TIDE

Tidal River Development

Restoration of a tidal foreland in the Werderland region - Feasibility study –

Extracts of the original explanatory report

Dipl. - Ing. M. Birkhoff
+ Partner

Project part-financed by the European Union (European Regional Development Fund)

The Interreg IVB North Sea Region Programme

IMPRINT

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Extracts of the original explanatory report

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Der Senator für Umwelt, Bau und Verkehr
Freie Hansestadt Bremen

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Tidal River Development

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- Feasibility study –

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Table of Contents of the original explanatory report

Chapters in italics are not part of the translated extract

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1 Motive and definition of the task, objective

1.1 Motive and definition of the task

Within the scope of the INTERREG IVB project 'Tidal River Development (TIDE)' it is planned to restore a tidal foreland and part of its riverbank in the Werderland region of Bremen, Niederbüren. The measure is part of the 'Weser Lifeline' development planning, which is in line with the protection of European nature and waters; it serves both the biodiversity of the fluvial topography and peri-urban recreation on the Weser in equal measure. [1] The main features can be traced back to the 'Weser Lifeline' concept study.[2]2

The restoration of this tidal foreland and riverbank in the Weser tidal floodplain gives us the chance of gathering experience in the preparation and implementation of concrete measures in the upper part of the Weser estuary and consequently with respect to the success of the measures and of whether the goals could be achieved. The study hence assumes a general character and the results can be transferred - albeit considering certain local conditions - to similar projects in the upper (limnic) sections of estuaries in the North Sea region in general and the Weser estuary in particular .

In view of the successive implementation of such a restoration measure in the Weser tidal floodplain, it is interesting to note that the necessity of strengthening the Weser and Lesum dike to the right of the Weser has now been recognised. The dike repair work will be carried out by the Bremischer Deichverband am rechten Weserufer. The encroachment into nature and the environment associated with the plans to build a dike could be compensated on the tidal foreland. At the moment it can be assumed that the compensation needed as a result of the dike repair will only require a partial use of the overall area. In the sense of a sustainable development and an efficient use of funds and resources, the awarding authority is pursuing the goal of an **overall plan** with the present study, a plan that should also provide the technical and planning framework for a step-by-step development of the overall planning area as far as possible. This can be realised in several stages, for example, in individual, independent approval procedures or eligible projects, which will allow a clear legal and budgetary separation and assignment of the funds. The present study accommodates this objective: when choosing the individual approaches (alternatives) care was always taken to ensure a step-by-step, quasi modular technical realisation.

[1] Cf. the operational programme EFRE Bremen 2007 – 2013, p. 74

[2] 2 BioConsult Schuchardt & Scholle GbR (2006). Section 'W 2' of the study describes the concept for an alluvial forest development in the area of the Werder tidal floodplain to the right of the Weser between river kilometre 14.100 and 15.400. In detail, the study recommends the creation of reed and shallow water zones, the initiation of an alluvial forest development as well as the lowering of the existing 'summer dike' with the aim of developing biotope structures that are typical for floodplains. Furthermore, the construction of a foot- and cycle-path along the base of the dike on the Weser side is suggested to encourage its use for recreational purposes. Author's note: The term summer dike in the aforementioned study is inapplicable from a technical point of view. The revetment to strengthen the banks of the Weser was extended, as was common at the time, to around 1.00 m above the mean high tide. Since the level of the terrain in the area is on average 2.45 to 2.50 m above MSL, the revetment crown was backfilled and drawn flat to the existing terrain. Although this gives the impression of a summer dike, it is not in fact a summer dike. Source: Martin, WSA (Water and Shipping Authority) Bremen, 23.08.2011 pers. Comm..

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In preliminary talks on the feasibility study it became clear that the aforementioned concept study would differ in two key aspects from the original plan. Firstly, the nature conservation authority defined the goal of earmarking large parts of the project area for the initiation of a fresh water mudflat zone, and secondly the idea of an unbroken foot- and cycle-path solution was abandoned. There are two arguments that support the abandonment of unbroken paths in the tidal foreland: less interference in the project area, but more importantly, the solution suggested for the paths of a berm 'leaning against' the dike clashes with the current and future dike repair. Instead, access to the area will be at selected points. Furthermore, the crown of the dike will be accessible in future, unlike former types of dike, i.e. the crown of the dike can be used to some extent as a path and will provide a spectacular view of the area.

There is, of course, more than one conceivable approach to the intended development of the area. Thus, there are two key parts to the feasibility study alongside the ascertainment and analysis of the basic facts:

1. the development and evaluation of several alternatives for developing the planning area, and
2. the preparation of a feasible preferred alternative to serve as a basis for further plans.

The individual stages of the work were organised and carried out in close cooperation with the awarding authority and a committee of involved experts. Figure 1 shows the process of work and the participation procedure up to now.

1.2 Functional objectives

The goal of the planned restoration is the development of a tidal foreland biotope that is typical for floodplains which will be largely left alone after its construction to allow a spontaneous, inherently dynamic development and whose functioning should be permanently guaranteed with as little maintenance work as possible.

This leads to the following specification for the order if these objectives are to be achieved:

- Functional development of the tidal floodplain with a focus on improving the function of the Weser
- Opening and possibly lowering of the revetment on the banks of the Weser, which now function like a summer dike (riverbank restoration)
- The creation of tidal foreland biotopes that are typical for floodplains (shallow waters, flooding pools, fresh water mudflats, alluvial forest and reed belts) through soil stripping
- The highest possible upvaluation with respect to nature conservation (guideline)
- Existing valuable and remarkable vegetation should be integrated in the planning (no findings anticipated)
- Sustained function (no or little silting-up)
- Lowest possible maintenance (costs)

A further **objective** is to develop parts of the area for recreational purposes and nature observation.

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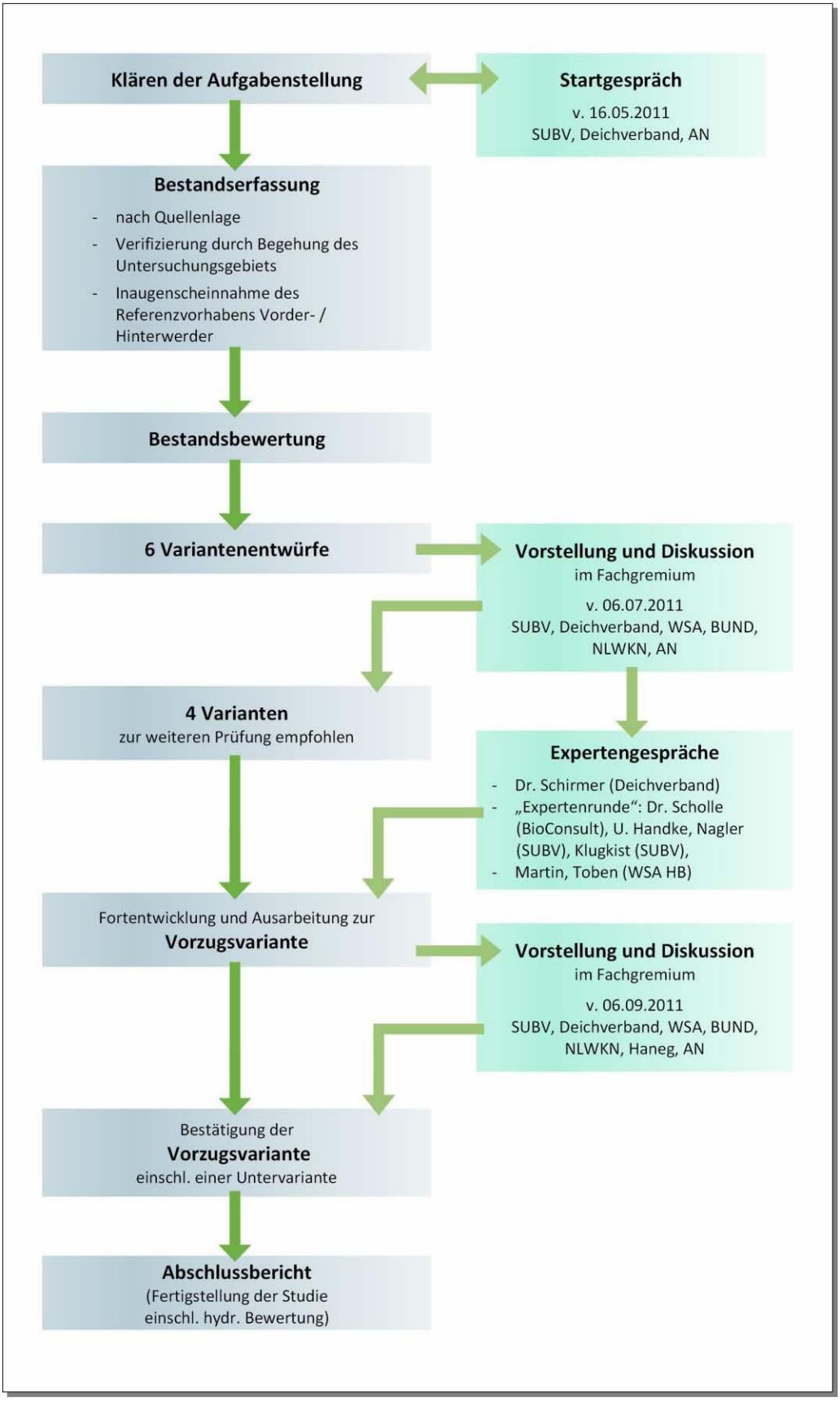

Fig. 1: Flow chart for the planning and dialog process (in English see next page)

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Definition of the task

Kick-off meeting
on 16.06.2011
SUBV, Deichverband, AN

Stocktaking
- new source
- verification through
  visit to investigation area
- inspection of reference
  project Vorder- / Hinterwerder

Evaluation of current situation

6 draft alternatives

Presentation and discussion
in stakeholder's circle
on 06.07.2011
SUBV, Deichverband, WSA, BUND,
NLWKN, AN

4 alternatives
Recommended for further examination

Discussion amongst experts
- Dr. Schirmer (Deichverband)
- 'Group of experts': Dr. Scholle,
  (BioConsult), U. Handke, Nagler
  (SUBV), Klugkist (SUBV)
- Martin, Toben (WSA, HB)

Further development and elaboration
of **preferred alternative**

Presentation and discussion
in stakeholder's circle
on 06.09.2011
SUBV, Deichverband, WSA, BUND,
NLWKN, Haneg, AN

Confirmation of the
preferred alternative
incl. a sub-alternative

Final report
(completion of the study incl. hydr. evaluation)

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2 Stocktaking

2.1 Location of the planning area

The plan area lies on the right bank of the Weser between river km 14.100 and 15.400, directly to the north of the urban district of Niederbüren on the Alter Deich. It is currently being farmed (grassland). The area is surrounded by four kinds of dike. The present report differentiates between the planning area and the investigation area. The planning area is limited to the tidal foreland area and its riverbank shown in Figure 2. The investigation area for the stocktaking in the *narrower* sense also covers the areas marked as reserve strips in the Figure and the dike embankment on the Weser side. The investigation area in the *broader* sense covers the entire surroundings of the planning area, wherever these are of interest for planning or evaluative statements.

