



**FIELD SURVEY TO EXAMINE THE FEASIBILITY OF CLEARING LANDMINES IN THE
FALKLAND ISLANDS (ISLAS MALVINAS)**

FIELD SURVEY REPORT

**CRANFIELD UNIVERSITY
9 JULY 2007**

VERSION FOR PUBLIC DISSEMINATION

The geographical names used in this report do not imply the adoption of any position by Cranfield University with regard to the sovereignty dispute over the Falkland Islands (Islas Malvinas), South Georgia and South Sandwich Islands and the surrounding maritime areas.



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EXECUTIVE SUMMARY

General framework of the project

On 11 October 2001, the Governments of the United Kingdom and the Argentine Republic agreed through an Exchange of Notes to examine the feasibility of clearing landmines remaining in the Falkland Islands (Islas Malvinas). The study is being carried out by both Governments by means of a British-Argentine Joint Working Party (JWP).

On 3 August 2006 both Governments agreed by Exchange of Notes that the feasibility study should include all unexploded ordnance (UXO) within mined areas, and agreed the procedures for conducting the field survey using a contractor.

These two Exchanges of Notes are covered by a formula which safeguards the British and Argentine positions on the sovereignty dispute on the Falkland Islands (Islas Malvinas), South Georgia and South Sandwich Islands, and the surrounding maritime areas, and were concluded in the light of the obligations in the Convention on the Prohibition of the Use, Stockpiling, Production and Transfer of Anti-Personnel Mines and on their Destruction of December 1997 (referred to in this report as the "Ottawa Convention").

On 7 August 2006 an invitation to tender was issued by the JWP. The Resilience Centre of Cranfield University was selected by the JWP to carry out certain tasks of the main study of the Feasibility Study, including a field survey on the Falkland Islands (Islas Malvinas), and a contract was signed in Paris on 3 November 2006.

Aim of field survey

The aim of the field survey was to provide a detailed assessment of the availability and suitability of the methods and techniques normally used to detect, clear and dispose of land mines and UXO, to provide an assessment of the potential environmental risks, and to estimate the costs for each clearance method and for the environmental remediation.

Background

The Argentine Government has reported to the United Nations that some 20,000 anti-personnel mines and 5,000 anti-vehicle mines were laid by its armed forces during the conflict which took place on the Falkland Islands (Islas Malvinas) in 1982. Most were laid on the approaches to Port Stanley, but others were laid in and around the settlements of Goose Green, Fox Bay and Port Howard, and in the coves of the Murrell Peninsula.

During hostilities a large number of ordnance was used by the UK and Argentine military. Some UXO remains inside the mined areas and has not yet been recovered. It is not possible to calculate exactly how much and which types of UXO remain within the mined areas, although the Study Team advises that the clearance of UXO will not impact significantly on demining operations on the Islands.

On 14 June 1982, Argentine forces handed over all minefield records available to them to the British forces. In the immediate aftermath of the conflict some mines were lifted by British Sappers. Argentine personnel assisted by providing essential information on the type and locations of mines. However, work was halted due to injuries. Battlefield area clearance (BAC) continued for two years with the aim of removing UXO, stockpiles of ammunition, the remains of destroyed aircraft and other hazardous debris of the war. Mine clearance was performed only when civilians were

in immediate danger, and to enable essential military tasks to be carried out. Since 1982 there have been no recorded civilian casualties from landmines or UXO on the Islands. In some areas, sheep and cattle can be seen grazing in mined areas, and penguins have established colonies behind minefield fences. Many sources and assessments suggest that the socio-economic impact of the mined areas is negligible.

When demining was halted, efforts shifted to minefield survey, marking and fencing. In some cases it was possible to identify areas accurately from Argentine minefield records. In other cases, potential hazardous areas were identified from information provided by local inhabitants of the settlements, and from evidence such as limbless cattle and sheep. Potential hazardous areas were recorded, marked and fenced, often using existing farm fences.

In some areas, sheep and cattle can be seen grazing in mined areas, and penguins have established colonies behind minefield fences. Many sources and assessments suggest that the socio-economic impact of the mined areas is negligible.

In late 1982, a major study was funded by the UK Ministry of Defence with the aim of identifying suitable technologies which could be used to remove the mines safely, but work was halted in 1986 once it became apparent that no equipment could achieve the very demanding level of clearance deemed necessary. At that time it was assumed the Islands would remain contaminated by landmines for some time, although it was intended to revisit the problem at a later date. Since 1986, there have been a number of technical suggestions and unsolicited proposals to remove the remaining mines from the Islands, but there has been little real progress in the absence of any political imperative.

However, recent international initiatives have re-focused political attention on the landmine issue. Of particular importance is the Ottawa Convention which requires governments within 10 years of entry into force of the Convention "... for each country to destroy or ensure the destruction of all anti-personnel mines in mined areas under (their) jurisdiction or control."

Definitions

For the purposes of this report the Falkland Islands (Islas Malvinas) shall be referred to as "the Islands". The survey and clearance of landmines and UXO shall be referred to as "demining". Technical terms as defined in International Mine Action Standards (IMAS 04.10) have been used in this report.

Approach and methodology

Cranfield University conducted the Study in five clearly defined stages:

(1) Scoping Study. In Stage 1 (the Scoping Study), Cranfield University reviewed, confirmed and agreed the aim, scope, planning assumptions, approach, resources and timings. Key references were collected and reviewed. The Study Team undertook a preliminary assessment of the geology, soils and hydrology of the mined areas in the Islands in order to develop an understanding of the geo-hydrological setting of the mined areas prior to the field survey.

(2) Field surveys and assessments. In Stage 2 (field surveys and assessments) the Survey Team deployed to the Islands and visited all known mined areas. During

each visit the Team collected and recorded information on the mine threat, terrain conditions and the environment. At the end of each visit the Team reviewed the information collected and assessed the demining options and environmental impact of each option. A summary of the Team's findings for each mined area is included in the Main Report. Throughout Stage 2, the work of the Survey Team was overseen by four monitors: two provided by the UK Government and two by the Argentine Government. During the survey, the Team discussed its approach and survey methods with the monitors.

(3) Review field survey. On returning from the Islands, the Study Team discussed the clearance options with three Panels of Experts and the environmental implications of each clearance option were reviewed in detail. The field data were used to generate vegetation mapping and sensitivity of the main fauna to disturbance which may be caused by proposed clearance work. Existing literature was reviewed. Draft mitigation and remediation proposals were produced and checked for coherence and appropriateness.

(4) Review draft reports. During Stage 4, the JWP reviewed draft reports. This included a meeting with the JWP in London on 20 February 2007 to consider a first draft report, and to discuss the JWP's comments and observations with the Project Director. Cranfield University submitted a second draft report on 15 March 2007.

(5) Prepare final report. During Stage 5, the Project Director met with the JWP in London between 28 and 30 March 2007 to consider the second draft report. At the meeting the JWP and Cranfield University agreed the content of the final report.

Sources of information

A number of sources of information were used by the Study Team. Sources included minefield records, assessments, visit reports and other information held by the Joint Services Explosive Ordnance Disposal (JSEOD) Detachment in Stanley. During the survey, notes were taken of meetings with landowners and other key informants on the Islands. The Team also drew heavily on historical information held in the UK including the terrain and environmental studies conducted in 1982, 1983 and 1985 on behalf of the UK Ministry of Defence, the assessment of technologies for detection and clearance conducted in 1983 and 1984 on behalf of the UK Ministry of Defence, and several reports and papers written in the immediate aftermath of the conflict which are held at the UK Defence Academy's library.

The Study Team used classic research methods for reviewing and assessing the information for accuracy and relevance. Wherever possible the Team characterised the information collected into substantiated data and opinion.

Key findings

(1) Dangerous Areas. The Study Team has calculated the total area currently recorded within the JSEOD database as "dangerous" to be 1,314.9 Ha (13.15 sqkm). Having reviewed existing information, visited the danger areas and spoken with key informants on the Islands, the Study Team considers that:

- (a) 577.5 Ha contains no landmines and as such the status of the land should be changed to "no known mines". However, we recognise that action will need to be taken to demonstrate to the Islanders that such areas are free of known

mines, and we recommend a combination of mechanical, manual and mine detection dogs be used to confirm the absence of mines and other explosive hazards. (Category A)

(b) 54.7 Ha of mined areas represent the greatest threat to human life; i.e. potential hazards are within 750m of any settlement or within 100m of a main paved road. (Category B)

(c) 664.8 Ha of mined areas represent a reduced threat to human life; i.e. potential hazards are not within 750m of any settlement or 100m of a main paved road. (Category C)

(d) 17.9 Ha of mined areas cannot be cleared easily and/or clearance would require significant environmental remediation. (Category D)

(2) Environmental Impact. An assessment of the terrain and environment at each mined area was conducted by the Survey Team to assess the suitability of different clearance methods and the need for post-clearance remediation measures to address environmental damage as a result of clearance. The Team has assessed the local impact on each area, and its findings are given in the Main Report. Overall, it is assessed that the environmental impact of clearance on 577.5 Ha of the mined areas (representing 44% of the total area) is low. It is assessed that there will be some environmental impact of clearance on the remaining 737.4 Ha, and this will require some remediation work to be undertaken. A small number of these sites will present significant environmental challenges, although it is anticipated these will be surmountable. Any environmental impacts from clearance operations have to be balanced against the remaining risk from uncleared landmines and unexploded ordnance, and should also be seen in the context of the greater environmental damage caused by previous over-grazing on the Islands and future longer term effects of climate change.

(3) Climate. The climate of the Islands is characterised by a narrow temperature range varying from 22°C (70°F) in January to -5°C (22°F) in July, with a mean annual temperature of some 5.6°C (42°F). The annual rainfall is 24 inches in Stanley with occasional snow all year, except in January and February. The weather will impact on clearance as the rain, cold temperatures and strong westerly winds will limit access to mined areas and the use of mechanical systems, mine detection dogs and manual clearance. It is assessed that clearance can take place for ten months each year. During the two months stand down, staff can take annual leave and attend training, and equipment can undergo major servicing.

(4) Depth of Mines. The Survey Team do not consider the presence of deep-buried mines to be likely. Mines are normally laid at a depth of about 5 – 7 cm, but unconfirmed reports suggested that anti vehicle and antipersonnel mines could sink under their own weight down to 60 cm or more. The Survey Team do not support this view. The density (weight ÷ volume) of the mines laid during the conflict is similar to (or lower than) the surrounding soil and as such would not sink, and certainly would not have dropped through the closely-knit network of fibrous roots found in peat. Over the past 25 years no more than 2 cm of additional soil will have formed above the mines (from the cumulation of rotted vegetation). It is the view of the Survey Team that mines will be found at depths of no more than 7 – 9 cm, unless there has been a movement of soil such as the shifting sand dunes in Stanley Area 1, or falling

peat overhangs in Stanley Area 2. Our review of clearance methods was predicated on this assessment.

(5) Clearance Methods. The report reviews the suitability of a range of clearance methods including: manual clearance, rolling, flailing, mechanical milling, digging, bulk excavation and the use of mine detection dogs. It is the view of the Study Team that no single clearance method will be suitable for all the mined areas; indeed, a number of clearance methods may need to be used for each area. This will require experienced mine action project managers and a sound understanding of the clearance methods for the unique terrain and mine threat which exists on the Islands.

(6) Environmental Remediation. The report reviews remediation practices used in the British Isles for the restoration of vegetation cover on deep peat, peat-topped and mineral soils. Some of these practices can be used on the Islands. However, there are differences in climate, soil types and species of flora and fauna, and it will be necessary to modify the practices to suit local conditions. The Study Team has proposed five remediation protocols ranging from “benign neglect” to the use of geotextiles to stabilise surface vegetation. The protocols represent a progression of intervention complexity, and hence cost. The degree of remediation required will depend on many factors including the opportunity costs of remediation work.

Strategic clearance options

A number of factors and issues will need to be considered before designing, developing and implementing a plan to clear the mines and unexploded ordnance remaining from the 1982 conflict. A range of clearance options are possible and these will dictate the duration and cost of the overall clearance programme. For the purposes of this study we have proposed five clearance scenarios. These scenarios are not clearance plans, but they illustrate the range of strategic clearance options possible and the range of costs.

(1) Scenario 1. Scenario 1 involves: setting up a project office on the Islands; conducting trials to determine the effectiveness of each clearance method on each type of terrain; developing appropriate mine action standards; developing procedures for accreditation, contracting and external quality assurance and control; developing procedures for conducting environmental impact assessments and environmental remediation; evaluating a range of clearance options; and drafting an outline clearance plan.

Outcome: A draft clearance plan

(2) Scenario 2. Scenario 2 involves Scenario 1 and: converting the project office into a Mine Action Coordination Centre; re-classifying all Category A mined areas; conducting confidence building measures such as using heavy rollers; conducting quality control of re-classified land in accordance with IMAS 09.20; remediating land; and handing over land in accordance with IMAS 08.30

Outcome: 577.5 Ha of land (currently classified and marked as ‘known minefield’ or ‘suspect area’) to be declared ‘safe’ and handed over in accordance with IMAS 08.30. This represents 44% of the total area currently classified as dangerous.

(3) Scenario 3. Scenario 3 involves Scenario 2 and: conducting a technical survey and environmental impact assessment of each Category B mined area; clearing all

Category B mined areas in accordance with IMAS 09.10; conducting quality control of cleared and re-classified land in accordance with IMAS 09.20; remediating land; and handing over land in accordance with IMAS 08.30

Outcome: In comparison with Scenario 2, this scenario results in an additional 54.7 Ha of land declared as 'safe', thus bringing the total to 632.2 Ha of land (currently classified and marked as 'known minefield' or 'suspect area') to be declared 'safe' and handed over in accordance with IMAS 08.30. This represents 48% of the total area currently classified as dangerous.

(4) Scenario 4. Scenario 4 involves Scenario 3 and: conducting a technical survey and environmental impact assessment of each Category C mined area; clearing all Category C mined areas in accordance with IMAS 09.10; conducting quality control of cleared and re-classified land in accordance with IMAS 09.20; remediating land; and handing over land in accordance with IMAS 08.30

Outcome: In comparison with Scenario 3, this scenario results in an additional 664.8 Ha of land declared as 'safe', thus bringing the total to 1,297.0 Ha of land (currently classified and marked as 'known minefield' or 'suspect area') to be declared 'safe' and handed over in accordance with IMAS 08.30. This represents 99% of the total area currently classified as dangerous.

(5) Scenario 5. Scenario 5 involves Scenario 4 and: conducting a technical survey and environmental impact assessment of each Category D mined area; clearing all Category D mined areas in accordance with IMAS 09.10; conducting quality control of cleared and re-classified land in accordance with IMAS 09.20; remediating land; and handing over land in accordance with IMAS 08.30

Outcome: In comparison with Scenario 4, this scenario results in an additional 17.9 Ha of land declared as 'safe', thus bringing the total to 1,314.9 Ha of land (currently classified and marked as 'known minefield' or 'suspect area') to be declared 'safe' and handed over in accordance with IMAS 08.30. This represents 100% of the total area currently classified as dangerous.

A summary of the five strategic options is given in Table 1. For each scenario, the key mine action activities, the areas re-classified and cleared, and the timings and costs are listed. *Note: The figures given in Table 1 have been calculated using data and assumptions discussed in the main report. Care should be taken in using and interpreting these figures without reference to the supporting data and assumptions.*

Recommendations

The clearance of mines from all of the areas on the Islands currently classified as 'minefields' or 'suspect areas' is challenging, but technically possible. Such clearance should be in accordance with IMAS 09.10, with post-clearance quality control carried out in accordance with IMAS 09.20.

The clearance work will have some environmental impact, although the degree of impact should be measured against the substantial environmental impact over many years from over-grazing and the likely future longer term effects of climate change. Some environmental remediation will be required.

The risk to the clearance programme in terms of time and cost can be substantially reduced by collecting more information on the effectiveness and efficiency of

different methods of technical survey, clearance and remediation through a series of planned trials on the Islands as proposed in Scenario 1.

A key element in the success of the clearance programme will be the establishment of a Mine Action Coordination Centre, based on the Islands with experienced mine action managers who are able to develop and apply appropriate standards and to establish management systems and procedures for accreditation, contracting, conducting technical surveys and environmental assessments, managing clearance, conducting post-clearance quality control and remediation, and the handover of cleared land.

Table 1: Summary of areas cleared, timings and costs of the five scenarios

Mine action phases and activities ▼	Area, time and cost			Scenario					Cumulative		
	Area (Ha)	Time (month)	Cost (£m)	1	2	3	4	5	Area (Ha)	Time (month)	Cost (£m)
Phase 1a Establish project office on Islands Phase 1b(1) Develop mine action standards Phase 1b(2) Develop procedures for EIAs & environmental remediation Phase 1b(3) Develop procedures for external QA and QC Phase 1c Trial effectiveness of clearance methods Phase 1d(1) Evaluate range of clearance option Phase 1d(2) Draft outline clearance plan	0	20	X	■	■	■	■	■	0	20	X
Phase 2a Convert project office to a MACC Phase 2b Re-classify Category A mined areas Phase 2c Conduct confidence building measures Phase 2d Conduct QC of re-classified land in accordance with IMAS 09.20 Phase 2e As required, environmentally remediate land Phase 2f Hand over re-classified land to MACC	577.5 (44%)	10	X		■	■	■	■	577.5 (44%)	30	X
Phase 3a(1) Conduct technical surveys of Category B mined areas Phase 3a(2) Conduct EIAs of Category B mined areas Phase 3b Clear all Category B mined areas Phase 3c Conduct external QC of all Category B mined areas Phase 3d As required, environmentally remediate land Phase 3e Hand over cleared land to MACC	54.7 (4%)	30	X			■	■	■	632.2 (48%)	60	X
Phase 4a(1) Conduct technical surveys of Category C mined areas Phase 4a(2) Conduct EIAs of Category C mined areas Phase 4b Clear all Category C mined areas Phase 4c Conduct external QC of all Category C mined areas Phase 4d As required, environmentally remediate land Phase 4e Hand over cleared land to MACC	664.8 (51%)	30	X				■	■	1,297.0 (99%)	90	X
Phase 5a(1) Conduct technical surveys of Category D mined areas Phase 5a(2) Conduct EIAs of Category D mined areas Phase 5b Clear all Category D mined areas Phase 5c Conduct external QC of all Category D mined areas Phase 5d As required, environmentally remediate land Phase 5e Hand over cleared land	17.9 (1%)	30	X					■	1,314.9 (100%)	120	X

Note: The time includes periods when work will not be carried out due to inclement weather, equipment maintenance, leave, and/or training (for both individuals and organisations.) It has been assumed that 10 months productive clearance will be achieved each year; i.e. 5/6th of 12 months. For example in Phase 3, which will last a total of 30 months, it has been assumed that 25 months productive clearance will be achieved.



FIELD SURVEY TO EXAMINE THE FEASIBILITY OF CLEARING LANDMINES IN THE FALKLAND ISLANDS (ISLAS MALVINAS)

FIELD SURVEY REPORT (PART A)

SECTION 1: SURVEY REQUIREMENT

1.1 General framework of the project

On 11 October 2001, the Governments of the United Kingdom and the Argentine Republic agreed through an Exchange of Notes to examine the feasibility of clearing landmines remaining in the Falkland Islands (Islas Malvinas). The study is being carried out by both Governments by means of a British-Argentine Joint Working Party (JWP).

On 3 August 2006 both Governments agreed by Exchange of Notes that the feasibility study should include all unexploded ordnance (UXO) within mined areas, and agreed the procedures for conducting the field survey using a contractor.

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1.2 Aim of the Field Survey

The aim of the field survey was to provide a detailed assessment of the availability and suitability of the methods and techniques normally used to detect, clear and dispose of land mines and UXOs, to provide an assessment of the potential environmental risks, and to estimate the costs for each clearance method and for the environmental remediation.

1.3 Background

The Argentine Government has reported to the United Nations that some 20,000 anti-personnel (AP) mines and 5,000 anti-vehicle (AV) mines were laid by its armed forces during the hostilities which took place on the Falkland Islands (Islas Malvinas) in 1982. The British Government reports that one AP mine remains unaccounted for from those minefields UK forces laid and subsequently lifted after the cessation of hostilities.

During hostilities a large number of ordnance was used by the UK and Argentine military. Some UXO remains inside the mined areas and has not yet been recovered. It is not possible to calculate exactly how much and which types of UXO remain within the mined areas, although the Study Team advise that the clearance of UXO will not impact significantly on demining operations on the Islands.

On 14 June 1982, Argentine forces handed over all minefield records available to them to the British forces. In the immediate aftermath of the conflict some mines were lifted by British Sappers. Argentine personnel assisted by providing essential information on the type and locations of mines. However, work was halted due to injuries. Battlefield area clearance (BAC) continued for two years with the aim of removing UXO, stockpiles of ammunition, the remains of destroyed aircraft and other hazardous debris of the war. Mine clearance was performed only when civilians were in immediate danger, and to enable essential military tasks to be carried out. Since 1982 there have been no recorded civilian casualties from landmines or UXO on the Islands. In some areas, sheep and cattle can be seen grazing in mined areas, and penguins have established colonies behind minefield fences. Many sources and assessments suggest that the socio-economic impact of the mined areas is negligible.

In late 1982, a major study was funded by the UK Ministry of Defence with the aim of identifying suitable technologies which could be used to remove the mines safely, but work was halted in 1986 once it became apparent that no equipment could achieve the very demanding level of clearance deemed necessary. At that time it was assumed that the Islands would remain contaminated by landmines for some time; although it was intended to revisit the problem at a later date. Since 1986, there have been a number of technical suggestions and unsolicited proposals to remove the remaining mines from the Islands, but there has been little real progress in the absence of any military requirement or political imperative.

However, recent international initiatives have re-focused political attention on the landmine issue. Of particular importance is the Ottawa Convention which requires governments within 10 years of entry into force of the Convention for each country "... to destroy or ensure the destruction of all anti-personnel mines in mined areas under (their) jurisdiction or control."

1.4 Field Survey Assumptions and Constraints

1.4.1 Landmine survey

For obvious reasons no entry into the edges of the mined or suspect areas was made, but the mine clearance specialists were able to use the safe lanes within the Stanley Common Fence, where all observations were made from vehicles. The value of the inspection was limited by the fact that the vegetation within the areas had grown significantly since 1982, and it was difficult to identify clues on what lay beneath (landmines and UXO), especially in areas over 200 metres across. The

survey was constrained in time, due to the 117 individual mined and suspect areas to be visited, the time involved in moving to these areas, some of which were on the West Island, and the limited overall time available. The information collected was as accurate as the team could make it, but was well below the levels required for a General or Technical survey. The assessment was carried out in the summer season, when the weather was hot and reasonably dry, which made accessibility easier than it would have been in the winter season. These limitations have to be kept in mind when reading the report.

1.4.2 Ecological survey

Given the limitations outlined in Section 1.4.1 above, a full survey of species and vegetation type within each mined area was not possible. Descriptions of vegetation within each area are therefore based on what could be visibly assessed from the perimeter of each visited mined area and what species were present around the periphery. It is believed this gives a good overview of the vegetation present, however it is stressed this approach cannot identify the presence of small infrequent or rare species within mined areas. Therefore we cannot guarantee that the presence of some plants within some mined areas has not been missed. Without detailed survey within each mined area this is inevitable.

It should also be noted that details and comments regarding the presence or absence of fauna in, or close to, mined areas can only be based on the observations taken over a very restricted period at each site, typically an hour or less. It is clearly impossible to record species that were not apparent at that time and hence it is not possible to exclude any species that may use each area outside this limited period. To help provide some redress to this problem the mined area summaries have been added to using local knowledge and information by our consultants on the islands. It should be accepted therefore that prior to actual work commencement a more temporally extensive and spatially intensive survey of species of ecological concern should be undertaken.

1.4.3 Soil assessment

In parallel with the comments above, it was not possible to examine the soil within mined areas. Soil descriptions have therefore been made using information gained from sample sites directly adjacent to each mined area that were considered to represent the soils within each. However, it has to be accepted that unseen variations in soil type and soil depth occur within some mined areas. Planning for clearance and remediation options should consider this factor.

1.4.4 Environmental remediation

Suggestions for possible approaches to re-vegetating any invasive mine clearance methods are only suggested and outlined based on experience and experiment gained within the UK environment. To our knowledge very few, if any, trials of natural vegetation establishment have been undertaken on removed or deeply disturbed peat on the island. It is strongly recommended that experimental testing of all proposed approaches is undertaken on trial areas before extensive restoration is attempted.

A strong caveat must also be made on mitigation proposals, and the remediation of land damaged by demining activities undertaken close to penguin rookeries.

Although there has been some experimental research on the effects of disturbance on penguin metabolic activity e.g. Regel & Pütz (1997) and breeding success (Giese 1996) including some assessment on the Islands (Bingham 2004) there are insufficient data to determine with accuracy the full environmental impact.

1.5 Terms and Definitions

For the purposes of this report:

- a. The Falkland Islands (Islas Malvinas) shall be referred to as “the Islands”;
- b. The Cranfield University team (of mine action and environmental experts) which deployed to the Islands from 1 - 25 December 2006 shall be referred to as the “Survey Team”;
- c. Anti-personnel (AP) and anti-vehicle (AV) mines, booby traps and unexploded ordnance (UXO) shall be referred to as “landmines”, although this goes beyond the requirements of the Ottawa Treaty; and
- d. The survey and clearance of landmines shall be referred to as “demining”.

Technical terms as defined in International Mine Action Standards (IMAS 04.10) have been used in this report.

A summary of the key terms and definitions used is at Annex A.

SECTION 2: THE SETTING

2.1 The Landmine Threat

2.1.1 The 1982 conflict

From June 1982, 137 areas suspected of containing mines and UXO were fenced off. (Twenty mined areas were subsequently cleared by British troops and are now declared as 'safe' areas.) The mines were laid in three phases. Initially AV and AP mines were laid around possible beach landing sites in anticipation of a seaborne assault from the east and south east of Stanley. The second phase was laid after the British landings at San Carlos on 20 May 1982 when it was evident that the advance was coming from the west. The final phase was laid in the final hours of the conflict, mainly around Wireless Ridge and Mount Longdon. It is reported¹ that mines were laid in haste and under artillery fire.

In the main, minefields were carefully laid and well recorded, particularly during the initial phase². Most minefields comprise 'panels' of mines of up to six rows, with 8-16 mines per row. Each row should have been 32m long and marked with a red stake at one end and a yellow stake at the other, although many of the rows were marked with stones or piles of peat. The rows were laid out using a string template, although the spacing between mines was not constant. Minefields were generally marked using a single strand of wire on the side closest to the defending troops. Some mined areas were not marked.

Four types of AP mine were laid: Argentine FMK-1, Italian SB-33, Spanish PB-4 and Israeli No 4 (box with trip wire). Apart from the No 4 mine, all the AP mines were encased in plastic with minimal metal content and were virtually undetectable by conventional mine detectors. Five types of AV mines were laid: Argentine FMK-2/3, Italian SB-81, Spanish C-3-B, Israeli No 6 and US M1A1. Only the M1A1 and No-6 are easily detectable.

The Joint Service (JSEOD) Headquarters in Stanley have the original Argentine records for 67 of the 117 uncleared mined areas. These records include 2,502 AV mines, 9,721 AP mines and 111 booby traps³. The remaining 50 mined areas may contain another 7,922 mines and booby traps. Over the past 24 years some work has been done to develop the minefield database, but prior to this Study there had been no comprehensive analysis of the mine threat based on a General Mine Action Assessment and/or technical surveys.

During hostilities a large number of ordnance was used by the UK and Argentine military. Some UXO remains inside the mined areas and has not yet been recovered. It is not possible to calculate exactly how much and which types of UXO remain within the mined areas, although the Study Team advise that the clearance of UXO will not impact significantly on demining operations on the Islands.

2.1.2 Clearance post-conflict

At the conclusion of hostilities, British Sappers were tasked with conducting immediate post-conflict BAC in the vicinity of Stanley. An EOD team cleared the Stanley airfield and Royal Navy divers cleared underwater EO hazards. Argentine personnel assisted by providing essential information on the type and location of mines.

Priority was given to clearing areas where civilians were in immediate danger and to enable essential military tasks to be carried out, such as the laying of a ship-to-shore fuel pipeline. This phase was halted due to injuries, and thereafter work was focused almost entirely on minefield survey and marking. Before demining was halted over 1,382 mines and booby traps had been lifted.⁴

Once demining was halted, the focus of effort shifted to the survey and marking of hazardous areas. Large areas of land were declared free of mines, which enabled the local inhabitants to move around with increasing safety and confidence. This task was eased when some Argentine minefield records were handed over, although no records exist for minefields in the areas of the Goose Green, Fox Bay, Port Howard, Port Fitzroy and the coves of the Murrell peninsula. Six further mine incidents occurred, including Major Hambrook at Fox Bay on 15 January 1983 and Maj Ward at the Canache, near Stanley on 22 August 1983.⁵

The expedient minefield marking was subsequently replaced by heavy duty stock fences with a '40 year life'. There is an ongoing maintenance requirement to repair the damage caused by cattle and weather, and to replace the warning signs.

JSEOD units are based at Stanley and Mount Pleasant in the Islands. The units have an EOD role. Routine peacetime tasks include EO awareness training to major roulement units, individuals and school children.

There is an ongoing requirement to ensure that mines which are uncovered are made safe using REDFIRE⁶ equipment.

2.2 Socio-economic Impact of the Landmines

The total fenced area of the mined areas and suspect areas is 1,314.9 Ha. This represents just 0.1% of the land used for farming, so the economic impact of landmines on the Islands' farming communities is negligible. During the field survey, the evaluation team spoke with a number of farmers on the Islands who confirmed that the remaining landmines were an "inconvenience", but had negligible impact on their livelihoods.

In most mine action programmes, the priorities of clearance are based on the socio-economic impact of mined areas. Thus, areas of higher impact are normally cleared before areas of lowest impact. The mine action community has established a set of protocols which enable scores to be given to impacted communities; these scores reflect the degree of risk (based on recorded deaths) and blockages to land, water and markets which have some economic impact. In the case of the Islands, the mined areas have negligible socio-economic impact, and as such other approaches can be used to prioritise clearance. This is addressed in Section 8 of the report where we propose four categories of land for clearance.

2.3 Ottawa Convention and International Mine Action Standards

2.3.1 Ottawa Convention

The Ottawa Convention requires each State Party to "... destroy or ensure the destruction of all anti-personnel mines in mined areas under its jurisdiction or control, as soon as possible but not later than 10 years after the entry into force of the Convention for the State Party." There has been considerable debate over the years

on the measures required to “ensure the destruction” since by definition you can only destroy those mines which are known. Furthermore, locating all mines is impossible in practice. It is generally accepted that the requirement to “ensure destruction” is met by clearing AP mines in accordance with International Mine Action Standards (IMAS).

2.3.2 International Mine Action Standards

IMAS have been developed by the United Nations on behalf of the international mine action community to improve safety, efficiency and effectiveness in mine action and to promote a common and consistent approach to the conduct of mine action operations. IMAS provide guidance, establish principles and, in some cases, define international requirements and specifications. They provide a frame of reference which encourages the sponsors and managers of mine action programmes and projects to achieve and demonstrate agreed levels of effectiveness and safety. They provide a common language, and recommend the formats and rules for handling data which enable the accurate and timely exchange of important information.

The marking and fencing of minefields and the conduct of mine risk education on the Islands adheres to the requirements of IMAS. If a demining programme was established on the Islands there would be a need to develop a set of appropriate standards and guidelines which were consistent with IMAS.

The definition of ‘clearance’ and ‘cleared land’ is particularly important regarding a Government’s responsibilities as a State Party of the Ottawa Convention (see 2.3.1 above). IMAS 09.10 states that “.... land shall be accepted as 'cleared' when the demining organisation has ensured the removal and/or destruction of all mine and UXO hazards from the specified area to the specified depth.”

IMAS 09.10 then states that:

“.... the specified area to be cleared shall be determined by a technical survey or from other reliable information which establishes the extent of the mine and UXO hazard area” and that

“.... the specified depth of clearance shall be determined by a technical survey, or from other reliable information which establishes the depth of the mine and UXO hazards and an assessment of the intended land use it (the depth of clearance) should be based on the technical threat from mines and UXO in the country and should also take into consideration the future use to which the land is to be put.”

IMAS 09.10 further states that “.... the removal and/or destruction of all mine and UXO hazards in the specified area to the specified depth shall be ensured by:

“.... using accredited demining organisation(s) with licensed capabilities, such as manual clearance, dog detection teams, mechanical systems and community liaison teams;

“.... using appropriate management practices, and applying safe and effective operational procedures;

“.... monitoring the demining organisation and its sub-units; and

“.... conducting a process of post-clearance inspection of cleared land.”

If the mined areas on the Islands are to be cleared to meet the requirements of the Ottawa Convention, then mine action should conform to the standards and guidance given in IMAS. In particular, there is a need to (1) accredit all clearance organisations in accordance with IMAS 07.30, (2) conduct a technical survey – to include an environmental impact assessment - prior to clearance in accordance with IMAS 08.20, (3) monitor the work of all clearance organisations in accordance with IMAS 07.40, and (4) conduct post-clearance quality control in accordance with IMAS 09.20. These requirements are addressed in detail later in this report.

2.4 Lessons Learned from International Mine Action 1982 to 2007

When the British Army started clearance in the Islands in 1982, the techniques for “humanitarian mine action” were not in place. There were no standards to work to, the Standing Operational Procedures adopted by the Army were inadequate, the Mk4c detectors in use were woefully inadequate against minimum-metal mines and awkward to use, and there were no tried and tested mechanical clearance equipments available. Matters did not advance much until 1989. By that time, the Cold War was ending, the regional or “proxy” wars being fought around the globe were beginning to reach a stalemate, and the requirement to clear the mines from Afghanistan after the Soviet occupation was forcing the use of new, slower and more thorough mine removal procedures. The clearance after the First Gulf War in 1991-2 accelerated this process, and the ending of conflicts in Africa and South-East Asia in the early to middle 1990s added yet further impetus. There was an increasing demand for mine action standards, which culminated in the production of some initial standards in 1997, which were completely re-written in 1999 to form the current IMAS. IMAS are now used as the basis for national mine action standards, and have provided sensible guidelines for humanitarian mine action world-wide ever since their first distribution by the UN in 2000.

The main lessons that have been learned since 1989 have been the need to pay strict attention to the factors of safety, quality and cost-effectiveness. The main drivers of these factors have been good management practices, good training of deminers and good equipment. Good management practices have evolved with increasing experience in many different environments. Deminer training has also developed, and has resulted in some NGOs and companies having highly experienced and capable field staff, many recruited from Africa, the Balkans or South-east Asia. New detection and technologies have not emerged as quickly as was predicted in 1994, but steady incremental improvements have produced better metal detectors, a new Ground Penetrating Radar, and a number of well-proven small and large vegetation cutters, flails and millers, all far more capable than anything available in 1983. The training and operational use of Mine Detection Dogs are also being refined, and under the right conditions of use they are proving highly effective.

Another important lesson learned is that every new theatre of mine clearance has to be approached with care, and that clearance project managers cannot assume that the conditions in one theatre will be similar to the conditions in others. It has often proved wasteful and sometimes actively dangerous to rush into the clearance process without re-training of the clearance force, and trying out the techniques to be used on the ground in a period of trials. This is especially important if mechanical equipments are to be used, or when the environment is particularly demanding, as it

will be on the Islands. Trials to hone skills and procedures may take time, but they will increase operational knowledge, allow optimisation of techniques, and ultimately save time, money and the limbs and lives of clearance staff.

SECTION 3: STUDY METHODOLOGY

3.1 Project Organisation

3.1.1 Project team

The project was coordinated by the Resilience Centre at CU. Alastair McAslan was the Project Director; Paddy Blagden was the Project Manager, responsible for technical survey and developing mine clearance plans; Dr Adrian Yallop led the group on ecological survey, remote sensing validation and remediation proposals. Prof Peter-Leeds Harrison led the group undertaking the geological, soil and hydrological studies and modelling required to underpin the environmental assessment exercise. Ian Strange and Dr Grant Munro, both residents of the Islands and members of the CU Project Team, provided local expertise and reviewed our mitigation and remediation proposals.

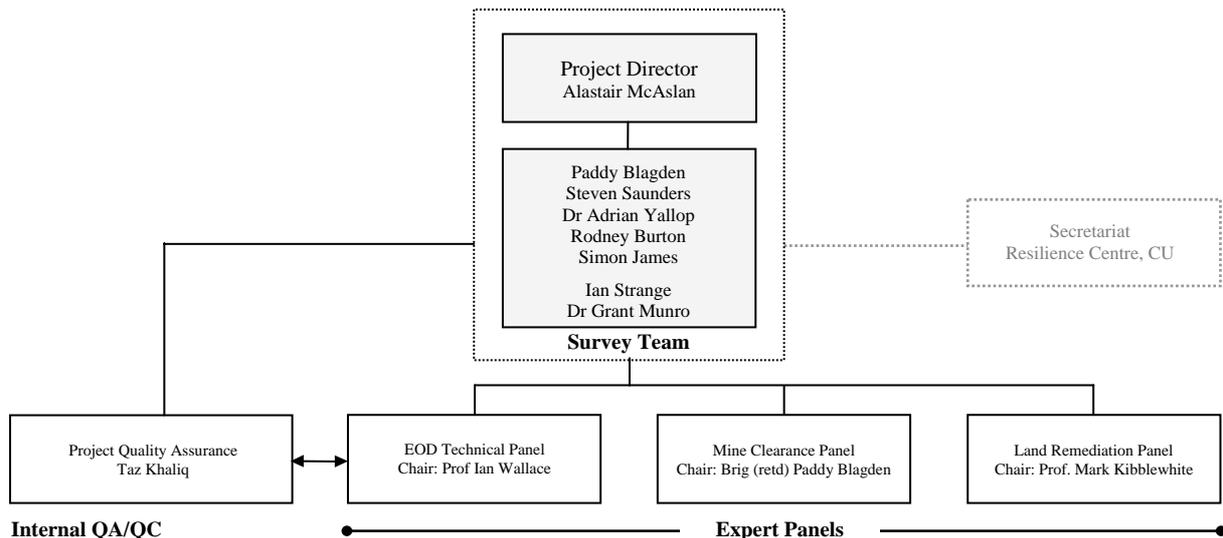


Figure 1, project organisation

3.1.2 Expert panels

Expert advice was provided to the project team by three panels:

- An EOD technical advisory panel advised on the technical aspects of explosives ageing, and the safe disposal of mines and UXO. The panel was formed from CU's ASET Group and was chaired by Professor Ian Wallace, Head of the Department of Materials and Applied Science.
- A mine clearance advisory panel advised on the survey, detection and destruction of mines and UXO. The panel included representatives from commercial companies, military organisations and NGOs currently engaged in the clearance of mines and UXO from military ranges and post-conflict

countries. The panel also advised on the suitability of existing and in-development detection technologies and mechanical systems to assist the survey, detection and destruction of mines and UXO. It was chaired by Brig (retd) Paddy Blagden, former Head of the UN's Demining Coordination Unit in New York, and more recently Director of Studies at the Geneva International Centre for Humanitarian Demining (GICHD).

- An environmental assessment and land remediation panel advised on systems, processes and procedures for the remediation of land, flora and fauna following clearance. It was chaired by Prof Mark Kibblewhite who provided an independent review of the activities of the group as well as adding considerable professional input in the arena of soil restoration.

The key positions in the project team were:

a. Project Director	Col (retd) Alastair McAslan
b. Manager: ecological assessment	Dr Adrian Yallop
c. Manager: geology, soils, hydrology	Prof. Peter Leeds-Harrison
d. Field surveyor: demining	Steven Saunders
e. Field surveyor: ecological assessment	Simon James
f. Field surveyor: geology, soils, hydrology	Rodney Burton
g. Specialist survey and conservation advisor	Ian Strange
h. Specialist survey and conservation advisor	Dr Grant Munro
i. Chair EOD Technical Panel	Prof Ian Wallace
j. Chair Mine Clearance Panel	Brig (retd) Paddy Blagden
k. Chair Land Remediation Panel	Prof. Mark Kibblewhite
l. Project quality assurance	Taz Khaliq

3.2 Stage 1: Scoping Study and Document Review

3.2.1 Scoping study

On award of contract, Cranfield University and the JWP reviewed the scope, planning assumptions, approach, resources and timings.

The Project Team collected, collated and reviewed information from a number of sources including the key references listed at Paragraph 6 of Attachment 1 to Part 1 of the ITT. The purpose of this pre-deployment review of information was to optimise the time spent on the Islands by the Survey Team.

Prior to deployment, Cranfield University and the UK's Mine Information and Training Centre (MITC) reviewed the status of the data held in the Information Management System for Mine Action (IMSMA) for the Islands. It was important at this early stage to agree on the information required by IMSMA, and to ensure that the information collected by the Survey Team would be in a form which could be readily transferred to IMSMA.

