ANALYSIS OF THE ARGYLL ARRAY TURBINE LAYOUT ITERATIONS IN RELATION TO ORNITHOLOGICAL CONSTRAINTS

2 November 2012

Project Number: SEC 7284

RPS
7 Clairmont Gardens
Glasgow
G3 7LW

Tel: 0141 332 0373
Fax: 0141 332 3182
Email: rhys.bullman@rpsgroup.com

QUALITY MANAGEMENT

Prepared by:	Name:	**Shaylon Stolk**	Title:	**Ornithologist**
	Signature:			
Authorised by:	Name:	**Rhys Bullman**	Title:	**Principal Ornithologist**
	Signature:			
Current Status:	**Final**			
Issue Date:	**2 November 2012**	Revision Number:	**Three**	
		Revision Notes:		
Project File Path:	**J:\7284 SEC - SPR Argyll Array Turbine Iterations\Technical\Reports in Progress\Reissue\Reissue 3\7284SEC Turbine Iterations Final B.doc**			

This report has been prepared within the RPS Planning and Development Quality Management System to British Standard EN ISO 9001 : 2008

REPORT TEMPLATE

TYPE:	Technical
ISSUE DATE:	18 May 2011
REVISION NUMBER:	-
REVISION DATE:	-

CONTENTS

EXECUTIVE SUMMARY

This report outlines three broad scenarios for turbine layouts at the Argyll Array proposed wind farm site and their relative potential impacts on sensitive ornithological receptors. These scenarios represent two levels of turbine removal, and compare these two potential layouts to the original proposed array configuration. The reduction in risk to avifauna from displacement and rotor collisions has been modelled and assessed for each of the layouts.

Each potential turbine layout was created using distance adjusted density maps of the species thought to have the highest sensitivity to displacement or collision due to behavioural patterns or on-site numbers. Turbine layouts were then designed by excluding turbines from areas with high levels of bird activity using three different density thresholds. The resulting layouts are intended to provide broad brush guidance in reducing any predicted negative effects on the species of concern.

Comparison of the configurations used in this analysis shows that the second, and more moderately reduced, configuration offers a significant reduction in predicted negative impacts to the avian species of primary concern whilst retaining most of the original proposed turbines. Furthermore, as this report presents a broad analysis, a more detailed approach may offer options for the inclusion of more turbines whilst maintaining the reduced collision and displacement risk.

1 INTRODUCTION

1.1 Aims and Scope of Works

The main aim of this report is to consider the existing ornithological constraints within the bird survey area and to determine whether it is possible to significantly reduce any predicted impacts to a more 'acceptable' level by the parsimonious removal of turbines. In order to do this, the following scope of works was agreed with Scottish Power Renewables (SPR).

- Three turbine reduction iterations were considered in the first instance leaving the potential for more detailed layout alterations at a later stage. Each of the iterations, informed by the bird data, overlaps as much as possible with the existing constraints as identified by SPR, e.g. the airport protected surface, the Hynish to Skerryvore view, the 1 km lighthouse buffer, areas within 5 km of shore, and water depths where construction is more challenging (Figure 1.1.1).
- An additive approach was used to model changes in displacement of each species under different turbine reduction iterations.
- These iterations took into consideration the reduction of predicted impacts such as collision risk, displacement and barrier effects on the overall conclusions of the EIA.
- The key species considered in these impact reduction example iterations are: great northern diver, northern gannet, European shag, common guillemot, black guillemot and Atlantic puffin
- Each of the iterations aims to minimise the loss of turbines whilst maximising the reduction of predicted impacts.
- Analysis was conducted assuming an array of 300 S120 (6mw) turbines in accordance with the current proposal. No adjustments were made to the type of turbines in the array.

Displacement from the turbine array area and mortality from rotor collisions are believed to be the main sources of possible negative impacts. This report seeks to provide a preliminary broad brush analysis outlining several turbine array scenarios which would reduce the potential risks, as currently predicted, to sensitive avifauna.

1.2 Bird Data Used to Inform the Study

All the information on bird activity on the proposed wind farm search area (both on the water and in the air) was taken from the results of the distance adjusted boat based survey data collected from September 2009 to August 2011. These data are presented in Figures 1.1 to 7.4. A desk study was used to determine the regional population, and the SPA population of each species within that species' foraging range. The region used for seabird populations was Region 2 as described in Stone *et al.* (1995).

The boat survey data used for the analysis excludes records collected in the 2 km buffer surrounding the proposed development area. For several of the target species, most notably herring gull, great northern diver and black guillemot, the majority of the site population was recorded in the buffer area and, for the purpose of this analysis, not subject to any predicted impacts.

1.3 Selection of Target Species

1.3.1 Species Selection

Of the range of species seen on the proposed wind farm site, great northern diver was of primary concern due to its presence in internationally significant numbers. A principal goal of this study, therefore, was to reduce considerably any negative impacts on this species from resulting from displacement by operational turbines.

As well as great northern diver, the following species were selected for analysis due to their relatively high numbers on the site and perceived vulnerability to displacement. The exception was northern gannet, a wide-ranging species, which was included due to large numbers of flying birds on site and the resulting potential collision risk. Most of these target species display localised foraging behaviour which often overlaps with the habitat preferred by the great northern diver. These target species are:

- Northern gannet;
- European shag;
- herring gull;
- common guillemot;
- black guillemot; and
- Atlantic puffin.

2 METHODS

2.1 Spatial Assessment of Ornithological Impacts

Survey data for the target species collected on the proposed wind farm search area were entered into ArcMap (ArcGIS10) and the data points for each species were extracted and rendered as points on a grid. Each point represents an aggregation of birds which had been sighted in flight or on the water. Each point has been scaled to represent the number of birds counted in that flock. This basic density map was used to detect areas of maximum bird activity. Modelling was conducted using a mean density, which accounted for high levels of intra-annual variation in bird records.

For collision risk modelling, records of birds flying at rotor height were extracted from the dataset. Due to the inability to distinguish birds passing through the wind farm area from birds flying to or from a foraging area within the wind farm, spatial analysis focused on alterations of turbine density and wind farm area, as well as relative percentages of flight activity in selected areas of the wind farm. Birds recorded on the water were excluded from collision risk analysis to prevent overestimating the at-risk population.

2.2 Selection of Turbine Configurations to Reduce Ornithological Impacts

A relative density surface of great northern diver was used as the primary selection criteria to outline areas of higher importance. This was calculated using kernel density analysis with a 5 km search diameter (Figure 1.1.1). This density does not represent a baseline count, but instead was used to highlight areas of high great northern diver activity.

Examination of distribution patterns for other bird species was assessed and areas of higher activity were demarcated in ArcMap, using a polygon tool to outline the relevant area, with the goal of minimising displacement of ornithological receptors (Figure 2.2.1). The turbine layout plan, with existing constraints as detailed by SPR already in effect (Figure 1.1.1), was imported into ArcMap and superimposed onto the map of potential constraints. This allowed the number of turbines to be removed in each configuration to be calculated. However, these numbers do not reflect potential modifications to the turbine array layout which may be made to increase turbine numbers or further decrease the risk of adverse impacts on avifauna.

The predicted impacts were also examined in the context of regional and SPA populations, as this allows the evaluation of impacts in their ecological context. The regional and SPA populations used for each species appear in Table 2.2.1.

TABLE 2.2.1: REGIONAL POPULATION (REGION 2) AND SPA POPULATIONS WITHIN FORAGING RANGE OF PROPOSED DEVELOPMENT SITE

Species	Regional population (Individuals)	SPA population (Individuals)
Great northern diver	3000*	n/a
Northern gannet	13930	11230
European shag	3341	n/a
Herring gull	15370	n/a
Common guillemot	42697	2705
Black guillemot	3046	671
Atlantic puffin	2597	1522

* Forrester and Andrews, 2007

2.3 Determining Impacts of Displacement

Displacement (or habitat loss) occurs when birds avoid entering the area of an offshore wind farm. Displacement may be caused by primary impacts, such as disturbance from vessels associated with the proposed development, or from secondary impacts, such as the reduction of prey abundance in the development area. The significance of any effects resulting from displacement impacts is difficult to quantify, but the effect may be more significant for species that rely on localised or 'patchy' food supplies than for species that have a widely available prey source. As recommended in Maclean *et al*. (2009), the assessment considers the sensitivity of a species to each impact, depending on its habitat flexibility and behaviour patterns with regards to avoiding areas populated by turbine arrays (Table 2.3.1). Potential impacts relating to disturbance by vessels, and the subsequent significance of these effects, are addressed in the species accounts where relevant.

Langston (2010) looks at a variety of factors affecting potential displacement levels and recommends that the level of displacement should be based on the broad categories (high, medium or low), and the proportion of birds displaced is assigned to each categories (Table 2.3.1).

TABLE 2.3.1: RELATIVE SENSITIVITY OF BIRD SPECIES TO DISPLACEMENT FROM OFFSHORE WIND FARMS AND APPROXIMATE PERCENTAGE DISPLACED (Langston 2010).

Sensitivity to displacement	Approximate percentage displaced (± 10%)	Species
High	75%	Great northern diver
Medium	50%	European shag, common guillemot, black guillemot, Atlantic puffin
Low	25%	Northern gannet, herring gull

These levels are not fixed and potential displacement figures ± 10% of the median will be presented. For species where there is evidence of a higher or lower potential level of displacement then this will be discussed (e.g., gannet, guillemot).

For some species there may be evidence from existing offshore wind farms to support an alternative rate of displacement other than those indicated in Langston (2010).

The potential impact of displacement will vary depending on season to account for the greater energy expenditure by birds during the breeding season, which is defined as April to July for these calculations. During the breeding period, birds may be more constrained to foraging within a limited distance from their nesting sites. Consequently, any displacement from foraging areas is predicted to have a greater level of impact than at other times. There is little or no evidence on what these impacts may be, but for the purposes of this assessment a mortality rate of 10% will be assumed for displaced birds (Table 2.3.2). It is recognised that this is an arbitrary figure but is still considered suitably precautionary for both EIA and HRA requirements.

During the post-breeding period (defined as August to October) seabirds leave their colonies and gather prior to winter dispersal. For many species the constraints are little different from the 'non-breeding' period, see below. However, Auks leaving their colonies accompanied by chicks are constrained to some extent, as the adults are attending to flightless young and are therefore unable to travel large distances rapidly in search for food. Birds that are displaced away from suitable foraging areas may be at higher risk of increased mortality than birds during the 'non-breeding period'. Post-breeding seabirds can, however, move further afield than breeding adults and therefore the potential effects from displacement are expected to be lower. Furthermore, the possible impacts from displacement are more transitory as the majority of birds are dispersing through the area. For the purposes of the assessment a 2 % mortality rate for Auks and Gannet displaced in the post-breeding period will be applied (Table 2.3.2).

During the 'non-breeding' period, seabirds are generally less constrained as they are not provisioning chicks or caring for non fledged young and therefore cover a much wider foraging area within their winter range or whilst on passage. For seabirds other than auks, this period was defined as August to March, for auks, November to March. Therefore, the potential impacts are predicted to be less than during the breeding season. For the purposes of this assessment, a 1% mortality rate will be applied to displaced birds (Table 2.3.2).

TABLE 2.3.2: SEASONAL VARIATION IN PREDICTED DISPLACMENT RELATED MORTALITY

Lifecycle phase	Species	% Displacement mortality
Breeding	All species	10
Post-breeding	Auks, Northern gannet	2
Non-breeding	All species	1

The 1%, 2% and 10% level of displacement are not fixed, but are used here as a guide to assess potential effects. They are, however, considered to be suitably precautionary based on the species potentially impacted i.e., piscivorous seabirds with mobile and often widespread prey that are therefore likely to have widespread foraging areas.

Peak counts for the area of each turbine array configuration, plus a 1km buffer, were taken for the periods described above. The count data is presented in Table 2.3.3

TABLE 2.3.3: SEASONAL PEAK COUNTS FOR EACH TURBINE ARRAY SCENARIO

Species	**Breeding**			**Non breeding**			**Post breeding**		
Configuration	1	2	3	1	2	3	1	2	3
Great northern diver	n/a	n/a	n/a	37	25	18	n/a	n/a	n/a
Northern gannet	203	174	118	302	270	232	300	271	230
European shag	51	31	20	91	64	3	n/a	n/a	n/a
Herring gull	9	9	7	53	41	3	n/a	n/a	n/a
Common guillemot	137	92	39	120	90	52	87	72	69
Black guillemot	25	20	7	114	103	10	96	88	7
Atlantic puffin	242	205	163	12	12	12	17	16	14

2.4 Determining Impacts of Collision Risk

Collision risk was assessed using data from birds in flight at potential risk height. A mean density was calculated for each month using the numbers recorded in the two-year survey period. Records of birds above or below rotor height for each turbine type were removed from assessment, as these birds were assumed not to be at risk of collision.

For several species, all the birds recorded flying around the site during the two years of surveys flew beneath rotor height. These species were common guillemot, black guillemot, Atlantic puffin and European shag, which all typically fly at low flight altitudes due to their relatively high body weight and heavy wing loading.

For the remaining target species in this study; great northern diver, herring gull and northern gannet; collision risk was assessed using the Band (2011) model. To account for temporal variation in site use, density was calculated separately for each month and entered into the model. This incorporates the number of flights at rotor height, the speed and wingspan of the bird species, the percentage of time each turbine is operational, and the radius of the rotor blades. S120 (6mw) turbines were used in accordance with the initial proposed layout provided. Density was recalculated for each turbine scenario to account for the weighted removal of turbines from areas of high bird activity. A large array correction factor was used for the final calculations.

Furthermore, the locations of the remaining turbines in each model array were assumed to remain constant. Due to the limitations of the current displacement model, collision risk was calculated separately, without accounting for avoidance behaviours.

New two-year mean density numbers were calculated for each proposed array layout, using count data and the area of the modified array. This allows for a location-sensitive approach to assessing collision risk.

3 TURBINE CONFIGURATIONS

3.1 Configuration 1: Current Proposed Turbine Array (300 turbines)

Configuration 1 (Figures 3.1.1 to 3.1.7) is presented as a basis for comparison with the possible reduced turbine configurations shown in sections 3.2 and 3.3 below. The turbine plan is based on the existing layout provided by SPR, with the visual and radar constraints already included in the placement of the turbine array. This initial layout consists of 300 turbines arranged in parallel lines throughout the proposed wind farm site (Figure 1.1.1).

3.2 Configuration 2: Intermediate Array 1 (242 turbines)

The layout presented as Configuration 2 (Figures 3.2.1 to 3.2.7) represents minimal alterations to the present turbine layout, whilst still reducing displacement and collision risk for the key ornithological receptors listed in Sections 1.3.1 and 1.3.2. A higher density threshold was used to identify places of highest bird activity and then selectively remove turbines in these locations, leaving 242 turbines in the wind farm site. The focus of this layout, as in the subsequent turbine arrangements modelled, is reduction of potential negative effects on the site population of great northern diver. However, due to the overlap in site use locations between species, minor adjustments to the density polygons allow the modelled layout to also reduce impacts to other key species at high risk of collision or displacement.

3.3 Configuration 3: Intermediate Array 2 (213 turbines)

The layout presented as Configuration 3 (Figures 3.3.1 to 3.3.7) represents a modified approach to incorporating ornithological constraints into the turbine layout, with a focus on great northern divers and black guillemots combined. A higher density threshold was used to identify locations of high bird activity, which reduced the target area to a strip along the southern edge of the current wind farm site. As described in Section 2.4, a polygon drawn around these target areas were cleared of turbines, leaving 213 turbines in the wind farm site.

4 RESULTS

4.1 Predicted Annual Displacement Mortality

The tables in Appendix 1 show the predicted mortality due to displacement, as determined by theoretical habitat loss and sensitivity to displacement (Furness & Wade 2011, MacLean *et al.* 2009). The peak count is used for these calculations. (Table 4.1.1-Table 4.1.3). Due to the data partitioning, the results are not presented as a proportion of regional or SPA populations, although they are included in the final calculations of total predicted mortality.

