MONITORING REPORT 2012/01

Department for Environment, Water and Natural Resources

Monitoring of Flow and Salinity during 2011 high flow recession (Lock 7 to Lock 1)

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Department for Environment, Water and Natural Resources
Science, Monitoring and Information Division

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1. INTRODUCTION

During flood recessions, large accessions of salt from numerous surface and groundwater sources may enter the River Murray and contribute to the overall salt load. Many of these accessions can be detected in near-real time by in-stream salinity monitoring techniques (e.g. pontoon sites with continuous data logging and telemetry equipment). However, instrumentation at some potential salt accession locations is aging and without telemetry, requires physical visits to access the monitored data. Furthermore, physical gaps between some continuous monitoring stations in the river reduce the ability to delineate the locations of some accession points using continuous data alone. This report identifies strategies that were used to overcome these monitoring deficiencies and to enhance the ability to measure salt accessions for the period identified.

These strategies included:

- refurbishing nine continuous salinity-monitoring stations
- temporary manual salinity-data collection
- collating community-group data collection activities, with the aim of further differentiating salinity accessions along the river.

Post flood salinity accessions were just starting to be measurable when further catchment rainfall and subsequent high river flows to South Australia raised levels and subsequently delayed the accessions for that particular event in 2011. All monitoring is ongoing and will be managed to enable further salinity accessions to be detected and recorded in the short term.

2. BACKGROUND

The Murray-Darling Basin Authority (MDBA) Forum, held in Adelaide on 18 February 2011, highlighted the opportunity to monitor possible salinity threats generated by recent floods within the Murray-Darling Basin.

One of the outcomes from the Forum was the decision to gain a better understanding and further advance knowledge in the area of surface water processes and their impact on salt accession during flow recession. One of the solutions to deliver this understanding was to undertake more frequent collection, both spatially and temporally, of salinity data in areas where salt accessions were thought to occur. The present monitoring regime, while adequate for normal river flow, has been regularly identified as a major obstacle to understanding salinity dynamics during and after flood events. DFW undertook a scoping exercise to develop a short term project to reduce the data gaps and better delineate areas where salt water accessions occurred during high flow recession.

At a further Forum convened on 3 March 2011 by the Murray-Darling Basin Authority Basin Salinity Management Advisory Panel (Meeting #8), the Commonwealth/MDBA agreed to support a short-term data collection project to monitor salinity impacts in the River Murray during flood recession. This was based on an estimate that River Murray flows at the South Australian border would reduce to approximately 40,000 ML per day by mid April 2011.

The Department for Water (DFW), now the Department of Environment, Water and Natural Resources, developed a project proposal for additional automated and manual monitoring of the flood recession. The proposal included updating the instrumentation on several key salinity pontoon monitoring stations and identifying manual EC sampling sites to advance the location of salinity accessions during the flood recession. The proposal included involvement of local community organisations in the data collection process in specific localised areas where salinity impacts were likely to occur during the recession. This community data was to be subsequently collated by DFW.

The objectives of this project were to:

a. Identify (additional to existing monitoring sites) sites for collection of data, duration and frequency for flow and EC readings to be collected following flood recession
b. Collect flow and EC readings from sites as per (a) by installing and using additional instruments and tools
c. Supply data (both raw and processed) to the MDBA on a regular basis, (currently raw data for operational sites is transferred on a daily basis, processed data is exported monthly)
d. Deliver a report on the project that includes a GIS based map of locations of monitoring sites and identifies any difficulties encountered during collecting data.

The Project Steering committee accepted the monitoring proposal in April 2011 (Proposal number MD1866 CD11 – 0113).

3. DATA COLLECTION METHODOLOGY

3.1 LOGGER REPLACEMENTS & UPGRADES

During the initial flood recession, all proposed logger upgrades and replacements were completed as soon as flows dropped sufficiently to enable safe access to pontoons (see Figure 1). Five aging salinity loggers were replaced by new Campbell instrumentation, while a further four salinity loggers were upgraded with installation of additional telemetry hardware (Table 1). All salinity monitoring stations were visited regularly and instrumentation checked and calibrated against field measurements in line with DFW technical procedure *Processing recorded EC and Temperature data*, TP_M_0011 version 4 (Appendix D).

The upgraded sites were included in the polling schedule of the DFW Information services and appear publicly in the State Water Archive, http://www.waterconnect.sa.gov.au/SWA/Pages/default.aspx. All upgraded sites will remain in place permanently and will continue to be funded by their original funding source.

Figure 1 Typical salinity monitoring pontoon

Table 1 Logger replacements and upgrades.

Station Number	Station Name	Activity
A4261091	Chowilla Ck upstream Murray River	Full Upgrade
A4260704	Murray River downstream of Chowilla Ck	Full Upgrade
A4260703	Murray River upstream Renmark	Full Upgrade
A4261023	Murray River upstream of Pike River outfall	Full Upgrade
A4261025	Murray River upstream of Moorook	Full Upgrade
A4260645	Pike River	Telemetry added
A4260537	River Murray at Berri	Telemetry added
A4260573	River Murray at Woolpunda	Telemetry added
A4260593	River Murray at Holder	Telemetry added

3.2 MANUAL DATA COLLECTION

The manual data collection sites were selected to enhance the ability to identify separate accession points, in order to map their location in the longer reaches of river between continuous monitoring stations (Appendix C). Sites were also selected to help identify salt accessions from salinised or potentially salinised wetlands off the main river channel. Even a small increase in EC downstream of a wetland can indicate a significant tonnage of salt.

The majority of manual data collection sites were monitored by DFW. Local community groups and businesses including Berri-Barmera LAP, Banrock Station, Renmark Irrigation Trust and Riverland West LAP were approached to monitor more remote wetlands and supply data to DFW.

All manual site data has been entered into spreadsheets maintained by DFW (Appendix A).

3.2.1 Department for Water manual sampling sites

Twenty three manual sampling sites were selected between the Berri to Lock 3 reach of the River Murray (Appendix A). This reach of river is known to yield the highest flood recession-driven surface water salinity accessions in South Australia based on historical data. All sites were sampled periodically during the initial recession in 2011.

The high river in 2012 restricted access to the majority of manual sampling sites, causing sampling to be suspended until flows receded sufficiently.

3.2.2 Community sampling sites

Manual sampling sites were monitored by community sources at the following locations:

- Renmark Irrigation Trust (RIT) samples daily at the Renmark Irrigation pumping station in the main river, just downstream of the Ral Ral Creek outfall. RIT also samples Ral Ral Creek weekly at Goolwa Street and Nelbuck Street. DFW extracts this data on a weekly basis from the RIT website and adds it to the Manual EC data spreadsheet.
- Banrock Station Wine and Wetland Centre carry out EC readings at the inlet and outlet wetland structures at Banrock lagoon and at the main lagoon as an operational requirement. This data is emailed to DFW Berri and added to the Manual EC data spreadsheet.
- Riverland West LAP takes manual EC readings at Ramco, Nigra and Hart lagoons. This data is emailed to DFW Berri and added to the Manual EC data spreadsheet.

- Berri-Barmera LAP, in conjunction with the SA Murray-Darling Basin Natural Resources Management Board, carried out manual readings at Overland Corner Wetland and Lake Bonney Jetty. This data is emailed to DFW Berri and added to the Manual EC data spreadsheet.

A field site form for manual readings, incorporating GPS locations, has been created (Appendix A).

The manual readings are emailed to the MDBA monthly.

3.3 ADDITIONAL ACTIVITIES

- GIS based location maps for all sites have been compiled and supplied to the MDBA (Appendix C).
- All continuous logger data is viewable and downloadable on the DFW website. http://www.waterconnect.sa.gov.au/RMWD/Pages/default.aspx
- All continuous logger data is incorporated in the regular monthly DFW data export to the MDBA.
- All continuous logger data sites are checked daily via online systems to ensure continued operation and to minimise data losses. These checks also enable any significant changes in river salinity data to be assessed individually and where necessary, to initiate further actions. For example, flow gauging can be conducted to allow calculation of salt loads from targeted locations.

4. DATA OBSERVATIONS

All data associated with this project are available in the locations indicated in Table 2. The Hydstra surface water archive contains all archived continuous logger data, telemetry files and gauging results, which is also available publicly in the web links provided. Manual data readings are held in spreadsheet form in the DFW network, as are other files such as photographs and other relevant information. Gauging data is exported with all other data from HYDSTRA and raw gauging material is kept within the DEWNR Berri Network, 28 Vaughan Tce, Berri 5343 SA and can be accessed through the DEWNR Resource Monitoring Services Unit.

Table 2 Data locations

Data Type	Database	Link	Description
Continuous Logger data archive	HYDSTRA	http://www.waterconnect.sa.gov.au/SWA/Pages/default.aspx	All continuous logger data both salinity and water levels. State surface water archive.
Telemetry	HYDSTRA	http://www.waterconnect.sa.gov.au/RMWD/Pages/default.aspx	All SA Murray-Darling sites web page. Look up any site listed and get predefined tables plots etc along with site history.
Gauging	HYDSTRA	Berri DFW Network	Any gauging data collected throughout project
Manual Data	Spreadsheet	Berri DFW Network	Collated manual data for the period of the project
Metadata	files:	Berri DFW Network	Photos, Emails, Spreadsheets, daily data information.

4.1 *MARCH TO SEPTEMBER 2011*

The 2010-11 flood recession did not fully eventuate. Figure 2 shows Flow to South Australia and calculated salt loads (in tonnes per month) at the SA border and Morgan from July 2010 to April 2012. Continuing rain in the catchment ensured a very slow decline in flow and water levels post-flood, to a minimum Flow to SA of 17,500 ML/d in early July 2011. Flows subsequently increased to approximately 35,000 ML/d in August 2011 and slowly receded again to 8000 ML/d in late October 2011.

During the initial period of flood recession from March to June 2011, large tonnages of salt were being flushed through the river system, generated from both upstream sources and from within SA. An initial analysis of data collected during this period indicated maximum total salt loads in excess of 450,000 t/month passing Morgan (Figure 2). Based on a difference between salt loads at the SA border and at Morgan, the maximum salt load contributed by SA was 130,000 t/month in April 2011.

Lake Bonney is a highly salinised terminal lake, the level of which is normally held steady by the upstream Lock 3 level. During the recent high rivers the level of Lock 3 was raised and hence the level of Lake Bonney was raised as well. Calculations from manual EC data at Kingston on Murray and continuous EC data from Woolpunda and U/S Overland Corner indicated that during April-May 2011, up to 6000 tonnes of salt/day were added to the River Murray from Lake Bonney during the initial Lock 3 level recession. When Lock 3 levels stabilised the salt accessions reduced as outflow from Lake Bonney slowed.

