行政院及所屬各機關出國報告提要

97年台美環保技術合作協定第8號執行辦法-水庫水質優養化管理考察報告

出國類別：考察

派赴地區：美國華盛頓州西雅圖及愛達荷州波易斯

出國期間：97年12月7日至97年12月14日

報告日期：98年3月2日

出國人員姓名：汪士鈞

服務單位：行政院環境保護署

職稱：環境工程師

電話：02-23117722

摘　要

水庫為台灣地區民生及工業用用水的主要來源，近年因集水區過度的開發及水土保持不良，造成水庫及集水區水質優養化問題嚴重，為此行政院環境保護署近年執行「飲用水水源水質保護綱要計畫-飲用水保護區五大流域養豬拆除補償作業」、「臺灣地區河川流域及海洋經營管理方案」及「河川及海洋水質維護改善計畫(第一、二期)」等相關計畫皆針對水質優養化的問題有所著墨。

本次出國行程為台美環保技術合作協定第 8 號執行辦法-水庫水質優養化管理考察，由美國環保署第十分區西雅圖辦公室協助安排，主要行程 4 天考察華盛頓州西雅圖市 High Point 環境敏感區域舊社區更新計畫，奧林匹亞市 Capitol Lake 水質管理、帕吉灣 (PUGET SOUND) 之 Hood Canal 之監測計畫及愛達荷州波易斯市(Boise)污水處理及畜牧業管理。最後並於第十分區西雅圖辦公室會談，討論美國環保署「以總量管制方式控制營養源」及「美國營養源管制數據制定」等議題及本次行程回顧，相關經驗可作為國內水庫優養化管理之參考。

目　錄

壹、 考察目的

本次行程為台美環保技術合作協定第 8 號執行辦法-水庫水質優養化管理考察，藉考察美國針對河川水庫(湖泊)優養化管理政策及實地參訪各項污染削減設施及實地現況，吸取美國較先進之經驗，爾後作為台灣地區河川水庫水污染整治之參考借鏡。

貳、 行程概要

考察「97 年台美環保技術合作協定第 8 號執行辦法
-水庫水質優養化管理考察」行程表

日序	日期	行程	備註
第 1 日	97.12.07	啟程出發至美國西雅圖	
第 2 日	97.12.08	1.準備 12/09 會議簡報 2.西雅圖城市發展歷史及市容建設考察	
第 3 日	97.12.09	上午 1.拜會美國環保署第 10 分區西雅圖辦公室 2.簡報本國水庫優養化現況討論行程 下午 1.參觀西西雅圖 High Point 區暴雨逕流處理	
第 4 日	97.12.10	1.華盛頓州首都奧林匹亞 Capitol Lake 2.赴華盛頓州 Hood Canal	
第 5 日	97.12.11	赴愛達荷州波易斯市(Boise) 上午：參觀 SMBR 污水處裡設施 下午：州營農場一貫化生產及廢棄物利用	
第 6 日	97.12.12	美國環保署第 10 分區西雅圖辦公室 1. 行程回顧 2. 交換意見	
第 7 日	97.12.13	待機	
第 8 日	97.12.14	回程	
第 9 日	97.12.15	回程	

參、行程說明

97.12.07　啟程，出發至美國華盛頓州西雅圖市

97.12.08　準備相關簡報資料及西雅圖市容考察（就西雅圖　地區歷史）

96.12.09 上午　赴美國環保署第 10 分區西雅圖辦公室拜會(協同督察總隊施勝鈞科長考察 EIA 行程)，美國環保署由 Kathy Veit 等人負責接待，本署施勝鈞科長簡報台灣地區環境影響評估施行現況，及汪士鈞工程師簡報台灣地區水庫水質現況及淡水河污染整治情形，美國環保署由 Holly Arrigoni 簡介美國環保署第十分區營養源污染歷史及挑戰。及後續行程討論。

下午　由 Kathy Veit 協同華盛頓州生態部門 Anne Dettelbath 參訪西西雅圖地區，高點(High Point)新社區，以降低暴雨逕流措施(高滲透性路面、草溝、草帶及滯洪池)，降低暴雨對該地區鮭魚迴游之溪流所造成之影響。

97.12.10 上午　先至第 10 分區辦公室由 Michael Rylko 簡介帕吉 灣(Puget Sound)營養源累積問題及監測計畫簡報及討論當日行程後，驅車前往華盛頓州奧林匹亞市，華盛頓州生態部門 Carol Malloy 討論州政府旁 Capitol Lake 營養源處理原則及參觀控制閘門。

下午　由 Michael Rylko 帶隊前往 Hood Canal(帕吉灣之一封閉型支流，兩岸皆為高級別墅)，說明營養源累積原因、監測方式及處理措施。

97.12.11 上午　與美國環保署西雅圖辦公室 Holly Arrigoni、Jenny Wu 及愛達荷辦公室 Bill Stewart 搭飛機

前往愛達荷州波易斯市(Boise)，由愛達荷州環境部 Mark Mason 帶隊前往市郊(沙漠地區)，新設置高級住宅社區設置之污水處理場參觀（污水全量回收）。

下午 前往愛達荷州（州營）3,000 頭乳牛場(佔地 1300 英畝)，參觀牛隻排泄物全回收再利用之經營方式，討論處理模式，及該廠之牛奶生產工廠。

97.12.12 於美國環保署第 10 分區西雅圖辦公室，Jenny Wu、Holly Arrigoni 及 Bill Stewart（by phone）回顧本次行程。Jenny Wu 說明美國環保署目前以總量管制方式控制營養源。及 Holly Arrigoni 簡報美國營養源管制數據制定。

97.12.13 參觀西雅圖市(等機位)

97.12.14-15 返程，回到台北

肆、 成果說明：

（一） 美國環保署控制水體營養源之方式

美國水體(峽灣、湖庫或河流)之營養源管制，主要利用水體總量管制方式（TMDLs，Total Maximum Daily Loads），除限制營養源排入（許可管制,聯邦）或水質交易方式(其他改善措施替代排入營養源,州政府)，由聯邦政府(美國 EPA)制定水質標準，而各州政府執行監測計畫，每 2 年提出該州水體水質狀況報告，超出標準之水體則需實行(提出)總量管制計畫，美國自 1990 年至今，已實行超過 1 萬件總量管制案。

（二） 水庫湖泊營養源管制

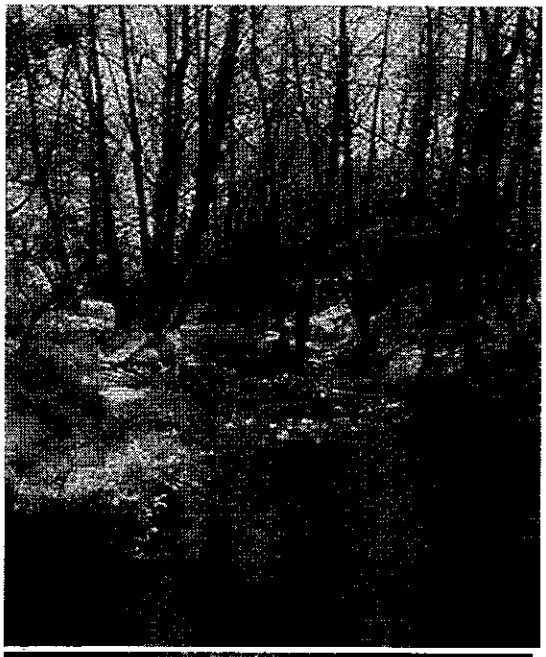
美國環保署於 1998 年發表了湖庫營養源策略，要求各州政府需於 6 年內發布水質數據標準，惟僅有明尼蘇達州於 2008 年完成全州湖泊營養源數據標準，主因湖庫水質標準數據如何訂定及訂定後如何去達成，對於州政府仍為一個難題。

目前發展出較標準之方式為先評估湖庫生態環境並分等級（http://www.epa.gov/wed/pages/ecoregions.htm），擇定污染指標（氮、磷、葉綠素 A、透明度等），由各等級中尋找出較乾淨的湖庫作為比較之參考。再建立各水庫營養源標準及實行方法，經幾年生態及水質監測，再評估所建立之標準及實行方式是否有效。

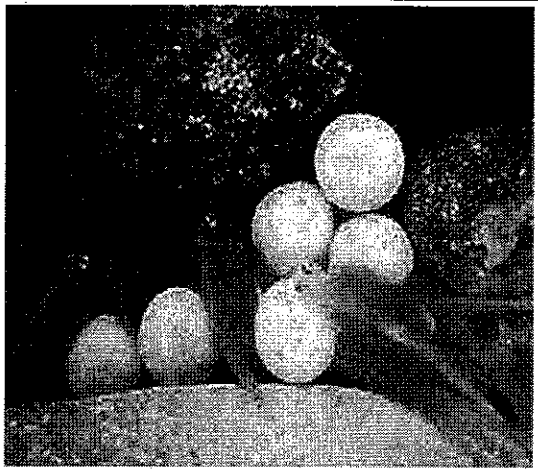
（三） 參訪點 1(12/9 下午)：西西雅圖地區，高點(High Point)新社區：

因社區下方為 Longfellow Creek，為鮭魚迴游及生態環境豐富之小溪，該社區之營造藉由高滲透性

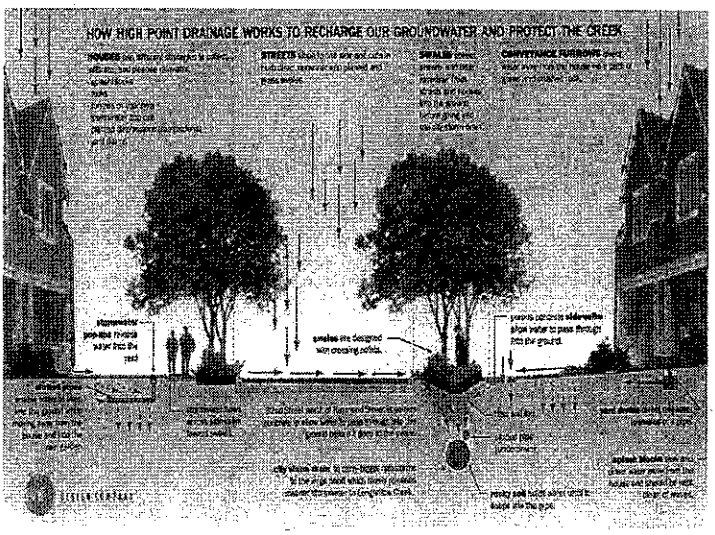
路面、房屋雨水收集、草溝、草帶及滯洪池等降低措施，降低暴雨對該地區生態之影響。對於台灣位於水源保護區的新社區，為極好的示範。



高點(High Point)社區下方為 Longfellow Creek 為鮭魚迴游及生態環境豐富之小溪



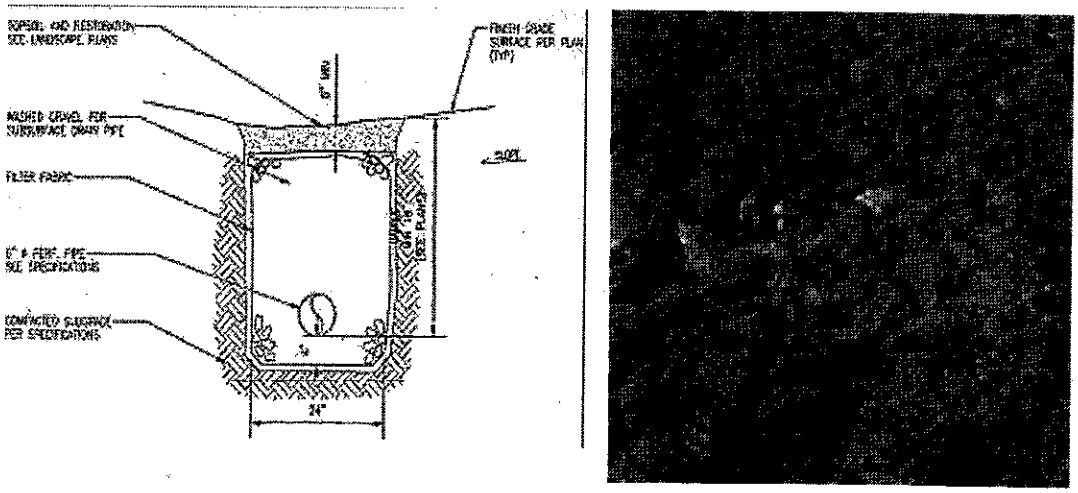
當地特殊種鮭魚迴游產卵之棲息地



各項降低暴雨逕流措施

該社區之草溝草帶

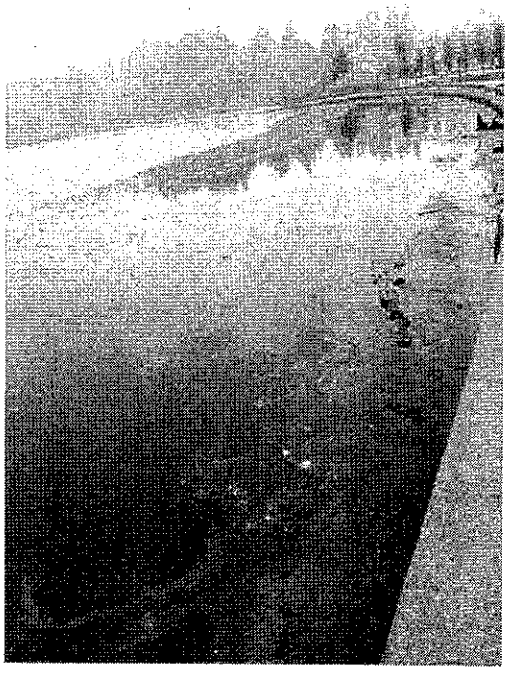
該社區之滯洪池



高滲透性路面及雨水收集系統

（四） 參訪點 2(12/10 上午)，奧林匹亞市（華盛頓州政府所在），州政府旁之奧林匹亞湖：

州政府辦公室旁之 Capitol Lake 淡水湖，為其上游水源為 Deschutes River，由經 30 呎落差流入 Capitol Lake 湖，其北方出口由控制閘門連接 Budd Inlet (Puget Sound 最南端)，近 2 年因候鳥及人類觀光影響造成藻類大量繁殖，目前州政府已委託顧問公司研擬各項方案(清除底泥、曝氣、拆除控制閘門等)，目前仍在評估及進行公民討論中。



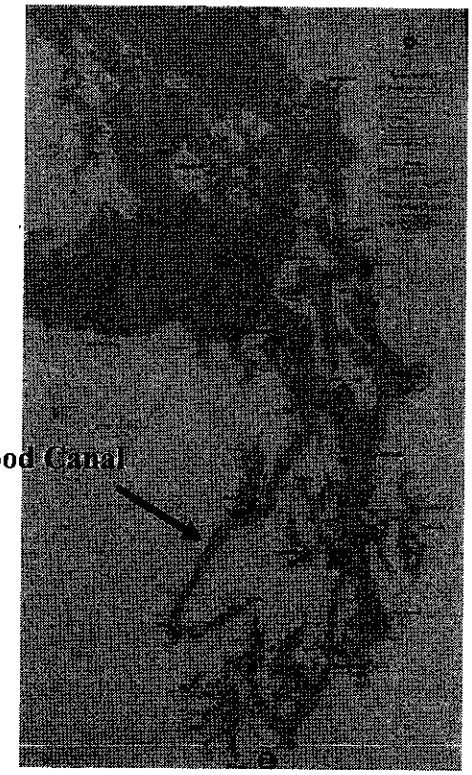
Capitol Lake 及 水質優養化現況

（五） 參訪點 3(12/10 下午)Hood Canal

Hood Canal 為一狹長內灣長度約 100 公里，其左側即為華盛頓州奧林匹亞國家公園，峽灣僅有一北方出口，兩旁為環灣公路及少量腹地，目前皆為渡假別墅及飯店，Hood Canal 峽灣為傳統牡蠣及蚌殼及海產採集地，近年溶氧值為歷年監測數據最低的，並於 2002-2003 年並造成初生鱸魚、章魚及海參等鹹水生物死亡。目前美國 EPA 針對該區域進行密集之監測及管制。

本區域污水處理方式以區域性管線收集後，已幫

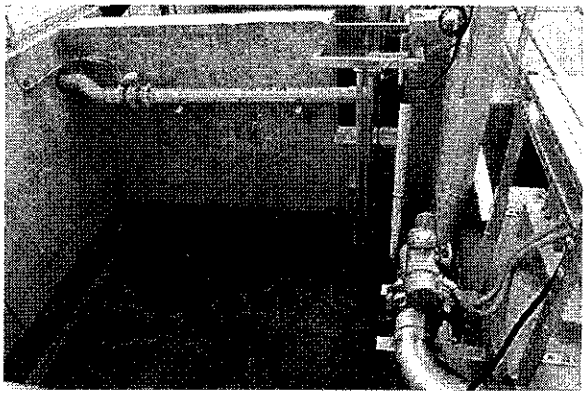
浦抽送至公路兩旁山上之小型污水處理場（大部分三級）至進行處理後，作為林地澆灌用。兩岸公路停車場則設置雨水收集系統，以礫石及草帶等設施降低報雨水逕流造成之污染，目前該區域亦嚴格管制新屋執照及舊屋修繕。



停車場雨水收集(草溝及礫石)

（六） 參訪點 4(12/11 上午)愛達荷州波易斯市，新設立獨立住宅區(700 戶)之污水處理廠（SMBR）

由愛達荷州環境部 Mark Mason 帶領前往波易斯市南方 15 公里處(沙漠)之新設立高級住宅區私人污水廠參觀，該污水廠以沉浸式薄膜生物處理系統（Submered Membrane Bioreactors, SMBR， 日本 Kubota），目前處理容量為 700CMD,未來可擴充至 3,000 CMD，該處理方式之優勢為占地面積小，處理後水質較佳(BOD<10mg/L，SS<10mg/L) 可達回收水水質要求。污泥停留時間長（10~30 days），生長速率緩慢的微生物得以滯留與增殖，有利於特殊或難分解污染物的去除，並可欄除大部分致病菌，減少消毒劑用量；惟初期設置成本較高。該社區處理後的污水全量回收，除部分作為社區植物之澆灌外，其餘污水灌入該區域一處深約 60 呎粗砂質土地再過濾後，補助地下水源。



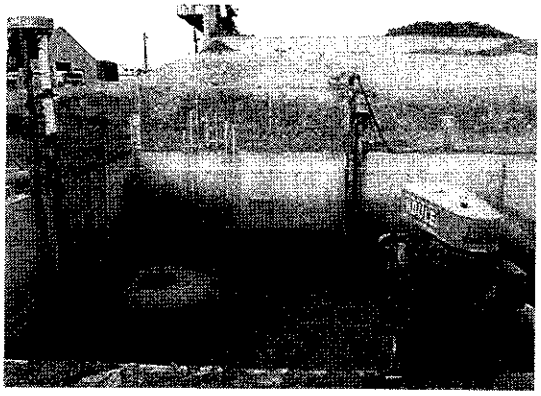
沉浸式薄膜生物處理系統（Submered Membrane Bioreactors, SMBR）

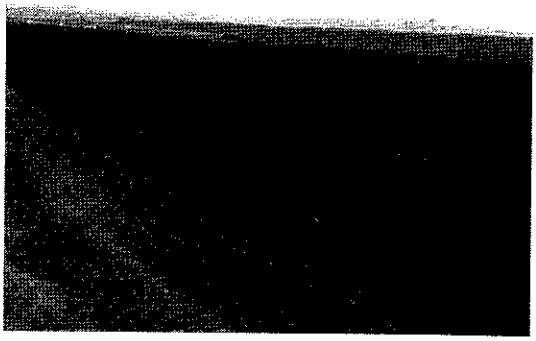
處理後的污水全量回收，除社區澆灌外，其餘注入砂質土層過濾後，補助地下水源。

（七） 參訪點 5(12/11 下午)愛達荷州(州營乳牛農場)

由愛達荷州農業部Hilary Simpson帶領前往愛達荷州營乳牛農場參訪，該農場佔地 1,300 英畝，養殖牛隻總數 5,000 頭（乳牛 3000 頭），該場為零廢棄產生，牛隻排泄物經粗篩後，固體物加入薄荷榨油後之殘渣(可增加碳源及吸收氨氣)及另依一定比例液態排泄物，進行半年發酵，發酵後產品除可以肥料販售外，發酵後產生溫度於冬季亦可作為牛隻鋪床使用，另其餘液態排泄物則為農場其他作物(稻草、薄荷、玉米等)澆灌用。

愛達荷州畜牧場之廢棄物處理，如採取土壤處理則皆需經過州農業部之評估，畜養隻數與澆灌農作物比例經過一定管控，避免過度澆灌及土壤有機物過高。





伍、 心得建議：

1. 對於污染超出負荷之河川，訂定總量管制標準來限制污染物排入；及新設立之大型開發案或工業區藉由水質交易方式提出其他替代方案改善河川水質，值得國內河川整治之參考。
2. 利用高滲透性路面、房屋雨水收集、草溝、草帶及滯洪池等降低措施，降低暴雨對該環境敏感地區之影響，對於台灣地區位於水源保護區或水庫集水區的社區規劃，為極好的示範。
3. 湖庫地區污水收集後送至鄰近山丘上污水廠處理後，放流水作為林地澆灌用，直接降低了大部分污染物的流達率，與國內污水處理廠必定於溪流旁地勢較低處有極大差異，應可參採。
4. Hood Canal 峽灣旁停車場及休息區以小型草溝配合礫石進行簡單過濾及污染削減，對於雨天油污及污染物有直接攔阻之效果，值得國內水庫、湖泊及風景區進行推廣。
5. 薄膜分離式污水處理系統（MBR）占地面積小，處理後水質較佳可達回收水水質要求；污泥停留時間長，有利於特殊或難分解污染物的去除，並可欄除大部分致病菌，減少消毒劑用量，可採行於水庫集水區及飲用水水質水量保護區之生活污水處理。

