Memorandum

To	Julian Reweti
Copy	
From	James Gladwin
Office	Whakatane Office
Date	16 May 2017
File	2-34250.11
Subject	Edgecumbe Urgent Sediment Sampling

Introduction

Opus International Consultants were engaged on 01 May 2017 to complete some urgent sediment sampling in the Edgecumbe Township following a breach of the stopbank on 06 April 2017. There were concerns that heavy metals may be a contaminant of concern from the sewer system and the oxidation ponds that overflowed during the storm event.

At the same time Opus were asked to check for and test any sediment deposits around the old sawmill based on Kowhai Avenue because of the perceived potential for Copper, Chromium and Arsenic contamination from the CCA treatment that has occurred onsite.

Site Visit

A site visit was completed on 01 May 2015 and the area surrounding the Kowhai Avenue Sawmill site was inspected first. No observable sediment deposits were found. A nearby low basin was also checked and this was also found to be clear of silt. No samples were taken from either of these locations.

Focus then moved onto the northern part of Edgecumbe as shown by the attached monitoring plan and site photos. Here, silt was found stockpiled on the side of the road as part of the ongoing clean-up process. Table 1 shows the description of photos taken of the sampling points and surrounding areas. Site photos have been appended to this memo.

Table 1 - Site photograph descriptions

Photo	Description
1	Kowhai Ave, looking south towards the wastewater pumpstation
2	Kowhai Ave, looking north from the wastewater pumpstation
3	Low land reserve between Totara St and Rimu St.
4	Sediment stockpile, Sample Point 1
5	Sediment stockpile, Sample Point 2
6	Sediment stockpile, Sample Point 3
7	Sediment stockpile, Sample Point 4
8	Sediment stockpile, Sample Point 5
9	Washed under fence, Sample Point 6
10	Sediment discharge onto school field, Sample Point 7
11	Panoramic of the school field
12	Grass die off on school field as a result of prolonged water submersion

13	Grass die off on school field as a result of prolonged water submersion
14	Cricket crease
15	Edge of cricket crease, Sample Point 8
16	Sediment on edge of Edgecumbe College tennis courts, Sample Point 9
17	Close up following sampling of sample point 9 showing dark sub layer
18	Sediment stockpile, Sample Point 10

Sampling and Analysis Plan and Field Quality Assurance Quality Control (QA/QC)

Opus were contracted to sample the sediments around Edgecumbe and have them analysed for metals. The attached sample plan shows where the sediments were sampled.

Sediments samples were taken on 01 May and sent to Hill laboratories for analysis of metals. Weather conditions were fine with periods of cloud. All samples were taken from a depth of 0 to 15cm using a stainless steel trowel. Decontamination of equipment was completed between each sample locations using clean water. Disposable nitrile gloves were worn whilst completing the sampling and changed between sample locations. All samples were sent to Hill laboratories for metals analysis. No blind replicas were completed for the sampling. A chain of custody (COC) form from Hill Laboratories has been provided.

Laboratory QA/QC

The Hill Laboratory Analysis report has been appended for perusal. This includes the analytical methods used by the laboratory and the laboratory accreditation for analytical methods used.

All Laboratory Analysis was completed through Hill Laboratories. Hill Laboratories are accredited by International Accreditation New Zealand (IANZ), which represents New Zealand in the International Laboratory Accreditation Cooperation (ILAC). Through the ILAC Mutual Recognition Arrangement (ILAC-MRA) this accreditation is internationally recognised.

Basis for Guideline Values

Soil Contaminant Standards (SCSs) were selected from the Ministry for the Environment's "Contaminated Land Management Guidelines – Methodology for Deriving Standards for Contaminants in Soil to Protect Human Health" and the "User's Guide – National Environmental Standard for Assessing and Managing Contaminants in Soil to Protect Human Health".

The "Rural residential/ Lifestyle block 25% produce" values found in "Table B2 – Soil Contaminant Standards for health (SCS (health)) for inorganic substances" has been provided in Table 2. These SCSs are the most conservative listed and have been selected on the basis that residents, kindergarten and primary school children are receptors at risk.

Table 2 – "Soil Contaminant Standards for health (SCS (health)) for inorganic substances".

	Arsenic	Boron	Cadmium (pH 5)[1]	Chromium		Copper	Inorganic lead	Inorganic mercury
				III	VI			
	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
Rural residential / lifestyle block 25% produce	17	>10,000	0.8	>10,000	290	>10,000	160	200
Residential 10% produce	20	>10,000	3	>10,000	460	>10,000	210	310
High-density residential	45	>10,000	230	>10,000	1,500	>10,000	500	1,000
Recreation	80	>10,000	400	>10,000	2,700	>10,000	880	1,800
Commercial / industrial outdoor worker (unpaved)	70	>10,000	1,300	>10,000	6,300	>10,000	3,300	4,200

New Zealand does not have soil contaminant standards specific to Nickel and Zinc.

"For contaminants that are not priority contaminants and/or for land uses that fall outside the five standard land-use exposure scenarios, the NES mandates the approach to be taken to select the applicable standard for the soil. In this case, either a site-specific soil guideline value can be derived (in accordance with the Methodology), or a guideline value can be chosen from national and international literature in accordance with the following document:

Contaminated Land Management Guidelines No. 2 – Hierarchy and Application in New Zealand of Environmental Guideline Values (Revised 2011) (referred to in the Users' Guide as CLMG No.2)"

The CLMG2 states that "The principles and basis for a hierarchy of environmental guideline values as contained in reference documents, including those documents most commonly used by contaminated site practitioners in New Zealand, is described and the hierarchy established. This hierarchy determines the order in which guideline values contained in those reference documents should be used in a contaminated site assessment. The hierarchy is:

1. *New Zealand documents that derive risk-based guideline values*
2. *rest-of-the-world documents that derive risk-based guideline values*
3. *New Zealand documents that derive threshold values*
4. *rest-of-the-world documents that derive threshold values."*

On this basis the SCS have been taken from the Canadian risk based guideline values for residential land and are 50 mg/kg and 200 mg/kg respectively.

The Bay of Plenty Regional Council (BOPRC) have released the Interim Environmental Health Soil Contaminant Standards for the Bay of Plenty Region which are outlined in Table 3.

Table 3 : BOPRC Interim Environmental Health Soil Contaminant Standards

	Arsenic	Boron	Cadmium (pH 5)	Chromium	Copper	Inorganic Lead	Inorganic mercury	Nickel	Zinc
	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
Environmental	100	-	7.5	400	325	250	0.75	105	400

Summary of Analytical Results

A complete record of laboratory analytical results and statistical summary completed using ProUCL has been attached.

A summary of the analytical results with SCS for human health and the environment is provided in Table 4. No identified SCS were exceeded.

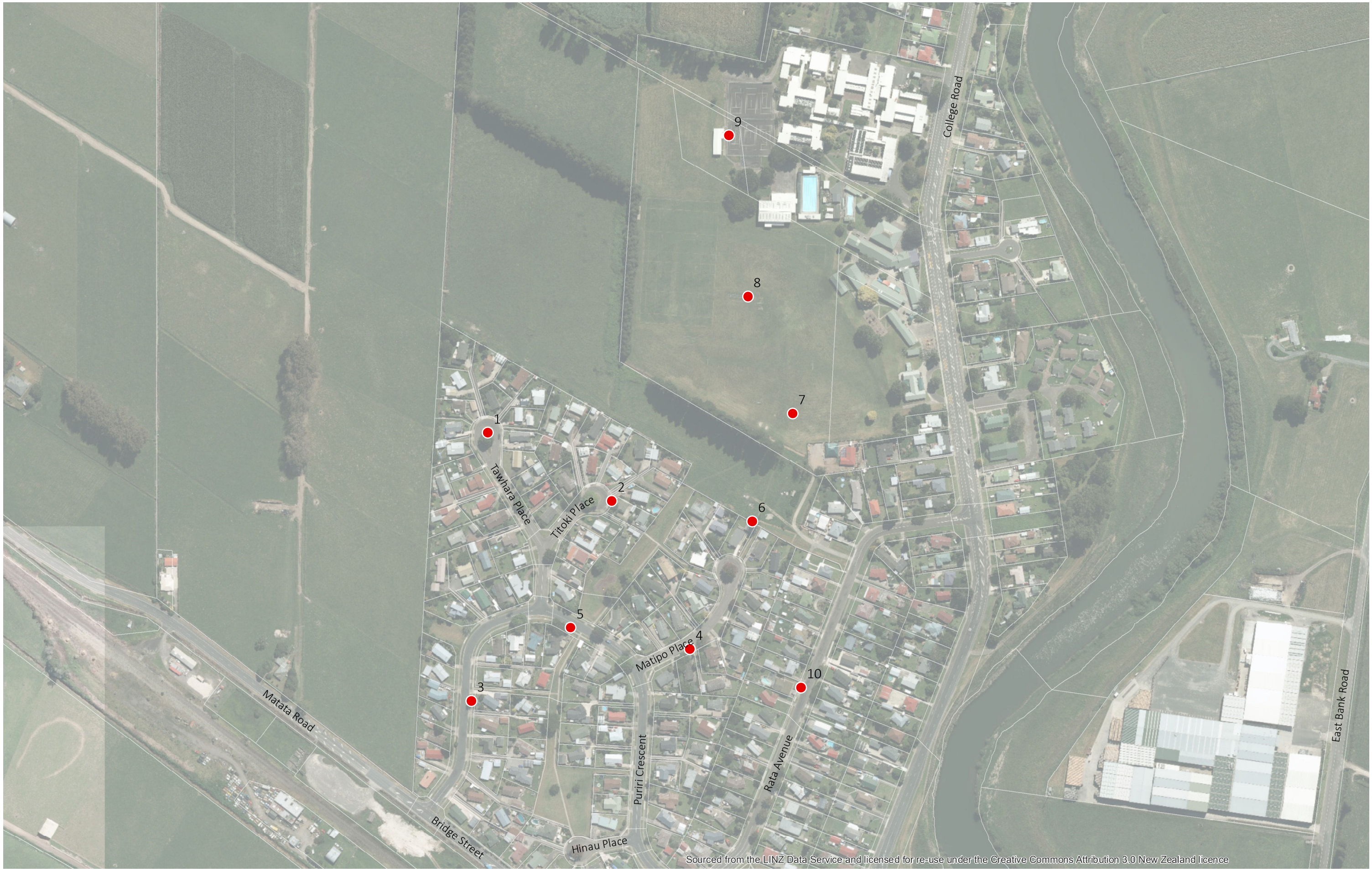
Table 4 - Summary of analytical results (Exceedances are highlighted in yellow)

Sample(s)	Analyte	Max Concentration (mg/kg)	Mean Concentration (mg/kg)	95% UCL (mg/kg)	Human Health SCS (mg/kg)	Environmental Guideline (mg/kg)	Exceedances of SCS
1 to 10	Arsenic	10	5.9	7.074	17	100	0
	Cadmium	0.1	0.01	0.0536	0.8	7.5	0
	Chromium	19	9.5	11.59	290	400	0
	Copper	17	11.2	13.15	10000	325	0
	Lead	17.9	14.35	16.11	160	250	0
	Nickel	9	5.5	6.417	50	105	0
	Zinc	195	76.1	100.9	200	400	0

Conclusions

Metal analysis completed by Hill Laboratories show that levels detected are below the identified Soil Contaminant Standards and are not considered a risk to human health or the environment.

