Reservoir design for the next 80 years –

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Introduction

Tank design has changed significantly throughout the past 20 years. With heightened water quality standards, we have seen the introduction of roofed reservoirs, improved security and more rigorous cleaning regimes. Likewise, with an increased focus on workplace safety, vertical ladders, handrails and rescue systems are now an integral part of reservoir design.

However, many items are still going unchanged. There are still new installations which are at risk of accelerated corrosion, or are potentially exposed to contamination sources. Consideration for maintenance regimes are not yet filtering through to the designers, resulting in reservoirs which have difficult access for divers and labour intensive areas to clean.

This paper discusses a number of reservoir design aspects with a view of longevity and cost effectiveness.

Access & Security

This section covers a broad spectrum of issues including contamination prevention, worker safety and future growth. Access begins with the tank site and ease of movement for vehicles. The main consideration here is what maintenance vehicles will be required? Cranes and EWP equipment will need a decent set down area for outriggers and also solid ground. The greater the space available, the easier it is to avoid underground pipe work. Maintenance trucks require close access to the main ladder for moving gear up to the roof area.

Figure 1 Security measures easily bypassed

Figure 2 Site access restricted

The reservoir site should be selected with consideration of future growth. The original reservoir may have fantastic access and tick all the boxes, but a second, future installation may not. Bringing this consideration into a new reservoir design can only assist the following generations.

As with internal pipe work, the less exposed metal materials that can corrode within a tank, the less demand on chlorine. Aluminium and steel ladders quickly corrode under water and will require replacement. Caged ladders also make for very difficult diver entry and rescue –

the diver must descend to the very bottom of the caged section before they can enter the tank. Similarly, they must swim to the bottom of the cage to ascend - this makes it very difficult for a rescue. Also, sloped and caged ladders will be difficult to navigate a robot through in years to come.
Design considerations for access & security:

- Can the reservoir be accessed right the way round by EWP vehicles?
- Security fences should be set up to prevent public access around the whole reservoir site.
- Staircases to access the reservoir roof could be built in place of ladders – reducing the fall from heights risk.
- FRP vertical ladders (without cages) could be used internally to prevent corrosion and to compliment safe access or rescue situations.
- Use two hatches – One roof mounted for diver entry (simple, vertical ladder, no cage) and one wall mounted for a dry-tank entry.

Hatches and Platforms

The most regularly used section of a tank roof is the hatch and platform area. As the primary point of entry for any internal works, a platform needs to fulfil a number of needs. There should to be sufficient space for storage of equipment, there needs to be adequate guard railing for fall prevention, all surface areas to be self-draining to prevent ponding (slip hazard and material corrosion) and it must protect the water supply.
With heightened awareness of fall prevention, holes have often been cut into hatch covers to allow for ladder stiles to extend through - this unfortunately results in a potential contamination point as the hatch is no longer sealed. Similarly, the front edges have been removed to eliminate trip hazards – this has allowed the platform area (with its usual amounts of residual contaminants) to drain into the reservoir.

Figure 3 Unsealed entry hatch area

Figure 4 Good platform design

Some design considerations for hatches and platforms:

- Ensure that water cannot drain from the platform into the reservoir.
- Have sufficient space for a team of people and equipment to work safely.
- Handrails to extend around the working area.
- Remove bird roosting spots such as telemetry aerials.

Roofs

The primary function of a roof is to prevent contamination of the water supply. Many reservoirs have had roofs retrofitted to prevent debris and animal ingress, and been very successful at that! However, routine inspections have shown a number of recurring issues arising with roofs. These include:

- Non-draining surfaces and ponding behind fixtures such as vents and platforms.
- Unsecured roof sheets.
- Ridge capping which allows for debris collection.
- Guttering which cannot be cleaned or which allows back flow events.
- Materials not compatible with humid environments.

These all have the potential to contaminate the water supply they intend on protecting.


Figure 6 Collapsed roof gutter


Figure 5 Debris build-up under roof flashing

Where improvements could be made:

- Elimination of gutters – reduces reservoir maintenance and eliminates the risk of gutter collapse and back flow.
- Eliminate ponding – roof fixtures (such as platforms, ventilation or pipes) should be installed so that water can pass around.
- Reduce ridge capping – this prevents build-up of materials underneath.
- Use suitable materials – the humid area below the roof will accelerate corrosion of unprotected materials. This includes the 'fall protection' mesh used during roof sheet installation. The edges of rolled zincalume purlins will corrode if not protected and may roof screws are failing due to poor quality issues.

