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Report on the evaluation of the
performance characteristics of
the ALPIU conductivity unit

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The Institute of Freshwater Ecology is part of the Terrestrial and Freshwater Sciences Directorate of the Natural Environment Research Council.

The evaluation consisted of the following:

(Quote 11.09.89)

1. Determination of the cell constant of 1 ALPIU sensor over a temperature range of 0 to 70°C (0, 10, 25, 40, 70°C) using standard potassium chloride solutions prepared by weight and using a standard dilution method with weight burette. Calibration to cover points in the range of 20-400 μS .
2. Calibrate 25 ALPIU sensors supplied as new by Martin-Baker. These will be cleaned by ultrasonication in an appropriate fluid. Initial tests will be performed to establish the most efficient cleaning procedure. The cell constant for each of the sensors will be determined at 25°C. The results will be analysed to obtain the mean value for the batch and variance from the mean. The results will also be expressed in terms of the effective resistance of the ALPIU sensor in different freshwaters ranging in conductivity from 2-100 $\mu\text{S cm}^{-1}$.
3. Two additional sensors which have been in service will be supplied by Martin-Baker. These will be calibrated using the procedure in 2. above. In addition, further cleaning tests and calibrations will be undertaken as necessary.
4. Equipment and procedures for production checks on the performance of the ALPIU conductivity sensor will be recommended.

The report is organised according to the above section numbers.

1. Determination of the cell constant of 1 ALPIU sensor over the range of 0 to 70°C (0, 10, 25, 40 and 70°C). ALPIU Sensor number 1

1.1 Measurement Cell

A cell was custom made to house the ALPIU unit and electrolyte solution. It consisted of an approximately 500 ml capacity pyrex vessel with a B34/35 ground glass joint to hold the ALPIU unit and B7/11 ground glass joint for the weight burette. The cell and contents were contained in a stainless steel/UPVC cage for immersion in a precision thermostat.

The ALPIU unit was attached to an electrode housing supplied by Martin-Baker. A cone adapter with seal was constructed from PTFE to ensure an air-tight seal when the unit was placed in the cell. A PTFE stirrer bar with magnetic cone was placed inside the cell. In operation this was rotated using a submerged motor (Rank).

1.2 Equipment

All conductance measurements were made using an Automatic Precision a.c. Bridge (B905, Wayne-Kerr). This was operated at frequencies of 1000 Hz, 400 Hz and 100 Hz. Ultrasonication was done using a Rapidis ultrasonicator (Ultrasonic Ltd) at 200 W for 2 minutes. All weighings were done on a Mettler 2000 electronic balance (4 decimal places) or Mettler P1210 (2 decimal places). Details of the precision oil thermostat are given in Appendix A.

1.3 Cleaning and Drying of Apparatus

The cell was cleaned with chromic acid and thoroughly washed with distilled water. Before each series of measurements the apparatus was washed three times with single distilled water and then three times with general-purpose grade (GPR) acetone. The cell was then dried in an air oven at 110°C for approximately 15 minutes. The weight burette was cleaned and dried using the same procedure.

After an experiment, the cell was emptied of solution and rinsed three times with distilled water, filled with distilled water and then left to stand overnight. After the initial cleaning the cell was not allowed to come in contact with chromic acid or detergents.

1.4 Preparation of new ALPIU units (Numbers 1 to 23)

All the ALPIU units were supplied with numbered tags. Numbers 1 to 23 were new units. Numbers 24 and 25 were units which had been in use and had been in contact with seawater.

All the new ALPIU units were washed and ultrasonicated before testing. This was done by immersing the sensor probe (detached from housing) in ≈ 50 ml of GPR acetone and ultrasonicated at ≈ 200 Watts for 2 minutes. The sensor was then dried at room temperature using a stream of nitrogen gas. The unit was then attached to the housing and placed into the measuring cell.

