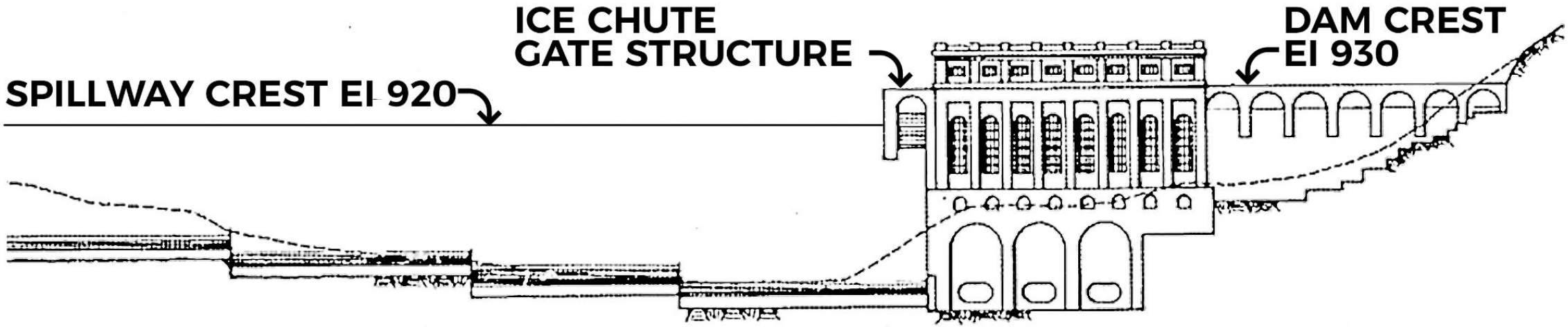
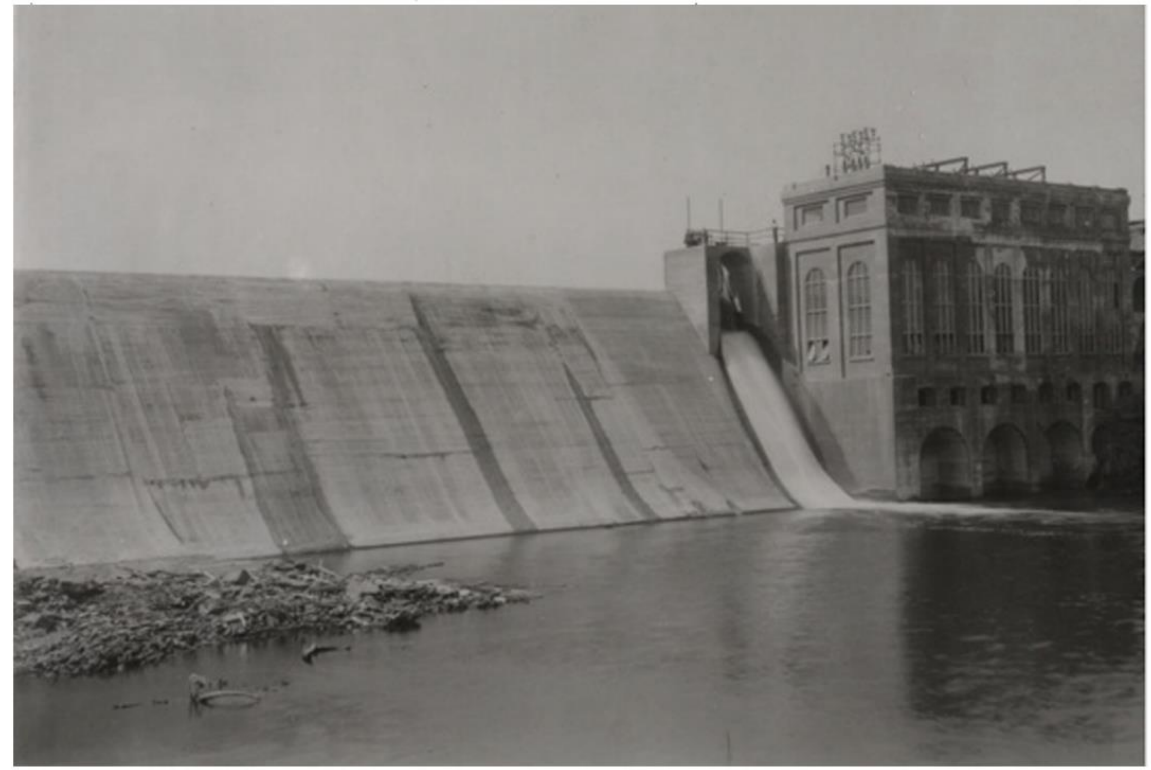
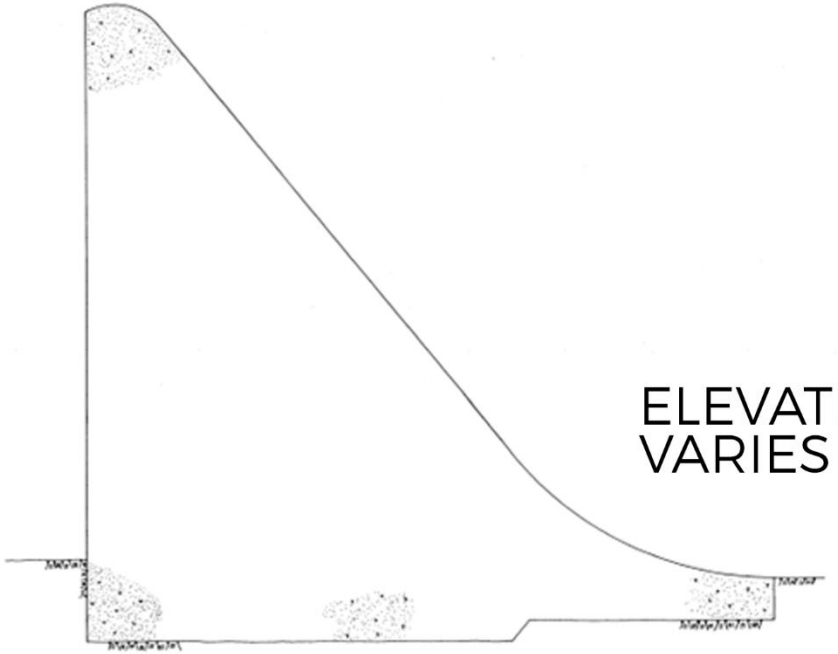
LAKE ZUMBRO HYDRO FACILITY INFORMATION



