FINAL REPORT

Peer Review of Rangiora Water Supply Reports

Prepared for

Waimakariri District Council

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27 October 2006

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Section 1 Introduction

The Waimakariri District Council (WDC) requested that URS New Zealand Limited (URS) undertake a peer review of reports prepared by MWH New Zealand LTD (MWH) and Pattle Delamore Partners Ltd (PDP) on the latest work undertaken for the Rangiora Water Supply. This work is a continuation of the URS reviews of both the "Rangiora Water Supply Upgrade: Geo-hydrological Study" (Pattle Delamore Partners, February 2004) and a subsequent report, "Rangiora Water Supply – Issues & Options" (MWH New Zealand, June 2004) which were completed by URS in 2004.

As set out in the WDC Request For Proposal (RFP), URS has reviewed the reports on behalf of WDC with the objectives of the review being as follows:

- Review the content of each report;
- Check and confirm agreement or comment on key assumptions;
- Check key calculations, in particular relating to the well testing analysis;
- Check project estimates; and
- Provide an independent and objective assessment of the findings of each report.

The reports that have been reviewed are:

Assessment of Groundwater Resources for Rangiora Water Supply – PDP, September 2005

Rangiora Water Supply Final Options Report – MWH, November 2005

Testing of the Smith Street Exploratory Well – PDP, Report due 9 October 2006

Where possible, this review follows the format of the individual reports and comments on each section in turn. Any issues associated with the reports as identified by URS are detailed in Sections 2.0 through 4.0. A discussion providing a summary of our independent assessment of the findings of each report is provided in Section 5.0.

Section 2 Pattle Delamore Partners Ltd - September 2005

2.1 Background

The report was prepared for WDC to provide advice about groundwater resources for future water supply for Rangiora Township. Rangiora and surrounding areas are anticipated to need an increased supply to replace current supplies and allow for future development and population growth. Theses issues result in a predicted demand increase from a current peak daily abstraction of 14,500 m^3/day to a future peak daily abstraction of 30,100 m^3/day. The current daily average abstraction is 5,844 m^3/day and the predicted future daily average abstraction is 10,050 m^3/day. This represents an approximate doubling of 2003 usage by the year 2053. A review of the demand assessment is provided in Section 3.0 of this report.

The PDP 2005 report builds on the previous assessments of the potential options for groundwater supplies for Rangiora which were identified as comprising either of the following:

- Ashley Aquifer Option; or
- Coastal Aquifer Option.

2.2 Ashley Aquifer Option

This option relates to further development of the shallow aquifers south of the Ashley River in and around Rangiora Township. WDC currently uses wells within this aquifer system for supply for Rangiora however concerns have been identified associated with water quality, sustainable yield and consentability of further development of this option.

The key areas covered in the PDP assessment of this option are set out below.

2.2.1 Well Yields

PDP have reviewed well data from the ECan wells database within the target area. This is considered to be a reasonable approach, and has identified that of 92 wells present, only 11 record abstraction rates in the range of 15 l/s and 30 l/s (the desired target rate per well) with only 6 of these being shallow wells (less than 23 m deep). As such, less than 10% of the existing wells would be suitable to meet future target requirements.

In order to better define well yields, PDP undertook well testing (constant rate and step tests) in two of the existing WDC wells at Ayers Street and Dudley Park. In addition a survey of existing wells across Rangiora was completed, and was used to identify the distribution of shallow strata beneath Rangiora, and hence define the locations of unconfined, leaky-confined and confined aquifer systems.

The methods of assessment and data seem reasonable, specific comments on pump testing and associated analysis is provided in 2.4 of this report.

The distribution of the shallow strata and definition of locations of the differing aquifer systems presented also appears reasonable. However, URS consider that the variability of permeability within fluvial gravels is likely to be high.

A comment is made regarding the corrosive nature of the groundwater at Dudley Park, however no data is given to state what this relates to (this is likely to be due to low pH). The effect however is to corrode well casing and screens and along with the current small well diameter results in between 39% and 88% of the drawdown being attributed to well losses. Larger well diameters and regular maintenance are noted as being required, however it is unclear whether this is taken into account in cost estimates for future wells within this option.

Well yields are noted to be similar in Eastern Rangiora, however this is based on limited data and no testing. To the south of Rangiora at Southbrook, two recently drilled wells produced yields of between 10 l/s and 26 l/s with large drawdowns, indicating that yields to the south are unlikely to meet future requirements. The deep wells to the south are noted to be even more variable, with marginal yields and high drawdowns.

In summary, PDP conclude that well yields of up to 30 l/s are achievable in the shallow unconfined aquifer and leaky/confined aquifer at Rangiora although the results are noted to be variable and not all the wells would successfully achieve the yield throughout dry seasons. URS considers that this is a key comment as demand would likely peak during these periods when well yields are potentially not sustainable.

