CAMP

Coordinated Aquatic Monitoring Program

Sediment and Water Quality Monitoring Report

Southern Indian Lake, 2014-2015

October 2016

COORDINATED AQUATIC MONITORING PROGRAM (CAMP)

SEDIMENTATION AND WATER QUALITY MONITORING REPORT

SOUTHERN INDIAN LAKE 2014-2015

October 2016

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Coordinated Aquatic Monitoring Program (CAMP). 2016. Sedimentation and Water Quality Monitoring Report: Southern Indian Lake (2014-2015).

EXECUTIVE SUMMARY

This report provides an overview of the sediment monitoring program implemented in Southern Indian Lake (SIL) during the 2014 open water and winter seasons, and the 2015 open water season as a part of the Coordinated Aquatic Monitoring Program (CAMP).

The data reported in this report includes the continuous and discrete water quality data (turbidity, temperature, conductivity, and dissolved oxygen), and sedimentation data (total suspended sediment, and particle size distribution) collected at 29 sites in SIL.

The concentration of suspended sediment at monitoring stations in SIL ranged from below detection (<2 mg/L) to a maximum value of 16 mg/L with most concentrations below 10 mg/L in open water periods and 6 mg/L in winter. A review of turbidity in relation to the climate data suggests a strong relationship between turbidity and wind events. Water temperature was also observed to change rapidly at several sites correlated to large changes in air temperature.

Data over a longer period of time would be required at varying discharges/levels to draw definitive conclusions on long term correlations between water levels and suspended sediment concentrations.

STUDY TEAM

This report was prepared by Water Resources Engineering Department (Physical Environment Group) of Manitoba Hydro. Field sampling was conducted by Hydraulic Operations Department of Manitoba Hydro.

TABLE OF CONTENTS

LIST OF TABLES

1.0 INTRODUCTION

1.1 Scope

This document reports the 2014 to 2015 sedimentation and water quality data collected as a part of the Coordinated Aquatic Monitoring Program (CAMP) in Southern Indian Lake, Manitoba.

The report provides an overview of the sediment monitoring and data collection program implemented in Southern Indian Lake during the 2014 open water and winter seasons and the 2015 open water season. The data reported in this document includes the continuous and discrete water quality data (turbidity, temperature, conductivity, and dissolved oxygen), and sedimentation data (total suspended sediment, and particle size distribution of suspended sediment).

1.2 Project Background

Southern Indian Lake (SIL) is a Canadian Shield lake in Northern Manitoba. SIL is used as a seasonal reservoir as it is typically filled during the open water period to store water for hydroelectric use during the winter when the lake is typically drawn down. Hydrologic operating decisions are made such that flow releases through Notigi and Missi control structures result in maximized system generation, while staying within regulatory limits for flows and water levels.

Southern Indian Lake has been historically divided into eight different zones (0-8, including Opachuanau Lake), based on the basin characteristics (Figure 1). The sedimentation monitoring program in SIL was initiated to collect data that will provide insights into sediment transport processes in SIL and the current state of aquatic ecosystem health in zone 4, a deep central part of the lake.

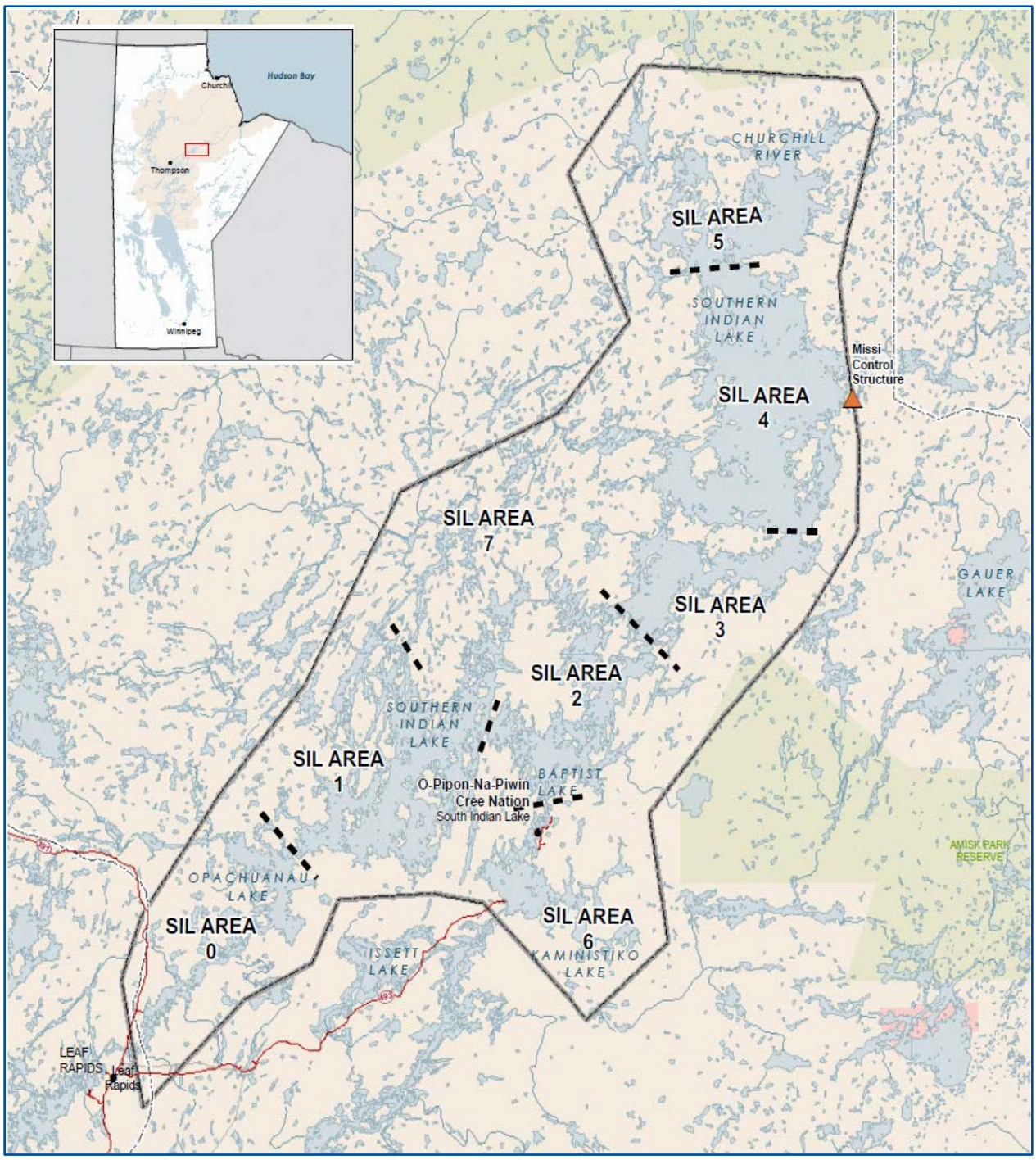


Figure 1: Southern Indian Lake Historical Study Zones

2.0 MONITORING PROGRAM DESCRIPTION

2.1 Program Objectives

The SIL sediment and water quality monitoring program was developed by a working group under the CAMP framework with the field program delivered by Manitoba Hydro. The objectives of this monitoring program can be described as:

- Use the study to test and review monitoring methods that may facilitate a more efficient system wide approach to sedimentation monitoring.
- Document the current state of sediment transport and sedimentation
- Monitor water quality and sediment parameters under varying hydrological, climatic and operational conditions, to determine the response of sedimentation processes and their impact on an ever dynamic aquatic environment

2.2 Program Implementation

As a part of this monitoring program, twenty-nine (29) monitoring locations were established in the study area (Figure 2). Table 1 provides information about the parameters collected during the reporting period at each monitoring site.

The following activities were undertaken during 2014 and 2015:

- Continuous monitoring of water quality parameters at seven (7) monitoring locations
- Discrete measurement of water quality parameters at all monitoring locations at monthly field visits
- Collection of water samples for laboratory testing at all monitoring locations at monthly field visits

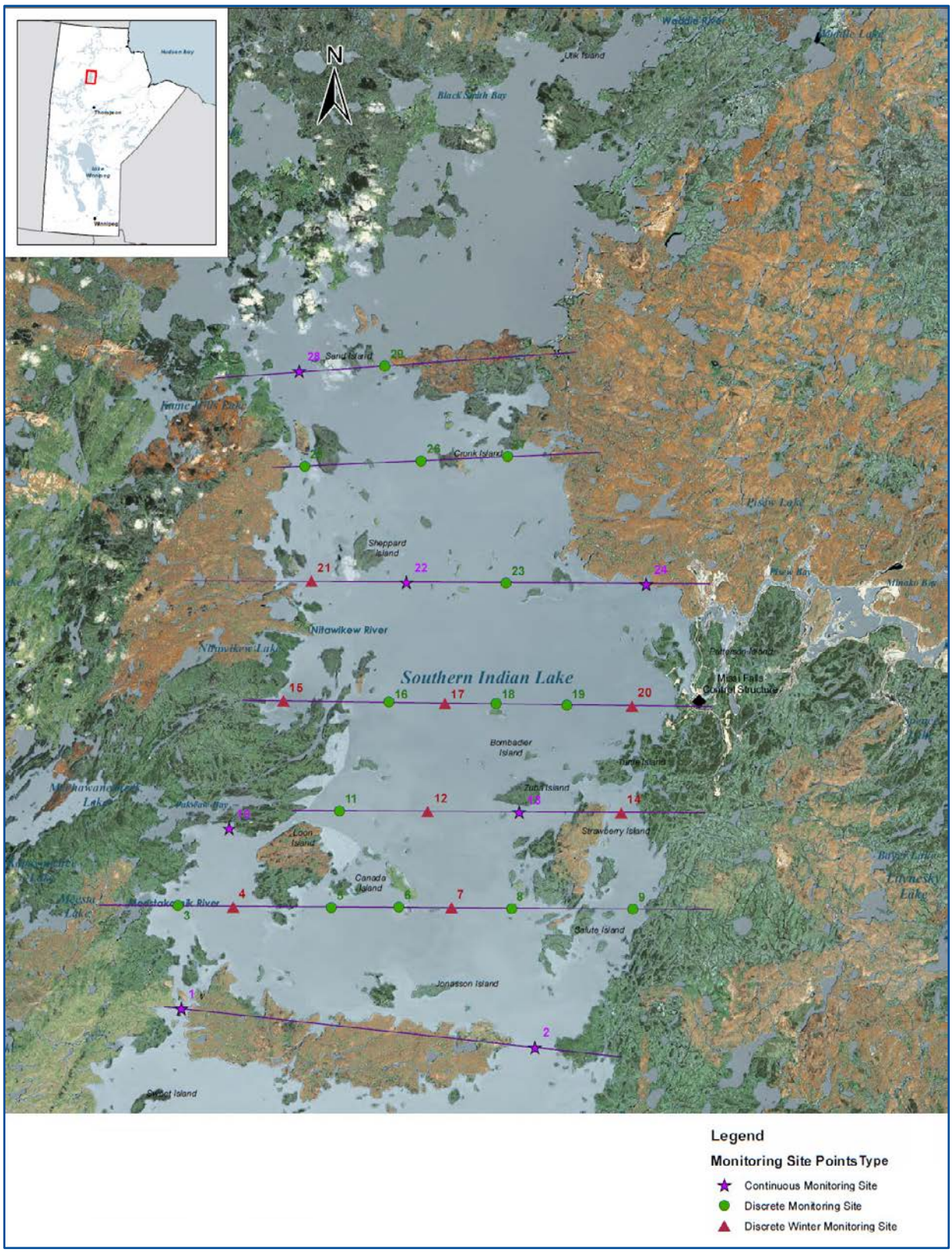


Figure 2: Southern Indian Lake – Zone 4 Sediment Monitoring Sites

Table 1: 2014-2015 Sediment Monitoring Locations at Southern Indian Lake

Name	Easting	Northing	Continuous Monitoring	Discrete Monitoring	Water Samples
SIL4-S-01	523104	6336014	X	X	X
SIL4-S-02	543107	6333830	X	X	X
SIL4-S-03	522934	6341810		X	X
SIL4-S-04	526043	6341740		X	X
SIL4-S-05	531599	6341710		X	X
SIL4-S-06	535436	6341740		X	X
SIL4-S-07	571788	6341710		X	X
SIL4-S-08	541786	6341650		X	X
SIL4-S-09	548665	6341610		X	X
SIL4-S-10	525811	6346180	X	X	X
SIL4-S-11	532062	6341710		X	X
SIL4-S-12	537056	6347140		X	X
SIL4-S-13	542249	6347100	X	X	X
SIL4-S-14	548003	6347070		X	X
SIL4-S-15	528887	6353390		X	X
SIL4-S-16	534840	6353320		X	X
SIL4-S-17	538015	6353220		X	X
SIL4-S-18	540926	6353220		X	X
SIL4-S-19	544895	6353120		X	X
SIL4-S-20	548599	6353090		X	X
SIL4-S-21	530475	6360130		X	X
SIL4-S-22	535833	6360070	X	X	X
SIL4-S-23	541488	6360030		X	X
SIL4-S-24	549426	6359970	X	X	X
SIL4-S-25	530078	6366620		X	X
SIL4-S-26	536693	6366910		X	X
SIL4-S-27	541554	6367180		X	X
SIL4-S-28	529780	6371990	X	X	X
SIL4-S-29	534609	6372270		X	X
SIL4-S-30	535833	6360070		X	X

The field crew visited the monitoring locations on a monthly basis, to:

- take discrete readings of water quality parameters using a YSI EXO2 sonde
- collect water samples for laboratory analysis
- download data and perform maintenance on YSI EXO2 continuous data loggers

The time frame of these field visits is provided in Table 2.

Table 2: 2014-2015 Field Visits for Water Sampling and Discrete Measurements

Field Visit	Date Range
OW 2014-01	June, 2014
OW 2014-02	23-29 July, 2014
OW 2014-03	18-23 Aug, 2014
OW 2014-04	16-23 Sep, 2014
ICE 2014-01	15-19 Jan, 2015
ICE 2014-02	6-7 Mar, 2015
OW 2015-01	21-25 June, 2015
OW 2015-02	24-30 July, 2015
OW 2015-03	19-24 Aug, 2015
OW 2015-04	18-21 Sep, 2015

3.0 DATA MANAGEMENT

The water quality data collected during this program are recorded and stored in several databases. The discrete data is recorded in Manitoba Hydro's Physical Environment database and the continuous loggers' data files are stored in Manitoba Hydro's WISKI database.

3.1 Data Processing and Quality Control

The Quality Control process was completed by following the Data Review Protocols developed for Manitoba Hydro's Physical Environment Monitoring field services projects (MH File: 00541-11100-0073_00). The data review process includes ensuring all metadata are accurately recorded in the database and all field data are screened for errors. The resulting good quality data was used to provide the key observations and to generate the summary tables and charts included in this report.

4.0 OVERVIEW OF HYDROLOGIC AND CLIMATE CONDITIONS IN SIL

The following is a summary of the hydrological and climatic conditions during the study period.

4.1 Inflow Conditions

Inflows to Southern Indian Lake are mainly received from the Upper Churchill River which is regulated further upstream in Saskatchewan.

The lake inflow showed little variation during each of the water quality monitoring seasons. In the 2014 open water season, the inflow into SIL averaged 830 m^3/s, ranging from 850 m^3/s to 780 m^3/s (Chart C.1). The inflow had little variation during the 2014 winter and 2015 open water season at 660 m^3/s and 615 m^3/s respectively (Chart C.2, C.3).

4.2 Outflow Conditions

Outflow from SIL is regulated through the operation of Missi Falls and Notigi control structures.

During the 2014 open water monitoring season Missi Falls discharge gradually reduced from around 850 m^3/s at the start of the season to around 500 m^3/s by the end of the monitoring season (Chart C.1). At the start of the winter period, discharge was held constant at 95 m^3/s reducing to 67 m^3/s in early February, followed by another reduction at the end of February to 47 m^3/s (Chart C.2). For most part of 2015 open water monitoring season discharge through Missi Falls CS was held at around 710 m^3/s (Chart C.3).

Discharge through Notigi CS changed from season to season but showed little variation during each of the three monitoring periods. The flows during the 2014 open water monitoring season stayed around 500 m^3/s, the 2014 winter season stayed around 950 $m^3/$ and the 2015 open water monitoring season was around 710 m^3/s.

4.3 Water Level

The SIL saw typical daily average water level variation during the water quality and sediment monitoring seasons of 2014 and 2015. The water level in SIL held constant at about 258.13 m during open water 2014 (Chart C.1). A linear drop of 0.33 m in water level, from 257.80 m in

January to 257.47 m in March was recorded during winter 2014 (Chart C.2). A linear increase of 0.41 m from 257.62 m to 258.03 m was measured during open water season of 2015.

4.4 Climatic Data

Raw wind and temperature data from Manitoba Hydro's Missi Falls Meteorological monitoring station during the monitoring periods is shown in Charts C.5 and C.6.

5.0 OVERVIEW OF WATER QUALITY AND SEDIMENT REGIME IN SIL

The results of the water quality and sedimentation data collected during the three monitoring seasons are presented in the following sections. A few general observations are also made identifying patterns noted during the data review process.

5.1 Water Quality Data

Water quality data was collected using multi-parameter YSI EXO2 sonde instruments in conjunction with water sampling for sedimentation parameters. A brief overview of collected parameters (turbidity, temperature, dissolved oxygen and conductivity) is given below:

5.1.1 Turbidity (Tu)

Continuous and discrete turbidity data were collected in Southern Indian Lake. A statistical summary of turbidity data is provided in Table 3 and graphically shown in Charts C.6, C.7, C.15, C.16, C.23 and C.24.

Table 3: Summary of Discrete and Continuous Turbidity (mg/L) measurements in SIL

Open Water season 2014

Location	Discrete			Continuous		
	Min	Mean	Max	Min	Mean	Max
SIL4-S-01	N/A	N/A	N/A	7	15	27
SIL4-S-02	8	9	9	6	13	20
SIL4-S-10	9	9	10	5	9	13
SIL4-S-13	6	7	7	4	7	11
SIL4-S-22	6	8	10	2	5	13
SIL4-S-24	2	4	7	N/A	N/A	N/A
SIL4-S-28	1	3	6	N/A	N/A	N/A

Winter season 2014

Location	Discrete			Continuous		
	Min	Mean	Max	Min	Mean	Max
SIL4-S-01	19	19	19	14	14	15
SIL4-S-02	6	6	6	3	3	5
SIL4-S-10	N/A	N/A	N/A	1	1	4
SIL4-S-13	5	5	5	3	3	4
SIL4-S-22	6	6	6	N/A	N/A	N/A
SIL4-S-24	5	5	5	N/A	N/A	N/A
SIL4-S-28	5	5	6	N/A	N/A	N/A

Open Water season 2015

Location	Discrete			Continuous		
	Min	Mean	Max	Min	Mean	Max
SIL4-S-01	15	18	23	11	18	26
SIL4-S-02	4	8	11	5	10	14
SIL4-S-10	5	7	9	4	8	31
SIL4-S-13	4	6	8	4	10	25
SIL4-S-22	4	6	11	3	4	6
SIL4-S-24	5	6	7	4	8	28
SIL4-S-28	4	5	6	3	6	13

The following observations were made after reviewing the continuous and discrete turbidity plots:

- SIL4-S-01 displayed higher turbidity values than other sites likely as a consequence of shoreline processes taking place in the surrounding area or sediment re-suspension.
- The turbidity spikes observed at near shore sites including SIL4-S-02, SIL4-S-10 and SIL4-S-24, are attributed to the change in localized conditions triggered by high wind events. These wind events likely caused the spikes by causing shoreline erosion or through re-suspension of fine sediment in shallow waters.
- The winter ice cover reduces the impacts of wind driven erosion, therefore resulting in lower and less variable continuous turbidity values during that period.

- Turbidity levels in SIL area 4 were not correlated to discharges and water levels during the monitoring period. However, data over a longer period of time would be required at varying discharges/levels to draw definitive conclusions on long term correlations.

5.1.2 Temperature (T)

Continuous and discrete temperature data was collected in Southern Indian Lake. A summary of temperature data is provided in Table-4. The water temperature recorded followed the general pattern of air temperature recorded at Missi Falls CS meteorological station (Charts C.8, C.9, C.17, C.18, C.25, and C.26). It was observed that a rapid change in water temperature occurred late in 2014 at site SIL4-S-10; the water temperature dropped 7 degrees in one day at this location.

