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WATER LEVEL MANAGEMENT OF LAKE JYRTINLAMPI, SYSMÄ

Preliminary project plan

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ABSTRACT

The objectives of the thesis were to identify the required measurements to apply for a water permit from the Regional State Administrative Agency and to prepare a preliminary project plan to raise the water level as a restoration method in the nationally significant bird water lake Jyrtinlampi.

The literature review was conducted by gathering information about bird wetlands, water level management as a restoration method for a eutrophicated lake, relevant legislation, permit application processes for managing the water levels, and study the case site lake Jyrtinlampi. The practice-based part of the thesis contained the production of the preliminary project plan for Jyrtinlampi.

According to the study, creating an application to apply for a water permit to increase the water level requires careful planning, various measurements and clarifications, and professional expertise. The produced preliminary project plan includes the essential information needed to proceed with the restoration project. The first steps involve commencing water level measurements and requesting consent from the property owners.

Keywords: bird wetland, water level management, restoration, eutrophication, preliminary project plan

CONTENTS

1 INTRODUCTION

Lake is a natural ecosystem that numerous different factors have affected over time. Lake location, the soil and vegetation of the area, the lake's catchment area, water flow, the organism's structure, climate, ice-cover period, and changes by human action affect the characteristics of the lake. Lakes are always in a slow naturally changing state. Human action accelerates these natural changes, typically leading to gradual eutrophication and overgrowth. The usual cause of eutrophication is the nutrient load from the catchment area of the lake. It can be either an internal or external load. The internal load comes from the bottom sludge of the lake when previously stored nutrients are released back into the water. In the external load, nutrients are transported to the lake with runoff from the catchment area. The nutrient load is dependent on the catchment area size, lake retention time, and land use. The accelerated changes in the lake can be slowed down with various restoration measures. (Sarvilinna & Sammalkorpi 2010, 9-10.)

Bird wetlands are typically shallow lakes or bays within larger bodies of water. Due to the solid load coming from the surrounding area and the plant and algal mass in the water, these areas are prone to rapid overgrowth. However, at their best, bird waters are characterized by a beautiful mosaic-like vegetative cover, with plants covering roughly half of the surface area. When restoring bird waters, the primary goal is to maintain open water areas by mowing vegetation, digging ponds, and raising water levels. (Mikkola-Roos & Väänänen, 2005, 287.)

Raising the lake’s surface will increase the volume of the water in the lake. Restoring the shallow lake’s usability is the goal of raising the water level. The vegetation reduces with increasing water depth, slowing the lake’s overgrowth. The consequences of the water level rise can affect a large part of the shore occupiers and users of the lake. The measure always requires the permission of the Regional State Administrative Agency (AVI). During the planning stage, a collaboration between different stakeholders is required to guarantee agreement on the objectives. (Sarvilinna & Sammalkorpi 2010, 57.)

In this thesis lake Jyrtinlampi in Sysmä was investigated for a possible opportunity to manage water levels to help with the progressive eutrophication of the lake and make it a more suitable bird habitat. The aim was to produce a preliminary project plan that helps to understand the required procedures and measures when applying for a water permit to raise the water level. This preliminary project plan was ordered by the town of Heinola, which coordinates both Heinola's and Sysmä's municipalities and non-governmental organizations (NGO) Helmi habitat programmes as municipal cooperation.

Jyrtinlampi is part of the Natura 2000 protection area called Sysmä's bird waters. Sysmä's bird waters are valuable lake and wetland areas that are part of the national bird water protection program. In 2020 Sysmä's bird waters management and use plan was drawn up to guide the renovation and maintenance measures to maintain or improve the areas' nature conservation values. For the plan, previous data and new nature mapping were analyzed. Based on the results, the most significant threat to the area is excessive eutrophication with parallel phenomena that have already reduced the number of birds in the area. (Metsänen & Häyhä 2021, 4.)

2 LITERATURE REVIEW

The literature review in this study covers the main topics related to the content of the thesis. It includes information to understand what bird wetlands are, how raising the water levels could be used as a restoration method in a eutrophicated lake, relevant legislation, the application process for raising water levels, and the background data about lake Jyrtinlampi.

2.1 Bird wetlands

Bird-significant waters, such as naturally lush and shallow ponds, lakes, and sea bays, are known as bird wetlands. They serve as essential nesting grounds for numerous shorebirds (Figure 1) and waterfowl. They serve as crucial stops for the birds to rest on their migration. The conditions ideal for significant bird wetlands have mostly been produced by human activity. Many shorebirds can

find adequate waterside meadows thanks to hay mowing and shore grazing. In the past, the lakes' water levels have been reduced to make more agricultural space along their edges. Numerous shallow bird lakes have resulted from that. (Suomen ympäristökeskus 2022.)

Figure 1. Shorebird in shallow bird wetland (This Photo by Unknown Author is licensed under CC BY-NC-ND).

The characteristics of a good bird wetland are open water areas, water depth, aquatic vegetation, islets, capes and bays, shorelines and – zones, mud beaches, underwater ridges and chains of islands, tree trunks, stones and hummocks, openness of the area, variation in water levels, and fishless. The ideal conditions for waterfowl (Figure 2) would be when half of the bird wetland is open water. Different water depths safeguard the wetland, allowing cleansing processes to occur and preserving the variety of wetland organisms. The sections of water where wetland vegetation predominates and provides sheltered feeding sites for ducklings are ideal for nutrient binding. The wetland's deep water sections are crucial for blocking solid materials and serving as a winter shelter for aquatic organisms. (Alhainen et al. 2015.)

Figure 2. Waterfowl couple in bird wetland (This Photo by Unknown Author is licensed under CC BY-NC-ND).

Aquatic plants play a vital role in wetland ecosystems by providing shelter and creating habitats for various species. They also help in binding soluble nutrients from wetland runoff and prevent solid matter from traveling with the water. To ensure a healthy wetland environment, it's recommended that half of the wetland area should be covered with helophyte water plants, which provide shelter. These plants should be spread out mosaic-like throughout the entire wetland area (Figure 3). Additionally, submersed aquatic plants growing in open water areas play an essential role in these ecosystems. They filter water and provide habitats for aquatic organisms. (Alhainen et al. 2015.)

Figure 3. Optimal structure of bird wetland (Alhanen et al. 2015).

Bird wetlands need maintenance and restoration to prevent overgrowth. When eutrophication sets in, the overgrowth accelerates and the habitats become less suitable, leading to a reduction in bird populations. When human activities such as grazing and routine mowing cease in these areas, the coastal meadows become thick and reforested, and the water areas become dominated by vegetation in nutrient-rich shallow waters. The loss of low-growing meadows and the accumulation of sediment in the environment are harmful to most species of shorebirds and waterfowl. Dredging or mowing can be effective methods for increasing the area of open water or removing aquatic vegetation (Figure 4). To expand the water area in bird wetlands, raising the water level is a practical approach. When it comes to restoring coastal meadows, the process involves cutting down trees and brushing and maintaining their openness through mowing or grazing. The number of young birds can be increased by eliminating non-native predators. Creating new nesting islands for black-headed gulls would help them to repopulate the bird wetlands. (Suomen ympäristökeskus 2022.)

Figure 4. Dredging with a long-boom tracked pontoon machine (Eveliina Sulo, 2024.).

2.1.1 Helmi habitat programme

The Helmi programme is aimed at strengthening Finland's biodiversity of nature and improving the condition of deteriorated habitats. The programme achieves this by protecting and restoring mires, managing wetlands, aquatic bird habitats, and semi-natural grasslands, safeguarding woodland habitats, and rehabilitating

small water bodies and shore habitats. The ultimate goal of the program is to enhance the state of biodiversity, promote ecosystem services and water protection, carbon sequestration, and contribute to climate change mitigation and adaptation. The program's actions help to improve the condition of numerous endangered species, and a large part of the country's threatened habitats. It's essential to note that the Helmi program is implemented based on voluntary action by landowners. (Gummerus-Rautiainen et al. 2021, 4.)

The municipal and NGO Helmi programme is a funding opportunity that is available to municipalities, municipal associations, and other municipally owned actors, associations, foundations, and cooperatives of common water areas in order to support their projects. The funding can cover up to 80 percent of the total expenses incurred by the project, based on the effectiveness of the project. In certain cases where the project involves endangered species, substantial natural resources, or a significant amount of volunteer work, the funding can cover up to 95 percent of the costs. (Vaikuta vesiin, n.d.)

2.2 Water level management

Raising the water level can be used as a method to restore bird wetlands. It can help restrict overgrowth, restore dried wetlands, rejuvenate vegetation, increase fish and insect fauna, and balance the nutriment competition between different species. (Mikkola-Roos 1995, 21.) Raising the water level is easy and cheap to implement, but it is well restricted by the law. Also, the effects on the surrounding lands need to be carefully investigated, so that housing, agricultural land, or forests will not get waterlogged.

