PREPARING AN ENVIRONMENTAL PERMIT APPLICATION

Case Study for a Small Scale Fish Farm

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ABSTRACT

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Preparing an Environmental Permit Application
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In 2011, approximately 10 million kg of rainbow trout were farmed in Finland, of which 1,6 million kg were farmed in inland water systems. The eutrophication of water systems caused by fish farming has decreased since the year 2000, mainly due to substituting fish meal with plant based proteins in fishfeed production, as well as the reduced consumption of fishfeed due to improved feeding techniques. The overall production of rainbow trout has also decreased in Finland, excluding Åland, where production has remained stable. Sustainable development of aquaculture to reclaim domestic markets from foreign fish suppliers is part of the strategic plans of the Finnish government.

The aim of this thesis was to prepare an environmental permit application for a small scale fish farm, Sampon Lohi, in Joutsa, Finland. During the summer of 2011, it was decided that an environmental permit was necessary operations using more than 2000 kg of fishfeed per year. In the thesis, information on this writer’s practical training at Sampon Lohi and a preliminary environmental assessment of its operations are presented, as well as the environmental legislation concerning the permit and the permit application. The main portion of the thesis concentrates on the actual content of the application.

Sampon Lohi provides healthy, locally produced food in an environmentally friendly manner, and would most likely be granted the permit if it is applied for. The state of the environment and future of Sampon Lohi are discussed, as well as the necessity and benefits of the environmental permit. The role of local small-scale food producers in an urbanising and cost-efficient Finland is also discussed. The effect of Sampon Lohi on its local rural community and on tourism during summer months is analysed.

Key words: environmental permit, environmental legislation, rainbow trout, aquaculture, sustainable development

TIIVISTELMÄ

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Suomessa kasvatettiin vuonna 2011 arvioilta 10 miljoonaa kiloa kirjolohta, josta sisävesialueilla noin 1,6 miljoonaa kiloa. Kasvatuksen aiheuttama vesistöjen rehevöitymінen on pienentynyt 2000-luvun alusta. Tähän syinä ovat lähinnä kalajauhon korvaaminen kasviperäisillä proteiineilla rehussa sekä käytetyn rehun määrän pienentyminen ruokintatekniikan parannuttua, että myös toiminnan vähentyminen Manner-Suomen alueilla. Vesiviljelyn kestävä kehitys kuuluu valtioneuvoston periaatepäätökseen, jossa tavoitellaan kasvaneita tuotantomääriä vuoteen 2015 mennessä.

Tässä opinnäytetyössä selvitetään ympäristölupahakemusta Sampon Lohi -nimiselle pienelle kalankasvatuslaitokselle. Kesällä 2011 todettiin yli 2000 kilon vuosittaiseen rehuruokintaan vaadittava ympäristölupa tarpeelliseksi. Työssä käsitellään harjoittelun vaiheita ja vedenlaadun tarkkailuun liittyviä analyysejä, sekä ympäristölupaa käsittelevää lainsäädäntöä, että lupahakemusprosessia. Keskeinen osa työtä on hakemuskaavakkeen käsittely kohta kohdalta.

Ympäristöministeriön internet-sivustolta löytyy ohjeita ja lomakkeita, jotka helpottavat pienyrittäjän toimintaa ympäristölupaa hakiessa. Vesistöjä Sampon lohitilalla ei ole luokiteltu huonokuntoisiksi, joten ruokinnan lisääminen olisi siltä osin mahdollista ilman vesistöjen pilaantumista. Sampon Lohen hakiessa ympäristölupaa pääsevät alueen ja lähiympäristön muut käyttäjät, kuten asukkaat, vaikuttamaan tilan toimintaan. Ympäristölupa on ikään kuin kompromissi taloudellisen tuottavuuden ja luonnonsuojelun välillä kestävän kehityksen turvaamiseksi. Sampon Lohi tuottaa tämän ajan trendien mukaisesti terveellistä lähiruokaa ympäristöystävällisesti.

Avainsanat: Ympäristölupa, ympäristölainsäädäntö, kirjolohi, vesiviljely, kestävä kehitys

CONTENTS

ABBREVIATIONS AND TERMS

AVI	Aluehallintovirasto (Regional State Administration Agency)
BAT	Best Available Technology
BEP	Best Environmental Practice
ELY-centre	Centre for Economic Development, Transport and the Environment
EPA (YSL)	Environmental Protection Act 86/2000 (Ympäristönsuojelulaki)
EPD (YSA)	Environmental Protection Decree 169/2000 (Ympäristönsuojeluasetus)
MMM	Maa- ja metsätalousministeriö (Ministry of Agriculture and Forestry)
MTT	Maa- ja elintarviketalouden tutkimuskeskus (Agrifood Research Centre)
N	Nitrogen
P	Phosphorous
RKTL	Riista- ja kalatalouden tutkimuslaitos (Finnish Game and Fisheries Research Institute)
TAMK	Tampere University of Applied Sciences
WA	Water Act (587/2011)

1 INTRODUCTION

1.1 Fish farming in Finland

Fish farming is an important form of aquaculture and local food production in Finland. Rainbow trout (*Oncorhynchus mykiss*) is the most commonly grown species. Production of fish for food began in Finland in the 1960s and 1970s mostly as small-scale economic activity. Activity grew, and in the beginning of the 1980s Finland was the largest salmon producer in the Nordic countries. The increasing trend in production turned to a decrease in the beginning of the 1990's. (Kansallinen vesiviljelyohjelma 2015, 2009, 4)

The amount of produced rainbow trout in 1999 was 15,3 million kg. In 2005, 218 fish farms in Finland produced approximately 14,4 million kg of fish for food, of which 13,7 million kg were rainbow trout. (Ojanperä, 2007). In 2009, 13,6 million kilograms of fish were grown for food in total, of which 12,7 million kg were rainbow trout. In 2010, the figure for rainbow trout production was 11 million kg. The amount of sites producing fish for food purposes dropped from 281 to 187 from the years 1998 to 2009, but the average production amounts per site grew by 35 %. (Silvenius, MTT 2012).

Of total fish produced for food in 2010, 9,800 million kg were produced in seawaters along the coast and Åland, and 1,9 million kg in inland water systems. Åland produced 5,3 million kg at 27 farms, with average annual production of 0,2 million kg per farm. The average annual production of the 62 inland farms was 31 tons. (Kalankasvatuksen ympäristönsuojeluohje, 2012)

The small scale of the majority of production sites, together with increasing requirements for environmental protection and other guidance from authorities for production have worked together to decrease the overall production in the 21st century. Another factor affecting the trend was increased global competition. Especially salmon imported from Norway caused competition in prices, which weakened the viability of Finnish producers. (Kansallinen vesiviljelyohjelma 2015, 2009, 4)

The Ministry of Agriculture and Forestry's (MMM) development program for the year 2015 (2009), embursed by the Finnish Government, aims for sustainable growth in the aquaculture industry, to catch up with neighboring Norway, Sweden and Russia and to ensure domestic supply of nutrition. The program's view of sustainable development consists of balance between ecological, social and economic sustainability as an optimum state in 2015. The program calls for sustainable growth for production, meaning decrease of environmental impacts in relation to growth in production. (Kansallinen vesiviljelyohjelma 2015, 2009, 8)

1.2 Environmental impacts of farmed rainbow trout

The main environmental impact of fish farming is the eutrophication of water systems caused by phosphorous and nitrogen emissions. It has been calculated that fish farming produces 2 % of the overall phosphorous into water systems in Finland. (Ojanperä, 2007) On a broader spectrum, environmental impacts of rainbow trout farming range from emissions caused by the production of fish feed and packaging materials to emissions from transportation of fish to home from shop by the end consumer.

