Water

Long-Term Trends in Groundwater Levels in B.C.

Up to 1 million British Columbians are estimated to consume groundwater, and hundreds of groundwater aquifers provide water for industries, municipalities, farms, and rural homeowners in B.C. British Columbia operates a provincial observation well network of over 200 wells, which was established in 1961 to monitor groundwater availability in areas of high human use.

- Observation wells are not used for domestic or commercial use, but instead provide monitoring information on groundwater levels over time.
- Monitoring groundwater levels allows us to know how much groundwater is available given human use patterns, aquifer characteristics, weather and climate patterns. Aquifers are geological formations of permeable rock, gravel, or sand containing or conducting groundwater.
- This indicator presents an analysis of long-term trends in groundwater levels recorded at 121 observation wells that have been monitored for ten years or more and that were active as of 2009.
- Groundwater level trends are summarized using three long-term trend categories: Stable or Increasing, Moderate Rate of Decline (3 to 10 cm/year), and Large Rate of Decline (more than 10 cm/year).

1
Provincial Summary of Trends in Groundwater Levels

- Of the 121 examined observation wells, 85% have water levels that are stable or increasing (with 9 wells showing increasing trends), 6% of wells show a moderate rate of decline in water levels, and 9% show a large rate of decline in water levels. Note that only wells with enough data for trend analysis are included in the following figures.
Summary of Trends in Groundwater Levels by B.C. Natural Resource Regions

- **Northeast**: 2 wells
- **Skeena**: 2 wells
- **West Coast**: 49 wells
- **Cariboo**: 10 wells
- **South Coast**: 16 wells
- **Thompson / Okanagan**: 34 wells
- **Kootenay / Boundary**: 7 wells
- **Omineca**: 1 well

Legend:
- Stable or Increasing
- Moderate Rate of Decline
- Large Rate of Decline
Trends in Groundwater Levels Observed at Observation Wells

- Stable or Increasing
- Moderate Rate of Decline
- Large Rate of Decline
- Currently Not Enough Data for Trend Analysis

[Map showing distribution of observation wells with various symbols indicating trends.]
Table 1: Summary of results of trend analysis of groundwater levels

Note that only wells with enough data for trend analysis are included.

<table>
<thead>
<tr>
<th>Region</th>
<th>Well</th>
<th>Date Range</th>
<th>Sig</th>
<th>Slope (m/yr)</th>
<th>Category</th>
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<td></td>
</tr>
<tr>
<td>West Coast</td>
<td>304 1988 - 2018</td>
<td>&lt; 0.05</td>
<td>-0.218</td>
<td>Large Rate of Decline</td>
<td></td>
</tr>
<tr>
<td>West Coast</td>
<td>310 1990 - 2019</td>
<td>0.97</td>
<td>-0.003</td>
<td>Stable</td>
<td></td>
</tr>
<tr>
<td>West Coast</td>
<td>312 1991 - 2018</td>
<td>0.66</td>
<td>0.010</td>
<td>Stable</td>
<td></td>
</tr>
<tr>
<td>West Coast</td>
<td>314 1992 - 2019</td>
<td>0.76</td>
<td>-0.058</td>
<td>Stable</td>
<td></td>
</tr>
<tr>
<td>West Coast</td>
<td>316 1994 - 2019</td>
<td>0.67</td>
<td>-0.017</td>
<td>Stable</td>
<td></td>
</tr>
<tr>
<td>West Coast</td>
<td>318 1993 - 2017</td>
<td>0.75</td>
<td>-0.014</td>
<td>Stable</td>
<td></td>
</tr>
<tr>
<td>West Coast</td>
<td>320 1992 - 2019</td>
<td>0.87</td>
<td>-0.012</td>
<td>Stable</td>
<td></td>
</tr>
</tbody>
</table>
### More About Groundwater Levels

Groundwater levels are sensitive to precipitation, aquifer storage capacity, recharge rate—the rate at which surface water trickles down to refill a groundwater aquifer—and human withdrawal. Groundwater level trends presented here indicate long-term changes in water level, but have not been corrected for changes in precipitation patterns or other factors. Thus, any significant trends are not necessarily directly attributable to human use. However, information on long-term trends can be useful for prompting further research and informing decision-making.

### References and Other Useful Links

- Visit the [Monitoring Aquifers: Provincial Observation Well Network homepage](http://monitoringaquifers.ca) for more information on groundwater monitoring observation wells.
- [Groundwater Wells and Aquifers (GWELLS)](http://www.gwel.bcparks.ca)
- [Water Data & Tools for British Columbia](http://waterdata.gov.bc.ca)
- [Previous B.C. State of Environment reports and indicators on groundwater levels in B.C.](http://www.env.gov.bc.ca/soe)

### Data

*By accessing these datasets, you agree to the licence associated with each file, as indicated in parentheses below.


