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Report OE102408F1

Dust Monitoring at Kerrs Rd, Kogan,16th–21th March 2015

for Global Road Technology Ltd

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Client Reference	
Investigation Period	*16th – 21th March 2015*
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Report Date	*20th April 2015*

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Executive Summary

Simtars was engaged by Global Road Technologies (GRT) to provide independent evaluation/measurements based on a statistical comparison of field data to evaluate the performance of GRT commercial product polymer GRT7000 in suppressing dust from a section of treated compared to untreated road.

The effectiveness of the product to reduce dust entrainment on a typical road was assessed by Simtars at sampling sites selected at Kerrs Road, near Kogan, Queensland (approximately 250 km west-north-west of Brisbane). The last product application and maintenance to this section of road was completed on 26th February 2015.

Dust production from the treated and untreated road surfaces was measured using two techniques. The first technique performed over a 5-day period, known as dust deposition monitoring, is a passive 2-dimensional technique that calculates the deposition in terms of mass per unit area per day. The second technique, used to collect 23.5-hour samples over 5 consecutive days, employs battery-powered Microvol samplers and is a 3-dimensional technique used to measure the dust mass per cubic meter of air as Total Suspended Particulates (TSP).

Multiple samplers (replicates) were used to measure sampling variability. Weather data were also collected on site to aid the interpretation of results.

The dust deposition results for insoluble solids show that Site 1 (treated) and Site 3 (background) were both notably lower than Site 2 (untreated). The mean insoluble solid deposition at untreated site was more than seven times that of the treated site. The treated site had both the lowest mean and also the lowest standard deviation of the three sites. The results for ash solids (mineral matter) show an even clearer difference between the treated and untreated sites; the treated site had the lowest mean ash solids deposition whereas the untreated site was 14 times higher.

The TSP results showed that the treated site had both the lowest mean/median deposition rate and also the lowest variability of the three sites. There was a clear difference between the untreated site and the other sites. The mean TSP for the untreated site was four times that of the treated site.

The results for the untreated site were notably greater than those from the other two locations for both dust deposition and TSP. Statistical testing was used to quantify this relationship for both the dust deposition and suspended particulates data. The results showed, statistically, that the dust suppression technology was effective at supressing dust at the Kerrs Road site under the environmental conditions of 16th–21st March 2015.

This Executive Summary was supplied in good faith as a common-language review, for the convenience of our clients. It must be interpreted in conjunction with the full report.

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1 Introduction

Simtars was engaged by Global Road Technologies (GRT) to conduct an independent analysis of the performance of their product GRT7000.

GRT7000 is a polymeric material supplied by GRT and used as a coating on unsealed road to minimise fugitive dust emission.

The project was conducted at Kerrs Road located near Kogan, Queensland (approximately, 250 km west-north-west of Brisbane) as shown in *Figure 1* of *Appendix A*. The road was first treated in August 2013. Coating occurs at 10-week intervals and the last application and maintenance was completed on 26th February 2015.

1.1 Objective

The objective of this study was to provide an independent evaluation of the performance of GRT7000 in suppressing dust from a section of treated road compared to an equivalent section of untreated road. The evaluation was based on the statistical comparison of dust field measurements for the treated and untreated sections of the road. Additionally a background location was used as reference point.

1.2 Scope of Work

The study was conducted by Simtars 16th–21th March 2015. The scope of work included the following:

- Identification of suitable dust monitoring sites at Kerrs Road, Kogan for the treated, untreated and the background location;
- Installation and operation of sampling equipment to measure dust emission from the road surface by two methods:
  - dust deposition was measured using Dust Deposition Gauges; and
  - Total Suspended Particulates (TSP) was measured using Microvol Gravimetric Sampler;
- Installation of a portable weather station to measure temperature, wind speed and direction;
- Analysis of the dust deposition samples by Simtars laboratory for insoluble solids, ash and combustible matter composition;
- Weighing of Microvol sample filters by Simtars laboratory and calculation of total suspended solids concentrations;
- Comparison of the results between the treated and untreated sites, with consideration of the background dust levels; and
- Statistical analysis and interpretation of the results.

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2 Background Information

GRT7000

GRT has formulated GRT7000 to minimise fugitive dust on unsealed roads. The product is manufactured directly by GRT and applied to seal roads for a wide range of applications including construction, forest, oil and gas projects, mine sites and other haulage roads.

According to the information provided, GRT7000 is a specially formulated 'non-ionising in water solution' liquid polymer engineered for use in civil construction. It is an aqueous emulsion with high solid content of styrene acrylic copolymer.

GRT7000 concentrate is simply added to a water truck and diluted with water to make anywhere from a 2.5% to 10% percent solution.

The applied solution of GRT7000 binds the silty dust particles together preventing them from becoming airborne. Subsequent maintenance applications will cause GRT7000 to build up and after a period of time, due to the accumulative residual of product, the application of GRT7000 can be suspended or reduced until blow on, tracked on, or traffic generated dust warrants another application of product.

The product components include:

- Nucleating agent;
- Surfactant;
- Emulsifier;
- De-foamer;
- Hydrophobic agent;
- Dispersive agent;
- pH control; and
- Adhesive agent.

Site Information

The site selected was located at Kerrs Road, near Kogan, Queensland (approximately 250 km west-north-west of Brisbane). The treated road section was south of Glen Mona Road junction (refer to *Figure 1* of *Appendix A*). The road is administered by the Queensland Western Downs Council and GRT was contracted to maintain roads in the Kogan area for Queensland Gas Company (QGC).

The road is used by both light and heavy vehicles involved in Coal Seam Gas (CSG) projects. The frequency of the heavy vehicles is approximately up to 60 per day. Light vehicle traffic is also due to the grazing and farming activities occurring at the properties adjoining the road.

The soil in the area is described as a sandy loam (Maher, 1996). GRT have not performed any soil analysis of the material at Kerrs Road. It is not known if any imported materials were used for the road construction.

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3 Assessment Criteria

Statistical analysis was used to quantify the comparisons of dust measurements (deposited mater and Total Suspended Particulates) between the treated and untreated sites. In statistical terminology, there is a null hypothesis (H0) and the alternate hypothesis (H1):

H0: Mean of Treated site result is greater than or equal to mean of Untreated site
(i.e. treatment is ineffective)

H1: Mean of the Treated site results is less than mean of the Untreated site
(i.e. treatment is effective).

Statistical analysis determines the probability that an outcome may have occurred by random chance. The analysis is about estimating the risk of being wrong in rejecting the null hypothesis if indeed it were true. If the risk (p) is sufficiently small, the null hypothesis is rejected and is called statistically significant. For the statistical testing employed for this project, the risk level used is $p = 0.01$ (1%).

Two types of statistical tests were selected for the analysis:

- The Student *t*-test is a well-known statistical test suitable for testing the difference between two means when there are only a limited number of samples (less than 30). The *t*-statistic is a derivative of the normal distribution (bell-shaped curve). This test is suitable for both dust deposition and total suspended particulate data.
- The Mann-Whitney test is a useful method which does not assume a specific underlying form of distribution. This test belongs to a class of tests termed “nonparametric”. It has several advantages over the parametric tests (such as the *t*-test) as it does not make as many assumptions. This test is suitable for total suspended particulate data only (a sample size limitation).

4 Methodology

4.1 Sampling Strategy

The project was scheduled to avoid sampling during or immediately after a significant rainfall with the objective of collecting data during normal to worst-case scenario (dustiest conditions).

The sampling sites were selected and setup with regards to *AS/NZS 3358.1.2007 Methods for sampling and analysis of ambient air – Guide to sitting air monitoring equipment*.

Dust deposition was conducted based upon *Simtars Procedure LP0182 - Procedure for Determination of Dust Deposition (AS3580.10.1).*

Dust monitoring was performed according to *AS/NZS 3580.9.9:2006 Methods for sampling of ambient air. Method 9.9: Determination of suspended particulate matter – PM_{10} low volume sampler – gravimetric method*.

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4.1.1 Sampling Locations

Sampling sites

The general sampling area for the project was selected by GRT near Kogan due to operational requirements. The project required three representative sampling sites:

- Site 1-treated section (20 metres);
- Site 2 -untreated section (20 metres); and
- Site 3 -background location (20 metres).

The sampling sites on Kerrs Road were selected as result of an inspection conducted by Simtars and GRT personnel based on the criteria outlined in the AN*/NZS 3580.1.2007 Methods for sampling and analysis of ambient air – Guide to sitting air monitoring equipment*. Specific requirements considered were:

- Select road segments with similar traffic loads;
- Not near road junctions or bends;
- Similar soil types;
- Open area, not encumbered by excessive vegetation;
- No nearby soil disturbance or activities;
- Sufficient separation between treated and untreated areas;
- Similar orientation to prevailing winds (expected to have some easterly component); and
- Safety aspects with regards to avoiding obstruction of road, safe access and vehicle parking.

The sampling sites selected are described in *Table 1* and shown in *Figure 1* and *Figure* 2 (*Appendix A*). Photographs of the sampling sites are shown in *Appendix B*. It was not possible to find sites in strict compliance with *AN/NZS 3580.1.2007* particularly with regards to nearby vegetation as Kerrs Road was located primarily in a forest area.

Table 1 Sampling sites location and description

Site Number	Description	Reference	Description
Site 1	Treated site	S27^{o} 08' 52" E150^{o} 46' 18"	Located on western side of roadway. Road orientation was north-south.
Site 2	Untreated site	S27^{o} 06' 19" E150^{o} 45' 42"	Located on western side of roadway. Road orientation was north-south.
Site 3	Background site	S27^{o} 06' 10" E150^{o} 45' 44"	Located on eastern side of roadway. Road orientation was north-south.

Monitoring points locations

Three (3) Dust Deposition Gauges were used at each of the three monitoring sites (Site 1, Site 2 and Site 3). Two (2) Microvol samplers were used at Sites 1 and 2, and a single sampler at Site 3. The site layout is outlined in *Figure 2* of *Appendix A.*

The setup included replicates which measure the variability of the sampling systems and consequently allow statistical analysis of the data to be performed.

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The monitoring points were installed assuming there would be some easterly component to the winds during the study. As such the monitoring equipment for the treated and untreated sites was placed on the western (downwind) side of the road and for the background site, on the eastern (upwind) side.

The monitoring points were selected with the aim of reproducing uniform conditions to ensure valid comparisons of dust generation, as free as possible from extraneous factors.

4.1.2 Sampling Techniques

Dust production from the treated and untreated road surfaces was measured using two techniques:

- **Dust deposition monitoring**. This is a 2-dimensional technique used to calculate the mass of dust per unit of surface area per day (a rate). This is a passive sampling technique typically used to assess nuisance dust levels using Dust Deposition Gauges.
- **Total suspended particulate monitoring**. This is a 3-dimensional technique that measures suspended particulates as mass of dust per cubic meter of air (concentration) using battery-powered Microvol samplers. This technique is related to dust which may be inhaled. For this study, the sampler was fitted with a Total Suspended Particulates (TSP) head as a wide range of particle sizes were of interest.

At Sites 1 and 2, three (3) Dust Deposition Gauges were located parallel to the road at 10 m intervals. Each Dust Deposition Gauge was located 7 m west from the road centre line at a standard 2 m height above the ground.

The two (2) Microvol samplers were located parallel to the road at 20 m intervals, 8 m west from the centre-line of the roadway to avoid interference with the Dust Deposition Gauges. The Microvol sampler's inlet height was set as 1.5 m above ground level.

At Site 3, three (3) Dust Deposition Gauges were located parallel to the road at 10 m intervals. Each Dust Deposition Gauge was located 31 m west from the road centre line at a standard 2 m height above the ground.

Only one (1) Microvol sampler was used at this location and it was installed 32 m east from the centre-line of the roadway. The Microvol sampler inlet height was set as 1.5 m above ground level.

