Before the Commissioner / Hearing Panel appointed by Canterbury Regional Council

IN THE MATTER OF	The Resource Management Act 1991
AND	
IN THE MATTER OF	Application CRC120223 by Christchurch City Council for a discharge permit to discharge contaminants (being stormwater) onto and into land and into water associated with the South West Area of Christchurch City.

Section 42A Officer's Report

Date of Hearing: 14 November 2011

Report of Paul Alexander Goff

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INTRODUCTION

1. Christchurch City Council (CCC) has applied for consent to discharge all current and future stormwater from the South-West Christchurch area (defined in Figure 2.11 of the Assessment of Environmental Effects ("the AEE")), with discharges to both land and surface water. Christchurch City Council (CCC) is applying for resource consent to discharge contaminated stormwater to land.

2. I am employed by Beca Infrastructure Ltd as a Senior Hydrogeologist. I hold a Master of Science Degree in Hydrogeology (Hons) and a Bachelor of Science Degree in Geography (Hons). I have ten years work experience in groundwater resource management, including four years with the UK Environment Agency, and four combined years as a consultant with Hyder Consulting (UK) Ltd and Marcus Hodges Environment (UK) Ltd.

3. My evidence has been prepared to support ECan in their determination of the CCC application.

4. My report will provide comments related to groundwater flow and level issues associated with the proposed stormwater mitigation scheme in the South-West Christchurch Catchment. Water quality and flood management issues have been covered elsewhere in the evidence of Lisa Scott (Groundwater Quality Scientist), Tony Oliver (Hazard Analyst), and Graham Levy (Integrated Catchment Management) respectively. I have therefore limited my comments to groundwater flow and level issues only.

5. My comments supplement the Overview Section 42A report prepared by Brent Hamilton.

6. I have read the *Code of Conduct for Expert Witnesses* in giving evidence to the Environment Court. I agree to comply with that code when giving evidence to the Hearing Panel in this matter. All my evidence is within my expertise and I have considered and stated all material facts known to me which might alter or qualify the opinions I express.

7. I have also read the joint *Christchurch City Council* and *Environment Canterbury* planning protocol for catchment-wide consents for stormwater discharges.

8. In the sections that follow I will outline:

   - Applicant's stormwater management philosophy and development proposed;
   - Overview of the Applicant's objectives;
   - Comments on the predicted changes to groundwater effects;
   - Review the Assessment of Environmental Effects;
   - Comment on mitigation and monitoring; and
   - Discuss proposed consent conditions.

SUMMARY

9. The South-West Christchurch SMP project area [the catchment] is found within the Christchurch-West Melton Groundwater Resource Zone. The catchment incorporates two rivers, and associated tributaries, known as the Upper Heathcote and the Upper Halswell Rivers. These areas contain contrasting topographic regions, namely the Port Hills to the east and the gently sloping Canterbury Plains to the west.

10. The Upper Heathcote and Upper Halswell catchments are characterised in the east by silty alluvium deposits overlying gravels, compared to coarser and free-draining gravel-dominated aquifers to the west.

11. Groundwater in the east is contained within a confined aquifer with artesian characteristics, and is unconfined to the west. Spring flow is thought to contribute significantly to base flows within Cashmere Stream and within tributaries of the Halswell and Heathcote Rivers.

12. The Applicant's mitigation strategy philosophy on surface water management is to "*adopt a system that will not exacerbate flooding in the receiving environment waterways*".

13. The basis of the Applicant's stormwater disposal options (for the Heathcote River and its tributaries) is derived from the *Heathcote River Floodplain Management Strategy*, '*which advocates soakage to ground in the Upper Heathcote catchment as mitigation, for new developments, where possible, and the preservation and possible enhancement of natural ponding areas such as Hendersons Basin*". The objective of the strategy is not to exacerbate existing flooding problems in the middle and lower reaches of the Heathcote River.

14. ECan do not currently have a flood management strategy in place for the Halswell River catchment. Christchurch City Council therefore propose an interim strategy expressed as '*not one drop more'* for the Halswell River so that there is no increase in flooding for the 2% AEP critical storm event.

15. Under the SMP, management of stormwater discharges is proposed by infiltration basins on areas overlying unconfined aquifers, and sedimentation basins and associated wetlands with downstream detention basins in areas with confined aquifers. In existing urban areas with insufficient stormwater management control, retrofitting of stormwater systems is being proposed to improve overall catchment conditions.

16. The Application discusses how the preliminary surface water management scheme is proposed to be implemented across each of nine surface water management areas (SWMA's) in South-West Christchurch.

General Overview

17. The investigation and assessment of predicted groundwater quantity effects is described in detail in Appendix E of the application [*Water Quantity Assessment*]. Appendix E provides the over-arching summary of surface-water and groundwater quantity technical support to the ICMP. It summarises the proposed receiving environment objectives and the outcomes of the Assessment of Environmental Effects.

