Comments and arguments against Alcoa's application for water abstraction of 1500 ML per year for 10 years

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Section 40 of the Water Act from 1989 provides guidelines for the assessment of water extraction applications. Our response to Alcoa's application has two parts: The first part provides specific comments and arguments addressing the criteria given in Section 40. Those comments are underpinned by a recently updated Discussion Paper prepared by Prof. Haese, which forms the second part.

Section 40 (1): In considering an application under section 36(1), the Minister must have regard to the following matters: (b) "the existing and projected availability of water in the area", (c) "the existing and projected quality of water in the area" and (d) "the adverse effect that the allocation or use of water under the entitlement is likely to have on (ii) a waterway or an aquifer and (iii) the drainage regime within the meaning of section 12(1)."

Water production from the upper Eastern View Formation over the 46 years of mine and power plant operation has evidently lowered the groundwater level and changed the associated distribution of the hydraulic heads at regional scale, see Section 4 of the Discussion Paper. Concurrently, we observed a drop of nearly 90% of flow in Salt Creek draining about 40% of the whole Anglesea River catchment, see Section 3 of the Discussion Paper. Unfortunately, no flow data is available for Marshy Creek. We have argued that the large drop in flow is a consequence of the altered groundwater system where a much larger proportion of rainfall is now infiltrating into the subsurface and much less water is available for overland flow, ie flows in the creeks and the river, see Section 5 of the Discussion Paper. In addition, the Discussion Paper provides the conditions and mechanisms leading to a much lower runoff ratio (fraction of overland flow relative to total rainfall) directly relating to the lowered groundwater level.

The altered groundwater system and the associated significant reduction in surface flow in the catchment has several severe consequences for groundwater-dependant ecosystems (GDEs), water quality in the river and estuary and the frequency of bar openings allowing for estuarine water exchange with the ocean.

Here, we address the question of potential changes to water quality:
Before 2019 the estuary often experienced seasonal acid flushing at the end of the winter / spring time, when soils in the catchment were soaked with water containing

sulphuric acid and any major rain event resulted in a run off event. The estuary became temporarily acidic, but turned pH neutral after the bar breached following a series of run off events. The high frequency of bar breaches was supported if not largely controlled by the discharge of pH neutral water of about 1640 ML/yr into the river by Alcoa (see Section 2 of the Discussion Paper) which terminated shortly after the mine stopped operating. With the lack of additional water discharge into the river and the very low flows in the creeks we now expect multi-year long periods of acid water in the estuary. The last acid period lasted from August 2019 to October 2022 (see Section 2 of Discussion Paper) and only transitioned into a pH-neutral phase by "one of the most devastating (floods) in Victoria's history" (Parliament of Victoria, 2024) causing a bar breach. One has to assume that acidic conditions would still prevail in the Anglesea River estuary today without this extraordinary rain event in 2022.

Acidic water is a threat to a healthy environment by itself. In addition, higher acidity increases the solubility of metals including aluminium, iron, manganese and heavy metals. While the community-based water quality monitoring program does not capture changes in metal concentrations in the river and the estuary, we can assume that elevated metal concentrations are associated with acidic (here: pH of ~ 4) water.

In summary, we argue that past and future water abstraction from the upper Eastern View Formation contributes to reduced flows in the catchment and as a consequence acidic periods in the estuary will change from short-term (weeks to months) to long-term (several years). Only no water production will ensure the most rapid return of the groundwater system to its original conditions and associated high flows and frequent bar openings.

Section 40 (1): In considering an application under section 36(1), the Minister must have regard to the following matters: (g) "the need to protect the environment including the riverine and riparian environment"

The Corangamite Catchment Management Authority has prepared maps showing artesian areas for the time before water abstraction associated with the mine operation commenced and for the present day (see Section 4 of the Discussion Paper). The groundwater data was provided by Barwon Water. The maps confirm anecdotal evidence that Marshy Creek and Salt Creek used to have extensive swamps all year round particularly in their lower reaches. In this case, the swamps are groundwater dependent ecosystems (GDEs) where the theoretical groundwater level is above the elevation. The artesian areas have more or less fully disappeared according to the maps, which agrees with absence of regional swamps in the catchment today. The disappearance of swamps as derived from the maps is in full agreement with a drop in the groundwater level observed in individual boreholes (see Fig. 9 of the Discussion Paper) and at regional scale as presented in Section 5 of the Discussion Paper.

In summary, we argue that past and future water abstraction from the upper Eastern View Formation has resulted in the loss of environmentally precious ecosystems in form of swamps along the lower reaches of the creeks. Only no water production will ensure the most rapid return of the groundwater system to its original conditions including a return of groundwater-dependant swamps along the creeks.

Section 40 (1): In considering an application under section 36(1), the Minister must have regard to the following matters: (l) "the purposes for which the water is to be used".

Alcoa wants to use the produced groundwater to fill the mine pit, which accelerates the transformation of the mine into a lake. This is in Alcoa's interest as they can only fully decommission the mine and transfer its liability once the mine pit is filled to a certain degree. However, this is not a priority of the local community and the Shire. As explained above, groundwater abstraction has several adverse consequences, which the community wants to see addressed as a matter of priority. In addition, we need to ask the ironic question: What is the purpose of forming an acidic lake? The water in the mine pit currently has a pH of 3.5 to 4 and this is not expected to change in the future. Such high acidity is a hazard to humans, therefore, the lake will most likely be fenced in according to Alcoa. Neutralization of the mine pit water is a possibility under a future mine rehabilitation plan, but this is currently not foreseen as part of the water allocation request. Even the proposition of forming a fenced-in, acidic lake between the township of Anglesea and the State Forrest is absurd and outrageous.

There is simply no sensible purpose for producing groundwater to create an acidic lake, which will be classified as a hazard to the community.

What has caused environmental decline in the Anglesea River catchment and estuary? – A Discussion Paper

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1. Our concerns

The Anglesea coal mine closure and rehabilitation plan has received much public attention and as a matter of priority, the open pit coal mine is currently being filled with water from the upper Eastern View Group.

In recent years the acidity in the Anglesea Estuary has gone from neutral, with occasional short lived low pH events, to a state of permanent acidity. Equally important, Salt Creek flow measurements indicate a nearly 10-fold reduction in flow between now and the 1970s.

These changes have rendered the Estuary entirely unsuitable for fish life. A once renowned fish breeding estuary is now barren. There has been noticeable changes in frog carolling behaviour, mosquito wrigglers thrive, local people are hesitant to swim and the estuary mouth to the sea is much less open.

Surprisingly there are no plans developed or implemented to address this situation. This is despite the many organisations sharing responsibility for the estuary and a multitude of reports, studies and committees.

The excuse for this inaction appears to be the unchallenged theory that the drying up and acidification of the creeks and swamps is due to ongoing and inevitable changes in climate. This theory suggests that the current situation is just a continuation of the progressive degradation first observed with the intermittent fish kills at around 2000.