Wind speed, direction and air temperature and rainfall were monitored using a portable weather station (Davis Vantage Pro 2). The station was mounted on a tripod and installed at the Site 3 (Background) 25 m from the road centreline to measure wind speed, wind direction, temperature and rainfall. The wind speed and direction sensors were located at a height of approximately 3 m and the windvane was checked for correct operation and aligned to true north.

4.1.3 Equipment

The sampling equipment is shown in *Figure 6* in *Appendix B.*

Weather Station

The Davis Vantage Pro 2 weather station is fitted with a wireless data logger unit (Davis Envoy) which reads the weather station's signal continuously and records the 10-minute averages, maxima and minima for each meteorological parameter. The console is placed in a protective box at the base of the weather station and the data were periodically downloaded and stored on a computer.

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Dust Deposition Gauges

These simple passive devices measure dust that falls out from the atmosphere. Deposited dust was sampled according to *Australian Standard AS 3580.10.1* (2003) which describes the collection of airborne particulate matter deposited into a circular collection device by the action of settling from the air. As required by the standard, the circular collection device consisted of a glass bottle fitted with a glass funnel of 150 mm diameter. The Standard requires deposited matter to be collected over a period of 30±2 days. However this project only monitored over 5 days as discussed in *Section 4.2 Limitations*.

Microvol samplers

Battery-powered low-volume Ecotech Microvol 1100 samplers were used at the three sites to measure Total Suspended Particulates. A Total Suspended Particulates head was fitted to the sampler which rejects particles greater than approximately 50 µm in size. The sampler was run for a 23.5-hour period at a flow rate of 3 L/min (0.18 m^3/hr). The sampler uses a volumetric constant flow-rate controller, which is compensated for temperature, barometric pressure and filter backpressure. The sampler directly measures the total volume of air which passed through the filter, corrected to standard conditions of 0^oC and 1013 hPa. The samplers was calibrated in the laboratory before the sampling event and do not require any calibration while in the field. The uncertainties quoted for the low-volume sampling methods are typically ±5 µg/m^3.

4.1.4 Analytical methodology

Dust Deposition Gauges

The collected samples are typically analysed to determine the weight of:

- Insoluble (combustible + ash)
  - The insoluble fraction is the material, which passes through a 1 mm sieve and is not soluble in water. It generally constitutes the bulk of the sample of interest. It consists of a combustible fraction and an ash (inorganic) component. The combustible component is the fraction of insoluble matter that is lost when the sample is burned in a high temperature laboratory furnace. It is determined by measuring the difference in weight between the insoluble fraction and the ash left after the sample is burned. The combustible portion represents the quantity of organic material in a sample. These organic materials may originate from the natural environment as leaves, bark, seeds, pollen, mould spores, algae, insects or bird droppings or from anthropogenic sources (particularly with coal mines). The ash content represents the mineral component of the deposited dust. It can contain natural soil components including clays, sand, pulverised rock or other materials such as iron oxide. Anthropogenic ash components can include metals from mining or from vehicle emissions.
- Soluble
  - The soluble fraction is the portion of the material that dissolves in water. It consists of various salts and may constitute a large proportion of a sample in seaside regions. Bird and animal dropping and urine may also contribute to the soluble content of the sample.

In summary, the following defines the relationships among the above components:

Total deposition = Soluble + Insoluble (Combustible + Ash)

For the current testing, the total and soluble solids results are not useful and consequently were omitted for this project.

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Microvol gravimetric analysis

This method determines the particulate concentration gravimetrically using 47 mm diameter, 2µm Teflon membrane filters. The weight gained by the filter during the sampling event is divided by this volume (corrected to standard conditions of 0^{o}C and 1013 hPa) to yield a measure of suspended particulates concentration in units of µg/m^3.

4.2 Limitations

National Association of Testing Authorities (NATA) accreditation applies to the dust deposition and Total Suspended Particulates measurements, but does not apply to the weather monitoring performed.

The exposure period to comply with *AS/NZS 3580.10.1:2003* defines a typical period of 30±2 days for routine monitoring programs. However, the dust gauge exposure period was 5 days due to the specialised requirements of this monitoring project.

A background sampling site was also setup to gauge baseline dust levels away from the road. This site proved to be of limited value for the study due to a number of constraints. The entire roadway is fenced and there were no suitable places found within a reasonable distance from the other two sites to establish a background site. As a compromise, a region of roadway was found at the Kogan creek crossing which had a short cement and bitumen cover. There was an area to the east of the creek crossing which allowed for the safe access. The location was selected as a reasonable distance from the roadway, commensurate with avoiding overhanging trees and safety issues associated with long grass (snakes) and fallen branches (trip hazards).

There was some upward drift with all the field blanks filters. The worst case was +0.057 mg relative to a limit of 0.03 mg. The resulting error is 15 µg/m^3 as an overestimation of Total Suspended Particulates. (The range for all the blanks was an increase of 0.028–0.057 mg with corresponding errors of 8–15 µg/m^3.)
The reason for this drift is not known as there was no significant drift with the laboratory blank (+0.003 mg). The filters were treated carefully. As this project is comparing the suspended particulates among sites, and the levels were very high at the untreated site, this drift should have no significant effect upon the conclusions drawn from the data.

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5 Results

5.1 Weather Data

Weather data for the study period (10-minute averages) were collected from the Simtars Davis weather station located at Site 3, the Background location.

No rainfall was recorded during the study period. The weather data for each sampling period are summarised in *Table 2*. *Figure 7–16* of *Appendix C* provides details regarding the wind conditions for each sampling period.

Table 2 Weather summary for the study period

Sampling Period	Temperature Minimum (°C)	Temperature Maximum (°C)	Wind Speed Average (km/hr)	Wind Speed Gust (km/hr)	Wind Direction range
16th–17th March 2015	18.4	31.4	4.7	25.7	North-north-easterly to East-north-easterly
17th–18th March 2015	19.6	30.3	5.8	25.7	Northerly to North-north-easterly
18th–19th March 2015	20.9	36.6	5.5	22.5	North-westerly to North-north-easterly
19th–20th March 2015	16.6	39.6	1.3	25.7	No predominant wind direction, calm conditions for substantial period.
20th–21st March 2015	23.1	40.7	3.2	24.1	North-north-easterly to East-south-easterly

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5.2 Dust Deposition Monitoring

The deposited matter results are detailed in *Table 3* (Site 1 - Treated), *Table 4* (Site 2 – Untreated) and *Table 5* (Site 3- Background). *Table 6* gives a description of the dust gauge contents.

Table 3 Deposited matter results for the Treated site (Site 1)

Site Number	Laboratory No.	Insoluble Solids ($mg/m^2/d$)	Ash (inorganic) Content ($mg/m^2/d$)	Combustible Solids ($mg/m^2/d$)	Combustibles as percentage of insoluble
Site 1 North	OE102408-01	61	28	33	54
Site 1 Centre	OE102408-02	47	24	23	49
Site 1 South	OE102408-03	61	25	36	59

Table 4 Deposited matter results for the Untreated site (Site 2)

Site Number	Laboratory No.	Insoluble Solids ($mg/m^2/d$)	Ash (inorganic) Content ($mg/m^2/d$)	Combustible Solids ($mg/m^2/d$)	Combustibles as percentage of insoluble
Site 2 North	OE102408-04	499	423	76	15
Site 2 Centre	OE102408-05	387	335	52	13
Site 2 South	OE102408-06	409	344	65	16

Table 5 Deposited matter results for the Background site (Site 3)

Site Number	Laboratory No.	Insoluble Solids ($mg/m^2/d$)	Ash (inorganic) Content ($mg/m^2/d$)	Combustible Solids ($mg/m^2/d$)	Combustibles as percentage of insoluble
Site 3 North	OE102408-07	52	24	28	54
Site 3 Centre	OE102408-08	87	46	41	47
Site 3 South	OE102408-09	87	50	37	43

Table 6 Description of dust deposition gauge contents

Site	Site Description	Comments
Site 1 North	Kerrs Rd, Treated surface	Small amount of black/brown organic debris, insects.
Site 1 Centre	Kerrs Rd, Treated surface	Small amount of black/brown organic debris, insects
Site 1 South	Kerrs Rd, Treated surface	Small amount of black/brown organic debris, insects
Site 2 North	Kerrs Rd, Untreated surface	Considerable amount of grey-brown sediment.
Site 2 Centre	Kerrs Rd, Untreated surface	Considerable amount of grey-brown sediment, insects
Site 2 South	Kerrs Rd, Untreated surface	Considerable amount of grey-brown sediment.
Site 3 North	Kerrs Rd, Background	Small amount of black/brown organic debris, piece of grass, insects.
Site 3 Centre	Kerrs Rd, Background	Small amount of black/brown organic debris, plant materials.
Site 3 South	Kerrs Rd, Background	Small amount of black/brown organic debris, plant materials and insects.

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5.3 Total Suspended Particulates (TSP)

The results are tabulated in *Table 7 – Table 11*, representing each of the five sampling periods. The results are expressed in units of normalised volume.

Table 7 TSP results of 16th-17th March 2015

Site Number	Laboratory No.	Sampling Period	Sampling time	Volume sampled (Normal m^3)	Total Suspended Particulates (µg/m^3)
Site 1 North	OE102408-10	13:15–12:45	23.5 hrs	3.71	36
Site 1 South	OE102408-12	13:15–12:45	23.5 hrs	3.71	39
Mean					**38**
Standard Dev.					2.1

Site Number	Laboratory No.	Sampling Period	Sampling time	Volume sampled (Normal m^3)	Total Suspended Particulates (µg/m^3)
Site 2 North	OE102408-13	13:15–12:45	23.5 hrs	3.59	230
Site 2 South	OE102408-14	13:15–12:45	23.5 hrs	3.72	180
Mean					**205**
Standard Dev.					35.3

Site Number	Laboratory No.	Sampling Period	Sampling time	Volume sampled (Normal m^3)	Total Suspended Particulates (µg/m^3)
Site 3 Centre	OE102408-15	13:35–13:05	23.5 hrs	3.70	54

Table 8 TSP results for 17th–18th March 2015

Site Number	Laboratory No.	Sampling Period	Sampling time	Volume sampled (Normal m^3)	Total Suspended Particulates (µg/m^3)
Site 1 North	OE102408-16	13:15–12:45	23.5 hrs	3.70	45
Site 1 South	OE102408-18	13:15–12:45	23.5 hrs	3.71	36
Mean					**41**
Standard Dev.					6.4

Site Number	Laboratory No.	Sampling Period	Sampling time	Volume sampled (Normal m^3)	Total Suspended Particulates (µg/m^3)
Site 2 North	OE102408-19	13:35-13:05	23.5 hrs	3.66	173
Site 2 South	OE102408-20	13:35-13:05	23.5 hrs	3.72	135
Mean					**154**
Standard Dev.					26.9

Site Number	Laboratory No.	Sampling Period	Sampling time	Volume sampled (Normal m^3)	Total Suspended Particulates (µg/m^3)
Site 3 Centre	OE102408-21	13:50–13:20	23.5 hrs	3.70	59

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Table 9 TSP results for 18th–19th March 2015

Site Number	Laboratory No.	Sampling Period	Sampling time	Volume sampled (Normal m^3)	Total Suspended Particulates ($\mu g/m^3$)
Site 1 North	OE102408-22	13:15–12:45	23.5 hrs	3.66	43
Site 1 South	OE102408-24	13:15–12:45	23.5 hrs	3.67	37
Mean					**40**
Standard Dev.					4.2

Site Number	Laboratory No.	Sampling Period	Sampling time	Volume sampled (Normal m^3)	Total Suspended Particulates ($\mu g/m^3$)
Site 2 North	OE102408-25	13:35–13:05	23.5 hrs	3.66	124
Site 2 South	OE102408-26	13:35–13:05	23.5 hrs	3.67	105
Mean					**115**
Standard Dev.					13.4

