Landsvirkjun

BÚÐARHÁLS POWER PLANT
CAPACITY UP TO 120 MW
AND
220 kV BÚÐARHÁLS LINE 1

ENVIRONMENTAL IMPACT ASSESSMENT

ENVIRONMENTAL IMPACT STATEMENT (EIS)24
January 2001

SUMMARY

Iceland's National Power Company, Landsvirkjun, proposes to build a power plant of up to 120 MW capacity, the Búðarháls power plant, on the River Tungnaá at Búðarháls, in the district of Rangárvallasýsla, to take advantage of the drop of some 40m there between the tail water of the Hrauneyjafoss power plant and the Sultartangi reservoir. The energy generating capacity of the plant is estimated at 520 GWh annually. Furthermore, Landsvirkjun proposes to construct a 220 kV high-voltage transmission line, Búðarháls line 1, from the powerhouse at the Búðarháls plant to the substation at the Sultartangi plant.

According to Act No. 42/1983, on Landsvirkjun, the company is to ensure a sufficiently reliable supply of electricity to meet the requirements of its customers at any time. The construction of the Búðarháls power plant is intended to meet increased electricity needs of industry and households.

The project is subject to environmental impact assessment as provided for in Points 2 and 22 of Annex 1 to Act No. 106/2000, on Environmental Impact Assessment.

This environmental impact statement (EIS) has been prepared for Landsvirkjun by Hönnun hf. Many parties were consulted and their comments sought during its preparation. The proposed development was presented at meetings held last autumn at both Laugaland in Holt and in Reykjavík. Local authorities, consultation parties and representatives of various NGOs were taken to Búðarháls to acquaint them with the project on-site. A proposed draft proposal as well as proposal for a scoping document were presented on Landsvirkjun's website.

The main proposal for the Búðarháls power plant assumes that a dam will be built across the stream Kaldakvísl a short distance above its junction with the River Tungnaá and across the outflow from the Hrauneyjafoss power plant. The dam will be 24 m high at its highest point and some 2,300 m in length. Damming Kaldakvísl will form an intake reservoir, Sporðalda reservoir, with an estimated surface area of some 7 km^2 at normal operating water level. The reservoir will mainly fill the channel of Kaldakvísl and also extend slightly into Þóristungur. The volume of the reservoir will be about 26 Gl. A headrace tunnel about 4 km long will be constructed from the intake structure at the Sporðalda reservoir, under Búðarháls to a surge basin and the powerhouse by the Sultartangi reservoir. The powerhouse will be above ground, but built into the western side of the slope of Búðarháls. The construction of Búðarháls power plant is expected to take 3-4 years. A decision as to when construction will commence depends upon demand for electricity.

Búðarháls line 1 will be built for 220 kV operating voltage. Most of the transmission line towers will be so-called M towers, which are guy-wired, steel frame towers, erected on concrete footings. The towers are 20-30 m high and around 20 m wide. The transmission line is to follow the current track part way from the Búðarháls plant powerhouse over Búðarháls, east of Fögrulindir and then along the proposed access road by Stóra-Hestatorfa and from there across the River Tungnaá just east of Hald. From there the line would be laid parallel to the current transmission lines to the substation at the Sultartangi power plant. Construction of the transmission line Búðarháls line 1 is expected to take 1½ years.

The Búðarháls power plant will further utilise water controls already in place in the Þjórsá and Tungnaá region, which increases the cost-efficiency of the power plant. The advent of a bridge crossing the River Tungnaá will make the Búðarháls area more accessible to the public. The proposed construction area is neither on the list of sites of special natural interest nor protected, and does not include any sites with special vegetation or geological interest.

The principal environmental impact of the Búðarháls power plant will be the flooding of around 2 km^2 of vegetated land by the Sporðalda reservoir. It is conceivable, however, that vegetation will increase in the area surrounding the reservoir due the higher groundwater level there. The advent of the Sporðalda reservoir will alter the land utilisation. Existing tracks in the reservoir site will be flooded. No extensive erosion is expected around the Sporðalda reservoir.

The project will not have any significant environmental impact on archaeological sites nor on fish runs or fishing.

The project will not have any significant environmental impact on tourism, although it is likely that tourist traffic will increase in the area once a bridge has been built over the River Tungnaá.

The main impact of the project on bird life will likely be to reduce the habitat of several dozen pair of pink-footed geese, as the River Tungnaá will dry up for the most part below the dam to the Sultartangi reservoir. While some of the duck species found in the area are on the endangered list, this is not a nesting area for these species.

Alternations are required to the Regional Plan of the Central Highlands to accommodate the proposed project. These will be advertised in tandem with the advertisement of the EIA.

The main environmental impact of Búðarháls line 1 is of a visual nature, where the line runs down from Búðarháls to the current high-voltage lines Hrauneyjafoss line 1 and Sigalda line 3.

The principal mitigating measures proposed for the project are connected with road construction. By making use of the same roads for both the power plant and transmission line, the environmental impact is reduced. Regard has been had for vegetated land in selecting the road route by utilising existing tracks, both from the proposed bridge over the River Tungnaá and from the dam part of the way to the powerhouse. Attempts will be made to reduce as far as possible unnecessary disturbance in building the road by Fögrulindir. There the road lies through a patch of wetland in one place; as a mitigating measure a culvert will be placed so that the water flow to and from these areas will be mostly unhindered. By building the road below Fögrulindir and along the Sultartangi reservoir the springs at Fögrulindir will be less disturbed. A new track will be laid, in co-operation with responsible authorities, to replace that which will be flooded by the Sporðalda reservoir.

Possible shore erosion of the Sporðalda reservoir will be monitored and mitigating measures applied if and as required. The advice of responsible authorities has been sought on possible mitigating measures due to the vegetation lost with the advent of the Sporðalda reservoir.

By having Búðarháls line 1 join up as soon as possible with existing transmission lines, the aim is to have a single continuous belt of these structures transversing the region to minimise the visual impact.

The overall conclusion of the environmental impact assessment for Búðarháls power plant and Búðarháls line 1 is that the projects will not have a significant impact on the environment or community.

CONTENTS

LIST OF ILLUSTRATIONS

LIST OF TABLES

ANNEXES

ANNEX A

Accompanying document 1

RALA 1999; *Búðarhálsvirkjun, athugun á gróðri* (Búðarháls Power Plant, Study of Vegetation). Report to Landsvirkjun

Accompanying document 2

RALA 1999; *Gróður á vegstæðum fyrirhugaðrar Búðarhálsvirkjunar* (Vegetation on the road routes of the proposed Búðarháls power plant). Report prepared for Hönnun hf.

Accompanying document 3

RALA 2000; *Gróður á línustæðum fyrirhugaðrar Búðarhálsvirkjunar* (Vegetation on the transmission line routes for the proposed Búðarháls power plant). Report prepared for Landsvirkjun

Accompanying document 4

Jóhann Óli Hilmarsson 2001; *Fuglalíf á áhrifasvæði Búðarhálsvirkjunar* (Bird life in the impact area of the Búðarháls power plant). Report prepared for Hönnun hf.

Accompanying document 5
Guðni Guðbergsson og Ragnhildur Magnússdóttir 2000; *Kaldakvísl og Sultartangalón. Fiskistofnar og lífríki* (Káldakvísl and the Sultartangi reservoir. Fish stocks and biosphere). Institute of Freshwater Fisheries

Accompanying document 6

Rannsóknir og ráðgjöf ferðaþjónustunnar 2001; *Búðarhálsvirkjun og Búðarhálslína 1. Áhrif á útivist og ferðaþjónustu* (Búðarháls power plant and Búðarháls line 1. Impact on outdoor leisure and tourism). Prepared for Landsvirkjun.

Accompanying document 7

Adolf Friðriksson og Orri Vésteinsson 1999; *Fornleifar á Búðarhálsi og í Þóristungum. Könnun vegna Búðarhálsvirkjunar* (Archaeological sites on Búðarháls and in Þóristungur. An investigation for the Búðarháls power plant). Institute of Archaeology.

Accompanying document 8

Hönnun hf. 2000; *Búðarhálsvirkjun-Sporðöldulón. Greinargerð um landbrot vegna fyrirhugaðs inntakslóns* (Búðarháls power plant – Sporðalda reservoir. A report on erosion due to the proposed intake reservoir). Prepared for Landsvirkjun.

ANNEX B

Accompanying document 1

Response of RALA to comments from the Soil Conservation Service of Iceland in its opinion on the Búðarháls power plant and Búðarháls transmission line, proposal for scoping document

Accompanying document 2

Various definitions of mitigating measures

I. GENERAL

1 INTRODUCTION

Landsvirkjun proposes to build a power plant on the River Tungnaá at Búðarháls, to take advantage of the drop of some 40m there between the tail water of the Hrauneyjafoss power plant and the Sultartangi reservoir. Preparations for the plant are based on a proposed capacity of up to 120 MW, producing up to 520 GWh per annum. Authorisation is provided in the Act on Electrical Power Stations, No. 60/1981, as subsequently amended, and in the Act on Landsvirkjun, No. 42/1983, as subsequently amended, for a power plant of this size at Búðarháls; however, authorisation from the Minister of Industry is required for the plant, following an environmental impact assessment. Landsvirkjun also proposes to construct a 220 kV high-voltage transmission line, Búðarháls line 1, from the substation at the Búðarháls power plant to the substation at the Sultartangi plant. Landsvirkjun will be the developer, owner and operator of the proposed power plant and high-voltage transmission line. Hönnun hf. has worked on preparing this environmental impact statement (EIS).

The project is subject to environmental impact assessment cf. Points 2 and 22 of Annex 1 to Act No. 106/2000, on Environmental Impact Assessment.

Following the procedure provided for in Art. 8 of the Act, concerning the compiling of the scoping document, the developer must prepare an EIA report. The arrangement and contents of the EIS shall be in accordance with the scoping document. The scoping document for the Búðarháls power plant and Búðarháls line 1 was approved by the Icelandic National Planning Agency on 23 November 2000.

The impact area of the proposed power development extends into three municipalities: Ásahreppur, Djúpárhreppur and Holta- og Landssveit in the district Rangárvallasýsla. The impact area extends roughly from the powerhouse by the Sultartangi reservoir east into the Þóristungur area to the proposed intake reservoir. From there the impact area follows the channel of the River Tungnaá to Hald. The impact area of the proposed high-voltage transmission line extends over the following municipalities: Ásahreppur, Djúpárhreppur and Holta- og Landssveit in the district of Rangárvallasýsla and Gnúpverjahreppur in the district of Árnessýsla. The high-voltage line and its impact area runs from the substation at the Búðarháls plant along Búðarháls, over the River Tungnaá a short distance above Hald and from there to Hrauneyjafoss line 1. The proposed transmission runs parallel to the latter, and part of the way parallel to Sigalda line 3, to the substation at the Sultartangi power plant. The transmission line is a total of 17 km in length.

Meetings presenting the proposed development were held last autumn at both Laugaland in Holt and in Reykjavík. On-site visits were made to Búðarháls with consulting parties, representatives of local authorities and various NGOs to acquaint them with the proposed development. A proposed draft proposal as well as proposal for the scoping document were presented on Landsvirkjun's website.

The construction of Búðarháls power plant is expected to take 3-4 years. A decision as to when construction will commence depends upon demand for electricity. Construction of

the transmission line Búðarháls line 1 is expected to take 1½ years.

The proposed construction area is neither on the list of sites of special natural interest nor protected and does not include any sites of special vegetation or geological interest.

The Master Plan for Utilisation of Renewable Energy Resources[1] prepared on behalf of the government, assesses possible power development options and classifies them with regard to their power potential and cost-efficiency, significance for the national economy and impact on nature and society. The Master Plan includes those power projects which have been approved by the Icelandic parliament *Althingi* but which have not yet been given the Minister's consent; the Búðarháls power plant is among the latter. The power project is classified among the power development possibilities which the project management of the Master Plan expect to be considered in the first stage.

The authorities may approve a power project which is under examination by the Master Plan project management. In such instances, the authorities consider it appropriate for project management to discuss the case and deliver its opinion, although it will do so in a shorter period of time than otherwise, and provided that an EIA is carried out.

[1] See, for instance, www.landvernd.is

2 PURPOSE AND OBJECTIVES

Landsvirkjun's purpose in constructing the Búðarháls power plant is to meet in a cost-effective manner increased industrial and household demand for electricity. Pursuant to Article 2 of the Act on Landsvirkjun, No. 42/1983, as subsequently amended, Landsvirkjun's role includes building and operating electricity generating plants and the country's main trunk transmission system; carrying out planning for new generating plants and trunk transmission lines in Landsvirkjun's energy region; and ensuring a sufficiently reliable supply of electricity to meet the needs of energy buyers at any given time. In addition, Art. 6 of the Act states that Landsvirkjun shall take the initiative in building generating plants in its energy region, in order to ensure that the energy and power needs of the company's customers will always be satisfied.

According to the national energy forecast of 2000, generally electricity consumption is expected to increase by 250 GWh from 2000 to 2005. This forecast does not include new power-intensive industry but only those contracts which have been signed. Demand for electricity for power-intensive industry in Iceland appears to be increasing, and discussions in this regard are underway with various parties. In order for such discussion to be effective, it is necessary to have reliable information on possible power development options available at all times, including EIA assessment. Since the preparation and construction time for hydro generating plants is generally longer than that of industrial plants, work on preparing possible power development options, including EIA, must begin earlier, even if no contract has been concluded on sale of electricity.

The proposed power generated by the Búðarháls power plant will be transmitted by the 220 kV Búðarháls line 1 from the Búðarháls plant to the Sultartangi station, where it will connect with Landsvirkjun's transmission network. The transmission line is included in this EIS.

The construction of the Búðarháls power plant represents the last harnessable drop (apart from the Vatnsfell power plant) between the Búrfell power plant and Lake Þórisvatn. The objective of the project is therefore to further utilise the already existing water controls and diversions of the Þjórsá and Tungnaá region. **Figure 2.1** shows the currently existing power plants on the rivers Þjórsá and Tungnaá, together with the area where the proposed Búðarháls power plant will be located.

Map of Búðarháls and surrounding area - Legend (p. 4)
Colour changes show 100m changes in elevation
Proposed reservoir
Headrace tunnel
High-voltage transmission line
Roads
Tracks

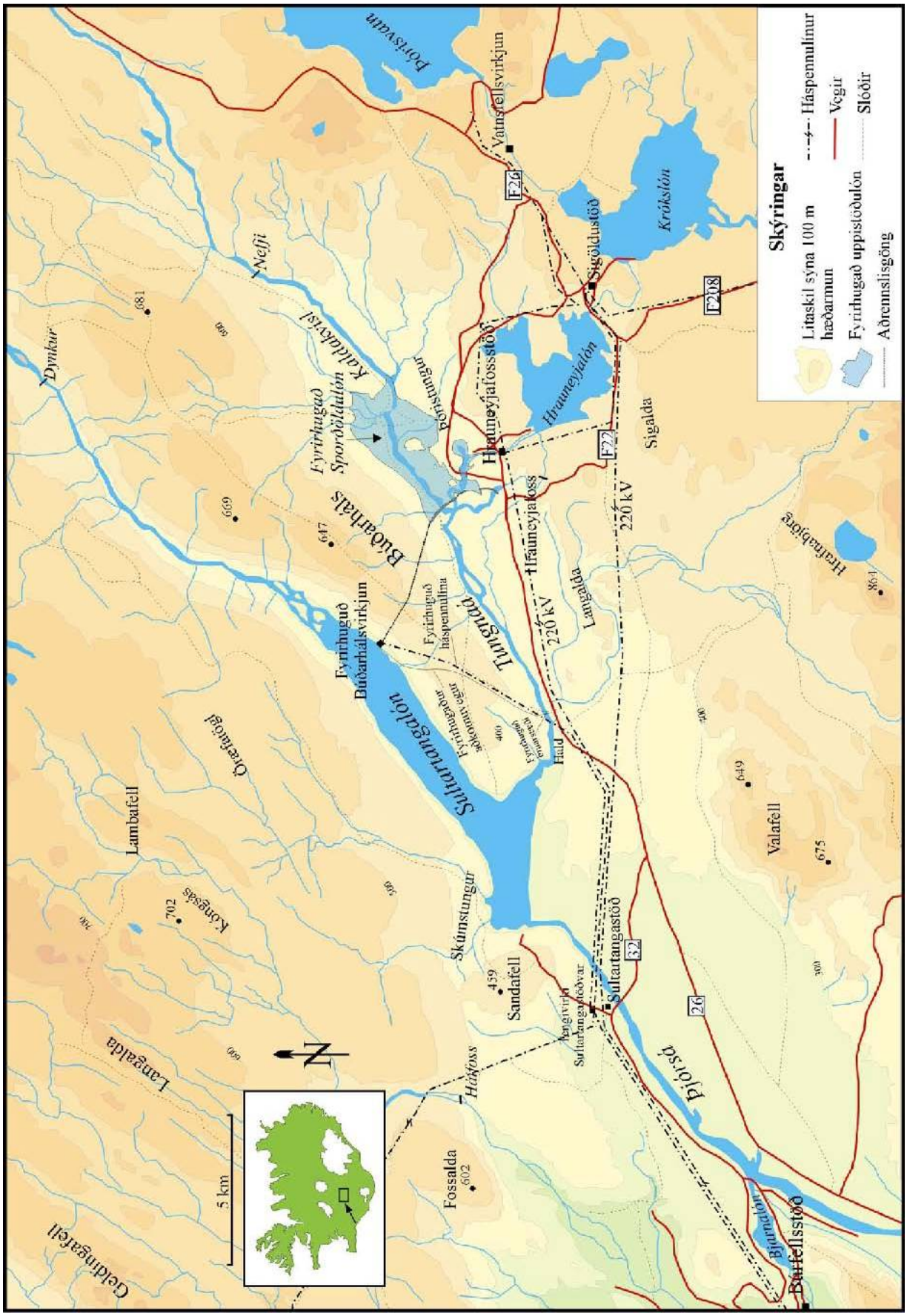


Figure 2.1 Map of Búðarháls and surrounding area

3 TOPOGRAPHY AND BASELINE STATUS

3.1 LANDSCAPE

Búðarháls is a rounded ridge, some 24 km in length and 10 km wide at it widest point, running NE-SW. The ridge lies between the River Þjórsá in the west and the streams Kaldakvísl and River Tungnaá in the east (**Fig. 2.1**). The southern and eastern slopes of Búðarháls are fairly gentle but steeper on the north and west. At its highest point the northern part of Búðarháls is around 680 m above sea level, but a major portion of the ridge is 300-600 m high.

3.2 GEOLOGY

Geological research with a view to proposed construction on Búðarháls has been carried out, with pauses, since 1970. In 1972 a detailed geological map of the region was drawn up[2] and at the end of that decade and the beginning of the next geological research continued with the drilling of exploratory holes and other measurements.[3] Exploration was subsequently continued in 1992-94 and the summer of 2000.

The bedrock of the region on and around Búðarháls was formed during the Ice Age and the Holocene. The alternating warmer interglacial and glacial periods of this era are clearly visible in the earth strata,
for instance, in the dolerite layers which formed during interglacial periods and the tuff and tillite from glacial periods. Roughly speaking the River Tungnaá separates the younger Þjórsá lava (<10,000 years old) in the south from the older rock formations in Búðarháls on the north (<700,000 years old)[4].

Under Búðarháls itself is a ridge of metamorphic rock formations which are likely over 2 million years old. While these metamorphic strata are limited in extent, their borders are uncertain. Above and to the south of this ridge are rock strata 1-2 million years old. These are alternately slightly metamorphosed basalt strata, originally lava which flowed during interglacial periods of the Ice Age, and sedimentary strata, primarily sandstone and tillite. At the top of Búðarháls is tuff, but this lies outside of and above all proposed structures. There is tillite on the border between the tuff and basalt rock.

There is also tuff east of Kaldakvísl, which is younger than that of Búðarháls. These tuff formations are the same as surround the Hrauneyjafoss station. Along Kaldakvísl there is the so-called Kaldakvísl dolerite, which is pillared basalt.