2.2.2 Well Interference

PDP recommend drilling multiple wells at each location to share the pumping load and "spread out" the associated drawdown effects. PDP state large distances will be required between well field locations in order to minimise interference effects and available drawdowns. These comments and assumptions are considered to be reasonable given the hydraulic characteristics of the aquifer system.

A series of well spacing and interference calculations are presented by PDP. URS has verified that the calculation methods are correct however we note that the spacing values stated do not entirely concur with the graphical plots presented (Figure 6). For example, for six wells in the unconfined aquifer at Ayers Street a spacing of 580 m is stated for 25 l/s abstraction from each well. Inspection of the graph indicates that this spacing is actually closer to 620 m.

In both assessments PDP make assumptions on aquifer properties across Rangiora based on limited pump test information (from two locations) whilst noting elsewhere within the report that the shallow aquifer systems are highly variable.

URS concurs that a significant well spacing on the order of 580 will be required between the well field locations however other factors including aquifer variability, land availability and surrounding land use will also factor into this decision.

2.2.3 Turbidity

Turbidity is noted to be a significant issue for shallow groundwater in Rangiora and in particularly to well locations in close proximity to the Ashley River. The New Zealand Drinking Water Standard (DWSNZ) (2005) sets a turbidity standard of 1.0 NTU for 95% of the time for effective UV disinfection.

An area of Rangiora close to the river is noted as consistently failing this requirement and as such no further development is recommended here. To the south of Ayers St the groundwater turbidity is generally below 1 NTU and would be suitable for UV disinfection. At Ayers Street however, regular monitoring would be required and at times the supply may not be compliant and would have to be either shutdown or diverted to waste. This may result in future supply restrictions and issues.

2.2.4 Groundwater Chemistry

Based on the data in the PDP report for groundwater quality from four locations around Rangiora all parameters measured meet the DWSNZ (2005) criteria excluding pH. The shallow groundwater typically has a pH below the aesthetic guideline value, which can contribute to metal pipework corrosion. Lime addition is currently required at Ayers Street, and would likely be required at future supplies. This represents an ongoing operational cost for future wells in Rangiora.

2.2.5 Well Security

The DWSNZ (2005) sets out a number of criteria upon which a "secure classification" for groundwater supply is determined. This classification is used to determine the frequency that the supply must be monitored for indicators of contamination by bacteria or viruses.

PDP note that the unconfined and leaky-confined shallow wells around Rangiora are unlikely to meet this secure classification such that regular monitoring and treatment would be required, with resulting additional operational costs. URS concur with the assessment of well security that has been undertaken.

2.2.6 Stream Depletion

Groundwater abstractions from shallow aquifers have the potential to cause stream depletion effects. A number of spring fed streams are present in and around Rangiora. As such PDP has undertaken an assessment of potential stream depletion resulting from abstraction from either the shallow unconfined or leaky-confined aquifer systems using the pump test derived aquifer parameters and estimates of stream bed conductance. The assessment was based on meeting the criteria for a 5 l/s threshold effect after 30 days continuous pumping under the WRRP and the NRRP low stream depletion classification.

The resulting separations were calculated at 250 m either side of a stream from the leaky-confined aquifer and 1000 m for the unconfined aquifer. These values appear reasonable.

2.2.7 Preferred Well Field Development Locations

Based on the above assessments, and given that well field locations are likely to be limited to public reserves and land owned by WDC, PDP therefore undertook a zoning approach to defining potential well field locations. The approach took into account the following issues:

- Areal extents of unconfined and leaky-confined aquifers;
- Availability of land – also allowing that at each well field a pair of wells would be required, located at least 150 m apart;
- Stream separation distances as outlined above;
- Avoiding areas affected by turbidity issues, close to streams, close to the landfill and close to existing groundwater users.

On this basis, two sets of six well fields (each containing 2 wells) were suggested as follows:

- 6 well fields in the unconfined aquifer spaced at least 580 m apart between Kippenberger Avenue and Ayers Street pumping station. Each well field designed to achieve combined minimum pumping rates of 25 l/s; and
- 6 well fields located in the leaky-confined aquifer spaced around 540 m apart located between Ayers Street and Boys Road. Each field containing two wells designed to reach a minimum pumping rate of 30 l/s.

PDP note that at times of low groundwater levels this strategy would not meet the projected peak demand such that alternative supply or water restrictions would be required. Furthermore, multiple well field locations may also require development of multiple treatment plants resulting in increased infrastructure costs.

These are both key issues and risks associated with the Ashley Aquifer Option and are discussed in later sections.

2.2.8 Risk Assessment

PDP have undertaken an assessment of risks with the Ashley Aquifer Option based on implementation risk and operational risks and a qualitative assessment identifying high, moderate or low risk items.

High risk items are noted as follows:

- Hydrogeology and well development uncertainty i.e. risk of poor yield;
- Well interference and stream/spring depletion;
- Land use restrictions and treatment infrastructure requirements;
- Seasonal variation in yields;

- Impacts on existing and future users; and
- Infrastructure operation and maintenance requirements.

