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DEPARTMENT OF MINES AND TECHNICAL SURVEYS

GEOLOGICAL SURVEY OF CANADA

TOPICAL REPORT NO. 97

REPORT ON INVESTIGATION OF RADIUM HOT SPRINGS, KOOTENAY NATIONAL PARK, BRITISH COLUMBIA

BY

R. O. VAN EVERDINGEN

OTTAWA
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(1) Introduction and acknowledgment

The investigation reported here was undertaken on the request of the National Parks Branch, Department of Northern Affairs and National Resources. Its aim was to determine possible sources of contamination of the Radium Hot Springs, as well as measures to protect the Hot Springs against contamination, especially during reconstruction of the Banff-Windermere Highway No. 93.

The cooperation and assistance rendered by Mr. H.B. Webb, Superintendent, and Mr. G.A. McKnight, Resident Engineer, Kootenay National Park, is gratefully acknowledged. Thanks are due to the Radium Aquacourt Staff, for extensive information and assistance.

Chemical analyses were made by J.F. Thomas, Industrial Waters Section, Mines Branch, Dept. of Mines and Technical Surveys.

(2) Location and setting

The Radium Hot Springs are located in the narrow valley of Sinclair Creek, a tributary of the upper Columbia River, approximately 1.1 mile east of the southwest gate of Kootenay National Park, B.C.

The springs emerge from a shattered zone in Jubilee limestone (dolomitic), 0.5 mile west of the great Redwall fault that brings Jubilee Formation (Middle-Upper Cambrian) into contact with limestones of the Beaverfoot-Brisco Formation (Ordovician-Silurian). The contact between the Jubilee limestones and shales of the McKay Group (Cambro-Ordovician) crosses the valley of Sinclair Creek just downstream of the springs.

The springs are related to the Redwall fault (parallel to the Rocky Mountain Trench). The shales of the McKay Group probably act as an impermeable barrier, forcing the water to emerge close to the Jubilee/McKay contact.

Evidence of solution activity in the Jubilee limestone is found on both sides of the valley upstream from the springs.

A large-scale plan of the springs-and-pool area is included as Figure 1.

(3) Problems and earlier protective measures

A. Earthquakes: Montana, U.S.A., August 17, 1959.
Alaska, U.S.A., March 27, 1964.

On both occasions the Radium Hot Springs were affected, showing:

1. A definite reddish-brown muddiness.
2. A drop in water temperature from 114° to 103°F (11°F).

Both phenomena point to "contamination" of the spring-water from another, near-surface, source.

On the day after the Alaska earthquake a sample of muddy water was taken and sent to the Geological Survey. The water and the sediment were analysed separately. The water analysis is incomplete because of the small amount available. The only indications of "trouble" are the low pH and hardness, and the high potassium and low SiO_2 contents. The hot pool was kept closed from March 28 till March 31st. Temperature recovered to 113°F by April 2nd and was back to 114°F on April 7th. At the time the stage of Sinclair Creek was low.

B. Rainstorms: June 13 and 16, 1964; July 3 and 4, 1964.

After a heavy rainstorm on June 13 the spring water became extremely muddy in the late afternoon of that day. Investigation revealed a "sink-hole" in the highway drainage-ditch on the north side of Highway No. 93. The sink-hole was taking in water from both east and west. The temperature in the springs dropped from 114° to 85°F, a drop of 29°F.

The hole was temporarily covered with a sheet of plywood, covered in turn with sand. Turbidity and low temperature of the spring-water continued. It was thought possible that water from Sinclair Creek (running between Highway No. 93 and the springs and hot pool) was entering the spring's channel-way. This would be the first time that high water in Sinclair Creek influenced the spring flow. Either the Alaska earthquake of March 27 or erosion of the creek bed could have opened a connection between creek and springs.

Consequently, sandbags were placed on the south bank of Sinclair Creek to stop such possible leakage. A total of 300 sandbags were put in place on June 14. The spring-water flowing into the hot pool started clearing. The water-level in Sinclair Creek had not fallen appreciably since the day before. By 8:00 a.m. on June 15 the spring-water was almost clear, while its temperature had returned to 110°F (4°F below normal).

