communication. Furthermore, architects are used not only to working with different partners from the design phase until the realization phase, but also to accompany the process iteratively. In the public sector, institutional barriers and hierarchy levels often break this continuity. Strategic design concepts are already today applied in corporate structures, but have hardly found their way into public institutions (Steinberg, 2011). As water management remains a public task, it may be fruitful to involve architects in the process design.

### **Visualization of Data and Images for Scenario Development**

While expert disciplines during the industrial era were capable of providing reassurance, this is no longer feasible to the same extent. Demands to raise levels of communication and participation and to educate and provide understanding, prerequisites transparency to enable a larger group to become active. This once more requires a transdisciplinary layer to professionalize feed-back loops. Visual communication is part of the architects/designers task. Yet, this data needs to be accessible to be visualized. To enable visualization, there has to be a political will to do so. Specifically in German water management, the visualization of, for example, project alternatives are either not accessible or nonexistent, sections are not available, or expert information is, in many cases, considered confidential. Again, the incentive to change this could come from ICPR. Five recommendations can be made for the engagement of (landscape) architects and other designers in the strategic and spatial design of UFI projects:

R1 Involve architects, landscape architects, urban designers from the initial stage to enable their engagement also in the strategic design of a project

R2 Enable design to become part of a systemic approach that aims for capacity building and therefore includes ecological, economic and cultural conditions through a transdisciplinary approach.

R3 Make the invisible layers visible: Visualize systems/expert information to make them accessible and to enable communication between disciplines.

R4 Host design competitions in cooperation with local stakeholders to trigger emergence by bringing people and ideas together.

R5 Apply back-casting strategies to move beyond existing conceptions. Design may thus becomes "telescopic" and allow a challenge of existing givens. The visualization of concepts again playing a central role.

## **Future Research Recommendations**

### **River Segments Approach - Development of Design Guidelines**

Design guidelines that aim to produce emergence between the layers of the systemic river landscape and the spatial qualities of the different river segments can serve as a basis for a strategic design approach that includes spatial quality.

#### **To Develop Design Guidelines**

- interdisciplinary expert workshops could be held for the individual river segments
- the experience from the design guidelines for the Dutch Rhine branches could serve as examples how to approach river landscapes
- recent or ongoing river-related projects could be used as case studies to extract links between qualitative and systemic layers.

In this regard, capacities of ongoing or recent mitigation and adaptation projects, but also other river-related developments (e.g. navigation) could be evaluated in an academic research project. In collaboration with the practice, smaller scale pilots as part of existing mitigation programs on a river segment scale could aim to substantiate the findings.

### **Strategic Design - Cost-Benefit Analysis**

Further research to substantiate the recommendation for a transdisciplinary design layer could involve a cost-benefit analysis also to trigger political will. Currently, one of the main reasons for procrastination and cost increases in the Rhine 2020 project's execution of mitigation measures are local objections. If the integration of spatial qualities based on a holistic approach were to reduce costs by raising local stewardship and acceptance, this would be a very strong argument for transdisciplinarity.

The consolidated findings brought forth in this research show a missing design strategy in German mitigation projects. At the same time, we find large-scale mitigation projects which produce local resistance and therefore procrastination and an increase of costs. At the same time, the program approach has not been updated since the decision to lower water tables in order to improve the restorative capacity of the retention polders beyond a recreational concept. Although the Dutch and the German flood risk landscapes are very different in topography and therefore in urgency, we can also conclude that the inherent damage potential of dike breaches for certain areas along the German Rhine, specifically the Upper Rhine, is severe enough to threaten regional economies (Ludwig, 2009:14). In any case, the dimension of the Rhine 2020 retention measures in the context of the urbanized landscape that has evolved in the former flood plain, are in terms of scale, costs and impact by all means comparable to the Dutch river widening measures. Therefore, their relation to the built environment needs consideration as a potential for remediation and development. This demands

for an according agency that is capable of supporting local emergence based on the respective landscape-, infrastructure- and land use conditions on site - beyond political and administrative borders. Organized under the ICPR as the initiating agency, it could produce the feed-back loops necessary to create a learning environment for the successful integration of large scale mitigation projects.