Email correspondence to: envreportbc@gov.bc.ca
Appendix: Detailed Maps & Graphs for Groundwater Observation Wells Included in the Analysis

Three plots were created for each examined groundwater observation well, including a map of the well’s location (upper left).

The graph to the right of the map shows monthly groundwater levels relative to the annual average water level. This illustrates the seasonal nature of water levels recorded in that well—many wells will have higher than average water levels in the spring, and lower than average levels in the late summer and fall. The shaded blue area shows the range of variation within which 90% of water level observations in that month fall.

The bottom plot—called a “hydrograph”—on each page shows the monthly groundwater levels for the history of the well, with light grey dots show missing values which were interpolated (see Methods). The trend category is provided below the title—if the trend is significant, based on a combination of statistical and environmental significance criteria—the calculated change in annual average groundwater levels is provided (meters per year) and visually represented by an orange trend line.
Cariboo Region

Cariboo: Observation Well #80

Monthly Groundwater Level Patterns

- Range of 90% of Water Levels
- Mean Deviation from Yearly Average

Observed Long-term Trend in Groundwater Levels

Category: Stable
Cariboo: Observation Well #81

Monthly Groundwater Level Patterns

- Range of 90% of Water Levels
- Mean Deviation from Yearly Average

Observed Long-term Trend in Groundwater Levels
Category: Stable

Interpolated (Missing) Values
Groundwater Level
Cariboo: Observation Well #82

Monthly Groundwater Level Patterns
- Range of 90% of Water Levels
- Mean Deviation from Yearly Average

Observed Long-term Trend in Groundwater Levels
Category: Stable
Cariboo: Observation Well #88

Monthly Groundwater Level Patterns

- Range of 90% of Water Levels
- Mean Deviation from Yearly Average

Observed Long-term Trend in Groundwater Levels
Category: Large Rate of Decline (−0.28 m/year)
Cariboo: Observation Well #260

Monthly Groundwater Level Patterns
- Range of 90% of Water Levels
- Mean Deviation from Yearly Average

Observed Long-term Trend in Groundwater Levels
Category: Increasing (+0.061 m/year)
Cariboo: Observation Well #261

Monthly Groundwater Level Patterns
- Range of 90% of Water Levels
- Mean Deviation from Yearly Average

Observed Long-term Trend in Groundwater Levels
Category: Stable

Depth Below Ground (metres)

Interpolated (Missing) Values
Groundwater Level

Depth Below Ground (metres)

Cariboo: Observation Well #289

Monthly Groundwater Level Patterns

- Range of 90% of Water Levels
- Mean Deviation from Yearly Average

Observed Long-term Trend in Groundwater Levels

Category: Increasing (+0.072 m/year)
Cariboo: Observation Well #364

Difference from Groundwater Level Yearly Average (metres)

- Range of 90% of Water Levels
- Mean Deviation from Yearly Average

Monthly Groundwater Level Patterns

Observed Long-term Trend in Groundwater Levels

Category: Stable

Depth Below Ground (metres)

- Interpolated (Missing) Values
- Groundwater Level
Cariboo: Observation Well #374

Monthly Groundwater Level Patterns
- Range of 90% of Water Levels
- Mean Deviation from Yearly Average

Observed Long-term Trend in Groundwater Levels
Category: Stable
Cariboo: Observation Well #376

Monthly Groundwater Level Patterns
- Range of 90% of Water Levels
- Mean Deviation from Yearly Average

Observed Long-term Trend in Groundwater Levels
Category: Increasing (+0.089 m/year)
Kootenay / Boundary Region

Kootenay / Boundary: Observation Well #74

Monthly Groundwater Level Patterns

- Range of 90% of Water Levels
- Mean Deviation from Yearly Average

Observed Long-term Trend in Groundwater Levels

Category: Stable
Kootenay / Boundary: Observation Well #291

Monthly Groundwater Level Patterns
- Range of 90% of Water Levels
- Mean Deviation from Yearly Average

Observed Long-term Trend in Groundwater Levels
Category: Stable

Depth Below Ground (metres)
- Interpolated (Missing) Values
- Groundwater Level
Kootenay / Boundary: Observation Well #306

Monthly Groundwater Level Patterns
- Range of 90% of Water Levels
- Mean Deviation from Yearly Average

Observed Long-term Trend in Groundwater Levels
Category: Stable

Depth Below Ground (metres)

Groundwater Level
Kootenay / Boundary: Observation Well #309

Monthly Groundwater Level Patterns
- Range of 90% of Water Levels
- Mean Deviation from Yearly Average

Observed Long-term Trend in Groundwater Levels
Category: Stable
Kootenay / Boundary: Observation Well #362

