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Aggregates – 2022 (110)

Proficiency Testing Program Report

Accredited for compliance with ISO/IEC 17043

Report

This report is available on the LabSmart Services website. The issue of this proficiency report was authorized by Jeffrey Mulholland, General Manager, LabSmart Services, in May 2023.

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Please note that any technical questions regarding this program are to be directed to the program coordinator.

Z-scores Summary

A z-scores summary for this program was issued in November 2022. This technical report supersedes the z-sores summary.

Accredited Proficiency Testing Provider

LabSmart Services is accredited by NATA to **ISO/IEC 17043,** Conformity assessment – General requirements for proficiency testing. Accreditation number 20650. The accreditation provides additional assurance to participants of the quality and importance we place on our proficiency testing programs.

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Amendment History

Reports may be downloaded from the LabSmart Services website.
Version 1 – Issued 8 May 2023

Contents

1. Program Aim

This proficiency program was conducted during September and October of 2022 with 47 participants throughout Australia. The program involved the performance of the following nine tests:

- AS 1141 **11** Particle size distribution
- AS 1141 **12** Material finer than 75 µm
- AS 1141 **14** Particle shape by proportional calliper (2:1)
- AS 1141 **15** Flakiness index
- AS 1141 **20.1** Average least dimensions
- AS 1141 **6.1** Apparent particle density
- AS 1141 **6.1** Particle density on a dry basis
- AS 1141 **6.1** Particle density on a *saturated–surface* dry
- AS 1141 **6.1** Water absorption

Testing to the relevant sections of AS 1141 was preferred, but other equivalent methods were accepted.

The program provides confidence to the construction materials testing industry regarding the competency of participants (and the industry) to perform these tests. Each participant's performance is statistically assessed and used as a measure of competency relative to all those who participated. Other measures of performance are also used.

This report has been prepared using **robust statistics**. Information regarding the conduct and design of the program can be found in section 5.

Comprehensive technical comment (section 3) is provided to assist participants in improving their overall performance on these tests. In addition, test data has been reviewed for consistency, and additional feedback regarding consistency has also been provided.

2. Performance

2.1. Identified Outliers

There were 26 outliers identified across the 9 tests performed. These outliers were spread across 15 participants. This represented 34% of the 44 participants who returned results in this proficiency program (Table 1).

Participant's test results are tabulated in section 4, along with the robust statistics and a z-score graph. The z-score indicates how far away a participant is from the program's median value. A z-score of 0 indicates a strong consensus with respect to all other participants and represents a very good outcome. The z-score graph gives a quick visual indication of how a result compares to others in the program.

Outliers are where a z-score value is greater than 3 or less than -3. It is recommended that participants with outliers **investigate** their performance of the test. Participants with outliers are detailed in Table 1.

Participants with z-scores greater than 2 or less than -2 should **review** their testing methodology. Only those approaching a z-score of 3 (i.e. outside ± 2.75) have been identified explicitly in Table 1 as feedback. Additionally, some participants will be asked to **review** any 'non-statistical' issue detected during LabSmarts analysis; information on these participants 'non-statistical' issue will be found in the relevant sections.

More detail on the robust statistics used can be found in section 5.

Technical comments and feedback in section 3 are provided to assist participants in investigating or reviewing their results and those seeking to improve their testing performance.

Table 1: Participant codes where further action is recommended based on z-scores

Test		Investigate	Review
Particle size distribution (% Passing)	13.2 mm	**T2, R3 & R8**	**-**
	9.5 mm	**T2, J4, R3 & Y6**	**-**
	6.7 mm	**J4 & R3**	**Q8**
	4.75 mm	**N7, J4, R3, R8 & N9**	**-**
Material finer than 75 µm (by washing)		**W2, M2, U8, X8, N3, X5, W4 & N9**	**-**
Flakiness index		**L4**	**-**
Average least dimensions		**-**	**-**
Apparent particle density		**L4**	**-**
Particle density on a dry basis		**L4**	**-**
Particle density on a saturated-surface dry basis		**-**	**-**
Water absorption		**L4**	**U8 & N9**
Particle shape by proportional calliper (2:1)		**-**	**-**

2.2. Program Summary

Overall a satisfactory level of performance[1] was achieved by the majority of participants, with 34% having one or more outliers[2]. The performance of participants is very good overall and compares favourably with previous aggregate proficiency programs.

Overall, the majority of participants achieved a satisfactory level of performance[1].

Outliers are not the only indicator of satisfactory performance in a proficiency program; this report also identifies inaccurate and incorrect calculations. These inconsistencies should be viewed as outliers, and in many cases, these matters could have been picked up with better laboratory practices using checksums and general checking by a supervisor.

Many of the outliers in this program would have been avoided had the results been thoroughly checked.

The proficiency program was a useful exercise, allowing laboratories to have greater confidence in their results while providing others an opportunity to improve their competency concerning the tests in this program. The following summarises the test results obtained (Table 2)[2]. Unrounded statistics for the program are shown in section 3.8.

Table 2: Summary of test results from the program

Test	Units	Participants	Median	Normalized IQR
Particle size distribution (% Passing) 13.2 mm	%	44	64.3	1.52
9.5 mm		44	41.0	0.44
6.7 mm		44	22.6	0.30
4.75 mm		44	10.0	0.21
Material finer than 75 µm (by washing)	%	42	5.99	0.10
Flakiness index	%	37	13.9	2.15
Average least dimensions	mm	30	6.6	2.21
Apparent particle density	t/m3	30	2.740	0.007
Particle density on a dry basis	t/m3	30	2.670	0.015
Particle density on a saturated-surface dry basis	t/m3	30	2.690	0.007
Water absorption	%	30	0.94	0.12
Particle shape by proportional calliper (2:1)	%	23	23.7	9.71

(1) Overall performance outcomes can vary from one aggregate program to another and should not be taken as either an improvement or deterioration in industry performance. Variation in program outcomes may be attributed to the difficulty of the material under test or where participants overall in one program may have more experience or greater skill levels than those in another program. Evaluation of industry performance endeavours to balance these issues. Industry outcomes and individual performance outcomes are detailed in sections 2.2 and 3.

(2) Statistics relating to the number of outliers or participation rates are intended as an overview only for the aggregates program. They are calculated based on the total number of participants. however, not all participants perform each test.

3. Technical Comment

The more often a participant's code appears during the following feedback, the greater the general need to investigate testing practice. A participant code shown in bold indicates an outlier or is associated with an outlier.

Note(s):

- *Some participants did not indicate using the nominated test method shown on the log sheet. This report has assumed, in these instances, that the nominated test method has been used.*
- *The term "absolute" is used when discussing z-scores, e.g. absolute z-score of 3 or |3|. This means it may be either -3 or +3 etc.*

3.1 Particle Size Distribution (PSD)

General

The Performance of the sieve analysis by participants was good. There were 44 participants in the PSD Test.

There were 5 participants that recorded material retained on the 19.0mm sieve (**J8, Q8, N3, L9** & **A8**). See Table 5. Z-scores have not been calculated for this aperture size due to the low number of participants recording a result and the small amount of material retained on this fraction. The amounts were small and had minimal impact on the analysis and z-score calculated for the remaining fractions. LabSmart Services screened the material over the 19.0mm sieve to mitigate any material retained on this sieve. Therefore, participants with material retained on the 19.0mm sieve should check that sieving has been thoroughly carried out. If the sieve is in a new condition, it is possible that a stone may be retained in the 19.0mm sieve.

There were 22 outliers across 14 participants (32%) identified for the PSD and material finer than 75 µm tests. It should be noted that with the PSD test, errors can flow through multiple fractions leading to multiple outliers, as can be seen in Table 3. It is recommended that these participants **investigate** the results obtained.

Table 3: PSD and <75µm Outliers (Green)

Particle Size Distribution (% Passing)					
CODE	**13.2 mm**	**9.5 mm**	**6.7 mm**	**4.75 mm**	**<75 um**
W2					
M2					
U8					
T2					
X8					
N7					
J4					
N3					
X5					
R3					
W4					
R8					
N9					
Y6					

The following feedback is provided for laboratories who wish to improve their testing practices or **investigate** outliers.

Participant **R3** was identified in Table 5 as having inconsistencies between the data supplied and the supplied '% passing' result. There could be many reasons for the inconsistencies around the data supplied; therefore, it is difficult for LabSmart Services to comment on these outliers. This participant need to **review** the reason for this inconsistency.

For participant **Y6,** It should be noted that they only had an outlier on one sieve (9.5mm), and the spread of results for the 9.5mm sieve was tighter than seen in a lot of our previous programs; it would be beneficial for this participant to review their outlier; however, LabSmart does not see it as being of great concern.

R8 was identified as an outlier on both the 13.2mm and 4.75mm sieves. This participant supplied results rounded to the whole number for their '% passing'. LabSmart Services recalculated their results from the data supplied and obtained results to 1 decimal point. If they had supplied the result to 1 decimal point, they would not have been an outlier for the 4.75mm sieve, and even though they would have been an outlier for 13.2mm, it would have been a more favourable outcome.

Participant **J4** was identified as an outlier on 3 separate sieves. Recalculation was not possible as they did not supply starting and washed masses; however, it should be noted that participant **J4** shows less passing than most other participants on all of these outliers. Based on this information, it is possible that the sample was under-sieved, resulting in multiple sieves recording incorrect values. Although this can not be confirmed at this point, participant **J4** could benefit from reviewing their sieving methodology.

Additionally, along with participant **J4**, one other of the 13 participants identified in Table 3 (**N7**) did not supply Initial dry masses, and LabSmart could not recalculate/analyze the data thoroughly. As a result, further comment is difficult. This participant needs to review why they did not submit all the data on the 'result log' sheets.

Participant **T2** was identified as an outlier on both the 13.2mm and 9.5mm sieves. It was noted in the ‘Check Sum’ section of this report that participant **T2** had a recalculated 'check Sums' values higher than 1%. This participant needs to **review** the reason for this inconsistency.

There was a group of participants with outliers for Material finer than 75 µm (**W2**, **M2**, **U8**, **X8**, **N3**, **X5**, **W4** & **N9**). A discussion relating to these outliers can be found there (3.2 Material finer than 75 µm)

Sieve Diameter

Of all participants that recorded their sieve diameter, 37 recorded using 300mm diameter sieves and 4 recorded using 200mm diameter sieves. Only three participants did not indicate which sieve diameter they used.

Sieve Overload

For this program, the sample used was selected to avoid overloading on 300mm sieves. For a participant using sieves with a diameter of 200mm, there would be potential for overload across most sieves (See Table 4).

Usually, the sample could have been split and only a portion sieved, but the proficiency testing instructions indicate that the whole sample was to be used.

Table 4: 'Sample A' average mass per sieve and sieve overload limits

Sieve	Typical retained mass on 300 mm diameter sieve* (g)	300 mm overload values (g)	200 mm overload values (g)
13.2	608	900	**400**
9.5	458	600	250
6.7	251	500	225
4.75	156	400	**200**

*masses taken from the average mass retained for all participant, rounded to the whole number

The need to sieve in more than one pass or split complicates the calculation process and increases the possibility of an incorrect calculation. Thorough checking is essential. It is recognized that this is a difficult task in 'one person' laboratories.

Splitting

LabSmart supplied an approximate of 1.5kg sample for PSD (Sample A) and instructed participants to use the whole sample. All participants that supplied initial dry masses appear to have complied with these instructions.

Overall, a poorly mixed sample or poor splitting technique may have a significant impact on the results. Depending on the sieves' diameter, overloading or calculation errors may also contribute to different performance outcomes.

Washing

Most participants appear to have washed the sample, but those with very high pan amounts may not have. For further discussion, see 'Pan' in this section, as well as section 3.2 'Material finer than 75µm'.

Drying

There were 3 participants (**L5, G7 & C2**) who indicated using a 'hot plate' rather than an oven to dry the material. The test method does allow for this, but only in cases where it can be shown not to affect the result. For example, this generally applies to material where the history is known, such as in a quarry. For unknown materials, such as in a proficiency program, it is recommended that the standard oven method should be used. 7 participants (**N4, F7, K9, R9, Y2, A5 & Z6**) did not indicate the drying method used.

% Passing

For each participant, the '% Passing' values were also recalculated from the mass retained data submitted and compared to each participant's submitted result. Most participant's calculations were identical to the recalculated '% Passing' or within an acceptable rounding tolerance (i.e. <0.5%). See Table 5.

The value 0.5 % was chosen as the point where such a difference could affect the result reported when rounded. It should be noted that such errors can be cumulative, and if it occurs on a larger aperture sieve, it can flow through to the smaller aperture sieves.

Participant’s results where one or more' % Passing' results were greater than 0.5 % are shown in Table 5 and are noted with a yellow 'N'.

Table 5: Variation in results compared to those calculated based on data submitted

Code	19.0 mm				13.2 mm				9.5 mm				6.7 mm				4.75 mm			
	%Passing	Recalculated %Passing	Difference	<0.5 %	%Passing	Recalculated %Passing	Difference	<0.5 %	%Passing	Recalculated %Passing	Difference	<0.5 %	%Passing	Recalculated %Passing	Difference	<0.5 %	%Passing	Recalculated %Passing	Difference	<0.5 %
U4	100	100	0.0	Y	65	64.7	0.3	Y	40.5	40.4	0.1	Y	22.5	22.5	0.0	Y	10	9.9	0.1	Y
Z2	100	100	0.0	Y	65	65.0	0.0	Y	41	40.5	0.5	Y	22	22.4	-0.4	Y	10	9.6	0.4	Y
U9	100	100	0.0	Y	64				40				22				10			
W2		100				63.0				41.0				22.8				10.1		
U5	100	100	0.0	Y	65	64.6	0.4	Y	41	41.0	0.0	Y	23	22.7	0.3	Y	10	10.0	0.0	Y
B6		100																		
M2	100	100	0.0	Y	63.9	63.9	0.0	Y	40.8	40.8	0.0	Y	22.4	22.4	0.0	Y	9.7	9.7	0.0	Y
N4	100	100	0.0	Y	63	63.0	0.0	Y	40.4	40.4	0.0	Y	22.6	22.6	0.0	Y	9.7	9.7	0.0	Y
U8	100	100	0.0	Y	64.3	64.3	0.0	Y	40.8	40.8	0.0	Y	22.3	22.3	0.0	Y	9.7	9.7	0.0	Y
M3	100	100	0.0	Y	64.1	64.1	0.0	Y	41	41.0	0.0	Y	22.4	22.5	-0.1	Y	9.8	9.8	0.0	Y
T2		100			70.7	70.7	0.0	Y	42.5	42.5	0.0	Y	22.5	22.6	-0.1	Y	10.2	10.2	0.0	Y
X8	100	100	0.0	Y	65.2	65.2	0.0	Y	40.7	40.7	0.0	Y	22.6	22.7	-0.1	Y	10.1	10.1	0.0	Y
T5	100	100	0.0	Y	67	66.7	0.3	Y	41	41.0	0.0	Y	23	22.7	0.3	Y	10	9.8	0.2	Y
F7	100	100	0.0	Y	66.8	66.8	0.0	Y	41.1	41.1	0.0	Y	22.8	22.8	0.0	Y	10	10.0	0.0	Y
J8	99.4	99.4	0.0	Y	64.3	64.3	0.0	Y	41.5	41.5	0.0	Y	23	23.0	0.0	Y	10.1	10.1	0.0	Y
E2	100	100	0.0	Y	65	65.0	0.0	Y	41	41.4	-0.4	Y	23	22.5	0.5	Y	10	10.1	-0.1	Y
K9	100	100	0.0	Y	65.9	65.9	0.0	Y	40.9	40.9	0.0	Y	22.6	22.6	0.0	Y	9.7	9.7	0.0	Y
R9	100	100	0.0	Y	64.2	64.2	0.0	Y	40.4	40.4	0.0	Y	22.5	22.5	0.0	Y	9.7	9.7	0.0	Y
Y2	100	100	0.0	Y	64.9	64.9	0.0	Y	41.1	41.1	0.0	Y	22.5	22.5	0.0	Y	9.6	9.6	0.0	Y
Q8	99.1	99.1	0.0	Y	65.8	65.8	0.0	Y	41.6	41.6	0.0	Y	23.4	23.4	0.0	Y	10.1	10.1	0.0	Y
N7	100	100	0.0	Y	64.5				41				22.8				11.4			
L4	100	100	0.0	Y	63	62.6	0.4	Y	40	40.2	-0.2	Y	22	22.5	-0.5	Y	10	9.7	0.3	Y
L5	100	100	0.0	Y	64.5	64.8	-0.3	Y	40.9	40.9	0.0	Y	22.5	22.5	0.0	Y	9.8	9.8	0.0	Y
J4	100	100	0.0	Y	63.9				37.1				17.7				4.2			
Y5		100			63.1				40.4				22.3				9.8			
N3	98	98.0	0.0	Y	62.3	62.3	0.0	Y	41.3	41.3	0.0	Y	22.7	22.7	0.0	Y	9.8	9.8	0.0	Y
G7	100	100	0.0	Y	62.1	62.1	0.0	Y	41.1	41.1	0.0	Y	22.4	22.4	0.0	Y	9.8	9.8	0.0	Y
C2	100	100	0.0	Y	65.7	65.8	-0.1	Y	40.9	41.0	-0.1	Y	22.7	22.7	0.0	Y	9.9	10.0	-0.1	Y
A5	100	100	0.0	Y	64.8	64.8	0.0	Y	40.9	40.9	0.0	Y	23.1	23.1	0.0	Y	10.2	10.2	0.0	Y
Z6	100	100	0.0	Y	63.9	63.9	0.0	Y	41.6	41.6	0.0	Y	22.6	22.6	0.0	Y	10	10.0	0.0	Y
X5	100	100	0.0	Y	65	65.2	-0.2	Y	41	40.9	0.1	Y	23	22.8	0.2	Y	10	9.9	0.1	Y
Z9	100	100	0.0	Y	62.75	62.8	0.0	Y	40.51	40.5	0.0	Y	22.48	22.5	0.0	Y	9.66	9.7	0.0	Y
L9	98.7	98.7	0.0	Y	61.3	61.3	0.0	Y	41.2	41.2	0.0	Y	22.2	22.2	0.0	Y	9.7	9.7	0.0	Y
A8	99.3	99.3	0.0	Y	62.7	62.7	0.0	Y	40.7	40.7	0.0	Y	22.5	22.5	0.0	Y	9.96	10.0	0.0	Y
Y3	100	100	0.0	Y	65.9				41.4				22.5				9.7			
X2		100			66.23	66.2	0.0	Y	41.03	41.0	0.0	Y	22.68	22.7	0.0	Y	10.1	10.1	0.0	Y
R3	100	100	0.0	Y	59.6	62.0	-2.4	N	36.3	40.1	-3.8	N	17.7	22.6	-4.9	N	11.3	10.0	1.3	N
W4	100	100	0.0	Y	66.1	66.1	0.0	Y	40.8	40.8	0.0	Y	22.7	22.7	0.0	Y	9.9	9.9	0.0	Y
Z4																				
R8	100	100	0.0	Y	59	59.4	-0.4	Y	40	40.5	-0.5	Y	23	22.6	0.4	Y	11	10.5	0.5	Y
B5	100	100	0.0	Y	64.61	64.6	0.0	Y	41.28	41.3	0.0	Y	22.83	22.8	0.0	Y	10.08	10.1	0.0	Y
N9	100	100	0.0	Y	66.2	66.2	0.0	Y	42	42.0	0.0	Y	23.1	23.1	0.0	Y	10.8	10.8	0.0	Y
C5	100	100	0.0	Y	61.8	61.8	0.0	Y	40.7	40.7	0.0	Y	22.7	22.7	0.0	Y	9.9	9.9	0.0	Y
K5	100	100	0.0	Y	63	63.0	0.0	Y	40.4	40.4	0.0	Y	22.7	22.7	0.0	Y	9.9	9.9	0.0	Y
P2	100	100	0.0	Y	64	64.3	-0.3	Y	41	40.9	0.1	Y	22	22.4	-0.4	Y	10	9.9	0.1	Y
G9																				
Y6	100	100	0.0	Y	61.3	61.3	0.0	Y	39.6	39.6	0.0	Y	22.3	22.3	0.0	Y	9.8	9.8	0.0	Y

