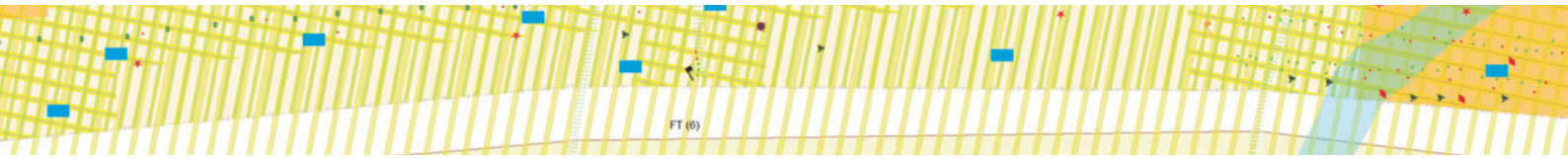
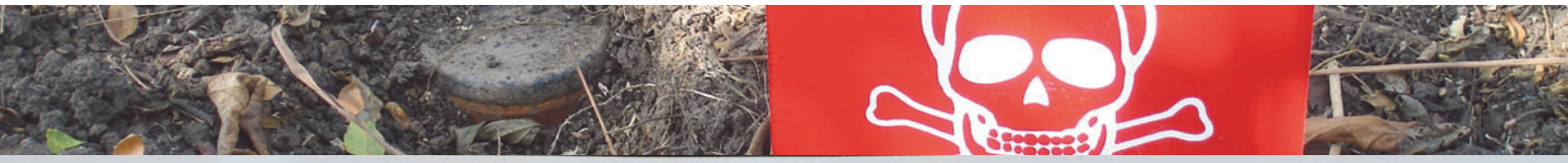
A Review of External

Post-Clearance Inspection

in Mine Action





The inspection of cleared land: guidelines for the use of

IMAS 09.20

GICHD | CIDHG

The Geneva International Centre for Humanitarian Demining (GICHD), an international expert organisation legally based in Switzerland as a non-profit foundation, works for the elimination of mines, explosive remnants of war and other explosive hazards, such as unsafe munitions stockpiles. The GICHD provides advice and capacity development support, undertakes applied research, disseminates knowledge and best practices and develops standards. In cooperation with its partners, the GICHD's work enables national and local authorities in affected countries to effectively and efficiently plan, coordinate, implement, monitor and evaluate safe mine action programmes, as well as to implement the Anti-Personnel Mine Ban Convention, the Convention on Cluster Munitions and other relevant instruments of international law. The GICHD follows the humanitarian principles of humanity, impartiality, neutrality and independence.

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A REVIEW OF EXTERNAL POST-CLEARANCE INSPECTION IN MINE ACTION

MARCH 2012

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EXECUTIVE SUMMARY

The primary objective of humanitarian demining is the identification and removal or destruction of all mines and Explosive Remnants of War (ERW) from a specified area to a specified depth.

In order to achieve this objective it is essential that each organisation and programme that is involved in survey and clearance activities develops a Quality Management System[1] to ensure the overall quality of the entire process. Both quality assurance and quality control (in the form of post-clearance inspection, through sampling), have roles to play in ensuring that the beneficiaries of humanitarian demining are confident that released land is safe for their use.

It should be noted that the current IMAS definition of quality management is somewhat narrow compared to the ISO 9000 series standard, but for the purpose of this study we are using the terminology and definitions as outlined in IMAS 09.20.

Post-clearance inspection (ie external quality control) was introduced in the IMAS in 2000, and since then, much time, money and effort has been spent conducting this process. However, only a very small number of (missed) mines/ERW have been found as a result of post-clearance inspection.

This study seeks to examine post-clearance inspection, including its costs and benefits, and explore how external quality control is implemented across the sector. The study also seeks to determine what additional statistical confidence external quality control provides, to ensure that land is free from explosives hazards post clearance.

This study does not deal with the 'internal' quality control carried out daily by the operator's section/team leaders, supervisors and quality assurance officers, as this is considered a part of normal daily/weekly clearance operations and a vital component of any organisation's internal quality management system.

Preference Consulting[2], on behalf of the GICHD, conducted research into the added value of external quality control within clearance operations. Their research indicated that although the associated costs of external quality control are considerable, the added confidence that the land is in fact free of explosive hazards post-clearance is negligible. In fact, Preference Consulting calculated that there is a reasonable expectation that existing standards of clearance in most mine action programmes, already exceed those laid down in IMAS. Based on data for 2010 from five of the six countries included in the case study, a total of 7.1 million m^2 was sampled to a cost of 5.9 million USD and approximately 6 mines were located[3].

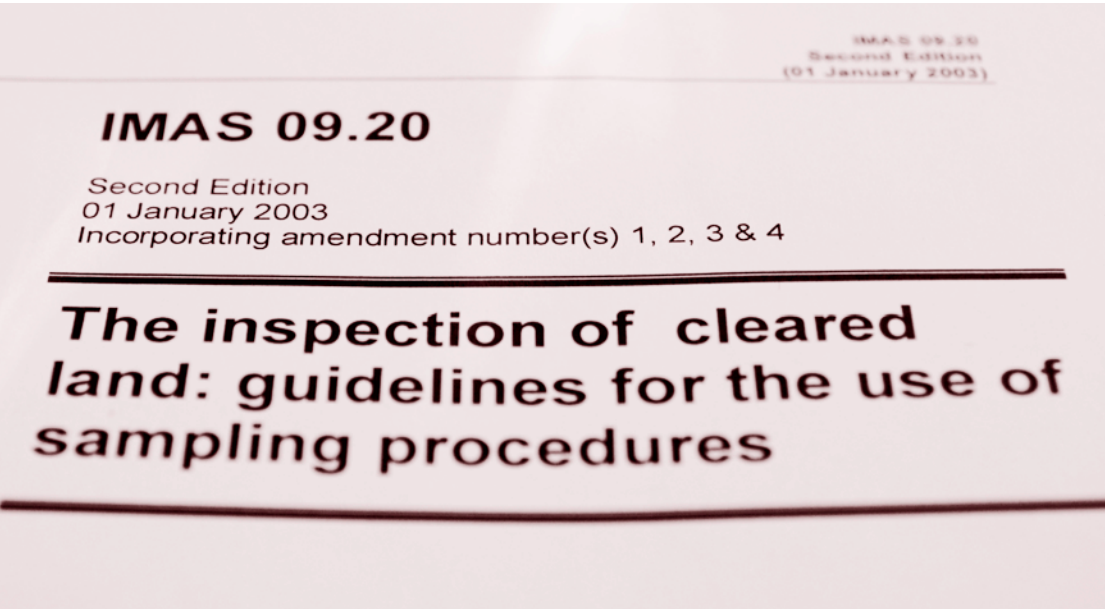
IMAS 09.20 is based on ISO 2859, which was developed to sample industrial production processes, rather than for the sampling of land cleared during demining operations. In 2000, when external post-clearance inspection standards in mine action were initially proposed, it was deemed appropriate at that time to model quality control in demining on the existing quality control processes used within industry. Since then IMAS 09.20 has been the primary reference for post clearance inspection. Given the accumulated data, knowledge and experience gained over the past decade, as well as the fact that IMAS 09.20 has not undergone a revision since its inception, then perhaps now would be an appropriate time to do this.

