water acumen

Memorandum 01

WA Ref:	WA/011
Date:	11 June 2026
To:	Rob Stewart, McKenzie & Co.
cc:	Brylee Halliday, Luke Hermanson, McKenzie & Co.
From:	Robert White
Re:	Ladies Mile, Queenstown Wastewater Servicing

Ladies Mile Development – Wastewater Servicing

The Ladies Mile development is anticipated to include up to 5,780 dwellings (or dwelling unit equivalents - DUE) in addition to the Simplicity Living development of approximately 1,078 units (719 DUE).

Ladies Mile development area slopes from the west to the east, allowing the area to be serviced via gravity to the eastern end of the development.

From the eastern end of the development to the high point adjacent to Stalker Road roundabout is approximately 1.5 kms.

From the above high point, flows are conveyed to the wastewater treatment plant via an inverted siphon across the Shotover River Bridge.

As with any new development, there is a challenge of designing a system that is able to service the first property connected to the ultimate number of properties connected.

If the development is serviced as a standalone development, from a wastewater perspective, initial retention times can be very high, with low velocities, resulting in potential settlement / sedimentation issues along with odour and septicity.

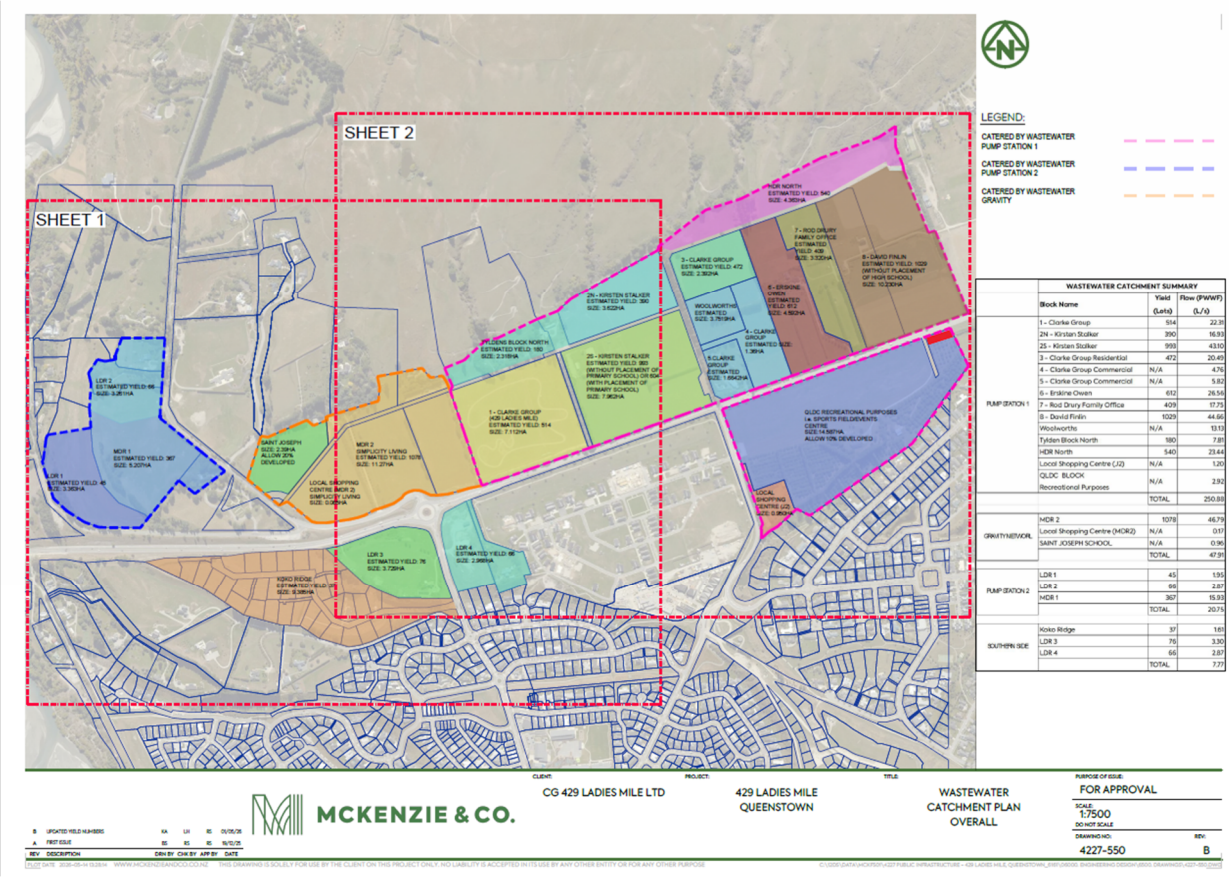


Figure 1: Ladies Mile Development Area

Existing wastewater infrastructure

Hayes WWPS servicing Arrowtown and Erskine Road WWPS pump flows along SH6 / Frankton – Ladies Mile Highway from the respective pump station sites to the high point adjacent to the Stalker Road roundabout.

Both rising mains are relatively long with significant friction losses impacting on velocities and capacities of the pipelines.

The current operation of these pump stations is as follows:

	Rising main length (m)	Flow (L/s)	Pump head (m)
Hayes WWPS	4,825	80	~48
Erskine WWPS	2,760	~20	~55

As previously stated, there are challenges in starting a new rising main with low flows but designed to ultimately service significant flows. It is much easier to start a pump station with a reasonable flow and then double that volume. If the two existing wastewater pump stations (Hayes (Arrowtown) and Erskine) were diverted to the new Ladies Mile pump station it would allow 3 cycles a day to be achieved in the rising main straight away, minimising issues associated with odour and septicity due to high retention times.

The new Ladies Mile wastewater pump station would be built at the eastern extent of the development.

Feeding these two pump stations into a new Ladies Mile WWPS reduces headloss due to friction and / or allows for flows to be increased from the respective pump stations.

Revised duty points maintaining the current flows is as below:

	Rising main length (m)	Flow (L/s)	Pump head (m)
Hayes WWPS	3,300	80	~28
Erskine WWPS	600	~20	~25

Design Populations / Flows

Existing and anticipated flows have been determined as below:

Arrowtown:

The 2023 Census[1] identifies:

- Population = 2,860
- Dwellings = 1,620 (population of 4,860 based on 3 people per house or an extra 2,000 people over the census figure)

Review of pump station flow data (minute) for the period of 1 March to 30 March 2026 is as below:

Flow Rate (L/s) (across full day)	Flow Rate (L/s) (when pumping)	
78.8	78.8	Max
77.8	78.4	99.9th percentile
76.3	77.2	99th percentile
74.5	76.2	95th Percentile
14.28	67.95	Average

A daily average of 14.28 L/s equates for 1,272.9m^3/day. Assuming 250 L/p/day and 3 people per due equates to 1,697 DUE.

Hourly flow data for the period 1 July 2024 to 30 June 2025 identifies an average daily flow of 1,233.0m^3/day against 1,272.9m^3/day for March 2026.

	DUE	People/ DUE	People	L/p/day	ADWF (L/s)	pf	PWWF (L/s)
Arrowtown - Population	953	3	2,860	250	8.28	5	41.4
Arrowtown + Dwellings	667	3	2,000	250	5.79	5	28.9
Arrowtown + Growth	200	3	600	250	1.74	5	8.7
TOTAL	1820		5,460		15.81		79.0

[1] *https://tools.summaries.stats.govt.nz/places/SA2/arrowtown*

Allowance for an additional 200 dwellings has been included in the calculation to match the current pump rate of ~79 L/s.

The theoretical pump duty point is modelled as below.