Note: Results highlighted green have been recalculated by the program coordinator. Participants highlighted blue did not supply enough information to recalculate the results.

There was 1 participant (**R3**) identified as having an inconsistency when recalculated by Labsmart Services; had they supplied the results “recalculated by LabSmart Services”, participant **R3** would not have been identified as an outlier.

Participants with codes highlighted in Blue (6 participants or around 14%) failed to supply some aspect of the raw data requested, and the results could not be recalculated; some of these participants had outliers.

Check Sums

Particle size distribution calculations should have "check sums" to aid in detecting errors. Several approaches can be used for 'hand calculated' results. A single “check sum” that adds all the weights and compares it to the starting mass is usually sufficient for computer spreadsheets. If a “check sum” does not agree, it may mean that there has been an incorrect reading of the balance, transcription error, incorrect calculation or possibly lost material. The sign associated with the difference gives a clue as to where to begin.

Participant's masses were added and checked against the start mass they supplied. Several participants did not supply all the requested data, so checks could not be performed.

It is desirable that any 'unaccounted mass' be less than 1%. Most participant’s unaccounted mass' was very low, less than 0.5 %. This is a very good outcome.

Participants **T2 & E2** had recalculated 'check Sums' values higher than 1%. It should be noted that 'check sum' is only a guide and relies on the data supplied. These participants may benefit from reviewing the data and calculations submitted.

Pan

Assessment of the pan contents depends largely on the knowledge of the material as to what is acceptable. For this program, additional material was added between 4.75 and 75µm, pan amounts of between 52.1g to 67.6g were expected (this was determined from a z-score analysis of all Pan masses).

For this program, there were no abnormally low pan masses. However, those participants with low pan amounts may have;

- had additional sieves in place,
- may have lost material during sieving or washing,
- not sieved long enough,
- or there has been a calculation/transcription error.

Participants **T2**, **N7** & **R8** all had abnormally high pan masses; participants with high pan amounts may have;

- over sieved
- not washed completely
- or there has been a calculation/transcription error.

Some participants may have sieved without washing.

Pan amounts are important in the checking process. Although in this program, they do not constitute as an outlier, they can affect the 'material finer than 75 µm' result.

There were 2 participants (**E2** & **L4**) who did not submit values for material retained in the pan. It is good practice to record this amount for use in the "Checksum" process.

There were 2 participants (**L9** & **A8**) that did not submit results for "material finer than 75um", but from the information supplied, they could have calculated a result. Even if a participant does not perform the "material finer than 75um" test, participants still need to wash the sample. Retained dust on the aggregate may affect the '% passing Results" by 1 or 2% on various fractions.

The material used for this program did not appear to break down during sieving. However, any breakdown in the material would have had minor influence on the '% passing' results obtained.

Incomplete or inaccurate results

Many participants only supplied some of the data requested. For example, often the following was missing:

- Initial dry mass
- Washed mass
- Mass retained
- All of the above

Participants with incomplete data (%) where '% Passing' could not be recalculated by LabSmart Services are shown in Table 5 with codes shaded blue. There were 6 participants (**U9, W2, N7, J4, Y5, Y3**) with incomplete data.

Incomplete data means only limited feedback can be given.

Based on the data supplied and LabSmarts recalculations, all possible incorrect calculations are shown in Table 5. Only participants with significant differences are highlighted with a yellow "N" in the table.

Some participants dropped trailing zeros, i.e. 64 instead of 64.0. This is poor practice. It is unknown to the person checking if indeed the zero has been left off or a figure not recorded. The result may have been incorrectly rounded. The result shown as 64 may have been 64.0, 64.3, 64.9 or 63.8 etc.

As noted earlier in the report, there was 1 notable participant (Greater than 0.5%) identified in Table 5 as having inconsistencies between the data supplied and the supplied '% passing' results (**R3**).

'% Retained' – Appendix C

Mass retained results are often helpful in understanding issues associated with testing. Therefore, '% Retained' and associated z-scores have been calculated for information purposes only and are shown in Appendix C. Participants do not have to investigate the z-scores greater than |3| in Appendix C (noted by #). In many cases, if the 'retained mass' was incorrect, to begin with, then it will result in a z-score greater than 3 for the % passing as well.

Appendix C is missing '% retained' results for Five participants. All participants (**U9**, **N7**, **J4**, **Y5** & **Y3**) did not supply enough information to allow for the recalculation of '% Retained', All participants that didn't provide enough information have the participant code shown in orange in Appendix C.

Rows shown in green show the participants that submitted at least one outlier with their submitted '%passing' results, with the outlier highlighted ('Bold').

3.2 Material finer than 75 µm

Participant's performance overall was acceptable for this test, with several participants being identified where improvement could be made. In addition to the z-scores calculated, all calculations were checked using the supplied participant data.

There were two participants that had supplied all the required data for this test but did not report a result. If these participants calculated a result based on their supplied data, they would have received a satisfactory z-score (**L9** & **A8**).

Several participants (**T2**, **R9**, **Y2**, **G7**, **C2**) had a difference between the result reported and the recalculated 'material finer than 75µm' Value. It should be noted that AS 1141.12 requires that results be rounded to the whole number, and for a lot of the participants in question, the difference was small enough to not affect the requirement of the standard. However, in some cases, participants appeared to have rounded to the whole number as per the standard and then report the result to either one or two decimal points. It is essential that participants undertaking proficiency testing pay close attention to how a request for additional information can affect calculations.

There were 8 outliers (**W2, M2, U8, X8, N3, X5, W4,** & **N9**) identified for 'material finer than 75 µm'. It should be noted that the NIQR assocated with the spread of results for the material finer than 75 µm was tighter than in previous years, this is tied to the interquartile range (with smaller groupings, there is a smaller range before being identified as an outlier). This tight grouping resulted in a considerable increase in the number of outliers. For participants with z-scores slightly above |3| on the material finer than 75 µm, it would be beneficial for these participants to review their outliers; however, LabSmart does not see them as being of great concern.

For more information on this, see section 5.2.5.

3.3 Flakiness Index

Unlike grading, the skill of the tester has little influence over the outcome of the test. Provided the test is performed correctly, a tester should be able to retest each fraction and get essentially the same result.

The spread of results observed may be more indicative of the manufacturing process than that of the participants. So, unlike the other tests, the standard deviation should reflect the manufacturing process rather than the precision of the testers. Therefore, the proficiency testing program will only pick up gross departures from the median result. This is satisfactory from a proficiency program perspective; it just means that an outlier is possibly outside both the testing confidence interval and the material's natural variation associated with production.

The spread of results obtained for the flakiness test is generally less than the proportional calliper test.

There was 1 outlier (**L4**) identified, and overall, participants' performance was satisfactory for the flakiness test. This is in line with previous years with a similar NIQR (Approximated Standard Deviation).

Participants with z-scores above 1.0 or below -1.0 may benefit from reviewing their testing practices. This may involve checking that particles are not missed during the testing process. More rounded particles may need to be manipulated several ways before it will eventually pass through the slot.

Other aspects of the test methodology that may cause inaccurate results to be obtained include:

- Incorrect performance of PSD
- Failure to mix and split sample correctly
- Worn gauge
- Incorrect slot used
- Insufficient manipulation of stone to check all orientations
- Forcing stones through gauge
- Loss of stones, both before and during testing
- Incorrect weighing
- Balance inaccuracy

3.4 Average Least Dimensions

This test produced results with a minimal variation across most of the 30 participants. According to the result logs, all but 4 participants performed the test to AS 1141.20.1

As with flakiness, the tester's skill should have little influence over the outcome of the test. Provided the test is performed correctly, a tester should be able to retest the sample and get essentially the same result. However, there is some variation associated with the different equipment that can be used for this test, e.g. slotted, vernier etc.

The spread of results observed may be more indicative of the manufacturing process rather than that of the participants. So, unlike the other tests the standard deviation is more likely to reflect the manufacturing process rather than the precision of the testers. The proficiency testing program, therefore, will only pick up gross departures from the median result. This is satisfactory from a proficiency program perspective; it just means that any outlier is possibly outside both the testing confidence interval and the material's natural variation associated with production.

Consequently, the homogeneity and participant's statistics should be quite similar. However, it should be noted that it is very dependent on having a representative sample. The test method indicates 100 stones as a minimum. The higher the number of stones used, the greater the confidence in the result obtained as well as reducing the impact of any stones incorrectly 'sized' during testing.

Previous programs have indicated that there is very little difference between using a flat bed, slotted gauge or vernier callipers. Table 6 compares the variation.

The statistics for this program yielded similar outcomes to previous programs in terms of variation in results, as shown in Table 6.

Table 6: Comparison of ALD statistics for 2022, 2021, 2020, 2019, 2018, 2017, and 2016 programs

Program	Statistics	All	Flatbed	Slotted	Vernier	Calculated (20.3)
2022(110)	No. Participants	30	8	13	5	4
	Average	7.2	6.6	6.9	7.5	8.7
	Standard Deviation	1.5	1.1	1.5	1.9	0.5
2021(104)	No. Participants	28	6	17	3	2
	Average	8.0	8.2	7.9	6.8	9.3
	Standard Deviation	1.0	1.1	0.8	0.6	0.1
2020(96)	No. Participants	35	11	11	7	6
	Average	8.2	8.3	7.9	8.1	8.6
	Standard Deviation	0.8	0.8	0.5	0.7	1.3
2019(90)	No. Participants	25	2	12	3	7
	Average	7.2	6.3	7.1	7.5	9.1
	Standard Deviation	0.8	-	0.8	-	0.3
2018(82)	No. Participants	42	10	13	9	10
	Average	6.9	5.8	6.4	6.4	9.2
	Standard Deviation	1.7	1.0	0.9	2.1	0.2
2017(75)	No. Participants	50	17	15	8	6
	Average	8.1	8.0	7.7	8.0	9.1
	Standard Deviation	0.8	0.8	0.4	0.6	0.2
2016(68)	No. Participants	44	43	34	9	2
	Average	8.2	8.2	8.1	8.4	9.2
	Standard Deviation	0.8	0.8	0.8	0.8	-

Note: All Results include outliers

Method 20.3

Four participants chose to use the calculation method. The method tends to give very consistent results, (i.e. very little variation).

Previous proficiency programs have indicated that there has been little if any difference regardless of whether AS 1141: 20.1 or 20.3 is used. The homogeneity was undertaken using both the slotted gauge and calculation method.

With past programs, the calculation method has tended to give rise to results that are higher than the slotted gauge but still close to one standard deviation of the median.

Despite the homogeneity displaying smaller variation for the calculated ALD (method 20.3), it may not be as accurate as using direct measurement (method 20.1). If the measurement uncertainty was to be calculated for both methods, it might be more significant for method 20.3 as it uses several other test results (parameters) to derive the ALD value (i.e. '% Passing' and FI). A further drawback with method 20.3 is that any inaccuracies with the parameters used to calculate the ALD will also affect the result obtained.

Table 7: ALD results.

Code	Average Least Dimensions				
	All	Flatbed	Slotted	Vernier	Calculated (20.3)
U4	8.7				8.7
Z2	5.7		5.7		
U9	8.9			8.9	
W2	8.7				8.7
U5	8.8	8.8			
N4	10.3			10.3	
U8	6.2	6.2			
M3	5.7	5.7			
T2	5.2		5.2		
T5	5.5		5.5		
F7	5.3		5.3		
J8	8.1		8.1		
E2	6		6		
Q8	5.5			5.5	
N7	8.8				8.8
L4	6.5			6.5	
J4	6.3	6.3			
G7	8.8				8.8
C2	6		6		
A5	8.8		8.8		
Z6	8.9		8.9		
X5	5.7	5.7			
Y3	8.4		8.4		
W4	5.6	5.6			
R8	6.5	6.5			
B5	8.5		8.5		
N9	8.4		8.4		
C5	8.1	8.1			
P2	5.8		5.8		
Y6	6.7			6.7	
Nº Participants	30	8	13	5	4
Average	7.2	6.6	6.9	7.5	8.7
Standard Deviation	1.5	1.1	1.5	1.9	0.5

3.5 ‘Apparent Particle Density’, ‘Particle Density on a Dry Basis’ & ‘Particle Density on a Saturated-Surface-Dry Basis’

The material used (Sample B) in this program was selected to give reasonably consistent results across all three tests. Out of the 30 participants who undertook this test, 29 participants performed the tests to AS 1141.6.1, with one participant tested to AS 1141.6.2.

The tests involve operations that require skilled technicians to obtain accurate and consistent results.

The test, as intended, is sensitive to surface irregularities and internal voids. However, the more surface irregularities, the harder it is to determine the "surface dry" state. This may influence the spread of results observed depending on the skill level of the overall group of participants.

The more homogenous the material under test (i.e. with the same surface and voids in each stone), the smaller the variation is likely to be. Homogeneity testing was undertaken before releasing the samples to participants and the results were found to be Homogenous

Of the 30 participants, there were two outliers identified (see z-score results in section 4) these outliers only involved 1 participant (**L4**)**.** Participant **L4** needs to look at the Apparent Particle Density and Particle Density on Dry Basis results in relation to each other when reviewing this outcome, as these results have impacts on each other.

The spread of results was within the range expected for all particle density tests as compared to previous years of this program (Table 8).

