Summary report

Environmental impact assessment previous to installation of a new main effluent treatment plant of the Municipality of Os.

RAPPORT

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Environmental impact assessment previous to installation of a new main effluent treatment plant of the Municipality of Os.

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PREFACE

On assignment from the Municipality of Os Rådgivende Biologer Ltd in 2008 carried out a recipient assessment in relation with the construction of a new main sewage treatment plant in Kuhlenvika in the Municipality of Os, Western Norway. The new plant will receive sewage from large parts of the municipality. It is estimated that 9000 pe will initially be connected to the plant, but this will increase to approx. 20 000 pe by the year 2025.

This survey will assess whether the recipient of the plant will be negatively affected when running at maximum capacity (20 000 pe). An application of primary treatment is planned. Supplementary investigations are carried out in accordance with methods described in chapter 4.3 of the SFT-Guide TA1890/2005. The existing outlet is modest (1010 pe) and the present study will primarily function as a reference investigation previous to the establishment of a larger, extended outlet.

Rådgivende Biologer Ltd. wants to thank all who has contributed to this comprehensive report. Chemlab Services Ltd analysed water and sediment samples. Biotic analyses were carried out by Eurofins Norway Ltd. Christine Johnsen sorted the animals from the sediment samples and the determination of species was done by Inger Dagny Saanum. Arne Bjorøy and Erling Warberg lent us a boat and assisted in the field. Halvor Mohn at Argus Remote Systems Ltd supplied data on the bottom topography. Calculations of mixing depth and simulations of outlets from the treatment plants were carried out by Jan Langfeldt. Willy-Andrè Gjesdal (Norconsult) has been responsible for coordinating the work.

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Bergen, 14th of September 2009

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The Municipality of Os is located on the west coast of Norway, south of Bergen. It consists of three coherent and densely built-up urban areas; Osøyro with 7923 inhabitants, Hagavik with 1305 inhabitants and Søfteland with 1170 inhabitants. They are all situated in the central and southern part of the municipality, and within 2025 it is estimated that the population will exceeds 20 000 inhabitants. This will have implications for the wastewater treatment. This recipient investigation focuses upon two different aspects. An assessment of four alternative locations of the new main effluent outlet in Kuhnlevika and the expected effects this discharge will have on the marine environment.

In accordance with the EEC Urban Wastewater Treatment Directive 91/271, and the Norwegian pollution authorities, the municipality itself is responsible for authorizing effluents of maximum 10 000 pe to each distinct recipient, even though it may be discharged from several treatments plants. The urban areas of Os are expected to exceed 10 000 pe in the near future. This will require an extended level of waste water treatment, and the responsibility for the effluents will be transferred to the County Governor. However, if the planned increase in effluence will not inflict damage to the marine environment, primary treatment can be maintained. This report aims to present documentation for this decision.

According to the division of water bodies described by the Water Framework Directive the wastewater from Os is mainly discharged into one distinct coastal water body or recipient i.e. Fusafjorden, that within 2025 will receive effluents from approximately 20 000 pe from Os alone.

In 2008 and 2009, an extensive environmental impact assessment of the coastal waters outside Kuhnlevika in Os was carried out to assess the necessary and appropriate extent of wastewater treatment in accordance with the Waste Water Directive. All results are summarized according to the EEC Water Framework Directive and presented as classified Ecological Status in **table 1** on the subsequent pages.

The investigated water bodies of Fusafjorden were scarcely affected by supplies of nutrients, environmental pollutants both in sediments and biota, and were classified to ***high ecological status*** of coastal surface waters, as well for the sediment quality and biological diversity of soft bottom fauna.

The results from the recipient investigation and from modelling the effluent plumes at four alternative sites show that the discharge from this planned increased effluent probably still will have minor effects on the recipient. Surface water quality was overall near natural conditions, and will not be influenced by any of the four alternative sites of the new outlet. The biological diversity of soft bottom fauna within the recipient was overall high. The sediment quality was near natural conditions also with respect to organic contents and pollutants.