Salt load (tonnes/day) calculation is performed using the following equation:

$$\text{Load} = \triangle \text{EC (downstream} - \text{upstream)} \times \text{Flow} \times \text{conversion factor } (0.00055)$$

Units:

Units:	EC	µS/cm
	Flow	ML/d
	Load	t/d

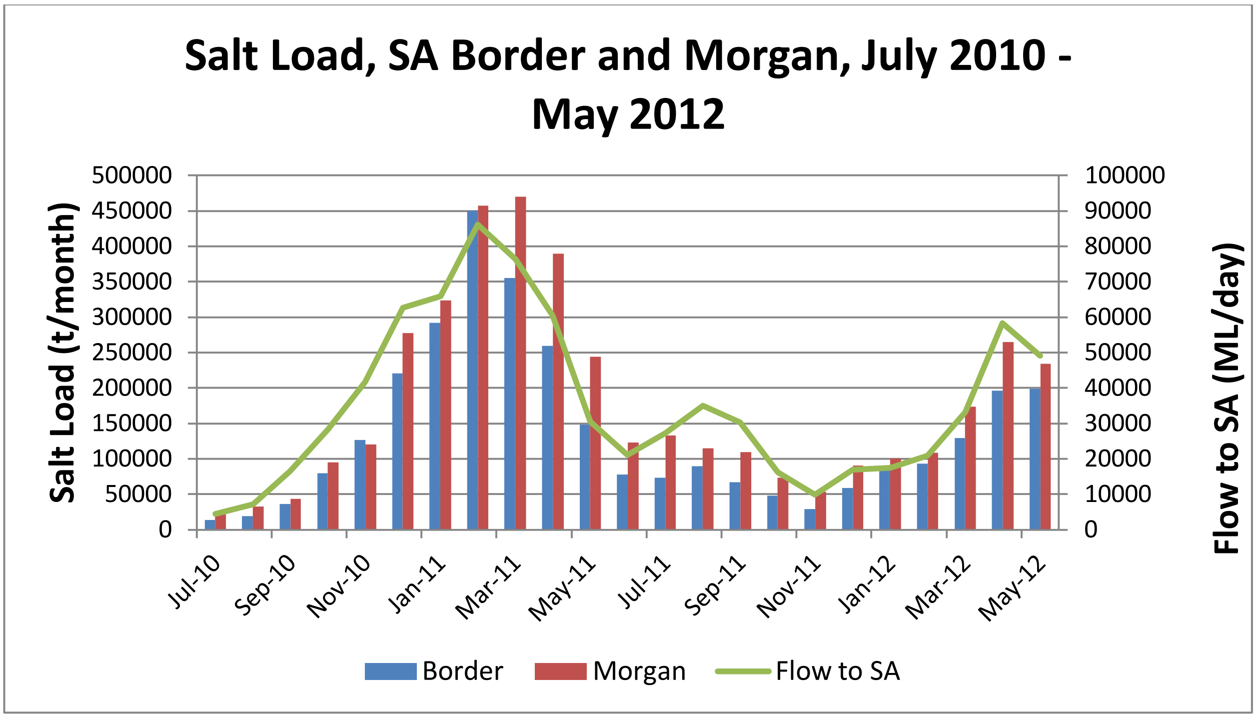

Figure 2 Salt load in South Australia, July 2010 to April 2012

4.2 OCTOBER 2011 TO MAY 2012

The Flow to SA declined in October 2011 to 8000 ML/d (Figure 2). Due to flooding flows from the Darling, Murray and Murrumbidgee Rivers, the Flow to SA increased to a maximum of 60,000 ML/d in April 2012 and in late May had slowly receded to 41,000 ML/d. The continued high flows have consequently suppressed saline accessions in South Australia. The monthly average daily salt loads at the SA border subtracted from the similar Morgan data have been calculated and show the highly variable nature of the SA salt load accessions (Figure 3). It is expected that the flows will recede in (July) to >10,000 ML/d. Ongoing data collection from the continuous monitoring stations and from the regularly read manual stations will provide further information about the salt accession during the recent multiple flood events. This data coupled with data collected during this project will provide a good insight into the mechanics of salt assession during flood recession.

The forecast flows for the 2012 high river were in the order of 60,000 ML/d. The pontoons carrying most of the in-stream EC monitoring instrumentation were able to withstand these flows and hence were left in place. All instrumentation is currently operational and will be able to monitor the current recession.

Examples of this data are plotted in Figures 4 to 7. All data is available in HYDSTRA on the Web and is sent to the MDBA monthly to update databases in Canberra.
http://www.waterconnect.sa.gov.au/SWA/Pages/default.aspx

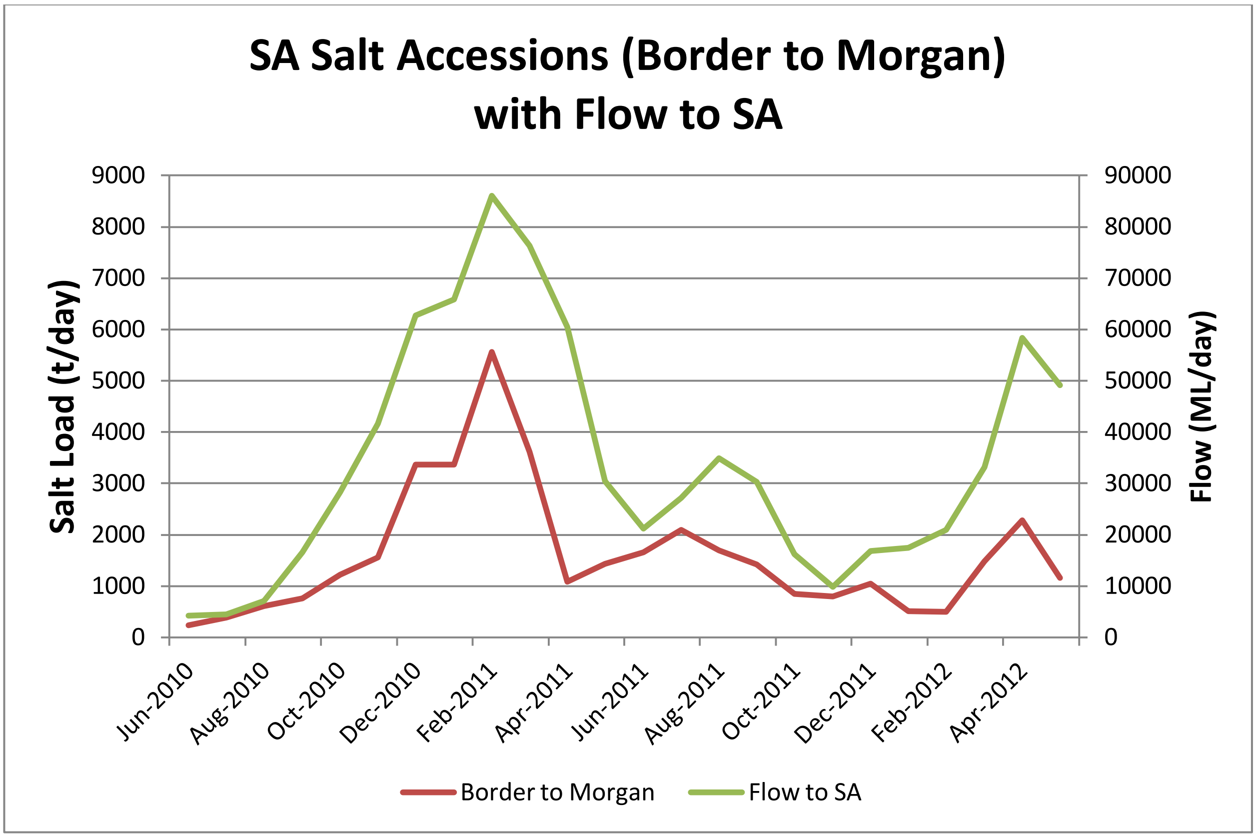

Figure 3 South Australian Salt Accessions with Flow to South Australia

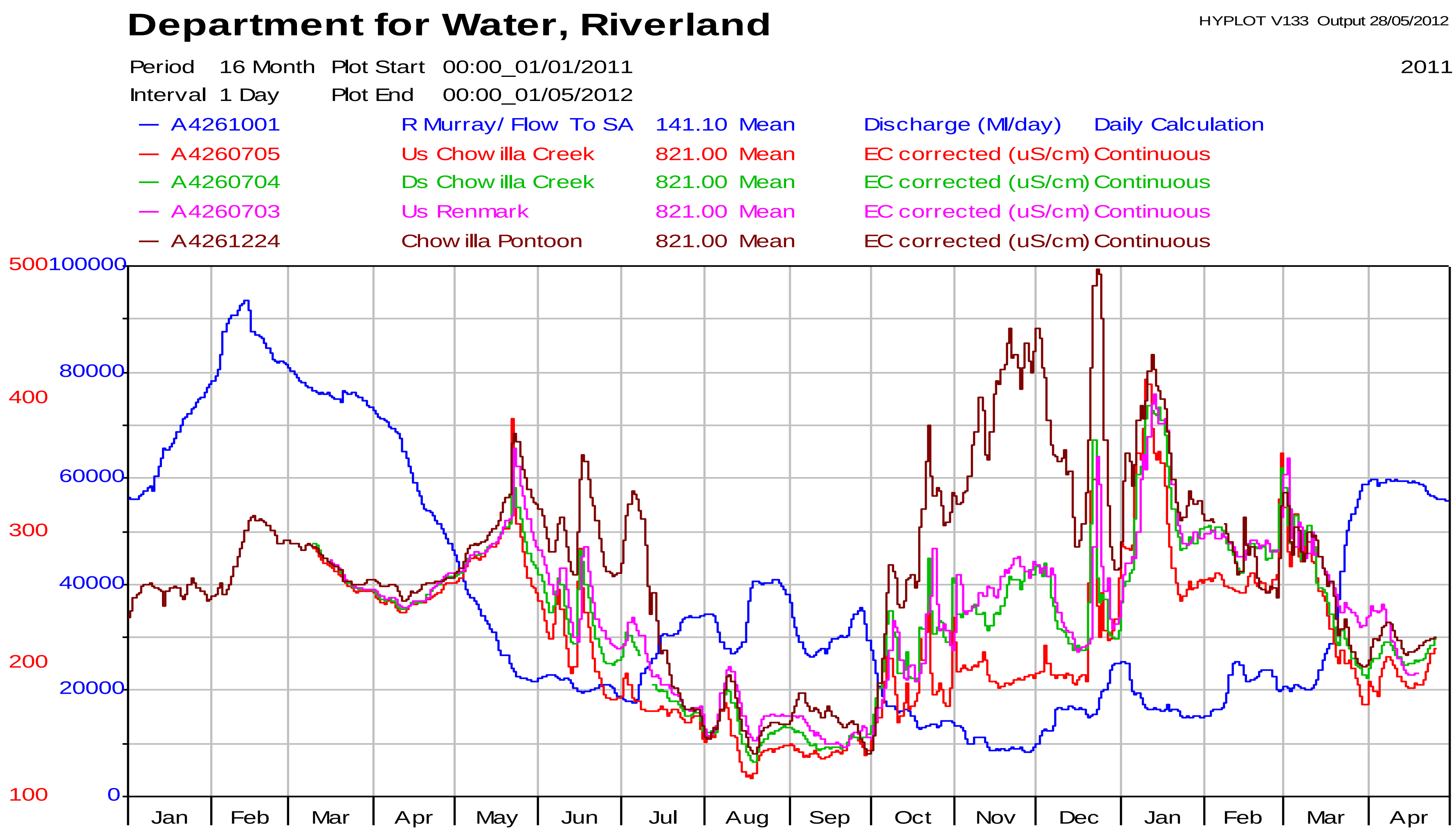

Figure 4 Flow to South Australia and salinity recordings for the Chowilla Reach of the River Murray

