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Management of Dredged Material in Germany; A Compromise between Economy and Ecology

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Abstract

Each year in Germany construction and maintenance of waterways produce considerable volumes of dredged material, which may contain varying amounts of contaminants. New priorities of waste and environmental policies entail considerable consequences for the handling of contaminated dredged material, since it is now mandatory to consider ecologically and economically reasonable uses before opting for upland or aquatic disposal.
Guidelines for the dumping or relocation of dredged material in waters have to be developed. A professional approach to dredged material management is required to work out a time-saving and cost-efficient solution – a compromise between economy and ecology – tailored to the specific circumstances of each project.

Introduction

Maintenance or capital dredging works on water bodies in Germany fall either under the responsibility of the Federal Administration, or the designated authorities of the 16 Federal States (*LAENDER*) or 16,099 municipalities (structured in 416 districts, 15,982 communities, 117 communities without district affiliation; DEUTSCHER STAEDTETAG, 1993) with overlapping occurring (see Figure 1). The Federal Ministry of Transport and its subordinated authorities are responsible for the Federal coastal and inland waterways (with a total length of 7700 km).

Dependent on the type of project, dredged material may consist of
- sediments or subaquatic soils of the water bottom;
- subsoils and their parent material from the immediate vicinity of the river bed, or
- top soil from the banks or the floodplains of the river (DIN 19731).

The fresh sediments on the river bottom usually make up only a small portion of the removed material in capital dredging, while they predominate in maintenance operations.
A nationwide inventory of volumes of dredged material and its contamination has not yet been made in Germany. Studies to acquire more knowledge and experiences from all 16 *LAENDER* about the real dimension of the volumes dredged in Germany are planned.

Maintenance works
The total volume of material dredged from *maintenance* works on Federal Waterways (inland and coastal waters) can be estimated around some 50 million m^3 each year or more, with merely 1-3 million m^3 originating from inland waterways upstream of the tidal reach. Consequently, most of the total volume being dredged annually stems from coastal waters. Although this material is mostly sandy and clean or only very slightly contaminated, the general image of dredged material is