Monthly Groundwater Level Patterns

- Range of 90% of Water Levels
- Mean Deviation from Yearly Average

Observed Long-term Trend in Groundwater Levels
Category: Stable

Groundwater Level

Interpolated (Missing) Values
Northeast Region

Northeast: Observation Well #124

Monthly Groundwater Level Patterns

- Range of 90% of Water Levels
- Mean Deviation from Yearly Average

Observed Long-term Trend in Groundwater Levels
Category: Increasing (+0.041 m/year)
Northeast: Observation Well #286

Monthly Groundwater Level Patterns
- Range of 90% of Water Levels
- Mean Deviation from Yearly Average

Observed Long-term Trend in Groundwater Levels
Category: Large Rate of Decline (−0.14 m/year)
Omineca Region

Omineca: Observation Well #378

Monthly Groundwater Level Patterns

- Range of 90% of Water Levels
- Mean Deviation from Yearly Average

Observed Long-term Trend in Groundwater Levels

Category: Stable
Skeena Region

Skeena: Observation Well #200

Monthly Groundwater Level Patterns

- Range of 90% of Water Levels
- Mean Deviation from Yearly Average

Observed Long-term Trend in Groundwater Levels

Category: Large Rate of Decline (~0.19 m/year)
Skeena: Observation Well #377

Monthly Groundwater Level Patterns
- Range of 90% of Water Levels
- Mean Deviation from Yearly Average

Observed Long-term Trend in Groundwater Levels
Category: Stable
South Coast Region

South Coast: Observation Well #2

Monthly Groundwater Level Patterns
- Range of 90% of Water Levels
- Mean Deviation from Yearly Average

Observed Long-term Trend in Groundwater Levels
Category: Stable
South Coast: Observation Well #8

Monthly Groundwater Level Patterns
- Range of 90% of Water Levels
- Mean Deviation from Yearly Average

Observed Long-term Trend in Groundwater Levels
Category: Moderate Rate of Decline (−0.032 m/year)
South Coast: Observation Well #15

Monthly Groundwater Level Patterns

- Range of 90% of Water Levels
- Mean Deviation from Yearly Average

Observed Long-term Trend in Groundwater Levels
Category: Stable
South Coast: Observation Well #255

Monthly Groundwater Level Patterns
- Range of 90% of Water Levels
- Mean Deviation from Yearly Average

Observed Long-term Trend in Groundwater Levels
Category: Stable
South Coast: Observation Well #259

Monthly Groundwater Level Patterns

- Range of 90% of Water Levels
- Mean Deviation from Yearly Average

Observed Long-term Trend in Groundwater Levels
Category: Stable
South Coast: Observation Well #272

Monthly Groundwater Level Patterns
- Range of 90% of Water Levels
- Mean Deviation from Yearly Average

Observed Long-term Trend in Groundwater Levels
Category: Stable

Depth Below Ground (metres)

Interpolated (Missing) Values
Groundwater Level
South Coast: Observation Well #275

Monthly Groundwater Level Patterns
- Range of 90% of Water Levels
- Mean Deviation from Yearly Average

Observed Long-term Trend in Groundwater Levels
Category: Stable
South Coast: Observation Well #292

Monthly Groundwater Level Patterns
- Range of 90% of Water Levels
- Mean Deviation from Yearly Average

Observed Long-term Trend in Groundwater Levels
Category: Stable
South Coast: Observation Well #299

Monthly Groundwater Level Patterns
- Range of 90% of Water Levels
- Mean Deviation from Yearly Average

Observed Long-term Trend in Groundwater Levels
Category: Stable

Depth Below Ground (metres)


Interpolated (Missing) Values
Groundwater Level
South Coast: Observation Well #301

Monthly Groundwater Level Patterns
- Range of 90% of Water Levels
- Mean Deviation from Yearly Average

Observed Long-term Trend in Groundwater Levels
Category: Stable
South Coast: Observation Well #352

Monthly Groundwater Level Patterns
- Range of 90% of Water Levels
- Mean Deviation from Yearly Average

Observed Long-term Trend in Groundwater Levels
Category: Stable

Interpolated (Missing) Values
Groundwater Level
South Coast: Observation Well #353

Monthly Groundwater Level Patterns
- Range of 90% of Water Levels
- Mean Deviation from Yearly Average

Observed Long-term Trend in Groundwater Levels
Category: Stable

Groundwater Level

- Interpolated (Missing) Values

Depth Below Ground (metres)
South Coast: Observation Well #354

Monthly Groundwater Level Patterns
- Range of 90% of Water Levels
- Mean Deviation from Yearly Average

Observed Long-term Trend in Groundwater Levels
Category: Stable
South Coast: Observation Well #357

Monthly Groundwater Level Patterns
- Range of 90% of Water Levels
- Mean Deviation from Yearly Average