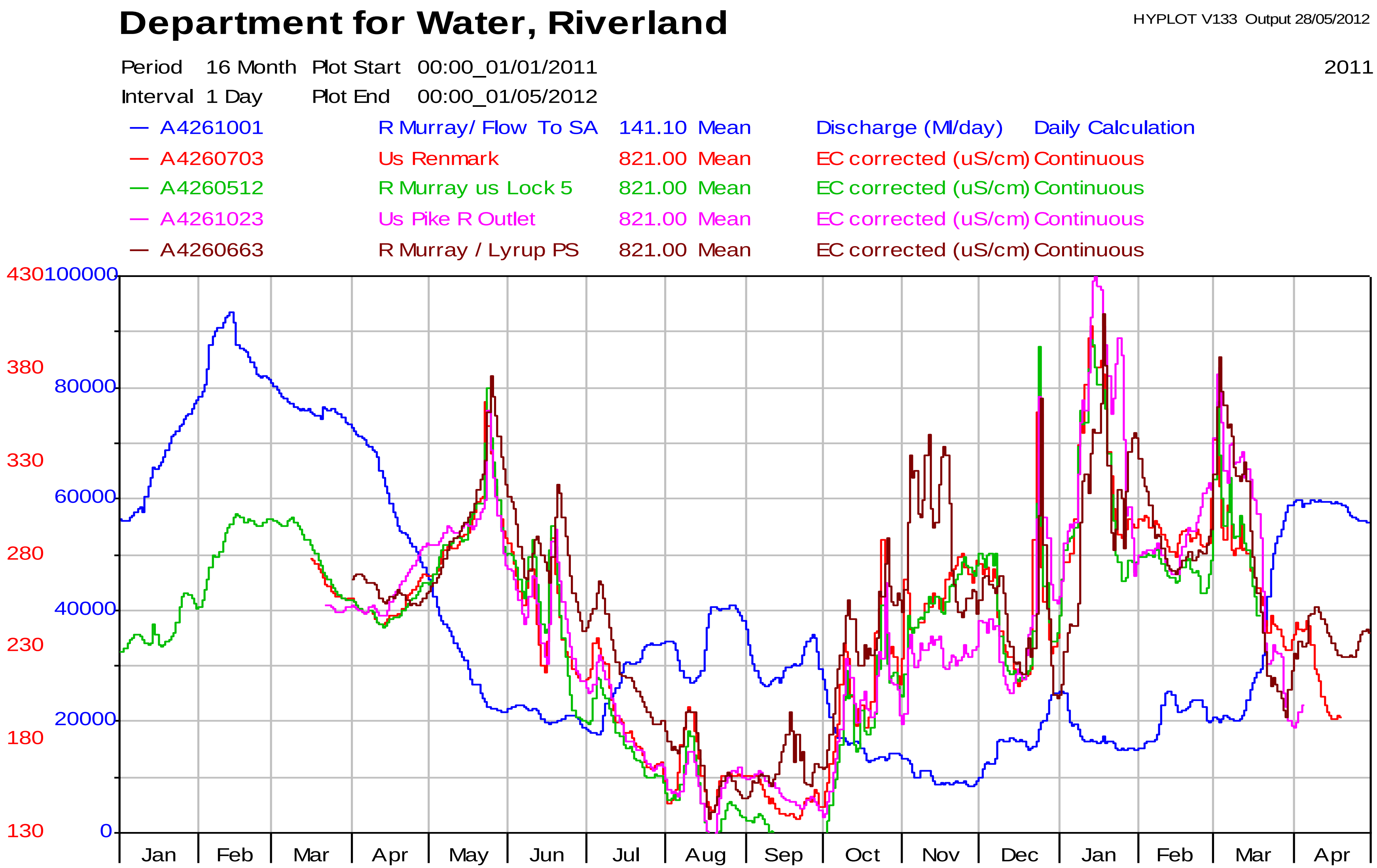

Figure 5 Flow to South Australia and salinity recordings for the Renmark to Lyrup reach of the River Murray

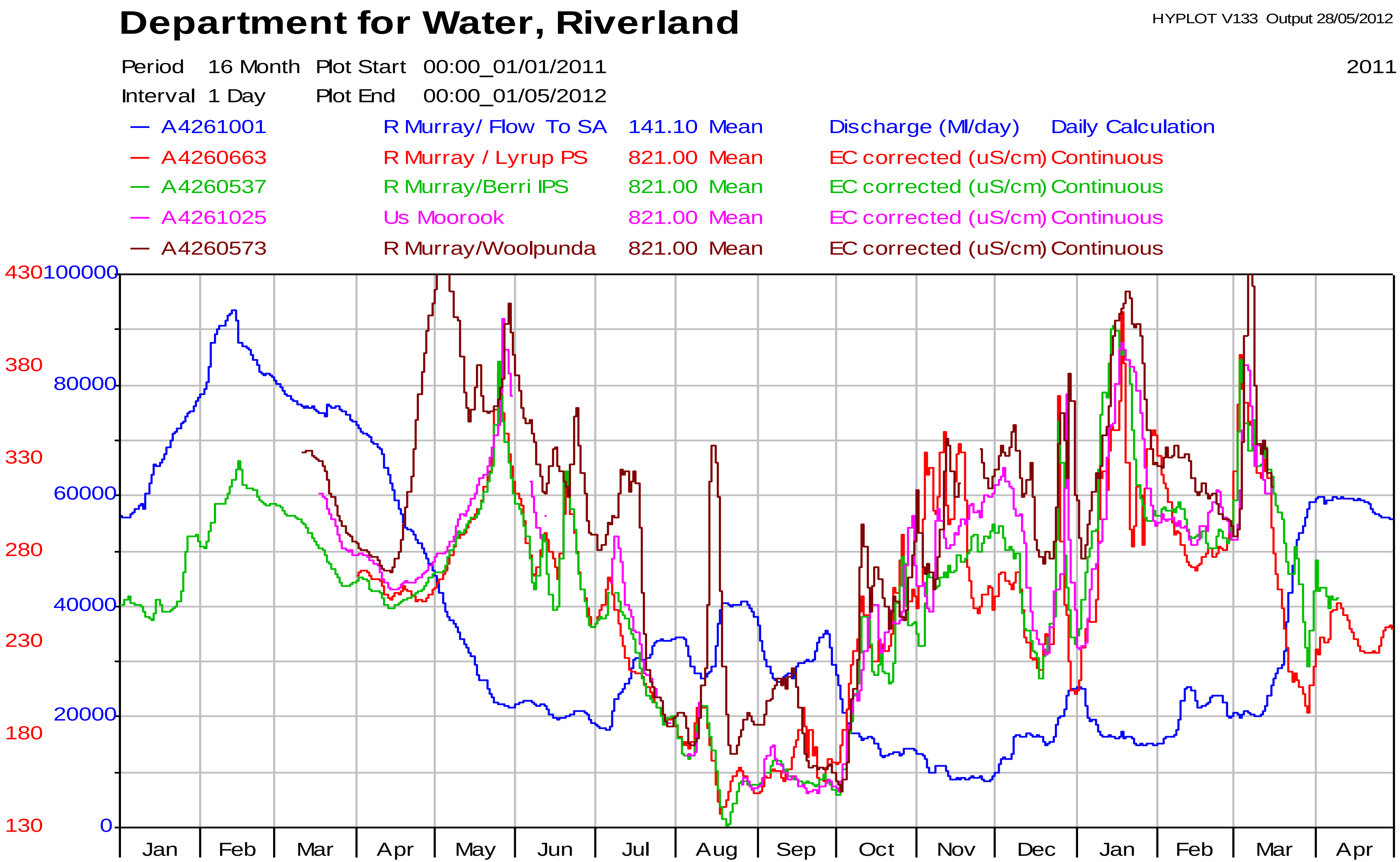

Figure 6 Flow to South Australia and salinity recordings for the Lyrup to Woolpunda reach of the River Murray

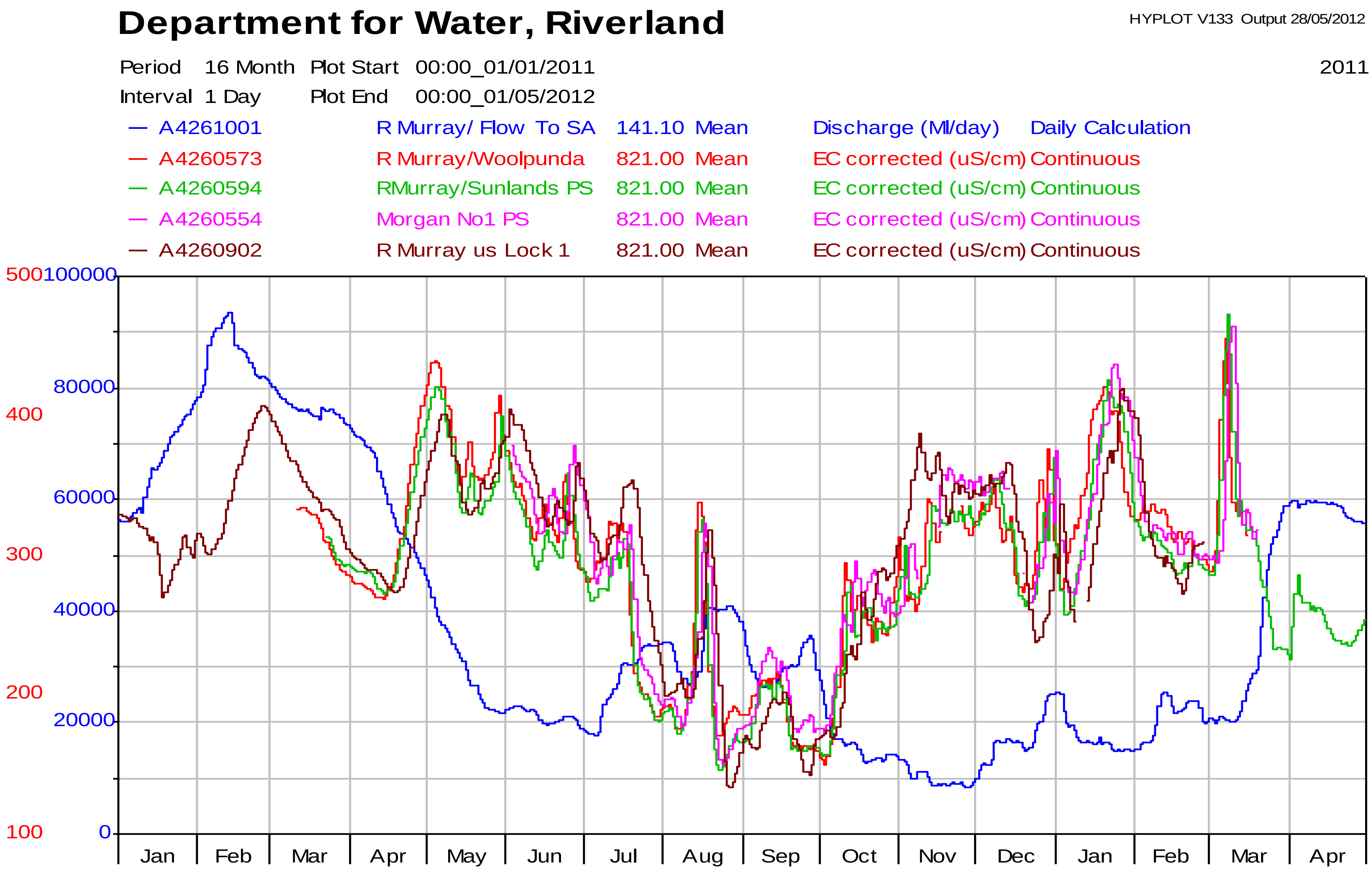

Figure 7 Flow to South Australia and salinity recordings for the Woolpunda to Lock 1 reach of the River Murray

4.3 MANUAL READINGS

Results from manual sampling locations are shown in Appendix B. The number of manual readings is limited due to interruptions to monitoring caused by the current high river. Further readings are required once the flow has receded sufficiently to allow appropriate data analysis to be conducted. Some points to note include:

- A 100 EC rise through Yatco lagoon several months after the peak river flows indicates the need for further manual sampling as the current recession occurs
- The Kingston EC sampling a few kilometres upstream of the Lake Bonney outlet provides a reasonable base for calculations of salt loads from Lake Bonney. Downstream of Lake Bonney and Lock 3 the continuous salinity monitoring stations at U/S Overland Corner and Woolpunda provide "end of reach" stations for salt load calculations
- EC sampling at the Gurra Lakes outlet provides a timing of non-surface water accessions into the Gurra Lakes complex
- EC sampling of the Overland Corner Wetland complex provided some interesting readings indicating the salinisation drivers of this wetland could be more complex than first thought.