Table 8: Comparison of previous and current program statistics

Particle density test						
Program	Apparent Particle Density		Particle Density on a Dry Basis		Particle Density on a Saturated-Surface-Dry Basis	
	Median (t/m^3)	Normalized IQR (t/m^3)	Median (t/m^3)	Normalized IQR (t/m^3)	Median (t/m^3)	Normalized IQR (t/m^3)
2022 (110)	2.740	0.010	2.670	0.015	2.690	0.007
2021 (104)	2.74	0.01	2.680	0.02	2.700	0.01
2020 (96)	2.805	0.065	2.570	0.037	2.650	0.035
2019 (90)	2.65	0.007	2.61	0.007	2.62	0.011
2018(82)	2.73	0.015	2.53	0.022	2.60	0.015
2017(75)	2.81	0.023	2.64	0.030	2.70	0.015

L4 was significantly different to all other participants across all three tests except for Particle density on a saturated-surface dry basis. For this participant, it is possible a systematic issue related to either a calculation, rounding or weighing error was the result of them being identified as an outlier. Without access to every individual measurement, it is not easy to give any particular comment on any one outlier, however:

Possible sources of variation in results include:

- Transcription errors
- Incorrect calculations
- Weighing error
- Not removing 4.75 retained
- Trapped fines in the basket. Need to remove fines after washing and absorption period – some stones break up.
- Insufficient washing
- Loss of stones during testing
- Basket touching side of the bucket
- Incorrect taring of balance with the bucket in the water
- Over or under drying
- Incorrect temperature correction
- Sample not dry after drying to constant weight
- Trapped bubbles
- Stones trapped in the basket
- Bucket not filled to the same spot with water

For particle density on 'dry' and 'saturated-surface dry' basis the drying to a 'surface-dry' state is critical to the accuracy of the test result. An outlier at either the low or high density may indicate either the material being too wet or too dry. Correct oven drying is also critical.

3.6 Water Absorption

All participants indicated that AS 1141.6.1 was used, except for **L5,** who reported using 1141.6.2.1

The spread in results is similar to previous years, as shown in Table 9. Homogeneity testing was undertaken prior to releasing the samples to participants. The Laboratory performing homogeneity testing found the material homogenous (see 5.7 Homogeneity Testing).

There was 1 outlier identified in this program, **L4,** who had significant differences from other participants.

Ultimately, variation in the performance of this test is strongly influenced by the skill of the tester (ability to determine surface dry) and the type of material under test (number of voids, porosity, etc.). Performing the test in both a controlled environment and in the same manner is essential. Changes in drying material or technique, temperature, wind, humidity, and lighting can have a significant effect.

Table 9: Variation in water absorption results for the past 5 years

Program Year	Median	***NIQR (Approximated Standard Deviation)***
2022	0.94	0.12
2021	0.84	0.13
2020	3.40	0.79
2019	0.59	0.11
2018	2.90	0.28
2017	2.35	0.27

3.7 Particle shape by proportional calliper (2:1 & 3:1)

Proportional calliper tests are most likely going to give a wide spread of results. The spread of results (variation) will depend on the grade of aggregate, time produced and manufacturer. The method of manufacturing aggregate has limited ability to control the particle shape. The coefficient of variation (CV) is typically upwards of the 20% mark for 2:1 and higher for 3:1. The results normally would be taken as indicative. However, the results are important and useful to both manufacturers and users of aggregate.

The NIQR (Approximated Standard Deviation) and CV (coefficient of variation) for this program were towards the higher side when compared to previous programs. During the pretesting phase, it was identified that one fraction (-19mm to 13.2mm) might not have enough particles to meet the 100 particles rule. Steps were implemented to counter this issue, including asking participants to exclude this fraction in their calculations (see instructions). Additionally, as stated above the spread of results observed may be more indicative of the manufacturing process rather than that of the participants. So, unlike the other tests the standard deviation is more likely to reflect the manufacturing process rather than the precision of the testers. The proficiency testing program, therefore, will only pick up gross departures from the median result. This is satisfactory from a proficiency program perspective; it just means that any outlier is possibly outside both the testing confidence interval and the material's natural variation associated with production.

The 3:1 proportional calliper test has been dropped from the program as it is, from a proficiency testing perspective, as it is a duplicate of the 2:1 test and reduces the testing required by participants.

No outliers were identified, and all participants indicated they used AS 1141.14.

Finally, Some stones are difficult to measure due to their shape. Participants need to be sure that the width and thickness are correctly identified. This will also account for some of the variation observed. Correct splitting of the sample to obtain 100 or more stones is the most significant source of error or variation for this test. The sample needs to be well mixed and show no signs of segregation prior to splitting. The number of stones used also has an impact.

4. Statistics: Z-Score & Graph

Sample A - Percent Passing 13.2mm: Z - Scores

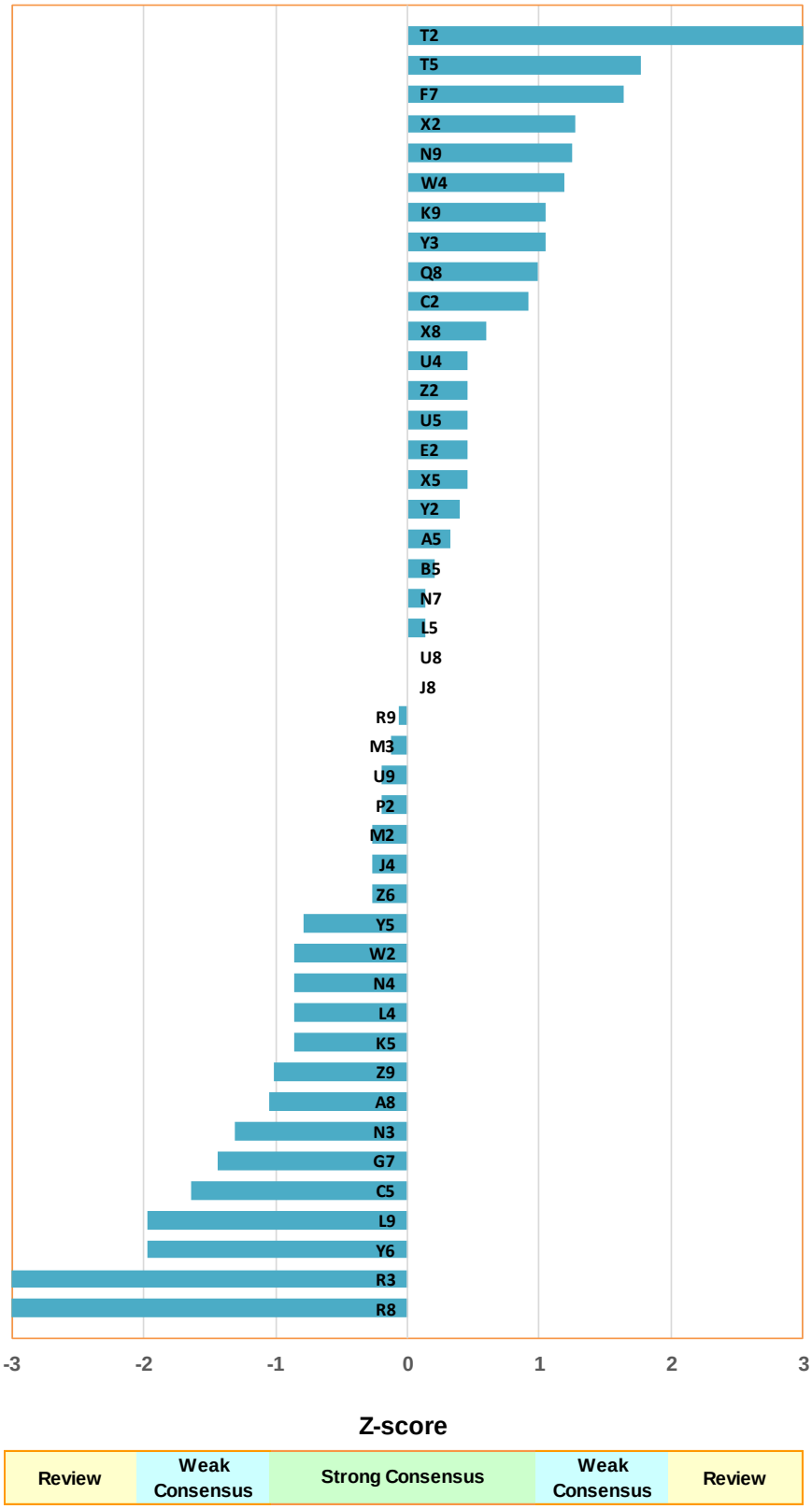
Code	Test Result %	Z Score
U4	65.0	0.46
Z2	65	0.46
U9	64	-0.20
W2	63.0	-0.86
U5	65	0.46
B6		
M2	63.9	-0.26
N4	63.0	-0.86
U8	64.3	0.00
M3	64.1	-0.13
T2	70.7	**4.21** #
X8	65.2	0.59
T5	67	1.78
F7	66.8	1.65
J8	64.3	0.00
E2	65	0.46
K9	65.9	1.05
R9	64.2	-0.07
Y2	64.9	0.39
Q8	65.8	0.99
N7	64.5	0.13
L4	63.0	-0.86
L5	64.5	0.13
J4	63.9	-0.26
Y5	63.1	-0.79
N3	62.3	-1.32
G7	62.1	-1.45
C2	65.7	0.92

Code	Test Result %	Z Score
A5	64.8	0.33
Z6	63.9	-0.26
X5	65	0.46
Z9	62.75	-1.02
L9	61.3	-1.97
A8	62.7	-1.05
Y3	65.9	1.05
X2	66.23	1.27
R3	59.6	**-3.09** #
W4	66.1	1.18
Z4		
R8	59	**-3.49** #
B5	64.61	0.20
N9	66.2	1.25
C5	61.8	-1.65
K5	63.0	-0.86
P2	64	-0.20
G9		
Y6	61.3	-1.97

Statistic	*Value*	
Number of results	**44**	
Median	**64.3**	
Median MU	**0.29**	
First Quartile	**63.0**	
Third Quartile	**65.1**	
IQR	**2.05**	
Normalised IQR	**1.52**	
CV (%)	**2.4**	
Minimum	**61.3**	(59.0)
Maximum	**67.0**	(70.7)
Range	**5.7**	(11.7)

Note: A # indicates an outlier where the z-score obtained is either greater then 3 or less than -3. Codes for all participates are shown. The results column shows a blank entry or 'NR' for those participants that did not submit a result for this test. Results in **green** have been calculated by the program coordinator. An R indicates an abnormal result rejected by the program coordinator. Minimum, Maximum and Range are calculated with outliers excluded, those in brackets include outliers.

Sample A - Percent Passing 13.2mm: Z - Score Graph



Sample A - Percent Passing 9.5mm: Z - Scores

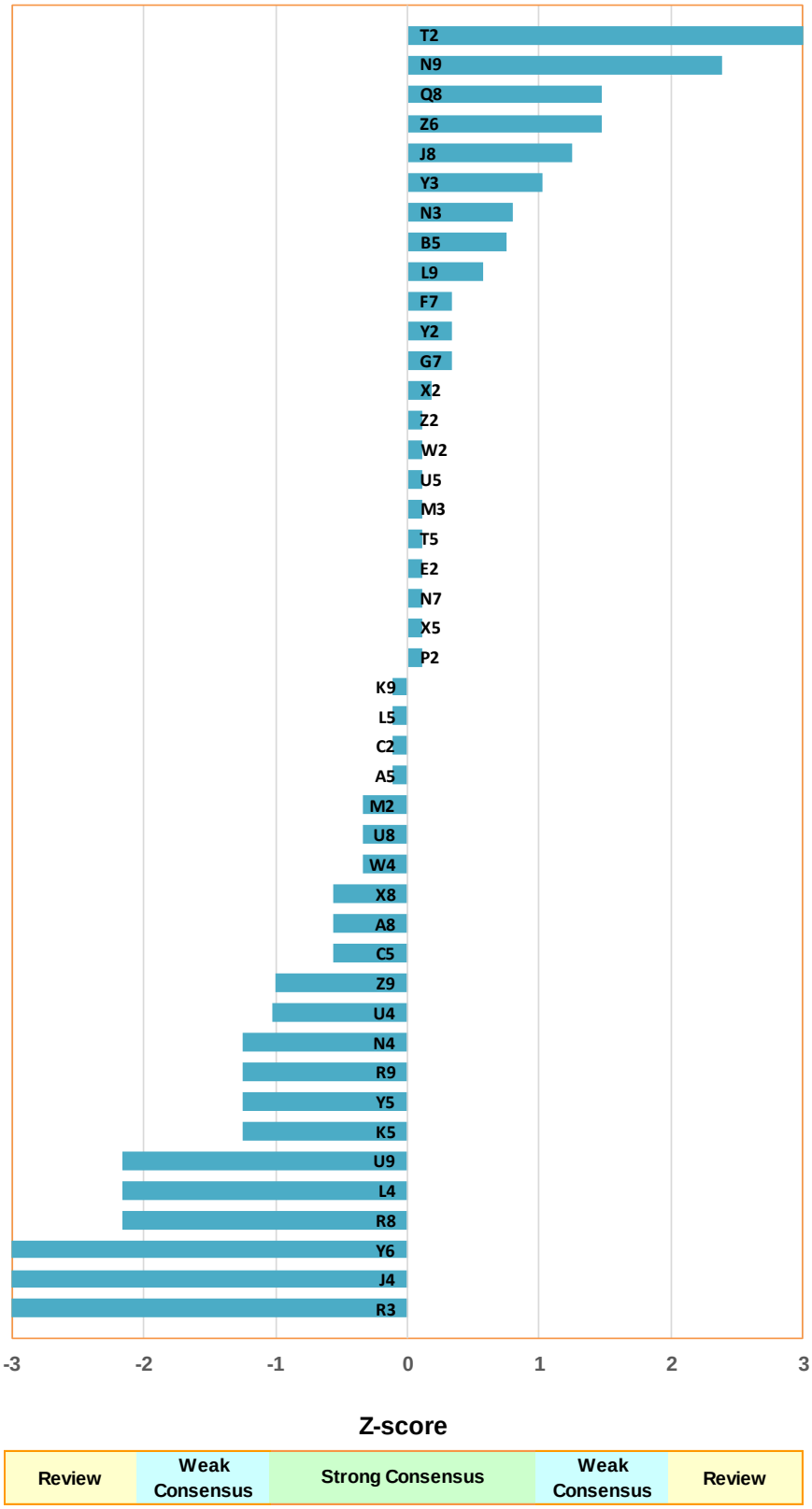
Code	Test Result %	Z Score
U4	40.5	-1.02
Z2	41	0.11
U9	40	-2.16
W2	41.0	0.11
U5	41	0.11
B6		
M2	40.8	-0.34
N4	40.4	-1.25
U8	40.8	-0.34
M3	41.0	0.11
T2	42.5	**3.53 #**
X8	40.7	-0.57
T5	41	0.11
F7	41.1	0.34
J8	41.5	1.25
E2	41	0.11
K9	40.9	-0.11
R9	40.4	-1.25
Y2	41.1	0.34
Q8	41.6	1.48
N7	41.0	0.11
L4	40.0	-2.16
L5	40.9	-0.11
J4	37.1	**-8.77 #**
Y5	40.4	-1.25
N3	41.3	0.80
G7	41.1	0.34
C2	40.9	-0.11

Code	Test Result %	Z Score
A5	40.9	-0.11
Z6	41.6	1.48
X5	41	0.11
Z9	40.51	-1.00
L9	41.2	0.57
A8	40.7	-0.57
Y3	41.4	1.02
X2	41.03	0.18
R3	36.3	**-10.59 #**
W4	40.8	-0.34
Z4		
R8	40	-2.16
B5	41.28	0.75
N9	42.0	2.39
C5	40.7	-0.57
K5	40.4	-1.25
P2	41	0.11
G9		
Y6	39.6	**-3.07 #**

Statistic	*Value*	
Number of results	**44**	
Median	**41.0**	
Median MU	**0.08**	
First Quartile	**40.5**	
Third Quartile	**41.1**	
IQR	**0.59**	
Normalised IQR	**0.44**	
CV (%)	**1.1**	
Minimum	**39.6**	(36.3)
Maximum	**42.0**	(42.5)
Range	**2.4**	(6.2)

Note: A # indicates an outlier where the z-score obtained is either greater then 3 or less than -3. Codes for all participates are shown. The results column shows a blank entry or 'NR' for those participants that did not submit a result for this test. Results in **green** have been calculated by the program coordinator. An R indicates an abnormal result rejected by the program coordinator. Minimum, Maximum and Range are calculated with outliers excluded, those in brackets include outliers.