Following the example of the "Quality Team" of the Dutch Room for the River program to link the initiating and executing agencies and scales of accumulative mitigation projects may be key to enable emergence on the local scale as a strategy to raise acceptance. As further research, a cost-benefit analysis may substantiate the viability of a transdisciplinary design layer. The analysis could calculate the correlation between the original time- and budget-frames of the retention measures along the Upper Rhine and their actual cost-increase as a consequence of extended realization phases due to local resistance. Assuming a design strategy to be successful, the increase in costs could be set against the costs of an iterative design strategy to link local programs with the polder function.

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## § 10.4 Reflecting On The Research Method Of UFI

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### Systems Approach

Moving from a trans-industrial approach towards UFI challenges some of today's givens, as these hinder the projects from becoming ecological in the broader sense of the term. The post-normal science approach as a methodology and the navigable Rhine catchment as a scope allowed an exploration of ongoing developments beyond existing disciplinary, political, spatial, cultural and economical boundaries.

The summarized results have been gained through the present research project by undertaking a multiscalar and international case-study analysis. The combination of four methodological categories: the catchment, the agencies involved, the urban/regional context, and the project scale, proves a successful way to investigate urban flood integration strategies within the geospecific context of the Rhine as a development corridor and a river catchment. Through this multi-layered perspective, the research project was able to identify key fields for a more emergent practice to continuously transform and renew the urban context along the Rhine. A key to enable a broader acceptance and emergence of these projects being design.

While this paper has disclosed many insights about border negotiations within varying urban contexts and along different river segments of the Rhine, the systemic analysis of design potentials for an expansive approach needs to be studied in much greater detail.

Evidently, water can not be isolated into categories such as surface water, ground water, pluvial, fluvial water, etc., but must be studied in systemically in order to further intelligence and thus urban flood integration along the Rhine. Needless to say, this clearly exceeds the scope of this dissertation and leaves many of the interdependencies crucial to the proposed approach unconsidered. Two further research proposals are formulated below, based on the findings of this research.

### **Learning from NL**

This research did not set out to compare Dutch and German spatial flood management approaches. Instead, it aimed to produce a typological overview of ongoing border negotiating projects in different city-river-landscape constellations along the Rhine. Yet it became clear that projects were clearly framed by European, national and federal programs. For a number of reasons, it was not fruitful to look merely at the spatial design of flood mitigation and adaptation projects. Nor did the inherent systems approach allow for a sole analysis of the spatial design as the author's the field of expertise, but required a strategic design analysis as well. In summary, differences in landscape, threat and political structures have produced different planning cultures in Germany and the Netherlands in terms of flood management. Whereas the Dutch approach to water is holistic in an extended ecological sense, in Germany, planning flood-related issues remains part of a sectoral water management (Hartmann, 2011) confronted by a strong ecological lobby. It is often outruled by local interests that do not coincide with the restrictive practice of flood plain rejuvenation.

What we can learn from the Dutch approach in the light of long-term strategies and programs is a more iterative planning practice that is capable of evolving with the experience gained. This especially applies for accumulative projects that are not necessarily implemented simultaneously. Dutch experience and corresponding policy adaptation has shown that a more permissive planning approach to allow additional programs within Room for the River measures (BGR, 2006 see FRM) can raise local acceptance and thus reduce negative effects.

German programs supposedly rely on penalties, but do not provide any. In Germany, water management agencies therefore avoid projects that could become precedence cases and thus enable repetition. This restrictive approach is a hindrance on the way to larger-scale strategies that rely on pilot projects as testing grounds. The Dutch approach seems to aim for incentives and actually provides them as the trade-off in the Nijmegen case shows (see Nijmegen / I+I). Moving from a restrictive to a responsive planning approach that includes incentives produces a breeding ground for a holistic approach and should always be a central component of any strategy.

In any case, the complexity of the federal administrative structures in Germany and the dynamics in Dutch flood risk management made it a true challenge to manage information. Whereas in Germany, the challenge was often the lack of data availability

and the complexity of the federal system, in the Netherlands, the discourse was moving so quickly with such a vast amount of publications that it was hard to stay on top.