3.2.2 Understanding the immediate technical threat

Cranfield University was able to draw on a large number of documents which refer to the period immediately following the conflict, and which are relevant to this project. In particular, it was possible to review the process which led to the decision to halt the clearance of mines post-conflict, and to focus efforts on marking and fencing the mined areas.

We spent some time collecting information which led to the decision to declare the Murrell Peninsula as a 'Suspect Area' and the positioning of the Stanley Fence. We used this knowledge to inform the scope of our survey and the information collected by the Survey Team during their limited time on the Islands.

3.2.3 Soil and vegetation studies

To optimise the pertinence of data acquisition during the field component of this investigation, and to inform interpretation of the data gathered, reports by King, Lang & Blair Rains (1969) and Maltby & Legg (1983) were accessed prior to departure. During the field study it was learned that copies of two further reports by Maltby, 1983 & 1985, were also available. These proved equally useful and were copied and returned to England. Ecological and nature conservation literature was also reviewed prior to departure including: 'Wildlife of the Falkland Islands and South Georgia', Ian Strange 1992; 'Seabird and Marine Mammal Dispersion', JNCC 1999. Additional 'peer-reviewed' sources have been reviewed and are cited in the bibliography and references. Further relevant literature was obtained from local sources during the field study and this has been used to inform proposals for mitigation and remediation.

3.2.4 Mechanical equipment studies

Large-scale trials were held in the UK from 1983 -1985 of mechanical mine clearance systems available at the time. These included flails, rollers, tillers and ploughs. Most of these were adaptations of agricultural machinery or prototypes, none of which proved capable of carrying out mine clearance in a reliable way. The studies were thorough, but the equipments were not constructed for mine clearance, and the report concluded that none of the equipments could clear mines reliably and should not be further developed. In fact, mechanical equipments have been under continuous development since the late 1980s, notably in Croatia, which since their mine action programme was over 80% national-funded, had every incentive to produce reliable and effective machines. Valuable studies have been carried out by the GICHD⁷, and many new machines are now on the market, some of which are being used successfully⁸. NGOs and commercial companies now routinely use mechanical equipment, where the operational problems arise more from management of integrated systems than the limitations of the systems themselves.

3.2.5 Review of information held by JSEOD Detachment

The JSEOD Detachment held folios on each of the major areas, such as the Murrell, Fitzroy Bridge, and Fox Bay. Some of the contents of these files were of interest, but they were incomplete, and much of the information was repetitive, and sometimes contradictory. The JSEOD staff went to great lengths to provide as much information as possible in a form that could be used by the assessment team, and they scanned most of the file documents which they put onto CD-ROMs, which are now held by CU. The synoptic information of the mine threat contained in the mine maps was

very helpful. An even more important element was the knowledge of the staff of the JSEOD Detachment, especially that which had been obtained by the longer-term members who had been visiting the Islands since the 1990s. It is strongly recommended that every effort is made to retain the knowledge of these people, whose contribution to the Study was considerable, and whose contribution to any mine clearance programme management would be equally great.

3.3 Stage 2: Field Surveys and Assessments

3.3.1 Survey of mined areas

Over the period 4–19 December 2006, the Survey Team visited the Murrell Peninsula, Port Fitzroy, Port Howard, Fox Bay, Goose Green, Stanley Common, and Stanley Areas 1, 2, 3 and 4. The survey programme is shown at Annex C.

The aim of the surveys was to collect information to inform the technical assessment of the methods and techniques considered suitable to detect, clear and dispose of the mines and UXO within the 117 mined areas, and to catalogue the environmental status of each mined area using agreed field protocols. All data collected during the surveys were spatially-referenced by direct capture with high-specification (sub-metre) DGPS (differential global positioning system) data loggers.

The Survey Team visited every site to which it could gain access. The approach to the site had to be made by 4x4 vehicles or tracked BV206s, which were the only way in which soft peat, deeply rutted tracks and soft sand dunes could be traversed. The team walked the perimeter of most of the minefields, checking the fences, and studying the area within the fences for markers, pegs or earlier fencing, put up by the Argentine or British forces. They also looked for signs of animal incursions, and any signs of old accidents to livestock, and the proximity of domestic animals or wildlife. Note was taken of the slope, roughness and variation of the terrain, to gauge the ease or difficulty of using mechanical clearance equipment. Records were made of the vegetation, noting how difficult it would be to clear down to the 2 cm necessary for the use of manual mine detectors. Special attention was paid to the accessibility of the sites, the time taken to get to them, and the availability of areas for setting up temporary field camps if necessary. Again, access was considered in terms of how to get mechanical plant to site, and whether the tracks and bridges would withstand the wheel or track loading. In the smaller settlements like Goose Green or Port Howard, note was taken of the extent to which the settlements could accommodate teams of deminers, without swamping the local resources. Photographs were taken of every site.

3.3.2 Survey of soils, vegetation and fauna

As the Survey Team could not use traditional soil survey methods such as augering and soil-profile analysis from within the mined areas, they obtained data from just outside the mine fences and related the data to the mined areas by visual interpolation.

Investigation of the soil was conducted using a 6cm diameter 'Dutch' auger, and in thicker peats using a 1.0m long gouge auger. Extension rods enabled augering to 3.8m. Samples removed from the borehole were analysed in the field for pH. The

borehole also was used to measure the depth of the water table. The trafficability and bearing strength of the site were measured using a cone penetrometer.

Interpretations of the soils and hydrology in the landscape were made on site, and this information was made available immediately to members of the Survey Team. All measurements and descriptive components were recorded on a computer-compatible form for storing in a database developed by Cranfield University.

The Survey Team took samples of soil material (peat and mineral soil) and subjected them to extreme mechanical disturbance to assess the changes in the structure and physical properties of these soils in order to determine the post mine clearance state of these soils.

Vegetation data for satellite image interpretation were acquired using DGPS data loggers, with abundance of each main species present being recorded. To inform descriptions of vegetation present at each site high resolution digital photographs were taken at identified points along each mined area boundary of the habitats and species, including flora and fauna, found within the mined areas. These digital images were then used to make species identification from published references and/or local and UK experts with knowledge of the species found on the Islands. The digital images were catalogued by date and mined area number, and returned to the UK to form part of the reference collection for the study.

The Survey Team drew heavily on the experience and views of individuals living on the Islands, and in particular the local expert advice of Ian Strange and Dr Grant Munro.

3.3.3 Information collected from local inhabitants

Systematic efforts were made to meet with local inhabitants, some of whom had been present during the conflict. The aim of these meetings was to extract as much co-lateral evidence as possible on where mines might have been placed, where accidents had taken place to livestock, and the effectiveness of the fences marking the mined areas. They were also asked about the logistical capacity of the settlements, and whether they would assist with the logistics of demining teams.

The views of the local inhabitants were important to understand the perception of risk to people and animals from the mines and UXO, and to assess the socio-economic impact of the mined areas.

This need to draw heavily on the experience and views of individuals living on the Islands was set out in Section 3.2.2 of the project proposal.

3.4 Stage 3: Review Data from Field Survey and Prepare Draft Report for JWP

3.4.1 Analysis of information and consideration of clearance options

The information obtained during the assessment mission made it clear there was a wide spectrum of conditions to be faced, some of which were very challenging. The knowledge of the mine threat in each suspect area varied from partial to nothing, and even suspect areas with mine records had in some cases been partially cleared after the conflict, but with no record of the clearance work. The size of the 117 suspect areas varied from small (0.10 Ha) to large (105 Ha) to very large (the Murrell, at 550

Ha). The terrain varied from flat short cropped grass over thin peat to steeply sloping white grasses, rushes, ferns and empetrum over deep peat, with outcrops of large rocks. Clearly, no single clearance method will be suitable for all the mined areas; indeed, a number of clearance methods may need to be used for each area. This will require experienced mine action project managers and a sound understanding of the suitability of clearance methods for the unique terrain and mine threat which exists on the Islands.

In most programmes, much of the landmine clearance is done manually, using mine detectors and prodders, but there are other clearance options. Detection can also be done by dogs (MDD) to detect the scent of mines. Mines can be cleared mechanically, by rollers to cause mines to detonate, by diggers that can remove mines from the ground, by flails that either cause detonation or break up the structure of the mines or by milling machines that grind up the soil, and the mines within it. Under certain circumstances, such as M117 in Stanley Area 1, ordinary front-end loaders (with armoured cabs) can be used to move soil with mines in onto a flat area where it can be spread out and manually inspected, and any mines removed for destruction. The best and most cost-effective mine clearance involves the use of two or more systems, but the management demands of using multiple systems can be severe.

Manual clearance. Manual clearance is the most versatile of all demining options, but on the Islands it will be slow because of the tough vegetation. In practice, manual clearance is rarely effective against mines emplaced deeper than about 15 - 20cm unless the surface soil is removed, but the Survey Team do not consider the presence of deep-buried mines to be likely. Mines are normally laid at a depth of about 5 – 7 cm, but unconfirmed reports suggested that AV and AP mines could sink under their own weight down to 60 cm or more. The Survey Team do not support this view. The density (weight ÷ volume) of the mines laid during the conflict is similar to (or lower than) the surrounding soil and as such would not sink, and certainly would not have dropped through the closely-knit network of fibrous roots found in peat. Over the past 25 years it is highly unlikely that more than 2 cm of additional soil has formed above the mines (from the accumulation of rotted vegetation). It is the view of the Survey Team that mines will be found at depths of no more than 7 – 9 cm, unless there has been the movement of soil such as the shifting sand dunes in Stanley Area 1, or falling peat overhangs in Stanley Area 2. A summary of the Survey Team's assessment of this important issue is given at Annex D.

Rolling. The use of rollers may also be viable, except in areas where the ground surface is very soft. Rolling does not adversely affect the soil or the vegetation, but cannot be used where AV mines are indicated, but there are many suspect areas, especially on harder soils in many areas, especially those found in Fox Bay, Goose Green and parts of Port Howard, where at least part of the suspect area could be rolled. This process could assist in speeding-up the area reduction process.

Mine detection dogs. Dogs can be excellent at finding individual mines, and as such are good tools for survey, area reduction and Quality Assurance. The use of dogs requires good logistic planning, and their performance can be adversely affected by weather but they would be of help in completely unrecorded suspect areas such as the Murrell, M111 and M65. The use of dogs was dismissed in earlier reports, but no

reasons were given for the exclusion. A study of the meteorological records for the Islands⁹ showed that use of dogs may be possible. Their use becomes even more possible if some simple form of shielding can be devised against wind.

Digging. Diggers are best used on beaches, such as the coves in the Murrell, Surf Bay and Rookery Bay, where any damage caused by the excavation can be restored by tidal movement. They can also be used where mines have become covered with a deep layer of surface soil, as in the blown sand dunes in Stanley Area 1. Digger rakes and arms can even withstand AV mine detonations, provided that the cab is armoured and the hydraulic hoses are attached to the top of the arms for protection from the blast.

Flailing. Mechanical flails are much quicker in operation than manual deminers, and can be used both to cut away surface vegetation and to beat up the soil, to a depth of up to 20 cm, depending on the flail type and the soil. The rotating flails are designed to hit the mine pressure pads, and make them detonate. Flails could cause permanent damage in certain soils, so there might need to be a trade-off between clearance speed and environmental damage. Depending on the soil and the drainage, remediation after flailing may be possible, and this should be the subject of a trial on the Islands. In other areas, some on the Western Island, re-growth is more likely due to the soil type, for example in Port Howard. Since the remediation might include sowing better feed grasses, the overall effect of the clearance/remediation process would be beneficial to the landowners.

Mechanical milling. Millers have rotating milling teeth which dig into the vegetation and soils. Most can dig down to about 20 cm or more. The milling process is perhaps the most invasive of all, and has to be used with care. That said, milling is only a more severe form of “rotavation”, which is used on the Islands by farmers wishing to improve their feed grasses, so discussions with the landowners may permit the use of such equipment. Millers could be used on the Islands, especially around the mine-affected settlements, but the constraints and advantages would be similar to the flail systems mentioned above.

Burning. In some countries, burning the surface vegetation has been attempted as a clearance process, but mines rarely detonate, unless they are surface-laid. It is not sufficiently reliable as a clearance method to be considered by professional mine clearance organisations, and might produce disastrous peat fires if used in the Islands. The Terms of Reference of the study stated that burning should not be considered as a clearance option on the Islands, and as such the Study Team did not address its suitability.

Bulk excavation. One method that has been used in Afghanistan is the excavation of the ground surface down to the anticipated level of the mines, which may be as deep as 2-3 metres, especially sandy conditions. Large-scale excavation in peat soils might prove highly invasive, even if the disturbed peat was returned to its place, because the root systems underlying the peat would be severed. Large-scale excavation may however be necessary in the sand dune areas behind the beaches to the north and south of Stanley Airport.

Choice of clearance options. The choice of the options for clearance will depend on many factors, such as the bearing capacity of the soil, density of vegetation, size of the suspect area, and whether the clearance method is being used for technical

survey, area reduction, actual clearance, post-clearance quality control, or confidence-building on re-classified land. Each mined area may require a different set of options, and may need different options in different places in the one area. The option to be used will also depend on the degree of invasive digging that the topsoil will accept without permanent degradation, or the degree to which degraded topsoil will respond to remediation measures. At present, these are unknown factors, and will need to be explored before the choice of clearance options can be made. In reality, the clearance method options will depend on trade-offs between speed of clearance, cost of clearance and environmental damage limitation.

More details of the mine clearance process and clearance methods can be found in Section 5, and illustrated examples of mechanical equipments can be seen on the GICHD website.¹⁰

3.4.2 Assessment of environmental implications of clearance options

Following return to the UK the field data on soil type and depth together with the analyses of vegetation were reviewed together with specific field assessment of the sensitivity of each site. This review, in conjunction with the experience of the team, was used to produce a first draft of mitigation and remediation protocols. The outcomes were then discussed with UK-based practitioners in peatland restoration outside of Cranfield to clarify the appropriateness of each suggestion and obtain indicative costs. It should be noted these are based on UK experience and the project group advise strongly that possible mitigation procedures should be trialled, monitored and reviewed before operational deployment. This will allow the most appropriate, and therefore cost-effective, methods to be used for each combination of mined area/clearance method combination.

Following this the assessment of impacts, remediation and restoration proposals were offered for review by conservation experts on the Islands.

3.4.3 Assessment of costs

The cost estimates were based on other mine action programmes, weighted to cover the cost of living in the Islands, and the costs of providing stores, supplies and equipment. To provide a rational time and activity framework for the costs, the whole clearance programme was divided into a series of five scenarios, which are discussed later in Section 8. It was assumed that some equipments and transport could be leased for the initial set up and the early scenarios, and included the costs of establishing a Mine Action Coordination Centre in Stanley, a contractor's base and field camps where necessary. The operational costs included a factor to account for the effects of weather, but assumed in the work calculations that operations could take place for 10 months in the year. Where possible, costs were based on information gathered by the Survey Team in Stanley, with other information coming from suppliers. The costing calculations were done in accordance with the GICHD paper on costing and sensitivity analysis¹¹, although a different approach had to be used in other areas, which had previously been used in World Bank and EC cost estimates.

3.4.4 Preparation of reports

During the field survey, detailed reports were prepared on each cluster of mined areas covering the technical threat, terrain conditions, hydrology, vegetation cover and site access. Cranfield University's findings were reviewed by the JWP, and following discussions between the University and the JWP a revised draft report was submitted electronically on 19 March 2007. This was discussed at a meeting of the JWP and Cranfield University in London on 29 and 30 March 2007. Printed copies of the report subsequently were made available by Cranfield University.

3.5 Quality Management of the Study

Throughout the project considerable emphasis has been placed on quality assurance of our processes, and on quality control of our outputs. This was achieved at two levels: internal and external quality assurance and control.

Cranfield University has proven quality management systems, and has established policy and guidelines on the application of these systems to its work. The Project Director, Alastair McAslan was responsible for the quality of the University's work on this project and regularly reviewed the project's progress and findings. He drew on technical experts from the Shrivenham and Cranfield campuses as required.

The University welcomed the involvement of the external monitors (two provided by the UK Government and two provided by the Argentine Government). The role and active involvement of the monitors was particularly important during the field survey. At the start of the field survey phase, the Project Director discussed with the monitors our approach, assumptions and initial findings. The views of the monitors were acknowledged, and when appropriate our approach was modified to reflect their views. When the Project Director departed the Islands, this approach was continued by the Survey Team leader, Paddy Blagden, and the presence of the monitors added considerable value to the survey.



FIELD SURVEY TO EXAMINE THE FEASIBILITY OF CLEARING LANDMINES IN THE FALKLAND ISLANDS (ISLAS MALVINAS)

FIELD SURVEY REPORT (PART B)

SECTION 4: ANALYSIS OF ENVIRONMENT AND CLIMATE OF THE ISLANDS

4.1 Geographical Position, Size and Features of the Islands

The Islands lie on the Patagonian continental shelf at between latitude 51° and 52°30' south and longitude 57°30' and 61°30' west. There are 750 islands covering some 12,173 square kilometres; the largest two of these, West and East Falkland, form by far the largest land areas.

The 1,288 km coastline of the Islands is typically highly indented with many rocky headlands, however numerous sandy coves and beaches are also found. The highest points are Mount Usborne (705m) in the Wickham Heights Range and Mount Adam (700m) in the Hill Cove Mountains Range on East and West Falkland respectively.

There are no large bodies of water present on any of the Islands, although low relief and poor drainage means numerous permanent small lakes, together with seasonal peaty pools can be found in many areas. Only three principal rivers, the Warrah and Chartres on West Falkland, and San Carlos River on East Falkland, are recognised.

The climate of the Islands can be considered as mild oceanic, and is characterised by a narrow temperature range from a maximum of 21°C in January and a minima - 3°C in July, with summer average temperatures of typically 9-10°C falling only to an average of 5-7°C in winter.

Contrary to many perceptions, rainfall is relatively low and evenly distributed throughout the year. The average is around 625 mm per year on East Falkland (Stanley) and only as little as 310 mm per year in the southwest of the Islands. Snow may occur any month except January and February, but seldom remains for very long.

Strong winds, however, are an omnipresent feature of the Islands climate with a prevailing westerly wind direction and an annual average speed of between 7 - 8m sec⁻¹. Although, for around 60% of the time wind speeds may be less than 9m sec⁻¹

(17 knots), winds of nearly double this (up to 17m sec^{-1}) may blow for up 25% of the time throughout the year. Speeds greater than this occur for perhaps the remaining 12% of the year, mainly during June to August.

4.2 Geology of the Islands

The oldest rocks in the Islands are resistant gneiss and granite of Pre-Cambrian age. They occupy a small area at the southern extremity of the West Island. They are succeeded in the West Island and the northern half of the East Island by the West Falkland Group of sedimentary rocks of Silurian to Devonian age, relatively soft sandstones and mudstones (e.g. the Fox Bay Formation) and hardened, resistant quartzites. The quartzites have been thrust and folded and now form much of the high ground of the Islands. Most notable are the Port Stanley Formation quartzites which underlie the minefields west and north of Stanley. The southern part of the East Island has Carboniferous tillite, with boulders encased in massive, hardened glacial mud, and Carboniferous and Permian sandstones, siltstones and mudstones (collectively the Lafonia Group) which also occupy the whole of Lafonia. Narrow intrusive dykes of basalt and dolerite, formed during the Jurassic age, criss-cross the older rock formations.

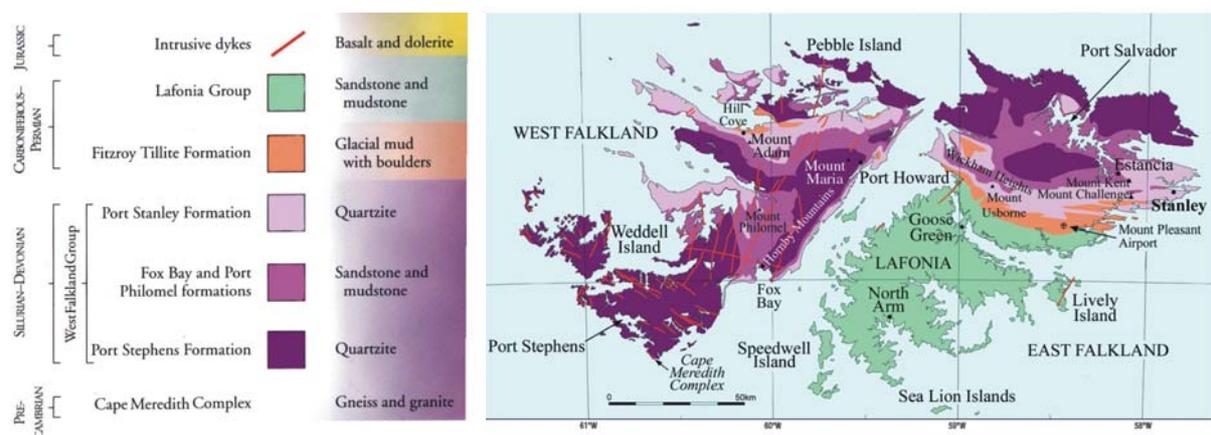


Figure 1. Simplified geology map. (Stone et al. 2005)

During the Pleistocene (Ice Age), the Islands experienced periglacial conditions rather than being covered by glaciers; the legacy of these intensely cold periods can be seen in the residual tors on hilltops, the 'stone runs' of sorted stripes and extensive blockfields, and solifluction of soil material that formed as summer flows above the permafrost of the time. During the present post-glacial period much of the land surface has been blanketed by an organic-rich layer, with peat as thick as 5 metres forming on Stanley Common.

In general the soils covering the main islands are acidic, tending to peat formation and low fertility. These peat soils vary from shallow, rather hard dry forms overlying quartzite ridges, to soft black humus-type peat in lower, damper regions. Accumulations of peat are widespread and vary from a few centimetres to several meters in depth, depending on rainfall and local drainage. On higher elevations (>500m) the peat layers may be replaced by thin, stony or clay soils supporting feldmark formations dominated by cushion plants, those more typical of Alpine Heath. The peat accumulations on the lower slopes are frequently interspersed with stone runs. In the lower valleys and in many coastal areas, peat accumulations are

replaced by peaty soils of higher fertility, supporting plant communities of fine grasses and sedges.

4.3 Ecology of the Islands

4.3.1 General description of flora

Large areas of the two main Islands are covered with oceanic heath formations. On soils with poor drainage, these are dominated by White Grass (*Cortaderia pilosa*). On drier, better drained soils, dwarf shrub communities of Diddle-dee (*Empetrum rubrum*), Mountain berry (*Pernettya pumila*) and Christmas bush (*Baccharis magellanica*) are principal components of the vegetation cover. However, within these two heath formations are a complex variety of other plant communities depending on the composition of the subsoil and topographic conditions. In the moister areas of White Grass heath, accumulations of Brown Swamp Rush (*Rostkovia magellanica*) form almost pure stands which are used by a variety of ground nesting birds. Within the dwarf shrub heath, Tall Fern (*Blechnum magellanicum*) can form large dense beds on the drier Diddle-dee heath and among rocks on the hill sides, with carpets of Small Fern (*Blechnum penna-marina*) found particularly on damper ground. These 'fern beds' form another nesting habitat for some ground nesting birds, especially in coastal areas.

In general terms the predominant oceanic heath formations, which cover the higher elevations in the interior regions of the main Islands, support low frequency of animal life, especially birds. However, where this heath meets or integrates with other habitats, there is a noticeable increase in both the numbers and diversity of bird species.

The heath lowlands are crossed by many streams, some seasonal, and the valley beds are often bordered by rich green swards dominated by the Small rush (*Juncus Scheuzeroides*), annual grasses (*Poa* sp.) and Cinnamon Grass (*Hierochloa redolens*). These narrow valleys form a very small percentage of the total heath area, but they attract a number of bird species. Where stock grazing has not eliminated it, the valleys support Fachine bush (*Chiliodendron diffusum*) and where Fachine does survive, the numbers of passerine birds are noticeably higher. On the grass swards in particular, the Upland Goose and Ruddy-headed Goose are frequent grazers. Where the lowland valleys open onto low-lying coasts, the greens are generally more extensive and frequently dotted with shallow freshwater ponds and can attract large numbers of duck and grebe.

Most low-lying coastal greens are associated with extensive sandy areas, shingle or sand beaches. These areas often have communities of Sea Cabbage (*Senecio candicans*), rushes, sedges such as Sword Grass (*Carex trifida*) and grasses such as Mountain Blue Grass (*Poa alopecurus*) and Blue Couch-grass (*Agropyron magellanicum*). The once common Tussac Grass (*Poa flabellata*) found as a coastal fringe community is now scarce on the main Islands. These tall grass and sedge communities are important habitats for some passerine bird species. A more detailed description of the main vegetation communities present on the Islands is offered in Annex E.

4.3.2 Summary of avifauna interest of the Islands

The seabird populations of the Islands are of international importance. By 2004 a total of 219 species had been recorded of which two species are endemic and only 9 species were song birds. Of the species recorded as breeding on the Islands, ten are of global conservation concern being listed under one of the various categories of risk by the International Union for the Conservation of Nature (IUCN). The Islands hold a quarter of the world's population of Gentoo Penguin and a significant proportion of the world's population of Magellanic Penguin. Both the Gentoo and Magellanic penguins are listed as Near-threatened by the IUCN.

4.4 Environmental Developments

The intensive grazing of sheep and cattle on the Islands in the 18th, 19th and 20th Centuries had a major impact on the environment. Developments post 1982 have continued to harm the Islands' flora and fauna, and future economic developments are likely to impact on the Islands' environment, as is climatic change.

Any future demining programme will undoubtedly affect to some degree the Islands' environment and it will be necessary to reduce the impact through the careful choice of equipment and mechanical equipment, and by appropriate post-clearance remediation measures. However, the scale of any possible impact from demining must be measured against the much greater harm that has already been caused through over-grazing, by recent infrastructure projects, and likely future economic development on the Islands.

4.5 Environmental Standards

Cranfield University reminds the JWP of the need to fully comply with environmental standards applicable to any future mine clearance programme on the Islands.

SECTION 5: CLEARANCE METHODS

The demining process is the series of operations needed for identifying suspected areas where buried or surface-laid mines might be, for locating where the mines actually are within the suspect area, for locating each individual mine and for destroying it or removing it for destruction¹². Demining also involves the clearance of any bits of unexploded bombs, shells, rockets or other explosive material which might cause harm to humans or animals. It is a step-by-step process, which is the subject of international standards, and if properly carried out is subject to strict quality control measures.

5.1 General Mine Action Assessment

IMAS defines the general mine action assessment as a process which aims::

- to assess the scale and impact of the landmine problem;
- to investigate all reported and / or suspected areas of mine or UXO contamination, quantities and types of explosive hazards; and
- to collect general information such as terrain, soil characteristics, climate, access to sites, infrastructure and local facilities, to assist the planning of future mine action projects.

The general mine action assessment process gathers information on local capabilities and potential to address the problem, and the need for external assistance including financial, human skills, material and information. It involves finding the location of suspected areas by seeking for any maps or records that may have been kept by the combatants, by checking records to find where accidents or incidents have occurred to humans or animals during and after the conflict, by contacting medical authorities for information on mine injury cases, and even by studying a history of the combat to assess where combatant groups may have used mines for defensive or offensive purposes. Where possible, general survey is done nation-wide, sometimes by a specialist survey organisation. The field survey carried out by Cranfield University has *de facto* met many of the requirements of a general mine action assessment for the Islands.

5.2 Technical Survey

5.2.1 Technical data

IMAS defines technical survey as a detailed topographical and technical investigation of known or suspected mined areas identified during the planning phase. Such areas may have been identified during the general mine action assessment (see above) or have been otherwise reported. The technical survey should normally take place prior to actual clearance activities after sites have been selected from a prioritised list. Technical survey information is needed to prepare a tasking order before it is issued by the Mine Action Coordination Centre (MACC). The tasking order indicates the area to be cleared and the required clearance depth, as well as the requirements for monitoring and inspection.

In the immediate aftermath of the conflict on the Islands, existing fences and temporary military minefield marking was used to delineate the mined areas. When heavy duty stock minefield fences were erected later, a safety margin of 2 – 5m was

added in many cases. Technical surveys will aim to identify the land which contains mines and the land which does not, with the aim of reducing the amount of land which needs to be cleared.

For example, in the suspect areas south of Stanley, and in Port Howard and Fox Bay the Survey Team assesses that large parts of the mined areas do not contain mines or UXO . In this case, a technical survey of the ground will look for mines or the marks of mine-laying, and the ground itself will be sampled for the presence of mines. Safe lanes will be prepared using manual clearance (see below), 2-5m wide and sometimes 30m apart, to try and find any groups of mines. Using these lanes as safe baselines, dogs or machines will be used in the areas between the lanes. If a mine is found, the area around the find will be carefully cleared out to between 25 - 50m, to find any other mines, until the entire mine group or line has been identified. This is done by clearing test lanes through the suspect area, either manually, by mine detection dogs (MDD) or by machine. The results of the technical survey are a better-defined map, allied to a clear marking of the reduced area where the mines actually are, all of which is provided to the mine clearance team for clearance. Often the mine clearance team does its own technical surveys, so the transfer of information is immediate.

5.2.2 Environmental data

Under certain conditions, such as those on the Islands, the mine clearance methods that can be used will depend on the environmental conditions, so Environmental Impact Assessments (EIA) need to be carried out to ensure that irremediable damage is not done to the terrain, vegetation, population or wildlife.

In many mine action programmes very little formal attention is given to environmental issues. However, on the Islands a more comprehensive approach will have to be used because of the sensitivity of the terrain, and advice will need to be sought from environmental specialists before mined areas are cleared.

The field survey gathered information on the Islands' environment and our findings and assessment are given in this report. Environmental issues are likely to be addressed at many stages in the demining programme: during the field trials, in the planning stage, during clearance and with post-clearance remediation.

5.3 The Clearance Process

The next step is the clearance itself, and this can be done manually, or with mechanical assistance, as described in Paragraph 5.3.2.

5.3.1 Manual clearance

Manual clearance is the most common form of clearance because of its versatility. Manual clearance requires the deminers to detect and clear individual mines. To do this, they work in 1 metre lanes, working from a safe lane or track. They first have to remove the vegetation from the ground along their 1 metre lane to within 2 cm of the surface, then to try to detect the mine by getting a reading from the very small metallic components in landmines with a metal detector. Having detected something metallic, the deminer then prods the earth with a sharp rod near the detected signal or scoops the earth away to see if the detector has picked up a stray piece of scrap metal, such as a bullet or bit of shrapnel, or a mine. If it is scrap, it is carefully

removed. If it is a mine, it is cleared of soil, and then destroyed by burning or detonation, often in situ. Both the detector and the prodder can normally work down to about 13 – 15 cm which is usually sufficient, since most buried mines are seldom more than 7cm below the surface. Manual clearance is slow and labour-intensive, but it can be used even on steep slopes, such as those found in M59 near Wall Mount where machines cannot reach, and in AV or mixed mined areas where machinery cannot go, as in many mined areas in Stanley Areas 2, 3 and 4. Metal detectors used in manual clearance are now well developed, although they can still lose sensitivity in metallic soils. Fortunately, metallic soils are not found on the Islands.

5.3.2 Mechanical assistance¹³

The most basic form of mechanical assistance is the simple hand-held brush-cutter, which is used to cut the vegetation in the deminer's working lane down to 2cm. In areas of heavy vegetation, this can increase the speed of the manual deminer by a factor of four, although a different lane system may have to be used. Heavy vegetation is widespread on the Islands, and the thick white grass, brown rush, empetrum and ferns will need mechanical clearance of this type. Bigger flails such as the Tempest or Bozena can also be used for vegetation clearance, and can detonate AP mines. Although they can withstand AP mine detonations, they would be badly damaged by AV mines. The biggest flail systems, such as the Scanjack can withstand the detonations of AV mines, but they are heavy, expensive to operate and difficult to manoeuvre in small spaces.

Rollers can either be fitted as the wheels to mine-protected vehicles such as the Wolf or Casspir, or be towed behind an armoured tractor such as the Pearson SMTT. Rollers are primarily used against AP mines, but are best used in hard soils, such as the turf above beaches in the Murrell, M116 and the settlements.

Mechanical millers, with rotating drums with teeth like those used to grind down tree stumps, can be mounted on large vehicles, or attached to the arms of armoured back-hoes. These crunch up the earth, and any mines in it, destroying the firing mechanisms, often before any form of detonation can take place. Other mechanical assistance can be given by normal front-end loaders, which can dig out mine polluted soil, and spread it out in a thin layer for inspection. Armoured back-hoes can be fitted with digging rakes, which can remove mines from soft soils such as sand or peat, and put them to one side for destruction. These have been used successfully in other national programmes¹⁴.

5.3.3 Mine detection dogs

Mine detection dogs (MDD) can be used to detect the smell of explosive that emanates from the mines or UXO. When well trained, they are very effective at finding isolated mines, such as the outside mine in a group, or a random mine placed outside an existing line or pattern. They are therefore often used for area reduction, operating between cleared lanes. They can be expensive to train and maintain, but can operate where manual clearance is almost impossible. They are dependent on weather conditions, and even medium winds can disperse the explosive vapours at ground level. For this reason MDD may not be cost-effective to use on the Islands, where high winds are common, unless some form of shielding can be developed that will protect against the wind, but this should be trialled.

5.3.4 Combining clearance systems

Combining clearance systems can lead to major increases in effectiveness and productivity, and many mine clearance organisations are looking to mixed manual and mechanical, or manual and MDD teams to improve output and increase confidence that all mines and UXO have been located and cleared. To work with a mixture of systems requires experience and managerial skill, to ensure that all systems carry out clearance at the same rate. If a mechanical vegetation cutter can operate five times faster than the clearance team that is following, it will only be working at 20% effectiveness. If the manager can arrange the clearance site so that the single cutter can meet the needs of up to five clearance teams, the utilisation of the two clearance systems will be in balance with each other, which will maximise the productivity of both. This requires the operations manager to work out how the site can be adapted to the clearance systems he intends to use, which in the past has not always happened.

5.3.5 Re-classification of land

In most mine action programmes some of the land considered to be contaminated by mines and / or UXO is not hazardous, and the reasons or evidence for this suspicion are obscure. Under these circumstances, to carry out a full clearance programme on an area where there is no evidence of the laying of mines would be a waste of resources. In some areas, and the Fitzroy Bridge site and parts of the Murrell Peninsula are cases in point, it may be sufficient to carry out some form of confidence-building measure such as rolling or using MDD to assure the local people that there are no mines present. This should be enough to allow the areas to be re-classified as clear. In practice, the landowners would probably put sheep onto the land as their own checking process, but where they and their sheep were already walking the area before the mine fences were erected, as in Port Howard, they may simply accept the re-classification and revert to normal usage of the land.

5.4 Quality Management

5.4.1 The quality approach

A vital component of the clearance process is the system for ensuring that all the work has been done to the right quality standards. Quality management has to be exerted at many levels. At the first level, it is necessary to choose and accredit the right clearance contractor, with a proven track record and a wide level of experience. At the second level, the contract for the mine action must be carefully written, to include provisions that require the contractor to work to IMAS. In the case of a major mine clearance programme, a separate contract would normally be let to an independent company to carry out the external quality assurance and quality control functions on behalf of the MACC. At the third level, contractors bidding for the work would need to explain to the MACC what procedures they would use to carry out the clearance, and also how they would ensure that their own internal quality management processes were sufficiently rigorous. Both of these aspects would have to be agreed by the MACC.

5.4.2 Internal quality management

All clearance agencies are required to conduct internal quality assurance and control, and quality checks should take place routinely at the beginning and end of every working day, usually under the direction of the team leaders on site. Some agencies have separate teams to carry out these checks. Quality assurance and control measures should be part of a demining organisation's Standard Operating Procedures. Ideally, demining organisations should have a rigorous internal quality management regime, but sometimes routine monitoring and equipment checks are missed, or are not carried out with sufficient rigour or independence. For this reason there is a need to augment internal quality assurance and control with external quality assurance and control.

5.4.3 External quality management

A fourth level of quality management involves random inspections of the work in progress by external agencies, such as teams directed by the MACC, to ensure that the clearance is being done safely, efficiently and in accordance with the contractor's agreed procedures.

5.4.4 Post-clearance quality control

The fifth level of quality management requires that the land cleared by the contractor will need to be sampled, to check that no mines remained. This is normally done on behalf of the government by quality control teams directed by the MACC. The procedures for carrying out this sampling are contained in IMAS, which lays down the recommended sizes of the areas to be sampled, depending on the levels of confidence required. The level of sampling depends on how the land is to be used after clearance, for instance a bathing beach for families or a school playground would need a higher level of confidence than a large area of sheep pasture.

5.4.5 Handing over cleared land

When all the quality checks mentioned above have been successfully carried out, the clearance agency will ask the MACC for permission to formally return the land. The MACC will issue a clearance certificate, which will certify that all necessary steps have been taken to remove the mine and UXO hazards.

SECTION 6: REMEDIATION METHODS

6.1 General

This section of the report addresses the practices commonly adopted in the British Isles for the restoration of vegetation cover on deep peat, peat-topped and mineral soils. Some general practices are applicable to the Islands, but there are differences in climate, soil types and species composition, and as such it will be necessary to modify the practices to suit local conditions.

The protocols outlined below can be considered as representing a progression of intervention complexity, and hence cost. The choice adopted will depend on many factors including proven success in similar circumstances. As there is a lack of evidence from the Islands to guide such judgments it is recommended that the final selection of remediation protocol(s) should be made following trials on the Islands.

Additional interventions may be required including the addition of nutrients, the adjustment of pH, and the provision of additional water during periods of drought. The need for such interventions will need to be established by experimentation and monitoring of the initial restoration work. In all cases, landowners should be discouraged from using the recovering land for grazing until the vegetation cover becomes stable and resilient to damage.

The probability of success of all protocols will be higher for smaller areas. The clearance of mine rows, leaving undamaged strips of vegetation between them will be easier to remediate than continuous disrupted surface.

6.2 Vegetation Remediation Protocols

6.2.1 Remediation Level 0: soil pre-treatment

The majority of soils likely to be affected by demining activities on the Islands can be described as 'peat topped' or 'peat'. Peats form and are maintained through a restriction of microbial decomposition of plant material because of a lack of oxygen (anaerobiosis) arising from saturation of the soil. Any disruption of the structure allows oxygen access into the peat. Once this occurs the peat will begin to decompose rapidly, releasing both dissolved organic carbon compounds and carbon dioxide. All demining activity that mechanically disrupts the peat structure will therefore require remediation to restore the peat structure.

The most likely solution will be to compress the peat/soil after clearance in order to re-establish its bulk density and to prevent its degeneration in an oxygen-rich environment. The ground pressures to achieve this will need to be identified through formal trialling prior to large scale clearance.

It should be noted that the inclusion of woody fragments from the process of flailing and milling will create spaces in the peat and may make compression difficult. Processes to separate vegetative material from soil, either during or post clearance, should be explored.

6.2.2 Remediation Level 1: benign neglect

Benign neglect is, essentially a 'leave alone' protocol. Following compaction of the soil surface, the area should be left to re-vegetate from residual propagules (i.e.

portions of a plant, such as seeds, buds, rhizome and root fragments from which new plants may develop) together with seed which is imported through natural causes from adjacent areas.

Re-establishment of the vegetation type to pre-clearance form and quality may require some intervention to improve the success of germination e.g recreation of fine surface features and variations. Leaving colonisation to occur naturally in this way is likely to be suitable only for small areas, narrow bare areas where propagules for re-establishing the vegetation are immediately adjacent to the mined area, or for areas where damage has been slight.

6.2.3 Remediation Level 2: addition of propagules, re-seeding etc.

The addition of propagules is a progression from 'benign neglect'. It reinforces the measures described above to increase success and/or rapidity in regeneration. The primary driver may be a need to ensure stability of substrate i.e. reduce erosion risk or reduce undesired outcomes arising from colonisation of unwanted species such as ruderals or aliens. However, a desire to provide visible evidence of progress in restoration success may also provide a valid reason for such intervention.

Sources of propagules may be provided by the surface application of 'brash' or cut material from community types representing those seen as the desired end-point of restoration. Not only does this supply a source of seed and fragments of root and shoots with regeneration potential but also helps provide favourable micro-environments for germination and establishment. Typically the fragments applied are within the scale of 1cm to perhaps 20cm and rolling into the soil surface is sometimes undertaken. With the high wind speeds frequently present on the Islands this might be considered in this case.

Level 2 intervention, or variations of it, is likely to be the optimal procedure when demining activities have removed vegetation and damaged the surface of the soil. However this requires good colonisation, and without trials of the protocol its success cannot be guaranteed.

