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GDL WHIM HOUSING DEVELOPMENT

WATER SUPPLY DESIGNS

CLIENT: GORE DEVELOPMENTS LIMITED
2C BRAEMAR AVENUE
KINGSTON 10

VERSION 1.0
June 28, 2009

Overview

Gore Developments Limited proposes to develop a housing estate on lands west of the Old Harbour Bay Road and South of Highway 2000 known as The Whim. The location of the proposed development is shown in **Figure 1**. The developer also intends to extend the project to the Brampton Lands and this water supply report includes the requirements for that project.

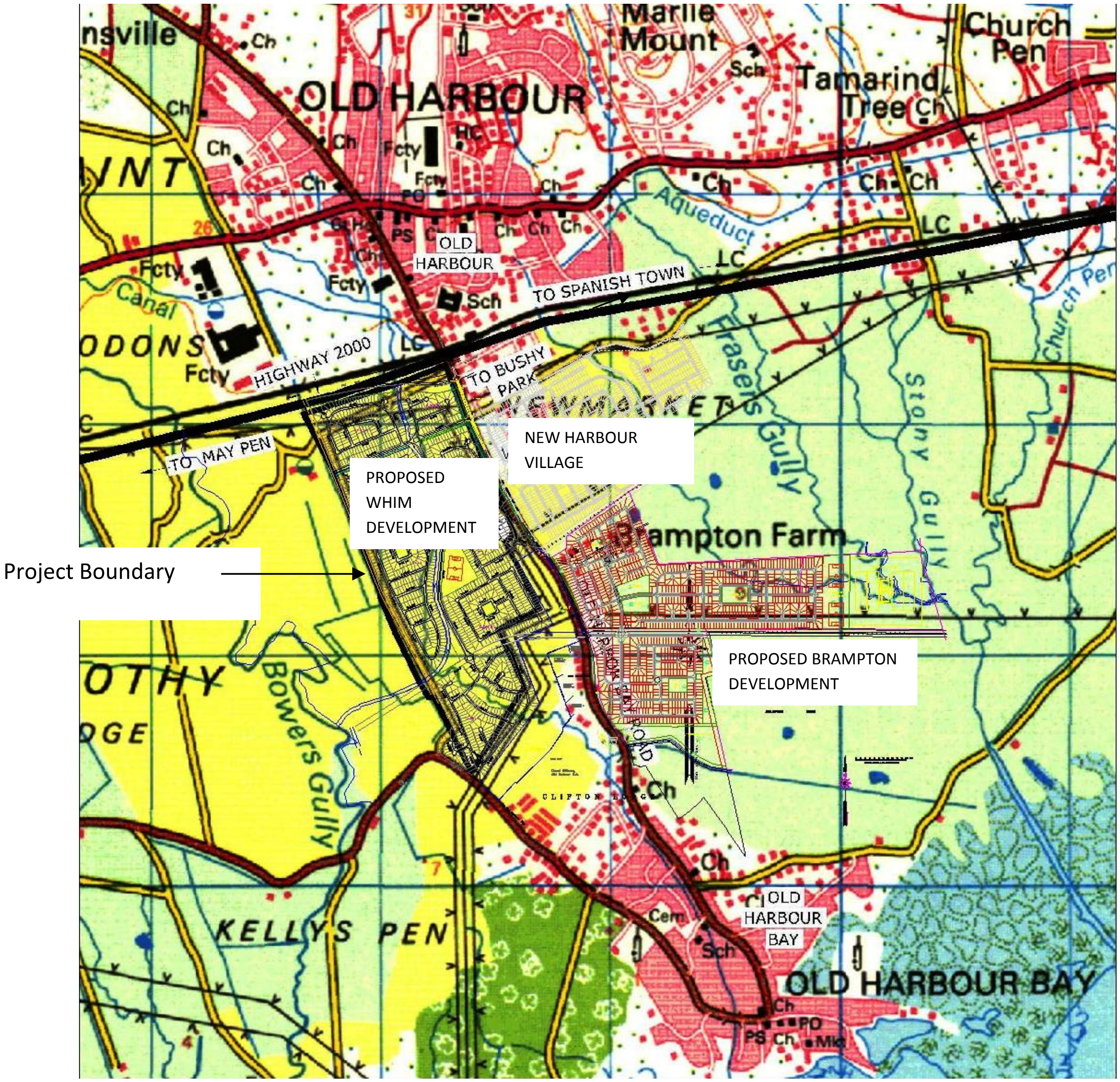


Figure 1 Location plan for the proposed GDL Whim Housing Development

The proposed Whim development includes approximately 1,400 housing units, and basic school. The proposed development plan is shown in **Figure 2**. The Brampton project is planned for 950 houses, basic school and commercial facilities.

Figure 2 Proposed Whim Development Plan.

Parts of this report are taken from a similar report prepared by this author while working for Foreman Chung & Sykes Consultants Limited for a previous version of the Master Plan. That report did not include designs for the Brampton Development.

The developer intends to invest in the nearby Brampton Lands and the current development plan includes a housing estate, Basic School and Shopping area. The water supply for both developments will be integrated and the quantity, quality and delivery information for both is included in this report. The estimated average daily water demand is 2,752m^3/day. The Developer had investigated the availability of existing water works to supply the water needs for the proposed developments but those were found to be inadequate. The Developer has secured the rights to the Rodons Well located approximately 1.2km north west of the proposed development that has been licensed (No A2008/46) for a maximum abstraction rate of 4360 m^3/day with licensed water use stated for "*Domestic purpose(s)*".

The source development, water treatment, storage tank, distribution pumping and transmission pipeline to the development will be submitted to the authorities in accordance with the NRCA permit requirements.

This report is prepared to demonstrate that the water resources are available and secured to serve the proposed development and that the users will be supplied with water at or above the minimum requirements of service as set out by the Office of Utility Regulations.

1.0 Estimate of water demand for the proposed development

The estimate of water demand is based on the projected population to occupy the development and the projected water demand for commercial and social areas. The population estimate is based on information from the Statistical Institute of Jamaica and the commercial and social facilities water is based on the guidelines from the Jamaica Institution of Engineers recommended guidelines for design and construction of housing infrastructure volume 3 water supply systems.

The Statistical Institute of Jamaica states that the average number of persons per dwelling in 2001 was 3.6 down from 4.2 in 1991. For this evaluation 4.5 persons per dwelling is used to give a conservative population estimate and resulting water demand for the proposed development.

The area for the Commercial use was considered to require similar water demands. Twenty percent (20%) of the total area of land reserved for those activities was estimated to be the active floor space. 30UK gallons/100sq ft of floor space was used to estimate the water demand.

As is advertised by the National Water Commission (NWC) municipal water is not intended for irrigation and this is excluded from the estimate of water demand. Irrigation water is available from nearby infrastructure and service provider but distribution of that water is not included in this project.

Water losses on the distribution network were taken as 20% of the estimated average day water demand as recommended by the NWC. **Table 1** displays the calculation of the daily water demand for the proposed Whim Development.

Table 1 Estimate of the Water Quantity required for the proposed Development

GDL Whim and Brampton Water Demand Estimate			
Item	**Description**	**Qty**	**Unit**
1	**Number of residential lots GDL WHIM**	1,400	No
2	**Number of residential lots Brampton**	953	No
3	Estimate of the number of persons per lot	4.50	No
4	Population Estimate	10,589	No
5	Average per capita consumption per househole resident	227	Liters
6	Estimate of domestic water use	2,403,590	Liters
7			
8	**Commercial and Light Industry**		
9	Commercial and shopping area	33,496.00	m^2
10	Usage per unit area commercial space	14.68	L/m^2
11	% Area used for commercial floor space	20%	
12	Estimate of floor space	6,699.20	m^2
13	Water for commercial and light Industry	98,345	L
14			
15	**Basic Schools 1 and 2**		
16	Student Population	300	No
17	Staff Population	30	No
18	Total Basic School population	330	No
19			
20	**Primary School**		
21	Student Population	1,800	No
22	Staff Population	144	No
23	Total primary school population	1,944	No
24			
25	Per Capita demand for each head of school population	57	Liters/day
26	Estimate of Basic School demand	18,810	Liters/day
27	Estimate of Primary School demand	110,808	Liters/day
28			
29	**Other water use** (5% domestic use)	120,179.48	Liters
30			
31	**Average day demand**	**2,751,732.02**	**Liters**
32		**2,752**	**m^3/d**
33	Peak day in peak month factor	1.40	
34	Peak hour factor	1.50	
35	Peak factor	2.10	
36	Leak factor	20%	
37	**Average day including leaks**	**3302**	**m^3/d**
38		872,316.99	US gpd
39	Peak day water demand	4,622.91	m^3/d
40		1,221,243.79	US gpd
41			
42	**Rodons Well Licenced abstraction**	**4,360.00**	**m^3/d**
43			

Table 2 Basis of Water quantity estimate for unplanned areas

Unit demands for areas without detailed plans			
44	Commercial Demand JIE	30	UK gal/100ft^2 day
45		136	l/100ft^2 day
46		15	L/m^2
47			
48	Employee/ Teacher/Student water demand	15	US gal/day
49		57	L/d

The nature of the users of water is such that there will be peak and minimum water demand during specific months of the year, days of the week and hours of the day.

The water distribution system will be required to deliver water to the user during the varying conditions. As the demand increase and more water is expelled from the system the pressure in the system will fall. The distribution system is adequate if the variation of user demands results in pressures and flows that satisfy the design criteria.

The peak day in the peak month factor and peak hour factor used to set the upper range of demand on the system are shown in **Table 1**. The minimum demand is estimated to be 0.125 of the average day demand. These factors when applied to the average day demand approximate the maximum and minimum demands the system is likely to experience in the service life of the system.

Water Distribution Design

Approach to the Distribution Network Analyses

To size the water distribution pipelines EPANET 2, a water distribution network analysis programme developed by the Water Supply and Water Resources Division (formerly the Drinking Water Research Division) of the U.S. Environmental Protection Agency's National Risk Management Research Laboratory, was used. The method used in EPANET to solve the flow continuity and head loss equations that characterize the hydraulic state of the pipe network at a given point in time can be termed a hybrid node-loop approach. The method of Hydraulic analysis is explained in Appendix D of the EPANET Users Manual.

The Hazen-Williams method of determining head loss by water flowing in a pipe due to friction with the pipe walls was used and the corresponding coefficients used in the analysis.

The user's manual for EPANET that describes the methods of analysis is available free online at http://www.epa.gov/nrmrl/wswrd/dw/epanet.html and can be referenced there.

The layout of the water distribution network was developed by identifying the areas throughout the development that are likely to demonstrate the upper and lower limits of demand, pressure and flow. Pipe junctions also called nodes are located at the various points of interest throughout the development and a network of pipes used to connect them. As groundwater is the source of water for the development a reservoir was used to model the aquifer and an anticipated arrangement of pumps, tank and pipes used to model the source works. The source works and distribution network were connected by a transmission pipeline resulting in an overall model from aquifer to the demand node. The demand node represents a group of users. **Figure 3** shows the overall network layout.

