

QAIR ICELAND EHF

HYDROGEN AMMONIA PLANT "AURORA"

EXTERNAL NOISE

NOISE ASSESSMENT

ADDRESS COWI A/S
Parallevej 2
2800 Kongens Lyngby
Denmark

TEL +45 56 40 00 00

FAX +45 56 40 99 99

WWW cowi.com

CONTENTS

1	Technical summary	2
2	Introduction	3
3	Description of the plant	3
4	Noise limits	3
5	Operation and noise sources	4
6	Sound propagation and background noise	5
6.1	Background noise	5
7	Noise prediction	5
7.1	Calculation method	5
7.2	Receivers	6
7.3	Results	6
7.4	Character of noise	8
7.5	Extended uncertainty	8
7.6	Low-frequency noise and vibrations	8
8	Conclusion	9

APPENDICES

Appendix A	Noise propagation maps	10
------------	------------------------	----

PROJECT NO. DOCUMENT NO.

A257971 004

VERSION DATE OF ISSUE DESCRIPTION PREPARED CHECKED APPROVED

1.0 2024.01.05 Technical note, Noise MRLR MNLR MRLR

1 Technical summary

Noise assessment of the Hydrogen Ammonia Plant Aurora has been carried out with preliminary estimation of noise sources of the plant, necessary to fulfil Icelandic regulation (No. 724/2008). It is expected equipment and processes at the plant will be at or below the included sound power levels, or otherwise screened and/or attenuated accordingly.

Construction of the Aurora plant will be carried out in three phases. The normal operation of the plant includes all processes involved in the hydrogen-ammonia production. Notable noise sources are compressors, cooling, and the transformer substation. Furthermore, noise from the pilot flame in the Flare, as well as noise from the Storage area has been included. As the electrolyser process is carried out inside buildings, it is estimated that noise from this process is insignificant to the overall external noise. A ship will arrive approximately every 14th day to transport the ammonia. The ship can be moored for more than 24 hours, i.e., span all hours of the day.

Noise calculations show that with the expected sound power levels for noise sources, noise from the Aurora plant will be below Icelandic requirements at own property line and at all noise sensitive neighbours.

Additionally, in conjunction with the Environmental Impacts Assessment (EIA), noise from current industry and road traffic has been considered in combination with the added noise from the Aurora plant (cumulative noise). Existing industry noise includes the aluminium plant and the harbour, based on noise measurements and noise model by EFLA in 2016.

Considering cumulative noise, the Aurora plant will in general add no significant noise at noise sensitive neighbours. A 3 dB increase (considered to be a "clearly audible difference") in the northern direction is expected to be observed up to approximately 1.0-1.5 km from the Aurora plant's property line. Further away the difference will decrease, until it is not audible (< 1 dB) approximately 2.5 km north of the plant. In all other directions, the Aurora plant will not add any noticeable noise to the existing noise.

2 Introduction

As part of the Environmental Impacts Assessment (EIA) of a new hydrogen ammonia plant in Grundartangi, Iceland, COWI has performed a noise prediction to assess the noise impact in the surroundings.

Furthermore, noise from the new plant has been compared to the existing noise in the area (industry and road traffic). The existing industry noise includes the aluminium plant and Grundartangi harbour.

3 Description of the plant

The hydrogen ammonia plant is situated at Grundartangi in Iceland 30 km north of Reykjavik. An existing aluminium plant and the Grundartangi harbour is situated just west of the site. Surrounding noise sensitive neighbours are scattered residential dwellings, farms, and vacation houses.



Figure 3-1 Site illustration, Conceptual design study, COWI/Arkitema.

The plant is expected to be constructed in three phases, phase 3 being the fully developed plant. Each phase contains equipment for water treatment, ammonia synthesis, air separation unit, cooling water system, as well as an electrolyzer building. The entire plant has shared pipe rack/flare, storage, transformer substation, and an administration building. Moreover, an export terminal for vessels up to the size of 80.000 m³ will be constructed.

4 Noise limits

The threshold limit values for external noise from industry are described in the Icelandic standard no. 724/2008.

Table 4-1 Limits for noise emitted by industry, no. 724/2008, stated in dB(A) - excerpt.

Type of dwelling	LAeq (07-19) Day	LAeq (19-23) Evening	LAeq (23-07) Night
Industrial sites ¹⁾	70	70	70
Residential dwellings in residential areas	50	45	40
Vacation houses	35	35	35

1) Includes own property line

Noise limits shall be respected at building facades outside opening windows, 2.0 meters above ground level.

If the noise contains clearly audible tones or impulses at the neighbour, a 5 dB(A) penalty shall be added to the calculated/measured noise levels, to account for the higher nuisance caused by such tones/impulses.

5 Operation and noise sources

The proposed plant utilizes hydrogen from electrolysis and nitrogen from air separation. The hydrogen is then converted to ammonia for transportation purposes.

All processes of the plant are expected to run at full capacity (100%) at all hours.

Noise emissions will primarily come from various compression and cooling steps throughout the conversion process, and be emitted from pumps, pipes, machinery etc. Additionally, the transformer substation, storage area, and flare (pilot flame) are expected to emit noise. Noise from the electrolyzer buildings is considered insignificant in the relation to the overall noise emission from the plant. Due to the low detail level of the project at this stage, the noise is modelled as estimates of combined sound power levels of equipment and processes.

A vessel will arrive approximately every 14th day to transport the ammonia. The ship can be moored for more than 24 hours, i.e., span all hours of the day, and is expected to be powered by auxiliary engines when moored.

Below are listed sound sources with respective sound power levels (L_{WA}) used in the noise model.

As the detail level of the plant increases in the later design stages, the model shall be updated, and the noise emissions re-evaluated to make sure the project is compliant with local noise requirements.

Table 5-1 Noise sources Aurora plant.

Name	Sound power level, L_{WA} [dB(A)]	Height [m]	Operation
Phase 1, combined	115	6.0	100%
Phase 2, combined	115	6.0	100%
Phase 3, combined	115	6.0	100%
Transformer substation	105	6.0	100%
Storage	95	6.0	100%
Flare (pilot flame)	85	50.0	100%
Ship ¹⁾	105	30.0	100%
Ship pump(s)	105	3.0	100%

1) Noise from moored ships, Witte (2010), auxiliary engines

6 Sound propagation and background noise

The noise prediction includes electrolyzer buildings within the plant's area, acting as noise-screening elements. Due to the low detail level, noise screening by equipment locally at the plant has not been accounted for at this stage.

Ground areas are modelled as acoustically hard or soft depending on the ground characteristics and will therefore be reflective or absorptive according to the actual terrain.

6.1 Background noise

The main contributors to background noise are industry and road traffic.

Existing noise from the aluminium plant and harbour in the noise model are based on model and measurements by EFLA Engineers in 2016. Road traffic noise is based on current publicly available traffic numbers (2022) including a 15% increase in traffic for all roads as the traffic load is expected to increase over the coming 10 years.

7 Noise prediction

7.1 Calculation method

The noise propagation was calculated using the Nordic General Prediction Method for external noise from industry, described in the Danish Environmental Protection Agency's guideline no. 5/1993, "Beregning af ekstern støj fra virksomheder" (Calculation of external noise from industry). Noise from road traffic was calculated using Nord2000.

All calculations were carried out using SoundPLAN ver. 9.0. In SoundPLAN, a 3D topographical model was created, including terrain, noise sources, buildings and other screening or reflective objects. The model was digitalised based on orthophotos and the site layout plan of the plant.

7.2 Receivers

Noise is calculated at selected receiver points chosen as representative for the most noise-sensitive surroundings. All calculations were carried out at a height of 2.0 metres above ground level. The locations of the receiver points are shown in the noise maps in appendix.

Noise threshold limits for each receiver point are shown in Table 7-1.

R1-R7 are located at the Aurora plant's own property line. R10 and R11 are residential dwellings toward northeast and north, respectively. R12 and R13 are primarily vacation houses across the bay.

Table 7-1 Threshold limit values for noise impact at the receiver points, stated in dB(A).