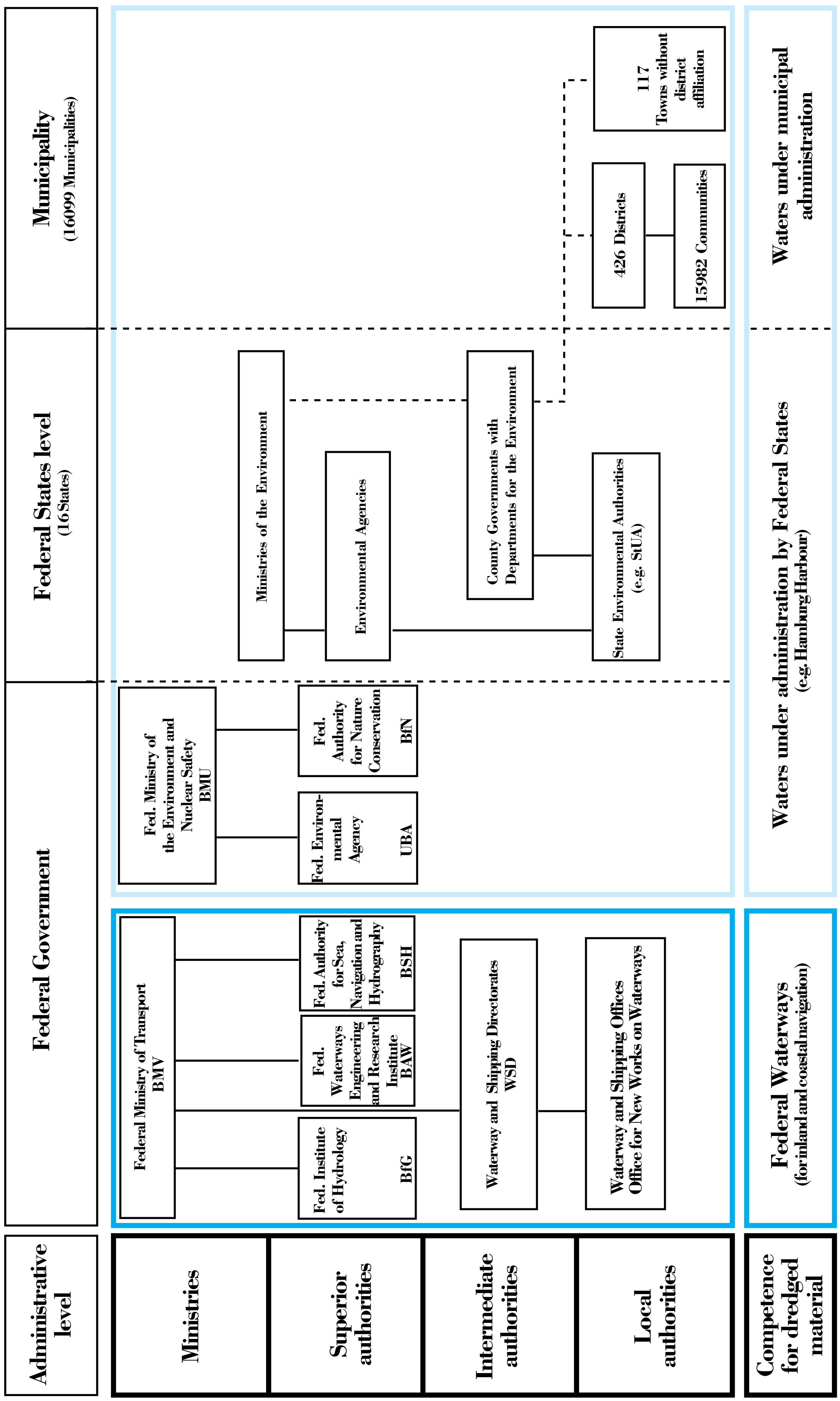


Figure 1. Administrative structure in the Federal Republic of Germany regarding the handling of contaminated dredged material from German waterways.

Figure 2. Old "workhorse" WD Gateway doing maintenance dredging in Hamburg.

very negative. This negative image is dominated by higher contaminated fine-grained sediments, which occur mostly inland more or less close to the sources of pollution. This problem is well known from many other countries too (Vellinga, 1995; PIANC, 1996).

The volumes of potentially fine-grained material from annual maintenance dredgings in all German inland waters (Federal Waterways and *LAENDER* waters) can be estimated very roughly at about 5-10 million m^3. About three million m^3 of this amount is being dredged annually in the *LAENDER* harbours of Hamburg and Bremen (Koethe, 1995a) (Figure 2).

Construction works

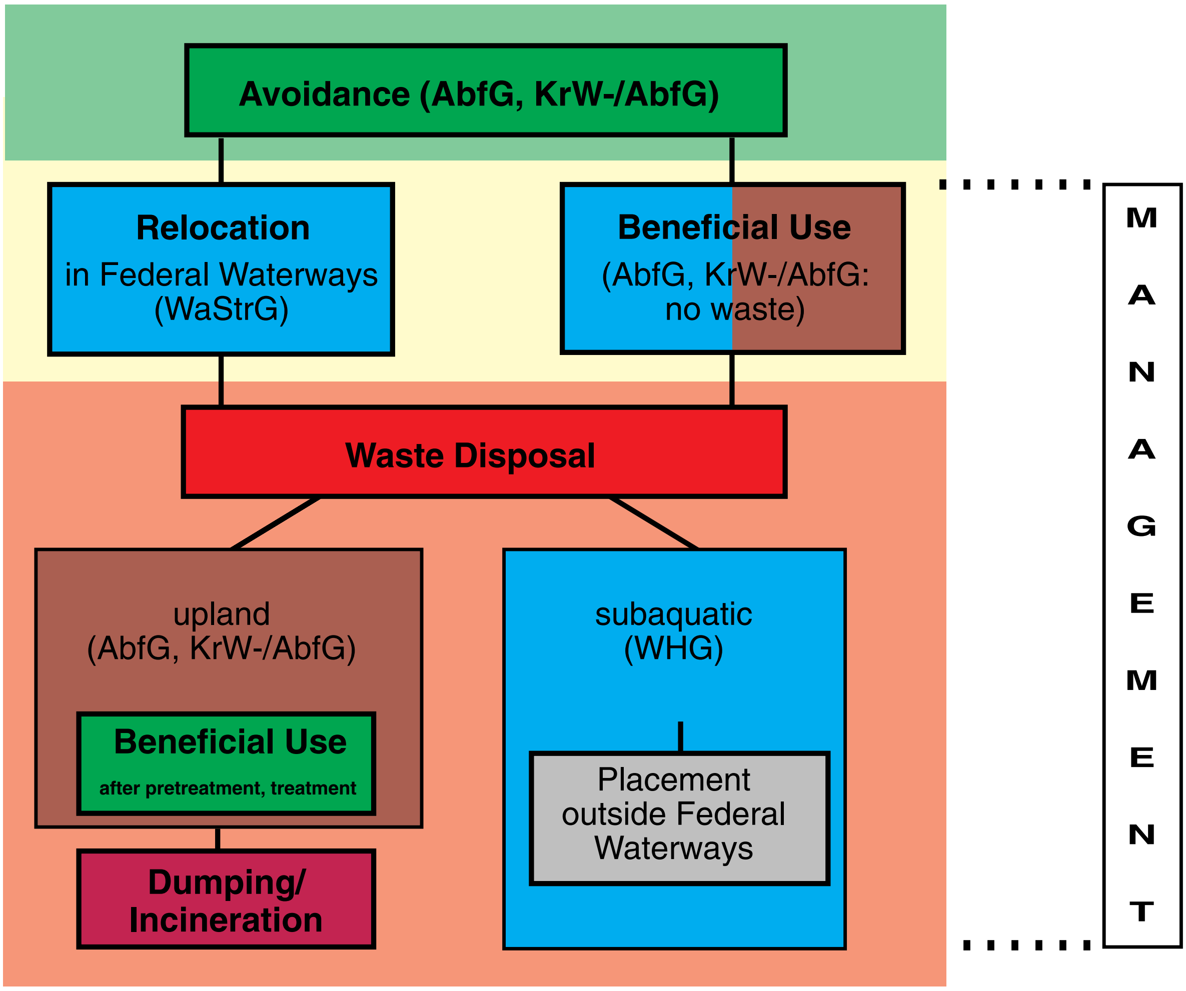
Additionally, the dredged volumes from water *construction* projects have to be regarded. The current planning of the Federal Ministry of Transport for instance provides for 29 major projects to adjust waterways to the larger, more efficient and competitive barges of today (WaStrAbG, [E. 1995]). Experience shows that the total volume dredged during a capital dredging project ranges mostly between 100,000 m^3 and 10,000,000 m^3. Although usually only 1 to 10% of the huges masses moved in these capital dredging projects are contaminated, this portion may cause great problems in disposal and beneficial use, especially in larger projects (Figure 3).