THE ORIGINAL SPILLWAY DESIGN INCORPORATED A 10' SQUARE OPENING TO BE USED AS A SLUICE GATE AND ICE CHUTE. IN 1983 THE ICE CHUTE WAS REMOVED AND REPLACED BY A 14 INCH DIAMETER "MINIMUM RELEASE" VALVE.



SPILLWAY CREST EI 920

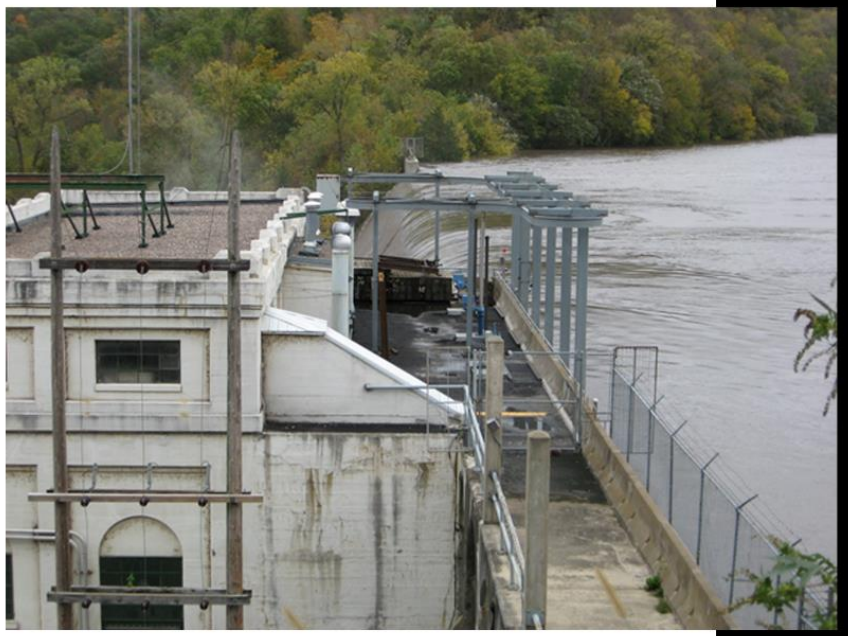


TYPICAL CROSS SECTION OF SPILLWAY

THE MAIN SPILLWAY IS 440 FEET LONG ABUTTED ON THE EAST END TO A NON-OVERFLOW SPILLWAY AND THE POWER HOUSE STRUCTURES ON THE WEST END. IT IS ASSUMED THE NON-OVERFLOW SPILLWAYS (CONSTRUCTED OF EARTH) WILL MOST LIKELY FAIL AND RELEASE FLOODWATERS, SHOULD THE LAKE LEVEL EXCEED 924.6' MSL.

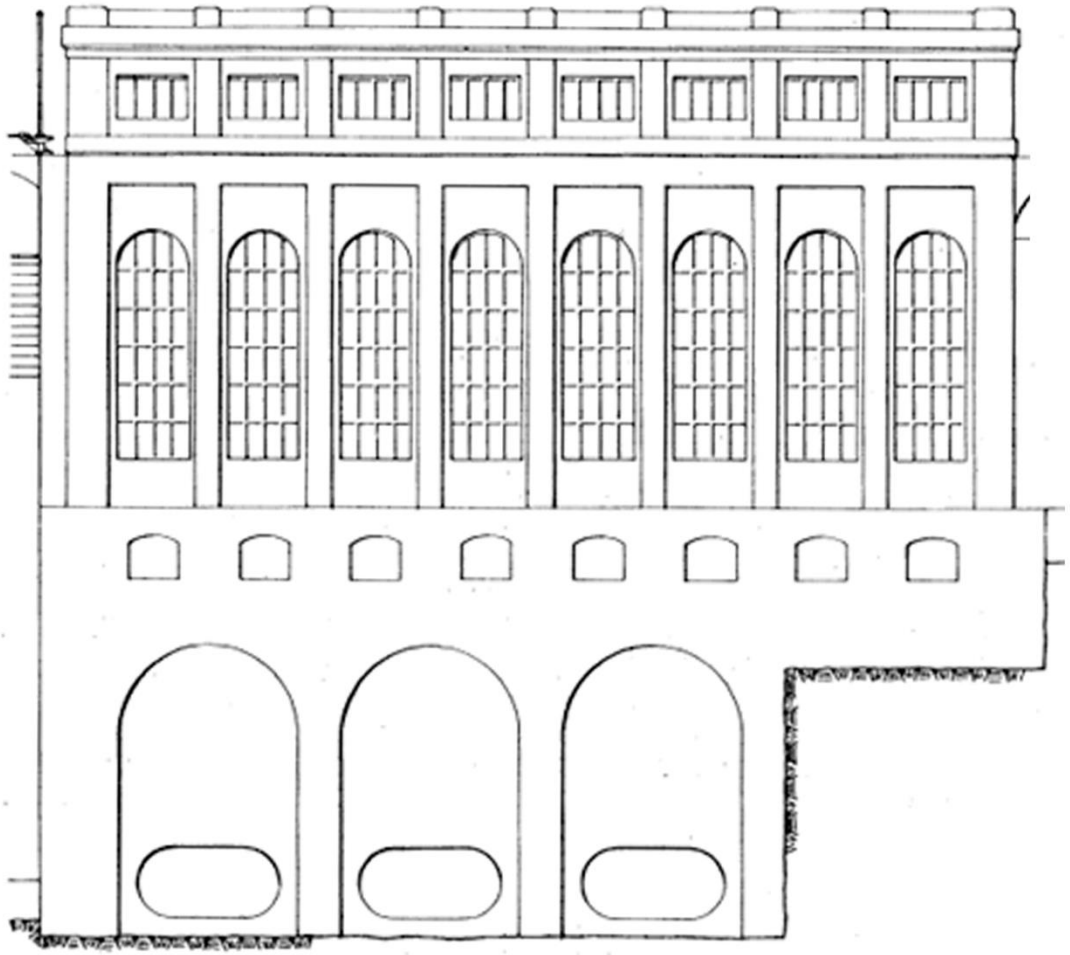
HISTORICAL RECORDS SHOW SEVERAL SIGNIFICANT HIGH WATER EVENTS.