4.4 FLOW GAUGINGS AND SALINITY MAPPING.

Only two gaugings were carried out during the initial recession in 2011. Gaugings in Lindsay River and Pike River confirmed preliminary analysis of salt loads entering the River Murray. The Lindsay River flow gauging on 1/11/2011 indicated a combined Lindsay-Mullaroo salt load of 53.5 tonnes/d. The two flow gaugings at Pike River on the 3 and 22 November 2011 gave calculated salt load accessions of 85 and 108 t/d respectively. Further gauging as part of the 2012 recession are planned when instream salinity recorders indicate higher localised accession may be occurring. Gauging records are provided in HYDSTRA and uploaded to the MDBA archive monthly.

5. CONCLUSIONS

- All the new equipment installations and refurbishments were carried out in time to monitor the start of salinity accessions as the river flows from the 2010 – 2011 high flow event declined. The community and government manual monitoring networks were also mobilised to commence data collection at the same time.
- The real time assessment of salt accessions in the River Murray enabled monitoring decisions, such as timing of gaugings, to quantify salt loads made during the event. This will continue during future recessions.
- The manual data collection program was interrupted by high flows in 2011 but is continuing into 2012 recession.
- The two Pike River gaugings indicated accessions of 85 and 108 t/d. Initial calculations from river monitoring gave calculated loads of 87 and 112 t/d. These results confirm the ability to delineate accessions from normal operational river monitoring, as well as the primary anabranch sources.
- The monitoring undertaken in this recession event will allow future monitoring to be continued in a similar context but will provide for alterations to the monitoring to better manage multiple recession and data gaps experienced throughout this event.

6. RECOMMENDATIONS

- The current recession should continue to be monitored closely; the many years of pre-flood drought may provide a significant increase in post flood accessions when the river returns to a "normal" operational state. Manual readings should be resumed once flows and water levels recede to appropriate levels.
- During future recessions and other significant potential salinity events, the listed manual monitoring sites should be sampled regularly to enable assessments of salt loads in the minor reaches. Positive results from this sampling may support moves for further continuous monitoring stations to be installed.
- Continuous simple assessment of reach by reach salinity accessions is possible; the data should be examined regularly to provide this assessment. Automatic graphical presentations of the telemetered real time data have been developed to enable visual checking of salinity traces and comparisons along the river. The use of these tools should be continued.

7. REFERENCES

FILE LOCATIONS

Location of files associated with this report within the Department for Water, Berri office computer network:

Report File

*Q:\Monitoring\Data\Backup\2011 Recession\Surface Water Recession**2011 EC Recession Monitoring Report.docx***

Data Files

Q:\Monitoring\Data\Backup\2011 Recession\Surface Water Recession

APPENDIX A MANUAL EC SAMPLING LOCATIONS

Site	East	North	Sampling	EC (µS/cm)	Comment
Salt Ck Bridge	463779.8	6202815.4	S end of bridge, watch out for traffic		
Goldmine Cliffs	463254.8	6201790.4	Approx 50m DS of pump shed		
Solora Pumps	462809.8	6197460.4	At Level Station		
Loxton B Ramp	459834.8	6187980.4	Off pontoon		
Milichs Landing	454269.8	6188375.4	At ramp		
Pyap	453649.8	6189965.4	Behind Pump shed		
Pyap Freundt Rd	446854.8	6194580.4	Off bank		
New Residence	445479.8	6196545.4	Off bank		
Yatco @ Sunbird Houseboats	442049.8	6204660.4	Off bank between houses		
Moorook IPS	441769.8	6206020.4	Off walkway		
KOM B Ramp	439644.8	6213310.4	Off bank in current		
Beldora Fence	443669.8	6204215.4	At fence line		
Loveday Basin	445134.8	6208470.4	Off mid point of causeway in current		
Loveday IPS	444694.8	6208595.4	In current under suctions		
Culverts	444309.8	6211500.4	In current downstream of road		
Cobby B Bank	444334.8	6212000.4	In current upstream of road		
Cobby A Bank	444979.8	6212820.4	In current upstream of road		
L Bonney @ Jetty	450269.8	6210095	Off end of jetty		
Nappers Bridge	447019.8	6215660.4	Off bank in current		
Nappers In/Out			Direction of Flow		
Chambers Ck @ Sugarloaf	442609.8	6212880.4	Off bank @ old crossing		
Knockburra @ Pump	442569.8	6215560.4	Off bank @ old pump		
Knockburra @ Balls	442554.8	6216490.4	Off bank in current		
RIT Pump Station	477335	6219355	Off Structure		
RAL Ral & Goolwa	476980	6222995	Off bank in current		
RAL Ral & Nelbuck	474875	6226070	Off bank in current		
Ramco Lagoon					
Boardwalk	400714	6218641			
Adjacent SIS track	400940	6219160			
Northern side of lagoon	400166	6219768			
Inlet/outlet creek structure	399892	6219964			
Inlet/outlet creek 50m from opening	399881	6220708			
River side of inlet/ outlet creek	399911	6220739			
Ramco Rd upstream creek	401699	6218765			
Nigra Ck DS regulator	400625	6228085			
Nigra Ck @ river	400035	6228385			
Hart Lagoon Inlet creek @ structure	405400	6218495			
Hart Outlet creek meets river Riccuito en	403285	6219205			
Banrock Outlet	438890	6217800			
Banrock Inlet	439965	6214355			
Banrock Nth Boardwalk	439035	6216885			
Overland Corner Wetland Outlet	438945	6220015			
Martin Bend Outlet	464330	6205815			

APPENDIX B SAMPLE OF MANUAL DATA COLLECTION RESULTS SPREADSHEET

2011 Recession Manual EC readings (µS/cm)

Date	Gurra Bridge	Goldmine Cliffs	Solora Pumps	Loxton B Ramp	Milichs Landing	Pyap	Pyap Freundt Rd	New Residence	Yatco @ Sunbird	Moorook IPS	Beldora Fence	Loveday Basin	Loveday IPS	Culverts
16/03/2011							317	322	359	329	332	351	338	332
17/03/2011	457	304	307	309	310	310								
30/03/2011														
14/04/2011	357	255	259	269										
19/04/2011														
21/04/2011	393													
28/04/2011	385		265	269	265	266		271	285	271				
2/05/2011														
19/05/2011														
24/05/2011														
30/05/2011												689		648
14/06/2011	673													
29/08/2011														
11/10/2011			229						287	216				
12/10/2011														216
24/10/2011	823			251	251		256		366	262				

APPENDIX C MONITORING LOCATIONS

Flood Recession Salinity Monitoring Locations, River Murray South Australia

Continuous Monitoring Sites

Site ID	Site Name
A4260200	River Murray downstream Rufus River (AMTD 696km)
A4260508	River Murray at Lock 7 Upstream (AMTD 696.6km)
A4260509	River Murray at Lock 7 Downstream (AMTD 696.6km)
A4260510	River Murray at Lock 6 Upstream (AMTD 619.8km)
A4260511	River Murray at Lock 6 Downstream (AMTD 619.8km)
A4260512	River Murray at Lock 5 Upstream (AMTD 562.4km)
A4260513	River Murray at Lock 5 Downstream (AMTD 562.4km)
A4260514	River Murray at Lock 4 Upstream (AMTD 516.2km)
A4260515	River Murray at Lock 4 Downstream (AMTD 516.2km)
A4260516	River Murray at Lock 3 Upstream (AMTD 431.4km)
A4260517	River Murray at Lock 3 Downstream (AMTD 431.4km)
A4260518	River Murray at Lock 2 Upstream (AMTD 362.1km)
A4260519	River Murray at Lock 2 Downstream (AMTD 362.1km)
A4260528	River Murray at Overland Corner (AMTD 417.5km)
A4260537	River Murray at Berri Irrigation PS (AMTD 525.7 Km)
A4260550	River Murray at Loxton Irrigation PS (AMTD 493.9 Km)
A4260554	River Murray at Morgan No1 Pump Station (AMTD 321.7 Km)
A4260573	River Murray at Woolpunda Pump Station (AMTD 411.5 Km)
A4260593	River Murray at Holder (AMTD 392.0 Km)
A4260594	River Murray upstream Sunlands PS (AMTD 373.6 Km)
A4260642	River Murray upstream Rilli Island (AMTD 500.5km)
A4260645	Pike River at Picnic Grounds upstream River Murray
A4260652	River Murray upstream Overland Corner (AMTD 426.5km)
A4260663	River Murray at Lyrup Pumping Station (AMTD 537.7km)
A4260702	River Murray downstream Hogwash Bend (AMTD 347.5km)
A4260703	River Murray upstream Renmark (AMTD 570.6km)
A4260704	River Murray downstream Chowilla Creek (AMTD 609.0km)
A4260705	River Murray upstream Chowilla Creek (AMTD 613.3km)
A4260902	River Murray at Lock 1 Upstream (AMTD 274.3km)
A4260903	River Murray at Lock 1 Downstream (AMTD 274.3km)
A4261022	River Murray upstream Old Customs House (AMTD 637.1km)
A4261023	River Murray upstream Pike River Outlet
A4261024	River Murray us Katarapko Ck Outlet (AMTD 482.4km)
A4261025	River Murray upstream Moorook (AMTD 455.6km)
A4261065	River Murray at Solora Pumping Station (AMTD 504.5km)
A4261066	River Murray at Clarke's Sandbar (AMTD 513.4km)
A4261091	Chowilla Creek downstream Monoman Creek
A4261110	River Murray downstream Morgan (AMTD 316.5km)

- Continuous Monitoring Site - Project Upgrade
- Continuous Monitoring Site - No upgrade
- Manual Readings

0 5 10 20 30 40

Kilometers

N

Map Production: Science, Monitoring and Information Division
Map Projection: Lambert Conformal Conic
Map Datum: GDA94
Date: May 2011
Imagery Source: Geoscience Australia NATMAP Digital Maps 2008

APPENDIX D PROCESSING RECORDED EC AND TEMPERATURE DATA

Resource Monitoring Technical Procedure
TP_M_0011 version 4.0

TECHNICAL PROCEDURE

RESOURCE MONITORING

PROCESSING RECORDED EC AND TEMPERATURE DATA

TP_M_0011

VERSION 4.0

Describes the standard approach to the processing and coding of digitally recorded electrical conductivity (EC) and water temperature data using the Hydstra TS system.

Government of South Australia
Department for Water

FOREWORD

This document is one of a set of Control Documents that form part of the Monitoring, Quality Management System that specify how monitoring tasks are to be conducted to ensure the monitoring activities match monitoring requirements and are compliant with adopted standards.

