Camassia Natural Area
Monitoring of Hydrology and Hydric Plant Communities

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Purpose

The purpose of this project was to collect baseline information and create long term monitoring protocols for the ecological and hydrological systems of the Camassia Natural Area. The data will be used to determine the effects of, and possible solutions to mitigate for, the storm water run-off from the Villa Roma Estates located upstream from the preserve. West Linn H.S. students and Nature Conservancy volunteers will monitor the baseline data over time. The City of West Linn will use this data to attempt to solve the problem of the increase in surface water run-off.

This paper is meant to be an introduction for students and volunteers who will continue this work at the Camassia Natural Area. It should explain the work which has been completed as well as that which we hope will be completed.

Introduction

The Camassia Natural Area, managed by the Nature Conservancy, is located along I-205 in West Linn, Oregon (Appendix 4). Since 1977, the Camassia Natural Area has been altered by storm water runoff from the Villa Roma Estates. The Area collects water more quickly than it can disperse it. This creates floods, erosion, and damage to the downstream neighborhood homes. The increase in water levels also effects the plant life by creating an ideal habitat for English Ivy (which kills trees) and Himalayan Blackberry, both of which are non-native, invasive species. There are three major inflows into the Camassia Natural Area coming from Villa Roma Estates (Apendix 1). These storm drains were constructed in 1979 to direct stormwater from this subdivision through three small creeks running into the Area. Trails have since been eroded and the rainy season creates a big problem for residents on Walnut Road. Two of the culverts have runoffs all along the north and south side of the ponds and adjacent wetlands. The third, and main contributing culvert has multiple channels, all leading to the central pond.

Methods

Although maps of the Camassia Natural Area have been made in the past, natural erosion, recent development, and runoff have made these maps incomplete. Maps made in the past also did not identify the vegetation found along the waterways and ponds. Waterways which were not on the most current maps were identified. New maps were constructed to illustrate the hydric plant communities and their physical relation to the waterways.

Hydrology

In order to monitor the hydrological system, a water budget must be completed. A water budget is the balance of the inflows and outflows of water to a wetland system. There are three factors which affect the inflows: net precipitation, surface inflows, groundwater inflows. There are also three factors which affect the outflows in a wetland system. They are evapotranspiration, surface outflows, groundwater outflows (Mitsch and Gosselink, 1993).

Precipitation (rainfall and snowfall) is one of the major factors that contribute to a water budget. The vegetation in Camassia often catches a lot of the precipitation. The water that passes through the vegetation to ground level is called throughfall.

Surface inflows are exactly what they sound like, inflows into a wetland system on the surface of the soil. There are several different types. The first is overland flow. It is the nonchannelized flow that immediately follows heavy rainfall or spring thaws. The second is streamflow, a stream that flows through the wetland. The third is quickflow. Quickflow is the amount of precipitation that results in direct runoff. In the Camassia Natural Area this is especially critical since precipitation falls on impermeable surfaces in the Villa Roma subdivision and directly influence the Area. Surface outflows are the opposite. They are the outflows on the surface of a wetland system. They are normally in the form of a stream or creek. In the Camassia Area these streams are flooding neighborhood homes.

Groundwater inflows and outflows are the hardest to measure and may be a very important variable in the Camassia Natural Area due to the basalt formations. They consist of the water that is flowing into and out of a wetland system below ground. Groundwater outflows are the waters that are flowing out of a wetland below the surface.

Evapotranspiration is the water that evaporates (water that changs from a liquid phase to gas phase) together with water that passes through vascular plants to the atmosphere (transpiration).

Plant Community Structure

Vegetation communities were identified using a line transect sampling method (Smith 1980). Three sample locations were identified for long term monitoring (Appendix 2). In this technique, a line of constant length is used in order to make a frequency rating of the appearance of plants in a study area. At each meter of the 30 meter transect the species present was identified. A percentage was taken in order to find the percent occurrence of each species.

In addition to the quantitative data, a map showing the current distribution of plant communities in the preserve. More attention was given to the current distribution of plant communitties along the waterways (Appendix 2).

Results and Future Work

Hydrology

Based on several site visits existing maps were updated (Appendix 1). With streams and ponds identified, flow meters and staff gauges can be installed to monitor inflows, outflows and pond levels. Elevations of existing ponds should be measured and monitored. This data will be used to create a water budget.

Oak tree in the preserve

No data were collected to calculate a water budget. Future work should be directed towards collecting data which will be used in creating a water budget. The water budget will establish the effects of the inflows from Villa Roma Estates.

Plant Community Structure

One sample survey was taken of each of the three transects (Appendix 3). These data combine the ground and shrub layers of vegetation. In the future each stratum of vegetation should be surveyed along a line transect. Data sheets should be created to standardize data collection.

A map was created to show the physical relation of plant communitiies to the waterways (Appendix 2). This map provides a baseline for future changes in plant community location.

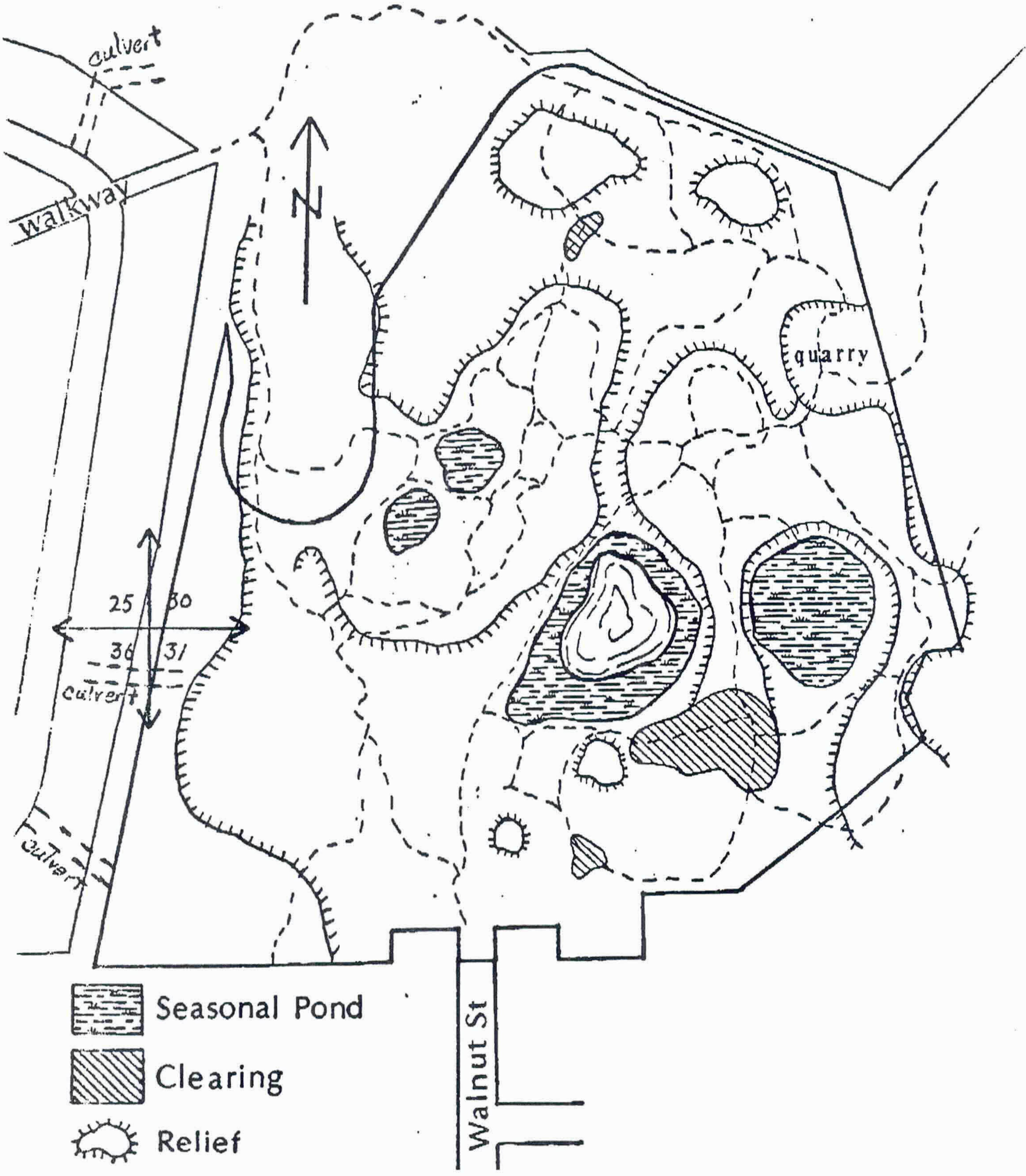
References

1993 Wetlands, 2nd ed., Van Nostrand Reinhold, New York.

1980 Ecology and Field Biology, 3rd ed., Robert Leo Smith, New York.

Camassia

1" = 200'



Appendix 1. Map of Inflows, Ponds, and Outflows in the Camassia Natural Area

Appendix 2. Map of Plant Community Distribution in the Camassia Natural Area

not available

Appendix 3. Frequency of Herb/Shrub Stratum in Three Established Transects

All fractions were reduced to the lowest common denominator and are ranked from top to bottom. Totals do not add up to 100 percent because of the combination of shrub and herb strata.

Transect 1- frequency

Ivy	13/15
Blackberry	4/15
Maple	4/15
Duck Feet	1/6
Sedge	1/6
Bracken Fern	2/15
Western Sword Fern	1/15
Grass	1/30
English Holly	1/30

Trancect 2- frequency

Bracken Fern	4/15
Blackberry	3/15
Ivy	2/15
Grass	2/15
Duck Feet	1/10
Snow Berry	1/15
Western Sword Fern	1/30
Alder	1/30

Transect 3- frequency

Ivy	15/21
Blackberry	7/21
Duck Feet	9/21
Bracken Fern	2/21

Combined Total- frequency

Ivy	45/81
Blackberry	31/81
Duck Feet	17/81
Bracken Fern	14/81
Maple	8/81
Sedge	5/81
Grass	5/81
Western Sword Fern	3/81
Snow Berry	2/81
Alder	1/81

ANAGEMENT AND USE

ıray Miller's wish to preserve Camassia for ıre generations of students and lovers of ıral history has come true. Since its protec-ı, thousands of schoolchildren, college dents, local residents and nature enthusiasts :oughout Portland's metropolitan area have ndered over Camassia's 27 acres to study and ɔy this beautiful natural area. An endow-nt was established in 1981 by the Frank ndari Family in memory of Antonio and gelina Cundari. This endowment provides ds for the management of the special values tected at Camassia.

ı too are an important part of the continued tection of this special place. Camassia is ɜry fragile natural area. Its shallow soils, ıds and swales and rare plants can be easily :urbed. It is important that visitors treat the d with extreme sensitivity. The rocky teaus are especially fragile—each step nages the mosses, lichens and other small nts that cling to the bedrock (vibram soled ɔes are not recommended).

EASE

tay on the trails
'o camping or fires are allowed
ɔ not pick flowers, leave them for others to enjoy
eave your dog at home
ick up any trash you might encounter

ɛearcher examines rare plants at Camassia.

Volunteer removes Scotchbroom from grassy plateau.

THE NATURE CONSERVANCY

The Nature Conservancy is the only private nonprofit land conservation organization dedicated solely to the preservation of natural diversity. The Conservancy has protected over 2 million acres of forests, savannas, marshes, prairies and aquatic systems throughout the country. In Oregon, the Conservancy manages 32 preserves totaling nearly 35,000 acres. All preserves are acquired through private dona-tions of land or money, and all donations are tax deductible.

For further information about The Nature Conservancy, its preserves, activities, or membership, contact:

The Nature Conservancy
Oregon Field Office
1234 NW 25th Avenue • Portland, Oregon 97210
Telephone: (503) 228-9561

The Nature Conservancy

Appendix 4

CAMASSIA NATURAL AREA

THE NATURE CONSERVANCY

CAMASSIA NATURAL AREA

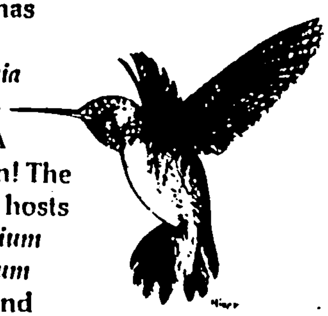
WELCOME

In 1962, through the encouragement of Murray Miller, a long-time resident of Oregon City and well known naturalist, The Nature Conservancy purchased its first preserve in Oregon. On the bluffs overlooking the Willamette River near West Linn, the Camassia Natural Area has kindled the imagination of Oregonians for the preservation of an additional 32 preserves on 35,000 acres throughout the state. While Camassia remains one of the smallest preserves n the state, its importance has increased with he development of the Portland metropolitan rea. Since its purchase, several rare plant species and habitat types have been identified at Camassia. These elements of Oregon's natural liversity are nowhere better protected than iere.

NATURAL HISTORY

Camassia's tangled woodland of Oregon white ak, madrone and Douglas fir, its wildflower neadows and rock gardens, its maple and cotonwood forests, and willow and aspen swales nd ponds, contain a great iversity of plant life. Over three hundred pecies have been idenfied including many that e slowly disappearing om the Willamette alley. Hall's aster *(Aster allii)*, Willamette Valley ittercress *(Cardamine pendiflora)*, pale larkspur *Delphinium leucophaeum)*, d quaking aspen *opu s tremuloides)* still rive in is protected rner of W Linn. In id to-late A the

grassy plateaus are awash with the color of blooming camas *(Camassia quamash)*, large flowered collinsia *(Collinsia grandiflora)* and rosy plectritis *(Plectritis congesta)*. A sight never to be forgotten! The maple/cottonwood forest hosts giant fawn lilies *(Erythronium oregonum)*, trilliums *(Trillium chloropetalum, T. ovatum)* and western wild ginger *(Asarum caudatum)*. Poison oak *(Rhus diversiloba)* is abundant amongst the oak and madrone—so watch your step!