1.5 Frequency extrapolation

The conductance of electrolyte solutions, including freshwater, increases with increasing frequency. This effect is attributed to polarisation at the electrodes and can be allowed for by measuring the conductance at several frequencies. In this investigation, a linear extrapolation was obtained for a plot of conductance $G(f)$ at frequency f against $1/f$. Measurements were made at 100, 400 and 1000 Hz to obtain the conductance at infinite frequency, $G(\infty)$.

1.6 Methodology for Measurements at 0, 10, and 25°C

Precise data are available for the conductivity of dilute potassium chloride solutions of different molarity for temperatures of 0, 10, 18 and 25°C.

The molar conductance of potassium chloride solutions may be written in the form:

$$\Lambda = \Lambda_0 - Sc^{1/2} + Ec \log c + J_1 c - J_2 c^{3/2} \quad (1)$$

where c is the concentration (mol dm^{-3}) and the coefficients Λ_0 , S , E , J_1 and J_2 are shown in Table 1. By measuring the conductance of dilute solutions of potassium chloride at one of these temperatures, it is possible to calculate a cell constant, s , from the calculated value of Λ , i.e.

$$s = 1000 \Lambda c / G(\infty) \quad (2)$$

where $G(\infty)$ is the conductance of the solution extrapolated to infinite frequency (μS).

All measurements were made with the cell described above immersed in the precision thermostat (details in Appendix A). A stock solution of potassium chloride was prepared by dissolving Aristrar grade KCl in 100 ml of triple-distilled water. This preparation was done by weight with displacement of nitrogen gas from the container. The cell was dried, flushed with nitrogen (white spot purity) and weighed. Approximately 400 ml of triple distilled water was added, the head-space flushed with nitrogen and reweighed. The volume of water was determined from the weight difference with appropriate buoyancy corrections for nitrogen displacement. The ALPIU unit attached to the housing and adaptor was then fitted into the cell. The complete unit was then fitted to the immersion cage and placed in the oil-thermostat. The solution was then left stirred for about 1 hour until the conductance reading was stable and temperature equilibration had been achieved.

At equilibrium, the conductance of the solution was measured at the three frequencies. Following this, an addition of stock KCl was made using the weight burette. The amount of KCl added was determined by weight difference with the appropriate buoyancy corrections for nitrogen displacement. Care was needed to minimize evaporation from the weight burette after the stock solution addition and before the final weight measurement.

Some difficulties were observed with bubble attachment to the ALPIU unit following immersion. It was found necessary to remove the cell and inspect the unit from time to time. Generally, once the unit was immersed and bubbles shaken free, no further problems were encountered.

After a further 10-20 minutes to permit equilibration, the conductance of the solution was measured at the three frequencies. Subsequent additions of stock solution were made as described above so that conductance readings in the 0-600 μS range were obtained.

At the end of the calibration experiment, the results were analysed using a BASIC program CELCON on an APPLE II computer. The results of the experiment and calculations at 0, 10 and 25°C are shown in Tables 2, 3 and 4.

Table 1. Coefficients for Equation (1) used in this work

Author	Temp/ ^o C	Λ_0	S	E	J_1	J_2
Fuoss (LZF)	25	149.93	94.65	58.74	198.4	-
Fuoss, Hsia	25	149.936	94.88	58.67	221.0	229.0
Justice	25	149.89	94.87	58.63	229.0	264.3
Barthel	25	149.873	95.01	38.48	183.1	176.4
	18	129.497	80.38	32.87	154.3	143.0
	10	107.359	64.98	27.07	125.4	110.3
	0	81.700	47.80	20.60	93.8	79.3

Table 2 Details of measurements at 0°C using ALPIU unit 1

Stock KCl 1.5558 g in 98.2495 g triple-distilled water
 Weight of solvent 385.41
 Solvent conductance (∞ frequency) 1.6655 μS

Mass of Stock g	G, Conductance/ μS			
	1000 Hz	400 Hz	100 Hz	∞
0.5914	90.78	87.61	79.86	91.28
1.5255	299.45	274.30	226.90	300.63
1.1857	446.06	398.40	317.02	446.61
1.1662	580.1	509.0	394.72	579.52
1.4150	732.5	631.8	479.11	