These documents are constantly under review and revision. Printed copies are considered to be 'uncontrolled' as they may not be the latest approved version. Always check for the latest version at the primary reference location: http://thewatershed.sa.gov.au/BA/ResourceMonitoring/Pages/Home.aspx

VERSION HISTORY

Version	Date	Author	Detail of Changes
1.0	01/08/2003	P. Stace	Original draft version published as SWP_SWD0007
2..0	27/08/2007	P. Stace	Full revision of SWP_SWD0007 in new format, with revised quality codes and variables
3.0	25/09/2007	P. Stace	Change to Quality Codes
4.0	28/03/2011	P. Stace	Revised format, modified content to include surface water groundwater

RELEASE AUTHORISATION

Date	13/05/2011	**Authorised**	Quality Manager	**Reference**	DWLBC 0187/07 .1
File Name	TP_M_0011_v4.0.docx				

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Preferred way to cite this publication

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1. PURPOSE AND SCOPE

This procedure provides a standard approach to the processing and coding of digitally recorded electrical conductivity (EC) and water temperature data using the Hydstra TS system.

2. PRIOR KNOWLEDGE REQUIREMENTS

The following knowledge and experience is assumed:

- General knowledge of water monitoring processes and procedures.
- General experience in the operation of water monitoring sites, in particular sites recording EC and water temperature.
- General experience in the use of Hydstra TS, in particular the use of the Data Managers Workbench.

3. RESPONSIBILITIES

Monitoring Officers

- Process all recorded EC and temperature data in accordance with this procedure.
- Maintain required Site Related Tables including Ratings used in the processing of EC and temperature data.

Hydstra System Administrator

- Provide support to Monitoring Officers to maintain Ratings Tables and variable conversion mechanisms used in the processing of EC and temperature data.

4. INTRODUCTION

The measurement of how well an electric current passes through a water sample is used as a standard method for indicating the salinity of the sample. Electrical Conductivity (EC) however changes in direct response to the temperature of the sample. Thus when measuring water salinity two related data sets, EC and water temperature, are required to enable a temperature correction to be applied to the 'raw' EC readings.

Whilst some continuous recording sensor/logger systems and some hand held instruments can provide 'automatic' temperature corrections to their readings the more reliable method is to record both 'raw' EC (with no temperature correction) and water temperature. The temperature correction is applied a as a post processing task after any necessary adjustments have been made to the 'raw' data.

5. QUALITY CODES FOR SPECIFIC WATER LEVEL RANGES

5.1. SURFACE WATER

In larger permanent streams that always contain water (eg River Murray) EC recorders are generally placed on floating pontoons mid-stream where salinity is more representative of the mean of the entire stream. The pontoon is able to move up and down with changing water levels and thus the EC sensor is always positioned at the same depth below the surface.

However, in smaller streams where water is not always present and water variations are far more dynamic EC sensors are generally attached to a fixed support in the stream channel. As water level (and flow rates) change the sensor remains in the same fixed position and depth over the sensor varies. Figure 1 shows a typical small stream arrangement with separate EC and water level sensors located upstream of a control weir.

A number of data coding issues arise with different water level situations.

When water levels are above cease to flow (CTF) the EC and water temperature data can be related to flows and salt loads can be calculated. Producing salt load information is one of the primary aims of these types of sites as it provides a measure of the total amount (volume) of salt being transported by the stream over a period of time. For the segment of data above CTF 'standard' quality coding would be used as appropriate to describe the quality of the EC and temperature data.

When water level falls below CTF the sensor will still be recording both EC and water temperature. This data is of interest as it provides information on the salinity and temperature of non-flowing pools that can be related to groundwater interactions, aquatic biology and 'stream health'. As the water level is below CTF the flow derived through the stage-discharge relationship would be zero. With zero flow, zero salt load would be produced by Hydstra. For the segment of data below CTF down to a level near the top of the sensor 'standard' quality coding would be used as appropriate to describe the quality of the EC and temperature data. There is no need to specifically code this segment of record or to add comments that flag that the water level is below CTF. Should an end user wish to separate flowing and non-flowing EC or temperature data a Hydstra application 'HYPARTST – *Partitioned Statistical Report'* (first available from Hydstra version 9.4.0) can be used that partitions and separates data based on a criteria applied to a time series data set e.g. partition EC data based on water level being greater than the CTF value to produce a time series of salinity data for flowing conditions only.

NOTE: *Monitoring Officers must ensure the CTF value in the Hydstra STATION Table is correct.*

HINT: *Refer to the Hydstra Help System (Version 9.4.0 or latter) for further information on the HYPARTST application.*

As the water level drops close to the top of the EC sensor, EC readings become unstable and the data recorded may not represent the actual salinity of the water body. Once the water level drops below the sensor altogether erroneous EC readings ranging from small positive values to odd negative values may be recorded. This spurious data needs to be coded '*Missing – outside recordable range'* (Quality Code 153).

Within this range where EC readings become spurious the temperature sensor will continue to function and as the level drops below the sensor, air temperature rather than water temperature will be recorded. This temperature data also needs to be coded '*Missing – outside recordable range*' (Quality Code 153) as the required parameter is water temperature not air temperature.

Coding the EC and temperature data as '*Missing*' makes the data 'invisible' to data processes, reporting and plotting applications. The actual data points however remain in the time series file and can be extracted or converted to another variable and quality at a later time if required. There is no need to edit out or delete this data as it becomes, in effect, invisible to all Hydstra processes.

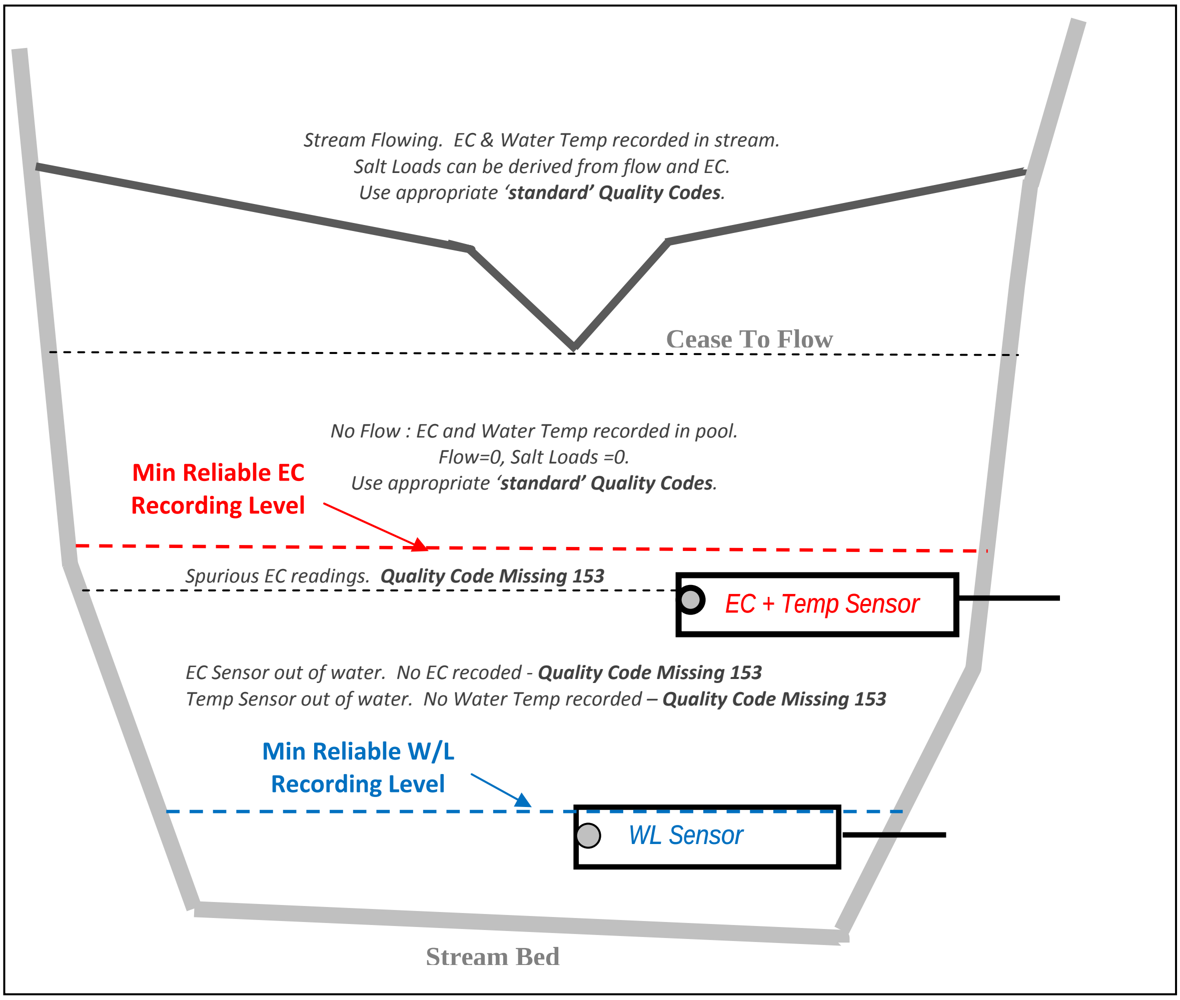

Figure 1 Surface Water Level Related EC and Temperature Quality Codes

To be able to appropriately code the EC and water temperature data the level at which EC readings become doubtful (minimum depth over sensor for reliable readings) should be known. In some cases the erratic shape of the recorded data may itself provide an indication of this position, however levels of the sensor taken during level surveys can assist in determining the correct level to be used during data processing.

> **NOTE:** *All EC and temperature data* ***above*** *the minimum reliable reading level use '****standard' quality*** *codes.*
>
> *All EC and temperature data* ***below*** *the minimum reliable reading level code as* ***'Missing – outside recordable range'****, (Quality Code 153).*

5.2. GROUNDWATER

Recording groundwater salinity and temperature presents similar, but somewhat simpler, issues of data quality in relation to water level. Generally in groundwater monitoring the water level and EC and temperature sensor are a single combined unit rather than in separate units as is more common in surface water monitoring applications. In addition there is no concept of a flow 'control' in groundwater level monitoring.

Any data recorded where water level is above the minimum reliable level of recording, just above the sensor, is potentially valid data and 'standard' quality codes would be applied (see Figure 2). As water level falls to a point just above the sensor spurious readings may start to be recorded. This position will be dependent on the type of instrument and the exact location of the sensor cell within the sensor body. This band of spurious data should be coded as Missing. As the level continues to fall below the sensor water level should be zero, EC should be zero and water temperature will actually be air temperature. With many sensors when the sensor is out of water the recorded water level and EC values may include odd positive and negative values that do not relate to actual water levels. All data below the sensor must be coded as Missing to prevent it being reported, exported or used in any data process.