The elevation of zinc from sample 9 which was located on the Edgecumbe College tennis court is considered to be a result of the sample locations proximity to galvanised fencing. The zinc was likely in the lower (darker) layer of material as shown in images 16 and 17 and is considered to have been present onsite prior to the flood.



0 50 100 200 Metres

Edgecumbe Sediment Sampling

Prepared by: wkjwg0 Approved by: wkpda0

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11 May 2017

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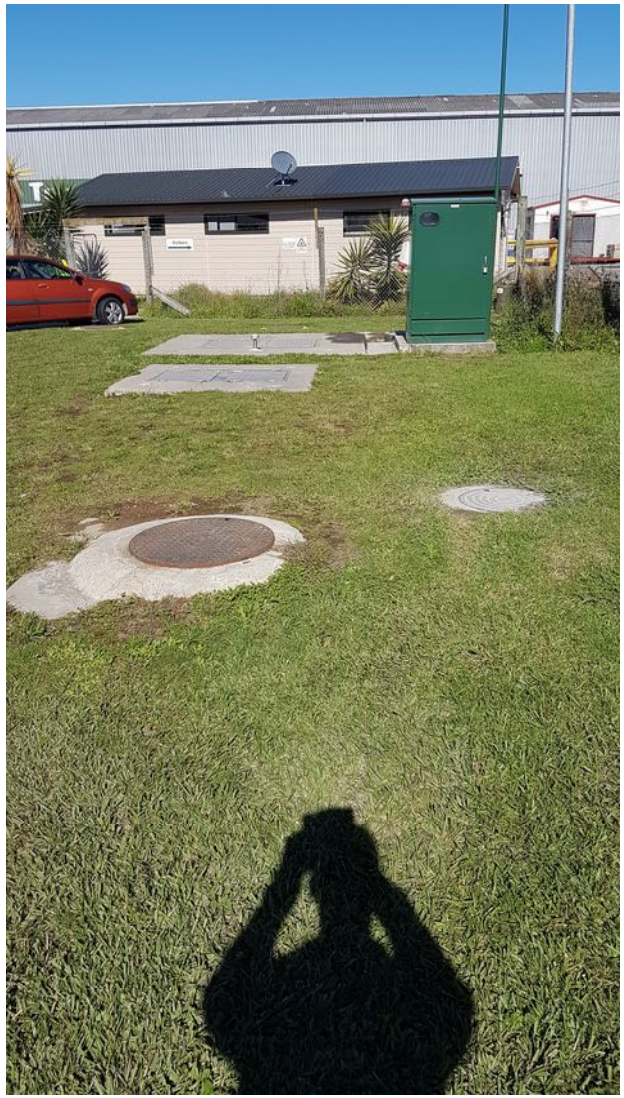
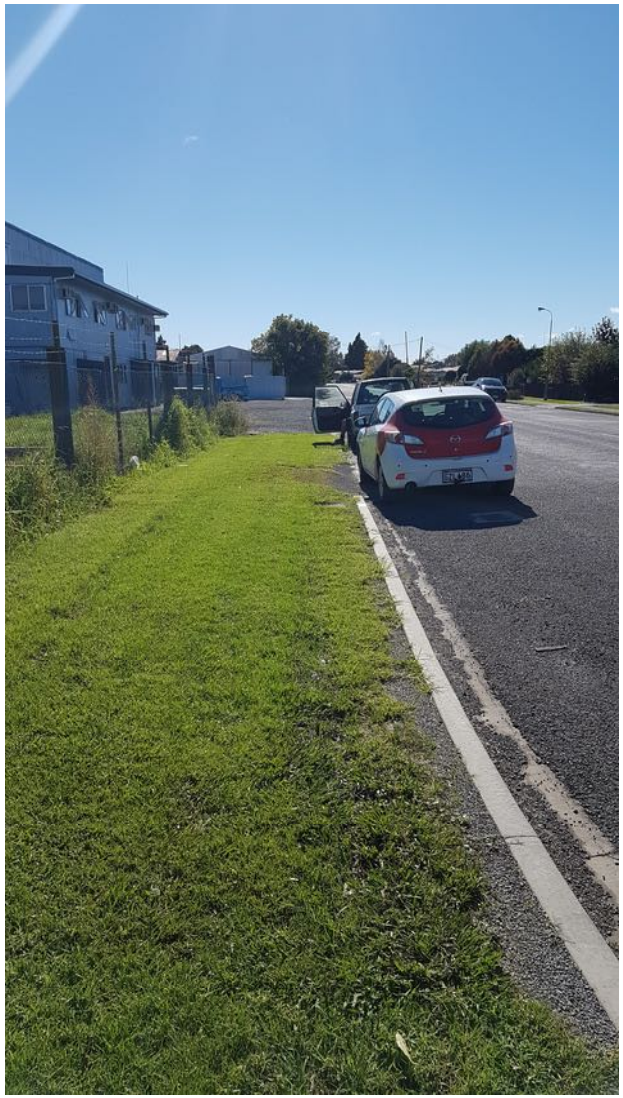


Photo (1)



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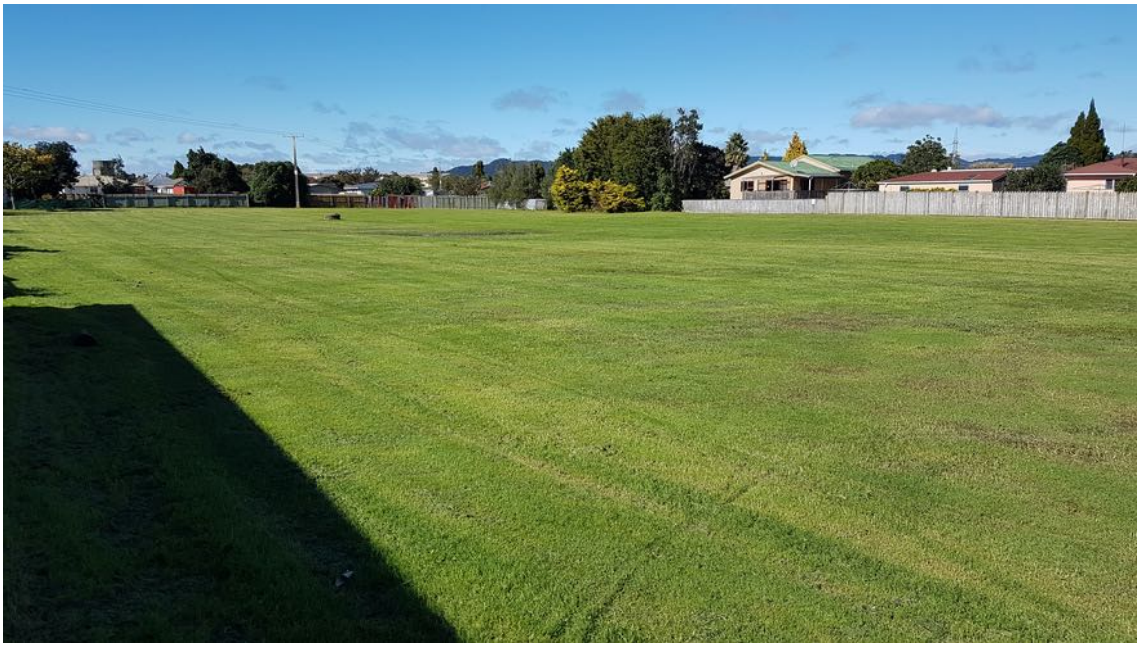

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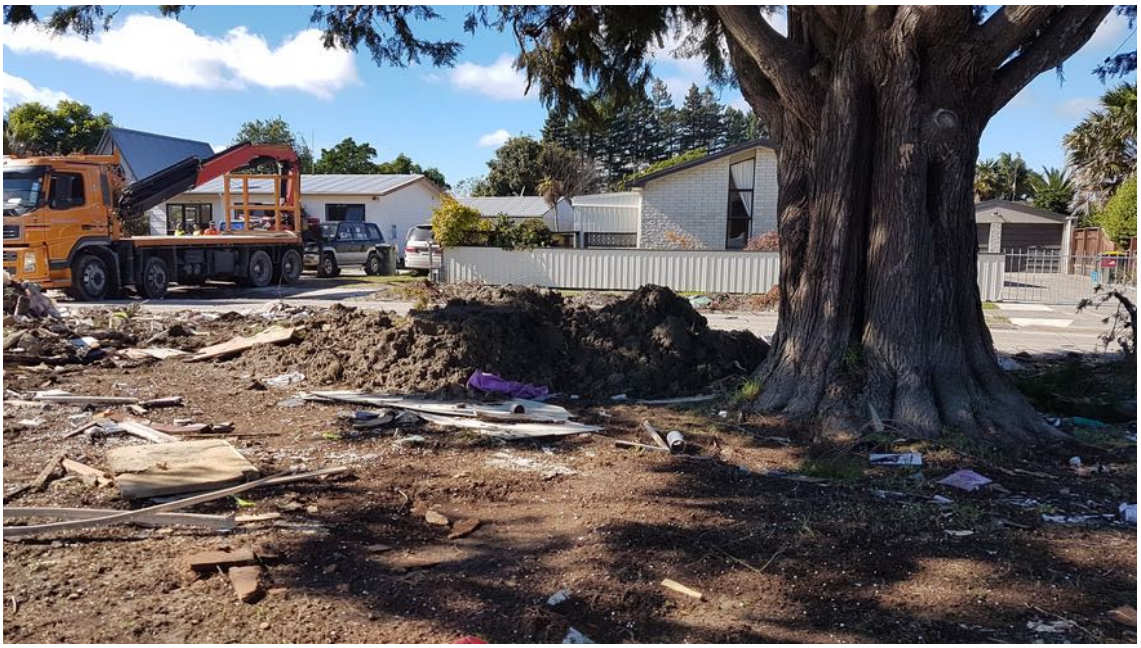

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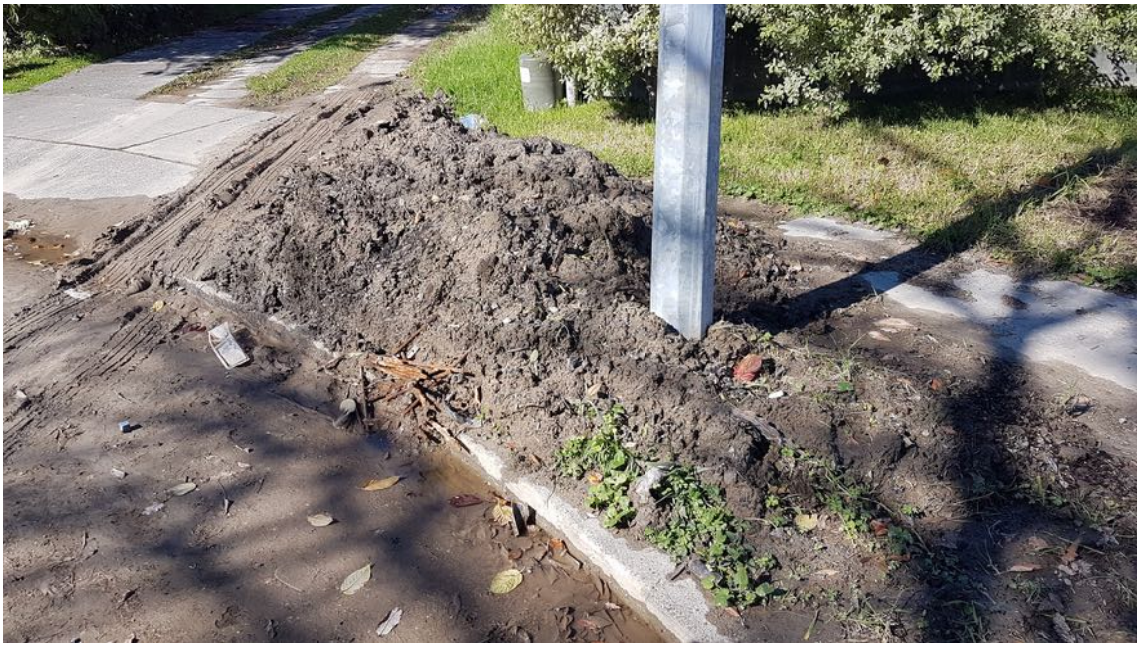

