LANDFILL REMEDIATION MADE POSSIBLE BY RE-OPENING A FORMER WASTE TIP

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SUMMARY: A waste tip causing serious groundwater contamination was re-opened for controlled sanitary disposal of waste. The landfill fee enabled remediation of the site to be achieved without encroaching on government budgets. Remediation was carried out fifteen years earlier than programmed under government priorities. Simultaneously a problem in planning for new landfill volume was resolved.

1. INTRODUCTION

The "Schoteroog" landfill site is situated near the city of Haarlem and encompasses 24 ha of former marshy meadowland. The landfill was constructed in 1971 by the community of Haarlem. Part of the topsoil was removed prior to landfilling but no barrier was installed. To prevent contamination of soil and groundwater a drainage system for collection of leachate was installed. Leachate was collected in a ditch and pumped to a nearby communal waste water treatment plant. Monitoring and maintenance were very poor. During the investigation and construction work very little evidence of the collection system's existence could be found. Between 1973 and 1977 1.5 million m^3 of waste was disposed of at Schoteroog. Initially only coarse household waste was landfilled, but from 1974 onwards household waste was also included, as much as 50% of the total input. Furthermore waste water treatment sludge and industrial waste (absorbent clay and paint residues) were landfilled. The waste extended over 15.3 ha with an average thickness of 4.5 m. The "Schoteroog" landfill was closed in 1977 when the "Velsen" landfill site was opened. The "Velsen" landfill site was the first geohydrologically controlled sanitary landfill in the region.

2. PLANNING OF LANDFILL VOLUME

The "Velsen" landfill site was constructed and operated by the Department of Environment and Water (DMW) of the Provincial Authority of North-Holland. DMW was responsible for the continuity of environmentally sound waste disposal in the region. In the mid 1980's it became clear that the remaining volume of the "Velsen" landfill would only last until the mid 1990's. DMW started on the permit procedure for the construction of a new landfill site in the region between Haarlem and Amsterdam. However decision making proceeded very slowly. DMW therefore proposed re-opening the "Schoteroog" landfill to create landfill volume and upgrading the environmental measures to present day standards. Temporary re-opening would guarantee continuity in waste disposal and carefully considered decisions with respect to new landfill volume.

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At the same time the regional public body involved in development of recreational areas (RSS) studied the reclamation of the “Schoteroog” landfill. In 1991 RSS commissioned an extensive soil survey to clarify not only the nature and the extent of the soil contamination, but also the required measures to control the situation: i.e. to prevent further spreading of contaminants. The results of the survey showed that the groundwater was seriously contaminated. The most important contaminants were benzene, monochlorobenzene and PAH's. Comparison with national standards and laws indicated that remediation was required. The same year a plan was drawn up to prevent spreading of pollution by installing a perimeter drainage system and a clay capping. However financing of these measures was a problem. The community of Haarlem, the owner of the “Schoteroog” landfill, was not able to allocate the necessary budget, while funding by the Provincial or National Authorities could not be expected before the year 2010.

After consultation of government officials of Local and Provincial Authorities the DMW proposal was accepted. The community of Haarlem issued a permit for temporary re-opening of the “Schoteroog” landfill site. The Provincial Authorities issued the necessary permits with respect to the Environmental Management Act. It was decided that the Provincial Authority would commission the remediation plan and finance the remediation by means of the landfill fee. Furthermore the Provincial Authority would be responsible for the disposal of waste and would guarantee aftercare after final closure of the “Schoteroog” landfill site.

3. PLANNING OF THE REMEDIATION

In 1992, part of DMW was privatised in order to create a more efficient organization that could guarantee continuity in waste disposal and respond swiftly to developments in waste generation and treatment. The new organization, NV Afvalzorg Noord-Holland (Afvalzorg literally translates as “waste care”), is responsible for development and operation of waste disposal facilities. The Provincial Authority is the only shareholder. Afvalzorg took over the experience and responsibility of accepting, registrating and processing waste on landfill sites. At the moment Afvalzorg operates five landfill sites in two Provinces and has an annual turnover of Dfl 60 million (US$ 31.8 million). By spreading cost and income Afvalzorg is able to use a uniform landfill fee on all landfill sites. Moreover Afvalzorg has the organisational structure to finance protective measures, to create aftercare funds and to carry out aftercare. In consultation with the Local and Provincial Authorities it was decided that Afvalzorg would initiate and realize the “Schoteroog” project, would process the waste, would create an aftercare fund and will carry out aftercare in the future. Early in 1993 Afvalzorg commissioned a more detailed geohydrological survey in order to clarify the speed and the direction of spreading of contaminants in the groundwater of the “Schoteroog” landfill and to produce a remediation plan. The 1993 situation is shown schematically in figure 1.

