SMOCS
SUSTAINABLE MANAGEMENT OF CONTAMINATED SEDIMENTS

Multicriteria Analysis for Dredging and Treatment

Case Study – Concept Selection

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Summary

In the engineering design different types of concept selection tools are widely used. As the design of a product and the "design" of a process for a complex project like dredging and treatment are similar, both involves the creation of possible concepts and their further evaluation. Concept selection tool is considered as a possible mean for the decision making process when evaluating dredging and treatment combinations. In order to assess if the tool could be useful for the multi criteria a hypothetic case is analyzed using concept selection approach.

The concept selection process is presented in Figure 2; it is executed in following phases:

Phase 1

- Generation and identification of potentially feasible concepts
  - Recognition of need
  - Generation of concepts
  - Preliminary selection of feasible alternatives

Phase 2

- Formulation and clarification of a selection
  - Identification and ranking of criteria (attributes)
  - Evaluation of alternatives
  - Ranking of alternatives
- Post evaluation analysis

In order to have a useful tool it is important; i)to have a clear set of concepts, ii) to have a clear set of evaluation criteria, iii) to declare the relative importance of each criteria, iv) to rate the concepts against the criteria, and v) then to develop numerical scores/rankings for each design concept. When done objectively the results of this process can be very good, however when subjective bias is introduced the method falters. Typical procedural problems include i) elimination of viable concepts before using the matrix, ii) under- or overstate the weight of an evaluation criteria, and iii) not appropriate relative weight is

The big advantage with the concept selection process is that it creates "systematic" discussions. However it is important that the constraints do not exclude too many of the concepts generated.

1. Background

Dredging is a complex process. If the dredging includes contaminated sediment the process becomes even more complicated. When evaluating different concepts for dredging and treatment it is important to consider all steps in the process. The choice of uptake method will influence which possible treatment options that can be used. The constraints in the environmental permit and the physical settings also influence the possible use of a concept. Within the SMOCS project different multi criteria analyzing tools are evaluated. In this study the tool Concept Selection is evaluated.

