

Historical temporal trends in groundwater levels from British Columbia, Canada

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Management of groundwater quantity and quality is an important resource development issue in Canada [1]. Overuse and/or contamination of groundwater supplies has the potential to restrict future use of this resource [2]. In the western Canadian coastal province of British Columbia, increasing attention is being paid to the scientific and legislative/regulatory aspects of surface and groundwaters. Aquifer types in the province have been classified [3] and various investigations have employed case-study type approaches to determine the status of groundwater resources, developed rigorous quantitative models of representative aquifers with predictive capacity, and attempted to assess future changes due to natural and/or anthropogenic forcings (see, e.g., ref. [4-16] and references therein). In our previous work, we examined temporal trends in groundwater monitoring wells for the western Canada prairie province of Saskatchewan [17]. We found that groundwater resources in this region generally appear to be increasing over time and do not appear to be under current threat from depletion. As part of the current study, we have conducted a similar investigation on time trends for groundwater monitoring well levels in British Columbia.

Groundwater data was obtained from the British Columbia Ministry of Environment online Groundwater Observation Well Network database [18]. Trend data is available for a total of 210 groundwater monitoring well stations throughout the province (Figure 1 and Table 1) with end-of-month water levels (presented as meters below ground surface) over the period of record. Substantial end-of-month water level data gaps are present throughout the available historical record for the large majority of monitoring wells. At many sites, significant interannual variability in water levels is expected to have occurred due to natural and/or anthropogenic causes, precluding reliable reconstruction of complete inter- and intraannual monthly well level records using interpolative techniques. Consequently, the dataset was screened and correspondingly reduced to only include years with a complete set of monthly records. Average annual groundwater levels were calculated as the mean of the twelve individual end-of-month groundwater levels for each year over the resulting usable historical record at each site. Temporal trends in average annual groundwater levels at each site were examined using standard parametric linear regression [19].

Of the 210 groundwater monitoring well stations, 166 stations (79.0%) contained records of greater than two years (Table 2). The remaining stations had either 0, 1, or 2 years of complete annual records, and were not considered further. The average usable record length is 9.5 years with a standard deviation of 8.2 years and a range from 0 to 39 years. The majority (62.4%) of the usable record lengths are between 0 and 10 years, with 10% of the records at 0 years (Figure 2). Only 10% of the records are longer than 21 years, and 1% of the records are longer than 32 years.

Significant temporal trends in groundwater levels were found at 67 stations (40.4% of all stations amenable to statistical examination, and 31.9% of all available stations). Of these 67 stations, 10 had increasing groundwater level trends and the remaining 57 had declining groundwater level trends. Thus, 34.3% of stations with a sufficiently long time series for analysis displayed declining groundwater level trends, while 6.0% have increasing trends, and 59.6% of these stations appear to have no significant temporal variation in groundwater levels.

Geographic distinctions in groundwater level time trends are difficult to make owing to the unbalanced distribution of monitoring sites throughout the province. About 65% of all stations are concentrated in Regions 1 (Vancouver Island) and 8 (Okanagan), and only ~14% of the stations are located in the heavily populated Region 2 (Lower Mainland), where the large majority (~60%) of the province's population resides. Based on percentages of total stations with a sufficiently long monitoring record for statistical analysis, it appears that the semi-arid Thompson/Nicola (Region 3) and Okanagan (Region 8) zones are most likely to have declining groundwater levels. This finding is climatically intuitive, but since the representative nature of the monitoring sites cannot be rigorously examined within and between the various regions, additional in-depth analysis is not justifiable.

A prior report [20] employing a different statistical approach to analyze temporal trends for levels in the groundwater monitoring well network has indicated that, depending on the five-year interval period under study between 1985 and 2005, between 14% and 35% of all monitoring wells examined in British Columbia had declining groundwater levels that could be attributed to human activities. While the current work does not attempt to distinguish between anthropogenic and/or natural causes of any temporal trends in groundwater levels, our results are generally in good agreement with this previous study. The linearized rates of groundwater declines vary widely (from -0.5 ± 0.1 cm/year at the “Osoyoos North of Pond” site to -35.6 ± 1.7 cm/year at the “Williams Lake [Scout Island]” site), as do the rates of increasing groundwater levels (from $+0.6 \pm 0.1$ cm/year at the “Kalawoods” site to $+30.5 \pm 3.8$ cm/year at the “Vernon [Falcon Road, Silver Star Mtn.]” site). A frequency distribution histogram of the linear rates of annual change for the 67 stations with statistically significant temporal groundwater level patterns is shown in Figure 3. A bias towards net declining groundwater levels (measured as water level below ground surface) is clearly evident. The normal distribution fit also indicates the actual distribution is skewed towards more high-rate declines compared to the fewer (and less variable) increasing groundwater levels.

