

8. GERMANY

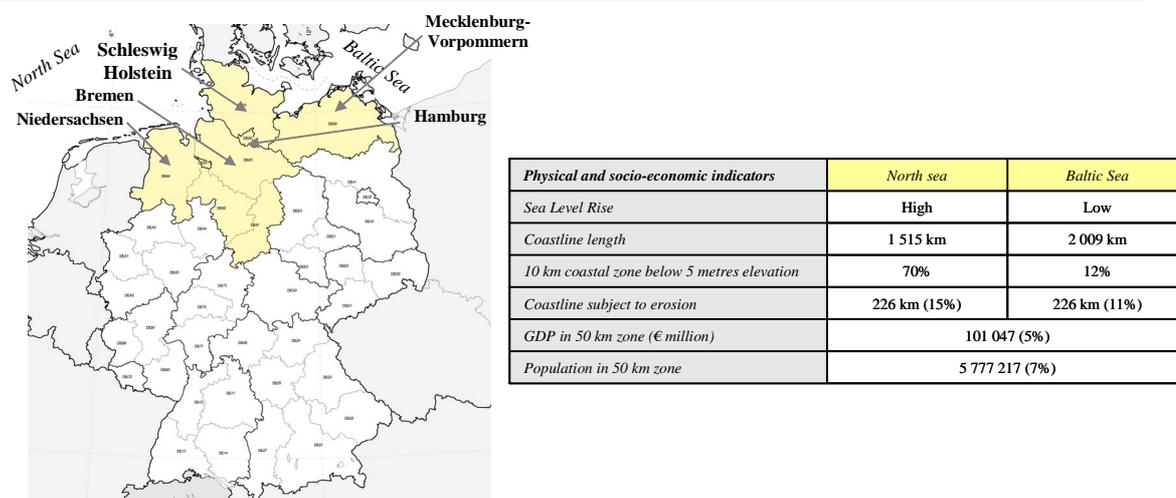
This country fiche provides a comprehensive overview and assessment of climate change adaptation in Germany. After detailing the vulnerability of Germany's coastal zones, the responsibility and financing for coastal protection is explained. Next, the fiche presents the relevant research activities, the coastal defence, risk reduction and adaptation plans available in Germany as well as the current and future protection and adaptation expenditure. The persons contacted and sources of information used are listed at the end.

8.1. VULNERABILITY OF GERMANY'S COASTAL ZONES TO CLIMATE CHANGE

Germany has a coastline of more than 3 500 km along both the North Sea (1 515 km) and the Baltic Sea (2 009 km). Three German states (*Länder*) have borders with these two seas: *Lower Saxony* (Niedersachsen) with the North Sea, *Mecklenburg-Vorpommern* with the Baltic Sea and *Schleswig-Holstein* shares coasts with both seas. In addition, the states *Hamburg* and *Bremen*, situated respectively along the River Elbe and Weser, are exposed to the North Sea tides. *Figure 8-1* provides an overview of the coastal states of Germany and the main physical and socio-economic indicators of the coastal zones.

Climate change vulnerability assessments for German coastal zones focus mainly on the increased risk of flooding as this constitutes the main threat for the country's coastal zones. The following paragraphs discuss the main climate change risks for the coastal zones of Germany.

Figure 8-1: Coastal states of Germany and their main physical and socio-economic indicators



Source: Policy Research based on Sterr H., 2008, Assessment of vulnerability and adaptation to sea-level rise for the coastal zone of Germany, *Journal of Coastal Research* vol. 24 p. 380-393 (for Sea Level Rise and 10 km coastal zone below 5 metres elevation); European Commission (EuroSION study), 2004, *Living with coastal erosion in Europe: Sediment and space for sustainability* (for coastline length and coastline subject to erosion); Eurostat 2004 (for GDP and population in 50 km zone)

a/ Flooding and erosion

The expected Sea Level Rise (SLR), the length of the coastline and the considerable number of low-lying areas near the North and Baltic Sea make Germany sensitive to coastal flooding. However, with the exception of the seaport cities, Hamburg and Bremen, the German coastal zones are not heavily populated and most economic activities take place further inland.