Calculation of cell constant from G (∞) with correction for lead resistance

Weight of KCl (G) = 1.5558
 Weight of solvent (G) = 98.2495
 Lead resistance (ohms) = .39
 Weight of solvent in reservoir (G) = 385.41

Cell constant (Barthel) at temperature = 0°C

Mass KCl g	Concentration mmol/l	Conductance μS	Cell constant cm^{-1}
.592	.3201	89.6131	.28882
2.1191	1.1414	298.9948	.30585
3.306	1.7753	445.0172	.31813
4.4734	2.3951	577.9802	.32922
5.8899	3.1422	728.1167	.34153

Average cell constant = .31671 cm^{-1}

Conductivity range 26 to 250 $\mu\text{S cm}^{-1}$

Table 3 Details of measurements at 10⁰C using ALPIU unit 1

Stock KCl 1.5558 g in 98.2495 g triple-distilled water
 Weight of solvent 406.69 g
 Solvent conductance (∞ frequency) 2.4964 μ S

Mass of stock /g	1000 Hz	400 Hz	100 Hz	∞
0.0687	15.648	15.527	15.175	15.678
0.4994	107.99	104.15	94.70	108.61
0.5289	201.30	189.96	164.97	202.55
0.9152	352.34	323.20	266.86	353.99
0.7393	466.13	419.95	336.82	467.52

Calculation of cell constant from $G(\infty)$ with correction for lead resistance

Weight of KCl (g) = 1.5558
 Weight of solvent (g) = 98.2495
 Lead resistance (OHMS) = .39
 Weight of solvent in reservoir (g) = 406.69
 Cell constant (Barthel) at temperature = 10⁰C

Mass KCl g	Concentration mmol/l	Conductance μ S	Cell constant cm^{-1}
.0687	.0352	13.1816	.28634
.5686	.2914	106.1183	.2918
1.0981	.562	200.0696	.2973
2.0143	1.0286	351.5381	.30815
2.7543	1.404	465.1043	.31691

Average cell constant = .3001 cm^{-1}
 Conductivity range 4 to 150 μ S cm^{-1}

Table 4 Details of measurements at 25⁰C using ALPIU unit 1

Stock KCl 1.5558 g in 98.2495 g triple-distilled water

Mass of Stock g	G, Conductance/ μ S			
	1000 Hz	400 Hz	100 Hz	∞
<i>Run 1</i>	Weight of solvent = 391.25 g Solvent conductance (∞ frequency) = 3.1529 μ S			
0.8421	218.70	211.67	195.14	219.68
1.3431	518.4	488.41	419.43	522.29
0.4348	612.0	572.7	481.49	617.26
<i>Run 2</i>	Weight of solvent = 394.13 g Solvent conductance (∞ frequency) = 2.757 μ S			
0.5639	150.03	146.23	136.92	150.64

Calculation of cell constant from $G(\infty)$ with correction for lead resistance

Mass of stock /g	Concentration mmol/litre	Conductance μ S
0.8429	0.4474	216.55
2.1874	1.1573	519.25
2.6227	1.386	614.26

Cell constant (all in units of cm^{-1})

	Barthel	LZF	FCC(FH)	J
<i>Run 1</i>	0.3056	0.3057	0.3057	0.3056
	0.3270	0.3271	0.3271	0.3270
	0.3304	0.3305	0.3305	0.3304
<i>Run 2</i>	0.2929	0.2930	0.2930	0.2930
<i>Average</i>	0.3070	0.3071	0.3071	0.3070

Average cell constant (Barthel) = 0.3070 cm^{-1}
Conductivity range 44 to 203 μ S cm^{-1}

1.7 Methodology for measurement at 40 and 70°C

All measurements were done using a reservoir containing the ALPIU sensor and a glass conductivity cell (Phillips, model PW9510/60). The temperature of the water thermostat was controlled to $\pm 0.1^\circ\text{C}$. The cell constant of the glass electrode was determined as $0.7027 \pm 0.0004 \text{ cm}^{-1}$ over a conductance range 700-3000 μS using Aristrar grade KCl and triple-distilled water and the method described in §1.6. The data were interpreted using the equations of Barthel et al. (1980) (see Table 1) to obtain the necessary cell-constant of the reference cell.

