Feedback on Council's 9-Year Plan
In respect of South Dunedin's Inadequate Storm-water Infrastructure

Neil Johnstone

Email

Cell:

I wish to speak at the hearing.

A CONSULTATION PROCESS SUBMISSION WITH REGARD TO DCC'S NINE YEAR PLAN

A PLEA TO CORRECT MISINFORMATION SURROUNDING THE MAIN CAUSES OF SOUTH DUNEDIN'S WORSENING FLOOD RISK AND TO IMPLEMENT PROPERLY CONSIDERED SOLUTIONS IMMEDIATELY, A SHAMEFUL TEN YEARS AFTER THE 2015 DISASTER:

NEIL P. JOHNSTONE CPEng ret.

1. I am a semi-retired professional flood control and river management engineer, having spent most of my 50-odd years working life in Otago, including lengthy periods as Investigations Engineer with the Otago Catchment Board then Otago Regional Council and - for more than 2 decades – running my small consultancy, Flood Sense Limited.

2. Of my many successfully completed projects, one most comparable to the South Dunedin situation was possibly my role as a key advisor to the central – Government initiative Project Seeking Practicable Solutions For Clutha River System Flooding (June 2000) following the disastrous catchment-wide flood event of November 1999. I contributed or co-contributed approximately a dozen reports or papers to that project, which was infinitely more demanding and complex than that that has confronted DCC in South Dunedin since at least June 2015. At the completion of the Clutha Catchment project its convenor, Alex Adams acknowledged my technical input and ability to impart my knowledge as "inspirational".

KEY POINTS OF THIS SUBMISSION

1. The blameless citizens of South Dunedin have been consigned to a stressful, uncertain existence in sometimes unsanitary conditions as a result of decades of Council neglect and a refusal or inability to recognise the prime cause of South Dunedin flooding following the disastrous events of June 2015.

2. The prime cause of South Dunedin's now-severe flood risk is demonstrably the creeping uncontrolled (since at least 1968) increase of impermeable

areas that rely on the stormwater system for their drainage. Neither elected members nor staff seem willing to address the realities of the issue, despite the hard surface area's near-doubling and the capacity of the stormwater system consequently near-halving since the drainage scheme was "updated". It is suggested that an unwillingness to admit responsibility for the situation or to fund the remedies may be the reason for treating South Dunedin residents like second class citizens.

3. DCC has done virtually nothing to reduce the risk of stormwater flooding since the damaging flooding of June 2015. Council inaction has even seen some residents' houses being repeatedly invaded by sewage-laden stormwater.

4. Elected members have - often through no fault of their own - been central to the spread of misinformation that continues to undermine the health, safety and general well-being of South Dunedin residents.

5. The replacement of the screens at the Portobello Road Pumping Station following the 2015 flood was desirable for operational reasons, but made no material difference to the pumping efficacy of the pumps, noting particularly that the peak pumped outflow achieved in October 2024. was - according to DCC's own data - essentially identical to that achieved in both the events of March 1968 and June 2015.

6. The lesser flooding experienced in October 2024 compared with June 2015 was simply a consequence of a considerably less demanding rainfall intensity distribution in the latter rainfall event when several periods of lighter rainfall intensity allowed the pipe and pumped system to "catch up" with demand. (Refer graphs attached). The benefit of work carried out by DCC at the pump station's screen is minimal, and arguably zero.

7. The current "alleviation" measures promoted by elected members almost 10 years after the 2015 flooding are supported by no credible assessment of benefit, are seemingly far inferior to workable and beneficial solutions

recommended to DCC by experts from consultants at OPUS in July 2017. These recommended solutions appear to have remained unseen by the public - and possibly from Councillors - despite the OPUS report being labelled *"for consultation"*.

8. The much publicised South Dunedin Futures initiative dabbles with possible climate change scenarios and promotes several - in my view - poorly researched and costed "options". For several years its prioritisation has had the effect of impeding progress on the identification of flood cause and implementation of overdue urgent – even emergency - solutions that are desperately needed NOW, and have been demonstrably needed for decades, but most obviously since 2015.

