Mechanical Assistance Equipment Test and Evaluation Program

Volume 8 – Equipment Evaluation (Miscellaneous Equipment)

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Abstract

In a program conducted by the Canadian Centre for Mine Action Technologies in the summer of 2000, four machines were evaluated for their potential as Mechanical Assistance Equipment in humanitarian demining operations. This program also developed test and evaluation protocols and highly realistic but inert “reproduction mines” for use in such tests. This report is prepared in 8 separate volumes. While each volume is intended as a stand-alone document, there are important interdependencies between some of the volumes. This volume details two additional machines, a garden rototiller and a soil sorting bucket, which were given a cursory examination but were not evaluated in detail.

Résumé

Dans le cadre d’un programme mené par le Centre canadien des technologies de déminage à l’été 2000, on a évalué quatre systèmes de déminage pour en connaître le potentiel en tant qu’équipement d’assistance mécanique pour les opérations de déminage humanitaire. Des protocoles d’essai et d’évaluation, ainsi que des mines de reproduction très réalistes mais inertes ont été conçues pour effectuer les essais. Le présent rapport compte huit volumes distincts. Bien que chaque volume soit conçu comme un document indépendant, certains volumes révèlent d’importantes interdépendances. Une des machines essayées dans le cadre du programme était le mini fléau téléguidé Omega 5 Aegis, décrit dans le présent volume.

Executive summary

The Mechanical Assistance Equipment Test and Evaluation Program sought (i) to develop meaningful, standardized test and evaluation protocols and tools for mechanical assistance technology, and (ii) to identify promising technologies and procedures that could be proposed to the humanitarian demining community. In support of these goals a test facility was designed and constructed, test procedures were drafted, standardized test targets were designed, constructed and installed in the test area, and finally, machines were tested.

In addition to the four machines initially selected for this program, two additional machines were examined briefly but were not tested as extensively as the four original selections. An unmodified garden tractor with a rototiller attachment was given a qualitative evaluation to determine whether a simple, low cost demining rototiller might be worth considering. A sorting bucket, originally obtained for other purposes was given a qualitative analysis and was subsequently tested in one of the four test environments at the DRES test site.

This report is divided into multiple volumes to adequately deal with the subject matter. This volume describes the Test and Evaluation of the two additional machines. At a minimum, Volume 1 (which contains the overall program summary) should be read in combination with this volume.

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Sommaire

Le Programme d’essai et d’évaluation d’équipements d’assistance mécanique visait (1) à élaborer des outils et des protocoles d’essai et d’évaluation normalisés et utiles pour la technologie d’assistance mécanique et (ii) à déterminer les technologies et les procédures prometteuses qu’on pourrait proposer pour le déminage humanitaire. Dans la poursuite de ces objectifs, on a construit une installation d’essais, élaboré des procédures d’essais, conçu des cibles d’essai normalisés, construit et installé l’aire d’essais et, enfin, essayé les machines.

On a dû arrêter l’essai du mini-fléau télécommandé Omega 5 Aegis lorsque celui-ci a subi une rupture structurale et n’a pas très bien fonctionné contre les pièces d’essai lors des évaluations préliminaires.

On a divisé le rapport en volumes multiples pour que le sujet en question soit bien traité. Ce volume-ci décrit l’essai et l’évaluation du mini fléau Omega 5 Aegis. Le volume 1 (qui contient le sommaire global du programme) devrait être lu au moins en conjonction avec le présent volume.

Coley G, Bergeron D M, Fall R W. 2001. Mechanical Assistance Equipment Test and Evaluation Program, Volume 8. DRES TR 2001-078 Defence Research Establishment Suffield.

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Other key personnel from the Defence Research Establishment Suffield (DRES) provided vital assistance throughout the program. Scott Trebble and Randy Linde provided excellent photographic capability. Maj. Kent Hocevar, Mr. Wayne Sirovyak, and Mr Jack Toews each provided much needed assistance and advice in construction of the test area, surveying the test plots before and after the trials, assisting with the scanning and documentation of the test area, and also in picking up the slack in other activities while the authors were immersed in this program.

Finally, special mention is given to some of the people who assembled, identified, documented, and buried the Mechanical Reproduction Mines and then located and removed the remains of these devices following the trials. Mr. Jim Roseveare, Mr. Dan Roseveare, Mr. Doug Roseveare, Mr. Paul Schile, Mr. Blair Mullen, Mr. Corry Milner, Mr. Gary Milner, and Mr. Erin Milner all performed these tedious and largely invisible duties with good humour and the greatest co-operation.

1. Document Overview

The documentation of this program has been divided into a number of separate volumes. While each volume listed below is intended as a stand-alone document, there are important interdependencies between some of the documents. For example, the evaluation of the performance of any of the machines is tightly tied to the facilities and types of test pieces used. As each of the machines are intended to perform completely different tasks, no attempt has been made at direct comparisons between the machines. The volumes that make up this document include:

- Volume 1 – Summary
- Volume 2 – Mechanical Reproduction Mines
- Volume 3 – Test and Evaluation Procedures and Facilities
- Volume 4 – Equipment Evaluation (ProMac BDM48)
- Volume 5 – Equipment Evaluation (Loken Mine Disker)
- Volume 6 – Equipment Evaluation (Schulte Extractor Mine Picker)
- Volume 7 – Equipment Evaluation (Omega 5 Aegis Slapper Flail)
- Volume 8 – Equipment Evaluation (Miscellaneous Equipment)

2. Introduction

The Mechanical Assistance Equipment (MAE) test program proposed two main activities for each machine. The first activity, Phase 1, was to be a set of preliminary tests which would be conducted in Humboldt, Saskatchewan at a site owned by the Prairie Agricultural Machinery Institute (PAMI). This preliminary testing was to examine the machine's operation in a qualitative sense and to help revise the test procedures that would be used in the detailed, quantitative tests to follow. In addition, this was a training period during which the machine operators would become familiar with the use of the machine against something approaching real mines. This is important in that many machinery manufacturers and their respective machine operators have no experience in any kind of demining.