We believe the climate variation theory should be properly challenged and tested and the effects of mining in the catchment should also be evaluated. This is particularly important as our alternative theory proposes that extraction of water from the upper Eastern View Group aquifer is a major contributor to the problem.

This discussion paper provides the evidence of the described decline of conditions in the physical environment and provides a hypothesis for the cause of acidic waterway and a decline in flows.

2. Acidic water in the catchment and estuary

The Anglesea Estuary has recorded short term dips in pH since monitoring began in the 1970s. The estuary has been monitored by community members since 2007. Estuary monitoring data is accessible through the Estuary Watch web site. Continuous pH monitoring for the estuary was initiated in 2010.

Short periods (typically weeks) of acidic water with a pH < 6 were observed between 2010 and 2016 followed by a 1-year and a > 2-year period of acidic water in the estuary (Figure 1).

The short acidic periods typically commenced in the late winter following major rain fall, while the more recent long acidic periods are no longer seasonal. Rainfall data is provided by the Bureau of Meteorology (BOM).

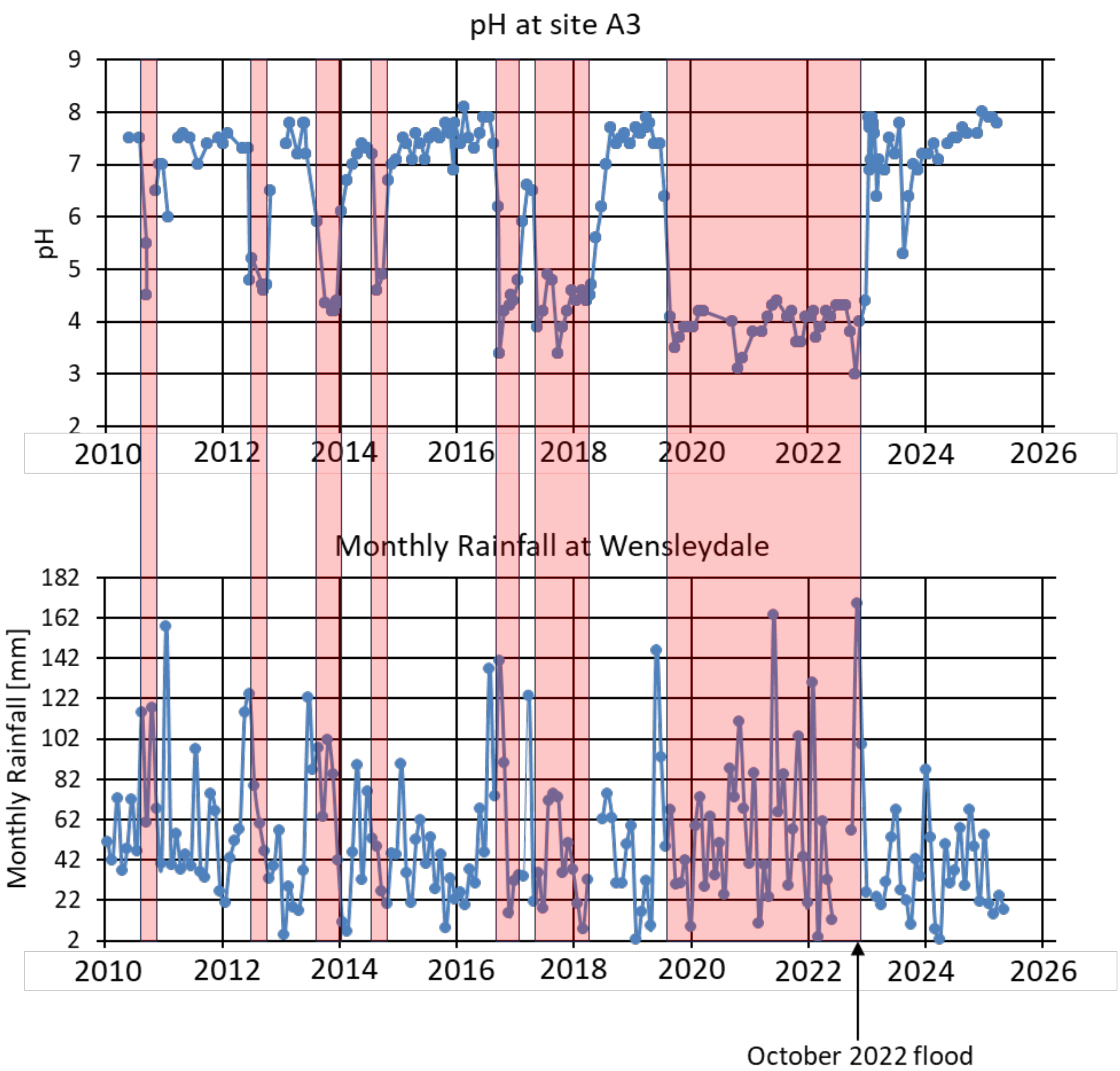

Figure 1: Monthly pH (with low pH being acidic) for the Anglesea Estuary and rainfall at Wensleydale since 2010. Heavy rainfall on 22 – 23 October 2022 resulted in "one of the most devastating (floods) in Victoria's history" (Parliament of Victoria 2024)

The river pH has been typically between 4 and 5 since August 2019 and shows no signs of improvement.

The cause of the permanent acidification of the estuary is attributed to the end of discharging pH-neutral ALCOA water which was mostly a by-product of the Power Station cooling system. This stream of typically 1640 ML/year was more than the total of recent Salt and Marshy Creek annual flows of 343 and 635 ML respectively. The typical pH of Salt and Marshy Creeks during flow periods are about 4 and 3 respectively.

The question is where does this acidity come from and why are the creeks always acidic now?

Obviously, they weren't always acidic as the estuary was previously healthy even without the good water from ALCOA.

A report by Maher (2011) attributed the flush of acidic water to natural processes, where pyrite-containing sediments are oxidised resulting in the formation of sulfuric acid commonly referred to acid sulphate soils (ASS). The acid is mobilised when soils are soaked (water-saturated) and discharge water into creeks. The availability of large amounts of acid throughout the catchment has been further substantiated in a report by Wong et al. (2020) and a student project report by Pajank (2019) confirmed the occurrence of acidic water throughout the catchment. The presence of pyrite in sediments of the Anglesea Formation, which forms the top sediments in the area of the Anglesea coal mine has been confirmed by Holdgate et al. (2001).