3. It is my considered view that the proposed short-term initiatives to alleviate South Dunedin flooding are nothing more than a poorly-considered, possibly politically-inspired (in election year) band-aid reaction to the flooding that occurred in South Dunedin in October 2024 following a decade of inaction. In that regrettable decade of neglect, misinformation has been - not necessarily deliberately - regularly distributed by DCC.

4. The near-decade of inaction and misinformation has been bookended by two - of many - unfortunate Mayoral statements, admittedly mostly in the earlier years. At his first opportunity after the 2015 flood, Mayor Cull told ODT readers on 5 June of that year that *"Infrastructure in South Dunedin had coped as well as could be expected... we know the infrastructure is up to scratch..."*. It wasn't, and still isn't. Then, on 7 October 2024 current Mayor Radich told ODT readers in an article headed Infrastructure Gets Tick, But More Needed: Mayor in which he was reported as saying *"the area's recently "tuned up" Three water infrastructure performed well. Mud tanks, pipes and screens were kept clean and the system worked well"*. Except it didn't: South Dunedin was under threat once rainfall intensities reached a mere 7mm per hour, or thereabouts. The spin needs to cease.

5. It is undeniably foolhardy and irresponsible to initiate expensive and potentially disruptive flood management works unless - and until - the causes of

flooding are properly understood, and acknowledged. To this end in August 2024 (note: before the October flooding) I followed up on apparent unresolved anomalies in South Dunedin's stormwater runoff performance during lesser rainfall events post- June 2015 (but prior to October 2024). I researched South Dunedin stormwater design reports from the 1940s, 1950s and 1960s, being the period in which the stormwater system draining South Dunedin was converted by 1964 from a simple gravity system to a pipe and pumped system to accommodate the Otago Harbour Board's (now Port Otago) intentions to reclaim a large area of land at the head of the harbour; i.e. the so-called Southern Endowment, generally to the north-east of Andersons Bay Road. From that research, I was able to demonstrate that the design intention was to instal a stormwater system that would accommodate an appropriate rainfall intensity of 14mm/hour, and up to 19mm/hour. The significant, but largely under-reported, rainfall and flood event of March 8-9 1968 demonstrated more than 50 years ago that the system as installed was already incapable of meeting those standards. The issue was seemingly glossed over, possibly for "economic" reasons. A significant part of the problem was that development across the South Dunedin catchment had already occurred in a manner that created substantially more impermeable areas than had originally been envisaged. These impermeable areas are required to be serviced by the stormwater system. Subsequently, the impermeable areas of South Dunedin continued to increase through continuing reclamation, intensification of housing (especially villas replaced by multi-unit townhouses with paved access, and now, apartments), plus loss of playing fields to North Dunedin (Carisbrook, Caledonian Grounds).

6. My paper, sent pro bono and in good faith, to every DCC Councillor and to DCC's Chief Executive in August 2024 is included as part of this submission. It demonstrated that the impermeable areas of South Dunedin had approximately doubled from approximately 200 hectares (ha) since the "new" scheme was designed to approaching 400 ha currently, and as a result, the stormwater system's ability to accommodate rainfall intensities had been allowed to drop from an intended 14mm/hour (plus) to about 7mm/hour. This - and not climate change - is in my opinion far and away the prime reason that South Dunedin's flood susceptibility has progressively worsened. The accuracy of my analysis was sadly but inevitably demonstrated by the flooding that commenced about 7pm

on October 3 2024, associated with recorded rainfall readings of around just 7-8mm/hour.

7. My paper's content was universally ignored by DCC. It is a matter of speculation whether that was because of individual Councillor lack of interest, or a co-ordinated wish for the issue to disappear. I do not believe that this is acceptable. A copy of my paper forms part of this submission.

8. Extraordinarily, Council 3-Waters reports and consequent consultation documents continue to misinform readers that impermeability across South Dunedin has increased from 45% to 60% (approximately). That is an increase of about just one-third, and is a gross underestimate of the reality. The 60% (approximately) figure is at least as old as the ICMP report of 2010/2011, and the 45% figure is of unknown (to me) source. My paper better describes the realities with tight references.