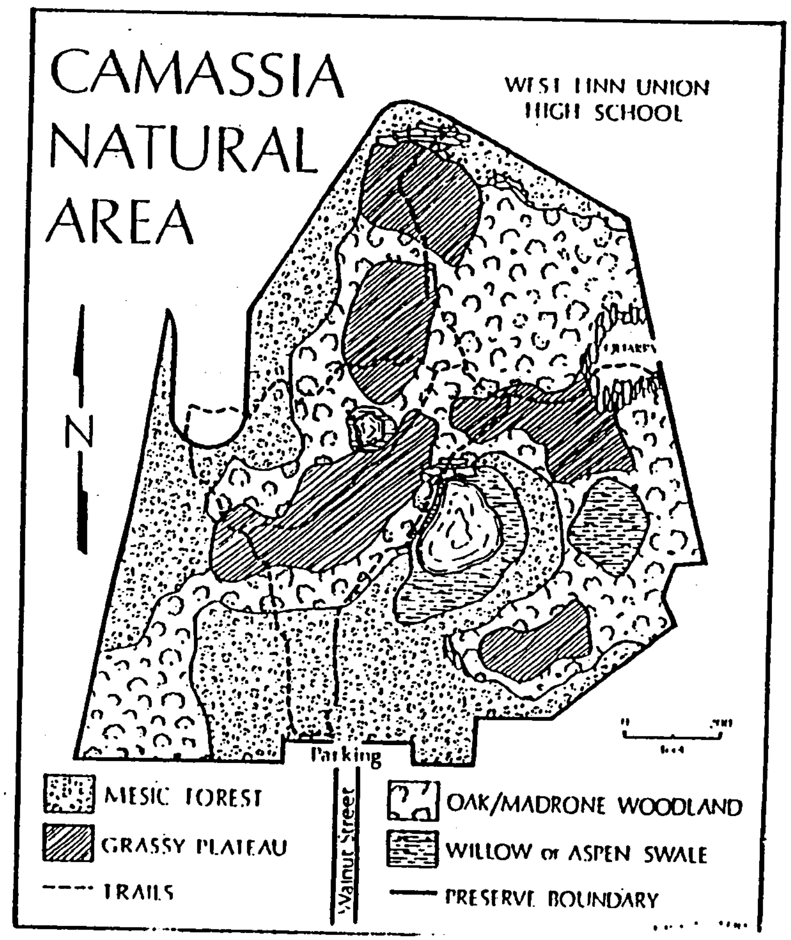


This diversity of plant communities and habitats provides for a wide variety of wildlife on the preserve. Species such as the white-footed mouse, ringneck snake, Pacific tree frog, and the western gray squirrel can be seen on the preserve. Wood ducks sometimes use the ponds and it is common to see California quail, rufous hummingbirds, hairy woodpeckers, western bluebirds, golden crowned kinglets and cedar waxwings flying overhead or nesting in the trees.

GEOLOGY

The rich diversity of plants and animals found on the Camassia Natural Area is a result of a catastrophic geologic history. The bedrock that is exposed so beautifully at Camassia is Yakima Basalt from a series of lava flows which occurred about 15 million years ago, flowing through a broad ancestral valley of the Columbia River from vents in eastern Oregon and Washington.

From 12,000 to 19,000 years ago, a series of major floods, the Missoula or Bretz Floods, poured down the present Columbia River Gorge and up the Willamette River Valley as far south as Eugene. The Willamette River rose 400 feet, widening the valley. The force of these floods swept soils and vegetation from parts of the valley and deposited ice rafted granitic boulders (erratics) from as far away as Canada. The Camassia Natural Area contains an excellent record of these events. The dark grey basalt bedrock is exposed throughout the meadows. Examples of the granitic erratics (salt and pepper colored) are found in the quarry.



WHY PRESERVE BIOLOGICAL DIVERSITY?

Biological diversity refers to the natural variety of living things and the processes that support them. Diversity is measured not only in the quantity of living things but in the quality of the ecosystems in which they survive. Genetic diversity within species is important as well as diversity between species. Extinction is a natural process of evolution. Over the past 600 million years the natural background rate of extinction has been about one species per year. Unfortunately around the world now the rate has dramatically increased to more than one species going extinct each day!

Why should we care? Because humans depend on the survival of other species. Here are just four compelling reasons for protecting biodiversity. First, each species plays a discrete role in nature, interacting with other species through a complex web of relationships. A rich diversity of species ensures the balanced healthy environment on which ecosystems depend. When one link in this complicated web of life weakens or disappears the rest of the chain is affected.

Second, and perhaps most directly felt by humans, are the benefits we derive from plants and animals. Almost half of our pharmaceutical products that lessen our pains, cure diseases, and lengthen lives are derived from other species (mostly plants). Our food crops also are dependent on the continued existence of wild species. The world's agriculture relies on only a few species and we must continue to strengthen our domestic varieties by hybridizing them with wild species in order to improve their vigor, taste, disease resistance or climatic tolerance. Scientists have only explored a tiny fraction of species for potential benefits to humans and we need to assure the survival of the diversity of life so that we have the opportunity to continue to do research. Natural areas provide opportunities for scientific inquiry into natural ecological processes. The Pacific Yew is just one example of a species that was once considered useless to humans until recently when taxol was discovered to be useful in treating cancer.

There are other reasons for preserving species that are difficult to evaluate in terms of economic benefits. Species and communities have aesthetic value and enrich lives in a variety of ways. Biologic diversity in its natural landscapes provide creative inspiration, recreation and relaxation as well as a place where our children can play and learn about the natural environment.

Finally, one may have moral or ethical reasons to respect and protect other species. Some believe that species have intrinsic value and the right to live because they are living. Perhaps humans have the moral responsibility to protect life of earth.

CAMASSIA PRESERVE USE GUIDELINES

The Camassia Natural Area is visited by thousands of people each year. This high level of public use needs to be managed so that it is not damaging to the preserve and the natural heritage it protects. Therefore we ask you to abide by the following use guidelines. Our efforts will educate visitors about the values of natural areas, genetic diversity, and habitat preservation, while demonstrating to visitors the importance of conscientious and caring use of the preserve.

Leaders planning a group visit to Camassia should contact the Conservancy prior to scheduling a final date for the outing. The Conservancy needs to track the amount of public use the area gets.

Stay on the trails. This will avoid excess erosion and the disturbance of vegetation. Trails on the preserve are known to be excessively muddy in the spring so bring appropriate footwear or avoid those areas of the preserve.

Beware of the dangers inherent in poison oak, and the presence of ticks. Ticks are not very common at the preserve but poison oak is! This plant is a native therefore we do not discourage it except to cut it back from the trails. This is another good reason to stay on the trails.

Do not pick flowers. Enjoy their beauty and charm but do not disturb them. A picked flower cannot reproduce future generations.

Do not disturb vegetation, wildlife, or scientific study plot markers.

Dogs are not allowed in order to prevent disturbing ground nesting birds and other animals. Dogs are not native to this ecosystem.

Horses are not allowed in order to reduce erosion of the trail, reduce the spread of non-native plants and prevent unsafe interactions with pedestrians.

Bikes and other vehicles are not allowed. They can cause a great deal of damage to the soils and vegetation.

No hunting or firearms allowed. This is a residential area.

No camping and no fires. The natural area is fragile and should not be trampled under campsites. Escaped fire is a threat to the preserve and surrounding neighbors.

Do not litter. Unfortunately it seems that garbage is often left on the preserve. Please take time to pick up any trash you see and deposit it in the trash can at the preserve entrance.

SPECIAL TOPICS

Poison oak is found in large quantities throughout the preserve. Many people are allergic to the oil, urosiol, found in its sap. After several hours the oil is absorbed by the skin. People sensitized to poison oak break out in itchy, swelling rashes, sometime after contact with the oil. The oil can also be spread about on a person, to others, or from pets and tools. Recognize poison oak as a slender shrub or vine, with 3-lobed leaves, that are often red and shiny. If touched, the oil, and thereby its effects, should be washed off with soap and water as soon as possible. Although it is a nuisance to many humans, poison oak is a native plant and a natural part of the Camassia Natural Area. The berries are a favorite among many of the birds. Therefore we do not consider this plant a weed. We cut it back from the main trail but do not disturb it elsewhere. See line drawing of poison oak in the appendix.

The largest human-made topographic feature at Camassia is an **abandoned quarry** in the preserve's northeast corner. The quarry was excavated by the city of West Linn in the early 1900's and used as a source of basalt blocks and gravel for decades. The quarry is a horseshoe-shaped pit, opening to the east, and is approximately 20ft deep and 175ft across at its widest point. Over the years the quarry has become a unique feature to the preserve, serving as a habitat for an array of rock-adapted species. **Special care should be taken on the trails surrounding the quarry because of the significant drop and risk of injury.**

Yellowjackets are also a concern to be aware of when hiking on the preserve. Ground nests are common throughout the natural area so make sure the group stays on the established trails to avoid the unwelcome surprise of meeting these aggressive bees as you hike.

HISTORY OF OWNERSHIP OF CAMASSIA NATURAL AREA

In 1962, through the encouragement of Murray Miller, a long-time resident of Oregon City and well known naturalist, The Nature Conservancy purchased its first preserve in Oregon. On the bluffs overlooking the Willamette River near West Linn, the Camassia Natural Area has kindled the imagination of Oregonians for the preservation of an additional 49 preserves on over 40,000 acres throughout the state. While Camassia remains one of the smallest preserves in the state, its importance has increased with the growth of the Portland metropolitan area. Several rare plant species and habitat types have been identified at Camassia. These elements of Oregon's natural diversity are nowhere better protected than here.

Historically, ownership of the land can be traced back to two brothers, Hugh and Dan Burns. Following the Donation Land Claim Act of 1850, each claimed 320 acres, with the Camassia site occupying a part of both brother's claims. No historical land use is documented, but Murray Miller believes that the Burns brothers once used the land for grazing. He bases his claim on remnants of an old fence he found during his early years at Camassia. It is also believed that the area was selectively logged.

After the Burns brothers, Portland General Electric acquired the land for some time before it was sold to Les Wievesiek, an Oregon City realtor. It was from Wievesiek that The Nature Conservancy purchased Camassia in 1962.

MANAGEMENT CONCERNS AT CAMASSIA

Camassia is a natural area surrounded almost entirely by developed lands. Although there are some pockets of native vegetation outside the preserve boundaries, extensive urbanization has effectively isolated the preserve. Most of the adjacent lands are privately owned, with the exception being the boundary shared with West Linn High School.

The increased urbanization in the area has created various management concerns. The increase in the number of people in the surrounding area means that the preserve gets a higher amount of public use. The preserve is open to the public and the Conservancy encourages educational and passive recreational use of the area, but higher levels of use means a greater need for management of that use so that it does not negatively affect the area. Higher use is correlated with other potential problems including higher amounts of litter, greater risk of fire from human causes, and the disturbance of vegetation if people do not stay on defined trails.

Impact to the hydrology of the preserve is another management concern. Construction of the subdivision west of the preserve changed a portion of Camassia's watershed from natural runoff to stormdrain flow. Therefore the water quality and quantity have been altered from its natural condition.

The introduction of exotic species is also a serious management consideration at Camassia. Non-native species that are introduced into a native ecosystem compete for resources with the native vegetation and in some cases these weeds can crowd out the natives. The exotic species that are the main problems at Camassia include Scotch broom, English ivy and English holly.

The Stewardship department works to eradicate these species by organizing work parties to pull these weeds and remove them from the property.

TOPOGRAPHY AND GEOLOGY

Camassia is positioned on a basalt terrace on the east side of the Willamette Heights Hills, one-quarter mile north of Oregon City Falls. The terrace has a downward slope southeasterly towards the Willamette River. The elevation of the preserve drops from 340 ft at the west boundary to 250 ft at the southeast boundary. In the center of the preserve is a basalt plateau intermediate in elevation to the high ground to the west and low ground to the east and south.

The bedrock that is exposed at Camassia is Columbia River Basalt from a series of lava flows which occurred about 15 million years ago, flowing through a broad ancestral valley of the Columbia River from vents in eastern Oregon and Washington. Columbia River Basalt is a dark gray to black, dense and finely crystalline basalt, often columnar jointed.

During the end of the last ice age between 12,800 and 15,000 years ago, a continental ice sheet (glacier) dammed the Clark Fork River near the Idaho/Montana border creating a vast lake. Periodically the lake broke through the ice dam resulting in a series of colossal floods called the Bretz floods. Fifty cubic miles of water were released in an estimated two weeks. The water poured down the present Columbia River Gorge and up the Willamette River Valley as far south as Eugene. The Columbia River rose 400 feet widening the valley and covering Camassia with 100 feet of water.

As the flood waters rushed over Camassia, soil, rock and vegetation were scabbed off the basalt. Boulders of basalt were broken loose from the bedrock. The currents carved out gullies, which are now swales north, south, and east of the central basalt plateau. Soil and rock washed from the bedrock has left 30 to 40 foot scarps towering over gullies along the northern boundary of the preserve. Depressions in the central plateau have since become seasonal ponds. A number of ice-rafted, granite eratics were deposited on Camassia by the Bretz Floods, and can be found there today.

HYDROLOGY

Four seasonal ponds are located within the preserve. The most eastern of the large ponds is filled with willow. Even is winter when the pond is full, there is no open water. The other large pond, located near the center of the preserve, contains over 900 square feet of open water surface when full. The other two ponds are much smaller and not visible from the trail. In summer all four ponds may dry completely.

Water runoff from the central plateau is the primary source of water for the ponds. Water drainage from the upper elevations of the Willamette Heights hills supplies water to gullies in the west, north and south portions of Camassia.

The key stewardship objective for the seasonal ponds at Camassia has been to maintain water quantity and quality as close to pre-development levels as possible. Because of surrounding influences, the water quality and quantity has been affected. See map in appendix.