6.2.4 Remediation Level 3: hydro-seeding

Re-seeding by cleaned seed sources will provide more increased seed densities than Level 2 which may be preferred in species with low germination success. Will typically require some form of additional surface manipulations or specific seed application methods. In the UK it is possible to use commercial sources of seed, however harvesting of indigenous genotypes from areas adjacent to the restoration sites, will be preferable, and is often undertaken in the British Isles with heather, for example. Treatment may be required to break any germination dormancy present in some species. Subsequent 'bulking-up' of the collected material may be required by cultivation and subsequent harvesting.

In some circumstances the application of seeds by methods which add nutrients and/or provide enhanced establishment success by creating optimal micro-environment for seed germination such as hydro-seeding or hydro-mulching could be applied where it is considered that the measures described above might fail. The preferred seed source for this process should be harvested locally.

6.2.5 Remediation Level 4: direct planting of established seedlings

The direct planting of established seedlings should be explored where the use of seed is considered to be too sparse or too slow to stabilise the surface of the soil surface, e.g. *Ammophila* on dune systems or where micro-propagation techniques are the only means of getting native flora to produce new plants. This protocol may also be applied where rare species need to be re-introduced following disturbance and other methods are deemed to be insufficiently reliable e.g. some orchids, cotton grass or cloudberry.

The preferred source of seed for the establishment of seedlings will be local genotypes growing adjacent to the area requiring remediation.

An alternative method is to harvest 'turfs' from adjacent areas and embed them into the damaged area, often in a grid layout, to act as 'islands of recolonisation'. This method has the advantage that the species composition within the turfs is representative of that naturally occurring. Harvesting turfs tends to be more robust to challenging environmental conditions, and becomes established faster than seeding or planting individual seedlings. It also does not require the exclusion of low density grazing from the 'donor' sites.

6.2.6 Remediation Level 5: addition of soil stability protocols

As an additional treatment to those described above it may be necessary to stabilise the surface using geo-textiles. For most applications the use of biodegradable materials such as geo-jute is recommended.

6.2.7 Additional comments on vegetation/habitat remediation protocols

All methods of vegetation remediation will require monitoring, and further work may be needed if recovery is not deemed adequate.

Apart from the use of commercial seed sources all of the remediation protocols will probably require enhancement of seed density by removal of grazing in 'donator' plots in the season prior to harvesting of either seed or cuttings. The establishment of infrastructure to deliver large quantities of seedling plants may also be required. This will have a significant 'lead-time' arising from the need to create nursery and greenhouse resources on the Islands together with experimentation to establish the best cultivation methods. Unlike the British Isles, where there is a developed network of specialist commercial horticultural companies able to undertake the work, this capability will need to be developed on the Islands.

The demining programme will need to accommodate the development of such local capabilities if remediation is to occur immediately following clearance.

6.3 Faunal Remediation Protocols

6.3.1 Invertebrates

The amount of land to be demined will be relatively small – just 0.1 % of the total Islands. and as such, there will be little need to take specific remediation measures for invertebrate fauna. Recolonisation from surrounding unaffected areas should be rapid in most events.

However, we would recommend that technical surveys prior to clearance should investigate invertebrate populations to identify whether small and localised colonies

of rare species are present exclusively in the mined areas. If rare species are discovered it may be necessary to modify clearance procedures and to restrict the use of some mechanical systems.

6.3.2 Vertebrates

Penguins

The species most likely to be impacted by demining activities are the Gentoo and Magellanic penguins. Although the number of rookeries affected is small compared to the overall population on the Islands, both species are listed as 'near threatened' globally. The way the demining programme deals with these highly visible and charismatic species will present a strong message to environmental groups worldwide.

Should any disturbing or invasive activities need to be undertaken within the colonies of these birds it is strongly recommended to canvas opinion and share knowledge prior to undertaking any work in areas containing penguins.

There are many options for recreating suitable nesting habitats for penguins, including burrows and identifying such sites should form part of any Environmental Impact Assessment prior to clearance. The Study Group is not aware of any experience of the recreation of penguin rookeries following destructive activities such as demining. We therefore advise caution, experiment and the accumulation of experience before conducting demining activities which will affect penguins.

Other fauna

Demining activities may also affect nesting birds. It is recommended that demining is not carried out during nesting periods or, where this is unavoidable, measures should be undertaken to prevent nesting in the zones of activity by use of bird scaring prior to the nesting season.

As stated above, the amount of land to be demined will be relatively small and the overall bird populations affected will be few and the impact will be of limited duration. However, the Environmental Impact Assessment for each mined area will need to recommend appropriate mitigation procedures for affected birds.

6.4 Clearance Options and Remediation Protocols

Manual clearance has only limited impact on the vegetation and soil, and land which has been manually cleared will require little remediation. In contrast, more 'aggressive' clearance methods such as the use of flails and millers will require more substantial remediation work. As stated above, the degree of remediation required will depend on many factors including the opportunity costs of remediation work.

For the purposes of this study, Cranfield University has summarised the suitability and cost of the five remediation protocols for each clearance option. A decision on the suitability and affordability of each remediation protocol will depend on many factors, and it would be inappropriate for Cranfield University to make recommendations. However, for the purposes of this study, and the need to propose indicative costs, we have used a level of remediation which we consider to be 'suitable', i.e. a level which would return the land to a state which would enable it be used in the same way as adjacent land.

Suitability and cost of the five remediation protocols for each clearance option

	Remediation levels					
	0	1	2	3	4	5
Cost of remediation per Ha (£1000)	0	0	5-10	10-15	10-15	40-50
Re-classification of land	Blue	Blue	Blue	Blue	Blue	Blue
Manual clearance	Cyan	Green	Blue	Blue	Blue	Blue
Mine detection dogs	Cyan	Green	Blue	Blue	Blue	Blue
Mechanical assistance: rollers	Cyan	Green	Blue	Blue	Blue	Blue
Mechanical assistance: light flails	Yellow	Red	Olive	Olive	Olive	Blue
Mechanical assistance: millers	Yellow	Red	Olive	Olive	Olive	Olive
Mechanical assistance: heavy flails	Yellow	Red	Olive	Olive	Olive	Olive
Mechanical assistance: armoured back-hoes	Yellow	Red	Red	Olive	Olive	Olive

 Essential pre-requisite	 Ideal	 Unsuitable
 Suitable	 Mostly unnecessary	 Unnecessary

Notes:

- (1) Some soils, including those in the settlements, might accept any aggressive form of clearance, yet could be restored by “benign neglect”.
- (2) Areas of soft wet peat anywhere on the Islands might be so sensitive to any form of invasive clearance measures that permanent damage may be caused. The degree(s) of damage in such circumstances will become clear only after the trials scheduled in Scenario 1.
- (3) Cost estimates per unit area are indicative only.

SECTION 7: ANALYSIS OF MINED AREAS

A visual inspection of the suspect areas was done from the bordering fences, but the value of the inspection was at times limited as the vegetation within the areas had grown significantly since 1982, and it was difficult to establish what lay beneath. For obvious reasons no entry into the mined or suspect areas was permitted, but the mine clearance specialists were able to cross the Stanley Common Fence, where all observations were made from vehicles. These limitations have to be kept in mind when reviewing the study observations and recommendations.

A detailed analysis of the mined areas is given in Annex F. Supporting data on the environment which was recorded during the field survey phase of the study is held separately by Cranfield University on behalf of the JWP.

The following is a summary of the terrain and clearance options for each of the nine areas visited, and an assessment of the environmental implications and cost of clearance.

7.1 *The Murrell Peninsula*

7.1.1 **Terrain** The Murrell peninsula is relatively flat, but undulating, and with some small rocky hillocks at the north end. The soils are mostly a peaty layer from 20cm to 3 metres in depth, over clay, but nearer the coves the peat layer comes to an end, and there is short grass on top of a rocky strip leading down to the sandy beach. In some areas the rock crops out to below water level. Vegetation consists of white grass (*Cordateria pilosa*), small fern (*Blechnum penna-marina*) and tall fern (*Blechnum magellanica*), occasional Brown swamp rush (*Rostkovia magellanica*) and a heather-like bush common on the Islands, and known as “diddle-dee” (*Empetrum rubrum*). There are many sheep pasturing in the suspect area, and a large colony of Magellanic penguins. Other song-birds live in the grasses, and geese were seen near the sea shore.

Summary

Suspect areas: 5
Area: 605 Ha
Mines: AP, possibly AV
Clearance: Manual,
Rolling, beach digging

7.1.2 **Clearance options** The whole of the Murrell peninsula was classified as suspect on the basis of very little evidence, except for the five coves, which are assumed as mined. Since then, the whole area has been heavily pastured for 25 years by sheep and possibly cattle without accident, and a colony of penguins lives in the middle of it. The entire peninsula, except for its coves, could probably be re-classified as clear if some confidence-building clearance activity took place. The confidence measures mentioned above could be achieved by the cutting of check strips across the peninsula by flail or manually to locate any lines of mines, and the rolling of as much of the ground surface as possible. Care would have to be taken not to roll over the nesting holes of penguins. Clearance of the coves could be achieved by manually clearing the grass strips, by digging out the immediate area above the beach by back-hoe and rake, and by raking strips of sand from the beach out to sea, taking care not to disturb the penguin routes across the sand to the sea.

7.1.3 **Environmental implications of clearance options** The whole of the Murrell peninsula contained within the fenced suspect area will undoubtedly require planning restitution procedures for damage by demining as part of a full EIA.

The use of flails to clear strips of terrain would damage the surface vegetation, fragmenting the root mat overlying the peat. This damage could extend to the underlying peat. Vegetation recovery programmes are likely to be effective, depending on the extent of demining damage and protocol adopted, however testing of these will be necessary to provide good evidence for the type of method to be proposed.

The presence of Gentoo Penguins and Magellanic Penguins within the mined and/or suspect areas should however be treated as severe constraints. Both species are internationally important. There are no useful data on the possible impact of disturbance on these birds from operations like de-mining to enable clear and safe guidelines to be proposed. Further research, linked to type of demining proposed, should be a priority before any demining operations are attempted.

Similarly, ground-nesting birds will require mitigation measures to prevent harm from occurring, particularly during the breeding season.

Manual clearance would be more benign, but nesting birds might be disturbed during the clearance process, and so clearance should ideally take place outside the breeding season, when the number of nest sites disturbed by creating check lines would be small.

7.2 *Fitzroy Bridge*

7.2.1 Terrain The suspect area is small in size at 1.79 ha, and follows the line of the shallow cliffs above four small coves, and is relatively flat, although a small stream runs through the western end. The vegetation immediately above the cliff represent a species poor maritime cliff community overlying thin peat, between 10 and 30 cm in depth. Species present here include Thrift or Sea Pink (*Armeria maritima*) and Sheep's Sorrell (*Rumex acetosella*). Further back from the shore/cliff edge Diddle-Dee dominates communities typical of Dwarf Shrub but with some grass species typical of the island habitat know as 'greens'. The beaches either have a narrow strip of sand leading to flat stony patches, or stones and rocks almost up to vegetation level. Numerous resident waders were observed as well as several song birds or passerines such as the Falkland thrush. It should be assumed these are breeding.

Summary

Suspect areas: 1

Area: 1.79 Ha

Mines: AP, possibly AV

Clearance: Manual,

Rolling, beach digging

7.2.2 Clearance options This area was declared clear in 1983, but fenced. There is no visible evidence of mine-laying, except for the possibility that a cow carcass was the result of a mine accident rather than death by natural causes. It is considered that this area could be re-classified as clear after confidence-measure clearance action has been taken, and some inspection of the beaches. Confidence measures could include rolling the top edge of the cliff, where there was room to do so, with perhaps a manually cleared check strip as a back-up. On the beaches below the cliffs, some confidence-building could be done by using a back-hoe and rake wherever possible in the sandy areas, and visual inspection of the stonier areas.

7.2.3 Environmental implications of clearance options None of the clearance measures proposed are invasive, and should have little or no lasting effect on either the flora or fauna. Rolling operations should be executed outside the period that nests contain eggs or young and disturbance beyond these areas or direct operations should be minimised. If this is impossible consideration should be given to limiting nesting within the affected areas by the use of 'scarers' prior to season's commencement. The area is small and this temporary loss of nesting habitat for one season is unlikely to be important.

7.3 Port Howard Settlement

7.3.1 **Terrain** The Port Howard area is a small settlement lying adjacent to a creek, surrounded to the north and west by rolling hills punctuated by streams and gullies. A few streams are also present and these support an impoverished marginal and aquatic macrophyte flora. The main features are slopes rising to north, White and Clippy Hill. The vegetation essentially comprises various mixes of acid-grassland, white-grass and dwarf-shrub communities, these are summarised separately in the fuller descriptions comprising Annex F. The fauna observed includes Falkland Thrush, Long-tailed Meadowlark and Dark-faced Ground Tyrant amongst others passerines which can assumed to be possibly nesting within mined areas. Crested Caracara were also observed although they are probably not nesting within the mined areas.

Summary

Suspect areas: 5

Area: 128 Ha

Mines: AP, possibly AV

Clearance: Manual,

Rolling, Milling/Flailing

7.3.2 **Clearance options** Although Port Howard has a small number of suspect areas, they present a number of different challenges. At least one of the suspect areas (PH1) is said to have no mines, and has been used for grazing since the conflict. In two of the remainder (PH5 and 6), re-classification combined with some confidence-building will probably be sufficient to return the land to normal use. To do this confidence-building, the areas near the creek could be rolled, as the grasses are short. The gorse hedges would have to be trimmed back for manual checking. The upland suspect areas such as PH3 (Clippy Hill) may need area reduction using test strips, made either manually or using machines, except in the wet valleys. Dogs might be used on PH5 and PH6, but the upland areas have longer and denser vegetation.

7.3.3 **Environmental implications of clearance options** Rolling and manual checking would have few vegetation or soil implications, providing disposal was also conducted in ways that did not directly influence them. Rolling operations should be executed outside the period that nests contain eggs, or young or consideration should be given to limiting the nesting within the affected areas by the use of 'scarers' prior to seasons commencement. If more invasive methods are used, e.g. flails, remediation will be more complex and incur additional costs.

7.4 Fox Bay Settlements

7.4.1 **Terrain** The Fox Bay settlement is in two parts, on the east and west sides of Fox Bay. The area is mainly low-lying, on both sides of the bay, but there are small rocky hills with peat banks, lakes and marshy areas. The southern end of the Western Island has probably the driest climate of all parts of the Islands. The underlying soil of peat over silt or clay is reasonably firm in most areas, but near the lakes, the peat has worn away in places, leaving open patches of silty ground. The vegetation is normal white grass, with occasional patches of rushes with clumps of empetrum and fern. In areas of previous cultivation, there is cropped turf over wide areas, with clumps of gorse bushes. One mined area is close to a Gentoo colony.

Summary

Suspect areas: 12

Area: 239 Ha

Mines: AP, possibly AV

Clearance: Manual,

Rolling, Milling/Flailing

7.4.2 Clearance options With the sole exception of one site in Fox Bay East (the western half of FB8), which is probably not mined, the remaining areas must remain as suspect until a Technical Survey is made of them. Some area reduction will have to be made, because it is alleged that the new fences extended the suspect areas, as a safety precaution after the accident to Maj Hanbrook. The slopes on both sides of Fox Bay are gentle enough, and in most cases the ground is smooth enough, for mechanical clearance techniques to be used. In some areas the ground has been previously cultivated, so careful use of flails or millers would not destroy the chances of re-growth, which could be boosted by re-seeding, should the landowners permit it. Technical survey could therefore be done using machines as well as manually, because no laying of AV mines or AV mine accidents have been reported. Manual clearance will require the use of vegetation cutters in many places, especially where large clumps of rushes and empetrum are found. Dogs might be used on the areas near the creeks, and could assist the Technical Survey mentioned above, should the wind conditions permit it.

7.4.3 Environmental impact of clearance options In general, the clearance options suggested are relatively benign, and will have little impact, except perhaps on ground-nesting birds. To prevent issues here demining should take place outside of the nesting season. If this is not possible then prevention of nesting within affected areas should be executed by the use of bird scarers prior to the season commencing. The use of dogs would have no impact, but the use of flails and/or millers will have implication for soil and vegetation remediation which will incur additional costs.

7.5 Goose Green and Darwin Settlements

7.5.1 Terrain The area of the settlements is flattish and low-lying, with gently rolling hills. The subsoil appears to be a thinner layer of peat than is found in other areas of East Island, possibly due to intensive cultivation for many years. The subsoil appears to be a sandy loam. There are a small number of watercourses running through some of the suspect areas, but in the main the surface is firm. The whole of the area is covered with white grass, down to fine sea turf on the areas above the beaches. There were very few empetrum patches seen, and the natural grasses were lush and greener than in other parts of the Islands. There are ground-nesting birds, but no colonies of penguins were seen.

<p>Summary <u>Suspect areas:</u> 8 <u>Area:</u> 19 Ha <u>Mines:</u> AV and AP <u>Clearance:</u> Manual, Rolling, Milling/Flailing</p>

7.5.2 Clearance options The Settlement area will need a full Technical Survey, possibly assisted by information provided by the settlement manager. There are eight mined areas, and some, such as the beach mined area next to Brenton Loch, are likely to have been completely cleared, and might be re-classified as clear after confidence-building measures. Since the ground is in general firmer than is found elsewhere, and has been much cultivated, rolling could be used for confidence-building, technical survey or quality assurance. It is likely that the soil would be less disrupted by flails or millers than in other areas, so these could be used to assist by cutting safe lanes or clearance

strips. The suspect areas are relatively small, so manual clearance would be relatively fast. Dogs could be used to assist technical survey or as a quality assurance measure if the weather permitted.

7.5.3 Environmental implications of clearance options Most of the clearance options suggested will have little impact, except perhaps on ground-nesting birds. To prevent issues here demining should take place outside of the nesting season. If this is not possible then prevention of nesting within affected areas should be executed by the use of bird scarers prior to the season commencing. The use of dogs would have no impact, but the use of flails and/or millers will have implication for soil and vegetation remediation which will incur additional costs.

7.6 Stanley Area 1

7.6.1 Terrain The dominant feature of Stanley Area 1 is the blown sea sand, which has formed large dunes. These dunes have grown considerably since 1982, and have also moved to the south-east. They have been stabilised with marram grass, which was apparently introduced in the 1930s, and which allows the dunes to grow by continuing to grow upwards. Some of the local residents have stated that the dunes are part of their heritage, which may indicate that their partial removal, which may be necessary, will meet opposition from the environmentalists. Some forms of dune remediation are apparently available and these should be further investigated. The dunes also contain the nesting sites of some ground-nesting birds, and there are penguin colonies in the area, but not amongst the dunes.

Summary <u>Suspect areas:</u> 10 <u>Area:</u> 18 Ha <u>Mines:</u> AV and AP <u>Clearance:</u> Manual, Rolling, dune digging, possible milling/flailing

7.6.2 Clearance options All the suspect areas in Area 1 will have to be treated as mined, and no re-classification will be possible without full clearance. Some areas of shallow sand can be rolled to test whether mines will detonate, which if successful, would give valuable indications of where the lines of mines are, but this can only be used where there are no AV mines, because no rollers so far fielded can sustain the damage caused by a succession of anti-vehicle mine detonations. Military rollers, such as those mounted on Soviet Army tanks, have a limited life, and do not cover even the tank track width with high reliability. Otherwise, there is no alternative to exposing the mines by removing the dune sand to the level at which they were laid. This can be done using an armoured back-hoe fitted with a rake to dig up the mine. This it will do by lifting the sand, which will sift through the rake tines, exposing any mines, which can then either be placed to one side for destruction, or, if an AP mine, can be detonated by pressure with one of the rake tines. Where the lines of mines appear to enter a large dune, the removal of the top levels of sand will have to be done using a normal back-hoe bucket, but this may not be suitable for the sifting process mentioned above.

7.6.3 Environmental implications of clearance options Stanley 1 presents considerable ecological challenges, not only for the restoration of dunes following clearance but in the dangers of uncontrolled loss of sand, and subsequent deposition on areas of ecological interest. Since the mines cannot

be removed without being detected, the processes to be used within the dunes will require further development and testing. Disturbance of ground nesting birds behind the dunes will also require mitigation whatever approaches are adopted.

7.7 Stanley Area 2

7.7.1 Terrain Stanley Area 2 lies to the south of Stanley. It is gently sloping, flattish in parts, with watercourses, soft wet flush sites and peat holes. Low coastal dunes occur in the east between the Canache and Rookery Bay, and these sandy areas are backed by a low, poorly-drained strip with small ponds. The bulk of the land has peat over a layer of sticky, impermeable clay. The peat layer varies in depth between 4.1 m depth, and the more usual 30 – 100cm. There are many rocky outcrops and peat banks, and there are several large ponds. The vegetation in the area mainly consists of clumps of short and long white grass, with mosses, tall and low ferns, and flattish patches of *Astelia*. In some areas inside the Common Fence the empetrum has completely dominated the area, whereas in the upper levels nearer to Stanley and the MPA road, the white grass tends to predominate. There are few domestic animals using the land, although some wild sheep live in some of the mined areas. There are numerous species of ground-nesting birds, and some geese and raptors feeding in the rubbish dump at Eliza Cove.

Summary

Suspect areas: 32

Area: 136 Ha

Mines: AV and AP

Clearance: Manual, Rolling, dune digging, possible milling/flailing, mine detection dogs

7.7.2 Clearance options Most of the suspect areas are known to be mined, and estimates are available of the numbers of mines left in the area after partial clearance. Only three areas (M108, M95 and M65) are completely unknown. All are large (about 23 Ha each), and although M95 may contain 96 AP mines and M108 may contain 30, M65 may contain none. M65 might need some confidence-building to release it for public access, but as it lies within the Stanley Common Fence, it is unlikely to be released until the Common Fence has been removed. For that reason, the status of all the suspect areas must remain as “possibly mined”, and no re-classification can be considered at this stage. It is obvious that many of the suspect areas need substantial area reduction, and almost all need a thorough technical survey. Any form of manual clearance will require vegetation removal, whether by hand-held motorised “strimmers”, or by light flails. Vegetation removal will not be easy. Grasses and empetrum tend to gather peat and soil in their roots, which adds to the “clumping” effect. Even manual grass cutting with clippers will be more labour-intensive than usual. If some form of remediation can be applied, flails or millers should be used to create safe lanes, both for manual mine clearance or area reduction. Dogs might be usable for Technical Survey, area reduction and quality management if the wind conditions allow it.

7.7.3 Environmental implications of clearance options There will probably have to be some aggressive mechanical forms of mine clearance carried out in many of the suspect sites in this whole area. The method of clearance used will have to be considered as a trade-off between damage to the peat, and cost of alternative forms of clearance. These will require significant remediation to be undertaken, and incur costs. The forms of clearance will have to be agreed

before the clearance starts, and discussions will have to be held with the contractor at each suspect site. Remediation methods will need to be trialled alongside development of clearance protocols. It will not be possible to change the method of clearance to a more benign but labour-intensive system after the contract prices have been agreed, unless the contractor is to be compensated. Clearance operations should be executed outside the period that nests contain eggs or young, or consideration should be given to limiting the nesting within the affected areas by the use of 'scarers' prior to season's commencement. If invasive methods are used, e.g. flails, remediation will be more complex and incur additional costs.

7.8 Stanley Area 3

7.8.1 Terrain The general environmental situation in Stanley Area 3 is similar to Area 2, with peat of the same general depth (30 – 100cm), rocky outcrops, peat banks and a few ponds. The ground is similar, sloping down from Sapper Hill, Mount William and Mount Harriet. A number of the mined sites border the MPA road. The vegetation in the area mainly consists of clumps of short and long white grass. There were brown rushes, and small clumps of Oreob. Also near the road there are periglacial rock stripes. To the south, the white grass predominates, tall and low ferns, and flattish patches of Astelia. There are few domestic animals using the land, although M59 was thought to have two resident wild sheep, and signs of sheep ingress under the fences were clearly visible. Numerous ground and rock nesting bird species are present, including possibly Crested Caracara.

Summary

Suspect areas: 18

Area: 136 Ha

Mines: AV and AP

Clearance: Manual, rolling, beach digging, possible milling/flailing, mine detection dogs.

7.8.2 Clearance options Since the sites and the surface vegetation are similar to Area 2, the clearance options are much the same. All of the suspect areas, especially the larger ones needing substantial area reduction, will need a technical survey. There is only one site that might be eligible for re-classification, which is M116, a small bay on the south of Port Harriet Point. This site housed a small rookery of penguins, and there was anecdotal evidence that the landowner may have declared the area mined to get fences erected to stop people from stealing the penguin eggs. Otherwise, the bigger suspect areas M91A, M91B, which have no records and a combined area of 43 Ha, will both require technical surveys to establish whether they are mined or not. For the remainder, it is probable that they are mined, and cannot be re-classified. The terrain of some of the sites near the road is rocky, so manual clearance may have to be used, and vegetation removal will be as great a problem as in Area 2, because of the clumps of grasses. Again, dogs might be usable for technical survey, area reduction and quality management if the wind conditions allow it.

7.8.3 Environmental implications of clearance options The method of clearance used will have to be considered as a trade-off between possible damage to the peat, and cost of alternative forms of clearance. Again, the forms of clearance will have to be agreed before the clearance starts, and remediation methods trialled to establish the most cost-effective protocol. Discussions will have to be

held with the contractor at each suspect site. Operations should be executed outside the period that nests contain eggs or young, or consideration should be given to limiting the nesting within the affected areas by the use of 'scarers' prior to seasons commencement. If more invasive methods are used, e.g. flails, remediation will be more complex and incur additional costs.

7.9 Stanley Area 4

7.9.1 Terrain Stanley Area 4 is dominated by the hills, especially Mount Longdon and Wall Mount, with sloping fields and wet valleys. The vegetation in the hilly area is much the same as in Areas 2 and 3, with short and long white grass, rush, small and tall ferns and empetrum. There are also different species of sphagnum moss present. The river sites have some gorse. Outcrops of rock are very common, with rock stripes off the mountain slopes. The ground is frequently cut with streams or stream beds which have cut through the surface peat, leaving holes or peat overhangs. There are few domestic animals, but many ground-nesting birds. There are sea birds near Hearnden water, but no colonies of penguins were seen.

Summary

Suspect areas: 26

Area: 31 Ha

Mines: AV and AP

Clearance: Manual, rolling, possible milling/flailing, possible mine detection dogs.

7.9.2 Clearance options The clearance options remain similar to those in Stanley Areas 2 and 3 for the hilly sites on the slopes of Mount Longdon. Although nothing is known about many of the suspect areas, none could safely be re-classified as clear. The suspect areas are smaller in average size (0.99 Ha) than in any other of the regions of the East and West Islands, but their status must remain as suspect, and they cannot be re-classified until a full Technical Survey has been carried out. Rolling will probably be of little effect in some areas because of the unevenness of the ground, and the number of wet ditches and peat banks. The softness of the ground will make mechanical clearance difficult, but some milling might have to be done on the more level sites, if it is possible to get the plant onto site. The lushness of the vegetation will make mechanical vegetation cutting a cost-effective option. On the river bank sites, rolling might be possible, as the vegetation on some sites is lighter and the ground a bit firmer. Dogs could be used in both hilly and river bank terrains, provided that the weather will allow it. The logistics of operating in the hilly areas is likely to be a major problem for the clearance organisation.

7.9.3 Environmental implications of clearance options The need to use mechanical clearance means on soft peat is an environmental problem, albeit relatively small-scale in the context of the landscape. If invasive methods, e.g. flails are used, remediation will be more complex and incur additional costs. The hilly areas are not used for livestock at present, so no grazing land will be lost. Again, the forms of clearance should be agreed by the landowner and environmental experts before the clearance starts, and discussions should be held with the contractor at each work site. As for Stanley Areas 2 and 3, some form of Impact Assessment will have to be made for each suspect area before the contract is let. Operations should be executed outside the period that nests contain eggs or young, or consideration should be given to limiting the nesting

within the affected areas by the use of 'scarers' prior to season's commencement.

7.10 Islands Clearance

- 7.10 The analysis carried out as a result of the study showed that every available current clearance technique may well have an important role, but none of these techniques have been used under the unique operational conditions of the Islands. There is also no doubt that new initiatives will be needed, such as experimenting with wind-shelters for dogs. The problems are so complex, and the uncertainties so many, that it is strongly recommended that any clearance programme starts with a period of trials, to prove that the management methods, clearance procedures and choice of clearance resources are all operationally viable. Although this in turn means that the programme must start slowly, it will greatly reduce risk. This means risk of operational failure, of mis-applied training, of badly chosen methods and equipment, of waste of money and ultimately of damage to the lives and limbs of deminers, and those that use the ground after clearance has been completed.

7.11 Condition of the Mines

- 7.11 After over 20 years immersed in damp and acidic soils, it is possible that some of the mines have been degraded by internal corrosion. This should be examined during any trials phase by recovering some active mines and dismantling them. This will give an indication of whether they will function. This will not affect the need to remove them, but will affect the type of clearance or confidence-building methods being considered for use. It will also decrease the threat to the deminers, although it will not alter their normal safety procedures.

SECTION 8: STRATEGIC OPTIONS

8.1 *Categorisation of Mined Areas*

For ease of prioritisation, mined areas are often classified into certain group types, with certain characteristics. This enables land that can quickly be returned to its former use to be checked over first. It also means that areas that impact on the ordinary people are also dealt with as a priority. A typical example on the Islands is that mined areas adjoining roads or habitation, such as those immediately to the south of Stanley and near the Stanley to MPA road should perhaps be cleared before suspect areas in open areas. Typical of the open sites are the valleys between Mount Longdon and Wall Mount, which are rarely visited unless by guided parties of tourists, for whom, perversely, a mine fence is a tourist attraction. Such prioritisation is a useful guide, but at times it is logistically sensible to deal with all suspect areas in one discrete area, especially when deminer campsites have to be set up to reduce travel time and movement over peat tracks.

For the purpose of this feasibility study, the Survey Team considered it important to provide some form of categorisation, and divided the suspect areas into four main groups:

- **Category A** These are suspect areas which, in the opinion of the Survey Team, the JSEOD Detachment and the landowners, probably have no mines. Clearance would therefore be confined to carrying out confidence-building measures, and possibly some proportional sampling. Areas falling into this category are the Murrell peninsula (less the fenced off coves MP1 – MP5), the headland and beach to the west of Fitzroy Bridge (PF1), one large suspect area within the Stanley Common Fence (M65) and the western part of FB8 in Fox Bay East¹⁵.

The total area in this category is 577.5 Ha.

- **Category B** These are suspect areas falling within 750 metres of a major area of habitation, or within 100 metres of a main paved road, which could cause the most threat to human life. These would be cleared as a matter of priority, by whatever means was the most appropriate. Areas in this category are the three mined areas south of Stanley, but north of the Stanley Common Fence (M63A, M63B and M110), three mined areas just inside the Stanley Common Fence (M97, M98 and M22), a line of mined area alongside or abutting the Stanley to MPA road (M24, M25, M26, M27 and M28, M54 and M55, M56, M57 and M60). It also might have to include a 100 metre cut from M56 and M59. It would also include GG10 and GG11 at Goose Green, PH5 at Port Howard, and the eastern part of FB8 in Fox Bay East.

The total area in this category is 54.7 Ha.

- **Category C** These are suspect areas which are far from human habitation or well-used roads, and which cause minimal risk to human life. These would be cleared at a lower priority, using the most appropriate clearance methods, but accepting some environmental damage. Areas in this category are all the suspect areas within the Stanley Common Fence except M65, M97, M98 and M22, the remaining suspect areas in Area 3, and all the suspect areas in Area 4. They also include the suspect areas in Port Howard, Fox Bay East and West,

Darwin and Goose Green, the coves in the Murrell peninsula, and a very small suspect area (M117) in Area 1.

The total area in this category is 664.8 Ha.

- **Category D** These are suspect areas which present major technical challenges, and which cannot be cleared without major and obvious environmental damage to areas considered by many to be sites of natural beauty. They are all on beaches to the north and immediate south of Stanley Airport peninsula.

The total area involved is 17.9 Ha.

8.2 Strategic Clearance Options

8.2.1 General

A number of factors and issues will need to be considered before designing, developing and implementing a possible future plan to clear the land mines remaining from the 1982 conflict. A range of clearance options are possible and these will dictate the duration and cost of the overall clearance programme. For the purposes of this study we have proposed five clearance scenarios. These scenarios are not clearance plans, but they illustrate the range of strategic clearance options possible and the range of costs. We have also proposed the use of small teams, which can be assimilated into the local environments, including the smaller settlements, without imposing logistic strains on the residents.

8.2.2 Assessment of costs

The assessment of costs was carried out using the best data available, both from the Islands and from experience in other clearance programmes, but in many areas there was no data at all, so estimations had to be made. These estimations became less reliable in the later scenarios, because they entirely depended on the results of Scenario 1.

8.2.2.1 Assumptions. In putting together the cost estimates, it was assumed that some use of mechanical equipment will be possible, and funds for the purchase or lease of these equipments are included. If the trials using certain confidence-building and clearance methods are to succeed, and the effects of aggressive mechanical clearance can be repaired by remediation measures on a reasonable proportion of the terrain, then much of the clearance can be carried out using mechanical assistance. This will affect the rate of completion more than the finances, since the operating costs in fuel and spares would be small compared to the cost or purchase, lease and shipment to the Islands.

8.2.2.2 Inflation. No account is taken of inflation during the life of the programme, nor of any shifts in exchange rates. The costs used in the Study are based on April 2007 prices.

8.2.2.3 Sensitivity analysis. Some sensitivity analysis calculations have been conducted. Since manpower salaries and living allowances are always a major cost-driver in mine clearance programmes, a sensitivity test was done in this area. A 25% rise in the wages and allowances produced a 13% rise in overall costs.

8.2.2.4 Cost risk analysis. It is not considered that a meaningful cost risk analysis could be made until the Scenario 1 trials had been completed. Before that time, no valid cost balance comparisons can be made between the cost and speed of manual clearance, against the cost and speed of mechanical clearance followed by remediation. A full cost-risk analysis will need to be made at the end of the trials.

8.2.3 Scenario 1

Phase 1a: Establish a project office on the Islands;

Phase 1b: Develop appropriate mine action standards; develop procedures for accreditation, contracting and external quality assurance and control; and develop procedures for conducting environmental impact assessments and environmental remediation;

Phase 1c: Conduct trials to determine the effectiveness of each clearance method on each type of terrain; and

Phase 1d: Evaluate a range of clearance options, and draft an outline clearance plan.

Outcome: A draft clearance plan based on the outputs from Phases 1a -1d.

A Scope of Work for Scenario 1 is proposed at Annex H, fulfilling Paragraph 8.2.2 of the Study Terms of Reference; see Annex B. It has been prepared as a narrative to explain the logical progression of activities leading to the development of a costed clearance plan. The Scope of Work has been written in advance of any decision on a clearance plan, and so it is envisaged that it will require further development.

A summary of the proposed costs of Scenario 1 is shown at Annex I.

8.2.4 Scenario 2

Phase 1 as proposed above.

Phase 2a: Convert the project office into a Mine Action Coordination Centre (MACC);

Phase 2b: Re-classify all Category A mined areas;

Phase 2c: Conduct confidence building measures such as using heavy rollers;

Phase 2d: Conduct quality control of re-classified land in accordance with IMAS 09.20;

Phase 2e: Remediate land; and

Phase 2f: Handover land in accordance with IMAS 08.30.

Outcome: 577.5 Ha of land (currently classified and marked as 'known minefield' or 'suspect area') to be declared 'safe' and handed over in accordance with IMAS 08.30. This represents 44% of the total area currently classified as dangerous.

8.2.5 Scenario 3

Phases 1 and 2 as proposed above.

Phase 3a: Conduct technical survey and EIA of each Category B mined area;

Phase 3b: Clear all Category B mined areas in accordance with IMAS 09.10;

Phase 3c: Conduct quality control of cleared land in accordance with IMAS 09.20;

Phase 3d: Remediate land; and

Phase 3e: Handover land in accordance with IMAS 08.30.

Outcome: In comparison with Scenario 2, this scenario results in an additional 54.7 Ha of land declared as 'safe', thus bringing the total to 632.2 Ha of land (currently classified and marked as 'known minefield' or 'suspect area') to be declared 'safe' and handed over in accordance with IMAS 08.30. This represents 48% of the total area currently classified as dangerous.

8.2.6 Scenario 4

Phases 1 to 3 as proposed above.

Phase 4a: Conduct technical survey and EIA of each Category C mined area;

Phase 4b: Clear all Category C mined areas in accordance with IMAS 09.10;

Phase 4c: Conduct quality control of cleared land in accordance with IMAS 09.20;

Phase 4d: Remediate land; and

Phase 4e: Handover land in accordance with IMAS 08.30.

Outcome: In comparison with Scenario 3, this scenario results in an additional 664.8 Ha of land declared as 'safe', thus bringing the total to 1,297.0 Ha of land (currently classified and marked as 'known minefield' or 'suspect area') to be declared 'safe' and handed over in accordance with IMAS 08.30. This represents 99% of the total area currently classified as dangerous.

8.2.7 Scenario 5

Phases 1 to 4 as proposed above.

Phase 5a: Conduct technical survey and EIA of each Category D mined area;

Phase 5b: Clear all Category D mined areas in accordance with IMAS 09.10;

Phase 5c: Conduct quality control of cleared land in accordance with IMAS 09.20;

Phase 5d: Remediate land; and

Phase 5e: Handover land in accordance with IMAS 08.30.

Phase 5f: Handover responsibility for ongoing EOD to relevant entity.

Outcome: In comparison with Scenario 4, this scenario results in an additional 17.9 Ha of land declared as 'safe', thus bringing the total to 1,314.9 Ha of land (currently classified and marked as 'known minefield' or 'suspect area') to be declared 'safe' and handed over in accordance with IMAS 08.30. This represents 100% of the total area currently classified as dangerous.

A summary of the five strategic options is given in Table 1. For each scenario, the key mine action activities, the areas re-classified and cleared, and the timings and costs are listed.

8.2.8 Risk assessment

The study has provided much information which can be used to assess the clearance options. It has confirmed the boundaries of the mined areas, the extent of information held by the JEOD Detachment, local knowledge and opinions, likely environmental impact of clearance and potential remediation methods. But experience from global mine action over the past 15 years has shown that local clearance requirements, and hence programme costs, can only be fully understood following the completion of technical surveys and with experience from trials and early clearance operations. This early trials and clearance experience is necessary to increase the overall productivity of the programme, and reduce risk.

The approach adopted by the Study of identifying four categories of mined areas, and five scenarios for clearance assists in understanding the extent of the risk involved in any programme to clear the mined areas. We have identified the elements of risk, the probability and impact of each element of risk, and we have proposed mitigating measures. Our detailed risk assessment is at Annex K.

A summary of our risk assessment for the five scenarios is shown below.

	Risk of successful outcome	
	On time	To budget
Scenario 1	Low	Low
Scenario 2	Low	Medium
Scenario 3	Low/medium	Medium
Scenario 4	Medium	Medium/high
Scenario 5	High	High

Table 1: Summary of areas cleared, timings and costs of the five scenarios

Mine action phases and activities ▼	Area, time and cost			Scenario					Cumulative		
	Area (Ha)	Time (month)	Cost (£m)	1	2	3	4	5	Area (Ha)	Time (month)	Cost (£m)
Phase 1a Establish project office on Islands Phase 1b(1) Develop mine action standards Phase 1b(2) Develop procedures for EIAs & environmental remediation Phase 1b(3) Develop procedures for external QA and QC Phase 1c Trial effectiveness of clearance methods Phase 1d(1) Evaluate range of clearance options Phase 1d(2) Draft outline clearance plan	0	20	X	■	■	■	■	■	0	20	X
Phase 2a Convert project office to a MACC Phase 2b Re-classify Category A mined areas Phase 2c Conduct confidence building measures Phase 2d Conduct QC of re-classified land in accordance with IMAS 09.20 Phase 2e As required, environmentally remediate land Phase 2f Hand over re-classified land to MACC	577.5 (44%)	10	X		■	■	■	■	577.5 (44%)	30	X
Phase 3a(1) Conduct technical surveys of Category B mined areas Phase 3a(2) Conduct EIAs of Category B mined areas Phase 3b Clear all Category B mined areas Phase 3c Conduct external QC of all Category B mined areas Phase 3d As required, environmentally remediate land Phase 3e Hand over cleared land to MACC	54.7 (4%)	30	X			■	■	■	632.2 (48%)	60	X
Phase 4a(1) Conduct technical surveys of Category C mined areas Phase 4a(2) Conduct EIAs of Category C mined areas Phase 4b Clear all Category C mined areas Phase 4c Conduct external QC of all Category C mined areas Phase 4d As required, environmentally remediate land Phase 4e Hand over cleared land to MACC	664.8 (51%)	30	X				■	■	1,297.0 (99%)	90	X
Phase 5a(1) Conduct technical surveys of Category D mined areas Phase 5a(2) Conduct EIAs of Category D mined areas Phase 5b Clear all Category D mined areas Phase 5c Conduct external QC of all Category D mined areas Phase 5d As required, environmentally remediate land Phase 5e Hand over cleared land	17.9 (1%)	30	X					■	1,314.9 (100%)	120	X

Note: The time includes periods when work will not be carried out due to inclement weather, equipment maintenance, leave, and/or training (for both individuals and organisations.) It has been assumed that 10 months productive clearance will be achieved each year; i.e. 5/6th of 12 months. For example in Phase 3, which will last a total of 30 months, it has been assumed that 25 months productive clearance will be achieved.