The second activity in the MAE test program, Phase 2, was the testing of each machine in a detailed, quantitative set of trials at DRES. With its procedures suitably modified via the preliminary tests, each machine would be "put through its paces" on the standard test lanes at DRES. The performance of the machine would be quantified in terms of number of mines engaged (extracted, triggered, broken, or otherwise influenced as specific to the machine), area covered per unit time, soil conditions (include soil profile and/or tillage depth) before and after the operations, and any other parameter relevant to the machine.

It was expected that the combination of results of the preliminary tests and the detailed tests would allow the performance of the machines to be evaluated and reported in an objective and consistent manner.

It is critically important that there be some means of evaluating whether a machine or a technology is (i) worth testing, and (ii) mature enough to undergo testing. Regardless who is paying for the MAE testing of a given machine, it is very expensive in terms of time, labour, equipment, and facilities. As constructed for this set of trials at DRES, a test lane for one machine costs well in excess of $30,000. Premature testing of a machine can destroy in minutes what it took many weeks and tens of thousands of dollars to prepare, all without producing any useful data.

It is also critical that everyone be <u>absolutely clear</u> from the start as to what the machine is supposed to accomplish and how the machine is supposed to accomplish it. In this first-of-type program there was considerable slack in establishing the definition of what a machine was to accomplish. It became very clear that any program which seeks to test machines in a fair, consistent, unambiguous manner must <u>first</u> establish the definition of the machine's intended task. In addition, it is necessary to define the data that define the machine's performance. Is the machine's purpose to eliminate all live mines from an area? Does it succeed in this task if it simply moves them intact to another (controlled) location? Does it succeed if it destroys the mines but leaves large numbers of fuzes, detonators, and other potential Explosive Ordnance Disposal (EOD) hazards behind? Does it make a difference whether those EOD hazards are in the processed area or in the other "controlled" location? Does it succeed in the task <u>only</u> if it leaves “smoking holes” where mines used to be? These and other questions need to be addressed before testing commences, and it should be largely the responsibility of the machine manufacturer to establish exactly what the machine is supposed to do, and how it is supposed to go about doing it. If this has not been done by the manufacturer, the exercise must be undertaken prior to formal Test and Evaluation (T&E) activities in order to interpret the test results in a fair, unbiased manner.

2.1 Machine Descriptions

2.2 Rototiller

During a lull in the phase 1 testing at PAMI, an older model garden tractor with a rear mounted rototiller was observed (see Figure 1). With the testing of the Omega 5 Aegis mini-flail having just been aborted (see Volume 7 of this report), there were several MRMs in the ground that needed to be recovered. Rather than dig them up by hand, it was decided to use the rototiller. This would serve the dual purposes of recovering the buried MRMs, and of examining the potential of such a device for humanitarian demining service. This was not intended to be a formal test, nor a detailed investigation.

Figure 1. *Garden Tractor Rototiller*

The machine in question was a 25 year old. 18hp, hydrostatic drive Case tractor with a 42” (1.07m) rototiller. While it was originally rated at 18hp, this was an ageing machine and it was probably no longer capable of that power output. In addition, the rototiller attachment was well used, and therefore probably not capable of peak performance. Nevertheless, this was a purely qualitative, “proof of concept” test, and the equipment was considered perfectly adequate for the task.

It is also clear that a rototiller in a demining environment would need to be significantly reconfigured from this arrangement. It would be necessary, at the very least, to mount the tool in front of the machine and to provide the operator with blast and fragmentation protection. Again, this was a proof-of-concept test of a rototiller, and not of the particular configuration of this implement.

2.3 VRL-8 Sorting Bucket

During the testing of the ProMac BDM48 (see Volume 4 of this report), a discussion was held regarding the need to process the berm of loose soil created by the BDM48. One of the ways that was suggested was to use a sorting bucket like the type used for sorting or grading gravel, or for separating large debris from the smaller rocks at demolition sites. One of the main attractions of such a device is that, like the BDM48, it could be attached to a hydraulic track-hoe. In this application, the same host vehicle could operate both tools.

Terra Firm, the supplier of the Case 9040B track-hoe used with the ProMac BDM48, was contracted to provide a Vibra-Ram Wack VRL-8 sorting bucket, shown in Figure 2 and Figure 3. This sorting bucket, superficially similar in appearance to a conventional digging bucket, used a hydraulic motor to vibrate a clotted cage. This cage, suspended on rubber mounts between the two side plate of the bucket would capture larger pieces while letting small pieces fall through. By fitting the cage with different sized screens, the size of the retained material could easily be adjusted.

It is important to note that the VRL-8 sorting bucket is not suited to heavy or even “normal” digging. With the internal portion of the bucket replaced by the floating cage, any heavy digging could easily damage the rubber mounts or the structure of the cage. The VRL-8 should only be used for light duty digging, carefully done.

Figure 2. *Commercial VRL-8 Sorting Bucket*

Figure 3. *VRL-8 Sorting Bucket with Replaceable Screen*

3. Phase 1 Testing – Humboldt Saskatchewan

The rationale behind the phase 1 testing is detailed in Volume 3 of this report, along with the goals, procedures, etc. For convenience, these are briefly summarized below.

Phase 1 testing was conducted in a sand, clay soil, black earth, prairie sod, and in poplar and willow groves. This testing was intended to train the operators, revise the test procedures if necessary, evaluate each machine against trees/brush as appropriate, and to act as a filter to eliminate any machines that were clearly not mature or capable enough to warrant the more expensive phase 2 testing at DRES.

Test patches were laid out in each soil/environment for each machine. In each test patch MRMs were buried at depths ranging from 0mm ("flush" buried) to 200mm. The machines were then allowed to operate on each test patch in whatever manner (within certain limitations) seemed most appropriate to the manufacturer. Following each "operation" by the machine, the MRMs were checked to determine the effectiveness of that operation, and a decision was made whether to repeat the operation or to declare that test patch "finished."