Table 4: Summary of Discrete and Continuous Temperature (°C) measurements in SIL

Open Water season 2014

Location	Discrete			Continuous		
	Min	Mean	Max	Min	Mean	Max
SIL4-S-01	10	10	10	14	17	21
SIL4-S-02	10	10	10	10	15	19
SIL4-S-10	6	11	17	11	15	21
SIL4-S-13	11	11	11	10	15	20
SIL4-S-22	5	8	12	12	16	19
SIL4-S-24	11	17	20	N/A	N/A	N/A
SIL4-S-28	9	9	9	N/A	N/A	N/A

Winter season 2014

Location	Discrete			Continuous		
	Min	Mean	Max	Min	Mean	Max
SIL4-S-01	0	0	0	0	0	0
SIL4-S-02	0	0	1	0	0	0
SIL4-S-10	0	0	0	0	0	0
SIL4-S-13	0	0	0	0	0	0
SIL4-S-22	0	1	2	N/A	N/A	N/A
SIL4-S-24	0	0	0	N/A	N/A	N/A
SIL4-S-28	0	0	1	N/A	N/A	N/A

Open Water season 2015

Location	Discrete			Continuous		
	Min	Mean	Max	Min	Mean	Max
SIL4-S-01	10	14	18	10	15	19
SIL4-S-02	9	13	16	10	14	17
SIL4-S-10	6	13	17	6	14	18
SIL4-S-13	7	13	17	N/A	N/A	N/A
SIL4-S-22	5	11	14	7	13	17
SIL4-S-24	7	12	15	7	13	18
SIL4-S-28	8	11	14	8	14	18

Temperature profile readings were also noted at all monitoring stations in September 2015; however, a conclusive statement about the thermal stratification in Southern Indian Lake could not be made at this moment, because much of that data did not pass the quality control test. The available good data indicates weak to no thermal stratification present during the monitoring times (Chart C.31).

5.1.3 Conductivity (Co)

Continuous and discrete conductivity data was collected in Southern Indian Lake. A summary of conductivity data is provided in Table 5. The continuous water conductivity at all sites ranged from 78 to 116 µS/cm, except at SIL4-S-10 during open water season of 2014, when the conductivity range was recorded as 109 to 134 µS/cm. No cause of this anomaly could be determined. In general, continuous conductivity plots for all sites were very close to each other and followed the variation pattern of temperature plots (Charts C.10, C.11, C.19, C.20, C.27, and C.28).

Table 5: Summary of Discrete and Continuous Conductivity (µS/cm) measurements in SIL

Open Water season 2014

Location	Discrete			Continuous		
	Min	Mean	Max	Min	Mean	Max
SIL4-S-01	95	95	95	93	101	110
SIL4-S-02	96	96	96	83	96	103
SIL4-S-10	78	90	108	109	121	134
SIL4-S-13	107	107	107	90	100	108
SIL4-S-22	93	93	93	94	104	113
SIL4-S-24	N/A	N/A	N/A	N/A	N/A	N/A
SIL4-S-28	100	100	100	N/A	N/A	N/A

Winter season 2014

Location	Discrete			Continuous		
	Min	Mean	Max	Min	Mean	Max
SIL4-S-01	75	75	75	75	81	86
SIL4-S-02	82	83	84	85	87	88
SIL4-S-10	85	85	86	82	85	88
SIL4-S-13	N/A	N/A	N/A	85	86	87
SIL4-S-22	71	81	89	N/A	N/A	N/A
SIL4-S-24	74	79	82	N/A	N/A	N/A
SIL4-S-28	78	81	84	N/A	N/A	N/A

Open Water season 2015

Location	Discrete			Continuous		
	Min	Mean	Max	Min	Mean	Max
SIL4-S-01	94	99	107	88	101	111
SIL4-S-02	82	97	104	86	100	108
SIL4-S-10	78	98	107	78	99	109
SIL4-S-13	83	98	105	N/A	N/A	N/A
SIL4-S-22	75	92	100	78	103	116
SIL4-S-24	83	96	104	84	99	110
SIL4-S-28	78	89	98	78	96	105

5.1.4 Dissolved Oxygen (DO)

The Dissolved Oxygen data is only available for the open water season of 2014. In other monitoring seasons, the data was either not measured or was lost due to technical challenges.

The discrete DO values ranged between 10.3 and 12.4 mg/L (Chart C.12). A summary of DO data at select locations is provided in Table 6.

Table 6: Summary of Discrete and Continuous Dissolved Oxygen (mg/L) measurements in SIL

Open Water season 2014

Location	Discrete			Continuous		
	Min	Mean	Max	Min	Mean	Max
SIL4-S-01	10.3	10.3	10.4	N/A	N/A	N/A
SIL4-S-02	N/A	N/A	N/A	N/A	N/A	N/A
SIL4-S-10	N/A	N/A	N/A	N/A	N/A	N/A
SIL4-S-13	N/A	N/A	N/A	N/A	N/A	N/A
SIL4-S-22	11.0	11.9	12.4	N/A	N/A	N/A
SIL4-S-24	10.9	11.0	11.1	N/A	N/A	N/A
SIL4-S-28	10.5	10.6	10.7	N/A	N/A	N/A

5.2 Sediment Data

Water samples were collected at all monitoring locations during the field visits and sent to the laboratory to determine the TSS concentration and their grain size distribution. At each site, duplicate samples were collected at 0.3 and 0.6 depths following standard protocols.

Water samples collected at all monitoring sites during open water seasons of 2014 and 2015 and those gathered at seven monitoring sites (locations of continuous monitoring) during 2014 winter season were analyzed in laboratory for above mentioned parameters.

5.2.1 Total Suspended Sediments (TSS)

In general, the TSS concentration in Southern Indian Lake remained less than 10 mg/L during the open water seasons and less than 6 mg/L in the winter season, with an exception of two sites, namely SIL4-S-01 and SIL4-S-30 (Charts C.13, C.21, and C.29). The higher TSS at these sites is consistent with higher turbidity values measured at the sampling time (Charts C.7, C.16, and C.24).

A summary of TSS concentration is provided in Table 7.

Table 7: Summary of Total Suspended Sediments concentration (mg/L) at selected sites in SIL

Open Water season 2014

Location	Min[1]	Mean	Max
SIL4-S-01	<2	7	16
SIL4-S-02	<2	4	5
SIL4-S-10	<2	3	4
SIL4-S-13	<2	2	4
SIL4-S-22	<2	4	9
SIL4-S-24	<2	3	5
SIL4-S-28	<2	4	6
SIL4-All Sites	<2	3	16

Winter season 2014

Location	Min	Mean	Max
SIL4-S-01	3	5	9
SIL4-S-02	<2	4	7
SIL4-S-10	<2	4	10
SIL4-S-13	<2	3	6
SIL4-S-22	<2	3	7
SIL4-S-24	<2	3	<2
SIL4-S-28	<2	3	5
SIL4-All Sites	<2	3	10

Open Water season 2015

Location	Min	Mean	Max
SIL4-S-01	4	8	12
SIL4-S-02	3	5	9
SIL4-S-10	3	4	5
SIL4-S-13	<2	3	5
SIL4-S-22	<2	4	7
SIL4-S-24	3	4	5
SIL4-S-28	4	5	8
SIL4-All Sites	<2	4	12

[1]The TSS values are rounded up to the next integer

5.2.2 Particle Size Distribution

The average particle size distribution of the suspended sediments present in the water samples collected at each monitoring site during field monitoring is included in this report. (Charts C.14, C.22, and C.30). The analysis indicated that the suspended sediments comprised silt with traces of clay and very fine sand.

A summary of average particle size distribution by monitoring season is provided in Tables 8, 9 and 10.

Table 8: Average Particle Size Distribution of Total Suspended Solids in SIL during 2014 open water season

Location	% finer by Particle Ratio						
	0.064	0.032	0.016	0.008	0.004	0.002	0.001
SIL4-S-01	97.3	83.8	66.2	34.5	12.2	1.6	0.0
SIL4-S-02	95.0	83.9	66.1	25.9	8.9	1.3	0.0
SIL4-S-03	100.0	100.0	78.6	35.1	11.8	1.5	0.0
SIL4-S-04	100.0	80.3	62.6	28.3	9.1	1.3	0.0
SIL4-S-05	100.0	84.5	60.4	30.3	10.3	1.4	0.0
SIL4-S-06	100.0	95.7	68.2	32.2	11.0	1.3	0.0
SIL4-S-07	92.8	75.9	64.7	32.9	11.8	1.6	0.0
SIL4-S-08	100.0	93.3	78.0	33.3	10.3	1.4	0.0
SIL4-S-09	100.0	83.4	69.0	32.9	10.2	1.3	0.0
SIL4-S-10	97.2	90.8	67.4	32.7	9.7	1.1	0.0
SIL4-S-11	100.0	88.1	81.1	38.9	12.5	1.6	0.0
SIL4-S-12	100.0	87.3	74.3	36.7	12.6	1.6	0.0
SIL4-S-13	100.0	86.6	69.7	37.7	13.0	1.7	0.0
SIL4-S-14	100.0	79.8	61.0	27.2	7.7	0.8	0.0
SIL4-S-15	100.0	82.9	70.7	36.6	10.3	1.2	0.0
SIL4-S-16	100.0	88.9	68.5	33.5	11.0	1.6	0.0
SIL4-S-17	92.3	78.7	66.2	32.2	10.6	1.4	0.0
SIL4-S-18	87.8	84.7	67.0	31.7	9.0	1.2	0.0
SIL4-S-19	93.0	75.4	49.2	23.7	7.7	1.0	0.0
SIL4-S-20	100.0	87.1	55.0	29.5	8.4	1.0	0.0
SIL4-S-22	94.3	87.0	62.4	32.6	10.7	1.4	0.0
SIL4-S-23	100.0	77.1	59.0	33.4	10.6	1.5	0.0

Location	% finer by Particle Ratio						
	0.064	0.032	0.016	0.008	0.004	0.002	0.001
SIL4-S-24	100.0	87.0	71.0	36.4	10.7	1.4	0.0
SIL4-S-25	93.8	74.3	60.4	31.6	10.0	1.1	0.0
SIL4-S-26	94.3	92.1	77.6	39.7	12.7	1.6	0.0
SIL4-S-27	100.0	85.8	67.3	35.2	11.5	1.4	0.0
SIL4-S-28	100.0	84.6	70.3	36.5	13.5	1.8	0.0
SIL4-S-29	88.8	68.3	46.0	20.3	5.0	0.6	0.0

Table 9: Average Particle Size Distribution of Total Suspended Solids in SIL during 2014 winter season

Location	% finer by Particle Ratio						
	0.064	0.032	0.016	0.008	0.004	0.002	0.001
SIL4-S-01	100.0	66.7	59.3	18.2	4.5	0.6	0.0
SIL4-S-02	100.0	83.5	63.2	22.8	6.9	1.0	0.0
SIL4-S-10	93.9	50.3	33.1	14.3	4.7	0.7	0.0
SIL4-S-13	93.1	49.0	26.1	7.1	1.4	0.2	0.0
SIL4-S-22	100.0	80.2	47.6	18.7	5.5	0.8	0.0
SIL4-S-24	85.3	61.9	39.6	13.0	3.0	0.3	0.0
SIL4-S-28	91.1	84.5	46.8	16.8	4.3	0.6	0.0

Table 10: Average Particle Size Distribution of Total Suspended Solids in SIL during 2015 open water season

Location	% finer by Particle Ratio						
	0.064	0.032	0.016	0.008	0.004	0.002	0.001
SIL4-S-01	100.0	72.5	55.2	31.4	10.0	0.9	0.0
SIL4-S-02	85.6	67.6	40.8	22.8	7.7	0.6	0.0
SIL4-S-03	85.9	64.0	46.3	23.7	6.1	0.5	0.0
SIL4-S-04	82.9	49.6	41.1	22.1	6.4	0.5	0.0
SIL4-S-05	76.3	48.1	32.8	17.7	5.0	0.3	0.0
SIL4-S-06	90.5	58.8	36.9	18.8	5.1	0.4	0.0
SIL4-S-07	70.9	52.0	33.2	17.4	4.9	0.4	0.0
SIL4-S-08	88.8	53.2	32.1	16.1	4.4	0.3	0.0
SIL4-S-09	94.4	71.8	47.7	26.6	7.4	0.6	0.0
SIL4-S-10	90.7	48.0	29.0	14.3	3.5	0.3	0.0

Location	% finer by Particle Ratio						
	0.064	0.032	0.016	0.008	0.004	0.002	0.001
SIL4-S-11	83.4	44.8	28.2	15.1	4.2	0.3	0.0
SIL4-S-12	85.1	41.6	25.3	12.6	3.3	0.3	0.0
SIL4-S-13	93.0	58.3	35.5	16.7	4.3	0.4	0.0
SIL4-S-14	85.6	57.2	33.1	17.1	4.3	0.4	0.0
SIL4-S-15	86.9	54.7	35.2	18.7	4.9	0.4	0.0
SIL4-S-16	81.6	64.7	48.4	24.9	6.6	0.5	0.0
SIL4-S-17	94.5	56.2	37.9	19.8	5.2	0.4	0.0
SIL4-S-18	82.1	54.0	35.9	18.1	5.1	0.4	0.0
SIL4-S-19	84.4	50.7	32.1	16.0	4.5	0.4	0.0
SIL4-S-20	80.3	54.7	31.9	16.0	4.6	0.4	0.0
SIL4-S-21	88.2	48.2	29.2	15.3	3.9	0.3	0.0
SIL4-S-22	80.2	53.4	30.7	14.8	3.5	0.3	0.0
SIL4-S-23	79.6	54.7	39.6	20.2	5.0	0.4	0.0
SIL4-S-24	76.2	49.9	32.4	14.4	3.2	0.2	0.0
SIL4-S-25	85.1	53.4	35.2	18.1	5.0	0.4	0.0
SIL4-S-26	80.2	51.0	28.3	14.0	3.7	0.3	0.0
SIL4-S-27	87.9	49.4	31.5	15.3	4.4	0.4	0.0
SIL4-S-28	95.5	50.1	29.9	12.0	2.6	0.2	0.0
SIL4-S-29	92.5	58.7	32.7	16.1	4.3	0.4	0.0
SIL4-S-30	90.2	54.0	33.0	14.8	3.1	0.2	0.0

6.0 SUMMARY

Water quality and sediment data were collected in SIL in 2014 and 2015 at 29 sites throughout Area 4. The following is a summary of the main observations:

- Turbidity and TSS were highest at site SIL4-S-10 and similar between the other sites
- Water temperature was observed to change rapidly at several sites correlated to large changes in air temperature
- The concentration of suspended sediment at monitoring stations in SIL ranged from below detection (<2mg/L) to a maximum value of 16 mg/L with most concentrations below 10 mg/L in open water periods and 6 mg/L in winter.
- The suspended sediments mainly contained silt fraction with a small fraction of clay and very fine sand.
- A review of turbidity in relation to the climate data suggests a strong relationship between turbidity and wind events.
- Data over a longer period of time would be required at varying discharges/levels to draw definitive conclusions on long term correlations between water levels and suspended sediment concentrations.

7.0 APPENDIX A - Charts

Chart C.1
Southern Indian Lake
2014-15 Sedimentation and Water Quality Monitoring Report
SIL Inflow, Outflows and Water Level during open water monitoring season 2014

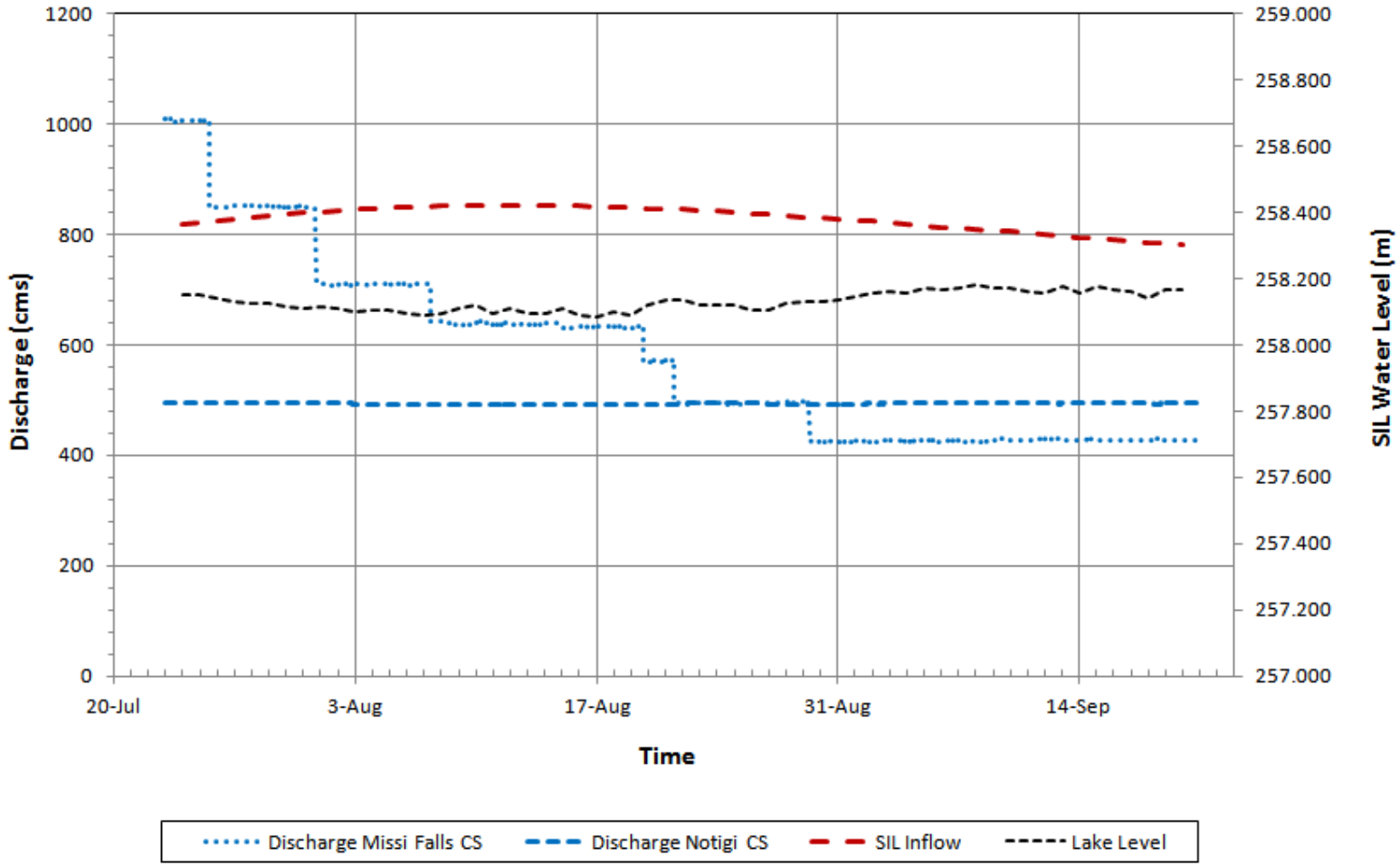


Chart C.2
Southern Indian Lake
2014-15 Sedimentation and Water Quality Monitoring Report
SIL Inflow, Outflows and Water Level during Winter monitoring season 2014