SECTION 9: RECOMMENDATIONS

The clearance of mines from all of the areas on the Islands currently classified as 'minefields' or 'suspect areas' is challenging, but technically possible. Such clearance should be in accordance with IMAS 09.10, with post-clearance quality control carried out in accordance with IMAS 09.20.

The clearance work will have some environmental impact, although the degree of impact should be measured against the substantial environmental impact over many years from over-grazing and the likely future longer term effects of climate change. Some environmental remediation will be required.

The risk to the clearance programme in terms of time and cost can be substantially reduced by collecting more information on the effectiveness and efficiency of different methods of technical survey, clearance and remediation through a series of planned trials on the Islands as proposed in Scenario 1.

A key element in the success of the clearance programme will be the establishment of a MACC, based on the Islands with experienced mine action managers who are able to develop and apply appropriate standards and to establish management systems and procedures for accreditation, contracting, conducting technical surveys and environmental assessments, managing clearance, conducting post-clearance quality control and remediation, and the handover of cleared land.

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GLOSSARY OF TERMS AND DEFINITIONS

Area reduction	<p>the process through which the initial area indicated as contaminated (during the general mine action assessment process) is reduced to a smaller area. [IMAS 04.10]</p> <p>Note: Area reduction may involve some limited clearance, such as the opening of access routes and the destruction of mines and UXO which represent an immediate and unacceptable risk, but it will mainly be as a consequence of collecting more reliable information on the extent of the hazardous area. Usually it will be appropriate to mark the remaining hazardous area(s) with permanent or temporary marking systems.</p> <p>Note: Likewise, area reduction is sometimes done as part of the clearance operation.</p>
Avifauna	birdlife
Camp	term sometimes used to describes the areas outside of Stanley. Derived from Campo, Spanish for countryside.
Cleared area	<p>an area that has been physically and systematically processed by a demining organisation to ensure the removal and/or destruction of all mine and UXO hazards to a specified depth. [IMAS 04.10]</p> <p>Note: IMAS 09.10 specifies the quality system (i.e. the organisation, procedures and responsibilities) necessary to determine that land has been cleared by the demining organisation in accordance with its contractual obligations.</p> <p>Note: Cleared areas may include land cleared during the technical survey process, including boundary lanes and cleared lanes. Areas cleared for worksite administrative purposes, such as car parks, storage locations, and first aid posts need not be officially documented as cleared, unless national procedures so require.</p>
Demining	activities which lead to the removal of mine and UXO hazards, including technical survey, mapping, clearance, marking, post-clearance documentation, community mine action liaison and the handover of cleared land. Demining may be carried out by different types of organisations, such as NGOs, commercial companies, national mine action teams or military units. Demining may be emergency-based or developmental. [IMAS 04.10]
EclA	Ecological Impact Assessment: a formal process of assessing the ecological impact of any activity or development. Often subsumed into an EIA.
EIA	Environmental Impact Assessment: a formal process of assessing the environmental impact of any activity or development.
Explosive ordnance	all munitions containing explosives, nuclear fission or fusion materials and biological and chemical agents. This includes bombs and warheads; guided and ballistic missiles; artillery, mortar, rocket and small arms ammunition; all mines, torpedoes and depth charges; pyrotechnics; clusters and dispensers;

cartridge and propellant actuated devices; electro-explosive devices; clandestine and improvised explosive devices; and all similar or related items or components explosive in nature. [AAP-6]

General assessment	the process by which a comprehensive inventory can be obtained of all reported and/or suspected locations of mine or UXO contamination, the quantities and types of explosive hazards, and information on local soil characteristics, vegetation and climate; and assessment of the scale and impact of the landmine problem on the individual, community and country. [IMAS 04.10]
GPS/DGPS	Global Positioning System/Differential Global Positioning System: the capture of timing data from the American NAVSTAR satellite system and subsequent processing to deliver accurate positional information about ground location. DGPS uses an additional fixed data source to correct positional estimates to a higher accuracy.
Handover	the process by which the beneficiary (usually the mine action authority) accepts responsibility for the cleared area. The term 'alienation' is sometimes used to describe a change of ownership of the land which accompanies the handover of a cleared area. [IMAS 04.10]
Handover certificate	documentation used to record the handover of cleared land. [IMAS 04.10]
Harm	physical injury or damage to the health of people, or damage to property or the environment. [ISO Guide 51: 1999(E)]
Hazard	potential source of harm. [ISO Guide 51:1999(E)]
Humifaction	the processes by which organic matter decomposes to form humus
MAA	Mine Action Authority. The entity charged with the regulation, management and coordination of mine action (adaptation of IMAS 04.10)
MAC	Mine Action Centre: an organisation that carries out mine risk education training, conducts reconnaissance of mined areas, collection and centralisation of mine data and coordinates local (mine action) plans with the activities of external agencies, of (mine action) NGOs and of local deminers. [UN Terminology Bulletin No. 349] For mine action programmes, the MAC usually acts as the operational office of the MAA. [IMAS 04.10]
MACC	Mine Action Coordination Centre; see MAC
Mine	A munition designed to be placed under, on or near the ground or other surface area and to be exploded by the presence, proximity or contact of a person or vehicle. [MBT and JWP Study Terms of Reference 3.3.4]

Mined area	an area which is dangerous due to the presence or suspected presence of mines. [MBT and JWP Study Terms of Reference 3.3.2]
Minefield	an area of ground containing mines laid with or without a pattern. [AAP-6]
Mitigation	Actions taken to reduce the impact of an activity. In this case to reduce the ecological impacts of demining by, for example, avoiding work during bird breeding seasons.
Monitoring	in the context of humanitarian demining, the term refers to the authorised observation by qualified personnel of sites, activities or processes without taking responsibility for that being observed . This is usually carried out to check conformity with undertakings, procedures or standard practice and often includes recording and reporting elements. [IMAS 04.10]
Penetrometer	device for assessing the 'firmness' of a material, in this case soil, by measuring the force required to penetrate the soil with an object of known dimensions.
Propagule	part of a plant able to initiate growth of a new plant, e.g. seed, spore, root fragment etc.
Remediation	action taken to restore an area to a predetermined standard following ecological damage.
Residual risk	in the context of humanitarian demining, the term refers to..... the risk remaining following the application of all reasonable efforts to remove and/or destroy all mine or UXO hazards from a specified area to a specified depth. [IMAS 04.10; modified from ISO Guide 51:1999]
Risk	combination of the probability of occurrence of harm and the severity of that harm. [ISO Guide 51:1999(E)]
Risk analysis	systematic use of available information to identify hazards and to estimate the risk. [ISO Guide 51:1999(E)]
Risk assessment	overall process comprising a risk analysis and a risk evaluation. [ISO Guide 51:1999(E)]
Risk evaluation	process based on risk analysis to determine whether the tolerable risk has been achieved. [ISO Guide 51:1999(E)]
Risk reduction	actions taken to lessen the probability, negative consequences or both, associated with a particular risk.
Technical survey	the detailed topographical and technical investigation of known or suspected mined areas identified during the planning phase. Such areas may have been identified during the general mine action assessment or have been otherwise reported.
UXO	unexploded ordnance: EO that has been primed, fused, armed or otherwise prepared for use or used. It may have been fired, dropped, launched or projected yet remains unexploded either

through malfunction or design or for any other reason. [IMAS and JWP Study Terms of Reference 3.3.3]

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STUDY TERMS OF REFERENCE

1. GENERAL FRAMEWORK OF THE PROJECT

The Governments of the United Kingdom of Great Britain and Northern Ireland and the Argentine Republic signed in Buenos Aires, on October 11, 2001, an Agreement by Exchange of Notes for the carrying out of a Feasibility Study on the Clearance of Land Mines in the Falkland Islands (Islas Malvinas).

Both Governments also signed in Buenos Aires, on 3 August 2006 an Agreement by Exchange of Notes about the inclusion of unexploded ordnance (UXO) within the scope of the 2001 Exchange of Notes and the procedure to contract the carrying out of certain tasks belonging to the Main Study of the Feasibility Study.

Both abovementioned Exchanges of Notes are covered by the sovereignty formula which safeguards the British and the Argentine positions on the sovereignty dispute on the Falkland Islands (Islas Malvinas), South Georgia and South Sandwich Islands and the surrounding maritime areas, and were concluded in the light of the obligations in the Convention on the Prohibition of the Use, Stockpiling, Production and Transfer of Anti-Personnel Mines and on their Destruction of December 10, 1997 (hereinafter the "Ottawa Convention").

2. GENERAL OBJECTIVE OF THE CONTRACT

The Feasibility Study consists of a preliminary study (already undertaken), a main study which includes a field survey of the Falkland Islands (Islas Malvinas), and a final report. The field survey, which includes a written report of the findings, will be let as a single contract.

The aim of the field survey is to provide a detailed assessment of the availability and suitability of the methods and techniques normally used to detect, clear and dispose of land mines and UXOs, to provide an assessment of the potential environmental risks, and to estimate costs for each clearance method and for the environmental remediation.

This contract covers the field survey and report of the field survey only. For purposes of this contract, the contractor selected to conduct the field survey, shall be excluded from bidding for any subsequent follow-on requirement.

3. DETAILED SCOPE OF WORK

3.1 Application of International Rules on Humanitarian Demining

According to the Exchange of Notes of October 11, 2001, the UK and Argentine Governments have agreed to use International Mine Action Standards (IMAS)¹⁶. IMAS 08.10 - General Assessment - will be used as the basis of the field survey.

3.2 EOD Support

EOD support will be provided to the Contractor by appropriate personnel on the Falkland Islands (Islas Malvinas), in accordance with the instructions set out in the

attached “Joint Working Party (JWP) Notification to the Contractor on operative aspects regarding the performance of the contract”.

3.3 Terminology

Below are some formal definitions taken from IMAS with the explanation of their relevance to the Falkland Islands (Islas Malvinas).

3.3.1 General Assessment:

“The continuous process by which a comprehensive inventory can be obtained of all reported and/or suspect locations of mines or UXO contamination, the quantities and types of explosive hazards, and information on local soil characteristics, vegetation and climate; and assessment of the scale and impact of the landmine problem on the individual community and country”.

The process of general assessment has been underway for some years and a considerable amount of data are held. This task will be less a matter of collecting data but collating that which are held and their subsequent analysis.

3.3.2 Mined Area:

“An area which is dangerous due to the presence or suspected presence of mines”.

The term “mined area” is used in preference to “minefield” as its definition more accurately describes the situation on the Falkland Islands (Islas Malvinas).

The United Kingdom has reported to the JWP that all mined areas are marked on the ground by a standard cattle fence with wooden stakes, heavy gauge wire and minefield marking signs. All these are annotated as red areas on 1:25,000 scale maps which are available. A table, cross referencing the marked areas to the information of mines and UXO within each area is also available.

Very little is known about the mines in some of the mined areas. It is quite likely that some of them contain nothing at all. At the time they were fenced, the soldiers clearing them may not have had sufficient confidence that all the mines had been cleared enabling them to remove the fences. It is possible that some areas were fenced because of “combat indicators” such as empty mine boxes (in which mines had been carried). Such indicators might have raised concern that mines were present even if none were seen. In some cases, it is possible, that an area still fenced actually has no mines.

In some of the large mined areas, if they contain anything at all, the actual area of mines is probably a small proportion of that fenced. In some cases the soldiers erecting the original fencing may have used existing fence lines as a short-term expedient. Some of the mined areas are on sand and a few of these are mobile beaches with extensive movement of dunes. In these latter cases, it is possible that some mines will have moved.

3.3.3 Unexploded Ordnance (UXO):

“Explosive ordnance that has been primed, fused, armed or otherwise prepared for use or used. It may have been fired, dropped, launched or projected yet remains unexploded either through malfunction or design or for any other reason”.

The United Kingdom has reported to the JWP that a considerable quantity of UXO remained after the conflict and most of it was cleared using battle area clearance techniques; mainly visual search. There may still be some UXO not yet cleared outside the mined areas and there will be UXO inside the mined areas possibly including BL 755 submunitions. The presence, and subsequent destruction, of UXO within mined area perimeters must be factored into the consideration of appropriate clearance techniques.

3.3.4. Mine:

“A munition designed to be placed under, on or near the ground or other surface area and to be exploded by the presence, proximity or contact of a person or vehicle”.

The actual number of mines contained within the mined areas is not exactly known. The Argentine Republic has declared to the United Nations, that 20.000 anti-personnel mines and 5.000 anti-vehicle mines were planted during the 1982 conflict.

The exact number of mines is irrelevant since every mined area represents today a “fear zone” and all of them must be cleared independently from the number of mines contained in each of them. The following type of mines are known to have been used by troops on the Falkland Islands (Islas Malvinas):

Designation	AP/AT	Minimum Metal	Origin	Remarks
C-3-B	AT	Yes	Spain	
P-4-B	AP	Yes	Spain	
SB-81	AT	Yes	Italy	
SB-33	AP	Yes	Italy	
N° 6	AT	No	Israel	Copy of Russian TMN 46
N° 4	AP	No	Israel	Case in plastic, switches are metal
FMK-1	AP	Yes	Argentina	
FMK-2	AT	Yes	Argentina	
M1A1	AT	No	USA	1944 manufacture
Elsie	AP	No	Canada	

The United Kingdom has reported to the JWP that it laid 3 minefields immediately after the cessation of hostilities. All were lifted in 1986 but a single mine (Elsie) could not be found. Following extensive searches in that area, the mine was still not found. This area is still fenced and will form part of the eventual clearance project and therefore must be part of the field survey.

3.3.5 Booby Trap:

“An explosive or non explosive device, or other material, deliberately placed to cause casualties when an apparently harmless object is disturbed or a normally safe act is performed”.

The United Kingdom has reported to the JWP that some of the mined areas are known to have contained booby traps, usually a hand grenade linked to a tripwire. Some booby traps may remain in place.

3.4 Scope Strategy

The United Kingdom has reported to the JWP its assessment that the Falkland Islands (Islas Malvinas) is an environment where all land is considered safe except for those marked as mined areas. Therefore the field survey is expected to include the analysis of clearing 100% of the landmines and UXOs through the total excavation of the mined areas down to a layer impermeable¹⁷ to any moving mine, together with other options acceptable by IMAS.

3.5 Pre-Start Mobilisation

The Contractor shall:

- Confirm that he has any relevant registration and licences to undertake the work set out in the contract.
- Confirm that he has all the required insurance, to include, but not limited to, accident, medical repatriation, Third Party Liability and Employer's Liability.
- Undertake a comprehensive hazard assessment of risks and hazards likely to be faced during the contract by the members of the field survey team.

3.6 Mobilisation

Notwithstanding the key programme dates (paragraph 6), the contractor shall be prepared to be fully mobilised on the Falkland Islands (Islas Malvinas) within two weeks from the signature of the contract.

3.7 Task Commencement

The Technical Project Manager will confirm the exact date of task commencement and other details including flight coordination to and from the islands.

4. THE TASK

4.1 Introduction

There are three phases to the field survey: pre-deployment analysis; survey on the Falkland Islands (Islas Malvinas); and the reporting of the field survey findings. The contractor must take into account that the time on the islands will be limited and may be affected by weather. Therefore it is important to build flexibility into the plan of work whilst there.

Given its remoteness, once the field survey team leaves the islands, it will be difficult to obtain information that should have been collected during the field survey. Under no circumstances will this contract be amended to allow a second visit.

4.2 Pre-deployment analysis

The Technical Project Manager will provide the contractor with every available data about the number of mined areas, their location and estimated contents, by type.

4.3 Mined area perimeters

The perimeter of the mined areas will have been accurately assessed by the time of the field survey and will be made available to the contractor. For each mined area, a plan drawing is required at a scale of 1:10,000 showing its perimeter¹⁸.

4.4 Environment

The field survey is to catalogue the environmental status of each mined area with at least the following information:

- A geological assessment of the area to identify the underlying soil characteristics which will support any mitigation proposals. This could be undertaken using map based resources or visual inspection only.
- Undertake a survey of the flora within the affected areas to a level consistent with the International Vegetation Classification or equivalent.
- A survey of the fauna, consistent with the international classification, in the mined areas and areas adjacent to them including an analysis of any species likely to be affected by the clearance techniques recommended.
- The best route for vehicle and equipment access to each mined area is to be decided and an estimate of damage likely to be caused along that route is to be made.
- Identify mitigation proposals for all mined areas.
- Consider the best options for post-clearance restoration at each site, which as a minimum should consider translocation of flora habitats and translocation of fauna, and spreading of cuttings, etc.
- Consider mitigation for the fauna on and adjacent to the sites, which will include as a minimum, noise disturbance and breeding seasons.

4.5 Technical Assessment

The Contractor's technical assessment shall include an assessment of the methods and techniques considered suitable to detect, clear and dispose of the landmines and UXO within the mined areas on the Falkland Islands (Islas Malvinas) The Contractor is expected to visit every accessible mined area.

Although the field survey is not limited to these, it will consider the possibilities of using:

- detection systems;
- manual demining techniques;
- mechanical systems.

The field survey shall not consider techniques that might cause uncontrollable environmental damage, such as:

- burning the peat in which some mines are laid;
- using chemical defoliant.

The Contractor's technical assessment shall include all the component equipment, systems and manpower. When appropriate, specific equipment and systems should be named.

4.6 Costs and risks analysis

The field survey will assess the costs and risks, including environmental risks, of each option viewed as technically feasible and will produce a cost-benefit analysis, leading to an order of preference for the various options.

4.7 Priority of Clearance

The field survey is to recommend an order of priority among the mined areas for the clearance of landmines and UXO taking into account proximity to centres of population and based on the most efficient use of the human, material and financial resources required.

4.8 Supplementary Issues

4.8.1 Treatment of any explosive item located: In the event that a mine or an item of UXO is found during the field survey, it must not be touched or moved and its location must be reported according to the instructions given in paragraph 3.2 and in accordance with the instructions set out in the attached “Joint Working Party Notification to the Contractor on operative aspects regarding the performance of the contract”.

4.8.2 Quality assurance and quality control: There are two aspects to this requirement: firstly, that of the field survey itself; secondly that of any subsequent follow-on clearance work.

For the field survey itself, the Contractor shall ensure that the quality of its work is to be as high as practically possible.

For any subsequent follow-on clearance work, the field survey must consider how the quality control of clearance is compatible with relevant IMAS, including the 100% level (see paragraph 3.4). This must be included in the draft Scope of Work to be provided at the conclusion of the field survey (see paragraph 8.2.2).

5. LOGISTICAL ASPECTS

5.1 Joint Working Party provided items

5.1.1 Transport: Transport will be provided in accordance with the instructions set out in the attached “Joint Working Party Notification to the Contractor on operative aspects regarding the performance of the contract”.

5.1.2 Personnel: No more than two (2) monitors from each country will accompany the Contractor during the field survey. Names will be agreed in advance by the JWP.

5.1.3 Maps, plans and reports: The Technical Project Manager will provide the Contractor with maps, overall islands plans and geotechnical data.

5.2 Contractor provided items

The contractor shall provide all equipment, material and services not provided by the JWP. The contractor must make his own provision of accommodation whilst on the Falkland Islands (Islas Malvinas).

6. KEY PROGRAMME DATES

Issue ITT
Return of bids

D Day
D + 6 weeks

Notification to companies by	D + 10 weeks
Contract signed by	D + 11 weeks
Pre-Start Mobilisation	D + 14 weeks
Commencement of Field Survey	D + 16 weeks

The time on the Falkland Islands (Islas Malvinas) is subject to further discussion and flight availability. For planning it is estimated to be in the order of 18 days.

Draft report by	D + 26 weeks
Comments from JWP to contractor by	D + 29 weeks
Final report by	D + 32 weeks

7. CONTRACTOR'S METHOD STATEMENT

The contractor shall provide through the tender response a method statement detailing the methods and resources to be employed in executing the service requirement.

8. INFORMATION TO BE DELIVERED BY THE CONTRACTOR

8.1 Technical and commercial information

The contractor shall provide to the JWP a project-specific method statement with its tender containing the following:

- Management Plan
- Methodology
- A task risk assessment
- QA/QC plan
- Task programme
- Mitigation proposals
- Details of equipment to be provided by the contractor
- Names and details of all those in the team.

8.2 Operational information

8.2.1 Reports: The Contractor shall provide a draft report of the visit by D + 26 and a final report in two parts by D + 32, containing the following information:

1. Part 1 - A review of how the work was undertaken during the field survey.
2. Part 2 - The technical information required:
 - a) A catalogue of all the landmines and UXO thought to remain a threat within the mined areas using the data collection forms in operation with the in place Information Management System Mine Action (IMSMA)¹⁹.
 - b) A catalogue showing each mined area, its perimeter, probable explosive content, and environmental status.
 - c) The options for clearance: techniques, timescales, financial, logistic and environmental costs.
 - d) The options for environmental restitution: techniques, timescales and financial costs.

- e) The recommended best option. If a single technique is not considered best for all the areas, then recommend the range of options considered.

Comments from the JWP on the draft report will be sent to the Contractor by D + 29.

8.2.2 Draft Scope of Work for Possible Clearance. The Contractor shall draft a suitable Scope of Work to be included in an invitation to tender for any subsequent clearance work.

8.2.3 Confidentiality. All data collected and the reports will be the property of the United Kingdom and Argentine Republic governments.

9. CONTACTS WITH THE JOINT WORKING PARTY

9.1 Technical Project Manager: Lieutenant Colonel Robin C. SWANSON, SO1 CPAC IHL2, Level 4, Zone N, Ministry of Defence, Main Building, Whitehall, London, SW1A 2HB. Tel.: 44(0)20 72181318, United Kingdom. E-mail: robin.swanson266@mod.uk

9.2 Financial Project Manager: Secretary of Embassy Gerardo A. DÍAZ BARTOLOMÉ, Esmeralda 1212, 13th floor, 1007 Buenos Aires, Tel.: (54-11) 4310-8111, Argentine Republic. E-mail: dbg@mrecic.gov.ar

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FIELD SURVEY TIMINGS AND KEY EVENTS

7 August 2006	JWP issues an invitation to tender
18 September 2006	Cranfield University submits proposal
3 November 2006	Contract signed in Paris on 3 November 2006
30 November 2006	Survey Team departs UK
1 December 2006	Survey Team arrives on the Islands
4 December 2006	Survey Team visits the Murrell Peninsula
5 December 2006	Survey Team visits Port Fitzroy
6 December 2006	Survey Team visits Port Howard
7/8 December 2006	Survey Team visits Fox Bay
9 December 2006	Survey Team visits Stanley Area 1
11 December 2006	Survey Team visits Stanley Common
12 December 2006	Survey Team visits Stanley Area 2
13/14 December 2006	Survey Team visits Stanley Area 3
15/16/18 December 2006	Survey Team visits Stanley Area 4
19 December 2006	Survey Team visits Goose Green
20 December 2006	Survey Team carries out aerial reconnaissance of Stanley Area 1 and the Murrell peninsula
25 December 2006	Survey Team departs the Islands
26 December 2006	Survey Team arrives UK
20 February 2007	Cranfield University's Project Director attends JWP meeting in London
29/30 March 2007	Cranfield University's Project Director attends JWP meeting in London to consider the draft report.
9 July 2007	Cranfield University provides printed copies of its report.

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**ASSESSMENT OF POTENTIAL MOVEMENT
OVER TIME OF MINES LAID IN PEAT**

Background

Most minefields laid by the Argentine forces comprise 'panels' of mines of up to 6 rows, with 8-16 mines per row. Each row should have been 32m long and marked with a red stake at one end and a yellow stake at the other, although many of the rows were marked with stones or piles of peat. The rows were laid out using a string template, although the spacing between mines was not constant. Minefields were generally marked using a single strand of wire on the side closest to the defending troops. Some mined areas were not marked.

Mines were laid at a depth of about 5 – 7 cm, but unconfirmed reports suggested that AV and AP mines could sink under their own weight down to 60 cm or more.

The purpose of this Annex is to assess the possibility of movement over time of mines laid in peat.

Dimensions, weight and density of mines

The table below summarises the dimensions, weight and density of mines laid in the Islands.

Mine type	Origin	Diameter (cm)	Footprint area (cm ²)	Footprint pressure (g/cm ²)	Height (mm)	Volume (cm ³)	Weight (g)	Density (g/cm ³)
SB-33 AP	Italy	8.5	56.75	2.47	3.0	170.25	140	0.82
P-4-A/B AP	Spain	7.2	40.72	4.20	4.3	175.10	171	0.97
No 4 AP	Israel	13.5x6.5	87.75	3.96	5.0	438.75	348	0.79
FMK-1 AP	Argentina	8.2	52.82	4.79	4.0	211.28	253	1.19
SB81 AV	Italy	23.0	415.53	7.94	9.0	3739.7	3300	0.80
C-3-A/B AV	Spain	29.0	660.60	7.57	6.0	3963.6	5000	1.26
FMK-3 AV	Argentina	25.0 x 25.0	625.00	11.36	9.0	5625.0	7100	1.26
M1 AV	USA	20.3	323.70	16.37	7.5	2427.8	5300	2.18
No6 Mk1 AV	Israel	30.5	730.71	10.94	11.0	8037.8	8000	0.99
Elsie AP	Canada	5.1	21.24	6.82	9.0	106.2	104	0.97

Characteristics of peat soils

Peat soils are essentially formed from the accumulation of partially decomposed plant materials. This occurs where the normal microbial decay processes, responsible for the decomposition of plants, effectively cannot 'keep pace' with new annual productivity.

Peats differ intrinsically from mineral soils in that the dry density of the particles of peat is much lower than that of mineral soils (1.4 compared to 2.65 g/cm³) and their bulk density is also lower at between 0.1 and 0.3 g/cm³ compared to mineral topsoils which have densities greater than 1.0 g/cm³. In addition the saturated water content of a peat may be around 80% while a sandy loam may be saturated at around 35-40%. The ability of peat to hold water is one of the reasons it is used in horticulture.

Most surface layers of peat (0 – 30 cm depth) contain fibrous peat, or at least semi-fibrous in the lower parts of the topsoil, with a structure displaying horizontal laminations reflecting the gradual accumulation of little-decomposed plant debris. It is assessed that this structure, combined with the light weight and relatively large basal surface area of the mine, will continue to support the mine preventing it subsiding through the peat mass more than a few centimetres. The structure will be physically stronger when the peat is dry (e.g. in raised areas of peatland) but less so when it is wet. Where vegetated, this structure is further strengthened by a network of modern roots.

Measurements of the bearing strength of the soil profile at intervals of 1 cm depth using a cone penetrometer were recorded by the Survey Team. These measurements indicate that even soft, humified peats below 30 cm depth have enough bearing capacity to support a mine, while they remain in situ; however, any disturbance while in a wet state may impart some thixotropic properties to the peat.

It is known for objects, such as stones, of dissimilar nature to the surrounding soil, and in particular with different moisture content, to move through the soil. However, the process involved is one of water movement through the soil followed by segregation of ice beneath the enclosed object; when repeated this produces heave of the enclosed object, in an upwards direction, but requires ground conditions at least approaching permafrost. Sorting of stones into polygons and stripes (e.g. stone runs) partly involved this process but the present climate of the Islands would not support this action.

Movement of peat soils

Maltby and Legge (1983) report that "... where peat has attained a critical thickness on some slopes, failure has occurred resulting in distinct peat slips. Pools develop in some of the slips and bare peat is a common feature of erosion scars. Peat 'fronts' are developed at the edges of eroding peat and these are probably receding due to a combination of mass movement and erosion processes. Collapse of the peat mass on more level terrain may be responsible for some of the ponds and linear 'tears' observed from air photographs. Massive failure resulting from excessive additions of water to peat at a critical thickness on a threshold slope angle can produce sudden flows of semi-liquid peat debris. Such bog bursts might also occur due to site disturbance."

Maltby (1983) states that "...the instability of peat banks in the Mt Harriet – Goat Ridge area raises important questions about mine movement. Similar peat banks occur in mined areas such as Minefield 49 on Stanley Common and both horizontal and vertical movement of mines must be reckoned with as distinct possibilities. In some cases this will be obvious because of the presence of a slumped or slipped edge to the peat mass. However within the peat bank itself vertical or arcuate shears may develop or the entire peat bank itself may be liable to some movement especially on slopes >5°."



Under mature *Empetrum* / diddle-dee vegetation, the dry surface layer of this old peat bank consists of a slab of firm, resistant fibrous peat, overlying less resistant humidified peat, near Minefield 52.
(Rodney Burton image 2652 439969E 4271020N)



An eroding peat bank on the edge of Minefield 36; blocks of peat have cascaded down the scarp and in the right middle distance there is a hollow filled with soft humidified peat.
(Rodney Burton image 2880 431972E 4269055N)

Interaction of mines and peat soils

With the exception of the M1 AV mine, the density (weight ÷ volume) of the mines laid during the conflict is similar to the surrounding soil and as such they would not sink, and certainly would not have dropped through the closely-knit network of fibrous roots found in peat. For the mine to be forced down into the peat, pressure would need to be applied from above and this could have detonated the mine.

In some localised areas the peat would offer less support. These include: (1) humified peat at the surface in a more or less permanently waterlogged state and with little vegetation cover; (2) sedimentary peat filling depressions or former pools, although these are unlikely to have been laid with mines; and (3) areas of *Sphagnum* peat, usually in wet depressions, as the structure of the *Sphagnum* is vertically aligned rather than horizontally. Occurrence of *Sphagnum* was not seen to be common during the field survey.

As suggested in the 1983 reports, the movement of mines is possible along the commonly occurring courses of eroding peat banks or where they were laid in close proximity to shear planes or tears, but this movement is more likely to be horizontal than vertical. Mass movement of peat would require excess saturation and/or a build-up of the peat mass to a critical level beyond self-containment, on sloping ground (say more than 5°) and most likely situated behind an existing weakness such as a peat bank. Current rates of peat accumulation are thought to be slow except in wet depressions. A possible explanation of the reports that mines have sunk could be due to the fact that trial holes dug for the mines were dug too deep, cutting through the fibrous roots to the softer areas beneath. Even then, only the mines with high densities would sink.

Conclusions

Mines were laid at a depth of about 5 – 7 cm. Over the past 25 years it is highly unlikely that more than 2 cm of additional soil has formed above the mines (from the accumulation of rotted vegetation).

It is the view of Cranfield University that mines will be found at depths of no more than 7 – 9 cm, unless there has been the movement of soil such as the shifting sand dunes in Stanley Area 1, or falling peat overhangs in Stanley Area 2.

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SUMMARY OF THE VEGETATION COMMUNITIES ON THE ISLANDS

The following summarises the main characteristics of the vegetation/habitat types that are present to various degrees within each mined area. It is intended that this provides a more comprehensive description of the summary survey information within each mined area. These also therefore represent the target end-point of restoration protocols following possible future demining activities.

This review is based on a synthesis of the interpretations of: Skottsberg (1911); Broughton (2000); Broughton & McAdam (2001) and Broughton & McAdam (2002)

Tussac grass formation

This formation is confined to coastal areas and generally restricted to below 200m and to a distance of less than 300m from the coast. Tussac grass typically grows to a height of around 2m (although it can reach between 3m – 4m) and features a tussock-like growth form around a fibrous pedestal. The pedestals accumulate slowly within a skirt of dead leaves. The leaves, which can grow to 2m in length bush out from the living crown and provide valuable nesting cover for a variety of passerines, birds of prey and coastal birds.

Tolerance of, or a requirement for, moist salt-laden air allows tussac grass to become dominant around coastal regions to about 300m from the shore. Therefore, with exception of small islands of less than 600m diameter, tussac tends to form a fringing strip of habitat. Due to the pressures of sheep over-grazing over the last couple of hundred years, much of this habitat has been lost from the main islands and it is estimated that over 80% of this original habitat type has been lost since the Islands were first settled.

Tussac can be split into two main categories: “dense tussac” where tussac is the dominant vegetation cover and “mixed tussac” where tussac is part of another plant community, usually “oceanic heath formation”. The dense tussac communities have previously been described as “Maritime Tussac Grass formation” and the mixed tussac as Tussac Island heath formation”

Dense Tussac dominant species:

Tussac Grass	<i>Poa flabellata</i>
Sword Grass	<i>Carex trifida</i>
Wild Celery	<i>Apium australe</i>

Mixed Tussac

The following species may be co-dominant:

Native Woodrush	<i>Luzula alopecurus</i>	Blue Couch-grass	<i>Agropyron magellanicum</i>
Yellow Daisy	<i>Senecio littoralis</i>	Creeping Pratia	<i>Pratia repens</i>
Mountain Blue Grass	<i>Poa alopecurus</i>	Marsh Daisy	<i>Aster vahlii</i>
		Wild Strawberry	<i>Rubus geoides</i>

Improved grassland

Improved grassland, or pasture, is characterised by grass-dominated swards of low species diversity, normally forming a short turf of fine grasses, as opposed to the coarse grasses of grass-heath. Such areas have been actively modified by man having either been sown, or created by modification of unimproved grasslands by fertilisers and selective herbicides, for agricultural and recreational purposes. Improved grassland includes the short lawn vegetation resulting from intensive grazing that is often found around settlements where grazing pressure and artificial enrichment of soil from animal droppings has improved fertility. The dominant species are usually those that have been artificially re-seeded and depend upon the species mix sown.

Dominant species

Perennial Rye-grass	<i>Lolium perenne</i>	Lesser Trefoil	<i>Trifolium dubium</i>
Sweet vernal-grass	<i>Anthoxanthum odoratum</i>	White clover	<i>Trifolium repens</i>
Red fescue	<i>Festuca rubra</i>		

Greens and Neutral Grassland

The local term “greens” and neutral grassland include all semi-improved and unimproved grassland occurring on circumneutral soils or in areas of nutrient flushing on otherwise acid soils (greens). Coastal greens are often associated with seabird colonies, where the nutrient input is from guano. The vegetation is grass-dominated, which are inundated with water periodically, permanently moist or even waterlogged. It includes fine-grassed vegetation (often grazed) found in coastal and valley areas and in areas of flushing, and areas of ranker grasslands, including stands of Cinnamon Grass and Tall Rush.

Dominant species

Common Bent	<i>Agrostis capillaris</i>
Creeping Bent	<i>Agrostis stolonifera</i>
Sweet vernal-grass	<i>Anthoxanthum odoratum</i>
Red fescue	<i>Festuca rubra</i>
Yorkshire fog	<i>Holcus lanatus</i>
Perennial Rye-grass	<i>Lolium perenne</i>
Annual Meadow-grass	<i>Poa annua</i>
Smooth-stalked meadow Grass	<i>Poa pratensis</i>
Squirreltail fescue	<i>Vulpia bromoides</i>
Andean Pearlwort	<i>Colobanthus quitensis</i>

Associated species

Cinnamon Grass	<i>Heirochloa redolens</i>
Tall Rush	<i>Marsippospermum grandiflorum</i>
Short Rush	<i>Rostkovia magellanica</i>
Dusky Sedge	<i>Carex fuscula</i>
Daisy	<i>Bellis perennis</i>
Cudweed	<i>Chevreulia lycopodiodes</i>
Sheep's Sorrel	<i>Rumex acetosella</i>

Acid grassland

Under previous classifications (pre-2004) “acid grassland” would have been categorised as “grass heath” a sub-division of “oceanic heath formation”. Acid grassland includes all semi-improved and unimproved grasslands dominated by White Grass (*Cortaderia pilosa*) and other rough grasses. It covers the largest areas of the Islands’ mainlands occurring on acid soils and wet acidic areas typified by the Juncaceae (rushes) and is widespread on level or undulating land below 100m, and is also common on slopes up to an altitude of approximately 180-200m.

The name “whitegrass” reflects the fact that the growing area of the leaf is generally beneath a longer dead leaf mass, giving an overall light buff appearance. On better

drained sites the plant can adopt a tussock growth form and is often associated with pig vine (*Gunnera magellanica*). On less well drained soils it can take a less tufted form giving a more uniform covering and tends to be associated with rushes and sedges, and is often referred to as “soft camp”. Acid grassland provides shelter for a wide variety of inland birds, invertebrates and flowering plants.

Dominant and common species

White Grass	<i>Cortaderia pilosa</i>	Felwort	<i>Gentianella magellanica</i>
Wavy Hair-grass	<i>Deschampsia flexuosa</i>	Sheep's Sorrel	<i>Rumex acetosella</i>
Creeping Bent	<i>Agrostis stolonifera</i>		
Pig Vine	<i>Gunnera magellanica</i>	Soft Camp co-dominant species	
Lawn Lobelia	<i>Pratia repens</i>	Astelia	<i>Astelia pumila</i>
Chickweed	<i>Cerastium sp.</i>	Oreob	<i>Oreobolus obtusangulus</i>
Dusky Sedge	<i>Carex fuscula</i>		

Dwarf shrub heath

Under previous classifications Dwarf shrub heath would have been classed as a sub-division of “oceanic heath” along with “grass heath”. Dwarf shrub heath includes vegetation types dominated by Ericaceae and other dwarf shrub species and is typically found overlying acid, free-draining, often rather shallow soils.

Dwarf shrub heath is dominated by low growing shrubs particularly Diddle-dee (*Empetrum rubrum*), however Christmas Bush (*Baccharis magellanica*) and Mountain Berry (*Pernettya Pumila*) can be locally important. This vegetation type is often in association with patches of Tall Fern (*Blechnum magellanicum*) and Small Fern (*Blechnum penna-marina*).

Dominant species

Diddle-dee	<i>Empetrum rubrum</i>
Christmas Bush	<i>Baccharis magellanica</i>
Balsam Bog	<i>Bolax gummifera</i>
Tall Fern	<i>Blechnum magellanicum</i>
Small Fern	<i>Blechnum penna-marina</i>
Mountain Berry	<i>Pernettya pumila</i>
Teaberry	<i>Myrteola nummularia</i>

Common species

Scurvy Grass	<i>Oxalis enneaphylla</i>
Vanilla Daisy	<i>Leuceria suaveolens</i>
Almond Flower	<i>Luzuriaga marginata</i>

Common species cont.

Pale Maiden	<i>Sisyrinchium jubatum</i>
Violet	<i>Viola maculata</i>
Dog Orchid	<i>Codonorchis lessonii</i>
Wavy Hair-grass	<i>Deschampsia flexuosa</i>
Native Wood-rush	<i>Luzula alopecurus</i>
Tall Rush	<i>Marsippospermum grandiflorum</i>
Short Rush	<i>Rostkovia magellanica</i>
Dusky Sedge	<i>Carex fuscula</i>
Andean Pearlwort	<i>Colobanthus quitensis</i>
Emerald-bog	<i>Colobanthus subulatus</i>
Procumbent	
Pearlwort	<i>Sagina procumbens</i>
Sheep's Sorrel	<i>Rumex acetosella</i>

Montane habitats

This classification includes all vegetation dominated by cushion plants such as Balsam Bog and Cushion Plant (*Azorella sp*), often in association with scattered areas of Tall Fern and Small Fern. It also includes moss and lichen dominated heaths of mountain summits. It does not include montane dwarf shrub heaths, flushes, grasslands and rock/scree communities that can also be found at lower elevations with little change in floristics, and which are treated as components of other broad habitat types. Under previous classifications there would have been a broad overlap with the “Feldmark” formations. The harsh conditions and more open

nature of this habitat mean that it generally lacks the diversity of species found in other formations.

Dominant species

Balsam Bog
Cushion Plant

Bolax gummifera
Azorella sp

Associated species

Tall Fern
Small Fern

Blechnum magellanicum
Blechnum penna-marina

Fern Beds

Areas of continuous cover of Tall Fern. It does not include areas with scattered patches of fern or areas that are less than 0.25 ha as these are included in the broad habitat type with which they are associated

Dominant species

Tall Fern

Blechnum magellanicum

Scrub

This category includes patches of scrub that form a continuous canopy. It does not include loose associations of bushes in a vegetation otherwise of another broad habitat type.

Only two native species grow as bushes: Fachine (*Chiliodendron diffusum*) and Boxwood (*Hebe elliptica*). Both species are sensitive to grazing and have declined significantly since human settlement, now being virtually absent from the main islands of East and West Falkland. Gorse (*Ulex europea*), introduced in 1848 for cattle fencing can now be found around most settlements and has become invasive into the surrounding habitats.

