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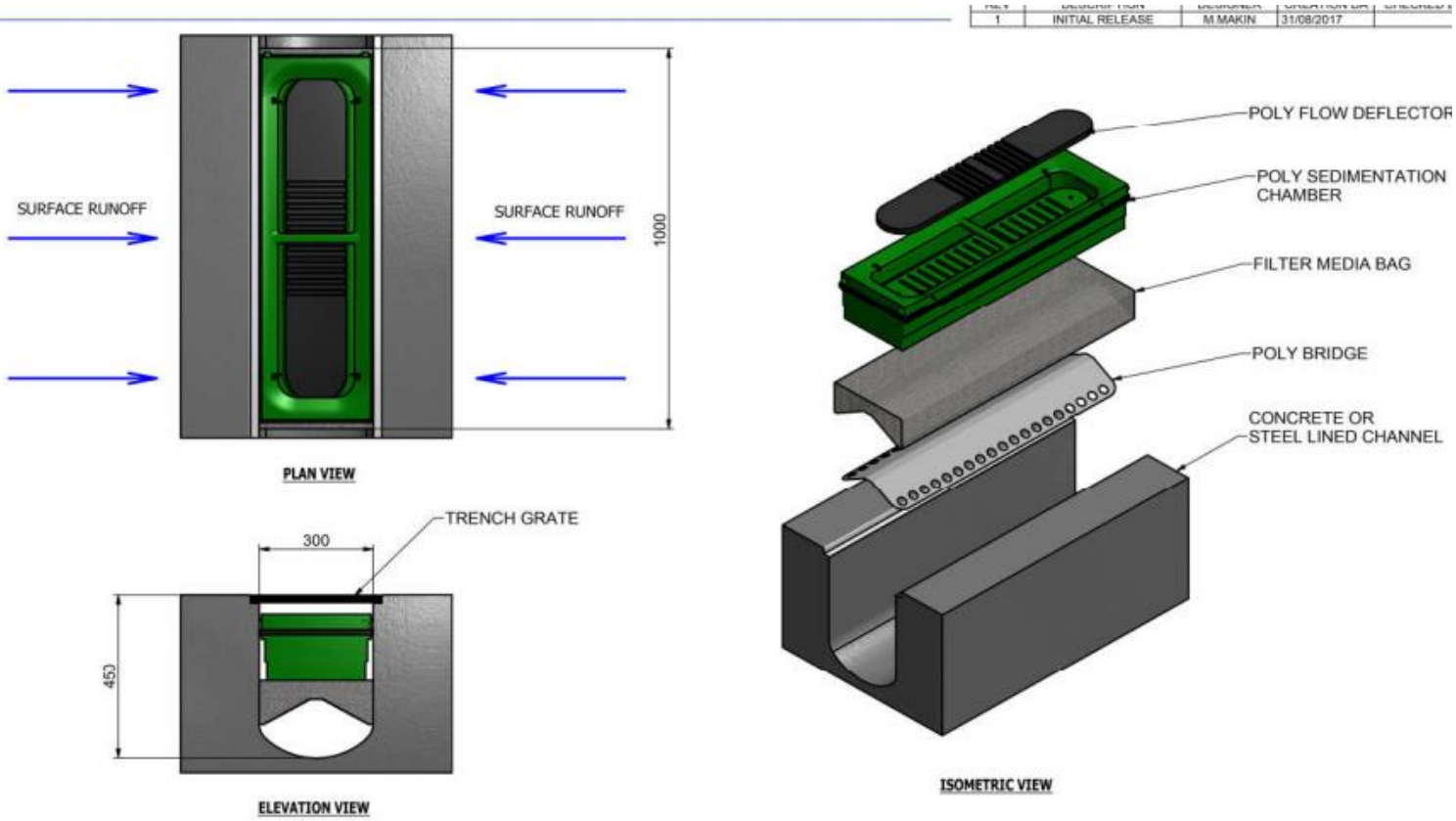

SPEL HYDROCHANNEL INDEPENDENT EVALUATORS JOINT REPORT

485-01_SQIDEP_Assessment

Date	19 June 2021
Version	v01a- updated to incorporate MUSIC node reporting
Author	AA
Client	Stormwater Australia

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Climate Change Statement

A wide range of sources, including but not limited to the IPCC, CSIRO and BoM, unanimously agree that the global climate is changing. Unless otherwise stated, the information provided in this report does not take into consideration the varying nature of climate change and its consequences on our current engineering practices. The results presented may be significantly underestimated; flood characteristics shown (e.g. flood depths, extents and hazards) are may be different once climate change is taken into account.

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1. Introduction

This document reports on the independent evaluation of an application by SPEL Stormwater (hereafter SPEL) to have Stormwater Australia approve a SPEL Hydrochannel under the requirements included in Stormwater Quality Improvement Device Evaluation Protocol (SQIDEP) v1.3 (hereafter referred to as SQIDEP) published in 2019 by Stormwater Australia. SQIDEP v1.3 is available on Stormwater Australia's website at the time of reporting.

This is a joint report prepared by Independent Evaluators, Andrew Allan, with review by Chris Beardshaw of Afflux Consulting and Damian McCann, a Director of Australian Wetlands Consulting. The Independent Evaluators were engaged by Stormwater Australia on a fee for service basis to carry out an independent evaluation of a SPEL Hydrochannel which can be described as a modular system that uses filter media to treat surface runoff.

Evaluators Declaration of Independence

It is declared that both evaluators, Andrew Allan and Damian McCann, are completely independent and neither Independent Evaluator has any conflict of interest with respect to this engagement.

We jointly declare that:

We are not, nor have we ever been employed or commissioned by the Applicant, SPEL Stormwater. We have not been involved in the design or development or monitoring of the SPEL Hydrochannel. We have undertaken this assessment without prejudice and in good faith.

Name- Andrew Allan	Name- Damian McCann
Signature 	Signature 

Independence of Monitoring Scientist(s)

The field data collected in accordance with the SQIDEP and presented for assessment was collected two entities, by University of Queensland and Drapper Environmental Consulting (DEC).

Reports prepared for assessment by these entities contains statements to attest to their independence.

In addition Dr Darren Drapper (DEC) has provided a signed statutory declaration in accordance with the SQIDEP.

2. Background

Stormwater Australia published the Stormwater Quality Improvement Device Evaluation Process (SQIDEP) in January 2019. The SQIDEP process seeks to "provide a uniform set of criteria to which stormwater treatment measures can be field-tested and reported. These criteria should guide and inform field monitoring programs seeking to demonstrate pollutant removals for stormwater treatment measures included in pollutant export modelling software. Future revisions of the protocol are anticipated to also include laboratory testing." (Stormwater Australia, 2019).

The SQIDEP process is shown below. Two pathways for evaluation exist under the protocol and this application involves the Body of Evidence Pathway. The Independent Evaluators have not been involved with this project prior to this evaluation, for example at QAPP stage.

Review Documents

The following documents form the basis of this independent evaluation:

- University of the Sunshine Coast, Stormwater Research Group, Evaluation of Treatment Performance of SPEL Hydrochannel at Sippy Down, Final report May 2018
- Dr Darren Drapper, R. Biggins, SPEL Stormwater, Field Monitoring of a SPEL Hydrochannel at University of Sunshine Coast 90 Sippy Downs Dr, Sippy Downs QLD 4556, SQIDEP Supporting Information, Issue 1, 19th March 2021.
- Dr Darren Drapper, R. Biggins, B. Jedras, SPEL Stormwater, Field Monitoring of a SPEL Hydrochannel at University of Sunshine Coast 90 Sippy Downs Dr, Sippy Downs QLD 4556, SQIDEP Supporting Information, Issue 2, 23rd March 2020.
- Drapper Environmental Consultants, USC SPELBasin & Hydrochannel Sample Collection Procedure
- SPEL Hydrochannel setup (device and sampling) (digital video)
- Chain of Custody documentation and Results certificates for the duration of the monitoring periods
- Statutory Declaration made by Dr Darren Drapper confirming role in monitoring data, maintaining field equipment, co-ordinating sample collection, identifying qualifying events and calibration of monitoring equipment

The review process involved the reviewers providing initial feedback to the claimant and their representatives for response. This initial assessment and responses provided are included as Attachment.

Sippy Downs SPEL Hydrochannel

A SPEL Hydrochannel was submitted for evaluation against the SQIDEP protocol in March 2020. Testing for the system was conducted over the period from August 2016 to April 2018 by the University of Sunshine Coast (USC) with results provide in their report dated May 2018. Over the testing period the SQIDEP was finalised, and Drapper Environmental Consultants (DEC) prepared a subsequent report to reinterpret data in line with changes to qualifying event criteria.

The documentation establishes that the USC as the independent organisation that undertook the testing on a fee for service basis, and DEC collecting field samples and delivering these for analysis with accompanying Chain of Custody documentation.

According to the claim as submitted the Hydrochannel *'performs a combination of physical and chemical treatment functions to remove pollutants including hydrocarbons, heavy metals, Total Suspended Solids*

(TSS) Total Phosphorus (TP) and Total Nitrogen (TN) from stormwater. Water flows from the surface into the Hydrochannel via a grated inlet where physical removal of coarse solids such as gravel and leaves take place in the HDPE sedimentation chamber. Flow must pass upwards under the poly shroud that prevents leaf litter overtopping into the filter section. The pre-treated water passes through the filter bag where organic and inorganic pollutants are chemically adsorbed by the proprietary filter media. Filtered water flows through the poly bridge into the free flow area of the channel where it can be re-used or discharged.'