Measurements were made by comparing the conductance reading of the ALPIU sensor and reference cell (glass electrode) in a period of 1 minute. The conductivity of the solution was gradually increased to obtain measurements on the prerequisite range. Each cell constant was determined from the mean of three readings. The conductance of the reference cell was found to be only slightly dependent on the measurement frequency ($\approx 0.2\%$ at $70 \mu\text{S cm}^{-1}$) and measurements at 1000 Hz were equal to the value obtained from the extrapolation to infinite frequency. The conductance readings of the ALPIU sensor were made at three frequencies and extrapolated in the usual way.

The results of the measurements at 40 and 70°C are shown in Tables 5 and 6 respectively.

1.9 Summary

Mean cell constants were obtained as follows:

Temperature / $^\circ\text{C}$	Cell constant / cm^{-1}	Conductivity range/ $\mu\text{S cm}^{-1}$
0	0.3167	26-250
10	0.3001	4-150
25	0.3070	44-203
40	0.3223	14-225
70	0.3039	33-209

Average 0.3100 ± 0.0092 (S.D.)

The standard deviation (S.D.) of the cell constants over the temperature range $0-70^\circ\text{C}$ is comparable with the standard deviation obtained for the measurements at each temperature. For temperatures of 0, 10, 25, 40 and 70°C the standard deviations are 0.0204, 0.0124, 0.0178, 0.0052, 0.0159 and 0.0143 respectively with a mean value of 0.0143 cm^{-1} . This indicates there is no significant variation in the cell constant with temperature.

The results in Tables 2-6 show that the cell constant increases with increasing electrolyte concentration (typically 10-20% in the range measured). This is not normally observed for conductivity cells used for environmental monitoring or electrolyte measurements. In this instance, the variation originates from the substantial frequency dependence of the conductance measurement observed at all temperatures. This is illustrated in Tables 2, 3 and 4. Extensive measurements of the frequency dependence of the conductance readings at 40 and 70°C are available but are not included in the report. The size of the frequency dependence make the extrapolation to infinite frequency less certain. The effect is less evident at low conductance values.

Table 5 Details of measurements made at 40°C using the ALPIU unit 1 and reference cell

Determination number	Conductivity / $\mu\text{S cm}^{-1}$	Mean cell constant cm^{-1}	Standard error cm^{-1}
1	13.65	0.3008	0.0008
2	33.94	0.3100	0
3	76.07	0.3181	0.0001
4	119.69	0.3259	0
5	184.24	0.3364	0.0001
6	225.45	0.3427	0.0001

Average cell constant = 0.3223 cm^{-1}
 Conductivity range 14 to $225 \mu\text{S cm}^{-1}$

Table 6 · Details of measurements made at 70⁰C using the ALPIU unit 1 and reference cell

Determination number	Conductivity / $\mu\text{S cm}^{-1}$	Mean cell constant cm^{-1}	Standard error cm^{-1}
1	32.99	0.2973	0.0003
2	81.15	0.3006	0.0001
3	120.27	0.3040	0.0002
4	163.23	0.3069	0.0003
5	209.14	0.3107	0.0001

Average cell constant = 0.3039 cm^{-1}
 Conductivity range 33 to $209 \mu\text{S cm}^{-1}$

2. Calibration of 23 ALPIU sensors at 25°C

2.1 Method

All measurements were done using the cell described in §1.1 and the oil thermostat at 25 ± 0.0002°C.

The ALPIU units were first cleaned by immersing in 50 ml acetone and ultrasonication for 2 minutes at approximately 200 W. The sensor was then removed, rinsed with acetone and allowed to dry (or blow dried with nitrogen).