The majority of humanitarian mine action programmes throughout the world rely on rigorous quality assurance regimes to ensure clearance is performed to the required standards. Because these programmes impose such stringent standards, the general opinion is that there is no need to also implement an additional external quality control process to ensure quality and confidence.

There are very limited official statistics on the number of accidents that have occurred on previously cleared land that had been handed over to the local population. The general sentiment within the mine action sector suggests that the quality of cleared land within mine action programmes that do not employ external quality control is not lower than those mine action programmes that do. It is therefore recommended that mine action programmes should strive to improve their quality assurance practices and look to implement external quality control only in circumstances where it is felt that it is needed.

Once landmines and ERW have been located, clearance is a relatively straightforward process. The biggest challenges are in defining precisely the location of the mines and ERW, and in determining the boundaries of the contamination, ordinarily activities carried out during the survey process. There are a number of IMAS that provide guidance on quality management, but the main focus is on the clearance process, and adequate guidance on the survey process is not provided. It is therefore recommended that IMAS address the lack of guidance currently provided on the quality management of the survey process.

Based on the findings of this report, it is suggested that IMAS 09.20 undergoes a complete revision to ensure that the most suitable and cost efficient quality management practices are applied to areas cancelled and released through survey and clearance.



TERMINOLOGY

The title of this document is *"A Review of External Post-Clearance Inspection"*. It should be noted that, as per IMAS, the term "External Post-clearance Inspection" is interchangeable with "External Quality Control".

Table 1 | Table showing how quality control is practically implemented on a field level

Overview of the different types of Quality Control in demining (according to IMAS)

		Covered by this project
Internal QC	Sampling of cleared areas, performed on a daily basis within the demining organisations during a break	
External QC	Sampling conducted during an external quality assurance visit by an external quality assurance officer. Normally not recorded	
	Post-clearance inspection IMAS 09.20 Sampling by an external body once a site has been completed	X

This review concentrates on inspections (sampling) performed by organisations outside the clearance operators themselves, hence the word, "external".

External post-clearance inspection is usually implemented, either by independent monitoring organisations tasked by the National Mine Action Authorities (NMAAs), or the NMAA themselves. The actual sampling takes place when a task has been completed, but before the land is officially handed over to the end user. The inspection is conducted by sampling or reclearing a certain percentage of the land that has been cleared by an operator. Manual deminers are typically used in this function.

External post-clearance inspections aims at ensuring that the quality of the product reaches an agreed standard. In the case of mine action, the quality standard is that the area is free of evidence of mines/explosive remnants of war (ERW).

It is acknowledged that internal quality control is a vital component of any organisation's internal quality management system. Internal quality control can take place in the form of post-clearance inspection, performed by section/team leaders, supervisors and quality assurance officers within organisations, during a break or at the end of a working day.

For all six countries visited as case studies for this project, there was a degree of confusion in regard to the terminology associated with quality management in demining. In most cases, quality control was seen as being part of the quality assurance process. In accordance with the current IMAS terminology, this is not the case; external post-clearance inspection is a quality control that is a separate, yet complementary, process to quality assurance.

IMAS 09.20 states the following:

The aim of demining Quality Management is to provide confidence (to the beneficiary, the demining organisation and the NMAA) that clearance and quality requirements have been met and that cleared land is indeed safe for use. Quality management for demining comprises three complementary components.

The three components are accreditation, monitoring and post-clearance inspection. According to IMAS 09.20, accreditation and monitoring is a part of quality assurance, while post-clearance inspection is a part of quality control.

Figure 1 | Flow-chart outlining the relationship between components of QUALITY MANAGEMENT in accordance with IMAS

In IMAS, quality control and quality assurance are distinct components of quality management.

- The purpose of quality assurance in humanitarian demining is to confirm that management practices and operational procedures for demining are appropriate, are being applied, and will achieve the stated requirement in a safe, effective and efficient manner[4].
- Quality control relates to the inspection of a finished product. In the case of humanitarian demining, the 'product' is safe cleared land[5].

The essential difference between the two is that quality assurance ensures that the **processes** for demining are appropriately applied, while quality control ensures that **the product (the cleared land)** is indeed free from mines and ERW hazards, down to a specified depth. Quality assurance takes place prior to and during survey and clearance operations, while external quality control takes place once an operator has completed an agreed clearance task.

Occasionally, the external body responsible for quality assurance and external quality control conducts sampling on an area of land cleared by a demining organisation, but before the land has been released for external QC. This ongoing sampling is more common in mine action programmes where quality assurance monitors are permanently present on worksites. The exact location of this sampling is generally not recorded, unless a critical non-conformity is found, and it does not influence external post-clearance inspection.

A cleared area has been physically and systematically processed by a demining organisation, to ensure the removal and/or destruction of all mine and ERW hazards to a specified depth[6]. The clearance is achieved through using an asset capable of providing a clearance result, eg, manual deminers.

For the purpose of this document, and in accordance with IMAS, the following areas are not considered cleared:

- areas that have been cancelled or released through non-technical survey
- areas that have been mechanically prepared or processed, without follow-up by a second asset, but not fully excavated

These areas should not be subjected to external post-clearance inspection.

The IMAS definition of quality management is narrow and heavily-focused on clearance. However, clearance is only one part of the overall process of releasing land suspected to be contaminated by explosive hazards to an end user. The ISO 9000 series understanding of quality management and the quality management system approach is wider and includes several principles, such as:

- leadership (senior management responsibility)
- customer focus
- continual improvement etc

The system approach involves formulating a quality policy, establishing the objectives of the organisation, allocating resources, defining roles and responsibilities, and laying down processes, including methods, to measure their effectiveness and efficiency.

INTRODUCTION

Post-clearance inspection (ie external quality control) was introduced in the IMAS in 2000, and since, much time, money and effort has been spent conducting it. However, only a very limited number of missed mines/ERW have been found as a result.

This study seeks to examine post-clearance inspection, including its costs and benefits, and explores:

- how external quality control is implemented across the sector
- findings during external quality control (number of critical non-conformities)
- pros and cons of external quality control
- what additional statistical confidence does external quality control provide to ensure that land is free from explosives hazards after clearance
- the cost implications of external quality control

This study does not cover the 'internal' quality control carried out daily by the operator's section/team leaders, supervisors and quality assurance officers.

The majority of countries with humanitarian mine action programmes do not appear to implement external quality control processes, and instead, employ a stringent quality assurance approach. This study seeks to examine several countries that implement an external quality control process.

Under the heading *conclusions and recommendations* at the end of this report, some suggestions are provided for a possible revision of IMAS 09.20. The aim of this project was not to conduct a full review of IMAS 09.20, but to analyse the field application of external post-clearance inspection as a quality control, and gather lessons learned and best practices to make way for a possible future full review of IMAS 09.20.

