INTAKE THAT ALMOST FLOATED

George, the chief design engineer, had arrived at the new hydro facility to undertake a pre-commissioning inspection, only to be confronted with a major crisis. The large intake, constructed on an over-consolidated glacial till, was in danger of floating from excessive uplift. The problem had been anticipated in the design, and several measures had been taken to counter uplift. These included a short upstream blanket, a ring of sheet steel piles around the periphery and embedded in the concrete foundation slab, an elaborate network of drains below the slab, a string of vertical drains extending 15m. down into the till and terminating in a 2m. square drainage gallery built below the trashracks, accessible by a 25m. ladder from a manhole at deck level. There were piezometers in the gallery to measure uplift at three levels in the till below the intake, and a drain pipe extending downstream, adjacent to the penstock.

All these measures were deemed necessary, since the glacial till contained horizontally stratified discontinuous sand lenses, and if a lens below the intake became pressurized from the headpond water, it would act as a jack, lifting the intake. The intake was built at the end of a long side-hill canal, and was flanked on one side by several rings of sheet steel piles which formed the cofferdam for the second intake, to be built at a future date, and on the other side by a concrete wing wall which served as the abutment for the earth dyke forming one wall of the canal. To test water tightness, the canal had been half filled with water for four weeks, during which time readings were taken in the drainage gallery of piezometer water levels and drain outflow. All went well until George's arrival. He was met by the resident engineer, who informed him that after no change in piezometer water levels, the readings in the two lower piezometers had just started to increase rapidly, and that if they continued at the same rate, the drainage gallery would start to flood within a few hours.

The headpond had to be drained before uplift became excessive. Unfortunately, the only way of emptying the headpond was through the turbine, which was not ready to rotate, since the thrust bearing was not yet fully installed, and at least two more days would be required to finish turbine installation. Meanwhile, piezometer readings were being taken every half hour, and with the bottom of the gallery now flooded, it was possible to calculate water inflow rate. The net result was that allowing for drainage outflow, the gallery would be filled within 18 hours and the uplift pressure would exceed intake weight in about 24 hours!. What to do?. The headpond just had to be evacuated, and the only way was through the turbine. A quick calculation indicated that if the wicket gates could be opened to about 6%, the headpond would empty in about 10 hours.

The turbine erector was instructed to stop bearing installation and tie down the 150MW generator by attaching wire ropes from the generator spider to any fixed point in the powerhouse. Within two hours the generator was laced with rope and secure. The wicket gates were opened to 6% and a close watch was kept on water level in the gallery and flow in the drain. After three hours, it became evident that the battle was being lost, and that the wicket gates would have to be opened further. After some discussion, and over the vociferous objections of the turbine erector, the wicket gates were opened to 11%. By this time the noise and vibration within the powerhouse was indescribable - expected, since something like 20,000 horsepower of energy was being dissipated through the stationary turbine!. The effect on the rate of water level rise in the gallery was immediate. Nevertheless, the water level peaked within 0.3m. of the gallery roof before subsiding. Within a few hours the headpond was empty, and the crisis was over.

What had gone wrong?. A detailed examination of the headpond upstream of the intake revealed a watertight blanket, and the sand lenses did not extend into the headpond. However, the rate of water inflow to the gallery indicated that there must have been a direct connection to sand lenses adjacent to the intake. Eventually, the investigation concentrated on the sheet steel piles beside the intake, where it was found that there was just enough flow area within the interlocks to conduct water down to the sand lenses, through and below the perimeter sheet steel piling and into the gallery. Water could flow into the pile interlocks through the vertical steel slots where the steel to steel contact was discontinuous. The remedial work included welding closed all the vertical interlock slots from 3m. below grade to 1m. above maximum water level, the addition of a bentonite beneficiated blanket contact with the sheet steel piling to 3m. below grade to improve impermeability, and a float operated alarm in the drainage gallery. The repairs proved successful and operated without incident until the second intake was built several years later.

Lessons Learned.

Where was "plan B"?. No thought had been given to how the headpond would be evacuated in an emergency if the turbine was not operational. In the rush to commission the plant, the headpond was filled while the turbine was still being assembled. Fortunately, the headpond was only filled to mid-trashrack height to test water tightness, and also fortunately, the water was kept on the racks for a month, the time required for the sand lenses to fill, pressurize, and for water to flow into the gallery. If the headpond had been filled at the last minute, and the unit commissioned shortly thereafter, a catastrophe would have probably ensued since there would have been infrequent piezometer monitoring and the problem would have not been detected in time. Always have a second safety plan in case something goes wrong - particularly during commissioning.