### **Atlas**

One of the main findings of this research is the absence of a visual layer for ongoing programs and projects, specifically in Germany (which may be an additional indication of the lacking involvement of designers in German spatial flood risk management projects). This research aims to contribute to a broader understanding by providing an atlas of selected flood-adaptation and flood-mitigation typologies along the Rhine between Basel and Rotterdam. The final outcome of the multiple case-study investigation within this incomplete atlas is seen to be valuable for a number of different organizations, such as governmental and educational institutions dealing with the geo-specific context and spatial development along the Rhine, representatives from the building sector and venture capitalists, as well as people with a personal interest in ecological urbanism in the context of the Rhine.

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## **Appendix A** Semi-Structured Interviews

This research started out with a riverfront bike tour of 11 agglomerations along the Rhine and interviews with someone from the municipal planning department and from water management (see list below). The main questions being how the two departments collaborate on urban development projects and what role climate change plays in current developments. Except for the two Dutch cities, there were no projects with an active collaboration and climate change was not considered relevant for the urban development plans at the time. Below the questionnaire.

### **Water**

- What areas are flood endangered?
- Water levels?
- What is the current flood management strategy?
- How is it embedded in larger scale programs?
- Are there any statistics regarding the impact of (future) floods?
- Has there been any discussion on climate change and a possible increase of floods?
- How do you collaborate with the urban planning dept.?

### **City**

- Post-productive city? What are current challenges/agendas?
- Is there a vision concept? If so, what role does the river play?
- Are there projects directly related to the river?
- Are there buildings or planned projects outside of the dikes?
- What role do changing water levels play for the urban development of the city?
- Does the urban planning take place in a regional context? If so, how?
- What role do inner city harbours play? Are they active? Transhipment of goods in tons?
- Are there any other post- larger productive development areas within the city region?

### **BASEL / May 24, 2007**

- Urban Planning Martin Sandtner / Baudepartement Basel-Stadt / Structural Development
- Water Management Frank Schmidt+Ruedi Bossert / Tiefbauamt

### **STRASBOURG / June 14, 2007**

- Urban Planning Jeanine Ruf / Agence de développement et d'urbanisme de l'agglomération strasbourgeoise (ADEUS)
- Water Management /

**KARLSRUHE / June 14, 2007**

Urban Planning Mansdörfer / Stadtentwicklung Karlsruhe  
Water Management Roland Adomat / Tiefbauamt Karlsruhe

**MANNHEIM / summer 2007**

Urban Planning Frank Gwildis / Stadtplanungsamt Mannheim  
Water Management Patrick Garecht / Fachbereich Baurecht und Umweltschutz

**MAINZ / JULY 19, 2007**

Urban Planning Claus-Uwe Witzel  
Water Management Manfred Nüsing

**KOBLENZ / summer 2007**

Urban Planning  
Water Management

**BONN / Aug 6, 2007**

Urban Planning Jürgen Linke Stadtplanungsamt  
Water Management Herr Franke

**LEVERKUSEN / Sep 4, 2009**

Urban Planning Daniel Zerweck  
Water Management Ulrich van Acken

**DÜSSELDORF /summer 2007**

Urban Planning Heiko Heinzel Stadtentwicklung  
Water Management Kristian Lütz Stadtentwässerungsbetrieb

**DUISBURG / summer 2007**

Urban Planning Herr Höfgen + Herr Hoffe  
Water Management Waldemar Kesicki

**NIJMEGEN / summer 2007**

Urban Planning Matthieu Schouten  
Water Management /

**DORDRECHT / June 29, 2007**

Urban Planning Ellen Kelder+ Saskia van Waalwijk  
Water Management /

**Follow-up interviews / inquiries were held with:**

Kristine Eberhardt. Wasser- und Schiffahrtsamt Köln. Feb. 11, 2008  
Mathieu Schouten. Municipality Nijmegen. Feb. 11, 2008

Heinrich Webler. icon hydraulic engineering Mainz. Nov. 16, 2009  
Martin Baumgärtner. rheinkolleg e.V. January 26, 2011  
Jan Dieterle. co-author Urban Region Karlsruhe 2030 –beyond boundaries.Jan. 31, 2011  
Günther Wendel. former project manager Polder Rappenwört at Regierungsbezirk Karlsruhe. Feb 18, 2011  
Thomas Henz, Designer Landschaftspark and Rheinauenerlebnispark, Gartenbauamt Karlsruhe. March 6, 2012  
Hans-Martin Waldner, Ministry for the Environment Baden-Württemberg. May 30, 2011  
Heike Rohleder, SGD SÜD Neustadt, January, 2010  
André Schmid-Breton, ICPR, Koblenz, August 30, 2011  
Peter Geiss, project manager Zollhafen, Stadtwerke Mainz AG. March 14, 2012  
Ralf Schernikau, Ministry for the Environment Rheinland-Pfalz, telephone interview, March 22, 2012  
a.o. (add)