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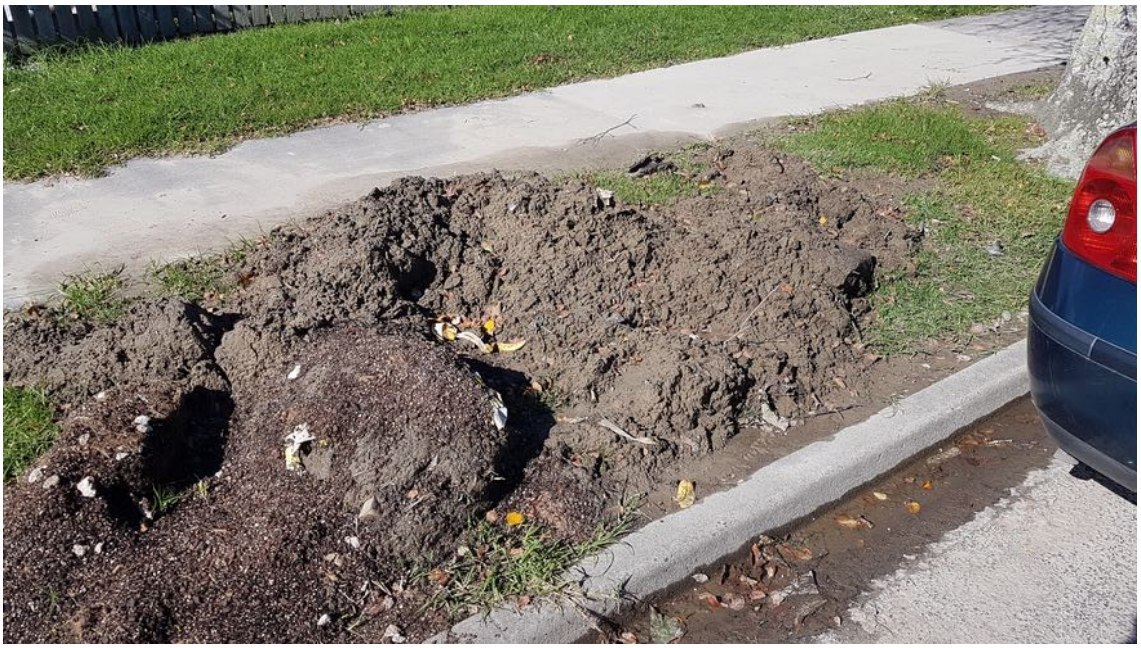

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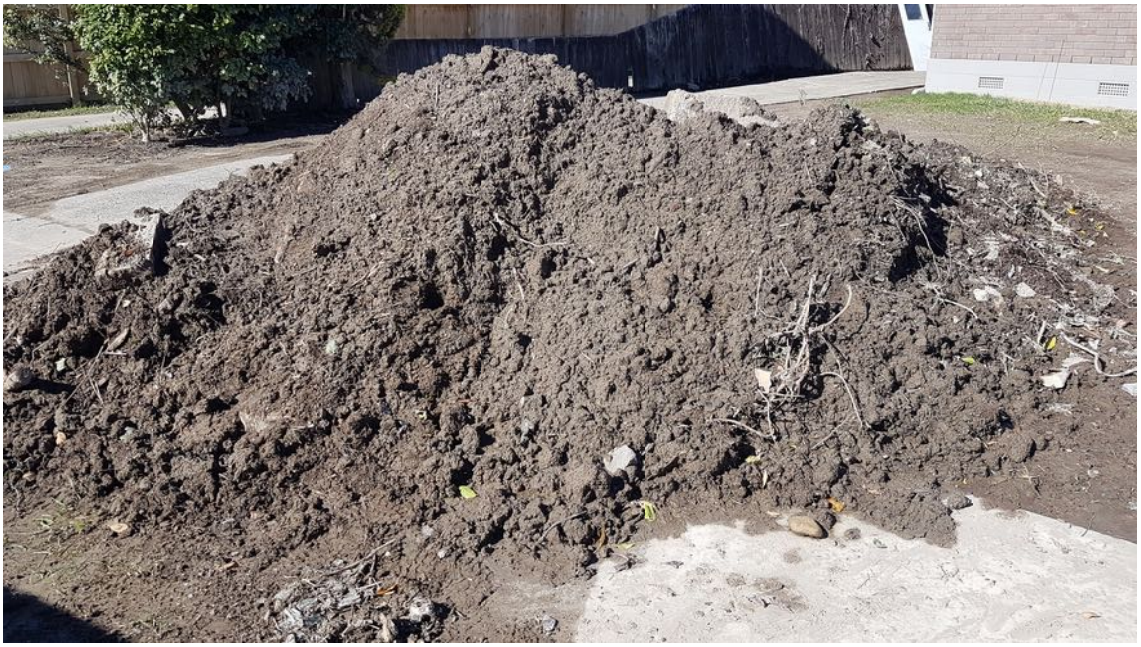

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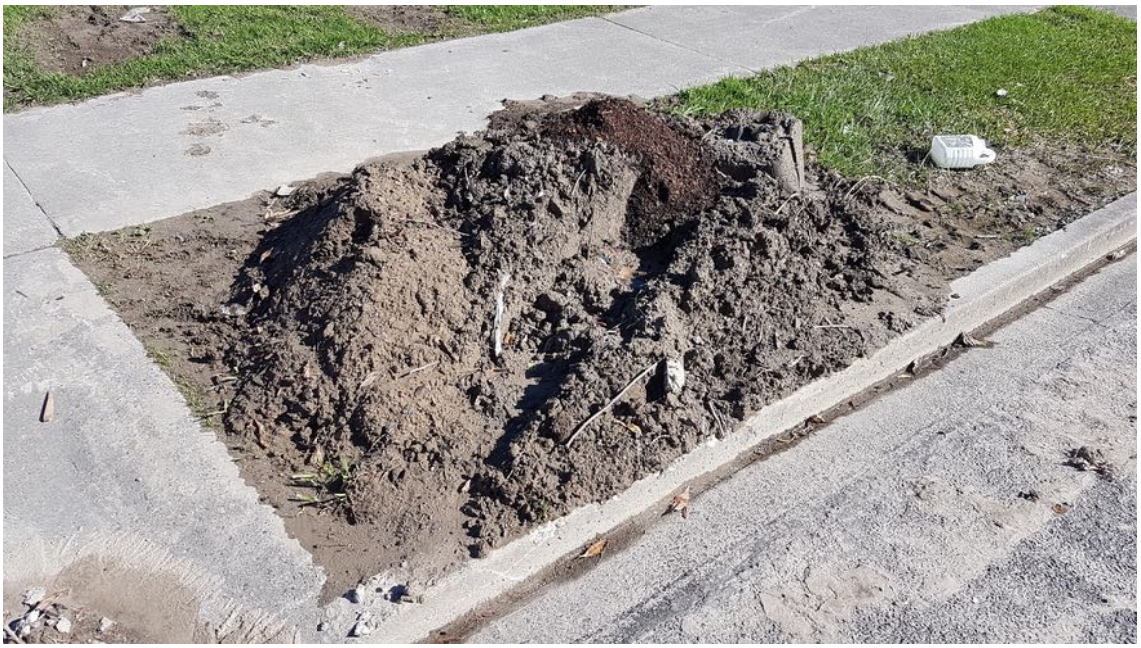

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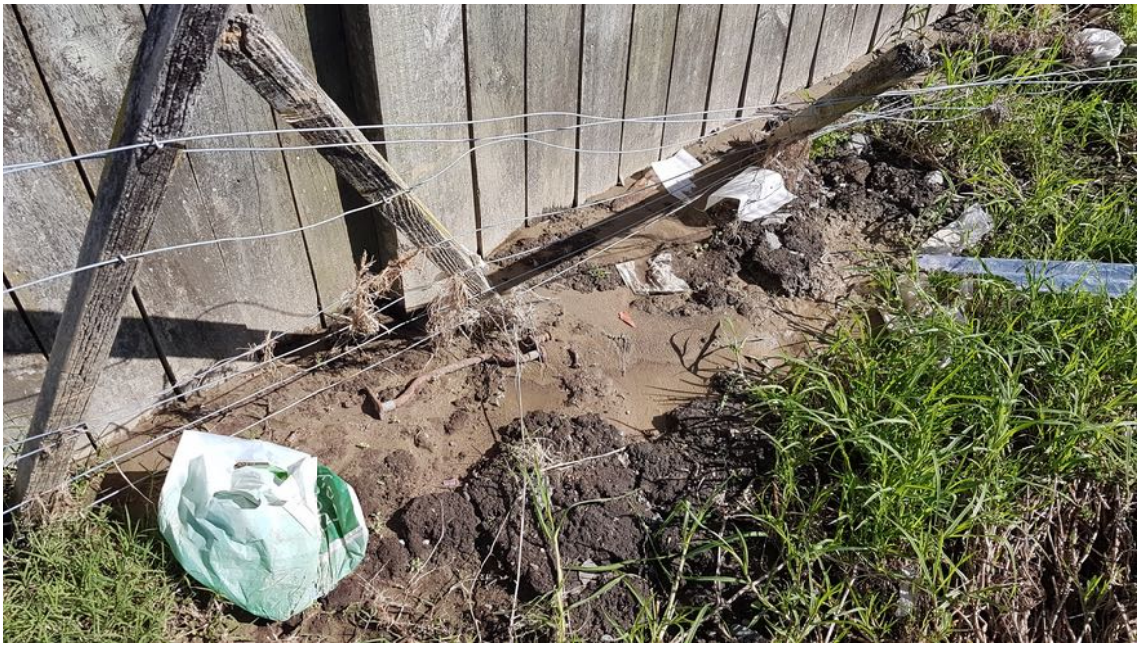

