3 Civil Services

3.1 WATER SUPPLY

(1) Masterton

NETWORK DESCRIPTION

Extraction and treatment

The source of Masterton's urban water supply is the Waingawa River, whose catchment lies in the eastern Tararuas. Water extracted from the Waingawa River is by a siphon system, with a delivery main to the treatment plant that is seven kilometres long and 600 millimetres in diameter, constructed of rubber-ring-jointed concrete pipes (**Figures 3.1, 3.2 and 3.3.**). This section was constructed in 1971-72.

Figure 3.1. The Masterton water supply siphon intake is located in the pool in the foreground. Water is conveyed across the Waingawa River (Kaituna) in the middle distance.

Figure 3.2. Waingawa River at Kaituna and the siphon intake for the Masterton water supply.

Figure 3.3. Pipe bridge conveying water over the Waingawa River to the Masterton treatment ponds.

The treatment plant has three raw water ponds with a total capacity of 40,000 cubic metres, three filters, and a clear water storage pond with a capacity of 5,500 cubic metres (**Figure 3.4.**). These were built between 1970 and 1972. The main treatment facilities consist of a clarifier and two new filters with provision to add a further filter added in 1980-83. The treatment plant has the capacity to treat 36,000 cubic metres per day.

A standby generator capable of operating the treatment plant and a portable generator capable of operating the siphon is provided to cope with a power failure. The emergency standby power capacity is insufficient to operate the backwash pumps. The treatment plant is monitored by telemetry, with alarms to the duty operator.

The demand for water in the Masterton urban area is, on average, about 15,000 cubic metresper day. There is a maximum in the order of 30,000 cubic metres per day in summer, while the minimum is around 11,000 cubic metres per day in winter.

Figure 3.4. The Masterton water treatment plant at Upper Plain. The three water ponds are on the left of the picture and the clear water pond is in the foreground. The clarifier is in the middle of the picture and the filters and treatment plant building are above the clarifier.

Storage and mains

The 9000 cubic metres main reservoir for the town was constructed during the period 1980-82, 5 kilometres west of Masterton. It has reinforced concrete and pre-stressed panels.

This reservoir is fed by a 600 millimetre rubber ring-jointed concrete pipeline from the clear water storage ponds to a booster pump. It is then fed by a 450 millimetre gibault jointed concrete-lined steel pipeline from the booster pump to the main storage reservoir. This supply pipeline incorporates an on-line booster pump, and a by-pass is available. The pipeline has a capacity to convey 25,000 cubic metres per day from the clear water pond to the main storage reservoir under gravity. When the demand increases to over 25,000 cubic metres per day, the booster pump is operated to increase the supply.

From the reservoir, two 450 millimetre diameter concrete-lined steel pipes run to a manifold. From the manifold, a 250 millimetre cast-iron pipeline, a 300 millimetre riveted steel pipeline and a 450 millimetre concrete-lined steel pipeline convey water to the Ngaumutawa Road/Renall Street intersection, to supply the Masterton urban area. These three mains also interlink at Fernridge School and at the Ngaumutawa Road/Renall Street intersection. The 300 millimetre steel riveted pipeline was the original supply water main to the Masterton urban area laid in the late 1800s. A concrete-lined 300 millimetre steel pipeline runs from the Ngaumutawa Road/Renall Street intersection across the Waipoua River on the railway bridge to feed the 2250 cubic metre concrete reservoir constructed in 1962 on Titoki Street in Lansdowne. Two 250 cubic metre reservoirs were added in 1982. These were constructed with timber staves to provide high-level storage to feed the high-level zone of Lansdowne. A fully welded joint concrete-lined steel 450 millimetere diameter pipeline was laid in 1993 from Fernridge School across farm land to Westbush Road, linking into the supply line at Ngaumutawa Road to boost the supply to the south of the town.

Reticulation

The reticulation pipelines vary in diameter from 300 millimetres down to 40 millimetres on ridermains. The pipe materials include cast iron, steel, asbestos cement, PVC and polyethylene, with different types of joints such as lead-packed, rubber ring, gibaults and fusion. Ages range from the late 1800s up to the present day.

The service connections are a mix of lead, galvanised iron, copper and medium-density polyethylene. There is a very limited number of old connections in lead. Galvanised iron connections are common on mains older than 40 years while copper connections were typical between 1960 to 1980. Since the early 1980s, MDPE (medium density polyethylene) has been used, with pushlock fittings.

Information on the components of the network is broadly summarised in **Tables 3.1-3.3** below.

The predominant material is concrete-lined steel with unlined steel ranking second. To date, concrete-lined steel, cast iron, PVC and PE have a better maintenance record than asbestos cement and unlined steel pipelines.

In terms of pipe ductility, asbestos cement and cast iron pipes are considered more brittle, while steel, PVC and PE are considered more ductile. Within the more ductile pipes it is anticipated that polyethylene (PE), and steel with fully-welded joints will have a superior ductility under ground movement than gibault or rubber ring jointed pipes.

Diameter (mm)	Asbestos cement	Steel unlined	Steel conc-lined	Steel riveted	Cast iron	PVC	PE
40						1995	
50	2720				210	1865	
75		1290			685	380	65
100	14925	17745	8610		10540	11870	115
150	1830	9475	3215		5405	4885	
200			1850			4580	160
250		3040	5470		8055	1420	
300		950	6480	4665			
450			7770				
Totals (metres)	19475	32500	33395	4665	23895	26995	340

Table 3.1 Network components by diameter (mm), material and length (m).

Diameter (mm)	A/C lined	Steel unlined	Steel lined	Steel riveted	Cast iron	PVC	PE
-1910				4665			
1910-1919	220	830			6180		
1920-1929	3845	16935	2880		13020		
1930-1939	320	4495	2440		2365		
1940-1949	365	1957	120		360		
1950-1959	465	3425	5020		1770		
1960-1969	7214	4590	12300		200	3560	
1970-1979	7046	160	2320			450	
1980-1989			5815			5400	
1990-1999		108	2500			17485	340
Total (metres)	19475	32500	33395	4665	23895	26895	340

Table 3.2 Network components by year installed, material and length (m)

Diameter (mm)	Grade 1	Grade 2	Grade 3	Grade 4	Grade 5
450	2,675		5,095		
300		1,530	9,780	785	
250	2,230	1,850	11,590	2,315	
200	4,740	1,420	430		
150	2,980	5,730	9,840	5,260	
100	5,370	10,350	24,840	15,580	7,665
75	440		1,260	720	
50	1,350	1,240	3,445		
40			1,995		
Totals (metres)	19,785	20,880	68,275	24,660	7,665

Table 3.3. Network grading (metres of pipe) from Grade 1 (very good) to Grade 5 (very poor).

The condition grading of the pipelines, as determined in accordance with the protocol established by the NZ Infrastructure Asset Management Manual (1996), has been broken down by diameter and length in Table 3.3. The network grading ranges from 1 (very good) down to 5 (very poor). From the table the percentage by length of pipeline graded 1 and 2 is 27 percent, while the proportion by length of pipeline graded 4 and 5 is 14 percent. Where no information on the condition of pipelines exists, a grading of 3 is accorded.

VULNERABILITY ASSESSMENT

From the vulnerability chart of the Masterton Urban Water Supply, the following general comments are provided.

Intake pipe from river

This is seen as vulnerable to floods which bring down trees, which can damage the pipe intake. A seismic event could cause slipping of the rock face on which the pipeline is fixed, if the rock is fractured.

Vacuum system

There is a risk of the overhead power lines supplying the vacuum pumps being damaged in a severe wind storm as the site is in a gorge exposed to northwest winds.

Pipe bridge

This bridge over the Waingawa River supports the raw water pipeline which conveys water from the siphon to the raw water ponds. It is at a risk in the event of a flood because debris can build up behind an obstruction caused by floating trees. The hold-down mechanism of the bridge structure at the abutments needs analysis and possibly strengthening. The bridge is not well braced laterally.

Raw water pipeline

The 600 millimetre R R-jointed concrete raw water pipeline traverses river terraces along the left bank of the Waingawa River from the pipe bridge. In some places, the pipeline runs very close to the edge of the river bank which is susceptible to erosion. This makes the pipeline vulnerable to large flood events.

Raw water ponds

These are three earth embankment ponds which have leaks in the embankments. The embankments are vulnerable in the event of earthquake or settlement. Failure of the embankment could be catastrophic, due to erosion and the forces of floodwater on surrounding land and structures. There is also a risk that, during a seismic event, water sloshing in the raw water ponds could damage surrounding structures. In the supply of raw water to the treatment plant the ponds could be bypassed. This would lower its ranking, but the consequences of a failure on the surrounding structures could be catastrophic . In order to bypass the ponds, the bypass valve would need to be opened, and the valve on the drawoff line from pond 1 would have to be closed.

Clarifier

This may have some vulnerability to ground settlement, though it is of modern design. The clarifier can be bypassed in the treatment process.

Filters and treatment plant building

These are built to modern codes but may still have some vulnerability to ground settlement. The plant and filters can be bypassed with lesser treatment, i.e. with disinfection of water.

Clear water pond

This is an unlined pond in the surrounding land which stores the treated water before it is fed to the Upper Plain main storage reservoir. This structure is vulnerable to ground shaking causing sloshing. Ground settlement is a potential threat to the structure.

Sludge recovery system

This has low importance as the plant can function without this facility.

Pipeline from clear water pond to Upper Plain reservoir

This has high importance to the water supply. The section from the clearwater pond to the boost pump is rubber ring jointed concrete pipeline and from the boost pump to the Upper Plain reservoir is gibault-jointed concrete-lined steel pipeline. These sections are not considered vulnerable, except for one section, which has original laying defects causing deteriorating pipe walls.

Boost pump station

This is only needed in times of high water demand. It therefore has low importance as it can be bypassed. To bypass the pump involves opening and closing two valves in the pump chamber. These valves can be operated either by telemetry from the treatment plant or by manual override at the site. It is vulnerable to flooding from the Waingawa River or power supply failure in a wind storm.

Upper Plain reservoir

The reservoir can be bypassed. It is of modern design and construction and so is considered to have medium vulnerability to ground shaking and ground settlement. This structure is the main water storage for the town and the water in it is likely to be needed immediately after a significant earthquake.

Trunk mains from Upper Plain reservoir to town

These mains have a high importance, They are vulnerable to fault displacement and, to a lesser extent, to ground shaking, ground settlement and possible flood if the Waingawa River were to break out of its banks and flow towards the Waipoua River. (NB – a new stop bank has been erected to lessen this risk).

Lansdowne main

This is a steel main with gibault joints which is not considered especially vulnerable on its route. However, where it crosses the Waipoua river on the rail bridge, it is particularly vulnerable to both ground shaking and flood waters eroding the support at each end of the bridge.

Waipoua State Highway 2 crossing

An alternative supply to Lansdowne is a 150 millimetre steel pipe across the Waipoua River on the State Highway 2 road bridge. This is considered vulnerable to ground shaking and settlement, especially if the bridge suffers damage at either end.

Titoki Street reservoir

Compared with the Upper Plain reservoir, this concrete reservoir is of an older design and construction.

It could be vulnerable to ground shaking and ground settlement. It can be bypassed but all pipes pass through a chamber built into the walls of the reservoir, which may cause some difficulties in the event of a significant earthquake.

Manuka Street reservoirs

These are timber-staved reservoirs which can be isolated from the reticulation without problems, in times of low water demand. They are likely to be vulnerable to ground shaking.

Waingawa River crossing on State Highway 2 bridge.

This is a polyethylene main of recent construction feeding the Jukken Nissho Mill. It has a low importance because the Mill has an alternative source of water from a bore. It is considered to have medium-risk vulnerability from flood, ground settlement and ground shaking.

Telemetry

The telemetry has a relatively high importance because it is the main source of information on the status of the water supply – i.e. reservoir depths, plant operation etc. Its aerials are vulnerable to wind effects, and severe storms involving lightning strikes could possibly disrupt the electronics.