附 錄

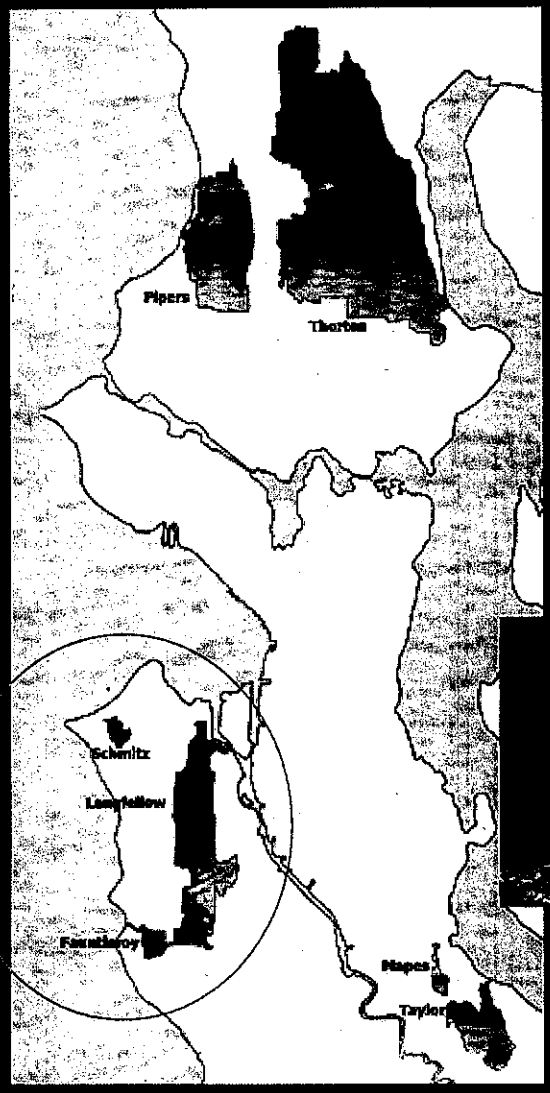
附錄 1：高點(High Point)社區設置簡報

SvR DESIGN COMPANY

Civil Engineering
Landscape Architecture
Environmental Restoration
Planning

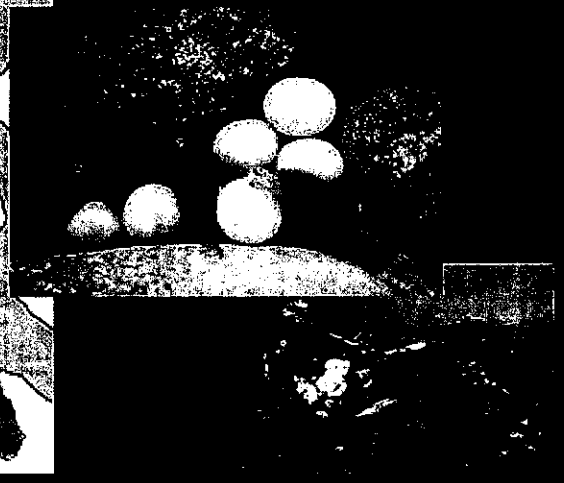
High Point Tour Handout

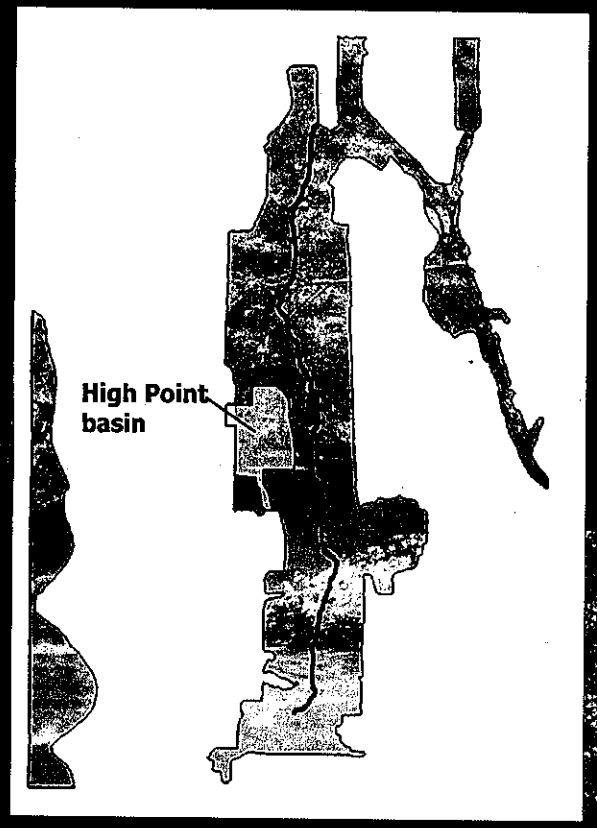
Kathryn Gwilym, PE, LEED® AP



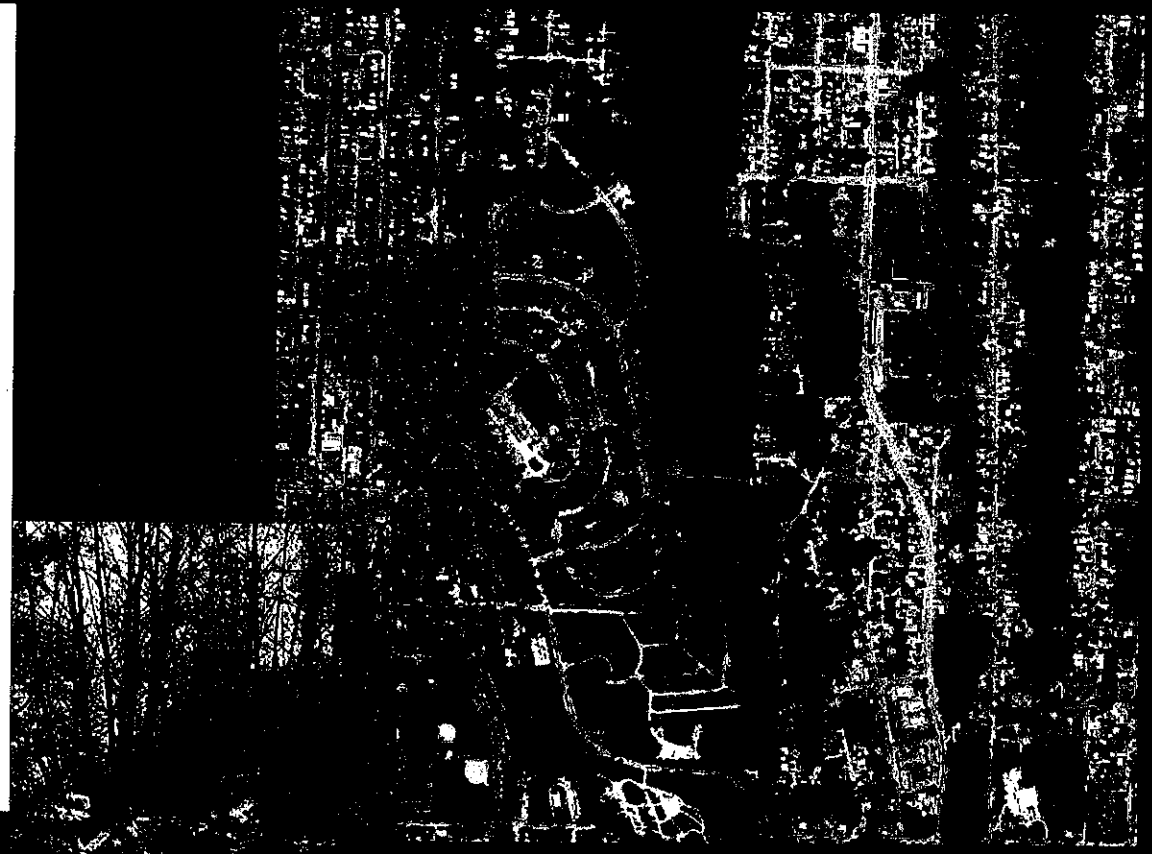
High-priority, salmon-bearing watershed that has been identified by "the community and the City as a significant and valuable resource"

Collects storm water runoff from an urban area of approximately 1,730 acres and eventually outfalls into Puget Sound



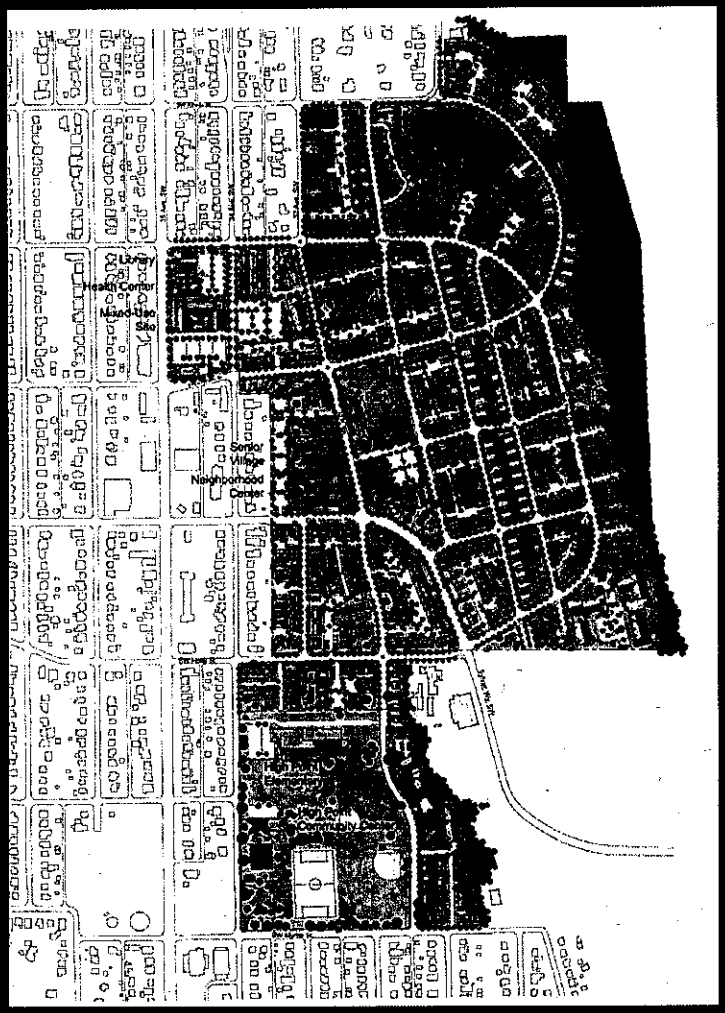


Longfellow Creek watershed



High Point prior to redevelopment

Longfellow Creek



Mithun Architects + Planners

120-acre mixed income housing redevelopment

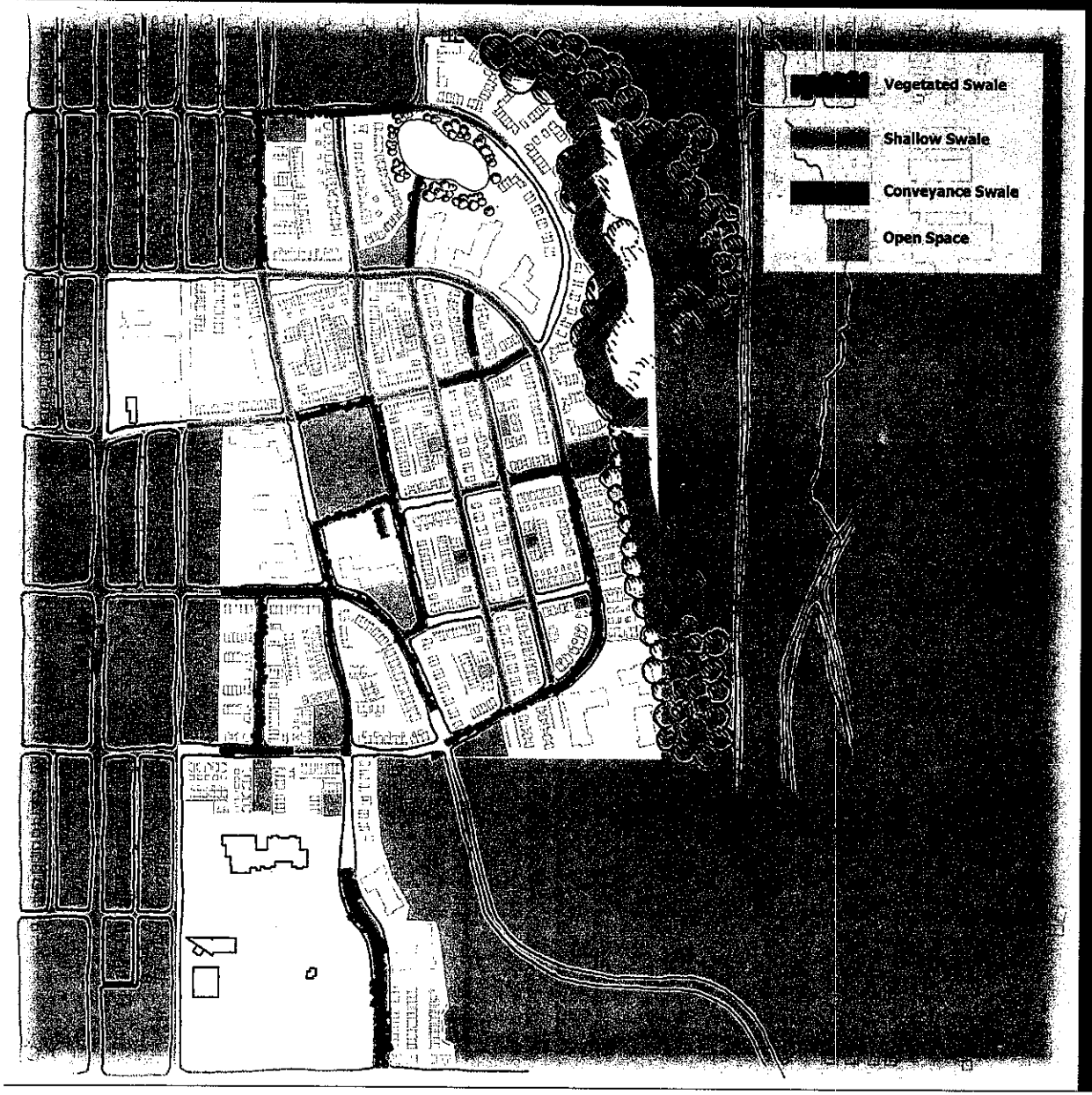
New Urbanist principles

Master plan designed prior to decision to do natural drainage systems

34 blocks of new streets with new utilities, street trees, sidewalks, parks and open space

1,600 housing units, neighborhood center, library, and mixed-use block

Density ranges from
16 units/acre to 30 units/acre of ground-related housing

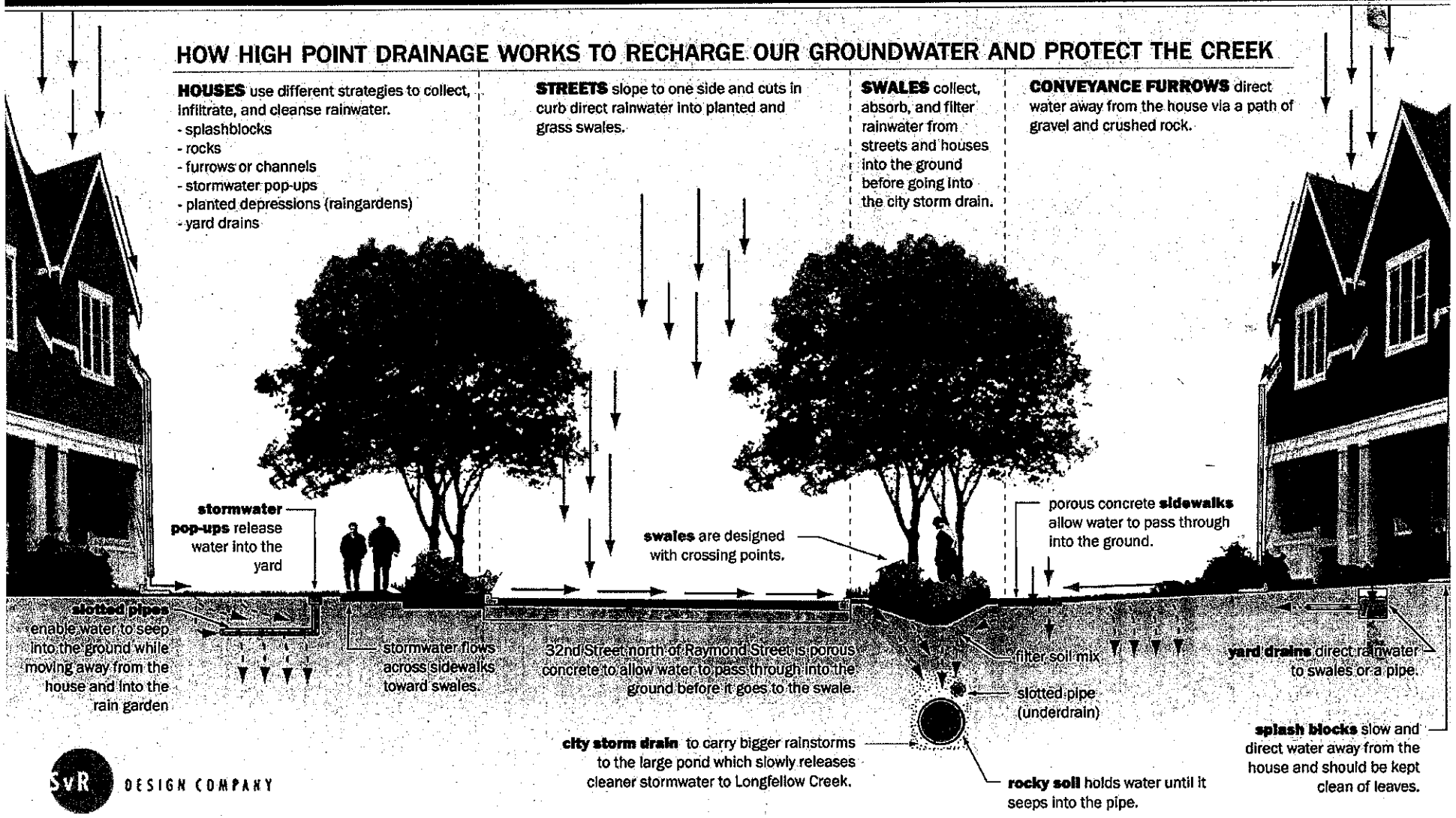


Vegetated, shallow grass and grass conveyance swales along 15,000 lf of residential streets

Traditional storm drain conveyance pipe for large storm events

Storm water detention and wetpond: 16 acre feet (22 total acre feet, including freeboard)

Pervious Pavement


HOW HIGH POINT DRAINAGE WORKS TO RECHARGE OUR GROUNDWATER AND PROTECT THE CREEK
HOUSES use different strategies to collect, infiltrate, and cleanse rainwater.
- splashblocks
- rocks
- furrows or channels
- stormwater pop-ups
- planted depressions (raingardens)
- yard drains
STREETS slope to one side and cuts in curb direct rainwater into planted and grass swales.
SWALES collect, absorb, and filter rainwater from streets and houses into the ground before going into the city storm drain.
CONVEYANCE FURROWS direct water away from the house via a path of gravel and crushed rock.
stormwater pop-ups release water into the yard
swales are designed with crossing points.
porous concrete **sidewalks** allow water to pass through into the ground.
slotted pipes enable water to seep into the ground while moving away from the house and into the rain garden
stormwater flows across sidewalks toward swales.
32nd Street north of Raymond Street is porous concrete to allow water to pass through into the ground before it goes to the swale.
filter soil mix
slotted pipe (underdrain)
yard drains direct rainwater to swales or a pipe.
city storm drain to carry bigger rainstorms to the large pond which slowly releases cleaner stormwater to Longfellow Creek.
rocky soil holds water until it seeps into the pipe.
splash blocks slow and direct water away from the house and should be kept clean of leaves.
SvR DESIGN COMPANY

Water quality treatment: 6 month storm

NDS combined with the stormwater pond detain and match duration up to the 2 year, 24-hour storm assuming pasture conditions

Piped conveyance sizing for 25-year storm

Site drainage distributed at the block scale

Peak flow control for COS 100 year storm (0.5 cfs/ac)

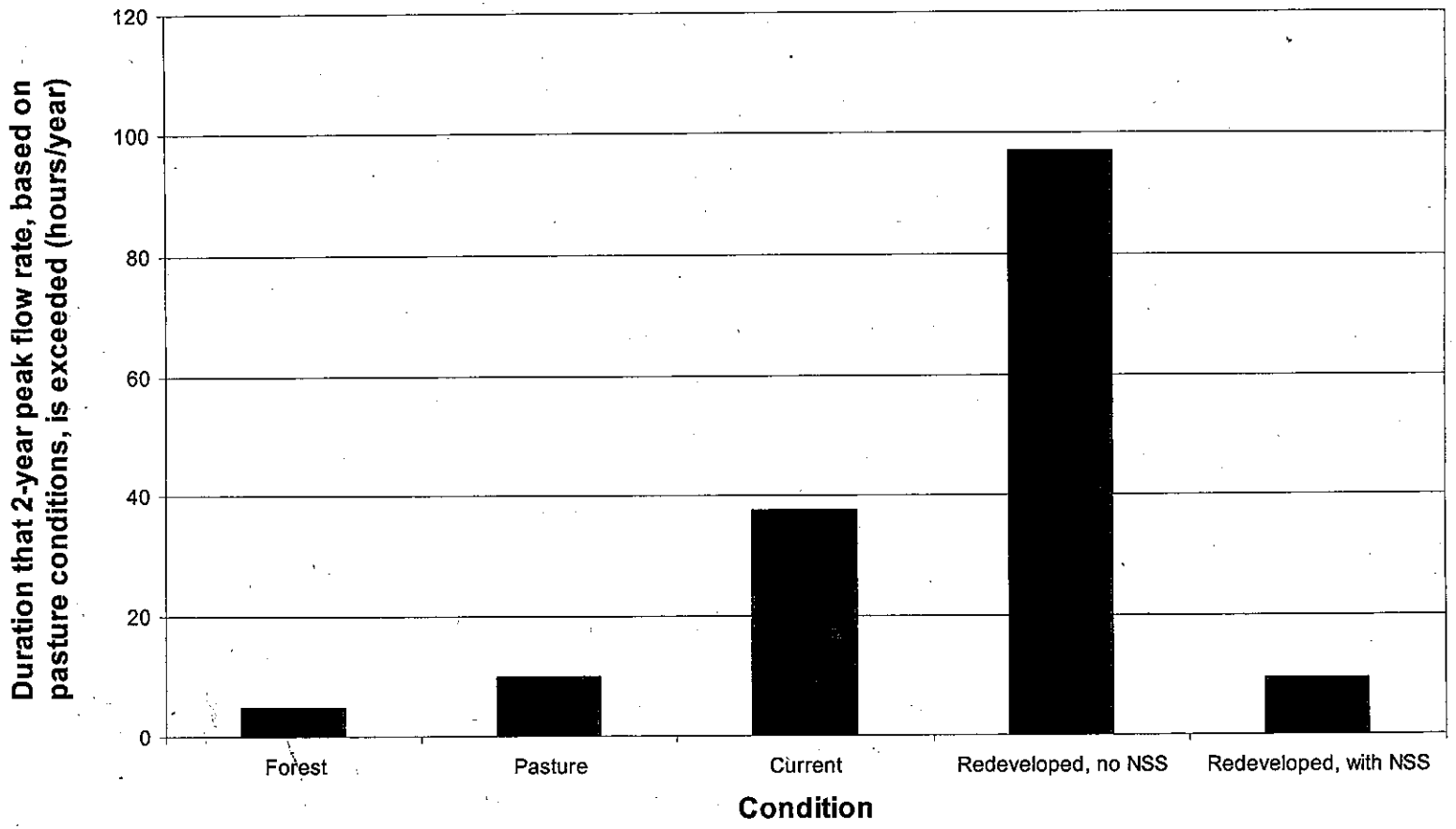
Conveyance of DOE dam safety flows downstream of storm water pond (5000-year storm event).

