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Impact of Water Meter Replacement on a Water Utility’s Revenue

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Edits to Research Report based on Examiner 1 and Examiner 2 reports

Impact of Water Meter Replacement on a Water Utility's Revenue

No.	Examiner Comment	Remedial Action or Edit	Page or Location
Response to Examiner 1 based on the marked-up research report			
1	I don't agree with this assertion - the acceleration is largely due to the fact that the project has been largely delayed. Rather, the projected deficit for the Vaal system is a good sign of reduced water availability	Removed the following: "Based on the need for the implementation of the Lesotho Highlands Water Project Phase 2, scheduled for completion in 2025; Since the introduction of the National Water Act in 1997, Water Service Authorities have been tasked to conserve water and promote responsible water usage"	Page 5
2	I do not agree again - this is best practice and its cheaper than. You are better off discussing the lack of availability from a water balance perspective from the water resource studies (e.g. WR2005 to the current WR2015 I think) – with reference to National Water Act in 1997, Water Service Authorities have been tasked to conserve water	Additional information included as follows: "However, in contrast to the above, when considering the information contained in the Water Resources of South Africa Studies, WR2005 and WR2012, the Mean Annual Runoff (MAR) has only decreased slightly between the various studies undertaken: -WR90 – 51 121.30million kl /a (Time-period: 1920-1989) -WR2005 – 49 210.32million kl /a (Time-period: 1920-2004) -WR2012 – 49 114.74million kl /a (Time-period: 1920-2009) This would imply that the surface water availability has remained relatively stable or constant. The WR2012 report further went on to indicated that there are large variations in water quality across the country as a result of contamination of the resources. Therefore, although the surface water may remain constant, contamination thereof would reduce the availability of water to consumers."	Page 6
3	True, but keep in mind that 5 years is a very short time to talk of a continuous decline in climatic factors. There are better and open datasets that can make your point better (with reference to dam level decline)	Additional information included as follows: "It is noted that a 5-year time period, as indicated above can be considered short in terms of climatic factors, however a study titled 'State of the Climate in 2017', completed by the American Meteorological Society, indicated that Cape Town experienced its driest year in 2017 since 1933. Further, there has been a steady increase in annual mean temperatures since 1951 (Figure 1-4)."	Page 6

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4	Check the Cape Town Water Outlook for precise info, updates and definitions on this – with reference to "Day Zero"	Additional information included as follows: "The restrictions were applied in order to avoid what was termed "Day Zero". "Day Zero" is the day that almost all of the taps in the City of Cape Town would be "turned-off" and each person would have to queue for water at one of approximately 200 sites. In June 2018, following the winter rainfall, the dam levels were at 42.7% (News24, 2018), which was at a higher level for the same time periods in 2016 and 2017. The Cape Town Water Outlook 2018, reported that dam levels had risen to 55.8% as at 19 July 2018 (Figure 1 5). City of Cape Town managed to avoid Day Zero, as a result of the intense water demand management programmes, constant communication, awareness campaigns and behavioral changes with regards to water usage (Figure 1 6)."	Page 7
5	This is not an assumption. It has been proven in literature beyond any doubt – with reference to the assumption that aging water meters are less accurate due to mechanical wear	The word "assumption" has been replaced with "premise"	Page 9
6	I am sure this is not what you mean here. Meter READING accuracy and meter accuracy are two different things - with reference to Hypothesis 1	Edited to the following "Hypothesis 1. The replacement of aging residential water meters positively impacts the accuracy of water consumption logging. This is based on the assumption that the water meters accuracy degrades over time."	Page 11
7	He is not the first one to have found this... He actually adopted an existing method in his mini-dissertation – with reference to Moahloli (2017) Literature review	Included the following comment: "Moahloli (2017), Fantozzi et al. (2009) and Arregui et al. (2006) found that a relationship exists between water meter age and accuracy, in addition to the total registered volume and accuracy."	Page 16 Edited version Page 18