						Colebrook White			
Length (m)	ks (mm)	SDR	Diameter DN (mm)	Diameter ID (mm)	Flow (L/s)	Velocity (m/s)	H_L (m)	Static Lift (m)	Pump Head (m)
3,021	0.60	13.60	355.00	302.79	80.00	1.11	15.05	11.00	26.05
1,552	0.60			300.00	80.00	1.13	8.11	12.00	20.11
256	0.60	13.60	355.00	302.79	80.00	1.11	1.28	-	1.28
4,829									**47.44**

Erskine WWPS (LAKE HAYES WASTEWATER PUMP STATION – 4)

Analysis of Erskine WWPS flow data for the period of 1 January 2024 to 30 June 2025 provides the following data:

Flow Rate (L/s) (across full day)	Flow Rate (L/s) (when pumping)	
33.19	33.19	Max
20.77	22.28	99.9th percentile
16.79	**19.00**	99th percentile
10.81	13.94	95th Percentile
2.87	7.90	Average

Note: 0.1% of the day is equal to 1.44 minutes.

A daily average of 2.87 L/s equates for 247.82m^3/day. Assuming 250 L/p/day and 3 people per due equates to 330 DUE.

Back calculating the pump flow rate to match Peak Wet Weather Flow identifies a catchment of ~440 DUE

	DUE	People/ DUE	People	L/p/day	ADWF (L/s)	pf	PWWF (L/s)	Pump Rate (L/s)
Erskine	438	3	1,314	250	3.80	5	19.0	19.0

The theoretical pump duty point is modelled as below.

						Colebrook White			
Length (m)	ks (mm)	SDR	Diameter DN (mm)	Diameter ID (mm)	Flow (L/s)	Velocity (m/s)	H_L (m)	Static Lift (m)	Pump Head (m)
535	0.30	11	200.00	163.64	19.00	0.90	3.30	30.68	33.98
2,057	0.30			150.00	19.00	1.08	19.91		19.91
169	0.30	13.6	250.00	213.24	40.20	1.13	1.15		1.15
2,760									55.04

The Operation and Maintenance manual for the Erskine Road WWPS states:

- *Pump Flow average: **11-25 L/s**. Pump station runs on "follow-the-flow" principle and will ramp up and down based on well level. Pumps have a minimum speed on drive and flow rate will vary according to how much rag there is in the impellor. Pumps also have a de-rag function that will trigger when the pump flowrates are less than operator- defined set points. These can be adjusted in SCADA.*

Note: the 40.2 L/s for the final 169m includes Jones WWPS operating at 20.3 L/s.

Jones WWPS (LAKE HAYES WASTEWATER PUMP STATION – 9)

Analysis of Jones WWPS flow data for the period of 1 January 2024 to 30 June 2025 provides the following data:

Flow Rate (L/s) (across full day)	Flow Rate (L/s) (when pumping)	
28.00	28.00	Max
20.20	20.80	99.9th percentile
19.20	20.30	99th percentile
9.10	19.70	95th Percentile
0.93	11.14	Average

A daily average of 0.93 L/s equates to 80.74m^3/day. Assuming 250 L/p/day and 3 people per due equates to 108 DUE.

Back calculating the flow rate to match Peak Wet Weather Flow identifies a catchment of ~470 DUE

	DUE	People/ DUE	People	L/p/day	ADWF (L/s)	pf	PWWF (L/s)	Pump Rate (L/s)
Jones	468	3	1,404	250	4.06	5	20.3	20.3

The theoretical pump duty point is modelled as below.

						Colebrook White			
Length (m)	ks (mm)	SDR	Diameter DN (mm)	Diameter ID (mm)	Flow (L/s)	Velocity (m/s)	H_L (m)	Static Lift (m)	Pump Head (m)
742	0.30	11.00	160.00	130.91	20.30	1.51	16.57	12.00	28.57

The Operation and Maintenance manual for the Jones WWPS states:

- *Minimum design flowrate: 14.4L/s.*
- *Target pump design duty 16L/s @ 19m.*

Stalker WWPS (SHOTOVER COUNTRY WASTEWATER PUMP STATION)

Analysis of Stalker WWPS flow data for the period of 1 January 2024 to 30 June 2025 provides the following data:

Flow Rate (L/s) (across full day)	Flow Rate (L/s) (when pumping)	
107.07	107.07	Max
23.39	24.28	99.9th percentile
16.09	**16.18**	99th percentile
15.48	15.75	95th Percentile
5.99	10.49	Average (when pumping)

A daily average of 5.99 L/s equates for 517.792m^3/day. Assuming 250 L/p/day and 3 people per due equates to 690 DUE.

Back calculating the flow rate to match Peak Wet Weather Flow identifies a catchment of ~375 DUE

	DUE	People/ DUE	People	L/p/day	ADWF (L/s)	pf	PWWF (L/s)	Pump Rate (L/s)
Stalker	373	3	1,119	250	3.24	5	16.2	16.2

The theoretical pump duty point is modelled as below.

						Colebrook White			
Length (m)	ks (mm)	SDR	Diameter DN (mm)	Diameter ID (mm)	Flow (L/s)	Velocity (m/s)	H_L (m)	Static Lift (m)	Pump Head (m)
1,457	0.30			150.00	16.20	0.92	10.34	49.76	60.10

The Operation and Maintenance manual for the Stalker WWPS states:

- *Pump Flow average: 10l/s*
- *Once a month where it will fill wells beyond normal levels, then run both pumps to pump at 20L/s and flush the pump main with an increase velocity wastewater.*

Ladies Mile (Theoretical)

Provisional calculations have been based on an ultimate development of 5,780 units.

	DUE	People/ DUE	People	L/p/day	ADWF (L/s)	pf	PWWF (L/s)
Ladies Mile	5,780	3	17,340	250	50.17	5	250.9

Simplicity Living (Theoretical)

1,078 units within the Simplicity Living development equates to 719 DUE.

	Units*/ DUE	People/ DUE	People	L/p/day	ADWF (L/s)	pf	PWWF (L/s)
Simplicity*	1,078	2	2,156	250	6.24	5	31.2
Simplicity	719	3	2,156	250	6.24	5	31.2
Shopping	4				0.03	5	0.17
School	22				0.19	5	0.96
	745						32.32

- Local Shopping Centre (MDR2)
- Saint Joseph School

Current pump station typical flows:

	PWWF (L/s)
Hayes WWPS Arrowtown	80
Erskine WWPS	19.0
Jones WWPS	20.3
Stalker WWPS	16.2
TOTAL	135.5

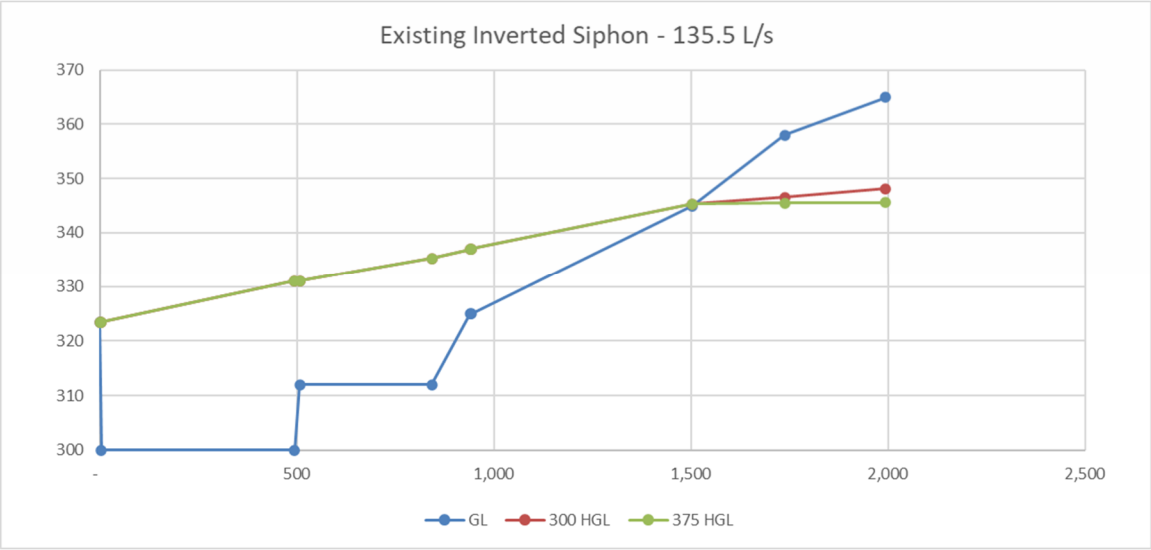
The capacity of the existing inverted siphon has been identified as 160 L/s.