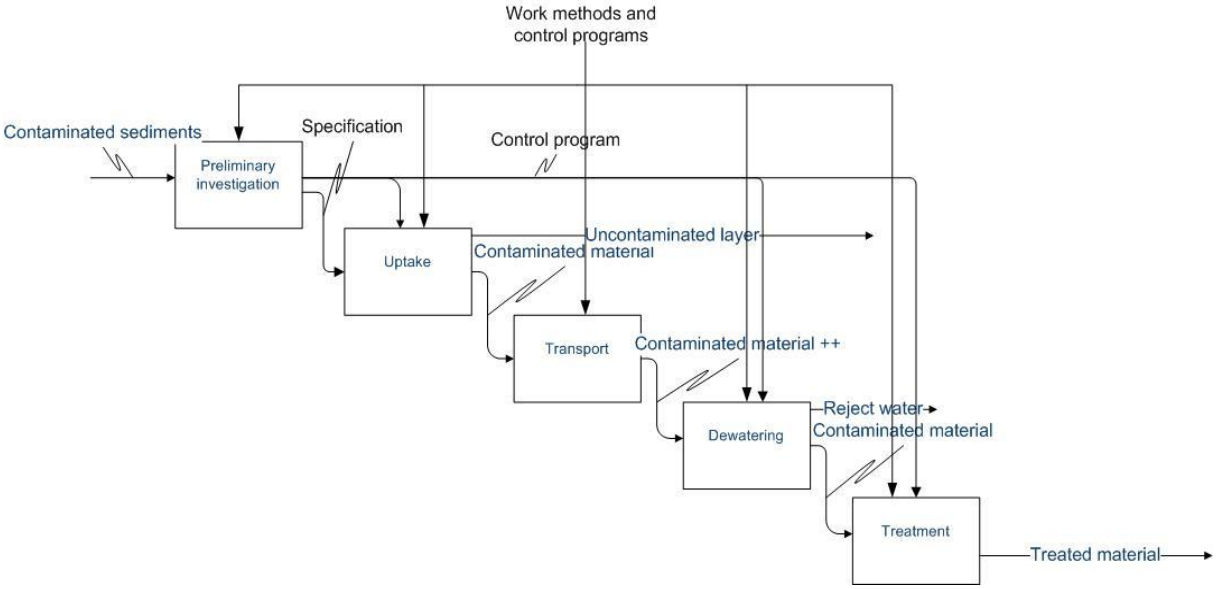


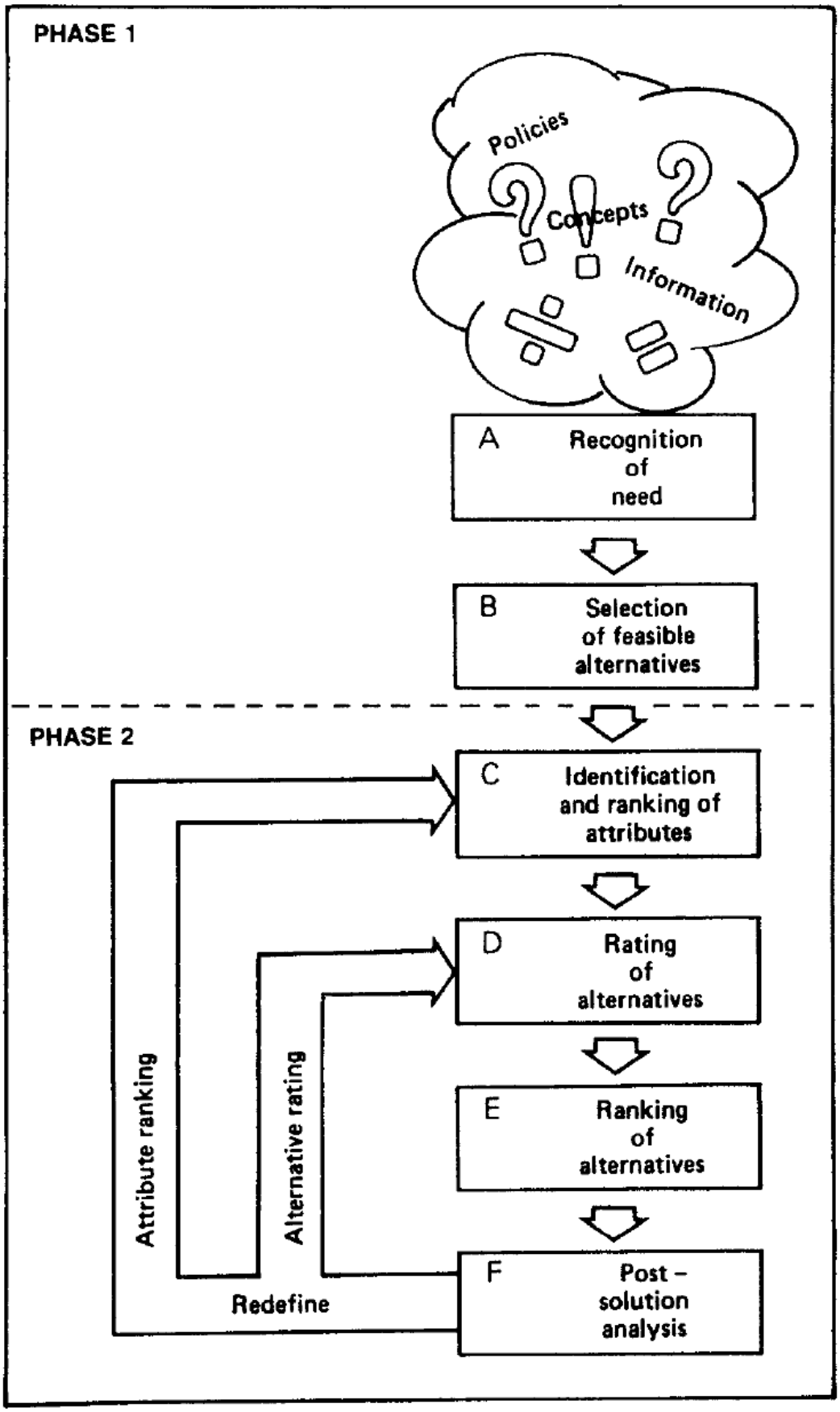
Figure 1. The many steps of a dredging operation.

2. Concept selection

Decision-matrix methods are perhaps the most commonly used approach to concept selection in engineering design practice. Furthermore, they are typically used in the selection process at least in some form, if not used extensively. Concept screening and scoring are popular variants of the decision matrix based method. The method is a systematic decision making tool that is used in early development phases to validate different technical solutions/products/processes in relation to basic criteria and constraints for a project. Concept has the potential to identify the strengths and weaknesses of a few candidate concepts and consider the possibility of adopting the strong aspects and improving on the poor ones. Essential project criteria have to be established prior to the selection process as a basis for evaluating different concepts. Then, all candidate concepts are compared with a benchmarked product in accordance to each selection criterion.