Site Number	Laboratory No.	Sampling Period	Sampling time	Volume sampled (Normal m^3)	Total Suspended Particulates ($\mu g/m^3$)
Site 3 Centre	OE102408-27	13:50–13:20	23.5 hrs	3.66	56

Table 10 TSP results for 19th–20th March 2015

Site Number	Laboratory No.	Sampling Period	Sampling time	Volume sampled (Normal m^3)	Total Suspended Particulates ($\mu g/m^3$)
Site 1 North	OE102408-28	13:15–12:45	23.5 hrs	3.67	32
Site 1 South	OE102408-30	13:15–12:45	23.5 hrs	3.68	60
Mean					**46**
Standard Dev.					19.8

Site Number	Laboratory No.	Sampling Period	Sampling time	Volume sampled (Normal m^3)	Total Suspended Particulates ($\mu g/m^3$)
Site 2 North	OE102408-31	13:35–13:05	23.5 hrs	3.67	210
Site 2 South	OE102408-32	13:35–13:05	23.5 hrs	3.67	180
Mean					**195**
Standard Dev.					21.2

Site Number	Laboratory No.	Sampling Period	Sampling time	Volume sampled (Normal m^3)	Total Suspended Particulates ($\mu g/m^3$)
Site 3 Centre	OE102408-33	13:50–13:20	23.5 hrs	3.66	139

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Table 11 TSP results for 20th–21th March 2015

Site Number	Laboratory No.	Sampling Period	Sampling time	Volume sampled (Normal m^3)	Total Suspended Particulates ($\mu g/m^3$)
Site 1 North	OE102408-34	13:15–12:45	23.5 hrs	3.64	43
Site 1 South	OE102408-36	13:15–12:45	23.5 hrs	3.65	46
Mean					**45**
Standard Dev.					2.1

Site Number	Laboratory No.	Sampling Period	Sampling time	Volume sampled (Normal m^3)	Total Suspended Particulates ($\mu g/m^3$)
Site 2 North	OE102408-37	13:35–13:05	23.5 hrs	3.65	167
Site 2 South	OE102408-38	13:35–13:05	23.5 hrs	3.64	143
Mean					**155**
Standard Dev.					17.0

Site Number	Laboratory No.	Sampling Period	Sampling time	Volume sampled (Normal m^3)	Total Suspended Particulates ($\mu g/m^3$)
Site 3 Centre	OE102408-39	13:50–13:10	23.5 hrs	3.63	41

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6 Data Analysis and Discussion

6.1 Weather

The sampling sites were setup assuming there would be some easterly component to the winds during the study. As such the sampling equipment for the treated (Site 1) and untreated (Site 2) sites was placed on the western (downwind) side of the road and for the background site (Site 3), on the eastern (upwind) side.
The data from the on-site weather station (*Section 5.1* and *Figure 7–16* of *Appendix C*) showed that this was generally a reasonable assumption except for the 18th–19th March 2015 sampling period, where there was some north-westerly winds.

6.2 Dust Deposition Monitoring

For the current testing, the total and soluble solids results are not considered useful and consequently were omitted for this project. Therefore, only the insoluble solids component was evaluated.

Total dust deposition = Soluble Solids + Insoluble Solids (Combustible + Ash)

The insoluble solids data are summarised for the three sites in *Table 12* and are expressed as daily average.
The ash fraction of the insoluble solids is summarised in *Table 13* and the combustible fraction is summarised in *Table* 14.

The insoluble solids results are shown graphically in *Figure 17* (*Appendix C)*. The proportional composition of the insoluble solids at each sampling site is shown in *Figure 18* (*Appendix C)*.

Table 12 Insoluble Solids Deposition Monitoring data between 16th and 21st of March 2015 (daily average)

Site Location	Site 1 (Treated) Insoluble (mg/m^2/day)	Site 2 (Untreated) Insoluble (mg/m^2/day)	Site 3 (Background) Insoluble (mg/m^2/day)
North	61	499	52
Centre	47	387	87
South	61	409	87
Mean	**56**	**432**	**75**
Standard Dev.	8.1	59.3	20.2

Table 13 Ash Solids Deposition data between 16th and 21st of March 2015 (daily average)

Site Location	Site 1 (Treated) Ash (mg/m^2/day)	Site 2 (Untreated) Ash (mg/m^2/day)	Site 3 (Background) Ash (mg/m^2/day)
North	28	423	24
Centre	24	335	46
South	25	344	50
Mean	**26**	**367**	**40**
Standard Dev.	2.1	48.4	14.0

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Table 14 Combustible Solids deposition data between 16^{th} and 21^{st} of March 2015 (daily average)

Site Location	Site 1 (Treated) Combustible (mg/m^2/day)	Site 2 (Untreated) Combustible (mg/m^2/day)	Site 3 (Background) Combustible (mg/m^2/day)
North	33	76	28
Centre	23	52	41
South	36	65	37
Mean	**31**	**64**	**35**
Standard Dev.	6.8	12.0	6.7

The dust deposition results for insoluble solids show that Site 1 (treated) and Site 3 (background) were both notably lower than the Site 2 (untreated). The untreated site mean for insoluble solids was more than seven times that of the treated site.

The treated site had both the lowest insoluble solids mean and also the lowest standard deviation of the three sites. The background site had a higher mean result than the treated site. This indicates the location of the background site was not optimum.

Ash solids are indicative of mineral matter which is the expected content of the dust from the untreated road surface. The results show a marked difference between the treated and untreated sites. The result for the untreated site mean was 14 times higher than the treated site. The untreated site had the highest proportion of ash solids relative to combustible solids. The treated site had the highest proportion of combustible solids which reflects the lower entrainment of road dust at the treated site and greater influence of organic material from the surrounding trees and grasses.

Once again the background site had a greater mean ash solids result than the treated site (by 1.5 times).

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6.3 Total Suspended Particulates (TSP)

The Total Suspended Particulates data for the three sites are summarised in *Table 15* (as daily averages for Site 1 and Site 2, and the result for Site 3). These data are graphed as *Figure 19* of *Appendix C*. This box-and–whiskers plot is a method of visually comprehending trends and variability in a dataset. The box represents the interquartile range, which represents 50% of the data (25% above and below the median). The internal line represents the median (the mid-point in ranked data). The whiskers represent 1.5 times above the third and below the first the interquartile range. “Outliers” are identified as being above or below this statistic.

Table 15 Combined data for Total Suspended Particulates

Sampling period	Site 1 (Treated) TSP μg/m^3	Site 2 (Untreated) TSP μg/m3	Site 3 (Background) TSP μg/m3
16th-17th Mar 15	38	205	54
17th-18th Mar 15	41	154	59
18th-19th Mar 15	40	115	56
19th-20th Mar 15	46	195	139
20th-21th Mar 15	45	155	41
Minimum	32	105	41
Maximum	60	230	139
Mean	**42**	**165**	**70**
Median	41	170	56
Standard Deviation	7.9	38.6	39.3

The treated site had both the lowest mean/median and also the lowest variability of the three sites. There was a marked difference between the untreated site and the other sites. The TSP mean for the untreated site was four times that of the treated site. The TSP data for the untreated site data showed a small amount of negative skewing (distribution around the mean is asymmetric with more extreme values at the low-end of the data).

There is a similarity between the treated location and the background location. The background results were slightly higher than those from the treated site and statistically showed higher variability with outliers. This indicates the location of the background site was not optimum (as previously noted).

The variation of TSP at each site with time is shown in *Figure 20* of *Appendix C*. The TSP at the treated site remained at a relatively low level and constant over the 5 days of the project. The untreated site showed a steady decrease for the first three days of sampling, which was not reflected at the other sites. The reason for this is not apparent. A peak was evident at both the untreated and background locations for the 19th–20th March 2015 sampling period. At this time the weather data showed that the average wind speeds were low and showed no predominant direction (*Table 2, Figure 13* and *Figure 14* of *Appendix C*).

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6.4 Statistical analysis

The dust deposition data are given in *Table 3* (Site 1, Treated) and *Table 4* (Site 2, Untreated). The total suspended particulate data are given in *Table 7–Table 11*.

The results for the untreated site were notably greater that those from the other two locations for both the dust deposition and Total Suspended Particulates. A Student "*t*" statistical test was used to quantify this relationship for the treated and untreated sites.

The Total Suspended Particulates data obtained from the study were combined for statistical analysis, divided into Site 1 (Treated) and Site 2 (Untreated) as given in *Table 15*.

The statistical test was performed on these data using the standard t-test formula (Zar, 1984), for two-samples as a 1-tailed test.

The statistical null hypothesis tested was: dust levels were either equal at both sites or greater at the treated site (i.e. the product does nothing or makes the road dustier).

The results of the statistical testing at the 1% error level (*Table 16*) were in all cases to reject the Null Hypothesis (and accept the Alternate Hypothesis) and conclude there is significantly less dust at the treated site than at the untreated site. This was true for the Total Suspended Particulates, insoluble solids, ash solids (mineral-matter) and combustible solids deposition.

The data for Total Suspended Particulates were also subjected to the non-parametric Mann-Whitney (U) statistical test (*Table 17*). The result was again to reject the null hypothesis at the 1% error level and conclude there is significantly less dust at the treated site than at the untreated site. It was not possible to use this statistical test with the dust deposition data as the sample set was too small.

Table 16 Summary of statistical results comparing Site 1 and Site 2 (parametric Student "*t*" test)

H0: Mean of Treated site is greater than or equal to Mean of Untreated site H1: Mean of the Treated site is less than mean of the Untreated site Tails for test: 1				
	Total Suspended Particulates	**Insoluble Solids Deposition**	**Ash Solids Deposition**	**Combustible Solids Deposition**
t-test result	-9.866	-10.855	-12.211	-4.223
t-test critical level	-2.552	-3.747	-3.747	-3.747
Degrees of Freedom	18	4	4	4
Level of Significance (alpha)	1%	1%	1%	1%
Result	Reject H0	Reject H0	Reject H0	Reject H0

Table 17 Statistical test result comparing Site 1 and Site 2 (non-parametric Mann-Whitney test)

H0: Mean of Treated site is greater than or equal to Mean of Untreated site H1: Mean of the Treated site is less than mean of the Untreated site Tails for test: 1	**Total Suspended Particulates**
Mann-Whitney U-test result	100
Mann-Whitney critical level	81
Level of Significance (alpha)	1%
Result	Reject H0

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7 Conclusions

Simtars was engaged by Global Road Technologies (GRT) to provide independent evaluation/measurements based on a statistical comparison of field data to evaluate the performance of GRT commercial product polymer GRT7000 in suppressing dust from a section of treated compared to untreated road.

The testing was conducted by Simtars at three locations on Kerrs Road, Kogan between 16th and 21th March 2015. The testing involved measurement of dust production from 20 metres sections of treated and untreated road by two different methods: dust deposition gauges for deposited dust and Microvol samplers to measure Total Suspended Particulates.

A background site was also monitored to access general dust levels in the region; however this proved to be of limited value and not used for this project.

The insoluble solids dust deposition results showed that the treated site had notably lower deposition than the untreated site. The untreated site's mean for insoluble solids was more than seven times that of the treated site. Similarly, ash solids deposition showed a marked difference between the treated and untreated sites. The result for the untreated site mean was 14 times higher than the treated site. The untreated site had the highest proportion of ash solids relative to combustible solids. Ash solids are indicative of mineral matter which is the expected content of the dust from the untreated road surface. The treated site had the highest proportion of combustible solids which reflects the lower entrainment of road dust at the treated site and greater influence of organic material from the surrounding trees and grasses.