The Hydrochannel installation is on a carpark at Sunshine Coast University (Carpark 6), Sippy Downs and can be seen below. Greater description is contained in reference documents provided for review.

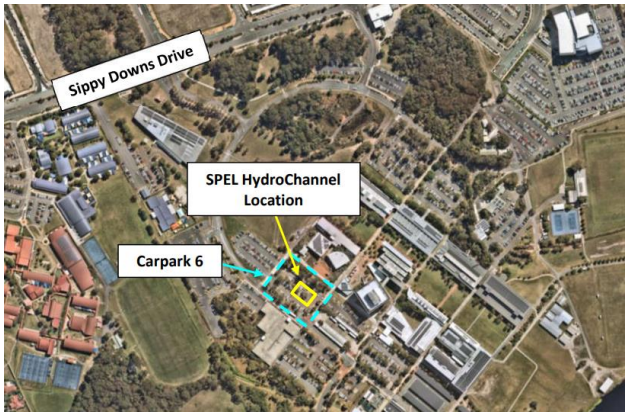


Figure 1. Hydrochannel test location

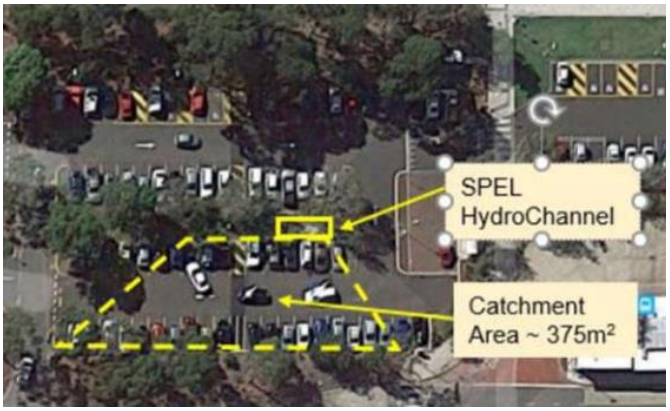


Figure 2. Hydrochannel- catchment area

Figure 3. Hydrochannel sample setup

Under the SQIDEP protocol there are separate pathways to demonstrate whether a device is able to achieve pollutant reduction under field conditions. This claim is being assessed under the Body of Evidence pathway which includes an assessment of field testing/ monitoring across a range of storm events, and independent evaluation of claims as indicated in Figure 4.

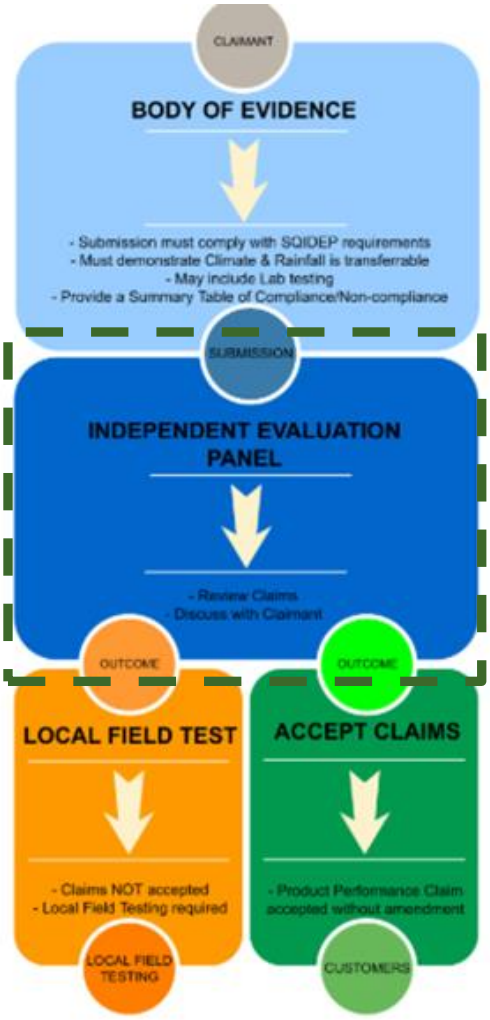


Figure 4. SQIDEP Pathway- Body of Evidence

Performance Claim

The field monitoring claims to have met all of the criteria of the SQIDEP protocol to achieve pollutant removal rates stated in the application (see Table 1), and this is the claim evaluated in this report. In the documentation provided a reduced claim is proposed based on the fact that changes between draft and final versions of SQIDEP affected the number of qualifying events in the USC study.

It should be noted that these claims are contingent on the device being sized (designed) and installed correctly, and with appropriate maintenance undertaken.

Table 1. SPEL Hydrochannel pollution reduction claim

Pollutant	Removal claim (BoE application)	Revised claim (DEC report)

Total Suspended Solids (TSS)	88%	88%
Total Phosphorous (TP)	72%	69%
Total Nitrogen (TN)	69%	67%
Gross Pollutants	99%	99%

This Body of Evidence (BOE) claim is based only on field test results from the Sippy Down site; it does not include any additional test data.

It is noted that gross pollutants were not tested, however the claim is made for a substantial reduction in this pollutant category. Based on the physical nature of the device and its mode of operation (i.e. water passing through a filter media is treated) it is expected that gross pollutants will be removed from the treated effluent stream and prima facie this could be considered a legitimate claim. It should be noted that gross pollutants are likely to be washed downstream when the device is operating in bypass mode, unless they are removed prior.

Based on a strict interpretation of the protocol the reviewers have formed the view that Gross Pollutant removal should not be claimed based on the evidence presented.

It remains a separate consideration if the product is marketed for gross pollutant removal but to retain integrity of the SQIDEP process, any promotional material should avoid implying that compliance has been achieved.

Site Background and Assumptions

The catchment is a carpark located at the University of Sunshine Coast. We have reviewed available aerial imagery and can confirm that the carpark was constructed well before the monitoring period commenced and thus could be expected to be an established catchment and suitable for monitoring.

Over the monitoring period the carpark appears to have been reasonably well utilised (i.e. half full to full), and based on the catchment area provided approximately 30 cars parked within.

As the site was located off a main transport route it has not been possible to independently verify the installation using tools such as Google Street view, however the application includes referenced photos which have enabled key landmarks to be identified.

3. SQIDEP Compliance

Interim Assessment

As part of the review process, independent reviewers provided SPEL with an interim assessment table against which responses were sought. This interim feedback was provided in early 2021.

Subsequent to this a conference call was held with representatives from SPEL on the 3rd March 2021 via teleconference, and the independent assessors in attendance. The purpose of this meeting was to work through the feedback provided in the interim assessment table to see if it could be resolved with direct discussion, or if further information was required. The attendees at the meeting are listed in Table 2.

Table 2. Meeting Attendees- Interim Assessment

Organisation	Name	Role
Stormwater Australia	Sadbh Duffy	Administration Officer
Afflux Consulting	Andrew Allan	Independent Assessor
Australian Wetlands Consulting	Damian McCann	Independent Assessor
SPEL	Andy Hornbuckle	Claimant Representative
Drapper Environmental Consultants	Dr Darren Drapper	Claimant consultant

In total the interim assessment table identified 30 items for response and/ or clarification, and fell into several categories as summarised below:

- Request for further information to clarify field set up and/ or procedures used for sampling and maintenance
- Evidence to demonstrate calibration of equipment
- Evidence to substantiate sample collection, preservation and holding times (i.e. Chain of Custody)
- Further description determining treatable flow rates and compliance with protocol requirements
- Information pertaining to the loading rates and possible maintenance/ replacement cycles for media

Subsequent to this meeting the claimant provided an updated evaluation report (version 2) which included sections which addressed issues raised in the interim assessment report and further information as requested to facilitate review. This feedback was clearly listed in a table response to the interim assessment and all significant issues have now been closed out. A copy of the interim assessment table and final status is provided in Appendix B,

SQIDEP Assessment

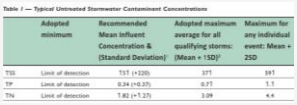
The SQIDEP provides a structured framework in which to present evidence and information. Compliance with all elements of SQIDEP Table 3- Minimum data and qualifying event requirements for assessment (SA, 2019) can be used as a basis for determining if the BOE test has been met. Following receipt if supplementary information Table 2 provides a status against each of the Performance criteria.

Note that while the initial USC testing included events that subsequently did not meet qualifying event criteria the data collected is none the less useful as it adds to the robustness of the entire dataset. As such, and where appropriate this has been referenced.

Table 3. SQIDEP Assessment

Performance Criteria	Performance requirement	Monitoring action or result	Outcome
Min number of events	15 or enough to achieve 90% confidence interval	Initial report (USC) identified 28 qualifying events which was reduced to between 17 and 25 based on a consideration of influent and effluent concentrations against SQIDEP requirements. Depending on the analyte, the number of samples changes, but in all cases meets the requirement for 15.	Compliant.
Min rainfall depth	Sufficient to collect minimum sample volume for lab testing.	Triggers established for commencement of samples. A review of hydrographs indicates sample collection occurred throughout storm.	Compliant
Inter event period	Minimum 6 hours dry	Review of hydrograph coverage and selected storms indicates this is achieved. On basis of USC data the minimum antecedent period was 12 hours (average 134 hours). Reported events and sample collection provided as Appendix (DEC report). A high-level review of event durations indicates these ranged from 45mins to 24 hours, with the majority between 2- 6 hours, and unlikely to compromise number of qualifying events.	Compliant
Device Size	Full size	3 x modular unit, each sized for 0.5l/s (i.e. 1.5 l/s total).	Compliant. Claims should be conditional on sizing advice provided.