Reticulation mains

The reticulation mains are generally of lower importance because of their redundancy. Their vulnerability will vary depending on their construction and the soils they are laid in.

Impact of damage

The 'impact of damage' section of the vulnerability chart is an assessment of the impact in terms of disruption and resources in getting a particular component of the water supply functioning again. This may be either on a temporary basis and/or then to full functionality.

The main components where the damage impact is considered to be high are as follows:

Intake pipe

The intake pipe would be difficult to replace or repair because of the limited access and difficult nature of the site.

Pipe bridge

Damage to the pipe bridge is likely to be very significant for the whole structure, because considerable resources would be needed for repair or replacement.

Raw water pipeline

The raw water pipeline would require significant resources to repair and it would be important to get the line back into service as soon as possible.

Clear water pond

The clear water pond is an important component in the supply and would need repairing very soon after an event so as to provide clean backwashing water. However, it is feasible to backwash using the raw water ponds.

Pipeline from clear water pond to Upper Plain reservoir

This is an important pipeline and would require immediate repair to enable water to be delivered to town. There is no redundancy for this line.

Upper Plain reservoir

This can be bypassed, but it is the main water storage for the town and would require repairs in the event of damage. This would probably require specialist concrete engineers.

Trunk mains from Upper Plain

These are the main delivery pipelines to town. There are three mains. Two of them are very old and are made from cast iron and riveted steel. These would have to be replaced if they were badly damaged.

Reticulation mains

There would be a significant impact if the reticulation mains were badly damaged. Repairs over a long period by specialist crews would be needed to return the mains to normal.

Alternative supply

Alternative sources of potable water to the Masterton urban water supply include the small rural schemes situated outside of Masterton. Using these rural schemes to supply Masterton would require water tankers and/or the filling of water containers. The minimum water demand for Masterton – i.e. drinking and cooking for a population of 20,000 people at five litres per person per day, is 100,000 litres per day. There are two water tankers in the Wairarapa – one owned by McAuleys Transport with 12,800 litres capacity and the other by Pinfolds Transport with 10,000 litres capacity.

The Fernridge scheme is a supply 10 kilometres to the west of Masterton, which draws from a shallow well constructed in an old river channel on the Waingawa River. The delivery rate of the well pump is about three litres per second, via an 80 millimetre PVC main to a

95 cubic metre reservoir sited to the north of Upper Plain Road. This supply could yield 160,000 litres per day. It would be relatively quick to install a tee, a valve and a stand pipe on Upper Plain Road to fill the tankers. However, filling the tankers would be slow.

The Wainuioru scheme is a supply to the hill country east of Masterton. The bore is situated on Watsons Road and has resource consent to draw eight litres per second. This supply is another potential source of potable water for filling tankers or water containers in an emergency.

The Opaki Water Supply scheme supplies the rural area to the north of Masterton. Its well is situated on Willowpark Drive, adjacent to Rathkeale College. This is a shallow well in river gravels, approximately 400 metres from the Ruamahanga River. It is vulnerable to a one in 100 year flood event. The water from the well is pumped via a 110 millimetre diameter PVC pipe out to State Highway 2 and then to the north and south. Reservoirs are situated on a rise adjacent to the Mauriceville road corner and on the Lansdowne hill alongside the urban water supply timber stave reservoirs. There is an interconnection to enable the Opaki Scheme to be supplied from the urban supply in an emergency. The cross connection is too small to be of practical use for urban supply in an emergency. The Opaki scheme could supply tankers in an emergency.

These small schemes all depend on electricity for their operation and in the event of a power cut, they would require portable generators.

Masterton urban water supply has an emergency supply point approximately one kilometre from the intake, where the pipeline is close to the river. At this point there is an air break point with an access hatch for this purpose. There is a PTO-driven high-flow low-head pump with a canvas hose to pump water from the river into the pipeline. This pump is capable of delivering 400 litres per second.

In the event of the town being isolated from the water supply on Upper Plain, there is the possibility of making a connection into the water supply pipeline to Titoki Street reservoir, where it crosses the Waipoua River on the rail bridge. It would be feasible to pump into the line from the Waipoua River – thereby feeding Lansdowne – and to the three water mains supply line at the interconnection on Ngaumutawa Road and Renall Street corner – to feed all of the town. A pump for this purpose would need a capacity in the order of 70 litres per second.

Another point of potential connection would be at the southern end of the reticulation water pipelines at the Waingawa River bridge on State Highway 2.

MITIGATION MEASURES

All components with a low risk rating will be managed by routine procedures. Components with risk from moderate to extreme are specifically identified and the work planned for.

Intake pipe

The intake pipe is that section of steel pipe below the rock face on the riverbank which extends into the river to extract water. The rock face is fissured and a rock slide could potentially damage the pipe. A geotechnical assessment of the rock face would determine the degree of risk. Mitigation measures could include reinforcing the rock face with mesh and rock anchor bolts. The other moderate risk is damage from the impact of large logs on the pipe and entangling of the pipe with debris. Mitigation measures should include a structural assessment of the strength of the pipe and, if necessary, determine any strengthening. An assessment of the rock face and pipe vulnerability is estimated to cost $5,000.

Pipe bridge over the Waingawa River

There is a high risk of failure at the bridge abutments in a moderate to large seismic event. In very high floods, logs could catch on the structure and debris build-up could cause the bridge to fail. Mitigation measures should include a structural assessment and strengthening of the bridge. In the event that the bridge was damaged or destroyed, water could be pumped from the river into the main, at a point some 350 metres downstream of the bridge. The Council's portable low head high volume PTO driven pump would be used. The structural assessment and design modifications are estimated to cost $5,000.

Raw water pipeline

The raw water pipeline is a 600 millimetre rubber-ring-jointed concrete pipeline laid on the terraces alongside the river bank between the intake and the treatment plant. Some points on the pipeline route have experienced riverbank erosion, at a level that could threaten the pipeline's integrity.

The risks are considered moderate for both river erosion in flood events, and seismic events causing joint failure.

Mitigation measures should include an assessment of re-routing the pipeline beyond the river bank erosion zones. Alternatively, ongoing river training and bank protection works should be carried out to limit the risk of bank erosion.

To mitigate the risk of joint failure due to a seismic event in the siphon (vacuum) section of the pipeline, it will be necessary to assess its efficiency. It will also be necessary to assess future replacement options, particularly those using a more ductile material. Funding provision has been made for this study.

Raw water ponds

The raw water ponds are vulnerable to a seismic event – either from sloshing overflow or pond rupture. Pond No 1 is concrete lined while the other two are unlined. Pond No 1 is the least vulnerable, and is expected to be the last to fail. The mitigation measure for the raw water ponds is to bypass the ponds.

The in-ground clear water pond is the most vulnerable structure in the event of a raw water pond failure. The other structures, such as filters, the treatment plant building and clarifier, are concrete and considered to be sufficiently robust to withstand sloshing overflow from the ponds. Mitigation measures include the planned replacement of the in-ground clear water pond with a reservoir. The reservoir will be sited clear of any impact from possible failure of the raw water pond.

Clear water pond

Council is planning to replace this structure and the design of a replacement reservoir will take hazard vulnerability into account.

Pipeline from clear water pond to Upper Plain reservoir

This pipeline is at risk from earthquake damage. The section of the pipeline from the clear water pond to the boost pump is made from rubber ring jointed reinforced concrete. The section from the boost pump to the reservoir is gibault jointed steel and may have been damaged during the construction period in some sections, losing strength in the pipe walls. The 2000/2001 annual plan included funding for an efficiency review of this line, and to identify mitigation measures with respect to its seismic resistance.

Trunk mains from Upper Plain reservoir to Masterton

The three mains were laid between the late 1800s and the 1960s. They cross the Mokonui Fault on Upper Plain Road. Mitigation measures will include ensuring that future replacement pipelines have a high degree of ductility.

Lansdowne main and Waipoua rail bridge crossing

The Lansdowne main is seen as a point of extreme risk where it crosses the Waipoua River on the rail bridge. This is due to its age and detailing of the transition from the ground onto the bridge structure. The pipeline has been disrupted in previous floods, due to erosion of its supporting bank. Subsequent bank protection work has lessened the risk of further erosion. Mitigation measures will include modifying the pipeline to a structurally sound condition. The structural assessment is estimated to cost $2,000.

Landsdowne reservoirs - Manuka Street and Titoki Street

The Titoki Street reservoir is a concrete structure which requires a structural assessment to ascertain its seismic resistance. The assessment should include the embedded pipe fittings at the inlet and outlet pipes on the concrete structure. The two lined timber staved Manuka Street reservoirs also require a structural assessment to determine their seismic resistance. A structural review of the three reservoirs is estimated to cost $3,000.

Reticulation mains

The interconnection of the reticulation pipeline makes the network less vulnerable to damage. Mitigation measures should include regular checking to ensure valves are functioning in good condition. The latest maintenance contract covers this, as a scheduled item of work. As maintenance work is carried out, opportunity is being taken to install additional valves, which can be used to isolate areas and limit the spread of potential damage. As reticulation pipelines are scheduled for replacement, the design will consider, as an important factor, the use of pipe materials which have high ductile properties – such as medium density polyethylene pipes.

The main mitigation work yet to be carried out consists of more detailed assessments by specialists, of various components of the infrastructure. Individually, these items are estimated to cost around $22,000.

(2) Carterton

NETWORK DESCRIPTION

Extraction and pre-treatment

Carterton's urban water supply is sourced from two locations. The primary source is Kaipatangata Stream in the Tararua Ranges (**Figure 3.5**). Additional water is obtained from two bores in the southwest part of Carterton.

The water is extracted from the Kaipatangata Stream by an assortment of intakes as listed below:

- 900 millimetre diameter vertical pipe feeding into a 380 millimetre perforated polyethylene pipe running approximately 30 metres downstream under the stream bed.

Figure 3.5 An impoundment dam on the Kaipatangata Stream forms one of the collection points for Carterton's water supply.

- 1050 millimetre manhole feeding 380 millimetre perforated steel pipe running approximately 10 metres across the stream under the bed.
- Approximately 10 metres of 380 millimetre perforated PVC pipe in a concrete channel at the foot of a concrete weir.

These intakes feed into a common 380 millimetre asbestos cement line which runs 250 metres to a coarse screen chamber.

A 350 cubic metre dam is positioned downstream of the intakes described above. This is filled by way of surface flow during the winter months, and maintained by underground flow during the summer months. A rose type intake is positioned at a still corner of this dam to supplement the water collected from the intakes during low summer flows. This feeds into a 380 millimetre asbestos pipe which runs 80 metres to the same screen chamber that is fed by the stream intake lines.

The coarse screen chamber has two stainless steel screens, which operate in parallel. These can be individually isolated for cleaning. These screens remove leaves and other debris using a four square millimetre mesh.

Treatment

Primary

A 380 millimetre asbestos pipeline runs 1500 metres from the screen chambers to a filtration plant. This consists of three multi-layer sand filters operating in parallel, feeding four 3.0 micron bag filter units which then discharge to a 500 cubic metre concrete reservoir. The water is dosed with a lime solution at the inlet to the filtration plant for pH control, and chlorine at the entrance to the reservoir for disinfection. The plant is automatically operated by a PLC, which relays information to Council officers by way of a radio telemetry system.

Alternative

The bores in the Carterton township are used to supply water during periods of plant shutdown at Kaipatangata, and to supplement supplies during periods of high summer demand. These operations are automatic and controlled by the telemetry system, in conjunction with information from the Kaipatangata plant. Water is pumped from the bores in parallel via caustic and liquid chlorine dosing into a 30 cubic metre reservoir. From there, the water is pumped into the town mains by way of a single electric centrifugal pump.

The average daily demand on the Carterton water supply is 3,800 cubic metres in summer, and 2,300 cubic metres in winter.