Overall, a substantial proportion of groundwater monitoring wells in British Columbia – which have been operated with varying record lengths dating from recent installations to sites with records back to the 1950s – are exhibiting declining levels. At a significant number of other sites in the monitoring network, records are too short and/or poorly populated to facilitate statistical analysis.

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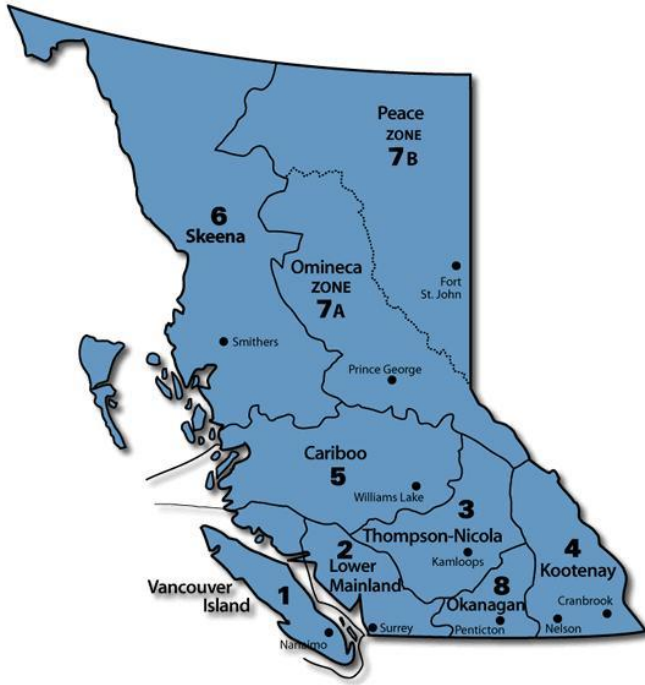


Figure 1. Schematic map of the groundwater monitoring well regions in British Columbia, Canada (taken from http://www.env.gov.bc.ca/wsd/data_searches/obswell/waterlevels/obs_wells_current.html).

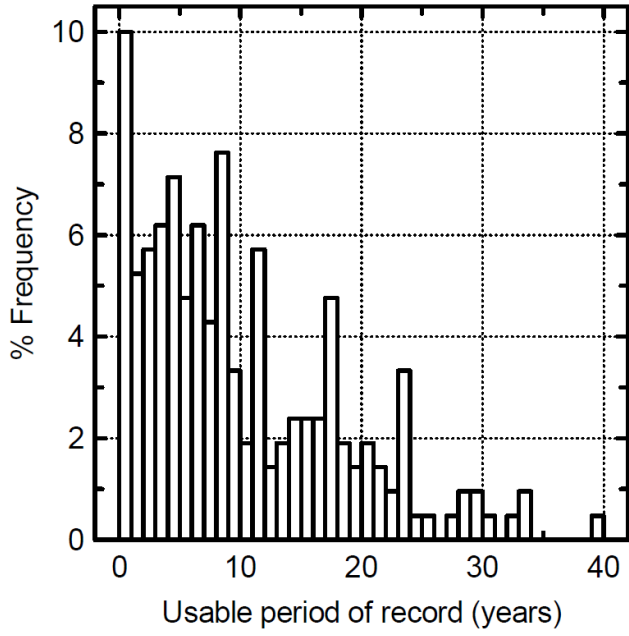


Figure 2. Frequency distribution histogram of the usable periods of record for the 210 groundwater level monitoring stations.

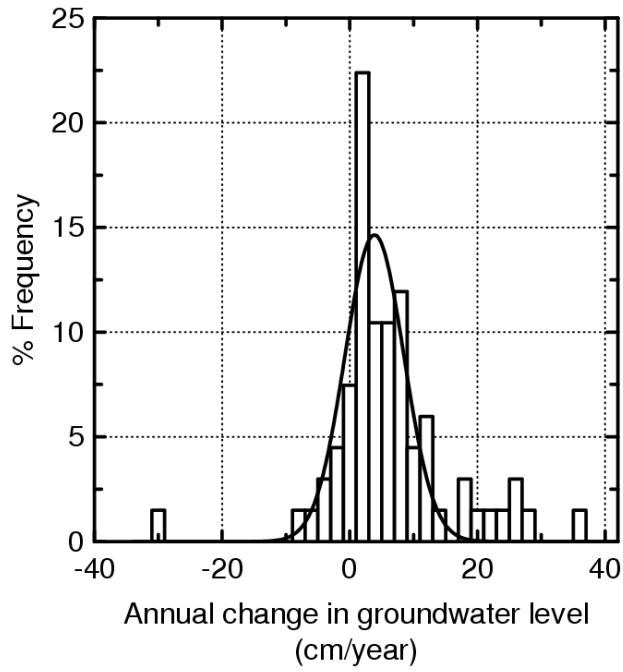


Figure 3. Frequency distribution histogram of the linear rates of change (measured as water level below ground surface) for the 67 monitoring network stations with statistically significant temporal groundwater level patterns.