		Likely can be scaled to suit different catchment sizes. Include commentary to ensure devices can be appropriately sized in practice.	
Runoff Characteristics	Target pollutant profile of influent and effluent	Site chosen to be typical of carpark. Regulated pollutants chosen for basis of claim and appropriate considering the intended application.	Compliant. Claim should include information in documentation about intended applications.
Runoff volume or peak flow	At least 2 events should exceed the 75% of the TFR and 1 event greater than the TFR. The TFR for the device is claimed to be 1.5 l/s based on the number of modular units installed.	Reference to USC Table 2 indicates this has been achieved. Out of 28 events there were 2 instances of peak flow being exceeded, and a further 4 where flow was greater than 75%.	Compliant
Automated sampling	Composite samples on a flow or time weighted basis	Samples collected every 30L of flow and adjusted to provide 1 aliquot (200ml) per 1mm of rainfall. Appendix shows collection of samples across events with spacing indicative of flow.	Compliant
Minimum number of aliquots	80% of field test collections should have at least 8 per event.	Minimum number of aliquots is 5. Reference to USC Table 2 indicates this has been achieved. Out of 28 events there were 23 which had 8 or more aliquots collected, or 82%. Need to include statement from revised. Check for compliance.	Compliant
Hydrograph coverage	At least 50% of qualifying storms should include the first 70% storm coverage	Visual review of hydrographs	Compliant

Hydrograph coverage	Multiple peaks should be accounted for (at least 1 occurrence).	Review of hydrographs indicates this occurred on multiple occasions	Compliant
Grab sampling	Not applicable		N/A
Sampling locations		Sampling locations were deemed to be appropriate to collect influent and effluent samples.	Compliant
Chemical and physical analytes	As identified in QAPP	No QAPP provided as testing had been completed. USC report covers pollutants and identifies these as regulatory requirements. Suite of analytes appropriate to claims made. While additional analytes were collected but not reported, these are not being claimed.	Satisfactory
Min and Max concentrations within range	Refer to Table 1 SQIDEP repeated below 	The inflow parameters for TSS and TP are below values indicated in SQIDEP, however are close to ranges provided for TN. Implication is that the site is likely to be 'cleaner' than average and likely harder to achieve pollutant reductions. There may be implications for longevity of media when used in dirtier settings which should be addressed when specifying product and maintenance schedules.	Compliant
Analytical methods	NATA accredited sample handling and analytical methods	USC report lists analytical methods, containers and preservation and holding times.	Compliant

		Australian Standard reference appropriate for sample handling. A Sample review of Chain of Custody documentation and lab certificates undertaken to corroborate.	
Flow measurement location	Inlet, outlet and bypass as applicable	Flow locations described and appropriate for analysing effluent passing through the treatment zone. Bypass is not possible given nature of device capturing sheet flow.	Compliant
Precipitation measurement	A pluviometer is required	Pluviometer used.	Compliant
Rainfall recording interval	5 minutes or less	From hydrographs there appears to be good resolution in rainfall recording, however some events indicated stepwise recording, but trend is evident and sample collection continued.	Satisfactory
Rainfall recording increments	0.25mm adopted		
Pluviometer calibration	To be calibrated twice during the monitoring period.	Claimed to be calibrated annually in accordance with manufacturer instructions. Pluviometer calibration records provided for one date, and service invoices submitted foe two calibration events. Rainfall has been cross checked against available radar rainfall indicating the presence of storms of similar duration and intensity to correspond with hydrographs and considered sufficient to corroborate.	Compliant

Performance indicators	The target pollutants and testing rationale must be described in the QAPP and Detailed Performance Report.	No QAPP provided (due to timing of testing commenced and SQIDEP being available). Performance indicators relate to regulated pollutants and are considered satisfactory.	Satisfactory
Performance indicators	ER and CRE. If CRE average and median > 10% difference inspect dataset.	CRE Average and Mean fall within allowed 10%	Compliant

In summary, Table 1 shows there is a high degree of compliance with SQIDEP v1.3

A number of other checks on the data have been performed and are reported below.

Comparison of Inflow Concentrations

Influent concentrations are impacted by a range of factors including antecedent conditions and catchment activity. Antecedent conditions allow accumulation of pollutants between events and it is possible to examine reported influent concentrations to identify indicative trends.

The inflow concentrations from this study were compared to previous studies of road catchments for cross-reference. In particular, the pollutant concentrations of TSS, TP and TN were extracted from Duncan (1999) which examined 42 (road) sites across Australia. A follow-up study, and one that is in close proximity to Sippy Downs was conducted by Drapper and Lucke (2015) for catchments within the South-East Queensland region. The pollutants concentrations from both studies are summarised below alongside the inflow concentrations found at Sippy Downs.

The most noticeable point between the studies is the pollutant concentration range. Drapper and Lucke (2015) cited that the inflow concentrations observed in that study were significantly different to results of Duncan (1999). And similarly, the Sippy Downs concentration ranges vary differently to those of the comparison studies, however they are still considered realistic. This highlights the difficulty of quantifying pollutant runoff parameters, and consequently, modelling inflows. It is noted that Sippy Downs appears to be on the low end of the spectrum which would yield a conservative result. Any MUSIC generic node developed from this BOE Application would be applicable to both clean and dirty sites.

We also note mean TSS influent concentrations, at 147mg/L are about 50% of default MUSIC road EMC values but not untypical for a new well sealed road, mean TN concentrations at 1.72 mg/L are not far off typical MUSIC default values at 2.2 mg/L while the TP loads were considered to be about 33% of default MUSIC values for a sealed road, i.e. low.

Table 4. Typical pollutant concentrations for road catchments

	Duncan (1999) study	Drapper and Lucke (2015) study	Current study – Sippy Downs Hydrochannel
TSS (mg/L)	60 – 700 (n=42)	1.45 – 5800 (n=325)	15 – 357 (n=25)
TP (mg/L)	0.1 – 0.8 (n=25)	0.08 – 26 (n=325)	0.04 – 0.49 (n=25)
TN (mg/L)	1 – 9 (n=17)	0.38 - 8.5 (n=325)	0.3-4.0 (n=20)

Dissolved Inorganic Nitrogen

This BOE claim is for TSS, TP and TN. It does not include subspeciation of nitrogen. We note that the USC report indicates that a range of nitrogen species were analysed and included Ammonia, Nitrate, Nitrite, Total TKN and dissolved TKN. While these have not been specifically reported the results were provided in laboratory Certificate of Analysis that were provided as part of the review process and we can make the following comments.

- Nitrates and Nitrites were generally reported at, or close to the levels of detection.
- There was generally reduction in concentrations in TKN (dissolved and total) between influent and effluent samples.
- Overall the trend in differences between total TKN between influent and effluent generally match the changes in Total Nitrogen used as the basis of claim.

A high-level analysis of the total nitrogen and dissolved nitrogen species does not indicate that the site runoff is dominated by particulate or dissolved fraction across all events, and generally reduction in nitrogen occurs across all events.

As such, the testing and analysis provided to substantiate the performance clam finds that the device performance is statistically significant in relation to TN removal and would indicate the device is removing both particulate and dissolved forms of nitrogen.

Pollutant removal and statistical analysis

The statistical analysis and methodology for determining significance was reviewed. It was found that the steps taken follow standard procedures for evaluating stormwater data. Typically stormwater concentration data is not normally distributed, as denoted from a Shapiro-Wilk normality test. Log_{10} transformation does result in normality of the data. Paired Student T-test can be used on the transformed dataset to test significance between data sets.

Afflux Consulting undertook its own Paired Student T-test and found the same result as those reported by the Stormwater Research Group (see Appendix C).

Reported Concentrations Analysis

While the performance of the device is based on changes between influent and effluent concentrations as reported and elsewhere the influent concentrations are examined (see above) for representativeness of the recommended installation type, it is considered worthwhile to examine the influent concentrations with respect to antecedent conditions to gain an understanding of how the catchment is behaving.

Pollutant concentrations in runoff are influenced by a range of conditions that include the type, intensity and timing of catchment activity, and can be influenced by specific events that add to loadings, and detailed analysis is beyond a simple correlation with antecedent dry weather (ADW)conditions.

In general, it is expected that

- prolonged ADW will lead to increased pollutant concentrations; and
- some pollutants (e.g. Total Suspended Solids) will exhibit a more definitive correlation with ADW.

Influent concentrations are listed in Table 2 for three ranges of ADW and indicate that for all three pollutants of interest there is an average trend toward higher inflow concentrations with increasing ADW.

A review of aerial photographs across the field-testing period indicated stable catchment conditions (i.e. no major development) and reasonably consistent carpark utilisation.