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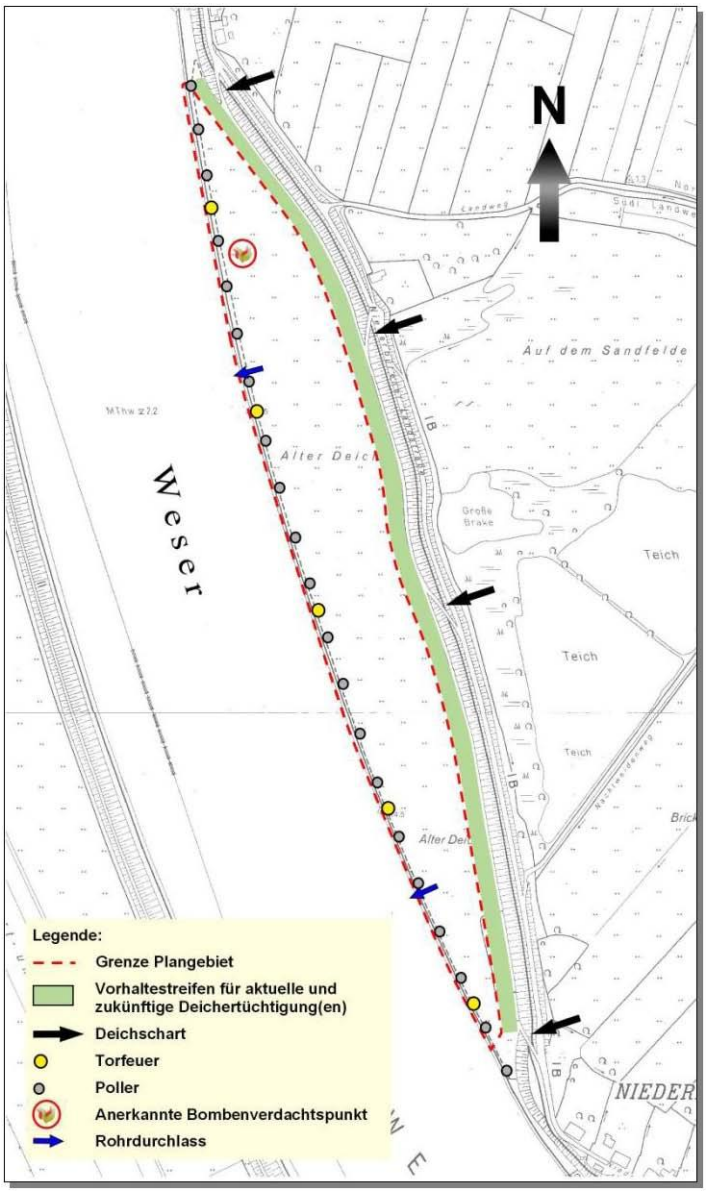

The limits of the planning area are defined by the land required for the expected dike repair as well as the mean low tide (MTnw). This means that the area's border to the east runs parallel to the present foot of the Weser dike at a distance of 25 m from this. In the west the border runs along the MTnw line (-1.57 m MSL).

The planning area is characterised by a relatively homogeneous landform configuration that is only crossed to some extent by former ditches. The most noticeable depression is in the area of the two pipe culverts. The most noticeable elevation is the crown of the Weser bank reinforcement.

Fig. 2: Planning area and narrower investigation area (reserve strips)

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Consequently, the revetment of the bank reinforcement as well as the supplementary reinforcements in the area of the culverts is within the planning area. There is no maintenance path parallel to the revetment, but there is a simple dirt track along the foot of the existing dike. There are 5 Weser navigation lights along the bank at intervals of 250 m, each of these directly to the east of the revetment. Between each of the navigation lights there are 4 emergency bollards made of timber piling and filled with concrete.

2.2 Use of the planning area, recreational

The planning area is currently being used as a pasture for local farmers. There is no further use of the area, apart from its sporadic use for recreational purposes. The latter is restricted to cyclists or local inhabitants using the benches on the different dikes, usually to sunbathe or read. A further activity is taking dogs for a walk. Nature observation is not or only very rarely carried out since the area does not hold any great attraction.

According to local inhabitants the area used to be used for clay extraction and was then filled in again. The inhomogeneous structure of two soil samples[3] from the area confirms these reports. According to the soil samples, no clay can be extracted from the area for the planned dike reinforcement.

The reinforcement of the Weser bank is not developed as a summer dike[4] so that the planning area does not assume the function of a polder. The upper edge of the revetment has an average height of 3.45 m above MSL. The area is drained by two pipe culverts at km 14.370 (DN 500) and km 15.020 (DN 1000).[5]

2.3 Types of biotope

The present mapping of the types of biotope[6] was checked and largely confirmed during an inspection of the site in week 17 2011. According to this, the planning area contains the following types of biotopes:

- Other floodplain grass (GFF, GFFw, GFFw- and GFFw+)
- Intensive floodplain pastures (GIA, GIAw)
- Extensive pasture with few species (GIEw)
- Other mesophilic pasture with few species (GMZw-)
- Exposed loam-clay soil (DOL)
- Exposed sandy soil (DOS)

[3] GRUNDBAULABOR BREMEN (2009) - The findings can be found in ***Appendix A1*** .
[4] Cf. p. 4, footnote 2
[5] Further details of the culverts can be found in ***Appendix A2***.
[6] AG JORDAN / ÖKOLOGIS (2007)

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There is also a small occurrence of

- Single trees (HBE), above all *Fraxinus excelsior* and *Salix alba*
- Other woody plants in accordance with the location HPS (incl. various species of shrubs)

The bank reinforcement was categorised for lack of any other suitable category in the mapping code[7]as TFS = area with natural stone paving.

The planning area is directly adjacent to the path at the foot of the dike including the dike types (OVW and GMZ), as well as the flood protection dike (GMZmwd).

Areas of exposed soil (DOL, DOS) can only be found sporadically: in the area of the culverts and at spots kept clear by cattle. There are no ditches and trenches in the area, only weakly shaped relicts (slight hollows).

According to the available aerial photos and visits carried out during the project, there are two small areas that carry water on a relatively regular basis in the area. These are backflow areas for the two pipe culverts. A small depression in the middle of the area occasionally holds water. The areas have not been mapped as standing water on account of their characteristics but as GFF and DOL according to the predominant and/or missing vegetation. This classification correlates with the assessment of former surveys[8].

The distribution and scope of the different types of biotopes can be seen in Fig. 3.

The riparian zones along the Lesum provide an indication of the current **development potential** of the planning area, as do the conditions on the Schönebecker Sand[9]. The following characteristics can be found here

- tidal river mudflat reed beds (FWR)
- River mudflat with no higher plant vegetation (FWO) (Lesum)
- Pioneer vegetation on muddy banks with chenopodium and bidens colonies (NPF) (Lesum)
- Reed fens (NR)
- Reed beds (NRS)
- River valley bankside shrubs (NUT) (Lesum)

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[7] NAGLER A. (2005)
[8] AG JORDAN / ÖKOLOGIS (2007) – see map 5.
[9] Cf. AG JORDAN . ÖKOLOGIS (2007) p. 72 ff.

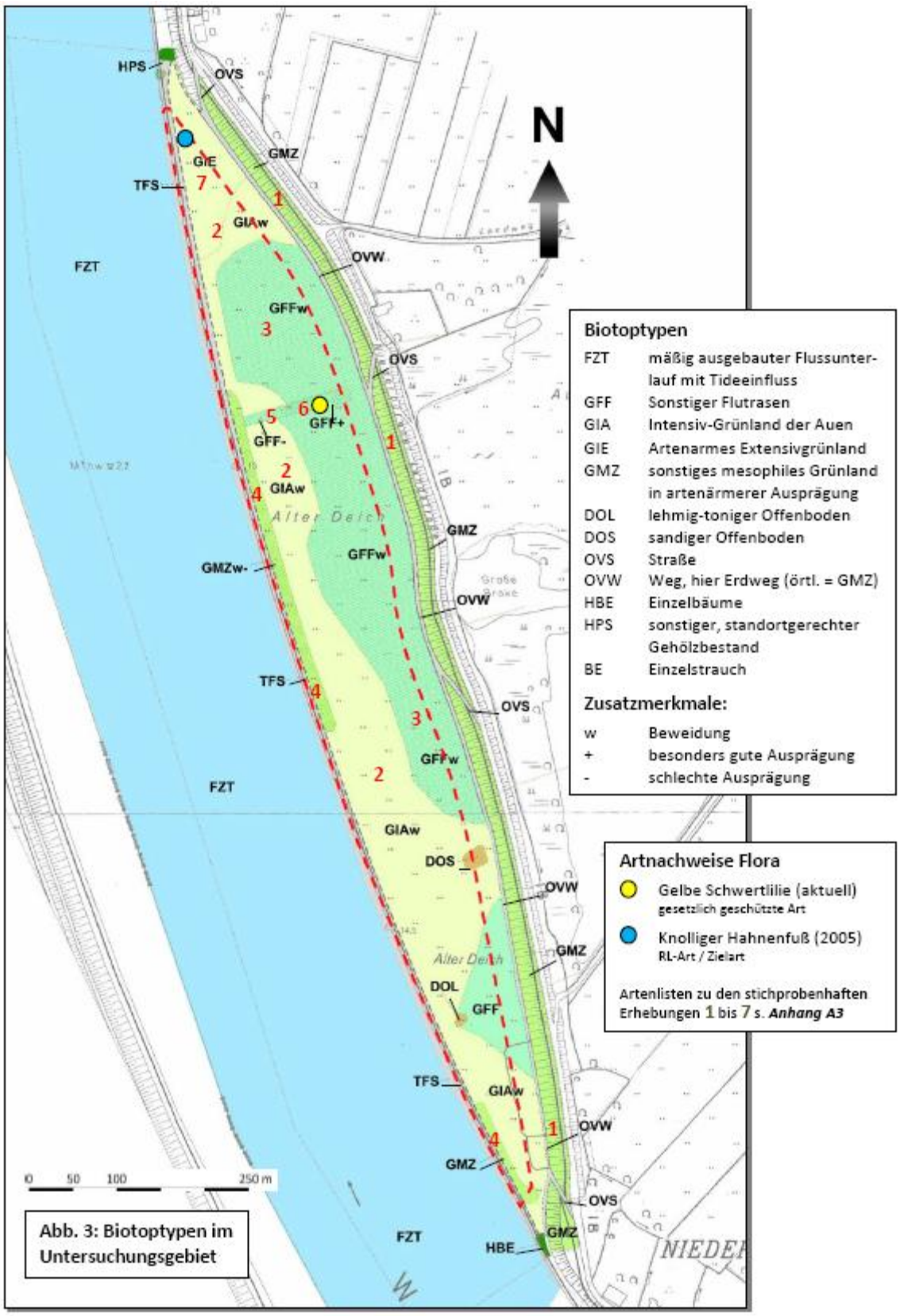

Fig. 3: Types of biotopes in the investigation area (in English see next page)

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Types of biotopes

FZT	moderately developed lower course of river with tidal influence
GFF	other floodplain grass
GIA	Intensive floodplain pastures
GIE	Extensive pasture with few species
GMZ	Other mesophilic pasture with few species
DOL	Exposed loam-clay soil
DOS	Exposed sandy soil
OVS	Road
OVW	Path, here dirt track (locally = GMZ)
HBE	Single trees
HPS	Other woody plants in accordance with the location
BE	Single bush

Additional features:

w	Grazing
+	very distinct development
-	poor development

Identified species of flora

Iris pseudacorus (current), species protected by law
Ranunculus bulbosus (2005) RL species / target species

For lists of species discovered in random surveys **1** to **7** see *Appendix A3* of the original explanatory report

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2.4 Flora

Random species identifications were carried out during the mapping of the types of biotopes. The findings are documented in *Appendix A3 of the original explanatory report*. The occurrence of the yellow iris *Iris pseudoacorus* (unprotected species according to BNatSchG, frequency 2a) in the area of the northern culvert is remarkable. This species was not documented in older surveys[10].