VEGETATION

Botanically the preserve contains an unusually high diversity of flora which can be separated into four distinct communities: 1) The Oregon white oak and madrone woodland was once much more common in the Willamette Valley. Now it is relatively rare because most of the valley has been cleared due to agricultural and developmental pressures. 2) The mesic forest consists of Douglas fir and big leaf maple and has a dense shrub layer of Oregon grape, poison oak, vine maple and salal. 3) The Oregon ash and willow swales surround the wet ponds. 4) The interior of the preserve consists of shallow-soiled open grassy plateaus that are covered with a beautiful display of wildflowers in the spring including the camas lily for which the preserve is named.

Over 350 species of plants are found at Camassia, including 45 species of mosses and lichens. Some of the more common wildflower species that bloom in May on the plateaus include camas lily, rosy plectritis, wild rose, collinsia and buttercup. In the shadier, wooded areas one would find trillium, fawn lilies, toothwort, and wild ginger blooming in the spring.

Included within its meadows and woodlands are plant species and plant communities whose occurrence is very rare in the Willamette Valley and are of particular interest to The Nature Conservancy. One is the wildflower Delphinium leucophaeum commonly known as pale larkspur. This species is a candidate for federal status as threatened or endangered. It occurs in scattered subpopulations on the thin, rocky soils of the preserve. The Heritage Program ranks this species G2S2, indicating that it is in danger of extirpation throughout its range. Camassia is one of the few protected habitats of this plant. The grassy plateau community is a remnant of an extremely rare habitat created by the Bretz floods. California oatgrass is the dominant species at only two other locations in the state. Another community type that is found at the preserve and considered rare is the pond which hosts quaking aspen and sphagnum moss.

See appendix for plant species list and a list of common wildflowers blooming in the spring as well as a map of the vegetation types

WILDLIFE

The diversity of plant communities and habitats provides for a wide variety of wildlife on the preserve. One is likely to see the tracks of raccoons and deer in the mud near the ponds in the spring and hear several species of birds singing.

Relatively common amphibians and reptiles in the area include the rough-skinned newt, the pacific treefrog, and the western fence lizard. The ring-necked snake has also been seen in the rocky areas of the quarry but is not common.

Mammals and rodents such as the white-footed mouse, western gray squirrel, deer, and raccoon find suitable habitat at Camassia. These creatures are relatively secretive so sitings are rare.

The rich diversity of bird life at Camassia includes rufous hummingbirds, hairy woodpeckers, western bluebirds, golden crowned kinglets, California quail, black-capped chickadees, cedar waxwings and many more species. One may see mallards and wood ducks utilizing the ponds in the natural area also. See appendix for a species list for Camassia.

CULTURAL HISTORY

Before white settlers came to the Willamette Valley the native people of the Chinook tribe inhabited the area. The Clackamas, Clowewalla, and Multnomah were members of this larger Chinook family and most likely were the inhabitants of Camassia Natural Area and its surroundings. The native people depended on the Willamette river as a trade route and source of fish for the main staple of their diets. The wood of the Douglas fir and western red cedar were used to build their dwellings and tools. Besides fish they hunted for meat and enjoyed a multitude of nuts, berries and roots of common northwest plants. Some of the staples included salal berries, elderberry, Indian plums, wappato roots, and camas bulbs. It is likely that the camas plateaus at Camassia were harvested by the Native Americans.

Harriet Smith wrote about this important plant in Camas: The Plant That Caused Wars which is summarized here.

Camas, or quamash root, was a staple vegetable food of Indians in the Pacific Northwest and grew abundantly in fields and low meadows which were moist from winter's rains and snow. Diarists, botanists, explorers, have written descriptions of the rippling fields of blue camas and described the sustenance it provided them.

Lieutenant William R. Broughton(1761-1821) journeyed up the Columbia with botanist Archibald Menzies(1754-1842). In October, 1792 Broughton recorded:

"bulbous root, about the size and not unlike the crocus, that ate much like mealy potatoes."

In the fall of 1805, thirteen years later, Meriwether Lewis entered an Indian village on September 20 and wrote:

"...They now set before them a small piece of buffaloe meat, some dried salmon, berries, and several kinds of roots. Among these last is one which is round and much like an onion in appearance and sweet to the taste: it is called quamash, and is eaten either in its natural state, or boiled into a kind of soup or made into a cake, which is then called pasheco. After the long abstinence this was a sumptuous treat."

Camas has been called a wild hyacinth. Greek mythology tells of how a plant started from the blood of a beautiful Spartan youth, Hyacinthus, whose death had been caused by jealous Zephyrus. Indian legend and lore includes references to camas. Indian oral tradition tells of how blood was shed when fighting broke out between jealous Indian tribes over the possession of the fields of hyacinth-like camas flowers.

Camas fields were the most desirable places for immigrant farmers to plow and plant. When the farmer began plowing up the meadows of camas and planting cultivated crops, the Indians saw a threat to their already limited food supply. After the Indians' effort of formal protest through the United States government officials failed fighting between farmers and Indians broke out.

The camas lily has certainly been important in Pacific Northwest history as a vegetable crop which had been harvested for centuries.

WHY IS THE NATURE CONSERVANCY PROTECTING CAMASSIA NATURAL AREA?

Camassia is a place of unique botanical and geologic features. Although Camassia is small its biological diversity is great and highly valued especially since it contains relatively isolated remnants of communities and species that were once much more common in the Willamette Valley. The pale larkspur, grassy plateaus, and aspen/sphagnum swale are protected at this natural area and very few other places. The Conservancy's goal is to assure the health of these rare species and communities by monitoring their condition and managing the area to protect them.

Camassia is unlike many of the Conservancy's other preserves. The 27 acre natural area is virtually surrounded by suburban pressures. The metropolitan surroundings create management challenges but Camassia's close proximity and accessibility leads to a wonderful educational opportunity. Hopefully the people that visit the preserve can gain insight and knowledge into the natural history of the area and also an understanding of the importance of protecting special places like Camassia.

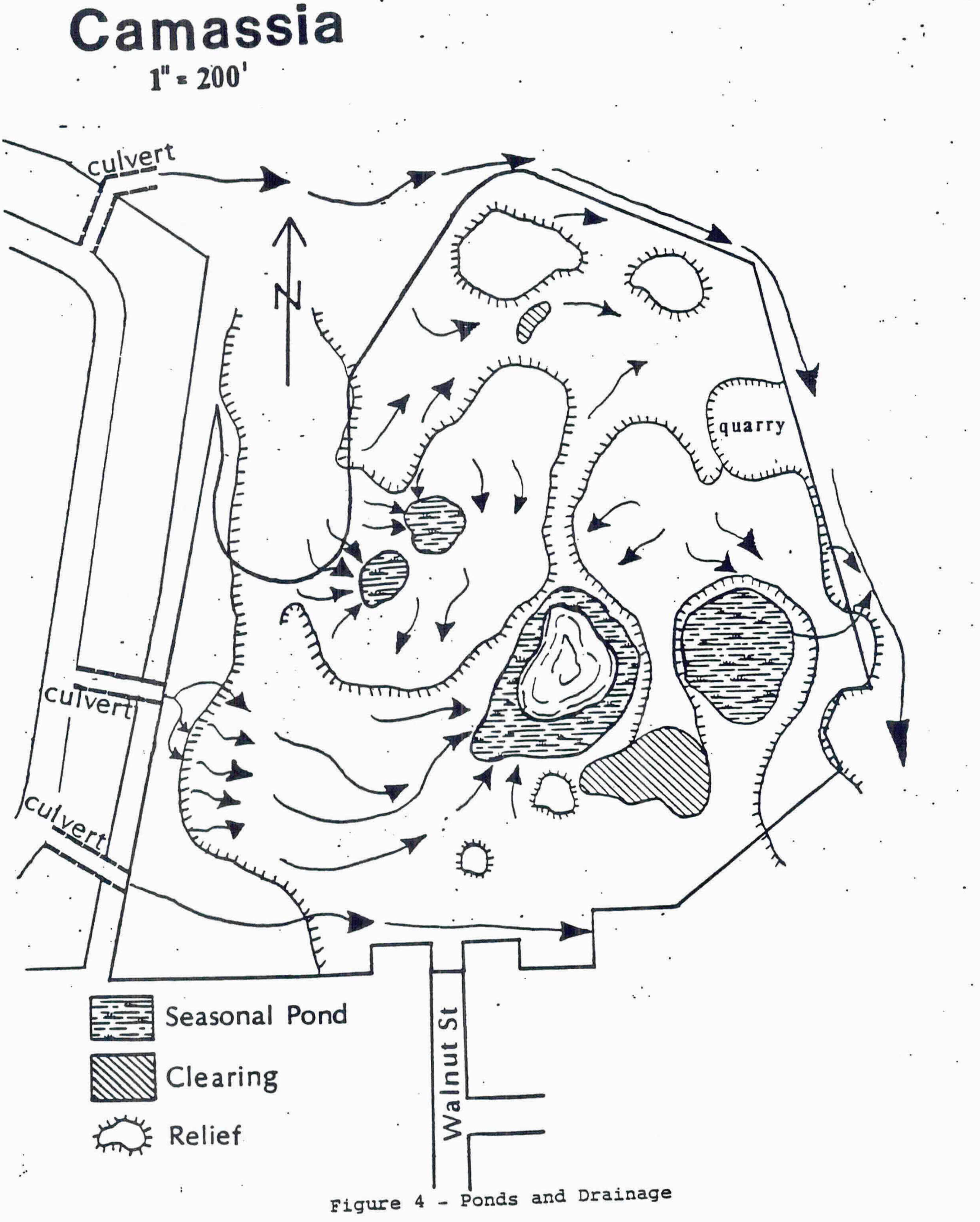
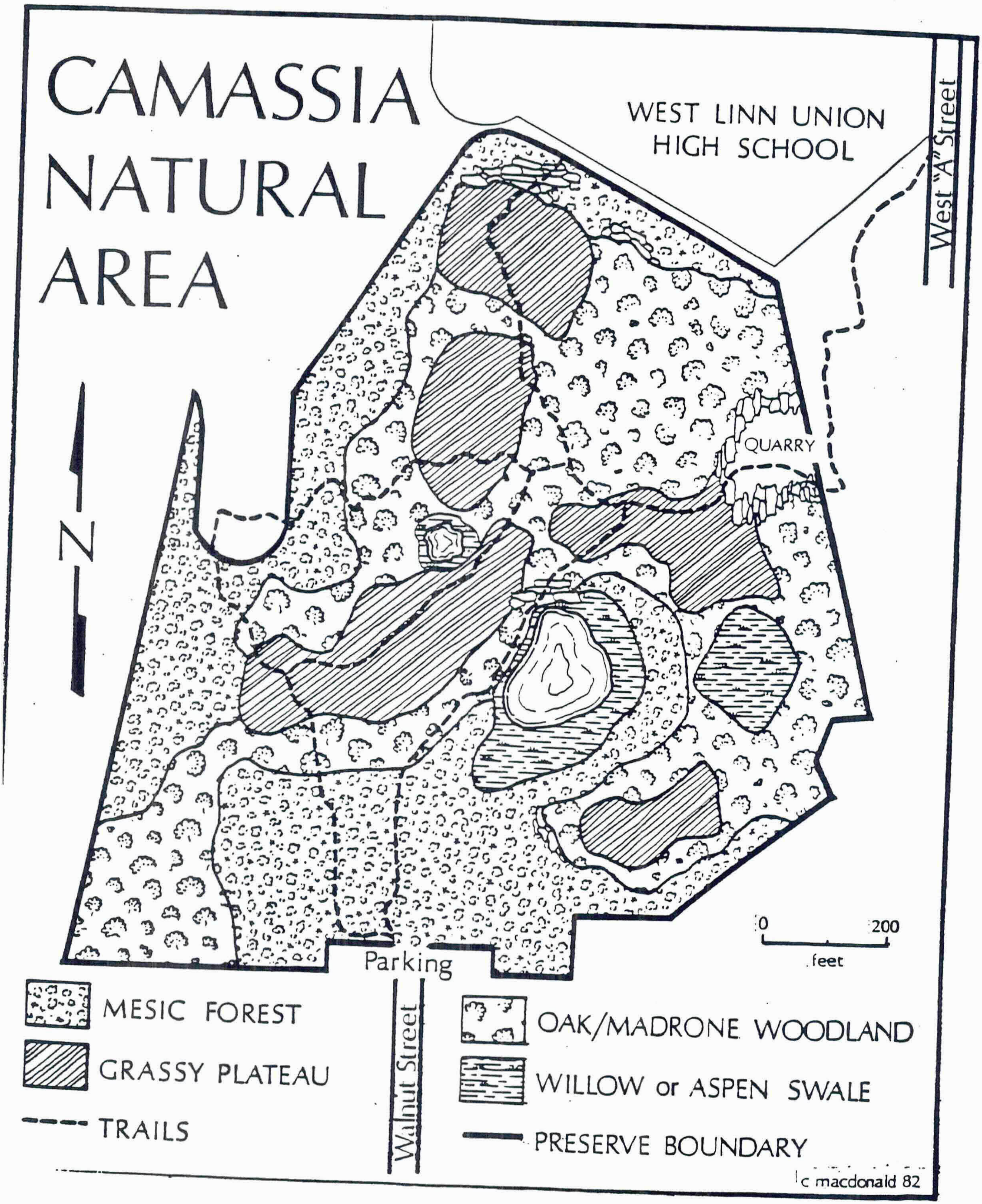


