

## **Finding the balance between sustainable extraction of floodplains and economic enterprise**

Ashley Roberts<sup>1</sup>, Guy Lampert<sup>2</sup>

1. GHD, 180 Lonsdale St, Melbourne, 3000. Email: [ashley.roberts@ghd.com](mailto:ashley.roberts@ghd.com)

2. GHD, Level 3, GHD Tower, 24 Honeysuckle Drive, Newcastle NSW 2300. Email: [guy.lampert@ghd.com](mailto:guy.lampert@ghd.com)

### **Key Points**

- There is presently a gulf between the interests and expectations of the respective parties in terms of what is considered sustainable sand or gravel extraction in floodplains
- The risk of pit capture is seen as the major risk of concern for the authorities
- A risk assessment framework has been developed that considers various modes of failure that lead to pit capture
- High degree of subjectivity in the application of the risk assessments to date, and no attempt has been made towards quantifying residual risk in the application of mitigation measures
- Through site specific consideration of floodplain hydraulics, geomorphology and geotechnical characteristics, more informed decisions can be made on the risk of pit capture occurring
- Further work is required to inform on risk assessments and advance the dialogue between water authorities and extraction companies

### **Keywords**

sand, gravel, floodplain extraction, pit capture, avulsion

### **Introduction**

Extraction of sand and gravel from within streams became uncommon in Victoria after the 1980s. However, extraction often shifted to floodplains, where gravel extraction companies have historically purchased land based on the volumes of sand and gravel resource expected, and extraction takes place under a “Works Authority” license. There is presently a gulf between the interests and expectations of the respective parties in terms of what is considered sustainable sand or gravel extraction in floodplains. The risk of pit capture is seen as the major risk of concern for the authorities. This is where a new channel erodes across the floodplain joining the river to the pit, and can potentially divert the river to a new position on the floodplain. In this Technical note we share some recent experiences after being involved in a number of sand and gravel extraction sites in Victoria seeking to continue or expand their floodplain extraction licenses. Our main contention is that through more detailed site specific investigations, more informed interpretations can be made on the risk of pit capture occurring, and the determination of sustainable extraction within a floodplain location.

### **Historical Perspective**

Accepting that typically the better sand/gravel materials occur as alluvial deposits in floodplains, and recognising the economic enterprise opportunities, this has led to significant extraction activity propagating throughout floodplains in Victoria. “Works Authority” licences have been issued to many sites located within floodplains across Victoria, with a range of conditions or limitations imposed in terms of extent, setback and depth of excavation. As a result of a recent piping failure, closer attention to the risks associated with extraction activities in floodplains has led to greater scrutiny on extraction licensing within the industry.

Direct extraction from active waterway channels presents the highest risk of pit capture or associated avulsion or floodplain instability, and this still occurs in some states. Whilst Victoria moved away from direct sand and gravel extraction from creek beds, there has been extensive extraction activity in the floodplains over the last 40 years. “Works Authority” licenses for extraction activities have been issued in many sites including the Goulburn and Ovens River floodplains in north east Victoria, and many have sought and continue to seek expansion to their existing “Works Authority” licenses. There are estimated to be nearly 500 sand and/or gravel extraction sites in operation or rehabilitated throughout Victoria, with many within floodplain locations. The well documented failure at the site in the Goulburn floodplain adjacent to an anabranch (Island Creek) is the first publicised pit capture failure of any sand or gravel extraction pit in Victoria.

## **Extraction Company Perspective**

Land has typically been purchased by gravel extraction companies based on geological resource mapping where projected volumes of extractable material created business enterprises. The commercial opportunities remain in terms of return on investments through the expansion of existing licenses. There is an expectation that new licensees at new sites on floodplains will be difficult to obtain, and therefore companies are more focused on looking to expand existing “Works Authority” licenses. Companies with an existing “Works Authority” license are looking to maximise the extent and depth of extraction activities within their purchased sites. Many extraction companies have recently been challenged by Water Authority responses to proposed expansion activities, and in some cases have led to Section 110 Notice being issued under the Mineral Resources (Sustainable Development) Act, that requires the Works Authority” holder to stop work. In a recent submission to the “Water for Victoria – Discussion Paper”, the Construction Material Processors Association (CMPA) response highlighted the need for a strategy for extraction on floodplains, that balances the environmental needs of protecting the floodplain with the broader and local economic and social benefits that the industry provides.