Table 1. Names, identification numbers, locations, available and usable periods of record and associated number of datapoints, and temporal average annual groundwater level linear regression analysis results over the usable period of record for the 210 groundwater monitoring wells in British Columbia, Canada: n/a=not applicable, n/s=not significant, *=significant at $\alpha=0.05$, **=significant at $\alpha=0.01$, ***=significant at $\alpha=0.001$, (+)=increasing trend, (-)=decreasing trend. Note that groundwater levels are measured as water level below ground surface; thus, positive trends indicate declining groundwater levels and negative trends indicate increasing groundwater levels.

No.	Name	Available period of record		Usable period of record		Regression analysis	
		Timeframe	n	Timeframe	n	Significance	Slope (m/yr \pm SE)
Region 1 – Vancouver Island							
Alert Bay							
201	Alert Bay (Fir Street)	1975-2011	31	2004-2009	6	n/s	n/a
Bowser							
310	Bowser (Deep Bay North at Gainsburg Road)	1990-2011	22	1992-2009	14	n/s	n/a
331	Bowser (Deep Bay South)	1996-2007	12	1997-2006	6	n/s	n/a
Chemainus							
355	Chemainus (Mt. Sicker Road)	2004-2011	8	2007-2010	3	n/s	n/a
Cobble Hill							
256	Cobble Hill	1980-2003	24	1990-1993	4	n/s	n/a
320	Cobble Hill (Braithwaite Estates)	1992-2011	20	1993-2009	9	n/s	n/a
345	Cobble Hill (Arbutus Ridge)	1999-2011	13	2005-2010	6	n/s	n/a
Comox							
280	Comox	1982-2001	20	1983-1999	17	n/s	n/a
351	Comox (Greenwood Road)	2001-2011	11	2002-2010	8	n/s	n/a
Coombs							
287	Coombs (Burgoyne Road)	1984-2011	27	1985-2010	11	***	+0.072 \pm 0.013
Cowichan Bay							
233	Cowichan Bay (Vee Road)	1979-2011	32	1982-2010	8	n/s	n/a
297	Cowichan Bay	1988-1997	10	1990-1996	6	n/s	n/a
298	Cowichan Bay (Cowichan Bay Road)	1988-2003	16	1990-1993	3	n/s	n/a
Denman Island							
268	Denman Island (Denman Road)	1981-2011	30	1986-2010	9	*	+0.023 \pm 0.009
Duncan							
204	Duncan (Duncan RV Park North, Boys Road)	1977-2011	32	1982-2010	16	**	+0.023 \pm 0.006
205	Duncan (Duncan RV Park South, Boys Road)	1977-2007	20	1993-2007	8	n/s	n/a
208	Duncan	1990-2003	14	1993-2000	6	n/s	n/a
211	Duncan (Marine Harvest Canada, Boys Road)	1976-2011	35	1983-2010	17	**	+0.030 \pm 0.009
318	Duncan Fish Hatchery (Wharncliffe Road)	1992-2011	20	1993-2010	14	***	+0.052 \pm 0.012
Fanny Bay							
371	T'sabie River (Hwy. 19A)	2006-2011	6	2007-2010	4	n/s	n/a
Galiano Island							
258	Galiano Island (Shopland Road)	1980-2011	32	1987-2010	10	n/s	n/a
326	Galiano Island (Sturdies Bay Road)	1994-2003	10	1996-2002	4	n/s	n/a
327	Galiano Island (Community School)	1995-2011	17	2000-2010	7	*	+0.254 \pm 0.099
Gabriola Island							
194	Gabriola Island (Highways Yard, North Road)	1973-2007	30	1990-2005	5	n/s	n/a
196	Gabriola Island (Buttercup Road)	1973-2011	33	1993-2010	6	n/s	n/a
197	Gabriola Island (North Road)	1973-2011	29	1990-2010	7	n/s	n/a
316	Gabriola Island (Oyster Way)	1992-2011	19	2004	1	n/a	n/a
317	Gabriola Island (Wild Cherry Terrace)	1992-2006	12	2005	1	n/a	n/a
385	Gabriola Island (Horseshoe Road)	2010-2011	2	none	0	n/a	n/a