Table 5. Comparison of Concentrations and Antecedent Conditions

	Date	Antecedent Dry Period (hrs)	TSS (mg/l)	TP (mg/l)	TN (mg/l)
SHORT ADWP (<24 Hrs)	11/08/2016	12	15	0.04	0.30
	15/09/2016	14	21	0.07	1.10
	17/10/2016	23	40	0.09	0.70
	1/11/2016	24	44	0.12	1.60
	1/03/2017	25	53	0.14	Excl.
	AVGE		**35**	**0.09**	**0.93**
MEDIUM ADWP (24- 100Hrs)	2/03/2017	26	122	0.12	1.90
	18/05/2017	29	32	0.09	0.90
	5/07/2017	48	190	0.18	1.80
	2/10/2017	51	36	0.09	0.90
	3/10/2017	65	120	0.22	2.20
	14/10/2017	72	50	0.13	1.40
	15/10/2017	72	64	0.10	1.50
	21/10/2017	77	167	0.21	2.80
	7/11/2017	80	153	0.22	2.70
	18/11/2017	83	Excl.	Excl.	0.00
	21/11/2017	94	81	0.18	1.90
	AVGE		**102**	**0.15**	**1.64**
LONG ADWP (>100Hrs)	29/11/2017	107	Excl.	Excl.	0.00
	30/11/2017	122	357	0.49	0.00
	25/12/2017	140	110	0.13	1.30
	31/12/2017	144	211	0.28	Excl.
	2/01/2018	147	190	0.33	4.00
	31/01/2018	232	171	0.26	3.50
	1/02/2018	240	317	0.47	Excl.
	10/02/2018	339	112	0.19	1.70
	22/02/2018	358	245	0.45	Excl.
	4/03/2018	360	40	0.12	2.00
	18/04/2018	441	141	0.15	1.80
	AVGE		**189**	**0.287**	**1.79**

Field testing occurred during a period when there were changes to the SQIDEP protocol which resulted in some changes to qualifying events status. The final validation report has accounted for these changes by removing non-compliant events and undertaking sensitivity testing of claims with these data points removed (either in their entirety, or for individual species).

Tables 2- 3 in the claimant report provide a full account of changes.

Sensitivity testing undertaken in the report is summarised in Table 5 with commentary on likely implications for acceptance of claims.

Table 6. Sensitivity Assessment summary

Sensitivity test undertaken	Description	Change	Implication
Removal of non-compliant events	Changes to the protocol that occurred during the field program resulted in some events or datapoints needing to be removed	Reductions of between 3 and 7%	Negligible if claim is conservative
Adjustment of LOD values as required by protocol		Reductions of 1-2 %	Negligible
Removal of outlier events for specific pollutants	Box and whisker plots were used to identify potential outlier events and compare the impact of their omission on results	No significant change in parameters for TSS and TP. No outliers identified for TN.	Negligible

.

A numerical summary of the sensitivity results is provided in Figure 5.

Table 5. Summary of Performance Metrics

Full Dataset	TSS	TP	TN
AvCRE	86%	68%	70%
Median CRE	87%	72%	74%
ER	94%	82%	78%
Median ER	87%	67%	68%
Average both ER & AvCRE metrics	**90%**	**75%**	**74%**
SQIDEP compliant	**TSS**	**TP**	**TN**
AvCRE	84%	65%	64%
Median CRE	87%	72%	70%
ER	88%	72%	69%
Median ER	90%	69%	72%
Average both ER & AvCRE metrics	**86%**	**69%**	**67%**
SQIDEP compliant 50% <LOD	**TSS**	**TP**	**TN**
AvCRE	86%	65%	64%
Median CRE	89%	72%	70%
ER	89%	72%	69%
Median ER	90%	69%	72%
Average both ER & AvCRE metrics	**88%**	**69%**	**67%**

Source: DEC

Figure 5. Sensitivity Results summary

The design of the SQIDEP included a recognition that different performance metrics, may result in slight changes in overall assessment, but that it was important that across all performance metrics there was an observable trend to have confidence in the interpretation of results.

Analysis undertaken indicates that the changes in performance metrics does not vary by more than 10, and as such the results represent a robust outcome.

Rainfall Review

The monitoring site was equipped with both a tipping bucket rainfall gauge and (outlet) flow meter to assist with identification of qualifying storm events (depth/ duration), determination of antecedent dry weather periods and to assist with determination of required sampling frequency (i.e. number of aliquots).

This information is presented in the report in tabular and graphical format and described against protocol requirements.

This site was located relatively close to a previous SQIDEP assessment undertaken for Stormwater Australia, and field testing was undertaken over a similar time period.

As part of this earlier review high level checks were made using a review of historic rainfall records to verify the existence and likely magnitude of any events.

In general terms:

- Higher rainfall intensities should manifest as higher peak flows through the device:
- Flow peaks through the device should match altered intensity as a storm front passes; and
- The duration of an event (from start to finish) should match the radar record.

This earlier analysis concluded that there was sound basis to accept the hydrographs developed in the study as representative of local conditions and hold for this study.

Cherry Picking of Storm Events

SQIDEP v1.3 does not explicitly require that sequential storm events be monitored and reported. None the less, the Independent Evaluators have checked for evidence of cherry picking.

We have reviewed all storms that were excluded from the data set and a summary of these as provided in the submitted information is shown in Figure 5.

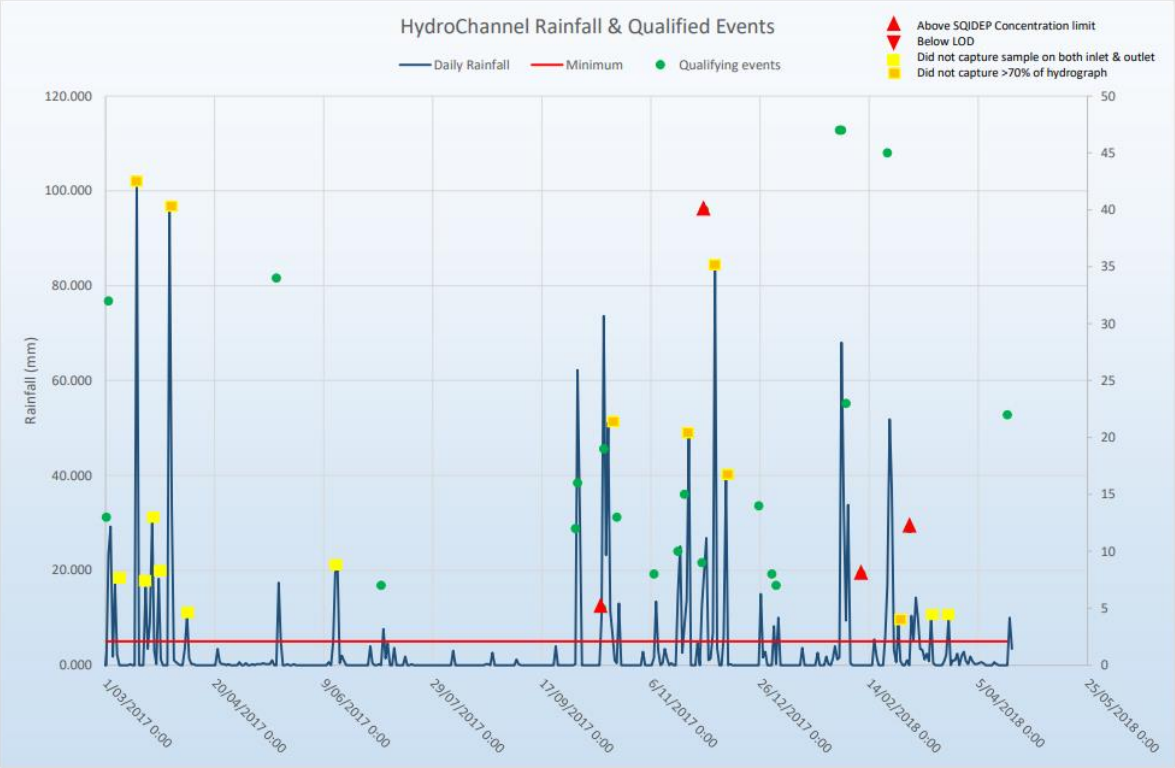


Figure 1 Reported rainfall and monitoring records.

The chart shows that there were 6 recorded storm events, intense events with an average depth of over 50mm which failed to capture more than 70% of the hydrograph and were therefore discarded. There were another 8 events which did not manage to capture both inlet and outlet samples, and these were associated with events of lesser magnitude (i.e. less than 50mm). These are distributed throughout the sampling program and are, with number at the start of the program, and are likely explained by a commissioning phase.

More significantly, the qualifying events appear to be captured across the entire duration of the monitoring program, and results indicate a variance in inputs, outputs and treatment efficacy across all pollutants.

A “cherry picked” dataset would, by definition, only include events with good performance. The duration of the monitoring period, which is considered relatively short at 13 months, is indicative of a study which did not wait for high performing events to occur.

On a first principles basis and assuming good faith by all parties, this study has the hallmarks of a robust scientifically sound assessment, i.e. it was undertaken with as much independence as is feasible, i.e. independent measurement, independent reporting and oversight and independent evaluation (peer review and is considered representative of typical field conditions and therefore will be repeatable under typical conditions.

MUSIC Node

MUSIC (Model for Urban Stormwater Improvement Conceptualisation) is an industry standard software program that is widely used in Australia for the sizing and conceptual design of stormwater treatment trains.

As such it is appropriate that some guidance is provided to enable the proposer inclusion of SPEL Hydrochannel in a stormwater quality

The DEC report provides an approach to developing a MUSIC node based on pollutant reduction and bypass rate of 1.5 lites/ second as follows. In each case the reduction on pollutants is essentially a straight line function, and as such the MUSIC node accurately represents the reductions for TSS, TN, and TP.

Based on a position of reviewers to not support the clams in relation to Gross Pollutants this has not been verified for the MUSIC node.

Table 7. MUSIC node verification

Pollutant	Influent range	Effluent Range	Reduction
Total Suspended Solids (TSS)	1000	120	88%
Total Phosphorous (TP)	5	1.4	72%
Total Nitrogen (TN)	50	15.5	69%

Evaluation of Enduring Performance

The Independent Reviewers have endeavoured to consider the long term enduring performance of the SPEL Hydrochannel.

