Response to the comments of Anonymous Referee #1

We would like to thank anonymous Referee # 1 for his/her valuable comments. Our responses are:

General Comments

The evaporation rates presented in the paper are higher than they were supposed to be. The corrected evaporation rates are 125 – 200 mmmonth^{-1} for summer and 0 – 40 mmmonth^{-1} for winter respectively (BOM 2013). This corresponds to 0.0060 mday^{-1} and 0.0013 m day^{-1} for summer and winter respectively. We have recalculated the groundwater fluxes using these correct values, and the fluxes only change by a maximum of 14%. The overall interpretation of the data remains similar.

The reported standard deviations of groundwater radon activities were incorrectly typed. The corrected standard deviations are 29400 Bq m^{-3}, 7500Bq m^{-3} and8400Bq m^{-3} for the upper, middle and lower catchments respectively. The correct standard deviations were used in the originalcalculations.

The spatial variation of chloride concentrations of groundwater is different to that of radon activities of groundwater. As a result, the chloride concentrations of groundwater used in the calculations are based on the distance downstream of the uppermost sampling site rather than assigning a value to the upper, middle and lower parts of the catchment as is indicated in Line 6 – 7, Page 5242. The quoted average chloride concentration of 45mg L^{-1} is corrected and is used for the area between 65 and 127 km which covers lower portion of middle catchments and upper portion of lower catchment. The reversed paper will make it clear in both text and table 2.

All terms and calculations in the revised paper will be checked to ensure their correctness.

Specific Comments

Abstract and Introduction

Page 226, Line 17: “in” will be inserted in “can result fluctuating”.

Page 5227, Line 9: “loosingstreams” will be changed to “losing”.

Page 5227, Line 19: The thesis reference will be removed.

Page 5228, Lines 8 – 10 and Line 13 – 17: Page 5228:We will cut down the references and emphasize the significant papers.

Page 5229, Lines 11 – 12: The term “Millennium drought (2001 – 2009)” will be used. Major regional flooding in Victoria, such as 2010, occurs on average 10 to 20 years (Comrie 2011). This statement will be included in the revised paper to assist non-Australia readers in understanding the context of this paper.

Page 5229, Line 16: The missing word “distribution” will be inserted into “temporal of GW-SW exchange”.

Study Area

Page 5231, Lines 2 – 4: “out crop” will be change to “outcrop”, “slit” will be changed to “silt” and rubbles will be changed to “cobbles”.

Page 5231, Lines 6 – 8: The misspelt word “Coonambnidgal Formation” will be corrected. The correct spelling is “Coonambidgal”.

Page 5231, Lines 12: The incorrect grammar will be corrected, from “fragment” to “fragments”.

In reply to the suggestion of stating that all three formations are not really distinguishable but the literature suggests they have differing hydraulic conductivities. The two major formations do have some differences, for example the Calivil Formation consists predominately of sand with lenses of kaolin and carbonaceous clay while the Shepparton Formation and the Coonambidgal Formation have a matrix of clay, silt and silty clay with lenses of sand and gravel. This leads to a difference in hydraulic conductivity. However, the formations grade into each other and the boundaries between them are not well defined. We will clarify this in the text.

Page 5231, Lines 19 – 20: The statement “head gradients are usually downwards” indicates that the vertical component of groundwater flow throughout the Ovens catchment is downwards, implying that overall the area is a recharge area. The only exception is areas within a few tens of metres of the river in the upper and middle catchment where there is an upward vertical gradient. The sentence will be rewritten to increase clarity:“The vertical head gradients throughout the Ovens catchment are downward except for few locations within a few tens of metres of the river in the upper and middle catchment where they are upwards. The regional groundwater flowis to the north or northwest parallel to the major valleys.”

Page 5232,Line 2 – 4: See General Comments above.

Results

Lines 4 –11, Page 5236 A Piper diagram may provide a visual representation of the chemical composition of groundwater in the Ovens Catchment. However, we feel that it does not value to the discussion of the paper.

Page 5237, Line 10 – 14: The sentence will be changed to assist the flow. The correction will be “from immature sediments in the alluvial valleys, containing abundant U-bearing fragments of granitic and metamorphic material, to more mature, weathered sediments on the plains that are dominated by quartz and feldspar.”

Page 5237, Lines 14 – 16: The difference in groundwater radon concentrations between the sampling rounds was not statistically tested. This will be addressed in the revised paper.