The cell was filled with potassium chloride solution of conductivity 45-70 $\mu\text{S cm}^{-1}$. This was allowed to equilibrate for 1 hour. The conductance of the ALPIU unit was measured at three frequencies. The ALPIU unit was then replaced by the reference cell (Phillips, model PW9510/60) and the measurement repeated. The potassium chloride solution was replaced after five measurements.

2.2 Comparison of the cell constant of the ALPIU sensors

The results are shown in Table 7. Two of the sensors (9 and 14) released particulate material on the first cleaning. They were subsequently re-cleaned as described above.

The mean cell constant was found to be 0.3057 cm^{-1} which is in good agreement with the value determined previously for unit 1, i.e. at a conductance of 216 μS a cell constant of 0.3056 cm^{-1} was obtained (see Table 4). All units were found to have a cell constant within two standard deviations from the mean value of the batch, i.e. 0.29 to 0.32 cm^{-1} .

2.3 Effective resistance of ALPIU sensors in different freshwaters (2-100 $\mu\text{S cm}^{-1}$)

Assuming a cell constant of 0.31 cm^{-1} (see §1.9 with the average cell constant over the temperature range of 0.3100 cm^{-1} and §2.2 with the average for the batch of 0.3057 cm^{-1}), it is possible to calculate the resistance of the ALPIU units in different freshwaters, i.e.

$$\text{conductivity} = G(\infty) \times \frac{\text{s}}{\text{cm}^{-1}} \quad (3)$$

$\mu\text{S cm}^{-1} \quad \mu\text{S}$

and

$$R(\infty) = 1 / G(\infty) \quad (4)$$

The results are shown in Table 8.

3. Calibration of the used ALPIU units numbers 24 and 25

3.1 Method

Three treatments were evaluated.

(1) 2 minutes ultrasonication in single distilled water, washed with acetone and dried at room temperature.

(2) 2 minutes ultrasonication in 0.5 M nitric acid, washed with distilled water and acetone and dried at room temperature.

Table 7 Summary of results for the calibration of 23 new ALPIU sensors at 25°C

ALPIU unit number	Conductance / μ S	Reference cell conductance / μ S	Cell constant / cm^{-1}
1	227.51	98.29	0.3036
2	143.96	64.73	0.2987
3	152.27	65.13	0.3006
4	153.09	65.32	0.2998
5	153.57	65.62	0.3003
6	151.25	65.78	0.3056
7	228.86	98.52	0.3034
8	220.56	96.33	0.3069
9*	228.77	98.83	0.3042
10	231.71	99.38	0.3014
11	234.23	99.73	0.2992
12	226.99	99.82	0.3090
13	213.05	96.17	0.3172
14*	214.49	96.45	0.3160
15	214.33	96.79	0.3173
16†	-	-	-
17	223.13	97.10	0.3058
18	223.94	97.22	0.3051
19	228.01	97.48	0.3004
20	230.51	97.68	0.2978
21	217.54	97.78	0.3159
22	231.49	97.81	0.2969
23	214.74	98.06	0.3208

* Sensors needed two cleaning treatments

† No stable reading was obtained; the conductance values indicated a fault in the insulation between the electrodes

Mean of results from 22 units is $0.3057 \pm 0.0072 \text{ cm}^{-1}$ (S.D.).

Table 8 Resistance, $R(\infty)$, of the ALPIU unit in different conductivity freshwaters. Cell constant = 0.31 cm^{-1} .

Conductivity of freshwater $/\mu\text{S cm}^{-1}$	Resistance $R(\infty)/\text{k}\Omega$
2	155.0
10	31.0
20	15.5
30	10.3
40	7.8
50	6.2
60	5.2
70	4.4
80	3.9
90	3.4
100	3.1

(3) 2 minutes ultrasonication in GPR grade acetone and dried at room temperature.

These were performed in sequence with triplicate conductance measurements made at three frequencies after each treatment. The conductance measurements were made according to the method described in §2.1.