Reticulation

Water is transported to town by gravity from the Kaipatangata plant through a 380 millimetre asbestos cement pipe. The pipeline is approximately seven kilometres long. Where the pipe crosses streams it comprises concrete-lined steel pipe. This pipe joins a 200 millimetre line which runs 850 metres from the bores on the western side of town to feed the town mains.

The pipe sizes in the town range from 100 millimetres to 200 millimetres with asbestos cement being the predominant type. Other materials used in the town are concrete lined steel, cast iron, uPVC, and LDPE. There is a total of 46 kilometres of water pipes in the Carterton supply. The materials and lengths are summarised in **Table 3.4**.

The service connections are a mixture of galvanised iron, copper, LDPE, MDPE, and uPVC. The galvanised iron connections are common on mains installed before 1960. Copper is the predominate material on mains installed between 1960 and the late 1970s. Following this period, a mixture of LDPE and

Material	Size (mm)	Length (m)	Expected life	Date installed	Average age (years)
Concrete lined steel	380	260	70	1950	51
Cast Iron	40 – 150	6,390	70	1940	61
Asbestos cement	50 – 380	30,100	70	1950 – 1980	38
UPVC	19 – 200	9,200	80	1980 – 2000	9
LDPE	40	100	55	1960	41
Total		**46,050**			

Table 3.4. Carterton water supply network.

uPVC pipes were used. All connections made today use MDPE pipe.

VULNERABILITY ASSESSMENT

From the vulnerability chart of the Carterton urban water supply, the following general comments are provided.

Weirs and intakes

Weirs and intakes in the Kaipatangata stream are vulnerable to earthquakes, floods, and landslides. All of these could result in the intakes being blocked or broken and no longer able to supply water to the filtration plant.

Dam

The dam could be ruptured by a major earthquake or filled with gravel by a landslide or major flood. Should the dam suffer a sudden failure, the resulting flash flood could wash out the access road to both the dam and a local lookout point. Such a flood could threaten the filtration plant and reservoir, which are adjacent to the bank of the Kaipatangata Stream, approximately 1.6 kilometres downstream of the dam crest.

Intake pipeline

The intake pipeline could be washed out by a flash flood as it follows the course of the stream to the filtration plant. The pipe is also at risk from seismic events.

Filtration plant

The filtration plant is housed in a modern structure built to current standards and is unlikely to be damaged by earthquake. The plant is mostly fixed to the concrete foundations and would move as one, minimising damage. The chlorine is stored in a one tonne cylinder, which could fall off its mounting trolley, leading to a chlorine gas leak.

Power supply

In a sustained power outage, the plant could not supply water at its rated capacity. It would be unable to backwash the main filters. However, it would be able to operate, albeit at a reduced capacity.

Treated-water reservoir

A major earthquake could effect the reservoir resulting in the loss of treated-water storage capacity.

Supply main to town

This vital main would be very prone to failure in large earthquakes, due to the inflexible nature of the pipe material. Sections of the main are exposed at stream crossings where they are attached to the downstream sides of bridges. The main is vulnerable to flooding events large enough to threaten the bridges.

Supplementary supply bores

There is some risk from earthquake-related activity affecting the supply of water from the bores. There is minimal risk from other hazards. The delivery mains to the plant are PVC and are subject to similar levels of risk. The bore pumps are well secured to the top of the bores by the rising main pipes, which are galvanised iron. They are likely to survive anything but severe ground movement.

Supplementary reservoir

The reservoir is a timber stave reservoir cabled together, with a rubber liner. This is likely to be vulnerable to ground shaking.

Supplementary plant

This plant is constructed in accordance with modern building practice and should survive all but catastrophic ground shaking. There are minimal treatment processes, and the water should be relatively safe to supply without treatment in case of emergency as it is sourced from a secure aquifer. This would obviously necessitate monitoring following a major earthquake, to ensure the integrity of the bores was not compromised.

Supplementary power supply

There is no redundant power supply at the supplementary plant, and in the event of a major outage a generator would be required. The plant needs modifying to allow a generator supply to be connected. An upgrade is programmed to be completed by August 2002.

Water mains

These are of lower importance as there are alternative ways of supplying the water. Vulnerability varies depending on the material and the ground conditions in which they are laid.

Impact of damage

Impact of damage is considered high for the following components:

- Intakes and weirs, dam, and intake pipeline. These would require major works to restore supply in the event of failure.
- Filtration plant. The plant is relatively simple and major components are unlikely to be seriously damaged. It is likely that the pipework within the shed would need replacing, but council staff could carry out this work.
- Kaipatangata power supply. If lost the plant could only operate for a few hours and a generator would be required.
- Kaipatangata reservoir. This can be bypassed in the event of failure and is not critical to the operation of the supply.
- Trunk mains. If lost these would require substantial work to restore. This would be a lower priority due to the proximity of the supplementary supply to town.
- Supplementary plant and bores. Depending on the extent of damage, these could be repaired to the stage of supplying standpipe water relatively quickly.
- Supplementary power supply. This plant requires power to extract water from the bores and to pressurise the reticulation. The supply stops immediately on loss of power. A generator truck from Oldfield Asphalts Ltd is usually less than four hours away, and two trucks are available.

Alternative sources of water

There are several alternatives for supply to Carterton. Minimum drinking and cooking water demand for Carterton is 22,500 litres per day. This is based on a population of 4500 requiring five litres per person per day.

The set-up of the water network provides redundancy by way of two separate plants in the first instance. Should one plant fail, the other plant could supply the full needs of the town. The plant with the lowest yield is the supplementary plant, which is capable of sustaining 144 cubic metres per hour, which would meet all but the peak summer demands of Carterton. Should both of these plants be unavailable, the first alternative would be to look to either the Masterton or the Greytown water supplies for treated water.

If neither of those supplies could provide suitable water, the Council would consider the possibilities of using water from either of the Carterton sources. The Kaipatangata water could be pumped directly into a tanker from the dam or the stream, and the supplementary water could be pumped out of either of the two bores. This water could then be chlorinated either by hand dosing hypochlorite from the supplementary plant, or using the 70 kilogram backup cylinder of gas chlorine from the Kaipatangata plant.

A bore was recently sunk to supply the small rural community of Gladstone. The bore is capable of supplying 144,000 litres per day and has not yet been tapped into. A pump for this operation could be sourced either from the supplementary supply, or from a local merchant. Most merchants carry pumps capable of supplying the minimum water demand of 22,500 litres per day (0.2 litres per second at 10 metre head). Either of the chlorinating methods mentioned above could be applied to this water source if required.

There are several suitable tankers available in the Wairarapa which could be called on in an emergency. The Council owns a 2000 litre tank which can be fitted to one of their trucks at short notice.

In addition, several alternative water sources are available, as outlined in the South Wairarapa and Masterton sections of this report. As well as these, there are numerous privately owned bores near the town, and several small stream catchments which supply relatively high quality water. It is very unlikely that individual items of plant from the Kaipatangata supply would be damaged. If they were unable to work as a complete system, elements of the system could be set up relatively quickly to provide individual unit processes (such as micro-filtration), thus providing a very safe emergency supply.

MITIGATION MEASURES

Although specific components of the Carterton water supply network could be damaged by earthquakes, severe storms, and flooding, it likely that the Council will be able to provide for the basic water needs of the community. The size of this community and the availability of resources would make it relatively easy to improvise in such events.

Specific mitigation measures identified for assessment are:

- Installation of a drain at the Kaipatangata water treatment plant to allow water to escape from the plant quickly in the event of a pipe burst, thus minimising damage to instrumentation and electronics.

- Securing the one tonne chlorine cylinder against ground shaking to prevent chlorine gas leaks.
- Progressive upgrading of the creek crossings on the trunk main, with underground polyethylene pipes. This will avoid the possibility of washout by flooding and provide greater ductility, thus minimising damage from ground shaking.
- Upgrading PLC programming on the telemetry network to include logic. This will isolate failed components within the network.
- Purchase of a standby generator to be based at the supplementary plant. It could be mounted on a sledge to enable it to be transported to the Kaipatangata plant should the need arise.
- Immediate modifications to the wiring of both treatment plants to allow Oldfield Asphalts' portable generators to be connected if required.
- Replacement of rigid riser pipes to the bores at the supplementary plant with polyethylene, to minimise ground shaking damage.
- Completion of the upgrading of information systems computerised maps, to include all reticulation.
- Installation and operating of a dynamic reticulation network model to determine the best routes for water delivery in case of section failures.

(3) Greytown and Featherston

NETWORK DESCRIPTION

Intake storage and treatment

The water supply originates from the Waiohine River, which flows from a large bush-clad catchment in the Tararua Ranges. An existing diversion channel, forming the inlet of the Moroa water race, is located adjacent to the Waiohine River, and diverts water for rural stock water supply. The Greytown water supply is extracted from this channel by two Allis-Chalmers centrifugal pumps. These pump the water at up to 180 litres per second through a 300 millimetre mPVC pipe, to two raw water ponds on a terrace, 25-30 metres above the river (**Figure 3.6**). The two 18,250 cubic metre ponds receive raw water and operate in series. These ponds provide approximately three to four days of storage. From the ponds, two KSB Ajax centrifugal pumps feed raw water to an ultra-filtration plant which processes up to 7,000 cubic metres per day (**Figure 3.7**). Permeate water is chlorinated and stored in a 750 cubic metre timber tank.

Figure 3.6 Waiohine River intake to Moroa water race and Greytown/Featherston water supply. The filtration plant and storage ponds are sited to the west of the Wairarapa Fault.

Figure 3.7. Waiohine River intake pumps for the Greytown/Featherston water supply.

Reticulation

Water flows from the timber tank to both Greytown and Featherston. Water from Greytown is stored in a 700 cubic metre concrete tank, from which it gravitates through a 300 millimetre asbestos cement pipe to Greytown, approximately 6.5 to 7 kilometres away. Water for Featherston gravitates through a 300 millimetre PVC main and links in with the Taits Creek main approximately four kilometres away.

Greytown

The Greytown urban reticulation consists of a 20 kilometre pipe varying in size from 50 millimetres to 150 millimetres. Pipe material is predominantly asbestos cement, though an increasing amount of uPVC has been laid in recent times. A quantity of fibrolite, steel and alkathene pipe has also been used. A 150 millimetre mains feeder has been laid through the centre of town.

Some areas of Greytown suffer from pressure and flow fluctuations. However, pressures are predominantly in the range of 500 to 600 kPa while flows are in the range of 16 to 41 litres per second. The average daily water demand is estimated at 2000 cubic metres per day, with a peak of 3000 cubic metres per day.

Water gravitates approximately 1,200 metres from the holding reservoir to Featherston, through a 200 millimetre asbestos cement pipe. The urban reticulation consists of 26.2 kilometres of pipe, mostly of 100 millimetre and 150 millimetre diameter. Featherston has a mixture of asbestos-cement, concrete lined steel, fibrolite and reinforced concrete pipe.

The central part of Featherston is serviced by a ring main of 150 millimetre and 200 millimetre pipe. Pressure and flow distribution is relatively even, with few areas suffering from fluctuations as a result of undersized pipes. The average daily demand is estimated to be 2,500 cubic metres per day with a peak of 3,600 cubic metres per day.

VULNERABILITY ASSESSMENT

Component segment vulnerability

The Moroa water race intake and race are sited on a river berm at the base of a cliff. Should the cliff face slip due to an earthquake, the water supply would be cut off. The pump house and associated pumps/control gear are sited at or about the 20 year flood level and therefore have an associated level of risk.

Severe storm conditions would also interfere with telemetry control and supply of power to the site. The 300 millimetre AC gravity main to town is vulnerable at various points to seismic events.

The reticulation mains generally have a lower importance in terms of damage. AC or ‘fibrolite’ mains will, however, be vulnerable by nature of the pipe material and age. The ultra-filtration plant is generally not regarded as a significant risk except for some component damage during an earthquake.

The supply main which crosses the Tauherenikau River is vulnerable to both earthquake and flood events. The river is degrading and the pipe crossing is becoming increasingly vulnerable to flood damage.