Figure 4 and Figure 5 illustrate the placement and marking of the MRMs in this test phase.

Figure 4. *Placement and Marking of MRMs for Phase 1 Testing*

Figure 5. *MRMs Were Located Around Trees And Roots In Poplar Grove*

3.1 Rototiller T&E Results (Phase 1)

The tractor-rototiller combination was used in the tilled black earth that was unused after testing of the Aegis ceased. It was also tested in sand using MRMs remaining after the Aegis operation. In addition, it was used to till some of the undisturbed prairie sod simply to evaluate how well it would penetrate such soil; no MRMs were included in the prairie sod test.

As this was not part of the “official program,” detailed records were not made, nor were the tests conducted with the same rigour as used in preparing and conducting the tests for the “official” machines. Figure 6 through Figure 8 show the results described below.

- The rototiller used in these tests was old and worn as was the tractor on which it was mounted. The tiller tines were too short to dig effectively beyond about 100mm, and certainly were too short to reach MRMs at 200mm. An MAE rototiller should have tines long enough to dig out MRMs/mines to 200mm DOB.

- As tested, the rototiller was under-powered. It had some difficulty digging through the prairie sod unless forward motion was very slow. Greater power to the tiller and better slow control of forward motion would be of great benefit.

Figure 6. *Garden Tractor Rototiller Bringing MRMs To The Surface*

- In the sand test area there were three live MRMs with two buried at 100mm and the third at 25mm. Two of the three MRMs were brought to the surface with the rototiller, while the third was brought to within 5-10mm of the surface. They were not checked for their condition (live/dead).

- In the tilled black earth were 6 MRMs. Two were at 100mm DOB with one each at 0mm, 25mm, 50mm, and 200mm DOB. All were live before the test. On the first pass three MRMs were brought to the surface by the rototiller, and were removed by hand. Two remained live while the third had been triggered. On the second pass, the 200mm DOB MRM remained buried and live, while a PMA-2 was live and had been brought to the surface. This PMA-2 had lost its plunger and the top cover was partially removed. The last MRM had been triggered and was on the surface.

- Aside from the deeply buried (200mm) MRM, there was no effort at correlating which mines from which depth were recovered or their respective states after each pass of the machine. This was intentional. Unfortunately there can be a great tendency to start evaluating numerical data even when the numbers are far too low for statistical significance. The real significance of this qualitative set of tests is that of the 8 MRMs buried within reach of the rototiller tines, 6 were recovered to the surface or very near the surface on the first attempt and the other two on the second attempt. Some had been detonated and some remained “live.” In addition, the soil had been tilled to the point where manual prodding would be very easy.

Based on the very limited data obtained in these tests, and recalling that the machine was old, worn, and not designed at all for this type of work, it seems that some form of purpose-built rototiller might be a credible MAE machine. A properly designed and built device would have to undergo proper MAE testing before making any real conclusions on this point, however.

Figure 7. *MRMs Brought to the Surface by the Rototiller*

Figure 8. *PMA-2 Plunger Removed and Lid Partially Removed By Rototiller*

3.2 VRL-8 Sorting Bucket T&E Results (Phase 1)

There are no phase 1 results to report for the VRL-8 sorting bucket it was brought in mid-way through phase 2.

4. Phase 2 Testing – DRES

As with the phase 1 testing, the procedures, layout, and methods of conducting the tests are detailed in Volume 3 of this report. For convenience they are briefly summarized here as they apply to the machines in question.

4.1 General

Only four test lanes had been prepared in the MAE test area. These corresponded to the four originally scheduled machines, leaving no provision for additional machines such as the VRL-8 sorting bucket. As noted above and in Volume 7 of this report, the Omega 5 Aegis mini-flail encountered difficulties during phase 1 testing which delayed its intended delivery for phase 2. By the time the VRL-8 bucket had been used to process the ProMac BDM48 berm, the Aegis flail has been delayed several times and communication from Omega 5 had ceased. It was therefore decided to test the VRL-8 sorting bucket in one of the four test frames previously reserved for the Aegis flail. The prairie clay soil (frame 2) was chosen for this purpose.

4.2 Rototiller

The rototiller was only given a qualitative evaluation in phase 1 and was not pursued in phase 2 of the program.

4.3 VRL-8

The original purpose for bringing in the VRL-8 was to process the berm left by the ProMac BDM48. The operation of the BDM48 had left a berm of pulverized soil beside the test frames. This berm contained a variety of MRM pieces from essentially intact MRMs to tiny fragments smaller than a fingernail. The frame itself had been swept clear of almost all MRM fragments by the BDM48. The intent was for the VRL-8 to sift out pieces that might represent potentially hazardous partial-mine fragments, so a screen was installed in the VRL-8 with a square mesh size of about 25mm. Clearly some of the smaller fuzes might slip through such a mesh, but a mesh small enough to capture all conceivable fragments would be so small as to render the bucket almost incapable of sifting. The compromise at 25mm was felt to be adequate to prove the concept at least.

The VRL-8 was positioned at the end of the cleared frame. A bucketful of soil was pulled from the berm and held above the frame while sifting. The captured pieces were then dumped in a clear area and recovered by hand. During the sifting process many of the smallest fragments were released along with the soil. Where practical these were removed by hand, although there was no concerted effort to remove them all. As sifted soil began to fill the frame, the system would advance into the filled area; the process was continued until the entire berm had been sifted back into the frame.

In testing the VRL-8 bucket on its own, only a single frame was used rather than all four test frames as with the other MAE candidates. It was acknowledged that this would not yield the same degree of statistical results as a full test program but it was felt that it would provide a good initial evaluation of this machine which was brought in at the last moment.