During the years 2010-2012, the Agrifood Research center in Finland (MTT) conducted a life cycle analysis of rainbow trout produced in Finland, in co-operation with the Finnish Game and Fisheries Research Institute (RKTL). The study was conducted as an update to a study done in 2003, mostly due to improved composition of feed and thus lowered eutrophication values. The study compared climate impact and eutrophication values of different production methods, as well as production of different meat products: beef, pork and chicken. Nutritional values of end products were also taken into consideration for a broader analysis.

The study covered the whole production chain of fish farming beginning from agriculture for growing plant-based ingredients, fishing for fishmeal and oil to manufacture the fish feed, to the growing stages of hatchlings, transportation to fisheries, cleaning the fish and filleting the fish. Transportation of products between different stages, energy used for refrigeration and maintenance of production, as well as the packaging material of feed sacks and polystyrene used for boxes for keeping the fish refrigerated during transport were also included. (Silvenius, MTT 2012)

Results showed that the eutrophication impact had lowered 26 % from 2002-2009, mainly due to increased quality in feed by replacing fish meal with plant based proteins, leading to an increased feed conversion factor, meaning less feed is necessary to gain same growth in fish. Also feeding technologies have improved, optimizing feeding amounts. Primary energy consumption declined by 10%, leading to a declined climate impact. (Silvenius, MTT 2012)

In comparison to other meat products as mass of product, the carbon footprint of rainbow trout was lower. Beef had three to seven times the climate impact, pork and chicken had about 2,5 and 1,5 times the climate impact at their highest level when compared to that of same mass of rainbow trout fillet. Eutrophication impact, however, was higher for rainbow trout than other meat products; about two to seven times that of beef and pork production, and five to ten times that of chicken production. Recirculating farming reduces the phosphorous emissions by approximately 32 %, and even more if the effluents are treated at a wastewater treatment plant. (Silvenius, MTT 2012)

The Ministry of Agriculture and Forestry's development program for 2015 mention some positive environmental impacts of aquaculture. Populations of many valuable species of fish, which have nearly disappeared from natural waters have been recovered and strengthened by aid of aquaculture and transplanting farmed hatchlings into water systems. Farmed fish also provides local food, reducing climate impacts of transportation. As poikilothermic species, fish use available nutrition more efficiently for growth in mass than homeothermic livestock. Fish need no shelter and heating during the winter as they survive under the ice cover. (Kansallinen vesiviljelyohjelma 2015, 2009, 3) Fish have many health benefits, especially rainbow trout, due to high content of essential fatty acids and valuable protein. (Silvenius, MTT 2012, 48)

1.3 Information on Sampon Lohi

Pekka Sampo's rainbow trout farm is located next to Kostamonjoki, in Joutsa, Finland. The site has had fish farming related operations since the 1960s. Pekka has been running the site since the year 2000. The fish farming operations consist of 7 ponds in total with water from Kostamonjoki flowing through the ponds. Water for the ponds is derived from Kostamonjoki at two spots: one from an old dam where a mill used to stand, and one at a turn in the river about 100 meters downstream from the old mill dam. The farm is quite close to being in a natural state, with vegetation covering the whole site, including the sides of the ponds. In the picture below are 3 of the 5 ponds on the north-east side of the river. The ponds are approximately 30 meters long, 4 meters wide, and 1,5 meters deep, and have concrete bottoms. They are generally used for growing smaller fish, aged 1-2 years. A map of the ponds on site can be seen in Appendix 1.

PICTURE 1. Salmon growing ponds at Sampon Lohi (Photo: Mikko Heiskanen 2011)

The 2 ponds on the southwest side of the river are earth bottomed, and larger. They cover approximately 300 square meters. The larger of the two is 1,5 meters deep, while the smaller is about 1 meter deep. They are used for larger fish to grow and mature in. The larger of the two is also used for recreational fishing purposes, as it is big enough for casting a fishing line. Trying to catch a rainbow trout with a lure is especially popular among families with younger children as an activity during their summer vacations.

Signs along Korpilahdentie, in both directions from Sampon Lohi, advertise a fishing opportunity. (Heiskanen, 2011)

Sampon lohi also sells smoked salmon grown in his own ponds. Mature fish, ranging from approximately 700 grams to 2 kilograms are captured with a net, after first lowering the depth of water in pond to concentrate the fish onto the bottom. This activity consists of one man wading in the pool with a net, catching the fish, and another on shore, waiting for salmon to be thrown to him. The man on shore is then ready to stun them by striking them behind the neck with a wooden stick and cutting the area between the gills and front fins with a knife, after which placing the fish into a wheelbarrow for the blood to be drained.

About 20-30 kg of fish are taken at a time, and transported a few hundred meters with the wheelbarrow to be gutted and cleaned. This is done in the evenings, and the fish are left to be salted overnight in a refrigerator. The next morning, the salted salmon are smoked in a big oven, after which they are ready to be sold during the day. Separate signs advertising smoked salmon are placed roadside of Korpilahdentie close to the site when there is smoked salmon to be sold. On occasions, Sampo buys whitefish from a local fisherman, and sells smoked whitefish along with smoked salmon. Separate roadside notifications are placed when whitefish is available. (Heiskanen, 2011)

1.4 Aim of the thesis

The aim of the thesis is to study the environmental permit application process of the case of Pekka Sampo’s rainbow trout farm, and to compile necessary information for the permit application. Content of the application presented in the thesis is not a final version of the application that will be sent to the environmental authorities.

The thesis should familiarize the reader of the scope of information related to the environmental permit process, and generally of the purpose of the environmental permit. The reader should gain a general idea of the legislation behind the permit, as well as the role of authorities in the permit process, as defined in the legislation.

In the discussion, the role of small-scale rural aquaculture is considered as a whole, from an environmental as well as social and economic point of view. Also, the author will attempt a subjective analysis of the environmental impacts and meeting of environmental permit requirements of Sampon Lohi.

2 METHODS

2.1 Field work

The thesis process started at the beginning of a three-month practical training period in Joutsa during the summer of 2011. Based on a statement from environmental authorities at the ELY -centre at Jyväskylä from the previous year, it was decided that an environmental permit was necessary in the near future of the farm. (Rekonen, 22.6.2010)

Practical work was of importance in providing knowledge and expertise in compiling the information for the application. During the period, knowledge and practical skills on the processes involved in maintaining and operating the site were gained. One set of measurements was conducted to aid in estimating the nutrition emissions from the site.

2.1.1 Flow measurements

To understand better the nutrient load and aquatic environment of the site, flow measurements were conducted, as advised by environmental inspector Raija Rekonen, from Jyväskylä ELY- centre. For conducting the measurements a Flowtracker handheld acoustic doppler velocimeter, manufactured by Sontek, was borrowed from the University of Jyväskylä biology department. Limnology student of the University of Jyväskylä Ville Juusela, former Environmental Engineering student from TAMK, operated the velocimeter and aided in the measurements on August 27, 2011.

