Questions re: Hidden Lake

Councilmember Roberts' Questions

1. **Does the staff have access to the King County staff reports/ objectives of the creation of Hidden Lake that can be shared with the Council?**

Attached is the King County Hidden Lake Design Report.

2. **Also, if we were to do a limited dredging, $50,000 or so worth, do we have a preliminary sense if it would it accomplish much of clearing the sentiment buildup or hamper any transition to a natural wetland?**

If the City decides to only limit a contract to $50,000, approximately 1,200 Cubic yards of sediment could be removed; this removal would not return the sediment forebay to a functional level and would likely result in further siltation away from the forebay leading to future removal being more difficult. Partial dredging and/or full removal of sediment would not hamper the transition to a natural wetland but does not meet the existing maintenance standard for the facility.

Councilmember Hall's Questions

3. **Has the Hidden Lake situation been discussed by WRIA 8 or the King County group that deals with Puget Sound direct drainages?**

Hidden Lake has not currently been discussed with WRIA 8; WRIA 8 would likely be consulted during a proposed feasibility study mentioned in the staff report.

4. **This may be a stupid question that was answered long ago, but why do we want to prevent sediment from flowing downstream from Hidden Lake? I understand human alterations may have changed the pre-development rates of erosion and sediment transport, but what is the ecological benefit of using a dam to interrupt the flow of sediment?**

The change in sediment transport downstream would be evaluated in the proposed feasibility study mentioned in the staff report. Based on the 1995 Ling County Design Report, the forebay of the Hidden Lake facility was designed to capture sediment to allow for the aquatic habitat benefits associated with the Hidden Lake open water feature. The removal of sediment was supposed to also benefit the salmon and anadromous cutthroat spawning habitat in the lower reaches of Boeing Creek.

Jim Kelly
Office
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Recommendations Report

HIDDEN LAKE RESTORATION

KING COUNTY
SURFACE WATER MANAGEMENT DIVISION

By:

James R. Hartley
Joe Brogan
Kirt Hanson
Adrian Lee

July 11, 1995

TABLE OF CONTENTS

1.0 INTRODUCTION

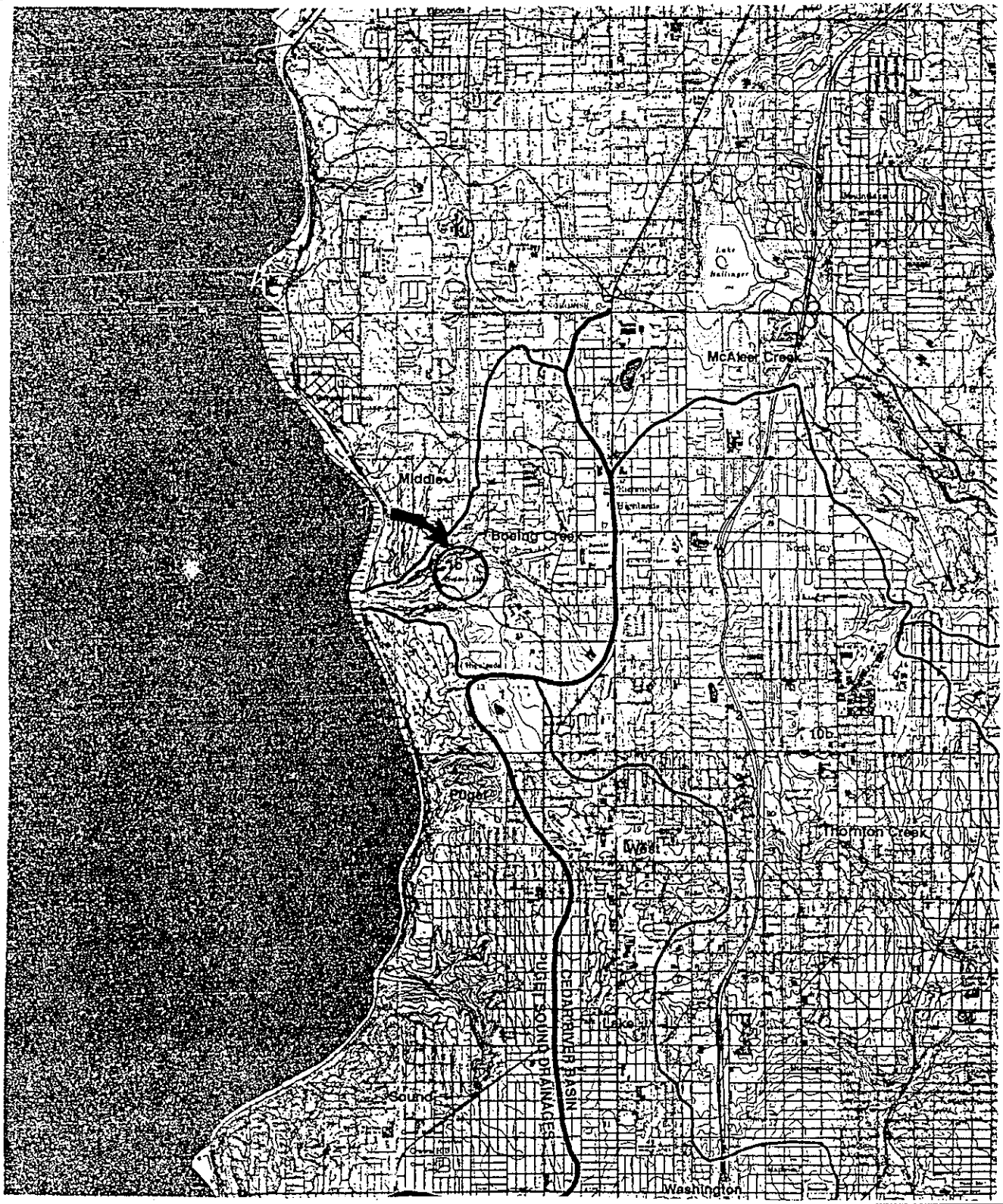
The proposed Hidden Lake project will restore a small lake on the main stem of Boeing Creek, within the boundaries of the City of Shoreline in northwestern King County. The Hidden Lake restoration site is located immediately upstream of Innis Arden Way approximately midway between the headwaters of Boeing Creek and Puget Sound, and in the lower third of the watershed. Boeing Creek is one of several tributary systems which drain into Puget Sound north of the City of Seattle and south of Edmonds (Figure 1), and is a Class 2 stream with salmonids under the King County Sensitive Areas Ordinance. Boeing Creek is listed in the catalog of Washington Streams (WRIA) as Tributary 08-0017 and is also called Hidden Lake Creek. The Boeing Creek watershed encompasses less than 2,000 acres. The basin includes portions of Sections 1, 11, 12, 13 and 14, Township 26 North, Range 3 East; and portions of Sections 6, 7, and 18, Township 26 North, Range 4 East (Figure 2).

