COSENS BAY LAGOON STUDY

by

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EXECUTIVE SUMMARY

A study of the physical and biological features of Cosens Bay Lagoon was undertaken to evaluate the ecological implications of certain proposed park developments and to identify key interpretive values.

Cosens Bay Lagoon is believed to have been formed by long-shore processes during a period of declining lake level. Sediment cores indicated the lagoon has been stable since the eruption of Mount St. Helens, 3 200 years ago. The lagoon is slightly saline, eutrophic, extremely shallow and subject to major water level fluctuation. The lagoon supports a diverse aquatic and marginal flora which has developed a distinct zonation due to fluctuating water levels. The many interpretive values of Cosens Bay Lagoon are a result of a unique combination of physical and biological features.

A recommended trail and boardwalk system will allow public access while minimizing the disturbance of wildlife and vegetation. If water level manipulation is considered necessary, the impact to marginal plants will be minimized if some degree of water level fluctuation is allowed to continue.

Increasing the width of the bar, by adding fill adjacent to the lagoon to accomodate a picnic area, will compromise some valuable interpretation features. Two alternate options are presented for further consideration: widen the bar by adding material to the lake side of the bar or relocate the picnic area south to the Cosens Creek delta.

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1. INTRODUCTION

Cosens Bay Lagoon is located within Kalamalka Lake Provincial Park at the head of Cosens Bay (Figure 1). The purpose of this study was to assess the impact of a park development proposal being considered by the Ministry of Lands, Parks and Housing on Cosens Bay Lagoon. The geology, hydrology, water quality and plant ecology of the immediate area were studied to identify the critical aspects of the lagoon's interpretative value and how this would be impacted by the specific development proposal under consideration. Information on the natural history of the lagoon area derived from this investigation can also serve as a basis for interpretive presentations to park users.

The lagoon is about 200 m long by 75 m wide and separated from Kalamalka Lake by a bar about 15 m wide and 1.0 m high (Photograph 1). The beach fronting Kalamalka Lake consists of sand at the north end of the lagoon and coarse gravel near the outlet of Cosens Creek, about 375 m south of the lagoon. The lagoon is very shallow and has an extensive population of reeds about 30 m wide near the bar and submerged aquatic plants in the slightly deeper areas. It is apparent from aerial photographs that there is a considerable yearly variation in water levels. There is only an intermittent surface water inflow to, and no surface outlet from the lagoon. The human influences and natural history of this area have been previously documented by Cannings (1975).

The lagoon and the adjacent beach area has been identified by the Ministry of Lands, Parks and Housing as having the highest "preservational and interpretive" value within Kalamalka Lake Park. This area has also been determined to have high "recreational potential." In order to optimize the recreational potential of this area, it has been proposed that the bar, which forms a relatively narrow beach separating the lagoon from Kalamalka Lake, be widened by 10-20 m to facilitate a picnic area extending the full length of the lagoon and beyond. A proposed trail would provide access to the entire shoreline of the lagoon. Other developments adjacent to the lagoon under this proposal would include the addition of new shade trees, removal of some dying cottonwoods, planting a hardy grass cover, installation of about 30 tables, an irrigation system, a "turn around drop off" area, and a change house with toilets (Figure 2). Water level stabilization by pumping in water from Kalamalka Lake is also being considered as a means of maintaining the wetland features during dry periods.

In order to assess the impact this development might have on the lagoon, it was necessary to define the present condition of the lagoon and to determine how unique the interpretive features of this area were to the Okanagan Valley. In particular, it was necessary to determine what affects water levels in the lagoon, how this might change and how the emergent and submerged vegetation may be affected by increasing the width of the bar. Information was required on water quality to determine how the lagoon would be affected by irrigating and possibly fertilizing the day use area. There was a concern that the lagoon might be evolving rapidly and would soon be filled by emergent vegetation, followed by a rapid progression to terrestrial plants. Therefore, study objectives included an assessment of the age of the lagoon and rate of sediment accumulation.

2. METHODS

Field information was collected by Water Management Branch staff during the period April through September, 1982. A staff gauge was installed in the lagoon on April 2, 1982 and surveyed to a geodetic reference. Other staff gauges were installed in other water bodies in the park and water levels were monitored at all locations at least weekly during spring, and twice monthly in summer and fall. Kalamalka Lake water levels were obtained from the Inland Waters Directorate, Environment Canada. Surface water flow in Red Hawthorn Creek and Cosens Creek was visually assessed during each survey. Water levels were also estimated for specific dates in 1978-1980 using colour aerial photographs taken by Surveys and Resource Mapping Branch at a scale of approximately 1:5 000.

A bathymetric survey of the lagoon was carried out on April 2, 1982. Eight transects were positioned across the lagoon, perpendicular to a baseline running parallel to the bar. Water depths were measured at approximately 8 m intervals along each transect line. Water depth was measured to the actual lagoon bottom. This depth is different from the apparent depth within the Scirpus population due to the fact that Scirpus roots and rhizomes produce a mat of variable thickness over the actual bottom. Depth contours were mapped at 10 cm intervals using the measured depths and aerial photographs.

Several sediment cores were taken from the deepest area of the lagoon to assess the depth and composition of sediment. Cores were taken with a 3.8 cm inside diameter plastic pipe in an outer sleeve pounded into the sediment yielding 40-60 cm long cores. One core was divided into visually distinct sections and each section was analysed separately for percent organic composition and particle size by the Ministry of Transportation and Highways Geotechnical and Materials Laboratory. The longest core had a layer of volcanic ash which was sent to Dr. J. Westgate, University of Toronto for identification.

Samples were taken from the lagoon for water quality analysis on April 1 and July 17, 1982 and submitted to the Environmental Laboratory, Ministry of Environment.

Vegetation in and around the lagoon was surveyed on July 6, 1982. Voucher specimens were collected for each species identified and are filed in the Water Management Branch herbarium. Vegetation zones in this area were visually defined on the basis of species composition and habitat characteristics. Vegetation was also surveyed for species diversity in the uphill ponds on July 7 and 8 and in other lagoon-type habitats in the Okanagan Valley on July 20 (Skaha Lake) and August 27 and 28 (Osoyoos Lake). The similarity of species lists for all these water bodies was compared using a Braun-Blanquet hand sorting technique.

Wildlife observed during water level monitoring and other sampling were recorded. Photographs were taken of the major features of the lagoon area.

3. LAGOON GEOLOGY

The surficial geology at the head of Cosens Bay consists mostly of mixed unconsolidated deposits associated with the advance of the last glacial period, 10 000 years ago. When the glaciers receded, a thin mantle of post glacial morainal deposits and till was left. Erosion of this material by Cosens Creek formed a delta of sand and gravel south of the present beach. Prevailing southwesterly winds resulted in erosion in the delta area, and the deposition of a bar north of the delta cutting off a portion of the original indented shoreline of the lake, creating a lagoon (Figure 3, Photograph 2). Subsequent drops in the lake level (Nasmith, 1962) exposed more of the bar and ensured the lagoon's isolation from the larger body of water. Establishment of vegetation (i.e. cottonwoods) no doubt helped stabilize the bar.

Sediment core analysis indicated that the lagoon has remained intact at least 3200 years. A volcanic ash layer at a depth of about 55 centimetres (Figure 4) corresponds to an eruption of Mount St. Helens which occurred approximately 3200 years ago (Westgate et al., 1970; Westgate, personal communication, 1983). Such a distinct ash layer (Photograph 3) could only remain intact at an undisturbed site which was not subjected to the erosional activity associated with a lake shore, therefore, the bar formation must have been complete 3200 years ago. Based on the core depth of the ash and the date of the Mount St. Helens eruption, the sedimentation rate for the last 3200 years has been estimated as 0.17 mm per year. Chemical analysis of the sediment layers revealed that most of the sedimentation likely originated from decayed plant material, most probably aquatic plants.

4. HYDROLOGY

4.1 UPSTREAM HYDROLOGY

In addition to general surface runoff, the only surface inflow source to Cosens Bay Lagoon is from Red Hawthorn Creek which originates above another Kalamalka Lake Provincial Park water body known as the Cattle Pond. Red Hawthorn Creek, which flows out of Cattle Pond, is diverted into a forested depression on the middle bench (Figure 5). Outflow from this depression via Red Hawthorn Creek and into the lagoon will not occur until a considerable amount of standing water accumulates in the depression. It appears that the construction of the present road and the orientation of a culvert running under it may have diverted all or some of Red Hawthorn Creek into this depression. The pre-mature mortality of the ponderosa pine and cottonwoods observed in the depression may be due to the poor drainage caused by this diversion. Aerial photographs taken as recently as 1975 indicate that this area was completely forested (Photograph 4). More recent photographs show a clearing developing in the centre due to tree mortality (Photograph 5). During 1982 standing water was present here throughout the year (Table 1, Photograph 6). Table 1 summarizes the relative water levels and extent of surface water flow of these ponds and creeks during this study.

4.2 KALAMALKA LAKE LEVELS

A new control structure has been installed at the outlet of Kalamalka Lake to effect more control over lake levels and to minimize erosion downstream in Vernon Creek. The main strategy for operating the control structure is to lower the lake level prior to freshet in relation to snowpack to accommodate the freshet volume expected. Therefore, water levels will not tend to rise as high during freshet, and rare event extreme high water levels should not occur. The water levels during the summer will be held near traditional levels. During the 1982 study, water levels in

Kalamalka Lake varied by about 0.35 m from a low in late April to a high in late July (Table 1, Figure 6).

4.3 COSENS BAY LAGOON HYDROLOGY

Water input to the lagoon is via direct precipitation, groundwater seepage and intermittent surface runoff from Red Hawthorn Creek. There is no surface outflow; water is lost by evaporation, transpiration, and groundwater seepage to Kalamalka Lake.

A bathymetric survey of Cosens Bay Lagoon was carried out on April 2, 1982. At that time, the water level of the lagoon was moderately high (391.8 m elevation) and the maximum water depth was 60 cm. At this water level, approximately 64 percent of the lagoon surface area was less than 30 cm deep (Figure 7). From April to September 1982, water levels in the lagoon varied by 0.5 m from a maximum elevation of 392.2 m in May to a minimum of 391.7 in September (Figure 6). Lower water levels were observed on aerial photographs from 1978 to 1980; the minimum was estimated to be 391.5 m in July, 1979. Local residents claim that the lagoon occasionally dries. Considering the small volume to surface area ratio, dewatering could occur due to evaporation during a dry summer.

Based on available water level data it appears that a typical low water level would be about 391.55 m, coinciding with the 30 cm contour of Figure 7. During 1982, water levels rose 39 cm above the highest depth contour provided in Figure 7, at which time the lagoon had a maximum depth of 1 m.

Cosens Bay Lagoon is subject to rapid water fluctuations. Between May 12 and May 19, the water level rose 45 cm (Figure 6). Following this rapid increase, the water level declined 18 cm between May 19 and June 23. After June 23, there was a slow decline in water levels through the rest of the summer, but this decline would presumably have been much more rapid if not for the record high rainfall during June, July and September (Table 2). The initial rapid increase in water level in May was not associated with rainfall, or surface water inflow through Red Hawthorn Creek, but was solely due to groundwater input, presumably associated with snowmelt from higher altitudes.

During the period April-September, 1982, water levels in the lagoon remained 8 to 55 cm higher than the water level in Kalamalka Lake. However, in some years it is likely that water levels in the lagoon would go lower than the lake levels by 20 to 30 cm in mid to late summer (e.g. July, 1979 on Figure 6). Water levels in the lagoon appear to fluctuate quite independently from Kalamalka Lake levels.

5. WATER AND SEDIMENT QUALITY

5.1 WATER QUALITY

Water quality analyses of samples collected on April 1 and July 7, 1982, characterized Cosens Bay Lagoon as saline and alkaline by fresh water standards. The lagoon is also eutrophic in terms of the concentration of plant stimulating nutrients. The concentration of all parameters decreased dramatically between April and July (Table 3). Despite the decrease, the concentration of nutrients still remained within the eutrophic range. The decrease was attributed to dilution and flushing caused by groundwater inflow and heavy rains prior to sampling on July 7. Due to the small volume of water present in this shallow lagoon, the concentration of dissolved substances will vary dramatically with water input.

Eventually, nutrients and salts that enter the lagoon by surface or groundwater inflow become concentrated due to evaporation and transpiration. In April the total salinity of the lagoon was approximately 820 mg/L. By July the salinity had declined to 325 mg/L. Generally, truly saline waters are considered to have salinities greater than 5000 mg/L. The fact that the lagoon is not more saline suggests that some flushing is achieved by groundwater outflow, as surface outflow is not likely to occur.

In April 1982, the lagoon water was also found to be highly coloured and turbid. The colour is an indication of the high concentration of various solutes, and the turbidity is largely due to suspended material. At the time of sampling, the water appeared greenish-brown, with visibility reduced to a few centimetres. The supersaturated levels of oxygen suggest that abundant phytoplankton may have been largely responsible for the turbidity. Lagoon water was also tested for the presence of coliform bacteria. The results indicated that the concentrations of both total coliforms and fecal coliforms were low.

In July, turbidity and colour were greatly improved; the water was transparent enough to see aquatic plants clearly. Oxygen concentrations were also found to be supersaturated during midday and before sunrise. The high concentration of oxygen ensures that sulfurous odours produced in the mud are unlikely to escape.

5.2 SEDIMENT QUALITY

Red Hawthorn Creek is not considered a major source of stream borne suspended sediment due to intermittent low flow. The majority of sediment accumulation which has occurred is due to plant decomposition. Bottom sediments were found to consist of 40-50% organic matter by weight. When disturbed, the sediment released a strong hydrogen sulfide smell, indicating a highly anaerobic condition. Approximately 15 cm of soft organic sediment lies over a firm layer of compacted sediment, also high in organic content.

Detailed stratographic analysis of a 50 cm sediment core indicated that the surface sediment is the most organic and the most coarse (Figure 4). Deeper sediments were generally about 20% organic matter by weight with a median grain size of about 0.01 mm.

Coring difficulties were encountered due to the unconsolidated nature of the surface sediments. Sediment depths determined from core samples are only approximate, and probably underestimate the actual depth due to compaction during sampling.

6. PLANT ECOLOGY

6.1 THE VEGETATION OF COSENS BAY LAGOON

Several distinct vegetation zones were distinguished in and around Cosens Bay Lagoon. In Figure 8 these zones are diagrammed and given letter and number codes. The boundaries of all these zones except zones 5 and 6 are only approximate because each zone is gradually transitional to its neighbours. Zones are identified solely to facilitate the presentation of plant distribution information. The delineation of the zones as indicated in Figure 8 does not coincide closely with the depth contours shown in Figure 7 due to factors such as slope, exposure, colonization potential and grazing which vary independent of depth. In addition, depth contour lines are difficult to assign in soft bottomed, zero visibility ponds at intervals of 10 cm. The scientific and common names of the aquatic and marginal plants found in Cosens Bay Lagoon are listed in Table 4.

The letter-coded zones A, B and C are transitional between aquatic and terrestrial habitats. During the summer growing season they are exposed. Zones A and C are subjected to much more seepage than zone B and rarely dry out completely. Zones A and B are narrow, up to one metre wide, and divided into two subzones; a narrow, wetter marginal band and a wider, drier, more remote band, which merges gradually with the surrounding terrestrial vegetation.