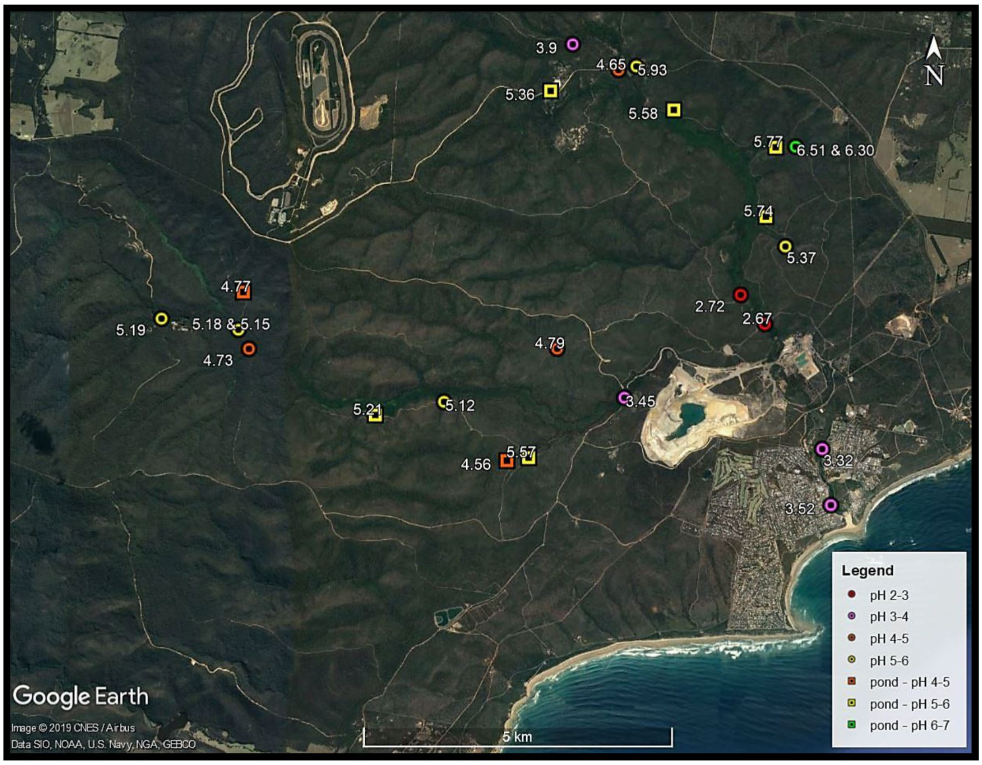

Figure 2: pH in surface water samples collected from the Anglesea River catchment, 30 September to 03 October 2019 (Pajank, 2019).

3. Significant reduction in annual Salt Creek flows compared to the 1960s and 1970s

Water flow data from the lower Salt Creek is available for the periods from 1968 to 1981 and again since 2010. Unfortunately, almost 30 years of data is missing. Annual flow in Salt Creek is plotted against annual rainfall in Figure 3. Flows and rainfall co-vary year-to-year until 1980, for example, 1974 and 1978 have the highest rainfall and flows, but a general correlation cannot be seen. Importantly, annual flow in the period up to 1982 had an estimated average of 3250 ML with peak annual flows of 6900 to 8200 ML per year. In contrast, the estimated average annual flow since 2010 is 343 ML with a maximum annual flow of 1100 ML. Alcoa argues the reduction in flow is associated with a drying climate, however, this is not reflected in the rainfall data (see below). It is further important to note, the catchment outside of the mine, the power plant and the township is State Forrest, therefore potential man-made changes at the surface such as changes to the surface hydrology or plant community and associated changes in evapotranspiration are considered negligible. This prompts the question what caused the drop of flow by nearly 90% since the 1970s.

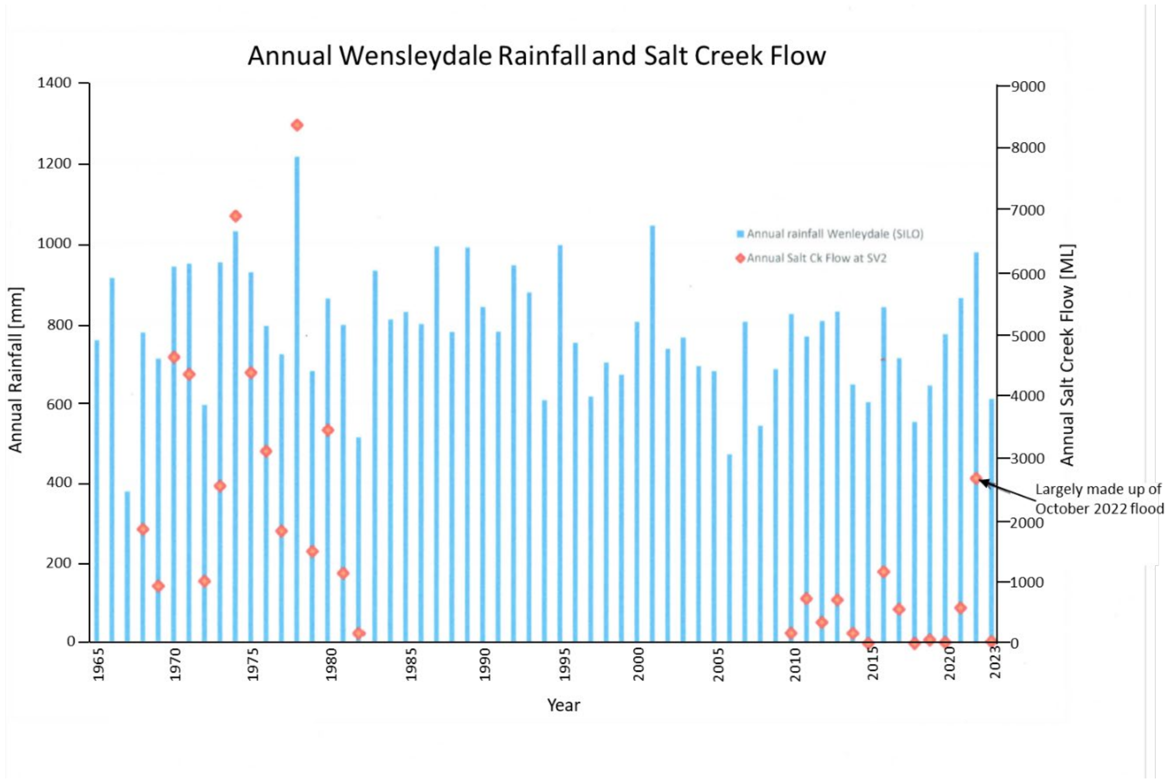

Figure 3: Annual rainfall (blue bars) and annual flow in the lower Salt Creek (red diamonds) since 1965. Rainfall data provided by BOM and SILO. Salt Ck Flow data provided by DELWP website https://data.water.vic.gov.au/

Long term climate variation and rainfall

For many years (hundreds?) prior to 1968 the estuary provided a safe breeding ground for fish even without the help of a considerable quantity of good water from ALCOA. What has changed between then and now?

The conventional theory is that rainfall has reduced and evapotranspiration increased so that Acid Sulphate Soils have been activated by drying in the catchment swamps and creeks.

The available data for Wensleydale from the SILO website contradicts the reduced rainfall part of this theory. Prior to the commencement of the mine there were several longer lasting, much drier periods (Figure 4). The first half of the 20th century was much drier than currently but the estuary maintained good health. Daily rainfalls for Wensleydale are easily accessible from the SILO website. Increases in evapotranspiration is unlikely from our point of view because negligible changes in the plant community. However, this could be evaluated by experts if necessary.