Dominant species

Fachine
Boxwood
Gorse

Chiliodendron diffusum
Hebe elliptica
Ulex europea

Fen, marsh and swamp

This community type includes vegetation that is ground-water fed, and is permanently, seasonally or periodically waterlogged peat, peaty or mineral soils, where grasses do not predominate. These areas, generally surrounding open water, feature tall emergent vegetation e.g. 'reed beds' composed of California Club-rush (*Schoenoplectus californicus*) and Spike-rush (*Eleocharis melanostachys*). This classification includes a herb-rich, grass-poor vegetation found on damp level ground near the coast and dominated by Native Rush (*Juncus scheuchzerioides*) and Pig Vine. This classification does not include wet grassland which is included under "Greens and neutral grassland" habitat type.

Dominant species

California Club-rush
Spike-rush
Native Rush

Schoenoplectus californicus
Eleocharis melanostachys
Juncus scheuchzerioides

Associated species

Marsh Marigold
Starwort
Water-milfoil

Caltha sagittata
Callitriche antarctica
Myriophyllum elatinoides

Pig Vine
Soft Rush

Gunnera magellanica
Juncus effusus

Marsh Buttercup
Blinks

Ranunculus hydrophilus
Montia fontana

Bog

Bog comprises wetlands that are not nutrient flushed and supports vegetation that is normally peat forming. In the Islands 'bog' is generally a reference to areas of deep plastic peat topped with a layer of tolerably firm vegetation. Occasionally, small areas of Sphagnum-covered mire, covering only a few square metres, are found in depressions or erupting on the shoulders of slopes. The predominant vegetation is normally short rushes or cushion bog dominated by *Asteila*, dwarf marigold, *Gaimardia* and sundew. It includes raised bog communities dominated by sphagnum, bristle sedge and blinks. Associated plants include lawn lobelia, *Lilaeopsis*, buttercup and pimpernel.

Dominant species

Brown Swamp Rush
Asteila
Dwarf marigold
Gaimardia
Sundew
Bristle sedge
Blinks

Rostkovia magellanica
Asteila pumila
Caltha appendiculata
Gaimardia australis
Drosera uniflora
Carex microglochin
Montia Fontana

Spagna

Spagnum sp.

Associated species

Lawn lobelia
Lilaeopsis
Buttercup
Pimpernel

Pratia repens
Lilaeopsis macloviana
Ranunculus trullifolius
Anagallis alternifolia

Standing open water

Standing open water includes naturally occurring lakes and ponds as well as man-made waters. The vegetation includes submerged, free-floating or floating-leaved species, which can occur in the open water zone, at the water fringes and in the adjacent wetland habitats. Small areas of open water in a predominantly terrestrial habitat such as bog pools and temporary pools in heathland and acid grassland are included in the terrestrial habitat type.

The nature of ponds varies considerably and is dependent on geology, soils, topography, surrounding vegetation, weather patterns and surrounding land use. Vegetation is likely to include Water-milfoil, Water-starwort and tall Rush with Tasselweed in brackish pools.

Common species

Water-milfoil
Marigold
Starwort

Myriophyllum elatinoides
Caltha sagittata
Callitriche Antarctica

Blinks
Spike-rush
Native Rush

Montia fontana
Eleocharis melanostachys
Juncus scheuchzerioides

Rivers and streams

The classification Rivers and Streams comprise of habitat from bank-top to bank-top including the open water zone, water-fringe and exposed sediments, which may contain submerged, free-floating and fringe vegetation.

Common species

Water-starwort

Callitriche antarctica

Ladle-leaved Buttercup

Ranunculus trullifolius

Stitchwort	<i>Stellaria debilis</i>	Prickly-burr	<i>Acaena magellanica</i>
Berry-lobelia	<i>Pratia repens</i>	Beadplant	<i>Nertera granadensis</i>
Lilaeopsis	<i>Lilaeopsis macloviana</i>	Spike-rush	<i>Eleocharis melanostachys</i>
Blinks	<i>Montia fontana</i>	Nodding Club-rush	<i>Isolepis cernua</i>
Arrow-leaved Marigold	<i>Caltha sagittata</i>	Native Rush	<i>Juncus scheuchzerioides</i>
Marsh Buttercup	<i>Ranunculus hydrophilus</i>		

Inland rock

The thin soils and underlying geology result in many areas of exposed rock, either as exposed bedrock, or surface stones such as stone runs. It also includes cliffs, ledges, caves, screes, quarries and quarry-waste. Whilst these areas are almost devoid of vegetation they can be colonised by lichens and specialist plants such as Snakeplant (*Nassauvia serpens*) and Falkland Lavenda (*Perezia recurvata*).

Common species

Snakeplant	<i>Nassauvia serpens</i>	Mountainberry	<i>Gaultheria pumila</i>
Falkland Lavenda	<i>Perezia recurvata</i>	Tall Fern	<i>Blechnum magellanicum</i>
Woolly Ragwort	<i>Senecio littoralis</i>	Small Fern	<i>Blechnum penna-marina</i>
Smooth Ragwort	<i>Senecio vaginatus</i>	Red-haired Filmy-fern	<i>Serpilopsis caespitosa</i>
Groundsel	<i>Senecio vulgaris</i>	Wiry Azorella	<i>Azorella filamentosa</i>
Diddle-dee	<i>Empetrum rubrum</i>		

Sand dunes

Sand dunes are categorised as areas of loose, shifting or semi-stabilised sand found both in coastal areas and further inland. It includes the vegetation of the supralittoral zone, such as Sea Cabbage (*Senecio candicans*) and Curled Dock (*Rumex crispus*) as well as more permanent vegetation types dominated by Marram (*Ammophila arenaria*) and Lyme Grass (*Leymus arenarius*).

Dominant species

Marram	<i>Ammophila arenaria</i>
Lyme Grass	<i>Leymus arenarius</i>

Common species

Sea cabbage	<i>Senecio candicans</i>
Native rush	<i>Juncus scheuchzerioides</i>
Shore meadow-grass	<i>Poa robusta</i>
Curled Dock	<i>Rumex crispus</i>
Wild celery	<i>Apium australe</i>

Maritime rock, shingle, cliff and slope

Land above the high water mark influenced by wave-splash and sea spray (supralittoral zone). Vertical rock, boulders, gullies, ledges and pools may be present depending on the exposure and geology of the site. The habitat is species poor dominated by Lesser sea-spurry (*Stellaria marina*), Sheep's Sorrel (*Rumex acetosella*) and spare grasses associated with seabird colonies, particularly penguin rookeries. This classification also encompasses the plant communities found in rock crevices such as Pearlwort (*Colobanthus spp.*), Stonecrop (*Crassula moschata*) and Skottsberg's buttercup (*Ranunculus acaulis*); plants found on shingle dominated by Thrift (*Armeria maritima*), Wild Celery (*Apium australe*) and Nodding Club-rush (*Isolepis cernua*).

Dominant species

Lesser sea-spurry	<i>Stellaria marina</i>
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Common species

Pearlwort	<i>Colobanthus spp</i>
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Sheep's Sorrel

Rumex acetosella

Stonecrop

Skottsberg's buttercup

Thrift

Wild Celery

Nodding Club-rush

Crassula moschata

Ranunculus acaulis

Armeria maritima

Apium australe

Isolepis cernua

Littoral sediments

This habitat type stretches from the upper margin of the littoral zone to the lower margin and includes a wide variety of plant communities. Salt marsh forms a narrow fringe around the sheltered muddy mouths of larger creeks, to beaches and intertidal mudflats. Salt marsh is typified by extensive mats of Thrift Plantain (*Plantago barbata*) or Shore Meadow-grass (*Poa robusta*), with Andean Pearlwort (*Colobanthus quitensis*), Antarctic Hair-grass (*Deschampsia antarctica*) and Stonecrop (*Crassula moschata*). On lower mudflats Lesser sea-spurry (*Spergularia marina*) may be important, while Goosefoot (*Chenopodium macrospermum*) and Sea Knot-grass (*Polygonum maritimum*) may be found on the coarser sediments.

Eroded areas

Eroded areas can occur in almost all habitat types and feature exposed soil or rock, often caused by overgrazing, burning and/or physical disturbance. If the underlying soil is peaty it can be prone to drying out and blowing away especially if the rooting zone has undergone physical disturbance by vehicle traffic or livestock activity.

**SUMMARY OF INFORMATION
COLLECTED DURING FIELD SURVEY
AND SUBSEQUENT ANALYSIS**

THE MURRELL PENINSULA

History

There is no history of mines having been laid in the Murrell peninsula as such, but there are five coves which were probably mined. No records exist of the laying of mines in the Murrell, except on the cove beaches. Evidence for mines in the coves comes from early reports of injured animals which may have strayed from the suspect area and died outside it, and from mines which appeared on the surface next to the beach mined area boundary fences. Foot reconnaissance carried out in 1983 and 1985 revealed no signs of mining in the Murrell itself, but the presence of the dead animals has been sufficient to have the whole area declared as suspect. A track leading to the portion of a Rapier battery detachment was in continuous use after the conflict, but when the battery had been withdrawn, the track was no longer used, and reverted to the status of the rest of the suspect area.

Present situation

Large numbers of animals graze in the suspect area, because the main Murrell fences are not an obstacle to determined animals. A route across the Murrell to the Mingear lighthouse and beacon ceased to be used, and is also now in the suspect area, and with maintenance carried out by boat. Even the two fences around the two cove mined areas we were able to visit are regularly penetrated by penguins moving to and from the beach to their nesting sites. No incidents involving mines or UXOs have been reported since 1985.

Access

Access to the peninsula from Stanley can be achieved by helicopter, by boat or by vehicle. There are no landing strips or designated helicopter landing zones, although there are a number of flatter areas where helicopters could land for emergency evacuation in reasonable weather, but some pilots will not fly over suspect areas. Boats can be used from Stanley, and in the summer season there is a privately-owned jetty for small craft, which could be used with the owner's permission. As mentioned, the Mingear Point lighthouse and beacon is serviced by sea, but fine weather is needed with low wind conditions, situations not always found in the Port Stanley area. There is a good gravel road to Murrell Bridge, but the track between the bridge and the peninsula is medium to poor, especially in wet weather, where the combination of peat and mud makes the track almost impassable, even for BV206 tracked vehicles or quad-bikes.

Landscape and the environment

Flora

Oceanic heath formation, comprising both Whitegrass heath and dwarf shrub heath (*Empetrum rubrum*) interspersed with fen and bog communities in low hollows, before sloping down the coastal fringe or littoral zone vegetation. Low-lying coastal greens are associated with extensive sandy areas, shingle or sand beaches. These areas have communities of Sea Cabbage (*Senecio candicans*), rushes, sedges such as Sword Grass (*Carex trifida*) and grasses such as Cinnamon Grass (*Hierochloa redolens*), Mountain Blue Grass (*Poa Alopecurus*) and Blue Couch-grass (*Agropyron magellanicum*).

Fauna

Three species of penguin observed as being present (King, Gentoo and Magellanic) of which two species were breeding (Gentoo and Magellanic). There may be colonies of other seabirds on the peninsula that have not been located as access by observers has been prevented by the risk of mines. The Breeding Birds Survey of 1983-93 recorded 46 and 51 species as being present in the two 10Km grid squares that incorporate the Murrell peninsula.

Gentoo penguin were observed in two main breeding colonies, one within the suspect area and one outside of the fence. There were well defined 'highways' from the colonies to the sea, which crossed into the danger area of MP2 and possibly MP3 (observation not possible). It is possible that other colonies are present within the main MP suspect area that were not observable from the fence-line. A single king penguin was observed within one of the Gentoo colonies. Magellanic penguin were observed at numerous points on the beaches and in association with nesting burrows in the fringing grassland and heath. The colonies of these birds can be extensive and cover several hectares. Guidance notes indicate that these birds are sensitive to disturbance.

Several ground-nesting wader species were observed including Black Oystercatcher (*Haematopus ater*), Pied Oystercatcher (*Haematopus leucopodus*), Two-banded Plover (*Charadrius falklandicus*), and the Rufous-chested Dotterel (*Charadrius modestus*). Various song bird species were observed including Falkland Thrush (*Turdus falcklandii falcklandii*), Falkland Pipit (*Anthus correndera*), Long-tailed Meadowlark (*Sturnella loyca falklandica*), Black-throated Finch (*Melanodera melanodera*), and the Dark-faced Ground-tyrant (*Muscisaxicola macloviana*).

Domestic animals

There are many herds of sheep on the peninsula, which were even seen in the suspect area, which the landowner is not allowed to enter, but he probably sends in his sheepdogs in to get them out. There are also horses and cows grazing in the general area. There are many animal skeletons to be found, mostly of lambs and ewes, but these have usually been picked clean by the various raptors, and it is difficult to assess whether they are victims of landmines. This is unlikely, because many farmed animals die of illness or age, and a mine explosion is usually heard and reported.

Implications for demining

Vegetation consists of short grasses and ferns, with occasional longer grasses and *Empetrum*. The bushes grow to 5-15 cm in height, and would have to be cleared to permit manual mine clearance, or use of mine detection dogs. The soils are mostly a peaty layer from 20cm to 3 metres in depth, over clay, but nearer the coves the peat layer comes to an end, and there is short grass on top of a rocky strip leading down to the sandy beach. In some areas there are no sand strips, but rock outcrops leading to below water level.

Landmine information

There is little information on the landmines in the Murrell peninsula, although the coves have been declared “known minefields”, and there was an unsubstantiated single report of the sighting of a helicopter dropping anti-personnel mines. In 1982, it was believed that there were hardly any mines there, but for the sake of caution in 1985 the fence was reinforced to make it a suspect area fence, and marked with mine signs. As stated, the existing tracks across it were included in the suspect area. The two mined areas visited were MP1 (Mine Cove) and MP2 (Kidney Cove). There is no mine information available about either. A helicopter flight to get a view of the remaining coves did not show obvious signs of mines, but gave excellent views of the terrain, and the conditions facing the mine clearance teams.

Ecological considerations

The presence of Gentoo Penguin and Magellanic Penguin within the mined and/or suspect areas should be treated as severe constraints and should be considered as providing the greatest challenge to successful environmentally appropriate operations. Both species are internationally important. Similarly, ground-nesting birds will require mitigation measures to prevent harm from occurring, particularly during the breeding season.

Gentoo penguin colonies and highways

This species is classified as being a breeding resident (remains on the Islands all year). Guidance notes²⁰ advise that during the breeding months this species is vulnerable to disturbance and that breeding sites should be avoided by a distance of at least 50 metres, where they cannot be avoided altogether. This distance may need to be significantly increased if the cause of potential disturbance is prolonged or explosive.

Breeding sites are mainly situated on low, open coastal heath or grassland, usually hundreds of metres inland. Some populations use the same site annually while others progress inland selecting new sites each year. The penguins travel from the sea to the colony via well defined traditional ‘highways’. Breeding begins with the establishment of colony groups and nest building in late September. A clutch of two eggs is laid in mid to late October. The incubation period is generally 33-34 days. The young are fully moulted by late January and begin to enter the sea in late February/early March.

Magellanic penguin and their burrows

This species is classified as being a breeding migrant (comes to the Islands to breed) and large populations exist on the north-east and north coast of East Falkland. Magellanic Penguins breed in underground nesting burrows usually located in soft soil or peat, on slopes facing the sea. The burrows slope downwards

and are up to 2m in length. On the north coast of East Falkland the birds return to their burrows about 12-14 September. Egg-laying commences in mid-October and incubation lasts for 38-41 days. Fledglings leave their burrows in late January and adults vacate the sites after their moult in March.

Ground-nesting birds

In the Islands, due to the absence of trees, many of the wading and passerine species will use ground-nests, although some will use Tussac pedestals and artificial structures upon which to build nests. Nesting season for these species can run from August to January and some species can be double-brooded (have two broods in a year). The following species were observed: Black Oystercatcher (*Haematopus ater*), Pied Oystercatcher (*Haematopus leucopodus*), Two-banded Plover (*Charadrius falklandicus*), and the Rufous-chested Dotterel (*Charadrius modestus*), Falkland Thrush (*Turdus falcklandii falcklandii*), Falkland Pipit (*Anthus correndera*), Long-tailed Meadowlark (*Sturnella loyca falklandica*), Black-throated Finch (*Melanodera melanodera*), and the Dark-faced Ground-tyrant (*Muscisaxicola macloviana*).

The following comments regarding impact and mitigation on penguins in the area are subject to the caveat that there are few exemplars of similar 'industrial' type disturbance of these birds or of successful approaches to minimising impacts.

In Gentoo Penguin colonies and walkways operations should be undertaken, where possible, outside of the nesting season. Access 'highways' used by the Gentoo penguins should be left intact and undisturbed where possible. Where it is not feasible to leave the pathways undisturbed, adjacent areas should be cleared along the entire route from the sea to the rookery to act as a replacement highway for the following seasons. Only once the new highway has become established and used by the penguins, should the traditional path be disturbed by demining work.

Prior to any activity in areas suspected as containing Magellanic Penguin their nesting burrows need to be located and marked. Operations should be undertaken, where possible, outside of the nesting season. Where it is considered necessary to undertake destructive clearance of the mined areas, or suspect areas occupied by penguins and where operations cannot be undertaken outside of the nesting season, the burrow area should be subdivided and an area of not more than 25% of the total, and fenced off prior to the nesting season, to prevent access by penguins. Demining work can commence within the excluded area, once it has been confirmed that no penguins are present. During subsequent years further 25% exclusion areas can be systematically demined. This should leave 75% of the nesting burrows available to the penguins for breeding in any one season. However, we again note there are few guidelines or data available to determine the validity of these proposals are we would stress the need for further studies once the extent and robustness of the demining operations required are better understood.

To minimise the impact of disturbance on all other ground nesting species operations should be undertaken, where possible, outside of the nesting season. Where demining operations cannot be undertaken outside of the nesting season, consideration should be made of using audiovisual methods (scarers) to dissuade birds from nesting in the areas to be cleared prior to nesting season. However, given the individual mined area, relative to the total area of similar habitat surrounding

them, and the anticipated low density of ground nesting birds, it may be considered that additional effort to dissuade nesting in the mined areas would be disproportionate to the potential harm occasioned.

Vegetation

There are areas of deeper and wetter peats in some places which create a particular concern for successful remediation of vegetation cover following any invasive protocols. Failure to rapidly cover these with a natural sward could cause exposed peat to dry and decompose. Recovery from this will present problems and may require higher levels of intervention such as pH correction and nutrient additions.

The use of mechanical methods over large areas would raise particular concerns, if this is necessary it would be preferable to clear and remediate these in sections over the course of a few years.

Clearance options

For the two mined areas shown, MP1 (6.75Ha) and MP2 (23.24 Ha) the flattish areas of turf away from the shoreline could be rolled, and the beach could be excavated down to 30cm using a rake on a back-hoe. Care would have to be taken not to roll over the penguin nesting holes in the flattish areas, and to rake the beach in segments, retaining ample space for the penguins to reach the sea. The same could be done on the other cove beaches, MP3 (4.04 Ha), MP4 (13.25 Ha) and MP5 (7.10 Ha). Access would need to be made by re-opening the paths across the peninsula. The Murrell itself is 550 Ha in size, which represents a major clearance task, but it has been trodden on by penguins, sheep and cattle for 24 years. Some areas could be rolled to increase public confidence, but the ground has rocky outcrops and soft peat, so the method might not be fully successful. Dogs could be used to detect isolated mines and UXO, should the weather allow it.

Logistics

The journey to the Murrell from Stanley is time-consuming, and the extra traffic could cause major damage to the peat. It would be cost-effective to create a small camp on the peninsula, and within the fenced area. There is one sheep shearing and wool shed available, which could be used as temporary accommodation or storage. For much of the year it would be possible to bring in fuel, food, water and personnel by boat to Sparrow Cove, which would save time and vehicle traffic. Heavy machinery would have to move under its own power, but discussions with the landowner would be needed to determine the best and least disruptive routes. The landowner has stated that he would be willing to assist any mine clearance activity, and was not disturbed by the idea of heavy traffic on his land.

Post-clearance remediation options

Impacts on vegetation are likely to be moderate if areas to be flailed are kept to a minimum. Rolling should require only Level 1 remediation with monitoring. Flailing should respond to Level 2 although trialling of this process, followed by monitoring of plant recovery in test areas should be undertaken prior to determining the most appropriate and cost effective methods.

PORT FITZROY BRIDGE

History

There is a report that the Argentine forces prepared the Port Fitzroy Bridge for demolition, and that the demolition firing party put a small protective minefield around their position. There is anecdotal evidence that the firing party was there for too short a time for mines to be laid, and during the visit only the firing pit could be positively identified²¹. The bones of a cow were found inside the fence, but the cause of death was not obvious.

Present situation

Sheep have penetrated the SOP311 fencing, but have not detonated a mine. Visual inspection revealed no remaining signs of mine-laying, although bits of the firing cable remain in the firing pit and elsewhere, and a portion of detonating cord was identified by the southern fence. No mine related incidents have been reported.

Access

Access from the main Stanley - Airport road to Fitzroy Settlement is across a bumpy track, but it is relatively short and can be used by 4x4 vehicles in the summer months. It might become boggy in the wet season.

Landscape and the environment

The suspect area lies on the northern shore of the creek to the north of Fitzroy settlement. It is a narrow strip of land running along cliffs bordering a series of coves, sinking to an area where a small stream runs into the creek. The vegetation in the area consists of mostly short grasses on top of a steep bank falling down to the cove beaches. The area immediately above the slope to the beach is flat, and firm underfoot. There are rocky outcrops falling down to the beach in the middle of the site. The beach is mostly stony with some sandy patches.

Flora

Primarily maritime Rock, Shingle, Cliff and Slope with thin acidic soils above the high water mark influenced by wave-splash and sea spray (supralittoral zone). Little freshwater vegetation was noted in the stream leading into the bay. Vertical rock, gullies, and ledges with associated Maritime cliff communities were present. The habitat was species poor and comprised Sheep's Sorrel (*Rumex acetosella*), Thrift (*Armeria maritima*) and various grasses. Other plant communities expected to be found in unobserved rock crevices include species such as Pearlwort (*Colobanthus* spp.), Stonecrop (*Crassula moschata*) and Skottsberg's buttercup (*Ranunculus acaulis*). Further back from the shore/cliff edge Diddle-dee dominated communities typical of Dwarf Shrub Heath were found, along with inclusions of fine grass species representative of 'greens' and the White grass typical of Acid Grassland, interspersed with the cushion plants of Montane habitats such as Balsam Bog (*Bolax gummifera*) giving a small-scale mosaic of different plant communities.

Fauna

No species of penguin were observed as being present. Several ground-nesting wader species were observed including Black Oystercatcher (*Haematopus ater*) and

the Two-banded Plover (*Charadrius falklandicus*). Various song bird species were observed including Falkland Thrush (*Turdus falcklandii falcklandii*), Falkland Pipit (*Anthus correndera*), Long-tailed Meadowlark (*Sturnella loyca falklandica*).

Domestic animals

There are many herds of sheep and cows in the area. As stated, there were signs that the sheep have roamed freely within the fenced area, and the bones of a cow which died there can still be seen.

Fencing

The suspect area is contained in a standard SOP311 fence, all of which was in good condition, but containing many locations where sheep have obviously penetrated. It is maintained under contract by a local landowner, assisted by the JSEOD team, which monitors the condition of the fences fairly regularly. There were no signs of Argentine fencing, but there was a low picket on the south side with detonating cord wound round it.

Wildlife

There seemed to be some ground-nesting birds on the grasses behind the cove, and sea-birds were seen in one of the coves. There were no signs of penguins or seals in the coves in front of the firing position.

Local population

The owner of the Fitzroy bridge area expressed the same opinion as the majority of the population, that the impact of the mines was small, and the fence around the coves was a relatively minor inconvenience.

The mine problem

The only suspect area at this location is small at 1.79 Ha, and much of it is steeply sloping to the cove beaches. The mine problem was thought to be AP mines in front of the firing area, but there is conflicting information on this point. There were also stated to be booby traps, but no signs of the posts or wires remain. It could well be true that no protective minefield was laid for the firing party, although the containers and transit plugs for some AP mines were alleged to have been found. After inspections, the area was declared clear of mines on 1 April 1983, but still remained fenced. There are no records of mined areas. Except for the dead cow mentioned above, there have been no accidents to intruding animals.

Ecological considerations

Given the scale of the area to be cleared there would appear to be few over-riding ecological constraints to demining activities providing comments about mitigation are observed. Non-invasive methods will require little restoration activity.

To minimise the impact of disturbance on all ground nesting species operations should be undertaken, where possible, outside the nesting season. Where demining operations cannot be undertaken outside of this period, consideration should be made of using bird scaring devices to dissuade birds from nesting in the areas to be cleared prior to nesting season. Again, given the individual area of each mined area, relative to the total area of similar habitat surrounding them, and the anticipated low

density of ground nesting birds, it may be considered that additional effort to dissuade nesting in the mined areas would be disproportionate to the potential harm occasioned.

The main issues with vegetation and soil conservation will be the timely reinstatement of vegetation cover following demining. It is unclear exactly what the consequences of partial or slow regeneration of vegetative cover on peat soils will be, however it is unlikely to be benign and may require more complex interventions to be made in the future.

Clearance options

The top areas of flattish turf and white grasses are firm, and could be rolled, but aggressive mechanical clearance could result in the sloping surface soil being washed into the cove. The checking of beaches for AP mines that had washed out from above would be difficult to achieve by digging on the beaches themselves. The best that could be done would be a careful surface search amongst the stones.

Logistics

It might be possible to accommodate a small mine clearance team in Port Fitzroy, but the distance from Stanley is not great. The checking or clearance is likely to be a small task, especially if mechanical equipment can be brought in.

Post-clearance remediation options

Reference to Section 6.2 should be made. Rolling will require little remediation, Level 1 is likely to suffice. Invasive methods of demining will present soil stability issues on steeper slopes that will need control as part of a re-vegetation programme. Restoration therefore may necessitate the use of anchored geotextile support (Level 5) following rolling of the soil surface (Level 0) prior to re-seeding (Level 3). As an alternative, and given the size of the area affected it may be decided appropriate to regrade the slope following demining activity and prior to re-seeding, to prevent soil movement. Such a process would raise few long-term ecological concerns.

PORT HOWARD SETTLEMENT

History

There were a small number of military defensive positions in the Port Howard area, and some protective minefields were apparently laid. Signs of mine action were present in the form of pickets, and the remains of trenches could be found in or near the six areas which were said to have been mined. Some mine clearance was carried out by UK military, but no records of that clearance are available. It is alleged that records of both the original minefields and the clearance existed, but were destroyed. Evidence for mines is said to have come from injured animals, but the usual losses of animals due to natural causes have left many skeletons in the fields. A Harrier crashed on the eastern side of the Port Howard Creek, and some BL755 bomblets have not yet been accounted for.

Present situation

Large numbers of animals graze in the fenced areas, because there are usually places where the SOP311 fences can be penetrated. No recent mine accidents have been reported.

Access

Access from the Port Howard settlement is good, on gravel roads, with some areas a short distance across field tracks.

Landscape and the environment

Flora

PH1 This is a site of predominantly improved grassland on the slopes of the valley with inclusions of White grass and Diddle-dee communities as well as gorse scrub. The valley bottom contains a stream which supports an impoverished marginal and macrophyte flora. Wet grassland fill the valley bottom to sloping sides of the valley.

PH2 This site comprises a mosaic of habitats including Acid Grassland with gorse scrub, White grass and outcrops of Dwarf Shrub Heath with Diddle-dee and associated plant communities. There are areas of exposed 'sand-bunkers'; green flushes of vegetation associated with water seepage on the valley sides, and small pools of open water with wet-grassland and marsh vegetation in the valley bottom.

PH3 'Clippy Hill' is an extensive mined area with habitats that comprise predominantly White grass communities of Acid Grassland, with areas of Dwarf Shrub Heath and areas of Fen, Marsh and Swamp where they are in proximity to Standing Open Water, along with vegetation typical of Bog communities. There are Eroded Areas, both man-made from vehicle trackways and naturally occurring peat scars' or eroded peat cliffs.

PH5 This mined area has a narrow strip of short acid-grassland dominated communities by the cliff-edge to the north nearest to the settlement and jetty, with Littoral communities along the shore edge, inclusions of Maritime rock, eroded soils, gorse and Diddle-dee communities. To the south of the jetty area the mined area opens out into typical Acid Grassland dominated by typical White grass communities until reaching the stream, where the area opens out into littoral sediments and beach, with a safe-lane separating PH5 from PH6.

PH6 This mined area is a continuation of PH5 and comprises Acid Grassland and Dwarf Shrub Heath over thin soils, with some eroded areas along vehicle trackways.

Fauna

Notable bird species observed included the Crested or Southern Caracara (*Caracara plancus*), Long-tailed Meadowlark, Falkland Thrush, Falkland Pipit, Dark-faced Ground Tyrant (*Muscisaxicola macloviana macloviana*), Black-throated Finch. Giant Petrel (*Macronectes sp*) were observed flying along the shoreline of PH5 and PH6. No penguin species were observed at any of the Port Howard mined areas.

Domestic animals

There are many herds of sheep and cows in the area, with some horses. As mentioned, many were roaming freely around the fenced areas.

Implications for demining

The vegetation in the area consists of short and long grasses, sometimes in the form of tussocks, with outcropping rocks and small streams. The tussocks form clumps of grass up to 15 cm in height, which would have to be removed if manual mine clearance was to be used. There are also clumps of low mosses and cropped grass, and small ferns. There are occasional clumps of gorse bushes, often on the lines of fencing, which might also have to be removed.

Fencing

All of the suspect areas were fenced with standard SOP311 fencing, all of which is in good condition. It is maintained under contract by a local landowner, assisted by the JSEOD team, which monitors the condition of the fences fairly regularly. Inside the fenced areas, there were signs of previous fencing, but this may have been part of Argentine defensive works.

Local population

The number of local people contacted was small due to the fact that shearing of sheep was in progress. The general attitudes expressed were that the impact of the mines was small, and the fences were a relatively minor inconvenience. In an interview with a local resident²², who lived at Port Harcourt during the conflict, he claimed that in his opinion the mine threat was greatly over-stated. PH5 was only considered suspect because the Argentine troops had booby-trapped the jetty with barrels of mines, and a mine had been found further downstream, causing the whole area to be fenced. He believed that all the mined areas had either never had mines in them, such as PH6, or had been cleared, as had PH3. He had roamed on foot or tractor all over the suspect areas before the fences had been erected. This may affect the approach to the clearance problem.

The mine problem

The main mine problem was the lack of detailed information, and the wide areas involved. There was anecdotal information available from a local resident (see above), and various conflicting reconnaissance reports from 1982 to 1985. There were five indicated mined areas, which were clearly fenced and marked.

- **PH1.** This is a small area of 2.04 Ha, on a steep slope falling down to a creek, and continuing just beyond it. The mine threat was of AP mines. There was a herd of cows grazing in it, and no record of recent incidents, and according to a local resident (see above), there were never any mines in this area.
- **PH2.** This is a larger area of 4.38 Ha, which again is stated to be clear of mines. It stretches up a hill, with upland grasses, but clumps of white grass in the middle, which would have to be cleared before any detection could start.
- **PH3.** This is a large area of 105.19 Ha, known as Clippy hill. In military terms, the purpose of this mined area is unclear and illogical, because it was in the middle of three military positions. According to a local resident (see above), this was mined, but the mines were removed, with his assistance, and he walked on

the area and kept stock on it until the fences were installed. This suspect area is shown on two reconnaissance sketches from 1983, but one shows a linear minefield to the north, stretching almost to PH2, and the other shows the whole area as being full of AP mines. There was a small flock of sheep in the valley in the middle of the twin hills, and no record of accidents since 1986. The vegetation is white grass and empetrum, but there are soft patches in the valley bottom.

- PH5 and PH6. These are along the edge of the Port Howard Bay, with a combined area of 16.67Ha. The suspect area starts at the jetty, and continues south. According to a local resident (see above), the area to the north just below the jetty was only declared mined because barrels of mines were used as booby traps to prevent use of the jetty, and some were washed off and may have shed their contents. The ground is sloping, with rough grass, and thick gorse hedges. It was recommended that the gorse should be trimmed back for inspection, but this was never done. There were signs of animal occupation, and early reports state that farmers held sheep on these areas. There had apparently been one accident in this area, but no reports remain.

Ecological considerations

Two main considerations should be made. Numerous birds were recorded in the area and can be assumed to be nesting. Clearance should therefore take place outside of the nesting season. Where this is impossible consideration should be given to preventing nesting within areas to be affected by the use of bird scarers prior to the nesting period. However, some of the areas are large and it may also be advisable to tackle these in sections to minimise short term population effects by preventing nesting over too large an area. Prior to clearance it would be advisable to execute a fuller bird survey to identify any active nest sites for raptors, and planning of activity should avoid these during the breeding season.

Secondly consideration needs be made to establishing rapid vegetative cover following any mechanical clearance options. It is difficult to predict exactly what the consequences of partial or slow regeneration of vegetative cover on peat soils will be, however it is unlikely to be benign and may require more complex interventions to be made in the future.

Clearance options

The beach areas of PH5 and PH6 will probably need visual inspection only, because it is unlikely that any beach mines remain intact. Rolling or tracking of the flatter areas might give some indication of the presence and pattern of any mines, and the same could be used on the top and bottom of PH1. On PH5 the stands of gorse can be clipped, but the main trunk and roots will have to be left intact, or erosion could take place. PH3 will need a major area reduction exercise. Some rolling could take place on the upper reaches of Clippy Hill, but further liaison with a local resident (see above) will be needed to ascertain where he believes that the mines were laid.

Logistics

The Port Howard settlement could probably accept up to 30 deminers, but making a start with a smaller team would be prudent, and allow the use of existing structures for accommodation. Equipment could be brought in by sea to the jetty. The road

network is good, and the tracks around the suspect areas are all reasonably firm as in general the ground is not as wet as on the East Island, but the boggy areas in PH3 may need special care. Local farmers were seen to use trail bikes.

Post-clearance remediation options

Reference to 6.2 should be made. Rolling should have little effect and Level 1 may be appropriate here if no mechanical clearance is used. If conducted with care the clearance of vegetation to allow manual investigations to take place should have no adverse long term effects.

FOX BAY SETTLEMENTS

History

During the conflict, there was a regimental position in the Fox Bay settlement, on both sides of the settlement, with an engineer troop on the east side. There are 10 recorded mined areas, of which FB1 to FB7 are on the West side, and FB8 to FB10 on the East. It is alleged that some mine records were received, but these are now lost. It was also alleged that some mine clearance was carried out by the Royal Marines, but again there are no records available. Signs of possible mine-laying were present in the form of support pickets, marker pickets, barbed and plain wire and the remains of trenches could be found in or near the fenced areas. Evidence from local people has revealed that there have been a number of mine incidents with livestock, which confirms that landmines remain in the area. That said, the last active incident involving a domestic animal took place in 1986. There is also evidence from the local population that following an accident to Major Hanbrook in 1983 the mine fences were extended a further 50 metres as a precaution, and there were signs that the SOP311 fences erected in 1990-91 extended the area still further.

Present situation

Due to undulation in the ground, there are places where sheep can push themselves under the fences, and domestic animals were seen in mined areas in the West, but no livestock were seen to have entered FB8, 9 or 10. Sheep dung could not be seen in the areas which could be observed from the fences.

Access

Access to both the East and West sides of the Fox Bay settlement is good, on grass tracks which are mostly comparatively flat and suitable for tracking machines if necessary. There is a small port in the bay, and a helicopter landing point. There is also a landing strip for small aircraft.

Landscape and the environment

Flora - Fox Bay West

FB1 Extensive Acid Grassland dominated area with Dwarf Shrub communities and small areas of Fachine scrub (*Chilotrichum diffusum*). FB1 is contiguous with FB7.

FB7 This mined area is a continuation from FB1 and has large areas of bare, eroded soil near to its juncture with FB1. The community type changes from Acid Grassland to Dwarf Shrub dominated communities, however there are areas of inland sand-dune vegetation by lakes of standing water with fringing Fen, Marsh and Swamp communities. FB7 continues into FB2.

FB2 This mined area is a continuation of FB7 and is dominated by Acid Grassland communities of White grass with inclusions of Dwarf Shrub Heath communities typified by Diddle-dee (*Empetrum rubrum*). FB2 continues into FB3.

FB3 This mined area is dominated by Acid Grassland, interspersed with Diddle-dee communities and areas of thin eroded soil associated with vehicle trackways and, possibly, animal holding areas. FB3 continues into FB4.

FB4 A continuation of Acid Grassland dominated by White grass (*Cordaderia pilosa*) communities.

FB6 Within the mined area fence the habitats comprise mainly Acid Grassland dominated by White grass (*Cordaderia pilosa*) communities and occasional Dwarf Shrub Heath communities. Outside of the excluded mined areas the habitats have the appearance of grazed semi-improved grassland with occasional clumps of Diddle-dee. The southern end of FB6 terminates at the shore of a maritime bay called South Arm where the communities are typical of Maritime cliff and slope with some communities of Montane habitat. FB6 is separated from FB5 by a stream that enters into the sea at South Arm.

FB5 This mined area is similar to FB6 with vegetation communities dominated by White grass and occasional areas of Diddle-dee. Near to the shore there are areas of 'Greens' where the vegetation is predominantly short fine grasses and plant communities of Maritime cliffs and slopes with areas of 'Feldmark' formation containing plants such as Balsam Bog (*Bolax gummifera*) and Cushion Plant (*Azorella selago*).

Flora - Fox Bay East

FB8 This mined area lies to the south of the main Fox Bay East settlement as a narrow coastal strip on either side of the headland. The vegetation communities are primarily Maritime cliff and slope with some Montane habitat (Feldmark formation).

FB9 Fox Bay 9 is divided into North and South sections by a vehicle trackway. The vegetation of both areas are dominated by Acid Grassland communities typified by White grass, with areas of Montane habitat and the occasional 'Green' where the local topography results in increased water availability. Eroded areas are typically found along vehicle trackways.

FB10 This mined area is dominated by short Acid Grassland with tussocks of White grass interspersed by areas of short fine grasses and occasional Dwarf Shrub Heath communities.

FB11 This mined area is located to the north west of Annie Brook's Bay and has vegetation communities typical of both littoral sediments and bare sand where it borders the shore. A freshwater stream with associated plant communities runs along the bottom of the valley and was bordered by short fine grasses interspersed with Diddle-dee and White grass. The valley sides had more extensive coverage of

White grass before emerging into areas of bare eroded soils at the top of the slope where some Montane communities were found.

Fauna

No penguins were observed within any of the FB mined areas although one colony of Gentoo penguins was observed in the vicinity of FB10. However, it is not believed that it should be necessary for the demining work to intrude on the rookery or the penguin 'highways' from the rookery to the shore.

Passerine (song bird) species included Long-tailed meadow-lark, Falkland thrush, Falkland Pipit. Waders include Black Oystercatcher, Pied Oystercatcher, Rufous-chested dotterel, and Two-banded Plover. Upland Goose (*Choenhaga picta leucoptera*) and Turkey Vulture (*Cathartes aura falklandica*) were commonly sighted.

Domestic animals

There are many herds of sheep and cows in the area, with some horses. Many were roaming freely inside the fenced areas.

Implications for demining

The vegetation in the area consists of short and long grasses, sometimes in the form of tussocks, with outcropping rocks and sandy areas, where the top covering of peat has been worn away. Some clumps of grasses up to 15 - 20 cm in height will have to be removed if manual mine clearance is to be used. There are also clumps of low mosses and cropped grass, and small ferns. There are occasional clumps of gorse bushes, often along the lines of fencing, which might also have to be removed. The rainfall in Fox Bay is less than in any other of the mine-affected areas, so there were some differences in peat layers compared to the Stanley Areas.

Fencing

All of the suspect areas are fenced with standard SOP311 fencing, all of which is in good condition. It is maintained under contract by a local landowner. He stated that the fences are generally in good repair. The JSEOD team monitors the condition of the fences fairly regularly, but due to reductions in staff cannot visit the West Island as often as the team members consider necessary. As with Port Howard, there are signs of the original UK fencing inside the fenced areas, as well as some Argentine defensive works.

Local population

The general attitudes expressed by the local people was that they were used to the mines by now, and that their presence is an inconvenience, and the impact of the mines is small. The landowners agreed that they would help the mine clearance where they could. Their initial opinion was that they would not use the land even if it was cleared, however this was modified after hearing of the IMAS clearance standards and quality management procedures.