3.2 Comparison of cleaning procedures

The results of the cell constant determinations are shown in Table 9.

All measurements produced cell constants within the range of the main batch (number 1 to 23), i.e. 0.29 to 0.32 cm⁻¹. The treatment with nitric acid produced a reduction in the cell constant for both units. The subsequent treatment with acetone made little difference. The nitric acid should assist in removing salt deposits and acetone should dissolve some organic contaminants.

The results indicate that for the two sensors tested, a brief ultrasonication in distilled water was adequate. However, unit 24 produced a noisy signal after washing with water alone. The signal was steady after the nitric acid treatment.

3.3 Polarisation of ALPIU units

It was noticed whilst making the measurements that the frequency dependence of the conductance varied between sensors. Although no systematic study was made of this effect, it may be quantified for solutions of conductance ~200 μS using the ratio:

$$\delta = 100[G(1000 \text{ Hz}) - G(1000 \text{ Hz})]/G(1000 \text{ Hz}) \quad (5)$$

This ratio, δ , varied between 10% and 60% for the ALPIU units 1-23.

It was also noted that units 24 and 25 had low values of δ . These are tabulated for each of the cleaning methods in Table 9. It is seen that repeated ultrasonication and cleaning leads to a reduction in δ and less polarisation at the sensor surface. Because polarisation effects are particularly sensitive to the surface treatment, this behaviour is not surprising. However, the polarisation characteristics will affect the "effective resistance" of the sensor on its initial contact with water. The results indicate that as the frequency of the a.c. signal used in the bridge circuit is reduced, the resistance of the ALPIU sensor increases.

4. Recommendations for Production Checks

4.1 Cleaning

No problems were encountered because of contamination of the electrolyte solution by the ALPIU sensors. A 2 minute ultrasonication in acetone proved satisfactory.

It is recommended that ALPIU units which have been in service should be thoroughly cleaned by ultrasonication in dilute nitric acid (0.5 M) and acetone.

Table 9 Comparison of cleaning procedures for ALPIU units 24 and 25

Cleaning Fluid	δ %	Cell constant /cm ⁻¹	S.D. /cm ⁻¹
<i>Unit Number 24</i>			
Distilled water	10.2	0.3091	0.0041
0.5 M Nitric Acid	7.8	0.2799	0.0051
Acetone	5.7	0.2979	0.0003
<i>Unit Number 25</i>			
Distilled water	18.6	0.3072	0.0008
0.5 M Nitric Acid	8.7	0.2962	0.0006
Acetone	8.5	0.2983	0.0002

δ : For definition see equation (5)

4.2. Performance Checks

The most reliable method of determining the cell constant of the ALPIU units in production is to compare the conductance of the unit immersed in dilute potassium chloride ($\approx 50 \mu\text{S cm}^{-1}$) with the conductance of a reference electrode, e.g. platinized glass electrode. The cell constant of the ALPIU unit is then:

$$S(\text{ALPIU}) = \frac{G(\text{reference})}{G(\text{ALPIU})} \times S(\text{reference}) \quad (6)$$

where G are the appropriate conductance readings (μS) and S(reference) is the cell constant of the glass reference electrode (cm^{-1}).

4.3 Equipment

4.3.1 Thermostat bath

The temperature needs to be controlled to $\pm 0.1^\circ\text{C}$. The choice of temperature is not important because the results obtained here show that the cell constant is insensitive to temperature in the range of 0 to 70°C .

4.3.2 Measurement cell(s)

This is best constructed of pyrex glass and could hold the reference electrode together with either one, or a number of, ALPIU units. If it holds the reference electrode and one ALPIU unit, then a capacity of approximately 500 ml is suitable. The cell needs to be airtight.

4.3.3 Stirrer motor

The contents of the cell need to be *thoroughly stirred*. This is best done by a magnetic bar coated with PTFE with a motor mounted underneath the cell. An alternative is to use a paddle stirrer mounted from above the cell. Care is required to minimize vapour and gas exchange between the head-space in the cell and the atmosphere. Ingress of carbon dioxide or outgress of water vapour may lead to a substantial drift in conductance. The use of a reference cell should enable errors associated with such drift to be minimized.