The gravel extraction companies make reference to the longevity of their operations, and existence of active and rehabilitated extraction sites without the occurrence a failure until recently. There is acknowledgement that the recent failure that occurred at Island Creek was due to the encroachment of typical setback requirements, and allowance to create significant depths in a dry operation well beyond the adjacent water course bed level. However, the extraction companies had proposed, that with the appropriate consideration of failure mechanisms (in this case piping failure and engineering interventions to manage), and a change from the previous dry extraction (to wet extraction) the failure that occurred at this location could have been avoided. Extraction companies are wanting to challenge the limitations imposed on extent and depth of excavation, and seeking whether such mitigation strategies can reduce the risk and be acceptable to the authorities.

## **Water Authorities’ Perspective**

There are concerns regarding risk to the environment and related infrastructure as a result of water quality, floodplain stability and avulsion risks. The recent failure (Island Creek) has led to a risk-averse response from the approval authorities, and where the risk of pit capture to the physical environment and infrastructure is of concern. These concerns are focused on floodplain stability risk, where potential irreversible damage to the waterways and floodplain may occur leading to potential damage of property and infrastructure. The creation of pits and increasing the size of existing pits is considered to increase the likelihood of the occurrence of an avulsion event where the process of sudden erosion can cause the change in course of the river alignment.

The potential modes of failure or pit capture to be considered includes lateral erosion of waterway to pit, piping failure between pit and waterway, or overtopping failure (or erosion of the buffer zone) between pit

and waterway. The authorities are looking to impose limitations on both depth, size and overall extent of extraction to protect floodplain integrity. Furthermore, the authorities also have concern with reliance on structural (mitigation) solutions, as well as legacy issues, associated with ownership, responsibility and ongoing maintenance and/or repair as may be required over time post extraction.

The authorities suggest that there may not yet have been flood events large enough to lead to pit capture failure via the various identified failure mechanisms. They are concerned about their being a number of active sites exposed as well as legacy issues of the past that if left unmitigated could lead to pit capture in the event of say a 1 in 100-year magnitude flood.

## **Independent perspective**

Whilst the authority concerns are often framed around flooding and environmental concerns, the floodplain stability risk (or risk of avulsion and “pit capture”) is the primary concern for the authorities. There are currently no clear industry guidelines for managing the risk of pit capture, and the guidelines that are currently referenced are more focused on flooding impacts and risks to water quality and river health implications (e.g. Guidelines for the Protection of Water Quality (North East Planning Referrals Committee, 2001). Lack of guidance or a clear framework has historically allowed companies to encroach into floodplains towards active water courses and flow paths, that may have led to creating higher risks. There has been some recent work towards developing a risk based framework for managing the risks associated with water quality, flooding and floodplain stability.

Recent work has been undertaken to develop a risk assessment framework that considers various modes of failure that lead to pit capture. However, there is a high degree of subjectivity in the application of the risk assessments to date. These are leading to different risk assessment outcomes depending on the perspective and vested interest. The subjectivity of these risk assessments has led to a mismatch between authority and extraction companies’ views on the risk assessment outcomes and acceptable risk mitigation approaches that can be implemented.

The following are the key modes of failure for pit capture that have been considered in various risk assessments

- Risk 1 – Lateral erosion of waterway into pit
- Risk 2 – Piping failure between waterway and adjacent pit due to hydraulic head differential
- Risk 3 – Overtopping failure or erosion of the buffer zone between pit and waterway (due to uncontrolled (overtopping) flood flows entering pit)

From various levels of involvement in the risk assessment process to various “Works Authority” sites, an understanding and awareness of the issues and risks has been gained and challenges of reaching agreement on what is fair and reasonable for the parties involved. A study undertaken by Jacobs on behalf of the Goulburn Broken Catchment Management Authority (GBCMA) focused on the Works Authority licences within the Goulburn floodplain has led to the development of a risk assessment framework. Through various levels of involvement at a number of sites within the Goulburn River and Ovens River floodplains, the interpretation of the risk assessment process and outcomes has provided an opportunity to considered the application of the risk assessment framework.

