Cunninghamia 1(4), 503–536 (1986)

ALGAE OF THE PEEL RIVER AND THE NEWLY CONSTRUCTED CHAFFEY DAM, NEW SOUTH WALES, AUSTRALIA

VALERIE MAY & J. M. POWELL

(Accepted for publication 21.2.1986)

ABSTRACT

May, Valerie & Powell, J.M. (National Herbarium of New South Wales, Royal Botanic Gardens, Sydney, Australia, 2000) 1986. Algae of the Peel River and the newly constructed Chaffey Dam, New South Wales, Australia. Cunninghamia 1(4): 503–536. The algal floras of the Upper Peel River above and below Chaffey Dam were studied between October 1977 and September 1981, and the algal flora of Chaffey Dam surveyed from October 1979, to investigate some of the biological changes induced by the formation of a dam in a river. Seventy-two taxa were recorded; 42 were present in all areas, 24 were found only in the River and one was restricted to the Dam. Changes in the presence of individual taxa and in their frequency, abundance, duration of occurrence and seasonality were found to be related to changes in waterflow, differences in water depth and temperature, and availability of nutrients. Successional changes may have contributed to some changes within the Dam. Colonization was more or less concurrent throughout the Dam, and there was a general increase in the number of species over time. Some taxa appeared to be favoured by the habitat conditions of the Dam, but others were more obviously fluvial. In all areas the number of species increased during drought and while some taxa were favoured at such times, others flourished more during times of normal waterflow. Long-term, detailed studies of river and lake floras are needed to provide a sound base for the use of algae in biological surveillance.

INTRODUCTION

There is a need for detailed and prolonged studies of aquatic flora and fauna. Williams (1976) has emphasized the lack of basic ecological data for most Australian inland aquatic environments, whilst Bowen & Smalls (1980) remark that "few data exist which indicate the nature of changes taking place in Australian reservoirs during the initial phases of their existence". Lund (cited in Smalls,1978), discussing a blue-green alga (also known as a Cyanobacterium), says "observations over a single year may give a false idea of the changes taking place", and Youngman (cited in Smalls,1978) noted that results had differed each year in the reservoir he studied from 1965 to 1973. Bowen & Smalls (1980) studied the phytoplankton of Prospect Reservoir in 1964 and again in 1977; they found that increased eutrophication was reflected by changes in both the nature and density of the algal crop.

This study began in 1977 when collections of the algae of the Peel River were started, two years before Chaffey Dam was completed. Study of the dam is continuing. The aim is to record the algal flora of a river and to monitor any changes in the flora caused by the formation of a dam. In this paper the results of the first four years of study are reported. Details are given of changes in the floras of mainly microscopic algae and in the distribution of a few macrophytes, (a) in the River above the Dam over a period of four years, (b) within the newly formed Dam over two years, and (c) in the River below the Dam over four years, including the period of construction and functioning of the Dam. This forms the first Australian study in such detail; the significance of the algal investigation is enhanced by the concurrent physio-chemical studies by officers of the Water Resources Commission of New South Wales, and by observations on the less readily identified diatoms, reported by Holland (Appendix 2).

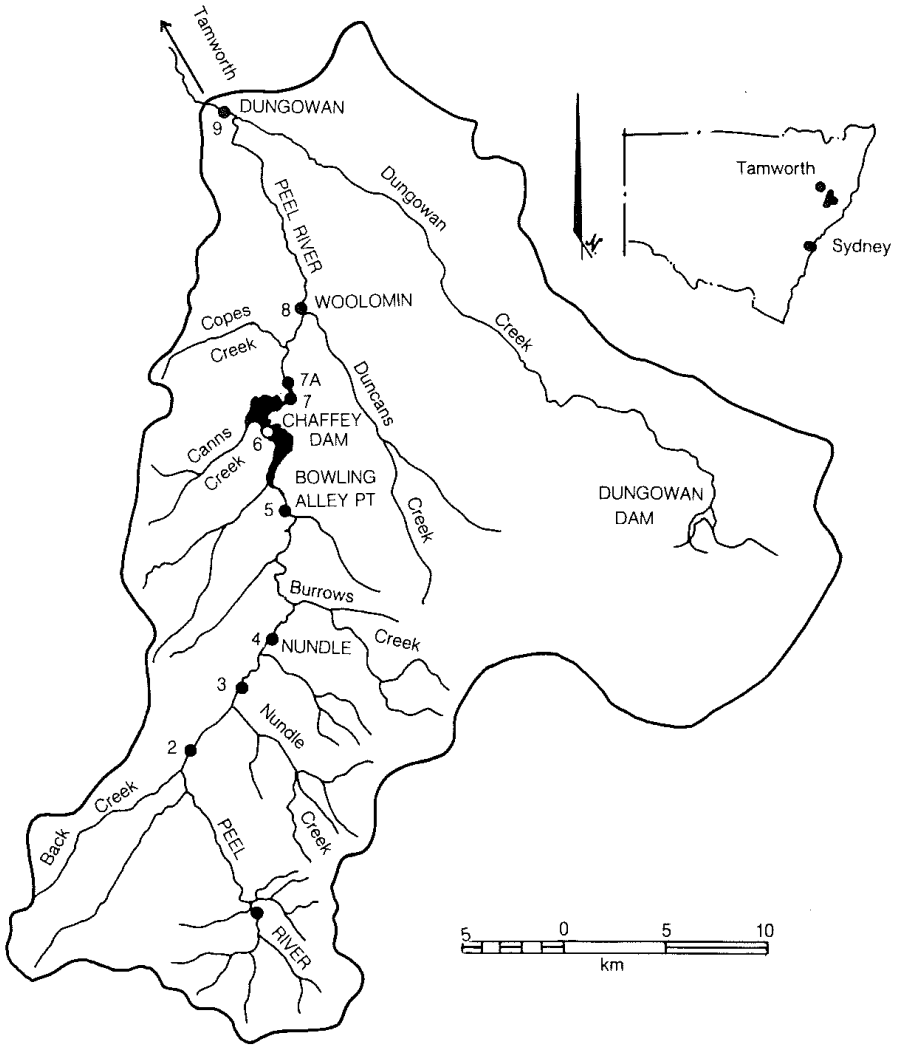

Figure 1. Location of Peel River and Chaffey Dam showing collecting stations on the Peel River.

The study area and monitored stations

The Peel River runs north from the relatively undisturbed natural vegetation and pastoral land areas of the Great Divide on the Northern Tablelands of New South Wales and flows into the Namoi River and thence into the western drainage system of New South Wales. Chaffey Dam, at 31°33′S, 151°12′E is north of Nundle township (32 km south of Tamworth; Figure 1).

In 1977 ten stations were set up for monitoring along the Peel River. Five of these (1–5) were located upstream from the Dam site, while station 6 was engulfed during Dam construction; records from this station are available for the first two years only. The other four river stations (7, 7A, 8, 9) were downstream of the Dam site (Figure 1). In 1979 five stations were established within Chaffey Dam itself (Figure 2A).

The flow of the Peel River above Chaffey Dam is extremely variable. At times of normal rainfall there is an inflow of water from numerous small tributaries and water depths at the monitored stations range from 0.5 to 1.0 metres. Station 4 also receives septic tank and other drainage from Nundle.

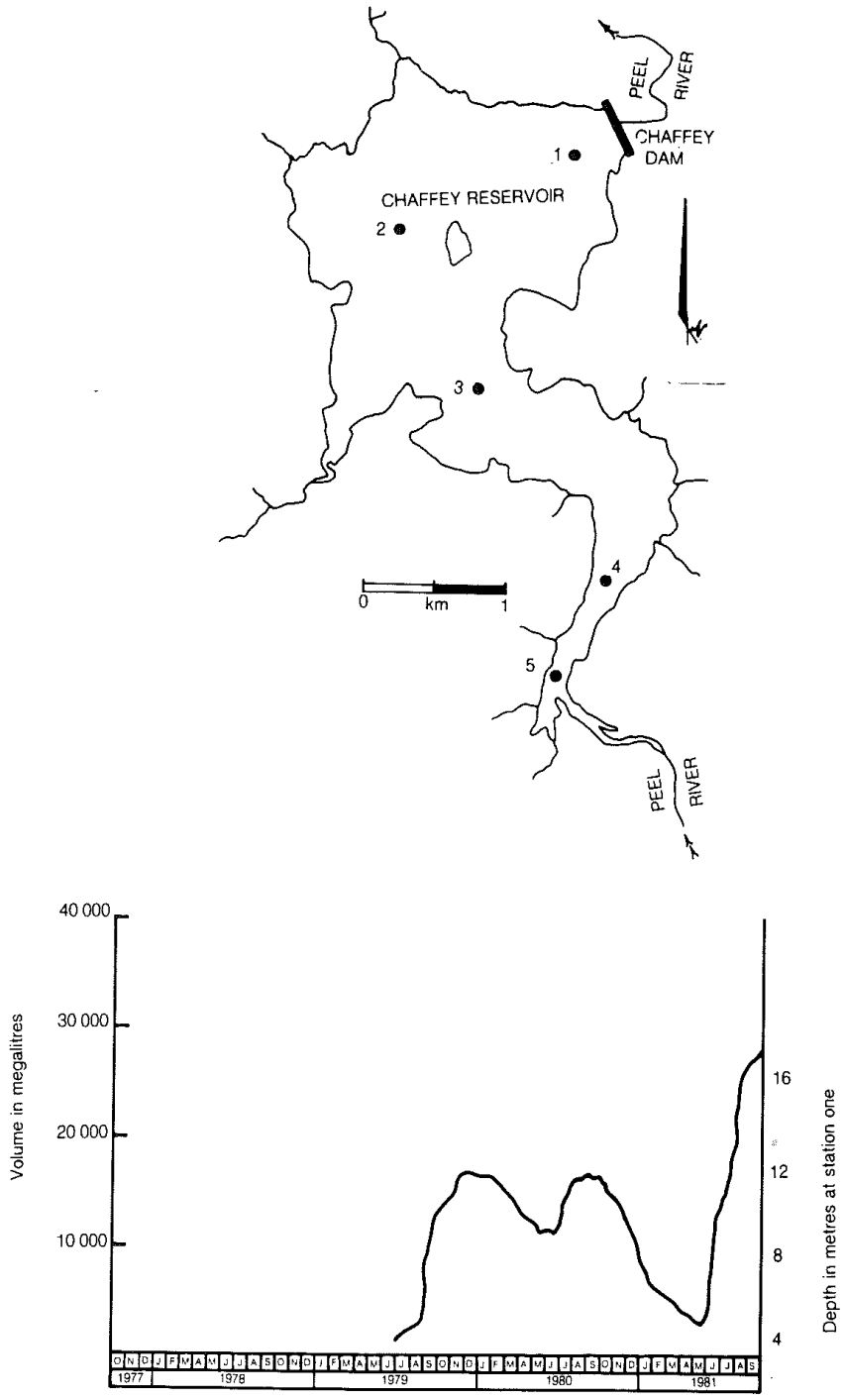

Figure 2. Chaffey Dam: (A) Locations of stations; (B) Volume of storage and approximate depth at station 1.

During droughts the volume of water is greatly reduced and some tributaries become stagnant and/or dry. During summer and autumn of both 1980 and 1981, the most severe periods of drought during the present study, water continued to flow only at station 4.

Construction of Chaffey Dam began before 1977, but the river flow was not affected until April 1979. The filling of the Dam was delayed by drought and even by September 1981 it was not full. At the five Dam stations (Figure 2A) low water depths restricted sampling over much of the study period and at

station 5 water depth was insufficient for collection until August and September 1981. The data from this station are discussed but not included in the Figures. Water levels were affected by flow out of, as well as into, the Dam, water being released intermittently after 11 December 1979. At Dam station 1 between October 1979 and October 1980, water depth ranged between nine and 12 metres, with the lowest recordings in March and April. After October 1980 the depth gradually dropped to six metres by February 1981, remained between five and six metres until the end of May and then began to rise, to 11 metres by June, 15 metres by July 1981. Water depth remained between 15 and 16 metres from then until the end of the present observations (Figure 2B). The stations first covered by water were earlier in developing conditions pertaining to a dam rather than a river and, being deeper, were less affected by the drought.

After October 1979 intermittent aeration was applied whenever the temperature difference between top and bottom water equalled or exceeded four Centigrade degrees and/or the dissolved oxygen fell below 2 mg per litre. This achieved artificial overturn at the time.

River stations 7, 7A, 8 and 9, downstream of Chaffey Dam (Figure 1) were subjected to a number of different conditions:

(1) between 28 September 1977 and 20 March 1979, drainage was affected by soil disturbance from Dam construction, but there was no interference with the water flow,

(2) between 20 March 1979 and 26 June 1979, the flow of the River was partly impeded as the Dam filled,

(3) between 16 July and 11 December 1979, the Dam outlet prevented all water flow, and water levels immediately below the Dam wall dropped rapidly; flow continued at stations 8 and 9, however, as they received water from tributaries (Figure 1),

(4) after 11 December 1979, intermittent releases of water allowed a slow flow downstream of the Dam despite drought conditions.

METHODS

Collection of samples

Water samples were collected in a five-litre perspex free-flow sampler at fortnightly or monthly intervals between October 1977 and September 1981 at the River stations and between October 1979 and September 1981 at the Dam stations given that sufficient water was present to allow flow. Samples taken at river stations were from the surface region of well-mixed running water, while those from the dam stations were from three depths: top (surface), bottom (near the sediment), and middle or from the thermocline when present. The thermocline was determined by measuring temperatures. The attached algae and angiosperms at each station were collected separately.