No.	Examiner Comment	Remedial Action or Edit	Page or Location
8	This was developed by Arregui et al. and it would help to refer back to it. For instance, the error is a weighted error combining consumption profiles and meter error which is not what Moahloli used. Also, the optimal n is found by solving for the least NPVs from the chain. Another important factor to keep in mind is that this equation has been validated with real measurements of meter accuracy and consumer profiles. These differences need to be at the least acknowledged as they are significant. With reference to Equation 2.1	The following was included: "With regard to the above-mentioned formula, it was originally developed by Arregui et al. (2006), who stressed the importance of the meter error determination (ε). Arregui et al. (2011), indicated that metering error is dependent on the operating flow rate, which follows a very specific characteristic curve path (i.e. error curve of the meter), which is further dependent on meter type. Each meter type has a varying error curve, and each was verified by a lab test of on average 35 new meters at the Polytechnic University of Valencia. It was further noted that since the errors vary throughout the measurement range, the amount of water not registered by a water meter depends on both the shape of the curve, as well as, the consumption flow rates of the consumers. Therefore, as a result both parameters need to be combined to calculate the weighted error of a meter. Several authors have proposed different methods to calculate the weighted error of a meter (Male et al., 1985; Allender, 1996; Yee, 1999; Johnson, 2001; Ferreol, 2005; Arregui et al., 2006). However, the selected methodology will have a significant impact on the final results (Arregui et al., 2009). Moahloli (2017) opted to make use of the following formula (van Zyl, 2011) to determine the error of the meter::	Page 16 Edited version page 18 to 19
9	See above. A critical review of why this substitution of different terms and methodologies is acceptable is warranted, I think. With reference to Equation 2.2		Page 16 Edited version page 18 to 19
10	This is not your work but it would be interesting to review this in your work. By the definition of the NPVC, I would expect its curve to actually include the meter installation and water loss cost giving you different graphs to what is contained here With reference to Figure 2.3	Note the curve does include the meter installation and water loss costs	Page 18 Edited version Page 20
11	Or simply because the users are simply different? With reference to the following comment "This may be as a result of the limited sample size used by Allender (1996), when compared to Davis (2005)	Inclusion "or as a result of the varying consumption patterns from different consumers."	Page 19 Edited version page 21

No.	Examiner Comment	Remedial Action or Edit	Page or Location
12	I actually do not see the value of these maps in this study... With reference to Figure 2.8	Disagree with comment, the Figures illustrate the importance of considering all factors when rolling out a meter replacement strategy and GIS can be a valuable tool in this regard	Page 26 Edited version pages 27 and 28
13	Surely, there cannot be just one study on this. You might want to be specific as well to talk to this as an alternative methodology compared to what was described prior With reference to Section 2.2. Water Meter Degradation Studies	Combined sections 2.2 and 2.3 into one section “Water Meter Degradation and Inaccuracy Studies” Apparent losses definition moved to the introduction	Page 28 Edited version page 30
14	These heading are a bit confusing as they all mean the same thing to me. Meter inaccuracy is from meter degradation With reference to Section 2.3 Water Meter Inaccuracy Studies		Page 32 Edited version page 30
15	This would have been nicer at the beginning with reference to the apparent losses description		Page 32 Edited version page 30
16	It is commercial loss by definition. With reference to the comment “This can therefore be considered a commercial loss, as it is directly linked to water which is not accounted for and thus not paid for”	Edited sentence “this by definition is considered a commercial loss, as it is directly linked to water which is not accounted for and thus not paid for.”	Page 32 Edited version page 30
17	“at variable flow rates” - Deleted because the evaluation of meter performance can only be done at variable flow rates for it to qualify as evaluation - in fact the approval of meter is also based on variable flow rates. The critical element is how many of these test flow rates are done to be able to reproduce the metering error	Deleted	Page 32
18	I am uncomfortable with these comparisons as you are not comparing like with like. Couvelis is an unvalidated alternative approach	Inclusion: “It should be noted however that the investigation was based on database information, and was not validated by physical meter testing information.”	Page 33 Edited version page 33
19	maybe this should be on its own? – with reference to On-site leakage section	Disagree with comment, kept within existing section	Page 33
20	□ Cape Town 13.1 % □ Manguang – 2.7 % □ Johannesburg – 10 % Percentage of what?	Edited as follows: □ Cape Town – 13.1 % (2.81l/h per leaking property) of the on-site leakage is unmetered □ Manguang – 2.7 % (1.1l/h per leaking property) of the on-site leakage is unmetered □ Johannesburg – 10 % (1.7l/h per leaking property) of the on-site leakage is unmetered	Page 34 Edited version page 34