The Greytown-Featherston treated-water main not only crosses the Wairarapa Fault near the ultra-filtration plant but also runs parallel with the fault, only 200 metres away. When it crosses the fault the pipeline is designed to absorb a certain amount of differential movement.

The treated-water main to Featherston follows a vehicle access track formed into the hill above the stream. This will be vulnerable to ground shaking, fault displacement and landslide.

There are signs that some of the fibrolite reticulation mains would now be sensitive to ground shaking.

Impact of damage

Both the river intake and the section of the stock water race to the pump house would require extensive work using earthmoving machinery. Access would be reasonable and temporary direct pumping from the river could cover any delays in reinstatement of the normal water supply.

The rising main to the ponds may require immediate repairs following an earthquake. Impact of damage would extend to the period following an event. There could be some associated difficulties in undertaking permanent repairs but these should not affect the community as interim arrangements for a temporary rising main could be made.

Both the concrete and timber contact tanks could be bypassed in the period following an earthquake. Concrete and timber construction/repair specialists could be needed. During the period these tanks were unuseable, it would be difficult to manage a treated supply to Greytown.

Greytown supply

The gravity main to Greytown is a critical component. Following an earthquake, sections of the line could be completely missing. Damage to other sections of the main might not be obvious. Most of the available resources would need to be directed towards restoring this main.

Parts of the reticulation would have high impact following a seismic event and their repair could take considerable time. While this would be critical in terms of returning the main to normal operation, alternative sources of reticulated supply would be available to customers.

Featherston supply

The Taits Creek line would require work in a number of places and access to the main would be difficult.

The extent of damage and repairs to the Tauherenikau

River crossing would be difficult to assess and undertake. River water levels would have to be low enough to permit repairs.

Alternative sources

Greytown

Until 1994, the Greytown ponds could be supplied from an intake on Bassetts Creek, approximately 1,600 metres away. This source was abandoned as the cost of repairs to the intake and main were prohibitive. The Waiohine River flows past the town, approximately two kilometres to the northwest. There are a number of access routes to this source. The Moroa water race system, from which the main extraction occurs at Woodside, has a number of branches passing through the urban area of Greytown. Water could be extracted at individual properties through which the races flow, or at road crossings where vehicle access should be unhindered. A number of private wells exist in and about the urban zone. These are for individual and private irrigation purposes. Taits Creek and Boar Bush Gully are also able to supply water to Greytown via the new Greytown/Featherston water main.

Featherston

The previously mentioned supply catchments of Boar Bush Gully and Taits Creek are retained for emergency supply purposes. They are described in Section (4). A number of large irrigation bores are operating on dairy farms close to Featherston. The Tauherenikau River is also potentially available and is located approximately 3.5 kilometres to the east of the town.

(4) Featherston emergency supply

NETWORK DESCRIPTION

Intake storage and treatment

Featherston and Greytown have three sources of raw water. Under normal situations, both communities are fed with water from the Greytown ultra-filtration plant. Two further sources are available for use under emergency conditions. The two emergency supplies are described below. The emergency supplies can supply both Greytown and Featherston.

The Boar Bush Stream catchment area of three square kilometres is located approximately one kilometre northwest of Featherston, within the Tararua Forest Park (**Figure 3.8**). The catchment area is largely in native vegetation or regenerating bush. It feeds a dam, built around 1965, which has a capacity of 80,000 cubic metres when full, an area of two hectares, and a maximum depth of seven metres. Raw water from the dam is conveyed approximately 870 metres to the treatment facility via a main consisting of a 250 millimetre concrete lined steel and 250 millimetre class B asbestos cement pipe.

Figure 3.8. Boar Bush Gully dam supplying Featherston water.

The Taits Creek system was installed around 1976 and consists of a stream intake with a weir. Raw water from both sources enters the Boar Bush treatment facility by a gravity-fed 300 millimetre concrete-lined steel (externally coated with fibreglass) pipeline 8.6 kilometres long.

Flows are controlled by a Clayton valve and pass into an 81 cubic metre reservoir, where chlorination and mixing occurs. The treated water then flows into a 455 cubic metre holding reservoir.

VULNERABILITY ASSESSMENT

Component/segment vulnerability

Taits Creek Intake and main (intake to river) are sited in a steeply graded and bush clad catchment. There is a risk of damage due to ground shaking but more importantly the supply is highly vulnerable to landslide and flooding. The supply main is supported on pedestals in places and is likely to be damaged from falling trees due to high winds.

The treatment plant and auxiliary equipment will be exposed to effects of ground shaking, landslide and storm effects. This facility is located on a narrow plateau above Boar Bush Stream.

Impact of damage

Taits Creek line would require work in a number of places, and access to the main would be difficult. The extent of damage and repairs to the Tauherenikau River crossing would be difficult to assess and undertake.

Water levels in the river would need to be at a level to permit repairs. Access to the headworks and water mains at Boar Bush could be limited following an earthquake. It could be some time after an event before the full extent of damage would be known and repairs could be made. Failure of a number of the reticulation mains would disrupt consumer supply for a reasonable period following an earthquake.

(5) Martinborough

NETWORK DESCRIPTION

Intake storage and treatment

The Martinborough town water supply comes from two sources. The principal source of water is the groundwater aquifer in the vicinity of the Ruamahanga River. Water is pumped from two bores by submersible pumps at a rate of up to 75 litres per second, and sent approximately 1,400 metres to Martinborough via 200 millimetre and 300 millimetre PVC mains. Any water surplus to demand is stored in twin 850 cubic metre concrete and 920 cubic metre timber reservoirs approximately 40 metres above and on the eastern side of town. When pumping is not occurring, water from the reservoirs gravitates back through the same pumping main to Martinborough via a 250 millimetre asbestos cement main.

The Huangarua River provides a supplementary or emergency source of water for Martinborough. A 30 metre diversion channel takes water from the Huangarua River to a wet well. Water is then pumped approximately 1,100 metres via a 150 millimetre steel main to reservoirs 30 metres above the site.

Reticulation

The urban reticulation consists of 29.8 kilometres of pipe, mostly 100 millimetres and 150 millimetres in size. A 150 millimetre asbestos-cement ring-main surrounds the residential area of Martinborough. The supply serves the urban area of Martinborough and the immediate rural fringe areas. It is estimated that 20-25 percent of peak flow rate is used for non-domestic purposes – mainly irrigation. The average daily demand is estimated to be 1,500 cubic metres per day, with a peak flow of 3,000 cubic metres per day.

VULNERABILITY ASSESSMENT

Component/segment vulnerability

The Huangarua supply and rising main are influenced by the Huangarua Fault. The siting of the pumphouse also means that the pumps are susceptible to damage during a flood. As Huangarua is not a preferred supply, this is of lesser importance.

The Herricks supply is sited in the middle of an intensive dairy farming region. Various factors make this primary supply extremely vulnerable. They include ground shaking, liquefaction and ground settlement. The supply point is on the main floodplain and is also sufficiently exposed so that the power supply and telemetry control will be vulnerable to wind effects.

The Martinborough storage facility and rising/gravity main to the east of town is vulnerable to ground shaking. The power supply and telemetry control will also be vulnerable to wind effects. The new timber tank is particularly vulnerable to ground shaking due to the nature of its construction.

The reticulation system is of uPVC and AC pipe of high standard. The vulnerability ratings are the same as for Greytown and Featherston.

Impact of damage

The Herricks supply, including the source and rising mains, is critical. The bores may require re-drilling and development, while the rising mains may require local repairs. Substantial resources to make physical repairs could be needed for some time after an earthquake. Health problems could follow flooding and potential groundwater contamination.

The Martinborough storage facility could become critical to the town's water supply, depending on the degree of damage to Herricks. Any damage suffered to the reservoirs following an earthquake would be immediately obvious, and resources could be allocated. If the reservoirs and rising/gravity main still operated and sufficient storage existed, severe usage restrictions would be needed to continue limited supply until other system components were repaired.

Damage to the Huangarua supply wold only be critical if other sources were down for extended periods.

MITIGATION MEASURES

Alternative sources

Private irrigation bores exist along the Ruamahanga Flood Plain. The Ruamahanga River is the major surface water source within the Wairarapa. The river is one to two kilometres from the town, and has numerous access points. The Huangarua River flows into the Ruamahanga River just northeast of Martinborough. Two major roads cross the river at about one kilometre and 3.5 kilometres from the town.

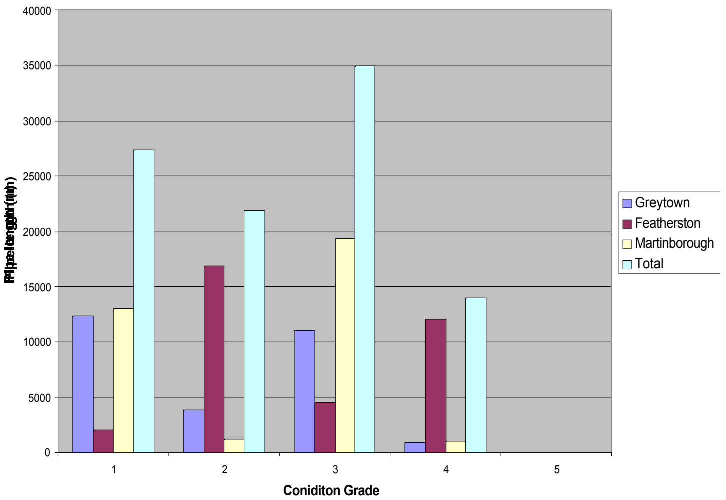

Figure 3.9. Summary of pipe condition for the water supplies of the south Wairarapa towns of Greytown, Featherston and Martinborough. (See Table 3.3. for an explanation of the grades)

3.2 SEWER SYSTEM

(1) Masterton

NETWORK DESCRIPTION

The Masterton urban sewer system can be broadly divided into the sewerline network and the treatment plant. The sewerlines are the major component of the system. The sewerline network can be further subdivided into trunk, arterial, collector, rider collectors and laterals. The functions of the collector and the arterial sewerlines are almost similar and so they are discussed together. However, in the Masterton urban sewer system, the quantity of rider collector sewerlines is small and is accounted for under collector and arterial sewerlines.

Trunk sewers

The trunk sewer mains have pipe diameter sizes varying from 225 millimetres to 838 millimetres and are of either earthenware or reinforced concrete materials. The trunk sewerlines are gravity operated. A siphon is constructed to cross the Waipoua River on the Colombo Road Bridge. There are eight trunk sewerline sections identified in the system:

Bentley Street to Colombo Road

This section of the trunk sewerline comprises 300 millimetre and 380 millimetre diameter reinforced concrete with rubber ring joints. The 300 millimetre sewerline takes off from the west end of Bentley Street, runs to a manhole about 200 metres down-stream on this line after the bridge on SH2 over the Waipoua River. From here the 380 millimetre sewerline takes off to link with the River Road trunk sewerline down-stream of the siphon. The line serves the area north of

(A)
Summary of pipe sizes

Size (mm)	Greytown	Featherston	Martinborough	Subtotal
<50, Unknown	511	3,422	2,422	6,355
50	506	1,074	2,337	3,917
75	2,025	20	552	2,597
100	11,998	17,391	17,544	4,6933
150	2,188	2,572	6,286	1,1046
200	0	1,299	1,345	2,644
225	0	1,140	0	1,140
250	0	0	2,710	2,710
300	10,827	8,626	1,390	20,843
Subtotal	28,055	35,544	34,586	98,185

(B)
Summary of pipe type

Pipe material	Greytown	Featherston	Martinborough	Subtotal
Unknown	0	0	0	0
AC	12,771	6,849	18,322	37,943
ALK	623	2,962	1,180	4,765
FIB	1,820	5,109	0	6,929
STEEL	0	125	1,125	1,250
UPVC	12,331	1,647	13,004	26,982
CLS	0	13,910	0	13,910
CU	0	222	739	961
GALV	510	811	216	1,537
POLY	0	412	0	412
RC	0	3,497	0	3,497
Subtotal	28,055	35,544	34,586	98,185

(C)
Summary of pipe age

Age	Greytown	Featherston	Martinborough	Subtotal
Unknown	0	0	0	0
0 to 10	5,969	1,817	4,846	12,632
11 to 20	7,656	16,523	124	24,303
21 to 30	7,886	16,476	0	24,362
31 to 40	4,366	218	28,595	33,179
41 to 50	420	510	1,021	1,951
51 to 60	1,101	0	0	1,101
61 to 70	0	0	0	0
71 to 80	0	0	0	0
81 to 90	657	0	0	657
Subtotal	28,055	35,544	34,586	98,185

(D)
Summary of pipe condition

Condition grade	Greytown	Featherston	Martinborough	Subtotal
1	12,331	2,059	13,004	27,394
2	3,816	16,872	1,180	21,868
3	11,013	4,530	19,381	34,924
4	895	12,083	1,021	13,999
5	0	0	0	0
Subtotal	28,055	35,544	34,586	98,185

Table 3.5 a-d. Summary of pipe size, type, age and condition for the water supply of the South Wairarapa towns of Greytown, Featherston and Martinborough. The above data is provided from the SWDC asset register system and has not been subject to complete quality assurance procedures. The information should be regarded as indicative only. Lengths are in metres.