UNTIL SEPTEMBER 24, 2010 THE RECORD FLOW OVER THE SPILLWAY OCCURRED ON JULY 22, 1951 WITH A PEAK LEVEL OF 922.8' MSL. THE FLOOD OF 2010 EXCEEDED THE PREVIOUS RECORD BY REACHING 923.21' MSL. THIS EQUATES TO 46,755 CUBIC FEET PER SECOND (OR 350,000 GAL/SEC) FLOWING OVER THE 440' SPILLWAY.



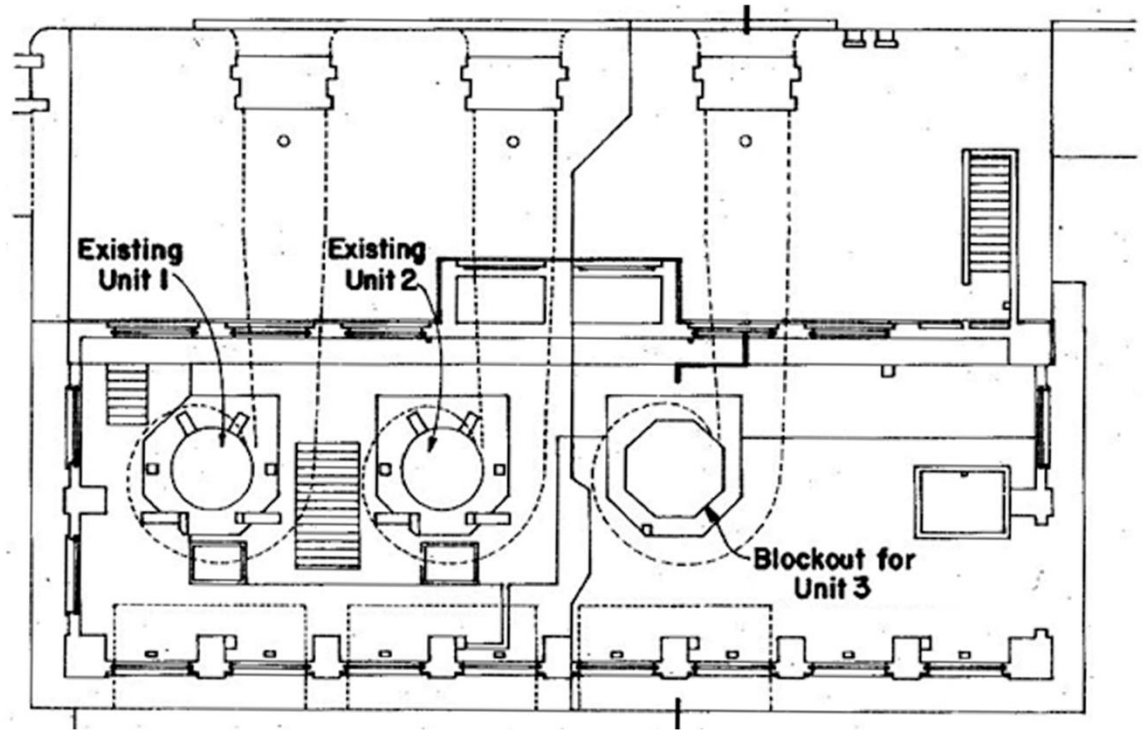
FLOODS (2010 PICTURED) MAY REQUIRE RPU PERSONNEL TO SHUT DOWN THE FACILITY DUE TO WATER ENTERING THE FACILITY THROUGH THE DOWNSTREAM OPENINGS. **ELECTRICITY AND WATER DO NOT MIX!** HIGH WATER LEVELS CAN BE VERY DAMAGING TO NATURAL AND MAN-MADE STRUCTURES, ESPECIALLY DOWN STREAM OF THE DAM.

FRONT VIEW
(FROM THE NORTH)