Sample A - Percent Passing 9.5mm: Z - Score Graph



Sample A - Percent Passing 6.7mm: Z - Scores

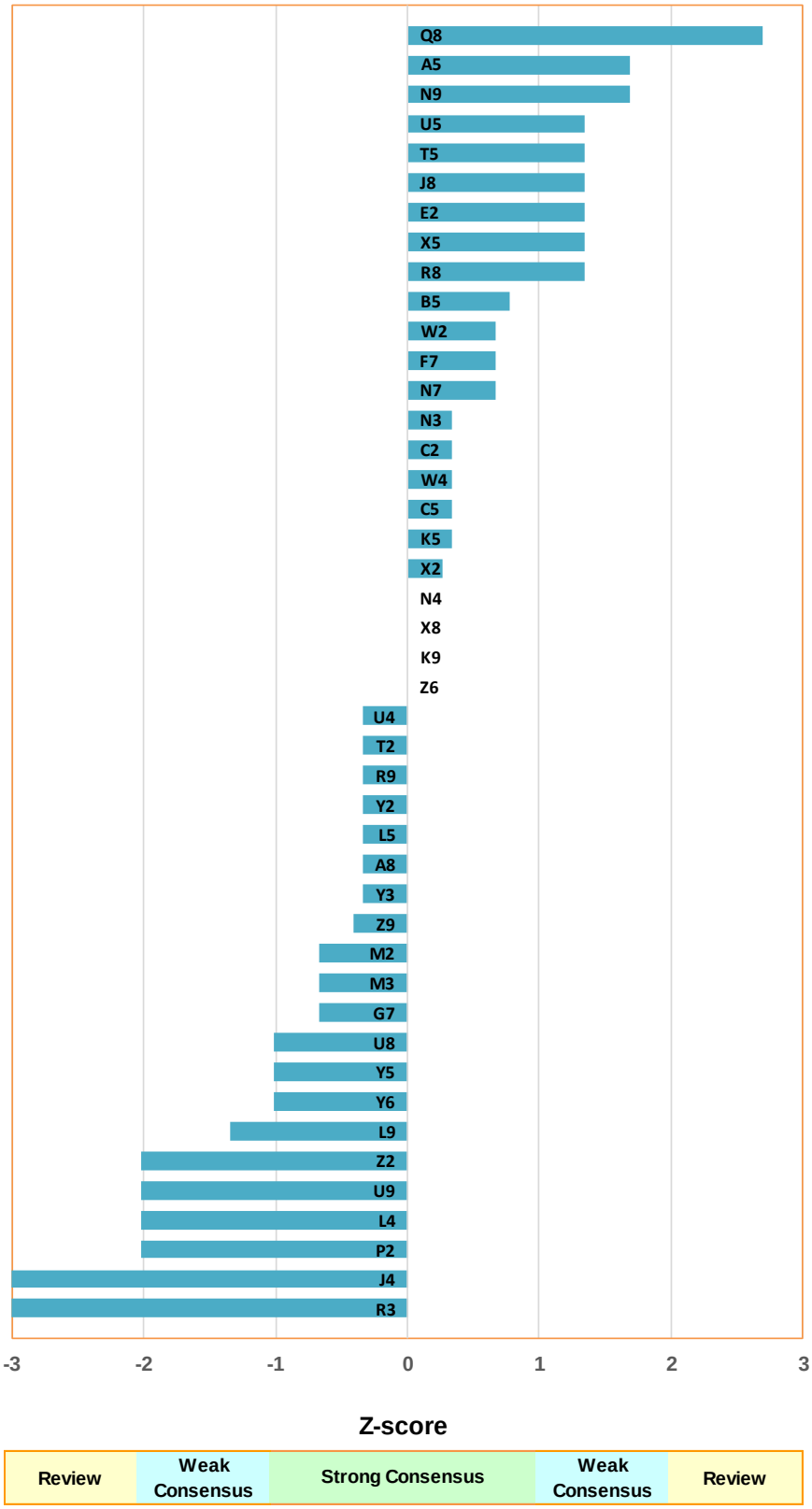
Code	Test Result %	Z Score
U4	22.5	-0.34
Z2	22	-2.02
U9	22	-2.02
W2	22.8	0.67
U5	23	1.35
B6		
M2	22.4	-0.67
N4	22.6	0.00
U8	22.3	-1.01
M3	22.4	-0.67
T2	22.5	-0.34
X8	22.6	0.00
T5	23	1.35
F7	22.8	0.67
J8	23.0	1.35
E2	23	1.35
K9	22.6	0.00
R9	22.5	-0.34
Y2	22.5	-0.34
Q8	23.4	**2.70**
N7	22.8	0.67
L4	22.0	-2.02
L5	22.5	-0.34
J4	17.7	**-16.53** #
Y5	22.3	-1.01
N3	22.7	0.34
G7	22.4	-0.67
C2	22.7	0.34

Code	Test Result %	Z Score
A5	23.1	1.69
Z6	22.6	0.00
X5	23	1.35
Z9	22.48	-0.40
L9	22.2	-1.35
A8	22.5	-0.34
Y3	22.5	-0.34
X2	22.68	0.27
R3	17.7	**-16.53** #
W4	22.7	0.34
Z4		
R8	23	1.35
B5	22.83	0.78
N9	23.1	1.69
C5	22.7	0.34
K5	22.7	0.34
P2	22	-2.02
G9		
Y6	22.3	-1.01

Statistic	*Value*	
Number of results	**44**	
Median	**22.6**	
Median MU	**0.06**	
First Quartile	**22.4**	
Third Quartile	**22.8**	
IQR	**0.40**	
Normalised IQR	**0.30**	
CV (%)	**1.3**	
Minimum	**22.0**	(17.7)
Maximum	**23.4**	(23.4)
Range	**1.4**	(5.7)

Note: A # indicates an outlier where the z-score obtained is either greater then 3 or less than -3. Codes for all participates are shown. The results column shows a blank entry or 'NR' for those participants that did not submit a result for this test. Results in **green** have been calculated by the program coordinator. An R indicates an abnormal result rejected by the program coordinator. Minimum, Maximum and Range are calculated with outliers excluded, those in brackets include outliers.

Sample A - Percent Passing 6.7mm: Z - Score Graph



Sample A - Percent Passing 4.75mm: Z - Scores

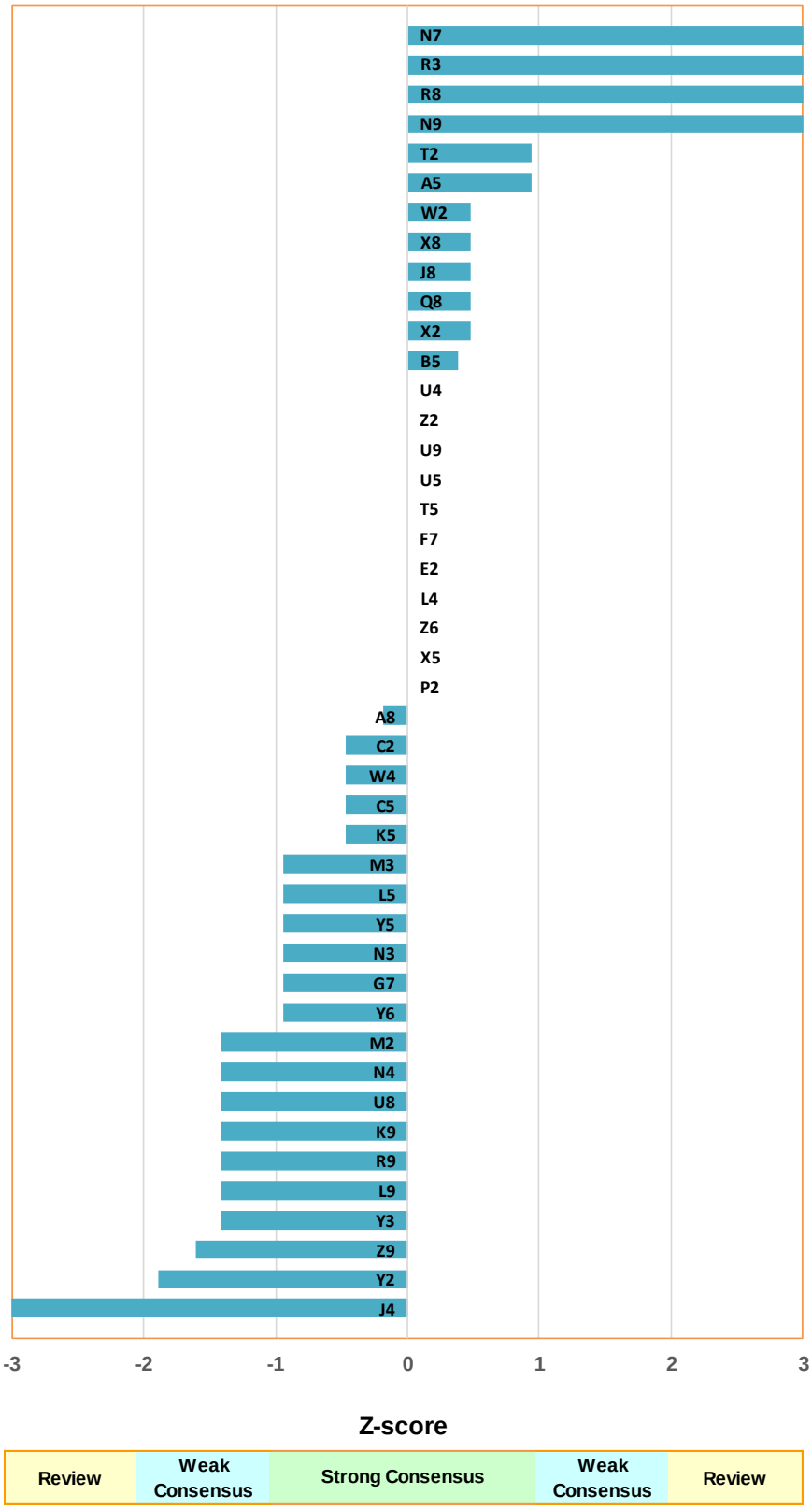
Code	Test Result %	Z Score
U4	10.0	0.00
Z2	10	0.00
U9	10	0.00
W2	10.1	0.47
U5	10	0.00
B6		
M2	9.7	-1.42
N4	9.7	-1.42
U8	9.7	-1.42
M3	9.8	-0.95
T2	10.2	0.95
X8	10.1	0.47
T5	10	0.00
F7	10.0	0.00
J8	10.1	0.47
E2	10	0.00
K9	9.7	-1.42
R9	9.7	-1.42
Y2	9.6	-1.89
Q8	10.1	0.47
N7	11.4	**6.63** #
L4	10.0	0.00
L5	9.8	-0.95
J4	4.2	**-27.45** #
Y5	9.8	-0.95
N3	9.8	-0.95
G7	9.8	-0.95
C2	9.9	-0.47

Code	Test Result %	Z Score
A5	10.2	0.95
Z6	10.0	0.00
X5	10	0.00
Z9	9.66	-1.61
L9	9.7	-1.42
A8	9.96	-0.19
Y3	9.7	-1.42
X2	10.10	0.47
R3	11.3	**6.15** #
W4	9.9	-0.47
Z4		
R8	11	**4.73** #
B5	10.08	0.38
N9	10.8	**3.79** #
C5	9.9	-0.47
K5	9.9	-0.47
P2	10	0.00
G9		
Y6	9.8	-0.95

Statistic	*Value*	
Number of results	**44**	
Median	**10.0**	
Median MU	**0.04**	
First Quartile	**9.8**	
Third Quartile	**10.1**	
IQR	**0.29**	
Normalised IQR	**0.21**	
CV (%)	**2.1**	
Minimum	**9.6**	(4.2)
Maximum	**10.2**	(11.4)
Range	**0.6**	(7.2)

Note: A # indicates an outlier where the z-score obtained is either greater then 3 or less than -3. Codes for all participates are shown. The results column shows a blank entry or 'NR' for those participants that did not submit a result for this test. Results in **green** have been calculated by the program coordinator. An R indicates an abnormal result rejected by the program coordinator. Minimum, Maximum and Range are calculated with outliers excluded, those in brackets include outliers.

Sample A - Percent Passing 4.75mm: Z - Score Graph



Sample A - Material Finer Than 75µm: Z - Scores

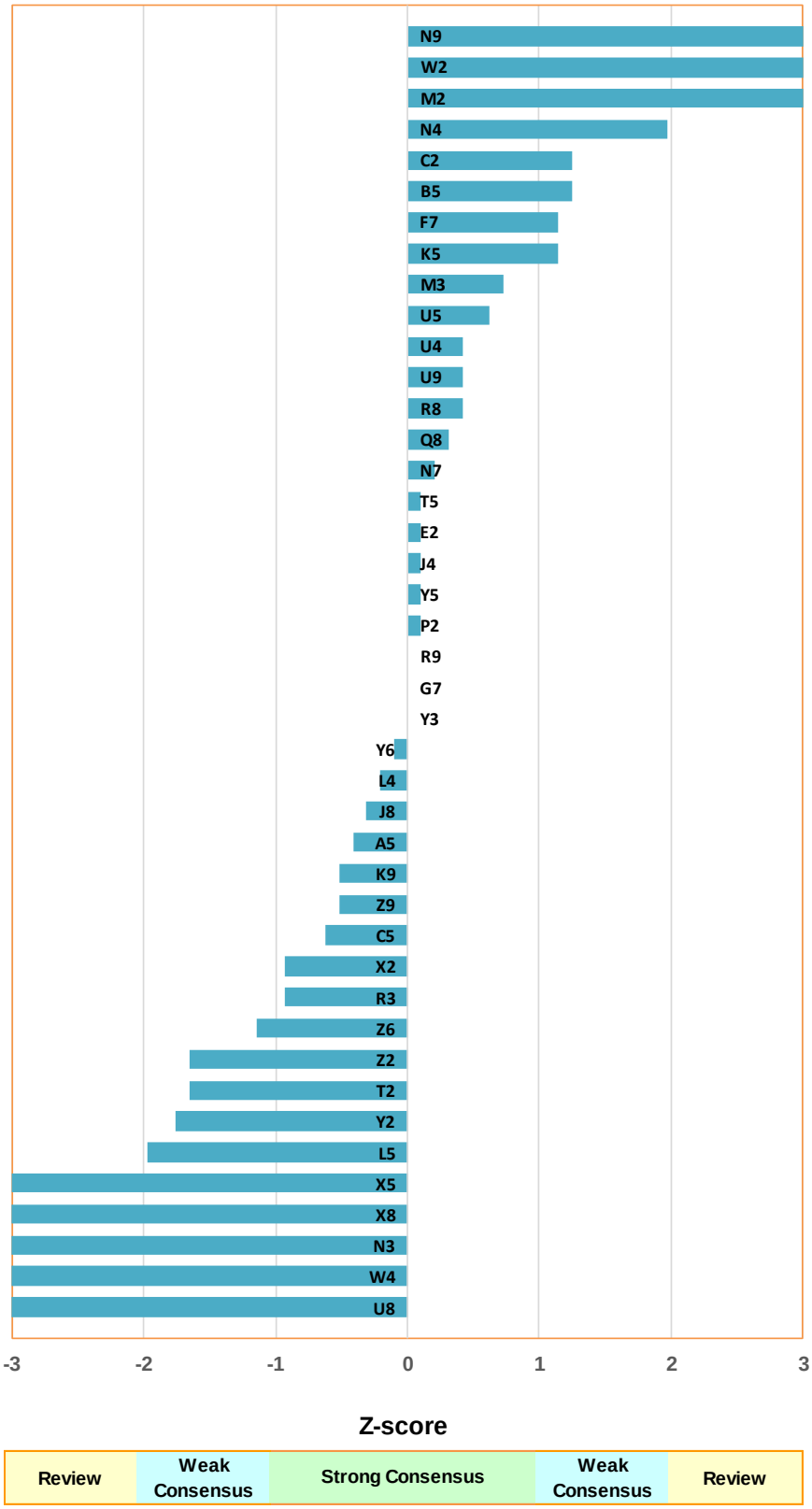
Code	Test Result %	Z Score
U4	6.03	0.42
Z2	5.83	-1.66
U9	6.03	0.42
W2	6.43	**4.57** #
U5	6.05	0.62
B6		
M2	6.30	**3.22** #
N4	6.18	1.97
U8	5.47	**-5.40** #
M3	6.06	0.73
T2	5.83	-1.66
X8	5.67	**-3.32** #
T5	6.0	0.10
F7	6.1	1.14
J8	5.96	-0.31
E2	6	0.10
K9	5.94	-0.52
R9	5.99	0.00
Y2	5.82	-1.76
Q8	6.02	0.31
N7	6.01	0.21
L4	5.97	-0.21
L5	5.8	-1.97
J4	6.00	0.10
Y5	6.00	0.10
N3	5.59	**-4.15** #
G7	5.99	0.00
C2	6.11	1.25

Code	Test Result %	Z Score
A5	5.95	-0.42
Z6	5.88	-1.14
X5	5.7	**-3.01** #
Z9	5.94	-0.52
L9	NR	
A8	NR	
Y3	5.99	0.00
X2	5.9	-0.93
R3	5.90	-0.93
W4	5.56	**-4.46** #
Z4		
R8	6.03	0.42
B5	6.11	1.25
N9	6.61	**6.43** #
C5	5.93	-0.62
K5	6.1	1.14
P2	6.0	0.10
G9		
Y6	5.98	-0.10

Statistic	*Value*	
Number of results	**42**	
Median	**5.99**	
Median MU	**0.02**	
First Quartile	**5.90**	
Third Quartile	**6.03**	
IQR	**0.13**	
Normalised IQR	**0.10**	
CV (%)	**1.6**	
Minimum	**5.80**	(5.47)
Maximum	**6.18**	(6.61)
Range	**0.38**	(1.14)

Note: A # indicates an outlier where the z-score obtained is either greater then 3 or less than -3. Codes for all participates are shown. The results column shows a blank entry or 'NR' for those participants that did not submit a result for this test. Results in **green** have been calculated by the program coordinator. An R indicates an abnormal result rejected by the program coordinator. Minimum, Maximum and Range are calculated with outliers excluded, those in brackets include outliers.