The probability of extreme water levels causing flooding is currently significant lower along the Baltic than at the North Sea coast. On the Baltic, more than half of the coast belongs to the so called Bodden-Coast¹, making the German Baltic Sea a semi-enclosed sea where tides are quite small and SLR is expected to be modest. Frequency of storm surges along both coasts is comparable, but water level heights related to these storms can be more than two times higher along the North Sea than along the Baltic.

Beach erosion on the other hand, causes serious problems along the Baltic coast. Locally, the retreat of the beach line may reach 40 cm per year. This hampers the tourist use of these beaches and nourishments are very expensive due to the limited availability of sand in the neighbourhood.

b/ Freshwater shortage

Water is not scarce in Germany and public water supply is of good quality. It is estimated that annually only 24% of the available water resources are used. Groundwater is the main source of freshwater supply².

Currently, no detailed studies are available on the impact of climate change for drinking water supply in Germany. Modelling done by the Federal Environment Agency shows that precipitation patterns will shift both seasonally and regionally by the end of the 21st century. In eastern Germany, which is already dry today, summer precipitation could continue to decline. However, the projection of regional precipitation by climate models comes with large uncertainties. Depending on the model, the scenarios differ sharply from each other. Drinking water extraction could be negatively impacted due to more frequent low water levels and a drop in the water table locally, but in general, no shortages in drinking water are expected.

c/ Loss of coastal eco-systems

In Germany, the Wadden Sea³ is one of the most important coastal eco-systems. The area is famous for its rich fauna and flora and the Frisian Islands form a natural flood protection barrier for the mainland. The Wadden Sea area is characterised by barrier islands or high sandbanks at the seaside and tidal flats as well as salt and brackish marshes along the mainland coast. In Germany, most parts of the Wadden Sea area have been declared as national parks⁴.

Sea Level Rise and increased storminess constitute a substantial risk for the area. Under a modest SLR of 25 cm in 50 years it is expected that most of the tidal systems will be able to adapt by increased sediment re-distribution. However, if the sea level were to rise 50 cm in 50 years the intertidal area might reduce and the Wadden Sea basins could start evolving into coastal lagoons which would substantially alter the natural environment.

Aside from climate change, coastal defence measures used to protect the mainland may threaten Wadden Sea eco-systems. Hard coastal defence measures in combination with accelerated SLR could result in 'coastal squeeze' along the North Sea coast, thus threatening important Wadden Sea eco-systems such as salt marshes and the tidal mud flats.

¹ Bodden are shallow bays and inlets cut off from the open Baltic Sea by islands, peninsulas and narrow spits.

² Potsdam Institute for Climate Impact Research on behalf of the Federal Environment Agency, 2006, *Climate change in Germany – vulnerability and adaptation of climate sensitive sectors*.

³ The Wadden Sea stretches from Den Helder in the Netherlands, passes the river estuaries of Germany to its northern boundary at Skallingen north of Esbjerg in Denmark along a total length of some 500 km.

⁴ The area consists of three national parks: the national park of Schleswig-Holstein, the national park of Hamburg and the national park of Lower Saxony; the Danish Wadden Sea area will become a natural park in 2009.

8.2. RESPONSIBILITY AND FINANCING FOR COASTAL PROTECTION AND CLIMATE ADAPTATION

The organisation and administration of coastal defence in Germany is the sole responsibility of the respective state government. Hence, decision-making for coastal protection does not follow a uniform path across *Schleswig-Holstein, Lower Saxony, Mecklenburg-Vorpommern, Hamburg* and *Bremen*. The federal government can become more involved, but will rarely do so, with the exception of research into the impact of climate change which is mainly supported at federal level.