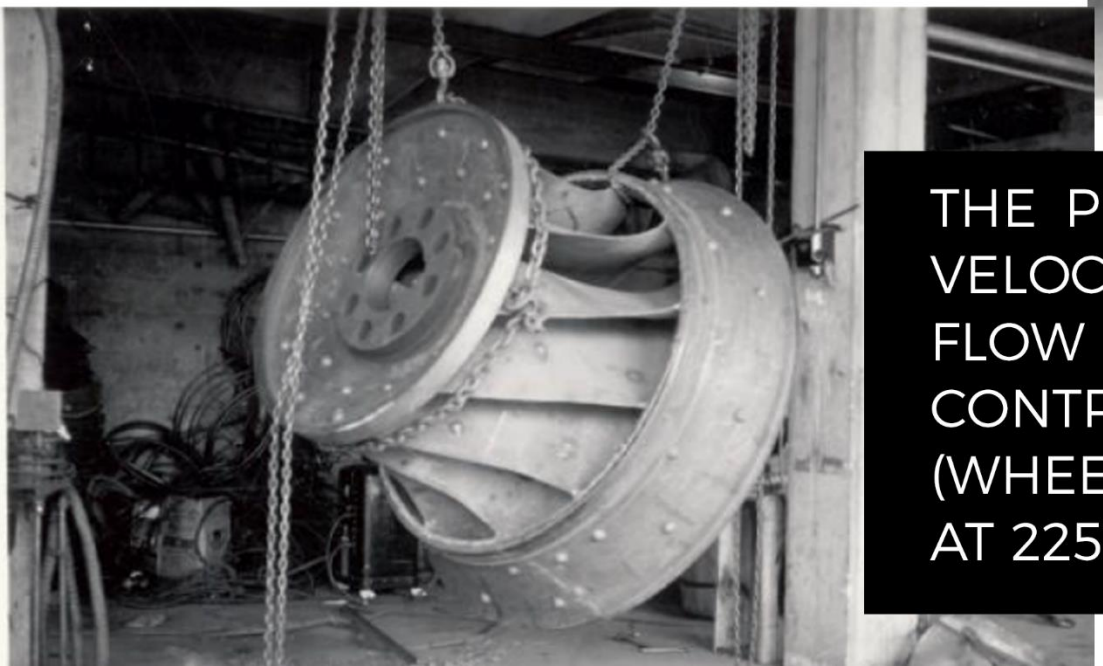
THE POWERHOUSE PROVIDES A PROTECTIVE ENCLOSURE FOR THE GENERATING AND ASSOCIATED EQUIPMENT. THE FLOOR PLAN SHOWS THREE OPENINGS FOR TURBINE GENERATORS BUT ONLY OPENINGS #1 & #2 ARE USED FOR POWER GENERATION. OPENING #3 WAS MODIFIED IN 1988 TO RE-ROUTE THE MINIMUM RELEASE FLOW.

TOP VIEW

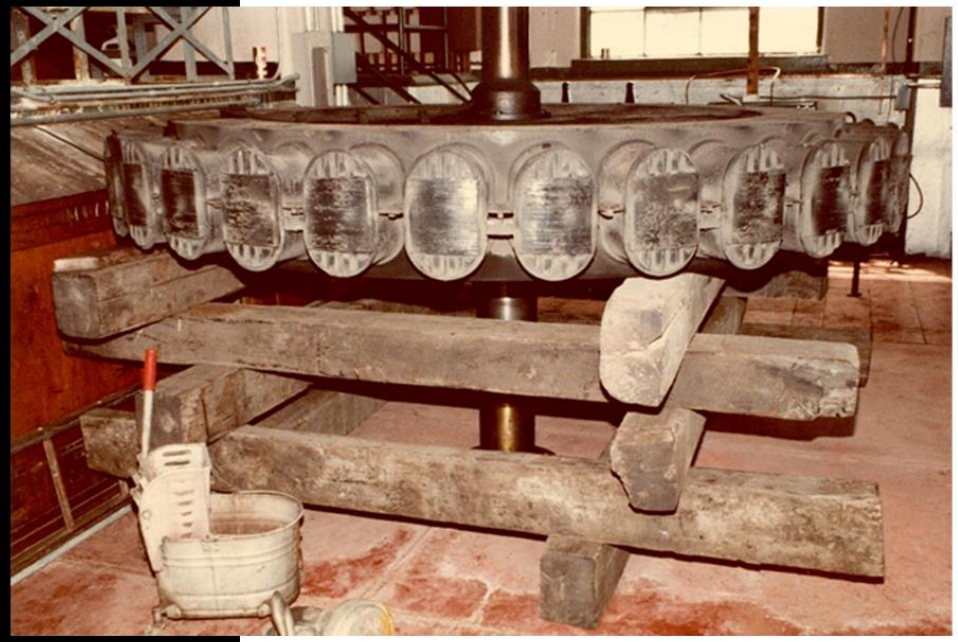


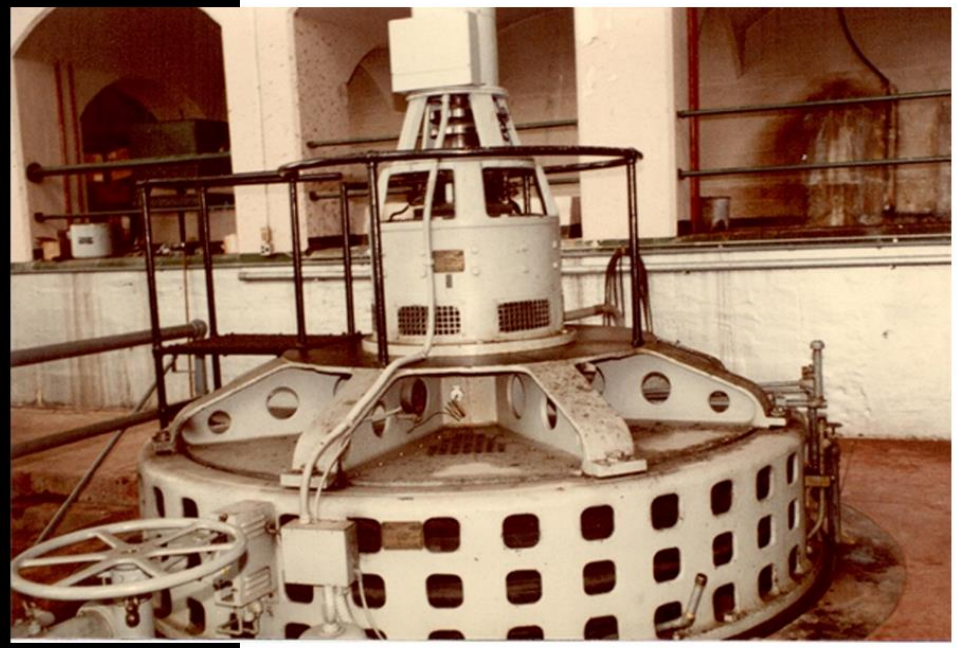
UNDER LOAD, **THE GENERATORS PROVIDE SOME HEAT TO THE POWERHOUSE.** ORIGINALLY, SUPPLEMENTAL HEAT WAS PROVIDED WITH A SMALL, OIL FIRED CAST IRON SECTIONAL (“PORK CHOP”) BOILER. NOW, THE BUILDING IS HEATED BY A SERIES OF LP FIRED FORCED AIR SPACE HEATERS. THE LOWER LEVEL HAS VENTILATION FANS IN THE WINDOWS TO CIRCULATE COOLER AIR DURING WARM WEATHER OPERATION.