- GHD, Arrowtown-Lake Hayes rising main capacity assessment Transient assessment and hydraulic analysis Queenstown Lakes District Council 8 May 2023: theoretical maximum capacity of 160 L/s.

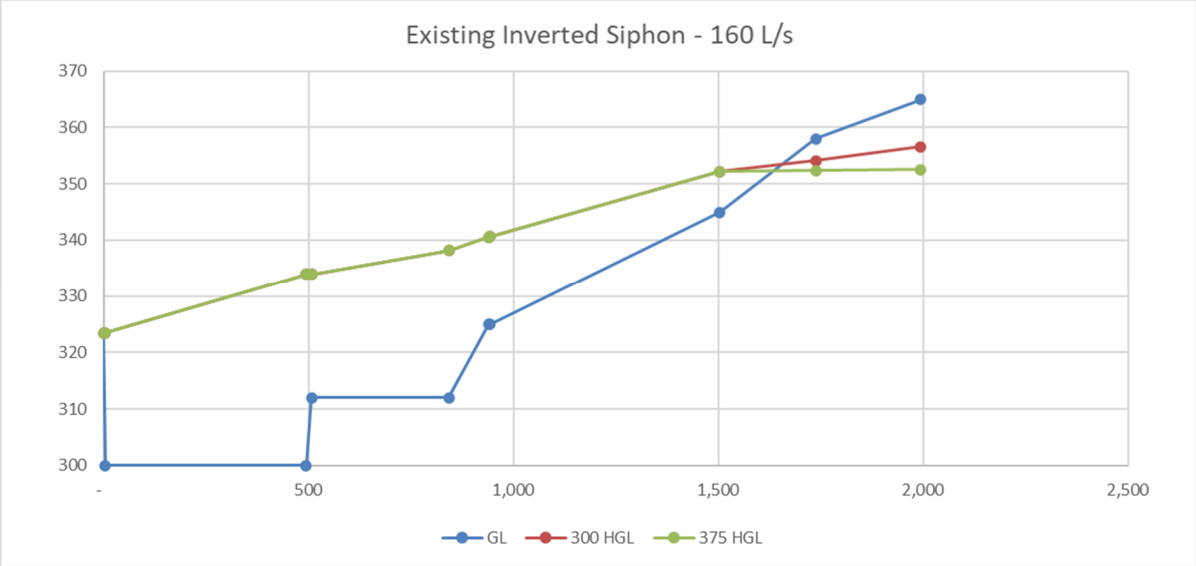
- WSP Queenstown Lakes District Council, Te Pūtahi Ladies Mile 3 Water Servicing Concept Plan, 22 September 2025 quotes the theoretical maximum capacity of 160 L/s identified by GHD.

A simple cross check of the theoretical inverted siphon capacity has been undertaken as below.

Pipe diameter and length data has been taken from the QLDC GIS, with an assumed wastewater treatment plant inlet level of 323.5mRL.



The cross check identifies a current peak flow freeboard of > 15m at ~135 L/s.



The cross check identifies a freeboard of approximately 10m for a peak flow of 160 L/s.

It is recommended that a pressure sensor be installed on the siphon pipework on the upstream section of the bridge to provide actual pressures (and top "water" level) within the siphon, rather than relying on theoretical calculations.

Design Concept.

It is proposed to daisy-chain Hayes WWPS and Erskine WWPS with the proposed Ladies Mile WWPS. This is considered to be advantageous for the following reasons:

- Provides initial flows in the rising main with regards to retention time and odour and septicity issues.
- Ladies Mile projected flows are greater than can be serviced via a single prefabricated GRP pump station such that two pump station chambers are required anyway.
- Twin rising main are required to ultimately service Ladies Mile WWPS, and if not connected, Hayes WWPS would require a separate rising main, resulting in three rising mains.
- Splitting the Hayes WWPS rising main increases the capacity of this system, allowing for growth in Arrowtown.

Combined Design Populations:

Ladies WWPS and Rising Mains

The Ladies Mile WWPS and Rising mains service: Arrowtown (Hayes WWPS), Erskine and Ladies Mile.

	DUE	People/ DUE	People	L/p/day	ADWF (L/s)	pf	PWWF (L/s)
Arrowtown - Population	953	3	2,860	250	8.28	5	41.4
Arrowtown + Dwellings	667	3	2,000	250	5.79	5	28.9
Arrowtown + Growth	200	3	600	250	1.74	5	8.7
Erskine	438	3	1,314	250	3.80	5	19.0
Ladies Mile	5,780	3	17,340	250	50.17	5	250.9
TOTAL	8,038		24,114		69.78		348.9

Assuming twin rising mains, each main would need to service ~175L/s.

Inverted Siphon / Shotover Bridge Crossing

The inverted siphon across the Shotover River accommodates all the above flows.

	DUE	People/ DUE	People	L/p/day	ADWF (L/s)	pf	PWWF (L/s)
Ladies Mile WWPS	8,038	3	24,114	250	69.78	5	348.9
Jones	468	3	1,404	250	4.06	5	20.3
Stalker	373	3	1,119	250	3.24	5	16.2
Simplicity +	745						32.32
TOTAL	9,624		27,756		80.32		417.72

Assuming twin siphons, each siphon would need to service ~210 L/s.

Pump Station and Rising Mains

It is proposed that the pump station is located within QLDC Owned land at the eastern end of Frankton-Ladies Mile Highway (Lot 4 DP 621997)

Rising Mains

It is considered that initially, the existing 300 rising main could be utilised.

Diameter (mm)	Flow (L/s)	Pump Head (m)	Self-Cleansing	Slime Shear
300	80	~26m	Yes	Yes

The maximum flow rate of 80 L/s has been recommended due to the pipe class and cyclical pressure on the pipe due to pump start and stop.

If the current arrangement with an air valve at the high point was replaced with a break-pressure chamber it is anticipated that surge pressures on the rising main would reduce, increasing the lifespan of the pipe and/or allow flows to be marginally increased.

It is recommended that modelling be undertaken to review surge pressure within the existing pipeline if it was to be utilised by the proposed Ladies Mile WWPS, discharging into a break-pressure chamber at the highpoint of the Frankton-Ladies Mile Highway in proximity of the Stalker Road roundabout / Lower Shotover Road intersection with Spence Road.

Ultimately twin DN400 SDR11/PN16 rising mains are proposed, 1,425m long, from the proposed Ladies Mile WWPS to the break-pressure chamber. It is anticipated that the new rising mains would be designed to be constructed within the proposed 10m set back of the northern road boundary / widening of the highway reserve, discharging into break-pressure chambers.

Diameter DN (mm)	Flow (L/s)	Pump Head (m)	Self-Cleansing	Slime Shear
400	80	~20	Yes	No
400	175	~38	Yes	Yes

Adopting twin DN355 rising mains would result in a high pump head, at the top end of the typical operating range of a Flygt sewer pumps at 175 L/s.

