APPENDIX I

Bootjack Lake Hydrodynamic Modelling

TECHNICAL MEMORANDUM

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TO Colleen Hughes and Luke Moger
Mount Polley Mining Corporation

FROM Shadi Dayyani and Jerry Vandenberg **EMAIL** Shadi_Dayyani@golder.com; Jerry_Vandenberg@golder.com

MOUNT POLLEY MINE – BOOTJACK LAKE HYDRODYNAMIC MODELLING – ASSESSMENT OF EFFECTS OF SEEPAGE FROM THE SPRINGER PIT ON BOOTJACK LAKE

1.0 INTRODUCTION

The Mount Polley Mine (the Mine) is a copper-gold mine owned and operated by Mount Polley Mining Corporation (MPMC), and is located 56 km northeast of Williams Lake, British Columbia. Since 4 August 2014, all mine contact water has been conveyed to and stored in the Springer Pit. A short-term water management plan that included a discharge of treated effluent, was approved on 29 November 2015, and discharge commenced on 1 December 2015. A Technical Assessment Report (TAR) has been developed for the Long-term Water Management Plan, and the modelling described herein was completed in support of that TAR.

Hydrogeological modelling (Appendix B of TAR) indicated there will be seepage from the Springer Pit to Bootjack Lake, which is located immediately west of the mine, as the pit lake elevation rises above 1,030 metres above sea level [masl]. To evaluate the influence of Springer Pit seepage within Bootjack Lake, a hydrodynamic model was developed that simulates the three-dimensional transport of seepage once it reaches the lake.

This memorandum summarizes the development and results of the Bootjack Lake hydrodynamic model. The objective of the hydrodynamic modelling was to evaluate the influence of seepage from the Springer Pit on Bootjack Lake water quality at the edge of an initial dilution zone (IDZ) in the event that the Springer Pit is used as a contingency to store Mine contact water for an extended period. A secondary objective was to evaluate the influence of a potential mine closure treated effluent on the lake. Using the dilution rates presented in this memo, a full suite of water quality constituent concentrations in Bootjack Lake at the IDZ was predicted based on modelled Springer Pit seepage water quality (Appendix D of the TAR).

Model predictions were also generated for six model sensitivity scenarios to assess changes in dilution rates at the IDZ as a result of:

- changes in the Springer Pit seepage rate
- shoreline length that seepage enters the lake
- inclusion of treated mine effluent discharge at closure

The model development, calibration, simulations, and predictions are described in the following sections.

2.0 METHODS

2.1 Model Description

The Bootjack Lake model was developed in the Generalized Environmental Modeling System for Surface waters (GEMSS). GEMSS is an integrated system of three-dimensional (3-D) hydrodynamic and transport modules embedded in a geographic information and environmental data system. GEMSS is in the public domain and has been used for similar studies throughout North America and worldwide. GEMSS was developed in the mid-1980s as a hydrodynamic platform for transport and fate modelling. The hydrodynamic platform ("kernel") provides 3-D flow fields from which the distribution of various constituents can be computed. The constituent transport and fate computations are grouped into modules. The modules used for Bootjack Lake simulations were the hydrodynamic and transport module and the user-defined constituent module.

The theoretical basis of the hydrodynamic kernel of the GEMSS is the 3-D generalized, longitudinal-lateral-vertical hydrodynamic and transport model (Edinger and Buchak 1980, 1985). This computation has been peer reviewed and published (Edinger and Buchak 1995; Edinger and Kolluru 1999; Edinger et al. 1994, 1997). The kernel is an extension of the longitudinal-vertical transport model written by Buchak and Edinger (1984) that forms the hydrodynamic and transport basis of the water quality model CE-QUAL-W2 (US Army Engineer Waterways Experiment Station 1986). Improvements to the transport scheme, construction of the constituent modules, incorporation of supporting software tools, geographic information system (GIS) interoperability, visualization tools, graphical user interface, and post-processors have been developed by Kolluru et al. (1998, 1999, 2003) and Kolluru and Fichera (2003).

GEMSS was selected to assess conditions in the mixing zone because the 3-D grid allows for simulation of finer-scale processes within an irregularly shaped lake such as Bootjack Lake. The dilution rates predicted by this model were then used to predict a full suite of constituent concentrations by the mass balance model, which is more computationally efficient in terms of model run and output processing times.

2.2 Model Segmentation

A 3-D grid was developed that covers Bootjack Lake. The grid is illustrated in plan view in Figure 1. A grid spacing of 100 metres [m] horizontally was selected with a vertical resolution of approximately 1 m. The grid included a total of 16 active vertical layers and 293 active cells.

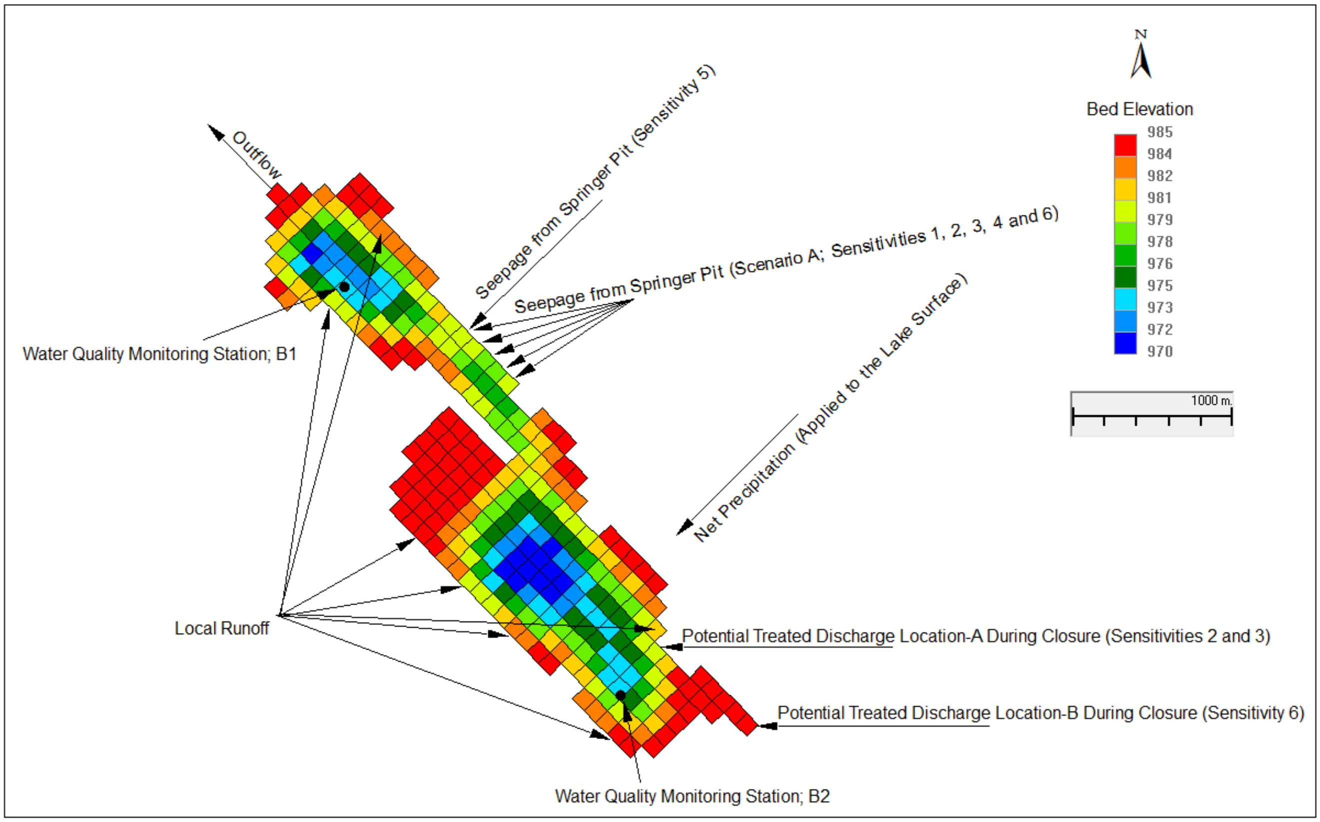

Figure 1: Bootjack Lake Model Grid (Plan View), Inflows, Outflows, and Calibration Stations

2.3 Model Inputs

All known source lake inflows and outflows were included in the model, as shown in Figure 1. Inputs to the model include meteorological, hydrologic, and water quality data, as described in the following sections.

2.3.1 Meteorological Inputs

Meteorological inputs are key drivers of lake circulation and thermal dynamics, which could affect the behaviour of non-point and point sources to the lake. The following meteorological input data were required for this hydrodynamic model: air temperature, dew point temperature, wet bulb temperature, atmospheric pressure, wind direction, wind speed, and solar radiation.

An hourly time-series was constructed for each of these inputs during the calibration time period (i.e., 2012 to 2016) based on observed data from on-site meteorological stations (Weather Stations 1-near the mill and 2-TSF; Litke 2016a, pers. comm.), with the exception of atmospheric pressure. Both weather stations have measured data from 2012 to 2016 for rainfall, temperature, relative humidity, solar radiation, wind speed, and direction. The elevations at Weather Stations 1 and 2 are 1,171 and 964 metres above sea level (masl), respectively (Golder 2015: Section 3, Table 1). Data from Weather Station 2 were used for the hydrodynamic model since the elevation of this station was closer to the elevation of the lake (986 masl). Where gaps existed in the data from Weather Station 2, data from Weather Station 1 were used. Where both stations were missing data, the data gaps were either filled by interpolation (small gaps) or by the annual average value for the specific hour (larger gaps).

An hourly time series of atmospheric pressure was constructed from the Pacific Climate Impacts Consortium Lee's Hill meteorological station (PCIC 2016). Hourly time series of wet bulb temperatures were calculated based on recorded air temperature, relative humidity, and atmospheric pressure. For model predictions, the time series used to calibrate the model was repeated.

2.3.2 Hydrologic Inputs

For the calibration time period (2012 to 2016), the hydrologic inputs to Bootjack Lake were local runoff from the watershed and direct precipitation on the lake. The outflows in the model were discharge at the lake outlet and evaporation.

Based on a catchment delineation completed for Bootjack Lake, it was determined that approximately 14% and 86% of the natural runoff reports to the east and west sides, respectively, of the lake (Appendix B of TAR). These runoff proportions were distributed evenly along the west (five locations) and east (two locations) sides of the lake since the runoff will come from several tributaries (Figure 1).

For the modelling predictions, the hydrologic inputs to Bootjack Lake were the same as those described for the calibration time period, with the addition of Springer Pit seepage. As part of the sensitivity scenarios, a potential mine closure treated effluent discharge to the lake was included. The IDZ was set as the five grid cells along the east shore where seepage is anticipated to reach the lake, and a sensitivity analysis was completed using a single grid cell as the IDZ (see Section 2.8). These flows are shown schematically in Figure 1.

Springer Pit seepage estimates to Bootjack Lake were predicted using a hydrogeological model (Appendix B of TAR) for the future simulations. Hydrogeological modelling indicates that seepage from the Cariboo-Springer Pit to Bootjack Lake will increase to a maximum of 420 m^3/d, under average conditions (base case, Appendix B of TAR) when the pit lake elevation is 1,050 masl.

A treated effluent discharge rate was assumed as an initial estimate of water that might eventually be discharge to Bootjack Lake. The rate is subject to optimization based on the results of a pilot passive water treatment system (Appendix F of the TAR). A discharge rate of treated effluent during Closure was assumed to be 0.008 m^3/s, which is 10% of the Bootjack Lake long-term average outflow (Appendix B of the TAR).