THE **FRANCIS** TURBINE DESIGN OPERATES UNDER A 55’ HEAD. WATER FLOWS FROM THE PENSTOCK INTO A SCROLL CASE WITH A DIMINISHING GEOMETRY.



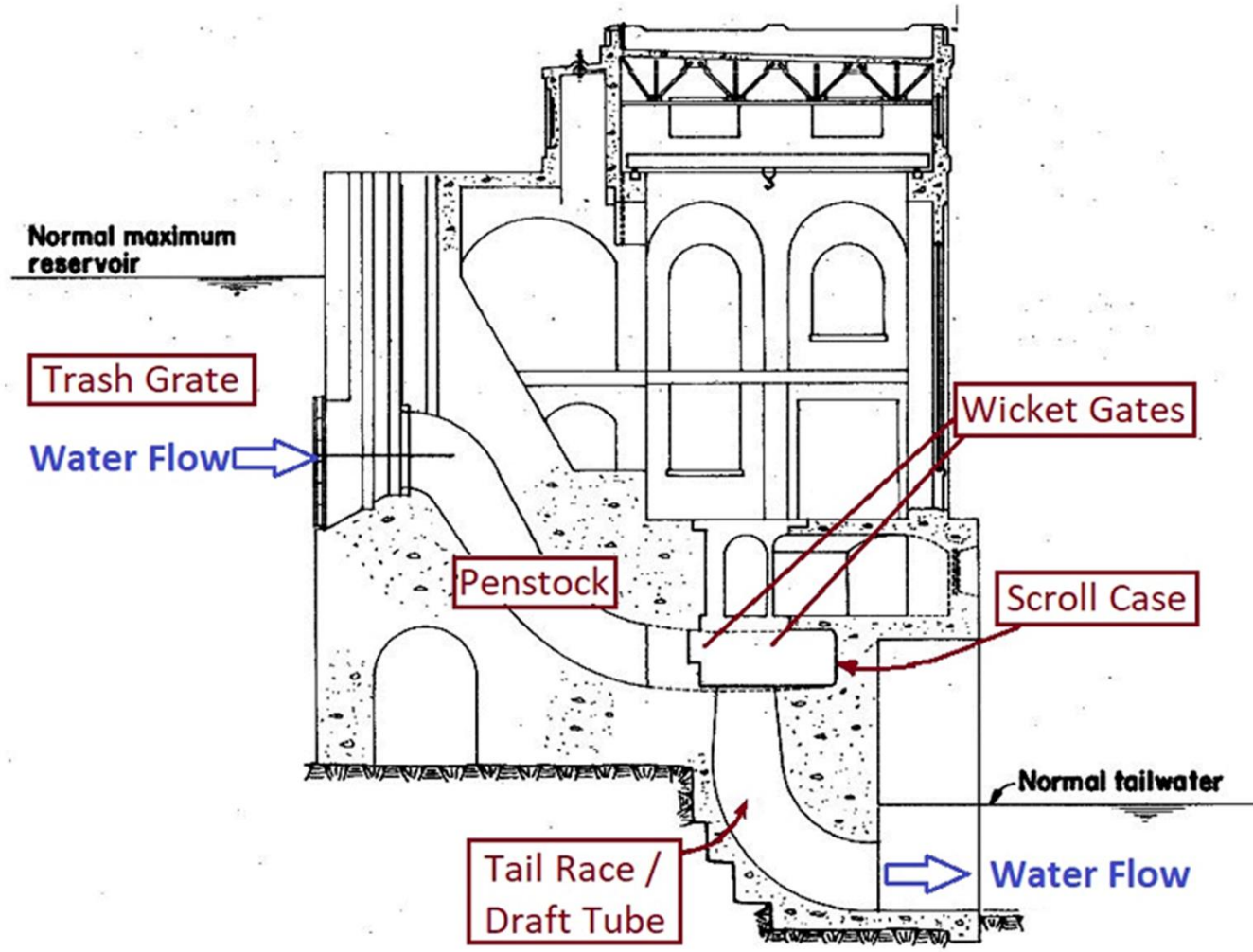
THE PRINCIPLE BEHIND THIS IS TO MAINTAIN UNIFORM VELOCITIES AROUND THE ENTIRE TURBINE RUNNER. THE FLOW OF WATER IS REGULATED THROUGH (GOVERNOR CONTROLLED) WICKET GATES. THE TURBINE RUNNERS (WHEELS) ARE DESIGNED TO PRODUCE 1,900 HP (1,375 KW) AT 225 RPM.