PDP summarise that there are numerous risks associated with the Ashley Aquifer option in particular related to potential issues around yields during summer periods (low groundwater). Furthermore, the assessment has been based on pumping tests from two locations within an aquifer system noted to provide highly variable yields. URS consider the Ashley Aquifer option has correctly been classified as a relatively high risk option and that further characterisation of the aquifer would be required if this option was to be pursued further.

2.3 Coastal Aquifer Option

The coastal aquifer is identified as incorporating both shallow and deep aquifers along the coastal strip of land between the Waimakariri River and the Ashley River. The area to the north of Lees Road (north of Kaiapoi) was deemed unsuitable for two reasons:

- Shallow and intermediate groundwater quality is variable and commonly unsuitable for drinking water supply; and
- Deep, productive aquifers have rarely been intersected to the north of Kaiapoi.

The coastal aquifer option therefore focuses on areas underlain by deep (>50 m), high capacity (>30 l/s) wells in aquifer systems that are deemed secure in terms of the DWSNZ (2005), in and around Kaiapoi and capable of supplying good quality water.

The Kaiapoi area is noted to contain similar geological and hydrogeological structure to Christchurch with a layered aquifer system present. The available well records indicate maximum yields occurring at about 80-100 m depth with a few wells up to 140 m deep producing significant yields of up to 100 l/s.

URS concurs with this approach to identifying the coastal aquifer option, and the assessment of Kaiapoi as a proposed target location.

2.3.1 Well Yield

In order to assess likely well yields PDP undertook a search of the ECan wells database which confirmed that there are more high yielding wells in and around Kaiapoi rather than north of Lees Road. In addition, recent investigations inland from the coastal aquifer at Bramleys Road generally intersected low yielding strata at depths greater than 50 m.

PDP state that further investigations of areas west of State Highway 1 are unlikely to produce high yielding wells. For this reason Kaiapoi was selected as the target area. Based on our understanding of well yields in the area and the hydrogeology of the Coastal confined aquifer system, URS consider the proposed target area to be appropriate.

2.3.2 Groundwater Chemistry

PDP present groundwater chemistry data from one well in Kaiapoi (M35/0834) which complies with the DWSNZ (2005) criteria. Whilst this is based on limited data, in URS's experience good quality water is generally produced from deep wells in the Kaiapoi area.

2.3.3 Preferred Well Locations

PDP confirms that the area around Kaiapoi has the greatest potential for locating the wells with a location to the west of Kaiapoi preferred due to pipeline construction considerations. An area of publicly owned land is identified for development of a well field. URS concur with this approach for well location.

2.3.4 Risk Assessment

As with the Ashley Aquifer option, PDP has undertaken a qualitative assessment of risks associated with the Coastal Aquifer Option divided into implementation and operational risks and assigned either a high, moderate or low risk rating.

The only high risk items noted are as follows:

- Infrastructure – length pipeline to maintain and ongoing pumping costs.

PDP then present the advantages and disadvantages of each option. In summary they recommend the following:

1) If an economic assessment shows that deep aquifers in the area on the western side of Kaiapoi provide a feasible water supply option for Rangiora, then it is recommended that further well development should take place in this area because it contains secure wells, characterised by high yields, with good quality water suitable for public supply purposes.
2) From a groundwater development perspective the area in and around Rangiora is less favoured for further well development because although it contains many wells, they exhibit only moderate yields, relatively low available drawdowns and are more likely than those in the Kaiapoi area to suffer from consenting and water quality issues.
3) Further discussions with ECan and the Community and Public Health Board should be undertaken prior to proceeding with the implementation of a preferred option.

URS concurs with these recommendations.

2.4 Appendix D – Summary of Aquifer Tests

2.4.1 Dudley Park Aquifer Test

The Dudley Park aquifer test was carried out by pumping well M35/0249 (screened 16.5 to 19.5 m) and monitoring M35/0252 (screened 16.6 to 19.5 m) and M35/4327 (5m deep) and M35/0361 (6m deep). The shallow and deeper wells are reported to be separated by layers of low permeability material.

The methods used to determine aquifer parameters for the deeper (16-19m aquifer) are considered appropriate and the results appear accurate. The determination of aquifer parameters for the shallow aquifer (~6m) are derived from drawdown while pumping the deeper aquifer. Drawdown levels over the test periods for the two shallow wells are less than 10cm. It is therefore very difficult to match a drawdown curve over a very small range.

In the absence of a pump test directly on the shallow aquifer, URS have reservations over the aquifer parameters obtained using drawdown effects of <10cm while pumping the deeper aquifer.

2.4.2 Stream Depletion of Dudley Park Abstraction

The report makes reference to the PDP/ECan Stream Depletion guidelines which states that stream depletion is unlikely to occur if the depth to groundwater below the stream bed is greater than five times the depth of water in the stream. As the depth in the streams immediately adjacent to the wells is only 0.05 m, and the depth to groundwater is 1.4 m, stream depletion is unlikely to occur.