[2] National Energy Authority (*Orkustofnun*), 1973
[3] National Energy Authority, 1978
[4] National Energy Authority, 1983

3.3 LAND UTILISATION

The proposed impact area[5] of the power plant and transmission line is used primarily for sheep grazing, although declining numbers of sheep have reduced grazing in recent years. Travellers have also shown interest in the area and the Hrauneyjar highland centre is close by. The former route over Sprengisandur lies over Búðarháls, and from there tracks lead to waterfalls along the River Þjórsá, such as Gljúfurleitarfoss and Dynkur.

Aggregate and gravel for concrete has been extracted from part of the proposed reservoir area in connection with power projects in the Tungnaá region.

3.4 VEGETATION

3.4.1 GENERAL

Data on the vegetation of Búðarháls and the surrounding area extend back to the year 1967, when a vegetation map of the area was prepared by the Agricultural Research Institute (RALA).

Due to the proposed construction at Búðarháls, however, a special examination of vegetation was made in the summer of 1998, focusing on the vegetation in the region which would be disturbed by the proposed Búðarháls power plant.[6] An examination was also made in September 1999 of vegetation in the area proposed for roads[7] and in August 2000 along the route of the proposed Búðarháls line 1.[8]

Regard was also had for previous examinations of the vegetation of proposed power plant locations in the water catchment area of the River Tungnaá,[9] as well as a report by the Soil Conservation Service of Iceland and RALA on soil erosion in Iceland.[10]

The previously mentioned vegetation map from 1967 was used as reference. In the estimation of RALA, the map of 1967 is sufficient for the purposes of the work (see further Annex B, accompanying document 1). RALA also examined a new satellite photograph (Landsat 7, 2000) of the area. A comparison of the photo with the 1967 vegetation map revealed that the extent of continuous vegetation and unvegetated areas was practically the same in both these illustrations. Therefore the advance of vegetation in the area could be said to have been practically nil over the 33 years. It could be suggested that e.g. volcanic eruptions (Mt. Hekla in 1970, 1980, 1981, 1991 and 2000), climate and animal grazing had made an impact on the advance of vegetation in this location.

5 See definition of the impact area in Section 8.3.
6 Annex A, Accompanying doc. 1.
7 Annex A, Accompanying doc. 2.
8 Annex A, Accompanying doc. 3.
9 Jóhann Pálsson and Þórir Haraldsson, 1981.
10 Ólafur Arnalds et al., 1997.

According to a research project by the Soil Conservation Service and RALA, the common grazing lands beyond Búðarháls, (Holtamannaafréttur) are practically a desert; 88% of the area is classified as desert and mountains. Vegetation on Búðarháls is also regarded as highly sensitive due to ash settling from Hekla eruptions, sand deposition from the commons and its elevation above sea level.

The discussion of vegetation in the proposed construction area is divided between, on the one hand, the reservoir, powerhouse and other power plant structures and, on the other hand, the high-voltage transmission line and roads.

3.4.2 RESERVOIR, POWERHOUSE AND OTHER POWER PLANT STRUCTURES

As previously mentioned, in the summer of 1998, an investigation was carried out of the vegetation which would be disturbed by the proposed power plant.[11] The area examined can be divided up into the reservoir, dam site and spillover, and the area where the powerhouse is located. An examination was made of the vegetation in 10 locations, with the species of higher plants listed and samples taken of the main species of mosses and lichens. A total of 217 plant species were listed, of which 106 were higher plant species, 91 were mosses and 20 lichens. None of the species found is on the endangered list, nor were there any rare plant species found in the area. Moss heath and gravel flats are dominant but there are also spongy grasslands. Þóristungur is the largest vegetated area in the region, part of which will be flooded. The vegetation in Þóristungur differs considerably from that, for example, in Þjórsárver. The area is lower lying and much of it sloping, and there is no permafrost with palsas,[12] as is common in Þjórsárver. There are also few ponds and bogs in Þóristungur.

Much of the reservoir area is classified as barren ground, which includes gravel flats, sandbars in rivers, and sandy plains; this is especially visible in the westernmost and upland part of the reservoir area. In more vegetated areas, moss heath predominates, followed by moorland. There are occasional grassy or newly sprouted patches, but little wetlands vegetation. On the southwestern part of the reservoir area, however, there is a well established patch of wetland with a pond in the middle. The best conditions for vegetation are along the banks of creeks, and creeks are most conspicuous in the eastern part of the reservoir area.

By the proposed powerhouse site moss heath dominates with willows and other small shrubs. The slope is steep and scored by gullies and hollows which add to the variety of plant habitats. At the bottom of the slope and on the sandbars by the Sultartangi reservoir, the vegetation cover becomes more skimpy and fewer species flourish than on the slope itself, due to the different conditions there.

The proposed dam location and spillover lies for the most part over gravel flats and moss heath by Kaldakvísl. To the south of Kaldakvísl mostly barren gravel flats and hillocks are predominant, with mainly moss heath or even grassy spots between them. To the north of Kaldakvísl, the ground becomes rockier; here the dam will lie across barren gravel flats.

11 Annex A, Accompanying doc. 1.
12 Palsas are low hills or knobs with a core of ice and frozen overlying soil.

3.4.3 HIGH-VOLTAGE TRANSMISSION LINE AND ROADS

Examination of vegetation was made at six locations along the transmission line route and at five locations along the roads.

Where the transmission line and roads cross Búðarháls, gravelly flats predominate with fringe moss (racomitrium ericoides) the most common plant species. There is also much moss heath, with fringe moss also dominant here together with a considerable amount of lamb's wool moss (racomitrium lanuginosum). Of the sites examined, vegetation was most varied on the west of the ridge, where 72 species of higher plants were found. This species diversity can be attributed to the varied habitats in the area, which include for instance, moorland slopes, sheltered hollows, creeks, gullies and wetland patches. On the eastern side of the ridge gravel flats dominate and species diversity is less. South of the River Tungnaá there is little diversity and scanty vegetation, with sand-covered lava the dominant type of terrain.

Wetlands are scarce at Búðarháls and are limited to a few small areas. At Fögrulindir, in the western part of the ridge, close by proposed routes for the transmission line and roads, there is a patch of wetland as well as very varied vegetation which preferably should be disturbed as little as possible (Fig. 3.1).

An examination of the vegetation to the west of the River Þjórsá was made in 1996 in connection with the EIA for the Sultartangi power plant.[13] It states that southeast of Sandafell there are grassy slopes scored by gullies with fairly varied vegetation but no rare plant species were found there.

Fig. 3.1 View south over part of Fögrulindir

13 Borgþór Magnússon and Ásrún Elmarsdóttir, 1996

3.5 BIRD LIFE

Very little information was available on birds in the area of the power project, but a few years ago the bird life in the former channel of the River Tungnaá was investigated in connection with mapping bird nesting grounds.

An investigation into the bird life in the impact area of the Búðarháls power plant was therefore made due to the proposed projects at Búðarháls in the summer of 2000.[14] The focus was primarily on what bird life flourished in the reservoir area of the proposed reservoir Sporðalda, on Búðarháls and along the River Tungnaá. The species composition and density of bird life was investigated at all seasons of the year. No part of the proposed project area is listed as an international significant bird protection area.

According to this investigation, the bird life in the area is fairly diverse. A total of 33 species were found in the area, 15 of them confirmed as nesting species, 6 probably nesting species, 21 spring and summer visitors (some of them also nesting species), 7 were autumn visitors and 6-7 winter visitors. The area is a stopover location for highland species on their way to nesting grounds; the pink-footed goose appears to be the most common and widespread nesting species. Some 20-30 pair of pink-footed geese nest on the islets of the River Tungnaá and in the former river channel. The bird also uses this area during its spring and autumn migrations. The power project is not considered a threat to any rare bird species. Several of those birds in the area are on the endangered list, where they are classified as rare or only found in specific locations.[15] These species are the goosander (*mergus merganser*), harlequin duck (*histrionicus histrionicus*) and Barrow's goldeneye (*bucephala islandica*).

The golden plover (*pluvialis apricaria*) and dunlin (*calidris alpina*) are the most conspicuous among moorland birds. They are also common stopover species, the dunlin and purple sandpiper in the spring and the golden plover both in the spring and autumn. The number of ducks on the River Tungnaá was striking, but they were fewer on Kaldakvísl.

The area under examination includes the highest limits of redshank (*tringa totanus*) nesting grounds, and the whimbrel (*numenius phaeopus*) and common snipe (*gallinago gallinago*) found are also in the upper reaches of their nesting areas.

The area under examination was divided into 5 sections for convenience and more detailed description.

3.5.1 EASTERN PART OF THE RESERVOIR AREA IN ÞÓRISTUNGUR

The region is quite well vegetated and characterised by moorland birds. Species diversity is considerable, but density is low, around 32 pairs per km^2, which is similar to that of well vegetated but treeless lowland lava. Pink-footed geese frequent the area from spring to autumn but they probably do not nest in this part of the reservoir site. Traces of ptarmigan (*lagopus mutus*) were found and fair numbers of harlequin ducks (*histrionicus histrionicus*) and long-tailed ducks (*clangula hyemalis*) were seen on rivers and streams in May and June.

[14] Annex A, Accompanying doc. 4.
[15] Iceland Institute of Natural History, 2000.

3.5.2 WESTERN PART OF THE RESERVOIR, FLUTNINGSKVÍSL[16] AND CHANNEL OF THE RIVER TUNGNAÁ

The region is varied with scantily vegetated undulating barren gravel, moss heath, heather, sand and fens. There is plenty of vegetation on the Búðarháls side of Kaldakvísl, where there are many small streams emptying into Kaldakvísl. Moorland birds are the most common here, with many species but low density (32 pair per km^2). Both loons and swans nest in a pond in channel of the River Tungnaá and red-necked phalarope (*phalaropus lobatus*) have been seen. Considerable signs of a raven were found in a gully of the River Tungnaá.

3.5.3 KALDAKVÍSL, FROM TJALDAKVÍSL TO THE JUNCTION OF THE RIVER TUNGNAÁ AND FLUTNINGSKVÍSL

The lower section of Kaldakvísl is characterised by sandbars and islets, as the river splits into several streams here. A fair number of birds were seen in this area in May and June, including harlequins and long-tailed ducks, pairs of greylag geese (*anser anser*) and some pink-footed geese (*anser brachyrhynchus*).

3.5.4 RIVER TUNGNAÁ, FROM THE RIVER JUNCTION TO HALD

A good number of pink-footed goose nests were found on three islets in the River Tungnaá. Some ducks seen by the largest islet at the end of May and in June had disappeared in July. Probably some of the ducks nest here.

3.5.5 BÚÐARHÁLS

Búðarháls has alternating areas of vegetated and barren land. Moorland birds nest where their favourite habitat is found, e.g. in the rocky patches with vegetation found widely which offer quite a variety of bird life. The slopes facing the River Þjórsá are quite well vegetated. Nesting birds on Búðarháls are e.g. the golden plover (*pluvialis apricaria*), ringed plover (*charadrius hiaticula*) purple sandpiper (*calidris maritima*), whimbrel (*numenius phaeopus*), northern wheatear (*oenanthe oenanthe*) and snow bunting (*plectrophenax nivalis*). Bird life in Gljúfurleit, on the the northwest of Búðarháls, is considerable. The types of vegetation there are very similar to that around the powerhouse.

3.5.6 COMPARISON WITH OTHER AREAS

If bird life in the impact area of the Búðarháls power plant is compared to that in other regions of the Southern Highlands, it is around or above average. The wetlands of Þóristungur, together with rivers and streams, are the most important for bird life in the area. The area is more important as a stopover for birds passing through and less important for nesting birds.

Bird life on Búðarháls is considerably more diverse than, for instance, at Sultartangi and much more diverse that in areas by Hágöngur or Vatnsfell. In the Southern Highlands, it is primarily Þjórsárver, Hvítárnes and Veiðivötn which are more significant than the Búðarháls area.

[16] Flutningskvísl is the current outflow of the Hrauneyjafoss power plant. It was previously Sporðöldukvísl.

3.6 FISH STOCKS AND SPORT FISHING

3.6.1 GENERAL

In the autumn of 2000 the Institute of Freshwater Fisheries carried out a study for Landsvirkjun of the extent, conditions for life and state of the fish stocks in the Sultartangi reservoir, in Kaldakvísl below the falls Nefji (see **Fig. 2.1**) and in the River Tungnaá as far as Sultartangi reservoir.[17] Benthic species in the lower reaches of Kaldakvísl and in the River Tungnaá were also examined as well as plankton and benthic species in Sultartangi reservoir. Information on fish stocks for purposes of comparison with this study is fairly well known in Iceland.

The purpose of the study was to examine areas which could be affected by the proposed construction for the Búðarháls power plant, having regard for fishing and the conditions for fish life in the freshwater ecosystem of the area.

The conditions for fish life in the Tungnaá and Kaldakvísl catchment area have been shaped by the water controls and operating of power plants in recent decades, which are located both above and below the area encompassed by the study. It is important to understand the changes involved in the controls and altered flow pattern; the principal changes to the water system in the Kaldakvísl and Tungnaá region are connected with the flow controls and power plants. Table 3.1 shows the principal changes which have taken place in the area.

Table 3.1: Changes to water flows in the Kaldakvísl and Tungnaá region

Year	Project	Impact on/change to water flows
1972	Kaldakvísl dammed above Þórisós at Sauðafell and diverted into Lake Þórisvatn (Sauðafell power plant).	Sauðafell reservoir formed Lake Þórisvatn becomes a control reservoir coloured by glacial run-off, was previously clear spring water Fluctuations in water level, erosion of banks and impact on the Lake Þórisvatn biosphere Spring water in Kaldakvísl, was previously glacial run-off, decreased flow at Þóristungur Glacial spillover water runs into Kaldakvísl below Þórisós when water level is highest in Lake Þórisvatn
1977	Krókur reservoir (for Sigalda power plant) created River Tungnaá dammed at the top of Sigalda	Control reservoir Changes to water level. Impact on biosphere.
1982	Hrauneyjar reservoir (for Hrauneyjafoss power plant) created. River Tungnaá dammed above Hrauneyjafoss	Control reservoir Changes to water level. Impact on biosphere.
1983	Sultartangi reservoir created.	Control reservoir

[17] Annex A, Accompanying doc. 5

	Reservoir enlarged in 1999. (for Sultartangi power plant)	
19811984	Phase 1-4 of Kvíslaveitur diversion	Spring water streams east of River Þjórsá diverted into Kaldakvísl above Sauðafell
1996	Phase 5 of Kvíslaveitur diversion	Eastern streams of the River Þjórsá diverted through a canal to the Kvíslaveitur diversion and on into Kaldakvísl and Þórisvatn. Water in Kvíslaveitur diversion is clear until joined by the eastern streams of the River Þjórsá.
1997	Hágöngur reservoir. Dam at Syðri-Háganga	Hágöngur reservoir holds almost all the summer flow of Kaldakvísl. Water from Hágöngur reservoir used for Lake Þórisvatn in winter. Most of the coarser sediment from Kaldakvísl settles out in the reservoir.

Source: Magnús Jóhannsson 1988, Þórólfur Antonsson and Guðni Guðbergsson 1990, Orkustofnun 1990 and Annex A, Accompanying doc. 5.

The greatest changes to Kaldakvísl occurred when the Sauðafell diversion was opened and water from Kaldakvísl was diverted into Lake Þórisvatn. This made Kaldakvísl a spring water stream for most of the year while at the same time its flow decreased substantially in Þóristungur.

3.6.2 FISH STOCKS

As is evident from **Table 3.1**, power plants and water controls have resulted in substantial changes to the water system in the area. There have also been other changes resulting from human activities. There were no arctic char (*salmo alpinus*) in the water catchment area of the River Tungnaá until fry were released there for the first time in the 1960s. Prior to that there were only brown trout (*salmo trutta*). The char have since spread considerably to neighbouring rivers and streams and in some places taken over former brown trout locations. In 1988 brown trout fry were released into Kaldakvísl to see whether such seeding was a feasible option to increase fishing there.

Prior to the days of water controls (1972) there were spawning brown trout in Lake Þórisvatn, but how or when they reached the lake is not known. The spawning and rearing conditions in Lake Þórisvatn deteriorated after Kaldakvísl was diverted into Lake Þórisvatn and its outflow dammed, as the damming of Þórisós, for instance, left some spawning grounds on dry land.[18] In Lake Þórisvatn and Kvíslaveitur there is now only brown trout which has been released there.

In Kaldakvísl there are both Arctic char and brown trout stocks. The conditions for these stocks and their feed in Kaldakvísl are determined to a large extent by when Kaldakvísl begins to flow over the spillover at Sauðafell; this boosts the flow of the river greatly and what's more this is glacial water. Water generally begins to flow over the spillover in late summer. The conditions below the falls Nefji, which is above the proposed Sporðalda reservoir (see **Fig. 2.1**), are probably more suitable for Arctic char than for brown trout, whiles above the falls and to the Sauðafell reservoir the rearing conditions for brown trout are limited.

Both brown trout and Arctic char are found in the River Tungnaá and side streams, with Arctic char much more prominent since seedings in the 1960s, as previously mentioned.

[18] Þórólfur Antonsson and Guðni Guðbergsson 1990.

The study[19] revealed a substantial difference in measured visibility in the eastern and western areas of the Sultartangi reservoir. Visibility indicates how far down into the water light reaches and how deep primary production occurs. The difference is likely due to the effect of water from the River Þjórsá in the west, which has more sediment than the River Tungnaá which flows into the eastern part. The River Tungnaá has already passed through two storage reservoirs en route, where much of the coarser sediment settles out, before it flows into the Sultartangi reservoir. The difference is also apparent in the varying amounts of plankton and benthic species in these two areas.

3.6.3 FISHING

Brown trout were caught in Kaldakvísl 1930-60 below Tjaldakvísl and after 1960 catching of Arctic char begins following their release into the River Tungnaá.[20]

There has been some fishing in Kaldakvísl after it was diverted into Lake Þórisvatn (primarily in the region below Nefji). The Holtamannaafréttur fishing society has sold sport fishing licenses there. Catches consist of both Arctic char and brown trout, with the former around 2/3 of the catch according to catch reports. Figures are available for sport fishing in Kaldakvísl for 1987 and 1988 and also for 1995-99. During these years the average annual catch was 113 Arctic char and 22 brown trout caught by sport fishermen in Kaldakvísl.[21] There are no figures on catches in the River Tungnaá below the river junction to the Sultartangi reservoir.

3.7 OTHER WILDLIFE

As far as other wildlife is concerned, Arctic foxes have been seen in the area. They are attracted to human dwellings in Hrauneyjar during the winter. According to information from a fox hunter, there are some 4 dens in Búðarháls each year. The number of foxes has dropped or remained steady in the highlands while at the same time there are more of them in settled areas.[22]

The area is a favourite habitat of field mice and mink probably frequent the streams and rivers of the area.

3.8 HYDROLOGY

3.8.1 SURFACE WATER AND GROUNDWATER

The average flow through the power plant is estimated to be 189 m^3/s.

There are extensive lava fields southeast of the impact area of the Búðarháls power plant, where groundwater flow is substantial, as the lava is porous in these areas. On the Búðarháls side, i.e. northwest of Kaldakvísl, the bedrock is denser. High-volume springs flow forth around the edges of the porous areas and in low areas.

[19] Annex A, Accompanying doc. 5.
[20] Magnús Jóhannsson 1988.
[21] Annex A, Accompanying doc. 5.
[22] Annex A, Accompanying doc. 4.

A considerable amount of information is available on the groundwater levels in the River Þjórsá and River Tungnaá region which has been obtained from monitoring holes drilled in the area.

3.8.2 SEEPAGE

The construction of Búðarháls power plant will create a 7 km^2 reservoir. The reservoir is outside of the lava area, on relatively well known Ice Age bedrock. Groundwater flows are low and there should be little seepage from the reservoir. Some seepage can be expected, however, during the first years which will decrease as time passes and silt plugs the bottom of the reservoir. How long this will take depends, for instance, on the bedrock, fissures and silt deposition.