The marginal wet portion of zone A is dominated by *Eleocharis palustris* but also contains variable quantities of *Juncus balticus*, *Potentilla anserina*, *Rumex maritimus* and *Carex* spp. Behind this marginal band is a wider band of *Festuca rubra* containing sporadic additions of *Hordeum jubatum*, *Potentilla anserina* and *Rumex maritimus*. There is a wider, flat, low bench behind zone A whereas zone B is limited by the steep-sided bar. Thus, zone A is generally wider than zone B. In the narrow wet marginal band of zone B, *Eleocharis palustris* is dominant with additions of *Equisetum* scirpioides, Juncus balticus, Potentilla anserina and Rumex maritimus (Photograph 7). This band, badly disturbed by cattle, merges gradually into zone 4. The higher and drier band of zone B is mostly Festuca rubra with scattered additions of Rumex maritimus, Equisetum fluviatile, Equisetum scirpioides, Potentilla anserina and Hordeum jubatum. Zone C is characterized by a hawthorn (Crataegus sp.) thicket with a few cattle trails and little undergrowth. In places this zone extends to the lagoon edge so that hawthorn overhangs the pond.

The transitional zones, A, B and C, plus zones 1 to 4 in the lagoon are all suffering from the grazing and trampling of cattle (Photograph 8). This impact will undoubtedly have affected the rate and direction of succession in the lagoon. Changes will likely be observed in the species composition and relative dominance within the plant community once cattle activity ceases. Within the lagoon three habitats may be distinguished based upon water levels and periods of exposure. One habitat, encompassing zones 1-4, is shallow and subject to regular seasonal exposure. A second, zones 5-6, is shallow but only rarely and irregularly exposed. The last habitat, comprised only of zone 7, remains covered by water year round.

Zones 1 to 4 comprise a shallow, marginal, habitat which is subject to regular, seasonal, drops in water level down to, or below, the sediment surface. The root zone of the plants, however, remains wet. Zones 1 to 3 are narrow marginal zones. Zone 1 contains Eleocharis palustris, Polygonum amphibium and Zannichellia palustris. The Eleocharis is emergent but the others generally remain submerged. Zone 2 contains three emergent species, Alisma plantago-aquatica, Sparganium sp. and Cyperus sp. Zone 3 is a shallow water habitat of Elodea canadensis, Polygonum amphibium and Lemna minor.

The largest zone of this third habitat type is zone 4. This is the most diverse and interesting zone in the pond and one which has suffered the most damage by trampling, and possibly grazing, by cattle. The bottom is covered almost completely by a carpet of Chara sp. and moss. The surface of the water is about one-half covered by floating Lemna minor. Throughout the zone there are scattered clumps of Eleocharis palustris, which is emergent; Ranunculus sceleratus and Rumex maritimus, which are amphibious and generally grow only where they will be exposed by falling water levels late in the season; Zannichellia palustris and Utricularia vulgaris, which are submerged while actively growing but can survive a dry period; and Polygonum amphibium, which is amphibious and grows well either floating or exposed on wet mud. In the shady south end of the zone there is more Eleocharis and less Lemna. Point 8 is an isolated, large clump of Alisma plantago-aquatica, an emergent, within zone 4.

Zones 5 and 6 comprise a habitat which is normally covered in water but may be exposed for brief periods in dry years. The dominant vegetation is emergent and rooted in the wet bottom. Zone 5 consists almost exclusively of Typha latifolia while zone 6 is almost exclusively Scirpus lacustris. The bottom in zone 6 is covered by a mat of aquatic moss and about half of the free water surface is covered in Lemna minor. There is a little Polygonum amphibium and Utricularia vulgaris growing among the Scirpus stems at the surface.

Zone 7 is the only deep water, permanently covered habitat (Photograph 9). The plants in this zone are all completely submerged and only flower and fruit stalks project above the surface of the water. The entire water column is fully occupied by a dense bed of vegetation consisting of Chara sp., Potamogeton pectinatus, Potamogeton berchtoldii and Zannichellia palustris. There is also a small amount of the floating duckweed, Lemna minor, on the surface of this zone.

6.2 COMPARISON OF COSENS BAY LAGOON WITH OTHER PONDS IN KALAMALKA LAKE PARK

Cosens Bay Lagoon was formed by longshore drift. None of the other three ponds in the park which were examined (Figure 5) were formed in this way. Site 1034 is an undrained depression in the grasslands near the park entrance. Site 1036, known as the Cattle Pond, is a reservoir made by damming a small creek, and site 1035 is a seepage and overflow pond which drains from the reservoir and into Cosens Bay Lagoon (site number 1026). Species lists for these ponds are given in Table 5 which clusters similiar ponds together. As can be seen, these three ponds are each unique, do not cluster with one another, with Cosens Bay Lagoon or any other pond sampled. Thus, of the ponds within the park, Cosens Bay Lagoon was formed in a unique manner and is vegetationally unique. Only the lagoon has large seasonal variations in water level which, due to its shallow depth, results in distinct habitats and a high species diversity.

The bar separating the lagoon from Kalamalka Lake supports a stand of overmature black cottonwood trees, Populus trichocarpa, along the top. These trees are valuable in stabilizing the bar but when they die they need to be replaced. This is occurring naturally by the proliferation of new shoots from the roots and bases of existing trees; however, grazing, trampling and cutting remove the new shoots. If human and cattle disturbances are minimized a new stand of young trees will quickly grow. These trees and the associated grasses and undergrowth will continue to stabilize the bar against wind and water erosion. This is important since present bar formation processes are inadequate to naturally repair the upper portion if it is eroded.

6.3 COMPARISON OF COSENS BAY LAGOON WITH SIMILAR WATER BODIES IN THE OKANAGAN VALLEY

A number of other ponds, embayments and lagoons, adjacent to the mainstem Okanagan lakes, were examined to determine how unique Cosens Bay Lagoon might be. Cosens Bay Lagoon was formed by longshore drift building a bar across an embayment in the shoreline of Kalamalka Lake. Although many other types of ponds and small lakes have been examined in the Okanagan Valley, only those presumed to have been formed by longshore drift are discussed below.

There are several examples of longshore drift bar formation creating isolated ponds or lagoons along the east side of Skaha Lake, around Haynes Point in Osoyoos Lake, and along the east shore of the north basin of Osoyoos Lake. The latter form a successional or evolutionary series of lagoons with the older, more enclosed ones mostly at the north end and the younger, unenclosed ones at the south end. The locations of these ponds and their identity numbers are shown on Figures 9 to 13.

The plant species found in each of these ponds/lagoons are listed in Table 5. In this table the lagoons are arranged into clusters to illustrate similar species groupings.

The upland ponds in Kalamalka Lake Park, sites 1034, 1035, and 1036, comprise group A in Table 5. These sites do not form a coherent group nor do they ally themselves to any other group. The species composition in these ponds was different from the other water bodies surveyed - which were embayments or lagoons adjacent to the mainstem Okanagan Valley Lakes.

Cosens Bay Lagoon, site number 1026, has been placed in the heterogeneous group B, which also includes sites 1047, 1049 and 1050. Site 1047 is a pond on the east shore of Osoyoos Lake amidst the group E ponds but has a flora quite distinct from the group E flora. The reason for this is not known. Sites 1049 and 1050 are embayments on the east shore of Skaha Lake. These presently have the highway situated where the bar or berm may or may not have been. There are culverts under the road at lake level connecting the ponds to Skaha Lake.

Although Cosens Bay Lagoon has a flora similar to the other three lagoons in group B, none of these other lagoons or ponds are similar to Cosens Bay Lagoon, either physically or ecologically. The number of species found in Cosens Bay Lagoon is slightly greater than that of the other ponds. No species are unique to Cosens Bay Lagoon nor are any of the species rare to British Columbia or the Okanagan Valley. It is the overall particular combination of characteristics which makes the lagoon unique. In most ponds where Scirpus lacustris or Typha latifolia occur they form a marginal fringe along the shore; only in Cosens Bay Lagoon do they form a shallow island in the centre of the pond. Only this lagoon has such an expanse of semi-aquatic habitat with a diverse flora and regularly fluctuating water levels. Cosens Bay Lagoon is much more mature, has a higher bar and is more isolated from the lake than the other ponds. It is the most northerly of the ponds and was formed at an earlier geological era when lake levels were dropping. With present controlled lake levels the incipient lagoons on Osoyoos Lake may not be able to complete their succession to a form similar to Cosens Bay Lagoon.

Group C sites, (1040 and 1041), are the two outermost ponds south of Haynes Point and both are open and exchange water with Osoyoos Lake. These are populated with common and widespread species; diversity is very low in these sites.

Sites 1033, 1038, 1039 and 1043 form group D. Site numbers 1039 and 1038 respectively include the innermost and presumably oldest lagoon south of Haynes Point Park on Osoyoos Lake, plus the adjacent large embayment. These two are isolated from Osoyoos Lake except at very high water and are screened by extensive Scirpus lacustris beds. Site 1033 is Coldstream lagoon - just north of Coldstream Creek at the northeast end of Kalamalka Lake but not isolated from the lake. Site 1043 is an incompletely separated lagoon at the north end of Osoyoos Lake which has a very dense Scirpus lacustris fringe separating it from the lake. This is the most northerly of the Osoyoos ponds which were examined. These four sites contain a moderately diverse number of species that are common and widespread throughout the Okanagan Valley.

Sites 1044, 1045, 1046, 1042 and 1048 form group E and are all ponds along the east shore of Osoyoos Lake. Only 1048 is still connected to the lake at normal summer water levels; the others are isolated by complete bars or berms but may be connected to the lake at high water. These sites are much younger than Cosens Bay Lagoon and have a much less diverse flora.

7. WILDLIFE

During the course of taking regular water level readings, casual observations of wildlife encountered were recorded. This information is presented in Table 6. A more detailed species inventory is presented by Cannings (1975). Canada geese, mallards, western painted turtles, muskrats and red-winged blackbirds are examples of the most conspicuous wildlife observed in the lagoon. Cosens Bay Lagoon supports a variety of wildlife typical of the Okanagan, in a relatively undisturbed state.

8. KEY INTERPRETATIONAL VALUES

8.1 GEOLOGY

Spit and bar formations are relatively common geological processes which are important to man's use of ocean and lake foreshores. The formation of Cosens Bay Lagoon is particularly interesting as it occurred concurrently with a drop in lake level during the recession of the last glacial period. The fact that the approximate minimum age of the lagoon was determined by the presence of volcanic ash from an eruption of Mount St. Helens, 3,200 years ago, will have special relevance due to the more recent eruption of this volcano in 1980.

8.2 PLANT ZONATION

Due to seasonal fluctuations in water level, lagoon vegetation is distributed in zones which reflect the differing abilities of plants to tolerate dewatering and flooding. This zonation is apparent as parallel bands of plant communities distributed in relation to depth or proximity to the deepest part of the lagoon (Photograph 7). The transition zones between exclusively terrestrial and exclusively aquatic plants includes the majority of species present in the lagoon.

8.3 PLANT DIVERSITY

Cosens Bay Lagoon is the most diverse of the 18 ponds and lagoons investigated in this survey. The presence of at least 15 species of aquatic plants in a relatively small water body is impressive (Table 4). The average person usually is not aware of the diversity of aquatic and marginal aquatic plants due to the difficulties of access to aquatic habitats. Cosens Bay Lagoon offers a unique opportunity for the public to visit such a diverse example of a poorly known habitat.

One aquatic plant that will be of particular interest to park users will be the bladderwort (*Utricularia vulgaris*). This plant is a carnivore which may receive part of its nitrogen requirement by capturing small invertebrates. *Utricularia* spp. are equipped with numerous bladders which have lower internal hydrostatic pressure than the surrounding water so that the bladder walls are compressed by internal suction. If the trigger bristles adjacent to the valve covering a bladder opening are disturbed, the valve opens and the quarry will be drawn into the abruptly expanding bladder by the rush of water (Figure 14).

8.4 WILDLIFE

Although a thorough inventory of lagoon wildlife was not conducted in the present study, it was apparent that the wildlife associated with and directly dependent on the lagoon and it's vegetation represents an important interpretive feature. Wildlife such as mallards, Canada geese, red-winged blackbirds, kingfishers, various shore birds, frogs, muskrats, western painted turtles, yellow bellied marmots and white tailed deer will be seen in or around the lagoon.

9. POTENTIAL IMPACT OF DEVELOPMENT

9.1 WATER QUALITY

Cosens Bay Lagoon is presently in a eutrophic condition; widening the bar, irrigation and fertilization adjacent to the lagoon are not expected to have a significant detrimental effect on water quality. Water quality will continue to be highly variable due to the small volume of water in the lagoon. Heavy growths of aquatic vascular plants and algae, which are characteristic of eutrophic waters, will also continue.

Artificial maintenance of the lagoon's water level above a minimum summer level by pumping in water from Kalamalka Lake could potentially alter water chemistry and plant ecology. Input of relatively nutrient poor water from Kalamalka Lake will dilute the eutrophic lagoon water. However, nutrient release from the muddy bottom, decaying organisms and evaporation will tend to increase nutrient concentrations. The net impact will depend on the volume of water which must be pumped in to achieve the desired water level. However, as water quality is presently eutrophic and highly variable, occasional input of low nutrient water from Kalamalka Lake is not expected to have any significantly detrimental impacts.

9.2 LAGOON VEGETATION AND ECOLOGICAL SUCCESSION

Cosens Bay Lagoon is very shallow with a highly organic sediment and could be classified as being in the final stages of pond evolution to a terrestrial habitat. The lagoon is inhabited primarily by marginal and emergent vegetation. However, sedimentation is occurring very slowly and it is expected that the lagoon will remain in the present state for many more hundreds of years. The proposed developments are not expected to have any impact on the overall evolution processes, although certain components of the biota will be lost by widening the bar.

The lagoon biota have been severely degraded by cattle grazing and trampling. Recent reduction in the number of cattle using the area has resulted in considerable recovery. It is recommended that cattle not be allowed access to the lagoon. This will result in continued recovery of plant populations in areas which presently appear as muddy and unvegetated (Photograph 8), and will greatly enhance the interpretive values of the lagoon. The trampling effect of humans on the lagoon margins should be more controllable and therefore less destructive than recent trampling by cattle.

Artificial water level stabilization can potentially alter the diversity and zonation of marginal and aquatic plants. A large portion of the plant species presently occupying the lagoon are specifically adapted to fluctuating water levels. The zonation of plants is a direct result of seasonal water level fluctuations. Natural water level fluctuations should be allowed to continue if the present biota are to be maintained.

Cosens Bay Lagoon may be subject to excessively low water levels and perhaps complete dewatering during occasional dry years. Addition of water to prevent the water level from dropping below a minimum level which corresponds with the purely aquatic plant zone will not have any detrimental impact and should have some benefit to the wholly submerged fauna and flora. Maintenance of a minimum water level could prevent the elimination or stress of certain aquatic plants during rare event dry summers. It is suggested that if the water level declines below 391.45 m (0.40 m contour on Figure 7), about 360 m^3 of water could be pumped in to bring the level up to 391.55 m (0.30 m contour). This degree of manipulation should not have any detrimental impact on present lagoon ecology but may slow the successional development of the lagoon toward an otherwise inevitable terrestrial condition.

The development of a trail system adjacent to the lagoon should not cause harm to vegetation if certain precautions are taken. A floating boardwalk projecting from shore to the deepest part of the lagoon would provide access to most vegetation zones and should preclude park users from wandering and trampling through marginal vegetation (Figure 15). The trail system should be oriented in such a fashion that it is not used for general beach access, and is only suitable for those park users wishing to explore the lagoon. This can most easily be achieved by making it a dead-end. Other arguments concerning trail location are presented in Section 9.3.