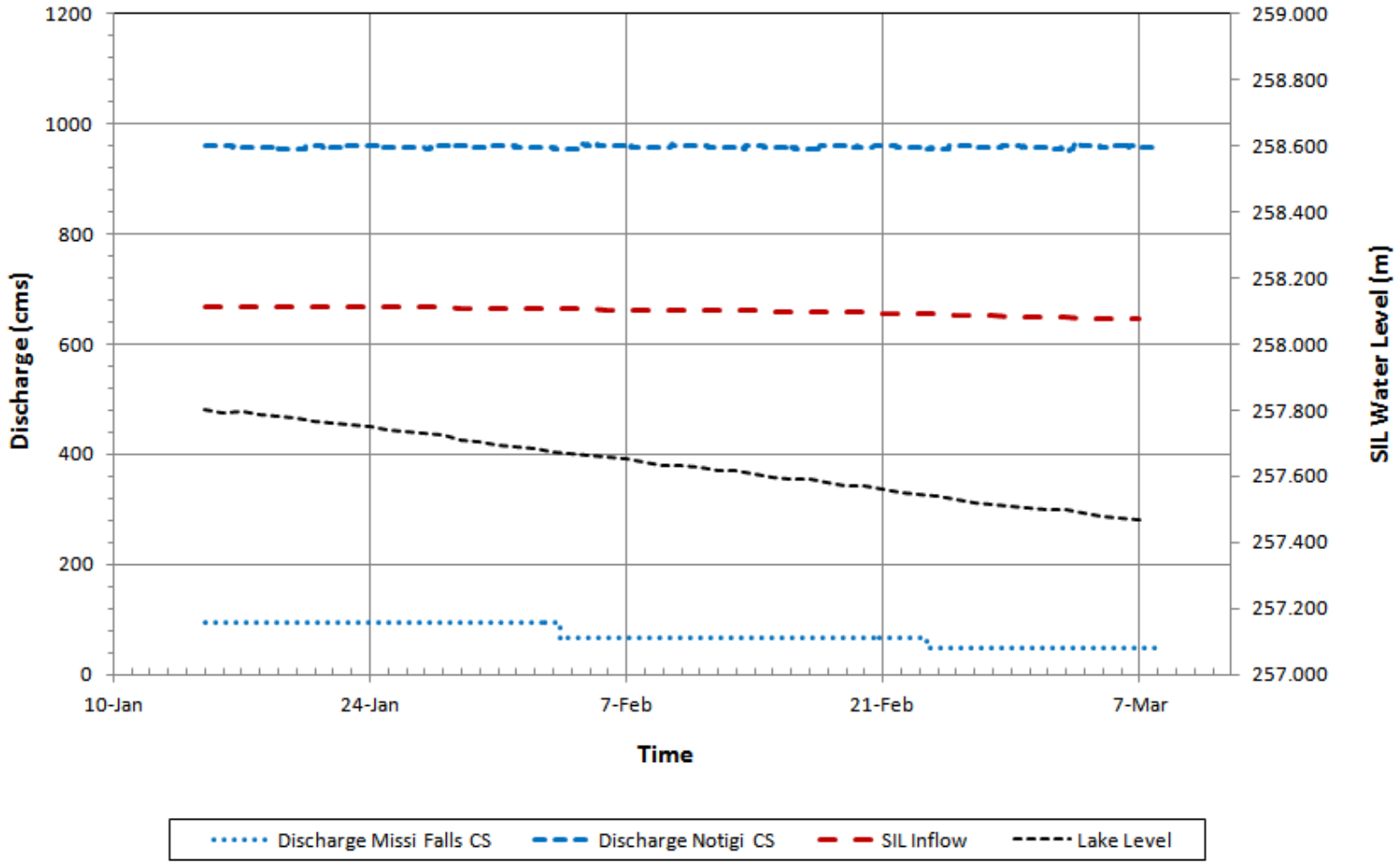


Chart C.3
Southern Indian Lake
2014-15 Sedimentation and Water Quality Monitoring Report
SIL Outflows and Water Level during open water monitoring season 2015

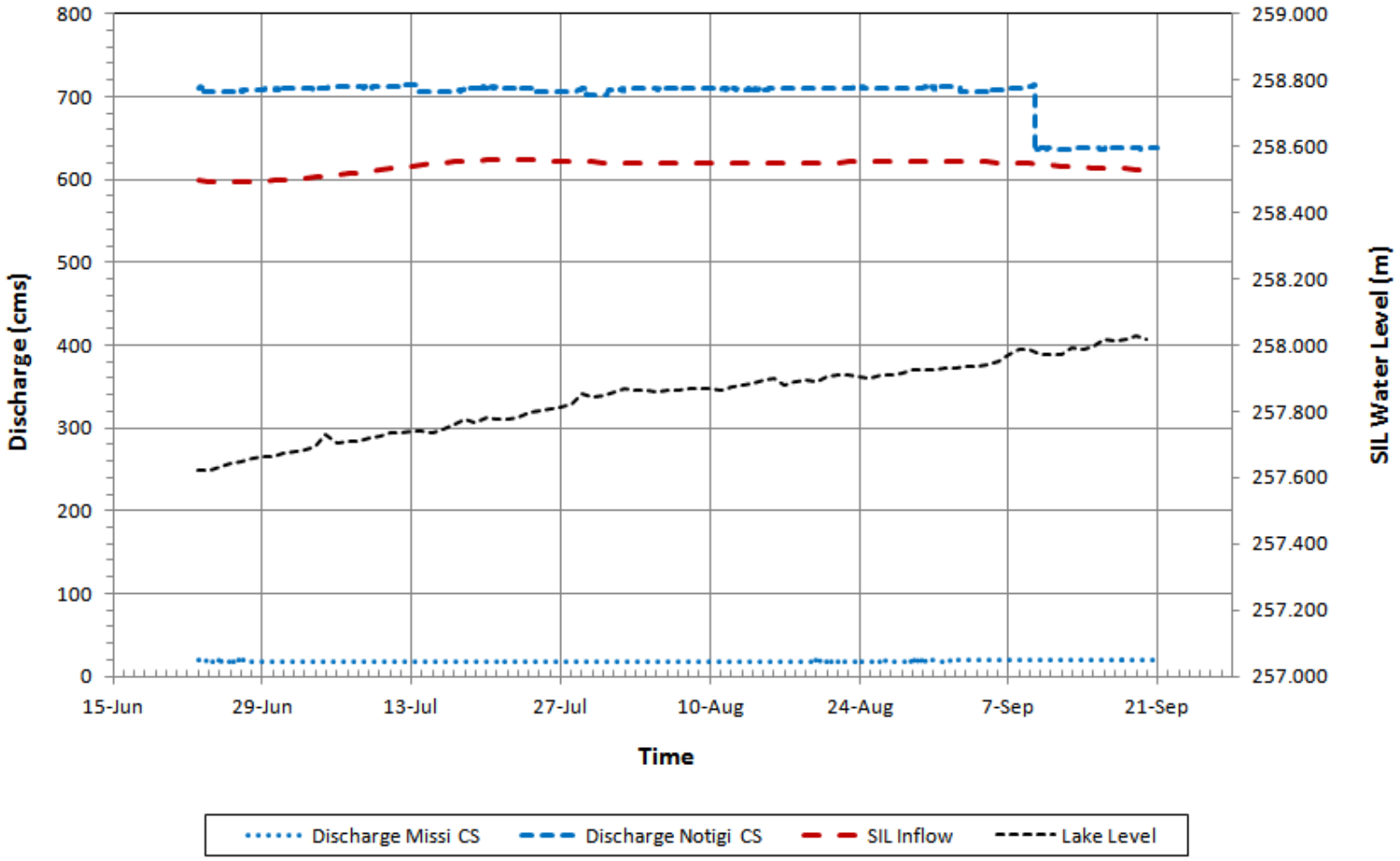


Chart C.4
Southern Indian Lake
2014-15 Sedimentation and Water Quality Monitoring Report
SIL Wind speed and direction during open water monitoring season 2014

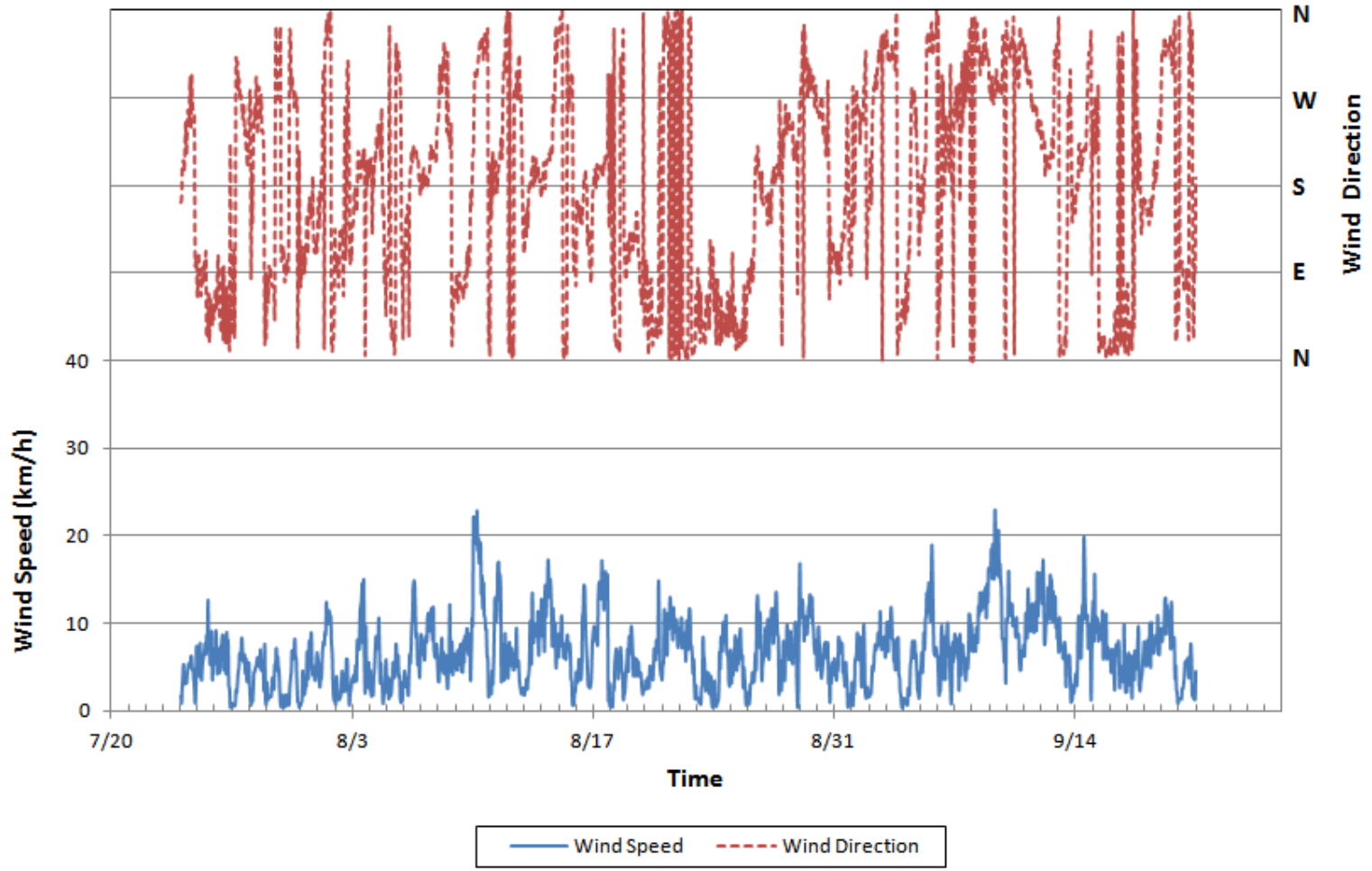


Chart C.5
Southern Indian Lake
2014-15 Sedimentation and Water Quality Monitoring Report
SIL Wind speed and direction during open water monitoring season 2015

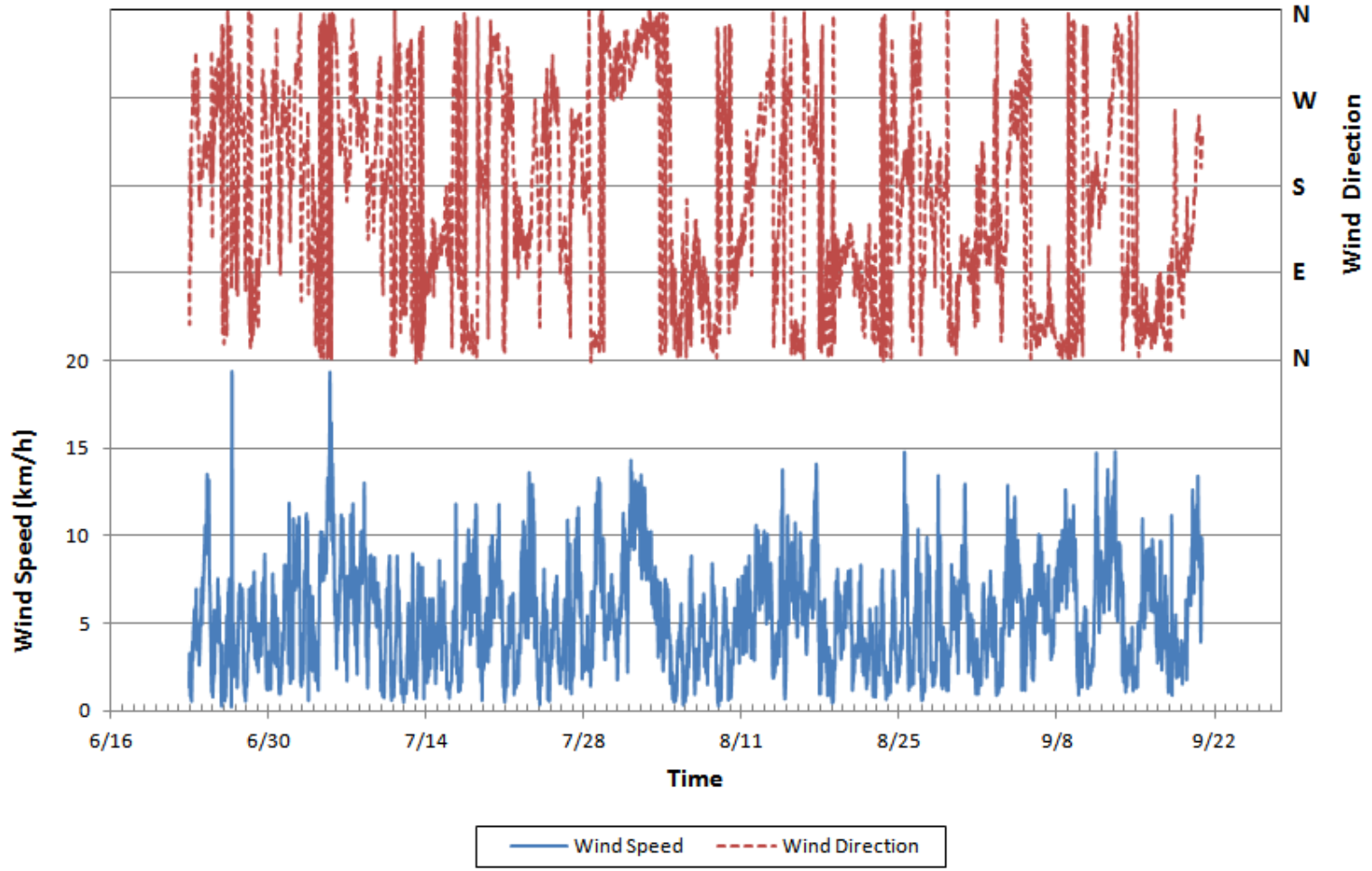


Chart C.6
Southern Indian Lake
2014-15 Sedimentation and Water Quality Monitoring Report
Water Turbidity at contiuous logger sites during Open water season 2014

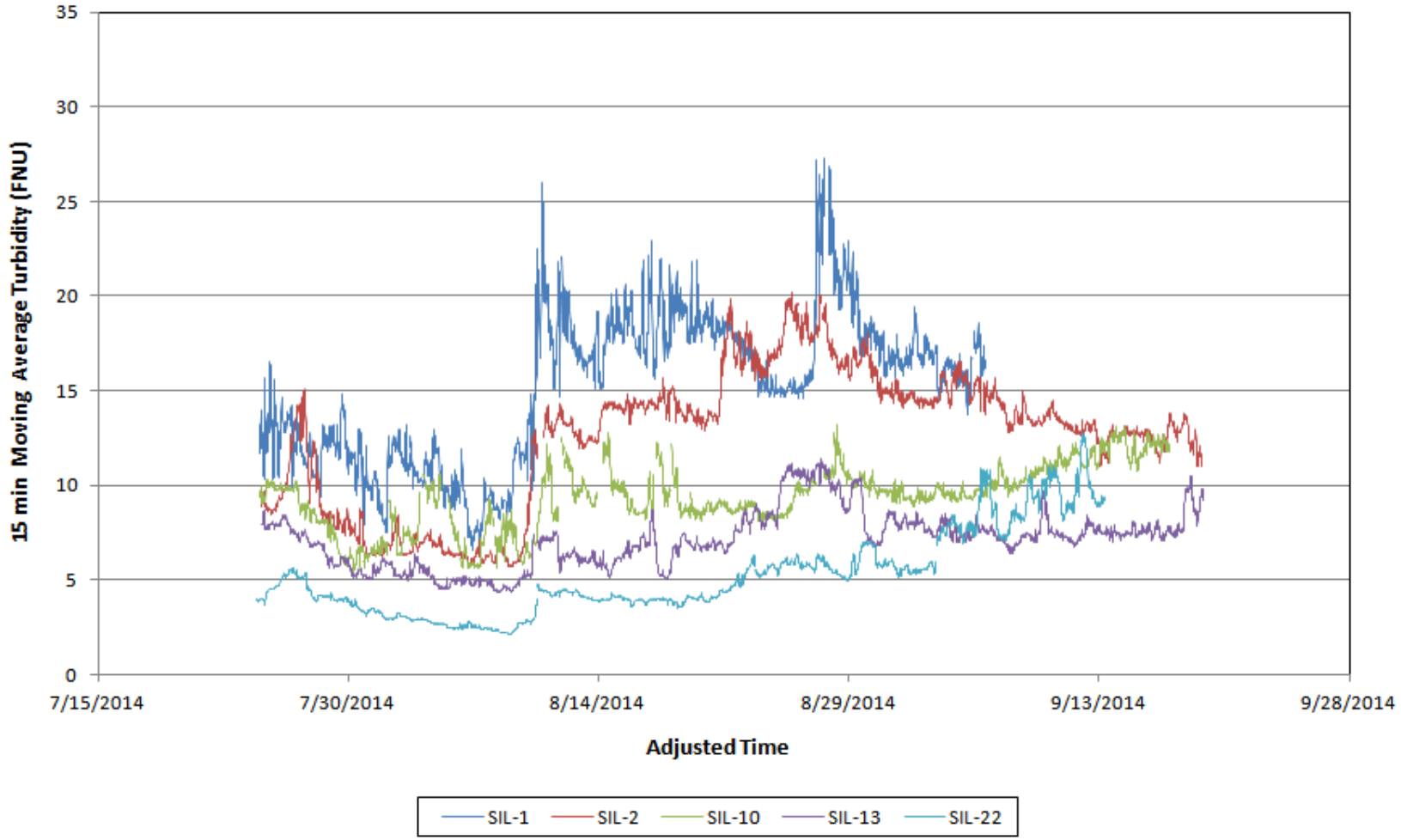


Chart C.7
Southern Indian Lake
2014-15 Sedimentation and Water Quality Monitoring Report
Water Turbidity by site during Open water season 2014

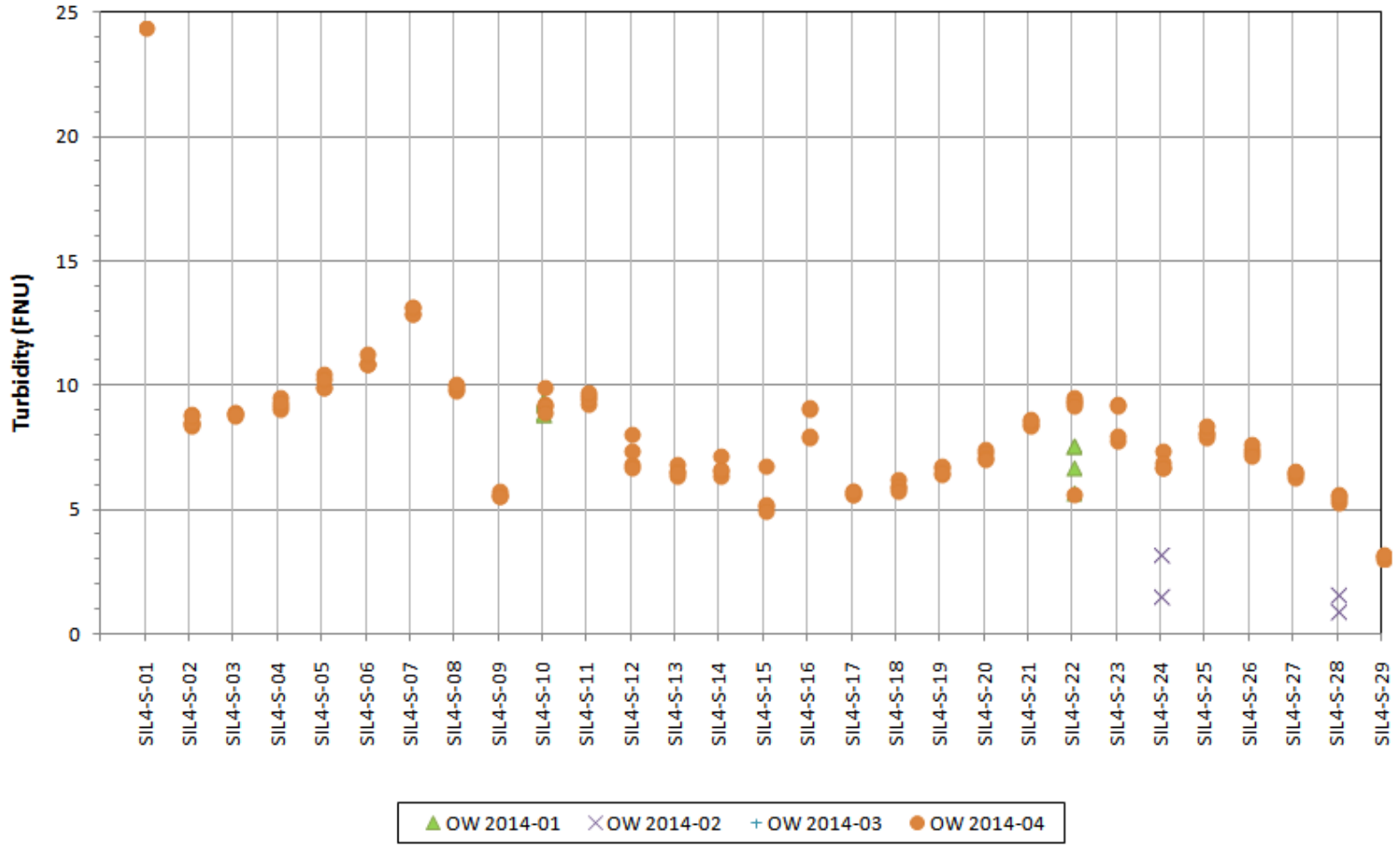


Chart C.8
Southern Indian Lake
2014-15 Sedimentation and Water Quality Monitoring Report
Water Temperature at contiuous logger sites during Open water season 2014

