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Assessment of hydrogeological processes surrounding the Solomon Hub Mine – responsive expert witness report.

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FMG Solomon Hub Mine
4 March 2024

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Executive summary

1. This report has been prepared at the request of Allen and Overy (solicitors) who represent Fortescue Metals Group Ltd. This matter concerns the alleged impact of the Solomon Hub Mine (SHM) on the surrounding environment. This Expert Witness report is in response to a report written by Dr Guan, who has been appointed by the Yindjibarndi Ngurra Aboriginal Corporation RNTBC (YNAC).
2. Specific matters to be addressed are:
   a. changes to vegetation richness, extent and any other markers of ecological health caused by the Mining activities in the Solomon hub to groundwater dependent terrestrial vegetation;
   b. changes to connectivity of surface flows, particularly at Kangeenarina and Weelumurra Creeks, and groundwater flows;
   c. observed or predicted impacts to groundwater levels as a result of dewatering, including after mine closure, and associated long term ecological impacts related to changes in the water table; and
   d. any other hydrogeological or ecological impacts at or surrounding the Solomon Hub.
3. The methodology adopted in this report is to consider what available data exists, to review the many previous reports on the above matters, to produce an opinion on the hydrogeological processes in operation in relation to the above matters and then to comment on how and why my opinion might agree or disagree with Dr Guan's opinions.
4. The proposed regional hydrogeological conceptual model comprises generally high permeability paleochannels surrounded by low permeability bedrock. Dewatering of the paleochannel sediments is required to enable mining. The generally low permeability bedrock will not transmit the impacts of dewatering (i.e. groundwater level decline) any significant distance. The numerical model produced supports this concept. This is in contrast to Dr Guan's conceptual understanding.
5. Analysis of data from many rainfall stations in the region has identified a moderate spatial variation and a significant temporal variation. It is demonstrated that a relatively wet phase existed from approx. 1995 to 2013, which has been followed by a drier phase since then. More importantly the region in the vicinity of the SHM has experienced a clear drier phase, whereas some rainfall stations far away from the SHM have not exhibited the drier phase in recent years. There is evidence that the last 2 years (2022 and 2023) have been somewhat drier than previous years.
6. Groundwater levels across the region have been shown to be generally falling in recent years. Within the SHM there are, as expected, significant declines. Away from the SHM there are variable rates of decline ranging from 0 m/yr to typically 0.2 m/yr. These regional declines are believed to be strongly related to the reduced rainfall since approx. 2014, and are not due to SHM dewatering.
7. NDVI (Normalised Difference Vegetation Index) analysis has been undertaken by FMG and Dr Guan. The two data sets show similar results. In my opinion, with the possible exception of the last two years, there has been no clear decline in vegetation health outside of the SHM.

There is some evidence that recent lower rainfall may have resulted in reduced vegetation health in some areas. In my opinion, any decrease in vegetation health outside of the mine disturbance envelope is not due to dewatering, but is a climate related process.

8. In my opinion, the two pool supplementation schemes are working as designed and effectively stopping any migration of the mine drawdown impacts beyond the mine disturbance envelope.

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1. Scope

9. On 24 January 2024 Allen and Overy, representing Fortescue Metals Group Ltd and its wholly owned subsidiaries (FMG), invited me to prepare an Expert Witness report which addressed specific questions, as listed below. This is in relation to Federal Court of Australia action WAD 37 of 2022, whereby the applicant, the Yindjibarndi Ngurra Aboriginal Corporation RNTBC (YNAC), seeks against the State of Western Australia and other respondents (together, FMG) compensation under the Native Title Act 1993. Further details concerning the nature of the relevant claim are in Appendix A. Suffice to say that the matter is essentially about the claimed impact of dewatering at the Solomon Hub Mine (SHM) on the surrounding environment. Abbreviations used in this report are listed in Appendix E.

10. YNAC has commissioned an expert hydrologists report from Dr Huade Guan dated 19 December 2023. I have been asked to consider the Guan report and provide comment on the conclusions reached in the report in relation to:

    a. changes to vegetation richness, extent and any other markers of ecological health caused by the Mining activities in the Solomon hub to groundwater dependent terrestrial vegetation;

    b. changes to connectivity of surface flows, particularly at Kangeenarina and Weelumurra Creeks, and groundwater flows;

    c. observed or predicted impacts to groundwater levels as a result of dewatering, including after mine closure, and associated long term ecological impacts related to changes in the water table; and

    d. any other hydrogeological or ecological impacts at or surrounding the Solomon Hub.

11. I am aware that my overriding duty is to the Court. In this context, my primary function is to assist the Court and, in this capacity, I must provide an unbiased opinion as an independent witness in relation to those matters which are within my area of expertise.

12. I confirm that I have read the Federal Court of Australia Expert Evidence Practice Note (GPN-EXPT) and the Harmonised Expert Witness Code of Conduct. I have complied with this practice note and agree to be bound by it. Furthermore my opinions are based wholly or substantially on specialised knowledge arising from my training, study or experience. I confirm that in writing this report, I have adhered to these obligations.

13. In relation to points 10c and 10d above I am not an ecologist and am not able to comment on general ecological matters. However, through my work on many projects working with and for ecologists and especially my work on Groundwater Dependent Ecosystems I believe I can competently comment on ecological issues relating to remote sensing and hydrogeological impacts on ecosystems.

14. This report is structured such that I discuss my technical understanding of specific aspects of the matter and then proceed to comment on Dr Guan's interpretation of the matter.

2. Dr Evans Disclosure and Qualifications

2.1 Disclosure

15. I have no conflicts of interest in undertaking this engagement. I have not worked for FMG, or any of its associated companies, nor do I have any financial interest in FMG.

2.2 Qualifications and Experience

16. I have a BSc (Hons), a PhD and am Senior Principal Hydrogeologist with Jacobs. Jacobs is an engineering, scientific and environmental consultancy company operating throughout the world. I have 40 years of experience in all aspects of water resource planning and development with a focus on groundwater resource management, groundwater dependent ecosystems and surface water groundwater interaction. I have worked on numerous water resource projects throughout Australia and Asia.

17. I am the author of the Australian Groundwater Management Policy which has been adopted as the Australia wide policy. I have undertaken groundwater management projects in every State in Australia and overseas. I have undertaken several major national assessments on groundwater dependent ecosystems (GDE) and undertook the first national assessment of GDE in Australia. I initiated and guided the development of the Bureau of Meteorology GDE Atlas. I have undertaken a major assessment for the World Bank on the influence of climate change on the groundwater resources of the World. I have acted as an Independent Expert Witness for many disputes involving groundwater and surface water matters. In Western Australia, I have undertaken a review of the groundwater licensing policies for the Department of Water, studies of groundwater dependent ecosystems on the Gnangara Mound, and an assessment of the feasibility of managed aquifer recharge in the Pilbara.

18. I was awarded the CSIRO Chairmans Medal in 2008 for work on surface water groundwater interaction. I was awarded the 2005 Land and Water Australia Senior Research Fellowship to study the influence of groundwater use on Australia's rivers. I was a member of the World Bank Groundwater Management Advisory Team. I am a member of the technical advisory group of the National Centre for Groundwater Research and Training. I was the President of the International Association of Hydrogeologists, Australia, from 2010 to 2014. My CV is in Appendix B.

3. Report structure and relationships

19. The approach taken in this report is to review the supplied information and data, and additional reports as referenced, and using my general hydrogeological experience to then form my own opinion of the hydrogeological processes which ultimately influence groundwater dependent ecosystem health. This logic is outlined in Figure 3-1.

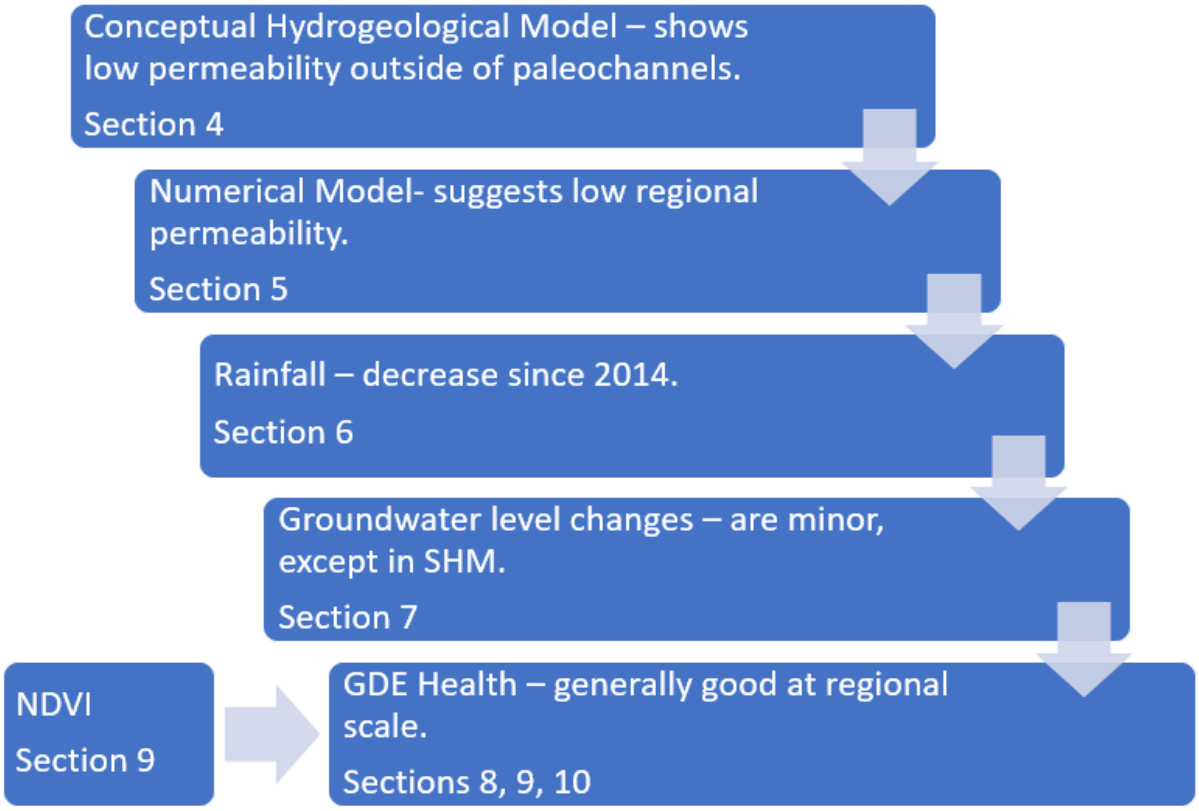


Figure 3-1: Report structure and key conclusions

20. In section 4 of my report I explain the Conceptual Hydrogeological Model which shows that, outside of the paleochannels, there are low permeability rocks which results in only localised impacts. This conceptual model is supported by the numerical model in section 5 which also suggests that formations below the SHM will not transmit any significant volume of groundwater regionally.

21. Following the development of the Conceptual Hydrogeological Model, the other key input to understand the potential impacts is rainfall. The clear trend of a reduced rainfall cycle since 2014 over the region surrounding the SHM is demonstrated in section 6. This in turn is reflected in section 7 in a slight decrease in groundwater levels across the region. In the SHM there is much greater groundwater level decline due to mine dewatering.

22. Sections 8, 9 and 10 move on to discuss the evidence of any impacts on vegetation health and in stream pool levels. The NDVI analysis and other data indicate generally little impact on vegetation health outside of the SHM. Similarly, in section 10, I explain that the supplementation schemes are operating effectively.

4. Hydrogeology and the Conceptual Hydrogeological Model

23. A Conceptual Hydrogeological Model is a description of the interpretation of where and how groundwater recharge, flow and discharge occurs within the overall geological system. The terms aquifers and aquitards refer to the ability for groundwater to flow into and through the geological formations. Aquifers generally allow ready flow of water into and through them, whereas aquitards generally only allow a very limited flow of water. Groundwater recharge occurs when rainfall and or streamflow transmits into the aquifers; flow refers to the rate of flow through the aquifers (which is called "permeability") and discharge refers to the exit of groundwater from the aquifers, typically as evapotranspiration (ET) and baseflow to streams. ET is the process whereby groundwater transpires to the surface and may be a water source for vegetation.

24. There are numerous reports on the hydrogeology of the SHM and surrounding region. MWH (2010) and FMG (2021) provide comprehensive assessments of the regional and local hydrogeology. I have reviewed most the reports in Appendix C (including a large number of the reports listed as attachments to Dr Guan's report) and have formed my own opinion on the basis of these reports, as to the features of the Conceptual Hydrogeological Model, which is summarised below.

25. The SHM is set within the Hamersley Ranges which is part of the Lower Fortescue Catchment. Locally there are major paleochannels filled with Tertiary aged sediments. (Paleochannels are ancient stream channels which have been subsequently filled with sediments). Some of the units in the paleochannels contain high permeability aquifers which need to be dewatered so that the Channel Iron Deposits (CID) can be mined. The paleochannels are typically 1 to 2 km in width, stretch for many kilometres and are up to 120 m deep. Underlying the paleochannels beneath the SHM is the low permeability Brockman Iron Formation which in turn is underlain by the low permeability Mt McRae Shale. Beneath these units again is the dolomitic Wittenoom Formation, which is a typical low permeability fractured rock when fresh. The location of these formations is shown on the geological base in **Figure 7-1** (Section 7).