Stable water levels eventually undermine wetland habitats' ability to preserve their natural state. In particular, common reed and water horsetail spread quickly in regions with open water. The extent of open carex wetlands likewise declines when reeds invade the shore, turning the open carex swamps into areas covered with willows. Water level fluctuations promote the regrowth of the vegetation. Restoring the natural fluctuation in water levels, with high water levels in the spring and fall and low water levels in the winter and summer, is the greatest

method to guarantee species diversity. Each bird wetland region should be evaluated individually for the effects of water levels on the flora and fauna; however, a one-time elevation rise of 20–30 cm is advised. A greater increase would probably wipe out vegetation, and the impact of a smaller increase on the biota is difficult to determine due to natural annual variations in water levels. (Mikkola-Roos 1995, 21-22.)

2.2.1 Methods for raising water level

Constructing a dam at the outlet of a lake is a commonly practiced approach for elevating the water level while simultaneously preserving the desired flow-dependent water levels within the lake. Dam structures are divided into two main groups: overflow dams and surface dams.

Wide bottom overflow dams (Figure 5) are often the preferred choice for raising water levels in streams and larger bodies of water while still allowing for fish migration. This technique can be applied to wetlands of any size in terms of catchment area. Ensuring fish passage through stone-clad bottom dams in bodies of water requires a gentle slope, while in areas where fish passage is not a concern, constructing a rising threshold on the bottom dam's crest is a feasible option. (Alhanen et al. 2015, 32.) The bottom overflow dam is constructed in a narrow section of the riverbed with compact soil. Often moraine is deposited beneath the water's surface, densely packed. The moraine is then overlaid with a filter fabric and topped with large stones measuring 20-40 cm in diameter to secure them in position as water flows through. (Aitto-Oja et al. 2010.) Accurate measurement of the bottom overflow dam's crest shape, length, and width requires data on water flow and levels. This entails monitoring underflow, overflow, and middle flow at the dam site, as well as accounting for seasonal fluctuations. It is also important to document low, high, and average water levels at the dam and its vicinity, considering seasonal variations. Additionally, factors such as ice floes, freezing temperatures, ice cover thickness, and ice movement must be taken into account, as they can impact dam construction. Anticipating these freezing conditions is crucial for the dam's construction. (Huttu et al. 1985, 11.)

Figure 5. A bottom overflow dam (Alhanen et al. 2015, 33.).

One type of surface dam includes an adjustment well (Figure 6) that is integrated into the dam embankment and receives water through a pipe. The water is then directed away from the adjustment well through a pipe installed at the bottom of the outlet ditch. The size of the pipes is determined on a case-by-case basis, taking into account the maximum possible flow during a flood. The water level in the well is mechanically regulated using a disk. In the event of a flood, flood pipes should be incorporated into the dam embankment. The adjustment well can be constructed using well rigs or plastic pipes or purchased as a factory-made unit. Additionally, the well is suitable for year-round use as it typically does not freeze in winter. (Virtaamanhallinnan suunnittelu n.d.)

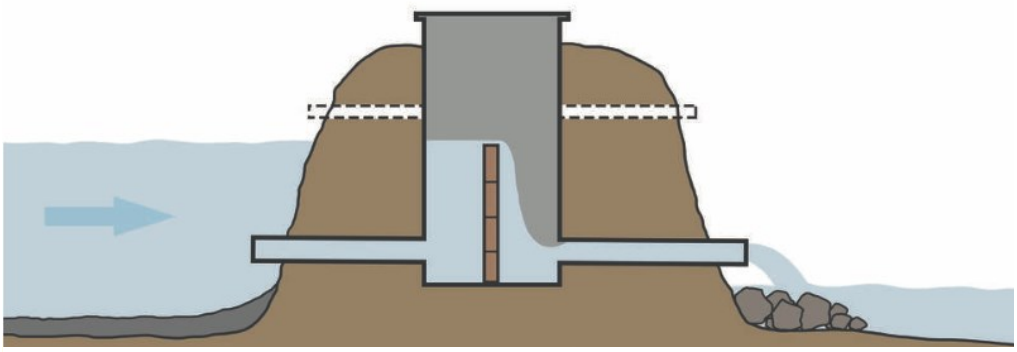

Figure 6. An adjustment well (Virtaamanhallinnan suunnittelu n.d.).

A stop log dam (Figure 7) is a metal frame typically installed on a drain pipe, allowing perpendicular boards to be used for adjusting water flow and height. Utilizing stop log dams is one way to control water levels, with manufactured structures available for connecting to drain pipes. In cases where drain pipes are present at a lake's outlet, stop log dams are effective with minimal added cost. It's important to note, however, that stop log dams are not allowed in areas where fish passage is feasible. (Virtaamanhallinnan suunnittelu n.d.)

Figure 7. A stop log dam (Hulkkianjärvi 2009.).

2.3 Legislation and permits

Effective water resource management in Finland depends largely on adherence to two critical pieces of legislation - the Water Act (587/2011) and the Government Decree on Water Resources Management (1560/2011). Since their introduction in 2012, these regulations have played a pivotal role in defining the rights and obligations of all stakeholders involved in the utilization of this precious resource. They lay out the requirements for permit acquisition, the necessary prerequisites for permit application submission, and the decision-making processes for permit approval, all in accordance with the Water Act. (Regional State Administrative Agency, n.d.)

In the Government Decree on Water Resources Management Chapter 1, § 1, § 2, and § 6 are relevant when applying permit to raise the water level. The Water Act Chapter 6 is about permanently changing the mean water level.

2.3.1 Application

According to the Water Act, Chapter 11, the person responsible for submitting a permit application must have the necessary skills and knowledge to do so, considering the project's magnitude, complexity, and potential consequences. If the applicant lacks prior experience in obtaining water permits and preparing the mandatory documentation, it is strongly recommended to seek professional help in preparing the application and its accompanying materials.

Chapter 1 of the Government Decree on Water Resources Management outlines all the necessary information for permit applications. Section §1 specifies basic information, including the applicant's name and contact details, the project's purpose and general description, an overview of the water body affected by the project, a map of the affected area, descriptions of structures and measures, drawings of work sites and equipment, and information on the height system used. Additionally, the section requires an explanation of the project's execution, including schedules and necessary property codes, and a map of the relevant area. (Valtionneuvoston asetus vesitalousasioista 1560/2011, Chapter 1, § 1.)

Section §2 requires certain information to be presented in the application for a water management project. This includes a map of the area that will be affected by the project, along with longitudinal and cross-sectional drawings of the channels that will be gutted and excavated. The application must contain a description of the water levels and flows, as well as the expected effects of the project on them. Furthermore, it must include details of the project's impact onshore areas, buildings, structures, equipment, hydropower, water traffic, floating, water abstraction, recreational use, and other uses of the water body and its shores. (Valtionneuvoston asetus vesitalousasioista 1560/2011, Chapter 1, § 2.)

Additionally, the application should describe the zoning situation and an assessment of the project's impact on zoning. It should contain detailed measures to prevent or reduce losses caused by the project, and proposals for compensation for loss of interest. The application must identify the parties concerned, their addresses, and the properties on which they are based, along with a map showing the location of these properties. If required, the application should describe the quality of the water, the state of the water body, and the effects of the project on them, including the fish population and fishing, and the need to enable fish and other aquatic organisms to pass by dam structures. It should also provide a description of groundwater conditions, aquatic habitat types, protected areas, and other protected sites, and an assessment of the project's impact on them. (Valtionneuvoston asetus vesitalousasioista 1560/2011, Chapter 1, § 2.)

The application must also include a map and explanation of the area that will be affected by the project and the area for which the applicant requests the right of use or expropriation. It should provide information on water management projects that may have an impact on the implementation of the project and permit decisions concerning those projects. Additionally, the application must include a report on the risk of damage caused by the dam and its impact on the dam dimensioning criteria, along with relevant agreements and consents, and other information and calculations clarifying the legal prerequisites of the project. The application should contain a brief summary of the project and its impacts. (Valtionneuvoston asetus vesitalousasioista 1560/2011, Chapter 1, § 2.)

Section §6 of the regulations covers projects that result in a permanent change to the average water level. To apply for such a project, the following information must be included: approved rules from the water legal community, registration information or confirmation of the community's rules, details on the low, mean, and high water levels, an explanation of any significant changes to the depth relationships of the lake or pond, consent from area owners, and clarification of the water and land ownership for which consent has been given. Additionally, the application must include a cost estimate for the project, clarification of intended

beneficiaries, a project cost breakdown by property, and a proposal of a cost-sharing plan. If the cost breakdown differs from the project's original plan, a maintenance and construction split cost proposal must be provided. For applying to raise the mean water level, a map showing the boundaries of the prevailing and mean water levels according to the application, drawn to a scale that allows the determination of underwater land on a property-by-property basis is required. (Valtionneuvoston asetus vesitalousasioista 1560/2011, Chapter 1, § 6.)

The Water Act Chapter 6 states the scope of the application, the private benefit from raising the mean water level, the permit applicant, the special conditions, the consents of the owners of the area, the right to use another's area, participation in the costs, the association to be established for the purpose, and the collection of fees.

