Geosynthetics, J. Kuwano & J. Koseki (eds)

On-going performance of a double LLDPE liner in a concrete lined reservoir with 200 column penetrations

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Keywords: concrete reservoir, columns, double liner, leak detection, monitoring.

ABSTRACT: The 220,000 m^3 capacity Tamworth Hill Reservoir in Perth, Western Australia, has experienced episodes of significant leakage through joints and cracks in the concrete liner during its 21 year service life. Concern for the long term structural integrity of the reservoir due to the potential undermining of the foundations by leakage arose and a decision was made in 2001 to line the entire reservoir with a plastic geomembrane liner in conjunction with other remedial works addressing the foundation issues. A significant challenge for the liner system was sealing around the more than 200 internal columns supporting the roof, as well as a number of pipe penetrations. The adopted liner system consists of a double layer of LLDPE geomembrane liner with a leak detection and drainage layer consisting of a coarse geotextile and closely spaced, flat, slotted drainage pipes. This paper will provide details of the on-going monitoring of leakage performance through the underdrainage system and seek to relate the performance to decisions made during the design and execution of the project.

1 BACKGROUND

Tamworth Hill Reservoir in Perth, Western Australia, has experienced episodes of significant leakage through joints and cracks in the concrete liner during its 21 year service life. Concern for the long term structural integrity of the reservoir due to the potential undermining of the foundations by leakage arose, and a decision was made in 2001 to line the entire reservoir with a plastic geomembrane liner in conjunction with other remedial works addressing the foundation issues.

Tamworth Hill Reservoir is a concrete lined, steel roofed reservoir with a capacity of 220,000 m^3. The reservoir is 10 m deep, concrete lined, with a flat floor measuring 150 m × 120 m and side walls sloping at 1V:1.25H. The steel roof is supported by more than 200 internal concrete columns which are mounted on concrete pedestals. A typical view of the reservoir interior is shown on Figure 1.

Because of the tight time with the work to be completed by November 2002 the adopted procurement strategy for detail design and construction was a Design and Construct Tender process.

2 LINER SYSTEM

2.1 *Overall approach*

The specification for the Tamworth Hill liner system was developed on the basis of essentially not relying on the existing concrete liner to be waterproof, and looking to have a double liner geosynthetic liner system with a zoned leak detection and recovery system between the two liners. Twelve leakage zones of about 2,000 m^2 each were required to each drain to a separate drainage pipe which then went under gravity to an external sump.

Unreinforced polypropylene was not permitted by the specification due to recent issues in the area with the performance of thin, unreinforced polypropylene.

The primary liner system performance acceptance criterion was a maximum leakage rate of 20 L/min for the whole reservoir. This is acknowledged as being conservative as it allowed for the difficulty of sealing around the large number of penetrations.

LLDPE was adopted in a thickness of 1.5 mm for both layers of the double liner system based on the consideration that LLDPE would provide more flexibility than HDPE should there be movement in

Figure 1. A typical view of Tamworth Hill Reservoir interior.

the floor slabs. The reservoir roof meant that there was no UV exposure so that was not an issue.

Industry experience with the performance of the very flexible LLDPE over a HDPE geonet was found to be very limited. Concerns about the potential long term creep of the LLDPE liner into the geonet voids led to the selection of a thick geotextile based composite drainage layer that offered more support to the liner.

It was recognised that the composite did not have sufficient planar flow capacity to meet the specification flow requirements under low heads and it was therefore supplemented by flat drainage pipes in both a slotted form and unslotted form.

The adopted penetration sealing system was a mechanical batten and compressible rubber gasket to seal around the large number of column and a few pipe penetrations. In addition, concern over the potential for leakage through the concrete between the batten and the column bases lead to the use of a spray applied polyurea membrane that also provided an improved subgrade for the batten system.

3 CONSTRUCTION AND QA/QC

Construction of the liner system took place in the wet and cool winter months from August to November 2002, and generally progressed well as most of the reservoir remained roofed.

The LLDPE manufacturing and installation QA/QC plans followed established geomembrane industry practice with some limited third party inspection and testing of the materials.

It was apparent that the spray polyurea work practices did not have an established QA/QC plan and a suitable plan was eventually developed with a variety of both destructive and non-destructive methods being applied.