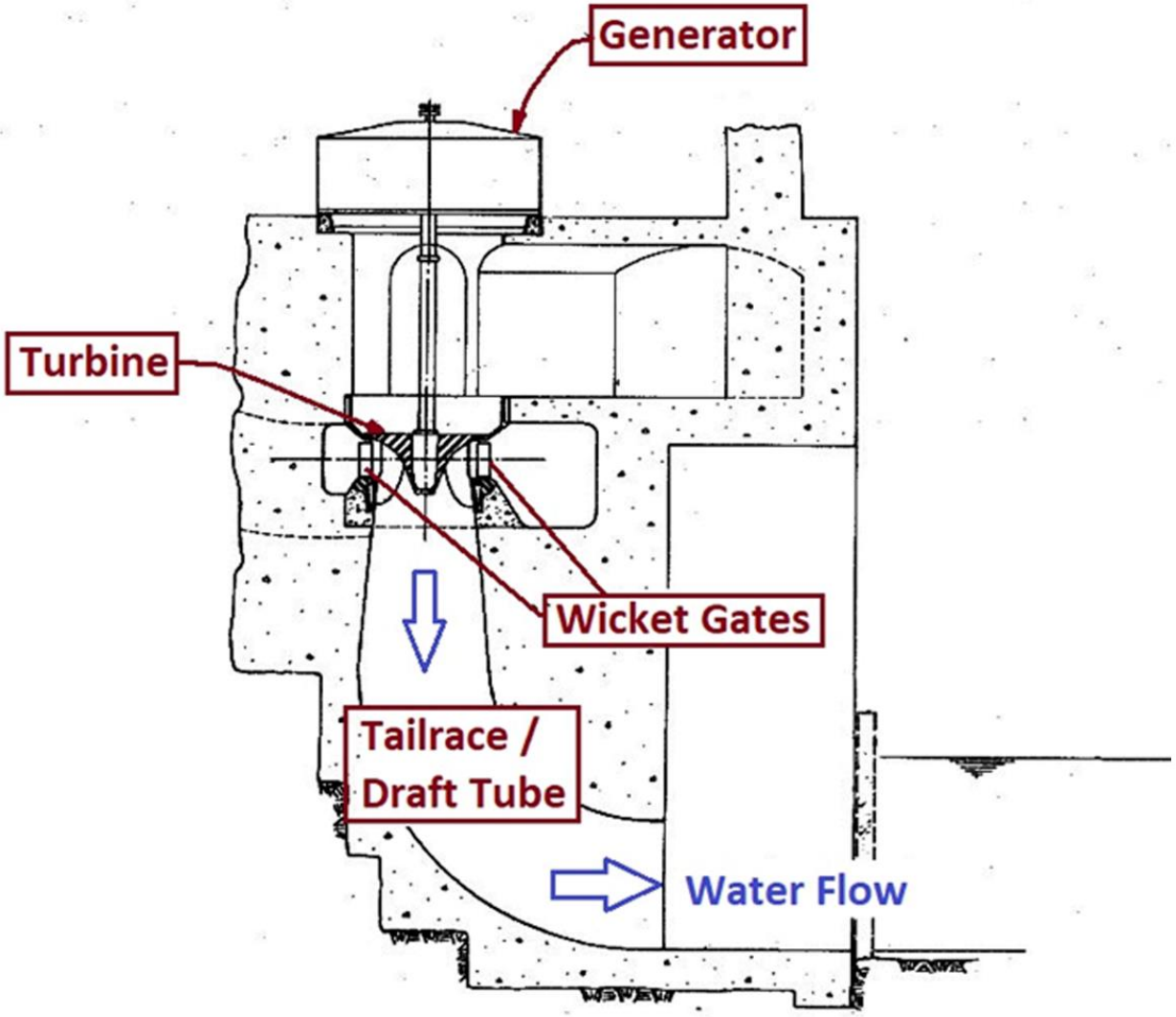




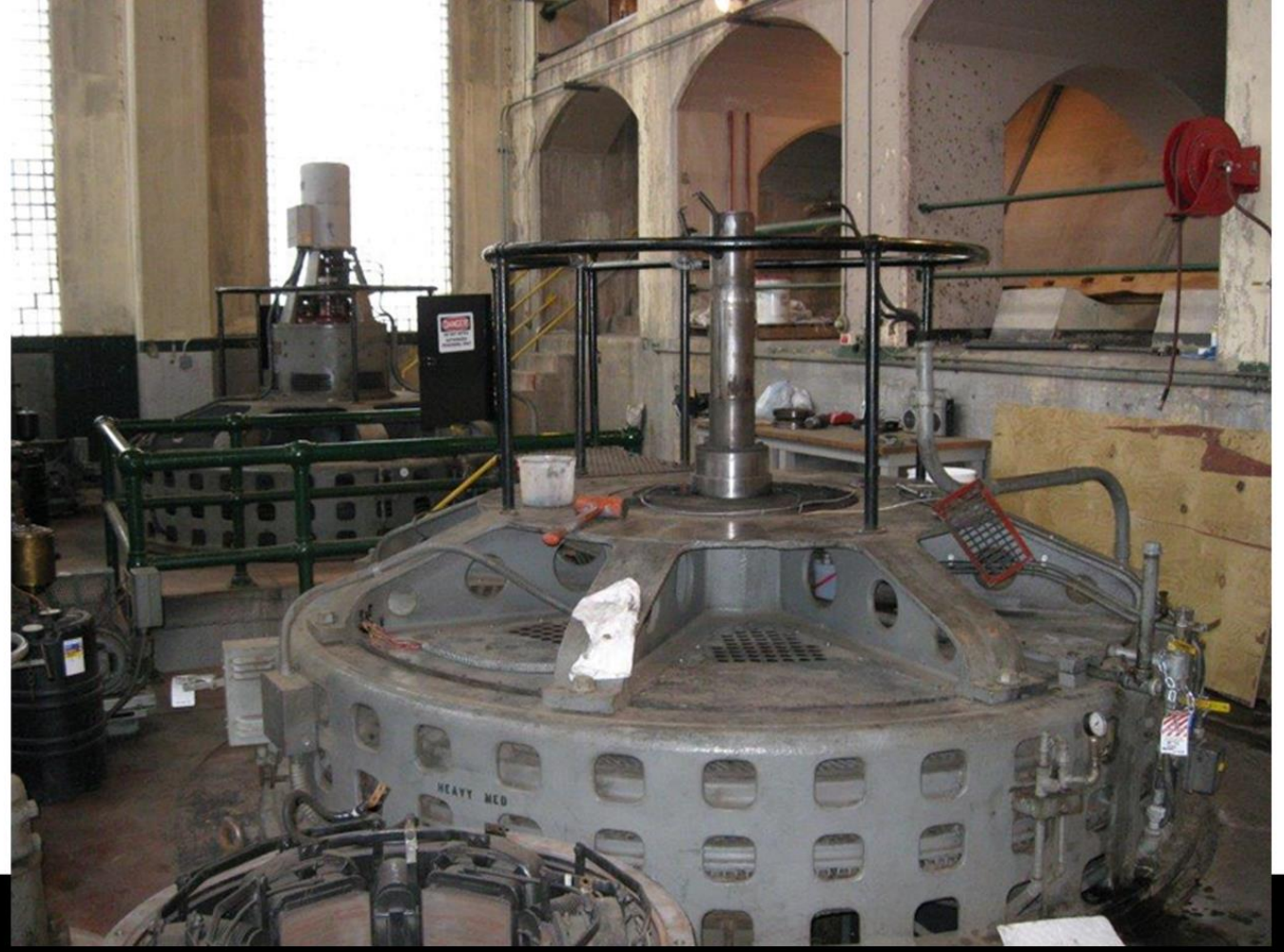
THE GENERATORS WERE MANUFACTURED BY **GENERAL ELECTRIC**. POWER OUTPUT WAS ORIGINALLY 900 KW, 2.4 KV, 60 HZ AT 225 RPM (32 POLES) BUT THE 1984 REBUILD INCREASED THE GENERATOR CAPACITY TO 1,350 KW.