Note: Seattle tends to get drizzle versus the high intensity storm event. Ex. 100 year storm event is 3.84 inches/24 hour

Seattle Annual Average Precipitation 37 inches/94 cm

Rainfall Precipitation for Seattle Design Storm Events:

- 2 Year: 1.68 inches (4.27 cm)
- 10 Year: 2.74 inches (6.96 cm)
- 25 Year: 3.125 inches (7.94 cm)
- 100 Year: 3.84 inches (9.75 cm)

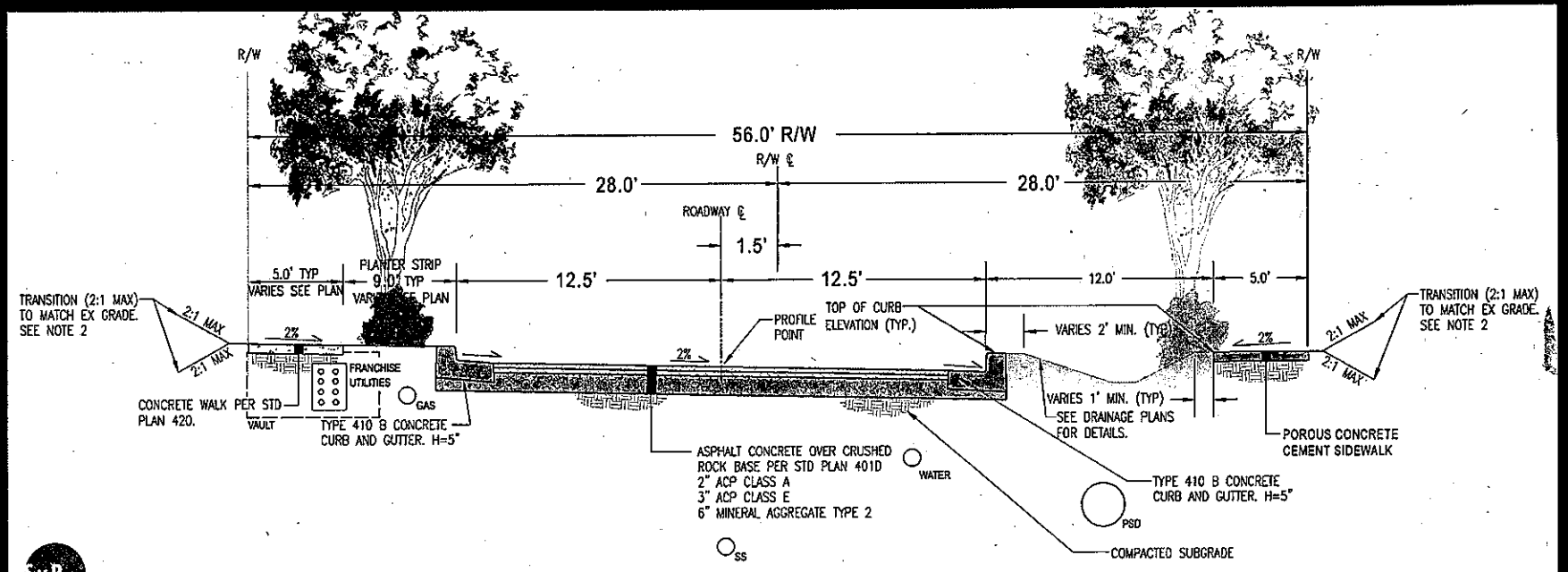

Duration that 2-year peak flow rate, based on pasture conditions, is exceeded (hours/year)
120
100
80
60
40
20
0
Forest
Pasture
Current
Redeveloped, no NSS
Redeveloped, with NSS
Condition

R·W·BECK

↑ Concept

←Under construction:
Porous walks, curb cuts and swales

↑ After Construction



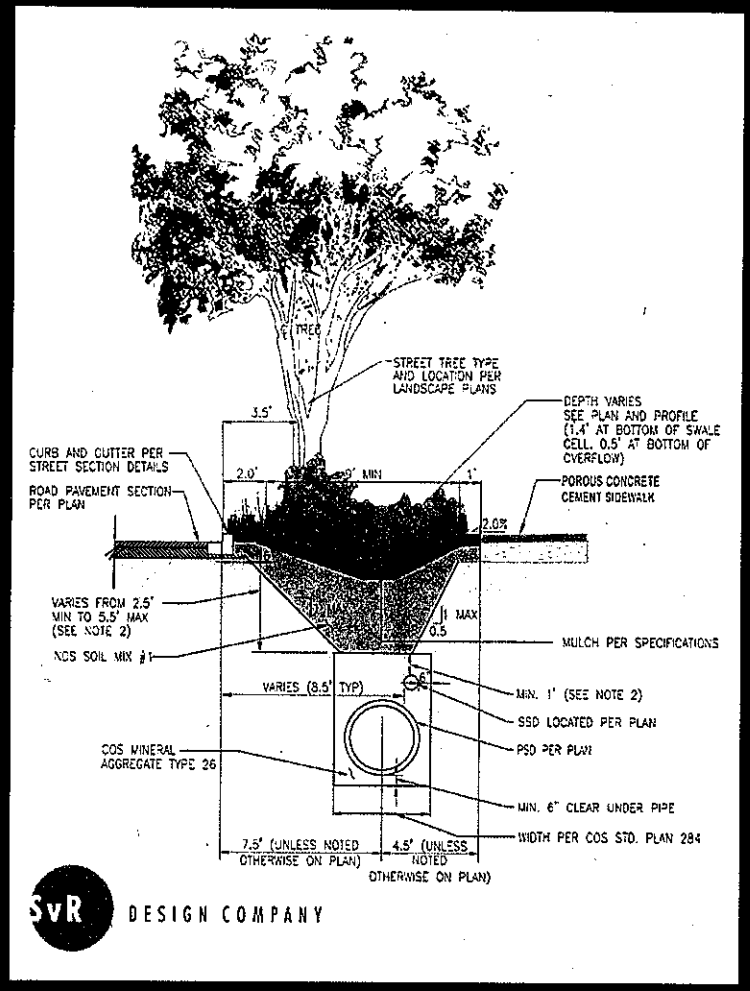
Typical Residential Street Section with 25' Roadway and 56' Right-of-Way

The cross sections for the NDS swales were developed through discussions with various City of Seattle departments (decisions by inches)

Street widths: 25 feet/56 right of way; 28 feet/56 ft rw; 32 feet/60 ft rw

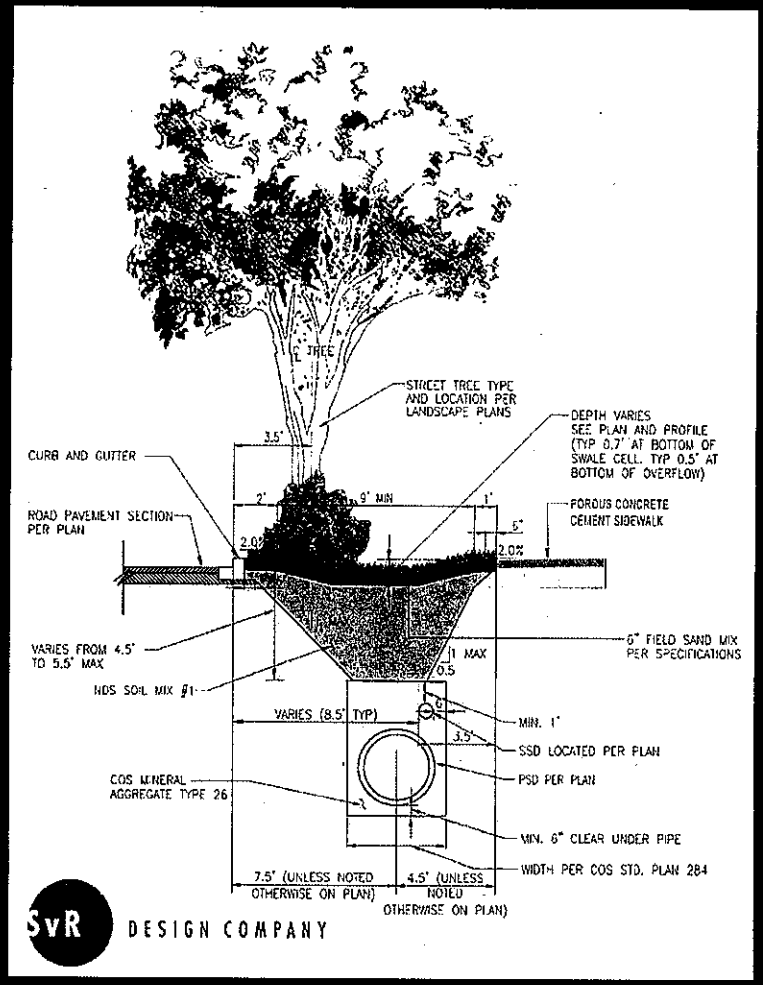
Curb height, swale width, street tree locations, berm locations, side slopes, bottom width, etc. were established

Porous sidewalks on the swale side



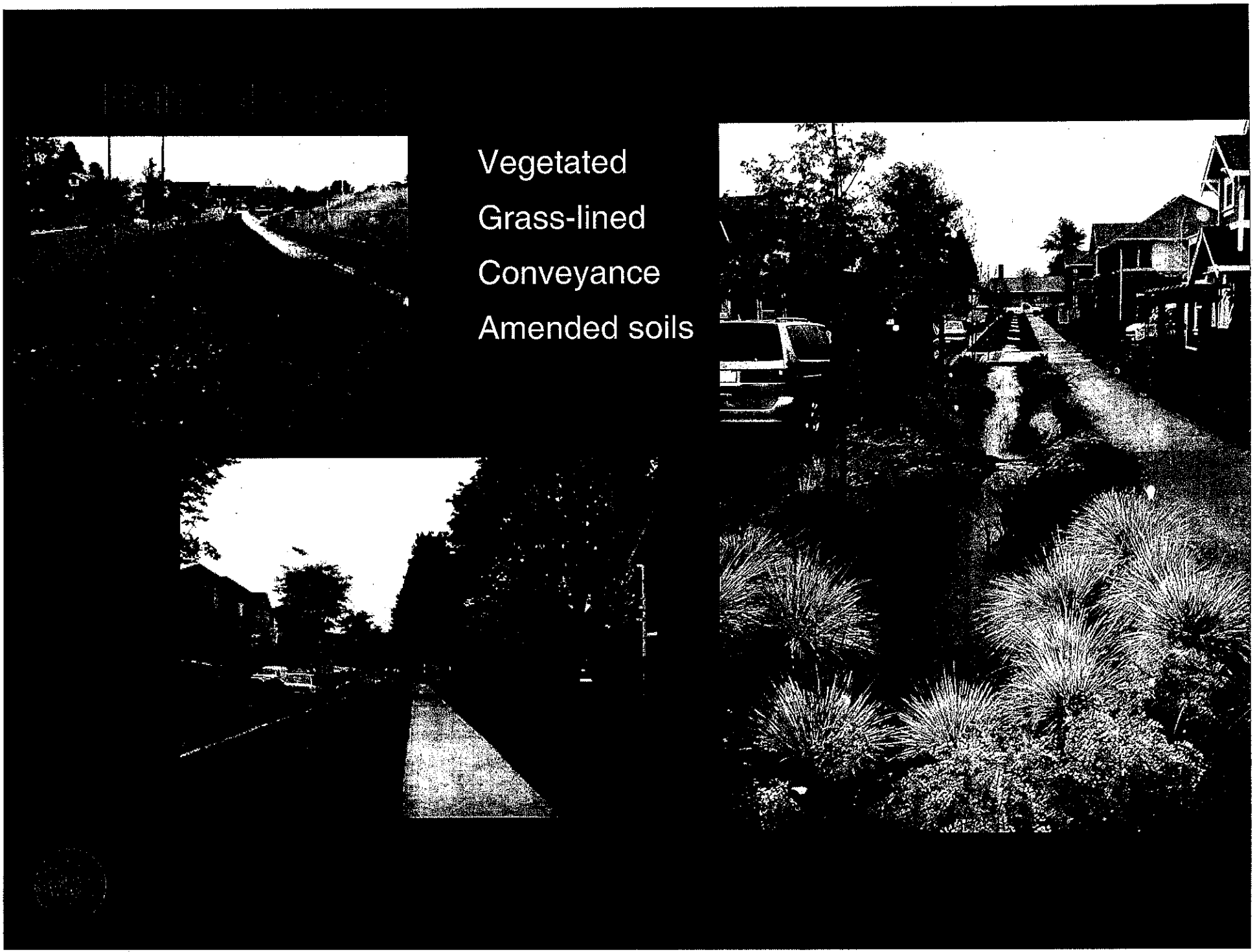
Vegetated swale

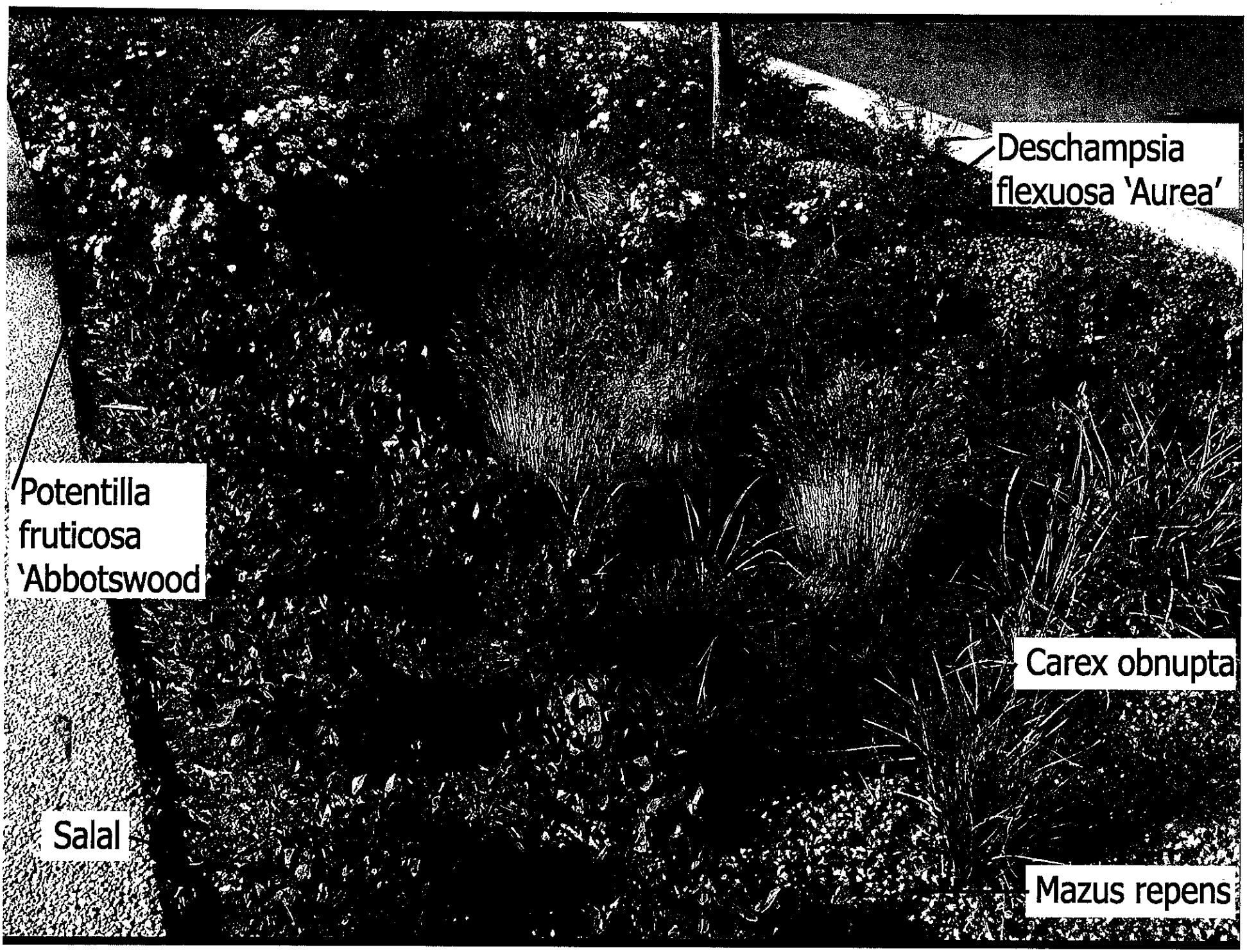
18” grading depth for 10” of ponding



Grass-lined swale

8” grading depth for 2” of ponding


Vegetated
Grass-lined
Conveyance
Amended soils


Deschampsia flexuosa 'Aurea'
Potentilla fruticosa 'Abbotswood
Carex obnupta
Salal
Mazus repens

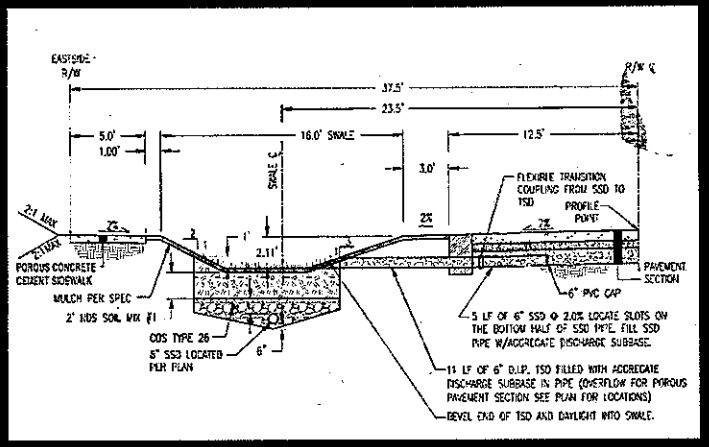
Prior to construction

Subbase & check dams

Placing concrete

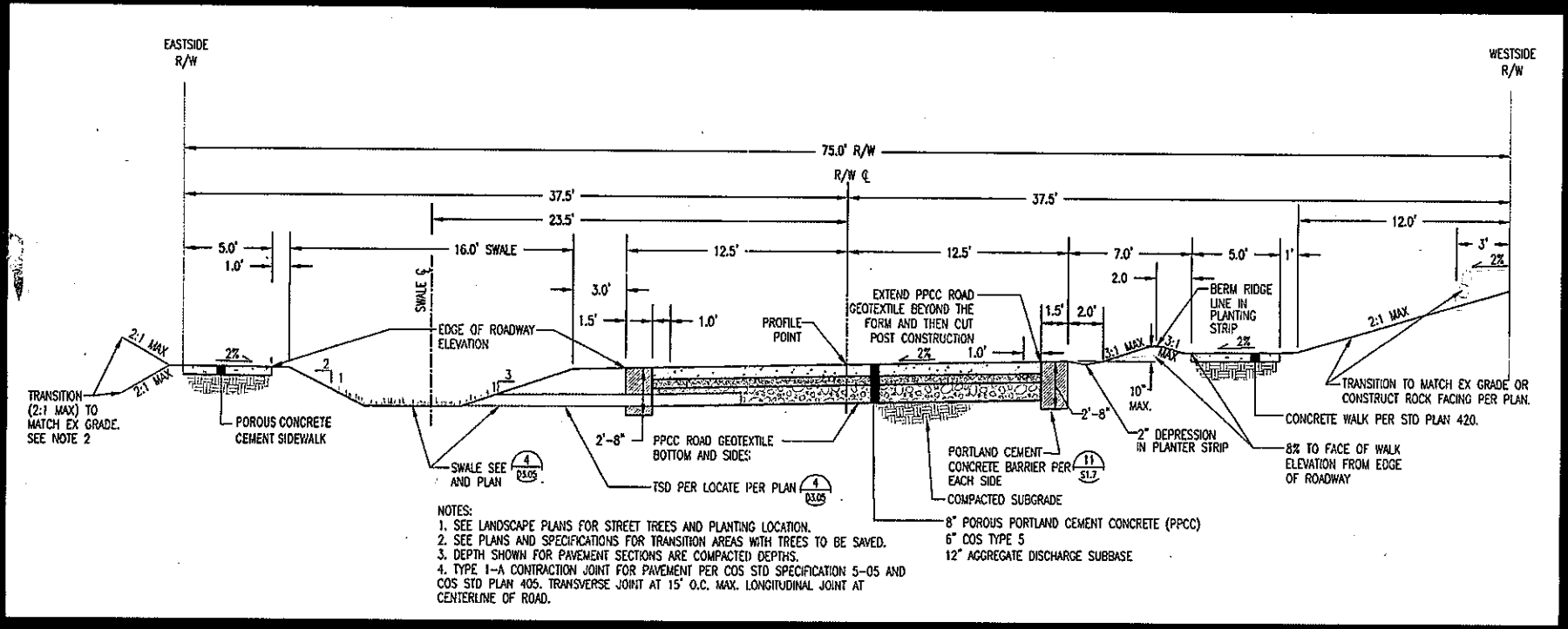
Joint placement

Post construction



Cross-Section of Swale & Pavement

Pavement Installer: Gary Merlino Construction Company. Mix Supplier: Stoneway



Integration between redevelopment and adjacent single family neighborhood

75 foot right-of-way allows greater swale width

Porous pavement roadway, no curbs (first public porous street in Seattle)

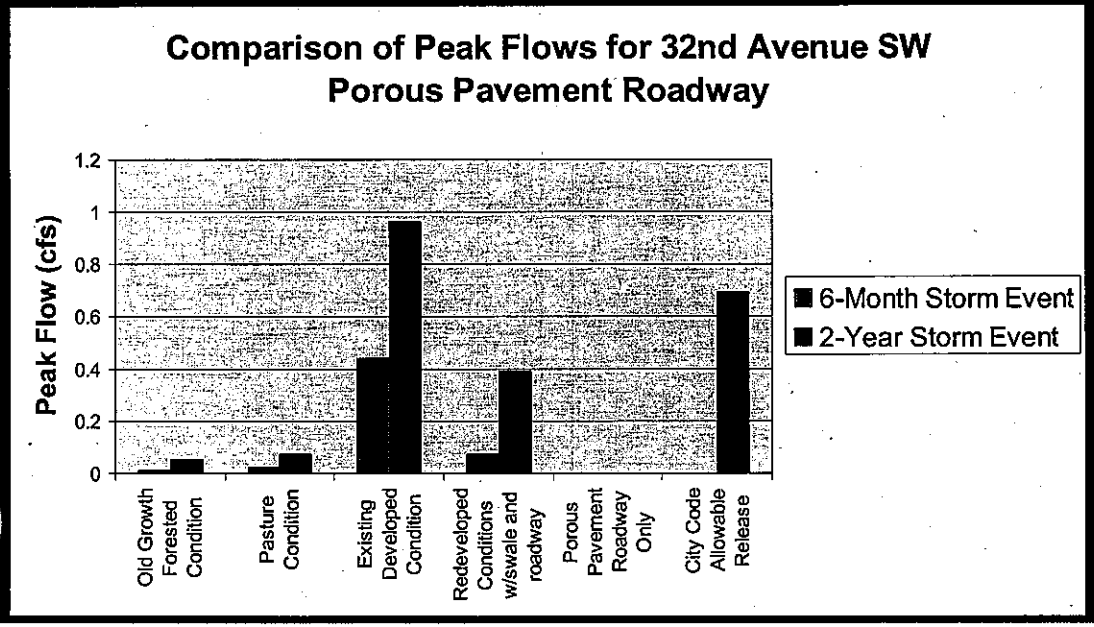
Two test panels were placed (564 lbs* & 600lbs) & exceeded design requirements for strength.