With the Case 9040B alongside the test frame, "reaching into the minefield," the VRL-8 bucket was used exactly like a normal digging bucket to extract the soil. The Case superstructure was swung 90° and the soil sifted out into a berm beside the frame. This allowed a visual inspection of the frame during and after the operation. Annex A shows this operation.

As each bucketful of soil was sifted the MRMs captured were checked twice with the MRM Interrogator. They were checked inside the bucket right after sifting to determine whether the digging/sifting operations had triggered them. They were then dumped onto the ground in a clear area and checked again to see if that action triggered them.

4.4 VRL-8 Sorting Bucket T&E Results (Phase 2)

The VRL-8 sorting bucket was used in three separate manners, only two of which were actually T&E activities. Volume 4 of this report should be consulted for additional information on the combination of the VRL-8 with the ProMac BDM48.

4.4.1 Berm Processing (ProMac BDM48 Follow-up)

The berm processing operation went smoothly and reasonably quickly. Annexes A and B show photographs of the VRL-8 system in operation and the types of fragments retrieved by the VRL-8 when processing the ProMac BDM48 berm.

Because there was no way to know how many fragments there were, or their size, there was no real way to qualitatively measure the performance of the VRL-8 in this process. The data presented in Volume 4 shows that, of the fragments that were collected, most were collected by the VRL-8, but this is somewhat misleading for several reasons.

- A short trial of the Schulte Extractor Mine Picker (see Volume 6) sifting the ProMac BDM48 berm meant that the fragments found by the Schulte machine were unavailable to the VRL-8.

- A few fragments were collected by hand and were therefore unavailable to the VRL-8.

- While there were many very small fragments which were captured by the VRL-8, there were many which escaped through the screen; there was no way to know how many escaped, nor how many were there to begin with.

As a berm processor for the ProMac BDM48, the VRL-8 performed very well under the conditions available at DRES. The soil was very dry and had been pulverized by the BDM48. This allowed quick, efficient sifting. Had the soil been wet or filled with brush cutting slash, the sifting might not have been as efficient. A tighter screen mesh would certainly capture more fragments but only at the expense of longer sifting times.

4.4.2 VRL-8 As MAE

The application of the VRL-8 as an MAE device may be limited by the soil conditions in many locations. While the soil conditions in this test frame were ideal, many minefields are in areas in which the ground is extremely hard during the summer or the dry season. As the VRL-8 is unsuited to heavy digging, this might make it unsuited to use during this period. In many of these places, the soil will soften considerably as a rainy season arrives, but this may result in soil too wet for the VRL-8 to handle effectively. Areas with softer soil but with heavy tree roots or very large boulders might also preclude the use of the "light-duty digging only" VRL-8. Specific environments would have to be evaluated carefully before applying the VRL-8 as an MAE device on its own. Figure 9 and Figure 10 show the system as tested in this program.

To establish the work rate of the VRL-8, each bucketful of soil was timed from the start of the dig until the bucket came to rest for MRM checking with the interrogator. This included time for digging, sifting and machine movement. It must be considered that this data, shown in Table 1, is heavily coloured by the size and speed of the host machine (in this test, the Case 9040B), the operator skill, the hardness, moisture content and cohesion of the soil, the size of screen or mesh used in the bucket, and perhaps other factors. The raw data for this table is shown in Annex C.

In addition to establishing the rate of work, it was also necessary to establish the quality of the work. There were two measures of this, one of which was strictly a measure of the operator skill.

Knowing how many MRMs were present in the test area, it was a simple matter to evaluate how many had been extracted or triggered by the VRL-8. This data is presented in Table 2.

Figure 9. *VRL-8 Alongside Test Frame in "MAE Mode"*

Figure 10. *VRL-8 Extracting MRMs in "MAE Mode"*

Table 1. *VRL-8 Work Rate Summary*

Total Time to Process Frame (5m x 23m) to required depth of 250mm (to obtain MRMs at 200mm DOB)	1 hour, 44 minutes, 20 seconds
Work Rate	1.1 square metres per minute
Minimum Time Per Bucket Load	25 seconds
Maximum Time Per Bucket Load	6 minutes, 20 seconds
Average Time Per Bucket Load	1 minute, 23 seconds
Average Time Per Bucket Load Excluding Extreme Minimum and Extreme Maximum (Anomalies?)	1 minute, 20 seconds

Table 2. *VRL-8 MRM Recovery*

MRM TYPE	QTY LIVE BEFORE TEST	QTY LIVE IN BUCKET	QTY TRIGGERED DURING DIG/SIFT	QTY LIVE ON GROUND	QTY TRIGGERED DURING DUMPING
PMA1	38	1	37	1	0
PMA2	40	39	1	39	0
PMA3	37	23	14	19	4
PMN	13	8	5	8	0
Total	128	71	57	67	4

Notes:

- 2 additional MRMs were recovered by the VRL-8 but were "dead" (triggered) prior to the test. They have been omitted from the data as they do not add any clear data.
- 2 additional PMA3 MRMs were live prior to the test and subsequently continued to register as live. Detailed examination of the MRMs after the test showed that while they continued to register as live, they had actually been triggered. This was later found to be a problem with the construction of the PMA3 and PMN MRMs. Those MRMs which exhibited this behaviour are omitted from the data as they do not add any clear data.
- Although the PMA2 MRMs were recovered by the VRL-8 as noted, 33 of the original 39 were found to be without their plungers when in the VRL-8 bucket. In such a situation there is no way to know whether the dumping operation would have triggered these MRMs.

The second measure of work quality is the depth, and consistency of depth, to which the system excavated. This was evaluated simply by measuring the depth of the excavated area at several locations. The results are presented in Table 3 and Figure 11. This data is accurate at the locations measured but should not be interpolated, especially near the edges of the test area. The depth around the outside of the test frame is (obviously) zero millimetres. The depth at a position 0.5 metres in from that edge is accurate as shown, but there is not a smooth transition of depth between these locations. On the other hand, it is reasonable to interpolate between the remaining values. Again, this data is a measure of the operator's skill, and not the performance of the VRL-8. It is presented simply to show that with a skilled operator the machine can produce a consistent, uniform cut to the required depth.