1.1 BASIN DESCRIPTION

The Boeing Creek watershed has land uses ranging from a community preserve with some remnant old-growth forest to high density commercial property. The lower part of the watershed including the relatively low density suburban residential neighborhoods of Innis Arden and a section of the Highlands, is less intensively developed with more natural drainage features than the upper reaches of the basin. The upper part of the basin contains higher density residential neighborhoods and commercial development, and is serviced by a stormwater drainage system with regional ponds (Figure 3). Both newly constructed and retro-fitted R/D ponds constrain much of the storm water which previously contributed to the large erosive flows in Boeing Creek. Historically, these flows resulted in the sedimentation of Hidden Lake and the stream bed of the creek. A more detailed description of basin hydrology is in Section 2.21.

Consultants Brown & Caldwell (1993) reported the following basin statistics in their stormwater drainage study of the portion of the Boeing Creek watershed upstream of the Hidden Lake site:

Description	Quantity
Total area	1,557 acres
Pervious surface area	936 acres
Impervious area	621 acres
Overall % impervious surface	40%

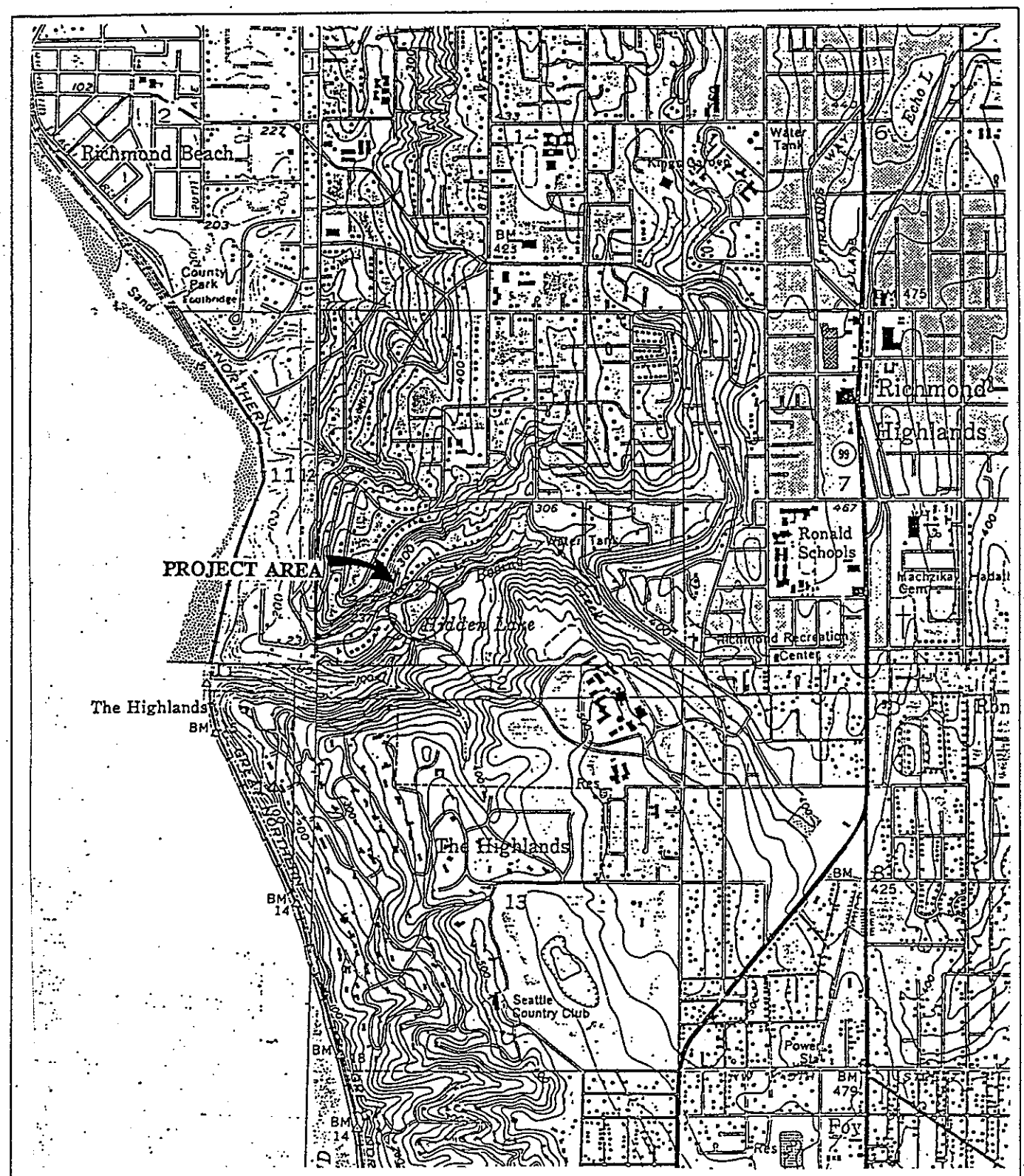


KING COUNTY DEPARTMENT OF PUBLIC WORKS
Paul Tanaka, Director
SURFACE WATER MANAGEMENT DIVISION

FIGURE 1

GENERAL VICINITY MAP

Bocing Creek WRIA 0017
Project OA1755
KING COUNTY, WASHINGTON

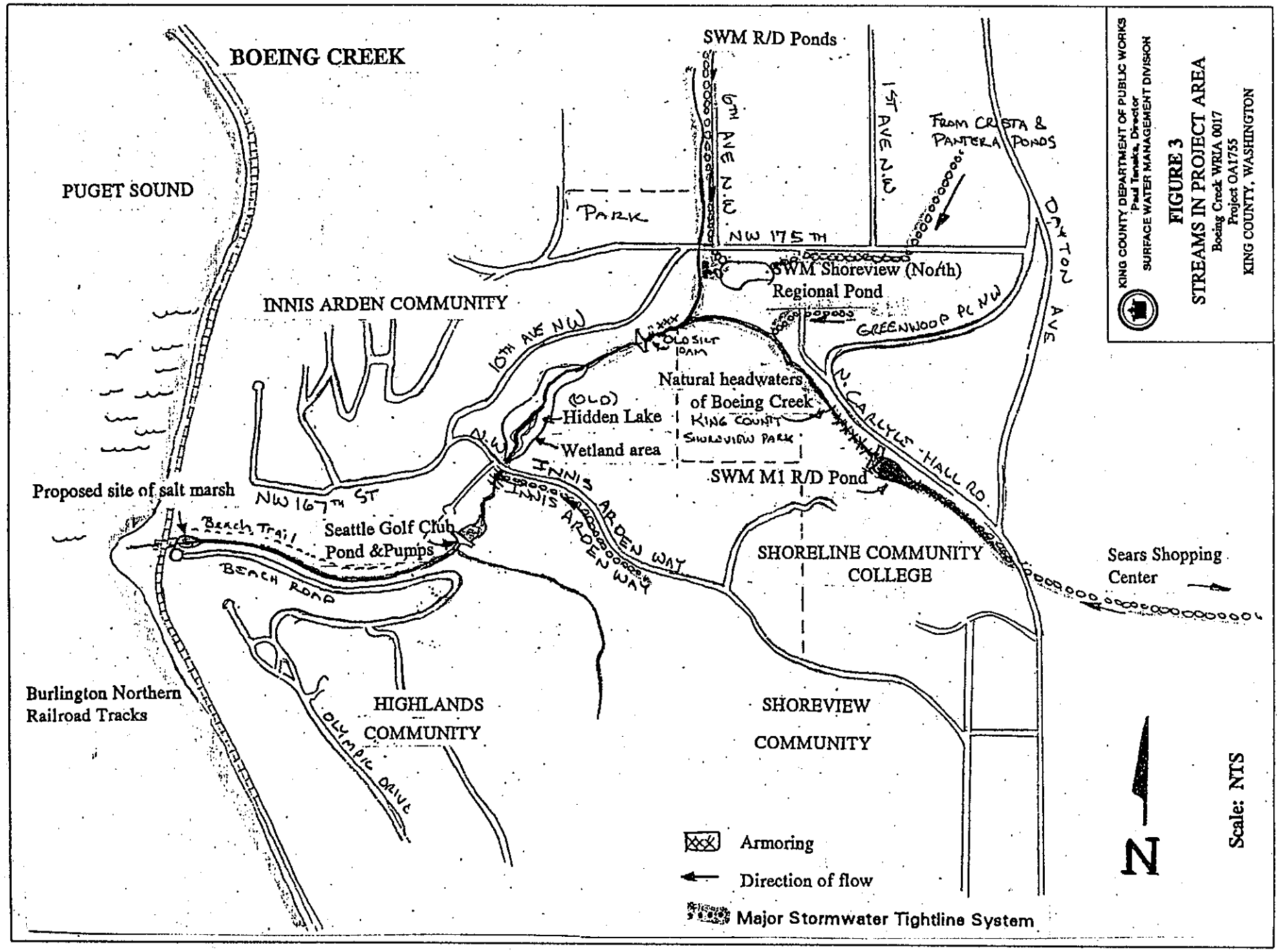


KING COUNTY DEPARTMENT OF PUBLIC WORKS
Paul Tanaka, Director
SURFACE WATER MANAGEMENT DIVISION

FIGURE 2

TOPOGRAPHIC MAP OF PROJECT AREA

Boeing Creek WRIA 0017
Project OA1755
KING COUNTY, WASHINGTON


BOEING CREEK
PUGET SOUND
SWM R/D Ponds
1ST AVE N.W.
FROM CRISTA & PANTERA PONDS
PARK
NW 175TH
SWM Shoreview (North) Regional Pond
GREENWOOD PL NW
DAYTON AVE
INNIS ARDEN COMMUNITY
10TH AVE NW
OLD SILT DAM
Natural headwaters of Boeing Creek KING COUNTY SHORELINE PARK
(OLD) Hidden Lake
Wetland area
N. CARLYLE HALL RD.
SWM M1 R/D Pond
Proposed site of salt marsh
NW 167TH ST
Beach Trail
Seattle Golf Club Pond &Pumps
INNIS ARDEN WAY
BEACH ROAD
SHORELINE COMMUNITY COLLEGE
Sears Shopping Center
Burlington Northern Railroad Tracks
HIGHLANDS COMMUNITY
OLYMPIC DRIVE
SHOREVIEW COMMUNITY
Armoring
Direction of flow
Major Stormwater Tightline System
N
Scale: NTS
KING COUNTY DEPARTMENT OF PUBLIC WORKS
Paul Tanaka, Director
SURFACE WATER MANAGEMENT DIVISION
FIGURE 3
STREAMS IN PROJECT AREA
Boeing Creek WRIA 0017
Project OA1755
KING COUNTY, WASHINGTON

Most of the Boeing Creek riparian corridor between the saltwater outlet and the main stem SWM M-1 R/D facility, is characterized by a continuous green belt of mature second-growth forest (Figure 3). The forest has contributed a substantial amount of large woody debris (LWD) to the valley floor and into the stream. The LWD in the stream has helped retain some pool complexes and fish habitat despite slope failures, colluvial sediment loading, and high sediment loads which are transported along the stream bed. The topography of the main stem stream system can be generalized as a v-shaped ravine which increases in depth from the head of the watershed at the eastern edge of the plateau towards saltwater. There are areas throughout the ravine with steep, unstable slopes.

1.2 HISTORY OF HIDDEN LAKE

Hidden Lake has long been affected by human forces. It appears a natural lake was at the site before being modified by Mr. William Boeing in 1920, although the original size of the lake is unknown. Mr. Boeing dredged the existing lake and built a dam to create a 2.4 acre lake.