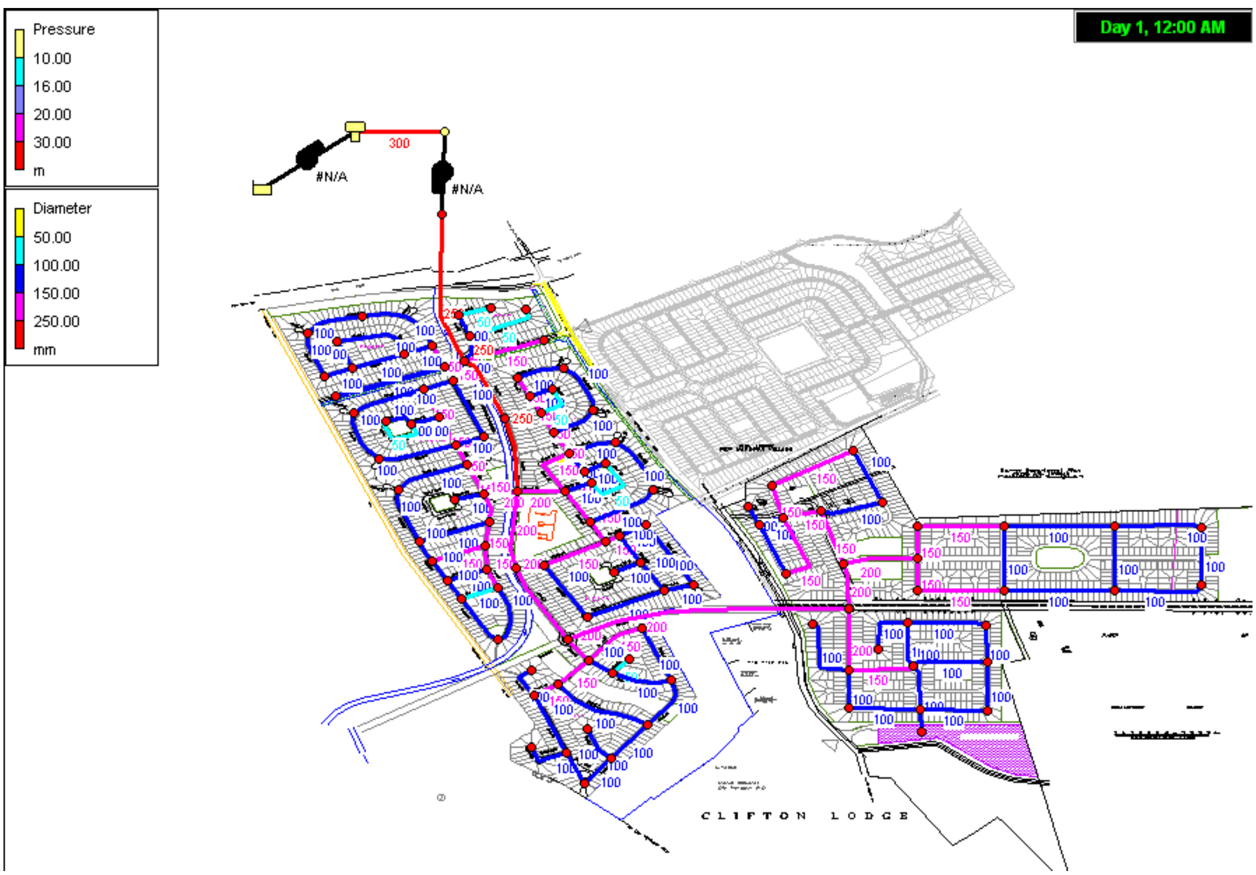


Figure 3 Water distribution model for the proposed WHIM and Brampton Developments

The nodes were assigned a base demand equal to the average water demand for a group of users that are located in a sub area of the development. The boundaries of the subareas are generally midway between nodes.

The EPANET programme allows for the variation of demand at nodes by use of time patterns that apply a multiplier to the base demand to simulate the demand at hour long time steps throughout the day. The time steps and multipliers are shown in Tables 3 and 4.

The programme is operated to analyse the network and the resulting maximum and minimum parameters are compared to the design criteria to ensure that the network meets the limits. The size and configuration of the various components of the network are varied until an economic and acceptable network is achieved.

Water distribution network criteria

The service delivery standards for water distribution systems in Jamaica are set by the Office of Utilities Regulation. The recommended minimum pressure at the service connection during peak demand is 20psi (14m of water or 138kPa). The Jamaica Institution of Engineers (JIE) Guidelines for Design and Construction of Housing Infrastructure recommend that the residual pressure at the hydrant during fire events be 5psi (3.52m of water or 34.47kPa). The water scheme was designed by taking into account the guidelines of the latest National Water Commission Developer's Manual requirements, the AWWA M-31 Distribution system requirements for fire protection and JIE guidelines. The maximum pressure of 64.92m of water or 689kPa (100psi) as stated in the JIE guideline were used in the evaluation of the system acceptability.

The NWC Developers manual recommends that "Pipelines should be sized to carry flows capable of servicing the maximum demand flow plus fire flows based on individual or group hydrant requirements."

It further states that "In urban sub-divisions street mains should be at least 100 mm (4") diameter except for short dead ends where 51 mm (2") diameter pipe running not longer than 45 m (150') are allowed at the discretion of the NWC. Velocities in pipes should not exceed 1.2 m/s (4 f.p.s) under normal circumstances and at no time should exceed 3.0 m/s (10 f.p.s)."

The rule of thumb of not using 50mm diameter pipes beyond 45m may have been exceed in the development as the model would demonstrate that the flow and pressure criteria can be achieved in the configurations used and modelled in the network.

Water distribution Network

The subdivision will be designed with varying sizes of PVC pipe ranging from of 250mm to 50mm diameter, with the latter size serving a maximum of 16 lots. The network was modelled and analysed to ensure that the minimum pressure is 14m of water (20psi) during peak demand (without fire flows) periods .The network was also checked to ensure that a minimum pressure of 5psi (34kPa or 3.5m of water) is maintained at hydrants when fire flows are drawn off the system while peak day demand flows are also drawn from the system.

Figure 3 shows the layout of the water distribution model superimposed on the proposed Whim Development layout. The model includes a reservoir, pumps, storage tank, pipes and nodes (which are pipe junctions). The water source is idealised as a reservoir with the total head set at the assumed drawdown water level in the well. The model is prepared as an open network. The network without background showing more clearly the pipes and components is shown in **Figure 4.**

The well was modelled as a reservoir with total head 1.0m above MSL. The existing ground elevation was estimated to be 26.4m above mean sea level (MSL) and was taken from the 1:12,500 Jamaica Survey Department map for Old Harbour.

The well pump for purposes of this model was assigned a flow of 40Lps and head of 35m as the duty point on the pump curve. The discharge piping from the well pump is connected directly to the storage tank. The base of the tank was modeled as the same ground elevation as the well. Chlorine will be injected into the discharge pipe from the well upstream of the storage tank to provide disinfection requirements and the storage tank will allow for more than adequate contact time before distribution of the water. It is estimated that a 40% of tank capacity will provide 4 hours of contact time with the chlorine.

The upper most ground elevation in housing blocks is in Block F and the elevation is 21.1m (node 14). The difference in elevation between the tank base and that area of the development is 5.3m. That elevation difference will not provide the minimum pressure of 14m of water in that housing block. To achieve the minimum service pressure a distribution pump was introduced into the model downstream of the storage tank.

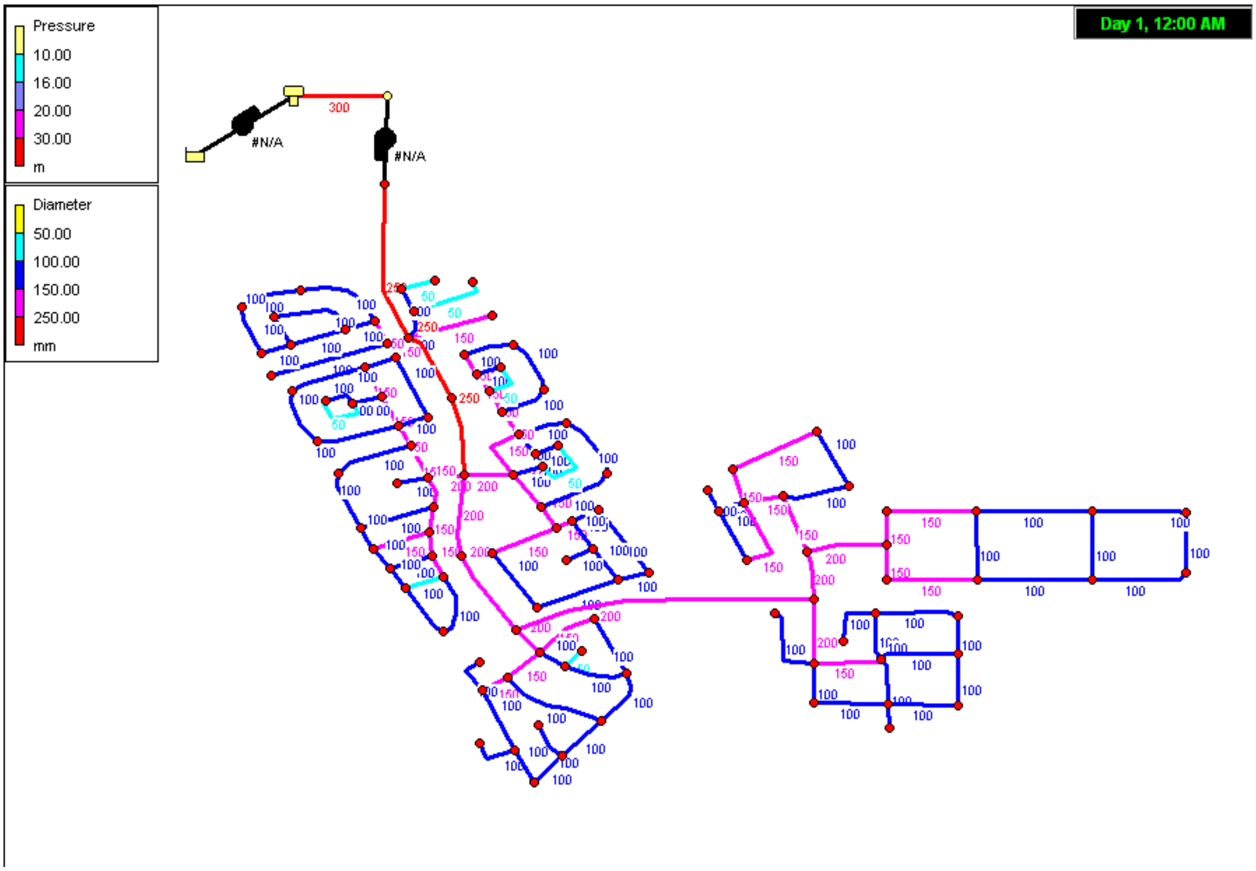


Figure 4 Pipe sizes used to analyse the proposed distribution system for The Whim and Brampton Development.

The well was included in the model to demonstrate the adequacy of the storage tank and to check for over pumping of the well given the variation in head that will occur in the storage tank. The booster pump configuration used in the model is not what is expected to be constructed. It is used however to demonstrate the flow and head that will be required to be delivered by any other configuration to satisfy the proposed pipe sizes presented in this report.

In Block F (see Figure 2) node 14 is located at the highest elevation in any housing Block and a hydrant is also proposed close to that location. That location is likely to experience the lowest pressure in the system during peak flows or if ever there is need for fire flows in that location. If the demand during fire flow is met and the minimum allowable pressure is exceeded then the network would satisfy the acceptable criteria for service during a fire in that area. It is likely that all other points in that subdivision with similar pipe layout will be similarly acceptable. Therefore typical situations were analysed and the piping configurations in similar pressure zones were duplicated.

The water demand for each node was determined by estimating water demand for the houses or other intended land use whether school, commercial etc within that area.

The pipe layout showing the sizes used in the network analyses is shown in **Figure 4**.

Extended period simulations of 72 hours were run on the model. The 24 hour diurnal variation is repeated in 24 hour periods throughout the simulations.