It is obvious that construction and maintenance work on waterways in Germany each year produce considerable volumes of dredged material, which may contain varying amounts of contaminants. The handling of dredged material has increasingly become a problem, last but not least because dumping or relocation in waters is becoming more and more restricted with regard to the protection of the environment.
Moreover there is a general shortage of upland disposal or dumping capacities in Germany, which may cause problems even for the disposal of clean dredged material. A professional dredged material management scheme is needed to coordinate all the different requirements to run a dredging project successfully.

Consequences of Waste and Environmental Policies for Dredged Material Handling

Every dredging project has to deal with the decision, whether the dredged material has to be classified as waste. Owing to the lack of specific laws or nationwide regulations for handling dredged material, the new "Act on Waste Management and Recycling" (Kreislaufwirtschafts- und Abfallgesetz, KrW-/AbfG 1994), which will come into force in October 1996, has to answer these questions. Pursuant to §3 KrW-/AbfG the "will to dispose of" (in the sense of throwing away) is the decisive criterion for the classification of a substance as waste.

Figure 3. The new "jumbo" TSHD Amsterdam pumping her first load of sand ashore for the reclamation of the Europa quay at a container terminal in Hamburg. The sand was dredged from the North Sea, 120 km away.



Explanation of abbreviations for German laws:

AbfG – Waste Act
KrW-/AbfG – Waste Recycling Act
WaStrG – Federal Waterway Act
WHG – Water Balance Act

Figure 4. Legislative framework for the management of dredged material in the Federal Republic of Germany.

Thus, if dredged material is abandoned without any further beneficial use, it has to be classified as "waste" irrespective of its contamination (§3 KrW-/AbfG). "Waste" that is beneficially used, is "usable waste" and "waste" that is disposed of is "disposable waste" (§4 KrW-/AbfG). §4 KrW-/AbfG sets the following priority if this notion of "waste" is applied to dredged material:

1st: Avoidance
2nd: Beneficial use
3rd: Dumping

These new priorities entail considerable consequences for the handling of contaminated dredged material, since it is now mandatory to consider ecologically and economically reasonable uses before opting for upland disposal or dumping. This makes the application of treatment technologies to remove or isolate the contaminants more and more necessary. Figure 4 is a simplified legislative scheme for dredging projects on federal waterways. It gives an overview which laws apply dependent upon the handling of the dredged material (HABAB, draft 1996).

As mentioned before, most of the material dredged in Germany is clean or only slightly contaminated. There is no doubt, relocation of the dredged material in the water is the most cost-efficient way to handle the material. Consequently, there is a need to define criteria for the relocation of dredged material in water, which has not yet been done in any nationwide regulation. To date there is neither a specific law to govern the handling of dredged material nor nationwide criteria for the relocation of dredged material in the water in Germany.

The Federal Ministry of Environment and the 16 *LAENDER*-Ministries of Environment are responsible for the protection of the environment. They have appointed expert groups with delegates from all *LAENDER* and the Federal Administration to define target values for the water, suspended solids, and the sediments of the waters in Germany (Schudoma, 1993).

These values are very strong and they can be understood as a political aim to bring back better water and sediment qualities in German waters in the future (ecological aim). To keep the present maintenance and capital dredging work running (economical aim), it is necessary to have a different regulation, practically orientated, for dredged material including criteria for the relocation of dredged material in the water. Consequently for the Federal Waterways two directives – one for coastal (HABAK-WSV, 1992) and one for inland waterways (HABAB-WSV, draft 1996) – contain such criteria with regard to the aims of the environmental policy mentioned above, but with the first priority not to allow the present environmental situation to deteriorate. Besides this there are also activities in different *LAENDER* to develop guidelines and criteria for single rivers with regard to the special environmental and political situation around this river (e.g. Arge Elbe, 1996).

In this context many controversial discussions about environmentally acceptable contamination limits for the relocation in waters, about cost-participation of the producer of the contamination, and about improved practices of source control have taken place and are still going on with the intention of developing guidelines and criteria that find nationwide acceptance.