Calculation points	LAeq (07-19) Day	LAeq (19-23) Evening	LAeq (23-07) Night
R1 (Own property line)	70	70	70
R2 (Own property line)	70	70	70
R3 (Own property line)	70	70	70
R4 (Own property line)	70	70	70
R5 (Own property line)	70	70	70
R6 (Own property line)	70	70	70
R7 (Own property line)	70	70	70
R10 Kalastaðakot	50	45	40
R11 Galtarholt	50	45	40
R12 Snorravík	35	35	35
R13 Stampar/Breiðamýri	35	35	35

7.3 Results

Two scenarios have been calculated:

- > **Normal operation:** Full operation of hydrogen ammonia production of the fully developed plant (phase 3).
- > **Maximum operation:** Full operation of hydrogen ammonia production of the fully developed plant (phase 3) incl. one moored ship being loaded with liquid ammonia.

Noise calculations were performed for day, evening, and night.

Table 7-2 Calculation results stated as the equivalent sound pressure level L_{Aeq} in dB(A). **Normal operation.** Threshold limits in parenthesis.

Calculation points	L_{Aeq} (07-19) Day	L_{Aeq} (19-23) Evening	L_{Aeq} (23-07) Night
R1 (Own property line)	64.0 (70)	64.0 (70)	64.0 (70)
R2 (Own property line)	66.0 (70)	66.0 (70)	66.0 (70)
R3 (Own property line)	69.2 (70)	69.2 (70)	69.2 (70)
R4 (Own property line)	67.1 (70)	67.1 (70)	67.1 (70)
R5 (Own property line)	64.8 (70)	64.8 (70)	64.8 (70)
R6 (Own property line)	55.7 (70)	55.7 (70)	55.7 (70)
R7 (Own property line)	58.7 (70)	58.7 (70)	58.7 (70)
R10 Kalastaðakot	35.8 (50)	35.8 (45)	35.8 (40)
R11 Galtarholt	36.3 (50)	36.3 (45)	36.3 (40)
R12 Snorravík	22.7 (35)	22.7 (35)	22.7 (35)
R13 Stampar/Breiðamýri	21.8 (35)	21.8 (35)	21.8 (35)

Table 7-3 Calculation results stated as the equivalent sound pressure level L_{Aeq} in dB(A). **Maximum operation.** Threshold limits in parenthesis.

Calculation points	L_{Aeq} (07-19) Day	L_{Aeq} (19-23) Evening	L_{Aeq} (23-07) Night
R1 (Own property line)	64.2 (70)	64.2 (70)	64.2 (70)
R2 (Own property line)	66.0 (70)	66.0 (70)	66.0 (70)
R3 (Own property line)	69.2 (70)	69.2 (70)	69.2 (70)
R4 (Own property line)	67.1 (70)	67.1 (70)	67.1 (70)
R5 (Own property line)	64.8 (70)	64.8 (70)	64.8 (70)
R6 (Own property line)	55.7 (70)	55.7 (70)	55.7 (70)
R7 (Own property line)	59.6 (70)	59.6 (70)	59.6 (70)
R10 Kalastaðakot	36.0 (50)	36.0 (45)	36.0 (40)
R11 Galtarholt	36.5 (50)	36.5 (45)	36.5 (40)
R12 Snorravík	23.9 (35)	23.9 (35)	23.9 (35)
R13 Stampar/Breiðamýri	22.5 (35)	22.5 (35)	22.5 (35)

Supplementary noise calculations were carried out using a grid with points spaced 50 metres apart, to plot interpolated noise level contours. Noise contour

maps are shown in Appendix A for all phases. Noise maps have also been prepared for road noise year 2032, cumulated noise and a difference map showing the difference in noise level that the new plant will cause.

7.4 Character of noise

On the current basis, it is not possible to assess whether the noise in the surroundings will contain clearly audible tones or impulses that may trigger an addition of +5 dB. Therefore, no correction for this has been made, and the plant's noise impact is presumed to be identical to the calculated sound pressure levels L_{Aeq} .

It is recommended that, in connection with the tender requirements for each structural part, it shall be stipulated that noise from systems, plants etc. is not permitted to cause clearly audible tonal noise in the surroundings, cf. the Environmental Protection Agency's rules on assessment of tonal noise.

7.5 Extended uncertainty

No extended uncertainty regarding the calculation of the noise impact was determined since this noise calculation is to be used for planning purposes. When planning, the calculation uncertainty cannot be considered when assessing compliance with noise limits.

7.6 Low-frequency noise and vibrations

The operation of the plant is not expected to cause any significant low-frequency noise and vibrations in the surroundings.

In connection to the tender requirements for each structural part, it is recommended to be stipulated that any machinery, structural item, or part of the plant is not permitted to cause significant low-frequency noise and vibrations in the surroundings, cf. the Environmental Protection Agency's rules on assessment of low-frequency noise and vibrations.

8 Conclusion

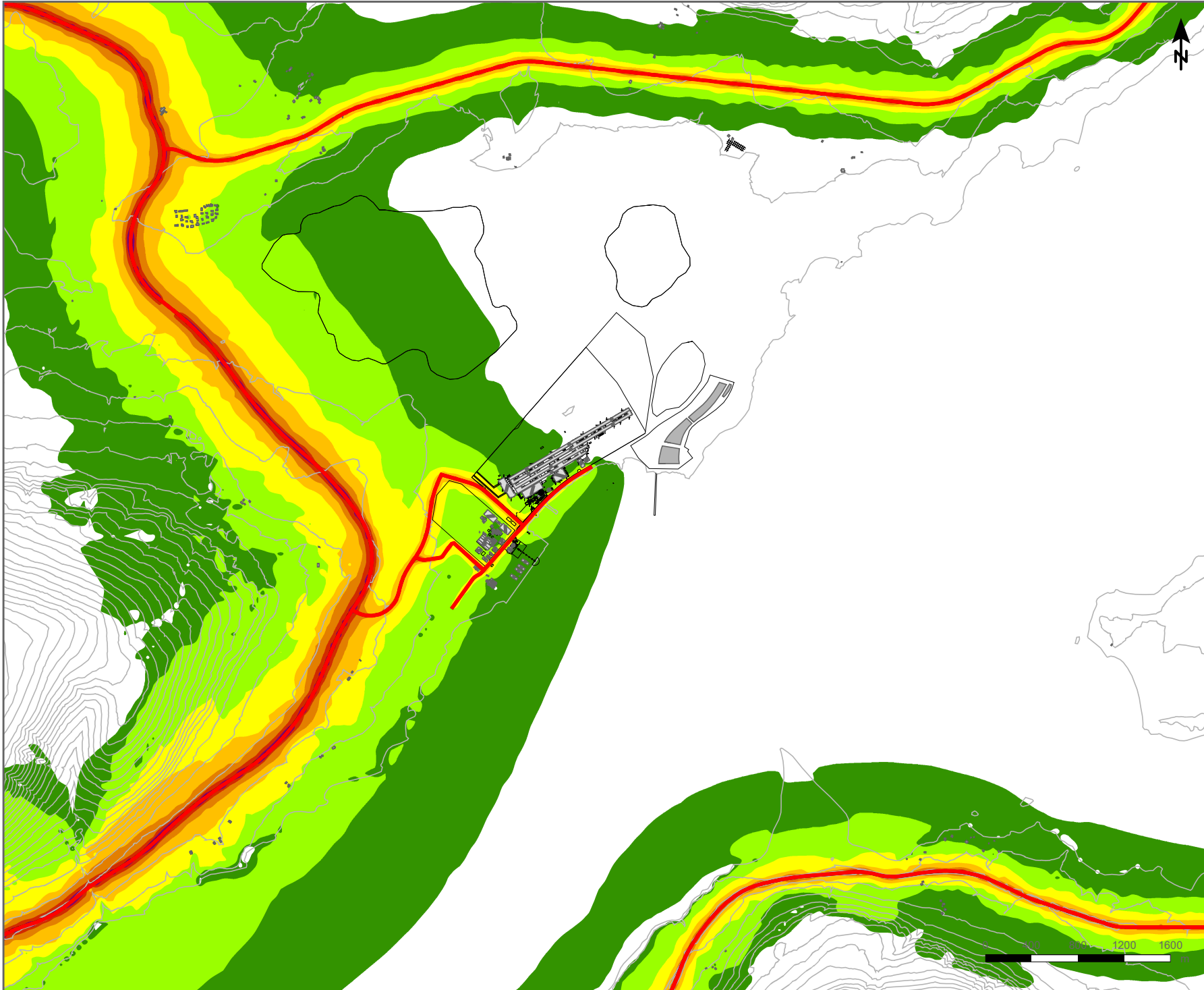
The noise impact in the surroundings was calculated for a fully developed hydrogen ammonia plant (normal operation) and a scenario including a moored ship being loaded (maximum operation).