18. The objectives presented on the groundwater-receiving environment (Appendix E, Section 4.5, pp 37) have been developed over a series of workshops and meetings with stakeholders, and are based on measurement of baseflow, identification of springs, and investigation and assessment of infiltration rates. The objectives set out in relation to groundwater quantity include:

(a) Protection and enhancement of groundwater recharge within South-West Christchurch;

(b) Avoidance of local groundwater level increases that cause drainage problems in urban areas; and

(c) Protection of springs that provide baseflow.

19. In terms of the assessment of environmental effects of groundwater quantity, Appendix E contains two sub-appendices prepared by Pattle Delamore Partners Limited [PDP] that outline in more detail the investigations and assessments undertaken, and that are summarised in the main application report.

(a) Sub Appendix B is entitled "G*roundwater Assessment for South-West Christchurch Planning Study September 2004"* [*Stage 2 Report*]; and

(b) Sub-Appendix C is entitled "*Groundwater Quantity Assessment for South-West Christchurch February 2007"* [*GQA Report*].

20. Changes in national and regional planning documents and the consented environment (i.e. *Central Plains Water Scheme*) have occurred since these PDP reports were prepared. It should be noted that PDP refer to infiltration basins where the Golders' *Water Quantity Assessment* (Appendix E*)* and AEE refers to the infiltration basins as soil adsorption basins which are one and the same.

21. The *Water Quantity Assessment* concludes that "*the assessment of groundwater effects predicts a net increase in groundwater recharge from rainfall of four percent across the entire project area as a result of the …. scheme. No adverse effects on springs and baseflow are predicted*".

Description of Receiving Environment

22. The *Stage 2 Report* provides an assessment of general groundwater, spring and baseflow conditions, and has been used as a preliminary tool to zone three areas for infiltration development potential (low, varying and high) and is used for the basis of a water balance assessment presented in the *GQA Report.* The *Stage 2 Report* includes:

(a) Investigation of groundwater levels and soil types in South-West Christchurch;

(b) Snapshot view of river and drain flows within the area;

(c) Investigation into the occurrence of springs and geological features; and

(d) Investigation into ground infiltration rates.

23. The key conclusions presented in the *Stage 2 Report* include:

    (a) "*Major springs are recognised within Hendersons Basin and in the Upper Halswell catchment"* which are "*important contributors to base flow in the Henderson catchment*";

    (b) "*There is drilling evidence of a complex relationship between localised lithological variation (thickness and lateral continuity) in the gravel strata and the prevailing water table conditions. Whilst general predictions concerning the suitability of gravel strata …. can be made, these should be confirmed prior to design, with an infiltration test"*.

24. The report reviews infiltration rates including existing information and presents the Applicant's own measurements of infiltration rates and depths to gravel. The These measurements of water infiltration rates were carried out by three methods depending on the soil type encountered, including trial pits, double-ring infiltrometers, and constant head tests. They conclude that "*the silty strata underlying much of the South-West Christchurch area have highly variable infiltration rates ranging from 2 mm/hour to 40 mm/hour*" and "t*he occurrence of gravels at shallow depths in some areas indicate that very high infiltration rates are feasible*"

25. The infiltration tests undertaken are limited to, at most, two tests at each site. Actual infiltration rates may therefore be less than reported, due to the progressive wetting up of unsaturated soils. The Applicant does however include a caveat that the use of soil maps in conjunction with geological data and on-site inspections is required before detailed zoning of infiltration is made and that "*further infiltration tests may be required as part of the detailed stormwater management planning process*".

26. Based on the Applicant's comments, presented information on infiltration should not be used for detailed design.

27. The Applicant's primary view of the hydrogeological conceptual setting is presented in the *GQA Report* and describes:

    (a) A catchment controlled by a confining 'low permeability' layer in the eastern part of the study area, which maintains artesian groundwater levels, and a more permeable unconfined gravel-dominated deposit to the west;

    (b) The recharge source of groundwater in the catchment comes mainly from rainfall infiltrating through soils in the western part of the city, from groundwater through-flow from more distant (westerly) areas, and some seepage out of the Waimakariri River to the northwest; and

    (c) Vertical hydraulic gradients between gravel layers tend to be downwards beyond the western margin of the SWAP area, neutral at the western end of the SWAP area and upwards at the eastern end of the SWAP area;

    (d) The depth to groundwater ranges from "about 15 m in the western part of the project area to less than 2.5 m at the base of the Port Hills. The depth to groundwater then decreases towards the east-south-east and groundwater approaches the surface in the area of Hendersons Basin". "*East of Wigram Road and Halswell-Lincoln Road area, the groundwater pressure in the confined gravel aquifer is close to or above the ground surface and the water table is less than 2 m deep*".