Two 100 ml sub-samples were taken from the original five litre sample for examination of planktonic algae; one sub-sample was preserved in Lugol's solution immediately, the other was packed with iced "bricks" in an insulated container and transferred to the laboratory as quickly as possible, usually within two days.

Analysis of samples

The non-preserved sub-sample was shaken and filtered, the algae being washed to the base of the filter paper during the process, and then mounted on a slide for immediate examination. If the non-preserved sample was damaged in transit, the Lugol's material was used. The filter paper was examined for any

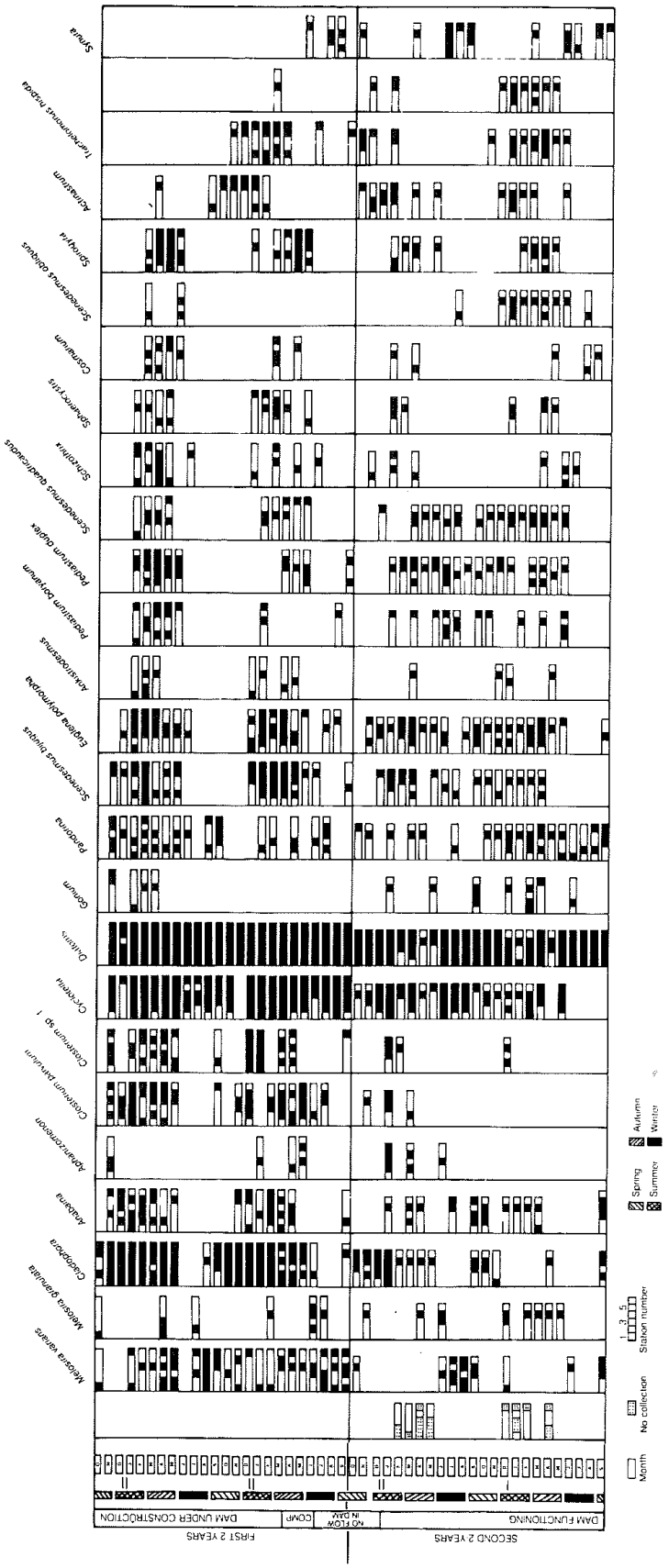

Figure 3. Occurrence of common taxa at stations 1–6 in the Peel River above Chaffey Dam. On the left hand side of the diagram the periods of construction and functioning of the Dam are shown together with the seasons, years, calendar months, and times of restricted water sampling.

remaining algae (for example, clumps of *Anacystis* if in bloom, or other larger species) and these were noted. The slides were studied at magnifications of 40 to 200x using a binocular compound microscope. The species present were recorded and the numbers of each taxon obtained by counting taxa along traverses of the slide. These figures formed the basis for estimating abundance. The following ratings were used: high—more than 50 per mm^2, medium—5–50 per mm^2, and low—less than 5 per mm^2. With colonies such as *Anacystis,* or larger-growing species such as *Volvox,* a subjective estimate was made; this was normally an underestimate as some material may have remained on the filter paper, as discussed above. Attached algae and drift material of larger plants (in the Dam study) were recorded merely as present.

Presentation and interpretation of data

Where only one species of a genus is reported in this study, the generic name alone is used. A full list of species names and authorities is given in Appendix 1. Only a few diatom taxa were identified (*Melosira, Cyclotella, Asterionella*), others being grouped as "Diatoms"; they are discussed more fully by Holland (Appendix 2).

Sampling at fortnightly intervals usually gave little, if any, additional information over monthly sampling and so the data are presented as monthly records. The data obtained for each taxon were sorted and plotted, in order of first occurrence at any station. Trends and changes in the plant populations could then be considered. Frequency and seasonal comparisons are based on the monthly data. The term "seasonality" refers to the range of seasons over which the taxon occurred within a defined time period (of 18 months, 2 years, etc.) whilst "duration of occurrence" refers to the total period of time (in number of months, not necessarily sequential) that the taxon was present within the defined time period. Frequency was calculated as the actual number of occurrences divided by the maximum theoretical number of occurrences and expressed as a percentage. The abundance data are expressed as the number of station-months that the taxon was recorded with medium or high abundance ratings. In interpreting these data any occasional low or high reading is not considered important, since a local change of environmental conditions, for example, a change of wind or a flush of water, can cause quite different concentrations of planktonic algae. A single occurrence noted some months apart from others is regarded as a chance occurrence.

The data on rare species (defined as being present on only 5 per cent or less of the total station-months recorded in each region) are graphed separately from the common species, and less detailed information is given on them; full records are deposited in the library of the National Herbarium of New South Wales.

The data for the different regions of the River (above and below the Dam site) and for the Dam itself are presented separately. The times of restricted sampling due to low water levels and the periods of construction and functioning of the Dam, relevant for comparative discussions, are shown also. The floras of the three regions are then compared, with similarities and differences discussed.

RESULTS

Algae occurring in the Peel River above Chaffey Dam

River stations 1–5 were unaffected by the Dam construction, so the four years of observation provide a good basis for discussion of the behaviour of the various algal taxa found there (Figures 3–5). The records from station 6, which was engulfed during the Dam construction, did not differ greatly from those of stations 1–5 and are included for the first 2-year period. The observations are

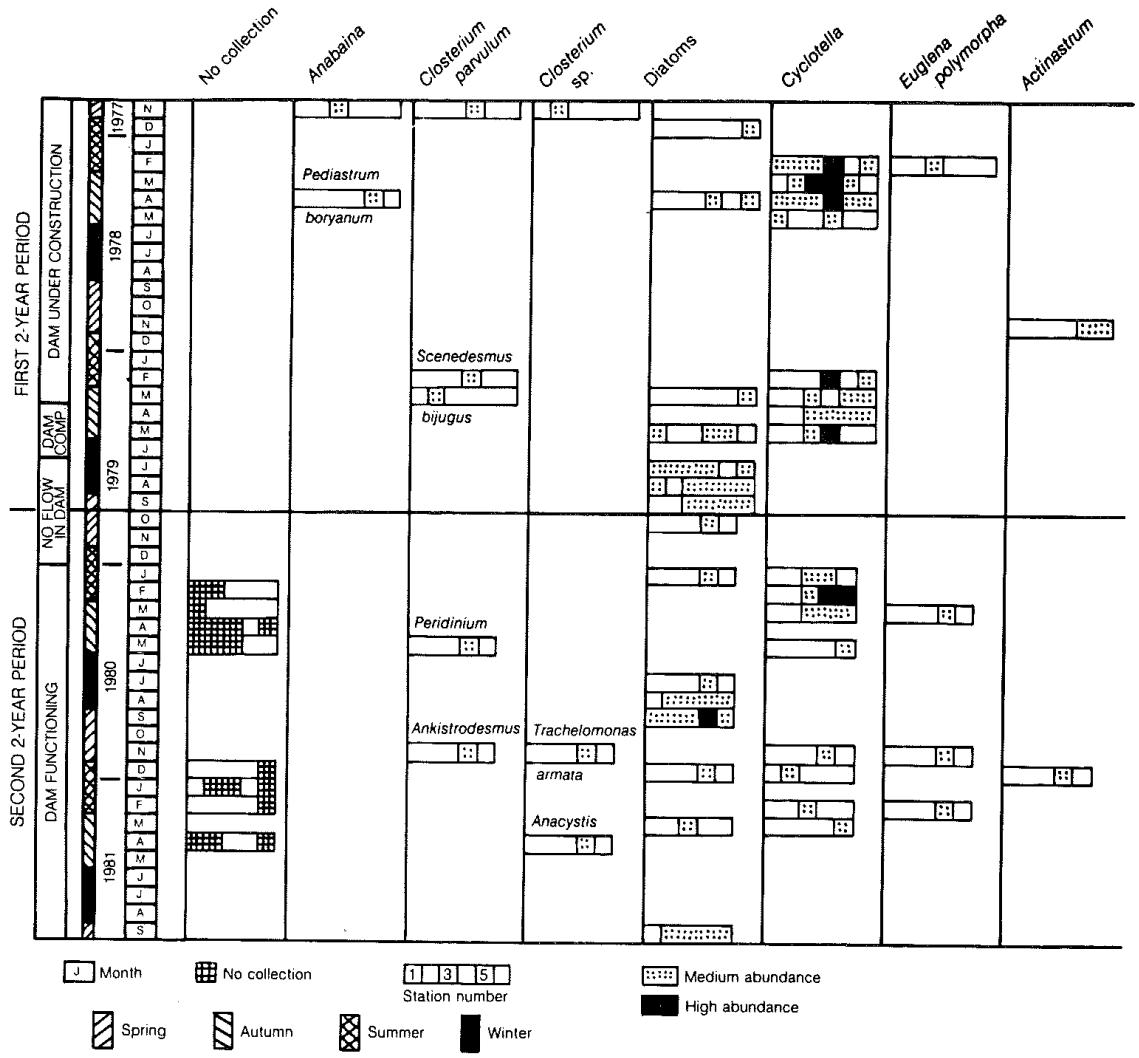

Figure 4. Abundance ratings for taxa at stations in the Peel River above Chaffey Dam. Taxa with only 1 to 2 occurrences are plotted together on the left of Diatoms. On the left hand side of the diagram the periods of construction and functioning of the Dam are shown together with the seasons, years, calendar months and times of restricted water sampling.

considered in two equal time periods: (a) from October 1977 to September 1979, during normal river flow; (b) from October 1979 to September 1981, including the periods of drought.

Species composition

Fifty-seven taxa were recorded at these stations, 37 of which were found during both time periods. Four taxa were found only within the first 2 years (1977–1979), and 16 others only within the second 2-year period (1979-1981; Figures 3, 5). One of the latter group, *Anacystis*, was recorded as abundant (Figure 4).

Of the 37 taxa found during both time periods, 11 were rare (frequency of 5 per cent or less); they occurred on less than 12 occasions in any station over the four years and often at only one station at any particular time (Figure 5). One, *Peridinium*, was recorded as abundant once (Figure 4). Twenty-six taxa were common (Figure 3) and of these 11 recorded medium or high abundance