WATER IS CONDUCTED FROM THE UPSTREAM FACE OF THE STRUCTURE, THROUGH THE **TRASH GRATES**, INTO THE **PENSTOCKS**, FLOODING THE **SCROLL CASE**. AS THE WATER FLOWS THROUGH THE TURBINE BLADES THE FORCE IMPARTS MECHANICAL ENERGY IN THE FORM OF ROTATION. THIS TURNS THE ROTATING FIELD IN THE GENERATOR TO PRODUCE ELECTRICAL ENERGY.

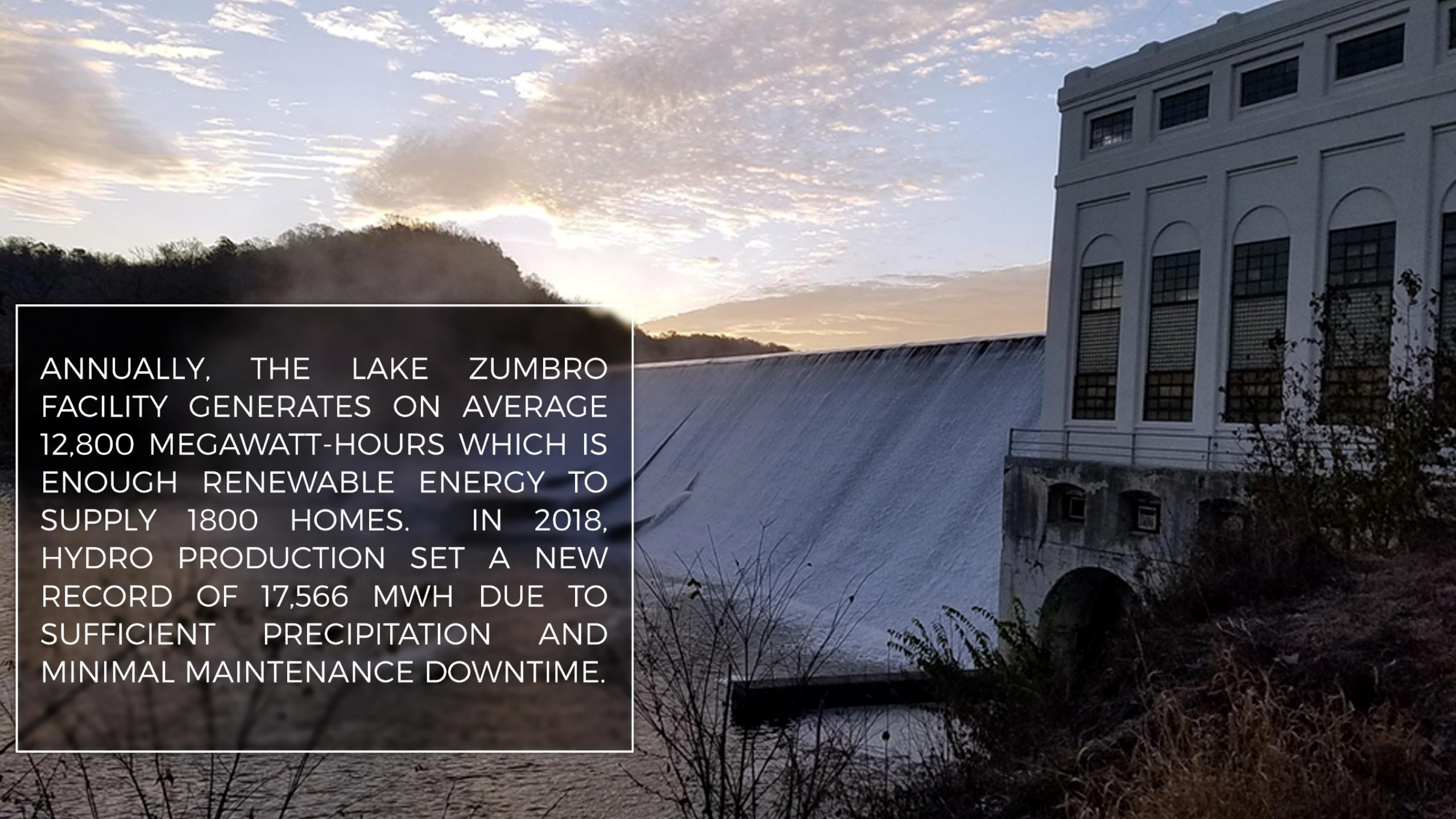




AN EQUALLY IMPORTANT COMPONENT OF THE FLOW STRUCTURE IS THE **TAILRACE**. AS THE WATER LEAVES THE TURBINE RUNNER, IT TRAVELS DOWN THE **DRAFT TUBE** OR THE TAILRACE. THE DROPPING WATER CREATES A SIPHON ON THE UNDERSIDE OF THE RUNNER, THUS ENHANCING THE MECHANICAL POWER OUTPUT.