TABLE 4.1.1: PREDICTED DISPLACEMENT MORTALITY BY SEASON FOR CONFIGURATION 1

Species	Breeding	Non breeding	Post breeding
Great northern diver	n/a	0.28	n/a
Northern gannet	5.08	0.76	2.71
European shag	1.28	0.23	n/a
Herring gull	0.23	0.13	n/a
Common guillemot	6.85	0.60	0.87
Black guillemot	1.25	0.57	0.96
Atlantic puffin	12.10	0.06	0.17

TABLE 4.1.2: PREDICTED DISPLACEMENT MORTALITY BY SEASON FOR CONFIGURATION 2

Species	Breeding	Non breeding	Post breeding
Great northern diver	n/a	0.19	n/a
Northern gannet	4.35	0.68	2.71
European shag	0.78	0.16	n/a
Herring gull	0.23	0.10	n/a
Common guillemot	4.60	0.45	0.72
Black guillemot	1.00	0.52	0.88
Atlantic puffin	10.25	0.06	0.16

TABLE 4.1.3: PREDICTED DISPLACEMENT MORTALITY BY SEASON FOR CONFIGURATION 3

Species	Breeding	Non breeding	Post breeding
Great northern diver	n/a	0.14	n/a
Northern gannet	2.95	0.58	2.30
European shag	0.50	0.01	n/a
Herring gull	0.18	0.01	n/a
Common guillemot	1.95	0.26	0.69
Black guillemot	0.35	0.05	0.07

Atlantic puffin	8.15	0.06	0.14

4.2 Predicted Annual Collision Risk Mortality

Table 4.2.1 shows the reductions in predicted annual mean collision risk mortality using a 98% avoidance rate. The mean density from the two-year survey period was used for each month to calculate a mean annual density from which collision risk was modelled. These three species were the only ones included in this study that had any flights recorded in the rotor swept area of the S120 turbines.

TABLE 4.2.1: PREDICTED ANNUAL COLLISION RISK MORTALITY FOR EACH TURBINE ARRAY SCENARIO USING A 98% AVOIDANCE RATE

Species	Configuration 1	Configuration 2	Configuration 3
Great northern diver	38	10	9
Northern gannet	615	195	172
Herring gull	333	25	23

The relative benefits from the proposed configurations can be seen in Figure 4.2.1. This demonstrates a high degree of similarity in predicted mortality for all modified array layouts presented, all showing a significant improvement in impact mitigation over the original design. The significant difference in predicted collision risk between the modified layouts presented and the original proposed layout is due to the non-random removal of turbines (see Section 2.1 and Section 2.2), where a random removal of turbines from the array might result in a more linear relationship between turbine numbers and collision mortality.

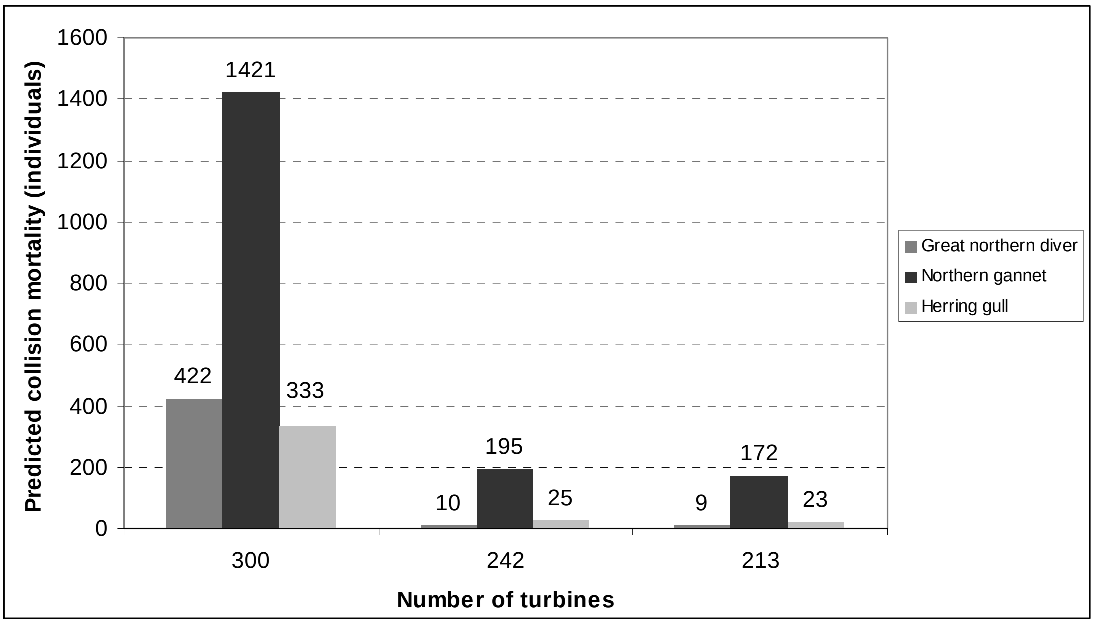

Figure 4.2.1. Comparison of predicted avian collision mortality to the number of turbines

Note that turbine removal is assumed to take place at areas with the greatest density of birds in order to maximise impact reduction.

4.3 Predicted Total Mortality: Collision and Displacement

The total annual mortality was calculated by adding the predicted collision mortality to the median predicted displacement mortality for each turbine layout. This figure was added to the annual national mortality numbers (Robinson 2005) for each species and divided by the current national population to find the percentage of additional mortality relative to the regional or SPA populations which could be caused by wind farm construction and operation. These predictions reflect a worst-case scenario (Table 4.3.1).

TABLE 4.3.1: COMPARISON OF INCREASED MORTALITY DUE TO PROPOSED DEVELOPMENT WITH NATIONAL BACKGROUND MORTALITY RATES.

Species	Background annual mortality (% of national population)	Additional increase in background mortality (% of population)					
		Configuration 1		Configuration 2		Configuration 3	
		Region	SPA	Region	SPA	Region	SPA
Great northern diver*	8%	1.267	-	0.333	-	0.300	-
Northern gannet	6%	4.459	5.532	1.437	1.783	1.265	1.569
European shag	12.2%	0.042	-	0.042	-	0.042	-
Herring gull	7%	0.022	-	0.002	-	0.001	-
Common guillemot	5%	0.021	0.323	0.014	0.213	0.007	0.102
Black guillemot	13%	0.099	0.413	0.099	0.413	0.000	0.000
Atlantic puffin	8%	0.471	0.804	0.394	0.673	0.317	0.541

5 CONCLUSIONS

5.1 Displacement

Using the results given in Section 4.1, **Configuration 2** is recommended as the most effective scenario for the reduction of potential displacement. Furthermore, as the mortality rates given in these predictions represent worst-case scenarios, the actual mortality rates may be significantly lower. This sensitivity-based approach, which does not incorporate turbine layout and avian behavioural adaptations, should be seen as a high prediction of possible mortality.

The 2 km buffer holds large numbers of the target species which indicates that suitable habitat exists outside of the proposed development area. This suggests that these areas may be more suitable for foraging than some areas within the wind farm site.

A more finely-tuned approach bird density modelling may enable an increase in turbine numbers in this configuration without increasing predicted mortality.

5.2 Collision Risk

Table 4.2.1 shows that **Configuration 2** is recommended as the best scenario for impact reduction while maximising the number of turbines. Again a more finely-tuned approach to collision risk modelling may enable an increase in turbine numbers in this configuration without increasing avian collision mortality (see Section 4.2.1).

5.3 Further Study

The results presented represent a broad approach for impact reduction which attempts to locate areas of maximum risk for key bird species of conservation concern. A more detailed approach focusing on the location of individual turbines near areas of high bird activity, as calculated by methods such as density surface modelling, may allow for retention of a greater number of turbines whilst providing a similar reduction in potential negative impacts to the scenarios outlined in Section 3. The introduction of different turbine types may also allow increased options.

Further study of other species at risk of collision or displacement will also help to inform adjustments in the turbine array configuration in order to reduce the potential for negative ecological impacts.

6 REFERENCES

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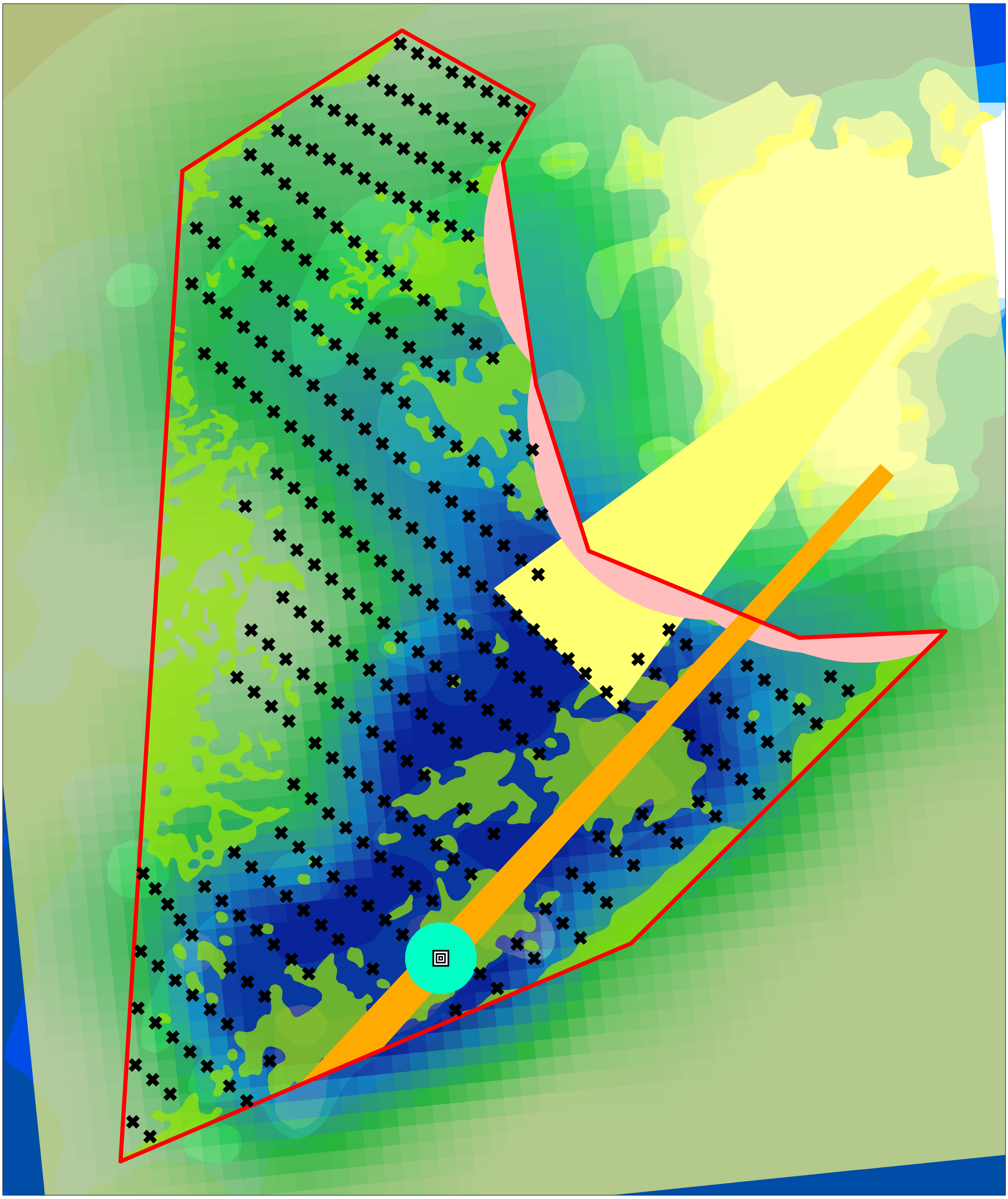
APPENDIX 1– FIGURES



Legend

▣	Skerryvore Lighthouse
🟩	Lighthouse Buffer
🟧	Visibility Corridor
🟨	Airport Landing Constraints
🟩	Depths Under 20m
🟥	5km Shore Buffer
✖	Turbine locations
▭	Site boundary

Great Northern Diver Density

Value

High : 2.6594

Low : 0

Data Source: RPS 2012

Status: FINAL

Project Ref: 7284SEC

RPS

7 Clairmont Gardens Glasgow G3 7LW
T 0141 3320373 F 0141 3323182 E rpsgw@rpsgroup.com W www.rpsgroup.com

Client: Scottish Power Renewables

Project: Argyll Array

Title: Visual and Logistical Constraints

Scale: A3 @ 1:105,000

0 2 4 km

N

Date: 31/10/2012 Datum: OSGB36 Projection: BNG

Drawn: SBS Checked: RB Job Ref: 7284SEC

Figure No: **1.1.1** Revision: **01**

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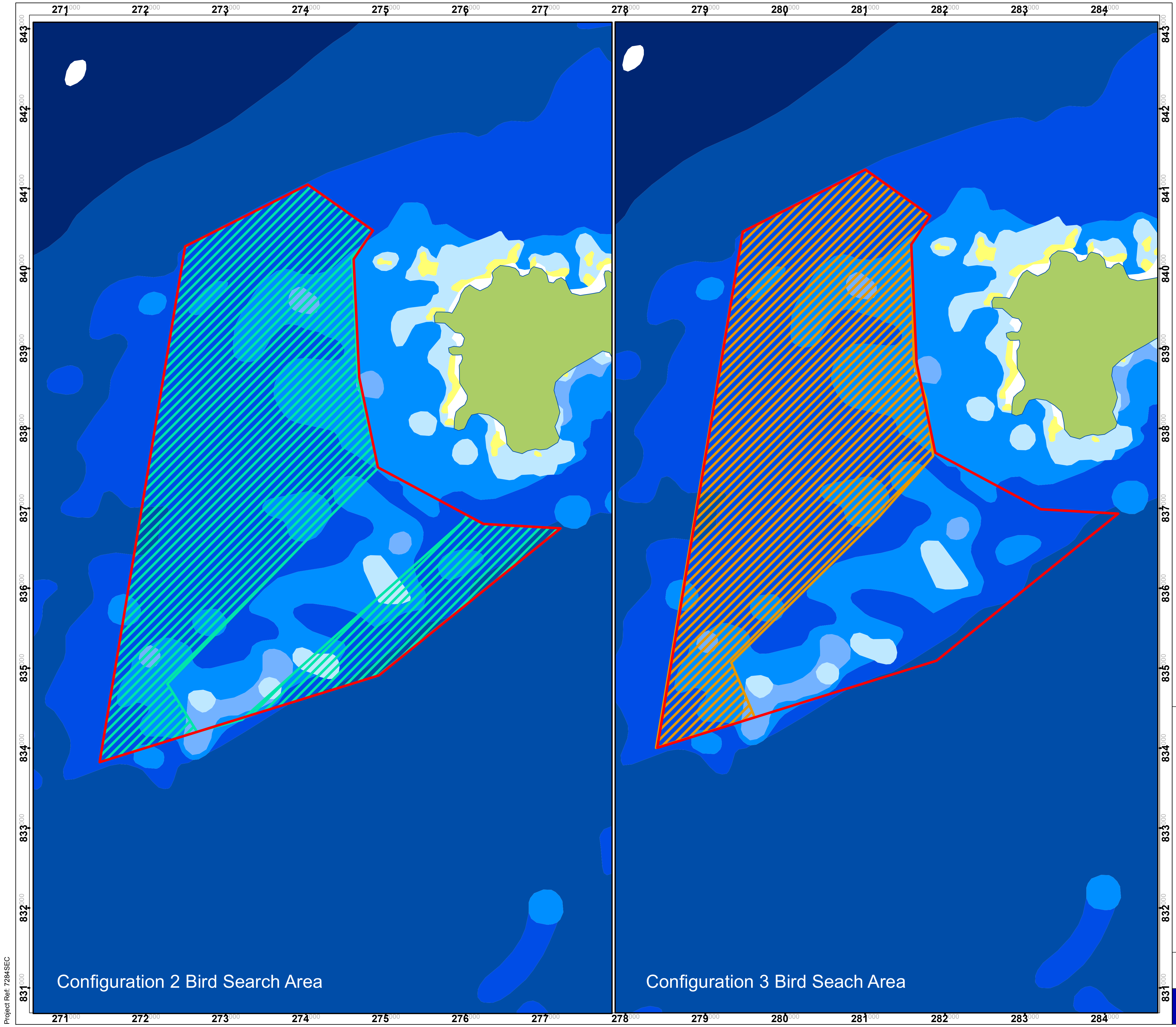

