Grunnafjörður **U**nified **A**ction for **R**estoration and **D**evelopment

(GUARD)

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Watershed Overview

Location of Watershed

Located in western Iceland just north of Reykjavik, the capital of Iceland. Grunnafjörður is a shallow coastal fjord adjacent to the town of Akranes within the Hvalfjarðarsveit municipality. It's important to note Grundarfjordur city is different from the Grunnafjörður watershed.

Geology

A small mountain range lines the northern segment of a straight passage. To the south, a series of hills create a border to the narrow valley that creates an elevated platform that allows water to drain into the Laxa (in Kjos) River. Three Lakes are also formed at higher elevations of the watershed that flow into the Laxa River. At the mouth of the river, there is a large wetland that eventually flows into the ocean at the westernmost point of the watershed. The Laxa River is 20 kilometers long and hosts several waterfalls.

The watershed is positioned just above the Atlantic ridge, a separation of tectonic plates pushing several continents apart in the middle of the Atlantic Ocean. The ridge lies in the middle of Iceland, below our watershed. The stone within the watershed is mostly bedrock and basalt. The runoff and erosion of the watershed lead to an accumulation of silt and sand found in the wetlands. This will lead to a flourish of wildlife and biodiversity in the Grunnafjorder wetlands.

Figure 1. Geographical image of the Grunnafjörður watershed.

Ecology

According to the Icelandic Environment and Energy Agency, the wetlands of the Grunnafjörður watershed's lower reaches possess significant ecological value as this area was designated a protected nature reserve in 1994. In 1996 the area was approved as a Ramsar site and has since been protected in accordance with the Convention on Wetlands of International Importance. These protections are largely attributed to the Grunnafjordur's diverse birdlife, which has attracted significant attention from bird enthusiasts and scientists alike. The most important avian species to the ecology of this area are brant geese, red knots, and sanderlings (Umhverfisstofnun, n.d).

Recreation

The three lakes in the mid-upper reaches of the Grunnafjordur are prominent tourist attractions that are highly lucrative during warm fishing seasons. Largely originating in Lake Skorradalsvatn, large quantities of brown trout and salmon can be found throughout the Laxa River. Local municipalities have since capitalized on this attraction by establishing several fisheries within the northern lakes and lodges throughout the watershed (Laxa in Kjos, n.d.). These lodges attract tourists at all times of the year as the Grunnafjörður watershed is also a major location for sightseeing. Sights like waterfalls and nature preserves are quite prominent. In addition, the watershed is a popular area for activities such as kayaking and hiking due to its diverse terrain.

Policy Affecting the Region

Main Legal Body

The main legal body overseeing the Grunnafjörður watershed is the Icelandic Environment and Energy Agency. This agency is tasked with implementing the Water Management Act (WMA), a comprehensive framework that ensures the sustainable use, protection, and restoration of Iceland's water bodies, including rivers, lakes, groundwater, and coastal waters.

The cornerstone of Iceland's watershed governance is Act No. 36/2011, which lays out the principles and requirements for protecting water resources. This act aligns with commitments under the EU Water Framework Directive, despite Iceland not being a full EU member. Key elements of Act No. 36/2011 include:

- Establishing environmental quality objectives for all water bodies.
- Identifying and designating water bodies at risk.
- Implementing measures to prevent deterioration and restore degraded water bodies.
- Protecting drinking water sources through monitoring and risk-based management.
- Ensuring public access to information and encouraging stakeholder participation in planning processes

Grunnafjörður is a watershed of significant ecological importance and became a protected nature reserve in 1994, later becoming a Ramsar site in 1996, which is a wetland identified for its international importance and protection. This ties in with more recent policies protecting Grunnafjörður through the Environmental Impact Assessment Act, No. 111(Alþingi). This policy implements that any proposed developments or changes in land use within or near the Grunnafjörður watershed may require an Environmental Impact Assessment (EIA) under this act. The EIA evaluates potential impacts on water bodies, biodiversity, and landscape, and outlines mitigation measures.