Bower (1997), referenced in the Stream Depletion Guidelines (2000) states that the depth to groundwater needs to be two times greater than the width of the stream before stream depletion is unlikely to occur as the stream is perched above the water table. The width of the stream is not discussed in the report.

The stream depletion assessment on the North Brook (located 300m distant) does not specify the streambed conductance value used other than to suggest it is conservative. The stream depletion

rationale presented is for 150 days pumping. While this may be appropriate for an irrigation well, a longer pumping duration may be more reflective of a public supply well.

2.4.3 Step Tests on Dudley Park Wells

The step tests have been undertaken using standard procedures, and the results have been analysed using a recognised method. The results are however only applicable to the wells on which the tests were performed.

2.4.4 Ayers St Aquifer Test

The Ayers Street aquifer test was carried out by pumping well M35/0217 (screened 5.7 to 13.7 m) and monitoring M35/0216 (8.8m deep). The drawdown in the observation well only has been reported, while there is no reference to the drawdown from the pump well. This is surprising as the pump well data is very useful and would confirm the results from the observation well.

The calculations used to determine aquifer transmissivity have been checked and confirmed as accurate. A transmissivity (T) value of 5,100 m^2/day is high, however this is what is calculated from data. A potential explanation behind the high T value could be due to the observation well being shallower than the pump well and is therefore not experiencing the full drawdown effects. However, given the close proximity of the observation well, this seems unlikely. Presentation of drawdown data from the pump well would have confirmed the aquifer transmissivity derived from the observation well.

2.4.5 Interference Effects

The projections presented in the report are based on the aquifer parameters derived from the pump test. The drawdown assessment does not appear to take into account the reduction in drawdown in the latter part of the aquifer test or the potential for recharge during the modelled pumping scenarios (particularly 1000 days). Provided the aquifer parameters used are accurate, the predicted drawdown could be expected to be a worst case scenario.

2.4.6 Stream Depletion Effects of Ayers Street Wells

The assessment undertaken appears to be reasonable given the level of information available. The conclusion that the abstractions may be subject to minimum flow restrictions also seems reasonable.

2.4.7 Step Tests on Ayers St Wells

The step tests have been undertaken using standard procedures, and the results have been analysed using a recognised method. The results are however only applicable to the wells on which the tests were performed.

2.4.8 Bramleys Road Exploratory Well Step Test

The step test was undertaken using standard procedures, and the results have been analysed using a recognised method. The results seem accurate given the information presented.

2.4.9 Bramleys Road Exploratory Well Aquifer Test

The pump test was carried out on the abstraction well (screened 70.8-72.8m, 79.7-82.7m, 86.4-88.4m) with no observation wells available. The report made reference to a well 40m deep and 200m away which experienced water shortages during the testing. This has not been quantified but URS consider it may demonstrate that shallower wells have some hydraulic connection to the Bramleys Road exploratory well.

The calculations used to determine aquifer transmissivity have been checked and confirmed as accurate with a transmissivity (T) value of approximately 120 m^2/day.

2.5 Key Issues and Risks identified by URS

Based on our review of the available information and our knowledge of the groundwater resources of the Rangiora and Kaiapoi areas, URS has identified the following key issues and risks associated with each option.

2.5.1 Ashley Aquifer Option

Meeting Required Yields

The PDP report states, a number of times, that the shallow aquifer systems beneath Rangiora are highly variable such that yields from wells are also highly variable. The aquifer is recharged primarily from the Ashley River such that during periods of low flow (summer and/or drought) the aquifer recharge will be reduced. This will likely coincide with peak demand, and also may incur low flow restrictions as part of consent. In addition, future rainfall recharge is likely to be further reduced by increased urbanisation and development in Rangiora with increased runoff and reticulated stormwater systems.

The combination of the above issues are such that the potential for this option to not meet the required yield particularly at times of peak demand is considered to have a high level of risk.

Vulnerability to Contamination

PDP rate the risks of contamination from point source and non-point source (diffuse) contamination as moderate. In URS's opinion the risks are high given that half of the well fields would be located in unconfined aquifers within an existing semi-urban setting. Over the course of a 50 year period the potential for a contamination incident to impact at least one of the well fields is considered to be moderate to high. This would result in initial removal of the well field from supply followed by either contamination remediation or installation of additional treatment for the water supply.

Concentrations of contaminants resulting from diffuse sources (such as nitrate nitrogen) from agricultural activities upgradient of Rangiora also have the potential to increase. In either case, additional treatment (other than UV) of the water supply source may be required resulting in increased operational costs.

Land Availability and Restrictions on Use

The availability of locations for the proposed 12 well fields is limited given the requirement for use of either public reserve or WDC owned land. Furthermore, in order to be utilised as a public water supply, restrictions on land use immediately surrounding the well field and upgradient will apply.

