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Prepared for Ranhill Bersekutu SDN BHD

LINGGIU DAM YIELD EXTENSION REVIEW

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LINGGIU DAM YIELD EXTENSION REVIEW

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PURPOSE

Ranhill presented to SAJ in December 1995 a report entitled "Linggiu Regulating Reservoir System Yield/Storage Relationship Analysis". This gave the results of a hydrological analysis to determine an appropriate gross yield[1], given that the reservoir had been built to full height and filled encouragingly quickly to its 760,000 ML capacity. Ranhill concluded that a value of 2440 Mld could be adopted for gross yield.

Such a high figure had not been contemplated previously without the assistance of refill pumping from downstream at Sayong on the main stem channel. I was asked to confirm the report's findings with particular reference to avoiding conservative limits.

The context of this review is the existence of a full reservoir that is enabling the Johor River to provide for current water demands on it, and the intention of the water agencies concerned to provide pumped refill of Linggiu when it is justified.

This review is an executive summary and additional technical details can be provided if required. It aims to answer questions such as:-

- Would the stated yield be "mining" the surplus water now stored in the lake, or would it be sustainable in the long term?

- Should the yield be connected not only with the rarity of the design drought but with an acceptable period for refilling from near-emptiness?

[1] Gross yield is the total regulated flow in the lower Johor river that will be available for abstraction and/or discharge to the estuary due to reservoir's releases.

BACKGROUND

The initial development of the Johor in terms of its regulation envisaged 320,000 ML live storage to back up a drawoff at intakes above Kota Tinggi of 1136 Mld (250 mgd) and a suitable residual flow to the estuary. SAJ wishes to see the surplus storage at Linggiu of 440,000 ML (within the total of 760,000 ML actually built) put to good use without the imposition of unnecessarily conservative limits on abstraction.

The Malaysian/Singapore agreement that led to the construction of the dam had behind it the need for the technical representatives of both nations to understand the maximum possible yield of which the Johor River might be capable. This necessitated estimation of a 10 year long synthetic design drought sequence (SMHB, 1985) so that all reasonable critical droughts were foreseen. A 1 in 50 year chance of just failing to supply was countenanced for planning purposes, although all parties recognised that in rare droughts, not more often than one year in 10, measures are likely to be taken to conserve water and reduce demand in case the impending drought turns out to be worse than the 1:50 case.

The writer was part of the original design team as consultant hydrologist and hence accepts the inherent assumptions that have been carried over into the Ranhill study. There is no reason to believe that the new simulations of reservoir performance have not followed the original yield calculations sufficiently faithfully based on my overview of the results.

In the 1985 study a gross yield of 1940 Mld was thought an advisable limit beyond which refill pumps should be installed. In a design drought, with its worst years coming first, it was foreseen that the reservoir would be below top water level for five continuous years; more difficult was the expected drop in a single year by 320,000 ML in storage. That concern is lessened considerably by the current starting storage being as large as 760,000 ML.

In a 1989 study the recorded flows (1978-86) for the Linggiu dam site were noted as relatively low but correlation with Macritchie Reservoir (Singapore) suggested that there it had been anomalously dry in that period compared with the period from 1880. (Singapore is a close enough comparison when considering multiyear droughts; it would not be realistic to apply this test on a single dry season). The successful filling of the Linggiu storage suggests that rains of the most recent decade have returned towards the long term average, raising confidence in its yield potential.

KEY ANALYSIS

The heart of Ranhill's work is in their Figure 1, included here as well for convenience. There will be little loss of live storage from sediment in the next few years so the 760,00 ML live storage figure remains relevant. Figure 1 shows that a planning yield of just over 2500 Mld could be achieved but without absolute certainty over refilling before the end of the available 10 year long design drought sequence.

While maintaining a gross yield of 2440 Mld refilling can be seen to occur within year 10, five years after being nearly 90% empty. Progressively lower yields improve performance indicators such as length of drawdown, speed of refill and mean reservoir level. However it is interesting to note that with a synthetic drought of this type, where every runoff duration includes an equally rare (1 in 50) low flow, the period from lowest contents to full is never less than 4 years. This is always likely to be true in a basin subject to high percentage regulation as is the Johor.

I note that the regulation inefficiency assumptions of the original 1985 study have been retained. As experience with a comparable structure in South West England in the 1995 drought has shown, it is necessary to be vigilant about regulation release procedures and to minimise waste releases by good forecasting and a sound understanding of the channel hydraulics. I have no reason to suppose the original assumptions are other than safe but commend careful monitoring of release efficiency in order to develop the best possible computer model of operational control.

It is normal to examine the haphazard sequence of droughts and their rarities that are embodied in the period of historic record. Examining one available to me from a previous study for 1970-1984 shows how dry 1970-77 was, but with some relief in 1973 and 1975. 1978-80 would have permitted rapid refilling even with a gross yield of 2440 Mld.

It normally becomes very difficult to develop a gross yield in excess of 50% of average daily flow at the regulated intake site on any river that is responsive to each rainstorm, as is true for the Johor. This has been observed in a wide variety of major schemes internationally and is a function of rain frequency and flow recession rates; only an impounding reservoir can achieve a higher proportion of inflow as yield. In this case 2440 Mld is 49% ADF and so it is not surprising that the simulations have shown this yield to be achievable.

CONCLUSIONS

1. The Linggiu Reservoir as built is capable of a conventional safe yield of 2440 Mld for planning purposes.

2. This is a sustainable yield that will not require any presumption of mining the surplus storage created by full height dam development.

3. Additional confidence in taking such a high yield will occur if it is not allowed to begin until the reservoir is full.

4. Refilling criteria are not well established but vary locally; the technical need is to be sure that refilling is a sustainable and managed process. For a major storage such as Linggiu, which has been the subject of considerable study and simulation, a period of refill not exceeding six years is recommended and has been advocated for economy previously[2]. Any longer period would require more study of climatic cluster events.

5. However it must be realised that over six years demand is likely to rise and it would be preferable to agree a linearly rising gross demand falling on the Johor that averages 2440 Mld over a decade.

6. Sooner or later another unrepresentative dry decade will occur which will tax the reservoir's performance;pumped refilling from Sayong or elsewhere will become necessary and this interim expedient of maximising the yield of the dam as built should be taken in context with plans for related source development.

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[2] Twort, A.C., Law, F.M. and Crowley, F.W. (1985) Water Supply, Third Edition, p 104, E. Arnold.