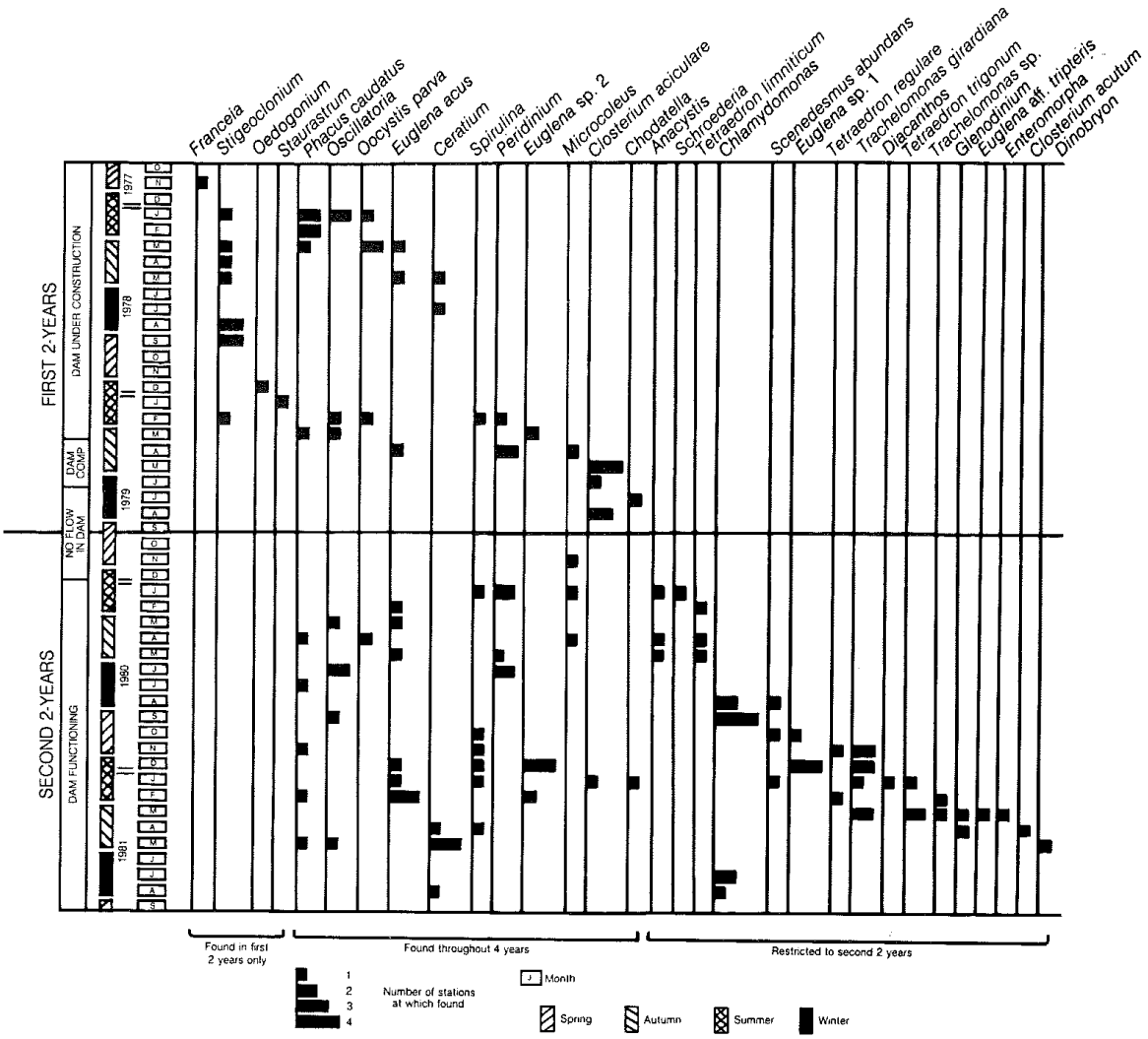

Figure 5. Occurrence of rare species at stations in the Peel River above Chaffey Dam. Only the total number of stations at which each species was found is given. Data on the left are shown as in Figure 3 except for the times of restricted water sampling.

ratings on one or more occasions (Figure 4). The data on duration of occurrence and frequency for all taxa are summarized in Tables 1 and 2, with abundance data for the common taxa included also in Table 1.

The data indicate that:

(1) more species occurred during the second 2-year period than the first (53 compared with 41; Figures 3, 5)

(2) more species showed higher frequencies in that second 2-year period (22 compared with 13; Tables 1, 2)

(3) more species were present for a greater number of months in that period (21 compared with 15; Tables 1, 2), and

(4) the number of taxa that recorded medium or high abundance ratings was reduced slightly during the second period (eight compared with nine; Figure 4).

Thus, more species appeared and more species showed a greater frequency and occurred for more months during the period of drought than during normal times. This is in accord with Swale (1964) who found that algal populations

TABLE 1

Summary of data on duration of occurrence, frequency and abundance of the common taxa in the Peel River above Chaffey Dam

Taxon	No. months present per 2-year period		Frequency (%)		Abundance*	
	1977–79	1979–81	1977–79	1979–81	1977–79	1979–81
Plankton						
Actinastrum	7	11	8	17	2	1
Anabaina	14	11	26	20	1	0
Ankistrodesmus	7	4	6	4	0	1
Aphanizomenon	4	3	4	7	0	0
Closterium parvulum	16	3	34	5	1	0
C. sp. 1	12	3	26	6	1	0
Cosmarium	6	5	8	5	0	0
Cyclotella	22	19	76	50	24	13
Diatoms	23	24	95	100	21	17
Euglena polymorpha	15	19	28	35	1	3
Gonium	4	7	4	11	0	0
Melosira granulata	5	8	6	10	0	0
M. varians	20	8	33	16	0	0
Pandorina	15	18	21	27	0	0
Pediastrum boryanum	7	10	10	15	1	0
P. duplex	9	16	17	25	0	0
Scenedesmus bijugus	15	14	30	20	2	0
S. obliquus	2	9	2	12	0	0
S. quadricaudus	9	15	10	21	0	0
Schizothrix	9	6	12	8	0	0
Sphaerocystis	9	5	9	9	0	0
Synura	3	10	4	19	0	0
Trachelomonas armata	1	8	1	12	0	1
T. hispida	8	10	13	19	0	0
Attached algae						
Cladophora	19	13	63	27	0	0
Spirogyra	9	8	21	13	0	0

* Number of station-months taxon recorded medium or high abundance ratings.

TABLE 2

Summary of data on duration of occurrence and frequency of rare taxa occurring during both 2-year periods in the Peel River above Chaffey Dam.

Taxon	No. months present per 2-year period		Frequency (%)	
	1977–79	1979–81	1977–79	1979–81
Ceratium	2	3	1	5
Chodatella	1	1	<1	<1
Closterium aciculare	3	1	4	<1
Euglena acus	3	6	2	8
Euglena sp. 2	1	2	<1	4
Microcoleus	1	3	<1	3
Oocystis parva	3	1	3	1
Oscillatoria	3	4	3	5
Peridinium	2	3	2	5
Phacus caudatus	4	5	4	5
Spirulina	1	6	<1	6

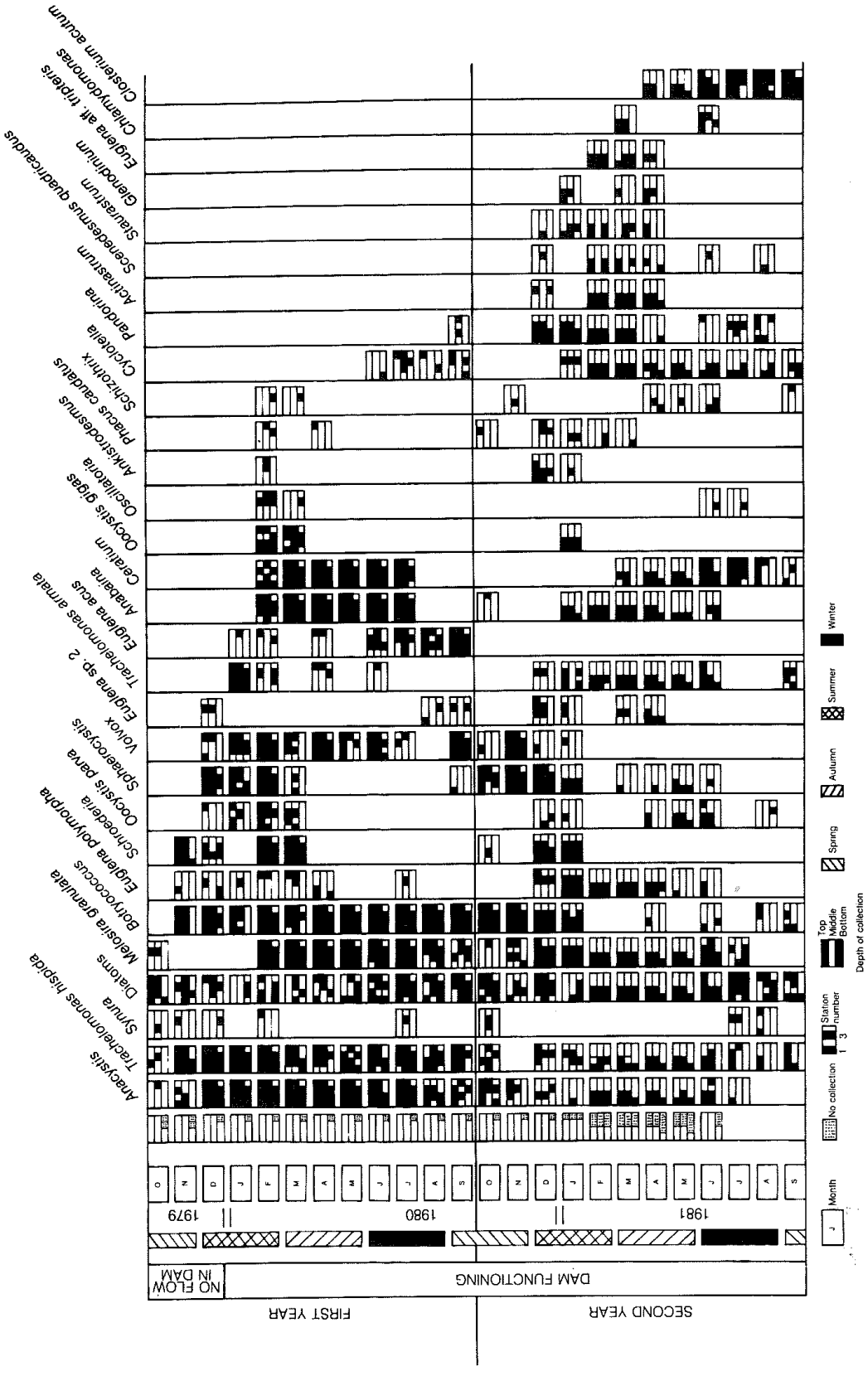

Figure 6. Occurrence of common taxa at different depths at each station in Chaffey Dam. On the left hand side of the diagram the periods of no flow and of the Dam functioning are shown together with the seasons, years, calendar months and times of restricted water sampling.

TABLE 3
Number of taxa present at each station in the Peel River above Chaffey Dam

Station	Number of species	
	1977–79	1979–81
1	19	12
2	30	31
3	27	33
4	29	50
5	29	32
6	26	under dam

were largest in periods of low rainfall. Drought is associated with low water levels, low aeration, and usually with high nutrient levels and such conditions obviously favour certain species. It is noteworthy that some of the taxa listed as associated particularly with the low water levels, namely *Anacystis, Euglena* and *Synura*, are often found in polluted (enriched) water (V. May, pers. observ.).

Distribution of species

Table 3 gives the number of taxa found at each station in each of the 2-year periods. In the first two years, apart from a low reading at station 1 (which is high in the catchment area, has less reliable water-flow, lower nutrient export and is away from the main source area for "seeding" or the introduction of additional species) all stations had a relatively similar number of taxa occurring in them. By contrast, during the second 2-year period, which included the period of drought, the number of taxa at station 1 decreased, while there was an increase at all other stations and particularly at station 4.

Of the 53 species that occurred during the second 2-year period, only three did not occur at station 4, while seven others occurred only at that station. The drainage from the tributaries and from Nundle was sufficient to keep the water level high here despite drought conditions, and the nutrients in this drainage (as indicated by high water conductivity readings: Garman & Townsend, pers. comm.) were sufficient to stimulate the appearance and growth of many species and possibly to extend the occurrence and increase the frequency of others.

Algae of Chaffey Dam

In Figures 6 and 7 the patterns of occurrence of the 48 taxa recorded from Dam stations 1–4 are plotted. In Figure 6 the information for the 30 common taxa is given for all depths of collection at each station, whilst in Figure 7 the data for the 14 rare and four drift species (pieces of formerly attached algae carried down from upstream) are expressed on the basis of station number only. Abundance ratings for the common taxa are shown in Figure 8.

The observations are considered in two equal time periods, from October 1979 to September 1980, when dam conditions were developing, and from October 1980 to September 1981, when conditions were affected by several months of drought. The data on duration of occurrence and on frequency are given in Tables 4 and 5 with abundance data also in Table 4.

Species composition

Twenty-two of the 30 common taxa were present during both 12 month periods, one (*Euglena acus*) was found only during the first 12 months and seven others were restricted to the second 12 months (Figure 6). Various frequency and abundance patterns were shown by these taxa (Table 4, Figure 6). Amongst

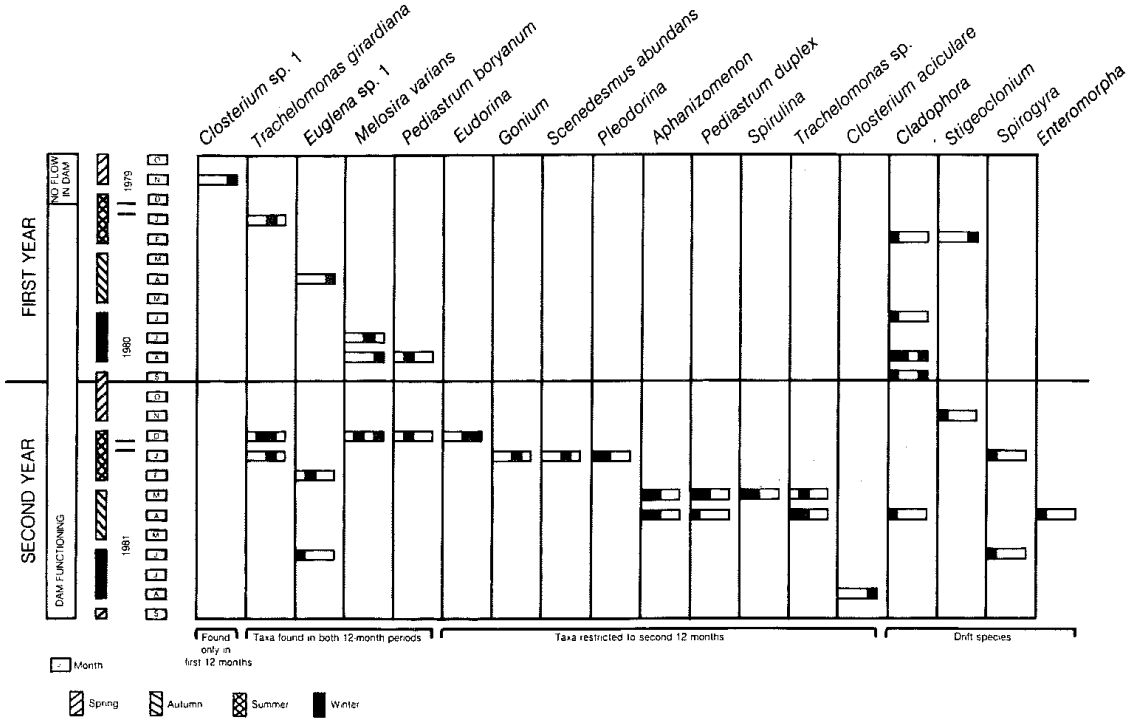

Figure 7. Occurrence of rare and drift species at each station in Chaffey Dam. Data on the left show the period of functioning of the Dam, seasons, years and calendar months.

the 14 rare planktonic taxa, one (*Closterium* sp. 1) was found only during the first 12 months, and 9 were restricted to the second 12 months (Table 5, Figure 7). Of the four species found only as drift material, *Cladophora* was the most common, with *Enteromorpha, Spirogyra* and *Stigeoclonium* being present less frequently (Table 5, Figure 7).