The device includes an ion exchange element. The cation exchange capacity of the media has been confirmed to have a long life-time at typical hydraulic loading rates and this indicates the device would not need to have its media replaced to maintain chemical water quality outcomes within the life expectancy of the media.

However the media may be subject to blocking and reduced hydraulic conductivity from occlusion by sediment. The device comes fitted with a sediment chamber and filter bag which were serviced once during the assessment period, and upon which the performance results were produced.

It is therefore reasonable to assume that these pre treatment items need to be maintained regularly to protect the filter media, and this may well be a function of the catchment and deposition processes within.

Product specification should include guidance on maintenance based on typical deployment situations, and if possible, indicators to monitor accumulation over time to aid in scheduling of maintenance.

It should be discussed and agreed with SPEL to include a requirement in their Technical Design Guideline that if the media was observed to not fully drain down to its lowest level within a specified period (e.g. 2 hours) that the media be investigated and if required replaced. This would ensure that hydraulic conductivity was maintained at reasonable levels and the Treatment Flow Rate would be maintained in turn ensuring that the claimed treatment train effectiveness would be achieved in the longer term.

Maintenance is often overlooked and/ or underfunded, however the provision of technical guidance should transfer the risk of underperforming systems from the manufacturer to the operator (i.e. the device can't be blamed for underperformance if it is not maintained).

A sensitivity analysis of the device was undertaken by modelling its performance in MUSIC with a reduced high flow bypass rate. Assuming the hydraulic conductivity and consequently the high flow bypass was reduced by 30% (indicative of partially clogged filter media) the performance of the device would reduce by around 10%. Although the treatment performance does not reduce proportionally with reduced treated flows it does highlight the need for ensuring maintenance levels are maintained.

It is noted that it is not possible nor required of the Evaluators to determine the life of the device or the media and we are confident that under similar conditions to the test site that the device will have a reasonable life expectancy. It is recommended that SPEL continues to monitor at least the hydraulic performance of the SPEL Hydrochannel to confirm its long term performance and range of media life-expectancy under both light and heavy pollutant loading rates.

Discussion

Our independent evaluation finds that:

- The field study appears to be a scientifically sound study and would be repeatable under similar conditions which it is noted are deemed representative.
- As shown in Table 1, the testing regime and results comply with SQIDEP protocol requirements.
- In addition, the catchment parameters, expected runoff concentrations, and rainfall mapping to event recording are within standard, or expected guidelines and it is noted this site experienced no catchment disturbance during the monitoring period. In addition, the influent concentrations suggest the site is in the lower range of pollutant generation and is considered “clean” or lightly loaded relative to default EMC values adopted in MUSIC. This implies that, based on diminishing returns, the performance claims are more difficult to achieve and therefore conservative however the device itself may demonstrate clogging more prematurely on more heavily loaded sites.
- There will be some sites where media efficacy is impacted due to higher sediment loads (which may blind inlet capacity) and we note this SQIDEP claim and this independent evaluation do not involve an assessment of expected media life.
- This however is addressed in part by the need for the asset owner to observe draining times and if draining times fall below 2 hours to then investigate if the media is blocked and needs replacing.
- The SQIDEP protocol does not assess the effective life of the media and is unable to verify any claim by the supplier in this regard.
- Based on information provided the device is likely to perform well for typically expected service life (i.e. several years) when deployed in similar situations. Nonetheless SPEL should provide guidance on how and when the viability of media should be measured as part of its operational guidelines.
- We did not find evidence of cherry picking of storm events.
- We found that the dominant forms nitrogen in this study were dissolved nitrogen indicating that filtration, absorption and adsorption are occurring.
- The final claimed Pollution Reduction Performance was developed after consideration of sensitivity of testing results to slight changes in protocol parameters, and ensures a robust claim.
- The final claim has been revised from the initial submission and responds to changes in protocol parameters that occurred during the monitoring period and is based on a combination of recommended metrics and is considered credible and therefore recommended to be accepted.

Table 8. SPEL Hydrochannel performance claim

Pollutant	Final Claim (DEC report)	Outcome
Total Suspended Solids (TSS)	88%	Verified
Total Phosphorous (TP)	69%	Verified
Total Nitrogen (TN)	67%	Verified
Gross Pollutants	99%	Not verified

Scalability and Hydraulic Loading Rate

The question of scalability of these results has been considered as part of this review. The design treatment rate of 1.5 L/s over 3 modules was tested in the field and at least 4 events out of the qualifying 18 events approach or exceed this value (i.e. 85% or greater).

Of these larger events there is a spread of CRE values, with some well below the claimed reductions and some above. Viewing these results more critically it would seem that the antecedent conditions, and shape of the hydrograph are just as important precursors to the CRE as the actual flow rate. Clearly more field data may better define these correlations, however given the 90% confidence rate already, the care taken to remove outliers and non-qualifying events and defined SQIDEP protocol it is accepted that natural variations will occur and that a treatment rate of 0.5L/s per module acceptable limit.

How these flow rates play out in installations is a further consideration. It is expected that SPEL will provide sizing guidance for prospective applications, and that some relationships between catchment area and linal treatment length will need to be developed for design scenarios. If this information is prepared it should be within the realms of a suitably qualified stormwater practitioner to confirm that installation is appropriate for prospective sites.

3.1. Limitations of Acceptance

The limitations of the acceptance of these testing results include:

- The results are for a road based catchment. The results lie within acceptable inflow limits for this type of catchment and based on the analysis are found to be acceptable. This does not necessarily relate to other catchment types, though it is noted that hard stand catchments will behave similarly. Cleaner, roof catchments may not achieve the same pollutant reduction targets.
- The results are for a hydraulic loading rate up to 0.5l/s per module. Should the hydraulic load rate exceed this, the results would be expected to decline in line with excessive loading on the device.
- The results are reliant on the maintenance of the device being consistent with the manufacturers guidelines and those that are contained in the report. Most importantly the cleaning of the Storm Sack and filter cartridge at regular intervals.
- The life expectancy of the device and the media is unknown, although the supplier has suggested an effective life of 6 year. It is suggested that an estimated lifespan of both media and the whole device be written into any technical guidelines as the filter material will deteriorate over time.
- Performance is contingent upon the installation being similar to that shown in this trial. Alternative installations may result in different outcomes.

Recommendation for Associated Technical Guidelines

- The results of this analysis can be seen to be reliant on a number of factors, a number of which could be tied strongly to a set of technical installation and maintenance guidelines. As such it is strongly recommended that the SQIDEP results be tied to a product guideline to ensure future consistency.

Conclusions

SPEL have submitted for assessment a body of evidence (BOE) to demonstrate that performance claims for the Hydrochannel proprietary device have been tested within a trial compliant SQIDEP Version 1.3. This trial was completed in a carpark at Sunshine Coast University, Sippy Downs on the Sunshine Coast ran from August 2016 to April 2018.

Based on the results presented and the analysis shown in this report, the authors are satisfied that the BOE application complies with the SQIDEP protocol and the performance reduction claims shown in Table 6 at a treatable flow rate of 0.5l/s (per module) are substantiated as indicated.

It is recommended that these results and acceptance be packaged with a MUSIC node and a technical guideline.

4. References

Stormwater Australia, Stormwater Quality Improvement Device Evaluation Protocol v 1.3, Stormwater Australia, 2018

University of the Sunshine Coast, Stormwater Research Group, Evaluation of Treatment Performance of SPEL Hydrochannel at Sippy Down, Final report May 2018

Dr Darren Drapper, R. Biggins, SPEL Stormwater, Field Monitoring of a SPEL Hydrochannel at University of Sunshine Coast 90 Sippy Downs Dr, Sippy Downs QLD 4556, SQIDEP Supporting Information, Issue 1, 19th March 2021

Dr Darren Drapper, R. Biggins, B. Jedras, SPEL Stormwater, Field Monitoring of a SPEL Hydrochannel at University of Sunshine Coast 90 Sippy Downs Dr, Sippy Downs QLD 4556, SQIDEP Supporting Information, Issue 2, 23rd March 2020

Drapper Environmental Consultants, USC SPELBasin & Hydrochannel Sample Collection Procedure SPEL Hydrochannel setup (device and sampling) (digital video)

Appendices

Appendix A - Interim Assessment Table and close out/ acceptance of items

Feedback and responses to issues identified by reviewers

Attachment 1

Table 1 Assessment of the SPEL Hydrochannel against SQIDEP (v1.3) requirements (the respective page number where the requirement is discussed in SQIDEP v1.3 is shown for ease of reference).