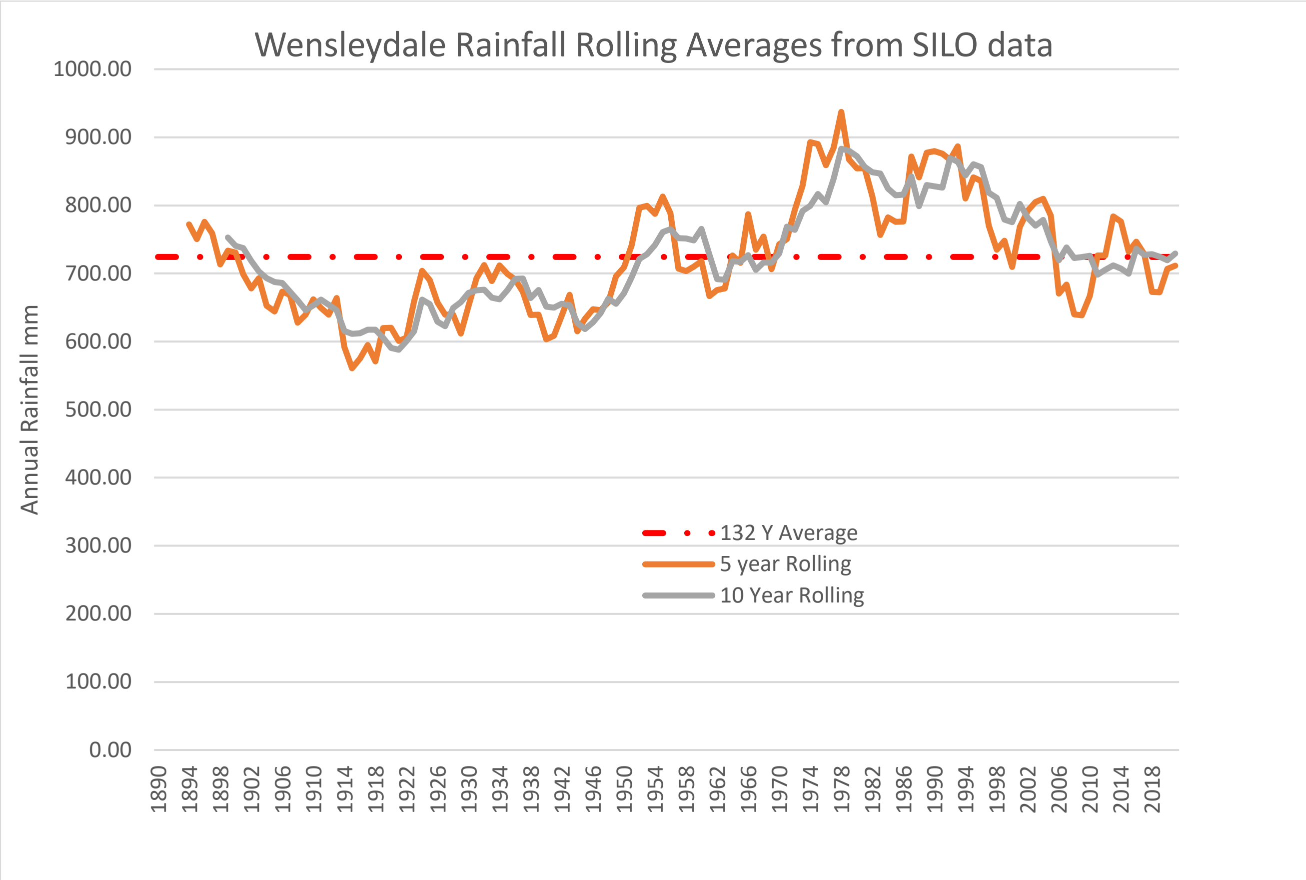

Figure 4: SILO data showing annual rainfall at Wensleydale (Automotive Testing Ground).

4. Hydrogeology in the vicinity of the coal mine and swamps of the Salt Creek and Marshy Creek

The general distribution of aquifers is given through a cross section as shown in Figure 5.

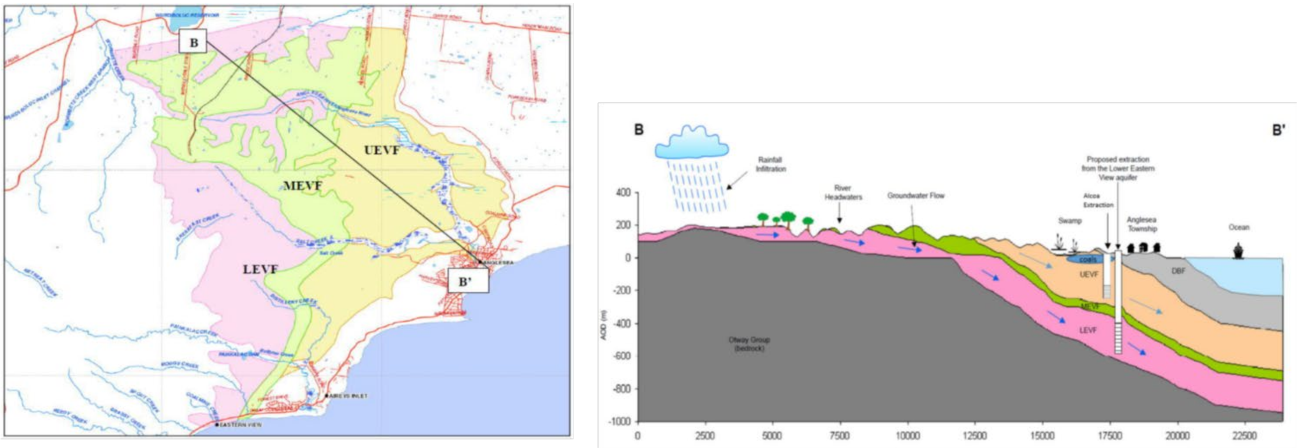

Figure 5: Left: The distribution of the Demons Bluff Formation (DBF), Upper Eastern View Formation (UEVF), Middle Eastern View Formation (MEVF) and Lower Eastern View Formation (LEVF), Salt Creek and Marshy Creek with associated swamps and the B to B' transect in map view. Right: B to B' transect showing the subsurface distribution of stratigraphic units. Figures from Wong et al. (2020).

It is important to note that the boundary between the Eastern View Formation and the Demons Bluff Formation is represented differently in Figure 6 based on a revised stratigraphy and detailed geological mapping of the mine and rock descriptions from wells nearby (Holdgate et al., 2001). Holdgate et al (2001) used the more updated stratigraphic system whereby the Eastern View and Demons Bluff formations are upgraded to group status (Figure 6). The top of the Eastern View Group is defined by the upper boundary of the A1 coal seam which was mined by Alcoa (Holdgate et al., 2001). The A1 coal seam is overlain by 30 – 40 m of sediments of the Boonah, Anglesea and Salt Creek formations in the area of the Alcoa coal mine (Fig. 6), which belong to the Demons Bluff Group. A transect across the mine and adjacent areas with the distribution of stratigraphic units is shown in Figure 7.