Hornby Island							
288	Hornby Island (Central Road at Sandpiper Road)	1984-2011	27	2002-2010	8	n/s	n/a
323	Hornby Island (Whaling Station Bay)	1993-2007	15	1994-2005	6	*	+0.071±0.025
324	Hornby Island	1993-2006	14	1994-2005	3	n/s	n/a
Ladysmith							
315	Ladysmith (Yellowpoint Road)	1992-2004	13	1994	1	n/a	n/a
337	Ladysmith (Woodley Range)	1999-2011	13	2008-2010	2	n/a	n/a
Mayne Island							
125	Mayne Island (Horton Bay Road)	1972-2011	40	1975-2010	21	n/s	n/a
126	Mayne Island (Georgina Point Road)	1972-2006	35	1974-2005	23	*	-0.008±0.003
127	Mayne Island	1972-1996	25	1975-1995	20	n/s	n/a
128	Mayne Island (Skana Gate Road)	1972-2011	40	1974-2010	29	n/s	n/a
Mill Bay							
350	Mill Bay	2001-2005	5	2004	1	n/a	n/a
Nanaimo							
388	Nanaimo (Benson Meadows Park)	2010-2011	2	none	0	n/a	n/a
390	Cedar (Holden-Corso Road)	2011	1	none	0	n/a	n/a
228	Cassidy (Timberlands Road)	1954-2011	58	1955-2008	39	n/s	n/a
312	Cassidy (Haslam Creek on T-Bridge Road)	1991-2011	21	1992-2010	18	**	+0.063±0.017
330	Cassidy (Nanaimo River at Harmac)	1996-2007	12	1997-2006	8	n/s	n/a
232	Lantzville (Harby Road)	1979-2011	32	1988-2010	11	n/s	n/a
340	Lantzville (Valmar Road)	1999-2011	13	2001-2010	8	n/s	n/a
Nanoose							
392	Nanoose (Dawson Road Deep)	2011	1	none	0	n/a	n/a
393	Nanoose (Dawson Road Shallow)	2011	1	none	0	n/a	n/a
Oyster River							
368	Black Creek Gravel Pit - Oyster River Bedrock	2006-2011	6	2007-2010	4	n/s	n/a
369	Black Creek Gravel Pit - Oyster River Unconsolidated	2006-2011	6	2007-2009	3	n/s	n/a
Parksville							
304	Parksville (Despard Road at Springwood Park)	1988-2011	24	1989-2010	15	***	+0.174±0.015
313	Parksville - HC7	1992	1	none	0	n/a	n/a
314	Parksville (Springhill Road)	1992-2011	20	1993-2010	14	***	+0.144±0.023
Pender Islands							
283	Pender Island (Paisley Road)	1983-2011	29	1985-2010	23	n/s	n/a
284	Pender Island (Pirates Road)	1983-2011	29	1985-2010	17	*	+0.054±0.020
Quadra Island							
383	Quadra Island (Heriot Bay Road)	2008-2011	4	2009-2010	2	n/a	n/a
Qualicum							
391	Little Qualicum (Meadowood Way)	2011	1	none	0	n/a	n/a
295	Qualicum Beach (Berwick Road)	1986-2011	26	1987-2010	16	n/s	n/a
303	Qualicum Beach (Yambury Road)	1988-2011	24	1990-2009	4	*	+0.232±0.033
321	Qualicum (Leeward Way)	1992-2011	19	2004-2010	7	n/s	n/a
389	Qualicum Beach (W. Island Hwy)	2010-2011	2	none	0	n/a	n/a
Saltspring Island							
276	Saltspring Island	1982-1990	9	1984	1	n/a	n/a
281	Saltspring Island (Long Harbour Road)	1982-2011	28	1983-2008	7	n/s	n/a
373	Saltspring Island (Mt. Belcher Heights)	2006-2011	6	2009-2010	2	n/a	n/a