No.	Examiner Comment	Remedial Action or Edit	Page or Location
21	I don't think you have understood the quoted studies properly. For instance, while Davids used age as a proxy, the methodology explicitly includes the average volume consumed. Mutikanga talks of volume as a better indicator	Inclusion into text: “or volume consumed”	Page 35 Edited version page 35
22	What do these mean exactly? “non- and under-registration components of the unregistered volume”	Edited version’ “The critical conclusion by Mukheibir et al. (2012) was that to create meter replacement strategies solely on the basis of registration age or volume consumed, as proposed by Davis (2005), Ncube (2015), Mutikanga (2012), Moahloli (2017), and Viyakespan (2010) is not cost effective. Consideration must be given to both the non- and under-registration components of volume passing through the meter (i.e. non-registration component is water which is not measured by the water meter at all and under-registration is water which is measured in the lower flow ranges but has a higher error associated with the readings and is therefore considered inaccurate).”	Page 35 Edited version 34
23	I would be careful with this assertion - I don't recall anything above proving this “Meters tend to over-read within the first year of operation”	Removed	Page 42 Edited version page 44
24	Johannesburg Water is not an independent company but a state-owned enterprise	Edited to State-owned enterprise	Page 44 Edited version page 45
25	This is in essence Couvelis's method, it would help to reference it as such “the investigation was only based on 12 months’ worth of meter readings prior to the meter replacement and 12 months’ post meter readings after the replacement.”	Inclusion into text: “This is similar to the approach followed by Couvelis (2012), who made use of consumer meter database information and compared consumption one year before and after a meter is replaced.”	Page 48 Edited version page 48

No.	Examiner Comment	Remedial Action or Edit	Page or Location
26	You therefore could have used the class in some instances. Was an evaluation done to see how many records for the old meters would have the meter class? "the alpha-numeric serial number is often a prefixed with meter class"	Inclusion: "Unfortunately, Database 1 provided by Johannesburg Water did not include meter class, meter make, meter model and meter size. An analysis was done of the old meter information based on serial numbers and meter manufacturer naming conventions, and only 35 meters could accurately be assigned a class. Of that class information, only 11 had a change in class from old to new meter. The sample size was deemed insignificant and was therefore not investigated further."	Page 52 Edited version page 51
27	This table makes no sense and should be deleted. The info is repeated below in Table 3-12	Deleted table	Page 56 Edited version page 55
28	I find this 3-page lengthy equation a total waste. The block tariff can be described in a much simpler and shorter way - maybe graphical? And the tariff is one, just different steps as opposed to tariff 1, 2, 3... With reference to equation 3.3	Disagree with comments – majority of people do not understand the block tariff structure calculation and therefore the calculation or equation remains	Page 57 Edited version page 57
29	A statement to that effect can save you from having to repeat this for every table With reference to "the above comparison was completed for all 3679 properties"	Statement included under Step	Page 60 Edited version page 57
30	Are hypothesises still proposed?	Hypothesises are still prosed at this stage of the report	Page 62
31	I believe you have rushed into the financial aspects without a proper understanding of the volumes. Some statistical analysis that looks at the distribution of these volumes per meter category, user category etc would have been very useful to enable you to unpack the underlying properties. I would have expected some histograms at the very least showing the distribution of these volumes With reference to Table 4.1	Included the following analyses into Section 4.1 • Regression analysis • T-paired analysis • Standard deviation	Page 65 Edited version 64 to 67