Legend

□ Site Boundary

Data Source: RPS 2012

Status: FINAL

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7 Clairmont Gardens Glasgow G3 7LW
T 0141 3320373 F 0141 3323182 E rpsgw@rpsgroup.com W www.rpsgroup.com

Client: Scottish Power Renewables

Project: Argyll Array-- Turbine Iterations

Title: Layout Polygons: Configurations 2 and 3

Scale: A3 @ 1:46,126

0 1 2 km

N

Date: 29/10/2012 Datum: OSGB36 Projection: BNG

Drawn: SBS Checked: RB Job Ref: 7284SEC

Figure No: **2.2.1** Revision: **1**

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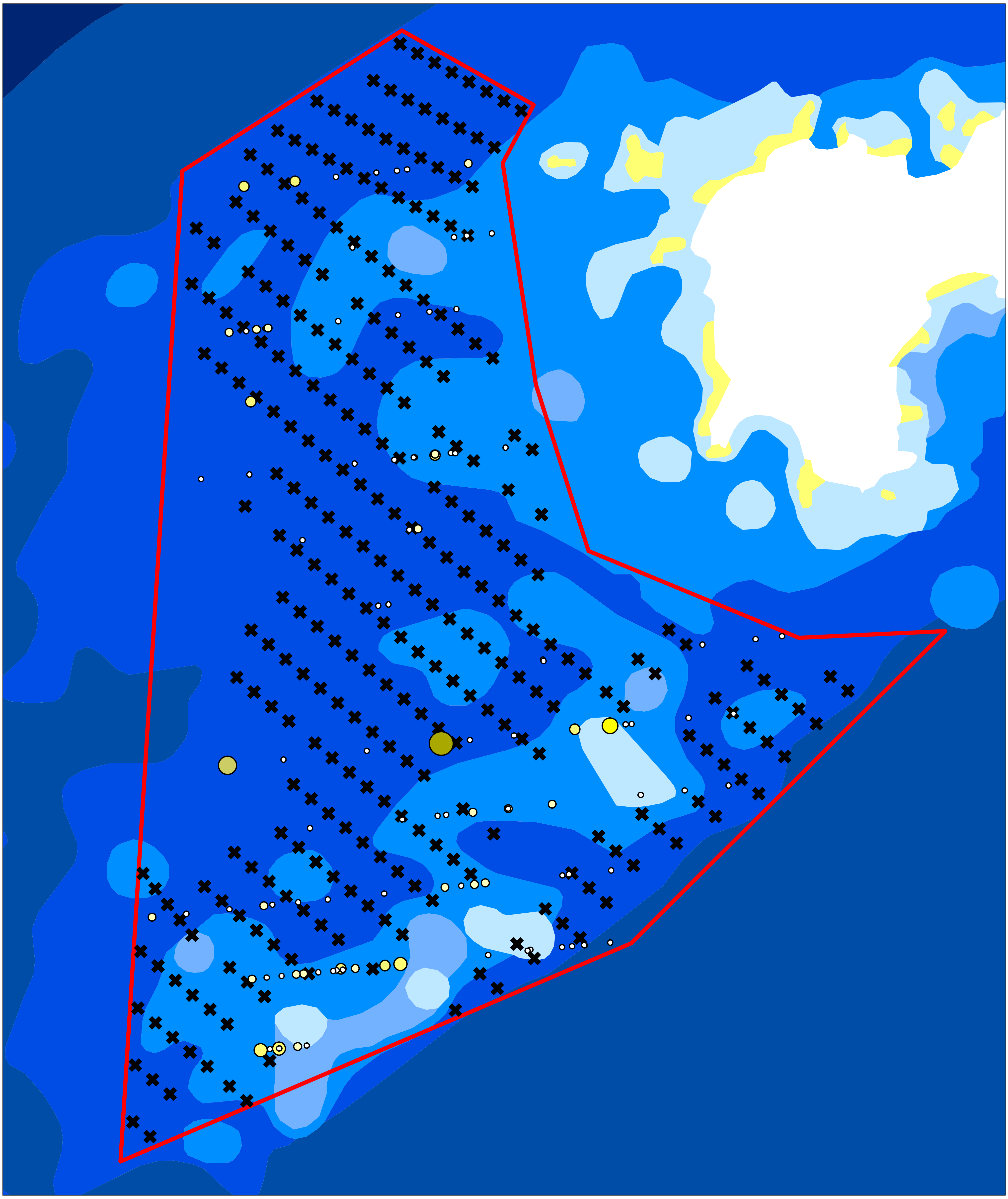

Legend

Great Northern Diver Number ✖ **Turbine locations** ▭ **Site boundary**

- ○ **1**
- ○ **2**
- ○ **3**
- ○ **4**
- ● **5**
- ● **6**
- ● **10**

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T 0141 3320373 F 0141 3323182 E rpsgw@rpsgroup.com W www.rpsgroup.com

Client: Scottish Power Renewables

Project: Argyll Array

Title: Great Northern Diver Density in Configuration 1

Scale: A3 @ 1:105,000

0 2 4 km

N

Date: 04/07/2012 Datum: OSGB36 Projection: BNG

Drawn: SBS Checked: RB Job Ref: 7284SEC

Figure No: **3.1.1** Revision: **03**

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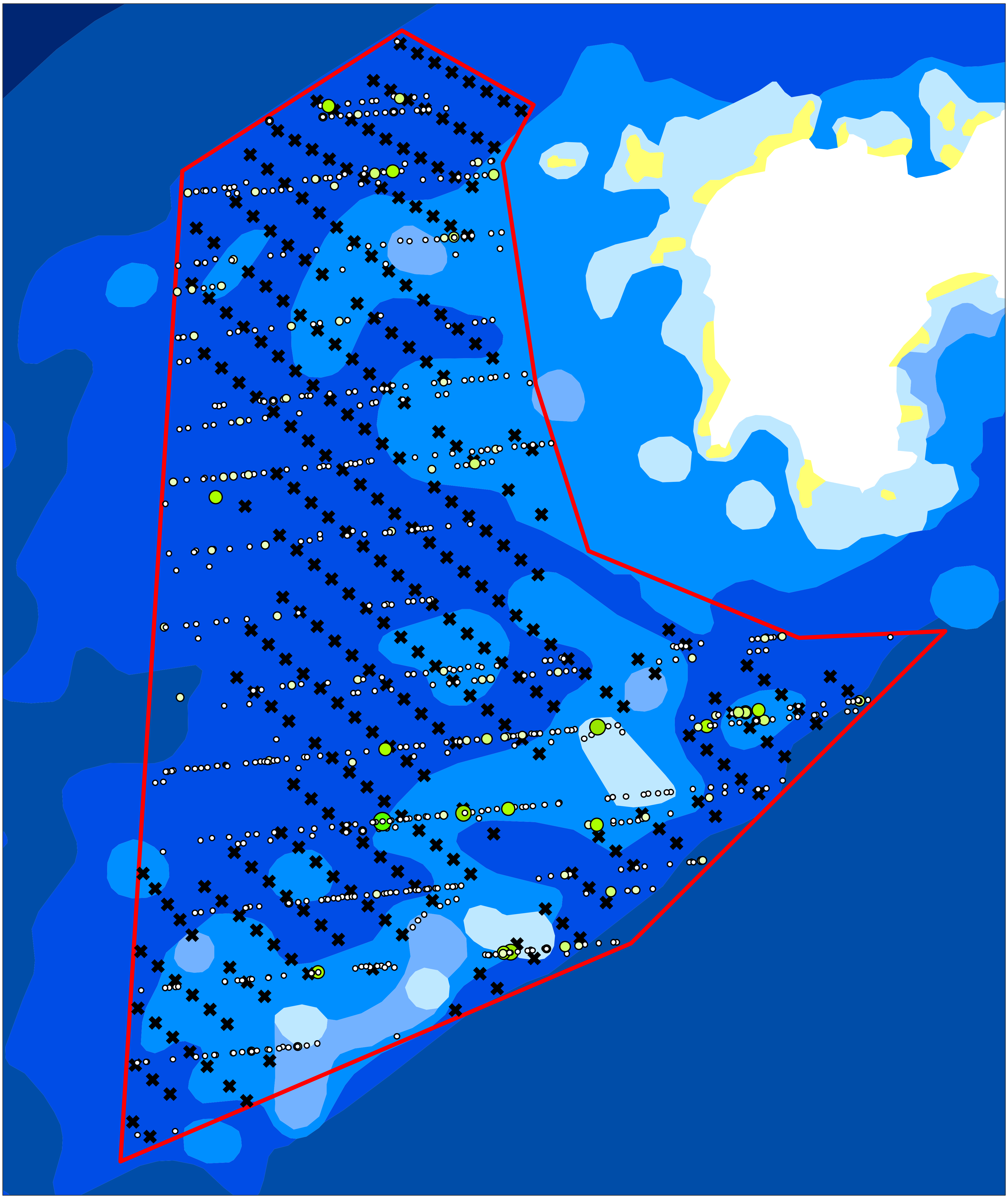

Legend

Northern Gannet Number

- ○ **1**
- ● **2**
- ● **3**
- ● **4**
- ● **5**
- ● **6**
- ● **8**

✖ **Turbine locations**

▭ **Site boundary**

Data Source: RPS 2012

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Client: Scottish Power Renewables

Project: Argyll Array

Title: Northern Gannet Density in Configuration 1

Scale: A3 @ 1:105,000

0 2 4 km

N

Date: 04/07/2012 Datum: OSGB36 Projection: BNG

Drawn: SBS Checked: RB Job Ref: 7284SEC

Figure No: **3.1.2** Revision: **03**

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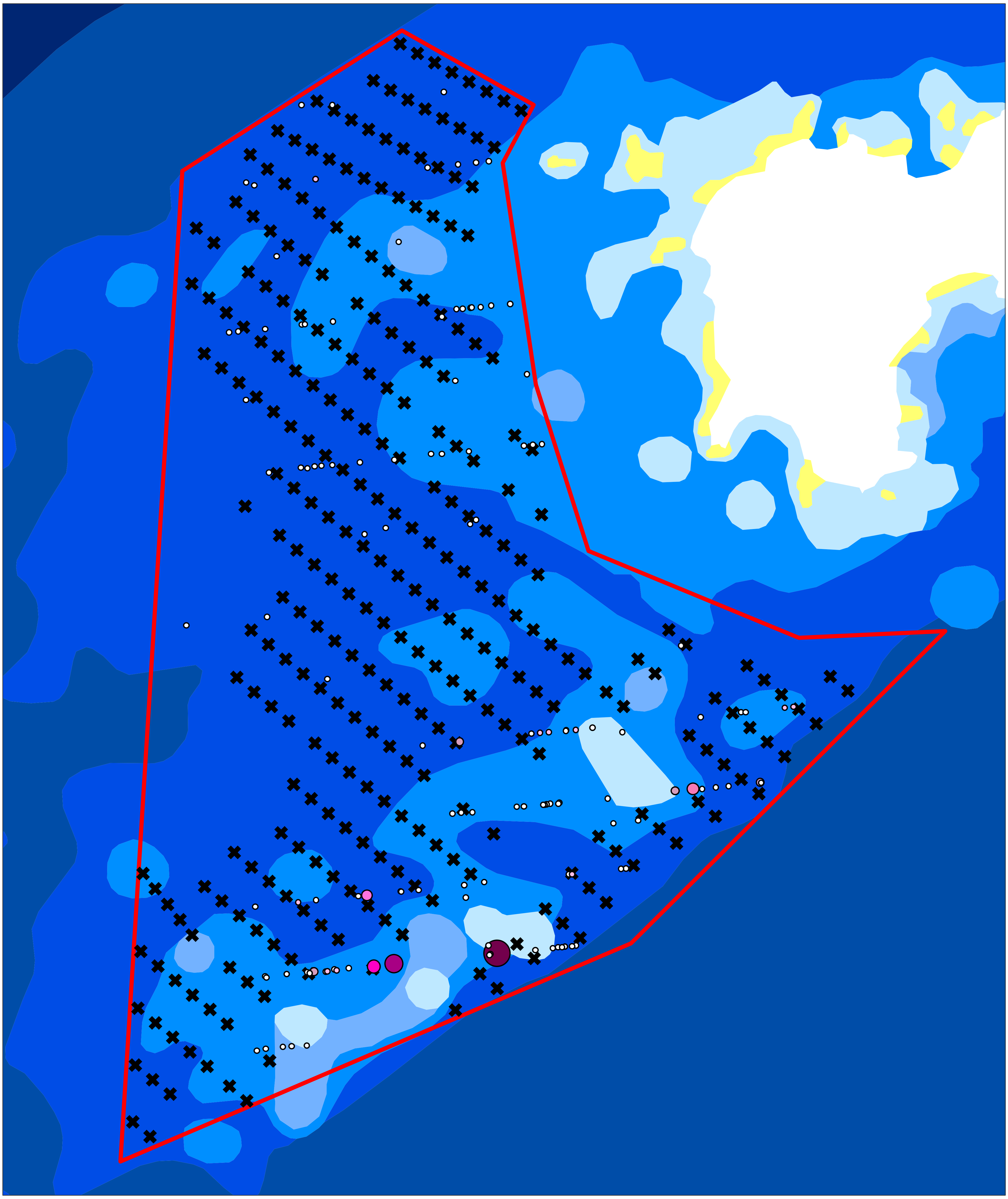


Legend

European Shag Number
- ○ 1
- ○ 2
- ● 3
- ● 4
- ● 5
- ● 7
- ● 10
- ● 46

✖ **Turbine locations**

□ **Site boundary**

Data Source: RPS 2012

Status: FINAL

Project Ref: 7284SEC

RPS
7 Clairmont Gardens Glasgow G3 7LW
T 0141 3320373 F 0141 3323182 E rpsgw@rpsgroup.com W www.rpsgroup.com

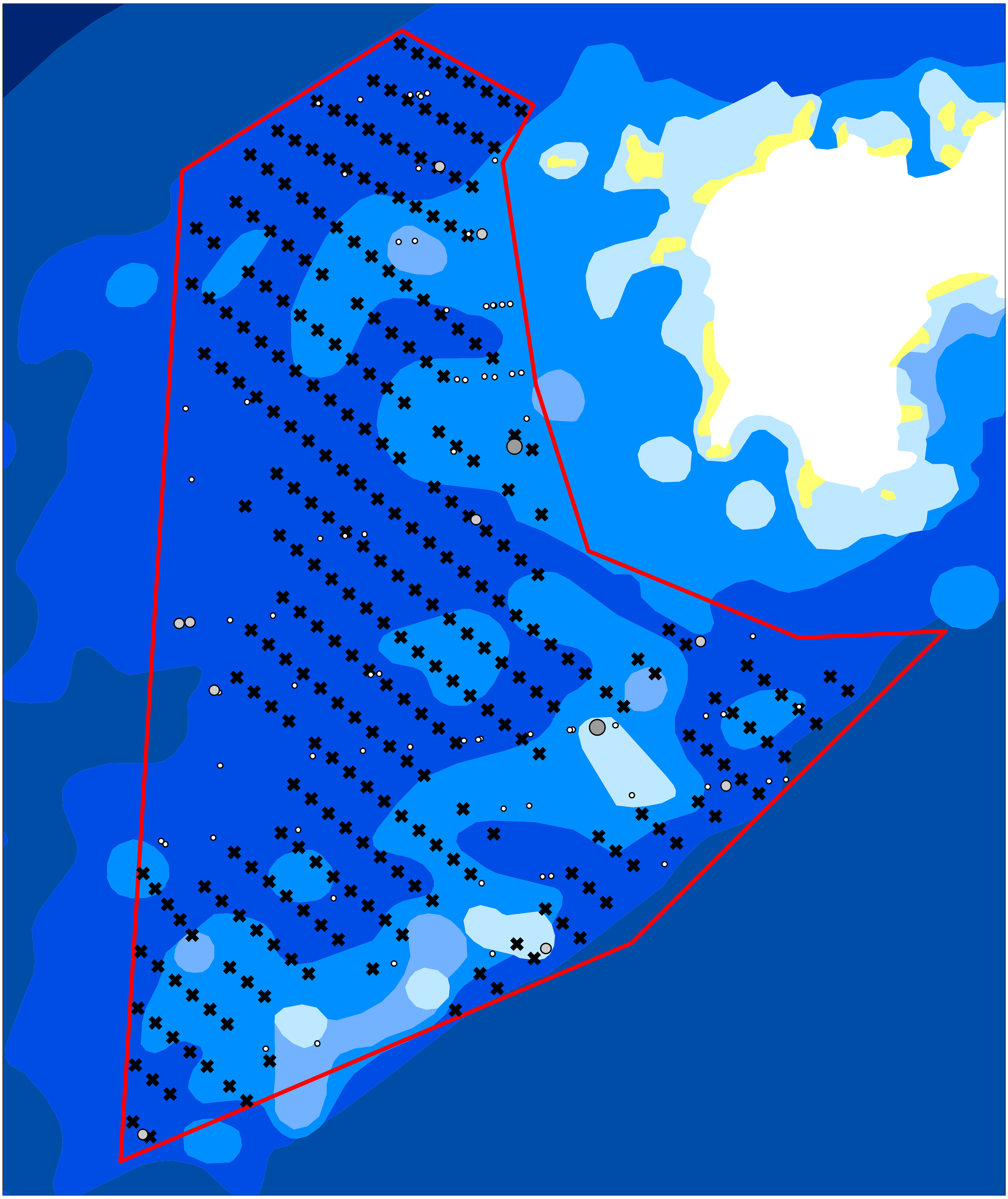
Client: Scottish Power Renewables
Project: Argyll Array

