Scottish Environment Protection Agency
Buidheann Dìon Àrainneachd na h-Alba

AQUACULTURE MODELLING SCREENING & RISK IDENTIFICATION REPORT: Lurignish (LURI1)

Version One: March 2022

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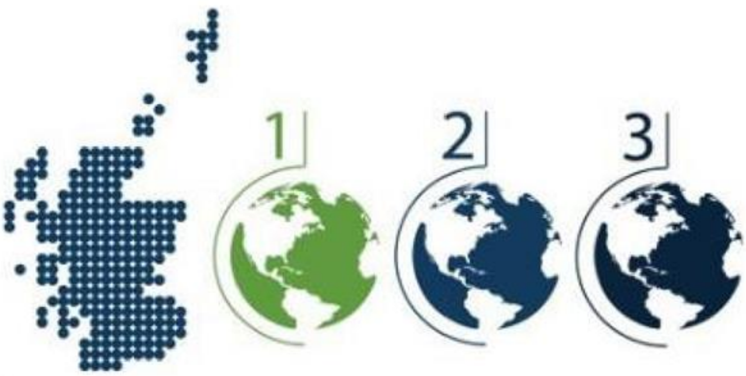

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Scope of report

As part of the SEPA Aquaculture Regulatory Framework it is recommended that a proposed application for a marine fin fish aquaculture site should undergo a Screening Modelling and Risk Identification process. SEPA carries out this work and this is described on the SEPA aquaculture website Pre-application section:

(https://www.sepa.org.uk/regulations/water/aquaculture/pre-application/)

This report presents information arising from that process. Screening modelling methods are outlined and maps and tables describing the modelled impacts are shown. Risks arising from consideration of the model output are listed. Conclusions and recommendations are made regarding the proposed site.

Executive summary

SEPA has received a proposal for a semi enclosed marine fin fish aquaculture site called Lurignish (LURI1). This is located within Loch Linnhe, at location: 193975, 751416 (Easting, Northing). There is no existing site at this location and the proposed weight of fish to be farmed is 8000t. As this is a novel semi enclosed farm, CFD modelling is to be undertaken to assess the proportion of waste expected to be captured. As this proportion is currently unknown, screening modelling has been done to investigate the risks associated with 90%, 50% and 0% waste capture. No medicines are being applied for due to the semi – enclosed nature of the farm, therefore no screening modelling of bath medicines have been undertaken.

Following screening modelling and risk identification we have concluded the following:

- It is possible that discharges from Lurignish (LURI1) will be able to comply with the relevant aspects of the SEPA Aquaculture Regulatory Framework. This is dependent on the results of the CFD modelling, and the percentage of waste capture demonstrated to be realistic. A standard 8000t (i.e. not semi – enclosed) farm would not be suitable for this area as the flow dynamics are not suitable for this large biomass.
- Nutrient influence has been identified as a potential risk from this farm. Conservative tracer modelling of nutrients should be undertaken to examine this risk.
- Features at risk, identified at this stage, do not appear to influence the feasibility of the proposed site with respect to the regulatory framework. These risks should be examined using a detailed marine model.
- Lurignish (LURI1) is suitable to progress to the next stage of the pre-application process. For this semi enclosed novel farm, a CFD modelling method statement will be required as the first step. Once CFD modelling has been completed, this screening report will be updated to reflect any perceived changes to the risk. and identified features at risk.
- NewDepomod modelling should be undertaken for the proposed site, using the output from the CFD modelling, to ensure the local impacts of the proposed biomass and waste capture are acceptable. It is strongly recommended that default NewDepomod modelling is undertaken prior to any marine modelling.

List of abbreviations

SEPA Scottish Environment Protection Agency

List of chemical abbreviations

AZA Azamethiphos

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1 Introduction

Screening Modelling and Risk Identification are important steps in the SEPA regulatory framework for marine pen fish farms. They are carried out by SEPA at the pre-application stage, which is described in detail at:

https://www.sepa.org.uk/regulations/water/aquaculture/pre-application/.

This document briefly describes the objectives of screening and risk identification and summarises the methods used. Screening output for the proposed site is then presented with comments. Risks identified from the screening output are detailed. Conclusions and recommendations about the suitability of the proposed site are then made.

1.1 The objectives of screening modelling and risk identification

A summary of the modelling methods employed during screening modelling is outlined in section 1.2. The objectives of screening modelling and risk identification are outlined below.

1.1.1 Screening modelling

Marine Modelling technology can be used to simulate and predict the potential influence of discharges on the marine environment. SEPA will require the majority of proposed farms to conduct detailed marine modelling, as outlined in our Aquaculture Modelling guidance [1] and on the SEPA Website.

Marine modelling can also be used at an earlier stage to provide an initial estimate of the influence of material discharged from a proposed site.

SEPA will carry out marine modelling at the screening and risk identification stage. This is a simplified version of the detailed modelling required of the applicant. However, it will be sufficient to perform an initial risk assessment of a proposal. Screening marine modelling will also include discharges from other relevant aquaculture sites and major sources.

The objectives of the simplified screening modelling are to:

- Produce maps of the predicted dispersive and erosive capacity of the sea areas in the vicinity of aquaculture sites
- Produce maps of the predicted spread of sediment discharged from aquaculture sites
- Produce maps of the predicted spread of bath treatment medicines from aquaculture sites
- Present an analysis of the potential influence of sediment and bath treatment discharges from the proposed site alongside existing sites within the surrounding sea area

- Present information on the sensitive features and sites of interest within the surrounding sea area, which must be addressed during pre-application work
- Present a summary of the suitability of the proposal with respect to the dispersal of waste and how this may be modelled.

1.1.2 Risk identification

Maps and analysis of screening output will be compared to information relating to sensitive features and relevant areas of interest. These may include:

- Marine Protected Area (MPA)
- Special Area of Conservation (SAC)
- Priority Marine Feature (PMF)
- Any site identified via consideration of other permitted or regulatory activities.

SEPA Staff will meet to discuss screening model output and the relevant sensitive features information. Following this meeting, a list of identified risks will be added to this report.

1.1.3 Conclusion of screening modelling and risk identification

Following the identification of risks, SEPA will present a summary of the suitability of the proposal with respect to the:

- Dispersal of waste from the proposed site and other sources
- Risks posed to sensitive features
- Likely level of modelling that will be required to address the risks identified.

1.2 Screening modelling methods

Marine models divide the sea up into a “grid” of boxes or triangles (often called cells). Each of these is given a water depth. For the screening modelling presented in this report the Marine Scotland “Wider Loch Linnhe System” (WLLS) has been used. An image of the WLLS model grid is shown in Figure 1. This grid has been set up within a marine modelling software package called MIKE 21 which is manufactured by the company DHI A/S (https://www.dhigroup.com/).

Marine models carry out calculations across a grid to work out how seawater moves and mixes in response to tidal and weather forces. Marine models can also be used to simulate how seawater moves and mixes due to salinity and temperature differences across an area, particularly in response to inputs of freshwater from rivers. For pollutant influence assessments the mixing (dispersion) of dissolved (bath medicine) and particulate (sediment) pollutants can also be estimated. Calculations within a marine model can be performed in three dimensions (3D), where the grid is split into layers to better represent how properties of the sea change with depth. Two dimensional (2D) models can also be created where processes over the water depth are simplified. The amount of mixing in a marine model can be varied using settings in the software.

Screening modelling is currently carried out with 2D models using average mixing settings in the model software. In many areas, this approach will be sufficient to make an initial estimate of the influence of a proposed site. Our screening assessment will take into account factors which may limit a 2D approach. We will also consider whether a particular location is adequately represented by the available models.

1.2.1 Water movement and mixing modelling

Water movement and mixing modelling (hydrodynamics) has been carried out to generate one month of results. The boundaries (edge(s) of) the model have been driven using the "wider domain" Scottish Shelf Model [2]. Wind forces and freshwater inputs have been applied to the model from the same source. The results generated are an estimate of the average water movement and mixing conditions within the model area.

1.2.2 Sediment waste modelling

Screening modelling provides a precautionary and **indicative** estimate of the size, location and intensity of waste organic material released from aquaculture sites.

The release of sediment from sources within the model area is simulated using one month of hydrodynamic results with particle tracking modelling technology. Virtual particles are continually introduced to the model grid to represent the potential dispersion of sediment from the sources. Particles in the model are moved and mixed by the hydrodynamics. Additionally, particles are assigned simplified properties, which allow them to settle through the water and be re-suspended (eroded and lifted) from the sea bed.

1.2.3 Bath medicine modelling

Screening modelling provides a precautionary and **indicative** estimate of the size, location and concentration of bath medicine releases.

The release of bath treatment medicine from sources within the model area is simulated using hydrodynamic results along with particle tracking modelling technology. Virtual particles are introduced to the model grid to represent the potential dispersion of bath medicines from the sources. Particles in the model are moved and mixed by the hydrodynamics. Releases of bath medicines are simulated under worst case mixing (dispersion) conditions, which occur under neap tides. The maximum treatment amount likely to be used at each site is released into the model at the same time and plumes are tracked over the following 96 hours (4 days). Treatment amounts used at screening have been derived from an analysis of historical data. Additionally, all bath medicine particles are concentrated within the top 5 m of the sea area. As all bath medicines are likely to disperse in a similar way, only Azamethiphos (AZA) has been modelled at the screening stage.

1.2.4 Nutrient assessment

Whilst nutrients are not directly modelled during screening, the dispersion of bath medicine releases will give an indication of the likely level of nutrient dispersion. This will be considered alongside any pre-existing nutrient assessment information that may be available.

1.2.5 Anaysis of modelling output

SEPA processes the screening modelling output and places it into a standard analysis application built in TIBCO Spotfire. The application allows for the production of standard maps and tables, which are presented below.