In order to increase the area available for picnic tables along the bar, it has been proposed that the bar be widened by adding fill along the west bank of the lagoon. The approximate area that would be affected is indicated on Figure 16 and Photograph 6. This development would eliminate all of transitional zone B and most of lagoon vegetation zone 4. Zone 8 and part of lagoon zones 5 and 6 would also be eliminated. Immediately adjacent areas not covered by fill are sure to suffer considerable damage.

The elimination of zones B, 4 and 8 would result in the loss of the following species which are not found elsewhere: Equisetum scirpioides (the smallest native species of horsetail), Equisetum fluviatile and Ranunculus sceleratus. Many of the other species found in these zones would be greatly reduced in numbers since their primary location is zone 4. It is the loss of this most diverse and interesting zone which is important, rather than the loss of the three species or 13% of the species found in the lagoon and along its margins. Sixteen of the 23 species are found in these affected zones.

9.3 WILDLIFE

Any degree of park development will increase human traffic around the lagoon, and will result in disturbance of lagoon wildlife. The location of a picnic area, whether on the present bar or a widened bar, and the trail-boardwalk system will disturb those species not tolerant to the presence of humans.

The maximum interpretational value of the lagoon wildlife would be realized by location of the proposed picnic area away from the lagoon. The presence of picnic activities on the bar will disturb the feeding and mating activities of wildlife, and will also be a distraction to those park users exploring the lagoon.

The disturbance caused by trail access could be minimized by ensuring that a portion of the lagoon and adjacent shore is left inaccessible. This would leave a refuge for shy species. It is suggested that the southeast section of the lagoon, which is presently protected by a dense hawthorn thicket, not have trail access. Locating the boardwalk at the northwest end of the lagoon, as indicated in Figure 15, will provide access to most ecological zones in the lagoon and yet leave a significant portion undisturbed.

9.4 LAGOON DEVELOPMENT CONFLICTS AND SUGGESTED OPTIONS

The lagoon area, which includes a beach and a forested bar, has been identified as having the highest preservational and interpretational values in Kalamalka Lake Park. The bar is also a highly desirable location for a picnic area, due to the natural beauty of the site and proximity to the lake and beach. The exploitation of all these presents a conflict, and some compromises must be made.

Resolution of this conflict depends on the relative priorities placed on the interpretive and preservational values of the lagoon area as opposed to the need to locate a picnic area on the bar. To widen the bar in order to accommodate more picnic tables is a significant compromise of the interpretive values of the lagoon. To develop the present bar as a picnic area reduces the impact on the lagoon, but compromises the development of an adequate picnic area. The presence of picnic activities on the bar, whether widened or not, compromises the preservational and interpretive values of the lagoon to varying degrees.

Broadening the existing bar to accomodate beach and picnic use without sacrificing lagoon vegetation features could be achieved by placement of additional sand on the lake face of the bar. This would be preferable to the option under consideration, from the nature interpretation perspective. This option would require careful consideration of the shoreline contour stability and the resultant cost implications.

An alternate picnic area may be found along Kalamalka Lake between the present access road and Cosens Creek, although the shore adjacent to this area is rocky, and is presently not attractive as a beach. The rocks could be removed and sand brought in. A short breakwater oriented lakeward from shore should prevent this sand from being washed northward and may trap wave transported sand from the bay. The breakwater could be integrated with boat moorage and perhaps a diving board. The design and construction of a breakwater would have to take into consideration the potential impact on beach processes and nuisance aquatic plant growth.

Directing some park development and use away from the lagoon would minimize disturbance of the interpretive features of this area. Foreshore improvements near Cosens Creek will increase the amount of useable beach and will avoid concentrating several activities in the small area adjacent to the lagoon.

10. LITERATURE CITED

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Westgate, J.A., D.G.W. Smith and M. Tomlinson. 1970. Late Quaternary tephra layers in southwestern Canada. In: Early Man and Environments in Northwest North America. Students Press, University of Calgary, Calgary, Alberta. pp. 13-33.