28. The application identifies that "*groundwater forms the major, if not total, contribution to the upper sections of the Cashmere Stream and the Heathcote and Halswell Rivers in the form of spring flow under baseflow conditions…"* and that "*any negative effect on base flow conditions could adversely affect stream ecology*".

ASSESSMENT OF ENVIRONMENT EFFECTS

29. The Assessment of Environmental Effects is summarised in Section 7 of the application and outlined in more detailed in Appendix E (Section 7). I firstly summarise the Applicant's key conclusions and then comment on these in terms of:

    (a) The Applicant's assessment of the changes in recharge and effects on springs and base flow; and

    (b) The Applicant's assessment of effects on groundwater levels, including mounding.

30. I note that the assessment is based on a proposed development scenario that has been determined by CCC. This scenario considers development 'possible for 2024 growth predictions'. I have not considered the appropriateness of the scenario adopted or potential effects beyond 2024 growth. This is discussed in the evidence of Graham Levy.

31. An outline of the key conclusions on groundwater quantity effects (presented in Appendix E, Section 7.3) include:

    (a) "*It is anticipated that there will be an increase of approximately 7% in groundwater recharge from rainfall over the unconfined aquifer. The overall increase in recharge from rainfall is 4% over the entire project area under the proposed development scenario. The total increase in flow through the aquifer as a result of the increased groundwater recharge from rainfall is estimated to be 2%*";

    (b) As a result of (a), "*this small increase preserves the groundwater balance for the area but is unlikely to have a significant impact on groundwater levels*";

    (c) "*The disposal of stormwater into infiltration basins is beneficial in areas of permeable strata and where there is sufficient depth to groundwater. Infiltration basins in these settings dispose of stormwater through the basin floor and can contribute to the maintenance of groundwater levels and baseflow into spring-fed streams*";

    (d) "*Groundwater modelling suggests there is a general increase in groundwater levels around the infiltration basins. This mounding is localised and short-term as the infiltrated water is also of short-term duration*";

    (e) "*In areas where there are existing drainage problems as a result of high groundwater, the additional increase in groundwater elevation for a short period of time may lengthen the period of time required to drain the area. Indicative modelling has demonstrated that increases to groundwater levels are short-term in nature and that groundwater levels are expected to recover between infiltration events*";

    (f) "*For infiltration basins with a large volume of infiltration or for infiltration basins located over areas with a shallow water table, the maximum mounding in relation to the highest groundwater levels will be below the basin elevation and that infiltration can be expected to be maintained*"; and

(g) "*The extent of mounding is limited and does not extend to more than 150 m beyond the basin footprint. Provided the basins are located no closer than 300 m from the nearest landfill, the inundation effects into the landfill are expected to be of a minor nature*".

Groundwater Recharge

32. The Applicant's key conclusion on recharge is based on a simplified water balance, to assess changes in water inputs and outputs from the hydrological system. Little consideration has been given by the Applicant to the catchment-wide effects on the receiving environment. This is also recognised in the URS peer review report (Appendix H).

33. The Applicant has assumed an equivalent recharge rate of 289.5 mm/yr across the catchment (compared to the total yearly rainfall of about 700 mm) irrespective of variations in the soil and geological conditions.

34. Whilst I accept the Applicant's use of a simplified assessment to predict the increased recharge of 59% in unconfined areas (*GQA Report*, pp 11 to 13), I do not consider that the method correctly establishes the magnitude of effects resulting from development in confined areas, which assumes a reduction in recharge. The applicant's conclusions may therefore mask any consideration of potential long term adverse effects across the catchment.

35. To support my views I have outlined the Applicant's assessment below in terms of unconfined, confined and average recharge effects.

Recharge to Unconfined Areas

36. In determining the change in recharge associated with unconfined areas, the Applicant assumes that currently 42% of the actual rainfall enters groundwater, either at the development site or where the runoff is collected and disposed via infiltration. The rainfall-recharge ratio adopted, while consistent with published studies for the area, is at the high end of that range and is markedly higher than modelled results for the Central Plains[1]. The result would overestimate the volume of recharge to the aquifer system.

37. The Applicant has broken the development area down into three land use types. For residential areas, it is assumed that 55% of the land is pervious, while for industrial areas it is 10%. In areas where infiltration basins will be used to manage stormwater (predominantly within the unconfined catchment) it has been assumed that 80% of runoff from impervious areas is redirected to a basin, with the remaining 20% removed from the system ("*either through evaporation, collection in depressions or soakage into pavement").*

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[1] Williams *et al.*, 2008 *Adaptive management of groundwater in the Rakaia-. Selwyn Groundwater. Allocation Zone: technical and implementation issues*. Report No. R08/64.