The next heavy rainstorm, on June 16, 1964, caused renewed turbidity of the spring-water. This time the highway drainage-ditch was partly filled and sealed with asphalt.

At approximately 15.$^{\underline{00}}$ hours on July 3, 1964, rain started in the Radium area, continuing intermittently until 19.$^{\underline{00}}$ hours. At 17.$^{\underline{00}}$ hours the Park Superintendent discovered that the measures taken on June 14 and 16 were not effective. Turbidity developed in the spring-water, increasing to the point where patrons had to be removed from the hot pool. (The larger swimming pool is fed by filtered and chlorinated spring-water and consequently was not affected.)

It was found that water was again disappearing through the bottom of the highway drainage-ditch, close to the original sink-hole. Some more extensive measures were taken; a low retaining wall was built in the ditch, approximately 100 feet upstream from the trouble spot, and the ditch was thoroughly cleaned from the retaining wall to below the first lamp-post, approximately 250 feet.

At $22.^{\underline{45}}$ hours the spring-water was clear again. The next rain, however, starting at $09.^{\underline{00}}$ hours on July 4, again caused turbidity of the spring-water. On July 5 the water had cleared again.

Further measures taken after this last occurrence were; installation of a culvert under the highway, just upstream from the retaining wall, diverting water from the drainage-ditch to the creek; sealing of the drainage ditch with asphalt and cement, from the retaining wall to below the first lamp-post (250 feet); a number of large logs were placed along the side of the ditch to prevent driving and parking in the now shallow ditch.

Heavy rainfalls between July 10 and 20 did not affect the spring-water. Apparently the latest modifications of the highway drainage are effective in preventing entrance of drainage water into the spring channel-way. Sinclair Creek was high and quite muddy during this period. Therefore it can be assumed that no connection exists at the present time between the creek and the springs.

(4) Present investigation

The investigation was extended from the highway tunnel at the Red Wall fault to the pool area. Rocks on both sides of the valley are severely fractured, dipping 40° to 80° to the west. Evidence of solution activity and possible "thermal action" is clearly present near the sink-hole. None of these solution channels provides ready access to the water-carrying hot-spring channel. Only one of the holes apparently produces a flow of warm and moist air.

Water can be seen in a larger solution hole, in the northeast corner of the lawn near the hot pool. The level of the water in this hole goes up and down with the level of the spring-water behind the east wall of the hot pool when the pool is filled or drained. At all times the water in the hole is below the level of Sinclair Creek. The water can be seen flowing to the south towards the springs, and on a cool night the hole "steams".

On the night of Friday, September 4, temperature readings and water samples were taken from the springs, after the hot pool was drained ($23.^{\underline{00}}$ hours). (Analyses 3, 4, 7, 8 and 9 in Table I.)

On the morning of Saturday, September 5, water samples were taken at various places from Sinclair Creek. (Analyses 10, 11, 12, 13 and 14 in Table I.)

Comparison of the analyses of these samples with analyses made in 1956 and July 1964 (springs contaminated through highway drainage), shows that in Springs I and III magnesium, sodium and potassium values were about 5-10 per cent lower during the contamination.

Further there seems to be a continuing increase in the fluoride content of the water from Springs I and III, as well as a continuing decrease in the nitrate and silica contents.

Analyses 8 and 9 indicate that the flow under the hot pool drain is derived from one or possibly two additional spring channels. The spring designated as IV shows higher NO_3 and Cl contents than the others; the spring designated as V shows lower F and higher SO_4 values than any of the others. Analysis 14 shows the influence of spring-water, discharging from the hot pool, on the composition of the creek water, by the increase in the values for Ca, Mg, Na, SO_4, Cl and SiO_2. Analysis 13 might indicate some leakage from cracks in the concrete of the hot pool, by the somewhat increased content of SO_4, Cl and SiO_2.

(5) Conclusions

1. Water from Sinclair Creek does not enter the spring channel at present, but even some minor erosion of the creek bed might change this.

2. Water from the drainage-ditch entering the spring channel indicates a connection between the solution holes on the north side of Highway 93, and the

hot springs south of Highway 93 and Sinclair Creek. It does not necessarily mean that part or all of the spring-water is derived from north of the highway.