BACKGROUND

Before 2000, there were no globally accepted standards in place to measure the quality of land considered safe through survey and clearance. Nor were there any agreed approaches to measure how appropriate, efficient or effective the survey and clearance methodologies employed were. In 2000, steps were taken towards incorporating some of the International Organisation for Standardisation (ISO) standards that focused on quality in the mine action sector.

At the time, the ISO standards themselves were evolving, with production industries first moving from a focus on quality control (checking the product) to also focusing on quality assurance (checking the process). By 2000, lessons learned from the production industries showed that a more balanced approach to quality management was required, and that quality assurance and quality control should be given a more equal status.

In late 1999, as part of the ongoing work on IMAS, a working group on the application of risk management to clearance standards was established, and named the *Working Group on Clearance Standards* (WGCS). The group initially consisted of the GICHD, the European Land Mine Solution, Cranfield University, Mine Tech and RONCO.

Extensive research was conducted into statistical analysis options, best practices and lessons learned from other industries. The WGCS final paper recommended identifying tolerable risk in mine action, using the ISO-approved method – the *acceptable quality level* (AQL). Following accepted international practice, compliance with the AQL must be verified through random sampling of the product. The area of cleared land that would need to be sampled is based on a combination of factors;

- the quality record of the clearance organisations
- the planned future use of land
- the size of the contaminated area

One of the results of the work done by WGCS was the development of IMAS 09.20 *The inspection of cleared land: guidelines for the use of sampling procedures*. IMAS 09.20 is based on ISO 2859, the standard developed for production line processes, such as the manufacturing of car parts. Application of ISO 2859, assumes that the product (in the case of demining, according to IMAS "cleared land" is homogeneous; eg, the product has the same composition throughout, or is of uniform make-up.

In order to calculate the level of sampling in accordance with ISO 2859, the *specified quality limit* (SQL) had to be established. The SQL provides an indication of the quality of clearance operations. For sampling in IMAS 09.20, it is set at 0.35 per cent, which equates to a maximum of 35 non-conformities per 10,000 samples, or 35 non-conforming square metres for every 10,000 square metres sampled. In sampling terms, this is a fairly strict criterion.

It was agreed that the SQL should be reviewed at a later stage, however this has not yet been done. Prior to the adoption of IMAS 09.20, the SQL for other industries were also examined. As an example, the SQL for demining 0.35 per cent is approximately equivalent to the risk of a surgeon contracting HIV from a latex glove breaking while operating on a HIV positive patient[7]. By conveying principles from other industries to mine action, a number of adaptations and assumptions were made. IMAS 09.20 mentions that when applying the IMAS principles, there will be an acceptable degree of probability, or confidence that a cleared area is actually mine/ERW free.

As previously stated, and as per the IMAS definition, the product within demining is cleared land which has been processed by an asset capable of providing a clearance result. According to IMAS, this includes:

- manual mine clearance methods
- the use of two accredited mine detection dogs (MDD)
- a machine followed by a second asset
- land that has been fully excavated to a specified depth
- soil processed for mines/ERW

External quality control is therefore only applicable in areas that have been fully cleared.

The institutional application of external quality control is not a common activity in mine action programmes. In fact, most rely on a rigorous quality assurance regime instead. The International Campaign to Ban Landmines (ICBL) reports that a total of 72 states and seven disputed areas are confirmed or suspected to be mine-affected. ICBL also reports that there are approximately 50 active mine action programmes throughout the world. Research has shown that approximately 14 programmes implement post-clearance inspection, or approximately one quarter of all current active mine action programmes.

ASSESSMENT METHODOLOGY

The assessment methodology took the form of four distinct activities:

- review of probability and sampling theories at an academic level
- an analysis of relevant IMAS, NMAS, SOPs and identification of recommendations for improvement
- case studies, involving interviews and meetings with mine action operators and stakeholders in the various countries (field visits and discussions during meetings of state parties, etc)
- an analysis of the development of the current version of IMAS 09.20 and the rationale behind the initial decision to incorporate external quality control into IMAS in the form that was adopted

Probability and Sampling Theories

The methodology for external quality control in demining is described in IMAS 09.20 and is based on ISO 2859. The academic review of probability and sampling theories aimed at establishing the appropriateness of basing external quality control in demining on the random sampling approach, as outlined in ISO 2859.

The key result wanted from the academic review was to establish if external quality control adds any extra confidence in regard to the land being free of mines/ERW after clearance, and, if so, how much. This was also linked to the mathematical probability of finding missed mines or ERW while using an external quality control system based on IMAS 09.20.

The academic review was carried out by Preference Consulting, a Swedish company, with strong links to the Swedish Royal Institute of Technology, Stockholm University and Mid Sweden University. Preference Consulting had previously worked with GICHD on projects related to efficiency during survey and clearance operations.

Analysis of Relevant IMAS, NMAS and SOPs

The analysis of relevant IMAS, NMAS and SOPs was designed to discover how external quality control meant to be conducted in the field, what differences there were between various countries, and why these differences existed.

Case Studies

The goal of the case studies was to gather data and solicit opinions on post-clearance inspection from actors involved in external quality control at all levels – internationally, nationally, NGO, commercial and governmental.

An additional goal was to examine how external quality control was carried out in practice, and then compare this to the existing NMAS. Field trips to six mine-affected countries that implement external QC were undertaken as part of the study. These were Azerbaijan, Afghanistan, Bosnia, Colombia, Croatia and Jordan.

The programmes selected were of different sizes and ages and drawn from three continents. In order to avoid unfavourable comparisons between the countries visited, and to promote access to initial data, programmes will not be mentioned again by name in this report. Statistics will be linked to a coding system; Country A to Country F.

Background to the Current IMAS on External Post-Clearance Inspection

The analysis of the initial development of IMAS 09.20 on external post-clearance inspection, and the rationale for the initial decision to adopt an ISO 2859-based system, involved a visit to Cranfield University in the UK.

The university, together with the GICHD and a number of other mine action organisations, was closely involved in developing external quality control for demining. Separate discussions with other key actors regarding the development of IMAS at the time were also held. Further detail on the background to IMAS is found under the heading *background* in this report.

KEY FINDINGS

The sampling process outlined in IMAS 09.20 was not exactly replicated in any of the six programmes visited. The complexity of IMAS 09.20 does not make full adoption easy, and each programme has developed its own system with adjustments made to the IMAS.

In addition to the confidence external quality control may inspire in the quality of the cleared land, it also has a beneficial normative effect on clearance organisations. Based on discussions with the national authority and clearance organisations, the general perception is that operators are more motivated to perform quality work according to standards, if they believe their work will be inspected by external quality control. All organisations are very much aware of the potential of losing their reputation, and the significant costs reclearance may require, in the event of non-conformities being discovered during external quality control.

Five of the six countries visited demonstrated some confusion about what constitutes quality control and what constitutes quality assurance. In all six cases, quality control is incorporated into all the national standards on quality assurance, and there is no national standard on quality management as a whole. Therefore, quality control is seen as being part of quality assurance, rather than being a distinct, but complementary, set of processes.