38. Based on the above assumptions, the predicted change in groundwater recharge over unconfined areas is reported as follows:

Condition	Area (ha)	Groundwater recharge – undeveloped (current) (m^3/year)	Groundwater recharge – proposed development (m^3/year)	PDP percent change in recharge (reported)
Catchment areas where stormwater infiltration will occur (unconfined areas)				
Over proposed residential areas	258	747,000	1,051,000	+59%
Over proposed industrial areas	205	594,000	1,077,000	
Parks and rural areas	322	932,000	932,000	-
Total	785	2,273,000	3,060,000	+35%

39. I consider that the percentage change proposed by the assessment is reasonable and likely to adequately reflect the increase in recharge in unconfined areas following development.

Recharge to Confined Areas

40. I do not agree with the Applicant's assessment on recharge over confined areas of the catchment (*GQA Report*, Table 2).

41. Calculations used to assess the change in groundwater recharge *'over proposed and residential areas to basins with discharge to streams/wetlands*' (confined areas) are not provided. Based on an assessment of values presented, this leads to my understanding that the equivalent rainfall-recharge ratio assumed by the Applicant's consultant would be 42% (as used for unconfined areas). If my understanding is correct, such magnitude of recharge cannot be logical due to the impervious silty nature of the soils.

42. Recharge to confined parts of the aquifer system relies on areas where the confining layer is absent, or where leakage across a confining layer occurs. In the latter case, the vertical hydraulic conductivity of the confining layer, the thickness of the confining layer and the head difference across it will control the amount of recharge. No information on the potential for leakage or the recharge volume in the confined zone is given.

43. As indicated in the *GQA Report*, the less permeable deposits found in the eastern part of the catchment will therefore be much more susceptible to runoff and evaporation loss processes and will not provide the extent of recharge found in the more permeable western areas, which conflicts with the Applicant's other view. Recharge in the confined part of the catchment is expected to be significantly less than reported. In general, the proposed use of settling basins and wetlands in the confined area to manage the volume and rate of runoff to the water courses means that the infiltration rate would likely remain unchanged.

44. To support this view I present the following as an indicative example of comparative changes in recharge over confined areas. I adopt the Applicant's assumptions (as given above) and assume my own 'alternative' recharge condition; in which 10% of total rainfall contributes to recharge in the confined part of the catchment pre-development and 15% post-development (i.e. allowing for limited recharge in confined

areas pre-development, with a subsequent increase in recharge following development due to construction of retention / detention basins and longer surface ponding residence times).

Condition	Area (ha)	Groundwater recharge – undeveloped (current) (m^3/year)	Groundwater recharge – proposed development (m^3/year)	Percent change in recharge (my assessment)	PDP equivalent percent change in recharge (reported)
Catchment areas where stormwater basins will discharge to streams/wetlands (confined areas)					
Over proposed residential and industrial areas	414	285,000	427,500	+50%	-45%
Parks and rural areas	928	640,000	640,000	-	-
Total	1,342	925,000	1,067,500	16%	7%

45. My alternative scenario suggests that recharge over confined developed parts of the catchment could be 50% above that of natural baseline conditions and significantly greater than assumed by the Applicant.

46. Following the initial application in 2008, the Applicant was asked to supply additional information on the recharge characteristics of the confined area of the catchment in support of their conclusions. In response (dated 13 August 2009), the Applicant acknowledged that '*some issues remain with the water balance*' presented, but maintains that '*no reduction in recharge is predicted and that therefore the adverse effects will be less than minor or positive*.'

47. I do not consider that the magnitude of any change has been reliably defined by the assessment presented and that increases in recharge display a positive effect in all situations. It is noted that the latest application recognizes that local differences are possible.

Cumulative Effects

48. The Applicant has considered the cumulative effects of changes to overall recharge across the unconfined and confined parts of the catchment, which I have summarised below. Based on my own assessment, it also includes changes to recharge in confined areas.

Condition	Area (ha)	Groundwater recharge – undeveloped (current) (m^3/year)	Groundwater recharge – proposed development (m^3/year)	Comparative percent change in recharge	PDP equivalent percent change in recharge (reported)
Total Catchment Wide Effects					
Over all proposed residential and industrial areas in catchment	877	1,626,000	2,699,000	+66%	+10%
Over all proposed changes in catchment area	2,127	3,198,000	4,127,500	+29%	+4%

49. The comparison presented indicates that when considering my scenario, the difference in the predicted overall effect of recharge, for pre- and post-development conditions, would be an increase of around 30% over the entire catchment. Although my calculations are not presented, even when assuming a lower rainfall-recharge ratio (e.g. 20% - 30% instead of 42%), the change increases as the adoption of infiltration basins assumes a larger proportion of rainfall is redirected to the aquifer system.