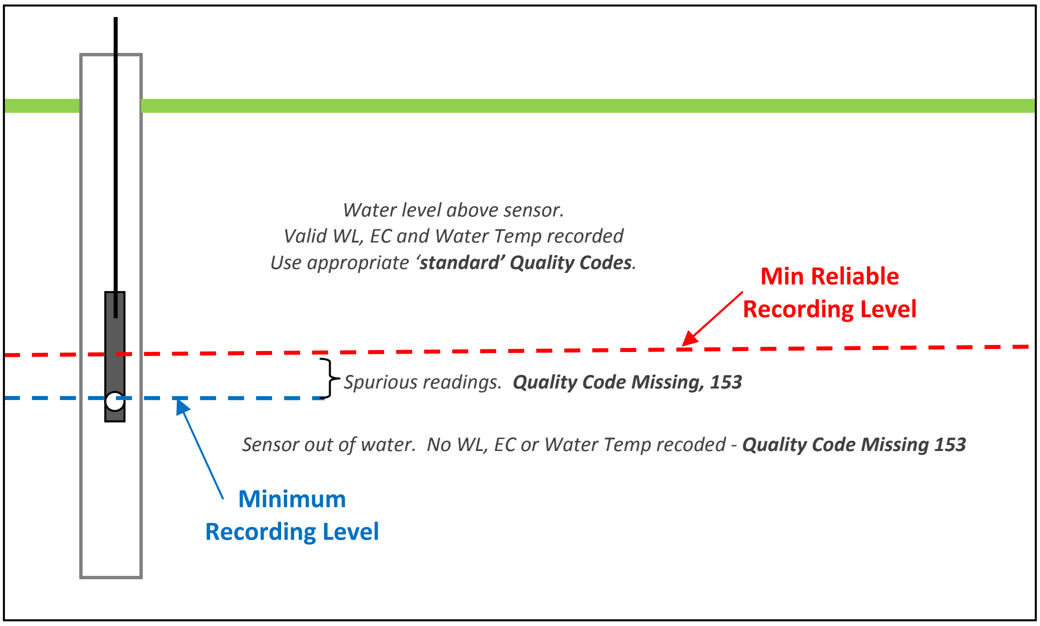

Figure 2 Groundwater Level Related EC and Temperature Quality Codes

> ***NOTE:*** *All EC and temperature data* ***above*** *the minimum reliable reading level use '****standard' quality*** *codes.*
>
> *All EC and temperature data* ***below*** *the minimum reliable reading level code as '****Missing – outside recordable range'****,(Quality Code 153).*

6. EC VARIABLE CODES

Depending on the make and model of the sensor EC may provide readings as automatically temperature corrected EC in microSiemens/cm at 25°C or un-corrected values in microSiemens/cm or milliSiemens/m. Different Hydstra Variable Codes are used to identify the different recorded EC data sets:

Table 1 Hydstra Variables for Recorded EC and Temperature Data

Variable	Description	Units	Example Sensor
450.00	Water temperature	C^{o}	All sensors
816.00	EC un-corrected	microSeimens/cm	Mindata, Greenspan
820.00	EC un-corrected	milliSeimens/m	Unidata
821.00	EC temp corrected (by Hydstra)	microSeimens/cm@25Co	Hydstra derived

NOTE: *Sub-Variables may be used to describe different sub-locations at a Site e.g. 821.01 = Downstream, 821. 02 = Upstream.*

Variable 450 (water temperature °C)

All EC sensors must be capable of providing temperature readings in degrees centigrade.

Temperature must ***always*** be recorded with EC.

WARNING: Temperature must always be recorded with EC.

Variable 816 (un-corrected EC in microSeimens/cm)

- Wherever possible salinity recording should be in un-corrected EC in microSeimens/cm (Var 816).
- Var 816 data is used as the base data set that is saved unchanged in the Raw Data Archive, is then adjusted, corrected and annotated with comments and then stored in the Archive.
- Var 816 is used together with temperature as the basis to derive temperature corrected EC using the Hydstra EC-Temp correction process.

NOTE: *'Raw' recorded EC data should be Var 816, un-corrected EC in microSeimens/cm.*

Variable 820 (un-corrected EC in milliSeimens/m)

Any sensor producing milliSeimens/m, Var 820 (e.g. Unidata), must have the data converted to microSeimens/cm within the data logger using the internal scale factor function. The resulting recorded data would be downloaded and processed as Var 816 using the same method as any other Var 816 data.

> ***NOTE:*** *All un-corrected EC data held in the State Water Archive must be in microSeimens/cm (Var 816).*
>
> *All milliSeimens/m (Var 820) data must be converted to microSeimens/cm (Var 816) by the logger.*

> ***CAUTION:*** ***No un-corrected milliSeimens/m (Var 820) data is to be stored in the archive.***

Variable 821.00 (Hydstra derived temperature corrected EC in microSeimens/cm)

- This is the final set of recorded EC data held in the archive.
- Variable 821 cannot be directly measured or recorded. Only un-corrected EC can be measured and temperature corrected readings derived through the Hydstra process (Var 821.00).
- Variable 821 is produced from the un-corrected EC in microSeimens/cm (Var 816) using Hydstra HYCRSUM and the associated recorded water temperature (Var 450) data for the same site (see Section 8, Temperature Correction following).

> ***WARNING:*** ***Variable 821 must be derived from un-corrected EC and temperature record for every EC monitoring site and saved to the archive.***

Telemetered sensor temperature corrected EC in microSeimens/cm

- At some sites there is a requirement for EC data to be made available in near-real time to data users using telemetry.
- Whilst some EC sensors have inbuilt temperature correction capability the temperature factor used varies between manufacturers and these functions are not used for final archived data.
- Instead un-corrected EC and temperature are read and functions in the data logger used to undertake the temperature correction utalising the same conversion factor as is used in the Hydstra post process.
- All telemetered logger-corrected EC data is Quality Coded as unverified.
- Telemetered logger-corrected EC data is not processed to the Water Data Archive but is maintained in a separate data storage area.

> ***NOTE:*** ***Sensor-corrected** EC data is not processed to the archive.*
>
> *If temperature corrected EC is required for telemetry purposes the correction is made using the data logger and the same temperature correction factor as used in the 'standard' Hydstra process.*

7. PROCESSING EC DATA

Primary adjustments, modifications and editing of EC recordings must be undertaken on the 'raw' as-recorded data (Var 816) ***prior to*** the temperature correction being applied (see Figure 3).

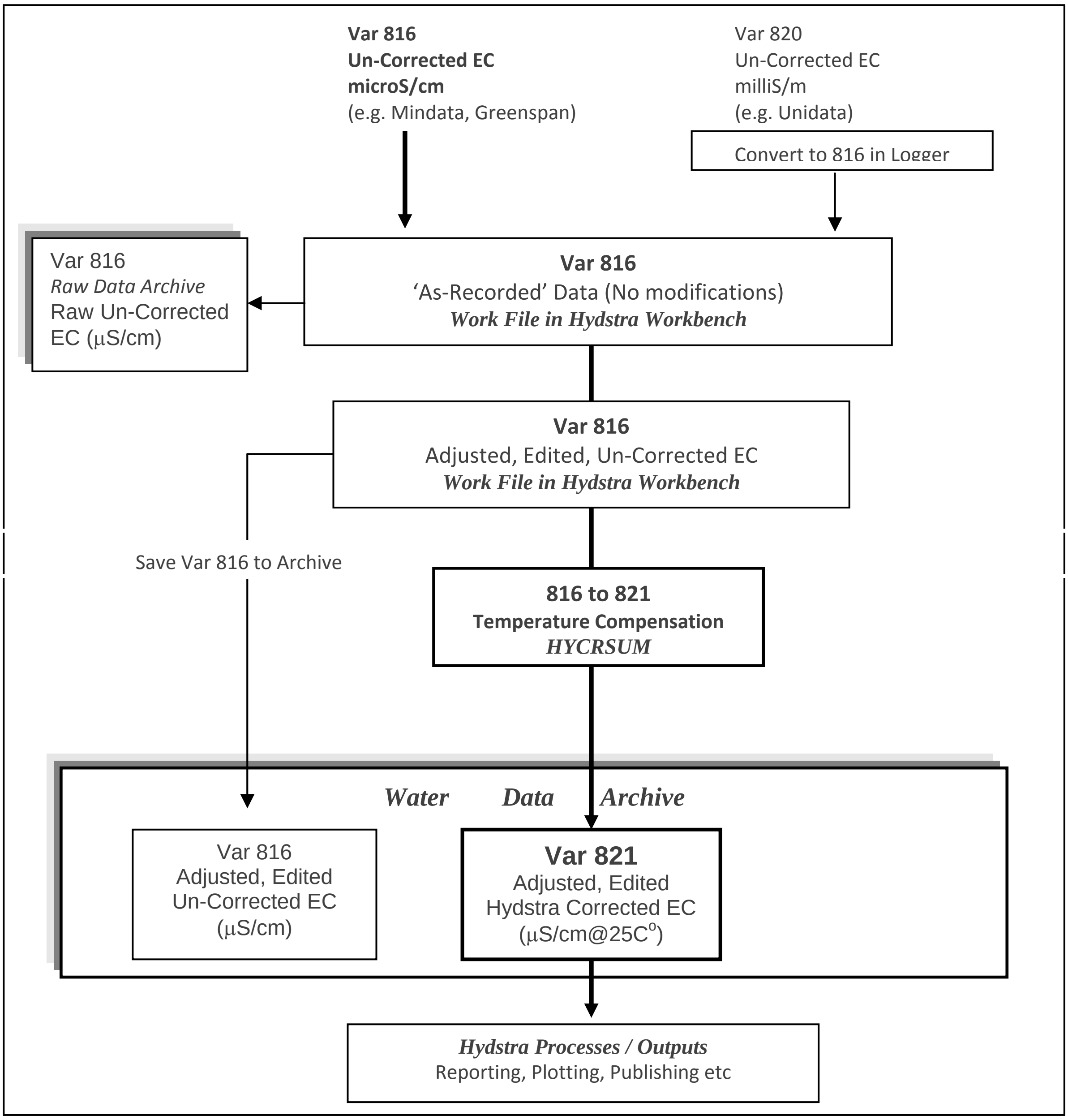

Figure 3 EC Data Processing

Should any refinement to the temperature corrected relationship occur in the future then a new set of temperature corrected EC could be derived based on the original edited non-temperature corrected EC record and the new correction factor. This is a similar approach to the process of calculating a new set of flow data using a new discharge rating without any change being made to the water level data.

WARNING:	***All adjustments and modifications to EC data must be completed on the Var 816 data prior to converting to Var 821. Do not modify Var 821 data.***

To validate and if necessary adjust and edit recorded EC data manual EC readings must be taken at each site visit in un-corrected EC in microSeimens/cm together with a corresponding water temperature reading.

NOTE:	*Always take a manual un-corrected EC reading and water temperature reading at each site visit (when any water is present).*

7.1. DATA EDITING

When comparing recorded EC or temperature against on-site manual readings taken with a calibrated precision EC meter, readings from the portable EC meter are considered the most reliable and precise and would be used as the primary value to adjust the recorded data. (Provided that all standard practices have been followed and the manual readings are taken in the same water as is being measured by the logger's EC sensor.)

The Hydstra Data Managers Workbench is used to view and if necessary adjust and edit the recorded time series data (refer to TP_M_0016). Appropriate comments should be attached to the record (refer to TP_M_0004) and appropriate quality codes used (refer to TP_M_0021). Modifying EC and temperature data should generally be limited to making any required calibration adjustments and correcting obvious (instrument) errors.

CAUTION:	*Do not alter data unless the change can be validated against some reliable, tangible evidence or information.*

Typical situations where editing may be necessary include:

- Erroneous spikes caused by instrument 'glitches' should be removed.
- If the trace is 'painting', possibly due to poor instrument performance, then this should remain unaltered, an appropriate comment inserted and the quality code changed accordingly.
- Unusual events such as 'salinity slugs' that are not associated with a corresponding known event should be left unaltered, unless there is proof that the event was in fact an instrument malfunction or human interference.

