General guidelines for designing stormwater retention ponds in the mining industry

José Adriasola V., MSc
Chief Hydraulic Engineer, LA Region
Bechtel Chile Ltda.

Jorge Gironás L., PhD
Assistant Professor Hydraulic/Hydrology Engineering
Pontificia Universidad Católica de Chile

Outline

1. Objective and Motivation
2. Pollution of surface stormwater runoff and regulations
3. Main concepts and definitions
4. Different purposes of stormwater retention ponds
5. Stormwater retention ponds in extremely dry areas
6. Stormwater retention ponds in extremely wet areas
7. Complementary works for stormwater retention ponds
8. Conclusions and recommendations

1. Objective and Motivation

- Objectives:
  - Provide general guidelines to have a consistent approach when sizing stormwater retention ponds
  - Ensure effectiveness of stormwater retention ponds at the minimum CAPEX
  - Promote successful practices observed in urban environments which are applicable to the mining industry
  - Show the importance of getting field data from existing operations
- Motivation:
  - Have seen a number of bad approaches and too few good approaches, especially during “super fast-track” studies and execution phases in mining projects

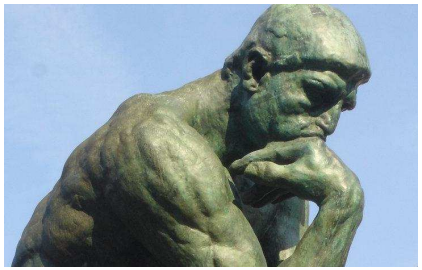
2. Pollution of surface stormwater runoff and regulations

- Stormwater “washes” the industrial site surface during a rain event – diffuse pollution (no single source of pollution)
- The stormwater surface runoff turns into “polluted” or “contacted” water, which cannot be released to the environment without complying with specific regulations related to water quality and/or quantity (included in EIA)
- With respect to quantity, the industrial site produces more stormwater runoff volume and peak flows, due to increased imperviousness in comparison with greenfield conditions
- With respect to quality, specific regulations can be found in several countries and also in international entities (e.g. the International Finance Corporation (IFC) guidelines)

… so what do you do?

Quality issues…

Quantity issues…

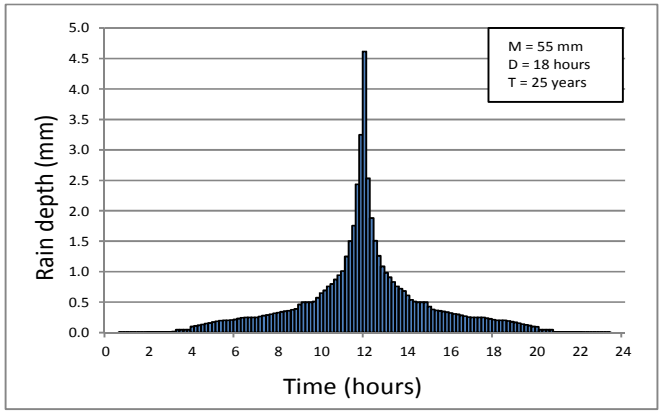


- There are different alternatives to handle the problem, depending on the regulations you need to comply and the complexity of the water treatment required
- A stormwater retention pond could be a good alternative since it's less expensive than other treatment facilities

3. Main concepts and definitions

- "Design storm": a way of representing actual rainfall events. It is defined by the total magnitude "M" (mm), total duration "D" (hours), intensity distribution during the storm and a return period "T" (years). All these hydrological random variables have to be analyzed and understood to do a good and soundness design work
- "Build-up": the process in which pollutants accumulate on land surfaces during dry times between rain events
- It is also critical to analyze the dry time between rain events "Td" as a separate random variable, because it has a big impact in the design of the stormwater retention pond and outflow structures and/or equipment

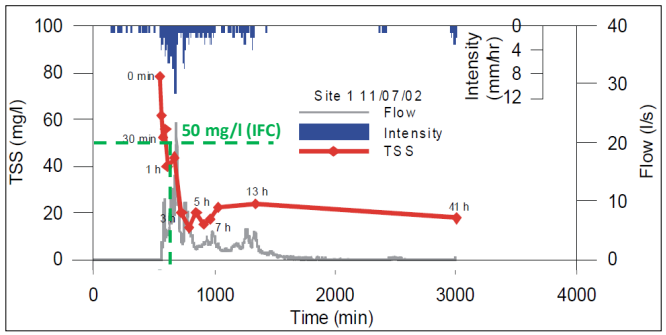
3. Main concepts and definitions



3. Main concepts and definitions

- "Hydrograph": a graph showing the flow rate versus time in a specific point in a channel or conduit conveying fluid
- "Pollutograph": a graph of pollutant concentration 'C' in stormwater runoff as a function of time
- "First flush": the discharge of a larger mass or higher concentration of a certain pollutant in the early part of a storm relative to the later part of it. It's a complex phenomenon. For simplification purposes, in practice the first flush is a fixed volume expressed as the surface runoff produced by the first "x" millimeters of rain. Without specific field data from existing mining operations, we just could assume typical values used for industrial areas in cities: 25 – 30 mm

3. Main concepts and definitions



- If I have enough data to confirm a pollutograph pattern, I could design the stormwater retention pond volume accordingly, if reducing a specific pollutant concentration was the unique goal

4. Different purposes of stormwater retention ponds

- Improvement of water quality: settling solids in the stormwater runoff will considerably improve the overall water quality (need specific assessment); establishing performance targets based on design flow and sediment characteristics is critical
- Capturing the stormwater runoff to use in industrial processes: need to consider stormwater in the overall process water balance; need to have a comprehensive understanding of the local hydrology; need to run Monte Carlo simulations to ensure water supply security level desired
- Limiting the peak flow discharged through the pond's outlet: the stormwater retention pond would be used as a buffer to flatten the inlet hydrograph and therefore reduce the outlet hydrograph's peak flow to an acceptable magnitude