2.3.2 Application process

The application can be sent electronically using the regional administration's e-services, email, or by paper copies. On average, it takes approximately eight months for the Regional State Administrative Agency (AVI) to process a water permit application. However, if modifications are made or the application is incomplete during the processing period, the processing time may be extended by several months. To streamline the process, it is advisable to schedule an advance advice meeting with the permit authority to ensure the application is comprehensive and includes all necessary attachments. Further, sharing pertinent project details with all involved parties beforehand can minimize confusion and mitigate the need for additional reminders related to the application. AVI charges a fee for processing the application, whether the application is rejected, or the permit is issued. (Regional State Administrative Agency, n.d.) The fees are listed in the Government Decree on payments by regional administrative agencies (867/2023). In the Government Decree attachment 1 chapter 3.3. are water management matters according to the Water Act (587/2011). (Valtioneuvoston asetus aluehallintovirastojen maksuista heinä-joulukuussa vuonna 2023 867/2023, Attachment 1, Chapter 3.3.)

2.4 Jyrtinlampi

Lake Jyrtinlampi (14.221.1.288) is a small lake, less than 2 kilometers northwest of Sysmä town center (Figure 8). The lake is part of the Häme Centre for Economic Development, Transport and the Environment (ELY) environmental responsibility area, and VHA2 Kymijoen-Suomenlahden water treatment area (Suomen ympäristökeskus, n.d.). Jyrtinlampi is part of the Sysmä's bird waters, which was approved in 1982 under the bird water protection program. The area is part of the Natura 2000 program, Member State of Special Protection Area (SPA) based on bird values, and Sites of Community Importance (SCI) based on habitat type values. Jyrtinlampi is a private nature reserve, established to implement the national bird water protection program. (Metsänen & Häyhä. 2021, 7.) The lake is eutrophicated and largely overgrown (Figure 9). With funding from the Helmi habitat programme, restoration of the lake is ongoing, aiming to improve the lake's quality and bird habitats.

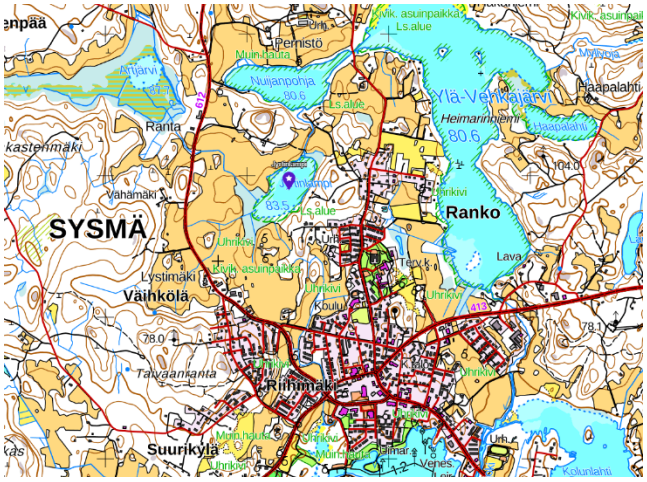

Figure 9. Location of lake Jyrtinlampi (Karttapaikka, n.d.).

Figure 8. Lake Jyrtinlampi in November 2023 (Eveliina Sulo 2023.).

3 MATERIALS AND METHODS

The materials and methods section provides detailed information on how the preliminary project plan for the case site lake Jyrtinlampi was prepared. The preliminary project plan aimed to research and collect data required for the water permit to raise the water level in Jyrtinlampi.

3.1 Preliminary project plan

The preliminary project plan presents comprehensive information about Jyrtinlampi, encompassing its location, general description, objectives, previous plans, and the necessity of a permit under the Water Act. The plan provides a thorough description of the water's current state, including its watershed, hydrology, and the species that inhabit it. The catchment area and lake usage were included, disclosing relevant data on soil, zoning, real estate, and drainage community. The plan also outlines the necessary operations and presents possible solutions. Impact assessments, including possible flood models, were created, along with budget and schedule estimates.

The preliminary project plan was informed by various sources, including a previous study of Sysmä's bird waters treatment and operating plan for 2021-2030 by Metsänen and Häyhä. Interviews were conducted with professionals from the municipality of Heinola, consultants experienced in water level-raising projects, and the Centre for Economic Development, Transport, and the Environment (ELY Centre). The VALUE catchment area delineation tool was utilized to gather data about the catchment area, while the Geological Survey of Finland (GTK) provided information on ground properties. Finnish government-maintained map sites were consulted for land and real estate maps and drainage community information. Materials related to the necessary operations from the Finnish Environment Institute were studied.

3.1.1 Water level modeling

A free, open-source geographic information system software QGIS was utilized for water level modeling, by using open data provided by the National Land Survey of Finland (NLS). The Elevation Model 2m is a high-resolution model that shows the elevation of the ground surface relative to sea level. The model's height values are in accordance with the system N2000, and for coordinates, ETRS-TM35 was used. The size of the grid is 2m x 2m, and the dataset is based on laser scanning data that covers the entire country. The point density of the laser scanning data is at least 0.5 points per square meter. (NLS, n.d.)

The Elevation Model 2m is produced in two quality classes. Class I has an average elevation accuracy of 0.3 meters, while class II has an elevation accuracy that varies between 0.3 meters and one meter. Open data from lake Jyrtinlampi provides an elevation model of 2m from 2016, with an update check from 2022, and is in quality class I. This data was used to create a water level model that shows how rising water levels of 20cm and 30cm would impact the surrounding areas. (MML, n.d.)

For the models, QGIS 3.36 version was used. To use open interface services from the National Land Survey of Finland to get the background maps for the models, registration is required, and a unique API key is created. With the API key, NLS open interface services can be linked with QGIS. (NLS, n.d.) The background, topographic and plain maps, orthophotos, property boundaries, and property identifiers are available through the unification. The elevation model data (DEM) is ordered from the NLS geospatial data service in TIFF form. (Metsäkeskus, n.d.)

For the model, a topographic map, property boundaries, and identifiers were used with the elevation model data. The DEM was modified from properties (Figure 10). First, from symbology, band rendering was set as singleband pseudocolor, min/max value selected, and statistics extent to current canvas (Kwast, H., 2019.).

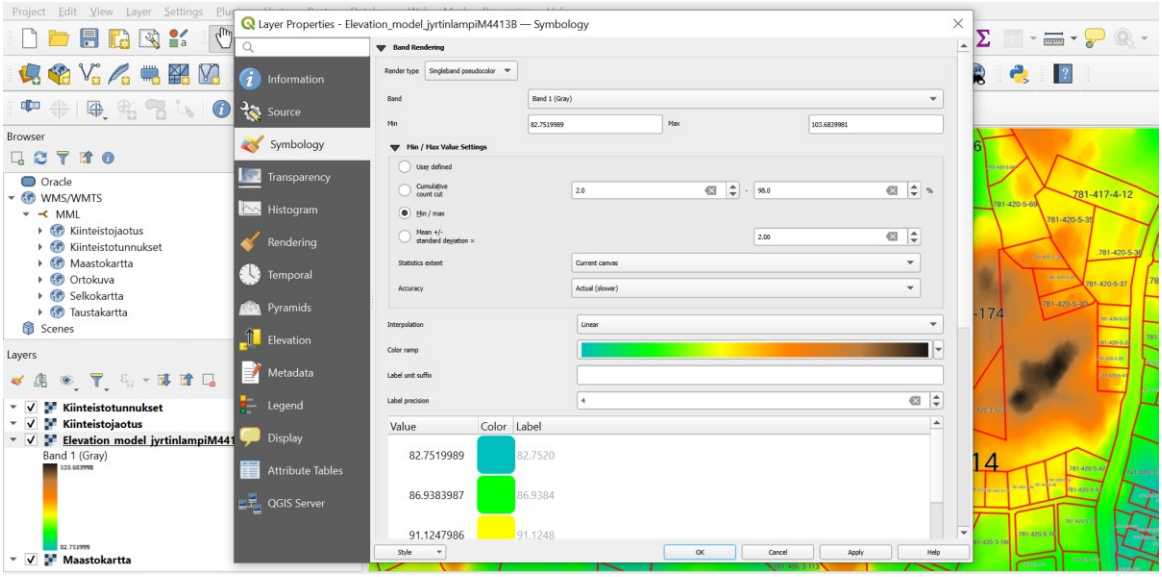

Figure 10. DEM modifications in QGIS (QGIS 3.36.2 – Maidenhead. 2024.).

Next, the current water level of the lake was determined by using the Paikkatietoikkuna terrain height profile tool (Paikkatietoikkuna, n.d.). Then in QGIS the DEM's properties were set according to the current water level. In symbology tool, interpolation was set as discrete, values set the lowest being the current water level and the rest of the values to transparent (Figure 11). With this information modifications to wanted flood models can be made by setting the DEM's elevation values accordingly. For this study, two different water levels were modeled, 20 cm and 30 cm higher than the current water level.