- Avg. Compressive Strength 2195*- 3380
- Avg. Infiltration 138 in/hr- 1244* in/hr

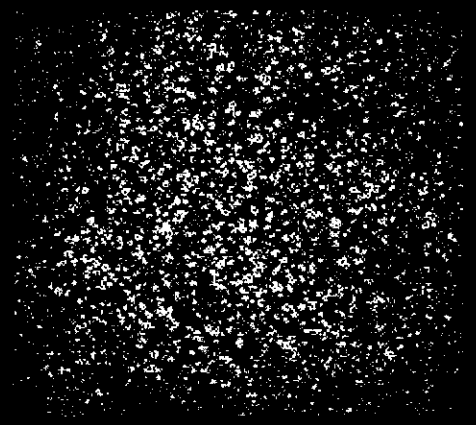
For Road Placement, Two Mix Designs Used to compare over time (564* lbs/cy & 582** lbs/cy)

- Avg. Field Infiltration (1614 in/hr* & 876 in/hr**)
- Avg. Voids (30%* & 26%**)

Seattle Public Utilities to monitor performance



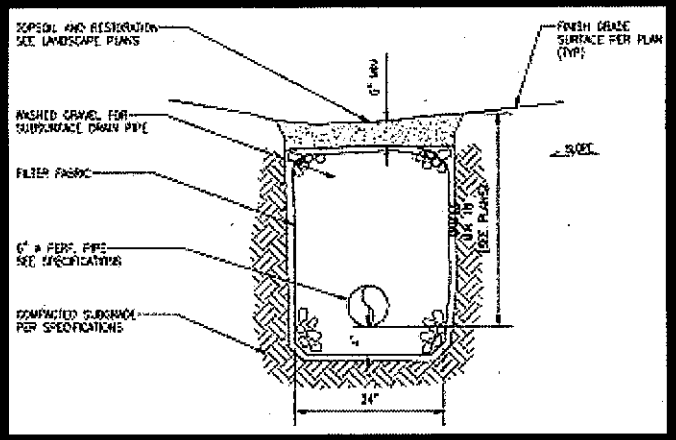
NOTE: In comparison, with impervious roadway, to meet same goal for developed basin during 6-month storm event approx. 533 ft of 36" detention pipe would have been required plus water quality treatment.

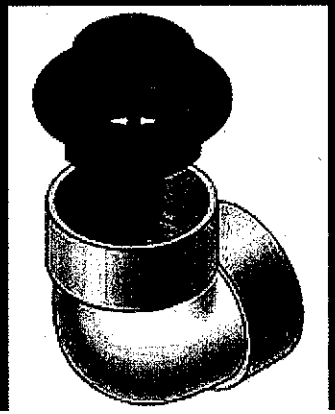


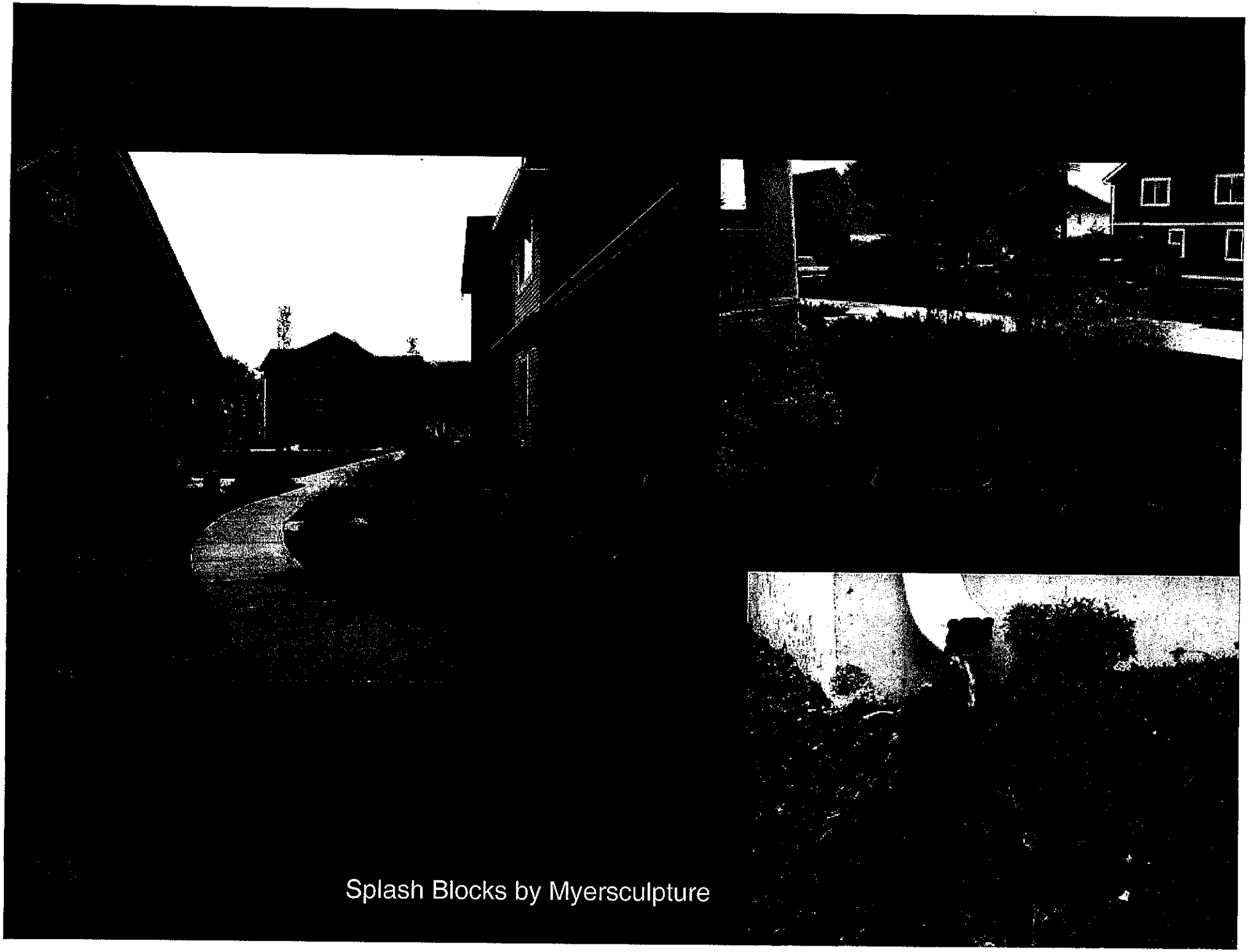
High Point Drainage Technical Standards and requirements for each lot per the plat

Examples of Methods to use:

- Porous pavement
- Conveyance furrow
- Dispersal trench
- Rain garden
- Pop-up emitter
- Downspout Disconnect
- Reduce Impervious footprint







Splash Blocks by Myersculpture

Receives 130 acres (53 hectares) of run-off (106 acres from High Point redeveloped areas)

Flow control for up to 100-year Storm Event

Water Quality Treatment in combination w/upstream NDS swales

Maximum Depth 15.5 feet (4.72 m)

Total Volume 22+ acre-feet (27,123 m^3)

Pond within 3.5 acre Tract (1.42 hectares)

Wet Pool for Additional Water Quality:

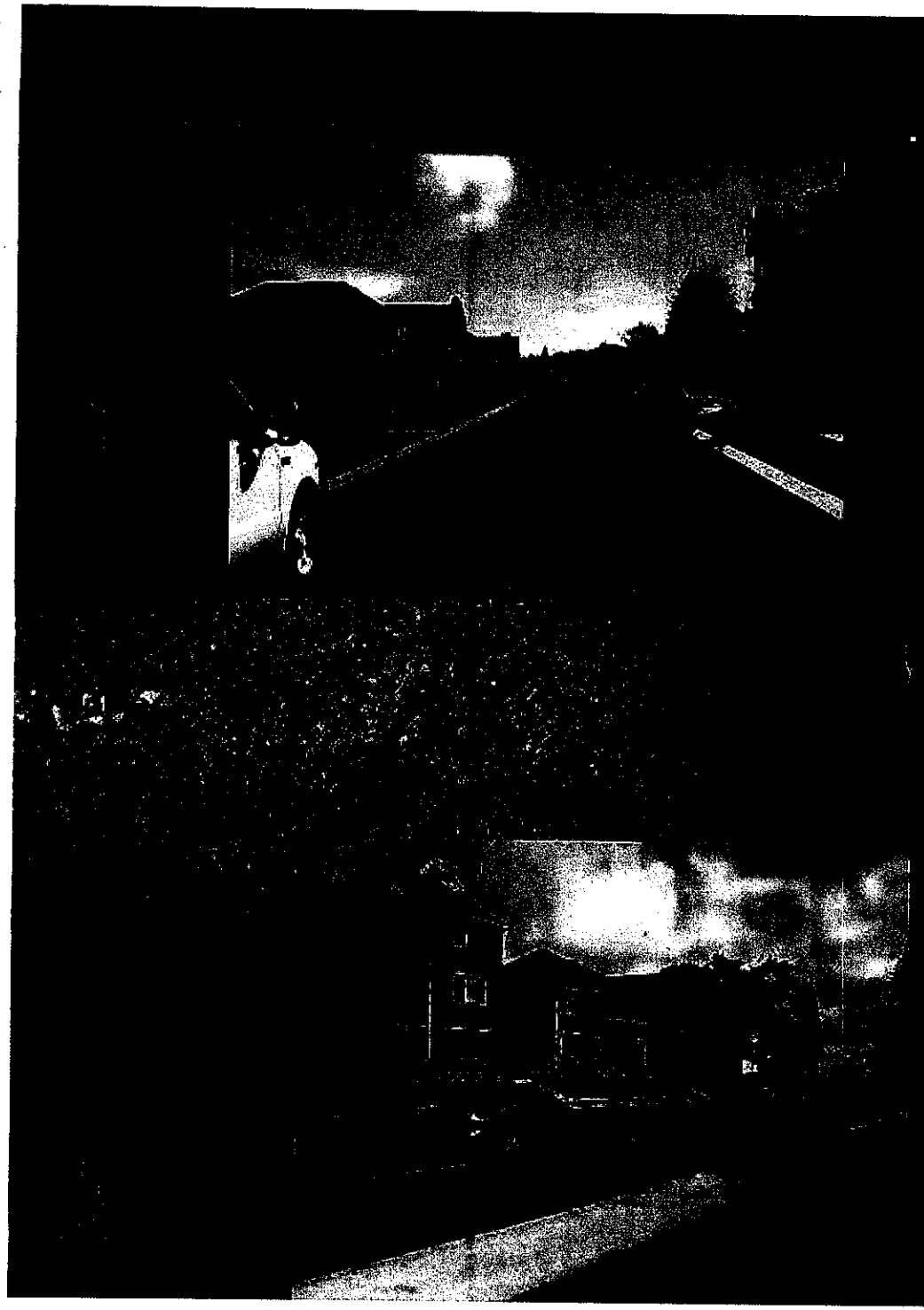
- Storage: 4.2 acre-feet (5,178 m^3)
- Depth: 4.5 feet (1.37 m)

Live Storage for Flow Control/Detention:

- Volume: 11.8 acre-feet (14,546m^3)

Remaining 3.2 acre-feet (freeboard and Dam Safety flow)

Conveyance system out of pond designed for 5,000 year storm event for Dam Safety (Two 8-foot (2.44 m) diameter concrete risers below pier)



... proven installations that are now being applied across the country

- Low Impact Design/Site Drainage Technical Standards
- Reduced impervious footprints
- Mature tree protection techniques
- Site fully integrated with Low Impact Development techniques
- Reduced road widths
- Site-wide pedestrian circulation and safety enhancements
- Use of porous paving applications for walks, road and parking lots

… proven installations that are now being applied across the country

- Multifunctional stormwater park
- Menu driven low impact development approach
- Defined permitting review process
- Interagency collaboration
- Community education
- Resident education
- Maintenance and operation standards
- Art integration
- Aesthetic treatment of drainage swales

Sandblasting by
Myersculpture

Seattle Public Utilities had a vision for a neighborhood with a naturalistic drainage approach.

Seattle Housing Authority had a vision for a diverse, sustainable neighborhood.

These two public agencies have worked hard to implement these visions.

Recognition:
Seattle Housing Authority
Seattle Public Utilities

Other Agencies:
Washington State Department of Ecology
US Department of HUD
Seattle Department of Planning and Development
Seattle Department of Transportation
Seattle City Light
Seattle Parks Department

Artist
Myers Sculpture

For more information:
and www.seattle.gov/util/naturalsystems

Consultants:
SvR Design Company
Mithun Architects and Planners

Resource Consultants:
Shannon and Wilson
RW Beck & Herrera
Nakano Associates
Stoneway Concrete
Cedar Grove Composting
NW ACPA

Ph I Natural Drainage System Contractors:
Absher Construction (ROW & SHA Hsg)
Gary Merlino Construction (ROW)
T. Yorozu Gardening Co. (ROW)
Fardig (SHA Hsg)

Ph II Natural Drainage System Contractors:
Tri-State Construction Inc. (ROW)
T. Yorozu Gardening Co. (ROW)
Absher Construction (SHA Hsg)

Learning curve for both designers and permitting agencies

Owner/Developer understanding of differing site constraints

Broad tool kit necessary for site plan treatments

Contractor information

Fine grading for site contractors

Expect to answer questions- (Why are you doing this?)

