1910

Preliminary investigation for the development of an hydro-electric plant Okanagan Valley British Columbia

Robert Arthur Barton

Degree of Civil Engineer.

PRELIMINARY INVESTIGATION FOR THE DEVELOPMENT OF AN HYDRO-ELECTRIC PLANT OKANAGAN VALLEY BRITISH COLUMBIA.

June 1910,

Robert Arthur Barton.

I N D E X.

INTRODUCTION:

The Okanagan Valley of British Columbia extends one hundred and thirty-nine miles North from the International Boundary and is immediately West of the Gold Range, an off-shoot of the Rockies.

The arable land lies from fourteen hundred to two thousand feet above sea-level, while the mountains rise some five thousand feet.

The climate is dry: the average annual precipitation for the last twelve years amounted to about twelve inches, inclusive of snow. The temperature ranges from ten degrees below zero to forty degrees above, from November to March; and the summer temperature, from fifty degrees to one hundred degrees above, from April to October.

The suitability of the soil and climate for growing fruit and other special crops has long been recognised; and in the favoured localities, where water is easily obtainable for irrigation, great advance has been made in the last ten years in this direction.

Several companies have been formed for the development of irrigation projects. The largest of these projects, that of the White Valley Irrigation & Power Co., Ltd., covers some twenty thousand acres in the vicinity of Vernon, - the principal town in the valley. Within this area lies the famous Coldstream Estate, owned by Lord Aberdeen (a former governor-general of Canada).

There are at the present time about eight thousand acres in orchard, the average age of which is five years; and it is estimated that the average yield is equal to three tons per acre. In five years the yield will be from five to eight tons per acre.

In order to profitably market fruit, it must be handled as little as possible, kept at an uniform temperature, and reach its destination quickly. A tram system would make it possible to bring standard gauge, regrigerator cars to packing-houses situated at numerous points throughout the valley, and thereby meet the above conditions.

In a mountainous country, where water is abundant and power is needed for transportation, lighting towns, and running factories, the natural result is an investigation for the development of an hydro-electric plant.

LOCATION:

Vernon, the centre of the Okanagan Valley, situated about four miles East of the head of Okanagan Lake, is on the Shuswap and Okanagan railway - which is a branch road joining the C. P.Ry. main line at Sicamous Junction, forty-six miles North of Vernon.

The Shuswap Falls, on the Spallumcheen River, -which is a tributary of the Thompson, one of the chief feeders of the Fraser- are twenty-six miles East of Vernon. The river at this point runs through a box canyon for a little over a mile and in that distance falls nearly 100 feet. The greater part of this drop occurs within a distance of 2,000 feet in a series of cascades.

SURVEY.

In November 1908, a survey was made of the Falls to ascertain the power available for hydro-electric development.

Three parallel traverses were run: one as close to the water's edge as possible; and two, one along either bank, some one hundred feet above the water. These three lines were tied to-gether, the error of closure was 1 in 3700. An assumed datum was taken, and levels were run over each line. The error in the circuit was 2 tenths of a foot. The traverses were then plotted by co-ordinates, on field sheets, to a scale of 1 in. to 100 ft.: and 5 ft. interval, contour lines were drawn in, in the field, these being determined by hand level and tape as in railway work.

At the most uniform place in the river-bed, a careful cross-section was taken, and gauges were set on either bank. The following is a table of approximate discharges to date:

Shuswap Falls.