Vivian Smith, the daughter of the man who sold the site to Mr. Boeing, remembered a lake at the site before it was modified. Her childhood memories of the lake include snags, deep water (or at least it appeared deep to a child), and a forested fringe. Her memories of more than 75 years ago did not include beaver or a dam, but she had not been completely around the lake (Vivian Smith 1994). Other second hand anecdotal accounts also refer to a lake before the enhancement by Mr. Boeing. These accounts of an earlier lake are most consistent with a natural lake formed by beaver activity, though any beaver were probably trapped out well before 1920.

William Boeing used the enhanced Hidden Lake as a private fishing lake, stocking it with trout from a hatchery located on the site. The two silt dams he built upstream of Hidden Lake indicated a sedimentation problem early in the history of the lake. Throughout the 1940s and 1950s, much of the surrounding properties were logged and residential neighborhoods were built. As more of the basin was developed slope failures increased and delivered more sediment to the creek and the lake. The number and size of the slope failures increased following the logging of the areas know as Innis Arden and Shorewood.

In 1964 Sears and Roebuck began construction of a new shopping center in the upper basin. Drainage from the construction site and parking lot was routed into the main stem of Boeing Creek. The increased flows incised the channel as much as 12 feet, de-stabilized hill slopes, initiated mass wasting events and deposited the materials in Hidden Lake. Hidden Lake began filling with sediment decreasing the volume of water contained in the lake until 1970 when the dam failed during a major storm. In a 1974 attempt to reestablish Hidden Lake and stabilize the hill slopes upstream, King County dredged the sediments that were deposited in the former lake and filled upstream areas that had been eroded or de-stabilized. Some rip-rap was placed in the channel on top of the fill, but the size and quantity was inadequate to armor the channel from the increased flows. During the first storm in the fall of 1974 the creek re-incised and deposited the material back into Hidden Lake.

In 1983 an in-stream retention/detention dam (the M-1 Dam) was completed on the main stem of Boeing Creek to control stormwater flows from the Sears parking lot and upper basin. A second major retention/detention pond (the North Pond) was built in Shoreview Park in 1991 to control flows in the north fork of Boeing Creek (Figure 3). Since the completion of the North Pond, flows have been well regulated and the channel has become more stable. Some of the erosion sites have stabilized, become vegetated, and the channel has ceased incising.

No water has been impounded in Hidden Lake since the failed attempts to reestablish the lake in 1974. The former lake site has become vegetated with a young forest of alder, cottonwood and willow.

1.3 PROJECT HISTORY

In February, 1993, the Municipality of Metropolitan Seattle (Metro) sponsored a grant program for public agencies interested in applying for shoreline restoration and acquisition funds for projects within the Metro service area. This opportunity resulted from a negotiated settlement related to the expansion of the West Point Treatment Plant for secondary sewage treatment. As part of the agreement with the City of Seattle, Metro provided mitigation funds to offset impacts to the shorelines within the project area. A 5 million dollar grant program was created for shoreline related projects that replace, enhance or provide substitute environments and provide wildlife habitat and public access.