Bentley Street, a portion west of the railway line and a section on the north end of Dixon Street.

Roberts Road - Te Ore Ore Road-Colombo Road to siphon

This section of the trunk sewerline is reinforced concrete with rubber ring joints in three pipe sizes: 225, 300 and 375 millimetres. The 225 millimetre sewerline begins at Roberts Road and runs to Te Ore Ore Road/Colombo Road corner, from where the 300 millimetre diameter sewerline runs for a further 185 metres, increasing to 375 millimetres by the time it reaches the siphon. This line serves the eastern area of Lansdowne. The Blair Street to Colombo Road trunk line joins into this line up-stream of the siphon.

Blair Street to Colombo Road

This section of the trunk sewerline is a 225 millimetre diameter reinforced concrete pipe with rubber ring joints. It begins at Te Ore Ore Road and continues through Blair Street to link with Colombo Road. The line serves the western area of Lansdowne and the hospital complex.

River Road from siphon to Johnstone Street

This section of the trunk sewerline is a 450 millimetre reinforced concrete pipe with rubber ring joints. This line collects the sewer from the Bentley Street sewerline and the siphon on Colombo Road by the Waipoua River and runs to the Johnstone Street trunk sewerline.

Makora to Nursery Road

This section of the trunk sewerline is a reinforced concrete 380 millimetre pipe with rubber ring joints. It begins at Makora Road and links to the Johnston Street trunk sewerline at the intersection of Nursery Road. This line serves the area north of Herbert Street and south of Worksop Road and Cornwall Street.

Makora/Kuripuni St Corner – Homebush

This section of the trunk sewerline is a 380 millimetre reinforced concrete pipe with rubber ring joints. It begins at the Makora Road/Kuripuni Street corner and links the Johnston Street trunk sewerline with Homebush. The line serves the area south of Kuripuni Street and north of Fleet Street and Vivian Street.

Solway to Homebush

This section of the trunk sewerline is reinforced concrete pipe with rubber ring joints, in five pipe sizes: 300, 375, 450, 525 and 600 millimetres. The 300 millimetre diameter pipeline begins at the left bank of Waingawa River beside the bridge on State Highway 2. The lengths of each section are respectively 1,750, 1,550, 850, 1,400 and 1,025 metres. The line serves the western-most part of the town, extending to Fleet Street and Vivian Street.

Colombo Road/Johnston Street Corner to Treatment Plant

All the sewerlines converge to flow into Johnston Street at different points. The pipes are of reinforced concrete and earthenware with rubber ring joints in the following sizes: 450, 600 and 840 millimetres. The line has one barrel up to River Road, two barrels up to Homebush and three barrels to the treatment plant. There is also a redundant 450 millimetre pipeline running from Homebush to the treatment plant.

The information on the sewer trunk network is broadly summarised with respect to materials and the pipe sizes in **Table 3.6**, and with respect to year of installation and material in **Table 3.7**.

Diameter (mm)	Earthenware (m)	Reinforced concrete (m)
225		1,370
380		5,620
450	2,950	2,475
525		1,390
600		3,945
840		1,725
Total	2,950	20,325

Table 3.6. Trunk sewer network by size, material and length.

Material	1910-1919	1950-1959	1970-1979	Total (m)
Earthenware	2,950			2,950
Reinforced concrete		4,750	15,575	20,325
Total	2,950	4,750	15,575	23,275

Table 3.7. Trunk sewer network by year of installation, material and length.

Siphon over Waipoua River on Colombo Road

This section siphons the sewerlines from the left bank of the Waipoua River to the right bank. The sewer then flows in the River Road trunk sewerline. The pipe material is Hobas, which has high resistance to corrosion, is very brittle but has flexible joints. Incorporated with this structure is a soakage pit on the left bank of the Waipoua River to be used in an emergency.

Collector and arterial reticulation

The urban sewerage scheme in Masterton is a conventional reticulated system. Pipe sizes vary between 100 and 300 millimetres. They are made of asbestos cement, earthenware, reinforce concrete and uPVC. The scheme is predominantly a gravity flow system.

There are two pump stations. One is located on Chapel Street and the other on State Highway 2 near the Waingawa Bridge. The first station elevates the sewer line from a low level invert to a manhole, with a higher level invert to incorporate the sewerlines into the gravity system

The second station elevates the flow from a gravity flow sewer system on the right bank of the Waingawa River to a higher-level gravity flow sewer system on the left bank. The only pressure flow sewerline in the system is at the crossing of the sewerlines over the Waingawa River, flowing from the right bank to the left bank.

A large portion of the sewerline is of 150 millimetre diameter pipe, while a smaller portion of 100 millimetre diameter sewerlines serve as rider collectors.

The information on the sewerline network is broadly summarised in **Table 3.8** with respect to materials and the pipe sizes of the system. **Table 3.9** summarises year of installation and materials.

Diameter	Asbestos cement	Earthenware	Reinforced concrete	PVC
100	675		225	
150	20,425	35,815	23,760	2,160
225	90	6,660	2,675	265
300		6,180	535	
380			450	
Total	21,190	48,655	27,645	2425

Table 3.8. Sewerage network by size, material and length.

	Earthenware	Reinforced concrete	PVC	Total
1910-1919	9,383			9,383
1920-1929	28,039	3,150		31,189
1930-1939	10,344			10344
1940-1949		4,450		4,450
1950-1959	889	10,760		13,659
1960-1969		7,310		14,994
1970-1979		1,975		12,157
1980-1989				1,314
1990-1999			2,425	2425
Total	48,655	27,645	2,425	99,915

Table 3.9. Sewerage network by year of installation, material and length.

The condition grading of the sewerlines (determined in accordance with the protocol established by the NZ Infrastructure Asset Management Manual (1996)) has been broken down by diameter and length in **Table 3.10.** The network is graded from 1 (very good) down to 5 (very poor). There is limited information on the sewerlines. Where no information on the condition of pipelines exists, a grading of 3 is accorded. A large proportion of the sewer line falls into this category.

A peak flow of 463 litres per second has been recorded in the system. Surface water and groundwater is known to enter the reticulation system.

Diameter (mm)	Grade 1	Grade 2	Grade 3	Grade 4	Grade5
100		900			
150	2,000	23,000	30,000	25,000	2,425
225	265	3,000	4,795	3,000	
300			5,000	800	915
380			6,070		
450			5,425		
525			1,390		
600			3,940		
840			1,725		

Table 3.10. Pipe grade relative to diameter and length (m).

Laterals

The sewer laterals are 100 millimetre diameter mortar jointed earthenware or rubber ring jointed PVC.

Figure 3.10. Masterton sewage treatment ponds at Homebush. The two primary ponds are in the foreground and the secondary pond and discharge are in the background.

Treatment plant

The treatment plant is located southeast of the town near the Makoura Stream and Ruamahanga River (**Figure 3.10.**). The wastewater flow gravitates into the inlet works for pre-treatment screening prior to discharge into the primary oxidation ponds. The screening process is done by an automated step screen. There is a backup manual screen. A sluice gate controls the selection and direction of the flow of wastewater for the screening grid to be used. There are two primary oxidation ponds, and a dividing weir structure divides the flow into these ponds after the screening process. From the two oxidation ponds the discharge flows into a tertiary pond before finally discharging to Makoura Stream about 400 metres upstream of the confluence with the Ruamahanga River.

Each pond has an area of approximately 8.5 hectares. The two primary ponds can be aerated by using two floating aerator units on each of the oxidation ponds.

The residue from the screening process in the inlet works passes through a press before deposition into a purpose-built screenings trailer. The step screen has a telemetry link to alert the office of any malfunctions.

VULNERABILITY ASSESSMENT

All sewerlines are at risk of damage by ground-shaking. The earthenware pipes are more vulnerable to damage than the reinforced concrete pipes. The potential liquefaction area is on the eastern side of urban Masterton and more likely to have effects on the treatment plant and the trunk and arterial sewerlines. Liquefaction of soils may cause differential settlement causing damage to sewerlines and dislocation of the manholes. The Masterton Fault traverses the Masterton urban area on the north-western side and the collector and arterial sewer lines may be vulnerable to damage. Landslide hazards are possible in the Lansdowne area beside the river, while most of the other areas are fairly flat.

Following are general comments on degrees of vulnerability from the vulnerability assessment chart for the Masterton urban sewer system:

- Sewer laterals are likely to be vulnerable to ground shaking but unlikely to be vulnerable to fault displacement and ground settlement. Most of the laterals are earthenware with either mortar or rubber ring joints.
- The collectors and earthenware arterial sewerlines are likely to be vulnerable to ground shaking but unlikely to be vulnerable to fault displacement and ground settlement. The earthenware arterial sewerlines will be rarely vulnerable to land slide. The reinforced concrete arterial sewerlines are possibly vulnerable to ground shaking and unlikely to be vulnerable to fault displacement and ground settlement.
- Trunk sewerlines are likely to be vulnerable to ground shaking, but unlikely to be vulnerable to liquefaction and ground settlement. They will be vulnerable to floods on rare occasions.
- Manholes are possibly vulnerable to ground shaking. They are unlikely to be vulnerable to severe storm and rarely vulnerable to ground settlement and flood. All manholes are constructed in concrete.
- Pumping stations are possibly vulnerable to ground shaking, unlikely to be vulnerable to severe storms and ground settlement and rarely vulnerable to flood. All pumps are of submersible type.
- The siphon is possibly vulnerable to flood but unlikely to be vulnerable to ground settlement and ground shaking. The pipe material on the siphon is Hobas, which is very brittle. There is a possibility of damage to the pipe by flood debris in the river.
- The flume is likely to be vulnerable to ground shaking, but unlikely to be vulnerable to ground settlement, flood and severe storm. It will be rarely vulnerable to liquefaction, fault displacement and volcanic ash.
- The screen is possibly vulnerable to ground shaking, but unlikely to be vulnerable to ground settlement and flood. It will be rarely vulnerable to liquefaction, fault displacement, severe storm and volcanic ash.
- The building is possibly vulnerable to flood but rarely vulnerable to ground shaking, liquefaction, fault displacement, ground settlement, wind storm and severe storm.
- The pond feed pipes are likely to be vulnerable to ground shaking, possibly vulnerable to flood, and rarely vulnerable to liquefaction, fault displacement and ground settlement.
- The aerators are possibly vulnerable to wind storms, unlikely to be vulnerable to ground shaking and rarely vulnerable to volcanic ash.
- Pond connection pipes are likely to be vulnerable to ground shaking, unlikely to be vulnerable to flood and rarely vulnerable to liquefaction, fault displacement, ground settlement and severe storm.
- Pond walls are likely to be vulnerable to ground shaking, possibly vulnerable to flood and severe storms and rarely vulnerable to liquefaction, fault displacement, and wind storm.
- The outlet structure is possibly vulnerable to ground shaking and flood, but unlikely to be vulnerable to ground settlement and rarely vulnerable to liquefaction, fault displacement, and severe storm.
- The power supply to pumping stations is possibly vulnerable to flood, wind storms and severe storms but rarely vulnerable to ground shaking, ground settlement and volcanic ash.