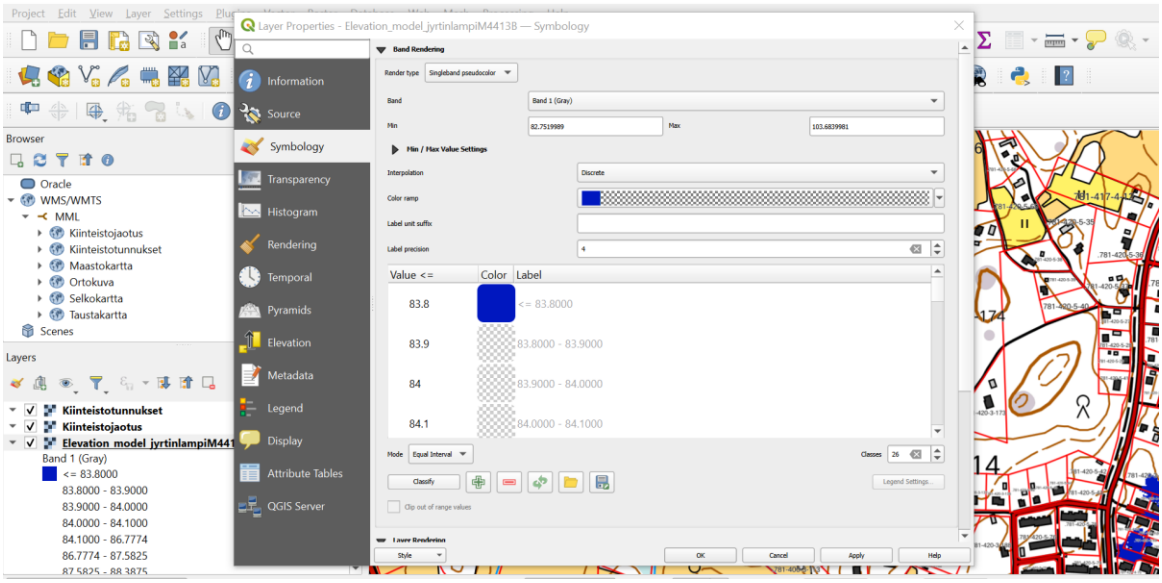

Figure 11. Setting the water level values in QGIS (QGIS 3.36.2 – Maidenhead. 2024.).

4 RESULTS

In the preliminary project plan, all required details for applying for permission to raise the water level are explained, and currently available details and results are presented. The plan is delivered to the town of Heinola. It will be used to start the required steps for applying for a water permit from the Regional State Administrative Agency to raise the water level in Jyrtinlampi.

4.1 General description of the project and objectives

The ongoing restoration of the significant aquatic bird habitat lake Jyrtinlampi is a collaborative effort between the municipal cooperation of Heinola and Sysmä, as part of the Helmi habitat programme. This project is aligned with Sysmä's bird waters treatment and operating plan, established in 2021, and aims to improve the conditions of nationally valuable bird waters. Part of the project is to investigate the possible raising of the water level as one option for restoration. The shallowness of the water and overgrowth has led to a reduction of bird habitat, made recreational use more difficult, and caused overgrowth along the shores. By raising the water level and increasing water volume and depth, the project seeks to reduce silting and improve the living space for birds while enhancing the recreational value of the beaches.

4.2 Basic information

Lake Jyrtinlampi is located in Sysmä, about 2 kilometers northwest of the town center. The coordinates of the lake from the middle are approximately (ETRS-TM35) N 6820900 and E 429324. The lake is about 7,5 hectares with a shoreline of just over 1 kilometer (Figure 12). The official depth information on the lake is not available but based on Pirkanmaan ELY-centre measurement in 1999 the total depth of the lake was 1.5 meters. (Avoimet ympäristötietojärjestelmät – Hertta 5.7 n.d.)

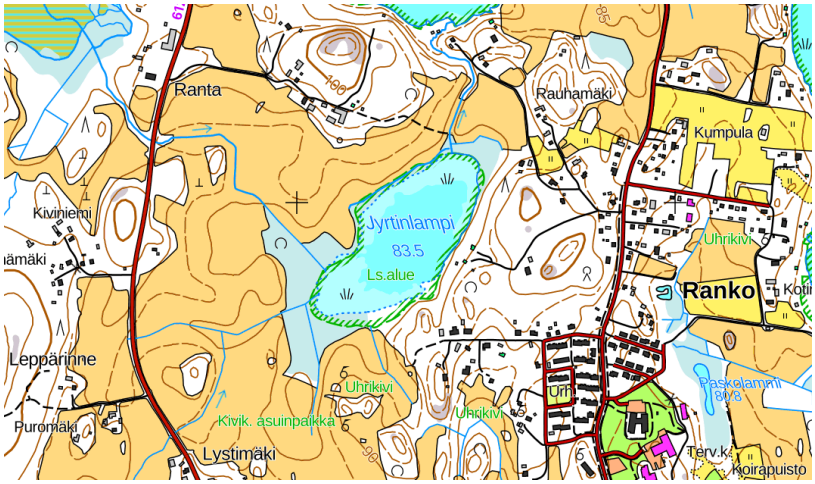

Figure 12. Topographic map of lake Jyrtinlampi (Paikkatietoikkuna, n.d.).

4.3 Previous projects and plans

4.3.1 Historical aerial photos of Jyrtinlampi

The historical aerial photos (Figure 13) of Jyrtinlampi show the various stages of the lake's development. The drainage outfall of Jyrtinlampi was initially dug and cleared between the 1920s and 1930s, leading to lower water levels as presented in the historical photo from 1952. The effects of eutrophication between 2013 and 2021 are also clearly discernible.

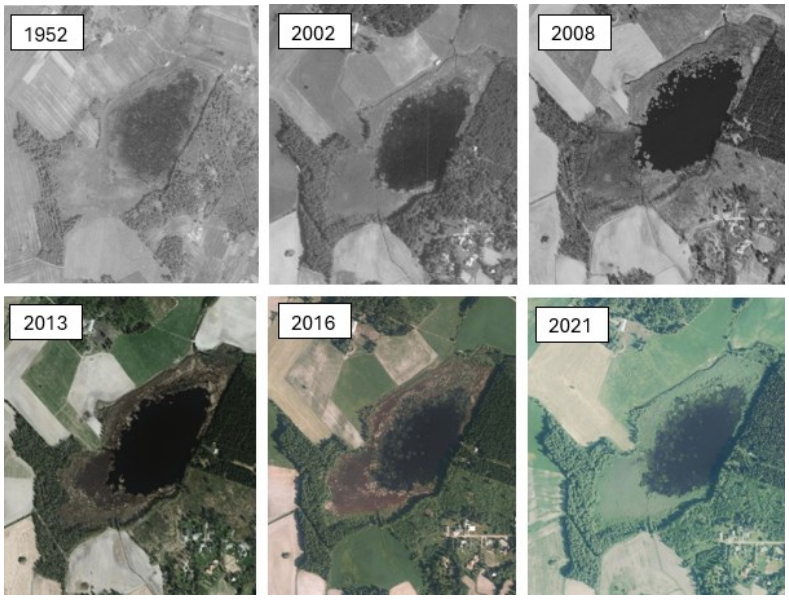

Figure 13. Historical air photos of lake Jyrtinlampi between 1952 and 2021 (Paikkatietoikkuna, n.d.).

4.3.2 The dredging plan in 1965

In 1965, a new dredging plan was developed for the Jyrtinlammi and Artjärvi ditches (Figure 14). Meeting records from the drainage community (Figure 15) in 1965 indicate that the minimum water level (NW) of Jyrtinlammi was not lowered in accordance with the dredging plan, but instead, a livestock watering area was established. The primary objectives of the dredging in the 1960s were to mitigate detrimental spring floods, reduce excessively high groundwater levels, and enhance the economic viability of these areas for agriculture and forestry. (Sillfors 2023.)

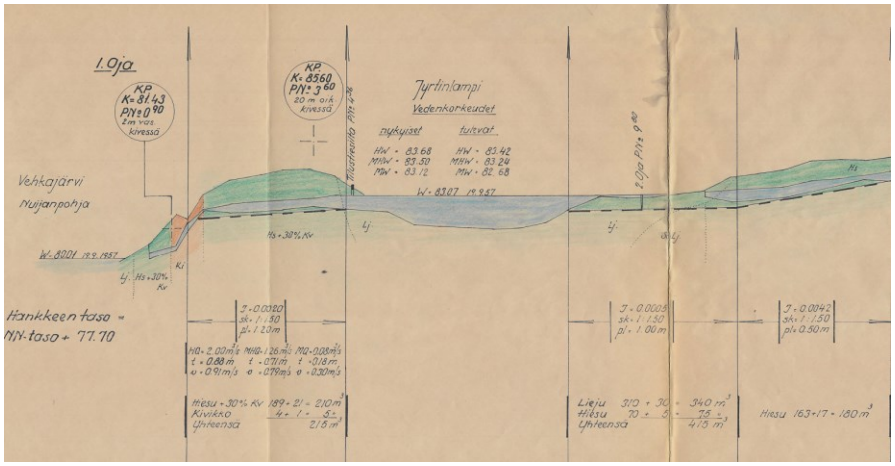

Figure 14. The dredging plan to lower the water level in Jyrtinlampi in the 1960s (Sillfors 2023.).