The choice of a steel batten system effectively made it impractical to take advantage of the electronic leak detection systems which are available and

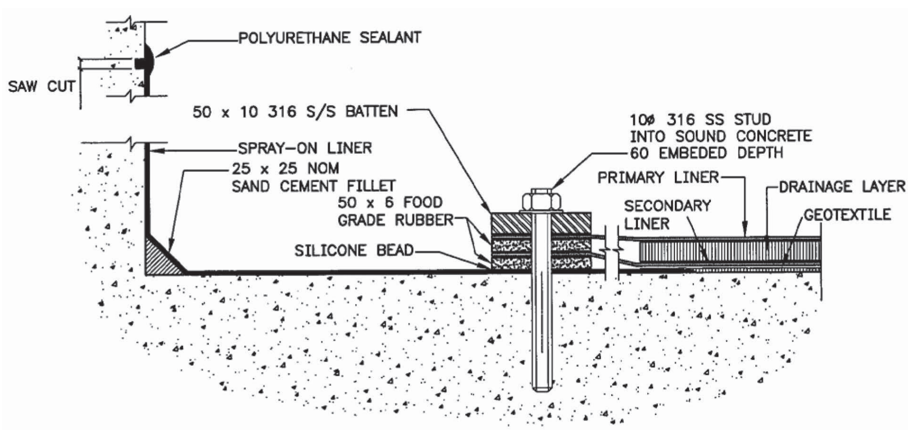

Figure 2. Typical batten and spray polyurea system at columns.

there was some disappointment at the inability to effectively test the batten systems for their effectiveness especially as the large numbers of identical columns presented an opportunity for development of suitable systems.

4 RESULTS OF LEAKAGE TESTING AND MONITORING

The liner system was subjected to a seven day hydrostatic leak test under full reservoir head at the end of November 2002. Figure 3 shows the results of the leakage monitoring (total leakage rate) from late November 2002 to the end of October 2003. The initial water expulsion rate exceeded the allowable rate as accumulated water was released and then reduced to acceptable levels.

After the initially high leakage rate due to the expulsion of construction water the leakage has so far remained below the target value set. The fact that the actual leakage rate is of the same order and not much lower than the target value indicates that significantly more leakage is occurring than the lower leakage rate that would be expected for an equivalent liner system with no column penetrations.

Initially differing leakage rates from individual drainage zones proved useful in guiding diving inspections to suspected leakage areas. Two thorough diving inspections to date have confirmed that all minor leaks that have been found were located at the battens.

Since January 2003 the leakage rates have remained within acceptable limits.

Figures 4 and 5 show the typical results of monitoring from individual leak zones, in L/min, over the period from November 2003 to November 2005. Space does not permit inclusion of more results and the results presented are representative of the others.

Overall the leakage rates continue within acceptable bounds although there are occasional increases in leakage rate which then drop back to quite low rates.

There is some speculation that this might be due to the lower flow capacity of the geotextile drainage layer and its supplementation by pipes at intervals. It is hypothesised that leakage water may accumulate in the drainage layer until the head in the drainage layer builds up enough to push the water through to the drainage pipes.

5 CONCLUSIONS

The double liner system with a leak detection system installed in the Tamworth Hill Reservoir in 2002 is apparently performing to expectation without excessive leakage being observed as of November 2005.

REFERENCES

Sadlier and Finlay (2004). 'Geosynthetic and Technical Aspects of a Double LLDPE Liner in a 200,000 m^3 Roofed, Concrete Lined Reservoir' GeoAsia 2004.

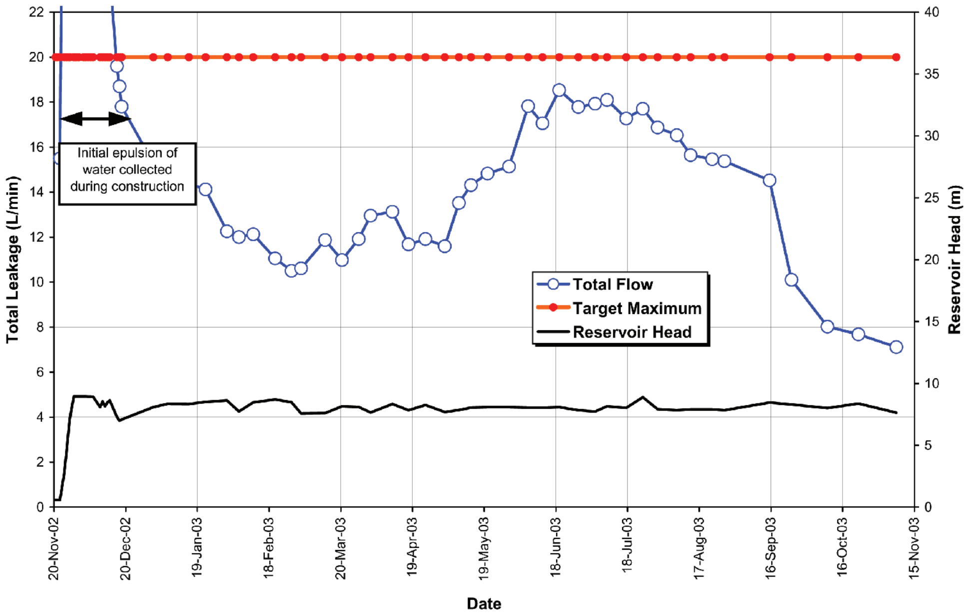

Figure 3. Typical leakage results from commissioning in December 2002 to October 2003 – Total flow.