Figure 4 - Ponds and Drainage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PRESERVE BOUNDARY
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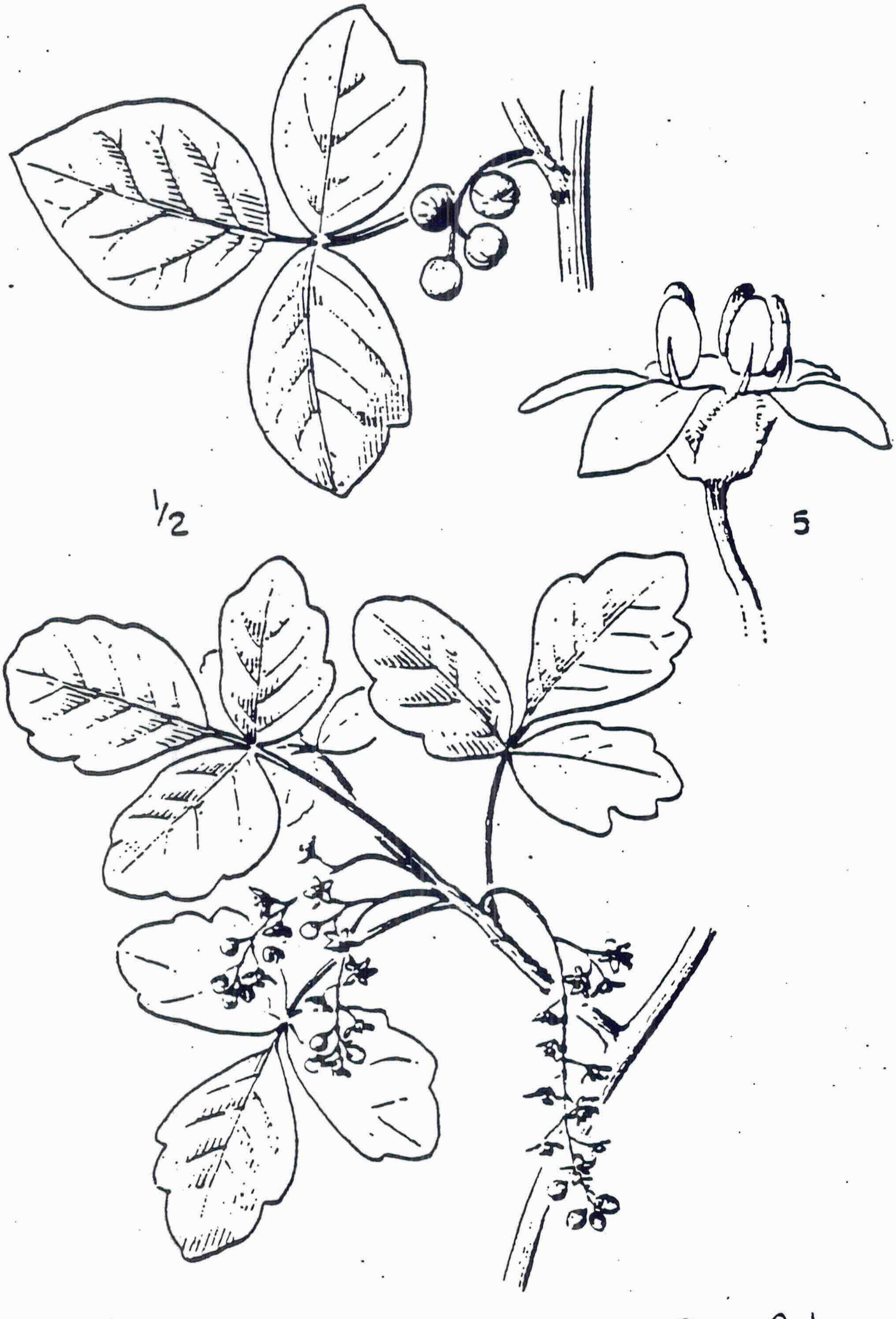
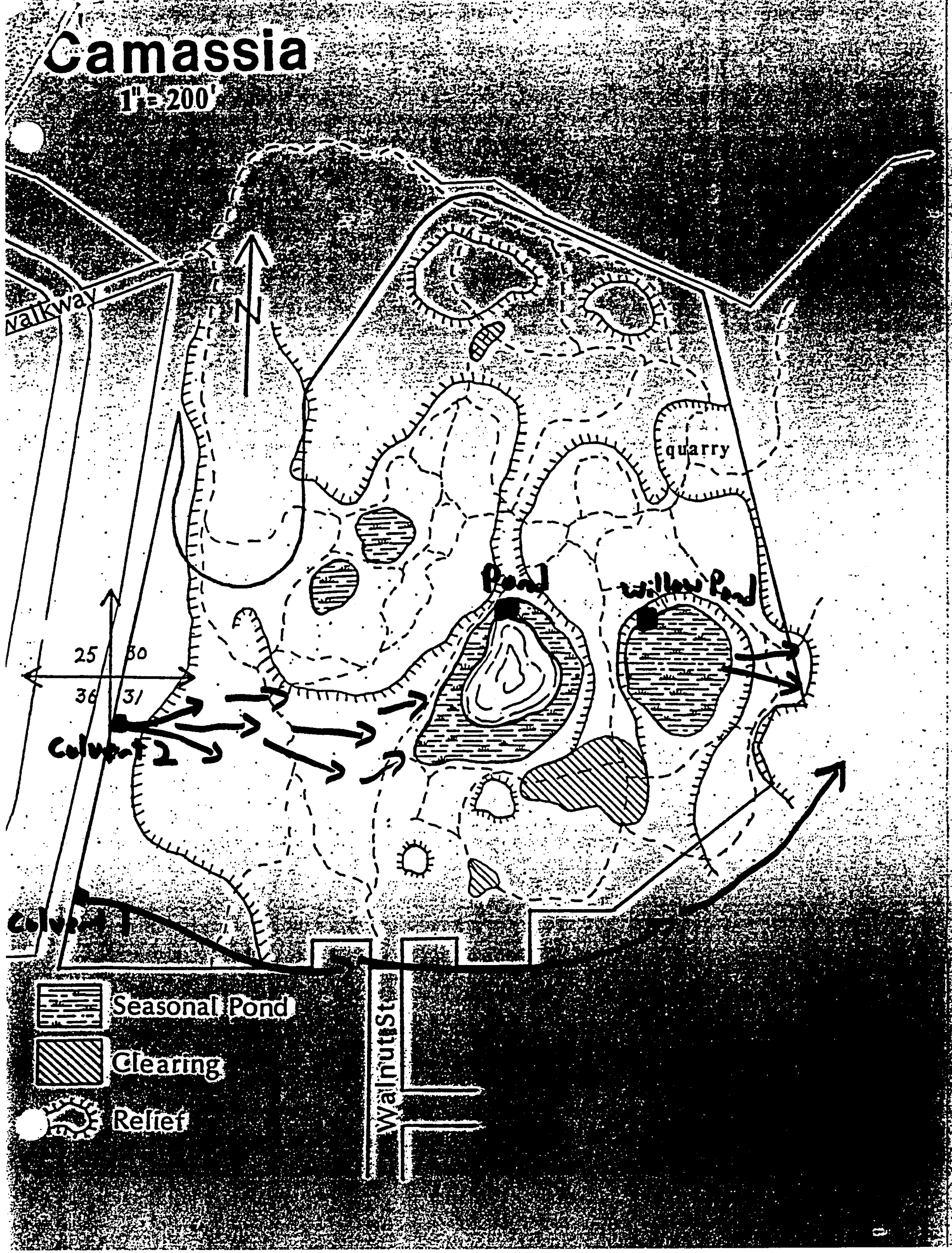


Rhus diversiloba Poison Oak

Camassia Hydrology: Monitoring Flow and Water Quality

David Wildes
Adrienne Hopkins


Camassia
1" = 200'
walkway
N
quarry
Pond
willow Pond
25
30
36
31
Culvert 2
Culvert 1
Walnut St
Seasonal Pond
Clearing
Relief

Contents

Introduction

This purpose of this study was to gather data on the quantity and quality of water flowing from several storm water culverts onto the Nature Conservancy's Camassia Preserve. This study was meant to build on earlier work by Alyssa Gregg, Larisa Meisenheimer, and Joel Sankey of Oregon Episcopal School, entitled *Camassia Natural Area: Monitoring of Hydrology and Hydric Plant Communities.*

The procedures for this study can be split into two broad groups: those to determine quantity and those to determine quality. The former involved essentially standing at a culvert and measuring the amount of time it took for the water to fill a two gallon bucket. For the latter, extensive use was made of the Hach DR700 Colorimeter, a device that precisely measures the color of a solution. Levels of various chemicals were determined by mixing samples with various color changing reagents, then allowing the machine to determine the exact concentration of the chemicals.

What follows is a breakdown of the results of this study. Explanations of the data precede tables of raw data, and graphical analyses of those more interesting parameters.

Flow

Concerns about the quantity of water flowing from the south and center culverts was the initial motive for a study on the hydrology of Camassia. Originally, it was a goal to develop a water budget for the preserve, accounting for all water flowing onto and out of the preserve. However, certain complications quickly arose. Inflow is fairly easily measured; two people can make measurements simultaneously because there are only two significant sources of incoming water. Outflow is a bit more difficult. There is one major outflow area, but it essentially holds only water from the south culvert, and that water does not really enter the preserve. Outflow from the more significant center culvert leaves the preserve by a number of routes, and each is only accessible by dangerous and illegal hiking on the freeway. because of these complications, the water budget concept was abandoned in January, fairly early in the study.

Following that decision, the study of quantity focussed entirely on the center culvert. The goal was to establish a critical flow above which water would flow above ground and across the trail system. This goal was frustrated by the excessively high rainfall this Spring. The flow never even came close to dropping below such a point. No really important conclusions can be made with the data collected on flow; the real successes of this study came from quality, not quantity, data.

Ph

The Ph levels found in Camassia do not suggest much human intervention. The Ph of the water in both culverts hovered around a neutral seven, so acid rain is probably not a factor on the preserve.

The Ph of both the pond and willow pond tended to fluctuate more than that of either culvert. The two bodies also tend to be about ten times more acidic than their chief sources of inflow. The large amounts of decaying vegetation in these two highly eutrophic bodies of water is probably the culprit. The by-products of decay tend to be acidic, and will lower the Ph of a body of water.

Nitrogen

The strongest evidence of pollution in the water coming into Camassia via the culverts came from the analysis of various forms of the element nitrogen. At some point during the study, enormous quantities of either nitrate or ammonia were found in both culverts.

Nitrate is an important ingredient in fertilizers. It is essential for plant growth. It is also damaging to all water systems in all but the most miniscule quantities. Relatively high quantities of nitrate were measured in the center culvert throughout the study. During the time that its water was analyzed, the south culvert showed even more excessive levels. A prominent spike in nitrate is apparent in February. This coincides, potentially, with the first application of the year of lawn fertilizer. The unusually high February rainfall may have also flushed excess fertilizer out of the soil. Nitrate levels slacked off somewhat in the later months, but remained high. Again, fertilizer is the most likely suspect.

Ammonia is usually not directly present in fertilizer, but is a product of the breakdown of nitrate and urea, both very common fertilizer additives. Unusually high levels of ammonia were recorded in the winter at the center culvert. Winterizing fertilizer is suspect. The relationship between the levels of ammonia and nitrate was interesting to examine. In the pond, the two appear to be inversely related. This relationship may be caused by bacterial systems in the pond.

Biological filtration is evident upon examination of the data regarding nitrogen. Nitrate in particular appears to be removed from the water in the pond and willow pond. This removal is small in the winter, when plant growth is minimal, but rises markedly in the spring. Apparently the plants in the two bodies of water remove the nitrogen as they grow. The pond and willow pond seem to play an important role in keeping fertilizer runoff from entering the Willamette River.

Chloride

Except in extremely high concentrations, chloride has no deleterious effects on an ecosystem. It is an important chemical to test for, however, because it is also never naturally present in an ecosystem. Chloride is an indicator of human intervention and pollution. As would be expected, there is a relatively high quantity of chloride in the water from the culverts. This water comes from backyards and street runoff, so it is not surprising that chloride is present. The actual source of this chloride could be swimming pool overflow, although non-point sources are equally likely. As with nitrogen, some biological filtration is evident upon examination of the chloride data.

Chromium

Chromium is a highly toxic heavy metal that is not normally found in above trace quantities. Potentially damaging levels of chromium were not found in Camassia, but it is evident that some is entering the preserve, mostly from the center culvert. The source of this chromium may be the culvert itself; the center culvert is a galvanized metal pipe, and some chromium may be present in the plated metal. This chromium is washed into the flow as the pipe corrodes. With chromium the opposite of biological filtration appears to occur: there is more chromium in the pond and willow pond, on average, than in the culverts. Chromium must be deposited in the mud and silt at the bottom of the pond, where it concentrates. This is cause for some concern, as heavy metals tend to concentrate even further in animal tissues. Chromium may biomagnify in food chains based on invertebrates that live in the mud at the bottom of the ponds.

Iron

Iron is far less toxic than chromium. In this area, it is also frequently present in soils. The highest levels of iron were consistently recorded at the center culvert, where telltale traces of red may be seen in the soil. It is possible that this is natural iron, or, like the chromium, it may come from the culvert. The incredible spike in iron levels in February may be attributed to the heavy rainfall that month. Iron may have been washed from the soil, or dislodged from the interior of the center culvert.

Zinc

Like chromium, zinc is a relatively toxic heavy metal that is not normally found in waterways. Not enough zinc was detected to be of great concern, but it is important to note where the metal is coming from. The highest concentration of zinc was found in the center culvert in early November, when the flow was relatively low, and thus undiluted. Zinc is the primary coating in galvanized metal, because it is relatively unreactive despite its high position on the activity series, and is therefore useful for cathodic protection. Most likely some zinc is entering Camassia as this pipe corrodes.