The bulbous buttercup *Ranunculus bulbosus* (RL, ZA), whose occurrence was documented on the northern border of the planning area in 2005, on the other hand, could not be identified. As was to be expected, the yellow meadow-rue *Thalictrum flavum* (RL, ZA), could not be identified either, though it does occur slightly to the north and outside the investigation area[11].

As regards the RL species it should be noted that a classification of the species was not part of the order. Thus, the fact that the named RL species could not be identified does not necessarily mean that they do not occur in the area. However, the probability of a positive finding is very low on account of the nature of the area.

2.5 Fauna

Bird life

As was to be expected. the planning area is not particularly significant for fauna. This also applies for the **bird life**, even though the planning area lies within the borders of the Werderland Birds Directive Area. The main reasons for this, apart from the use, are probably the structural deficiency and lack of open water. The low importance is also reflected by the findings of the given surveys of breeding birds:

Breeding birds in the area:

	1990	1994	1998	2005
Redshank	6	1	1	0
Lapwing	2	0	0	0
Black-tailed godwit	1	0	0	0
Field lark	3	0	0	0
Whinchat	2	0	0	1

Tab. 1: Breeding birds according to source [12]

The other important species of breeding birds that were identified are outside the area.

During various visits to the area in the course of the project, attention was paid to the bird life, though no explicit surveys were carried out. It can be said that the random observations correlate with the present state of knowledge. No distinctive species were observed, nor could any brood be seen.

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[10] AG JORDAN / ÖKOLOGIS (2007) – map section
[11] AG JORDAN / ÖKOLOGIS (2007) – map 6
[12] Cf. AG JORDAN / ÖKOLOGIS (2007) map section

What is remarkable is the proximity of the investigation area to the ponds and grassland areas in the Niederbürener Feldmark (IEP subarea WL 13), which are regularly classified as being very important as resting grounds for waterfowl and terrestrial passage migrants (see also . Fig. 4).[13]

Interpretation of potential for bird life:

The investigation area has great potential for bird life – provided its cultivation and husbandry is abandoned. If it were not used for grazing, one could expect a development similar to the higher-lying Schönebecker Sand, i.e. reed fens would become established at certain points on account of the relatively moist conditions. Species of birds associated with reed beds would profit from this. However, the lack of larger, permanent bodies of water would remain a limiting factor. This means that the existing potential can be improved by simple means if corresponding bodies of water are provided.

Nor is the area's potential limited to reed bed species. In view of the spatial proximity to the neighbouring breeding and resting grounds for waterfowl and waders, the area has a great development potential, provided a larger body of water with neighbouring mudflats can be created. Species that have been identified in the Werderland would also visit the planning area.

Invertebrates

As regards **other groups of species**, the grid details on the occurrence of the slender groundhopper *Tetrix subulata* deserve a mention, even if the findings were probably made outside the planning area.[14] (see raster map, IEP map 24)

Interpretation of potential for invertebrates:
A survey of the invertebrate fauna would have gone beyond the scope of this feasibility study and would not have contributed to any new knowledge that would be relevant for any decisions. This is why no there is no specific interpretation of the potential here. Nevertheless, some basic conclusions are obvious: the following statements were made during the discussions amongst experts (see Fig. 1)

- A development of the planning area could generally help the invertebrates of the riparian cenosis [15],
- A belt of shrubs to shelter the area could enrich the habitat available for invertebrates, as could an intermediate zone between mudflat / reed bed too.[16] Furthermore, a lowering of the bank reinforcement fixed in the crown would benefit the ground beetle populations.[17]

[13] AG JORDAN / ÖKOLOGIS (2007) – see See 40 Fig. 9.
[14] AG JORDAN / ÖKOLOGIS (2007) – map 24
[15] Discussion amongst experts on 15.08.2011 (unpublished.)
[16] Dr. Schirmer, 12.08.2011, pers. comm.
[17] U. Handtke, 15.08.2011, pers. comm.

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Fish fauna

The proximity of the area to water is of particular significance for the planned measures. Of course, this is currently of no importance for the fish fauna, but the area can develop a great potential through appropriate measures.

With this in mind, the river lamprey *Lampetra fluviatilis* and sea lamprey *Petromyzon marinus* species that migrate in the Weser and Lesum in particular should be mentioned. The twaite shad *Alosa fallax*, with the proven reproduction success in Farge (focal point of the spawning ground between Weser km 20 and 32), on the other hand, does not migrate up the Weser to the planning area.

Interpretation of potential for fish fauna

In its present condition the area has no structural potential whatsoever. The only factor that makes the area important is its location in front of the Weser dike. It is almost uniquely important in Bremen as the only large tidal foreland available for floodplain development. The area's potential is therefore primarily dependent on the objective of the measures and secondly the accepted (building) work.

The layout and size of the area are adequate to create a tidal tributary that is directly connected to the Weser whose importance results from the functional significance as a resting, spawning and winter habitat. We have to qualify this statement by saying that – irrespective of which plan is implemented – there will very probably be no direct advantages for the key species of twaite shad. A tributary with little current can be a resting area for river and sea lamprey. For all other species in the Weser, a tributary would be a valuable habitat in several respects. A clear indication of the possibility of achieving this goal is provided by the findings of the compensatory measure 'Vorder- / Hinterwerder', which will therefore be included in the considerations in the following as reference projects (see Chap. 4).

The planning area also becomes important as a potential stepping stone on account of its location between the Vorder- / Hinterwerder and the mouth of the Lesum.

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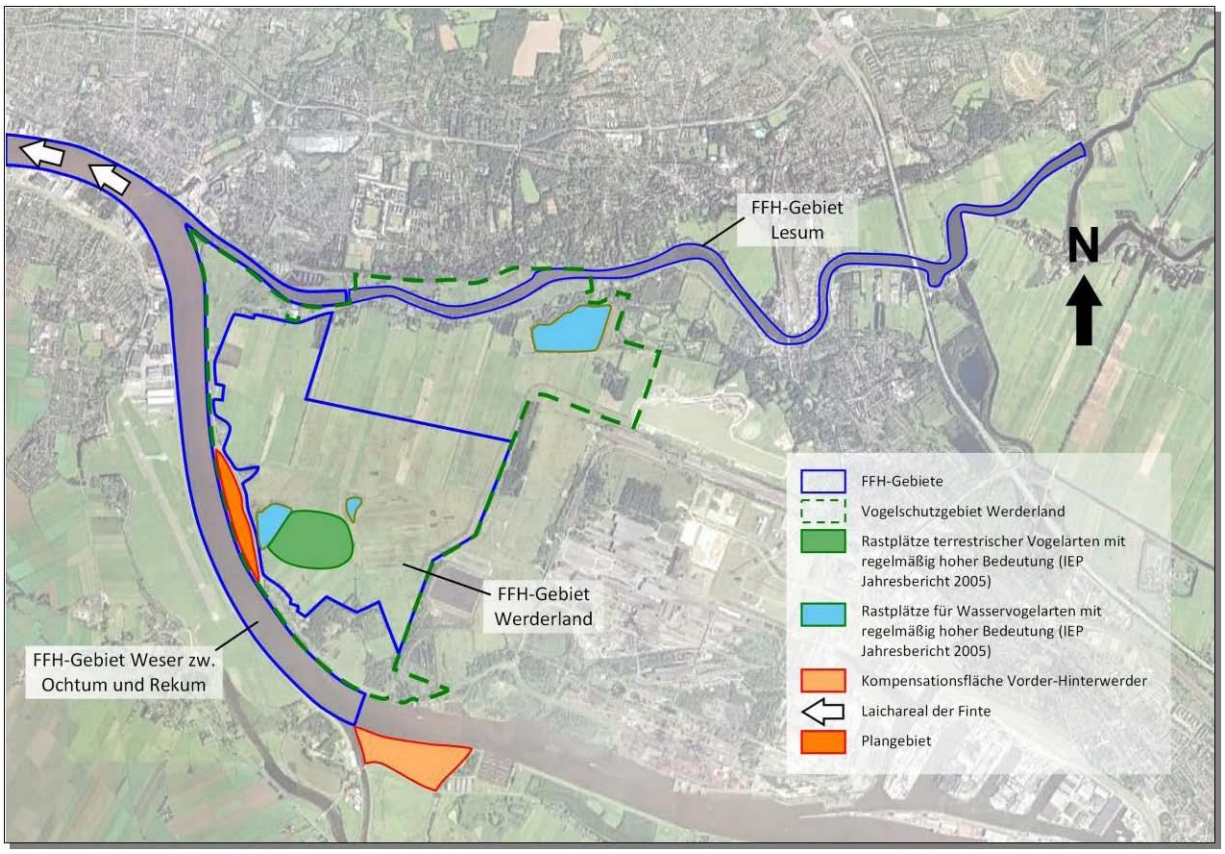

Fig. 4: Location of the planning and investigation area in the region (Habitats Directive areas and Birds Directive area)

2.6 Protected areas, programs, general principles, preservation and development objectives

Since it can be assumed that the circumstances in the surroundings of the planning area are known to all experts involved, there is no need for a detailed description. The key aspects and protected areas will hence only be listed for sake of completeness.

The planning area is a *floodplain* in accordance with § 91 ff BremWG. (Bremen water laws)
It is part of the *landscape protection area 'Werderland and Lesum reed beds'*
and part of the *Birds Directive Area 'Werderland'* (DE – 2817-401).

It is directly adjacent to

the Habitats Directive area Weser between Ochtum and Rekum (DE - 2817-370),
the Habitats Directive area Lesum (DE – 2818-304),
the Habitats Directive area Werderland (DE - 2817-301) with the nature protection area Werderland (part I),
and is close to the nature protection areas Werderland and Dunger See

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In the landscape program for Bremen[18] the investigation area is shown as part of the Werderland in the category protection and development of the recreational potential of areas mainly used for agriculture and forestry as well as grasslands for limited public use (inventory). The Niederbürener Landstraße is classified in the category protection, development and creation of new green links and recreational paths between settlements.