A constructed time-series, with temporal resolution that varied according to the availability of information for each source, formed the basis of the water balance for the hydrodynamic model. Monthly information was available for most of the hydrologic inputs, which were aligned with the Site Wide Water Balance Model (SWWBM; Appendix B of the TAR).

As ice forms on the lake, constituent mass remains in the lake, resulting in increases in lake constituent concentrations during the ice-covered season. The following assumptions, related to ice formation, were included in the model (Litke 2016b, pers. comm.):

- ice formation occurred over a 60-day period from 1 December to 30 January each year
- ice melting occurred over a 60-day period from 1 March to 30 April each year
- an ice thickness of 0.5 m was used each year

2.3.3 Water Quality Inputs

Water quality inputs required for the Bootjack Lake model are temperature and total dissolved solids (TDS) concentrations of the inflows (e.g., natural runoff and seepage from Springer Pit) and in the lake for calibration. Only one water quality monitoring sample was available for the tributaries (local runoff); thus, the tributaries' TDS concentrations were represented by median TDS concentration calculated using Bootjack Lake monitoring results at locations B1 and B2 (Figure 1) collected between 2013 and 2015 for the open-water season (Hughes 2016, pers. comm.).

A local runoff temperature time series was generated using the monthly average of monitored data from monitoring locations B1 and B2. A temperature of 0.5°C was assumed for the months of December, January, and February where the data were missing.

For the model scenarios, a TDS concentration of 1,150 mg/L was applied to seepage from the Springer Pit (Section 5 of the TAR). The temperature of seepage from the Springer Pit was assumed to be 4°C.

2.4 Modelled Constituents

The following constituents were included in the model: TDS, temperature, and a conservative, generic water quality constituent (i.e., a tracer) for evaluating seepage and sensitivity scenarios.

2.5 Quality Assurance

Quality assurance procedures were implemented to check the following items against the objectives of the model:

- **Model framework**— Other modelling software packages were considered, and the GEMSS (a 3-D model) was selected based on its ability to match grid cell size to the IDZ.
- **Model linkages**— Model linkages considered for this study include the flows from the SWWBM, predicted Springer Pit seepage and discharge concentrations from the site water quality model, and seepage rates from the pit from the hydrogeological model.
- **Data used for model inputs**—Time series of raw data were graphed against generated model inputs so that the raw data were represented accurately in the model. The lake volume calculated based on the model grid and bathymetry were plotted to confirm the lake geometry was accurately represented. The meteorological data were plotted and reviewed visually to confirm there were no outliers or anomalies in the dataset.
- **Model set-up**— A grid was set up for the lake's physical domain using the bathymetry file. The model input files were loaded into the model to define boundary conditions, and model parameters were set up.
- **Calibration steps**— Several runs of the model were performed during calibration. Modification of model default parameters did not improve calibration significantly, except for applying a sediment heat exchange function.
- **Model scenarios and sensitivity analysis**— Modelling objectives were reviewed to define model and sensitivity scenarios.

Peer reviews of the model were performed at various stages throughout its development, which was an iterative process whereby issues were identified and addressed.

2.6 Model Calibration

The Bootjack Lake model was calibrated for temperature and TDS to observed data from September 2012 to April 2016 at monitoring locations B1 and B2. Time series and vertical profile figures were created to compare model results to measured data at both locations. The lake's initial conditions were obtained from monitored water quality data at locations B1 and B2.

The first step in the calibration process was to achieve a water balance within the model based on inflows and outflows from the SWWBM (Appendix B of the TAR). Predicted surface water elevations in the lake indicated that the lake volume is balanced over the calibration period.

The hydrodynamic component of the model was calibrated to match measured and modelled thermal and transport behaviour in Bootjack Lake. As the goal of calibration is to apply the formulae and constants that most closely approximate the behaviour of the system under study, adjustment of parameters is standard practice during calibration (Cole and Wells 2008). Default model parameters were used for the thermal variables, with the following exception: to improve thermal profiles, sediment heat exchange was added to the model. The sediment temperature was set at a constant value of 5°C. Additionally, a sediment-water heat exchange coefficient of 6×10^{-7} m/s was added to the model.

Time series plots of surface water temperature at locations B1 and B2 are provided in Attachment A, Figure 1 and show that the model matched the surface water temperatures well. During the open-water season, the modelled thermal profiles fit the measured profiles well on most days (Attachment A, Figures 2 and 3).

At both locations, B1 and B2, modelled temperature profiles were colder than measured data in April (Attachment A, Figures 2 and 3), which may be the result of the assumed duration of the ice-covered season. As discussed in Section 2.3.2, it is assumed in the model that the ice melting period extends until the end of April. The model may underestimate the water temperature in April of 2015 and 2016 since these years were warmer than average and ice may have melted sooner than the end of April based on the measured data. The modelled temperature profiles were also colder than measured data in September and October 2015.

The transport calibration considered the horizontal and vertical distribution of TDS in the lake. For the horizontal transport calibration, the model matched measured TDS concentrations reasonably well at both locations B1 and B2 (Attachment A, Figure 4). Cyclical annual patterns evident in the time series figures are due to salt rejection during ice formation and dilution during ice thawing.

For the vertical transport calibration, default model parameter values were used for hydrodynamic parameters. For the vertical component of the transport calibration, measured specific conductivity profile data were compared to predicted TDS profiles since measured TDS depth profiles were not available (Attachment A, Figures 5 and 6). The calibration was considered adequate if the observed specific conductivity profiles and the predicted TDS profiles followed the same vertical pattern, while recognizing that the absolute values would not be expected to match. Modelled TDS profiles at B1 and B2 locations in the lake matched the observed conductivity profiles reasonably well (Attachment A, Figures 5 and 6). Both the modelled and measured profiles showed minimal vertical TDS gradient on any day.

Overall, the transport calibration indicates that the model is tracking the movement of water and dissolved constituents throughout the vertical and lateral extents of the lake well enough to meet the objective listed in Section 1.

2.7 Model Scenarios

A key objective of the hydrodynamic model was to evaluate the dilution of Springer Pit seepage in the Bootjack Lake IDZ for a contingency scenario, in which all Mine contact water would be conveyed to Springer Pit. This is referred to as a “No Discharge” scenario, and details of this scenario are provided in Section 5.2.1 of the TAR.

The Bootjack Lake hydrodynamic model for this scenario was set up using the calibrated model, assuming seepage from the Springer Pit reaches Bootjack Lake on 31 March 2017, and is evenly distributed over five grid cells in the northeast region of the lake (Figure 1). The seepage was distributed vertically to all grid layers in the cells the seepage reported to, which represents a non-point source along the lake bed and bank. The base case seepage rates were used for this scenario (Appendix B of the TAR).

The model simulation period for this scenario was from 2012 to 2040, which consists of three periods:

- **Period 1 (1 September 2012 to 31 March 2017)**—no seepage; represents the period before seepage from Springer Pit reaches the lake.
- **Period 2 (1 April 2017 to 18 April 2018)**—represents the period of Springer Pit filling (i.e., lake elevation is less than 1,050 masl).
- **Period 3 (19 April 2018 to 31 December 2040)**—represents the period after the water level in the Springer Pit reaches and remains at 1,050 masl.

Seepage rates were calculated for simulation Periods 2 and 3. For Period 2, a time series of seepage rates were generated using the time series of water elevations in the pit (extracted from the SWWBM, Appendix B of the TAR) and seepage rates estimated in the hydrogeological model (Appendix B of the TAR). These rates assume instantaneous groundwater transport from the Springer Pit to the lake starting on 31 March 2017.

For simulation Period 3, the maximum base case seepage rate (corresponding to water level of elevation 1,050 masl in the pit) was applied constantly through the whole period (Appendix B of the TAR).

A tracer was applied to the seepage inflow from Springer Pit to the lake at a constant concentration of 100 mg/L.

2.8 Model Sensitivity Scenarios

The following model sensitivities were performed:

Sensitivity 1— Same as the No Discharge scenario with the following change: upper bound seepage rates from the Springer Pit (Appendix B of the TAR) were applied from 31 March 2017, to 31 December 2040.

Sensitivity 2—For this scenario, it was assumed that treated mine effluent will be discharged to Bootjack Lake at Closure (shown as Location A in Figure 1). Both seepage from the pit and treated effluent are active in this scenario to assess conditions at the IDZ for each loading source. Treated mine effluent was also added as a conservative generic constituent at constant concentration of 100 mg/L to estimate the cumulative effects. A TDS concentration of 1,150 mg/L (similar to the TDS concentrations of seepage from the pit) was applied to the treated mine effluent discharge (Appendix F of the TAR).

The temperature time series constructed for the local runoff was applied to treated effluent. In this scenario, upper bound seepage rates from the Springer Pit were applied from 31 March 2017 to 31 December 2040. This sensitivity scenario was run to evaluate the influence of a potential mine closure treated effluent on the lake.

Sensitivity 3— Same as Sensitivity 2 with following the change: the base case seepage rates from the Springer Pit were applied.

Sensitivity 4— Same as the No Discharge scenario with the following change: constant base case seepage rate from the Springer Pit was applied throughout the whole simulation period. This scenario was run to assess the effects of applying maximum seepage rate through the whole simulation period (assuming that water level in the pit is at its maximum level of 1,050 masl).

Sensitivity 5— Same as the No Discharge scenario with the following change: all Springer Pit seepage is directed to one grid cell (Figure 1). This scenario was run to test the effects of the assumed non-point source input location.

Sensitivity 6— Same as Sensitivity 3 with the following change: treated effluent was discharged to a deeper area to improve near-field dilution (shown as Location B in Figure 1).

3.0 RESULTS

3.1 Model Results

Time series of predicted tracer concentrations for the No Discharge scenario are presented in Figure 2. Results at the cells that directly receive seepage were used to estimate concentrations at the edge of the IDZ. Seepage form the Springer Pit was predicted to increase concentrations in Bootjack Lake until they reach a steady state (with seasonal variation) at around 2036. Cyclical annual patterns occur as a result of salt rejection during ice formation and dilution during ice thawing.

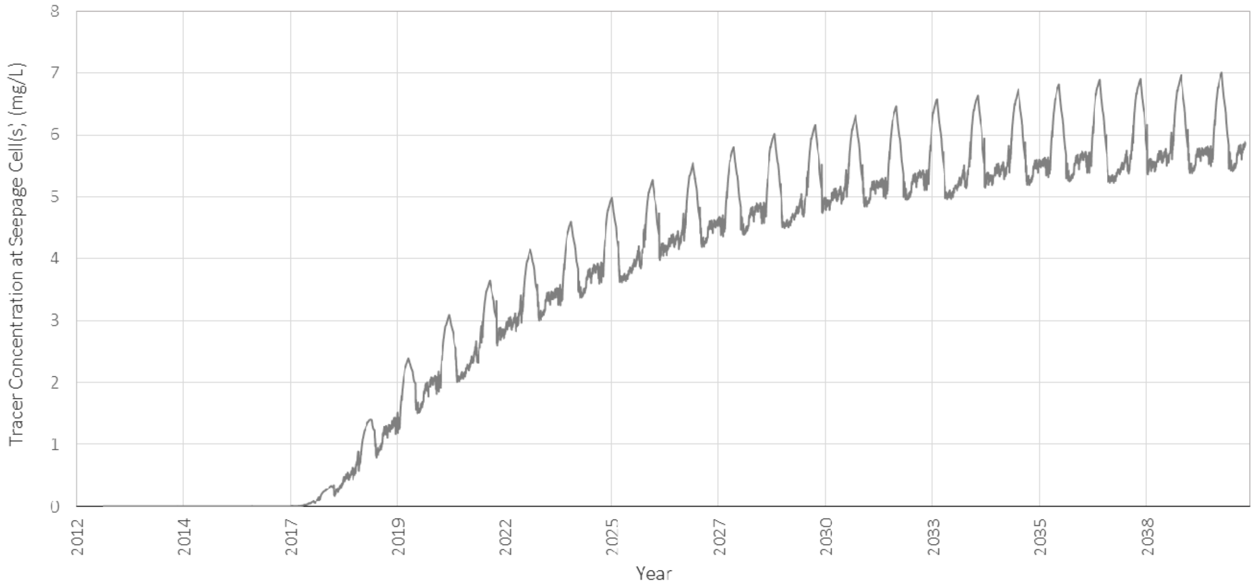

Figure 2: Predicted Tracer Concentrations at the Edge of Mixing Zone around the Seepage from the Springer Pit to Bootjack Lake

3.2 Model Sensitivity Results

Time series of predicted tracer concentrations for Sensitivities 1 to 6 are presented in Figures 3 to 5. Predictions of tracer concentrations from these sensitivities were compared to predictions of tracer concentrations from the No Discharge scenario where applicable.