9. It gets worse. DCC commissioned OPUS to review aspects of its handling of the 2015 flood. In its "peer review" report of 1 July 2016, OPUS made a number of recommendations, the first of which was that:

> *"Council re-visit the South Dunedin stormwater system design parameters in light of changed imperviousness* (my underline), *updated rainfall data, climate change, and the lack of secondary flow paths".*

10.Council has clearly not addressed the change of imperviousness (i.e. impermeability) as it is still publishing ad nauseum old and misleading data that predates the Opus review. Extraordinarily, however, Mayor Cull told ODT readers (July 7, 2016) that Council was

> *"already carrying out all the recommendations in the report* (again, my underline)".

In the same ODT report, Chief Executive Sue Bidrose claimed that

> *"all recommendations in the report were being acted on".*

And yet DCC, almost a decade on, is still misinforming the true state of the South Dunedin catchment's massively increased impermeability.

11. It gets still worse. Earlier this year I sent a copy of my paper on impermeabilities to Council's 3 Waters team. It appeared that none of the

recipients of my paper back in August had done so. I eventually received a reply on March 12 from a member of the team that included the following

> *"I have shared your estimates of permeability with our team for their consideration and I would seek to assure you that we have some excellent engineers assessing this (both in house and external consultants). We have undertaken significant investment in our integrated catchment modelling to address the magnitude of the challenge and the different impact of different solutions. This model does include data relating to impermeable areas but also a number of other factors such as groundwater levels and associated ingress to the stormwater system. Extracting the impermeable area information to answer your question* (as to the actual impermeable area of South Dunedin catchment) *would take some time, and so at this stage I can't provide you with a number".*

!!!!!!!! (The exclamation marks are mine).

12. So, after nearly 10 years of Council inaction in respect of South Dunedin's worsening flood risk, it appears that its 3 Water division can't even answer what should be the most fundamental question in respect of the South Dunedin stormwater catchment flood risk. That is, what is the actual area that the stormwater system is now required to service? In their possible defence, it may be that any real work on achieving stormwater justice for the residents of South Dunedin has been stymied by elected Councillors' and others' preoccupation with South Dunedin Futures. South Dunedin's flood woes are predominantly caused by development across the catchment that has been allowed by DCC to continue apace without proper accompanying upgrading of the stormwater system. It is long overdue for a program possibly called SDN (South Dunedin NOW) to be initiated as a genuine emergency measure. I believe that is an obligation, not simply a matter for protracted consideration as is, I believe, the inevitable fate of the climate change dominated South Dunedin Futures process.

The following consists of some comment on a report that 3 Waters staff have presented to Council as Item 14 South Dunedin Flood Alleviation – Short Term Options to Inform Meeting 28 January 2025.

13. When one reads the 3 paragraphs of the Executive Summary of the report, it is clear that there are still no solutions to South Dunedin's flood "challenges", despite almost ten years of Council investigation following the 2015 flooding.

14. The Report presents 3 options, stated to be a response to requests from the Mayor and Councillors and to reflect community calls to combat short term flood risk. Every South Dunedin flood victim that I have spoken with wants a comprehensive long-term solution.

A fourth responsible option should, in my opinion, have read:

> iv) *Identify the full causes of South Dunedin flood vulnerability and address the emergency urgently.*

Why was such an option not provided?

15. Paragraph 6 of the Report purports to summarise Mayor Cull's address to South Dunedin residents of June 2016. I should point out that three of the six points allegedly raised by Mayor Cull are NOT mentioned in the written presentation, of which a copy is held by me, and delivered in absentia (as was customary) on 16 June 2016 to a large group of mostly angry and sceptical residents. In that version, Mayor Cull made no mention of Forbury Road, models, or issues associated with the Green Island Wastewater Treatment Plant. How there have become "alternative" versions of the letter should be addressed.

16. Paragraph 6 of the report might have presented Mayor Cull's address in full, so that the reader can appreciate how poorly informed (or self-informed) Mayor Cull was.

17. Paragraph 10 of the report considers inter alia splitting the catchment into two sub-catchments by installing additional pipe networks. This has considerable merit, in my view. However, it is brought to Councillors' attention that this was the **recommended option** of the OPUS South Dunedin Stormwater Stage 3 Modelling Report Draft for Consultation, received by DCC in June 2017.