In the city state Bremen the Weser, Wümme and Ochtum as well as the Geeste in Bremerhaven are identified as cyprinidae waters, i.e. as bodies of water in which the requirements for carp-like fish have to be satisfied.

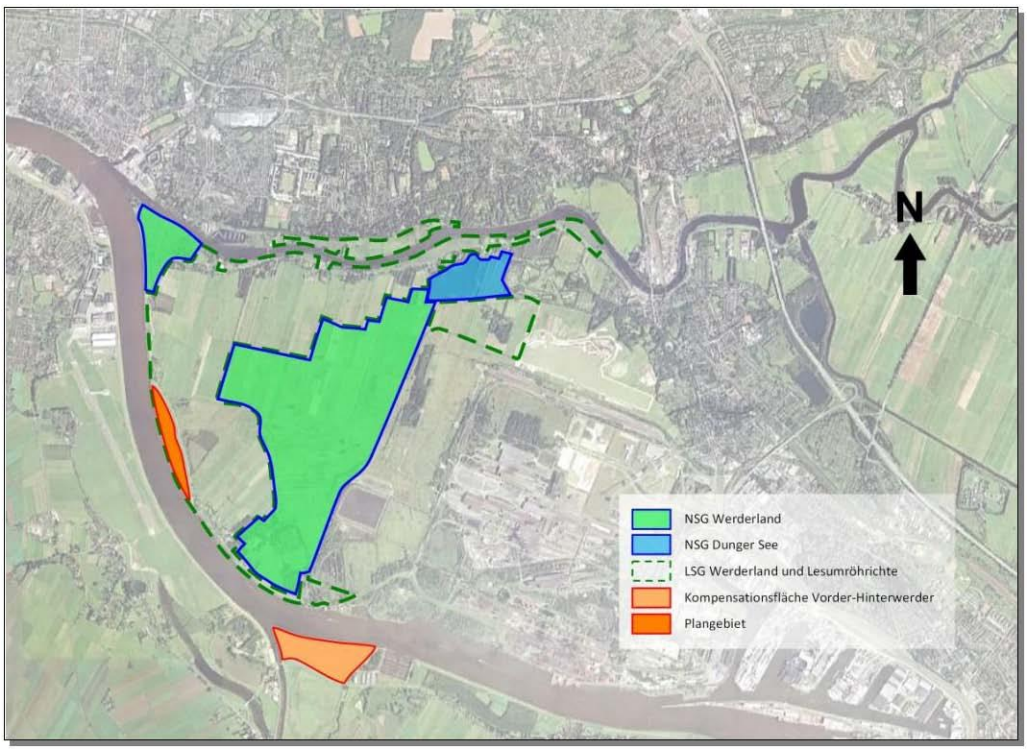

Fig. 5: Nature and landscape protection areas

On account of the particular significance of the Habitats Directive areas and the Bird Directive Areas for the functional context, the characteristics of the area and development objectives have been summarised in ***Appendix A4***. Unfortunately the preservation and development objectives are as yet incomplete and in a relatively ambiguous wording. The integrated management pan Weser (IBP)[19], which so far is available with its technical paper 'Natura 2000'[20] (revised preliminary draft from June 2011) promises to largely remedy this deficit. Since the main requirements on the restoration of the Weser tidal floodplain are based on the general principles, preservation and development objectives, the most important statements of the technical paper 'Natura 2000' on the IBP Weser have been summarised in the following (abbreviated in part)[21].

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[18] FREE HANSEATIC CITY OF BREMEN - SENATOR FOR ENVIRONMENT , CONSTRUCTION AND TRANSPORT (2011)
[19] NLWKN and SUBV (2011)
[20] KÜFOG GMBH (2011)
[21] The page references refer to KÜFOG GMBH (2011)

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Overall spatial concept for the tidal Weser (… target state B)**:**

- Shallow water zones in the Außen- and Unterweser each account for an approx. 10% share of the overall area of the tidal space. The transition from eulitoral to shallow water zones, to the flat sublitoral and deep sublitoral is gently sloping wherever allowed by the current and width of the river. There is a largely natural vegetation zone to the mean high tide line. (p.304)
- The riverbank vegetation is diversified and has a favourable development (p.305)
- On the Unterweser. 75 % of the foreland in the floodplain has favourably developed structures. Tidal riparian forests exist at suitable locations on the higher-lying foreland. They are concentrated in the limnic section of the Unterweser and account for a total of approx. 10 % of the area
- In the limnic zone of the Weser, Hunte and Lesum, parts of the original cenosis have been able to develop in shallow water areas with a slower current (in particular bivalves, snails, ephemerae, diptera, caddis flies, water beetles, aquatic bugs and dragonflies) (S.306)
- The permanent riverbank development will be reduced. (p. 307)
- Environment-friendly recreational and tourist activities such as controlled 'nature experiences' are widespread but eco-sensitive subareas are excluded from recreational use. (p. 308)

The following have a high priority when phrasing the overall spatial preservation objectives of the IBP (see p. 309f.):

- Habitats/types of biotopes typical for estuaries and tidal floodplains compared to 'other' types of biotopes
- The under-represented habitats such as (..) shallow water zones, intertidal estuarine mudflats and alluvial forest
- Those functions that depend on the effects of the tide have priority in the foreland over functions that can also be fulfilled inland

The following general deficits were named (p. 310)**:**

- A lack of permanent, flat overflowed shallow water zones and lateral areas with a slower current
- (..) A lack of unused / extensively used tidal foreland
- (..) A lack of any progression in vegetation structures from the foreland to the mudflats
- Missing natural riparian structures
- No link between the river and aquatic habitats in the floodplains, e.g. because of riverbank revetments

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Consequently, the following overall spatial preservation objectives can be derived from this (p. 311f.):

- Preservation and development of (…) processes and functions that are typical for (tidal) floodplains so as to achieve favourable abiotic condition and the typical hydromorphological structures
- Preservation and development of (…) habitats that are typical for (tidal) floodplains and their dynamic changes – incl. the development, enlargement and upgrading of shallow water zones (…)
- Preservation and development of habitats and biocenoses that depend to a large extent on the natural dynamics of morphological processes (e.g. mudflats, shallow water zones, …),
- Preservation and development of the characteristic types of biotope that occur in the planning area in a size, spatial distribution and interaction such that those species that are typical for the biotope can occur in long-term viable populations
- Development of a balanced ratio between mudflats, shallow water zones, flat sublitoral and deep sublitoral whilst guaranteeing the safety of shipping
- Development of lateral areas with shallow water zones and natural transitions between water and land and the encouragement of natural vegetation structures and biotope quality
- Development of favourable species for riparian structures
- Preservation and development of alluvial forest structures

Special preservation objectives will be defined, amongst others for twaite shad see lamprey:

twaite shad: Preservation and encouragement of a vital, long-term viable population of twaite shad that consists of several generations of spawning fish; Preservation and development of the unhindered passability of the estuary between the marine nursery and wintering area as well as the spawning grounds and nursery habitats of the fish larvae in the limnic section of the estuary

Sea and river lamprey

Preservation and development of the unhindered passability of the estuary and tidal Weser for lampreys (sea and river) between the marine nursery areas and as well as the spawning grounds and nursery habitats of the European brook lamprey in upstream sections of water and tributaries of the estuary;

The following were put forward as concrete measures (p. 317ff.):

- Lowering of existing riverbank reinforcements (measure no. 15), lowering of summer dikes, here in particular the revetment in the planning area (p. 444)
- Change in the agricultural use of the foreland, possibly its abandonment (measure no. 17)
- Creation of shallow water zones (measure no. 21)
- Measures to protect and develop alluvial forest structures (measure no. 43)
- Creation of pond areas with a slower current as part of a stepping stone system from resting areas for lampreys (measure no. 50)

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2.7 The Weser

The Weser is part of the 'Ströme der Marschen' river basin. Like the nearby Lesum, it is classified as a moderately developed lower course of a tidal river (FZT) (see Fig. 3 Types of biotopes). The aquatic habitats of the Weser and Lesum were not investigated in the course of the IEP.[22] After reviewing the pertinent literature, the state of the Weser with respect to ecological parameters can be summarised as moderate, and in terms of the chemical parameters as very good. What is striking is that the evaluation of the Weser with respect to the ecological potential differs in the sources.[23]

Management plan Weser 2009[24]

- Ecological potential of the 'greatly changed body of water': moderate
- Ecological state of the phytoplankton: moderate
- Ecological state of macrophytes / phytobenthos: unsatisfactory
- Ecological state of the macrozoobenthos: unsatisfactory
- Ecological state of the fish fauna: moderate
- Chemical state: good
- Chemical state, heavy metals: good
- Chemical state pesticides: good
- Chemical state other pollutants: good

Programme of action Bremen 2009[25]*:*

- Ecological potential of the 'greatly changed body of water': unsatisfactory
- Chemical state (according to applicable law): good
- Chemical state (according to daughter directive priority substances): not good
- Ecological state for fishes: moderate
- Ecological state for the macrozoobenthos: unsatisfactory
- Ecological state for macrophytes, phytobenthos: unsatisfactory
- - Ecological state for phytoplankton: moderate

[22] AG JORDAN / ÖKOLOGIS (2007) – see p. 41.
[23] The contradiction in the named sources is of no significance for the results of the present feasibility study and hence can be ignored. It should be noted at this point that SUBV is looking to clarify the facts.
[24] Cf. FLUSSGEBIETSGEMEINSCHAFT WESER (N.D.)
[25] FREE HANSEATIC CITY OF BREMEN - SENATOR FOR ENVIRONMENT, CONSTRUCTION, TRANSPORT AND EUROPE (2009). With respect to the apparently contradictory data for the chemical state, see Fig. 5 and Fig. 6.

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Hydrological parameters:

The regular tide change and associated changes in the current and fluctuations in water level are characteristic for the Weser. The planning area is between river km 14.100 and 15.400. Hydrological properties can be derived from the levels in Vegesack and Oslebshausen.

Water levels 2001 - 2010
in metres, reference MSL

	Level Vegesack	Level Oslebshausen	Year	USG1	USG2
River km	17.850	8.375		15.400	14.100
Mean high tide	2.39	2.52		2.42	2.44
Mean low tide	-1.55	-1.62		-1.57	-1.58
HQ10	not available				
Highest high tide	5.33	5.34	1962	5.33	5.33
Lowest low tide	-3.29	-3.22	1964	-3.27	-3.26

Tab. 2: Water levels for the closest levels in Vegesack and Oslebshausen as well as the planning and investigation area[26]

When comparing the available data it is noticeable that the averaged values for the mean high tide and mean low tide in the current summary of the WSA (Tab. 2) are higher than the values for the monitoring period 1996 – 2005 (Tab. 3). The upward trend in the water level can hence already be seen in this short period of time.