Capital coastal protection measures are open to co-financing of up to 70% by the federal government, whereas the maintenance of existing structures is financed 100% by the respective state. The involvement and role of the local water boards differs from state to state. In Hamburg, the water boards do not play any role in coastal protection whereas in Schleswig-Holstein, water boards are responsible for regional dikes at the mainland coast of the Baltic Sea and for the second dike line at the North Sea coast and the state dikes are state responsibility. Also in Niedersachsen the state government and water boards work together.

8.3. RESEARCH INTO GERMANY'S VULNERABILITY TO CLIMATE CHANGE AND CLIMATE CHANGE SCENARIOS

In Germany, marine and coastal climate change research is considerably supported at federal level. Research is conducted in the framework of Germany's High-Tech Strategy on Climate protection and is mainly carried out by three marine and climate Clusters of Excellence in Bremen, Hamburg and Kiel and in many institutes such as the Alfred-Wegener-Institute for Polar and Marine Research (AWI), the German High Performance Computing Centre for Climate- and Earth System research (DKRZ), GKSS Research Centre, Max Planck Institute for Meteorology, the Potsdam Institute for Climate Impact Research (PIK), KlimaCampus Hamburg and the University of Bremen. Climate modelling and prognoses methodologies differ however amongst the various institutes. In addition, service institutions like scientific regional climate bureaus or the Climate Service Centre (CSC) have been established in recent years.

The German Coastal Engineering Research Council (KFKI) initiates studies directed towards the prediction of natural phenomena, aiming at the environmentally friendly and sustainable use of coastal and adjacent areas. Within KFKI projects are funded that deal with topics such as sea/dike interaction, probabilistic model approaches to flooding of coastal areas, or the high resolution analysis of tidal water levels.

The different German states decide independently on the research results and climate scenarios they take into account in their Coastal Defence Master Plans. Although many effects of climate change are

investigated in Germany, Sea Level Rise is the only formal scenario considered in the different Master Plans. Research results on changes in storm surges or wave run-up are considered too premature for use at this stage.

In 2001, the Federal Ministry of Education and Research launched the *German Climate Research Programme*. Up until 2006, more than 130 projects were financially supported for a total amount of €37 million in the areas of climate impact research, climate variability, regional studies in the Baltic Sea Area and research to past climates. Within the framework of this programme, the University of Bremen carried out the research project *KRIM* 'Climate Change, Preventive Risk and Coastal Protection Management on the German North Sea Coast'. The project focused on the potential impact and risks associated with climate change and promoted the development of proper adaptation measures and management tools. The project ran from 2001 until 2004 with a budget of €3 million.

In 2006, the Federal Ministry for Environment established under the Federal Environment Agency, *KomPass*⁵, a competence centre on global warming and adaptation to climate change. KomPass aims to bundle available climate research results, to educate decision-makers of public administrations and businesses as well as the general public on climate change effects, impacts and adaptations needs.

8.4. COASTAL DEFENCE, RISK REDUCTION AND ADAPTATION PLANS IN RELATION TO CLIMATE CHANGE

At present, no coastal defence, risk reduction or adaptation plans are available at the national level. With the creation of the KomPass competence centre in 2006, the Ministry of Environment announced the development of a national scheme of adaptation to global warming. As to spatial planning regulation, the German states use the 2008 Federal Spatial Planning Act as a legally binding document to establish their own legislative structures and laws⁶.

At the sub-national level, every German state has its own Coastal Defence Master Plan, except for Lower Saxony and Bremen who drafted their plan jointly and Hamburg who publishes annual Building Programmes instead. Actions to protect the Wadden Sea eco-systems are coordinated by the Wadden Sea Secretariat, but each country (Denmark, Germany and the Netherlands) bears the responsibility for its respective Wadden Sea area.

a/ Coastal Defence Master Plans⁷

Table 8-1 lists the most recent Master Plans on Coastal Protection in Germany. The reinforcement of dikes to protect against the risk of flooding is the main action undertaken, although authorities are

⁵ Kompetenzzentrum Klimafolgen und Anpassung.