- Did Councillors see this (Opus) report?
- Was it indeed available for consultation?
- Did the residents of South Dunedin see it?
- If not, why not?

- If its distribution was restricted, why and by whom?
- And, most importantly, why was it not acted on eight years ago? Perhaps the cost was considered too high to spend on South Dunedin?

18. Paragraph 15 of the report repeats the much falsely used underestimation that impermeability has increased by one-third (45% to 60%). Refer discussion earlier in this submission.

19. Appendix A (titled Overview of South Dunedin Stormwater and Wastewater Systems) of the Report should be read with caution. Much of the content has been merely cut and pasted from earlier reports/publications. For clarity, the source of such material should have been noted. Much of the stormwater section appears to have been lifted from the confused DCC post - flood report of November 2015. In particular, the conclusion that the maximum runoff that the system can convey in a long-duration storm is around 4.1mm/hour is misleading and obviously contrary to reality, as has so much information that has filtered through to Councillors over the years.

20. The short section on wastewater in the report avoids mention of the regular overspilling of sewage during even moderate floods in parts of residential South Dunedin. This is a public health issue that DCC staff and elected members seem keen to ignore, and apparently wish that others would do likewise. **Council's attitude to this public health issue is a disgrace, and surely of questionable legality?**

21. Council's current lack of urgency to address the urgent and worsening flood issues across South Dunedin may be a consequence of what has become an urban myth that the replacement of the Portobello Road Pumping Station screens in mid-2016 has made a significant improvement to the performance of the pump station, with a resulting decrease in flood risk. Councillors should read Mayor Cull's ill-informed letter to South Dunedin residents to possibly discover the genesis of the myth. Mayor Cull wrote: *Specifically, the Portobello* (sic) *screens blocked which meant the pumps worked below capacity. This made the flooding worse. In addition, and to a lesser extent (*my underline), *mud tanks were blocked*. My analysis, as part of a paper presented to Council's Chief Executive in late 2020, demonstrated that the build up of material on the screens contributed a maximum of 38mm to the general flood depth, the majority of

which was caused by the absence of available workers to undertake clearing early in the event.

22. A further urban myth has been created that the flooding experienced in October 2024 would have been considerably greater had the screen replacement not been carried out.

The reality is rather different:

1. The screens did not "block" in 2015. Some debris was collected by the screens during the morning of the rainfall event. This is exactly what screens are designed to achieve. Experienced field staff recognised the issue as of lower priority and did not send workers to clear the incipient build-up until about noon on 3 June. Although the clearing task required some effort (hence, the advisability of screen replacement), material was thence progressively removed on an as required basis for the duration of the event. Councillors should watch the video screening of the full Council meeting of 30 November 2015, during which a full account of the activity at the pump station during the event is given by a senior staff member, Laura McElhone. The video is also instructive as to how discussion on flood-related issues was suppressed.

2. The allegedly "blocked" screens allowed the discharge of a peak discharge of just $5.3m^3/s$, according to the data, despite the station's intended design capacity being $6.3m^3/s$. This shortfall has been falsely attributed to screen issues. However, reference to reported data following the bigger rainfall event of March 1968 reveals that the same maximum outflow ($5.3m^3/s$) was achieved then also. This strongly suggested that the pump station's performance was not affected by screen performance, but the myth was perpetuated. And then in the event of October 2024, with the $310,000 screens long in place, the data clearly shows that the maximum pumps stormwater flow recorded clearing the South Dunedin flat into the harbour was - again - $5.3m^3/s$. It cannot be deduced that the much vaunted screen replacement has had any significant hydraulic impact, positive or otherwise. The recordings are the same for all 3 flood events. The South Dunedin public hasn't been told this (but they have unfortunately been left relying on challengeable information); Have

Councillors been reliably informed of the reality? It is concerning that Council's Chief Executive (email of 8 October 2024) and 3 Waters staff (email of 12 February 2025) both informed me in similar language that

i). the pump station *"ran hard for the entirety of the event"*, and

ii). *"all the pumps were running flat out throughout the October 2024 event"*.

The terms "running hard" and "running flat out" both convey an unduly optimistic description of the reality, which is the pump typically hunted between only 4.5 and 5.3 m^3/s when they are supposed to deliver $6.3m^3/s$.