26. The South Fortescue paleochannel and the Lower Fortescue paleochannel are generally located above the Wittenoom Formation which when weathered and fractured may have moderate permeability. The typical depth of weathering is 15m and beneath this depth the fresher rock is much lower permeability.

27. It was recognised from the start of mining that dewatering of the paleochannels could cause lowering of the water table in the vicinity of the SHM and hence a possible impact on surface water and vegetation. Hence extensive conditions were placed on the primary approval of the mine.

28. An important part of the Conceptual Hydrogeological Model for the SHM is that the vast majority of the recharge over the region occurs over the paleochannels, both because the shallow soils are more permeable and also because the streams (which normally only flow after heavy rain) provide a ready recharge source. Hence the majority of the SHM is a recharge area. However at the local scale it is more complex as both through flow and discharge may occur locally. The recharge into the Tertiary aquifers also discharges down gradient to become flow into the creeks, principally the Kangeenarina Creek and the Weelumurra Creek. This discharge maintains the pools in the creeks, which is discussed in Section 10.

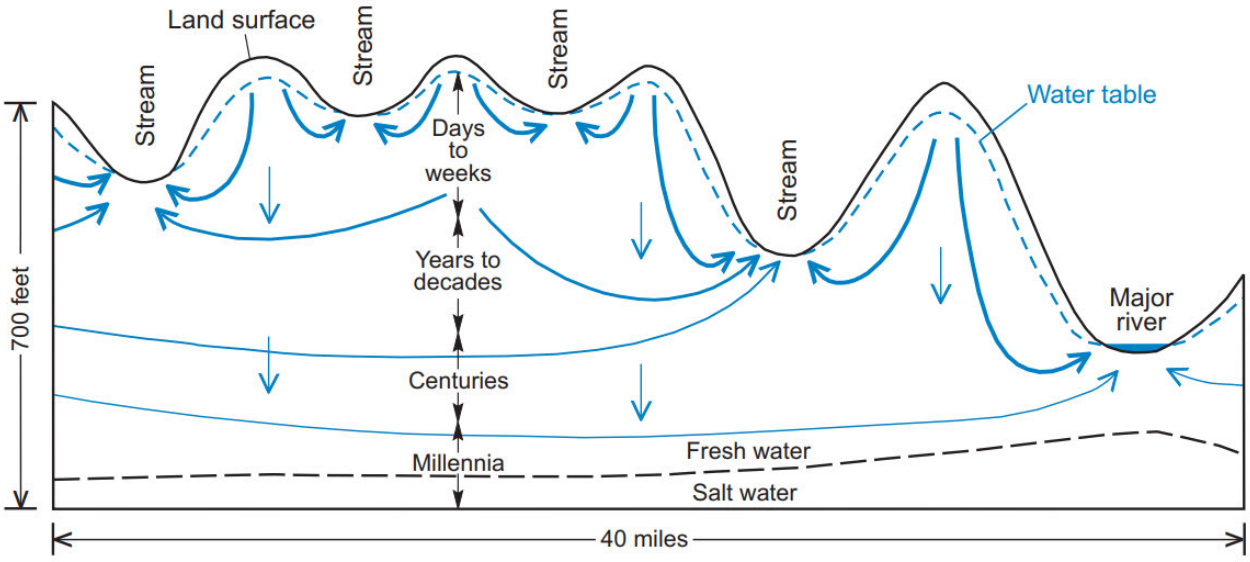
29. Within the Hamersley Ranges, the Wittenoom Formation is essentially an aquitard. This is because the permeability of the formation is low and also the steeper topography encourages greater runoff, rather than recharge. In the larger valley systems of the Southern and Lower Fortescue River, the Wittenoom Formation directly underlies Tertiary paleochannel sediments. In this setting, the Wittenoom Formation is sometimes weathered and fractured and in these circumstances it acts as an aquifer with some limited recharge during heavy rainfall events. At depths beyond the weathering horizon, typically 15 m, the Wittenoom Formation permeability reduces. Some water supplies have been established in the Wittenoom Formation. McFarlane (2015) reports that the "Basement rocks are tight outside weathered /fractured zones and contain little or no groundwater (HydroConcepts, 2014)". There is significant evidence from many studies that at the regional scale the Wittenoom Formation has low permeability, except where it is weathered. For example, RioTinto (2018) stated that "Outside of the areas of mineralisation and weathering, the Wittenoom Formation will have limited permeability and constrain groundwater flow." Also for example, RPS (2015) in their review of the Eastern Pilbara Region conclude that the Wittenoom Formation and the Mt McRae Shale have low to very low permeability.

30. It is recognised that flow in the Wittenoom Formation in the Pilbara is strongly controlled by the presence of very low permeability geological units, principally dykes and sills. This has been described by RioTinto (2022) in nearby investigations for other iron ore mines. This means that where more permeable parts of the formation exist the flow is essentially localised and compartmentalised.

31. The above discussion results in a Conceptual Hydrogeological Model of essentially all relatively local scale hydrogeological processes in operation. Groundwater flows almost exclusively within the existing paleochannels systems, because it is bounded by the low permeability bedrock. This means that the SHM impacts are all expected to be felt locally and in the vicinity of the dewatering.

32. A concept which is presented by Dr Guan is that of local, intermediate and regional flow paths. This is shown in Figure 20 of Dr Guan's report. At a very general conceptual level, this idea is accepted. However this concept is highly idealised and in reality, it is necessary to analyse the specific hydrogeological situation. In practice, in an environment such as the Hamersley Ranges, with significant paleochannels, aquitards and other impediments to groundwater flow, it is more complex. Significantly, Dr Guan implies that the deep formation beneath SHM (in this case the Brockman Iron Formation and the Mt McRae Shale) acts as an aquifer and has a reasonable permeability over large distances. However, in my opinion, this is not the case, as demonstrated in paragraphs 25 to 31, and hence the broad scale impacts which Dr Guan is postulating will not occur. Figure 7.1 shows that significant aquitards (the Brockman Iron Formation and the Mt McRae Shale) underlie the SHM and separate it from the Wittenoom Formation.

33. Another aspect of the local, intermediate and regional flow system concept is of time. This is shown diagrammatically in Figure 4-1. Local systems recharge and discharge within days to weeks, intermediate systems recharge and discharge in years, while regional systems typically exhibit time frames from recharge to discharge of decades to centuries or even longer. (This is of course assuming that the deep regional systems act as aquifers, which evidence indicates they do not). Hence, if regional systems were to operate as Dr Guan has proposed, the impacts of SHM dewatering would not be felt for at least decades.



Groundwater flow paths (indicated by the blue arrows). The thickness of the lines reflect the relative amount of groundwater flowing through the groundwater system.

Figure 4-1: The time impacts of local, intermediate and regional flow systems. From Fleeger, 1999

34. Another important concept in groundwater studies is the time lag involved in hydrogeological and Groundwater Dependent Ecosystem studies. When rainfall occurs, there is often a time lag as rainwater travels through the unsaturated zone and reaches the water table (i.e. groundwater recharge). This is expressed as a water table rise. This may take from hours to months, depending upon many factors, but especially the permeability of the unsaturated zone. Then the impact of this rising (or falling) groundwater level on groundwater dependent ecosystem health (generally vegetation in the context of this report) will often also have an additional time lag. In the case of vegetation health, this may be months or years.

5. Numerical modelling of Solomon Hub Mine Impacts

35. The Conceptual Hydrogeological Model which I have explained above finds support from the good calibration of the numerical model undertaken by FMG (2015), as I explain below.

36. Numerical groundwater models are routinely used to quantify the hydrogeological water balance, including input (generally recharge), change in storage, and output (generally discharge as ET and flow to streams). They comprise mathematical equations which describe groundwater processes. The typical modelling steps involve hydrogeological conceptualisation (as explained in the previous section), calibration and then scenario development (e.g. the impact area of mine dewatering). The calibration process is an important step whereby the overall water balance is compared (calibrated) against actual field observations. Modelling results are non-unique in the sense that different combinations of input parameters can produce apparently well calibrated results. However, the quality of the calibration can provide useful insights as to how realistic the conceptual model is in practice and it also provides understanding of the hydraulic properties of the region covered by the model (of which permeability is usually the most important). Put another way, if the hydraulic properties input to the model are not realistic then the model will result in a poor calibration (or not able to be calibrated at all).

37. FMG have undertaken numerical groundwater modelling for their major SHM operations. The mine model (FMG, 2015) comprises 4 layers with a basal layer of weathered bedrock with very low permeability. The basal layer has a thickness of from 10 m to 40 m. A comprehensive transient calibration was undertaken combined with a detailed recharge algorithm. Scenarios with and without supplementation to Kangeenarina and Weelumurra Creeks were evaluated.

38. I have reviewed the model calibration and have found the fit is good. This is because the model is regularly recalibrated based on actual data (usually groundwater levels). The good model calibration implies that the adoption of low permeability weathered bedrock is a reasonable approach. If it had been acting as an aquifer (i.e. of higher permeability), the calibration may not have been so good. Hence, in my opinion, this adds some support to my conclusion that the formations below the SHM will not transmit any significant volume of groundwater regionally, and over a short time frame. This is contrary to that which has been postulated by Dr Guan.

6. Rainfall Trends in the vicinity of the Solomon Hub Mine

39. Having established the importance of the Conceptual Hydrogeological Model above, the other key input to understand the potential impacts is rainfall.

40. A standard method to present rainfall data in hydrogeological studies is to plot the cumulative deviation from the mean (CDFM) over time. The CDFM is used to characterise rainfall trends. It is calculated by determining the mean of the rainfall for the period in question, subtracting the mean from each data point to determine the departure from the mean, and then accumulating the resulting departures. In periods where mostly above average rainfall occurs, the graph shows a positive variation from the mean, i.e. an upward gradient. When drier rainfall periods occur the graph shows a negative variation from the mean, i.e. a downward gradient. If the period in question shows average rainfall then the gradient is flat. Although commonly used in surface water assessments, the CDFM is especially useful in groundwater studies. This is because the cumulative impact of successive rainfall events is what generally results in groundwater recharge. Also, there is usually a time lag exhibited in groundwater systems and hence longer-term trends (typically over years) are especially relevant to groundwater systems.

41. Figure 6-1 (from FMG, 2019) presents rainfall data from several rainfall stations from 1995 to 2020. This demonstrates a wetter phase from 1995 to 2006 (Period 1), an average rainfall period from 2007 to 2013 (Period 2) and a drying phase from 2014 to 2020 (Period 3). As shown in Figure 6-3, a drying phase, continues until now. Note that during Period 2 there is, as normally experienced, some variation between stations and over time, and parts of this period could be interpreted as a continuation of a wetter phase. Note that average daily rainfall is that used in the Solomon groundwater model. The Solomon groundwater model rainfall sequence is a combination of a select number of FMG rainfall gauges, and where gaps exist the Wittenoom station data was used. The Average Hammersley Gauges refers to data from a combination of Hammersley, Mt Florence, Mulga Downs, Wittenoom and Coolawanya Gauges.

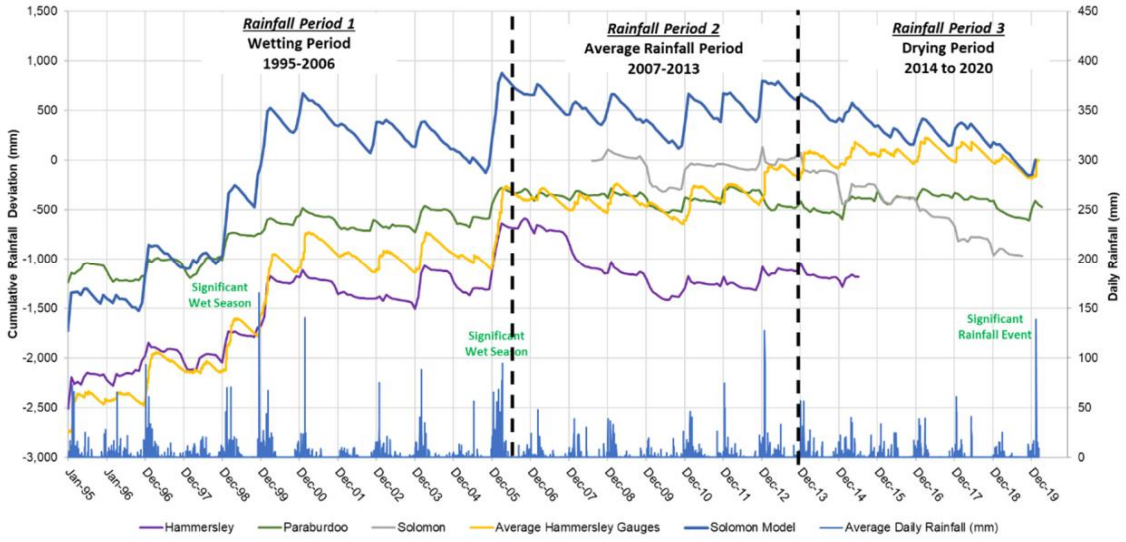


Figure 6-1: Long term rainfall data, from FMG (2019)

42. Rainfall data is available from many locations in the region of the SHM, as shown in Figure 6-2. Rainfall data from the seven relevant rainfall gauges has been collected and CDFM plots

are shown in Figure 6-3. In this figure, the rainfall means have been determined based on the data since 2011 at each rainfall station. Appendix D presents slightly different data. Appendix D1 uses the long term mean data at each rainfall station (typically 50 to 100 years, except Solomon). Appendix D2 presents the Solomon data compared against the long term means at each of the stations. All the three graphs show similar trends. I have chosen to focus on the data in Figure 6-3 because it presents the clearest and most relevant comparisons.