FIGURE 1. LOCATION OF KALAMALKA LAKE PROVINCIAL PARK, COSENS BAY LAGOON AND LAGOON 1033

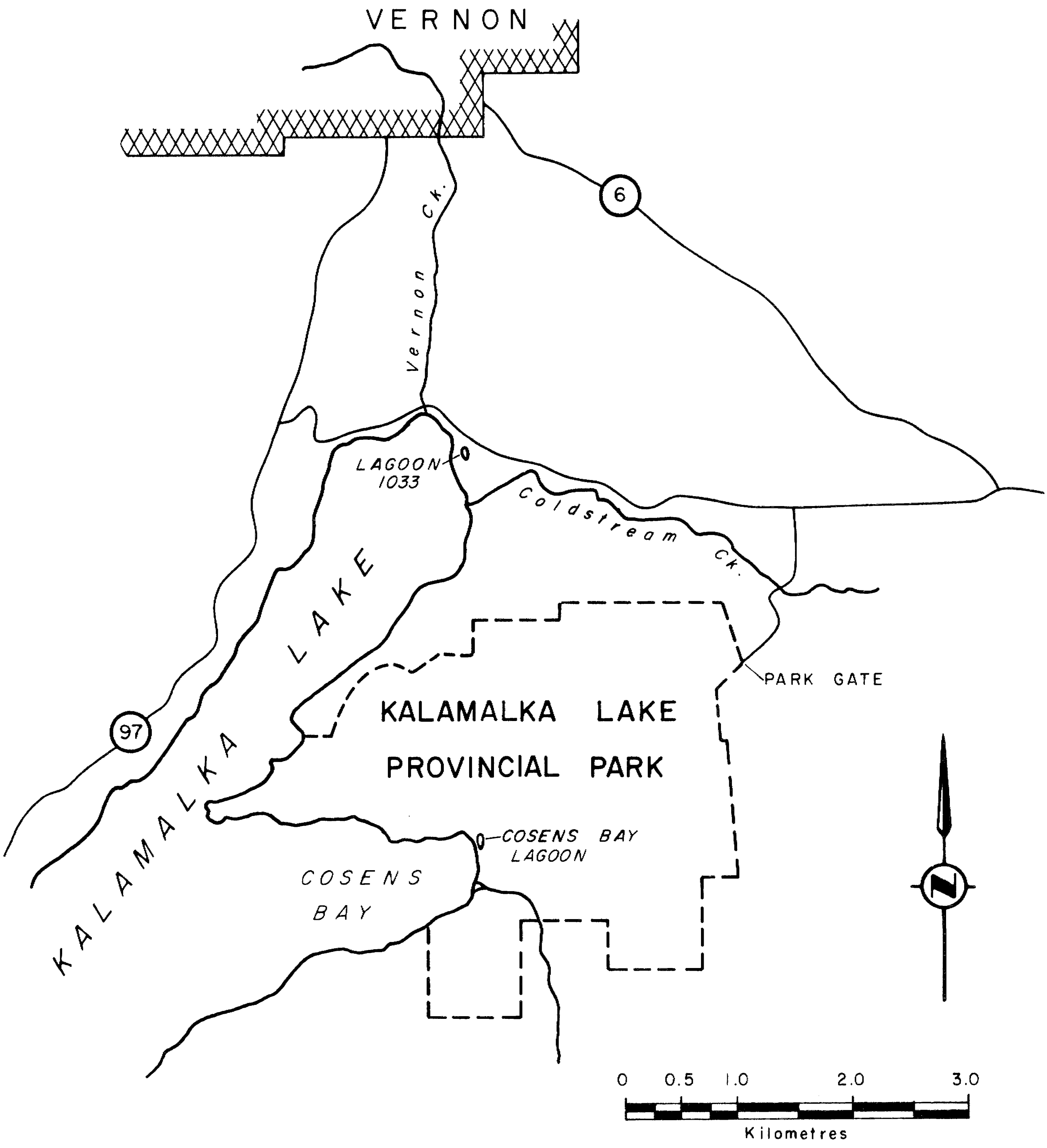


FIGURE 2 . PROPOSED DEVELOPMENT OF BEACH AND LAGOON AREA

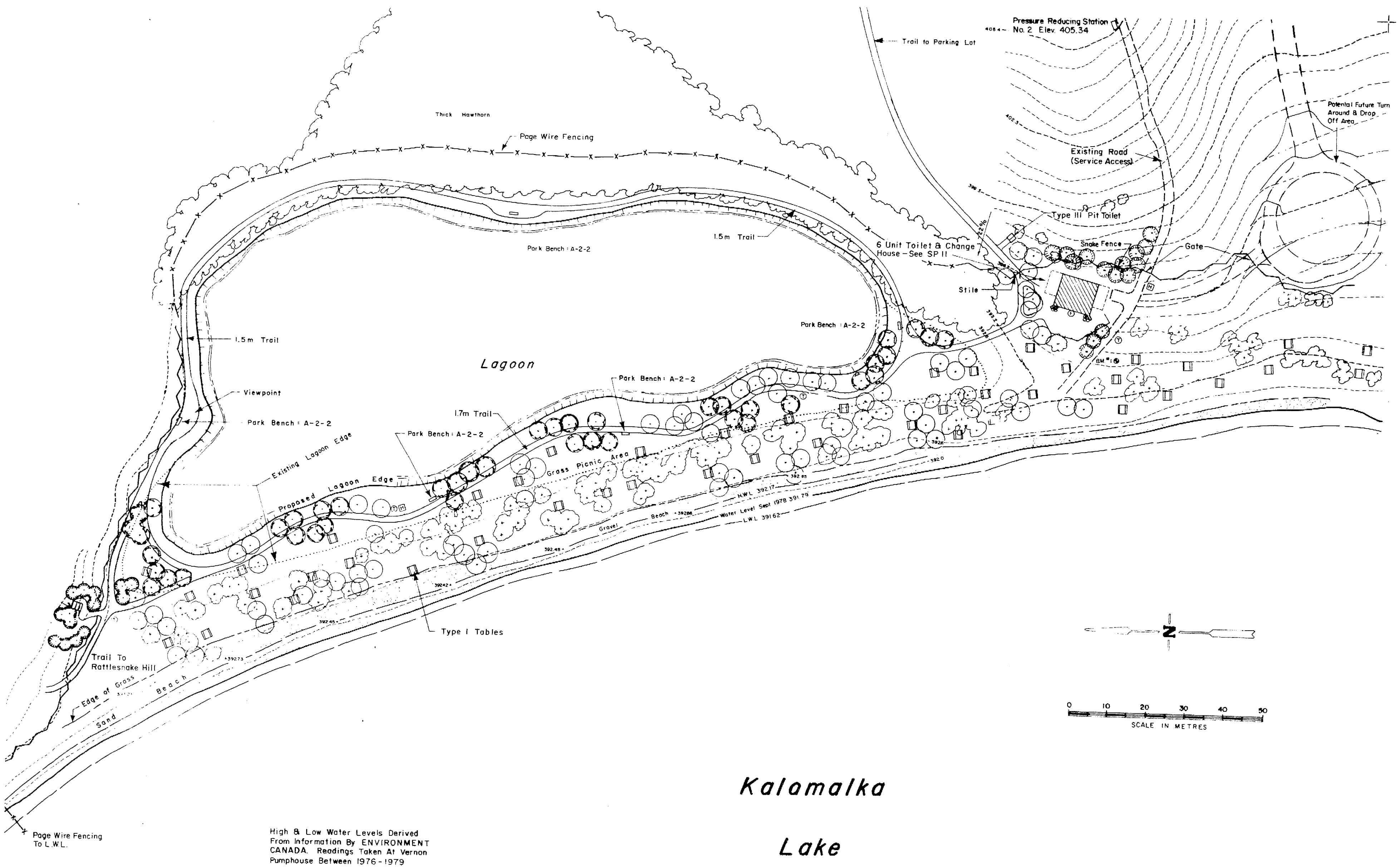


FIGURE 3. GEOLOGY OF COSENS BAY LAGOON FORMATION

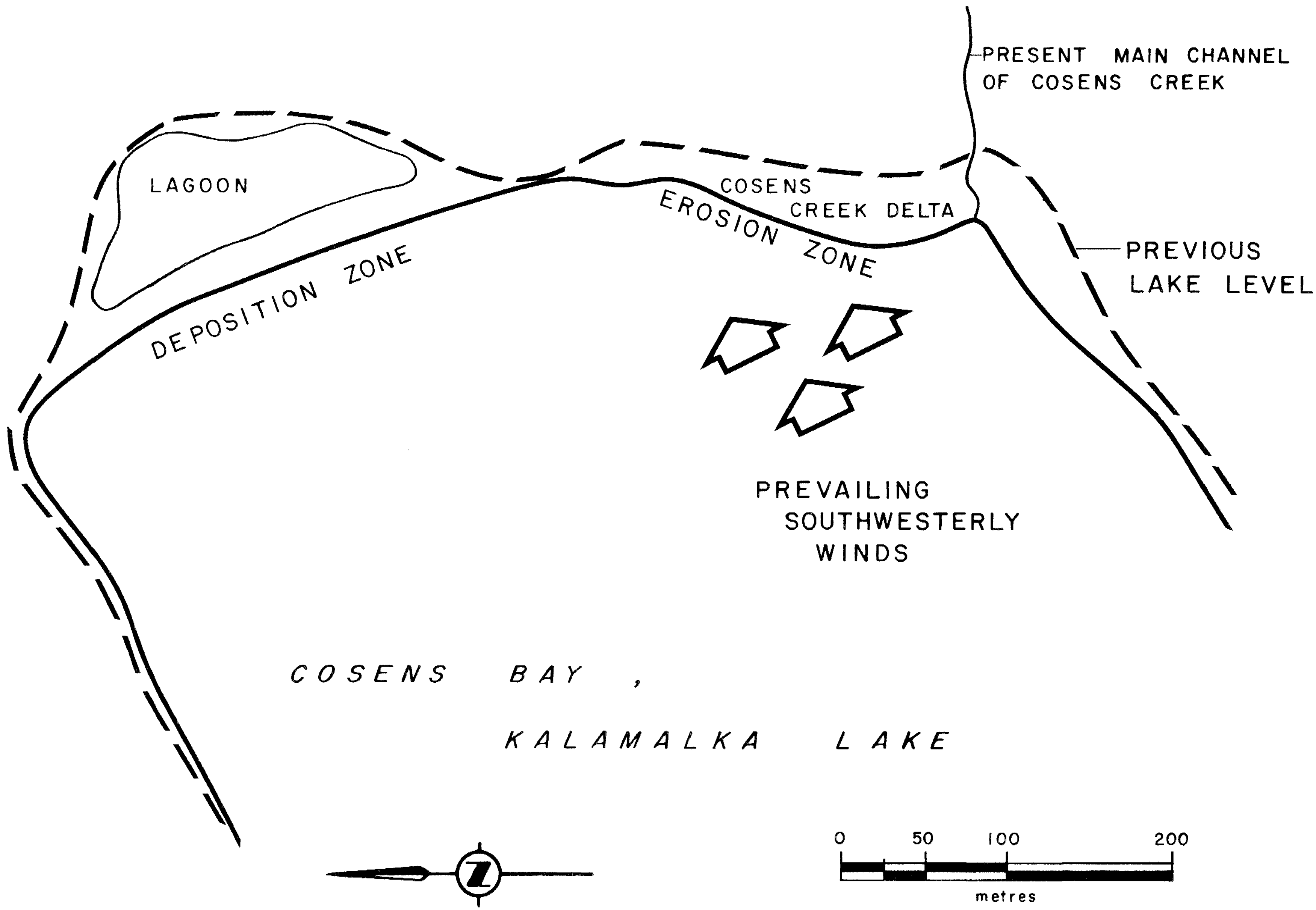
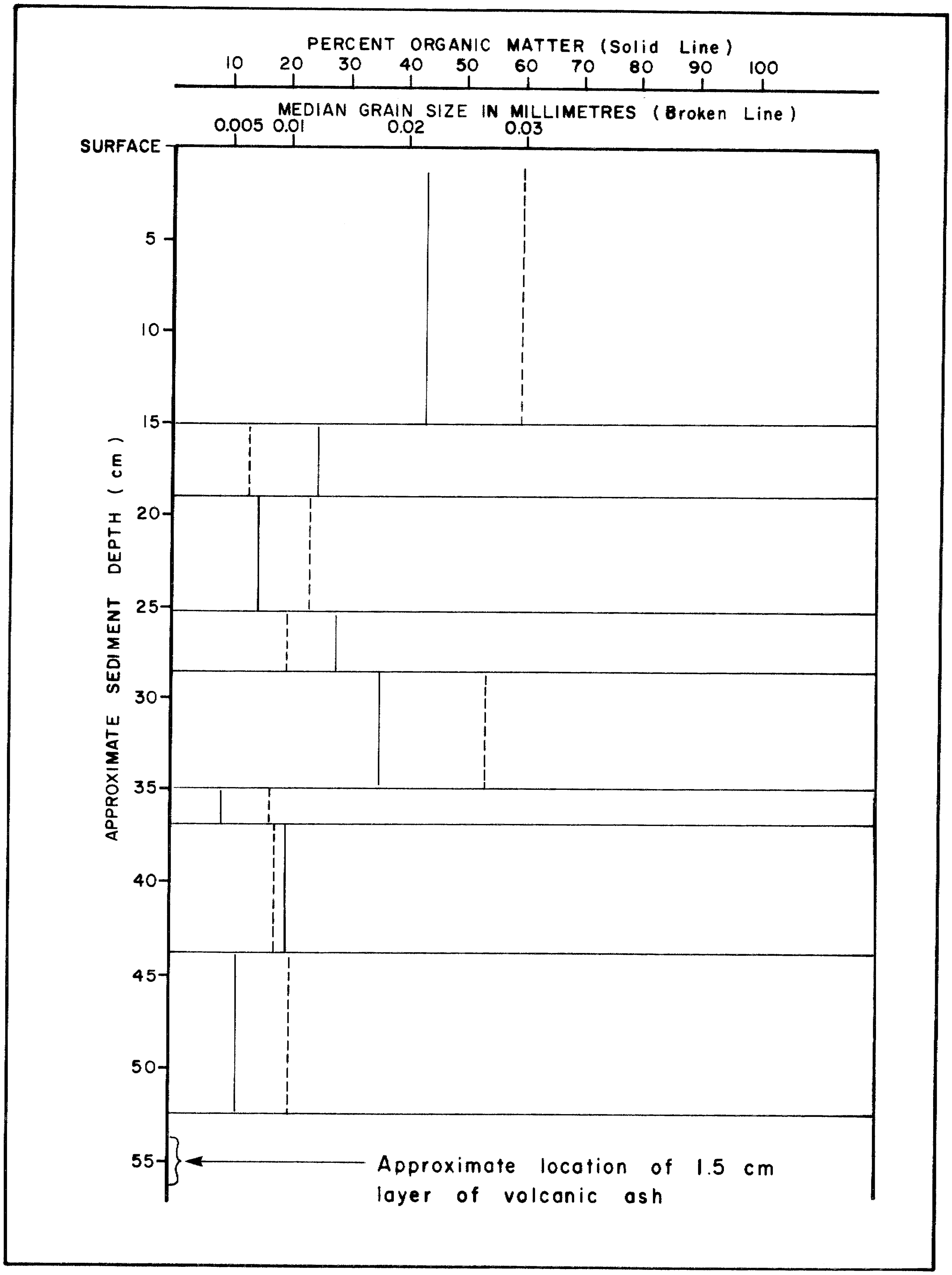