SQIDEP Requirement	Initial AWC comments	Compliance	Claimant Response	Final AWC/ reviewer comments / compliance	Status
Catchment area (p14)	375m^2	Y	Refer Section 1.3 of SQIDEP Supporting Information Report (DEC)	Satisfactory	Closed
Land Use (p14)	Car Park	Y	Refer Section 1.3 of SQIDEP Supporting Information Report (DEC)	Satisfactory	Closed
Percentage Impervious cover (p14)	100%	Y	Refer Section 1.3 of SQIDEP Supporting Information Report (DEC)	Satisfactory	Closed
Aerial photos (p14)	Figures 5 and 6	Y	Refer Section 1.3 of SQIDEP Supporting Information Report (DEC)	Satisfactory	Closed
Site Photos (p14)	Figures 7	Y	Refer Section 1.3 of SQIDEP Supporting Information Report (DEC)	Satisfactory	Closed
Potential pollutant sources (p14)	Not specified. Please comment.		Refer Section 1.4 of SQIDEP Supporting Information Report (DEC)	Satisfactory	Closed
Site map showing: (p14) • Catchment area • Drainage system layout • Treatment device • Sampling points	Figures 5 to 10	Y	Refer Figures 1 - 6 of SQIDEP Supporting Information Report (DEC)	Satisfactory	Closed
Treatable flow rate (TFR) (p14)	1.5L/s	Y	Refer Section 3.4 of SQIDEP Supporting Information Report (DEC)	Satisfactory	Closed

SQIDEP Requirement	Initial AWC comments	Compliance	Claimant Response	Final AWC/ reviewer comments / compliance	Status
Rainfall ≤ 5 min time interval (p15)	Not specified, however, the USC report stated: *"The sampling equipment was triggered when a tipping bucket rain gauge recorded ≥ 1.0 mm rainfall within 10 minutes"*	Y	Rainfall is recorded instantaneously from the tipping bucket raingauge.	Satisfactory	Closed
Rainfall ≤ 0.25mm increments (p15)	0.2mm increments	Y	Rainfall is recorded instantaneously from the tipping bucket raingauge.	Satisfactory	Closed
Rainfall - Location shown on site map (p15)	Not specified. Please comment.		Refer Section 1.3 & Figure 3 of SQIDEP Supporting Information Report (DEC)	Satisfactory	Closed
Rainfall - Checked, cleared of debris and calibrated at least two times during the testing period (p15)	The Statutory Declaration states the pluviometer was calibrated annually by Drapper Environmental Consultants in accordance with the manufacturer's requirements	Y	Refer Appendix A of SQIDEP Supporting Information Report (DEC)	Satisfactory	Closed
Rainfall - Protected from excessive wind velocities (p15)	Not specified. Please comment.		Refer Section 1.3 & Figure 3 of SQIDEP Supporting Information Report (DEC)	Satisfactory	Closed
Min 15 events (p15-16)	16 qualifying events were recorded and observed	Y	Refer Section 4.8 of SQIDEP Supporting Information Report (DEC)	Satisfactory	Closed

SQIDEP Requirement	Initial AWC comments	Compliance	Claimant Response	Final AWC/ reviewer comments / compliance	Status
Each monitoring program will need to identify the period delineating the end of one event and beginning of the next – typically 24hrs or the time taken to reset monitoring equipment (p15-16)	This was not provided. Please comment.		Refer Section 4.3 of SQIDEP Supporting Information Report (DEC)	Satisfactory	Closed
Hydrographs for each event to demonstrate the program has representatively captured the event (p15-16)	Hydrographs provided.	Y		Satisfactory	Closed
Min 2 peak inflows from the sampled events should exceed 75% of the design TFR of the device + 1 ≥ than its design TFR (p15-16)	4 of the 16 qualifying events exceeded 75% of the design TFR. 2 of the 28 events were greater than the design TFR. However, the product specifications state that once the hydraulic capacity of the device is reached, flow bypasses down the gutter. If flows were measured at the outlet pit how were flows greater than the TFR of 1.5 L/s observed. This requires clarification.		Refer Section 3.4 of SQIDEP Supporting Information Report (DEC). Hydraulic testing from Germany has focused solely on the HDPE insert in the precast channel, excluding the filter media bag. Subsequently, this field testing has defined the Treatable Flow Rate under Australian conditions, with the specified media mix	Satisfactory	Closed

SQIDEP Requirement	Initial AWC comments	Compliance	Claimant Response	Final AWC/ reviewer comments / compliance	Status
Events to be sufficiently distributed throughout the monitoring period to capture seasonal influences on storm conditions & The independent evaluation panel must be satisfied that the qualifying storms includes a good range of storm event (longer and shorter duration) (p15-16)	Monitoring period of qualifying events approx. 12 months (1/3/17 to 18/4/18) Number of events per season: • Summer: 4 • Autumn: 4 • Winter: 1 • Spring: 7 Only one storm event from Winter. Please comment. Rain depth for qualifying storm events ranged from 5.6 to 68.2mm		Refer Section 4.5.1 of SQIDEP Supporting Information Report (DEC).	Satisfactory	Closed
50% of qualifying storms should include the first 70% storm hydrograph coverage (p15-16)	Hydrographs confirm	Y	Refer Hydrographs in supporting files.	Satisfactory	Closed

SQIDEP Requirement	Initial AWC comments	Compliance	Claimant Response	Final AWC/ reviewer comments / compliance	Status
Flow measurement at the inlet and outlet are recommended. Monitoring of bypass flows is optional, however, at a minimum the monitoring information should be sufficient to identify periods when device is operating in bypass (p17)	V-notch weir & pressure transducer installed in the downstream collection pit (outlet). Details of when the device was operating in bypass was not discussed. Furthermore, the product specifications state that once the hydraulic capacity of the device is reached, flow bypasses down the gutter. If flows were measured at the outlet pit how were flows greater than the TFR of 1.5 L/s observed? This requires clarification.		Refer Section 3.4 of SQIDEP Supporting Information Report (DEC)	Satisfactory	Closed
Make, model and procedures and schedule for calibration, inspection and cleaning shall be provided (p20)	ISCO GLS Autosamplers. Sampling procedure provided. The Statutory Declaration states the equipment was maintained and calibrated Drapper Environmental Consultants in accordance with the manufacturer's requirements, however, records are preferred. Please comment.		Refer Section 3.9 of SQIDEP Supporting Information Report (DEC) and Appendix A. As discussed during the IEP workshop, this project commenced prior to the release of SQIDEP v1.3, hence some documentation has not been formally recorded. The Statutory Declaration was provided in good faith, and subsequently, our redacted invoices to SPEL for these services are now also included.	Satisfactory	Closed

SQIDEP Requirement	Initial AWC comments	Compliance	Claimant Response	Final AWC/ reviewer comments / compliance	Status
Flow proportional sampling requires at least 80% of the submitted events have at least 8 aliquots collected from the event which should be collected from the rising and falling limbs of the hydrograph to form the composite sample (p21)	Only 1 of the 16 events had < 8 aliquots. Hydrographs show when aliquots were sampled.	Y		Satisfactory	Closed
Sample blanks for field and analytical testing to be supplied (p21)	USC 2018 states random duplicated blanks were collected but no COC or COA documentation is provided. Please comment.		Refer Section 4.3.1 of SQIDEP Supporting Information Report (DEC) and QC & QCI reports supplied in the Dropbox folder	Satisfactory	Closed
COC documents identifying sample collection, collection agency, collection time, preservation used, laboratory receipt of sample and sample collection shall be provided (p21)	Supplied. We note that for some events there were several days between sample collection and laboratory drop-off e.g. for the 25/12/17 event there was period of 9 days. Please comment on sample preservation.		Refer Section 4.3.2 of SQIDEP Supporting Information Report (DEC). USC sample collection also enabled storage in 4deg C cold room across the Christmas period when the laboratories were closed.	Satisfactory	Closed

SQIDEP Requirement	Initial AWC comments	Compliance	Claimant Response	Final AWC/ reviewer comments / compliance	Status
NATA accreditation (p21)	Composite samples were analysed by the NATA accreditation ALS laboratory in Brisbane	Y		Satisfactory	Closed
Method of analysis detailed (p21)	Methods stated in Table 1 USC 2018	Y		Satisfactory	Closed
Effluent sample results below the limit of detection (LOD) shall be set at 0.5 x LOD and must be accompanied by a sensitivity analysis showing impact on performance metrics of adopting both LOD and 0 (p23).	LOD's were reported but there was no discussion about the sensitivity analysis in the report. Please comment.		Refer Section 4.8 of SQIDEP Supporting Information Report (DEC) for Sensitivity Analyses.	Satisfactory.	Closed
Analysis should clearly indicate how treatment and bypass flows (either external or internal to the device) have been accounted for in the presentation of results (p25)	Not discussed in report. Please comment.		Refer Section 3.5 & 4.6 of SQIDEP Supporting Information Report (DEC).	Satisfactory	Closed
Average and Median Concentration Removal Efficiency (p25)	No median values provided. Please comment.		Refer Section 4.8 of SQIDEP Supporting Information Report (DEC)	Satisfactory	Closed

SQIDEP Requirement	Initial AWC comments	Compliance	Claimant Response	Final AWC/ reviewer comments / compliance	Status
The Event Mean Concentration and Mass Discharge variability are required to verify the ability of the device to manage large variability in EMCs and mass discharges. Box and whisker plots should be prepared for influent and effluent EMCs as well as mass loads (where presented). The number of EMCs and mass loads contributing to each distribution should be clearly indicated (p30)	EMC's specified. Mass Discharge was not specified – please comment. Box and whisker plots provided.		Refer Section 4.9.1 of SQIDEP Supporting Information Report (DEC). A formula and methodology for calculating the Mass Discharge Variability (MDV) is not provided by SQIDEP v1.3. It is considered that estimating the MDV by approximating the EMC for nonqualifying events and applying it to the flow volume recorded will likely increase inaccuracy and be less conservative than the current metrics. Therefore, for this submission it is not used to verify any performance claim.	Satisfactory	Closed
Achieve at least 90% statistical significance between paired samples of influent and effluent (p15-16)	Statistical testing conducted on the 16 complying events. Testing results verified.	Y		Satisfactory	Closed