Contrasting viewpoints

Two extreme points of view stand in contrast to each other about how best to handle the material:

a) the immediate observance of target values for water and sediment quality intended by environmental policy. Enacting this would create very high costs for the handling and treatment of large amounts of only slightly contaminated dredged material, so that many maintenance or construction projects could not be realised. This would have severe economic consequences.

b) the permission to relocate all sediments within the same hydrological system, irrespective of the degree of contamination, is supported by two important arguments:

- the contaminated sediments dredged annually represent only a small percentage of the total amount of contaminated suspended solids flowing downstream every year; and
- the authorities responsible for the maintenance or construction of waterways are not usually the producer of the pollution and to get cost-participation of the producers of the pollution is often very difficult or impossible.

Though there may be truth in this argumentation, from the view of environmental protection policy, this extreme way of acting cannot be allowed. However in developing policy one tries to strike a happy medium. This means that the important aims and target values intended by environmental policy should be adhered to in daily routine practice. Therefore, a step by step development is needed to come closer and closer to these aims, in order to be able to continue our daily business.

Consequently, a compromise between ecological aims and economic possibilities has to be worked out and tailored to the specific circumstances of each project. Insofar the handling and treatment of dredged material has become a very complex affair (PIANC, 1996). Every project leader (maintenance or construction) in order to save cost and time is well advised to use a professional approach to dredged material man0agement (DMM) from the early planning phase on.

Tasks and Benefits of a Dredged Material Management (DMM) Scheme

As mentioned before it is difficult in many projects to find a cost-efficient and environmentally acceptable solution for the ultimate destination of the dredged material (DM). For projects on inland waters sometimes even clean dredged material has become a problem, especially when large volumes have to be handled. The decision whether the material can be relocated in the water, used beneficially, disposed of or treated is dependent on the following main factors:

- the volumes of DM
- the degree of contamination in the DM
- the physical, chemical, and biological composition of the DM
- realistic alternatives in the region
- the use-dependent risks to the environment
- the budget of the project owner
- political movements and interest groups in the region.

The main task of a DMM scheme is to coordinate the work on all those aspects in a time-saving and cost-efficient way and with regard to the environment. The main aspects of the tasks and the benefits of a DMM scheme are described briefly in the following paragraphs.

A good communications plan

It is not difficult to imagine that many interests may conflict with the project plans. It is essential to establish contact with the competent authorities, associations or interest groups in an early stage to create an atmosphere for open and trustful cooperation. Consequently, a very important element of the DMM scheme is a good communication plan, which will help to prevent time-consuming and cost-intensive interferences through fundamental political objections in a later project phase, e.g. in plan approval procedure.