Expect to make adjustments

Demonstrated results

Installed examples now common place

Accepted practice with many jurisdictions

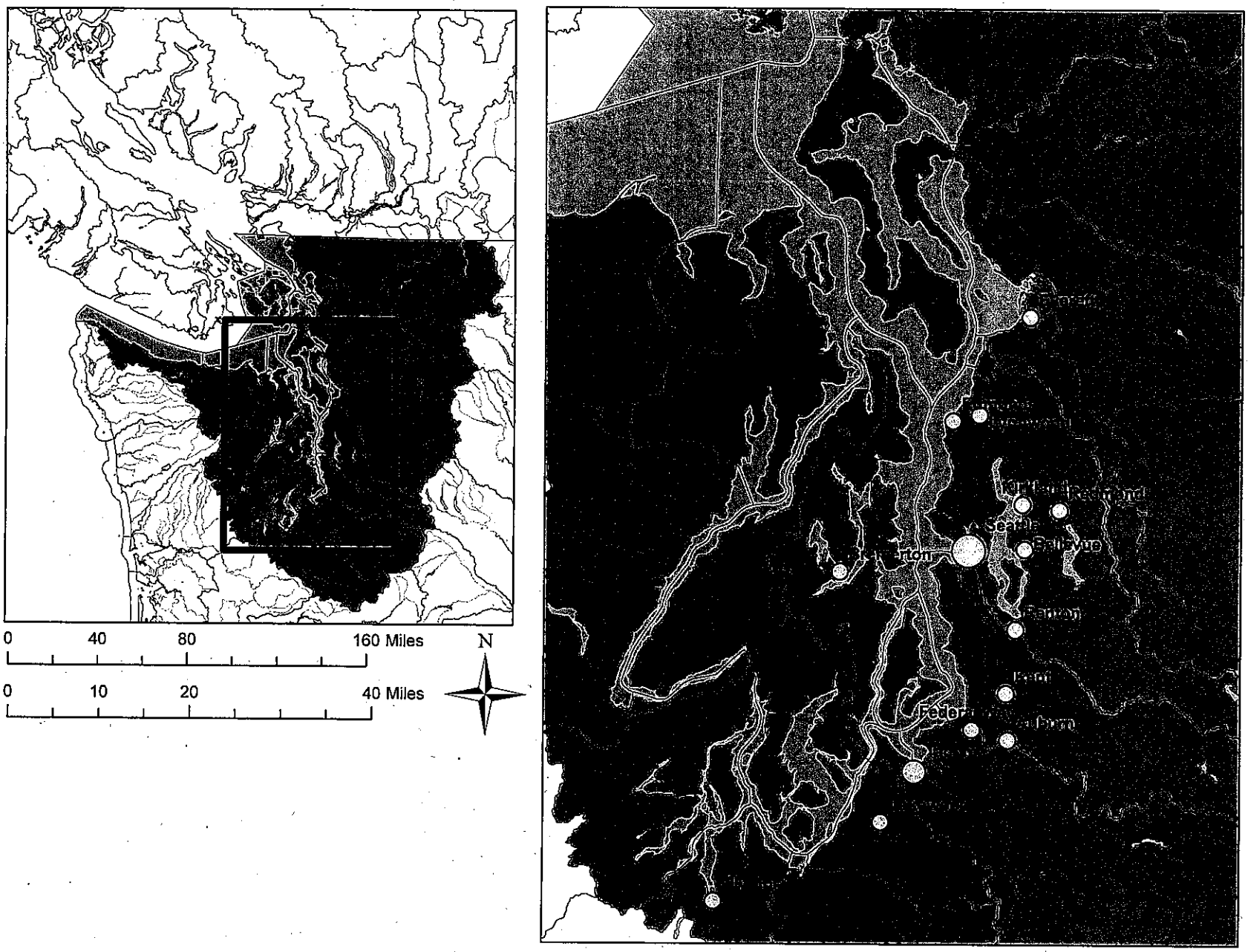
Accepted treatment by the public

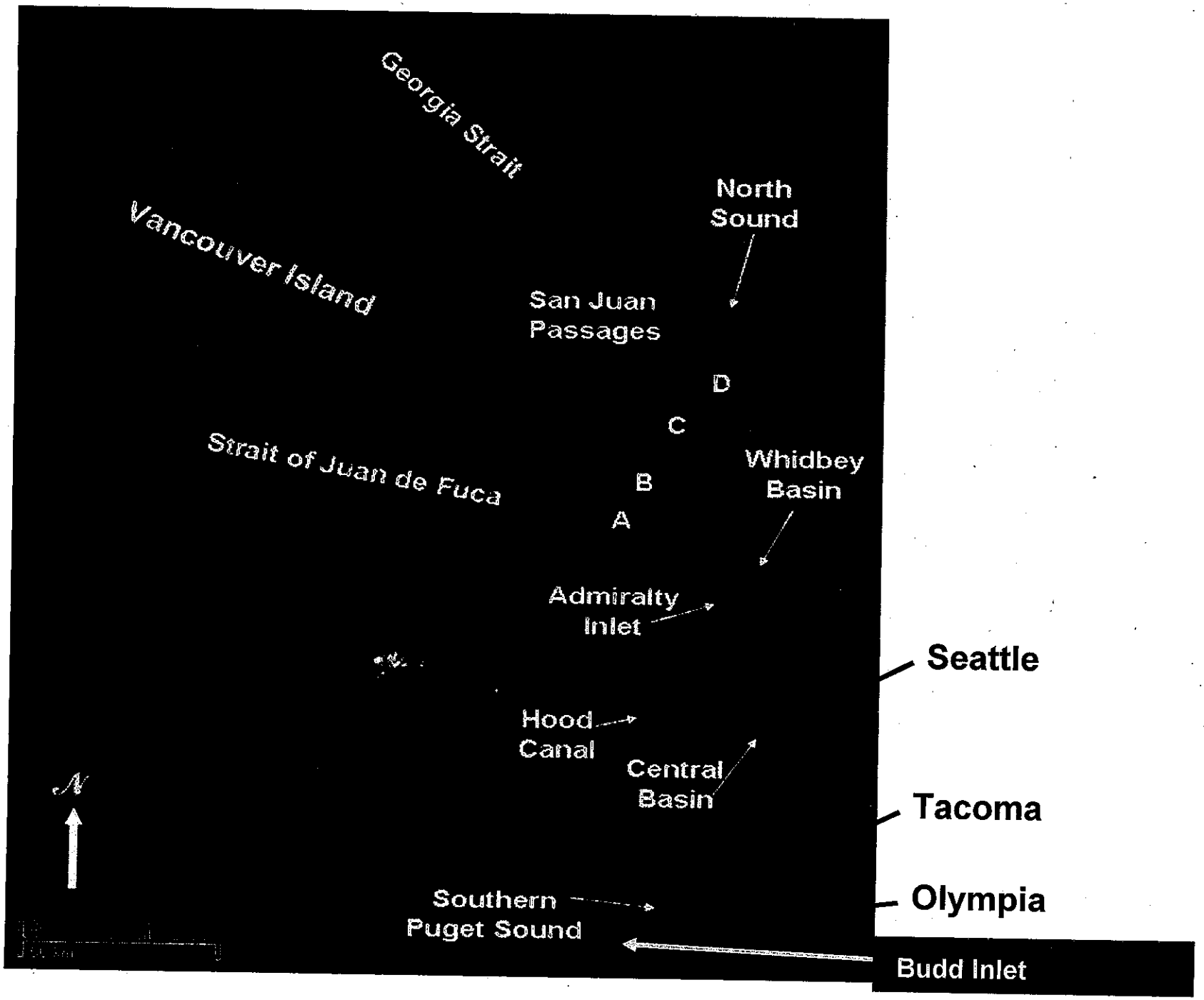
Value added/practical

附錄 2：普吉灣(Puget Sound)水質探討簡報

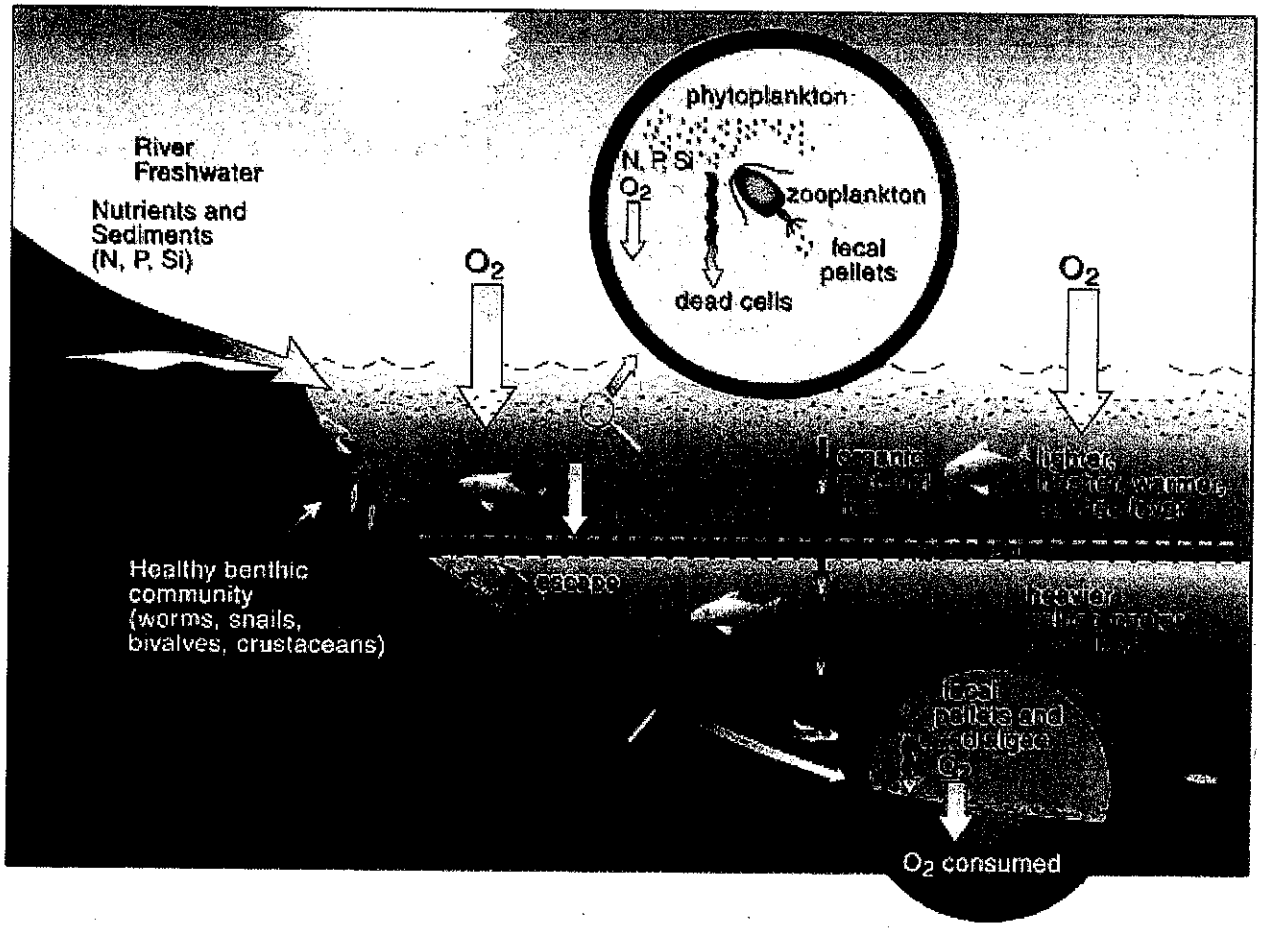
Puget Sound Dissolved Oxygen Studies

Ben Cope
EPA Region 10

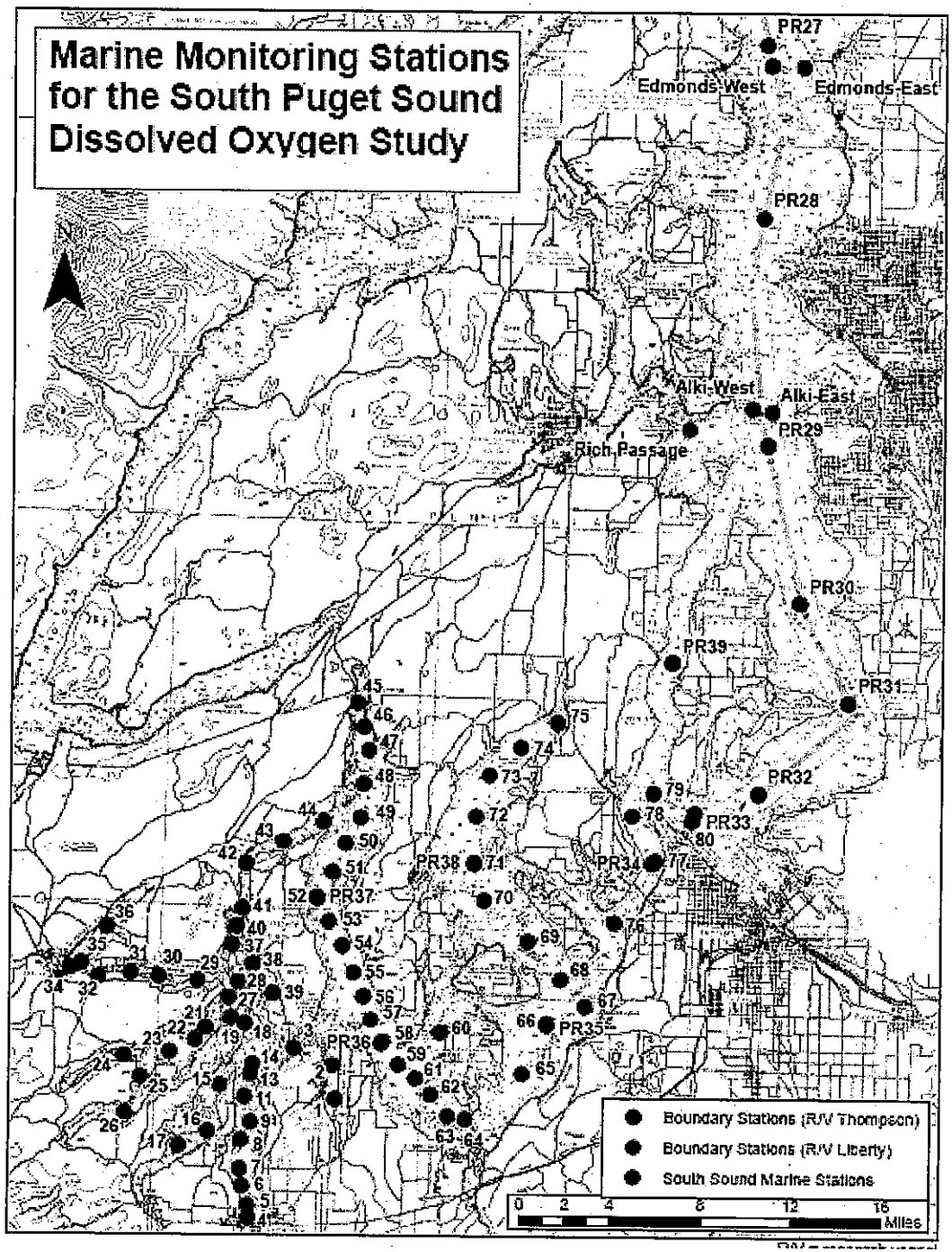

0 40 80 160 Miles
0 10 20 40 Miles
N
Seattle
Bellevue
Renton
Federal Way


Georgia Strait
Vancouver Island
North Sound
San Juan Passages
D
C
B
A
Strait of Juan de Fuca
Whidbey Basin
Admiralty Inlet
Seattle
Hood Canal
Central Basin
Tacoma
Olympia
Southern Puget Sound
Budd Inlet

Processes that Reduce Dissolved Oxygen




Campbell River
Whistler
Vancouver
Bellingham
Everett
Seattle
Tacoma
Seawater Stratification Patterns
Red = strong/persistent
Orange = strong intermittent
Yellow = moderate infrequent
Green = weak infrequent
commenspace.org


Marine Monitoring Stations for the South Puget Sound Dissolved Oxygen Study
PR27
Edmonds West
Edmonds East
PR28
Alki West
Alki East
PR29
Rich Passage
PR30
PR39
PR31
PR32
PR33
PR34
PR35
PR36
PR37
PR38
Boundary Stations (R/V Thompson)
Boundary Stations (R/V Liberty)
South Sound Marine Stations
0 2 4 8 12 16
Miles

Dissolved Oxygen in South Puget Sound

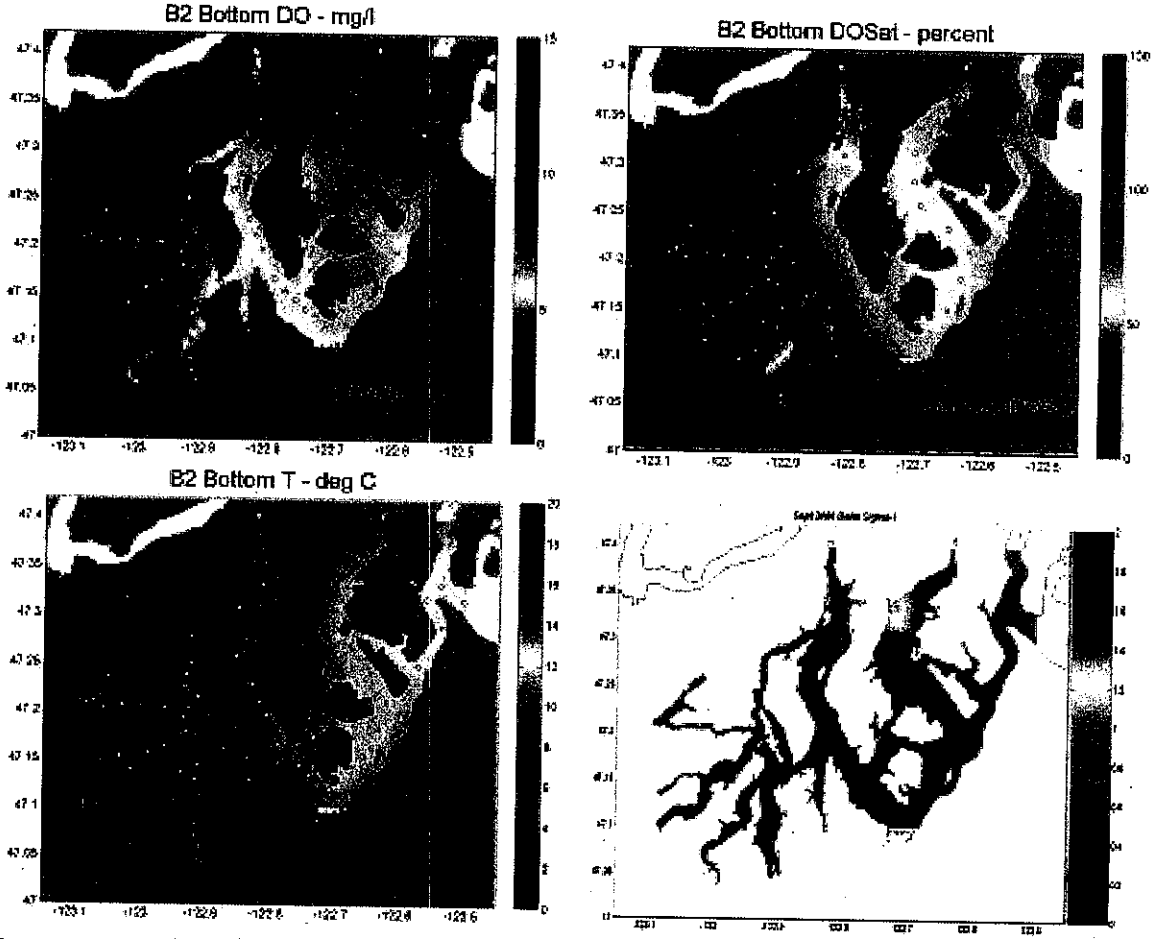


Figure 82. Near-bottom results from the intensive September 25-27, 2006 cruise. (A) corrected DO (mg/L), (B) corrected DO saturation (%), (C) temperature (°C), and (D) stratification (delta sigma-t).

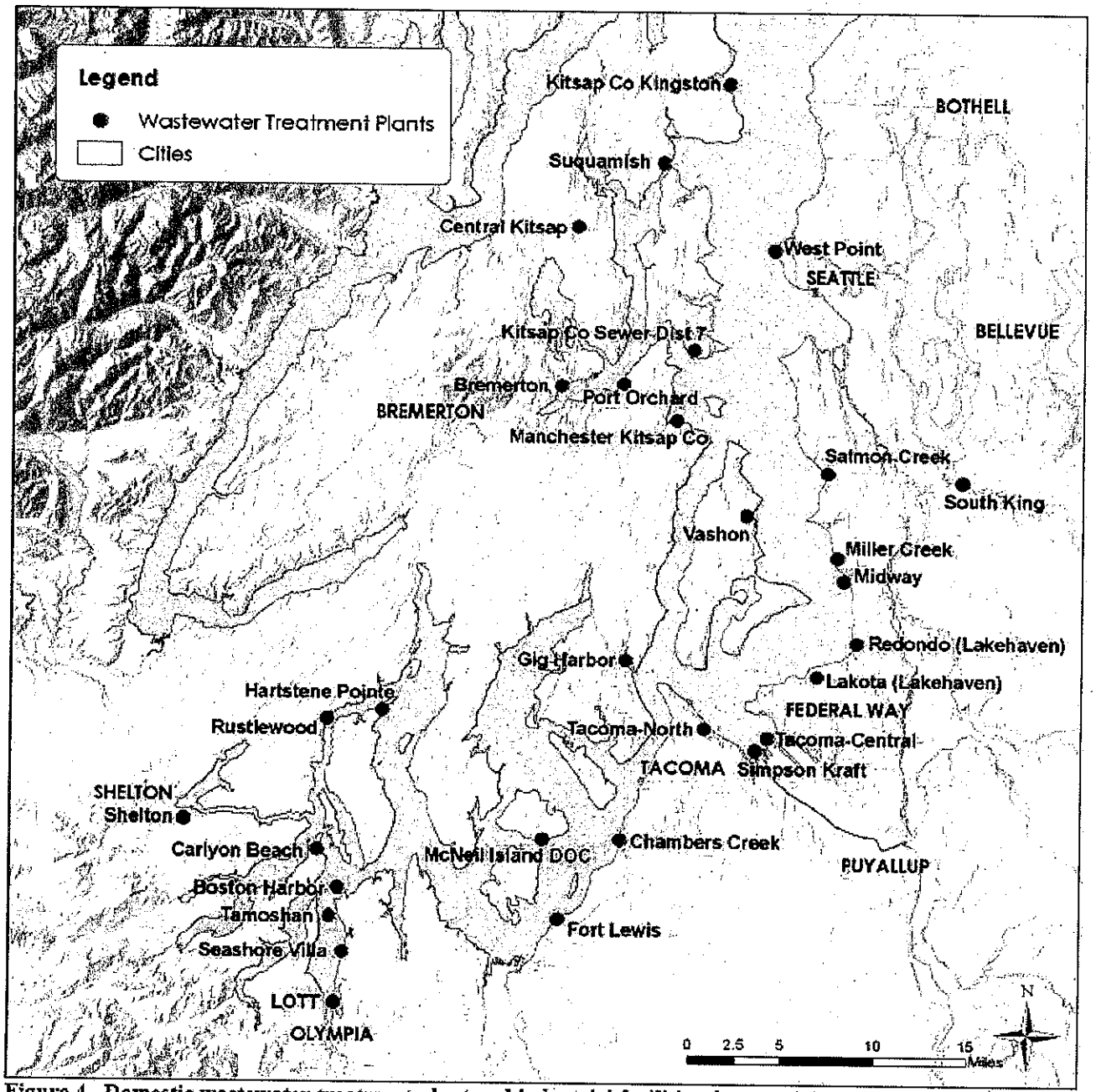
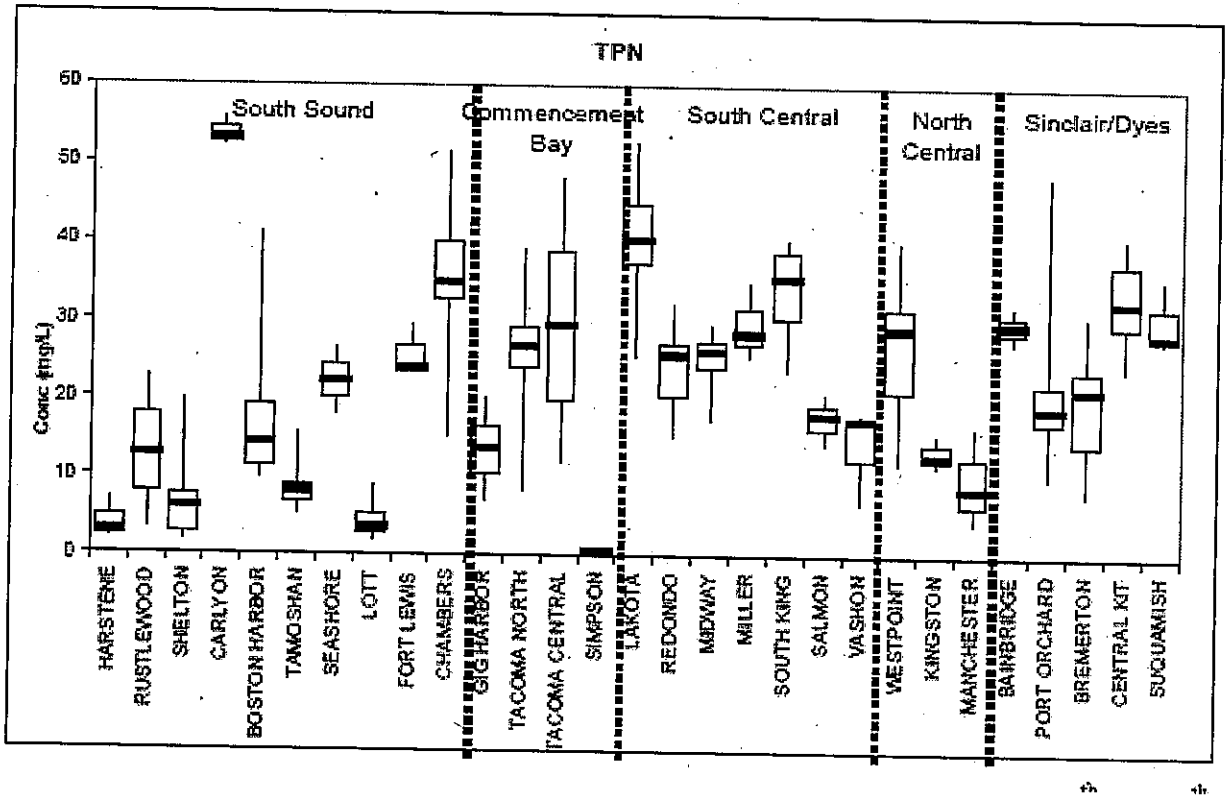


Figure 4. Domestic wastewater treatment plant and industrial facilities that participated in supplemental effluent monitoring.

Nitrogen from Sewage Treatment Plants



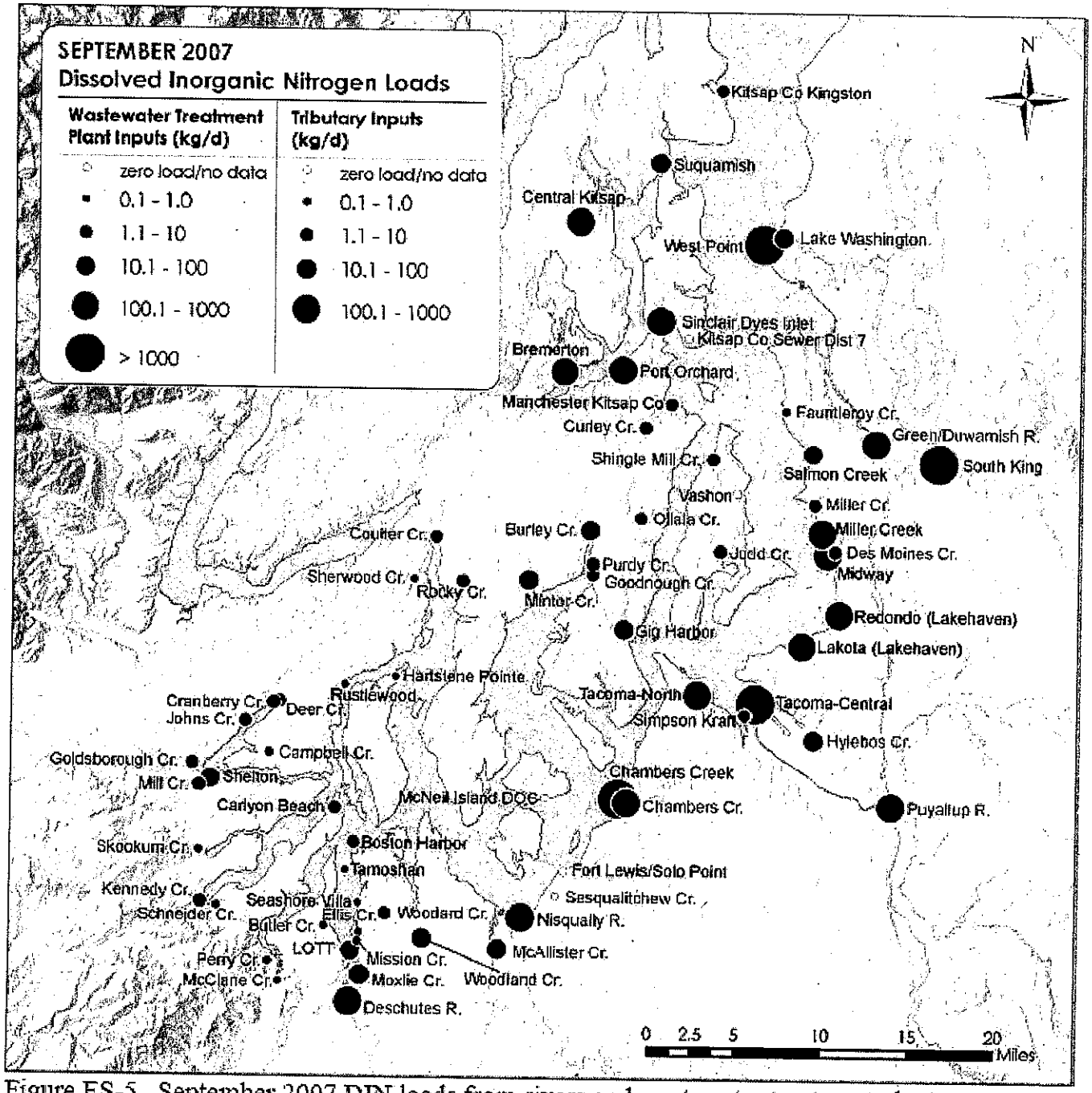
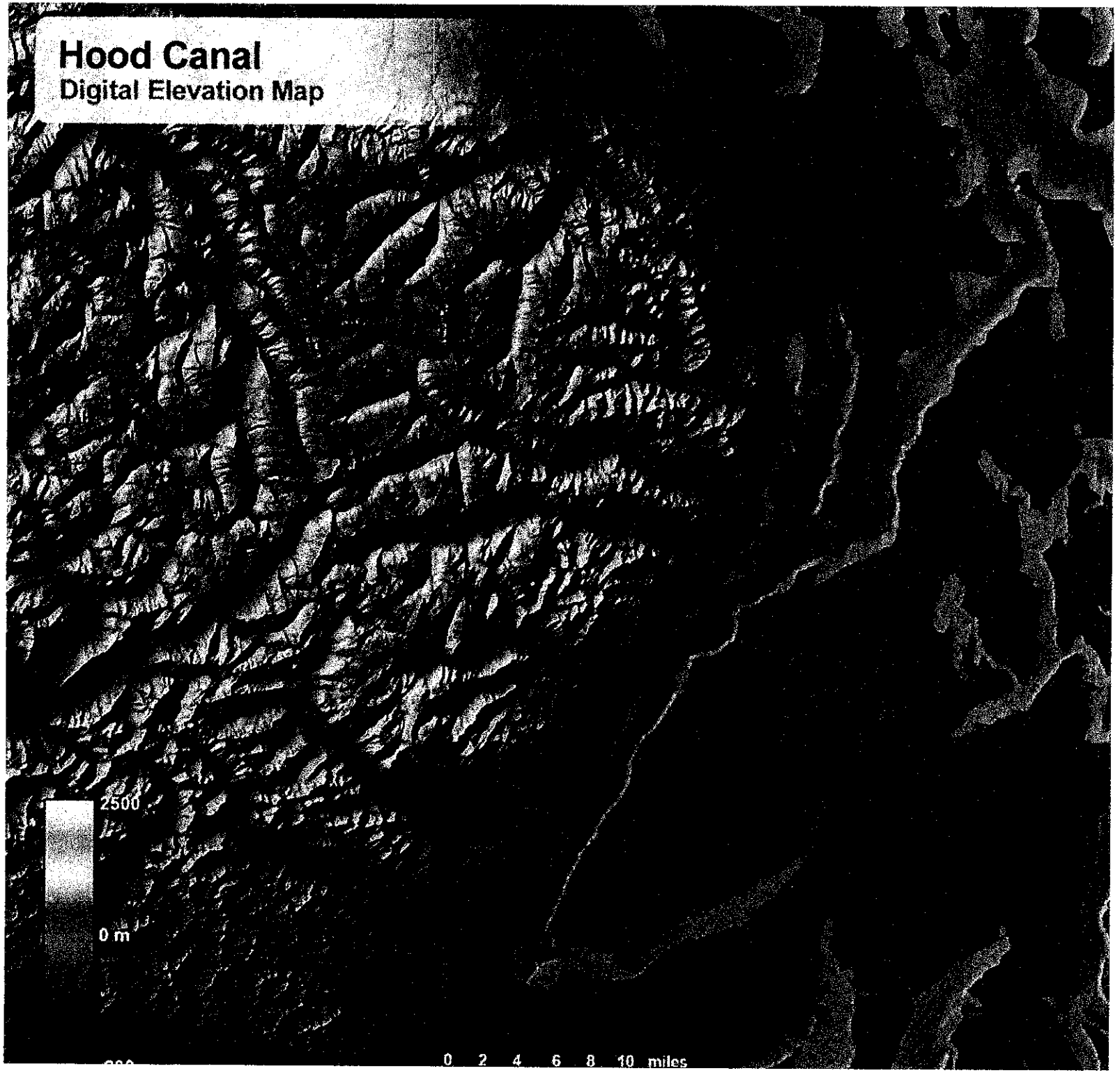
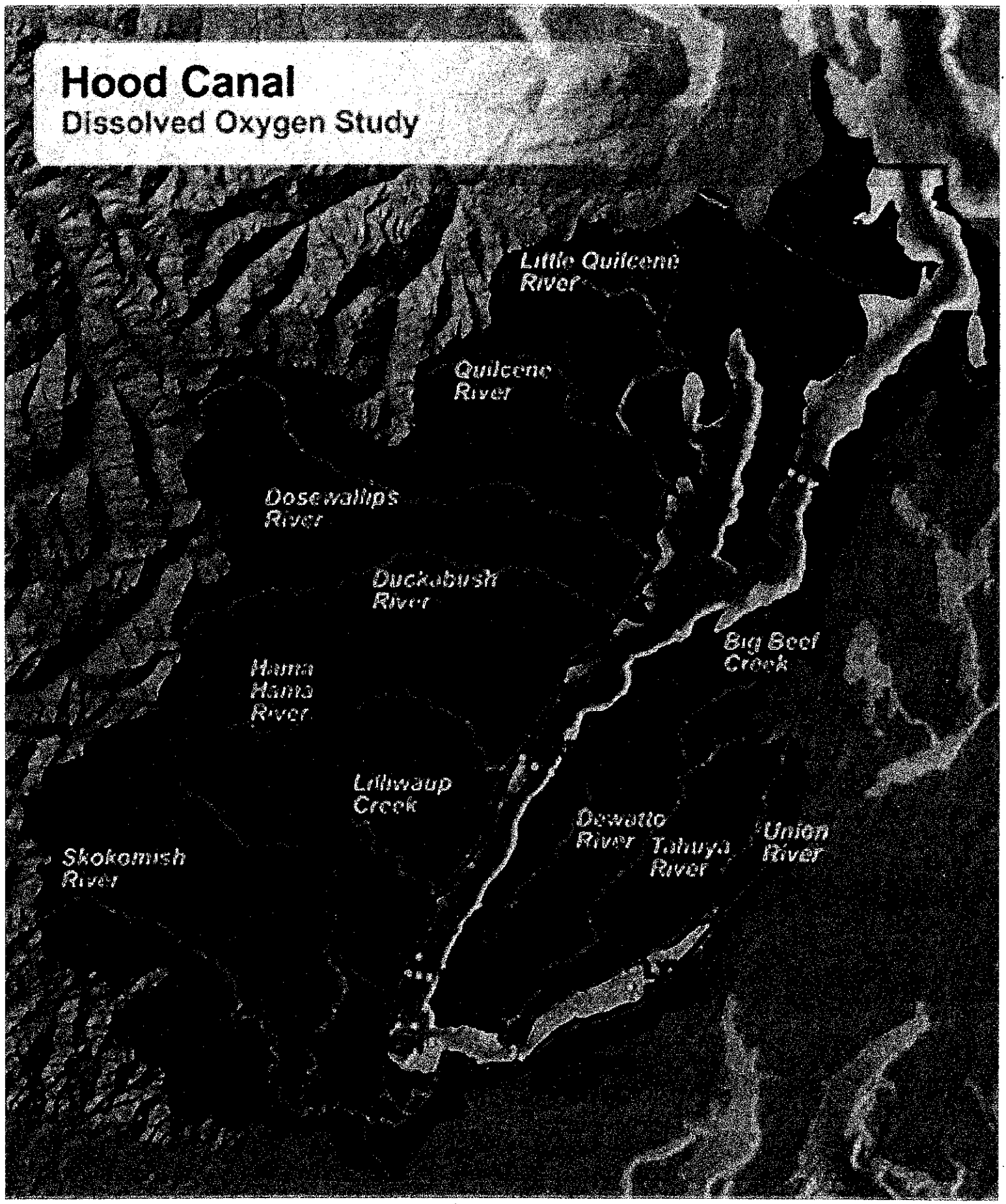
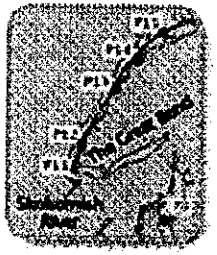