In general, the Bootjack Lake model was not sensitive to changes made in Sensitivities 4 and 5. The model shows sensitivity to other scenarios (Sensitivities 1, 2, 3, and 6).

In detail, model results for the six model sensitivity scenarios showed the following (Figures 3 to 5):

- Tracer concentrations in the cells receiving pit seepage in Bootjack Lake were predicted to increase as a result of applying upper bound seepage rates (Sensitivity 1) compared to predictions of tracer concentrations from the No Discharge scenario (base case seepage rates).
- Addition of mine closure treated effluent was predicted to increase tracer concentrations at the edge of the IDZ (Sensitivities 2, 3, and 6) compared to the No Discharge scenario and Sensitivity 1.
- Applying a constant seepage rate instead of a time series in Period 2 was predicted not to change tracer concentrations over the long term (Sensitivity 4).
- Tracer concentrations were not sensitive to the shoreline length over which seepage enters the lake (Sensitivity 5). This is because the seepage enters the lake in a well-mixed narrow part of the lake which connects north and south sections (Figure 1).
- Changing the location of mine closure effluent from a shallow cell (Sensitivity 6) to a deeper cell (Sensitivity 3) was predicted to result in lower concentrations at the edge of the IDZ.

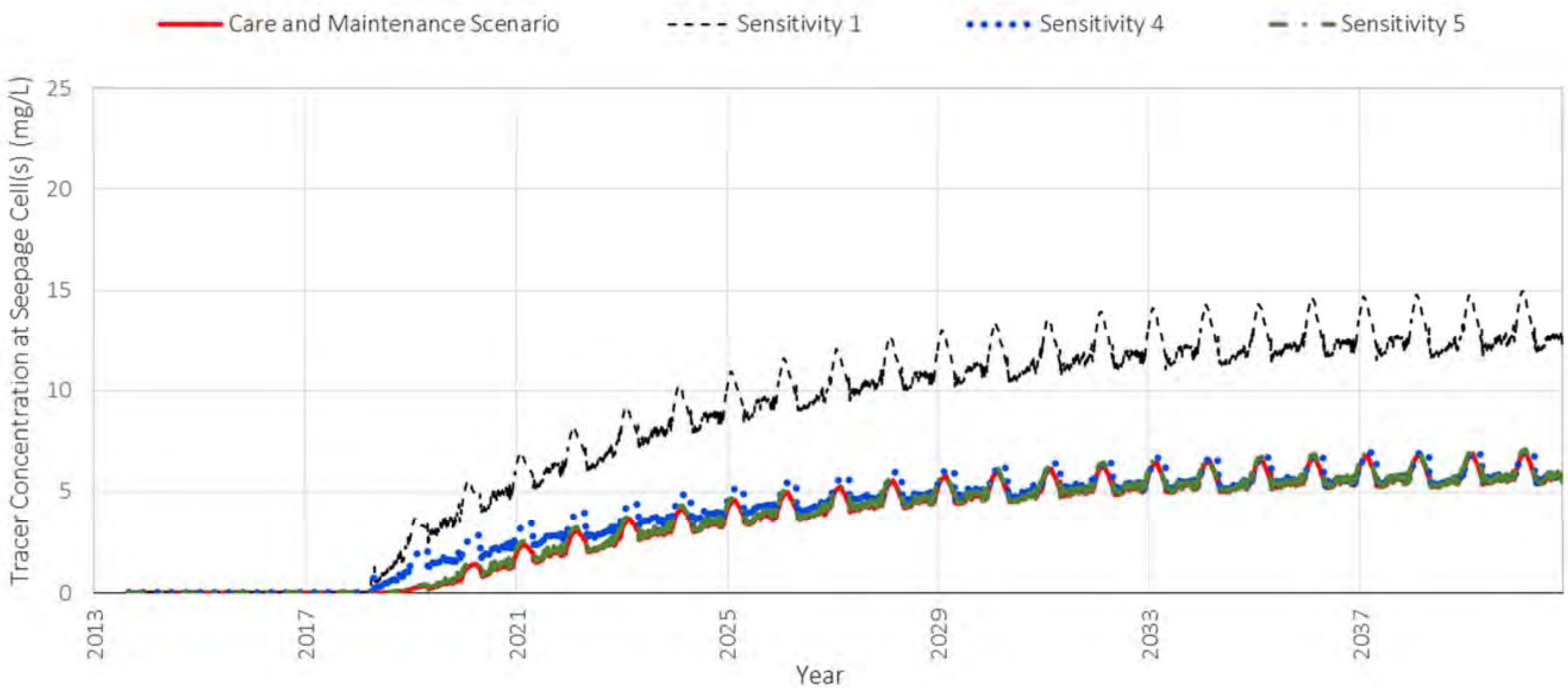

Figure 3: Bootjack Lake Tracer Concentrations at the Seepage Cell(s) (Edge of IDZ) – Sensitivity Analysis (Part 1)

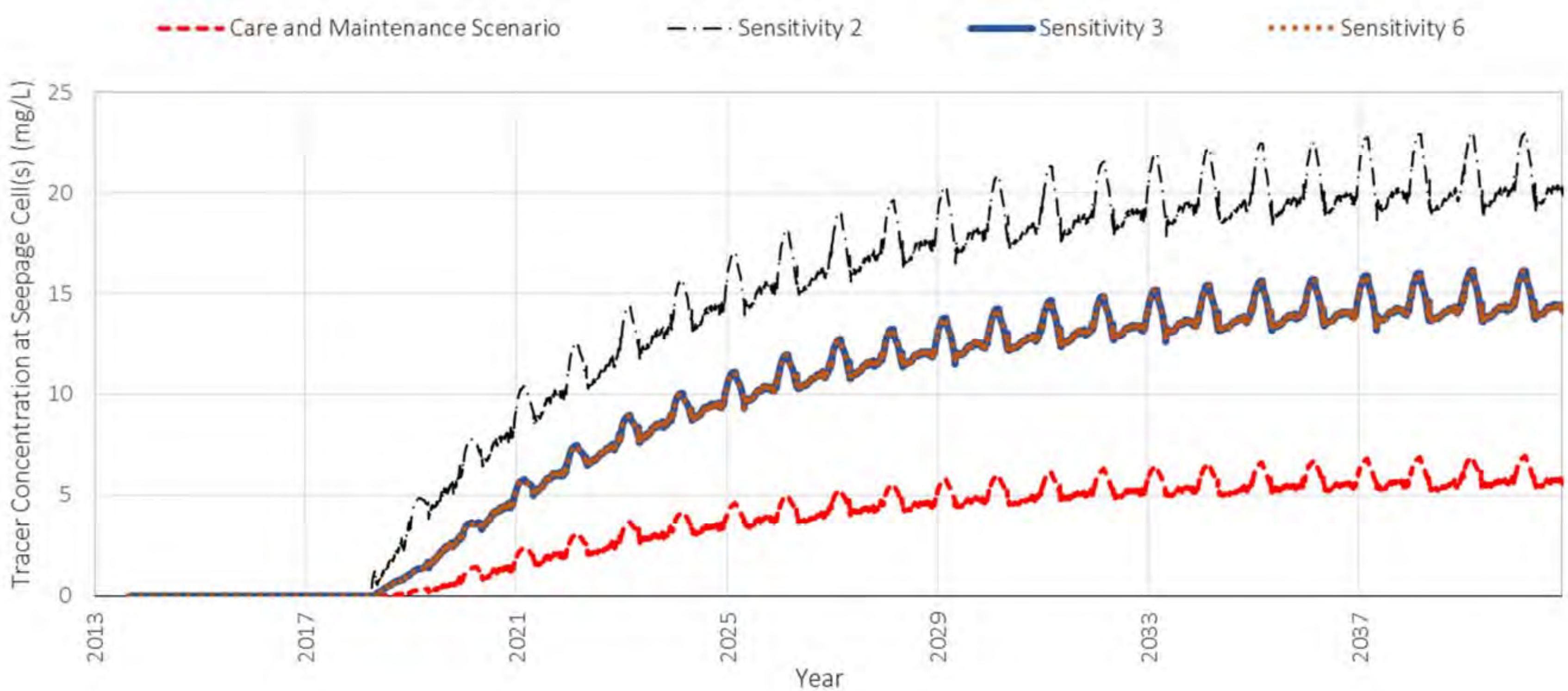

Figure 4: Bootjack Lake Tracer Concentrations at the Seepage Cell(s) (Edge of IDZ) – Sensitivity Analysis (Part 2)

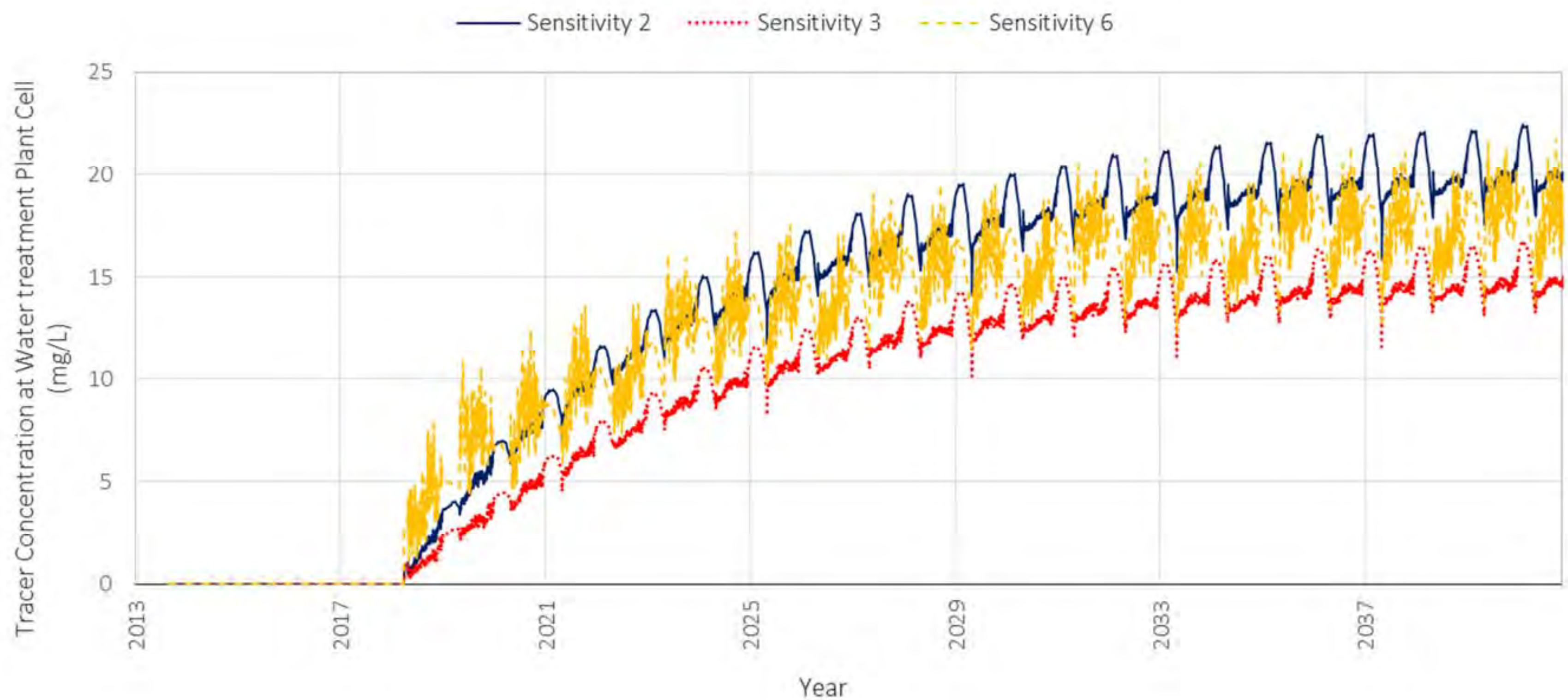

Figure 5: Bootjack Lake Tracer Concentrations at the Mine Effluent Discharge Location (Edge of IDZ) – Sensitivity Analysis