Sample A - Material Finer Than 75µm: Z - Score Graph



Sample A - Flakiness Index: Z - Scores

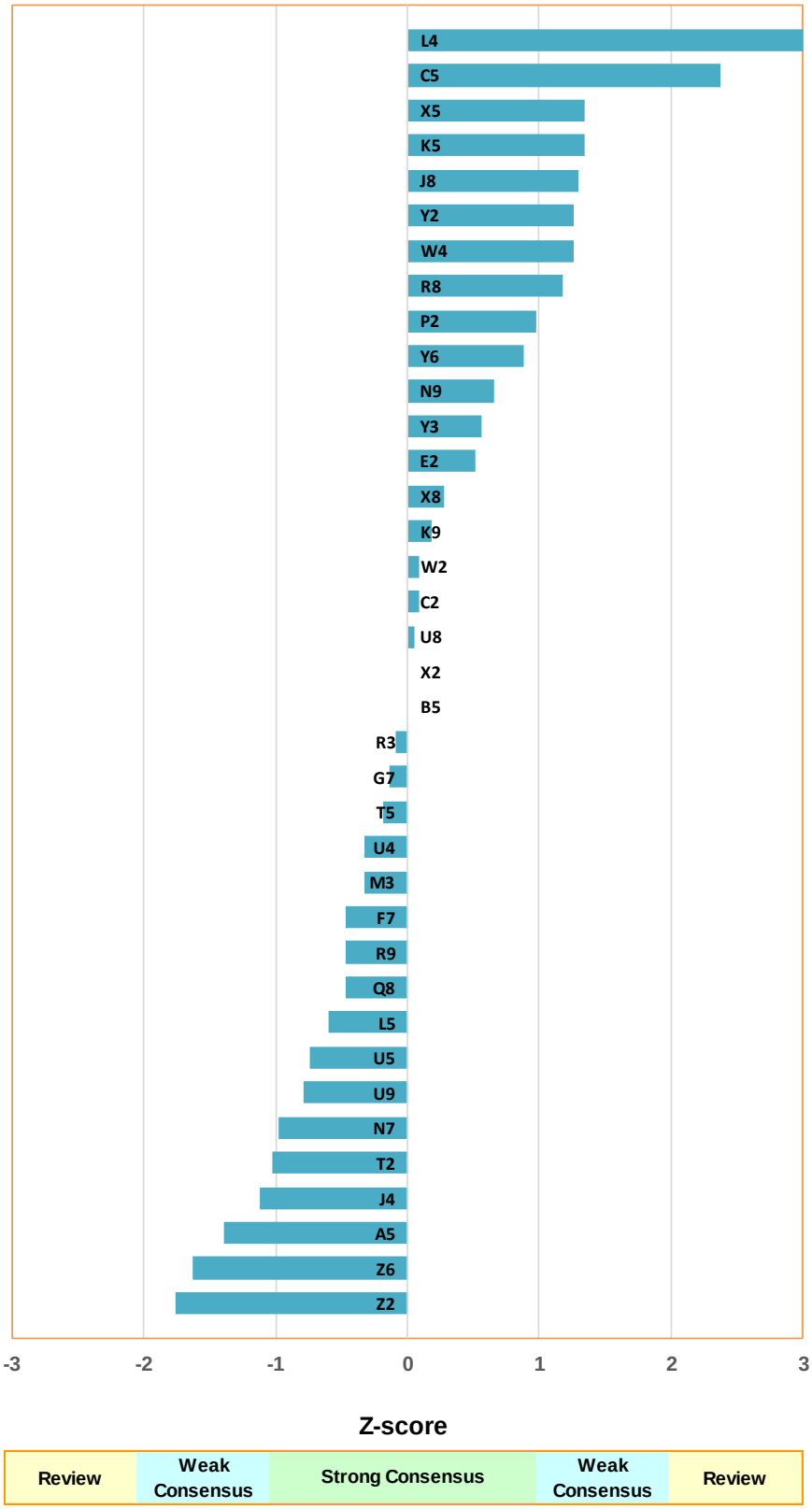
Code	Test Result %	Z Score
U4	13.2	-0.33
Z2	10.1	-1.77
U9	12.2	-0.79
W2	14.1	0.09
U5	12.3	-0.74
B6		
M2	NR	
N4	NR	
U8	14.0	0.05
M3	13.2	-0.33
T2	11.7	-1.02
X8	14.5	0.28
T5	13.5	-0.19
F7	12.9	-0.47
J8	16.7	1.30
E2	15	0.51
K9	14.3	0.19
R9	12.9	-0.47
Y2	16.6	1.26
Q8	12.9	-0.47
N7	11.8	-0.98
L4	85.7	**33.40** #
L5	12.6	-0.60
J4	11.5	-1.12
Y5	NR	
N3	NR	
G7	13.6	-0.14
C2	14.1	0.09

Code	Test Result %	Z Score
A5	10.9	-1.40
Z6	10.4	-1.63
X5	16.8	1.35
Z9	NR	
L9	NR	
A8	NR	
Y3	15.1	0.56
X2	13.9	0.00
R3	13.7	-0.09
W4	16.6	1.26
Z4		
R8	16.44	1.18
B5	13.9	0.00
N9	15.3	0.65
C5	19.0	2.37
K5	16.8	1.35
P2	16.0	0.98
G9		
Y6	15.8	0.88

Statistic	*Value*	
Number of results	**37**	
Median	**13.9**	
Median MU	**0.44**	
First Quartile	**12.9**	
Third Quartile	**15.8**	
IQR	**2.90**	
Normalised IQR	**2.15**	
CV (%)	**15.5**	
Minimum	**10.1**	(10.1)
Maximum	**19.0**	(85.7)
Range	**8.9**	(75.6)

Note: A # indicates an outlier where the z-score obtained is either greater then 3 or less than -3. Codes for all participates are shown. The results column shows a blank entry or 'NR' for those participants that did not submit a result for this test. Results in **green** have been calculated by the program coordinator. An R indicates an abnormal result rejected by the program coordinator. Minimum, Maximum and Range are calculated with outliers excluded, those in brackets include outliers.

Sample A - Flakiness Index: Z - Score Graph



Sample A - Average Least Dimensions: Z - Scores

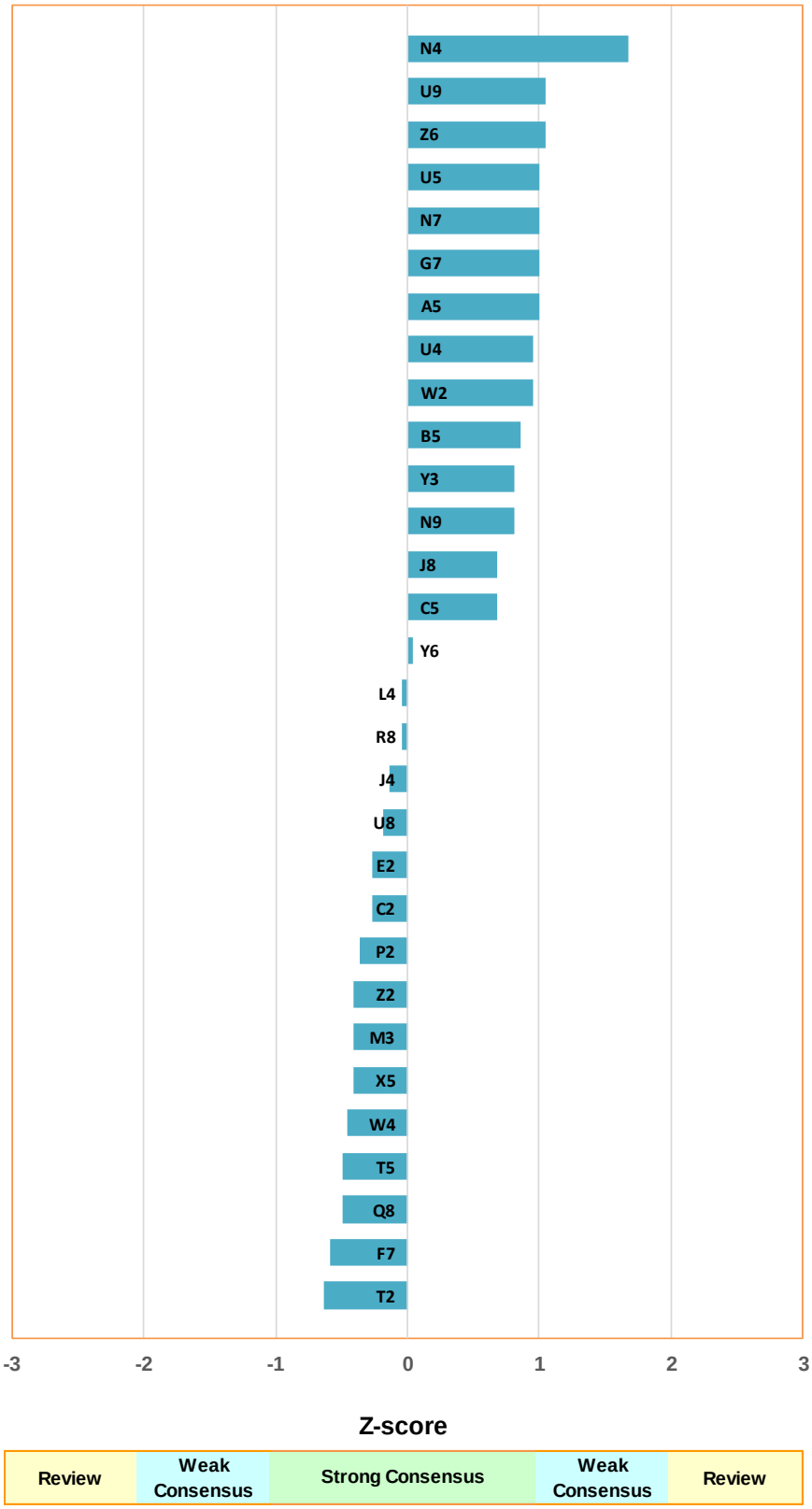
Code	Test Result mm	Z Score
U4	8.7	0.95
Z2	5.7	-0.41
U9	8.9	1.04
W2	8.7	0.95
U5	8.8	1.00
B6		
M2	NR	
N4	10.3	1.68
U8	6.2	-0.18
M3	5.7	-0.41
T2	5.2	-0.63
X8	NR	
T5	5.5	-0.50
F7	5.3	-0.59
J8	8.1	0.68
E2	6.0	-0.27
K9	NR	
R9	NR	
Y2	NR	
Q8	5.5	-0.50
N7	8.8	1.00
L4	6.5	-0.05
L5	NR	
J4	6.3	-0.14
Y5	NR	
N3	NR	
G7	8.8	1.00
C2	6.0	-0.27

Code	Test Result mm	Z Score
A5	8.8	1.00
Z6	8.9	1.04
X5	5.7	-0.41
Z9	NR	
L9	NR	
A8	NR	
Y3	8.4	0.82
X2	NR	
R3	NR	
W4	5.6	-0.45
Z4		
R8	6.5	-0.05
B5	8.5	0.86
N9	8.4	0.82
C5	8.1	0.68
K5	NR	
P2	5.8	-0.36
G9		
Y6	6.7	0.05

Statistic	*Value*	
Number of results	**30**	
Median	**6.6**	
Median MU	**0.50**	
First Quartile	**5.7**	
Third Quartile	**8.7**	
IQR	**2.98**	
Normalised IQR	**2.21**	
CV (%)	**33.4**	
Minimum	**5.2**	()
Maximum	**10.3**	()
Range	**5.1**	()

Note: A # indicates an outlier where the z-score obtained is either greater then 3 or less than -3. Codes for all participates are shown. The results column shows a blank entry or 'NR' for those participants that did not submit a result for this test. Results in **green** have been calculated by the program coordinator. An R indicates an abnormal result rejected by the program coordinator. Minimum, Maximum and Range are calculated with outliers excluded, those in brackets include outliers.

Sample A - Average Least Dimensions: Z - Score Graph



Sample B - Apparent Particle Density: Z - Scores

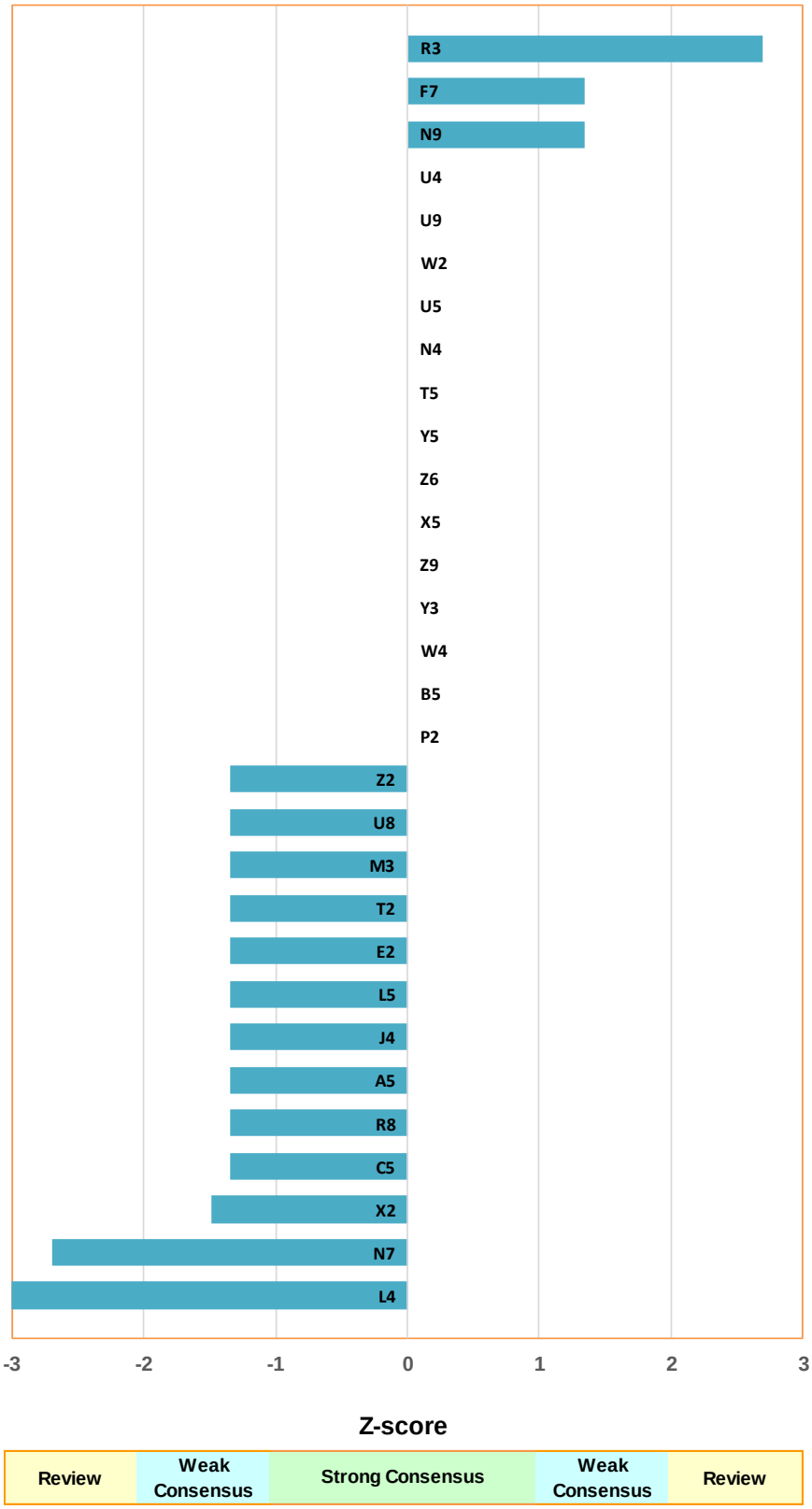
Code	Test Result t/m³	Z Score
U4	2.74	0.00
Z2	2.73	-1.35
U9	2.74	0.00
W2	2.74	0.00
U5	2.74	0.00
B6		
M2	NR	
N4	2.74	0.00
U8	2.73	-1.35
M3	2.73	-1.35
T2	2.73	-1.35
X8	NR	
T5	2.74	0.00
F7	2.75	1.35
J8	NR	
E2	2.73	-1.35
K9	NR	
R9	NR	
Y2	NR	
Q8	NR	
N7	2.72	-2.70
L4	2.46	**-37.77** #
L5	2.73	-1.35
J4	2.73	-1.35
Y5	2.74	0.00
N3	NR	
G7	NR	
C2	NR	

Code	Test Result t/m³	Z Score
A5	2.73	-1.35
Z6	2.74	0.00
X5	2.74	0.00
Z9	2.74	0.00
L9	NR	
A8	NR	
Y3	2.74	0.00
X2	2.7290	-1.48
R3	2.76	2.70
W4	2.74	0.00
Z4		
R8	2.73	-1.35
B5	2.74	0.00
N9	2.75	1.35
C5	2.73	-1.35
K5	NR	
P2	2.74	0.00
G9		
Y6	NR	

Statistic	*Value*	
Number of results	**30**	
Median	**2.740**	
Median MU	**0.002**	
First Quartile	**2.730**	
Third Quartile	**2.740**	
IQR	**0.010**	
Normalised IQR	**0.007**	
CV (%)	**0.3**	
Minimum	**2.72**	(2.46)
Maximum	**2.76**	(2.76)
Range	**0.04**	(0.30)

Note: A # indicates an outlier where the z-score obtained is either greater then 3 or less than -3. Codes for all participates are shown. The results column shows a blank entry or 'NR' for those participants that did not submit a result for this test. Results in **green** have been calculated by the program coordinator. An R indicates an abnormal result rejected by the program coordinator. Minimum, Maximum and Range are calculated with outliers excluded, those in brackets include outliers.