Considering the common and rare species together (omitting drift species):

(1) there was a general increase in the number of taxa recorded over time (Figure 9), with more species being present during the second 12 months than during the first (42 compared with 28). The greatest increase in species numbers occurred in spring and summer.

(2) more species occurred for more months during the second year (30 compared with 10) and showed higher frequencies (33 compared with 11; Tables 4 and 5).

(3) differences in frequency were shown by many of the species over the two 12-month periods. Thus, some taxa were more common during the first 12 months; they showed higher frequencies and were usually present for more months then, while others were more common during the second 12-month period. Some others showed similar frequencies and duration of occurrence in each of the two 12-month periods (Tables 4, 5).

(4) differences in abundance between the two 12-month periods were shown also by some taxa. Of the 17 taxa that were recorded as having medium or high abundance ratings, three were restricted to the first 12 months and a further five were more often abundant then. Six other taxa were restricted to the second 12

TABLE 4

Summary of data on duration of occurrence, frequency and abundance of the common species of Chaffey Dam

Taxon	No. months present per 12-month period		Frequency (%)		Abundance*	
	1979–80	1980–81	1979–80	1980–81	1979–80	1980–81
Plankton						
Actinastrum	—	4	—	18	—	—
Anabaina	6	7	50	31	6	3
Anacystis	12	10	90	56	5	3
Ankistrodesmus	1	2	4	10	—	1
Botryococcus	11	8	92	56	1	2
Ceratium	6	7	50	51	4	3
Chlamydomonas	—	2	—	13	—	1
Closterium acutum	—	6	—	51	—	1
Cyclotella	4	9	19	44	—	2
Diatoms	12	12	94	95	1	2
Euglena acus	7	—	40	—	—	—
Euglena polymorpha	7	7	23	36	—	—
Euglena aff. *tripteris*	—	3	—	13	—	—
Euglena sp. 2	3	4	8	21	—	—
Glenodinium	—	3	—	13	—	—
Melosira granulata	9	10	67	67	3	2
Oocystis gigas	2	1	17	5	—	—
Oocystis parva	4	6	25	28	—	—
Oscillatoria	2	2	6	5	—	—
Pandorina	1	8	4	44	—	3
Phacus caudatus	2	5	6	18	—	—
Scenedesmus quadricaudus	—	6	—	23	—	—
Schizothrix	2	5	4	18	—	—
Schroederia	4	3	29	18	3	2
Sphaerocystis	5	8	31	49	1	2
Staurastrum	—	5	—	23	—	—
Synura	5	3	10	13	—	—
Trachelomonas armata	4	8	19	49	—	1
Trachelomonas hispida	12	11	94	77	2	—
Volvox	8	4	63	18	5	—

* Number of station-months taxon recorded medium or high abundance ratings

months (two of these attained high abundance ratings) and a further three were more often abundant then (Figure 8, Table 4). *Anabaina, Anacystis, Ceratium, Melosira granulata* and *Schroederia* were the taxa most often recorded with medium and high abundance ratings and hence probably contributed most to the biomass in the Dam; such abundance ratings were reached mainly in summer and autumn but occurred also occasionally in winter.

The differences in frequency probably related to a number of factors, including changing water conditions (from flowing to still water) and water depths. The taxa more important during the first 12 months were early colonists and probably tolerant of changing conditions while those more important during the second 12 months may have been favoured by the drought conditions.

The greater algal growth during the second year of the Dam's existence may have resulted from a decrease in water turbidity then or from an increase in "available phosphorus" or from both (Garman & Townsend, pers. comm.).

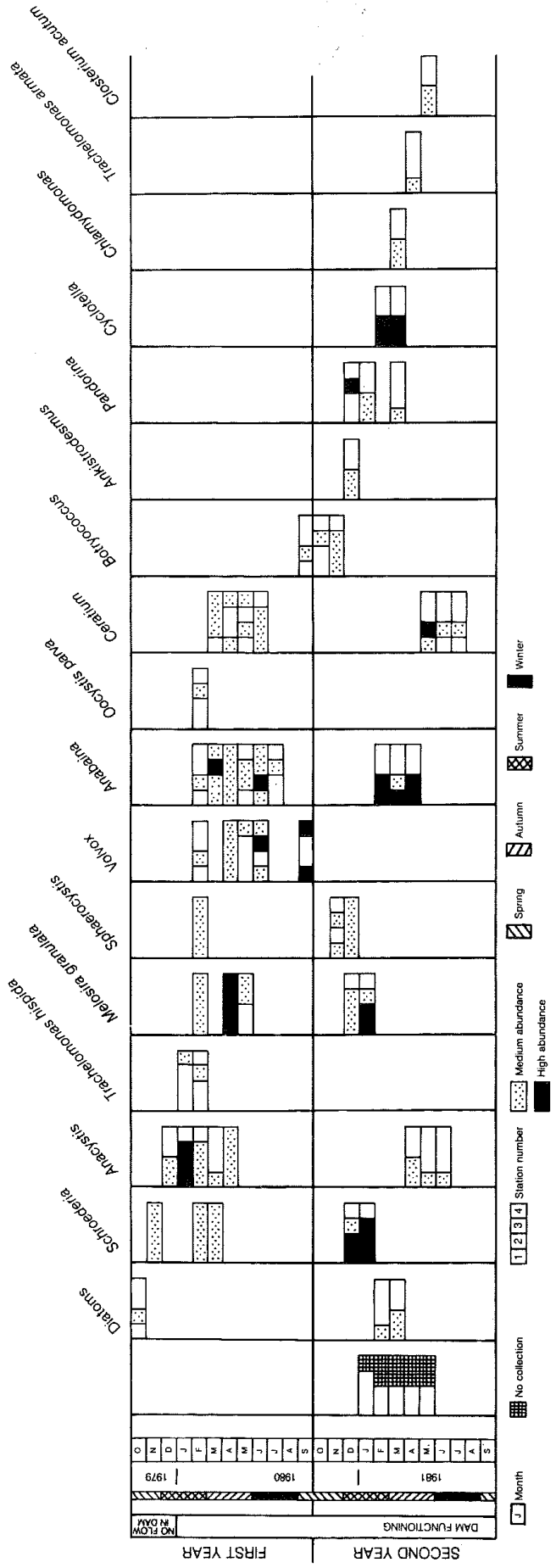

Figure 8. Abundance ratings for taxa at stations in Chaffey Dam. Data on the left show the period of functioning of the Dam, seasons, years, calendar months and times of restricted sampling.

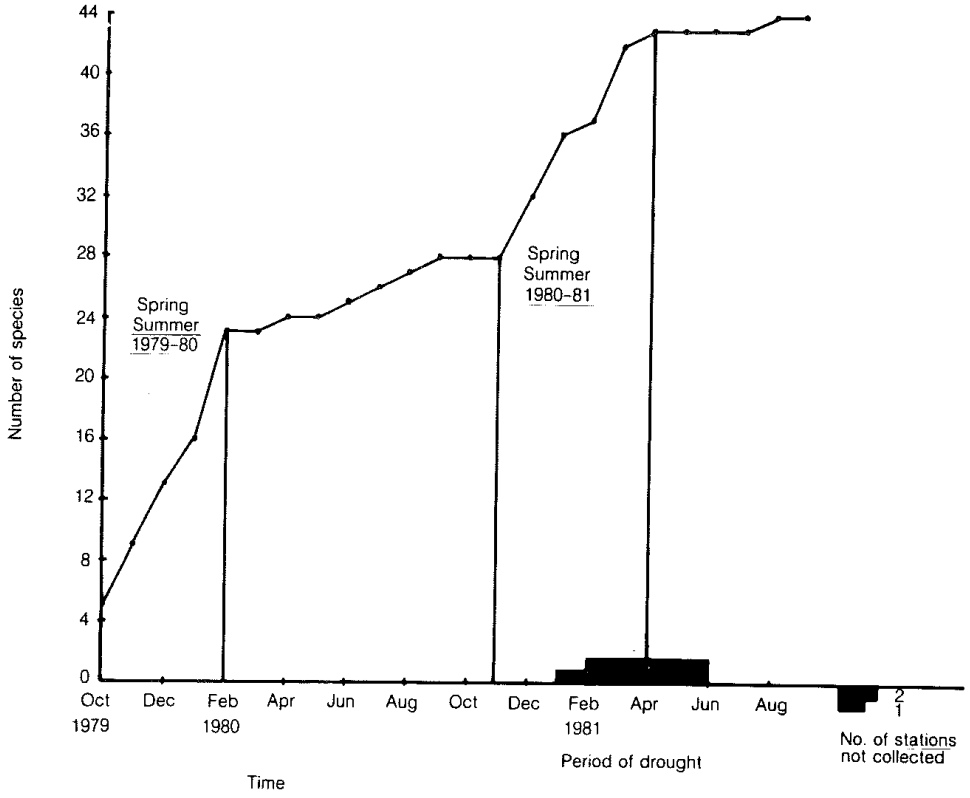

Figure 9. Species-time curve for Chaffey Dam.

Differences between stations

During the first 12-month period, many of the common species were found at all stations within a month or two of their first appearance, suggesting that colonization was more or less concurrent (Figure 6). Some remained more restricted, however, and others, in particular the late summer arrivals were present at only one or two stations. During the second year some species extended their distribution, others changed somewhat, and a number became more restricted (Figure 6). Differences in abundance ratings were not obvious between stations (Figure 8).

Most of the taxa shown in Figure 6 occurred most often at stations 1 and/or 2, the stations that were covered with water first and were least affected by drought conditions. Seven species did not follow this pattern; they occurred equally (*Ankistrodesmus, Phacus caudatus*) or more often (*Euglena acus, E.* sp. 2, *Oscillatoria, Synura, Volvox*) at the upstream stations (3 and 4). The sequence of colonization at station 1 (the oldest, deepest and most stable station, Figures 6 and 7) indicates that these species favour upstream conditions; the taxa listed above (with the exception of *Volvox*) occur late in the sequence and infrequently, if at all, at station 1.

Differences relating to depth of collection

For those taxa with a frequency of over 40 per cent, differences relating to the depths of collections were analysed (Table 6). The majority of the species were surface or near surface dwellers, only *Melosira granulata, Cyclotella* and the "Diatoms" (i.e. other diatom taxa grouped together) being more often at the bottom. *Anabaina, Schroederia* and *Pandorina* appeared to be evenly distributed over the collection depths. Considering differences in abundance (Table 7) a similar pattern was shown, medium and high abundance ratings

TABLE 5

Summary of data on duration of occurrence and frequency of the rare and drift species of Chaffey Dam

Taxon	No. months present per 12-month period		Frequency (%)	
	1979–80	1980–81	1979–80	1980–81
Plankton				
Aphanizomenon	—	2	—	10
Closterium aciculare	—	1	—	3
Closterium sp. 1	1	—	2	—
Eudorina	—	1	—	5
Euglena sp. 1	1	2	2	5
Gonium	—	1	—	3
Melosira varians	2	1	4	5
Pediastrum boryanum	1	1	2	3
Pediastrum duplex	—	2	—	8
Pleodorina	—	1	—	5
Scenedesmus abundans	—	1	—	3
Spirulina	—	1	—	5
Trachelomonas girardiana	1	2	2	8
Trachelomonas sp.	—	2	—	8
Drift species				
Cladophora crispata	4	1	15	3
Enteromorpha	—	1	—	3
Spirogyra	—	2	—	5
Stigeoclonium	1	1	2	3

TABLE 6

Comparison of species presence in top and bottom collections at stations 1 and 2 of Chaffey Dam.*

Taxon	Station 1 No. months present 1979–80		1980–81		Station 2 No. months present 1979–80		1980–81		Totals	
	T†	B†	T	B	T	B	T	B	T	B
Anabaina	5	5	5	6	6	6	4	3	20	20
Anacystis	11	9	7	5	10	9	7	1	35	24
Botryococcus	10	7	6	4	11	8	5	5	32	24
Ceratium	6	5	6	3	5	5	6	2	23	15
Closterium acutum	—	—	6	4	—	—	6	2	12	6
Cyclotella	—	2	5	8	—	1	4	6	9	17
Diatoms	7	7	9	10	4	9	7	9	27	35
Euglena polymorpha	1	2	6	3	2	1	5	4	14	10
Melosira granulata	5	7	7	9	7	8	8	6	27	30
Oocystis parva	2	—	3	1	3	—	4	1	12	2
Pandorina	—	—	5	5	—	—	4	4	9	9
Schroederia	3	3	2	2	4	3	2	2	11	10
Sphaerocystis	4	2	6	4	3	3	5	4	18	13
Trachelomonas armata	1	1	6	5	1	2	7	2	15	10
T. hispida	8	8	8	3	12	8	9	2	37	21
Volvox	6	4	1	1	7	4	3	1	17	10

* Only taxa with a frequency of over 40 per cent included.
† T = Top collection; B = Bottom collection.