The flow rate of water was measured at the intake of water into the upper growing ponds, and of the whole river as well, upstream from the intake. The flow at the intake was measured to be 19,1 cm/s. The area of the water flowing through concrete gap, 40 by 90 cm, was input into the instrument, and the overall flow rate was found to be 51,6 l/s. Converted to cubic meters per day, the amount is approximately 4500 m^3/d. Juusela conducted measurements upstream of the dam, and calculated the entire flow of the river to be about 200 l/s. (Heiskanen, 2011)

Upon reflection of the water level of Kostamonjoki on the day of the flow measurements, Sampo estimated the flow to be close to the median flow of the river. Highest flow rates are during the spring when snow melts and heavy rains during the summer and autumn. During dry and warm periods, the water level drops below the median flow. (Heiskanen, 2011)

2.1.2 Water sampling and analysis

Sampling

Along with the flow measurements, nutrient content from the river gives an estimate of the total amount of nitrogen (N) and phosphorous (P) emissions of the farm. An attempt for preliminary analysis was conducted on the same day as the flow measurements were done, but it was found that they did not conform to standards as they were kept refrigerated too long before analysis. In September 2011, a new set of sampling was decided on, this time complying with ISO standards 5667-6:2005(E) Water quality - Sampling – Part 6: Guidance on sampling of rivers and streams, and 5667-3:2003(E) Water quality – Sampling – Part 3: Guidance on the preservation and handling of water samples.

On September 14, 2011, a polystyrene cool-box, cool packs and plastic 0,5 l bottles for samples were fetched from TAMK waste and wastewater laboratory, and driven to Sampon Lohi. The cool packs were put into a freezer upon arrival. The next day, samples were taken according to the ISO standard. A log sheet was created into the practical training diary, including details needed for thorough reporting according to the standard. The weather was rainy and windy, and air temperature was 17 degrees Celsius. There had been heavy rainfall in days prior to the sampling, and the flow of the river as higher than usual. The water was dark, with lots of suspended organic matter, most likely from peatlands upstream. (Heiskanen, 2011)

The samples from above the site were taken from a bridge, and the following details were in concurrence with the standard: there was a sufficient depth of water so that when submerged, the container would not disturb the sediment, the sample was taken from downstream of the bridge, and no contaminants from the structures of the bridge entered the container. The containers were rinsed using the stream water before the samples were taken, and samples were taken directly by hand by reaching into the water, at about 25 cm, with the neck of the bottle pointing toward the current. The bottles were filled to the brim, and closed, to avoid excess gas exchange. Three samples of 0,5 liters were taken, and were labeled Upstream 1, 2 and 3

Samples from downstream were taken at a wide and shallow portion of the river, with a rocky bottom. Samples were taken from the middle, by wading in wearing rubber boots. Again the bottles were rinsed with the stream water. The samples were taken from right below the surface, with the bottles nearly horizontal, facing upstream. The bottles were filled to the brim, and closed, totaling three 0,5 liter samples. The samples were marked Downstream 1, 2 and 3.

The samples were refrigerated on site directly after being taken. For the two hour drive to Tampere, they were placed in the cool-box with the cool packs. Arriving in Tampere, the samples were delivered directly to a refrigerator at the TAMK waste and wastewater laboratory. Laboratory work began on the following day, September 16, to not exceed the limits for storing samples before conducting analyses. (Heiskanen, 2011)

Analysis

The samples were analyzed for phosphates, nitrates, total P and total N. Analysis was begun by allowing the samples to warm up by taking them out of the refrigerator. Once warmed up to 12 degrees Celsius, the pH and electric conductivity were measured and the EC again at 18,7 degrees Celsius. The pH was measured with Mettler Toledo FE20 pH meter, and the electric conductivity with a Mettler Toledo FE30 conductivity meter. A slight acidification of the water can be noticed, as well as a slight decrease in electric conductivity (table 1).

TABLE 1. pH and Electric conductivity of samples

	pH	EC at 12 °C	EC at 18,7 °C
Upstream	6,04	49,3 µS/cm	54,2 µS/cm
Downstream	5,96	48,3 µS/cm	52,6 µS/cm

After the pH and EC measurements, the samples were filtrated with a vacuum flask to rid of the suspended organic matter. 300 ml of each filtrated sample was preserved according to ISO 5667-3:2003, by adding 10 ml of sulphuric acid (H_2SO_4, 4M) per one liter of sample, and labeled accordingly. 100 ml of each filtrated sample was left in labeled beakers for analysis of phosphate and nitrate concentrations, which were conducted immediately afterwards. Determination of phosphate (PO_4^{3-}) and nitrate (NO_3) concentrations were conducted using a DR 2800 portable Spectrophotometer (HACH) manufactured by Hach Company.

For determination of nitrate concentration, Cadmium Reduction Method for range of 0,1 to 10 mg/l of NO_3 was used. Instructions were followed from the Hach instructions manual (HACH, Method 8171). Test number 353 (Nitrate MR PP) was chosen from the menu. A glass sample cell was filled with 10 ml of sample, and a powder pillow containing NitraVer 5 Nitrate Reagent was emptied into into the cell. A stopper was placed on the cell, and a 1-minute timer was started from the touch screen of the DR 2800, during which the cell was shaken vigorously. After the timer expired, another timer of 5 minutes was started for a reaction period. Another 10 ml of sample was filled in another sample cell, serving as a blank sample. The sample cell containing the blank sample was wiped thoroughly and inserted into the cell holder. The instrument was zeroed by pressing “Zero” on the display, after which the display showed 0,0 mg/L NO_3^-–N. Within 2 minutes of the timer expiring the prepared sample was wiped, placed in the cell holder, and “Read” pressed on the display. The result was shown in mg/L NO_3^-–N. This procedure was replicated 3 times with each sample.

For determination of phosphate concentration, the PhosVer 3 (Ascorbic Acid) Method for range of 0,02 to 2,50 mg/L PO_4^{3-} was used. Instructions were followed from the Hach instructions manual (HACH, Method 8048). Test number 480 was selected from the menu. A sample cell was filled with 10 ml of sample, and contents of a PhosVer 3 phosphate Powder Pillow were added to the cell. A stopper was placed on the cell, and the sample was shaken vigorously for 30 seconds. Once shaken, a 2-minute reaction period was started on the program. A blank sample was prepared by pouring 10 ml of sample into a second sample cell. The blank was wiped carefully, and placed into the cell holder once the timer had expired. The instrument was zeroed by pressing “Zero” on the display, after which the display showed 0,00 mg/L PO_4^{3-}. The prepared sample cell was then wiped and placed in the cell holder, and "Read" was pressed on the display. The result was shown in mg/L PO_4^{3-}. Again, the procedure was replicated 3 times with each sample.

Total phosphorous (TP) and total nitrogen (TN) were analyzed from the preserved samples during the following weeks, within the time period required by ISO standard 5667-3:2003. The method used for determination of TP was the Acid Persufate Digestion Method, according to the Standard Methods for the examination of water and wastewater 4500- P B & E. In this method, the phosphates present as organic and condensed inorganic forms were first converted to reactive orthophosphate by digesting the samples, and then the phosphorous content was determined by the PhosVer 3 (Ascorbic acid) Method. Prior to the analysis, a 2,625 M sulphuric acid (H_2SO_4) solution and a 5 M sodium hydroxide (NaOH) solution were prepared.