Schedule WQL2 of the Proposed Natural Resources Regional (PNRRP) specifies how the protection zone of a community drinking water supply well is to be determined. The radius surrounding all wells less than 70 metres deep is specified at 200 metres regardless of well depth. For wells less then 30 metres deep, the protection extends a further 1,000 metres in an upgradient direction. Specific information regarding the potential for contaminants within the protection to enter groundwater is required for a resource consent application, while land use restrictions would apply once the protection zone was established.

Water Quality

PDP has correctly identified water quality as a potential issue for the Ashley Aquifer both in terms of demonstrating "secure" status and removal of turbidity prior to UV treatment. Ongoing monitoring costs associated with demonstrating compliance with the DWSNZ are likely to increase over time.

Within the lifetime of the project there may also be further increased statutory requirements on public water supplies requiring additional treatment, monitoring and/or infrastructure. Shallow sourced supplies

are more likely to require upgrading to meet additional requirements than supplies sourced from deep confined aquifer systems.

Consenting

Planning and consenting issues for the Ashley Aquifer Option are likely to be significant with issues related to potential effects on existing users, spring fed streams, the Ashley River and land use restrictions following the establishment of well protection zones. These issues may result in complex consent conditions and restrictive operating conditions for the scheme adding additional costs and time delays in securing the consents.

2.5.2 Coastal Aquifer Option

Well Interference

The potential exists for well interference to be an issue should a number of deep wells be drilled in the area proposed to the west side of Kaiapoi, as identified by PDP. Interference between the newly drilled wells themselves and also with existing deep wells in the area could however be mitigated by developing adjacent wells at differing depths within the layered system such that nearby wells are effectively hydraulically isolated from one another.

Infrastructure

Key issues related to infrastructure are the costs associated with construction of the pumping stations and pipeline to pipe water from the Kaiapoi area to Rangiora. This may involve pipework crossings of State Highway 1 with resulting costs and increased requirements to protect infrastructure from potential accidents or spills. These issues would be addressed as part of the scheme design and are outside the scope of this report.

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3.1 Demand Assessment and Construction

Population estimates provided in the MWH report are based on the WDC Long Range Future Population Model[1].

Water demand is based upon historical data extending back to 1970 along within a comparison of demand figures for other regions supply. The assessment looked at average daily demand, peak daily demand and instantaneous peak demand.

The design criteria for the supply system is to meet peak daily demands within the reticulation system, including provision of storage, designed to meet peak instantaneous demands including emergency storage and fire fighting requirements.

Assessed demands are in the 3.0m^3/connection/day and when reviewed with other demand figures for other regions this value was considered acceptable. The report states that the study used a maximum daily flow of 2.5 m^3/day with 0.4l/s /ha for commercial/industrial areas. It is assumed that there was approximately 31 ha of commercial industrial area in 2003 which equates to 3.0 m^3/day.

Demand is strongly linked to weather patterns and therefore there will be distinct regional variance and therefore review of demand figures for other areas needs to be undertaken with care. It should also be noted that there has been no consideration or discussion of climate change or variation in weather patterns and their impact. Climate change predictions indicate drier summers in the eastern districts. In addition to this, NIWA scientists have identified an additional weather cycle indicating that the 30 year period prior to 1998 may have been wetter than normal and that we have now moved into a cycle where there is increased potential for el niño weather systems and the associated drought. These two effects may result in an increase in the peak daily demand compared with historic data.

Forecasting demand out 50 years is highly problematic with any one of a number of variables having potential to change predictions significantly. While the demand figures used appear to be appropriate some sensitivity analysis would be worthwhile to identify the need for or extent of flexibility of demand in any water supply system.

The peak demand storage referred to in the MWH report was sourced from the Waimakariri District Long Range Future Population Model[2]. Insufficient information is provided to comment upon this beyond general review of the numbers which look appropriate.

The discussion of the options for the phasing of the construction covers the key issues and proposes an appropriate phasing approach for assessment.

3.2 Water Supply Options

The report discusses two options, namely the Ashley Aquifer Supply and a supply from the deeper coastal Kaiapoi aquifer system.

The options considered are likely to be the two most appropriate solutions with no obvious alternatives.

3.2.1 Option 1 Kaiapoi Well System

A summarised version of the hydrogeology and water availability for the Coastal Aquifer system based on the PDP report October 2005 is provided. This information includes a list of wells and takes including the proposed take for Pegasus township. It is understood that an alternative water source is being

[1]WDC Ref 04042200031 (2004)

developed for the Pegasus township and therefore the proposed well at the Kaiapoi golf course is no longer required, decreasing demand on the aquifer system.

The proposed well field is on the outside of the stopbank system for the Kaiapoi River. It is understood that this stopbank system is provided to protect against elevated water levels in the river as a result of high flows in the Waimakariri River. While it is anticipated that the risk of bank failure is low there does not appear to have been any consideration of this or general flood risk.