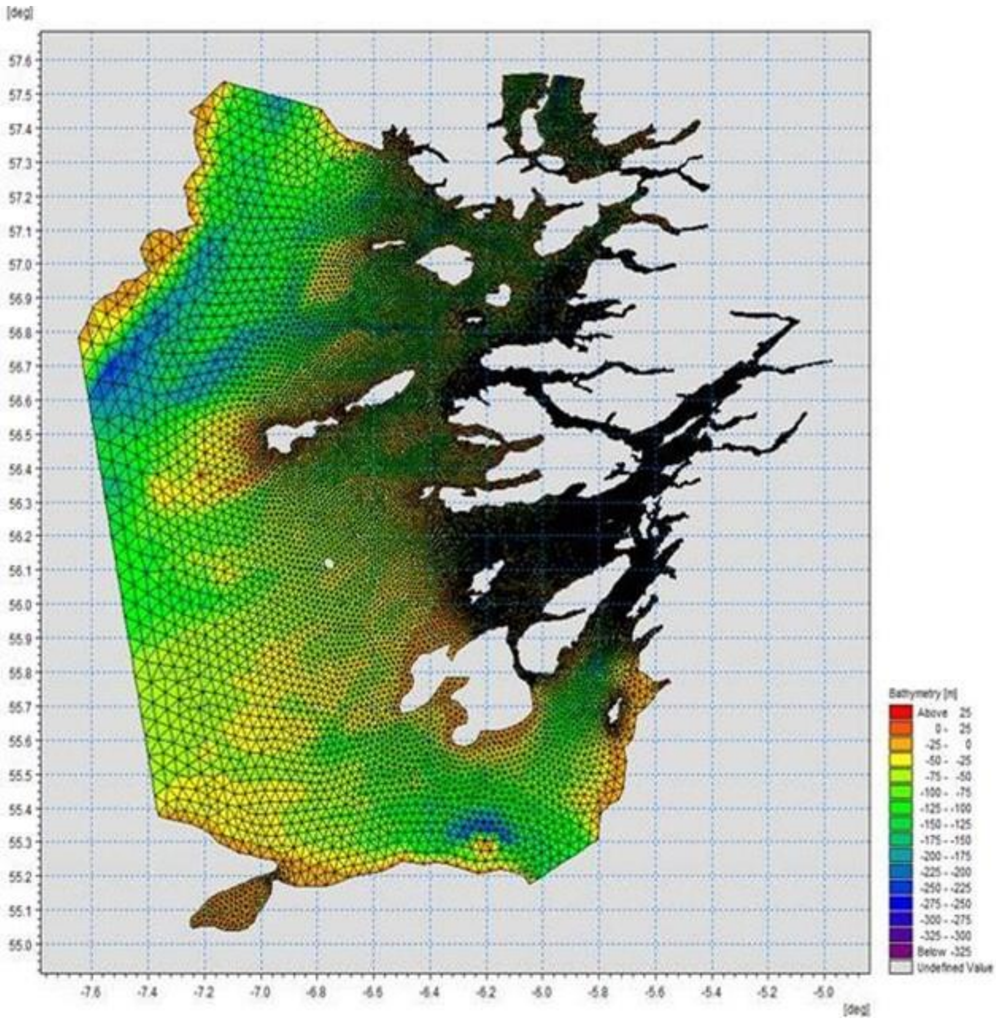

Figure 1: Wider Loch Linnhe System model grid

2 Screening modelling

2.1 Site proposal

Screening modelling has been carried out for a proposed new semi - enclosed farm: Lurignish (LURI1). The proposal is to site the farm at location: 193975, 751416 (Easting, Northing). The proposed weight of the fish to be farmed at this location is 8000 tonnes. For the screening modelling presented here all relevant licenced sites have been modelled in conjunction with the proposed new site. CFD (Computational Fluid Dynamics) modelling is to be undertaken to assess the proportion of waste expected to be captured. As this proportion is currently unknown, screening has been done to investigate the risks associated with 90%, 50% and 0% waste capture. No medicines are being applied for due to the semi – enclosed nature of the site, therefore no bath medicine screening modelling has been undertaken. Instead, we have used bath medicine modelling output to examine the potential influence on nutrients released from the farm.

2.1.1 Accuracy of model in the area surrounding the proposal

The Wider Loch Linnhe System model used for screening modelling has a relatively high resolution in this area. Comparison against various sources of observed current meter data indicates that the model provides a reasonable description of the physical processes in the vicinity of the proposed site. However, due to the sea loch nature of the area of interest our tools may overestimate the amount of mixing of non-sediment material.

2.2 Dispersion and erosion capacity maps

Modelled water movement in a sea area can be analysed and presented to show the capacity of the water to move and disperse discharged substances. It is also possible to show the capacity available to erode substances from the seabed. This information is a useful guide to the potential size of a marine fin fish aquaculture farm at a particular location.

Marine fin fish aquaculture farms using open-net pens will benefit from operating in locations where there are strong, repeating, water currents to erode and disperse waste.

For the purposes of screening we consider locations which meet the following water flow criteria to be generally suitable for larger farms:

Locations with average water flow speeds of greater than, or equal to, 0.12 metres per second (0.23 knots)
Locations where water flow speeds are often above the threshold of 0.095 meters per second (0.18 knots).

Locations with these properties are likely to disperse discharged material rapidly, and regularly erode sediment discharged to the seabed. In general, we would look for these properties to be maintained over a large area around a proposed site.

The thresholds stated above are indicative.

A map of modelled average water flow speed for the area surrounding the proposed site is shown in Figure 2. The average water flow speed in each cell of the model grid (see section 1.2) has been assigned a shade. The key for the shading is shown in the top left of the figure. Grid cells that have average speeds less than 0.12 m/s (metres per second) are marked on the figure. The greater the shading, the slower the average current speed and the lower the capacity for dispersion.

Figure 3 is a map of the percentage of time the modelled water flow speed in a grid cell is above 0.095 m/s (metres per second). The greater the shading, the lower the capacity for material to be eroded from the seabed.

Licenced aquaculture farms in the vicinity of the proposed site are also marked on Figure 2 and Figure 3. Discharges of material from these sites have been included in the screening modelling.

Based on the maps of the modelled water flow properties we can make the following observations about the proposed site location:

- It lies in a moderate dispersion area.
- It lies in an area where water flow has a relatively low capacity to erode material on the seabed.

2.3 Sediment influence maps and analysis for 0% waste capture (i.e. standard farm).

Modelled particles in a sea area can be analysed for each modelled grid cell and presented to show the potential influence of discharged sediment on the surrounding sea area.

2.3.1

Figure 4 shows a map of the modelled average sediment intensity over one month (time average) for the proposed site only. Grid cells within the model that are influence by modelled sediment are shaded according to the intensity of the influence in grams per square metre (g/m2).

> Values less than 1 g/m^2 have been excluded from the map and subsequent calculations. These low concentration cells are produced by the particle tracking approach but they are not considered to be representative of the main influence of a discharge.

The shading key is shown in the top left of the figure. Cells which are shaded black are similar to the average intensity in the total area of influence shown in the map. Cells shaded pink are similar to the median (middle value in the range) intensity value shown on the map. White shaded cells are similar to the minimum intensity value shown on the map.

- The average and median sediment intensity over the area of influence is 57.98 g/m2 and 11.13 g/m2 respectively.
- Cells influenced by the proposed site do not appear to lie close to other modelled farm sites.

Figure 5 shows a map of the modelled average sediment intensity over one month for the proposed site and other relevant sites. Grid cells within the model that are influenced by modelled sediment are shaded according to the intensity of the influence in grams per square metre (g/m2). The shading key is shown in the top left of the figure and is in a similar format as that shown in Figure 4. The average sediment intensity, after including all relevant sites, is decreased.

- The average and median sediment intensity over the area of influence is 16.31 g/m2 and 2.68 g/m2 respectively.
- A small number of cells influenced by other modelled sites appear to lie close to the proposed site.

2.3.2 Sediment influence analysis

Model grid cells can be analysed to estimate the size and concentration of the potential sediment influence from the modelled sites.

- The total area of sediment influenced by the twelve sites modelled is estimated to be 15.21 square kilometres (km2).
- As shown in Figure 5, the average and median intensity over this area is 16.31 and 2.68 g/m2 respectively.
- The total weight of fish that generates this modelled influence is 23911 tonnes.

Table 1 shows the information for each individual site modelled. It is important to note that the total area of influence for all sites is not the sum of the numbers in Table 1. The total area of influence worked out above takes into account that the individual areas of influence from different sites will overlap.

Table 1: Sediment influence information for each site, where 0% of waste is captured at the proposed site (LURI1).

Site Name	Average Intensity (g/m^2)	Area of Influence (km^2)	Median Intensit y (g/m^2)	Max weight Of Fish (tonnes)
LURI1	57.98	1.79	11.13	8000 (with 0% waste capture)
ARDG1	4.19	3.88	1.72	2500
CALL1	13.29	1.49	4.58	1607
FFMC18	23.43	0.42	5.68	800
FFMC19	9.55	1.46	2.74	1500
FFMC20	8.86	1.60	2.78	1500
FFMC40A	72.96	0.12	26.46	680
FFMC40B	2.17	0.45	1.56	500
FFMC41	3.06	1.19	1.80	999
FFMC60	1.95	3.68	1.50	1925
GORS1	13.77	2.27	3.97	2500
KING1	263.04	0.07	6.58	1400

There are no Environmental Standards for sediment intensity. However, we consider that:

- underneath farm pens, an intensity of 2000 g/m^2 or less is likely to lead to an acceptable sea bed ecological outcome
- at the edge of the mixing zone, an intensity of 250 g/m^2 or less is likely to lead to an acceptable sea bed mixing zone outcome

The estimate of influence detailed above is indicative. The values presented are lower than the sediment intensity values given above. However, we recognise that low sediment concentrations may be useful for the identification of risks.

2.4 Sediment influence maps and analysis for 50% waste capture.

Modelled particles in a sea area can be analysed for each modelled grid cell and presented to show the potential influence of discharged sediment on the surrounding sea area.

2.4.1

Figure 4 shows a map of the modelled average sediment intensity over one month (time average) for the proposed site only. Grid cells within the model that are influence by modelled sediment are shaded according to the intensity of the influence in grams per square metre (g/m2).

Values less than 1 g/m^2 have been excluded from the map and subsequent calculations. These low concentration cells are produced by the particle tracking approach but they are not considered to be representative of the main influence of a discharge.

The shading key is shown in the top left of the figure. Cells which are shaded black are similar to the average intensity in the total area of influence shown in the map. Cells shaded pink are similar to the median (middle value in the range) intensity value shown on the map. White shaded cells are similar to the minimum intensity value shown on the map.

- The average and median sediment intensity over the area of influence is 33.16 g/m2 and 7.31 g/m2 respectively.
- Cells influenced by the proposed site do not appear to lie close to other modelled farm sites.

Figure 5 shows a map of the modelled average sediment intensity over one month for the proposed site and other relevant sites. Grid cells within the model that are influenced by modelled sediment are shaded according to the intensity of the influence in grams per square metre (g/m2). The shading key is shown in the top left of the figure and is in a similar format as that shown in Figure 4. The average sediment intensity, after including all relevant sites, is decreased.

- The average and median sediment intensity over the area of influence is 13.07 g/m2 and 2.66 g/m2 respectively.
- A small number of cells influenced by other modelled sites appear to lie close to the proposed site.

2.4.2 Sediment influence analysis

Model grid cells can be analysed to estimate the size and concentration of the potential sediment influence from the modelled sites.

- The total area of sediment influenced by the twelve sites modelled is estimated to be 15.01 square kilometres (km2).
- As shown in Figure 5, the average and median intensity over this area is 13.07 and 2.66 g/m2 respectively.
- The total weight of fish that generates this modelled influence is 23911 tonnes.

Table 1 shows the information for each individual site modelled. It is important to note that the total area of influence for all sites is not the sum of the numbers in Table 1. The total area of influence worked out above takes into account that the individual areas of influence from different sites will overlap.