Observed Long-term Trend in Groundwater Levels
Category: Stable

Interpolated (Missing) Values
Groundwater Level
South Coast: Observation Well #359

Monthly Groundwater Level Patterns

- Range of 90% of Water Levels
- Mean Deviation from Yearly Average

Observed Long-term Trend in Groundwater Levels
Category: Large Rate of Decline (-0.23 m/year)
South Coast: Observation Well #360

Monthly Groundwater Level Patterns

- Range of 90% of Water Levels
- Mean Deviation from Yearly Average

Observed Long-term Trend in Groundwater Levels
Category: Stable

Depth Below Ground (metres)

Interpolated (Missing) Values
Groundwater Level

Thompson / Okanagan Region

Thompson / Okanagan: Observation Well #35

Monthly Groundwater Level Patterns

- Range of 90% of Water Levels
- Mean Deviation from Yearly Average

Observed Long-term Trend in Groundwater Levels

Category: Stable
Thompson / Okanagan: Observation Well #45

Monthly Groundwater Level Patterns

- Range of 90% of Water Levels
- Mean Deviation from Yearly Average

Observed Long-term Trend in Groundwater Levels

Category: Stable

Depth Below Ground (metres)

Interpolated (Missing) Values

Groundwater Level

Thompson / Okanagan: Observation Well #76

Monthly Groundwater Level Patterns

- Range of 90% of Water Levels
- Mean Deviation from Yearly Average

Observed Long-term Trend in Groundwater Levels

Category: Stable
Thompson / Okanagan: Observation Well #96

Monthly Groundwater Level Patterns

- Range of 90% of Water Levels
- Mean Deviation from Yearly Average

Observed Long-term Trend in Groundwater Levels

Category: Stable

Depth Below Ground (metres)

Groundwater Level

Interpolated (Missing) Values
Thompson / Okanagan: Observation Well #105

Monthly Groundwater Level Patterns

- Range of 90% of Water Levels
- Mean Deviation from Yearly Average

Observed Long-term Trend in Groundwater Levels

Category: Stable
Thompson / Okanagan: Observation Well #115

Monthly Groundwater Level Patterns

- Range of 90% of Water Levels
- Mean Deviation from Yearly Average

Observed Long-term Trend in Groundwater Levels
Category: Stable

- Interpolated (Missing) Values
- Groundwater Level
Thompson / Okanagan: Observation Well #117

Monthly Groundwater Level Patterns
- Range of 90% of Water Levels
- Mean Deviation from Yearly Average

Observed Long-term Trend in Groundwater Levels
Category: Stable

- Interpolated (Missing) Values
- Groundwater Level
Thompson / Okanagan: Observation Well #118

Monthly Groundwater Level Patterns
- Range of 90% of Water Levels
- Mean Deviation from Yearly Average

Observed Long-term Trend in Groundwater Levels
Category: Stable

Interpolated (Missing) Values
Groundwater Level
Thompson / Okanagan: Observation Well #122

Monthly Groundwater Level Patterns

- Range of 90% of Water Levels
- Mean Deviation from Yearly Average

Observed Long-term Trend in Groundwater Levels

Category: Stable

Interpolated (Missing) Values

Groundwater Level
Thompson / Okanagan: Observation Well #154

Monthly Groundwater Level Patterns

- Range of 90% of Water Levels
- Mean Deviation from Yearly Average

Observed Long-term Trend in Groundwater Levels

Category: Stable
Thompson / Okanagan: Observation Well #172

Monthly Groundwater Level Patterns

- Range of 90% of Water Levels
- Mean Deviation from Yearly Average

Observed Long-term Trend in Groundwater Levels
Category: Stable
Thompson / Okanagan: Observation Well #180

Monthly Groundwater Level Patterns

- Range of 90% of Water Levels
- Mean Deviation from Yearly Average

Observed Long-term Trend in Groundwater Levels
Category: Moderate Rate of Decline (−0.087 m/year)
Thompson / Okanagan: Observation Well #185

Monthly Groundwater Level Patterns
- Range of 90% of Water Levels
- Mean Deviation from Yearly Average

Observed Long-term Trend in Groundwater Levels
Category: Stable

Depth Below Ground (metres)

- Interpolated (Missing) Values
- Groundwater Level
Thompson / Okanagan: Observation Well #203

Monthly Groundwater Level Patterns

- Range of 90% of Water Levels
- Mean Deviation from Yearly Average

Observed Long-term Trend in Groundwater Levels

Category: Stable
Thompson / Okanagan: Observation Well #236

Monthly Groundwater Level Patterns
- Range of 90% of Water Levels
- Mean Deviation from Yearly Average

Observed Long-term Trend in Groundwater Levels
Category: Stable

Interpolated (Missing) Values
Groundwater Level
Thompson / Okanagan: Observation Well #262