The discussions regarding treatment and the requirement for disinfection are considered appropriate.

Pipeline design

The pipeline route is similar to the recently constructed wastewater line and is the most direct route.

The outline design criteria for the pipeline have been provided and assume the use of polyethylene. The calculation method has not been provided, however, check calculations indicate that the design diameter of 630mm is correct but that this is the outside diameter rather than the inside diameter as stated in the body of the report. The option cost estimation has been based on the correct size.

The use of polyethylene (PE) has been adopted for costing purposes although the basis for this selection over PVC is not clearly defined. The use of PE is appropriate and PVC pipe may not be readily available in the larger diameters required.

Construction considerations include the ground conditions encountered. As a pipeline has already been constructed along the route details of conditions are well defined. It is noted in the report that groundwater is typical 1-1.5m below ground level and therefore pipe installation may require dewatering, however, groundwater levels in the area are seasonal and construction may be able to be timed to avoid elevated water level conditions. There is no specific allowance for dewatering in the cost estimates.

3.2.2 Option 1 a Kaiapoi Well system via two pipes to Rangiora

This is a viable alternative option for supplying water from the Kaiapoi site reducing the initial outlay and allowing some modification of sizing for the second phase if variations in forecast demand require.

Details of the outline design have not been provided in the report, however, using similar velocity and friction loss criteria the pipe sizing for costing purposes is appropriate.

3.2.3 Option 2 Ashley Aquifer Supply

The discussion for Option 2 clearly defines the issues with this option with regards water quality and security in accordance with NZDWS and although reliability of supply on a volumetric basis and potential for restriction on abstraction is also discussed, there is no quantification or definition of the risk. The shallow aquifer system is more susceptible to climatic effects and climate change and increased potential for drought could further reduce the capacity of this system to provide required volumes.

The MWH report provides for water treatment using Ultraviolet (UV) radiation. The treatment method, general layout of the treatment plant and storage requirements appear appropriate as does the well design.

The alternative Option 2 using treatment at each well is valid and there are potential costs savings on upgrading of reticulation.

3.3 Planning

The planning section appears to have identified all relevant planning requirements for the construction and operation for the various options.

3.4 Option Evaluation

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The tables setting out the advantages and disadvantages for the various options cover the main benefits of the options, however some are more significant than others and a number of these should be qualified. In particular, the reuse of wells of the Ashley source, as these wells require re drilling and refitting to achieve the required yields, therefore there may be no significant benefit beyond being more straightforward to consent. Furthermore, the assessed disadvantage of a single source for the Kaiapoi site may be offset by having wells at different depths to source the different aquifers.

3.5 Risk assessment

The ranking system for the various risks is relatively coarse which leads to some minor anomalies such as surety of volumes for both sites being the same. The accuracy of population predictions for 45 years into the future along with other factors affecting water demand is limited. However, as this affects both options equally this has no significant impact.

The score for robustness of technology in Option 2 is incorrect. It should be three rather than two and the overall risk rating for Option 2 increases to 30. This change has no substantive effect of the overall ratings.

3.6 Costs Analysis

The NPV discounting rate is considered to be on the high side as there is no allowance for inflation which should be subtracted from this. The discount rate is a combination of capital cost and inflation such that if the marginal cost of capital is 8% and inflation is 3%, a 5% discount rate should be used. Or alternatively, you must inflate your annual costs which has not been done.

The maintenance and operating costs reported in the document differ from those provided in the costing spreadsheets. The report specifies rates of 1% of capital cost for civil works and 4% for capital cost of mechanical works. Calculation values in the spreadsheet use 0.3% and 2% respectively. We would propose rates of 0.3% and 4% respectively, however, details of the breakdown of items into civil and M&E have not been provided and if civil items are predominantly pipework the a rate of 1% may be more applicable.

A numerical review was performed on the cost analysis section of the report (Appendix 3 – Option Costs).

The numerical review included a:

- Methodology check of the calculation procedures;
- Arithmetic check of spreadsheet calculations; and
- Comparative exercise of unit rate costs, multiplies, factors etc.

The calculation procedure is very standard. MWH have produced a capital cost summary and an operation and maintenance schedule, these are then combined into an overall (Net Present Value) NPV calculation. The bottom line figure (Capital costs and NPV) are presented in the report for option comparison.

A numeric check was performed for each key spreadsheet. This was accompanied by random checks (with focus was on high value items) on all spreadsheets attached in Appendix 3, The purpose of the check was to ensure the spreadsheet did not include any fundamental flaws and are all operating accurately. No numerical inconsistencies were identified.

The review of estimate rates is a high level review comparing values with recent tendered works and a general reality check where limited information was available or there was limited definition of the work item. Some issues were identified with specific line items, these included:

- Installation rates for pipes are the same for all diameters; and

- A small difference in rate between rural and urban installation costs is utilised, it is considered that the potential for disturbance and interference with services in the urban area would result in a greater variation in rate.