⁶ According to the Lower Saxony Dike Law constructions are not allowed in a 50 m buffer zone.

beginning to realise that maintaining and improving hard defences can become rather costly in the long run. Sea Level Rise has been taken into account by each single state government.

A strategy to overcome the potential ecological impact of hard coastal defences has not been defined in any of the current plans. Nevertheless, states do aim at minimising the impact on nature and the landscape. To this end, environmental impact assessments are carried out. In addition, specific measures to preserve the ecological sites of the Wadden Sea islands such as the dunes and salt marshes have been incorporated in the Master Plan of Schleswig-Holstein and new measures will prevail for Lower Saxony and Bremen by 2009. Furthermore, in Schleswig-Holstein already in 1995, a common salt marsh management plan has been established by coastal protection and nature conservation authorities. The plan explicitly acknowledges the ecological and coastal protection significance of salt marshes and provides sustainable measures to maintain salt marshes.

Although the ecological value of these sites is recognised by the respective states, the Master Plans mostly refer to the importance of their flood protective character as they reduce the impact of waves on the mainland.

Table 8-1: Overview of the German coastal defence plans in relation to climate change

| | <i>Schleswig-Holstein Master Plan</i> | <i>Lower Saxony, Bremen Master Plan</i> | <i>Mecklenburg-Vorpommern Master Plan</i> | <i>Hamburg Master Plan and Building Programmes</i> |
|-----------------------------|---------------------------------------|--|---|--|
| <i>Responsibility level</i> | State Schleswig-Holstein | State Lower Saxony State Bremen | State Mecklenburg-Vorpommern | City of Hamburg |
| <i>Planning period</i> | 2001-2015 | 2007-2025 | <i>n.a.</i> | 1990-2012 |
| <i>Protection level</i> | 1:100 | <i>n.a.</i> | <i>n.a.</i> | 1:400 |
| <i>Scenarios used</i> | SLR: 50 cm / 100 year | SLR: 50 cm / 100 year ⁸ | SLR: 15-25 cm / 100 year | SLR: 30 cm / 100 year |
| <i>Protection against</i> | Flooding and erosion | Flooding and erosion | Flooding and erosion | Flooding |
| <i>Costs⁹</i> | € 282 million | LS: €520 million Bremen: €205 million | €128 million | €600 million |

⁷ A Master Plan is not legally binding, but a strong self-commitment of the state government who adopts it.

⁸ By the time the Bremen Master Plan was established, the 2007 IPCC scenarios were not published yet; therefore, the plan initially took 25 cm SLR into account; it was decided to increase the SLR scenario to 50 cm to calculate potential flood peaks; as a result, the estimated amount for the implementation of the plan was increased from €100 million to €205 million.

⁹ Costs are solely related to capital measures, implemented by the respective state over the respective planning period and co-financed by the federal government up to 70%.

The most recent *Schleswig-Holstein Master Plan for Coastal Defence* dates from 2001. The main coastal defence measures included in the plan are the strengthening of 110 km of primary dikes, sand nourishments mainly on the beaches of Sylt and Föhr and salt marsh management. Prior to drafting the plan, a safety check was carried out for all primary dikes to verify if the design water level met the basic requirements:

- A statistical return period of 1:100;
- Not lower than the highest water level observed in the past;
- Not lower than the sum of the highest spring tides and the highest observed surge.

In 2007, *Lower Saxony and Bremen* established their Master Plan jointly for the first time. For both states, the focal points of their coastal protection strategy are the protection against flooding by means of dikes and other hard coastal defences as well as establishing a regional flood warning system. In Lower Saxony, around 125 km of dikes need to be increased and strengthened in the coming years and in Bremen about 55 km. The implementation of these measures is expected to start mid 2009. The plan is focused on coastal defence of the mainland and does not include any measures for the Lower Saxony barrier islands. A separate plan for the Wadden Sea islands is being developed and expected to become published in 2009.