Title: European Shag Density in Configuration 1

Scale: A3 @ 1:105,000
0 2 4 km
N

Date: 04/07/2012 Datum: OSGB36 Projection: BNG
Drawn: SBS Checked: RB Job Ref: 7284SEC

Figure No: **3.1.3** Revision: **03**



Legend

Herring Gull Number

- ○ 1
- ● 2
- ⬤ 3

✖ **Turbine locations**

🟥 **Site boundary**

RPS

7 Clairmont Gardens Glasgow G3 7LW
T 0141 3320373 F 0141 3323182 E rpsgw@rpsgroup.com W www.rpsgroup.com

Client: Scottish Power Renewables

Project: Argyll Array

Title: Herring Gull Density in Configuration 1

Scale: A3 @ 1:105,000

0 2 4 km

N

Date: 04/07/2012 Datum: OSGB36 Projection: BNG

Drawn: SBS Checked: RB Job Ref: 7284SEC

Figure No: **3.1.4** Revision: **03**

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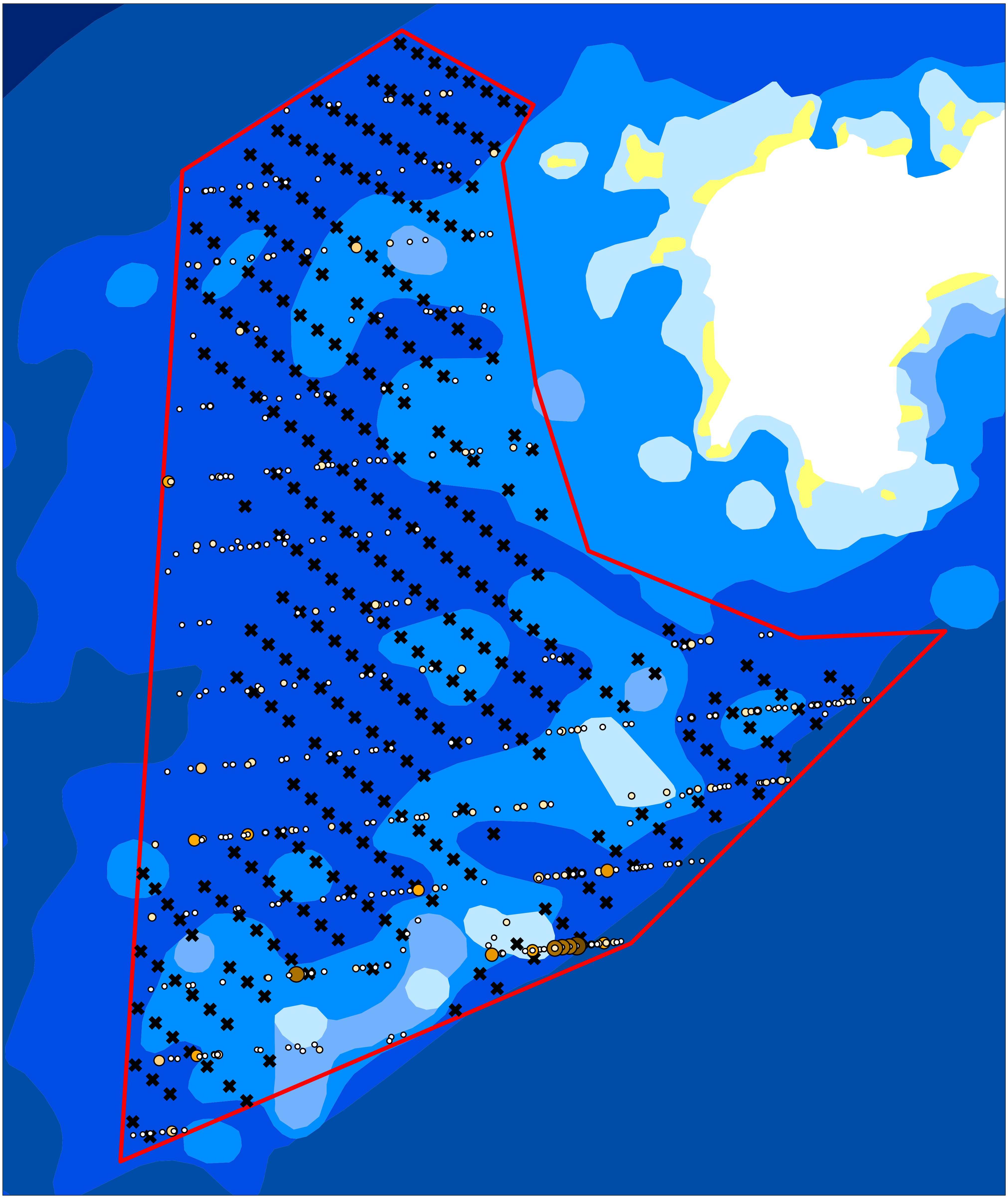
Project Ref: 7284SEC

Data Source: RPS 2012

Status: FINAL



Legend

Guillemot Number

○	1
○	2
○	3
●	4
●	5
●	6
●	8
●	9

✖ **Turbine locations**

▭ **Site boundary**

Data Source: RPS 2012

Status: FINAL

Project Ref: 7284SEC

RPS

7 Clairmont Gardens Glasgow G3 7LW
T 0141 3320373 F 0141 3323182 E rpsgw@rpsgroup.com W www.rpsgroup.com

Client: Scottish Power Renewables

Project: Argyll Array

Title: GuillemotDensity in Configuration 1

Scale: A3 @ 1:105,000

0 2 4 km

N

Date: 04/07/2012 Datum: OSGB36 Projection: BNG

Drawn: SBS Checked: RB Job Ref: 7284SEC

Figure No: **3.1.5** Revision: **03**

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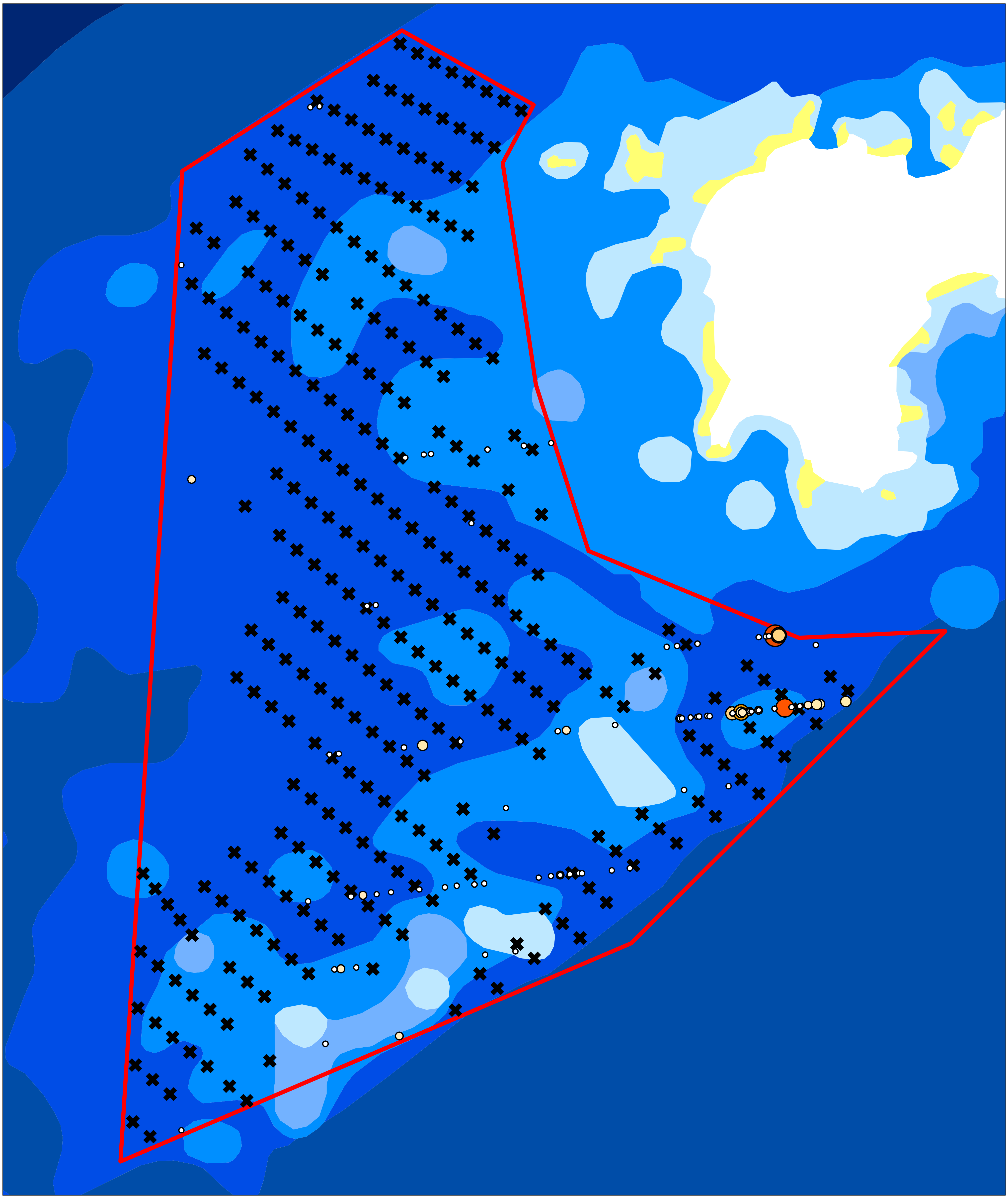


Legend

Black Guillemot Number

- ○ **1**
- ● **2**
- ● **3**
- ● **4**
- ● **5**
- ● **6**
- ● **7**

✖ **Turbine locations**

▭ **Site boundary**

Data Source: RPS 2012

Status: FINAL

Project Ref: 7284SEC

RPS
7 Clairmont Gardens Glasgow G3 7LW
T 0141 3320373 F 0141 3323182 E rpsgw@rpsgroup.com W www.rpsgroup.com