Icelandic River Basin Management Plan

The Iceland River Basin Management Plan (RBMP) 2022–2027 establishes national priorities to preserve surface waters, groundwater, and coastal habitats according to Act No. 36/2011. Compared to restoring the deteriorated water bodies of many European nations, Iceland's RBMP is set to focus more on protection and monitoring because most of Iceland's water resources are high-quality and undisturbed. The plan prioritizes baseline monitoring, ecological status surveys, and species watching—especially in ecologically vulnerable areas like Ramsar sites—to prevent decline in any species.

Active restoration measures are limited in this planning cycle, in line with the preventive approach of Iceland's water policy strategy. The RBMP is aligned with general environmental law, such as the Nature Conservation Act, and uses regulatory tools like environmental impact

assessments to guide land use and development decisions. It also promotes transparency and public engagement by revealing water quality data and planning documents to stakeholders.

Governance Structure

Due to its size Iceland is considered as a single River Basin District, which is divided into four water regions. Each of these water regions possess a Water Region Committee that is represented by local authorities and local health inspectorates. Led by a representative from the aforementioned Environmental Agency, the Water Region Committees work to coordinate the work within each water region and gather any necessary information for the RBMP, Program of Measures, and the Monitoring Plan (Umhverfisstofnun, 2023).

The Water Council is another government entity responsible for the implementation of water laws and regulations. Within the council there are five members, who also serve as representatives from three separate Ministries and the Icelandic Association of Local Authorities. Their primary responsibility is to advise the Minister of the Environment, currently held by Jóhann Páll Jóhannsson, on the Water Framework Directive (WFD). They may offer their advice and service by supervising, proposing, reviewing, and monitoring the effectiveness of the current management plans in place.

The final entity of watershed governance are the Water Consultant Committees that work with the Environmental Agency. These two committees are the Consultant Committee of Governmental Institutes and Inspectorates and the Water Consultant Committee of Stakeholders. Together, these committees serve as advisories to the Environmental Agency and the Water Council by providing necessary environmental data and information when available.

Mission Statement

GUARD's mission is to assess the effects of anthropogenic activity on the watershed and develop appropriate remedial efforts to alleviate any concerns. The primary focus of this plan will be to reinvigorate deteriorated wetlands and minimize the impacts of glacial outburst floods to maximise ecological function by 2035.

Problem and Causes

Problem	Description	Causes
Declining Water Storage	Drainage practices in the nation's farms have drained most of the wetlands. This leads to more land to farm on but less area to support a healthy array of life. The leftover land is also abandoned or overgrazed.	Agriculture Practices Improper land management
Glacier melts and floods, altering stream flow and channels.	Glacial outburst floods, jökulhlaups, are typically volcanic or climate change triggered. water and sediment mixed floods released from ice-dammed sections or subglacial lakes due to glacial melts. These jökulhlaups and smaller scale floods have devastating land erosion and sediment deposition into waterways. These large scale floods occur frequently in Iceland every 4-6 years.	Climate Change Volcanic Activity Glacier Melts
Climate change due to the reduction of wetlands.	Drained wetlands do not have the same ecological functions as healthy wetlands. When a wetland is drained it no longer acts as a sink for carbon dioxide, and instead releases carbon dioxide (CO2). This release of CO2 causes the greenhouse effect that warms the earth. In warmer than usual conditions, existing healthy wetlands release more methane, another substantial greenhouse gas (USGS.gov)	Drainage of wetlands

Declining Watershed

Problem

Drainage practices such as ditching have been implemented in the wetlands of Iceland and specifically Grunnafjörður . These drainage efforts lower the water table, allowing for greater hay production, grazing, and agricultural uses. While this created more farmland, a massive total area of wetlands was destroyed. Furthermore, the areas converted to farmland by drainage practices have been overgrazed and abandoned, rendering them useless for any

application. The practice that the farmers use is tile drainage. Tile drainage uses a pipe and ditch network to drain the soil of water that infiltrates the wetlands. These abandoned areas provide no ecological support and struggle with biodiversity.