The survey revealed that at an average depth of 12 m a layer of clay was present with a thickness of 2 m. Above the clay was a layer of sand (8 - 9 m thickness). Immediately beneath the landfill the remaining part of the overlying layer of peat (originally 3 - 4 m thick) was compressed to 0.1 - 0.5 m. The survey indicated that the rate of vertical infiltration of contaminants was 3 m per year and the rate of horizontal spreading 5 m per year. Six different schemes were compared in order to determine the most suitable remediation method. The results of the survey suggested that a vertical cut-off wall in combination with deep wells to reduce the water level within the cut-off wall would be the best remediation method. This scheme combines the highest level of geohydrological isolation with removal of small amounts of water to maintain waterlevels. Moreover it requires little maintenance, which is rather important in view of the fact that, after capping the landfill, the area will be prepared for intensive recreation. In 1994, in accordance with the remediation plan, Afvalzorg drafted the specifications for a 2,550 m cut-off wall with an average depth of 12 m and 21 deep-wells with an average depth of 7.5 m. The project was tendered in December 1994 using a system of preselection.

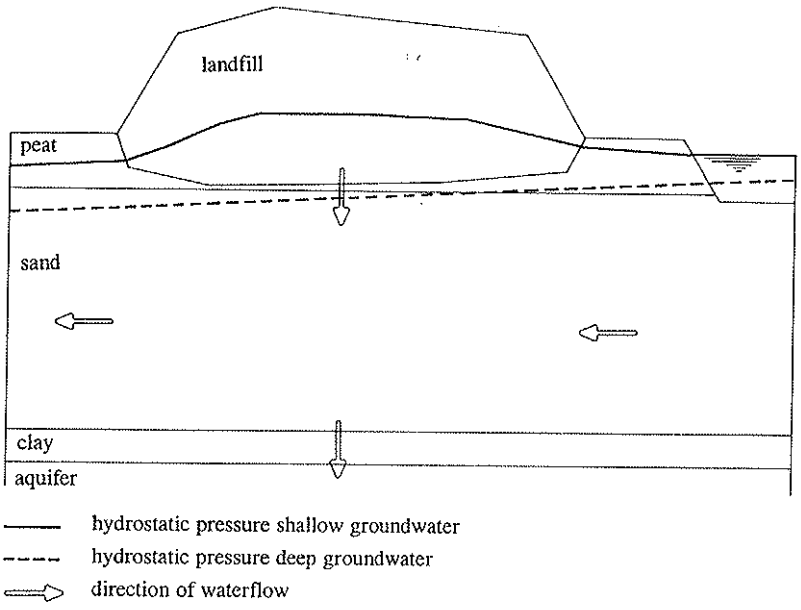

Figure 1. Schoteroog landfill situation in 1993

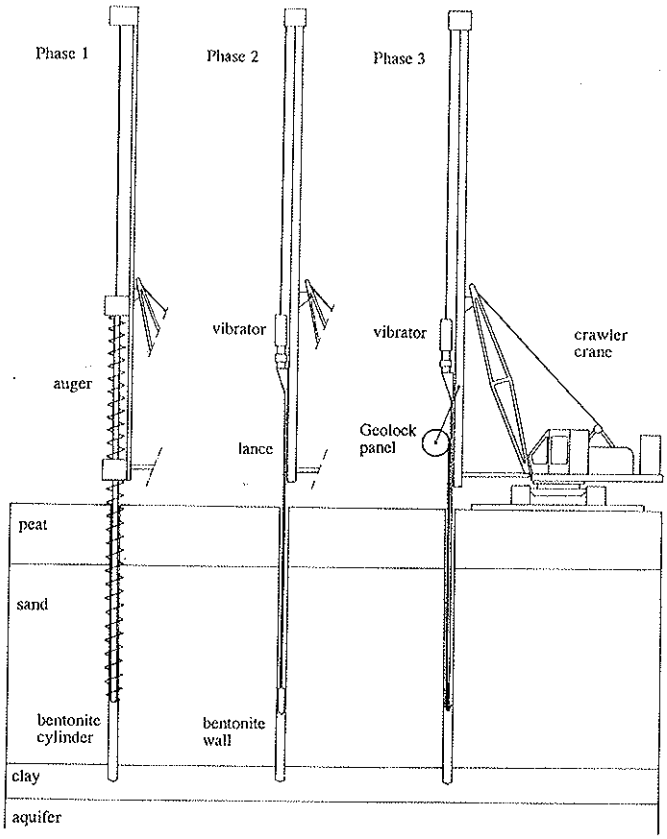

Figure 2. Construction phases of the cut-off wall

4. CONSTRUCTION

The contractor that was selected proposed construction of a “combination cut-off wall”, consisting of a 2 mm HDPE-sheet embedded in a cement-bentonite mixture. Construction was planned in three phases (see Figure 2):

1. At 0.6 m intervals 12 m deep holes were drilled with an auger. During “screwing out” of the auger a cement-bentonite mixture was injected. This resulted in 12 m deep cement-bentonite cylinders with the diameter of the core of the auger (15 cm).
2. Between the cylinders a lance with a width of 0.6 m and 12 cm thickness was inserted by means of vibration to a depth of 12 m. During insertion of the lance the cement-bentonite mixture was added. Upon reaching the required depth, extra cement-bentonite was added to secure a watertight connection to the clay layer. During retraction of the lance cement-bentonite was added to compensate for the volume of the lance.