Thus it is concluded that the new main waste water outlet in Kuhnlevika will probably have only small and local effects close to the effluent, and no overall negative impacts on the marine environment outside Kuhnlevika in Fusafjorden. It is not expected to influence on the migration of salmon smolts from and adult salmons returning to the river Oselven.

INTRODUCTION

On contract from the Municipality of Os Rådgivende Biologer Ltd. have carried out an environmental impact assessment in relation the installation of a new main effluent treatment plant of the municipality in Kuhlenvika. The work is carried out in accordance with Norwegian Standard NS 9422 and 9423, and the evaluation is done in accordance with SFTs classification of environmental quality (SFT 1993; 1997; 2007). This survey will describe the environmental conditions as they are before the new treatment plant is established.

A detailed mapping of the bottom and ROV-documentation of the bottom conditions has been carried out on the site of the outlet and the surrounding areas. The currents have been measured on four alternative locations for the new main outlet (**figure 1**) and hydrographical- and water quality evaluations have been carried out on the same four locations plus two locations further out in the recipient. Sediment quality, environmental pollutants and soft bottom fauna was examined on two of the alternative locations plus one reference location further east. Seaweed and mussels were collected from three locations in the littoral zone south and north of Kuhlenvika and a survey of macro algae and zoology was carried out in the littoral and sub-littoral zone.

The area outside Kuhlenvika is situated in the water body Fusafjorden in the south-eastern part of the Municipality of Os and the recipient is classified as “less sensitive” according to the EEC Urban Wastewater Treatment Directive (Molvær et al. 2005). Fusafjorden is classified ac *CNs4 = “fresh water influenced protected fjord”*, and the area where the new main outlet is planned has “high ecological status”. The sea area is exposed to the northeast and southeast, and the planned outlet will drain into a fjord with very favourable current and water exchange conditions. Hence, the recipient capacity is good and is not expected to be very vulnerable to local effluents.

The current measurements showed that currents and water exchange are favourable on all four of the alternative locations for a new main outlet, both during summer and winter. Overall there is no qualitative difference between the four locations in terms of current speed and water exchange, and dispersal and dilution of effluents will probably be good.

On all locations the main direction of the surface currents is south/south-westerly, and the direction of the flux is fairly stable both summer and winter. At “Os north”, “Os inner” and “Os outer” the currents occasionally had a north/north-easterly direction, i.e. opposite of the main direction. At “Os south” the winter flux was more south/south-easterly, turning southeast along the shore. At 15 and 20 m depth near “Os north”, “Os inner” and “Os south” the direction of the currents was relatively stable. Besides the predominant current direction towards south/southwest and south/southeast on all locations, some currents near “Os north” and “Os inner” went east and northeast, respectively.

At 30 m depth at “Os inner” and “Os outer” the directional stability was poorer both summer and winter. This is normal at a depth where compensational currents are found, i.e. currents that go partly or completely in the opposite direction of the surface currents. At “Os inner” the deep water currents mainly went south or northeast during summer and winter. At “Os outer” the main current direction was north during summer and south during winter, and in both seasons some currents went outwards in the south-easterly direction. At “Os south” the predominant current direction at 30 m depth was south-easterly. At 40 and 50 m depth the currents were more erratic at “Os north” and “Os outer”, with the main current direction at “Os north” being north-westerly while the main current direction at “Os outer” was westerly in summer and north/north-westerly in winter.