Table 3

Diurnal variation in average day water demand	
Time Period	Multiplier
Midnight to 1:00 A.M.	0.125
1:00 - 2:00	0.125
2:00 - 3:00	0.300
3:00 - 4:00	0.330
4:00 - 5:00	0.650
5:00 - 6:00	0.800
6:00 - 7:00	1.200
7:00 - 8:00	1.600
8:00 - 9:00	1.250
9:00 - 10:00	1.250
10:00 - 11:00	1.280
11:00 - 12:00	1.200
12:00 - 1:00	1.180
1:00 - 2:00	1.160
2:00 - 3:00	1.100
3:00 - 4:00	1.000
4:00 - 5:00	1.200
5:00 - 6:00	1.250
6:00 - 7:00	1.300
7:00 - 8:00	1.300
8:00 - 9:00	1.400
9:00 - 10:00	1.250
10:00 - 11:00	0.900
11:00 - Midnight	0.850

Table 4

Diurnal variation in peak day water demand based on average day demand	
Time Period	Multiplier
Midnight to 1:00 A.M.	0.175
1:00 - 2:00	0.175
2:00 - 3:00	0.420
3:00 - 4:00	0.462
4:00 - 5:00	0.910
5:00 - 6:00	1.120
6:00 - 7:00	1.680
7:00 - 8:00	2.100
8:00 - 9:00	1.750
9:00 - 10:00	1.890
10:00 - 11:00	1.792
11:00 - 12:00	1.680
12:00 - 1:00	1.652
1:00 - 2:00	1.624
2:00 - 3:00	1.540
3:00 - 4:00	1.400
4:00 - 5:00	1.680
5:00 - 6:00	1.750
6:00 - 7:00	1.820
7:00 - 8:00	1.820
8:00 - 9:00	1.960
9:00 - 10:00	1.750
10:00 - 11:00	1.260
11:00 - Midnight	1.190

The diurnal variation of demand at nodes throughout the average day is shown in **Table 3**. However the distribution system must support the peak day demands. The average demand during the peak day is estimated to be 1.4 times the average day demand as recommended by the JIE guidelines. The diurnal variation for that condition is shown in **Table 4**. The peak hour of the peak day is 2.1 times the average day demand and that is set for 7:00 to 8:00 A.M.

Analysis of Network for peak day flows

Two simulations are presented in this report. The first is a simulation of peak day flows repeated over three days. It is unlikely that three consecutive days of peak flow will occur but this check shows the robustness of the system designed. The second is a simulation of fire flows set at various nodes during the peak day demands.

The diurnal variation in **Table 4** shows the multiplier applied to average flow demand for each node at each time step used in the first simulation. The results from nodes at the highest (Node 14) and lowest elevations (Node 100) in the housing Blocks and a node in a Block at an intermediate elevation (Node 73) are shown in this report to demonstrate the variation in pressure throughout the network. The duty point for the distribution pump/s required to satisfy the peak hour on the peak day flow is determined to be 45Lps at 25m head.

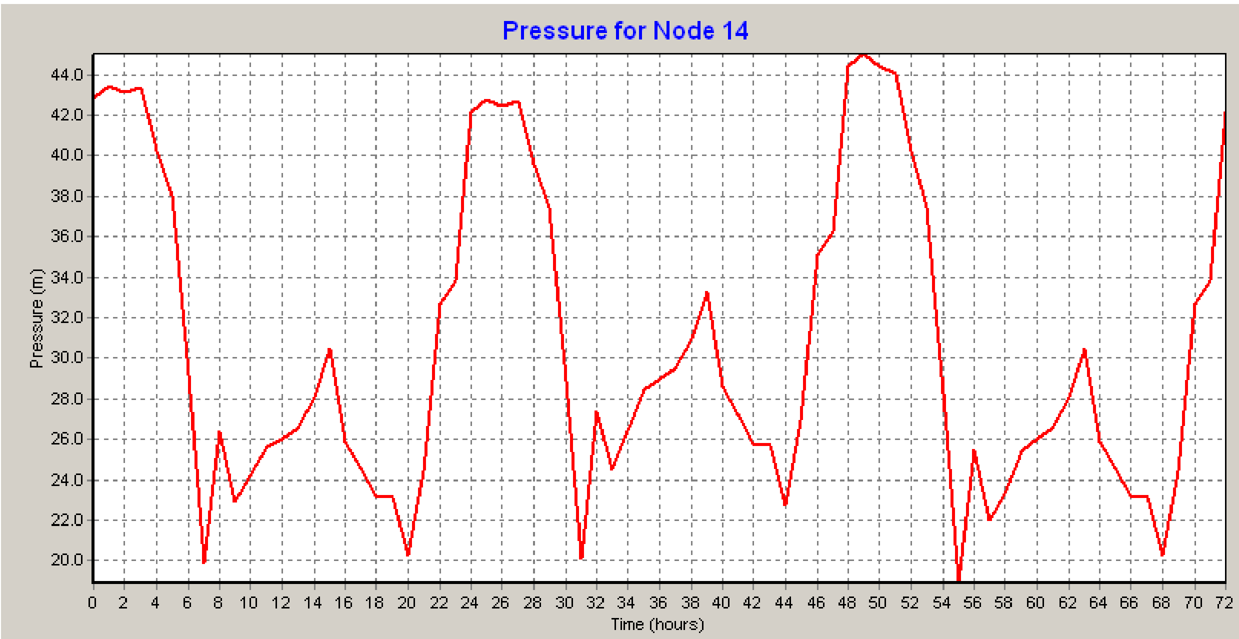


Figure 5 Pressure variations at node 14 the node at the highest elevation in the housing blocks for peak day demands.

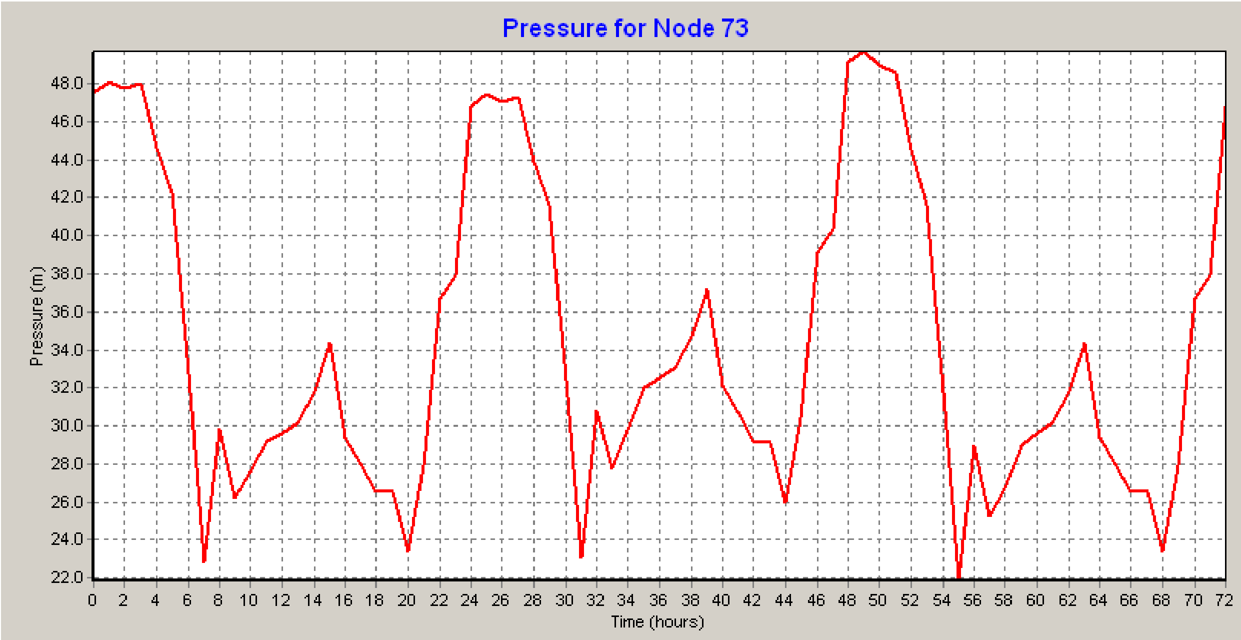


Figure 6 Pressure variations for node 73 a node at an intermediate elevation in the housing blocks for peak day demands.

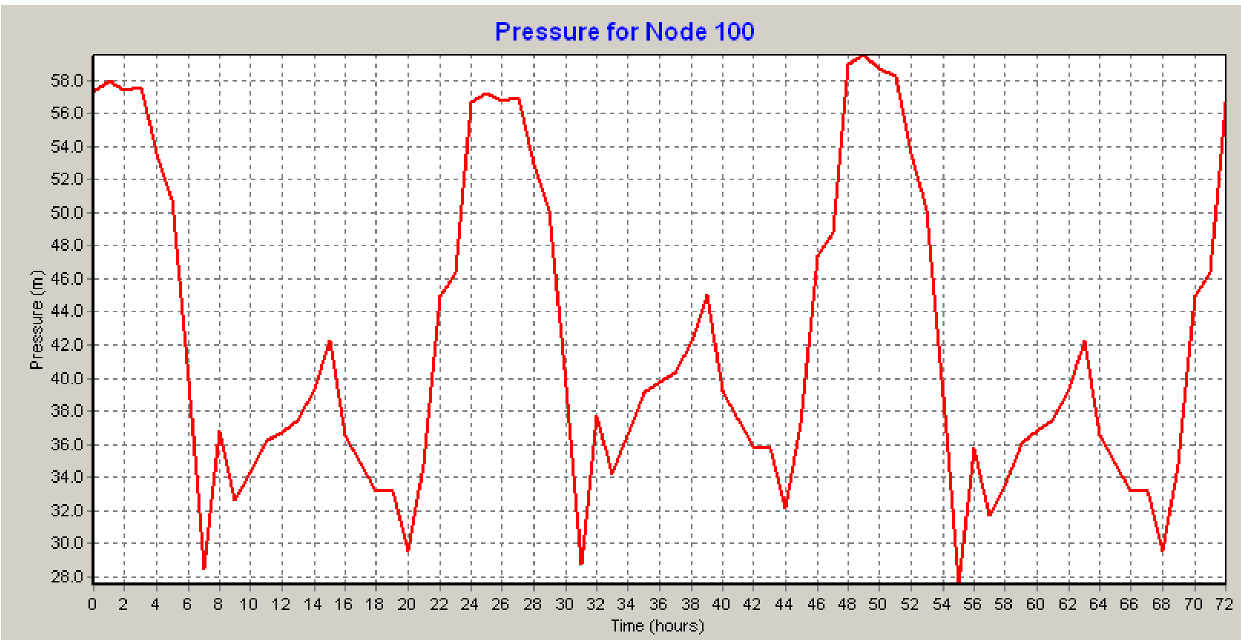


Figure 7 Pressure variations for node 100 the node at the lowest elevation in the housing blocks for peak day demands.

Table 5 Node results at peak hour on peak day demand.

