**BEFORE A HEARINGS PANEL OF THE GREATER WELLINGTON REGIONAL COUNCIL**

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| **UNDER** | **the Resource Management Act 1991 ("the Act")** |
| **IN THE MATTER OF** | **Resource Consent Applications to Greater Wellington Regional Council pursuant to section 88 of the Act to discharge contaminants to land, air and water** |
| **BY** | **South Wairarapa District Council** |
| **FOR** | **the proposed staged upgrade and operation of the Featherston Wastewater Treatment Plant** |

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# BRIEF OF EVIDENCE OF CHRISTOPHER NEILL PARK ON BEHALF OF SOUTH WAIRARAPA DISTRICT COUNCIL

## FLOW MONITORING AND INFILTRATION AND INFLOW

**DATED 29 MARCH 2019**

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**EVIDENCE OF CHRISTOPHER NEILL PARK ON BEHALF OF SOUTH WAIRARAPA DISTRICT COUNCIL**

1. My full name is Christopher Neill Park. I hold a Bachelor of Environmental Engineering from Unitec Institute of Technology (2007)

**RELEVANT EXPERIENCE**

2. I currently lead the Auckland based monitoring team at Mott MacDonald which provides monitoring and consultancy services to clients throughout New Zealand and Australia. I have been involved in network flow monitoring and infiltration and inflow (I/I) investigation since first joining Mott MacDonald (formerly AWT) in 2004. From 2007 to 2008 I worked at Auckland Council (formerly Manukau City Council) as a Resource Compliance Engineer before returning to Mott MacDonald in 2009 to further my network monitoring specialisation. Throughout my career I have been involved in a range of projects from small to very large network assessments. These projects focused on the following key areas:

   *a.* Developing monitoring strategies

   *b.* Flow (stormwater, water and wastewater), water level, rainfall, pump station and groundwater monitoring

   *c.* Instrument installation and calibration

   *d.* Hydrological data analysis

   *e.* Real-time overflow alarming

   *f.* Assessment of I/I

   *g.* Inflow detection (smoke testing, property inspections and network asset inspection)

   *h.* Groundwater infiltration detection (night flow isolation) *i.* Saline ingress detection (conductivity and flow investigation)

*j.* Developing plans to prioritise network improvements.

**CODE OF CONDUCT**

3. I have read the Code of Conduct for Expert Witnesses in section 7 of the Environment Court's Practice Note (2014). I agree to comply with that Code of Conduct. Except where I state that I am relying upon the specified evidence of another person, my evidence in this statement is within my area of expertise. I have not omitted to consider material facts known to me that might alter or detract from the opinions which I express.

**MY ROLE IN THE PROJECT**

4. This evidence is presented in respect of South Wairarapa District Council's ("SWDC") application for resource consents to enable the ongoing operation, maintenance and upgrade of the Featherston wastewater treatment plant ("FWWTP Project" or "the Project" or "the Scheme").

5. I have been involved in this project as a consultant/contractor for I/I assessments for SWDC since September 2013 when I was first engaged to make high level assessments on the historical influent flow meter data and a 2004 network flow monitoring report undertaken by others. Following the original engagement, I undertook a site-based groundwater infiltration investigation requiring the measurement of night flow in defined areas of the network. I analysed the results to rank each area based on the contribution of groundwater infiltration. The report was then extended to include rehabilitation cost estimates and post-rehabilitation flow reduction estimates. My work was used by

others in an assessment which optimised the rehabilitation (flow reduction) spend to achieve increased hydraulic retention time (HRT) (see Steve Couper's evidence) and lowest overall scheme cost.

6. I produced or assisted in the production of four relevant reports covering I/I, rehabilitation costs and post-rehabilitation flow reductions:

   a. *South Wairarapa Integrated Wastewater Scheme – Technical Review (August 2013) (assisted with I/I sensitivity assessment).*

   b. *Featherston Wastewater Flow Monitoring Review (September 2013) (primary author of review of existing information).*

   c. *I/I workshop (November 2013) (Assisted presenting the results of the optimised rehabilitation and treatment scheme costing).*

   d. *Featherston Groundwater Infiltration Investigation (December 2013) (Field investigations and primary author of report).*

**SCOPE OF EVIDENCE**

7. My evidence will address the following:

   a. I/I issues and importance to the scheme costs
   b. Detailed groundwater infiltration investigation methodology and results
   c. Estimations of rehabilitation costs and effectiveness
   d. Derivation of the most cost-effective level of rehabilitation
   e. Implementation of I/I rehabilitation and adaptions to the approach
   f. Response to submissions and officers/technical reports where necessary

g. Conclusion.