Diameter DN (mm)	Flow (L/s)	Pump Head (m)	Self-Cleansing	Slime Shear
355	80	~25	Yes	Yes
355	175	**~57**	Yes	Yes

The option of DN355 and DN400 mains – with initially only the DN355 in operation, before just the DN400, before both put into operation, was considered, but not developed based on the additional complexity of switching lines and flushing the DN 355.

Additionally, the twin DN400 option, with pumps operating at ~38m pump head at 175 L/s provides additional capacity for growth over and above the calculations included, providing a factor of safety in the proposal.

Pump Stations

As the ultimate flow of ~250 L/s (standalone) for Ladies Mile is considered too large for a prefabricated GRP pump Station, it is proposed that twin prefabricated pump stations are constructed, with only one utilised initially.

Including Hayes and Erskine WWPSs, the Ladies Mile pump station will ultimately operate at ~350 L/s, with each pump station operating at ~175 L/s.

Utilising 900Qp/S to calculate requires operational volume:

Qp	0.175	m^3/s (max. inflow)
S	12	(starts per hour)

Operational Volume 13.13 m^3

GRP Pump Chamber:

Diameter	3.5m
Area	9.62 m^2
Operational Depth	1.36 m
Op Volume	13.13 m^3

Provisional levels are as follows:

Ground Level	320	mRL	6.00m	Inlet pipe depth
Inlet	314	mRL	0.20m	
Start	313.8	mRL	1.36m	Operational depth
Stop	312.44	mRL	0.50m	
PS Invert	311.94	mRL		
			8.06 m	Pump Station Depth

Emergency Storage

It is proposed that the Ladies Mile WWPS would be interlinked with Hayes and Erskine WWPSs such that if it failed, the two upstream WWPSs would shut down and store flows locally.

As such only storage of 30 minutes of flow from Hayes pump stations has been included within the emergency storage calculations. This can be revisited if emergency storage capacity at this pump station is not considered sufficient.

Nine hours emergency storage[2] has been considered for Erskine as it is understood that there is no emergency storage at this WWPS.

	DUE	ADWF (L/s)	Storage Hours	ADWF (m^3/hr)	Storage (m^3)
Arrowtown - Population	953	8.28	0.5	29.79	15
Arrowtown + Dwellings	667	5.79	0.5	20.83	10
Arrowtown + Growth	200	1.74	0.5	6.25	3
Erskine	438	3.80	9	13.69	129
Ladies Mile	5,780	50.17	9	180.63	1,626
					1,783

Table x: Emergency storage based on 9 hours ADWF

[2] *QLDC's document Appendix G – Sewer Pump Station*

In line with QLDC's document Appendix G – Sewer Pump Station, "*Where the pump station is considered "large" and has a standby generator and spare pump supplied (additional to duty / standby pumps) – with the agreement with Council, emergency storage may be reduced*".

Based on the size of the pump station(s) and the risk mitigation features, it is proposed that a reduction in emergency storage requirements is sought. Risks are mitigated by the proposal to operate via twin rising mains; the provision of two pump stations, each with a minimum of duty / standby pumps (minimum of four pumps); and the proposal to provide a standby generator.

	DUE	ADWF (L/s)	Storage Hours	ADWF (m^3/hr)	Storage (m^3)
Arrowtown - Population	953	8.28	0.5	29.79	15
Arrowtown + Dwellings	667	5.79	0.5	20.83	10
Arrowtown + Growth	200	1.74	0.5	6.25	3
Erskine	438	3.80	4	13.69	57
Ladies Mile	5,780	50.17	4	180.63	723
					808

Table x: Emergency storage based on 4 hours ADWF

GRP Cylinders (9 hours ADWF)

GRP cylinders are a typical response to the provision of emergency storage but require a significant area when a large storage volume is required.

Diameter	3m		
Length	15m		
Volume	106.m^3		
Number	17	99.9%	volume used
Total Volume	1,802m^3		

Land area required:

Spacing	2	m
Clearance	2	m
Area		
Length	19	m
Width	87	m

Reinforced Concrete Chamber (9 hours ADWF)

A rectangular concrete chamber(s) requires a smaller footprint but typically have a higher capital cost that GRP cylinders.

Depth	3.5	m
Length	28.7	m
Width	17.9	m
	1,800	m^3

If concrete tanks are proposed, consideration must be given to septicity and the risk of chemical attack on the concrete.

GRP Cylinders (4 hours ADWF)

Adopting 4 hours ADWF results in a storage requirement of 808m^3.

Diameter	3m		
Length	15m		
Volume		106.m^3	
Number	8	95.3%	volume used
Total Volume	848m^3		

Land area required:

Spacing	2	m	
Clearance	2	m	
Area			
Length		19	m
Width		42	m

Staging

It is anticipated that emergency storage would be constructed in stages, rather than all at once. Additional storage, over and above that required to meet emergency storage requirements could be utilised in early stages as operational storage to maintain a flow rate of 80 L/s in the existing rising main alongside Frankton – Ladies Mile Highway, whilst allowing peak inflows into the pump station to be greater than 80 L/s.

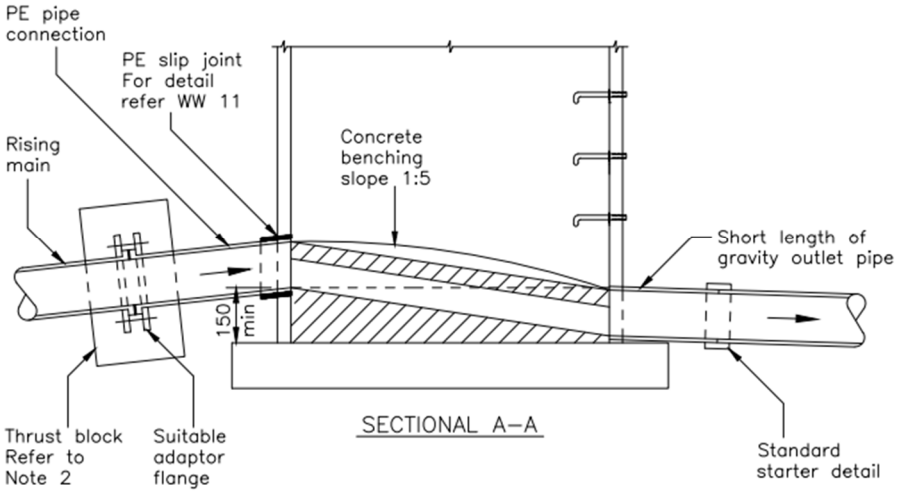
Further details are included in the section – Staging – below.

Break-Pressure Chamber

It is proposed that the rising mains discharge into a break-pressure chamber, followed by a section of gravity / pressurised pipework before becoming the inverted siphon.

This ensures that variations in operating pressure in the rising main are reduced and that there is no risk that the whole length of pipe fills, and then operates as an inverted siphon.

The rising main obvert should be lower than the gravity pipe invert to ensure that the rising main remains full and sections do not empty out between pump cycles, or as shown below, with rising main terminating as a high point.



Air / odour management will be required at this location. This could include an elevated ventilation pipe or odour management such as utilising an Armatec[3] Green Dome GDOF 48 is noted to service a PWWF of 180 L/s (GDOF 60 = 280 L/s)

Inverted Siphon

As previously identified, assuming twin siphons, each siphon would need to service ~210 L/s.

The siphon is considered to be made up of four sections. The friction losses through these sections combined with the discharge level determines the maximum level on the upstream side of the inverted siphon, which needs to be below the break-pressure chamber cover level, also allowing a freeboard.