The other dust monitoring technique, for Total Suspended Particulates, showed a similar relationship between measurements at the treated compared to untreated site: the TSP mean for the untreated site was four times that of the treated site.

The conclusions were then tested for statistical validity. Two hypotheses were tested:

- **Null Hypothesis:** Mean of Treated site result is greater than or equal to mean of Untreated site ; and
- **Alternate Hypothesis:** Mean of the Treated site result is less than mean of the Untreated site

The Null Hypothesis (H0) says that the treatment is ineffective; it does nothing or increases the dust.
The Alternate Hypothesis (H1) says that the treatment is effective and reduces dust production. Only one of these hypotheses can be true. Under statistics theory the Null Hypothesis can never be proven true, it can only be falsified.

Statistical testing was performed using two different techniques on the TSP data. This was done to verify the results. Unfortunately only one technique could be used for the dust deposition data as the Mann-Whitney Test requires a more extensive sampling campaign.

All the statistical tests performed managed to falsify the Null Hypothesis and accept the Alternate Hypothesis. This was the case for TSP and insoluble solids, ash solids and combustible solids deposition.

The results showed, statistically, that at Kerrs Road during the period 16th–21th March 2015 the applied GT7000 product was effective at supressing dust. It decreased the mean insoluble fraction of deposited dust by 7 times and the TSP by 4 times.

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Appendix A: Site Location

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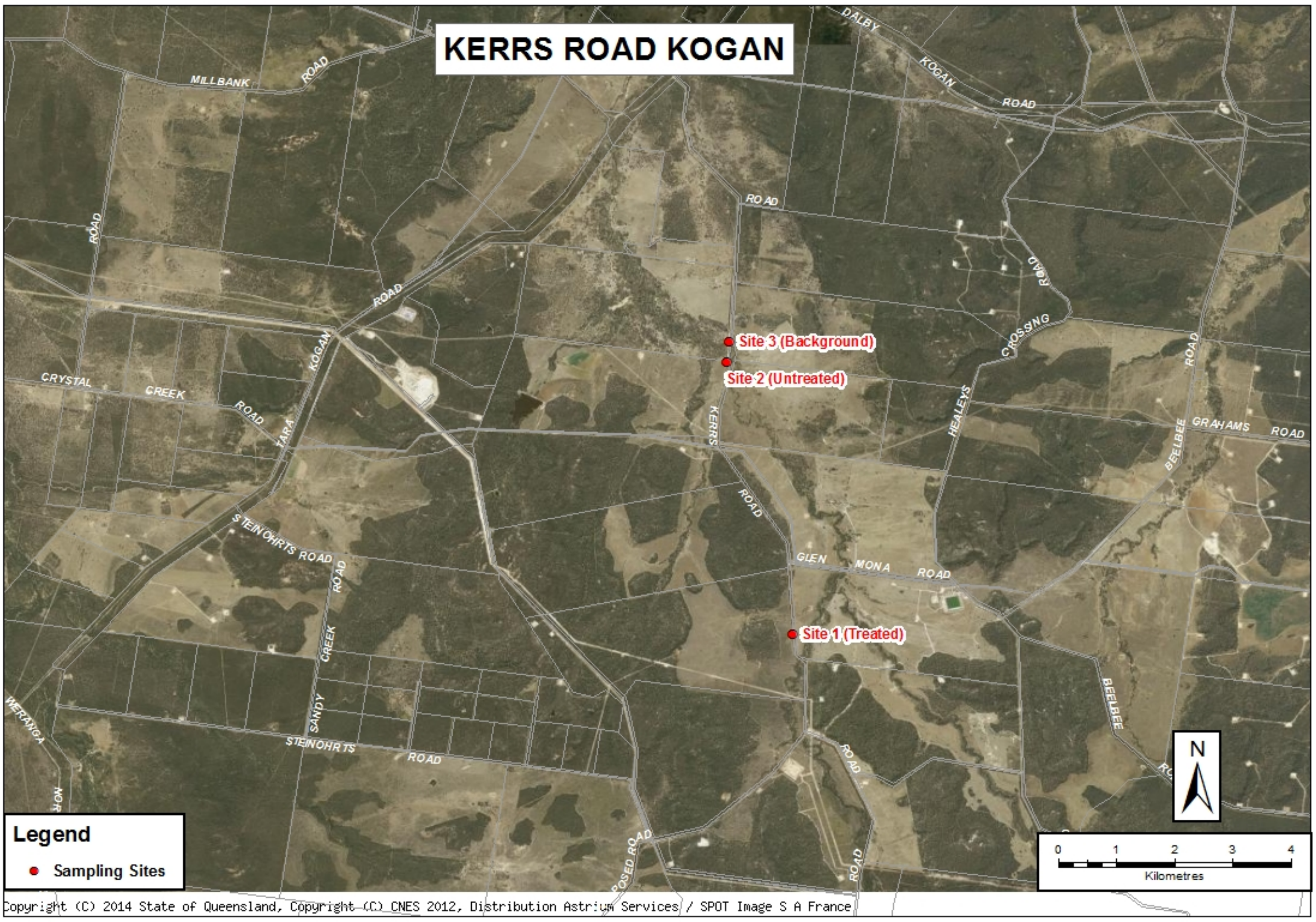

Figure 1 Map showing sampling location of background, treated and untreated sites

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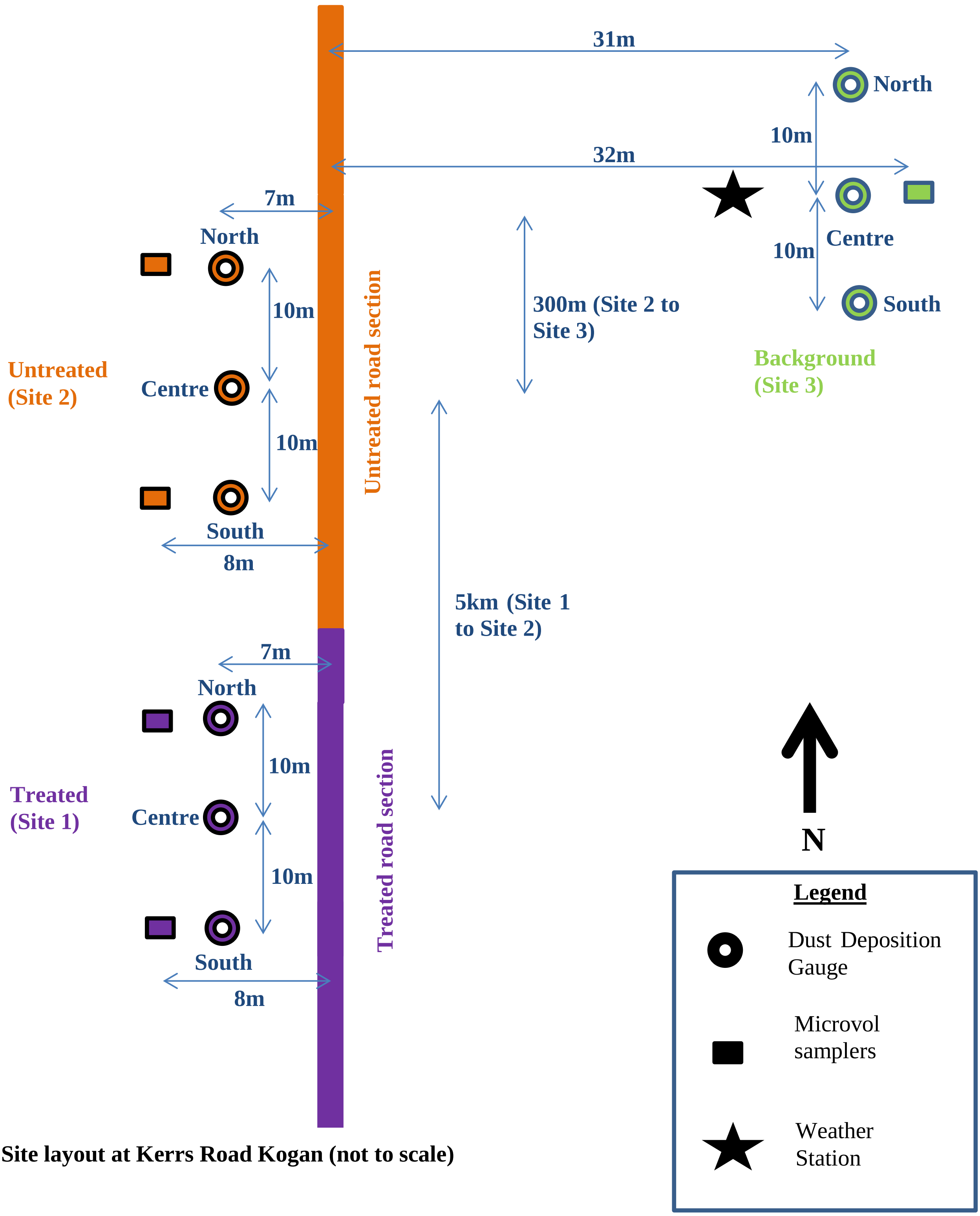

Figure 2 Site layout at Kerrs Road Kogan (not to scale)

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Appendix B: Site Photographs

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Site 1 Treated, looking to the south

Site 1 Treated, looking to the north

Site 1 Treated, looking to the west

Site 1 Treated, looking to the south

Site 1 Treated, road surface looking to the south

Site 1 Treated, close view of surface

Figure 3 photographs of Site 1 (Treated road)

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Site 2 Untreated, looking to the south-west

Site 2 Untreated, looking to the south

Site 2 Untreated, looking to the south-east

Site 2 Untreated, looking to the north

Site 2 Untreated, road surface looking to the south

Site 2 Untreated, close view of surface

Figure 4 Photographs of Site 2 (Untreated road)

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Site 3 Background, looking to the east

Site 3 Background, looking to the south-east

Site 3 Background, looking to the south at Kogan Creek crossing (Site is at top left)

Site 3 Background, looking to the east at Kogan Creek (Site is at top right)

Site 3 Background, road surface looking to the south

Site 3 Background, road surface looking to the north

Figure 5 Photographs of Site 3 (Background)