**EVIDENCE**

8. **High level characterisation of I/I issues:**

*a.* A review of historical FWWTP influent flow data (managed by SWDC and not validated by Mott MacDonald) from 2007-2012 was undertaken. See Figure 1[1] below applying to points b, c & d below:

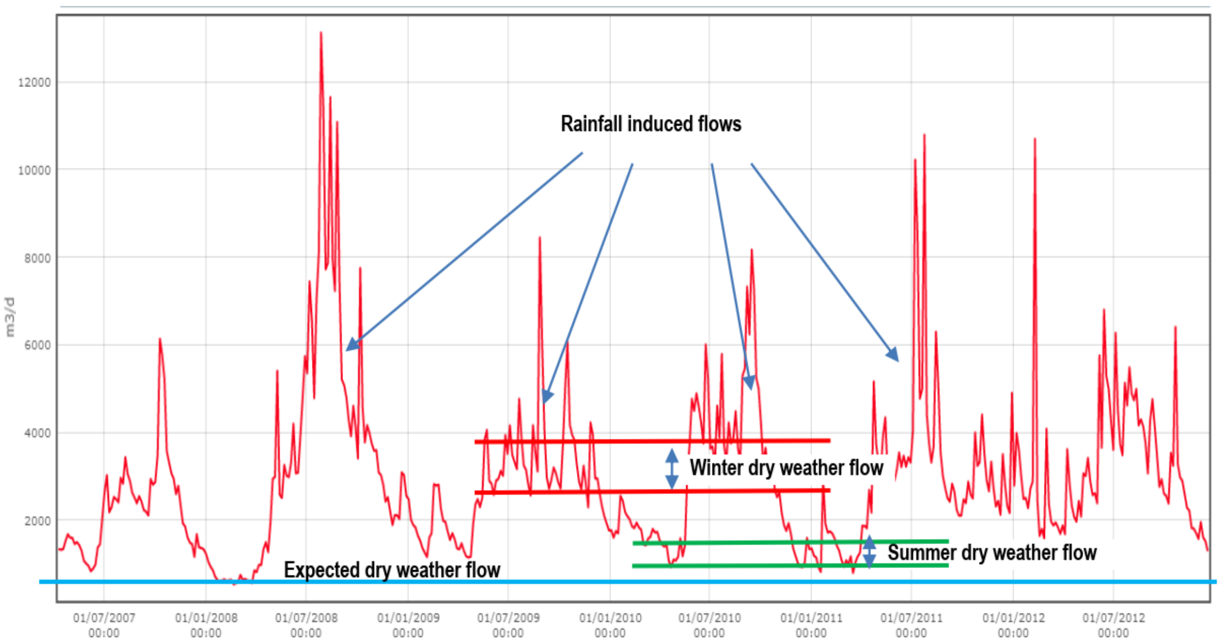


***Figure 1: Influent flow data (provided by SWDC)***

*b.* The data showed an unusually high average daily flow of 2,721m$^3$/day (averaged annually). Based on the population at the time of 2340 and a typical wastewater production rate of 250L/p/day, dry weather flows of approximately 585m$^3$/day were expected.

*c.* The most notable trend was the seasonal variation. In summer dry weather baseline flows ranged between 500-1000m$^3$/day. Flows

[1] Note: A high resolution and larger size graph is provided in Appendix 1.

steadily increased with the onset of winter each year and following rain events the network recovered to a significantly elevated baseline of 3000-4000m$^3$/day. Flows remained high until extended dry periods in December/January.

*d.* Rainfall events added further volume with peaks of 5,000-12,000m$^3$/day recorded during typical winter events. The flow slowly receding to a recovery point which in winter was typically greater than the baseline flow before the event, hence the trend of increasing flows.

*e.* Elevated dry weather flows and prolonged high flow following rainfall were deemed to have the greatest impact on the cost and operation of any future treatment scheme. Wet weather peaks, while notable for peak single day volumes, were considered subordinate to the potential volumetric issues caused by the prolonged periods of elevated flow resulting from what appeared to be groundwater infiltration (GWI) and rainfall dependent infiltration (RDI).