Date	Gauge (feet)	Aver. Vel. (ft./sec.)	Area. (sq.ft.)	Approx Dis. (cu.ft /sec.)	#Corrected Dis.
1908.					
Nov. 17	93.65	2.2	400	900	1035
Nov. 27	93.70	2.3	407	940	1080
Dec. 24	93.15	1.5	324	500	575
1909.					
Jan. 20	River frozen over.				
Mar. 1	92.85	1.2	282	338	385
Apr. 20	93.15	1.5	324	490	565
May 6	93.70	2.3	390	900	1035
Jly. 2	95.55	4.5	830	3740	4300
Sept.25	93.50	1.8	380	680	780
Nov. 8	93.75	2.4	400	950	1090
Dec. 23	93.90	1.4	440	600	690
1910					
Jany.28	93.20	1.4	333	466	535
Mar. 9	92.85	1.2	280	338	385

March 1st, 1909, the water level fell to the lowest elevation on record, so a close current-meter gauging was taken, which gave a discharge of 385 cu. ft. sec. This gauging shows an excess of 14% over the approximate reading, taken with floats on the same date, consequently

the discharges in the foregoigg table should be increased by this percentage.

An interesting confirmation of these results is obtained from the general law given by Wilson for the relation between maximum, average, and minimum discharges of streams to the run-off, for regions West of the Rockies.

Area of watershed, 500 sq. mls.

Probable, annual precipitation, 36 ins.

Probable run-off (66% of this) 640,000 ac.-ft. annually.

This is equal to an average flow of 1800 ac.-ft. per day.

Which again is equal to an average flow of 900 cu.-ft. per sec.

Applying Wilson's law to this average, we get:

10 x aver.=maximum 9,000 cu. ft./sec.

½ x aver.=Minimum 450 cu. ft./sec.

POWER OBTAINABLE.

The proposed dam site is at a point about 1200 feet up stream from the high way bridges near the Falls.

The proposed location of power house is at a point about 3,000 ft. down stream, measured on a straight line from the dam site.

The amount of power that could be developed is dependent upon the height of dam to be erected, the banks of the river about the proposed location and for considerable distance up stream, being generally of such steep slope, that little or no damage could arise by dam flooding.

For conveying the pond water from the dam to the penstocks at power house, it might be best to tunnel a passage through the intervening elevation of granite rock. For general permanence and suitability it would be difficult to devise any better means, or cheaper in the end; but as the tunnel out-lay would be heavy, considering the comparatively small amount of power in prospect of utilization, during the first few years, a wood stave pipe is suggested - necessarily of greater length than the tunnel - as the supply conduit, for at least the first unit of power to be installed; subsequently the tunnel could be adopted, or additional pipes laid as might seem advisable.

Reverting to the proper height and style of dam to build, it is recommended the elevation to be such as would retain the pond level at 220.00 ft. above the datum level.

Allowing for a storage of five feet in depth, or in other words, for drawing the pond down, when necessary 5 feet below high water elevation: and further, for a loss of seven feet in over-coming the friction in the conduits: and assuming the tail water at ordinary high flow of the river to rise to an elevation of 98.00 ft. above datum, the net head available, left for use, would be 110 feet.

Under a working head of 110 feet and reckoning upon turbines of 80% efficiency, which is fair result in practice, each cubic foot of water volume represents 10 horse power delivered on the water wheel shafts.

Assuming next that the minimum volume of the entire stream be 350 cubic feet per second, the natural flow then represents a constant capacity at lowest run, of 3500 horse power net, delivered on the turbine shafts.

DAM.

The nature of the dam proposed is expensive of contruction, chiefly concrete, and is calculated to provide for a log sluice and fishway. The dam would be of the overflow type, the over-flow taking place through weirs controlled by stop logs to be manipulated by winches, according to the varying volume of the river's run.

WOOD-STAVE PIPE FLUME.

If a tunnel were determined upon to carry the water from the dam to the power house, the tunnel should be driven and finished the full size that might be ultimately required for complete development of the power plant, thus entailing an immediate outlay of some $100,000, the length of bore being about 3,000 feet according to scale of the plan.

On the other hand, with the adoption of a wood-stave pipe, traversing the best obtainable line, and grade around the hill base - about 4500 ft., plan measurement - the cost of the pipe for the first 1,000 horse power, and probably sufficient for the first few years, need not exceed, say, $27,000; and such pipes constantly filled with water, are practically rot-proof.

