DEPARTMENT OF THE ENVIRONMENT
ENVIRONMENTAL PROTECTION SERVICE
PACIFIC REGION

A COMPUTER-CONTROLLED WATER COLUMN PROFILING SYSTEM

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TABLE OF CONTENTS

SUMMARY

Earlier methods using the traditional bottle casts and separate transmissometer profiles to collect oceanographic data and turbidity measurements were time consuming, labour intensive and unable to give a continuous profile of the water column. Sampling often had to be done over several days in order to determine an effluent dispersion pattern for a given tidal stage or span several stages of the tide. Upon return from the field, unnecessary effort and time delays were experienced in processing the field data for final reporting.

The introduction of a single electronic profiling system capable of instantly measuring conductivity, temperature and depth (CTD), coupled with water sampling capabilities, a 25 cm light path transmissometer for turbidity measurements, and a microcomputer has vastly improved the efficiency and effectiveness in determining effluent distribution within the receiving environment. The quality and quantity of information collected are far superior to previous methods used, allowing for ready access to the data for decisions in the field and processing for final reporting with a minimum amount of manual effort and time.

Time to complete each sample station has been reduced from in excess of one hour to less than 10 minutes, permitting complete coverage of most effluent fields within a single stage of the tide, maximizing vessel time and manpower. With the computer storage and processing capability, data can be analyzed and made available within a few weeks following collection as opposed to as much as a year with the older system. Cost of the profiling system complete with microcomputer and winch was approximately $50,000.

1. INTRODUCTION

It is often necessary during investigations at various coastal industrial and municipal discharge sites to define as precisely and as quickly as possible the boundaries of the effluent plume. These boundaries must be determined under various tidal conditions, as well as a variety of oceanographic conditions such as temperature, salinity, water density, etc.. In one particular case, the Amax/Kitsault mine, the tailings discharge is governed by special regulation (i.e. Alice Arm Tailings Deposit Regulations, AATDR) which specify where in the receiving water the effluent plume is permitted. This requires a rapid and efficient method for assessing compliance of the effluent plume with limits set by regulation.

Apart from assessing compliance with federal regulations, establishing the effluent plume boundaries aids in the interpretation of biological, chemical, and physical monitoring results and in establishing meaningful sampling sites for monitoring purposes. Much of the oceanographic data collected also assists in understanding the dynamics of the receiving environment and its influence on waste discharge.

Over the past few years an electronic conductivity, temperature, depth and transmissometer profiling system (CTD-Transmissometer) coupled with a microcomputer has been assembled. This has greatly enhanced capabilities of assessing effluent distribution and behaviour in the receiving environment under various oceanographic conditions. The system is designed to operate from small (20-25 ft.) vessels or larger oceanographic ships. The amount of data collected, its quality and storage along with the speed at which the information is made available to the observer in the field and for final reporting has been increased markedly over earlier profiling methods and equipment.

With the transmissometer, the system is especially applicable to tracing particulate bearing effluents but could be adapted for use on non-particulate bearing effluents, such as from pulp mills, through the use of fluorometry.

1.1 Initial System

Initially, sampling procedures consisted of a series of standard hydrocasts where a number of NIO water bottles equipped with reversing thermometers were deployed to collect water samples for salinity and temperature from specific depths throughout the water column. Following this, a one metre light path transmissometer was lowered separately to obtain light transmittance levels at 5 or 10 metre intervals throughout the water column. The transmissometer was coupled to a deck unit by a 1/2" multiconductor cable and lowered by hand. All readings were hand recorded from a meter readout.

If chemical identification of the particulate matter was required, a third cast had to be made using a series of 2 or 4 litre Niskin water bottles arranged to cover a number of depths in the water column.

The time to complete a single station was normally in excess of one hour if three hydrocasts were required. This generally allowed approximately 8-10 stations to be sampled in a 12 hour shift. Apart from limiting the number of stations which could be reasonably done in a day, complete coverage of the plume area often had to span several stages of the tide or within a single stage of the tide, if done over several days. The influence of the tide obviously can have a considerable affect on plume distribution and must be considered when sampling.

The method of discrete water sampling at various depths obviously cannot provide a continuous picture of the water column and has the risk of missing key features which may be important in final interpretation.

1.2 Second Stage System

The initial system was subsequently replaced by an electronic CTD sensor system manufactured by Plessy Environmental Systems (now Grundy, see specifications) and coupled with a 25 cm path length transmissometer manufactured by Sea Tech Inc. (see specifications). Signals from the probe are transmitted in separate frequencies through a 1/8", single conductor multiplex cable to a five-parameter digital display unit also manufactured by Plessy Environmental Systems (see specifications) (Figure 1). The cable also serves to lower the instrument, allowing up to 350 metres to be mounted on a small hydraulically driven winch. With the appropriate adaptor base and hydraulic flow controls, this winch can be used on large oceanographic ships or connected directly to a hydraulic pump on a small inboard driven boat. The small size of the conductor cable allows for sending a messenger down to the probe to trip a 5 litre water bottle mounted on the protective cage (Figure 1) if a water sample is needed for chemical identification. The sample is then guaranteed to be taken from the exact depth of the probe, giving a more representative sample than several separate hydrocasts.

Initially, the digital data was hand recorded at 5 metre intervals. Later, a cassette tape recorder was added. However, hand recording was still required to obtain data immediately for use in the field. Through the use of this system, the number of hydrocasts for each station was reduced to one from the previous three. If more water samples were required throughout the profile, a series of casts in quick succession could be made by raising and lowering the probe and bottle. The main advantage of this is to collect oceanographic and transmissometer data at precisely the same depth as the water sample used for chemical identification. The time required to complete each station was reduced to approximately 20 minutes, with the limiting factor being the time needed to hand record data. This method permitted more complete coverage of the effluent field within a given stage of the tide and allowed for a continuous profile of the water column.