TABLE 7

Comparison of species abundance in top and bottom collections at stations 1 and 2 of Chaffey Dam

Taxon	No. times recorded medium or high abundance ratings					
	Station 1		Station 2		Totals	
	T*	B*	T	B	T	B
Anabaina	6	5	7	6	13	11
Anacystis	7	1	3	2	10	3
Botryococcus	1	0	2	1	3	1
Ceratium	3	1	4	1	7	2
Closterium acutum	1	1	1	1	2	2
Cyclotella	2	2	2	2	4	4
Diatoms	1	0	0	1	1	1
Melosira granulata	4	2	4	3	8	5
Pandorina	2	0	2	0	4	0
Schroederia	4	1	5	2	9	3
Sphaerocystis	2	0	2	0	4	0
Trachelomonas armata	1	0	0	0	1	0
Volvox	3	0	2	1	5	1

* T = Top collection; B = Bottom collection.

being more often in top collections; equal distribution occurred only with *Cyclotella,* "Diatoms" and *Closterium acutum.*

Results obtained from the thermocline or mid-point collections (Figure 6) were less definite.

Colonization at station 5

In August 1981 rising water levels led to station 5 being covered and nine taxa were recorded then: *Botryococcus, Ceratium, Closterium acutum,* "Diatoms", *Melosira granulata, Trachelomonas hispida, Cyclotella, Pandorina,* and *Spirulina.* In September, *Anabaina* and *Trachelomonas armata* appeared also. The first six of these taxa were amongst the seven most common to be expected in the Dam at any time of the year; only *Anacystis* was absent. Of the other five, three (*Cyclotella, Pandorina, Trachelomonas armata*) occurred in other stations at the same time of year but less commonly.

Cyclotella, Melosira granulata and *Pandorina,* all of which were slow in colonizing the new Dam in the first 12 months (Figure 6) were noted as soon as station 5 became covered with water, and *Closterium acutum* and *Spirulina,* taxa that occurred only in the second year of the Dam's existence (Figures 6 and 7), were present also in August 1981 at station 5. Thus, the presence of water at station 5 appears to have permitted extensions of range of species occurring within the Dam waters at the time, rather than following the pattern of colonization of a new dam.

Algae occurring in the Peel River below the Dam

Species compositions: changes over time-periods 1 to 4

Of the 36 common taxa recorded (Figure 10), 30 were found during the period of Dam construction (period 1: 28 September 1977–20th March 1979). The majority of these appeared in spring and summer 1977–78 (24 taxa), the remainder in later seasons. *Cyclotella* and the other "Diatoms" became abundant on a number of occasions during summer and autumn at all stations during period 1 and five other taxa became abundant at times (Figure 11).

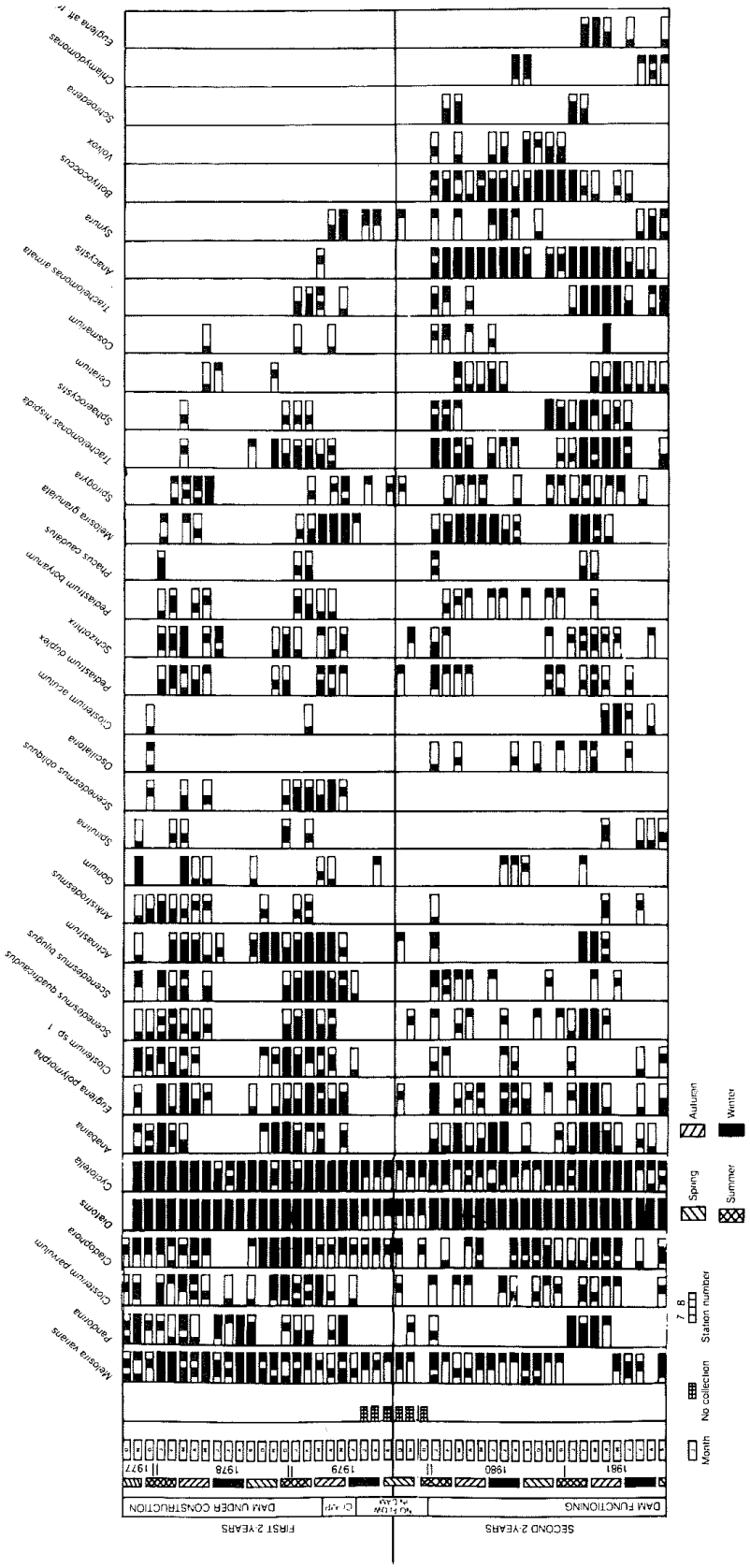

Figure 10. Occurrence of common taxa at stations 7–9 in the Peel River below Chaffey Dam. Data on the left is shown as in Figure 3.

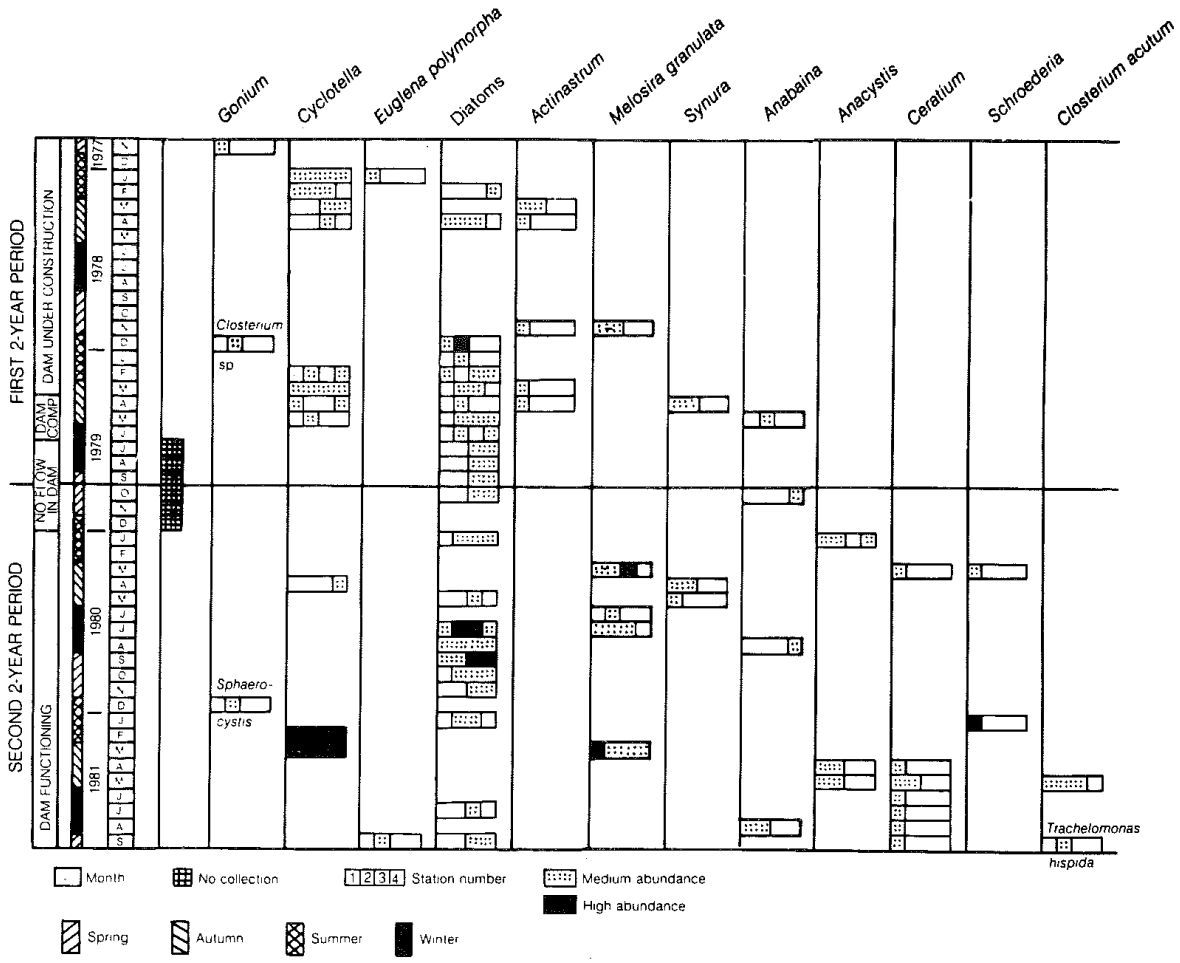

Figure 11. Abundance ratings for taxa at stations in the Peel River below Chaffey Dam. Taxa with only 1 to 2 recordings are plotted together in the first and last columns. Data on the left are shown as in Figure 4.

During period 2 (20th March–26th June 1979, when the Dam was completed) 23 common taxa were recorded. While 10 taxa increased in frequency and one (*Synura*) appeared, the other taxa were either reduced in frequency or were not recorded. Five taxa became abundant on one or more occasions (Table 8, Figure 11).

The number of species recorded was reduced further, to only 14 in period 3 (16th July–11th December 1979), when there was no flow from the Dam. Frequencies were reduced in most cases also, although *Cladophora* and *Melosira varians* increased and the other "Diatoms" remained as before; only two taxa became abundant (Table 8, Figure 11).

During period 4 (after 11th December 1979), when the Dam was functioning, 35 common taxa were recorded. All taxa previously noted, except *Scenedesmus obliquus*, reappeared and five new planktonic algae were recorded. Many of the taxa were present during all seasons and were recorded at all stations at one time or another, but some showed seasonality and/or restricted distributions (Figure 10). Twelve taxa were recorded with medium abundance ratings during period 4 and four of them recorded high ratings once or twice (Figure 11).