Figure ES-5. September 2007 DIN loads from rivers and wastewater treatment plants.


Hood Canal
Digital Elevation Map
2500
0 m
0 2 4 6 8 10 miles


Hood Canal
Dissolved Oxygen Study
Little Quilcene River
Quilcene River
Dosewallips River
Duckabush River
Hama Hama River
Big Beef Creek
Lilliwaup Creek
Dewatto River
Tahuya River
Union River
Skokomish River

Average Dissolved Oxygen - Depth>20 m

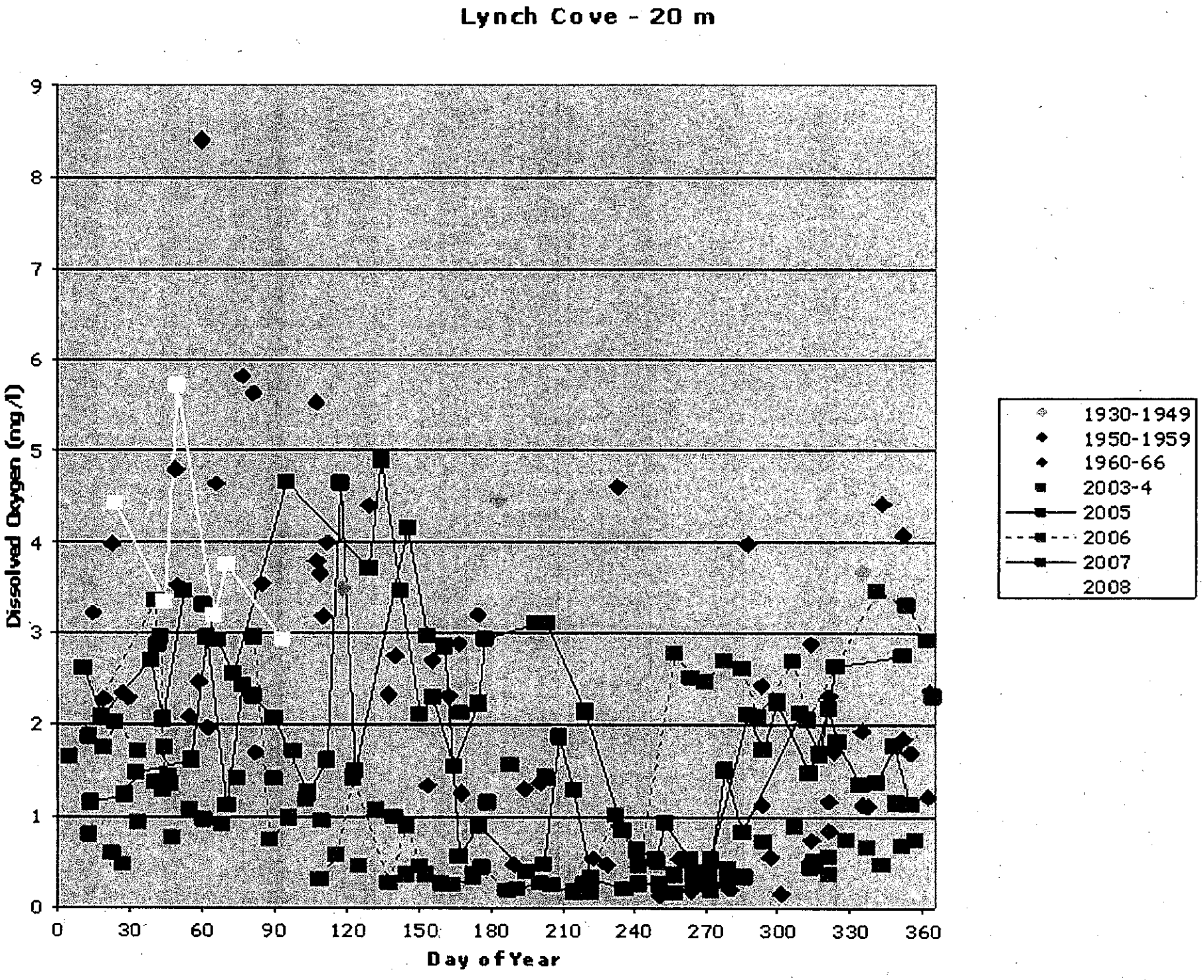


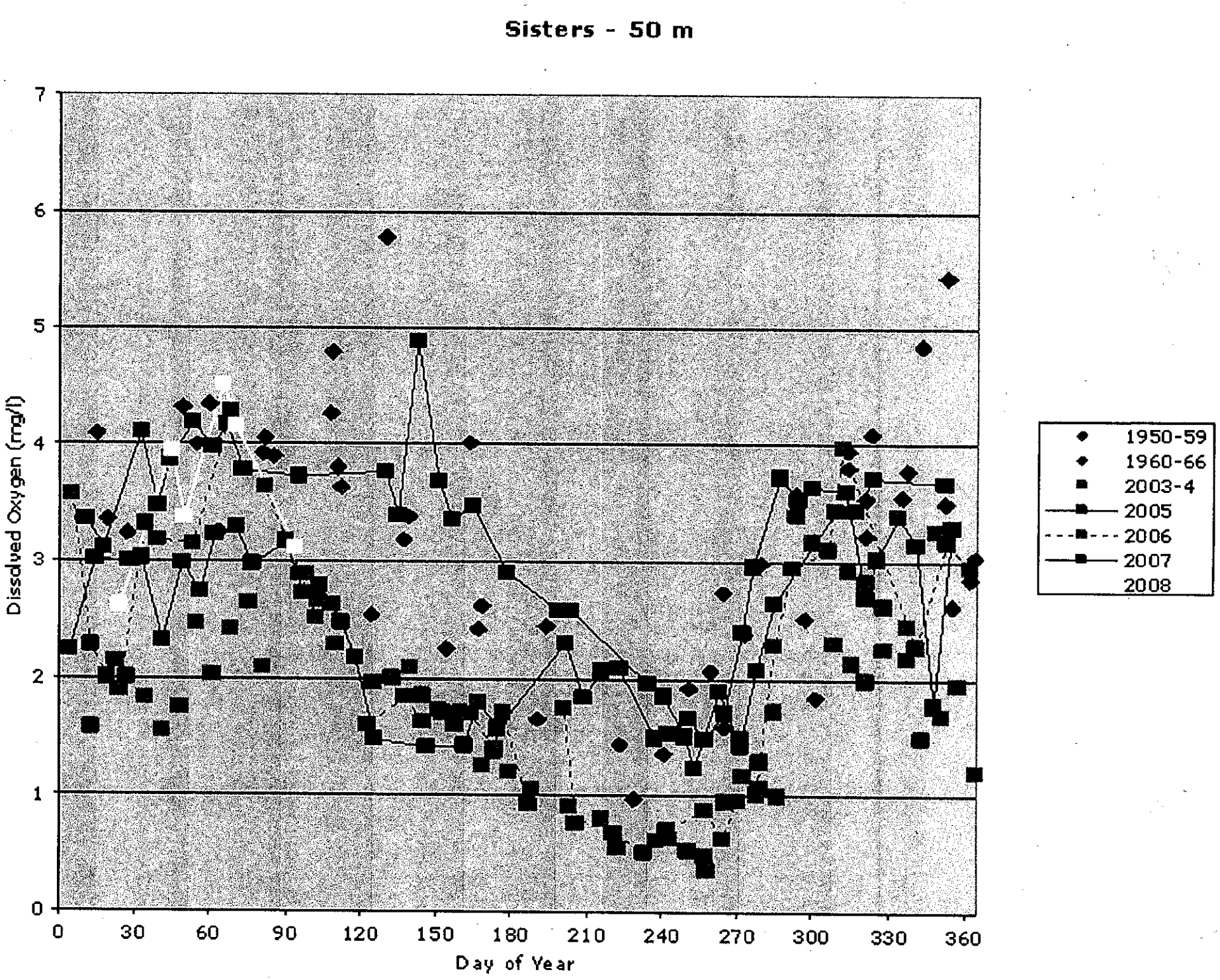
8.000
7.000
6.000
5.000
4.000
3.000
2.000

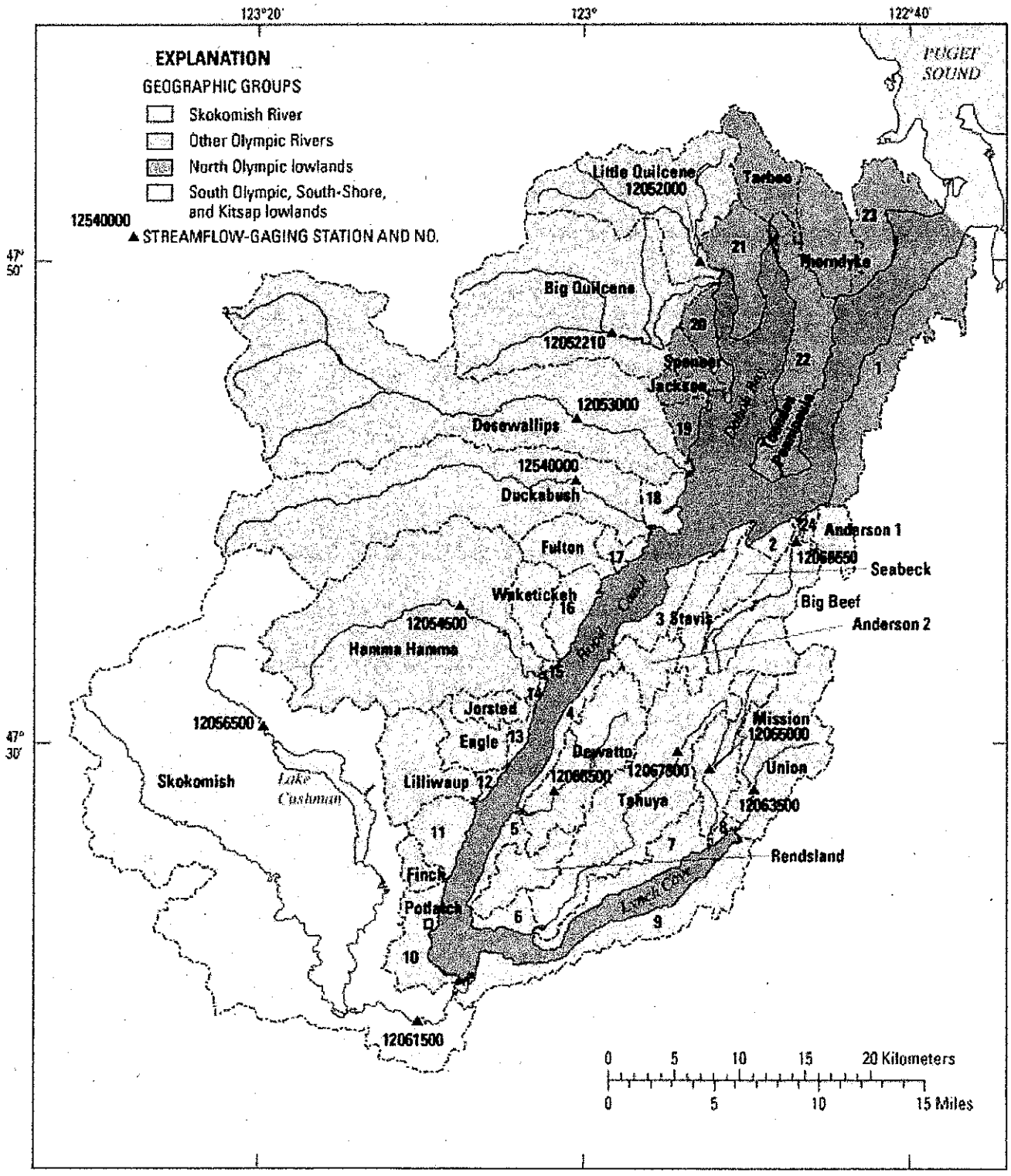
0 30 60 90 120 150 180 210 240 270 300 330 360

Day of Yea

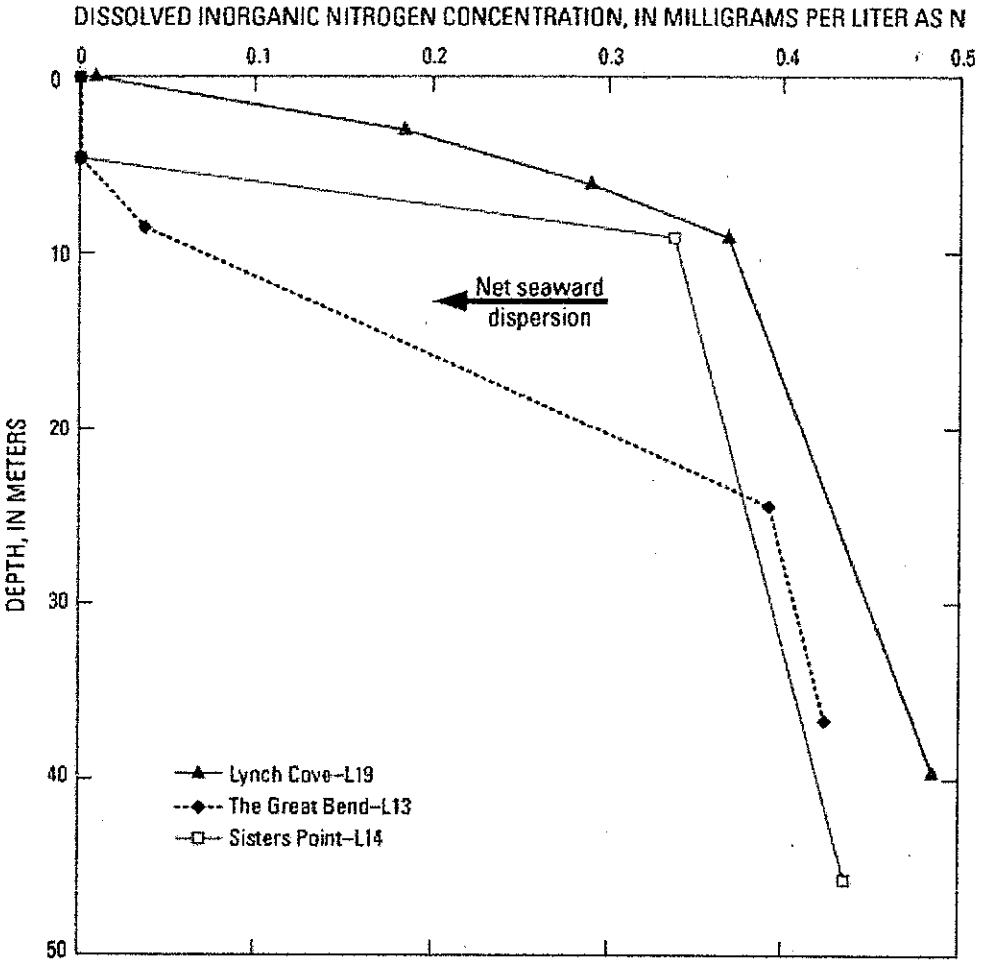
1952-3 1954 1955 1956 1957 1958 1959 1960 1961
1962 1963 1965 1966 1998 1999 2000 2001 2002
2003 2004 2005 2006 2007 2008


Lynch Cove - 20 m
Dissolved Oxygen (mg/l)
0
1
2
3
4
5
6
7
8
9
0
30
60
90
120
150
180
210
240
270
300
330
360
Day of Year
1930-1949
1950-1959
1960-66
2003-4
2005
2006
2007
2008


Sisters - 50 m
Dissolved Oxygen (mg/l)
Day of Year
0
1
2
3
4
5
6
7
0
30
60
90
120
150
180
210
240
270
300
330
360
1950-59
1960-66
2003-4
2005
2006
2007
2008



Base from U.S. Geological Survey digital data, 1992, 1:100,000
Universal Transverse Mercator projection, Zone 10, NAD83


DISSOLVED INORGANIC NITROGEN CONCENTRATION, IN MILLIGRAMS PER LITER AS N
0
0.1
0.2
0.3
0.4
0.5
DEPTH, IN METERS
0
10
20
30
40
50
Net seaward dispersion
Lynch Cove–L19
The Great Bend–L13
Sisters Point–L14

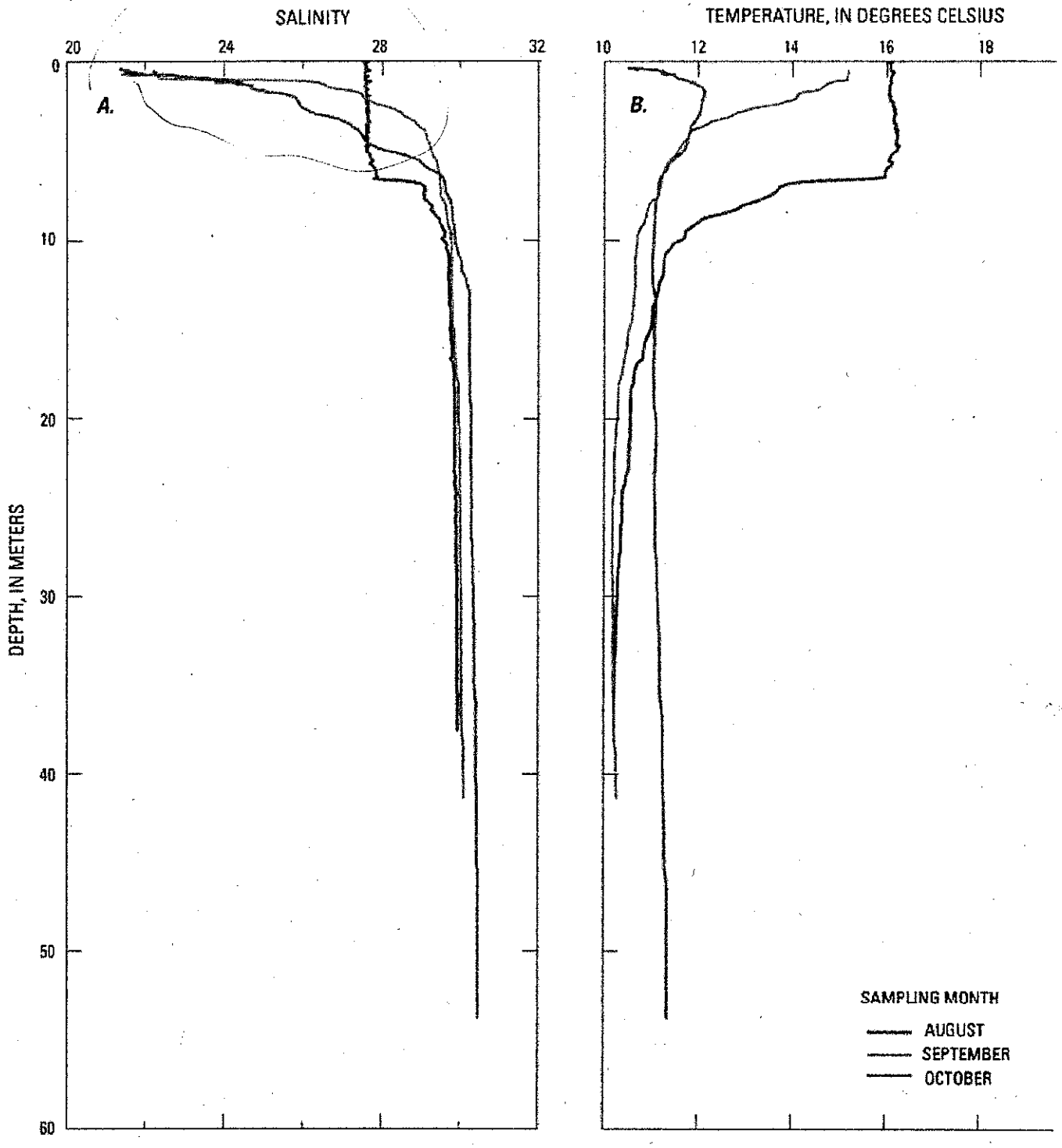

SALINITY
20
24
28
32
A.
TEMPERATURE, IN DEGREES CELSIUS
10
12
14
16
18
B.
DEPTH, IN METERS
0
10
20
30
40
50
60
SAMPLING MONTH
AUGUST
SEPTEMBER
OCTOBER