At any later date, additional pipes could be laid along side, or if preferable, the tunnel could be driven, without interrruption to the operation of the plant in either case.

Without knowing what term would elapse before complete development of the plant, it cannot be estimated whether the interest on the tunnel investment , if made in the first place, would render the tunnel, or the pipes the more economical in the end.

FORE BAY.

The forebay would be a concrete or crib work structure to serve as a reservoir, receiving from the flumes or tunnel, and delivering to the wheel penstocks, without communicating the occasional and unavoidable water hammer in the latter, to the flumes and would be designed to afford access to any impaired penstock or turbine unit without interrupting the working of the other units.

STEEL PENSTOCKS.

These would be cylindrical steel pipes conducting the water under full pressure from the forebay to the turbines.

For the sake of economy in the first installation, a small branch pipe from near the lower end of the main penstock, to run the exciter turbine is in contemplation. Later on, when even slight interruptions to the steady delivery of power would mean so much more to the power value, independent penstocks would be installed for the exciters.

POWER HOUSE:

The capacity of the initial power house would be for two units throughout, and the building would provide for the housing of the electrical sub-station also intended for two units. The entire structure should be as nearly fire-proof as practicable.

TAIL-RACE.

The tail-race though a simple end of a water power scheme, well repays careful study, and provision must be made for contingencies liable to arise peculiar to the situation.

HYDRAULIC MACHINERY.

The installation of modern high-class turbine water wheels fixed on horizontal shafts extending through stuffing boxes into the machinery room and operating the electric generator runners, fixed on the same shafts, dispenses with the complication and disadvantage of belts or gears and affords the highest precentage of power deliverable from the water to the electric switch-board and transmission line.

ROAD-MAKING and TRANSPORTATION EXTRAS.

These are items of expense which naturally must be reckoned with where heavy machinery, plant and supplies are to be conveyed to locations more or less out of the way from the regular high ways, although in this instance the convenient proximity of the power house and the immediate proximity of the dam to the public roadway, would almost justify the elimination of the road-making item.

GENERAL.

On the 18th of February, 1909, it was noticeable that the River had been considerably choked a few days previously by "Frazil" or anchor ice. The evidences were that the formation of the ice had taken place chiefly at and below rather than above the Falls, which naturally would be the case.

Such formation is common in the rapids of streams during spells of very low temperature, and sometimes becomes troublesome where running above the headworks of water power plant, by temporarily choking the racks, or waterway entrances, in this case, if any trouble should arise at the headworks it will be very slight, at least until the main body of the current be diverted for power purposes and made to draw the floating anchor ice into rather than past the flume entrances; by that time, however, the character and extent of the trouble - if any - will have become so well understood that the operating staff will be in good position to guard against interruption to the steady running of the plant, if not to over-come the cause entirely.

At the tail works the worst to be feared would lie in the rise of back water, perhaps 5 or 6 feet, during a few days of intense cold weather, when the main channel might become clogged with the " frazil" ice. That would result only in a small loss of power by reason of reduced working head until the river readjusted itself.

As far as can be learned, there is nothing on record to indicate that gaugings have been taken in the past to determine the quantity of flow in the river, except the measurements given above (and with the exception of the current meter gauging) these measurements are not represented as else than good approximations on the particular dates taken.

The flow immediately above Shuswap Falls was on March 1st, 1909, 385 cu. ft. per sec., and dilligent inquiry from residents, on the stream familiar with its fluctuations for the past 15 or 18 years, and who appear to be the best authorities on the question, have given their opinion that the regular low water period is during the winter months, and that the flow on and about the date just mentioned was, in their judgment, as low as the minimum run of any season.

Deducting from the volume found, 35 cu. ft., or nearly 10%, as a margin of safety, the minimum flow then becomes 350 cu. ft. per sec., and represents 3500 horse power already referred to, as the net minimum capacity of the stream under 110 feet head.

It is a well established fact, that where hydro-electric companies furnish power to a number of customers, and for a variety of purposes, there is ordinarily no probability that the customers will at all times be using each to his prescribed limit of power.