Thirty taxa were recorded as rare (Figure 12); 28 of these were algae, the other two being Angiosperms (*Myriophyllum* and *Potamogeton*). Fifteen taxa

TABLE 8

Frequency and abundance of common taxa in the Peel River below Chaffey Dam in each of four periods with differing environmental conditions

Taxon / Period:	Frequency (%)				Abundance*			
	1	2	3	4	1	2	3	4
Plankton								
Actinastrum	49	42	8	14	5	1	—	—
Anabaina	39	17	—	42	2	—	—	11
Anacystis	1	—	—	75	—	—	—	7
Ankistrodesmus	21	—	—	5	—	—	—	—
Botryococcus	—	—	—	50	—	—	—	—
Ceratium	4	—	—	25	—	—	—	8
Chlamydomonas	—	—	—	12	—	—	—	—
Closterium acutum	3	—	—	11	—	—	—	3
C. parvulum	39	17	8	18	—	—	—	—
C. sp. 1	35	25	—	8	1	—	—	—
Cosmarium	3	8	—	11	—	—	—	—
Cyclotella	86	100	92	63	16	3	—	9
Diatoms	94	100	100	100	12	6	8	26
Euglena polymorpha	38	42	8	35	1	—	—	1
Euglena aff. *tripteris*	—	—	—	13	—	—	—	—
Gonium	17	8	8	5	1	—	—	—
Melosira granulata	15	75	—	44	—	2	—	3
M. varians	67	42	58	33	—	—	—	—
Oscillatoria	3	—	—	12	—	—	—	—
Pandorina	40	42	8	16	—	—	—	—
Pediastrum boryanum	14	8	—	11	—	—	—	—
P. duplex	22	25	8	19	—	—	—	—
Phacus caudatus	8	—	—	6	—	—	—	—
Scenedesmus bijugus	33	58	—	12	—	—	—	—
S. obliquus	18	42	—	—	—	—	—	—
S. quadricaudus	29	25	8	19	—	—	—	—
Schizothrix	25	25	17	14	—	—	—	—
Schroederia	—	—	—	12	—	—	—	2
Sphaerocystis	6	—	—	31	—	—	—	1
Spirulina	8	—	—	6	—	—	—	—
Synura	—	50	42	19	—	1	1	3
Trachelomonas armata	10	8	—	36	—	—	—	—
T. hispida	22	17	—	48	—	—	—	1
Volvox	—	—	—	16	—	—	—	—
Attached algae								
Cladophora	49	33	58	38	—	—	—	—
Spirogyra	17	33	25	20	—	—	—	—

* Number of station-months taxon recorded medium or high abundance ratings.

occurred in period 1. Five of these taxa were recorded also in period 2 and two additional taxa appeared then, but all except *Trachelomonas girardianum* disappeared by the beginning of period 3. During period 4, 11 of the taxa previously recorded reappeared and 11 additional algae were recorded, together with the two Angiosperms (Figure 12).

Considering the common and rare taxa together, it is clear that great changes in species number occurred during the four periods. The reductions in period 3 seem to be associated with the lower water levels and minimal waterflow, together with seasonal changes, while the increase during period 4 follows the renewed flow of the river, achieved by the intermittent discharge of water from the Dam, which brought further nutrients, oxygen and algae into the downstream area. Garman & Townsend (pers. comm.) report that both

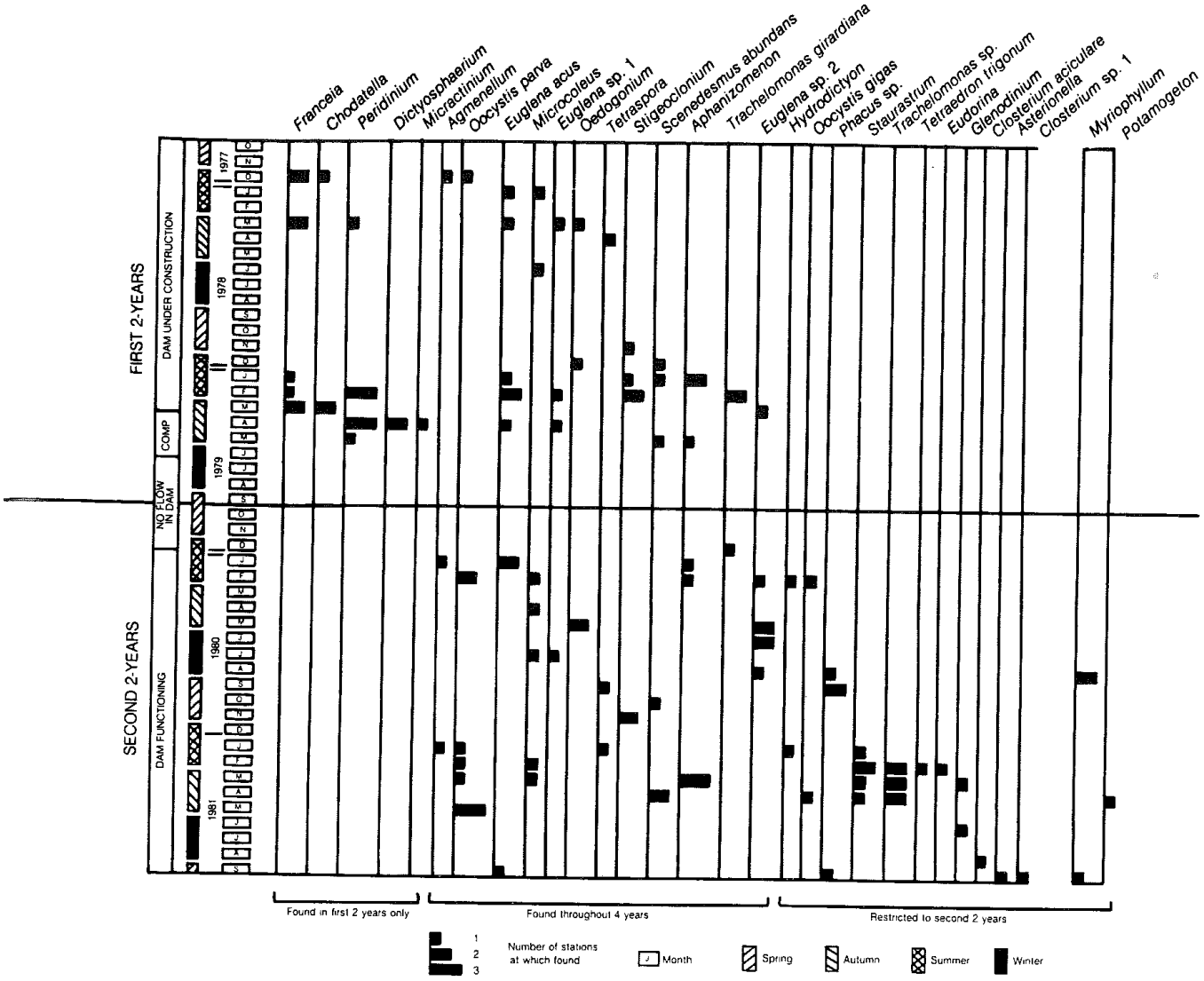

Figure 12. Occurrence of rare algal species and of angiosperms at stations in the Peel River below Chaffey Dam. Data on the left are shown as in Figure 5.

phosphorus and nitrogen were present in significantly higher than normal concentrations at the downstream stations during period 4. Some species are likely to thrive under these enriched conditions. Comparison of the common species in periods 1 and 4 indicate that while *Scenedesmus obliquus* was found only during the first period, six taxa (*Botryococcus, Chlamydomonas, Euglena* aff. *tripteris, Schroederia, Synura* and *Volvox*) occurred only in the fourth period; amongst the rare species, three occurred only in the first period while 11 algae and two angiosperms were found only in the fourth. Some of these taxa were recruited from the Dam waters, but it seems likely that the increased numbers of taxa in Period 4 were also a response to particularly high nutrient levels.

Comparison of the two 2-year periods

The data for the common species for the two 2-year periods (Table 9) indicate that there were a greater number of taxa present during the second 2-year period (35 compared with 31), and that more taxa were present for a greater number of months during the second period compared with the first (22 compared with 12). Also, more taxa were recorded as abundant during the second period (12 taxa compared with 9).

TABLE 9

Summary of data on duration of occurrence, frequency, abundance and seasonality of the common taxa in the Peel River below Chaffey Dam

Taxon	No. months present per 2-year period		Frequency and abundance*		Seasons present†	
	1977–79	1979–81	1977–79	1979–81	1977–79	1979–81
Plankton						
Actinastrum	15	5	44 (6)	14	All	Sp, S, A
Anabaina	12	16	33 (2)	39 (11)	Sp, S, A	All
Anacystis	1	19	1	70 (7)	A	All
Ankistrodesmus	10	3	17	4	Sp, S, A	S, A, W
Botryococcus	—	17	—	47	—	All
Ceratium	3	12	3	23 (8)	A, W, Sp	A, W, Sp
Chlamydomonas	—	5	—	11	—	W, Sp
Closterium acutum	2	4	2	10 (3)	S	A, W
C. parvulum	16	14	33	18	All	All
C. sp. 1	14	7	31 (1)	8	All	S, W
Cosmarium	3	5	3	10	S, A	All
Cyclotella	23	24	89 (19)	64 (9)	All	All
Diatoms	23	24	96 (24)	100 (28)	All	All
Euglena polymorpha	14	15	36 (1)	33 (1)	Sp, S, A	All
Euglena aff. *tripteris*	—	5	—	12	—	All
Gonium	7	5	16 (1)	4	Sp, A, W	Sp, S, W
Melosira granulata	9	12	22 (2)	41 (3)	S, A, W	S, A, W
M. varians	24	18	63	34	All	All
Oscillatoria	1	8	1	11	S	All
Pandorina	16	6	38	16	All	Sp, S, A
Pediastrum boryanum	8	9	12	10	S, A	All
P. duplex	10	11	21	19	Sp, S, A	All
Phacus caudatus	3	3	7	6	S	S, A
Scenedesmus bijugus	12	8	34	11	All	All
S. obliquus	9	—	21	—	S, A	—
S. quadricaudus	13	11	27	19	Sp, S, A	All
Schizothrix	11	10	23	16	All	All
Schroederia	—	4	—	11 (2)	—	S, A
Sphaerocystis	4	11	4	29 (1)	S, A	All
Spirulina	5	4	7	6	Sp, S, A	A, W, Sp
Synura	4	10	7 (1)	18 (4)	A, W	All
Trachelomonas armata	4	11	9	33	S, A	All
T. hispida	8	15	20	44 (1)	Sp, S, A	All
Volvox	—	8	—	14	—	All
Attached algae						
Cladophora	21	17	48	39	All	All
Spirogyra	9	14	20	20	All	All

* Figures in brackets give number of station-months taxon recorded medium or high abundance ratings.

† Sp = spring; S = summer; A = autumn; W = winter; All = all year.

A similar pattern was shown by the rare taxa with regard to species number. However, changes in the duration of occurrence amongst the taxa found during both periods were not marked (Table 10).

Distribution of species

During the period of Dam construction (period 1), more species were recorded at station 7 than at other stations downstream from the Dam work-site (Table 11). During Period 2 the same pattern of distribution was shown, but once the Dam became functional (period 4), a relatively similar number of

TABLE 10

Summary of data on duration of occurrence and frequency of rare taxa occurring during both 2-year periods in the Peel River below Chaffey Dam

Taxon	No. of months present per 2-year period		Frequency (%)	
	1977–79*	1979–81†	1977–79*	1979–81†
Plankton				
Agmenellum	1	2	1	2
Aphanizomenon	2	3	3	6
Euglena acus	5	2	7	3
E. sp. 1	3	1	3	1
E. sp. 2	1	4	1	7
Microcoleus	2	5	2	6
Oedogonium	2	1	2	2
Oocystis parva	1	5	1	9
Scenedesmus abundans	3	2	3	3
Tetraspora	1	2	1	2
Trachelomonas girardiana	1	1	2	1
Attached alga				
Stigeoclonium	3	1	4	2

* Includes periods 1, 2 and half of 3; † includes second half of period 3 and period 4.

species was found at each station. The higher species richness of station 7 compared with the other stations during the first two periods was probably related to the effect of increased nutrients (as shown by high conductivity readings; Garman & Townsend, pers. comm.), which became available following soil disturbance at the work-site.

Taxa with medium abundance ratings were recorded more often at stations 7 and 7A than at stations 8 and 9, but high abundance ratings were more or less equally spread between stations (Table 11, Figure 11).

TABLE 11

Number of species present and recording medium or high abundance rating at stations 7–9 during periods 1 to 4 and over each two years

Station	Period								Two-year period			
	1		2		3		4		1977–79		1979–81	
	No.	Ab.	No.	Ab.	No.	Ab.	No.	Ab.	No.	Ab.	No.	Ab.
7	39	6	26	3	—	—	41	9	42	7	41	9
7A	31	5	19	4	—	—	46	10	35	6	46	10
8	33	2	16	1	11	1	42*	4	34	2	43*	4
9	26	2	13	2	9	2	43†	4	28	2	43	4

* Plus two angiosperms; † plus one angiosperm.
No. = number of species present; Ab. = Abundance (i.e., number of taxa recording medium or high abundance ratings).

DISCUSSION

Comparison of taxa at upstream stations (1–6) and downstream stations (7–9)

Of the 71 taxa recorded at the various river stations during the study, 52 were present at both sets of stations at some time or another. Comparison of the data from the two sets of river stations for the two 2-year periods indicates a wide range of distribution and occurrence patterns, with some taxa found as common, others as rare at both sets of stations during both time-periods (Figures 3, 5, 10, 12), while others were noted as rare at the upstream stations, common downstream, or showed the reverse pattern.

Five species were restricted to the upstream stations: *Diacanthos, Dinobryon, Enteromorpha, Tetraedron limniticum* and *T. regulare;* they were found only during the second two years and then only rarely. Fourteen species were restricted to the downstream stations. Of these, two were found rarely during the first two years (*Dictyosphaerium, Micratinium*), two were rarely present during both periods (*Agmenellum, Tetraspora*) and ten others were found only during the second two years.

Comparison of the data on number of species, duration of occurrence and seasonality of individual species indicate that similar trends were shown by both sets of stations. Thus, at both the upstream and downstream stations there was an increase in the number of taxa present during the second 2-year period (which included the period of drought), and this was particularly so in the downstream stations; and more species were present for a greater number of months then. Also, some species showed extensions to the range of seasons during which they were recorded in the second two years. On the other hand, comparisons of frequency and abundance ratings indicate differences between the two sets of stations. At the upstream stations more species showed higher frequencies during the second 2-year period but the number of taxa becoming abundant during the second two years was reduced slightly compared with the first two years, while at the downstream stations, the number of species showing increased frequencies during the second 2-year period did not increase, but more taxa became abundant then. It is suggested that overflow from the Dam acted to increase the abundance of some of the common species there.