Ensuring that clearance or mechanical processing has been conducted to the specified depth is part of quality assurance, yet various national standards describe it as a component of quality control. Measuring the depth of clearance ensures that clearance or ground preparation processes have been correctly applied. Quality control merely ensures that the cleared land meets the required quality standards.

Case Study Summary

Country A – regardless of the amount of land that IMAS suggests should be sampled, Country A caps it at five per cent. If IMAS suggests sampling less than five per cent, this is done, but more than five per cent is never sampled. There is no mechanism in the national standards for increasing the amount of square metres sampled, reducing the level of sampling, or not carrying out sampling at all.

After manual clearance with detectors, there is no requirement for the cleared land to be metal-free. The requirement is that all signals are investigated, which is almost impossible to verify once it has rained on the worksite and the traces of the excavated areas have been erased.

Critical non-conformities found during external post-clearance inspection are defined as *un-investigated large pieces of metal* (in the case of manual clearance) or as explosive traces (in the case of MDD). Finding a critical non-conformity will result in a requirement to reclear the applicable lot.

The majority of tasks in Country A are technical survey tasks, which involves a systematic investigation, by dividing the suspected area into boxes, either manually or by using MDD. Lanes between the boxes are checked for any indications of mines/ERW, but the boxes themselves are not. However, when it comes to the external quality control process, all of the land, including inside the boxes, is checked. However, this is not in actual fact sampling, because the boxes themselves were never cleared during the initial technical survey operation. In this case, quality control has been misnamed; it is actually additional technical survey, deliberately designed to build confidence that the technical survey operation did not miss any indications of mines/ERW.

Country A employs quality assurance monitors, who are also responsible for producing an external quality control plan and for overseeing the external quality control process. However, the actual external post-clearance inspection is undertaken by the clearance organisation itself. This could put the issue of transparency in question. Sampling is also undertaken by the quality assurance monitors, but this was targeted at weaker deminers or at areas more likely to contain mines/ERW. This sampling, conducted while work is ongoing, is not recorded, meaning that the external quality control could be undertaken on areas that have already been subjected to some form of sampling.

Approximately 635,000 m² of land in Country A was sampled in 2010, at an approximate cost of USD 1.057 million. Country A reported critical non-conformities found during external quality control resulted in 55,182 m² being recleared in 2010. Since 2004, eight missed mines have been found during external post-clearance inspections. In total, between 1998 and 2010, 58 missed mines and/or ERW were found in areas previously handed over as cleared.

Country B has a very complex interpretation of IMAS 09.20 incorporated in its national standards, in comparison with the other mine action programmes. Because of their complexity, the national standards are routinely ignored by those conducting external quality control on the ground. In reality, only one per cent of land is sampled post-clearance. There is no mechanism for having "tightened, reduced or skip inspections".

As in Country A, there is no requirement for the cleared land to be metal-free, once manual clearance using detectors has taken place. The requirement is that all signals must have been investigated (disruption of the soil), which, however, is difficult to verify once it has rained on a worksite and the disrupted ground has settled.

Similar to Country A, Country B conducts sampling while work is still ongoing and does not record these areas as post-clearance inspection, opening the possibility of the land to undergo further external quality control. Again similar to Country A, in technical survey tasks, the external quality control is conducted both in the uncleared boxes and the cleared lanes around them. These are the only two countries where this practice was found during the case studies.

Unlike Country A, the NMAA in Country B employs a dedicated external quality control team, which undertakes sampling under the direction of an NMAA quality assurance officer. The external quality control is partially targeted on areas where mines/ERW is more likely to be found. The only type of critical non-conformity, that can result in a requirement for reclearance, is finding a missed mine/ERW. There were two critical nonconformities found in 2010, and five in 2009. Just over 500,000 m^2 were subjected to external quality control in 2010, at an approximate cost of USD 1.1 million. In 2010, unofficial reports stated that 83 missed mines/ERW were found in areas that had already been handed over as cleared.

Country C has carried out external quality control since 2002. The NMAA samples a minimum of ten per cent of each cleared area, although this can be as much as 30 per cent in a tightened regime. There is no mechanism for reducing inspections below 10 per cent, or for skipping inspections.

External quality control is random in principle, but the team leader tends to focus on areas where there were more indications during clearance, or where mines are more likely to be encountered. The last time a missed mine was found during external quality control was in 2003. However, missed ERW have been found on approximately 14 occasions in the last ten years. These missed ERW were all found during the clearance operations of destroyed ammunition storage areas. In 2010, 2,637,729 m^2 were sampled. A missed mine or ERW has never been found in a previously cleared area.

Country D implemented external quality control in 2005. For commercial clearance organisations, ten per cent of cleared land has been sampled since 2005. Since 2007, the ten per cent sampling practice has also been extended to NGOs. However, external post-clearance inspections are not carried out on all worksites; they are only carried out if the quality assurance visits indicate problems in the quality of clearance.

Dedicated quality assurance/quality control teams carry out external quality control. In 2010, two critical non-conformities were found during external quality control, but these were not missed mines/UXO (large pieces of metal or similar). The last year of figures for square metres sampled is 2007, when 209,000 m^2 were processed.

Country E has been conducting external quality control since 2006 and has dedicated teams conducting the sampling, which, in 2010, consisted of 3,259,400 m². The sampling standard is 23 per cent, and a critical nonconformity is defined as a missed explosive device. No critical non-conformities (for example evidence of missed mines/ERW, or a piece of metal with a similar composition to the suspected explosive hazard) have been found since sampling began in 2006.

Country F implemented external quality control in 2006. It began by using the formula suggested in IMAS 09.20, but changed this over time. Sampling is now semi-targeted, with 80 per cent of time spent on areas where mines were found. There is a dedicated sampling team conducting sampling of all completed areas. Since 2006, only three missed mines have been found, and all of these were found outside the mine rows of areas processed by mechanical assets and MDD. In 2010, sampling was conducted on 14,000 m², at an estimated cost of USD 57,000.

Figure 2 | Example of a sampling plan for post-clearance inspection. Each black box represents a sample where the ground has been re-cleared by manual deminers