Impact of damage

Laterals

Damage to lateral lines is likely to be confined to extremely localised areas. Damage impact would be minor. The failure would result in domestic sewerage flooding and possible minor overland flow.

Collectors and arterial

Damage to collector lines would only occur in a localised area. The damage impact would be moderate. Collector line failure would result initially in a build-up of wastewater in manholes and pipelines and eventually an overland flow from the lowest-level manholes. Damage to arterials would be more serious than damage to collector lines. The overland flow and the area affected would be much larger.

Trunk sewer

The impact of the damage would be catastrophic. However, risk to health would be relatively low because most of the trunk mains are located in the outer area of the urban settlement.

Manholes

Depending on the line in which the manhole is located, the impact on the manhole will be similar to that of the corresponding sewerline. The impact of damage may differ on manholes from variable in the lateral to moderate in the trunk sewerline.

Pumping stations

The impact of damage to a pumping station would be minor.

Siphon

Damage to the siphon would have a moderate impact on the Lansdowne area.

Treatment plant

Screen: The impact of damage to the screen would be moderate.

Building: The impact of damage to the building would be minor to insignificant.

Pond feed pipes: The impact of damage on the pond feeder pipes would be moderate.

Aerators: The impact of damage to the aerator would be insignificant.

Pond connection pipes: The impact of damage on the pond connection pipes would be moderate.

Pond walls: The impact of damage to the pond walls would be moderate.

Outlet structure: The impact of damage to the outlet structure would be moderate.

Power supply to treatment plant: The impact of damage to the power supply to the treatment plant would be minor.

MITIGATION MEASURES

All components with a low risk rating will be managed by routine procedures. Components with risk from moderate to extreme are specifically identified and the work planned for.

The level-of-risk values derived from the vulnerability and impact-of-damage charts identify the following areas of risk, for which mitigation needs to be considered:

Collector and arterial reticulation lines

The earthenware and reinforced concrete pipelines are identified as being at moderate to high risk from ground shaking.

The earthenware pipelines have an extreme risk from ground settlement.

The reinforced concrete pipelines have high risk from ground settlement.

The earthenware and reinforced concrete pipelines are identified to have moderate risk from landslide.

Mitigation measures should include identification of the condition and material of pipelines, and progressively replacing older pipes with pipes made from more ductile material.

Cost-benefit ratios may be useful in identifying appropriate action for poor condition pipelines which are carrying larger flows.

Secondary flow paths and/or controlled overflow discharges should be investigated for larger lines. This may include controlled land discharges (as in the existing emergency overflow for the siphon on Colombo Road). There is a need to identify optimum locations adjacent to sewer lines where overflows can be pumped.

Collector lines crossing the Masterton Fault should be specifically identified, and some consideration given to procedures in case of fault displacement.

Trunk mains

The pipelines are at extreme risk from ground shaking and ground-settlement and at high risk from ground liquefaction. Mitigation measures should include identifying and providing an auxiliary flow-path, which would allow repair work to be carried unimpeded in the event of damage. Consideration should be given to constructing an emergency overflow trench/channel between Nursery Road and the town boundary and/or remedial work.

Optimum locations need to be identified at which flows may be pumped to adjacent sewer lines.

The redundant sewerline running parallel to the existing trunks in the Homebush area should be recommissioned.

Additional controlled sewer overflows from the Kuripuni, Makoura and Solway lines to land, or to the Makoura Stream, may be necessary.

Manholes

The risk from ground-shaking to arterial sewer line manholes is identified as moderate.

Identification of manhole/pipe connections should be carried out, initially on the arterial pipelines, with the aim of ensuring that all major manholes have rocker pipe connections, which would allow flexibility during ground settlement/ground shaking events.

Pumping stations

Risk to the pumping station and the Colombo Road siphon is identified as moderate for flooding events. Mitigation measures should include having replacement parts available for repairs.

Flume

The risk to the flume is identified as moderate for ground shaking. Mitigation measures should include installing flexible rocker pipes at the inlet and outlet pipes from the structure. However, it is possible to bypass this structure and still operate the system.

Screen

The risk is identified as moderate for ground shaking. It is possible to by-pass the screening and have the screening done manually.

Pond-fed pipes

The risk is identified as high for ground-shaking and moderate for ground settlement and flood events. Mitigation measures should include cutting open the channel to feed the pond temporarily until repairs are attended to.

Consideration should be given to replacing pipes with ductile material, as they fail. A record should also be kept of earthmoving machinery available in the area.

Pond connection pipe

The risk is identified as high for ground shaking.

Mitigation measures should include investigating the possible location and planning for possible breaches of pond walls.

Pond walls

The risk is identified as moderate for ground-shaking, and flooding. Mitigation measures should include ensuring riverbank protection works are maintained and enhanced where necessary. Northern pond embankment heights should be raised to prevent flood water overtopping.

Outlet structure

The risk to the outlet structure is identified as moderate for ground-shaking. Mitigation measures should include an investigation into potential options to lessen the risks.

(2) Carterton

NETWORK DESCRIPTION

Carterton's sewer system comprises some 29 kilometres of reticulation with seven small lift (pump) stations feeding a treatment plant consisting of screening, primary sedimentation, cold sludge digestion, and oxidation pond finishing (**Figure 3.11.**). The treated effluent discharges to the Mangaterere Stream adjacent to the treatment plant. **Table 3.11** below shows the make up of the piped reticulation.

Figure 3.11. Carterton sewage treatment plant at Dalefield. The plant buildings in the centre of the photo are surrounded by the three treatment ponds. The Mangaterere Stream is in the foreground.

Material	Size (mm)	Length (m)	Expected Life	Apprx. date installed	Average Age (years)
Reinforced concrete	150-380	6772	80	1940-1960	51
Earthenware	100-225	9122	80	1940-1960	51
Asbestos Cement	100-225	11153	60	1940-1970	46
UPVC	80-250	1918	80	1990-2000	6
Total		28965			

Table 3.11 Sewer reticulation network.

VULNERABILITY ASSESSMENT

From the vulnerability chart of the Carterton sewer system, the following general comments are provided.

Screen

The screen relies on electricity and water supply for its operation. Should the screen fail, effluent will bypass this process.

Pump station

The pump station relies on electricity for operation. Should this fail, the effluent will bypass the clarifier and sludge disposal processes and flow directly to the oxidation ponds. The pump station houses the automatic controls which operate the electrical function of the treatment processes, and relay information back to Council operators. Failure of this would result in the effluent being treated by the oxidation process.

Primary clarifier/sludge digester/main fluming/internal pipework

These processes are all primary which, in the event of failure, would result in the oxidation ponds carrying out all treatment.

Power supply

This is by way of overhead power cables. The supply is particularly prone to wind damage and if lost, would result in the oxidation ponds carrying out all treatment.

Oxidation ponds

These ponds carry out most of the treatment operations. The biggest risk to these ponds is scour during flooding. This could threaten the banks of one of the primary ponds, as well as the tertiary pond. This is a low-level risk, as flood flows in the area are relatively slow moving. Should one of these ponds be lost, effluent could be diverted to the other pond resulting in a lower quality final effluent being discharged to the stream.

Reticulation

The level of vulnerability of the mains depends on their materials and their location. As the system mainly relies on gravity flow to the treatment plant, failure in the lower parts of the system could cause overflows in the upper parts of the system. Overflows are a risk to public health.

Pump stations

The pump stations are all small stations servicing small catchments. Most of the stations have excess storage capacity and in the event of failure of the pumps or power supply, they could be manually pumped out.

Impact of damage

The greatest impacts would come from damage to the oxidation ponds. All other processes can be bypassed with relatively small impact on the final effluent quality. However, should the ponds be put entirely out of action, untreated effluent would be discharged to the stream.

MITIGATION MEASURES

Some components of the sewer network are at risk of damage in the event of major earthquakes, severe storms, and flooding. Given the size of the community and the redundancies built into the system, repairs should be relatively straightforward. The primary emphasis would be on repairing one or more of the oxidation ponds. In the unlikely event of this not being possible, portable modular treatment systems are available which can service small populations such as Carterton. They are widely used by aid organisations around the world and likely to be available on relatively short notice.

Specific mitigation measures identified by this project for further assessment are:

- Install and operate a dynamic network model which can identify alternative routes for effluent flow in the event of failure of parts of the reticulation network.
- Investigate the availability and logistics of procuring portable modular treatment systems for 4,500 people.

(3) Greytown

NETWORK DESCRIPTION

Sewage treatment plant

Greytown has an oxidation pond treatment system using two ponds in sequence (**Figure 3.12**). This is located at the end of Pah Road, three kilometres from the urban area. Effluent is discharged into Papawai Stream, which flows into the Ruamahanga River 1,500 metres downstream. Pond number one has an area of 18,500 cubic metres and pond number two an area of 15,000 cubic metres. Based on an average depth of 1.4 metres, the total volume of the system is 46,900 cubic metres. The ponds are elevated both above Papawai Streem and low lying surrounding farmland making the external embankment heights in excess of three metres.

Both ponds were constructed in the 1970s, but until 1994 only one pond was used. Both ponds are clay-lined and some leakage has been experienced in one pond. The overall retention in the ponds is approximately 56 days at average dry weather flow (ADWF).

Reticulation

Greytown is essentially a gravity system (95 percent) with some minor pumping (five percent). The Greytown urban reticulation consists of 15.5 kilometres of pipe varying in size from 100 millimetres to 225 millimetres. Pipe material is predominantly fibrolite, concrete and PVC. The delivery main to the oxidation ponds is a 225 millimetre concrete pipe approximately 3.7 kilometres long. A small sewer pumping station services a small pocket of seven properties.

Figure 3.12. Greytown sewage treatment ponds.

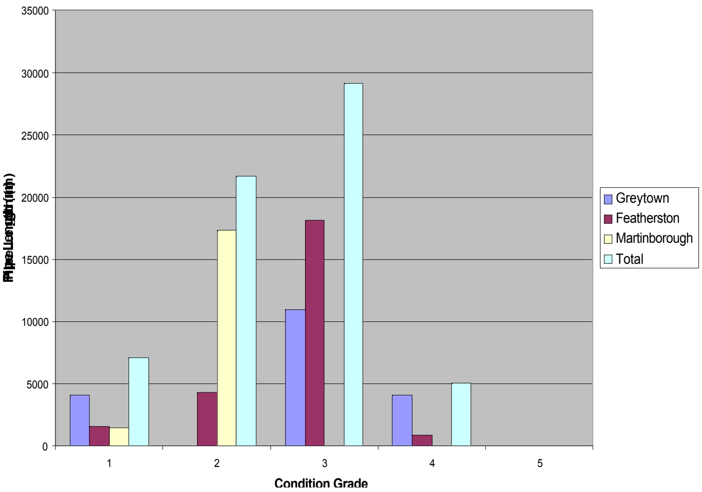

Figure 3.13. Summary of pipe condition for the sewer network of the south Wairarapa towns of Greytown, Featherston and Martinborough.

Tables 3.11 is characteristic of the sewer pipes for all of the three South Wairarapa communities.

The above data is provided from the SWDC asset register system and has not been subject to completed quality assurance procedures. The information should be regarded as indicative only.

VULNERABILITY ASSESSMENT

The Reading Street pumping station relies on the power supply to the site which could be disrupted during severe storm conditions.