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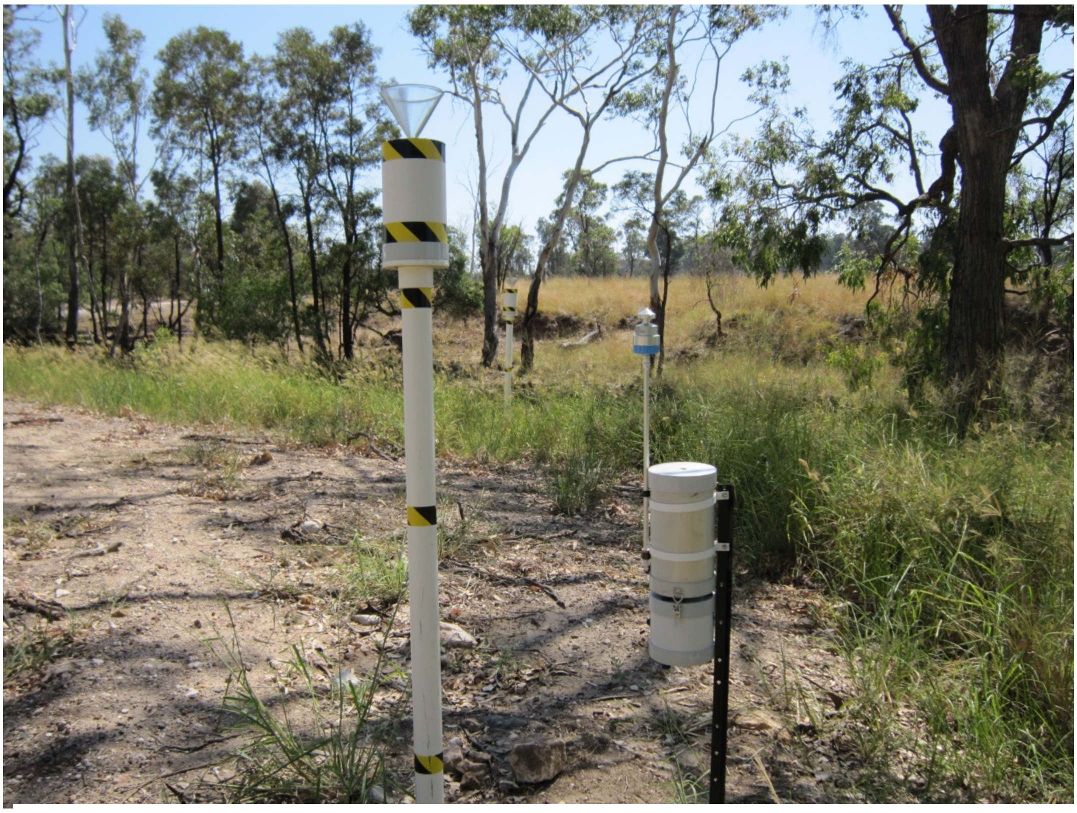
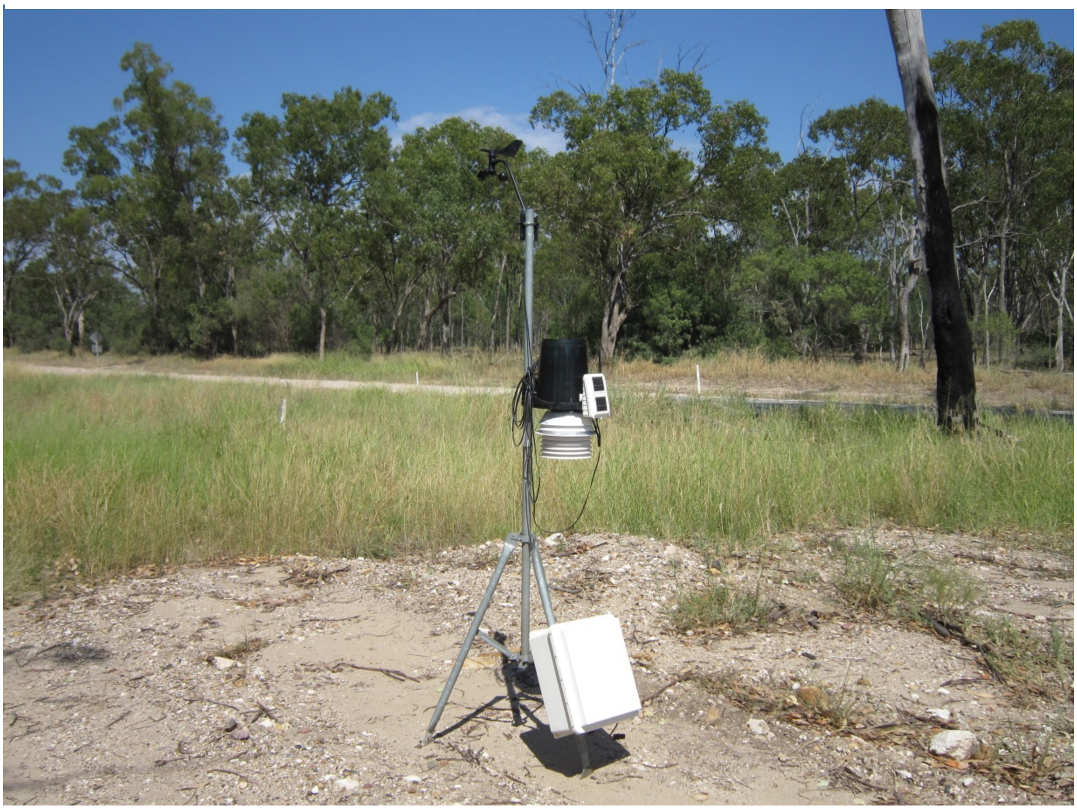


Site 3 Background, looking to the north, showing close view of Dust Deposition Gauge and Microvol sampler



Site 3 Background, looking to the south-west, showing close view of the portable weather station

Figure 6 Photographs of Site 3 showing close view of the dust monitoring equipment

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Appendix C: Figures

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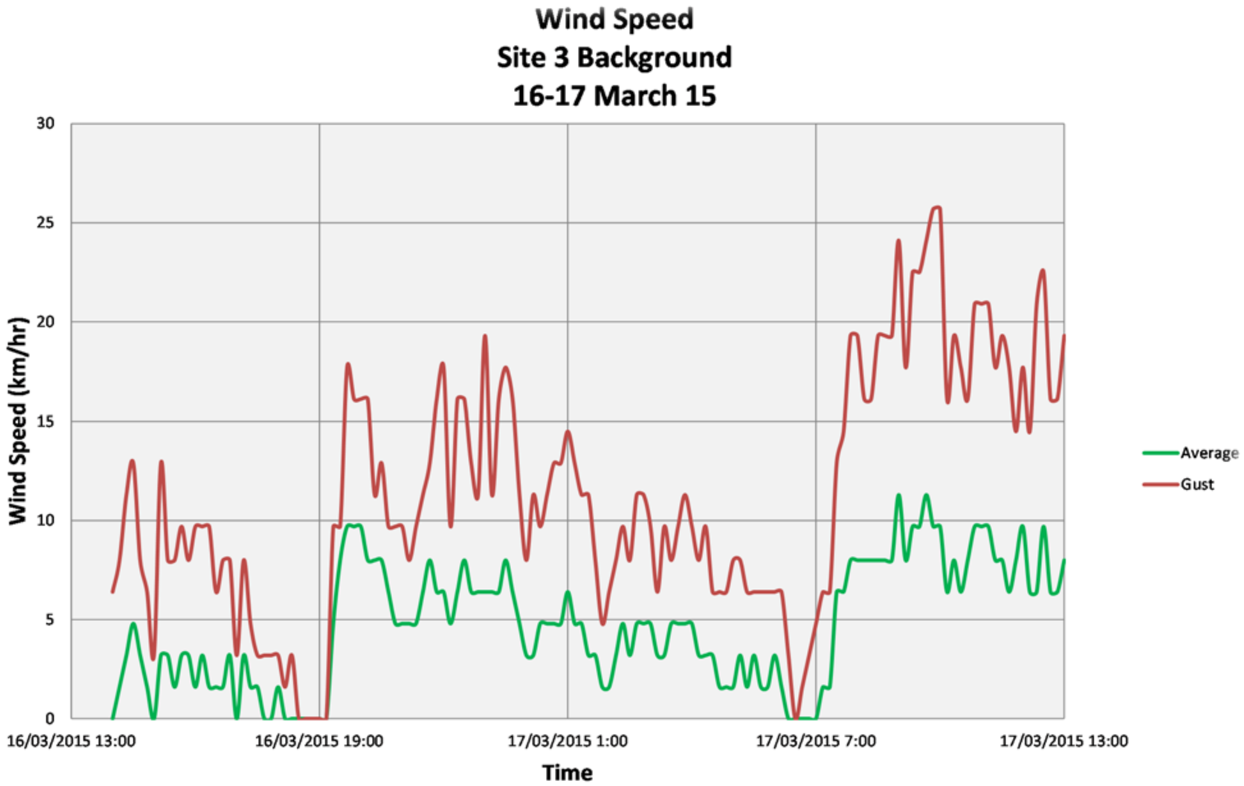
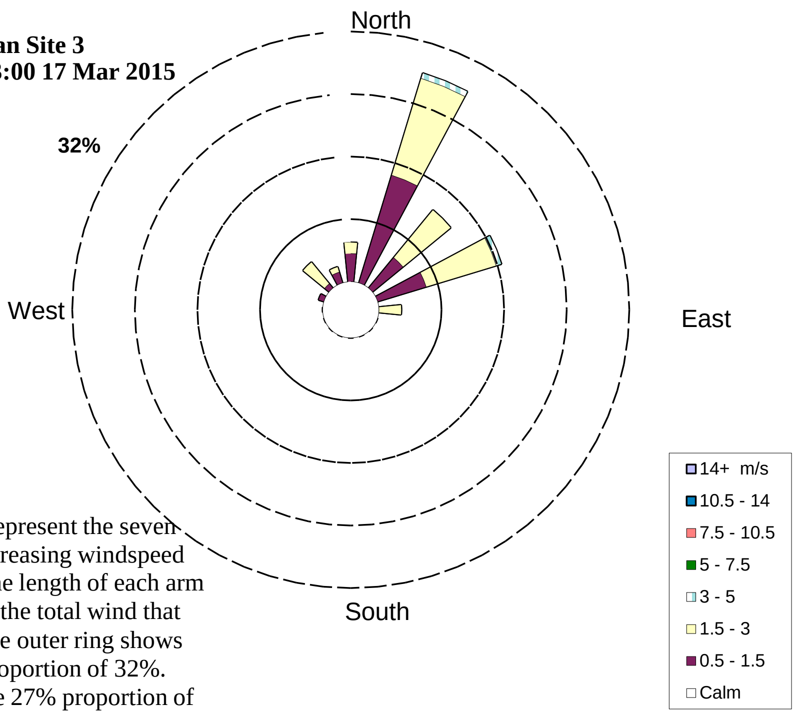


Figure 7 Wind speed 16-17 March 2015

Location: Kerrs Rd Kogan Site 3
Dates: 14:00 16 Mar - 13:00 17 Mar 2015
Averaging time: 10 min



The segments of each arm represent the seven wind speed classes, with increasing windspeed from the centre outwards.The length of each arm represents the proportion of the total wind that blew from that direction. The outer ring shows the length equivalent to a proportion of 32%. The inner ring represents the 27% proportion of calm conditions.

Figure 8 Windrose 16-17 March 2015

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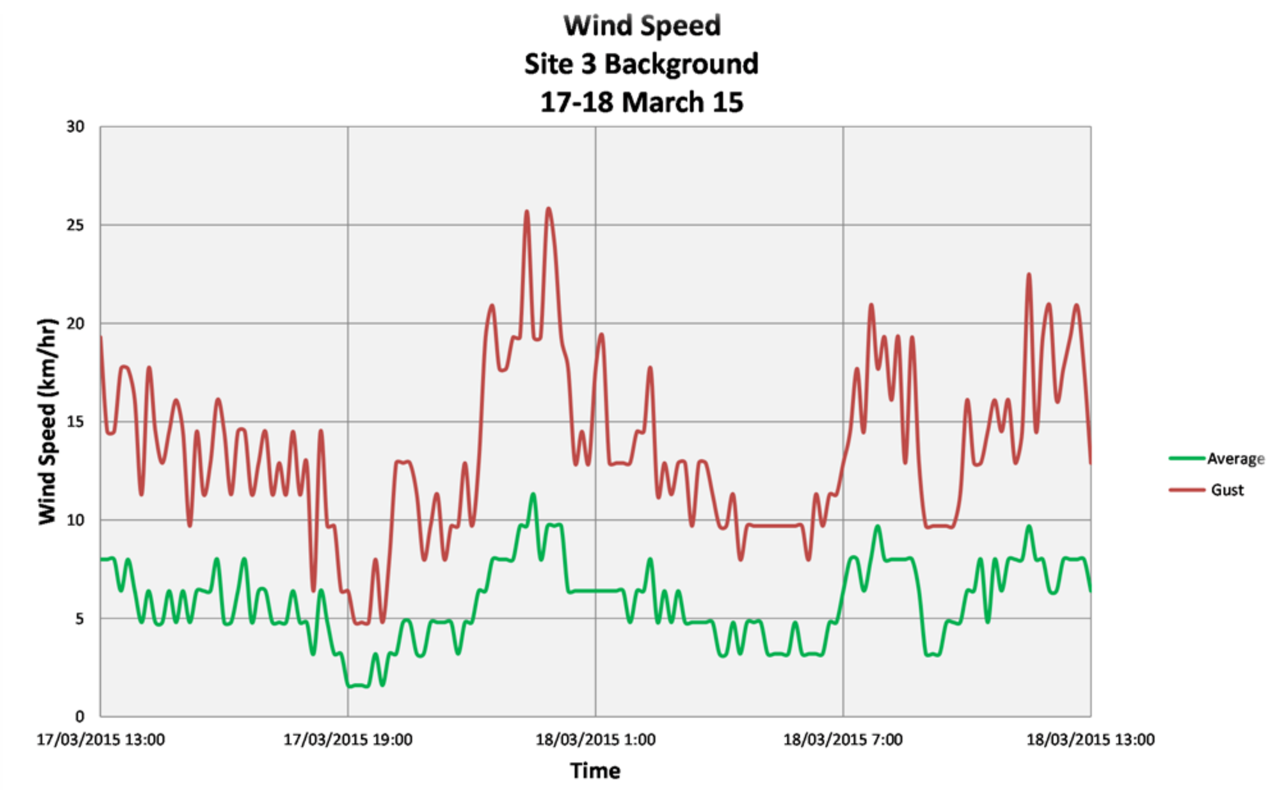