*f.* The presence of the three components of I/I, direct stormwater inflows, RDI and GWI, have been inferred from flow data observations. The presumption is that direct inflows of rainfall will cause a rapid increase in flow which recedes quickly after all fast draining sources are exhausted. If high flows persist for an extended period after rainfall it is assumed that a stored source is present, such as saturated surrounding soils (groundwater), causing flows to enter gradually through submerged network defects. Following rainfall, soil saturation and local groundwater levels are presumed to be the highest, causing a temporary increase in infiltration. This portion of infiltration is termed rainfall dependent infiltration as it is directly linked to the effects of a rain event. When dry weather flow or the recovery point following rainfall is higher than the expected dry weather flow rate based on population, it is presumed that a more stable source of groundwater is infiltrating the network, driven by the groundwater system with its wider rainfall and geological influences. This is groundwater infiltration and is assumed to be the cause of seasonal increases in dry weather flows and high night flow rates. When present, typically in winter, rainfall response is often exaggerated as the inflow and RDI response adds to the already elevated baseline dry weather flows.

*g.* When assessing I/I a distinction is made between GWI and RDI to more accurately understand the source and potential issues. From a rehabilitation perspective, the presence of either GWI or RDI implies the same type of defects. GWI however, is generally considered a more significant issue due to the continuous nature of its influence and the potential size of the source (the stable groundwater system can be fed by a catchment much larger than the immediate wastewater catchment area). It is also highly likely that a network with GWI will have an issue with excessive RDI. The impact of an RDI issue on the other hand, when it is RDI alone, is limited to the period immediately following rain with flows returning to expected dry weather conditions.

9. **Detailed GWI investigations**

*a.* The *South Wairarapa Integrated Wastewater Scheme – Technical Review (August 2013)* included an I/I sensitivity assessment that modelled the cost benefit of flow reductions on the WWTP scheme. The inputs were historical flows, WWTP CAPEX (based on an established flow rate to cost relationship), typical flow reductions (based on the Water NZ I/I Control Manual) and estimated rehabilitation costs for various levels of rehabilitation applied to various proportions of the network. The conclusion was that flow reductions could reduce the FWWTP scheme costs especially if the sources were well isolated to optimise rehabilitation costs. An investigation was planned to develop a more accurate cost benefit analysis.

*b.* The investigation focused on isolating pipes with GWI and the method used was night flow isolation. The basic concept is to measure flows within small sections of pipe or mini-catchments at night in winter (while the network is most susceptible to being submerged by groundwater) with insertable weirs (accurate to 2-5%) to determine the rate of infiltration or "leakiness". Dry weather is required to control for the influence of stormwater and it is assumed that night flow comprises primarily GWI (providing a good estimate of GWI severity). Large sources of trade waste can skew the results but were considered unlikely in Featherston.

*c.* 17 study catchments were defined for the investigation. The total measured flow from each included infiltration from all upstream assets including laterals. The study took place over 7-8th October 2013.

*d.* The investigation successfully identified areas contributing a disproportionate rate of GWI. For example, it was found that only 23% of the network was contributing 83% of night flow. The study was carried out when the measured inflow to the plant was 2,363m$^3$/day, which is near the annual average daily flow of 2,721m$^3$/day. It was therefore deemed to be a good representation of the pipes responsible for the majority of GWI and RDI. Figure 2 below shows the disproportionate isolation of sources.