Seepage from other reservoirs in the area is considerable. It is greatest from the Krókur reservoir, around 16 m^3/s, and considerably less from Hrauneyjar reservoir and Sultartangi reservoir, around 1 m^3/s in each case. According to calculations, about 14 m^3/s of the seepage from Krókur reservoir is utilised by the Hrauneyjafoss power plant, around half of the seepage from the Hrauneyjar reservoir is utilised by the Sultartangi power plant and around 1/3 of the seepage from Sultartangi is utilised by the Búrfell power plant. Seepage can be considerably higher initially when the loan fills for the first time. Initial seepage from the Sultartangi reservoir when it filled for the first time in 1984 was around $5m^3/s$. Seepage from the proposed Sporðalda reservoir is expected to be minimal and less than from the Sultartangi reservoir. In addition, the seepage water should end up in the power plants below the Búðarháls power plant.

3.9 OUTDOOR LEISURE AND TOURISM

In the autumn of 2000 a study was carried out for Landsvirkjun on the possible impact of the Búðarháls power plant and Búðarháls line 1 on outdoor leisure and tourism in the vicinity of the project.[23] Apart from that no other research is known to have been carried out concerning outdoor leisure and tourism on and around Búðarháls. The study included investigating the views of various parties on the project through the following three surveys:

- A telephone survey was conducted during the period 23 October – 10 November 2000. Responses were obtained from 800 of a random sample of 1100 people, aged 18-75 years from all Iceland (73% response rate). They were asked whether they had at any time during the past 30 years travelled to or through various locations in the area from the Búrfell power plant to Sprengisandur or seen the structures in the Þjórsá-Tungnaá region or the near vicinity.
- A study of the views of travel industry parties covering the domestic departments of travel agencies (department heads or managing directors) as well as spokesmen for the 4x4 travel club, the Touring Club of Iceland, the travel association Útivist and the Sport Hunting Association of Iceland. A total of 16 parties were contacted.
- A survey was taken among travel service operators in nearby communities, i.e. Hrunamannahreppur, Gnúpverjahreppur, Holta -og Landsveit,

[23] Annex A, Accompanying doc. 6.

Rangárvallahreppur, Djúpárhreppur and Ásahreppur, of their views on the proposed project. A total of 18 parties were contacted.

The results of the telephone survey showed that three out of four respondents had visited Þjórsárdalur and over half of them had visited Landmannalaugar. One in seven had travelled to Búðarháls at some time during the last 30 years.

The study of the views of travel industry parties revealed that three out of four said they had often organised tours in the summer which travelled in the vicinity of the proposed project area of the Búðarháls power plant and Búðarháls line 1. Landmannalaugar and Þjórsárdalur are by far and away the locations most frequented by organised groups in the area. Practically all of those contacted often organised trips for travellers/members to Landmannalaugar and most also visited Þjórsárdalur and the recreated Settlement Age farm. Only two of the respondents said the frequently visited the power plants or travelled to Búðarháls.

The results of the survey of travel service operators in the local districts revealed that around half of those questioned thought their summer visitors often travelled through the proposed impact are of the Búðarháls power plant and the other half thought this was rarely.

The general conclusion which can be drawn from these opinion surveys is that by far the greatest number of travellers in the area go on general sightseeing tours, on the one hand to Þjórsárdalur and the surrounding area and, on the other hand, past that area on the way to Landmannalaugar and across Sprengisandur. Only a small minority of travellers visits Búðarháls itself.

On the whole, the opinion of various respondents appeared to reflect their view that it is sensible to have power plants in demarcated areas, which makes the Búðarháls power plant acceptable or desirable, in view of the fact that it is located in an area which is already used for power production.

The main conclusion of the assessment is, that the proposed project is not likely to have any special impact on tourism in the area. At most, there is a possibility that a transmission line over Búðarháls could deter certain travellers, such as hikers. But it could also be concluded that improved access to Búðarháls, with the advent of a bridge over the River Tungnaá, could boost the numbers of visitors to the region.

3.10 ARCHAEOLOGICAL SITES

In 1999 the Institute of Archaeology investigated archaeological remains[24] on Búðarháls and in Þóristungur[25] due to the proposed EIA for the Búðarháls power plant. There are no known previous studies of archaeological remains in or by Búðarháls.

[24] According to the National Heritage Act, No. 88/1989, the archaeological heritage includes: A) archaeological remains of ancient man-made structures and other localised remains, including historical remains, and B) old artefacts, movable objects from the past. They include objects 100 years of age or older.
[25] Annex A, Accompanying doc. 7.

The examination revealed six sites in the proposed project area. Old structures are only found at one of these sites, a sheep collect in Byrgisver (**Fig. 5.1**) the others are not visible. A ferry crossing can be located at the junction of Kaldakvísl and the River Tungnaá (**Fig. 5.1**) but other sites are not shown, as the study did not enable their exact location.

According to the National Heritage Act No. 88/1989, all archaeological sites are protected and may not be damaged, destroyed, covered or transported elsewhere without the permission of the Archaeological Heritage Committee.

4 PLANNING

The proposed project area for the Búðarháls power plant and Búðarháls line 1 is in the commons Holtamannaafréttur in the municipalities of Ásahreppur and Djúpárhreppur and the commons Landmannaafréttur in the municipality Holta- og Landsveit. It also includes the municipality Gnúpverjahreppur, where Búðarháls line 1 will connect with the Sultartangi station to the west of the River Þjórsá.

The local authorities grant building and development permits based on their detail plans. Permission is also required from the Health Surveillance of South Iceland *(Heilbrigðiseftirlit Suðurlands)* for the building and operation of work camps in the area.

4.1 EXISTING ZONING PLANS

The current Regional Plan for the Central Highlands of Iceland until 2015 was approved in 1999. It assumes arrangements for Búðarhálsvirkjun which are roughly in accordance with the current proposal. There are some deviations, however, concerning the location of the powerhouse and road links. In the current regional plan, for instance, the powerhouse is shown on the side of Sporðalda reservoir and in addition no high-voltage transmission line was shown.

The municipal plan for Gnúpverjahreppur was adopted in June 1995. It assumes that the route of Búðarháls line 1 to the substation of the Sultartangi station will be similar to that of the current plans.

Work has recently begun on the municipal plan for the municipalities Ásahreppur and Holta- og Landssveit; the plan proposals are to be advertised in the latter half of 2001.

Work is underway on reviewing the regional plan to accord with Option 1 (see Chapter 5) for the power plant and transmission line. Changes to the regional plan will be advertised in tandem with the EIA advertisement.

4.2 PLANNING PROCEDURE

A detail plan of the entire impact are of the power plant will be prepared, as provided

for in Art. 23 of Act No. 170/2000, amending the Planning and Construction Act, No. 73/1997, as subsequently amended. The detail plan will cover all aspects of the power development, including transmission lines and road construction.

Art. 19 of the same Act contains the following Temporary Provision:

"In the absence of a municipal plan a local plan may be drawn up on the basis of a regional plan for individual regions or pieces of land where developments are proposed, if the regional plan has outlined the policy toward the categories concerned."

The following provision is also temporary:
"In the absence of an approved municipal or regional plan, or adopted detail plan, a local authority may, after receiving the recommendations of the Planning Agency, approve specific projects upon application and set certain conditions for such approval. In the absence of an approved municipal or regional plan, a local authority may also advertise a proposal for a local plan after receiving the recommendations of the Planning Agency. The conclusions of the Planning Agency concerning such a request may be referred to the Rulings Committee, cf. Article 8."

The detail plan must show, on the one hand, all projects requiring developmental permission from the local authority on a scale of 1:15000 and, on the other hand, structures which require building permits from the local authority on a scale of 1:1000.

5 DESCRIPTION OF PROJECT

5.1 BÚÐARHÁLSVIRKJUN

5.1.1 DAM AND ARTIFICIAL RESERVOIR

The Búðarháls power plant was designed in 1998-99, following which a project design report was issued from which the greatest portion of the following project description was prepared.[26]

The main dam will lie across the channel of Kaldakvísl, a short distance above the junction of Kaldakvísl with the River Tungnaá, and across the former Sporðöldukvísl (now the outflow from the Hrauneyjarfoss power plant, also referred to as Flutningkvísl) somewhat higher up (**Fig. 5.1**). The dam is a traditional earthfill dam with core, a filter, supporting fill and armour stone, partly formed of low walls. The length of the dam, including the spillover, is around 2300 m and the height around 24 m at the highest point.

All dam material can be obtained from the surrounding area (**Fig. 5.2**). The impervious core of the dam will be of glacial moraine, obtained from a quarry near the dam on the slope of Búðarháls and from quarries used for the Hrauneyjafoss dam. Material from the

[26] Hönnun hf., 1999.

sand bars of Kaldakvísl would be used as filter material, pillow lava from the spillover area and ground rock extracted from the tunnel would be used for supporting fill. Rock for the dam will be extracted from the headrace canal, tunnel, nearby gravel flats or blasting for the specific purpose in the reservoir area.

Damming Kaldakvísl will form an intake reservoir, Sporðöldulón, with an estimated surface area of some 7 km^2 at normal operating water level. The reservoir will mainly fill the channel of Kaldakvísl and extend slightly into Þóristungur. A reservoir level between 332.5 and 337 m above sea level would mean the volume of the reservoir would be 26 Gl. **Fig. 5.1** shows the proposed reservoir area. The surface area of the reservoir will vary somewhat, as this is not an equalisation reservoir.

5.1.2 SPILLOVER, BOTTOM OUTLET AND TUNGNAÁ DIVERSION

The main spillover is to be built a short distance northwest of Landsvirkjun's current landing strip by Hrauneyjafoss power plant, with a 170 m long concrete threshold on a ridge of pillow lava (Fig. 5.1). The top of the spillover will be 338 m above sea level. The back-up spillway is a trough 190 m wide through rock at a height of 337.5 m above sea level. To prevent water from flowing into this spillway, except when a major flood arises, a fuse plug is to be constructed across the trough, which will be washed away when the water flows over the fuse plug or it is breached. The top of the plug will be 339.6 m above sea level. It will be possible to drive along the dam when water is not running over a spillover. Water is not expected to run over a spillover except during spring flooding or major floods; smaller flood peaks can be drawn down through the bottom outlet.

The bottom outlet is a chute some 100m in length. During the construction, the bottom outlet will be used to divert water. Two diversion dams (cofferdams) will be built to divert water during the construction period, one across Kaldakvísl and the other across Sporðöldukvísl (which is the current outlet from the Hrauneyjafoss power plant).

A spillover is to be built in the channel of the River Tungnaá, north of the current bridge above the junction with Kaldakvísl, and from there a diversion channel dug to Sporðöldulón (the River Tungnaá diversion). This is done to ensure the operation of the Búðarháls power plant if operations were shut down at the Hrauneyjafoss plant. The spillover will be of concrete, 115 m in length, while the diversion ditch will be around 630 m in length.

5.1.3 HEADRACE CANAL AND HEADRACE TUNNEL

A headrace canal will be blasted through the rock strata of Búðarháls (**Fig. 5.1**). The canal will be 420 m long, primarily through basalt rock.

At the end of the headrace canal is a concrete water intake structure with two openings. This is followed by a headrace tunnel extending 4 km from the intake to the surge basin (**Fig. 5.3**). The rock strata along the course of the tunnel are in some respects similar to those of the tunnel of the Sultartangi power plant and are regarded as acceptable for tunnel construction. An estimated 50% of the way the tunnel are through basalt, 10% through scoria, 30% through sedimentary rock, 5% through liparite and 5% through other types of rock. The tunnel changes direction midway under Búðarháls to avoid

poor tunnelling strata thought to be there.

The tunnel is to be blasted in traditional manner in two phases. First the chamber will be blasted out and reinforced, after which the lower section of the tunnel will be blasted. Blasting work will be carried out from both ends of the tunnel. Material extracted on the Sporðalda reservoir end, which is not utilised in dams and roads, will be dumped below the water level of the Sporðalda reservoir, while material extracted from the tunnel on the end of the Sultartangi reservoir will be utilised to create a level area and a storage area beside the power house and for road construction.

Map 5.1 showing **Structures of the Búðarháls power plant, p. 20.**
Legend
Power plant reservoir
River channel which will mostly dry up
Colour changes show 100 m changes in elevation
Archeological sites
20 m contour lines

Map 5.2 showing **Quarries and work camps, p. 21**
Legend
Power plant reservoir
Colour changes show 100 m changes in elevation
20 m contour lines
Material for road construction
Dam material
Aggregate for concrete
Work camp for Búðarháls power project
Work camp for road and transmission line construction

Fig. 5.3 showing **Cross-section of the tunnel and powerhouse of the Búðarháls power plant, p. 22**
Legend
Trenches
Tunnel
Dam
Sultartangi reservoir
Powerhouse
Water intake
Surge basin
Búðarháls
Sporðalda reservoir
Headrace tunnel