Monthly Groundwater Level Patterns
- Range of 90% of Water Levels
- Mean Deviation from Yearly Average

Observed Long-term Trend in Groundwater Levels
Category: Large Rate of Decline (−0.13 m/year)
Thompson / Okanagan: Observation Well #282

Monthly Groundwater Level Patterns

- Range of 90% of Water Levels
- Mean Deviation from Yearly Average

Observed Long-term Trend in Groundwater Levels
Category: Stable
Observed Long-term Trend in Groundwater Levels
Category: Stable

Monthly Groundwater Level Patterns
- Range of 90% of Water Levels
- Mean Deviation from Yearly Average

Depth Below Ground (metres)
- Interpolated (Missing) Values
- Groundwater Level
Thompson / Okanagan: Observation Well #296

Monthly Groundwater Level Patterns
- Range of 90% of Water Levels
- Mean Deviation from Yearly Average

Observed Long-term Trend in Groundwater Levels
Category: Stable
Thompson / Okanagan: Observation Well #302

Monthly Groundwater Level Patterns
- Range of 90% of Water Levels
- Mean Deviation from Yearly Average

Observed Long-term Trend in Groundwater Levels
Category: Stable
Thompson / Okanagan: Observation Well #332

Monthly Groundwater Level Patterns

- Range of 90% of Water Levels
- Mean Deviation from Yearly Average

Observed Long-term Trend in Groundwater Levels
Category: Stable
Thompson / Okanagan: Observation Well #344

Monthly Groundwater Level Patterns
- Range of 90% of Water Levels
- Mean Deviation from Yearly Average

Observed Long-term Trend in Groundwater Levels
Category: Stable

Groundwater Level
Interpolated (Missing) Values
Thompson / Okanagan: Observation Well #346

Monthly Groundwater Level Patterns

- Range of 90% of Water Levels
- Mean Deviation from Yearly Average

Observed Long-term Trend in Groundwater Levels

Category: Stable
Thompson / Okanagan: Observation Well #356

Monthly Groundwater Level Patterns
- Range of 90% of Water Levels
- Mean Deviation from Yearly Average

Observed Long-term Trend in Groundwater Levels
Category: Increasing (+0.10 m/year)
Thompson / Okanagan: Observation Well #365

Monthly Groundwater Level Patterns
- Range of 90% of Water Levels
- Mean Deviation from Yearly Average

Observed Long-term Trend in Groundwater Levels
Category: Stable
Thompson / Okanagan: Observation Well #366

Monthly Groundwater Level Patterns

- Range of 90% of Water Levels
- Mean Deviation from Yearly Average

Observed Long-term Trend in Groundwater Levels

Category: Increasing (+0.37 m/year)
Thompson / Okanagan: Observation Well #375

Monthly Groundwater Level Patterns
- Range of 90% of Water Levels
- Mean Deviation from Yearly Average

Observed Long-term Trend in Groundwater Levels
Category: Stable

Depth Below Ground (metres)

Groundwater Level
Thompson / Okanagan: Observation Well #381

Monthly Groundwater Level Patterns
- Range of 90% of Water Levels
- Mean Deviation from Yearly Average

Difference from Groundwater Level Yearly Average (metres)

Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec

Observed Long-term Trend in Groundwater Levels
Category: Increasing (+0.12 m/year)

Groundwater Level
Long-term Trend
Thompson / Okanagan: Observation Well #384

Monthly Groundwater Level Patterns
- Range of 90% of Water Levels
- Mean Deviation from Yearly Average

Observed Long-term Trend in Groundwater Levels
Category: Large Rate of Decline (−0.10 m/year)
Thompson / Okanagan: Observation Well #464

Monthly Groundwater Level Patterns

- Range of 90% of Water Levels
- Mean Deviation from Yearly Average

Observed Long-term Trend in Groundwater Levels

Category: Increasing (+0.19 m/year)
West Coast Region

West Coast: Observation Well #58

Monthly Groundwater Level Patterns
- Range of 90% of Water Levels
- Mean Deviation from Yearly Average

Observed Long-term Trend in Groundwater Levels
Category: Stable

Depth Below Ground (metres)
West Coast: Observation Well #60

Monthly Groundwater Level Patterns

- Range of 90% of Water Levels
- Mean Deviation from Yearly Average

Observed Long-term Trend in Groundwater Levels
Category: Stable
West Coast: Observation Well #65

Monthly Groundwater Level Patterns
- Range of 90% of Water Levels
- Mean Deviation from Yearly Average

Observed Long-term Trend in Groundwater Levels
Category: Stable
West Coast: Observation Well #71

Monthly Groundwater Level Patterns
- Range of 90% of Water Levels
- Mean Deviation from Yearly Average