The mine problem

Fox Bay has seven fenced suspect areas in the West Settlement (FB1 - FB7), and there were four in the East Settlement (FB8 – FB11), although two of these are divided into two parts.

a. West Settlement

- **FB1.** This is a small fenced area, to the north of the West Settlement, 4.11 Ha in size. There were no available records of the mined area in this area, but there are thought to be AP mines in the fence-line, and a horse was apparently injured in January 1983. Some pegs and pickets were seen, but these may have been part of earlier fencing. The area is covered in white grass and empetrum, and moderately flat.
- **FB7.** This is a large fenced area to the north of the settlement, 72.39 Ha in size, which formed an extension to FB1 on the western side. There are no available records of mine laying, but evidence of troop positions, and anecdotal evidence of mines, and a horse was injured in April 1983 before the SOP311 fences were installed. Some sapper mine clearance took place, but stopped after the injury to the commander of a squadron on FB4. The ground cover is white grass, with large clumps of empetrum. There is a slightly raised rocky plateau in the middle, with a peat bank, which was said to have been a company position.
- **FB2.** This area is connected to the western edge of FB7, and to the north west of the settlement. It is about 14.26 Ha in size. There are no minefield records, but a Mercedes jeep lost a tyre on an AP mine. There is a track between it and FB3 and 4, which lies to the west. The terrain is gently sloping, but rises up to the edge of the plateau in FB7. There are signs of earlier fencing inside the SOP311 fence. The ground cover is white grass, empetrum and Christmas bush.
- **FB3.** This area is also to the north west of the settlement, but further west than FB2. It is 20.62 Ha in size, and the main evidence of mining is that an agricultural tractor lost a tyre on an AP mine in August 1982. The ground slopes gently west towards a lake. There are fence posts to be seen inside the area, but the SOP311 fencing erected in 1990-91 was placed over 50m beyond the original fence line. This was attributed by a local landowner to the accident to Major Hanbrook on 15 January 1983, and one diagram shows the accident to have taken place in FB3, but in other documents the accident is placed in FB4. The terrain is white grass and empetrum, with flatter patches of sand and shale.
- **FB4.** This is a larger area, 50.65 Ha in size, almost due west of the settlement. Four incidents were said to have taken place due to AP mines between November 1983 and August 1984, including the accident to Major Hanbrook mentioned above. This is a flatter area, sloping down towards the south, with terrain covered by white grass and empetrum, but with similar patches of sandy shale as FB3. Sheep could be seen feeding in the area.
- **FB6.** This suspect area is south west of the settlement, and stretches down to South Arm creek, running due east along the creek for 300m. It is 23.77 Ha in size. The ground above the creek is reasonably flattish, but heavily covered by white grass, and empetrum crops out in large areas nearer to the creek. It was assessed in 1983 as being an AP minefield, but no records exist of its laying or partial clearance. No accidents or incidents have been recorded.

- FB5. This suspect area runs along the north edge of South Arm Creek, and is an eastern continuation of FB6. It is 17.56 Ha in size. At the western end, a road was constructed in 1990 to get access to a water reservoir at the creek's edge, but this is now no longer in use. The ground is relatively flat, but there are water runs in it. The vegetation is mainly white grass, with some empetrum. Nearer to the Fox Bay entrance, the peat thins down to a stony sea shore. No accidents or incidents have been recorded.

b. *East Settlement*

- FB8E. The mined area FB8 was laid to the east and west sides of a small promontory between Fox Bay entrance and South Shore. FB8E lies along the edge of South Shore, and the suspect area is 3.86 Ha in size. There is no record of accidents or incidents. The ground slopes up from the sea, and is mainly lightly undulating, with short grass, leading to tufts of white grass and empetrum.
- FB8W. The suspect area runs south from the East Settlement jetty, along the shore line to the bay entrance. It is 2.45 Ha in size. There is anecdotal evidence that it was the site of a BL755 strike, because parts of a crown were found, although this was not reported in an EOD search in 1984. The ground is a thin strip of well-cropped grass, leading to the rocky shore. To the south, it becomes the settlement rubbish tip, where all scrap metal, wood and animal corpses are dumped into the sea. It is highly unlikely that it is mined, as no signs of mining remain, although the EOD report from 1984 stated that there were trenches or shell scrapes on the promontory. There are signs of sheep ingress.
- FB9N. This is a linear mined area running north to south due east of the settlement. There were apparently trenches to the west of the suspect area. It is in two parts – the northern part is 6.27Ha in size, and contains a small local cemetery. It is bordered to the south by a cattle run. There are no records of mines, although an early mine map suggests that a record was held. There is a steep-sided re-entrant running through the middle, with thick white grass. In other places the ground is fairly flat, with a hard surface, thickly covered with empetrum and grass. There are signs that sheep have grazed in the area.
- FB9S. This is the southern end of FB9, starting at the cattle run, and continuing to the sea at Weasel's Bay. It is 7.19 Ha in size. It was originally marked at the seaward end by oil drums, but they have rusted away. The ground is undulating, but the grass covering varies from long white grass nearer the cattle run to short turf grass nearer the shore line. There are cliffs on the eastern shore where the suspect area meets the sea.
- FB10. This is another linear mined area, running north-west to south-east, round the eastern edge of a hill some 2 km east of the settlement. It is narrow, and 6.64 Ha in overall size. No minefield records exist for this area, but some signs of marking and pickets are evident, and some previous fence line, probably of UK origin. The terrain slopes upwards from the northern end, then gently downwards to the sea. The vegetation starts in the north with empetrum and grass clumps with small green ferns, but the white grass takes over to the

south end. The mined area ends at a rocky cliff descending some 10 metres to the sea.

- **FB11.** This suspect area surrounds Annie Brook's Bay, about 4 km from the settlement. It is 9.61 Ha in overall area. There are no minefield records for this area, and it is not recorded on early mine maps. The suspect area starts on the north edge of the beach, but extends some way inland, to higher ground overlooking the bay from the south. There are no obvious signs of mine-laying, but parts of an earlier fence can be seen. There are no reported accidents or incidents in this area.

Ecological considerations

Clearance of FB10 should be undertaken outside of penguin nesting periods and disturbance to the colony kept to a minimum. All 'highways' to the colony should be avoided or minimally disturbed by non-mechanical means.

Nesting passerines and waders species should be protected by executing work outside the nesting period. Where this is not possible it may be appropriate to exclude nest establishment in areas to be cleared, and areas used as operation bases, by the use of bird scarers before the nest season commences.

Prior to commencement of work more exhaustive bird surveys should be undertaken to determine whether active nest sites of raptors are likely to be disturbed and operations planned to minimise impacts on these sites taken.

The main issues with vegetation and soil conservation will be the timely reinstatement of vegetation cover following demining. It is unclear exactly what the consequences of partial or slow regeneration of vegetative cover on peat soils will be, however it is unlikely to be benign and may require more complex interventions to be made in the future.

Clearance options

The majority of the Fox Bay area is drier than most areas in the East Island, and the ground is harder. This would make rolling a more practical clearance or area reduction tool. In general, there are fewer peat banks or ditches, and no AV mine incidents have been reported, so the use of flails for vegetation removal or even surface impact might be a possibility. There was relatively little wind for part of the time of the visit, so the use of detection dogs might be a possibility in areas such as FB8, where the metallic rubbish at the bottom end would make detection by normal mine detectors impractical. Landowners might welcome the rotavating effects of milling, so that new grasses could be introduced.

Logistics

The settlements are limited in the number of people that can stay in the area, but teams of up to 15 might be acceptable to the local people. If not, mobile accommodation might be needed. Resupply would be relatively easy, as there is a regular boat from Stanley, which moors at East Settlement Jetty. Most of the ground can be driven on by 4x4 transport, unless it gets very wet.

Post-clearance remediation option

Providing mitigation suggestions are followed and no damage occurs within the penguin nesting areas or highways the only restoration required will be those related to vegetation reestablishment. Rolling should require little remediation, and Level 1 should suffice. Flailing will require greater remediation effort, most probably Level 2 of some form. If the soil has been disrupted Level 0 pre-treatment must be used as a precursor to addition of propagules.

GOOSE GREEN AND DARWIN SETTLEMENTS

History

The Goose Green and Darwin settlements saw some of the fiercest fighting of the conflict. The Argentine forces had laid several mined areas around the Darwin and Goose Green Parks, some of which were cleared by UK engineer units after the combat.

Present situation

Eight mined areas have remained, but evidence from the settlement manager suggests that there are very few mines in any of them. He ran cattle and sheep in the supposedly mined areas, and walked them himself without a problem. Some accidents did occur immediately after the conflict, but there have been no such accidents since 1983.

Access

Access to the mined areas is relatively good, because the surface soil is much less peaty than in the Stanley area, and the tracks are bumpy but not soft. There are a number of roads and tracks across the Parks area, which made access to the suspect areas very easy. The Parks area is undulating, but with no steep hills.

Landscape and the environment

Flora

GG2 Semi-improved grassland with grass species typical of nutrient improvement and reseeded. Some native species representative of Acid Grassland such as White grass, with damper grassland species in areas adjacent to the seasonal watercourse.

GG3 This mined area is dominated by White grass with occurrences of other species such as Pale Maiden (*Sisyrinchium jubatum*) and Vanilla Daisy (*Leuceria suaveolens*). Where the stream passes through the mined area plants typical of wet grassland are present including Pig Vine (*Gunnera magellanica*), Native Rush (*Juncus scheuchzerioides*) and Soft Rush (*Juncus effusus*).

GG5 This mined area runs in a strip along the Eastern edge of Brenton Loch and has plant communities typical of Acid Grassland on thin soils including White grass and Pale Maiden. There are areas of bare eroded soils, Montane and Dwarf Shrub Heath communities, with one depression that had short grasses typical of 'Greens'.

GG7 This area to the north of Darwin is characterised by thin acid soils with bare rock outcrops. Plant communities are typically those associated with White grass and representative of Acid Grassland interspersed with Dwarf Shrub Heath species.

GG8, 10, 11 and 12. All these sites are dominated by the species of improved grassland with the occasional presence of remnant Acid Grassland and Dwarf Shrub Heath species such as White grass, Diddle-dee, Pig Vine and Pale Maiden.

Fauna

Few song birds were noted within the mined areas apart from the Long-tailed Meadow-lark and Falklands Thrush.

Domestic animals

There are sheep and cattle in the area, and a large number of animal carcasses and skeletons, some inside the suspect areas. Inside the settlement hens were observed.

Implications for demining

The whole of the area is covered with shorter grasses, down to fine sea turf on the areas above the beaches. The soil appears to be thin topsoil over sandy loam. The surface is firm, and although there are watercourses running through some of the suspect areas, in the main they present little challenge to manual demining, and are flat enough to use rollers or other machinery where necessary.

Fencing

All the eight suspect areas are fenced and marked in accordance with SOP311, and were erected in 1991-2. They are maintained by the settlement manager who stated that some of them would soon need renewing, but were still in reasonable repair.

Local population

The only local person present was the settlement manager, who farms 150,000 acres locally. He stated that all the local community in Goose Green were well used to the mines and the fences, and were in no hurry to see them removed. They represented a tiny proportion of his land, and had a proportionately small impact. If they had to be cleared, he expressed great interest in the methods used to clear them, and stated that even invasive methods would be acceptable on his land because the soil was such that re-growth would occur. He stated that he and the other local inhabitants would help as much as possible.

The mine problem

As stated, there are eight suspect areas in Darwin and Goose Green, and these were all inspected from outside their perimeter fences. Information was also available from a reconnaissance report dated 13 October 1982. In this report it was claimed that many mines and booby traps had been removed after the conflict, but detailed records are not available.

- GG2. This is a small (0.89 Ha) suspect area in two parts, with a prominent track running between them. There are apparently two rows of mines, and the area was then fenced, but it is alleged that a Gurkha soldier was injured by a mine, although no records of that incident are available. The enclosed area has

clumps of longish grass, and there are the pickets in the enclosed area from an earlier fence. The fencing is intact.

- GG3. This is another small area (2.54 Ha), with no records of laying or clearance, and no accidents. The ground is covered with longish white grass, which would have to be removed before clearance. There is broken ground at the end, and a watercourse runs through it, making the area very soft going. It was considered in 1982 to be the most likely mined area with mines still uncleared, due to the vegetation.
- GG5. This is a strip area along the edge of Brenton Loch, about 2.37 Ha in size. Again, there were signs of previous fencing within the suspect area, and many animal bones inside and outside it. The 1982 report states that the mines were lifted, but 1 x AP mine was found. The surface is medium white grass in clumps, with areas of flat turf.
- GG7. This is a small (2.59 Ha) suspect area above the Darwin Settlement. There were no records of mine laying or clearance, but evidence was seen in 1982 of both AV and AP mines. There are pickets of an earlier fence, probably British. The surface is white grass, but with a sandy part in the middle. There are no records of any accidents or incidents.
- GG8. This is a slightly larger area, 6.29 Ha in size. There are no records, but booby traps may have been set, and two cows were apparently shot when they strayed into the area. This may be being confused with a reported accident when another cow was blown up in 1983, but the inner row of AP and AV mines had been detonated, and the holes remained. There was a stake in the middle with wire wound round it. The grass is long, and will need removal if the suspect area was to be cleared manually
- GG10. This is a small (0.88 Ha) suspect area, the nearest to the Goose Green Settlement. There were no records available, and no accidents were recorded, but the 1982 report stated evidence of AP mines. There were the signs of an earlier UK 1983 fence. There had never been any accidents, and there were no signs of animal incursions. The vegetation is longish white grass.
- GG11. This mined area is 2.06 Ha in size, and is situated at the end of a small promontory, which juts out into Darwin Harbour. It is stated to be the site of an accident in 1983 when the trailer of a tractor detonated an AV mine, but also that a Mercedes 4x4 was blown up in July 1992. Other debris showed that it was probably the site of a BL755 strike. The area is frequented by sheep, and by many geese. These keep the grass short, and there are patches of turf and patches of short white grass.
- GG12. This is a small suspect area, about 1.65 Ha, which stretches down towards Carcase Bay in Darwin Harbour. Unlike other suspect areas next to a coastline, this does not extend to the water level. The 1982 records state that there were holes for mines visible, but no mines, and sheep had deliberately been driven over the area, which had afterwards been walked over by soldiers and others. Despite this fact, it is fenced, and the pickets of an earlier warning fence can be seen. The surface is mainly long grass, but there are some patches of low ferns, and there is a watercourse that runs through it.

Ecological considerations

Nesting passerines should be protected by executing work outside the nesting period. Where this is not possible it may be appropriate to exclude nest establishment in areas to be cleared, and areas used as operation bases, by the use of bird scarers before the nest season commences.

Prior to commencement of work more exhaustive bird surveys should be undertaken to determine whether active nest sites of raptors are likely to be disturbed and operations planned to minimise impacts on these sites taken.

The main issues with vegetation and soil conservation will be the timely reinstatement of vegetation cover following demining. It is unclear exactly what the consequences of partial or slow regeneration of vegetative cover on peat soils will be, however it is unlikely to be benign and may require more complex interventions to be made in the future.

Clearance options

In many areas, the ground is flat enough to carry out area reduction using rollers or flails. In some areas, such as GG11, manually cleared check strips will be needed, to look for AV mines. In many of the mined areas, the ground has been so heavily trodden by stock that the presence of active AP mines is unlikely. The landowner has stated no objection to the use of flails or millers, and since most of the areas are small, and re-growth is possible, this system could be used.

Logistics

Goose Green is a small community, but there are sheds available which could be used as temporary accommodation for mine clearance teams. There is a working jetty, so re-supply could be done by sea, although the road from Stanley is reasonable. There is an airstrip, so casualty evacuation would be simplified. In many ways it is logistically less challenging than other areas.

Post-clearance remediation options

The only restoration required will be those related to vegetation reestablishment. Rolling and manual detection should require little remediation, and Level 1 should suffice. Flailing will require greater remediation effort, most probably Level 2 of some form. If the soil has been disrupted Level 0 pre-treatment must be used as a precursor to addition of propagules.

Some of the areas exhibited traits suggesting some forms of agricultural improvement had been undertaken prior to mining. It may be appropriate to restore these areas using more productive grass mixes if the owners prefer.

STANLEY AREA 1

History

Stanley Area 1 lies to the east of Stanley, and consists of the whole of the promontory on which Stanley Airport stands. It includes 23 suspect areas, of which 13 have been cleared, which were mainly booby-trap areas. Since Stanley Airport was one of the main supply routes for the Argentine forces on the Islands, the bays to the north of Stanley Airport were mined and defended against seaborne assault. Area 1 also includes the narrow neck of land joining the promontory to the Stanley Common area, to the east of which is Surf Bay, which was also mined and to the west of which is the Canache. Some data is available on these mined areas, and the original minefield records have been retained, and are now in possession of the JSEOD section in Stanley. Some of the booby-trap fields were cleared, especially those nearest to Cape Point, and are now unfenced. Attempts were made to clear some of the mined areas, but no records were kept of the number or location of the mines cleared. Some accidents to engineer plant equipments occurred during the clearance of a route for a fuel pipe, but there have been no recorded accidents involving humans or livestock, probably because no livestock live on the airport promontory.

Present situation

The mined areas along the coves to the north of the promontory have remained very much as laid, but in the period between the conflict and 2006 the sand dunes have grown immensely in size, especially in Yorke Bay, and some of these dunes are thought to have built up directly over rows of mixed AP and AV mines. This provides a major challenge to the removal of the mines. The same applies to a lesser extent in Surf Bay. Since the dune land has apparently become a tourist attraction, the restoration of the sand dunes (if they have to be removed) may become a factor of the clearance. There have been few incidents, because there are no livestock roaming on the Airport promontory.

Access

There is good access to the promontory via the airport road, and there a number of firm tracks on the promontory itself, and near Surf Bay, the most southerly extremity of Area 1. Off the roads, the tracks are hard until the sand area is reached. Among the dunes, especially in the dune area east of Yorke Bay, the ground is so soft that sand tracks will be necessary on tracked vehicles such as a BV206, or special matting will have to be brought in to allow vehicle movement.

Landscape and the environment

Flora

Stanley Area 1 is dominated by the mined areas associated with the massive sand dune complex of Yorke Bay and to a lesser extent by Surf Bay and Stanley Airport. The plant communities include the vegetation of the supra-littoral zone, such as Sea

Cabbage (*Senecio candicans*), and Curled Dock (*Rumex crispus*) as well as more permanent vegetation types found on the sand dunes themselves such as Marram (*Ammophila arenaria*) and Lyme Grass (*Leymus arenarius*). Behind the sand dunes are areas of bare rock and eroded soils with patches of Montane, Maritime, and Dwarf Shrub Heath communities and White grass, Fachine, Pig Vine, Thrift (*Armeria maritima*), and Nodding Club-rush (*Isolepis cernua*), sedges such as Sword Grass (*Carex trifida*) and grasses such as Cinnamon Grass (*Hierochloa redolens*). It is understood that some vulnerable plant species, such as Dusen's Moonwort (*Botrychium dusenii*) are to be found just inland from the sand dune complex.

Fauna

Magellanic penguins are found with their breeding burrows in the suspect area on the peninsular to the north of Yorke Bay within the Gypsy Cove Nature reserve area. Song birds noted included Grass Wren (*Cistothorus platensis falklandicus*), Falkland Thrush and Long-tailed Meadowlark.

Domestic animals

There are no officially-owned domestic animals in the area, and none were seen on the promontory.

Implications for demining

The whole of the area of the promontory itself is flattish, but has rock outcrops nearer to the edges of the coves, and medium to deep sand dunes. The vegetation on most of the rest of the promontory consists of grasses, flatter sand and stone areas, and ferns, with occasional stream beds and ditches.

Fencing

All the individual mined areas are fenced with SOP311 fencing, but mined areas 18, 17, 15, 14, 5A and 7 are all within a common fence line, and there is a common fence around mined areas 5 and 4.

Local population

The local population used to visit Surf Bay as a bathing beach before the conflict, and the same applied to Yorke Bay, where the penguins can be seen from behind the fence line. The penguins apparently do not object to humans on the beaches. There is a degree of local opposition against the clearance of the mined areas in this area, because of the environmental damage that might be caused to the dunes. The fact that the dunes are self-healing does not mitigate the opposition.

The mine problem

The mined areas were approached as near as possible during the visit, but the dunes made walking impractical, and the common fence mentioned above meant that access to some of the mined areas was limited. The mined areas are described in the order in which they were seen.

- M117. This is not a mined area at all, but a contractor's spoil heap which it is thought contains a mine, because there were mines in the area from which the spoil was taken. It is 0.14 Ha in size, with dump tracks all round it, and room to spread out the spoil in the heap for examination.

- M18. This is a small suspect area, and is the north-western point of Yorke Bay. It is 0.55 Ha in size, and leads directly onto M17. It is a recorded mixed minefield, with 64 AV mines and 56 AP mines. No clearance has been attempted. The terrain is difficult, with tufty beach grasses and bushes above the beach line, and a sandy soil, becoming more sandy as the beach line moves south and east. There is a colony of penguins that live at the north end of the beach. M18 is within the common fence in the dune area.
- M17 and M15. These two mined areas follow straight on from M18, and together are 6.38 Ha in size. Both are recorded, and together contain about 308 AV mines and 446 AP mines of various types. There are mine row markers to be seen, and at least one row leads directly into a major sand dune area. The whole terrain is increasingly made of dune sand, capped with marram grass. Clearance will require removal of some of these dunes, which are now considered a beauty spot by some of the local inhabitants.
- M14. This is another recorded mined area within the dune fence area. It is 0.53 HA in size, and it contains 118 AV mines and 44 AP mines. It is completely covered with dune sand, which will require some form of removal before clearance is attempted.
- M5a and M7. These two mined areas lie to the east of Yorke Point, outside Yorke Bay. They are recorded, with a total area of 4.88 Ha. Together they are said to hold 5 AV mines and 411 AP mines. They are also contained within the dune common fence, and in places completely covered with dune sand. A Combat Engineer Tractor and Caterpillar D6 Bulldozer were blown up in this mined area, while trying to install a fuel pipeline. Routes were cleared to extract the machines in December 1982 and January 1983, but no mines were found during this clearance process.
- M5 and M4. These are small mined areas, laid to protect possible landing sites, east of M5a and M7 but within the dune common fence. They are 0.71 Ha and 0.41 Ha in size respectively. M5 contains 39 AV mines and 1 AP mine, and M4 contains 46 AV mines and 23 AP mines. As with the other mined areas above, they are covered with dune sand, with all the attendant problems of clearance.
- M8. This mined area lies on the south side of the promontory, and straddles the road to Stanley Airport. It is split, with majority being to the east, and a small section to the west. The total area is 4.38 Ha. It is recorded and fenced. It is recorded, and there are said to be 533 AV mines, and 454 AP mines. The terrain is difficult, lumpy and uneven with tufty grasses and sand above the beach line on either side. There are former military positions in the dune area.

Ecological considerations

There are two highly significant ecological challenges to demining within Stanley Area 1: penguin burrows and large areas of dune formations.

The presence of Magellanic Penguin within the mined of north York Bay should be considered a severe constraint to demining activity and methods used. This species, classified as a breeding migrant on the Islands is internationally important. They breed in downward sloping underground burrows up to 2m in length, usually located in soft soil or peat, on slopes facing the sea. Falkland birds return to their burrows

about the 12-14 September and egg-laying commences around mid-October and incubation lasts for 38-41 days. Fledglings leave their burrows in late January and adults vacate the sites after their moult in March.

The large areas of dune present an ecological problem. They arise primarily through the presence of the introduced grass *Ammophila arenaria*. As such they represent an area of low ecological value in terms of native flora of the Islands. However, their reconstruction would undoubtedly be required. The dismantling and reassembly of these in the highly windy environment presents a considerable ecological challenge. The problems of sand blow from poorly controlled demining activities, because of the potentially large area impacted, are a real concern. The plant Dusen's Moonwort (*Botrychium dusenii*), nesting passerines and possibly wader and geese are to be found immediately inland from the sand dune complex and impact of wind blown sand presents a considerable threat to these.

Elsewhere nesting passerines and waders species should be protected by executing work outside the nesting period. Where this is not possible it may be appropriate to exclude nest establishment in areas to be cleared, and areas used as operation bases, by the use of bird scarers before the nest season commences.

The main issues with vegetation and soil conservation on areas of peat soils affected will be the timely re-instatement of vegetation cover following demining. It is unclear exactly what the consequences of partial or slow regeneration of vegetative cover on peat soils will be, however it is unlikely to be benign and may require more complex interventions to be made in the future.

Clearance options

Area 1 presents what is probably the most challenging mine clearance problem in the Falkland Islands (Islas Malvinas). There is no doubt that to reach the mines in the sand dunes, parts of the dunes will have to be dug away. This will be a slow and labour-intensive procedure. It may be necessary to try to rebuild some of the dunes after clearance has been completed, because spreading the sand out on the shore and allowing nature to carry out the restitution will not produce a quick enough answer. There is no method of detecting individual mines in deep sand. Bomb locators work because there are changes in the earth's magnetic field, but a plastic low metal mine will not be detectable by this method. Deep penetrating radar is also unlikely to have the resolution to detect mine-size targets, so exposure may end up as the only answer. It will be necessary to carry out trials to establish how the sand can best be moved without causing an environmental problem, and what methods of restitution can be applied, at what cost.

Logistics

It will be relatively easy to approach the dune area via the Stanley airport road, but once in the dune area, some form of artificial trackway may be needed to reach the inner mined areas. Sand shifts a considerable amount in high wind, so even the trackway may have to be raised periodically and repositioned. Some form of sand-moving equipment will be necessary. Accommodation and re-supply will be simpler than in many areas, because Stanley can accommodate relatively large numbers of deminers. Casualty evacuation, where necessary, will be quick to reach the hospital on the Islands.

Post-clearance remediation options

There are no known protocols for nest burrow reconstruction therefore any mine clearance operations directly affecting Magellanic penguin nesting burrows in Yorke Bay should be of minimally invasive forms such as manual clearance. In any event all these should be undertaken outside the nesting period. All areas of penguin use in Yorke Bay beyond the nesting burrows should likewise only be cleared outside the breeding season. However, if cleared outside that period areas like the beach might be suitable for more invasive methods such as flails if absolutely necessary.

The impact of an uncontrolled loss of sand from the dunes represents a considerable threat. Methods of containment of cleared sand before attempting recreation of individual dunes would undoubtedly be necessary and require developing and testing before large scale mine clearance operations are undertaken.

Stabilisation and re-establishment of sand dune systems is however something of a 'known art' and a number of stabilisation and planting protocols could be deployed following clearance. However, again owing to the lack of experience with the use of these methods in such extreme winds as those experienced on the Islands, it is strongly recommended that combinations of methods of providing mechanical stability, together with planting and surface treatment, are tested prior to wholesale attempts to move these dunes.

Whatever methods are ultimately used it is strongly advised that the 'processing' of dune material is undertaken in stages, not least to minimise the impacts of loss of control of the material.

STANLEY AREA 2

History

Stanley Area 2 contains a ring of 34 mined areas or booby-trap fields surrounding Stanley to the south from the edge of the Canache in the east to the lower slopes of Sapper Hill in the west. These were laid to defend Port Stanley against attack from the sea, and to protect defended positions in Sapper Hill and Mount Tumbledown. Data on some of these mined areas are available from the original minefield records, and these are held in the JSEOD section in Stanley. All but three of the mined or suspect areas are fenced off by a single linear fence called the Stanley Common Fence, which starts from a point near the Airport road, runs past Rookery Bay, and proceeds south-west across the road to Eliza Cove to a point almost due south of Stanley before rising north-west to the main Stanley to MPA road. After this, it turns south again to Mullet Cove. The fence encloses 325 Ha east of the road to Eliza Cove, and 652 Ha to the west of it. It is normally only possible to view the suspect areas from the Common Fence, but special permission was granted to enter the prohibited area inside it and view those suspect areas which were not visible from outside. Immediately after the conflict, some Royal Engineer units carried out limited mine clearance on some of the mined areas in 1982-3, but due to their lack of knowledge of non-military mine clearance requirements for data recording, none of

the individual mined areas can be declared as being fully cleared, and remain individually fenced, both outside and inside the Stanley Common Fence.

Present situation

These mined areas have remained very much as laid. Most of the suspect areas are known to be mined, and estimates are available of the numbers of mines left in the area after partial clearance. Only three areas (M108, M95 and M65) are completely unknown. All are large (about 23 Ha each), and although M95 many contain 96 AP mines and M108 may contain 30, M65 may contain none. There have been few incidents, because there are hardly any herds of livestock in this particular section of the Islands, and the Common Fence is a deterrent to incursions by animals and humans.

Access

Access to the Stanley Common Fence is generally easy from Stanley, from the MPA road and from the paved road to Eliza Cove. Off the paved roads, there are sections of the track along the Common Fence that are so boggy that they would be impassable to Landrover-type 4x4 vehicles, even in the summer season. BV206-type vehicles, Quad-bikes and trail bikes can be used in most places for most of the year. On well-used tracks, where the peat had been broken or washed away, there are deep ruts in the peat over 1m deep. Access inside the Stanley Common Fence is more difficult, because there are few entry points, and only one marked safe lane track running through it. Like most tracks in the south of the islands it had to pass over ditches and very steep peat banks, and in places is very boggy. It might be necessary to reinforce the track if much traffic needs to use it. The paved road down to the tip at Eliza Cove runs through the middle of Area 2, and gives easier access to some of the mined areas nearby.

Landscape and the environment

Flora

Close examination within the Stanley Common Fence was restricted. Landscape assessment using binoculars showed the presence of the following habitats within the area:

Littoral sediments; Maritime rock, slope and shingle; Sand dunes; Eroded areas: both acid soils and peat 'scars'; Acid Grassland; Dwarf Shrub Heath; Neutral grassland and 'Green's' (wet grassland); Fen, Marsh and Swamp; Bog; Streams together with areas of Standing Open Water. Identification of the specific components of these was not fully possible with the exception of Whitegrass (*Cordaderia pilosa*) and Diddle-dee (*Empetrum rubra*).

Outside of the Common Fence (63A, 63B, 110) the mined area habitats are predominantly short Acid Grassland and Dwarf Shrub Heath with some indications of improved pasture and garden escapees.

Fauna

Magellanic penguins were observed on the shore of bays within the fenced area in Rookery Bay, in the east of Stanley Area 2, and Gentoo penguins are also reported as being present. It is probable both species are breeding here.

Common species of passerine such as the Long-tailed Meadowlark and Falkland thrush were observed in a variety of habitats. The Grass Wren was observed in areas of tall grass and sedge. Other species observed include: the Rufous-chested Dotterel; Two-banded Plover; Common Snipe (*Gallinago gallinago*); Upland Goose and Turkey Vulture. Evidence of both rabbit and hare were observed.

Domestic animals

There were some horses in the area, mostly in the east, near Stanley. There were few sheep, except those that had escaped from abattoir enclosures. There are signs that such sheep have managed to get into at least one of mined areas.

The whole of the area south of Port Stanley is flattish to gently sloping, with watercourses, soft wet flush sites and peat hollows. Low coastal dunes occur in the east north between the Canache and Rookery Bay, some of which have already begun to engulf the mined area fencing. The sandy areas are backed by a low, poorly-drained strip with small ponds. The bulk of the land has peat over a layer of sticky, impermeable clay. The peat layer is particularly thick along the Common Fence in the eastern section. 4.1 m depth has been proved, and in other areas the peat layer is consistently thick (30 – 100cm). The mainly gentle relief is broken by a few rocky outcrops and peat banks. Several large ponds occur within the Common Fence, notably Pebbly Pond to the east, and Round Pond and Mile Pond to the west. The vegetation in the area mainly consists of clumps of short and long white grass, with mosses, low ferns and empetrum shrubs. In some areas inside the Common Fence the empetrum has completely dominated the area, which will make clearance difficult. There are occasional clumps of gorse bushes.

Fencing

All of the suspect areas outside the Common Fence were fenced with standard SOP311 fencing, which remains in good condition, because it is maintained by a local landowner. The same applies to the Stanley Common Fence itself. Inside the Common Fence the original marking and wiring is used, because the public have no legal access. The JSEOD team monitors the condition of the fences on a regular basis. In many cases there are signs of other strands of fencing inside the fenced areas, some of which were probably of UK origin, and some were probably part of an Argentine mine fence or part of a defensive low wire entanglement.

Local population

The general attitudes expressed by the local residents were entirely positive towards the activities of the Cranfield University Survey Team, but they clearly stated that they are used to the mines by now, and that their presence was an inconvenience, which did not affect their livelihood.

The mine problem

These are addressed in two groups – those that were inspected from outside the Stanley Common Fence, and those that were inspected inside the fence. In both cases the mined areas are listed in order from east to west.

a. *Those inspected from outside the Common Fence*

- M97/98. These are recorded mined areas, on the coast just south of the Airport Road, and south of the Canache. They are about 1.20Ha in size. There are stated to contain 142 AP mines in total. These mines are possibly the source of the mines found in the east of Rookery Bay, moved there by tidal action. The terrain back from the beach is uneven small and large dunes with flattish areas between. The dunes are capped with marram grass.
- M11. This is a recorded mined area on the beach in Rookery Bay, but whose northern boundary can be seen from the Stanley Common Fence. The size is 1.12 Ha. The records are contradictory. It is now estimated that there are 75 AV mines and 88 AP mines. The terrain is sandy dunes back from the edge of the beach, and there are picket lines visible. There are reported to be sheep grazing in this area.
- M99. This is an unrecorded suspect area, about 500m inland, and one km west of M97/98. It is 0.61Ha in size. It is said to contain 48 AP mines, based on information from POWs. The terrain slopes down from Stanley, and there are outcropping banks of peat, with white grass and empetrum.
- M42. This is a recorded mined area, running south-west along the Common Fence, containing 253 AP mines. It is 1.99 Ha in size. The terrain is flattish, but contains large soft sunken areas where the peat is covered with large clumps of empetrum and white grass, which can easily be penetrated by vehicles. There are also peat banks, which make movement difficult.
- M43. This is also a recorded mined area, further along the Common Fence from M42. It is 2.25 Ha in size, and said to contain 300 AP mines. The terrain is mainly slightly uneven but this is difficult to gauge as the clumps of empetrum are up to 15 cm tall, which hides the contours of the ground beneath.
- M45/46. This is a deeper mined area, with its north edge abutting the Common Fence, and its western end next to the road to Eliza Cove. It is 13.91 Ha in size. It is recorded, and is stated to contain 517 AP mines. Its starting point is marked with a prominent oil drum. The terrain is much the same as the other mined areas; uneven surface, with white grass, empetrum and some clumps of fern, but some areas show signs of burning, with the peat showing through the burnt-off vegetation. The track to the north along the Common Fence has worn through the vegetation in many places.
- M49. This mined area starts to the west of the Eliza Cove road, again along the line of the Stanley Common Fence. It is 3.77 Ha in size. It is a recorded mixed minefield, which is stated to contain 84AV mines and 165 AP mines. The pickets of a British fence line can plainly be seen. The terrain is flattish, but shows signs of burnt areas. Other areas are being colonised by dense ferns and red sorrel, replacing the normal white grass.
- M50 A/B, 66. This is a large mined area, 18.41 Ha in size, running due south west from M49 along the Common Fence line. It is a recorded mined area, and is said to contain 160 AV mines and 253 AP mines. The ground is flattish but uneven, with mainly white grass, but isolated clumps of empetrum and ferns. Again, the original British fence can be seen.

- M52. This is a smaller mined area, 1.35 Ha in size, about one km north of the end of M50/66, but still on the Common Fence line, and beginning to slope north-west towards Sapper Hill. It is a recorded mined area, but the records seem inaccurate. It is stated that there were originally 80 AV mines present, but 89 have been removed since 1987, so the total number emplaced is still uncertain. The terrain remains uneven, and the vegetation is mainly thicker and longer white grass.
- M53. This mined area is still on the Stanley Common Fence, but is sloping upwards in a north-west direction towards Sapper Hill. It is 1.67 Ha in size. It is a recorded mined area, and is stated to consist of 49 AV mines and 165 AP mines. The terrain is sloping, uneven, and covered with longish white grass, but there are burnt areas, and the track gets very boggy near this point.
- M22. This is the last mined area of the Stanley Common Fence before it turns south to Mullet Creek. It runs close to the Stanley - MPA road at its western end. It is about 400 m in length, and 2.16Ha in size. It is a recorded mined area, stated to contain 240 AP mines. The ground slopes south east from Sapper Hill. The terrain is reasonably flattish, and covered with white grass, with occasional rock outcrops, and patches of ferns and empetrum.
- M63A. This and the following two suspect areas were the three mined areas not included in the Stanley Common Fence. The area of M63A is 0.79 Ha. It was reported as phoney, but P4B mines were found, some of which were lifted by UK troops, but no records exist of the mines removed. There are now estimated to be 200+ AP mines in the area. From the length, there were possibly 10 panels in all. There were signs of marker pegs and wire. Clearance could be done by check lanes to establish if a pattern can be found, followed by manual clearance down the line of mines, and rolling of the remainder as a confidence measure.
- M63B. This is also linear, set slightly to the south of M63A, and 0.44 Ha in area. Again, no records exist of the number of mines, or of the success of clearance by UK troops. The mined area is dominated by an Argentine knife-rest defensive barrier, but where the mines are within the barrier cannot be seen, although there is a bottle buried neck-down as a lane marker. Clearance can be achieved by removing the entanglement, by check lanes to establish if a pattern can be found, followed by manual clearance down the line of mines, and rolling of the remainder as a confidence measure. There is a hole or watercourse in part of the entanglement that may need manual checking.
- M110. No records exist, but information from POWs alleges that there are AP mines and booby-traps made with TNT slabs, 105mm HEAT rounds, mortar bombs or rockets. The mined area is 1.37 Ha in size, is sloping to the north, and covered in low wire entanglements, with many wires and pickets with wires stretched in between. No signs were seen of booby-trap tripwires. Parts of the mined area appeared to be phoney, and in other parts the mines have been surface-laid in the disarmed state, Clearance can be achieved by removing the entanglement, by check lanes to establish if a pattern can be found, followed by manual clearance down the line of mines, and rolling of the remainder as a confidence measure.

b. Those inspected from inside the Common Fence

- M97/98. This is a recorded AP mined area, 1.20 Ha in size, with some 96 mines. The front fence of this mined area was seen from outside the fence, but the rear fence is a double strand of wire on pickets, which in one area had been completely enveloped in an advancing sand dune. This was the site of an accident, in which an Sapper officer lost a leg. Being close to the access point, this might make a useful training area for operations in sand, which will be the predominant terrain feature in Yorke Bay and Surf Bay.
- M101. This is a recorded mined area, running along the edge of Rookery Bay. It apparently contains 12 AV and 24 AP mines. The mined area is 1.01 Ha in size, and the terrain is sandy and stony above the beach line, with short white grass, which could be rolled in places. There is a cleared booby trap area parallel to it.
- M100. This is an unrecorded mined area, 1.21 Ha in size, said by POWs to contain 175 AP mines. The terrain is undulating, with part appearing to be dunes and peat. In other places it is similar to M101.
- M21. This is a small recorded mined area on the coast, 0.72 Ha in size, in the next bay down from Rookery Bay. It is fenced, and said to contain 8 AV mines and 11 AP mines. The terrain is mainly short white grass and large areas of empetrum.
- M20. This is a booby-trap field, recorded but believed to have been cleared of 30 booby-traps. It is situated parallel to but behind M102. It is about 0.99 Ha in size. The terrain is similar to M21.
- M102. This is recorded as a mixed mined area, 1.36 Ha in size, stretching down towards Phillips Point. It is said to contain 156 AP mines and 50 AV mines. The rear marker fence is clear to see, and the terrain is sandy turf and short white grass.
- M40. This is a thin AP barrier minefield, 1.14 Ha in size, with UK fencing still visible. It was recorded, and thought to contain 223 AP mines. The terrain is uneven, mainly clumps of white grass and empetrum.
- M108. This is as a large area about 22.49 Ha in size, with no records but reported by POWs to contain 32 AP mines. It is fenced, and the terrain is similar to M40, grass and empetrum, with stream beds running through it.
- M106. This is a mixed barrier minefield, 2.66 Ha in size. It was reported by POWs, with unknown numbers of AP and AV mines. Again, the ground appears flattish, but covered with empetrum and white grass. The rear fence is marked with UK fencing.
- M83. This is a barrier of booby traps inland from the rubbish tip area of Eliza Cove. It is 1.62 Ha in area. It is said to have been cleared in 1984, but remains a suspect area. The terrain is again mostly white grass and empetrum.
- M51. This is a recorded mixed mined area around Eliza Cove, 4.12 Ha in size, thought to contain 130 AV mines and 254 AP mines. Some clearance was done in 1982 by UK military, and further clearance by JSEOD, during which a REDFIRE was destroyed by an AV mine high order explosion during burning.

The terrain is mostly rocks and sandy grass near the beach, changing to longish white grass further inland. This would make a good deminer training area because of its proximity to the rubbish tip road.

- M95. This is another wide area, about 11.80 Ha in size, recorded as having 96 AP mines and two booby-traps. The terrain is undulating, with longish white grass and isolated clumps of empetrum. There were also some rocky outcrops.
- M65. This is yet another wide area, 22.98 Ha in size, to the north of M95. It is unrecorded, with no information of any kind to justify its inclusion as a suspect area. The terrain is similar to M 95, undulating, with longish white grass and empetrum.
- M64. This is a recorded mixed minefield, 2.02 Ha in size, said to contain 32 AV mines and 84 AP mines. It is fenced, and a P4B mine was visible on the surface. The terrain is mainly white grass, ferns and empetrum, but with many rocky outcrops.