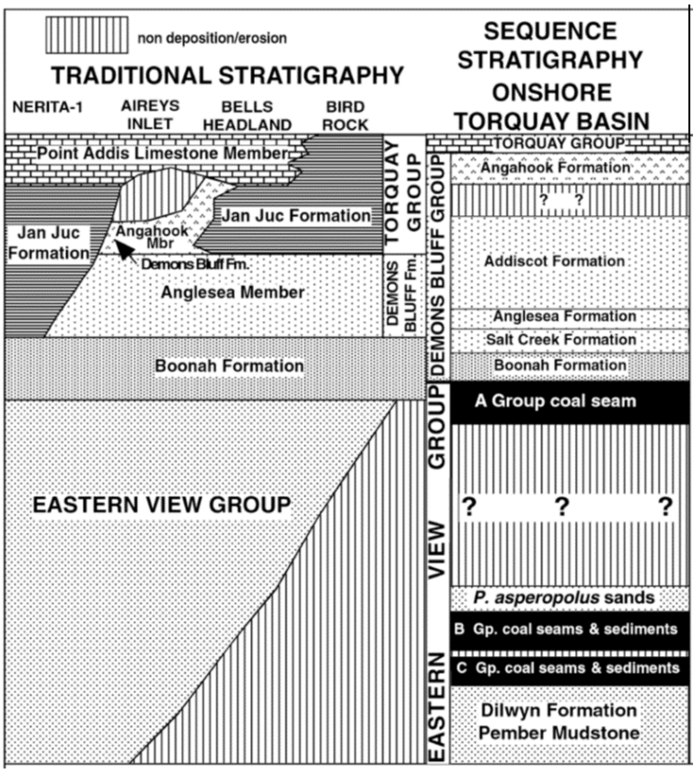

Figure 6: Traditional and new stratigraphic sequence according to Holdgate et al. (2001).

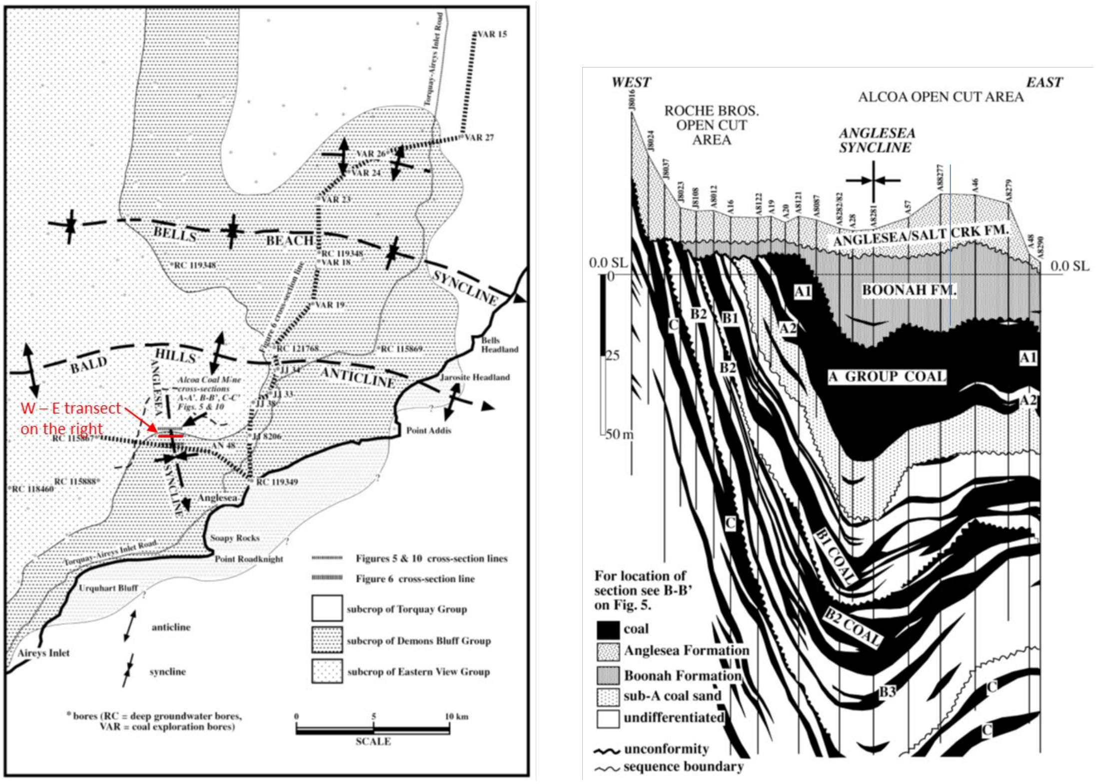

Figure 7: Left: Map view of the sub-crop distribution of stratigraphic units and the location of the transect (red) shown on the right. Right: Vertical distribution of stratigraphic units along the W – E transect covering the Roche Bos. And the Alcoa mines. Note the 30 – 40 m of Demons Bluff Group sediments above the A1 coal seam. Figures from Holdgate et al. (2001)

The nature of Demons Bluff Group sediments may play an important role in supporting the swamps around the creeks and in controlling flows in the creeks. The swamps are believed to be currently sustained by perched aquifers, which form on top of local, impermeable units. According to Holdgate et al. (2001), the Salt Creek Formation is part of the Demons Bluff Group and “comprises micaceous kaolinitic sandstone and carbonaceous mudstone 20–25 m thick … a localised 1 m-thick coal seam a few metres above the base, and a more regional 2 m-thick coal seam approximately 10 m above the base that can be correlated across the current mine highwall”. The described rock types may well serve as impermeable units supporting perched aquifers. Importantly, the laterally continuous, 2 m thick coal seam which can be traced across the mine with a diameter of about 1 km may have served as a regional aquitard separating an unconfined aquifer above from a confined aquifer below. This would also explain the occurrence of artesian springs in the hills surrounding the Salt Ck swamp before and during the early days of the mine. Local residents with a long connection with mining and earthworks in the area are available as a reference.

Alcoa pumped 1.6 GL per year from the upper Eastern View Group in order to keep the mine dry and use the water for cooling in the power plant. The water was treated and then discharged into the Anglesea River. The pumping of groundwater caused a regional lowering of the groundwater level of up to 60 m at the production well below the power plant. The lowered groundwater level is referred to as the cone of depression and is shown in Figure 8. The groundwater level is lowered far beyond the coal mine and the power plant extending to areas underneath the swamps.

It should also be noted that wells away from cone of depression for example 116458 near the corner of Forest and Gum Flats Road, 121768 on Forest Rd and 115869 near the cnr of GOR and Jarosite Rd were virtually unaffected for the whole period since 1993. Note 121768 and 115869 appear to have been affected to a small extent by the Barwon Water tests in the lower Easters View Group in 2012.