No.	Examiner Comment	Remedial Action or Edit	Page or Location
32	This graph does not communicate the stated average but rather that there is a more or less an equal proportion on either side. Consider a different representation. Discussing volumes prior and disaggregating your data may also reveal some interesting insights With reference to Figure 4.1 and Figure 4.2		Page 65 Edited version 64 to 67
33	So what's the use of Table 4.2?	Included to demonstrate the CPI since project inception	Page 68
34	Why January 2018? Wasn't it possible to calculate each payback value based on the actual year of replacement and then find the average?	The tariff structure utilised was based on 2017/2018 figures therefore based date for capital costs was taken as January 2018 Included NPV calculation	Page 68 Edited version page 69
35	I would be weary of purely going for the average in such analysis. If anything, Figs 4.1 and 4.2 show that there is an equal distribution on either side that might warrant separate treatment. Coupled with table 4.3 info there is a case of doing your analysis at least per homogenous grouping of meters	Regression analysis included, in addition to Standard Deviation calculation	Page 69 Edited version page 69 to 74
36	These high number deserve a concerted effort in just understanding these meter grouping better. I would in fact expect you to deal with groups one and two in more detail as all the other groups have insufficient number of meters to produce statistically significant With reference to Table 4.3		Page 69 Edited version page 69 to 74
37	This is an interesting upsizing that warrants some discussion. With reference to Table 4.3 – Group 4	Inclusion: “With regards to Groups 4 and 5 the meter change was an extreme variation and is discussed below:	Page 69 Edited version page 71

No.	Examiner Comment	Remedial Action or Edit	Page or Location
38	Another interesting downsize. Any explanation? With reference to Table 4.3 – Group 5	□ Group 4: Meter was a 25mm changed to an 80mm – meter originally supplied a petrol station which was expanded to include a car wash and restaurant facilities, therefore the overall demand increased. □ Group 5: Meters were originally 40mm changed to 15mm meters – original meter size was based on supply pipe diameter and not the consumption patterns of the property, thus resulting in an oversized meter. The downsized was approved based on consumption demand."	Page 69 Edited version page 71
39	These are too small Groupings 6,9 and 11	Agreed and were excluded from detailed analysis, however still included for overall analysis with a note that the sample size is too small to have a significant result Further the following was included: "It should be noted that this analysis is based on this particular project and these payback periods are associated with the increased potential revenue of this particular project. The payback periods may not be similar for an alternative project."	Page 70 Edited version page 77
40	Its rather curious that for smaller meters there was zero replacement with similar sized meters. Some text on this might be good With reference to Table 4.4	Inclusion: "The sample did not include any meters which were replaced like-for-like (i.e. 15mm with a 15mm), this may be as a result of the 15mm meter only being introduced in more recent years and no older 15 mm meters being found in the field."	Page 70 Edited version page 73
41	These results need to be further interrogated. The average consumption in Johannesburg is about 30kl/month (which you have not mentioned in the report) and the results indicate a disproportionate amount of change of that consumption in either direction. What would be the explanation for this particularly since you are purely dealing with averages. In your analysis, I do not recall a treatment of stuck meters, i.e. those meters that had a zero consumption prior to the change. With reference to Table 4.4	Regression analysis included, in addition to Standard Deviation calculation	Page 70 Edited version page 69 to 74