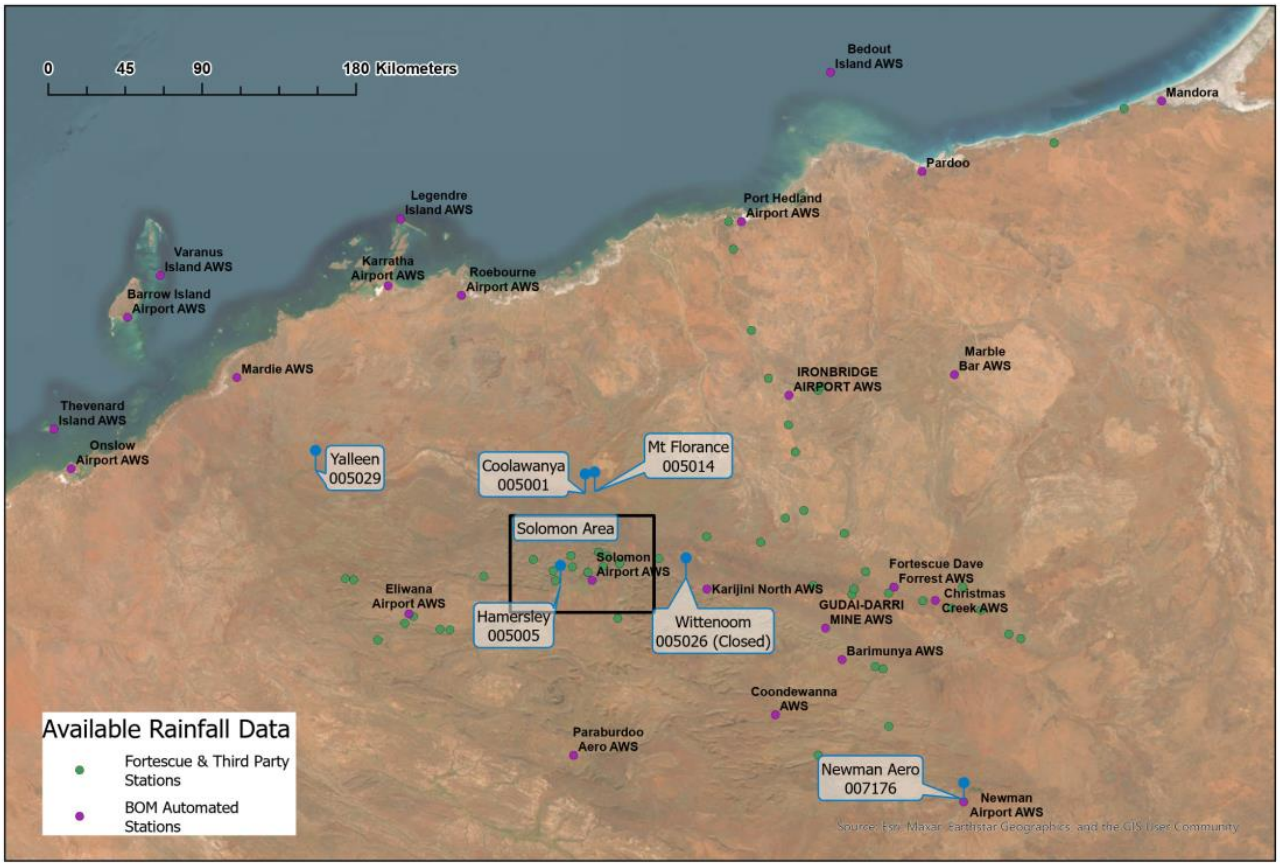


Figure 6-2: Rainfall Stations in the vicinity of the Solomon Hub Mine. (Material provided by Allen and Overy).

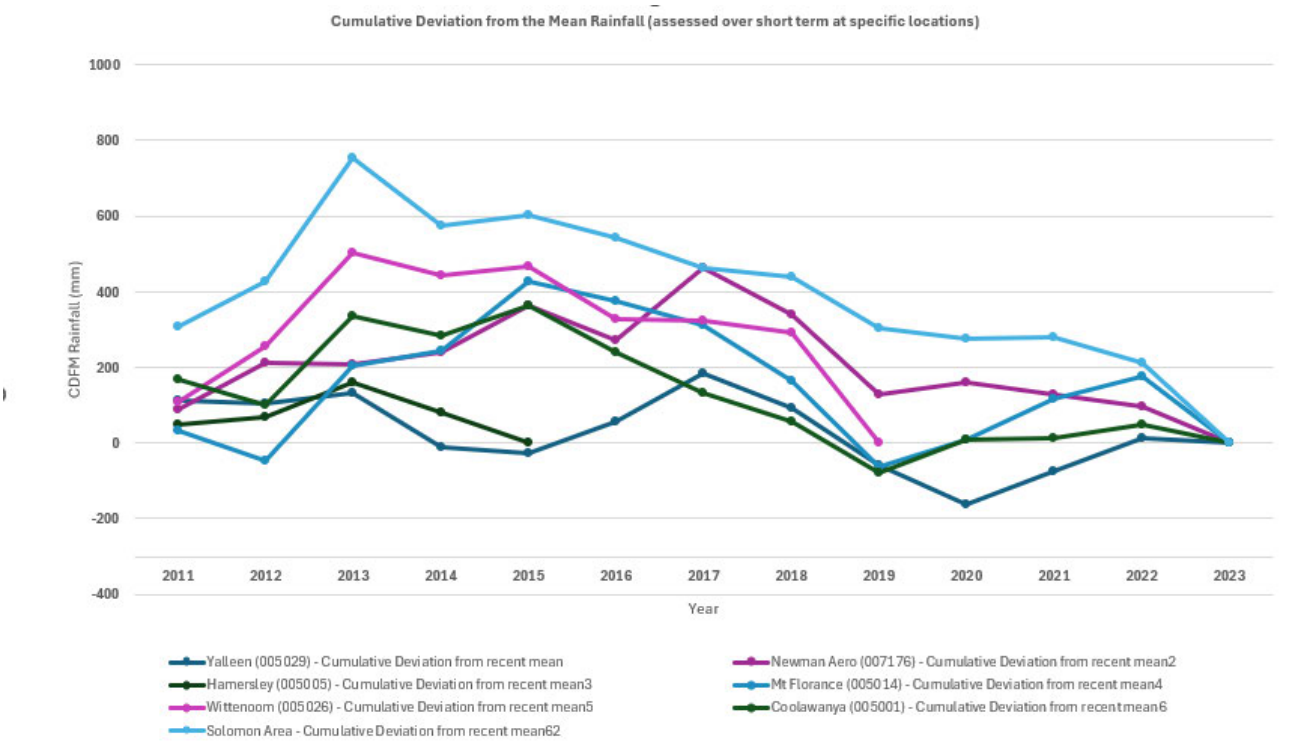


Figure 6-3: Cumulative Deviation from the Mean (CDFM) plot over time for seven rainfall stations using recent means at each station (i.e. 13 years of data, since 2011). Derived from material provided by Allen and Overy).

43. The Solomon Area data refers to the average (on a monthly basis) rainfall over the 11 gauges which FMG monitor over the region defined in Figure 6-2. None of the 11 gauges has a complete set of rainfall data, and hence the average rainfall refers to varying numbers of gauges at different times. Nonetheless, it provides the best understanding of the rainfall over the 12 years of records in the vicinity of the SHM.

44. The Wittenoom gauge was closed in 2019. This gauge has 70 years of data and hence provides the best long term record in the vicinity of the SHM. Similarly, the Hamersley station was closed in 2015.

45. Figure 6-3 shows a wetter period from 2011 to 2013, followed by either average rainfall at some stations and drier period at other stations. The three most relevant stations are the closest stations, which are the Solomon Area stations (shown in light blue), the Wittenoom station (shown in light purple), and the Hamersley station (shown in darkest green). The Solomon Area stations show a very clear drier period from 2013 to the end of 2023. The increased negative gradient in 2023 indicates a much drier period in almost all stations. Stations much further away from the SHM indicate a similar trend, albeit with greater variability. This relatively slight to moderate variation in rainfall over such a large region is completely normal for hilly country such as the Pilbara.

46. The overall conclusion from this data clearly shows a drier period after 2013 in the vicinity of the SHM, with an even drier year in 2023.

47. Dr Guan has only used data from two stations, the Yalleen station (shown in darkest blue; approx. 180 km from Solomon Airport) and the Newman Aero station (shown in dark purple; approx. 250 km from the Solomon Airport). These stations are a very long distance from the SHM and the rainfall data is not very relevant. Yalleen data indicates a generally drying and average phase since 2015, while Newman Aero data indicates a drier phase since 2017. Dr Guan's interpretation of a wetter period from 2018 to 2023 is not supported by these CDFM plots. The much closer data (i.e. Solomon Area) supports the interpretation of a generally drying period from 2013. This is fundamentally important to the interpretation of the potential impacts on groundwater levels, NDVI analyses and GDEs.

48. The two CDFM plots in Appendix D show similar trends to that shown in Figure 6-3. [redacted]

7. Interpretation of Groundwater level trends

49. Groundwater levels are important as they may influences vegetation health. Groundwater levels throughout the world go up and down due to a variety of causes, such as rainfall changes, land use changes and many other anthropogenic factors. The rate and magnitude of the changes varies greatly depending on many factors. However, the significant factor in most situations is rainfall changes, as this has a direct influence on recharge (refer to paragraph 20).

50. A map of 55 clusters of groundwater monitoring bores across the whole region is shown in **Figure 7-1**.

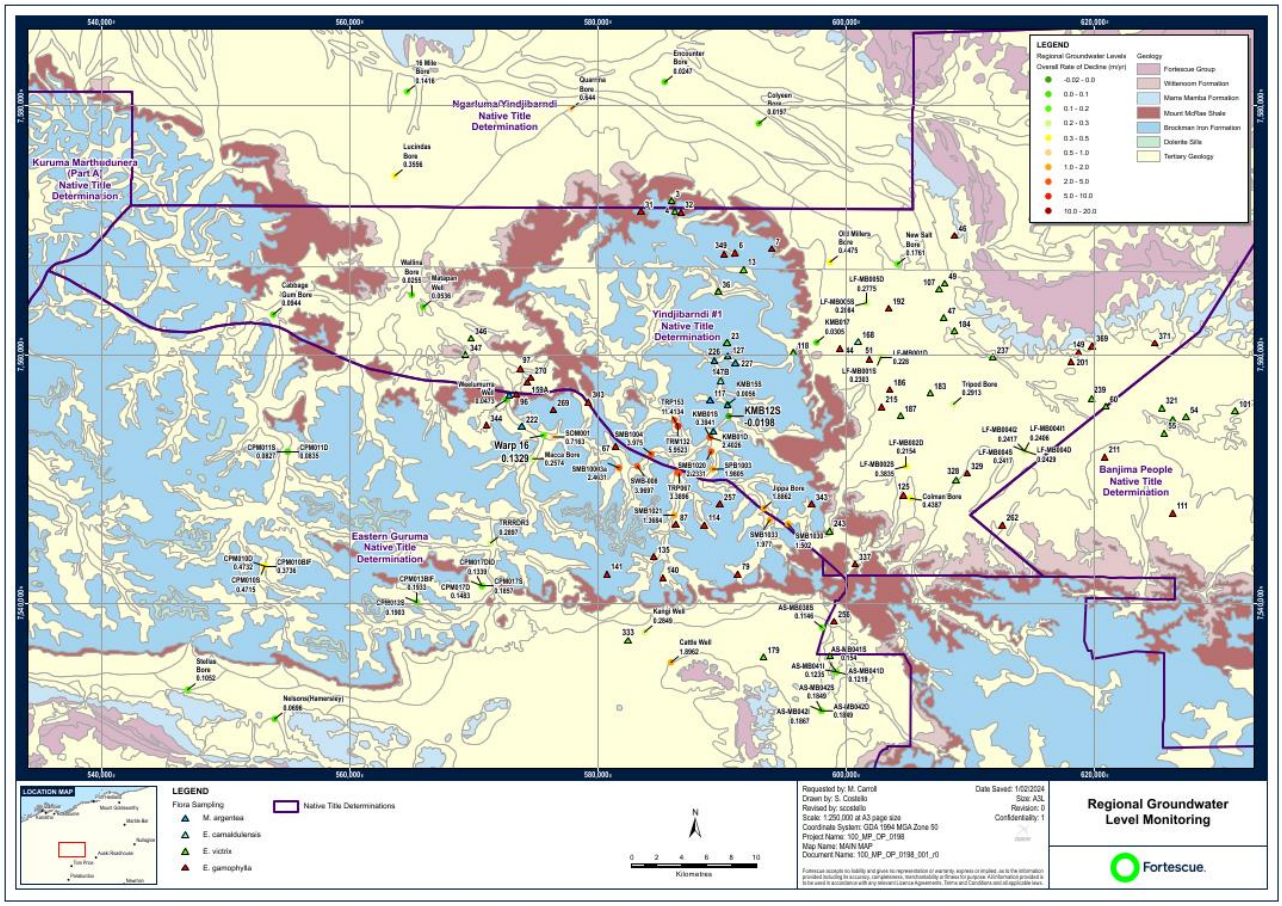


Figure 7-1: Location of groundwater monitoring bores, FMG Flora sampling sites and regional rate of decline of groundwater levels. Material provided by Allen and Overy.