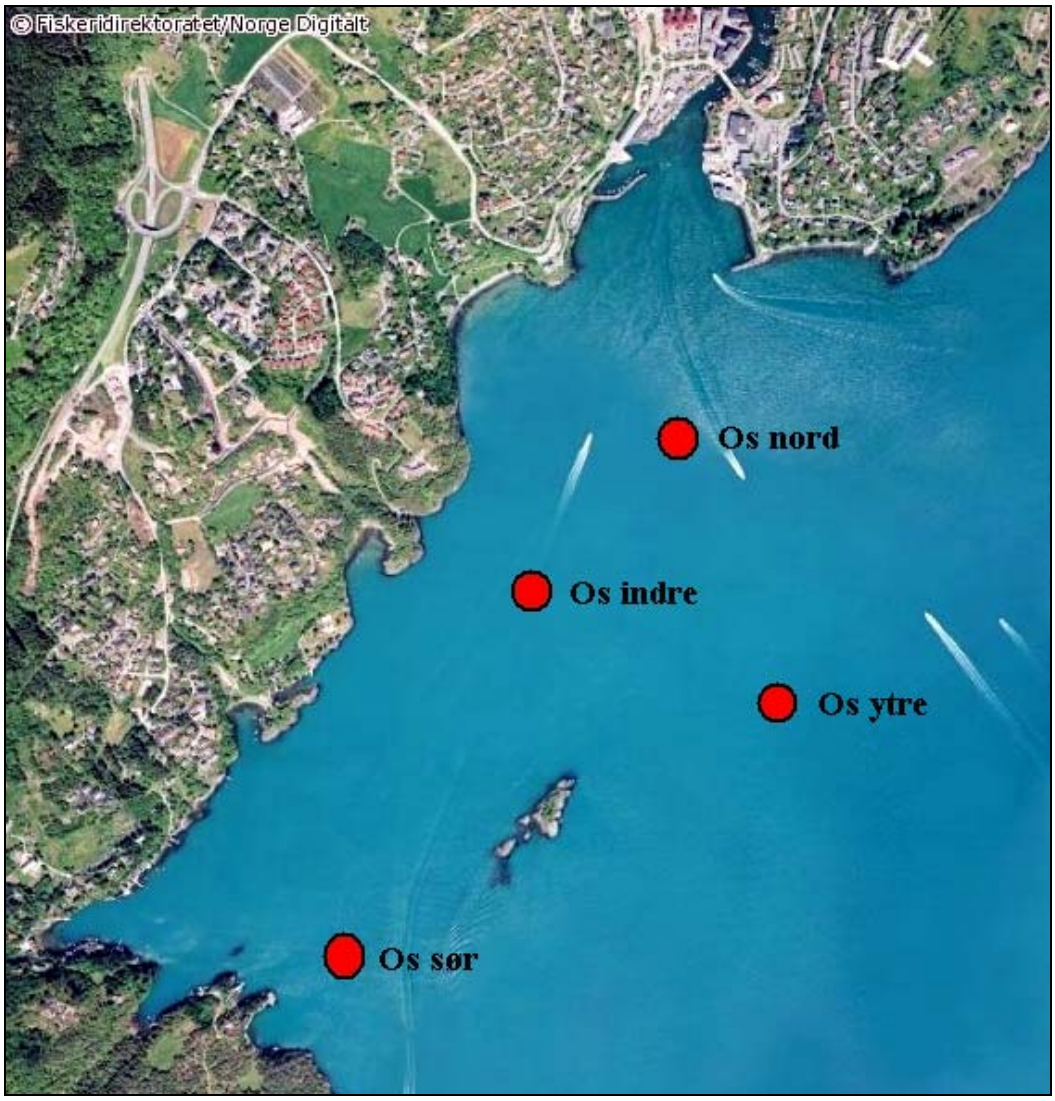

Figure 1. *Location of the four alternative outlets from the new main effluent treatment plant of the Municipality of Os. ("nord" = north; "sør" = south; "indre" = inner; "ytre" = outer)*

ENVIRONMENTAL STATUS

The overall environmental status corresponds to SFTs condition category I = "very good" an all locations in terms of nutrient richness, turbidity, bacterial level, visibility (summer and winter), chlorophyll a (summer), sediment quality and bottom dwelling fauna. The level of heavy metals and the organic pollutants PAH and TBT in the sediment corresponded the category I = "background", while the level of PCB corresponded to the category III = "moderately polluted". The organic content of the sediment was low, indicating favourable conditions for organic turnover in the area of the new outlet. The level of heavy metals and organic pollutants in blue mussels and limpets on all three locations examined is typical of what is normally found in areas with little pollution and good water exchange, and corresponds to category I = "negligible to modest pollution".