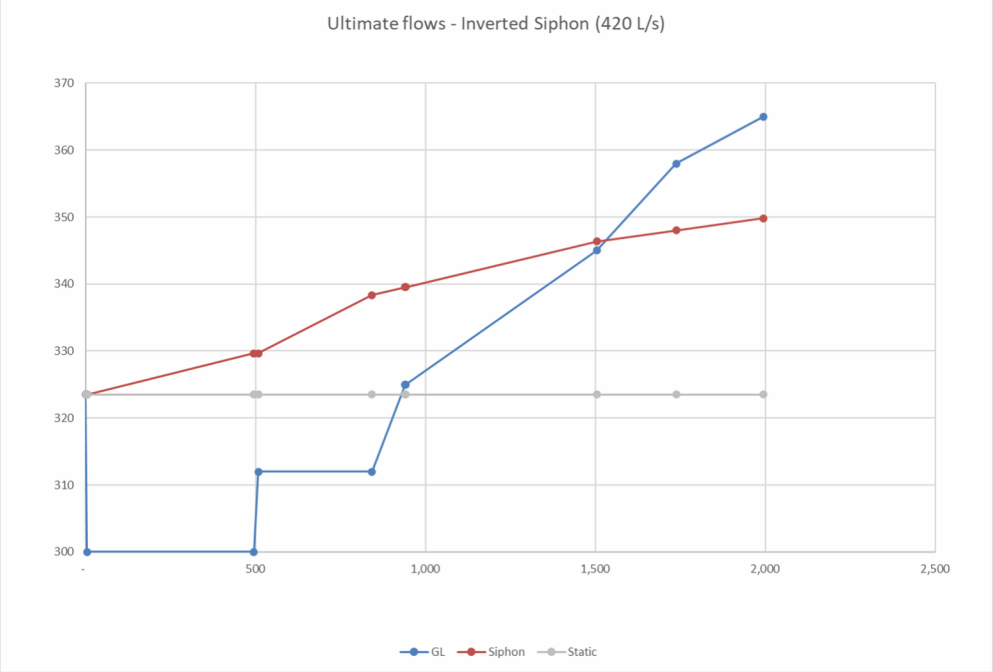
- Section 1 Before the bridge – above the discharge level – 323.5mRL
  - (Chn 1,831.1 to ~Chn 830)
- Section 2 Before the bridge – below the discharge level
  - (Chn ~830 to Chn 800)
- Section 3 Across the bridge
  - (Chn 800 to Chn 500)
- Section 4 After the bridge to the WWTP inlet.
  - (Chn 500 to Chn 0)

Chainages are as McKenzie & Co drawings 4227- 500 to 5005

The concept inverted siphon design is as below:

Note: The Wastewater Treatment Plant inlet has provisionally been set at 323.5mRL. This level, or range of levels, is to be confirmed by QLDC.

[3] *https://www.armatec.co.nz/green-dome-odour-filters*



Example: Simplified hydraulic grade line (twin DN 450 pipes)

Section 1 Before the bridge – above the discharge level (Chn 1,831.1 to ~Chn 830)

This section fills and empties as flows increase and decrease, and is empty with zero flow, the level in the pipe equal to the outlet level at the WWTP.

It is critical that this section is designed to fill from the bottom, and that inflow does not exceed the gravity capacity of the section of pipe.

Detailed design is required to size this pipe but is anticipated to be of a greater diameter than the rising main and downstream inverted siphon diameter.

Based on the provisional design, to accept a maximum flow of ~240 L/s (the capacity of the 318 pipe across the bridge at 3 m/s) the single upstream pipeline would need to be DN450 SDR17 / PN10 (395.9mm ID) at a gradient of 1.5% between chainages 1821.1 and 1499.2m.

Ladies Mile Wastewater

Inverted Siphon - transition section #1 (DN450 / SDR17 @1.0%)

Set units: m | mm | ft | in [Hide this line]

Inputs

Pipe diameter, d_0	0.3959	m	X
Manning roughness, n	0.011		X
Pressure slope (possibly ? equal to pipe slope), S_0	1.0	% rise/run	X
Relative flow depth, y/d_0	0.85	fraction	X

Results

Flow depth, y	0.3365	m
Flow area, a	0.1115	m^2
Pipe area, a0	0.1231	m^2
Relative area, a/a0	0.9059	fraction
Wetted perimeter, P_w	0.9289	m
Hydraulic radius, R_h	0.1201	m
Top width, T	0.2827	m
Velocity, v	2.2125	m/s
Velocity head, h_v	0.2496	m H2O
Froude number, F	1.12	
Average shear stress (tractive force), tau	11.7734	N/m^2
Flow, Q (See notes)	246.7411	l/s
Full flow, Q0	0.2395	m^3/s
Ratio to full flow, Q/Q0	1.0304	fraction

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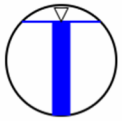

Ladies Mile Wastewater

Inverted Siphon - transition section #1 (DN500 / SDR17 @1.0%)

Set units: m | mm | ft | in [Hide this line]

Inputs

Pipe diameter, d_0	0.444	m	X
Manning roughness, n	0.011		X
Pressure slope (possibly ? equal to pipe slope), S_0	1.0	% rise/run	X
Relative flow depth, y/d_0	0.65	fraction	X

Results

Flow depth, y	0.2886	m
Flow area, a	0.1065	m^2
Pipe area, a0	0.1548	m^2
Relative area, a/a0	0.6881	fraction
Wetted perimeter, P_w	0.8327	m
Hydraulic radius, R_h	0.1279	m
Top width, T	0.4235	m
Velocity, v	2.3082	m/s
Velocity head, h_v	0.2717	m H2O
Froude number, F	1.47	
Average shear stress (tractive force), tau	12.5456	N/m^2
Flow, Q (See notes)	245.9054	l/s
Full flow, Q0	0.3251	m^3/s
Ratio to full flow, Q/Q0	0.7564	fraction

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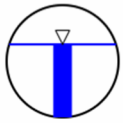

Between chainages 1499.2m and 940.0m with a gradient of 1.0%, a DN500 SDR17 / PN10 (444.0mm ID) operates at ~65% depth at 240 L/s.

Ladies Mile Wastewater

Inverted Siphon - transition section #2 (DN450 / SDR17 @6.6%)

Set units: m | mm | ft | in [Hide this line]

Inputs

Pipe diameter, d_0	0.3959	m	X
Manning roughness, n	0.011		X
Pressure slope (possibly ? equal to pipe slope), S_0	6.6	% rise/run	X
Relative flow depth, y/d_0	0.45	fraction	X

Results

Flow depth, y	0.1782	m
Flow area, a	0.0537	m^2
Pipe area, a0	0.1231	m^2
Relative area, a/a0	0.4364	fraction
Wetted perimeter, P_w	0.5822	m
Hydraulic radius, R_h	0.0923	m
Top width, T	0.3939	m
Velocity, v	4.7692	m/s
Velocity head, h_v	1.1598	m H2O
Froude number, F	4.13	
Average shear stress (tractive force), tau	59.7224	N/m^2
Flow, Q (See notes)	256.2338	l/s
Full flow, Q0	0.6152	m^3/s
Ratio to full flow, Q/Q0	0.4165	fraction

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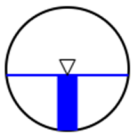


Between chainages 1499.2m and 940.0m with a gradient of 6.6%, a DN450 SDR17 / PN10 (395.9mm ID) operates at 45% depth at 240 L/s.

Section 2 Before the bridge – below the discharge level (Chn 830 to 800)

This section is always charged with a downslope such that solids are easier to move.

Provisional calculations suggest that this pipe should be DN450 SDR17 / PN10.

Section 3 Across the bridge (Chn 800 to 500)

This section is always charged.