3. DCC has maintained that flooding across South Dunedin was less extensive in 2024 than in 2015 because of "improvements" that have been made. This is an extension of the myth. The reason that 2024 was a smaller flood event than 2015 can be found in comparison of the rainfall distributions across the two events. Refer the hourly charts of rainfall intensity, for which the key work was undertaken by experienced engineer, Julian Doorey. I have superimposed a 7mm/hour threshold line to identify the periods when rainfall intensities were arguably (by me) sufficient to cause flooding. There were 14 such hourly periods in 2015, and just nine in 2024. But more significantly, there were 6 hourly periods during the 2024 flooding event timeframe when rainfall intensities dropped substantially below the threshold, but none in 2015. The effect of the periods of reduced intensities was to allow the pipe and pump system to partially empty and "catch up" so that the risk of prolonged flooding did not materialise. That had everything to do with good luck, and nothing to do with good management.

My paper of August 2024

Dear DCC Councillor

I am generally supportive of Councillors O'Malley and Benson Pope's concerns (ODT 23 August) over the increasing areas of impermeable land across South Dunedin as a result of congested apartment-style development on predominantly hard surface surrounds. Such development unquestionably creates more and faster runoff into the undersized storm-water system.

As a long-time professional in the field of waterway management and flood control, I have followed with interest and some considerable concern at the lack of action in the near-decade following the flooding of June 2015.

Most recently, having also noted with concern the mushrooming of near-totally impermeable residential (and other) developments within South Dunedin, I sought to rationalise why a relatively unexceptional rainfall intensity (about 6 mm/hr) in February 2020 should have required the Portobello Pumping station to reportedly operate at its maximum capacity of around 6.3 m^3/s. My simple analysis suggests that the total area of impermeable land serviced by the storm-water system must then have been of the order of 377 hectares. This is some 10% more than suggested by DCC in the aftermath of the 2015 flood event. The recent trend to high density apartment development is certain to be worsening the situation even further.

I have endeavoured to assess how the impermeabi0lity of the South Dunedin catchment has been allowed to increase in the past 80 years or so, and particularly in the years following the replacement of the gravity-driven, half-tide system that served the area prior to the reclamation of the Southern Endowment during the 1940s to 1980s.

My research has centred on 3 DCC reports, each of which is presumably accessible to you:

1. South Dunedin Storm-water Drainage, Proposed Pumping Station, Portobello Road (1959), and appendices;
2. Dunedin Drainage and Sewerage Board Engineer's Department, The Storm of 9 March 1968;
3. Infrastructure Performance During June 2015 Flood Event

My findings are outlined in the attached summary and graph. In brief, the amount of impermeable land required to be serviced by the storm-water drainage system has more or less doubled since the 1940s or thereabouts. As a result, the envisaged ability to handle rainfall intensities of some 14 mm/hour has reduced by half to about 7 mm/hour or less, as was evident in the relatively minor rainfall event of February 2020.

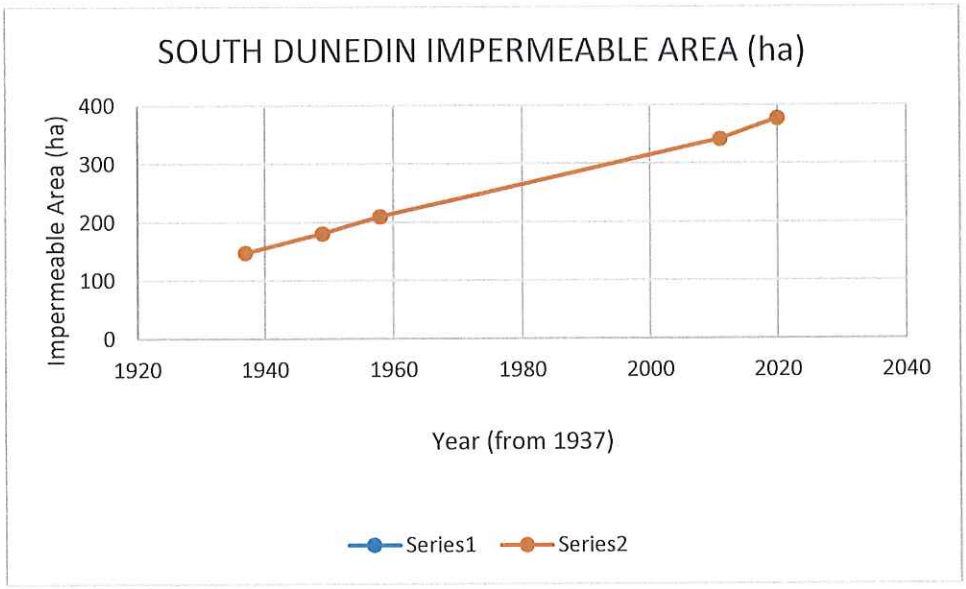
In my professional opinion, the historic and ongoing increase in impermeable land across the South Dunedin catchment is the most significant and urgent flood issue facing the community. It has arisen entirely independent of any threatened climate change considerations, and might have been addressed in a timely manner had the Council received more accurate and detailed engineering analyses after the flood events of 1968 and 2015. It is an issue that, also in my opinion, needs to be addressed as a compelling priority.