Figure 9 Wind speed 17-18 March 2015

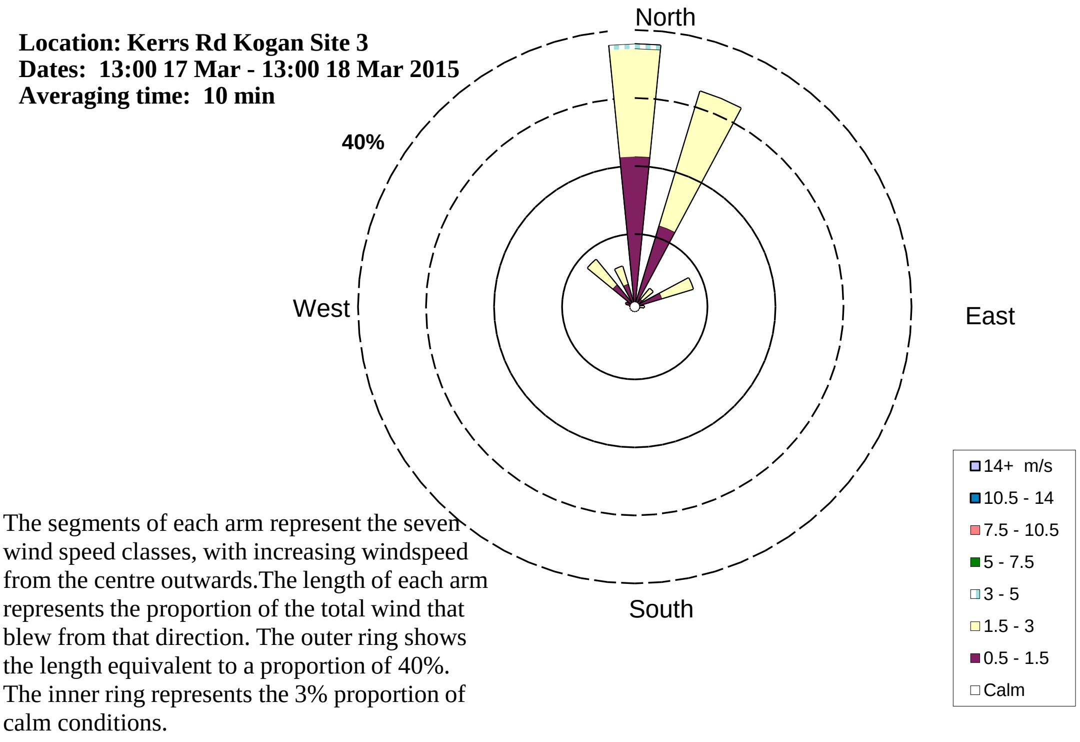

Figure 10 Windrose 17-18 March 2015

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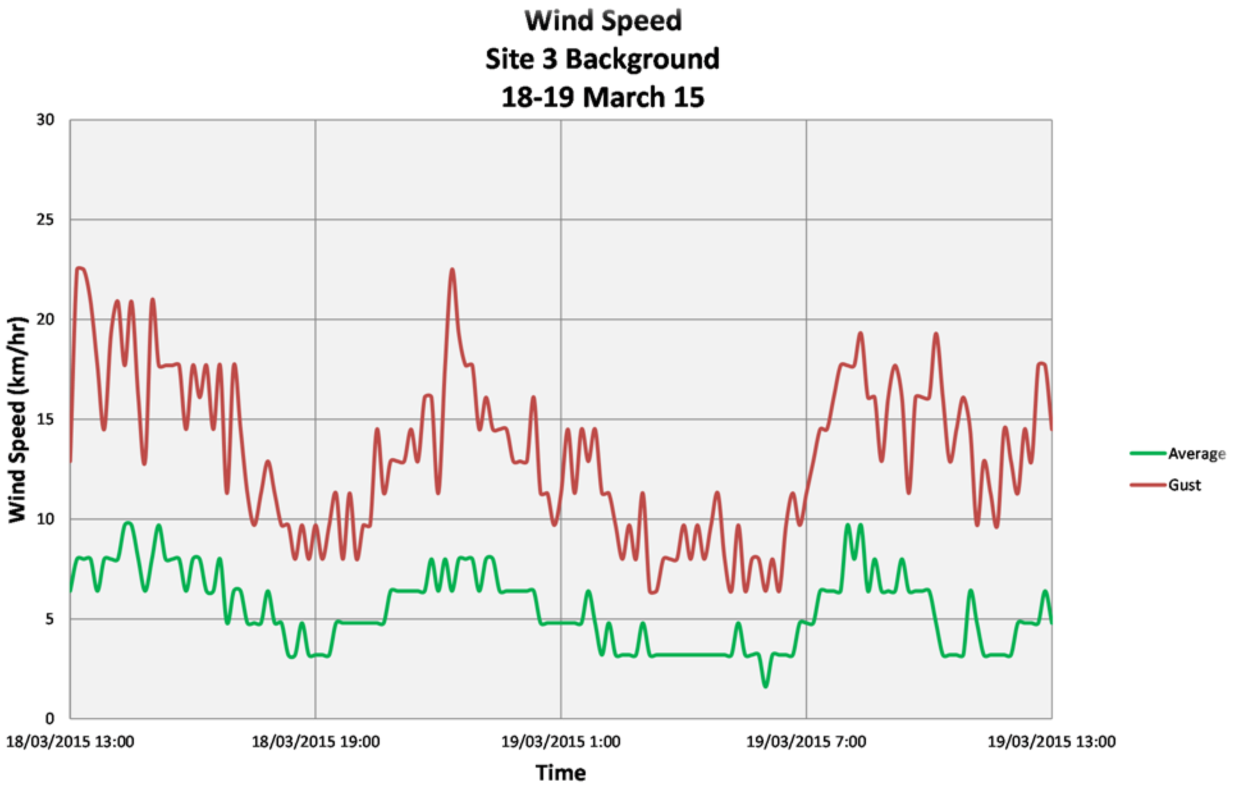
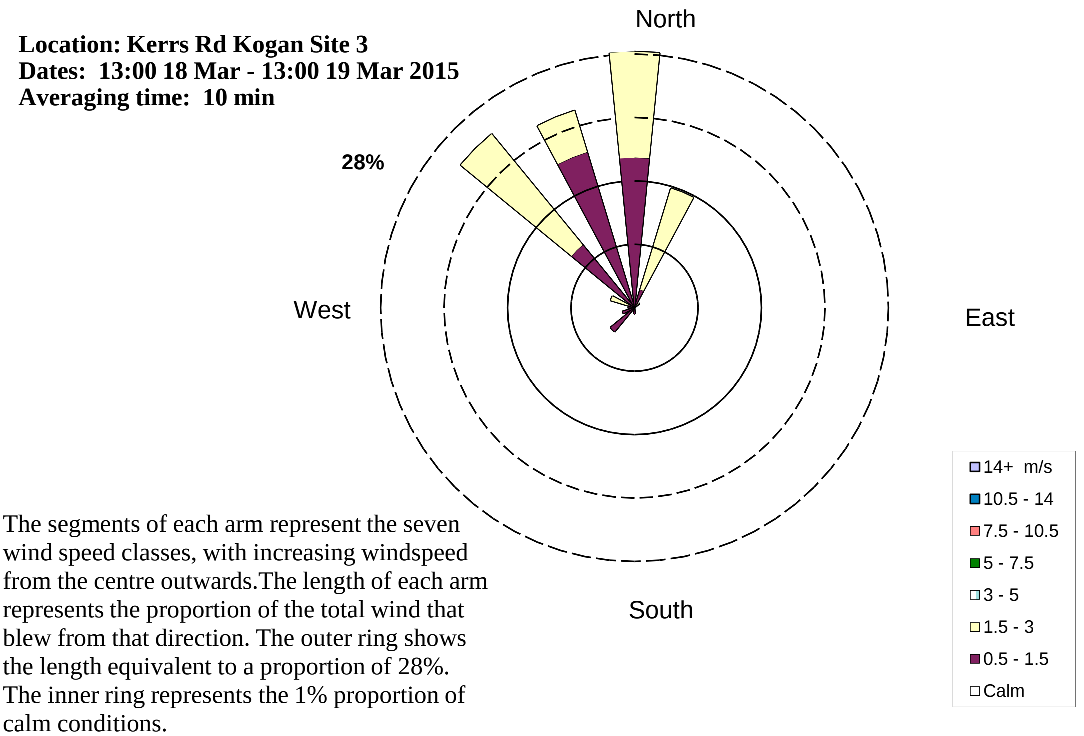


Figure 11 Wind speed 18-19 March 2015



The segments of each arm represent the seven wind speed classes, with increasing windspeed from the centre outwards.The length of each arm represents the proportion of the total wind that blew from that direction. The outer ring shows the length equivalent to a proportion of 28%. The inner ring represents the 1% proportion of calm conditions.