FIGURE 4 . VARIATIONS IN ORGANIC MATTER AND GRAIN SIZE OF SELECTED* CORE STRATA FROM COSENS BAY LAGOON



* Strata differentiated on visual appearance

FIGURE 5 . MAJOR HYDROLOGICAL FEATURES OF COSENS BAY LAGOON WATERSHED

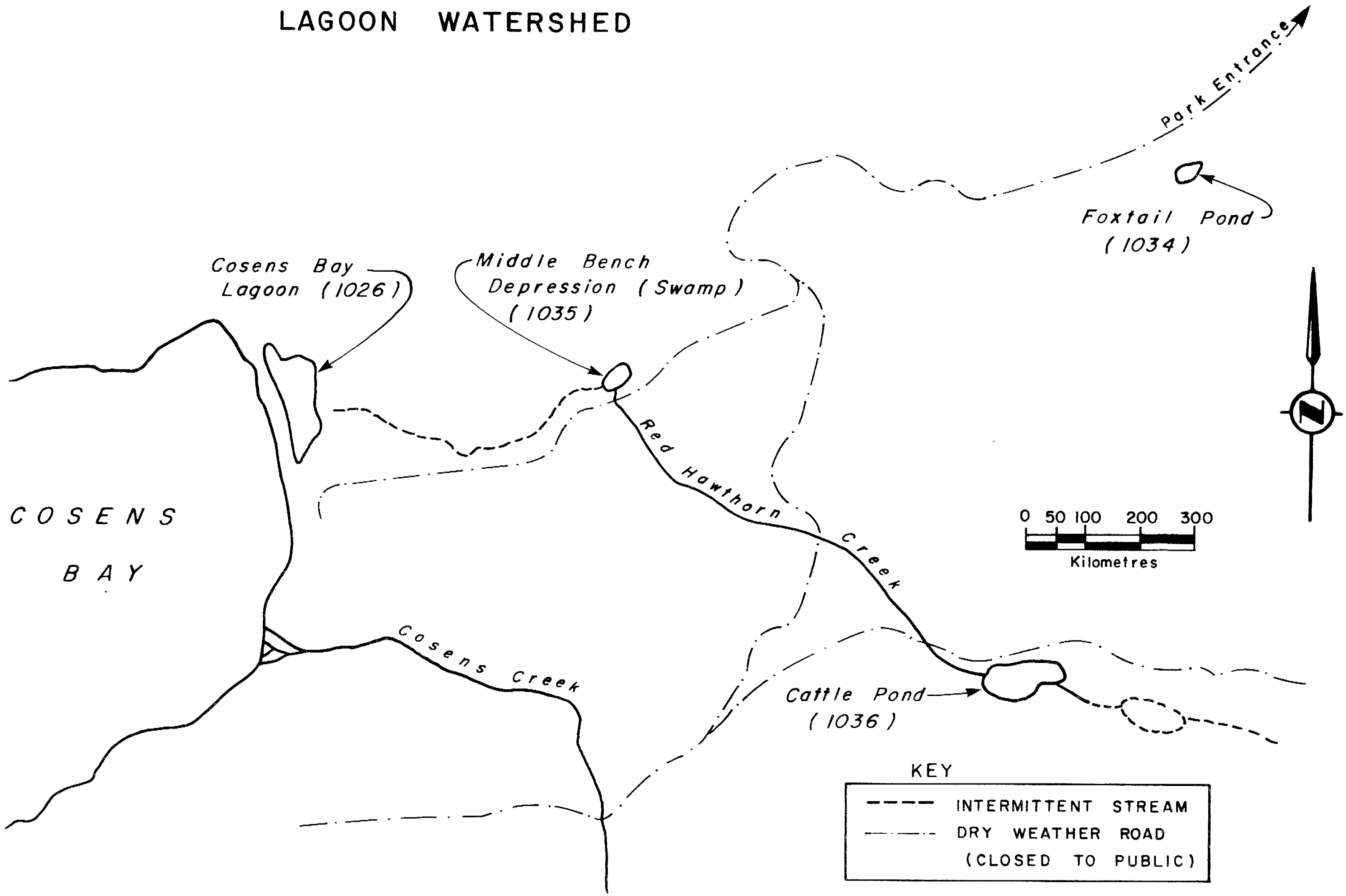


FIGURE 6. WATER LEVELS OF COSENS BAY LAGOON AND KALAMALKA LAKE

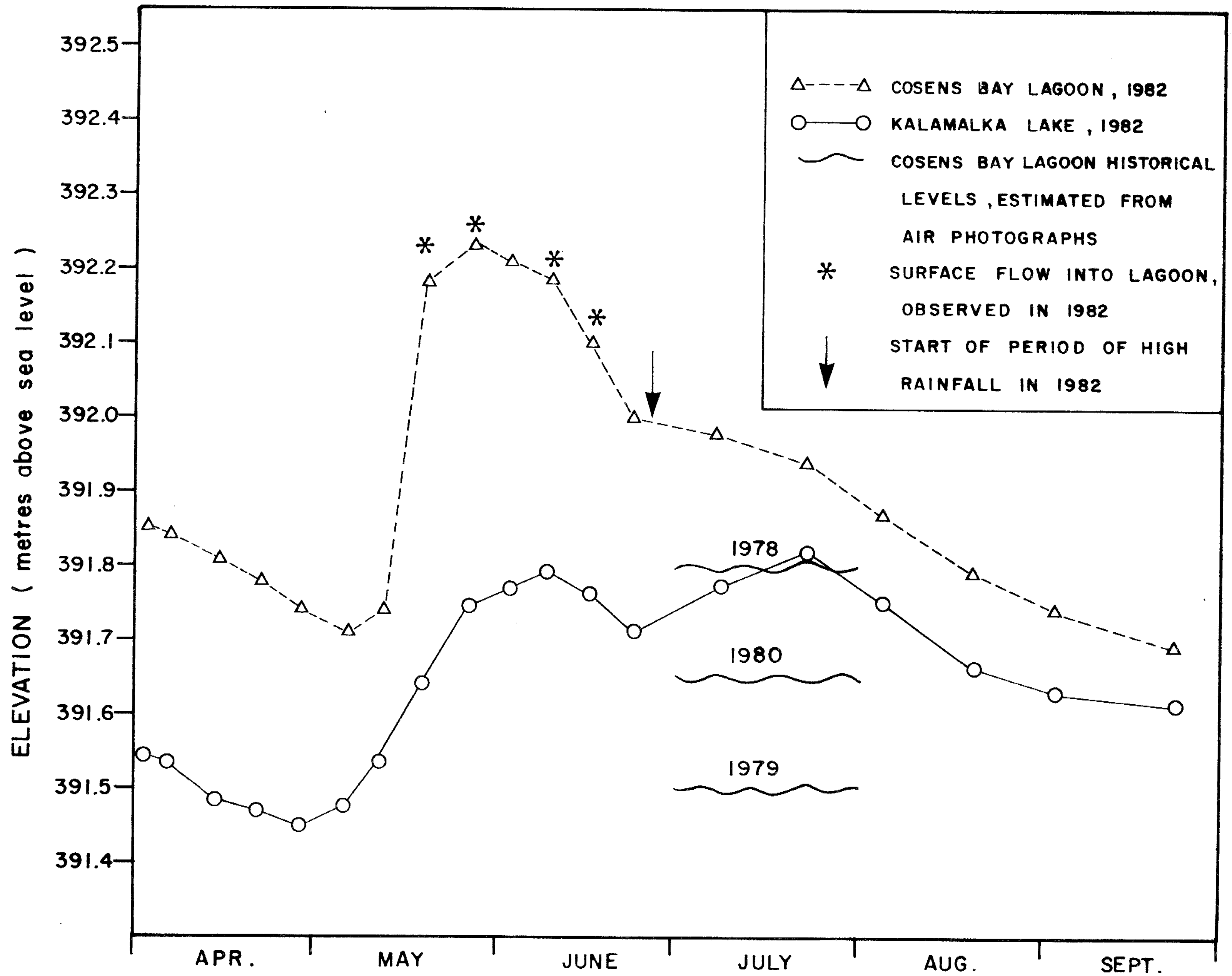


FIGURE 7. COSENS BAY LAGOON BATHYMETRY

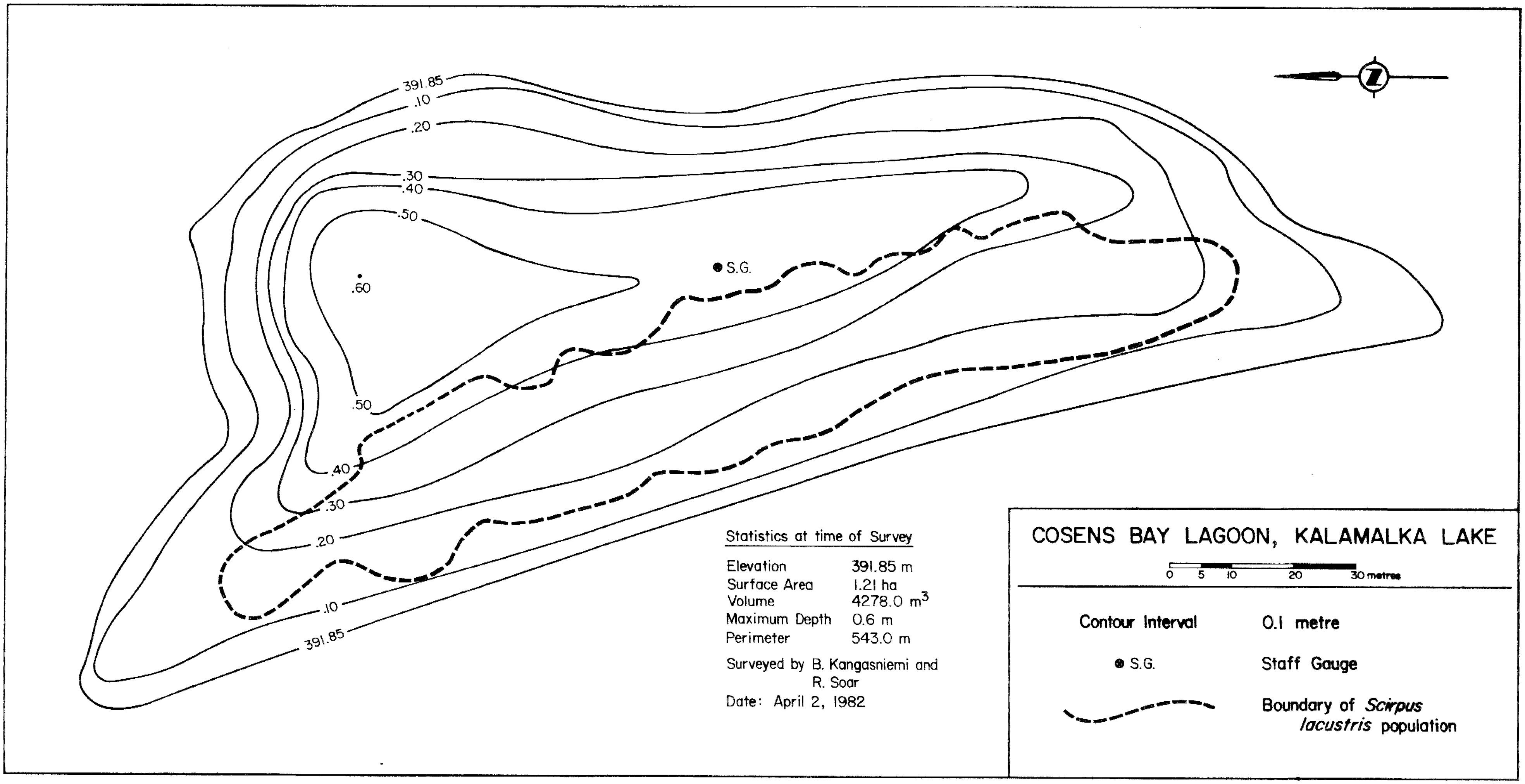


FIGURE 8 . COSENS BAY LAGOON VEGETATION ZONES

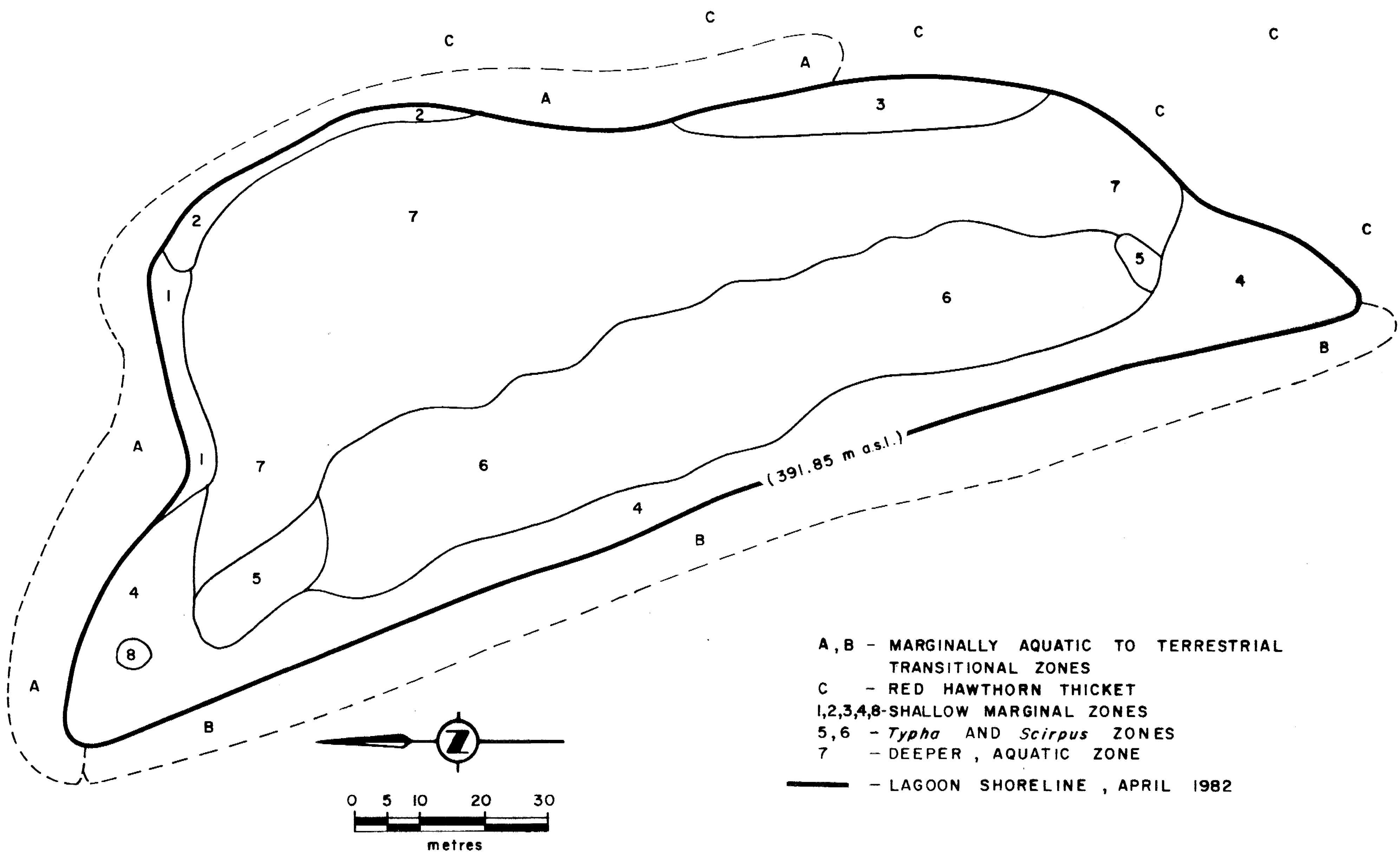


FIGURE 9 . LAGOONS 1049 AND 1050, SKAHA LAKE

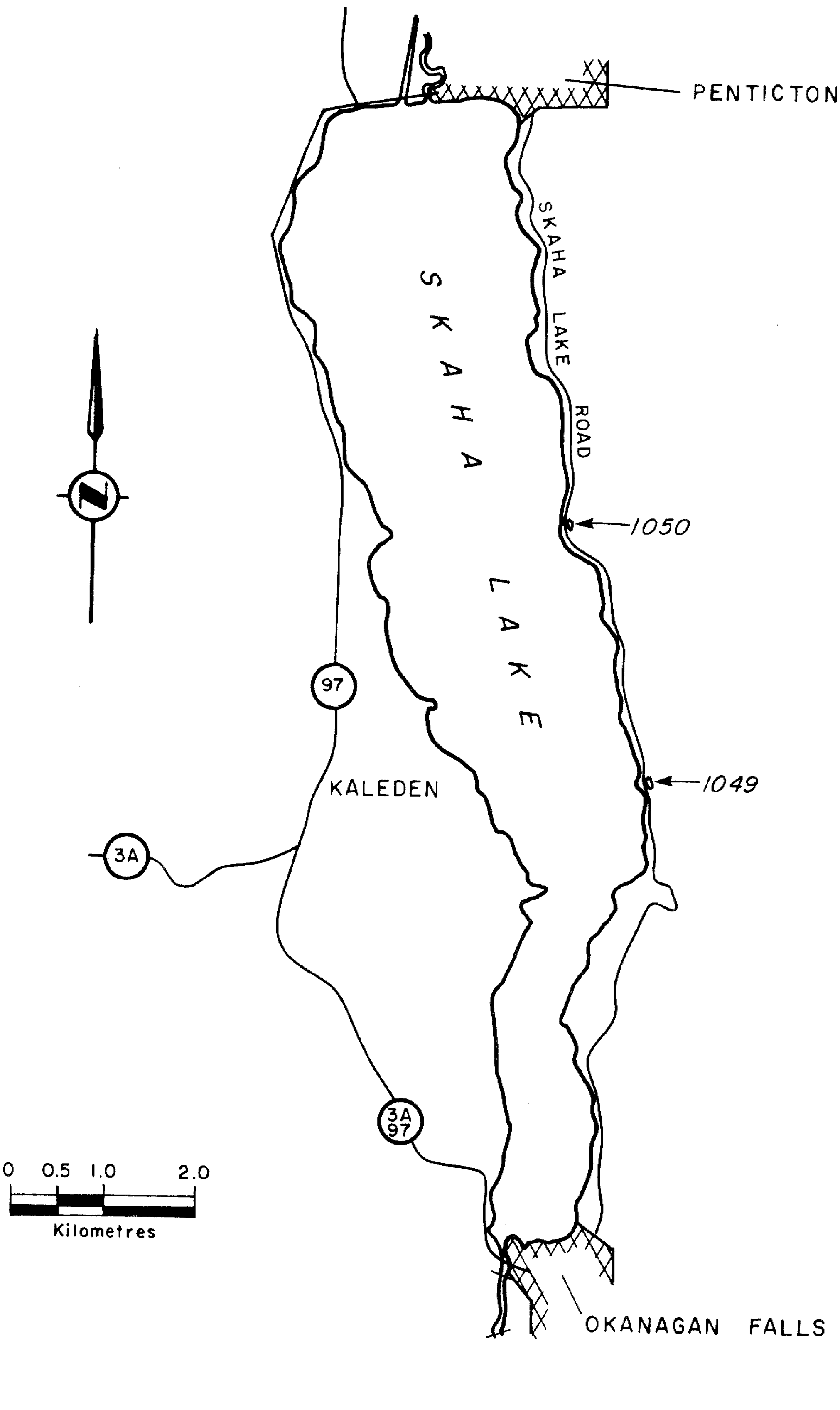


FIGURE 10. LOCATIONS OF OSOYOOS LAKE LAGOONS

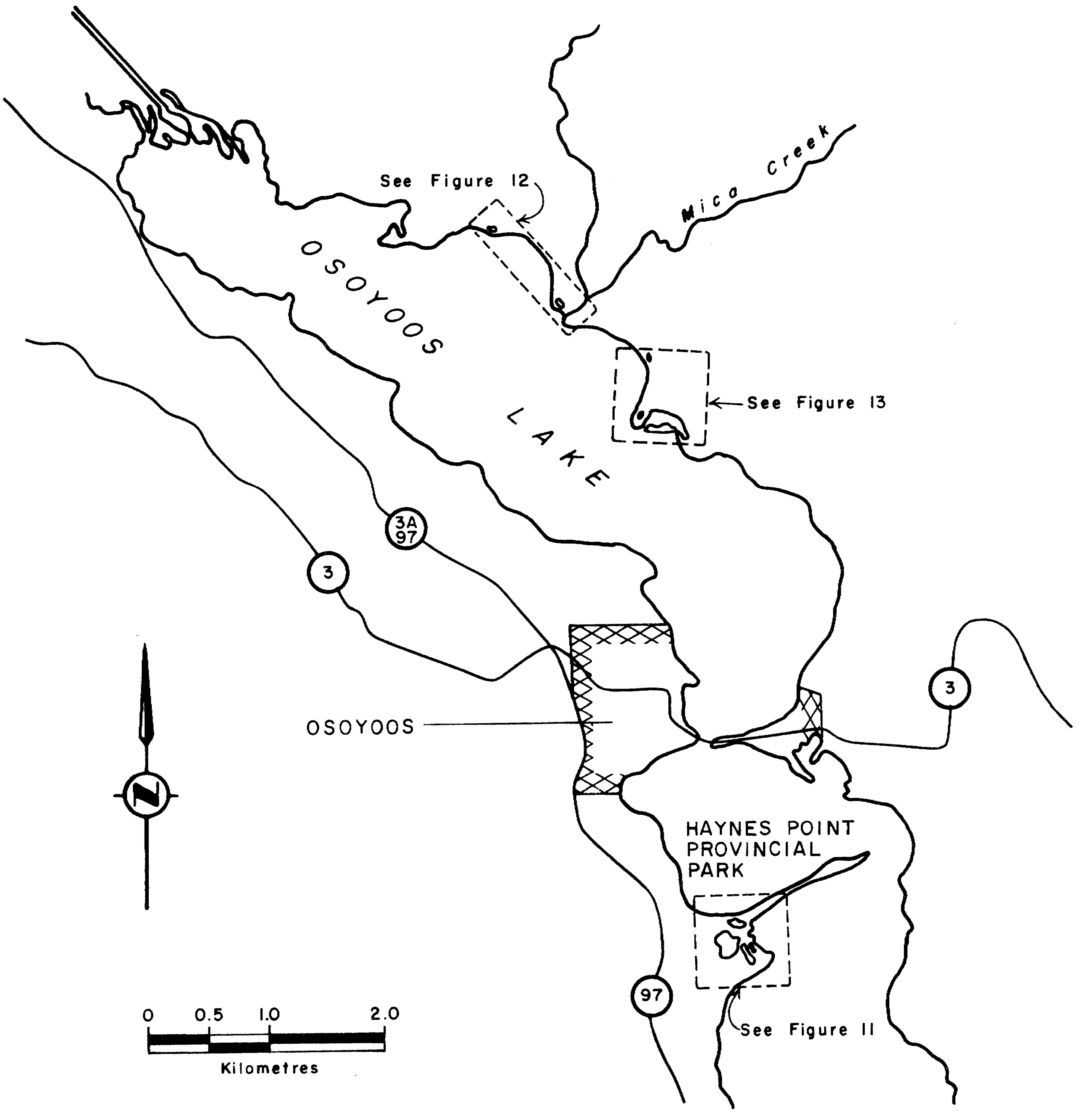