In October 1993, the Metro Council awarded King County Surface Water Management (SWM) Division $460,000 in grant funds for two projects within the Boeing Creek watershed. The first project involves the restoration of Hidden Lake, the second project involves the creation of a salt marsh at the mouth of Boeing Creek.

The purpose of the Hidden Lake project is to restore open water habitat that was lost when the lake was filled with sediment as a result of development of the upper watershed in the 1950s and 1960s. Considerable public support for this project exists in the community and 16 local community organizations endorsed the SWM grant application.

The SWM Division was asked to match the Metro Council's award to account for the balance of the proposal's costs. The SWM Division obtained the necessary match through a cooperative agreement with the King County Department of Parks, Planning and Resources (Parks). Parks has set aside $500,000 in funding to cover the balance of project costs associated with the construction of Hidden Lake. As a result, both projects are fully funded at $960,000.

1.4 PROBLEM DEFINITION

The sedimentation of Hidden Lake was a result of watershed-wide characteristics and processes. The restoration of the lake should also be considered within a watershed context, as one of several actions to restore and enhance the Boeing Creek watershed. The Hidden Lake project will be designed to capture sediment from the upper watershed in addition to reestablishing and enhancing the previously existing lake and wetland habitats.

The primary problems in the Boeing Creek watershed have been degradation and loss of aquatic habitat and continued erosion and sedimentation. Both of these problems can be ultimately attributed to mismanagement of surface water. The stormwater detention facilities constructed in the upper watershed have already reduced the erosive stormwater flows which initiated the excessive sedimentation leading to the destruction of Hidden Lake and degradation of riparian habitat within the creek. However, additional measures are necessary to control ongoing sedimentation and to reverse habitat loss throughout Boeing Creek.

Since the upper watershed is expected to continue to produce and transport excess fine sediments in the creek regardless of past and expected future efforts to reduce erosion, a sediment basin is being incorporated into the Hidden Lake project design. This basin will reduce recruitment of sand to the downstream reaches of the creek and prevent sediment from filling the restored Hidden Lake. Salmon and anadromous cutthroat trout spawning habitat in the lower reaches of Boeing Creek will benefit from this reduction of sedimentation.

1.5 PROJECT GOAL

The goal of the Hidden Lake project is to permanently reestablish the lake in a way that increases habitat for fish and wildlife and provides additional benefit to Boeing Creek aquatic habitats by preventing the passage of fine sediments to downstream reaches of the creek.

2.0 EXISTING CONDITIONS AT SITE

2.1 GENERAL SITE DESCRIPTION

2.1.1 Landscape and Watershed Position

The Hidden Lake site is located in the lower third of the watershed, approximately in the middle of the perennial portion of Boeing Creek (Figure 1).

The gradient of the bottom of the ravine is considerably steeper downstream of the site, and somewhat steeper upstream (Figure 4). In a King County Surface Water Management Division study of the creek, the stream was divided into two reaches, with Reach 1 extending downstream of the Seattle Golf and Country Club Dam to Puget Sound, and Reach 2 extending upstream from Innis Arden Way to the M-1 Dam (Boehm 1994). The short reach (approximately 650 feet) downstream from Innis Arden Way to the Golf and Country

Club Dam was not evaluated in detail. The Hidden Lake site is in the lower portion of Reach 2 (Figure 3).

The lower section of Reach 1 varies in gradient from 1%-8% within a forested ravine, with the upstream section of Reach One (below the Golf and Country Club Dam) varying from 9%-12% gradient. The Hidden Lake section, comprising the lower part of Reach Two, has a lower gradient which varies from 1%-2.5% gradient. Upstream of the Hidden Lake site the stream gradient increases mid reach to 3%-10% throughout most of the rest of the reach. The stream grade immediately downstream of the outfall of the SWM M1 dam is 17% and lies within a steep-sided, second growth, forested ravine.

2.1.2 Topography

The Hidden Lake project area is in a relatively wide and flat part of the Boeing Creek ravine, approximately 180 feet above sea level. The slope on the floor of the ravine at the project site is less than 2.5 % and the sides of the ravine vary from 20 % to nearly vertical in areas adjacent to the lake.

2.1.3 Land Use and Ownership

Land use in the riparian zone varies over the length of Boeing Creek. Most of the stream is within a forested ravine which has experienced little recent development. However, urban development in the Boeing Creek Basin away from the creek itself has removed forested uplands and wetlands, which store and release storm flows over an extended period of time.

The proposed project site is partially contained within King County Shoreview Park, a parcel owned by METRO, and portions of 4 private residential lots. These lots are the Daly, Kellett, Lankford and Jans parcels. These homeowners support the restoration of the lake.

2.2 BOEING CREEK

2.2.1 Hydrology and Hydraulics

2.2.1.1 Hydrology

Boeing Creek hydrology is dominated by the developed upper reaches of the basin. The development consists of commercial, light industrial, and dense to moderately dense residential development. There are undeveloped areas adjacent to the creek channel near Shoreview Park and the Innis Arden Reserve. The resulting flashy runoff hydrographs are typical of developed basins. The M-1 dam on the main stem and the North Pond on the north fork capture 90% of the developed basin and attenuates the flashy hydrographs to within the historic two year and a ten year flow rates. However, the attenuated flow rate of the two and ten year return period are similar, and there is little hydraulic difference between the two flow rates. This explains why downcutting of the stream due to the unattenuated flow has been reduced, but sediment recruitment continues at higher than historic rates. It appears the basin and creek have reached a new equilibrium.

Precipitation

The Boeing Creek basin receives about 36.7" of rainfall annually. This is based on USGS rain gauge "Seattle State EMSU". This is comparable with the annual precipitation at the Seattle Tacoma International Airport (SeaTac), which receives about 37.1" of rainfall annually. In order to generate a long term peak flow record the SeaTac hourly data was used. A scaling factor of 1.0 was used due to the similarity of the two rain fall records. The 43 year record from SeaTac allows the model to generate a data base from which a reliable frequency analysis can be performed.

Geology

The upper reaches of the basin are characterized by shallow depressions which have little topographical definition. This area comprises approximately 83% of the basin tributary to the Hidden Lake area of Boeing Creek, and is underlain by Vashon till. Portions of this upland area were probably large isolated wetlands, especially along State Highway 99 in the vicinity of the Sears development. Advance outwash, 150 to 250 feet thick, underlies the till cap and is exposed at the surface in a narrow thread. The narrow thread runs up into the basin along Dayton Avenue, the main channel stem, and 6th Avenue NW. The advance outwash comprises the remaining 16% of the basin tributary to Hidden Lake.

The till soil provides little storage and generates surface water runoff early in a storm event. The advance outwash provides significant storage and deep groundwater recharge. Therefore, little surface runoff is generated from the exposed outwash areas. However, the majority of the storm runoff in Boeing Creek is now generated from developed impervious areas, and lawns in the till soil areas which are directly connected to the piped conveyance system. The forested till areas and undeveloped outwash areas continue to

contribute to the base flow. During the 100 year flood event the base flow comprises about 7% of the peak flow.