A SUMMARY OF THE UNDERMINING OF SOUTH DUNEDIN'S DRAINAGE SYSTEM **N.P. Johnstone CP Eng ret**	**COMMENTARY** **29 AUGUST 2024**
Circa **1938** R.H.C. Galbraith assessed the area to be drained was 1075.81 acres (435 ha), of which 34% (**148 ha**) were deemed impermeable.	This led to the design of the box culverts along Anderson's Bay Road to accommodate 174 cusecs (4.93 m3/s.
1948 Tenders were called – but never actioned – for the supply of 7 main electrical pumps and 2 diesel pumps having a total capacity of 400 cusecs (11.3 m^3/s)	These are considered likely to have been split roughly 8/3 m^3/s.
1949 Ritchie and Kingsland undertook "further investigations". They accepted Galbraith's gross catchment area, but identified a higher impermeability factor of 41.6%, making **181 ha** impermeable. They suggested a reduced capacity of the pump station of 300 cusecs, being 250* cusecs (7.1 m^3/s) electric and 50 cusecs (1.4 m^3/s) emergency diesel.	*Seemingly the approximate average of 232 and 273 cusecs. Very significantly, Ritchie was of the opinion that, having regard to the sizes and gradients of the pipes and conduits, a flow of over 300 cusecs could not be justified. This suggests that the pump station's design capacity was dictated by existing limited feeder pipe capacities despite impermeability being on the rise, and reclamation pending.
1958 J.E. Berry made "entirely new calculations". He assessed the catchment area as 1169 acres, and the impermeability factor as 44.3%, giving an impermeable area of 518 ac (**210 ha**), the increases in area and impermeability likely to be a result of reclamation allowances.	Berry's estimates of increased hard areas might have been expected to require a further increase in both conduit and pumping capacity, but he extraordinarily based his design storm hydrograph on an event lasting only 43 minutes, and therefore assuming that there would be insufficient flow volume to fill the pipe network to capacity. He was thus able to suggest a pump capacity of 210 cusecs (5.95 m^3/s) which essentially remains the station's capacity 66 years later.** To make matters worse, Berry also used the convenience of a short design storm to disregard the impact of any foreign flood flows arriving from St Clair or elsewhere, and Drainage Engineer George Armstrong (1959) assumed that "*It is unlikely that the overall impermeability will increase to any extent as, although there may be some further industrial development, re-building of the present rather high-density residential districts is likely to be at a lower density than at present*". ** 6.3 m^3/s electric and 2.5 m^3/s diesel standby