## Appendix B Triangle Phd Research Collaboration (Summaries)

Stalenberg, B. (2010). *Design of Flood-proof Urban Riverfronts. (doctoral dissertation).* TU Delft, Delft University of Technology, Delft, NL.

Water serves many purposes. Besides the fact that developed countries see water as a luxurious architectonic feature, water is primarily used for drinking water, for nourishment of crops, as cooling water for industry, for energy, and for inland navigation. Water has made life on earth possible and easier. However, water can also cause a threat to mankind. Floods cause damaged goods, disconnected traffic facilities, power loss and polluted drinking water.

In the Netherlands, the risk of flooding has significantly increased due to the economic development and population rise during the last century. This development created higher consequences if a flood occurs. More people would be hit by a flood, especially a storm surge or a fluvial flood, and more assets would be damaged which results in more economic and social damage. Additionally, the transformation of rural land into urban land caused an increased probability of pluvial floods in particular. From the end of the 19th century, canals were transformed into traffic roads or rail tracks and the construction of residential districts transformed green fields into paved fields with buildings. The flood risk in the Netherlands is also influenced by physical processes. The probability of a flood is likely to increase due to the effects of climate change. Changes in temperature are expected to cause changes in precipitation and evaporation. More and heavier downpours tend to cause higher amounts of storm water and higher river discharges. Climate change also affects the sea level.

Due to climate change and especially economic change of the last decades improvement of the current flood defense system is needed in several Dutch Rhine cities today; the uncertainties in climate change and economic change likely demand improvement of flood defences in more Dutch Rhine cities in the future. At the same time, urban river fronts are subjected to changes due to trends and desires of inhabitants and policy makers. Freedom in this transformation process is desired.

Unfortunately, both improvement of flood retaining structures and the redevelopment of an urban riverfront are extremely difficult. Aim of this research is therefore to find a solution for the difficulties in improving the flood protection structures and the redevelopment of an urban riverfront in the shared realm. Is it possible to create and maintain synergy in an urban riverfront between the technical function of flood protection and urban functions, taking economic development and physical processes into account?

This thesis shows that it is possible to create and maintain physical synergy in an urban riverfront by adopting the concept of Adaptable Flood Defences, also called AFD concept. This concept has the potential to create physical synergy by providing innovative structures which combine urban functions and the technical function of flood protection into one multifunctional structure. Structures like car parks, buildings, dwellings and roads are designed or transformed with the additional capability of protecting the hinterland against floods.

The feature 'multifunctional' sees to it that the presence of a flood defence in the urban riverfront is no longer seen as degradation, but as a contribution to the urban quality. Creating physical synergy in an urban riverfront by adopting the AFD concept should not be a snapshot, but a sustainable affair. It is therefore important to take the aspect of time into account. The AFD concept ensures maintaining physical synergy between the technical function of flood protection and urban functions. The feature 'Adaptable' of the AFD concept enables flood controllers to cope with the uncertainties of external influences like climate change or economic change and to extend the technical lifespan of flood retaining elements.

This thesis also shows that it is possible to create and maintain synergy in the (re)design process of an urban riverfront by consulting the tool 'Urban Flood Protection Matrix', also called UFM Tool. This decision support tool has the potential to create and maintain synergy in the process of (re)designing an urban riverfront by letting flood controllers and urban planners work (more closely) together in the conceptual design cycle during the analysis phase and synthesis phases.

The web-based UFM tool is a creative method, like brainstorming, that contributes to the process of decreasing the difficulties in improvement and adaptation of flood retaining structures and adaptation of urban structures in the shared realm of an urban riverfront. The developed demo version of the UFM tool contains two datasets, three matrices and three decision trees, and a website as interface. The datasets contain a number of types of riverfronts, like a road, and a number of types of flood retaining structures, like a quay wall. The scores that are presented in the matrices are based on the completion of the decision trees and show the feasibility of a combination type of riverfront - type of flood retaining structure from an urban planner's point of view and from a flood controller's point of view.