The section of pipe across the Shotover River is attached to the bridge. Assuming a velocity of 3m/s across the bridge 318.5mm pipe = 239 L/s.

This section of pipe ultimately needs to be duplicated but is not considered to be on the critical path.

	DUE	People/ DUE	People	L/p/day	ADWF (L/s)	pf	PWWF (L/s)
Arrowtown - Population	1,843	3	5,530	250	16.00	5	80.0
Erskine	438	3	1,314	250	3.80	5	19.0
Ladies Mile	1,666	3	4,998	250	14.46	5	72.3
							173.6
Stalker	373	3	1,119	250	3.24	5	16.2
Jones	468	3	1,404	250	4.06	5	20.3
Simplicity	1,078	2	2,156	250	6.24	5	31.2
							239.0

Assuming that Ladies Mile is developed at 200 dwellings per year, with the first dwelling connected in 2027, duplication of the pipework on the bridge would be required by 2035.

Section 4 After the bridge to the WWTP inlet. (Chn 0 to 500)

This existing section of pipe is shown as a 300 uPVC pipe.

Concept design has been based on this section ultimately being upgraded to twin DN450 SDR17 / PN10 pipes (~370mm ID)

The final upward section of pipe should be designed as a smaller diameter to ensure higher velocities to ensure that solids are conveyed forward to the WWTP and not deposited within the pipe.

Proposed Staging (Concept)

The following are proposed staging of the required upgrades, at concept stage. It is recommended that respective pump station flows are monitored along with recording of the pressure at the upstream end of the Shotover Bridge to allow the maximum fluid level, relative to the break-pressure chamber invert / cover level to be determined.

S = Inverted Siphon

LM = Ladies Mile WWPS / Rising Mains

Stage S-1 – Upstream Inverted Siphon

This stage would include:

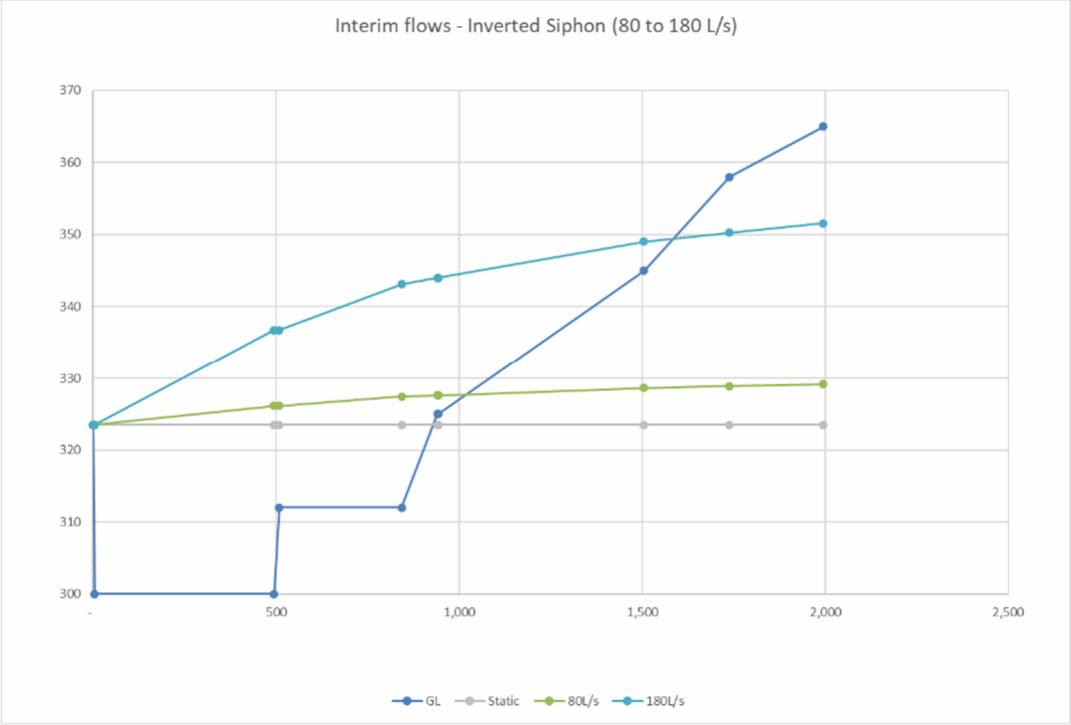
- DN450 upstream inverted siphon
- Break-pressure chamber at high point
- Redirection of existing rising mains to break-pressure chamber (Hayes 300; Erskine/Jones DN250 and Stalker DN160)

It is understood that with the installation of the required watermain in Frankton – Ladies Mile Highway from the Shotover Bridge to service the Simplicity Living Development, that the new inverted siphon pipeline will be installed at the same time.

Extending this pipeline to the highpoint, constructing the break-pressure chamber and diverting the existing rising mains into the break-pressure chamber has been modelled as below:

The existing Hayes and Erskine / Jones rising mains to be connected across Frankton – Ladies Mile Highway to connect into Break-pressure chamber.

Stalker WWPS rising main to connect to new road crossing utilising existing DN250 – feeding back via the DN250 currently connecting Erskine/Jones WWPS to the 375.



This would allow full buildout of the Simplicity Living Development of 1,078 units, with the Ladies Mile development limited to 360 DUE (**assuming no flow buffering at Ladies Mile WWPS**).

An alternative example of a peak flow of 180 L/s would be $^1/_3$ of the Simplicity development and approximately 800 dwellings to be constructed within the Ladies Mile development, prior to further upgrades being implemented (without flow buffering at Ladies Mile WWPS).

This would see the Ladies Mile WWPS operate at 133.4 L/s.

Stage LM-1a - Ladies Mile WWPS

This stage would include:

- Construct Ladies Mile WWPS (single pump chamber) and emergency storage (part).
- Divert the Hayes WWPS rising main into the new Ladies Mile WWPS.
- Hayes WWPS: Review pump duty point (replace pumps?)
- Erskine WWPS would continue to operate as standalone

Limitation is 80 L/s in existing 300 rising main.

	DUE	People/ DUE	People	L/p/day	ADWF (L/s)	pf	PWWF (L/s)
Hayes (Arrowtown)	1,843	3	5,529	250	16.00	5	79.99
Ladies Mile	745	3	2233.6	250	6.46	5	32.31
							112.31
Erskine	438	3	1314	250	3.80	5	19.01
Stalker	373	3	1119	250	3.24	5	16.19
Jones	468	3	1404	250	4.06	5	20.31
							36.50
Simplicity	1,078	2	2156	250	6.24	5	31.19
							180.0

The operation of the Ladies Mile WWPS would initially be limited to 80 L/s as identified in the GHD report[4] to not overstress the existing rising main. This should be reviewed further to connection to the break-pressure chamber, which will have the effect of reducing surge pressure on the existing pipeline.

Inflows greater than 80 L/s would be buffered through the use of surplus emergency storage.

[4] *Arrowtown-Lake Hayes rising main capacity assessment Transient assessment and hydraulic analysis Queenstown Lakes District Council 8 May 2023*

Operational Storage

Peak Hour (Hayes WWPS)

The peak hour between 1 July 2024 and 30 June 2025 recorded a flow of 208 m^3/hour, against a peak pump capacity of 288 m^3/hr at 80 L/s.

The spare capacity of 80 m^3/hr (22.2L/s) equates to a PWWF from 512 DUE.

DUE	People/ DUE	People	L/p/day	ADWF (L/s)	pf	PWWF (L/s)
512	3	1,536	250	4.44	5	22.2

Under this scenario, flows from Ladies Mile would only need to be buffered whilst Hayes WWPS was operating.