The results of the noise prediction show that it will be possible to comply with the noise limits at all selected receiver points for all scenarios.

The difference noise map in appendix (ref. 310) shows the noise increase in the area caused by the Aurora plant. Considering cumulative noise, the Aurora plant will in general add no significant noise at noise sensitive neighbours. A 3 dB increase (considered to be a "clearly audible difference") in the northern direction is expected to be observed up to approximately 1.0-1.5 km from the Aurora plant's property line. Further away the difference will decrease, until it is not audible (< 1 dB) approximately 2.5 km north of the plant. In all other directions, the Aurora plant will not add any noticeable noise to the existing noise.

Appendix A Noise propagation maps

Aurora - Road traffic - Year 2032



Customer:
Qair

Project:
Hydrogen Ammonia Plant Aurora
A257971

Noise from:
Road - LAeq24

Scenario:
Year 2032

LAeq [dB(A)] - 2.0 m.a.t.

35 <	<=35
40 <	<=40
45 <	<=45
50 <	<=50
55 <	<=55
60 <	<=60
65 <	<=65
70 <	<=70

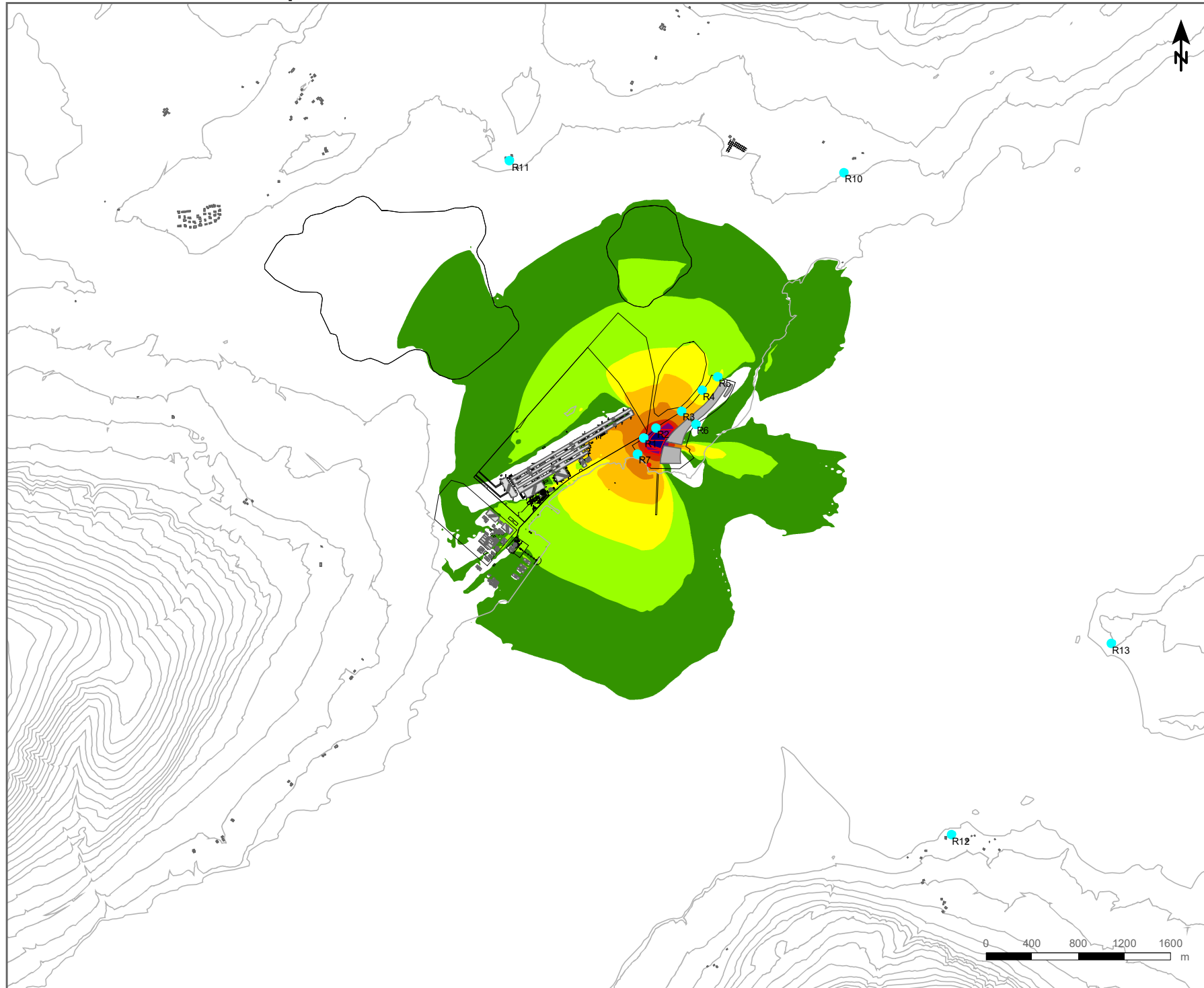
Legend

- Receiver
- Building
- Noise source, point
- Noise source, area
- Building, other
- Elevation line

Reference : 001
Date : 2023.12.21
Calc. no. : 1210
Prepared : MRLR
Checked : MNLR
Approved : MRLR



Aurora - Phase 1 - Normal operation - All hours



Customer:
Qair

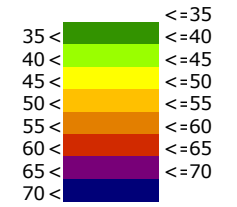
Project:
Hydrogen Ammonia Plant Aurora
A257971

Noise from:
Industry - LAeq - All hours

Scenario:
Aurora plant, Phase 1
Normal operation

Noise sources (LwA):
Phase 1 comb. 115 dBA
Transformer substation 105 dB(A)
Storage 95 dB(A)
Flare (pilot flame) 85 dB(A)

LAeq [dB(A)] - 2.0 m.a.t.



Legend

- Receiver
- Building
- Noise source, point
- Noise source, area
- Building, other
- Elevation line

Reference : 101
 Date : 2023.12.21
 Calc. no. : 1201
 Prepared : MRLR
 Checked : MNLR
 Approved : MRLR



Aurora - Phase 1 - Maximum operation - All hours

Customer:
Qair

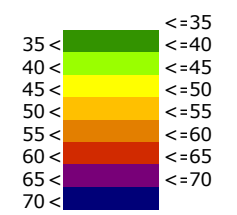
Project:
Hydrogen Ammonia Plant Aurora
A257971

Noise from:
Industry - LAeq - All hours

Scenario:
Aurora plant, Phase 1
Max operation (incl. ship)

Noise sources (LwA):
Phase 1 comb. 115 dBA
Transformer substation 105 dB(A)
Storage 95 dB(A)
Flare (pilot flame) 85 dB(A)
Ship pump 105 dB(A)
Ship 105 dB(A)