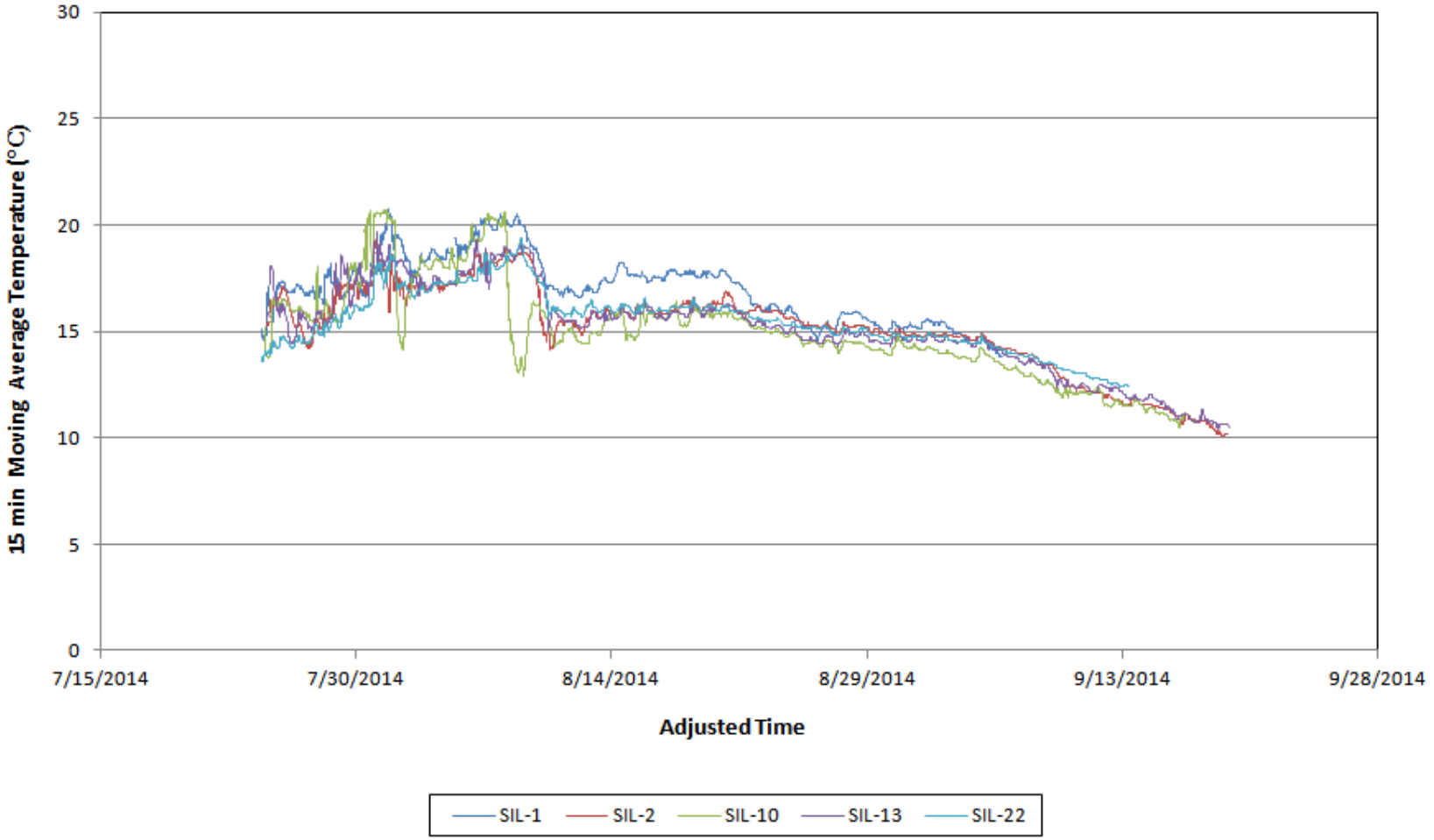


Chart C.9
Southern Indian Lake
2014-15 Sedimentation and Water Quality Monitoring Report
Water Temperature by site during Open water season 2014

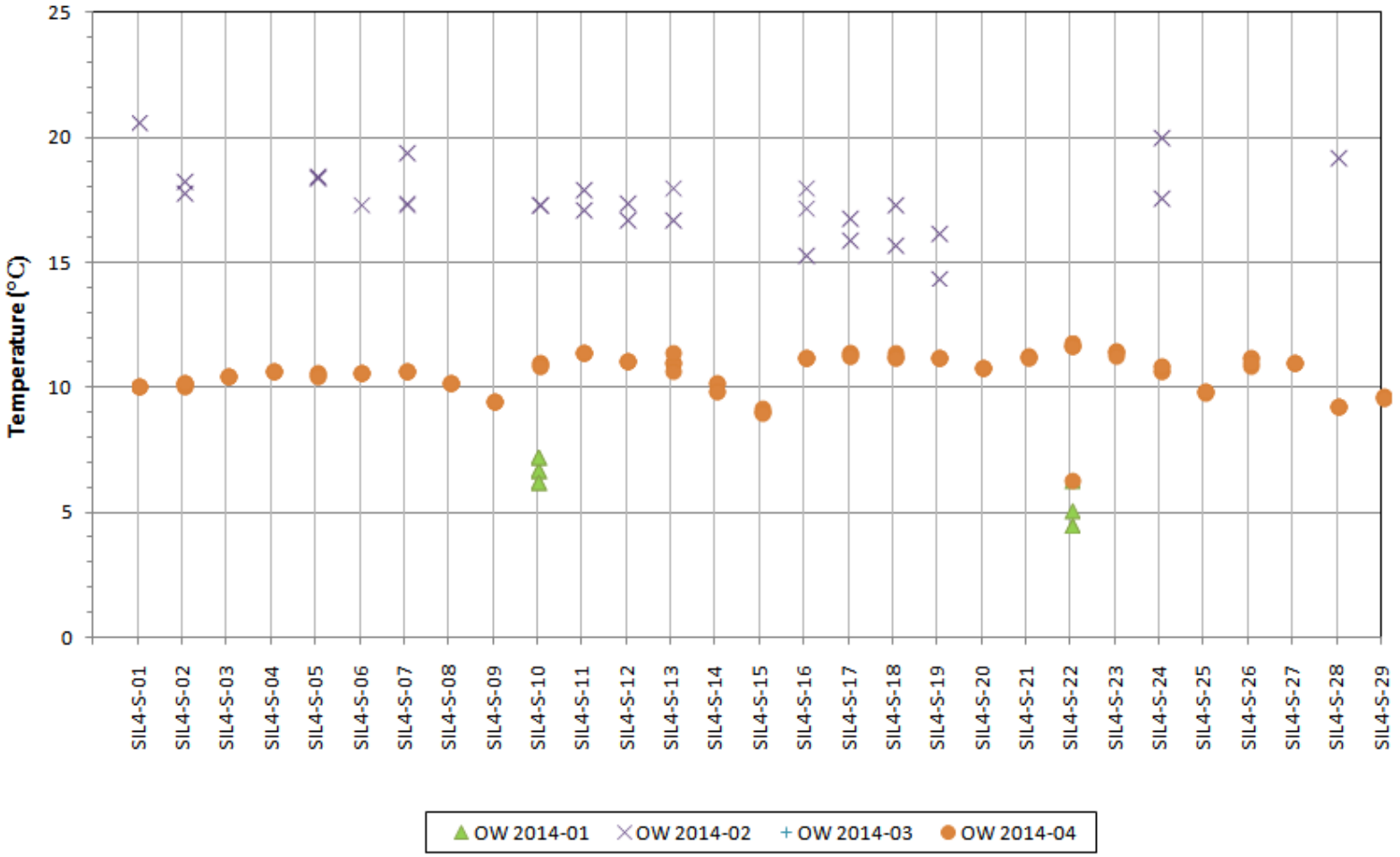


Chart C.10
Southern Indian Lake
2014-15 Sedimentation and Water Quality Monitoring Report
Water Conductivity at contiuous logger sites during Open water season 2014

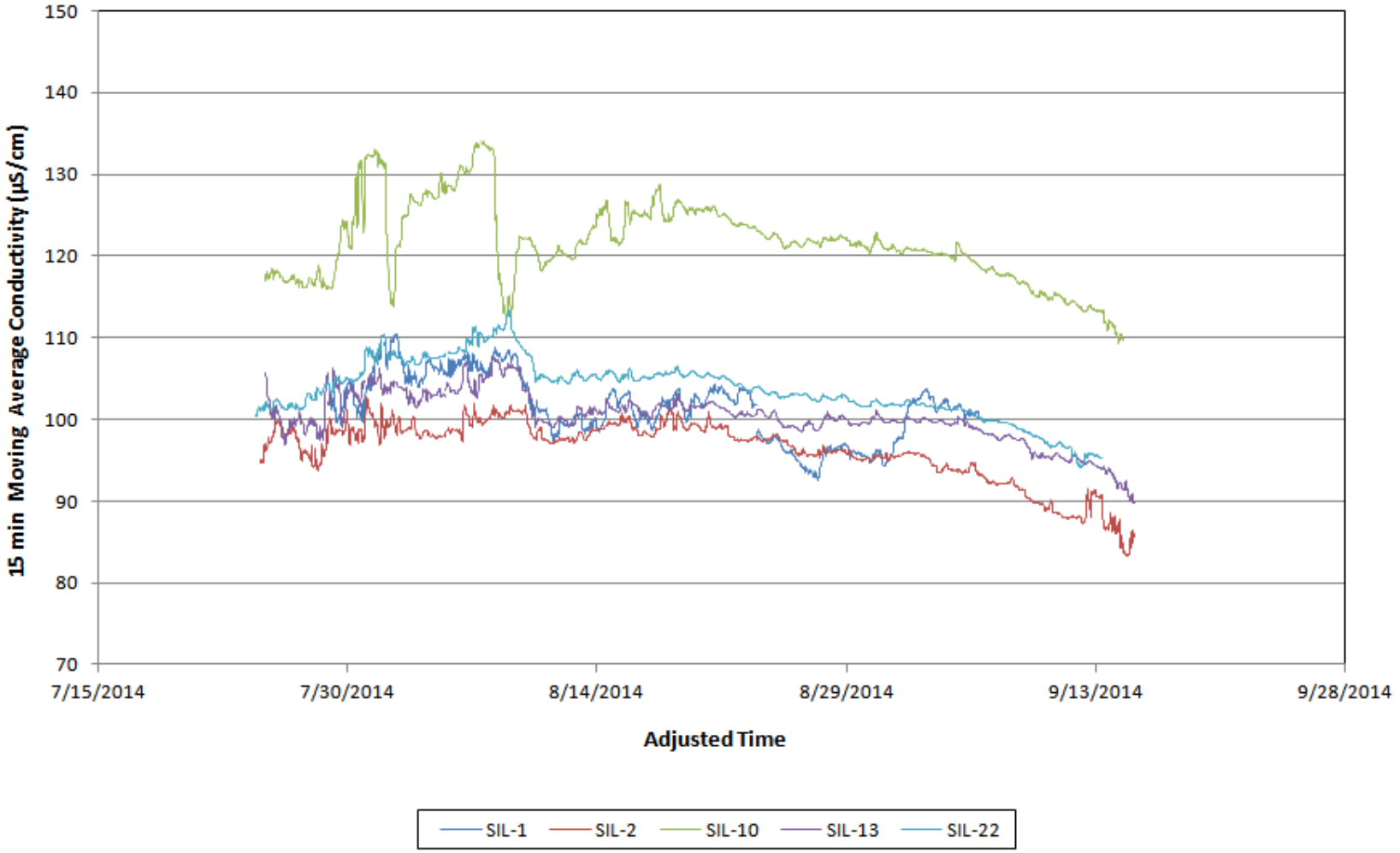


Chart C.11
Southern Indian Lake
2014-15 Sedimentation and Water Quality Monitoring Report
Water Conductivity by site during Open water season 2014

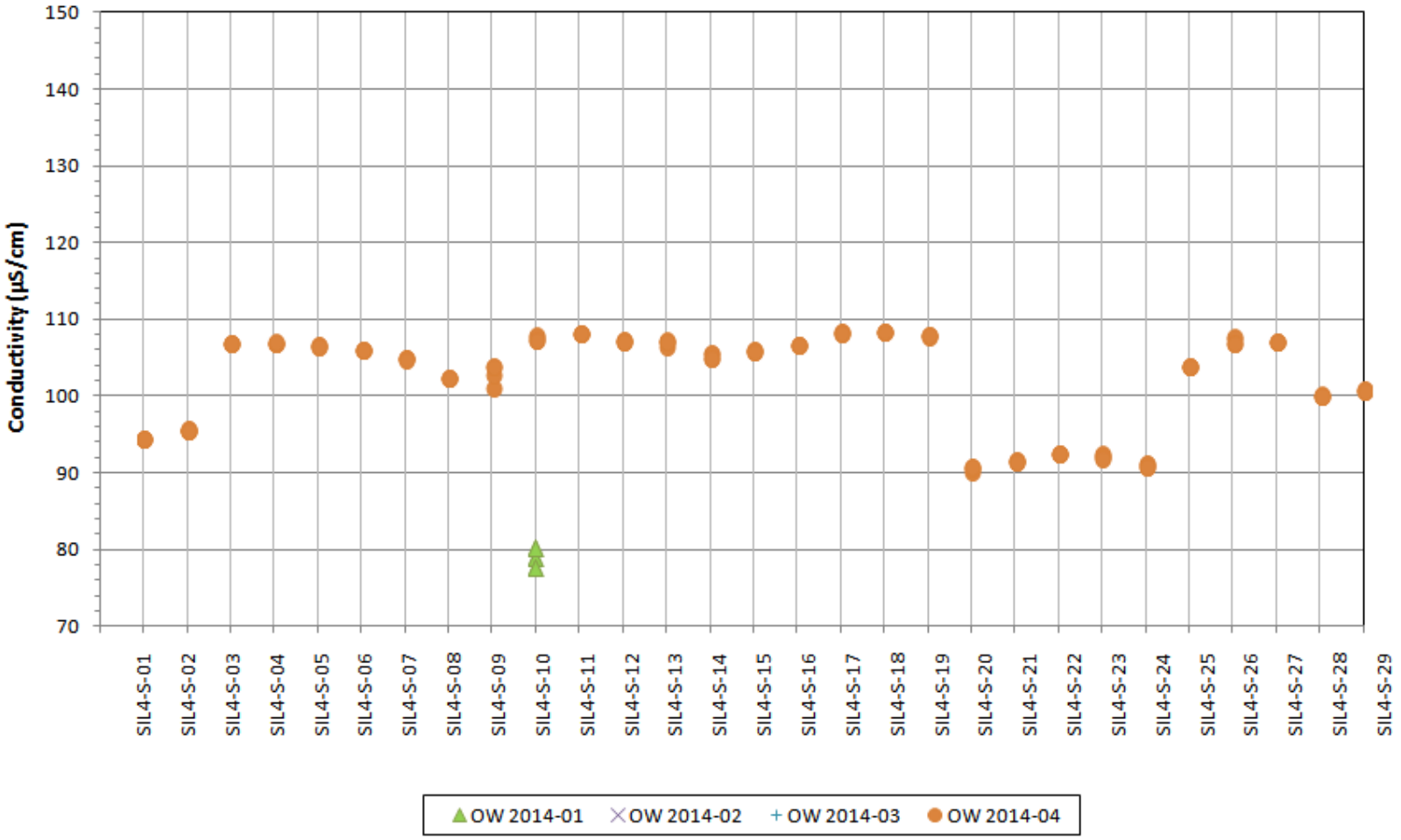


Chart C.12
Southern Indian Lake
2014-15 Sedimentation and Water Quality Monitoring Report
Dissolved Oxygen by site during Open water season 2014

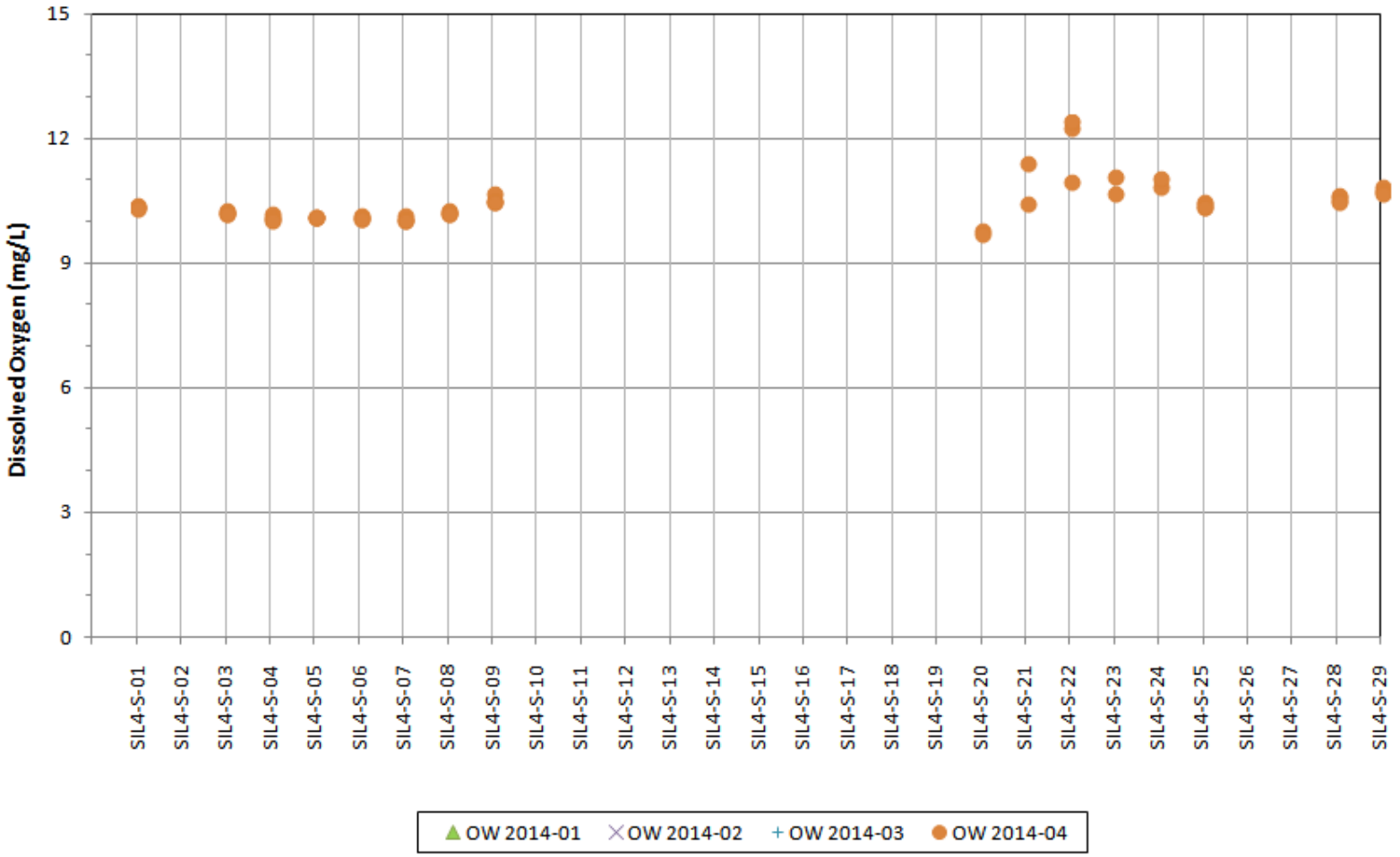


Chart C.13
Southern Indian Lake
2014-15 Sedimentation and Water Quality Monitoring Report
Total Suspended Solids by site during Open water season 2014