50. The result serves to highlight the importance of gaining a clear understanding of the hydrogeology, and inputs and outputs to the system when assessing the water balance.

51. My assessment shows that the change in recharge across the catchment could be significantly greater than 4%, because any change will be primarily driven by an increase in recharge due to the adoption of infiltration basins and not a loss of recharge in confined areas, the latter of which will be controlled by runoff. The main influence on groundwater through-flow and levels in unconfined areas is recharge, which (with an estimated increase of about 35 %) is likely to result in higher sustained groundwater levels than currently occur and ultimately larger spring and river base flows. The risks associated with any increase in recharge will be:

   (a) Reduction of the thickness of the unsaturated zone and associated impact on infiltration basin capacity including localised flooding during winter or wetter periods;

   (b) Recurrence of existing springs and development of new ones in unconfined areas of the catchment, and more active artesian springs in confined parts; and

   (c) Exacerbation of flooding within the catchment due to an increased proportion of baseflow and reduction of stream capacity.

Changes to Recharge

52. In the latest application/submission, the Applicant has (in part) taken on board my view and discusses the possibility of localised increases in groundwater recharge and higher seasonal groundwater levels. Should localised increases in groundwater recharge and higher seasonal groundwater levels become evident and there are adverse effects (refer proposed condition 13), the Applicant states in Section 7.2.2 of the AEE that they have an option to convert some adsorption basins to simple sedimentation basins and redirect stormwater as surface water discharges, to reduce recharge.

53. The Applicant notes that they have assessed the theoretical effects of increasing the volume of water treated via sedimentation basins using the Heathcote River hydrological/hydraulic model. They conclude that "*an additional constant flow of 200 L/s to the Upper Heathcote River could result in a relatively small increase in water levels downstream, above those expected for a 2% AEP design storm with full mitigation*".

54. The details of modeling undertaken and the rationale for applying 200 L/s in the assessment are not provided; however I note that the additional flow of 200 L/s is equivalent to the total proposed infiltrated flow to the entire unconfined catchment. The assessment considers converting the Awatea facility from an infiltration basin to a sedimentation basin, which "*represents close to 50% of the total infiltration surface area*" and I can only presume that they have done this to consider the worst case position of zero recharge to the unconfined aquifer.

55. The Applicant's response to the Section 92(a) request includes additional discussion (not covered in the AEE) on what constitutes suitable mitigation to address uncertainties regarding the effects of change in recharge patterns arising from SWAP stormwater management systems (Question 4). They discuss the need for groundwater monitoring and adoption of an adaptive management approach to increase/decrease infiltration as necessary.

56. The Applicant has also considered (Section 92(A) response – Question 5) suitable mitigation for the Halswell Drainage Scheme where changes to baseflow occur. They conclude that "*they can be managed by the same approach applied to the potential variability in groundwater recharge*" – i.e. an adaptive management approach to increase/decrease water directed to surface waterways. The Halswell catchment is within a confined section within the SWAP area and baseflow is reported to be "*more related to the upwelling of water from the wider aquifer systems*". If this is the case, diversion of water from basins to surface waterways will likely be possible, but direction of flow into rapid soakage chambers will not be possible due to the positive pressure head.

Concluding Remarks

57. While I concur with the Applicant's conclusion that an increase in recharge will occur (based on the proposed scheme), the magnitude of groundwater level rise and associated effects has not been adequately determined.

58. The Applicant has looked to address the potentially adverse effects from changes in recharge and groundwater levels, by assessing an alternative mitigation scenario that would re-divert all infiltrated flow in the unconfined catchment to surface waters. I consider that by re-diverting all recharge from the unconfined catchment the opposite effect would be caused, with a lowering of groundwater levels and reduction in associated spring and base flow.

59. The Applicant has also considered alternative mitigation for maintaining base flow conditions in the Halswell catchment.

60. The assessment of mitigation effects presented in Appendix E provides an important conclusion and indicates that mitigation can likely be adopted (where appropriate) to address potential flooding issue. In my view, the current assessment is not adequate to assess the potential effects and a fine balance will be required in monitoring of groundwater levels and management of the stormwater catchment. It is noted that the outcome of this assessment is omitted from the over-arching AEE document.

Groundwater Level Effects

61. The Applicant identifies that an ‘overall’ increase in recharge will result in a change in groundwater levels in the study area and that this is expected to result in mounding in the vicinity of infiltration basins (*GQA Report*, pp 14 to 17).