Current risk assessments are highly subjective, particularly when considering the likelihood and consequence, and have been used in an attempt to assess appropriate setback distances and limits to depth of excavation as the only acceptable forms of risk mitigation. The combination of these limitations being imposed can lead to unviable outcomes for extraction companies which may be an appropriate outcome for some locations, but not necessarily all. Some of the limitations on current documented approaches to risk assessments include:

- The risk assessments that have been undertaken assume pit capture failure occurs once floodwaters from the floodplain enter the pit
- There is tendency to be conservative where it is difficult to be definitive, and therefore the “precautionary principle’ is being applied, particularly in terms of applying the Likelihood
- The occurrence of a pit capture failure, does not necessarily result in the occurrence of an avulsion event that leads to the catastrophic consequences being described
- There needs to be clarity in terms of how geometric properties of the pit (in terms of extent and depth) provide a basis for the likelihood of failure, or whether these properties have more bearing on the Consequence
- There needs to be distinction made between the risk profile of excavated pits that remain active and in an operation phase, to pits that have been rehabilitated in accordance to requirement of “Works Authority” licence conditions
- There needs to be further consideration on a site by site basis on the refined or residual risk assessment outcome once appropriate and acceptable mitigation measures have been developed.

The subjectivity can be reduced through informed and integrated assessments against the various modes of failure involving the following specialist inputs:

- Geomorphology – Lateral erosion, Overtopping failure
- Geotechnical/Hydrogeology - Piping, Lateral erosion
- Floodplain Hydraulics - Overtopping, Piping

These investigations that could be undertaken to inform the risk assessment associated with the various modes of failure, and also the risk mitigation options that consider both extent and depth limitations combined with alternative structural interventions. As an example of mitigation, a means of reducing the risk of failure during operation may include allowing the water level within the pits to remain at the natural groundwater levels. This would require “wet extraction” during operation, and may need to be done with conditions applied to limit environmental implications, but wet extraction may result in:

- Reduced driving heads that would reduce the risk of piping failures (during operation) i.e. the worst case scenario for piping failures would have an empty pit adjacent to a waterway conveying flood flows for an extended period of time
- Reduced airspace volumes (and therefore shorter time periods and durations to fill the pits to balance the water levels for both active and rehabilitated sites.

The authorities also consider there to be residual risk associated with pits full of water and their function within a floodplain during a flooding event. The low resistance of the high flow conveyance path that is provided by the effective flow area of a full open pit is considered to alter the floodplain hydraulics during flood events. This phenomenon needs to be further explored and understood in terms of truly understanding the associated risk profile. Whilst this would seem to be a plausible issue that warrants consideration, there has been no documented occurrence of this type of failure, and current risk assessments do not quantify the residual risk that remains.

## Conclusions

Further work is required to determine a basis for both likelihood and consequence of pit capture occurring to inform on risk assessments and advance the dialogue between water authorities and extraction companies. Through site specific consideration of floodplain hydraulics, geomorphology and geotechnical characteristics, more informed decisions can be made on the risk of pit capture occurring. The question remains whether the sought after outcome of a compromise can be achieved, that will enable the extraction companies and authorities to move forward co-operatively. This would be expected to incorporate:

- A compromise on both setback and depth of excavation, that allows for some level of alternative mitigation to enable a viable extraction operation to remain
- Agreement on acceptable structural mitigation measures that can reduce the risks to tolerable levels (e.g. inflow / outflow control structures to each pit).
- A proposed arrangement between the parties (extraction companies & the authorities) for the long term ownership, responsibility and ongoing maintenance of any assets including those created as part of the mitigation measures.

The application of risk assessments extended to mitigation scenarios combined with allowed extraction beyond current imposed limits will need to be worked through as part the detailed assessments to inform whether the above can be achieved.

## Acknowledgments

Miscellaneous information provided by Bell Cochrane who manage a number of extraction sites throughout Victoria.

## References

Department of Primary Industries (2010). Extractive Industry Work Plan Guideline, Mineral Resources Sustainable Development Act 1990.

GHD (2013). Report for Barro Group - Island Creek Realignment and Supporting Works

Ladson, A. R. and Judd, D. A. (2014). A review of the effect of floodplain gravel mining on river stability. In: Vietz, G., Rutherford, I. D., and Hughes, R. (editors). Proceedings of the 7th Australian Stream Management Conference. Townsville, Queensland, pp. 249-258.

Jacobs (2015a). Risk assessment of floodplain mining pits in the mid-Goulburn Valley. GBCMA.

Jacobs (2015b). Risk assessment of floodplain mining pits in the mid-Goulburn Valley. GBCMA. Rehabilitation works to stabilize existing floodplain pits