3. When 5 - 10 m of cement-bentonite trench was installed the HDPE-sheet was inserted. The sheet was constructed of 2 m by 14 m Geolock panels. The lock construction with an expanding neoprene insert (see Figure 3) provides a watertight connection between the panels.The panels were connected to a lance and inserted by means of vibration.

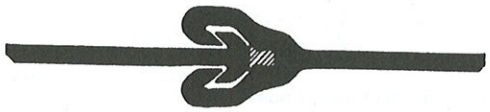

Figure 3. Geolock connection with expanded insert

In March 1995 the construction started with a test wall. It turned out that insertion of the lance between two 15 cm diameter cement-bentonite cylinders was not possible. Therefore all the soil had to be removed from the boreholes to create 40 cm diameter cement-bentonite cylinders. The result was that only 20 cm of soil remained between the boreholes. The lance used to create a 12 cm wide cement-bentonite wall drove the remaining soil into the cylinders. After retraction of the lance inspection of the wall revealed that the cement-bentonite trench partly filled up with sand before the HDPE panels could be installed. This not only obstructed the insertion of the panels, but also resulted in a very inhomogenous cement-bentonite wall. It was concluded that construction of this type of “combination cut-off wall” was not possible in the soil structure of “Schoteroog”.

Negotiations with the contractor and investigations into the cause of the problem delayed the project by several months. The contractor argued that the characteristics of the layer of sand were not in accordance with the results of previous surveys by different consultants. The consultants had both reported that the sand was angular and varied in particle size. In the contractor’s opinion the sand was round with very little difference in particle size. This would have resulted in very little resistance to vibration energy, causing the sand to flow into the cement-bentonite trench. Experts consulted by Afvalzorg opposed this point of view and concluded the problems were not caused by the sand but by the method of vibration.

The contractor guaranteed that the permeability of the HDPE sheet meets the requirements in the specification of the “combination cut-off wall” and developed a test to prove it. As result of the negotiations the requirement for a “combination cut-off wall” was dropped. The HDPE sheet was considered to be the isolation measure and the cement-bentonite mixture as an expedient to install the cut-off wall resulting in some extra security for the isolating properties of the HDPE sheet. In return Afvalzorg demanded a 10 year guarantee of watertightness of the cut-off wall.