Client: Scottish Power Renewables

Project: Argyll Array

Title: Black Guillemot Density in Configuration 1

Scale: A3 @ 1:105,000

0 2 4 km

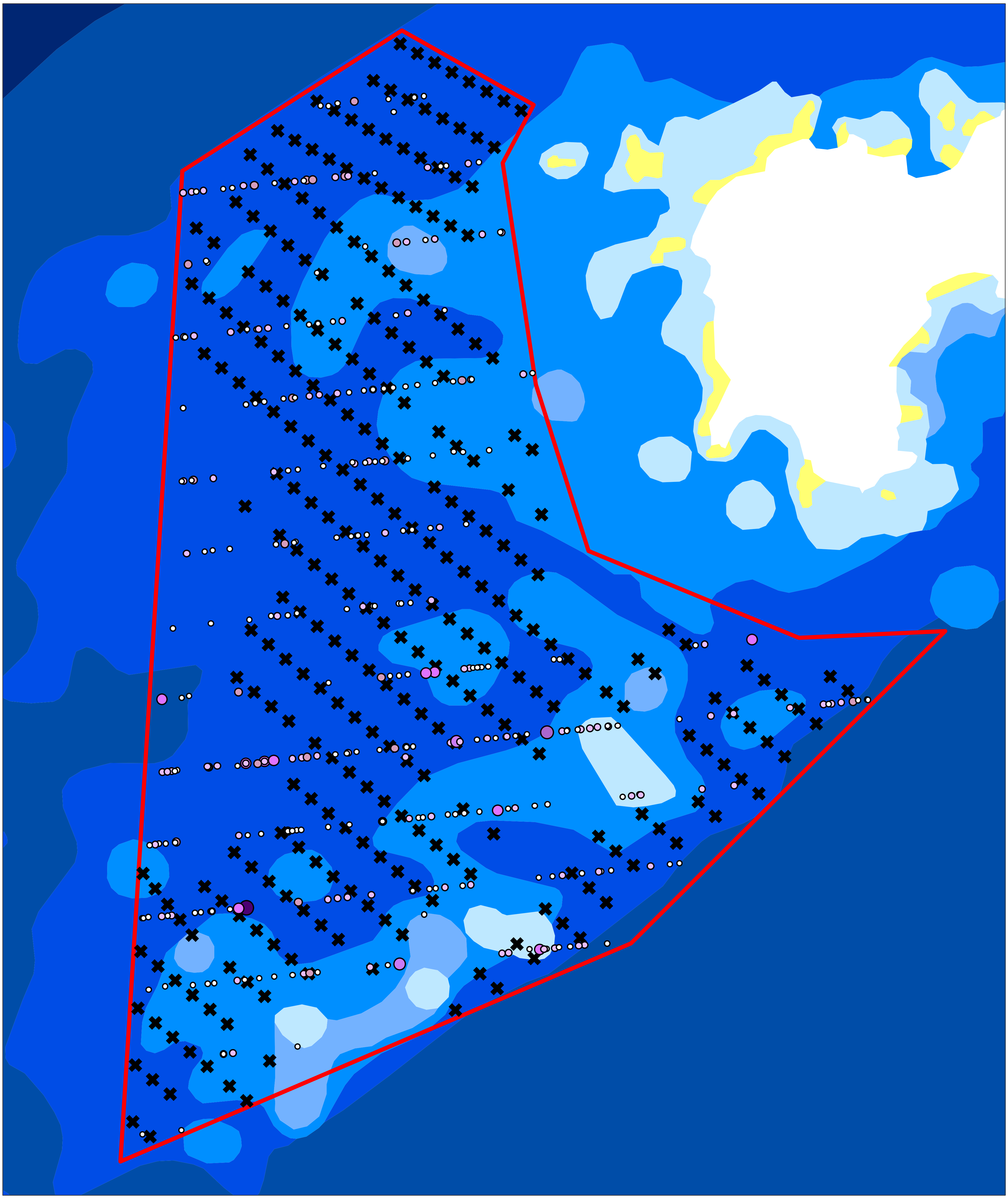
N

Date: 04/07/2012 Datum: OSGB36 Projection: BNG

Drawn: SBS Checked: RB Job Ref: 7284SEC

Figure No: **3.1.6** Revision: **03**

www.rpsgroup.com



Legend

Atlantic Puffin Number

○	**1**
●	**2**
●	**3**
●	**4**
●	**5**
●	**6**
●	**7**

✖ **Turbine locations**

▭ **Site boundary**

RPS

7 Clairmont Gardens Glasgow G3 7LW
T 0141 3320373 F 0141 3323182 E rpsgw@rpsgroup.com W www.rpsgroup.com

Client: Scottish Power Renewables

Project: Argyll Array

Title: Atlantic Puffin Density in Configuration 1

Scale: A3 @ 1:105,000

0 2 4 km

N

Date: 04/07/2012 Datum: OSGB36 Projection: BNG

Drawn: SBS Checked: RB Job Ref: 7284SEC

Figure No: **3.1.7** Revision: **03**

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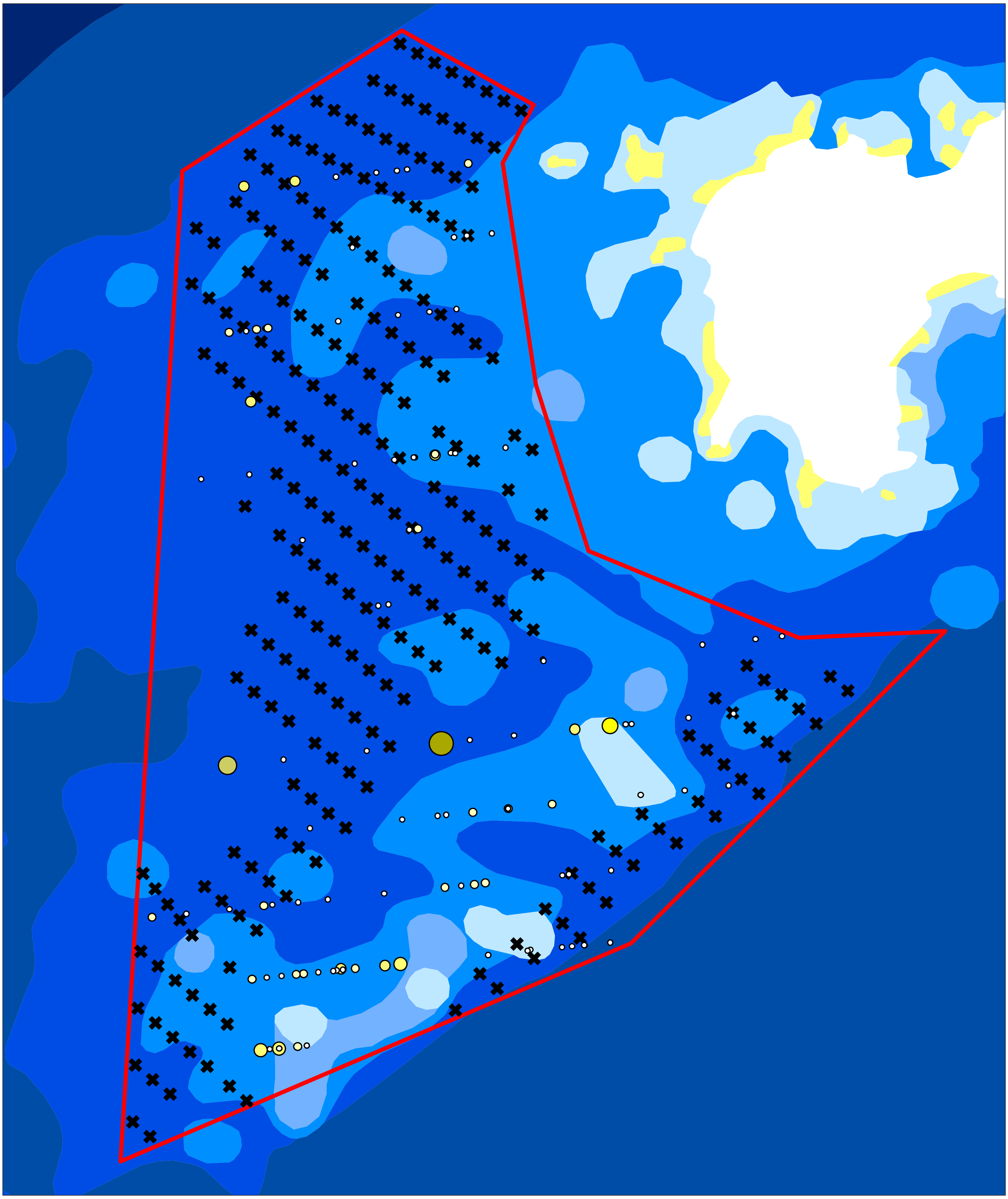
Project Ref: 7284SEC

Data Source: RPS 2012

Status: FINAL



Legend

Great Northern Diver Number

○	1
○	2
●	3
●	4
●	5
●	6
●	10

✖ Turbine locations

▭ Site boundary

Data Source: RPS 2012

Status: FINAL

Project Ref: 7284SEC

RPS
7 Clairmont Gardens Glasgow G3 7LW
T 0141 3320373 F 0141 3323182 E rpsgw@rpsgroup.com W www.rpsgroup.com

Client: Scottish Power Renewables

Project: Argyll Array

Title: Great Northern Diver Density in Configuration 2

Scale: A3 @ 1:105,000

0 2 4 km

N

Date: 04/07/2012 Datum: OSGB36 Projection: BNG

Drawn: SBS Checked: RB Job Ref: 7284SEC

Figure No: **3.2.1** Revision: **03**

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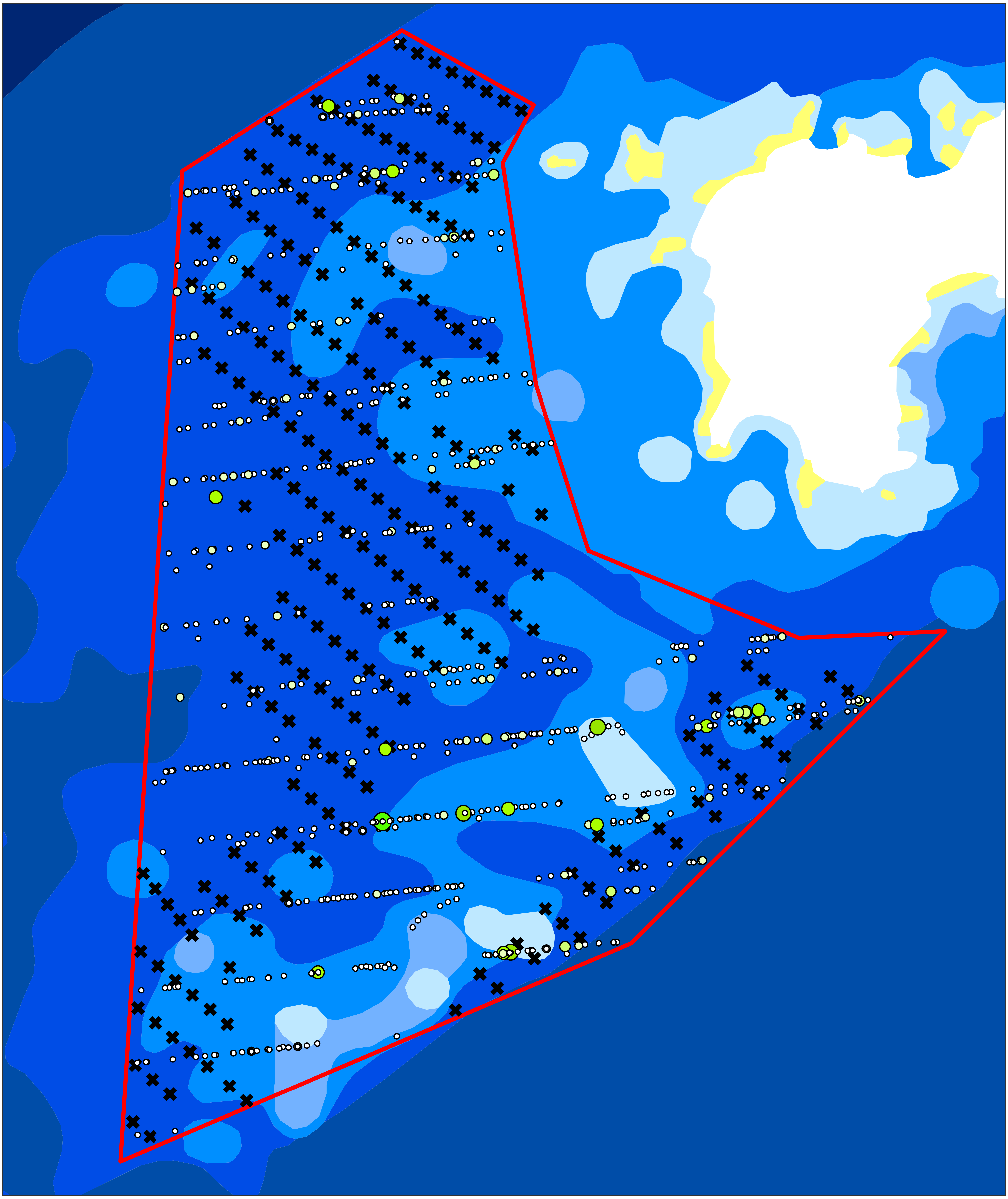


Legend

Northern Gannet Number

○	1
●	2
●	3
●	4
●	5
●	6
●	8

✖ **Turbine locations**

▭ **Site boundary**

Data Source: RPS 2012

Status: FINAL

Project Ref: 7284SEC

RPS
7 Clairmont Gardens Glasgow G3 7LW
T 0141 3320373 F 0141 3323182 E rpsgw@rpsgroup.com W www.rpsgroup.com

Client: Scottish Power Renewables

Project: Argyll Array

Title: Northern Gannet Density in Configuration 2

Scale: A3 @ 1:105,000

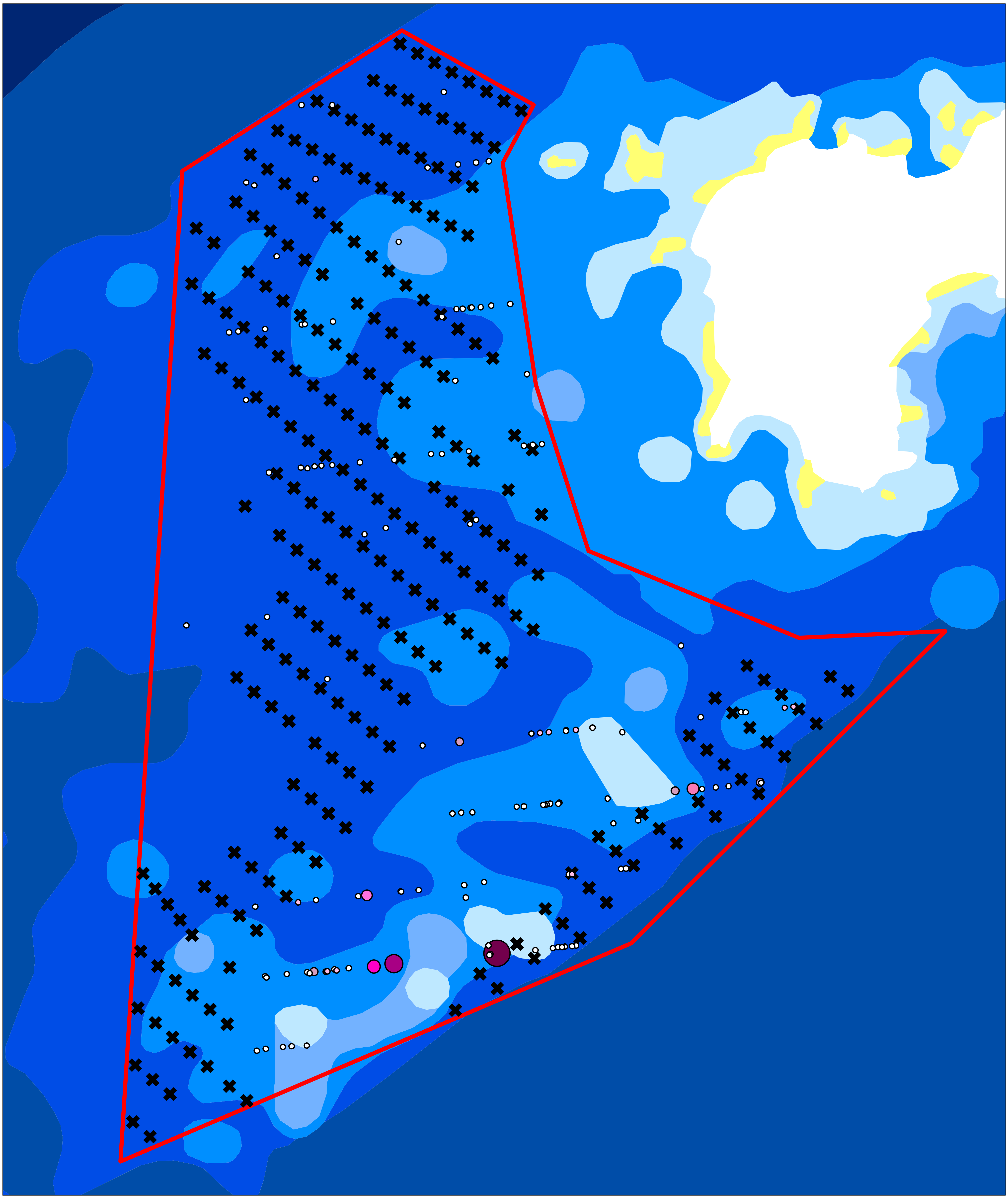
0 2 4 km

N

Date: 04/07/2012 Datum: OSGB36 Projection: BNG

Drawn: SBS Checked: RB Job Ref: 7284SEC

Figure No: **3.2.2** Revision: **03**



Legend

European Shag Number

○ **1**
○ **2**
● **3**
● **4**
● **5**
● **7**
● **10**
● **46**

✖ **Turbine locations**

▭ **Site boundary**

Data Source: RPS 2012

Status: FINAL

Project Ref: 7284SEC

RPS
7 Clairmont Gardens Glasgow G3 7LW
T 0141 3320373 F 0141 3323182 E rpsgw@rpsgroup.com W www.rpsgroup.com

Client: Scottish Power Renewables

Project: Argyll Array

Title: European Shag Density in Configuration 2

Scale: A3 @ 1:105,000

0 2 4 km

N

Date: 04/07/2012 Datum: OSGB36 Projection: BNG

Drawn: SBS Checked: RB Job Ref: 7284SEC

Figure No: **3.2.3** Revision: **03**

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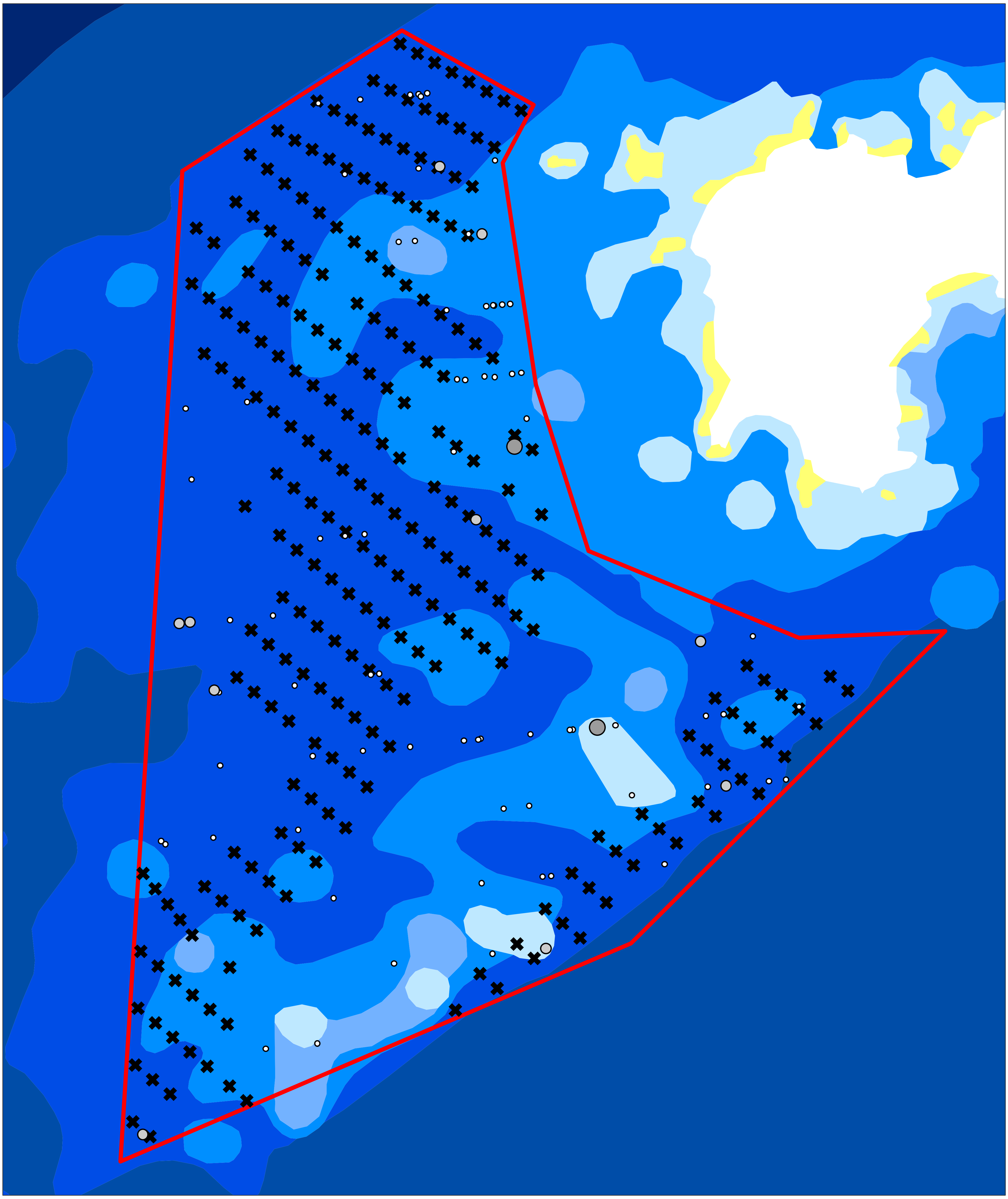