Saturna Island							
290	Saturna Island (East Point Road at Gaines Road)	1985-2011	27	1985-2010	9	*	+0.015±0.006
319	Saturna Island (Tumbo Channel Road)	1992-2011	20	2007-2008	2	n/a	n/a
Ucluelet							
329	Ucluelet (Highways Yard)	1995-2011	17	1999-2010	9	n/s	n/a
Victoria							
372	District Of Highlands - Gowlland Tod Park	2007-2011	5	2008-2010	3	n/s	n/a
341	Metchosin (Arden Road)	1999-2006	8	2005	1	n/a	n/a
212	North Saanich (Maple Road)	1977-2010	34	1978-2009	17	n/s	n/a
240	North Saanich (Carnoustie Crescent)	1979-2011	33	1982-2010	20	*	+0.035±0.013
265	North Saanich (Gleneg Road)	1980-2011	32	1981-2010	17	*	+0.087±0.037
300	North Saanich Matheson 220 ft.	1988-1998	11	1993-1996	3	n/s	n/a
333	Central Saanich	1997-2006	10	2001-2005	4	n/s	n/a
334	Central Saanich	1998-1999	2	none	0	n/a	n/a
338	Central Saanich (Seabrook Road)	1998-2011	14	2002-2010	9	*	+0.120±0.046
343	Central Saanich (Mt. Newton X Road)	1998-2011	14	2001-2009	6	n/s	n/a
58	North Saanich (Mainwaring Road)	1966-2011	46	1978-2009	20	n/s	n/a
60	North Saanich (Littlewood Road)	1966-2011	46	1978-2008	23	n/s	n/a
61	South Saanich (Glidden Road)	1966-2011	46	1974-2010	17	*	-0.012±0.005
62	North Saanich (Wain Road)	1975-2005	31	1976-2001	18	n/s	n/a
64	North Saanich	1974-1998	25	1976-1997	16	n/s	n/a
65	Sidney (Victoria International Airport)	1975-2011	37	1975-2010	33	**	-0.012±0.004
69	North Saanich	1975-1998	24	1980-1997	15	n/s	n/a
71	Saanich (Cordova Bay Road)	1976-2011	36	1978-2008	23	n/s	n/a
Region 2 – Lower Mainland							
Abbotsford							
14	Abbotsford (Fraser Valley Trout Hatchery, Vye Road)	1972-1998	27	1979-1998	8	n/s	n/a
15	Abbotsford (Fraser Valley Trout Hatchery, Vye Road)	1972-2010	38	1980-2007	12	n/s	n/a
2	Abbotsford (Airport, Huntingdon Road West of Clearbrook Road)	1962-2011	48	1966-2010	27	n/s	n/a
272	Abbotsford (34288 Farmer Road)	1981-2011	31	1983-2010	11	n/s	n/a
273	Abbotsford (Farmer Road near McKenzie Road)	1981-2006	26	1991-2005	8	n/s	n/a
274	Abbotsford (Vye Road East of McKenzie Road)	1982-2002	21	1982-2001	7	*	+0.076±0.019
299	Abbotsford (Mt. Lehman Road North of Marshall Road Extension)	1987-2011	25	1992-2010	7	n/s	n/a
3	Abbotsford (30244 Taylor Road)	1962-2004	35	1978-2001	4	n/s	n/a
301	Abbotsford (King Road West of Bradner Road)	1988-2011	24	1992-2010	12	n/s	n/a
357	Abbotsford (30244 Taylor Road)	2004-2010	7	2005-2009	4	n/s	n/a
8	Abbotsford (Vye Road East off McCallum Road)	1962-2011	45	1978-2009	14	**	+0.044±0.012
Belcarra							
349	Belcarra (3400 Block Main Avenue)	2001-2011	11	2002-2008	3	n/s	n/a
Chilliwack							
406	Chilliwack	2010-2011	2	none	0	n/a	n/a
Langley							
12	Langley (2145 200 th Street)	1964-2004	33	1979-2002	8	*	+0.052±0.018
13	Langley (19659 36 th Ave)	1964-2003	32	1978-2002	7	n/s	n/a
328	Langley (238 th Street N of 50 th Avenue)	1994-2003	10	1998-2002	4	n/s	n/a
353	Langley (196 th Street near 36 th Avenue)	2004-2011	8	2007-2010	4	n/s	n/a
354	Langley (238 th Street near 50 th Avenue)	2004-2011	8	2005-2010	3	n/s	n/a