Table 3.*VRL-8 Depth & Consistency of Cut*

DEPTH OF VRL-8 CUT (MM)					
LOCATION ACROSS FRAME WIDTH *(metres)*	**LOCATION ALONG FRAME LENGTH** *(metres)*				
	0.0m	3.0m	11.75m	20.5m	23.5m
0.0m	0 mm	0 mm	0 mm	0 mm	0 mm
0.5m	0 mm	340 mm	300 mm	403 mm	0 mm
1.0m	0 mm	363 mm	395 mm	406 mm	0 mm
1.5m	0 mm	362 mm	396 mm	400 mm	0 mm
2.0m	0 mm	362 mm	412 mm	409 mm	0 mm
2.5m	0 mm	370 mm	450 mm	406 mm	0 mm
3.0m	0 mm	404 mm	476 mm	456 mm	0 mm
3.5m	0 mm	442 mm	412 mm	480 mm	0 mm
4.0m	0 mm	460 mm	441 mm	472 mm	0 mm
4.5m	0 mm	485 mm	530 mm	507 mm	0 mm
5.0m	0 mm	432 mm	504 mm	520 mm	0 mm
5.5m	0 mm	415 mm	294 mm	466 mm	0 mm
6.0m	0 mm	0 mm	0 mm	0 mm	0 mm

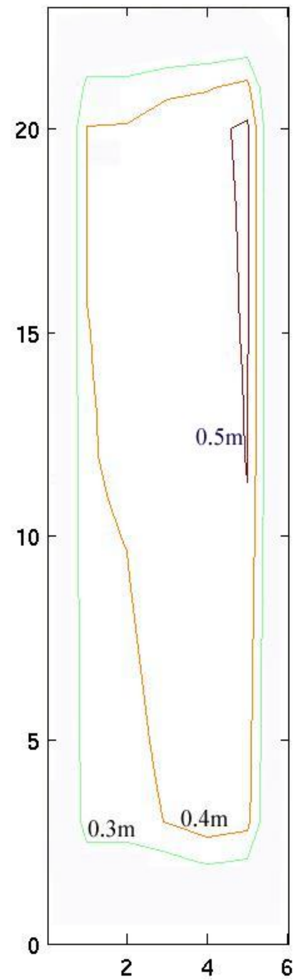

Figure 11. *VRL-8 Depth and Consistency of Cut – Contour Plot of Test Frame*

4.4.3 Range Cleanup

At the time that the VRL-8 sorting bucket was available, the other MAE candidate machines has finished testing. It was necessary at this point to recover any MRMs or large MRM fragments remaining in the ground. Given the good performance of the VRL-8 in sifting through the BDM48 berm, it was decided that the sorting bucket would be used to sift the MRMs and fragments from the soil through the rest of the test site. Results are seen in Figure 12.

This was not an activity that could be quantitatively measured. It was observed that the device operated at much the same speed and in the same manner described in paragraph 4.4.2.

Figure 12. *Range Clearance By VRL-8 Sorting Bucket*

The use of the VRL-8 in range clean-up activities would be limited by the same considerations as its application as an MAE device. Soil hardness, moisture content and digging obstructions would all have to be considered.

5. Conclusions and Recommendations

5.1 Rototiller Conclusions and Recommendations

The qualitative analysis of the rototiller suggested that a properly designed and constructed, small, low-cost rototiller might have application in certain circumstances. Formal testing of such a device in a future MAE T&E should be considered.

5.2 VRL-8 Conclusions and Recommendations

The Vibra-Ram Wack VRL-8 sorting bucket was observed to be have potential in range clean-up activities providing that the soil is relatively soft and dry. It is not recommended in areas where heavy digging would be necessary. Its utility in wet soil is unknown. In combination with other machines which can eliminate the need for heavy digging (e.g.: grader, front-end loader, excavator, etc), the VRL-8 might be more widely useable.

As in the case of range clean-up, the VRL-8 sorting bucket may be useful in certain environments as an MAE device in its own right. There is insufficient data to make definitive conclusions on this point.

As a companion to another MAE device, the VRL-8 might have considerable utility. Providing that the soil is dry enough to sift effectively, the VRL-8 could be used to extract mines and/or mine fragments from the soil. Machines which break up hard soil into manageable pieces or machines which create a berm might benefit from a berm processor such as the VRL-8.

If the manufacturer is interested in pursuing the application of the VRL-8 in range clearance, or as MAE either on its own or in combination with other MAE, tests should be conducted to determine the bucket's resistance to mine and UXO blast and fragmentation. It is critically important that the complete system (the VRL-8 bucket, the host vehicle, and the human operator) are all properly protected. A protection package was designed, constructed and tested for the host vehicle (and operator) that was used with the VRL-8. This activity, described in DRES Report TR01-079, was in support of the ProMac BDM48 which was tested in Thailand (DRES Report TR-01-080), but did not involve the use of the VRL-8.

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Annex A –Photographs – VRL-8 Sorting Bucket In Use

Mechanical Assistance Equipment Test and Evaluation Program

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In the photographs that follow:

- Figure A-13 and Figure A-14 show the results of using the Vibra-Ram Wack VRL-8 Sorting Bucket in a range clearance role. The soil from the test areas has been sifted to remove MRMs and larger MRM fragments leaving the sifted soil and (potentially) small MRM fragments in the berm.
- The images shown in Figure A-15 through Figure A-20 show the testing of the VRL-8 sifting bucket as a possible MAE candidate in its own right.
- Figure A-21 through Figure A-26 shows images of the VRL-8 Sorting Bucket processing the berm left behind by the ProMac BDM48.