GDL WHIM and BRAMPTON DEVELOPMENTS										
Network Table - Nodes at 7:00 Hrs (Peak hour of peak day demand)										
Node ID	Elevation	Base Demand	Demand	Pressure		Node ID	Elevation	Base Demand	Demand	Pressure
	m	LPS	LPS	m			m	LPS	LPS	m
Junc 3	24	0	0	8.31		Junc 60	14.1	0.225	0.47	24.82
Junc 4	24	0	0	27.52		Junc 61	14.25	0.26	0.55	24.65
Junc 5	17.75	0.083	0.17	23.48		Junc 62	14.2	0.154	0.32	24.71
Junc 6	18.4	0.13	0.27	22.73		Junc 63	15.3	0.449	0.94	23.68
Junc 7	18.8	0.118	0.25	22.23		Junc 64	15.2	0.142	0.3	23.8
Junc 8	17.2	0.106	0.22	23.94		Junc 65	14.9	0.166	0.35	24.06
Junc 9	18.48	0.296	0.62	22.09		Junc 66	15.2	0.331	0.7	23.72
Junc 10	18.2	0.26	0.55	23.03		Junc 67	15.6	0.248	0.52	23.52
Junc 11	18.8	0.13	0.27	22.33		Junc 68	15.7	0.272	0.57	23.42
Junc 12	18.9	0.177	0.37	22.22		Junc 69	16.35	0.296	0.62	22.78
Junc 13	19.3	0.319	0.67	21.75		Junc 70	16.72	0.154	0.32	22.48
Junc 14	21.1	0.343	0.72	19.85		Junc 71	16.1	0.355	0.75	23.16
Junc 15	19.2	0.177	0.37	21.72		Junc 72	16.3	0.118	0.25	22.92
Junc 16	19.05	0.177	0.37	21.87		Junc 73	16.4	0.118	0.25	22.8
Junc 17	19.9	0.213	0.45	21.03		Junc 74	16.5	0.059	0.12	22.7
Junc 18	19.9	0.307	0.64	21.04		Junc 75	16.95	0.154	0.32	22.22
Junc 19	18.45	0.367	0.77	20.51		Junc 76	16.9	0.201	0.42	22.25
Junc 20	18.9	0.177	0.37	20.08		Junc 77	17.6	0.248	0.52	21.54
Junc 21	18.5	0.272	0.57	20.48		Junc 78	17.4	0.154	0.32	21.75
Junc 22	17.25	0.213	0.45	21.74		Junc 79	17.3	0.071	0.15	21.85
Junc 23	16.8	0.106	0.22	22.17		Junc 80	16.8	0.154	0.32	22.36
Junc 24	17.7	0.154	0.32	21.27		Junc 81	17.2	0.083	0.17	21.95
Junc 25	17.7	0.367	0.77	21.27		Junc 82	13.3	0	0	24.1
Junc 26	17	0.166	0.35	22.01		Junc 83	10.9	0.142	0.3	25
Junc 27	16.8	0.189	0.4	22.18		Junc 84	14.4	0.142	0.3	20.99
Junc 28	16.8	0.331	0.7	22.31		Junc 85	13.95	0.378	0.79	21.43
Junc 29	17.3	0.437	0.92	21.8		Junc 86	11.5	0.615	1.29	23.86
Junc 30	15.8	0.26	0.55	23.44		Junc 87	13.1	0.331	0.7	22.36
Junc 31	15.7	0.154	0.32	23.56		Junc 88	13.8	0	0	21.6
Junc 32	17.4	0.284	0.6	22.9		Junc 89	12.7	0.497	1.04	22.69
Junc 33	16.2	0.059	0.12	23.19		Junc 90	12	0.532	1.12	23.62
Junc 34	15	0.189	0.4	24.12		Junc 91	11	0.568	1.19	24.36
Junc 35	15	0.213	0.45	24.16		Junc 92	10.6	0.213	0.45	24.91
Junc 36	15.1	0.177	0.37	24.02		Junc 93	10	0.24	0.5	25.4
Junc 37	15.5	0.177	0.37	23.62		Junc 94	11	0.26	0.55	24.4
Junc 38	15	0.154	0.32	24.1		Junc 95	9.2	0.626	1.31	26.12
Junc 39	14.5	0.118	0.25	24.6		Junc 96	9	0.733	1.54	26.32
Junc 40	14.3	0.248	0.52	24.79		Junc 97	8	0.485	1.02	27.07
Junc 41	13.3	0.272	0.57	25.8		Junc 98	7.3	0.473	0.99	27.77
Junc 42	12.9	0.166	0.35	26.19		Junc 99	7	0.662	1.39	27.98
Junc 43	15.2	0.236	0.5	23.18		Junc 100	6.5	0.674	1.42	28.47
Junc 44	12.8	0.236	0.5	24.55		Junc 101	9.5	0.319	0.67	26.32
Junc 45	12.6	0.307	0.64	24.69		Junc 102	11.9	0.272	0.57	23.9
Junc 46	13	0.248	0.52	24.27		Junc 103	9.4	0.26	0.55	26.16
Junc 47	13.2	0.142	0.3	24.06		Junc 104	9.9	0.402	0.84	25.68
Junc 48	13.5	0.39	0.82	23.83		Junc 105	8.8	0.508	1.07	26.88
Junc 49	12.5	0.177	0.37	24.8		Junc 106	8.3	0.26	0.55	27.3
Junc 50	12.6	0.095	0.2	24.63		Junc 107	8.7	0.378	0.79	26.88
Junc 51	11.95	0.26	0.55	25.27		Junc 108	8.5	0.402	0.84	27.1
Junc 52	12.3	0.166	0.35	24.91		Junc 109	8.2	0.284	0.6	27.43
Junc 53	11.3	0.177	0.37	25.91		Junc 110	9.2	0.367	0.77	26.48
Junc 54	11.7	0.142	0.3	25.52		Junc 111	7.8	0.35	0.73	27.8
Junc 55	12.4	0.177	0.37	24.81		Junc 112	13.8	0.059	0.12	21.59
Junc 56	11.8	0.272	0.57	25.46		Junc 113	20	0.213	0.45	20.93
Junc 57	11.7	0.213	0.45	25.59		Resvr 1	1	#N/A	0	0
Junc 58	13.4	0.225	0.47	25.51		Tank 2	26.4	#N/A	-58.49	6.12
Junc 59	13.5	0.248	0.52	25.41						

Table 6 Pipe results at peak hour on peak day demand.

GDL WHIM and BRAMPTON DEVELOPMENTS																
Network Table - Links at 7:00 Hrs				(Peak hour of peak day demand)												
Link ID	Length	Diameter	Roughness	Flow	Velocity	Friction	Status		Link ID	Length	Diameter	Roughness	Flow	Velocity	Friction	Status
	m	mm		LPS	m/s	Factor				m	mm		LPS	m/s	Factor	
Pipe 4	50	300	140	58.49	0.83	0.036	Open		Pipe 74	200	150	140	1.94	0.11	0.029	Open
Pipe 5	2000	250	140	58.49	1.19	0.018	Open		Pipe 75	200	100	140	1	0.13	0.029	Open
Pipe 6	200	150	140	0.55	0.03	0.034	Open		Pipe 76	200	100	140	0.53	0.07	0.032	Open
Pipe 7	200	100	140	1.36	0.17	0.028	Open		Pipe 77	200	100	140	0.16	0.02	0.038	Open
Pipe 8	200	50	140	0.62	0.32	0.028	Open		Pipe 78	200	100	140	-0.31	0.04	0.035	Open
Pipe 9	200	100	140	0.52	0.07	0.032	Open		Pipe 79	200	100	140	-1	0.13	0.029	Open
Pipe 10	200	50	140	0.25	0.13	0.032	Open		Pipe 80	200	150	140	-2.38	0.13	0.028	Open
Pipe 11	200	150	140	4.32	0.24	0.025	Open		Pipe 81	200	100	140	1.03	0.13	0.029	Open
Pipe 12	200	100	140	0.37	0.05	0.033	Open		Pipe 82	200	100	140	0.16	0.02	0.038	Open
Pipe 13	200	150	140	3.67	0.21	0.026	Open		Pipe 83	200	100	140	0.55	0.07	0.032	Open
Pipe 14	240	100	140	1.41	0.18	0.028	Open		Pipe 84	200	100	140	0.04	0	0.047	Open
Pipe 15	120	100	140	0.69	0.09	0.032	Open		Pipe 85	200	100	140	-0.54	0.07	0.032	Open
Pipe 16	200	100	140	-0.13	0.02	0.039	Open		Pipe 86	200	100	140	-1.16	0.15	0.029	Open
Pipe 17	200	100	140	-0.47	0.06	0.033	Open		Pipe 87	200	150	140	-3.4	0.19	0.026	Open
Pipe 18	200	100	140	-1.59	0.2	0.027	Open		Pipe 88	200	100	140	0.93	0.12	0.03	Open
Pipe 19	200	100	140	0.47	0.06	0.033	Open		Pipe 89	200	100	140	0.59	0.07	0.032	Open
Pipe 20	200	100	140	0.03	0	0.051	Open		Pipe 90	200	100	140	0.32	0.04	0.035	Open
Pipe 21	200	250	140	52.09	1.06	0.02	Open		Pipe 91	200	100	140	0.15	0.02	0.038	Open
Pipe 22	200	250	140	51.49	1.05	0.02	Open		Pipe 92	200	50	140	0.1	0.05	0.037	Open
Pipe 23	200	200	140	10.3	0.33	0.024	Open		Pipe 93	200	150	140	2.24	0.13	0.028	Open
Pipe 24	200	150	140	5.29	0.3	0.025	Open		Pipe 94	200	150	140	1.27	0.07	0.03	Open
Pipe 25	200	150	140	4.22	0.24	0.026	Open		Pipe 95	200	150	140	0.89	0.05	0.032	Open
Pipe 26	200	150	140	2.11	0.12	0.028	Open		Pipe 96	200	150	140	0.62	0.04	0.033	Open
Pipe 27	200	150	140	1.11	0.06	0.031	Open		Pipe 97	200	100	140	0.3	0.04	0.035	Open
Pipe 28	200	100	140	0.54	0.07	0.032	Open		Pipe 98	200	100	140	-0.22	0.03	0.036	Open
Pipe 29	200	100	140	-0.23	0.03	0.036	Open		Pipe 99	200	100	140	-0.64	0.08	0.031	Open
Pipe 30	200	100	140	-1	0.13	0.029	Open		Pipe 100	200	100	140	0.12	0.02	0.04	Open
Pipe 31	200	100	140	0.55	0.07	0.032	Open		Pipe 101	200	50	140	0.06	0.03	0.04	Open
Pipe 32	200	100	140	0.28	0.04	0.035	Open		Pipe 102	200	200	140	6.3	0.2	0.026	Open
Pipe 33	200	50	140	0.05	0.02	0.041	Open		Pipe 103	500	200	140	24.01	0.76	0.02	Open
Pipe 34	200	100	140	0.38	0.05	0.034	Open		Pipe 104	200	200	140	15.72	0.5	0.023	Open
Pipe 35	200	100	140	-0.54	0.07	0.032	Open		Pipe 105	200	150	140	5.44	0.31	0.025	Open
Pipe 36	200	100	140	0.2	0.02	0.037	Open		Pipe 106	200	150	140	3.34	0.19	0.026	Open
Pipe 37	200	100	140	-0.38	0.05	0.034	Open		Pipe 107	200	100	140	0.38	0.05	0.034	Open
Pipe 38	200	100	140	-0.77	0.1	0.03	Open		Pipe 108	200	100	140	0.3	0.04	0.035	Open
Pipe 39	200	100	140	0.55	0.07	0.032	Open		Pipe 109	200	100	140	-0.04	0.01	0.046	Open
Pipe 40	200	150	140	4.14	0.23	0.026	Open		Pipe 110	200	150	140	-1.09	0.06	0.031	Open
Pipe 41	200	100	140	0.99	0.13	0.029	Open		Pipe 111	200	150	140	1.87	0.11	0.029	Open
Pipe 42	200	100	140	0.05	0.01	0.044	Open		Pipe 112	200	150	140	1.08	0.06	0.031	Open
Pipe 43	200	150	140	-0.82	0.05	0.032	Open		Pipe 113	200	100	140	-0.21	0.03	0.037	Open
Pipe 44	200	150	140	2.7	0.15	0.027	Open		Pipe 114	200	100	140	-1.41	0.18	0.028	Open
Pipe 45	200	150	140	1.51	0.09	0.03	Open		Pipe 115	200	200	140	9.17	0.29	0.024	Open
Pipe 46	200	100	140	0.26	0.03	0.036	Open		Pipe 116	200	150	140	4.38	0.25	0.025	Open
Pipe 47	200	100	140	0.51	0.06	0.032	Open		Pipe 117	200	150	140	3.83	0.22	0.026	Open
Pipe 48	200	150	140	1	0.06	0.031	Open		Pipe 118	200	100	140	2.41	0.31	0.026	Open
Pipe 49	200	100	140	0.44	0.06	0.033	Open		Pipe 119	200	100	140	1.4	0.18	0.028	Open
Pipe 50	200	50	140	0.06	0.03	0.04	Open		Pipe 120	200	100	140	-0.01	0	0.063	Open
Pipe 51	200	100	140	0.37	0.05	0.034	Open		Pipe 121	200	100	140	-1.4	0.18	0.028	Open
Pipe 52	200	100	140	-0.02	0	0.056	Open		Pipe 122	200	100	140	0.01	0	0.055	Open
Pipe 53	200	200	140	30.81	0.98	0.021	Open		Pipe 123	200	100	140	-2.41	0.31	0.026	Open
Pipe 54	200	200	140	30.31	0.96	0.021	Open		Pipe 124	200	100	140	-0.12	0.01	0.04	Open
Pipe 55	200	150	140	3.18	0.18	0.027	Open		Pipe 125	200	150	140	-3.84	0.22	0.026	Open
Pipe 56	200	150	140	1.83	0.1	0.029	Open		Pipe 126	200	150	140	-4.35	0.25	0.025	Open
Pipe 57	200	100	140	0.3	0.04	0.035	Open		Pipe 127	200	200	140	7.98	0.25	0.025	Open
Pipe 58	200	100	140	1.01	0.13	0.029	Open		Pipe 128	200	100	140	1.77	0.23	0.027	Open
Pipe 59	200	100	140	0.35	0.04	0.034	Open		Pipe 129	200	100	140	1	0.13	0.029	Open
Pipe 60	200	100	140	0.12	0.01	0.04	Open		Pipe 130	200	100	140	0.73	0.09	0.031	Open
Pipe 61	200	100	140	-0.26	0.03	0.036	Open		Pipe 131	200	100	140	0.74	0.09	0.031	Open
Pipe 62	200	100	140	0.37	0.05	0.034	Open		Pipe 132	200	100	140	-0.1	0.01	0.04	Open
Pipe 63	200	100	140	-0.93	0.12	0.03	Open		Pipe 133	200	100	140	0.67	0.09	0.031	Open
Pipe 64	200	100	140	0.71	0.09	0.031	Open		Pipe 134	200	100	140	-0.12	0.02	0.04	Open
Pipe 65	200	100	140	-0.79	0.1	0.03	Open		Pipe 135	200	100	140	0.55	0.07	0.032	Open
Pipe 66	200	100	140	-0.85	0.11	0.03	Open		Pipe 136	200	100	140	-1.51	0.19	0.028	Open
Pipe 67	200	150	140	-1.67	0.09	0.029	Open		Pipe 137	200	100	140	1.07	0.14	0.029	Open
Pipe 68	200	100	140	0.96	0.12	0.029	Open		Pipe 138	200	100	140	-1.32	0.17	0.028	Open
Pipe 69	200	50	140	0.2	0.1	0.033	Open		Pipe 139	200	150	140	4.97	0.28	0.025	Open
Pipe 70	200	100	140	0.39	0.05	0.034	Open		Pipe 140	200	100	140	0.57	0.07	0.032	Open
Pipe 71	200	200	140	10.26	0.33	0.024	Open		Pipe 3	200	100	140	0.24	0.03	0.036	Open
Pipe 72	200	150	140	5.18	0.29	0.025	Open		Pump 1	#N/A	#N/A	#N/A	0	0	0	Closed
Pipe 73	200	150	140	4.62	0.26	0.025	Open		Pump 2	#N/A	#N/A	#N/A	58.49	0	0	Open