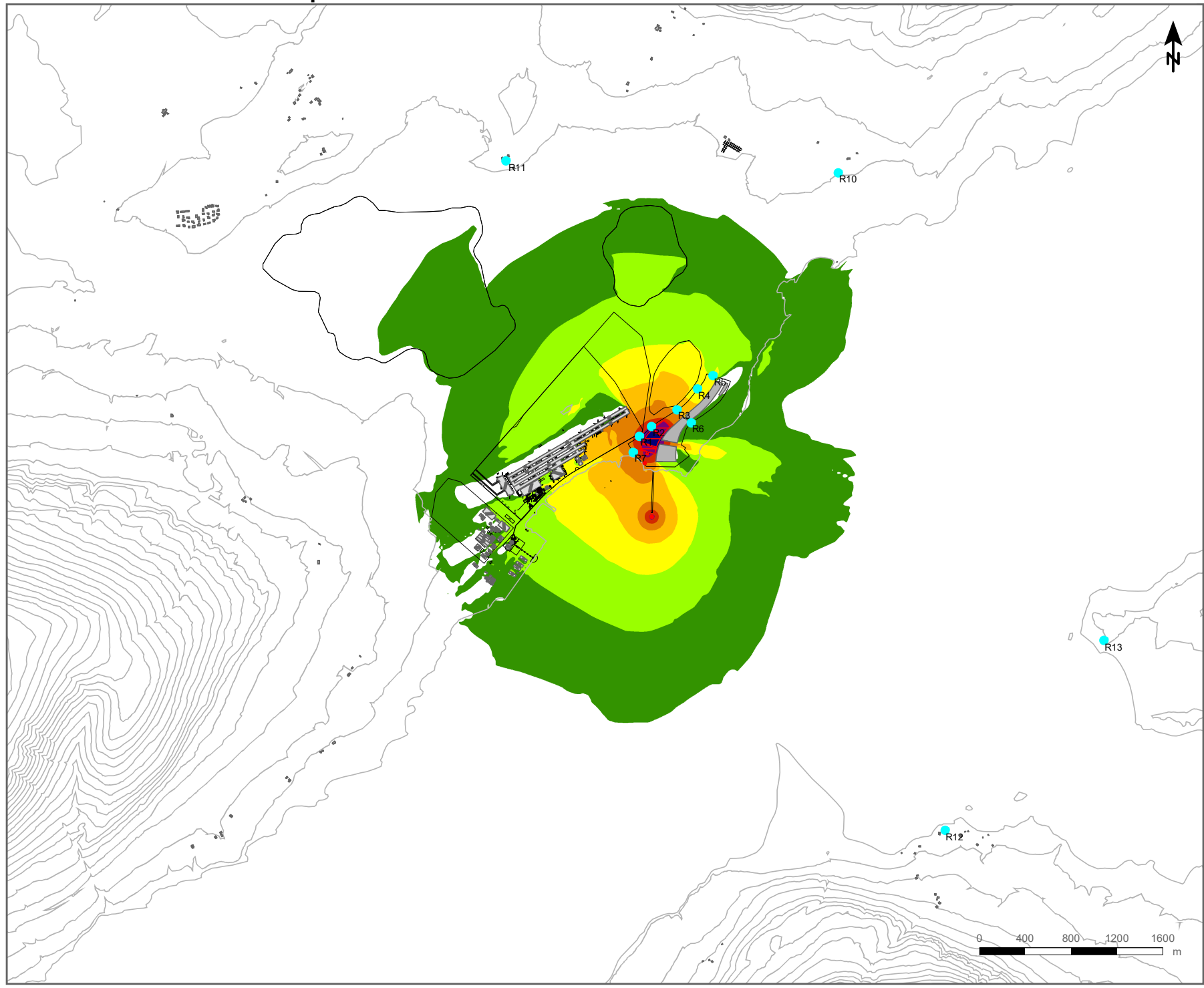
LAeq [dB(A)] - 2.0 m.a.t.



Legend

- Receiver
- Building
- Noise source, point
- Noise source, area
- Building, other
- Elevation line

Reference : 102
Date : 2023.12.21
Calc. no. : 1202
Prepared : MRLR
Checked : MNLR
Approved : MRLR



Aurora - Phase 2 - Normal operation - All hours

Customer:
Qair

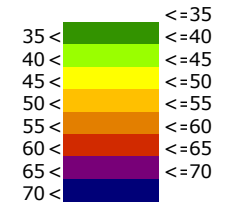
Project:
Hydrogen Ammonia Plant Aurora
A257971

Noise from:
Industry - LAeq - All hours

Scenario:
Aurora plant, Phase 2
Normal operation

Noise sources (LWA):
Phase 1 comb. 115 dBA
Phase 2 comb. 115 dBA
Transformer substation 105 dB(A)
Storage 95 dB(A)
Flare (pilot flame) 85 dB(A)

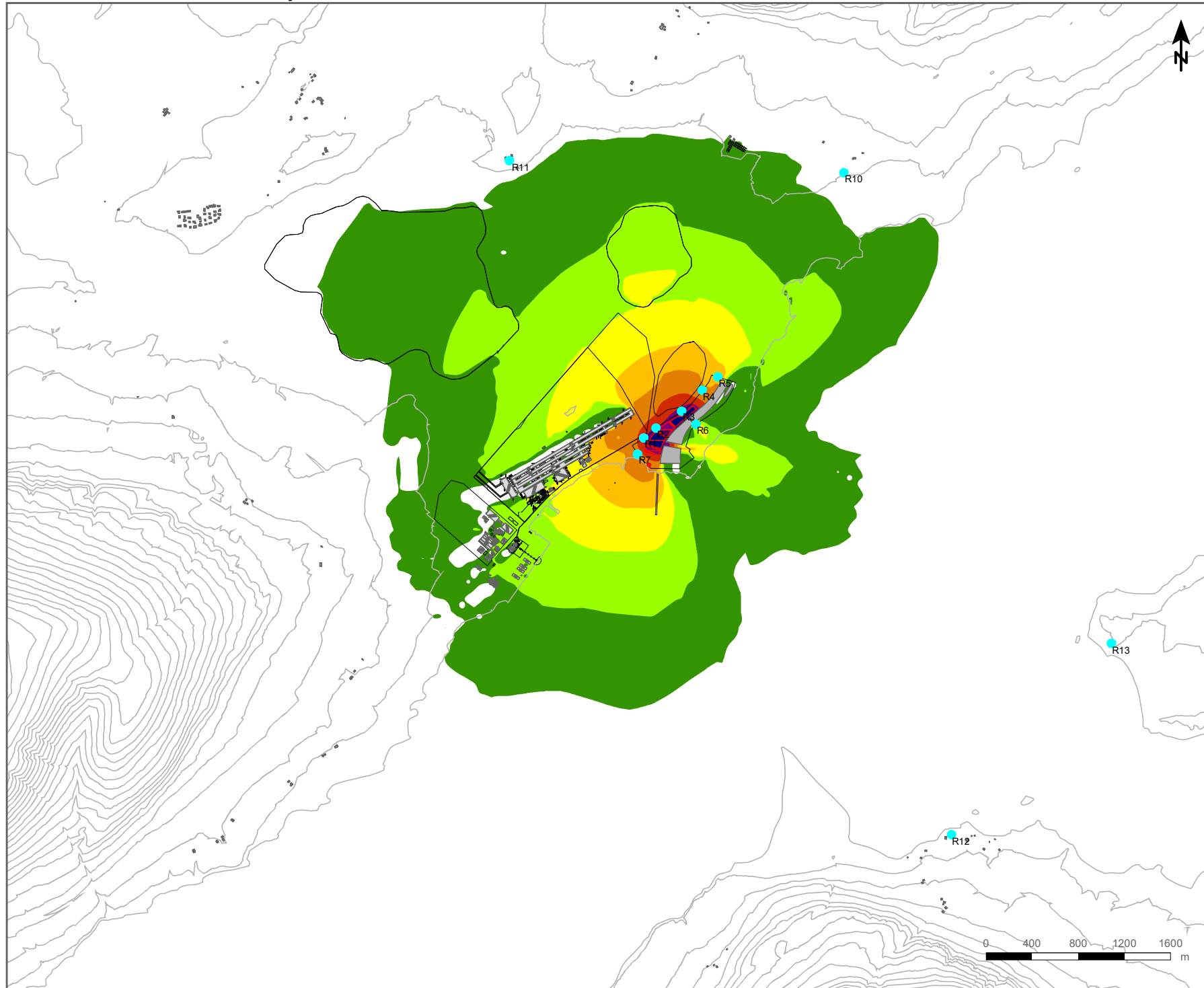
LAeq [dB(A)] - 2.0 m.a.t.