Legend

Herring Gull Number

- ○ 1
- ● 2
- ⬤ 3

✖ Turbine locations

▭ Site boundary

RPS

7 Clairmont Gardens Glasgow G3 7LW
T 0141 3320373 F 0141 3323182 E rpsgw@rpsgroup.com W www.rpsgroup.com

Client: Scottish Power Renewables

Project: Argyll Array

Title: Herring Gull Density in Configuration 2

Scale: A3 @ 1:105,000

0 2 4 km

N

Date: 04/07/2012 Datum: OSGB36 Projection: BNG

Drawn: SBS Checked: RB Job Ref: 7284SEC

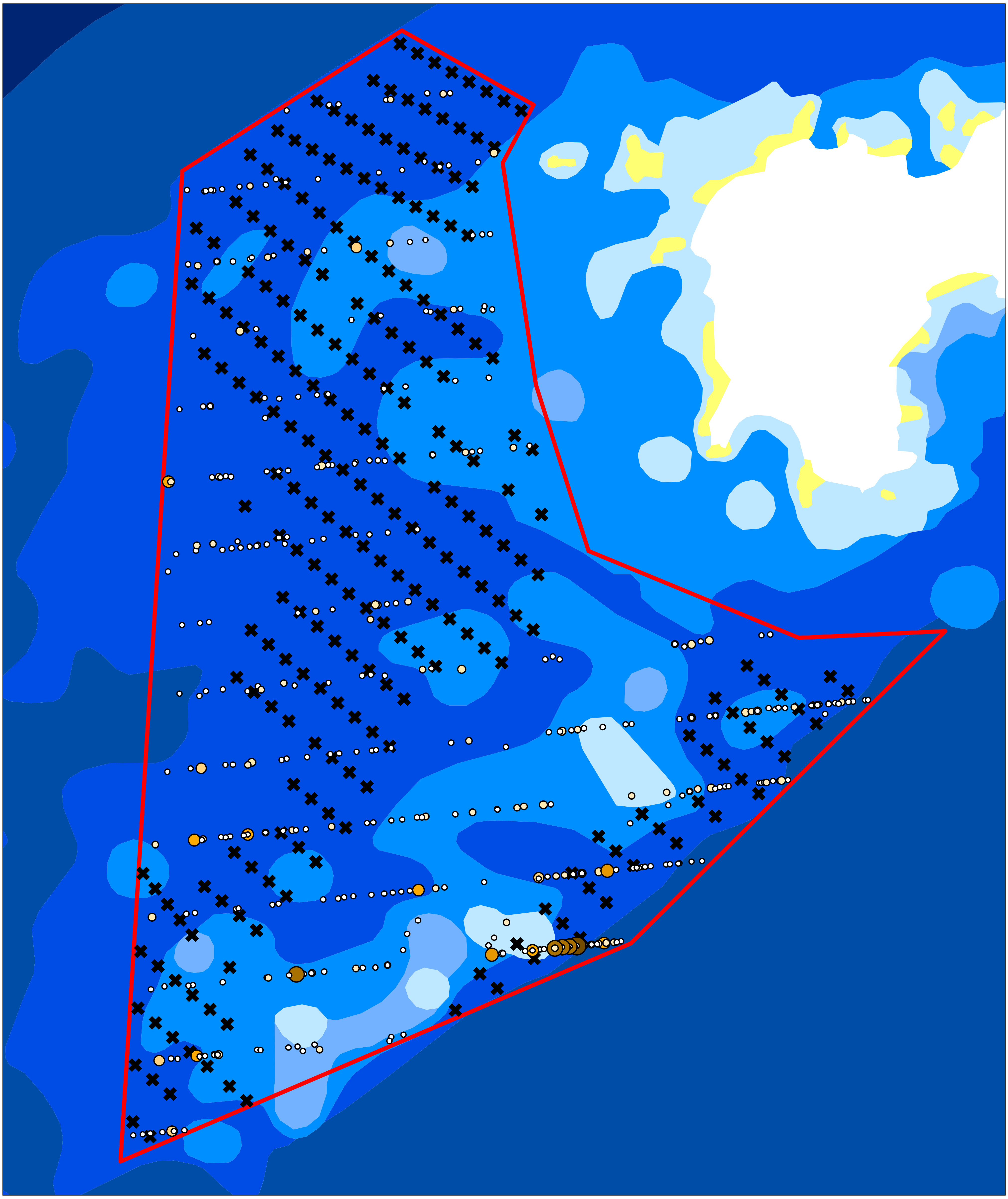
Figure No: **3.2.4** Revision: **03**

www.rpsgroup.com

Project Ref: 7284SEC

Data Source: RPS 2012

Status: FINAL



Legend

Guillemot Number

○ 1

○ 2

○ 3

● 4

● 5

● 6

● 8

● 9

✖ **Turbine locations**

□ **Site boundary**

Data Source: RPS 2012

Status: FINAL

Project Ref: 7284SEC

RPS
7 Clairmont Gardens Glasgow G3 7LW
T 0141 3320373 F 0141 3323182 E rpsgw@rpsgroup.com W www.rpsgroup.com

Client: Scottish Power Renewables

Project: Argyll Array

Title: GuillemotDensity in Configuration 2

Scale: A3 @ 1:105,000

0 2 4 km

N

Date: 04/07/2012 Datum: OSGB36 Projection: BNG

Drawn: SBS Checked: RB Job Ref: 7284SEC

Figure No: **3.2.5** Revision: **03**

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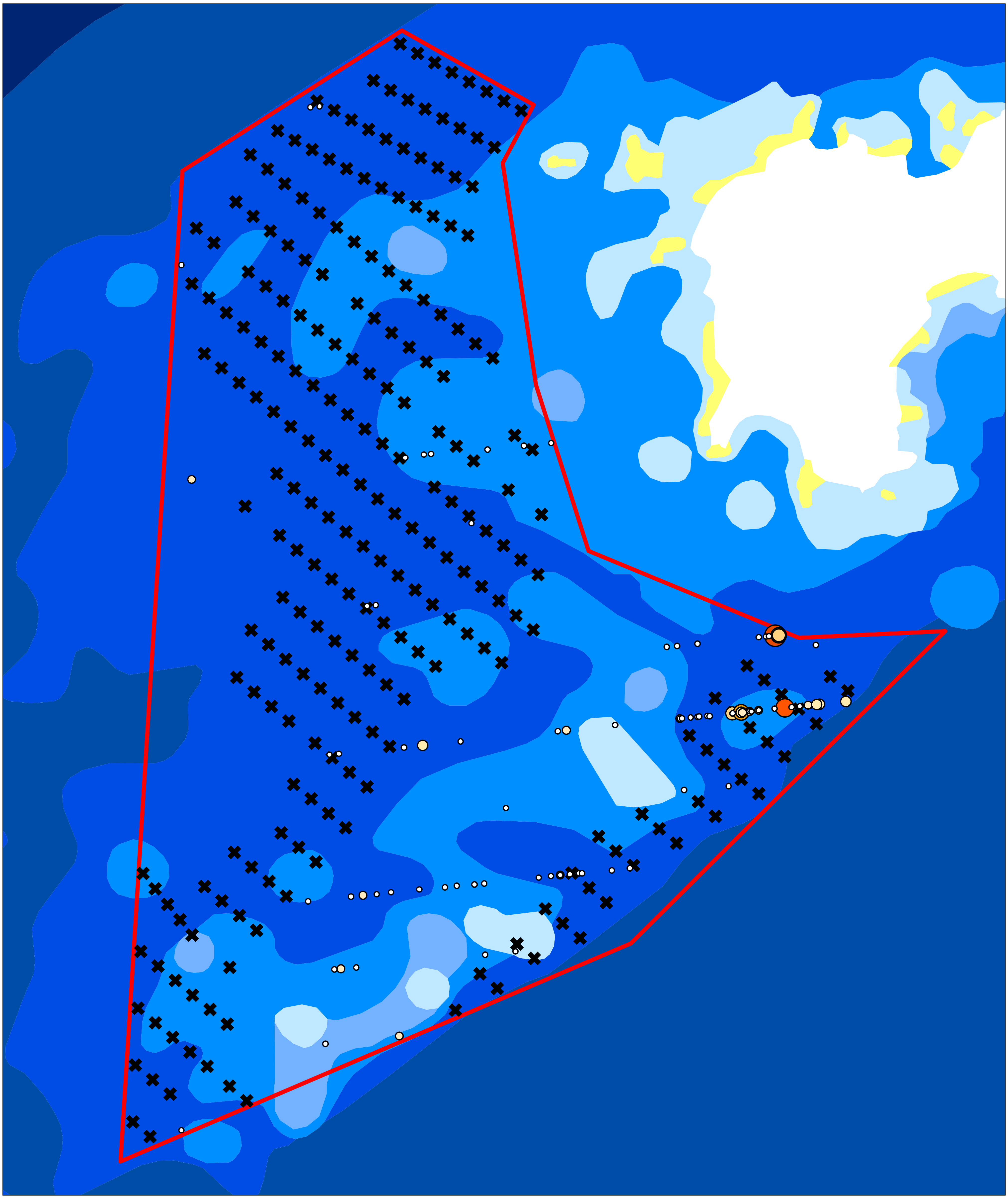


Legend

Black Guillemot Number

○	**1**
○	**2**
○	**3**
●	**4**
●	**5**
●	**6**
●	**7**

✖ **Turbine locations**

▭ **Site boundary**

Project Ref: 7284SEC

Data Source: RPS 2012

Status: FINAL

RPS
7 Clairmont Gardens Glasgow G3 7LW
T 0141 3320373 F 0141 3323182 E rpsgw@rpsgroup.com W www.rpsgroup.com

Client: Scottish Power Renewables

Project: Argyll Array

Title: Black Guillemot Density in Configuration 2

Scale: A3 @ 1:105,000

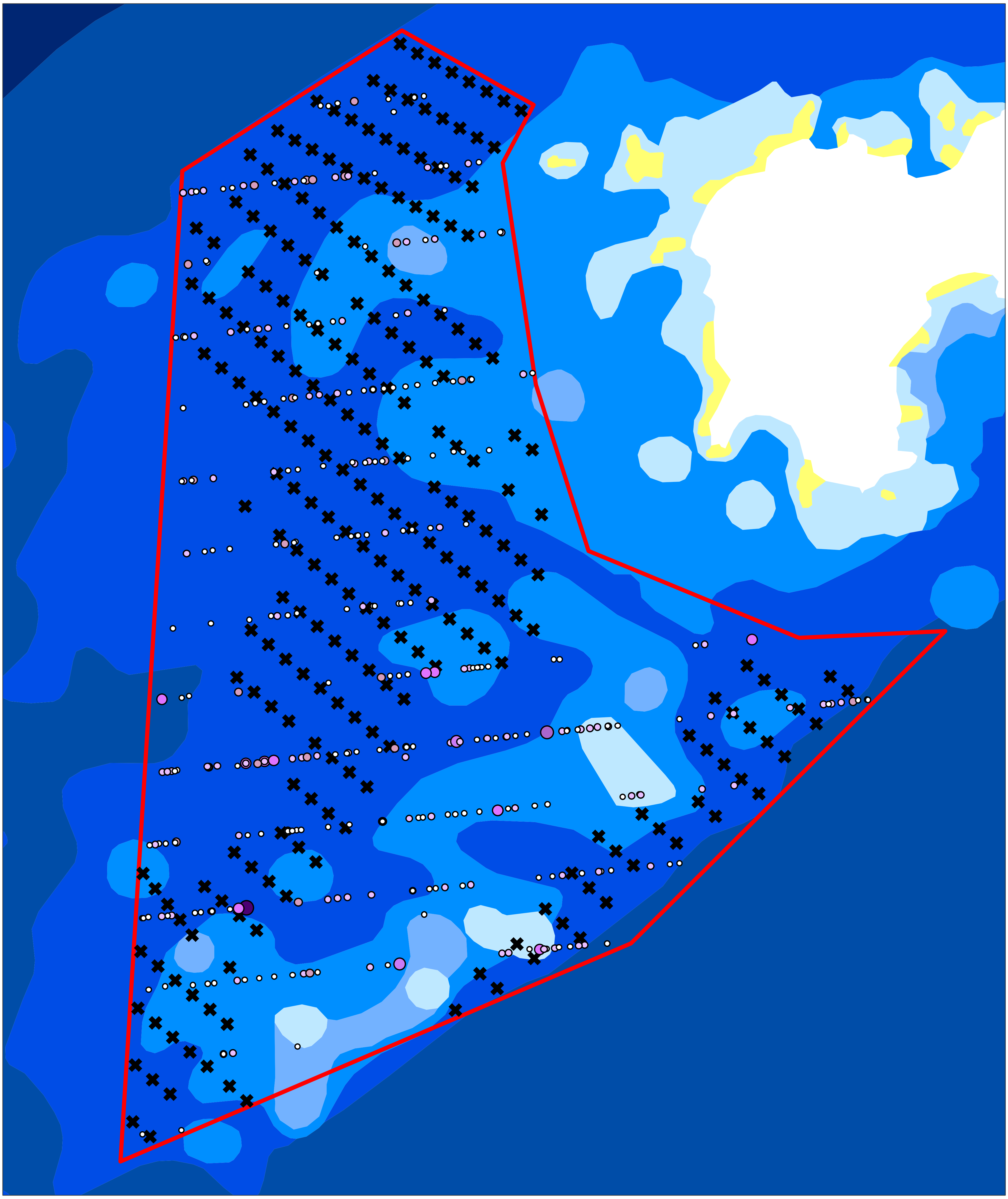
0 2 4 km

N

Date: 04/07/2012 Datum: OSGB36 Projection: BNG

Drawn: SBS Checked: RB Job Ref: 7284SEC

Figure No: **3.2.6** Revision: **03**



Legend

Atlantic Puffin Number

○ **1**

○ **2**

● **3**

● **4**

● **5**

● **6**

● **7**

✖ **Turbine locations**

▭ **Site boundary**

Project Ref: 7284SEC

Data Source: RPS 2012

Status: FINAL

RPS
7 Clairmont Gardens Glasgow G3 7LW
T 0141 3320373 F 0141 3323182 E rpsgw@rpsgroup.com W www.rpsgroup.com