The results shown in Figures 5, 6 and 7 show that the minimum pressure anticipated in the housing blocks is 19m of water (27psi). The maximum velocity in any pipe at peak hour of the peak day in the peak month estimated to be 1.19m/s as shown in Table 6. Tables 5 and 6 show the demands and resulting pressures as well as the velocity of flow in the pipelines in the network during the peak hour of the peak day in the peak month demand.

Analysis of Network for fire flows

The AWWA M31 manual outlines a number of methods to assess the Needed Fire Flow (NFF) and duration. The method used in this report is the Insurance Services Office method to determine the fire flow needed for a fire in an extended house in the proposed development.

The fire flow used for this project is two streams from a hydrant anywhere in the subdivision.

Needed Fire Flow (NFF) for a dwelling in proposed development

The Insurance Services Office Method defines the NFF as the rate of flow considered necessary to control a major fire in a specific building. The calculation of a NFF, in US gallons per minute considers the construction (C_i), occupancy (O_i), exposure (X_i) and communication (P_i) factors of that building.

$$NFF = (C_i)\,(O_i)\,(X + P)_i$$

$$C_i = 18\,F\,(A_i)^{0.5}$$

Where F = 1.0 for construction class 2 (jointed masonry)

A_i = effective area, where the effective area is the total square footage of the largest floor plus 50% of all other floors for class 2 construction

The effective area will be taken as 60% of a standard lot for a ground and a suspended floor. This is because the houses being sold can be expanded to this maximum.

A_i = 3,600 sq ft x 0.6 x 1.5 = 3,240 sq ft.

C_i = 18 x 1.0 x $(3,240)^{0.5}$ = 1,024 US gpm

O_i = 0.82 *(From table 1-2 AWWA M31 limited combustible C-2)*

X_i = 0.21 *(From table 1-3 AWWA M31)*

P_i = 0.3 *(From table 1-4 AWWA M31)*

Therefore NFF = 1,024 x 0.82 x (0.21 + 0.3) = 428.34 US gpm or 1,621Lpm of 27Lps

Two streams from a single hydrant can supply 30.3 Lps which will be adequate to suppress a fire from the building considered.

The fire flow used to check the distribution network is a minimum of 30 Lps at selected hydrants. Quantity of water for fire is estimated to be 30.3Lps for two hours that being a minimum of 218.2m^3.

Fire flows were set at three nodes (14, 73, and 100) the highest, intermediate and lowest elevations in the housing blocks in the development. The fire flows were set at time steps 7:00 - 8:00A.M. ,1:00 - 2:00P.M. , 4:00 - 5:00P.M. for the three respective nodes. The multipliers though varying are all above 1.4 the average peak day flow.

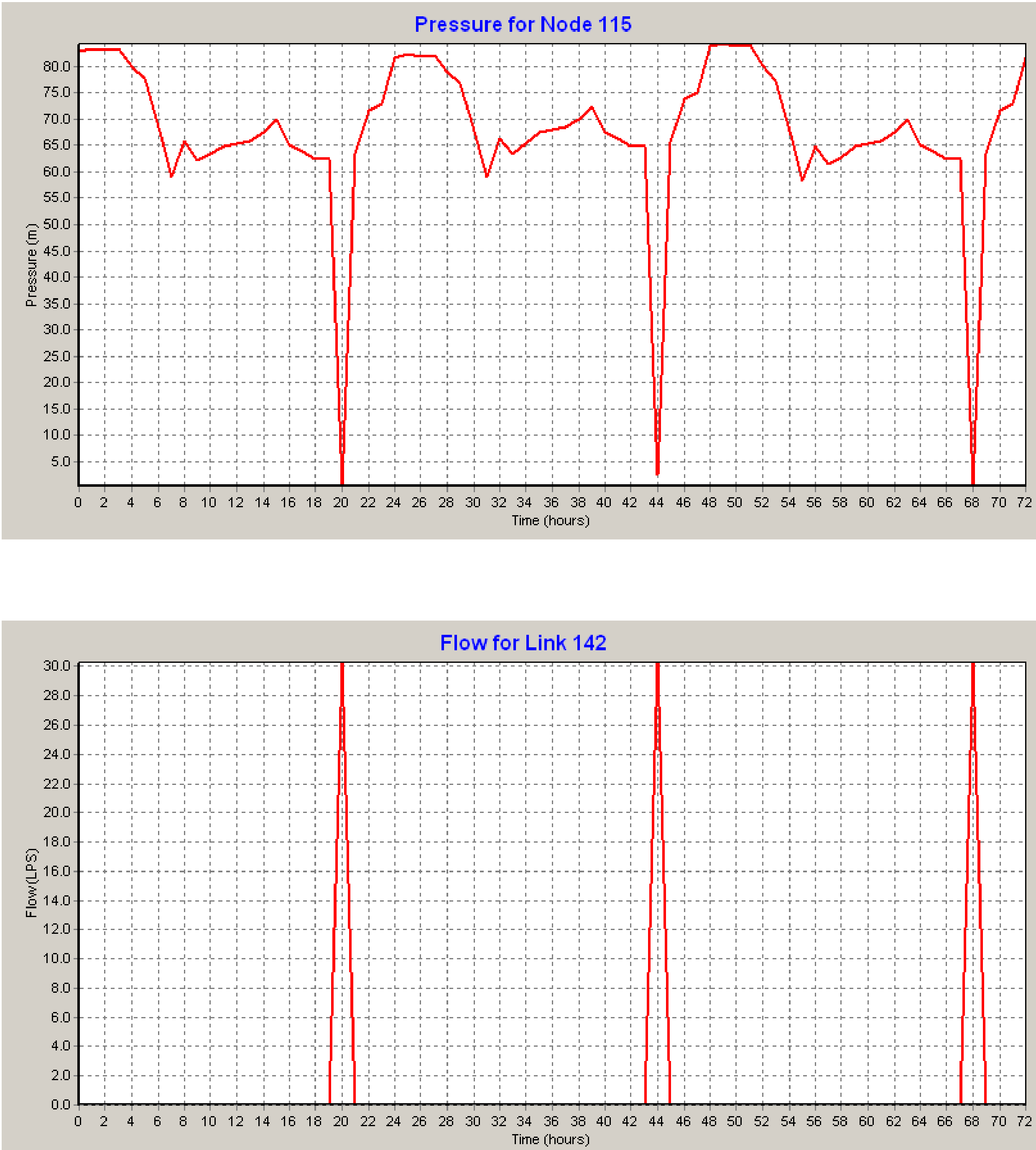
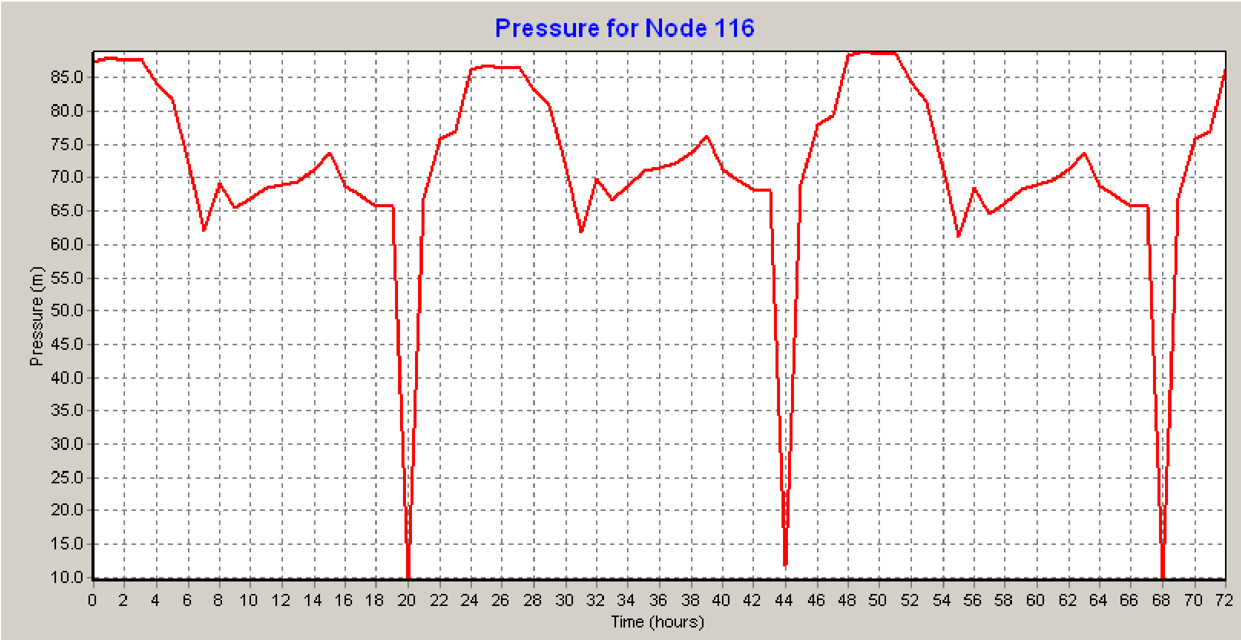


Figure 8 Pressure and demand (flow) variations for Node 115 and pipe 142. Pipe 142 connects node 115 to node 14 the node at the highest elevation in the housing blocks for fire flows with peak day demand.