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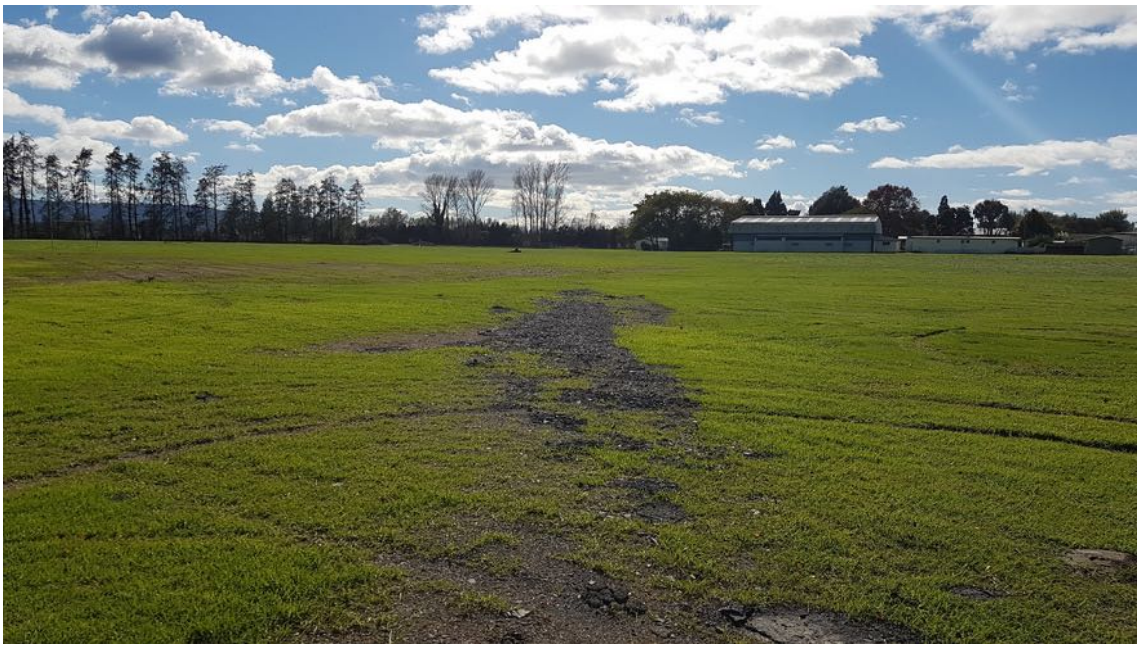
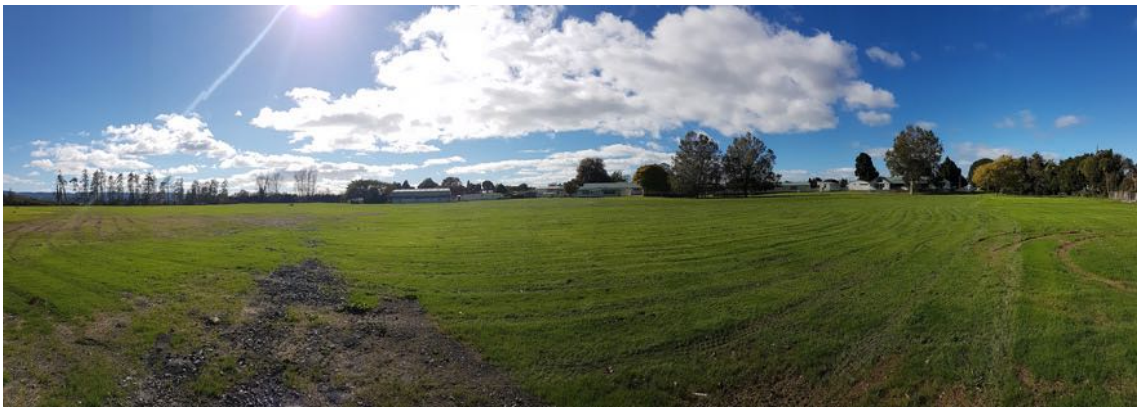


Photo (10)



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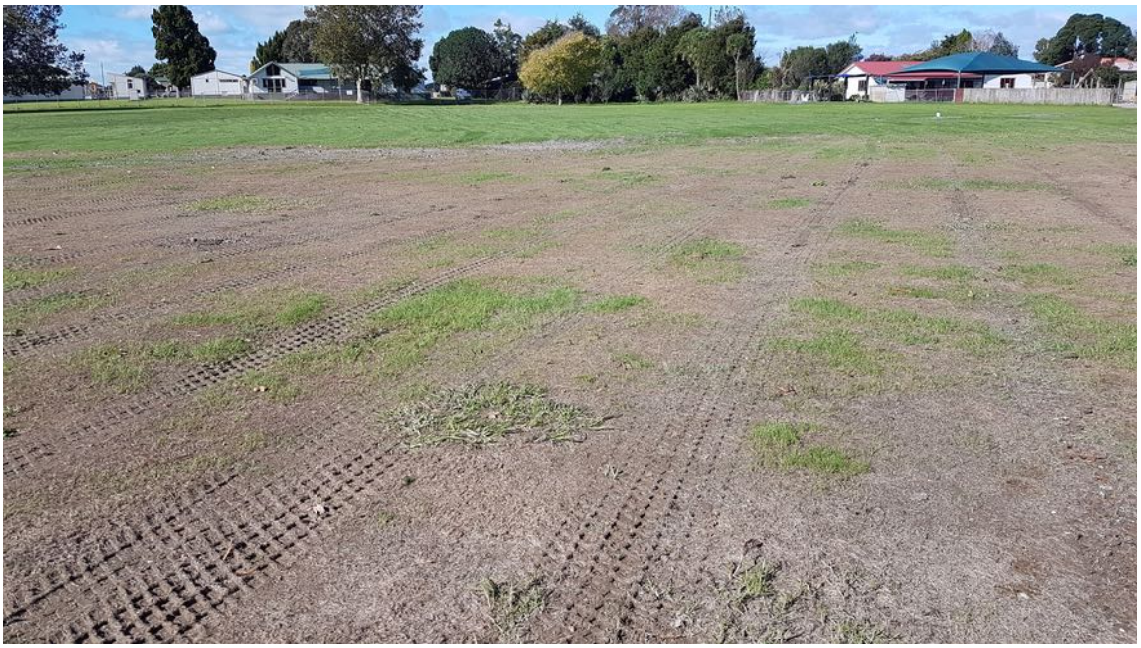

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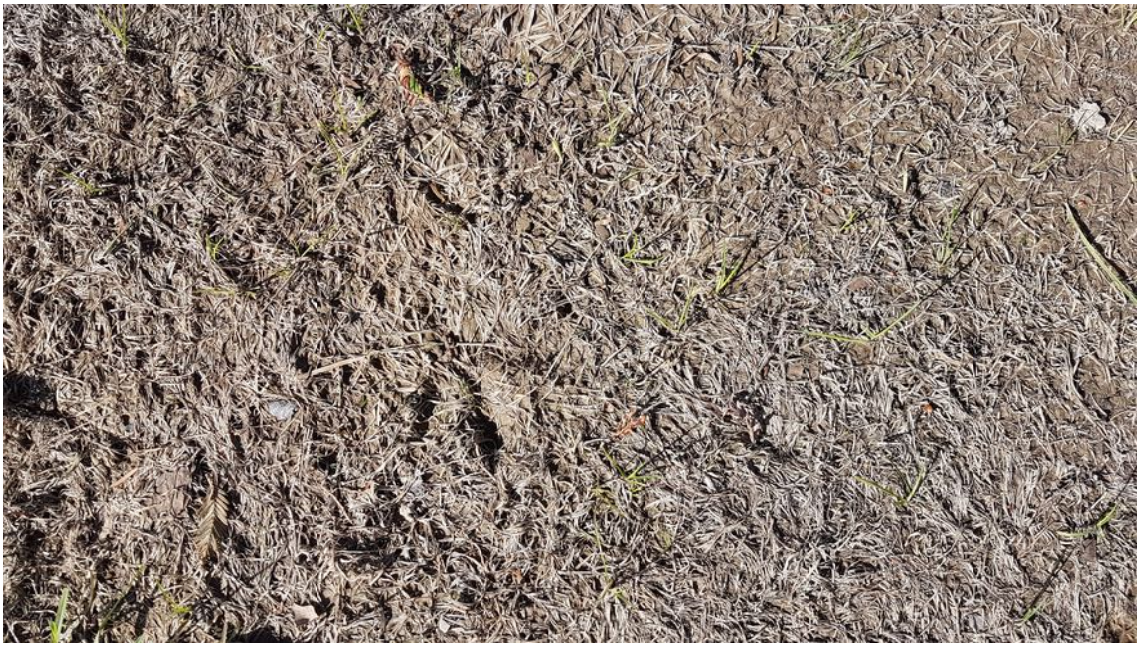

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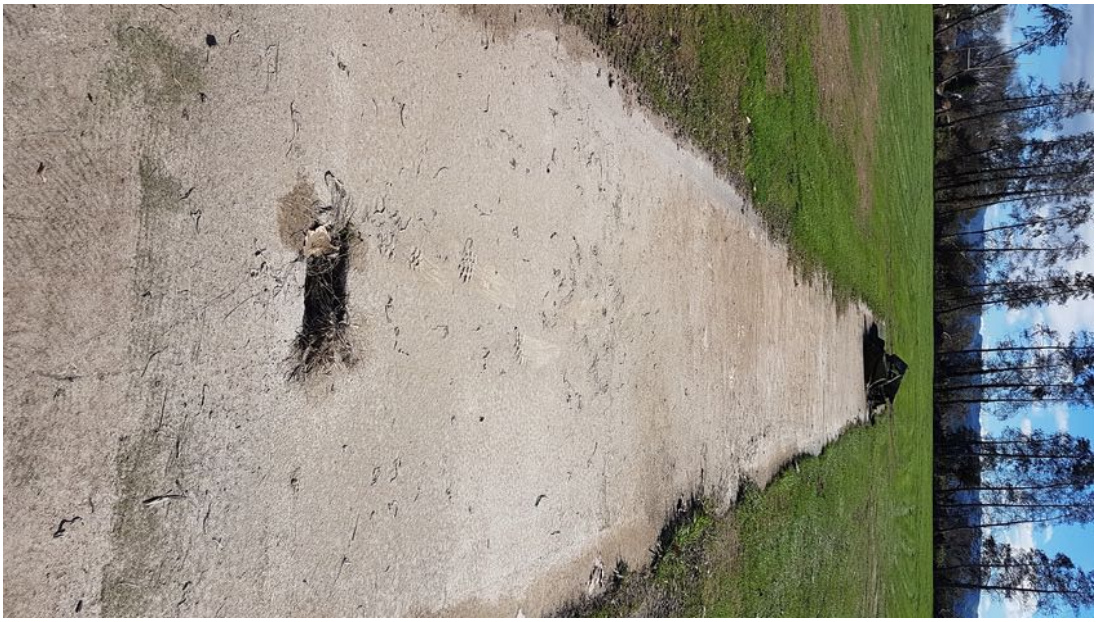

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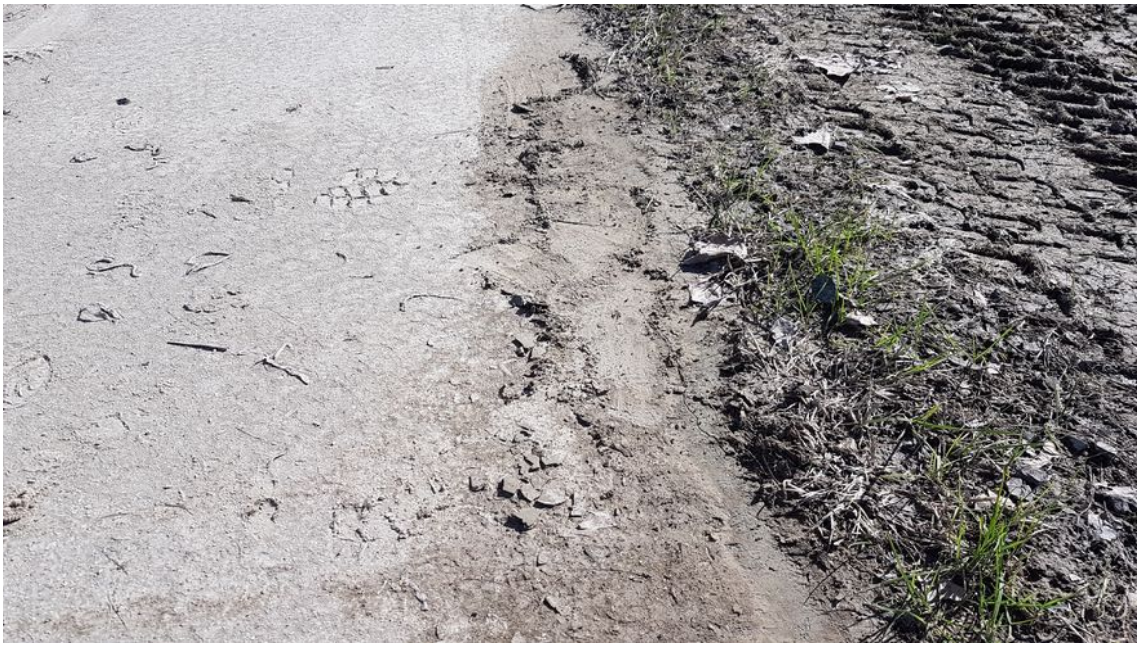