In *Mecklenburg-Vorpommern* the protection against flood-risk also forms the basis of the Master Plan. The reinforcement of dikes, the replenishment of dunes and construction of other types of flood protection barriers represent 2/3rd of the total protection measures foreseen in the Master Plan. Along the open coast, Mecklenburg-Vorpommern opts for groins, breakwaters and sand nourishments.

The master plan for *Hamburg* was established in 1990, outlining all actions needed to repair and strengthen the existing dikes by 2012 and to heighten them by on average 1 metre. The master plan as such has never been published. Hamburg publishes annual building programmes instead detailing the works that have to be performed during that specific year. These building programmes concern the public dike lines. The strengthening and maintaining of private dikes is the shared responsibility of private owners and the Hamburg Port Authority. For the period 2013-2035 a new master plan will be established. New dike heights will be defined and the costs will depend on the results of ongoing research as well as the coordination with the neighbouring states Lower Saxony and Schleswig-Holstein. The first proposals may be expected in 2010.

A remarkable city development project in Hamburg illustrating the incorporation of climate change in territorial development is ‘Hafencity Hamburg’, situated between the historic city district and the River Elbe, on the waterside of the main dike line¹⁰. As the site is being developed in front of the main

¹⁰ The site will increase the size of Hamburg’s city centre with 40% and offers amongst others 5 500 residences for approximately 12 000 people, office and business premises with a potential for more than 40 000 jobs, a concert hall and the International Maritime Museum of Hamburg.

dike line, flood protection will be provided by means of ground level elevation. Construction sites which are today situated 4.50 to 7.20 m above sea level will be elevated to at least 7.50 metres to comply with the general safety standards for Hamburg. Each elevated site will be connected to the main dike line by special flood-protected roadways, ensuring access for fire brigades and ambulance vehicles at all times. Building's foundations will serve as ground floor garages, which can be flooded in severe cases. The development of the entire area started in 2000 and will continue until 2020-2025. The project is managed by Hafencity Hamburg GmbH, a 100% subsidiary of the Free and Hanseatic City of Hamburg and financed as a public-private partnership. The public investment will amount to approximately €1.3 billion, private contributions are in the range of €5 to 5.5 billion.

b/ Coastal protection in the Wadden Sea region

Since 1978, the responsible ministries of the Netherlands, Denmark and Germany have been working together on the protection and conservation of the Wadden Sea covering management, monitoring and research as well as political matters. Trilateral Governmental Conferences held every 3 to 4 years are the highest decision-making body in the framework of the collaboration. The next conference will take place in Germany in 2010.

Questions regarding climate change, especially SLR, entered the political agenda of the Wadden Sea cooperation in 1997. A trilateral expert group¹¹, the *Coastal Protection and Sea Level Group* was established to investigate the potential impact of SLR for the Wadden Sea eco-systems and to develop recommendations for coordinated coastal defence and nature protection policies in the Wadden Sea. The results of their work have been detailed in two reports, published respectively in 2001 and 2005. The main recommendations of the group include:

- Consider coastal defence and climate change in coastal spatial plans and verify the feasibility of such plan with the support of experts from nature protection, spatial planning and coastal defence;
- Apply sand nourishments wherever feasible to combat erosion along sandy coastlines;
- Carry out a feasibility and impact study of sand nourishments to balance the sediment deficit of the Wadden Sea tidal basins under increased SLR;
- Establish regional salt marsh management plans.

8.5. PAST, PRESENT AND FUTURE ADAPTATION EXPENDITURE

In Germany, capital coastal protection measures are co-financed up to 70% by the federal government and up to 5 to 10% by the EU, whereas the maintenance of existing structures is financed 100% by the respective state. The total expenditure to protect the German coastal zones against flooding and

¹¹ The members of the group represent coastal and nature protection authorities of Denmark, Germany and the Netherlands.

erosion amounted to €134.8 million¹² in 2008. Over the entire 1998-2015 period, the total amount to protect the German coasts against flooding and erosion is close to €2.3 billion.