4.3.4 Conductance Bridge

An a.c. bridge operating at a single frequency of 1000 Hz should be adequate. If polarisation effects are to be quantified then a more sophisticated a.c. bridge will be necessary.

4.4 Procedure

(a) Prepare a solution of approximately 0.025 g of Analar KCl in 1 litre of distilled water. Larger quantities may be prepared as required.

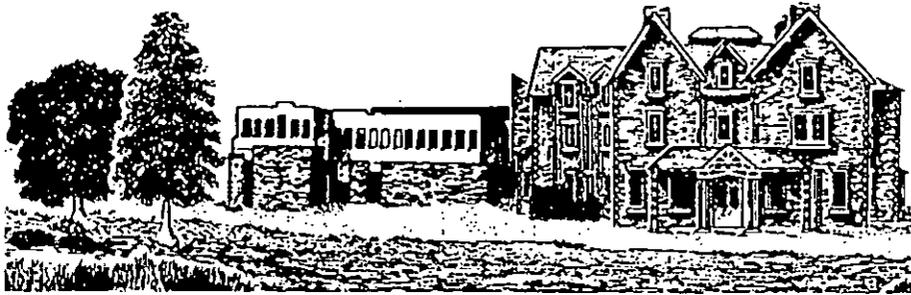
(b) Fill the measuring cell, insert the reference electrode and equilibrate the cell in the thermostat. Make sure the reference electrode is *free of air bubbles* and the solution is well stirred.

(c) Measure the conductance of the reference electrode.

(d) Insert the ALPIU unit and leave 10-15 minutes to equilibrate. *Ensure no air bubbles* are attached to the sensor. Measure the conductance of the ALPIU unit and the reference electrode in quick succession. Recheck that the conductance of the ALPIU unit has not changed. Repeat as necessary.

(e) Calculate $S(\text{ALPIU})$ using equation (6).

(f) Repeat (d) for subsequent sensors. Any significant contamination of the KCl solution in the measuring cell will be easily noticed from the conductance reading of the reference electrode. If contamination does occur, then the ALPIU unit will need to be recleaned and the KCl solution replaced with a fresh batch.



The **Freshwater Biological Association** is the leading scientific research organisation for the freshwater environment in the United Kingdom. It was founded in 1929 as an independent organisation to pursue fundamental research into all aspects of freshwater biology and chemistry. The FBA has two main laboratories. The headquarters is at Windermere in the Lake District and the River Laboratory is in the south of England. A small unit has recently been established near Huntingdon to study slow-flowing eastern rivers.

The FBA's primary source of funding is the Natural Environment Research Council but, in addition, the Association receives substantial support from the Department of the Environment and the Ministry of Agriculture, Fisheries and Food who commission research projects relevant to their interests and responsibilities. It also carries out contracts for consulting engineers, water authorities, private industry, conservation bodies, local government and international agencies.

The staff includes scientists who are acknowledged experts in all the major disciplines. They regularly attend international meetings and visit laboratories in other countries to extend their experience and keep up to date with new developments. Their own knowledge is backed by a library housing an unrivalled collection of books and periodicals on freshwater science and with access to computerized information retrieval services. A range of experimental facilities is available to carry out trials under controlled conditions. These resources can be made available to help solve many types of practical problems. Moreover, as a member of the Terrestrial and Freshwater Sciences Directorate of the Natural Environment Research Council, the FBA is able to link up with other institutes to provide a wider range of environmental expertise as the occasion demands. Thus, the FBA is in a unique position to bring relevant expertise together for problems involving several disciplines.

Recent contracts have involved a wide variety of topics including biological monitoring, environmental impact assessment, fisheries problems, salmon counting, ecological effects of reservoirs and other engineering works, control of water weeds, control of insect pests and effects of chemicals on plants and animals.

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