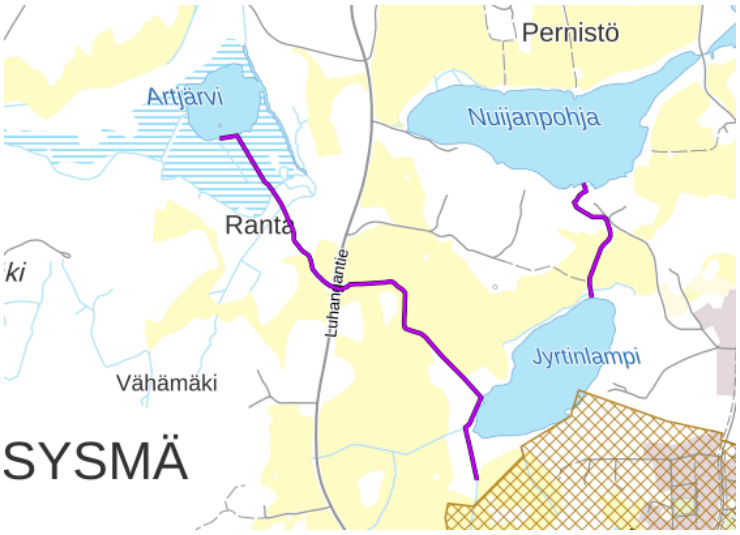

Figure 15. Drainage community in Jyrtinlampi (Ojitusyhteisöt n.d.).

4.3.3 Water samples

Water sample from Jyrtinlampi was collected by the Pirkanmaan ELY center on July 28, 1999 (Table 1). Based on the sample, it was found that Jyrtinlampi was slightly turbid at 2.5 FNU. The chemical oxygen demand (COD_{Mn}) and the color of the water both indicated that the lake was rich in humus. The chemical oxygen demand measures the amount of oxygen required to chemically oxidize organic and inorganic matter in water. High COD values indicate a high level of oxidizable pollutants, which can deplete dissolved oxygen (DO) in the water, as oxygen is consumed by the oxidation process. The COD_{Mn} value in Jyrtinlampi was 140 mg/l Pt (humus waters) and the dissolved oxygen level was low at 5.9 mg/l. The oxygen saturation, which measures the amount of oxygen dissolved (DO) in water compared to the maximum amount that can be dissolved at the given temperature and pressure, also indicated poor water quality at 63%. Total nitrogen, phosphorus, and chlorophyll-a levels indicated that the lake was eutrophic. (Oravainen 1999, 8, 14-19.)

Alkalinity acts as a buffer, helping to maintain a stable pH in the water by neutralizing acids. It ensures a stable environment for aquatic life. pH indicates the current acidity or basicity of the water, affecting chemical solubility, biological processes, and overall ecosystem health. In Jyrtinlampi, the alkalinity was 0.51 mmol/L, indicating a good level, and the pH was at a normal level for fresh surface waters at 6.8. (Oravainen 1999, 12-13.)

Table 1. Water sample results from Jyrtinlampi in 1999 (Avoimet ympäristöjärjestelmät-Hertta 5.7, n.d.; Oravainen 1999, 4, 8, 10, 12, 14-17, 19,21; Suomen ympäristökeskus n.d.).

Analysis	Results from 1 meter	Units	Limit values
Temperature	18	°C	
Dissolved oxygen (DO)	5.9	mg/l	summer 8-9, winter 12-13
Oxygen saturation	63	%	excellent 85-110, good 80-110, satisfying 70-80 and 110-120, bad 40-70 and 120-150, really bad 0 and 150
Turbidity	2.5	FNU	clear <1, slightly turbid 1-5, turbid >5

Conductivity	7.8	mS/m	low <5, normal 5-10, high in agriculture 15-20
Alkalinity	0.51	mmol/l	good >0.2, satisfying 0.1-0.2, tolerable 0.05-0.1, bad 0.01-0.05, run out <0.01
pH	6.8		aquatic life adapted 6.0-8.0, typical 6.5-6.8
Color	140	mg/l Pt	colorless <15, slightly humus-rich 20-40, humus-rich 40-100
Total nitrogen	970	µg/l	barren <400, slightly eutrophic 400-600, eutrophic 600-1500, highly eutrophic >1500
Total phosphorus	45	µg/l	barren <15, slightly eutrophic 15-25, eutrophic 25-100, highly eutrophic >100
Iron	2100	µg/l	inland waters 500-1000 mire rich catchment areas 1000-2000
Chlorophyll-a	21	µg/l	barren <3, slightly eutrophic 3-7, eutrophic 7-40, highly eutrophic >40
Chemical oxygen demand (COD_{Mn})	18	mg/l	clear <4, colorless 4-10, humus waters 10-20
Chloride	2.3	mg/l	fresh surface water <10

4.3.4 Sysmä's bird waters treatment and operating plan for 2021-2030

Sysmä's bird waters treatment and operating plan was published in 2021. The treatment and operating plan was crafted to provide guidance for the renovation and maintenance activities within the area, with the primary objective of preserving or enhancing the area's nature conservation values. Throughout 2020, a range of studies were undertaken, including surveys of breeding birds, waterfowl brood count, migratory bird populations, and the presence of moor frogs, lilypad whiteface and yellow-spotted whiteface dragonflies, as well as the Natura 2000 habitat types of the area. These surveys, alongside existing data, revealed a decline in several bird species within the area, with some species disappearing entirely. The primary threat to the natural values of the area was identified as overgrowth and excessive eutrophication. The plan sets out measures to restore the bird and nature values of the area, as well as address the desires of users to improve water body conditions, prevent overgrowth, and

promote recreational use. The restoration recommendations for Jyrtinlampi included analyzing and reducing nutrient loads, managing water levels, hunting small game animals, grazing by the shore, mowing aquatic plants, dredging, adding small water pools, clearing bushes and trees, and adding settling basins. (Metsänen & Häyhä 2021, 4, 80.)

4.4 Water condition

The data from previous surveys of the lake were used as starting data. The starting materials used were open environmental information systems – Hertta 5.7., water maps by SYKE to describe the state of the water body, VALUE - catchment area delineation tool KM10, and Sysmä's bird waters treatment and operating plan.

4.4.1 Watershed and hydrology

The lake's basic information is presented in Table 2.

Table 2. Basic information of the lake Jyrtinlampi (Avoimet ympäristötietojärjestelmät – Hertta 5.7 n.d.).

Municipal	Sysmä
Province	Päijät-Häme
ELY centre	Häme
Water treatment area	Kymijoen-Suomenlahden
Lake number	14.221.1.288
Watershed	Päijänteen lähialue 14.221
Main watershed	Kymijoki 14
Surface area (ha)	7.45
Volume (m^3)	10^3
Shoreline (km)	1.1
Catchment area (km^2)	8,7898

The ecological status of Jyrtinlampi has not been determined, but the adjacent lake Ylä-Vehkajärvi is classified as satisfying (yellow). Other water bodies in the area are generally classified as either good (green) or satisfying. In the map (Figure 16) The color blue in the map demonstrates the lake's condition being excellent. Jyrtinlampi is marked with a light blue spot.

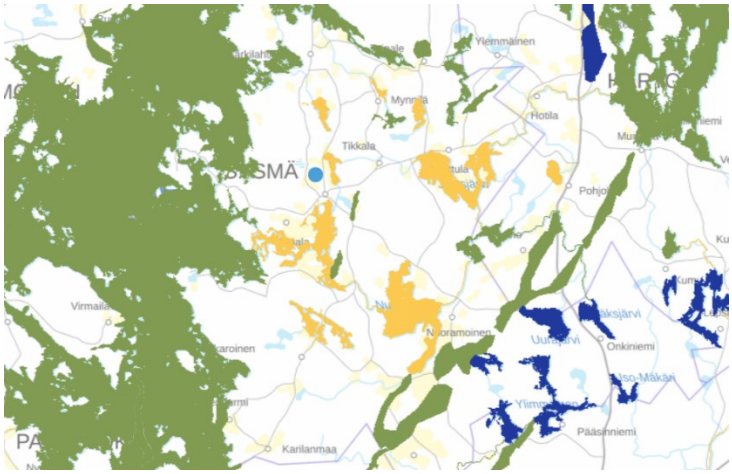

Figure 16. The ecological status of the water bodies (Vesikartta n.d.).