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Figure A-13. VRL-8 Sorting Bucket Range Clearance

Figure A-14. VRL-8 Sorting Bucket Range Clearance

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Figure A-15. VRL-8 Sorting Bucket Digging/Sifting as MAE

Figure A-16. VRL-8 Sorting Bucket Digging/Sifting as MAE

Figure A-17. VRL-8 Sorting Bucket Digging/Sifting as MAE

Figure A-18. VRL-8 Sorting Bucket Digging/Sifting as MAE

Figure A-19. VRL-8 Sorting Bucket Digging/Sifting as MAE

Figure A-20. VRL-8 Sorting Bucket Digging/Sifting as MAE

Figure A-21. VRL-8 Sorting Bucket Processing ProMac BDM48 Berm

Figure A-22. VRL-8 Sorting Bucket Processing ProMac BDM48 Berm

Figure A-23. VRL-8 Sorting Bucket Processing ProMac BDM48 Berm

Figure A-24. VRL-8 Sorting Bucket Processing ProMac BDM48 Berm

Figure A-25. VRL-8 Sorting Bucket Processing ProMac BDM48 Berm

Figure A-26. VRL-8 Sorting Bucket Processing ProMac BDM48 Berm

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Annex B – Photographs – MRM Fragments Created By ProMac BDM48 And Subsequently Collected By VRL-8

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In the photographs that follow:

- The images in Figure B-27 through Figure B-78 show MRM fragments which were created by the ProMac BDM48 and subsequently collected by the Vibra-Ram Wack VRL-8 Sorting Bucket.
- Figure B-79 is an example of fragments which were missed by the VRL-8 Sorting Bucket. These are similar to fragments that were missed by the Schulte Extractor. In both cases they are generally the result of (i) being small enough that they escaped through the mesh/perforations or (ii) simply not being picked up by the machine.
- The MRMs which remained live after the ProMac BDM48 were all removed by hand. Hence there were no intact MRMs to be photographed after the BDM48/VRL-8 combination.
- Results from the different soil types are indistinguishable.
- Fragments which could be identified to a specific MRM serial number are shown as such. Fragments which could not be attributed to a specific serial number are simply grouped together.
- For a discussion on the meaning of “Possible EOD fragments” please see Volumes 3 and 4 of this report.

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Figure B-27. MRM Fragments Retrieved By VRL-8 After ProMac BDM48