Figure 12 Windrose 18-19 March 2015

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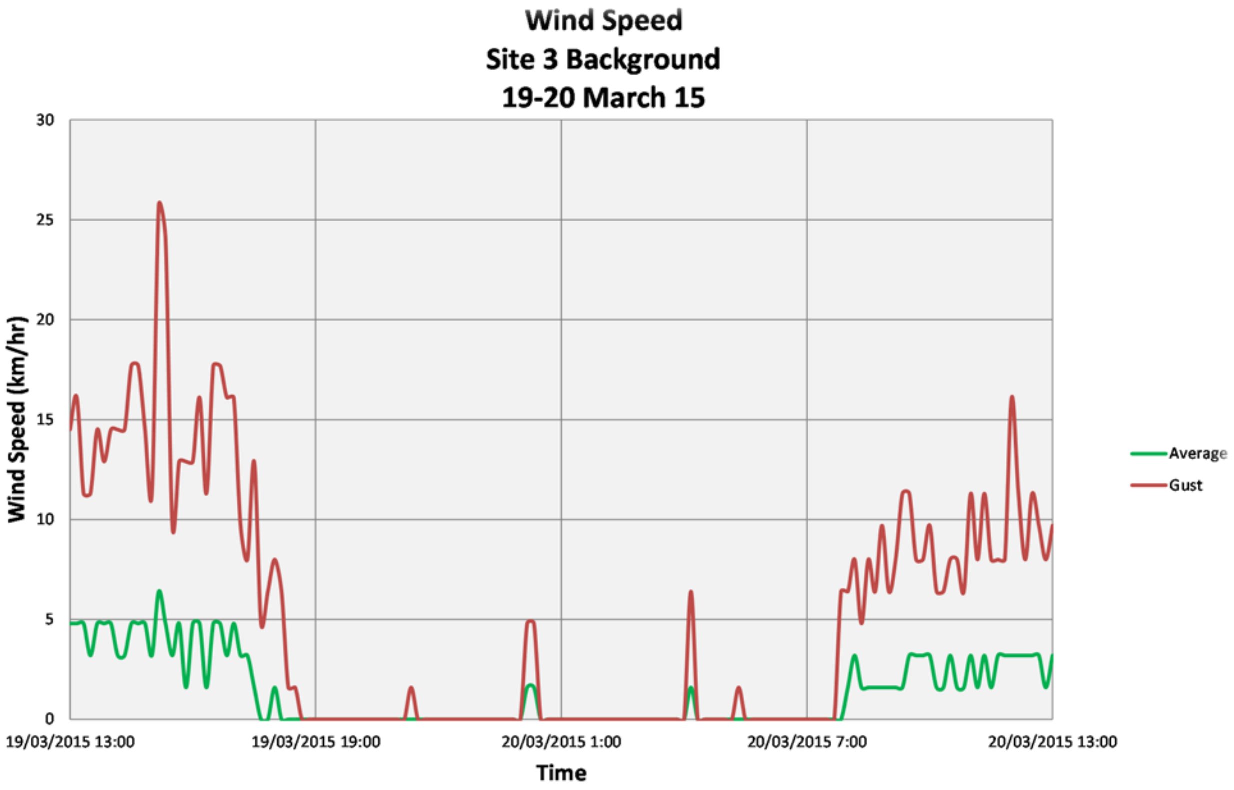
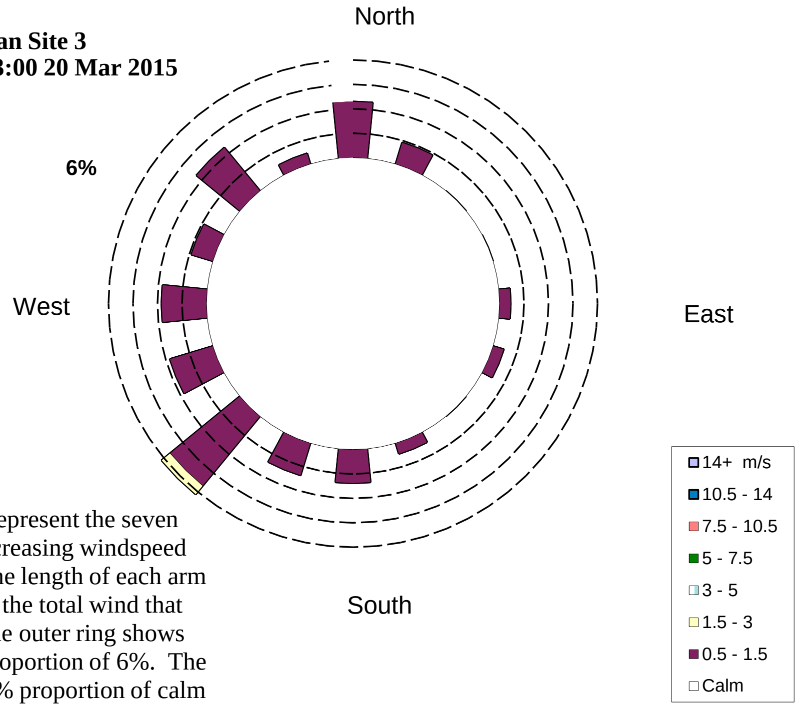


Figure 13 Wind speed 19-20 March 2015

Location: Kerrs Rd Kogan Site 3
Dates: 13:00 19 Mar - 13:00 20 Mar 2015
Averaging time: 10 min



The segments of each arm represent the seven wind speed classes, with increasing windspeed from the centre outwards.The length of each arm represents the proportion of the total wind that blew from that direction. The outer ring shows the length equivalent to a proportion of 6%. The inner ring represents the 72% proportion of calm conditions.

Figure 14 Windrose 19-20 March 2015

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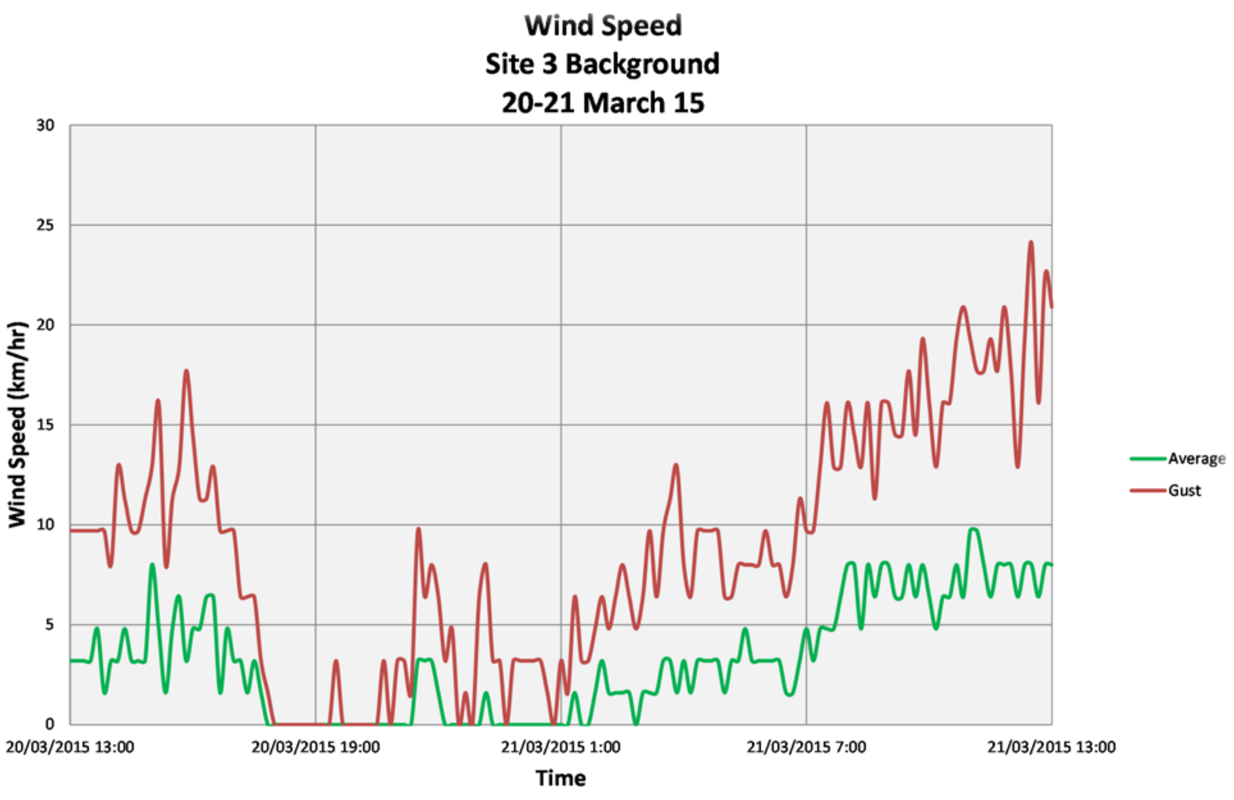
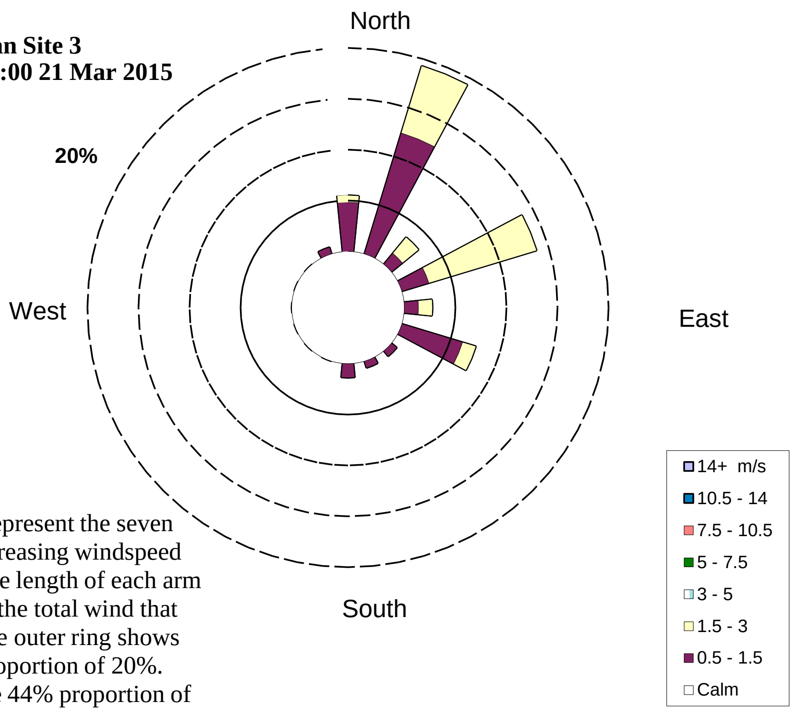


Figure 15 Wind speed 20-21 March 2015

Location: Kerrs Rd Kogan Site 3
Dates: 13:00 20 Mar - 13:00 21 Mar 2015
Averaging time: 10 min



The segments of each arm represent the seven wind speed classes, with increasing windspeed from the centre outwards.The length of each arm represents the proportion of the total wind that blew from that direction. The outer ring shows the length equivalent to a proportion of 20%. The inner ring represents the 44% proportion of calm conditions.

Figure 16 Windrose 20-21 March 2015

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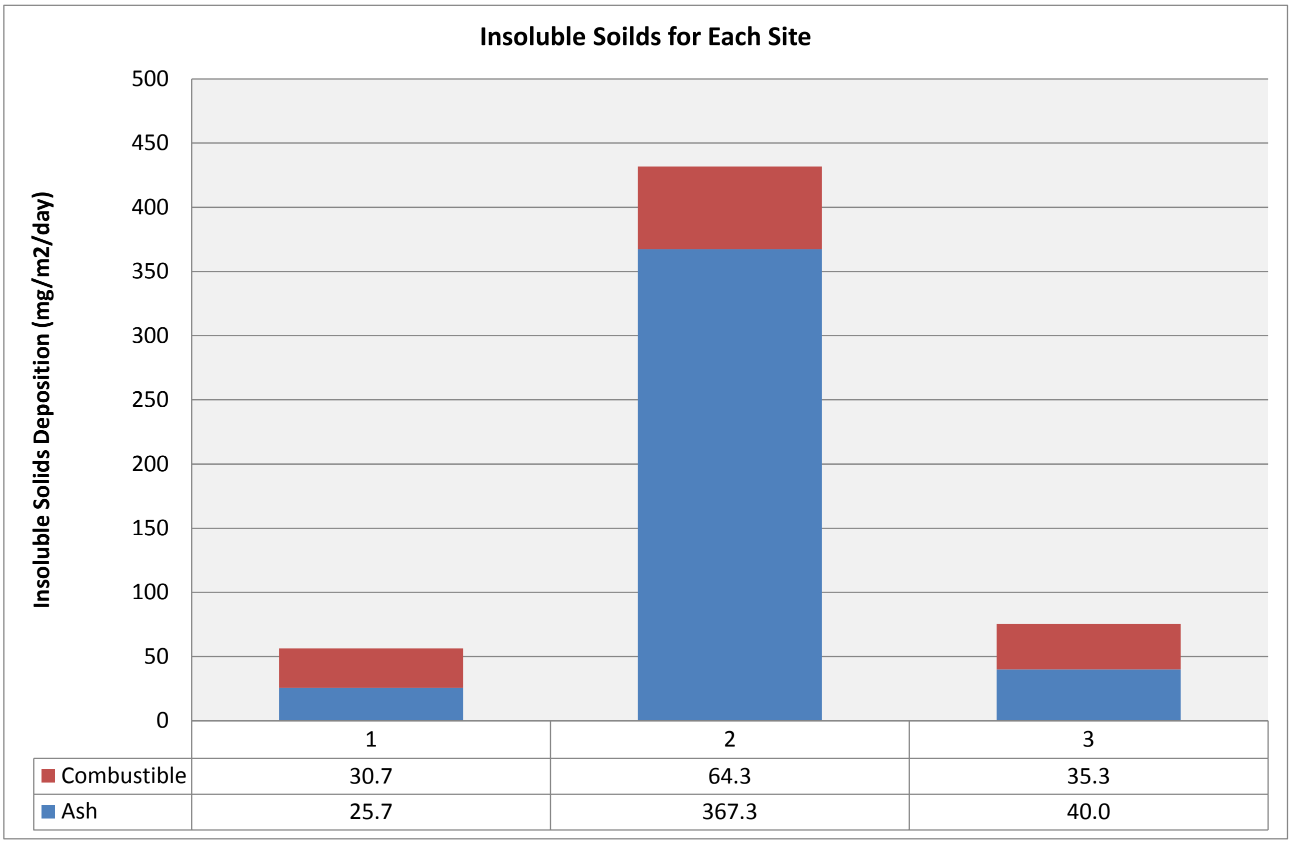