Analysis was begun by 25 ml of sample being placed into a 125 ml Erlenmeyer flask. Contents of a potassium persulphate powder pillow was added to the sample, and the flask swirled for a few seconds. 2 ml of the H_2SO_4 solution was measured and added to the flask. The mixture was then heated for 30 minutes under a hood on a hotplate, while maintaining the volume at around 20 ml by adding UHP (ultra high purified) water. Then the sample was cooled to room temperature, 2 ml of NaOH solution added, and the sample swirled. The volume of the sample was then adjusted to 25 ml using a graduated cylinder. Finally, the sample was analysed using the DR 2800 Spectrophotometer using the PhosVer 3 Method, as was used with the phosphates analysis. The process was conducted one sample at a time, with four replicas (4 x 25 ml).

The method used for the determination of TN was the Kjeldahl method, according to the Finnish standard SFS 5505. Nitrogen in a water sample is in organic forms, consisting of ammonia (NH_3) and ammonium (NH_4^+), and inorganic as nitrate (NO_3), nitrite (NO_2^-) and ammonium. The Kjeldahl method measures both organic and inorganic nitrogen in a sample, for a range of 1-30 mg/l of TN in a sample. The process consisted of a digestion phase, a distillation phase, and finally a titration phase.

The digestion was performed using a digester system K-437, manufactured by Büchi. An array of 24 sample tubes was prepared, including 4 blanks of deionized water. 100

ml of sample was placed in each tube, and 100 ml of deionized water in the 4 blanks. 2 ml of 98 % H_2SO_4 and 2 Kjeldahl tablets were added in each tube. A Büchi scrubber unit B-414 was attached to the digester system and the K-437 was turned on once the samples were ready and in place, and the machine heated the samples to 370 °C for one hour. The samples were allowed to cool thoroughly before moving to the next phase.

The distillation was performed with the K-314 distillation unit, also manufactured by Büchi. Each tube was put into the distiller one by one, after adding 2 ml of UHP water and 20 ml of NaOH solution. On the receiving end of the distiller was placed an Erlenmeyer flask containing 20 ml of boric acid (H_3BO_3) solution (0,3 mol/l), and a sher indicator. After 4 minutes, the distillation was ready, and the Erlenmeyer from the receiving end containing the distillate was removed. (Heiskanen, 2011)

The distillation was conducted with a Metrohm 775 Dosimat titrator, by titrating the distilled samples with diluted H_2SO_4 (0,005M) until the sample changed color from blue to grayish brown, indicting pH of 4,56. The total N of the sample was then calculated with the following formula (1):

$$X = V_3 - V_4 * C * 14 * 2 * 1000 * V \quad (1)$$

Where

X = Nitrogen content of the sample (mg/l)

V_3 = Volume of 0,005M H_2SO_4 used in sample titration (ml)

V_4 = Volume of H_2SO_4 used for titration of blank sample (ml)

C = Concentration of H_2SO_4 (mol/l)

14 = Molar mass of Nitrogen (g/mol)

1000= Multiplication factor (mg/g)

2 = Multiplication factor of the H_2SO_4 acid (N=2)

V = The volume of digested (ml)

(Viskari, 2010)

Results

The results are found as a table in Appendix 2. The data obtained deviates quite much, and cannot be considered as a reliable source for estimating emissions from the site. Human errors in the analysis process are the main causes for the great variability. Sampling on a regular basis and gaining familiarity of the analysis procedures would give more reliable values.

2.2 Literature research

The Finnish environmental agency's website proved to be essential in guiding the process of the permit application. Compiled on the website are extensive instructions on applying for environmental permits for all varieties of activities. Specific forms and guides to fill the forms were found, and based on the form and guidance the process for applying an environmental permit for fish farming got on its way.

For aiding in background research and information on the permit application, studies, statements and guides were found online. These proved to be of great importance of gaining insight of the history, present, and future aspects of aquaculture in Finland.

TAMK library provided literature on the environmental permit process. These helped with gaining a better holistic view of the whole process, from the side of the applicant as well as the authorities. These are mostly referred to in the discussion and conclusions section.

Studies on rainbow trout production from environmental and economic aspects in Finland provided useful background information and data on the field on a broad spectrum. These studies allowed comparison of Sampo's case to other operations, and will be used in the discussion as reference.

2.3 Contacting environmental authorities

On August 16, 2011, the applicant and the author of the thesis visited the Regional Centre for Economic Development, Transport and Environment (ELY-centre) in Jyväskylä to meet with environmental inspector Raija Rekonen, who had been responsible of inspecting Sampon lohi's activities and need of an environmental permit. The time for the meeting had been organized beforehand by phone. The purpose of the meeting was to gain information on the environmental permit process from an administrative point of view, as the possibility for aid in the permit process from authorities is mentioned in the guide for filling the application. (Ohje 6024, p.3)

Inspector Rekonen aided the permit procedure by sharing materials and information. Rekonen printed copies of maps required for the appendices for the application, which portray groundwater areas, water systems (Appendices 3 and 4), as well as copies of a permit from November 1976, issued by the water administration, an administration at the time responsible for protecting water systems. She advised to conduct flow measurements of the river for reference in the application.

Rekonen told about the upcoming monitor of the site once the permit would be implemented, and advised to check the *Kalankasvatuksen ympäristönsuojeluohje* from November 2000 for more information. The updated version of *Kalankasvatuksen ympäristönsuojeluohje* from April 2012 has been used as a source for this work, proving to be very informative. She provided the contact information of AVI in Vaasa, where the ready application was to be sent to. (Rekonen, 2011)

2.4 Legislation

The Environmental Protection Act (86/2000) and Environmental Protection Decree (169/2000) are the fundamental legal texts for defining terms, guiding environmental protection and the permit process. For aid in terminology used in this thesis, the unofficial english translations of the legal texts provided by the Ministry of the Environment of Finland have been used. (www.finlex.fi/en) The Water Act (Vesilaki 587/2011) is also central to defining terms of aquaculture and protection of water systems.

2.4.1 Environmental Protection Act

The Environmental Protection Act (EPA) consists of a broad set of regulations, and its purpose is defined in section 1 of the EPA. Shortly, the objective is to prevent environmental pollution, upkeep an ecologically diverse environment, promote sustainable development, increase citizens' opportunities to influence decision-making, and to combat climate change.

Areas under jurisdiction of the EPA include general principles and responsibilities of environmental protection, the necessity of an environmental permit for operations, the permit process, permit consideration, permit authorities, monitoring, compensating for environmental damage and treatment of contaminated soil and groundwater. The necessity for an environmental permit is defined in EPA Section 28 subsection 1:"A Permit is required for activities that pose a threat of environmental pollution." Further, it also states that a permit is also required for "activities that may cause pollution of a water body." This applies to directly to permit requirements of aquaculture. (Environmental Protection Act 86/2000)

2.4.2 Environmental Protection Decree

The Environmental Protection Decree (EPD) is a set of regulations to implement the requirements of an environmental permit stated in EPA section 28. The decree defines what operations need a permit and what information is required in the permit for each operation. It sets regulations and requirements on the actions of the environmental authorities responsible for the permit process. For example, Chapter 6 defines details on supervision and monitoring of environmental permits, details on what information is to be entered into the environmental protection database, as well as how inspections should be carried out.