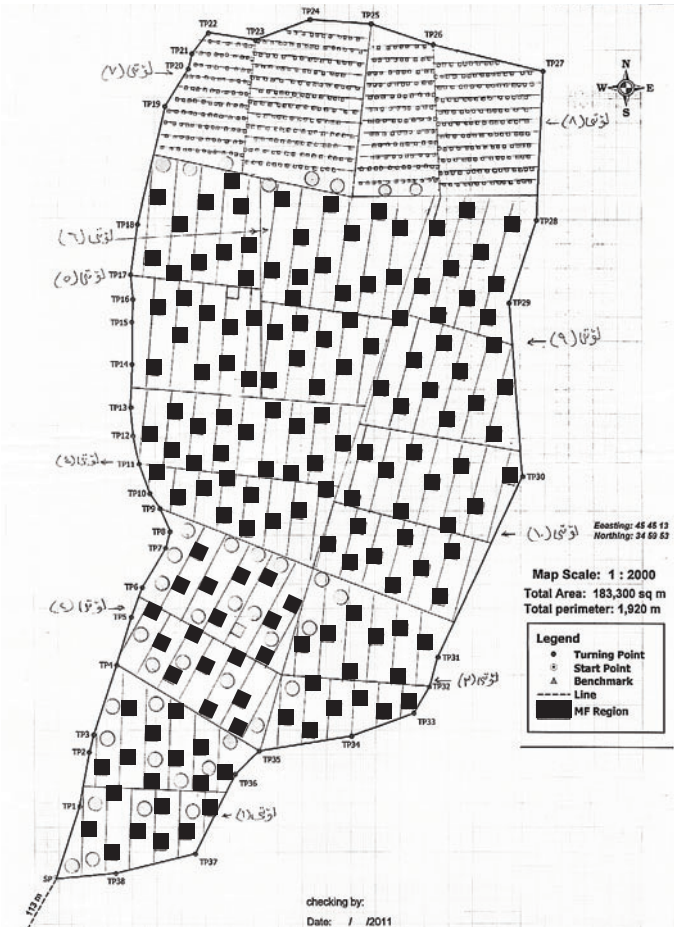


Figure 3 | Example of a sampling plan for post-clearance inspection. Each black box represents a sample where the ground has been re-cleared by manual deminers

Sampling plan | 1 cm = 6 metres

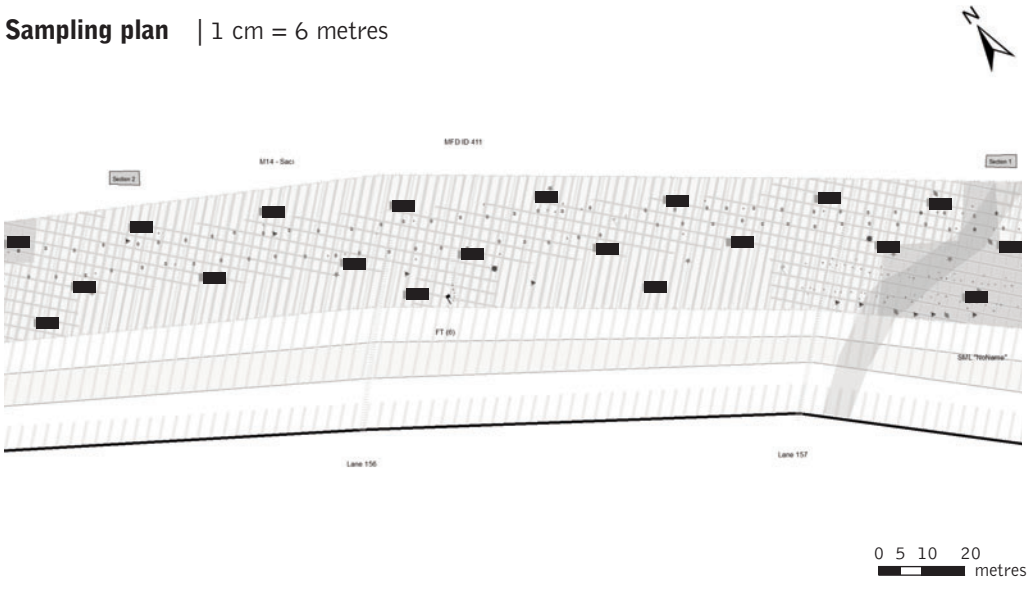


Table 2 | Table summarising the statistics from the six case studies

	Number of mines/ERW or critical non-conformities found during external QC	m² sampled during external QC 2010
Country A	8 mines since 2004	635,000
Country B	2 in 2010 and 5 in 2009 (it is unknown if this critical non-conformities are missed mines/ERW or large piece of metal etc.)	500,000
Country C	last missed mine in 2003	2,637,729
Country D	2 in 2010 (not missed mines/ERW)	209,000 (2007) Note: no data available for 2010
Country E	0 since the beginning of sampling in 2006	3,259,400
Country F	3 since the beginning of sampling in 2006	14,000
TOTAL		**7.1 million m²**

For 2010, the total area sampled during post-clearance inspections for the above countries (country D excluded) was **7.1 million m²**. The cost per square metre cleared differs widely between countries. To calculate the total cost, an estimate price of 0.82 USD per m² was used (a comparatively low price per m²). Based on this assumption, the total cost for 2010 was **USD 5.9 million**, and a total of **5.7 mines** were located the same period.

Table 2 contd. | Table summarising the statistics from the six case studies

	Estimated cost USD 2010	m² sampled/mine 2010	Mines found 2010
Country A	1.057 million	557,017	1.1**
Country B	1.1 million	250,000	2
Country C	Unknown*	2,637,729	0
Country D	Unknown*	N/A	2
Country E	Unknown*	3,259,400	0
Country F	57,000	23,333	0.6**
TOTAL			**5.7 mines**

* the country specific price/m² is not known

** average number of mines found per year

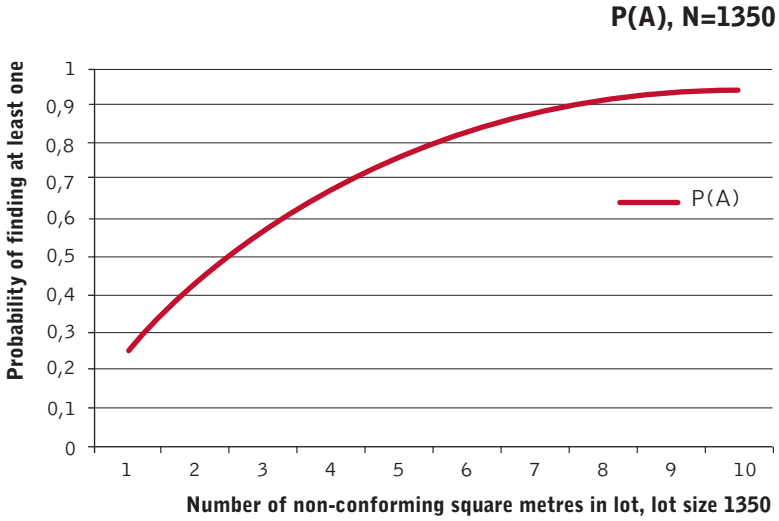
Theoretical Review of IMAS 09.20

Preference Consulting is a Swedish company with strong links to the Swedish Royal Institute of Technology, the University of Stockholm and the Mid-Sweden University. The company was hired by the GICHD to produce a report which analysed the mathematical probability of finding a mine/ERW that had been missed, using the sampling plan suggested in IMAS 09.20, which is based on ISO 2859. The result is presented in the graph below.

Preference Consulting also sought to:

- explore alternative approaches to the IMAS 09.20 sampling plan from both theoretical and practical perspectives
- develop a method to assess, from the perspective of mathematical probability theories, any increase in confidence

Figure 4 | Illustrates the probability P(A) of finding at least one non-conforming square metre in a lot size of 1,350 m^2. The sample size here is 339 m^2, in accordance with the IMAS 09.20 standard. In this formula, reduced level of inspection* and Land Use (LU)2** was used. If, for example, the lot contains one missed mine, there is a 25 per cent chance that it will be found (assuming that 1 mine = 1 m^2)



* **Inspection levels** The inspection levels reflect the proven effectiveness and capabilities of the demining organisation. Four different levels may be applied: normal, tightened, reduced and skip inspections (no post clearance inspection at all).