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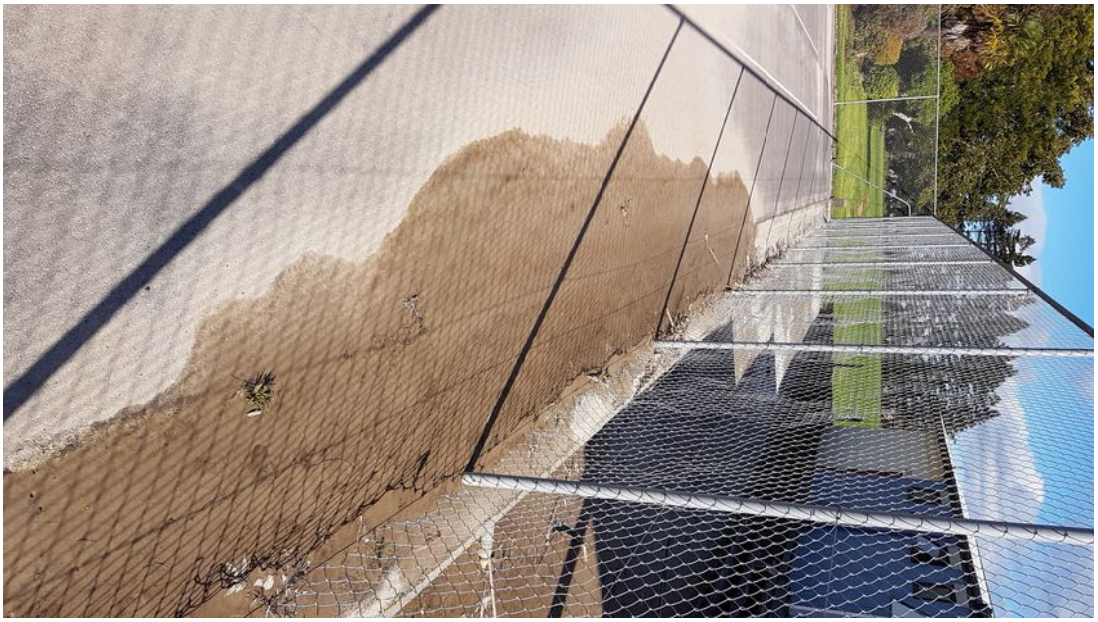

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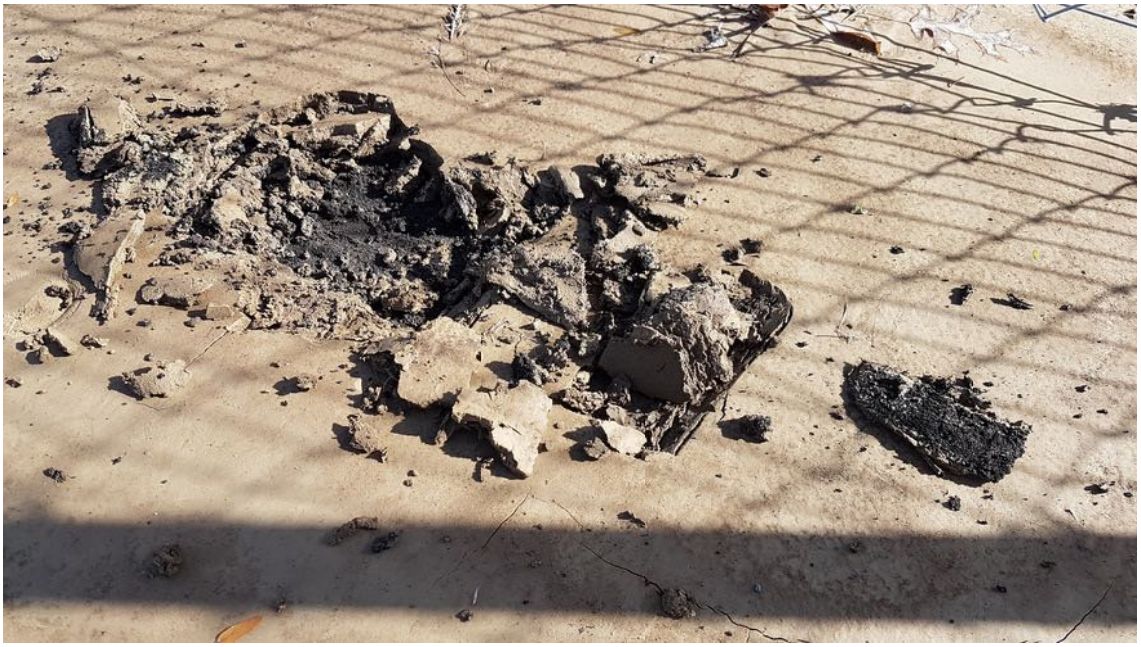

Photo (17)

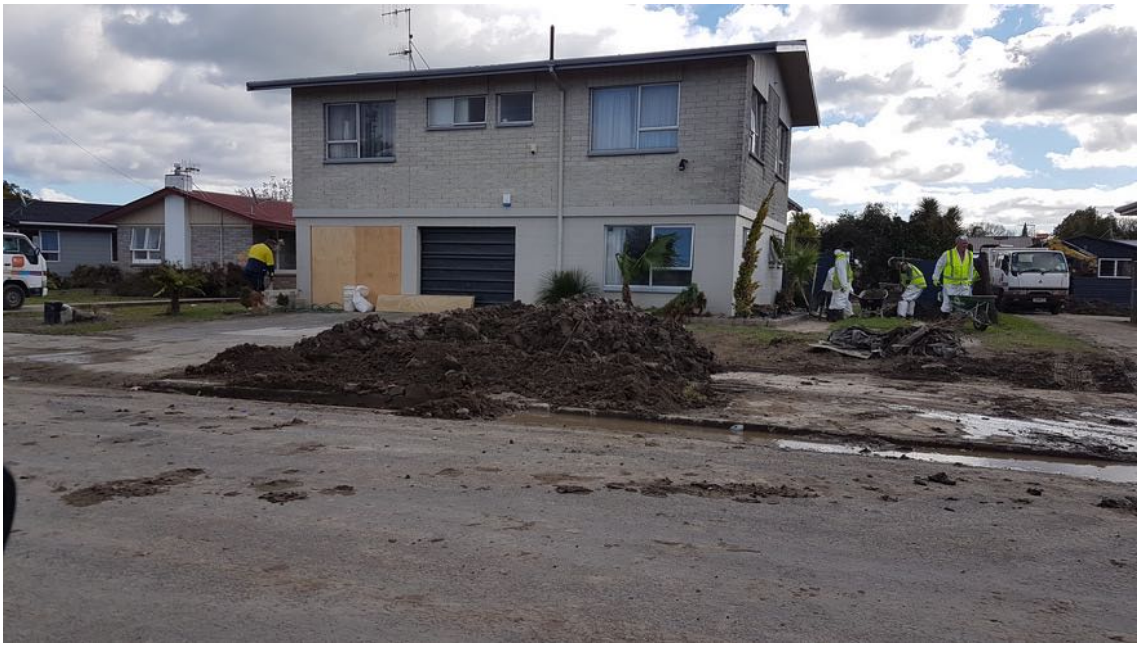

Photo (18)

Hill Laboratories
TRIED, TESTED AND TRUSTED

ANALYSIS REQUEST

R J Hill Laboratories Limited
1 Clyde Street Hamilton 3216
Private Bag 3205
Hamilton 3240 New Zealand

T 0508 HILL LAB (44 555 22)
T +64 7 858 2000
E mail@hill-labs.co.nz
W www.hill-laboratories.com

Job No: **176 7560**
Date Recv: 02-May-17 05:30
Received by: Chloe Vedder

Quote No 85139

Primary Contact J Gladwin 111561

Submitted By J Gladwin 111561

Client Name OPUS International Consultants 14896

Address PO Box 800, Whakatane 3158

Phone 07 308 0139 Mobile

Email

Charge To OPUS International Consultants 14896

Client Reference Urgent Sediments

Order No

Results To *Reports will be emailed to Primary Contact by default. Additional Reports will be sent as specified below.*

☑ Email Primary Contact ☐ Email Submitter ☐ Email Client

☐ Email Other

☐ Other

ADDITIONAL INFORMATION

CHAIN OF CUSTODY RECORD

Sent to Hill Laboratories
☑ Tick if you require COC to be emailed back
Date & Time: 01/05/17 16:00
Name: J Gladwin
Signature: JG

Received at Hill Laboratories
Date & Time: 2/5/17 6:59
Name: Charlotte O'Leary
Signature:

Condition ☐ Room Temp ☐ Chilled ☐ Frozen
Temp: 14.5

☐ Sample & Analysis details checked
Signature:

Priority ☐ Low ☐ Normal ☐ High
☑ **Urgent** (ASAP - extra charge applies, please contact lab first)

NOTE: The estimated turnaround time for the types and number of samples and analyses specified on this quote is by 4:30 pm, 3 working days following the day of receipt of the samples at the laboratory.

Requested Reporting Date

Quoted Sample Types

Sediment (Swab)

No.	Sample Name	Sample Date/Time	Sample Type	Tests Required
1	1	01/05/17	Sediment	Metal Suite as per quote
2	2			
3	3			
4	4			
5	5			
6	6			
7	7			
8	8			
9	9			
10	10			

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W www.hill-laboratories.com

Job Information Summary

Client:	OPUS International Consultants	**Lab No:**	1767560
Contact:	J Gladwin	**Date Registered:**	02-May-2017 6:53 am
	Level 1, 13 Louvain Street	**Priority:**	Urgent
	Whakatane 3120	**Quote No:**	85139
		Order No:	
		Client Reference:	Urgent Sediments
		Add. Client Ref:	
		Submitted By:	J Gladwin
		Charge To:	OPUS International Consultants
		Target Date:	05-May-2017 4:30 pm

Samples

No	Sample Name	Sample Type	Containers	Tests Requested
1	101-May-2017	Sediment	GSoil300	Heavy metal screen level As,Cd,Cr,Cu,Ni,Pb,Zn
2	201-May-2017	Sediment	GSoil300	Heavy metal screen level As,Cd,Cr,Cu,Ni,Pb,Zn
3	301-May-2017	Sediment	GSoil300	Heavy metal screen level As,Cd,Cr,Cu,Ni,Pb,Zn
4	401-May-2017	Sediment	cGSoil	Heavy metal screen level As,Cd,Cr,Cu,Ni,Pb,Zn
5	501-May-2017	Sediment	GSoil300	Heavy metal screen level As,Cd,Cr,Cu,Ni,Pb,Zn
6	601-May-2017	Sediment	GSoil300	Heavy metal screen level As,Cd,Cr,Cu,Ni,Pb,Zn
7	701-May-2017	Sediment	GSoil300	Heavy metal screen level As,Cd,Cr,Cu,Ni,Pb,Zn
8	801-May-2017	Sediment	GSoil300	Heavy metal screen level As,Cd,Cr,Cu,Ni,Pb,Zn
9	901-May-2017	Sediment	GSoil300	Heavy metal screen level As,Cd,Cr,Cu,Ni,Pb,Zn
10	1001-May-2017	Sediment	GSoil300	Heavy metal screen level As,Cd,Cr,Cu,Ni,Pb,Zn

SUMMARY OF METHODS

The following table(s) gives a brief description of the methods used to conduct the analyses for this job. The detection limits given below are those attainable in a relatively clean matrix. Detection limits may be higher for individual samples should insufficient sample be available, or if the matrix requires that dilutions be performed during analysis.