Pipework

The primary function of pipework is to deliver or carry water away from the reservoir. Delivering water into the reservoir is a balance between enough mixing (dead patches within the water can increase chlorine demand) and too much stirring up of sediment. Sediment should be allowed to settle within the tank to prevent it from entering the reticulation system – it is more cost effective to clean a tank rather than the distribution system pipework.

Many positions for inlets have been used; through the roof, through the wall and in the floor. In terms of water quality, roof based inlets may result in ponding when roof drainage cannot flow around the penetration area and floor sediments can be re-suspended when water levels are low. Through wall inlets generally continue into the reservoir to re-suspend floor sediments – penetrations should be directed upwards at 30 to 45 degrees. For the purpose of mixing, an inlet coming through the floor with a directional nozzle provides good water blending without stirring up the bottom layer with sediment.

Outlets can pose a risk to divers when there is a large penetration size or significant flow rate. But many protective screens are too large and cannot be cleaned internally (especially by robots!). Outlets which are flush to the floor, or have surrounding flat areas, will also suck sediment through to the reticulation system, so having a raised base on the outlet screen keeps the sediment layer intact.

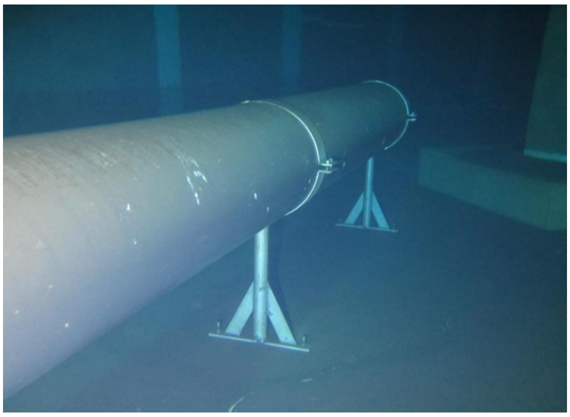

Figure 7 Internal pipe work – poor outcomes

Figure 8 Inlet directional nozzles – good results

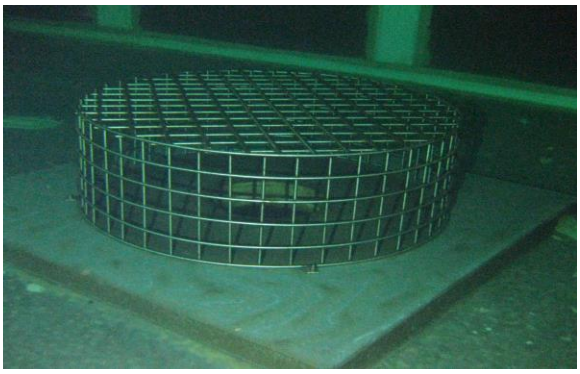

Figure 9 Outlet area cannot be cleaned

Figure 10 HDPE outlet screen – good result

Reducing the amount of exposed pipework within the reservoir has a two-fold benefit. Firstly, less pipe work reduces the chlorine demand due to corrosion (if un-coated steel is used) and requires less maintenance to replace in the future. Secondly, there are fewer obstacles for divers (or robots!) to navigate around when cleaning and inspecting.

Some pipe design considerations:

- Minimize the amount of pipe within the reservoir to prevent corrosion.
- Protect steel pipe work with a coating or use PE/Poly/FRP for internals.
- Ensure bolts are of a similar material or are insulated to prevent localised corrosion.
- Raise the outlet off the floor to prevent sediment pick up.
- Screens should be small enough to fit neatly over penetrations but large enough to not impede water flow. Screens should also have a solid base section (no holes) up to approximately 150mm in height to prevent sediment falling into the outlet.
- Overflows can be a simple through wall pipe with the riser external to the reservoir.

Conclusion

There are many aspects to reservoir design needing consideration for future maintenance activities and growth. Drawing from field observations, many issues are recurring throughout the industry that could be easily solved during the design phase of a project. A different view should be taken when designing reservoirs for the future – what are future maintenance requirements? What are future safety standards? What are future water quality standards?