Ecological considerations

Close examination of all mined areas was not possible and it is impossible to judge exactly what restrictions to operations might be present beyond those that were immediately apparent. As such more detailed survey should be undertaken before demining operations are planned, in particular before any clearance work is undertaken the entire coastal stretch encompassed by Stanley 2 should be thoroughly surveyed for the presence of over-looked or new small nesting colonies of both penguin species observed in the area.

As elsewhere on the islands the presence of Magellanic and Gentoo Penguins within Rookery Bay should be considered a severe constraint to demining activity and methods used. Where they are present in Stanley 2 they can be considered as providing a very visible challenge to successful environmentally appropriate operations. Both species are internationally important.

Magellanic penguin and their burrows

Magellanic are considered breeding migrants on the Islands. They underground burrows, excavated in soft soil or peat. Island birds return to their burrows around the 12-14 September, beginning egg-laying around mid-October. Incubation lasts for 38-41 days with fledglings leaving their burrows in late January. Adults vacate the sites after their moult in March.

Gentoo penguin colonies and highways

Gentoo's are a breeding resident using mainly low, open coastal heath or grassland sites, usually hundreds of metres inland. The penguins travel from the sea to the colony via well defined traditional 'highways'. Establishment of colony groups and nest building occur in late September with egg-laying in mid to late October. The young begin to enter the sea in late February/early March. Guidance notes²³ advise that during the breeding period Gentoo's are vulnerable to disturbance and that breeding sites should be avoided by a distance of at least 50 metres, *where they cannot be avoided altogether*. For the level of possible disturbance arising from demining with machinery this should be considered to be an absolute minimum and machinery use closer than 300-500m to a colony should only be undertaken

following investigation as to the species responses to trial disturbances. In any event it would be advisable not to undertake any clearance close to colonies, especially mechanical, during the breeding season.

Ground-nesting birds

The remaining bays and coves are likely to support breeding waders and beyond the areas affected by penguins operations here should again be executed outside breeding season.

The bulk of Stanley 2 covers large areas of oceanic heath and will support many pairs of breeding passerines. Nesting season for most of these species encompasses August to January. Clearance operation should avoid these periods if possible. If this is not possible then some consideration could be given to preventing nesting in areas to be cleared during nesting periods by use of scaring devices. However, the total area of mined areas in Stanley 2 is large and to prevent local bird population depression it is strongly recommended the operation is undertaken in discrete sections within the area over the course of a few years.

The area of Stanley 2 also contains areas of open water. These may support invertebrate populations of interest although this could not be ascertained during the visits. They may also support nesting geese. Damage to these should be avoided.

Vegetation

The main issues with vegetation and soil conservation will be the timely re-instatement of vegetation cover following demining. It is unclear exactly what the consequences of partial or slow regeneration of vegetative cover on peat soils will be, however it is unlikely to be benign and may require more complex interventions to be made in the future.

Clearance options

One of the major factors affecting the clearance options will be the state of the peat, and the extent to which mechanical equipment can be used without causing major environmental damage. Another factor is the sheer size of some of the suspect areas such as M65 and M95. If these areas are not to waste time and resources, some method of area reduction will be necessary. Machines can be used to create safe lanes or test strips may be a sensible compromise between the environmental and resource pressures. The use of mine detection dogs should not be ruled out, but the prevailing winds may severely limit the number of hours per week that they can be used, unless some form of screening can be developed. In the sandy areas to the east, the small dunes can be removed by digging out. This could provide a good trial area for digging techniques. The Eliza Cove area could also make a good trial area for demining, with its alleged high mine content, but good road and telephone access.

Logistics

There would be no problem in setting up an accommodation and re-supply base in Stanley for about 60 people, and if necessary this could be increased incrementally as the mine clearance programme developed. There is no problem in getting to the edges of the area by the MPA Road, but the internal tracks are poor, and might

require some preparation before being negotiable to wheeled 4x4 vehicles. This preparation would have to be discussed with the landowners.

Post-clearance remediation options

There are no known protocols for nest burrow reconstruction therefore any mine clearance operations directly affecting Magellanic penguin nesting burrows should be of minimally invasive forms such as manual clearance. In any event all these should be undertaken outside the nesting period. All areas of Magellanic penguin use in Rookery Bay beyond the nesting burrows should likewise only be cleared outside the breeding season. However, if cleared outside that period more invasive methods such as flails in these areas might be acceptable.

The creation of new nesting areas as part of the demining process could bring ecological benefits and should be considered.

Vegetation remediation will depend on the final choice of clearance methods to be used. Rolling should require little remediation, and Level 1 should suffice. Flailing will require greater remediation effort, most probably Level 2 of some form. If the soil has been disrupted Level 0 pre-treatment must be used on all peat soils as a precursor to addition of propagules. Trials must be undertaken to establish exactly how much damage does occur with all mechanical methods.

STANLEY AREA 3

History

The eastern end of Stanley Area 3 starts at the western end of the Stanley Common Fence, and covers the area from Sapper Hill in the East to the slopes of Two Sisters, Wall Mount and Mount Harriet to the west, a length of about 12 km. It is bordered to the north by a line about two kilometres north of the main Stanley to MPA road, and it extends as far west as mined areas 59, 60 and 91B. It is roughly bisected on an east-west axis by the Stanley-Mount Pleasant (MPA) Road. There were many defended positions to the west of Stanley, mainly to defend the military force positions in the town when it became obvious that the main threat was an attack from the west rather than from the sea coves to the east and south. This led to the laying of a series of mined areas north and south of the road, near Wall Mount and Mount Harriet. Immediately after the conflict, the various Royal Engineer units carried out limited mine clearance, but due to their lack of prior training on non-military mine clearance, few records were kept, and none of the individual mined areas can be declared as being fully cleared.

Present situation

These mined areas have remained very much as they were when landmine clearance stopped in 1983. It contains 19 mined or suspect areas, of which only five have no recorded data. The remaining mined areas have some of the original records, but no records of any clearance done after the conflict, which leaves some

doubt as to the status of the area concerned. M36 had a visible AP mine which had fallen from a peat bank, and M56 had casualties during the partial post-conflict clearance. There have been few incidents in Area 3, because there are few herds of livestock in this particular section of the Islands except for one herd of beef cattle, and almost no incursions have been made by cows or sheep.

Access

Although there are no roads running south from the MPA road, access to the 19 mined areas is in general reasonable, especially for the 11 sites that abut that road, but where peat tracks have to be traversed, there are boggy patches, which make them impassable to landrovers, but still passable to quad-bikes and BV206 vehicles. The northern end of the Area has harder ground, but M59 is partially on the side of a rocky hill, and partially on a soft and wet valley, neither of which are easy to access. The off-road conditions deteriorate badly in the wet season. All sites are within about 30 minutes of Stanley.

Landscape and the environment

Flora

One notable geological feature within the Stanley 3 area is the presence of periglacial rock striping. These support a fair lichen flora and specialist vascular species such the stonecrops and occasional distinctive cushion plants (*Azorella sp.*)

Stanley Area 3 comprises a large area of essentially homogenous habitat, with most mined areas covered in mosaics dominated by Whitegrass (*Cortaderia pilosa*) with Pig Vine (*Gunnera magellanica*) and dwarf-shrub heath with Diddle-dee (*Empetrum rubrum*) Christmas Bush (*Baccharis magellanica*) Balsam Bog (*Bolax gummifera*) and the pteridophytes Tall and Small Fern (*Blechnum magellanicum* and *pennamarina*) together with Oreob *Oreobolus obtusangulus*. *Astelia* (*Astelia pumila*) is also frequently present and forms numerous small patches. At the higher reaches of Area 3 the habitat begins to grade into that previously described as 'Feldmark' type outcrops of rock supporting a fair lichen flora and specialist vascular species such the stonecrops and the distinctive cushion plants (*Azorella sp.*).

Fauna

A small colony of Gentoo penguins is present on the beach and dunes within M116, north of Beach Point.

Numerous passerines (song bird species) were observed including Falkland Thrush (*Turdus falcklandii falcklandii*), Falkland Pipit (*Anthus correndera*), Long-tailed Meadowlark (*Sturnella loyca falklandica*). Crested Caracara (*Caracara plancus*) were observed both in flight and perched on a few rocky outcrops. Although not observed it is likely the patches of rock exposure at higher elevations serve as nesting Dark-faced Ground-tyrant (*Muscisaxicola maclovianus maclovianus*).

Domestic animals

There are some horses in the area, and at least one herd of cows was seen, but there are few sheep, and little of their dung could be seen. One or two sheep, who have managed to escape from the enclosures serving the local abattoir, live wild inside the fenced areas, seemingly without damage to themselves.

Fencing

All of the suspect areas were fenced with standard SOP311 fencing, which remains in good condition, because it is maintained by a local landowner. The JSEOD team monitors the condition of the fences on a regular basis. In many cases there are signs of other strands of fencing inside the fenced areas, some of which were probably of UK origin, and some were probably part of a protective mine fence or part of a defensive low wire entanglement.

Local population

The general attitudes expressed by the local people were entirely positive towards the activities of the Survey Team, but they clearly stated that they were used to the mines by now, and that their presence was an inconvenience, which did not affect their livelihood.

The mine problem

- M24, M26, M27. These mined areas are linked, and together they stretch just over 2km on the south side of the main Stanley – MPA road. Together they are about 9.51 Ha in size. They are recorded, and contain 312 AV mines and up to 1,164 AP. All areas were part-cleared, but no records remain of how many mines were removed. The terrain is flattish, covered with patches of grasses, ferns and empetrum.
- M25. This is a linear defensive position, sloping down the West side of Sapper Hill, 0.54 Ha in size. It is peaty, with thin peat over clay soil. There are said to be 190 AP mines in the mined area, and a possible submunition strike at the bottom of the hill. The area is more heavily vegetated at the lower ends, with denser ferns and empetrum. There are signs of wire and pickets.
- M28. This linear mined area is about 1.45 Ha in size, said to contain 192 AP mines, but was apparently cleared by UK military so there is some doubt as to why it is still marked as a suspect area. There are some pickets and wire showing through the vegetation. The vegetation and soil conditions, white grass with patches of fern, are similar to M25, but the site is almost level.
- M33. This is a small mined area, 0.38 Ha in size, said to contain 73 AP mines and 3 booby-traps. It is similar in vegetation to M25 and 28, with white grass and patches of empetrum and fern, but on a more sloping site down towards the road. There are marker pickets still visible.
- M35. This mined area is on the lower slopes of Mounts Tumbledown and William. It is 2.16 Ha in size, recorded, and is stated to have 215 AP mines. No post-conflict clearance has taken place. The terrain is generally sloping, but undulating, mainly covered with white grass, but with small rocky outcrops. There are steel pickets, marker posts and a datum point still visible.
- M86. This is a larger mined area, 9.87 Ha in size, midway between the MPA road and the coast. It is recorded, and no clearance was done on it after the conflict. There are said to be 87 AP mines and an unknown number of booby traps, possibly in 12 areas. The terrain is relatively flat, with longish grass and

clumps of empetrum. There are signs of mine activity, with some wooden pegs visible from the perimeter fence.

- M36. This is a linear mined area running north to south, thin and long, 9.45 Ha in size. It is now reckoned to contain 524 AP mines, following some limited clearance after the conflict, during which the mine clearers became casualties. The terrain is flattish with white grasses and clumps of empetrum, and with pickets and signs of earlier fencing, probably UK in origin. There are a number of shell holes still visible in the peat. At the lower end there is a peat bank, now eroding away, and a P4B mine is visible just below the bank.
- M116. This is a mined area surrounding a cove north of Beach Point, below Port Harriet Point. It is 5.96 Ha in size, and is said to have an unknown number of AP mines in situ, but two were removed in September 1984. Anecdotal evidence states that the landowner declared it a danger area to prevent the theft of penguin eggs from the resident penguin colony in the cove. The terrain around the cove is flattish turf leading to white grass, with a rocky cliff on the south edge.
- M54. This mined area is linear north to south, but has its top edge adjoining the main road. It is 1.27 Ha in size, and was partially cleared after the conflict. The records state that there were originally 50 AV mines and 142 AP mines, but many were cleared, and now only 43 AV and 136 AP mines remain.
- M55. This was a small mined area, 0.50 Ha in size, adjoining the main road and extending both sides of it. There are no records for it, and there were originally reported to have been 30 AV mines in the area, but according to POW information they have all been lifted. The ground is flattish, and covered with medium white grass, with clumps of low ferns and empetrum.
- M56. This is a large mined area, running generally north to south, with the northern edge adjacent to the main road. It is 18.00 Ha in size. It is recorded, and originally had 144 AV mines and 240 AP mines, but there was some partial lifting by the UK military, but they received casualties in 1982 in the area down by a lake in the bottom eastern corner of the field. The ground is undulating, with peat banks. The vegetation is the usual white grass, with large patches of empetrum.
- M57. This is a small AV mined area straddling the main road. It is only 0.21 Ha in size. It is recorded, and originally had 30 AV mines, but all lifted in Mar 83, so it is assumed to be free of mines. The terrain is uneven, with a watercourse in one corner. The vegetation is long grasses, rushes, and clumps of ferns.
- M58. This mined area is also small, only 0.95 Ha in size. It runs from north to south, with the northern edge abutting the main road. It is recorded, and originally was stated to have 100 AP mines, but there are now possibly 97 AP mines, because three were apparently lifted. Some surface-laid mines were seen in 1985, but these are now overgrown. There is evidence that sheep have entered the mined area. The terrain is mostly flattish, and covered with white grass, but there is a rocky outcrop on the western side, where the empetrum has established itself.

- M59 This is a large mined area, 33.28 Ha in size, running roughly north to south on the eastern slopes of Wall Mount. It is recorded, and was stated to have 968 AP mines and one AV mine. There was apparently some random mining that took place under fire at the northern end during the withdrawal of the Argentine forces, so the numbers may be inaccurate. The terrain is boggy on the lower peat slopes, with rock runs as the slopes increased. There are steel pickets, pegs and mine boxes as evidence of mine-laying activity. It is said to have two resident sheep.
- M60. This mined area is recorded as having originally 30 AV mines, but 22 mines and 8 fuses were recovered during a minefield breaching operation, so it is assumed that only 8 AV mines remain. There is a mine area datum point in the ground. It is small, at 0.15 Ha in area. One soldier on a motorcycle was killed during the conflict. The terrain is lumpy, and covered with long white grass, with outcrops of ferns and empetrum.
- M91A, M91B. These are two large unrecorded mined areas, with a combined area of 42.75 Ha. There are unknown numbers of AP, but no clearance done. A mine accident was recorded in M91B. Some full FMK1 boxes were found in the area, and some possible row markers in the form of pickets, but there is no certainty that mines were laid in either area. According to the landowner, sheep and the occasional cattle have been known to get through the fences, and there is evidence of fleece on the fence wires, but there have been no accidents. The land is flattish, with white grass, large areas of empetrum and some patches of ferns.

Ecological considerations

Gentoo penguin colonies and highways

M116 presents particular issues with the presence of a small colony of Gentoos. The sensitivity of these birds to disturbance during nesting, represents a severe constraint on activities in this mined area. Establishment of colony groups and nest building occur in late September with egg-laying in mid to late October. The young begin to enter the sea in late February/early March. All clearance here will need to be undertaken outside of this nesting period and should be of non-mechanical forms. However, all other mined areas are some distance from this colony and will not influence them providing contractors are instructed not to disturb them.

Ground-nesting birds

Numerous ground nesting species were observed; mitigation measures to prevent harm from occurring, particularly during the breeding season, will be required. Manual clearance would be more benign, but nesting birds might be disturbed during the clearance process, so clearance should ideally take place outside the breeding season, when the number of nest sites disturbed by creating check lines would be small.

If operations are required during the summer nesting period it is recommended that activities are undertaken to limit the number of birds nesting in each mined area and affected areas by the use of 'scarers' during the early part of the nesting season. The scale of the mined area to be cleared in the context of the landscape are relatively

small and the reduction of areas for nesting should have little short-term effect on populations.

Rock-nesting species

The probable occurrence of nesting Crested Caracara and Turkey Vulture at higher levels may create reasons for concern. It is recommended that a fuller bird survey is undertaken of the mined area containing habitat suitable for nesting of these birds to identify active nest sites prior to commencement of work and working arrangements adopted to minimise disturbance in these areas during the breeding season.

Vegetation

There are areas of deeper and wetter peats in some places which creates a particular concern for successful remediation of vegetation cover. Failure to rapidly cover these with a natural sward could cause exposed peat to dry and decompose. Recovery from this will present problems and may require higher levels of intervention such as pH correction and nutrient additions.

Clearance options

The mined areas in Area 3 pose a complicated problem, mainly due to the thickness of the peat, and the need to protect the roots under the surface from complete destruction. As in other areas, rolling may be possible in some areas, but a test may well be needed to certify that rolling does not push mines into the ground without activating them. A simple device could be constructed that would achieve this, and allow testing before rolling began. Flails could be used in suspected AP mined areas to clear the dense vegetation. The use of flails or millers in the clearance mode may be possible on some more level areas, provided that remediation measures can be shown to be effective on the peat types that are encountered. On some larger suspect areas which need area reduction, it might be possible to construct a safe-lane using a miller or flail, which could then give evidence of where the mine lines might be. In other areas, manually-cleared safe lanes and check strips will probably be necessary. Whatever method is to be used should be discussed with environmentalists and landowners.

Logistics

Since the outer edge of Area 3 is only some 12 km from Stanley, an accommodation and re-supply base for up to 60 people in Stanley will probably be acceptable to the local population, and reaching the mined areas will be comparatively simple along the Airport road. The problem of how to cross some of the softer areas will still remain, and quad-bikes with trailers may provide an answer, if low-ground pressure tracked vehicles cannot be used.

Post-clearance remediation options

Assuming non-invasive measures are adopted in M116 for the clearance of any mines within areas used by Gentoo penguins remediation is primarily related to re-establishment of vegetated cover within any areas where mechanical techniques are adopted.

Rolling is expected to have little effect and should require minimal intervention, Level 1 or perhaps 2 in some patches. If removal of vegetation prior to any manual

clearance is not undertaken with a flail but a clean cutting edge then manual clearance should have no impact and level 1 can be adopted.

All areas where the soil surface is disturbed will require some form of remediation with the purpose of increasing the rapidity of establishment of vegetative cover with a species composition similar to that prior to clearing. Assuming trials show good response to the application of brash Level 2 should be adequate. Prior to any form of revegetation, Level 0 pre-treatment must be undertaken.

STANLEY AREA 4

History

Stanley Area 4 is geographically the largest of the areas, starting at the Murrell in the east, and ending west of Two Sisters, with its southern boundary being the north edge of Area 3. The area was on the main axis of withdrawal during the conflict, which resulted in rapid laying of mined areas around the main defensive positions in the hills around Mount Longdon, Two Sisters and Mount Harriet. Immediately after the conflict, the various Royal Engineer units carried out valuable but limited mine clearance. Due to the lack of any records of their actions, none of the individual mined areas can be declared as being fully cleared.

Present situation

These mined areas have remained very much as laid, apart from the limited clearance mentioned above. Area 4 contains 27 suspect areas, six of which are confined within a common fence situated between Mount Longdon and Two Sisters, and could not be inspected. Some of the sites, such as M74 to M77, are subdivided into discrete smaller areas. Most of the suspect areas are in the hills, but seven sites are on the Murrell River and Hearnden water. Records are held for about half of these. Some limited clearance was carried out on some of the sites, but no records remain. There have been no recorded accidents, although a British soldier lost a leg on one of these mined areas during the conflict. There have been few incidents, because there are hardly any livestock in this particular section of the Islands, and few incursions have been made by cows or sheep.

Access

Access to the mined areas is poor, because there are few roads into the area, and those that exist are in poor condition and need repair. The sites on the river can be accessed relatively easily, but the tracks are soft. The sites in the hills can only be accessed from Moody Brook in the east, and the track from Moody Brook to Longdon is in very bad condition, and may need restoration if work is to be done in the Longdon area. Access is possible from the west, but is apparently worse than from the east. Off-road tracks become difficult to traffic in wet weather, but are still passable to quad-bikes and BV206-type vehicles. The tracks can deteriorate badly due to over-use, especially in the wet season. This poor access will be a major hindrance to any clearance in the Longdon area.

Landscape and the environment

Flora

Stanley Area 4 shares a high degree of vegetative commonality with Area 3, and is a large area of essentially homogenous habitat comprising a mosaic of Whitegrass (*Cortaderia pilosa*) and Pig Vine (*Gunnera magellanica*) interspersed with large patches of dwarf-shrub heath with Diddle-dee (*Empetrum rubrum*) and Christmas Bush (*Baccharis magellanica*). Patches of Tall and Small Fern (*Blechnum magellanicum* and *penna-marina*) together with Oreob (*Oreobolus obtusangulus*), are found as is Astelia (*Astelia pumila*), often in small patches. Outcrops of rock support a lichen flora and vascular species such as stonecrops and cushion plants (*Azorella* sp.).

Fauna

Crested Caracara (*Caracara plancus*) and Turkey Vulture (*Cathartes aura falklandica*) were observed both in flight. Numerous passerines (song bird species) were observed including Falkland Thrush (*Turdus falcklandii falcklandii*), Falkland Pipit (*Anthus correndera*) and Long-tailed Meadowlark (*Sturnella loyca falklandica*). Although not observed it is likely the patches of rock exposure serve as nesting for the endemic Dark-faced Ground-tyrant (*Muscisaxicola maclovianus maclovianus*). Evidence of both rabbit and probably hare, were also noted.

Domestic animals

During the visit to the area, there were a few horses, mainly nearer Stanley, and the landowner runs a herd of cattle. A few sheep live in the area, which have escaped from the abattoir pens to the south of the area. Occasional sightings were made of sheep and cow dung in the mined areas, but there were very few animal skeletons.

Fencing

All of the suspect areas are fenced with standard SOP311 fencing, which remains in good condition, because it is maintained by a local landowner. The JSEOD team monitors the condition of the fences on a regular basis. In many cases there are signs of other strands of fencing inside the fenced areas, some of which were probably the original UK markings from 1982-3, and some were probably part of a protective mine fence or part of a defensive low wire entanglement.

Local population

The general attitudes expressed by the local people were entirely positive towards the activities the Cranfield University Survey Team, but they clearly stated that they are used to the mined areas by now, and their presence is a minor inconvenience and does not affect their livelihood.

The mine problem

These are grouped west to east.

- **M39N and S.** This is a recorded AV mined area in two parts totalling 0.34 Ha in size, to the north of Two Sisters. A total of 64 AV mines were said to be laid, but 60 were lifted, and one destroyed a Snowcat in 1982. The terrain is flattish, and covered in white grass with some clumps of empetrum.

- M114. This is a suspect area, 1.54 Ha in size, on one of the lower slopes of the Two Sisters area. There are no records for it, but signs of row markers, and some stockpiled AP mines were removed in 1982. It is gently sloping, and the peaty soil is mainly covered with medium length whitegrass. There were no signs of animal incursion.
- M113. This again is a suspect area, 6.00 Ha in size. There are no records of mine-laying, but row markers and empty mine boxes (possibly C3B) were found in 1982, so the area was fenced off.
- M81C. This is a recorded mined area, enclosed within the Longdon complex, and sloping northwest from Two Sisters. It is estimated at 0.90 Ha in size. It is said to contain 280 AP mines, but was partially cleared by UK military, though no records remain on how much of the area was cleared. The terrain is uneven, and varies between grass and empetrum at the top to dense patches of small fern and mosses further down the slope. There are ditches and natural gullies on the lower areas. There are many signs of pickets and some rear-edge wiring on low pickets to be seen within the common-fenced Longdon complex, but it was difficult at a distance to distinguish which of the seven suspect areas they belonged to. There were signs of animal incursion.
- M77. This is a set of two suspect areas on the northern slopes of Mount Longdon, 1.92 Ha in size. There are no records, and information on these areas was supplied by POWs. Both fenced areas have the remains of internal fencing of the UK pattern, and both sites have some rocky outcrops. The vegetation is white grass and empetrum.
- M76. This is another set of two suspect areas, close to M77, totalling 2.59 Ha. There are no records, but a British soldier apparently was blown up on a mine in one of these sites. Information on the sites came from POWs. The sites generally slope downward in a northerly direction. They contain internal fencing with red triangles, probably put up in 1982-3 by a UK unit. There are rock runs through both sites, and probably more rocky outcrops under the vegetation, which is white grass and empetrum.
- M111. This is a small suspect area, 0.25 Ha in size, on the track from Moody Brook to the Longdon fenced complex. No records or information are available for it, but row markers were seen in 1982, so it was fenced. The terrain is bumpy and rocky, with a covering of white grass and empetrum.
- M105. This is a slightly bigger suspect area, about 2.50 Ha in size, right at the head of the tidal part of the Murrell River. There are no records, but information is based on POW reports of the laying of 70 AP mines. The terrain is similar to other mined areas on river banks, with white grass, empetrum and grass, but there are rocky outcrops at the western end, where the mined area fence meets the river. The river bed in the tidal area is stony, but muddy upstream.
- M75. This is another set of four recorded mined areas, also on the northern slopes of Mount Longdon, totalling 0.75 Ha in size. The total number of mines is said to be 62 AP mines. All have internal fence pickets. The terrain in all of them is predominantly white grass with varying amounts of empetrum. One fenced area has a sunken rock outcrop in the centre.

- M74. This is a set of three unrecorded mined areas next to M73, totalling 0.33 Ha. The information on it is based on statements by POWs. All three fenced areas are similar in shape and size. They are all flattish, but covered in white grass and empetrum. All have signs of inner fencing.
- M73. This is one of a series of small mined areas on the northern slopes of Mount Longdon. Its size is 0.13 Ha. It is recorded, and was part-cleared by UK military in 1983, but no records of that clearance remain. The terrain is slightly uneven ground covered with white grass. There are signs of an inner fence, probably erected by a UK unit.
- M32. This is a linear mined area astride the Moody Brook, 0.97Ha in size. Records are held for this mined area, and it is stated to have 80 AV mines and 79 AP mines. No clearance was done after the conflict. The terrain slopes down gently from both sides to the river, and is soft and boggy in the middle. The vegetation is mostly white grass, with some empetrum, and mosses nearer to the river.
- M72. This is a recorded mined area, 0.37 Ha in size, on the northern slopes of Wireless Ridge. It was part-cleared by UK military in 1982. There are said to be 40 AV mines and 32 AP mines. There are mine boxes, pickets and pegs visible in the fenced area. The terrain is flattish, with white grass, and some clumps of empetrum.
- M71. This is another small mined area (0.07Ha), well up the Murrell River bank, near the new Murrell Bridge. It is recorded, and said to contain 3 AV mines and 29 AP mines. The terrain is very similar to M70, uneven above the beach level, with white grass and gorse, with some empetrum and fern.
- M70. This is a small (0.01 Ha) AP mined area on the Murrell River. It is a recorded mined area, fairly flat, with a peaty soil covered with white grass and empetrum, but with a river running through it. It is stated to have 14 AV mines and 7 AP mines, and to have been partially cleared by UK military in 1982, but there are no records, and mines may have been left in situ. The size of the mined area seems too small for the number of mines shown.
- M68/69. This is a linear mined area along the south bank of Hearnden Water, some 4.20 Ha in size. Records are held on both parts. There are reports of 224 AP mines and possibly some booby traps. The AP mines are apparently subject to tidal action. No clearance action has been taken. The bank is uneven, and covered with dense clumps of empetrum, with areas of grass and fern. Below the bank is a rocky shoreline, with sand below the high tide mark.
- M67. This is a small mined area around Watt Cove, at the mouth of Hearnden Water, 2.53 Ha in size. There is no record of the number of mines, but information from POWs indicated that there could be 35 AP mines, some booby-traps and an indeterminate number of AV mines. Five AV mines were destroyed in 2002. The terrain above the beach area is uneven, and covered with white grass.
- M96. This a mixed mined area, recorded, said to contain 48 AV mines and 96 AP mines. It is about 1.03 HA in area. There has been no clearance since the conflict. The area is covered with white grass, with some empetrum bushes.

- M115. This mined area lies downstream from Watt Cove, and is about 0.90 Ha in size. There are no records for this mined area, but it possibly contains a number of AV and AP mines, and possibly some booby-traps of 200gm blocks on trip-wires. The terrain above the beach level is uneven, with white grass and large outcrops of empetrum. The beach is stony.

Ecological considerations

It is recommended that additional bird surveys are undertaken prior to commencement of work to identify areas containing active nest sites of raptors (both Crested Caracara and Turkey Vulture were observed) prior to commencement of work and planning of activity is undertaken to minimise disturbance to any nest sites.

Nesting passerines and waders species should be protected by executing work outside the nesting period. Where this is not possible it may be appropriate to exclude nest establishment in areas to be cleared, and areas used as operation bases, by the use of bird scarers before the nest season commences.

As with Stanley 3, with which Stanley 4 shares a high degree of commonality, the main concern with vegetation and soil conservation lies with the ability to regenerate vegetative cover rapidly after any disruptive disturbance of the plant cover and underlying soil surface. It is unclear exactly what the consequences of partial or slow regeneration of vegetative cover on peat soils will be, however it is unlikely to be benign and may require more complex interventions to be made in the future.

Clearance options

The majority of these mined areas will need grass, fern and empetrum removal as a matter of priority, before any form of mine or UXO clearance. This may have to be done by hand in mixed AV and AP mined areas. Caution will have to be taken in areas near beaches, in case the peat banks edging the beach are weakened, and made open to erosion. There is the possibility of rolling some of the areas immediately above the beaches, because they are flatter. The inland mined areas are sloping and undulating, but will also require vegetation clearance, which can be done by machinery in known AP mined areas. Milling would be possible in flatter areas, provided that the cutters were not placed too deep, and remediation measures were taken, but advice on such measures should be sought from landowners and environmentalists.

Logistics

The logistic problems of working in this area are many. There are no roads, but only peat-covered tracks, which can disintegrate easily. Transport will be difficult, but the use of quad-bikes, together with trail bikes, might make less environmental impact than 4x4 trucks or tracked vehicles of the BV206 type. It should be possible to set up a temporary camp using portakabin-type structures, which would give better protection than tents against wind and weather. The presence of a temporary camp would make re-supply a weekly task rather than requiring daily movement. The landowner has agreed this concept. It might also be necessary to improve the road between the Moody Brook bridge and the main Longdon complex, which would be of significant importance to the landowner.

Post-clearance remediation options

Rolling is expected to have little effect and should require minimal intervention, Level 1 or perhaps 2 in some patches. If removal of vegetation prior to any manual clearance is not undertaken with a flail but a clean cutting edge then manual clearance should have no impact and level 1 can be adopted.

All areas where the soil surface is disturbed will require some form of remediation with the purpose of increasing the rapidity of establishment of vegetative cover with a species composition similar to that prior to clearing. Assuming trials show good response to the application of brash, Level 2 should be adequate.

Prior to any form of revegetation attempts of disturbed soils Level 0 pre-treatment must be undertaken.

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MINED AREAS - SUMMARY

Area	Minefield Reference #	Area (Ha)	Category	Mines and UXO 1982	Mines and UXO 2006	Remarks
(a)	(b)	(c)	(d)	(e)	(f)	(g)
Fox Bay	1	4.11	C	Quantity unknown	Quantity unknown	C3B, P4B & SB33 mines believed to be laid in this area due to evidence found since the conflict
Fox Bay	2	14.26	C	Quantity unknown	Quantity unknown	
Fox Bay	3	20.62	C	Quantity unknown	Quantity unknown	
Fox Bay	4	50.65	C	Quantity unknown	Quantity unknown	
Fox Bay	5	17.56	C	Quantity unknown	Quantity unknown	
Fox Bay	6	23.77	C	Quantity unknown	Quantity unknown	
Fox Bay	7	72.39	C	Quantity unknown	Quantity unknown	
Fox Bay	8 West (8W)	2.45	A	Quantity unknown	Quantity unknown	
Fox Bay	8 East (8E)	3.86	B	Quantity unknown	Quantity unknown	
Fox Bay	9 North (9N)	6.27	C	Quantity unknown	Quantity unknown	
Fox Bay	9 South (9S)	7.19	C	Quantity unknown	Quantity unknown	
Fox Bay	10	6.64	C	Quantity unknown	Quantity unknown	
Fox Bay	11	9.61	C	Quantity unknown	Quantity unknown	
Port Howard	1	2.04	C	Quantity unknown	Quantity unknown	Pipe bombs, mines and booby traps may exist
Port Howard	2	4.38	C	Quantity unknown	Quantity unknown	
Port Howard	3	105.19	C	Quantity unknown	Quantity unknown	
Port Howard	5	8.37	C	Quantity unknown	Quantity unknown	
Port Howard	6	8.30	B	Quantity unknown	Quantity unknown	
Port Fitzroy	1	1.79	A	Quantity unknown	Quantity unknown	Mines and booby traps may exist
Murrell Peninsula	1	550.3	A	Unknown	No mines	Less coves MP1-5
Murrell Peninsula	MP1	6.75	C	Quantity unknown	Quantity unknown	
Murrell Peninsula	MP2	23.24	C	Quantity unknown	Quantity unknown	
Murrell Peninsula	MP3	4.04	C	Quantity unknown	Quantity unknown	
Murrell Peninsula	MP4	13.25	C	Quantity unknown	Quantity unknown	
Murrell Peninsula	MP5	7.10	C	Quantity unknown	Quantity unknown	
Darwin & Goose Green	2	0.89	C	Quantity unknown	Quantity unknown	FMK-1, No6, P4B, C3B, BL755 Bomblets and booby traps have been cleared in these
Darwin & Goose Green	3	2.54	C	Quantity unknown	Quantity unknown	

Darwin & Goose Green	5	2.37	C	Quantity unknown	Quantity unknown	areas.
Darwin & Goose Green	7	2.59	C	Quantity unknown	Quantity unknown	
Darwin & Goose Green	8	6.29	C	Quantity unknown	Quantity unknown	
Darwin & Goose Green	10	0.88	B	Quantity unknown	Quantity unknown	
Darwin & Goose Green	11	2.06	B	Quantity unknown	Quantity unknown	
Darwin & Goose Green	12	1.65	C	Quantity unknown	Quantity unknown	
Stanley Area 1	4	0.41	D	46 x SB81 23 x SB33	40 x SB81 23 x SB33	
Stanley Area 1	5	0.71	D	39 x C3B 1 x No6	39 x C3B 1 x No6	
Stanley Area 1	5A	2.85	D	155 x No6 5 x C3B	155 x No6 1 x C3B	Partial clearance carried out post conflict. Fenced inside Yorke Bay minefield fence with 7, 14, 15, 17 and 18
Stanley Area 1	7	2.03	D	256 x SB33	250 x SB33	Vulcan 1000lb bomb crater in the middle of area. Fenced inside Yorke Bay minefield fence with 5A, 14, 15, 17 and 18
Stanley Area 1	8	4.38	D	533 x SB81 454 x SB33 57 x booby traps	509 x SB81 444 x SB33 35 x booby traps	22 x booby traps lifted April 1983
Stanley Area 1	14	0.53	D	60 x SB81 45 x FMK-1 60 x M1	27 x SB81 34 x FMK-1 22 x M1	Fenced inside Yorke Bay minefield fence with 5A, 7, 15, 17 and 18
Stanley Area 1	15	4.36	D	208 x SB81 126 x SB33 112 x No4 64 x No6 Unknown x M1	207 x SB81 126 x SB33 111 x No4 64 x No6 Unknown x M1	Fenced inside Yorke Bay minefield fence with 5A, 7, 14, 17 and 18
Stanley Area 1	17	2.02	D	96 x SB81 44 x SB33	82 x SB81 34 x SB33	Fenced inside Yorke Bay minefield fence with 5A, 7, 14, 15 and 18
Stanley Area 1	18	0.55	D	64 x C3B 56 x P4B	64 x C3B 56 x P4B	Fenced inside Yorke Bay minefield fence with 5A, 7, 14, 15 and 17
Stanley Area 1	117	0.14	C	Possibly SB81, SB33	Possibly SB81, SB33	Area of spoil removed in error from MF 8 at Surf Bay by PSA and deposited at Mary Hill Quarry (MF 117) 09/10/85

Stanley Area 2	11	1.12	C	112 x SB81 112 x SB33 48 x C3B 48 x P4B	42 x SB81 50 x SB33 33 x C3B 38 x P4B	Within Stanley Common minefield fence
Stanley Area 2	20	0.99	C	30 x Booby Traps	Nil x Booby Traps	Area believed to be clear Within Stanley Common minefield fence
Stanley Area 2	21	0.72	C	12 x C3B 12 x P4B	8 x C3B 11 x P4B	Within Stanley Common minefield fence
Stanley Area 2	22	2.16	C	384 x P4B	240 x P4B	Within Stanley Common minefield fence
Stanley Area 2	40	1.14	C	224 x P4B	223 x P4B	Within Stanley Common minefield fence
Stanley Area 2	42	1.99	C	256 x P4B	253 x P4B	Within Stanley Common minefield fence
Stanley Area 2	43	2.25	C	300 x P4B	300 x P4B	Within Stanley Common minefield fence
Stanley Area 2	45	7.45	C	320 x P4B	309 x P4B	Within Stanley Common minefield fence
Stanley Area 2	46	6.46	C	208 x P4B	208 x P4B	Within Stanley Common minefield fence
Stanley Area 2	49	3.77	C	87 x C3B 166 x P4B	84 x C3B 165 x P4B	Within Stanley Common minefield fence
Stanley Area 2	50A	5.52	C	160 x P4B	96 x P4B	Within Stanley Common minefield fence
Stanley Area 2	50B	7.38	C	84 x C3B 166 x P4B	81 x C3B 157 x P4B	Within Stanley Common minefield fence
Stanley Area 2	51	4.12	C	197 x C3B 264 x P4B	130 x C3B 254 x P4B	Partial clearance by UK military in 1982 Within Stanley Common minefield fence
Stanley Area 2	52	1.35	C	80 x C3B	Unknown x C3B Records Inaccurate	89 x C3B Mines Removed from the minefield since 1987 Within Stanley Common minefield fence
Stanley Area 2	53	1.67	C	70 x C3B 179 x P4B	49 x C3B 165 x P4B	Within Stanley Common minefield fence
Stanley Area 2	63A	0.79	B	Unknown x P4B	Unknown x P4B	Partial clearance in 1982. No record of what was lifted
Stanley Area 2	63B	0.44	B	Unknown x P4B	Unknown x P4B	Partial clearance in 1982. No record of what was Lifted
Stanley Area 2	64	2.02	C	32 x C3B 88 x P4B 2 x Booby Traps	32 x C3B 88 x P4B 2 x Booby Traps	Within Stanley Common minefield fence
Stanley Area 2	65	22.98	A	UNKNOWN	UNKNOWN	No records held Within Stanley Common minefield fence
Stanley Area 2	66	5.51	C	80 x C3B	79 x C3B	Record not accurate Within Stanley Common minefield fence

Stanley Area 2	83	1.62	C	54 x booby traps	Nil x booby Traps	Area believed to be clear. Within Stanley Common minefield fence
Stanley Area 2	95	11.80	C	96 x SB33 2 x booby traps	96 x SB33 2 x booby traps	Within Stanley Common minefield fence
Stanley Area 2	95A	11.09	C	112 x SB33 2 x booby traps	112 x SB33 2 x booby traps	Possibly fenced within MF 95 Within Stanley Common minefield fence
Stanley Area 2	97	0.52	B	96 x P4B	84 x P4B	Within Stanley Common minefield fence
Stanley Area 2	98	0.68	B	128 x P4B	58 x P4B	Within Stanley Common minefield fence
Stanley Area 2	99	0.61	C	80 x P4B	70 x P4B	Within Stanley Common minefield fence
Stanley Area 2	100	1.21	C	176 x P4B	175 x P4B	Within Stanley Common minefield fence
Stanley Area 2	101	1.01	C	12 x C3B 36 x P4B	4 x C3B 31 x P4B	Within Stanley Common minefield fence
Stanley Area 2	102	1.36	C	156 x P4B 52 x C3B	156 x P4B 50 x C3B	Within Stanley Common minefield fence
Stanley Area 2	106	2.66	C	Unknown x P4B Unknown x C3B	Unknown x P4B Unknown x C3B	Within Stanley Common minefield fence
Stanley Area 2	108	22.49	C	Poss 32 x AP mines	Poss 32 x AP mines	Within Stanley Common minefield fence
Stanley Area 2	110	1.37	B	Unknown x P4B Unknown x booby traps	Unknown x P4B Unknown x Booby Traps	All information provided by POWs
Stanley Area 3	24 & 26 combined	7.22	B	672 x P4B	672 x P4B	Partial Clearance by UK military in 1982 Continuous minefield with MF26 & MF27
Stanley Area 3	25	0.54	B	190 x P4B	190 x P4B	BL755 Strike to the south of this area.
Stanley Area 3	27	2.29	B	288 x SB81 24 x C3B 492 x P4B	288 x SB81 24 x C3B 492 x P4B	Partial clearance by UK military in 1982 Continuous minefield with MF24
Stanley Area 3	28	1.45	B	192 x P4B	Nil x P4B	Clearance by UK military in 1982
Stanley Area 3	33	0.38	C	72 x SB33 3 x booby traps	72 x SB33 3 x booby traps	Type of booby trap unknown
Stanley Area 3	35	2.16	C	216 x SB33 9 x booby traps	215 x SB33 9 x booby traps	Type of booby traps unknown
Stanley Area 3	36	9.45	C	544 x P4B	514 x P4B	Partial clearance by UK military in 1982
Stanley Area 3	54	1.27	B	50 x C3B 142 x P4B	5 x C3B 6 x P4B	BL755 case was found in side this Minefield. EOD located and cleared the area to the north where the strike landed.