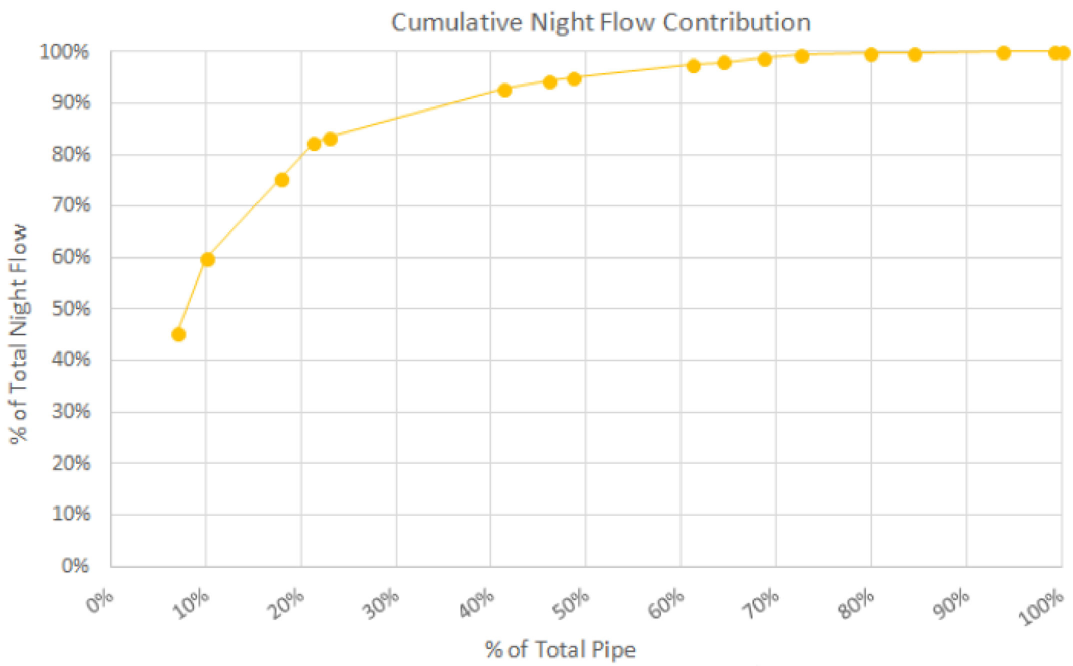


*Figure 2: Isolation of night flow sources*

10. **Rehabilitation costs and effectiveness (flow reductions)**

*a.* Flow reductions, post-rehabilitation flows and costs were estimated for each of the 17 study catchments based on two rehabilitation scenarios.

*b.* Flow reduction figures were taken from case study data and guidelines from the New Zealand Water and Wastes Association Infiltration and Inflow Control Manual (1st Ed 1996) which has since been updated to the Water New Zealand Infiltration and Inflow Control Manual (2nd Ed 2015), hereafter referred to as the Water NZ I/I Manual. Our estimations are consistent with the more detailed figures in the latest edition (Vol 1, p35-40). Cost ranges were estimated by a rehabilitation specialist.

*c.* Variability in rehabilitation technique, quality control and the method of effectiveness monitoring make estimating actual reductions difficult. Accordingly, the case study data shows a wide range of outcomes. The latest Water NZ I/I Manual cites two main factors influencing how effective rehabilitation will be:

i. Percentage of the network rehabilitated in target catchment. We assumed approximately 60% of the total study catchment would be rehabilitated if only public pipes were addressed and 100% if private laterals were included. The I/I Manual quotes GWI volume reductions of 50% and 80% respectively under these scenarios.

ii. The initial severity of the I/I. Detail was lacking on the specific impact of initial GWI to the reductions achieved, however, the general rule is the greater the initial I/I volume the greater the percentage reduction. E.g. At high rates of rainfall ingress (% of total rainfall that enters the network) of 20%+, 70-80% and 85-95% I/I volume reductions are estimated for 60% and 100% catchment rehabilitation respectively. At a lower ingress rate of 5%, only 35% and 40% volume reductions are estimated. Featherston was shown to have severe GWI based on per capita flows and seasonal dry weather flows and therefore maximal reductions could be expected.

*d.* It is sometimes suggested that after rehabilitation is carried out infiltration will migrate to unrehabilitated parts of the network due to local groundwater mounding occurring as a result of removing the sub-soil drainage provided by the defective pipes. The actual prevalence of this phenomenon and its ability to undermine flow reductions is difficult to ascertain due to being difficult to measure with certainty. The NZ I/I Control Manual states that the risk of this occurring is reduced if a greater extent of rehabilitation is completed. The impact is assumed to be negligible for this project based on the comprehensive rehabilitation (laterals included) that is currently preferred. This and any other issues with effectiveness can be identified and addressed though the long term influent monitoring and an adaptive approach to flow management.