** **Land Use (LU)** The land use is linked to how the land will be used, and the required confidence in the quality of clearance. An area that will be used for a school will require higher levels of confidence that all mines/ERW have been removed, compared to an area used for grazing. There are three levels of land use (LU1, LU2 and LU3) which represent confidence levels.

ISO 2859 uses sampling by attribute, ie, a sample is taken from a lot which is rejected if the number of non-conforming items exceeds a certain threshold. In demining terms, this threshold is 0.35 per cent, which equates to 35 non-conforming square metres for every 10,000 square metres sampled.

ISO 2859 is designed for quality control of batches of production. Preference Consulting determined that sampling plans based on ISO 2859 are not optimal for all applications and may lead to unsatisfactory costs.

A quantitative investigation of the sampling plans specified in IMAS indicated that sampling, conducted when the lot size is small and the quality of the clearance is high, results in relatively high costs for only a marginal return in confidence of the clearance. It may therefore be beneficial to reduce the level of sampling or, in some programmes, consider ceasing external post-clearance inspection altogether, rather than concentrating on quality control activities, with no real increase in confidence in the clearance product.

Preference Consulting showed that the quality of mine clearance of the Bosnian mine action programme was far better than that sought by IMAS. Any actual confidence increase provided by sampling tended to be quite low, as the confidence in the quality of the cleared land prior to sampling was already very high.

As Preference Consulting states, when conforming to the IMAS procedures for lot rejection:

> *"…the corresponding optimal sampling plan is…not to perform sampling at all[8]."*

Normative Effect

All of the countries visited wanted to maintain external quality control in one form or another. The reasons given were rarely about increasing confidence in the quality of the cleared land, but rather the normative effect that external quality control has on demining organisations.

This was especially the case when there were large numbers of commercial companies competitively bidding for clearance contracts. Some NMAAs commented that the likelihood of cutting corners is higher in commercial companies than in non-profit organisations.

There is an argument to be made for the positive normative effect of external quality control, but the majority of mine action programmes throughout the world choose not to use external quality control, and instead have a quality assurance approach.

This is based on the reasoning that if the processes are appropriate and carried out in accordance with accredited SOPs, the quality of the cleared land will naturally follow. There are limited official statistics on the number of accidents that have occurred on land that has been cleared and handed back to the local population.

The general impression within the mine action sector is that there is no argument that the quality of the cleared land in mine action programmes, without external quality control, is lower than that of mine action programmes where quality control has been employed.

Cost of External Post-Clearance Inspection

The exact additional costs that result from external quality control are difficult to quantify. However in two of the six countries visited, the annual cost was estimated to be in excess of one million US dollars. This was purely for external quality control, based on the average cost of clearing one square metre of ground, multiplied by the number of square metres sampled.

In addition to the simple financial cost of external post-clearance sampling, additional time required should also be taken into account. During field visits, it was not unusual to find that external quality control added five to ten days or even longer to the overall duration of a task.

Throughout the world, many millions of square metres of cleared land are sampled by external quality control teams, but very few missed mines/UXO are actually found. The majority of those that are found could potentially have been avoided by implementing a more rigorous quality assurance system. This is especially the case where clearance has not been conducted to the specified depth.

Additionally, some missed mines/ERW were found during external quality control because the initial threat assessment had been done incorrectly. The precise area containing the missed mines/ERW was therefore not considered as requiring clearance, and was left without a technical intervention.

Based on findings from the case studies and the work by Preference Consulting, it is therefore clear that the quality of the majority of cleared areas is generally high and sampling adds little additional confidence in whether or not the area is free from explosive hazards after clearance.

CONCLUSIONS AND RECOMMENDATIONS

Based on the discussions during the case studies and with other stakeholders, it is evident that general understanding of quality management, and the systems involved in this, in the mine action sector are limited.

IMAS and subsequently most NMAS provide only a limited and fairly narrow description of the issue. This implies that opportunities to achieve efficiency and effectiveness, as well as learning and continual improvement, are being missed.

Both quality assurance and control play a role in ensuring that land released through survey and clearance is as safe as possible, and the risk level of missed mines/ERW to the end users is as low as is reasonably practicable.

In approximately ten years of external quality control, millions of square metres of already cleared land have been sampled, and a comparatively small number of missed mines/ERW have been found. This indicates that the quality of the final product, the cleared land, is typically very high.

In such instances, the question of costs versus the added value of external quality control should be considered – especially in programmes with limited funding. The findings of this study show that, for five of the countries in 2010, 7.1 million m^2 of previously cleared land was recleared during external quality control, in five countries. This cost USD 5.9 million but only close to six mines were found[9].

I. Applicability of ISO 2859 in humanitarian mine action

IMAS 09.20 is based on ISO 2859, which was developed to sample industrial production processes, rather than for the sampling of land cleared during demining operations. In 2000, when external post-clearance inspection standards in mine action were initially proposed, it was appropriate to model quality control in demining on the existing quality control processes used in industry. IMAS 09.20 has been a source of reference for over ten years, and should perhaps now be reviewed in the context of the experience gained since its inception.

II. Focus on quality assurance

The majority of humanitarian mine action programmes in the world rely on stringent quality assurance regimes to ensure clearance is performed to the required standards, and does not also implement external quality control. Limited official statistics exist on the number of accidents that occurred on previously cleared land that had been handed over to the local population. The general impression within the mine action sector suggests that there is no argument that the quality of the cleared land in mine action programmes without external quality control is lower than that of mine action programmes which do. By developing a well-functioning internal and external quality assurance process, including regular monitoring visits, the need for external quality control can be reduced, or in many cases entirely removed. Therefore it is recommended that mine action programmes improve quality assurance practices and see external quality control as complementary.

III. High costs for a negligible increase in confidence

Research conducted by Preference Consulting concluded that external quality control provides only a marginal amount of additional confidence, yet the costs are considerable. In fact, Preference Consulting calculated that there is a reasonable expectation that existing standards of clearance already exceed those laid down in IMAS, based on the fact that very few mines are found during external quality control. The money and time spent on external post-clearance inspection does not result in an appreciably higher level of confidence in most cases, as the quality is high already. This money and time could be better invested in additional quality assurance and additional clearance efforts. Data in 2010 for five case studies showed that a total of 7.1 million m² of land was sampled at a cost of USD 5.9 million, and only close to six mines were located. This is a fairly conservative calculation based on certain assumptions, see Table 2 on page 16.

IV. Focus on quality management of the survey process

The current guidance provided in IMAS on quality management has a strong focus on the clearance process. Clearance of landmines and ERW is a relatively straightforward activity once they have been located. For demining operators, the main challenges lie in defining precisely their location, where are the boundaries of the contamination, and deciding where to start and stop clearance. With the land release methodology, much more land is released by survey and less by actual clearance. This normally increases the need to focus on the quality of the survey process. It is therefore recommended that IMAS focuses more on the quality management of the survey process, as well as the clearance process itself.