Advantages with systematic methods:

- Focus on the specific projects features
- A competitive choice of process/product
- Good product – process coordination
- A time saving method
- Effective group decisions
- Documentation of the decision making process


PHASE 1
Policies
Concepts
Information
A Recognition of need
B Selection of feasible alternatives
PHASE 2
C Identification and ranking of attributes
D Rating of alternatives
E Ranking of alternatives
F Post – solution analysis
Attribute ranking
Alternative rating
Redefine

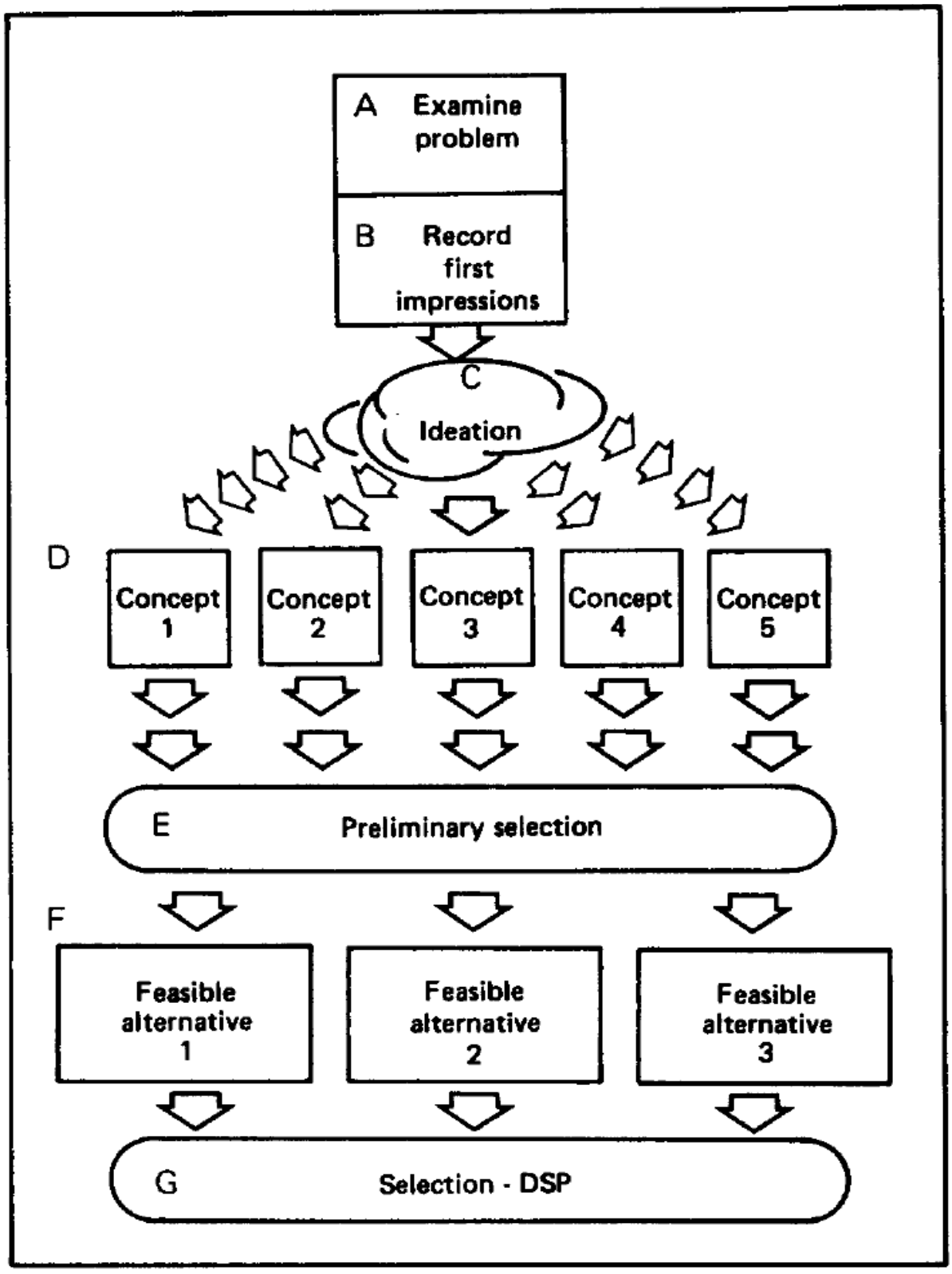


Figure 2. The process of concept selection, (Kuppuraju, 1985).