Effect of changing water levels and water flow conditions on various species

Comparison of the data on duration of occurrence and on frequency for the common species at the two sets of river stations indicate that some species were present more often and for longer periods during normal conditions (*Ankistrodesmus, Cladophora, Closterium parvulum, C.* sp. *1, Cyclotella, Melosira varians, Scenedesmus bijugus* and *Schizothrix*), whilst others were favoured by drought conditions (*Melosira granulata, Synura, Trachelomonas armata, T. hispida*; also *Ceratium* and *Oscillatoria* (rare at upstream stations but common at stations 7–9)). The data for the other common species differed from one set of stations to the other, for example, *Actinastrum, Gonium, Pandorina, Scenedesmus obliquus* and *S. quadricaudus* all showed increased frequencies and duration of occurrence during the second 2-year period at the upstream stations, but decreased or disappeared at downstream stations 7–9. The opposite trend was shown by *Anabaina.* Comparisons for the rare species are not considered meaningful.

Comparison of species within Chaffey Dam with those at the upstream and downstream river stations

Forty-three species were found in both the Dam and the stations in the river upstream of the Dam. Of these, 14 were common in both places, while eight others were rare in both places. It seems likely that the appearance of the species in the Dam resulted from transfer from the upstream stations with subsequent development as the Dam filled. Some of the common species at the

upstream stations (*Closterium parvulum, Cosmarium, Scenedesmus bijugus, S. obliquus*) and a number of the rare species (*Chodatella, Diacanthos, Dinobryon, Franceia, Microcoleus, Oedogonium* and *Peridinium*) were not recorded in the Dam. It seems that these taxa did not survive under Dam conditions, or were never transferred to the Dam.

Five other taxa were found in the Dam but not in the upstream stations (*Botryococcus, Eudorina, Oocystis gigas, Pleodorina* and *Volvox*); these appear to have been recruited from outside the section of the Peel River studied.

Forty-six species were found in both the Dam and the downstream stations. Of these, 24 were common in both areas at various times and another eight were rare in both places; the remaining taxa showed various patterns of distribution and frequency categories (Tables 4, 5 compared with 9, 10). Four of the five species recorded as present in the Dam, but not at the upstream stations, were recorded at the downstream stations: *Botryococcus* and *Volvox* were common in both areas, *Eudorina* rare in both and *Oocystis gigas* common in the Dam but rare at the downstream, stations. It seems that water discharged from the Dam at various times permitted the transfer of these taxa to the stations downstream.

Lacustrine and fluvial species

Some 13 taxa, rare at the upstream river stations became common in the Dam (*Anacystis, Ceratium, Euglena acus, E.*sp. *2, Oocystis parva, Oscillatoria, Phacus caudatus, Schroederia* and the later entrants, *Chlamydomonas, Closterium acutum, Glenodinium, Euglena* aff. *tripteris* and *Staurastrum*); it appears that these taxa were favoured by Dam habitat conditions (more stable waters and temperatures than in the river) and they may be assigned tentatively to a "lacustrine species" category. Some, such as *Euglena acus, E.* sp. *2, Glenodinium, Oocystis parva* and *Staurastrum,* were rare also at the downstream stations, but the others listed above were noted as common at the downstream stations. Water discharge from the Dam may have affected the frequency ratings of these taxa, or other factors, such as water temperatures or nutrient availability, may have been involved.

Eight other taxa, common at the upstream river stations become rare in the Dam; included here were *Closterium* sp. 1, *Melosira varians, Pediastrum boryanum, Cladophora* and *Spirogyra,* and the later arrivals in the Dam, *Aphanizomenon, Gonium* and *Pediastrum duplex.* These species were common also in the downstream river stations (except for *Aphanizomenon* which was rare there); together with others recorded as present only within both areas of the river (*Chodatella, Closterium parvulum, Cosmarium, Franceia, Microcoleus, Oedogonium, Peridinium, Scenedesmus bijugus, S. obliquus* and *Tetraedron trigonum*) or restricted to one part of the river or the other (as discussed previously). They appear to be favoured by river habitat conditions, and can be assigned tentatively to the "fluvial species" category.

Pleodorina was the only species noted as restricted wholly to the Dam itself. These results contrast strongly with those of Aykulu (1982) who states "it is rare to find lake plankton species in the river plankton". The difference could well be due to the short history of the Chaffey Dam. At least some differences are beginning to become apparent, as discussed above, and these may become more defined in later years.

Abundance ratings

Comparison of these data for the comparable 2-year period (1979–81) indicate that more species became abundant within the Dam than outside of it (17 taxa compared with eight at upstream river stations and 12 at downstream river stations) and also more species recorded high abundance ratings within the Dam (eight taxa compared with two at the upstream stations and four at the downstream stations). Contrasting with this, however, were the two most

frequently present taxa in this area, *Cyclotella* and the other "Diatoms"; both recorded medium abundance ratings less often and the latter also high abundance ratings less often within the Dam compared with the outside river stations. Three other taxa, *Actinastrum, Euglena polymorpha* and *Peridinium* became abundant at one or both sets of river stations only (Figures 4, 8, 11).

Influence of dam waters on downstream stations

The possible influence of discharged Dam waters on the stations downstream has already been mentioned in relation to the composition of the floras and the changes in frequency for individual species. Further support for the suggestion comes from the abundance ratings. A number of the taxa that recorded medium and/or high abundance ratings within the Dam also became abundant at the downstream stations but did not do so at the upstream stations. The difference was particularly marked with *Anabaina* and *Ceratium.* It seems likely that these taxa were carried with the discharged dam water, surviving and developing further at the downstream stations.

The attached species

There were a number of larger plants that occurred in the river from time to time growing attached to the substrate. The most recurrent of these was *Cladophora,* and *Spirogyra* was also commonly present.

Active growth of *Cladophora* usually started between August and November and continued until May or June, but at times it persisted all through the year. Specimens varied greatly in the frequency of branching, cell width and degree of infestation of diatoms, but this was not directly seasonal. Both old plants bearing epiphytes and young actively branching plants could be obtained together at times. Generally, however, associated (epiphytic or entangled) species, mainly diatoms, became more frequent between January and May.

Occurrences of *Cladophora* at stations 7 and 7A were very low compared with those at other stations in the river during 1977–79 (Figures 3, 10); the attached alga may have been adversely effected by the presence of sediment in the water, caused by the construction of the Dam. *Cladophora* thrived everywhere in the absence of drought. This result is surprising since Williams (1978) reports that *Cladophora* is favoured by the presence of high mineral, particularly phosphate, levels, such as likely to obtain during droughts. Whitton (1970) on the other hand, has pointed out that *Cladophora* tends to be more prolific where there is maximum water movement and aeration. However, very strong increases in waterflow can cause the disappearance of the alga, for example, after heavy rain in May 1978 there was no attached *Cladophora* at any station until the following August.

The growth of *Spirogyra* contrasts somewhat with this. It was seasonal at stations 1–5, but was found throughout the year at stations 7–9. It did not seem to be adversely affected by the drought conditions, or by other factors such as sediment loads in the water. Occurrences at all stations varied throughout the study period, but were not markedly more or less at stations 7 and 7A than elsewhere. At stations 7–9, *Spirogyra* was recorded for more months during the second 2-year period, with frequencies nearly the same during both periods. At the upstream river stations duration of occurrence was equal during the two time periods while frequencies were reduced somewhat during the second two years.

The other attached species, namely *Enteromorpha, Hydrodictyon, Oedogonium* and *Stigeoclonium* amongst the algae, and *Myriophyllum* and *Potamogeton* amongst the macrophytes, were only of rare occurrence anywhere in the Peel River area studied.

CONCLUSIONS

1. Seventy-two taxa were recorded: 64 planktonic algae, six attached algae and two aquatic angiosperms. While some taxa were restricted to river areas (24), to the Dam (1) or were found in the Dam and in one part or another of the River (5), most were present in all areas (42 taxa).

2. Changes in the presence of individual taxa and in their frequency, abundance, duration of occurrence and seasonality were related to changes in water flow, to differences in water depth and temperature, and in the availability of nutrients. Successional changes may have contributed to some changes within the Dam.

3. In all areas an increase in the number of species and increases in frequency and duration of occurrence of some taxa were associated with times of drought. Some taxa, however, flourished more during periods of normal water flow.

4. In downstream areas increased nutrient availability associated with soil disturbance during the construction of the Dam resulted in a temporary increase in the number of taxa occurring at the station immediately below the Dam wall.

5. Colonization was more or less concurrent at the Dam stations with algae derived mainly from upstream, but some from outside this region. There was a general increase in species number over time. Most taxa in the Dam flourished at or near the surface rather than at lower depths.

6. Discharged or overflowing water from the Dam influenced to some extent the composition and characteristics of the flora at downstream stations. More species were recorded as abundant there and in the Dam than at the upstream river stations.

7. Some taxa appeared to be favoured by the habitat conditions of the Dam, while others were restricted to the River or were favoured more by river conditions. They can be assigned tentatively to "lacustrine species" and "fluvial species" categories respectively.

Present knowledge of the physiological requirements of individual algal species is incomplete, but detailed records of changes in the occurrence, frequency, abundance and seasonality of indivdual species under differing conditions, such as given here, are a pre-requisite for the proper use of these organisms in biological surveillance. It should be emphasized, however, that there are profound differences in the flow regimes of rivers in Australia compared with those in many other parts of the world and hence some of the results obtained within Australia may not be applicable elsewhere.

ACKNOWLEDGMENTS

All water samples were collected by Officers of the Water Resources Commission of New South Wales, as part of their water quality assessment programme, and drafts of Figures 1 and 2 were provided by them also; their help is gratefully acknowledged. We should like to thank also Dr Surrey Jacobs and Mr Ian Smalls for constructive comments on a draft of this paper.

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APPENDIX 1

Species recorded from the Peel River and Chaffey Dam

Actinastrum hantzschii Lag.
Agmenellum thermale (Kuetz.) Drouet & Daily
Anabaina circinalis Rabenh.
Anacystis cyanea (Kuetz.) Drouet & Daily (*Microcystis aeruginosa* Kuetz.)
Ankistrodesmus falcatus (Corda) Ralfs
Aphanizomenon (ecophene of *Calothrix parietina* (Naeg.) Thuret)
Asterionella sp.
Botryococcus braunii Kuetz.
Ceratium hirundinella (O. F. Muell.) Dujardin
Chlamydomonas sp.
Chodatella subsalsa Lemm. (*Lagerheimia*)
Cladophora crispata (Roth) Kuetz.
Closterium aciculare T. West
C. acutum (Lyngb.) de Bréb.
C. parvulum Naeg.
C. sp. 1
C. sp. 2
Cosmarium sp.
Cyclotella meneghiniana Kuetz.
Diacanthos belenophorus Korch.
Diatoms (undetermined species)
Dictyosphaerium pulchellum Wood
Dinobryon sertularia Ehrenb.
Enteromorpha sp.
Eudorina elegans Ehrenb.
Euglena acus Enrenb.
E. polymorpha Dang.
E. aff. *tripteris* (Dujardin) Klebs
E. sp. 1
E. sp. 2
Franceia droescheri (Lemm.) G. M. Smith
Glenodinium sp.
Gonium pectorale Muell.
Hydrodictyon reticulatum (L.) Lag.
Melosira granulata (Ehrenb.) Ralfs
M. varians Ag.
Micractinium pusillum Fres.
Microcoleus lyngbyaceus (Kuetz.) Crouan
**Myriophyllum* sp.
Oedogonium sp.
Oocystis gigas Archer
O. parva West & West
Oscillatoria ? lutea Ag.
Pandorina morum (Muell.) Bory
Pediastrum boryanum (Turp.) Meneghini
P. duplex Meyen
Peridinium granulosum P'fair
Phacus caudatus Huebner
P. sp.
Pleodorina sp.
**Potamogeton ochreatus* Raoul
Scenedesmus abundans (Kirchner) Chodat
S. bijugus (Turp.) Kuetz.
S. obliquus (Turp.) Kuetz.
S. quadricaudus (Turp.) de Bréb.
Schizothrix calcicola (Ag.) Gomont
†*Schroederia judayi* G. M. Smith
Sphaerocystis schroeteri Chodat
Spirogyra sp.
Spirulina subsalsa Oersted
Staurastrum pingue Teiling
Stigeoclonium sp.
Synura adamsii G. M. Smith
Tetraëdron limniticum Borge
T. regulare Kuetz.
T. trigonum (Naeg.) Hansgirg
Tetraspora lubrica (Roth) Ag.
Trachelomonas armata (Ehrenb.) Stein
T. girardiana (P'fair) Deflandre
T. hispida (Perty) Stein
T. sp.
Volvox globator L.

* Angiosperms

† There is some current concern about the identity of this species. Although our material appears to match the description and illustrations of the species named, neither the senior author nor Mr I. Smalls (per. comm., New South Wales Metropolitan Water Drainage and Sewerage Board) have ever seen flagellate zoospores, as might be expected in *Schroederia*.

APPENDIX 2

The Diatom Flora of the Peel River and Chaffey Dam, New South Wales

by

John Holland, 4/19 Greenwich Road, Greenwich, N.S.W., Australia 2065

A study was made of the diatom flora of the Peel River from January, 1978 to August, 1981 and of that of the Chaffey Dam from April, 1980 to February, 1983. Because of drought the collections were not continuous and no conclusions could be drawn about the effect of the dam on the diatom population of the river.