Table 2: Sediment influence information for each site, where 50% of waste is captured at the proposed site (LURI1).

Site Name	Average Intensity (g/m^2)	Area of Influence (km^2)	Median Intensit y (g/m^2)	Max weight Of Fish (tonnes)
LURI1	33.16	1.56	7.31	8000 (with 50% waste capture)
ARDG1	4.19	3.88	1.72	2500
CALL1	13.29	1.49	4.58	1607
FFMC18	23.43	0.42	5.68	800
FFMC19	9.55	1.46	2.74	1500

FFMC20	8.86	1.60	2.78	1500
FFMC40A	72.96	0.12	26.46	680
FFMC40B	2.17	0.45	1.56	500
FFMC41	3.06	1.19	1.80	999
FFMC60	1.95	3.68	1.50	1925
GORS1	13.77	2.27	3.97	2500
KING1	263.04	0.07	6.58	1400

There are no Environmental Standards for sediment intensity. However, we consider that:

- underneath farm pens, an intensity of 2000 g/m^2 or less is likely to lead to an acceptable sea bed ecological outcome
- at the edge of the mixing zone, an intensity of 250 g/m^2 or less is likely to lead to an acceptable sea bed mixing zone outcome

The estimate of influence detailed above is indicative. The values presented are lower than the sediment intensity values given above. However, we recognise that low sediment concentrations may be useful for the identification of risks.

2.5 Sediment influence maps and analysis for 90% waste capture.

Modelled particles in a sea area can be analysed for each modelled grid cell and presented to show the potential influence of discharged sediment on the surrounding sea area.

2.5.1

Figure 4 shows a map of the modelled average sediment intensity over one month (time average) for the proposed site only. Grid cells within the model that are influence by modelled sediment are shaded according to the intensity of the influence in grams per square metre (g/m2).

Values less than 1 g/m^2 have been excluded from the map and subsequent calculations. These low concentration cells are produced by the particle tracking approach but they are not considered to be representative of the main influence of a discharge.

The shading key is shown in the top left of the figure. Cells which are shaded black are similar to the average intensity in the total area of influence shown in the map. Cells shaded pink are similar to the median (middle value in the range) intensity value shown on the map. White shaded cells are similar to the minimum intensity value shown on the map.

- The average and median sediment intensity over the area of influence is 10.04 g/m2 and 2.75 g/m2 respectively.
- Cells influenced by the proposed site do not appear to lie close to other modelled farm sites.

Figure 5 shows a map of the modelled average sediment intensity over one month for the proposed site and other relevant sites. Grid cells within the model that are influenced by modelled sediment are shaded according to the intensity of the influence in grams per square metre (g/m2). The shading key is shown in the top left of the figure and is in a similar format as that shown in Figure 4. After including all relevant sites, the average sediment intensity is decreased, whilst the median is increased.

- The average and median sediment intensity over the area of influence is 13.14 g/m2 and 2.83 g/m2 respectively.
- A small number of cells influenced by other modelled sites appear to lie close to the proposed site.

2.5.2 Sediment influence analysis

Model grid cells can be analysed to estimate the size and concentration of the potential sediment influence from the modelled sites.

- The total area of sediment influenced by the twelve sites modelled is estimated to be 11.21 square kilometres (km2).
- As shown in Figure 5, the average and median intensity over this area is 13.14 and 2.83 g/m2 respectively.
- The total weight of fish that generates this modelled influence is 23911 tonnes.

Table 1 shows the information for each individual site modelled. It is important to note that the total area of influence for all sites is not the sum of the numbers in Table 1. The total area of influence worked out above takes into account that the individual areas of influence from different sites will overlap.

Table 3: Sediment influence information for each site, where 90% of waste is captured at the proposed site (LURI1).

Site Name	Average Intensity (g/m^2)	Area of Influence (km^2)	Median Intensit y (g/m^2)	Max weight Of Fish (tonnes)
LURI1	10.04	1.00	2.75	8000 (with 90% waste capture)
ARDG1	4.19	3.88	1.72	2500

CALL1	13.29	1.49	4.58	1607
FFMC18	23.43	0.42	5.68	800
FFMC19	9.55	1.46	2.74	1500
FFMC20	8.86	1.60	2.78	1500
FFMC40A	72.96	0.12	26.46	680
FFMC40B	2.17	0.45	1.56	500
FFMC41	3.06	1.19	1.80	999
FFMC60	1.95	3.68	1.50	1925
GORS1	13.77	2.27	3.97	2500
KING1	263.04	0.07	6.58	1400

There are no Environmental Standards for sediment intensity. However, we consider that:

- underneath farm pens, an intensity of 2000 g/m^2 or less is likely to lead to an acceptable sea bed ecological outcome
- at the edge of the mixing zone, an intensity of 250 g/m^2 or less is likely to lead to an acceptable sea bed mixing zone outcome

The estimate of influence detailed above is indicative. The values presented are lower than the sediment intensity values given above. However, we recognise that low sediment concentrations may be useful for the identification of risks.

2.6 Bath medicine influence maps and analysis for 0% waste capture (i.e. a standard farm).

Modelled particles in a sea area can be analysed for each modelled grid cell and presented to show the potential influence of discharged bath medicine on the surrounding sea area. Results presented are for the AZA medicine (see section 1.2.3).

2.6.1

Figure 6 shows a map of the modelled average AZA concentration over four days for the proposed site only. Grid cells within the model which experience an AZA influence are shaded according to the concentration of AZA in nanograms per litre (ng/l).

Values less than 10 ng/l have been excluded from the map and subsequent calculations. These low concentration cells are produced by the particle tracking approach but they are not considered to be representative of the main influence of a discharge.

Please note that the Environmental Standard for Azamethiphos with the lowest concentration is 40 ng/l. This must be met 72 hours after the material has been discharged. The estimate of influence detailed here is precautionary. In the information presented below areas of influence above 40 ng/l have been quoted. However the average and median concentrations are quoted for the entire area of influence above 10 ng/l.

The shading key is shown in the top left of the figure. Cells which are shaded black are similar to the average concentration in the total area of influence shown in the map. Cells shaded pink are similar to the median (middle value in the range) concentration shown on the map. White shaded cells are similar to the minimum concentration value shown on the map.

- The average and median concentration over the total area of influence is 24.07 ng/l and 15.59 ng/l respectively.
- Cells influenced by the proposed site do not appear to lie close to other modelled farm sites.

Figure 7 shows a map of the modelled average AZA influence over four days for the proposed site and other relevant sites. The average AZA influence, after including all relevant sites, is increased.

- The average and median AZA concentration over the total area of influence is 28.98 ng/l and 23.43 ng/l respectively.
- A small number of cells influenced by other modelled sites appear to lie close to the proposed site.

2.6.2 Bath medicine influence analysis

Model grid cells can be analysed to estimate the size and concentration of the potential AZA influence from the modelled sites.

- The area of AZA influenced above 40 ng/l from all sites modelled is estimated to be 4.47 square kilometres (km2).
- As shown in Figure 7, the average and median concentration over the total area of influence is 28.98 and 23.43 ng/l respectively.
- The total weight of fish that generates this modelled influence is 23911 tonnes.

Table 2 shows the information for each individual site modelled. It is important to note that the total area of influence above 40ng/l for all sites quoted above is not the sum of the numbers in Table 2. The total area of influence worked out above takes into account that the individual areas of influence above 40 ng/l from different sites will overlap.

Table 4: Azamethiphos influence information for each site, where 0% of waste is captured at the proposed site (LURI1).

Site Name	Average Intensity (g/m^2)	Area of Influence Above 40 ng/l (km^2)	Median Intensity (g/m^2)	Max weight Of Fish (tonnes)
LURI1	24.07	0.32	15.59	8000 (with 0% waste capture)
ARDG1	17.81	0.01	12.12	2500
CALL1	35.80	0.91	31.72	1607
FFMC18	19.98	0.16	14.88	800
FFMC19	18.90	0.05	15.26	1500
FFMC20	17.46	0	15.85	1500
FFMC40A	32.22	0.21	17.73	680
FFMC40B	13.89	0	12.80	500
FFMC41	28.37	0.52	18.52	999
FFMC60	21.06	0.28	17.19	1925
GORS1	36.96	1.28	25.82	2500
KING1	37.68	0.63	35.67	1400

Please note that the Environmental Standard for Azamethiphos with the lowest concentration is 40 ng/l. This must be met 72 hours after the material has been discharged. The estimate of influence detailed above is precautionary. The values presented are close to the 40 ng/l standard. Detailed modelling will be required to demonstrate compliance with all Environmental Standards.

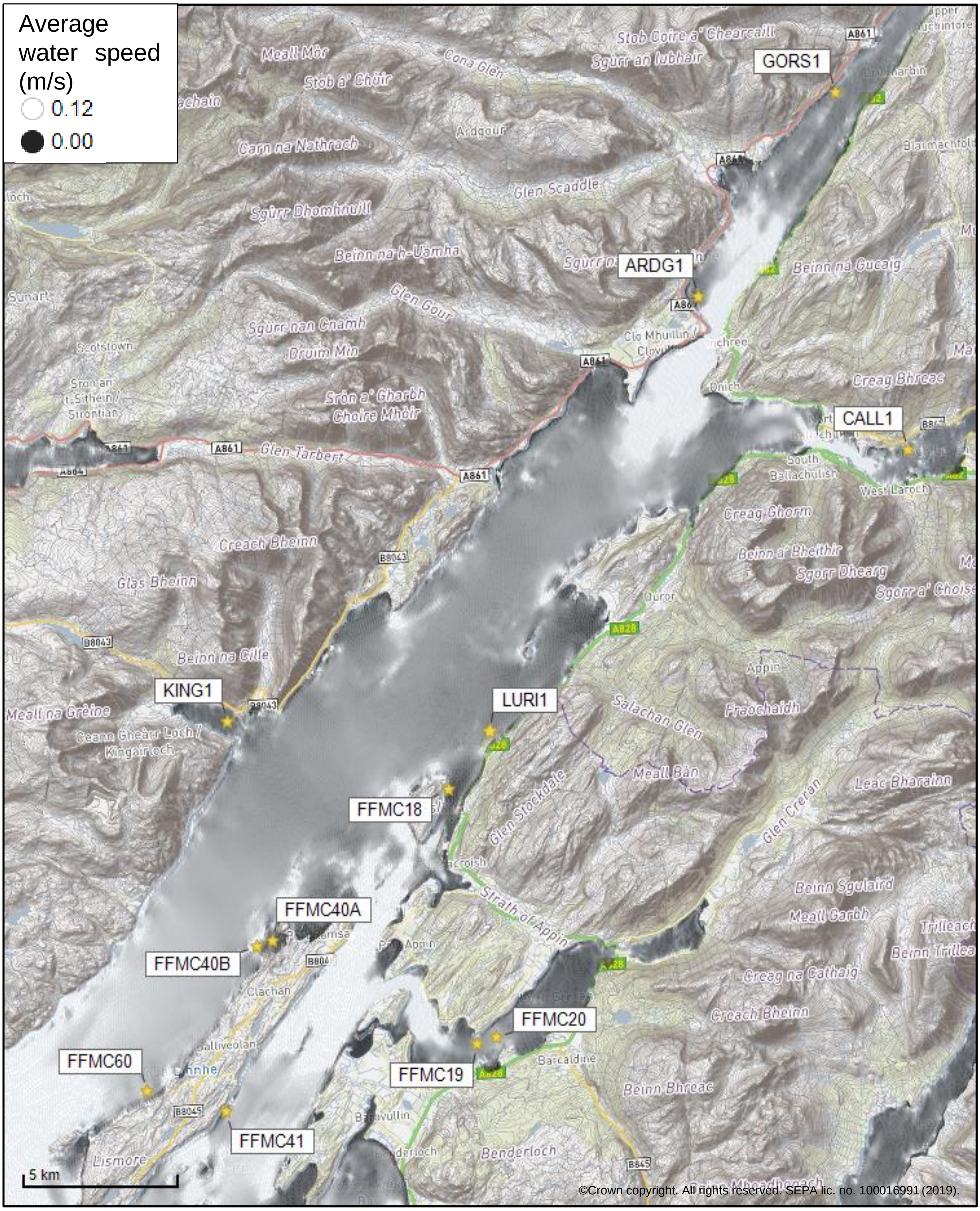

Figure 2: Modelled average water speed (metres per second – m/s) in the sea area surrounding the proposed site (Lurignish (LURI1)).