In this peak hour case, Hayes WWPS would have operated for just under 45 minutes in the hour. If this had occurred in one block, operational storage of 60m^3 would be required for a development of 512 DUE. This is considered conservative as it is considered unlikely that the pump would operate continuously for a single period in an hour.

	DUE	ADWF (L/s)	Storage Hours	ADWF (m^3/hr)	Storage (m^3)
Arrowtown +	1,820	15.8	0.5	56.88	28
Ladies Mile	512	4.44	9	16.0	144
Ladies Mile (Operational)					60
Required Total					**232**

It is recommended that pump station levels / operational storage volumes are monitored during operation to determine the number of properties that can be serviced within the Ladies Mile development utilising operational storage.

Stage LM-1b – New DN400 Rising Main (provisionally 2029)

This stage would include:

- Construct Ladies Mile WWPS DN400 rising main (on north side of road)
- Connect Erskine WWPS to Ladies Mile WWPS
- Replace Erskine WWPS pumps (revised duty point)

Limitation is inverted siphon (180 L/s).

	DUE	People/ DUE	People	L/p/day	ADWF (L/s)	pf	PWWF (L/s)
Hayes (Arrowtown)	1,843	3	5,530	250	16.00	5	80.0
Erskine	438	3	1,314	250	3.80	5	19.0
Ladies Mile	745	3	2233.6	250	6.46	5	32.3
							133.4
Stalker	373	3	1,119	250	3.24	5	16.2
Jones	468	3	1,404	250	4.06	5	20.3
							169.9
Simplicity	1,078	2	2156	250	6.24	5	31.2
							180.0

Further to construction of a new DN400 rising main from the Ladies Miles WWPS to the proposed break-pressure chamber, flows can be increased up to 133.4L/s, with the siphon operating at 180 L/s.

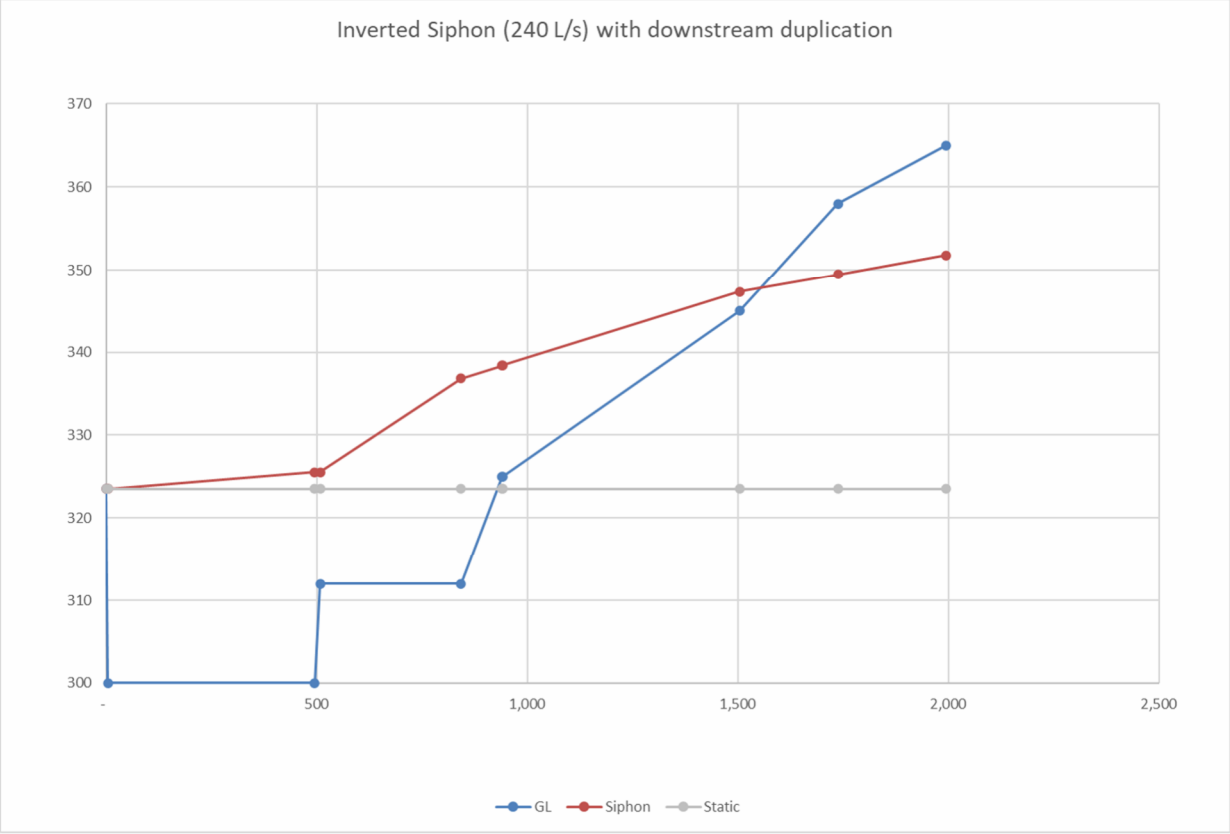
Future Stages – not to be built at this time.

Stage S-2 (Provisionally 2028)

This stage would include:

- Duplication of downstream pipeline, between the western abutment and the WWTP.

It is anticipated that this would be a duplication of the pipe downstream of the bridge – with the addition of a DN450 SDR17 / PN10 pipeline between the western abutment and the WWTP.



This upgrade is shown to allow a peak flow of ~240 L/s to align with the maximum flow (3m/s) across the Shotover River.

Ladies Mile WWPS flows increased up to 171L/s (siphon operating at 239 L/s)

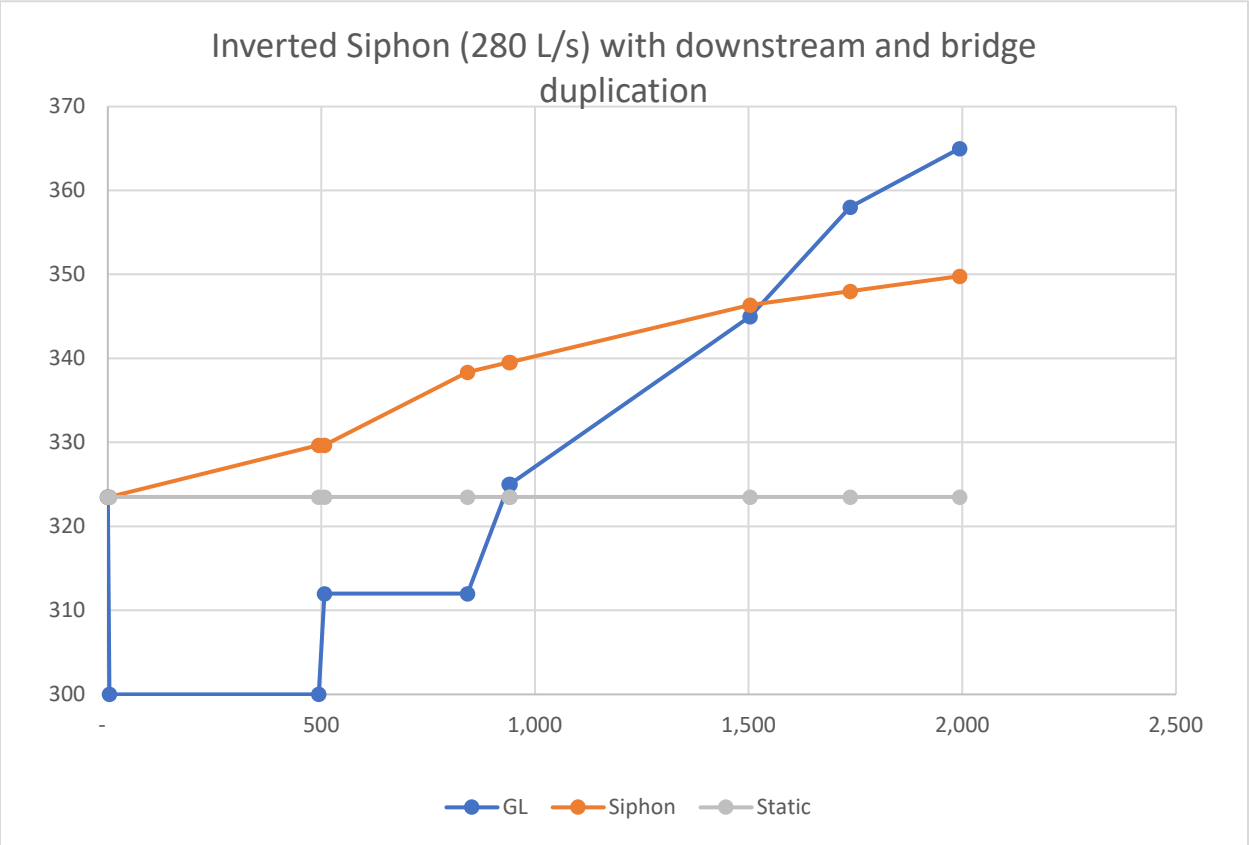
	DUE	People/ DUE	People	L/p/day	ADWF (L/s)	pf	PWWF (L/s)
Hayes (Arrowtown)	1,843	3	5,529	250	16.00	5	80.0
Erskine	438	3	1314	250	3.80	5	19.0
Ladies Mile	1,666	3	4998	250	14.46	5	72.3
							171.3
Stalker	373	3	1119	250	3.24	5	16.2
Jones	468	3	1404	250	4.06	5	20.3
							36.5
Simplicity	1,078	2	2156	250	6.24	5	31.2
							239.0