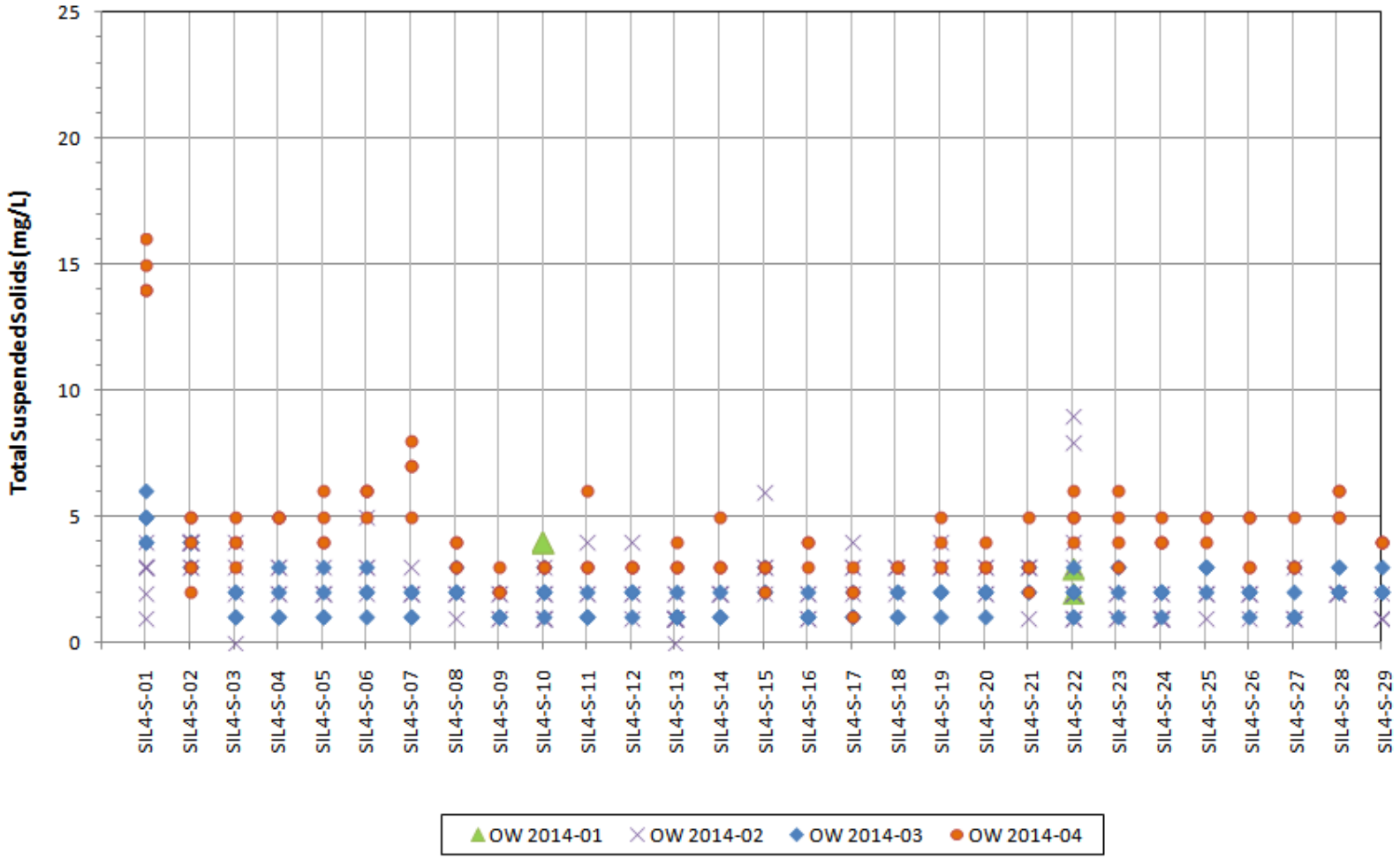


Chart C.14
Southern Indian Lake
2014-15 Sedimentation and Water Quality Monitoring Report
Average Grain Size Distribution of Total Suspended Solids by site during Open water season 2014

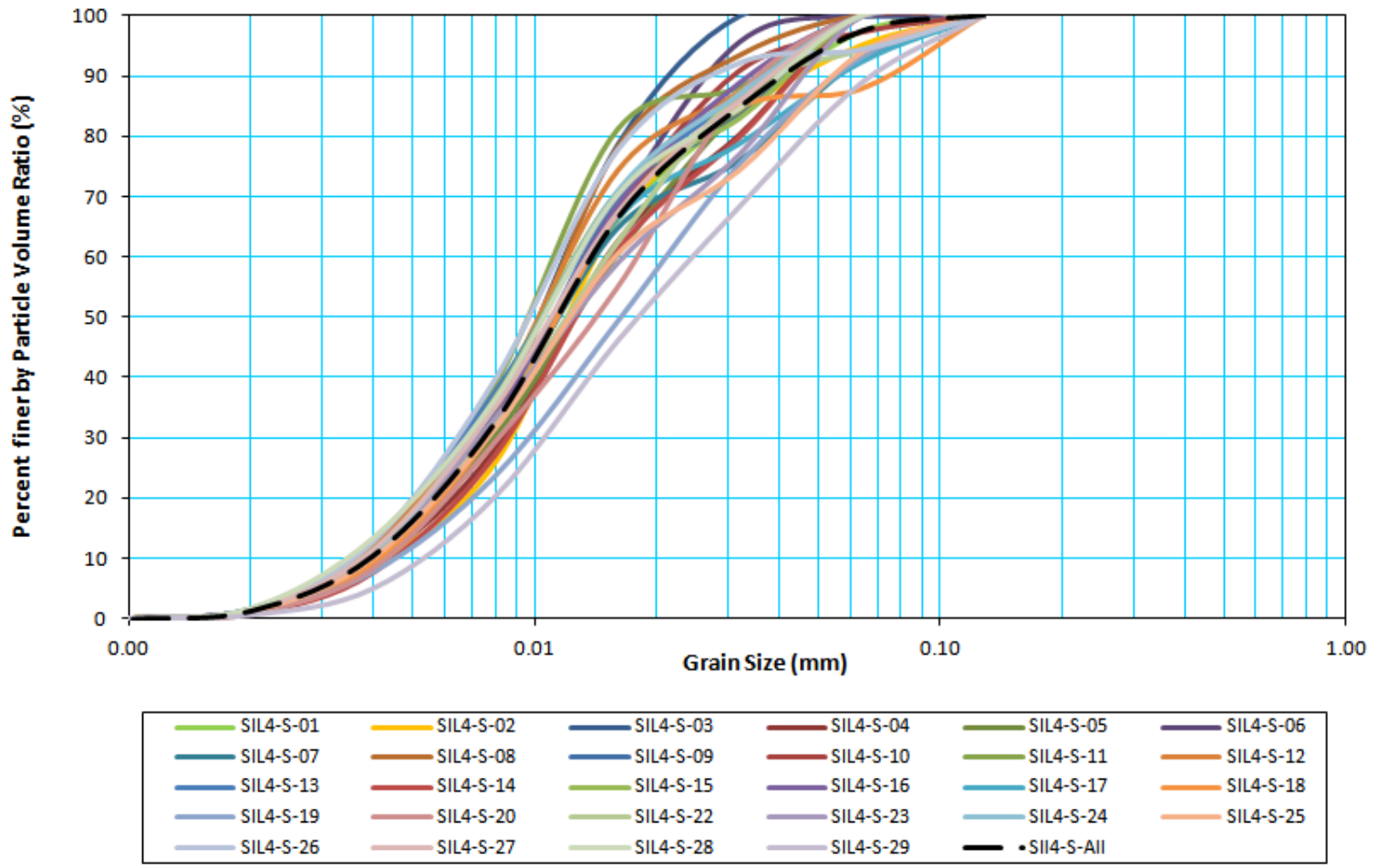


Chart C.15
Southern Indian Lake
2014-15 Sedimentation and Water Quality Monitoring Report
Water Turbidity at contiuous logger sites during Winter season 2014

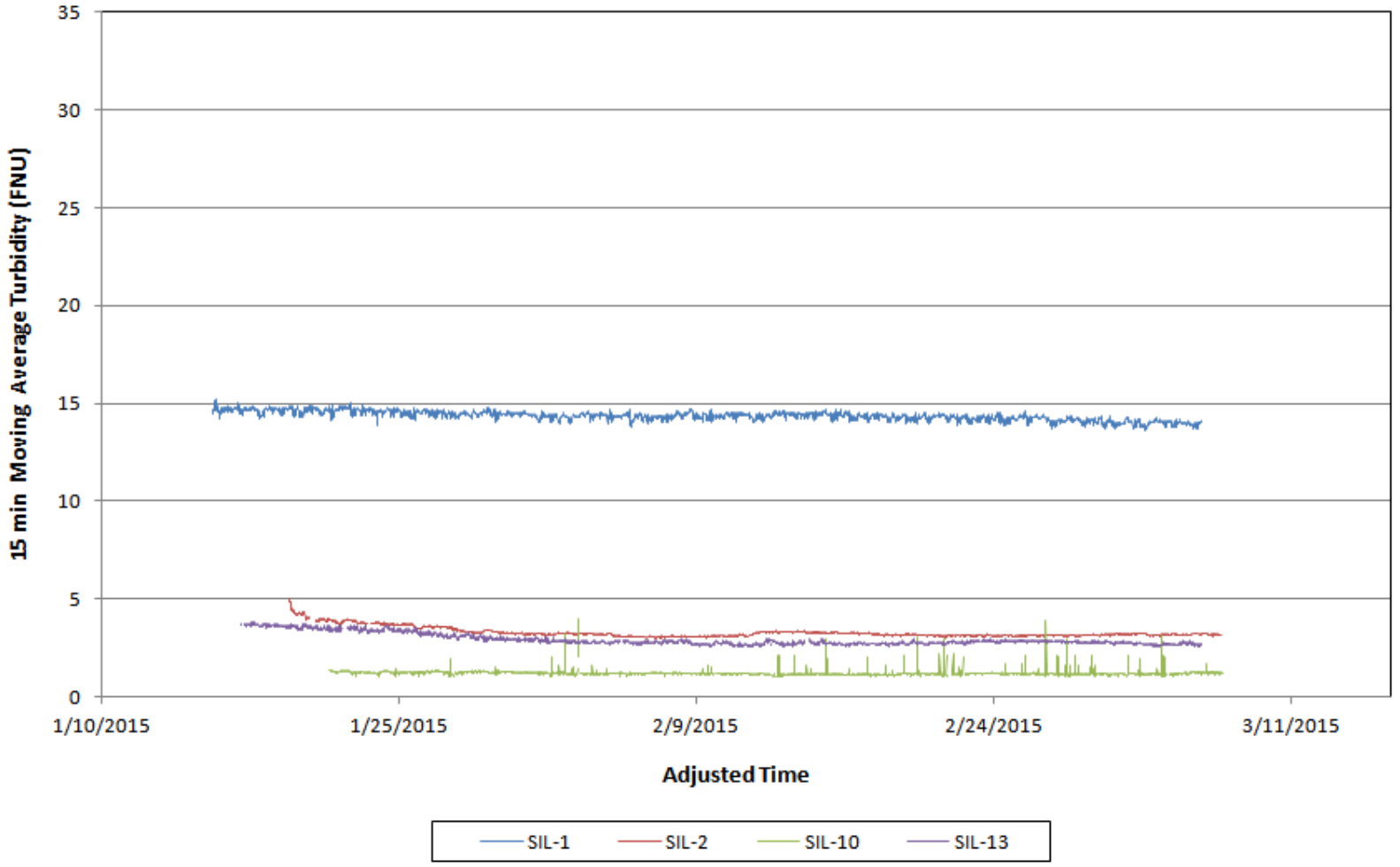


Chart C.16
Southern Indian Lake
2014-15 Sedimentation and Water Quality Monitoring Report
Water Turbidity by site during Winter 2014-15

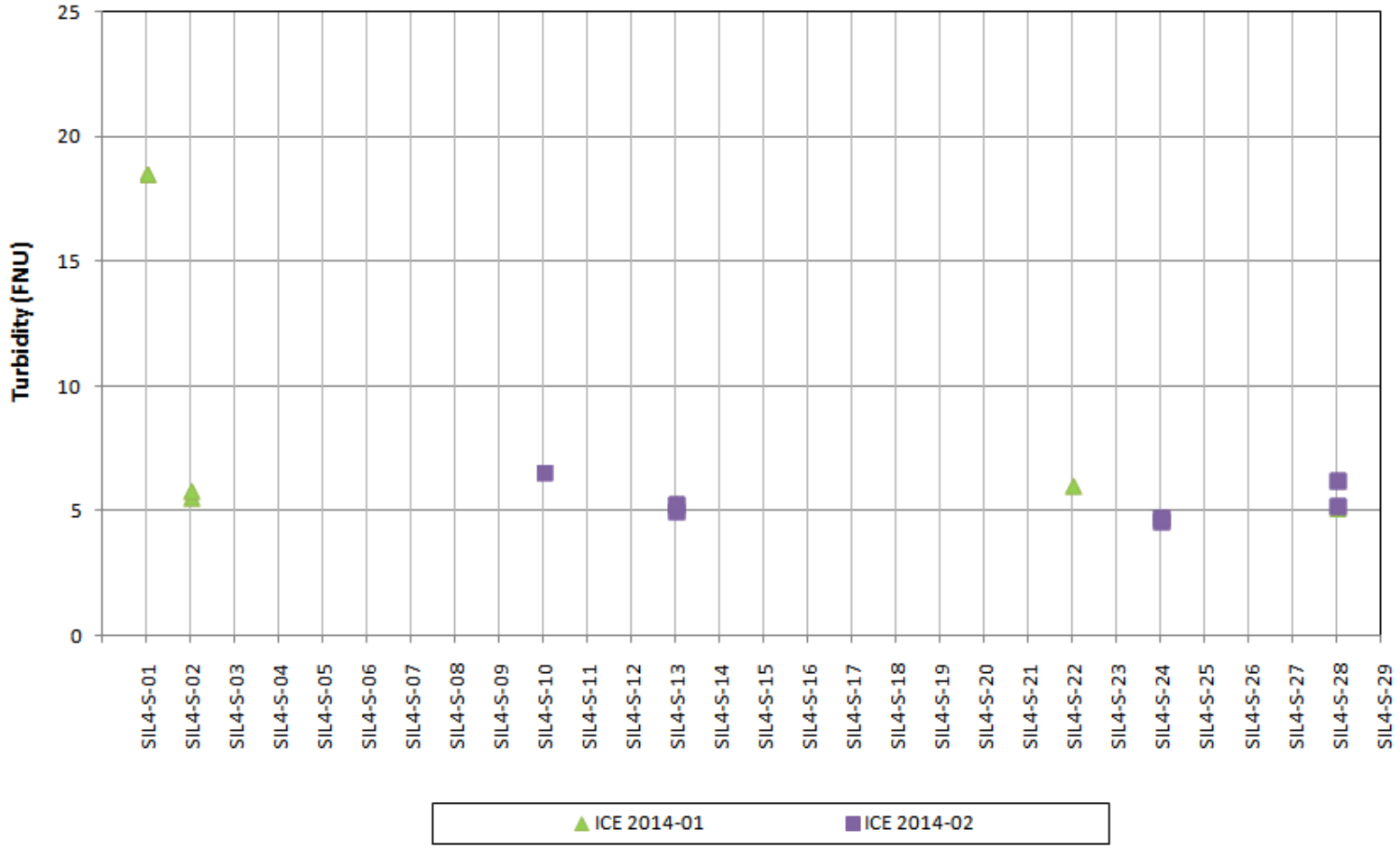


Chart C.17
Southern Indian Lake
2014-15 Sedimentation and Water Quality Monitoring Report
Water Temperature at contiuous logger sites during Winter season 2014

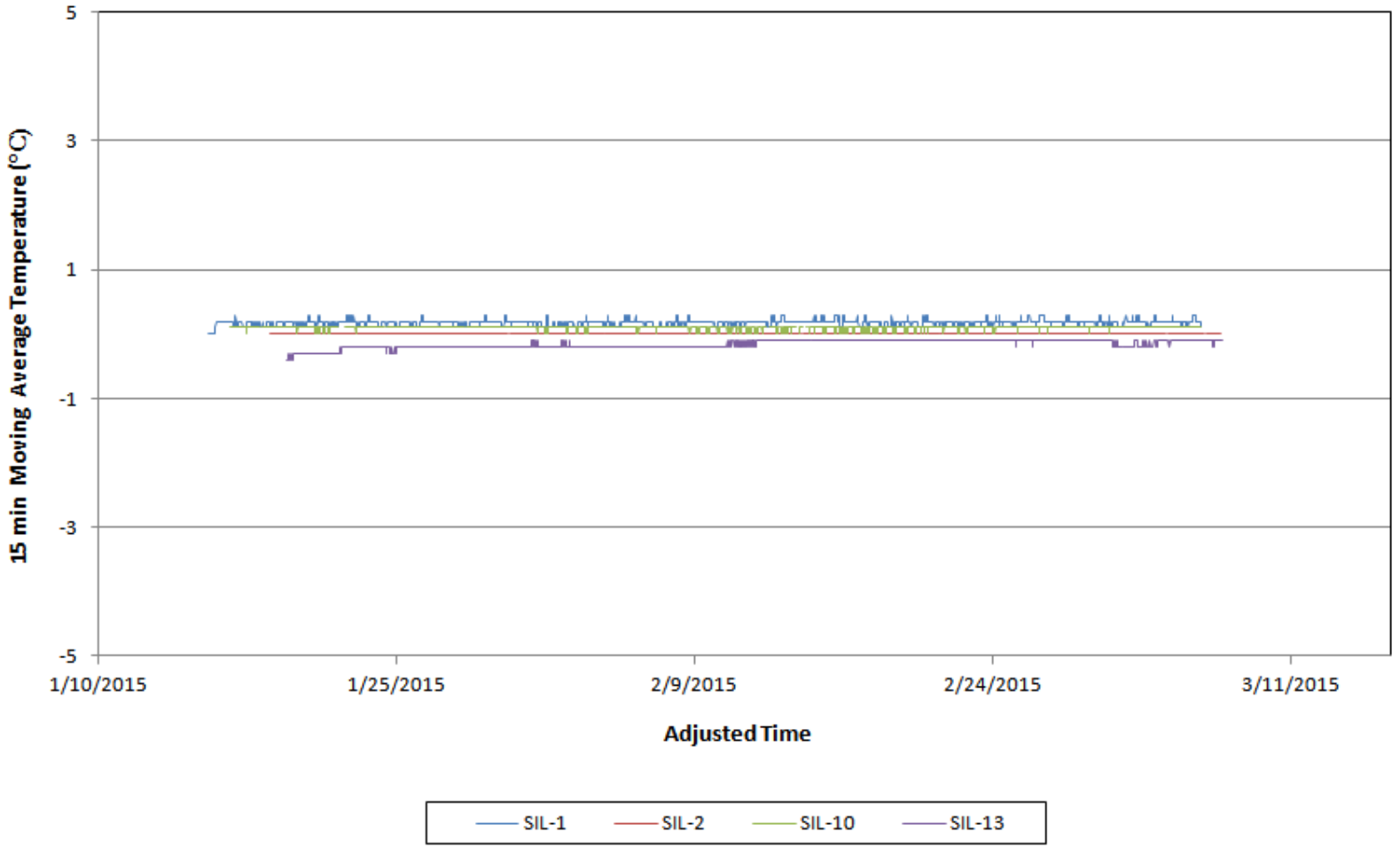


Chart C.18
Southern Indian Lake
2014-15 Sedimentation and Water Quality Monitoring Report
Water Temperature by site during Winter 2014-15