The roles of different environmental authorities and expert authorities and agencies are also defined in the EPD. More specifically, Chapter 7 defines responsibilities, functions and co-operations of specific authorities, such as Finnish Environmental Institute, ELY Centers, and municipalities; and expert agencies, such as RKTL and MTT.

Chapter 9 section 1 of EPD, Content of the application, lists all the information required for a valid application. Chapters 10 Attached information, 11 Additional information relating to discharges into waters, and 12 Additional information on waste and waste management are applicable as well, as they deal with water and waste related issues. In Sampo's case, section 12 is not applicable, as there is hardly any waste from the activities that need management. (Environmental Protection Decree 169/2000)

2.4.3 Water Act

The purpose of the Water Act (WA) is defined in Chapter 1 section 1: to ensure that the use of common waters and water environments are used in a socially, economically, and environmentally sustainable way. Chapter 1 section 2 of WA defines its connection with the EPA, stating that for any activity, which might pose a threat of spoiling waters, not specifically stated in the WA, the EPA is used for jurisdiction.

Fish farming operations need a permit for taking water from common water systems where the operator does not own the water they are using. (WA ch. 4, section 1) While applying for an environmental permit, the same application is used for a permit according to the Water Act. (Kalankasvatuksen ympäristönsuojeluohje 2012) According to WA chapter 11 section 4, the author of the application must have adequate expertise to compile the necessary details needed for the application. (Water Act 587/2011)

3 PERMIT APPLICATION

3.1 Content of the Permit Application

This part of the thesis concentrates on the actual permit application. A form for writing the application was available on the website of the Finnish Environmental Administration, requesting all necessary information defined in the EPA, EPD and WA. The subsections in this section are consistent with the sections in the actual application form. The 21 headings of the application were translated, as well as the required information for each section. The English translations of the legislation were used as aid in translation of the headings. A guide for filling the application was available online, and was used as guidance and reference. (Ohje 6024)

Each section is filled with information of the operations on site needed for the application, as is asked for in the specific section. Views on the information in relationship with working at the farm and knowing its practical processes are also expressed. The presented application is filled by the best abilities of the author, using knowledge and skills gained during studies in the degree programme and practical training at Sampon Lohi.

The information presented on the thesis does not portray the exact information presented on the final version of the application, which will be presented to the environmental authorities when Pekka Sampo sees it necessary. It is also worth mentioning that in case of delivering an incomplete application, Section 16 of the EPD states that the authority may give a chance to supplement the application and a chance to arrange consultations on unclear matters. The application is made public only once “the matter has been examined in sufficient detail.” (EPD 169/2000, section 16)

3.1.1 Operations for which the permit is applied

The activity for which the application was drafted was the increase of the amount of fish feed used per year on the site at Kostamonjoki to over 2000 kg, but up to 5000 kg in total. These amounts are stated in EPD 169/2000, chapter 1 part 11) c) where it reads that a fish farming facility which uses at least 2000 kg dry feed per year, where the growth of new fish in a year is at least 2000 kg, or the size of the growing ponds is over 20 hectares, requires an environmental permit.

3.1.2 Applicant's contact information

Here was written name, address and other contact information of Pekka Sampo. As a private person, no other information, such as a company register number is needed.

3.1.3 Operations' contact information

Same information is provided as in the previous section, as Sampo lives on site. The amount of yearly workforce was also asked. Sampo manages the site by himself, but does gain assistance in activities demanding several people.

3.1.4 Overview of activites, growth of fish, consumption of feed, nutrient information and emissions by site, and a public summary of the information presented in the application

Sampo has 7 pools on site, with water derived from Kostamonjoki. The species grown is rainbow trout (*Oncorhynchus mykiss*). 5 pools are on the east side of the river with cement bottoms, and 2 larger pools are on the west side, downstream, and have ground bottoms. The fish spend winters under ice in the ponds.

The fishfeed used is manufactured by Rehuraisio Oy, and bought from local K-Rauta store in Joutsa. The grain size differs, depending on the size and growth of fish. Feeding is conducted by hand, daily. Fish feed is poured from sack to a bucket, and thrown to the ponds. More information about feeding is provided in section 15 about BAT and BEP.

Main emissions from the site are from fish feed and fish excrement. However, the amount of emissions is relatively small, and will be discussed in sections 14, 15 and 18. Waste from activities is minimal, consisting of empty feed sacks and used old polystyrene fish boxes, which are taken to the local waste management site. (Heiskanen, 2011)

An overview of the growth of fish and used fish feed for seasons prior to the actual application are filled. The information is found on the annual management diary, requested by the ELY-centre. A public summary of the permit application will be included as an appendix to the application.

3.1.5 Active Permits, decisions and statements

A decision from the Water administration dating 11.11.1976 gives permission to use water derived from Kostamonjoki. A copy of the decision is included as an appendix to the application. Statements from the ELY-centre will also be attached as appendices to the application.

3.1.6 Information on the property, and buildings and operations located on the property (i.e. fish farming, winter storage, and fish cleaning), and their holders (with contact information)

The application will have a map attached marking the locations of the specific areas of operations. Other maps include a general map in 1:50000 scale (Appendix 3), a contour map in 1:20000 scale (Appendix 4) and maps of buildings on site, intended for registering property. The register numbers and names of the buildings on property are written here, and marked clearly on an attached map. This information will be filled in detail on the actual application.

3.1.7 Information on ponds by growing unit and winter storage unit

On site, there are 5 cement based ponds and 2 ground based ponds. The 5 cement based ponds are 30 meters long and 5 meters wide, approximately 1 meter deep in the centre, with the sides sloping upwards toward the long sides. Their approximate volume is 110 cubic meters, altogether approximately 550 cubic meters. They are mainly for smaller fish, not yet ready to be caught for food. Each has their own inlet and outlet.

The earth based ponds are of two different sizes, with their combined surface area being about 300 square meters, and their depth being about 1,5 meters on the center, with the sides sloping upwards towards shore. Their approximate volume is about 300-400 cubic meters. They are intended for mature fish, with more space to swim and grow. The locations of the ponds will be marked on a map as an appendix to the application. (Heiskanen, 2011)

3.1.8 Information of planned operations by growing unit and winter storage units

The amount of rainbow trout in each pond has changed during the years between the practical training and writing the thesis. This information will be filled into the actual application with detail. However, generally, the planned operation for which the application is intended would be the increased amount of rainbow trout grown on site. This would mean increased feeding of the trout.

Feeding practices are explained in this section, despite not being mentioned in the heading. Fish feed is stored in a shed near the ponds. Its location will be marked on an attached map. Fish feed used is manufactured by Rehuraisio Oy, and bought from the local K-Rauta store in Joutsa in 25 kg sacks. The grain size differs from two millimeters to 9 millimeters in diagram, depending on the size and growth of fish. Feeding is conducted by hand, daily. Fish feed is poured from sack to a bucket, and thrown to the ponds in scoopfuls of about 1 dl. Fish swarm near the surface of the pond when walking up to the pond, which indicates that the fish are hungry. Feeding is continued until the peak of the swarming is over, after which the fish in the next pond are fed. (Heiskanen, 2011)

3.1.9 Information regarding operations from current season by growing unit and winter storage unit

As with the previous section, this information will depend on which year Pekka Sampo will decide to apply for the permit, and will be applied once it is decided to apply.