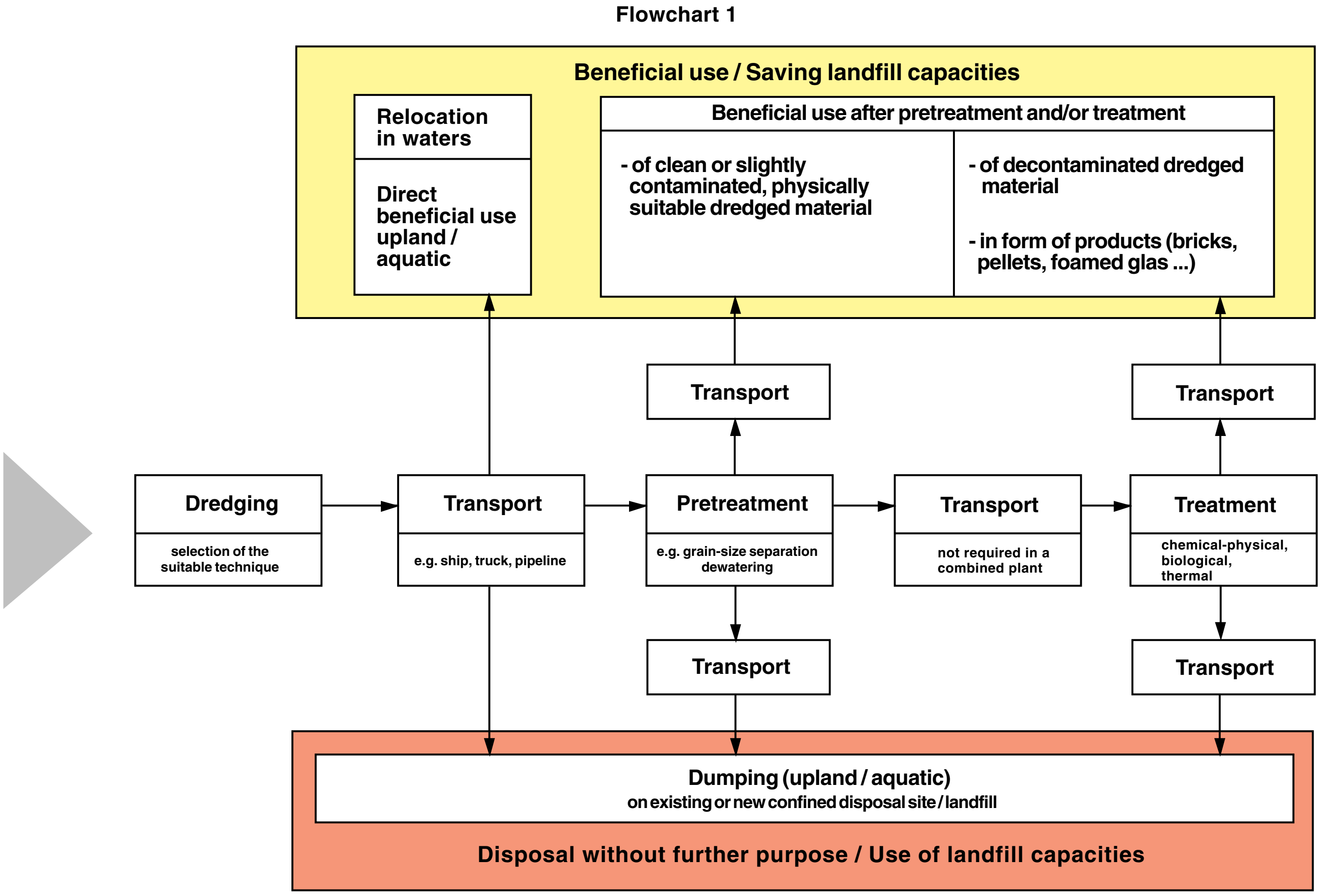


Figure 5. Management scheme for dredged material: Cost-relevant handling steps of the partial streams.

Characterisation of DM

Every DMM scheme needs a precise physical, chemical and biological characterisation of the material to be dredged over the whole dredging area and depth. These data provide the basis for all following decisions. Before starting surveying and collection of data one should have a concrete idea about the potential destination of DM including alternatives. Every investigation (in the field and in the lab) which can be combined with the survey in this early phase will be cheaper than studies at a later phase of the project.

Separation of DM

The next decision to be made is whether contaminated areas should be dredged separately. This can avoid the need of cost-intensive separation technologies at a later stage. The separation of clean material of different physical composition (e.g. gravel/sand from silt/clay) may be another interesting aspect for a further beneficial use (e.g. as construction material). There are many environmentally acceptable, selective dredging technologies available on the international market, which can be chosen for the specific demands in each project (Palermo, 1991; Rokosch, 1993; Van Der Veen, 1993; PIANC, 1997).

If it is cost-efficient the DMM scheme should favour the decision to split the total volume of dredged material into partial streams with different destinations. As shown below, this can be a very complex decision-making process. Only when the sum of all partial costs have been established can it be decided whether the whole project plan is cost-efficient or not.

The flowchart in Figure 5 is a simplified scheme showing the cost-relevant handling steps of the partial streams. The more handling steps necessary, the more complex and expensive is the DMM plan (Thibodeaux et al., 1994). The only exception (which proves the rule) is the case, when the whole mass runs on a short way directly to a waste facility. Because of the high costs for dumping on a waste facility it can be cost-efficient to increase the number of handling steps by using pretreatment and treatment technologies, which allow a beneficial use afterwards instead of dumping. In this case the aim of the waste policy would be reached perfectly (see above under Consequences of Waste). The general aim of the waste policy (KrW-/AbfG, 1994) is to save scarce dumping capacities by finding environmentally acceptable beneficial uses, with or without pretreatment and treatment (Figure 5). Only small quantities of residues from pretreatment and treatment processes, which are highly enriched with contaminants (concentrates), should end up on waste facilities.