In October 1995 construction of the cut-off wall was started. Two teams worked simultaneously at different locations. The wall was finished in March 1996. The average production was 20 m per day (240 $m^2\ d^{-1}$). This was half of the calculated production of 250 $m^2\ d^{-1}$ per team. Thus completion of the project was delayed by another three months. The delay was partly caused by the

weather conditions in the severe winter of 1995 - 1996. The most important reason, however, was the fact that HDPE panels got stuck in the sand halfway down the trench. These panels had to be removed in order to re-open the cement-bentonite trench before starting over again. Removal of such a panel sometimes took more than half a day. Re-opening of the trench results in extra cement-bentonite injections. Because of the larger diameter, more cement-bentonite was used in the vertical cylinders. The overall cement-bentonite consumption was therefore 52% higher than calculated.
Simultaneously 21 deep-wells were installed with filters at an average depth of 7.5 m. The deep-wells were connected by discharge pipes to a pumping-station. The pumping-station transports the mixture of leachate and groundwater to a nearby communal waste water treatment plant. A flowmeter and an automatic sampling device are installed in the pumping-station in order to determine the levy for waste water treatment. Reduction of the water level within the cut-off wall results in an inward and upward waterflow (see Figure 4). This prevents leakage of contaminants into the underlying aquifer.

By March and April 1996 the rest of the required infrastructure was installed. This included fences, gate, asphalt roads, shed, weighbridge, computer system, office and personnel quarters. The "Schoteroog" landfill was re-opened in May 1996. The permit requires that 450.000 m3 of landfill volume is filled in 18 months. The capping must be installed within seven years of re-opening.

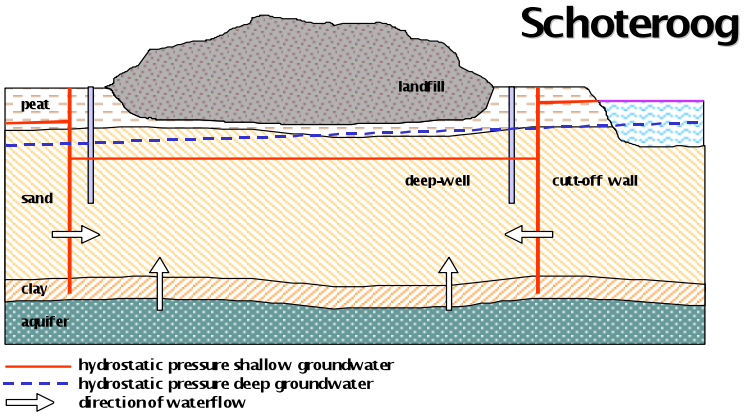

Figure 4. Schoteroog landfill situation in 1997

5. INVESTMENT AND OPERATIONAL COSTS

The costs of the cut-off wall, deep-wells and other facilities are summarized in Table 1. The operational costs are summarized in Table 2. The operational lifespan of the "Schoteroog" landfill is relatively short. Depreciation and interest have to be accounted for in 18 months and are therefore booked as a percentage (24.5%) of the turnover.

Table 1. Investment costs (1 Dfl (1997) = $ 0.53)

Preparation, surveys, specification, tendering, supervision	Dfl	840,000
Watersampling boreholes / filters		47,000
Deepwells, discharge pipes, pumping station		228,200
Power supply, control cables		428,000
Cut-off wall		5.225,500
Weighbridge		153,200
Office, personel quarters		236,000
Power supply		58,000
Fences, gate, security		81,200
Roads, shed, signs		159,100
Total		7,456,200

Table 2. Operational costs (May 1997-February 1997)

Depreciation and interest	Dfl	5,097,400-
Office costs		69,200-
Environmental insurance		4,600-
Waste handling and disposal contract		1,631,300-
Wages		582,300-
Site maintenance		397,400-
Waste water treatment levy		206,600-
Monitoring		125,400-
Capping fund		7,412,000-
Aftercare fund		4,562,800-
Total		20,089,000-
Turnover		20,867,200
Result		778,200