51. **Figure 7-1** includes the FMG Flora sampling sites which are described in Ecologia (2014). These are the same sites referred to the Dr Guan's report. The groundwater level data presented in **Figure 7-1** covers various time periods, with the oldest data being from 2007. Most groundwater level measurements commenced in 2012 to 2015. Almost all of the data is up to the end of 2023. Almost all data points show a groundwater level decline, of varying magnitudes, in m/yr. The monitoring bores within the SHM show significant declines, typically from 2 to 10 m/yr. However, away from the influence of the mine, dewatering the rate of decline is much less at typically 0 to 0.2 m/yr. In my opinion, the regional decline is completely consistent with the regional decline in rainfall during a drying phase, as described in Section 6.

52. It is believed that the wetter period, from 1996 to 2006, would have produced artificially high groundwater levels over much of the region. The onset of a drier phase shows a downward adjustment in groundwater levels in response.

53. Based on my experience and on the groundwater modelling results (Section 5) the impact on regional groundwater levels from the SHM would be expected to be felt along the paleochannels, but not regionally. This is consistent with what is demonstrated in **Figure 7-1**.

8. Groundwater Dependent Ecosystems

54. Groundwater dependent ecosystems (GDEs) are ecosystems which require access to groundwater on a permanent or intermittent basis to meet all or some of their water requirements so as to maintain their communities of plants and animals, ecological processes and ecosystem services (Richardson et al., 2011). Ecosystem dependency on groundwater may vary temporally (over time) and spatially (depending on its location in the landscape).

55. The first national assessment of GDEs (Hatton and Evans, 1998) identified five major GDE types: vegetation, streams, wetlands, stygofauna, marine. The two important GDE types pertinent to this report are vegetation and streams. The subsequent Bureau of Meteorology GDE Atlas chose to group GDEs into three groups: Aquatic (rivers, wetlands, springs), Terrestrial (vegetation) and Subterranean (cave and aquifer) ecosystems. The methodology adopted does not identify GDEs per se. Rather, using remote sensing, so called "Inflow Dependent Ecosystems" (IDEs) were identified and using a subjective attribute table the likelihood that these IDEs were actually GDEs was assessed. IDEs can obtain their water from multiple sources, such as unsaturated zone water, groundwater and surface water. In Dr Guan's figures 7 and 11, Moderate potential GDEs were identified. It is assumed that these are derived from the BOM GDE Atlas, as I am not aware of any other authoritative source in relation to the Pilbara.

56. The point to note is that the large areas of vegetation identified around the SHM are potentially GDEs, but not necessarily GDEs. This is because the methodology used in the BOM GDE Atlas does not differentiate between groundwater fed ecosystems and other water sources (such as unsaturated zone water and surface water). In Dr Guan's report, it is implied that the potential GDEs are likely GDEs, however, Dr Guan has not demonstrated and proven that this is actually the case.

57. Where groundwater discharges into streams to form pools these are definitely GDEs. The pools formed in streams (Kangeenarina and Weelumurra Creeks) are definitely GDEs because they exist only because of groundwater discharge. However, it is important to note that not all pools are GDEs because some ephemeral pools are a result of surface water flows.

9. NDVI analysis and vegetation health trends

58. In Dr Guan's report, he primarily relies on NDVI analysis to draw conclusions about vegetation health. In this section, I consider the Normalised Difference Vegetation Index (NDVI) analysis conducted by Dr Guan and 3rd party consultants to evaluate vegetation health.

59. The NDVI is derived from multispectral imagery (generally from satellites). The NDVI is a vegetation index which provides a quantitative measure of plant vigour and is commonly used to infer plant health. The accuracy of the NDVI results is influenced by many factors, including temporal and spatial resolution. The most common satellite in use is the Landsat which now provide 40 years of data and gives repeat coverage every 16 days. The accuracy of NDVI results is linked to the timing of data acquisition during a day, influenced by solar zenith angle and light conditions. Optimal accuracy in NDVI assessments is achieved by capturing satellite data around solar noon, minimizing variations in sunlight angle and shadows. Suboptimal times, like early morning or late afternoon, introduce variations in sunlight angle, potentially leading to shadows and affecting recorded reflectance values, thereby reducing NDVI accuracy. The magnitude of the accuracy also depends on factors such as vegetation type, local climate and geography, and can typically fall within the range of 5% to 15%.

60. Extensive vegetation monitoring in and around the Solomon Hub has been underway since 2011, as reported by Ecoscape (2022). This includes monitoring of what are called Groundwater Dependent Vegetation (GDV), Potential Groundwater Dependent Vegetation (PGDV) and Riparian vegetation. The potential impact monitoring sites are located at Kangeenarina Creek, Weelumurra Creek and Zalamea Creek. Seventeen potential impact sites covering these three vegetation classes were monitored. This monitoring included NDVI assessment, leaf water potential monitoring and field inspections. The Ecoscape report covers the period up to the end of 2022, and it documents the many previous monitoring programs which commenced in 2011.

61. The Ecoscape (2022) report has established a baseline comparison of vegetation health generally over a10 year period from 2001 to 2010. Ecoscape then compared the baseline results with the data up to 2022. The GDV, PGDV and riparian vegetation condition survey results are as follows. A comparison between the 2022 results and the baseline data indicates that 22 of the 28 sites (79%) were in Very Good or Excellent condition with the remaining sites being in Good condition. There had been minimal change in the condition of any assessed site since 2019. The most significant factors influencing the condition ratings are weeds and grazing intensity. This assessment was followed up by field inspection and measurements of tree health.

62. Even though no clear negative trend has been identified, for reasons explained later in this section, there is likely a decrease in vegetation health (as proposed by AQ2) due to a readjustment in vegetation vigour due to the past wetter cycle (1995 to 2013) ending and dryer phase now in operation (2014 to present). It is suggested that the NDVI analysis (undertaken by Dr Guan) that the decrease in NDVI in 2022 and 2023 is due to a combination of two factors, the decrease in rainfall in very recent times and the longer term readjustment as described previously.

63. One of the advantages of NDVI data is the ability to consider varied environmental conditions over several decades (such as rainfall and anthropogenic factors e.g. grazing, fires). NDVI values commonly fluctuate as a function of rainfall and other changing events. Typically, NDVI

values follow average periodic fluctuations. Ecoscape (2022) have undertaken NDVI analyses at 22 sites where GDV, PGDV and Riparian vegetation has been previously identified and these all show a typical variation in NDVI over the last 10 years with, as expected, some variations from the long term mean values. None of the results indicate any significant trends, nor any unexpected or anomalous behaviour, despite the decline in rainfall since approximately 2014. In my opinion, this may be due to typical time lags which exist in hydrogeological studies which are described in paragraph 29. A typical NDVI graph is shown in Figure 9-1.

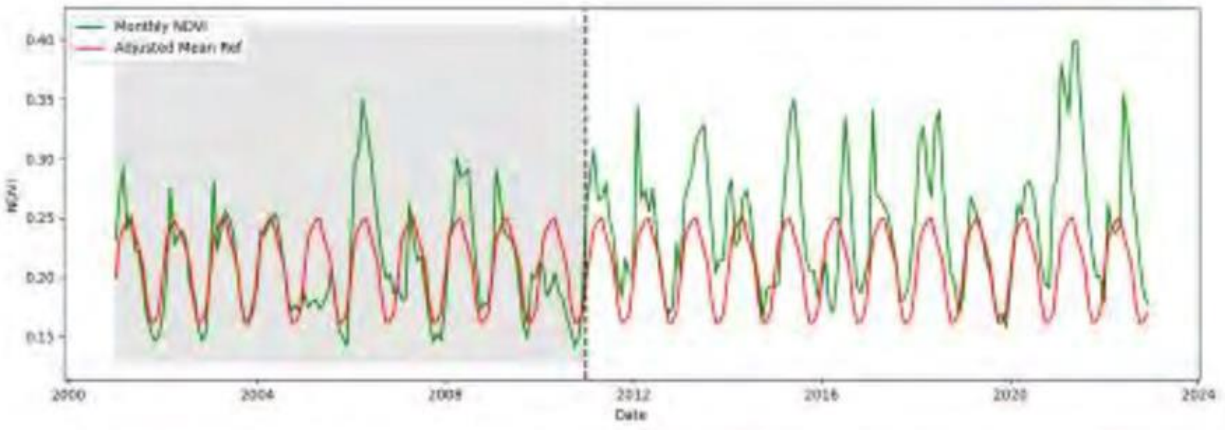


Figure 9-1: Monthly and mean NDVI measurements for downstream of Weelumurra Creek North Zone C. From Ecoscape (2022), Figure 85.

64. The NDVI results presented in Ecoscape (2022) are similar to the result presented in Dr Guan's report. However, the interpretation of the results is different. Ecoscape's data is up to the end of 2022 whereas Dr Guan's data is up to November 2023. This slight difference in reporting period may be relevant. The Ecoscape data is over 20 years and a baseline for comparison has been established. Ecoscape's baseline was defined before dewatering at the Solomon Hub Mine occurred and hence this represents a good comparison. As presented above a degree of variation in NDVI results due to rainfall variations and other factors is to be expected, and this is reflected in the data. Dr Guan's NDVI results suggest a decrease in NDVI in 2022 and 2023.

65. AQ2 (2019) report that even though the long term average annual rainfall is approximately 368 mm, the rainfall for the period 1994 to 2012 was above average. The vegetation surveys suggest that there was tree recruitment associated with the increased rainfall period. Hence, conditions measured in the riparian zone since 2008 are likely to reflect this higher rainfall period and may not represent the long-term average. AQ2 emphasise that the current conditions do not appear to represent a long-term baseline. They propose that "self thinning" of vegetation is likely as the system adjusts to average rainfall conditions, "following the exceptionally wet period". They also point out that at Kangeenarina Creek the water supplementation scheme has further accentuated tree recruitment. It is interesting to note that quadrat #221, with a positive trend, is in the middle of Kangeenarina Creek where supplementation is occurring.

66. The NDVI results presented in Figure 5 of Dr Guan's report for the period from 2001 to approximately 2012 clearly show the normal large variation in NDVI values over time. In my opinion, this normal variation is predominantly due to rainfall variations. This period is identified only because it was before any dewatering at SHM. This large variation is greater than the variation identified in later figures in Dr Guan's report (for example Figure 10) which he concludes is "very likely" due to the impact of dewatering at SHM.

67. Considering the data presented in Dr Guan's report in para 33 and in Table 1, of the 22 quadrats selected, six showed a statistically significant negative NDVI tend. Conversely, 16 showed no trend or a positive trend. Considering the one quadrat with the largest negative trend (#127), this is largely due to the last two years of data (2022 and 2023). This is consistent with the CDFM data presented in Section 6. All of the 7 sites identified in Table 1 in Dr Guan's report are shown on **Figure 7-1** in Section 7. In most cases, there are nearby groundwater monitoring bores. These monitoring bores indicate varying rates of groundwater level decline from zero up to small rates.

68. In relation to Dr Guan's comments on Zalamea Gorge, I have not specifically covered the Zalamea catchment because Dr Guan's claimed GDE degradation is not obvious and predominantly occurs in the SHM operation area.

69. In my opinion, considering the normal seasonal variation in NDVI values and the normal accuracy in the measurement of NDVI, it is not possible to conclude, as Dr Guan has, that there is any significant negative trend in NDVI values. However, there is an indication of decreased vegetation health in 2022 and 2023. Moreover, as demonstrated in Section 6, the rainfall decline in recent years can readily describe the postulated negative trend in the six sites. Also, Dr Guan's conclusion is at odds with the very comprehensive vegetation assessment, involving NDVI assessment and extensive field measurement and validation, as described in the Ecoscape (2022) report.

70. I conclude that even though no clear negative trend in vegetation health is evident, it is possible that some decrease in health has occurred since 2022 at some locations. This is consistent with the AQ2 (2019) proposition that "self thinning" is likely with the drier period since 2014. Assuming the current dry period continues, it is quite likely that a decline in vegetation health will occur in the future. It is also relevant to note that the dewatering rate from SHM has remained approximately constant since 2019. Hence, in my opinion, any decrease in vegetation health outside of the mine disturbance envelope is not due to dewatering, but is a climate related process.

10. Discussion of Surface Water, Groundwater and Pool Level Compliance and Management

71. The previous discussion has focused on groundwater levels, however well accepted GDEs are the pools and associated riparian vegetation. It is for this reason that FMG are required to operate supplementation schemes as described below. SHM impacts do extend along the paleochannels to some extent and the supplementation schemes are designed to limit this impact to close to the SHM. The conceptual model section (Section 4) show that these impacts are expected to occur along the paleochannels only.

72. Surface water groundwater interaction is a well known process whereby in most hydrogeological environments there is water flow between streams and groundwater. The direction of the flow and the magnitude of the flow can vary significantly depending on many factors, but the two most important factors are the hydraulic head (i.e. the groundwater pressure) in each system and the permeability of the underlying aquifer and stream bed material.

73. It is well recognised that dewatering at SHM could impact on flows in Kangeenarina and Weelumurra Creeks and pools. As both these creeks are highly ephemeral (i.e. they do not flow much of the time due to seasonal variations in rainfall) the focus of regulations has been on the longevity of the remaining pools and riparian vegetation surrounding the creeks.