Sample B - Apparent Particle Density: Z - Score Graph



Sample B - Particle Density on Dry Basis: Z - Scores

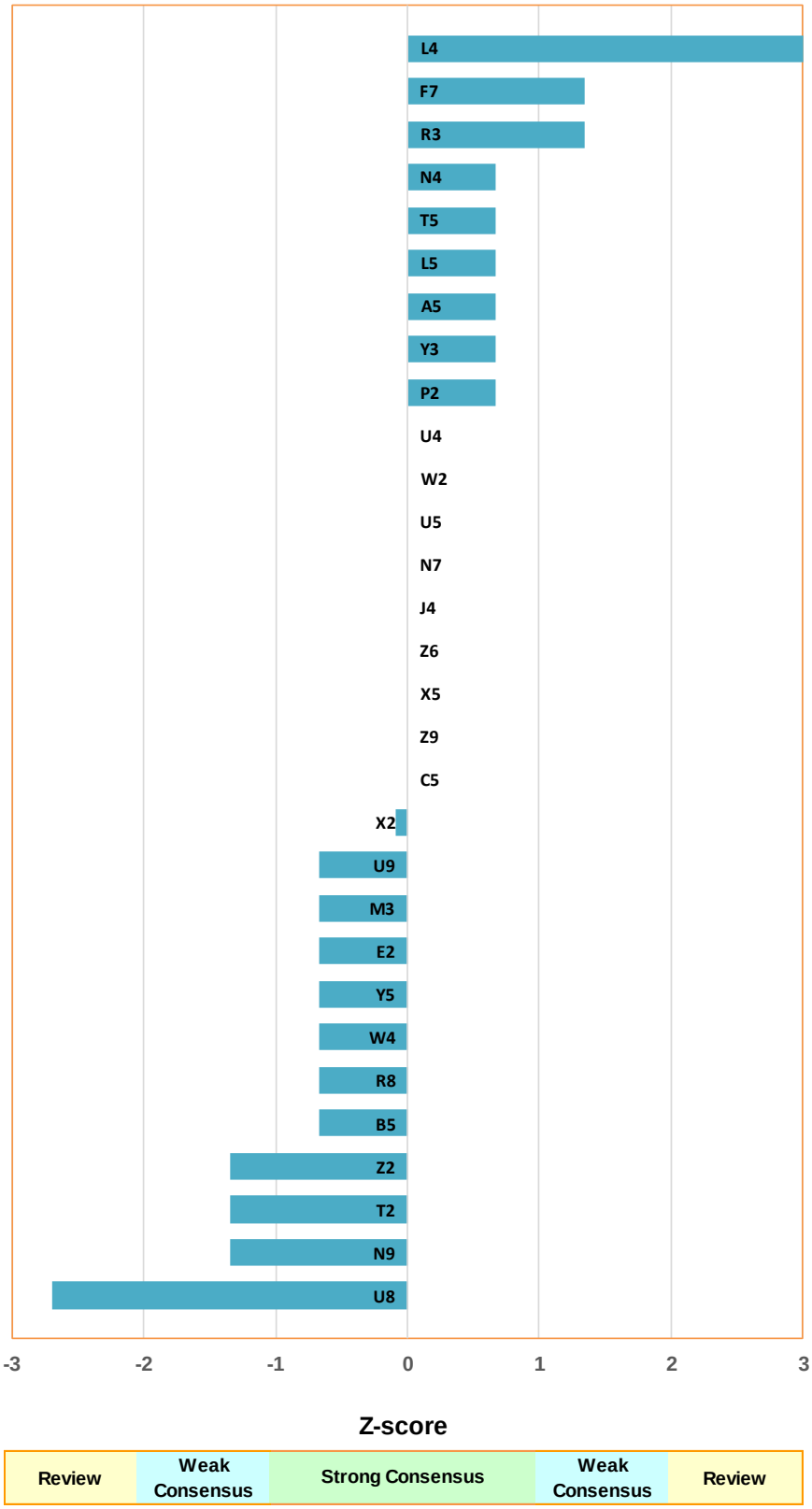
Code	Test Result t/m³	Z Score
U4	2.67	0.00
Z2	2.65	-1.35
U9	2.66	-0.67
W2	2.67	0.00
U5	2.67	0.00
B6		
M2	NR	
N4	2.68	0.67
U8	2.63	-2.70
M3	2.66	-0.67
T2	2.65	-1.35
X8	NR	
T5	2.68	0.67
F7	2.69	1.35
J8	NR	
E2	2.66	-0.67
K9	NR	
R9	NR	
Y2	NR	
Q8	NR	
N7	2.67	0.00
L4	2.85	**12.14** #
L5	2.68	0.67
J4	2.67	0.00
Y5	2.66	-0.67
N3	NR	
G7	NR	
C2	NR	

Code	Test Result t/m³	Z Score
A5	2.68	0.67
Z6	2.67	0.00
X5	2.67	0.00
Z9	2.67	0.00
L9	NR	
A8	NR	
Y3	2.68	0.67
X2	2.6686	-0.09
R3	2.69	1.35
W4	2.66	-0.67
Z4		
R8	2.66	-0.67
B5	2.66	-0.67
N9	2.65	-1.35
C5	2.67	0.00
K5	NR	
P2	2.68	0.67
G9		
Y6	NR	

Statistic	*Value*	
Number of results	**30**	
Median	**2.670**	
Median MU	**0.003**	
First Quartile	**2.660**	
Third Quartile	**2.680**	
IQR	**0.020**	
Normalised IQR	**0.015**	
CV (%)	**0.6**	
Minimum	**2.63**	(2.63)
Maximum	**2.69**	(2.85)
Range	**0.06**	(0.22)

Note: A # indicates an outlier where the z-score obtained is either greater then 3 or less than -3. Codes for all participates are shown. The results column shows a blank entry or 'NR' for those participants that did not submit a result for this test. Results in **green** have been calculated by the program coordinator. An R indicates an abnormal result rejected by the program coordinator. Minimum, Maximum and Range are calculated with outliers excluded, those in brackets include outliers.

Sample B - Particle Density on Dry Basis: Z - Score Graph



Sample B - Particle Density on Saturated - Surface Dry Basis: Z - Scores

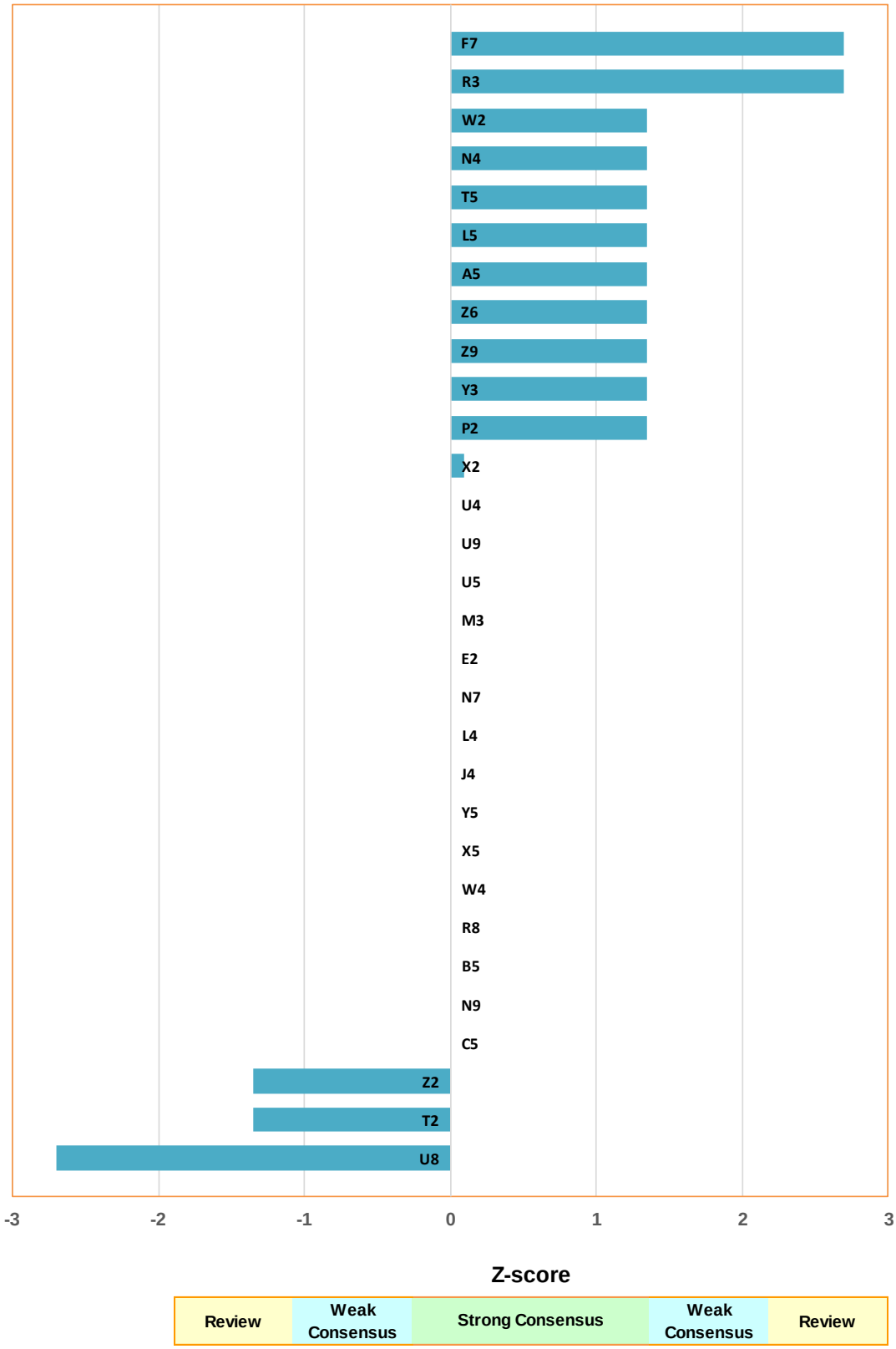
Code	Test Result t/m³	Z Score
U4	2.69	0.00
Z2	2.68	-1.35
U9	2.69	0.00
W2	2.70	1.35
U5	2.69	0.00
B6		
M2	NR	
N4	2.70	1.35
U8	2.67	-2.70
M3	2.69	0.00
T2	2.68	-1.35
X8	NR	
T5	2.70	1.35
F7	2.71	2.70
J8	NR	
E2	2.69	0.00
K9	NR	
R9	NR	
Y2	NR	
Q8	NR	
N7	2.69	0.00
L4	2.69	0.00
L5	2.70	1.35
J4	2.69	0.00
Y5	2.69	0.00
N3	NR	
G7	NR	
C2	NR	

Code	Test Result t/m³	Z Score
A5	2.70	1.35
Z6	2.70	1.35
X5	2.69	0.00
Z9	2.70	1.35
L9	NR	
A8	NR	
Y3	2.70	1.35
X2	2.6907	0.09
R3	2.71	2.70
W4	2.69	0.00
Z4		
R8	2.69	0.00
B5	2.69	0.00
N9	2.69	0.00
C5	2.69	0.00
K5	NR	
P2	2.70	1.35
G9		
Y6	NR	

Statistic	*Value*	
Number of results	**30**	
Median	**2.690**	
Median MU	**0.002**	
First Quartile	**2.690**	
Third Quartile	**2.700**	
IQR	**0.010**	
Normalised IQR	**0.007**	
CV (%)	**0.3**	
Minimum	**2.67**	()
Maximum	**2.71**	()
Range	**0.04**	()

Note: A # indicates an outlier where the z-score obtained is either greater then 3 or less than -3. Codes for all participates are shown. The results column shows a blank entry or 'NR' for those participants that did not submit a result for this test. Results in **green** have been calculated by the program coordinator. An R indicates an abnormal result rejected by the program coordinator. Minimum, Maximum and Range are calculated with outliers excluded, those in brackets include outliers.

Sample B - Particle Density on Saturated - Surface Dry Basis: Z - Score Graph



Sample B - Water Absorption: Z - Scores

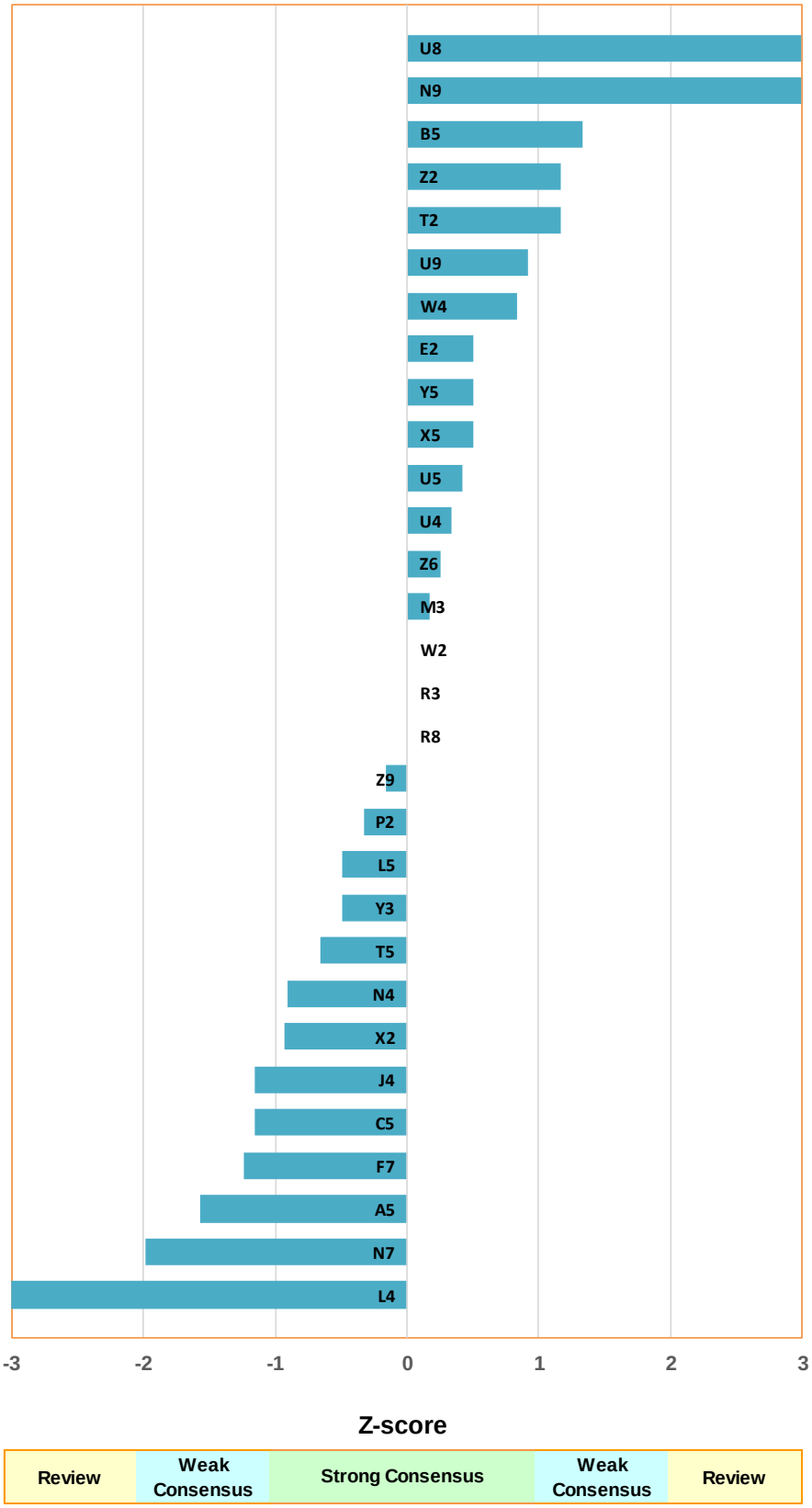
Code	Test Result %	Z Score
U4	0.98	0.33
Z2	1.08	1.16
U9	1.05	0.91
W2	0.94	0.00
U5	0.99	0.42
B6		
M2	NR	
N4	0.83	-0.91
U8	1.30	**2.99**
M3	0.96	0.17
T2	1.08	1.16
X8	NR	
T5	0.86	-0.66
F7	0.79	-1.25
J8	NR	
E2	1.0	0.50
K9	NR	
R9	NR	
Y2	NR	
Q8	NR	
N7	0.7	-1.99
L4	-5.62	**-54.46** #
L5	0.88	-0.50
J4	0.80	-1.16
Y5	1.0	0.50
N3	NR	
G7	NR	
C2	NR	

Code	Test Result %	Z Score
A5	0.75	-1.58
Z6	0.97	0.25
X5	1.0	0.50
Z9	0.92	-0.17
L9	NR	
A8	NR	
Y3	0.88	-0.50
X2	0.8281	-0.93
R3	0.94	0.00
W4	1.04	0.83
Z4		
R8	0.94	0.00
B5	1.1	1.33
N9	1.3	**2.99**
C5	0.8	-1.16
K5	NR	
P2	0.9	-0.33
G9		
Y6	NR	

Statistic	*Value*	
Number of results	**30**	
Median	**0.94**	
Median MU	**0.03**	
First Quartile	**0.84**	
Third Quartile	**1.00**	
IQR	**0.16**	
Normalised IQR	**0.12**	
CV (%)	**12.8**	
Minimum	**0.70**	(-5.62)
Maximum	**1.30**	(1.30)
Range	**0.60**	(6.92)

Note: A # indicates an outlier where the z-score obtained is either greater then 3 or less than -3. Codes for all participates are shown. The results column shows a blank entry or 'NR' for those participants that did not submit a result for this test. Results in **green** have been calculated by the program coordinator. An R indicates an abnormal result rejected by the program coordinator. Minimum, Maximum and Range are calculated with outliers excluded, those in brackets include outliers.