Observed Long-term Trend in Groundwater Levels
Category: Stable

Interpolated (Missing) Values
Groundwater Level

Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec

Depth Below Ground (metres)

West Coast: Observation Well #125

Monthly Groundwater Level Patterns
- Range of 90% of Water Levels
- Mean Deviation from Yearly Average

Observed Long-term Trend in Groundwater Levels
Category: Stable
West Coast: Observation Well #128

Monthly Groundwater Level Patterns
- Range of 90% of Water Levels
- Mean Deviation from Yearly Average

Observed Long-term Trend in Groundwater Levels
Category: Stable
West Coast: Observation Well #196

Monthly Groundwater Level Patterns

- Range of 90% of Water Levels
- Mean Deviation from Yearly Average

Observed Long-term Trend in Groundwater Levels

Category: Stable

Depth Below Ground (metres)

- Interpolated (Missing) Values
- Groundwater Level
West Coast: Observation Well #197

Monthly Groundwater Level Patterns
- Range of 90% of Water Levels
- Mean Deviation from Yearly Average

Observed Long-term Trend in Groundwater Levels
Category: Stable
West Coast: Observation Well #204

Monthly Groundwater Level Patterns

- Range of 90% of Water Levels
- Mean Deviation from Yearly Average

Observed Long-term Trend in Groundwater Levels

Category: Stable

- Interpolated (Missing) Values
- Groundwater Level
West Coast: Observation Well #211

Monthly Groundwater Level Patterns

- Range of 90% of Water Levels
- Mean Deviation from Yearly Average

Observed Long-term Trend in Groundwater Levels
Category: Moderate Rate of Decline (~0.035 m/year)
West Coast: Observation Well #212

Monthly Groundwater Level Patterns
- Range of 90% of Water Levels
- Mean Deviation from Yearly Average

Observed Long-term Trend in Groundwater Levels
Category: Stable

Interpolated (Missing) Values
Groundwater Level
West Coast: Observation Well #228

Monthly Groundwater Level Patterns
- Range of 90% of Water Levels
- Mean Deviation from Yearly Average

Observed Long-term Trend in Groundwater Levels
Category: Stable

Groundwater Level

Depth Below Ground (metres)


Interpolated (Missing) Values

Environmental Reporting BC
West Coast: Observation Well #232

Monthly Groundwater Level Patterns
- Range of 90% of Water Levels
- Mean Deviation from Yearly Average

Observed Long-term Trend in Groundwater Levels
Category: Large Rate of Decline (−0.11 m/year)
West Coast: Observation Well #233

Monthly Groundwater Level Patterns

- Range of 90% of Water Levels
- Mean Deviation from Yearly Average

Observed Long-term Trend in Groundwater Levels
Category: Stable
West Coast: Observation Well #240

Monthly Groundwater Level Patterns

- Range of 90% of Water Levels
- Mean Deviation from Yearly Average

Observed Long-term Trend in Groundwater Levels

Category: Stable

- Interpolated (Missing) Values
- Groundwater Level
West Coast: Observation Well #258

Monthly Groundwater Level Patterns

- Range of 90% of Water Levels
- Mean Deviation from Yearly Average

Observed Long-term Trend in Groundwater Levels

Category: Moderate Rate of Decline (−0.051 m/year)
West Coast: Observation Well #268

Monthly Groundwater Level Patterns
- Range of 90% of Water Levels
- Mean Deviation from Yearly Average

Observed Long-term Trend in Groundwater Levels
Category: Stable

Depth Below Ground (metres)
- Interpolated (Missing) Values
- Groundwater Level

Yearly Average (metres)

Difference from Groundwater Level Yearly Average (metres)

Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec

West Coast: Observation Well #281

Monthly Groundwater Level Patterns

- Range of 90% of Water Levels
- Mean Deviation from Yearly Average

Observed Long-term Trend in Groundwater Levels

Category: Stable
West Coast: Observation Well #283

Monthly Groundwater Level Patterns

- Range of 90% of Water Levels
- Mean Deviation from Yearly Average

Observed Long–term Trend in Groundwater Levels

Category: Stable
West Coast: Observation Well #284

Monthly Groundwater Level Patterns

- Range of 90% of Water Levels
- Mean Deviation from Yearly Average

Observed Long-term Trend in Groundwater Levels

Category: Moderate Rate of Decline (−0.069 m/year)
West Coast: Observation Well #287

Monthly Groundwater Level Patterns

- Range of 90% of Water Levels
- Mean Deviation from Yearly Average

Observed Long-term Trend in Groundwater Levels

Category: Moderate Rate of Decline (−0.081 m/year)
West Coast: Observation Well #288

Monthly Groundwater Level Patterns
- Range of 90% of Water Levels
- Mean Deviation from Yearly Average