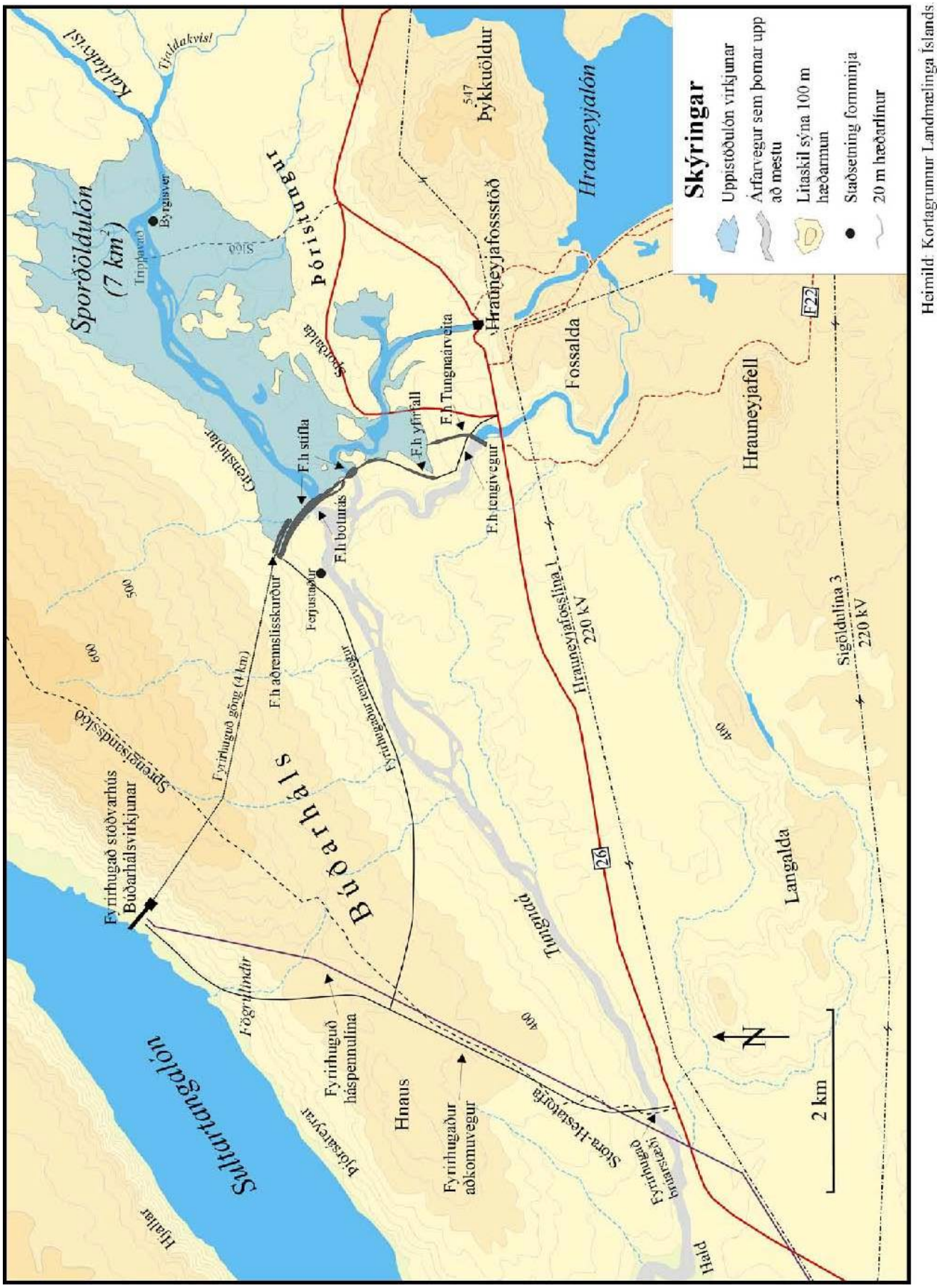


Fig. 5.1 Structures of the Búðarháls power plant

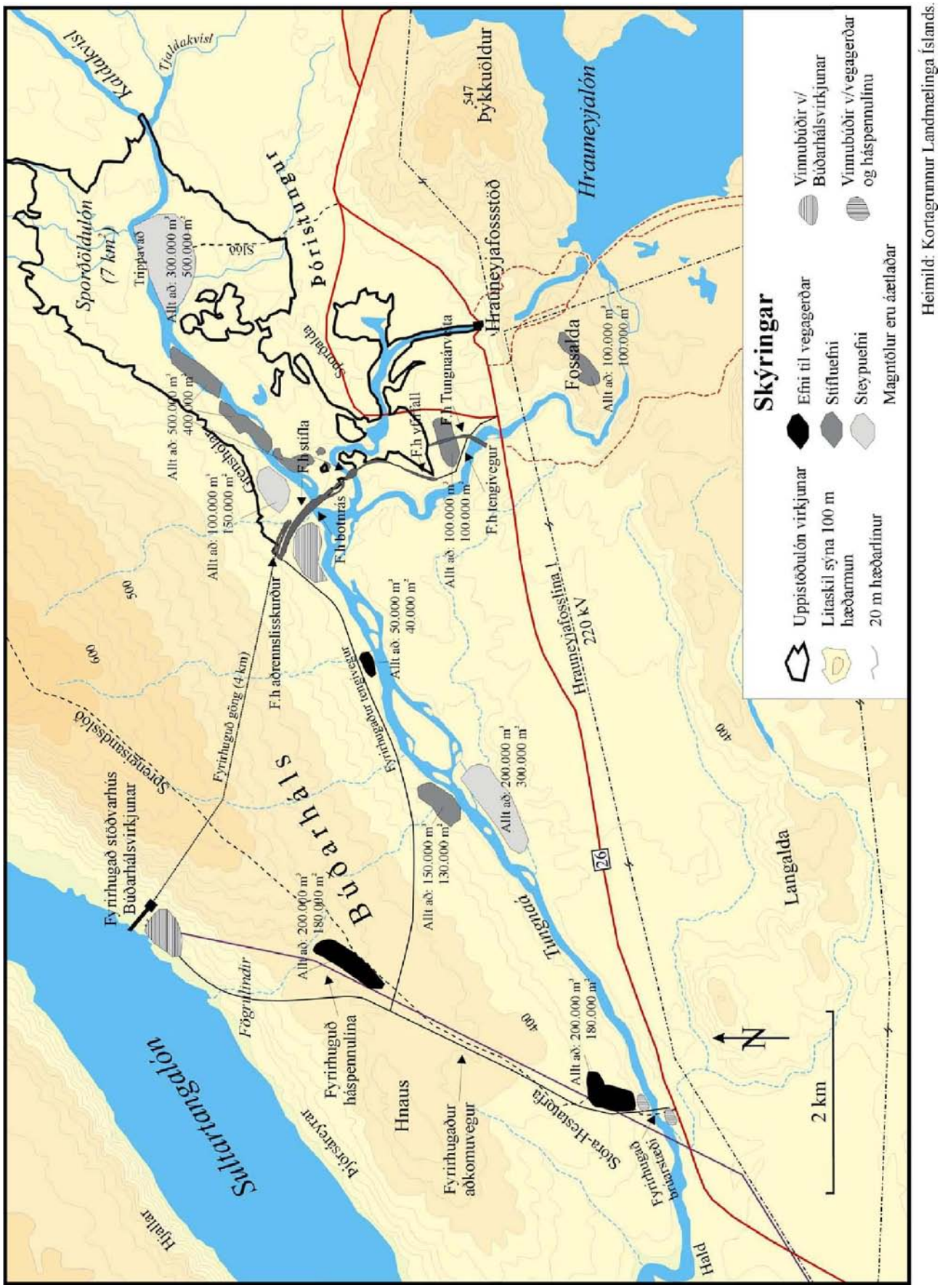


Fig. 5.2 Quarries and work camps

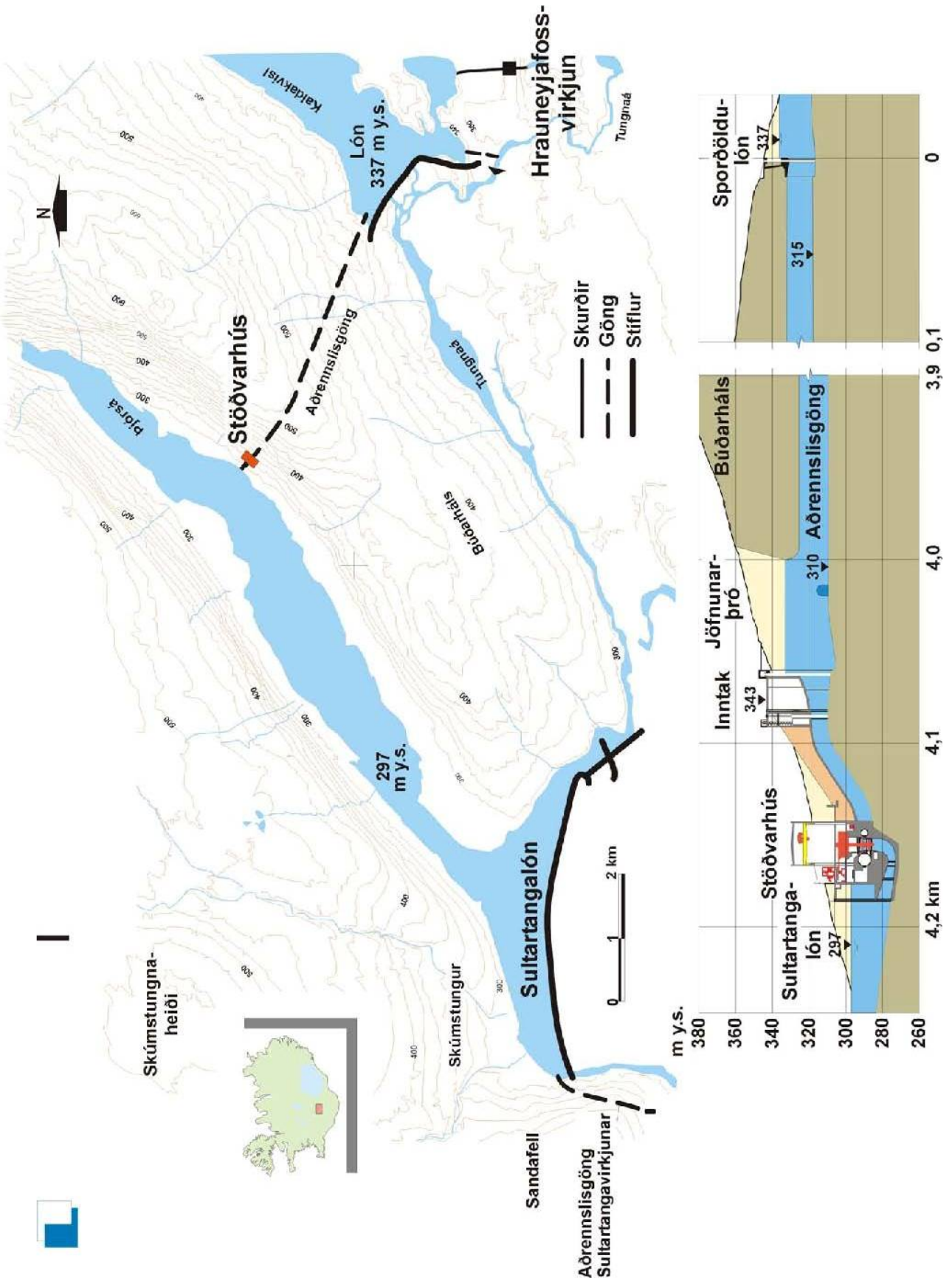


Fig. 5.3 Cross-section of the tunnel and powerhouse of the Búðarháls power plant

5.1.4 POWERHOUSE

The powerhouse is above-ground but set into the slope of Búðarháls at the Sultartangi reservoir (**Fig 5.1**). One or two turbines are planned, but the powerhouse will be in general situated so that the erection bay floor will be on the southwestern end and the control room in front of it (**Fig. 5.3**).

The substation building will be beside the tailrace canal, on a level site created with material extracted from the tunnel. The building is of concrete and located some 100 m from the powerhouse.

5.1.5 TAILRACE CANAL

Most of the tailrace canal will be excavated through loose material, but next to the powerhouse rock must be blasted. Loose material from the canal will be evened out along its banks. At the bottom the channel is 20 m wide and it ends at the Sultartangi reservoir, some 330 m from the powerhouse.

5.1.6 ESTIMATED PROJECT SCHEDULE AND WORKFORCE

The estimated construction time for Búðarháls power plant is 3-4 years. Additional preparation time is needed for design and compiling tender documents and negotiations with contractors and producers.

Setting up of facilities will begin as soon as possible in the 1st year of the project. Excavation for the powerhouse and road construction will begin early in the 1st year and the turbine activated at the end of the 4th year of construction. The plan has been drafted with the aim of shortening the time elapsing until the turbine is activated as much as possible.

An estimated 300 persons will work on the project at its peak and the total labour involved is estimated at around 500 man-years. During its operation, the station will generally be unmanned, but its operations will create 1-3 jobs. It will also create summer jobs,
including jobs for students with land reclamation and planting of vegetation and station maintenance work.

5.1.7 POSSIBLE LOCATION OF WORK CAMPS

A variety of activities take place in work camps, as discussed here. Firstly, they serve as the daily accommodations for contractors' and work purchaser's employees. Secondly, they include office facilities for both contractors and the work purchaser, workshops, storage areas and a concrete production plant. Care must be taken to ensure that workers' accommodations are at a sufficient distance e.g. from activities of large construction vehicles and machine shops due to the noise created by the activities which take place there.

Two locations can be considered for the location of work camps for the project (**Fig. 5.2**). They are to be located below the proposed dam on the Búðarháls side and also within walking distance of the powerhouse by the water's edge of the Sultartangi

reservoir. Once work on the power plant is concluded, the work camps and roads to them will be removed and the surrounding land restored as much as possible.

The probable location for a work camp for road construction would be on the Búðarháls side of the River Tungnaá, by the proposed bridge site (**Fig. 5.1**). This location would also be suitable for a work camp in connection with the construction of the transmission line.

5.1.8 ROAD AND BRIDGE CONSTRUCTION

A 7 km, paved access road will be laid to the powerhouse of the Búðarháls plant from the main road (Highway 26) between the Sultartangi power plant and the Hrauneyjafoss plant. This road must cross the River Tungnaá and the bridge will be located just above the current crossing by suspension cable, about 1 km above Hald. This road will be open to traffic by the public. It will be possible to drive along the dam if there is no spillover flow and along a 6 km connection road from the main dam to the access road to the powerhouse. This connection road will be build along the current track wherever possible. The main roads and tracks are shown in **Fig. 5.1.**

The draft scoping document (sent to the Planning Agency on 23 October 2000) suggested a link from the access road above Fögrulindir to the powerhouse. The current proposal, on the other hand, assumes a link from the access road below Fögrulindir and along the bank of the Sultartangi reservoir to the powerhouse. It should be pointed out that there are two existing tracks in this area, one above Fögrulindir and the other below it and down along a gully to the Sultartangi reservoir. After closer examination is was deemed preferable to take the route below Fögrulindir in part due to snow accumulation and a steep slope. This arrangement will also involve less disturbance to Fögrulindir.
Fig. 5.1 shows the altered arrangement of the access road. The proposed transmission line route is not altered by this arrangement as it follows a straight line down to the powerhouse. The track above Fögrulindir can be used as a working track for building the transmission line.

5.1.9 QUARRIES AND SPOIL SITES

All dam material can be obtained from the surrounding area. Material from the headrace canal, the tunnel, the intake and powerhouse site will be used as much as possible for the dam and road construction. Core material can be obtained north of Tungnaá, below its junction with Kaldakvísl, and possibly partly from the previous quarries by the Hrauneyjafoss power plant (by Fossalda). Filter material will be obtained from the sandbars of Kaldakvísl in the reservoir site and supporting fill from the spillover site, headrace canal, sandbars of Kaldakvísl and tunnel. Material for slope protection will probably be obtained from the headrace canal and tunnel. Rock for wave protection will be extracted from rock north of Kaldakvísl or graded rock from the headrace channel and tunnel. The possibility of extracting material from the reservoir bottom, where aggregate has been quarried for some time now, will also be investigated. Protective rock and aggregate for concrete can be extracted there. It is assumed that much of the aggregate to be used in concrete can be extracted from the sandbars of Kaldakvísl and/or the River Tungnaá.

Spoil sites for excavated material will be primarily on the bottom of the proposed

Sporðalda reservoir and in and by the Sultartangi reservoir.

Fig. 5.2 shows the proposed quarries and estimated maximum quantities of material and size of each location.

5.1.10 TRANSPORT OF HEAVY LOADS DURING THE CONSTRUCTION PERIOD

Transport of heavy loads on the national road system during the construction period will be required for electric and mechanical equipment, cement, reinforcing steel, steel piping and work camps. An estimated 1500-2000 trips will be needed during the construction period. In addition, considerable passenger transportation will be involved, including an estimated 500 bus trips with employees to and from the workplace.

5.1.11 QUANTITIES AND VOLUME

The key earthwork volume figures for the completed Búðarháls power plant are estimated as follows:

Table 5.1: Búðarháls power plant, quantities

	Excavation (m^3)	Fill material (m^3)
Dam	65,000	
Filter		105,000
Core		100,000
Supporting fill		320,000
Slope protection		85,000
Wave protection		35,000
Spillover	370,000	5,000
Bottom outlet	20,000	
Tungnaá diversion	100,000	
Headrace canal	145,000	
Headrace tunnel	590,000	
Powerhouse, intake and surge basin	330,000	20,000
Tailrace canal	70,000	
Road construction	50,000	270,000
Total	**1,740,000**	**940,000**

In addition around 54,000 m^3 of concrete will be used.

5.2 BÚÐARHÁLS LINE 1

5.2.1 TRANSMISSION LINE LOCATION

A 220 kV transmission line, Búðarháls line 1, is to be built from the substation of the Búðarháls power plant to the substation of the Sultartangi power plant to connect the Búðarháls power plant to Landsvirkjun's transmission grid.

The line is to follow the current track part way from the Búðarháls powerhouse over Búðarháls, east of Fögrulindir and then along the proposed access road by Stóra-Hestatorfa and from there across the River Tungnaá just east of Hald. From there the

line would be laid parallel to the current transmission lines to the substation at the Sultartangi power plant (**Fig. 5.4**). The transmission line is a total of 17 km in length. The illustration also shows the proposed new tracks which need to be made for Búðarháls line 1 and the tracks which will need improvement. **Fig. 5.5-5.7** show the proposed route of Búðarháls line 1. The perspectives are indicated in **Fig. 5.4.** Finally, the proposed Búðarháls line 1 and the proposed access road and powerhouse structures are shown from above the Sultartangi reservoir in **Fig. 5.8.** It must be pointed out that to show the position of the transmission line clearly, both the towers and the wires are shown with a darker colour on the photographs than they will actually be.

In selecting the route for the transmission line over Búðarháls, regard was had for the vegetation in the area.

Map 5.4 showing Proposed Búðarháls line 1, p. 27
Legend
Colour changes show 100 m changes in elevation
Transmission line
Repaired older track
New track
20 m contour lines

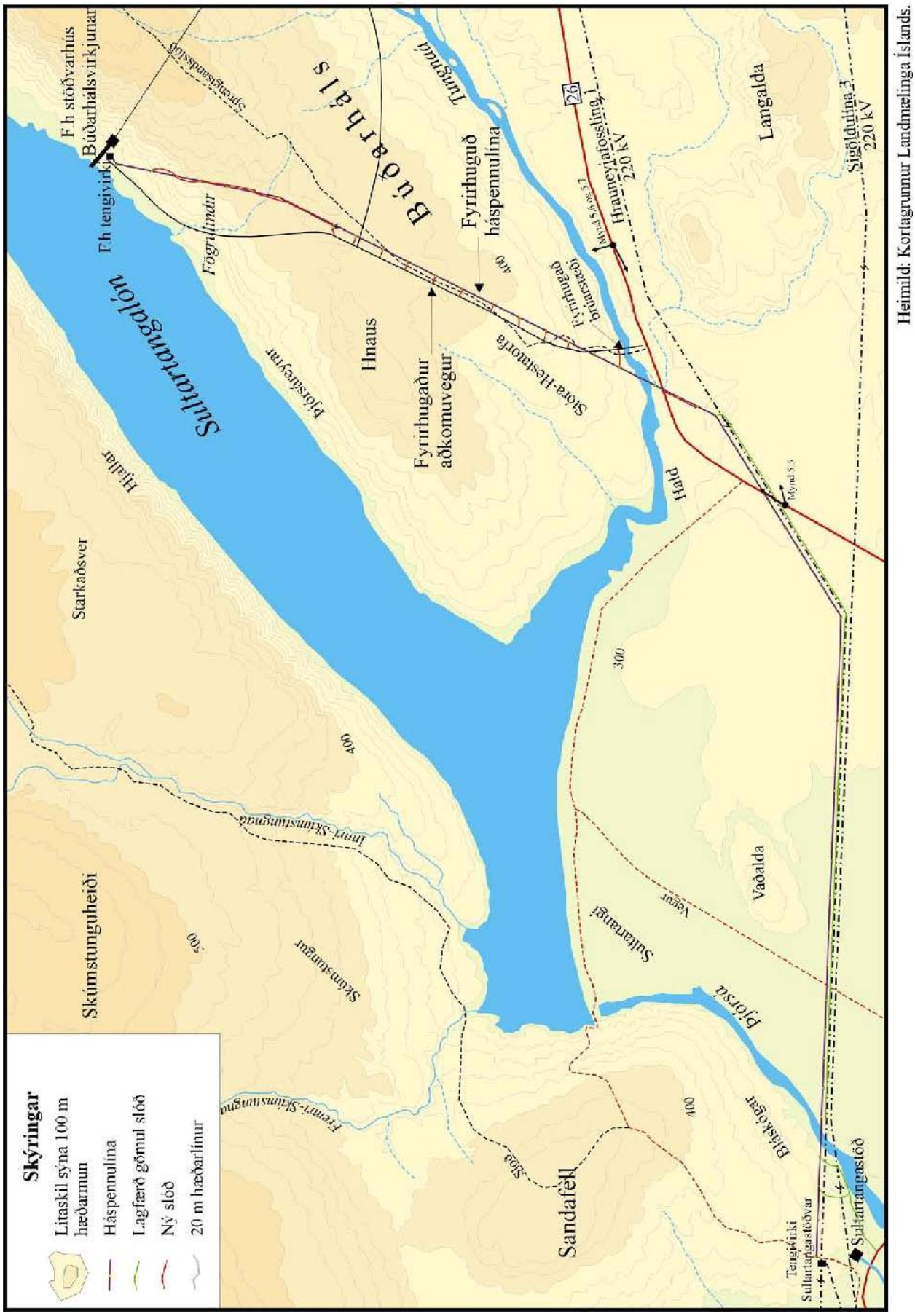


Fig. 5.4 Proposed Búðarháls line 1

Fig. 5.5 Búðarháls line 1, looking north over Búðarháls from Highway 26, with Hrauneyjafoss line 1 in the foreground. Both the towers and the wires are indicated more clearly by having them a darker colour than they will actually be.

Fig. 5.6 Búðarháls line 1, looking west along Highway 26. Both the towers and the wires are indicated more clearly by having them a darker colour than they will actually be.

Fig. 5.7 Búðarháls line 1, looking northwest over Búðarháls from Highway 26. Both the towers and the wires are indicated more clearly by having them a darker colour than they will actually be.

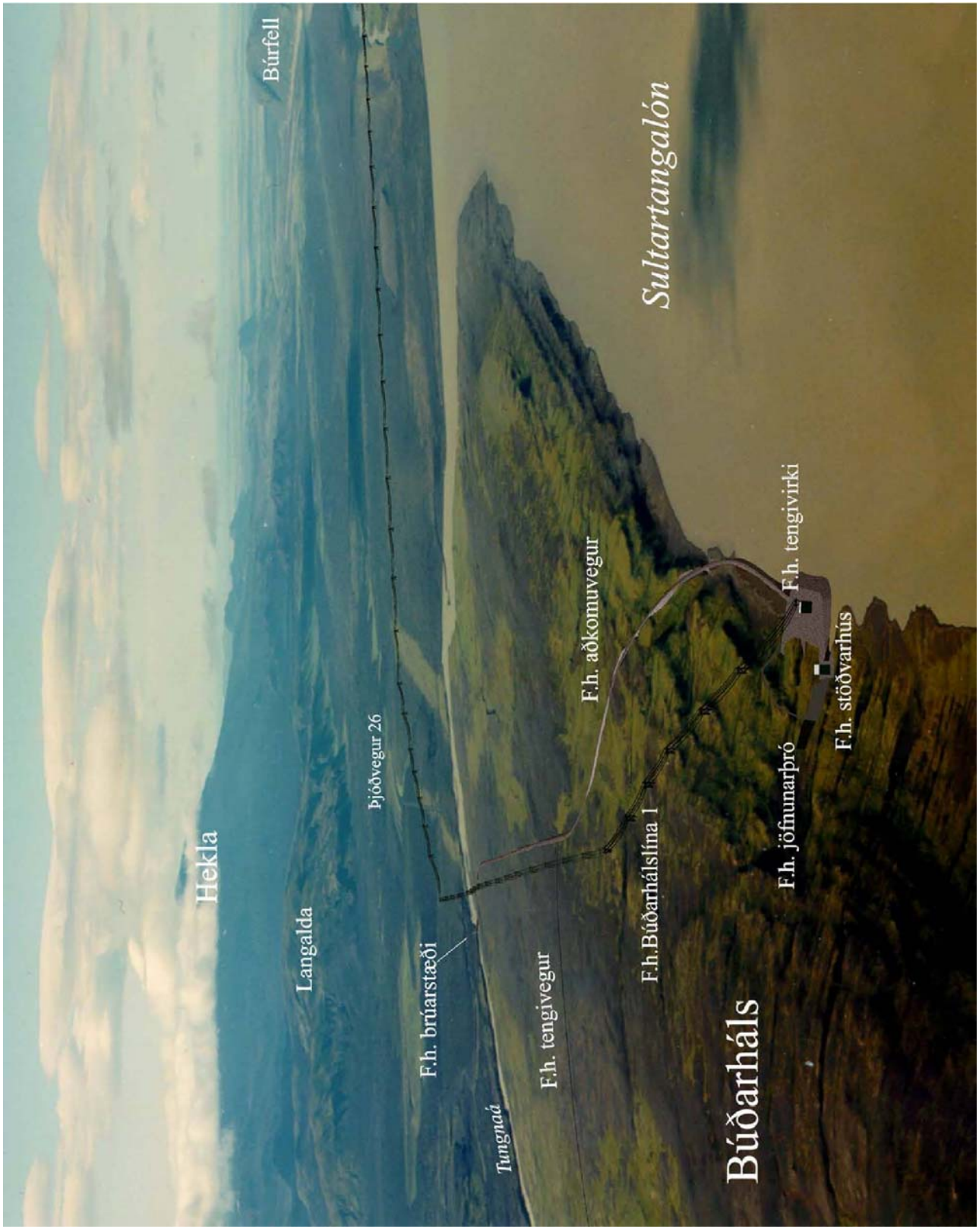
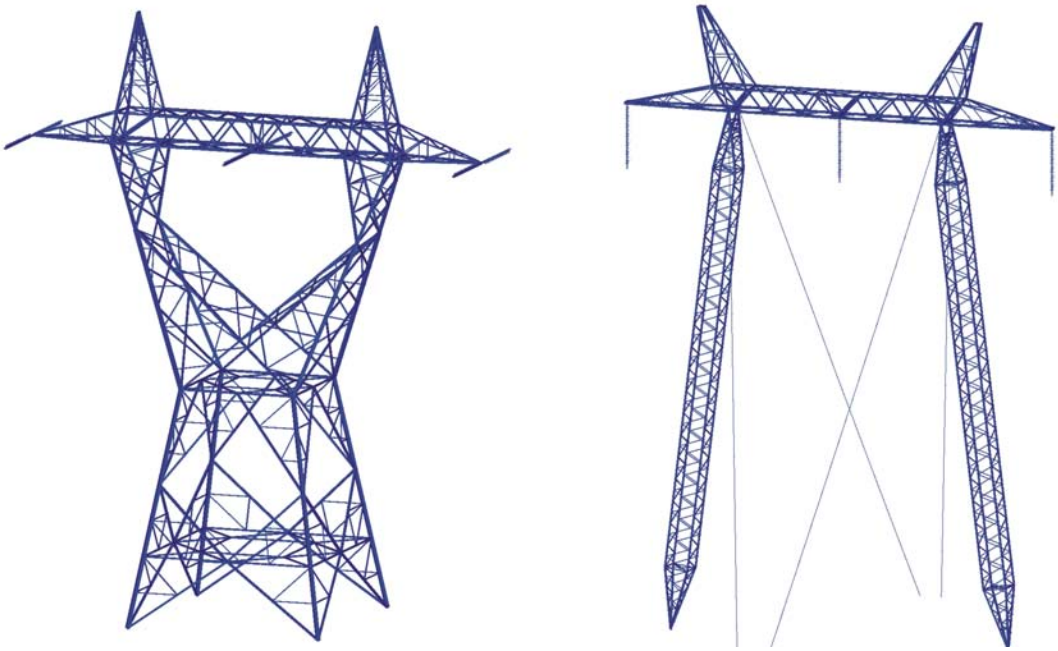


Fig. 5.8 Looking south over the proposed site of the Búðarháls powerhouse, Búðarháls line 1 and the access road. Both the towers and the wires are indicated more clearly by having them a darker colour than they will actually be (Photo: Hreinn Magnússon).