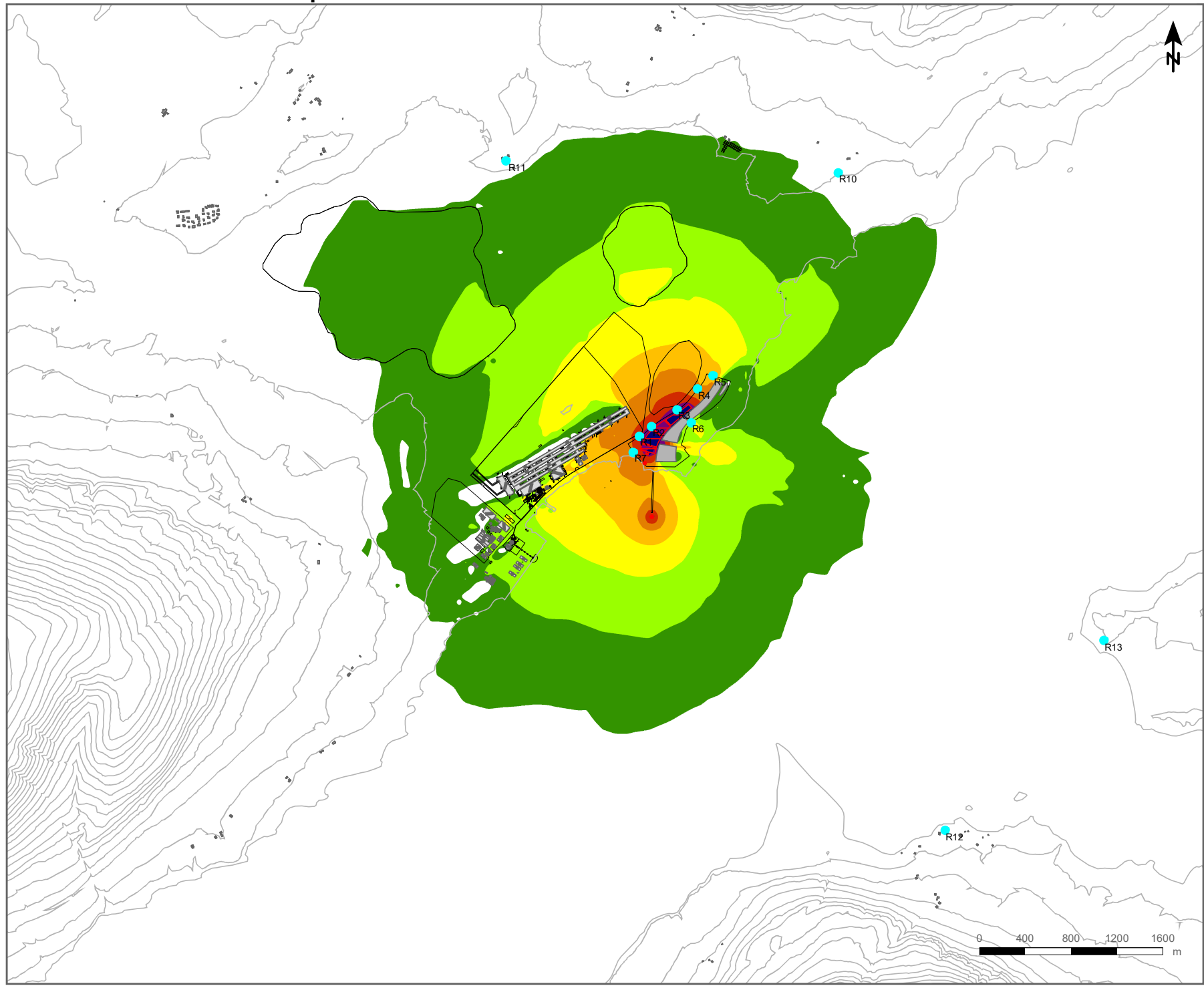
Legend

- Receiver
- Building
- Noise source, point
- Noise source, area
- Building, other
- Elevation line

Reference : 201
Date : 2023.12.21
Calc. no. : 1203
Prepared : MRLR
Checked : MNLR
Approved : MRLR



Aurora - Phase 2 - Maximum operation - All hours



Customer:
Qair

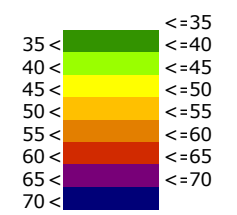
Project:
Hydrogen Ammonia Plant Aurora
A257971

Noise from:
Industry - LAeq - All hours

Scenario:
Aurora plant, Phase 2
Max operation (incl. ship)

Noise sources (LwA):
Phase 1 comb. 115 dBA
Phase 2 comb. 115 dBA
Transformer substation 105 dB(A)
Storage 95 dB(A)
Flare (pilot flame) 85 dB(A)
Ship pump 105 dB(A)
Ship 105 dB(A)

LAeq [dB(A)] - 2.0 m.a.t.



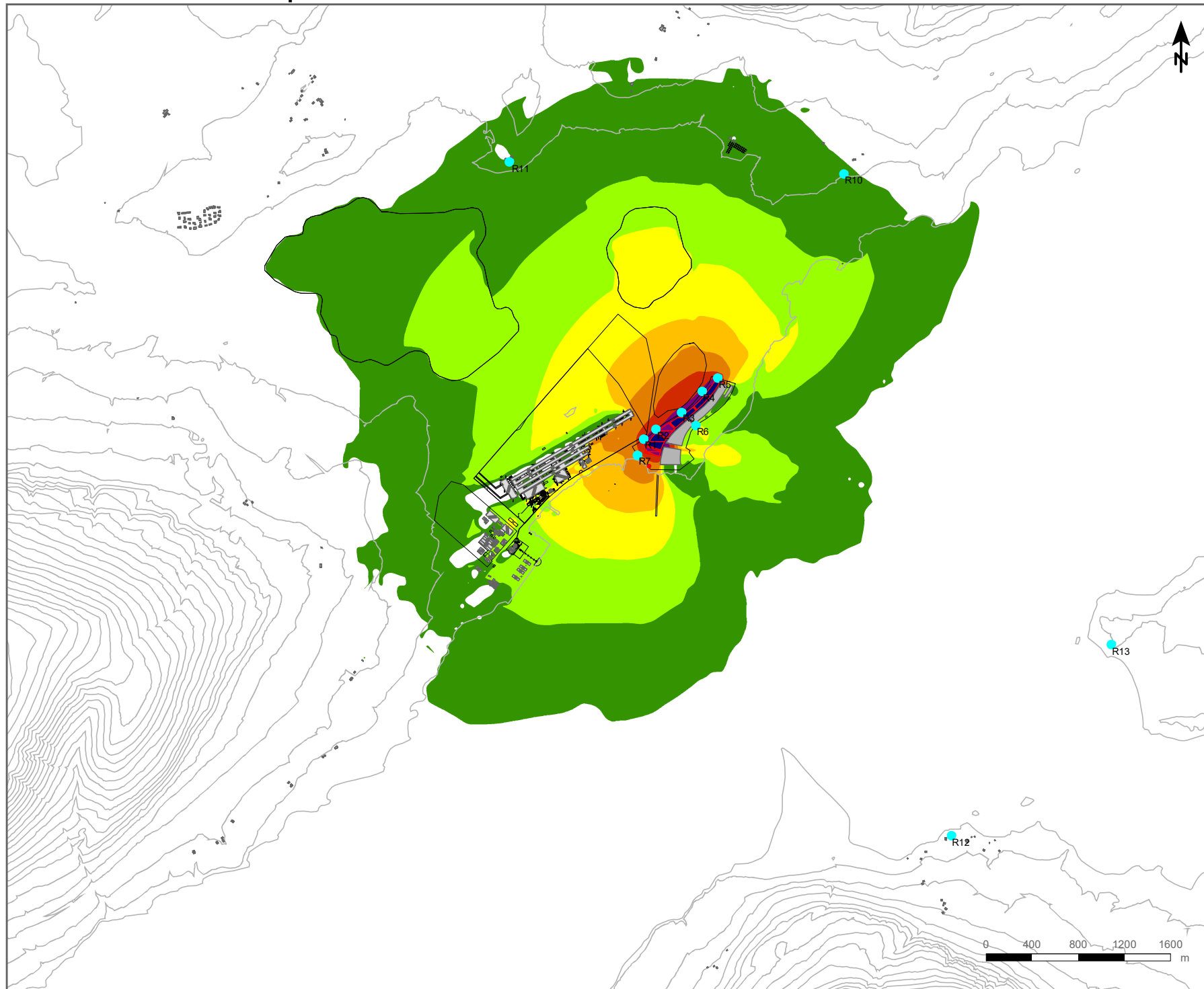
Legend

- Receiver
- Building
- Noise source, point
- Noise source, area
- Building, other
- Elevation line

Reference : 202
Date : 2023.12.21
Calc. no. : 1204
Prepared : MRLR
Checked : MNLR
Approved : MRLR



Aurora - Phase 3 - Normal operation - All hours



Customer:
Qair

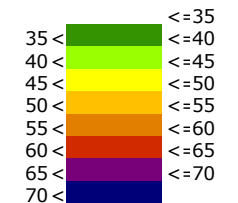
Project:
Hydrogen Ammonia Plant Aurora
A257971

Noise from:
Industry - LAeq - All hours

Scenario:
Aurora plant, Phase 3
Normal operation

Noise sources (LWA):
Phase 1 comb. 115 dBA
Phase 2 comb. 115 dBA
Phase 3 comb. 115 dBA
Transformer substation 105 dB(A)
Storage 95 dB(A)
Flare (pilot flame) 85 dB(A)

LAeq [dB(A)] - 2.0 m.a.t.