1.3 Computer Integrated System

The CTD-Transmissometer profiling system which is presently in use has now been coupled with a Hewlett Packard 9826 microcomputer (Figure 1). Use of the microcomputer was made possible through the development of a multichannel frequency counter which converts sensor voltages, transmitted to the deck unit in kilohertz, to digital numbers in computer language. The frequency counter was developed through the cooperation of the Institute of Ocean Sciences at Patricia Bay. The computing capabilities and speed of the microcomputer permits storage of a large volume of data collected during each cast, the appropriate processing and immediate display of the information enabling decisions to be made directly in the field on the most appropriate location for water sampling and the next sample station location. An average 350 m profile consists of approximatley 700 individual records for each of four parameters, conductivity, temperature, depth and light transmittance. A software package has been developed to automatically convert each parameter from frequency to scientific units (e.g. $^{0}/oo$, °C, metres, and % transmittance). Each parameter can be displayed separately on a 7 inch screen (CRT) and observed directly as the probe is lowered through the water column. During the descent, the numerical data are printed out at a rate ranging from once in every 1 to 20 seconds. At the end of each cast a hard copy of the profile can be obtained from a thermal printer. On the ascent a single water sample along with a plot with its location in the profile, record of sample numbers and three records of the CTD-Transmissometer data can be obtained the instant the messenger hits the water bottle at the desired depth. This can be repeated five times before having to re-set the computer for another profile. All data gathered during the profile can be stored on diskette for later analyses, graphical presentation in text quality single or multi-parameter plots and tabular summaries of the numerical data at specific depth intervals.

Using the microcomputer to process the data in the field has permitted the collection and storage of a considerable amount of information, continuously throughout the water column. The time required to complete a single station with the use of the microcomputer has been reduced to under 10 minutes. In most cases this allows complete coverage of the effluent plume within a single stage of the tide. All data collected can then be compiled into a report within several weeks after returning from the field.

Examples of some typical outputs are shown in Figures 2 to 8. Figure 2 is an example of the station information along with water sample information and any comments the operator wishes to make. Figure 3 shows the numerical data printed during the profile, in this case once every 10 seconds. Figure 4 is an example of transmissometer profile obtained following completion of the probe's descent and location of a water sample taken upon the ascent. As shown in Figure 5 the profile can be expanded if required. The numerical data can be summarized into specific depth intervals as shown in Figure 6. Upon return from the field single or multiparameter plots can then be prepared for final reporting (Figures 7 and 8).

Although there has been an initial cost outlay of approximately $50,000 and the sensors do require periodic servicing to ensure precise calibration, this system has allowed for much greater coverage of the receiving water within a shorter period, more precise information gathered continuously throughout the water column and substantial reduction in effort in obtaining and processing the data for final reporting. Use of manpower and vessel time can also be maximized, with considerable cost saving.

There has been no intention in this report to present the specific details of the computer software nor the procedures involved in conducting CTD-Transmissometer profiles. These can be obtained by contacting the authors at the Environmental Protection Service, Pacific Region, Kapilano 100, West Vancouver, V7T 1A2.

Efforts are presently underway to develop a calibration curve for the transmissometers to reduce the need for collecting water samples to determine suspended solids concentrations through gravimetric analysis.

2. SPECIFICATIONS

CTD Sensor - Model 9400

Dimensions - 30.5 cm wide x 40.6 cm high

Weight - 11.8 kg in air, 8.2 kg in water

Depth Capability - 350 m, 600 m available

Parameter	Conductivity	Temperature	Depth
Model	6500	4500	4600
Range	0 to 60 mmho/cm	-2°C to 35°C	300 m
Accuracy	± 0.03 mmho/cm	± 0.02°C	± 0.95% of full scale
Output Signal			
Frequency	4995-7901 Hz	2127-4193 Hz	9712-11,288 Hz
Resolution	0.0001 mmho/cm	0.0001°C	0.0002% FS
Time Constant	0.1 sec.	0.35 sec.	0.1 sec.

Digital Display Unit - Model 8500

Manufacturer - Plessy Environmental Systems, San Diego, California, now Grundy

Transmissometer

Depth Capacity - 750 metres

Dimensions - Length - 78 cm, Diameter - 10 cm

Light Source - Monochromatic collimated beam at 660 nm

Path Length - 25 cm

Manufacturer - Sea Tech Inc., Corvallis, Oregon

Analog-to-Digital Converter

EPS/IOS Multi-Channel Frequency Counter* for the conversion of voltage to digital counts necessary for computer processing. One second signal averaging is used between packet outputs to GPIO (HPIB) and RS-232 connector ports.

Parameter	Frequency Bandwidth (Hz)	Range
dissolved oxygen	1562 - 1913	-0.6 - 20.0 ppm
temperature	2015 - 4584	-4.0 - 42.0 deg.C
conductivity ratio	4995 - 8318	0.0 - 1.6
pressure	9526 - 11812	-35 - 400 dbar
transmission	14000 - 16000	100 - 0 %

Micro-Computer System

Processor: Hewlett-Packard 9826 desktop computer with RAM loading BASIC operating system.

Accessories: Memory - HP 256K RAM memory expansion board.
Printer - HP Model 2671G thermal graphics printer.
Plotter - HP Model 9872C eight pen fully programmable plotter for drawings up to 11 by 15 inches.

Software: EPS designed programs written in HP BASIC 2.0 for frequency counter data aquisition and processing, graphical presentation, listing and storage. Additional programs for diskette file maintentance including data editing and further outputs.

*Multi-channel frequency counter was developed through the cooperation of T.A. Curran from the Institute of Ocean Sciences, Pat Bay.