Checking data against recordings from another site on the same stream or in the same groundwater body (where available) may assist in verifying unusual events. It is however difficult to check these types of events against other sites, as salinity can be a 'localised' phenomenon.

8. TEMPERATURE CORRECTION

All EC data needs to be expressed in units at a standard temperature of 25°C. A standard process in Hydstra has been set up to correct 'raw' EC (µS/cm, Var 816) to temperature corrected EC (µS/cm@25°C, Var 821).

The Hydstra process uses HYCRSUM to 'extract' the corresponding temperature value and uses this to 'lookup' the appropriate temperature correction factor from the rating table ECTEMP. The corresponding raw EC is then multiplied by the appropriate temperature factor to produce a new time series of temperature corrected EC (µS/cm@25°C, Var 821).

> ***NOTE:*** *To be able to carry out the temperature correction process the Hydstra rating ECTEMP (VarCon 450 to 451) must be 'attached' to the site's rating tables. Contact the Hydstra Systems Administrator if you require assistance.*

The standard HYCRSUM process to apply the temperature correction is available as a 'Saved Job'. The 'Saved Job' **EC_Temp Correction** can be launched from the HYCRSUM application with all the standard fields completed (See Figure 4).

Edit and complete the required fields and then run the application. Some specific fields in HYCRSUM need to be completed:

- Insert the correct Site IDs and time series Work File letter in:
  - '**Primary Input File'** (existing file containing Var 816 EC data. E.g. 'A')
  - '**Secondary Input File** (existing file containing Var 450 temp data. E.g. 'A')
  - '**Output File**' (new file to contain Var 821 EC data. E.g. 'Q')
- Insert the appropriate date and times for the period of data to be processed:
  - 'Start Time'
  - 'End Time'
- The **Preserve Comments** option should be set to **YES** for the **Primary Input File** so that all existing editing comments in the Var 816 data are carried into the new Var 821 data file.
- Run HYCRSUM to produce the new '**Q**' extension Work File containing the temp corrected EC.

HYCRSUM will produce a new TS file containing the temperature corrected EC for the site in a Work File with the selected Output File suffix 'Q'. This file should be viewed and verified in the Database Managers Workbench. Any additional comments or changes to quality should be made prior to archiving.

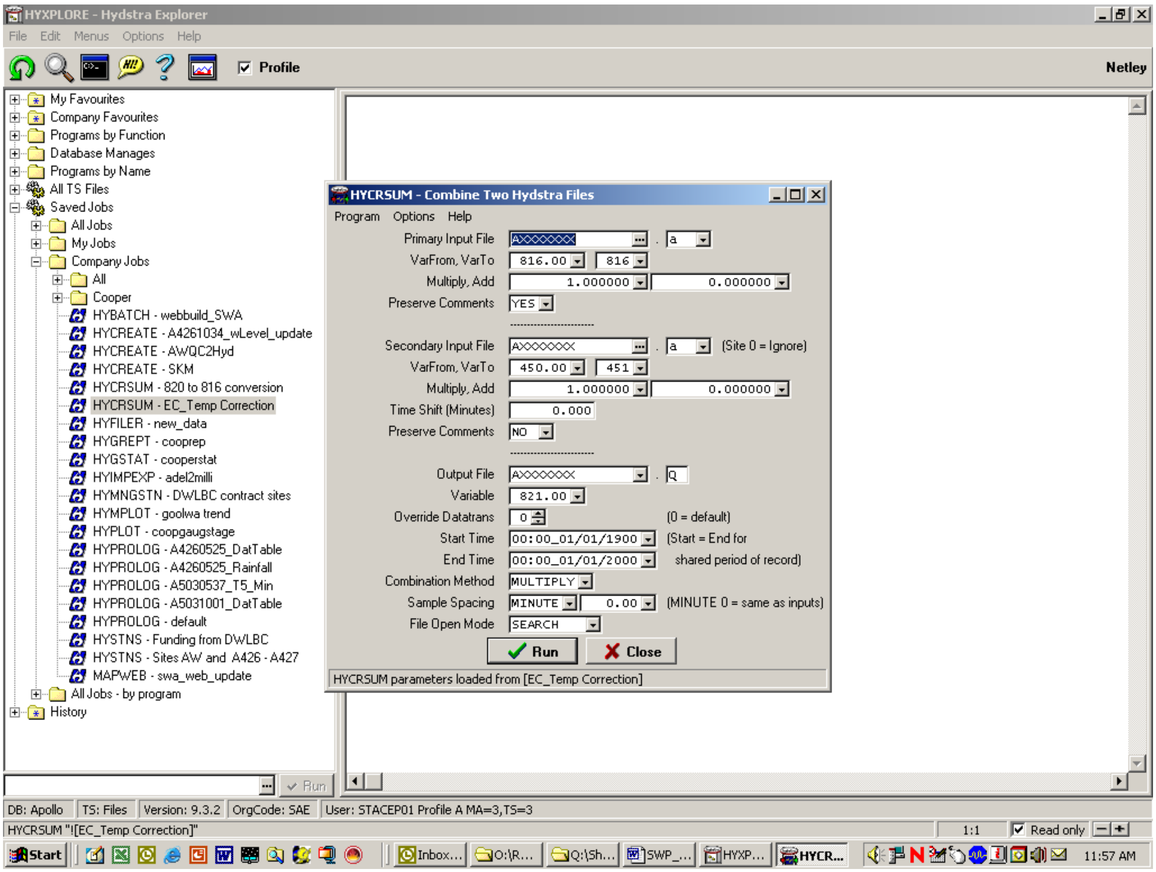

Figure 4 HYCRSUM Saved Job – EC_Temp Correction

9. CONVERSION TO TDS

EC is a physical measurement of electrical conductivity that provides an ***indication*** of the salinity of water. Total Dissolved Solids (TDS) is the generally used as the 'scientific' measurement of water salinity.

TDS is a measure of the total amount of dissolved solids in a given volume. This is expressed as Total Dissolved Solids in milligrams per litre (TDS mg/l). TDS is measured by drying a sample of water and measuring the weight of the remaining solids. TDS requires laboratory facilities and direct measurements of TDS cannot be undertaken on-site.

TDS is however related proportionally to EC and thus (approximate) TDS can be derived from EC data. The relationship between TDS and EC is complex and non-linear, being affected by variations in the chemistry of the water and a range of physical factors including temperature and turbidity.

A conversion algorithm was developed by the SA Water, Australian Water Quality Centre (AWQC) in the mid 1970's that is used as the standard conversion of EC to TDS for surface water within South Australia up to 45,000 µS/cm@25°C (approximate ocean water salinity).

> ***NOTE:*** *EC to TDS conversion using the standard 'EC2TDS' system are only valid for salinities of up to 45,000 µS/cm@25°C. Beyond this level this conversion relationship is not applicable.*

The conversion of EC to TDS is made using a Hydstra variable conversion process (VarCon 821 to 800). The conversion table is held in a Hydstra Rating Table 'EC2TDS' that must be entered in the Rating Tables for each site where EC data is required to be converted to TDS. This is generally only at surface water stream flow monitoring sites where salt loads are required as an output.

> **NOTE:** *To be able to carry out the EC to TDS conversion process the Hydstra rating EC2TDS (VarCon 821 to 800) must be 'attached' to the site's rating tables. Contact the Hydstra Systems Administrator if you require assistance.*

To produce TDS data for a site that has recorded EC data (and the EC2TDS rating) it is a simple matter of using a standard variable conversion of VarFrom 821.00 and VarTo 800.00.

Figure 5 shows a typical example where a graph of TDS is produced using HYPLOT. The first DATA row on the parameter screen will produce a graph of EC without any variable conversion (VarFrom 821.00 to VarTo 821.00).

The second row uses a variable conversion (VarFrom 821.00 to VarTo 800.00). Thus temperature corrected EC (Variable 821.00) is used to produce the plot of TDS (Variable 800). Figure 6 shows the resulting plot.

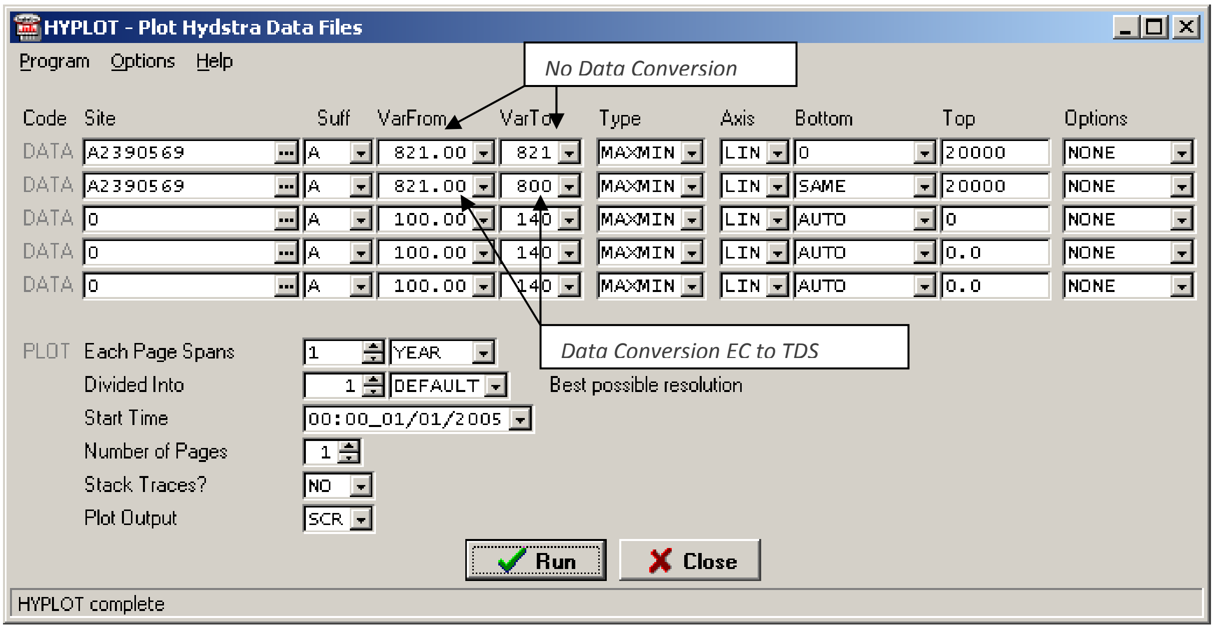

Figure 5 HYPLOT Application Parameter Screen for EC to TDS

Figure 6 HYPLOT EC to TDS

10. PRODUCING SALT LOADS

The conversion of EC to TDS is an essential step in producing salt load data. A standard variable conversion process (VarCon 821.00 to 1021.00) is used to convert EC readings to TDS then combine with the flow volume to produce salt load in tonnes. For salt load data to be produced the following components must be in the Hydstra Site Related records for the site:

- Time series temperature corrected EC in µS/cm@25°C (Var 821.00)
- The 'EC2TDS' rating must be active in the Ratings Tables.
- Time series water level data (Var 100.00).
- An active water level to flow rating (VarCon 100.00 to 140) must be in the Rating Table.

The variable conversion employs a 2-step Variable Mapping process to provide the result.