62. To assess the potential for mounding, a generic and simplistic analytical method, based on the Boulton solution, was used. The assessment considered the effects from the two types of infiltration basin proposed in the unconfined part of the catchment (‘first flush’ and ‘detention’) and the following scenarios:

    (a) Basins with large volumes of infiltration;

    (b) Basins over areas with a high groundwater table;

    (c) Basins located close to landfills; and

    (d) Long-term impacts on groundwater levels.

63. The key conclusions derived from the assessment were that:

    (a) Mounding occurs beneath infiltration basins containing large volumes of detained water, but remains within 150 m of the basin footprint; the maximum mounding beneath this type of detention basin is stated to be around 3 m;

    (b) Infiltration over areas with shallow groundwater is still possible;

    (c) As the specific landfill site considered was already inundated with groundwater, the impact of a small increase in water levels predicted due to mounding is small;

    (d) Modelling shows that the extent of mounding in the long-term, when continuous infiltration over an entire year is considered, is within 500 m of the basin footprint; and

    (e) Increases in groundwater levels are considered to be ‘*short-term in nature and that pre-infiltration groundwater levels are expected to recover between infiltration events*’. I have interpreted this to indicate that groundwater levels are expected to recover before the next infiltration event occurs.

64. I comment on these conclusions in the following sections.

65. The assessment focuses on the effects from individual infiltration basins rather than specifically assessing cumulative long-term effects within the catchment.

Mounding Effects

66. I agree with the Applicant's view that mounding will occur as a result of adopting infiltration basins. However, I have a number of concerns with the conclusions reached on mounding.

67. The Applicant's key conclusions were determined by adoption of published aquifer properties typical for the Christchurch-West Melton Groundwater Catchment (Transmissivity = 1,000 m^2/day, Storativity = 0.03) and the infiltration design rate associated with basin types proposed (20 mm/hr over two days for first flush basins and 20 mm/hr over seven days for detention basins). Assumptions on anisotropy are not presented, and so I presume that the analytical solution used by the Applicant does not account for variations in vertical and horizontal hydraulic conductivity [K]. Consequently, if the vertical K_v is less than the horizontal K_h (this is the usual case) mounding will be under-predicted. As already identified in the URS Peer Review (Appendix 9) the Applicant has not undertaken sensitivity analysis in their assessment of mounding effects.

68. Maximum groundwater levels are reported to be in the order of 3 m to 4 m below ground level and mounding magnitude to be 2.35 m. Firstly, I consider it remiss that the model used can establish mounding effects to a precision of +/- 5 cm. Furthermore, any variation in predicted mounding effects due to differences in K value or variations in existing water levels in some areas, (such as perching) could mean that the infiltration basins would not function as expected. Furthermore it appears that the applicant has assumed that infiltration occurs at the existing ground surface. As basins are likely to be excavated to below the ground surface, the available infiltration zone would be less and may be insufficient.

69. The applicants' evidence is based on modelled outputs from the Boulton Solution; the results of which are presented in a number of figures (showing the extent of mounding) with only a qualitative description on how they were generated (*GQA Report*). I consider that there is insufficient detail contained within the report to review the assessment of mounding effects presented.

70. The Applicant was requested (via Section 92(A)) to provide further detail on the methodology and assumptions used in their modelling approach. In their response (dated 12 August 2009) no additional information was supplied. The Applicant maintains that the modelling undertaken is appropriate and that although a sensitivity analysis could have been undertaken, the applicant considers that an extensive monitoring and maintenance plan will be adequate to address any uncertainty around the heterogeneity associated with the aquifer system and variations in water levels.

71. I consider that the Applicant's suggestion that monitoring and maintenance will be sufficient to mitigate design flaws is short-sighted. In the event of a basin failure, or where groundwater effects cause exceedance to receiving environment objectives, any attempt to retrofit discharge structures to improve conditions would likely be very difficult.

72. The Applicant has only qualitatively considered the cumulative mounding effects from episodic infiltration basin use (*GQA Report*, Section 6.1, pp 20). They point out that as the modelled effects of groundwater level rise from individual basins are localised as well as being short-term in duration, there is no need to assess the cumulative mounding effects, as long as a conservative approach to identify the separation distance between basins is adopted. The approach proposed is based on doubling the modelling estimates of maximum mounding extent, from 150 m to 300 m separation distance from the edges of the basin footprint.

73. The Applicant considers the extent of mounding as a consequence of infiltration through the basin from single rainfall events and does not consider multiple events within the groundwater mound recession period. If the Applicant's approach to establish the long term extent of mounding is correct, and mounding extends 500 m (1 km if doubled) from the basin footprint, the overall rise in groundwater levels across the catchment could be substantial as a number of proposed basins are in close proximity.

Long Term Effects

74. The Applicant modelled the mounding of groundwater beneath a high rate infiltration basin at a single site, assuming continual infiltration over the year (*GQA Report*, pp 17-18) to assess long term effects. The infiltration rate used is reported to be equivalent to the total volume expected to be applied in any one year. The infiltration rate assumed is not identified and operation beyond one year is not considered. The Applicant concludes that the extent of mounding extends up to about 500 m from the basin footprint.