Water levels 1996 - 2005
in metres, reference MSL

	Level Vegesack	Level Oslebshausen
River km	17.850	8.375
Mean high tide	2.36	2.47
Mean low tide	-1.55	-1.65

Tab. 3: Comparative date for the levels in Vegesack and Oslebshausen[27]

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[26] USG1 = northern end of the investigation area, USG2 = southern end of the investigation area. Year = Year of the event. Mean high tide and mean low tide = mean values from a 10-year monitoring period. Source: WSA BREMEN (2011).
[27] Martin, WSA Bremen, 31.05.11 pers. comm.

Current velocities
in cm/sec

	Level Vegesack	Level Oslebshausen	USG1	Level USG2
River km	17.850	8.375	15.400	14.100
Mean ebb tide	50	45	48.71	48.02
Mean flood tide	40	30	37.41	36.04
Max. ebb stream	100	65	90.95	86.15
Max. flood stream	80	50	72.24	68.13

Tab. 4: Current data for the levels in Vegesack and Oslebshausen as well as the planning and. investigation area[28]

2.8 Evaluation of today's state

The following evaluation is carried out on the one hand as spatial evaluation according to the guideline[29], an on the other with a view to functional aspects.

Types of biotopes: Although the majority of the planning area in terms of space is intensely farmed pastures with a high structural deficiency, the types of biotope prevalent in the area in its entirety can by all means be rated as medium on account of the large share of floodplain grass colonies (GFF – other floodplain grass). The few temporary and very small bodies of water and exposed soil areas, on the other hand, are unsuitable to attribute any greater significance to the area.

A compilation of the spatial shares in the planning area and their approximate evaluation according to the guideline can be found in **Appendix A5**. A more extensive, approximate 'balancing' that includes the evaluation of the current situation is presented in Chap. 6.4.

Flora: The by and large lack of RL species and target species (with the exception of the sporadic occurrence of yellow iris) emphasises the currently low significance of the area with respect to its flora.

Bird life: Hardly any breeding activity could be proven in the area. Furthermore, the area has no appreciable significance for passage migrants, so that its importance for bird life can be currently regarded as being very low.

Other groups of species: As regards other groups of species, there are no references in the available sources of any appreciable significance.

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[28] WSA BREMEN (2011)
[29] UNIVERSITY OF HANNOVER, INSTITUTE FOR LANDSCAPE MANAGEMENT AND NATURE CONSERVATION(2006)

Nor does the area have any real significance at present from a **functional point of view**. Apart from the lack of bodies of water and life-enhancing habitat structures, it is the barrier effect of the Weser dike with the accompanying Niederbürener Landstraße on the one hand, though more seriously the reinforcement of the Weser bank and its crown, which rises almost 1 m above the rearward land, that is noticeable.

The low significance of the area in its present state from a nature conservation point of view corresponds with the demarcation of the Natura 2000 areas, from which the area was also excluded (see Fig. 4).

Recreational use
On account of the present state of the area it has no appreciable appeal for recreational use. Although the area in front of the dike can be accessed thanks to the types of dike and the maintenance path along the foot of the dike, there are no incentives (experience nature, bird watching) to spend any time in the area. As regards experiencing nature, the area does have potential for development, even assuming that access to the area may have to be restricted from a nature conservation point of view.

2.9 Consequences for the choice of alternative

If one accepts the location of the area in the region, in particular the vicinity to the Werderland, Schönebecker Sand, Lesum and Weser, and not least the compensatory measure Vorder-/Hinterwerder and Ochtum, this reveals a development potential that goes far beyond the area's intrinsic potential if exploited accordingly on account of its functional aspects. Since the barrier effect of the Weser dike and Niederbürener Landstraße will only be able to be mitigated to a certain extent in future, conceivable measures can concentrate on the area on the one hand and/or look to reduce or eliminate the Weser barrier (bank reinforcement) on the other. Fig. 6 clearly shows that this leads to an area of conflict within which the bandwidth of possible scenarios is located.

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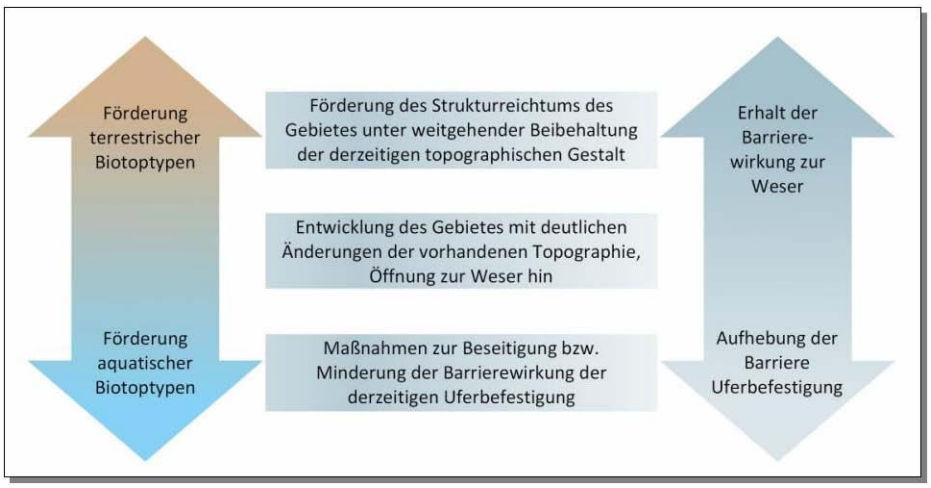

Fig. 6: Area of conflict for range of possible measures

It all boils down to two key questions:

- Will preference be given to the development of a primarily aquatic habitat or a more terrestrially-based habitat?

- Are we willing to reduce or largely eliminate the barrier effect of the riverbank reinforcement?

The requirements of overriding programmes as well as the preservation objectives of the neighbouring Habitats Directive areas and Birds Directive Area are crucial when answering these questions (see above).

It should also be remembered that the area is one of the few, if not the only larger **tidal foreland areas** in the tidal Unterweser in which nature protection plans can be taken into account during the floodplain restoration. With this in mind, the aspect of eliminating or reducing the barrier between the Weser and the area *and* the development of limnic types of biotopes becomes crucially important.

Summing up it can be said that solutions which partially maintain an extensive pasture management are also conceivable. However, this is only economical attractive for farmers if a sufficiently large area of land with a suitable layout is available. But since the all of the corresponding areas will become the property of the Deichverband as things stand, the planning scenarios can assume a complete abandonment of agricultural use in line with the development objectives of the IBP draft.

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3 Structural engineering restrictions

Before going on to discuss the alternatives suggested by the authors and how they arrived at these, some structural engineering aspects will first be addressed which have a big influence on the performance of the construction work and thus the possible costs.

3.1 Safety reservations dike construction

According to § 6 para. 3 of the statutes of the Bremischer Deichverband am rechten Weserufer, a 10 m strip has to be kept clear from the foot of the dike to any construction and (interfering) uses. This is why the planning area border on the dike side has been shifted 25 m away from the present foot of the dike. These reserve strips also take into account the necessary expansion reserve for future dike repairs.

3.2 Safety reservations shipping

A safety reservation for shipping always applies for any measures on the outside of the dike. The safety and ease of shipping traffic must be guaranteed at all times in accordance with BWaStrG (German law on inland waterways). In this regard, two risks of the planned measure have to be considered:

- A disturbance to the navigation lights during possible construction work
- The possible input of deadwood from the area with the risk of a collision for shipping.

It should be noted here that the continued operation of the navigation lights, even during possible construction work, can be guaranteed by suitable measures, e.g. the erection of one or more temporary lights. All of the plans in this feasibility study assume that the existing navigation lights can be retained or rebuilt at their present location.

The risk of an input of deadwood from the area presumes that an alluvial forest development will be initiated and successfully established in parts of the area. On account of the relatively long development periods, no real risk potential for shipping need be feared for around 5 decades. This statement is based on the assumption that fast-growing species such as *Salix alba* become established immediately on completion of the measure and reach maturity after around 40 years. A 10-year period of high vitality is then assumed before one can reckon with a gradual increase in the risk of massive deadwood development on account of a decreasing vitality (individual trees or parts thereof). This risk is probably even lower in reality. It should also be noted that there is less of a risk of damage to commercial shipping on account of the size and design of vessels than to yachting.

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3.3 Safety reservation protection of waters

Irrespective of the type of solution that is finally realised, the alternative measures discussed in this study can be realised with no pollution or contamination of the Weser with pollutants - assuming professional construction work - and as long as there is no, as yet unknown, source of contamination in the area. Corresponding surveys may have to be carried out in this respect in the further course of the planning process.

A further risk that has to be discussed is the potential erosion from the area into the Weser. The WSA insists on a guarantee as part of the safety reservations for shipping that this will not happen. From the author's point of view, there is no relevant risk of such erosion. The planning area is located on the inner bank of the Weser, an area in which in silting-up processes are more natural. Furthermore, all ports and tributaries connected to the Weser are threatened by silting-up, and are therefore subject to erosion. It should also be noted that it has been proven that there is a surprisingly low, but still positive mass balance for the compensatory area 'Vorder- und Hinterwerder', i.e. it would appear that there is no transport of soil into the Weser, rather this is deposited in the compensatory area.[30]

On the other hand, a temporary transport of soil into the Weser during the construction phase and in the first year following establishment of a measure cannot be ruled out on account of the various processes. In anticipation of further chapters, it should be noted here that this risk was taken into account when preparing the preferred alternatives in the form of corresponding recommendations for the design of the riverbank lowerings and instructions for the performance of the construction work[31].

[30] Cf. BIOCONSULT SCHUCHARDT & SCHOLLE (2011) p. 17 and p. 60. - The distance from the middle of the planning area to the intake structure of the tidal biotope 'Vorder- / Hinterwerder' is around 2.8 km. This is thus a plausible reference object on account of the spatial proximity.

[31] See description of the preferred alternatives in Chap. 6. – An expertise from Timme Consultant Engineers can be found in **Appendix A7**

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3.4 Connection of the area

The planning area can only be reached by public roads on the Burger Heerstraße and Lesumbroker Landstraße and carrying on from this the Niederbürener Landstraße. As of the Lesumbroker Landstraße, the carriageway has a load-bearing capacity of 26 t[32] and an average fortified width of 4.20 m, so that this is only of limited suitability for the necessary building site traffic. What's more, access to the construction site via the Lesumbroker Landstraße would probably trigger a big protest on account of the nuisances for local residents caused by the traffic.

Planning area centre – junction with Bremer Heerstraße plus distance to landfill site (11.83 km)	7.18 km
Planning area centre – AS Ihlpohl (A27/B74) plus distance to landfill site (11.82 km)	9.88 km
Planning area centre – AS A281 plus distance to landfill site (9.36 km)	9.67 km
Planning area centre – locations of large ponds	approx. 2.00 – 2.50 km

Tab. 5: Transport distances – public roads [33]

One alternative for road transport is to access the building site via the Acelor-Mittal steelworks. In this case only the Mittelsbürener Landstraße would be used. The main part of the route would be on the steelworks property and allow direct access to the A 281. Only a small share of local inhabitants would be affected by the building site traffic. This would require the consent of Acelor-Mittal.