Phosphorus

Phosphorus plays a similar role to nitrate; it is found in fertilizers, and significantly contributes to eutrophication. Unfortunately, the data collected on phosphorus is meaningless. Severe errors are present in much of the data. For example, organic, or orthophosphorus, and total phosphorus were both tested. Orthophosphorus is a part of total phosphorus, yet repeatedly the reading for the former was higher than that for the latter. This makes no logical sense, and suggests experimental error. The phosphorus test is extremely sensitive and delicate, and is thrown off by the presence of any trace of phosphate on the test cell surface. Most likely improper cleaning was the culprit in the enormously irregular phosphorus readings.

Dissolved Oxygen

Dissolved oxygen is affected by a number of factors, including water temperature and the quantity of decaying organic material. An ideal dissolved oxygen level is around 12 parts per million. There is plenty of oxygen in the culvert outflow, because that water flows quickly and has an extremely agitated surface. The stagnant pond and willow pond have extremely low levels of dissolved oxygen. This is probably not affected by pollution; both bodies of water are really more marshes than ponds, and have tons of vegetation growing in them. It is not realistic to expect there to be much oxygen in their waters.

Biochemical Oxygen Demand(BOD)

BOD is a measure of the demand for oxygen by decaying organic material. The water from the culverts had a fairly low BOD, because it is pretty clear and free of organic pollution. The pond and willow pond both had BODs that about equaled their dissolved oxygen levels. This indicates that the two are poor supporters of animal life, but this appears to be a natural state, and not something brought on by human interference.

November

	Culvert 1	Culvert 2	Pond	Willow Pond
pH		7.1	6	6.2
Ammonia		0.07	0.06	
Nitrate		0.27	0.03	
Ortho		0.06	0.4	
Phosphate		0.13	0.74	
Chloride		5.2	5	
Zinc		0.32		
Chromium		0.006	0.04	
Iron		1.18	1.15	
DO		12	1	
BOD				

December

	Culvert 1	Culvert 2	Pond	Willow Pond
pH		6.7	6	5.9
Ammonia		1.1	0.4	0.03
Nitrate		0.43	0.05	0.03
Ortho		0.1	0.05	0.02
Phosphate		0.33	0.1	0.05
Chloride		0.3	0.8	0.9
Zinc		0	0	0.02
Chromium		0.016	0.034	0.025
Iron		0.73	0.29	0.07
DO		8	1	1.5
BOD		3	1	1.5

January

	Culvert 1	Culvert 2	Pond	Willow Pond
pH		6.8	6.2	5.5
Ammonia		0.26	0.33	0.01
Nitrate		0.7	0.8	0.05
Ortho Phosphate		0.28	0.72	
Chloride		5.5	1.6	1.4
Zinc		0.03	0	0.03
Chromium		0.08	0.044	0.06
Iron		1.27	0.91	0.38
DO		9	1.5	1
BOD		2.5	1.5	1

February

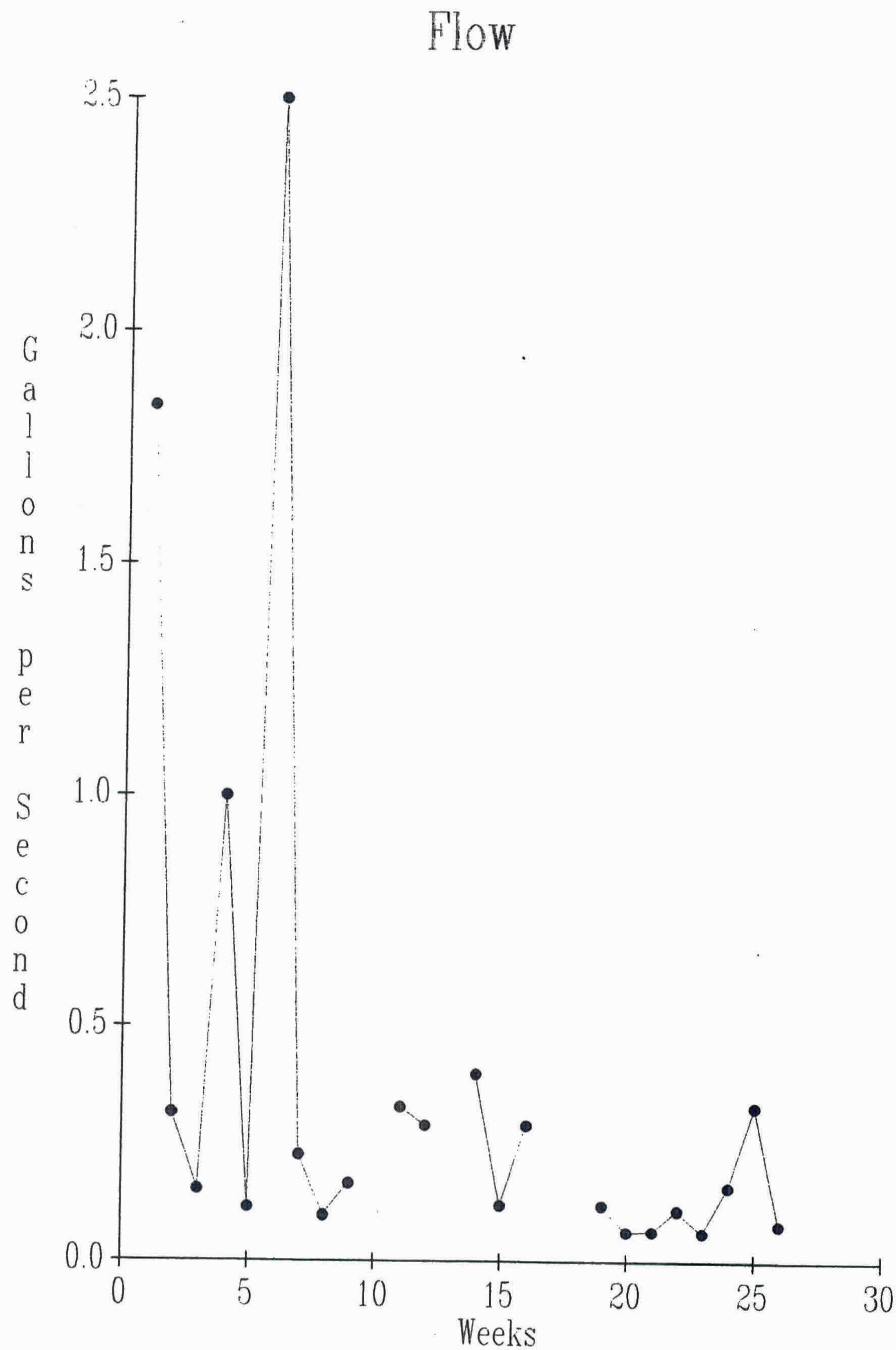
	Culvert 1	Culvert 2	Pond	Willow Pond
pH	6.8	6.6	5.8	6.2
Ammonia	0.01	0.04		3
Nitrate	2.9	1.8	1	0.9
Ortho	0.08	0.15	0.01	0.04
Phosphate	0.1	0.1	0.12	
Chloride	6.5	4.9	1.1	1.2
Zinc	0	0	0.11	0
Chromium	0	0.005	0.017	0.016
Iron	6.4	12.5	0.05	0.04
DO		11.5	3	1
BOD		4.5	2.5	0.5

March

	Culvert 1	Culvert 2	Pond	Willow Pond
pH	6.8	6.8	5.7	5.9
Ammonia	0.01	0.03	0.07	0.01
Nitrate	1.1	1.1	0.5	0.03
Ortho	0.14	0.18	0.07	0.06
Phosphate	0.08	0.12	0.37	0.06
Chloride	6.5	4.4	1	1
Zinc	0	0	0.01	0.02
Chromium	0.006	0.01	0.04	0.081
Iron	0.1	1.34	0.66	0.35
DO		11.5	2	1.5
BOD		4	1.5	1.5

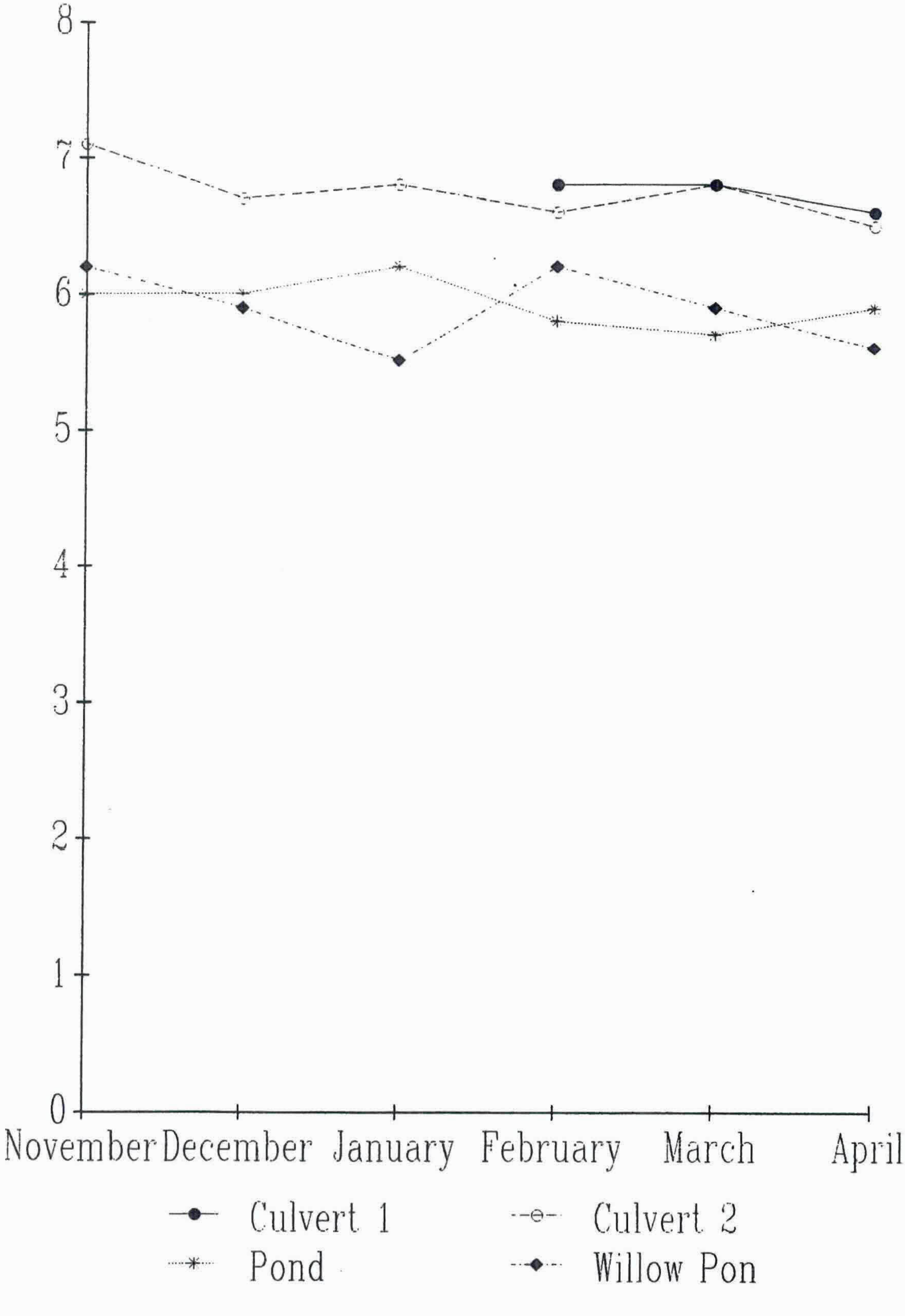
April

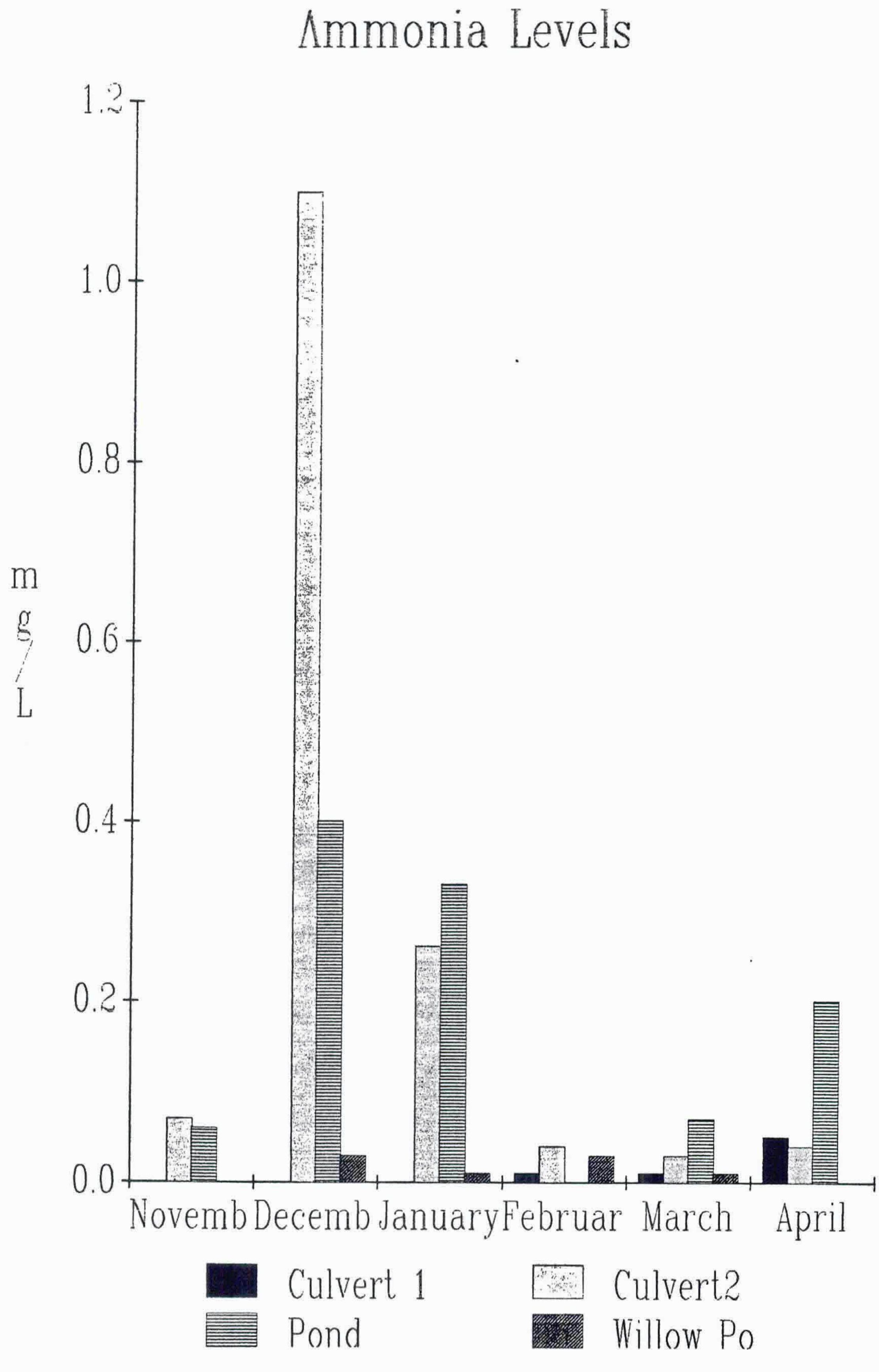
	Culvert 1	Culvert 2	Pond	Willow Pond
pH	6.6	6.5	5.9	5.6
Ammonia	0.05	0.04	0.2	0
Nitrate	1.6	0.53	0.02	0.03
Ortho	0.12	0.09	0.02	0.04
Phosphate	0.17	0.22	0.12	0.11
Chloride	2.6	5.3	2.8	2.5
Zinc	0	0	0.02	0.02
Chromium	0.011	0	0.027	0.031
Iron	0.12	1.09	0.6	0.46
DO				
BOD				