V. External quality control to remain an option

IMAS 09.20 states repeatedly that external quality control is optional. The case study however showed that the mine action programmes that do implement external quality control seem to carry out sampling on the majority of the completed areas cleared. The GICHD recommends that external quality control remains an option for NMAAs considering additional measures to review the work of clearance organisations. A selected application of external quality control is suggested. Clearance organisations that consistently fail to perform to acceptable standards should have their accreditation withdrawn, an option not available to all NMAAs.

VI. External quality control to focus on organisations with poor track records

In almost all programmes that implement external quality control, there is generally a set percentage of land that must be sampled on every worksite. This sampling is performed regardless of the track record clearance operators, and the option for reduced or skipped inspections does not exist. Clearance organisations that produce the lowest quality of work should be the target of external quality control, and this should be identified during the quality assurance inspections. Implementing this system would provide motivation for clearance organisations to attain and maintain an acceptable level of quality, because they would not then be liable for the additional costs in time and money that external quality control imposes upon them. Of course, this would be a normative benefit of a more flexible external quality control system.

If external quality control is applied, the following procedures may be taken into consideration:

- a percentage of tasks completed by an organisation are subjected to external quality control (for example every tenth completed task is inspected)
- external quality control is limited to areas worked by teams with a documented history of poor performance (identified through quality assurance)
- organisations with good, proven track records are exposed to reduced external quality control or no external quality control at all
- quality control is limited to areas worked by teams with a history of poor performance and the demining organisations themselves finance it
- targeting of areas where mines/ERW are more likely to be found
- post-clearance inspections, to focus on newly accredited operators
- targeting of tasks where mines may be more likely to be missed, such as areas with complex physical conditions and/or where assumptions have been made that may justify sampling

VII. Alternative sampling methodologies to be explored

There are innate differences between areas of land and the uniform items resulting from an industrial production process. ISO 2859 is not the most appropriate basis on which to develop a quality control concept for demining. This is because ISO 2859 entails sampling by attributes, which requires a great amount of homogeneity in the product to be sampled. Areas of cleared land do not, in most cases, have the level of homogeneity required by ISO 2859. Therefore it is recommended that alternative sampling methodologies are explored.

VIII. Suggested revisions to IMAS

Based on the findings of this report, it is suggested that IMAS 09.20 undergo a complete revision to ensure that the most suitable quality management practices are applied to areas released through survey and clearance.

a. There is some confusion among national programmes in regard to the differences between quality assurance and quality control. Often quality control is incorporated into national quality assurance standards, when it is a different, albeit complementary, process.

b. It is recommended that IMAS 09.20 is incorporated into a new IMAS on operational quality assurance, which would focus on the entire land release process, including survey and clearance. This new IMAS would clearly demonstrate how quality assurance and quality control are complementary components of quality management. It would also stress that quality control is only necessary if quality assurance does not provide sufficient confidence in the quality of the cleared land.

c. According to the findings of their project, ISO 2859 is not the most appropriate basis for external quality control in demining. Quality control should not be purely random because in general, mines are more likely to found in some areas than others. It is recommended that alternative sampling methodologies for demining are tested.

d. Having three different levels of quality control, dependent on the final land use, implies that the quality of the cleared land can be lower for certain land uses than for others. Clearly this is not the intention; IMAS 09.20 states that:

"…it is important to recognise that the use of LU3 during the sampling process does NOT equate to a lower standard of clearance."

Yet the mere statement that different land users require different standards of quality control inevitably implies that lower quality standards are acceptable. As the same clearance processes will be followed, regardless of the final land use, the quality of the clearance should be equal in all cases. It is recommended that whatever form of quality control is adopted, it should be equal for all land users. This would also help to simplify an overly complex formula.

e. IMAS 04.10 declares that:
for humanitarian demining *"…the "product" is safe cleared land."*
A more relevant definition of the product in humanitarian demining could be, safe land. This would include land that has been cleared of explosive hazards, land that has been cancelled and land that has been released through technical survey. This would enable quality control being used in a wider context and not solely for cleared land.

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ANNEXES

ANNEX A | LIST OF COUNTRIES APPLYING EXTERNAL QC

Afghanistan	Croatia	Kosovo
Azerbaijan	Iraq	Lebanon
Bosnia	Iran	Mozambique
Chad	Israel	Sri Lanka
Colombia	Jordan	

ANNEX B | EXTRACTION FROM IMAS 09.20
THE INSPECTION OF CLEARED LAND: GUIDELINES FOR THE USE OF SAMPLING PROCEDURES

Annex B (Informative) **Sampling plan**
The complete IMAS 09.20 The inspection of cleared land: Guidelines for the use of sampling procedures can be downloaded at: www.mineactionstandards.org

B.1. Cleared area
The area to be cleared and the depth of clearance should be determined in advance by a technical survey, or from other reliable information which establishes the extent of the mine and ERW, including unexploded sub-munitions hazard area, and should normally be defined in a contract or some other formal arrangement. (Clearance requirements are covered in detail in IMAS 09.10.)

B.2. Area to be inspected
The cleared area may be divided up for inspection into one or more 'lots' of land. The size of each lot will depend on many factors, including the total hazardous area to be cleared, and whether the area consists of a single large hazardous area or a series of small hazardous areas.

For statistical reasons, the sampling requirement (ie the area to be inspected) reduces proportionally as the size of lot increases. Therefore, as clearance work progresses satisfactorily, it will usually be more efficient to select larger lots for inspection.

For example: several groups of small hazardous areas are to be cleared by the same organisation in the same way, and the total area is three hectares (30,000 m^2). This might be divided into five lots of 2,000 m^2 during the initial stages of the clearance, rising to four lots of 5,000 m^2 as the clearance progresses. This would ensure that the sampling could be completed by the inspection body within days of completion of the clearance.

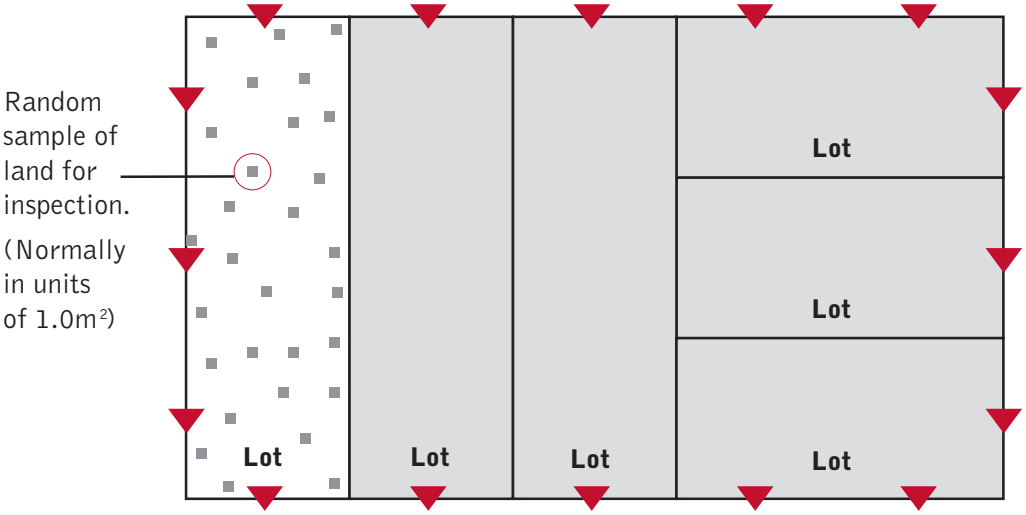
B.3. Sample size
The sample size (i.e. the area of land to be inspected in each lot) depends on three factors:

a) the lot size (see clause B.4. below);

b) the intended use of the land (see clause B.5. below);

c) the experience and effectiveness of the demining organisation (see clause B.6.below)