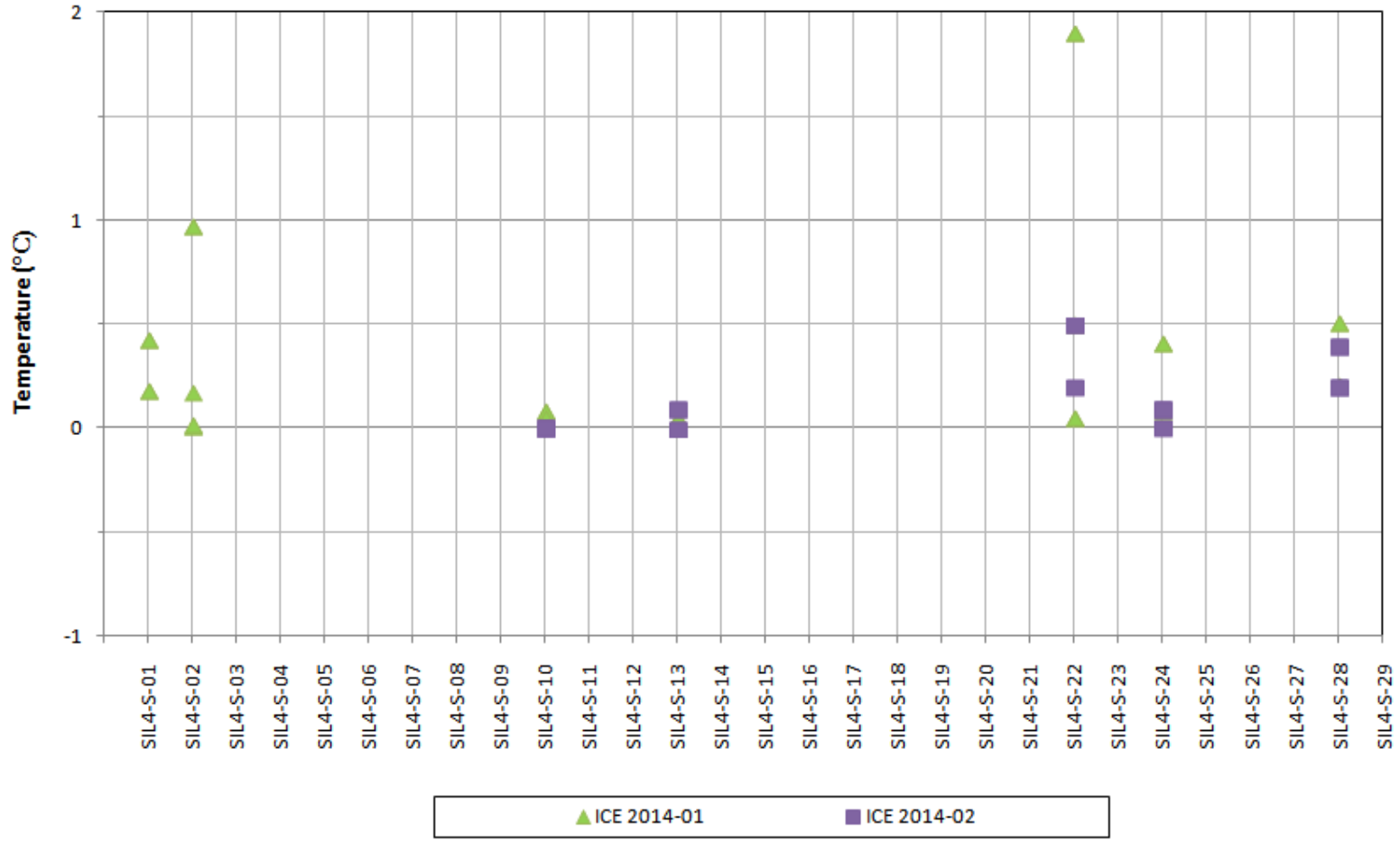


Chart C.19
Southern Indian Lake
2014-15 Sedimentation and Water Quality Monitoring Report
Water Conductivity at contiuous logger sites during Winter season 2014

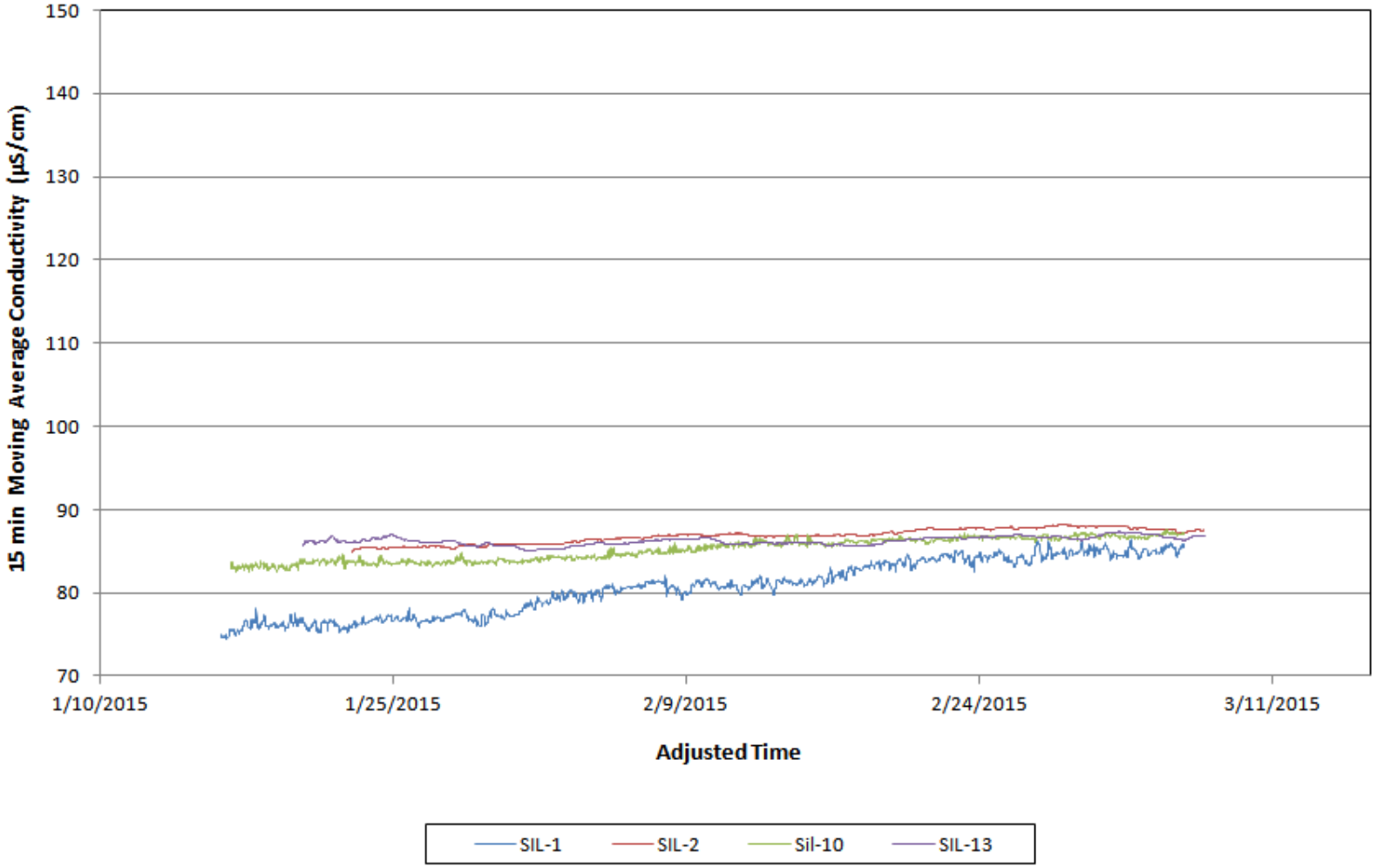


Chart C.20
Southern Indian Lake
2014-15 Sedimentation and Water Quality Monitoring Report
Water Conductivity by site during Winter 2014-15

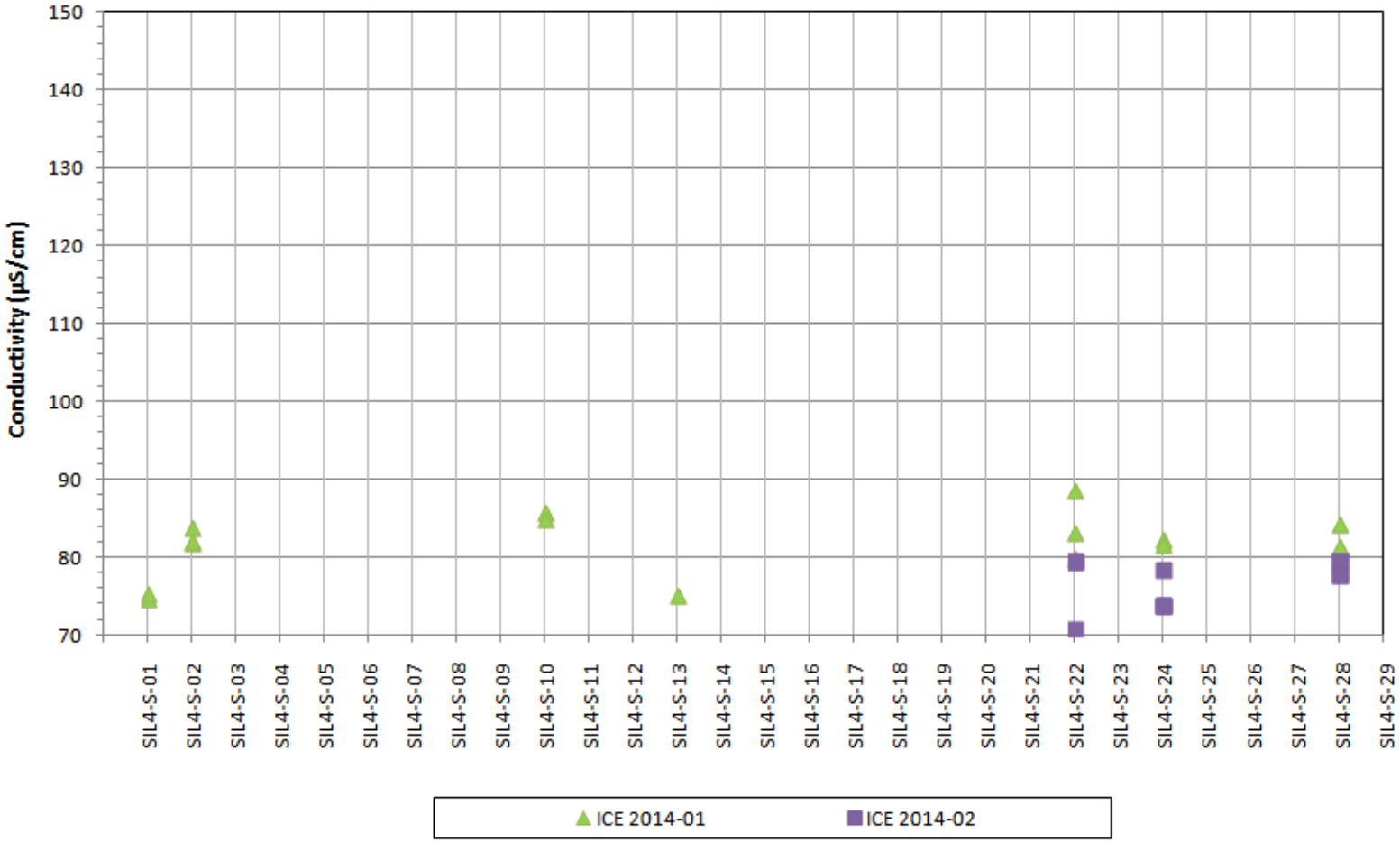


Chart C.21
Southern Indian Lake
2014-15 Sedimentation and Water Quality Monitoring Report
Total Suspended Solids by site during Winter 2014-15

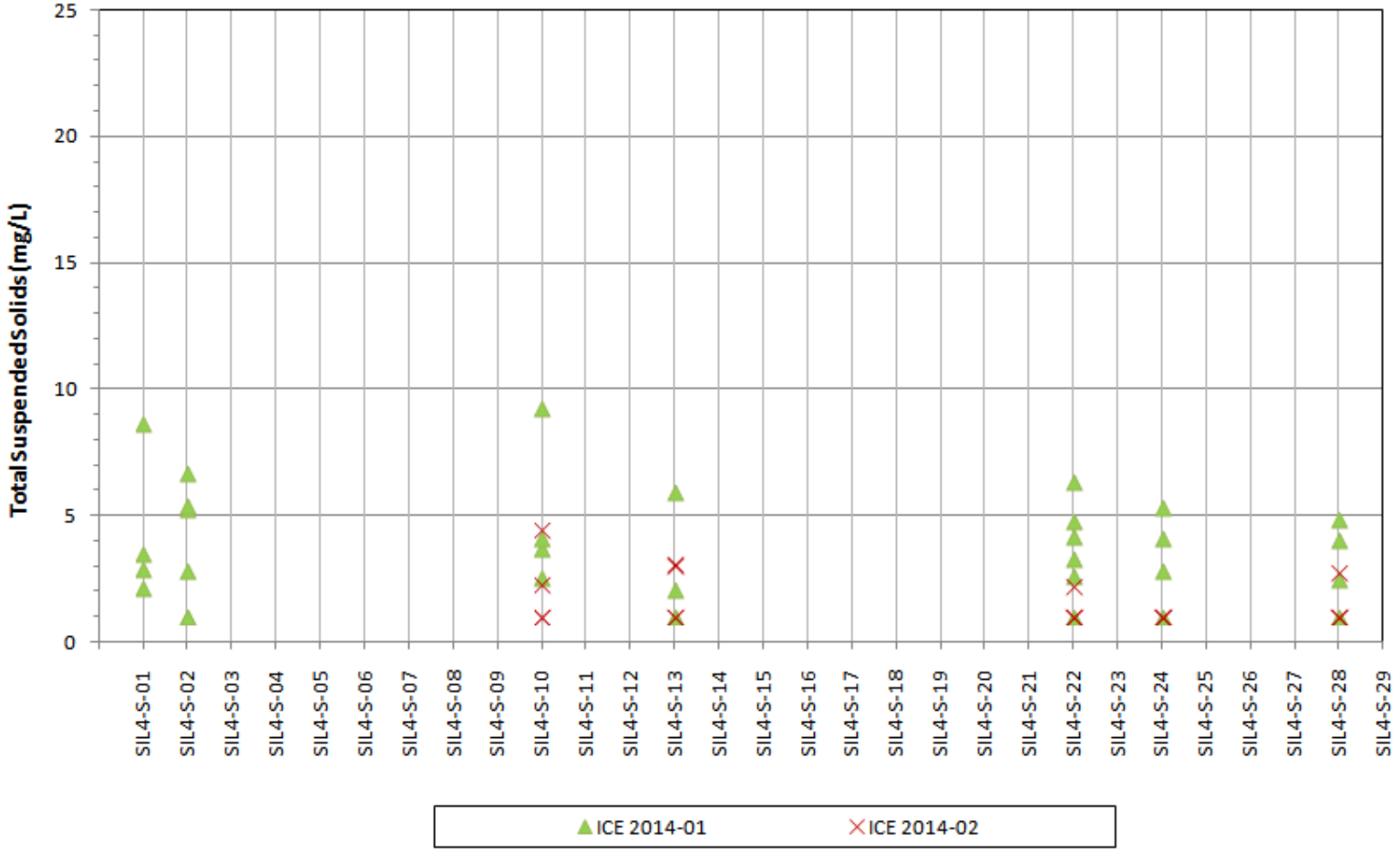


Chart C.22
Southern Indian Lake
2014-15 Sedimentation and Water Quality Monitoring Report
Average Grain Size Distribution of Total Suspended Solids by site during Winter 2014

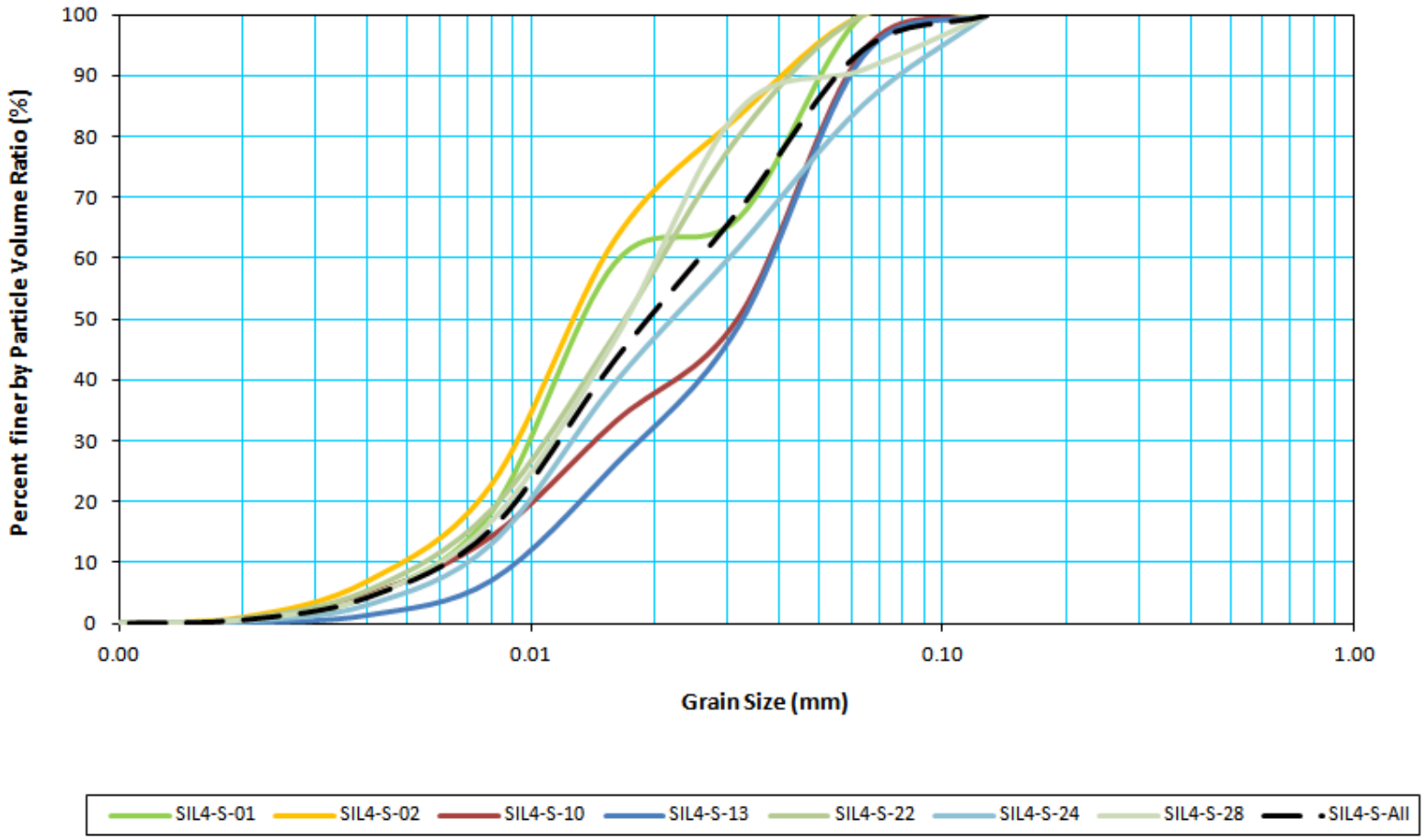


Chart C.23
Southern Indian Lake
2014-15 Sedimentation and Water Quality Monitoring Report
Water Turbidity at contiuous logger sites during Open water season 2015