It is generally difficult to provide overall costings accurate to within +/- 20% at the initial feasibility stage unless the works are relatively well defined. While the rates used are likely to be within this range, a number of items have significant potential for variation and the 20% contingency may be light.

While the costs provided are suitable for option comparison and selection it is also considered that a project of this magnitude should have a risk based contingency assessment carried out. Such an assessment would provide a base estimate, expected estimate (mean) and a 95%-ile estimate could then be established. This would allow WDC's exposure to risk to be better established, both in cost and for the wider issues in implementing the work.

3.7 NPV Calculation

The option costing estimates have been based on 2005/2006 construction costs, however, the NPV calculations have assumed a base period of 2008 with no inflationary allowance in construction costs up to this period.

The NPV costs have assumed the total capital costs are incurred in 2008, and 2023 for the phased construction, however, design, consenting, tendering and construction will extend over a period of at least two years and the expenditure should be phased accordingly.

The report comments on sensitivity of the options to construction costs and operational costs, however, no calculations are provided to demonstrate the impact of these variations.

It is also stated that consenting for the Coastal Aquifer is arguably more complex than the Ashley Aquifer option. This is contradictory to the risk table provided earlier in the report. While it is likely that there are more aspects of work requiring consent for the Coastal Aquifer, issues are likely to be less contentious than those for the Ashley Aquifer option which will impact on surface water flows in the Ashley River.

Section 4 Pattle Delamore Partners - October 2006

4.1 Background

It is our understanding that the consultants brief associated with the new Smith Street well at Kaiapoi required the following matters to be addressed:

- Aquifer characteristics;
- Sustainable yield;
- Number and location of additional wells necessary to meet Rangiora's long term water needs; and
- Predicted long term effects on other wells.

4.2 Well Completion

The new Smith Street well was drilled to a depth of 154.4 metres and screened from 147.7 to 149.7 metres.

There is no discussion in the report as to why the well was drilled to this depth. This may have been to avoid drawdown effects on existing wells, or due to the shallower aquifers having insufficient thickness or inadequate yield. Although numerous high yielding wells in the Kaiapoi area are screened at depth of 100-110 metres, no discussions have been made regarding the availability of groundwater at these depths.

4.3 Testing Procedures

For the purpose of assessing the drawdown effects on existing wells within a confined aquifer system at Kaiapoi, a pump duration of three days is more than likely sufficient. The number of monitoring wells available gave an opportunity to provide conclusive results on well interference effects. While the data loggers from some wells did not operate for the full period of the test and therefore the data was not used in the final analysis, the remaining data was adequate to clearly support the conclusions drawn.

4.4 Interference Effects

The new well is significantly deeper than 5 of the 6 WDC wells used to supply potable water to Kaiapoi. The Porters Place well is screened from 130-136.2 metres and therefore has the greatest potential to be affected by the new well.

The conclusion that the new Smiths Street well is screened in a different aquifer to the existing Kaiapoi supply wells seems reasonable given that there was no drawdown observed in the observation wells, including Porters Place. Furthermore, the log provided for the new Smith Street well identifies grey pug, peat and clay bound gravels between 134.7 and 144.5 metres, which would be expected to act as a confining layer separating the gravel accessed by the Smith Street well from the shallower aquifers utilised by the Porters Place well and other Kaiapoi water supply wells.

Analysis

The method of analysis is appropriate for the nature of the aquifer and rate of drawdown observed. The aquifer transmissivity was verified at approximately 3,500 m^2/day, this is consistent with other derived transmissivity values for the Kaiapoi confined aquifer system.

Some of the assessment carried out in the report was conducted using a lower transmissivity value of 2,700 m^2/day. This value was based on the results of the step test, which is influenced by well performance in addition to aquifer characteristics. The constant discharge test would be expected to provide more accurate results given its longer duration, however the use of a lower transmissivity value provides a more conservative assessment (i.e. predicts greater drawdown effects).

4.5 Well Yield

The testing was undertaken at 70 L/s, due to sand entering the well at 90L/s. The step test showed that the well is capable of yielding significantly greater than 70 L/s, although a surface pump would be required. The well would however require redevelopment to allow for higher flows. Further development may also increase the artesian flow from the well.

As recommended in the PDP report, URS agree that a step test should be conducted after redevelopment to confirm well capacity and optimal pump rate.

4.6 Additional Well Requirements / Potential Effects

Drawdown effects between future Rangiora supply wells at Kaiapoi could potentially be reduced by screening the wells in different aquifers. The report does not discuss the potential to yield water from shallower aquifers despite the presence of high yielding wells at 110 metres and 130 metres. While wells at shallow depths would have an effect on the existing Kaiapoi wells, this is expected to be less than that induced by having all the Rangiora wells screened in the same aquifer and located within 200 metres of each other.