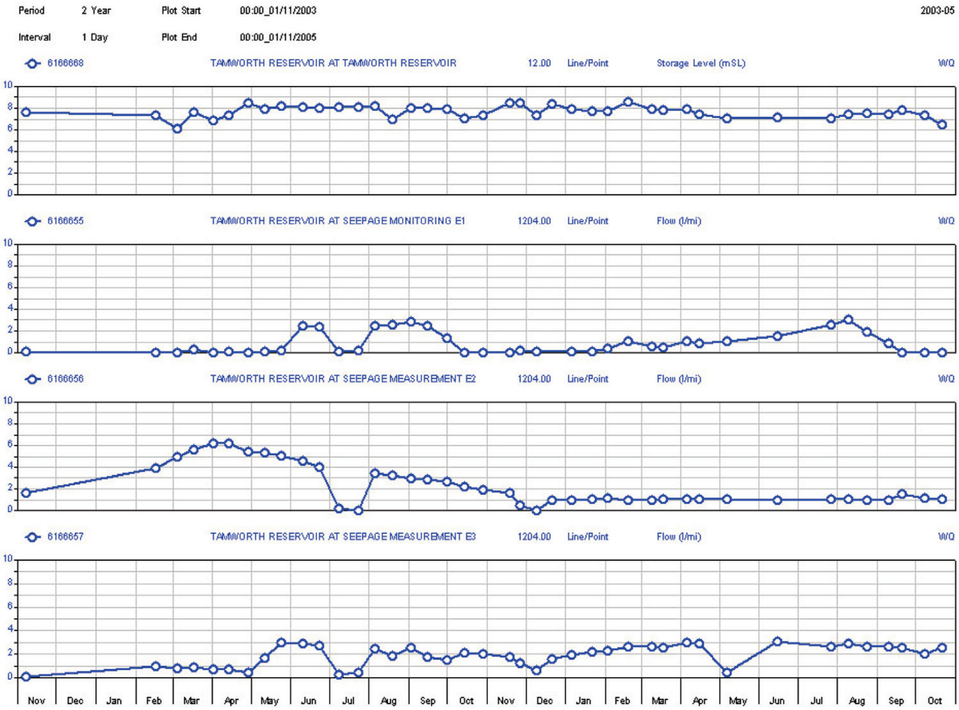

Figure 4. Typical leakage results from November 2003 to November 2005 east side.

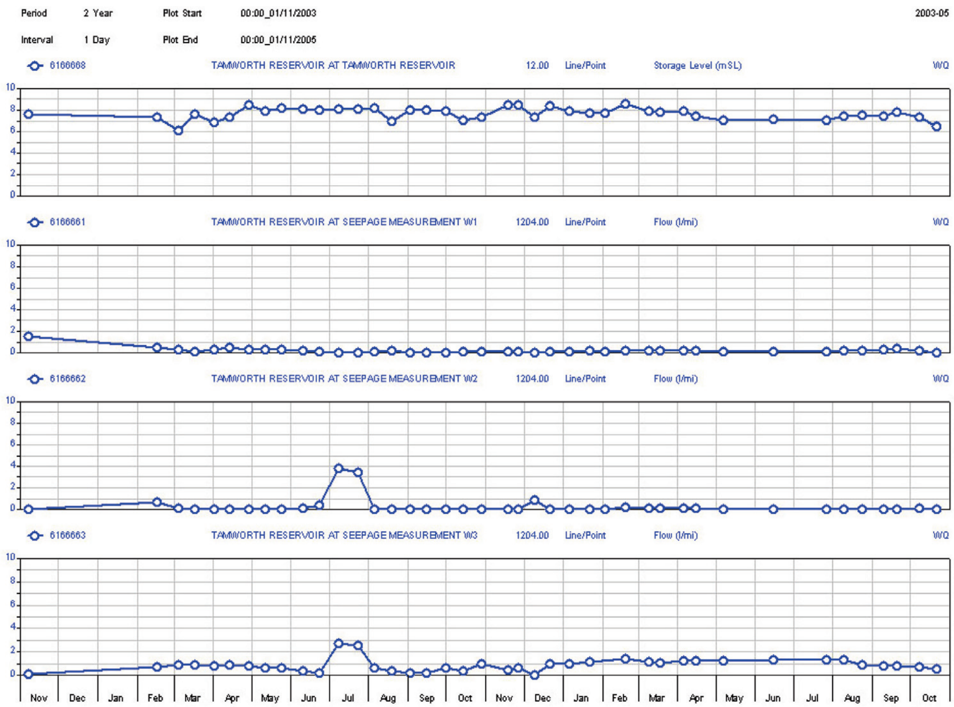

Figure 5. Typical leakage results from November 2003 to November 2005 west side.