Figure 6. Estimated Range of Nitrogen Contributions into Hood Canal

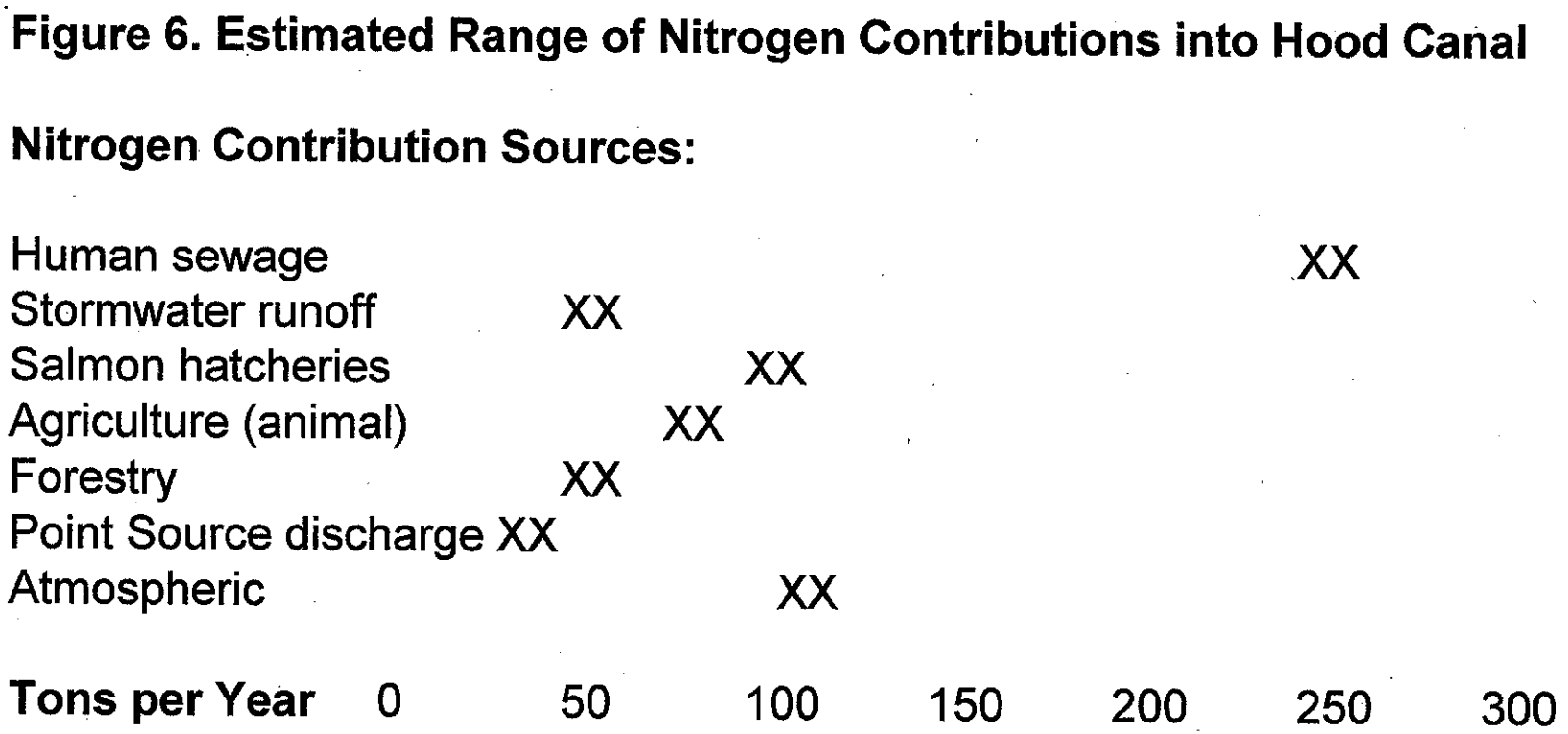
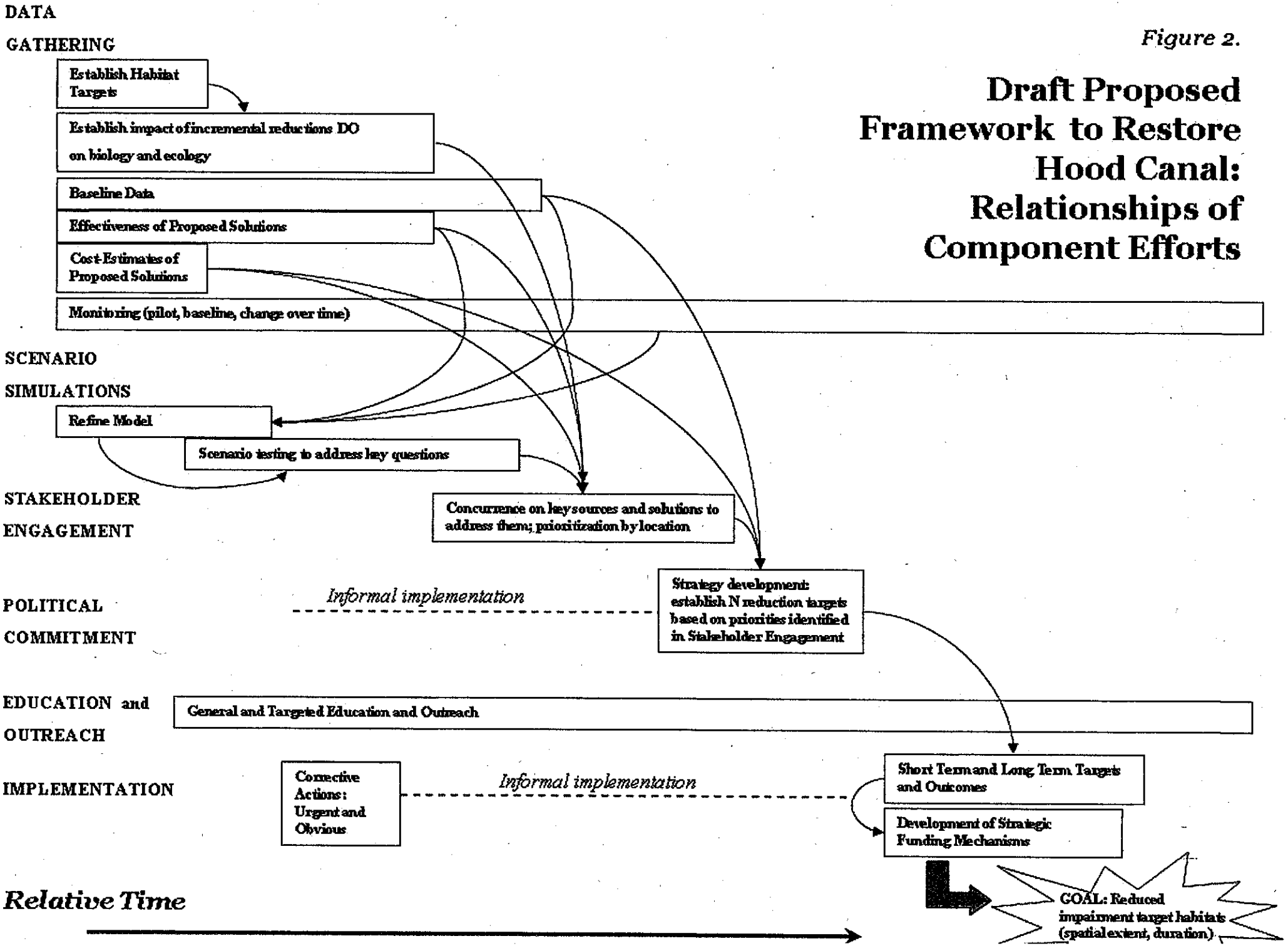


Figure 2.

Draft Proposed Framework to Restore Hood Canal: Relationships of Component Efforts



Hood Canal Dissolved Oxygen Program

Goals

Structure

Tasks

Partners

Key Messages

Background Information

Key Messages

The Problem

1. Hood Canal's dissolved oxygen concentrations are at their lowest in recorded history. Aquatic life needs oxygen to breathe, just as people do.
2. In recent years the low dissolved oxygen condition has become more widespread. The area of low dissolved oxygen is getting larger, spreading northwards. The periods of low dissolved oxygen last longer.
3. Hood Canal suffered significant fish kills during both 2002 and 2003. These events affected thousands of juvenile perch (June 2003) and numerous fish, octopi and sea cucumbers (fall 2002 and 2003).

Sources of the Problem

1. Many natural factors may contribute to the low dissolved oxygen problem: slow water circulation and mixing, the incoming ocean water quality, changes in the weather, high growth of algae, loadings of carbon and nitrogen, and changes in the native marine life composition.
2. People may be affecting the dissolved oxygen concentration in several ways, including altering the river flows, landscapes, and marine life, adding excess nutrients to the waters that can fuel extra algae growth, adding extra carbon to the ecosystem, and influencing climate change.

The Solutions

- The decrease in oxygen in Hood Canal took many years to be apparent and it may take that long or longer for it to recover. The Hood Canal low dissolved oxygen problem is still under scientific study. We don't yet completely understand the whole of the problem, so we can't devise the whole solution – but it's important to get started now.
- Twenty-eight entities, including local, state and federal agencies, tribal governments, non–profit organizations and universities, have come together to form the Hood Canal Low

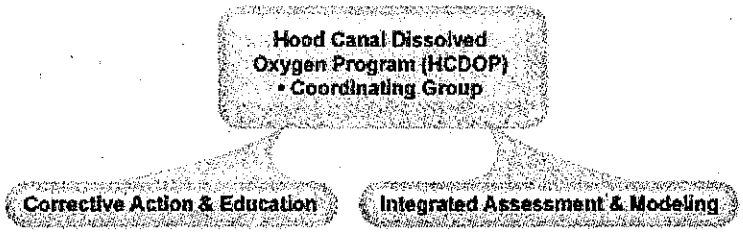
Hood Canal Dissolved Oxygen Program

Goals

The goal of the Hood Canal Dissolved Oxygen Program (HCDOP) is to determine the sources of low dissolved oxygen in Hood Canal and the effect on marine life. HCDOP will work with local, state, federal, and tribal government policy makers to evaluate potential corrective actions that will restore and maintain a level of dissolved oxygen that will reduce stress on marine life. HCDOP is a partnership of 28 organizations that conducts monitoring and analysis and develops potential corrective actions to address the low dissolved oxygen problem in Hood Canal.

Structure

HCDOP has two integrated and complementary arms: the Integrated Assessment and Modeling (IAM) study and the Corrective Action and Education group. This site describes the integratetd Assessment and Modeling study. For information on the Corrective Action and Education group, go to the Puget Sound Action Team Web site for Hood Canal.



(for more info click the Corrective Action & Education or the Integrated Assessment & Modeling buttons)

The IAM is a three-year study to use marine, freshwater and biota monitoring data and a computer model to quantify the role the various natural processes and human actions are playing to control the concentrations of dissolved oxygen in Hood Canal and test corrective action scenarios.

The Corrective Action and Education group focuses on preliminary assessment, corrective actions and demonstration projects that will help to improve levels of dissolved oxygen in Hood Canal. This

- Respond to fish kills and algal blooms, maintain diver observation records

Partners

Current partners are:

* Hood Canal Coordinating Council
* Hood Canal Salmon Enhancement Group
* Jefferson Conservation District
* Jefferson County
* Kitsap Conservation District
* Kitsap County
* Kitsap County Health District
* Lower Hood Canal Watershed Implementation Committee
* Mason Conservation District
* Mason County
* National Oceanographic and Atmospheric Administration
* NANOOS (Northwest Association of Networked Ocean Observing Systems)
* Northwest Indian Fisheries Commission
* Pacific Northwest National Laboratory
* Pacific Northwest Salmon Center
* Pacific Shellfish Institute
* Paladin Data Systems
* Port Gamble S'Klallam Tribe
* Puget Sound Action Team
* PSMEM (Puget Sound Marine Environmental Modeling)
* PRISM (Puget Sound Regional Synthesis Model)
* Skokomish Tribe
* U.S. Army Corps of Engineers
* U.S. Environmental Protection Agency
* U.S. Fish & Wildlife Service
* U.S. Geological Survey
* U.S. Navy
* University of Washington-Applied Physics Laboratory
* University of Washington-School of Oceanography
* Washington Department of Ecology
* Washington Department of Fish & Wildlife
* Washington Department of Health
* Washington Department of Natural Resources
* Washington Sea Grant Program - University of Washington
* Western Washington University
* WRIA 16 Planning Unit

Hood Canal Dissolved Oxygen Program

Goals
Structure
Tasks
Partners
Key Messages
Background Information

Background Information

April 2005

The Problem

1. The data collected by the University of Washington, Washington Department of Ecology-Puget Sound Ambient Monitoring Program, and most recently by the Hood Canal Salmon Enhancement Group and its citizen volunteers show that Hood Canal's dissolved oxygen (DO) concentrations are at their lowest as compared to data from the 1950s, 60s, and 90s.

2. Hood Canal has had a history of seasonally low DO concentrations, which have resulted in fish kills that have been documented over the years, including known records from as early as the 1920s.

3. In recent years the low DO condition in Hood Canal has become more widespread. The area of low DO is getting larger, spreading northwards. The periods of low DO last longer. In fact, during 2003-2004 the DO remained low throughout the wintertime, which is normally when concentrations rebound due to annual input of water from the ocean. This pattern was also evident during much of the late 1990s and the 2000s.

4. Hood Canal suffered significant fish kills during both 2002 and 2003. These events affected thousands of juvenile perch (June 2003), and numerous fish and shellfish (fall 2002 and 2003). A more minor fish kill was observed during September 2004. Low oxygen concentrations that can kill or stress marine life were recorded around the time of these fish kills.

5. Threats to the canal resources are threats to treaty-protected resources. The Tribal Treaty, or usual and accustomed, area, is the majority of the Hood Canal basin. The 1855 Treaty of Point No Point pre-dates Washington statehood.

Sources of the Problem

附錄 3：美國環保署第 10 分區優養化議題簡報

Nutrients
In EPA Region 10

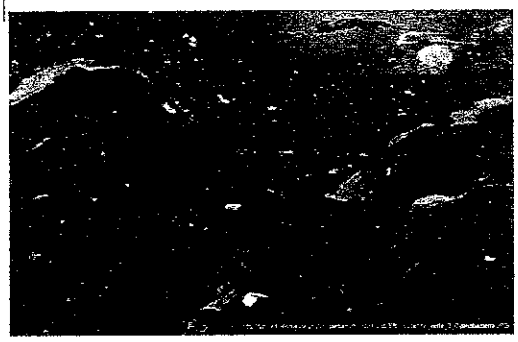
EPA Taiwan Nutrients Tour
December 2008

Overview

- Nutrient enrichment consistently ranks as one of the top causes nationwide of water resource impairment
- Sources include: agricultural runoff, wastewater treatment, construction, stormwater runoff and forest management
- Symptoms include: nuisance algal blooms, fish kills, dead zones, overabundance or decline of macrophytes, and loss of top predators

Challenges

- Politics
- Ecoregion diversity
- Implementation guidance is lacking
- Complexity
- Treatment technologies
- Insufficient data
- No authority to regulate non-point source pollution

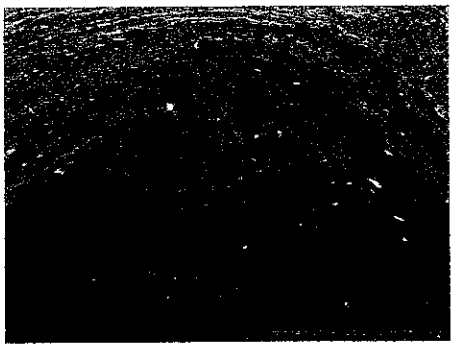


Politics

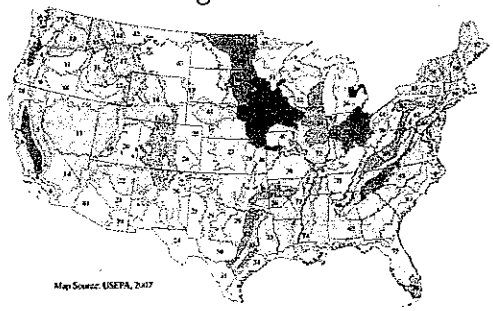
- Many different agencies, and levels of government, with different priorities, capabilities and budgets
- Interjurisdictional waters
- Substantial sway from special interest groups

Ecoregions

- The Pacific Northwest, like the rest of the U.S., is very diverse ecologically
- 3 very distinct Level II Ecoregions: Xeric West, Western Forested Mountains, and Coastal
- 13 distinct Level III Ecoregions



Level III Ecoregions – Lower 48



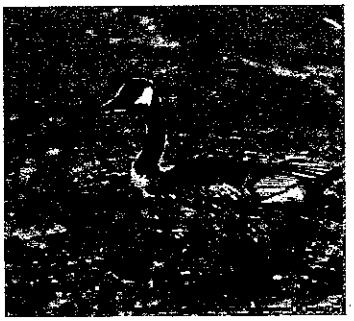
Map Source: USEPA, 2007

Implementation

- Substantial effort towards nutrient criteria development, but minimal guidance on effective implementation
- Each state perceives different efforts as being effective
- Despite nutrients ubiquitous nature, different organizations within a given agency don't always work together
- Inability to regulate non-point source pollution is crippling nutrient control efforts

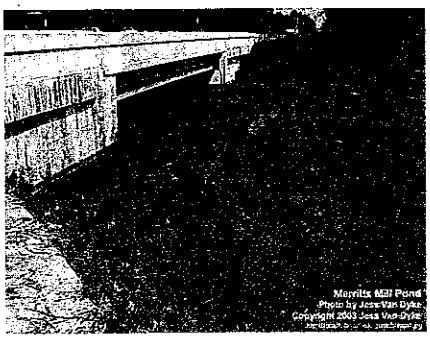
Complexity

- Difficult to determine appropriate nitrogen and phosphorus levels on a large scale
- Nutrients are necessary to a degree – how much is too much varies greatly across ecoregions
- Nutrients are ubiquitous
- Modeling
- Hydrology and geology play important role



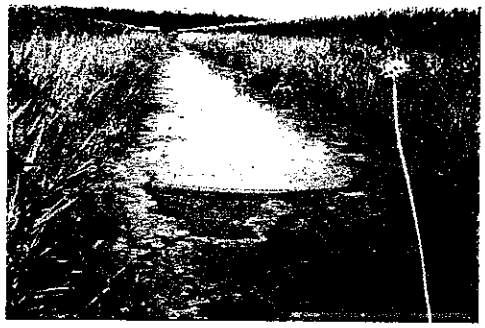
Treatment Technologies

- Very low levels can be difficult to achieve
- Disagreement on the level currently achievable
- Can be costly



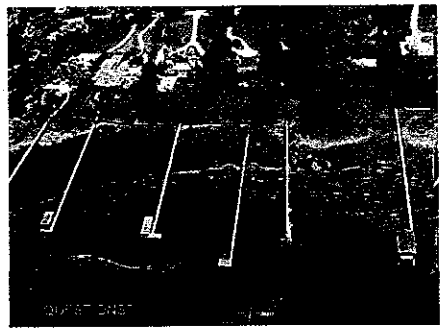
Current activities

- Several watershed scale plans (TMDLs) in progress
- Pushback from states on numeric criteria – working with states to develop report on why their current efforts are effective
- Continue to encourage states to pursue numeric criteria



Future Direction

- Numeric criteria are important to prevent backsliding, but will not result in lower nutrient levels without assistance from other programs
- Moving to a more holistic approach: numeric criteria, TMDLs and permitting
- Multiple lawsuits may put EPA in a position of having to promulgate numeric criteria



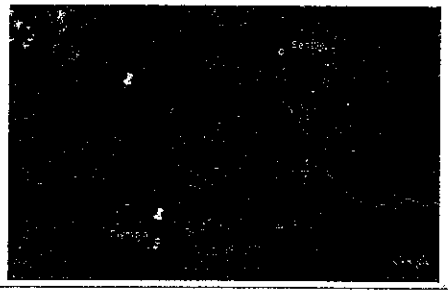
Itinerary for the rest of the week

Itinerary for the rest of the week

Day 1 – Visit High Point and Broadview

Itinerary for the rest of the week

Day 2 – Tour Puget Sound



Itinerary for the rest of the week

Day 3 – Visit agricultural and wastewater reuse sites in Idaho

Itinerary for the rest of the week

Day 4 – Back in the office for discussion on nutrient criteria development and next steps

Contact Information

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- **Bill Stewart**, stewart.williamc@epa.gov, **206-378-5753**
- **Jenny Wu**, wu.jennifer@epa.gov, **206-553-6382**

Numeric Nutrient Criteria Development for Reservoirs

EPA Taiwan Nutrients Tour
December 2008

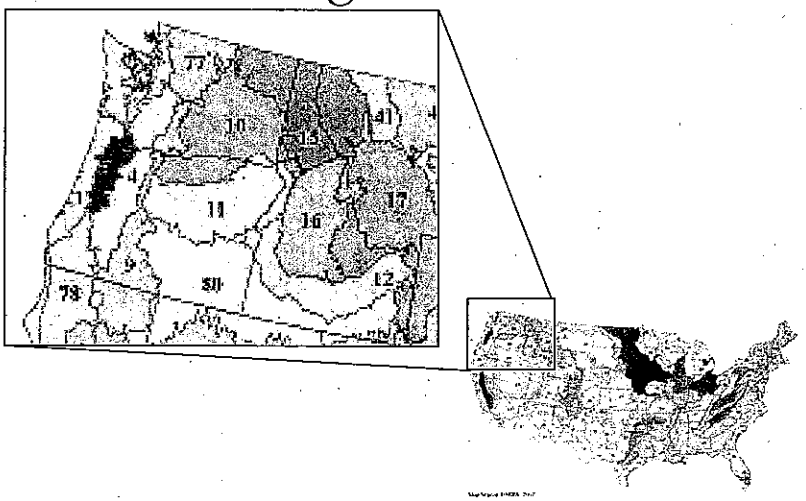
Overview

- 1998 – EPA released national strategy → 6年內發展 各州之標準數據
- States have struggled to develop numeric criteria
- To date, only Minnesota has developed statewide numeric criteria for lakes 僅M 於2008年 通過
- Nutrients responsible for "listing" of impaired waters
- Problem includes both determining the correct criteria value and how to implement once it is in place
  1. 標準為何
  2. 達了. 如何執行

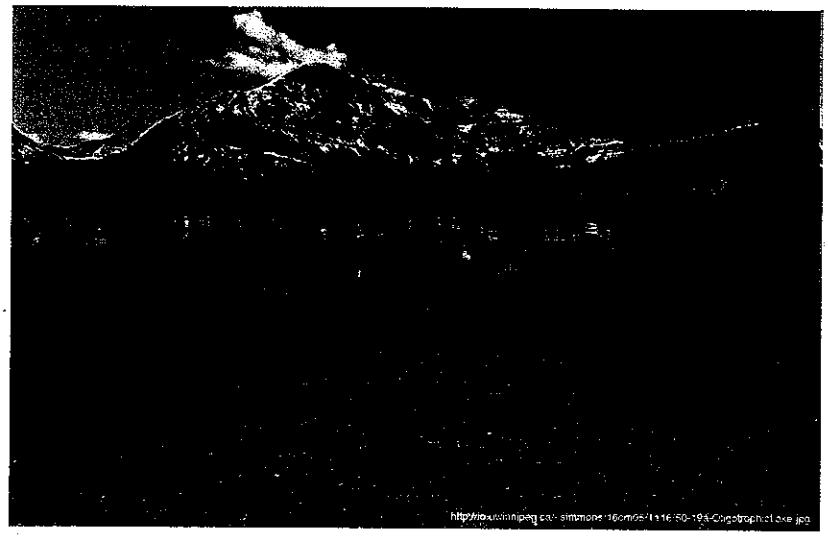
Process

- Evaluate Ecoregion/Classify reservoirs
- Select candidate criteria variables (TN, TP, chlorphyll *a*, Secchi, etc.)
- Select minimally impacted waters in each class and use to establish reference conditions
- Establish nutrient criteria
- Implement criteria
- Monitor and evaluate effectiveness

Level III Ecoregions



Reference Sites



Eutrophic Reservoir

Useful links

- NSTEPS: Nutrient Scientific Technical Exchange Partnership & Support
  http://n-steps.tetratech-ffx.com/NTSChome.cfm
- EPA Nutrient Website
  http://www.epa.gov/waterscience/criteria/nutrient/
- Ecoregional Nutrient Criteria Documents
  http://www.epa.gov/waterscience/criteria/nutrient/ecoregions/lakes/index.html

Watershed Approach to Nutrient Problems (Total Maximum Daily Loads)

U.S. EPA Region 10

Seattle, WA

December 12, 2008

When are TMDLs developed?