After final closure depreciation and interest (8%) have increased to Dfl 8.7 million. Office costs include maintenance and adjustments of software and hardware for acceptance of waste. The Afvalzorg staff on site consists of a weighbridge operator and a plant manager. Wages include the personnel on-site but also a proportional part of the wages of personnel at the main office involved in acceptance, administration, civil engineering, emission control etcetera. Waste handling and disposal is carried out by a contractor. The contract was tendered and, unlike other Afvalzorg landfill sites, it is not renewed at regular intervals because of the relatively short operational lifespan. The waste water treatment levy is paid to the nearby communal waste water treatment plant. The monitoring cost includes for continuously measuring and checking flows from the deep-wells, while water levels inside and outside the cut-off wall are measured twice a month. Based on these water levels the flows of the deep-wells are adjusted. In addition 15 boreholes inside and outside the cut-off wall have to be sampled and analysed for contaminants once a year. Ten per cent of the wages of an employee involved in the monitoring of all the Afvalzorg sites is incorporated in the monitoring cost. For the creation of a capping fund and an aftercare fund, 36.8 per cent and 22.7 per cent respectively of the turnover are set aside.

The “Schoteroog” landfill accepts non-combustible commercial waste, stabilized sludges, non-hazardous industrial waste, residues from construction and demolition waste recycling and contaminated soils. In the period from May 1996 to February 1997, 260,840 tonnes of waste were landfilled. The mixture of waste can be compacted to 1,000 kg per m^3, and, allowing for some settlement, the final contours will be reached by the end of 1997. The landfill fee was Dfl 80 per tonne of waste, which resulted in a turnover (May 1996 - February 1997) of Dfl 20.8 million. Allowing for profit of Dfl 778,200, the overall cost of the “Schoteroog” landfill is Dfl 77 per tonne of waste. This makes it the most expensive landfill site which Afvalzorg is operating.

6. CAPPING AND AFTERCARE

After discontinuing landfilling it is expected that 3 to 4 years will pass before settlement has reduced to an extent that a capping construction can be installed. Construction can start in the year 2000 or 2001. Allowing for adverse weather conditions in the winter, approximately 10 ha per year of capping can be installed. The capping construction can therefore be completed within seven years of re-opening (i.e. in the year 2003). According to Dutch laws and guidelines a capping of a mineral liner combined with a HDPE membrane is required. In 2001 the capping fund, including interest, will have grown to Dfl 17.1 million. The area within the cut-off wall is 19.6 ha. The fund will enable

construction of capping, including gas extraction to prevent damage by increased gas pressure, for the present cost of approximately Dfl 87 per m^2. It is expected that by using cheaper materials in the topsoil, thinner mineral liners or alternative liners the price of capping construction will be reduced over the next few years. Spreading of costs between Afvalzorg landfill sites secures construction of the capping of the "Schoteroog" landfill even when prices increase.

Once the capping construction is finished aftercare starts. Aftercare consists of three important elements: emission control (waste water treatment and gas extraction), monitoring for effectiveness of the protective measures and provision for replacement of any part of the capping found necessary. At the "Schoteroog" landfill, maintenance of fences, roads, and landscape will be financed and carried out by RSS. Once the capping is installed the waste water treatment levy will be reduced to less than 10 per cent of its present value. The monitoring cost will remain fairly constant. Based on the experience of 1996 and aftercare at two other landfill sites it is estimated that the cost for emission control and monitoring will come down from Dfl 365,000 to Dfl 185,000 per year. At the end of 1997 the aftercare fund will contain Dfl 7.8 million. The expected annual proceeds will be approximately Dfl 470,000. This will allow the aftercare fund to grow and guarantee solvency should parts of the capping have to be replaced in the future.

7. CONCLUSIONS

The "Schoteroog" landfill is an example of a project that can be financed without using up government budgets. Simultaneously a serious problem of planning new landfill volume in a densely populated area was solved. As part of the Provincial and National programmes for remediation of contaminated sites the "Schoteroog" landfill would not have been remediated before the year 2010. Cooperation between Afvalzorg, Local and Provincial Authorities has enabled remediation fifteen years earlier and has secured aftercare.

This type of project could have advantages in places where planning of new landfill volume encounters more public resistance than re-opening and remediating an existing landfill site. Similar projects are possible in any country where the landfill fee allows for the creation of a fund for isolation and aftercare. The success of the project depends on the balance between the required level of isolation, the possible landfill fee and the amount of waste to be added.

8. REFERENCES

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