74. Pools in both Kangeenarina and Weelumurra Creeks are groundwater supported, with groundwater recharge occurring via stream flow and groundwater throughflow from up catchment. If recharge declines the pools gradually dry out as the groundwater levels fall. Similarly, the riparian vegetation is supported by the groundwater adjacent to the pools. The Kangeenarina Pools Supplementation Plan (FMG, 2020) and the Weelumurra Creek Supplementation Plan (FMG, 2021a) are designed to address any possible impact from the SHM. There is no monitoring of creek water levels outside of the pools.

75. The Kangeenarina Pools Supplementation Plan essentially involves the flow of water into shallow buried slotted pipes which recharges the groundwater around the creek. This has the intention of maintaining groundwater levels and hence permanent pool water elevation approximately consistent with the natural pool water levels. A 2011 survey identified 108 individual pools. The pools are only those outside of the mine disturbance envelope (MDE). The plan is to maintain pool water levels within the observed natural range, but not necessarily mimicking natural seasonal variations. It is well documented in FMG (2020) that the pool levels fluctuate in response to rainfall and along the creek in response to the regional groundwater gradient. The pools quickly respond to the episodic recharge events and then gradually decline before the next recharge event. Some pools become dry with longer dry spells. The pool's elevation confirms that they are an expression of the water table depth.

76. Groundwater levels are monitored at KMB12S, KMB14S and KMB15S. The Pool level is monitored at CG05 (Pool 78). Tight trigger and limit levels have been set and an action plan is in place if these limits are exceeded. So called Tier 1 trigger levels are when the groundwater level at KMB12S falls below a baseline value. Tier 2 is 0.5 m lower, while Tier 3 is an additional 0.5 m fall. In my opinion, these triggers are very tight as a change in groundwater level in excess of 1.0 m is commonly observed across the region. The data up to 31/12/2022 indicates one tier 1 level breach in KMB12S in 2020 for 12 days. This is shown in Figure 10-1. This was due to the planned shut down to construct a new supplementation line.

The nearby pool monitoring (CG05) indicated water levels have been maintained throughout the monitoring period. In my opinion, the breach in KMB12S is minor and does not indicate any long term issue. On the contrary, it indicates that the supplementation scheme is very responsive.

77. The Weelumurra Creek Supplementation Plan operates in a similar manner to the Kangeenarina Plan. In the Weelumurra Creek Plan deep injection bores have been used. A grouted hydraulic barrier is also under construction. Groundwater monitoring for trigger compliance purposes occurs at two locations, at Warp 16 and Weelumurra Well. Pool monitoring occurs at WEEL_SS1 and WEEL_SS2. Even though the trigger values for Warp 16 have been exceeded on two occasions in 2018 and 2019, this is due to this bore, which is owned by RioTinto, being used for water supply purposes. Other minor breaches have also occurred in 2020 and 2022. Temporarily increasing injection has remedied these breaches. This monitoring bore is due to be replaced. Evidence in the Triennial Groundwater Monitoring Review (FMG, 2023) demonstrates that compliance with the management plan has been achieved. Moreover there is no evidence that the SHM is having any impact on the two major creek systems with supplementation in operation.

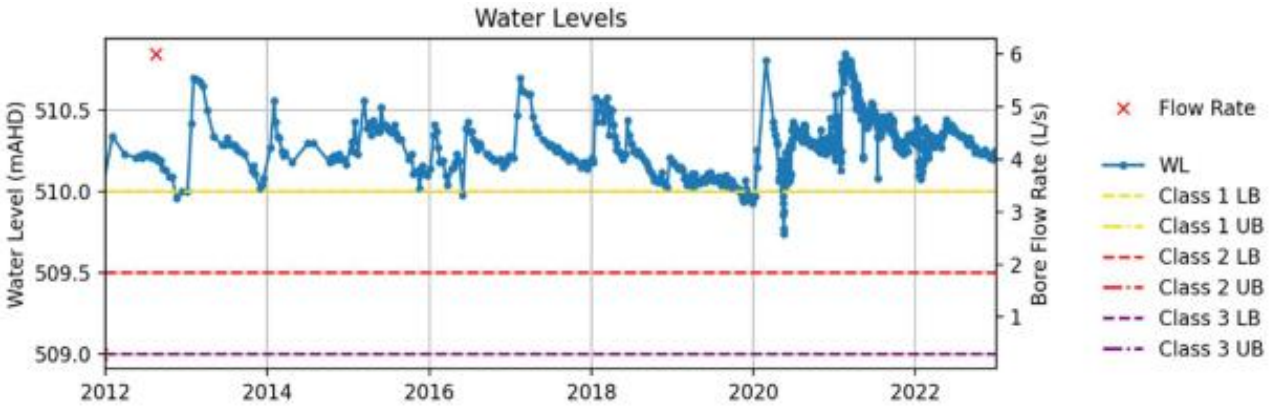


Figure 10-1: Hydrograph for KMB12S

78. It is noted that there is a decline in groundwater levels in Warp 16 over the period from 2014 to approximately 2018. This is shown in Figure 10-2. During this period relatively minor extraction of groundwater occurred from the Queens mining area. This could have contributed to the decline, but this also coincides with the drier rainfall period discussed previously, hence there are possibly several reasons for the decline. Supplementation commenced at Weelumurra Creek in 2018. This has apparently arrested any ongoing decline.

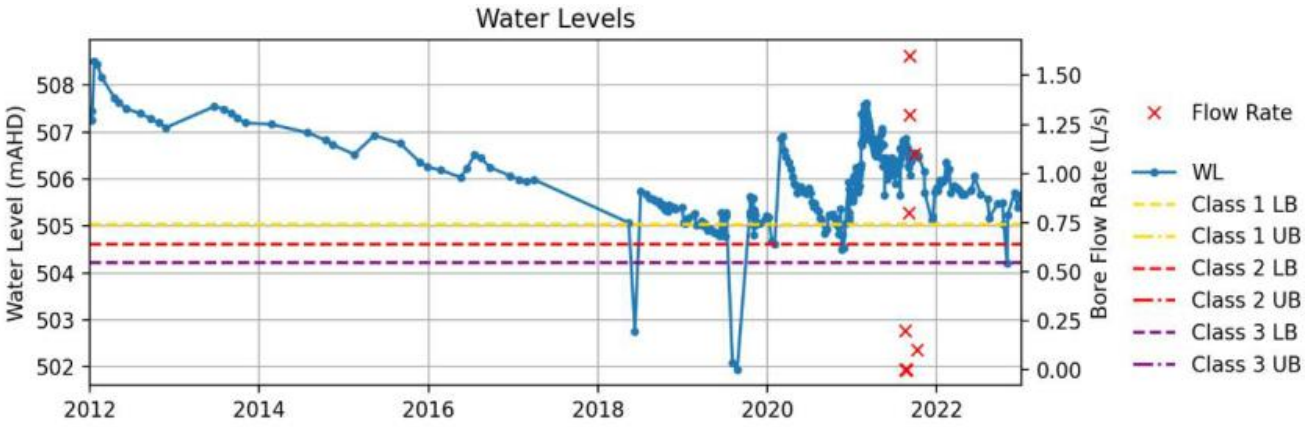


Figure 10-2: Hydrograph for Warp 16. From FMG (2023).

79. The potential impact on riparian vegetation in the vicinity of the creeks discussed above has also been raised. Vegetation surveys have been carried out and these are discussed in Section 9. AQ2 (2019) conclude that creek runoff events occurred more frequently during the wet period from 1994 to 2012 and hence "low flow channels flow full, on average, around every 2 years while this is likely to have been every year, during the wet period. Vegetation surveys suggest there was tree recruitment associated with the increased rainfall and runoff" associated with the wet period from 1994 to 2012. Hence "conditions measured in the riparian systems since 2008 are likely to reflect this and may not be representative of the long-term average".

80. What the above quote suggests is that there may be evidence of riparian vegetation decline in recent years which is due to a wet cycle being followed by the current dry cycle. There is no evidence to suggest, as Dr Guan proposes, that this is due to the influence of lowered groundwater levels due to the SHM.

11. Conclusions

81. The rainfall record over the last 25 years clearly indicates a wetter phase followed by a drier phase, which starts in approx. 2014. Comprehensive rainfall data in many rainfall stations indicates greater rainfall declines in the vicinity of the SHM in recent years. Less declines and even slightly increased rainfall is demonstrated in some other rainfall stations in the Pilbara. Hence even though there is normal spatial variation in rainfall, there is significant temporal variation.

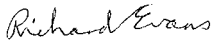
82. The relatively recent drier phase (i.e. after 2014) generally has resulted in falling groundwater levels. The rates of decline are generally small to modest, except within the SHM where larger declines due to mine dewatering is occurring.

83. The hydrogeological conceptual model strongly suggests that regional scale impacts from mine dewatering, which Dr Guan proposes, cannot occur, due to the low permeability of the deeper rocks. Even if they were to occur, then any impacts would occur over many decades or longer – certainly not in the time scale of the observations to date. The numerical modelling results indirectly support this conclusion. In my opinion, the falling groundwater levels are due to reducing rainfall in recent years.

84. NDVI analysis of vegetation health does not show any clear regional scale trends. Some sites indicate a decline in health, while the majority show no significant change in health. Comprehensive field based assessments up to 2022 do not indicate any significant change in vegetation health. In my opinion even with falling groundwater levels the impact on regional scale groundwater dependent vegetation health has not been demonstrated. It is proposed by others (AQ2, 2019) that there could be a decline in vegetation health due to a gradual adjustment to a lower rainfall, following the wetter period from approximately 1995 to 2013. This proposition is supported. Based on Dr Guan's report, there is an indication of decreased vegetation health in the last 2 years outside of the SHM at some locations. In my opinion, any decrease in vegetation health outside of the mine disturbance envelope is not due to dewatering, but is a climate related process.

85. The two creek supplementation schemes are operating as planned, such that there is no evidence of the effects of SHM dewatering impacts extending beyond the mine disturbance envelope.

86. The above conclusions are at odds with Dr Guan's interpretation. In my opinion, the regionally falling groundwater levels are not caused by the SHM dewatering but are instead due to regional changes in rainfall and hence decreased recharge.



Dr Richard Evans

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Appendix A. Preliminary Questions Letter: 24 January 2024.

ALLEN & OVERY

STRICTLY PRIVATE & CONFIDENTIAL

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24 January 2024

Dear Dr Evans

WAD 37 of 2022 - Yindjibarndi Ngurra Aboriginal Corporation RNTBC (ICN 8721) v The State of Western Australia - Preliminary questions

1. INTRODUCTION

1.1 Thank you for agreeing to act as an independent expert on behalf of Fortescue Metals Group Ltd and several of its subsidiaries (together, **FMG**).

1.2 In this letter, we set out some material background to the matter. We also set out questions which we would like you to consider, based on your expertise and the background we provide below.

1.3 We have set out, at **Annexure A**, a list of the briefing materials which have been provided to you.

2. BACKGROUND

2.1 In Federal Court of Australia action WAD 37 of 2022, the applicant, Yindjibarndi Ngurra Aboriginal Corporation RNTBC (**YNAC**) seeks against the first respondent, the State of Western Australia (**State**), and other respondents (together, **FMG**) compensation under the *Native Title Act 1993* (Cth) (**NTA**) as to the grants of certain mining tenements by the State to FMG (**FMG tenements**).

2.2 The FMG tenements form the basis of FMG's Solomon Hub mine, which is located in the Pilbara region of Western Australia. Certain of the FMG tenements, which are miscellaneous licences, were granted for purposes which include 'taking water', 'search for groundwater', and other water-related purposes (**Water Management Miscellaneous Licences**). FMG has also been granted licences under s 5C of the *Rights in Water and Irrigation Act 1914* (WA) authorising it to take the amounts of groundwater specified in each licence. Pursuant to the Water Management Miscellaneous Licences and the groundwater licences, FMG has abstracted water from within the Solomon Hub mining area

as set out in the spreadsheet titled "Abstraction Volume Check", provided as part of your briefing materials.

2.3 YNAC's Further Amended Points of Claim of 5 July 2023 (**PoC**) sets out the basis on which YNAC makes its claim for compensation. Relevantly, YNAC's claim for compensation includes a component for non-economic or cultural loss suffered by the Yindjibarndi People as a result of the grant of the FMG tenements (PoC [46(b)]). YNAC has indicated that its claim for non-economic or cultural loss will include a component for the effects of the Water Management Miscellaneous Licences on water resources in the area surrounding the Solomon Hub mine and consequent impacts on flora and fauna.

2.4 YNAC also relies on witness evidence in support of this claim. Relevantly, that evidence includes:

(a) an expert hydrologist's report from Associate Professor Huade Guan dated 19 December 2023 (the **Guan Report**), which we have provided to you along with the documents referred to in that report; and

(b) lay witness evidence from Yindjibarndi witnesses who assert that FMG's operations at the Solomon Hub have caused, or may in future cause, adverse impacts to certain specified watercourses and wetlands and to the surrounding country more generally. The relevant evidence is identified at Attachment 9 to the Guan Report.

2.5 FMG has filed lay witness evidence from Mr Christopher Ian Leonard Oppenheim in relation to its use of water at the Solomon Hub, and has produced documents concerning hydrology and hydrogeology to YNAC by way of discovery. We have previously provided to you, by way of background, the affidavit of Mr Oppenheim, as well as several reports prepared by FMG.

2.6 The permit and related regulatory conditions imposed on FMG do not require FMG to collect or report on surface water flow data (as distinct from surface water level data) in the vicinity of the Solomon Hub. Accordingly, there are no FMG records available in relation to surface water flow.