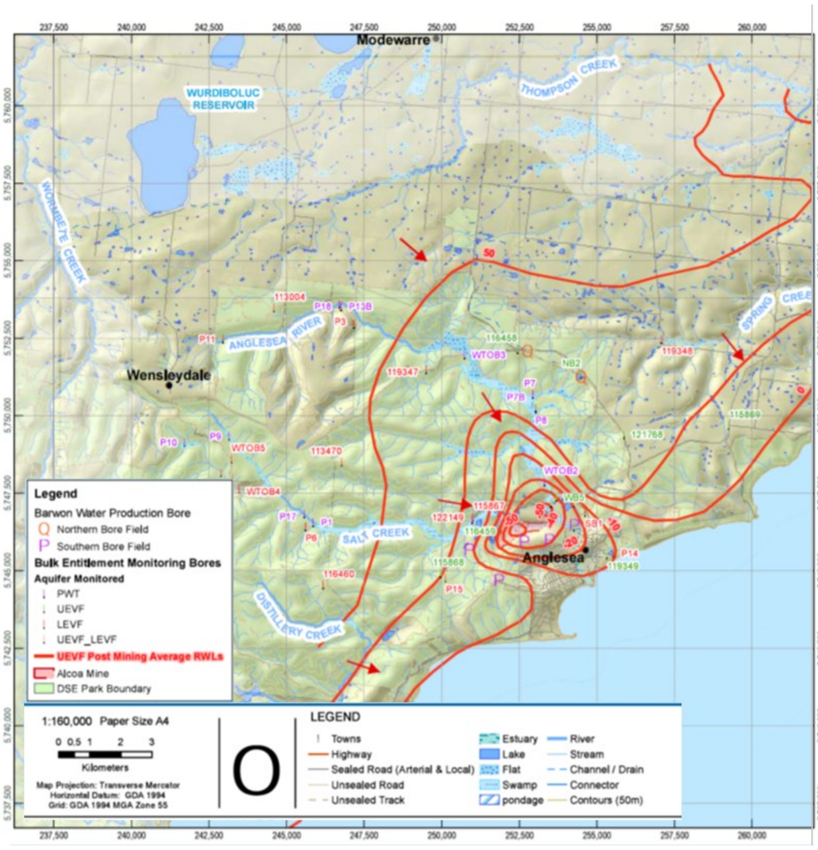

Figure 8: Groundwater contour lines (solid red lines) relative to sea surface level and groundwater flow direction (red arrows) together with creeks and swamps. Adopted and modified after Barwon Water Borefield report prepared by GHD (2013).

Changes in the groundwater potential of the upper Eastern View Group and a perched aquifer in the vicinity of the swamps are shown in Figure 9.

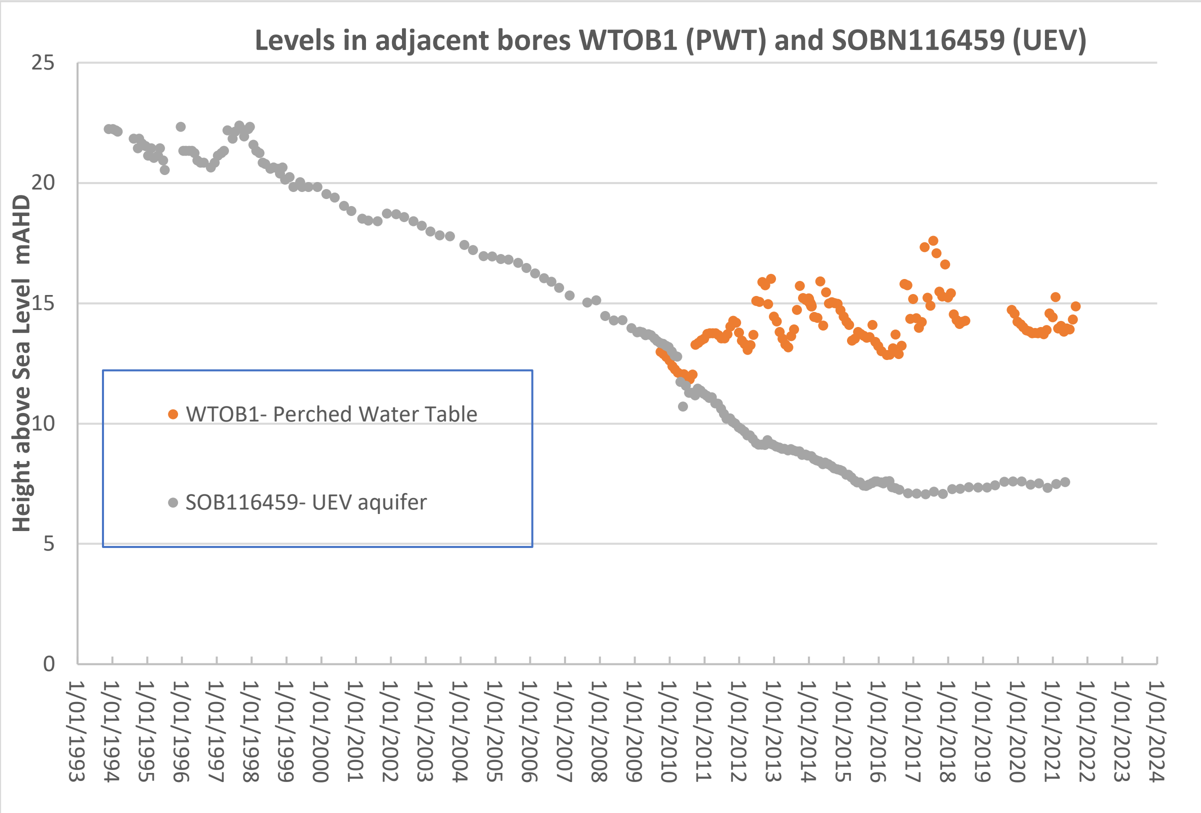

Figure 9: Potential groundwater levels of the upper Eastern View Formation (grey) and a nearby perched aquifer (orange) relative to Australian Height Datum (AHD) near Salt Creek since 1993.

The above graph shows measured groundwater levels from two bores meters apart near the Lower Salt Creek swamp on Bald Hills Road.

There are several things of interest in this graph:

- The groundwater potential level of the upper Eastern View continued to decline at the site until pumping stopped in 2016 suggesting the cone of depression continued to develop and previous groundwater potential maps such as the one prepared by GHD (2013) are no longer accurate.
- The water level of the perched aquifer is highly seasonal and often drops to a base level, which could be the bottom of the aquifer. If that is the case, the perched aquifer could temporarily dry out.
- It is also important to note the groundwater potential of the upper Eastern View Formation was higher than the perched aquifer level up until about August 2009 and then dropped below suggesting the perched aquifer changed from a receiving to a losing aquifer.
- The historically higher UEV aquifer level would have as a minimum reduced the seasonal variation in the perched aquifer by positively preventing losses to the UEV
- The Salt Ck lower swamp and perched aquifer run for a kilometre on the West side of Bald Hills road only about 500m from the Western wall of the mine pit. The wells are in this area and the measured drops of the perched aquifer could be partially due to leakage into the pit.