4.0 MODEL LIMITATIONS AND UNCERTAINTY

Modelling requires the use of many assumptions related to determining the physical and chemical characteristics of a system. Predictions are based on several inputs, all of which have inherent uncertainty. Given these inherent uncertainties, the results of a model should be used as a tool in project planning, and to outline potential risks, rather than to indicate absolute concentrations for future scenarios.

The key limitations of the model are as follows:

- **Changes to seepage and treated effluent discharge quantity and quality**—Predicted concentrations only apply to the seepage and effluent discharge rates and water quality concentrations noted in this memorandum. Changes to seepage and effluent discharge water quantity and quality may result in changes to constituent concentrations in the lake outside the range of concentrations predicted herein. Conservative inputs were selected to minimize the likelihood of under-predicting concentrations.
- **Changes to surface water quantity and quality**—Predicted concentrations only apply to the surface water quantities and qualities noted in this memorandum. Changes to surface water quantities or qualities may result in changes to concentrations in the lake outside the range of concentrations predicted herein.
- **Ice thickness**—The model assumes that ice forms on Bootjack Lake at the same rate and at the same thickness each year from 2012 to 2040. The magnitude of the cycle varies and depends on the ice thickness and the depth of the lake. Changes in ice thickness or the depth of the lake from modelled values could affect peak predicted concentrations presented in this memorandum.
- **Calibration data**—The water quality data used for calibration at monitoring locations B1 and B2 were based on data provided by MPMC (Hughes 2016, pers. comm.). Additional calibration data may result in changes to predicted concentrations in the lake outside the range of concentrations predicted in this memorandum.
- It was assumed that water chemistry data used as inputs to the Bootjack Lake model were representative of their respective sources. It is an inherent assumption in modelling that data obtained as part of monitoring programs adequately represent the input sources and will continue to do so in the future.

With the limitations noted above, the model is considered reasonably well calibrated and capable of achieving the objective of evaluating the influence of the seepage and mine closure effluent on Bootjack Lake water quality at the edge of their respective IDZs.

5.0 CONCLUSIONS

A hydrodynamic model of Bootjack Lake was developed using GEMSS to predict the dilution in the IDZ of seepage from the Springer Pit and release of treated effluent at Closure into Bootjack Lake. The model was calibrated using existing field data. Overall, the hydrodynamic calibration indicates that the model is tracking the movement of water and dissolved constituents well vertically and horizontally throughout the lake. Thus, the Bootjack Lake model is considered a reasonable representation of the system.

Sensitivity analyses were developed using different seepage rates and locations. In general, the dilution in the IDZ was not sensitive to the shoreline length over which seepage enters the lake (1 cell – 100 m, or 5 cells – 500 m) or applying a constant seepage rate versus an interpolated time series. It was sensitive to increasing the seepage rate (upper bound versus base case seepage rates) and addition of treated effluent during Closure.

6.0 CLOSURE

We trust that the content of this technical memorandum meets your expectations. Please do not hesitate to contact the undersigned should you have any questions or comments.

GOLDER ASSOCIATES LTD.

Shadi Dayyani, PhD, PEng Water Quality Modeller	Jerry Vandenberg, MSc, PChem Principal, Senior Environmental Chemist

SD/JV/bb/ls/kp

Attachments: Study Limitations
Attachment A: Calibration Plots

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REFERENCES

Cole TM, Wells S. 2008. CE-QUAL-W2: A Two-Dimensional, Laterally Averaged, Hydrodynamic and Water Quality Model, Version 3.6; User's Manual. Prepared for US Army Corps of Engineers Waterways Experiment Station. Washington, DC, USA.

Buchak EM, Edinger JE. 1984. Generalized, Longitudinal-Vertical Hydrodynamics and Transport: Development, Programming and Applications. Prepared for US Army Corps of Engineers Waterways Experiment Station. Vicksburg, MS, USA.

Edinger JE, Buchak EM. 1980. Numerical hydrodynamics of estuaries. In Hamilton P, Macdonald KB (eds), Estuarine and Wetland Processes with Emphasis on Modelling. Plenum Press, New York, NY, USA. pp 115-146.

Edinger JE, Buchak EM. 1985. Numerical waterbody dynamics and small computers. In Waldrop WR (ed), Proceedings of ASCE 1985 Hydraulic Division Specialty Conference on Hydraulics and Hydrology in the Small Computer Age. American Society of Civil Engineers. Lake Buena Vista, FL, USA. pp 705-710.

Edinger JE, Buchak EM. 1995. Numerical intermediate and far field dilution modelling. Water Air Soil Pollut 83:147-160.

Edinger JE, Buchak EM, McGurk MD. 1994. Analyzing larval distributions using hydrodynamic and transport modelling. In Spaulding ML (ed), Estuarine and Coastal Modelling III: Proceedings of the 3rd International Conference. American Society of Civil Engineers. New York, NY, USA. pp 536-550.

Edinger JE, Kolluru VS. 1999. Implementation of vertical acceleration and dispersion terms in an otherwise hydrostatically approximated three-dimensional model. In Spaulding ML, Butler HL (eds), Proceedings of the 6th International Conference on Estuarine and Coastal Modelling. New Orleans, LA, USA. pp 1019-1034.

Edinger JE, Wu J, Buchak EM. 1997. Hydrodynamic and Hydrothermal Analyses of the Once-through Cooling Water System at Hudson Generating Station. Prepared for Public Service Electric and Gas. Newark, NJ, USA.

Golder (Golder Associates Ltd.). 2015. Cariboo-Springer Pit Phase 4 Water Management Plan (TSF 970 m Design) Report. Submitted to Mount Polley Mining Corporation. Golder Doc. No. 1411734-094-R-Rev0-12000. November 2, 2015.

Kolluru VS, Fichera MJ. 2003. Development and application of combined 1-D and 3-D modelling system for TMDL studies. In Spaulding ML (ed), Proceedings of the 8th International Conference on Estuarine and Coastal Modelling. American Society of Civil Engineers. Monterey, CA, USA. pp 108-127.

Kolluru VS, Buchak EM, Edinger JE. 1998. Integrated model to simulate the transport and fate of mine tailings in deep waters. In Balkema AA (ed), Proceedings of the Tailings and Mine Waste '98 Conference. Fort Collins, CO, USA.

Kolluru VS, Buchak EM, Wu J. 1999. Use of membrane boundaries to simulate fixed and floating structures in GLLVHT. In Spaulding ML, Butler HL (eds), Proceedings of the 6th International Conference on Estuarine and Coastal Modelling. New Orleans, LA, USA. pp 485-500.

Kolluru VS, Edinger JE, Buchak EM, Brinkmann P. 2003. Hydrodynamic modelling of coastal LNG cooling water discharge. J Energy Eng 129:16-31.

PCIC (Pacific Climate Impacts Consortium). 2016. BC Station Data – PCDS. Available at http://tools.pacificclimate.org/dataportal/pcds/map/. Accessed on May 12, 2016. Station #: 47091 (Lee's Hill).

US Army Engineer Waterways Experiment Station. 1986. CE-QUAL-W2: A Numerical Two-Dimensional, Laterally Averaged Model of Hydrodynamics and Water Quality; User's Manual. Defence Technical Information Center. Washington, DC, USA.

PERSONAL COMMUNICATIONS

Hughes, Colleen. 2016. Environmental Coordinator, Mount Polley Mining Corporation. Monitored water quality data. Emails to Jordana van Geest, Environmental Scientist, and Michael Herrell, Senior Geochemist, Golder Associates Ltd. May 5, 2016.

Litke, Shauna. 2016a. Mount Polley Mining Corporation. Meteorological data measured at the mine site. Email to Jerry Vandenberg, Senior Environmental Chemist, Golder Associates Ltd. May 11, 2016.

Litke, Shauna. 2016b. Mount Polley Mining Corporation. Directions on the ice forming/melting assumptions. Email to Jerry Vandenberg, Senior Environmental Chemist, Golder Associates Ltd. Dated May 18, 2016.