This tile drainage problem affects the Grunnafjörður watershed and will affect many other watersheds in the country as the population increases. A 2016 study on the wetlands and lowlands of Iceland concluded that "About 47% of Icelandic inland wetlands are impacted by drainage. The ditch network extends about 30,000 km, mainly in lowland areas, where about 70% of the wetland areas are impacted." (Arnalds, 2016) This increase is not expected to slow down.

Goal

To address the declining water storage problem, GUARD is planning to restore 4 km^2 of unused land classified as dense and short vegetation by 2035. According to the Watershed Data Report onGrunnafjörður, there is 116 km^2 of land that is classified as dense and short vegetation. There is only 10 km^2 that is classified as wetlands. A primary function of wetlands is water storage. Additionally, wetlands will provide habitat for a variety of wildlife such as brant geese, red knots, and sanderlings.

4 km^2 seems like a small amount of land to start, but the Land and Forest Iceland group predicts that 1.5km^2 of wetlands will be restored by 2025. Land and Forest Iceland has been focused on funding wetland restoration projects since 2016. GUARD's goal looks to restore more land in the same amount of time.

To get funding for GUARD's work, GUARD will apply for grants through Land and Forest Iceland or work with the Icelandic group Votlendissjóður. Votlendissjóður finances wetland restoration projects and focuses on cooperation between landowners, municipalities, companies, and farmers.

Glacier Melts and Floods

Problem

Glacial outburst floods, also known locally as jökulhlaups, occur when a body of water fed by glacier melt breaches a dam and causes major flooding. These floods can be triggered by volcanic activity or climate change impacts. Jökulhlaups are also often sediment-mixed flood events, which erode land rapidly. Large-scale jökulhlaups and smaller-scale floods both contribute to land erosion, sediment deposition in waterways, and altered stream flows. As stated earlier, large-scale floods such as jökulhlaups occur frequently in Iceland, as often as every four to six years.

These floods and sediment deposits can be severely detrimental to aquatic ecosystems. Suppose the sediment is picked up from nonpoint source areas, including farm land and septic systems. In that case, the soil is potentially contaminated with nitrogen and phosphorus. Wetlands like to denitrify, but phosphorus can cause issues like eutrophication. Furthermore, if the sediment transportation arrives in a spawning period for fish and other wildlife, it could destroy spawning beds and young animals. This event would take years to allow the wildlife time to recuperate numbers, and a no-fishing restriction would be in place, further hurting the area's economy.

Goal

GUARD’s goal to address the issue relating to jökulhlaups is to establish levees around river banks bordering infrastructure and critical ecosystems and drainage tunnels to divert high flows. With this goal in mind GUARD aims to manage seasonal floods better to protect local communities, habitats, and water quality. Constructing levees along riverbanks is a common practice where Jökulhlaups occur frequently. Building levees is a necessary protective measure since there is a large urban community in the northern area of the watershed. Alternatively, some areas will be better suited for drainage tunnels that will divert the Jökulhlaups flow directly away from sensitive areas. GUARD will work with nearby communities and stakeholders to ensure levee and drainage placements are in the best-suited locations.

Greenhouse Gas Emissions

Problem

Drained wetlands do not have the same ecological functions as healthy wetlands. When a wetland is drained, it no longer acts as a sink for carbon dioxide and releases carbon dioxide CO2. In warmer conditions, existing healthy wetlands release more methane, another substantial greenhouse gas. Warmer temperatures allow for greater microbial activity, and thawed frozen soils create more area for microbes. Therefore, wetland functionality is highly susceptible to the effects of greenhouse gas emissions.

Methanogenesis is an example of microbial activity that occurs in wetland reduction. This is because salt water that mixes with freshwater is very sulfate-rich. The sulfate is used as an electron acceptor in microbial respiration processes within the wetlands. (Zhe Lyu, 2018) As the water level decreases in the wetlands, the sulfate-rich water also diminishes. The organisms then turn to a separate anaerobic process called methanogenesis, where they use oxygen in the water molecule as an electron acceptor to break down carbon food sources. This process releases carbon dioxide and methane into the atmosphere. Even though one organism releases a minuscule amount of methane, the entire wetland ecosystem can turn to this alternative process and create a relatively large amount of methane per day, which is 25 times more potent as a greenhouse gas than carbon dioxide.