5.2.2 TYPE OF LINE AND TOWERS

The Búðarháls line 1 will be constructed for 220 kV operating voltage, as previously mentioned. Most of the towers used for the line will be so-called M towers, which are guyed lattice steel towers, erected on concrete foundation footings. The towers will be assembled on-site or transported to the site in modules. The towers are 20-30 m high and around 20 m wide (**Fig. 5.9** and also **Fig. 5.5**).



Tension tower M tower

Fig. 5.9 Towers

Excavation is needed for the tower footings and guy-line anchors. For each tower a level area must be prepared which will be used for completing the footings, erecting the towers and other work involved.

The estimated volume of material needed for the tracks and level areas of the transmission line is around 20,000 m^3. Areas which can be considered for quarrying material are shown in **Fig. 5.2** along with quarries previously used for the Sultartangi power plant.

5.2.3 ESTIMATED PROJECT TIME AND WORKFORCE

Construction of Búðarháls line 1 is estimated to take around 1½ years and conclude shortly before the proposed Búðarháls power plant comes online.

The total work input is estimated at 23 man-years. The amount of work required varies and is spread over the construction period of around 1½ years. The workforce required depends upon the contractor's arrangements during the project period, but at the peak (during the summer) the maximum number of employees required will be around 25.

5.2.4 WORK CAMPS

It is assumed that a work camp and facilities for the contractor building Búðarháls line 1 will be set up on one side of the proposed Tungnaá bridge site. Another possibility would be to use the same work camp for the power plant and transmission line construction.

5.2.5

BUILDING TRACKS AND CLEAN-UP

Tracks need to be built to the towers. Older tracks can be expected to need improvement and new ones may need to be built. The transmission line will lie parallel to the access road to the power plant and make use of this road as access route to the line. There are numerous older tracks on Búðarháls (**Fig. 2.1 and 5.4**) and the former Sprengisandur route runs over the ridge from the suspension cable crossing over Tungnaá, around 1 km above Hald, while another track runs down Búðarháls north of Fögrulindir. As these tracks are close to the proposed Búðarháls line 1, they can be utilised for the project. Furthermore, an older track can be used in constructing the transmission line parallel to Hrauneyjafoss line 1 west to the substation at the Sultartangi power plant.

Once the construction of Búðarháls line 1 is complete, the surface area around the towers will be evened out and returned to the condition of the surrounding area.

5.2.6 QUARRIES AND SPOIL SITES

The same quarries and spoil sites will be used for Búðarháls line 1 as for the Búðarháls power plant, as well as quarries on the transmission line route south of Tungnaá, for instance, near the Sultartangi power plant.

6 OPTIONS

6.1 BÚÐARHÁLSVIRKJUN

For purpose of comparison with the main scenario of the Búðarháls power plant (Option 1), several other power station options have been examined and compared. In 1992 a report was issued comparing the options of an upper and lower Búðarháls power plant.[27] The current project design, and the proposal upon which the EIA is based, has been referred to as upper Búðarháls power plant (Option 1) as provided for in a project design report of 1999.[28]

Two main possibilities have been considered for utilising the drop between Hrauneyjafoss and Sultartangi, referred to as the upper Búðarháls power plant (Option 1, cf. Section 5.1) and the lower Búðarháls power plant (Option 2).

[27] Hönnun hf, 1992.
[28] Hönnun hf, 1999.

6.1.1 UPPER BÚÐARHÁLS POWER PLANT (OPTION 1)

This option has been described in Section 5.1. Since the adoption of the Regional Plan of the Central Highlands a change was made to have the project design for the Búðarháls power plant with an above-ground powerhouse by the Sultartangi reservoir and with its headrace tunnel rather than tailrace tunnel through Búðarháls. The upper Búðarháls power plant is included in the Regional Plan of the Central Highlands 2015, but the powerhouse was located on the east side of Búðarháls, by Sporðalda reservoir. The main reason for these changes is that it was deemed necessary for access and maintenance of the tunnel to have it above the water level of the Sultartangi reservoir and therefore change it to a headrace tunnel. The inflow of groundwater during the construction period will also be less as a result. This is the same option with an improved application. **Table 6.1** lists the advantages and disadvantages of this power plant option compared to Option 2.

Table 6.1: Advantages and disadvantages of upper Búðarháls power plant, Option 1

Advantages	Disadvantages
• All above-ground structures are north of the River Tungnaá, outside of the area with post-Ice Age lava, on relatively well explored bedrock. • Less seepage from the reservoir. • Smaller reservoir, less vegetation submerged under water. • Easier to deal with floods during construction period, since the Tungnaá river channel and flood route from the upper power plant is outside the construction area and only water flow in Kaldakvísl needs to be dealt with.	• A long headrace tunnel, with proportionally high drop losses, reducing the efficiency of the power plant. Reduction in generating capacity of 6-7%. • Construction area is more spread out than for the lower Búðarháls power plant. • Roads and high transmission line must lie over Búðarháls.

6.1.2 LOWER BÚÐARHÁLS POWER PLANT (OPTION 2)

There are two proposals for the lower Búðarháls power plant, which involve a power plant on the channel of the River Tungnaá at Hald. Both proposals call for damming Tungnaá about 1.5 km above Hald, with the dam stretching from Búðarháls straight across the river Tungnaá to Langalda. This would form a reservoir (referred to here as Langalda reservoir) with a surface area of some 21 km^2 (**Fig. 6.1).** The first proposal calls for an above-ground powerhouse and tailrace canal along the channel of the River Tungnaá. The second places the powerhouse underground and the tailrace tunnel down under Hald.

The main disadvantages of the lower Búðarháls power plant, compared to Option 1, is that the Langalda reservoir would be 3 times the size of the Sporðalda reservoir and uncertainty is high concerning seepage from the reservoir. The existing road to the south of the River Tungnaá, and Hrauneyjafoss line 1, would have to be moved out of the reservoir location. The main advantage of this option is the increased generating

capacity of 6-7%, while this is offset by higher cost of the power plant, making the difference in power price insubstantial.

Table 6.2: Advantages & disadvantages of the lower Búðarháls power plant, Option 2

Advantages	Disadvantages
• Water routes are short and drop losses low. • Structures to be built are all within a very limited area. • Reservoir volume is 90 Gl as compared to 24 Gl for the upper power plant option, which is more favourable from an operating point of view.	• The main dam would be constructed on a layer of very porous recent lava which is at least 40 m thick. Construction of the foundation would thus be difficult and the cost uncertain. Substantial seepage under the dam can be expected. • The dam and reservoir could conceivably be affected by volcanic activity. • The land flooded would be some 14 km2 more than that flooded following the upper option, resulting in greater environmental disturbance. • Research on the dam site would be more expensive due to the more complex geology than for the upper dam site. • Floods could be greater (Tungnaá + Kaldakvísl), requiring a larger spillover. • A 10 km stretch of the transmission line Hrauneyjafoss line 1 would need to be moved higher up Langalda, since the current line would cross the middle of the reservoir. • The road to Hrauneyjafoss power plant would need to be moved higher up Langalda, near the former road route to Sigalda, since the current road crosses the middle of the reservoir. • Should there be any rupture to the dam at Sigalda or Hrauneyjafoss, the main dam is in the path of the flood waters.

Map 6.1 showing Lower Búðarháls power plant, p. 36
Legend
Power plant reservoir
Colour changes show 100 m change in elevation
20 m contour lines

Map 6.2 showing Búðarháls line 1, Options
Legend
Colour changes show 100 m change in elevation
20 m contour lines
Options 1-5

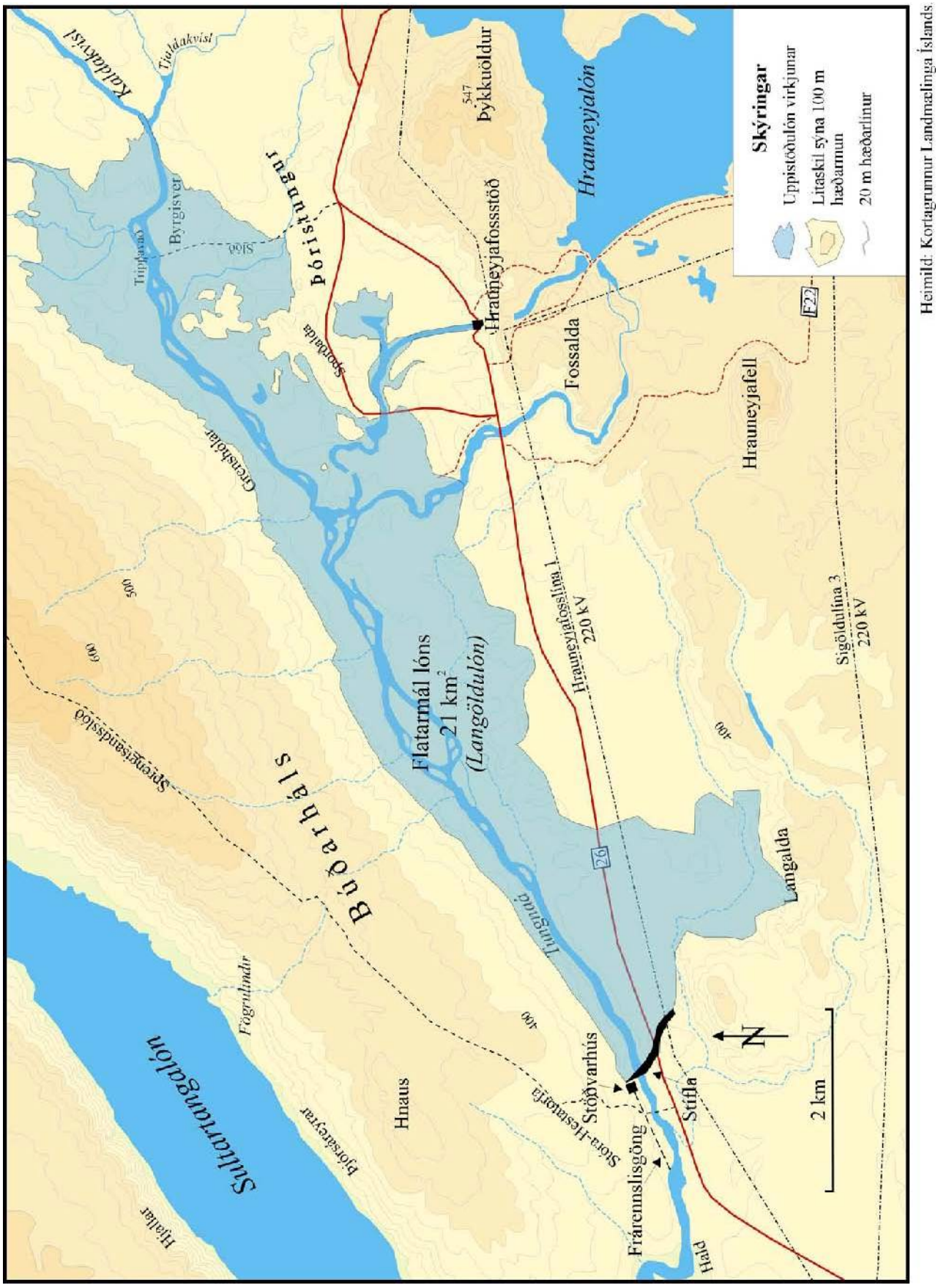


Fig. 6.1 Lower Búðarháls power plant

6.1.3 CONCLUSION

Taking the above points into consideration, it is considered evident that the upper Búðarháls power plant is the preferable option, despite the fact that the lower development option offers 6-7% greater generating capacity than the upper option. The Sporðalda reservoir is only 1/3 of the size of Langalda reservoir, floods would be greater at the lower power plant and dam construction more difficult. Seepage would also be greater at the lower power plant option. As far as transmission lines are concerned, the lower power plant option would not be more feasible, although it would avoid having to build a transmission line over Búðarháls, since Hrauneyjafoss line 1 would have to be moved from the reservoir site to a more conspicuous location. In the developer's estimation, Option 2 is a considerably less attractive solution to developing the drop between Hrauneyjafoss power plant and the Sultartangi reservoir.

6.2 BÚÐARHÁLS LINE 1

For purposes of comparison with the main proposal for Búðarháls line 1 (see Section 5.2), other transmission line routes in the are have been examined and compared (**Fig. 6.2)**.

6.2.1 OPTION 1

Option 1 is the proposed transmission line rout as described in Section 5.2, which is also the developer's prime choice.

6.2.2 OPTION 2

The Option 2 transmission line would lie across Fögrulindir and from there west over Hnaus and across the River Tungnaá just west of Hald. From there the line would run southwest to the existing Hrauneyjafoss line 1 and Sigalda line 3, and parallel to them to the substation at the Sultartangi power plant. The line would be around 16.2 km long.

6.2.3 OPTION 3

The Option 3 transmission line would be east of Fögrulindir, following a route similar to that of the main proposal for Búðarháls line 1. At the first tension tower on Búðarháls, the Option 3 route turns to cross Stóra-Hestatorfa and then over the River Tungnaá above Hald. From there the line would run to the existing Hrauneyjafoss line 1 and Sigalda line 3, and parallel to them to the substation at the Sultartangi power plant. The line would be around 16.6 km long.

6.2.4 OPTION 4

In Option 4 the transmission line would lie in a straight line from the substation at the Búðarháls power plant across Fögrulindir, Hnaus and Hald, then to Hrauneyjafoss line 1 and Sigalda line 3 and from there parallel to these transmission lines to the substation at Sultartangi power plant. The line would be around 16.4 km long.

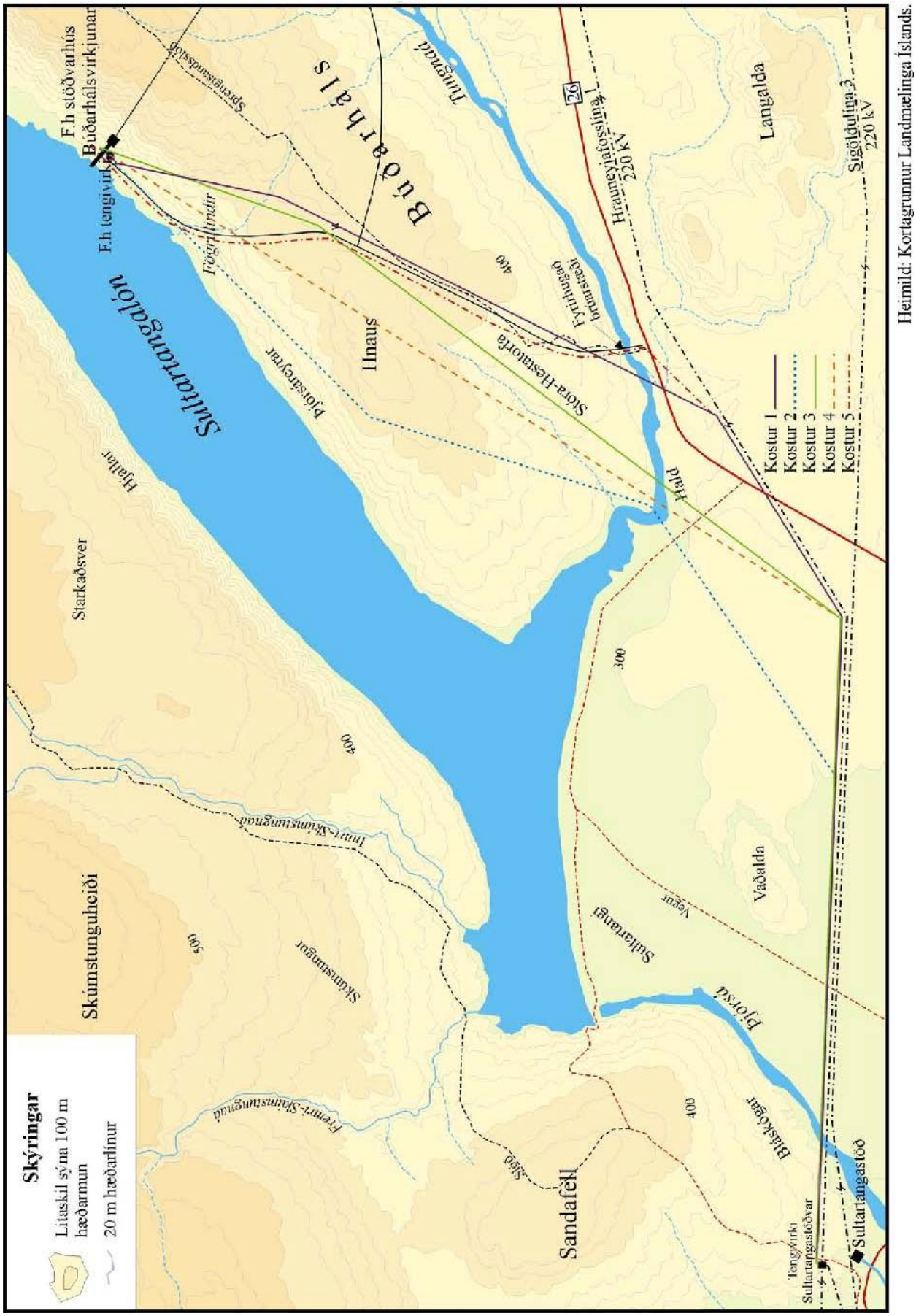


Fig. 6.2 Búðarháls line 1, Options

6.2.5 OPTION 5

In Option 5, Búðarháls line 1 would lie underground from the substation by the powerhouse of the Búðarháls power plant along a 7 km route across Búðarháls along the proposed access road to the substation at the site of the bridge over the River Tungnaá. A 300 m^2 area would there be fenced off for the substation and terminal facilities connecting the line to an above-ground transmission line to Hrauneyjafoss line 1 and Sigalda line 3. From there the transmission line would then run parallel to these lines to the substation at the Sultartangi power plant.