2.7 FMG does, however, collect data in relation to rainfall from various gauges within and surrounding the Solomon Hub area. That data is collected from the gauges identified in the map titled "Rainfall Map_V1" and is set out in the spreadsheet titled "Rainfall Data and Analysis_V1", both provided alongside your brief.

2.8 FMG also collects data in relation to changes in groundwater levels over time from groundwater bores within and surrounding the Solomon Hub area, which are variously owned by both FMG and third parties. That data is set out in the spreadsheet titled "Regional Groundwater Levels" and summarised in the map titled "Regional Groundwater Levels_v1", both provided as part of your briefing materials.

3. QUESTIONS AND ASSUMPTIONS

3.1 Please consider the Guan Report and provide your comments, explaining whether you agree or disagree with the analysis in that report (along with your reasoning in support of that view) . In particular, please comment on the conclusions reached in that report in relation to:

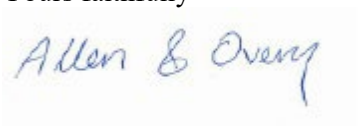
(a) changes to vegetation richness, extent and any other markers of ecological health caused by the mining activities in the Solomon Hub to groundwater-dependent terrestrial vegetation;

(b) changes to connectivity of surface flows, particularly at Kangeenarina and Weelumurra Creeks, and groundwater flows;

(c) observed or predicted impacts to groundwater levels as a result of dewatering, including after mine closure, and associated long-term ecological impacts related to changes in the water table; and

(d) any other hydrogeological or ecological impacts at or surrounding the Solomon Hub.

Yours faithfully



Mark van Brakel
Partner

ANNEXURE A

INDEX OF DOCUMENTS PROVIDED TO DR RICHARD EVANS

No.	Document Description	Date of Document
Initial Reading-in Materials		
1.	Expert Evidence Practice Note (GPN-EXPT), with annexures	25 October 2016
2.	Technical Report – Baseline Survey: Groundwater and Surface Water Pool Systems	October 2019
3.	Solomon Triennial Aquifer Review to 31 December 2019 Rev1	February 2020
4.	Solomon Combined Groundwater Operating Strategy Rev10	25 October 2021
5.	Solomon Groundwater Monitoring Summary 1 January 2021 to 31 December 2021 Rev0	17 February 2022
6.	Yindjibarndi Compensation Claim Map 3 – Regional Overview	27 July 2023
7.	Affidavit of Christopher Oppenheim sworn 4 August 2023	4 August 2023
8.	Dr Huade Guan, Assessment of Groundwater-Dependent Terrestrial Vegetation Surrounding the Solomon Mine, with attachments	19 December 2023
Materials Provided with Questions to Expert		
9.	Applicant's Further Amended Points of Claim	5 July 2023
10.	Spreadsheet titled "Regional Groundwater Levels"	12 January 2024
11.	Document titled "Regional Groundwater Levels_v1"	15 January 2024
12.	Spreadsheet titled "Abstraction Volume Check"	15 January 2024
13.	Spreadsheet titled "Rainfall Data and Analysis_V1"	15 January 2024
14.	Document titled "Rainfall Map_V1"	15 January 2024

Appendix B. Dr Evans Curriculum Vitae

JACOBS

Dr Richard Evans

PRINCIPAL HYDROGEOLOGIST

Fourty years experience in all aspects of hydrogeology. This experience has included groundwater resource assessment and development, groundwater policy and strategy development, surface water groundwater interaction, environmental assessments, mine impact studies, civil engineering projects especially tunnels, climate change studies, coal seam gas studies, subsidence analysis, groundwater dependent ecosystem studies, managed aquifer recharge assessment, numerical analysis of groundwater flow systems, development of groundwater management strategies, assessment of wastewater disposal effects, and the investigation and assessment of groundwater pollution problems. Written over 70 technical papers.

EDUCATION/QUALIFICATIONS

Ph.D., University of New South Wales, 1977

B.Sc. (Hons.), Melbourne University, 1973

MEMBERSHIPS AND AFFILIATIONS

President, International Association of Hydrogeologists, Australia, 2010-2014

Member, Institution of Engineers, Australia

Member, Australian Water Association

Member, Australian Geomechanics Society

EXPERTISE

Groundwater Resource Investigation and Management

Groundwater Policy Development

Groundwater pollution investigations

Groundwater Dependent Ecosystems

Groundwater-Surface water interaction

Managed aquifer recharge

Groundwater impacts of tunneling and mining

Climate Change impacts on groundwater

Major Project Experience

General

- Wrote the National Groundwater Management Policy for the Federal Government, which has been adopted by all States and the Commonwealth. This involved undertaking a major review of the groundwater management policies and practices throughout Australia.
- Provided technical and groundwater management advice, including expert witness statement, for appeal to NSW Land and Environment Court on the Draft Murrumbidgee Groundwater Management Plan.
- Reviewed the licensing requirements for groundwater extraction in Western Australia for DOW.
- Developed (with others) for DWE (NOW) a groundwater level response management framework.
- Managed an assessment of the effects of groundwater extraction on land subsidence in Gippsland.
- Technical input to the management of the groundwater resources in the vicinity of the South Australian-Victorian border
- Technical review of the Murray Darling Basin Commission Salt Interception Program and various dryland and irrigation salinity management plans via various MDBC working groups
- Independent Peer Review of many hydrogeology projects. Currently reviewing Five Wet Tropics Conceptualisation and Modelling projects for DERM.
- Undertook a major study for the World Bank on the impact of climate change on the groundwater resources of the World.
- Managed major investigation and modelling project to assess the groundwater resources of the Murray Darling Basin.
- Acted as expert witness for the Land and Environment Court of New South Wales for major planning appeal involving groundwater impacts of new major housing development.
- Investigated the groundwater resource potential of part of the Lachlan Valley, NSW, for a major new water supply.

Mining

Dr Richard Evans
PRINCIPAL HYDROGEOLOGIST

- Undertook PhD on the effects of coal mining in the southern Sydney Basin on vertical leakage and other effects.
- Undertook an assessment of the influence of longwall mining on the surface water resources of the Illawarra Region NSW for DECC.
- Groundwater resource evaluation for town and coal mine in East Kalimantan, Indonesia. This is the largest coal mine in the world.
- Assessment of hydrogeological aspects of mining for the new Poitrel Coal Mine in the Bowen Basin
- Review of the hydrogeology of the Millmerran Coal Mine EIS
- Developed groundwater model for Latrobe Valley coal mine dewatering and subsidence assessment.

Coal Seam Gas

- Managing a major investigation on measuring and predicting vertical leakage associate with coal seam gas development in the Surat Basin and Bowen Basin. Associated with this project are many other aspects of CSG developments, including spring assessments, subsidence, monitoring reviews, drilling planning, laboratory testing, hydrochemistry, modelling and managed aquifer recharge.
- Independent Peer Reviewer of the Gloucester Coal Seam Gas project.
- Assessment of monitoring requirements for CSG project in Bowen Basin

Great Artesian Basin

- Assessment of the Sustainable Yield of the New South Wales part of the Great Artesian Basin intake bed.
- Reviewed the Great Artesian Basin Sustainability Initiative.

Assessment of policy issues for groundwater management in the GAB

Groundwater Dependent Ecosystems

- Assessment of the dependence of ecosystems across Australia on groundwater for LWRRDC
- Review of environmental water requirements for groundwater dependent ecosystems in Australia.
- Wrote the groundwater component of the National "State of the Environment Report", 2001 and 2005, specifically focussing on ecologically sustainable development.
- Assessment of Groundwater Dependent Ecosystems in the Callide valley, Queensland.
- Developed a toolbox of methods for determining the environmental water requirements for groundwater dependent ecosystems.
- Development of the Blue Mountains Groundwater Management Plan.
- Developing the management framework to protect groundwater dependent wetland on the Perth coastal plains.
- Assessed the Environmental Water Requirements of GDE's for the Bundaberg region of Queensland.
- Initiated and guided the development of the BOM GDE Atlas.

Surface water – Groundwater Interaction

Dr Richard Evans
PRINCIPAL HYDROGEOLOGIST

- Investigated the technical and management issues associated with surface water - groundwater interaction in the Murray Darling Basin.
- Defined the extent of surface water groundwater interaction in the Upper Moorabool catchment
- Developed an approach for managing groundwater surface water interaction in the Ovens Valley.
- Wrote the draft National Policy on groundwater surface water interaction.
- Undertook a major assessment of the importance of groundwater extraction on affecting stream flow in Australia.
- Undertook detailed field investigations of 10 catchments in Qld and NSW to measure flux rates between surface water and groundwater with NOW and DERM.

Managed Aquifer Recharge

- Investigation, assessment and costing of a major artificial recharge scheme to control land subsidence in Bangkok
- Expert witness for major court case involving groundwater resource management, artificial recharge and allocation, Burdekin River Irrigation Area, Queensland
- Development of a Groundwater Management Strategy for China, including MAR in North China.
- Investigated MAR in the Barwon Downs Graben for Geelong Water Supply.
- Contributed to a synthesis report on MAR applications across Australia for the National Water Commission.
- Investigated MAR for Alice Springs wastewater disposal.
- Assessed the technical and economic feasibility of managed aquifer recharge in the Pilbara and the Northern Territory.

International Projects

- Provincial Towns Water Supply Feasibility Project. Assessment of groundwater resource potential and sanitation problems for 6 cities in Vietnam. 1994.
- Construction of Town Water Supply, Vietnam. Groundwater resource assessment and construction contract writing and management for major city (Thai Nguyen) water supply. 1997.
- KPC Coal Mine Stage 2 Expansion. Groundwater resource evaluation for new town and coal mine in East Kalimantan, Indonesia. 1996.
- Tanjung Bara Borefield Review. Review of existing groundwater supply resource and infrastructure, Indonesia. 1996.
- Bangkok Subsidence Assessment. Review of artificial recharge options to control subsidence in Bangkok, Thailand. 1997.
- Aral Sea Water and Environmental Management Plan. Uzbekistan. Project Director. 1998 – 2000.
- China Groundwater Management Strategy. Development of National Strategy for the World Bank; including review of the feasibility of wastewater and floodwater artificial recharge.1999 and 2000.

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- China Irrigation Water Conservation Project. World Bank missions to review effectiveness of project. 2001 and 2002.
- Hai Basin Integrated Water and Environmental Management Project (China). Member of the International Expert Review Team and advisor on groundwater investigations, management and planning. Missions to China in 2004, 2005, 2006, 2007, 2008, 2009, 2010.
- Establishing the China Groundwater Management Centre – Consultancy to the Ministry for Water Resources scoping the functions of the proposed Centre, 2011, 2012.
- Report on Conjunctive Use of Groundwater and Surface Water Opportunities throughout the World. World Bank, 2012
- Undertook a worldwide review for the World Bank of the impact of climate change on groundwater resources and the development of adaptation options.2010

Tunnelling

- Technical Review and Design of Hydrogeology aspects of the Tuhono Consortium for the Waterview Tunnel, Auckland, NZ
- Investigation of the hydrogeology for the Chatswood to Parramatta Rail Link including assessment of the feasibility for artificial recharge, inflow assessment and impact on streams.
- Conducted detailed analysis of the Melbourne City Link Tunnel Project - this resulted in a major redesign of the City Link Tunnels.
- Detailed technical analysis of tunnel design for Brisbane – Airport Link Project. Variety of complex tunnelling issues assessed, including groundwater pollution migration, dewatering impacts, possible effects on groundwater dependent ecosystems, drained versus tanked design options, drainage design.
- Hydrogeological design of the Melbourne Metro Rail Tunnels.
- Detailed design of the groundwater aspects of the West Gate Tunnel.