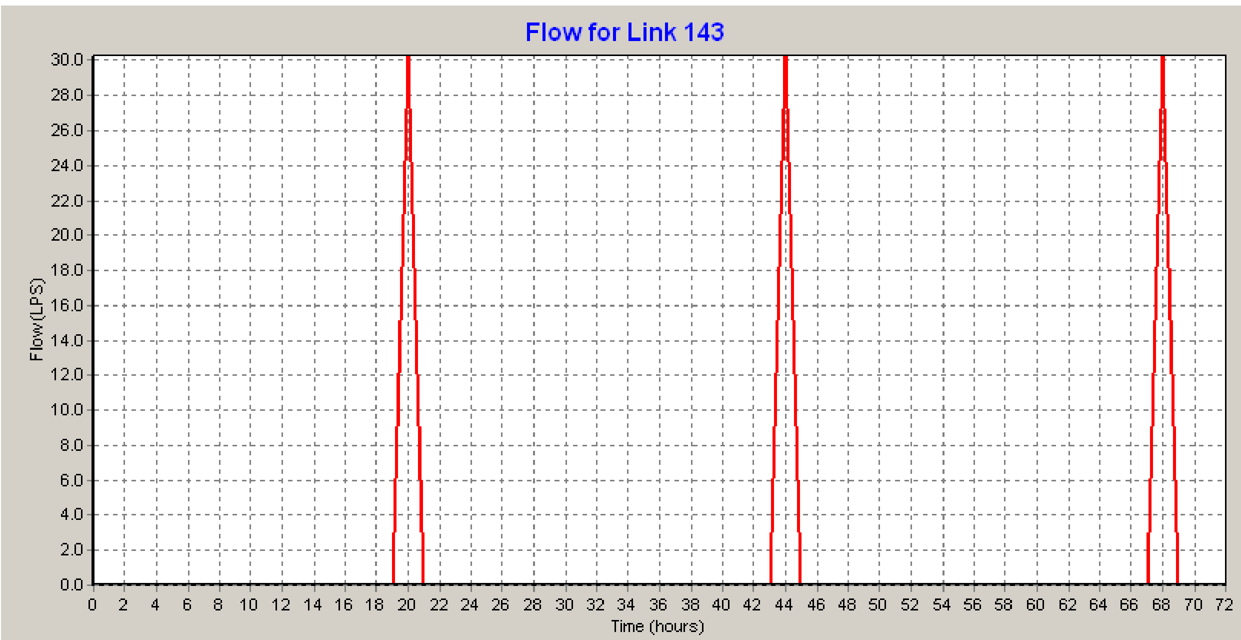
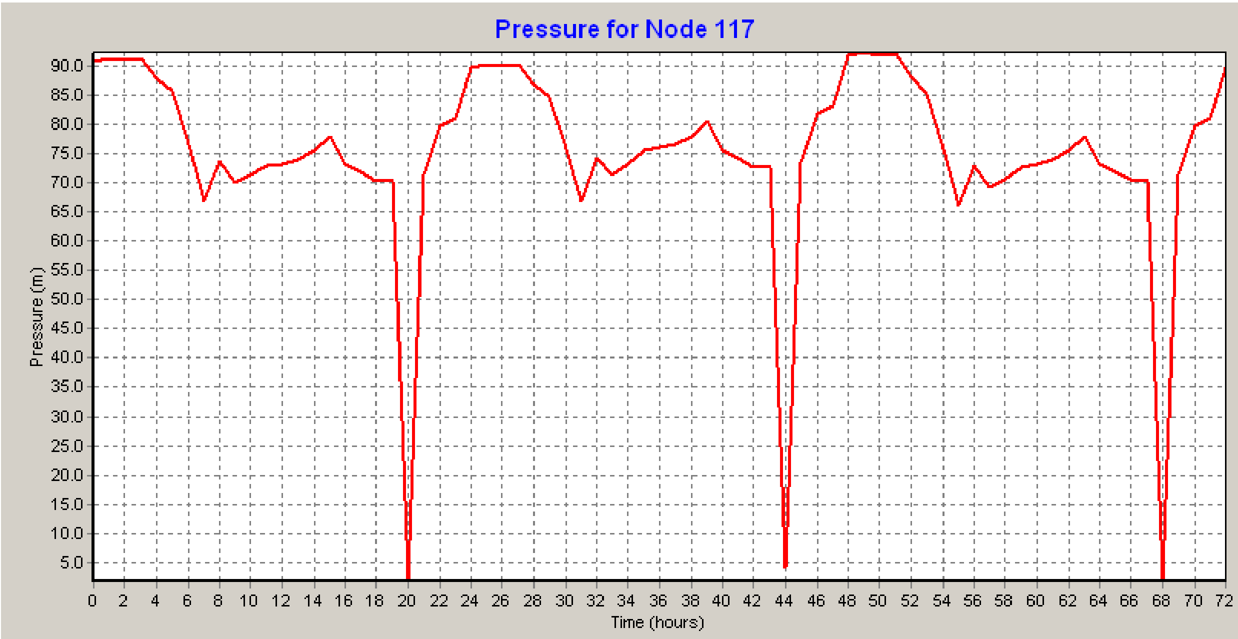


Figure 9 Pressure and demand variations for node 116 and pipe 143. Pipe 143 connects to node 116 to node 73 at an intermediate elevation in the housing blocks.



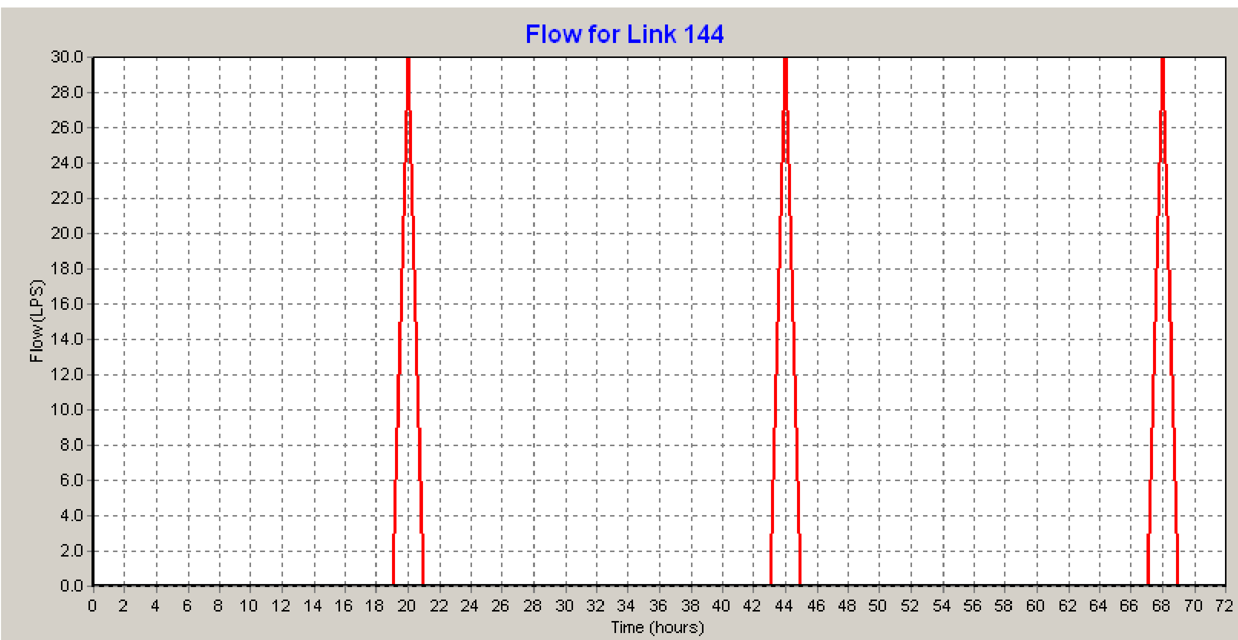


Figure 10 Pressure and demand (flow) variations for node 117 and pipe 144. Pipe 144 connects node 117 to node 100 the node at the lowest elevation in the housing blocks.

It is noted that the minimum pressure is above 3.25 m of water (5psi) in all checks. Node 100 delivers 29Lps at the peak day demand.

The velocities in the pipe lines were checked during various peak day demands with the fire flow. The scenario presented is expected to show the highest velocities in the pipe network when fire flows are assigned at the furthest node in the network. Node 100 is that node and Tables 7 and 8 show the node and pipeline parameters based on that scenario.

Table 7 Node results for peak day demand and fire flow at Node 117

GDL WHIM and BRAMPTON DEVELOPMENTS										
Network Table - Nodes at 20:00 Hrs (Fire flow at Node 117 with peak day demand)										
Node ID	Elevation	Base Demand	Demand	Pressure		Node ID	Elevation	Base Demand	Demand	Pressure
	m	LPS	LPS	m			m	LPS	LPS	m
Junc 3	24	0	0	-4.39		Junc 62	14.2	0.154	0.3	34.35
Junc 4	24	0	0	48.82		Junc 63	15.3	0.449	0.88	33.31
Junc 5	17.75	0.083	0.16	35.11		Junc 64	15.2	0.142	0.28	33.43
Junc 6	18.4	0.13	0.25	34.37		Junc 65	14.9	0.166	0.33	33.7
Junc 7	18.8	0.118	0.23	33.88		Junc 66	15.2	0.331	0.65	33.36
Junc 8	17.2	0.106	0.21	35.58		Junc 67	15.6	0.248	0.49	33.13
Junc 9	18.48	0.296	0.58	33.8		Junc 68	15.7	0.272	0.53	33.03
Junc 10	18.2	0.26	0.51	34.66		Junc 69	16.35	0.296	0.58	32.4
Junc 11	18.8	0.13	0.25	33.97		Junc 70	16.72	0.154	0.3	32.09
Junc 12	18.9	0.177	0.35	33.87		Junc 71	16.1	0.355	0.7	32.76
Junc 13	19.3	0.319	0.63	33.41		Junc 72	16.3	0.118	0.23	32.52
Junc 14	21.1	0.343	0.67	31.51		Junc 73	16.4	0.118	0.23	32.41
Junc 15	19.2	0.177	0.35	33.39		Junc 74	16.5	0.059	0.12	32.31
Junc 16	19.05	0.177	0.35	33.54		Junc 75	16.95	0.154	0.3	31.83
Junc 17	19.9	0.213	0.42	32.7		Junc 76	16.9	0.201	0.39	31.86
Junc 18	19.9	0.307	0.6	32.71		Junc 77	17.6	0.248	0.49	31.16
Junc 19	18.45	0.367	0.72	30.15		Junc 78	17.4	0.154	0.3	31.37
Junc 20	18.9	0.177	0.35	29.72		Junc 79	17.3	0.071	0.14	31.47
Junc 21	18.5	0.272	0.53	30.11		Junc 80	16.8	0.154	0.3	31.97
Junc 22	17.25	0.213	0.42	31.37		Junc 81	17.2	0.083	0.16	31.57
Junc 23	16.8	0.106	0.21	31.81		Junc 82	13.3	0	0	29.2
Junc 24	17.7	0.154	0.3	30.9		Junc 83	10.9	0.142	0.28	25.45
Junc 25	17.7	0.367	0.72	30.9		Junc 84	14.4	0.142	0.28	19.82
Junc 26	17	0.166	0.33	31.64		Junc 85	13.95	0.378	0.74	20.26
Junc 27	16.8	0.189	0.37	31.82		Junc 86	11.5	0.615	1.21	22.69
Junc 28	16.8	0.331	0.65	31.93		Junc 87	13.1	0.331	0.65	21.18
Junc 29	17.3	0.437	0.86	31.42		Junc 88	13.8	0	0	20.43
Junc 30	15.8	0.26	0.51	33.05		Junc 89	12.7	0.497	0.97	21.52
Junc 31	15.7	0.154	0.3	33.16		Junc 90	12	0.532	1.04	22.42
Junc 32	17.4	0.284	0.56	33.51		Junc 91	11	0.568	1.11	23.2
Junc 33	16.2	0.059	0.12	32.78		Junc 92	10.6	0.213	0.42	22.36
Junc 34	15	0.189	0.37	33.73		Junc 93	10	0.24	0.47	21.4
Junc 35	15	0.213	0.42	33.78		Junc 94	11	0.26	0.51	20.39
Junc 36	15.1	0.177	0.35	33.63		Junc 95	9.2	0.626	1.23	20.71
Junc 37	15.5	0.177	0.35	33.24		Junc 96	9	0.733	1.44	20.91
Junc 38	15	0.154	0.3	33.72		Junc 97	8	0.485	0.95	12.94
Junc 39	14.5	0.118	0.23	34.22		Junc 98	7.3	0.473	0.93	13.41
Junc 40	14.3	0.248	0.49	34.41		Junc 99	7	0.662	1.3	7.98
Junc 41	13.3	0.272	0.53	35.42		Junc 100	6.5	0.674	1.32	3.55
Junc 42	12.9	0.166	0.33	35.81		Junc 101	9.5	0.319	0.63	26.78
Junc 43	15.2	0.236	0.46	30.52		Junc 102	11.9	0.272	0.53	24.37
Junc 44	12.8	0.236	0.46	29.65		Junc 103	9.4	0.26	0.51	26.65
Junc 45	12.6	0.307	0.6	29.8		Junc 104	9.9	0.402	0.79	26.17
Junc 46	13	0.248	0.49	29.39		Junc 105	8.8	0.508	1	27.36
Junc 47	13.2	0.142	0.28	29.18		Junc 106	8.3	0.26	0.51	27.78
Junc 48	13.5	0.39	0.76	28.94		Junc 107	8.7	0.378	0.74	27.36
Junc 49	12.5	0.177	0.35	29.91		Junc 108	8.5	0.402	0.79	27.58
Junc 50	12.6	0.095	0.19	29.75		Junc 109	8.2	0.284	0.56	27.91
Junc 51	11.95	0.26	0.51	30.39		Junc 110	9.2	0.367	0.72	26.95
Junc 52	12.3	0.166	0.33	30.03		Junc 111	7.8	0.35	0.69	28.28
Junc 53	11.3	0.177	0.35	31.04		Junc 112	13.8	0.059	0.12	20.42
Junc 54	11.7	0.142	0.28	30.64		Junc 113	20	0.213	0.42	32.6
Junc 55	12.4	0.177	0.35	29.94		Junc 114	12.7	0	0	21.52
Junc 56	11.8	0.272	0.53	30.58		Junc 115	21.1	0	0	31.51
Junc 57	11.7	0.213	0.42	30.71		Junc 116	16.4	0	0	32.41
Junc 58	13.4	0.225	0.44	35.15		Junc 117	6.5	29	29	0.04
Junc 59	13.5	0.248	0.49	35.05		Resvr 1	1	#N/A	-49.48	0
Junc 60	14.1	0.225	0.44	34.47		Tank 2	26.4	#N/A	-34.11	3.41
Junc 61	14.25	0.26	0.51	34.29						