The catchment area of lake Jyrtinlampi (Figure 17) is 8,7898 km^2, by 7.5 hectares Jyrtinlampi being about 0.85% of the catchment area. The majority of the catchment area is covered by closed forest 68.7%, and 13.3% of agricultural land. Additionally, there is 10.7% of forest with sparse trees, thickets, and open pine barrens, 3% of inland wetlands and open mires, 1.8% of residential area, 1.1% of industrial, service and transport areas, 1% of inland waters, 0.3% of recreation and leisure areas, and 0.1% of graze land (Table 3). (VALUE-Valuma-alueen rajaustyökalu KM10 n.d.)

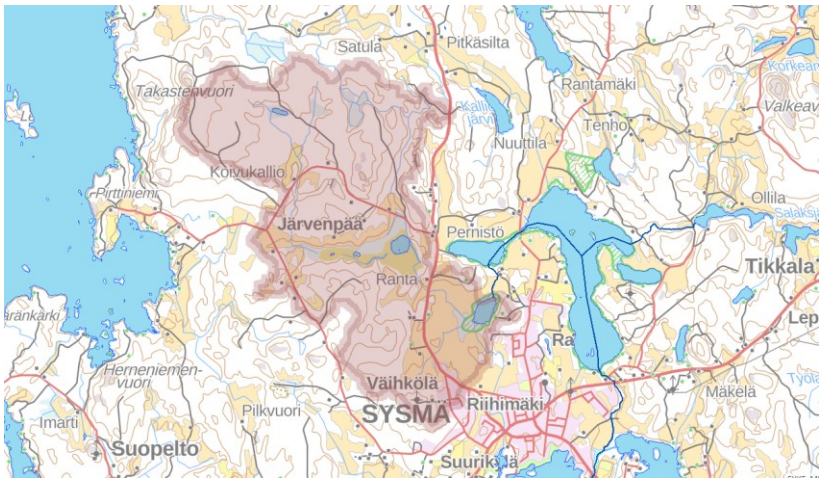

Figure 17. The catchment area of Lake Jyrtinlampi (VALUE - Valuma-alueen rajaustyökalu KM10 n.d.).

Table 3. Relative proportion of land use forms (%) in the catchment area (VALUE - Valuma-alueen rajaustyökalu KM10, n.d.).

Residential areas	1.8%
Industrial, service, and transport areas	1.1%
Recreation and leisure areas	0.3%
Agricultural land	13.3%
Graze land	0.1%
Closet forest	68.7%
Forest with sparse trees, thickets, and open pine barrens	10.7%
Inland wetlands and open marshes	3%
Inland waters	1%

4.4.2 Habitats

An inventory of Natura 2000 habitat types was made in the spring and summer of 2020 to locate and limit the habitat types of Annex 1 of the Habitat Directive (Council Directive 92/43/EEC of 21 May 1992 on the conservation of natural habitats and of wild fauna and flora) occurring in Jyrtinlampi. Based on the inventory Jyrtinlampi's natural stage, presence, and general assessment were categorized as good based on the Annex 1. (Metsänen & Häyhä 2021, 9-10, 36.)

In Jyrtinlampi there were transition mires and quaking bogs, as mentioned in the Habitat Directive. Open swamp in Jyrtinlampi was mainly common reed (Pharagmites australis) swamps, only in few small areas there was reed – sedges(Cyperaceae) swamps. In these swamps there grow purple marshlocks (Comarum palustre), northern water hemlock (Cicuta virosa), common marsh bedstraw (Galium palustre), Carex Canescens, tufted loosestrife (Lysimachia thyrsiflora), mad-dog weed (Alisma plantago-aquatica), Peucedanum, calla (Calla palustris), menyanthes (Menyanthes trifoliata), and yellow loosestrife (Lysimachia vulgaris). (Metsänen & Häyhä 2021, 29.)

In Jyrtinlampi, the outer edges of the shore swamps are mainly overgrown. On top of the overgrown, there grows narrow-leaf cattail (Typha angustifolia) and swamp grass. The areas without narrow-leaf cattail are taken over by Solanum dulcamara, marsh fern (Thelypteris palustris), big bur-reed (Sparganium),

Cyperus sedge (Carex pseudocyperus), lesser tussock-sedge (Carex diandra), bugleweed (Lycopus europaeus), and marsh skullcap (Scutellaria galericulata). (Metsänen & Häyhä 2021, 30.)

4.4.3 Species

Breeding birds were surveyed on three days two times per day in 2020. The surveys covered all the species in the area, by paying extra attention to Annex 1 of the Birds Directive (Directive 200971477EC of the European Parliament and of the Council of 30 November 2009 on the conservation of wild birds) to endangered and internationally responsible species. Waterfowl brood count was done twice in Jyrtinlampi in June 2020, and migratory birds were also surveyed. (Metsänen & Häyhä 2021, 10-11.)

The endangered species found during the breeding bird survey in the area included the Eurasian wigeon, coot, pochard, little crake, whinchat, black-headed gull, willow tit, greenfinch, and common reed bunting. The count results for the waterfowl brood were low. The great crested grebe had two broods, the whooper swan had one brood, the mallard had ten broods, the Eurasian green-winged teal had two broods, the goldeneye had four broods, and the Eurasian wigeon had two broods. The migratory birds that visited the area were the bean goose, barnacle goose, greater white-fronted goose, smew, Eurasian green-winged teal, and tufted duck. (Metsänen & Häyhä 2021, 56, 58.)

The moor frog (Figure 18), is a thriving and prevalent species within its typical habitats throughout the Sysmä bird waters area, as indicated by the 2020 population census. A total of 1146 individuals were observed and mapped during the surveys. These findings are presented on the map (Figure 19), which showcases the observation locations and a 30-meter radius reproduction buffer zone surrounding them. The primary objective of the buffer zone is to prevent human activities from diminishing or disrupting the frog's nesting habitat and its immediate environment. (Metsänen & Häyhä 2021, 60.)

Figure 18. Moor frog (This Photo by Unknown Author is licensed under CC BY-SA).

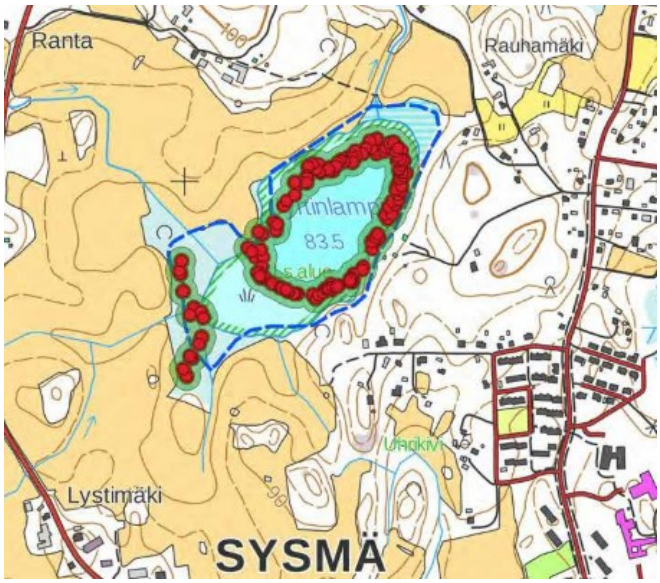

Figure 19. Moor frog observation locations in Jyrtinlampi (Metsänen & Häyhä 2021, 62.).

The bird waters of Sysmä are home to a variety of dragonflies, including the protected yellow-spotted whiteface (Leucorrhinia pectoralis) (Figure 20) and the lilypad whiteface (Leucorrhinia caudalis) (Figure 21) as outlined in Annex IV(a) of the Habitat Directive. A survey conducted in June 2020 at Jyrtinlampi revealed 47 yellow-spotted whitefaces, with four being female, and 38 lilypad whitefaces, with two being female. The breeding areas for both species are primarily within the shallow water vegetation zones and open water areas. (Metsänen & Häyhä 2021, 13-14, 66.)

Figure 20. The yellow-spotted whiteface (This Photo by Unknown Author is licensed under CC BY-NC).

Figure 21. The lilypad whiteface (This Photo by Unknown Author is licensed under CC BY-SA).

The status of fish stocks, benthic animals, and aquatic insects in Jyrtinlampi has not been determined. These factors could impact water quality and affect a food source for birds. No survey has been conducted on the population of bats, and the mammal species in the area. (Metsänen & Häyhä 2021, 70-72.)

4.5 Lake usage

4.5.1 Soil and bedrock

According to the GTK land survey (Figure 22) in Jyrtinlampi, the darker grey layer near the water area is identified as gyttja (Lj), while the lighter grey in the southwest is classified as carex peat (Ct). The presence of clay is denoted by the blue color, and the sandy till is marked by the light brown area, while the red area signifies an outcrop of bedrock. (GTK-Maankamara n.d.)