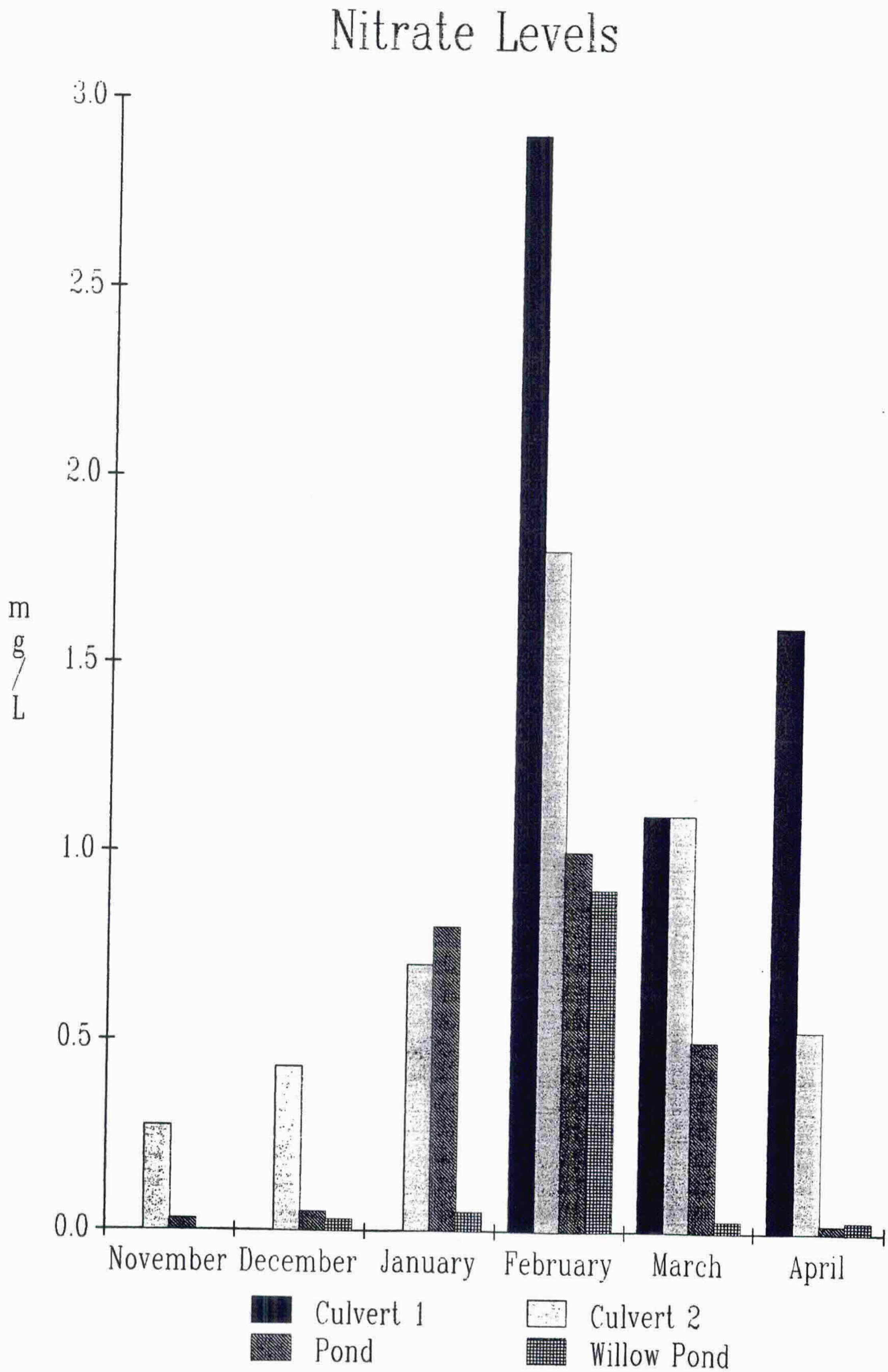


Flow
Gallons per Second
2.5
2.0
1.5
1.0
0.5
0.0
0
5
10
15
20
25
30
Weeks

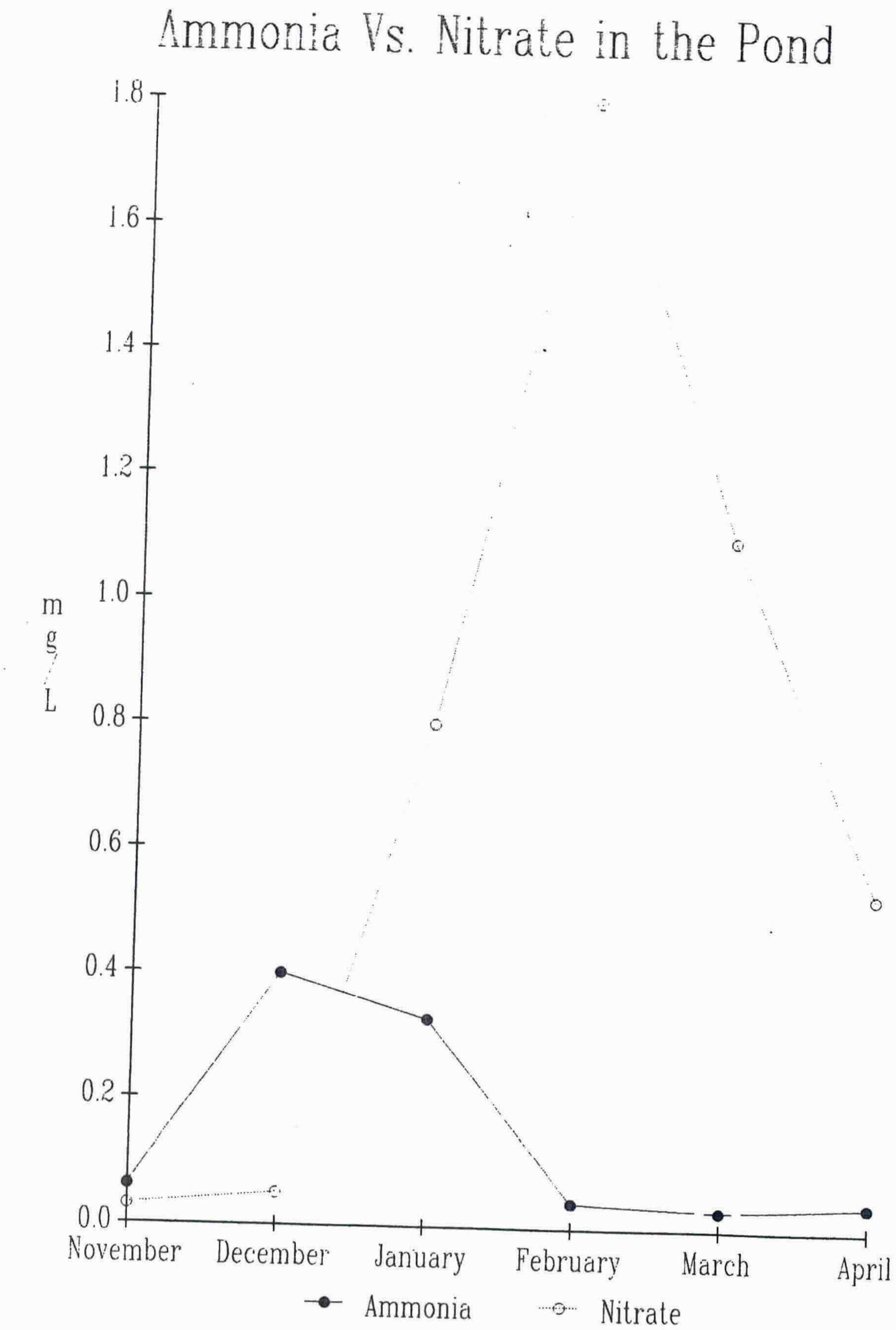
Ph


8
7
6
5
4
3
2
1
0
November
December
January
February
March
April
Culvert 1
Culvert 2
Pond
Willow Pon


Ammonia Levels
1.2
1.0
0.8
0.6
0.4
0.2
0.0
mg/L
Novemb
Decemb
January
Februar
March
April
Culvert 1
Culvert2
Pond
Willow Po

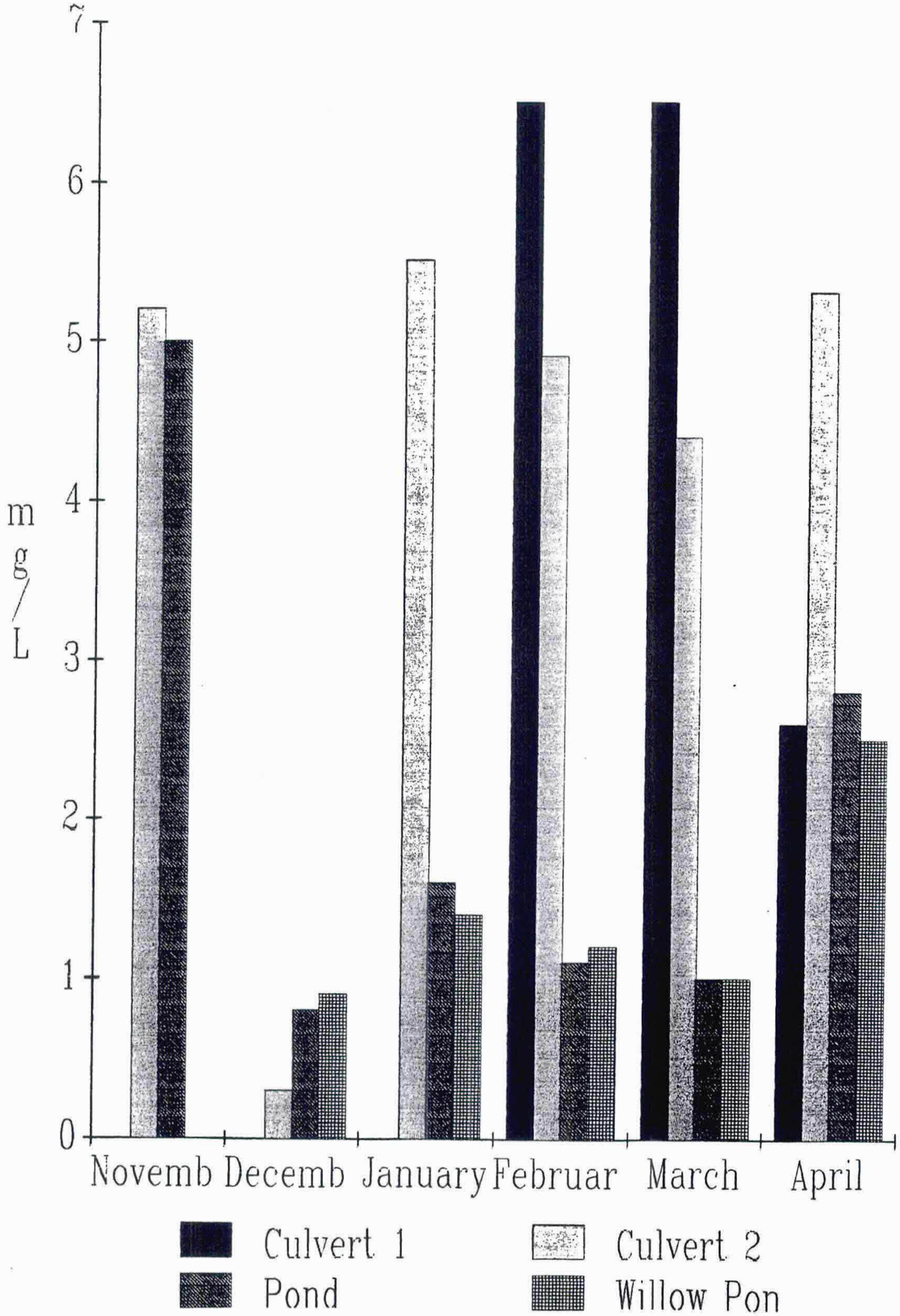


Nitrate Levels
3.0
2.5
2.0
1.5
1.0
0.5
0.0
mg/L
November
December
January
February
March
April
Culvert 1
Culvert 2
Pond
Willow Pond