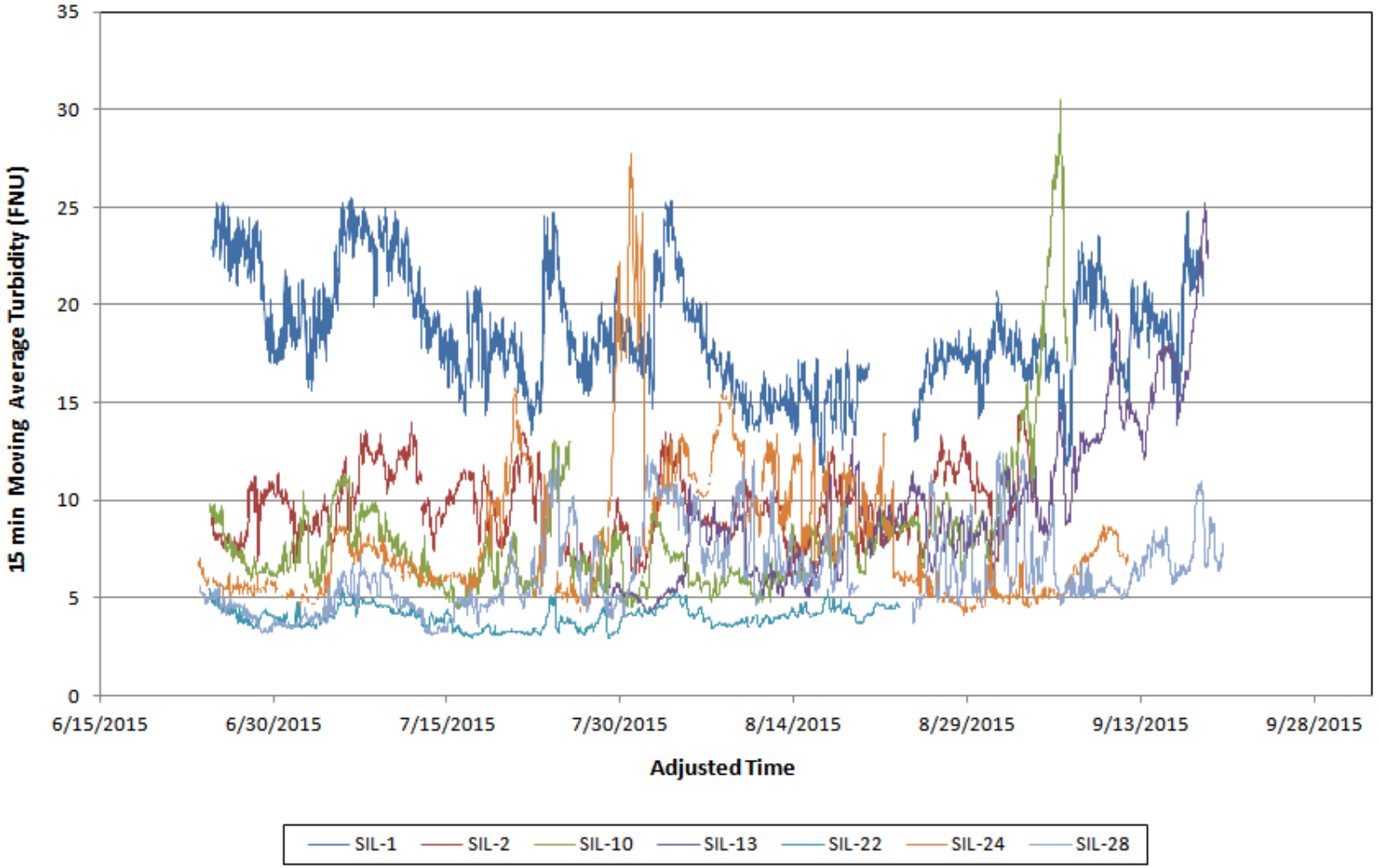


Chart C.24
Southern Indian Lake
2014-15 Sedimentation and Water Quality Monitoring Report
Water Turbidity by site during Open water season 2015

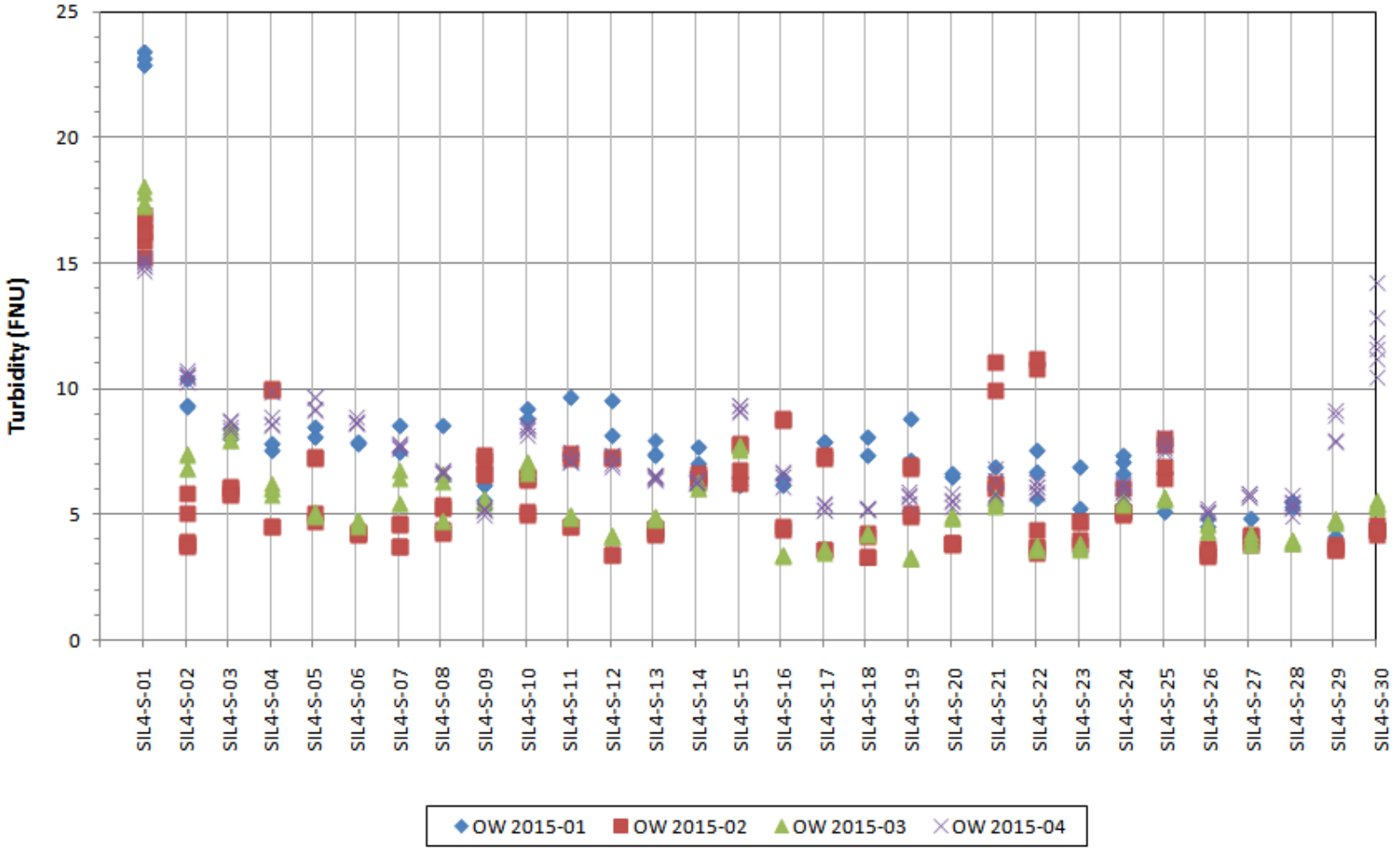


Chart C.25
Southern Indian Lake
2014-15 Sedimentation and Water Quality Monitoring Report
Water Temperature at contiuous logger sites during Open water season 2015

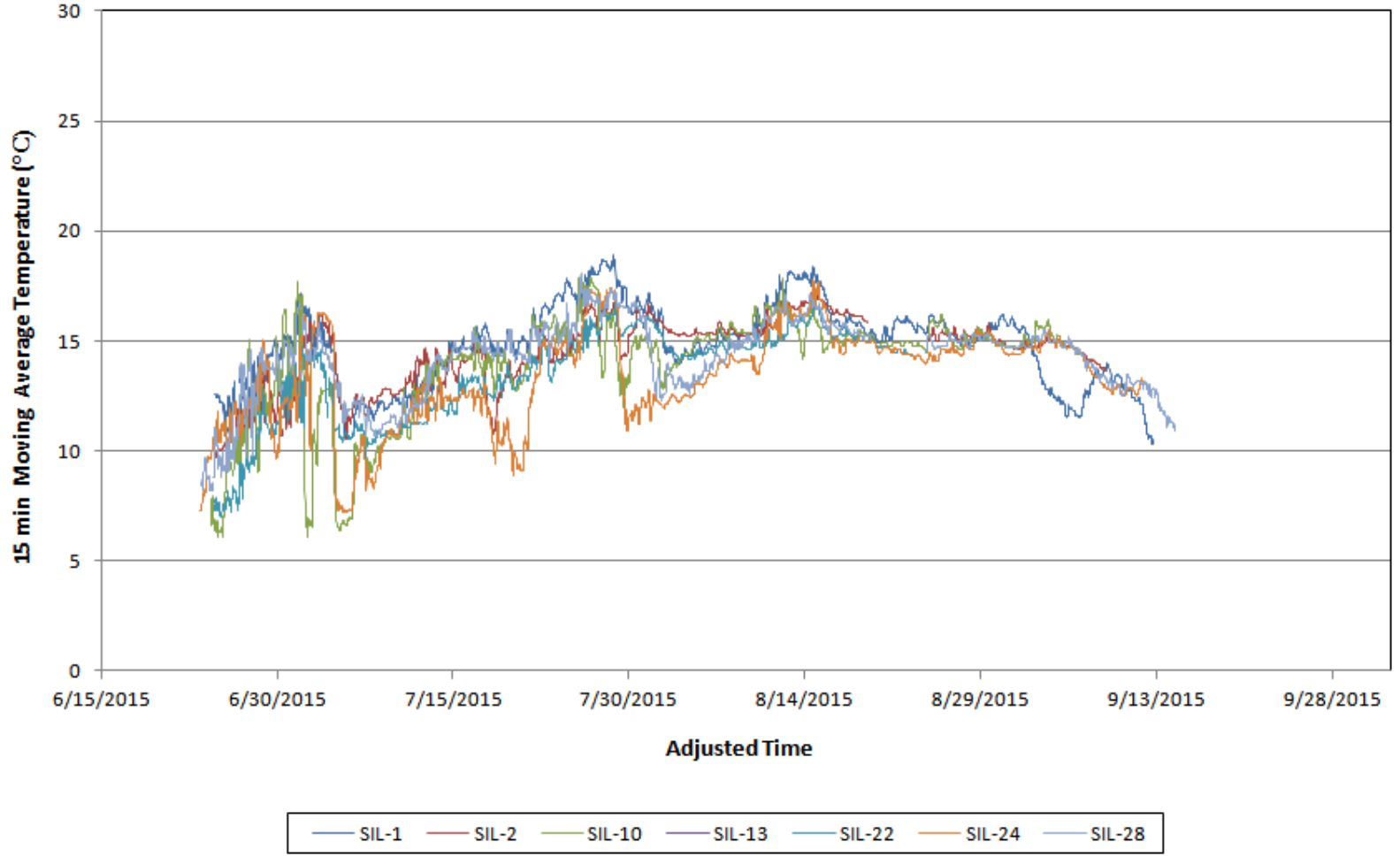


Chart C.26
Southern Indian Lake
2014-15 Sedimentation and Water Quality Monitoring Report
Water Temperature by site during Open water season 2015

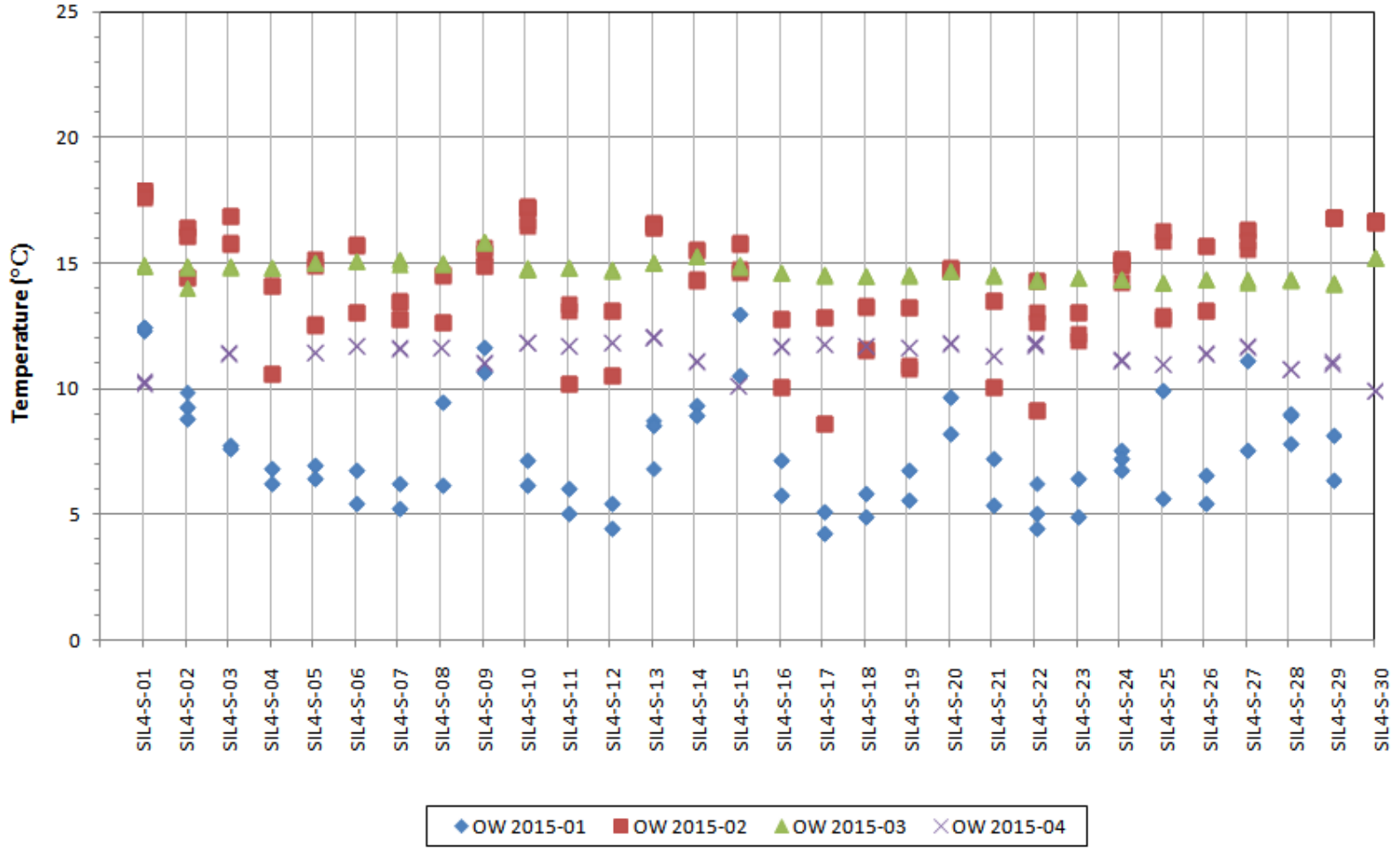


Chart C.27
Southern Indian Lake
2014-15 Sedimentation and Water Quality Monitoring Report
Water Conductivity at contiuous logger sites during Open water season 2015

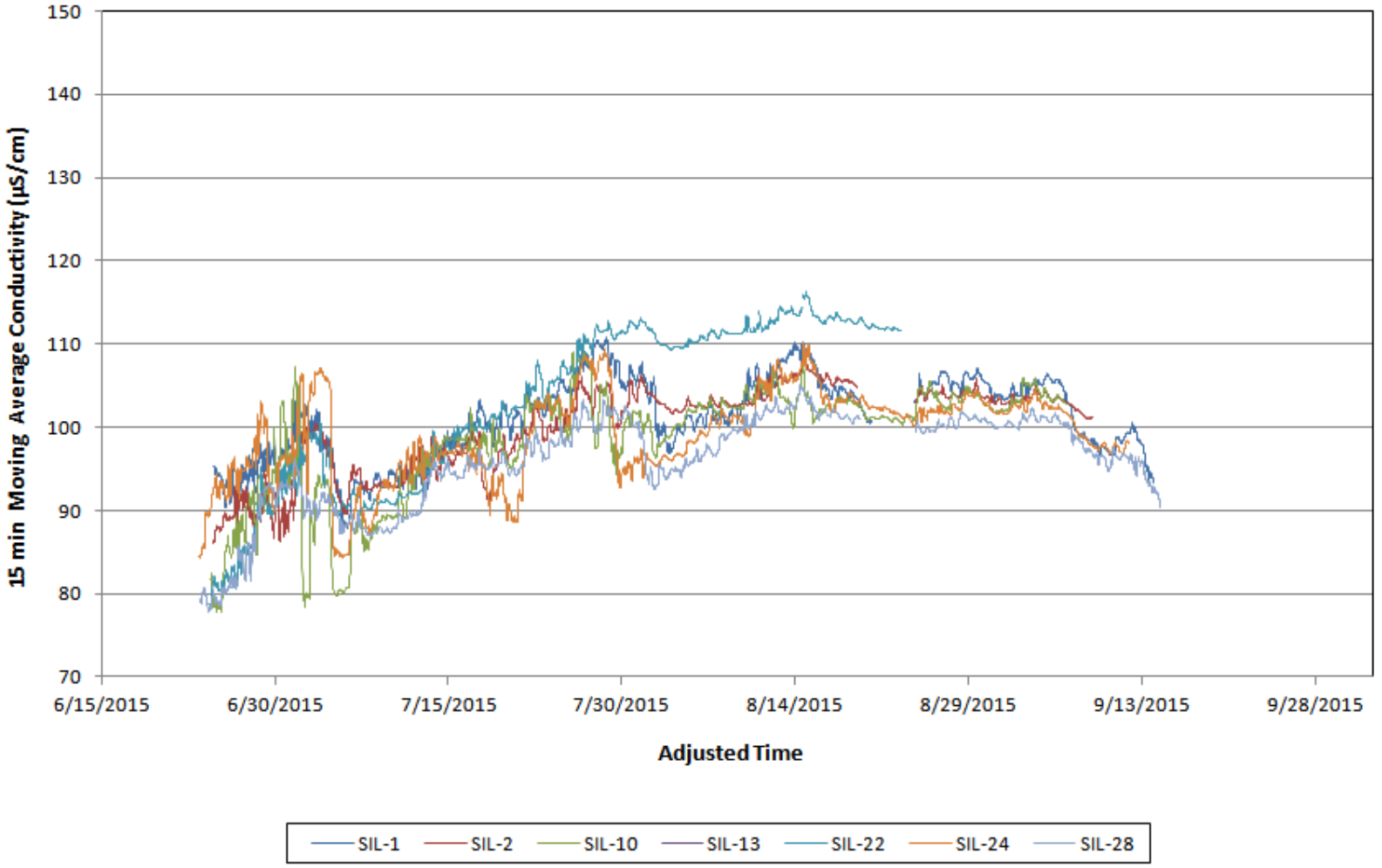


Chart C.28
Southern Indian Lake
2014-15 Sedimentation and Water Quality Monitoring Report
Water Conductivity by site during Open water season 2015

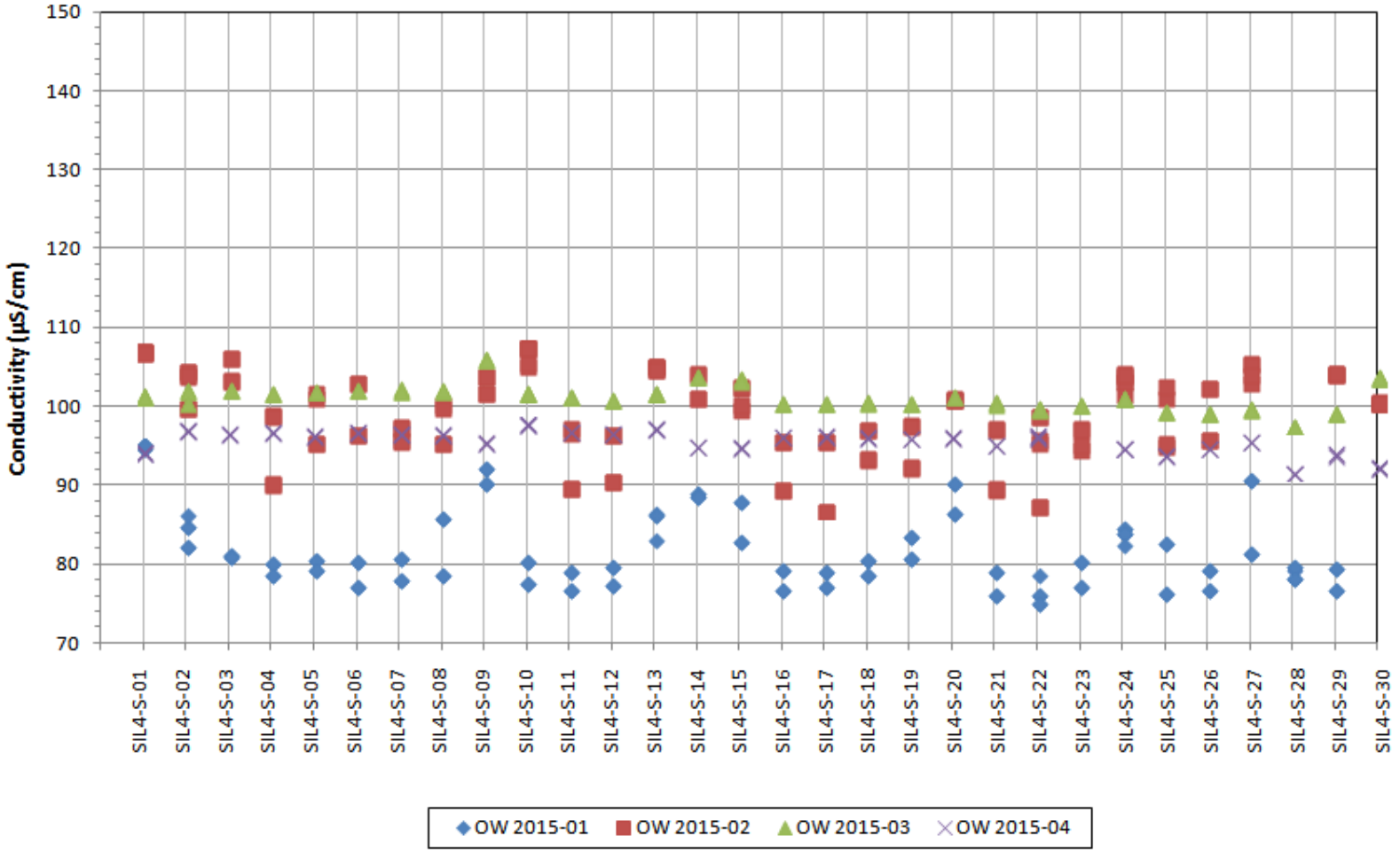


Chart C.29
Southern Indian Lake
2014-15 Sedimentation and Water Quality Monitoring Report
Total Suspended Solids by site during Open water season 2015