FIGURE 11 . LAGOONS 1038 TO 1041 , OSOYOOS LAKE

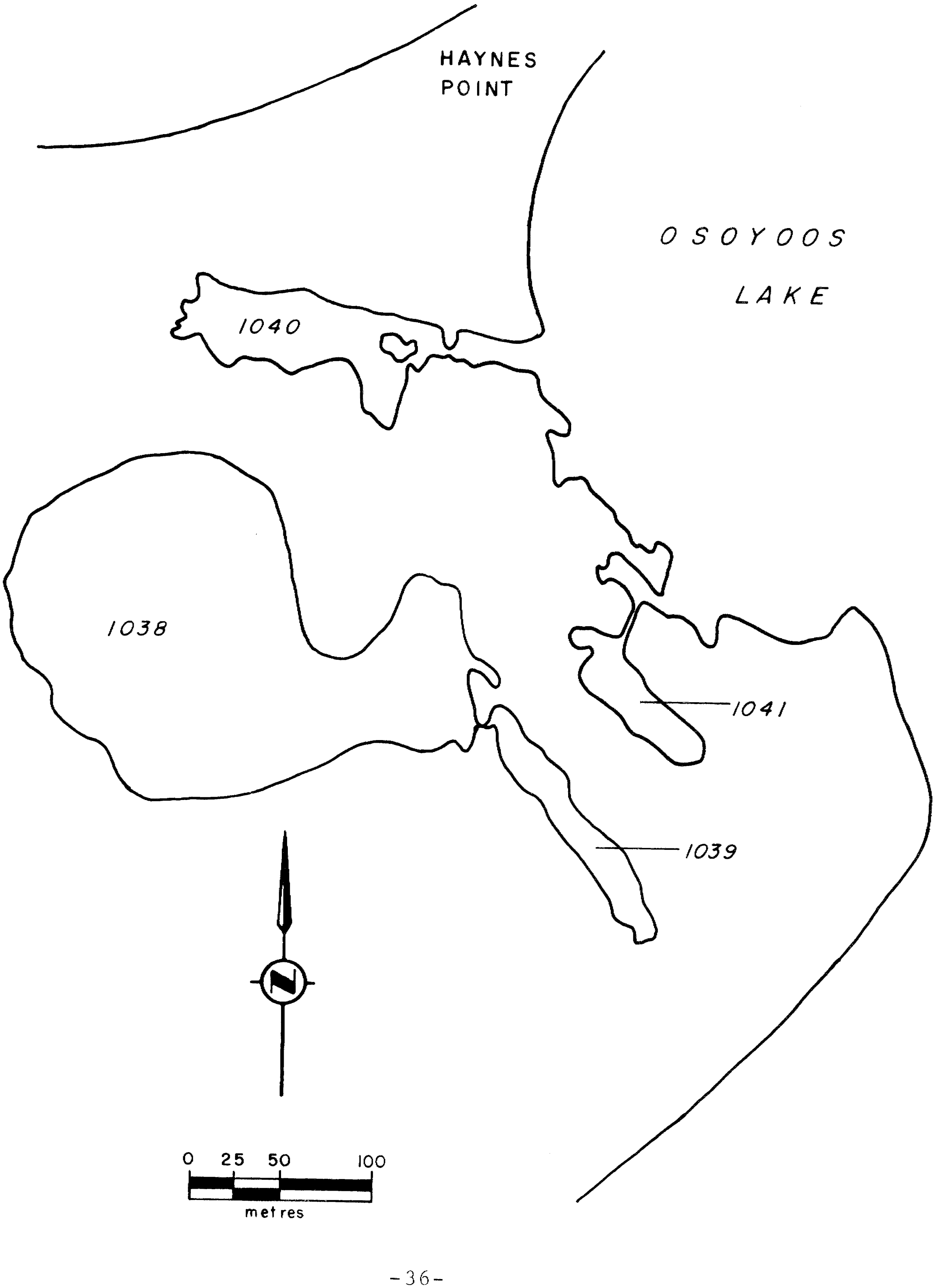


FIGURE 12. LAGOONS 1042 AND 1043, OSOYOOS LAKE

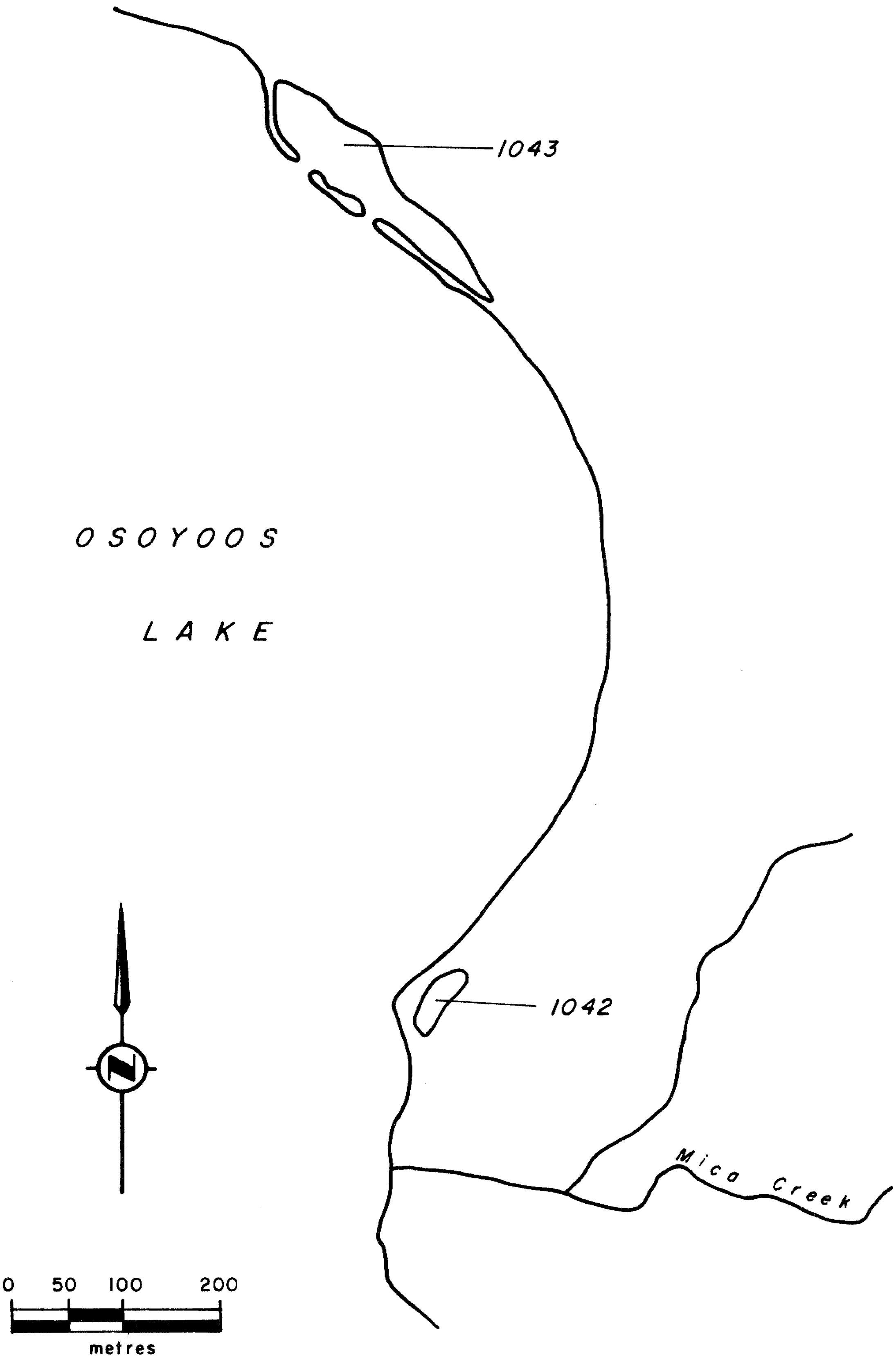


FIGURE 13. LAGOONS 1044 TO 1048, OSOYOOS LAKE

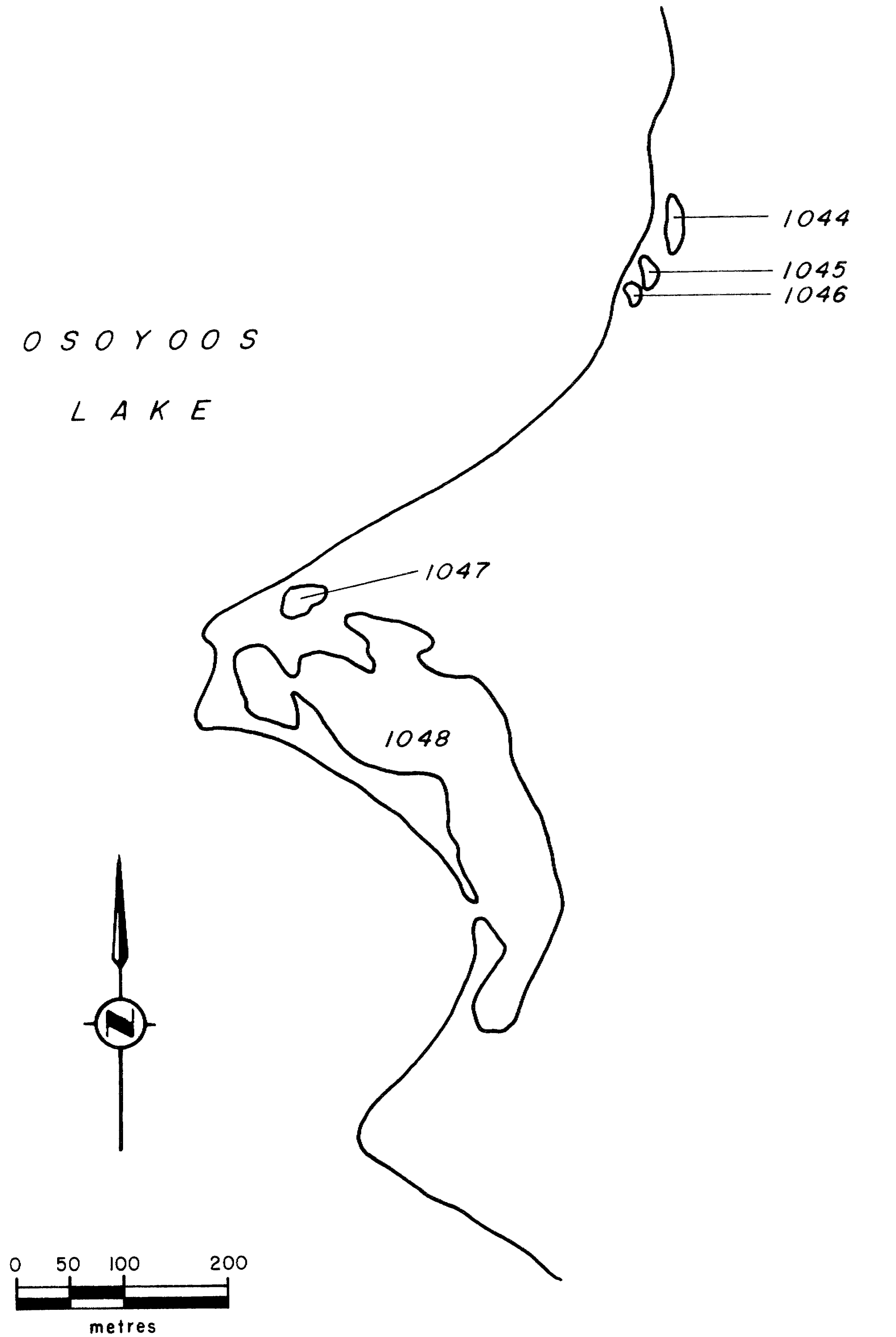
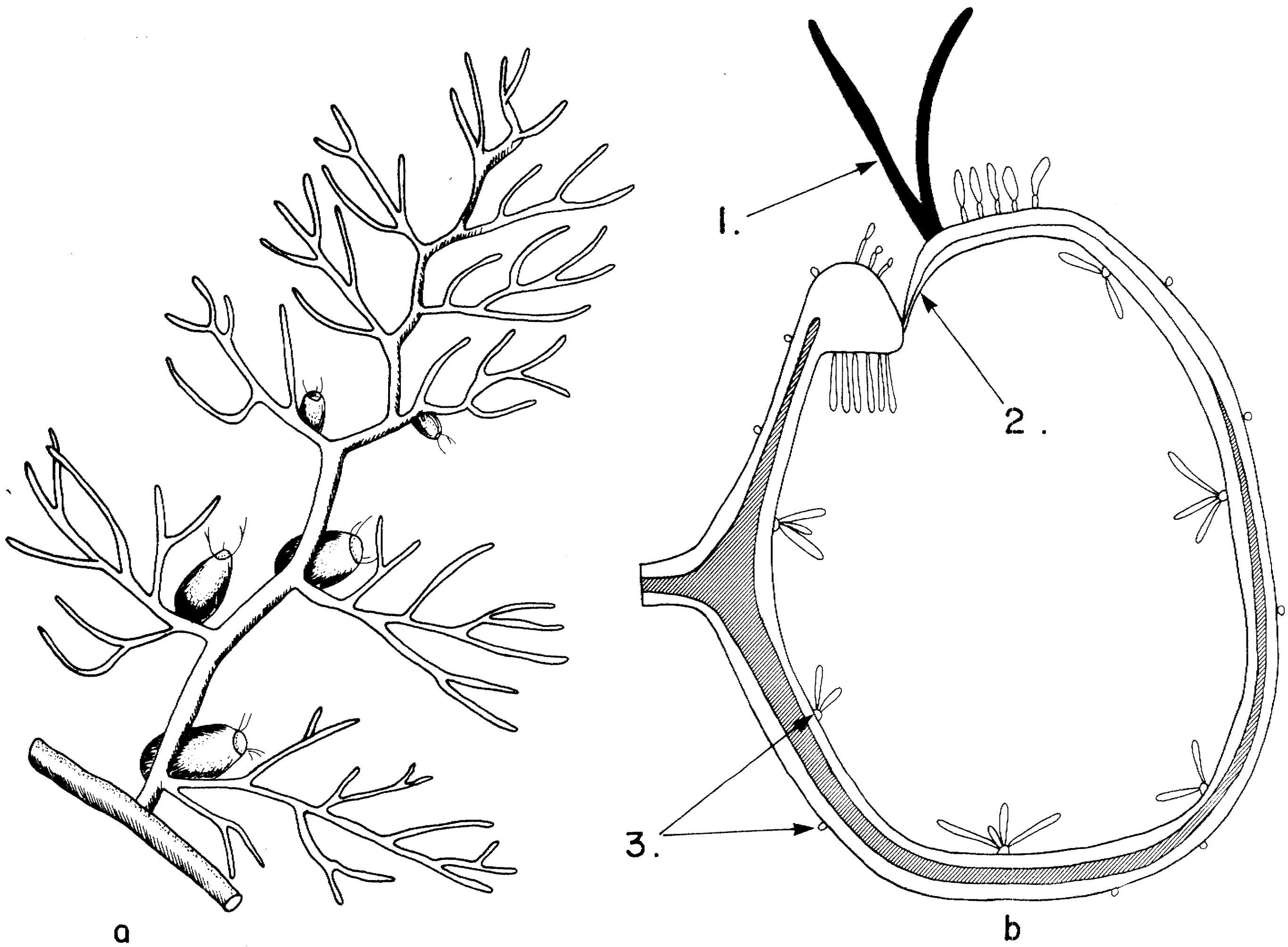


FIGURE 14. *Utricularia vulgaris* leaf and *Utricularia* sp. bladder *



a. Single *Utricularia vulgaris* leaf with bladders, or traps.

b. A single bladder (trap) for *Utricularia flexuosa* showing: 1. trigger bristles, 2. valve, and 3. internal and external glands. This bladder is typical for the *Utricularia* genus.

* From <u>The Biology of Aquatic Vascular Plants</u>. C. Duncan Sculthorpe. 1971. William Clowes and Sons Ltd., Great Britain