6.2.6. COMPARISON OF OPTIONS

The four options for above-ground transmission lines are compared and Option 1 is compared with the option of a transmission line partially below ground (Option 5).

ABOVE-GROUND TRANSMISSION LINE COMPARISON

The greatest differences between these options concern their route across Búðarháls, which is an area less disturbed than that south of the River Tungnaá, where the line meets Hrauneyjafoss line 1 and Sigalda line 3. There is also less vegetation along that part of the transmission line route than the section over Búðarháls.

The principal disadvantages of Options 2, 3 and 4, compared with the main option for Búðarháls line 1 are that the line route crosses more and more sensitive vegetation, new tracks need to be laid to the line routes and the lines do not join up with existing high-voltage transmission lines as soon. The following passage summarises the principal advantages and disadvantages of the various transmission line routes from the perspectives of cost-efficiency, safety, environmental concerns and technical aspects.

Cost-efficiency: The length of the transmission line is the prime factor determining its cost-efficiency. Generally, the shorter the line, the more cost-efficient it is in construction and operation. All of these transmission line options are of a similar length, and as a result the cost is practically the same.

Technical aspects: All the options are technically possible and do not present problems, since experience has been gained in construction of transmission lines like these.

Environmental concerns: The construction of new high-voltage transmission lines always involves some impact on the environment, due on the one hand to their visual impact and, on the other hand, the laying of tracks. The line routes in Options 2 and 4 lie across Fögrulindir and the more vegetated part of Stóra-Hestatorfa, while Options 1 and 2 [sic] lie above Fögrulindir and Option 1 lies outside of the vegetated are lower down on the ridge. The line routes in Options 2, 3 and 4 all join up with Hrauneyjafoss line 1 later, which adds further to their visual impact, while the route in Option 1 joins up with Hrauneyjafoss line 1 shortly after crossing the River Tungnaá. The line route in Option 2 has less visual impact on Búðarháls itself. Visual impacts are, however, always subjective and it is difficult to compare similar options and state definitively that one is better than another. Only the route in Option 1 (and part of Option 3) follows an existing

track over Búðarháls; for the routes in Options 2 and 4 new tracks would need to be laid over the ridge.

The electromagnetic field of the transmission lines would have a negligible impact for all of the options.

Safety: From safety perspective, there is no great difference between the line routes.

COMPARISON OF ABOVE-GROUND (OPTION 1) AND SUBTERRANEAN CABLE

Cost-efficiency is a major consideration in determining whether a high-voltage cable is subterranean or above-ground. The initial cost of laying the cable is highly dependent upon the type of land through which it passes, whether blasting is required for a subterranean cable or whether it needs to be placed in a concrete chute. For technical reasons, a 220 kV cable cannot simply be placed in a simple trench, as is done with lower voltage cables. It must also be pointed out that a subterranean cable would disturb a 10-15 m wide continuous belt, of a total of 10 hectares area of land upset. The difference in the cost of a 220 kV transmission line, either as a 17 km above-ground line or a 10 km above-ground and 7 km subterranean cable, over Búðarháls, is around ISK 300 million more for the subterranean cable option.

6.2.7 CONCLUSION

In the developer's estimation, Option 1 will have the least impact on the environment of the above-ground options examined. This is due in part to the fact that the least land area will be disturbed by the project under this option, both in the form of roads and disturbance of vegetation. Similarly, the routes in Options 2-4 meet up considerably later with existing transmission lines in the region, which adds to their visual impact.

The option of laying a subterranean cable along a 7 km stretch would partly reduce the visual impact but excavation would cause disturbance. The substation by the River Tungnaá would also be conspicuous. The cost of the subterranean cable would be around three times that of an above-ground line for the 7 km stretch in question, which would add some ISK 300 million to the cost. It should be borne in mind that a fair number of transmission lines exist in this area, which is a hydroelectricity producing region. When breakdowns occur, a considerably longer time, of as much as 2 weeks, may be required to repair a cable than an above-ground line. This is a disadvantage from the perspective of operational security where there is only a single line leading from the power plant, as will be the case for the Búðarháls power plant. On the other hand, the likelihood of malfunction is admittedly much lower for a subterranean cable than an above-ground transmission line.

Option 5 is not acceptable, in the developer’s opinion, as the uncertainty of any environmental advantage does not justify the greater initial cost.

6.3 ZERO OPTION

6.3.1 THE ZERO OPTION – NO POWER PLANT AT BUÐARHÁLS

The zero option would mean no hydropower development at Búðarháls. The area would be unchanged from its present state and no additional developments would be carried out between the Hrauneyjafoss power plant and Sultartangi reservoir. According to the Act on Landsvirkjun, No. 42/1983, as subsequently amended, Landsvirkjun's purpose includes the building and operation of hydroelectric generating plants and the country's main trunk transmission lines; and ensuring a sufficiently reliable supply of electricity to meet the needs of its customers at any given time.

Furthermore, Landsvirkjun is to take the initiative in building generating plants in its energy region, in order to ensure that the energy and power needs of the company's customers will always be satisfied.

A proposed power plant is to be constructed at Búðarháls due to increased demand for electricity. The Búðarháls power plant is a cost-effective solution to developing the drop between Hrauneyjafoss and Sultartangi, because the plant would further utilise the existing water equalisation and reservoirs.

Electricity consumption increases with economic growth, in addition to which power-intensive industry calls for a substantial increase in electricity production. Assuming that the increase in electricity consumption continues, it is clear that without the Búðarháls power plant, energy will have to be obtained elsewhere to meet the higher demand. Other hydroelectric projects can be considered, and geothermal energy could also be utilised or even thermal generating plants burning oil or coal. The proposed location of the Búðarháls power plant is in a region which has already been altered by human activity and is therefore an attractive development option. This development option has been included in master plans for exploitation of the Þjórsá-Tungnaá region for a long time. Legislative authorisation for the plant has already been granted.

6.3.2 ZERO OPTION – NO BÚÐARHÁLS LINE 1 CONSTRUCTED

The zero option as far as Búðarháls line 1 is concerned, i.e. that no high-voltage transmission line be constructed, could be said to be linked to the zero option for the Búðarháls power plant, since the transmission line is a pre-requisite for transmitting electricity from the plant to Landsvirkjun's transmission grid. Neither will be built without the other.

If Búðarháls line 1 is not built, the region will remain unchanged from its current state.

7 PRESENTATIONS

The draft scoping document for the proposed project has been presented on Landsvirkjun's website, www.lv.is The EIS will be made available on the website, and it is assumed that most parties will submit their comments and suggestions there. Anyone without an internet connection may send a letter containing comments to Landsvirkjun with the address "Búðarhálsvirkjun - Búðarháls line 1, Landsvirkjun, Háaleitisbraut 68, 103 Reykjavík".

Two on-site visits were made to the proposed project area in connection with the public presentation of the project. Statutory consultees and others were invited on an on-site visit on 24 October, which was attended by some 25 persons. Representatives of local authorities in the municipalities of Ásahreppur, Djúpárhreppur and Holta- og Landssveit were invited on a similar visit on 7 November. On 17 November the proposed project was presented to the Co-operation Committee for the Central Highlands and an on-site visit made to the area.

II. ENVIRONMENTAL IMPACT ASSESSMENT

8 INTRODUCTION

The following section describes the methods used to assess the environmental impact, discusses mitigating measures and the impact the project will have on the environment and, finally, examines possible mitigating measures as appropriate.

8.1 METHODS USED FOR ENVIRONMENTAL ASSESSMENT

The assessment of the environmental impact of Búðarháls power plant and Búðarháls line 1 is based primarily on research which has been carried out on the area, experience of other power development areas and suggestions from the parties consulted. The scoping document for Búðarháls power plant and Búðarháls line 1 includes a screening of influencing factors. Screening is used to define the main environmental aspects of the project which need to be emphasised in the EIA:

8.2 MITIGATING MEASURES

Mitigating measures can be of various types, and the mitigating measures applied depend upon the nature and scope of the project.

Art. 3 of the Regulation on Environmental Impact Assessment, No. 671/2000, defines mitigating measures as: “measures to avoid, reduce or offset negative environmental impacts”. Annex B, Accompanying document 2, provides more details of various definitions of mitigating measures.

In assessing the environmental impact of the Búðarháls power plant and Búðarháls line 1, mitigating measures are aimed primarily at the source of the impacts, i.e. to prevent or reduce the negative environmental impact right from the design stages of the structures. In this connection it could be mentioned, for example, that disturbance caused by road building will be kept to a minimum by using and improving previous tracks and roads, making use of the same access roads to the plant and tracks for the high-voltage transmission line, and routing the transmission line alongside of current lines for the greatest extent possible.

Sections 9-19 below discuss the environmental impact of the project and the principal mitigating measures taken.

8.3 DEFINITION OF THE IMPACT AREA

In assessing environmental impact it is important to define the impact area of a project like the Búðarháls power plant and Búðarháls line 1. The impact area for the projects is based, for instance, on their right of way. The right of way of Búðarháls line 1 is 86 m (based on 220 kV voltage). i.e. 43 m on both sides from the mid-line. No buildings are allowed within this area, in accordance with the Regulation on Electric Structures. The impact area is thus defined as the maximum distance at which the proposed project affects factors such as land use, vegetation, road construction etc. This comprises a long-term definition of the impact area and refers only to the direct impact; the visual impact, for instance, is excluded. For Option 5, i.e. laying the transmission line partly underground (see Section 6.2.5), the impact area is defined as a total of 15 m, which would be inside of the impact are of Option 1 as shown in **Fig. 8.2**).

All material for roads will be brought in, making the impact area for road building 40 m, i.e. the impact of road building will be felt on average for a distance of up to 20 m from the midline of the road.

The impact are of the Sporðalda reservoir is difficult to assess, because at this stage it is not clear how extensive the impact will be, for instance, on the vegetation surrounding the reservoir due to the higher ground water level. In this EIS the impact are of the reservoir is defined as extending 100 m from the banks, as it is assumed that an impact could be felt for a distance of up to 100 m from the average surface level of the water. The impact area of the River Tungnaá is defined by its current banks, except where quarries are proposed. There the impact area is based on the proposed size of the latter.

The impact area of the dams, powerhouse and other structures is defined as extending up to 50 m from their outermost points.

Table 8.1 shows the references which apply in determining the impact area of the Búðarháls power plant and Búðarháls line 1; the impact area of the proposed project is also shown in **Fig. 8.1** and **8.2**.

Table 8.1: Definition of impact area

Road building*	20 m
Dams, powerhouse and other structures**	50 m
Transmission line*	43 m
Sporðalda reservoir**	100 m
River Tungnaá	Current river banks

*From the midline

**From the external edges of the structures

The impact area of Búðarháls power plant and Búðarháls line 1 was also defined earlier in the assessment procedure, for instance, in the scoping document. There emphasis was placed on subjective assessment and the impact area was not mapped out precisely as has been done now. This explains any difference in the impact area shown in the scoping document and that which is discussed here.

Map 8.1 showing Impact area of the Búðarháls power plant
Legend
Impact area of the power plant
Colour changes show 100 m changes in elevation
20 m contour lines

Map 8.2 showing Impact area of Búðarháls line 1, Options
Legend
Impact area of transmission line for Option 1
Impact area of transmission line for Option 2
Colour changes show 100 m changes in elevation
20 m contour lines
Options 1-4

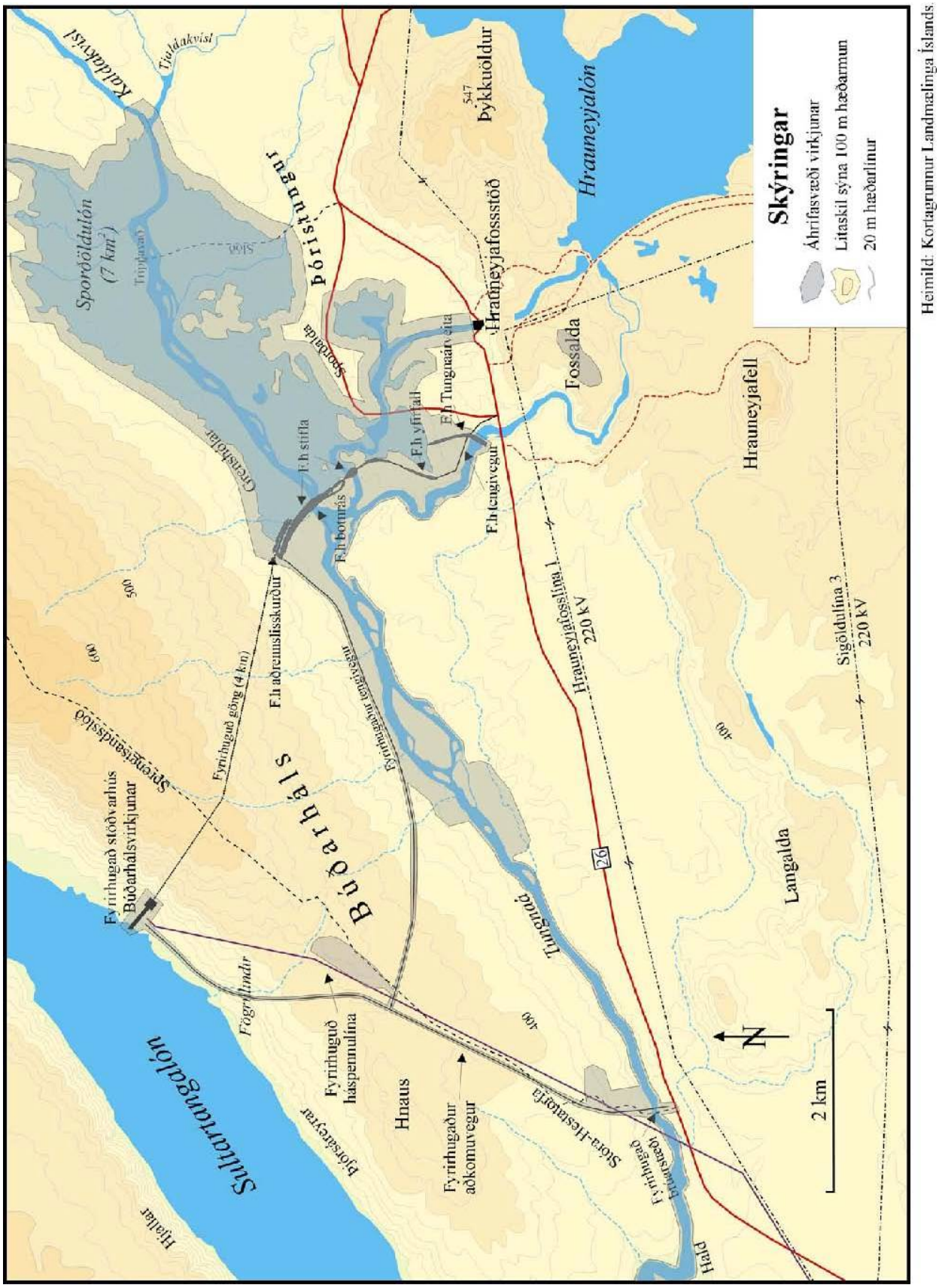


Fig. 8.1 Impact area of the Búðarháls power plant

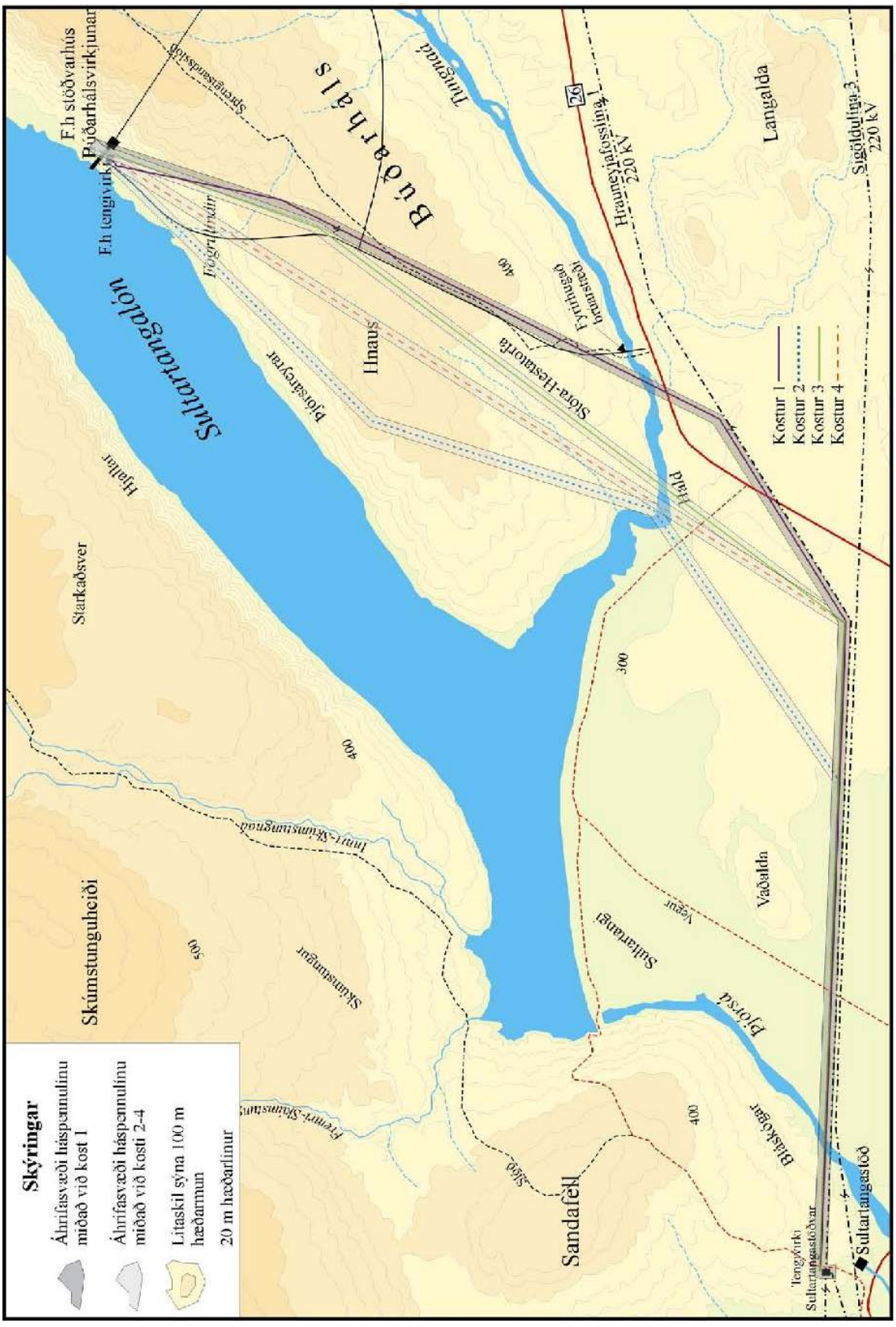


Fig. 8.2 Impact area of Búðarháls line 1, Options

9 LAND UTILISATION

9.1 IMPACT OF THE PROJECT ON LAND UTILISATION

9.1.1 SPORÐALDA RESERVOIR

The creation of the Sporðalda reservoir will mean loss of grazing land. Some trails will also disappear under water which have been used to collect sheep. A gravel quarry in the area will disappear. The ground water level in the near vicinity of the reservoir can be expected to rise. Experience of other similar structures suggests that new conditions can be created in some locations for vegetation in the area, e.g. in hollows close to the dam and reservoir.

9.1.2 ROAD CONSTRUCTION

The advent of a bridge over the River Tungnaá and the building of a road from there up onto Búðarháls will open up the area further. Today Kaldakvísl has to be forded at Trippavað, as the existing suspension cable crossing over the River Tungnaá is no longer considered serviceable. If the ford at Trippavað cannot be used due to high waters in Kaldakvísl, as generally happens in late summer, the only route is north to the bridge over Kaldakvísl and from there south to Búðarháls. Collecting sheep, for instance, will therefore be easier after the power plant is built than before.

9.1.3 DAMS AND OTHER STRUCTURES

Dams and other structures will not limit the current utilisation of land in the area.