STUDY LIMITATIONS

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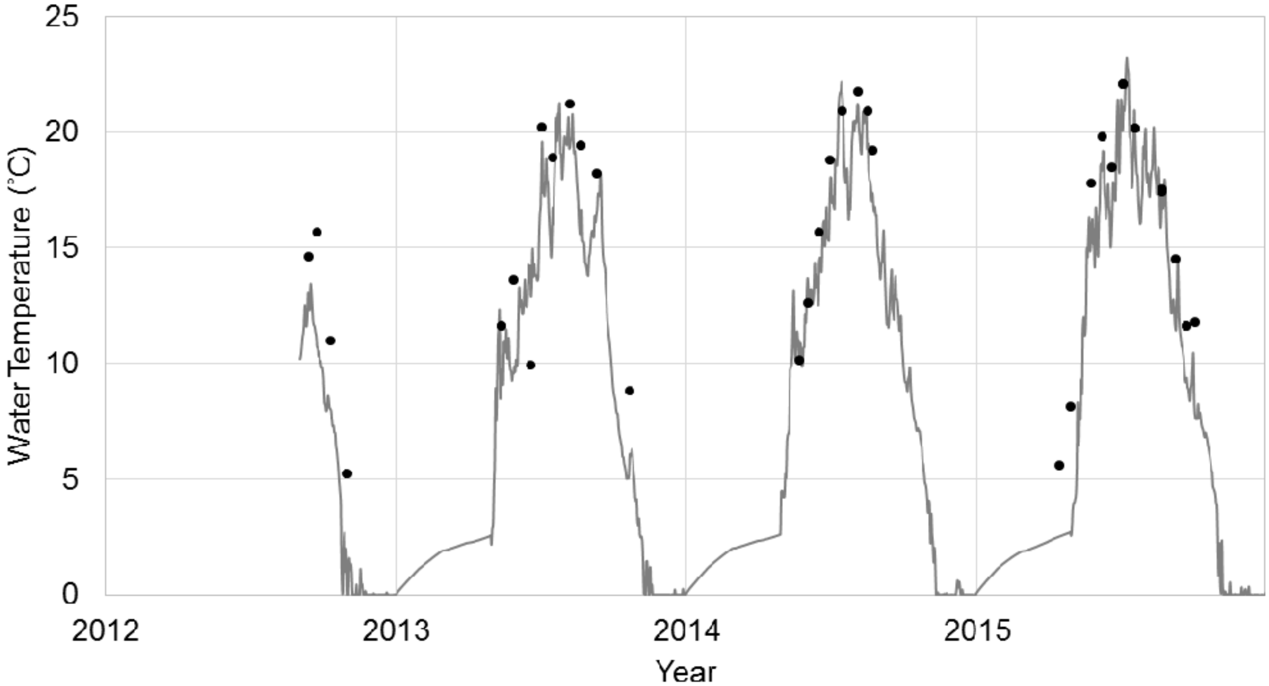
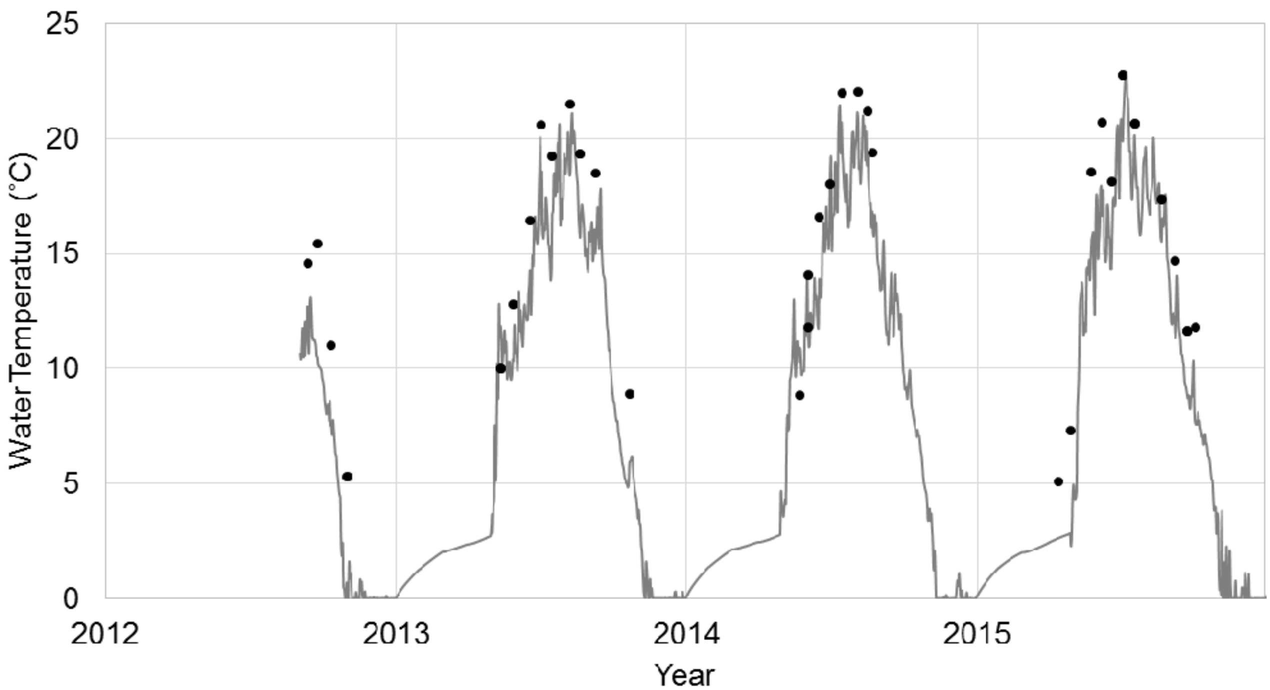
ATTACHMENT A
Calibration Plots



(a) at B1

Figure 1: Bootjack Lake Water Temperature Time Series Calibration Plot at B1 (a) and B2 (b)



(b) at B2

Note: Dots represent measured data; solid lines represent model results; B1 and B2 are calibration locations in Bootjack Lake.

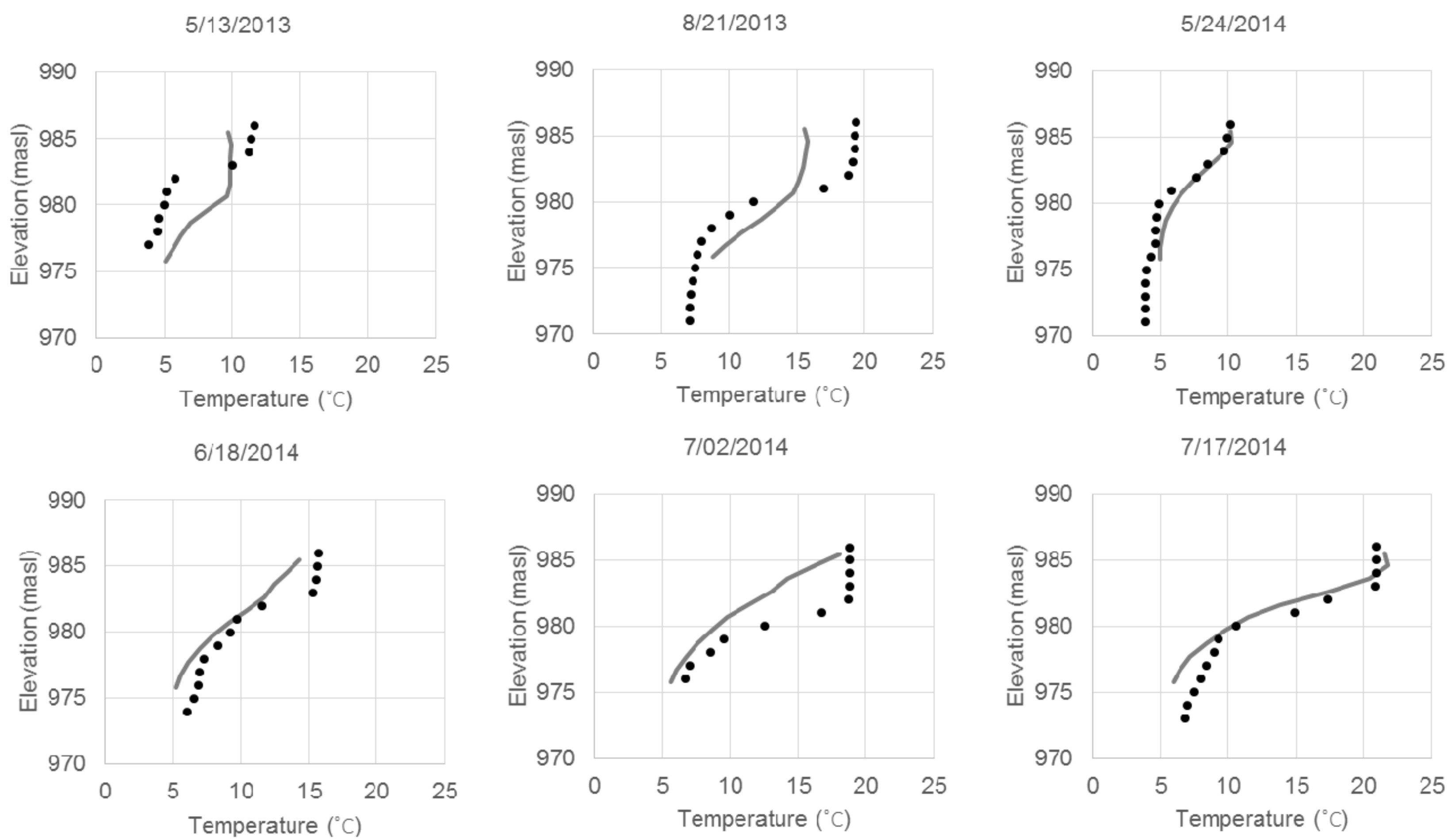


Figure 2: Bootjack Lake Water Temperature Profile Calibration Plots at B1

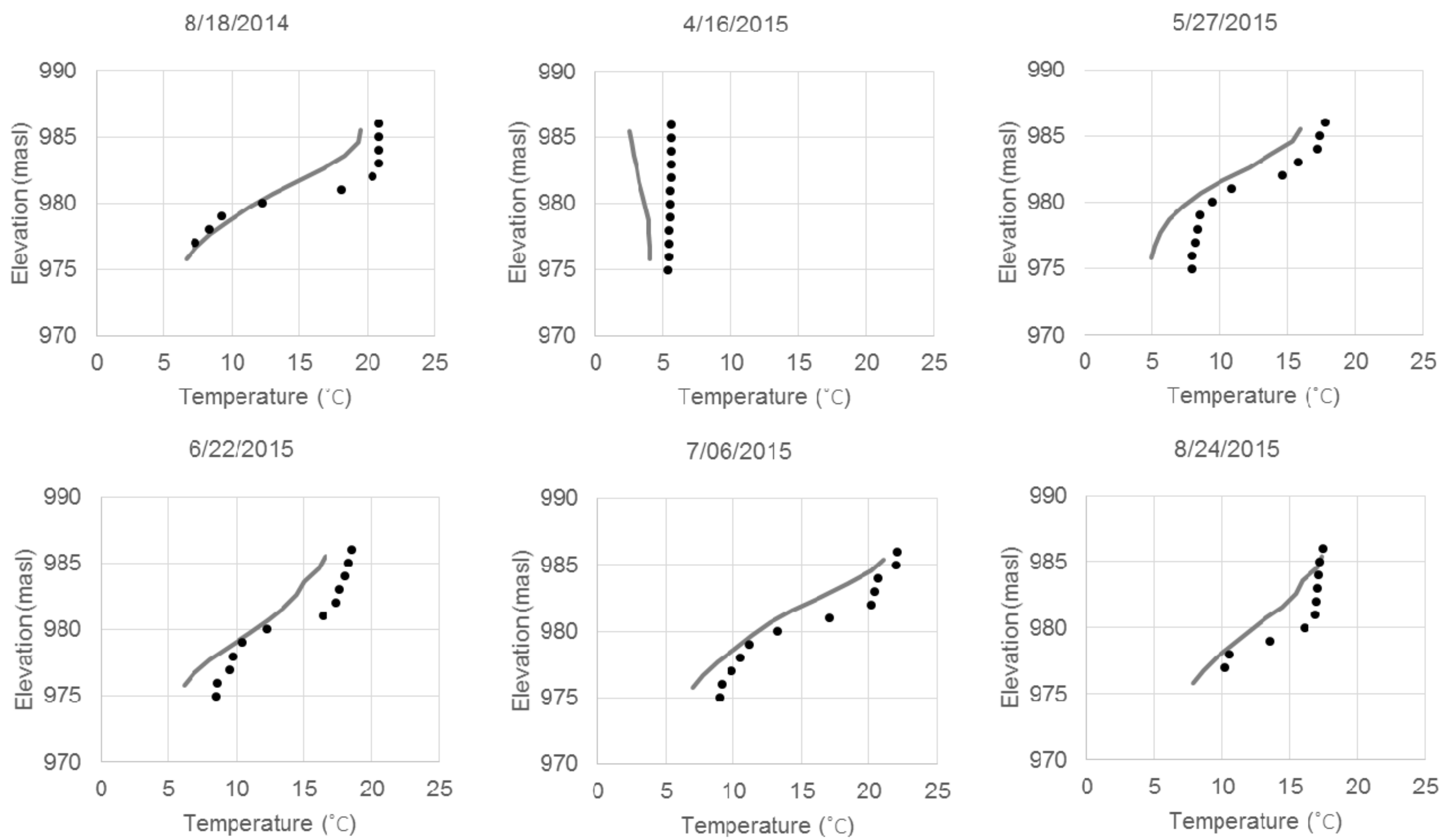


Figure 2: Bootjack Lake Water Temperature Profile Calibration Plots at B1 (continued)