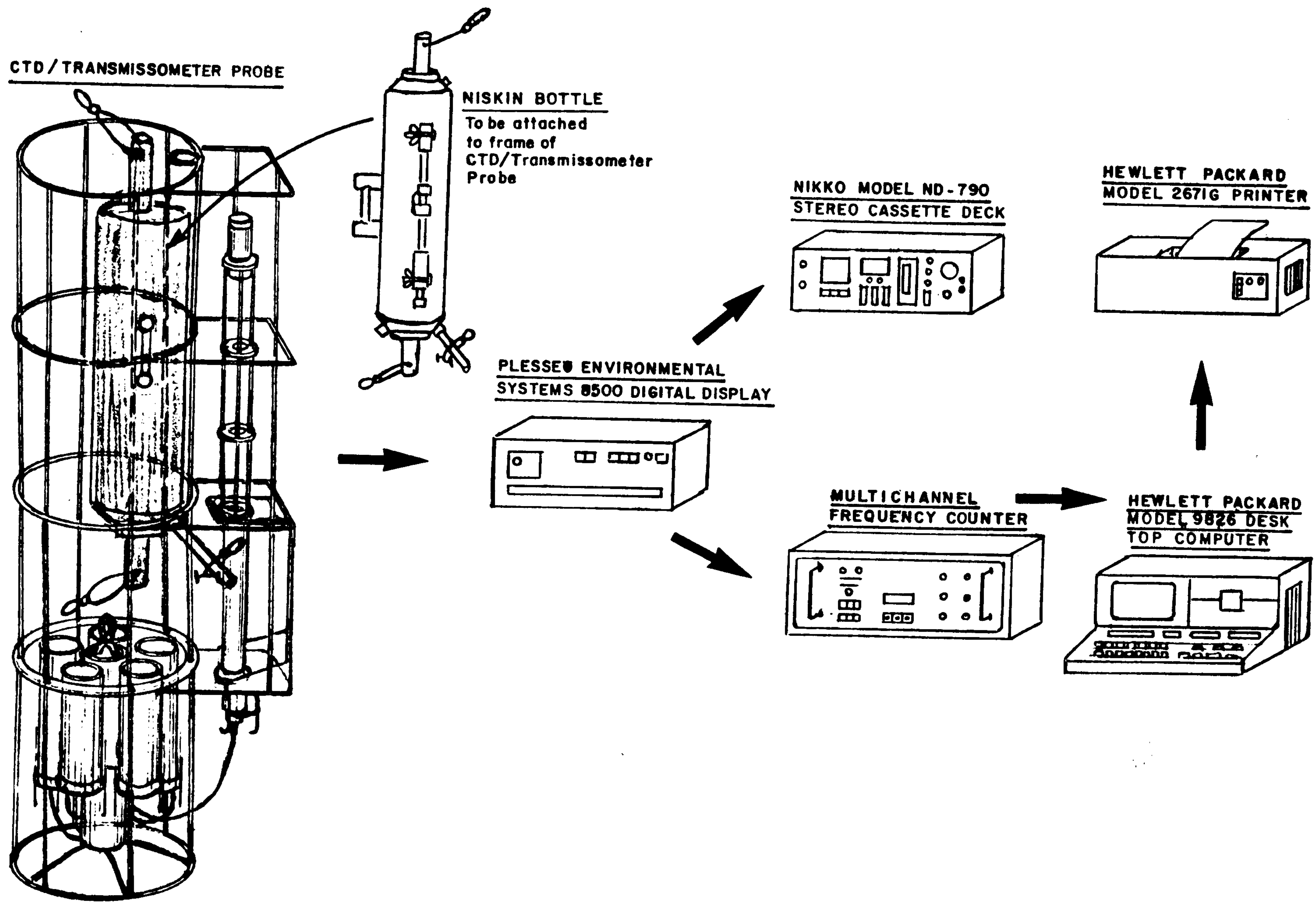

FIGURE 1 CTD - TRANSMISSOMETER PROFILING SYSTEM

Figure 2   Station and Water Sampling Information

CTD FILE LISTING ROUTINE : MARINE16

Survey Area : ALICE ARM
Date : 83/10/06

Station : Q 20

Lat : 55 26.7
Long : 129 31.8

Time (profile start) : 1033 PDT
(end of cast) : 1041 PDT

Air depth reading : 1.30 meters
Sounder depth : 263.00 meters

Cassette identification no. : 0

Counter at Air Reading : 0
at Profile Start : 0
at Profile Stop : 0
at End of Cast : 0

No.	Sample Bottle	Salinity Bottle	Depth (m)	Temp (C)	Salinity	Trans %
1	66	.....	252.85	6.44	31.0321	81.200
			253.04	6.46	30.9931	81.150
			252.85	6.48	30.9770	81.100
2	67	.....	101.98	7.93	29.5758	76.800
			101.79	7.89	29.6062	76.900
			101.98	7.88	29.6212	76.900
3	.....	68	98.36	8.00	29.3652	77.950
			98.55	8.04	29.3135	77.950
			98.55	7.98	29.3584	77.950

Operator Comments

: SALINITY CALIB. +3
: PLANKTON ID
: FROM #68
: -
: -

Figure 3 CTD Cast Profile Information

CTD CAST PROFILE INFORMATION.