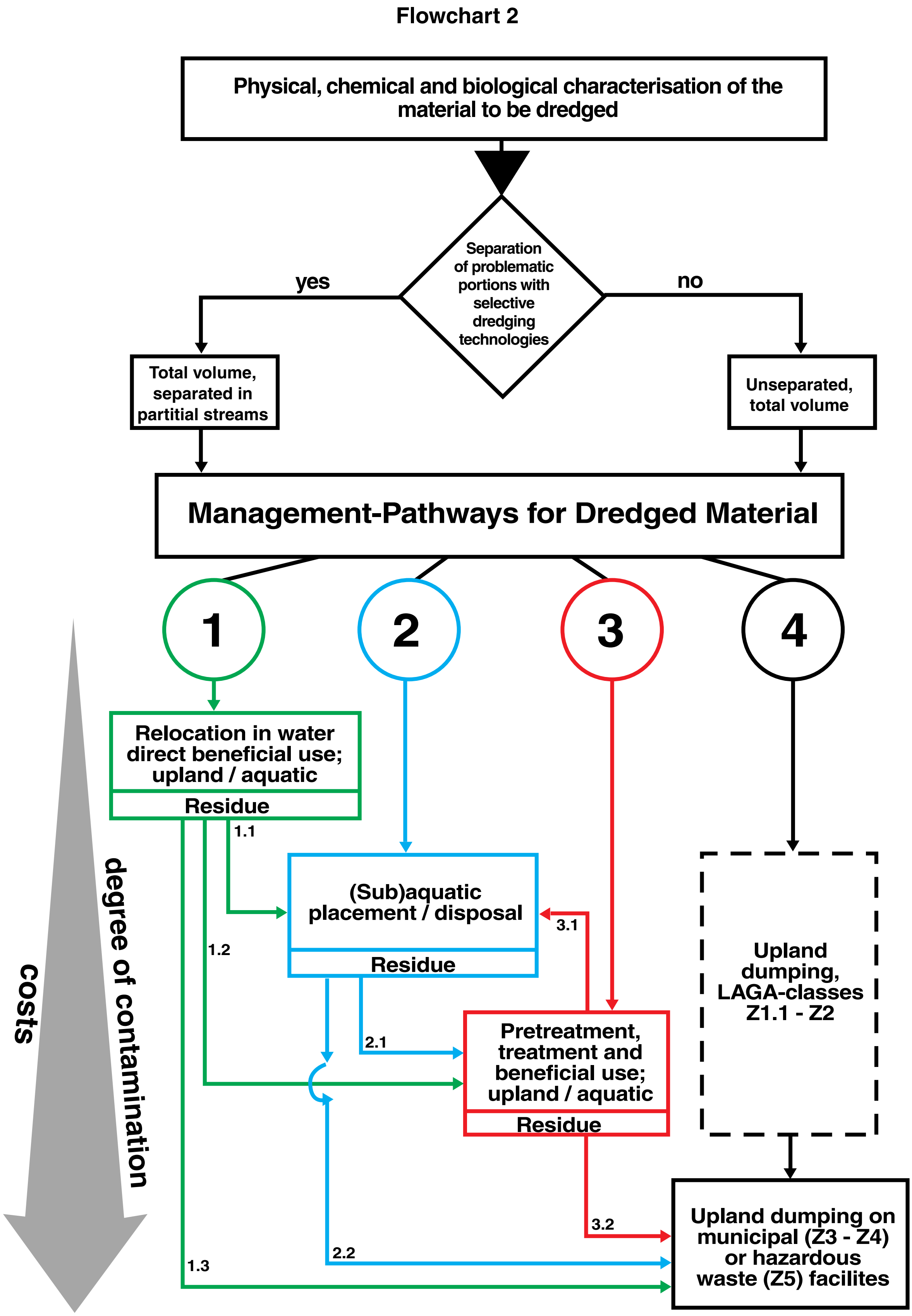


Figure 6. Basic possibilities for the management of dredged material.

Ranking destinations
From the view of cost-efficiency a general ranking of destinations can be made (Figure 6). Beneficial use – as intended by waste and environmental policies – is not always the cheapest solution compared with disposal, especially when treatment technologies are needed.

Sometimes this raises problems between the competent authorities who issue the permits, and the project owner who has to deal with a limited budget. In projects on Federal Waterways for instance, the project owner is an subordinated office of the government.
In this case the project owner receives the money for the project from the Federal Budget. The project owner has to take care that the costs for the project do not exceed the budget given for the project. On the other side the competent authorities for permits, which are funded by public money to take care for the environment, often have to impose cost-relevant demands in their permits, which may prohibit the cheapest solution. In order to deal carefully and responsibly with the Federal Budget and the environment, a compromise between economy and ecology is needed. Consequently, the question is: "How much do we want to spend for the protection of environment?" Because the Federal Budget is limited it may be better to ask: "On which other values do we want to renounce to finance the protection of the environment?"
Decisions on these questions have to be made on a political level. The purpose of a DMM scheme is not to make policy, but to bring the project on the practical and technical level to an economically and ecologically acceptable solution.

First realistic destination alternatives in the vicinity of the dredging area have to be found. Depending on local and regional circumstances not every possibility is of course practicable.

Using the flowchart
A use-dependent assessment of the collected data from the survey helps to decide whether the planned solution is environmentally acceptable or not (Figure 6).
To find the most cost-efficient possibilities one has to start in Pathway 1 in Figure 6). If relocation in the water or direct beneficial use is not possible, one has to start with other alternatives in Pathways 2 and 3, which will be more expensive. In general, one can say in the direction towards Pathway 3, ever more technical requirements are needed in the handling-train.
For instance in the case of Pathway 1 it is possible that residues have to be introduced into other pathways (1.1, 1.2, 1.3 in Figure 6). This is less expensive than handling the whole volume on another, generally more cost-intensive pathway.

The subaquatic placement of dredged material (Pathway 2, Figure 6) in suitable gravel pits (Koethe and Bertsch, 1996) or in confined disposal sites (Vellinga, 1995; Laboyrie, 1995) needs technical planning and construction. But again, this is less expensive than applying treatment technologies to the whole mass (Pathway 3, Figure 6). The cost-ranking of destination alternatives in Figure 6 is based on the assumption that the residues in Pathways 1 and 2 are partital streams dredged by selective dredging technologies. The residue in Pathway 3 may be a product of a pretreatment or treatment technology too.

With regard to the Pathways 3 and 4 in Figure 6, the central question in the decision-process on the DMM reads: "Is the use of pretreatment and treatment technologies to enable a beneficial use (in the sense of environmental policy) of the DM cost-efficient against upland dumping?"
Usually the use of treatment technologies is only cost-efficient when the contamination is so high, that the material has to be dumped upland on a waste facility.

LAGA classifications
In Germany the LAGA (federal government/federal states expert group for waste) has drafted a regulation for the beneficial use of mineral residuals including criteria for upland dumping of soil material (LAGA, 1994). A classification with the classes Z0 (unrestricted use) to Z5 (hazardous waste facility) is defined by contaminant concentration values in the solids and the eluate. A classification of the DM in Z2 and higher applies the dumping on a waste facility. There are special regulations for dumping material on a municipal waste facility (TASi, 1993) or on a hazardous waste facility (TA Abfall, 1991), which accept only consolidated and dewatered material.