9.1.4 HIGH-VOLTAGE TRANSMISSION LINE

The construction of the transmission line will limit utilisation of land as far as buildings are concerned. In the case of Búðarháls line 1, the right of way is 86 m wide (see Section 8.3). No other limitations are involved.

9.2. MITIGATING MEASURES

Proposed mitigating measures to reduce the impact of the project involve laying new tracks to replace those flooded under the Sporðalda reservoir. Possible road building would run north of the reservoir and connect with the built-up track from the dam to the access road of Búðarháls power plant. From an environmental perspective it could be favourable to have the track as close as possible to the bank of the reservoir, in part, to restrict the project to as limited an area as possible. The possibility of using a built-up road to combat erosion can be considered. Further details of the new tracks will be determined in co-operation with responsible parties and the Nature Conservation

Agency.

10 VEGETATION

10.1 IMPACT OF THE PROJECT ON VEGETATION

10.1.1 SPORÐALDA RESERVOIR

Wave erosion may be expected along the shores of the reservoir where the land slopes more than 7%. Where the shores are eroded, new shores with a slope of 7-10% are formed.[29] The geological and geographical conditions, higher ground water level and low fluctuations in surface level will substantially reduce the danger of wind erosion following wave erosion. Where the reservoir borders on flat land, the land can be expected to become wetter and vegetation conceivably to change in vegetated areas. It is also conceivable that conditions for vegetation could improve in unvegetated area. The power plant will generally operate with a full reservoir and its surface level will therefore fluctuate little. The advance of vegetation due to a higher groundwater level and steady surface level can be expected to be greater around the Sporðalda reservoir than around reservoirs where the surface level fluctuates greatly.

The total surface area of the Sporðalda reservoir is around 7 km^2. Around 2 km^2 of the land which will be flooded under water has extensive vegetation while around 4 km^2 is barren. Seed production will subsequently decrease in the area. The main areas which will disappear under the reservoir waters are gravel flats and sandbars (4.3 km^2) and moss heath (1.3 km^2). Wetlands vegetation covers around 0.1 km^2, grassland around 0.2 km^2 and various other types of vegetation cover just over 0.5 km^2. Moss heath and moorland are the most common types of vegetated land.

Some sheep grazing land will be lost due to the project. Declining numbers of sheep in the area have reduced grazing pressure in recent years.

No rare plants were found in the area and from the perspective of protecting vegetation there is no question of losing rare species.

10.1.2 ROAD CONSTRUCTION

The proposed roads follow for the most part the existing tracks in the are, making their impact on vegetation less than otherwise. At Fögrulindir a proposed access road comes close to wetlands and at one location the road crosses a wetland area.

10.1.3 DAMS AND OTHER STRUCTURES

Dam sites and other structures are mostly on gravel flats and moss heath on both sides of Kaldakvísl. On the south of the river there are almost barren gravel flats and low gravel hillocks. Moss heath is the most common type of vegetation in the area (see Section 3.4).

[29] Annex A, Accompanying doc. 8

The area around the powerhouse is primarily moss heath, and there are also sandbars below the slope towards Sultartangi reservoir.

Land below the dam could become waterlogged in a few places and vegetation could advance around the springs, as has been the case in the Kvíslaveitur diversion.[30]

10.1.4. HIGH-VOLTAGE TRANSMISSION LINE

The proposed transmission line route over Búðarháls is mostly over gravel flats and moss heath. Further west on Búðarháls the vegetation is denser and more varied and around Fögrulindir there is diverse vegetation and wetland patches. There the transmission line route avoids the wetlands for the most part.

The impact of Búðarháls line 1 south of the River Tungnaá, from the river to the Sultartangi power plant, will be slight since there is scant vegetation and little diversity, with sand-covered lava the dominant type of terrain. **Fig. 10.1** shows part of the proposed route for Búðarháls line 1 in this area. Part of Hrauneyjafoss line 1 is visible in the foreground and in the background the suspension cable crossing over Tungnaá is can just be seen.

Fig. 10.1 Sand-covered lava on the proposed transmission line route south of the River Tungnaá

10.2. MITIGATING MEASURES

10.2.1 RESERVOIR SITE

[30] Þóra Ellen Þórhallsdóttir 1994.

The proposed project will result in changes to the vegetation in the area, but there is not likely to be any loss of rare species, as previously mentioned. A total of 2 km^2 of the land which will be flooded by the advent of Sporðalda reservoir is well vegetated and includes around 0.1 km^2 of wetlands.

Land surrounding the reservoir will become wetter as a result of the higher groundwater level, especially where it is flat. The surface level of the reservoir will be kept as stable as possible and if the level of the reservoir needs to be lowered this will be done without damaging the vegetation.

Responsible parties will be consulted concerning possible mitigating measures due to changes in land utilisation arising from the Sporðalda reservoir. For instance, it could be possible to encourage sustainable advancement of vegetation in the are by protecting it from grazing.

No protective measures against erosion are proposed. If there is considered reason to repair individual locations, then the suggestion is made that eroded banks be repaired with material from the shores, so that it will fit in with the reservoir surroundings. A new, raised track (see Section 9.2) could, however, serve as protection against erosion. Banks will be monitored for possible erosion following the conclusion of the project and suitable measures taken if deemed necessary.

10.2.2 ROAD CONSTRUCTION

A special effort will be made to avoid all unnecessary disturbance in road building by Fögrulindir. There the road lies over a patch of wetland in one place; as a mitigating measure a culvert will be placed so that the water flow to and from these areas will be mostly unhindered.

Regard has been had for vegetated land in selecting the route and designing the road by utilising current tracks, both from the proposed bridge over the River Tungnaá and from the dam to the powerhouse.

By building the road below Fögrulindir and along the Sultartangi reservoir the springs at Fögrulindir will be less disturbed.

Once road building is complete, the disturbed areas will be repaired, evened out and seeded as appropriate.

10.2.3 POWERHOUSE AND OTHER POWER PLANT STRUCTURES

Since these structures will not have a decisive impact on vegetation there is no need to take special mitigating measures.

10.2.4 HIGH-VOLTAGE TRANSMISSION LINE

In designing the transmission line, regard has been had for the wetland patches by Fögrulindir and the line routed above them. An attempt was made to select the route so that it would have a minimal impact on vegetation. For instance, an existing track will be used to reduce the disturbance to the ground resulting from construction of the

transmission line.

Once construction of the transmission line is complete, the disturbed areas will be repaired, evened out and seeded as appropriate.

The transmission line is not expected to have a significant impact on vegetation elsewhere along its route, so no special mitigating measures will be taken there.

11 BIRD AND ANIMAL LIFE

11.1 IMPACT OF THE PROJECT ON BIRD LIFE

Bird life is fairly diversified in the proposed project area, which is at an altitude of 300-450 m above sea level with considerable vegetation. The project area is at the junction of highland and lowland areas and is a stopover spot for highland birds en route to nesting grounds farther inland. The unique feature of the area is its oases of vegetation, which provide habitats for a considerable number of bird species. The main impact of the project on bird life would result from a reduction of vegetated land area and the drying up of the channel of the River Tungnaá for the most part.

The power project is not considered a threat to any rare bird species. Several of those birds in the area are on the endangered list, however, where they are classified as rare or only found in specific locations. These species are the goosander (*mergus merganser*), harlequin duck (*histrionicus histrionicus*) and Barrow's goldeneye (*bucephala islandica*).

It is likely that the several dozen pair of pink-footed geese which nest in the area will move their nesting area, but this is a very small portion of the entire stock which is thought to number over
200,000 birds.

11.1.1 SPORÐALDA RESERVOIR

The impact of the reservoir (some 7 km^2) on bird life will be primarily due to the vegetated land flooded under water, around 2 km^2, which will reduce the birds' habitat. There will, however, be islands protruding in the reservoir (**Fig. 11.1**) which may possibly be suitable for birds after the area settles down once more following the project.

It is difficult to assess how and to what extent birds will somehow utilise the Sporðalda reservoir. There is little bird life on the reservoirs at Krókur and Hrauneyjar, but whether a reservoir attracts birds or not depends on how much glacial run-off is in the water: the more clear spring water, the better for the birds.

11.1.2 ROAD CONSTRUCTION

Up until now there has not been much traffic over Búðarháls in the spring when pink-footed geese and various other birds are nesting. The advent of a bridge over the River Tungnaá will open up the area still more with accordant traffic. Pink-footed geese will likely move away from the area, as the bird is sensitive to movement in the area. There

will be disturbance from traffic during the construction period, which could affect geese and other bird species in the area.

11.1.3 DAMS AND OTHER STRUCTURES

The channel of the River Tungnaá will dry up for the most part below the dam, although some seepage can be expected and some spring water will continue to flow in the channel. Ducks on the river and on Kaldakvísl from the junction with Tjaldakvísl, and nesting geese in the islands of the River Tungnaá, will probably decrease in number or even disappear when water no longer runs in the channel.

11.1.4 TRANSMISSION LINE

The impact of building the transmission line on bird life is of two particular types. Firstly there is the direct effect of the line, due to danger of flight collision, as it is fairly common for birds to fly into the lines and be killed. Secondly, work on building the towers directly impacts bird life, e.g. if construction takes place during nesting time. There is little traffic by swans in the area, and these are the birds which are in greatest danger of flying into the wires. Disturbance and movements during the construction period will cause some disturbance in those places where the transmission line crosses bird habitats.

Little research has been carried out in Iceland as to whether bird deaths drop several years after transmission lines have been built. Decades of experience by line maintenance personnel, travelling along the transmission lines for maintenance of Landsvirkjun's grid system, indicates that considerable numbers of birds fly into the wires during the first and second years after the lines are built. This then decreases and after several years have passed there are scarcely any dead birds found along the transmission line routes. There are some exceptions to this. Birds do appear to collide with the lines occasionally regardless of when they were erected.

11.2 IMPACT OF THE PROJECT ON FISH STOCKS AND FISHING

The water systems of the River Tungnaá and Kaldakvísl have already been altered by water controls and power plants, with accordant changes in the biosphere of the surrounding rivers and streams, as pointed out in Section 3.9.

The proposed Búðarháls power plant is not likely to make a decisive impact on the biosphere of the lakes and rivers of the area and substantially change the current sport fishing situation.

11.2.1 KALDAKVÍSL AND THE SPORÐALDA RESERVOIR

The conditions for primary production in Sporðalda reservoir are likely to be limited due to the high throughput. This will not likely affect the fish stocks in Kaldakvísl except that the lower section will be flooded by glacial water, which will reduce primary production in that area. The lower fishing spots of Kaldakvísl will also be flooded by the reservoir.

11.2.2 RIVER TUNGNAÁ

The advent of the Búðarháls power plant will mean the channel of the River Tungnaá will be almost dry below the dam, although some spring water will still flow down the channel, together with seepage from the dam. The advent of the Búðarháls power plant will therefore reduce the number of fish and conditions for fish to live below the dam and as far as the Sultartangi reservoir, since there will be little or no water flowing along the river channel. This is not regarded as a major change, since few fish are currently found in this area.

Fig. 11.1 The Sporðalda reservoir Photo: Hnit hf.).

11.3 IMPACT OF THE PROJECT ON OTHER WILDLIFE

The proposed project is not expected to have significant impact on other wildlife in the area.

11.4 MITIGATING MEASURES DUE TO THE IMPACT ON BIRD LIFE

11.4.1 SPORÐALDA RESERVOIR

No special mitigating measures are proposed.

11.4.2 MISCELLANEOUS

There are some nesting grounds in the near vicinity, e.g. in Rangárbotnar, Gljúfurleit and Veiðivötn, and it is conceivable that the geese, for example, could move there.

In building the roads, transmission line and all other development in the power plant area, an effort will be made to spare vegetated areas and thereby bird habitats as much as possible and to have regard for this in road building and other activities.

Apart from this, no other mitigating measures are proposed for the area due to the impact on bird life.

11.5 MITIGATING MEASURES DUE TO THE IMPACT ON FISH STOCKS AND FISHING

The flow and surface level of the reservoir Sporðalda will generally remain steady, and the less the fluctuations are in flow and surface level, the less is the impact on the biosphere.

12 HYDROLOGY

12.1 IMPACT OF THE PROJECT ON HYDROLOGY

12.1.1 SPORÐALDA RESERVOIR

The principal hydrological change resulting from the Búðarháls power plant will result from the proposed reservoir and increase in groundwater level in the near vicinity.

There will be some seepage from the reservoir, causing an increase in the groundwater level below the dam, in addition to which the flow of the springs lower down the channel of the River Tungnaá is likely to increase.

Seepage from the reservoir and a higher groundwater level could also cause oases of

vegetation to form in the low spots nearest to the reservoir. In all likelihood, seepage from the reservoir will end up in the Sultartangi reservoir.

12.1.2 ROAD CONSTRUCTION

The proposed road construction and bridge over the River Tungnaá and to the dam and powerhouse will not affect the hydrology of the area.

12.1.3 DAMS AND OTHER STRUCTURES

The damming of Kaldakvísl and the River Tungnaá will make the channel of the River Tungnaá below the dam practically dry up. While some seepage will flow into the channel, together with spring water, it is difficult to estimate how much water will flow along the channel.

12.2. MITIGATING MEASURES

No specific mitigating measures are proposed due to changes in hydrology, but changes will be monitored and measured regularly.

13 VISUAL IMPACT

13.1 IMPACT OF THE PROJECT ON THE VIEW

The creation of the reservoir Sporðalda, construction of the dam and powerhouse, and building of the transmission line Búðarháls line 1 and the access road to the powerhouse will cause visual impact.

13.1.1 SPORÐALDA RESERVOIR

The advent of the Sporðalda reservoir will alter the landscape in the area. The islands in the reservoir will, however, provide some variety, which can be considered to be an advantage (**Fig. 11.1**).

13.1.2 DAMS AND OTHER STRUCTURES

The dam construction, which includes a 2300 m long dam and spillover across Kaldakvísl, will cause a visual impact. The dam will be around 24 m high at its highest point.

The powerhouse will be above ground but partly set into the foot of the slope and is not expected to be very conspicuous, except perhaps if viewed from Skúmstungur west of the River Þjórsá.

13.1.3 TRANSMISSION LINE AND ROAD BUILDING

There is no way of avoiding the visual impact of Búðarháls line 1, both due to the line itself and the road route. The transmission line will lie across the ridge and to some

extent be silhouetted against the sky at its peak, but will be less conspicuous in other places where the land is lower. Once the line has crossed to the south of the River Tungnaá, it will follow Hrauneyjafoss line 1 and then also Sigalda line 3.

13.2. MITIGATING MEASURES

13.2.1 DAMS AND OTHER STRUCTURES

Emphasis will be placed on having the powerhouse and other structures fit in well with the surrounding environment.

13.2.2 TRANSMISSION LINE AND ROAD BUILDING

Efforts will be made to reduce the impact as much as possible by laying the line parallel to the proposed road and alongside of the existing Hrauneyjafoss line 1, then alongside of that and the existing Sigalda line 3, to the substation at the Sultartangi power plant. The transmission line is to join up with Hrauneyjafoss line 1 as soon as possible to avoid having transmission lines both sides of the highway for a great distance.

The proposed road construction involves mainly rebuilding of existing older tracks in the area. Disturbance due to new tracks will therefore be kept to an absolute minimum. An access road will be built up and paved and a track from the dam will also be built up, which could reduce off-road driving.

14 DISTURBANCE TO THE GROUND

14.1 PROPOSED QUARRYING AND EXCAVATION

The disturbance to land caused by the proposed project will be primarily due to excavation and to quarrying.

Borrow material will be obtained to a large extent from excavation of the headrace canal, intake, tunnel and powerhouse site and from the bottom of the Sporðalda reservoir. As a result, there will be fewer new quarries, although new quarries will be needed outside the reservoir site for material for road construction and the dam core.

The reservoir bottom will also be used as a spoil site as much as possible and material excavated from the powerhouse site and tunnel will be dumped by the Sultartangi reservoir.

14.2. MITIGATING MEASURES

The principal mitigating measures to prevent disturbance to the ground consist of limiting the quarrying and transport of material to the power plant area and cleaning up those areas affected well, as provided for by the Natural Protection Act, No. 44/1999 An access road will be built up and paved and a track from the dam will also be built up, which could reduce off-road driving.

Excavated material which cannot be used for construction of the dam or roads will be evened out upon conclusion of the project so that it fits in well with the landscape.

15 LANDSCAPE

15.1 IMPACT OF THE PROJECT ON THE LANDSCAPE

General speaking the main environmental impact of hydroelectric plants on the landscape is due to the land flooded by reservoirs, because of the changes which occur when watercourses are diverted from their natural course, and due to electricity transmission lines which must be built from the plants.

The land on the slopes of Búðarháls is well vegetated in many areas, especially in the north and west. The main environmental impact on the landscape will be due to disturbance of the ground, i.e. excavation for structures and quarrying. The reservoir which will be created will alter the landscape and the building of a transmission line from the power plant and roads will also mark the landscape.

Wave erosion can be expected along the shores of the reservoir where the banks slope more than 7%, but this is not expected to be very great. Where the shores are eroded, new shores with a slope of 7-10% are formed.

15.2. MITIGATING MEASURES

Excavated material which cannot be used for construction of the dam or roads will be evened out upon conclusion of the project so that it fits in well with the landscape. Quarry sites are expected to be similarly cleaned up afterwards, as provided for in the Natural Protection Act, No. 44/1999. The reservoir is relatively small compared to the size of the power plant and a major portion of the land which will be flooded is almost barren. The transmission line from the power plant will be relatively short and connect with the Sultartangi power plant. The line will lie alongside existing lines for much of its length, 10 km of a total of 17 km.

The main mitigating measures due the impact on the landscape are integrated into the design of the structures, good clean-up and landscaping following the conclusion of the project. Emphasis will be place on having structures fit in well with the landscape.

Although erosion around the Sporðalda reservoir is not expected to be great, this will be monitored and in individual areas repair of eroded banks could be required along the shores of the reservoir to reduce the extent of erosion.

16 OUTDOOR LEISURE AND TOURISM

16.1 IMPACT OF THE PROJECT ON OUTDOOR LEISURE AND TOURISM

Búðarháls and the vicinity is visited to some extent by travellers, primarily during the summer months. These are mainly organised sightseeing tours. On the other hand, by far the greatest amount of traffic passes by the area (to Landmannalaugar and over Sprengisandur) or stops short of this area (heading into Þjórsárdalur). The main conclusion is, that the proposed project is not likely to have any special impact on tourism in the area. It could also be concluded, however, that improved access to Búðarháls, with the advent of a bridge over the River Tungnaá, could boost the numbers of visitors to the region.

16.1.1 STRUCTURES OF THE BÚÐARHÁLS POWER PLANT AND SPORÐALDA RESERVOIR

The majority of travel operators surveyed were of the opinion generally that the proposed Búðarháls power plant project would have no impact on the travel industry or travellers in the vicinity of the power plant area.

Around 1/3 of all Icelandic travel service providers surveyed were of the opinion that the Sporðalda reservoir and dam would have generally a negative impact on tourism, while only 10% of local travel service providers were of this opinion.

16.1.2 ROAD CONSTRUCTION

Generally speaking the majority of travel service providers felt that a bridge over the River Tungnaá above Hald would have a positive impact on tourism, and most of them were of the opinion that the existing roads in the area needed improvement. Around 2/3 of local travel service providers also felt it was important to build new roads in the area, while national operators did not feel there was a need for new roads.

16.1.3 TRANSMISSION LINE

The majority of respondents were of the opinion that Búðarháls line 1 would have a negative impact on tourism and travellers.

16.2. MITIGATING MEASURES

Mitigating measures described above, e.g. in Chapters 13, 14 and 15, are expected to reduce negative impact on travellers. Furthermore, support will be provided for publication of a map of hiking and riding trails on Búðarháls and an information sign erected.

Apart from this no special mitigating measures are proposed due to the impact of the project on outdoor leisure and tourism.