3.1.10 Information on the water intake and water processing of growing ponds

Water is derived from Kostamonjoki at two places, which are marked on the map on the appendices of the actual application. The upper intake is situated where an old mill used to stand, where there is a dam, and a concrete structure to guide water past the dam into a pipe, splitting into 5 smaller pipes feeding water into the 5 ponds on the east side of the river. These are marked on a map of activities on the site, which is attached as Appendix 1 of this thesis.

Flow measurements of the ponds are stated here. Flow measurements for the intake of the ponds, which were conducted as reported in section 2.1 of the thesis, indicate approximately 50 l/s and 4300 m^3/d of water intake into the ponds. The median flow of the whole river was measured to be approximately 200 l/s and 17000 m^3/d. The method of measuring the flow rate will be reported as it is reported in section 2.1 of this thesis.

There is no form of water processing before it enters back into the stream. Only way of controlling the outlet is by regulating the surface of the ponds. In this way, the solid matter is allowed to settle on the bottom before it flows over the surface level controller before the outlet. The sludge on the bottom of pools is collected each spring, by emptying out each pool of fish and water. The sludge is sucked from the bottom into a tank, and used as nutrition on the field bordering the site. (Heiskanen, 2011)

3.1.11 Fish cleaning operations

Fish cleaning is conducted onsite in a building marked on a map of buildings on site. The fish, after being struck behind their head, have their blood drawn out into a wheel-barrow. The spot and route are also marked on an attached map. The amount of blood is significantly under 1 m^3 per annum. Blood from fishes is collected during the slaughtering, diluted, and used for plant nutrition.

Water used for fish cleaning is pumped from a well on site. After cleaning fish, the remains are mainly fetched by a local hunter, using them as carrion for animals. The rest of remains are disposed by composting on site. The water used is drained into a septic tank onsite, which is also used for sewage waters from the domestic facilities on site. (Heiskanen, 2011)

3.1.12 Information on the use and storage of raw materials and chemicals in the process

The only raw materials used are feed sacks, polystyrene boxes and fish nets. These are stored in a shed, marked on the map. A motor vehicle, running on diesel fuel, is used to transfer fish feed to site from local dealer. Dishwashing detergent is used to wash the cleaning facilities after fish cleaning operations. (Heiskanen, 2011)

3.1.13 Information regarding amounts and management of waste produced from the operations (excluding waste from fish cleaning and sludge from pools)

Feed sacks and used polystyrene fish storage boxes are collected as energy waste and transported to local waste management firm. Dead fish are composted on the site. (Heiskanen, 2011) Information will be provided in an accurate manner as a list on the actual application, including a name for the type of waste, amount per year, and how and where it will be disposed of.

3.1.14 Assessment of emissions to water, air and ground and information about noise created by processes, by growing and winter storage units

An estimation of nutrient emissions was calculated based on calculations presented by Ojanperä in the publication “Vesiviljelyn ympäristövaikutukset ja sijainninohjaus” (2007) on pages 35-37.) The amount of P which binds to fish during growth is 0,4 % and the amount of N is 2,75 %. The average estimated emissions per 1 kg of fish were 7 grams of P and 44 grams of N.

A significant figure in the calculation is the “feed coefficient” which indicates the amount of feed fed (kg) divided by the total growth during a season (kg). The average coefficient used by the environmental authorities in 2007 was approximately 1,2. The total P of 0,8 % and N of 5,92 % in the fishfeed used in the exemplary calculation (Ojanperä, 2007, p. 36) correllate to the fish feed used by Sampo, Royal Herkules by Raisio, 7-9 mm grain size.

Using these average coefficients with 2000 kg of fish feed used per year would give a growth of 1660 kg. The amount of nutrients in the feed would be:

P: 2000 /100 *0,8 = 16 kg
N: 2000 /100 * 5,92 = 118 kg

Using the average amount of nutrients bound per kg of fish, the amounts of nutrients bound in fish would be:

P: 1670 / 100 * 0,4 = 6,68 kg
N: 1670 / 100 * 2,75 = 45,93 kg

The overall emissions would be the total amount of nutrients in the feed minus the amounts bound to the fish:

16 - 6,68 = 9,3 kg/a of P
118 – 45.93 = 72,07 kg/a of N

The author conducted preliminary measurements by taking one set of samples in September 2011. However, the results cannot be reflected in any means to the amount of nutrient emissions, as the results varied greatly. According to some results, there were negative emissions from the site, as can be seen from appendix 1 of the thesis. Sampling on a regular basis and gaining familiarity of analysis procedures would give a more reliable estimation of emissions based on analysis and flow measurements.

Other emissions are minimal, and consist mainly of exhaust fumes, particulate matter and noise from Pekka Sampo's automobile while transporting feed sacks to the site.

3.1.15 Assessment of Best available technology (BAT) and best environmental practices (BEP)

The nature of the farm is quite close to being an organic farm, in the opinion of the author. Vegetation is allowed to grow on the sides of the ponds, and is quite abundant in the part of the river above the second dam, below the outlets of the upper 5 ponds and before the intake of the lower 2. The author sees the vegetation as removing its share of nutrients from the water in the ponds flowing out of the ponds, especially in the summer months, when the feeding and emissions are also most abundant.

Feeding practices constitute the main BEP, as the technology on the site is traditional. The overflow regulating wooden panels serve as technology to keep solid matters in the bottoms of the ponds. Feeding is practiced at the end of ponds close to the intake pipe, allowing the solid matter to sediment along the long bottom of the ponds. Feeding is also regulated by estimating the appetite of the fish based on their swarming behavior while feeding, as well as the temperature of the water. Feeding is ended when the swarming calms down from its peak, and before it ends completely, as there is still feed in the water. (Heiskanen, 2011)

3.1.16 The natural state of area affected by the activity

Kostamonjoki flows from Kostamonjärvi through an area of peatlands as a fairly small stream down into Angesselkä, over a length of approximately 10 km. The peatlands upstream seem to have an effect on the slight acidity of the water in Kostamonjoki (table 1).

This section requires very detailed biological and hydrological information on the natural state of the area, which the author did not compile during the practical training period at Sampon Lohi. Information needed about Kostamonjoki include percentage of forests, fields and lakes in the catchment area of Kostamonjoki, median water levels and median flows, information on annual rain fall and when how the ice cover forms, and depths of the river marked on the map, especially in detail near the fish farming site. The water quality is described in great detail, and other sources of emissions into the water are identified. (Ohje 6024, 2010. 8)

Nutrient and chlorophyll-a concentrations in the water are referred to in order to determine the level of eutrophication of the water. The most important biological factor is periphyton and information of algae and phytoplankton. Details on the bottom sediments from the pool and the affected area are shown. (Ohje 6024, 2010. 8)

This section would need much more research in order for the author to fill it in the actual application in required level of detail. However, it is up to the authorities to consider what amount of detail is sufficient.

3.1.17 Account of water use in the affected area, neighbors of the site and other possible concerned parties

This is not well researched yet, as no complaints have been heard during Sampo's time on the site. However, there have been requests on information about water turbidity during warmer months of the year, and Sampon Lohi was suspected of causing this phenomenon, but the peatlands upstream were the probable reason for this, as water was already turbid as it flowed to Sampon Lohi's part of Kostamonjoki. (Heiskanen, 2011)

This section would also need more research to fulfill requirements for the actual application. Details of registered property on shore downstream of the site might need to be included in the application, if the affected area is evaluated to be on neighboring property.