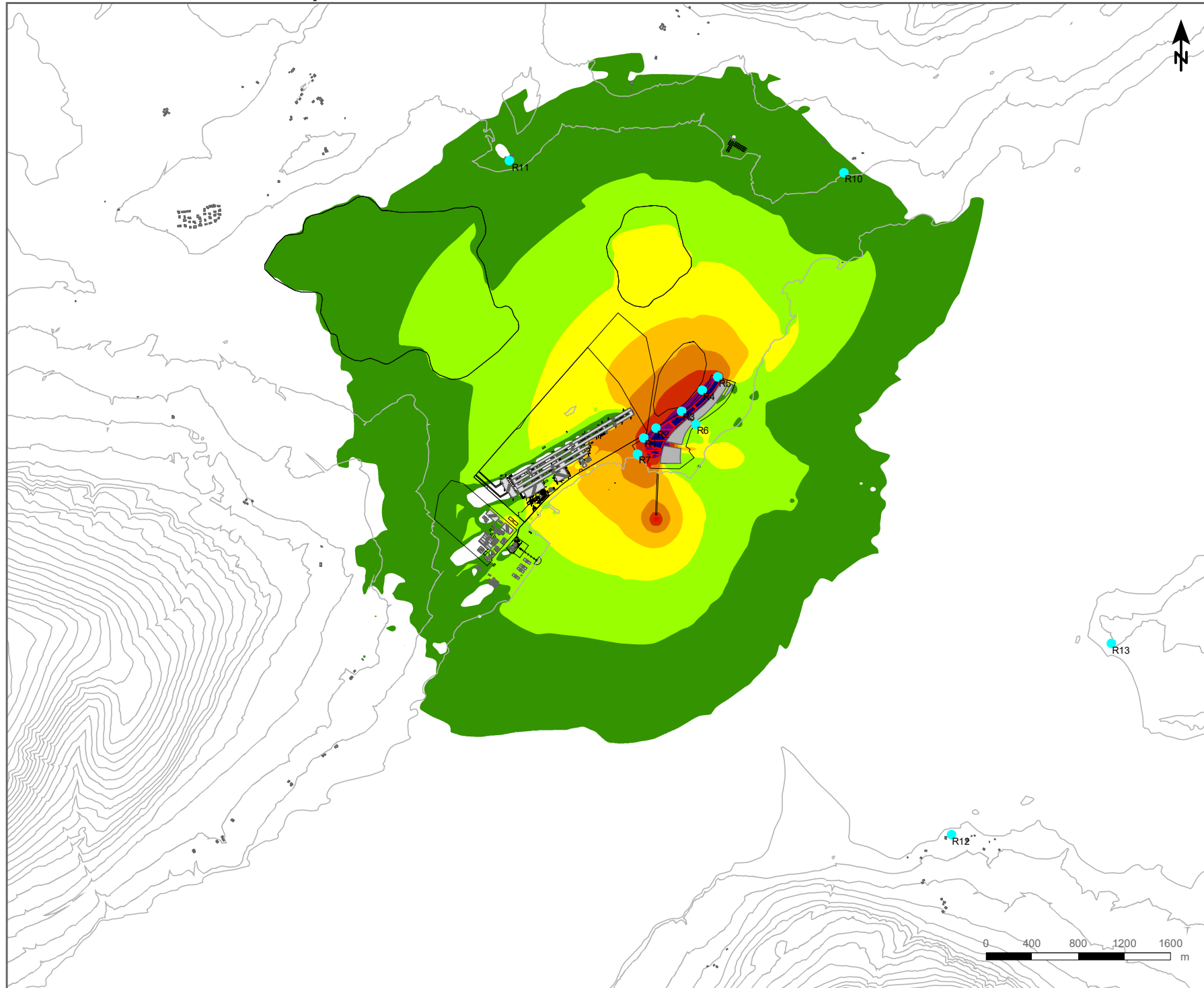
Legend

- Receiver
- Building
- Noise source, point
- Noise source, area
- Building, other
- Elevation line

Reference : 301
Date : 2023.12.21
Calc. no. : 1205
Prepared : MRLR
Checked : MNLR
Approved : MRLR



Aurora - Phase 3 - Maximum operation - All hours



Customer:
Qair

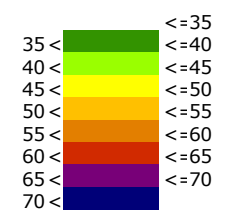
Project:
Hydrogen Ammonia Plant Aurora
A257971

Noise from:
Industry - LAeq - All hours

Scenario:
Aurora plant, Phase 3
Max operation (incl. ship)

Noise sources (LWA):
Phase 1 comb. 115 dBA
Phase 2 comb. 115 dBA
Phase 3 comb. 115 dBA
Transformer substation 105 dB(A)
Storage 95 dB(A)
Flare (pilot flame) 85 dB(A)
Ship pump 105 dB(A)
Ship 105 dB(A)

LAeq [dB(A)] - 2.0 m.a.t.



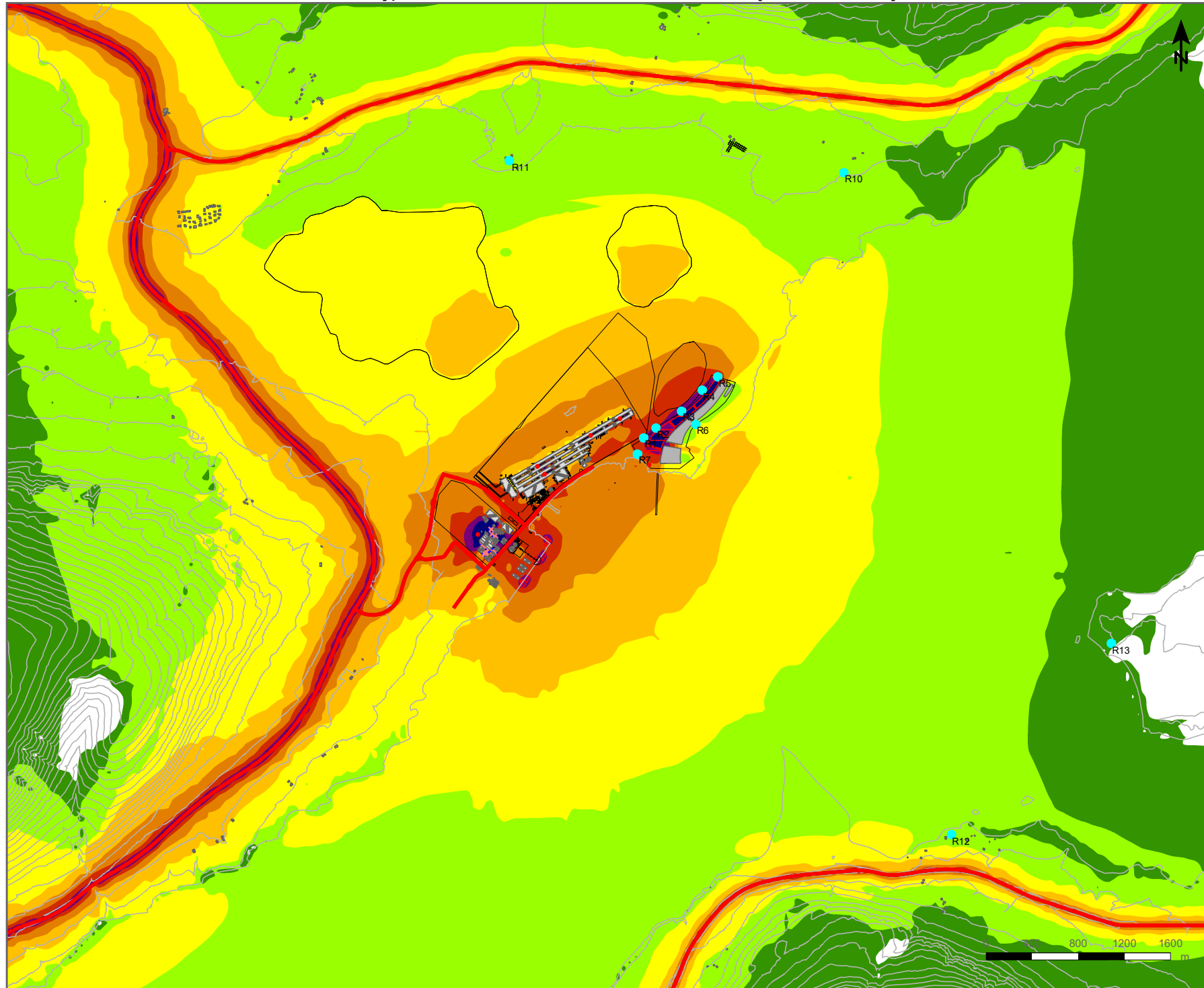
Legend

- Receiver
- Building
- Noise source, point
- Noise source, area
- Building, other
- Elevation line