<table>
<tr><th>SQIDEP Requirement</th><th>Initial AWC comments</th><th>Compliance</th><th>Claimant Response</th><th>Final AWC/ reviewer comments / compliance</th><th>Status</th></tr>
<tr>
<td>Treatment Claims reported in BoE:
<table>
<tr><td>TSS</td><td>88%</td></tr>
<tr><td>TP</td><td>72%</td></tr>
<tr><td>TN</td><td>69%</td></tr>
<tr><td>Gross Pollutants</td><td>99%</td></tr>
</table>
Treatment Claims reported in USC Report based on 16 qualifying events:
<table>
<tr><td></td><td>CRE</td><td>ER</td></tr>
<tr><td>TSS</td><td>84%</td><td>86%</td></tr>
<tr><td>TP</td><td>63%</td><td>60%</td></tr>
<tr><td>TN</td><td>69%</td><td>67%</td></tr>
</table>
CRE = Concentration removal efficiencies
ER = Efficiency ratio</td>
<td>Claims in the BoE are not consistent with the results reported from 16 qualifying events in the USC Report. Please comment.</td>
<td></td>
<td>Refer Section 4.8 & 4.9 of SQIDEP Supporting Information Report (DEC). Since the USC report was prepared prior to v1.3 of SQIDEP, and this submission is seeking evaluation under the current version, it is proposed that the average metrics for the SQIDEP compliant values (50%</td>
<td>Satisfactory</td>
<td>Closed</td>
</tr>
</table>

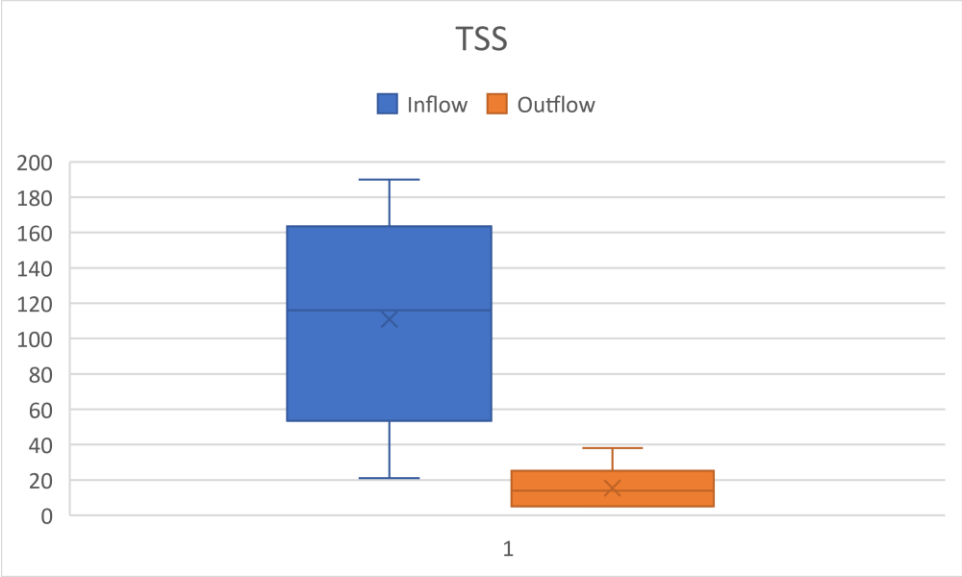
Appendix B - Statistical analysis and confirmation

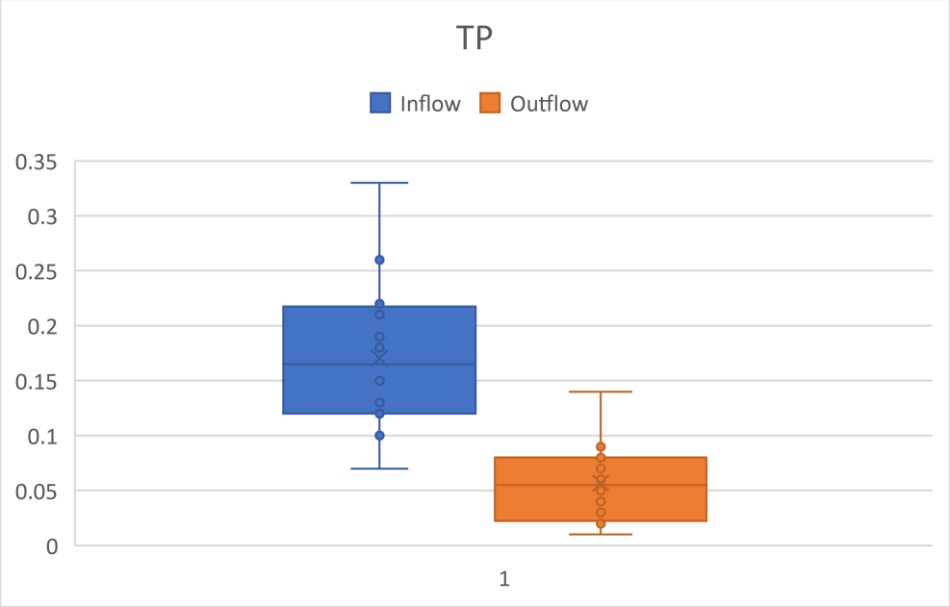
Statistical Checks

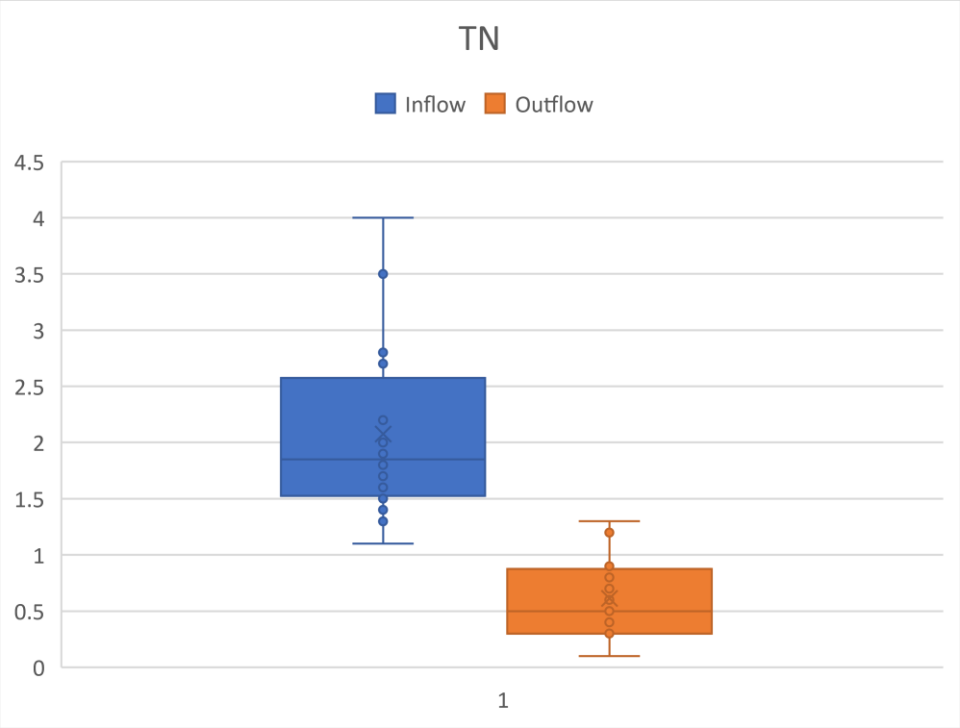
Raw Data- Selected events

	TSS		TP		TN	
	in	out	in	out	in	out
1/03/2017	50	5	0.13	0.04	1.4	0.3
2/03/2017	44	8	0.12	0.03	1.6	0.7
18/05/2017	167	16	0.21	0.01	2.8	0.4
5/07/2017	112	30	0.19	0.09	1.7	0.9
2/10/2017	171	32	0.26	0.08	3.5	1.2
15/10/2017	122	5	0.12	0.02	1.9	0.5
21/10/2017	120	5	0.22	0.02	2.2	0.1
7/11/2017	190	27	0.33	0.07	4	0.8
18/11/2017	110	15	0.13	0.05	1.3	0.5
21/11/2017	153	15	0.22	0.06	2.7	0.3
29/11/2017	190	20	0.18	0.05	1.8	0.3
25/12/2017	40	13	0.12	0.14	2	1.2
31/12/2017	81	38	0.18	0.08	1.9	1.3
31/01/2018	64	7	0.1	0.09	1.5	0.4
22/02/2018	21	5	0.07	0.02	1.1	0.3
18/04/2018	141	5	0.15	0.06	1.8	0.6
MEAN	111.00	15.38	0.17	0.06	2.08	0.61

Input Data- Box Plots




TP
Inflow
Outflow
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
1


TN
Inflow
Outflow
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
1

Data Log Transformed

	TSS in	TSS out	TP in	TP out	TN in	TN out
1/03/2017	1.70	0.70	-0.89	-1.40	0.15	-0.52
2/03/2017	1.64	0.90	-0.92	-1.52	0.20	-0.15
18/05/2017	2.22	1.20	-0.68	-2.00	0.45	-0.40
5/07/2017	2.05	1.48	-0.72	-1.05	0.23	-0.05
2/10/2017	2.23	1.51	-0.59	-1.10	0.54	0.08
15/10/2017	2.09	0.70	-0.92	-1.70	0.28	-0.30
21/10/2017	2.08	0.70	-0.66	-1.70	0.34	-1.00
7/11/2017	2.28	1.43	-0.48	-1.15	0.60	-0.10
18/11/2017	2.04	1.18	-0.89	-1.30	0.11	-0.30
21/11/2017	2.18	1.18	-0.66	-1.22	0.43	-0.52
29/11/2017	2.28	1.30	-0.74	-1.30	0.26	-0.52
25/12/2017	1.60	1.11	-0.92	-0.85	0.30	0.08
31/12/2017	1.91	1.58	-0.74	-1.10	0.28	0.11
31/01/2018	1.81	0.85	-1.00	-1.05	0.18	-0.40
22/02/2018	1.32	0.70	-1.15	-1.70	0.04	-0.52
18/04/2018	2.15	0.70	-0.82	-1.22	0.26	-0.22
MEAN	1.97	1.08	-0.80	-1.33	0.29	-0.30