*e.* The final assumed flow reduction and costs used in the cost benefit analysis are as follows:

i. Relining public pipes ($200-$350/m) and repairing all manholes ($1500/MH) - achieving 50% - 60% night flow reduction (consistent with the Water NZ I/I Manual's 50% reduction for 60% of network rehabilitated and taking into consideration the high existing infiltration rates and the resulting increase in reductions).

ii. Relining public pipes ($200-$350/m), repairing all manholes ($1500/MH), and relining all private laterals ($350/m) – achieving 65% - 75% night flow reduction (lower reduction rates than the Water NZ I/I Manual's 80% estimate for 100% of network rehabilitated making our upper estimates conservative).

*f.* The cumulative costs for rehabilitating each catchment in order of priority and the resulting flow reductions were used to produce the post rehabilitation flow vs cost curve below (Figure 3). Note the post-rehabilitation flows are still higher than the expected per capita flows due to the assumption that rehabilitation is never 100% effective.

*Important note: The estimated flow reductions presented here are based on the flow conditions captured during the investigation and the rehabilitation of defects that cause GWI and RDI i.e. the graph shows the reduction of GWI influenced dry weather flows through rehabilitation of manhole and pipe defects.*

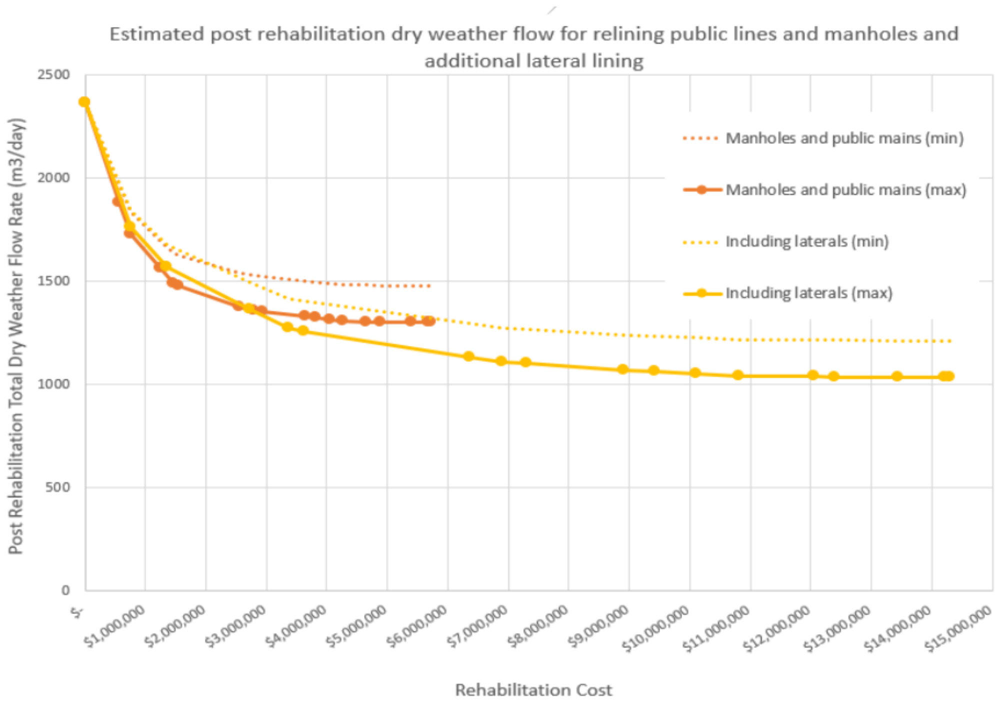


***Figure 3: Dry Weather Flow vs Rehabilitation Cost***

g. Estimating the treatment costs and treatment performance associated with post-rehabilitation flows required estimates of both normal (average dry weather) and high (wet weather) flows. Dry weather flow (GWI influenced) was established using the flows calculated in the GWI rehabilitation analysis (as presented in point 'e' above) however, as the investigation did not include wet weather, extrapolation of the dry weather flow reductions was necessary. An approximate reduction in wet weather flows was based on the following assumptions:

   i. The relative contribution of infiltration from each catchment would remain the same across the network at higher flows as was observed in the dry weather GWI field investigations i.e. the pipes that were found to be disproportionately contributing infiltration when the flow was 2,363m$^3$/day during the investigations would continue to do so when the flow was for example 10,000m$^3$/day. Targeted rehabilitation would therefore address the same percentage of infiltration during dry and wet weather.