3.1.18 Assessment of environmental impacts of operations on the general environment and water systems

Impacts of the operations build mainly of nutrient emissions into the water of Kostamonjoki. There has been monitoring of activites by ELY-centre of Jyväskylä.

3.1.19 Information on the monitoring of activities on site, and monitoring of emissions and their effect on the environment

Activities have been monitored by the ELY-centre in Jyväskylä, once every two years. The results from water analysis by the representatives of ELY-centre can be attached to the application as appendices.

3.1.20 Appendices

According to legislation on fish farming activities, the following appendices are added: A general map in 1:50000 ratio, a terrain map in 1:20000 ratio, a map of registered real estate in 1:10000 ratio. Other appendices include statements from ELY-centre concerning the site, and copies of any administrative decisions concerning activities on site.

4 DISCUSSION AND CONCLUSIONS

General overview of the and author's role in the process

At the time of finishing this thesis in May of 2013, the application has not been sent. Information has been prepared as part of practical training and the thesis process so that the application would be as ready as possible when Sampo decides to put forth the process. A statement from ELY-centre defined the need for an environmental permit in 2010, as reported amounts of fish feed used during previous years were borderlining the 2000 kg stated in the EPA (86/2000), being 1900 kg in 2009 and 2200 kg in 2008. (Rekonen, 22.6.2010)

The environmental permit process is well guided and made simple for the applicant with an access to the Internet. The Ministry of Environment's website provides extensive instructions on how to fill an application and what information is necessary for a complete application. The ready-made forms and instructions for filling them allow for an application to be filled without reading any legal texts, as the involved legislation is referred to in the instructions. The process and workload of authorities is made lighter by emphasizing that an application should be as complete as possible and sent as early as possible before initializing activities which the permit is applied for.

Studying the process has been a challenging task, especially on part of the legislation behind the permit process. A holistic view has been gained on the broad spectrum and specific detail of environmental legislation in Finland. It has been updated on required parts, and serves well in this year with the general update made in the 2000. The legislation is well available for anyone with access to the Internet, with a clear and functional interphase.

State of fish farming in Finland and how it reflects on Sampon Lohi

Fish farming and aquaculture is being developed in Finland in the near future so that domestic supply of fish for food will catch up with demand. This would decrease dependence on imported fish from Norway and Sweden. Environmental legislation is however stricter in Finland on the production amounts per site. In Sweden, Finnish businesses gained permits for production of 250-600 tons, whereas the permits for same businesses on the Finnish side of the Baltic sea have permits for production between 90-150 tons per unit. (Kansallinen vesiviljelyohjelma 2015, 2009. 6)

This reflects partially on the small amount of production for which the current legislation requires a permit. The strategic guidelines of the program for the future of aquaculture suggest more flexible permit requirements in areas where the water systems are in a very good state. The state of Kostamonjoki and Angesselkä have not been degraded to a bad state as a result of fish farming activities on the site, which is Sampon Lohi in this day.

Local impacts and influence of Sampon Lohi

Sampon Lohi is a unique small-scale fish farm, located in a rural area in middle Finland. It is a continuum of recent history into modern times, as activities on site began in the 1960s. It is not a fish farm aiming for large growth and big business, but maintaining a tradition and earning side income for the operator. It has made its mark in the local rural community, and local people come to buy smoked salmon from a recognized local producer.

The concept of local food has risen to a publicly discussed topic among rising environmental awareness. A rising demand for food products produced locally over imported products can be witnessed. A clear indicator of this is the Finnish “Aitoja Makuja” (“real tastes”) project, which aims to gather information on small local producers of foods and make it public. The project is funded by the European Fund for Rural Development and ELY-centre of Häme, Finland. (Lähi- ja luomuruoan paikalliset yritykset esiin, 2012)

As a suggestion, Sampo could add his information to the database, and gain more customers from local residents interested in supporting local producers as well as tourists in the area during summer months.

Subjective analysis of necessity and benefits of the environmental permit

The environmental permit is a concept to allow the spoiling of the environment within sustainable limits, to meet the demands of economic growth while ensuring a environment for future generations which is as clean as possible. Environmental legislation gives a framework of common rules, which everyone within Finland's borders must follow, or be sanctioned according to the law. It ensures equal treatment for all, atleast in principle. Economic sustainability calls for individual judgement from authorities in cases of environmental permits, where broader national interests are at hand.

Sampo's case might not be of broad national interest directly, but it will provide high quality nutrition for anyone venturing to Kostamonjoki, Joutsa, and buying some salmon, warm smoked, cold smoked, salted, frozen, or fresh from the pond. Granting an environmental permit to feed more than 2000 kg of fishfeed per year would not necessarily mean a boost in production, but would open a potential for growth, if local demand for salmon grew. It would mainly ensure that Sampo would not have to meticulously count the amount of sacks of fishfeed late in the season. It would ensure a constant supply of salmon in his ponds, as long as new hatchlings were brought each spring.

The residents downstream will also benefit from the permit. Even though there have been no complaints because of activities during Pekka Sampo's time, the environmental permit will act as an official instrument through which residents may complain about activities of Sampon Lohi.

A subjective analysis from the perspective of spending a summer on site and writing this thesis is that Pekka Sampo will gain the environmental permit once he decides to apply for it. The state of the environment is stable enough to handle excess nutrition. Once the application is accepted and an environmental permit granted, better monitoring of the quality of water and the state of the environment of Kostamonjoki would be required. Monitoring would be organized with collaboration with environmental authorities of Joutsa, ensuring that it will be known if the emissions begin to rise with increased feeding. If that would be the case, measures could be implemented to improve environmental management of the site to limit nutrient emissions.