Client: Scottish Power Renewables

Project: Argyll Array

Title: Atlantic Puffin Density in Configuration 2

Scale: A3 @ 1:105,000

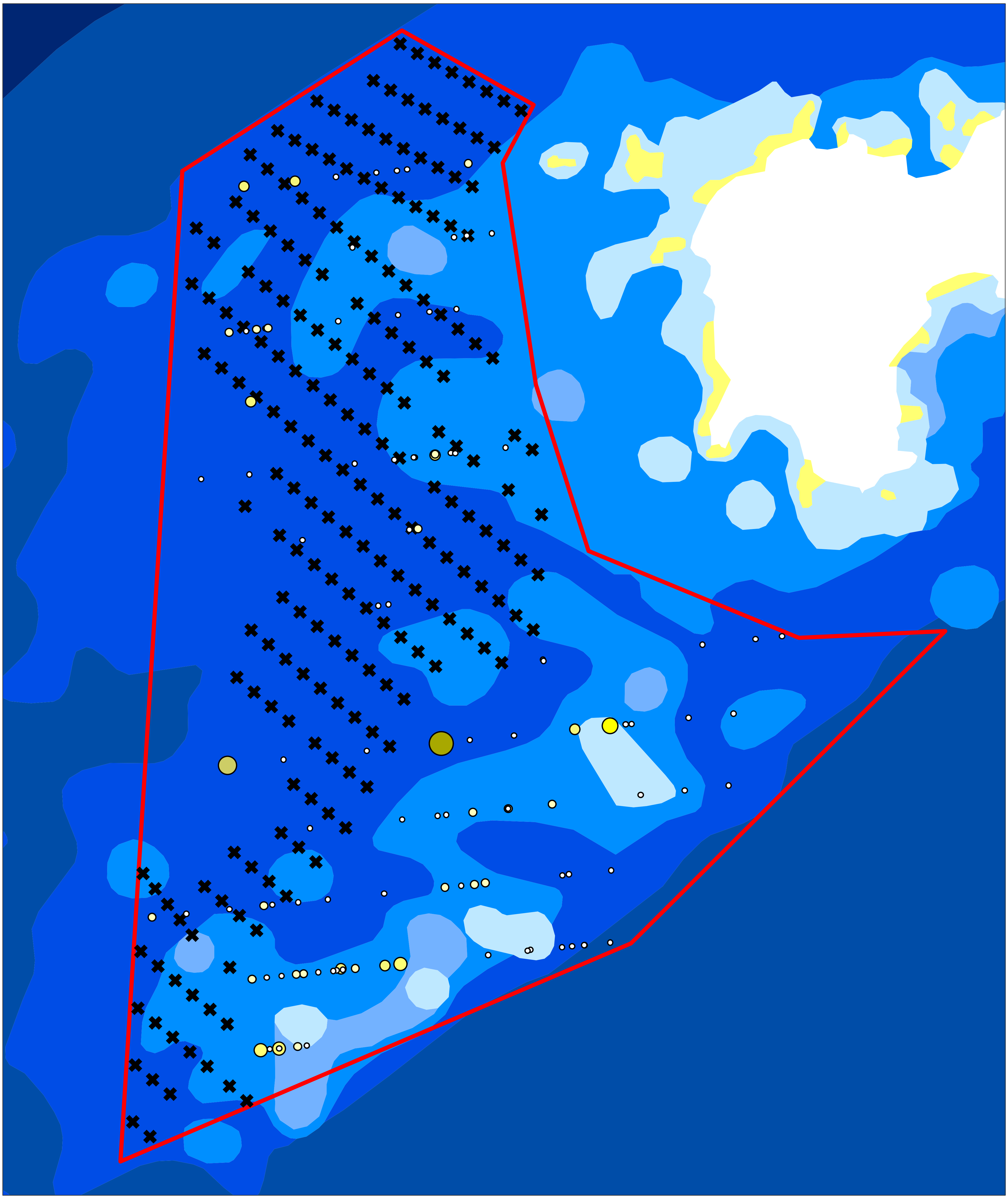
0 2 4 km

N

Date: 04/07/2012 Datum: OSGB36 Projection: BNG

Drawn: SBS Checked: RB Job Ref: 7284SEC

Figure No: **3.2.7** Revision: **03**



Legend

Great Northern Diver Number
- ○ 1
- ○ 2
- ○ 3
- ○ 4
- ● 5
- ● 6
- ● 10

✖ **Turbine locations**

▭ **Site boundary**

Data Source: RPS 2012

Status: FINAL

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Project Ref: 7284SEC

RPS

7 Clairmont Gardens Glasgow G3 7LW
T 0141 3320373 F 0141 3323182 E rpsgw@rpsgroup.com W www.rpsgroup.com

Client: Scottish Power Renewables

Project: Argyll Array

Title: Great Northern Diver Density in Configuration 3

Scale: A3 @ 1:105,000

0 2 4 km

N

Date: 04/07/2012 Datum: OSGB36 Projection: BNG

Drawn: SBS Checked: RB Job Ref: 7284SEC

Figure No: **3.3.1** Revision: **03**

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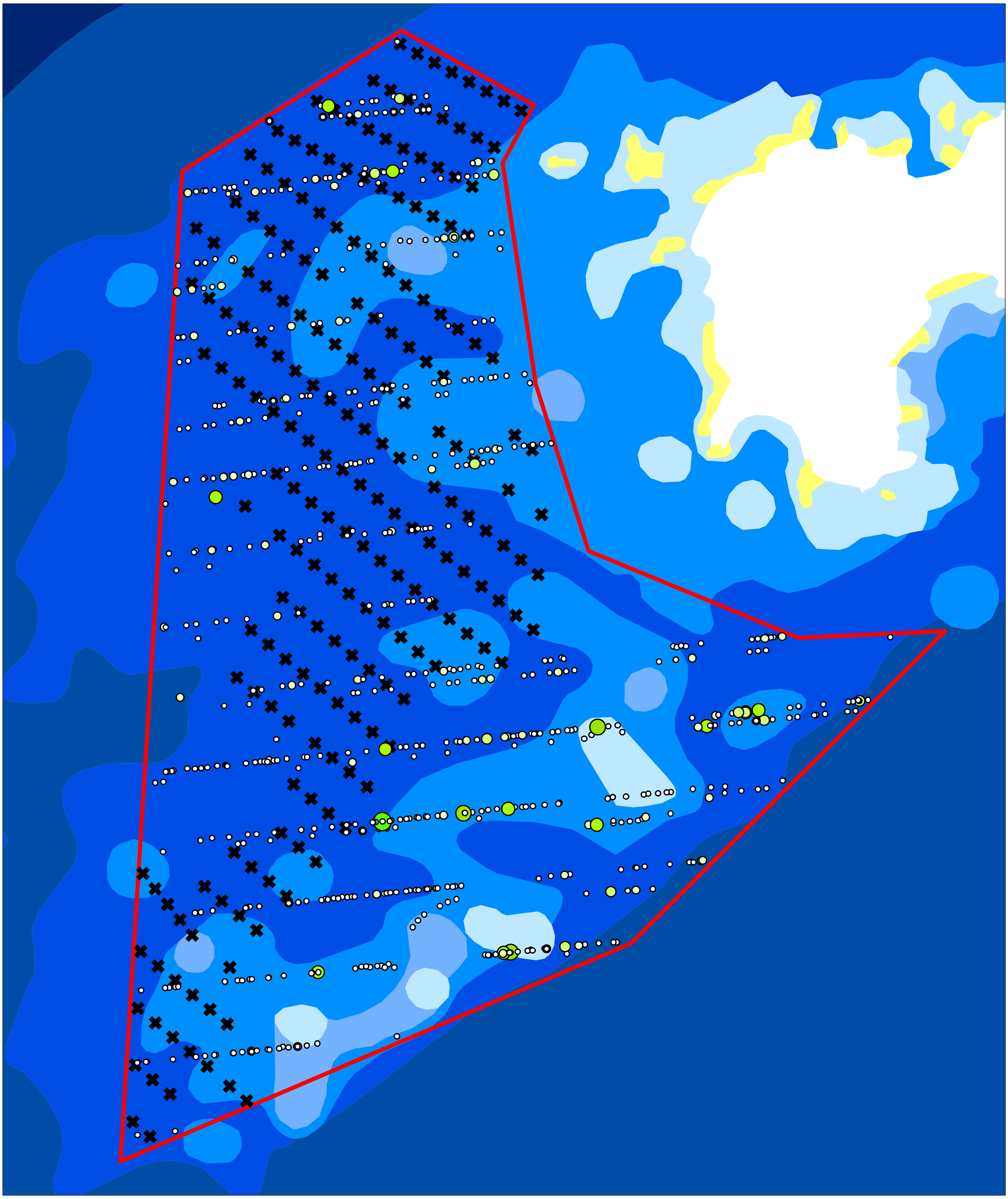


Legend

Northern Gannet Number

- ○ **1**
- ● **2**
- ● **3**
- ● **4**
- ● **5**
- ● **6**
- ● **8**

✖ **Turbine locations**

▭ **Site boundary**

Data Source: RPS 2012

Status: FINAL

Project Ref: 7284SEC

RPS
7 Clairmont Gardens Glasgow G3 7LW
T 0141 3320373 F 0141 3323182 E rpsgw@rpsgroup.com W www.rpsgroup.com

Client: Scottish Power Renewables

Project: Argyll Array

Title: Northern Gannet Density in Configuration 3

Scale: A3 @ 1:105,000

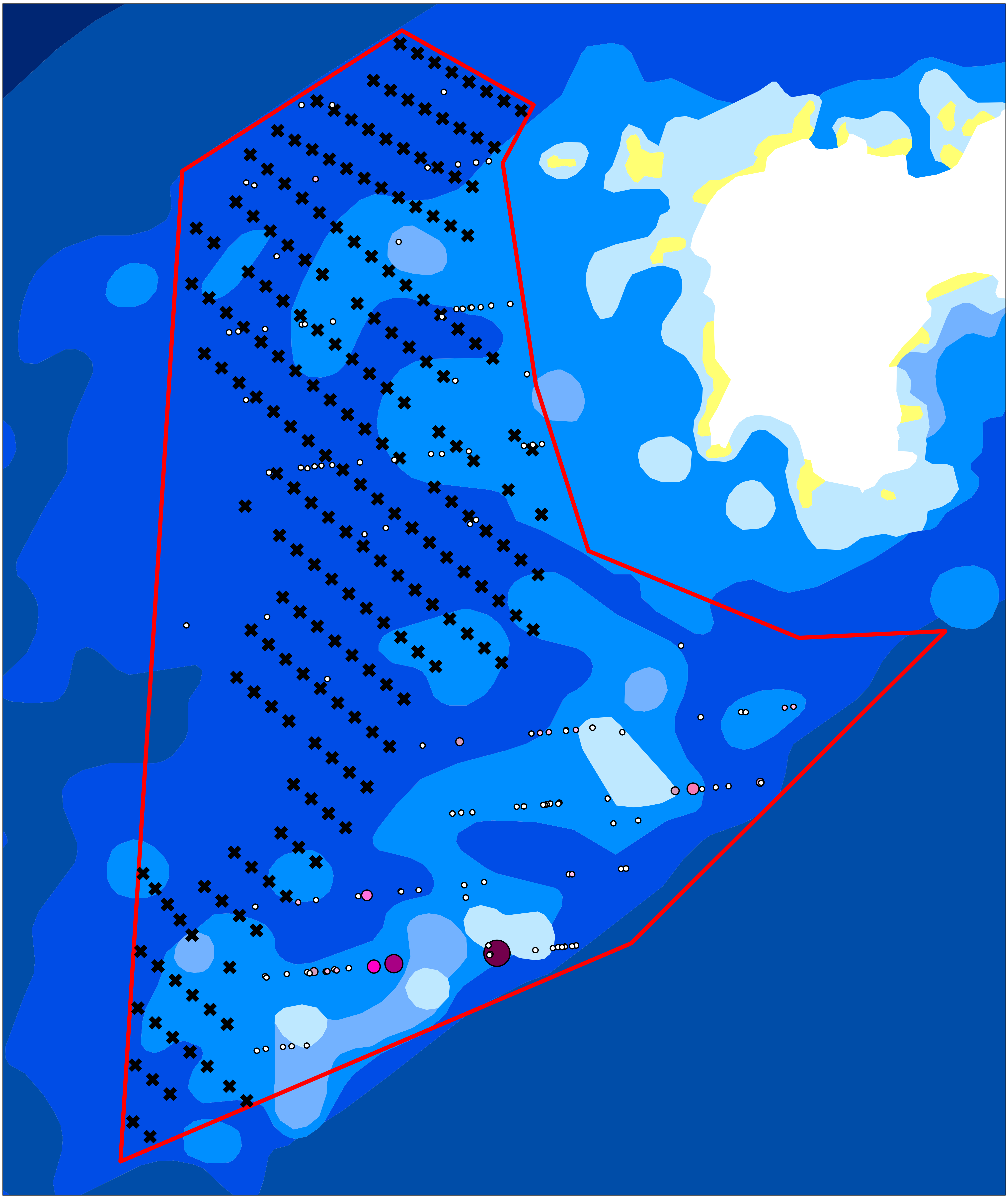
0 2 4 km

N

Date: 04/07/2012 Datum: OSGB36 Projection: BNG

Drawn: SBS Checked: RB Job Ref: 7284SEC

Figure No: **3.3.2** Revision: **03**



Legend

European Shag Number

- ○ 1
- ○ 2
- ● 3
- ● 4
- ● 5
- ● 7
- ● 10
- ● 46

✖ **Turbine locations**

🟥 **Site boundary**

Data Source: RPS 2012

Status: FINAL

Project Ref: 7284SEC

RPS
7 Clairmont Gardens Glasgow G3 7LW
T 0141 3320373 F 0141 3323182 E rpsgw@rpsgroup.com W www.rpsgroup.com

Client: Scottish Power Renewables

Project: Argyll Array

Title: European Shag Density in Configuration 3

Scale: A3 @ 1:105,000

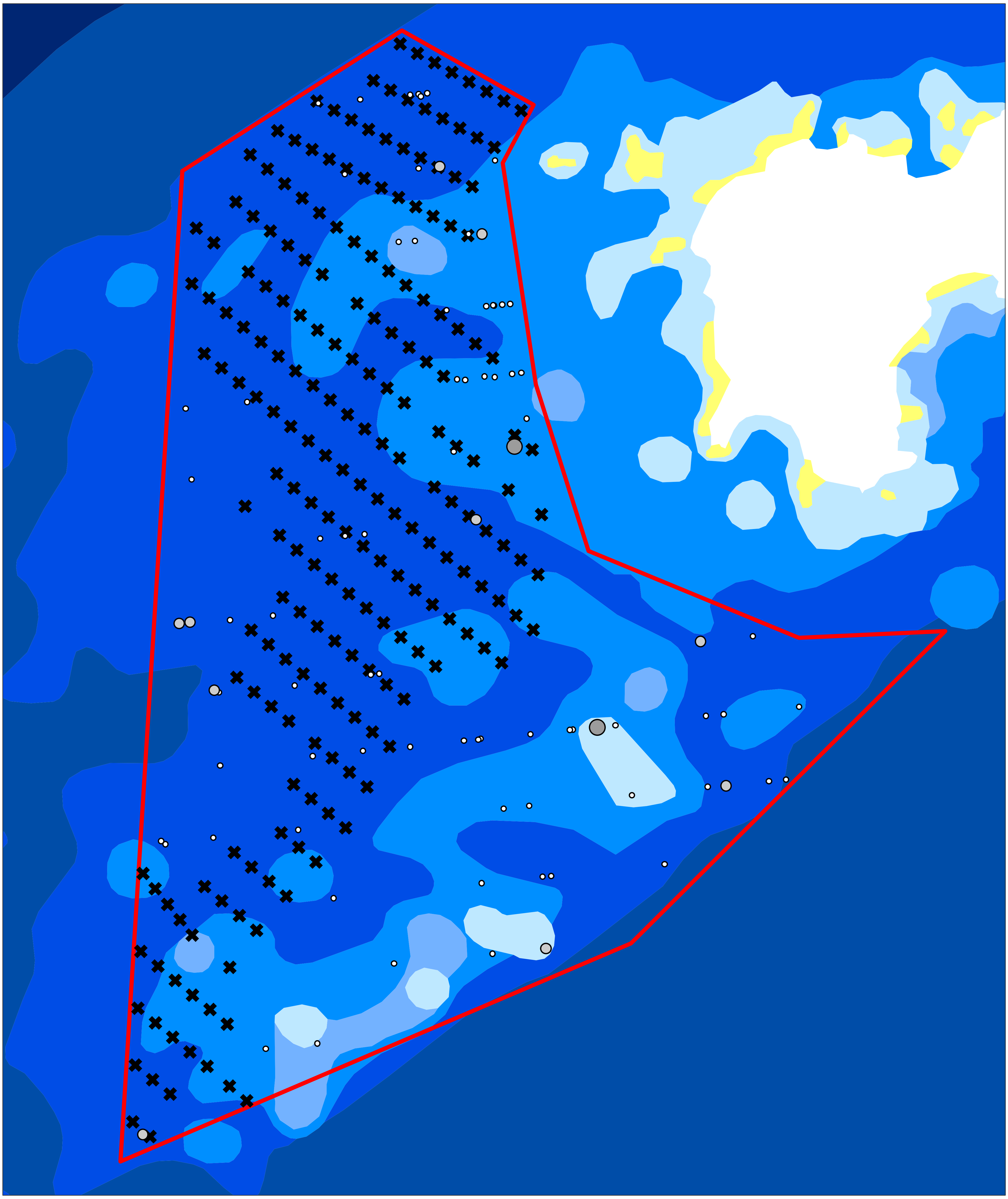
0 2 4 km

N

Date: 04/07/2012 Datum: OSGB36 Projection: BNG

Drawn: SBS Checked: RB Job Ref: 7284SEC

Figure No: **3.3.3** Revision: **03**



Legend

Herring Gull Number
- ○ 1
- ● 2
- ● 3

✖ **Turbine locations**

▭ **Site boundary**

RPS
7 Clairmont Gardens Glasgow G3 7LW
T 0141 3320373 F 0141 3323182 E rpsgw@rpsgroup.com W www.rpsgroup.com