Block	Fpres	Ftemp	Fcond	Fdoxy	Ftran	P dbar	Cond R	Oxygen	Depth M	Temp C	SigmaT	Conduct.	Salinity	Trans %
1	9725	2776	5942	464	14786	2.86	.4559	0.00	2.86	9.63	12.97	19.5572	16.9832	60.700
2	9725	2777	5944	428	14826	2.86	.4569	0.00	2.86	9.65	12.99	19.5985	17.0138	58.700
3	9725	2776	5945	449	14791	2.86	.4574	0.00	2.86	9.63	13.02	19.6192	17.0418	60.450
4	9725	2777	5944	455	14798	2.86	.4569	0.00	2.86	9.65	12.99	19.5985	17.0138	60.100
5	9724	2776	5944	462	14811	2.67	.4569	0.00	2.67	9.63	13.00	19.5985	17.0223	59.450
6	9725	2776	5945	428	14780	2.86	.4574	0.00	2.86	9.63	13.02	19.6192	17.0418	61.000
7	9725	2777	5943	447	14847	2.86	.4564	0.00	2.86	9.65	12.98	19.5779	16.9943	57.650
8	9725	2775	5943	465	14825	2.86	.4564	0.00	2.86	9.61	13.00	19.5779	17.0112	58.750
9	9725	2774	5943	446	14856	2.86	.4564	0.00	2.86	9.59	13.01	19.5779	17.0196	57.200
10	9725	2775	5944	490	14815	2.86	.4569	0.00	2.86	9.61	13.01	19.5985	17.0307	59.250
11	9725	2776	5942	423	14836	2.86	.4559	0.00	2.86	9.63	12.97	19.5572	16.9832	58.200
12	9725	2775	5943	463	14853	2.86	.4564	0.00	2.86	9.61	13.00	19.5779	17.0112	57.350
13	9724	2774	5942	448	14939	2.67	.4559	0.00	2.67	9.59	12.99	19.5572	17.0001	53.050
14	9725	2777	5942	462	14853	2.86	.4559	0.00	2.86	9.65	12.96	19.5572	16.9747	57.350
15	9725	2774	5942	454	14926	2.86	.4559	0.00	2.86	9.59	12.99	19.5572	17.0000	53.700
16	9725	2775	5942	481	14849	2.86	.4559	0.00	2.86	9.61	12.98	19.5572	16.9916	57.550
17	9725	2780	5943	459	14976	2.86	.4564	0.00	2.86	9.70	12.95	19.5779	16.9690	51.200
18	9725	2775	5942	461	14805	2.86	.4559	0.00	2.86	9.61	12.98	19.5572	16.9916	59.750
19	9725	2774	5942	455	14808	2.86	.4559	0.00	2.86	9.59	12.99	19.5572	17.0000	59.600
20	9725	2778	5942	467	14809	2.86	.4559	0.00	2.86	9.67	12.96	19.5572	16.9663	59.550
21	9725	2775	5941	456	14817	2.86	.4555	0.00	2.86	9.61	12.97	19.5366	16.9720	59.150
22	9725	2778	5941	445	14821	2.86	.4555	0.00	2.86	9.67	12.94	19.5366	16.9468	58.950
23	9725	2774	5941	456	14817	2.86	.4555	0.00	2.86	9.59	12.98	19.5366	16.9805	59.150
24	9725	2776	5941	459	14818	2.86	.4555	0.00	2.86	9.63	12.96	19.5366	16.9636	59.100
25	9725	2778	5940	444	14833	2.86	.4550	0.00	2.86	9.67	12.92	19.5159	16.9272	58.350
26	9725	2779	5941	465	14842	2.86	.4555	0.00	2.86	9.68	12.93	19.5366	16.9383	57.900
27	9725	2776	5940	472	14860	2.86	.4550	0.00	2.86	9.63	12.94	19.5159	16.9440	57.000
28	9728	2776	5941	466	14844	3.43	.4555	0.00	3.43	9.63	12.96	19.5366	16.9635	57.800
29	9732	2775	5944	422	14733	4.19	.4569	0.00	4.19	9.61	13.01	19.5985	17.0304	63.350
30	9736	2775	5955	480	14718	4.95	.4622	0.00	4.95	9.61	13.18	19.8257	17.2456	64.100
31	9739	2775	5964	467	14711	5.52	.4665	0.00	5.52	9.61	13.32	20.0115	17.4219	64.450
32	9743	2778	5985	450	14700	6.28	.4766	0.00	6.28	9.67	13.61	20.4451	17.8076	65.000
33	9746	2784	6049	454	14697	6.85	.5075	0.00	6.85	9.77	14.53	21.7667	19.0119	65.150
34	9749	2791	6108	457	14691	7.43	.5359	0.00	7.43	9.90	15.37	22.9851	20.1091	65.450
35	9752	2795	6177	465	14687	8.00	.5691	0.00	8.00	9.97	16.39	24.4099	21.4362	65.650
36	9756	2798	6201	360	14683	8.76	.5806	0.00	8.76	10.02	16.73	24.9055	21.8813	65.850
37	9759	2795	6205	480	14656	9.33	.5826	0.00	9.33	9.97	16.82	24.9881	21.9933	67.200
38	9762	2795	6207	486	14543	9.90	.5835	0.00	9.90	9.97	16.85	25.0294	22.0330	72.850
39	9765	2792	6213	446	14505	10.47	.5864	0.00	10.47	9.92	16.98	25.1533	22.1854	74.750
40	9769	2792	6225	430	14489	11.23	.5922	0.00	11.23	9.92	17.17	25.4011	22.4252	75.550
41	9771	2797	6228	449	14482	11.61	.5936	0.00	11.61	10.01	17.16	25.4631	22.4296	75.900
42	9775	2799	6232	426	14479	12.37	.5956	0.00	12.37	10.04	17.20	25.5457	22.4870	76.050
43	9778	2795	6251	452	14480	12.94	.6047	0.00	12.94	9.97	17.54	25.9380	22.9116	76.000
44	9781	2794	6262	439	14484	13.51	.6100	0.00	13.51	9.95	17.72	26.1652	23.1434	75.800
45	9784	2796	6265	412	14482	14.08	.6114	0.00	14.08	9.99	17.74	26.2271	23.1805	75.900
46	9788	2796	6270	429	14472	14.85	.6138	0.00	14.85	9.99	17.82	26.3304	23.2805	76.400
47	9790	2795	6274	453	14474	15.23	.6158	0.00	15.23	9.97	17.90	26.4130	23.3722	76.300
48	9794	2796	6294	428	14470	15.99	.6254	0.00	15.99	9.99	18.20	26.8260	23.7622	76.500
49	9798	2799	6312	450	14471	16.75	.6341	0.00	16.75	10.04	18.44	27.1977	24.0886	76.450
50	9800	2796	6329	457	14469	17.13	.6422	0.00	17.13	9.99	18.74	27.5487	24.4670	76.550
51	9804	2797	6349	455	14470	17.89	.6519	0.00	17.89	10.01	19.05	27.9617	24.8585	76.500
52	9806	2792	6356	450	14470	18.27	.6552	0.00	18.27	9.92	19.22	28.1063	25.0618	76.500
53	9810	2792	6364	462	14456	19.03	.6591	0.00	19.03	9.92	19.34	28.2715	25.2238	77.200
54	9813	2791	6387	496	14443	19.60	.6702	0.00	19.60	9.90	19.72	28.7464	25.7035	77.850
55	9816	2795	6402	443	14434	20.17	.6774	0.00	20.17	9.97	19.91	29.0562	25.9573	78.300