The UFM tool can be consulted to obtain inspiration during the design process, insight in each others' fields and mutual understanding amongst urban planners and flood controllers. The demo version is available at <http://www.urbanriverfronts.com>.

The case study in the Dutch Rhine city Nijmegen demonstrates that the AFD concept and the UFM tool could be applicable in existing Dutch river cities. It should be possible to

create a (more) synergetic and sustainable urban riverfront which simultaneously solves the current and future flood issues that threaten the urban riverfront.

The case study in the Japanese capital Tokyo demonstrates that the AFD concept has potential in other developed countries than the Netherlands. The super levee in Tokyo is an example of the AFD concept that has already been implemented in Japan. Additionally, the case city of Tokyo demonstrates that the UFPN tool is applicable in other developed countries like Japan.

The visible and physical quality of waterfronts has become more and more important and flooded cities have become less and less accepted. The case study in the Bengali capital Dhaka demonstrates that the AFD concept and the UFPN tool have less potential in developing countries. The urban quality is irrelevant to most Bengali people. The poor are striving at basic needs to survive for which good access to the river is priority. Aesthetics and visual quality are not yet important.

Concluding, this thesis demonstrates that it is possible to create and maintain synergy in an urban riverfront of a developed country between the technical function of flood protection and urban functions, taking economic development and physical processes into account, by adopting the concept of Adaptable Flood Defences, the AFD concept, to achieve physical synergy, and by consulting the web-based decision support tool 'Urban Flood Protection Matrix', the UFPN tool, to achieve synergy in the (re)design process.

**Cuppen, M.E. (2012, forthcoming). Legitimation of Flood management. (Unpublished doctoral dissertation). TU Delft, Delft University of Technology, Delft, NL.**

Recent changes in the approach to flood management in these states have led to new strains on the legitimacy of the flood management sector and its projects. Both in the Netherlands and in the UK emphasis has shifted from implementing technical measures to implementing mostly spatial measures to manage floods. Also both sectors are shifting from a government to a governance setting, meaning that more actors are becoming more intensively involved in developing new flood management policies, including the public, and power becomes more dispersed among the different actors. It has been suggested that personal experience is an important factor influencing legitimization. The increased participation of citizens in flood management projects can therefore be expected to influence the legitimization of these projects.

Legitimacy is the prestige of policy making that it is morally justifiable and therefore authoritative. It differs from support, since it is a group level concept: It is attributed to a flood management sector or a project by all actors who are impacted by it or influence it together. Legitimacy facilitates policy making, since it enhances voluntary compliance with policies and therefore lower enforcement and implementation costs. Considering the importance of legitimacy for policy making, it is important to

understand how policy making in multi-actor settings can be attributed legitimacy. In other words it is interesting to get a deeper understanding of legitimization, therefore I studied how flood management is legitimated. Since participating citizens seemed to also judge the policy sector and not only individual projects on basis of their experiences, this research distinguished between the legitimization of flood management projects and the legitimization of flood management as a whole, and paid special attention to how these two legitimization processes were related.

To study this topic, an international comparative case study was done, in which interpretative methods were combined with more classic qualitative methods such as surveys. I compared the effect of the Nijmegen-Lent dike-relocation project on the legitimization of flood management in the Dutch river region to the effect of the Oxford flood risk management strategy and the Short term measures-1 projects on the legitimization of flood management in the Thames river basin.