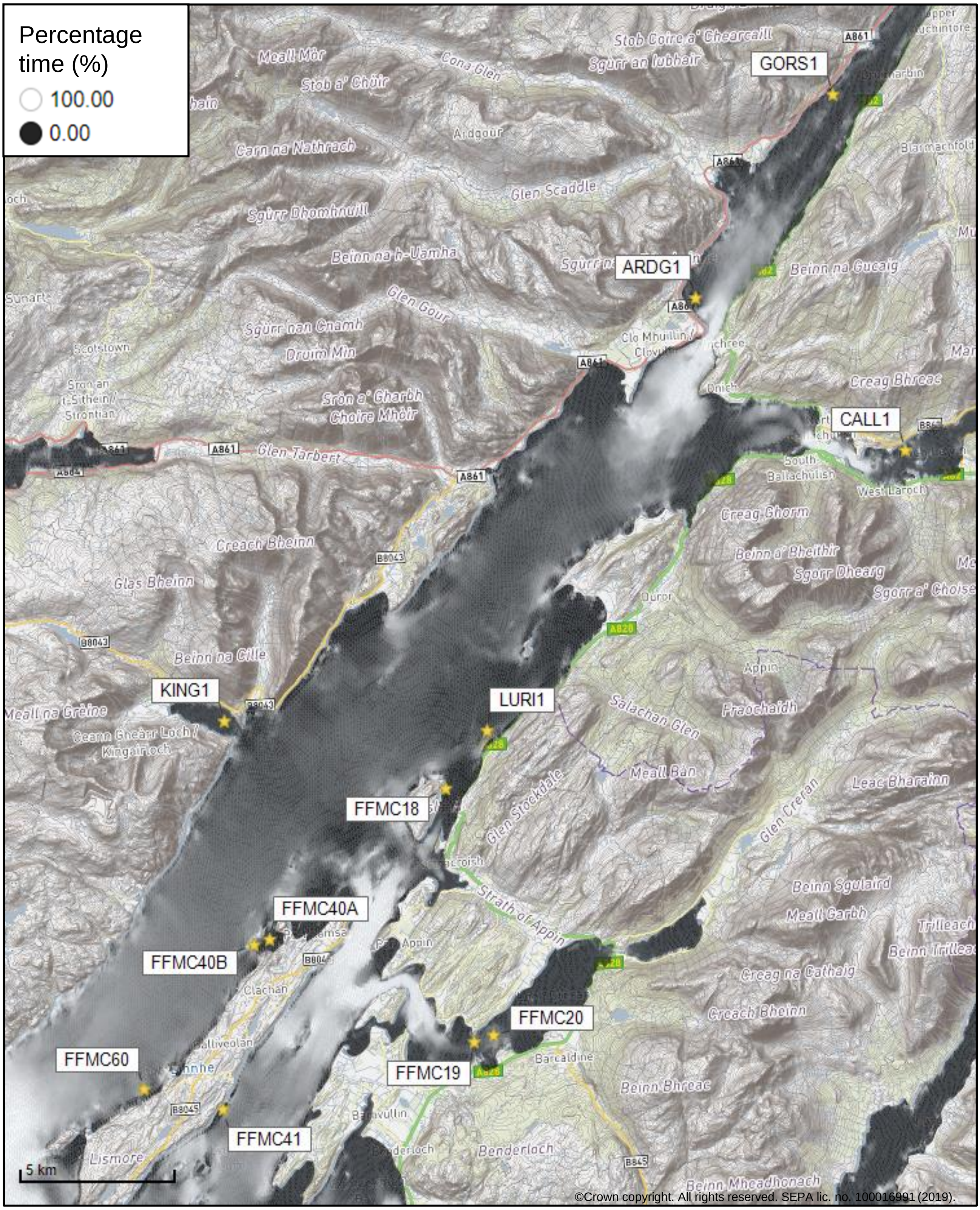

Figure 3: Modelled percentage of time the water flow speed is above 0.095 m/s in the sea area surrounding the proposed site (Lurignish (LURI1)).

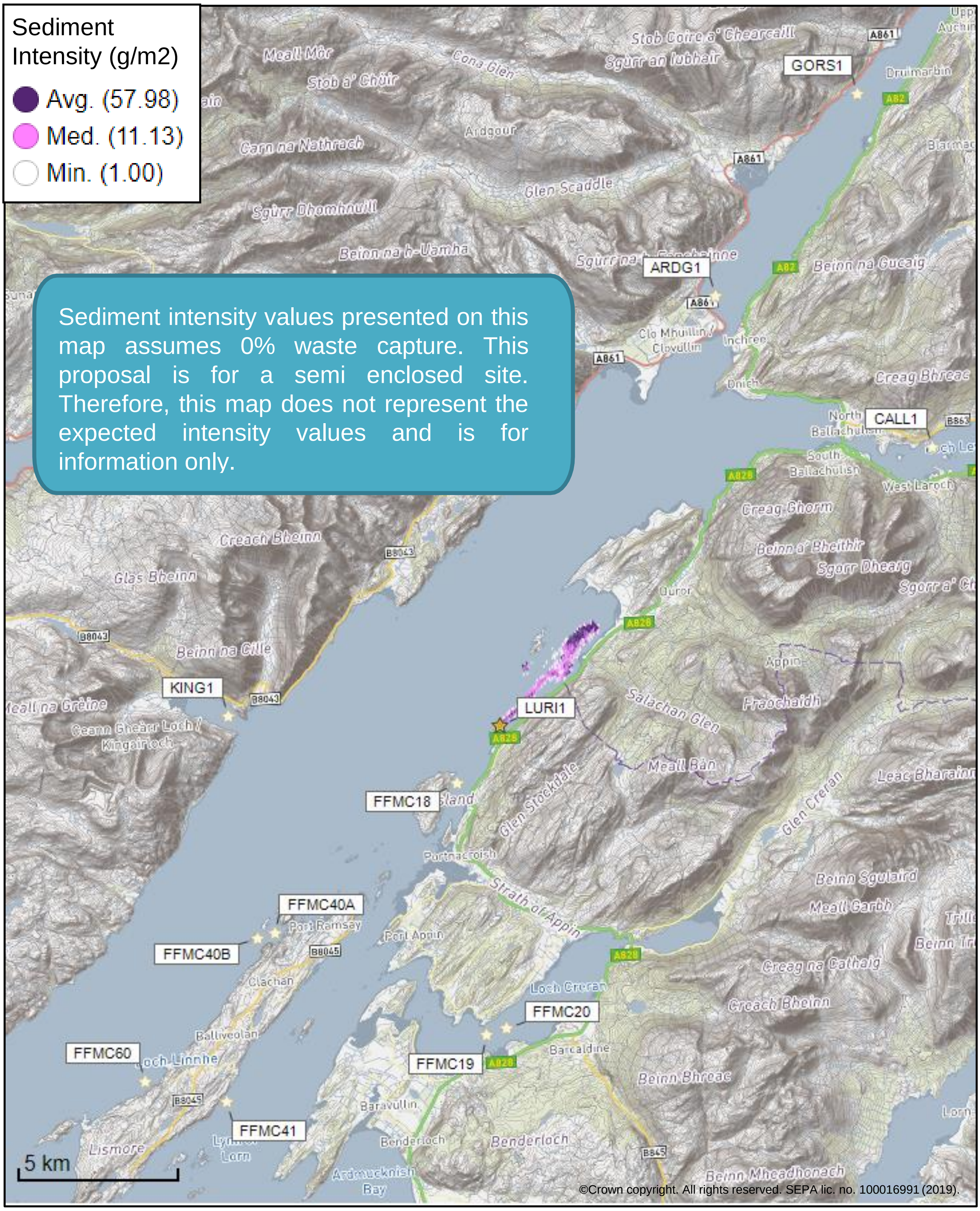

Figure 4: Modelled average sediment intensity over one month for the proposed site only (Lurignish (LURI1)), assuming 0% waste capture (i.e. a standard farm).