The recipient in Kuhlenvika has high ecological status (**table 1**). The ecological status describes an overall assessment of the physical, hydro-chemical and biological conditions in an ecosystem. The primary emphasis is the biological conditions, followed by sediment pollutants and the general conditions in the sediments.

Table 1. *Overview of the Norwegian EPA classification of environmental quality for all the investigated subjects on each of the places studied in 2008 and 2009. Classification of environmental quality is done according to the scale below (see SFT 1997 and 2007 for details regarding the quantitative limits). The overall qualities are summed into "ecological status".*

Element	Fusafjorden				
	Os inner	Os outer	Os north	Os south	Os ref.
Visibility (summer)	I	-	I	I	-
Turbidity	I	-	I	I	-
Chlorophyll a (summer)	I	-	I	I	-
Phosphorous	I	-	I-II	I-II	-
Nitrogen	I	-	I	I	-
E. coli	I-II*	-	I	I-II*	-
Water quality	I	-	I	I	-
Oxygen	I	I	I	I	I
Bottom fauna in recipient	II**	I	-	-	I
TOC in sediment	I	I	-	-	I
Sediment quality	I	I	-	-	I
Heavy metals in sediment	I	I	-	-	I
PAH in sediment	I	I	-	-	I
PCB in sediment	III	III	-	-	III
TBT in sediment	I	I	-	-	I
Pollutants in sediment	I	I	-	-	I
Pollutants in seaweed* **	I	-	I	I	-
Pollutants in mussels* **	I	-	I	I	-
Ecological status	**High ecological status**				

* *All surface samples were category I.*
** *Species composition was category I = "very good".*
*** *The samples were taken in the littoral zone in the vicinity of the respective locations.*

EVALUATION OF ALTERNATIVE OUTLETS

The four alternative outlet locations are evaluated according to the following criteria:

- The plume of the outlet must not break through to the surface and should not have a negative impact on the quality of the surface water
- The outlet must not influence negatively the salmonid migration to and from River Os
- The outlet must affect the environment negatively.

The qualitative differences among the four alternative outlets are small, and none of the alternatives are in conflict with the criteria above.

MODELLING OF THE OUTLETS

The calculations of mixing depths for the four alternative outlets, given effluents from 20 000 pe at average and maximum discharge, show that the effluent plumes will not reach the surface neither in summer nor in winter (**table 2**), and the margins are good.

The dilution of the outlet is normally strongest in winter because of the breakdown of the temperature stratification, but the calculations show that the mixing depth varies only slightly between seasons in "Os inner" and "Os outer", both with average and maximum discharge from the outlets. This is because the outlets are going to be placed at a depth where the temperature is fairly stable throughout the year.

However, a substantial variation is to be expected around the "average situations", and the combination of little or no stratification in winter or very low current speed in periods of high discharge may send the effluent plume closer to the surface. If the high discharge episodes are due to run-off from rain or melting snow the fjords will simultaneously receive large volumes of fresh water. This will effect a more pronounced vertical stratification, thus preventing the top of the effluent plumes from reaching the surface from the two shallower alternatives, "Os inner" and "Os south".

***Table 2**. Estimated mixing depth in summer by average current speed and mean and maximum flow of the four alternative locations for the planned wastewater effluents of Os, with maximum load in pe. (su/wi = summer/winter)*

Planned outlet	At mean flow						At maximum flow					
	Top of plume		Mixing depth		Dilution (1000 m)		Top of plume		Mixing depth		Dilution (1000 m)	
	su	wi	su	wi	su	wi	su	wi	su	wi	su	wi
Os inner, 50 m	12	13	22,5	22	340x	315x	10	8	20,5	17,7	245x	230x
Os outer, 80 m	33	32	43	44	450x	470x	22	26	40	39	315x	320x
Os north, 65 m	-	25	-	35	-	355x	-	22	-	32,5	-	245x
Os south, 55 m	-	22	-	30	-	265x	-	9	-	20	-	215x

Alternative 1: "Os inner"

Modelling of the effluent water indicates a mixing depth of more than 15 m both summer and winter even at maximum discharge. According to current measurements a mixing depth of 15 m or more results in the effluent water being transported in a south/south-easterly direction out into the deep fjord Fusafjorden. In the event of slow currents and high discharge during winter it is possible that the plume will rise higher in the water column, and then the effluents will mainly flow in south/south-westerly direction towards Lekvenvågen and Ferstadvågen. However, such episodes will be rare, and the effluents will be very diluted and mixed with surrounding waters by the time it nears Lekvenvågen and Ferstadvågen. It is highly unlikely that the effluents will break through to the surface, and thus it will not affect the quality of the surface waters neither to the southwest or northwest of the outlet.