Collections were made as described in the main paper. Species recorded each date could include planktonic species, epiphytes and diatoms caught in attached plants (the latter largely absent in the Dam study).

Of the numerous diatom species found in the river, 34 taxa which appeared fairly regularly or were distinctive, were selected for more detailed study. Increasing density of a taxon was recorded ranging from rare, low, moderate, frequent to dominant. If the total number of diatoms present on any one slide was above 100–200 then the chosen taxon was recorded as a percentage of the total diatom population of the sample. This percentage basis for recording was then adopted because of the vast variation in the total diatom concentration in the various samples.

The accompanying table gives a summary of the information obtained for eight of the most prevalent taxa using the following symbols to denote the concentration—

O = No samples available.
X = No specimens in sample.
R = Rare—less than 1 per cent.
L = Low—1–10 per cent.
M = Moderate—10–30 per cent.
F = Frequent—more than 30 per cent.
* = Dominant taxon in sample.

It should be noted that only occasional samples from Stations 7 and 7A were available for the period June, 1978 to November, 1979 and that few diatoms appeared there during this period, possibly owing to the absence of *Cladophora* during most of this time. The presence of large quantities of suspended clay in the water resulting from the construction of the Dam may also have affected the populations.

In addition to the taxa listed in the tables the following were also recorded—

Achnanthes lanceolata Breb. ex Kütz.
Amphora spp.
Anomoeoneis spp.
Cymatopleura spp.
Cymbella spp.
Epithemia spp.
Eunotia spp.
Fragilaria spp.
Frustulia spp.
Hantzschia amphioxys (Ehr.) Grun.
Melosira varians Ag.
Meridion circulare (Grev.) Ag.
Pinnularia spp.
Pleurosigma/Gyrosigma spp.
Rhopalodia spp.
Surirella spp.

The information obtained from the river is more complete than that from the Dam, since samples taken from a large body of water, well out from the shore, do not contain a very large number of diatoms unless there is a particularly heavy bloom of them present.

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Station No.	Year/Quarter																			
	1978				1979				1980				1981				1982				1983
	D/F	M/M	J/A	S/N	D/F	M/M	J/A	S/N	D/F	M/M	J/A	S/N	D/F	M/M	J/A	S/N	D/F	M/M	J/A	S/N	D/F
Cocconeis placentula Ehr.																					
Peel River																					
1.	F*	M	O	M	F*	F*	F	F*	F*	O	M*	L	O	M*	L						
2.	F*	F*	O	M	F*	F*	M*	F*	F*	O	R	L	O	L	L						
3.	L	L	O	M	F*	L	L	M	F*	O	L	L	O	R	R						
4.	F*	L	O	M*	F*	F*	L	M	F*	L	M	L	L	L	L						
5.	M	F*	O	M	F*	M*	L	F*	F*	L	L	M*	O	R	R						
7.	O	R	O	O	O	O	O	O	R	L	L	L	M	L	L						
7A.	O	R	O	O	O	O	O	O	R	L	M	L	R	M	M						
8.	L	M	O	M*	F*	L	M*	M	M	M	M*	L	M	M*	L						
9.	L	M	O	M	F*	L	L	M	M	M*	M*	L	M*	M*	L						
Chaffey Dam																					
1.										X	R	R	R	R	R	R	R	R	X	R	R
2.										X	X	X	X	R	R	R	X	R	R	X	R
3.										X	R	R	X	O	R	R	R	R	R	R	X
4.										R	R	R	R	O	R	L	R	R	X	X	O
5.										O	O	O	O	O	O	R	O	O	O	O	O
Cyclotella spp. (predominantly *C. meneghiniana* Kütz. with some *C. stelligera* Cleve & Grun.)																					
Peel River																					
1.	R	R	O	X	X	R	X	X	R	O	R	X	R	R	X						
2.	R	L	O	X	R	R	X	X	R	R	M*	R	R	R	X						
3.	R	L	O	X	X	L	R	X	M*	R	L	R	R	R	R						
4.	R	M*	O	X	X	L	X	X	M*	M*	M*	L	M*	L	R						
5.	R	L	O	X	X	L	R	X	M*	M*	L	L	O	M*	R						
7.	O	R	O	O	O	O	O	O	R	X	R	X	L	F*	M*						
7A.	O	R	O	O	O	O	O	O	L	X	X	L	M*	F*	L						
8.	R	L	O	X	X	R	L	R	L	R	R	R	M*	F*	R						
9.	R	L	O	X	X	M	R	X	L	L	L	L	L	F*	L						

Chaffey Dam																				
1.									X	R	R	M*	F*	F*	F*	L	F*	F*	F*	F*
2.									X	R	X	M*	F*	F*	F*	L	F*	F*	M*	M*
3.									X	R	R	X	O	F*	F*	L	F*	R	M*	M*
4.									X	R	X	R	O	F*	M*	L	F*	R	L	R
5.									O	O	O	O	O	M*	F*	R	O	O	O	O

Gomphonema spp. (including *G. accuminatum* Ehr. var. *coronata* (Ehr.) Kütz., *G. clevei* Fricke, *G. constrictum* Ehr., *G. gracile* Ehr. and *G. parvulum* (Kütz.) Grun.)

Peel River																				
1.	M	F	O	F*	M	M	L	F*	M	O	M	M	O	F*	M					
2.	M	M	O	M	M	M	L	F*	L	O	F*	F*	O	O	M					
3.	M	M	O	F*	L	L	M	F*	L	O	M	M*	O	L	L					
4.	M*	M	O	F*	L	L	L	F*	L	M	M	F*	M	L	L					
5.	L	M	O	M	L	L	L	F*	L	L	M	M	O	O	M					
7.	O	O	O	O	O	O	O	O	M	L	M	F*	F*	M	M*					
7A.	O	L	O	O	O	O	O	O	L	L	L	F*	L	L	M					
8.	L	L	O	F*	L	L	M	F*	M*	L	M	M	F*	L	L					
9.	M	L	O	F*	M	L	L	F*	M*	L	L	L	M	L	L					
Chaffey Dam																				
1.										R	R	L	R	R	R	R	R	R	L	R
2.										X	R	X	L	R	R	R	R	R	L	R
3.										R	R	L	R	O	R	R	R	R	R	R
4.										L	R	R	R	O	R	R	R	R	L	O
5.										O	O	O	O	O	R	R	R	O	O	O

Melosira granulata (Ehr.) Ralfs

Peel River																				
1.	X	X	X	X	X	R	X	X	X	X	X	X	R	R	X					
2.	X	R	O	R	L	R	X	X	X	O	R	R	O	O	X					
3.	X	X	O	X	X	R	X	X	X	O	X	X	O	O	X					
4.	X	X	O	X	R	R	X	X	X	X	R	X	R	L	X					
5.	X	X	O	X	X	M*	X	X	X	O	X	R	O	O	R					
7.	O	O	O	O	O	O	O	O	R	F*	L	L	L	L	R					

Station No.	Year/Quarter																			
	1978				1979				1980				1981				1982				1983
	D/F	M/M	J/A	S/N	D/F	M/M	J/A	S/N	D/F	M/M	J/A	S/N	D/F	M/M	J/A	S/N	D/F	M/M	J/A	S/N	D/F
Melosira granulata (Ehr.) Ralfs *continued*																					
7A.	O	R	O	O	O	O	O	O	L	M	L	X	R	R	X						
8.	X	R	O	X	R	R	X	X	R	R	R	R	R	X	X						
9.	X	X	O	X	X	M*	X	X	R	X	R	X	X	R	X						
Chaffey Dam																					
1.										F*	L	L	F*	L	L	L	F*	L	L	R	M
2.										F*	F*	X	M*	L	L	L	M*	L	X	R	M*
3.										F*	M*	R	M*	O	L	R	M*	L	X	R	M*
4.										F*	F*	R	R	O	L	R	M*	L	X	R	O
5.										O	O	O	O	O	R	R	M*	O	O	O	O
Navicula spp. (including *N. capitata* Ehr., *N. cuspidata* Kütz., *N. mutica* Kütz. and *N. radiosa* Kütz.)																					
Peel River																					
1.	L	L	O	R	L	R	X	L	R	O	R	R	O	L	R						
2.	L	L	O	R	L	R	L	L	X	O	L	L	O	M	L						
3.	X	L	O	X	R	L	R	R	L	O	L	L	L	L	L						
4.	L	L	O	R	L	L	R	L	L	L	L	L	M	M	L						
5.	R	L	O	R	R	L	L	L	L	L	L	L	O	O	L						
7.	O	R	O	O	O	O	O	O	M*	L	F*	M*	L	L	L						
7A.	O	L	O	O	O	O	O	O	M*	M*	M*	L	M*	M	F*						
8.	R	L	O	X	X	M*	L	L	M	M*	M	L	M*	M*	L						
9.	M*	M*	O	X	R	L	L	L	M	M	L	L	M	M	L						
Chaffey Dam																					
1.										X	R	R	X	R	L	L	R	R	R	L	L
2.										X	R	X	L	R	L	M	R	L	L	L	L
3.										R	M	L	L	O	L	M	R	R	R	M	L
4.										M	M	M*	X	O	M	M	R	R	X	L	R
5.										O	O	O	O	O	O	M	R	O	O	O	O

Nitzschia spp. (including *N. frustulum* (Kütz.)Grun. *N. linearis* W. Smith and *N. palea* (Kütz.) W. Smith)

Peel River																					
1.	X	L	O	L	L	L	R	M*	L	O	F*	F*	O	L	M*						
2.	X	L	O	L	L	L	M*	M	M	O	M*	M	O	M*	F*						
3.	X	L	O	L	L	L	L	F*	M*	O	F*	M	O	M*	M*						
4.	L	L	O	L	L	L	L	F*	M	L	F*	M*	F*	F*	F*						
5.	L	L	O	L	R	L	M	M*	M	L	M	M*	O	O	M*						
7.	O	O	O	O	O	O	O	O	L	L	M	L	L	L	L						
7A.	O	L	O	O	O	O	O	O	M*	L	F*	F	L	L	M*						
8.	L	L	O	L	X	M	F*	M*	F*	M*	F*	L	L	L	F*						
9.	L	L	O	L	L	L	F*	M*	F*	M*	M	L	M*	M	F*						
Chaffey Dam																					
1.										X	R	M	X	R	L	L	M	L	X	L	R
2.										X	R	X	L	L	L	L	M*	L	R	L	L
3.										R	L	R	R	O	L	M*	M*	L	X	L	L
4.										R	L	L	R	O	L	M*	M*	L	R	L	R
5.										O	O	O	O	O	O	L	M*	O	O	O	O

Rhoicosphenia curvata (Kütz.) Grun.

Peel River																					
1.	L	M*	O	L	L	R	R	L	R	O	L	L	O	L	L						
2.	L	L	O	R	L	R	L	L	R	O	L	L	O	O	L						
3.	M*	M	O	L	L	R	R	L	L	O	L	M	O	O	R						
4.	M	M*	O	M	L	M*	R	L	L	F*	M	M*	L	L	L						
5.	M*	M	O	L	R	L	L	L	R	O	L	M	O	O	L						
7.	O	R	O	O	O	O	O	O	R	M*	L	M*	M	L	L						
7A.	R	M*	O	O	O	O	O	O	L	L	M*	M*	M	M	M						
8.	M*	M*	O	L	L	L	L	M	M	M	M*	F*	F*	M	L						
9.	L	M	O	L	L	L	L	L	M	M*	M*	L	M	M	M						

Station No.	Year/Quarter																				
	1978				1979				1980				1981				1982				1983
	D/F	M/M	J/A	S/N	D/F	M/M	J/A	S/N	D/F	M/M	J/A	S/N	D/F	M/M	J/A	S/N	D/F	M/M	J/A	S/N	D/F
Rhoicosphenia curvata (Kütz.) Grun. *continued*																					
Chaffey Dam																					
1.										X	R	R	R	R	R	R	L	R	R	L	M
2.										X	R	X	R	R	R	R	R	R	X	X	L
3.										R	R	M*	R	O	R	R	R	R	X	R	R
4.										R	L	R	O	O	R	R	R	R	X	R	R
5.										O	O	O	O	O	R	R	R	O	O	O	O
Synedra ulna (Nitzsch) Ehr.																					
Peel River																					
1.	L	L	O	M*	M	R	R	X	R	O	L	M*	O	M*	R						
2.	L	L	O	R	R	L	L	R	R	O	L	M*	O	X	M						
3.	M	M*	O	X	R	M*	R	R	L	O	L	L	O	M*	R						
4.	L	M*	O	R	L	L	R	R	M*	L	M*	M	L	M*	L						
5.	L	L	O	R	R	L	M*	L	L	R	R	M*	O	R	R						
7.	X	R	O	O	O	O	O	O	M*	L	M*	F*	M*	M*	M*						
7A.	X	L	O	O	O	O	O	O	M*	R	M*	F*	R	M*	M						
8.	L	F*	O	L	L	M*	L	L	L	M*	M	M*	M	M	L						
9.	M*	L	O	R	L	L	L	L	L	M	F*	F*	M*	M*	M						
Chaffey Dam																					
1.										X	X	L	R	L	R	R	L	L	L	L	L
2.										X	R	X	L	L	R	L	L	L	L	L	L
3.										X	R	L	X	O	R	R	R	R	X	F*	L
4.										R	R	L	R	O	L	R	R	L	R	R	R
5.										O	O	O	O	O	R	R	R	O	O	O	O