Figure B-28. MRM Fragments Retrieved By VRL-8 After ProMac BDM48

Figure B-29. MRM Fragments Retrieved By VRL-8 After ProMac BDM48

Figure B-30. MRM Fragments Retrieved By VRL-8 After ProMac BDM48

Figure B-31. MRM Fragments Retrieved By VRL-8 After ProMac BDM48

Figure B-32. MRM Fragments Retrieved By VRL-8 After ProMac BDM48

Figure B-33. MRM Fragments Retrieved By VRL-8 After ProMac BDM48

Figure B-34. MRM Fragments Retrieved By VRL-8 After ProMac BDM48

Figure B-35. MRM Fragments Retrieved By VRL-8 After ProMac BDM48

Figure B-36. MRM Fragments Retrieved By VRL-8 After ProMac BDM48

Figure B-37. MRM Fragments Retrieved By VRL-8 After ProMac BDM48

Figure B-38. MRM Fragments Retrieved By VRL-8 After ProMac BDM48

Figure B-39. MRM Fragments Retrieved By VRL-8 After ProMac BDM48

Figure B-40. MRM Fragments Retrieved By VRL-8 After ProMac BDM48

Figure B-41. MRM Fragments Retrieved By VRL-8 After ProMac BDM48

Figure B-42. MRM Fragments Retrieved By VRL-8 After ProMac BDM48

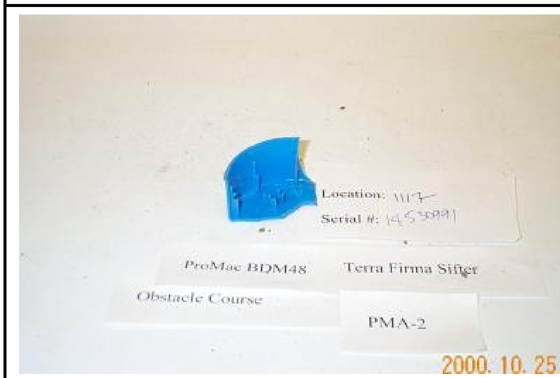


Figure B-43. MRM Fragments Retrieved By VRL-8 After ProMac BDM48

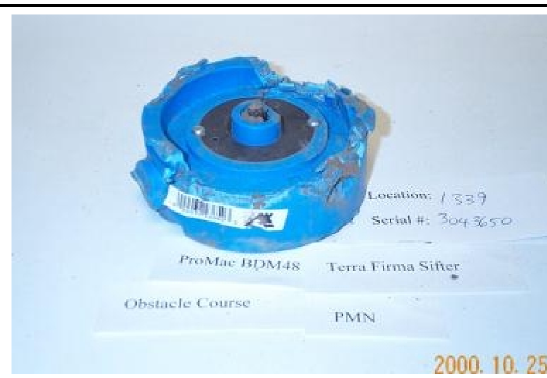


Figure B-44. MRM Fragments Retrieved By VRL-8 After ProMac BDM48

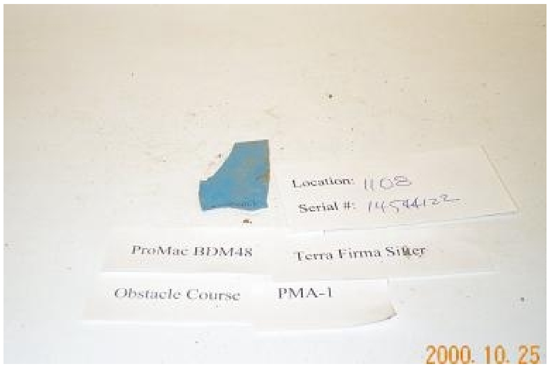


Figure B-45. MRM Fragments Retrieved By VRL-8 After ProMac BDM48

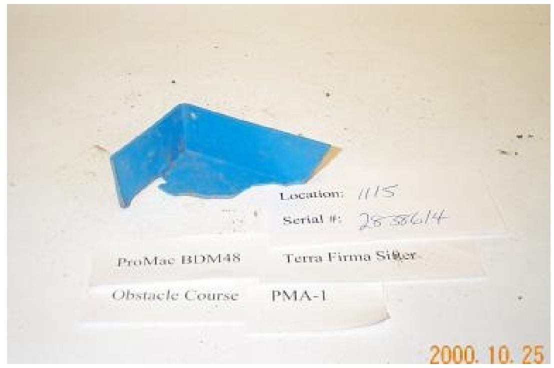


Figure B-46. MRM Fragments Retrieved By VRL-8 After ProMac BDM48

Figure B-47. MRM Fragments Retrieved By VRL-8 After ProMac BDM48

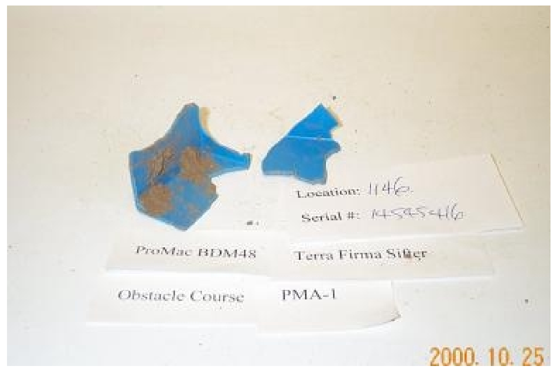


Figure B-48. MRM Fragments Retrieved By VRL-8 After ProMac BDM48

Figure B-49. MRM Fragments Retrieved By VRL-8 After ProMac BDM48

Figure B-50. MRM Fragments Retrieved By VRL-8 After ProMac BDM48

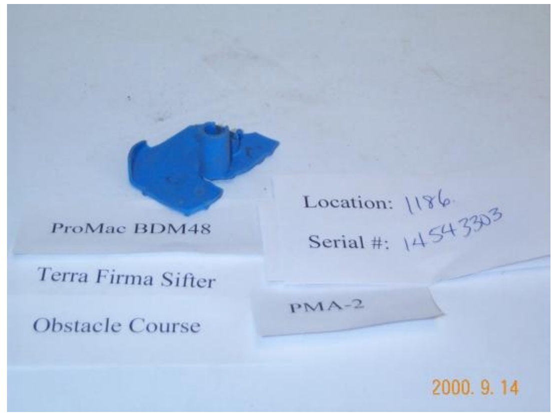
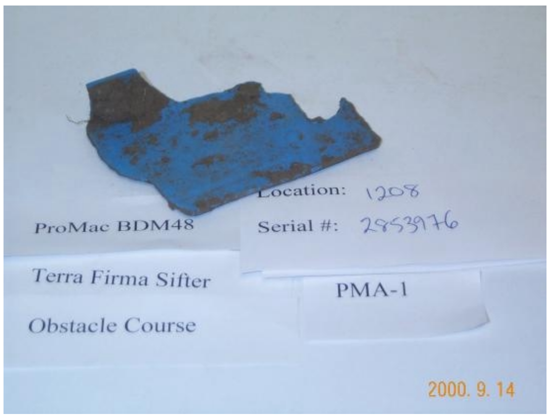
 Figure B-51. MRM Fragments Retrieved By VRL-8 After ProMac BDM48	 Figure B-52. MRM Fragments Retrieved By VRL-8 After ProMac BDM48
 Figure B-53. MRM Fragments Retrieved By VRL-8 After ProMac BDM48	 Figure B-54. MRM Fragments Retrieved By VRL-8 After ProMac BDM48
 Figure B-55. MRM Fragments Retrieved By VRL-8 After ProMac BDM48	 Figure B-56. MRM Fragments Retrieved By VRL-8 After ProMac BDM48