Land Use

The basin tributary to Hidden Lake is approximately 90% developed. Along State Highway 99 there is commercial and light industrial development where the land has been converted to virtually 100% impervious surface. However, the topography and the add-on style drainage system creates some local depression storage, and so the effective imperviousness is less than 100%. The remaining basin is suburban residential development with varying degrees of density. This area also includes schools, churches, playgrounds and retirement homes. This development pattern falls approximately between Fremont Avenue NW to the east and 6th Avenue NW to the west. The uppermost portion of the basin is bounded by NW 204th Street to the north, and NW 145th Street to the south. The majority of the residential development occurred before the advent of tight-lining down spouts to the conveyance system in the street. Therefore, most of the effective impervious surface includes the streets only. Since the basin is considered almost fully developed, it is anticipated that future peak runoff rates will not increase significantly.

Conveyance

The conveyance system consists of storm pipes, culverts and ditches. However, as roadways are improved the remaining ditches will be converted to pipe. The eastern portion of the basin (dominated by the development along SR-99 including Sears) and the southern portion of the basin (dominated by Shoreline Community College and residential plats) eventually discharge to Boeing Creek via a 48-inch storm drain under Carlyle Hill Road. This storm drain outlets to a rip rap channel approximately 1000 feet upstream of the M1 Dam. Below the M1 Dam adjacent local surface runoff and discharge from the M1 Dam are conveyed in the stream channel to Hidden Lake. The northern portion of the basin (dominated by residential plats and schools) is conveyed in two main trunk lines running north to south along Dayton Avenue NW and 6th Avenue NW. Both eventually discharge to the North Pond (in Shoreview Park) via a 36-inch and a 24-inch storm drain, respectively. The North Pond discharges to a gabion-basket protected section of the north fork, approximately 300 feet upstream from the confluence with the main stem. The remaining drainage basin tributary to Hidden Lake is conveyed to Boeing Creek via surface runoff (sheet flow), subsurface flow (interflow or seeps), and concentrated flow in roadside ditches. This area is small, contributing less than 10% of the flow during a storm event.

Flows

The mean annual flow at Hidden Lake is estimated to be 3.2 cubic feet per second. A base flow model, developed by Brown and Caldwell Consultants, for Boeing Creek predicts a minimum base flow between 0.68 and 1.95 cubic feet per second. The high low

(summer) flow occurred during the summer of 1951. The low summer flow occurred during the summer of 1991. An average year (approximately a two year return period) would have a summer base flow of about 1.0 cfs.

2.2.1.2 Hydraulics

Existing

The channel of Boeing Creek is confined by steep slopes throughout. No inundation of homes or streets would occur due to a rise in the water surface associated with the 100 year flood. The only extensive low areas adjacent to Boeing Creek are at the outlet to Puget Sound and at the Hidden Lake site. Historically, these areas were probably flood plains of the creek. However, the channel gradient at Hidden Lake is such that backwater or standing water normally associated with flood plains would not occur beyond the stream channel. The downstream hydraulic control at Hidden Lake is two 48-inch culverts under Innis Arden Way. The capacity of the culverts does not produce a significant backwater effect on the upstream channel. Assuming the channel would be stable during such an event, the 100 year flow of 170 cfs can be conveyed within the stream channel and would cause a backwater elevation of 182. This elevation extends about 100 feet upstream of the culvert inlets and would not inundate the Hidden Lake site.

Proposed

The outlet of Hidden Lake will maintain the water surface at an elevation of 188. The flow will be controlled by a precast manhole riser set in the upstream face of the confining berm. The precast manhole will operate like a sharp crested weir. The flow over the manhole structure will be conveyed through the berm via two 36-inch culverts. The culverts can convey the 100 year flow before cresting the emergency spillway of the berm. The outlet control will provide no attenuation of peak flood flows. The flow regime downstream of Hidden Lake is not expected to change, and hence downstream impacts should be negligible.

2.2.2 Sediment

Sediment supply, transport and size remain a significant problem in Boeing Creek. The increased discharge of urban stormwater to the creek has increased its capacity to transport sediment, and although the retention/detention facilities have decreased the peak discharges, significant sediment is still moved through the system.

The lowest exposed geological unit in the Boeing Creek basin is the Whidbey Formation. The Whidbey Formation consists of bedded medium to coarse sand with occasional lenses of fine to medium gravel, and is a significant sediment source to the lower portion of Boeing Creek below Innis Arden Way. Transitional beds (Lawton Clay equivalents) overlie the Whidbey formation. Transitional beds consist of massive thick to thin beds of gray clay and silt. When saturated, these clays become susceptible to a variety of mass wasting processes

including slumps, slides and debris flows. The clays are approximately 80 feet thick and are exposed at Innis Arden Way and at the Hidden Lake site. The advance outwash which is equivalent to the Esperance sand overlies the transitional clays. The advance outwash consists of a 160 to 250 foot sequence of well consolidated sand with occasional gravel lenses. In undisturbed areas this unit can hold a near vertical slope. The advance outwash is the dominant sediment source in the upper portion of the basin. Vashon Till overlies the advance outwash. Vashon Till is 3 to 6 feet thick and mantles the uplands. Vashon till is not a significant sediment source to the system due to its limited extent and lack of exposure.

Above the Hidden lake site, advance outwash is the dominant sediment source to the system. The advance outwash has the largest extent and exposures. Some transitional beds which are exposed at and above Hidden Lake contribute some fine grained sediment, but most exposures above Hidden Lake are relatively stable. The area above Hidden Lake is a medium to high use recreational area. Numerous trails intersect the stream. These trails are routed over steep slopes of advance outwash. Trail use has inhibited vegetation from covering the slopes and loose sand eroding from exposures flows overland to the edge of the creek where high flows mine the toes of the slopes. In other areas, the creek is eroding banks which have not been disturbed by human access.

A recent sediment study commissioned by SWM provided a reach-by-reach quantification of the sediment either being deposited or removed from Boeing Creek (West Consultants 1995). The study estimates that approximately 175 cubic yards of sediment are delivered to the Hidden Lake site each year.

2.2.3 Fish Habitat

2.2.3.1 Fish Presence

Adult salmon are unable to migrate upstream to the Hidden Lake reach of Boeing Creek because of several downstream blockages including the Seattle Golf and Country Club Dam, as well as cascades and slope failures between the dam and Innis Arden Way. However, juvenile coho salmon have been released into the upper reach, including placement of eyed eggs in gravel-filled tubes placed in the stream in the fall, and release of fry in the spring. Juveniles are able to migrate downstream to Puget Sound.

During a field evaluation in June, 1994, cutthroat trout (*Onchorynchus clarki*) that averaged 2-4 inches in length, and zero-aged coho salmon (*Onchorynchus kisutch*) were encountered in the lower reach of Boeing Creek (Reach 1) below the Seattle Golf and Country Club Dam. In December 1994, adult chum (*Onchorynchus keta*) and coho salmon were observed spawning in areas of Reach 1 where small gravel is underlain by coarse gravel heavily imbedded with sand. Fish were found to within approximately 70 feet below the dam. A few chum salmon carcasses were also noted in Reach 1. Overall, approximately 35 total adult salmon (chum and coho) are thought to have returned to Boeing Creek in December 1994.