Sample B - Water Absorption: Z - Score Graph



Sample B - Particle Shape 2:1: Z - Scores

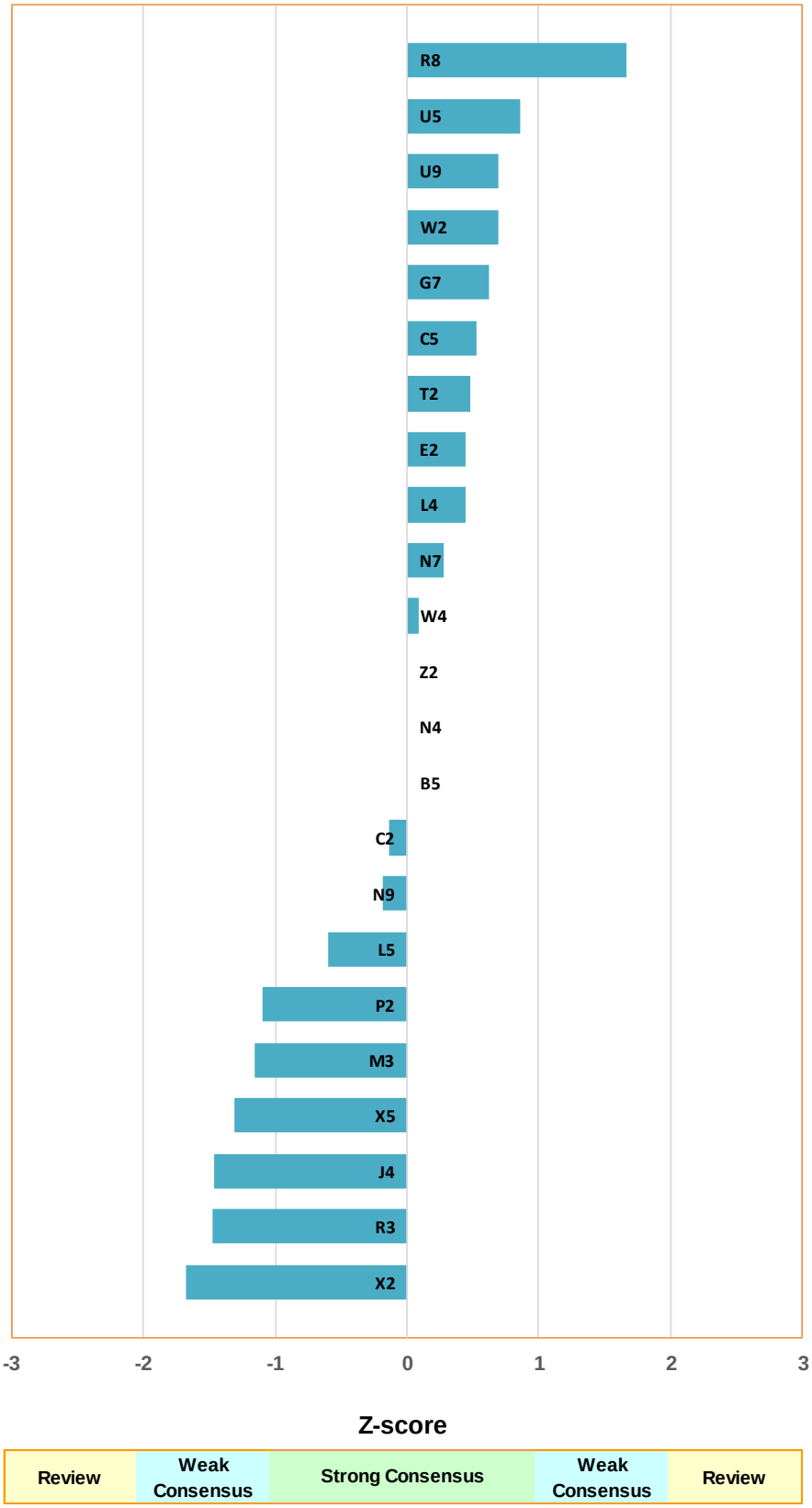
Code	Test Result %	Z Score
U4	NR	
Z2	23.7	0.00
U9	30.4	0.69
W2	30.4	0.69
U5	32.0	0.85
B6		
M2	NR	
N4	23.7	0.00
U8	NR	
M3	12.5	-1.15
T2	28.3	0.47
X8	NR	
T5	NR	
F7	NR	
J8	NR	
E2	28	0.44
K9	NR	
R9	NR	
Y2	NR	
Q8	NR	
N7	26.4	0.28
L4	28	0.44
L5	17.9	-0.60
J4	9.5	-1.46
Y5	NR	
N3	NR	
G7	29.7	0.62
C2	22.4	-0.13

Code	Test Result %	Z Score
A5	NR	
Z6	NR	
X5	11.0	-1.31
Z9	NR	
L9	NR	
A8	NR	
Y3	NR	
X2	7.4	-1.68
R3	9.3	-1.48
W4	24.6	0.09
Z4		
R8	39.9	1.67
B5	23.7	0.00
N9	21.9	-0.19
C5	28.8	0.53
K5	NR	
P2	13.0	-1.10
G9		
Y6	NR	

Statistic	*Value*	
Number of results	**23**	
Median	**23.7**	
Median MU	**2.53**	
First Quartile	**15.5**	
Third Quartile	**28.6**	
IQR	**13.10**	
Normalised IQR	**9.71**	
CV (%)	**41.0**	
Minimum	**7.4**	()
Maximum	**39.9**	()
Range	**32.5**	()

Note: A # indicates an outlier where the z-score obtained is either greater then 3 or less than -3. Codes for all participates are shown. The results column shows a blank entry or 'NR' for those participants that did not submit a result for this test. Results in **green** have been calculated by the program coordinator. An R indicates an abnormal result rejected by the program coordinator. Minimum, Maximum and Range are calculated with outliers excluded, those in brackets include outliers.

Sample B - Particle Shape 2:1: Z - Score Graph



5. Program Information

5.1 Z-score Summary

Initially planned for September, the proficiency program was conducted in September/October 2022.

A 'Z-score Summary' was issued on the 3rd of November 2022 and posted on the LabSmart Services website. The summary was also e-mailed to participants. The summary is intended as an early indicator of participant performance. The proficiency testing program report supersedes the z–score summary. Further information can be found in section 5.9, 'Statistics'.

5.2 Program Design

5.2.1 Design

It is expected that the level of experience/skill needed to perform these tests presents a reasonable assessment of the overall competency of the tester and industry performance.

Part of each program's design involves determining what information needs to be requested to allow for the correct analysis of the data collected. This allows the best possible feedback to be offered to enable participants to improve their performance in this test. The 'retained weights' for PSD are used for this purpose.

In designing a proficiency program, minimizing the effect of some inherent test method variability is sometimes necessary. Other considerations involving the design of the program are detailed below.

5.2.2 Selection of material used in the program

Materials are selected to mirror the range of materials encountered in practice.

Participants who work in a quarry may find that the material supplied is different from what they usually test. The test method does not stipulate a particular 'quality of material' to be used for testing purposes, so all testers need to be able to test a range of aggregate materials accurately.

The material supplied for Sample A was made up of known fractions. The fractions were as large as possible to ensure any breakdown of the material was small compared to the retained mass. In addition, as all participants received the same proportion of material, any breakdown of material (that could occur) while under testing would be similar across all participants. See sample preparation for more details.

Participants were instructed to use the whole sample for PSD (produced to be the same size for each participant), which mitigated the effect different sample sizes can have on the particle distribution results. Unaccounted material losses or gains (lost material, binding, material breakdown, etc.) have a more significant effect the smaller the sample size.

Two samples (A & B) were used. Each sample was prepared to be of different sizes so that if the samples were mixed up by a participant, the samples could be readily identified. See sample preparation for more detail.

5.2.3 Role of proficiency testing

The determination of outliers is an essential task of this proficiency program. A secondary function is to provide feedback that can help those with outliers identify possible areas to investigate, as well as assist all participants in improving.

In addition to the statistics, proficiency programs often obtain other information not commonly available in a final report (Equipment Used, Data used to calculate the final outcome, etc.). This additional information allows for a better understanding of the testing and can provide information that can lead to improvements in the testing process or test method.

Proficiency testing enables participants to measure competency against others. It is also a measure of staff performance and the equipment used. Apart from 'measurement uncertainty', it is the most useful tool a laboratory has in better understanding the performance of a test.

5.2.4 Participant assessment

The assessment of each participant is based on a z-score; the z-score is related to the program consensus value (median). It is this z-score that is used to determine any statistical outliers.

In addition, compliance with proficiency program requirements which include the correct calculation of results and adherence to the program and test method requirements. These may also be used as part of the assessment process.

Finally, Participants may also be asked to **Investigate**/**review** any discrepancies detected with the paperwork submitted.

5.2.5 Reporting of results - Significant figures

The number of decimal places (significant figures) reported for a test has a bearing on the statistical analysis and, therefore, the interpretation of the results. There is a need to strike a balance between what is desirable from a statistical viewpoint while recognizing how the results are used in practice.

Too few decimal places (e.g. due to rounding) can cause an increase in the observed spread of results. Increasing the number of decimal places (with respect to normal reporting) can distort the observed spread of results compared to that encountered in actual practice. Large numbers of similar, rounded results can also cause a distortion in the analysis.

For example, rounding to 0.5 % means that any number between 10.75 and 11.25 will be 11.0%. If the largest value is 10.75 in a set of results, it is pushed out to 11.0 through rounding. Rounded results are useful from "an end-user" perspective but are not as useful when considering laboratory performance. The test method acknowledges additional decimal places may be used for statistical purposes.

For this program, it was decided that the benefits of using additional decimal places would complement the aim of the proficiency program.

Participants results were analyzed as received regardless of whether there were 'more or less' significant figures than the number requested by the program.

5.2.6 Additional information requested

This program requested additional information as detailed in Appendix C not usually reported. The additional information is, however, strongly related to the performance of the test. The additional information is used to interpret the participant's performance and assist with providing technical comment, including feedback on outliers and possible participant improvement.

5.2.7 PSD data checks

A secondary function of proficiency testing is to provide feedback that can help those with outliers identify possible areas to investigate as well as assist all participants in improving. This information also helps with identifying any random or systematic errors associated with the test methodology.

Every participant's PSD results are recalculated. Checks, however, are only as accurate as the raw data supplied by each participant. These checks also help ensure that the data is comparable.

Any inconsistencies identified during this process do not need to be investigated but are identified as possible feedback for participant improvement.

5.2.8 Role of % Retained

The sieving component of this proficiency program is based on '% Passing' results as normally reported by laboratories. The '% Passing' involves a cumulative calculation which can at times give rise to misleading outliers, particularly on smaller aperture sieves. In such cases, an outlier may not necessarily be attributed to the sieve size on which the outlier occurred. Participants need to be aware of this should they need to undertake any investigation.

To provide feedback, '% Retained' is normally either requested or calculated for each participant (Appendix C). Increasing the number of significant numbers that results are reported also aids accurate analysis and feedback.

It should be noted that if the mass retained results submitted are themselves not correct, then this will show as z-scores greater than 3. This may be the case even if no outlier was obtained for the % passing results. To perform a comparison, there needs to be a 'one for one' % passing correspondence to the % retained for the analysis to be statistically valid. That is, the accuracy of the analysis is dependent on most participants supplying mass retained results.

5.2.9 Confidentiality

All information, including test results, are treated confidentially. The proficiency testing report does not identify either companies or individuals. Each participant is issued a unique identifying code during enrolment that is used in the report to ensure confidentiality of performance.

5.3 Sample Preparation

Two samples were prepared (A & B). Sample A consisted of an approximately 1.5 kg Sample, while sample B was prepared to have a minimum of 2.8 kg of aggregate.

For Sample A, an unwashed bulk sample was obtained and sieved into its constituent fractions. Each fraction was then thoroughly mixed, then recombined to produce a predetermined PSD. Sample B was prepared similarly from a bulk sample, however, sieving was only undertaken to remove undesirable particles (It had different fractions to that of sample A).

For both samples A & B, 100 samples were prepared. Samples were numbered and laid out in the order prepared. There were 10 samples selected at equal intervals from each set (A & B). These were used for homogeneity testing. Each participant received randomly drawn samples from the remaining A and B samples. Each sample set was assigned a unique participation code (combined A and B samples).

5.4 Packaging and Instructions

Each sample was sealed in a plastic bag, labelled with the program name and whether sample A or B. Samples were packed into a sturdy box. Participants were instructed to test according to the nominated test method and report the accuracy indicated on the 'results log' sheet. See Appendix A for a copy of the instructions issued to participants and Appendix B for the log sheet used. A set of instructions and log sheet were placed in the box prior to sealing and dispatch.

5.5 Quarantine

In order to meet the different requirements across Australia, LabSmart Services undertook heat treatment of both samples A & B. Additional information regarding handling and preparation of the sample may be included where necessary.

5.6 Sample Dispatch

Samples were dispatched to participants on the 11th of October 2022 using Pack and Send. Dispatched samples are tracked from dispatch to delivery for each participant by LabSmart Services.

5.7 Homogeneity Testing

Samples for homogeneity testing were packed in the same way as those for participants. There were 10 samples selected at equal intervals throughout the set of samples. The same instructions were given to the laboratory performing the homogeneity testing. Analysis of the homogeneity testing results indicated that the variability associated with the proficiency samples was acceptable (Table 10). The homogeneity assessment provides confidence that any outliers identified in the program represent statistically valid outliers.