2.1 The concept selection process

The concept selection process is executed in the following way, figure 2;

Phase 1

- Generation and identification of potentially feasible concepts
  - Recognition of need
  - Generation of concepts
  - Preliminary selection of feasible alternatives

Phase 2

- Formulation and clarificationof a selection
  - Identification and ranking of criteria (attributes)
  - Evaluation of alternatives
  - Ranking of alternatives
- Post evaluation analysis

2.1.1 Importance of criteria

When more than one criterion exists a relative weight can be assigned to the criteria. This is important as all criteria are not equally important. The process of adding weight is generally based on experience and insight from prior projects.

3. The case study

The hypothetic case contains a small harbor where the ridge is going to be elongated. The dredging is being done down to 10,5 meters. In connection with the ridge elongation maintenance dredging is also going to be done. In part of the dredging area the sediment is contaminated. The depth of the contamination is 30 cm. The overall depth of sediment to be dredged is 1 m.

The volume of uncontaminated sediment is 18 000 m^3. The volume of contaminated sediment is expected to be at 3000 m^3.

Uncontaminated sediments can be relocated to sea disposal. Contaminated sediment can be transported to a landfill or treated on site.

The environmental constraints are hard. No turbidity can be spread outside the working area when contaminated sediments are dredged. Dredging can only be done in the periodfrom September to April.

Dewatering can be done within the working area if all effluent water is clean. Reuse of the contaminated sediment asa construction material is not allowed.

4. Concept generation

Five different concepts have been generated.

Concept 1

Both contaminated and uncontaminated sediments are taken up using excavation dredging. Geotextile curtains are applied to avoid turbidity. Dewatering is carried out by building a small lagoon, the dewatered sediment is transported to the landfill 30 km inland by trucks. The uncontaminated (i.e sediment with contamination levels under the limit for dumping at sea) sediment is transported by tugs and barges to the dumping site at sea.

Concept 2

Uncontaminated sediments are taken up with excavation dredging. Freeze dredging is used for the uptake of contaminated sediments, no dewatering at site needed as the transport of sediment is made in frozen form directly to landfill. No geotextile curtains are being used as freeze dredging will not cause turbidity. The uncontaminated sediments will be dumped at sea.

Concept 3

Both contaminated and uncontaminated sediments are taken up using hydraulic dredging. No geotextiles are applied as the turbidity from the dredger head is low. Dewatering is carried out using geotubes. Effluent water treatment and transport to the landfill 30 km inland. Uncontaminated sediments are transported with long transport pipes directly to the dumping area.

Concept 4

Both contaminated and uncontaminated sediment are taken up using excavation dredging. Geotextile curtains are applied to avoid turbidity. Both the contaminated, and uncontamoinated sediment is stabilized and used as a construction material in the ridge elongation.

Concept 5

Excavation dredging is used for the uncontaminated sediments. Hydraulic dredging is used for the uptake of contaminated layer. The contaminated sediments are dewatered in a lagoon and treated through soil washing. The uncontaminated sediment is transported by tugs and barges to the dumping site at sea.

4.1 Criteria

Cost

In most projects cost is one of the most important factors. The costs for the concepts are evaluated as the total cost for dredging, dewatering, transport and treatment/landfill.

Water quality

Dewatering at the site might influence the water quality in the area. Effluent water needs to be analyzed.

Turbidity

In most dredging operations there are threshold values to consider.

Public opinion

In some cases the public opinion can be very important as public “anger” can lead to protests during process for environmental permit, and during the execution of the project. To evaluate this criteria information from public meetings and stakeholders are important to assess.

Space needed for work

In heavily populated areas space is always a limiting factor, lagoons for dewatering or space for onsite treatment can be difficult to find

Precision

As the project contains both contaminated an uncontaminated sediment precision during uptake both in vertically and horizontally is important. The precision of different dredging technologies vary.

Time/capacity

Time is a limiting factor, to have overcapacity in the rig makes it possible to force the work is weather or other unexpected obstacles occurs.

Flexibility

If pre investigations proves to be inaccurate different concept for dredging/dewatering can be useful if an “active design” approach need to be taken.

Reliability

As time is important a high reliability is crucial.

Transport volumes

Transport, and especially of contaminated material through city centers shall be avoided.

Energy consumption

It is always important to consider the carbon footprint.

Need for geotextiles

As there are many boats in the vicinity of the dredging area geo textiles are inappropriate.

4.1.1 Step 1. Concept screening; Does the Concept apply to the constraints of the project?

The five concepts are evaluated and compared to the constraints from the environmental permit and the physical settings.