75. As I have stated above, the details of modelling and inputs used are not provided and I am therefore unable to verify the conclusions presented. It appears that the Applicant has not recognised the recharge mechanisms associated with aquifer replenishment, i.e. that recharge occurs for a number of months throughout the winter period when evapo-transpiration rates are at their lowest. As the Applicant has smoothed the effect over a longer period, I consider that the magnitude of the long-term (seasonal) effect predicted would be greater than presented. Mounding effects could therefore extend over a distance greater than the 500 m predicted.

General Increase in Groundwater Levels

76. I do not agree with the Applicant's statement that increases in groundwater levels will be short-term in nature and that groundwater levels are expected to recover between infiltration events. Although I agree that individual recharge events are likely to be short-term in nature and that the peaking effect will be short-lived, an increase in recharge across the catchment will increase groundwater levels and establish a new (higher) baseline condition. As discussed above; the duration, nature and extent of the recharge season will therefore dictate the seasonal magnitude of groundwater level rise, which could have an impact on infiltration basin siting and design.

77. There is insufficient information presented in the application to verify the Applicant's findings.

Potential Impacts of Land Settlement and Underground Services

78. I do not consider land settlement to be an issue as more water is to be introduced into the underlying aquifers.

79. I agree with the Applicant's proposed approach that trenches used for the installation of underground services be backfilled with material that is similar in permeability to the original excavated materials.

Summary Remarks

80. The assessment presented by the Applicant suggests that adoption of infiltration basins in areas of 'shallow groundwater' could be at best marginal. It is likely that a widespread increase in groundwater levels will occur as a result of the increased recharge planned. Where mitigation is taken to re-divert infiltrated flow (to mitigate

any effects of increased recharge), the effects have not been assessed by the applicant, however any reduction in recharge could affect spring and base flows.

81. I consider that any proposed basin site will need to be carefully investigated and specific designs established prior to construction and modified as necessary during construction as new knowledge of the sub-surface conditions is gained.

82. The investigation and analysis reported is insufficient to allow the magnitude and long-term significance of some of the effects to be identified.

83. The Application does not consider the cumulative effects from catchment-wide implementation of infiltration (or soil adsorption) basins. In particular the effects of mounding, seasonal rainfall events and groundwater level rise. The potential for interference effects between infiltration basins is not adequately recognised in the Applicant's conclusions. The Applicant is proposing groundwater monitoring conditions to address the knowledge gaps and limitations of the submitted assessment of environmental effects.

MITIGATION SUGGESTED BY APPLICANT

84. The Applicant's understanding of mitigation provision (Appendix E, Section 6) has reportedly been based on the *Heathcote River Flood Management Strategy* and the CCC-adopted surface water management objective of '*not one drop more*' for the Heathcote and Halswell rivers, to maintain or improve the status quo of their river flood levels.

85. The Applicant considers that the receiving environment objectives can be achieved through temporarily increasing groundwater levels, promoting groundwater recharge, protecting springs that provide baseflow, and 'ensuring' infiltration and soakage systems maintain their design infiltration / soakage rates.

86. The new application has been revised to include recognition that where groundwater level effects exacerbate flooding, the objectives can be met by converting infiltration basins into sedimentation basins, or vice versa.

87. To achieve the objectives the Applicant has suggested the following mitigation measures, which have been transposed into a number of proposed conditions:

    (a) Monitoring of infiltration rates in a number of representative infiltration basins to determine the required frequency for soil remediation and/or replacement; and

    (b) Monitoring groundwater levels at existing monitoring bores downstream of a selected representative number of soil adsorption basins to validate modelling predictions.

88. The Applicant considers that groundwater quantity effects as a result of their proposals are readily mitigated by virtue that they maintain groundwater recharge or can be readily mitigated. However, the basis for mitigation proposed plays down any potential effects resulting from basin failure (for example) or spring and baseflow change due to the potential changes in recharge and is focused on a reactive approach. I consider that there remains uncertainty as to the suitability of basins in some areas and that further understanding on the long-term effects is required.

89. In my opinion, a pre-requisite to designing any infiltration system is to evaluate whether a site has sufficient capacity to assimilate water in excess of natural

infiltration rates before it is constructed. A catchment-wide assessment is also preferred to facilitate understanding of how changes to baseline conditions will be affected by the catchment-wide stormwater management approach proposed.

PROPOSED CONDITIONS

90. The proposed consent conditions are found in Section 12 of the Application (p 71) which were subsequently updated with the s92 response. In terms of groundwater quantity effects, the key components of the conditions are:

    (a) Conditions 7 to 10 outline proposed water quantity objectives.