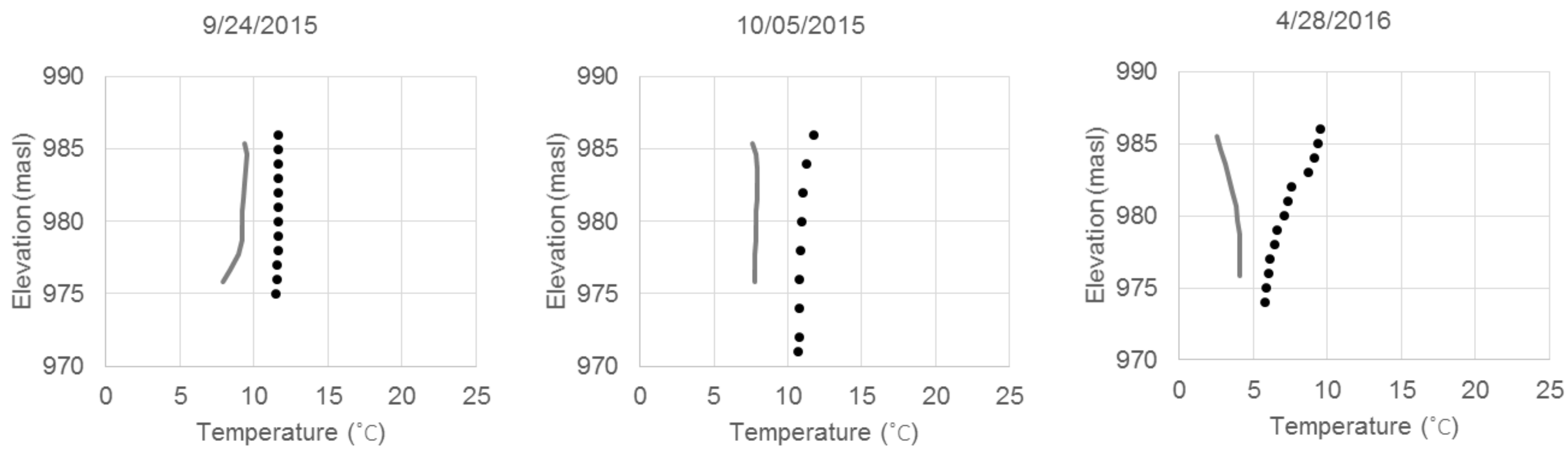


Figure 2: Bootjack Lake Water Temperature Profile Calibration Plots at B1 (continued)

Note: Dots represent measured data; solid lines represent model results; B1 is a calibration location in Bootjack Lake.

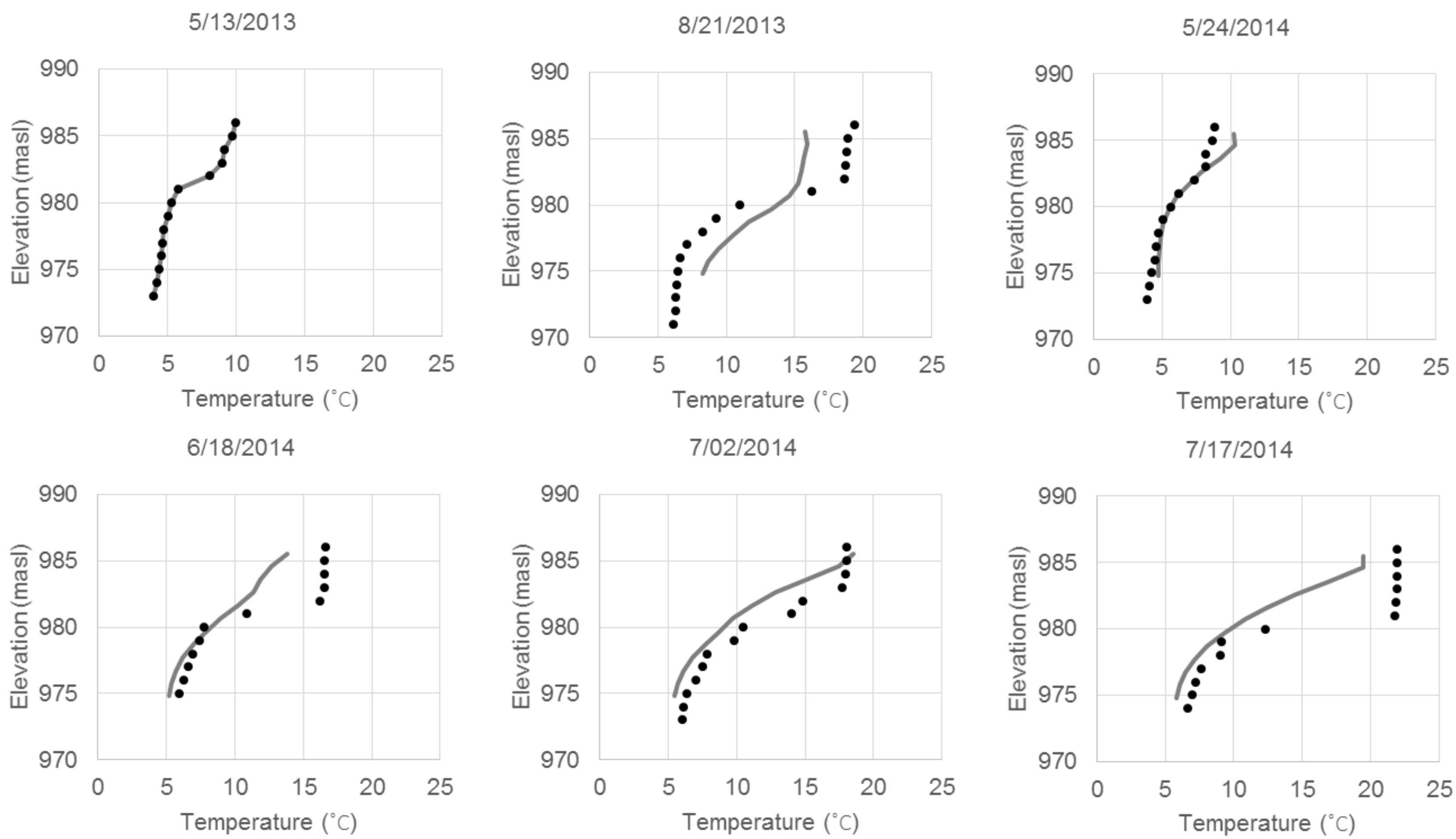


Figure 3: Bootjack Lake Water Temperature Profile Calibration Plots at B2

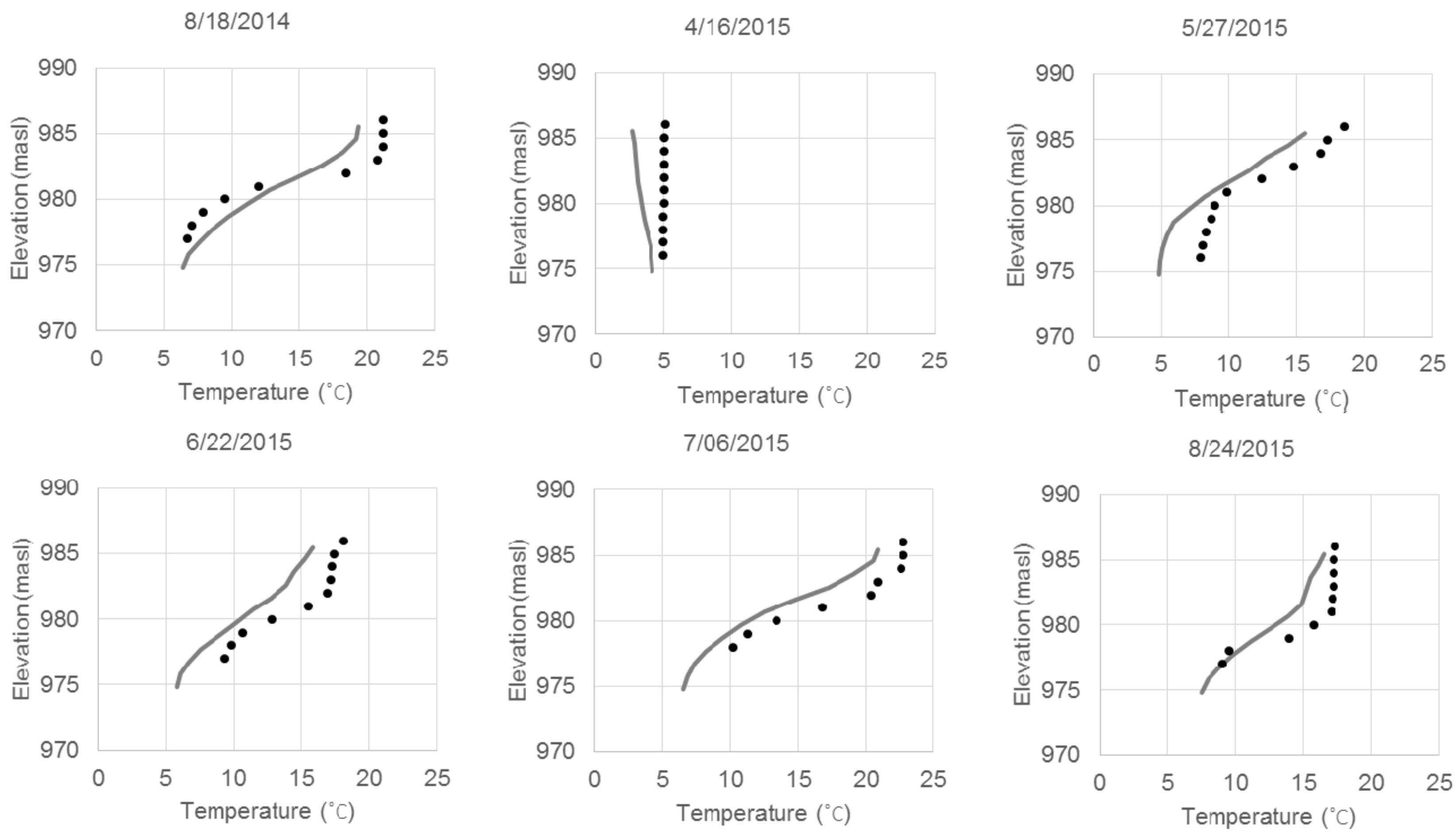


Figure 3: Bootjack Lake Water Temperature Profile Calibration Plots at B2 (continued)