ii. The RDI reduction percentages at high flow would be similar to those achieved for the GWI reduction estimate during dry weather i.e. 65%-75% reduction in infiltration volume, which is a conservative estimate compared to the Water NZ I/I Manual which states 85%-95% reduction of RDI with public and private network rehabilitation

iii. The inflow induced peak flow rate would also be reduced through the infiltration rehabilitation works due to the removal of significant background flows, especially during winter. This is perhaps the most uncertain assumption as the extent of direct stormwater inflow was not well understood.

iv. Based on the Water NZ I/I Manual, it could be said that an even greater percentage flow reduction is likely to be achieved during wet weather when there is more infiltration to remove. However, due to the uncertainties around peak flow reduction, a conservative assumption was made that the percentage reduction in flow would remain the same from dry weather to wet weather e.g. the optimised rehabilitation scenario in 11b below quotes a 35% flow reduction. This would be applied to both dry and wet weather flow despite the above assumptions showing a 42-48% reduction is possible at an example pre-rehabilitation flow of 8,000m$^3$/day.

v. The optimised rehabilitation work in principle targets catchments contributing approximately 69% of the total infiltration (flow volumes over the 585m$^3$/day wastewater flow) and reduces it by 65-75%.

## 11. Final cost benefit analysis

a. The rehabilitation costs were added to the WWTP CAPEX (from Mott MacDonald's internal database of treatment costs – refer to Steve Couper) for the given post-rehabilitation flow to determine a total project cost.

b. The lowest overall project cost for the preferred land disposal methodology with I/I reduction was achieved through $1.9M of I/I reduction works resulting in an approximate 35% reduction in all flows (still well above typical per capita flow volumes). Based on the post-rehabilitation flow, the land disposal scheme costs would decrease from $20.72M with no rehabilitation to $13.86M ($6.86M saving). The total estimated scheme cost comprising $1.9M rehabilitation and $13.86M land disposal was therefore estimated at $15.76M, a net saving of $4.96M compared to no I/I rehabilitation. This is illustrated in Figure 4 below (from November 2013 I/I workshop). I note that a number of submissions mention that land value has increased since this report was written. I also understand that there is shortage of suitable land in the area. Accordingly, the estimates may understate the savings to be derived from I/I reduction.

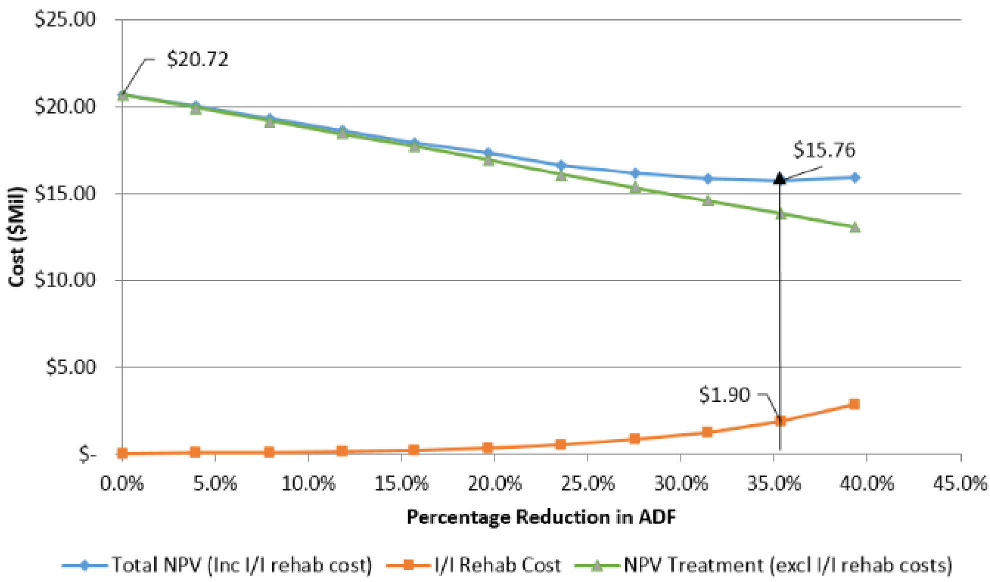


***Figure 4: optimal rehabilitation and treatment cost***

## 12. Implementation and adaptions

*a.* To achieve the desired flow reductions, the top 3 study catchments would require rehabilitation if laterals were included and the top 6 if only public mains were addressed.