Table 10: Homogeneity Results for Sample A & B

Sample A

Test		Results										Average	Minimum	Maximum	Range	s.d
Particle Size Distribution (% Passing)	Units	H1	H2	H3	H4	H5	H6	H7	H8	H9	H10					
13.2 mm	%	64.2	65.5	66.3	65.6	64.3	65.7	64.0	65.6	64.5	64.8	65.02	64.00	66.3	2.3	0.78
9.5 mm	%	40.7	41.1	41.1	41.0	41.2	40.8	40.6	40.9	40.9	40.9	40.91	40.64	41.2	0.6	0.18
6.7 mm	%	22.6	23.2	22.6	22.7	22.8	22.7	22.7	22.9	22.6	23.0	22.78	22.60	23.2	0.6	0.20
4.75 mm	%	9.8	10.6	9.9	10.0	9.9	10.0	9.8	10.0	9.9	10.0	9.99	9.81	10.63	0.8	0.23
Material finer than 75 um (By Washing)	%	6.14	6.19	6.18	6.10	6.07	6.06	6.01	6.20	5.88	6.11	6.09	5.88	6.20	0.32	0.10
Flakiness index	%	14.7	14.3	15.4	13.5	13.2	12.5	14.0	15.0	12.2	12.4	13.7	12.2	15.4	3.2	1.14
Average Least Dimension - 20.1	mm	5.3	5.1	5.5	5.4	5.5	5.4	5.6	5.3	5.7	5.6	5.4	5.1	5.7	0.6	0.18
Average Least Dimension - 20.3	mm	8.5	8.5	8.4	8.6	8.7	8.6	8.6	8.4	8.8	8.8	8.6	8.4	8.8	0.4	0.14

Sample B

Test		Results										Average	Minimum	Maximum	Range	s.d
	Units	H1	H2	H3	H4	H5	H6	H7	H8	H9	H10					
Apparent particle density	t/m^3	2.743	2.723	2.730	2.733	2.738	2.734	2.733	2.733	2.731	2.733	2.733	2.723	2.738	0.015	0.005
Particle density - dry basis	t/m^3	2.684	2.663	2.671	2.673	2.677	2.672	2.672	2.669	2.671	2.672	2.672	2.663	2.677	0.014	0.005
Particle density - saturated-surface dry	t/m^3	2.706	2.685	2.693	2.695	2.699	2.695	2.694	2.692	2.693	2.694	2.695	2.685	2.699	0.014	0.005
Water Absorption	%	0.81	0.83	0.81	0.82	0.83	0.84	0.84	0.88	0.83	0.83	0.83	0.81	0.88	0.07	0.02
Proportional Caliper 2:1	%	37.8	27.8	30.5	29.6	27.5	35.7	27.8	26.3	32.8	32.5	30.8	26.3	35.7	9.4	3.8

R - Result removed as outlier by program coordinator

5.8 Participation

There were 47 participants that entered the program. The nominated date for participants to return their results was 7th October 2022. Of the 47 participants, only 44 participants were able to return their results in time to be included in the main report.

5.9 Statistics

Z-Scores were calculated for each test and used to assess the variability of each participant relative to the consensus median. A corresponding z-score graph was produced for each test.

The use of median and quartiles reduces the effect that outliers have on the statistics and other influences. Therefore, z-scores provide a more realistic or robust method of assessment.

Some results were reported by participants to more decimal places than requested as part of the proficiency program and by others too few decimal places. In all instances, test results have been used as submitted by participants.

Assessment of participant's data is undertaken to ensure results are statistically comparable. Checks are undertaken to ensure the results calculated matches that reported by the participant and that the appropriate corrections etc. have been applied if required. The level of checking required varies from program to program. If significant inconsistencies are identified, the results may be removed or amended with the discrepancy highlighted.

A z-score is one way of measuring the degree of consensus with respect to the grouped test results. The z-scores in this report approximate standard deviation. For each test, a z-score graph is shown. Use the graph to visually check statistically how you compare to other participants.

The following bar (Figure 1) is shown at the bottom of each graph. This helps to quickly visualize where each participant's result falls

Review	Weak Consensus	Strong Consensus	Weak Consensus	Review

Figure 1: Z-score interpretation bar

For example:

- A **strong consensus** (i.e. agreement) means that your test result is close i.e. within 1 standard deviation of the median.

- A **weak consensus** means that your test result is satisfactory and is within 2 standard deviations of the median.

- If you have obtained a test result that is outside 2 standard deviations, then it may be worth **reviewing** your testing processes to ensure that all aspects are satisfactory. Only those obtaining a z-score approaching 3 (I.e. outside 2.75 range) have been highlighted in the report for review.

If you have obtained a test result that is outside 3 standard deviations, then you will need to investigate your testing processes to ensure that all aspects are satisfactory. Participant assessment is not based purely on statistical analysis. Compliance to proficiency program requirements, including the correct calculation of results and adherence to program requirements may also be used as part of the assessment process. Participants may also be asked to investigate any discrepancies detected with the paperwork submitted.

For further details on the statistics used in this proficiency, program can be obtained from LabSmart Services or download the 'Participant Guide' from the LabSmart Services website.

5.9.1 Z-score summary

A "Z-Scores Summary" is issued soon after most results are received. It gives participants early feedback as to any program outliers. The summary is available on the LabSmart Services website up until the final report is issued. The final report supersedes the z-score summary.

The final report contains detailed technical feedback regarding the performance of tests and revised z-scores. The inclusion of late results or corrections is at the discretion of the program coordinator. In some instances, this may change some of the z-scores slightly, but generally, the performance outcome remains the same. If there is any impact, it will be discussed within section 5.1 of the report.

5.9.2 Comparing statistics from one program to another

The statistics generated from one proficiency program are not usually comparable to those from another proficiency testing program. Only very general comparisons may be possible. The reason statistics from one program may not be compared to another is due to the range of variables that differ from one proficiency program to another.

These variables include:

- Type of material selected
- The number of participants
- Experience of participants
- Test methodology variations
- Equipment used
- Test methods used
- Experience of supervisors
- Range of organizations involved
- Program design and the statistics employed

The program outcome represents a 'snapshot' of the competency within the industry and hence provides an overview of the industry. The more participants involved in the program, then the more representative the overview.

5.9.3 Measurement uncertainty

The statistics detailed in this program do not replace laboratories' need to separately calculate measurement uncertainties (MU) associated with each test when required by the client or NATA. The proficiency program does give information useful for calculating the MU and benchmarking the MU calculated.

5.9.4 Metrological traceability

The assigned median value used in this proficiency testing program is derived from participant performance and is not metrologically traceable.

5.10 Non-statistical Matters

One of the issues faced by proficiency testing providers is what to do with an incorrect result even if its z-score is satisfactory. In many cases, they cannot be detected but still can have a significant impact on the statistics calculated. This can cause biased (or unfair) outcomes for other participants.

To limit the effect that erroneous results may have on a program, additional information is requested to allow the main results to be recalculated. In some cases, results shown to be erroneous may be rejected for inclusion in the program. If the result does not add any statistical bias it is left in the program.

The result, however, is incorrect even though it may have a satisfactory z-score. To highlight that the participant needs to investigate erroneous results, it is considered a 'non-statistical' matter.

This may also be applied to non-compliance to program requirements, e.g. incorrect reporting of results etc., or incorrect partial calculations/data.

Non-statistical matters were not used as part of the assessment process for this program.

Appendix A: Instructions for testers

LabSmart Services
Helping laboratories to work smarter!

Proficiency Testing Program

Aggregates – 2022 (110)

INSTRUCTIONS FOR TESTER

1. Please check that the package you have received contains:

   - Results log sheet.
   - Plastic sample bag marked Sample A – approximately 1.5 kg
   - Plastic sample bag marked Sample B – approximately 2.8 kg

   Contact LabSmart Services (0439 208 406) if material has escaped from the bags or any item is missing.

   Please do NOT mix sample A and B as they are **different aggregate samples**.
   Please make sure to recover all of the material for sample A from sample bags.

2. Read all the instructions and examine the results log sheet prior to testing. Follow these instructions carefully during testing.

3. Use AS 1141 test methods unless you are unable to do so. Complete those tests that you can perform. You may perform a test even if you are not NATA accredited for the test.

4. **Sample A (1.5 kg)**

   - Use all of Sample A. It has been specially prepared for this proficiency program to ensure consistency and is smaller than normally expected for this size aggregate.
   - Oven dry and wash the sample to perform the "Material finer than 75 micron" test. Oven dry and perform the PSD test.
   - Record the diameter of the sieve set used and the method of drying.
   - Do not lose any of the sample from the PSD test. Keep the fractions obtained separated.
   - From the PSD test use the information gained and the fractions to perform the Flakiness Index determination. Save the material tested.
   - Do not lose any of the sample.
   - Next perform the ALD using the saved material.
   - Circle on the results log whether a slotted gauge or vernier calliper etc was used for the average least dimensions test.

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5. Sample B (2.8 kg)

- Perform the density and absorption tests plus particle shape on sample B.
- Separate over a 4.75 mm sieve. Retain all material.
- Wash the sample to remove loose particles and dust coatings.
- Testing of the fine aggregate to AS 1141.5 is not required.
- Perform the density and absorption tests.
- Save all the 2.8 kg sample and oven dry.
- Perform the 'Particle shape by proportional calliper' for the **2:1 ratio only**.
- For 'Particle shape by proportional calliper', early testing indicated that the sample will have around 10% retained on -19.0 to +13.2. however there will not be 100 particles, disregard this portion and only test the -13.2 to +9.5 fraction.

6. Record all information and calculations as per the proficiency testing results log sheet and **to the accuracy shown on the results log sheet.** In many cases a greater reporting accuracy is required compared to that nominated by the test method standard.

7. The Laboratory Manager or person responsible for checking should sign the log sheet to indicate that it has been checked.

8. If more than one technician is involved in the testing, then please ensure that the laboratory's records indicate which technician did each test.

9. It is recommended that the entire sample following testing be retained until the proficiency testing technical report for this program has been issued.

10. Have a query? Contact LabSmart Service on 0439 208 406.

11. **Please e-mail the "Results Log" to LabSmart Services by 7/10/2022**

☞ E-mail: **info@labsmartservices.com.au**

12. Please retain the completed "Results Log" as this contains your participation code that will identify your results in the technical report. It is also recommended that a copy of completed worksheets be kept with the results log in your proficiency file.

13. Proficiency testing can also form part of a laboratories training records for the technician who performed the test.

NATA

Thank you for participating in this proficiency testing program.

Appendix B: Results Log

LabSmart Services
Helping laboratories to work smarter!

Aggregates Proficiency Testing Program – 2022 (110)

RESULTS LOG **Laboratory: xxxxxxxxxxx** **Participation Code: xxxx**

F Please e-mail (info@labsmartservices.com.au) the completed results log by

7th October 2022

Date proficiency sample received:						
Condition of samples:	**A**			**B**		
Sample A – Tests	**Report to:**				**Method** AS 1141	**Method** Tick or enter method used
Particle Size Distribution, Initial Dry Mass (g)	Nearest 0.1*				11.1	
Dry mass after washing [Washed mass] (g)						
Additional 'Mass Retained' column available to record split masses →→→		**Mass Retained 1** (per sieve, g)	**Mass Retained 2** (per sieve, g)	**% Passing**		
19.0 mm						
13.2 mm						
9.5 mm						
6.7 mm						
4.75 mm						
Pan						
Diameter of sieves used (mm)						
Materials finer than 75 µm (by washing)	Nearest 0.01 % *				11.1,12	
Method of drying						
Flakiness index (FI)	Nearest 0.1 %				15	
Mass of sample used	Nearest 1 g					
Method of drying						
Average least dimension (ALD) – Slotted Gauge OR	Nearest 0.1 mm				20.1	
Average least dimension (ALD) – Flatbed Tray Gauge OR						
Average least dimension (ALD) – Vernier Calliper/ Dial Gauge						

*Only if balance has appropriate accuracy

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Aggregates Proficiency Testing Program – 2022 (110)

Sample B – Tests	Report to:	Result	Method	
			AS 1141	Tick or enter method used
Apparent particle density	Nearest **0.01** t/m^3		**6.1**	
Particle density on a dry basis	Nearest **0.01** t/m^3			
Particle density on a saturated-surface-dry basis	Nearest **0.01** t/m^3			
Water absorption	Nearest **0.01 %**			
Particle shape by proportional calliper **(2:1)**	Nearest **0.1 %**		**14**	
Size Fractions Used for Particle shape by proportional calliper (see Instructions)	mm			
Tested by:				

*Only if balance has appropriate accuracy

COMMENTS: ……

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Supervisor Name *(Please Print)* **Signature** **Date**

In signing the above, I acknowledge that the above results have been approved and have been checked. I will also ensure that the results are kept confidential both internal and external to the laboratory until the issue of the final technical report covering this proficiency program.

Thank you for participating. Please retain these sheets for your records.

Have a query? Contact LabSmart Services. Phone: 0439 208 406.

Appendix C: % Retained

Appendix C - % Retained

	Code	13.2 mm		9.5 mm		6.7 mm		4.75 mm	
		% Retained	Z Score	% Retained	Z Score	% Retained	Z Score	% Retained	Z Score
1	U4	35.3	-0.09	24.3	0.53	18.0	-0.72	12.6	-0.71
2	Z2	35.0	-0.25	24.4	0.65	18.1	-0.41	12.8	0.37
3	U9								
4	W2	37.0	0.93	22.0	-1.00	18.2	-0.22	12.7	0.00
5	U5	35.4	0.00	23.6	0.06	18.3	0.10	12.7	-0.13
6	B6								
7	M2	36.1	0.38	**23.2**	**-0.21**	18.4	0.20	12.7	-0.15
8	N4	37.0	0.95	22.6	-0.59	17.8	-1.25	12.9	0.86
9	U8	35.7	0.15	23.5	0.00	18.5	0.70	12.6	-0.60
10	M3	35.9	0.25	23.1	-0.24	18.6	0.72	12.6	-0.40
11	T2	29.3	-3.71 #	28.2	3.15 #	20.0	4.32 #	12.3	-2.14
12	X8	34.8	-0.41	24.6	0.73	18.0	-0.63	12.5	-0.97
13	T5	33.3	-1.31	25.7	1.50	18.3	0.13	12.9	0.98
14	F7	33.2	-1.37	25.8	1.55	18.3	0.00	12.8	0.56
15	J8	35.1	-0.21	22.7	-0.50	18.6	0.70	12.9	0.85
16	E2	35.0	-0.27	23.6	0.09	18.8	1.45	12.5	-1.36
17	K9	34.1	-0.79	25.0	1.01	18.3	0.06	12.9	1.05
18	R9	35.8	0.21	23.8	0.22	17.9	-0.87	12.7	0.17
19	Y2	**35.1**	**-0.21**	23.8	0.21	18.7	0.98	12.8	0.60
20	Q8	33.3	-1.28	24.3	0.52	18.2	-0.27	13.3	3.19 #
21	N7								
22	L4	37.4	1.16	22.4	-0.73	17.8	-1.20	12.8	0.41
23	L5	35.2	-0.17	23.9	0.32	18.4	0.40	12.7	-0.09
24	J4								
25	Y5								
26	N3	35.7	0.16	21.0	-1.66	18.6	0.76	12.9	1.27
27	G7	37.9	1.46	21.0	-1.68	18.7	1.19	12.6	-0.69
28	C2	34.2	-0.74	24.8	0.90	18.2	-0.06	12.7	0.20
29	A5	35.2	-0.16	23.9	0.28	17.8	-1.09	12.9	1.26
30	Z6	36.1	0.40	22.3	-0.77	19.0	1.84	12.6	-0.79
31	X5	34.8	-0.42	24.3	0.57	18.2	-0.30	12.9	0.86
32	Z9	37.2	1.09	22.2	-0.83	18.0	-0.58	12.8	0.60
33	L9	37.4	1.15	20.2	-2.24	18.9	1.67	12.5	-0.91
34	A8	36.6	0.72	22.0	-1.01	18.1	-0.35	**12.6**	**-0.71**
35	Y3								
36	X2	33.8	-1.01	25.2	1.17	18.3	0.19	12.5	-0.94
37	R3	38.0	1.55	21.9	-1.08	17.5	-1.85	12.6	-0.76
38	W4	33.9	-0.91	25.2	1.18	18.2	-0.24	12.8	0.46
39	Z4								
40	R8	40.6	3.09 #	19.0	-3.04 #	17.9	-1.02	12.1	-3.64 #
41	B5	35.4	-0.03	23.3	-0.10	18.4	0.44	12.8	0.30
42	N9	33.8	-0.98	24.2	0.49	18.8	1.42	12.3	-2.10
43	C5	38.2	1.64	21.2	-1.56	18.0	-0.66	12.8	0.48
44	K5	37.0	0.94	22.6	-0.60	17.7	-1.37	12.8	0.35
45	P2	35.7	0.17	23.4	-0.08	18.5	0.56	12.5	-1.17
46	G9								
47	Y6	38.7	1.96	21.7	-1.20	17.3	-2.44	12.5	-1.17

Statistic	*13.2 mm*	*9.5 mm*	*6.7 mm*	*4.75 mm*
Number of results	**39**	**39**	**39**	**39**
Median	**35.4**	**23.5**	**18.3**	**12.7**
First Quartile	**34.8**	**22.3**	**18.0**	**12.6**
Third Quartile	**37.0**	**24.3**	**18.5**	**12.8**
IQR	**2.2**	**2.0**	**0.5**	**0.2**
Normalised IQR	**1.7**	**1.5**	**0.4**	**0.2**
CV (%)	**4.7**	**6.3**	**2.2**	**1.4**
Minimum	**0.0**	**0.0**	**0.0**	**0.0**
Maximum	**38.2**	**25.8**	**19.0**	**12.9**
Range	**38.2**	**25.8**	**19.0**	**12.9**

Note: "% retained" results have been calculated by the program coordinator based on submitted mass retained results. A # indicates where the z-score calculated is either greater then 3 or less than -3. ***Values above 3 are not outliers and do not need to be investigated but help identify sieves that have amounts retained that differ significantly from others in the program.*** This assists those with outliers from the "% Passing" to identify sieves that may have contributed to the outlier. Codes for all participates are shown. Codes shown in orange denote participants that did not supply sufficient data for the '% Retained ' to be calculated or participants that did not submit any results for this test. Minimum, Maximum and Range are calculated with **values greater than 3 or -3 excluded.**