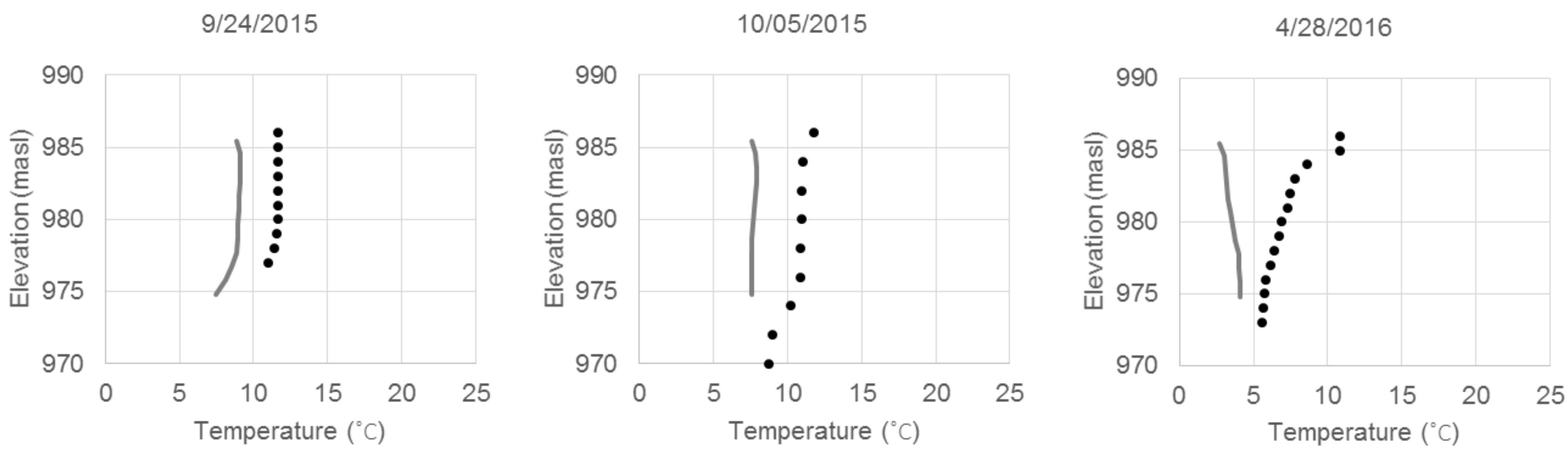
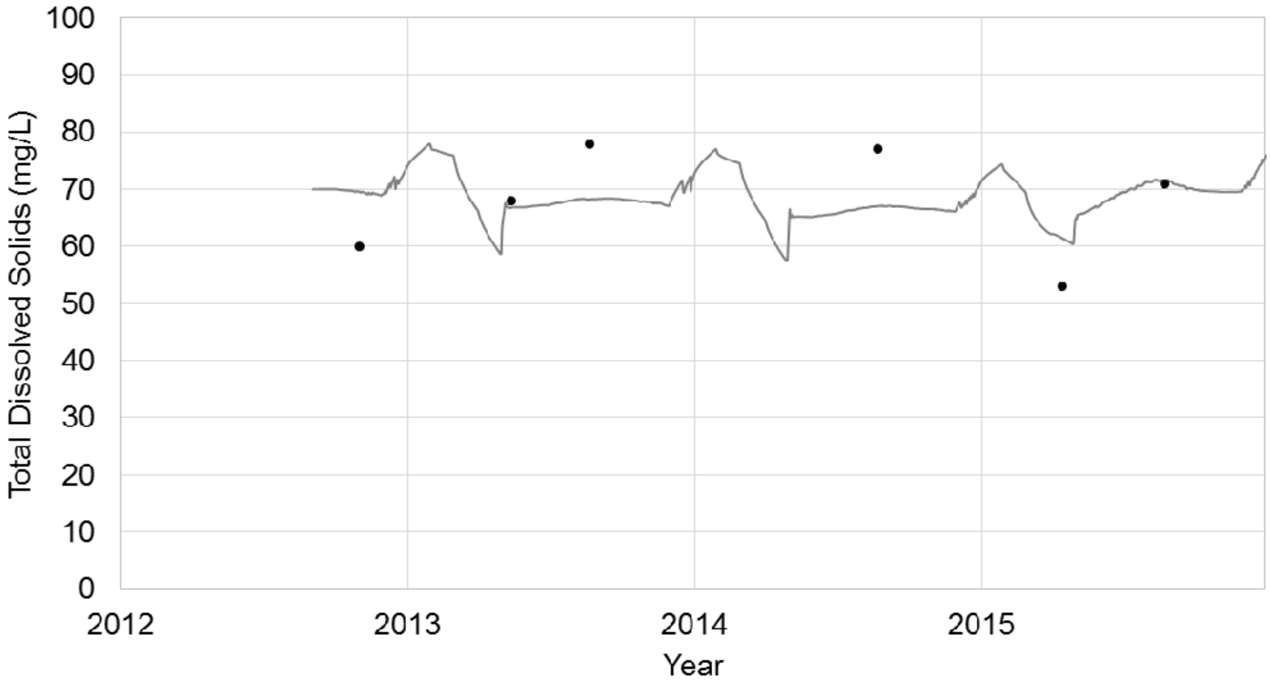


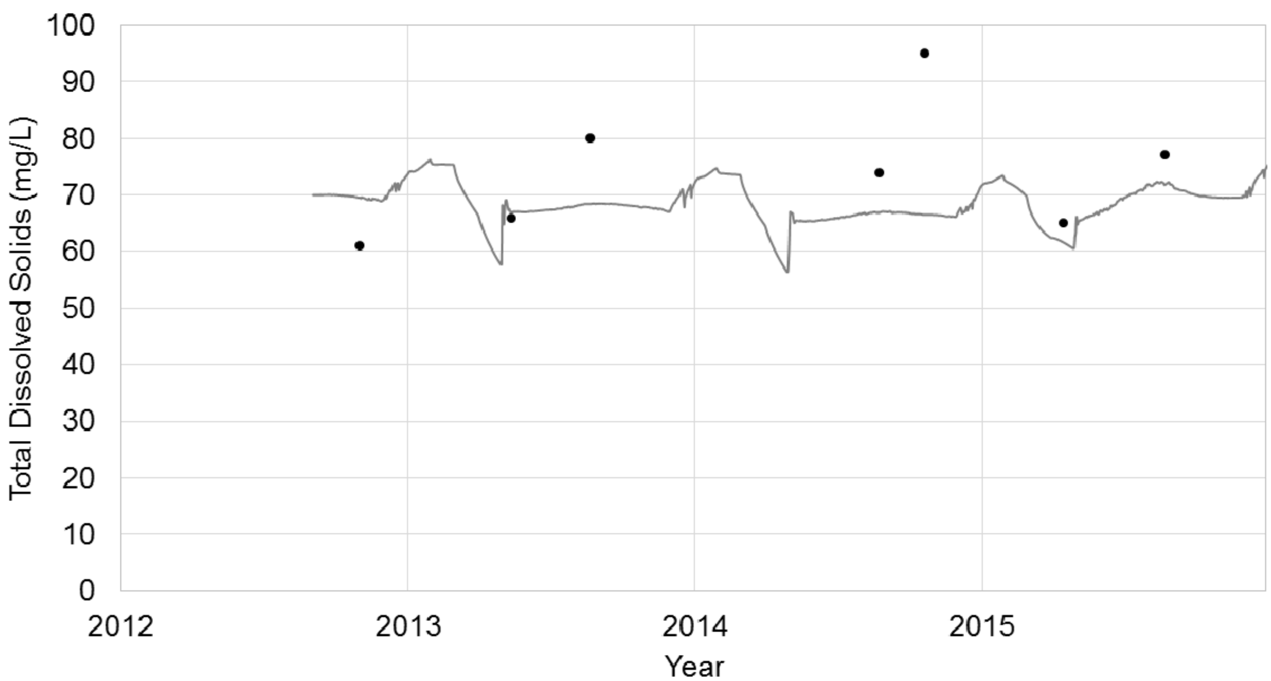
Figure 3: Bootjack Lake Water Temperature Profile Calibration Plots at B2 (continued)

Note: Dots represent measured data; solid lines represent model results; B2 is a calibration location in Bootjack Lake.



(a) at B1

Figure 4: Bootjack Lake Total Dissolved Solids Time Series Calibration Plots for B1 (a) and B2 (b)



(b) at B2

Note: Dots represent measured data; solid lines represent model results; B1 and B2 are calibration locations in Bootjack Lake.

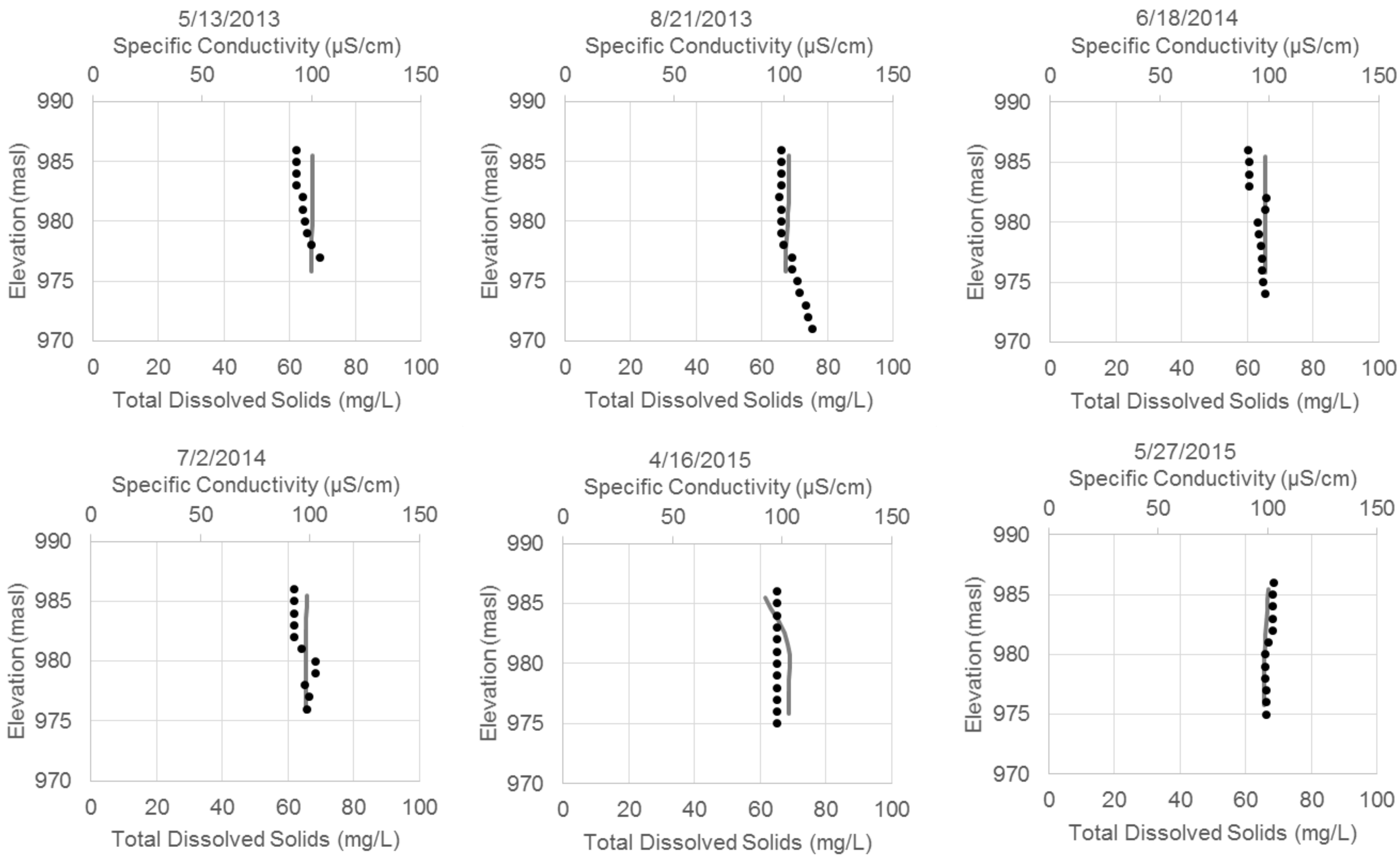


Figure 5: Bootjack Lake Total Dissolved Solids and Specific Conductivity Profile Calibration Plots at B1