The previously existing Hidden Lake was stocked with an exotic subspecies of cutthroat trout before the development of Innis Arden and presumably there were native resident cutthroat trout in this upper reach of Boeing Creek. Although it is possible some resident or stocked trout remain, no fish were found in March 1992 when the Washington State Department of Fisheries electrofished the project site (Rich Johnson, 1995). However, in the fall of 1992, several cutthroat trout were moved from the downstream reach of Boeing Creek to the upstream reach above Innis Arden Way (Ed Barnes 1995). It is not known if these transplants were resident trout or sea run cutthroat, if they have survived, or if they are successfully reproducing.

2.2.3.2 Bank Stability and Channel Morphology

Bank stability and channel morphology in Boeing Creek were assessed using the US Forest Service's Stream Habitat and Channel Stability Evaluation Forms in a recent study (Boehm 1994). The assessment yields a numerical score based on assessments of land form morphology, debris jam potential, riparian vegetation density, estimated channel capacity, observed cutting and deposition, and substrate character. Scores correspond to "excellent," "good," "fair," or "poor" categories.

The Hidden Lake area received a "good" rating for channel stability. Factors contributing to the score were lower gradient stream and side slopes, dense vegetation, and moderate down-cutting. The stream gradient in this section of Boeing Creek varies between 1 and 2.5%.

The majority of Boeing Creek downstream of the Hidden Lake site rated "fair" for channel stability. Significant factors are high density of vegetation, low bank rock content, moderate to steep slopes, limited scouring, and moderate to extensive sediment deposition in the stream channel. Reach One begins with a lesser gradient varying from 2%-5%, and has experienced limited downcutting and extensive sedimentation, including point bar and mid-channel sand bar formation. The upper section of Reach One flows with a moderate gradient, varying from 5-12%, and has experienced more extensive downcutting and sedimentation. Several sections of stream bank within Reach One were severely eroded.

Above Hidden Lake the channel stability was rated "fair." Significant factors are high density of vegetation, low to moderate bank rock content, steep slopes, downcutting, and moderate deposition in the channel. This reach has a moderate gradient varying from 2-10%, and like the portion of Boeing Creek downstream from Hidden Lake, has experienced downcutting and in-channel sediment deposition. Most sections of this stream reach were incised, with debris jams. The frequency of debris jams increases in areas with large trees and steep stream gradient, and has contributed to the stability of the channel. However, debris jams have locally forced water flow against adjacent banks, often causing significant bank erosion.

2.2.3.3 Substrate and Large Woody Debris

Downstream of Hidden Lake, the substrate has been affected by very high sediment deposition resulting from transport, local bank erosion and slope failures. In the portion of Reach 1 nearest to Puget Sound, the substrate consists of approximately 60% sand and 40% coarse gravel (> 0.25-100mm). In some of these areas the sand bars have formed midstream (Boehm 1994).

Substrate within the Hidden Lake reach (1%-2% slope) varies from 60% sand and 40% gravel to 30% sand, 40% gravel (25mm-100mm), and 30% cobble (100mm-256mm).

Upstream of the Hidden Lake site the substrate reflects the higher velocities and steeper gradient (2%-17%) with 20% sand, 30% gravel (25mm-100mm), and 50% cobble (100mm-256mm).

Large woody debris (LWD) is defined as wood pieces greater than 10" in diameter and 10' length interacting with the channel. There are few pools and very little LWD in the Hidden Lake site reach, consistent with the immature forest community adjacent to the creek. Abundant LWD exists downstream and upstream of the Hidden Lake reach, including numerous debris jams. The abundant debris jams in both reaches significantly influence local sediment transport which consists primarily of silt and sand. Most debris jams have effectively trapped sand. In some cases, flows have been forced around the debris creating islands, and active erosion has occurred along the stream banks. LWD is most abundant where the riparian corridor consists of mature second growth and remnant old growth forest. There is an abundance of pool habitats where there is abundant LWD.

2.2.3.4 Aquatic Insects

The Hidden Lake reach of Boeing Creek was qualitatively sampled for aquatic insect composition in late September 1993 (Boehm 1994). The following juvenile insects were found:

Common Name	Order	Family
Mayfly	Ephemeroptera	Baetidae
Caddis fly	Trichoptera	Limnephilidae
Larva midge	Diptera	Chironomidae

2.2.4 Other Animal Habitat

The riparian corridor and upland forest surrounding Boeing Creek has a varied bird and mammal population. Bird species sighted in the vicinity of Boeing Creek include mallard (*Anas platyrhynchos*), sharp-shinned hawk (*Accipiter striatus*), red tailed hawk (*Buteo jamaicencis*), bald eagle (*Haliaeetus leucocephalus*), great blue heron (*Ardea herodias*), band-tailed pigeon (*Columba fasciata*), great horned owl (*Bubo virginianus*), rufous

hummingbird (*Selasphorus rufus*), northern flicker (*Colaptes auratus*), hairy woodpecker (*Dendrocopos villosus*), western wood pewee (*Contopus sordidulus*), barn swallow (*Hirundo rustica*), violet-green swallow (*Tachycineta thalassina*), Steller's jay (*Cyanocitta stelleri*), American crow (*Corvus brachyrhynchos*), black-capped chickadee (*Parus atricapillus*), chestnut-backed chickadee (*Parus rufescens*), red-breasted nuthatch (*Sitta canadensis*), winter wren (*Troglodytes troglodytes*), robin (*Turdus migratorius*), Swainson's thrush (*Hylocichla ustulata*), golden-crowned kinglet (*Regulus satrapa*), ruby-crowned kinglet (*Regulus calendula*), starling (*Sturnus vulgaris*), Hutton's vireo (*Vireo huttoni*), Wilson's warbler (*Wilsonia pusilla*), brewer's black bird (*Euphagus cyanocephalus*), red-winged blackbird (*Agelaius phoeniceus*), evening grosbeak (*Hesperiphona vespertina*), Cassin's finch (*Carpodacas cassinii*), house finch (*Carpodacas mexicanus*), American goldfinch (*Spinus tristus*), rufous-sided towhee (*Pipilo erythrophthalmus*) and song sparrow (*Melospiza melodia*).

Mammal signs noted include the active burrows of mountain beaver (*Aplodontia rufa*), and the tracks of river otter (*Lutra canadensis*), raccoon (*Procyon lotor*), and coyote (*Canis latrans*). Other evidence of terrestrial wildlife indicated that moles, voles, mice, and a variety of other rodents utilize habitats within the Boeing Creek corridor. Seals (*Phoca vitulina*) and their pups have been seen hauled out on beach areas near the mouth of Boeing Creek.

Salamanders, frogs and crayfish are likely inhabitants of the aquatic habitats within the proposed project area.

2.3 WETLAND

The project site is in the historic flood plain of Boeing Creek, currently a low-lying alder-dominated forest containing 3 wetlands and bisected by the creek, and previously the site of the original Hidden Lake. The wetlands on the site were evaluated by King County Surface Water Management Division in 1994 (Ostergaard and Concannon 1994).