Alcoa regards the change in water levels at the two sites in close proximity to each other as evidence for two hydraulically disconnected aquifers, whereas we disagree with this conclusion. A perched aquifer is a local build-up of groundwater above impermeable sediments within a larger permeable complex such as the Salt Creek Formation. The perched aquifer and a regional (unconfined) aquifer are hydraulically connected.

It is further important to recognise that changes in the water content in coal seams affect their permeability. Water-saturated coal typically has a very low permeability while the loss of water results in higher permeability due to shrinking. This suggests the laterally continuous, 2 m thick coal seam as part of the Salt Creek Formation (see above) may have served as a regional aquitard before the cone of depression developed but lost this role in recent decades. Similarly, the remaining massive A1 coal seam within the cone of depression may have transitioned to a permeable rock.

The lowering of the groundwater level in the upper Eastern View Formation as shown for a well near the Lower Salt Creek swamp (bore SOB116459, Figure 9) has resulted in a large reduction in artesian areas as shown in Figure 10. These maps were prepared by the Corangamite Catchment Management Authority with data provided by Barwon Water. The groundwater table was mapped out based on groundwater levels measured in bores for different times. Areas where the groundwater table was above the surface elevation were classified as artesian areas.

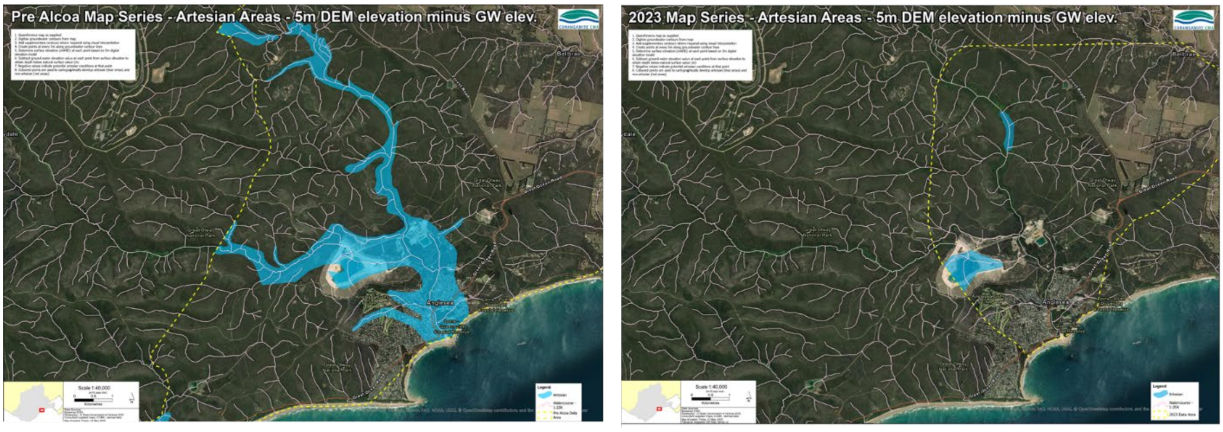

Figure 10: Artesian areas shown in blue before mining commenced (left) and at current time (right). Maps were prepared and provided by the Corangamite Catchment Management Authority.

It is clear that the water production associated with the mine and power plant operations resulted in a regional lowering of the groundwater level (‘cone of depression’, Figure 8) and a loss of large artesian areas. These areas were primarily swamps along Salt Creek (west of the river) Marshy Creek (north of the river). Swamps are groundwater-dependent ecosystems (GDEs), which are precious environmental assets requiring particular attention in groundwater extraction applications.

5. Our hypothesis explaining acidic water and reduced flows

It is clear that groundwater-dependant ecosystems such as the swamps around Salt Creek and Marshy Creek, as well as flows in creeks and rivers, are strongly controlled by the shallow geology and hydrogeology. We argue sediments of the Demons Bluff Group in the vicinity of the coal mine and the swamps probably play a critical role in controlling surface and shallow subsurface hydrology. The development of the cone of depression is expected to have significantly altered the original shallow groundwater system. The following two conceptual models for the shallow groundwater system before and during the pumping of water from the upper Eastern View Group are proposed:

The shallow groundwater system before pumping from the upper Eastern View Group commenced

The laterally continuous 2 m thick coal seam in the lower part of the Salt Creek Formation is expected to have served as an aquitard separating an unconfined aquifer above and a confined aquifer below (Figure 11) in the area of interest. This model is in agreement with anecdotal evidence of artesian wells tapping into the Boonah Formation. The areas of topographic depressions including the swamps around the creeks would have been water saturated for long periods, possibly permanently. A large proportion of rainfall would drain directly into creeks and rivers without infiltrating into the subsurface leading to high flows. The groundwater level in the unconfined aquifer would have been relatively stable as compared to the seasonal fluctuations currently observed for perched aquifers in the region. In areas where the water table of the unconfined aquifer extended into the pyrite-containing Anglesea Formation pyrite oxidation would be limited by the sub- or anoxic conditions of the groundwater leading to limited acid production. Importantly, the high proportion of overland flow would have diluted and neutralised acid discharged from the subsurface into surface water.

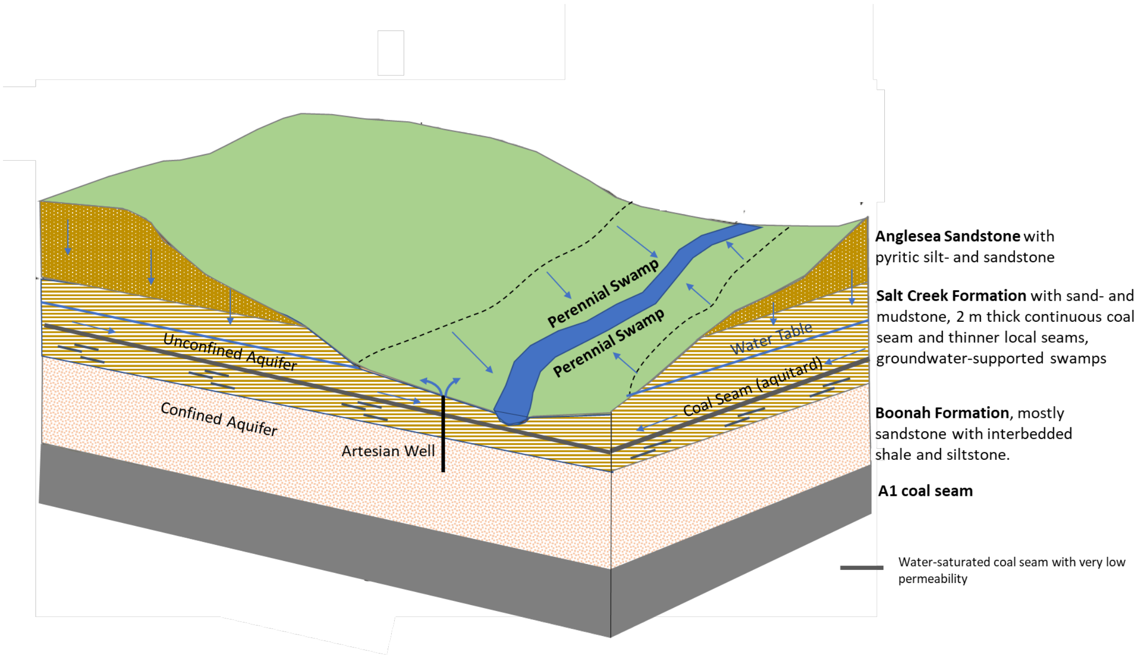

Figure 11: Conceptual representation of key elements of the groundwater – surface water system in the area of interest before the cone of depression developed.