FIGURE 15 . RECOMMENDED TRAIL AND BOARDWALK LOCATION

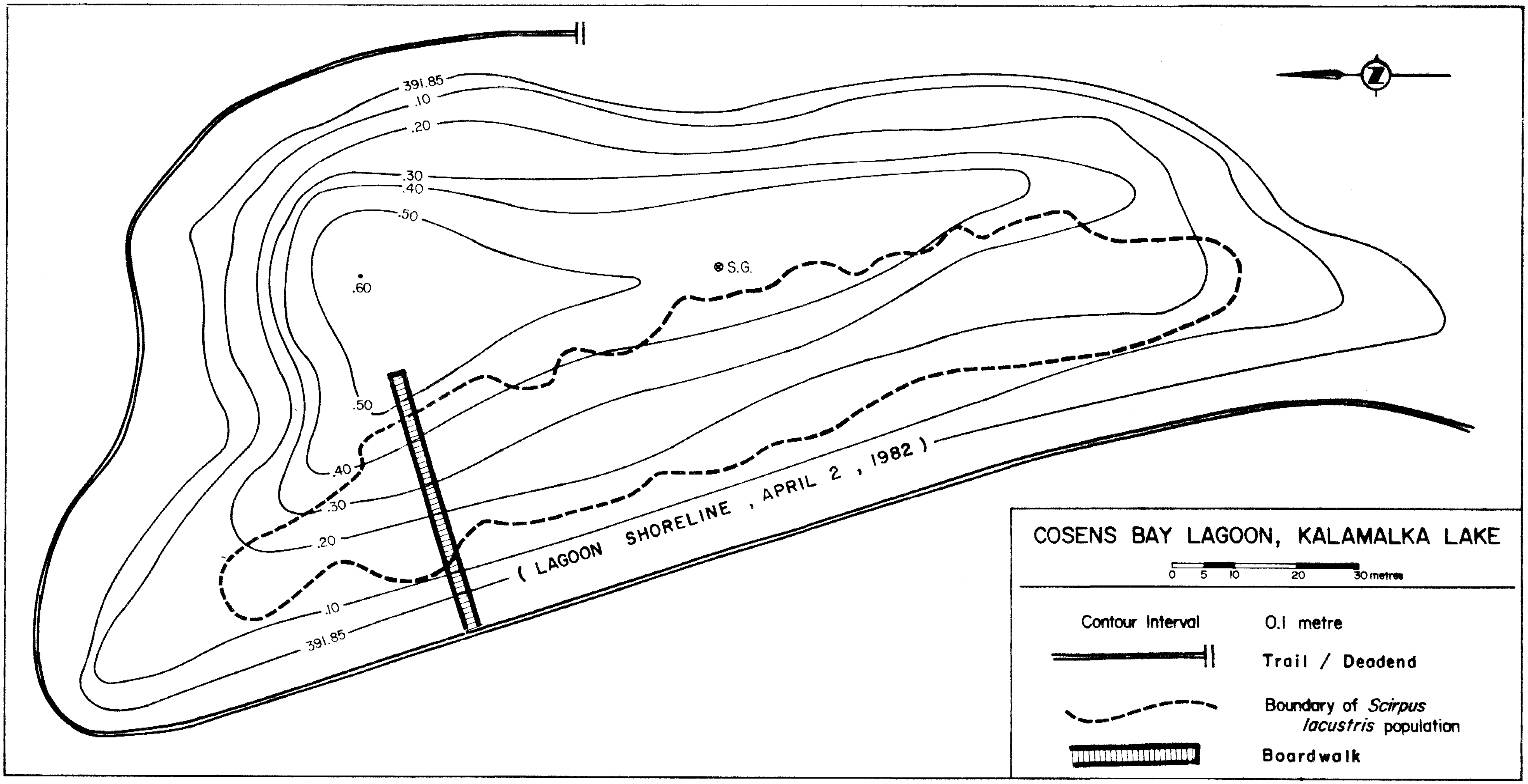


FIGURE 16. PLANNED BAR EXPANSION INTO COSENS BAY LAGOON

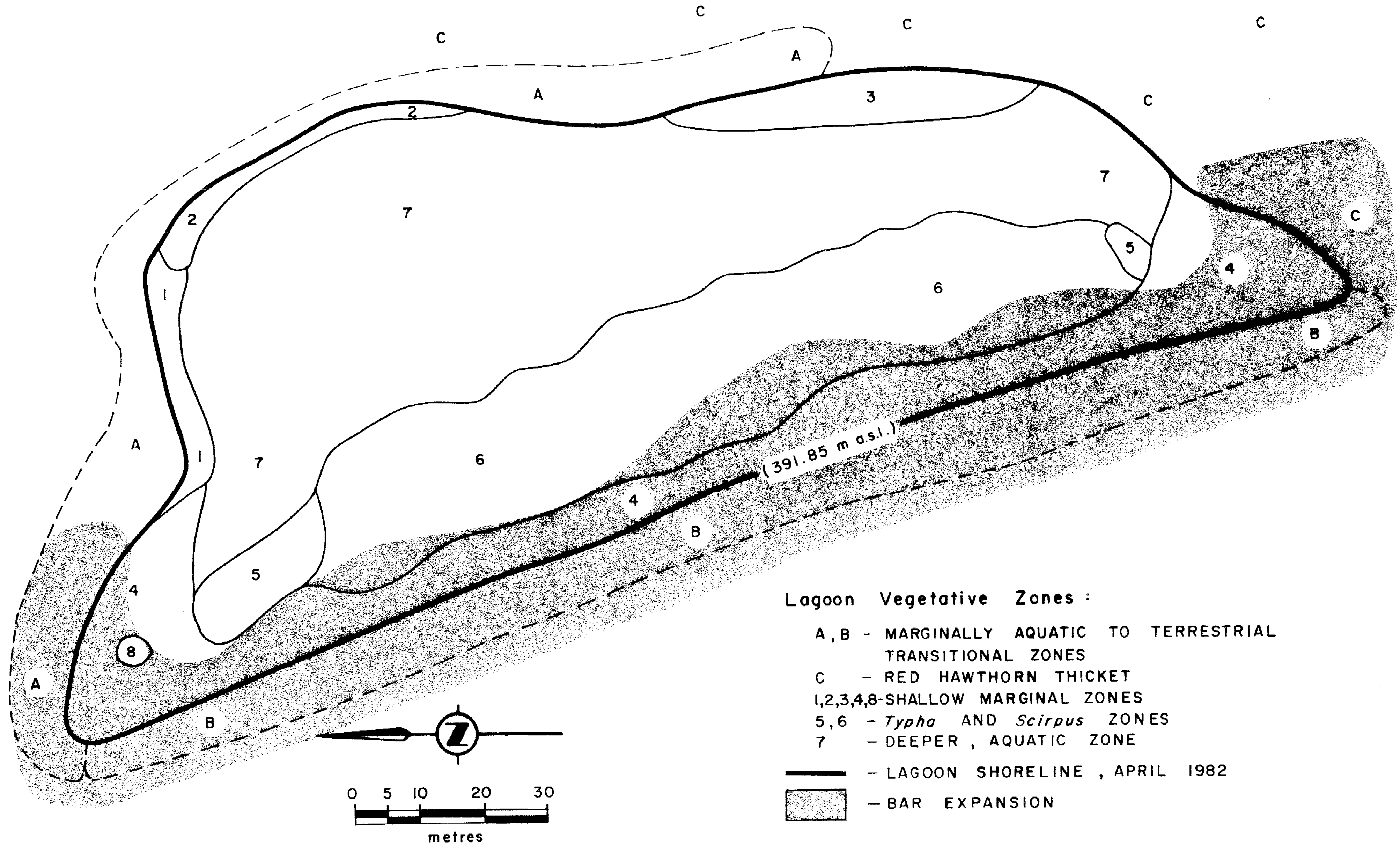


Table 1: Water Levels and Surface Flow Observations

Date (1982)	Water Levels: Kalamalka Lake[1] (m)	Cosens Bay Lagoon (m)	middle bench depression[2] (m)	Cattle Pond[2] (m)	Limit of Stream Flow: Red Hawthorn Creek[3]	Cosens Creek[3]
April 2	391.545	391.85	-	-	200 m u/s of middle bench depression	-
April 6	391.536	391.84	1.00	-	200 m u/s of middle bench depression	500 m u/s/ of Kalamalka L.
April 14	391.491	391.806	0.975	1.00	200 m u/s of middle bench depression	500 m u/s of Kalamalka L.
April 21	391.478	391.777	0.949	0.987	200 m u/s of middle bench depression	500 m u/s of Kalamalka L.
April 28	391.457	391.742	0.924	0.987	200 m u/s of middle bench depression	500 m u/s of Kalamalka L.
May 6	391.478	391.708	1.051	1.035	100 m d/s of middle bench depression	Kalamalka L
May 12	391.542	391.740	1.120	1.086	Cosens Bay Lagoon	Kalamalka L.
May 19	391.631	392.185	1.118	1.060	Cosens Bay Lagoon	Kalamalka L.
May 27	391.728	392.235	1.085	1.010	Cosens Bay Lagoon	Kalamalka L.
June 2	391.771	392.209	1.070	0.980	Cosens Bay Lagoon	Kalamalka L.
June 9	391.783	392.187	1.052	0.965	Cosens Bay Lagoon	Kalamalka L.
June 16	391.762	392.097	1.025	0.933	Cosens Bay Lagoon	Kalamalka L.
June 23	391.707	392.001	0.993	0.912	200 m d/s of middle bench depression	near Kal. L.
July 7	391.768	391.980	1.027	0.923	300 m d/s of middle bench depression	Kalamalka L.
July 22	391.811	391.938	1.050	0.939	300 m d/s of middle bench depression	Kalamalka L.
Aug. 4	391.740	391.867	1.019	0.925	300 m d/s of middle bench depression	near Kal. L
Aug. 19	391.658	391.795	0.90	-	200 m u/s of middle bench depression	300 m u/s of Kalamalka L.
Sept. 2	391.622	391.744	0.85	0.883	50 m d/s of Cattle Pond	700 m u/s of Kalamalka L.
Sept. 22	391.612	391.695	0.80	0.875	50 m d/s of Cattle Pond	700 m u/s of Kalamalka L.

[1] Water level at City of Vernon pumphouse

[2] Relative water levels not surveyed to geodetic reference

[3] u/s = upstream, d/2 = downstream

Table 2: 1982 Monthly Precipitation Summary at Kelowna Airport[+]

Month	Total Precip.	Normal	% of Normal
January	62.0	28.4	+118
February	19.7	21.0	-6
March	39.6	18.7	+112
April	12.0	17.7	-32
May	22.4	28.0	-20
June	62.2*	26.9	+131
July	94.2*	24.1	+291
August	27.6	30.8	-10
September	70.0	29.3	+140
October	24.4	19.0	+28

*New monthly record

+Kelowna Airport is approximately 28 km south of Cosens Bay Lagoon

Table 3: Lagoon Water Quality (sampled April 1, and July 7, 1982)

Water Quality Parameter	Results	
	April	July
Colour: True	150 Rel Unit	80 Rel Unit
Specific Conductivity	1010 μmho/cm	400 μmho/cm
Turbidity	7.4 N.T.U.	1.0 N.T.U.
Chloride: Dissolved	5.6 mg/L	1.1 mg/L
Hardness: $CaCO_3$	388 mg/L	N.A.
Nitrogen: Ammonia	<0.005 mg/L	0.005 mg/L
Nitrogen: $NO_2 + NO_3$	0.06 mg/L	<0.02 mg/L
Nitrogen: Organic	3 mg/L	1.42 mg/L
Nitrogen: Kjeldahl	3 mg/L	1.42 mg/L
Nitrogen: Total	3.06 mg/L	1.42 mg/L
Phosphorus: Ortho	0.007 mg/L	0.005 mg/L
Phosphorus: Tot. Dissolved	0.074 mg/L	0.039 mg/L
Phosphorus: Tot.	0.248 mg/L	0.066 mg/L
Silica: Reactive	14.9 mg/L	2.5 mg/L
Sulphate: Dissolved	181 mg/L	45.5 mg/L
Calcium: Dissolved	40.0 mg/L	N.A.
Sodium: Dissolved	58.5 mg/L	16.2 mg/L
Magnesium: Dissolved	70.0 mg/L	N.A.
Total Alkalinity	400.0 mg/L	174.0 mg/L
Potassium Dissolved	53.5 mg/L	19.0 mg/L
Total Salinity (Approximate)	824 mg/L	325 mg/L
pH	9.1	10.2
Oxygen	supersaturated	supersaturated
Temp.	$7^{\circ}C$	$23.5^{\circ}C$

Table 4: Plant Species List[1], Cosens Bay Lagoon

<u>Transition Zone Species</u>

Festuca rubra L.	red fescue
Hordeum jubatum L.	foxtail barley
Rumex maritimus L.	dock (or sorrel)
Potentilla anserina L.	silverweed (or cinquefoil)
Juncus balticus Willd.	long-styled rush
Carex sp. L.	sedge
Equisetum fluviatile L.	horsetail
Equisetum scirpioides Michx.	horsetail
Eleocharis palustris (L.) R.& S.	common spikerush

<u>Aquatic and Marginally-aquatic Zones Species</u>

Potamogeton pectinatus L.	sago pondweed
Potamogeton berchtoldii Fieb.	Berchtold's pondweed
Zannichellia palustris L.	horned pondweed
Elodea canadensis Rich.	Canadian pondweed
Chara sp. L.	stonewort
Utricularia vulgaris L.	common bladderwort
Sparganium sp. L	bur-weed
Polygonum amphibium L.	marsh smartweed (or amphibious bistort)
Scirpus lacustris L.	bulrush
Typha latifolia L.	cat-tail
Lemna minor L.	lesser duckweed
Eleocharis palustris (L.) R. & S.	common spikerush
Ranunculus sceleratus L.	cursed buttercup
Alisma plantago-aquatica L.	broadleaf water plantain
Cyperus[2] sp. L.	galingale

[1]Plant species were identified with the following keys:

<u>Vascular Plants of the Pacific Northwest</u> by C.L. Hitchcock, A. Cronquist, M. Ownbey, and J.W. Thompson. 1977. University of Washington Press. Seattle.

<u>Studies on Aquatic Macrophytes Part XXXIII. Aquatic Plants of British Columbia</u> by P.D. Warrington. 1980. British Columbia Ministry of Environment, Victoria.

[2] <u>Cyperus</u> species are normally associated with a transition zone and not an aquatic one.

Table 5: Water Body and Plant Species Clustering[+]

Group:	A			B				C		D				E				
Species: / Site Number:	1035	1036	1034	1047	1050	1049	1026*	1040	1041	1039	1033	1038	1043	1044	1045	1046	1042	1048
Ceratophyllum demersum		X						X	X	X								
Utricularia vulgaris							X	X	X	X			X	X	X	X		
Hippuris vulgaris													X	X	X	X	X	
Polygonum amphibium			X	X			X				X	X	X	X	X	X	X	X
Myriophyllum spicatum				X	X	X		X			X		X		X	X	X	X
Potamogeton pectinatus					X	X	X	X	X	X		X					X	X
Scirpus lacustris			X			X	X	X	X	X	X	X	X	X				
Typha latifolia					X	X	X	X	X	X	X	X	X					
Spirodela polyrhiza										X	X	X	X					
Lemna minor	X	X					X			X	X	X	X					
Potamogeton crispus					X	X		X			X	X						
Potamogeton berchtoldii		X		X	X	X	X			X								
Chara				X	X	X	X											
Potamogeton gramineus				X	X	X												
Potamogeton richardsonii					X	X												
Equisetum fluviatile						X	X											
Eleocharis palustris			X			X	X										X	
Zannichellia palustris					X		X											
Elodea canadensis					X													
Alisma plantago-aquatica	X						X											
Myosotis scorpioides	X	X																
Ranunculus macounii	X																	
Ranunculus aquatilis	X	X																
Ricciocarpus natans	X																	
Lemna trisulca		X																
Potentilla palustris		X																
Potamogeton natans		X																
Sparganium emersum		X																
Sagittaria latifolia														X	X			
Ranunculus sceleratus							X						X					X

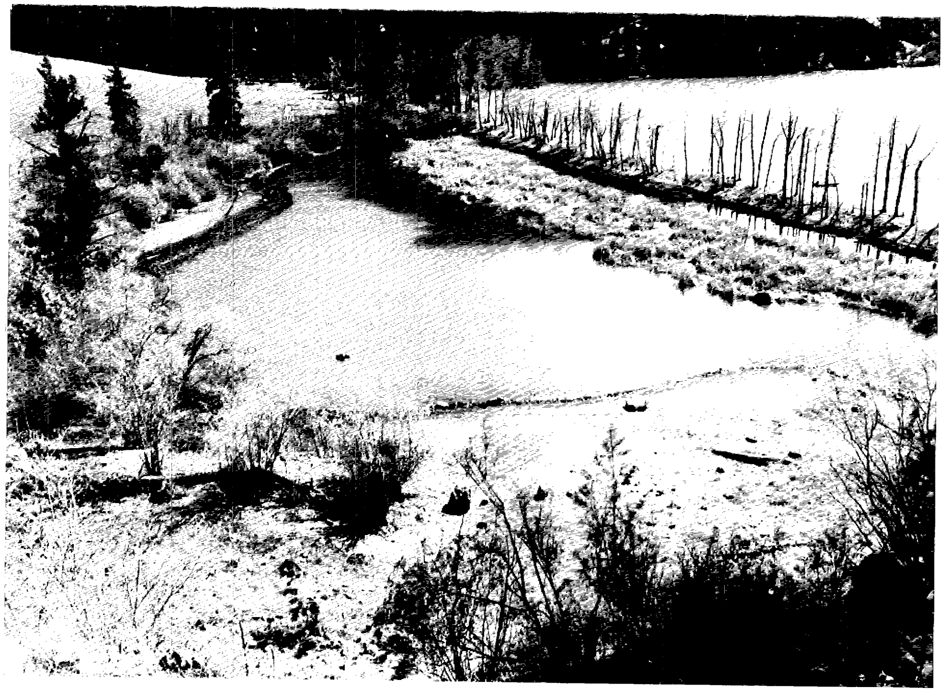
+This table was compiled to cluster groups of waterbodies with similar aquatic vegetation. The only criteria used was the presence of each aquatic plant species. Since all of these sites are shallow, formed by the same processes (except for Group A), and within the same climatic zone, other factors are assumed to be similar.

*Site number 1026 is Cosens Bay Lagoon.