2.3.1 Vegetation, Soils and Hydrology

The majority of the Hidden Lake site has a forested canopy dominated by red alder (*Alnus rubra*). Pacific willow (*Salix lasiandra*) trees are common throughout, and especially dense in the western lobe of the historic flood plain. Much of the site is an open stand; however, the western lobe supports a dense thicket of Pacific willow (*Salix lasiandra*) and salmonberry (*Rubus spectabilis*). Other trees and shrubs present include western hemlock (*Tsuga heterophylla*), western red cedar (*Thuja plicata*), bigleaf maple (*Acer macrophyllum*), red elderberry (*Sambucus racemosa*), Indian plum (*Oemleria cerasiformis*), and a domestic fruit tree (*Prunus sp.*). Himalayan blackberry (*Rubus discolor*) and pacific blackberry (*Rubus ursinus (=vitifolius)*) occur occasionally. The depauperate herbaceous layer contains Robert's geranium (*Geranium robertianum*), youth-on-age (*Tolmiea menziesii*), fringecup (*Tellima grandiflora*), stinging nettle (*Urtica dioica*), and a number of other species.

The Hidden Lake site is not included in soil maps in the Soil Survey, King County Area, Washington (Snyder *et al.* 1973). Based on the site evaluation, most of the soils are mixtures of sand, loam, and gravel. The soil appears to be sediment deposited as a result of upstream erosion which filled the original Hidden Lake.

The Hidden Lake site receives surface water from a number of sources. Boeing Creek bisects the area as it flows south and west towards Puget Sound, approximately 0.6 miles downstream. It carries water from the upper 1557 acre portion of the drainage basin. Steep slopes surrounding the Hidden Lake site contain many hillside seeps that flow year-round. Direct precipitation falling on the site, groundwater flow and surface runoff also contribute to the hydrology of this low area.

Detailed hydrological information was collected on the northern portion of the site for use in making a wetland determination. Direct observations of hydrology used in the wetland evaluation included monitoring well data, soil saturation, standing water in soil pits, and water seeping from the ground. Field indicators of hydrology observed during the evaluation included wetland drainage patterns and surface scoured areas.

Wetland A is a palustrine scrub-shrub (PSS) wetland associated with Boeing Creek. It is bordered by Boeing Creek on the east and by a residence to the west (Figure 5). Wetland A covers 7,168 square feet. It has been assigned a King County Class 3 rating because of its small size and lack of forested components or diverse habitat features.

Wetland A is dominated by salmonberry. It supports a few red alder trees, a non-native pine, and one western hemlock on a hummock. Some red elderberry grows within the wetland, and the sparse herbaceous layer is composed of Robert's geranium, lady fern (*Athyrium filix-femina*), youth-on-age (*Tolmiea menziesii*), large-leaf avens (*Geum macrophyllum*), and sword fern (*Polystichum munitum*). Stinging nettle (*Urtica dioica*), escaped English ivy (*Helix hedera*), and rhododendron (*Rhododendron sp.*) have encroached into the edge of the wetland as well. The majority of the dominant species have an indicator status of FAC or FACW, thereby satisfying the hydrophytic vegetation criterion.

Wetland B is a narrow palustrine emergent/palustrine scrub-shrub (PEM/PSS) wetland located on a steep bank near the southeast corner of the project area. It covers approximately 3,246 square feet within the project area. The wetland edge was flagged only near Boeing Creek, since the wetland extends directly up the slope outside the limits of the project (Figure 5). It has been assigned a King County Class 3 rating because it is under an acre in size and lacks a forested wetland component.

Salmonberry is the dominant plant in Wetland B. Red elderberry, common horsetail (*Equisetum arvense*), Robert's geranium, and lady fern are also found. It is fed by hillside seeps. Because of steep, unstable terrain, obvious indications of hydrophytic vegetation and wetland hydrology, no soil pits were dug. During the site evaluation, water was cascading from the bank wall to the edge of Boeing Creek, and the seep was still active in late September. Soils in Wetland B are highly erodible and unstable, except in the lower part

where an outcrop of consolidated material and impervious clay occurs. Large piles of soil line the lower slope from previous slope failures.

Wetland C is a palustrine, forested (PFO) wetland partially bisected by Boeing Creek (Figure 5). The toe of the western valley slope borders most of the west side, while the toe of the eastern valley slope forms the eastern edge. The wetland covers 56,176 square feet (1.29 acres) within the project area, and extends somewhat further north beyond the project limits. It has been assigned a King County Class 2 rating because it is over an acre in size and contains a forested class.

The vegetation community of Wetland C is characterized by a canopy of red alder interspersed with pacific willow over a sparse understory dominated by salmonberry, Robert's geranium and youth-on-age. Wetter areas in the wetland support slough sedge (*Carex obnupta*) and skunk cabbage (*Lysichitum americanum*). The east side of the site is fed by perennial seeps emanating from the base of the steep slope and has year-round surface-saturated soils supporting obligate wetland species such as water parsley (*Oenanthe sarmentosa*), lesser duckweed (Lemna minor) and marsh speedwell (*Veronica scutelatta*).

2.3.2 Functions

Ecological functions and values performed by wetlands include water quality improvement, flood flow moderation, biological support, groundwater exchange, and cultural and recreational values. The functional values of the project area wetlands summarized in Table 4 and discussed below, are from estimates in King County Surface Water Management's 1994 wetland evaluation of the site (Ostergaard and Concannon 1994).

Table 4. Wetland Functional Values, Hidden Lake, CIP #0A1755.

WETLAND FUNCTIONAL VALUES						
Wetland	Water Quality Improvement	Floodflow Moderation	Biological Support	Hydrologic Support	Groundwater Exchange	Cultural/ Recreational
A	L-M	L-M	L-M	L-M	M-L	L-M
B[1]	L-M	M-L	L-M	M	M	L
C[1]	M	M	M-L	M	M	L-M
Overall	L-M	M	M	M-L	M	L-M

L = Low; M = Moderate; H = High

[1]Functional values assessed only for the portion of the wetland occurring on-site.

2.3.2.1 Water Quality

Through a variety of physical, biological, and chemical processes, wetlands purify water by removing organic and mineral particulate matter and water-borne pollutants. Water quality improves as a result of the natural processes of sedimentation, ion exchange, algal and bacterial degradation of pollutants, aerobic decomposition, particulate absorption and adsorption, and nutrient uptake and recycling. Dense, primarily herbaceous vegetation is most effective at trapping particulates, and a large surface area is required for significant water purification by sedimentation and biochemical processes (Reppert et al. 1979).

Although the presence of hillside seeps contributes to the water quality value of Wetland A, it has low to moderate water quality improvement value because it is less than an acre in size, has little herbaceous vegetation, and is downstream from potential nonpoint pollutant sources. Wetland B has low to moderate value for water quality improvement. Wetland B is small, but has rapid flow of groundwater into Boeing Creek. It may, however, be a source of sediment due to the unstable nature of the steep slope. Wetland C has moderate value for water quality improvement. Wetland C is relatively large, and while the herbaceous vegetation is not dense, the permeable soils function as a filter for water from hillside seeps along the east side of the basin and for flood waters, which may carry large amounts of sediment.