The shallow groundwater system during water abstraction from the upper Eastern View Group

Water abstraction from the upper Eastern View Group created a cone of depression in the area of the coal mine and the swamps with a maximum lowering of the water table of 60 m. The cone of depression continued to expand until pumping was stopped in 2016. Swamps surrounding the creeks are supported by (local) perched aquifers rather than by a shallow unconfined aquifer (see above). We believe the 2 m coal seam within the Salt Creek Formation was (partly) dewatered in the area of the cone of depression. Consequently, the permeability of the coal increased and the coal seam lost its function as a regional aquitard (Figure 12). The shallow unconfined aquifer and its support for the swamps ceased to exist. The rate of infiltration into the deeper subsurface greatly increased while flows in the creeks greatly decreased. The lack of high flows means the acid produced in the shallow subsurface and mobilised during wet periods is no longer diluted and neutralised by the high flows, which explains the prolonged acidic periods in recent years. Similarly, the massive A1 coal seam became dewatered within the cone of depression and lost its capacity to retain water above the coal seam.

Another potential contributor to the observed reduction in Salt Creek flows may be the mine pit itself as it intersects the perched aquifers especially in the Salt Creek lower swamp area. This could have caused the Salt Creek perched aquifer to partially drain into the pit. This would reduce the flow continuously monitored at the SV2 site and increase the water level variations in the swamp perched aquifer. This increased variation would increase acid production. The overburden removal for Block 2 (Western pit) development started in 1979. This timing is also consistent with the large drop in Salt Creek flow between 1981 and 2009.

Our hypothesis provides a single cause for the prolonged acidic periods and the great reduction in flows.

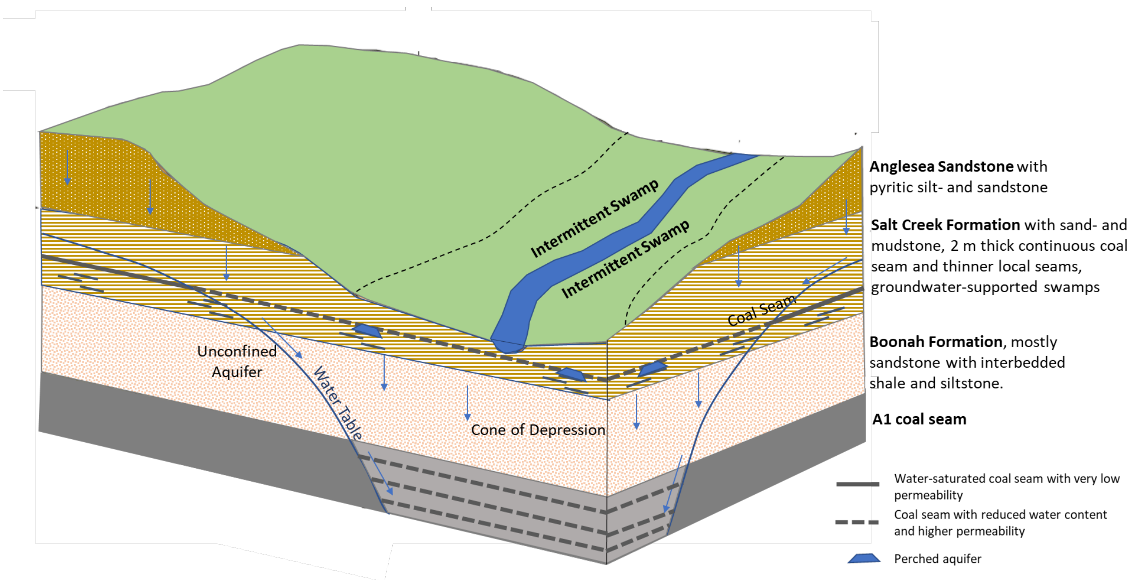

Figure 12: Conceptual representation of key elements of the groundwater – surface water system in the area of interest during the development of the cone of depression.

Questions and recommendations for further work

The overarching question of the mine closure and rehabilitation should be: How can we best rehabilitate the Anglesea River catchment and estuary? It should not be limited to determine the maximum volume of groundwater abstraction to fill the mine pit. It is incomprehensible and unacceptable that the acid problem and the reduced flows have not been explicitly addressed in the land rehabilitation plan.

It is our view that no credible root cause of the estuary acidification and the very significant reduction in flows has been identified or reviewed outside of this Discussion Paper. Currently the only cause proposed has been a vague reference to climate variation. The first task is to determine the real causes of the problem. This could be done by examination of existing reports and data, specific wellbore tests, groundwater models focusing in hydraulic connectivity and collection of anecdotal evidence. So far, the step of connecting the permanent acidification with the many available observations has not been made. Many of the assumptions that have been made in the past can now be proven wrong. The extraction of water from the upper Eastern View Group aquifer should be discontinued until a reasonable cause of the acidification is found.

It may be that the inbuilt limitations in our detailed knowledge of the geology may mean that the modelling cannot provide absolute proof of what happened in the past or would happen in the future. Even so, it would have great value in assessing and comparing various remediation strategies.

Groundwater tests and simulations should focus on hydraulic connectivity in the shallow subsurface (above the A1 coal seam) and the groundwater-supported swamps. Of particular importance is the role of the regional coal seam within the Salt Creek Formation before (water saturated coal seam) and after the water table was lowered (dry / partly saturated coal seam). Furthermore, if groundwater abstraction from the upper Eastern View Group by Alcoa would stop, when would the coal seam become water saturated? Would the re-flooding of the coal seam restore the regional unconfined aquifer?

A fully integrated groundwater model from the surface to the lower Eastern View Group should be developed with a particular focus on hydraulic connectivity within and across lithostratigraphic units. Is it possible that water production by Barwon Water from the lower Eastern View Group contributes the lowering of the groundwater table in the upper Eastern View Group? If water from the lower Eastern View Group was used for filling the mine pit, when could the mine pit be filled?

An independent panel of experts should have the power to contribute to the definition of objectives and the design of environmental assessments and rehabilitation measures. It should not be limited to the review of technical reports.

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