Reference : 302
Date : 2023.12.21
Calc. no. : 1206
Prepared : MRLR
Checked : MNLR
Approved : MRLR



Aurora - Phase 3 incl. current industry, harbour and road traffic - Normal operation - Daytime



Customer:
Qair

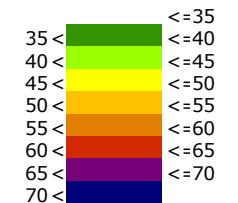
Project:
Hydrogen Ammonia Plant Aurora
A257971

Noise from:
Industry - LAeq - Daytime

Scenario:
Aurora plant, Phase 3
Normal operation

With current industry, harbour,
and road

LAeq [dB(A)] - 2.0 m.a.t.



Legend

- Receiver
- Building
- Noise source, point
- Noise source, area
- Building, other
- Elevation line

Reference : 303
Date : 2023.12.21
Calc. no. : 1207
Prepared : MRLR
Checked : MNLR
Approved : MRLR

COWI

Aurora - Phase 3 incl. current industry, harbour and road traffic - Normal operation - Night

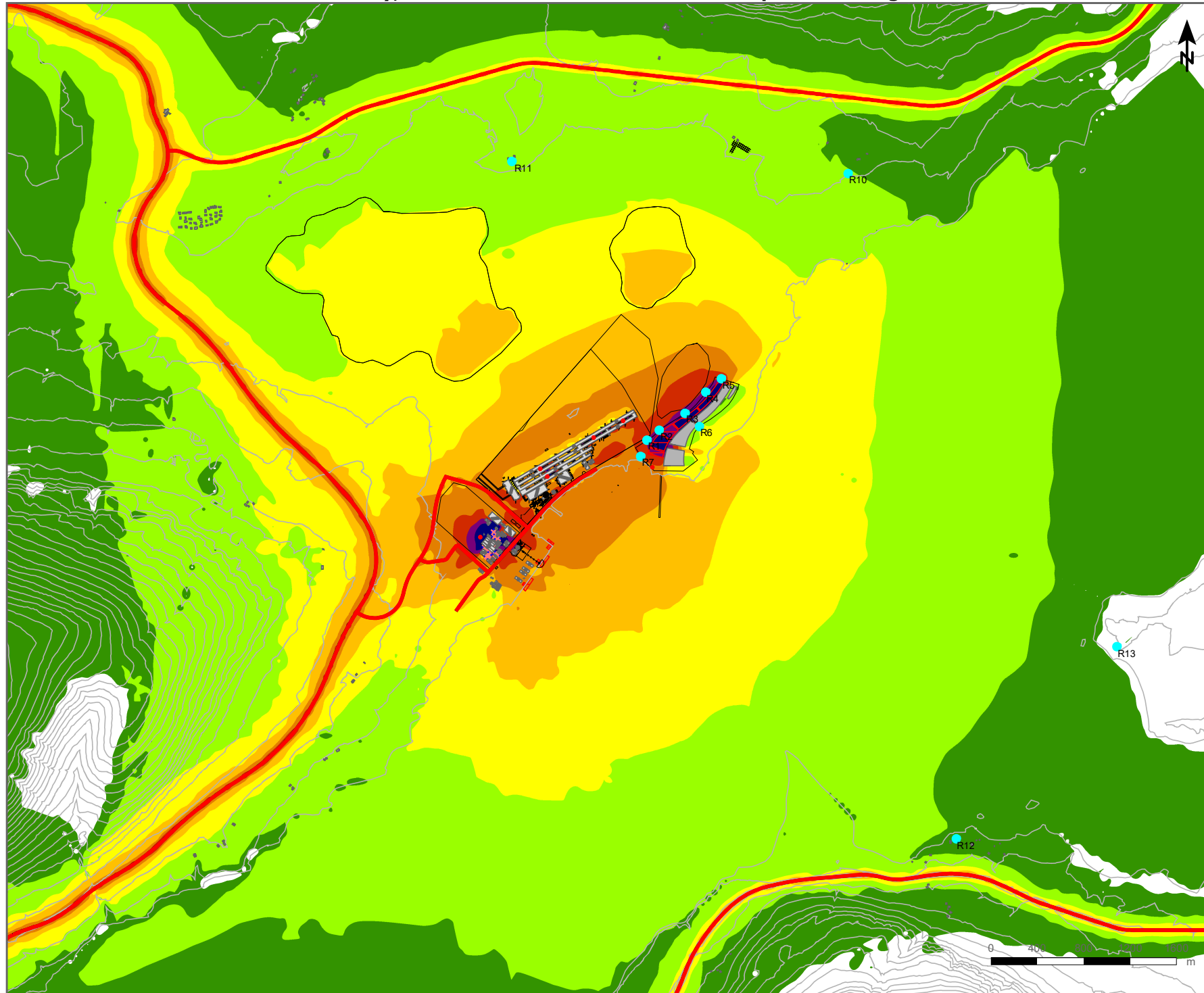
Customer:
Qair

Project:
Hydrogen Ammonia Plant Aurora
A257971

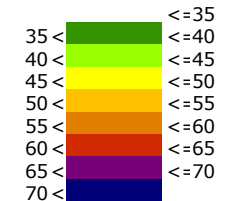
Noise from:
Industry - LAeq - Night

Scenario:
Aurora plant, Phase 3
Normal operation

With current industry, harbour,
and road



LAeq [dB(A)] - 2.0 m.a.t.