2.3.2.2 Floodflow Moderation/Stormwater Detention

Wetlands moderate floodflow by temporarily storing flood waters, slowing flood velocities, and reducing flood energy. As a result, flood peaks are desynchronized and reduced, while flow duration is increased. The storage capacity and the surface roughness (type and amount of vegetation) of wetlands are important variables in the ability of a wetland to perform this function (Reppert et al. 1979, Sather and Smith 1984). In watersheds where wetlands have been lost, flood peaks may increase by as much as 80 percent (Adamus and Stockwell 1983).

Large amounts of persistent vegetation, position in topographic depressions, large wetland size, and proximity to urban areas are factors that can enhance inherent ability and opportunity to perform the floodflow moderation function. Wetland A has low to moderate value for floodflow moderation due to its small size and because it is mostly located outside of the flood plain. Wetland B has moderate to low flood control value because of its small size and the rapid outflow of water into Boeing Creek observed during the site evaluation. Wetland C probably had moderate value for floodflow moderation because of its larger size and position in the floodplain of Boeing Creek, however the construction of detention facilities upstream has greatly reduced the incidence of flooding outside the channel at the Hidden Lake site.

2.3.2.3 Biological Support

The biological support function of wetlands is multi-faceted. They provide important wildlife habitat, may be highly productive, and they export vital nutrients to downstream or surrounding areas. Wetlands provide essential habitat and food for wildlife species. Biological support of fish and waterfowl is of particular economic and recreational value.

The number of plant species present, the structure (layering, density, interspersion, and juxtaposition) of the vegetation, and the numbers of distinct vegetation types all influence habitat value. For example, forested wetlands with three distinct layers (overstory, shrub layer, herbaceous layer), wetlands with more than one vegetation type (e.g., forested and scrub/shrub), and wetlands with a well-vegetated buffer at the wetland/upland edge (ecotone) all provide diverse habitats with higher biological support value than simpler habitats.

Wetlands A and B have low to moderate value as wildlife habitat, primarily because of their

small size, low plant diversity, and lack of unique habitat features. Wetland C has moderate to low value for wildlife habitat; it has moderate vegetation diversity and structure, but only one significant habitat type. Although it is larger than the other 2 wetlands, it is still less that 5 acres in size, and located within a highly residential area.

2.3.2.4 Groundwater Exchange

Groundwater exchange consists of both groundwater discharge and groundwater recharge. Groundwater recharge replenishes groundwater stores, while groundwater discharge not only creates and maintains wetlands, but can also maintain stream flows, support plant and animal populations in upland and wetland communities, and provide surface water for multiple uses (Sather and Smith 1984). The best current evidence suggests that wetlands are generally discharge areas. However, some wetlands are recharge areas and some wetlands support both functions simultaneously or at different times of the year (Sather and Smith 1984). The permeability of underlying soils and the location of the water table determine a wetland's groundwater exchange capacity.

It is thought that undeveloped upland areas are more efficient at groundwater recharge areas than wetlands. The rationale for this assertion is that soils under most wetlands are relatively impermeable, which is one reason why standing water is present (Mitsch and Gosselink 1986). Thus, it is suggested that groundwater recharge occurring in wetlands is associated with upland boundaries of the wetlands. In the few studies available, recharge was related to the wetland edge-to-volume ratio, so that small wetlands may make a disproportionately greater contribution to groundwater recharge than large wetlands (Mitsch and Gosselink 1986).

Cumulatively wetlands A, B and C have moderate local groundwater exchange value because they contain hillside seeps flowing directly into Boeing Creek (Wetland B) or flow through the wetland and then to Boeing Creek (Wetlands A and C). A combination of high permeability soils on top of low permeability soils appears to have created the high quantity of groundwater discharge occurring in the Hidden Lake basin.

2.3.2.5 Hydrologic Support

Wetlands associated with rivers, lakes, intertidal wetlands and marine waters can function as hydrologic support to these systems, regulating the hydrologic stability and integrity of the system. When a wetland borders a surface water, it may absorb water when the surface water level is high and release water slowly into the surface water at low water levels. Wetlands can be an integral part of the hydrologic processes of surface waters.

Cumulatively Wetlands A, B and C provide moderate hydrologic support value to the Boeing Creek. The groundwater discharge occurring along the steep hillsides within the wetlands supports the base flow of Boeing Creek during storm events by slowing the flood peaks, and during dry months, by providing a somewhat constant source of water for the base flow.

2.3.2.6 Cultural/Recreational Values

Wetland cultural and recreational values are related to quantitative and qualitative benefits they provide. Wetlands have been set aside for scientific study, education, and the protection of aquatic and terrestrial habitats. Some wetlands are important archeological or historical sites; others provide recreational opportunities such as bird watching, hiking, photography, boating, fishing, and hunting.

These values are both consumptive and non-consumptive socio-economic uses. Consumptive uses include harvestable resources produced in association with wetlands, such as commercial fisheries, renewable resources, and agriculture. Non-consumptive uses include scenic, recreational, educational, aesthetic, archeological, heritage, and historical values.

Cumulatively the wetlands in the proposed Hidden Lake restoration area have low to moderate cultural and recreational values. The area lacks interconnections with open space, and provides limited opportunity for passive recreation to those residents with access to the property. It has moderate aesthetic value.

2.4 UPLANDS

2.4.1 Vegetation

Upland areas adjacent the Hidden Lake site are mostly steep slopes covered with dense, second-growth coniferous forest. Douglas fir, red alder, western hemlock and bigleaf maple dominate in the tree canopy, with salmonberry, red elderberry and pacific blackberry the dominant shrubs. Robert's geranium, sword fern, and fringecup are important herbaceous layer plant. In the area adjacent to Wetland A, escaped English ivy is the dominant groundcover, and salmonberry and exotic rhododendron make up the open shrub canopy. Soils in the uplands have variable colors, and contain a high percentage of sand. Field indicators of wetland hydrology were not present and well monitoring data showed that hydrology criteria was not met. In the upland areas adjacent to the creek and the northwestern side of Wetland C, the vegetation community does not differ from that found within Wetland C, but soil and hydrology criteria were not met (Figure 5).

2.5 RECREATION

2.5.1 Public Use and Access

Approximately half of the Hidden Lake site is within King County's Shoreview Park. Currently, public access to the Hidden Lake site is via an informal trail along the creek. Downstream, from Innis Arden Way the trail enters the site across private property. Upstream, the trail enters the Hidden Lake site through King County Shoreview Park. Upstream the trail follows along the creek but is joined by several other informal trails entering from both banks.

3.0 PROPOSED PROJECT

3.1 CONFIGURATION OF LAKE

This report is a compilation and summation of information found in reports written by SWM staff and others. The design of the lake balances the restoration of the previously existing Hidden Lake with additional habitat features intended to mimic some of the attributes of the original natural lake. The environmental benefits of the restored lake include an increased habitat diversity compared to the existing young riparian forest, and intercepting sediment which now continues to be transported and deposited downstream in Boeing Creek. In addition to environmental factors, other design considerations include cost, sediment loading, site hydrology and hydraulics, maintenance access, embankment stability, water quality, public access and public safety. The earthen embankment design allows for the future addition of a fish ladder in the unlikely event that existing downstream blockages are removed.

Please see the attached figure 6 for a plan view of Hidden Lake.