Through the use of surface pumps, the wells may be able to produce upwards of 90 L/s. With a demand rate of 348 L/s, this could potentially be met through the installation of a total of 4 wells. Testing to confirm well interference effects, and the use of multiple aquifers would likely be required.

Section 5 Discussion

5.1 Pattle Delamore Partners Limited (September 2005)

The PDP report has undertaken a relatively detailed review of the two options for development of groundwater resources as the future public water supply for Rangiora. The methods and assessment approach are considered valid, and the assumptions made within the overall assessment of each option are also reasonable. URS has also checked the key aquifer parameters derived from the pump testing completed at Ayers Street and Dudley Park and find these to be largely valid.

One of the key issues raised within the PDP report however relates to the known variability of the shallow aquifer system beneath Rangiora particularly with regard to its potential to supply a reliable yield. The assessment has relied on pumping tests undertaken at two locations with the derived parameters then used to predict likely effects and yields across the proposed 12 separate well field locations. Using these assumptions, PDP are not confident that the calculated peak demand could be met by the proposed 24 wells.

With this level of uncertainty and the risks associated with vulnerability to contamination, existing water quality issues, land use availability and restrictions, and potentially protracted consenting issues, the Ashley Aquifer Option does not appear attractive from a groundwater resources point of view.

The Coastal Aquifer Option at Kaiapoi is considered to represent a much lower level risk in terms of reliability of yield and future security of supply. Well interference effects can be mitigated by suitable well field and bore design.

Overall URS concur with the observations made regarding the two options, however consider that more emphasis on the potential lack of reliability and well security of the Ashley Aquifer option is warranted.

5.2 MWH (November 2005)

While some adjustments to the cost calculations have been suggested, the general configuration and materials selected for the schemes are considered appropriate. The specific suggestions made regarding the cost calculation are not expected to significantly alter the costs or affect their ranking.

The information provided while defining the issues does not provide a method of clearly ranking the options. A costing assessment identifying risks to variation in costing and the impact of adjustment of the NPV discount rate would more clearly define the option costs.

Beyond a recommendation that there should be public consultation before committing to one scheme there is no discussion of aesthetic quality of the water provided at the tap.

5.3 Pattle Delamore Partners Limited (October 2006)

Having reviewed the pump test analysis and interpretation, URS can confirm that the methods used are appropriate and hydraulic characteristics derived are within the expected ranges. Aquifer characteristics have been derived from the test well and appear to be accurate. However, no discussion of the characteristics of the shallower aquifers (100 to 140 m) which provide for the existing Public Supply in Kaiapoi has been provided. These shallow aquifers are proven to be high yielding and reliable in other parts of Kaiapoi and as a whole (if present) could form part of any future scheme.

Based on a well performance of 70 l/s and identified potential for 90 l/s, the required future daily average abstraction of 10,050 m^3/day could be achieved by 4 to 5 wells. Based on the regional hydrogeology and our understanding of the Coast aquifer system, URS consider the proposed total abstraction to be sustainable at this location for the long-term.

Due to operational anomalies, interference effects or the lack of, could not be established in some wells for the full testing period. However, there is adequate data to demonstrate a lack of interference between the Smith Street well and the Kaiapoi water supply wells. Of note is the absence of any interference effect in the Porters Place well which is the deeper of the pre-existing Kaiapoi wells.

Section 5 Discussion

Overall, URS consider that PDP have met the specific objectives set out in the consultants brief. It is noted that further evaluation of the availability of the resource in the shallower (100 to 140 m) aquifers could be considered if the council wished to further reduce the risk of well interference.

5.4 Conclusion

Based on our review of the three reports listed above, URS consider that of the options presented, the Coastal confined aquifer option provides for the most reliable public water supply with a significantly higher degree of well security. Furthermore, it is our opinion that if the cost implications of identified risks associated with maintaining the required yield and water quality over the next 50 years were quantified for the Ashley aquifer system, the cost differential between the two options would be reduced.

Section 6 Limitations

URS New Zealand Ltd (URS) has prepared this report in accordance with the usual care and thoroughness of the consulting profession for the use of Waimakariri District Council and only those third parties who have been authorised in writing by URS to rely on the report. It is based on generally accepted practices and standards at the time it was prepared. No other warranty, expressed or implied, is made as to the professional advice included in this report. It is prepared in accordance with the scope of work and for the purpose outlined in the Proposal dated 22 September 2006.

The methodology adopted and sources of information used by URS are outlined in this report. URS has made no independent verification of this information beyond the agreed scope of works and URS assumes no responsibility for any inaccuracies or omissions. No indications were found during our investigations that information contained in this report as provided to URS was false.

This report was prepared during October 2006 and is based on the conditions encountered and information reviewed at the time of preparation. URS disclaims responsibility for any changes that may have occurred after this time.

This report should be read in full. No responsibility is accepted for use of any part of this report in any other context or for any other purpose or by third parties. This report does not purport to give legal advice. Legal advice can only be given by qualified legal practitioners.