Table 8 Pipe results at peak day demand with fire flow at node 117

GDL WHIM and BRAMPTON DEVELOPMENTS																
Network Table - Links at 20:00 Hrs				(Fire flow at Node 117 with peak day demand)												
Link ID	Length m	Diameter mm	Roughness	Flow LPS	Velocity m/s	Friction Factor	Status		Link ID	Length m	Diameter mm	Roughness	Flow LPS	Velocity m/s	Friction Factor	Status
Pipe 4	50	300	140	84.59	1.2	0.035	Open		Pipe 76	200	100	140	0.49	0.06	0.032	Open
Pipe 5	2000	250	140	84.59	1.72	0.017	Open		Pipe 77	200	100	140	0.15	0.02	0.038	Open
Pipe 6	200	150	140	0.51	0.03	0.034	Open		Pipe 78	200	100	140	-0.29	0.04	0.035	Open
Pipe 7	200	100	140	1.27	0.16	0.028	Open		Pipe 79	200	100	140	-0.94	0.12	0.03	Open
Pipe 8	200	50	140	0.58	0.3	0.029	Open		Pipe 80	200	150	140	-2.22	0.13	0.028	Open
Pipe 9	200	100	140	0.49	0.06	0.032	Open		Pipe 81	200	100	140	0.96	0.12	0.029	Open
Pipe 10	200	50	140	0.23	0.12	0.033	Open		Pipe 82	200	100	140	0.15	0.02	0.038	Open
Pipe 11	200	150	140	4.03	0.23	0.026	Open		Pipe 83	200	100	140	0.51	0.06	0.032	Open
Pipe 12	200	100	140	0.35	0.04	0.034	Open		Pipe 84	200	100	140	0.02	0	0.051	Open
Pipe 13	200	150	140	3.43	0.19	0.026	Open		Pipe 85	200	100	140	-0.51	0.06	0.032	Open
Pipe 14	240	100	140	1.32	0.17	0.028	Open		Pipe 86	200	100	140	-1.09	0.14	0.029	Open
Pipe 15	120	100	140	0.64	0.08	0.032	Open		Pipe 87	200	150	140	-3.12	0.18	0.027	Open
Pipe 16	200	100	140	-0.12	0.02	0.04	Open		Pipe 88	200	100	140	0.93	0.12	0.03	Open
Pipe 17	200	100	140	-0.44	0.06	0.033	Open		Pipe 89	200	100	140	0.36	0.05	0.034	Open
Pipe 18	200	100	140	-1.49	0.19	0.028	Open		Pipe 90	200	100	140	0.35	0.04	0.034	Open
Pipe 19	200	100	140	0.44	0.06	0.033	Open		Pipe 91	200	100	140	-0.11	0.01	0.04	Open
Pipe 20	200	100	140	0.02	0	0.054	Open		Pipe 92	200	100	140	0.34	0.04	0.034	Open
Pipe 21	200	250	140	78.62	1.6	0.019	Open		Pipe 93	200	150	140	2.09	0.12	0.028	Open
Pipe 22	200	250	140	78.06	1.59	0.019	Open		Pipe 94	200	150	140	1.19	0.07	0.031	Open
Pipe 23	200	200	140	9.62	0.31	0.024	Open		Pipe 95	200	150	140	0.83	0.05	0.032	Open
Pipe 24	200	150	140	4.94	0.28	0.025	Open		Pipe 96	200	150	140	0.58	0.03	0.034	Open
Pipe 25	200	150	140	3.94	0.22	0.026	Open		Pipe 97	200	100	140	0.28	0.04	0.035	Open
Pipe 26	200	150	140	1.96	0.11	0.028	Open		Pipe 98	200	100	140	-0.21	0.03	0.037	Open
Pipe 27	200	150	140	1.04	0.06	0.031	Open		Pipe 99	200	100	140	-0.6	0.08	0.032	Open
Pipe 28	200	100	140	0.51	0.06	0.032	Open		Pipe 100	200	100	140	0.11	0.01	0.04	Open
Pipe 29	200	100	140	-0.21	0.03	0.037	Open		Pipe 101	200	50	140	0.05	0.03	0.041	Open
Pipe 30	200	100	140	-0.93	0.12	0.03	Open		Pipe 102	200	200	140	5.88	0.19	0.026	Open
Pipe 31	200	100	140	0.51	0.06	0.032	Open		Pipe 103	500	200	140	52.41	1.67	0.018	Open
Pipe 32	200	100	140	0.26	0.03	0.036	Open		Pipe 104	200	200	140	44.68	1.42	0.02	Open
Pipe 33	200	50	140	0.04	0.02	0.042	Open		Pipe 105	200	150	140	5.08	0.29	0.025	Open
Pipe 34	200	100	140	0.35	0.04	0.034	Open		Pipe 106	200	150	140	3.12	0.18	0.027	Open
Pipe 35	200	100	140	-0.51	0.06	0.032	Open		Pipe 107	200	100	140	0.36	0.05	0.034	Open
Pipe 36	200	100	140	0.18	0.02	0.037	Open		Pipe 108	200	100	140	0.28	0.04	0.035	Open
Pipe 37	200	100	140	-0.35	0.04	0.034	Open		Pipe 109	200	100	140	-0.04	0	0.047	Open
Pipe 38	200	100	140	-0.72	0.09	0.031	Open		Pipe 110	200	150	140	-1.01	0.06	0.031	Open
Pipe 39	200	100	140	0.51	0.06	0.032	Open		Pipe 111	200	150	140	1.75	0.1	0.029	Open
Pipe 40	200	150	140	3.87	0.22	0.026	Open		Pipe 112	200	150	140	1.01	0.06	0.031	Open
Pipe 41	200	100	140	0.93	0.12	0.03	Open		Pipe 113	200	100	140	-0.2	0.03	0.037	Open
Pipe 42	200	100	140	0.05	0.01	0.044	Open		Pipe 114	200	100	140	-1.31	0.17	0.028	Open
Pipe 43	200	150	140	-0.77	0.04	0.032	Open		Pipe 115	200	200	140	38.56	1.23	0.02	Open
Pipe 44	200	150	140	2.52	0.14	0.027	Open		Pipe 116	200	150	140	19.08	1.08	0.021	Open
Pipe 45	200	150	140	1.4	0.08	0.03	Open		Pipe 117	200	150	140	18.57	1.05	0.021	Open
Pipe 46	200	100	140	0.24	0.03	0.036	Open		Pipe 118	200	100	140	17.37	2.21	0.02	Open
Pipe 47	200	100	140	0.47	0.06	0.033	Open		Pipe 119	200	100	140	18.85	2.4	0.019	Open
Pipe 48	200	150	140	0.93	0.05	0.032	Open		Pipe 120	200	100	140	-12.47	1.59	0.02	Open
Pipe 49	200	100	140	0.41	0.05	0.033	Open		Pipe 121	200	100	140	-13.77	1.75	0.02	Open
Pipe 50	200	50	140	0.06	0.03	0.04	Open		Pipe 122	200	100	140	-2.41	0.31	0.026	Open
Pipe 51	200	100	140	0.34	0.04	0.034	Open		Pipe 123	200	100	140	-17.13	2.18	0.02	Open
Pipe 52	200	100	140	-0.02	0	0.056	Open		Pipe 124	200	100	140	-0.23	0.03	0.03	Open
Pipe 53	200	200	140	58.75	1.87	0.019	Open		Pipe 125	200	150	140	-18.59	1.05	0.021	Open
Pipe 54	200	200	140	58.29	1.86	0.019	Open		Pipe 126	200	150	140	-19.06	1.08	0.021	Open
Pipe 55	200	150	140	2.97	0.17	0.027	Open		Pipe 127	200	200	140	7.45	0.24	0.025	Open
Pipe 56	200	150	140	1.71	0.1	0.029	Open		Pipe 128	200	100	140	1.66	0.21	0.027	Open
Pipe 57	200	100	140	0.28	0.04	0.035	Open		Pipe 129	200	100	140	0.94	0.12	0.03	Open
Pipe 58	200	100	140	0.94	0.12	0.03	Open		Pipe 130	200	100	140	0.69	0.09	0.031	Open
Pipe 59	200	100	140	0.33	0.04	0.034	Open		Pipe 131	200	100	140	0.69	0.09	0.031	Open
Pipe 60	200	100	140	0.11	0.01	0.04	Open		Pipe 132	200	100	140	-0.1	0.01	0.041	Open
Pipe 61	200	100	140	-0.24	0.03	0.036	Open		Pipe 133	200	100	140	0.63	0.08	0.031	Open
Pipe 62	200	100	140	0.35	0.04	0.034	Open		Pipe 134	200	100	140	-0.11	0.01	0.04	Open
Pipe 63	200	100	140	-0.86	0.11	0.03	Open		Pipe 135	200	100	140	0.51	0.06	0.032	Open
Pipe 64	200	100	140	0.66	0.08	0.031	Open		Pipe 136	200	100	140	-1.41	0.18	0.028	Open
Pipe 65	200	100	140	-0.74	0.09	0.031	Open		Pipe 137	200	100	140	1	0.13	0.029	Open
Pipe 66	200	100	140	-0.79	0.1	0.03	Open		Pipe 138	200	100	140	-1.24	0.16	0.028	Open
Pipe 67	200	150	140	-1.55	0.09	0.029	Open		Pipe 139	200	150	140	4.64	0.26	0.025	Open
Pipe 68	200	100	140	0.9	0.11	0.03	Open		Pipe 140	200	100	140	0.53	0.07	0.032	Open
Pipe 69	200	50	140	0.19	0.09	0.034	Open		Pipe 3	200	100	140	0.23	0.03	0.036	Open
Pipe 70	200	100	140	0.36	0.05	0.034	Open		Pipe 141	200	150	140	0	0	0	Open
Pipe 71	200	200	140	9.57	0.3	0.024	Open		Pipe 142	200	150	140	0	0	0	Open
Pipe 72	200	150	140	4.82	0.27	0.025	Open		Pipe 143	200	150	140	0	0	0	Open
Pipe 73	200	150	140	4.31	0.24	0.026	Open		Pipe 144	200	150	140	30	1.7	0.019	Open
Pipe 74	200	150	140	1.81	0.1	0.029	Open		Pump 1	#N/A	#N/A	#N/A	49.48	0	0	Open
Pipe 75	200	100	140	0.93	0.12	0.03	Open		Pump 2	#N/A	#N/A	#N/A	84.59	0	0	Open

The velocity in pipe 53 is 1.87m/s the highest in any pipe but less than the 3m/s limit. The other fire scenarios checked did not give any higher velocities in the pipes.