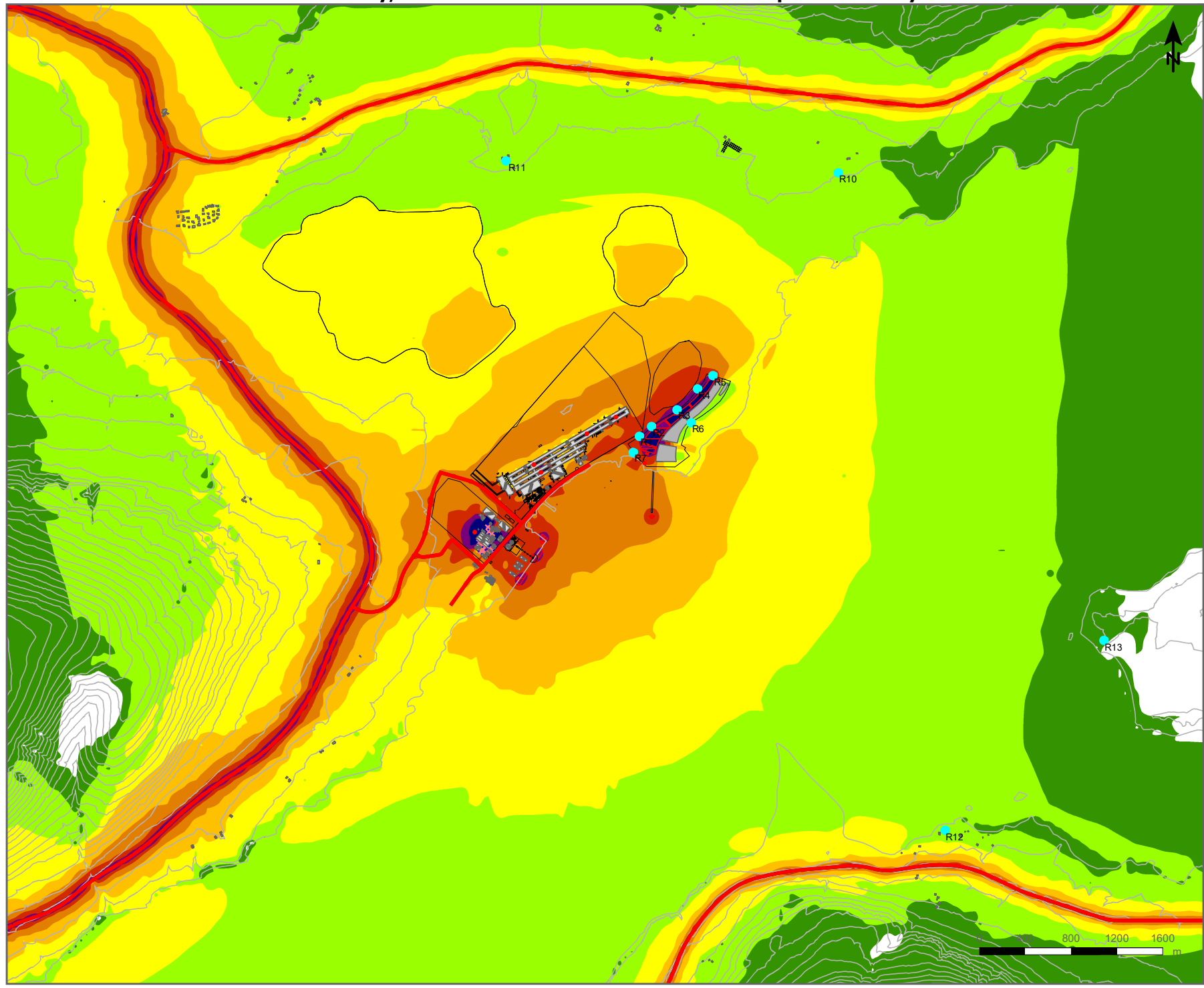
Legend

- Receiver
- Building
- Noise source, point
- Noise source, area
- Building, other
- Elevation line

Reference : 304
Date : 2023.12.21
Calc. no. : 1207
Prepared : MRLR
Checked : MNLR
Approved : MRLR

COWI

Aurora - Phase 3 incl. current industry, harbour and road traffic - Maximum operation - Daytime



Customer:
Qair

Project:
Hydrogen Ammonia Plant Aurora
A257971

Noise from:
Industry - LAeq - Daytime

Scenario:
Aurora plant, Phase 3
Maximum operation (incl. ship)

With current industry, harbour,
and road

LAeq [dB(A)] - 2.0 m.a.t.

35 <	<=35
40 <	<=40
45 <	<=45
50 <	<=50
55 <	<=55
60 <	<=60
65 <	<=65
70 <	<=70

Legend

- Receiver
- Building
- Noise source, point
- Noise source, area
- Building, other
- Elevation line

Reference : 305
 Date : 2023.12.21
 Calc. no. : 1208
 Prepared : MRLR
 Checked : MNLR
 Approved : MRLR



Aurora - Phase 3 incl. current industry, harbour and road traffic - Maximum operation - Night

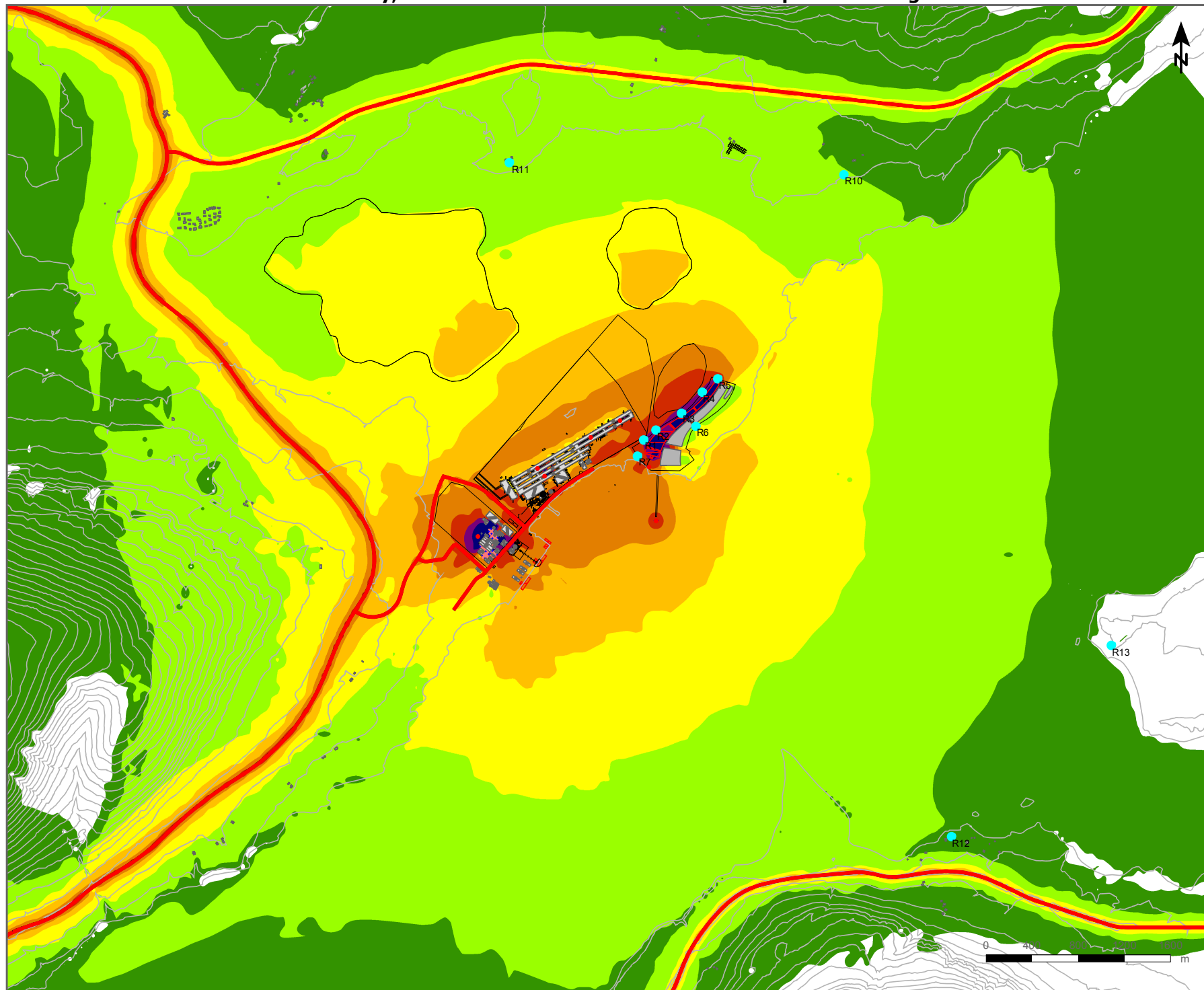
Customer:
Qair

Project:
Hydrogen Ammonia Plant Aurora
A257971

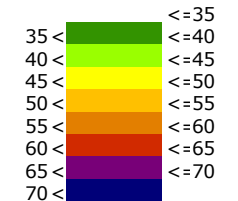
Noise from:
Industry - LAeq - Night

Scenario:
Aurora plant, Phase 3
Maximum operation (incl. ship)

With current industry, harbour,
and road



LAeq [dB(A)] - 2.0 m.a.t.



Legend

- Receiver
- Building
- Noise source, point
- Noise source, area
- Building, other
- Elevation line

Reference : 306
Date : 2023.12.21
Calc. no. : 1208
Prepared : MRLR
Checked : MNLR
Approved : MRLR



COWI

Aurora - Difference - Phase 3 impact on current noise - Maximum operation - Daytime

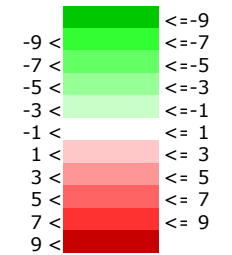
Customer:
Qair

Project:
Hydrogen Ammonia Plant Aurora
A257971

Noise from:
Industry - LAeq - Day

Scenario:
Aurora plant, Phase 3
Maximum operation (incl. ship)
vs.
Current industry, harbour,
and road

Difference [dB] - 2.0 m.a.t.



Legend

- Receiver
- Building
- Noise source, point
- Noise source, area
- Building, other
- Elevation line

Reference : 310
Date : 2023.12.21
Calc. no. : 0
Prepared : MRLR
Checked : MNLR
Approved : MRLR