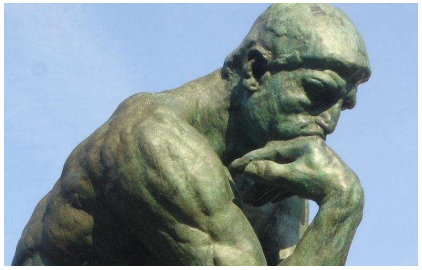
4. Different purposes of stormwater retention ponds

- Removing solid particles bigger than a given particle size 'd' due to hydraulic transport limitations downstream. If you are planning to transport the water in a pipe or open channel, or pump it back to the process water pond, it is critical to check that the solid remaining will be handled correctly
  - Gravity pipes and channels have limitations related to hydraulic transport of solid particles. This need to be considered and checked to avoid sanding in the pipe or channel
  - Water pumps also have limitations with this respect. Ask the pump provider about the maximum particle size recommended to get optimum operation and maintenance
- **Don't forget that the stormwater pond is part of a SYSTEM and you need the whole SYSTEM working correctly all the time… for a long time**

… so what's your stormwater pond for?

Single purpose?

Multiple purposes?



- Review and discuss what are the purposes of your stormwater retention pond. Do the corresponding calculations assuming a single purpose, for each one separately. Check which purpose drives the sizing of the stormwater retention pond. Finally, once you have sized the pond, check if the other purposes and its objectives are accomplished. If not… do loop

5. Stormwater retention ponds in extremely dry areas

- Typically very low annual rainfall depth and very infrequent rain events with considerable magnitude and short duration (e.g. Escondida, Quebrada Blanca, others in Chile)
- In general it would not be reasonable to consider stormwater in the overall process water balance. Other potential uses less critical to the mining processes
- It is reasonable to assume that the pollutants' build-up will be important and therefore the corresponding pollutographs during rain events will present pronounced peaks. Therefore, conceptually speaking, the use of stormwater first-flush retention ponds to improve water quality seems to be very appropriate in these cases

5. Stormwater retention ponds in extremely dry areas

- The time required to empty the stormwater retention pond is likely to be very long, because rain events are infrequent. This fact leaves room to consider using small non-fixed equipment to empty the pond (e.g. trucks with submergible pumps), or using no equipment at all (e.g. evaporation, taking advantage of the high evaporation rates existing in many dry areas)

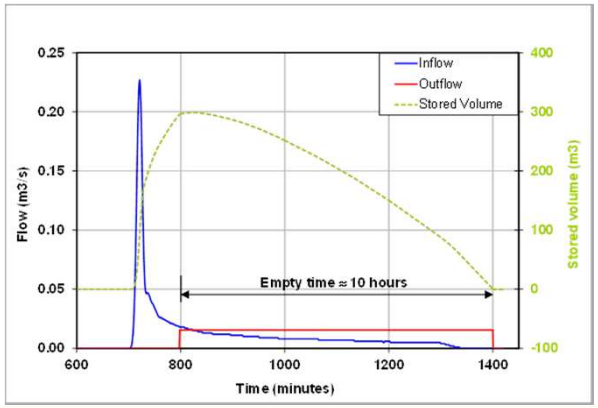
6. Stormwater retention ponds in extremely wet areas

- Typically significant annual rainfall depth and very frequent rain events with considerable magnitude and short duration (e.g. Frieda River – Papua New Guinea, Tampakan – Philippines, Antapaccay and Las Bambas – Perú, others)
- In general it would be reasonable to consider stormwater in the overall process water balance
- As rain events are frequent, it is reasonable to assume that the build-up of pollutants will not be very significant and therefore the corresponding pollutographs during rain events will not present pronounced peaks. The magnitude of the first-flush volume is expected to be significantly less than what should be considered in dry areas – opportunity to reduce costs!!

6. Stormwater retention ponds in extremely wet areas

- The time required to empty the stormwater retention pond is likely to be short, because rain events are frequent. This fact makes it necessary to consider fixed pumps to empty the stormwater retention pond in a short period of time, if gravity outlets are not feasible (this happens a lot), so that the pond is ready to operate before the next rain event
- Need to have a clear idea of where this water should be pumped (process water, tailings dam, other facility)
- Need to find a cost-effective balance between the size of the pond and size of the pumps (see figure in next slide)

6. Stormwater retention ponds in extremely wet areas



7. Complementary works for stormwater retention ponds

- Water inlet and outlet works
- Access and complementary devices for maintenance
- Imperviousness: check whether this is necessary to comply with regulations and EIA commitments
- Access for water quality monitoring: besides the access itself, it is very important to think a practical monitoring approach to demonstrate compliance to the authorities. For example, a practical way to measure TSS concentration in real time is to build an empirical relation between TSS concentration and turbidity (NTU), which will be site specific. So later you just measure turbidity, which is very fast and don't need laboratory tests

8. Conclusions and recommendations

- Make sure everybody in your project is aware of EIA commitments to get adequate alignment in the engineering design tasks
- A good understanding of local hydrology will help you understand what you need
- Determine what are the specific purposes of your stormwater retention pond and how they relate with regulation compliance, water supply, etc
- Identify the purpose that drives the sizing, do the design and later check that the other purposes (if any) are met
- Do campaigns of field data collection. It's not expensive and will help to understand and model pollutographs of major interest

General guidelines for designing stormwater retention ponds in the mining industry

THANKS…
Questions?

José Adriasola V., MSc -- jmadrias@bechtel.com
Chief Hydraulic Engineer, LA Region
Bechtel Chile Ltda.