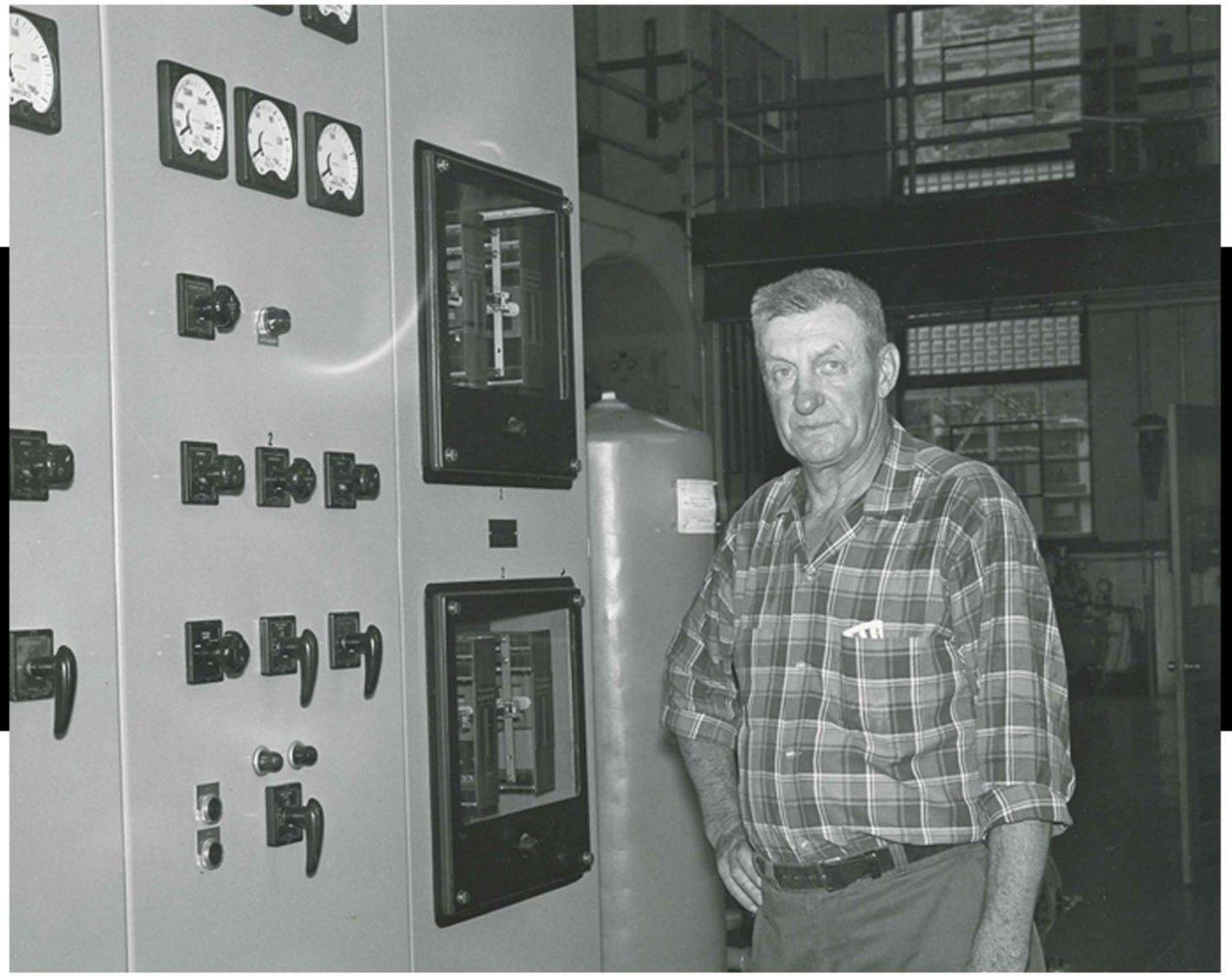


DURING OPERATION, CAREFUL CONSIDERATION HAS TO BE GIVEN TO ‘MINIMUM FLOW CAPABILITIES’ OF THE TURBINE AND AVOIDING THE POTENTIAL FOR CAVITATION. CAVITATION FROM ENTRAINED AIR DISTURBS THE UNIFORM WATER FLOW, CREATING IRREGULAR POWER DISTRIBUTION AND VIBRATION AND SUBSEQUENT TURBINE DAMAGE.



ANNUALLY, THE LAKE ZUMBRO FACILITY GENERATES ON AVERAGE 12,800 MEGAWATT-HOURS WHICH IS ENOUGH RENEWABLE ENERGY TO SUPPLY 1800 HOMES. IN 2018, HYDRO PRODUCTION SET A NEW RECORD OF 17,566 MWH DUE TO SUFFICIENT PRECIPITATION AND MINIMAL MAINTENANCE DOWNTIME.

TO PRODUCE THE SAME AMOUNT OF ENERGY FROM THE LAKE ZUMBRO FACILITY IN AN AVERAGE YEAR USING SOLAR, RPU WOULD HAVE TO BUILD 7.5 MW OF PANELS COVERING AN AREA OF AROUND 51 ACRES.



REMOTE CONTROLS WERE INSTALLED IN 1961 MAKING WORK SAFER AND MORE EFFICIENT FOR OPERATORS LIKE **ED HALING**, THE LAST OPERATOR TO BE STATIONED AT THE FACILITY.

THE HYDRO IS ESTIMATED TO HAVE PRODUCED **870,000 MW-HOURS** OVER ITS LIFETIME, ENOUGH ENERGY TO COVER 70% OF RPU'S TOTAL LOAD FOR 2018. THIS IS EQUIVALENT TO AROUND **4,533 RAILROAD CARS (100-TONS EACH) OF COAL**.