Goal

In order to reduce greenhouse gas emissions from the watershed, GUARD's goal is to restore 8 km^2 of previously dried abandoned wetlands. As they stand, the abandoned wetlands contribute to carbon dioxide emissions instead of acting as carbon sinks like healthy wetlands. By converting 8 km^2 back to healthy wetlands these areas will act as carbon sinks and consume excess nutrients from the environment. By acting as a carbon sink, the converted wetlands will help slow greenhouse gas emissions and the greenhouse gas effect. With a smaller greenhouse gas effect, temperatures will hopefully remain cooler, lessening the amount of methanogenesis occurring in healthy wetlands which will reduce the release of methane, another major greenhouse gas.

Conclusion

Located in western Iceland, the Grunnafjörður watershed is composed of areas with high ecological value and sites that have grown to become major tourist destinations. As it stands, Iceland has established strong and cohesive management plans that protect the nation's waterways, however, they lack a focus on individual watersheds. Issues that pertain to the Grunnafjörður watershed are not included in current policies such as the need for wetland restoration or control measures for glacier melts and floods. GUARD's objective is to establish measures to address these issues and mitigate environmental harm. By working with Iceland's western water district and its regional committee, GUARD believes that it can reasonably implement these desired changes and restore the Grunnafjordur's ecological functions by 2035.

Appendix

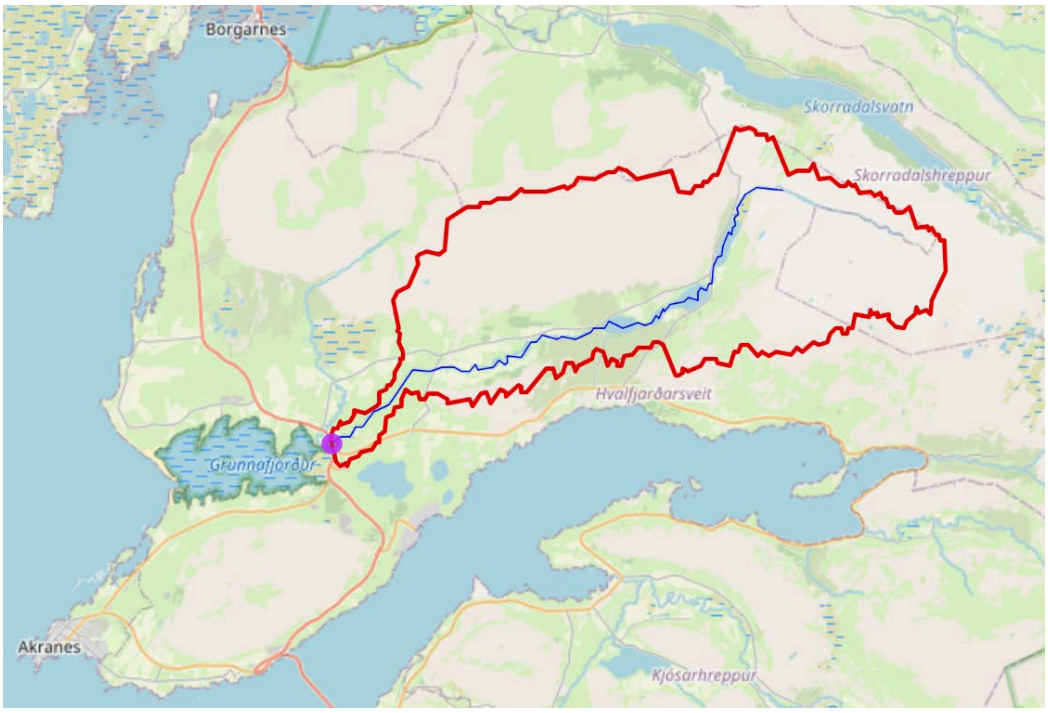

Figure 1. GIS map of the Grunnafjordur watershed. The red line is the elevation delineation.

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