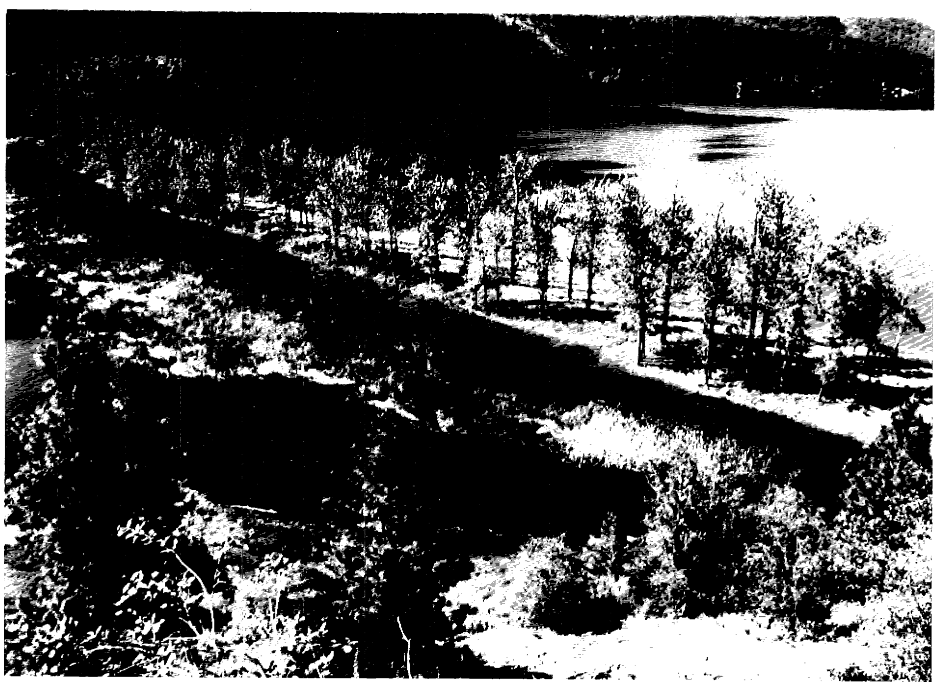
Table 6: Wildlife Observed in and adjacent to Cosens Bay Lagoon*

White-tail deer	*Odocoileus verginianus ochrourus* Bailey
Black bear	*Ursus americanus* Pallas
Yellow-bellied marmot	*Marmota flaviventris avara* (Bangs)
Muskrat	*Ondatra zibethica* (Linnaeus)
Western painted turtle	*Chrysemys picta belli* (Gray)
Western spotted frog	*Rana pretiosa pretiosa* Baird and Girard
Golden eagle	*Aquila chrysaëtos* (Linnaeus)
Osprey	*Pandion haliaetus* (Linnaeus)
Mourning dove	*Zenaidura macroura* (Linnaeus)
Red-winged blackbird	*Agelaius phoeniceus* (Linnaeus)
Belted kingfisher	*Megaceryle alcyon* (Linnaeus)
Goldeneye	*Bucephala* sp.
Cedar waxwing	*Bombycilla cedrorum* Vieillot
Mallard	*Anas platyrhynchos* Linnaeus
Canada goose	*Branta canadensis* (Linnaeus)

*Observations made by Water Management staff while collecting water level data during 1982.



Photograph 1: View of lagoon looking south, April 1982.



Photograph 2: View of bar looking south, June 1982.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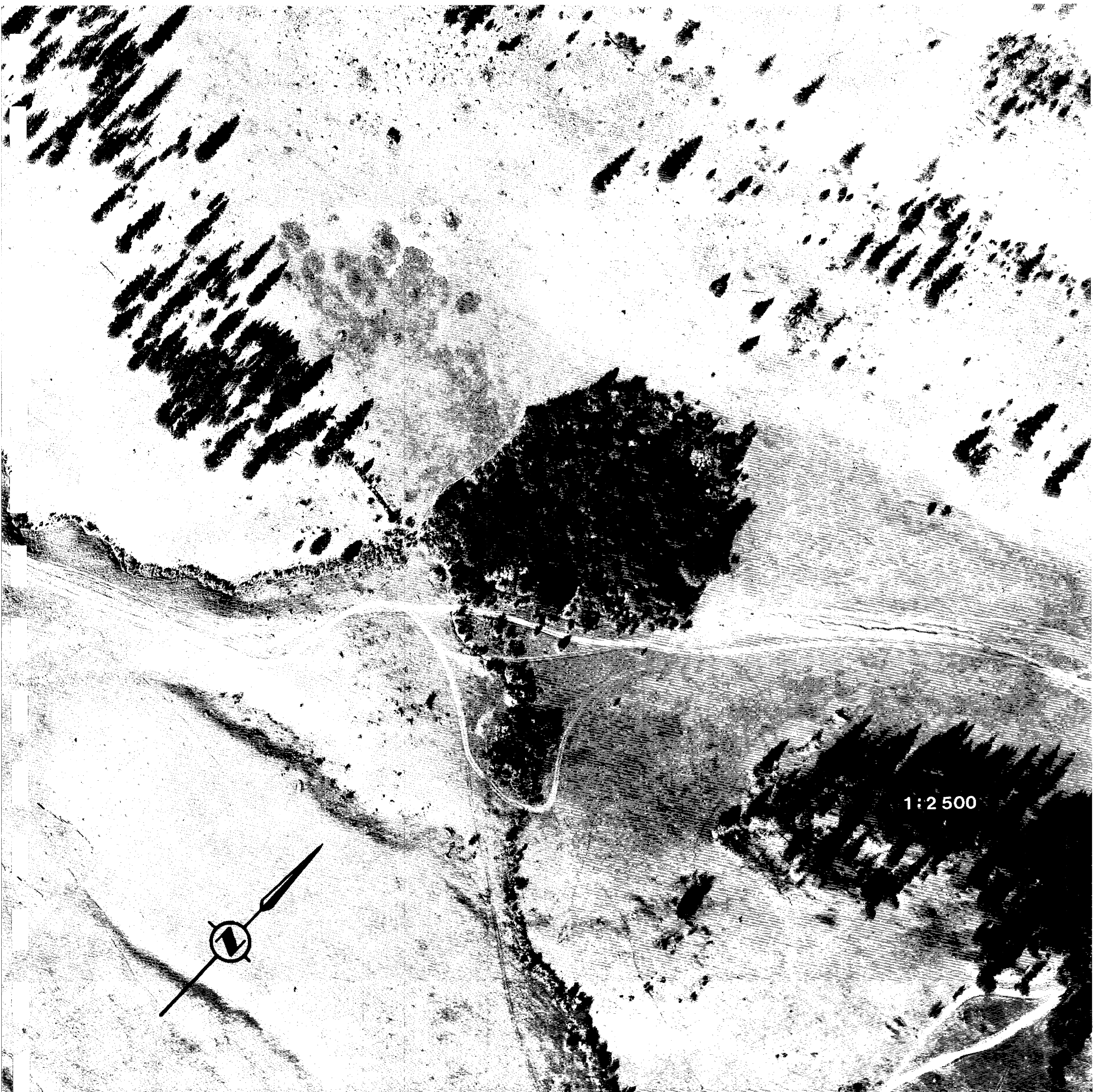
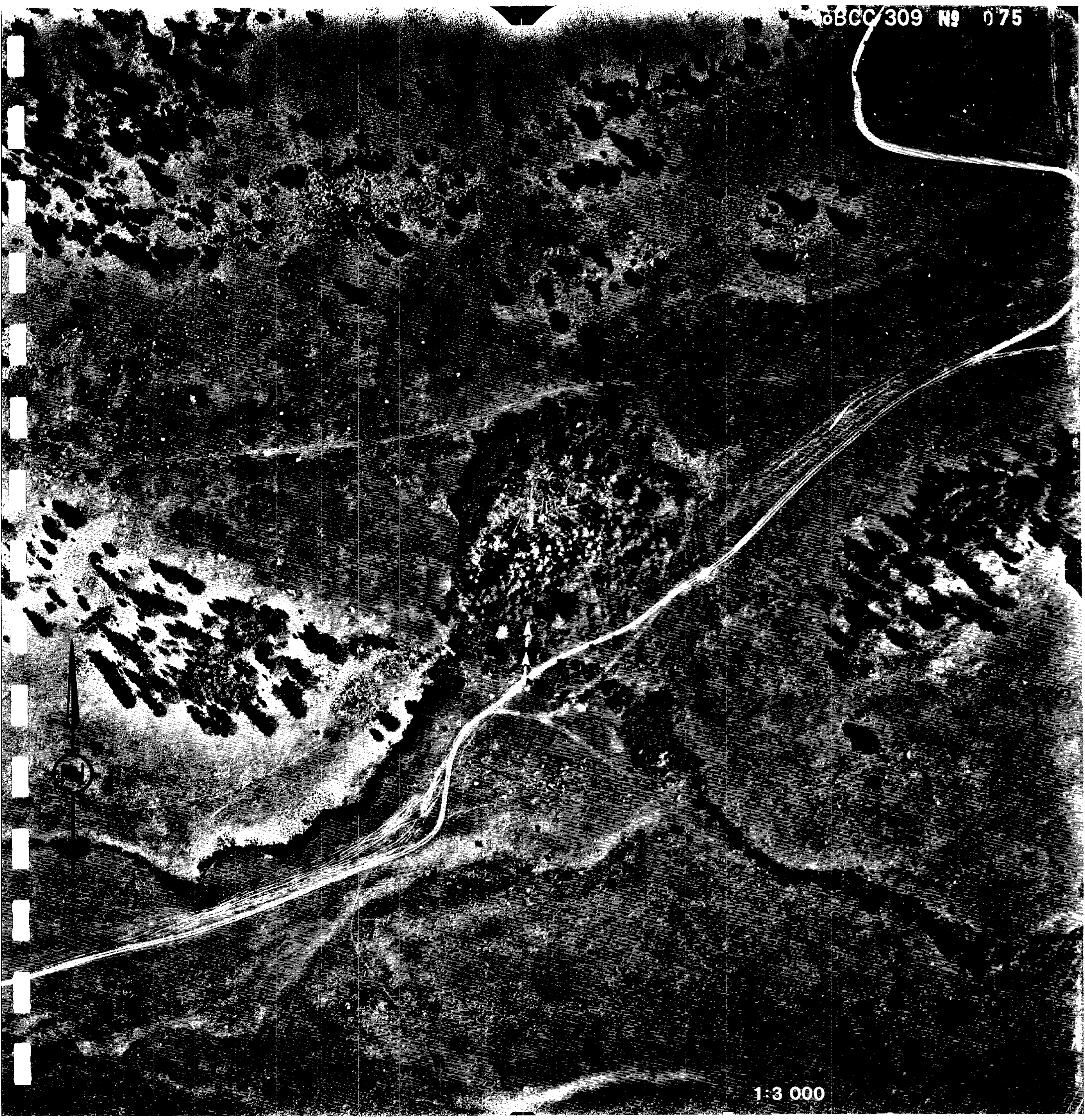
Photograph 3: Sediment core with Mount St. Helens ash layer from 3 200 years ago. Ash approximately 55 cm below sediment surface



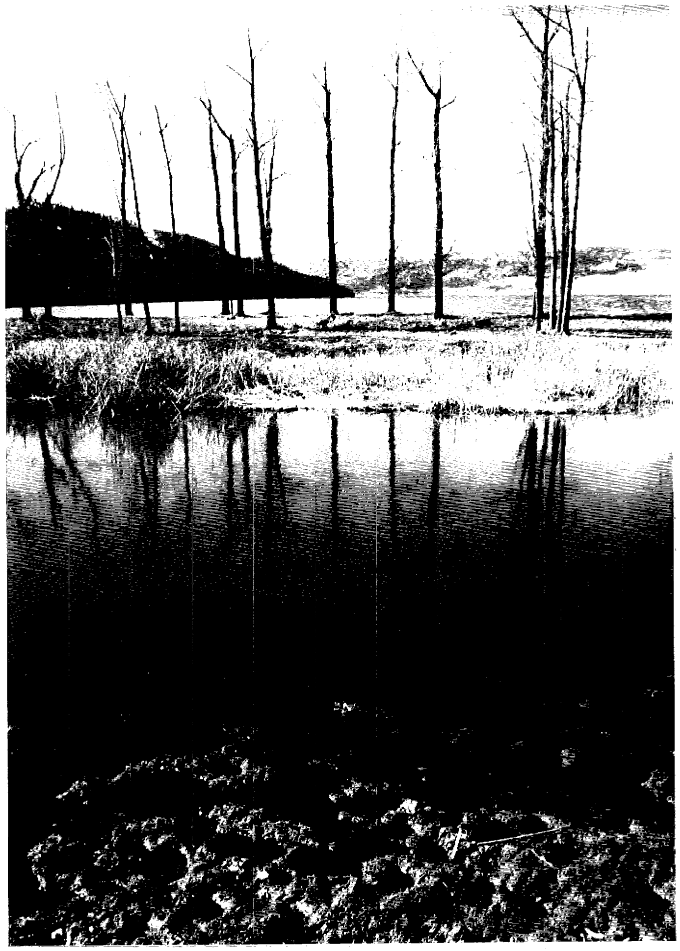
Photograph 4: Aerial view of middle bench depression, October 1975. The depression is the area in the centre of the photograph defined by the thickly wooded patch.



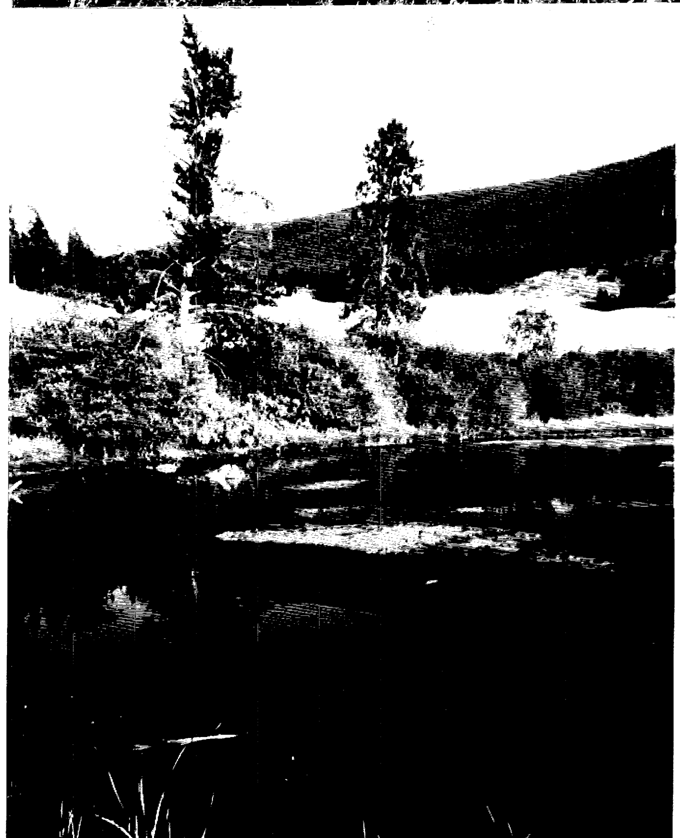
Photograph 5: Aerial view of middle bench depression, August 1982. Note tree mortality in centre of depression. Arrows indicate direction of inflow of Red Hawthorn Creek via culvert.

Photograph 6: Standing water in middle bench depression, April 1982.

Photograph 7: Plant zonation in area which would be covered by proposed fill. Zone numbers correspond to Figure 8. View is to the south, July, 1982.



Photograph 8: View of lagoon looking southwest with cattle damage in foreground. Note apparent lack of vegetation due to both cattle trampling and season (April 1982).



Photograph 9: Deep water zone (zone 7) looking to the southeast.