Stage S-3

This stage would include:

- Duplication of 318 Pipe across Shotover River Bridge

Increasing the flow to 280 L/s is as below:



Stage LM-3

This stage would include:

- Construction / commissioning of the second DN400 rising main
- Commissioning of the second Ladies Mile WWPS

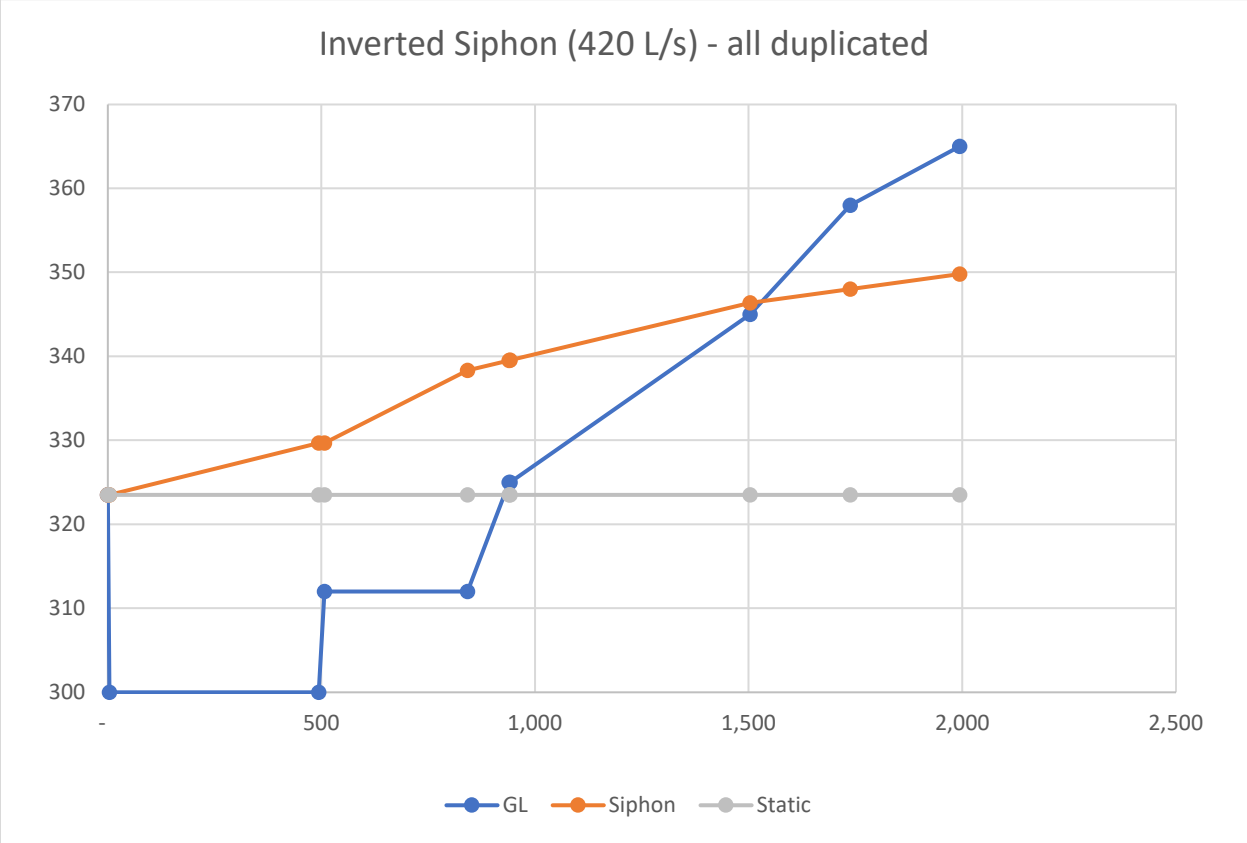
Stage 3a Duplication of DN400 rising main (South side of road / replace existing 300 / 150)

	DUE	People/ DUE	People	L/p/day	ADWF (L/s)	pf	PWWF (L/s)
Hayes (Arrowtown)	1,843	3	5,529	250	16.00	5	80.0
Erskine	438	3	1314	250	3.80	5	19.0
Ladies Mile	2,611	3	7831.6	250	22.66	5	113.3
							212.3
Stalker							
Jones	373	3	1119	250	3.24	5	16.2
	468	3	1404	250	4.06	5	20.3
							36.5
Simplicity	1,078	2	2156	250	6.24	5	31.2
							280.0

Stage S-4

This stage would include:

- Duplication of upstream inverted siphon pipework.



	DUE	People/ DUE	People	L/p/day	ADWF (L/s)	pf	PWWF (L/s)
Hayes (Arrowtown)	1,843	3	5,529	250	16.00	5	80.0
Erskine	438	3	1314	250	3.80	5	19.0
Ladies Mile	5,780	3	17340	250	50.17	5	250.9
							349.9
Stalker	373	3	1119	250	3.24	5	16.2
Jones	468	3	1404	250	4.06	5	20.3
							36.5
Simplicity	1,078	2	2156	250	6.24	5	31.2
							417.6

Staging Summary

Stages	Inverted Siphon (L/s)	Simplicity / Erskine / Jones / Stalker (L/s)	Ladies Mile WWPS / RM (L/s)	
Current	160	60	80	
Siphon 1	180	90	80 / 90*	Plus 30 L/s from Simplicity
Ladies Mile 1	180	90	80 (110**) 175	
Ladies Mile 2	180	70	110	Plus 30 L/s from Ladies Mile
Siphon 2	240	70	(170)	Plus 40 L/s from Ladies Mile
Siphon 3	280	70	(175)	
Ladies Mile 3		70	175 - 350	
Siphon 3	280	70	(210)	
Siphon 4	420	70	350	

*Further to conformation that existing 300 can operate at 90 L/s to break-pressure chamber.
**Further to conformation that existing 300 can operate at 110 L/s to break-pressure chamber.