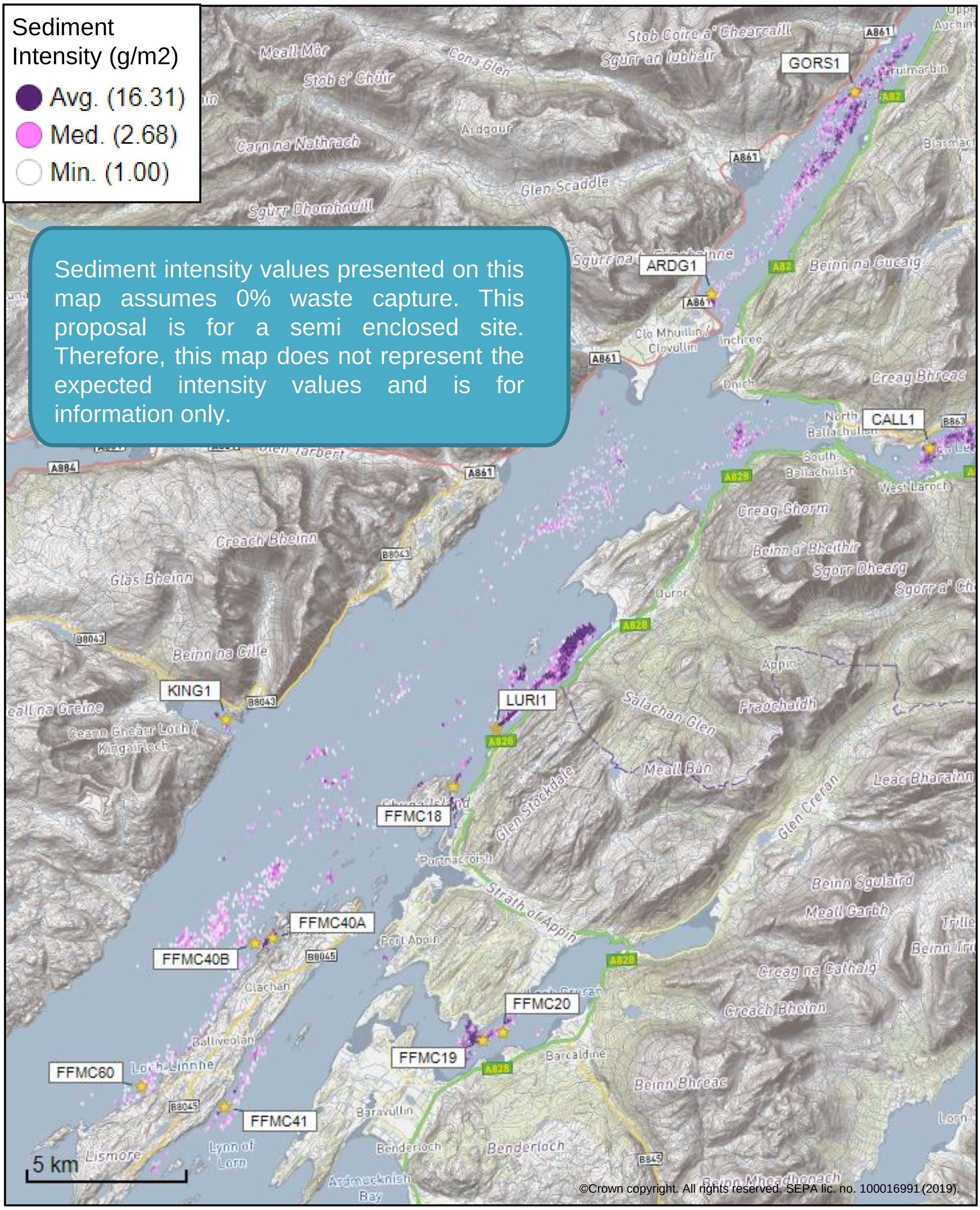

Figure 5: Modelled average sediment intensity over one month for the proposed site. (Lurignish (LURI1)), assuming 0% waste capture and other relevant sites

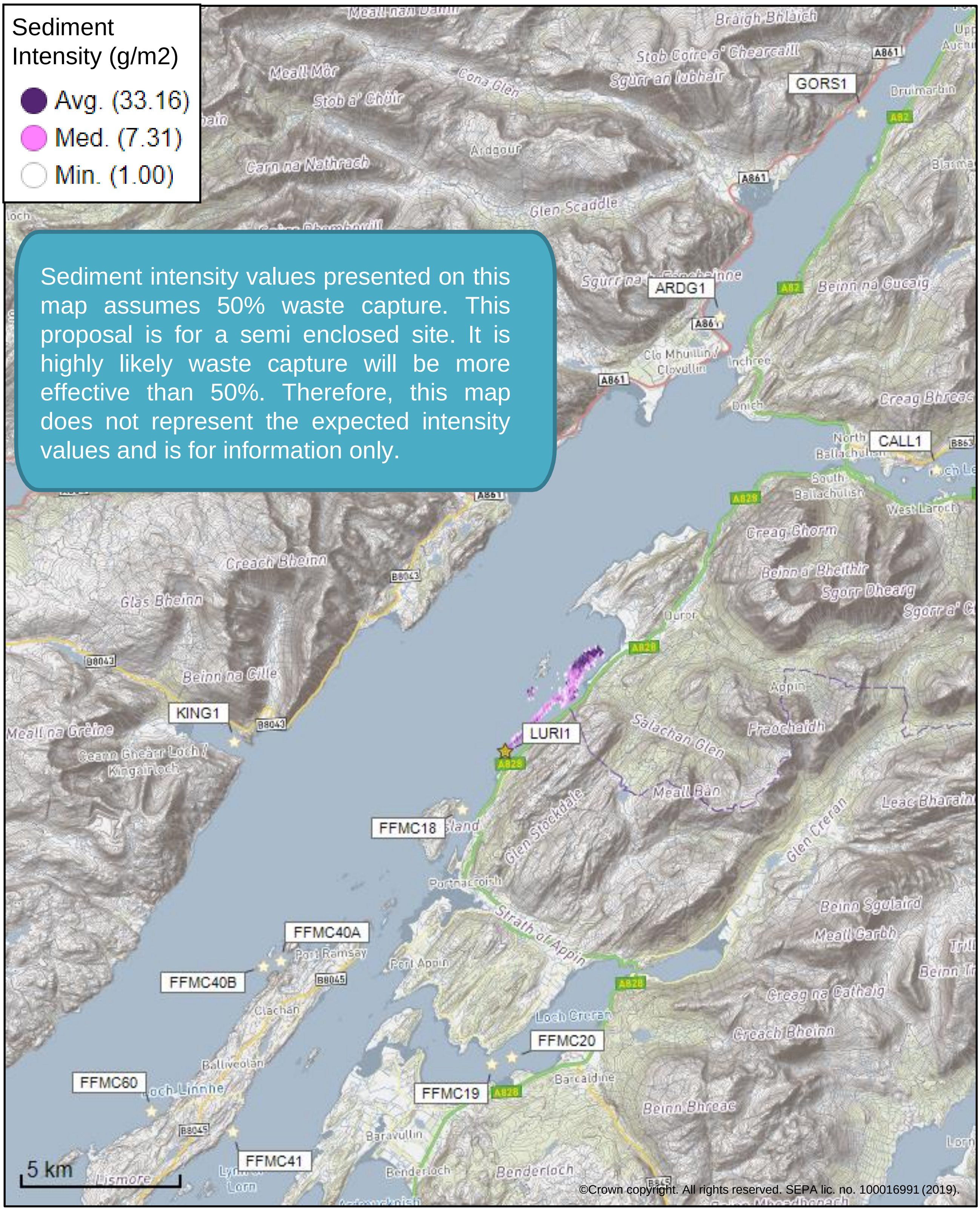

Figure 6: Modelled average sediment intensity over one month for the proposed site only (Lurignish (LURI1)), assuming 50% waste capture.

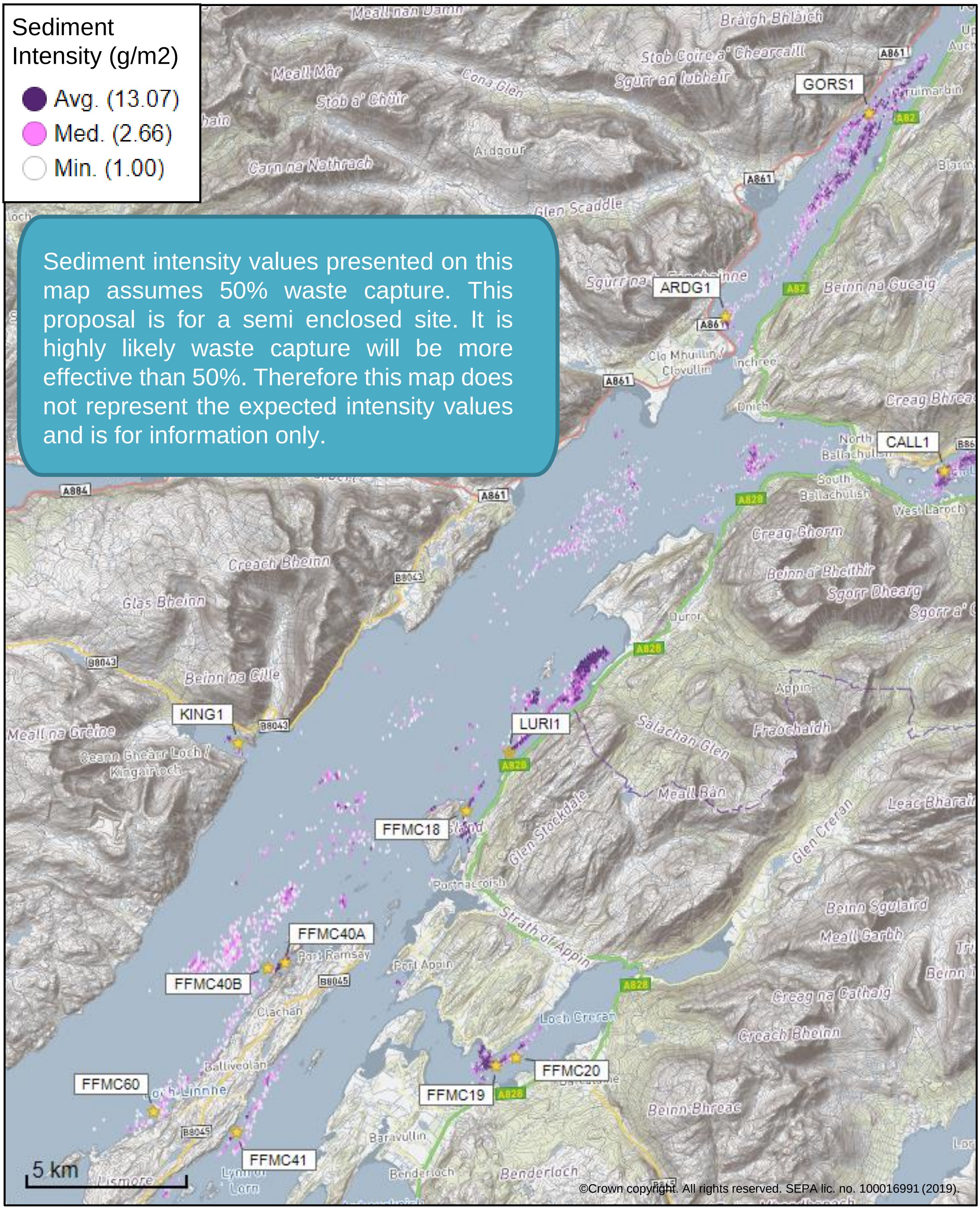

Figure 7: Modelled average sediment intensity over one month for the proposed site. (Lurignish (LURI1)), assuming 50% waste capture and other relevant sites.