Sample Type: Sediment

Test	Method Description	Default Detection Limit	Sample No
Environmental Solids Sample Preparation	Air dried at 35°C and sieved, <2mm fraction. Used for sample preparation. May contain a residual moisture content of 2-5%.	-	1-10
Heavy metal screen level As,Cd,Cr,Cu,Ni,Pb,Zn	Dried sample, <2mm fraction. Nitric/Hydrochloric acid digestion, ICP-MS, screen level.	0.10 - 4 mg/kg dry wt	1-10
Total Recoverable digestion	Nitric / hydrochloric acid digestion. US EPA 200.2.	-	1-10

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ANALYSIS REPORT

Client:	OPUS International Consultants	**Lab No:**	1767560 SPv1
Contact:	J Gladwin	**Date Received:**	02-May-2017
	Level 1, 13 Louvain Street	**Date Reported:**	04-May-2017
	Whakatane 3120	**Quote No:**	85139
		Order No:	
		Client Reference:	Urgent Sediments
		Submitted By:	J Gladwin

Sample Type: Sediment

		Sample Name:	1 01-May-2017	2 01-May-2017	3 01-May-2017	4 01-May-2017	5 01-May-2017
		Lab Number:	1767560.1	1767560.2	1767560.3	1767560.4	1767560.5
Heavy metal screen level As,Cd,Cr,Cu,Ni,Pb,Zn							
Total Recoverable Arsenic	mg/kg dry wt		5	4	5	8	10
Total Recoverable Cadmium	mg/kg dry wt		< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
Total Recoverable Chromium	mg/kg dry wt		8	8	8	8	19
Total Recoverable Copper	mg/kg dry wt		9	10	10	11	16
Total Recoverable Lead	mg/kg dry wt		13.1	15.5	12.4	15.7	13.8
Total Recoverable Nickel	mg/kg dry wt		5	4	5	5	6
Total Recoverable Zinc	mg/kg dry wt		52	66	63	65	79

		Sample Name:	6 01-May-2017	7 01-May-2017	8 01-May-2017	9 01-May-2017	10 01-May-2017
		Lab Number:	1767560.6	1767560.7	1767560.8	1767560.9	1767560.10
Heavy metal screen level As,Cd,Cr,Cu,Ni,Pb,Zn							
Total Recoverable Arsenic	mg/kg dry wt		6	5	3	6	7
Total Recoverable Cadmium	mg/kg dry wt		< 0.10	< 0.10	0.10	< 0.10	< 0.10
Total Recoverable Chromium	mg/kg dry wt		8	6	9	11	10
Total Recoverable Copper	mg/kg dry wt		10	7	8	14	17
Total Recoverable Lead	mg/kg dry wt		17.6	7.3	14.8	15.4	17.9
Total Recoverable Nickel	mg/kg dry wt		4	4	6	9	7
Total Recoverable Zinc	mg/kg dry wt		56	47	70	195	68

SUMMARY OF METHODS

The following table(s) gives a brief description of the methods used to conduct the analyses for this job. The detection limits given below are those attainable in a relatively clean matrix. Detection limits may be higher for individual samples should insufficient sample be available, or if the matrix requires that dilutions be performed during analysis.

Sample Type: Sediment

Test	Method Description	Default Detection Limit	Sample No
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Heavy metal screen level As,Cd,Cr,Cu,Ni,Pb,Zn	Dried sample, <2mm fraction. Nitric/Hydrochloric acid digestion, ICP-MS, screen level.	0.10 - 4 mg/kg dry wt	1-10
Total Recoverable digestion	Nitric / hydrochloric acid digestion. US EPA 200.2.	-	1-10

These samples were collected by yourselves (or your agent) and analysed as received at the laboratory.

Samples are held at the laboratory after reporting for a length of time depending on the preservation used and the stability of the analytes being tested. Once the storage period is completed the samples are discarded unless otherwise advised by the client.

Ara Heron BSc (Tech)
Client Services Manager - Environmental

UCL Statistics for Uncensored Full Data Sets

User Selected Options	
Date/Time of Computation	15/05/2017 10:52:32
From File	WorkSheet.xls
Full Precision	OFF
Confidence Coefficient	95%
mber of Bootstrap Operations	2000

Arsenic

General Statistics

Total Number of Observations	10	Number of Distinct Observations	7
		Number of Missing Observations	0
Minimum	3	Mean	5.9
Maximum	10	Median	5.5
SD	2.025	Std. Error of Mean	0.64
Coefficient of Variation	0.343	Skewness	0.771

Normal GOF Test

Shapiro Wilk Test Statistic	0.951	**Shapiro Wilk GOF Test**
5% Shapiro Wilk Critical Value	0.842	Data appear Normal at 5% Significance Level
Lilliefors Test Statistic	0.18	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.28	Data appear Normal at 5% Significance Level

Data appear Normal at 5% Significance Level

Assuming Normal Distribution

95% Normal UCL		**95% UCLs (Adjusted for Skewness)**	
95% Student's-t UCL	7.074	95% Adjusted-CLT UCL (Chen-1995)	7.12
		95% Modified-t UCL (Johnson-1978)	7.1

Gamma GOF Test

A-D Test Statistic	0.217	**Anderson-Darling Gamma GOF Test**
5% A-D Critical Value	0.725	etected data appear Gamma Distributed at 5% Significance Lev
K-S Test Statistic	0.153	**Kolmogrov-Smirnoff Gamma GOF Test**
5% K-S Critical Value	0.267	etected data appear Gamma Distributed at 5% Significance Lev

Detected data appear Gamma Distributed at 5% Significance Level

Gamma Statistics

k hat (MLE)	9.69	k star (bias corrected MLE)	6.85
Theta hat (MLE)	0.609	Theta star (bias corrected MLE)	0.861
nu hat (MLE)	193.8	nu star (bias corrected)	137
MLE Mean (bias corrected)	5.9	MLE Sd (bias corrected)	2.254
		Approximate Chi Square Value (0.05)	111
Adjusted Level of Significance	0.0267	Adjusted Chi Square Value	106.9

Assuming Gamma Distribution

95% Approximate Gamma UCL (use when n>=50))	7.285	95% Adjusted Gamma UCL (use when n<50)	7.562

Lognormal GOF Test

Shapiro Wilk Test Statistic	0.979	**Shapiro Wilk Lognormal GOF Test**
5% Shapiro Wilk Critical Value	0.842	Data appear Lognormal at 5% Significance Level
Lilliefors Test Statistic	0.171	**Lilliefors Lognormal GOF Test**
5% Lilliefors Critical Value	0.28	Data appear Lognormal at 5% Significance Level

Data appear Lognormal at 5% Significance Level

58	**Lognormal Statistics**											
59					Minimum of Logged Data	1.099			Mean of logged Data			1.722
60					Maximum of Logged Data	2.303			SD of logged Data			0.344
61												
62	**Assuming Lognormal Distribution**											
63					95% H-UCL	7.49			90% Chebyshev (MVUE) UCL			7.846
64					95% Chebyshev (MVUE) UCL	8.726			97.5% Chebyshev (MVUE) UCL			9.947
65					99% Chebyshev (MVUE) UCL	12.35						
66												
67	**Nonparametric Distribution Free UCL Statistics**											
68	**Data appear to follow a Discernible Distribution at 5% Significance Level**											
69												
70	**Nonparametric Distribution Free UCLs**											
71					95% CLT UCL	6.953			95% Jackknife UCL			7.074
72					95% Standard Bootstrap UCL	6.91			95% Bootstrap-t UCL			7.372
73					95% Hall's Bootstrap UCL	7.695			95% Percentile Bootstrap UCL			6.9
74					95% BCA Bootstrap UCL	7						
75					90% Chebyshev(Mean, Sd) UCL	7.821			95% Chebyshev(Mean, Sd) UCL			8.691
76					97.5% Chebyshev(Mean, Sd) UCL	9.899			99% Chebyshev(Mean, Sd) UCL			12.27
77												
78	**Suggested UCL to Use**											
79					95% Student's-t UCL	7.074						
80												
81	Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.											
82	These recommendations are based upon the results of the simulation studies summarized in Singh, Singh, and Iaci (2002)											
83	and Singh and Singh (2003). However, simulations results will not cover all Real World data sets.											
84	For additional insight the user may want to consult a statistician.											
85												
86												
87	**Cadmium**											
88												
89	**General Statistics**											
90					Total Number of Observations	10			Number of Distinct Observations			2
91									Number of Missing Observations			0
92					Minimum	0			Mean			0.01
93					Maximum	0.1			Median			0
94					SD	0.0316			Std. Error of Mean			0.01
95					Coefficient of Variation	3.162			Skewness			3.162
96												
97	**Normal GOF Test**											
98					Shapiro Wilk Test Statistic	0.366			**Shapiro Wilk GOF Test**			
99					5% Shapiro Wilk Critical Value	0.842			Data Not Normal at 5% Significance Level			
100					Lilliefors Test Statistic	0.524			**Lilliefors GOF Test**			
101					5% Lilliefors Critical Value	0.28			Data Not Normal at 5% Significance Level			
102	**Data Not Normal at 5% Significance Level**											
103												
104	**Assuming Normal Distribution**											
105					**95% Normal UCL**				**95% UCLs (Adjusted for Skewness)**			
106					95% Student's-t UCL	0.0283			95% Adjusted-CLT UCL (Chen-1995)			0.0371
107									95% Modified-t UCL (Johnson-1978)			0.03
108	**Gamma Statistics Not Available**											
109	**Lognormal Statistics Not Available**											
110												
111	**Nonparametric Distribution Free UCL Statistics**											
112	**Data do not follow a Discernible Distribution (0.05)**											
113												
114	**Nonparametric Distribution Free UCLs**											