Observed Long-term Trend in Groundwater Levels
Category: Stable

Deep Water Levels (metres)

- Interpolated (Missing) Values
- Groundwater Level

Depth Below Ground (metres)

West Coast: Observation Well #290

Monthly Groundwater Level Patterns
- Range of 90% of Water Levels
- Mean Deviation from Yearly Average

Observed Long-term Trend in Groundwater Levels
Category: Stable

Depth Below Ground (metres)

- Interpolated (Missing) Values
- Groundwater Level

Monthly Groundwater Level Patterns

- Range of 90% of Water Levels
- Mean Deviation from Yearly Average

Observed Long-term Trend in Groundwater Levels
Category: Increasing (+0.15 m/year)
West Coast: Observation Well #303

Monthly Groundwater Level Patterns

- Range of 90% of Water Levels
- Mean Deviation from Yearly Average

Observed Long-term Trend in Groundwater Levels
Category: Stable

- Interpolated (Missing) Values
  - Groundwater Level
West Coast: Observation Well #304

Monthly Groundwater Level Patterns
- Range of 90% of Water Levels
- Mean Deviation from Yearly Average

Observed Long-term Trend in Groundwater Levels
Category: Large Rate of Decline (−0.22 m/year)
West Coast: Observation Well #310

Monthly Groundwater Level Patterns

- Range of 90% of Water Levels
- Mean Deviation from Yearly Average

Difference from Groundwater Level Yearly Average (metres)

Observed Long-term Trend in Groundwater Levels

Category: Stable

Depth Below Ground (metres)

- Interpolated (Missing) Values
- Groundwater Level

109
West Coast: Observation Well #312

Monthly Groundwater Level Patterns

- Range of 90% of Water Levels
- Mean Deviation from Yearly Average

Observed Long-term Trend in Groundwater Levels
Category: Stable
West Coast: Observation Well #314

Monthly Groundwater Level Patterns

- Range of 90% of Water Levels
- Mean Deviation from Yearly Average

Observed Long-term Trend in Groundwater Levels

Category: Stable

- Interpolated (Missing) Values
- Groundwater Level
West Coast: Observation Well #318

Monthly Groundwater Level Patterns
- Range of 90% of Water Levels
- Mean Deviation from Yearly Average

Observed Long-term Trend in Groundwater Levels
Category: Stable

Interpolated (Missing) Values
Groundwater Level
West Coast: Observation Well #320

Monthly Groundwater Level Patterns
- Range of 90% of Water Levels
- Mean Deviation from Yearly Average

Observed Long-term Trend in Groundwater Levels
Category: Stable

Depth Below Ground (metres)

- Interpolated (Missing) Values
- Groundwater Level
West Coast: Observation Well #321

Monthly Groundwater Level Patterns

- Range of 90% of Water Levels
- Mean Deviation from Yearly Average

Observed Long-term Trend in Groundwater Levels

Category: Large Rate of Decline (−0.18 m/year)
West Coast: Observation Well #329

Monthly Groundwater Level Patterns
- Range of 90% of Water Levels
- Mean Deviation from Yearly Average

Observed Long-term Trend in Groundwater Levels
Category: Stable
West Coast: Observation Well #337

Monthly Groundwater Level Patterns
- Range of 90% of Water Levels
- Mean Deviation from Yearly Average

Observed Long-term Trend in Groundwater Levels
Category: Stable
West Coast: Observation Well #338

Monthly Groundwater Level Patterns
- Range of 90% of Water Levels
- Mean Deviation from Yearly Average

Observed Long-term Trend in Groundwater Levels
Category: Stable
West Coast: Observation Well #340

Monthly Groundwater Level Patterns
- Range of 90% of Water Levels
- Mean Deviation from Yearly Average

Observed Long-term Trend in Groundwater Levels
Category: Stable
West Coast: Observation Well #343

Monthly Groundwater Level Patterns

- Range of 90% of Water Levels
- Mean Deviation from Yearly Average

Observed Long-term Trend in Groundwater Levels

Category: Stable
West Coast: Observation Well #345

Monthly Groundwater Level Patterns
- Range of 90% of Water Levels
- Mean Deviation from Yearly Average

Observed Long-term Trend in Groundwater Levels
Category: Large Rate of Decline (-0.14 m/year)
West Coast: Observation Well #351

Monthly Groundwater Level Patterns
- Range of 90% of Water Levels
- Mean Deviation from Yearly Average

Observed Long-term Trend in Groundwater Levels
Category: Stable
**West Coast: Observation Well #355**

**Monthly Groundwater Level Patterns**
- Range of 90% of Water Levels
- Mean Deviation from Yearly Average

**Observed Long-term Trend in Groundwater Levels**
- Category: Moderate Rate of Decline (−0.033 m/year)
West Coast: Observation Well #369