(6) Recommendations

A. Treatment of creek bed and highway ditch.

1. The highway drainage-ditch and the creek bed should be made impervious.

2. The area to be treated extends at least from the new culvert (see location plan) to where the creek enters the present concrete flume beside the hot pool.

3. The best solution for Sinclair Creek is probably to put the creek in a large-diameter culvert over this whole reach. This would at the same time enable widening of Highway 93 without need for the removal of any solid rock from the valley sides.

4. The culvert to be installed should be absolutely water tight and the diameter should be large enough to carry at least the maximum recorded flow of 370 c.f.s.

5. The culvert should be as straight as possible, to avoid the possibility of plugging-up by debris. It should be large enough to enable inspection, cleaning and repairs during low-flow periods.

B. Blasting for the construction of Highway 93.

(See Map, Fig. 1)

1. Blasting operations in the stage from Iron Gate tunnel to well below the pool area should be kept to a minimum. A clause limiting the size of individual charges and requiring the use of delay caps should be included in the specifications. Careful selection of proper explosives should minimize the inconvenience.

2. In area 'A' under no conditions should any bedrock or well cemented rubble be removed; no blasting should be allowed at all. Loose rubble might be removed by hand if necessary. The area 'A' extends from the lamp-post to approximately 60 feet west of the new culvert under the highway (see map).

3. In areas "B_1" and "B_2" loose material and cemented rubble should be removed by methods not involving blasting. No bedrock should be removed.

4. In area "C" bedrock to be removed could be worked by blasting, provided minimum charges are used. Loose material in this area should be removed without blasting.

5. Adequate width of Highway 93 in area "A" can be assured, after treatment of the creek, by extending the pavement partly over the creek (see A. point 3).

C. Capture of spring-water

1. If the spring-water originates on the north side of Highway 93 then it could presumably be captured there and piped into the hot pool. This would eliminate the danger of contamination from highway drainage or creek flow. At present, however, no definite indication of such an origin exists. Further investigation would be needed to prove or disprove this possibility. Such investigations would involve either drilling or dye and tracer tests, or both. It is felt that the management of the Radium Hot Springs would be reluctant to authorize such investigations.

2. As indicated by the chemical analyses some extra spring flow could probably be captured at the south end of the hot pool (springs "IV" and "V"). Cleaning of the valley bottom to bedrock and erection of a cut-off wall, sealed to bedrock at the bottom and sides, would prevent escape of any spring-water other than through the pool drains (and through bedrock).

3. As no definite knowledge about the direction of origin of the springs exists at present, it is felt that grouting downwards and sideways from such a proposed cut-off wall into bedrock should not be attempted.

D. Influence on spring flow during the treatment period

1. If a minor connection exists between Sinclair Creek and the hot springs, temporary contamination of the springs with cold and muddy water could occur during the treatment period (decrease in temperature, increase in flow). This should not be a cause for alarm; it would only show that treatment was necessary for proper future operation of the Radium Hot Springs facilities.

2. The winter season, with lower attendance figures, should be used for this stage of the work if possible.

3. The effectiveness of the treatment should be apparent in a sustained perfect clearness and high temperature of the spring-water, even in periods of heavy precipitation and run-off. Besides, a slight reduction in flow-rate and a slight increase in temperature could result from the treatment of the creek. Capture of extra spring-water could offset any reduction in flow-rate.

4. It is recommended that a close watch be kept on developments during any treatment and construction undertaken near the springs. Frequent temperature readings on each of the captured springs (with the pool drained), the creek water and the atmosphere should be taken with a good quality thermometer. Changes in clearness and possibly flow-rate should also be noted.

E. Referring to the report by Messrs. Dolmage, Mason and Stewart, of Vancouver, B.C., dated October 19, 1964, the following observations are made:

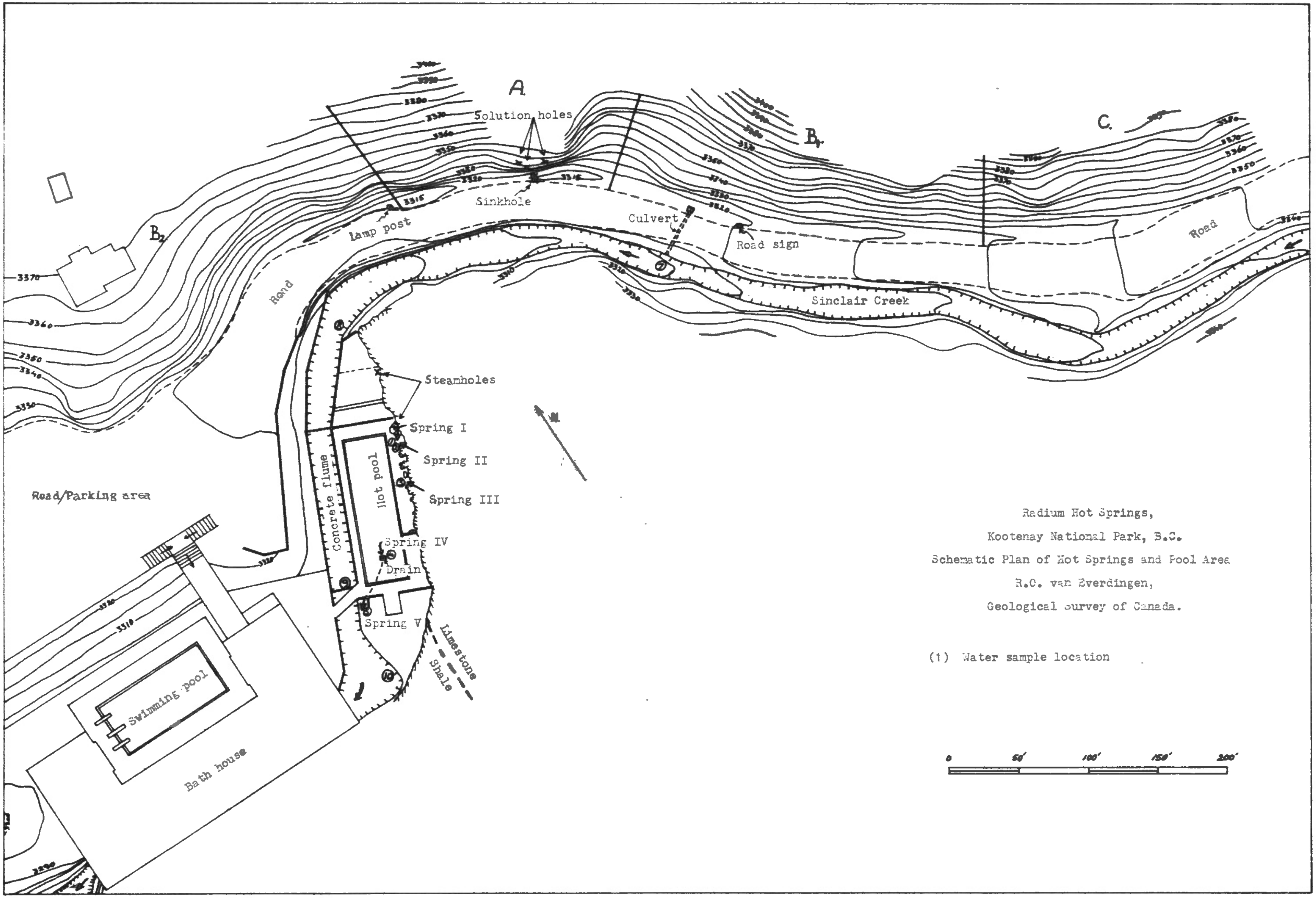
1. As no location plan is given in the report, the location of the tunnel, discussed in the above report, is deduced from the reference to shales and schists on page 1, to be down stream from the hot pool.