Another alternative that does not require road transport would be to supply the planning area by barge from the Weser. This alternative has some big advantages in combination with a simultaneous dike repair and a possible backfilling of excavated earth (mineral soil) in the Hemelinger See since the barge traffic could be organised in an ideal case with no empty trips.

Planning area centre – factory gate Acelor-Mittal (Moorlosenkirche)	2.43 km
Planning area centre – AS A281 via Acelor-Mittal plus distance to landfill site or backfill site (9.36 km)	7.89 km
Planning area centre – Hemelinger See via Weser	21.54 km one lock

Tab. 6: Transport distances – via Acelor-Mittal factory premises and waterways

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[32] Source: Stürgen, ASV 28203 Bremen, 24.06.2011, Tel.

[33] See Chap. 6.5 for the possibility of dumping excavated soil in ponds left by clay extraction

4 Development of alternatives

The alternatives for the development of the planning area presented in Chap. 5 have been derived on the one hand from the area's potential and on the other from the requirements of overriding programmes, guidelines and the preservation objectives of the neighbouring Natura 2000 areas. General principles as well as the development and preservation objectives for the Natura 2000 areas and the Birds Directive Area have already been presented in Chap. 2.6.

Table 7 summarises the derived objectives.

Habitat development for fish fauna
- Resting areas for diadromous species (sea and river lamprey) - Resting, winter and possibly breeding habitat for other species
Development as a stepping stone for various species
- - Waders - - Reed bed breeders - - Passage migrants
Development of characteristic, deficitary types of habitat
- - Permanent tributary - - Fresh water mudflat zone - - Alluvial forest - - Reed fens

Tab. 7: Summary of the derived objectives

Foregoing considerations

There is a particular challenge with respect to the development of permanent bodies of water and fresh water mudflat zones. Both are affected by the expected sedimentation processes and are subject to the risk of change.

The creation of permanent *bodies of water* with little current as a resting habitat for the fish fauna primarily calls for shallow water zones. These, however, are susceptible to sedimentation processes as well as unwanted heating up in summer. The latter can be overcome by a deeper body of water, and this also determines the nature of the body of water as a winter habitat. A sufficient depth of water is important not only as protection against the formation of ice but also to guarantee an adequate volume of oxygen beneath the ice cover. Consequently, successful plans will have to combine both shallow water and deep water areas.

In order to preserve *mudflat areas* in the long term, the virgin terrain must be below a level yet to be defined. Although this creates a reserve volume to prevent sedimentation all too quickly on the one hand, only a certain flood level can prevent the areas being completely covered by reed beds on the other.

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Alluvial forest development also depends on certain ground levels and this flooding frequencies and flood levels. This aspect turned out to be relatively uncomplicated. Once the decision had been taken in stakeholder circles to abandon the goal of a hardwood floodplain and to limit the development of the area to a softwood floodplain, there was little need for planning since the existing ground level doe not oppose this goal. In this regard, the present use only has to be abandoned and possibly some initial planting carried out.

Reed fens would develop in parts of the area when its present use was abandoned – as already explained in the description of the potential. A change of the landform configuration in favour of more moist locations would further increase the diversity of the development.

The results of compensatory measures were analysed in order to develop the most promising approaches with respect to the habitats 'permanent tributary' and fresh water mudflat zone. The following aspects favour a consideration of the tidal biotope as a reference biotope:

- comparable objective,
  - the creation of fresh water mudflat zones and reed beds, amongst other things, and
  - the creation of a body of water with shallow and deep water zones to encourage the fish fauna
- comprehensive monitoring findings
- the spatial proximity to the planning area (results can be transferred)

More than 10 years after the construction of the measure it can be said that the objectives that were set could be achieved to different extents (see Tab. 8). Apart from numerous positive findings - the compensatory measure 'Vorder- / Hinterwerder' has apparently proven itself to be successful in numerous aspects with regard to the encouragement of the fish fauna[34] - what is noticeable is that today, unlike earlier times[35], there are no appreciable mudflat areas. Temporary mudflat areas and strips only appear in a few, limited riparian zones as well as in the middle of the area at low tide in the area (NwG). The small mudflats in the middle of the area are visited by shorebirds immediately on their appearance, but the mudflats on the edges are not because they are too narrow. There are also deficits on account of the small expanse of the tidal lateral spaces as well as the missing habitat structures for the settlement of aquatic macrophytes and typical invertebrate benthos fauna[36].

On account of the few remaining mudflats, it has to be asked whether the small tide in the area, i.e. the low level of overdammed backwater, encourages the expansion of reed beds and is the cause of the small share of mudflats. Based on the level at Rodenkirchen, the author therefore investigated the water levels between which the transition from reed bed / mudflats permanently arises in the neighbouring areas of water.

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[34] Cf. BioConsult Schuchardt & Scholle (2011)

[35] Dr. Scholle, 15.08.2011, pers. comm.

[36] Cf. KüFOG GmbH (2011) p. 445

Characteristics of the 'Vorder-/Hinterwerder' area:	
Size of area:	22 ha
Objective:	comparable, incl. creation of mudflats
Overflow construction:	+1.70 MSL
Connection to Weser from 90 min. before mean high tide to 90 min. after mean high tide	
Tidal range in area:	0.70 m
Depth of water at Nw_G:	0.2 – 0.5 m, deeper areas as sediment traps
Overflow:	25 m wide, reinforced (ford)

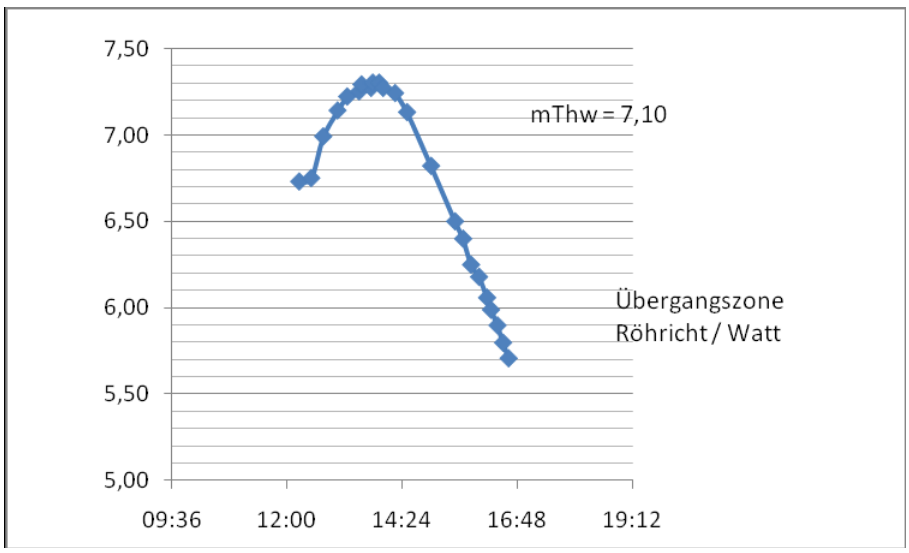
Findings on achievement of objectives:

- distinctive development of reed fens, hardly any mudflats
- increasing tendency of scrub encroachment

- visited as a resting biotope by avifauna (migrants)
- a small mudflat in the middle of the area is visited by waders as soon as it appears
- visited by fish fauna as a spawning and resting habitat. Proof of smelt, roach, bleak, bass, pikeperch, flounder, orfe, white bream, three-spined stickleback, sand goby. Visited as winter habitat (incl. individual proof of eel).

- Sedimentation in the area (positive mass balance)
- Sediment consists primarily of silt, sand shares only occur in the overflow area, where there are also distinct erosion processes.
- Relatively strong current in the overflow (0.33+ m/sec.)

Tab. 8: Findings for the reference measure: tidal biotope Vorder- / Hinterwerder[37]



Mean high tide = 7.10

Intermediate zone reed fen/mudflat

Fig. 7: Tidal curve for the Rodenkirchen level on 30.06.11[38]

[37] Sources: BioConsult Schuchardt & Scholle (2011), BioConsult Schuchardt & Scholle (2004), as well as Kundel W., Handke U. (2002), and Schirmer M. et. al. (2005). - Measurement of current: random sampling on 28.06.11 15:00 (receding tide) by author. – Photo: Overflow groundsill of the compensatory measure 'Vorder- / Hinterwerder' with receding water, the efficacy of the channel floor roughness on account of loosely-arranged hydraulic stones is easy to see (rough-bed channel).

[38] Recorded by the author. – The measurements refer to zero level, not MSL. Heights in m.

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The intermediate level between reed bed and mudflats that was observed is thus 0.80 – 1.40 m below mean high tide. Mudflats free of vegetation appear on approx. 80% of the shoreline at a mean water level of 1.10 m below mean high tide. The intermediate level is higher along shaded sections of the banks than sunny sections. The intermediate area has mainly steeper slopes, encouraging the existing reed beds to collapse over the edges.

Since the water regime in the planning area is of decisive importance for the development and future function of the Werder tidal floodplain, different levels for overflow groundsills were defined as a requirement for the development of alternatives, taking into account the experiences with the tidal biotope 'Vorder- / Hinterwerder' and observations of the intermediate zone reed bed-mudflats in Rodenkirchen. The objective here was to present very different approaches with regard to the groundsill level and the permanent storage level for those areas that are permanently under water, as well as different tides in the area for discussion. The alternatives represent an increasing opening of the area to the Weser in the sequence 1 to 3.

Three approaches were fixed: the first approach is based on the groundsill level of the compensatory measure 'Vorder- / Hinterwerder' (1.70 m MSL). The groundsill level in the second approach was defined as 0.92 m MSL. This value is 1.50 m below mean high tide and around 0.40 m below the mean level defined as an intermediate zone between reed bed and mudflats. A modelling of the virgin terrain at this level is a requirement for a development of permanent mudflats. The alternatives in 1a, 1b, 2a and 2b are based on these approaches.

The third approach has no overflow solutions and assumes a lowering of the existing bank reinforcement. Since this solution entails large amounts of excavated earth, two levels (0.80 and 0.00 m MSL) that require different amounts of lowering and excavated earth were considered. This approach led to the further development of alternatives 3a and 3b.

The type and extent of the areas of water as well as the modelling of the virgin terrain in the area finally determine how the different types of biotope are distributed in the area. The layout within the planning area can be varied to a certain extent: the solutions that are suggested can be combined in part with each other. One exception are alternatives 3a and 3b, which require a wholly different layout on account of the extensive lowering of the banks.

A 'zero' alternative has not been considered i.e. a solution where the current use is simply abandoned and the area is left to develop naturally. This would have led to a ruderalisation of the area, whereby a reed fens would have developed in certain parts, comparable to those found in parts of the nature protection area Schönebecker Sand. This development would give the area the character of a stepping stone, particularly for reed fen breeders. In talks with the awarding authority and the involved experts, this approach was unanimously rejected after extensive discussion[39] since such an approach does not comply with the general principles and development objectives and the opportunity offered by the area to establish types of biotopes that are lacking would be wasted.