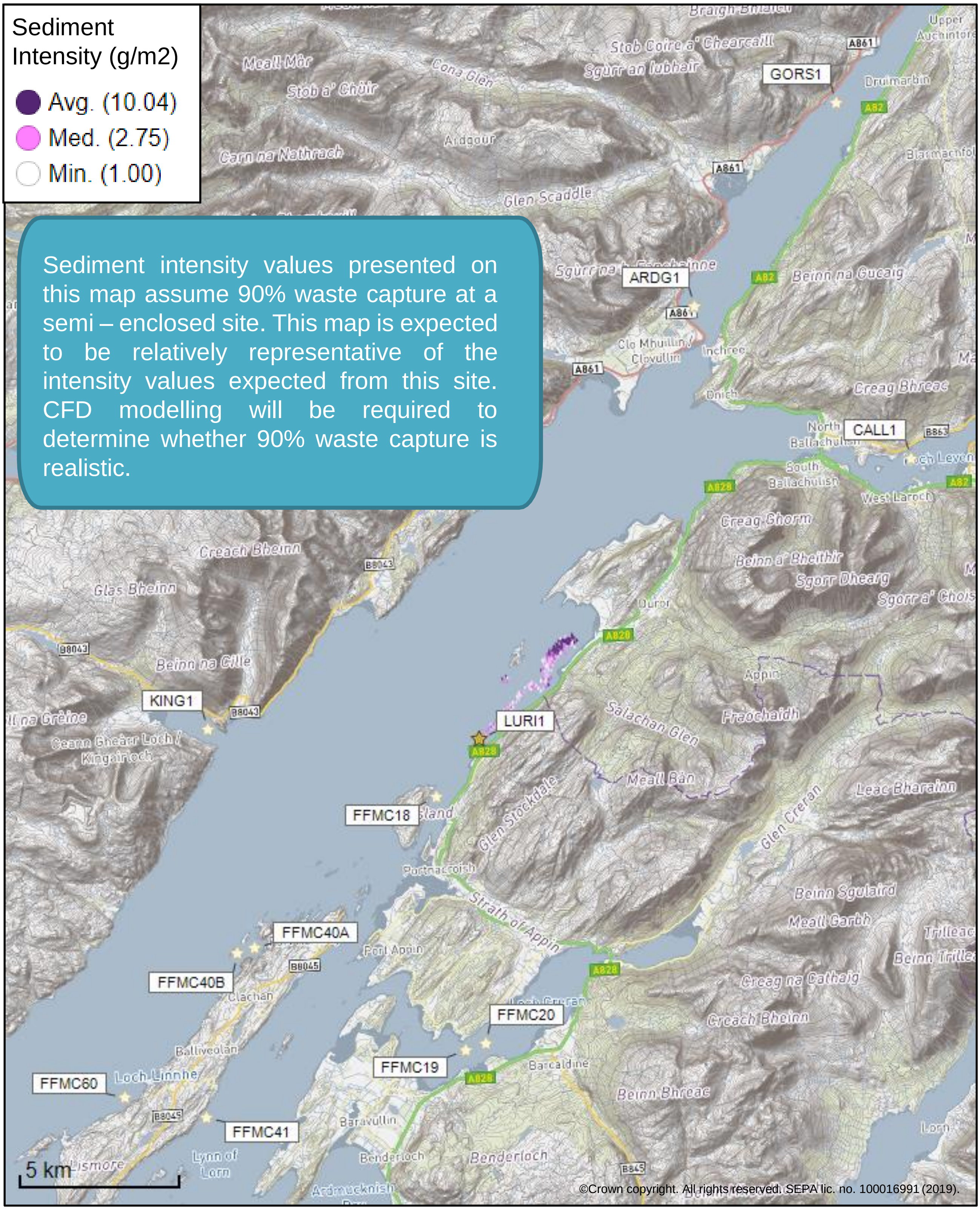

Figure 8: Modelled average sediment intensity over one month for the proposed site only (Lurignish (LURI1)), assuming 90% waste capture.

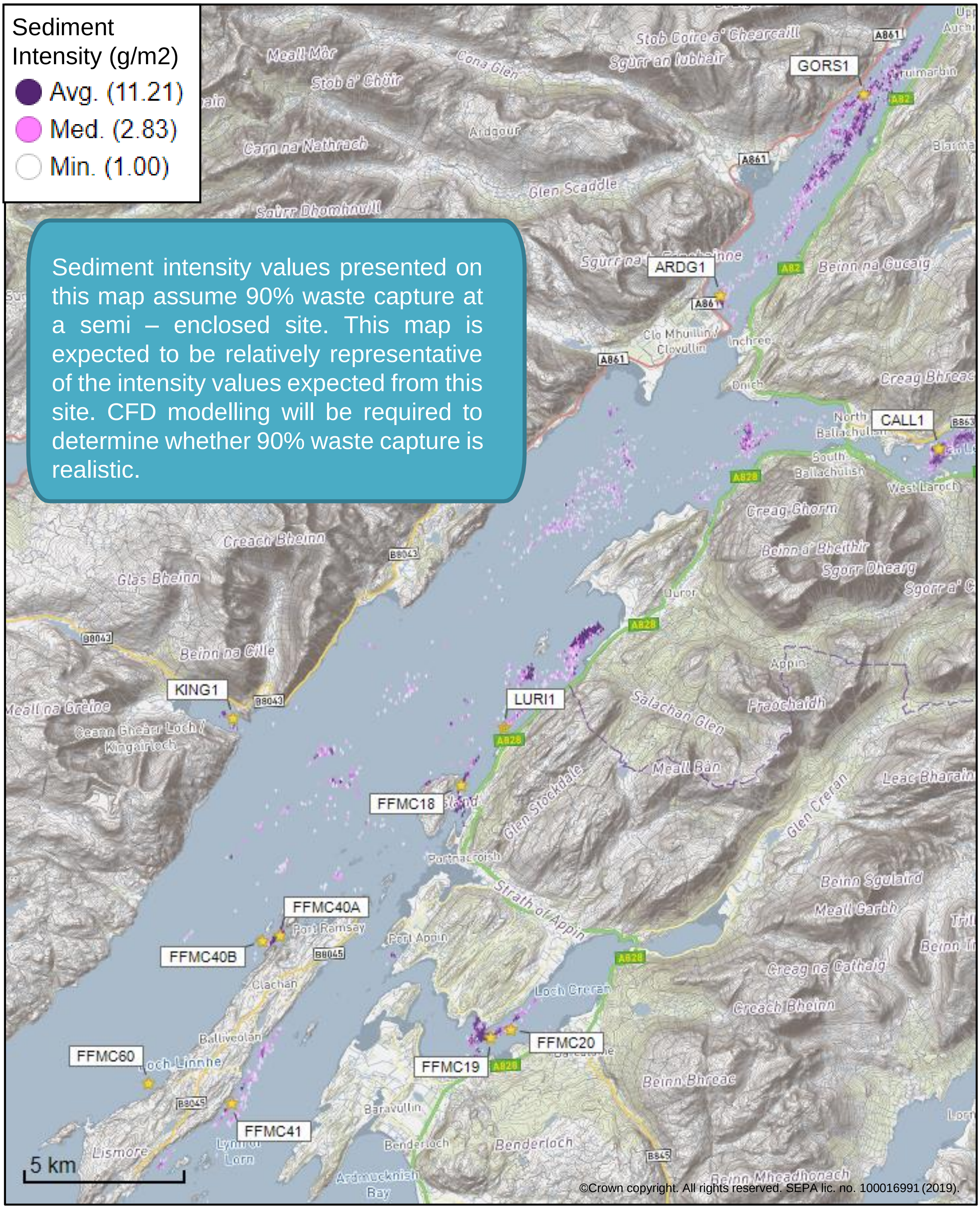

Figure 9: Modelled average sediment intensity over one month for the proposed site (Lurignish (LURI1)), assuming 90% waste capture and other relevant sites

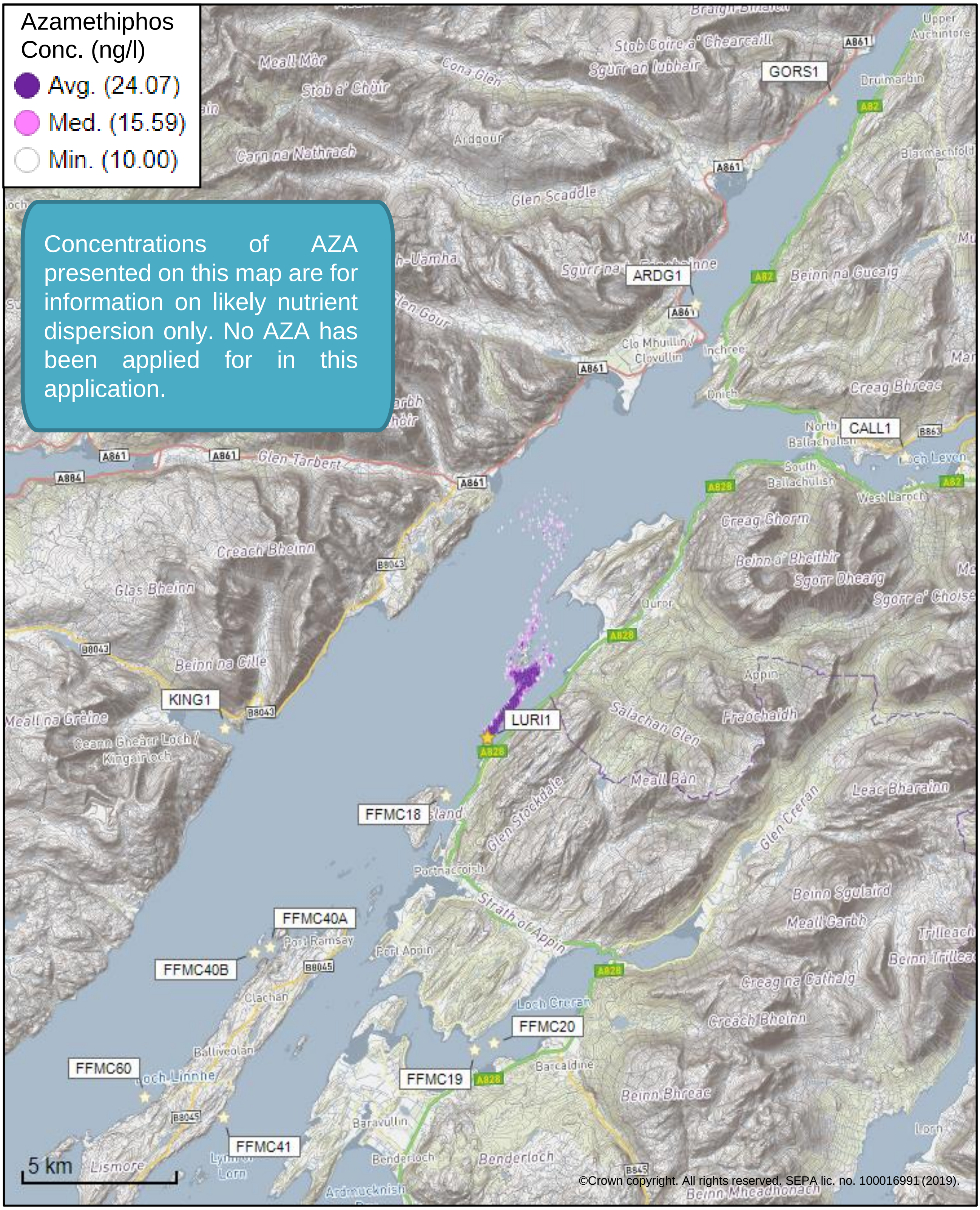

Figure 10: Modelled average Azamethiphos concentration over four days from neap tide release for the proposed site only (Lurignish (LURI1)).