Figure 3 (Cont.)

CTD CAST PROFILE INFORMATION.

Block	Fpres	Ftemp	Fcond	Fdoxy	Ftran	P dbar	Cond R	Oxygen	Depth M	Temp C	SigmaT	Conduct.	Salinity	Trans %
56	9819	2795	6408	427	14430	20.74	.6803	0.00	20.74	9.97	20.00	29.1801	26.0791	78.500
57	9823	2793	6418	443	14428	21.50	.6851	0.00	21.50	9.93	20.19	29.3866	26.3085	78.600
58	9826	2792	6427	423	14430	22.07	.6894	0.00	22.07	9.92	20.34	29.5724	26.5049	78.500
59	9829	2790	6428	451	14437	22.65	.6899	0.00	22.65	9.88	20.38	29.5931	26.5514	78.150
60	9832	2792	6430	448	14444	23.22	.6909	0.00	23.22	9.92	20.39	29.6344	26.5658	77.800
61	9835	2785	6440	426	14446	23.79	.6957	0.00	23.79	9.79	20.64	29.8409	26.8629	77.700
62	9839	2782	6447	469	14450	24.55	.6991	0.00	24.55	9.74	20.79	29.9854	27.0465	77.500
63	9841	2781	6451	440	14437	24.93	.7010	0.00	24.93	9.72	20.87	30.0680	27.1421	78.150
64	9845	2775	6454	455	14425	25.69	.7024	0.00	25.69	9.61	20.99	30.1300	27.2848	78.750
65	9848	2778	6455	439	14420	26.26	.7029	0.00	26.26	9.67	20.97	30.1506	27.2645	79.000
66	9851	2774	6457	464	14418	26.83	.7039	0.00	26.83	9.59	21.06	30.1919	27.3599	79.100
67	9854	2772	6462	434	14417	27.40	.7063	0.00	27.40	9.56	21.16	30.2952	27.4903	79.150
68	9857	2771	6470	432	14414	27.97	.7101	0.00	27.97	9.54	21.31	30.4604	27.6695	79.300
69	9860	2763	6473	429	14413	28.54	.7116	0.00	28.54	9.40	21.46	30.5223	27.8423	79.350
70	9863	2762	6476	428	14414	29.11	.7130	0.00	29.11	9.38	21.52	30.5843	27.9184	79.300
71	9866	2760	6480	420	14411	29.68	.7149	0.00	29.68	9.34	21.62	30.6669	28.0295	79.450
72	9869	2751	6483	435	14400	30.26	.7164	0.00	30.26	9.18	21.79	30.7288	28.2187	80.000
73	9872	2753	6486	437	14386	30.83	.7178	0.00	30.83	9.22	21.81	30.7908	28.2530	80.700
74	9875	2752	6487	458	14376	31.40	.7183	0.00	31.40	9.20	21.84	30.8114	28.2879	81.200
75	9879	2749	6487	417	14365	32.16	.7183	0.00	32.16	9.15	21.88	30.8114	28.3301	81.750
76	9882	2747	6488	454	14361	32.73	.7188	0.00	32.73	9.11	21.92	30.8321	28.3793	81.950
77	9885	2746	6489	430	14360	33.30	.7193	0.00	33.30	9.09	21.95	30.8527	28.4144	82.000
78	9888	2745	6489	423	14363	33.87	.7193	0.00	33.87	9.08	21.97	30.8527	28.4284	81.850
79	9891	2741	6490	415	14365	34.44	.7198	0.00	34.44	9.00	22.04	30.8734	28.5064	81.750
80	9895	2742	6491	432	14372	35.20	.7202	0.00	35.20	9.02	22.04	30.8940	28.5129	81.400
81	9897	2743	6492	429	14378	35.58	.7207	0.00	35.58	9.04	22.04	30.9147	28.5194	81.100
82	9901	2741	6493	436	14379	36.34	.7212	0.00	36.34	9.00	22.09	30.9353	28.5689	81.050
83	9904	2741	6494	438	14381	36.91	.7217	0.00	36.91	9.00	22.10	30.9560	28.5897	80.950
84	9907	2737	6494	431	14382	37.48	.7217	0.00	37.48	8.93	22.16	30.9560	28.6471	80.900
85	9911	2737	6496	421	14387	38.25	.7226	0.00	38.25	8.93	22.19	30.9973	28.6890	80.650
86	9913	2738	6496	438	14385	38.63	.7226	0.00	38.63	8.95	22.18	30.9973	28.6744	80.750
87	9917	2741	6496	404	14379	39.39	.7226	0.00	39.39	9.00	22.14	30.9973	28.6309	81.050
88	9920	2738	6496	439	14375	39.96	.7226	0.00	39.96	8.95	22.18	30.9973	28.6739	81.250
89	9923	2738	6497	442	14372	40.53	.7231	0.00	40.53	8.95	22.19	31.0179	28.6948	81.400
90	9927	2735	6496	442	14370	41.29	.7226	0.00	41.29	8.90	22.22	30.9973	28.7167	81.500
91	9929	2735	6497	417	14368	41.67	.7231	0.00	41.67	8.90	22.23	31.0179	28.7377	81.600
92	9933	2737	6497	437	14365	42.43	.7231	0.00	42.43	8.93	22.21	31.0179	28.7084	81.750
93	9936	2736	6498	411	14365	43.00	.7236	0.00	43.00	8.91	22.24	31.0386	26.7438	81.750
94	9939	2736	6499	436	14366	43.57	.7241	0.00	43.57	8.91	22.25	31.0592	28.7647	81.700
95	9943	2736	6499	443	14361	44.33	.7241	0.00	44.33	8.91	22.25	31.0592	28.7644	81.950
96	9945	2734	6499	425	14359	44.71	.7241	0.00	44.71	8.88	22.28	31.0552	28.7932	82.050
97	9949	2734	6500	438	14361	45.48	.7246	0.00	45.48	8.88	22.30	31.0799	28.8141	81.950
98	9951	2734	6499	429	14363	45.86	.7241	0.00	45.86	8.88	22.28	31.0592	28.7928	81.850
99	9955	2736	6501	440	14361	46.62	.7251	0.00	46.62	8.91	22.29	31.1005	28.8058	81.950
100	9958	2732	6501	442	14355	47.19	.7251	0.00	47.19	8.84	22.34	31.1005	28.8636	82.250
101	9962	2732	6500	442	14353	47.95	.7246	0.00	47.95	8.84	22.32	31.0799	28.8421	82.350
102	9964	2732	6501	455	14347	48.33	.7251	0.00	48.33	8.84	22.34	31.1005	28.8632	82.650
103	9968	2731	6500	435	14344	49.09	.7246	0.00	49.09	8.82	22.34	31.0799	28.8562	82.800
104	9971	2733	6501	439	14343	49.66	.7251	0.00	49.66	8.86	22.33	31.1005	28.8481	82.850
105	9974	2730	6502	461	14341	50.23	.7255	0.00	50.23	8.81	22.38	31.1212	28.9127	82.950
106	9978	2730	6502	433	14341	50.99	.7255	0.00	50.99	8.81	22.38	31.1212	28.9124	82.950
107	9980	2729	6502	449	14339	51.37	.7255	0.00	51.37	8.79	22.40	31.1212	28.9268	83.050
108	9983	2730	6502	438	14340	51.94	.7255	0.00	51.94	8.81	22.38	31.1212	28.9120	83.000
109	9987	2731	6502	424	14340	52.70	.7255	0.00	52.70	8.82	22.37	31.1212	28.8971	83.000
110	9990	2730	6502	446	14338	53.28	.7255	0.00	53.28	8.81	22.38	31.1212	28.9115	83.100