The diagram in Fig. 6 provides an overview of the individual alternatives with respect to the 'connecting level' with the Weser and the level of the permanent water planned in the area. The data for the tidal Werder are also shown this figure.

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[39] Presentation and discussion of the draft alternatives in the stakeholder circle on 06.07.2011

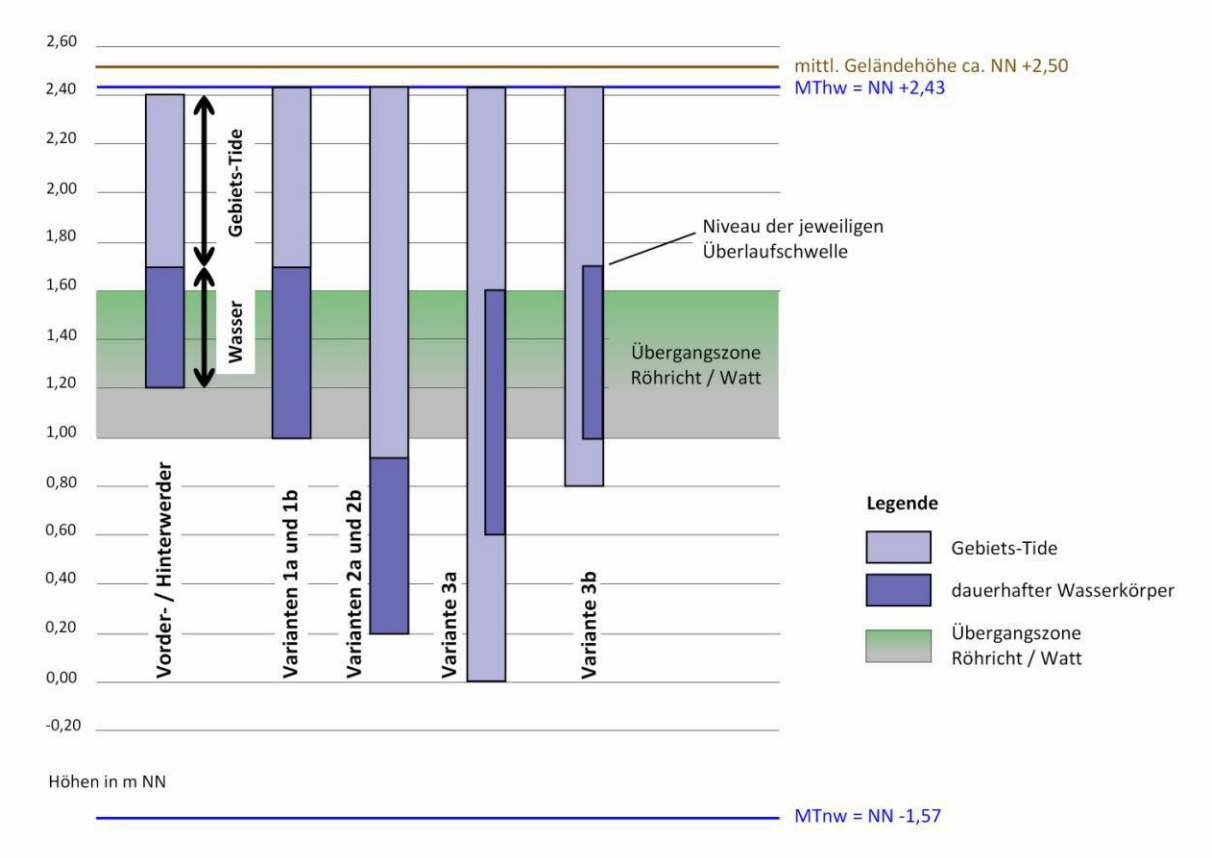

Fig. 8: Comparison of the alternatives according to tide in the area, body of water and overflow groundsill level

Mittl. Geländehöhe ca. NN +2.50	Mean surface level approx. MSL +2.50
MThw = NN +2.43	Mean high tide = MSL +2.43
Wasser	Water
Gebiets-Tide	Tide in area
Variante	Alternative
Niveau der jewelligen Überlaufschwelle	Level of relevant overflow groundsill
Übergangszone Röhricht / watt	Intermediate area reed fen/mudflat
Legende	Key
dauerhafter Wasserkörper	permanent body of water
Höhen in m NN	Heights in m MSL

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5 Designed alternatives

5.1 **Alternative 1a** see original report

5.2 **Alternative 1b** see original report

5.3 **Alternative 2a** see original report

5.4 **Alternative 2b** see original report

5.5 **Alternative 3a** see original report

5.6 **Alternative 3b** see original report

5.7 Comparison of alternatives

The following overview summarises the main differences between the six alternatives in a table. The top half shows the target spatial shares for the types of biotopes. The figures clearly show that alternatives 1a, 1b, 2a and 3a focus on specific points whereas alternatives 2b and 3b try for a heterogeneous structure. (The outstanding spatial shares are highlighted.)

The lower half of the table shows the key constructional aspects. The relevant volumes of excavated material are highlighted since these determine the costs. It should be noted that the term overflow groundsill does not apply for alternatives 3a and 3b; in this case it is a lowering of the revetment over a longer stretch of the riverbank. A ford here means a paved, accessible design of the corresponding overflow groundsill.

	V1a	**V1b**	**V2a**	**V2b**	**V3a**	**V3b**
Alluvial forest	19,000 sqm	19,000 sqm	19,000 sqm	19,000 sqm	19,000 sqm	19,000 sqm
Pasture	38,000 sqm	38,000 sqm	36,000 sqm	38,500 sqm	30,000 sqm	30,000 sqm
Reed bed		19,000 sqm	18,000 sqm	18,750 sqm	21,000 sqm	29,000 sqm
	36,000 sqm					
Mudflats			24,750 sqm	21,250 sqm	28,000 sqm	17,500 sqm
Water	13,000 sqm	30,000 sqm	8,250 sqm	8,500 sqm	2,000 sqm	4,500 sqm
Other					6,000 sqm	6,000 sqm
Totals	106,000 sqm	106,000 sqm	106,000 sqm	106,000 sqm	106,000 sqm	106,000 sqm
Overflow groundsills	2	1	2	1	Area	Area
Width	25 m	35 m	100 m	135 m	450 m	450 m
Height above MSL	1.70 m	1.70 m	0.92 m	0.92 m	0.00 m	0.80 m
Channel	yes	-/-	yes	-/-	-/-	-/-
Excavated material	36,000 m3	48,000 m3	55,000 m3	51,000 m3	70,000 m3	58,000 m3
Ford	necessary	-/-	necessary	-/-	?	?
Navigation light	-/-	-/-	-/-	-/-	affected	affected

Tab. 9: Comparison of alternatives

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It should be mentioned that - if one ignores the cost aspect - there is no alternative that can be clearly preferred or rejected. Each alternative has its advantages, along with certain disadvantages. Alternatives 1a and 1b were rejected by the stakeholders circle following their presentation on 06.07.2011. A development that comes to close the conditions at the Schönebecker Sand would bring no benefits for the fish fauna (alternative 1a) and at the same time would ignore the chance to improve the situation with respect to deficient biotopes (mudflats, tributary with little current, alluvial forest) along the Weser. Alternative 1 b was rejected since the aspect of fresh water mudflat zones was given too little attention and the tidal behaviour characteristic is too similar to that in the tidal biotope 'Vorder- / Hinterwerder'.

The process that will lead to the preferred alternative will be explained in the following chapter.

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6 Preferred alternative

In the discussions during the presentation of the alternatives on 06.07.2011, the question arose as to the value of fresh water mudflat zones compared to other types of biotopes. Since this aspect could not be conclusively clarified, a discussion amongst experts[40] was organised to deal with this topic. Various talks were held amongst experts parallel to this, the results of which have been taken into account in the further planning.

The results are summarised in brief here:

To begin with, it has to be said that fresh water mudflat zones are not a natural, original biotope in this section of the Weser. The historical Weser was a typical body of flatlands water with no appreciable tidal influence (30 – 40 cm). The river basin was characterised by sands and divided watercourses. The sand areas are not mudflat areas. Today's determinant tidal regime is a consequence of the man-made correction and deepening of the Weser. These interventions were responsible for creating the requirements for the development of fresh water mudflat zones, as in other lower stretches of the river. In this sense, the fresh water mudflat zones are relatively young 'types of biotopes'.

There have been few investigations of fresh water mudflat zones compared to salt water mudflat zones. Nevertheless, some basic statements can be made. To begin with, a decisive factor is that the productivity of fresh water mudflat zones is far below that of salt water mudflat zones. Large-area fresh water mudflat zones are by all means visited by waders. However, the low productivity means that there is an inadequate supply of food for waders, so that such areas can be regarded at best as stepping stones . On the other hand, the intermediate areas reed bed - mudflats are important on account of the development of green algae therein, since these form the staple diet of various species such as different species of snails.

The committee of experts came to the conclusion that, from a technical point of view, none of the different types of biotope to be developed can be rated as being of greater value than any other. All of the alternatives have their own value. It was also agreed that there had to be a focus on specific points on account of the limited size of the planning area. Whereas the twaite shad cannot be seen as a target species for the planning area, the area should by all means be developed as a spawning and feeding habitat for other typical species of fish as well as macrozoobenthos (and possibly a supplementary function as a feeding habitat for waterfowl and waders) and invertebrates of the eulitoral and sublitoral zone. It was thus recommended that the further planning concentrate on two main points:

- The creation of a permanent body of water of an adequate size and depth
- The creation of a fresh water mudflat zone with as much alluvial mud as possible

The agreement on the aforementioned main points led to the draft of a preferred alternative including a subalternative containing the elements of the original alternatives 3a and 3b as well as further specifications and suggestions voiced by the stakeholder circle:

- Minimum size of the body of water: 2 ha

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[40] On 15.08.2011, participants: Dr. Scholle (BioConsult), U. Handke, Nagler (SUBV), Klugkist (SUBV), Hürter (SUBV), Birkhoff (Birkhoff + Partner)

- Movement of the overflow groundsill inside the area as shown in alternative 3b to the south to enlarge the body of water

- Limitation of the area for alluvial forest development to the widening virgin terrain 'triangles' in the north and south of the planning area

- Lowering of the revetement to the level of the terrain in the northern half of the planning area (= subalternative)

- Construction of a second overflow groundsill in the north of the area (as an option within the scope of the subalternative or with a modular realisation)

The construction of a dam[41] in front of the dike that had been considered as protection against the effect of waves (north-west weather and shipping) was rejected. The risk of the dam generating an unwanted acceleration of the current parallel to the dike could not be ruled out with this solution. Instead, the alternative that produced the broadest possible strip of virgin terrain in front of the dike was pursued.

6.1 Description of the preferred alternatives

Objective:

Establishment of a permanent body of water with a dammed area of around 2 ha as well as areas of greater depth as a habitat, spawning, resting and wintering grounds for the fish fauna. In addition, the provision of areas that can potentially develop into a fresh water mudflat zone which – like the body of water - is coupled for a longer period of time to the Weser tide.