As the environmental permission does not allow stabilization and reuse of sediments concept 4 is not evaluated. Concept 3 is eliminated as pipeline transport to the dumping area is not possible due to ferry traffic.

4.1.2 Step 2. Concept scoring; Evaluation through comparison.

The concepts are scored using Concept 1 as a reference.

Table 1. Concept 1 is compared with the other concepts. The question asked is, is the concept better than, as good as or not as good as the reference concept?

			Concept Alternative		
Criteria		Weight	Concep 1	Concept 2	Concept 5
1	Cost		Ref	0	-
2	Time		Ref	-	0
3	Flexibility		Ref	+	+
4	Water quality		Ref	+	0
5	Turbidity		Ref	+	+
6	Space needed on land		Ref	+	-
7	Reliability		Ref	-	-
8	Transport volume		Ref	0	+
9	Energy consumption		Ref	0	0
10	Precision		Ref	+	+
11	Public opinion		Ref	+	+
12	Need for geotextiles		Ref	+	+
		Plus		7	6
		As good as		3	3
		Minus		2	3
		Sum		5	3
		Control		12	12

Concept 2 is ranked as the most favorable. Weight is added to the chart to ensure that the most important features are getting sufficient impact on the evaluation of concepts.

Table 2. Concept 1 is compared with the other concepts with weight is added to the chart.

			Concept Alternative		
Criteria		Weight	Concep 1	Concept 2	Concept 5
1	Cost	2	Ref	0	-
2	Time		Ref	-	0
3	Flexibility		Ref	+	+
4	Water quality		Ref	+	0
5	Turbidity		Ref	+	+
6	Space needed on land		Ref	+	-
7	Reliability		Ref	-	-
8	Transport volume	2	Ref	0	+
9	Energy consumption		Ref	0	0
10	Precision		Ref	+	+
11	Public opinion	2	Ref	+	+
12	Need for geotextiles		Ref	+	+
		Plus		8	8
		As good as		5	3
		Minus		2	4
		Sum		6	4
		Control		15	15

As concept 2 still looks like the best alternative, reference is changed and a new scoring run is made.

Table 3. Concept 2 is compared with the other concepts with weight is added to the chart.

			Concept Alternative		
	Criteria	Weight	Concept 2	Concept 1	Concept 5
1	Cost	2	Ref	0	-
2	Time		Ref	+	+
3	Flexibility		Ref	-	0
4	Water quality		Ref	-	-
5	Turbidity		Ref	-	0
6	Space needed on land		Ref	-	-
7	Reliability		Ref	+	+
8	Transport volume	2	Ref	0	+
9	Energy consumption		Ref	0	0
10	Precision		Ref	-	-
11	Public opinion	2	Ref	-	+
12	Need for geotextiles		Ref	-	0
	Plus			2	6
	As good as			5	4
	Minus			8	5
	Sum			-6	1
	Control			15	15

The rerun shows that concept 2 still is the best alternative.

4.2 Analyses

In order to improve the chosen concept, the criteria where other concepts are better is discussed.

Time: Concept two has the lowest capacity for the removal of contaminated sediments. As the expected volume of contamination is 3000 m^3 that should be not a problem. A decision is taken to run through the investigations one more time to see if there is a risk for a large underestimation of contamination.

Reliability: Excavation dredging has been done during maintenance before, there should be no uncertainties during this job. As Freeze Dredging has never been used in the area it is decided that references for similar materials should be delivered by the contractor.

5. Conclusions

This Case study is only a hypothetic example for how an evaluationprocess could be made. The main idea with concept selection is to create a good discussion around the alternatives. The process is easy to understand and the decision making process is well documented. Concept selection can be an excellent way to communicate a decision to other parties that are not taking part of the evaluation process.

To be a useful tool the following is important; i)to have a clear set of concepts, ii) to have a clear set of evaluation criteria, iii) to declare the relative importance of each criteria, iv) to rate the concepts against the criteria, and v) then to develop numerical scores/rankings for each design concept. When done objectively the results of this process can be very good, however when subjective bias is introduced the method falters. Typical procedural problems are i) to eliminate viable concepts before using the matrix, ii) the weight of an evaluation criteria isunder- or over-stated, and iii) the relative weight is not appropriate.

An important note is that physical constraints and constraints regarding treatment of the sediment exclude hydraulic dredging and S/S treatment. The physical setting are difficult to change but it is important that as many options as possible are considered and approved during the permitting process.

6. References

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