17 ARCHAEOLOGICAL SITES

17.1 IMPACT OF THE PROJECT ON ARCHAEOLOGICAL SITES

A total of 32 archaeological sites have been found on Búðarháls and in Þóristungur. Six of these are in the impact area of the proposed project, one of them is a man-made structure, an ancient sheep collect in Byrgisver. The other five sites are of a historical nature: routes, overnighting sites and ferry sites, but no remains of human activity are visible. No archaeological remains in the proposed power plant area are on the protected list, although all archaeological remains enjoy general protection. Permission will be sought from the Archaeological Heritage Committee prior to commencing work.

17.1.1 SPORÐALDA RESERVOIR

The following archaeological sites will be flooded by the reservoir Sporðalda.

- **Byrgisver** is an old sheep collect, with walls of large, unhewn stones, west of Fremstatunga on the west edge of Þóristungur. The walls of the collect are around 1 m high and 0.5 m wide. The entire collect is some 20 m long and 12 m wide.
- **Miðtungur** is an old overnighting site on the west edge of Þóristungur by Kaldakvísl. There was a camp ground here, but no visible signs of it have been found.
- **Fremstatunga** is an overnighting site in the southwest corner of Þóristungur across from Hrauneyjar. There was a camp ground here, but no visible signs of it have been found.

In the opinion of the Institute of Archaeology, the archaeological sites which end at the bottom of the reservoir will be preserved well by rapid sedimentation. This makes it likely that the sheep collect in Byrgisver will not be subject to much damage at the bottom of the reservoir Sporðalda.

17.1.2 ROAD BUILDING AND WORK CAMPS

Paths from former times lie through Stóra-Hestatorfa and on the former Sprengisandur route on Búðarháls, where a proposed access road is to run from the bridge over Tungnaá to the powerhouse on the Sultartangi reservoir. There are existing tracks on the proposed route and therefore destruction of remains by the new road building will be exceedingly little or none. At the junction of the River Tungnaá and Kaldakvísl, near the proposed work camp site, is an ancient ferry site, but there are no visible signs of man-made structures which could be spoiled.

17.2. MITIGATING MEASURES

Other sites in the area, apart from those mentioned above, have in the estimation of the Institute of Archaeology, limited value for preservation as there are no visible man-made structures.

All traffic, quarrying and deviations from the proposed project will be examined having regard to the list of archaeological sites in the area.

18 RISKS

18.1 EARTHQUAKES

According to an assessment and evaluation of the risk of earthquakes in Iceland,[31] it could be concluded that there is no major risk in the proposed project area. It must be assumed, however, that structures, machinery and other equipment of the Búðarháls power plant could be subject to strain caused by earthquakes.

There is no known active earthquake source area at Búðarháls or in the near vicinity. Some earth tremors could occur in connection with an eruption in Mt Hekla. The main active source areas for major earthquakes near the proposed Búðarháls power plant are:

1 The eastern part of the South Iceland lowlands, i.e. Rangárvellir, Landsveit, Holt and Hreppar districts. The maximum strength of an earthquake in this area on the Richter scale is estimated at 7.2.
2 The Mt Hekla area Earthquakes linked to activity in Hekla, around 5.0 on the Richter scale.
3 The Vatnajökull glacier area This area is characterised primarily by earthquakes in the area from Bárðarbunga to Grímsvötn. The maximum strength of an earthquake in this area would likely be 6.2-6.4 on the Richter scale.
4 The Mýrdalsjökull glacier area Although most of the activity is around the volcano Katla, some earthquake activity is known slightly north of the glacier, e.g. Reykjafjöll and the surrounding area. The maximum strength of an earthquake in this area has been estimated at 5.5 on the Richter scale.

18.2 VOLCANIC ERUPTIONS AND LAVA FLOW

The volcanic systems closest to Búðarháls are Mt Hekla and the volcanic system by Veiðivötn. During the Holocene (<10,000 years ago) there has been volcanic activity in many locations of the Veiðivötn system and the Þjórsá and Tungnaá lava ran over the area. The area is, however, considered to be on the fringe of the most active region.

Possible danger of volcanic activity in the region in the future has been mapped out for Landsvirkjun in the area surrounding the power plants on the River Tungnaá.[32] Such mapping is based on information on past eruptions and the geology of this volcanically active region. Based on past eruptions, the possibility was considered that as much as 1 km^3 of lava could flow along a 30-35 km long fissure, resulting in a lava flow averaging 11 m thick. Following this, the risk of lava flow in the region was assessed, based on the probable origin of the fissure eruption. Five different locations for the eruption fissures were examined. According to the risk maps drafted, the probability of lava running over the power plant structures east of Búðarháls was not great. On the other hand, there is a possibility that an eruption could occur in the Tungnaá region at some time in the future, which could even alter the river channel or threaten the structures in the area.

[31] Flosi Sigurðsson et al. 1998.
[32] Páll Imsland, 1987.

As far as ash fallout is concerned, power plant turbines and equipment are sensitive to ash, which could come from known strato volcanoes such as Mt Hekla or Katla and there is a possibility of ash fallout from eruptions at Vatnaöldur or the Torfajökull region. The amount of ash fallout, however, depends upon the amount spewed forth by the volcano, the distance away and the wind direction while the eruption lasts. The Vatnaöldur region is around 25 km from the powerhouse of the Búðarháls power plant, Mt Hekla is some 30 km away, Torfajökull around 45 km away and Katla some 70 km distant.

A substantial ash fallout (1-2 m) at the Búðarháls power plant must be regarded as unlikely and possible damage from ash settling would be of limited consequence.

18.3 STORMS

Weather can be harsh and unpredictable in a region which lies 300-450 m above sea level and far inland. Precipitation generally increases with greater elevation and the temperature decreases similarly. Several weather observation stations are operated in the vicinity of Búðarháls. The Hrauneyjar station is the one likely to give the best picture of the weather in this region (**Table 18.1**).

Table 18.1: Weather in the vicinity of Búðarháls

Weather station	Alt. above sea level, m	Avg. annual temp., °C	Avg. wind speed, m/s	Max. wind speed, m/s**	Max. gusts, m/s	Period
Búrfell	249	2.2	7.2	38.4	48.2	1994-2000
Hrauneyjafoss	420	1.0	6.1	35.0		1980-82
Jökulheimar	726	-1.0	7.9	36.4	60.0	1994-2000
Vatnsfell	555	-3.9	8.3	29.4	42.9	1999-2000*
Veiðivatnahraun	647	-0.8	6.3	35.9	45.3	1994-2000

*October-April
**Based on 10 minute avg. wind speed

The structures under discussion here are not of the sort which storms would damage e.g. due to water losses from the reservoir, malfunction of valve apparatus, etc. Storms therefore are not considered a risk to the power plant itself. The exception here, however, are transmission lines which certainly are at risk of such.

18.4 FLOODING

The Búðarháls power plant is expected to accommodate a flow of up to 325 m^3/s. Floods can be expected in Kaldakvísl and Tungnaá, especially in the spring when snows melt. In a design flood the flow over the spillover is estimated at 1800 m^3/s and 3,000 m^3/s in an extreme flood. The Sporðalda reservoir will reduce the impact of minor floods in Kaldakvísl below the reservoir but will have little impact on larger floods.

The flow in an extreme flood in the River Tungnaá is estimated at 3,500 m^3/s, and all of which is expected to be able to flow along the channel of the River Tungnaá by the Hrauneyjafoss power plant and to the Sporðalda reservoir.

18.5 GLACIER BURST (Icel. *hlaup*)

Increased geothermal activity or subglacial eruptions can cause a large glacier burst, as was the case in the Vatnajökull eruptions of 1996 and 1998. There are active geothermal areas and volcanoes under the western and northern areas of the glacier Vatnajökull. These include Kverkfjöll, Bárðarbunga and Grímsvötn, as well as the area between the last two.

The Kverkfjöll area is north of the watershed, and all glacial water from there run northward in the river Jökulsá á Fjöllum. In the Bárðarbunga region, where a glacier burst would flow would depend upon the actual location of the eruption. It could run northward or end up in the River Tungnaá and even in Kaldakvísl. The Grímsvötn area and part of the area between Grímsvötn and Bárðarbunga is, however, south of the watershed. Glacial water from this region runs along channels under the glacier and then appears on Skeiðarársandur in the streams Gígjukvísl and Skeiðará, as well as in Núpsvötn and the River Skaftá.

Although the area of the Búðarháls power plant facilities is not classified as a risk area for glacier flooding, glacier burst in the glacial rivers of western Vatnajökull could have a limited impact on power plant operations.

19 ECONOMIC AND SOCIAL IMPACT

19.1 IMPACT OF THE PROJECT ON THE ECONOMY AND COMMUNITY

The employment drawing area of the Búðarháls power plant can be expected to cover all of Iceland, as the project will be publicly tendered. Some 500 man-years are involved in the construction of the Búðarháls power plant and around 23 for the construction of Búðarháls line 1. Once it is in operation, the project will create 1-3 direct jobs, as well as jobs for summer employees (in particular young people working on land reclamation) and maintenance jobs.

Although large projects such as power plants temporarily draw large numbers of people during their construction, this is not a permanent move, as the project is far from settled areas, the construction period short and work is spread unevenly over the seasons. As a result, few people can be expected to move closer to the project area because of their work. No impact is expected on the number of residents of the district of Rangárvallasýsla, the demand for housing or public services such as primary health care or education. It is clear, however, that there could be some temporary change to population development in the area nearest the power plant, since some people who may have considered moving away from the area, e.g. due to limited employment possibilities, could postpone their move. It is, however, hardly likely that residents of South Iceland will increase in number due exclusively to the power plant project.

Jobs in power plant construction are generally well paid in comparison to other similar work elsewhere in the country. This makes it likely that unskilled and skilled labourers will apply for the jobs available at Búðarháls during the construction period, regardless of how the employment situation is in the construction industry at that moment. This could therefore cause some disturbance to industry in similar sectors.

In the longer term, the project will contribute to permanently increased employment, since the power plant is intended to boost electricity production, which will be utilised by industry.

Although building a power plant requires considerable capital, the manpower required is proportionally lower than for many other projects. No major disturbance is therefore expected to the labour supply and demand due to the construction of the Búðarháls power plant and Búðarháls line 1. This will depend, however, what projects are underway at the same time.

The experience in the district of Rangárvallasýsla indicates that the impact of the downturn upon the conclusion of the project is slight, since the number of in-migrants changed little e.g. during the construction periods of the Hrauneyjafoss and Sultartangi power plants or the Vatnsfell power plant.

19.2 MITIGATING MEASURES

The principal mitigating measures involve following the provisions of Regulations on pollution prevention, health and hygiene, fire prevention and occupational security to the letter, as well as ensuring effective co-operation of the local health surveillance representative concerning facilities and activities during the construction period and clean-up of the project area after its conclusion.

The safety of travellers in the area needs to be ensured, both during the construction period and afterward, by having satisfactory signs and proper working practices.

III. ENVIRONMENTAL MONITORING AND OVERALL IMPACT

20 ENVIRONMENTAL MONITORING

Article 18 of Regulation No. 671/2000, on Environmental Impact Assessment, states that an EIS must include, as appropriate, a proposal for an environmental monitoring plan.

In the developer's assessment, possible erosion of the banks of Sporðalda reservoir will need to be monitored and this will be checked every other year for at least 12 years after the project. Photos will be taken where the proposed banks of the reservoir will be before it fills for future reference.

Due to uncertainty as to how much vegetation will increase due to the higher groundwater level around the Sporðalda reservoir it will cause, the advance of vegetation will be checked every fourth year by the reservoir and in the area below it [along the] River Tungnaá for 12 years after the project. In other respects, the developer does not feel there is a need for a special monitoring plan due to loss of vegetation in the area, as it will be a matter for negotiation with responsible parties as to how such monitoring will be carried out.

During the construction period, the effectiveness of the road building and culverts at Fögrulindir needs to be checked.

The monitoring plan will be reviewed after 12 years have passed.

In addition to the above monitoring, Landsvirkjun's normal monitoring will be implemented, which involves, for instance, surveillance and checks of the dam and other structures.

21 OVERALL IMPACT

Projects like this always involve some changes to the environment and the impact on the natural environment and the community can be both negative and positive. The preceding Chapters 9-19 discuss the environmental impact of the Búðarháls power plant and Búðarháls line 1 and mitigating measures to limit the negative impact.

They summarise the studies made of the area and compare their conclusions with similar projects. This enables the prediction and assessment of possible environmental impacts of the proposed power plant and transmission line construction. As pointed out, regard will be had for the vegetation by avoiding wetland areas and the more vegetated areas of Búðarháls. The project and the altered land utilisation will naturally change the environment to some extent, but the project area is in a power development area and not on the list of protected natural sites, nor does it include any special known biological or geological sites. **Table 20.1** summarises the contents of Chapters 9-19.

Table 20.1 Summary of the environmental impact of the Búðarháls power plant and proposed mitigating measures

Environmental factors	Environmental impact	Mitigating measures
Land utilisation (Ch. 9)	- Grazing land lost - Tracks flooded - Quarries closed	- New tracks laid
Vegetation (Ch. 10)	- Permanent reduction of vegetation - Grazing land lost	- All unnecessary disturbance avoided in building roads - Culvert installed in wetland areas near Fögrulindir - Wetlands circumvented by transmission lines - Wetlands circumvented by roads constructed - Existing track used for building transmission line - Repair eroded reservoir banks as needed - Disturbed areas will be repaired, evened out and seeded as appropriate.

Environmental factors	Environmental Impact	Mitigating Measures
Bird and animal life (Ch. 11)	- Vegetated land flooded	- In building roads, transmission line and all other undertakings in the power plant area efforts will be made to spare vegetation.
	- Increased traffic, more disturbance at nesting time	- Reservoir level will generally be stable.
	- River Tungnaá will dry up for the most part below the dam, disturbing nesting grounds of pink-footed geese and ducks	
	- River Tungnaá will dry up for the most part below the dam, impact on fish stocks	
	- Fishing spots farthest down on Kaldakvísl flooded by reservoir	
	- Danger of birds colliding with transmission lines	
Hydrology (Ch. 12)	- River Tungnaá will be mostly dry below the proposed dam	- No mitigating measures proposed
	- Increase in groudwater level near the reservoir	
Visual impact (Ch. 13)	- The visual impact resulting from Sporðöldulóns	- Care will be taken to ensure that structures fit in well with the surroundings
	- Impact of a dam up to 24 m high and 2,300 m long	- Route the transmission line alongside of the existing lines for as much of its length as possible
	- Visual impact of transmission line	- Repair eroded reservoir banks
Disturbance to ground (Ch. 14)	- Disturbance to ground from quarrying amd excavation	- Previous quarries used, material obtained from the reservoir bottom and river channel
		- Unused excavated material evened out
		- Disturbed areas will be repaired, evened out and seeded as appropriate.

Environmental factors	Environmental Impact	Mitigating Measures
Landscape (Ch. 15)	- Disturbance to ground from quarrying	- Unused excavated material evened out and ground seeded as appropriate
	- Changes to landscape with advent of Sporðalda reservoir	- Clean up after project concludes
	- Structures	- Repair eroded reservoir banks
	- River Tungnaá will be almost dry below the dam	- Special care taken in designing the appearance of the powerhouse, clean-up of quarries, spoil areas and structures
Outdoor leisure and tourism (Ch. 16)	- Visual impact of Búðarháls line 1 Improved transportation following bridging of River Tungnaá	- Support for map showing hiking and riding trails on Búðarháls and erection of information sign
Archaeological sites (Ch. 17)	- 5 sites in the project area, one of them visible (stone sheep collect will be flooded)	- All traffic, quarrying and deviations from the proposed project will be examined having regard to the list of archaeological sites in the area.
Risks (Ch. 18)	- No major risks in the proposed project area	- No need for mitigating measures
Economic and social impact (Ch. 19)	- Increased employment in the region temporary. Longer-term direct impact slight. Indirect increase in employment.	- Follow provisions of regulations on pollution prevention, fire prevention and occupational safety - Ensure safety of travellers during the construction period and after.

The overall conclusion of the environmental impact assessment for Búðarháls power plant and Búðarháls line 1 is that the projects will not have a significant impact on the environment or community.

IV. REFERENCES

Alþingi, 1981: Act on Landsvirkjun, No. 42/1983.
Alþingi, 1981: Act on Electrical Power Plants, No. 60/1981.
Alþingi, 1989: National Heritage Act, No. 88/1989.
Alþingi, 1999: Nature Conservation Act, No. 44/1999.
Alþingi, 2000: Act No. 170/2000, amending the Planning and Construction Act, No. 73/1997, as subsequently amended

Borgþór Magnússon and Ásrún Elmarsdóttir, 1996: *Sultartangavirkjun. Athugun á gróðri*. (Sultartangi Power Plant. A vegetation study) Report to Landsvirkjun The Agricultural Research Institute of Iceland.

Flosi Sigurðsson, Björn Ingi Sveinsson, Arnþór Helgason and Helgi Valdimarsson, 1998: *Mat á jarðskjálftahættu á Íslandi. Gerð hröðunarkorts vegna EC8* (Assessment of Earthquake Risk in Iceland) (ENV 1998).

Hönnun hf. and Rafhönnun, 1999: *Búðarhálsvirkjun. Verkhönnun 100 MW virkjunar* (Búðarháls Power Plant. Project design for a 100 MW power plant). Landsvirkjun.

Hönnun hf., 1992: *Búðarhálsvirkjun efri og neðri. Samanburður kosta* (Upper and Lower Búðarháls Power Plant. Comparison of options). Landsvirkjun.

Jóhann Pálsson and Þórir Haraldsson, 1981: *Athugun á gróðurfari á fyrirhuguðum virkjunarstöðum á vatnasvæði Tungnár* (Study of Vegetation at Proposed Power Plant Locations in the River Tungnaá Catchment area). Orkustofnun, Vatnsorkudeild, JÞ-ÞH-81/01.

Magnús Jóhannson, 1988: *Kaldakvísl. Uppeldisskilyrði og seiðarannsóknir* (Kaldakvísl. Rearing conditions and fry research).Institute of Freshwater Fisheries South Iceland Section.
Icelandic Institute of Natural History, 2000. *Válisti 2 Fuglar* (Endangered List 2. Birds). Reykjavík.

Ólafur Arnalds, Elín Fjóla Þórarinsdóttir, Sigmar Metúsalemsson, Ásgeir Jónsson, Einar Grétarsson and Arnór Árnason, 1997: *Jarðvegsrof á Íslandi* (Soil erosion in Iceland). Soil Conservation Service of Iceland and Agricultural Research Institute (RALA)

National Energy Authority, 1973: *Búðarháls. Jarðfræðiskýrsla* (Búðarháls. Geological report). Prepared for Landsvirkjun.

National Energy Authority, 1978: *Búðarhálsvirkjun. Jarðfræði- og jarðvatnsrannsóknir* (Búðarháls Power Plant. Geology and groundwater research). OS-ROD-7819. Prepared for Landsvirkjun.

National Energy Authority, 1983: *Búrfell-Langalda. Berggrunnskort* (Búrfell-Langalda. Bedrock map). Map no. 3540-B. Landsvirkjun.

National Energy Authority, 1990: *Sigalda-Veiðivötn. Berggrunnu-Jarðgrunnur-Vatnafar* (Sigalda-Veiðivötn. Bedrock – Geology – Hydrology). Landsvirkjun.

Páll Imsland, 1987: Volcanic hazard map. Nordic Volcanological Institute. University of Iceland. A preliminary report to Landsvirkjun.

Paul A. Erickson, 1994: A Practical guide to Environmental Impact Assessment Measures, Academic Press, New England.

The International Energy Agency Implementing Agreement for Hydropower Technologies and Programmes, 2000: *Hydropower and the Environment. Effectiveness of Mitigation Measures*, IEA.

Þóra Ellen Þórhallsdóttir, 1994: *Áhrif miðlunarlóns á gróður og jarðveg í Þjórsárverum* (Impact of Equalisation Reservoir on the Vegetation and Soil of Þjórsárver). Biology Institute of the University of Iceland.

Þórólfur Antonsson and Guðni Guðbergsson, 1990: *Sultartangalón, Hrauneyjalón og Krókslón. Fiskrannsóknir 1990* (Sultartangi, Hrauneyjar and Krókur Reservoirs. Fishing research 1990). Institute of Freshwater Fisheries Ecology Section.

www.landvernd.is