Figure B.1 | Illustration of cleared area, lots and samples of land for inspection



B.4. Lot size
As stated in clause B.2. above, the required sample size is not directly proportional to the lot size. It is derived from the equation at clause B.3.4 of Appendix 3. For ease of application, examples of the relationship between the sample size and lot size are summarised in the table in Appendix 1. It can be seen that a smaller lot size requires a proportionally larger sample.

B.5. Land use
The sample size may be increased if additional confidence is needed in the quality of clearance. This will depend on the use to which the land is to be put, and the amount of human and animal traffic it will receive. Certain categories of land, for example tracks and footpaths, and areas around wells, housing and schools, will require higher levels of confidence (LU1), whereas land of little agricultural use and poorly frequented may only require a lower level (LU3). Three levels of land use (LU1, LU2 and LU3) are provided to represent the required confidence levels. The category of land use, and subsequent confidence levels, should be decided by the NMAA in accordance with national policy, and should be included in the clearance contract or some other formal agreement. If no level is specified, the highest confidence level, LU1, should be applied.

The target of humanitarian mine clearance remains the removal or destruction of ALL mines and ERW, including unexploded sub-munitions from the specified area to the specified depth. This is the responsibility of the clearance organisation, BUT the NMAA has a responsibility to ensure the quality of this work. The use of LU1, LU2 or LU3 is therefore not an indication of the level of clearance achieved, but rather an indication of the required confidence level in the organisation conducting the clearance.

The use of LU1 produces a sample size approximately double that of LU2 and therefore allows the NMAA to have a correspondingly higher level of confidence (10%) in the quality of that particular clearance operations. The NMAA will decide on the LU category to be used. They may choose to use LU1 for all land, but this would probably not be the most efficient use of scarce resources if the demining organisations have had an excellent track record of success. It certainly goes against the principles of QM and risk management on which IMAS is based. It is recognised that this is initially a complex area; however, it is important to recognise that the use of LU3 during the sampling process does NOT equate to a lower standard of clearance.

B.6. Inspection levels

The sampling procedures established in ISO 2859-0 for the inspection of critical non-conformities include four levels of inspection. The inspection levels reflect the proven effectiveness and capabilities of the demining organisation. They provide an incentive to improve performance. For the inspection of cleared land:

a) the 'normal' level of inspection defines the average size of sample which will achieve sufficient confidence that the demining organisation has removed and/or destroyed all mine and ERW hazards from the specified area to the specified depth;

b) the 'tightened' level of inspection should be applied at the start of a contract and at the start of each clearance task when the demining organisation has yet to establish a record of effective and efficient clearance. The 'tightened' level may also be applied to a successful demining organisation on the introduction of new and unproven operational procedures or new and unproven equipment;

c) the 'reduced' level of inspection gives credit to successful organisations with a proven record of safety and effective clearance; and

d) 'skip inspections' can be applied to demining organisations that have a consistent record of safe and effective clearance.

The switching procedures and rules which enable demining organisations to move between different levels of inspection are described in Appendix 2. NMAAs should seek expert advice before modifying the switching procedures and rules.

Example: A lot presented for inspection has a total area of 8,000 m². It comprises grazing land which is deemed (by the NMAA) to require the medium level of confidence (LU2). A demining organisation with a proven work record is being used, and the contract has been in progress long enough for the organisation to have gained the confidence of the NMAA. This allows a reduced sampling regime to be adopted. If these criteria are applied to the table in Appendix 1 (see extract at Figure B.2 below), a sample size of 444 m² would, if proved clear, achieve sufficient confidence that the entire lot has been cleared and is safe

Figure B.2 | Example: sample sizes for various lot sizes (extract from Appendix 1)

		Inspection Levels		
Lot size (Cleared Area) (m²)	**Land Use**	**Reduced** (m²)	**Normal** (m²)	**Tightened** (m²)
8,000	LU 1	636	784	1,173
	LU 2	444	506	585
	LU 3	334	373	418

Once a demining organisation has demonstrated a consistent record of safe and effective clearance, and has an effective and efficient system of QA, then the NMAA may consider allowing that demining organisation to conduct self-sampling for QC. The self-sampling must however, use the sampling methodology in use by the NMAA.

B.7. Sampling scheme

The individual units of land to be inspected (normally in units of 1.0 m^2) should be chosen in a random fashion. Any attempt to move away from random samples by applying assumptions and judgement could undermine the validity of the inspection process by introducing bias, and should therefore be discouraged.

Sampling units of 1.0 m^2 may be grouped into clusters for ease of inspection. All units inside each cluster shall be inspected. For the application of this IMAS, clusters shall be no larger than 30 m^2 in size. Clusters may be of any shape including, for example a circle, a square or a strip, but they shall be the same size in any single lot of land presented for inspection.

Small areas of land may be grouped into a single lot, and submitted as a single lot for inspection – so long as all the areas have been cleared by the same demining organisation under similar conditions (see clause 4. in the main text above). All areas, regardless of size, shall be inspected – the sampling effort shall be in proportion to the size of each area. This process is known as 'stratification'.

Example: A demining organisation has been contracted to clear four gardens in the same area (three are 1,000 m^2 and one is 2,000 m^2). The organisation has been authorised to group the gardens as a single lot and to submit that lot for inspection. The inspection body should stratify the sample by allocating 40% of the sampling effort to the bigger garden and 20% to each of the three smaller gardens.

ENDNOTES

1 Including a quality policy, objectives, allocated resources, defined processes and organisational clarity of roles and responsibilities

2 Swedish company, with strong links to the Swedish Royal Institute of Technology, Stockholm University and Mid-Sweden University

3 Conservative estimate based on available data

4 As defined in IMAS 04.10 Second Edition, 01 January 2003, Incorporating amendment numbers 1,2,3 & 4

5 Ibid.

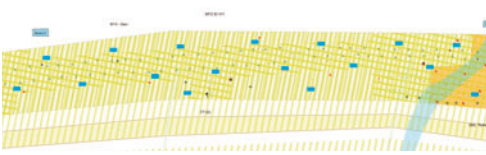
6 Ibid.

7 IMAS 09.20 Second Edition, 01 Jan 2003, Incorporating amendment number(s) 1, 2 & 3

8 Preference Consulting, On the Use of ISO 2859 Sampling by Attributes as Quality Control of Cleared Land in Humanitarian Demining, December 2011

9 Conservative estimate based on available data

NOTES



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