*b.* Rehabilitation beyond the point of optimal total cost was to be considered based on other potential benefits to treatment and network management. Note that the post-rehabilitation flows are still expected to be well above typical per capita flow volumes.

*c.* In each catchment selected for rehabilitation, CCTV and rehabilitation specialists were to confirm the presence of defects and design an appropriate rehabilitation method.

*d.* An influent meter was recommended and installed on 1/10/2014 in to improve the quality of the influent data with a view to quantifying the pre and post rehabilitation flows more accurately and refining the program.

*e.* Achieving the desired flow reductions hinged on the assumed reduction estimates so it was recommended that a pilot catchment (study catchment 3) was rehabilitated to refine the expectations – this was especially important for determining the impact of rehabilitating laterals as they are a large unknown and more difficult to rehabilitate.

*f.* I understand that rehabilitation works are still in progress therefore no post rehabilitation analysis is available at this time. The effectiveness of the work on the trunk, which is already underway, will be of critical importance as it was found to be the most significant contributor of infiltration. Lawrence Stephenson is presenting on the progress of the I/I program.

*g.* It is important to note that adaptive management options including storage, further rehabilitation and adjustments to the land application approach are available should the flow reduction be different to that predicted. In the case of pond sizing, it is desirable to defer the final design until post-rehabilitation flows are more certain as it will be directly impacted by this. Refer to Katie Beecroft's evidence for details.

13. **Response to officers' reports and submissions**

*a.* Lawrence Stephenson in his evidence deals with submissions on I/I rehabilitation programming, progress to date, and costs. I have considered submissions relevant to any technical queries on I/I.

*b.* I note that PDP have reviewed my methodology regarding the estimated I/I reductions and confirmed that it is reasonable.

*c.* Submitter 146 (Sustainable Wairarapa) suggest that there is exfiltration of wastewater from the sewer network to groundwater. The way this is typically assessed with flow data is to calculate the per capita flow volumes. Lower than 170 L/p/d implies exfiltration (Water NZ I/I Manual). Based on the available total network flow data, per capita flow rates are above this year-round, significantly so for most of the year due to the extent of infiltration therefore exfiltration is considered unlikely. There are limitations to this general assessment however, namely, the available data is for the total network and does not account for isolated instances of exfiltration. Higher resolution, calibrated flow data from smaller catchments would be required to accurately assess exfiltration based on per capita flows and expected night flows. Following the network rehabilitation programmes and based on the influent flows, high level assessment of potential exfiltration could be explored in the first instance in the absence of high resolution data which is not required by the current consent or unlikely to be required under the new discharge consent. Any issues could be dealt with separately alongside general asset maintenance and renewal work.

*d.* Sustainable Wairarapa also reference potential increases to groundwater levels and subsequent increases in stream flow following rehabilitation of the network which in its current state is acting as a sub-soil groundwater drain. Relative to the flow of the entire groundwater system, the additional groundwater post-rehabilitation is expected to be negligible and is not likely to have an observable impact.

## 14. **Conclusion**

*a.* Initial assessments showed that I/I, specifically, GWI and RDI should be addressed to improve the HRT and reduce the costs and footprint of the preferred land disposal scheme.

*b.* Exfiltration from the sewer network is considered unlikely and is best addressed through general sewer network renewals and maintenance along with the I/I reduction programme.

*c.* From a cost perspective, there is an optimal extent of rehabilitation works as established by the cost optimisation exercise. It was shown that 35% flow reduction achieved the lowest overall scheme cost, beyond this rehabilitation was not cost effective as the cost of the works outweighed the treatment cost savings.

*d.* Variability in the effectiveness of rehabilitation works is expected as case studies show a range of results. Based on the data available, the conservative assumptions adopted and considerations from established literature, the 35% reduction estimate is believed to be conservative and achievable. I do not agree with suggestions that flow reductions might be significantly less than 35%. An adaptive management approach to the I/I programme effectiveness is considered reasonable and practical should any variance be observed.

*e*. Further flow investigations and analysis should be carried out to refine the I/I programme based on the actual reductions achieved during the initial stages, with special attention paid to the effectiveness of lateral rehabilitation and the need to include direct inflow reduction.

Signed:

Chris Park

29/3/2019

**Appendix 1:** ***Figure 1, influent flow data (provided by SWDC)***