115					95% CLT UCL	0.0264					95% Jackknife UCL	N/A
116					95% Standard Bootstrap UCL	N/A					95% Bootstrap-t UCL	N/A
117					95% Hall's Bootstrap UCL	N/A					95% Percentile Bootstrap UCL	N/A
118					95% BCA Bootstrap UCL	N/A						
119					90% Chebyshev(Mean, Sd) UCL	0.04					95% Chebyshev(Mean, Sd) UCL	0.0536
120					97.5% Chebyshev(Mean, Sd) UCL	0.0724					99% Chebyshev(Mean, Sd) UCL	0.109
121												
122					**Suggested UCL to Use**							
123					95% Chebyshev (Mean, Sd) UCL	0.0536						
124												
125	Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.											
126	These recommendations are based upon the results of the simulation studies summarized in Singh, Singh, and Iaci (2002)											
127	and Singh and Singh (2003). However, simulations results will not cover all Real World data sets.											
128	For additional insight the user may want to consult a statistician.											
129												
130												
131	**Chromium**											
132												
133	**General Statistics**											
134					Total Number of Observations	10					Number of Distinct Observations	6
135											Number of Missing Observations	0
136					Minimum	6					Mean	9.5
137					Maximum	19					Median	8
138					SD	3.598					Std. Error of Mean	1.138
139					Coefficient of Variation	0.379					Skewness	2.389
140												
141	**Normal GOF Test**											
142					Shapiro Wilk Test Statistic	0.695					**Shapiro Wilk GOF Test**	
143					5% Shapiro Wilk Critical Value	0.842					Data Not Normal at 5% Significance Level	
144					Lilliefors Test Statistic	0.262					**Lilliefors GOF Test**	
145					5% Lilliefors Critical Value	0.28					Data appear Normal at 5% Significance Level	
146	**Data appear Approximate Normal at 5% Significance Level**											
147												
148	**Assuming Normal Distribution**											
149					**95% Normal UCL**						**95% UCLs (Adjusted for Skewness)**	
150					95% Student's-t UCL	11.59					95% Adjusted-CLT UCL (Chen-1995)	12.29
151											95% Modified-t UCL (Johnson-1978)	11.73
152												
153	**Gamma GOF Test**											
154					A-D Test Statistic	1.047					**Anderson-Darling Gamma GOF Test**	
155					5% A-D Critical Value	0.725					Data Not Gamma Distributed at 5% Significance Level	
156					K-S Test Statistic	0.269					**Kolmogrov-Smirnoff Gamma GOF Test**	
157					5% K-S Critical Value	0.267					Data Not Gamma Distributed at 5% Significance Level	
158	**Data Not Gamma Distributed at 5% Significance Level**											
159												
160	**Gamma Statistics**											
161					k hat (MLE)	10.54					k star (bias corrected MLE)	7.446
162					Theta hat (MLE)	0.901					Theta star (bias corrected MLE)	1.276
163					nu hat (MLE)	210.8					nu star (bias corrected)	148.9
164					MLE Mean (bias corrected)	9.5					MLE Sd (bias corrected)	3.482
165											Approximate Chi Square Value (0.05)	121.7
166					Adjusted Level of Significance	0.0267					Adjusted Chi Square Value	117.4
167												
168	**Assuming Gamma Distribution**											
169	95% Approximate Gamma UCL (use when n>=50))					11.62					95% Adjusted Gamma UCL (use when n<50)	12.05
170												
171	**Lognormal GOF Test**											

172	Shapiro Wilk Test Statistic				0.814	**Shapiro Wilk Lognormal GOF Test**						
173	5% Shapiro Wilk Critical Value				0.842	Data Not Lognormal at 5% Significance Level						
174	Lilliefors Test Statistic				0.257	**Lilliefors Lognormal GOF Test**						
175	5% Lilliefors Critical Value				0.28	Data appear Lognormal at 5% Significance Level						
176	**Data appear Approximate Lognormal at 5% Significance Level**											
177												
178	**Lognormal Statistics**											
179	Minimum of Logged Data				1.792	Mean of logged Data						2.203
180	Maximum of Logged Data				2.944	SD of logged Data						0.306
181												
182	**Assuming Lognormal Distribution**											
183	95% H-UCL				11.62	90% Chebyshev (MVUE) UCL						12.2
184	95% Chebyshev (MVUE) UCL				13.45	97.5% Chebyshev (MVUE) UCL						15.19
185	99% Chebyshev (MVUE) UCL				18.6							
186												
187	**Nonparametric Distribution Free UCL Statistics**											
188	**Data appear to follow a Discernible Distribution at 5% Significance Level**											
189												
190	**Nonparametric Distribution Free UCLs**											
191	95% CLT UCL				11.37	95% Jackknife UCL						11.59
192	95% Standard Bootstrap UCL				11.29	95% Bootstrap-t UCL						14.59
193	95% Hall's Bootstrap UCL				20.02	95% Percentile Bootstrap UCL						11.5
194	95% BCA Bootstrap UCL				12							
195	90% Chebyshev(Mean, Sd) UCL				12.91	95% Chebyshev(Mean, Sd) UCL						14.46
196	97.5% Chebyshev(Mean, Sd) UCL				16.61	99% Chebyshev(Mean, Sd) UCL						20.82
197												
198	**Suggested UCL to Use**											
199	95% Student's-t UCL				11.59							
200												
201	Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.											
202	These recommendations are based upon the results of the simulation studies summarized in Singh, Singh, and Iaci (2002)											
203	and Singh and Singh (2003). However, simulations results will not cover all Real World data sets.											
204	For additional insight the user may want to consult a statistician.											
205												
206												
207	**Copper**											
208												
209	**General Statistics**											
210	Total Number of Observations				10	Number of Distinct Observations						8
211						Number of Missing Observations						0
212	Minimum				7	Mean						11.2
213	Maximum				17	Median						10
214	SD				3.36	Std. Error of Mean						1.062
215	Coefficient of Variation				0.3	Skewness						0.751
216												
217	**Normal GOF Test**											
218	Shapiro Wilk Test Statistic				0.9	**Shapiro Wilk GOF Test**						
219	5% Shapiro Wilk Critical Value				0.842	Data appear Normal at 5% Significance Level						
220	Lilliefors Test Statistic				0.24	**Lilliefors GOF Test**						
221	5% Lilliefors Critical Value				0.28	Data appear Normal at 5% Significance Level						
222	**Data appear Normal at 5% Significance Level**											
223												
224	**Assuming Normal Distribution**											
225	**95% Normal UCL**					**95% UCLs (Adjusted for Skewness)**						
226	95% Student's-t UCL				13.15	95% Adjusted-CLT UCL (Chen-1995)						13.22
227						95% Modified-t UCL (Johnson-1978)						13.19
228												

	A	B	C	D	E	F	G	H	I	J	K	L
229	**Gamma GOF Test**											
230	A-D Test Statistic					0.414	**Anderson-Darling Gamma GOF Test**					
231	5% A-D Critical Value					0.725	etected data appear Gamma Distributed at 5% Significance Lev					
232	K-S Test Statistic					0.222	**Kolmogrov-Smirnoff Gamma GOF Test**					
233	5% K-S Critical Value					0.266	etected data appear Gamma Distributed at 5% Significance Lev					
234	**Detected data appear Gamma Distributed at 5% Significance Level**											
235												
236	**Gamma Statistics**											
237	k hat (MLE)					13.12	k star (bias corrected MLE)					9.248
238	Theta hat (MLE)					0.854	Theta star (bias corrected MLE)					1.211
239	nu hat (MLE)					262.3	nu star (bias corrected)					185
240	MLE Mean (bias corrected)					11.2	MLE Sd (bias corrected)					3.683
241							Approximate Chi Square Value (0.05)					154.5
242	Adjusted Level of Significance					0.0267	Adjusted Chi Square Value					149.7
243												
244	**Assuming Gamma Distribution**											
245	95% Approximate Gamma UCL (use when n>=50))					13.41	95% Adjusted Gamma UCL (use when n<50)					13.84
246												
247	**Lognormal GOF Test**											
248	Shapiro Wilk Test Statistic					0.94	**Shapiro Wilk Lognormal GOF Test**					
249	5% Shapiro Wilk Critical Value					0.842	Data appear Lognormal at 5% Significance Level					
250	Lilliefors Test Statistic					0.202	**Lilliefors Lognormal GOF Test**					
251	5% Lilliefors Critical Value					0.28	Data appear Lognormal at 5% Significance Level					
252	**Data appear Lognormal at 5% Significance Level**											
253												
254	**Lognormal Statistics**											
255	Minimum of Logged Data					1.946	Mean of logged Data					2.377
256	Maximum of Logged Data					2.833	SD of logged Data					0.29
257												
258	**Assuming Lognormal Distribution**											
259	95% H-UCL					13.59	90% Chebyshev (MVUE) UCL					14.29
260	95% Chebyshev (MVUE) UCL					15.69	97.5% Chebyshev (MVUE) UCL					17.64
261	99% Chebyshev (MVUE) UCL					21.47						
262												
263	**Nonparametric Distribution Free UCL Statistics**											
264	**Data appear to follow a Discernible Distribution at 5% Significance Level**											
265												
266	**Nonparametric Distribution Free UCLs**											
267	95% CLT UCL					12.95	95% Jackknife UCL					13.15
268	95% Standard Bootstrap UCL					12.81	95% Bootstrap-t UCL					13.64
269	95% Hall's Bootstrap UCL					13.36	95% Percentile Bootstrap UCL					13
270	95% BCA Bootstrap UCL					13						
271	90% Chebyshev(Mean, Sd) UCL					14.39	95% Chebyshev(Mean, Sd) UCL					15.83
272	97.5% Chebyshev(Mean, Sd) UCL					17.84	99% Chebyshev(Mean, Sd) UCL					21.77
273												
274	**Suggested UCL to Use**											
275	95% Student's-t UCL					13.15						
276												
277	Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.											
278	These recommendations are based upon the results of the simulation studies summarized in Singh, Singh, and Iaci (2002)											
279	and Singh and Singh (2003). However, simulations results will not cover all Real World data sets.											
280	For additional insight the user may want to consult a statistician.											
281												
282												
283	**Lead**											
284												
285	**General Statistics**											

286	Total Number of Observations					10	Number of Distinct Observations					10
287							Number of Missing Observations					0
288	Minimum					7.3	Mean					14.35
289	Maximum					17.9	Median					15.1
290	SD					3.037	Std. Error of Mean					0.96
291	Coefficient of Variation					0.212	Skewness					-1.367
292												
293	**Normal GOF Test**											
294	Shapiro Wilk Test Statistic					0.888	**Shapiro Wilk GOF Test**					
295	5% Shapiro Wilk Critical Value					0.842	Data appear Normal at 5% Significance Level					
296	Lilliefors Test Statistic					0.16	**Lilliefors GOF Test**					
297	5% Lilliefors Critical Value					0.28	Data appear Normal at 5% Significance Level					
298	**Data appear Normal at 5% Significance Level**											
299												
300	**Assuming Normal Distribution**											
301	**95% Normal UCL**						**95% UCLs (Adjusted for Skewness)**					
302	95% Student's-t UCL					16.11	95% Adjusted-CLT UCL (Chen-1995)					15.49
303							95% Modified-t UCL (Johnson-1978)					16.04
304												
305	**Gamma GOF Test**											
306	A-D Test Statistic					0.679	**Anderson-Darling Gamma GOF Test**					
307	5% A-D Critical Value					0.725	etected data appear Gamma Distributed at 5% Significance Lev					
308	K-S Test Statistic					0.19	**Kolmogrov-Smirnoff Gamma GOF Test**					
309	5% K-S Critical Value					0.266	etected data appear Gamma Distributed at 5% Significance Lev					
310	**Detected data appear Gamma Distributed at 5% Significance Level**											
311												
312	**Gamma Statistics**											
313	k hat (MLE)					19.51	k star (bias corrected MLE)					13.72
314	Theta hat (MLE)					0.735	Theta star (bias corrected MLE)					1.046
315	nu hat (MLE)					390.2	nu star (bias corrected)					274.5
316	MLE Mean (bias corrected)					14.35	MLE Sd (bias corrected)					3.874
317							Approximate Chi Square Value (0.05)					237.1
318	Adjusted Level of Significance					0.0267	Adjusted Chi Square Value					231.1
319												
320	**Assuming Gamma Distribution**											
321	95% Approximate Gamma UCL (use when n>=50))					16.61	95% Adjusted Gamma UCL (use when n<50)					17.05
322												
323	**Lognormal GOF Test**											
324	Shapiro Wilk Test Statistic					0.792	**Shapiro Wilk Lognormal GOF Test**					
325	5% Shapiro Wilk Critical Value					0.842	Data Not Lognormal at 5% Significance Level					
326	Lilliefors Test Statistic					0.22	**Lilliefors Lognormal GOF Test**					
327	5% Lilliefors Critical Value					0.28	Data appear Lognormal at 5% Significance Level					
328	**Data appear Approximate Lognormal at 5% Significance Level**											
329												
330	**Lognormal Statistics**											
331	Minimum of Logged Data					1.988	Mean of logged Data					2.638
332	Maximum of Logged Data					2.885	SD of logged Data					0.256
333												
334	**Assuming Lognormal Distribution**											
335	95% H-UCL					17.05	90% Chebyshev (MVUE) UCL					17.92
336	95% Chebyshev (MVUE) UCL					19.52	97.5% Chebyshev (MVUE) UCL					21.73
337	99% Chebyshev (MVUE) UCL					26.08						
338												
339	**Nonparametric Distribution Free UCL Statistics**											
340	**Data appear to follow a Discernible Distribution at 5% Significance Level**											
341												
342	**Nonparametric Distribution Free UCLs**											