Furthermore, a special restriction on municipal waste dumps is the limit set for the ignition loss (as a measure for all organic substance) at 3% (= LAGA-class Z3) or 5% (= LAGA-class Z4), aiming to keep the formation of digestion gases low. Problems for DM are foreseeable, in particular for highly polluted wet dredged material, as the ignition loss in contaminated dredged materials is practically always higher than 5%. Furthermore the material has to have a stability of a minimum shear strength of 20 KN/cm^2 (TASi, 1993).

Because most of the highly contaminated dredged material is wet, fine-grained and contains organic matter, it has to be treated at very high costs to render it suitable for dumping on these waste facilities. From the dumping of sewage sludge, which has some similarities in composition with wet, fine-grained dredged material (sediments), it is known that the total costs per tonne (dry weight) for waste dumping (including treatment, transport and dumping) ranges regionally between 1,500 and 2,000 German marks (Drescher, 1995; Wittchen and Püschel, 1995).

Under these circumstances it is obvious that suitable and cost-effective pretreatment and treatment technologies have to be chosen, which change the chemical and physical composition of the contaminated dredged material for an environmentally acceptable beneficial use (Koethe, 1995b). This aim can be reached at considerably lower costs compared with the dumping on waste facilities. The magnitude of these costs can be roughly estimated between 100 and 500 German marks per tonne. In general one can say the bigger the volumes for treatment are, the cheaper is the cost per treated tonne.

For less contaminated material (LAGA-class Z2 and lower) mono-dumps for dredged material with lower technological requirements are often chosen. Upland mono-dumps for dredged material are less expensive compared with the costs for dumping on waste facilities including the use of treatment technologies.

Depending upon the technical requirements the costs are more or less clearly less than 50 German marks/m^3. Another important reason to prefer mono-dumps lies in the physical composition of the DM. In contrast to coarse DM, beneficial uses without treatment are rarely possible with wet, fine-grained sediments.
The aim of environmental policy to protect dumping capacities will not be reached for this dredged material, which is a considerable portion of the total volume being dredged annually, as long as dumping solutions outside waste facilities are cheaper than solutions including treatment technologies.

Conclusion: Outlook

There is no doubt, the fastest way to reach the target values for water and sediment quality intended by the environmental policy is to close the sources of pollution and to observe discharges into the rivers and waterways very carefully.
Clean dredged material can be relocated in the water or may be used for many beneficial purposes without danger for the environment, when this is done properly.

Until this objective is met, more or less contaminated dredged material has to be handled in a very complex process, that is organised and executed in form of a dredged material management (DMM) scheme. In the sense of waste and environmental policy, pretreatment and treatment technologies have to be included, preferentially in those projects where they have a cost-efficient effect too.
Besides the technical project control, a good dredged material management has the function of an eco-controlling too, which helps to work cost-efficiently. Together with a strong responsibility for the environment the chances are very good that a compromise between ecology and economy can be found for every project on a case-by-case decision.

References

Arge Elbe
Umgang mit belastetem Baggergut an der Elbe, Zustand und Empfehlungen.- Ad-hoc AK Baggergut; Wassergütestelle Elbe; Hamburg. 1996. *(Management of contaminated dredged material at the river Elbe, present situation and recommendations).*

Deutscher Staedtetag
Statistisches Jahrbuch deutscher Gemeinden, 80. Jg. 193; Koeln. 1993. *(Statistical yearbook of German municipalities).*

DIN 19731
“Bodenbeschaffenheit - Verwertung von Bodenmaterial”. DIN Deutsches Institut für Normung e.V., Normenausschuß Wasserwesen (NAW); Berlin. *(Soil quality - utilisation of soil material).*

Drescher, D.
Maßnahmen zur vollständigen Klärschlammverwertung beim Abwasserverband Saar.- gwf Abwasser Special II, 136, Nr.15: 32-39. 1995. *(Measures for the complete utilisation of sewage sludge in the Wastewater Association Saar-Region)*

HABAK-WSV
Handlungsanweisung zur Anwendung der Baggergut-Richtlinien der Oslo- und der Helsinki-Kommission in der Wasser- und Schiffahrtsverwaltung des Bundes.- Bundesanastalt für Gewaesserkunde, BfG-0700, 102 S., Koblenz, Berlin. 1992. *(Directive for the Application of the OSLO AND HELSINKI Guidelines on the Disposal of Dredged Material).*

HABAB-WSV
Handlungsanweisung fuer den Umgang mit Baggergut aus dem Binnenland.- Bundesanastalt für Gewaesserkunde Koblenz. Draft 1996. *(Directive for the management of dredged material in federal inland waterways).*

Koethe, H.
“Legislative framework and technological improvement for the management of contaminated dredged material in Germany”. Paper for the 5th KfK/TNO Conference on Contaminated Soil in Maastricht (30 Oct- 3 Nov 1995). 1995a.