    (b) Conditions 11 to 12 define the need to prepare and agree a Monitoring Programme before first exercise of the proposed consent.

    (c) Condition 13 to 15 sets out trigger points and requirements for responding to adverse monitoring.

    (d) Condition 16 establishes reporting requirements.

91. The proposed water quantity objectives in Conditions 7 to 10 are focused on flooding and attenuation design issues. Given the uncertainty in catchment wide effects, I recommend that the conditions include a water quantity objective on spring flow and base flow to protect river flows during the drier months and in the event that recharge is reduced.

92. I propose that Condition 11 be rewritten to state that the Monitoring Programme shall be "*to investigate the effects of stormwater discharges on groundwater levels, <u>spring flows</u>, groundwater quality, surface water quality, the ecology of surface waterways and soil quality.*

93. Condition 13 refers to development of "*a remediation programme to reduce the amount of stormwater discharging to ground*". Whilst the applicant does not provide an indication of what remediation would include, the application discusses converting infiltration basins into sedimentation basins. I consider that there is a risk that this could result in a reduction in spring flows and base flows during drier months. I therefore suggest that this condition should include a requirement to assess the effects of remediation proposed prior to implementing mitigation.

94. Condition 16 sets out the requirements to provide an annual report that summarises the results of monitoring and any responses undertaken. I recommend that a sub-condition is included that requires CCC to notify ECan if evidence of an effect is established prior to the annual report being submitted.

95. In addition of the conditions proposed in my opinion I consider it important for a general design and construction management plan for each proposed facility be prepared. A suitable condition should be provided to include provision to assess the condition of soils and subsoils, infiltration rates and groundwater levels associated with each facility prior to its design or construction. The investigation work undertaken to date is limited, and does not provide sufficient detail to support site-specific facility design.

Monitoring Programme

96. In accordance with proposed Condition 11, a Monitoring Programme has been drafted and is included with the application as Appendix J and subsequently updated with the s92 response as revision 1.0. My comments in relation to the Monitoring Plan are as follows:

(a) The proposed groundwater level monitoring programme includes the use of existing wells within the catchment to determine the cumulative long term effect of discharging stormwater to land. I consider that the monitoring locations are well spread throughout the catchment, both up and down gradient of proposed basins.

(b) Groundwater level monitoring is proposed at three mitigation facilities that discharge stormwater into land. It would be useful at this stage to identify which three facilities will be monitored or to include an allowance to agree with ECan which mitigation facilities will be monitored.

(c) The number of monitoring wells at each facility has not been specified. The monitoring programme should be updated to include minimum monitoring requirements with an allowance to monitor up, down and across-gradient conditions. Where commissioned facilities are in close proximity to one another, additional monitoring would be recommended to assess any interference effects.

CONCLUSIONS

97. I generally agree with the Applicant’s statements on the following issues:

(a) There will be an increase in recharge resulting from the proposed development, in particular for the western unconfined area;

(b) There being no adverse effects (in terms of reductions) on springs and baseflow, as a result of (a); however there would likely be increases;

(c) Discharge of stormwater to ground will contribute to groundwater level and spring flows;

(d) There is unlikely to be any land subsidence or settlement as a result of urban development; and

(e) Potential groundwater level impacts following installation of underground services can be avoided by adoption of suitable mitigation.

98. I disagree (in part) with the Applicant’s conclusions about:

(a) Recharge and preservation of the groundwater balance resulting from development. (I do not accept that recharge across the confined part of the catchment would be as predicted);

(b) Mounding beneath infiltration basins. (In my view mounding may have a significant impact on the performance of infiltration basins in critical areas);

(c) Short-term, localised increases in groundwater levels around infiltration basins. (I consider that the catchment-wide effect as a result of (a) and proximity of infiltration basins to one another could result in a longer-term cumulative increase in groundwater levels).

99. I am unable to adequately review the Applicant's findings on impacts from mounding, cumulative, and long-term impacts on groundwater levels due to insufficient information provided within the Application.

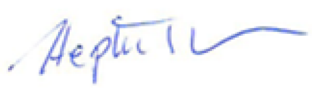
100. I consider that an adequate groundwater level monitoring programme and consideration of effects is important to assess the potential impacts of the proposed mitigation facilities (in isolation and cumulatively).

101. I consider that a good understanding of the change to recharge is critical to establish the catchment-wide effects on groundwater levels and how this might affect spring and base flow to rivers, and the performance of existing and future stormwater systems.

Signed: ________________________ Date: 26 October 2011

Paul Goff
Senior Hydrogeologist

Reviewed by:



Signed: ________________________ Date: 1 November 2011

Stephen Timms
Principal Consents Planner