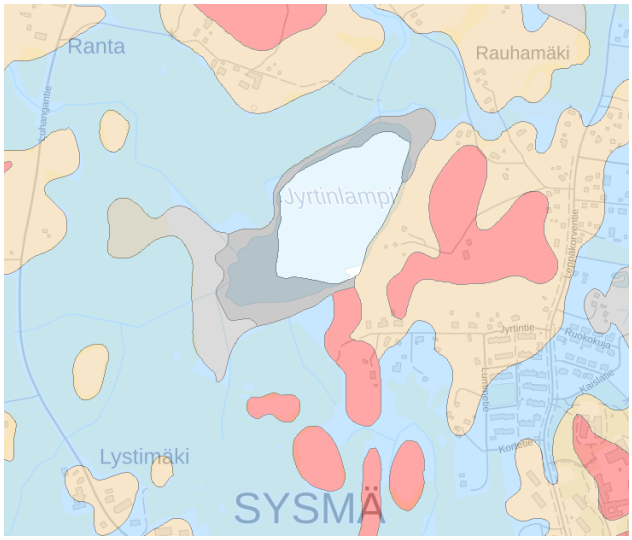

Figure 22. Land survey from Jyrtinlampi (GTK-Maankamara n.d.).

4.5.2 Properties and the drainage community

The planned project to raise the water level in Jyrtinlampi will be discussed with the shoreline property owners and the area's drainage community (Figure 23 and Table 4). The drainage community was established in 1965 and it is still legally existing. Members of the drainage community are all the owners of the properties along the drainage. The property owners of the shoreline and the drainage community will be consulted about possible effects on their property before any action is taken, and formal consent for the project will be asked for. The preliminary inquiries and on-site visits with landowners have produced positive feedback regarding the project's execution.

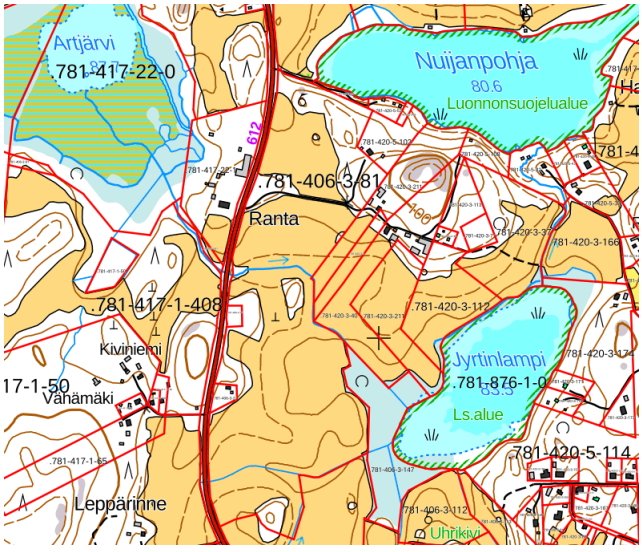

Figure 23. Property boundaries and identifiers (QGIS 3.36.2 – Maidenhead 2024.).

Table 4. Properties.

Property identifiers	Property owner
Jyrtinlampi water area:	
781-876-1-0	Suurenkylän osakaskunta
Jyrtinlampi shoreline:	
781-406-3-112	Peltola III
781-420-3-37	Taunola
781-420-3-112	Kaukola
781-420-3-40	Peltola
781-420-3-211	Rajala
781-406-3-147	Suoja-Jyrtinlampi
781-406-3-113	Jyrtin laidun
781-420-5-114	Opinahjo
781-420-3-170	Arjama
781-420-3-171	Jussila
781-420-3-174	Rouvala
781-420-3-166	Höltänpelto
781-406-3-81	Ranta
781-406-3-84	Härkäsuo
781-406-3-161	Rannanpelto
Drainage community 4069Ky1	
781-417-22-0	Authorized access only
781-417-22-1	Authorized access only
781-417-1-408	Authorized access only
781-406-3-81	Authorized access only
781-420-3-211	Rajala
781-420-3-6	Authorized access only
781-420-3-40	Peltola
781-406-3-147	Suoja-Jyrtinlampi
781-406-3-112	Peltola III
781-406-3-161	Authorized access only
781-420-3-37	Taunola
781-420-3-174	Rouvala
781-420-3-166	Höltänpelto
781-420-5-33	Authorized access only
781-420-5-32	Authorized access only
781-420-5-47	Authorized access only

4.6 Impact assessment

Lake Jyrtinlampi's water level is +83.8 meters above sea level (MSL) (Paikkatietoikkuna, n.d.). The water level was modeled with QGIS to understand how the shore of the lake is forming (Figure 24). The following models are indicative and based on data from the National Land Survey of Finland.

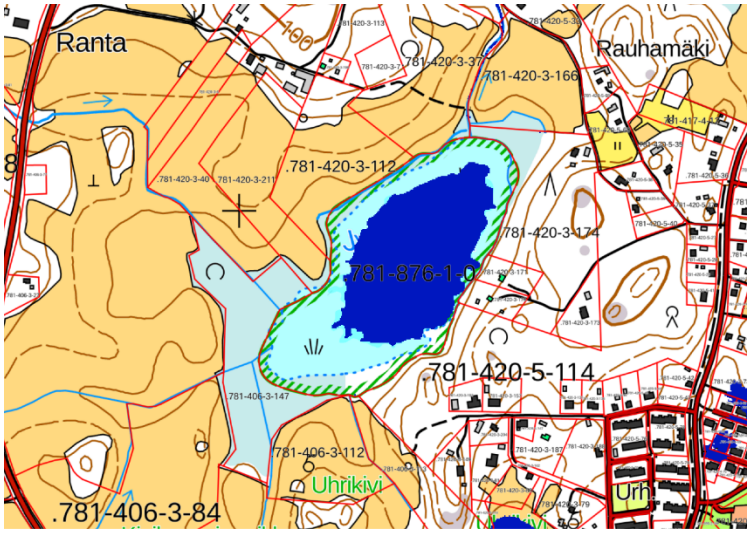

Figure 24.Jyrtinlampi current water level model by QGIS (QGIS 3.36.2 – Maidenhead, 2024.).

Two different water levels were modeled to understand how raising the water level by 20 cm and 30 cm would affect the surrounding area. If the water level is raised by 20 cm, in which case the water level would be +84 meters above sea level, small parts on the western side of agricultural land could get wet but otherwise water would mainly stay in the shore swamp area (Figure 25).

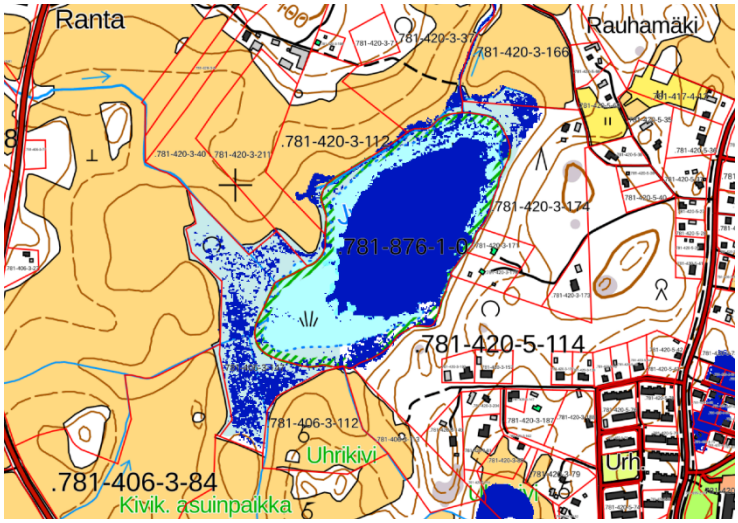

Figure 25. Water level model by +0,20 m with QGIS (QGIS 3.36.2 – Maidenhead, 2024.).

Raising the water level by 30 cm, to the level of +84,1 meters MSL, the agricultural lands in the northern part and the western shore of the lake are at risk of wetting, and conditions in the shore swamp would get moist (Figure 26).

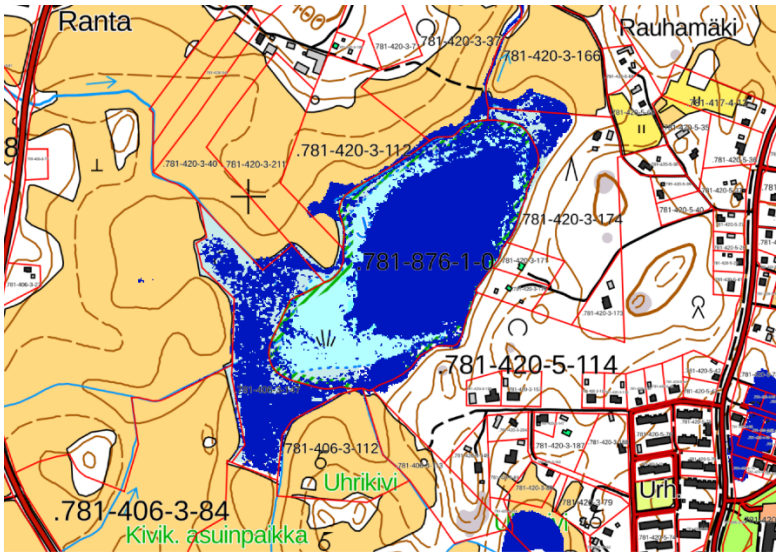

Figure 26. Water level model by +0,30 m with QGIS (QGIS 3.36.2 – Maidenhead, 2024.).