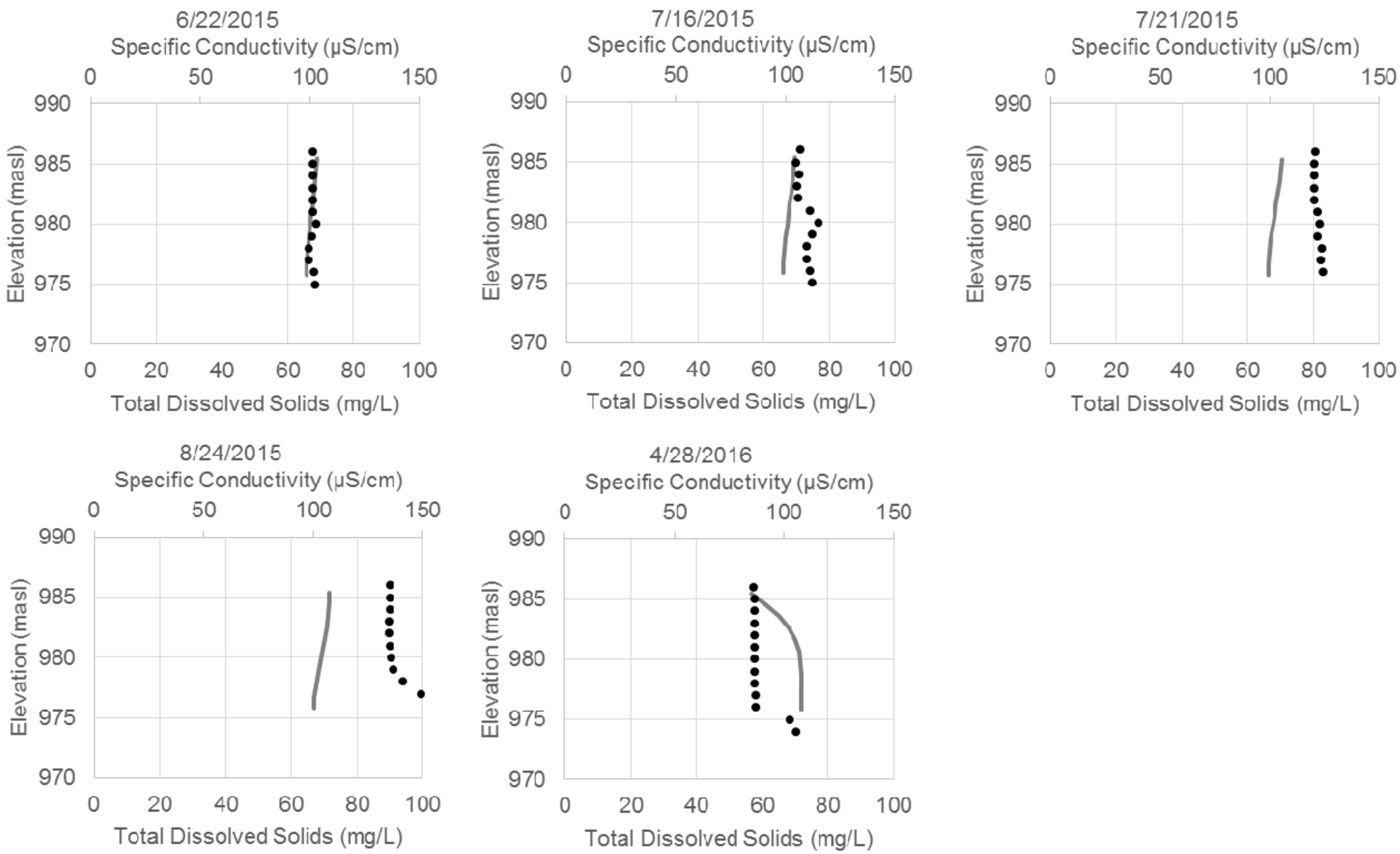


Figure 5: Bootjack Lake Total Dissolved Solids and Specific Conductivity Profile Calibration Plots at B1 (continued)

Note: Dots represent measured specific conductivity data; solid lines represent total dissolved solids model results; B1 is a calibration location in Bootjack Lake.

µS/cm = microsiemens per centimetre.

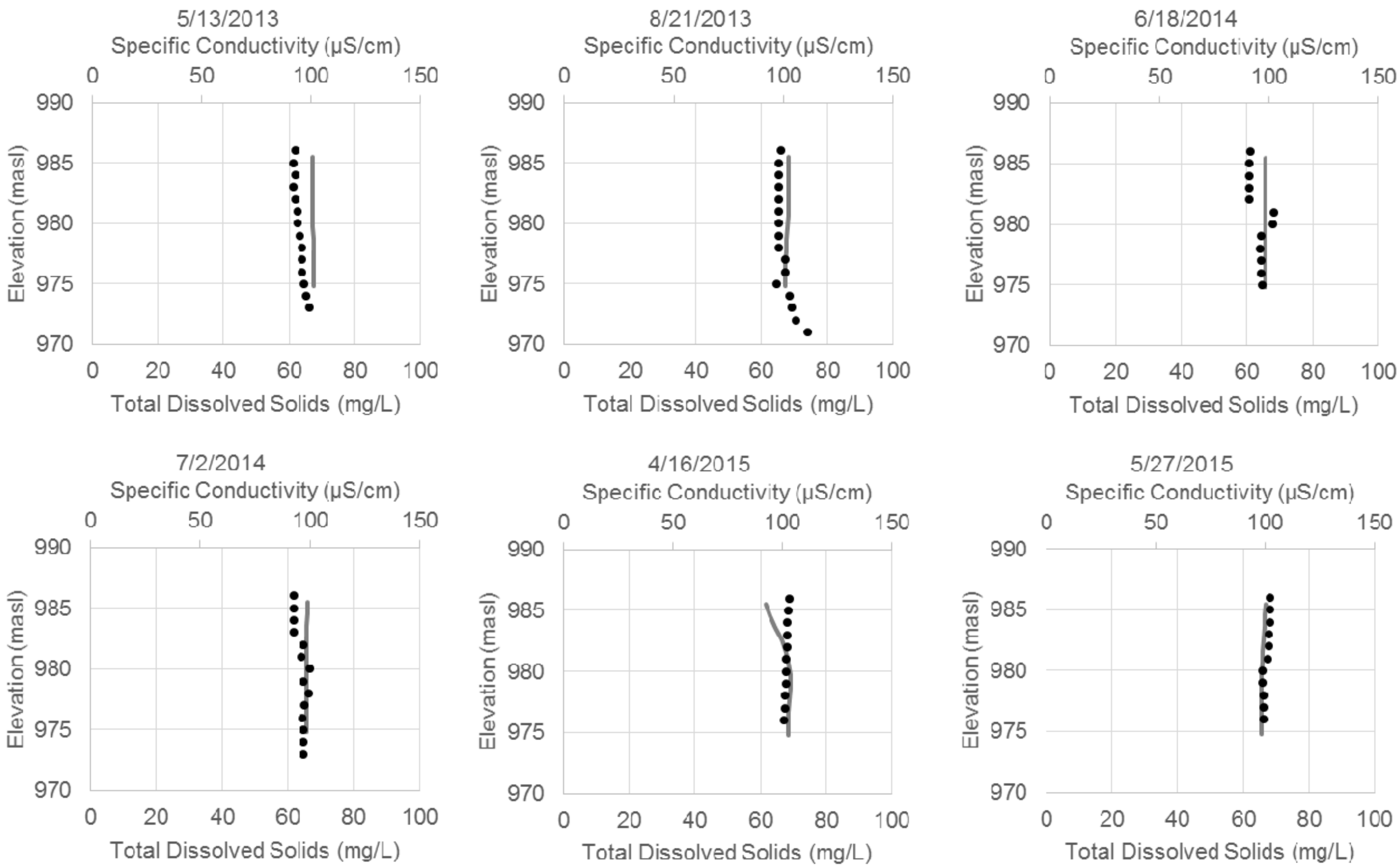


Figure 6: Bootjack Lake Total Dissolved Solids and Specific Conductivity Profile Calibration Plots at B2

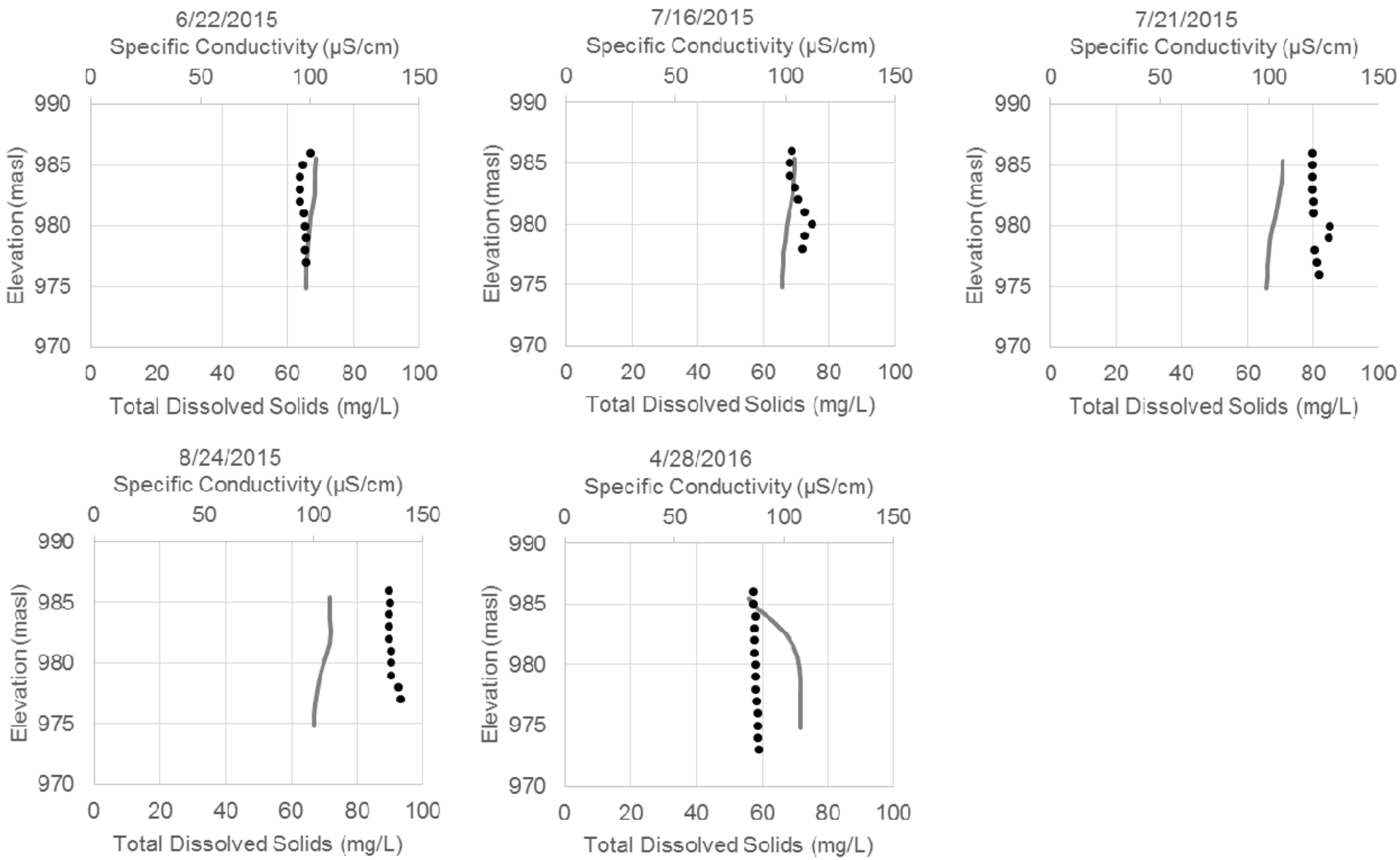


Figure 6: Bootjack Lake Total Dissolved Solids and Specific Conductivity Profile Calibration Plots at B2 (continued)

Note: Dots represent measured specific conductivity data; solid lines represent total dissolved solids model results; B2 is a calibration location in Bootjack Lake.

µS/cm = microsiemens per centimetre.

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