No.	Examiner Comment	Remedial Action or Edit	Page or Location
42	This is precisely while global average analysis is a bad idea. Your analysis need to be sufficiently disaggregated to avoid this With reference to “Furthermore, the largest impact in terms of revenue generation, can be seen in groups 6,9 and 11”		Page 70 Edited version page 69 to 74
43	An expected conclusion which begs the question of why is there a decrease in some cases. Consider unpacking this further. You mentioned there was meter class info on dataset 2, can this be explained by that? With reference to “25mm meters may have been slightly oversized and with the introduction of the 15mm”	Regression analysis included, in addition to Standard Deviation calculation	Page 72 Edited version page 69 to 74
44	This is what an average deviation should look like from an average consumption of 30kl/month. Why the difference with the prior results? With reference to “approximately 6kl/month)		Page 72 Edited version page 69 to 74
45	This is another pitfall of using averages particularly with rising block tariffs. It all depends on where the consumer is on the rising block - this can only be the case if they are already at higher level. In contrast, if your analysis was done individually and aggregated at a later stage you will have more realistic values (not that I am saying it wasn't - it just wasn't demonstrated). With reference to “approximately R203/month”		Page 72 Edited version page 69 to 74
46	Your graph doesn't communicate this average. In fact, it is a wrong graph type, none of these meters should be joined in a scatter graph with lines. What you need more than anything are charts like histograms that show your distribution With reference to Figure 4.5		Page 72 Edited version page 69 to 74
47	This is another curious result. One would expect better improvement in moving from 25mm to 15mm that from 20 to 15. Any explanations? With reference to Table 4.5		Page 73 Edited version page 69 to 74

No.	Examiner Comment	Remedial Action or Edit	Page or Location
48	This makes absolutely no sense, unless the flowrate of both meters were comparable which is unlikely. Such discrepancies warrant some explanation. database 2 should have better info on the new meter With reference to Table 4.5		Page 73 Edited version page 69 to 74
49	If Johannesburg water made than much money per month from just 2531 meters that would phenomenal. I trust this make my point about using global figures with the block tariff. Calculate individually and aggregate With reference to Table 4.6	It should be noted that the information contained in Table 4.12 is accurate. Johannesburg Water reported revenue collection of approximately R8.5 Billion in 2016/17, considering they have approximately 300,000 metered properties, the R2.2 Million rand per month potential revenue for 2531 properties is in the correct order of magnitude.	Page 74 Edited version page 76
50	You are on dicey ground here. You need to understand your variables for calculating the payback period - particularly the proportion of cost to revenue With reference to Table 4.7	Included individual calculations and NPV calculations (refer to Annexure C)	Page 76 Edited version page 77
51	Any concluding remarks on the impact of the meter size in meter replacements based on your results?	Inclusion: “It should be noted that this analysis is based on this particular project and these payback periods are associated with the increased potential revenue of this particular project. The payback periods may not be similar for an alternative project.”	Page 76 Edited version page 77
52	You are no longer comparing like for like here. There are compounding factors here, of which meter size is one. Such analysis should keep everything else constant but the meter age to determine if it is a factor. In fact, you have also lumped meters of different sizes here which distorts your before and after consumption. You were probably better off doing this within the groupings of the previous section, particularly Groups 1 and 2 with enough records in their respective sub-categories. The results might still be similar as they are the majority but it will make them more credible. With reference to Table 4.9	Inclusion of Table 4.16	Page 78 Edited version page 80

No.	Examiner Comment	Remedial Action or Edit	Page or Location
53	It would be proper to first introduce us to what is in these figures, probably at the same time you introduced Table 4.9, as the graphical representation of the table	Edited paragraph accordingly	Page 80 Edited version page 82
54	The results don't mean much as currently presented as everything is lumped up. It would also help to have a threshold of number records per age below which you do not include them in the analysis With reference to "the cause for the reduction is not clear, however, as the assessment is based on actual readings taken in the field, human error and the relatively small sample sizes may have contributed to the skewed outcome"	Results are broken down further from page 81 to page 85	Page 80 Edited version Page 81 to 85
55	This is how your age analysis should have been summarised. Remember though to start at the individual meter and aggregate With reference to Table 4.10	Refer to Annexures A to C	Page 83 Edited version page 86
56	If you plot your payback period against the age you might arrive at a different conclusion. A local minimum perhaps?	Refer to Figure 4.17	Page 83 Edited version page 86
57	The basic premise of your analysis is that you are comparing a before and after and 3 points is hardly adequate for such analysis. You will also note that all papers that attempted this has some form of regression analysis which you have not done as yet. I would therefore not even look at these meter sizes because of the numbers. Table 4.11	Agreed, and comment included that sample sizes are too small; however the data has been included in the tables for reference	Page 84 Edited version page 87
58	Give these some more thought. Why would the overall change be positive when on average the consumption is negative? With reference to Table 4.13	Corrected values were positive	Page 88 Edited version page 90