The research revealed that legitimization knows three central mechanisms, which I call attitude formation, attitude translation and attitude diffusion. Legitimation starts as a cognitive process at the level of the individual actor. Actors build a reservoir of information on the basis of information received from personal experience, discussions with others and news on flood management via the media. If an actor is sufficiently triggered, (s)he retrieves information from the reservoir of information to form a project or policy sector attitude. Attitudes are formed through an evaluative process in which specific elements of the policy sector or project, the legitimating elements, are evaluated in light of the personal norms the actor holds regarding the sector or project, the legitimating norms. The research showed that the single most important trigger for attitude formation is personal experience with the flood management sector. Actors who participated in a project were more likely to have developed a project attitude, than non-participating actors and these attitudes also seemed stronger. The research further demonstrated that extended personal experience was also necessary to trigger the mechanism of translation: With sufficient personal experience with flood management, an actor could use legitimating elements of a project to form an attitude towards the policy sector. Actor with extensive personal experience in the flood management sector, could use legitimating elements from the policy sector to explain and justify legitimating elements of a flood management project. Such extensive experience tended to be restricted to civil servants and experts and professional societal actors. The cases showed that conflicts could develop between actors translating down and actors translating up as participating citizens did not automatically accept the arguments of civil servants that were based on their downward translation. The research further revealed that under normal circumstances, most actors were unaware of the attitudes of other actors towards the flood management sector. Thus, only a dominant attitude developed and not a 'reputation'. I hypothesize that under special circumstances this dominant attitude can diffuse into a reputation, as actors become aware of each other's attitudes towards flood

management, because they are triggered to discuss flood management with each other or follow flood management news via the media. Further research is needed to study if such a diffusion mechanism can take place and what could trigger this diffusion.

The research further explored empirically which legitimating elements and norms were primarily used to legitimate flood management. I found that in both cases, flood management seems primarily legitimated as a technocratic system. Non-participating actors tended to desire a rational decision making processes, a central position of knowledge and experts, and effective, well-maintained measures that focused on preventing flooding. In the Netherlands, this technocratic legitimization was balanced by a desire for increased influence of citizens, and a responsive government. In the UK, the influence of citizens and responsiveness of government did not seem to influence policy sector attitudes of non-participating citizens. This puts into question if in all contexts, increasing public participation is the most effective way to increase legitimacy. In both cases, participating actors used different legitimating elements to legitimate the project and policy sector. For participating actors the following elements were important: 1) agreement on the substantive starting principles of the project, such as the problem definition, the approach, and the main issues and decision criteria. For instance, actors needed to agree on what is the problem definition, what were the main criteria and how were issues weighed against each other. 2) A process in which the input of societal actors is used in the outcome, and in which all actors have access to the stakeholders they wish to interact with. Participating citizens wanted their input reflected in the outcome of the project, as this showed they had had influence and their investment in the project was worthwhile. 3) A balance between the resources an actor can and wants to invest, the influence he has in the project and the input he is asked to give. For instance, the workload of an actor should not be too high. For this purpose, actors should have enough resources to perform their task (in the form of time, knowledge, and access to knowledgeables) Increasing the intensity of public participation seems to increase citizen's expectations of their influence in the governing system. Some activities in policy processes are highly intensive, but do not automatically give the participating actors more (visible) influence on the outcome of the process. Also actors tend to give most weight to activities they were involved in, which can lead to conflicts on how much each activity should contribute to the outcome of the project. Such conflicts can be detrimental to the project attitudes of participating actors.



# Curriculum Vitae

Cornelia Redeker (1972, Germany) graduated in architecture with a major in urban planning in 2001 at the University of Applied Sciences in Cologne (D) and received the Master of Excellence in Architecture in 2003 from the Berlage Institute, Postgraduate Laboratory of Architecture in Rotterdam. Her master thesis, 'K2O Urban Enclave / Retention / Bypass' proposing to elongate a derelict harbour basin in Cologne to create a secondary waterfront and a flood bypass (Rheinpreis 2009), started her interest in urban flood integration. Cornelia Redeker was assistant professor at the Chair for Urban Design and Regional Planning at the TU Munich from 2004-2011. In parallel, she worked as a PhD researcher at the Faculty of Architecture at TU Delft at the Chair for Urban Design - Theory and Methods from 2006-2010 which resulted in this dissertation. As an architect (CO/R CITIESONRIVERS) she has worked in as a consultant in different international contexts for projects such as the Interreg IVb FloodResilienCity project Mainz Zollhafen and the pilot project for the Nile Research Institute in Wasta Beni Suef Nile km 82.5-87.5. She co-authored the DWA building code 'Flood adapted planning and building' and has published and lectured internationally on the topic of Urban Flood Integration. Since 2012 Cornelia Redeker is associate professor for Architecture and Urban Design at the German University in Cairo where she is focussing on the topics of landscape-based urban design strategies framed by the urgencies of water and land scarcity in Egypt.



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