Figure B-57. MRM Fragments Retrieved By VRL-8 After ProMac BDM48

Figure B-58. MRM Fragments Retrieved By VRL-8 After ProMac BDM48

Figure B-59. MRM Fragments Retrieved By VRL-8 After ProMac BDM48

Figure B-60. MRM Fragments Retrieved By VRL-8 After ProMac BDM48

Figure B-61. MRM Fragments Retrieved By VRL-8 After ProMac BDM48

Figure B-62. MRM Fragments Retrieved By VRL-8 After ProMac BDM48

Figure B-63. MRM Fragments Retrieved By VRL-8 After ProMac BDM48

Figure B-64. MRM Fragments Retrieved By VRL-8 After ProMac BDM48

Figure B-65. MRM Fragments Retrieved By VRL-8 After ProMac BDM48

Figure B-66. MRM Fragments Retrieved By VRL-8 After ProMac BDM48

Figure B-67. MRM Fragments Retrieved By VRL-8 After ProMac BDM48

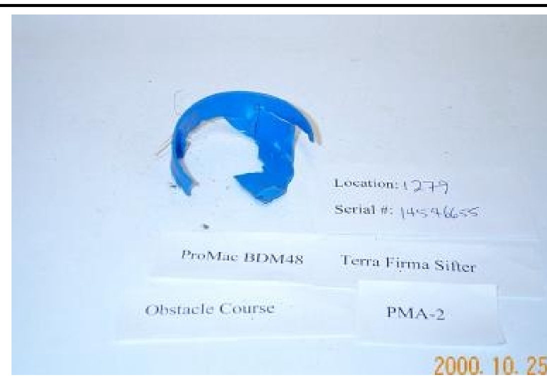


Figure B-68. MRM Fragments Retrieved By VRL-8 After ProMac BDM48

Figure B-69. MRM Fragments Retrieved By VRL-8 After ProMac BDM48

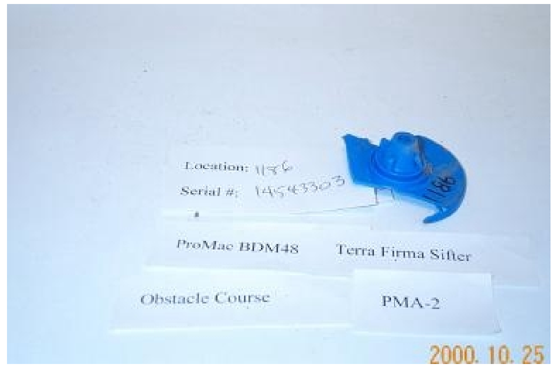


Figure B-70. MRM Fragments Retrieved By VRL-8 After ProMac BDM48

Figure B-71. MRM Fragments Retrieved By VRL-8 After ProMac BDM48

Figure B-72. MRM Fragments Retrieved By VRL-8 After ProMac BDM48

Figure B-73. MRM Fragments Retrieved By VRL-8 After ProMac BDM48

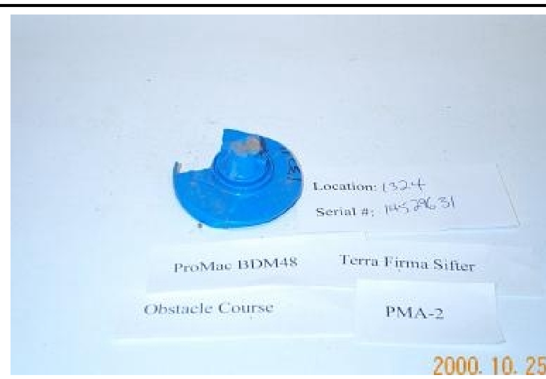


Figure B-74. MRM Fragments Retrieved By VRL-8 After ProMac BDM48

Figure B-75. MRM Fragments Retrieved By VRL-8 After ProMac BDM48

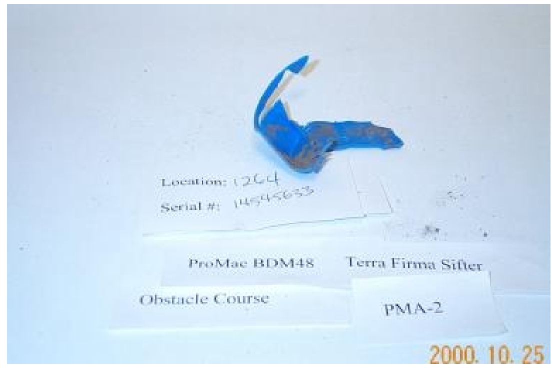


Figure B-76. MRM Fragments Retrieved By VRL-8 After ProMac BDM48

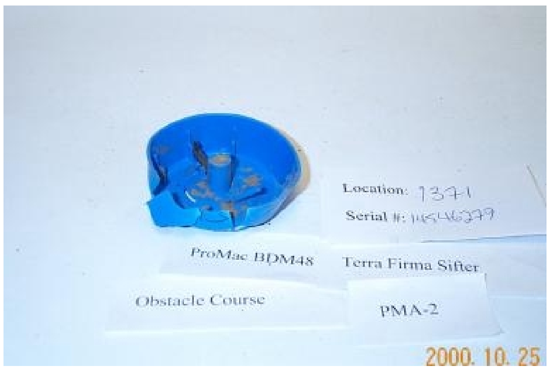


Figure B-77. MRM Fragments Retrieved By VRL-8 After ProMac BDM48

Figure B-78. MRM Fragments Retrieved By VRL-8 After ProMac BDM48

Figure B-79. MRM Fragments Not Retrieved By VRL-8 After ProMac BDM48

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Annex C – VRL-8 Sorting Bucket Data

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VRL-8 WORK RATE – PROCESSING TIMES FOR EACH BUCKET LOAD (SECONDS)

60	100	70	55	90	40	70	105
45	75	45	85	160	90	55	45
90	70	95	120	50	100	55	60
40	150	95	205	115	120	55	60
70	85	45	110	85	80	70	380
120	120	175	55	65	35	25	35
25	105	75	55	180	45	90	45
150	85	110	30	80	120	50	40
140	65	55	60	40	95	110	35
75	30	45					

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List of symbols/abbreviations/acronyms/initialisms

DRES	Defence Research Establishment Suffield
CCMAT	Canadian Centre for Mine Action Technologies
MRM	Mechanical Reproduction Mine
MAE	Mechanical Assistance Equipment
T&E	Test and Evaluation
EOD	Explosive Ordnance Disposal (see Glossary)
PAMI	Prairie Agricultural Machinery Institute
VRL-8	Model designation of Vibra-Ram Wack VRL-8 Sorting Bucket
BDM48	Model designation of ProMac BDM48 MAE candidate machine

Glossary

Technical term	Explanation of term
Berm	The pile or ridge of soil and debris remaining after a machine has processed an area.
EOD	“Explosive Ordnance Disposal” is used herein (inaccurately) to refer to pieces or fragments of mines left after a machine’s operation which must then be handled in some manner to render an area “clear.”
Slash	The cuttings produced when the BDM48 (or another machine) is used to cut and grind brush or trees.

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14. KEYWORDS, DESCRIPTORS or IDENTIFIERS (technically meaningful terms or short phrases that characterize a document and could be helpful in cataloguing the document. They should be selected so that no security classification is required. Identifies, such as equipment model designation, trade name, military project code name, geographic location may also be included. If possible keywords should be selected from a published thesaurus, e.g. Thesaurus of Engineering and Scientific Terms (TEST) and that thesaurus-identified. If it is not possible to select indexing terms which are Unclassified, the classification of each should be indicated as with the title.)

Canadian Centre for Mine Action Technologies
Mechanical Assistance Equipment
Test and Evaluation
Mechanical Reproduction Mine
Anti personnel landmine
Humanitarian demining
Neutralization
Rototiller
Vibra Ram Wack
VRL-8
Sorting Bucket