No.	Examiner Comment	Remedial Action or Edit	Page or Location
59	This does not make sense. If your consumption is less, the revenue will be less. The block tariffs make sure that such decrease in revenue is even steeper. Remember why you have a step tariff in the first place and the impact of going backwards on those steps. With Reference to "the average change in review was positive for every group (this is directly linked to the block tariff structure, where total consumption determines revenue and not average consumption)"	Statement removed	Page 89 Edited version page 91
60	Because you have lumped up all meter sizes here and the pitfalls of calculating in averages this results, and others before on payback, do not mean much. Consider doing for discrete grouping and calculate from the ground up With reference to Table 4.14	Data was analysed individual and the aggregated Refer to Annexures	Page 91
61	The trend is that the payback is generally increasing with the meter reading. Why? Isn't it counter-intuitive? Your averages could probably be the reason With reference to Table 4.15	The payback is based on total costs and total potential revenue per month.	Page 93 Edited version page 94
62	Any meter cloak-overs? Your database 1 might be able to answer this question	Inclusion: "It should be noted that of these meters only 6 were confirmed "clocked-over" meters, where the meter had started to register from zero again."	Page 94 Edited version page 95
63	This map can be clearer Figure 4.18	Map printed badly in PDF, but is clearer on actual print out	Page 95 Edited version page 97
64	Variance? I am not clear what you intend to communicate here	Sentence edited based on the new analysis completed	Page 97 Edited version page 98
65	You have just stated that it is regarded as the norm With reference to "it is assumed that water meter accuracy degrades over time	Edited: "It has become a generally accepted norm that meter accuracy degrades over time (Stoker et al. 2012), as a result of mechanical wear of the moving parts. Therefore, by installing a new water meter there should be an improvement in the overall accuracy of the reading as well an increase in potential revenue. Therefore, meter accuracy is directly linked to the chronological age of a water meter."	Page 97 Edited version page 99

No.	Examiner Comment	Remedial Action or Edit	Page or Location
66	What does this mean? That a bigger meter measures better? Is your sample size also big enough to give confidence to this assertion? With reference to "it should be noted that where the meter diameter was changed from an old meter of 50mm diameter to 40mm diameter new meter, there was a reduction in overall revenue of 35% (Table 4-6)"	Edited as follows: "Based on Table 4 20 the greatest increase in total consumption was noted to have occurred in the 0-1000 kl volumetric flow range, with an increase of 40 %, where the largest increase was expected to occur in the higher volumetric regions. However, when considering Table 4 23, a large portion of the meters which are 10 years old (total number 544) occur in this volumetric region and therefore the physical age of the meter may be contributing to this greater increase in consumption, which would imply that chronological age of a meter may be a better indicator for meter replacement rather than volumetric age. It should be noted that of the 544 meters in this range, only 6 were confirmed "clock-over" meters, where the meter reading starts from zero again."	Page 100 Edited version page 100

Response to Examiner 1 based on the '*Other Commentary*' section in Examiner 1's report. Note: All comments/edits/suggestions/etc. above the '*Other Commentary*' section were repeated in the marked-up research report. These have been responded to above.			
67	Numbering: the page numbering for the first sections up to the abbreviations use the alphabet which is unusual – rather adopt the roman numerals	Corrected to roman numerals	
68	Blank spaces" there are a lot of unnecessary blank spaces within the document such as acknowledgements and a number of other pages mostly related to tables and figures examples of which include page 46, 65, 68, 73 and 84 etc.	Blank spaces removed	
69	Introduction: a stronger case should have been made for basis of the research. In fact, there is also a legal requirement that talks to the continuous verification of meters to maintain them in a verifiable condition – no mention has been made of the related metering regulations and their impact on meter replacement policies	Edited introduction in line with comments above Regulation discussion included on page 43 and reference made to the Act on page 45	
70	Referencing" the list of references is listed in what was presumed to be the order of appearance but a closer examination shows otherwise. The correct refencing style (Hardvard0 must be adopted and for each reference, complete information of the reference should be included, which is currently not the case	References updated and placed in Alphabetic order	
71	Appendix: I was expecting some of the various longer data tables in the appendices as opposed to the data agreement. I don't think it is meant to be part of a future public document. I would therefore recommend for the removal of the agreement with JW from the appendix	Additional appendices included	