(A)

Summary of pipe material

Pipe material	Greytown	Featherston	Martinborough	Subtotal
Unknown	0	6,011	0	6,011
AC	789	4,204	17,350	22,343
EW	871	8,866	0	9,737
FIB	5,595	0	0	5,595
UPVC	4,114	1,552	1,476	7,142
RC	7,840	4,324	0	12,164
Subtotal	19,209	24,957	18,826	62,992

(B)

Summary of Pipe size

Size (mm)	Greytown	Featherston	Martinborough	Subtotal
100	640	95	125	860
125	282	0	0	282
150	11,485	21,534	15,340	48,359
200	382	537	3,361	4,280
225	6,420	0	0	6,420
250	0	668	0	668
375	0	2,123	0	2,123
Subtotal	19,209	24,957	18,826	62,992

(C)

Summary of pipe age

Age (years)	Greytown	Featherston	Martinborough	Subtotal
Unknown	0	0	0	0
0-10	2,202	1,039	1,437	46,787
11-20	6,291	174	0	6,465
21-30	4,360	23,744	17,389	45,493
31-40	2,933	0	0	2,933
41-50	0	0	0	0
51-60	1,043	0	0	1,043
61-70	0	0	0	0
71-80	0	0	0	0
81-90	2,380	0	0	2,380
Subtotal	19,209	24,957	18,826	62,992

(D)

Summary of pipe condition

Condition grade	Greytown	Featherston	Martinborough	Subtotal
1	1,552	4,114	1,476	7,142
2	4,324	0	17,350	21,674
3	18,161	10,971	0	29,132
4	920	4,124	0	5,044
5	0	0	0	0
Subtotal	24,957	19,209	18,826	62,992

Table 3.11 a-d. Summary of pipe size, type, age and condition for the sewer network of the South Wairarapa towns of Greytown, Featherston and Martinborough (May 2001). The above data is provided from SWDC asset register system and has not been subject to complete quality assurance procedures. Therefore the information should be regarded as indicative only.

Manholes and laterals will be suspect during seismic events. Manholes would be subject to damage, mainly at pipe entries/exits, while laterals will suffer varying damage, based on their material and condition.

The 225 millimetre diameter concrete main will be suspect in various sections of softer ground while pipes could be misaligned by failures in the pipe jointing. The fibrolite concrete reticulation mains will be vulnerable by nature of their age and material type.

Impact of damage

The oxidation ponds and structures are critical in terms of maintaining the treatment process and avoiding health problems. As large earthwork structures, they would take a considerable time to repair following a seismic event, depending on the scale of damage suffered. It is possible if only one pond were affected, it could be isolated while repairs are being carried out.

A seismic even could have high impact on parts of the reticulation, and repairs could take considerable time. This would be critical in terms of returning the infrastructure to normal.

Alternative discharge *(applies to Greytown, Featherston and Martinborough)*

In some cases disused septic tanks may still exist and offer temporary relief. Septic tank, portaloo and similar service providers would be able to offer limited facilities while repairs are being undertaken. Alternative means of discharging for material other than human waste could be easily arranged. This would include disposing waste water on gardens. Emergency discharge provisions also exist under the resource consent process.

(4) Featherston

NETWORK DESCRIPTION

Sewage treatment plant

Featherston has an oxidation pond treatment system using two ponds in sequence (**Figure 3.14**). These are located off Longwood West Road, 1.4 kilometres from the urban area. Effluent discharges into an open channel which flows into Donald's Creek, below Longwood Road. Each pond has an area of 20,000 cubic metres and incorporates a clay-sealing layer, polyethelene sealed sides and wavebands. Based on an average depth of 1.4 metres, the total volume of the system is 56,000 cubic metres. The ponds are slightly elevated above the surrounding farmland, making the external embankment height up to three metres.

Reticulation

Featherston is essentially a gravity system (85 percent) with some pumping (15 percent). The Featherston urban reticulation consists of 22.8 kilometres of pipe, varying in diameter from 100 to 250 millimetres.

Pipe material is predominantly asbestos-cement, concrete and earthenware. As pipes are replaced, increasing use is been made of uPVC.

The delivery main to the oxidation ponds is a 375 millimetre concrete pipe approximately 1.9 kilometres long. A sewer pumping station is sited at the intersection of Revans and Donald streets and delivers sewage into the gravity main to the oxidation ponds. The pump station handles additional loadings from part of the urban area during times of excessive stormwater infiltration.

Figure 3.14. Featherston sewage treatment ponds.

VULNERABILITY ASSESSMENT

Severe storm conditions would interfere with the telemetry system and supply of power to the Donald Street pump station. Flooding and stormwater infiltration would also make the pumping station vulnerable in terms of its ability to cope without overflowing.

Manholes and laterals would be suspect after earthquakes. Manholes would be subject to damage, mainly at pipe entry/exits, while laterals would suffer varying damage, based on material and condition.

The 375 millimetre concrete main will be suspect at the pipe jointing, and pipe misalignment could occur. The asbestos cement reticulation mains will be vulnerable by nature of their material type.

Impact of damage

Donald's Creek pumping station would require immediate attention following an earthquake. Structural and telemetry components would both need checking.

Comments on the oxidation ponds and reticulation are as included in the Greytown section.

(5) Martinborough

NETWORK DESCRIPTION

Sewage treatment plant

Martinborough has a single pond treatment system located at the end of Weld Street, 1.3 kilometres from the centre of town (**Figure 3.15**). Effluent discharges directly into the Ruamahanga River beside the pond. Based on the pond area of 20,000 cubic metres and pond depth of 1.4 metres, the total volume of the system is 28,000 cubic metres. The ponds are elevated above surrounding farmland on all but one side making the external embankment up to three metres high.

Figure 3.15. Martinborough sewage treatment pond and the Ruamahanga River.

Reticulation

Martinborough is purely a gravity sewer system. The Martinborough urban reticulation consists of 17.5 kilometres of pipe, varying in diameter from 100 to 220 millimetres. Pipe material is almost entirely asbestos-cement but increasing use is been made of uPVC, as pipes are been replaced. The delivery main to the oxidation ponds is a 200 millimetre diameter asbestos-cement pipe approximately 1.5 kilometres long.

Vulnerability assessment

Severe storm and local wind conditions would interfere with the telemetry system and power supply to the aerators at the oxidation pond. Manholes and laterals would be suspect during seismic events. Manholes would be subject to damage, mainly at pipe entry/exits while laterals would suffer varying damage, based on their material and condition. The 200 millimetre concrete main would be suspect at the pipe jointing, which could result in pipe misalignment. The asbestos cement reticulation mains will be vulnerable by nature of material type.

Impact of damage

Comments on the single oxidation pond and reticulation are as for Greytown.

3.3 STORM WATER

Within the Wairarapa, the urban areas and central business districts are relatively small, and are usually sited on plains with favourable gradients and readily available natural water courses. As a consequence, apart from the Masterton town drain, large-scale major piped stormwater systems have not been constructed to date. However, a number of modelling studies for stormwater management planning have been carried out, notably in Masterton (1995), Greytown (1998) and Martinborough (2000). These studies are used as the basis for the design of urban storm water networks and for the upgrading of existing networks.

The following is a summary of the basis for the design of urban stormwater networks within the region.

(1) Masterton

The Masterton town area is generally flat with some stormwater ponding and storage, and with the Waipoua River, at the southern end of the urban catchment, eventually receiving a significant part of the flow from a storm event. The design rainfall depths used for stormwater analysis are those in the HIRDS package. A one hour storm event is adopted.

Typical design criteria include:

- A design storm event of 10 years for piped (primary) systems where an associated flow path (secondary system) is available.
- A design storm event of 50 years for an overall (primary and secondary) system with a freeboard allowance of 50 millimetres to existing commercial floors.

(2) Carterton

Carterton is situated on a plain which slopes to the Ruamahanga River to the east and to the Mangatarere Stream to the west.

The design rainfall depths used for stormwater analysis are those in the HIRDS package.

Design storm events of two year and five year ARI, and one hour duration are adopted.

(3) Greytown

Greytown lies on an alluvial plain with a gradient of about 0.6 percent. The stormwater system must cope with runoff from the rural catchment above the town. The design rainfalls in the HIRDS package were used for the stormwater modelling. The design rainfall events used ARI's of 10 and 50 years for one hour's duration.

(4) Martinborough

Martinborough is situated on a plain of approximately one percent slope with a substantial upslope rural catchment area which contributes to stormwater flows in the urban area.

The design rainfalls in the HIRDS package were used for the storm water modelling. For the typical catchment, modelling of one, two, three and six hour duration events showed that the one hour event gave the highest peak runoff flows. Design storm events of 10 year, 20 year and 100 year ARI, and one hour duration are adopted.

3.4 FLOOD PROTECTION STRUCTURES

The Wellington Regional Council administers a number of flood protection and drainage schemes within the Wairarapa Valley. The main flood protection scheme is the Lower Wairarapa Valley Development Scheme (LWVDS), which was constructed between the mid-1960s and 1980. This scheme has a current asset value of $42 million and protects 40,000 hectares of highly productive farmland within the southern Wairarapa area. Included in this scheme are the lower Ruamahanga, Tauherenikau, and Huangaroa rivers, as well as other tributaries to Lake Wairarapa and the lower Ruamahanga River. The main components of the LWVDS are a major river diversion, the floodway system, 200 kilometres of stopbank (**Figure 3.16**), 130 drainage outfall culverts with floodgates, a flood detention dam and the Blundell Barrage (**Figure 3.17**).

The Blundell Barrage control gates are located at the outlet of Lake Wairarapa, and regulate water levels in both Lake Wairarapa and Lake Onoke (**Figure 3.18**). The Barrage also provides detention storage during major floods. With the exception of the Donalds Creek flood detention dam, which is located on the outskirts of urban Featherston (**Figure 3.19**), the scheme does not protect urban areas. The scheme does, however, have a role in protecting key access routes such as State Highways 2 and 53, Western Lake Road, the East-West Access Road, Kahutara Road and the Martinborough to Lake Ferry Road.

Figure 3.16. Part of the Ruamahanga River stopbank at Pukio, showing repairs in progress.

Figure 3.17. Lower reaches of the Ruamahanga River outlet from Lake Wairarapa. The Blundell Barrage combined flood protection structure and road bridge is located before the junction with the Ruamahanga River. All the flat land in the picture depends on stopbank protection and land drainage pumps.

In the central and northern part of the Wairarapa Valley, there are flood protection schemes on the Waiohine, Waingawa, Waipoua and upper Ruamahanga Rivers. These schemes are not as extensive as the LWVDS but do have stopbanks protecting rural areas, and urban centres such as Greytown and Masterton. These schemes also have a role in protecting key access routes such as State Highways 2 and 53, the Masterton-Martinborough Road, Paierau Road, Gladstone Road, Opaki-Kaiparoro Road and Kokotau Road.

There are 16 drainage schemes within the Wairarapa Valley, with a total drain length of 160 kilometres, servicing an area of 6,600 hectares of highly productive farmland. Ten of these schemes are within the LWVDS (including five pump drainage schemes) with the remainder in the central and northern part of the valley. In addition to the benefit to rural land, the Battersea scheme provides flood relief to State Highway 53 and the Manaia scheme provides a drainage outfall for urban Masterton.