2. If this is the case then all five recommendations on page 3 of the above report seem to be sound advice.

3. In view of our recommendation under A-5, and Dolmage's recommendation 3, it might be advisable to have a regular inspection carried out to check on, and if necessary remove, debris from the creek bed and valley sides, upstream from the proposed culvert and between this culvert and the proposed tunnel.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Location	Hot Spring No. I			No. II	Hot Spring No. III			Hot Spring No. IV	V	Sinclair Creek 1964				
Year	1956	1964	1964	1964	1956	1964	1964	1964	1964	Above Iron Gate tunnel	Above sink-hole	Below spring zone	End of concrete flume	Below pool drain
Date of sampling	August 14	July 13	Sept. 4	Sept. 4	August 14	July 13	Sept. 4	Sept. 4	Sept. 4	Sept. 5	Sept. 5	Sept. 5	Sept. 5	Sept. 5
Temp. at sampling, °F	112°	113°	114°	111.6°	96°	104°	96°	---	---					
CO_2, calculated	3	10	10	16	3	8	12	6	5	4	3	5	6	5
pH	8.0	7.5	7.5	7.3	8.1	7.6	7.4	7.7	7.8	7.9	8.0	7.8	7.7	7.8
Colour, Hazan units	0	5.0	5.0	5.0	0	10.0	5.0	5.0	5.0	5	5	5	5	5
Turbidity, units	0	0.9	----	1.0	0	0.6	0.5	3.0	0.5	0.5	0.5	0.5	2	2
Residue on evap., 105°C	738.	728.	752.	726.	591.	572.	578.	704.	758.	214.	219.	217.	230.	260.
Loss on ignit., 550°C	663.	140.	102.	92.8	529.	108.	81.6	134.	136.	28.0	64.4	64.4	84.4	92.0
Spec. cond., micromhos	951.	933.	946.	923.	797.	763.	766.	900.	955.	374.	369.	356.	370.	390.
Total hardness ($CaCO_3$)	498.	487.	513.	504.	416.	415.	421.	479.	510.	199.	200.	200.	200.	215.
Non carbonate (as $CaCO_3$)	322.	320.	332.	331.	235.	239.	235.	304.	335.	28.	29.	27.	27.	42.
Calcium (Ca)	148.0	150.	150.	144.	118.	122.	116.	138.	150.	51.4	51.4	51.7	51.7	55.9
Magnesium (Mg)	30.9	27.0	33.6	35.	29.6	26.8	29.7	32.6	32.9	17.1	17.4	17.2	17.2	18.3
Sodium (Na)	13.3	12.3	13.3	13.0	9.8	9.4	9.5	14.0	13.3	1.8	1.8	1.8	1.8	2.4
Potassium (K)	2.9	2.8	3.0	2.9	2.3	2.1	2.3	2.9	3.0	0.8	0.8	0.8	0.8	0.9
Iron (Fe)	0.01	0.07	1.3	0.64	0	0.05	0.04	0.32	0.19	0.08	0.25	0.12	0.07	0.19
Aluminum (Al)	0.18	0.03	0.02	0	0.15	0.05	0	0.02	0.01	0	0	0	0	0
Manganese (Mn)	Trace	0.01	0	0	0	0	0	0	0	0	0	0	0	0
Copper (Cu)	0.00	0.001	0	0.001	0	0	0.002	0.001	0	0.003	0.002	0.001	0.002	0.003
Zinc (Zn)	0.05	0	0.001	0	0	0	0	0.002	0	0.001	0.003	0.003	0.002	0.003
Bicarbonate (HCO_3)	215.0	204.	221.	211.	220.	215.	216.	213.	213.	208.	208.	211.	211.	211.
Sulphate (SO_4)	316.0	315.	325.	324.	230.	235.	232.	303.	336.h	27.1	27.1	27.9	28.2	42.8
Chloride (Cl)	10.4	9.9	10.2	10.0	7.7	7.3	7.1	12.6h	10.5	0.4	0.4	0.5	0.6	1.1
Fluoride (F)	0.3	0.7	0.8	0.8	0.3	0.34	0.6	0.75	0.16-1	0.12	0.12	0.12	0.12	0.14
Nitrate (NO_3)	2.8	0.4	0.2	0.4	1.6	0.6	0.5	1.3 h	0.2	0.1	0.1	0.1	0.1	0.2
Silica (SiO_2)	54.0	39.0	35.0	34.0	28.0	28.0	27.0	32.0	35.0	5.3	5.3	5.3	5.5	6.8
Sum of constituents	685.	658.	680.	668.	536.	537.	531.	642.	686.	207	207	207	210	232

CO_3 is zero in all cases.



Radium Hot Springs,
Kootenay National Park, B.C.
Schematic Plan of Hot Springs and Pool Area
R.O. van Everdingen,
Geological Survey of Canada.

(1) Water sample location