Water storage

Distribution storage can be economically justified if it takes care of normal daily variation and provide needed reserve for fire protection and minor emergencies.

A tank should be constructed at an elevation that will supply peak demands at the minimum required pressure. In this case the tank will not be at an elevation capable of supplying the development at the required minimum pressure, therefore a booster pump was added to the water distribution network.

Table 5 Sizing of water storage tank

Water Storage				
30% day's supply and fire flow	1,099,664.87	Lpd	290,500.78	USgpd
One day's supply	3,302,078.43	Lpd	872,316.99	USgpd

The proposed tank size for the Whim and Brampton Developments is 1,845 m^3 or 500,000US gallons.

The tank was modelled with minimum level 0.75m and maximum level 7m. The well pump control was set to start the pump when the level in the tank fell below 3m of water and stop when the level in the tank was at 7m. The Diameter of the tank was taken to be 18.1m.

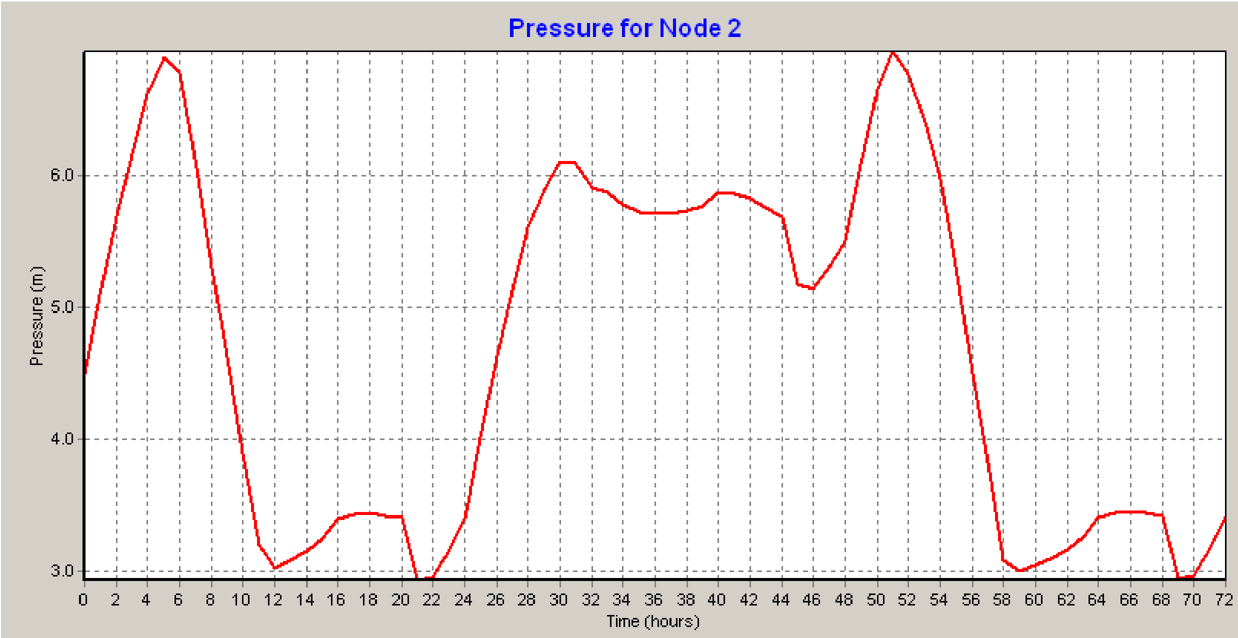


Figure 11 showing the variation in the tank for fire flow scenario.

The storage tank is adequately replenished by the well pump and there is a reserve of approximately 250m^3 which is more than the quantity needed to supply two streams from a hydrant for two hours.

Distribution Pumping

To achieve the minimum pressure on the distribution system a booster pump is proposed. For purposes of this report a single pump with duty point 45Lps flow and 25m head was used. The booster pumping station was simulated to satisfy peak day flows. The variation in flow and head resulting from this model should be carefully reviewed so that the eventual pump configuration will satisfy the range flows and pressures demanded by the network.

For the fire flows to be satisfied during the peak day demand the flow variation shown in Figure 12 was the result for a pump with duty point 80Lps at 50m head.

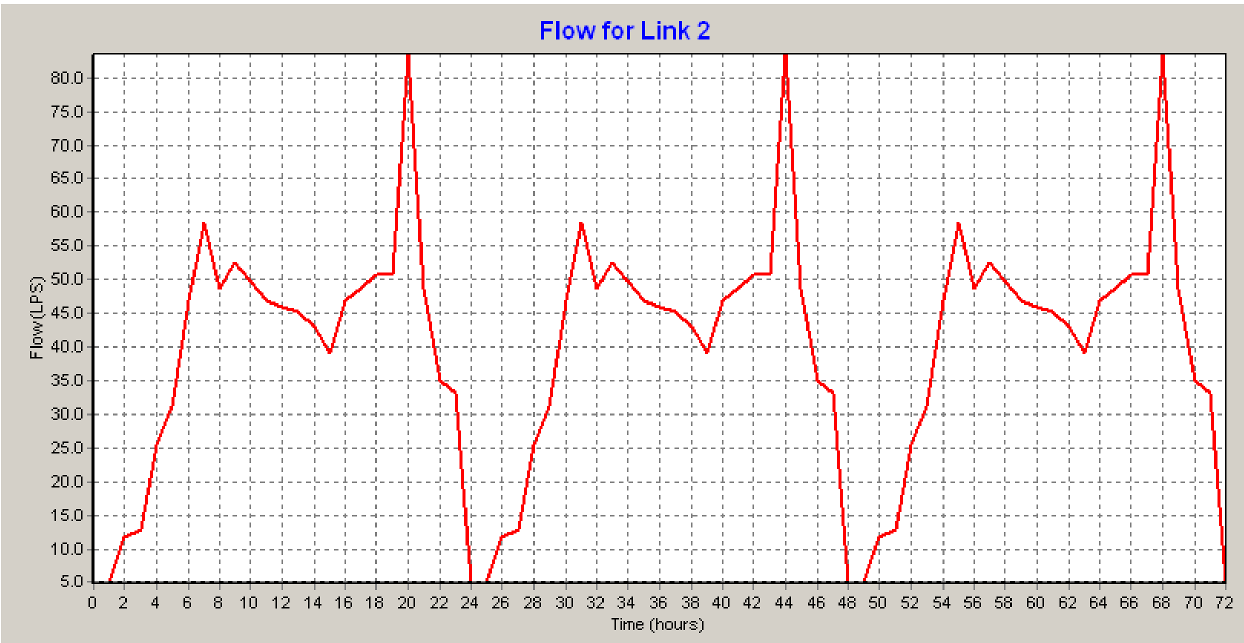


Figure 12 flow variation from distribution pump system to deliver fire flows and peak day demands.

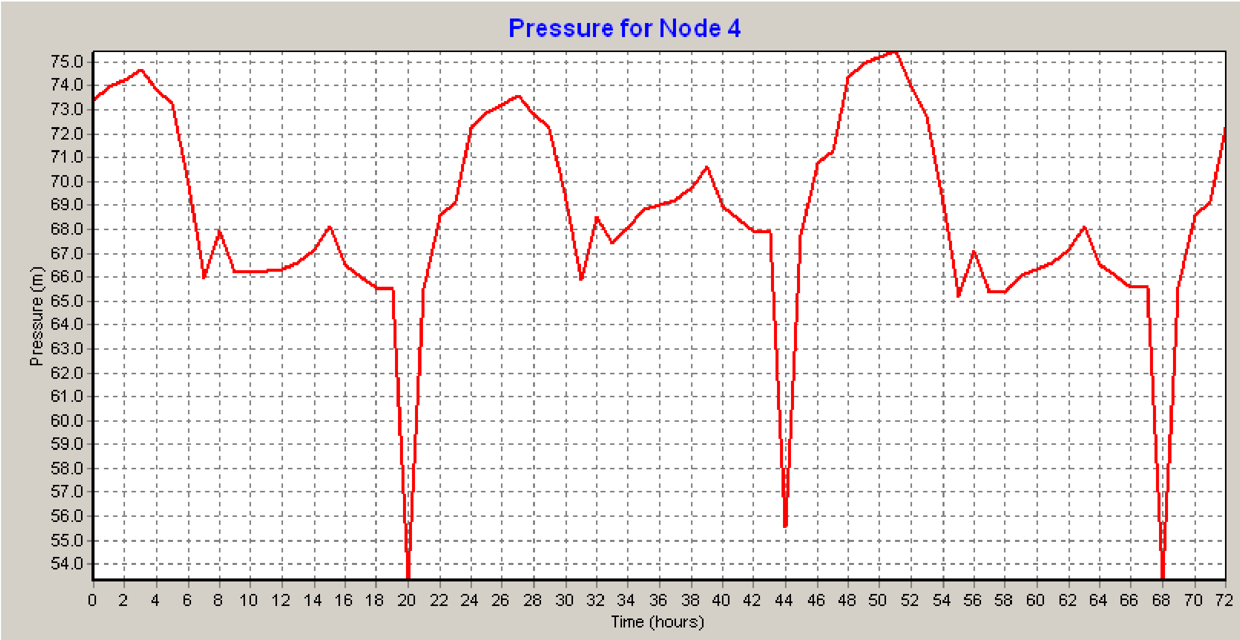


Figure 13 Pressure variations at node 4 the discharge end of the distribution pump to deliver fire flows and peak day demands.

Water piping

1. PVC pipe shall conform to JS 39: Part 2: 1987 **PVC plastic pipe SDR-PR. Part 2: Metric** criteria for classifying PVC plastic pipes and requirements and methods of test for material, workman-ship, dimensions and pressure ratings.

2. PVC pipe designs to conform to methods described in Uni-Bell Handbook of PVC Pipe: Design and Construction.

3. Installation of PVC pressure pipe to conform to AWWA Standard C605, Underground Installation of Polyvinyl Chloride (PVC) Pressure Pipe and Fittings for Water.

4. Ductile iron pipe shall be designed in accordance with the latest revision of ANSI/AWWA C150/A21.50 for a minimum 150 psi (or project requirements, which ever is greater) rated working pressure plus a 100 psi surge allowance (if anticipated surge pressures are other than 100 psi, the actual anticipated pressure should be used); a 2 to 1 factor of safety on the sum of working pressure plus surge pressure; Type laying condition and a depth of cover of feet.

Conclusion

The estimated water demand for the proposed development included anticipated losses is 3,302m^3/d. The Rodons well the source of water for the proposed development has a licensed capacity of 4,360 m^3/day. The proposed water source can amply supply the water demands for the proposed development. With additional storage and taking into account the actual water use per capita even more dwellings can be supplied by this system.

The water distribution pipe network presented in this report adequately provides a sustainable water scheme for the proposed developments.

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DATE: June 28, 2009