95% CLT UCL	15.93	95% Jackknife UCL 16.11
95% Standard Bootstrap UCL	15.84	95% Bootstrap-t UCL 15.67
95% Hall's Bootstrap UCL	15.66	95% Percentile Bootstrap UCL 15.76
95% BCA Bootstrap UCL	15.52	
90% Chebyshev(Mean, Sd) UCL	17.23	95% Chebyshev(Mean, Sd) UCL 18.54
97.5% Chebyshev(Mean, Sd) UCL	20.35	99% Chebyshev(Mean, Sd) UCL 23.9

Suggested UCL to Use

95% Student's-t UCL	16.11

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.
These recommendations are based upon the results of the simulation studies summarized in Singh, Singh, and Iaci (2002) and Singh and Singh (2003). However, simulations results will not cover all Real World data sets.
For additional insight the user may want to consult a statistician.

Note: For highly negatively-skewed data, confidence limits (e.g., Chen, Johnson, Lognormal, and Gamma) may not be reliable. Chen's and Johnson's methods provide adjustments for positvely skewed data sets.

Nickel

General Statistics

Total Number of Observations	10	Number of Distinct Observations	5
		Number of Missing Observations	0
Minimum	4	Mean	5.5
Maximum	9	Median	5
SD	1.581	Std. Error of Mean	0.5
Coefficient of Variation	0.287	Skewness	1.265

Normal GOF Test

Shapiro Wilk Test Statistic	0.863	**Shapiro Wilk GOF Test**	
5% Shapiro Wilk Critical Value	0.842	Data appear Normal at 5% Significance Level	
Lilliefors Test Statistic	0.224	**Lilliefors GOF Test**	
5% Lilliefors Critical Value	0.28	Data appear Normal at 5% Significance Level	

Data appear Normal at 5% Significance Level

Assuming Normal Distribution

95% Normal UCL		**95% UCLs (Adjusted for Skewness)**	
95% Student's-t UCL	6.417	95% Adjusted-CLT UCL (Chen-1995)	6.536
		95% Modified-t UCL (Johnson-1978)	6.45

Gamma GOF Test

A-D Test Statistic	0.461	**Anderson-Darling Gamma GOF Test**
5% A-D Critical Value	0.725	etected data appear Gamma Distributed at 5% Significance Lev
K-S Test Statistic	0.21	**Kolmogrov-Smirnoff Gamma GOF Test**
5% K-S Critical Value	0.266	etected data appear Gamma Distributed at 5% Significance Lev

Detected data appear Gamma Distributed at 5% Significance Level

Gamma Statistics

k hat (MLE)	15.15	k star (bias corrected MLE)	10.67
Theta hat (MLE)	0.363	Theta star (bias corrected MLE)	0.515
nu hat (MLE)	303	nu star (bias corrected)	213.5
MLE Mean (bias corrected)	5.5	MLE Sd (bias corrected)	1.684
		Approximate Chi Square Value (0.05)	180.6
Adjusted Level of Significance	0.0267	Adjusted Chi Square Value	175.4

Assuming Gamma Distribution

400	95% Approximate Gamma UCL (use when n>=50))					6.499	95% Adjusted Gamma UCL (use when n<50)					6.693
401												
402	**Lognormal GOF Test**											
403	Shapiro Wilk Test Statistic					0.905	**Shapiro Wilk Lognormal GOF Test**					
404	5% Shapiro Wilk Critical Value					0.842	Data appear Lognormal at 5% Significance Level					
405	Lilliefors Test Statistic					0.192	**Lilliefors Lognormal GOF Test**					
406	5% Lilliefors Critical Value					0.28	Data appear Lognormal at 5% Significance Level					
407	**Data appear Lognormal at 5% Significance Level**											
408												
409	**Lognormal Statistics**											
410	Minimum of Logged Data					1.386	Mean of logged Data					1.671
411	Maximum of Logged Data					2.197	SD of logged Data					0.266
412												
413	**Assuming Lognormal Distribution**											
414	95% H-UCL					6.546	90% Chebyshev (MVUE) UCL					6.884
415	95% Chebyshev (MVUE) UCL					7.514	97.5% Chebyshev (MVUE) UCL					8.39
416	99% Chebyshev (MVUE) UCL					10.11						
417												
418	**Nonparametric Distribution Free UCL Statistics**											
419	**Data appear to follow a Discernible Distribution at 5% Significance Level**											
420												
421	**Nonparametric Distribution Free UCLs**											
422	95% CLT UCL					6.322	95% Jackknife UCL					6.417
423	95% Standard Bootstrap UCL					6.289	95% Bootstrap-t UCL					6.903
424	95% Hall's Bootstrap UCL					7.72	95% Percentile Bootstrap UCL					6.3
425	95% BCA Bootstrap UCL					6.4						
426	90% Chebyshev(Mean, Sd) UCL					7	95% Chebyshev(Mean, Sd) UCL					7.679
427	97.5% Chebyshev(Mean, Sd) UCL					8.622	99% Chebyshev(Mean, Sd) UCL					10.47
428												
429	**Suggested UCL to Use**											
430	95% Student's-t UCL					6.417						
431												
432	Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.											
433	These recommendations are based upon the results of the simulation studies summarized in Singh, Singh, and Iaci (2002)											
434	and Singh and Singh (2003). However, simulations results will not cover all Real World data sets.											
435	For additional insight the user may want to consult a statistician.											
436												
437												
438	**Zinc**											
439												
440	**General Statistics**											
441	Total Number of Observations					10	Number of Distinct Observations					10
442							Number of Missing Observations					0
443	Minimum					47	Mean					76.1
444	Maximum					195	Median					65.5
445	SD					42.79	Std. Error of Mean					13.53
446	Coefficient of Variation					0.562	Skewness					2.888
447												
448	**Normal GOF Test**											
449	Shapiro Wilk Test Statistic					0.577	**Shapiro Wilk GOF Test**					
450	5% Shapiro Wilk Critical Value					0.842	Data Not Normal at 5% Significance Level					
451	Lilliefors Test Statistic					0.373	**Lilliefors GOF Test**					
452	5% Lilliefors Critical Value					0.28	Data Not Normal at 5% Significance Level					
453	**Data Not Normal at 5% Significance Level**											
454												
455	**Assuming Normal Distribution**											
456	**95% Normal UCL**						**95% UCLs (Adjusted for Skewness)**					

457				95% Student's-t UCL		100.9			95% Adjusted-CLT UCL (Chen-1995)			111.6
458									95% Modified-t UCL (Johnson-1978)			103
459												
460	**Gamma GOF Test**											
461				A-D Test Statistic		1.352	**Anderson-Darling Gamma GOF Test**					
462				5% A-D Critical Value		0.729	Data Not Gamma Distributed at 5% Significance Level					
463				K-S Test Statistic		0.324	**Kolmogrov-Smirnoff Gamma GOF Test**					
464				5% K-S Critical Value		0.267	Data Not Gamma Distributed at 5% Significance Level					
465	**Data Not Gamma Distributed at 5% Significance Level**											
466												
467	**Gamma Statistics**											
468				k hat (MLE)		5.869	k star (bias corrected MLE)					4.175
469				Theta hat (MLE)		12.97	Theta star (bias corrected MLE)					18.23
470				nu hat (MLE)		117.4	nu star (bias corrected)					83.49
471				MLE Mean (bias corrected)		76.1	MLE Sd (bias corrected)					37.25
472							Approximate Chi Square Value (0.05)					63.44
473				Adjusted Level of Significance		0.0267	Adjusted Chi Square Value					60.4
474												
475	**Assuming Gamma Distribution**											
476	95% Approximate Gamma UCL (use when n>=50))					100.2	95% Adjusted Gamma UCL (use when n<50)					105.2
477												
478	**Lognormal GOF Test**											
479				Shapiro Wilk Test Statistic		0.741	**Shapiro Wilk Lognormal GOF Test**					
480				5% Shapiro Wilk Critical Value		0.842	Data Not Lognormal at 5% Significance Level					
481				Lilliefors Test Statistic		0.296	**Lilliefors Lognormal GOF Test**					
482				5% Lilliefors Critical Value		0.28	Data Not Lognormal at 5% Significance Level					
483	**Data Not Lognormal at 5% Significance Level**											
484												
485	**Lognormal Statistics**											
486				Minimum of Logged Data		3.85	Mean of logged Data					4.244
487				Maximum of Logged Data		5.273	SD of logged Data					0.392
488												
489	**Assuming Lognormal Distribution**											
490				95% H-UCL		98.77	90% Chebyshev (MVUE) UCL					102.8
491				95% Chebyshev (MVUE) UCL		115.5	97.5% Chebyshev (MVUE) UCL					133.1
492				99% Chebyshev (MVUE) UCL		167.8						
493												
494	**Nonparametric Distribution Free UCL Statistics**											
495	**Data do not follow a Discernible Distribution (0.05)**											
496												
497	**Nonparametric Distribution Free UCLs**											
498				95% CLT UCL		98.36	95% Jackknife UCL					100.9
499				95% Standard Bootstrap UCL		96.4	95% Bootstrap-t UCL					161.4
500				95% Hall's Bootstrap UCL		205.8	95% Percentile Bootstrap UCL					101.4
501				95% BCA Bootstrap UCL		108						
502				90% Chebyshev(Mean, Sd) UCL		116.7	95% Chebyshev(Mean, Sd) UCL					135.1
503				97.5% Chebyshev(Mean, Sd) UCL		160.6	99% Chebyshev(Mean, Sd) UCL					210.7
504												
505	**Suggested UCL to Use**											
506				95% Student's-t UCL		100.9	or 95% Modified-t UCL					103
507												
508	Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.											
509	These recommendations are based upon the results of the simulation studies summarized in Singh, Singh, and Iaci (2002)											
510	and Singh and Singh (2003). However, simulations results will not cover all Real World data sets.											
511	For additional insight the user may want to consult a statistician.											
512												