Characterisation:

Lowering of the existing bank reinforcement in the southern part of the planning area over a length of around 350 m. Lowering to 0.00 m MSL (= mean high tide -2.42 m). *A deeper lowering is not planned since erratics were worked into the lower part of the revetment, the removal of which would lead to more building work. The retention of a part of the revetment and the design of the newly built crown in a trapezoidal shape also reduces the risk of sediment release into the Weser in the period immediately following completion.*[42]

Development of the area from the lowering in an easterly direction with a slight slope (< 1:10) to the virgin terrain. Modelling of this area with the aim of creating the largest possible spatial area below 1.35 m MSL to encourage the long-term establishment of a fresh water mudflat zone. *To protect the Weser dike against the wave effect of shipping and with heavy north-west weather the site will be profiled so that the level of the average virgin terrain will be reached at a distance of 50 m to the present foot of the dike.*

Excavation of the northern part of the site to create a permanent body of water with the following benchmark figures: dammed water level = 1.00 m MSL (= 1.43 m below the mean high tide); Base level in depressions below -0.50 m MSL; i.e. the body of water is not locally deeper than 1.50 m; moved soil and bank profiling, though slope gradient always less than 1:10. *movement of the body of water away from the remaining strip of land that separates it from the Weser to avoid the risk of water logging.*

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41 Suggested during talks with Dr. Schirmer (Bremischer Deichverband am rechten Weserufer) on 11.08.2011

42 Cf. TIMME A. (2011) p. 3

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Construction of an overflow with a groundsill level of 1.00 m MSL to guarantee the permanent retention of water in the northern part of the site. Design of the overflow with an extremely gently sloping ramp. *The hydraulic verification of the approach showed that there are no critical currents during almost the entire calculation period.*[43] *The necessary reinforcement of the groundsill uses the existing material. A ramp is integrated in the groundsill that allows the site to be accessed with AWD vehicles if necessary.*

The mudflat areas begin to flood around 140 minutes after **low water** (or approx. 220 min. before high water) and this lasts until around 240 minutes after high water (= 160 minutes before low water). Contact between the permanent body of water and the Weser extends from 135 minutes before to 145 minutes after HW. This means that there is a connection between the water and the Weser for almost 4.5 hours. The outer zones of the mudflats near the Weser will be flooded for approximately 8 hours.

The transitions between the lowered revetment and the remaining revetment will be reinforced in accordance with the hydro-engineering requirements and provided with base protection as well as a revetment crown. (see detailed drawing on map sheet 415-VV-D.) The material produced by the lowering can largely be used for this purpose. No grouting is planned.

The reduction of the section to be lowered from 450 m to 350 m (cf. alternatives 3a and 3b) is a consequence of the efforts to enlarge the area of water. This modification means that only one navigation light has to be set on new foundations.

The broadest possible strip of land should be retained between the Weser and the new body of water. In order to prevent any water logging of this strip of land, the target is a width of around 30 m from the rear edge of the revetment. *This is not shown clearly in the site plans since the existing level of the terrain in the affected area is largely below 2.50 m. The 2.50 m MSL contour line shown in the 'Site plan - preferred alternatives' is a permanent line in the corresponding area.*

The existing culverts in the present revetment (DN 1000 steel pipe, DN 500 concrete pipe) will be dismantled and disposed of or recycled.

Planting will only take place to a lesser extent in the area:

- An initial planting of softwood floodplain forest species in the triangle in the northern part of the planning area. Nothing will be planted in the southern triangle. Monitoring the development of both areas should provide information on the success of initial measures.

- A barrier of shrubs will be planted parallel to the course of the dike. Indigenous material can be obtained from the surroundings. The shrub barriers will protect the dike from flotsam. At the same time, rotting flotsam in the shrub barriers offer habitats and structures for small animals and insects.

  Also conceivable, though not shown in the plans, is the local planting of reed beds as an initial measure. This material can also be obtained from the surrounding area.

Map EB7: preferred alternative (see original report)

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[43] Cf. TIMME A. (2011) p. 2.

Further details of the type, scope and quality of all planting and initial measures are the concern of approval and implementation planning.

The different parts of the area that are not affected by the aforementioned planting measures should be largely left up to natural succession. The existing virgin terrain that is not affected by lowering or excavation work should be largely preserved during the construction work to allow the natural succession of pastures on these areas. Continuing agricultural land use is not intended.

If the measure cannot or is not realised in one phase of implementation, it is recommend that this be split into two stages:

- Step A: Creation of the body of water
- Step B: Lowering of the Weser revetment and excavation of the site (fresh water mudflat zone)

The classification of the steps *contains* an evaluation. Either of the two steps can, in principle, be carried out first. But in view of the importance of the Weser as a habitat on the one hand and the potential importance of the project area as a supplementary stepping stone for the aquatic fauna on the other, priority should be given to Step A. In this case an overflow should be provided to ensure a functioning 'tidal biotope', something that has not been integrated in this form in the former discussions. The base level of this overflow is in principle freely definable and can be set between the target height of 1.00 m MSL (see above) and any figure above this. A level between 1.70 m and 1.90 m is suggested to limit the construction work since the overflow is only of temporary importance.

(…)

6.4 Evaluation of the preferred alternative

(…)

Functional evaluation

The realisation of a tributary at the location will create a further natural link in one section of the Weser which at present is predominantly characterised by riverbank fixation. The provision of a permanent body of water as a resting, feeding, spawning and wintering habitat closes a gap between the tidal biotope 'Vorder- / Hinterwerder' and the mouth of the Ochtum on the on hand, and the mouth of the Lesum on the other. The development of a fresh water mudflat zone means not just the initiation of a type of biotope that is rare on the Weser; it also represents a supplement to the fresh water mudflat zones along the Lesum. The expected reed development in turn supplements the inventories of the neighbouring Schönebecker Sand.

The diversity of structures and habitats in the area will be improved on the whole, thus creating better living conditions for a wide range of species.

What's more, the barrier effect of the existing dike will be reduced in the course of the planned dike repair. The existing sheet piling will be dismantled or

covered so that soil animals will find it easier to cross the dike. This will improve the connection between the planning area and Werderland.

On the whole, a restored foreland will significantly upvalue the function of the surrounding Habitats and Birds Directive areas on account of its location and connections.

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7 Summary

In Werderland close to the settlement of Niederbüren which is part of Bremen, there is a dyke foreland available to realize a restoration project. Because the site is situated in the tidal section of the river Weser, hence it is part of the Wesers estuary, it is to proof what kind of possibilities exist to create and develop typical habitats of the estuary in this foreland. Realization of this measure will be done partly by different stakeholders, possibly as compensation due to impact mitigation regulation. To make sure that the foreland restoration will follow a general purpose the Senator of Environment, City Development and Transport of Bremen (SUBV) commissioned this feasibility study as contribution to INTERREG IVB-Project Tidal River Developement (TIDE). The study has to design a general concept to determine a framework for the areas restoration planning especially if it will be realized step by step.

Making the study was an iterative process accompanied by a stakeholders circle as there are SUBV, the Bremen Waterways and Shipping Administration (WSA), the Lower Saxony Water Management, Coastal Defence and Nature Conservation Agency (NLWKN), the Bremen Dyke Protection Association on the Wesers Right Shoreside and the environmental association B.U.N.D.

The dyke foreland is covered by pasture. Though there exist more frequently flooded spots (Flutrasen) the foreland in general shows no importance concerning the flora as well as the fauna. Reasonable is a lack of structures, a lack of lasting waters and the missing link to the river Weser. The existing revetments along the rivers shoreline and the surface level too mean a strong barrier. In consequence the area does not show any importance to the aquatic system of the Weser. At least it is to say that there exist no remarkable recreation activities too.

The area is part of the Birds Directive Area „Werderland“ and it is surrounded by Habitats Directive areas „Lesum“, „Werderland“ and „Weser between Ochtum and Rekum“ the latter migrating line of Sea Lamprey and River Lamprey and spawning area of the Finte. In some two kilometer distance there are the river mouth of Lesum downslope and the tidal biotope of “Vorder- / Hinterwerder” upslope, both important stepping stones within the Weser. All this indicates that a foreland restoration can create an adequate stepping stone in the upper Weser estuary.

Finally the aims were fixed as follows:

- Development of the function of the tidal embankment with main focus on the functional improvement concerning fish life, specially migrating species as there are Sea Lamprey and River Lamprey
- Creation of typical habitats o the upper tidal estuary (shallow waters, flooding pools, fresh water mudflats, alluvial forests and reed belts)
- High evaluation according formal biotope benchmark proceedings
- Stability of the final state and low cost maintenance

After discussion the stakeholders circle withdrawed a pure and only abandonment of the site. This would lead to a development similar to the nature protection area Schönebecker Sand, which is situated in the proximity and characterized by dryer reeds and scrub encroachment.

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First the location was analyzed and the results of different mitigation measures which have been realized along the river Weser during the last decade has been evaluated by the authors of the study. After discussing technical and other restrictions, i. e. the foreland is connected to the main traffic routes by small lanes only which causes problems of mass transport, further safety aspects had to be considered due to the Wesers importance as a sea lane, the authors of the study introduced six alternative plannings.

These alternatives differed in matters of size of enduring shallow waters and scale of tidal influence to this waters depending of different overflow levels. Further they differed concerning size and distribution of the aspired estuary typical habitats, specially shallow waters, fresh water mudflats and reeds.

Discussion of these alternatives finally led to an advanced preferred planning including a subalternative. Characteristics are: Lowering the existing revetments down to 0.00 m NHN (= mthw -2.42 m) for some 350 m, dredging a part of the area to 1.35 m NHN to implement a lasting fresh water mudflat zone, making a durable shallow water of some 2 hectare as spawn (breeding), resting and winter habitat for fish species. It will exist a 4.5 hours lasting connection between Weser and this shallow water. The outer zones of the mudflats will be flooded approximately 8 hours.

The planting of reed, shrubs and trees is suggested in small quantities only. Spontaneous natural development will be preferred. A spot for introducing an alluvial forest in the north of the foreland will be pushed by some initial plants while a similar spot in the south will not get any initial support to get findings about the success of initial measures. To shelter the Weser dyke against organic and waste deposal a barrier of shrubs (willows) is suggested parallel to the dyke. The rotting deposal will offer habitats and structures for small animals and insects. Remaining parts of the foreland which are not affected by dredging and lowering of the revetments or initial planting is left to its natural succession. Continuing agricultural land use is not intended.

The preferred planning is designed to allow a modular as to say step by step realization.

The subalternative includes an additional lowering of the remaining revetments and an additional overflow groundsill.

The study includes a calculation of the upvaluation according to the “Handlungsanleitung” (a guidance for mitigation affect a biotope benchmark proceeding of the City of Bremen) showing a significant excess. But more important than this formal calculation is the functional profit: In total a restored foreland will affect a significant functional plus to the surrounding areas according to the Habitats and the Birds Directive.

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