359	Langley (3364 240 th Street)	2004-2010	7	2007-2009	3	n/s	n/a
360	Langley (2145 200 th Street)	2004-2011	8	2005-2010	6	n/s	n/a
361	Langley (Aldergrove, 26B Avenue)	2005-2011	4	none	0	n/a	n/a
4	Langley (22317 16 th Avenue)	1962-2004	35	1978-2002	6	***	+0.085±0.008
5	Langley (21527 80 th Avenue)	1962-2004	33	1978-1983	5	**	+0.178±0.028
7	Langley (3364 240 th Street)	1962-2004	35	1978-2002	5	***	+0.271±0.005
Lindell Beach							
335	Lindell Beach (800 Columbia Valley Road)	1998-2004	7	2002	1	n/a	n/a
Maple Ridge							
259	Maple Ridge (Whonnock, 272 nd Street and 110 th Avenue)	1980-2011	32	1982-2009	21	***	+0.023±0.005
Powell River							
292	Powell River (2214 Victory Road)	1985-2011	27	1998-2010	8	n/s	n/a
Surrey							
275	Surrey (36 th Avenue near 194 th Street)	1981-2011	31	1983-2008	11	n/s	n/a
Whistler							
352	Whistler (Lakeshore Drive)	2003-2010	8	2006	1	n/a	n/a
Yarrow							
255	Chilliwack (Yarrow, Ratzlaff Road)	1979-2011	33	1987-2010	17	***	-0.015±0.004
Region 3 – Thompson/Nicola							
Avola							
270	Shannon Lake	1986-1990	4	none	0	n/a	n/a
Blue River							
375	Blue River (Murtle Lake Road)	2006-2011	6	2007-2010	4	**	+0.071±0.006
Cache Creek							
344	Cache Creek (Jackson Park, Valleyview Drive #1)	2000-2011	12	2001-2010	6	n/s	n/a
346	Cache Creek (Jackson Park, Valleyview Drive #2)	2001-2011	11	2004-2010	3	n/s	n/a
Clinton							
80	Clinton (Rodeo Grounds Cariboo Hwy. 97N)	1971-2011	39	1976-2010	16	***	+0.011±0.002
Kamloops							
399	Knutsford (Near Separation Lake)	2010-2011	2	none	0	n/a	n/a
Lone Butte							
78	Lone Butte Near Rail Station	1972-2008	26	1973-1997	8	**	-0.033±0.008
Malakwa							
302	Malakwa (Loftus Road)	1988-2011	24	1989-2010	5	n/s	n/a
Merritt							
296	Merritt (Garcia Road, at Library)	1989-2011	23	1994-2010	8	n/s	n/a
Salmon Arm							
185	Salmon River (Salmon River Road, SE Salmon Arm)	1974-2011	38	1991-2010	20	***	+0.025±0.004
381	Canon Creek Deep (Salmon Arm - Grindrod Hwy. 97B)	2007-2011	5	2008-2010	3	n/s	n/a
381	Canon Creek Shallow (Salmon Arm - Grindrod Hwy. 97B)	2008-2011	4	2009-2010	2	n/a	n/a
Scotch Creek							
365	Shuswap Lake Park Deep (Squilax - Anglemont Road)	2006-2011	6	2007-2010	4	*	+0.086±0.014
Stump Lake							
35	Stump Lake (Hwy. 5A and Old Kamloops Road)	1968-2011	44	1974-2010	8	***	+0.031±0.004
Westwold							
45	Westwold (Station Road)	1965-2011	47	1966-2010	33	***	+0.025±0.006
Region 4 – Kootenay							

Beaverdell							
306	Beaverdell (Hwy. 33 and 42 nd Avenue)	1989-2010	21	1990-2009	14	*	+0.014±0.006
Cranbrook							
230	Cranbrook near Highway Yard	1985-2003	18	none	0	n/a	n/a
291	Cranbrook (Gold Creek Road and 42 nd Avenue)	1985-2009	24	1990-2006	6	n/s	n/a
Golden							
308	Golden (River Street)	1991-2004	10	none	0	n/a	n/a
309	Golden (Hwy. 95 and Almberg Road)	1989-2010	22	1990-2008	13	n/s	n/a
Jaffray							
362	Jaffray (Jaffrey-Baynes Lake Road)	2005-2010	6	none	0	n/a	n/a
Ootischenia							
74	Ootischenia (Aaron Road - Castlegar Golf Course)	1966-2010	39	1970-2005	7	n/s	n/a
Revelstoke							
279	Revelstoke (Simpson Street)	1981-2010	22	1982-2009	6	**	+0.051±0.007
Wasa							
363	Wasa (Hwy. 93)	2005-2010	6	2006-2007	2	n/a	n/a
Region 5 – Cariboo							
108 Mile							
374	108 Mile Subdivision	2007-2011	5	2008-2010	3	*	+0.213±0.007
83 Mile							
81	83 Mile (Cariboo Hwy. 97N)	1967-2011	42	1979-2010	13	n/s	n/a
Barkerville							
82	Barkerville (Lower)	1975-2011	36	1987-2007	15	n/s	n/a
83	Barkerville (Upper Road)	1967-1999	30	1969-1997	8	**	-0.040±0.010
Quesnel							
260	Quesnel Red Bluff (Maple Drive and Borregard Road)	1980-2011	32	1987-2010	11	***	-0.070±0.009
347	Quesnel (Red Bluff 638 Fir Street)	2000-2006	7	2001-2005	5	n/s	n/a
364	Quesnel - 2 Mile Flats (Pinecrest Road)	2006-2011	6	2008-2010	3	n/s	n/a
Riske Creek							
376	Junction Sheep Range Park	2006-2011	6	2007-2008	2	n/a	n/a
Williams Lake							
261	Williams Lake (Dog Creek Road)	1980-2011	32	1982-2009	17	***	+0.108±0.019
289	Williams Lake (Pine Valley Subdivisdon)	1984-2011	28	1991-2010	12	*	-0.086±0.031
88	Williams Lake (Scout Island)	1971-2011	40	1979-2010	18	***	+0.356±0.017
Region 6 – Skeena							
Dease Lake							
200	Dease Lake	1973-2007	28	1991-2002	10	n/s	n/a
Smithers							
377	Smithers	2008-2010	3	2009	1	n/a	n/a
89	Smithers (Corner Powell and Lund)	1969-2010	36	1970-1975	4	n/s	n/a
Region 7A – Omineca							
Prince George							
293	Ferguson Lake North Kelly Road	1986-2008	22	1987-2007	5	n/s	n/a
342	Prince George Fish Trap Island	2000-2004	5	none	0	n/a	n/a
378	Prince George at 5 th and Ospika	2007-2010	4	2008-2009	2	n/a	n/a
Vanderhoof							
199	Vanderhoof	1973-2008	25	2006-2007	2	n/a	n/a