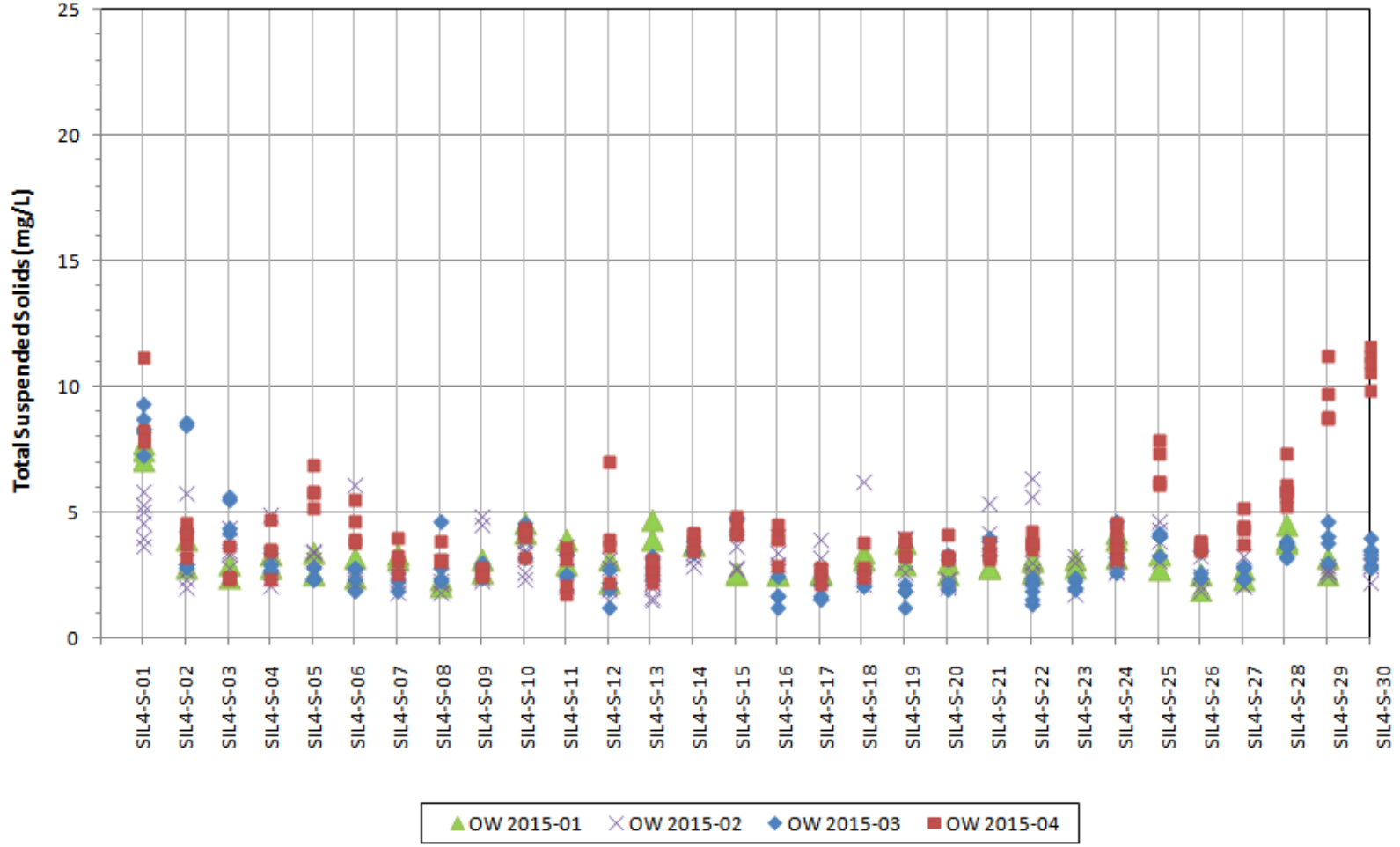


Chart C.30
Southern Indian Lake
2014-15 Sedimentation and Water Quality Monitoring Report
Average Grain Size Distribution of Total Suspended Solids by site during Open water season 2015

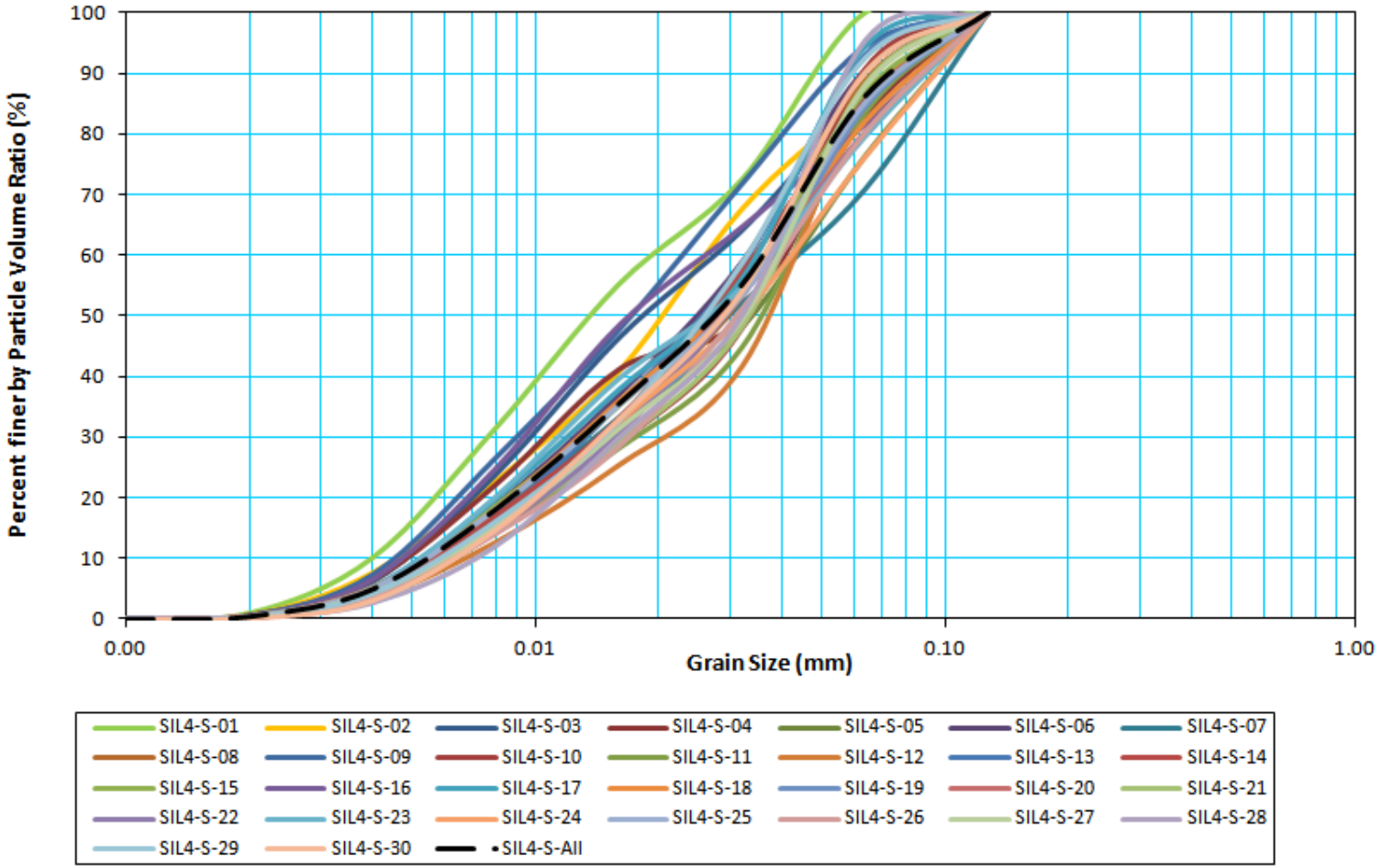


Chart C.31
Southern Indian Lake
2014-15 Sedimentation and Water Quality Monitoring Report
Water Temperature Profile by site during Open water season 2015

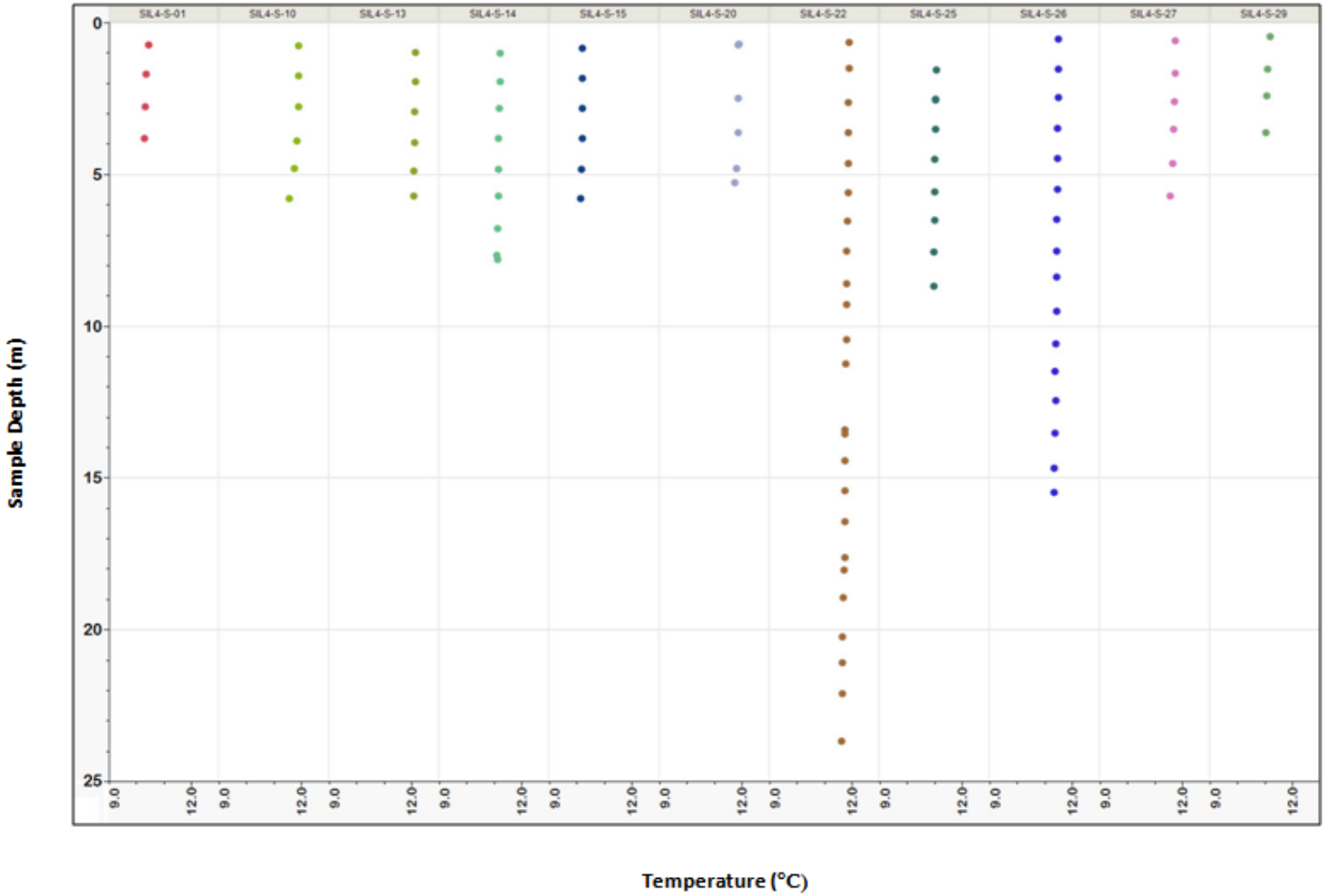


Chart C.32
Southern Indian Lake
2014-15 Sedimentation and Water Quality Monitoring Report
Water Turbidity Profile by site during Open water season 2015

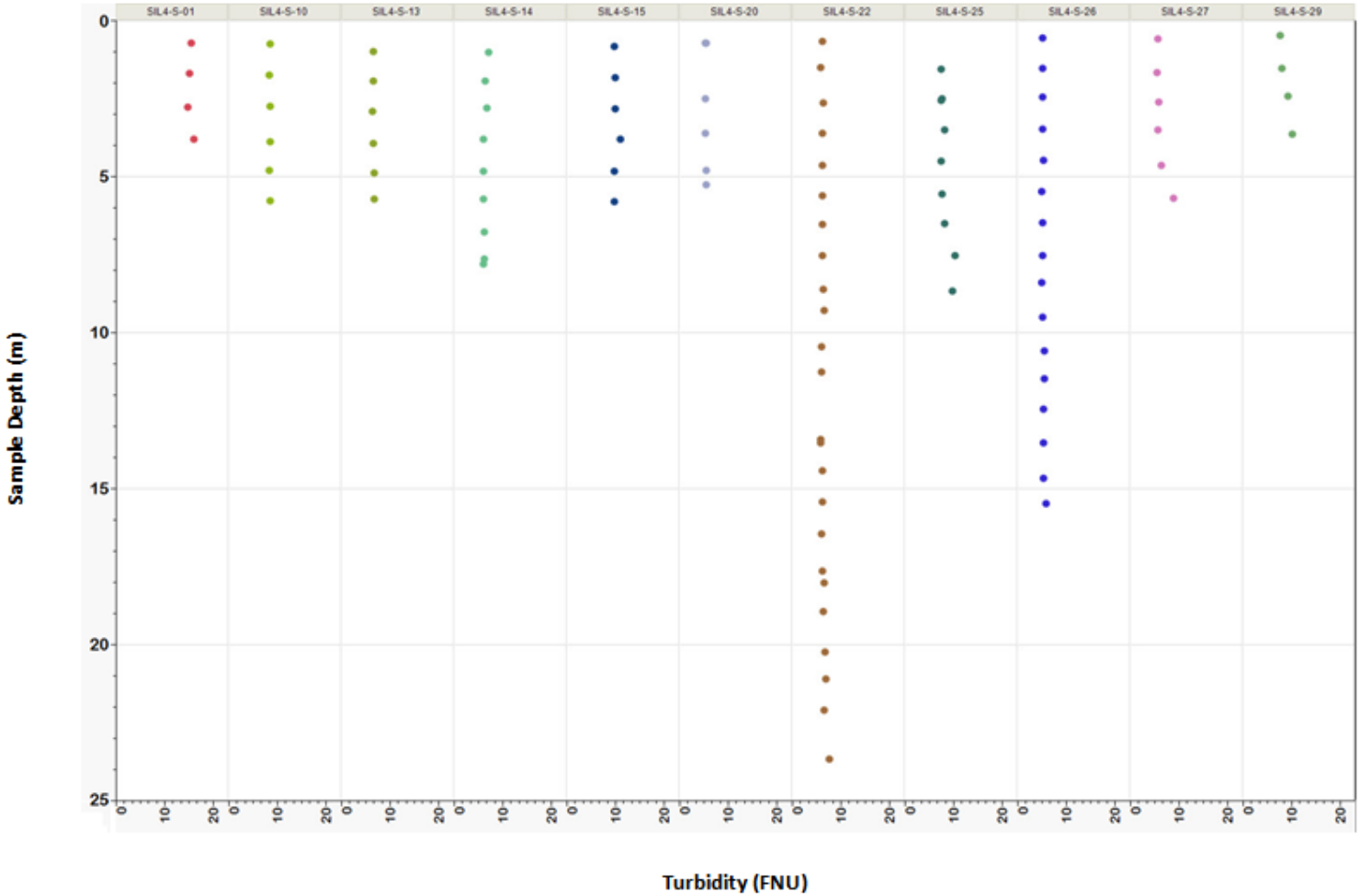
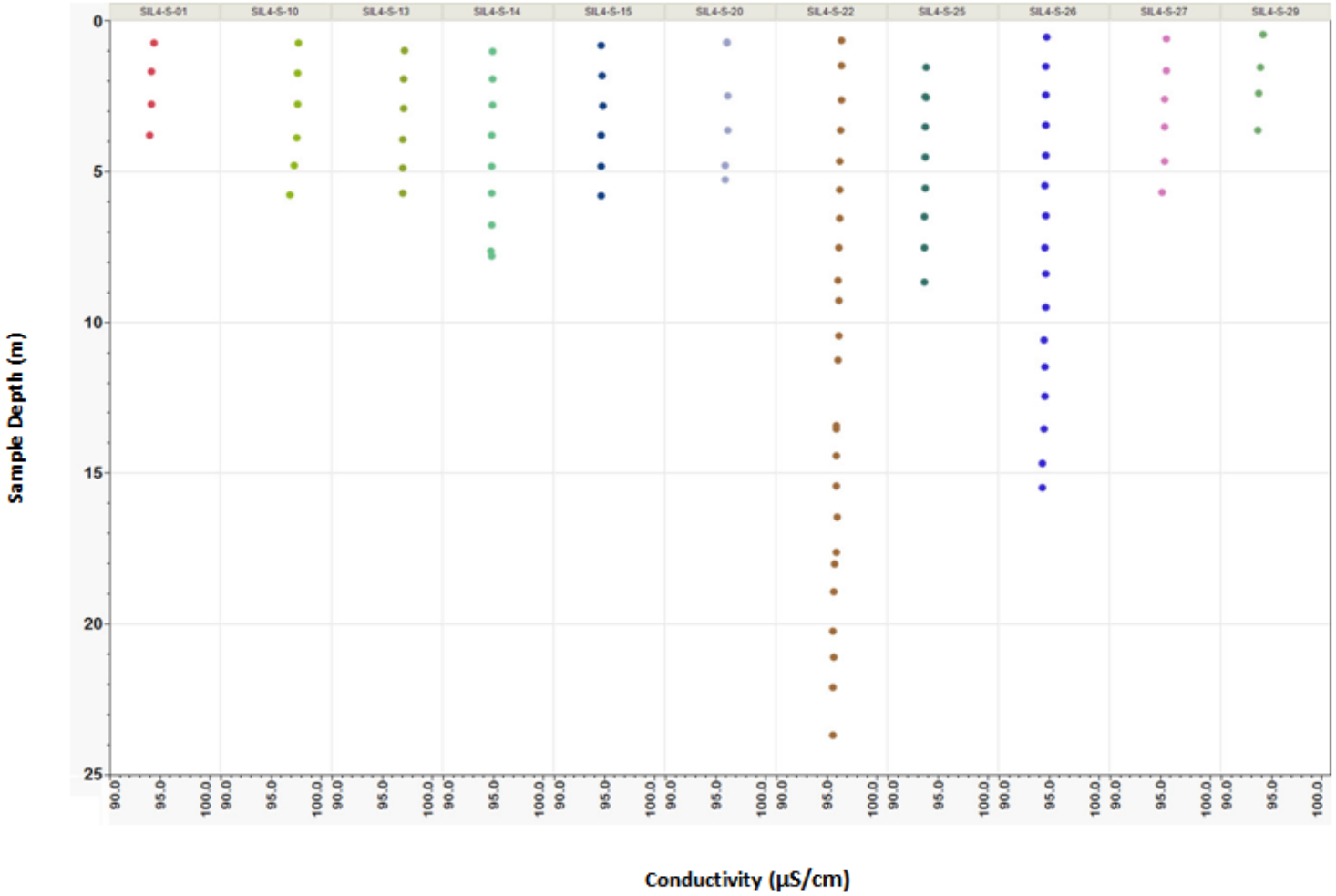


Chart C.33
Southern Indian Lake
2014-15 Sedimentation and Water Quality Monitoring Report
Water Conductivity Profile by site during Open water season 2015



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