Descriptive Statistics

	TSS (in)	*TSS (out)*	*TP (in)*	*TP (out)*	*TN (in)*	*TN (out)*
Mean	1.97	1.08	-0.80	-1.33	0.29	-0.30
Standard Error	0.07	0.08	0.04	0.08	0.04	0.07
Median	2.06	1.15	-0.78	-1.26	0.27	-0.30
Mode	2.28	0.70	-0.92	-1.70	0.28	-0.52
Standard Deviation	0.28	0.33	0.17	0.31	0.15	0.29
Sample Variance	0.08	0.11	0.03	0.10	0.02	0.09
Kurtosis	0.11	-1.56	-0.04	-0.25	-0.03	0.67
Skewness	-0.95	0.11	-0.15	-0.63	0.58	-0.59
Range	0.96	0.88	0.67	1.15	0.56	1.11
Maximum	2.28	1.58	-0.48	-0.85	0.60	0.11
Minimum	1.32	0.70	-1.15	-2.00	0.04	-1.00
Sum	31.58	17.21	-12.78	-21.36	4.65	-4.74
Count	16.00	16.00	16.00	16.00	16.00	16.00
Geometric Mean	1.95	1.03	-	-	0.25	-
Harmonic Mean	1.93	0.98	-	-	0.19	-
AAD	0.23	0.29	0.14	0.25	0.12	0.23
MAD	0.16	0.32	0.13	0.19	0.08	0.22
IQR	0.41	0.63	0.25	0.47	0.17	0.44

Multiplier 2.2

	TSS (in)	*TSS (out)*	*TP (in)*	*TP (out)*	*TN (in)*	*TN (out)*
Min	3.322219	2.69897	0.845098	0	2.041393	1
Q1-Min	0.457158	0	0.234083	0.433098	0.15572	0.477121
Med-Q1	0.284822	0.446047	0.136501	0.305462	0.0699	0.221849
Q3-Med	0.129998	0.188596	0.111588	0.164529	0.097645	0.216908
Max-Q3	0.084556	0.24617	0.191244	0.243038	0.237402	0.198065
Mean	3.974041	3.075483	1.201029	0.66515	2.290517	1.703965

Min	1.322219	0.69897	-1.1549	-2	0.041393	-1
Q1	1.779377	0.69897	-0.92082	-1.5669	0.197113	-0.52288
Median	2.0642	1.145017	-0.78432	-1.26144	0.267013	-0.30103
Q3	2.194198	1.333613	-0.67273	-1.09691	0.364658	-0.08412
Max	2.278754	1.579784	-0.48149	-0.85387	0.60206	0.113943
Mean	1.974041	1.075483	-0.79897	-1.33485	0.290517	-0.29604

Grand Min -2

Outliers	None	None	None	None	None	None

Shapiro-Wilk Test (Normality Test- all parameters)

	TSS (in)	*TSS (out)*	*TP (in)*	*TP (out)*	*TN (in)*	*TN (out)*
W-stat	0.895868	0.87992	0.977183	0.940016	0.960241	0.934554
p-value	0.069036	0.038693	0.937287	0.349212	0.66617	0.287551
alpha	0.05	0.05	0.05	0.05	0.05	0.05
normal	yes	no	yes	yes	yes	yes

d'Agostino-Pearson (Normality test- all parameters)

	TSS (in)	*TSS (out)*	*TP (in)*	*TP (out)*	*TN (in)*	*TN (out)*
DA-stat	2.959224	5.102863	0.11593	1.350468	1.160844	1.821255
p-value	0.227726	0.07797	0.943683	0.509037	0.559662	0.402272
alpha	0.05	0.05	0.05	0.05	0.05	0.05
normal	yes	yes	yes	yes	yes	yes

Grubbs' Test (outliers)- across all data

alpha	0.05
outlier	-2
G	1.864834
G-crit	3.195565
sig	no

T Tests (log transformed data)

TSS

T Test: Two Independent Samples

SUMMARY			Hyp Mea	0
Groups	*Count*	*Mean*	*Variance*	*Cohen d*
Inflow	16	1.97	0.08	
Outflow	16	1.08	0.11	
Pooled			0.09	2.94

T TEST: Equal Variances				Alpha	0.05				
	std err	*t-stat*	*df*	*p-value*	*t-crit*	*lower*	*upper*	*sig*	*effect r*
One Tail	0.11	8.30	30.00	0.00	1.70			yes	0.83
Two Tail	0.11	8.30	30.00	0.00	2.04	0.68	1.12	yes	0.83

T TEST: Unequal Variances				Alpha	0.05				
	std err	*t-stat*	*df*	*p-value*	*t-crit*	*lower*	*upper*	*sig*	*effect r*
One Tail	0.11	8.30	29.39	0.00	1.70			yes	0.84
Two Tail	0.11	8.30	29.39	0.00	2.04	0.68	1.12	yes	0.84

TP

T Test: Two Independent Samples

SUMMARY			Hyp Mea	0
Groups	*Count*	*Mean*	*Variance*	*Cohen d*
Inflow	16	-0.799	0.0294	
Outflow	16	-1.335	0.0968	
Pooled			0.0631	2.1338

T TEST: Equal Variances				Alpha	0.05				
	std err	*t-stat*	*df*	*p-value*	*t-crit*	*lower*	*upper*	*sig*	*effect r*
One Tail	0.0888	6.0354	30	6E-07	1.6973			yes	0.7405
Two Tail	0.0888	6.0354	30	1E-06	2.0423	0.3545	0.7172	yes	0.7405

T TEST: Unequal Variances				Alpha	0.05				
	std err	*t-stat*	*df*	*p-value*	*t-crit*	*lower*	*upper*	*sig*	*effect r*
One Tail	0.0888	6.0354	23.338	2E-06	1.7128			yes	0.7807
Two Tail	0.0888	6.0354	23.338	4E-06	2.067	0.3524	0.7194	yes	0.7807

TN

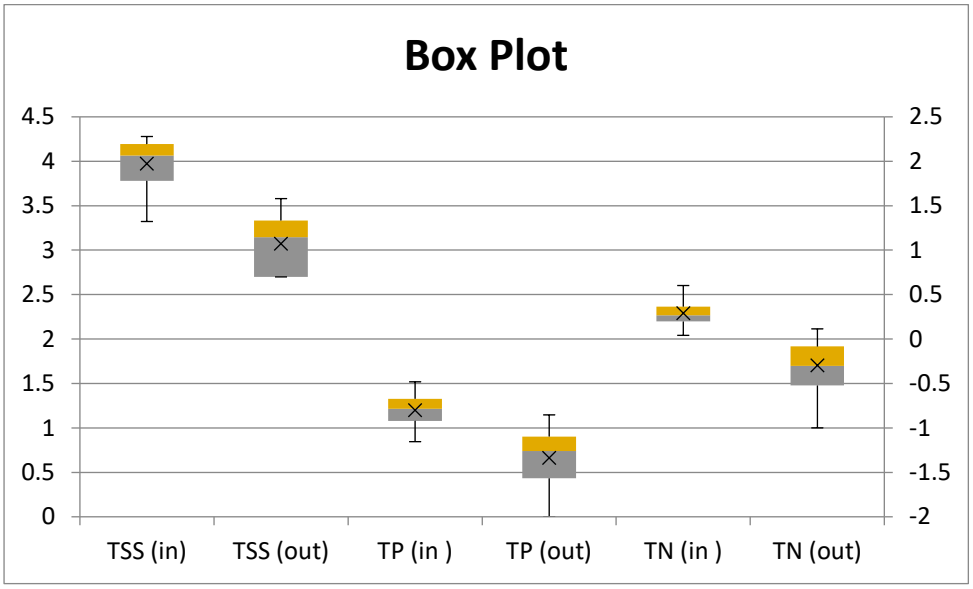
T Test: Two Independent Samples

SUMMARY			Hyp Mea	0
Groups	*Count*	*Mean*	*Variance*	*Cohen d*
Group 1	16	0.2905	0.0233	
Group 2	16	-0.296	0.0866	
Pooled			0.055	2.5017

T TEST: Equal Variances				Alpha	0.05				
	std err	*t-stat*	*df*	*p-value*	*t-crit*	*lower*	*upper*	*sig*	*effect r*
One Tail	0.0829	7.076	30	4E-08	1.6973			yes	0.7908
Two Tail	0.0829	7.076	30	7E-08	2.0423	0.4173	0.7558	yes	0.7908

T TEST: Unequal Variances				Alpha	0.05				
	std err	*t-stat*	*df*	*p-value*	*t-crit*	*lower*	*upper*	*sig*	*effect r*
One Tail	0.0829	7.076	22.525	2E-07	1.7154			yes	0.8305
Two Tail	0.0829	7.076	22.525	4E-07	2.0711	0.4149	0.7582	yes	0.8305

Box Plot- Log Transformed data



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