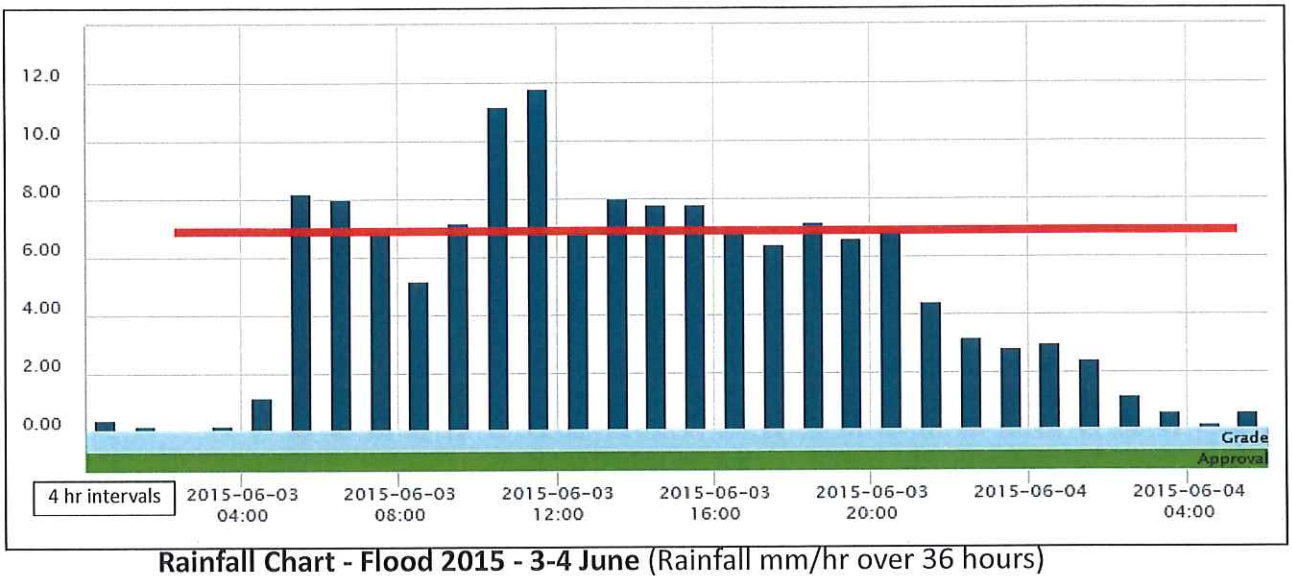
The above historical contributions from Galbraith, Ritchie and Berry are summarised in the December **1959** report of George Armstrong who was then Drainage Engineer. **1968** Now City Engineer, George Armstrong reported briefly on the March 9, 1968 flood event that inundated some 100 South Dunedin homes and businesses. Included in his report was his view that, *the reticulation system became overloaded because the rainfall was much more intense and of longer duration than it was designed for, and also because there were heavy overflows from adjacent catchments*.		These admissions seriously discredited the design assumptions, yet no improvements were forthcoming. There was no reassessment of catchment impermeability, and there was a curious claim that the design of the pumping station was "sound", despite it only passing 85% of its capacity; this surely indicating that there were bottlenecks, or worse in the system.
2011 The ICMP for the South Dunedin catchment (Beca, URS) reported that the impermeability of the South Dunedin catchment was now assessed at approximately 60%.		There was no accompanying recognition that, because this study included Chisolm Park in its derivation of catchment area (thus increasing the catchment to 570 ha), then the impervious area had in fact grown to **342** ha.
2015 McElhone and Stokes in their flawed reporting of the performance of infrastructure during the major flooding of June 3-4 2015, reported the 60% figure, but also failed to assess - or report - its significance.		My ongoing analyses indicate that the area of impermeable ground has continued to increase since 2011 at a near-constant rate to approaching double its value on which the pumping station and reticulation design relied. Refer the attached chart. **The design of the Portobello Pumping Station and associated infrastructure is therefore, as a result of a failure to properly assess increasing impermeabilities and of a totally unjustified original choice of design storm duration, grossly under-designed and long overdue for urgent upgrade. Home owners and businesses across South Dunedin remain at risk while being poorly informed.**

NOTE: Richard Hugh Courtney Galbraith: Reg Civil Engineer Dunedin, died 1991 aged 86