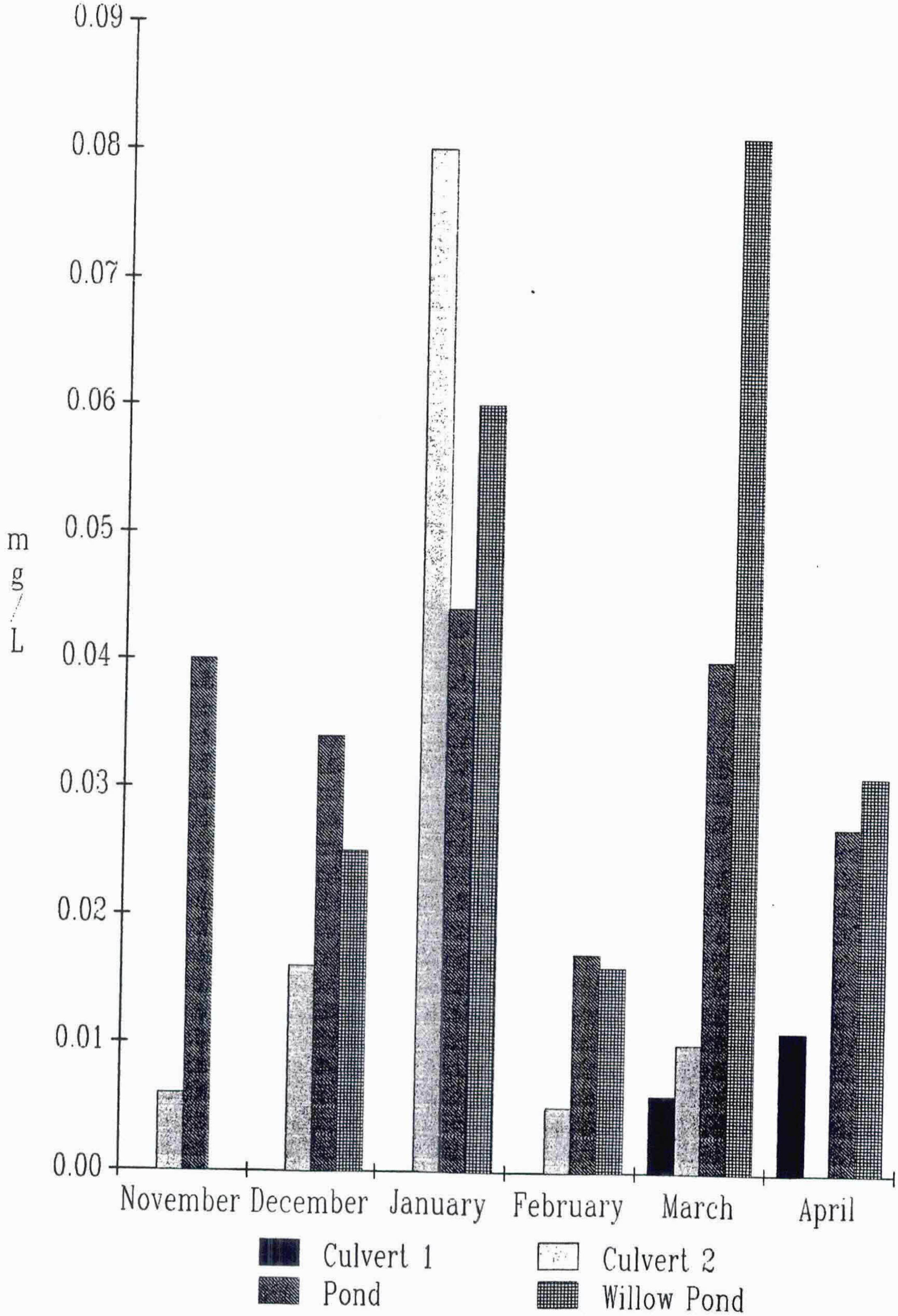


Ammonia Vs. Nitrate in the Pond
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
mg/L
November
December
January
February
March
April
Ammonia
Nitrate

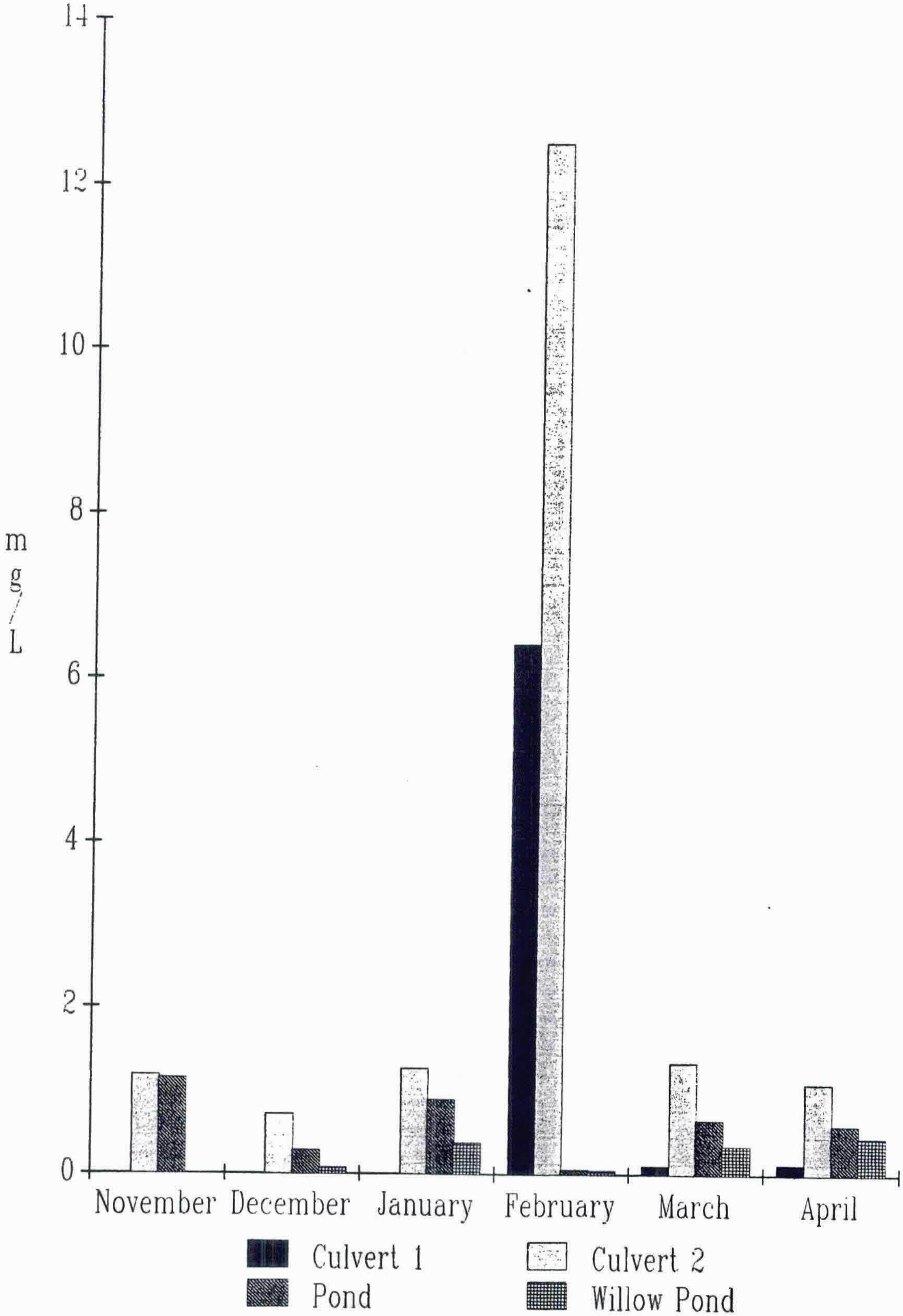
Chloride Levels



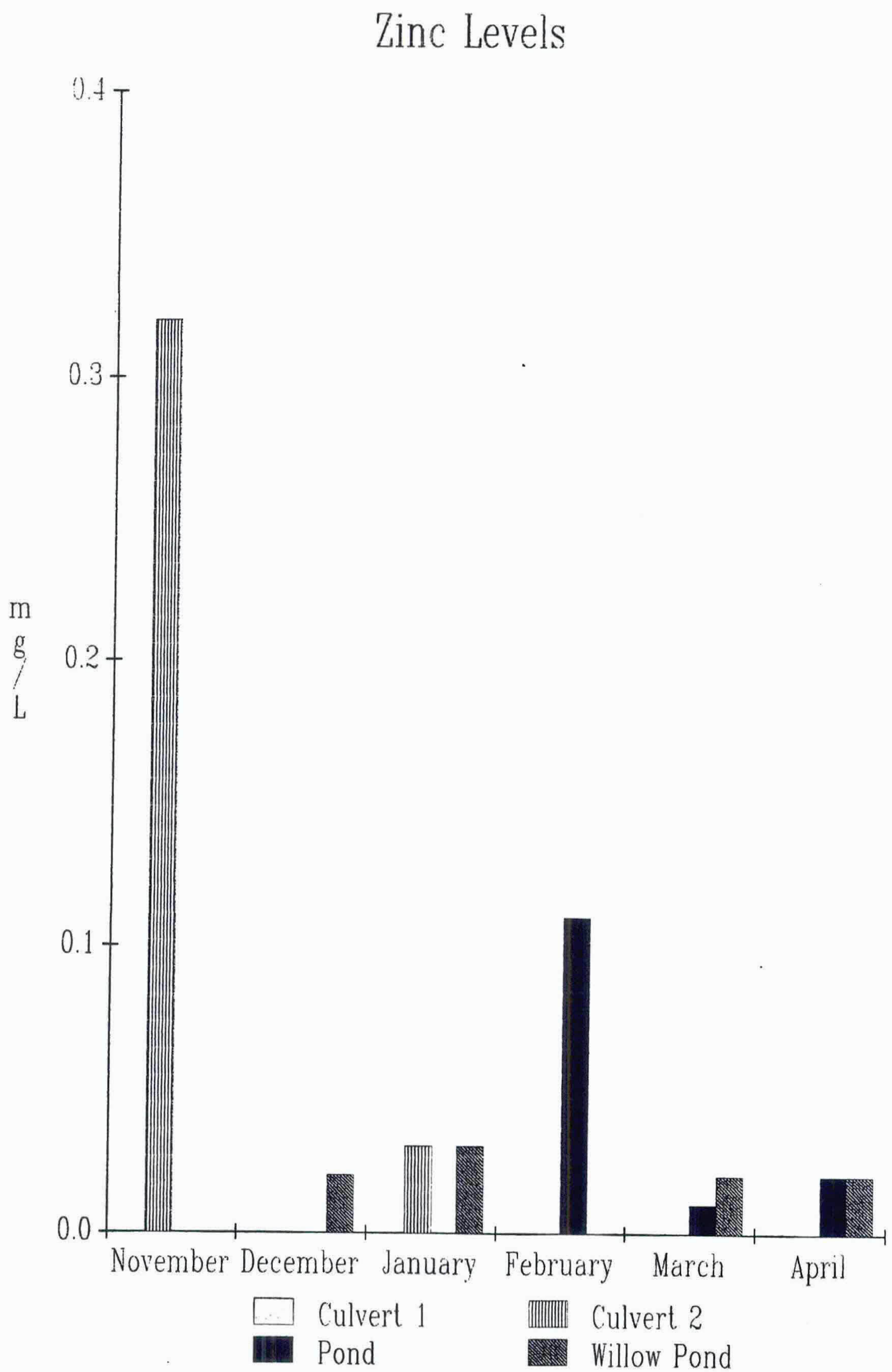
Chromium Levels



Iron Levels



14
12
10
8
6
4
2
0
mg/L
November
December
January
February
March
April
Culvert 1
Culvert 2
Pond
Willow Pond



Zinc Levels
0.4
0.3
0.2
0.1
0.0
mg/L
November
December
January
February
March
April
Culvert 1
Culvert 2
Pond
Willow Pond