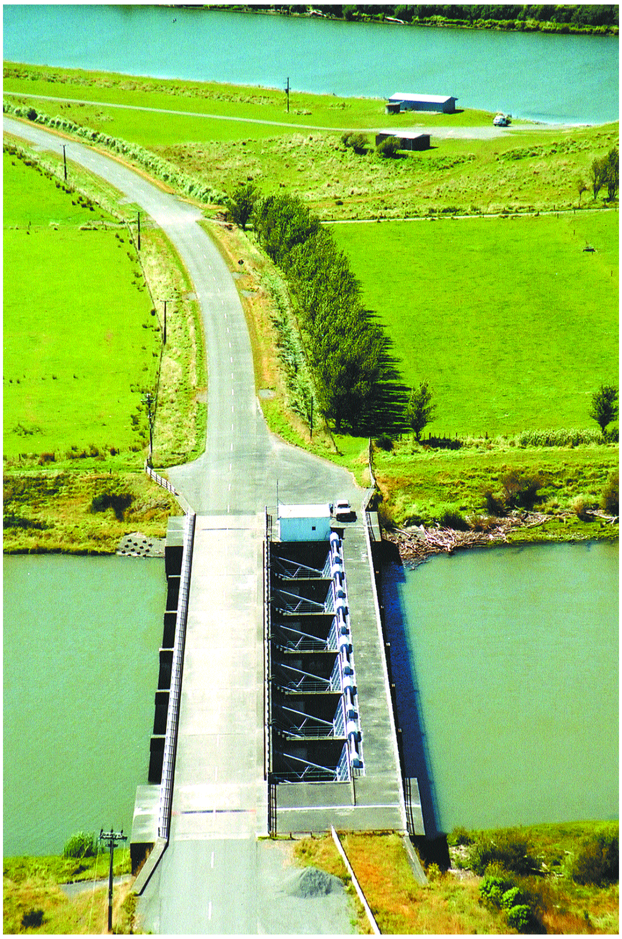

Figure 3.18. The Blundell Barrage is a combined flood control structure and road bridge. The Ruamahanga diversion and Boat Club are visible in the top of the picture. The radial steel gates control water levels and flood storage in the Lower Wairarapa Valley.

Figure 3.19. Flood detention dam and stopbanks for Donalds Creek, Featherston. State Highway 2 is in the centre of the picture and State Highway 53 is in the top of the picture.

The main natural hazards affecting the flood protection schemes are flood, tsunami and earthquake. The likely flood damage risks and scenarios are well understood, and excellent systems are in place for managing this risk. These systems include routine condition assessments, appropriate maintenance programmes, and satisfactory levels of funding for maintenance and flood damage reserves. The potential damage to stopbanks and drainage channels from natural hazards are summarised in **Table 3.13a-b**.

In the case of tsunami, the risk and scale of potential damage is not well understood. The worst damage is expected to be to stopbanks and pump stations in the Lake Onoke and Ruamahanga diversion areas. It is fortunate that no residential properties or key roads are protected by these stopbanks, as no practical and cost-effective mitigation measures are available.

In the case of earthquake-induced settlement and liquefaction, the risks and type of damage are better understood. Eartquake damage is likely to the lower Ruamahanga river and floodway stopbanks, Tawaha and Pukio East culverts, Oporua Floodway 'Ducksbill', and Blundell Barrage.

Based on experience in the 1987 Edgecumbe earthquake, damage to stopbanks is likely to consist of settlement, transverse and longitudinal cracking, and slumping. In the case of culvert structures, settlement, along with the cracking or separation of pipes, is likely to occur. The likely extent and degree of damage and the cost and time to restore damaged flood protection works are less well understood. There are no practical and cost-effective measures for mitigating these hazards. Awareness, contingency funding provision and prompt identification and repair of damage are the best approaches.

The Blundell Barrage is the critical component of the LWVDS and it seems to be particularly vulnerable to earthquake damage. Even minor damage caused by liquefaction or settlement could prevent the Barrage from operating properly and limit the effectiveness of the scheme as a whole. Further investigation should be undertaken to better understand the potential damage and to enable appropriate mitigation measures to be developed.

Again based on the 1987 Edgecumbe Earthquake experience, damage to drainage networks and pump stations is anticipated, due to earthquake-induced liquefaction and settlement. The most likely problem with drains would be blockage due to bank slumping and change in drainage gradient due to ground uplift or settlement. For pump stations, the most likely problems would be cracking of the outfall pipe at the pump station and headwall junctions, and damage to pumps due to overloading. Critical facility type screening checks have been carried out for each pump station and these are summarised in the following section.

In the case of the drains, there are no practical and cost-effective measures for mitigating these hazards. Awareness, contingency funding provision and prompt identification and repair of damage are the best approaches. An evaluation should, however, be carried put for each pump station to identify appropriate mitigation measures such as flexible pipe connections, structural strengthening, and anchorage of pumps or control panels.

Pump stations

All pump stations are conventional timber framed, with flat fibrolite sheet external cladding and CGI roofing. They are constructed on rigid RC cellular raft type structures which incorporate a pump well (**Figure 3.20**). Two pump stations equipped with monorails for servicing the pumps and motors have, in addition, structural steel portal frames. All the remaining stations have detachable roofs for servicing the pump-motor sets and switchboards.

Figure 3.20. Pouawha pump station in the Lower Wairarapa Valley. Twin electric pumps lift the water from the low-lying former Pouawha lagoon.

All pumps have cast iron casings. The pumps and motors are usually supported at their lower ends by structural steel grillages (in one case at mid-height), and a bolted flange connection to a steel puddle flange cast into the cell diaphragm wall. There is no restraint at floor level.

Outlet pipes are reinforced concrete with rubber ring bell and spigot joints with limited rotation capacity and no capacity to withstand longitudinal movements.

The vulnerable features common to all pump stations are summarised in **Table 3.13c**. Results of the hazard screening of pump stations are summarised in **Table 3.12**.

The station pump wells are cellular raft type structures founded on saturated soft soils, which appear to be loose sands and silts. The common founding conditions for the stations should be investigated and if necessary remedial work recommended. Some in situ soil testing will be required. The estimated cost for the investigation is $10,000.

1. The pump-motor sets would act like inverted pendulums under earthquake attack. They should be investigated and restraints provided at floor level. The estimated cost per station is $2,000-4,500.
2. Outlet pipes could fail due to relative movement at both the puddle flanges and the RR joints, and due to longitudinal movement. These possibilities should be investigated. The cost of the investigation is included in 1. above.

Hazard screening of pump stations - summary									
Pump station	Size	Date built	Pumps and motors	Power supply	Puddle flange cast iron diaphragm	Outlet pipes	Switchboard	Access for servicing equipment	Estimated cost of mitigation measures
Moon Moot	3.2*2.5	1970	2No 380/457	Transformer on pole	?	600 RC RR join. Gibbault joint	Wall mounted	?	$2,750
Onoke	6.33*4.15	1969	2No 762/762	250 kVA transformer External	Yes	900 RC RR joint	Free standing Needs restraint	Monorail	$4,750
Papatahi	3.86*3.86	1950s?	1No ?/375 1No 457/560	Transformer on pole	Yes	600 RC RR joint	Free standing. Adequate restraint.	Detachable roof	$2,050
Pouawha No 1.	5.11*3.35	1967	2No 610/762	Transformer on slab External	Yes	900 RC RR joint Gibbault joint	Free standing Needs restraint	Momorail	$4,750
Pouawha No 2.	6.33*4.3	1976	2No 762/762	Transformer on slab External	Yes	900 RC RR joint Gibbault joint	Free standing Needs restraint	Detachable roof	$4,050
Te Hopai	6.33*4.3	1977	2No 762/762	Transformer on slab External	Yes	900 RC RR joint	Free standing Adequate restraint	Detachable roof	$4,050
Investigate liquefaction potential of pump station sites									$10,000

Table 3.12 Summary of pump station hazard screenings

(A) STOPBANKS

Hazard	Effect	Comment
Ground shaking	• Cracking of stopbanks (both transverse and longitudinal. • Slumping of stopbank walls and rip rap protection. • Foundation failure.	There are a large variety of failure types. Many of these occurred following the 1987 Edgecumbe earthquake.
Liquefaction	• Foundation failure as soil liquefies or compacts. • Lateral spread – slumping of stopbank sides. • Settlement of banks relative to river can lower protection rating.	Depends greatly on underlying soils and stopbank construction.
Fault rupture	• Complete failure of the stopbank – cracking direction depends on fault orientation. • Horizontal and/or vertical displacement of bank.	Generally confined to known faultlines.
Land deformation	• Uplift and subsidence can cause varying effects – by changing river hydraulics. • Uplift on the plains can lower river gradient, increasing aggradation or may increase river downcutting and threaten to undermine stopbanks. • Subsidence can increase river energy and erosion, threatening to undermine stopbanks. • Changes in river course due to large-scale land level changes are probably the most major long term change.	Its location and extent are difficult to predict. Fault scarps indicate that movement can be several metres. Many of the effects are probably long term, but current critical areas of the system may become more critical.
Tsunami	• Erosive bore travelling upstream, eroding and/or overtopping banks.	Funnelling of energy in streams can cause water to reach long distances inland.
Flooding	• Scour of banks. • Overtopping.	These are typical stopbank design considerations.
High wind	• Erosion of banks.	Wave action and debris tools are often effective in eroding the banks; Direct wind erosion would only be an issue during extended dry periods.
Heavy rain	• Slumping and slipping of banks.	Localised heavy rain causing saturation of the stopbanks.

Table 3.13 (a) Potential damage to stopbanks and drainage system from natural hazards

(B) DRAINAGE CHANNELS

Hazard	Effect	Comment
Ground shaking	• Cracking of channel walls (both transverse and longitudinal). • Slumping of channel walls.	Failure types are similar to stopbanks. Many of these occurred following the 198 Edgecumbe earthquake
Liquefaction	• Lateral spread – slumping of channel sides. • Differential settlement of land may reduce drainage efficiency.	Depends greatly on soil types.
Fault rupture	• Complete failure of the channel – cracking direction depends on fault orientation. • Horizontal and/or vertical displacement of channel.	Generally confined to known faultlines.
Land deformation	• Uplift and subsidence can cause varying effects – by changing land drainage characteristics. • Uplift can reduce or even reverse channel gradient and flow directions. Uplift may reduce need for land drainage. • Subsidence can reduce or even reverse channel gradient and flow directions. An increased land area may need draining, so the current drains may be under-designed.	Its location and extent are difficult to predict. Fault scarps indicate that movement can be several metres. Changes in channel gradient can cause ponding relatively rapidly (days, weeks).
Tsunami	• Sediment carried in the wave may silt up channels. • Unlikely to funnel energy creating a bore.	Generally restricted to areas quite close to the coast.
Flooding	• Scour of banks. • Silting of channels.	Scour could occur from channel overload. Silting is likely to occur when floodwaters from the rivers flow across drained land.
High wind	• Erosion of drains.	Wave action and debris tools are often effective in eroding the banks; Direct wind erosion would only be an issue during extended dry periods.
Heavy rain	• Slumping and slipping of drain walls	Localised heavy rain causing saturation of the soil.

Table 3.13 (b) Potential damage to stopbanks and drainage system from natural hazards

(C) PUMP STATIONS

Hazard	Effect	Comment
Ground shaking	• Cracking of pipes, headwalls and structural members. • Separation of pipes. • Falling of un(der)secured items. • Seizing of pumps due to tilting.	Some of these failures occurred following the 1987 Edgecumbe earthquake.
Liquefaction	• Foundation failure. • Differential settlement of building. • Buoyancy of underground pipes etc.	Depends greatly on soil types underlying the structure.
Fault rupture	• Broken pipes. • Complete failure of the building.	Generally confined to known faultlines.
Land deformation	• Uplift and subsidence can cause varying effects. • Uplift can raise pipe inlet/outlet above required level. • Subsidence can lower key electrics closer to water levels. • If amount of water to be drained increases, pumps could be under-designed.	Its location and extent are difficult to predict. Fault scarps indicate that movement can be several metres.
Tsunami	• Complete destruction of building. • Salt-water affect electrics of the pump station.	Generally restricted to areas quite close to the coast.
Flooding	• Water levels affect electrics. • Scour around the pump building.	
High wind	• Structural failure.	Unlikely to occur since building should be properly structurally designed.
Heavy rain	• Overload of pump capacity causing localised flooding.	Localised heavy rain.

Note: Two reports were written by the Bay of Plenty Catchment Board detailing damage to their flood protection schemes following the 1987 Edgecumbe earthquake. There was widespread damage to the stopbanks and also a reduction of flood protection to below a 20 year standard. The total cost of reinstatement was estimated to be $3.9m (1987$) - $1.5m for immediate repairs to the stopbanks and $2.5m to reinstate the system to a 100 year standard. WRC has copies of these two reports.

Table 3.13 (c) Potential damage to stopbanks and drainage system from natural hazards