Alternative 2: ”Os outer”

Modelling of the effluent water indicate a mixing depth of more than 40 m both summer and winter even at maximum discharge. According to current measurements a mixing depth of 40 m or more results in the effluent water being transported in an easterly direction out into the deep fjord Fusafjorden during summer. In winter the effluents may go northwest towards Osøyro, west towards Kuhlenvika or south towards Fusafjorden, depending on the predominant current direction. In the event of slow currents and high discharge during winter it is possible that the plume will rise higher in the water column, and then the effluents will mainly flow in south-westerly direction towards Fusafjorden. The higher the effluent plume rises, the more will be transported out towards Fusafjorden both in summer and winter. In conclusion, an outlet at 80-85 m depth will under no circumstances reach the surface, and thus will not have a negative effect on the surface waters of the area.

Alternative 3: ”Os north”

Modelling of the effluent water indicate a mixing depth of more than 30 m both summer and winter even at maximum discharge. According to current measurements during winter a mixing depth of 30 m or more results in the effluent water being transported towards the shore in a south-westerly to northern direction, i.e. between Kuhlenvika and Osøyro. In the event of slow currents and high discharge during winter it is possible that the plume will rise higher in the water column, and the higher the plume rises the more of it will transported either east into Fusafjorden or in a south/southwesterly direction past Kuhlenvika. However, such episodes will be rare, and the effluents will most likely be mixed in at depths (more than 30 m) where it will be transported towards the shore between Kuhlenvika and Osøyro. Since it is highly unlikely that the effluents will break through to the surface it will not affect the quality of the surface waters neither to the southwest nor to the north of the outlet.

Alternative 4: ”Os south”

Modelling of the effluent water indicate a mixing depth of more than 30 m in summer and 20 m in winter even at maximum discharge. According to current measurements during winter a mixing depth of 20 m or more results in the effluent water being transported in a south-easterly direction towards Fusafjorden. In the event of slow currents and high discharge during winter it is possible that the plume will rise higher in the water column, but the effluents will maintain a south/south-easterly direction towards Fusafjorden. However, such episodes will be rare, and the effluents will most likely be mixed in at depths where it will still be transported towards Fusafjorden. Since it is highly unlikely that the effluents will break through to the surface it will not affect the quality of the surface waters in any direction from the outlet.

EFFECTS ON SALMON MIGRATION

Both salmon smolt migrating towards the sea and adult salmon returning to the river to spawn will mainly utilize the upper part of the water column, in the stratum between fresh/brackish surface and the saline layers underneath. The adult fish will actively swim towards the River Os, increasingly using the fresh water coming from the river in their homing. The brackish layer near the river may reach 20 m depth in May and June, when the main migration takes place.

Of the four alternative outlet locations, “Os inner” has the shallowest mixing depth and therefore the greatest risk of interfering with the salmon migration. It is not known, however, whether effluents can have an impact on the salmon’s homing ability.

ENVIRONMENTAL EFFECTS

In light of the good environmental conditions, the high ecological status of the area at present, and the favourable current- and water exchange conditions, it is probable that the new effluent treatment plant outlet of 20 000 pe will not have a negative impact on the environment in the main recipient of Kuhlenvika (cf. § 14-8). It is therefore possible to apply for exemption from the required secondary treatment of effluents from any of the alternative outlets that are eventually chosen.

CONCLUSION

An overall assessment af all elements in this survey concludes with the following ranking of the four alternative outlet locations:

1. ”Os outer”
2. ”Os north”
3. ”Os inner”
4. ”Os south”

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