Employment History

Jacobs (2014 – present)

Sinclair Knight Mertz (July 1995 – 2013)

Hydrotechnology (1983 – June 1995)

State Electricity Commission (Sep 1982 – Sep 1983)

Country Roads Board (Feb 1978 – Sep 1982)

Monash University, Lecturer (1977)

University of New South Wales, PhD Student (1974-1976)

State Rivers and Water Supply Commission (Nov 1973 – Apr 1974)

Associated Activities

Professional Committees:

- Member of the Organising Committee of the 5th International Rock Mechanics Congress, held in Melbourne - 1983
- Secretary of the Association of Computer Aided Design Geomechanics Technical Committee -1979 - 1982

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- Member of the Geomechanics Society (Victorian Division) Committee - 1983 - 1987
- Member of the Australian Water Resources Council Groundwater Committee - 1983 - 1985
- Member of the Research and Investigation Committee of the Victorian Salinity Programme - 1986 - 1995
- Member of the Murray Darling Basin Commission (MDBC) Groundwater Working Group - 1984 to 2000
- Member of the MDBC Salt Interception Working Group - 1982 to 2000
- Victorian representative on the SA/VIC Groundwater Sharing Committee - 1985 to present - President for 1994 - 1996
- Member of the Organising Committee of the Australian Water Resources Council Workshop on Groundwater Allocation
- Member of the Australian Water Resources Council Committee on Development of Groundwater Protection Guidelines for Pollution Prevention
- Member of the National Groundwater Committee. 1985 to 2005.
- Member of the Murray Darling Basin Irrigation Committee - 1997 to 2000
- Member of National Water Commission Groundwater Technical Advisory Committee – 2007 to 2012
- Member of the Murray Darling Basin Sustainable Yield project Technical Reference Committee – 2007 to 2008
- President of the Australian Chapter of the International Association of Hydrogeologists 2010 to 2014
- Organising Committee of the IAH Congress, Perth 2013

Contributions to Publications and Professional Working Groups:

- National Water Quality Management Strategy - Guidelines for Groundwater Protection in Australia. September 1995
- Australian Standard AS2368-1990 - Test Pumping of Water Wells. September 1990 and 2001.
- State Environment Protection Policy - Groundwaters of Victoria. December 1997
- Murray Darling Basin Status of Groundwater 1992
- Murray Darling Basin Groundwater Quality Sampling Guidelines 1993
- Murray Basin Groundwater Resource Potential 1996
- Steering Committee for eWater Surface Water Groundwater Interaction Module, 2008-2010

Conferences:

Member of the Organising Committee of numerous courses and conferences, as described in “Other Training”

Presentations:

Many hundreds of talks and presentations to community groups, politicians and professional committees, including:

- Murray Darling Basin Commission
- Great Artesian Basin Consultative Committee

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- Council of Australian Governments Water Reform Committee
- Australian Water and Wastewater Association Courses on Groundwater Processes
- Australian Drilling Industry Association Conferences
- Australian Beverage Council Conferences
- Australian Groundwater Schools
- National Water Commission
- Parliamentary Committees
- National Centre for Groundwater Research and Training

Other Training:

Attended numerous training courses and conferences as follows:

- December 1983 International Conference "Groundwater and Management" AWRC. Sydney
- August 1985 International Association Hydraulic Research Congress. Melbourne
- May 1986 Groundwater Systems Under Stress. AWRC. Brisbane
- October 1987 Groundwater Allocations Workshop. AWRC. Sydney
- May 1988 Murray Basin '88. BMR. Canberra
- February 1989 Groundwater Modelling Course by Jacob Bear
- February 1990 Hydrochemistry Course by Emanual Mazor
- July 1990 International Conference on Groundwater in Large Sedimentary Basins. AWRC. Perth
- November 1990 Murray Darling 1990 Workshop. Mildura
- October 1992 Murray Darling 1992 Workshop. Renmark
- February 1993 Aquifers at Risk. Canberra
- November 1994 Water Down Under. Adelaide
- September 1995 Murray Darling 1995 Workshop. Wagga Wagga
- August 1997 Murray Darling 1997 Workshop. Toowoomba
- February 1998 International Conference on Groundwater: Sustainable Solutions. Melbourne
- September 1999 Murray Darling 1999 Workshop. Griffith
- March 2001 3rd Australian Natural Resource Law and Policy Conference, Focus on Water, Adelaide
- March 2002 Great Artesian Basin Conference, Toowomba.
- May 2002 International Groundwater Conference, Darwin
- February 2004 9th Murray Darling Basin Workshop, Bendigo
- October 2004 Invited by the U.S. National Academy of Science to present paper at the Sackler Conference, California.
- February 2005 29th Hydrology and Water Resources Conference, Canberra
- March 2005 Outlook Conference, Canberra
- May 2005 Groundwater Surface water Interaction in the tropics, Darwin
- November 2005 IAH Conference, "Where Waters Meet" Auckland.
- July 2006 Australian Earth Sciences Convention, Melbourne

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- August 2006 Queensland Water Conference, Brisbane
- September 2006 Groundwater Surface Water Interaction in the Arid Zone, Alice Springs
- September 2006 10th Murray Darling Basin Groundwater Workshop, Canberra
- August 2007 Groundwater in Carbonate Rocks, IAH Conference, Darwin
- September 2007 35th IAH Congress, Portugal, Keynote speaker
- September 2008 International Water Association Congress, Vienna.
- October 2009 Irrigation and Drainage Conference, Swan Hill
- November 2010 Groundwater 2010 Conference, Canberra.
- September 2012 39th IAH Congress, Canada

September 2019 42nd IAH Congress , Spain

November 2019 IAH Conference Brisbane.

September 2022 IAH Conference Perth.

Member of the technical advisory group of the National Centre for Groundwater Research and Training.

Awards/Honors

Member of the World Bank Groundwater Management Advisory Team. 2004-2010

Awarded the 2008 CSIRO Chairman's Medal for work on the MDB Sustainable Yield project

Recipient of the 2005 Land and Water Australia Inaugural Senior Research Fellowship. Research topic: Surface water groundwater interaction.

Keynote speaker at the 2007 IAH Congress in Lisbon and 2014 IAH Congress in Morocco.

Awarded best paper at the Hydrology Conference, Institution of Engineers, 2008

Selected in the "Top 100 Engineers in Australia" by the Institution of Engineers, 2014.

PUBLICATIONS

Hundreds of technical reports.

Over seventy technical papers on hydrogeology and water resource planning, including:

- Joyce, E.B. and Evans, R.S., 1976. Some Areas of Landslide Activity in Victoria, Australia. Proc. Roy. Soc. Vict. 88, pp 95 - 108.
- Valliappan, S. and Evans, R.S., 1980. Finite Element Analysis of a Slope at Illawarra Escarpment. Proc. 3rd Aust. - New Zealand Geomechanics Conf., 2 pp 241 - 246.
- Evans, R.S., 1981. An Analysis Method of Secondary Toppling Rock Failures - The Stress Redistribution Method. Quat. Jn. Eng. Geol., 14, pp 77 - 86.
- Pump, W., and Evans, R.S., 1982. The Design of Foundations to Suit Geological Conditions - West Gate Freeway. Inst. of Engineers Annual Conf., Hobart.

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PRINCIPAL HYDROGEOLOGIST

- Evans, R.S., and Haustorfer, I., 1982. Groundwater Investigation Methods for Freeway Design and Construction. Proc. 11th ARRB Conf., Melbourne, pp 66 - 76.
- Evans, R.S., McDonald, P., and Worontnicki, G., 1984. Behaviour of Socketed Piles in Weathered Basalt. 5th Aust. - New Zealand Geomechanics Conf., 2, pp 372 - 377.
- Collett, K.O., and Evans, R.S., 1985. Hydrogeological Aspects of Salinity Control. Inst. of Engineers Annual Conf., Melbourne.
- Baker, D.J., Lakey R.C., and Evans, R.S., 1986. Management Options for Westernport Groundwater Basin, Victoria. AWRC Internat. Conf., on "Groundwater Systems Under Stress" Brisbane, pp 101 - 110.
- Evans, R.S., 1986. A regional Groundwater Model for Open Cut Coal Winning in the Latrobe Valley, Victoria. AWRC Internat. Conf., on "Groundwater Systems Under Stress" Brisbane, pp 459 - 468.
- Evans, R.S. 1987. Overview of Groundwater Allocations in Australia. Proc. of AWRC Workshop on groundwater Allocations. pp 5 - 14.
- Cox, F., and Evans, R.S. 1987. Dam Site Selection in Victoria. Victorian Geology Excursion guide. pp 95 -100.
- Evans, R.S., 1989. Saline Water Disposal Options in the Murray Basin. BMR Journal of Australian Geology and Geophysics, 11, pp. 167 - 185.
- Evans, R.S. and Nolan, J., 1989. A Groundwater Management Strategy for Salinity Mitigation in the Victoria Riverine Plain, Australia. Proc. of the Benidorn Symposium on Groundwater Management: Quantity and Quality. pp 487 - 499: IAHS Publ. No. 188.
- Evans, R.S., 1990. The Development of Groundwater Management for Salinity Control in the Victorian Riverine Plain. Abstract in Murray-Darling 1990 Workshop. Groundwater Research and Management. Mildura.
- Evans, R., Paton, M. and Walker, G., 1992. Hydrogeological factors in Landfill Planning in Victoria - Are "Dry Tombs" a myth? Landfill 1992. Melbourne.
- Evans, R. 1992. Groundwater Development Potential and Constraints in the Murray Basin. Extended Abstract in Murray-Darling 1992 Workshop. Renmark.
- Bannister, R. and Evans, R. 1993. Groundwater Quality Monitoring in the Murray-Darling Basin. "Aquifers at Risk" Workshop. Canberra.
- Evans, R, 1995. Dryland Salinity and Waterlogging. 13th Australian Groundwater School, Chapter 14, Perth.
- Evans, R. 1997. National Water Quality Management Strategy Groundwater Protection Guidelines. 16th Australian Groundwater School, Chapter 7, Sydney.
- Evans, R. 1998(a). Groundwater Management of the Great Arterian Basin - Transition from Theory to Practice. Proc. Outlook 98. ABARE Conference. Canberra. Vol. 1, pp 113-116.
- Evans, R. 1998(b). A National Framework for Improved Groundwater Management in Australia. Proc. IAH International Conference: Groundwater Sustainable Solutions. pp 825-830. Melbourne.

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PRINCIPAL HYDROGEOLOGIST

- Evans, R. and Young, M. 1998(c) Using Right Markets to Manage Diffuse Groundwater Pollution. Proc. IAH International Conference: Groundwater Sustainable Solutions. pp 831-836. Melbourne.
- Collett, K., Read, M., Evans, R. and Dudding, M. 1998(d). Long Term Groundwater Resource Planning and Investment for Victoria. Proc. IAH International Conference: Groundwater Sustainable Solutions, pp 819-824.
- Hatton, T., and Evans, R., 1998(e). Dependence of Ecosystems on Groundwater and its significance to Australia. LWRRDC Occasional Paper No 12/98.
- Evans, R. 1998(f). Groundwater Salinisation Mechanisms in Arid and Semi Arid Regions of Australia. Geological Society of America Symposium, October 1998
- Evans, R. 2001(a) Managing Over-allocated Groundwater Systems. 3rd Australasian Natural Resources Law and Policy Conference Proceedings, pp194-204. March 2001, Adelaide.
- Evans, R. and Clifton, C. 2001(b) A Policy Framework for Groundwater Dependent Ecosystems. Fenner Conference on the Environment 2001. Canberra.
- Clifton, C. and Evans, R. 2001(c) A Framework to Assess the Environmental water Requirements of Groundwater Dependent Ecosystems. The Third Australian Stream Management Conference, pp149-155. August 2001. Brisbane.
- Dudding, M. and Evans, R. 2001(d) Salt Discharge Mechanisms into the Murray River Floodplain at Lindsay Island. 8th Murray Darling Basin Groundwater Workshop, Paper 7B4, September 2001. Victor Harbour, SA.
- Evans, R. 2002(a) National Groundwater Reforms Applied to the GAB. GAB Fest 2002 A resource under pressure, 11-13 March 2002, Toowoomba, Queensland.
- Evans, R. 2002(b) A Groundwater Management Strategy for the North China Plain. IAH Balancing the Groundwater Budget, 12-17 May 2002, Darwin, NT.
- Green, D.K., Evans, R., Fleming, N.S., and Heaton, P. 2002(c) Sustainable Management of the Alice Springs Town Basin Aquifer. IAH Balancing the Groundwater Budget, 12-17 May 2002, Darwin, NT.
- Evans, R. 2002(d). Environmental Water Requirements of Groundwater Dependent Ecosystems – The South Australian Approach in the National Context. Hydrological Society of SA Conference.
- Fullagar, I. and Evans, R. 2003. Trading Groundwater Concepts. 28th International Hydrology and Water Resources Symposium. Wollongong. November 2003.
- Neal, B.P., Evans, R. and Nathan, R.J. 2004. Survey of Baseflows in Unregulated Streams of the Murray-Darling Basin. 9th Murray-Darling Basin Groundwater Workshop, 17-19 February 2004, Bendigo, Victoria.
- Parsons, S.G., Evans, R.S. and Dunn, B. 2004. In-River Salinity Control Scheme for the Wimmera River. 9th Murray-Darling Basin Groundwater Workshop, 17-19 February 2004, Bendigo, Victoria.

Dr Richard Evans

PRINCIPAL HYDROGEOLOGIST

- Evans, R.S., Merrick, N. and Gates, G. 2004. Groundwater Level Response Management – Strengths, Weaknesses and Opportunities. 9th Murray-Darling Basin Groundwater Workshop, 17-19 February 2004, Bendigo, Victoria.
- Evans, R.S. 2004. River – Groundwater Interaction in the Murray Darling Basin – Technical Status and Management Options. 9th Murray-Darling Basin Groundwater Workshop, 17-19 February 2004, Bendigo, Victoria.
- Foster, S., Garduno, H., Evans, R., Olson, D., Yuan Tian, Zhang, W. and Han, Z. 2004. Quaternary Aquifer of the North China Plain – Assessing and Achieving Groundwater Resource Sustainability. Hydrogeology Journal. Vol 12, No 1, February 2004.
- Evans, R. S. 2004 Groundwater Resource Management Challenges in North China. Proc. of Sackler Colloquia. US National Academy of Science.
- Dillon, P., Pavelic, P. Evans, R. and Williams, M. 2004 Characterising Sites for Water Banks in Sydney. Edgeworth David Symposium, University of Sydney.
- Evans, R., Dudding and Holland, G., 2005 River- Groundwater Interaction, A Practical Management Approach. 29th Hydrology and Water Resources Symposium. Canberra.
- Evans, R., 2005 Double Accounting of Surface Water and Groundwater Resources – The Tyranny of the Time Lag. Outlook Conference. Canberra.
- Austin, K., Shirley M., Evans R., Erlanger P. and Wilkinson S. 2005 Squeezing the balloon: investigating the competing needs for water in the Moorabool River catchment. 29th Hydrology and Water Resources Symposium. Canberra.
- Evans, R. and Neal, B. 2005 Baseflow analysis as a tool for groundwater surface water interaction assessment. IAH Conference Auckland 2005.
- Holland G F, Barnett B G, Evans R S and Dudding 2005 Taming the Time Lag: Integrated Groundwater-Surface water Management in the Upper Ovens River, Australia. IAH Conference Auckland 2005.
- Evans, R. 2006 Impact of Surface Water Groundwater Interaction in Affecting our Understanding of the Groundwater Resources of Australia. Australian Earth Sciences Convention, July 2006. Melbourne.
- Evans, R. 2006 Groundwater – A key part of Integrated Water Management. Queensland Water Conference, Brisbane.
- Evans, R. 2006. The impacts of 'far away" groundwater pumping on stream flow in Australia – the importance of evapotranspiration. 10th Murray Darling Basin groundwater Workshop. September 2006. Canberra.
- Evans, R., Dudding, M., Holland, G. Parsons, S. and Barnett, B. 2006 The development of a management approach for highly connected surface water and groundwater systems to maintain minimum stream flow. 10th Murray Darling Basin groundwater Workshop. September 2006. Canberra.
- Murphy, R., Neal, B., Nathan, R., Evans, R. and Helm, L. 2006. Non-climatic temporal trend in baseflow in areas of high groundwater use.