Var From **821.00** (Recorded temperature corrected EC in µS/cm@25°C)

Var To **1021.00** (Salt Load by EC in tonnes)

When the variable mapping from 821.00 to 1021.00 is entered in a Hydstra application such as HYPLOT the following sequence of variable conversion takes place:

VarMap Sequences

Step 1

821.00	⇒	lookup rating 821 to 800	⇒	800.00
EC (µS/cm@25°C)				TDS (mg/l)

Use the 'standard' EC to TDS rating to lookup each EC reading and apply the EC2TDS conversion to produce TDS.

Step 2

800.00	⇒	(trace multiply 100 to 151) / 1000	⇒	1021.00
TDS (mg/l)				Salt Load by EC (tonnes)

For every TDS value, extract the corresponding recorded water level value (100) and use the water level to flow rating to calculate the flow (151). Next multiply the derived flow by the TDS value and finally divide the result by 1000 to produce salt load in tonnes.

With in Step 2 above the calculation of flow (Var 100 to Var 151) made using a 3sub-step Variable Map sequence:

Sub-Step 1 Detail

100.00	⇒	lookup rating 100 to 140	⇒	140.00
Water level (m)				Flow rate (m/s)

Sub-Step 2 Detail

140.00	⇒	rescale (*86.4)	⇒	141.00
Flow (m/s)				Flow rate (Ml/day)

Sub-Step 3 Detail

141.00	⇒	integrate over time	⇒	151.00
Flow (Ml/day)				Flow total (Ml)

To produce salt load data for a site that has continuously recorded EC data and both the EC2TDS rating and a water level to flow rating are in place it is a simple matter to use a variable conversion of **VarFrom 821.00 and VarTo 1021.00.**

Figure 7 shows a typical example where a graph of salt load (tonnes) is to be produced using HYPLOT. The first DATA row on the parameter screen will produce the graph of salt load using the variable conversion (VarFrom 821.00 to VarTo 1021.00). Note that salt load is a volume over an interval of time and cannot be expressed as a value at a specific point in time such as instantaneous, maximum or minimum etc. A period for the calculation of the total volume must be set in the Hydstra application and in the case of HYPLOT the Graph Type needs to be set to 'TOT' (Total). In this example salt load totals are calculated over a one-day interval. Salt load data can also be calculated and displayed as cumulative 'CUM' type data providing a 'running' total of values for any desired period of time.

The second row of the parameter screen uses a variable conversion (VarFrom 100.00 to VarTo 140.00) to produce a graph of flow in cumecs from the water level data using the water level to flow (stage-discharge relationship) rating for the site.

The third row of the parameter screen will produce a graph of EC without any variable conversion (VarFrom 821.00 to VarTo 821.00). Figure 8 shows the resulting plot.

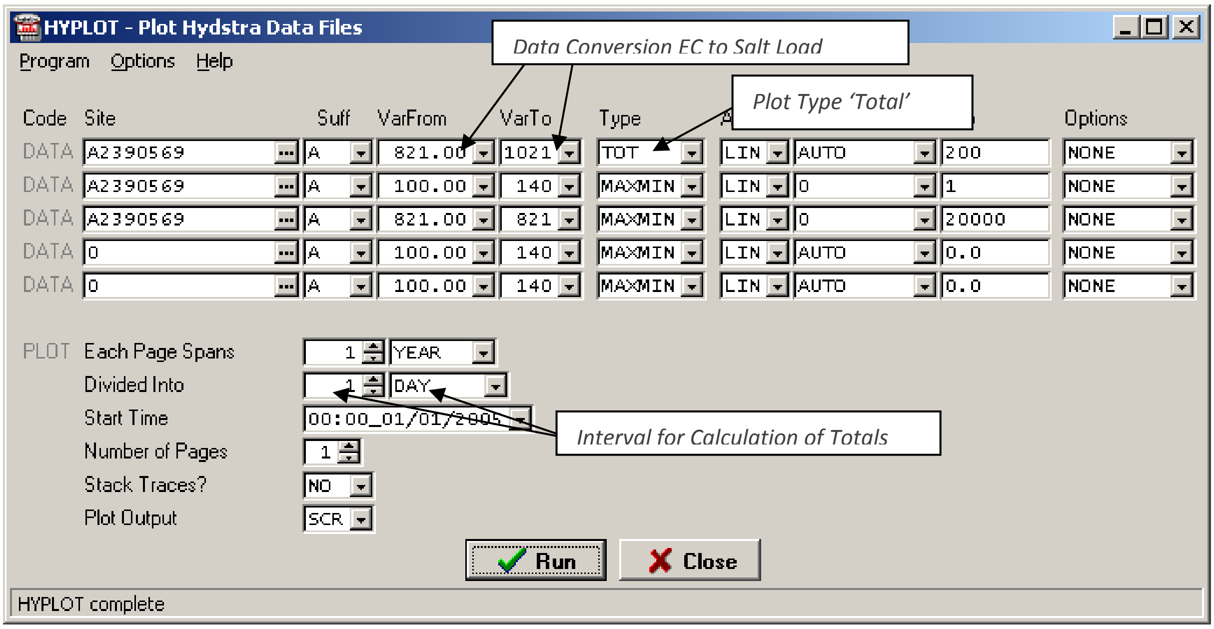

Figure 7 HYPLOT Application Parameter Screen for EC to Salt Load

Salt loads can also be produced in kg units using a Variable Conversion of VarFrom 821.00 to VarTo 921.00.

NOTES: *Salt load is a measure of salt volume over an interval of time and must be set as a 'Total' data type in Hydstra applications.*

To be able to carry out the EC to Salt Load conversion process the Hydstra rating EC2TDS (VarCon 821 to 800) and a valid water level to flow rating (VarCon 100 to 140) must be 'attached' to the site's rating tables. Contact the Hydstra Systems Administrator if you require assistance.

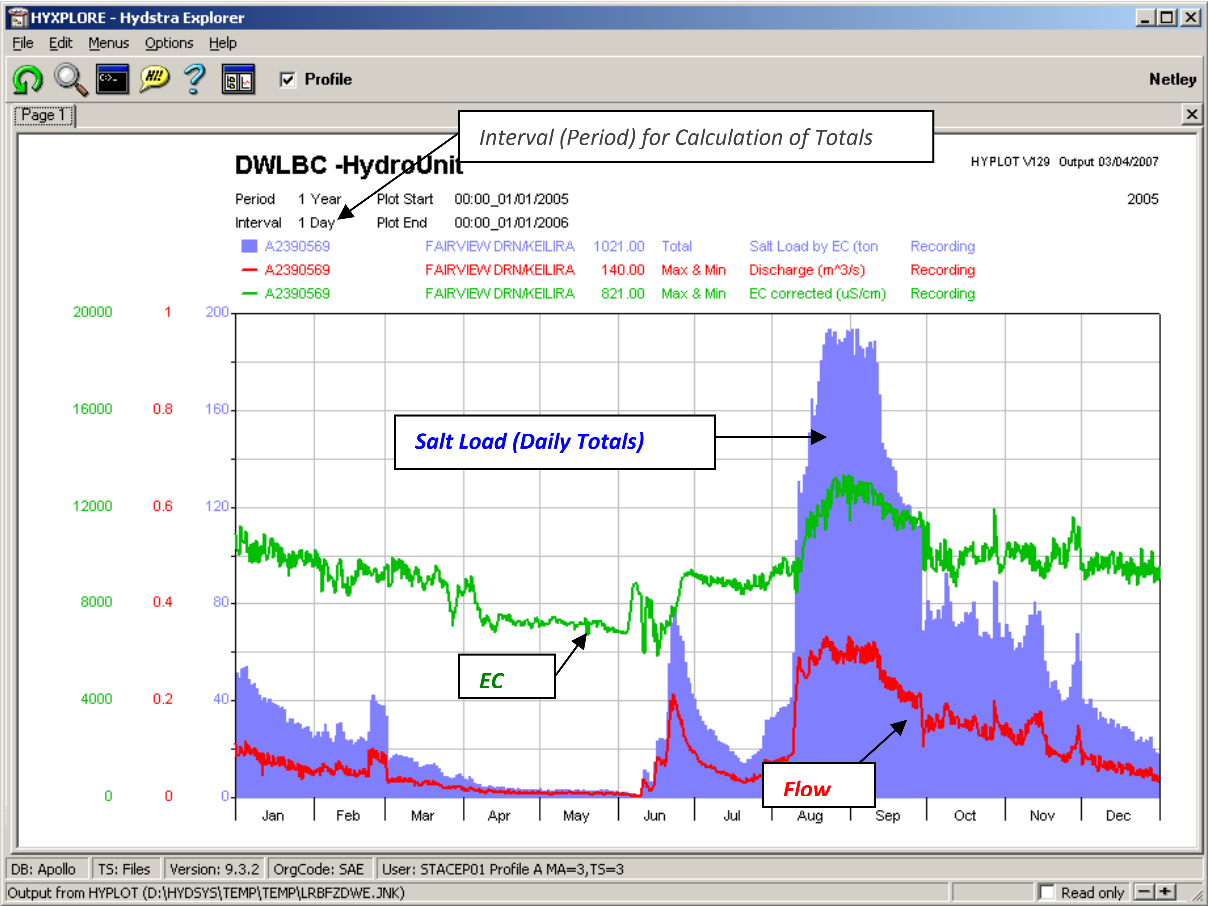

Figure 8 HYPLOT, EC to Salt Load

11. REFERENCES

Department for Water, 2010, *Attaching Comments to Time Series Data*, Document No. TP_M_0004, Department for Water, South Australia.

Kisters Pty Ltd 2005, *Hydstra Help v9.06*, digital help file system.

APPENDIX A: PROCESSING SUMMARY

Summary of Major Points to be Observed When Processing Recorded EC and Water Temperature Data

Data Collection

- Always record both 'raw' EC (with no temperature correction) and water temperature.
- 'Raw' recorded EC data should be un-corrected EC in microSeimens/cm (Var816).
- Always take a manual un-corrected EC reading and water temperature reading at each site visit.
- The temperature correction is applied as a post processing task after any necessary adjustments have been made to the 'raw' data.

EC Variable Codes

Variable	Description	Units	Example Sensor
450.00	Water temperature	C^o	All sensors
816.00	EC un-corrected	microSeimens/cm	Mindata, Greenspan
820.00	EC un-corrected	milliSeimens/m	Unidata
821.00	EC temp corrected (by Hydstra)	microSeimens/cm@25Co	Hydstra derived (Final Archive)

Data Processing and Editing

- All adjustments and modifications to EC data must be completed on the Var 816 data prior to the temperature correction being applied converting the data to Var 821. Do not modify Var 821 data
- Do not alter, modify or edit EC or temperature data unless the change can be validated against some reliable, tangible evidence or information.
- All EC and temperature data **above** the minimum reliable reading level use '**standard' quality** codes.
- All EC and temperature data **below** the minimum reliable reading level code as '**Missing – outside recordable range'**, (Quality Code 153).
- There is no need to delete or edit data below the minimum reliable sensor reading water level that is to be coded as missing as it becomes hidden to all Hydstra applications and will not be reported, exported or plotted.
- To be able to carry out the temperature correction process the Hydstra rating ECTEMP (VarCon 450 to 451) must be 'attached' to the site's rating tables. Contact the Hydstra Systems Administrator if you require assistance.
- Salt load is a measure of salt volume over an interval of time and must be set as a 'Total' data type in Hydstra applications.
- *To be able to carry out the EC to Salt Load conversion process the Hydstra rating EC2TDS (VarCon 821 to 800) and a valid water level to flow rating (VarCon 100 to 140) must be 'attached' to the site's rating tables. Contact the Hydstra Systems Administrator if you require assistance.*