Figure 4 Example of a Transmissometer Plot and Water Sample Locations

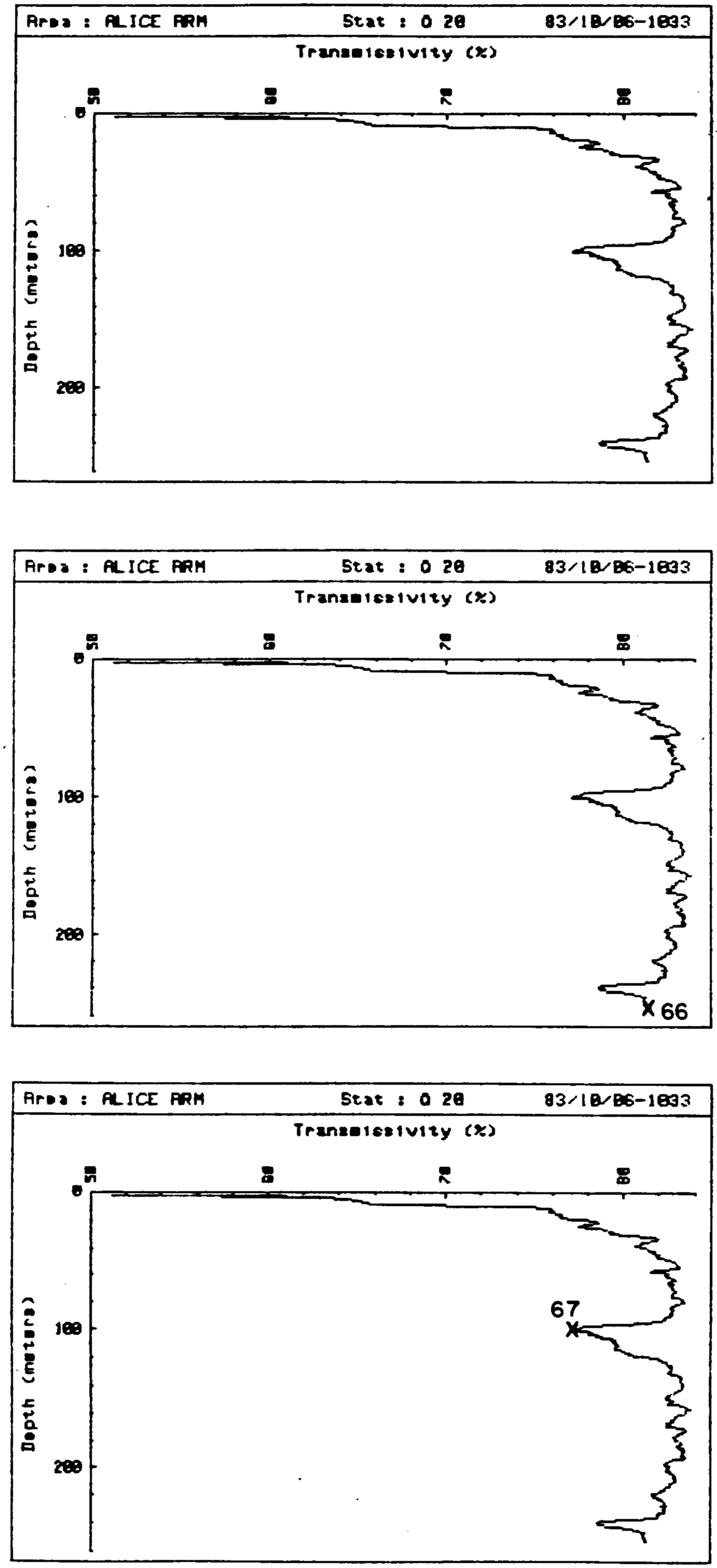

Figure 5 Example of an Expanded Transmissometer Plot

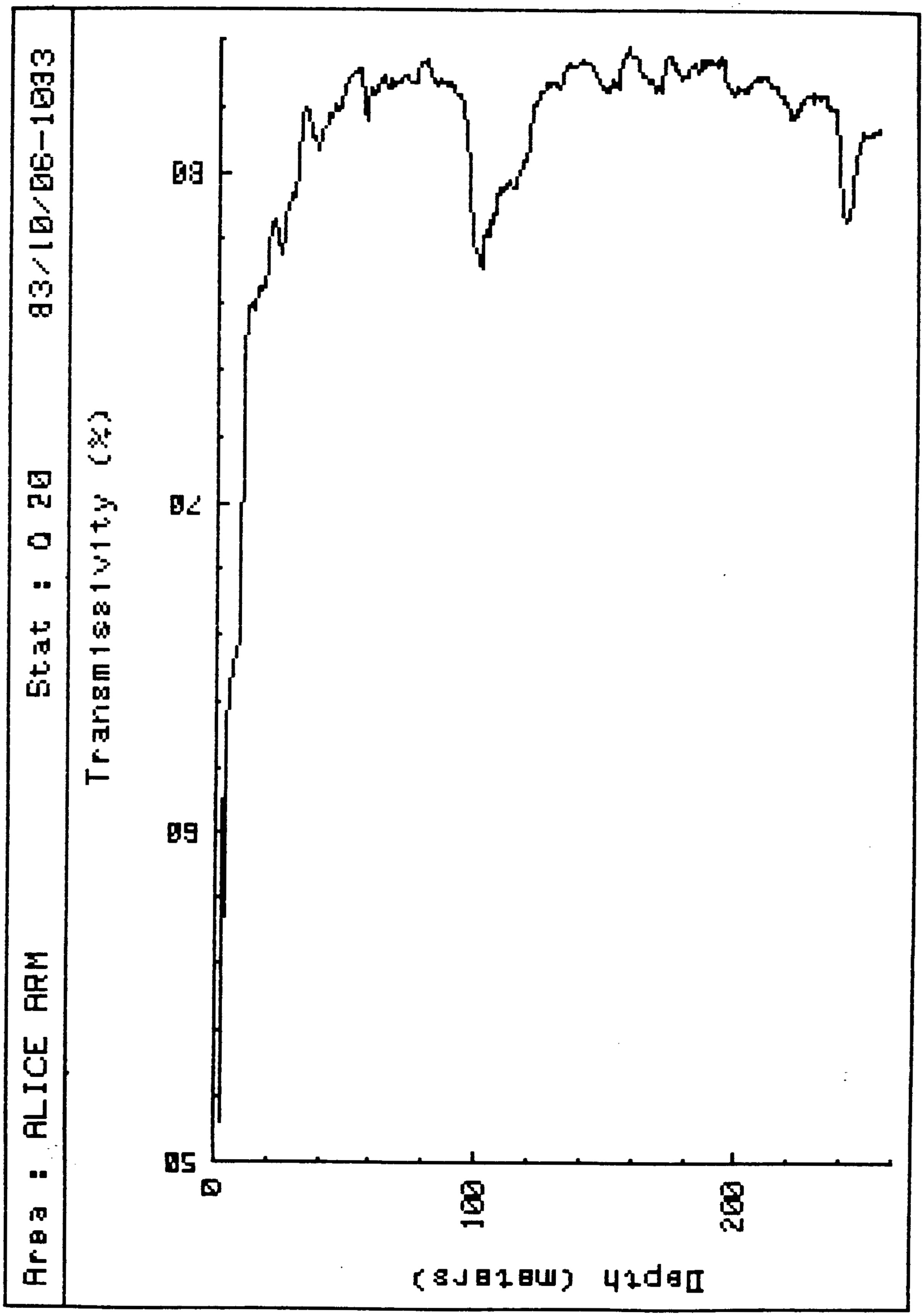

Figure 6 Table Showing Station Information and Numerical Data Printout by Depth

EPS MARINE CTD OCEANOGRAPHY

Survey Area : ALICE ARM
Station : Q 20
Latitude : 55 26.7
Longitude : 129 31.8
Date : 83/10/06

Time (start cast) : 1033 PDT
Time (stop cast) : 1041 PDT

Depth Reading in Air : 1.30 meters
Bottom Depth (sounder) : 263.00 meters

Depths adjusted for Air Reading Correction.