Monthly Groundwater Level Patterns
- Range of 90% of Water Levels
- Mean Deviation from Yearly Average

Observed Long-term Trend in Groundwater Levels
Category: Stable
West Coast: Observation Well #371

Monthly Groundwater Level Patterns
- Range of 90% of Water Levels
- Mean Deviation from Yearly Average

Observed Long-term Trend in Groundwater Levels
Category: Stable

Depth Below Ground (metres)
- Interpolated (Missing) Values
- Groundwater Level
**West Coast: Observation Well #372**

**Monthly Groundwater Level Patterns**

- Range of 90% of Water Levels
- Mean Deviation from Yearly Average

**Observed Long-term Trend in Groundwater Levels**

Category: Stable
West Coast: Observation Well #383

Monthly Groundwater Level Patterns
- Range of 90% of Water Levels
- Mean Deviation from Yearly Average

Observed Long–term Trend in Groundwater Levels
Category: Large Rate of Decline (−0.12 m/year)
Methods

**R** package and code: We have developed an R package to facilitate working with, analyzing, and visualizing British Columbia groundwater level data. Download the ‘bcgroundwater’ package from GitHub. The source code for repeating the analysis presented on this page is also available on GitHub.

Data

The data sets are all sourced from the B.C. Data Catalogue, distributed under the [Open Government Licence - British Columbia](https://catalogue.data.gov.bc.ca/).

- Provincial Groundwater Observation Well Network - Groundwater Levels Data: [https://catalogue.data.gov.bc.ca/dataset/57c55f10-cf8e-40bb-aae0-2eff311f1685](https://catalogue.data.gov.bc.ca/dataset/57c55f10-cf8e-40bb-aae0-2eff311f1685)
- Groundwater well metadata, such as location, depth, and aquifer type were obtained from the Ground Water Wells (Spatial View) Dataset: [https://catalogue.data.gov.bc.ca/dataset/e4731a85-ffca-4112-8caf-cb0a96905778](https://catalogue.data.gov.bc.ca/dataset/e4731a85-ffca-4112-8caf-cb0a96905778)
- Natural Resource (NR) Regions, accessed with the ‘bcmaps’ R package: [https://catalogue.data.gov.bc.ca/dataset/dfc492c0-69c5-4c20-a6de-2c9bc999301f](https://catalogue.data.gov.bc.ca/dataset/dfc492c0-69c5-4c20-a6de-2c9bc999301f)

Trend Analysis

Trend analysis was conducted using monthly groundwater levels from each groundwater observation well that had ten or more years of data, fewer than 25% of monthly observations missing, and was active as of January 1, 2008. This resulted in 121 wells with suitable data records for analysis.

For each month that had more than one observation, the median was taken. After the time series were constructed, each was inspected for consecutive missing values near the beginning or the end of the time series, due to the strong influence of these regions on trend analysis. If there were more than four consecutive missing values in the first or last 10% of the time series, the time series was truncated to remove the missing values. Remaining missing values were interpolated by first fitting a 12-period (i.e., monthly) basic structural time series model (BSM) to the data (Harvey 1990). Fixed-interval smoothing (Durbin and Koopman 2001) was then applied to the fitted model to generate predicted values for the entire time series; the predicted values were substituted into the original time series where there were missing data. This resulted in a full monthly time series for each well, with one observation per month. Finally, the mean annual groundwater level was calculated for each well, and trend analysis was performed using the annual values.

Each groundwater-level time series was analyzed for trend using Trend-Free Pre-Whitening to remove lag-1 autocorrelation, which can artificially increase the probability of detecting a significant trend (Yue et al. 2002). In this method, the slope of each time series is estimated using the Theil-Sen approach (Sen 1968). If the estimated slope is different from zero, then the data are detrended by the slope and the AR(1) is calculated for the detrended time series. The residuals and the trend are combined and then tested for significance using the Mann-Kendall trend test. These methods were implemented using the R package ‘zyp’ (Bronaugh and Werner 2013).

Observed Long-term Trend Categories

The observed long-term trends were categorized using a combination of statistical and environmental significance criteria. Based on both the significance and magnitude of the calculated trend, trends in water levels in wells were classified as exhibiting the following categories:

- **Stable or Increasing:** the trend was not significantly different from zero or the trend was significantly different from zero with an increasing trend or the trend was significantly different from zero with a declining trend of less than 3 cm per year.
- **Moderate Rate of Decline:** the trend was significantly different from zero with a declining trend of between 3 and 10 cm per year.
- **Large Rate of Decline:** the slope was significantly different from zero with a declining trend of more than 10 cm per year.
Time series were not corrected for precipitation or any other climatic or hydrologic processes. As such, no causation for trends are implied.

References