In common practice, the power actually used, by consumers, and forming the total load at the generating station, is found to fluctuate greatly every day.

The mean load of the day bears a relation to the day's peak load, but varies according to conditions, and is largely dependent upon the purposes for which the power is utilised.

Not uncommonly this daily mean will represent only 50% of the daily peak load, - or even less.

In this way it becomes no undue risk for a power vendor to undertake the responsibility of selling within certain limits, an aggregate of power beyond his actual capacity to supply, provided always he maintains his work in position to carry the peak load for whatever short period it may continue.

To this end the vendor should determine what quantity of surplus water he can store and replenish in his pond each day, to use as occasion demands.

Take the natural minimum flow, at Shuswap

Falls, as 350 cu. ft. per sec., (good for 3500 horse power) independent of storage, and assume the sale of 5,000 horse power to have been undertaken; then, as long as it shall last, the peak load, thrust upon the plant, may exceed the capacity of the natural run of water, during that period. But, the reserve supply may be drawn upon, to compensate for the shortage, and what will be needful, is to see that the reserve water be ample, but not so great that when depleted it cannot be replenished in time for the next following over-load.

Suppose the peak load to reach and continue at, 5,000 horse power, for the space of 4 hours; a simple computation will show that the storage required for that draft of power will be 2,160,000 cu. ft. of water, plus the natural flow and that during the remaining 20 hours of the day, the surplus flow over and above the required quantity will very much more than replenish the depletion. A small pond, 5 ft. deep will contain the needed reserve.

In short, the stream of 350 cu. ft. per sec. of minimum flow, and manipulated to form a small reservoir supply, as planned, is commercially good for at least 5,000 horse power.

Sugar Lake.

This lake is the main source of the stream at Shuswap Falls. Its outflow measuring on the 3rd March, '09, 297 cu. feet per second, the balance of the flow (350 cu. ft.) at Shuswap Falls, being made up of intermediate streams.

Sugar Lake lies approximately 20 miles distant from Shuswap Falls, and has its sufface area of some 3900 acres at normal level of the water - according to an accurate survey made.

The surrounding shores of the Lake are generally quite steep with some exceptions where the land is comparatively low and flat but not improved nor of high value.

On the River near the Lake outlet, there is a fall of about 38 feet, as per instrument levels taken.

At the head of the fall a dam could be erected on a rock foundation, and, as far as could be judged, during a brief examination, could be carried up to create a working head of 75 to 100 feet, without encountering special engineering difficulties or excess of cost.

Reckoning on an enlargement from the present lake area of 3900 acres, to an area of, say 4000 acres, at mean depth, a dam at the outlet of the lake, increasing the depth only 10 feet and permitting the storage to be drawn at will, would provide an extra volume of 100 cu. ft. per sec., continuously for a period protracted even to 200 days, were there occasion. The effect would be to augment the Shuswap Falls Development by 1000 horse power for utilization the year around.

It is to be borne in mind that a dam to be utilized, in the way just referred to, would entail the services of an attendant at least a portion of each year, as well as the establishment of telephone communications between the Shuswap Falls power house and Sugar Lake dam.

Roughly estimated, the cost of a 10-foot dam should not exceed $15,000 or $20,000 - where the main object would be only for the regulation of the river flow.

A high dam for creating an independent water power at the same location, would also serve the purpose of regulating the flow, both there and at the Shuswap Falls power, provided both powers should remain under one control.

CONCLUSION.

It will be seen that the developing of a water power at the Shuswap Falls, on the Spallumcheen River, is a perfectly good and sound proposition from an engineering stand point.

The market for the power within easy reach of the Falls, has been investigated and found to be remunerative and rapidly increasing.

The beneficial effects, of the installation of this power, on the surrounding district, can hardly be over-estimated, and keen interest is evinced by the public in the undertaking.

Robert A. Barton.

June 1910.