Dr Richard Evans

PRINCIPAL HYDROGEOLOGIST

30th Hydrology and Water Resources Symposium, December 2006, Launceston, Tasmania.

- Evans, R., Cook, P. G., Howe, P. and Clifton C. 2007. A toolbox for assessing the environmental water requirements of groundwater dependent ecosystems in Australia. Keynote address at the 35th IAH Congress. Lisbon.
- Evans, R. Parsons, S., O'Grady, T and Boulton, A. 2007 An assessment of Groundwater Dependent Ecosystems in the Burnett River Groundwater Area, Queensland, Australia. 35th IAH Congress. Lisbon.
- Richardson, S., Walker, G., Barnett, B., Daamen, C., Davies, P., Evans, R., Evans, W., Goode, A., Pritchard, J. and Waklawik, V. 2008 Murray Darling Basin Sustainable Yields Project: Prioritisation and assessment framework for Groundwater. 31st Hydrology and Water Resources Symposium. April 2008, Adelaide.
- Barnett, B, Goode, A., Evans, R, Walker, G, Cooke, P, and Evans, WR. 2008, The Impacts of Boundary Conditions on Predictive Model Results. "Modflow and More" Conference. Colorado, USA.
- Evans, R., Bastiaanssen, W., Molloy, R., Hulbert, S. and Miltenburg, I. 2009. Improving the picture for irrigation using SEBAL in Australia to measure evapotranspiration (ET). Proc. Irrigation and Drainage Conference, Swan Hill, Australia, Oct. 2009.
- Evans, R. Murrihy, E., Bastiaanssen, W. and Molloy, R. 2009. Using satellite imagery to measure evaporation from storages- solving the great unknown in water accounting. Proc. Irrigation and Drainage Conference, Swan Hill, Australia, Oct. 2009.
- Bastiaanssen, W., Miltenburg, I., Evans, R., Molloy R., Bastiaanssen, F. and van der Pol, E. 2009. An operational satellite based irrigation monitoring and scheduling tool for saving water in irrigation. Proc. Irrigation and Drainage Conference, Swan Hill, Australia, Oct. 2009.
- Walker, G., Evans R., Barnett, B., Daamen, C. and Parsons, S. 2009. The implications of surface water groundwater interaction on the water resources of the Murray Darling Basin. Proc. Irrigation and Drainage Conference, Swan Hill, Australia, Oct. 2009.
- Dillon P, Gale I, Contreras S, Pavelic P, Evans R, Ward J (2009) Managing aquifer recharge and discharge to sustain irrigation livelihoods under water scarcity and climate change. IAHS Publ 330, IAHS, Wallingford, UK, pp 1–12
- Evans, R., Bastiaanssen, W., and Davis, R. 2010 Remotely sensed ET measurement – is it the future of water management? Proc. Groundwater 2010 Conference. Canberra. November 2010.
- Evans, R., Clifton, C., Hayes, S. and Hirji, R. 2010 Adaptation options for the impacts of climate change on groundwater. Proc. Groundwater 2010 Conference. Canberra. November 2010.
- Nathan, R. and Evans, R. 2011 Groundwater and Surface Water Connectivity. Chapter 3 in Water Resources Planning and Management. Ed.: Grafton, Q. & Hussey, K. Cambridge University Press.

Dr Richard Evans

PRINCIPAL HYDROGEOLOGIST

- Evans, R., Cook, P and Cranswick, R. 2012 Cost versus accuracy of field methods to assess groundwater discharge to streams. 39th IAH Congress, Canada.
- Evans, R., Cook, P., Howe, P., Clifton, C. and Irvine, E. 2013 A toolbox for assessing the ecological water requirements for groundwater dependent ecosystems in Australia. In Groundwater and Ecosystems. IAH Selected Papers.
- Evans, R., Arunakumaren, J. and Grounds, J. 2013 Estimation and measurement of vertical connectivity in the Surat Basin, Australia. 40th IAH Congress Proceedings, Perth.
- Evans, R, Evans W and Holland G. 2014 Governance – the key to unlocking the promise of conjunctive management. 41st IAH Congress Morocco.
- Foster, S, Evans R & Escolero O. 2015 The groundwater management plan: in praise of a neglected 'tool of our trade'. Hydrogeology Jnl. Vol. 25 No. 5, August 2015.
- Hoxley G, Schelfhout C, Dowsley K, Evans R and George R. 2017 Feasibility of MAR and CWU for irrigation in the Pilbara. Australian Groundwater Conference, Sydney.
- Evans R, Lennon L, Hoxley G, Krake R, Yin Foo D, Schelfhout C and Simons J. 2017 The role of Managed Aquifer Recharge in Developing Northern Australian Agriculture – Case Studies to Determine the Economic Feasibility. AWA Journal. August 2017.
- Krusic- Hrustanpasic I, Randell J, Evans R and Barnett B. 2017 Site Conceptualisation and Numerical Model calibration to a Long Term Pumping Test within a Fractured Rock Aquifer. 16th Australasian Tunnelling Conference. October 2017.
- Parsons, S. and Evans, R. 2017. Determining the effective hydraulic conductivity of a rock mass for modelling purposes, Australasian Groundwater Conference, Sydney. 13 July 2017.
- Evans R and Parsons S. 2018 Tunneling and Groundwater. Paper presented at Australian tunneling Society Course. Melbourne. October 2018.
- Walker G, Crosbie R, Chiew F, Peeters L and Evans R. 2019 Climate Change and Groundwater: An Australian Perspective. IAHR Hydrolink Groundwater Special issue.
- Parsons S, Muir J and Evans R. 2019 Groundwater Control for Underground Construction in High Risk Urban Environments. AGS Tunneling Course, Adelaide.
- Evans R and Dillon P. 2019 Linking Groundwater and Surface Water: Conjunctive Water Management. Chapter 17 of "Advances in Groundwater Governance." CRC Press.
- Walker G, Wang QJ, Horne A, Evans R and Richardson S. 2020 Estimating groundwater-river connectivity factor for quantifying changes in irrigation return flows in the Murray-Darling Basin. Australasian Jnl of Water Resources. DOI: 10.1080/13241583.2020.1787702
- Walker G, Wang QJ, Horne A, Evans R and Richardson S. 2020 Potential cumulative impacts on river flow volume from increased groundwater extraction under the Murray Darling Basin Plan.

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PRINCIPAL HYDROGEOLOGIST

Australasian Jnl of Water Resources. DIO: 10.1080/13241583.2020.1804042

- Walker G, Crosbie R, Chiew F, Peters L and Evans R. 2022 Groundwater Impacts and Management under a Drying Climate in Southern Australia. In Integrated Water Assessment and Management under Climate Change. MDPI Journal

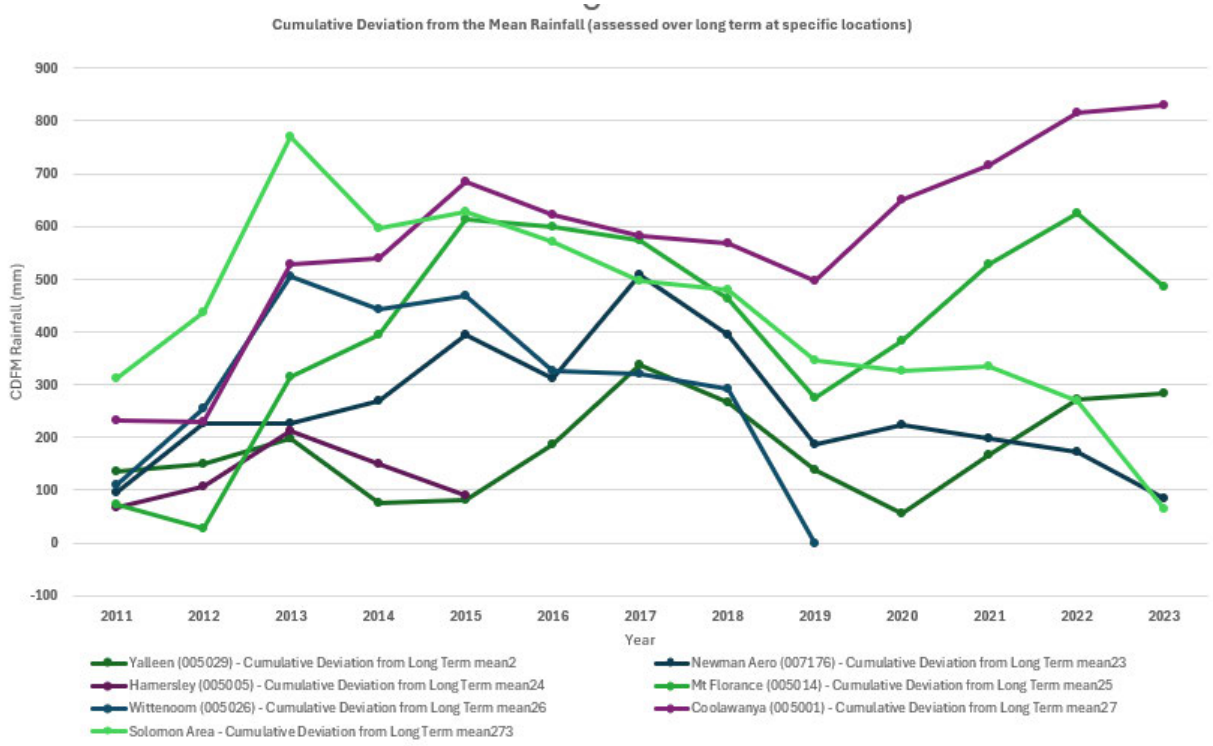
Appendix C. Index of Material provided to me.

INDEX OF DOCUMENTS PROVIDED TO DR RICHARD EVANS

No.	Document Description	Date of Document
Initial Reading-in Materials		
1.	Expert Evidence Practice Note (GPN-EXPT), with annexures	25 October 2016
2.	Technical Report – Baseline Survey: Groundwater and Surface Water Pool Systems	October 2019
3.	Solomon Triennial Aquifer Review to 31 December 2019 Rev1	February 2020
4.	Solomon Combined Groundwater Operating Strategy Rev10	25 October 2021
5.	Solomon Groundwater Monitoring Summary 1 January 2021 to 31 December 2021 Rev0	17 February 2022
6.	Yindjibarndi Compensation Claim Map 3 – Regional Overview	27 July 2023
7.	Affidavit of Christopher Oppenheim sworn 4 August 2023	4 August 2023
8.	Assessment of Groundwater-Dependent Terrestrial Vegetation Surrounding the Solomon Mine, with attachments	19 December 2023
Materials Provided with Questions to Expert		
9.	Applicant's Further Amended Points of Claim	5 July 2023
10.	Spreadsheet titled "Regional Groundwater Levels" (*superseded*)	12 January 2024
11.	Document titled "Regional Groundwater Levels_v1" (*superseded*)	15 January 2024
12.	Spreadsheet titled "Abstraction Volume Check"	15 January 2024
13.	Spreadsheet titled "Rainfall Data and Analysis_V1"	15 January 2024
14.	Document titled "Rainfall Map_V1"	15 January 2024
Materials Provided Subsequently		
15.	Map titled "100_MP_OP_0198_001_r0.pdf"	5 February 2024
16.	Spreadsheet titled "Regional Groundwater Levels_rev1"	14 February 2024

Appendix D. CDFM Rainfall Plots. Derived from material provided by Allen and Overy.

D.1 CDFM Rainfall plots for various stations using long term mean data



[redacted]

Appendix E. Abbreviations

Abbreviation	Name
BOM	Bureau of Meteorology
CDFM	Cumulative Deviation from the Mean rainfall
CID	Channel Iron Deposits
ET	Evapotranspiration
GDE	Groundwater Dependent Ecosystem
GDV	Groundwater Dependent Vegetation
FMG	Fortescue Metals Group and its wholly owned subsidiaries
IDE	Inflow dependent ecosystems
NDVI	Normalised Difference Vegetation Index
PGDV	Potential Groundwater Dependent Vegetation
SHM	Solomon Hub Mine
YNAC	Yindjibarndi Ngurra Aboriginal Corporation RNTBC

NOTICE OF FILING

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