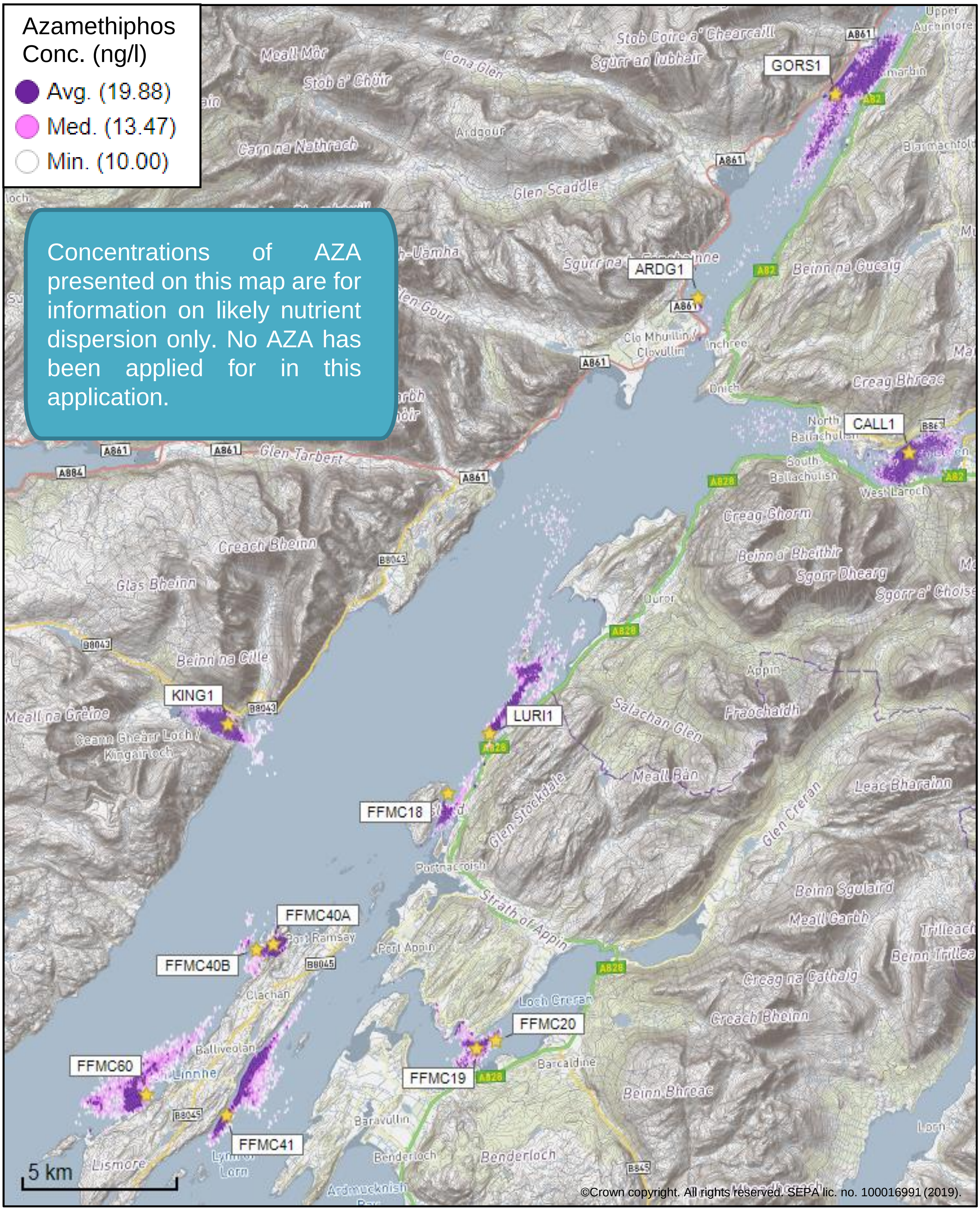

Figure 11: Modelled average Azamethiphos concentration over four days from neap tide release for the proposed site (Lurignish (LURI1)) and other relevant sites.

3 Risk Identification

The screening modelling output summarised in section 2 is compared against available information on features of interest (see section 1.1.2). Features which require attention are presented with any additional comments. Identified features will need to be considered during the pre-application phase.

These should be addressed in the applicant "Method Statement". Please refer to the Modelling Method Statement section on the SEPA Website. (https://www.sepa.org.uk/regulations/water/aquaculture/pre-application/)

3.1 Identified features which require attention

3.1.1 Table of identified features

Based on screening output the following features of interest have been identified.

Table 5: Table of identified features

No.	Feature Name	Feature Type	Location (Easting, Northing)	Brief Reason For Identification
1	Loch Creran	SAC/MPA	Shapefile1. (Figure 12)	At risk from nutrient influence
2				
3				

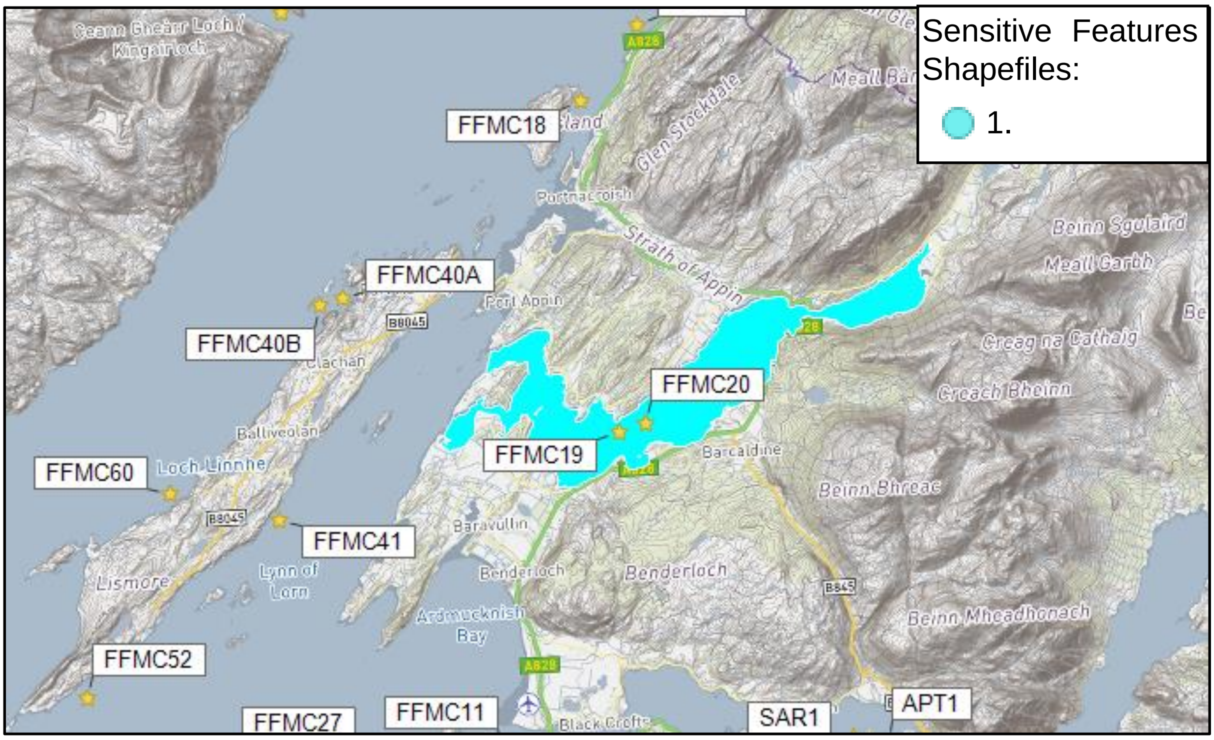

Figure 12. Shapefiles of identified features around the proposed site (Lurignish (LURI1)).

3.2 Additional comments on identified features

Whilst known PMFs within this area have been considered, screening modelling does not predict any significant sediment influence to these from (Lurignish (LURI1)) nor does it predict significant interactions between farms.Although levels of risk associated with this site are difficult to predict without CFD modelling to demonstrate realistic levels of waste capture at this site, should the levels of solids captured be within the expected region of 90% (as is conservative for similar technology), the solids impact on the wider environment is expected to be low. Therefore, marine modelling of solids will not be required, unless CFD modelling suggest the waste capture technology is less effective than expected.

The known PMFs in this area are also considered unlikely to be at risk from nutrients. However, the proximity of the farm to Loch Crenan MPA/SAC, means conservative tracer modelling of nutrients will be needed to demonstrate that there will be no significant nutrient increase into the Loch as a result of this proposed farm.

3.3 Risks identified from contextual site data

Should this application proceed, the total licenced biomass in this area would be 23911t.

Table 6: Table of licenced biomass from farms identified as potentially likely to add to cumulative risks.

Site Name	Location (Easting, Northing)	Biomass (tonnes)	Last Production Cycle
LURI1	193975, 751416	8000	Proposed
ARDG1	201386, 764579	2500	Currently stocked (since Sept 21)
CALL1	207994, 759498	1607	Currently stocked (since Oct 21)
FFMC18	192538, 749661	800	Fish last on site Jun 21
FFMC19	193080, 741703	1500	Currently stocked (since Sept 21)
FFMC20	193711, 741912	1500	Fish last on site May 21
FFMC40A	186586, 745245	680	Fish last on site Jun 19
FFMC40B	186038, 745101	500	Fish last on site May 19
FFMC41	184790, 740032	999	Currently stocked (since Oct 21)
FFMC60	182230, 740790	1925	Fish last on site Mar 21
GORS1	206146, 770663	2500	Currently stocked (since Aug 21)
KING1	185459, 752137	1400	Currently stocked (since Oct 21)

3.4 Risks identified due to novel semi enclosed farm

Given this application is for a novel semi – enclosed farm, screening modelling has been done for 0% waste capture, to help identify the level of risk under a worst-case scenario. Whilst the aim of reducing the environmental impact by developing semi-enclosed farms is appreciated, implications of the novel approach not meeting expectations should be considered. Screening modelling at 0% waste capture demonstrates very high levels of sediment would be deposited over a small area. Had this application been for a standard farm, it is very unlikely that it would be able to meet the current regulatory framework standards, as the flow conditions are unable to support the biomass. Therefore, in order to ensure structural/engineering failures of do not result in a substantial risk to the environment, this proposal needs to demonstrate that the likelihood of significant failures have been assessed, and that plans for appropriate measures to mitigate the environmental risk should failure occur, have been developed. In addition to the sediment material released directly from the pens, the waste captured material will be processed at a dewatering plant (nearby barge or shore base), and then returned to the loch. It is expected this will remove approx. 95% of the solids, releasing only the smaller sediments.