Stanley Area 3	55	0.50	B	Unknown x AV mines	Unknown x AV mines	60 x AV Mines lifted by UK military in 1982.
Stanley Area 3	56	18.00	B	144 x C3B 240 x P4B	144 x C3B 240 x P4B	Partial clearance by UK military in 1982
Stanley Area 3	57	0.21	B	30 x C3B	Nil x C3B	Clearance by UK military in 1982
Stanley Area 3	58	0.95	B(Part)	100 x P4B	97 x P4B	
Stanley Area 3	59	33.28	B(Part)	968 x P4B 1 x C3B	968 x P4B 1 x C3B	Possible random mine laying carried out, could be more mines than stated. Record states that this minefield came under artillery fire.
Stanley Area 3	60	0.15	B	30 x C3B	8 x C3B	Partial clearance by UK military in 1982
Stanley Area 3	86	9.87	C	87 x SB33 Unknown x booby traps	86 x SB33 Unknown x booby traps	Booby traps in 12 areas around minefield.
Stanley Area 3	91A	23.26	C	Unknown x P4B Unknown x FMK-1	Unknown x P4B Unknown x FMK-1	
Stanley Area 3	91B	19.49	C	Unknown x P4B Unknown x FMK-1	Unknown x P4B Unknown x FMK-1	
Stanley Area 3	116	5.96	C	Unknown x SB33	Unknown x SB33	
Stanley Area 4	32	0.97	C	80 x SB81 80 x SB33	80 x SB81 79 x SB33	
Stanley Area 4	39 North 39 South	0.34	C	64 x C3B	3 x C3B	60 x C3B mines lifted and 1 x C3B mine destroyed by Snowcat in 1982.
Stanley Area 4	67	0.53	C	35 x SB33 Unknown x C3B 44 x booby traps	35 x SB33 Unknown x C3B 44 x Booby Traps Unknown x SB81	5 x SB81 AV mines destroyed in 2002
Stanley Area 4	68 and 69	4.20	C	48 x C3B 264 x P4B	7 x C3B 210 x P4B	P4B AP mines found in minefield, washed from Minefield 68 by tidal action
Stanley Area 4	70	0.01	C	16 x C3B 8 x SB33	13 x C3B 7 x SB33	Partial clearance by UK military in 1982. However mines may have been left in situ.
Stanley Area 4	71	0.07	C	16 x C3B 32 x P4B	3 x C3B 29 x P4B	Mines subject to tidal action
Stanley Area 4	72	0.37	C	32 x SB33 40 x C3B	32 x SB33 27 x C3B	Partial clearance carried out, in error, by UK military in 1982 with no record of what was lifted.

Stanley Area 4	73	0.13	C	48 x $\left\{ \begin{array}{l} \text{SB33} \\ \text{FMK-1} \\ \text{P4B} \end{array} \right.$	26 x $\left\{ \begin{array}{l} \text{SB33} \\ \text{FMK-1} \\ \text{P4B} \end{array} \right.$	Partial clearance by UK military in 1982 No record of what was lifted
Stanley Area 4	74	0.33	C	96 x P4B	78 x P4B	3 separate fenced areas
Stanley Area 4	75	0.75	C	96 x FMK-1	62 x FMK-1	4 separate fenced areas
Stanley Area 4	76	2.59	C	Unknown x AP Mines	Unknown x AP Mines	2 separate fenced areas
Stanley Area 4	77	1.92	C	Unknown x AP Mines	Unknown x AP Mines	2 separate fenced areas
Stanley Area 4	78 & 80A	0.70	C	Unknown x P4B	Unknown x P4B	Fenced within Longdon Complex with MF 79, 80, 80A, 81A, 81B, 81C.
Stanley Area 4	79	0.45	C	P4B x 96	P4B x 96	Fenced within Longdon Complex with MF 78, 80, 80A, 81A, 81B, 81C.
Stanley Area 4	80	0.45	C	217 x C3B	49 x C3B	Fenced within Longdon Complex with MF 78, 79, 80A, 81A, 81B, 81C.
Stanley Area 4	81A	1.30	C	388 x P4B	388 x P4B	Partial clearance by UK military in 1982. No record of what was lifted Fenced within Longdon Complex with MF 78, 79, 80, 80A, 81B, 81C.
Stanley Area 4	81B	0.60	C	240 x P4B	232 x P4B	Partial clearance by UK military in 1982. No record of what was lifted Fenced within Longdon Complex with MF 78, 79, 80, 80A, 81A, 81C.
Stanley Area 4	81C	0.90	C	280 x P4B	280 x P4B	Partial Clearance by UK military in 1982. No record of what was lifted Fenced within Longdon Complex with MF 78, 79, 80, 80A, 81A, 81B.
Stanley Area 4	96	1.03	C	48 x C3B 96 x P4B	47 x C3B 96 x P4B	
Stanley Area 4	105	2.50	C	96 x P4B	70 x P4B	
Stanley Area 4	111	0.25	C	Unknown	Unknown	Row of marker pegs visible in 1982. Fenced as suspicious area
Stanley Area 4	113	6.00	C	Unknown x C3B	Unknown x C3B	Row marker pegs and empty mine boxes found in 1982. Fenced as suspicious area
Stanley Area 4	114	1.54	C	Unknown x P4B	Unknown x P4B	Row marker pegs and stockpiled P4B AP Mines removed in 1982. Fenced as suspicious area

Stanley Area 4	115	0.90	C	Unknown x C3B Unknown x SB81 Unknown x booby traps	Unknown x C3B Unknown x SB81 Unknown x booby traps	Booby traps are 200g TNT blocks on trip-wires
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Note: The areas shown in Column C were measured during the field survey by Cranfield University using GPS (to sub-10 metre accuracy).

Summary:

1. There are 117 x mined areas:

- a. Fox Bay 12 x minefields
- b. Port Howard 5 x minefields
- c. Port Fitzroy 1 x minefield
- d. Murrell Peninsula 5 x minefields (All within one minefield fence)
- e. Darwin and Goose Green 8 x minefields
- f. Stanley Area 1 10 x minefields (6 x minefields within Yorke Bay Fence)
- g. Stanley Area 2 32 x minefields (30 x minefields within Stanley Common fence)
- h. Stanley Area 3 18 x minefields
- i. Stanley Area 4 26 x minefields (7 x minefields within Longdon Complex fence)

2. From the 75 x minefield records that are held by the JSEOD Detachment:

- a. 10,832 x AP mines laid in 1982. 9,721 x AP mines remain in 2006.
- b. 3,506 x AV mines laid in 1982. 2,502 x AV mines remain in 2006.
- c. 1,160 x booby traps laid in 1982. 111 x booby traps remain in 2006.

3. Category A land: suspect areas which, in the opinion of the Cranfield Survey Team, the JSEOD Detachment and the landowners, probably have no mines.

4. Category B land: suspect areas falling within 750 metres of a major area of habitation, or 100 metres of a paved road, which could cause the most threat to human life.

5. Category C land: suspect areas which are far from human habitation or well-used roads, and which cause minimal risk to human life.

6. Category D land: suspect areas which present major technical challenges, and which cannot be cleared without major and obvious environmental damage to areas considered sites of natural beauty. They are all on beaches to the north and immediate south of Stanley Airport peninsula.

7. All Minefield Information has been taken from the available minefield records held by the JSEOD Detachment. Where the records are contradictory, unreliable or when no evidence of clearance is documented, then the higher mines contents figures have been entered.

8. Minefield types and amounts within the records should only be used as a guide to assess the possible contents of a minefield area, and 100% Clearance within each minefield fence area should be carried out to guarantee an acceptable safety standard for the general public.

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SCOPE OF WORK – SCENARIO 1

1. Introduction

This Scope of Work for Scenario 1 is proposed by Cranfield University to fulfil Paragraph 8.2.2 of the Study Terms of Reference (see Annex B). It has been prepared as a narrative to explain the logical progression of activities leading to the development of a costed clearance plan. It has been written in advance of any decision on a clearance plan, and so it is envisaged that it will require further development.

1.1 Background

In the field survey conducted by Cranfield University, the options for clearing landmines and UXO in the Islands have been presented as five indicative scenarios. In this Scope of Work we outline the approach, methods and constraints of the work to be done in Scenario 1. This is the scenario in which the methods, techniques and devices for clearance proposed in the field survey are trialled under operational conditions on the Islands, and will provide the foundation for the main clearance programme and its costing. The trials should be carried out in accordance with the requirements of International Mine Action Standards (IMAS) and the protocols of the International Test and Evaluation Programme (ITEP).

1.2 IMAS and ITEP

IMAS provide the main source of standards of mine action. Issued under the authority of the United Nations, they are maintained and updated by the Geneva International Centre for Humanitarian Demining. IMAS 03.40 covers the test and evaluation of mine action equipment.

ITEP is an international programme for cooperation and collaboration on test and evaluation efforts in support of worldwide humanitarian demining. The programme was formally launched with the signing of the MoU on 17 July 2000. Trials cover six categories of demining equipment: survey, detection, mechanical assistance, personal protection, manual tools and neutralisation. ITEP is one of the major enablers of effective mine action equipment at international level.

The Scenario 1 trials should follow the guidelines and principles laid down by IMAS and ITEP.

1.3 Terminology

This Scope of Work uses mine action terms and definitions as given in the IMAS glossary at IMAS 04.10, the Test and Evaluation guidelines at IMAS 03.40 and Annex A to the Study Report. IMAS can be accessed online at www.mineactionstandards.org.

1.4 The field survey

Cranfield University's Survey Team carried out the best survey they could within the constraints of time and access. The survey was confined to examination of the records held by the JSEOD Detachment, a visual examination of each of the known suspect areas from outside the fences, and soil sampling around the perimeter of

each area. A study was also made of local birds, animals, insects and plants. Since the vegetation had grown considerably in the 25 years since the conflict, signs of mine-laying activity were minimal. Animal skeletons were of no guidance as to mine explosions, since many sheep and cattle had died from natural causes, even inside the mine fences.

1.5 *The role and purposes of the trials*

The main purposes of the trials will be to:

- a. Assess the suitability of various mine clearance equipments and techniques;
- b. Assess the optimal mix of techniques and equipment in each mined area;
- c. Assess the environmental impact of each of the clearance options;
- d. Examine the range of options of peat remediation that may be appropriate for each clearance technique; and
- e. Examine the range of options for the procurement and support of equipment for the main clearance programme.

1.6 *Structure*

This Scope of Work examines the procedures required to set up the trials. Scenario 1 is divided into four phases, 1a to 1d.

2. *Establish Enabling Framework (Phase 1a)*

2.1 *Objective*

To establish the enabling framework necessary to guide a mine action programme in the Islands.

2.2 *Tasks to be completed*

2.2.1 *Establish the Mine Action Authority (MAA) and Project Office*

For the purposes of this Scope of Work, the authority overseeing any future demining programme on the Islands will be referred to as the Mine Action Authority (MAA).

2.2.2 *MAA*

The MAA should develop procedures allowing access by the demining contractor to the suspect areas, and for operating inside them. It would establish the Project Office in Phase 1 and the Mine Action Coordination Centre (MACC) in Phase 2. It would also develop appropriate standards, consistent with IMAS. It would devolve all mine action technical matters to the Project Office, who would act as its operating arm on matters of mine action. See IMAS 07.10 for further information.

2.2.3 *Project Office*

The Project Office would be the agency which runs the whole of Scenario 1. It would act as the nucleus for a possible future MACC. Its initial duties should be to:

- a. Set up the contractual process for the selection of the Contractor to carry out the Phase 1 trials;
- b. Arrange a reconnaissance of the Island's mined areas for representatives from prospective bidders;
- c. Draft the trials plan in accordance with IMAS 03.40;
- d. Arrange a bidder's conference, at which the trials plan is presented to the bidders;
- e. Draft a contract for the trials period; and
- f. Select the winning Contractor.

2.3 Staff numbers

The MAA and the Project Office might each be run by three members of staff.

2.4 Measures of success

The aim of Phase 1a will be successfully achieved when the MAA and Project Office are functioning effectively.

3. Develop Standards and Procedures (Phase 1b)

3.1 Objective

Develop appropriate mine action standards; develop procedures for accreditation, contracting and external quality assurance and control; and develop procedures for conducting environmental impact assessments and environmental remediation.

3.2 Background to mine action standards

As stated, the MAA would be required to develop standards and procedures necessary to allow the clearance programme to take place. It would also be necessary to generate appropriate mine action standards based on IMAS. The MAA and MACC would have to develop procedures for the accreditation of mine action organisations, machines and MDD. The Project Office should be able to shut down operations if they are considered unsafe, and dismiss contractors who are not complying with their contractual responsibilities.

3.3 Mine action standards

The Project Office would draft the mine action standards. Fortunately there are many examples of clearance programmes, which can be adapted for the particular conditions of the Islands.

3.4 Accreditation

For Scenario 1, the Project Office should examine the track record of the Contractor as part of the contractual process, and give temporary accreditation to the contracted organisation. MDD will also have to be accredited, which will require the creation of an MDD training and test area. By 2008-9 there will be methods of creating such a site rapidly, and without the need for fencing and guarding. IMAS contains some

details on accreditation, including accreditation of MDD, and these can be augmented as necessary by the GICHD.

3.5 Contracting

One of the main keys to achieving good mine clearance is the selection of the right contractor, and the drafting of a comprehensive contract. These two activities are interlinked. The contractor for Scenario 1 will need to be selected by contract. Since there are now many potential contractors seeking relatively few contracts, there will be many applicants, and a two-stage contractual process is suggested.

3.5.1 Applicant companies should be asked to submit details of their track records and the experience of their staff, and evidence of their financial viability. These should be checked by the Project Office, and up to five of the applicants may be selected to participate in the second stage of the tender process.

3.5.2 The selected applicants would be invited to the Islands for a contract briefing and reconnaissance. Both of these should be compulsory, and suitably senior members of the companies should be expected to attend. Following the contract briefing, the companies will be given copies of the full contract, and after a suitable period will submit their proposals to the Project Office. These bids would be assessed by a bid committee, which may seek further information and explanation from the applicants, following which the winning applicant would be selected.

3.5.3 The terms of the bidding process should require the applicants to submit more extensive details of their proposed clearance methods, proposed methods of purchasing or leasing the required equipment, their proposed administrative and logistic structures, their draft work plan for the 20 months of Phase 1, their Safety Plan, their Quality Plan and their draft Standing Operational Procedures.

3.5.4 Following the acceptance of the contract terms and conditions, the Contractor would be granted a period of set-up time, but required to start work within a set period from the contract start date. This date would have to recognise the difficulty of getting all the necessary supplies and stores to the Islands, much of which may have to come by sea.

3.5.5 The contractual process is detailed and comprehensive, and the use of a consultant is recommended. A tranche of funding has been included in the draft budget for the hire of such a consultant. The consultant would be needed at the start of Scenario 1, and for the selection of the Contractor to complete the work of the subsequent phases. There would also be a need for contracting a Quality Management group for Phases 2-5, which might need to follow the same procedures as shown above.

3.6 Quality management

The management of quality will be vital to mine clearance on the Islands. Quality management requires a multiple approach, from the selection of the contractor to statistical sampling of the work he has carried out.

3.6.1 During the selection process, the Contractor should be asked to present his Quality Plan, which involves the quality system in his organisation. Also during the selection process, checks will be made of the experience and competence levels of the proposed management and field staff.

3.6.2 Before the Contractor starts work, he shall give a presentation of his work methodology on the ground to the Project Officer, and shall also explain his internal quality system. In later phases this presentation shall be given to the MACC and its quality management staff.

3.6.3 When the work is under way, the Project Officer or his specialist representative should pay random visits to the worksite, to ensure that the methods being used are the same as those previously announced. If the Contractor has changed his work methods, for which he may have good reason, the Project Office should be informed.

3.6.4 When an area has been cleared, a member of the Project Office staff would carry out check clearance of a sample of the previously cleared land. In later phases this would be done by the MACC's external quality control staff. This would be the final check of the cleared ground, after which it would be handed back to the Project Office, on behalf of the MAA.

3.7 *Environmental Impact Assessments (EIAs)*

Ideally, the whole mine clearance programme should be subjected to an EIA during the trials period. The main environmental problems will be the extent to which mechanical equipments disturb the peat, and this will not be known until the Scenario 1 trials have taken place. Other environmental hazards such as the impact on wildlife, plants and insects would be a matter of conjecture until the suspect areas have been inspected.

It is essential to get these facts assessed before the contract for the main clearance (Phases 2-5) is started, or the uncertainties facing the contractor may require him to insert a large contingency into the budget to prevent a change in plan that increases his costs.

3.8 *Environmental remediation*

Many of the factors affecting the EIAs also impact on the need for environmental remediation. The scale of remediation will not be known until after the trials, when every type of equipment will be tried on as many different types of terrain as possible. This will require the immediate establishment of replicated remediation trial plots, to allow assessment of their success within the time-frame of Phase 1. However, if remediation trials are to produce worthwhile data it is essential they are undertaken in an appropriate replicated 'scientific' manner. It is strongly recommended that the winning contractor/consortium plans and undertakes this part of the work with guidance from an independent environmental agency. For proper acceptance of the demining programme in environmental terms such an approach should demonstrate the greatest degree of 'transparency'.

3.9 *Tasks to be completed*

The Project Office, assisted by a consultant, should:

- a. Draft mine action standards for the Islands within one month of the start of the programme;
- b. Draft and let the contracts as necessary for the trials contractors;

- c. Create an accreditation protocol for the trials contractors;
- d. Create an MDD test and accreditation area containing 24 test “boxes”. This should be sited near M110, and dog trials should be carried out in M51 and M95;
- e. Set up a quality management programme for the trials;
- f. In conjunction with the MAA, set up an EIA for the mine clearance and remediation trials;
- g. In conjunction with the appropriate environmental agency and external advice, create protocols for practical remediation programmes where necessary after each trial; and

In conjunction with the MAA, develop a monitoring and evaluation programme.

3.10 Measures of success

Success will depend on the number and effectiveness of the trials and on the quality of the information as judged by the Project Office and the monitors.

4. Conduct Trials (Phase 1c)

4.1 Objective

Conduct trials to determine the effectiveness of each clearance method on each type of terrain.

4.2 Background to the trials

4.2.1 Clearance in peat

Mine clearance in thick peat or deep sand has not occurred in many other locations in the world, and the environmental and operating conditions on the Islands are considered by Cranfield University to be unique. The Islands are the habitat of many rare bird, animal and plant species, some of which rely on the peat as the basis for their survival. There is a higher degree of ecological concern than has been found in any other mine action programmes. Peat can be easily disrupted to a stage where it will not recover, but die back to sub-soil level, losing its nutrient capabilities in the process. This is not a great concern for the local farming community, because the suspect areas represent only 0.067% of the farming land, but worries ecologists. Mechanical clearance techniques are vital to the success of any clearance programme on the Islands. If the whole area had to be cleared manually, it would need about 240 deminers working for ten years to complete, or about 400 for ten years if the Murrell had to be manually cleared as well. Since mechanical clearance techniques have not been used on the Islands except for some early post-conflict trials with unsuitable and prototype equipment in 1983-4, there is little available evidence of the effects of modern flails, millers and rakes on peat surfaces, and this and other remediation measures need trialling.

4.2.2 Conducting the trials

The trials will have to be conducted using an established mine clearance team, and the selection of this team should be done by competitive contract. The trials team

management will need to have extensive practical field experience of all forms of mechanical equipment, and the use of Mine Detection Dogs (MDD). They will also have to purchase or lease the various types of machines that are to be trialled, which will increase the costs of the trial. Trials of this type are rarely held before a mine clearance programme is set up, but in this case the areas to be cleared are so large and so difficult that manual clearance on its own for all scenarios is not a viable option. The Contractor will need full administrative backing, and more plant operator mechanics than is usual, to operate all the machines to be trialled.

4.2.3 Rolling trials

Under certain circumstances, rollers can be used to activate AP mines, a process which the rollers are strong enough to withstand. This activation will only work if the peat is solid enough for the roller to apply more than the required activation pressure without pushing the mines into the peat without actuation, and this should be the subject of a major trial, on a number of surfaces on both the East and West Islands. Rolling has very little effect on the ground, and remediation will not be required. It also has the advantage that even if some mines detonate, it can show any line or pattern in which the mines have been laid. This will materially assist other clearance measures. Rolling is unsuitable against AV mines.

4.2.4 Flail trials

Flails have been developed in many different sizes, and for many purposes. Small flails are effective against AP mines, and are also successfully used for removing dense vegetation from the ground. They can activate AP mines down to about 10 cm, and if the ground is soft enough, can disrupt mines that do not detonate by breaking their cases and detonation systems. Bigger flails can detonate mines down to 20 cm, and the biggest can withstand repeated detonations of heavy (usually AV) mines without undue damage, although some flail chains may have to be replaced. Once the flail begins to disturb the surface of the peat, it becomes damaged, but the extent of such damage will depend on many factors, including moisture content, thickness and slope. Trials are needed to establish whether any damage can be sustained by the peat without lasting effect, or can be repaired by remediation measures. The output of these trials will decide if and where such machines can be used on the Islands.

4.2.5 Milling trials

Millers actively grind up the surface of the ground, in the process physically destroying or activating any AP or AV mines. Their effect on the ground surface is more severe than that of flails, but they can achieve a higher level of reliability in terms of mines destroyed. As for the flails, millers need to be trialled on various peat surfaces under different types and depths of vegetation, and the results of the miller action and any subsequent remediation measures need to be analysed before a decision is made to employ them for clearance on the Islands.

4.2.6 Rake trials

In a number of places in the Stanley area, and on some beaches and coves on both the East and West islands, mines can be dug out of the beaches or sandy soils by use of a wide-tined rake mounted on a back-hoe. This technique has been successfully used in other clearance programmes, and might work on beaches near or below the tide level, which would be self-repairing, but trialling is needed to

confirm this. In some areas where sand dunes are covering rows of mines up to many metres in depth, extensive digging may be necessary, and as some of these sites are of special local interest and the nesting sites for sea-birds, some remediation may be necessary. In time, the dunes will restore themselves, but pressure will be applied on the clearance teams to return them to their original condition as quickly as possible.

4.2.7 Mitigation and remediation trials.

Phase 1b will need to inform a full clearance programme. Therefore methods of mitigation (reducing impacts) and remediation (restoration) will need to be developed and trialled alongside clearance trials.

Mitigation trials will include testing the ability to prevent nesting within mined areas prior to executing any work within the breeding season. Visual and acoustic disturbance associated with demining will also need to be assessed to inform an Environmental Impact Assessment (EIA) and Ecological Impact Assessment (EclA) for follow-on clearance tasks.

Differing levels of vegetation remediation will be required according to soil/clearance method adopted, ranging from “benign neglect” to extensive treatment and re-seeding. The correct level of remediation can only be assessed by trialing these options. It is considered essential these are undertaken in a formal scientific manner with full data capture and monitoring. The winner contractor/consortium would therefore need to demonstrate competencies in this arena in addition to the obvious demining experience.

During this phase there will also be a need to establish the capability to harvest seeds, and to propagate and cultivate seedlings on the Islands.

4.2.8 Mine condition trials

The mines that have been found since the conflict have all been destroyed by burning, and none has been opened up to assess their internal condition. After 25 years in acid soil, often in very moist surrounding conditions for long periods, it could well be that some of the mines are no longer capable of activation. This will not affect the need to clear them, but mines that will not activate cannot be cleared by rolling, so rollers, which are a primary tool in reducing suspect areas down to the actual site of the mines, will not be usable. At the same time, mines that cannot be activated will not cause casualties amongst mine clearance staff, who will be working in difficult terrain and environmental conditions.

4.2.9 MDD trials

Another method of reducing suspect areas is to search for the edge of the mined areas by using MDD. Well-trained dog teams can be very reliable, but they must be used to the terrain, and their operations can be adversely affected by bad weather, especially by wind. The Islands are almost always under wind conditions of varying strengths, indeed the average wind-speed over every day in the year is 15 knots. This may make the use of MDD impractical, unless some kind of wind shield can be erected to allow the dogs to operate in relative shelter. Since dogs can be so effective under the right conditions, a trial should take place to establish whether there are sufficient periods in a month where they can be used, and experiments should take place of wind protective shields or tunnels.

4.3 Tasks to be completed

The Project Office should be able to prepare and let a contract to such mine clearance organisations as necessary to conduct the trials as outlined above, and to carry out such trials on the following:

4.3.1 Manually clear parts of minefields M51 and M11 in Stanley 2 and M14 in Stanley 1.

4.3.2 In minefields M51 and M11 in Stanley 2 and M14 in Stanley 1, in conjunction with the JSEOD Detachment, assess the operability and internal condition of the AP and AV mine types in those minefields.

4.3.3 Test the effect of current rollers, flails and millers on dummy minefields set up in locations next to the Stanley Common Fence, near M50A, M50b and M66, using surrogate mines, to assess theoretical performance of the equipments and possible disruption to the peat surface at varying depths of digging.

4.3.4 Test the effect of current rollers, flails, millers and rakes on actual minefields, to assess their practical mine clearance performance in a number of mined areas at different locations and with different levels of vegetation, and to measure the disruption to the peat surface at various levels of digging. The rollers should be checked on PF1, the rakes on M4 and M5 in Stanley 1 and M97/98 in Stanley Area 2. The flails and millers should be checked on different terrain types such as M45/M46 in Area 2, M91A/M91B and the bottom of M36 in Area 2, and the northern parts of M59 in Area 4. In the settlements, FB2, 3 and 4 in Fox Bay West, and FB10 in Fox Bay East. Trials should cover a total of about 18 hectares. Note: these sites are indicative only. The final selection of sites should be made after an EIA has been conducted as the trials should be carried out in areas representing a range of environmental challenges.

4.3.5 Carry out trials on the likelihood of mines sinking in peat in a number of locations, from PF1 to M75 and alongside M81C in Stanley 4, and to create simple test gear for field use.

4.3.6 Apply various types of remediation to the disturbed peat surfaces after the trials, to assess the best method of minimising long-term environmental damage.

4.3.7 Assess the viability of using MDD in the Islands, with and without wind-breaks.

The Project Office is also to:

4.3.8 Draft and run the trials programme.

4.3.9 Log the trials procedures, including those of the remediation trials.

4.3.10 Record the time and rate of clearance, time of access to site, cost of clearance and cost of remediation per hectare.

4.3.11 Following the results of the trials, hold a trials workshop to assess the results, and discuss optimal clearance and remediation techniques with the environmental specialists and the programme monitors.

4.3.12 If all the machinery trials are completed before the end of the 20-month period but the remediation trials still await results, carry out complete clearance of M63A, M63B and M110.

4.3.13 Prepare the contract for the MACC staff for Phase 2.

4.3.14 Prepare the contract for the demining organisations and supporting agencies (companies or NGOs) for Phase 2.

4.4 Monitoring

A monitoring team would be selected by the MAA. The team should assist the Project Office with the assessment of the trials results, and the performance of the various equipments and remediation methods. The monitoring team should consist of mine clearance specialists with previous knowledge of the Islands, and understanding of multi-disciplinary clearance. One member of the monitoring team should have international experience in EIAs/ ECIAAs and environmental mitigation and remediation best practice.

4.5 Measures of success

This phase will be successfully completed when the trials are finished, when the best clearance methods have been identified, and when the overall plan for Phases 2-5 has been drafted.

5. Prepare Clearance Plan (Phase 1d)

5.1 Objective

Evaluate a range of clearance options, and draft an outline clearance plan.

5.2 Background to evaluation of clearance options

At the end of Phase 1, it will be possible to state which machines and techniques can clear the mines reliably without causing excessive damage or requiring large-scale remediation. This will allow the Project Office to estimate how the clearance on the Islands can be done, and what proportions of the clearance work can be done manually, by roller, flail or milling. On this basis, it will establish the productivity and cost-effectiveness of all the clearance means. It will also be possible to assess whether MDD can in fact be used for area reduction and post-clearance quality control.

Even if some clearance methods or remediation processes cannot be fully resolved, especially those for Phase 5, there will still be many months for further trials before the main clearance work in later phases will need to be done.

5.3 Tasks to be completed

The Project Office should:

- a. Assess every trial, and record the results;
- b. Hold a trials workshop, to include the MAA, Contractor, environment specialist and monitors;

- c. Decide which clearance techniques can be used, and which cannot until the remediation trials are finished;
- d. Discuss and agree the optimum clearance techniques, their rate of work and their cost per hectare; and
- e. When the optimised techniques have been agreed, draft the clearance programme for the Islands (Scenarios 2 to 5).

5.4 Measures of success

This phase will be considered successful when:

- a. All the tasks to be done in Phases 1a to 1d have been successfully completed;
- b. Preparations are in hand to increase the responsibilities of the Project Office to MACC status;
- c. The MACC is in place; and
- d. The draft contract for the clearance of the areas specified in Phase 2 is awaiting the invitation to tender.

6. Budget

A summary of the proposed costs of Scenario 1 is shown at Annex I.

INDICATIVE COSTS – SCENARIO 1

Ser	Function	Staff costs	Office costs	Lodging and food	Travel	Vehicles & eqpt	Supplies	Comms & IT	Insurance	Overhds & contingency	Sub-totals
1.	Mine Action Authority	X	X	-	-	X	-	X	-	-	X
2.	Project Office / MACC	X	X	X	X	X	X	X	X	X	X
3.	Equipment trials	X	-	X	X	X	X	-	-	-	X
4.	Environmental Group	X	X	X	X	X	X	X	X	X	X
5.	Mine clearance contractor	X	X	X	X	X	X	X	X	X	X
6.	Mine Dog Group	X	X	X	X	X	X	X	X	X	X
7.	Monitoring Group	X	-	X	X	-	-	-	-	X	X
8.	EIA / EcIA [Note 3]	X	X	X	X	X	X	X	X	X	X
9.	Scenario 1 totals	X	X	X	X	X	X	X	X	X	X

Notes:

- Costs based on 2007 prices.
- The costs given in this table have been calculated by Cranfield University using a model which includes over 235 sets of data and assumptions. Some of the figures can be predicted with accuracy and confidence such as the cost of hand held mine detectors, PPE and vehicles; others are dependent on issues which are more difficult to predict such as the income tax liability of technical advisors and demining staff for work carried out on the Islands.
- A detailed breakdown of the costs of the Environmental Impact Assessment (EIA) / Ecological Impact Assessment (EcIA) cannot be assessed at this stage. For the purposes of this table of indicative costs we have used the same overall proportions, e.g. staff costs represent 28.4% of the cost of Serials 1 to 7 therefore the staff costs for the EIC/EcIA is 28.4% of £ XXX = XXX.

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PROGRAMME MANAGEMENT

Effective programme management

Although the Terms of Reference of this study did not require Cranfield University to consider the programme management of the whole project, experience in other programmes has shown that a full and functional executive framework is needed to enable any effective mine clearance programme. The clearance of landmines and UXO in the Islands is likely to be a high profile operation, with many challenges and many critics. It is therefore important for the programme to be well founded and managed in a capable and effective way. This will mean bringing in mine clearance and mine action management skills that are not currently available on the Islands

There are a set of generic management functions which are considered universal in terms of definition and function. In mine action programmes there are normally two levels of direction and coordination: the Mine Action Authority (MAA) and the Mine Action Coordination Centre (MACC).

Mine Action Authority

The MAA will be the body that provides the enabling framework for mine action in the Islands, and will provide top level guidance and programming. Its function will be to establish the MACC and to approve the demining plan which will be developed and coordinated by the MACC.

Mine Action Coordination Centre

The role of the MACC is to manage the mine action programme. It is the implementing arm of the MAA, and carries out its decisions. Although the MAA is usually responsible under IMAS for the planning, preparation, clearance and post-clearance activities²⁴, it is the MACC that will usually carry out the accreditation of contractors, that prepares the contracts and carries out the contractor selection, and that monitors the clearance work. It also carries out the monitoring and provides external quality assurance and control of implementing organisations, and finally accepts the cleared land on behalf of the local inhabitants. The MACC has to have sufficient qualified staff to carry out all these roles, and this means that its staff members will initially have to be brought in from other mine action programmes. The majority of the MACC responsibilities are local, and they have day-to-day contact with the mine clearance on the ground.

Contract management

The key to good mine clearance is the writing of a good contract, and the monitoring of the contractors to ensure that they comply with the contract conditions. Mine action contracts are similar to any other works or services contracts, although some specialist advice may be necessary as mine clearance deals with unknown factors, such as variations in terrain, the mine or UXO threat, and unpredictable weather conditions. Care will need to be taken to set conditions and time and budget milestones that are practical and realistic. Contract management starts with the bidding process and the selection of the contractor and it is often more cost-effective

in the longer term to select an experienced contractor at a higher price than lower-priced contractor who may fail to achieve the aims through under-estimation and inexperience. The MACC will usually carry out the quality assurance and control checks on the contractor.. Contract management also involves the independent monitoring and evaluation of the contract at various stages in its life.

In many mine action programmes the MACC is responsible for writing the contracts and managing the contractors through monitoring and audits, and through external quality assurance and quality control. The decision on who will prepare and oversee future contracts for mine action in the Islands lies outside the scope of this Study, however expertise, resources and time will need to be made available to ensure the effective contracting of work.

Quality management

The MACC is usually responsible for quality management of its mine action programme. In a possible future clearance programme, we recommend that the practical monitoring and inspection of work in progress should be carried out by an independent contractor, but it will still be the responsibility of the MACC to ensure that the contractor establishes and maintains an effective regime of internal quality management, and the responsibility for carrying out safe and cost-effective mine action will always rest with the contractor.

Staffing

If the quality management function is put out to contract, the MACC can be kept as small as possible. The Programme Manager will need staff to cover a number of functions, including operations, quality management, logistics, communications, public relations and environmental considerations, some of whom can be part-time. It will also need some transport and a small secretariat. The initial numbers may well rise to about 15 staff in total (including the understudies recommended above), but will reduce as the understudies take over.

Cost of programme management

In programme terms, the management costs are always proportionately the greatest in the early stages, when the programme is being established. Effectively, mine clearance (as opposed to the re-classification of suspect areas) does not start until Phase 3b of Scenario 3. Overall, the proportion of total costs in Phases 3a – 3e of Scenario 3 is 30% of the budget. As a proportion this will diminish sharply in Scenarios 4 and 5, when the contractors will be at their maximum size, but the management element will reduce in costs as local staff take over from international specialists, and the higher level of monitoring needed during the trials and early implementation phases are no longer needed.

RISK MANAGEMENT OF CLEARANCE PROGRAMME

Ser	Elements of Risk	Likelihood	Impact	Mitigating Measures
1.	Unclear or complex command and control	Unknown	High	Agree and establish an organisation for the clearance programme (including a MAA and MACC, external QA/QC body and implementing entities) with clear and precise funding and decision-making systems and procedures. Ensure that an enabling framework is in place at the earliest opportunity.
2.	Rushed decision to implement clearance programme	Unknown	Medium	Prepare a work programme detailing the tasks, durations and key decisions required prior to the start of Phase 1. Identify the tasks on the critical path, and avoid situations that reduce the duration of any of these tasks.
3.	Insufficient funding for complete programme	Medium	Medium	Fund Phase 1 initially (i.e. Scenario 1) followed by subsequent phases as committed funds become available. Note: the disadvantage of this approach is that demining organisations may be required to lease rather than buy equipment, which will prove more expensive over the life of the clearance programme.
4.	Insufficient funding for Scenario 1	Low	High	Do not start the programme until there is sufficient funding to complete Phases 1a-1d.
5.	Inappropriate choice of equipment for clearance tasks	Low	High	Conduct comprehensive mechanical equipment trials during Phase 1 using internal experts with proven experience in the use of mechanical equipments in support of clearance. Develop appropriate guidelines for the use of mechanical equipment and ensure they are well understood by demining organisations. Monitor the performance (effectiveness, productivity and running costs) of mechanical equipment carefully and independently.
6.	Poor programme management	Low	High	Initially use international staff for key Project Office / MACC positions who are well trained and qualified, and have substantial relevant mine action experience. Over time, resident managers should be trained to assume all the key management and support staff positions in the MACC.
7.	Incomplete understanding of the environmental impact of clearance options	Medium	Medium	Conduct comprehensive EIA during Phase 1 using experienced environmental experts. Develop appropriate environmental standards and ensure they are well understood by demining organisations. Conduct site EIAs with each technical survey.
8.	Incomplete understanding on suitability of post-clearance remediation options	Medium	Medium	Conduct comprehensive remediation trials during Phase 1 using experienced environmental experts. Develop appropriate remediation protocols and ensure they are implemented as required during Phases 2-5.
9.	Incomplete understanding	High	High	Technical surveys should commence at the very

	of the extent and form of UXO hazards			earliest opportunity. The results of such surveys should be recorded in IMSMA by trained members of the Project Office (in Phase 1) and the MACC (in Phases 2-5).
10.	Deminer is injured by an exploding mine or UXO	Low	High	Each member of the programme will receive mine awareness training on arrival in the Islands. Full medical support will be arranged via the Island's hospital, with 2nd line support provided in South America and/or Europe. All deminers and managers will be provided with comprehensive medical insurance including MEDIVAC by air ambulance.
11.	Inclement weather (low cloud and heavy rain) during the trials phase	Medium	Medium	The programme should be timed so that the trials phase starts in early Spring, i.e. August. For later phases, technical survey and clearance should take place from mid August to mid June. Long leave and equipment maintenance should take place in mid winter, i.e. mid June to mid August.
12.	Problems with the acquisition and transportation of equipment, explosives and stores	Unknown	High	All potential problems including charges associated with the acquisition and transportation of equipment, and delays related to explosives transportation procedures should be addressed at the very earliest opportunity.

BIBLIOGRAPHY AND REFERENCES

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- (1) Capt J G Mullin, 9 Sqn, British Army Review December 1983.
 - (2) The Argentine Sappers assumed that they would be required to lift their own minefields if no conflict took place.
 - (3) Based on data provided with the ITT dated 7 August 2006.
 - (4) From JSEOD Islands database; but JSEOD MF Brief 1 dated January 97 suggests a higher figure of 4,000 - this may include the 2,000 stockpiled Argentine mines which were treated as EO clearance.
 - (5) A statement was made to the House of Commons in November 1983 that routine minefield clearance had ceased.
 - (6) REDFIRE is a small tracked teleoperated vehicle designed specifically for the Islands mined areas. It is used to destroy AV and AP mines without any risk to the operator.
 - (7) A study of Mechanical Application in Demining GICHD May 2004 ISBN 2-88487-023-7
 - (8) Mechanical Demining Equipment Catalogue GICHD January 2004 ISBN 2-88487-026-1
 - (9) Provided by the Meteorological Section, Mount Pleasant
 - (10) www.GICHD.ch. See the Mechanical Demining Equipment Catalogue ISBN 2-88487-026-1
 - (11) A study of Manual Mine Clearance Section 5: Manual Mine Clearance Costings and Sensitivity Analysis, August 2005. ISBN 2-88487-040-7
 - (12) More details are found in the GICHD document A Guide to Mine Action ISBN 2-88487-012-1, July 2003
 - (13) See the GICHD Mechanical Demining Equipment Catalogue ISBN 2-88487-026-1
 - (14) For more information on the use of mechanical equipment, see the GICHD Study of Mechanical Application in Demining ISBN 2-88487-023-7 dated May 2004
 - (15) The mined areas PH1, 5 and 6) at Port Howard also fall into this category.
 - (16) The IMAS are accesible via www.mineclearancestandards.org. The standards are frequently updated and this website will show the latest version.
 - (17) Impermeable in this context is defined as a geological layer that cannot be penetrated by a moving mine.
 - (18) Comment: the JWP has accepted that Cranfield University need not provide the plan drawings as IMSMA data was not complete at the time of the field survey.
 - (19) See IMAS 08.20 Annex D
 - (20) Ian Strange. 1992
 - (21) In the book "5th Brigade in the Falklands by Van der Bijl and Aldea Page 83, it is stated that mines were laid around the abutments of the bridge. However, PH1 suspect area is north west of the bridge, and well away from the abutments.
 - (22) Mr Rodney Lee.
 - (23) Ian Strange. 1992
 - (24) IMAS 07.10