Response to Examiner 2			
72	The study data was from between 2013 and 2015. Is this calendar year or financial years (01 July to 30 June)? This also has a bearing on the calculation of potential revenue as the tariffs are applicable over municipal financial years.	Inclusion: "It should be noted that he analysis was based on the tariff structure set in 2017/2018 and therefore replacement costs were escalated to 2018, to have a standard time period to confirm potential revenues (therefore not having to consider the municipal financial years compared to a typical calendar year)"	Edited version page 61
73	The use of units of measure should be standardized as far as possible. The candidate should decide between m^3 and kℓ.	Changed to kℓ throughout the document	
74	The candidate states that the majority of water meters (ON 15mm) do not register any flow below 15 litres/hour (pg.21). Surely this is dependent on the class of the meter – verify	This analysis was based on the literature review and was related to meters being tested. Edit: "It should be noted that majority of water meters under investigation in the study (DN 15mm meters) did not register any flow below 15 litres/hour, which contributes about 15 % of the flow range (refer to Table 2 2)."	Edited version page 21
75	On page 32 the candidate states: This can therefore be considered a commercial loss, as it is directly linked to water which is not accounted for and thus not paid for. - All the NRW Is not paid for, not just commercial losses. Rephrase this sentence	Edit: "This by definition is considered a commercial loss, as it is directly linked to water which is not accounted for and thus not paid for."	Edited version page 29
76	Unaccounted for water should be changed to non-revenue water (NRW) as per the IWA.	Edited throughout the document	
77	The Water Research Commission studies in tariff setting and the South African Regulations for setting tariffs were not reviewed as part of literature review section 2.5 on tariff structures linked to revenue collection. I think the candidate should have reviewed these as well as they would have given a local context	Included under page 43 of the edited document	
78	The candidate constantly uses the term "revenue". Revenue is only realized when the billed amount is paid. The candidate should rather refer to "potential revenue".	Edited to "potential revenue" throughout the document	

79	The candidate used CPI to determine the capital cost of replacing a meter in 2018 based on 2013 actual replacement cost (pg. 67). Why was the actual replacement cost in 2018 obtained from the water utility? CPI and inflation on water meter installations might not necessarily be the same	No projects have been undertaken by this particular Water utility since 2015, thus the utilization of inflation. Also comparing to other utilities is risky due to the varying structure of implementation contracts (i.e. some include materials, others don't etc.)	
80	Section 5.1.1: how does the increase in potential revenue due to meter size changes compare to when meters are replaced with the same size of meter? Is the difference due to a change in size or due to replacement of old meter with a new one?	Inclusion: "The sample did not include any meters which were replaced like-for-like (i.e. 15mm with a 15mm), this may be as a result of the 15mm meter only being introduced in more recent years and no older 15 mm meters being found in the field."	Page 70 Edited version page 73
81	How do the results/findings of this study compare to what has been found by other authors/studies that were reviewed in the literature review?	Majority of inclusion: "Therefore, the chronological age of the meter may have a larger impact on meter accuracy when compared to the volumetric age. Therefore Ncube (2015) and Mutikanga (2012) recommendations of 8 Ml as an appropriate guideline for meter replacement could not be validated. However, the above appears to be in line with Viyakesparan's (2010) findings that the maximum errors in meter readings occurs at a cumulative volume of 3.9 Ml. Further this also validates Viyakesparan's (2010) conclusion that there is no relationship between meter chronological age and cumulative volume and that both need to be considered in order to determine an optimum meter replacement period for a specific water utility."	Edited version page 102