This outlet pipe will need to be assessed using initial dilution calculations, as consistent with point source applications, but should also be included in any marine modelling of this site. Sea lice are not considered to be an issue in this proposal as the influx water pipe is expected to be below the sea lice zone. This is based on evidence from similar systems used in Norway. Considering this is an application for a very large farm, with no sea lice medicines applied for, a short description of processes which can be put in place to deal with an unexpected sea lice infestation will be required.

3.5 Potential risks due to increased nutrient release

Whilst medicines are not proposed to be used at this site, the screening output suggests that other dissolved material released from the farm, such as nutrients, is unlikely to be mixed quickly through the surrounding water. A build-up of nutrients, under specific conditions, in a water area can influence plankton growth. This may, in turn, lead to a deterioration in water quality. As outlined on our website, guidelines, prepared by Marine Scotland, can be used to assess the likelihood of nutrient risks to the marine environment.

The “hydrographic assumptions” which underpin the assessment of the NEI are simplified. The so called “tidal prism” method is known to “overestimate the exchange of water and therefore underpredict the flushing time” [4]. Given the simplified nature of the calculation of the flushing time used in [4] we feel that a more robust assessment of the flushing characteristics of the Loch Linnhe system is required to address any potential influence on water quality and how this may be reduced.

We recommend that a 3D marine model is used to derive a more accurate flushing time for Loch Linnhe which can be used with the NEI calculation.

Additionally, conservative tracer modelling should be carried out to provide an estimate of the likely nutrient concentrations Loch Linnhe. Focus should be given to the assessment of two key sources of nutrients from the farm:

1. Nutrients entering the Loch from the exchange of water with the farm pens.
2. Nutrients entering the Loch from a marine outfall linked to the processing of solid waste collected from the farm.

It will be important to identify, and model correctly, the release location and depth of any sources. Estimates of initial dilution of nutrients at the marine outfall will also be required.

This conservative tracer modelling should also be used to determine whether the addition of this farm, creates an additional risk from nutrients to the Loch Creran SAC/MPA.

The assessment of nutrient concentrations in Loch Linnhe should include other major sources including all farms identified in Figure 13. The approach to modelling these sources will be agreed in the Modelling Method Statement for the application.

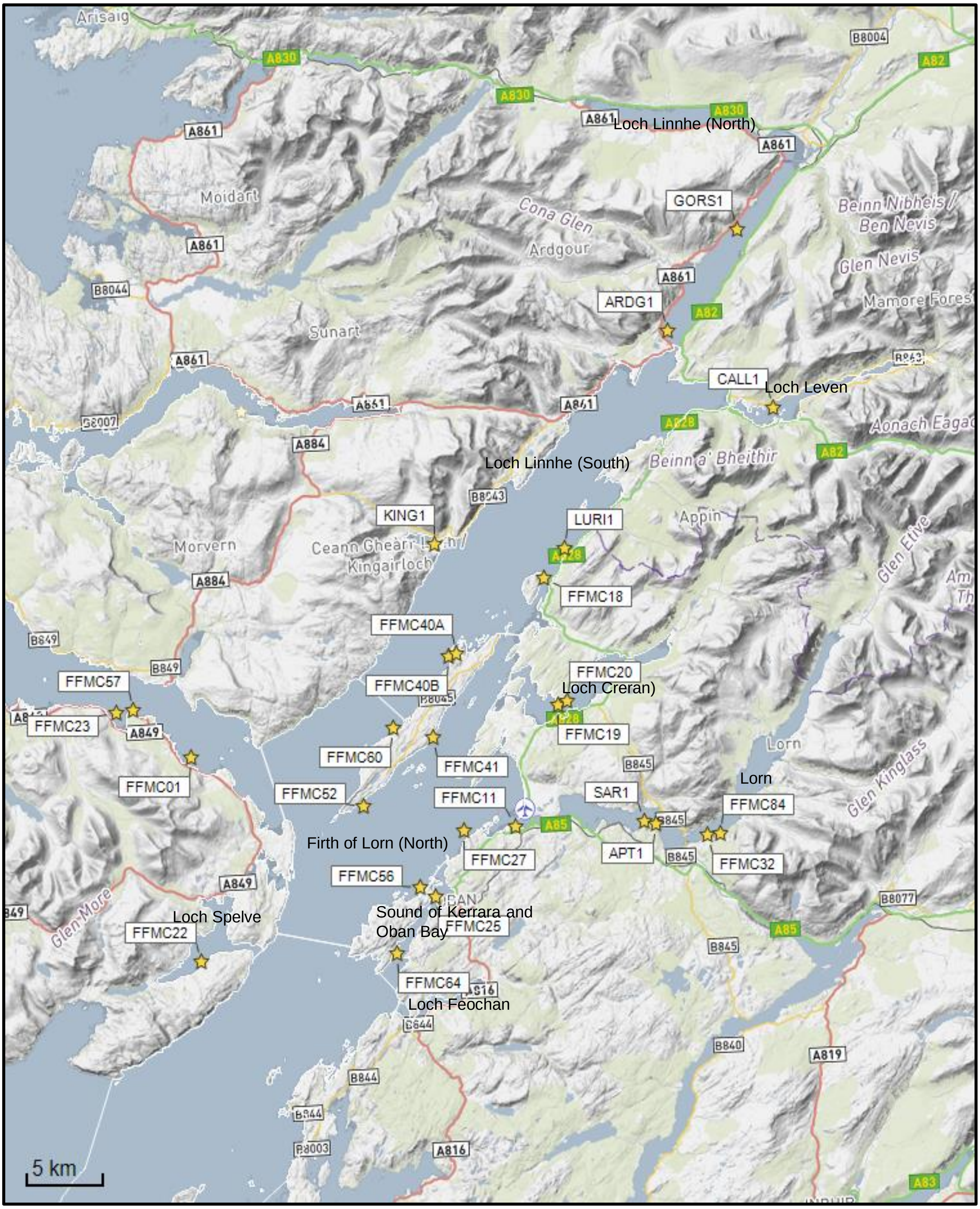

Figure 13. Figure showing all farms and waterbodies which should be included in the conservative tracer nutrient modelling.

4 Conclusions of screening modelling and risk identification

Following screening modelling and risk identification we make a number of conclusions and recommendations.

4.1 Conclusions

4.1.1 Screening Modelling

- According to screening modelling, the proposed site (Lurignish (LURI1)) is in an area of moderate dispersion and has a low capacity for erosion of material on the sea bed.
- From sediment and bath treatment modelling:
    - Information presented in section 2.2 indicates that if the application had been for a standard site (with 0% waste capture), at this location, the flow dynamics of the area are unsuitable for the proposed tonnage and the proposed site would be very unlikely to meet the current regulatory framework standards.
    - However, as this is a semi enclosed site, aiming to capture the majority of its waste, sections 2.3 and 2.4 suggests this site is likely to have low – moderate impact on the seabed. CFD modelling estimating the likely levels of waste capture are required to help ensure levels of influence are low, and the output from section 2.4 (90% waste capture), is a more realistic scenario.
    - All screening modelling shows the sediment influence on the surrounding sea area from Lurignish (LURI1) is likely to be low.
    - All screening modelling shows the areas of sediment influence from Lurignish (LURI1) and other sites modelled appear to interact at low levels.
    - No medicines from Lurignish (LURI1) have been applied for as this is a semi enclosed site. Therefore, screening modelling of bath medicines is not applicable. However, these model outputs have been used to assess the potential influence of nutrients.
    - Assuming waste capture is between 50 and 90%, Lurignish (LURI1) is likely to result in a moderate increase in the total influence of all sites modelled. This is separate from areas of influence generated by existing sites.
- Due to the low dispersion nature of the waters surrounding the site, nutrient discharges from Lurignish (LURI1) are likely to have an influence on the surrounding sea area. Conservative tracer modelling to provide assessment of nutrient influence will be required.

4.1.2 Risk identification

The modelled influence from Lurignish (LURI1) is expected to be low to moderate depending on the percentage of waste the semi enclosed system can capture. CFD modelling will need to be undertaken to demonstrate this percentage. However, the risk to the Loch Creran MPA/SAC (outlined in section 3), will need to be addressed with more detailed conservative tracer modelling of nutrients, in order to demonstrate that the influence on this area is low. All other actions outlined in sections 3.3 and 3.4, relating to concerns associated with this novel semi – enclosed farm, will need to be addressed.

4.2 Recommendations

4.2.1 Site suitability

Consideration of screening modelling and risk identification suggests that it is possible that discharges from the proposed site will be able to comply with the relevant aspects of the SEPA Aquaculture Regulatory Framework. This must be demonstrated with a detailed marine model. Nutrient issues identified in this report are particularly important to assess. This screening report will be updated based on the results from CFD modelling of waste capture, to provide a revised determination of risk level.

It is also possible that the site will be able to comply with our mixing zone regulatory framework, however this is highly dependent on the percentage of waste captured. This will need to be demonstrated using the NewDepomod model. As no calibration data is available, default NewDepomod settings will need to be used.

As this is a novel system, a CFD method statement should first be submitted. Once assessed by SEPA, CFD modelling can be undertaken, and following this, the screening report will be updated. This will allow a more informed screening report to be scrutinised at the engagement meeting(s).

Following the engagement meeting(s), this report will be revised again, which should allow the applicant to submit a method statement which address the issues raised in this document.

4.2.2 Further modelling

- CFD modelling will be required to determine the percentage of waste captured from Lurignish (LURI1).
- Due to the identified risks, conservative tracer, 3D modelling of nutrients should be carried out. Models used must calibrated/validated using appropriate field data.
- The marine model should include discharges from Lurignish (LURI1), and all other farms identified in Figure 13.
- The resolution of the marine model should be relatively fine around the proposed site and identified features at risk.
- NewDepomod modelling should be undertaken for the proposed site, using the output from the CFD modelling, to ensure the local impacts of the proposed biomass and waste capture are acceptable. It is strongly recommended that default NewDepomod modelling is undertaken prior to any marine modelling.

5 References

[1] *Regulatory Modelling Guidance For The Aquaculture Sector. Published on SEPA website.*

[2] http://marine.gov.scot/information/wider-domain-scottish-shelf-model.

[3] Marine Scotland Science, *Marine Scotland Science. Locational Guidelines for the Authorisation of Marine Fish Farms in Scottish Water. January 2015. Published online.*

[4] *Scottish Fisheries Research Report Number 63 / 2002. SCOTTISH EXECUTIVE LOCATIONAL GUIDELINES FOR FISH FARMING: PREDICTED LEVELS OF NUTRIENT ENHANCEMENT AND BENTHIC IMPACT. Published Online.*