Koethe, H.
“Criteria for the beneficial use or the disposal of contaminated dredged material in the Federal Republic of Germany”. *Proceedings of the XIVth World Dredging Congress Dredging Benefits, 14-17 Nov 1995, Amsterdam, The Netherlands. 1995b.*

Koethe, H. and Bertsch, W.
“Legal and technical requirements in Germany for the subaquatic disposal of contaminated dredged material in gravel pits”. *Proceedings of the International Congress CATS III: Characterisation and Treatment of Sludge, March 18-20, 1996, Ostend, Belgium. 1996.*

Kreislaufwirtschafts- und Abfallgesetz
KrW-/AbfG vom 27. September 1994, BGBl I S 2705. *(Waste Recycling Act).*

Laboyrie, H.P.
"The construction of large scale disposal sites for contaminated dredged material". *Proceedings of XIVth World Dredging Congress "Dredging Benefits,* 14-17 Nov 1995, Amsterdam, The Netherlands. 1995.

LAGA - Länderarbeitsgemeinschaft Abfall
Anforderungen an die stoffliche Verwertung von mineralischen Reststoffen/Abfällen. Technische Regeln (Stand: 7 September 1994). *(Requirements for the beneficial use of mineral residuals).*

Palermo, M.
"Equipment choices for dredging contaminated sediments". *Remediation,* Autumn 1991, p. 473-492. 1991.

PIANC
Handling and treatment of contaminated dredged material from ports and inland waterways", Volume 1. Report of PIANC-PTC I-WG No.17. Brussels, Belgium. 1996.

PIANC
Handling and treatment of contaminated dredged material from ports and inland waterways", Volume 2. Report of PIANC-PTC I-WG No.17. Brussels, Belgium. 1997 in preparation.

Rokosch, W.D.
"Dredging: A clean up technique for contaminated aquatic sediments". *Terra et Aqua,* number 50, January 1993.

Schudoma, D.
Ableitung von Zielvorgaben zum Schutz oberirdischer Binnengewässer für die Schwermetalle Blei, Cadmium, Chrom, Kupfer, Nickel, Quecksilber und Zink.- Erarbeitet im Auftrag des Bund/Länder-Arbeitskreises „Qualitätsziele" (BLAK QZ); Umweltbundesamt Berlin. 1993. *(Development of target values for the heavy metals lead, cadmium, chromium, copper, nickel and zinc for the protection of inland waters).*

TASi - Technische Anleitung Siedlungsabfall
Dritte Allgemeine Verwaltungvorschrift zum Abfallgesetz (TA Siedlungsabfall). Technische Anleitung zur Verwertung, Behandlung und sonstigen Entsorgung von Siedlungsabfaellen vom 14. Mai 1993.- Bundesministerium der Justiz [Hrsg.], Bundesanzeiger Jhrg.45, Nr. 99a vom 29.05.1993; Bonn. *(Technical Instruction for Municipal Waste. Third administrative ordinance on the utilisation, treatment, or other disposal of municipal wastes).*

TA Abfall - Technische Anleitung Abfall
Gesamtfassung der Zweiten allgemeinen Verwaltungsvorschrift zum Abfallgesetz (TA Abfall). Teil 1: Technische Anleitung zur Lagerung, chemisch/physikalischen, biologischen Behandlung, Verbrennung und Ablagerung von besondes ueberwachungsbeduerftigen Abfaellen vom Maerz 1991.- GMBl Nr.8, 139-214; Bundesminister f. Umwelt, Naturschutz u. Reaktorsichrheit [Hrsg.]. 1991. *(Technical Instruction for Waste. Part 1: Technical instruction for the storage, chemical/physical, biological treatment, incineration, and dumping of wastes requiring special surveillance).*

Thibodeaux, L.J., Reible, D.D. and Valsaray, K.T.
"So you want to remediate contaminated mud! These are your five choices." *Proceedings of the Second International Conference on Dredging and Dredged Material Placement.* Volume 1, pp 588-595. Lake Buena Vista, Florida, USA. ASCE, New York. 13-16 November 1994.

Van Der Veen, R.
"Contaminated Sediment Remediation, Dredging polluted bed materials - A study of environmentally effective dredging methods" (draft report). North Sea Directorate, Directorate-General for Public Works and Water Management (Rijkswaterstaat); The Netherlands. 1993.

Vellinga, T.
"Treatment and beneficial use of contaminated sediment, past and present: Port of Rotterdam case study". *European Water Pollution Control.* Volume 5, number 5, p. 31-37. 1995.

WaStrAbG - Wasserstrassenausbausgesetz
(E. 1995): Entwurf eines Gesetzes ueber den Ausbau der Bundeswasserstraßen und zur Aenderung anderer Gesetze.- Bundesministerium fuer Verkehr, Entwurf vom 20.02.1995; Bonn. *(Draft Act on development construction of Federal Waterways and on amendments of pertinent other laws).*

Wittchen, F. and Püschel, M.
Ausgangsituation und Zielstellung der Klärschlammbehandlung und -entsorgung.- gwf Abwasser Special II, 136, Nr.15: 22-31. 1995. *(Initial situation and objectives of sewage sludge treatment and disposal).*