Depth (m)	Temp (C)	Sigma-T	Conductivity	Salinity	Transmission %
1.6	9.63	12.97	19.5572	16.9832	60.700
2.0	9.63	12.98	19.5641	16.9894	58.046
3.0	9.61	13.01	19.5985	17.0304	63.350
4.0	9.61	13.25	19.9186	17.3338	64.275
5.0	9.67	13.61	20.4451	17.8076	65.000
10.0	9.95	16.70	24.8126	21.8373	71.350
15.0	9.99	18.39	27.0764	24.0089	76.387
20.0	9.91	20.10	29.2535	26.1952	78.067
25.0	9.60	21.08	30.2255	27.3875	78.787
30.0	9.21	21.79	30.7598	28.2289	80.794
35.0	9.00	22.09	30.9307	28.5707	81.156
40.0	8.93	22.21	31.0179	28.7089	81.500
45.0	8.87	22.30	31.0799	28.8174	82.125
50.0	8.82	22.37	31.1134	28.8971	82.962
60.0	8.74	22.47	31.1671	29.0145	82.516
70.0	8.64	22.57	31.1965	29.1152	82.776
80.0	8.58	22.63	31.2195	29.1897	83.012
90.0	8.34	22.79	31.1934	29.3516	82.119
100.0	7.98	23.05	31.1498	29.6096	78.097
110.0	7.59	23.40	31.2083	29.9964	79.706
120.0	7.21	23.76	31.2611	30.3804	81.878
130.0	7.03	23.90	31.2680	30.5376	82.931
140.0	6.91	24.02	31.2898	30.6689	83.178
150.0	6.81	24.09	31.2864	30.7464	82.879
160.0	6.73	24.13	31.2548	30.7783	83.139
170.0	6.65	24.18	31.2364	30.8306	83.076
180.0	6.63	24.19	31.2288	30.8339	83.153
190.0	6.60	24.20	31.2211	30.8491	83.184
200.0	6.58	24.21	31.2172	30.8601	82.570
210.0	6.55	24.23	31.2213	30.8810	82.672
220.0	6.54	24.25	31.2264	30.8959	82.057
230.0	6.51	24.27	31.2313	30.9213	82.148
240.0	6.50	24.27	31.2316	30.9263	79.862
248.6	6.48	24.29	31.2386	30.9446	81.231

Figure 7 Example of a Single Parameter Plot Prepared for Final Reporting

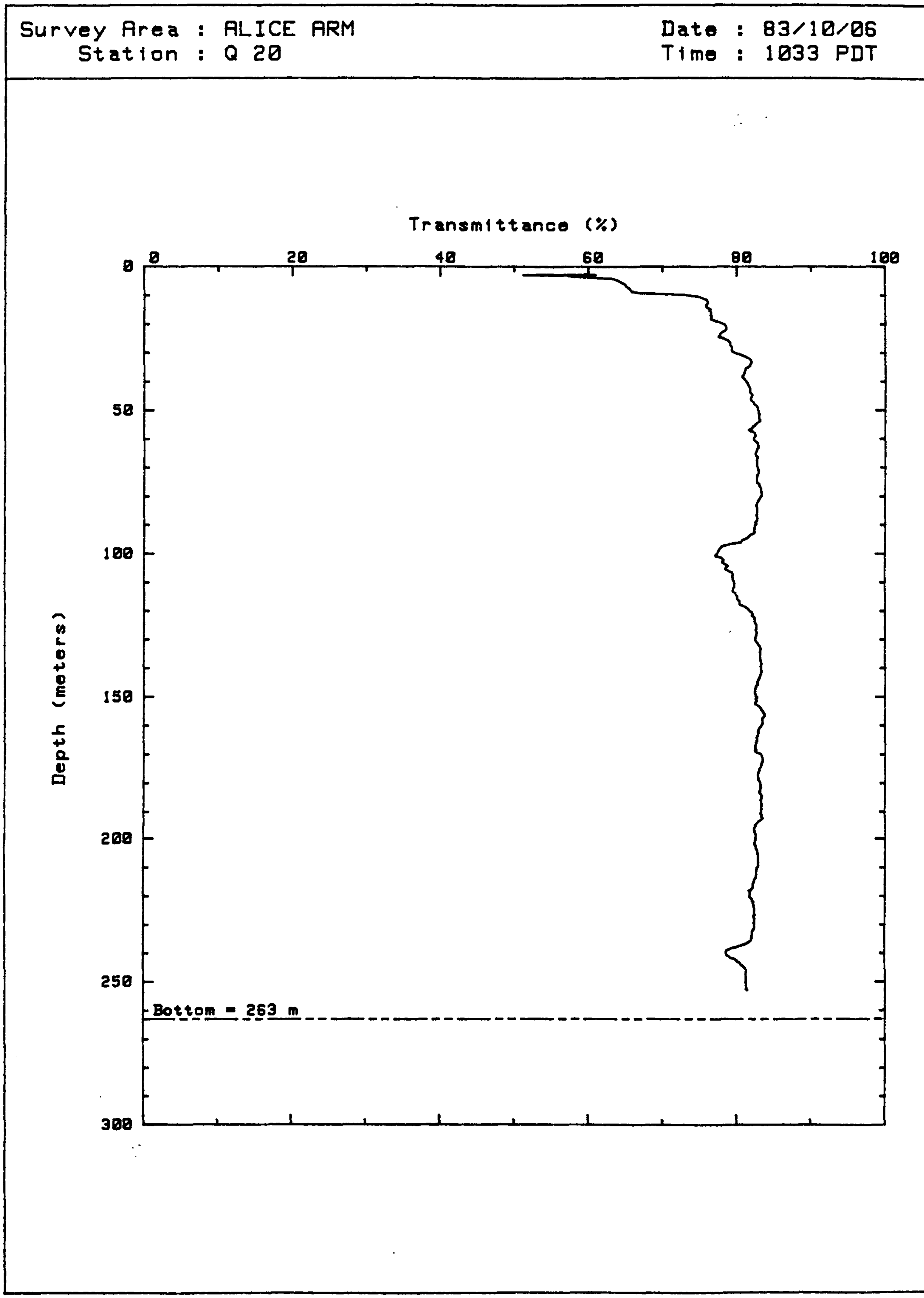

Figure 8   Example of a Multiparameter Plot Prepared for Final Reporting