In Schleswig-Holstein, the total cost foreseen for the Master Plan amounts to €282 million, out of which €250 million would be needed to strengthen the primary weirs. The capital expenditure in 2008 amounted to €18.8 million. In addition, annual maintenance costs and other small measures of €15 million are anticipated.

For Lower Saxony a total cost of €520 million is estimated for carrying out the measures proposed in the Master Plan, whereas for Bremen a total cost of €205 million was estimated. Implementation of these plans is targeted to run from 2009-2025.

For Mecklenburg-Vorpommern about €130 million has been estimated as total implementation cost for the Master Plan, which was established in 1995. In addition, the plan foresees that the technical planning of all measures will amount to about €17 million but no completion date has been specified in the Master Plan. For 2008, total capital expenditure reaches €15 million. The maintenance expenditure has been estimated at €2 million/year.

In Hamburg, the total implementation cost for the Master Plan is estimated at €600 million for the period 1990 to 2012¹³. So far, €475 million has been invested through the implementation of annual building programmes, with €34.50 million allocated in 2008. Additionally, the annual maintenance expenditure amounted to €2 million.

A more detailed overview can be found in *Table 8-2*.

¹² The maintenance costs of Bremen and Lower Saxony are not included in this figure as they can not be deducted from the budgets by the respective authorities. Yet, these amounts are thought to be rather limited.

¹³ In the case of Hamburg, the capital expenditure of the yearly building programmes is financed by the city of Hamburg (70-80%), the federal government (10-20%) and the EU (2-10%).

Table 8-2: Expenditure to protect against coastal flooding and erosion (in € million)

| Year | MAINTENANCE AND CAPITAL EXPENDITURE | | | | HOT-SPOT PROTECTION (Hamburg) | | TOTAL |
|--------------|-------------------------------------|----------------|-----------|----------------------------|-------------------------------|--|----------------|
| | Schleswig-Holstein* | Lower Saxony** | Bremen*** | Mecklenburg-Vorpommern**** | Maintenance expenditure | Capital expenditure (hard measures)***** | |
| 1998 | 15.00 | 44.00 | 3.50 | 13.44 | 2.00 | 31.20 | 109.14 |
| 1999 | 15.00 | 44.00 | 3.50 | 13.44 | 2.00 | 37.10 | 115.04 |
| 2000 | 56.40 | 44.00 | 3.50 | 13.44 | 2.00 | 48.20 | 167.54 |
| 2001 | 51.60 | 44.00 | 3.50 | 13.44 | 2.00 | 56.20 | 170.74 |
| 2002 | 49.50 | 44.00 | 3.50 | 13.44 | 2.00 | 49.10 | 161.54 |
| 2003 | 44.20 | 44.00 | 3.50 | 13.44 | 2.00 | 32.00 | 139.14 |
| 2004 | 46.00 | 44.00 | 3.50 | 13.44 | 2.00 | 33.40 | 142.34 |
| 2005 | 47.80 | 44.00 | 3.50 | 13.44 | 2.00 | 41.30 | 152.04 |
| 2006 | 45.80 | 44.00 | 3.50 | 13.44 | 2.00 | 39.20 | 147.94 |
| 2007 | 51.40 | 44.00 | 3.50 | 17.00 | 2.00 | 26.30 | 144.20 |
| 2008 | 50.80 | 44.00 | 3.50 | 17.00 | 2.00 | 34.50 | 151.80 |
| 2009 | 49.28 | 30.60 | 12.05 | 17.00 | 2.00 | 29.50 | 140.43 |
| 2010 | 49.28 | 30.60 | 12.05 | 17.00 | 2.00 | 35.50 | 146.43 |
| 2011 | 49.28 | 30.60 | 12.05 | 17.00 | 2.00 | 35.50 | 146.43 |
| 2012 | 49.28 | 30.60 | 12.05 | 17.00 | 2.00 | 19.30 | 130.23 |
| 2013 | 49.28 | 30.60 | 12.05 | 17.00 | 2.00 | 25.00 | 135.93 |
| 2014 | 49.28 | 30.60 | 12.05 | 17.00 | 2.00 | 25.00 | 135.93 |
| 2015 | 49.28 | 30.60 | 12.05 | 17.00 | 2.00 | 25.00 | 135.93 |
| TOTAL | 818.46 | 698.20 | 122.85 | 273.94 | 36.00 | 623.30 | 2572.75 |
| | | 1913.45 | | | | | |