Once the full impact of the project is understood, it is important to come to an agreement on specific property damages and potential compensation or mitigation measures to prevent future disputes. When it comes to compensating for damages caused by rising water levels, the starting point is to assess the damage caused by the new water level and subtract the damage caused by the current water level. There are established principles for evaluating water damage to agricultural land and forests, which have been applied to various water projects. When assessing damages, the average water level during the growing season is used as a starting point to calculate waterlogged areas. The current value of the affected field and forest is then considered, taking into account the overall quality compared to the average. (Lakso 2005, 232-233.)

Lower water bodies and low-lying coastal areas may suffer negative consequences from the project to raise water levels. This covers the effects of increasing water levels as well as variations in overflows and underflows. The most popular solution to these problems is to construct embankments to shield buildings and fields from the effects of rising water levels. (Lakso 2005, 234.)

4.7 Required operations

4.7.1 Permits

Raising the water level requires a water permit from the Regional State Administrative Agency. Also consent from three-quarters of the landowners, the drainage community, and the water cooperative is necessary.

4.7.2 To raise the water level

The bottom overflow dam technique is widely utilized due to its ability to maintain stability without the need for frequent adjustments under normal conditions. By shaping the crest of the dam, it becomes possible to effectively manage fluctuations in water levels in the lake and the flow in the lower regions. (Lakso 2005, 230.) The dam would be placed in the outlet of the lake at the north part of the lake (Figure 27).

Figure 27. Planned location of the dam (QGIS 3.36.2 – Maidenhead, 2024.).

4.7.3 Measurement and clarifications

Possible flooding points were marked in QGIS (Figure 28). These GPS (Global Positioning System) coordinates were then sent to the Heinola towns land surveying team for measuring the accurate current elevation of the critical locations.

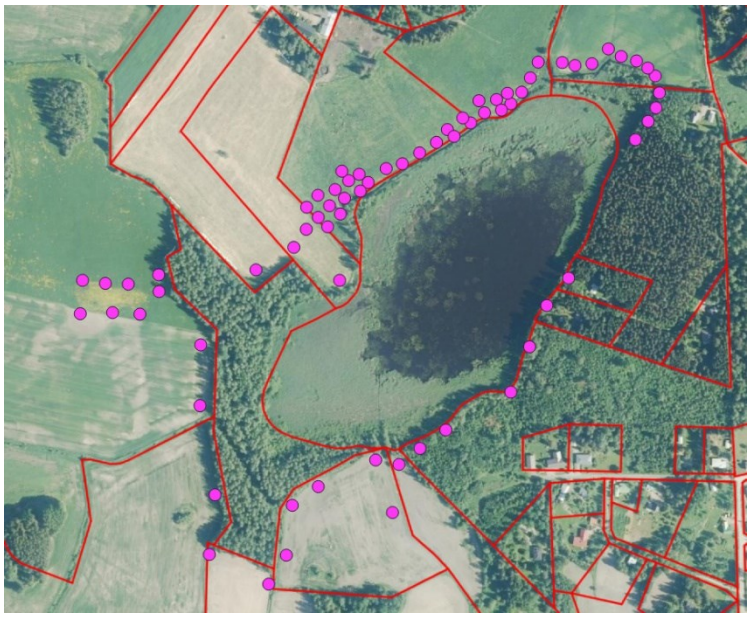

Figure 28. GPS measuring points (QGIS 3.36.2 – Maidenhead, 2024.).

Before starting the project, it is crucial to conduct the necessary measurements and assessments to generate the required documentation for the AVI application. It is essential to monitor the lake's water levels for at least one year before beginning the project. Using a continuously operating measuring device that provides daily data is the most effective approach to gain a comprehensive understanding of water level variations. Measuring water flow and depth, as well as taking water samples to monitor changes in water quality, are also important. It is important to conduct an impact assessment, consider the protected area and endangered species, develop a treatment plan, propose compensation, and take terrain measurements of the bottom dam area, as well as create positioning and design drawings.

4.8 Schedule

Table 7 introduces the initial project schedule. The permission process will take an average of nine months depending on the application. Construction work can not be started before the permission is approved and must be completed within five years of receiving the permission.

Table 7. Initial schedule for the project.

Measures	**Time**
Preliminary project plan	Spring 2024
Measurements: - Water level - Water flow - Depth - Elevation - Water samples	 Spring 2024 - Spring 2025 Spring 2024 Summer 2024 Summer 2024 Summer 2024
Consent from property owners	Summer 2024
Detailed operation plan	Autumn 2024
Applying for the water permit	Autumn 2024
Funding application	Autumn 2024
Treatment plan	Autumn 2024
Tendering of construction work	Winter 2024
Construction work	Summer 2025

4.9 Budget

The estimated budget is directive, some of the measurements are made by the land surveying team of the municipality of Heinola (Table 6).

Table 6. Estimated budget for the project.

Task	**Estimated budget (alv 0%)**
Project plan including construction supervision	8 000–13 000 €
Treatment plan	1 000–3 000 €
Water permits -Raising water level -Fitted dam (small area less than 0,1 km^2)	 7 900 € 7 900 €
Measurements	5 000–8 000 €
Dredging including soil transfers and application	3 000–5000 €
Dam	1 000–3 000 €
Compensations for affected lands	0–2 000 €
Monitoring of effects	1 000–2 000 €
In total:	**34 000–51 800 €**

5 DISCUSSION

In order to obtain a water permit to raise the water level of lake Jyrtinlampi from the Regional State Administrative Agency, research was conducted on the application process to understand the necessary components for the preliminary project plan. The goal of raising the water level is to enhance the bird habitats and recreational use for people in the eutrophicated and largely overgrown valuable bird lake Jyrtinlampi. The data presented in the results section of this study indicates that obtaining a water permit to elevate the water level necessitates the submission of various reports and studies. It is evident that certain measurements and clarifications needed for the application to the Regional State Administrative Agency are time-consuming and require professional expertise. The process should be initiated well in advance of the intended start date. Accurate water level data is essential prior to commencing the planning phase. This data must be gathered for a minimum of one year, which will significantly impact the project timeline and offer a comprehensive assessment of the feasibility of raising the water level without causing excessive damage to properties along the lakeshore and drainage areas. In Figure 26, where the water level was raised by 30 centimeters, only small areas of wetting were detected. These wetted areas could be managed by building embankments along the shoreline, but without water level monitoring, it is uncertain whether water reaches these areas.

The water analysis conducted on samples from Jyrtinlampi in 1999 revealed that the water quality did not meet the desired standards. The lake exhibited high levels of humus and eutrophication. It would be highly beneficial to obtain water samples before and after the project to assess the impact of raising water levels. To further enhance water quality, it is essential to restrict and minimize nutrient emissions from the catchment area. This can be achieved by implementing settling basins at the income stream of the lake and by lowering the nutrient sources in the catchment area.

The results of a comprehensive survey on the habitat types and species in Jyrtinlampi indicate that the area is a nationally valuable bird habitat. The area

features transitional mires and quaking bogs, which are considered protected under the Habitats Directive by the European Commission. Endangered and rare plants, such as the big bug-reed and cyperus sedge, were found in the area. Furthermore, the area is home to many vulnerable, endangered, and critically endangered bird species. Restoring the wetland could provide better habitats for these threatened birds to breed, and ultimately help to achieve the objectives of the Helmi habitat programme.

The lake is primarily surrounded by agricultural land, but there are two properties with recreational homes. Conducting discussions and interviews with local residents would offer a more comprehensive understanding of the lake's usage and potential water levels. It is essential to carefully monitor water levels near the homes to prevent any damage to the structures. Securing consent from all property owners is a fundamental initial step in initiating the project. Without consent, no actions can be taken. Therefore, establishing effective and transparent communication between all parties is vital for the project's success. Providing information about the project's objectives, timeline, and proposed measures to the landowners is crucial for understanding their receptiveness towards the project.

It is crucial to consider additional restoration methods alongside raising the water level. These methods involve clearing trees and bushes from the shore, mowing the common reed, adding settling bases to the income streams, creating small pools for birds to nest, and providing guidance to farmers on reducing the nutrient load from the catchment area. Implementing these combined efforts would significantly improve water quality, bird habitats, and recreational opportunities at the lake. When planning treatment and restoration methods for Natura 2000 areas, it is essential to carefully design the methods in a way that they do not harm the protected species or habitat types. Preserving natural values and enhancing the living conditions of protected species should always be the primary goals when planning actions.

6 CONCLUSION

The restoration of lake Jyrtinlampi is necessary to improve aquatic bird habitats and increase bird populations. One potential method for achieving this is to raise the water level, in addition to implementing other restoration techniques for optimal results. Although raising the water level is a quick, easy, and cost-effective process, obtaining the required permits will necessitate a significant amount of time, effort, and expertise. The study's findings indicate that additional measurements are necessary before initiating the project. Nonetheless, this study provides a solid foundation for the project.

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