Region 7B – Peace

Charlie Lake							
124	Charlie Lake	1972-2010	35	1977	1	n/a	n/a
Tumbler Ridge							
286	Tumbler Ridge	1983-2008	23	1993-2007	11	n/s	n/a
Region 8 – Okanagan							
Armstrong							
117	Armstrong (Otter Lake Cross Road)	1971-2010	40	1974-2009	28	***	+0.021±0.004
118	Armstrong (Back Enderby Road)	1971-2010	40	1974-2009	28	n/s	n/a
119	Armstrong (Pleasant Valley Road)	1971-2010	40	1974-2004	22	***	+0.069±0.007
180	Armstrong (Spallumcheen Way and Crozier Road)	1975-2010	36	1976-2006	29	**	+0.074±0.023
384	Armstrong (Schubert Road Spallumcheen)	2008-2010	3	2009	1	n/a	n/a
Carrs Landing							
53	Carrs Landing (Jersey Road)	1966-2008	42	1974-2002	17	n/s	n/a
54	Carrs Landing (Jersey Road)	1969-2008	40	1975-2001	19	n/s	n/a
Cawston							
264	Mt. Korbau	1980-2000	21	1981-1999	13	n/s	n/a
203	Cawston (Barcello Road)	1977-2010	34	1996-2009	5	**	+0.120±0.014
Enderby							
122	Enderby (Hwy. 97A)	1971-2010	38	1980-2009	19	n/s	n/a
Faulder							
379	Faulder Well	2006-2007	2	none	0	n/a	n/a
Grand Forks							
217	Grand Forks (Richmond Avenue)	1977-2010	34	1980-2010	19	n/s	n/a
Kelowna							
236	Rutland (Timrick Court)	1979-2010	32	1980-2009	18	**	+0.107±0.029
262	Kelowna (McCulloch Road and KLO Road)	1981-2011	31	1983-2009	15	***	+0.114±0.024
115	Mission Creek	1973-2009	37	1978-2009	11	n/s	n/a
305	Okanagan-Mission	1989-1998	10	1990-1997	4	n/s	n/a
Keremeos							
75	Keremeos (6 th Avenue and 5 th Street)	1963-2010	45	1967-2010	24	**	+0.014±0.004
76	Keremeos (9 th Avenue and 3 rd Street)	1965-2010	43	1967-2007	23	**	+0.012±0.003
77	Keremeos (Morrison Road)	1971-2010	30	1972-2007	16	n/s	n/a
Lumby							
294	Lumby (Whitevale Road and Horner Road)	1986-2011	26	1987-2010	15	**	+0.023±0.007
Oliver							
282	Willowbrook/Meyers Flats (Meyers Road)	1983-2011	27	1983-2010	21	**	+0.190±0.056
332	Oliver (87 th Street)	1997-2010	14	1999-2009	7	***	+0.115±0.005
348	Tug Lake - Vaseaux Lk	2000-2006	6	none	0	n/a	n/a
Osoyoos							
100	Osoyoos	1969-2008	35	1970-1992	10	*	+0.032±0.012
101	Osoyoos (160 th Avenue and Hwy. 97)	1969-2010	37	1970-1992	11	n/s	n/a
102	Osoyoos Lake	1969-2008	35	1974-1992	4	n/s	n/a
105	Osoyoos (146 th Avenue and Hwy. 97)	1969-2009	36	1970-1992	10	n/s	n/a
107	Osoyoos (148 th Avenue and 89 th Street)	1969-2009	36	1970-1992	11	n/s	n/a
96	Osoyoos (Wren Place)	1969-2010	40	1970-1992	11	n/s	n/a
97	Osoyoos North of Pond	1969-2008	39	1979-1992	5	*	+0.005±0.001