* Yearly maintenance cost of € 15 million; yearly capital measures as of 2000 up to 2008 based on actual figures provided by State Ministry for Agriculture, Environment and Rural Areas Schleswig Holstein; for the period 2009-2015 figures are based on the average expenditure between 2000-2008; actual figures between 2000-2008 could not be included in the final report anymore but do not influence any of the conclusions; the total expenditure for Germany over the period 1998-2015 used in the final report amounts to € 2.3 billion which is an underestimate of 11 million per year

** Total cost of the 2007 Master Plan is € 520 million, implementation foreseen between 2009-2020; equal distribution per year applied by Policy Research; average expenditure before 2009 estimated at € 44 million per year (indication 2007 Master Plan of 2.2 billion investment between 1955-2006)

*** Total cost of the 2007 Master Plan is € 205 million, implementation foreseen between 2009-2025; equal distribution per year applied by Policy Research; the average expenditure before 2009 is estimated at € 3.5 million per year (indication 2007 Master Plan of 2.2 billion investment between 1955-2006)

**** Capital expenditure between 1991-2006 is 183 million, future expenditure is estimated at € 15 million; the yearly maintenance cost amounts to € 2 million (1988-2015); proxy provided by Ministry for Construction, Regional Development and Environment Mecklenburg-Vorpommern; equal distribution per year applied by Policy Research

***** Expenditure provided by Free and Hanseatic City of Hamburg, Agency for Roads, Bridges and Waters; 2013, 2014 and 2015 is a proxy provided by Free and Hanseatic City of Hamburg, Agency for Roads, Bridges and Waters

8.6. PERSONS CONTACTED AND SOURCES OF INFORMATION USED

8.6.1. PERSONS CONTACTED

| <i>Name</i> | <i>Organisation</i> |
|-------------------------------|--|
| <i>Blum, Holger</i> | Lower Saxony Water Management, Coastal Defence and Nature Conservation Agency |
| <i>Buss, Thomas</i> | Free and Hanseatic City of Hamburg, Agency for Roads, Bridges and Waters |
| <i>Dr Dachkeit, Achim</i> | Federal Environment Agency |
| <i>Goericke, Frank</i> | Ministry for Construction, Regional Development and Environment Mecklenburg-Vorpommern |
| <i>Dr Gönnert, Gabriele</i> | Free and Hanseatic City of Hamburg, Agency for Roads, Bridges and Waters |
| <i>Dr Hofstede, Jacobus</i> | Schleswig-Holstein State Ministry for Agriculture, Environment and Rural Areas |
| <i>Prof Dr Jensen, Jürgen</i> | University of Siegen |
| <i>Dr Müller, Olaf</i> | Free and Hanseatic City of Hamburg, Agency for Roads, Bridges and Waters |
| <i>Dr Schindel, Klaus</i> | Federal Ministry of Education and Research |
| <i>Dr Schirmer, Michael</i> | University of Bremen |
| <i>Wunsch, Jens</i> | Free and Hanseatic City of Bremen, Ministry/Senator for Building, Environment and Transport, Hydrology and High Water Protection |
| <i>Zarncke, Thomas</i> | Ministry for Construction, Regional Development and Environment Mecklenburg-Vorpommern |

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