Discussion

Page 5237, Lines 21 – 24:Surface runoff can provide a means of physical weathering, which assists in chemical weathering. The statement explains that high Na/Cl ratio in the river samples from the upper reaches are probably caused bysurface runoff and throughflow containing a relatively high amount of dissolved ions resulted from the combination of physical and chemical weathering of silicate minerals on land surface or in the unsaturated zone within the upper catchment. To clarify this point, the sentence will be rewritten.

Page 5238, Lines 10 – 11: The statement does not just apply to the Ovens catchment but also other catchments in Australia and globally. Major ion chemistry is often measured in many surface water and groundwater studies, while river discharge is routinely recorded by state and local governments to monitor water balance in catchments. Many of these data are increasingly accessible to the public via internet. However, radon is still not routinely measured as measuring radon can be labour intensive and requires more specialised equipment.   Sentences will be added to clarify this point.

Page 5238,Line 18 – 19: The corrected evaporation rates will be used. See General Comments above.

Page 5238, Lines 23 – 27: It appears that when the radon concentration ofa river is below 300 Bqm^{-3}, hyporheic exchange will an effect on the relative baseflow calculation.However, the net baseflow is dominated by the few reached with high baseflow inputs; the relative errors in the baseflow calculations resulting from neglecting hyporheic exchange in these reaches is small.Overall, in a river with high baseflow inputs and relatively high radon activities such as the Ovens River accounting for hyporheic exchange makes little difference to the calculations. This general point was discussed by Cook et al. (2006) and was discussed on Page 5241, Lines 21 – 24.

Page 5239, Lines 6 – 7: the "*a*" in Equation was a typing error and has since corrected in the published discussion paper. It should be "*d*", defined as river depth.

Page 5239, Line 8 and Line 17: the typing and grammatical errors will be corrected; "steam discharge" will be changed to "stream" and "low-gradient rivers" will be changed to "river".

Page 5240, Lines 13 – 23: Comparing the calculated groundwater fluxes in Section 5.1 with ones derived from the head data via using the Darcy Law is a good suggestion.Unfortunately, the lack of groundwater observation bores (there are only 1 or 2 transects of bores in each sub-catchment) may not produce accurate calculations. Furthermore, the gauging stations are poorly surveyed (such that it is difficult to translate the river depth measurement to the height of the river), and many of the gauges are not near the transectsof bores. This makes estimating the gradient between river height and watertable difficult. The lack of infrastructure was one of the reasons for this study to adopt a chemical mass balance mixing approach in studying baseflow. However, an attempt will be made to compare calculated groundwater inflows with the observed increase in discharge during baseflow conditions.

Page 5241, Lines 6 – 8: See General Comments above in regards to errors in groundwater radon activities.

Pages 5242, Lines 6 – 8: See General Comments above in regards to spatial variation of groundwater chloride concentrations.

Page 5243, Line 21: The "*f*"term in equation 5 does refer to filtered quick flow, see Equation 3 in Nathan and McMahon 1990. To ensure consistency, the Equation 5 will be arranged to such a way that makes b_k (filtered baseflow) as a subject in the equation:

$$b_k = y_k - \left[\alpha f_{k-1} + \frac{(1+\alpha)}{2}(y_k - y_{k-1}) \right]$$

Page 5246, Line 27 – Page 5247, Line 1: The typing errors “the December 2010 around” and “September 2009 around” will be corrected as “round”.

Conclusion

More will be added in the discussion and in the conclusion in respect to the methodology and applicability of the results to a boarder context. See the response to the comments of anonymous Referee #2.

References

Bureau of Meteorology: Commonwealth of Australia Bureau of Meteorology, available at: http://www.bom.gov.au/jsp/ncc/climate_averages/evaporation/index.jsp (last assess: 24 June 2013), 2013.

Comrie, N., 2011. Review of the 2010-11 Flood Warnings and Response: Final Report, Victorian Government.

Cartwright, I., Hofmann, H., Sirianos, M. A., Weaver, T. R., Simmons, C. T., 2011. Geochemical and 222Rn constraints on 5 baseflow to the Murray River, Australia, and timescales for the decay of low-salinity groundwater lenses, Journal of Hydrology, 405: 333–343.

Cook, P. G., Lamontagne, S., Berhane, D., Clark, J.F., 2006. Quantifying groundwater discharge to Cockburn River, southeastern Australia, using dissolved gas tracers 222Rn and SF6, Water Recourse Research, 42, W10411, doi:10.1029/2006WR004921.

Nathan, R., McMahon, T., 1990.Evaluation of automated techniques for baseflow and recession analysis. Water Resources Research 26(7): 1465-1473.