Oyama							
162	Oyama (Trehitt Road)	1972-2010	39	1973-2009	30	*	+0.013±0.005
172	Oyama (Sawmill Road)	1977-2010	34	1978-2009	32	n/s	n/a
173	Oyama (Sawmill Road)	1972-2008	37	1974-2003	25	**	+0.006±0.002
174	Oyama (Oyama Road)	1972-2009	38	1974-2006	23	**	+0.008±0.002
175	Kalawoods	1972-2007	36	1974-2005	23	**	-0.006±0.001
176	Oyama (Broadwater Road)	1972-2008	36	1973-2005	22	**	+0.017±0.005
177	Kalawoods South of Wood Lake	1991-2003	13	1991-2002	11	n/s	n/a
Penticton							
387	Penticton Creek Watershed	2008-2010	3	none	0	n/a	n/a
404	Twin Lakes (Eastview Road)	2011	1	none	0	n/a	n/a
Princeton							
220	Princeton	1977-2004	25	1978-1998	11	***	+0.047±0.004
Silver Star Mountain							
47	Silver Star Mountain (Sovereign Lake Road)	1965-2010	46	1982-2009	13	n/s	n/a
Summerland							
152	Summerland	1988-1995	8	1992-1994	2	n/a	n/a
153	Summerland	1969-2007	39	1972-2005	9	**	+0.014±0.003
154	Summerland (Hwy. 97 and Thornber Street)	1969-2010	41	1972-2005	9	**	+0.037±0.008
158	Summerland North of North Side Creek	1969-2007	39	1981-2005	8	**	+0.065±0.014
366	Summerland (Bathville Road)	2005-2011	7	2009-2010	2	n/a	n/a
367	Summerland (Bathville Road PR-15274, WW-1)	2006-2010	5	2007-2009	2	n/a	n/a
Vernon							
311	Vernon (Keddleston Road, BX Creek)	1991-2010	16	1992-2000	8	n/s	n/a
322	Vernon (Falcon Road, Silver Star Mtn.)	1993-2003	11	1994-1999	5	**	-0.305±0.038
Winfield							
356	Winfield (Jim Bailey Road)	2004-2010	7	2005-2009	5	*	+0.269±0.077
57	Winfield	1975-2003	29	1976-2001	17	**	+0.107±0.029

Table 2. Summary of the total number of groundwater level monitoring wells in each geographic region of British Columbia, Canada, and the corresponding number/percentage of wells in each region with declining, increasing, or no significant temporal trends in groundwater levels, as well as the number of stations with an insufficiently long hydrogeological record for analysis.

Region	Total	Declining trend	Increasing trend	No trend	Insufficient record
Region 1 – Vancouver Island	85 ^a (66 ^b)	16 (18.8% ^c /24.2% ^d)	3 (3.5%/4.5%)	47 (55.3%/71.2%)	19 (22.4% ^c)
Region 2 – Lower Mainland	30 (26)	7 (23.3%/26.9%)	1 (3.3%/3.8%)	18 (60.0%/69.2%)	4 (13.3%)
Region 3 – Thompson/Nicola	15 (12)	6 (40.0%/50.0%)	1 (6.7%/8.3%)	5 (33.3%/41.7%)	3 (20.0%)
Region 4 – Kootenay	9 (5)	2 (22.2%/40.0%)	0 (0%/0%)	3 (33.3%/60.0%)	4 (44.4%)
Region 5 – Cariboo	11 (10)	3 (27.3%/30.0%)	3 (27.3%/30.0%)	4 (36.4%/40.0%)	1 (9.1%)
Region 6 – Skeena	3 (2)	0 (0%/0%)	0 (0%/0%)	2 (66.7%/100%)	1 (33.3%)
Region 7A – Omineca	4 (1)	0 (0%/0%)	0 (0%/0%)	1 (25.0%/100%)	3 (75.0%)
Region 7B – Peace	2 (1)	0 (0%/0%)	0 (0%/0%)	1 (50.0%/100%)	1 (50.0%)
Region 8 – Okanagan	51 (43)	23 (45.1%/53.5%)	2 (3.9%/4.7%)	18 (35.3%/41.9%)	8 (15.7%)
Total	210 (166)	57 (27.1%/34.3%)	10 (4.8%/6.0%)	99 (47.1%/59.6%)	44 (21.0%)

^a total number of stations. ^b total number of stations with a temporal record longer than 2 years. ^c percentage of total stations. ^d percentage of total stations with a temporal record longer than 2 years.