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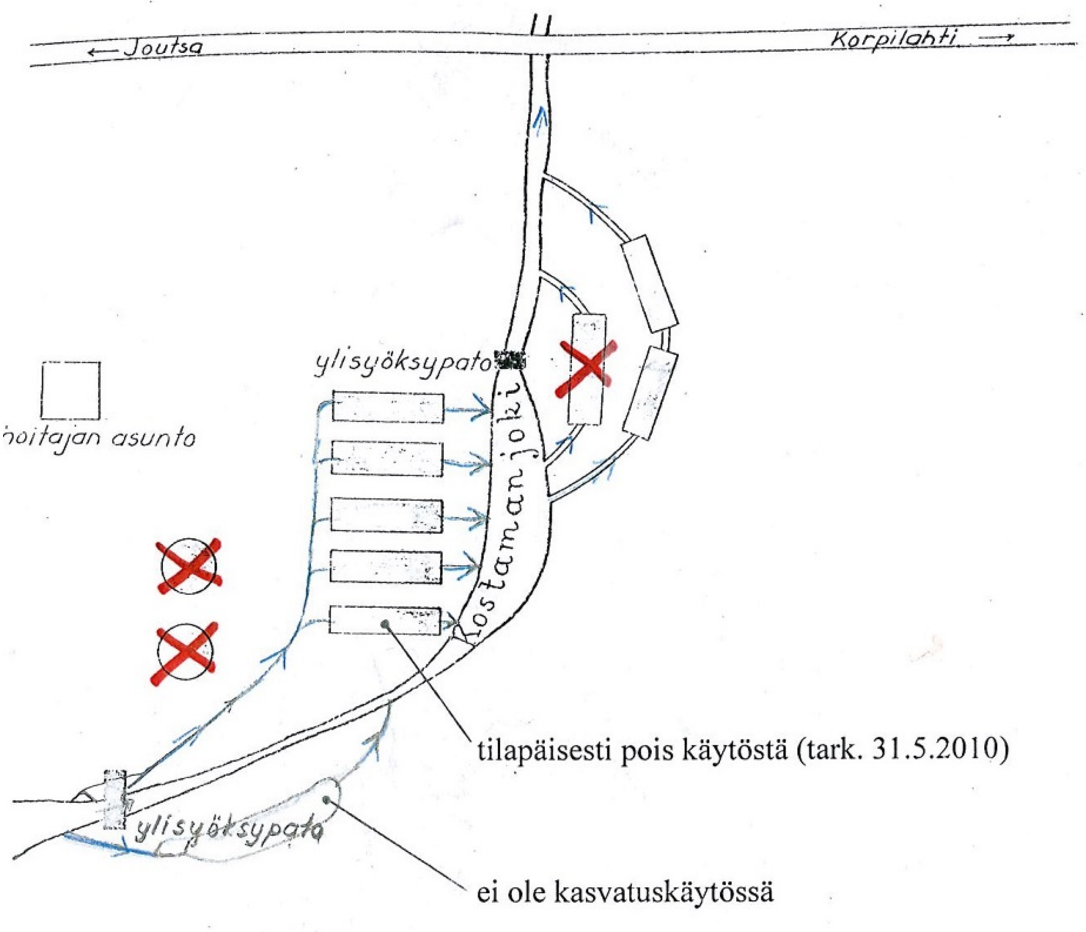
APPENDICES

Appendix 1. Map of operations on site at Korpilahdentie 300

Pekka Sammon kalankasvatuslaitos, Joutsa



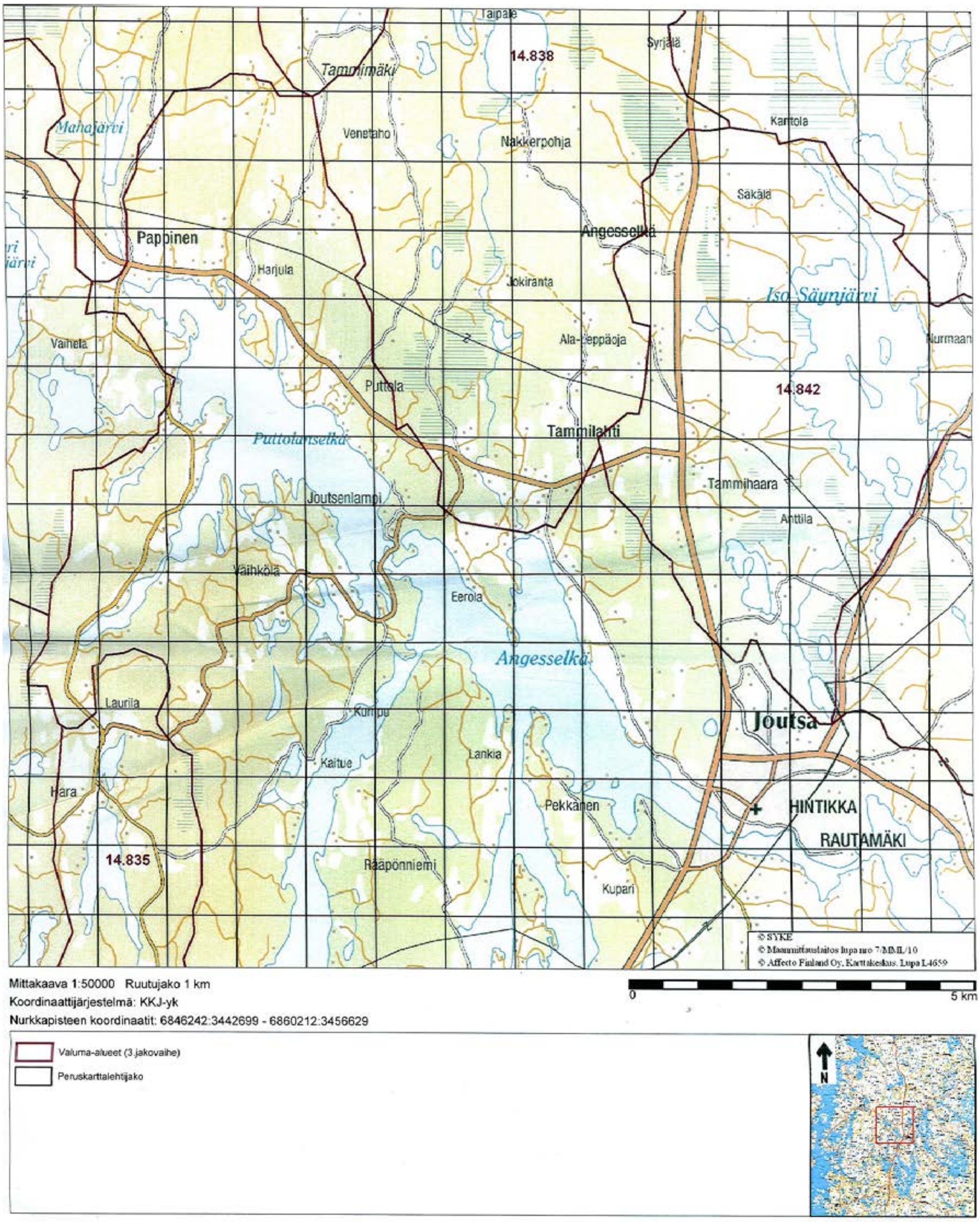
Merkitty tarkastuskäynnillä 31.5.2010 todetut muutokset vanhaan asemapiirrokseen.

(Note: North is pointing down on the map)

Appendix 2. Water Analysis Results

	PHOSPHATES (mg/l)	NITRATES (mg/l)	TOTAL P (mg/l)	Total N (mg/l)	
YLÄ 1	0,09	0,3	0,04	3,02	
	0,17	0,3	0,1	5,46	
	0,1		0,05		
			0,04		
YLÄ 2	0,11	0,2	0,02	5,61	
	0,18	0,2	0,01	26,3	(left out of avg due to high deviation)
	0,1		0,08	8,55	
			0,02		
YLÄ 3	0,31	0	0,02	8,69	
	0,16	0	0,02	10,65	
	0,08		0,05	14,29	
			0,01		
ALA 1	0,14	0,3	0,03	2,53	
	0,13	0,3	0,01	6,1	
			0,02		
			0,03		
ALA 2	0,12	0,3	0,02	5,64	
	0,14	0,2	0,01	25,35	(left out of avg due to high deviation)
			0,02	7,92	
			0,01		
ALA 3	0,12	0	0,01	9,95	
	0,12	0	0,01	5,92	
			0,01	10,26	
			0,01		
Upstream avg (mg/l)	**0,144444444**	**0,166666667**	**0,027083333**	**8,038571429**	
Downstream avg (mg/l)	**0,128333333**	**0,183333333**	**0,015833333**	**6,902857143**	

Appendix 3. 1:50000 scale map of area



Appendix 4. 1:20000 scale contour map of area