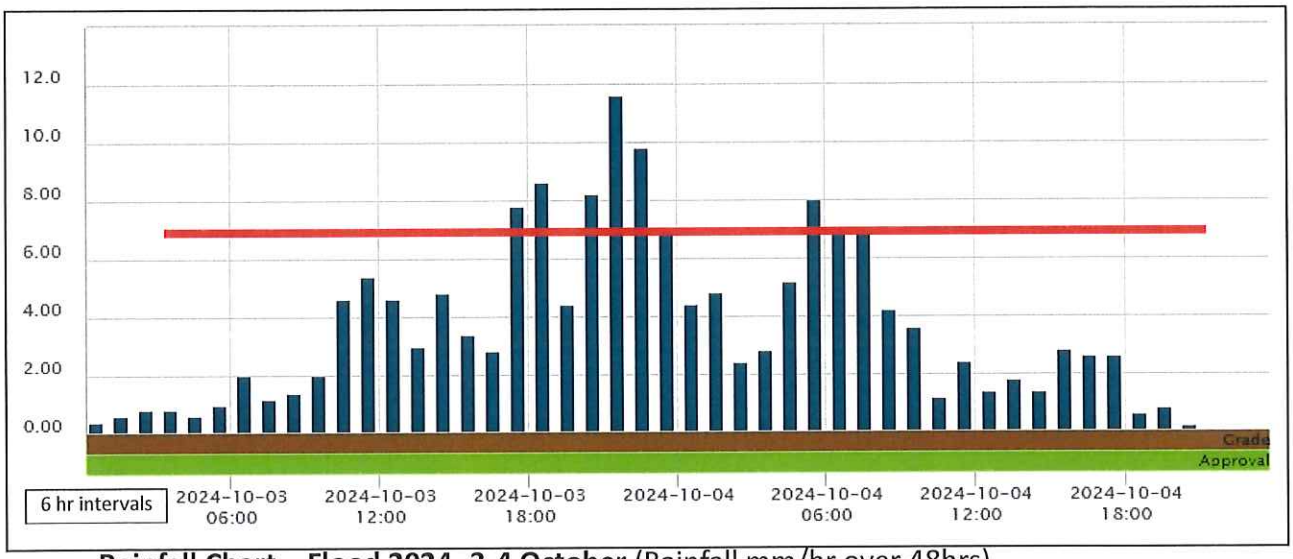
George Kent Armstrong: Reg City Engineer. Died 1982, aged 67


SOUTH DUNEDIN IMPERMEABLE AREA (ha)
Impermeable Area (ha)
400
300
200
100
0
1920
1940
1960
1980
2000
2020
2040
Year (from 1937)
Series1
Series2

Rainfall charts: The rainfall data is shown in chart and tabular form.



Rainfall Chart - Flood 2015 - 3-4 June (Rainfall mm/hr over 36 hours)



Rainfall Chart – Flood 2024 -3-4 October (Rainfall mm/hr over 48hrs)

Rainfall data

Rainfall intensity (mm/hr) recorded for the Jun 2015 and Oct 2024 events is shown in the table Ref

#	Flood 2015 hr	1	2	3	4	5	6	7	8	9	10	11	12
	3 Jun am	0.4	0.2	0.0	0.2	1.2	8.2	8.0	7.0	5.2	7.2	11.2	11.8
	pm	7.0	8.0	7.8	7.8	6.8	6.4	7.2	6.6	7.0	4.4	3.2	2.8
	4 Jun am	3.0	2.4	1.2	0.6	0.2	0.6	0.2	0.0	0.0	0.2	0.0	0.0
#	Flood 2024 hr	1	2	3	4	5	6	7	8	9	10	11	12
	3 Oct am	0.4	0.6	0.8	0.8	0.6	1.0	2.0	1.2	1.4	2.0	4.6	5.4
	pm	4.6	3.0	4.8	3.4	2.8	7.8	8.6	4.4	8.2	11.6	9.8	7.0
	4 Oct am	4.4	4.8	2.4	2.8	5.2	8.0	7.0	6.8	4.2	3.6	1.2	2.4
	pm	1.4	1.8	1.4	2.8	2.6	2.6	0.6	0.8	0.2	0.0	0.0	0.0

Flood 2015: Total rainfall = 144 mm over 36 hours. Average = 4.0 mm/hr.

Flood 2024: Total rainfall = 164 mm over 48 hours. Average = 3.4 mm/hr. Note: Shading for rainfall > 4 mm/hr was arbitrarily chosen to indicate heavier rainfalls.