Client: Scottish Power Renewables

Project: Argyll Array

Title: Herring Gull Density in Configuration 3

Scale: A3 @ 1:105,000
0 2 4 km
N

Date: 04/07/2012 Datum: OSGB36 Projection: BNG

Drawn: SBS Checked: RB Job Ref: 7284SEC

Figure No: **3.3.4** Revision: **03**

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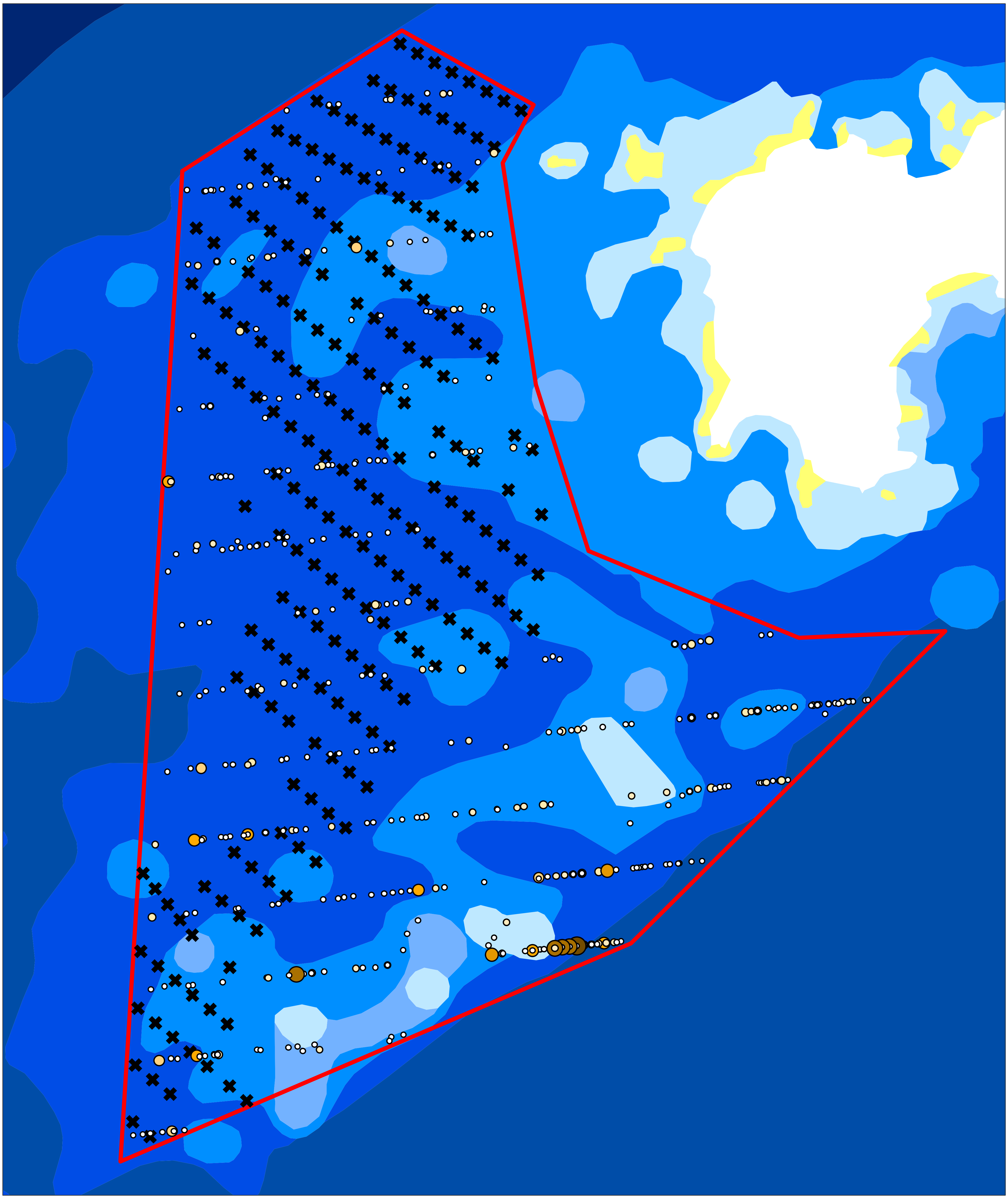
Project Ref: 7284SEC

Data Source: RPS 2012

Status: FINAL



Legend

Guillemot Number

○	1
○	2
○	3
●	4
●	5
●	6
●	8
●	9

✖ **Turbine locations**

▭ **Site boundary**

Project Ref: 7284SEC

Data Source: RPS 2012

Status: FINAL

RPS
7 Clairmont Gardens Glasgow G3 7LW
T 0141 3320373 F 0141 3323182 E rpsgw@rpsgroup.com W www.rpsgroup.com

Client: Scottish Power Renewables

Project: Argyll Array

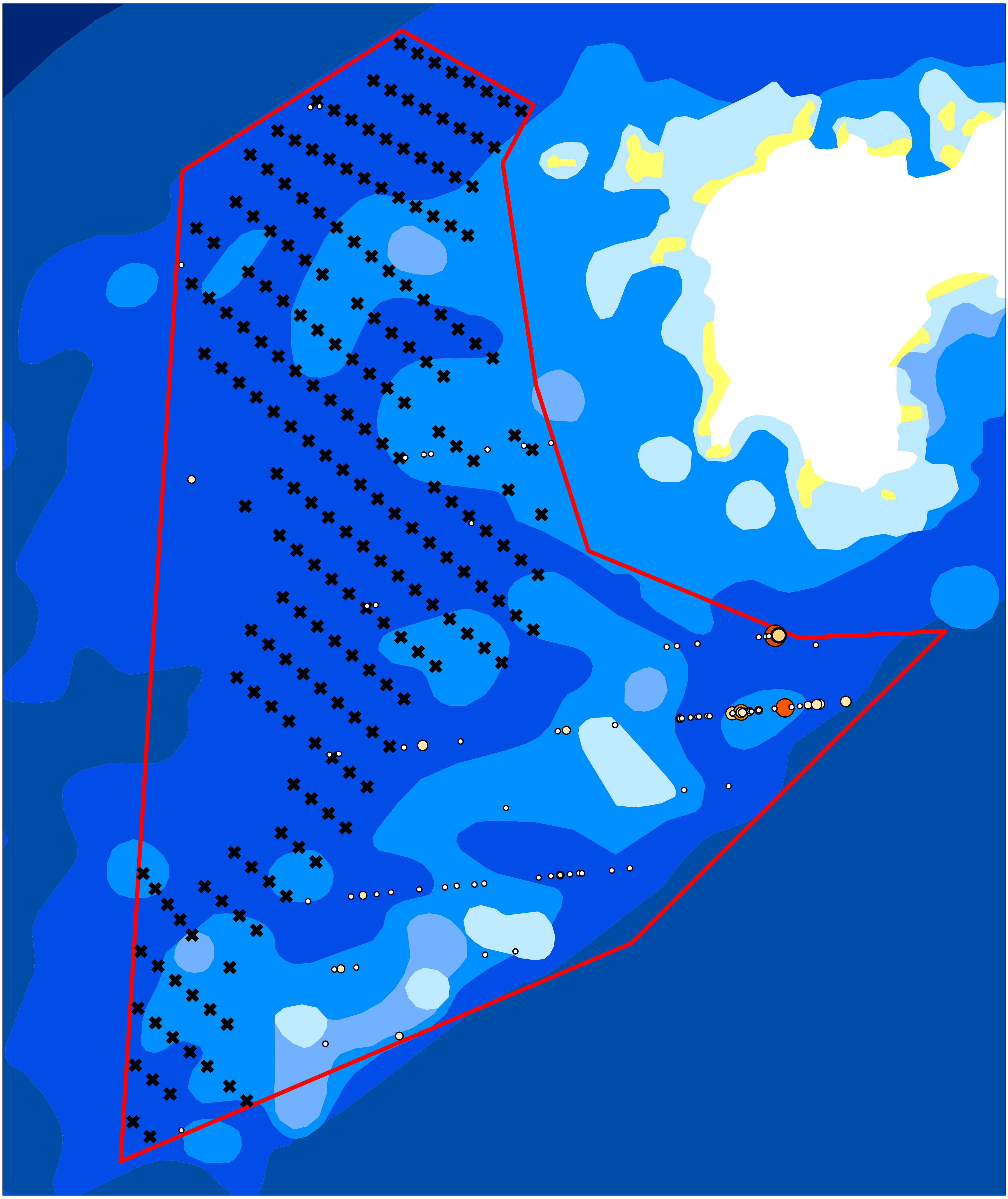
Title: GuillemotDensity in Configuration 3

Scale: A3 @ 1:105,000

Date: 04/07/2012 Datum: OSGB36 Projection: BNG

Drawn: SBS Checked: RB Job Ref: 7284SEC

Figure No: **3.3.5** Revision: **03**



Legend

Black Guillemot Number

○	**1**
○	**2**
○	**3**
●	**4**
●	**5**
●	**6**
●	**7**

✖ **Turbine locations**

▭ **Site boundary**

Data Source: RPS 2012

Status: FINAL

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Project Ref: 7284SEC

RPS
7 Clairmont Gardens Glasgow G3 7LW
T 0141 3320373 F 0141 3323182 E rpsgw@rpsgroup.com W www.rpsgroup.com

Client: Scottish Power Renewables

Project: Argyll Array

Title: Black Guillemot Density in Configuration 3

Scale: A3 @ 1:105,000

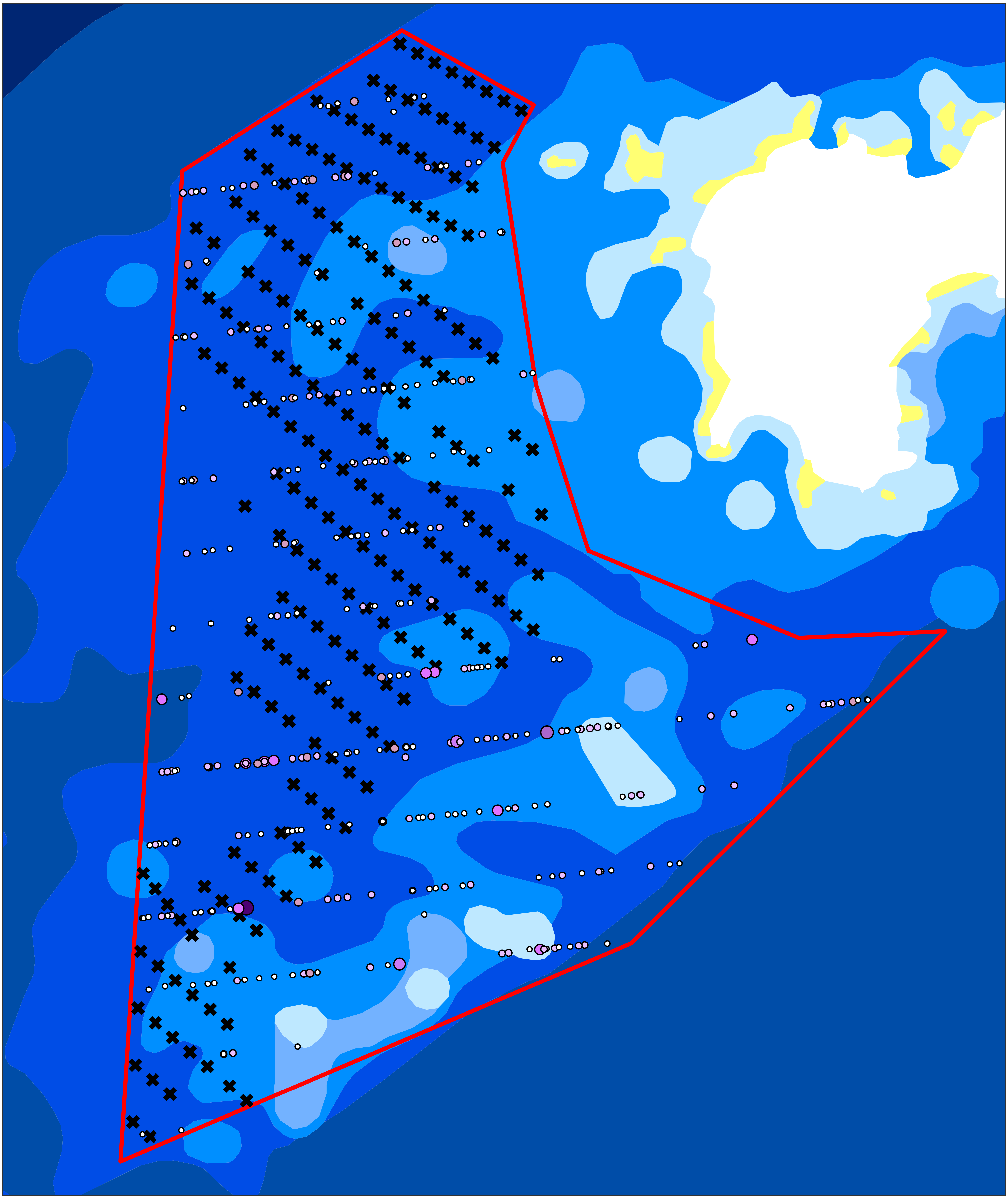
0 2 4km

N

Date: 04/07/2012 Datum: OSGB36 Projection: BNG

Drawn: SBS Checked: RB Job Ref: 7284SEC

Figure No: **3.3.6** Revision: **03**



Legend

Atlantic Puffin Number

- ○ 1
- ● 2
- ● 3
- ● 4
- ● 5
- ● 6
- ● 7

✖ **Turbine locations**

▭ **Site boundary**

Data Source: RPS 2012

Status: FINAL

Project Ref: 7284SEC

RPS
7 Clairmont Gardens Glasgow G3 7LW
T 0141 3320373 F 0141 3323182 E rpsgw@rpsgroup.com W www.rpsgroup.com

Client: Scottish Power Renewables

Project: Argyll Array

Title: Atlantic Puffin Density in Configuration 3

Scale: A3 @ 1:105,000

0 2 4 km

N

Date: 04/07/2012 Datum: OSGB36 Projection: BNG

Drawn: SBS Checked: RB Job Ref: 7284SEC

Figure No: **3.3.7** Revision: **03**

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