Figure 17 Insoluble Solids Deposition for Each Site

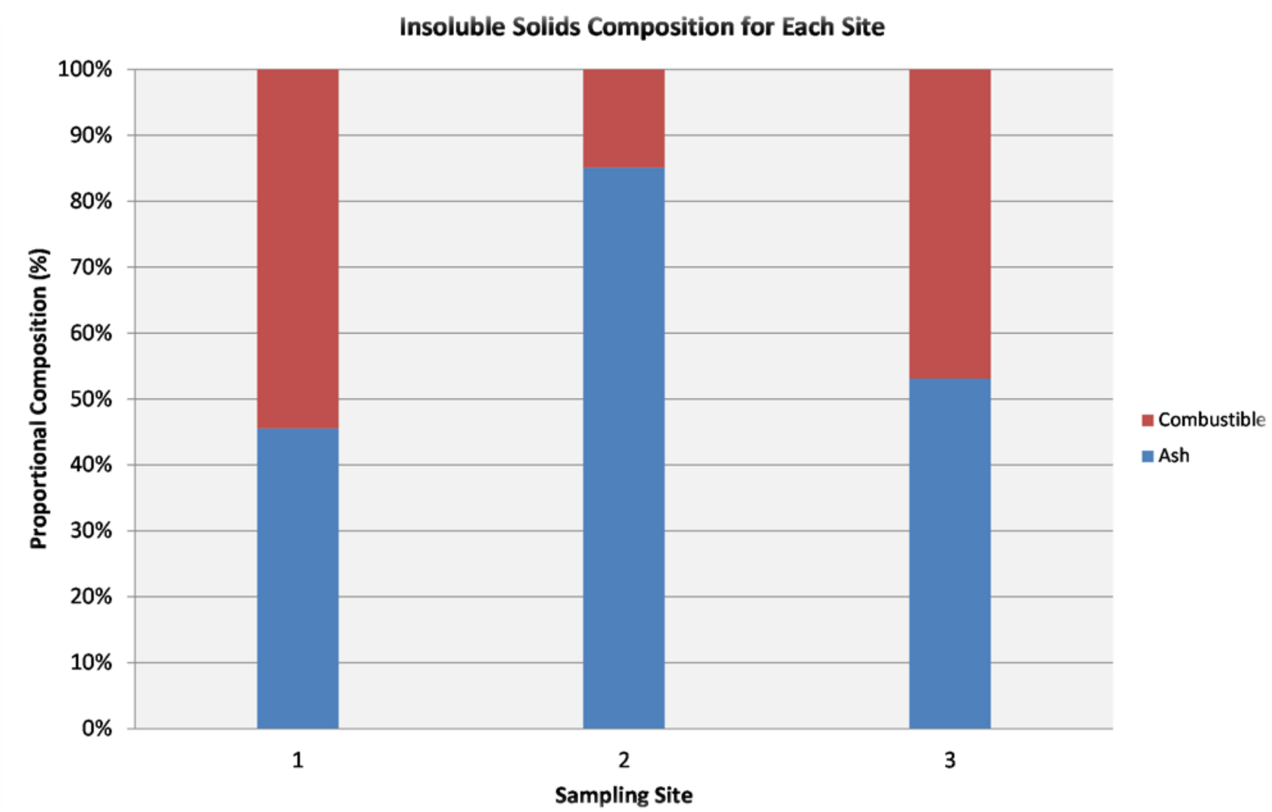

Figure 18 Insoluble Solids Composition for Each Site

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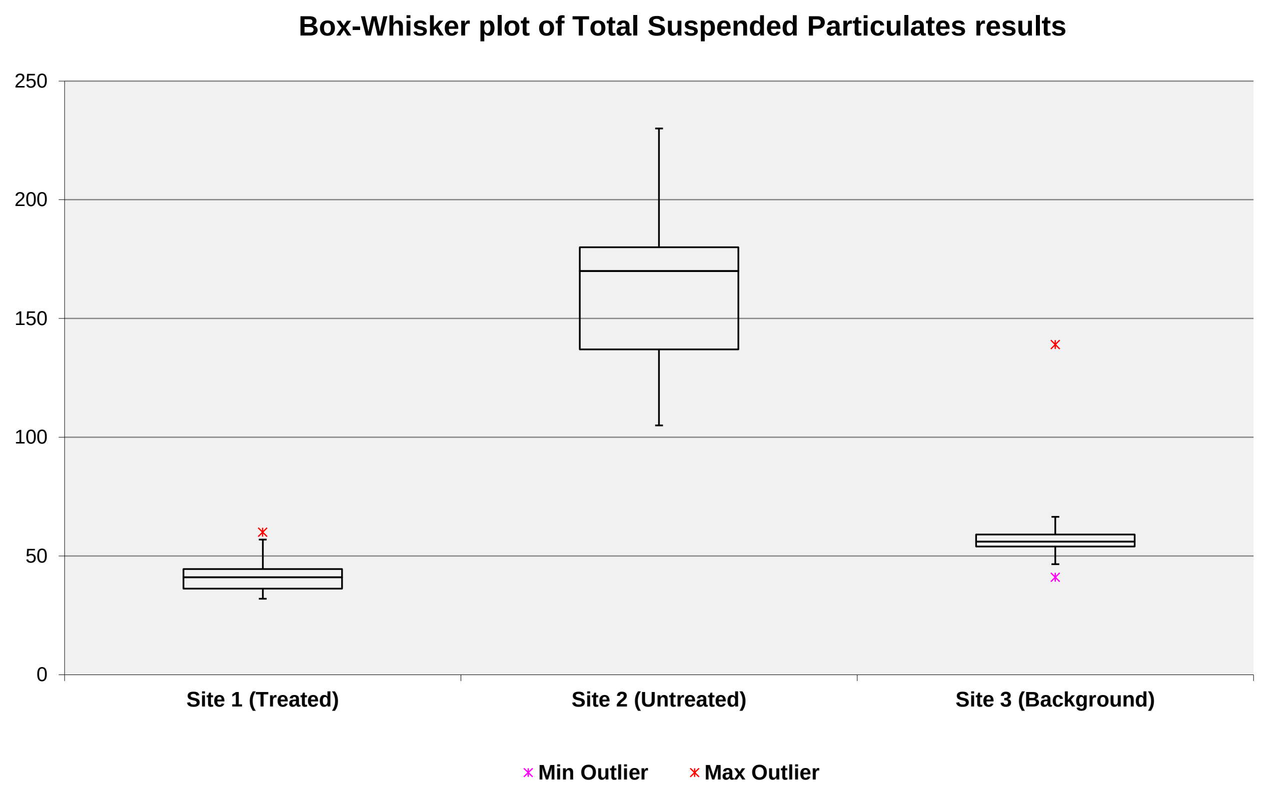

Figure 19 Box-Whisker plot of Total Suspended Solids results

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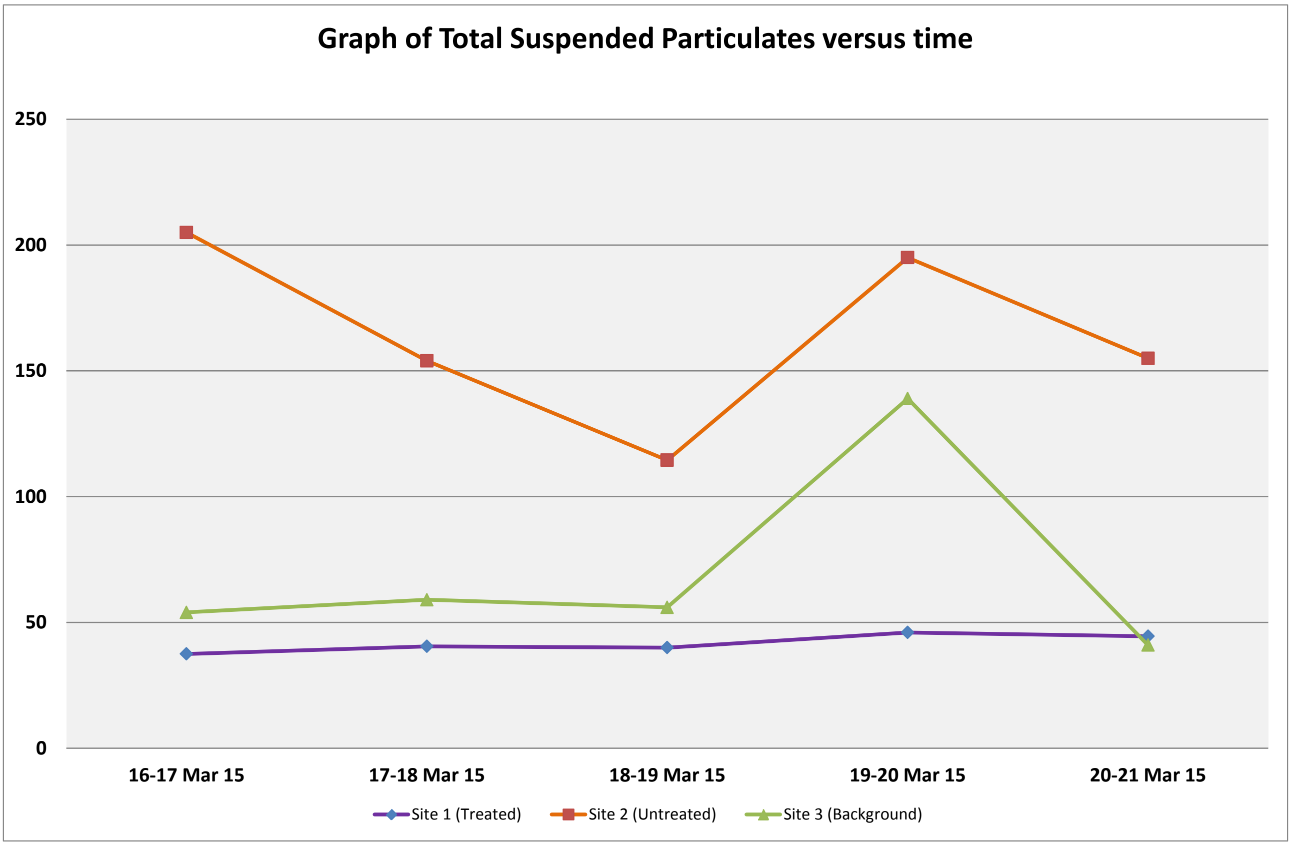

Figure 20 Total Suspended Particulates mean with time

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