Science Research Log Book

Adrienne Hopkins & David Wildes
Camassia / Nature Conservancy
Hydrology Project

Day 1, 9/6/95 Skimmed Ecological Experiments, nelson G. Hariston, Sr., Cambridge University Press, New York 1989: 67-8.
Day 2, 9/7/95 Define the problem and research strategy: The Nature Conservancy (TNC) preserve behind the school, Camassia, would be an excellent area for this project. An adequate area of study needs to be decided on. The Camassia steward, Eddie Huckins, will be un accesible up to the eighteenth of September. Until then, the project's course will be undetermined.
Day 3, 9/8/95 Discovered tht David Wildes is also interested in centering his science research project at Camassia. Hopefully our classes can be changed to coenside with each other. TNC wants to do a study on the effect of what comes down in Camassia (i.e. rainfall, debris, etc.) on the preserve. The high school contact is Paul Sherman. Information to be aquired from TNC representative, Eddie; the details of the problem and what the project's goal would be, what has already been done, how one would go about experiments, what TNC's involvement would be, etc.
Day 4, 9/9/95 Discussed ecology club possibilities with Jerry Kuykendall and the administration.
Day 5, 9/11/95 Sojourn to library to find pertinent information in the 574.5 section.
Day 6, 9/12/95 Ecology club business discussed.
Day 7, 9/13/95 Project at standstill until the eighteenth.
Day 8, 9/14/95 Discussed TNC's Camassia projects with student contact.
Day 9, 9/15/95 Talked to an enthusiastic ecology club about possible ties with TNC.
Day 10, 9/18/95 Out sick.
Day 11, 9/19/95 Called TNC, appointment with Eddie at 2:45 on Monday.
Day 12, 9/20/95 Need to set up meeting with Sherman and David.
Day 13, 9/21/95 Recycling setup discussed.
Day 14, 9/22/95 Discussed requirements for the class, failed attempts to talk to Sherman during class, lunch or after the ecology club meeting.
Day 15, 9/25/95 Talked to Eddie and Sherman with David about the project. The goal is to test runoff and drainage coming through Camassia. Scheduled a session to change science research period to be able to work with David and be supervised by Sherman. Pond at .5 meters.
Day 17, 9/26/95 TNC ownes 26 acres of Camassia, but a large sweil above the track belongs to the high school. Discussed connection with ecology club, i.e. work parties, building informational sign structures, putting in trash cans, getting training to lead hikes, etc. Science research project also discussed. There is a storm drain that conducts runoff from houses above Camassia into the park. The amount of water coming out of this drain is believed to have increased with the increase of houses above the park. As of yet, the amount and makeup of the water entering the park from this drain

is unknown and our project will be to determine this. The water flows from three culverts and finds its way into a pond that fluxuates from being empty to over 8 feet. The pond's water level eventually finds an eqilibrium with a smaller pond, the willow pond, below it. Some water from this pond drains down the hill into a ditch on the Tripp property and out onto I-205. TNC has promised any maps or other assorted info needed.
Day 17, 9/27/95 Attended Earth Club Confrence.
Day 18, 9/28/95 Pond at .6 meters. Rain for the past three days. A new development, a veritable waterfall has been pouring out onto the track behind the school from the preserve.
Day 19, 9/29/95 Little rain today, updated log book.
Day 20, 10/2/95 Rainy over the weekend, overcast today.
Day 21, 10/3/95 Pond at .6 meters. There two ways to get to the pipe, through other's property, which Eddie hasn't aquired permission for yet, and up a large slope, which we'll climb tommorrow. Mr. Sherman may be able to provide maps or detailed transects of o control slope. Park explored to acheive a better feel for it. Spotted deer in the preserve.
Day 22, 10/4/95 Flow taken today, 0.6 liters/second. A large root under the pipe makes it difficult to take flow properly, it may have to be removed. The water from the pipe is a yellow-orangish colour, due to the minerals in the water. The water going into the storm drain on the street above is brown, probably from the dirt washed away from lawns with sprinklers. Water tests should be started soon, however, procuring the equipment may prove interesting.
Day 23, 10/5/95 Made calls to arrange best recycling deal.
Day 24, 10/6/95 Talked to B&B Leasing and recycled.
Day 25, 10/9/95 Pond almost at 0.7 meters. Wandered around Camassia thinking about possible test.
Day 26, 10/10/95 Recycling. An alternative to cutting the root interfering with our flow tests may be to use a pan to flow the water from the pipe to our bucket. Trying to find a time to get the experiment tools from Mr. Sherman.
Day 27, 10/11/95 Pond at 0.9 meters, 0.2 meter increase in 48 hours. Preserve very soggy, pipe flow at 5 liters/second.
Day 28, 10/12/95 The project was discussed with Mr. Sherman and the summer chemical analysis and the maps of Camassia were procured. The pipes the project will concentrate on are two and three. The tests to do are; phosphate, total phosphate, nitrate, ammonia, chloride, zinc, chromium, iron, dissolved oxegyn, temperature, flow, pH and any other tests found applicable. Data tables needed for sinc, chromium, iron and flow. Procedures must be written up. A cumulative sample is going to be done every other month, flow taken once a week. The test equipment is located in the back of Mr. Sherman's room.
Day 29, 10/13/95 Recycling, discussed project problems with Mr. Sherman.
Day 30, 10/16/95 Took water samples from the pond, willow pond and culvert two. Stored in the refigerator, flow at .4 liters/second.
Day 31, 10/17/95 Chemical tests. The ammonia tests were a bit unprecise, but this may be due to duckweed in the sample. No word yet on permission to cross yard to take flow and aquire samples.

Day 33, 10/18/95 Tested for chloride, the numbers produced were extremely unprecise, so the test will be repeated tomorrow. This error may have been the result of poorly done procedure.
Day 34, 10/19/95 Redid the chloride test along with phosphate and pH. The result were odd, as we had two very precise numbers and one number that was no where near the others. New samples need to be taken.
Day 35, 10/20/95 Did zinc (with one repitition) chromium (problem with colourimiter, flashing E I symbol.) and iron.
Day 36, 10/23/95 New samples taken.
Day 37, 10/24/95 Dissolved oxygen test, set up for biochemical oxygen demand.
Day 38, 10/25/95 Did chromium, phosphate and zinc. (Results slightly bizarre.)
Day 39, 10/26/95 Recycling.
Day 40, 10/27/95 Nitrate tests.
Day 41, 10/30/95 The dissolved oxygen test for the culvert turned out very high. Pictures taken for the display, pond, culvert, various Camassia habitats.
Day 42, 10/31/95 Halloween.
Day 43, 11/1/95 Collected new pond sample. (Possibly for fecal coliform.) Reorganized data.
Day 44, 11/2/95 Both members gone.
Day 48, 11/6/95 Collected new pond and culvert samples, ran fecal coliform test, needs to incubate 24 hours.
Day 49, 11/7/95 Counted fecal coliform colonies.
Day 50, 11/8/95 Recycling.
Day 51, 11/9/95 Found flow for culvert two and three. Pond at 1.5 meters, determined to do macrovertibrete counts next week with ecology club.
Day 52, 11/10/95 No school.
Day 53, 11/13/95 Found culvert #3 outflow, pond above meter stick. (2.5 meters) Discussed future projects.
Day 54, 11/14/95 Future projects discussed, pond above meter stick.
Day 55, 11/15/95 Collected willow pond, culvert #2 and pond BOD samples. Pond above meter stick.
Day 56, 11/16/95 Discussed with ecology club its role in science research project.
Day 57, 11/17/95 Recycling, went to preserve.
Day 58, 11/20/95 Discussed ecology club matters.
Day 59, 11/21/95 Ecology club discussed.
Day 60, 11/22/95 Homework.
Day 61, 11/23/95 Talked to Mr. Sherman about future of project. Transects okay but not necessary or really useful.
Day 62, 11/24/95 The possibility of winter and summer mapping discussed.
Day 63, 11/27/95 Water samples taken.
Day 64, 11/28/95 Chemical tests.
Day 65, 11/29/95 Chemical tests.
Day 66, 11/30/95 Chemical tests. A constant pattern has appeared in the results. Out of three tests, two are close and one is an outlier.
Day 67, 12/1/95 Phosphorous on Camassia water and heavy metals on a Saum Creek sample.
Day 6, 12/4/95 Chemical tests. Fungus/bacteria grown on Saum Creek sample. Theory on biofiltration for iron.
Day 69, 12/5/95 Chemical tests. Ammonia tests do not seem to balance nitrate.
Day 70, 12/6/95 Chemical tests.
Day 71, 12/7/95 Flow taken. Filling out Nature Conservancy work forms.
Day 72, 12/8/95 Did dissolved oxygen on the pond.
Day 73, 12/11/95 Did dissolved oxygen on willow pond. Not sure what to do about flow over winter break.
Day 74, 12/12/95 Did dissolved oxygen on culvert two.
Day 75, 12/13/95 No school.

Day 76, 12/14/95 No school, did flow-very high.
Day 77, 12/15/95 Recycling.
Winter break flow data:
12/21/95 3:50 p.m. culvert 2 22, 22, 22, 22, 22
12/21/95 3:56 p.m. culvert 3 15, 15, 15, 15, 15
A lot of orangish-brown sediment/mud in the water.
12/28/95 12:31 p.m. culvert 2 21, 21, 20, 20, 18
12/28/95 12:37 p.m. culvert 3 9, 9, 8, 8, 7
More orangy-brown colouration, especially culvert two. There was an oily resi left on the bucket after the culvert three. There was a large oil spot on the street above the culvert that is probably tied to it. (i.e. oil leak)
Day 78, 1/3/96 Samples taken, January chemical tests started.
Day 79, 1/4/96 Recycling and flow.
Day 80, 1/5/96 Chemical tests.
Day 81, 1/8/96 Chemical tests
Day 82, 1/9/96 Water samples.
Day 83, 1/10/96 Chemical tests.
Day 84, 1/11/96 Chemical tests.
Day 85, 1/12/96 Chemical tests.
Day 86, 1/15/96 No school.
Day 87, 1/16/96 Recycling.
Day 88, 1/17/96 Recycling.
Day 89, 1/18/96 Flow and samples.
Day 90, 1/19/96 Chemical tests.
Day 91, 1/22/96 Chemical tests.
Day 92, 1/23/96 Recycling.
Day 93, 1/24/96 Finals, finishing touches on the lab book.
Day 94, 1/25/96 Finals.
Day 95, 1/26/96 Finals.
Day 96, 1/29/96 No school.
Day 97, 1/30/96 Reaffirmed class status.
Day 98, 1/31/96 Cleaned up recycling room.
Day 99, 2/1/96 Attempted water samples and flow, all water frozen.
Day 100, 2/2/96 Explored unmapped area and bench. Wandered on ice across pond slid on ice, retreated quickly after large crack was created.
Day 101, 2/5/96 School canceled due to sleet.
Day 102, 2/6/96 Recycling.
Day 103, 2/7/96 Pond and willow pond samples.
Day 104 2/8/96 Water samples from culvert two and three, flow on culvert two. Found pumpkin-head for trick-or-treating. Flooding.
Day 105, 2/9/96 Went up to preserve and took pictures of high water while the sun was out.
Day 106, 2/12/96 Chemical tests.
Day 107, 2/13/96 Chemical tests.
Day 108, 2/14/96 Flow and samples.
Day 109, 2/15/96 Phosphorous tests.
Day 110, 2/16/96 Chemical tests.
Day 111, 2/19/96 President's Day.
Day 112, 2/20/96 Recycling.
Day 113, 2/21/96 Chemical tests.
Day 114, 2/22/96 BOD samples.
Day 115, 2/23/96 Coffee.
Day 116, 2/26/96 Inservice day.
Day 117, 2/27/96 BOD tests.
Day 118, 2/28/96 Recycling.
Day 119, 2/29/96 La-de-da.
Day 120, 3/1/96 Dissolved oxygen.
Day 121, 3/4/96 Recycling.
Day 122, 3/5/96 Recycling.

Day 123, 3/6/96 Recycling.
Day 124, 3/7/96 Flow and samples.
Day 125, 3/8/96 Recycling.
Day 126, 3/11/96 Chemical tests.
Day 127, 3/12/96 Chemical tests.
Day 128, 3/13/96 Chemical tests.
Day 129, 3/14/96 Flow. Beautiful.
-Spring Break-
Day 131, 3/25/96 Samples taken and Spring watched.
Day 132, 3/26/96 Chemical tests.
Day 133, 3/27/96 Chemical tests.
Day 134, 3/28/96 Flow taken, football aquired and Spring appreciated.
Day 135, 3/29/96 Dissolved oxygen, BOD samples, chromium leftovers, total and ortho phosphorous; power testing.
Day 136, 4/1/96 Recycling.
Day 137, 4/2/96 Wandered around the preserve collecting poison oak. Workers there clipping scotch broom.
Day 138, 4/3/96 Control favour tests, BOD.
Day 139, 4/4/96 Flow and pictures (of blooming veggies) taken.
Day 140, 4/5/96 Inservice day.
Day 141, 4/8/96 Control tests for Mr. Sherman.
Day 142, 4/9/96 Samples taken and rainbow spinsock played with. Camassia has started to bloom. There are white fawn lilies with mottled leaves and heads that hang down like lamp shades everywhere. Also bright yellow Oregon grape. Most of the scotch broom on the upper plateaus has been cut down and left to decay where it fell.
Day 143, 4/10/96 Recycling.
Day 144, 4/11/96 Flow taken, it was slow despite the fact that it was raining, not to mention cold and windy.
Day 145, 4/12/96 Recycling.
Day 146, 4/15/96 Chemical tests.
Day 147, 4/16/96 Expanding vocabulary.
Day 148, 4/17/96 Went to second period representative meeting and were lectured on respecting diversity.
Day 149, 4/18/96 Flow taken, weather rainy.
Day 150, 4/19/96 No school.
Day 151, 4/22/96 Samples taken. Loppers and lovely black parasol found.
Day 152, 4/23/96 Chemical tests, freshman warded off.
Day 153, 4/24/96 Chemical tests.
Day 154, 4/25/96 Flow taken, prom discussed.
Day 155, 4/26/96 Recycling.
Day 156, 4/29/96 Samples taken, Burton dragged along. Watched ASB speeches.
Day 157, 4/30/96 Chemical tests.
Day 158, 5/1/96 Chemical tests.
Day 159, 5/2/96 Chemical tests, chicks appear & try to abscond flow bucket.
Day 160, 5/3/96 Phosphorous tests & the decision to end the chemical tests for the project.
Day 161, 5/6/96 Recycling, project discussed.
Day 162, 5/7/96 Recycling, David sick.
Day 163, 5/8/96 Homework, David has strep throat.
Day 164, 5/9/96 Flow taken with Andrea, David taking A.P. test.
Day 165, 5/10/96 A.P. testing.
Day 166, 5/13/96 Worked on presentation to give to Metro board and other Metro-funded project representatives.
Day 167, 5/14/96 Presentation at Metro, 4-6 with Eddie Huckins.
Day 168, 5/15/96 Sojourn to the Bagel Basket.
Day 169, 5/16/96 Recycling and Ecology Club discussed.
Day 170, 5/17/96 Project discussed.
Day 171, 5/20/96 Photos taken of preserve for presentation. Poison oak bl

along the trails, still boggy.
Day 172, 5/21/96 Recyling. Invitations and presentation requirements received for independent study night, May 28.
Day 173, 5/22/96 Recycling.
Day 174, 5/24/96 Project discussed.
Day 175, 5/24/96 Recycling.