- Waterbodies exceed water quality standards (uses and criteria)
  - Numeric criteria or
  - Narrative criteria
- States required to report waterbody status every 2 years (303(d) Integrated Report)
- Every waterbody that does not meet water quality standards must have a TMDL
- Program began in the 1990s, and now, over 10,000 TMDLs have been done.

TMDLs for Nutrients

- Two ways for nutrient TMDLs to be done
  - Numeric criteria exceeded of a secondary pollutant (DO, pH) caused by nutrients
  - Narrative criteria exceeded (nuisance algae observed)

TMDLs for nutrients (when DO, pH violates standards)

- Example: Umpqua Basin in southern Oregon
- Violations of aquatic weeds, pH in the summer
- pH has numeric standard of 6.5-8.5
- Source analysis: WWTPs, tributary inputs
- Water quality model and calibration
- Phosphorus inputs determined to be cause of pH violations
- Result 7 WWTPs discharged 3-4 mg/L TP; TMDLs require reductions to 0.048 to 0.5 mg/L TP
- Nonpoint sources reductions determined by reference sites in the area
- Agencies required to develop implementation plans to meet TMDL targets in 18 months in Oregon

TMDLs for nutrients (violations only from nuisance algae)

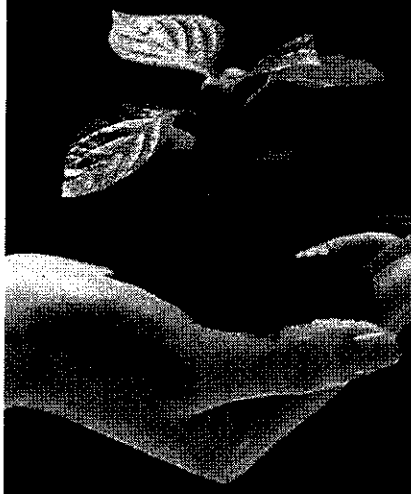
- Case Study: Lower Boise River
- No DO or pH exceedances observed; no diurnal continuous monitoring
- Records from 1980s show continued nuisance algae problems from periphyton
- Contributes to downstream Snake River/Hells Canyon DO/pH issues
- Would require City of Boise and several communities to reduce discharges from ? mg/L to 0.070 mg/L TP
- Supported by EPA ecoregion criteria, literature values

Implementation

- Point Sources – TMDLs set limits for point sources who get permits that are enforceable
- Nonpoint sources – TMDLs set limits for nonpoint sources that are not enforceable federally, but may be enforceable at the state level
  - Water quality trading
  - Grants
  - Encouragement

附錄 4：出國報告中英文簡報

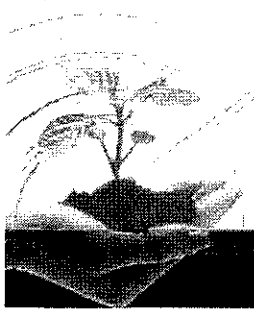
97年台美環保技術合作協定第8號執行辦法-水庫水質優養化管理成果簡報



環保署水保處 汪士鈞工程師

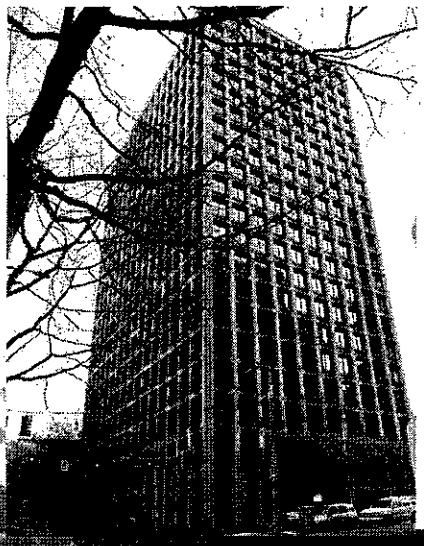
參訪目的

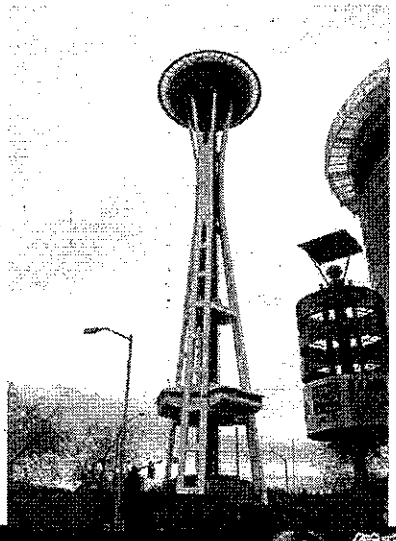
- 台灣地區水庫湖泊優養化日益嚴重，環保署近年已進行集水區點源及非點源污染問題探討及防治。
- 藉由台美環保技術合作協定第8號執行辦法-水庫水質優養化管理考察，參觀並學習美國環保署對於水庫湖泊優養化管理之技術及經驗



參訪行程概要1

- 本次出國計畫為台美環保技術合作協定第8號執行辦法下，由美國環保署第10分區(西雅圖辦公室)協助安排，主要參訪時間2008年12月9-12日



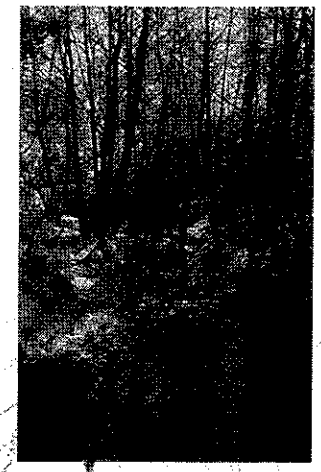
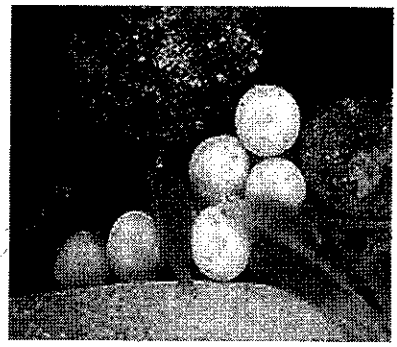


參訪行程概要2

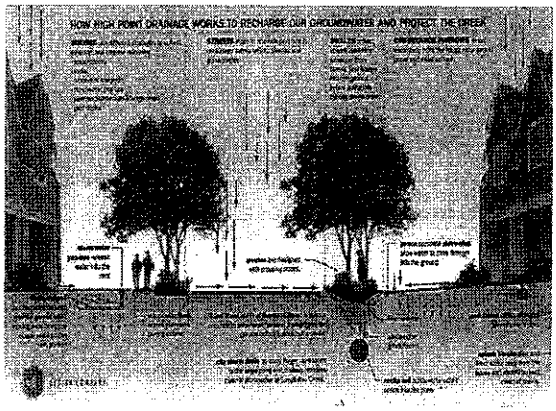
- 2008年12月9日上午拜訪美國環保署第10分區(西雅圖辦公室)，由汪士鈞工程師簡報，台灣地區水庫優養化現況，及Holly Arrigoni 簡報美國環保署在優養化議題之歷史及挑戰

參訪行程概要3

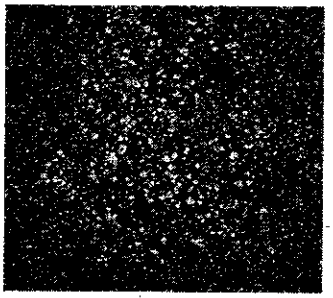
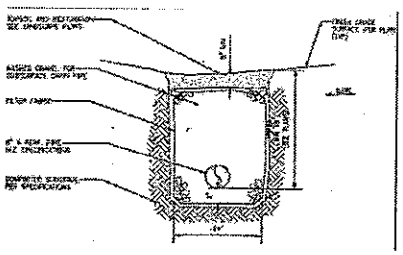
- 2008年12月9日下午參訪西雅圖西部地區，High Point 舊社區更新計畫，下方為Longfellow Creek生態較敏感區域


參訪行程概要4

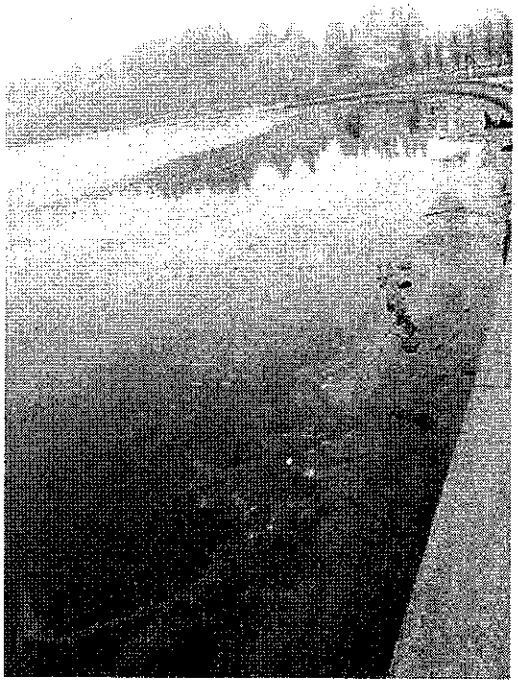


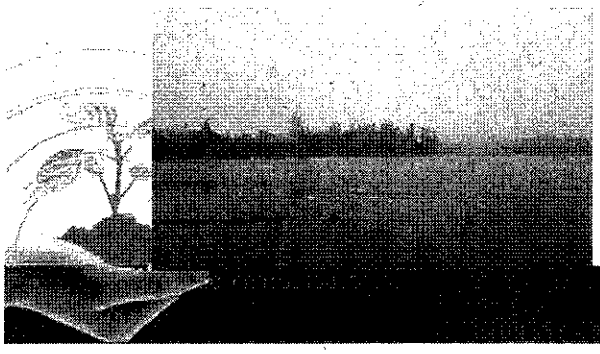
利用對當地環境及生態低衝擊之方式，以降低暴雨逕流措施(高滲透性路面、草溝、草帶及滯洪池)，降低暴雨對該地區鮭魚迴游之溪流所造成之影響。

參訪行程概要5

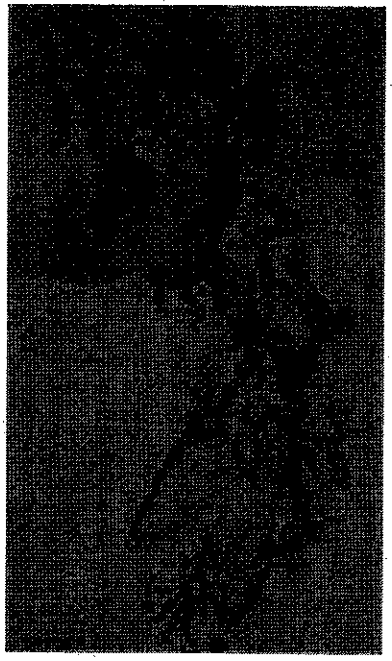
- 2008年12月10日上午
- 華盛頓州奧林匹亞市，州政府旁之Capitol Lake優養化情形，近2年因候鳥及人類觀光影響造成藻類大量繁殖，目前州政府已委託顧問公司研擬各項方案(清除底泥、曝氣、拆除控制閘門等)，目前仍在評估及進行公民討論中。





參訪行程概要6

- 2008年12月10日下午
- Hood Canal 為一狹長內灣長度約100公里，其左側即為華盛頓州奧林匹亞國家公園，峽灣僅有一北方出口，兩旁為環灣公路及少量腹地，目前皆為渡假別墅及飯店，Hood Canal峽灣為傳統牡蠣及蚌殼及海產採集地，近年溶氧值為歷年監測數據最低的，並於2002-2003年並造成初生鱸魚、章魚及海參等鹹水生物死亡。目前美國EPA針對該區域進行密集之監測及管制。



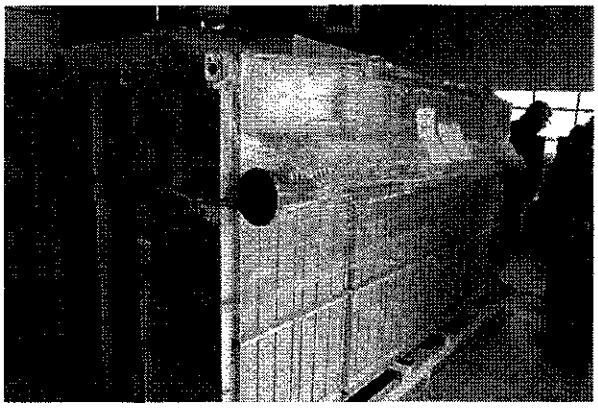
參訪行程概要7

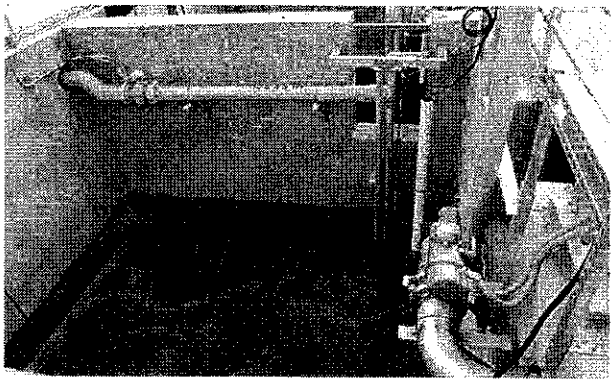
- 本區域污水處理方式以區域性管線收集後，以幫浦抽送至公路兩旁山上之小型污水處理場處理後，作為林地澆灌用。兩岸公路停車場則設置雨水收集系統，以礫石及草帶等設施降低暴雨水逕流造成之污染，目前該區域亦嚴格管制新屋執照及舊屋修繕。

參訪行程概要8

- 2008年12月11日上午
- 愛達荷州波易斯市，新設立獨立住宅區(700戶)之污水處理廠（SMBR）污水廠以沉浸式薄膜生物處理系統（Submered Membrane Bioreactors, SMBR），該處理方式之優勢為占地面積小，處理後水質較佳(BOD<10mg/L，SS<10mg/L）可達回收水水質要求。污泥停留時間長（10~30 days），生長速率緩慢的微生物得以滯留與增殖，有利於特殊或難分解污染物的去除，並可攔除大部分致病菌，減少消毒劑用量；惟初期設置成本較高。該社區處理後的污水全量回收，除部分作為社區植物之澆灌外，其餘污水灌入該區域一處深約60呎粗砂質土地再過濾後，補助地下水源。

參訪行程概要9

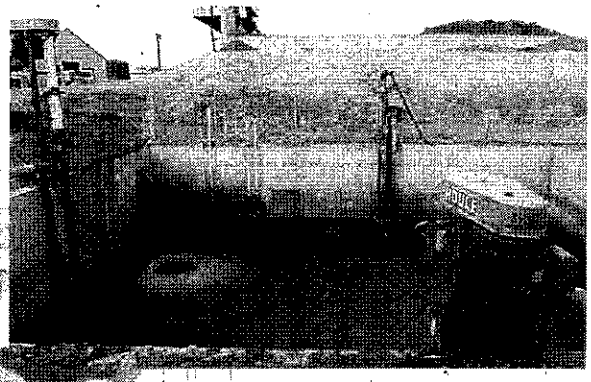


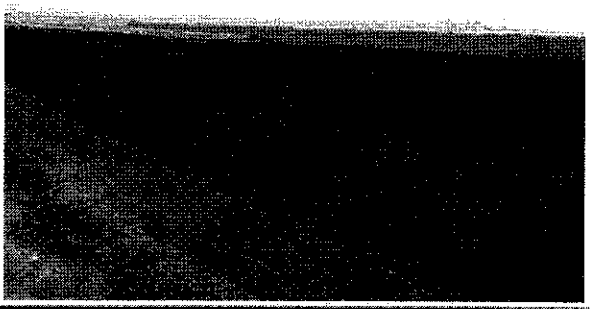


參訪行程概要10

2008年12月11日下午

- 由愛達荷州農業部帶領前往愛達荷州營乳牛農場參訪，該農場佔地1,300英畝，養殖牛隻總數5,000頭，愛達荷州畜牧場之廢棄物處理，如採取土壤處理則皆需經過州農業部之評估，畜養隻數與澆灌農作物比例經過一定管控，避免過度澆灌及土壤有機物過





心得與建議1

- 對於污染超出負荷之河川，訂定總量管制標準來限制污染物排入；及新設立之大型開發案或工業區藉由水質交易方式提出其他替代方案改善河川水質，值得國內河川整治之參考。
- 利用高滲透性路面、房屋雨水收集、草溝、草帶及滯洪池等措施，降低暴雨對該環境敏感地區之影響，對於台灣地區位於水源保護區或水庫集水區的社區規劃，為極好的示範。

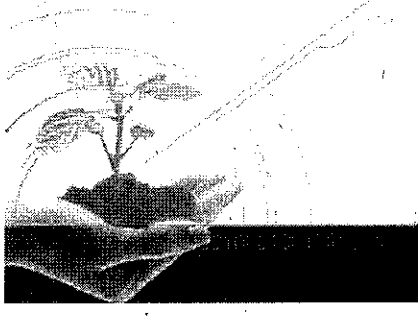
心得與建議2

- 湖庫地區污水收集後送至鄰近山丘上污水廠處理後，放流水作為林地澆灌用，直接降低了大部分污染物的流達率，與國內污水處理廠必定於溪流旁地勢較低處有極大差異，應可參採。
- Hood Canal峽灣旁停車場及休息區以小型草溝配合礫石進行簡單過濾及污染削減，對於雨天油污及污染物有直接攔阻之效果，值得國內水庫、湖泊及風景區進行推廣。

心得與建議3

- 薄膜分離式污水處理系統（MBR）占地面積小，處理後水質較佳可達回收水水質要求；污泥停留時間長，有利於特殊或難分解污染物的去除，並可攔除大部分致病菌，減少消毒劑用量，可採行於水庫集水區及飲用水水質水量保護區之生活污水處理。

簡 報 結 束



2008 Taiwan-U.S.A Environment technical cooperation No.8

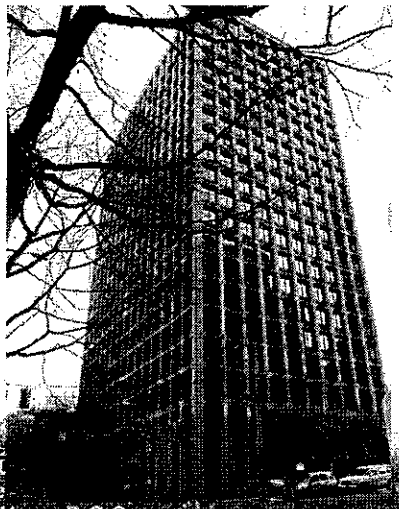
Reservoir Eutrophication Control

Preface

- Reservoir Eutrophication problem has been seriously in Taiwan. Taiwan EPA has begun to do the point and non-point source pollution control for protection the reservoir water quality.
- This visit is for learning U.S. EPA's experience and technique on reservoir eutrophication control.

Itinerary

- The visit is arranged by U.S. EPA zone10(Seattle office) under the Taiwan-U.S.A Environment technical cooperation No.8.
- The date is 2008/Dec/9 - 12

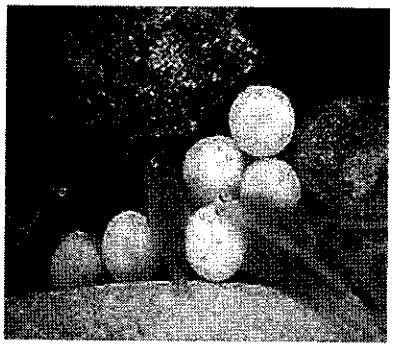


Itinerary-2

- 2008/12/9, visit Seattle office, zone 10, U.S. EPA
- Mr. Wang, engineer of Taiwan EPA, presented the reservoir eutrophication condition in Taiwan.
- Holly Arrigoni presented the history and challenge of eutrophication control of management by U.S. EPA

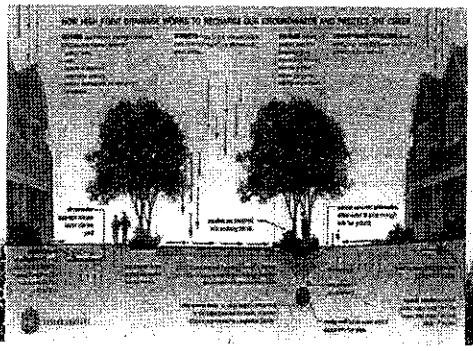
Itinerary-3

- 2008/12/9 afternoon, visit High Point Community renew program in west Seattle.
- These photos show the ecological sensitive zone, Longfellow Creek


Itinerary-4

- Use the low environment and ecology impact practice, including high permeability road, grass swale, grass buffer zone and detention pond, to reduce the first flush impact to salmon migrate.

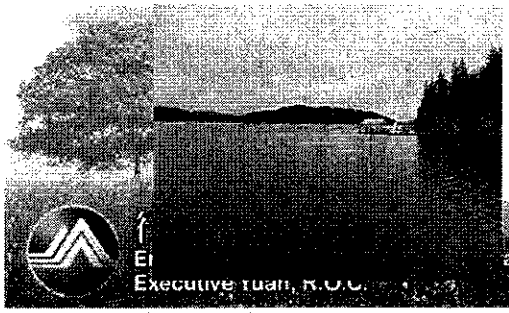




Itinerary-5

- 2008/12/10 morning, visit Capitol lake at Olympia City, Washington
- Capitol lake turns to eutrophication due to recreation and migratory birds these years.
- The government already hired the consultant to find out the solutions, such as cleaning sludge, aeration, and remove control gate.
- The plan is still under evaluation and discussion.

Itinerary-6

- 2008/12/10 afternoon, visit Hood Canal
- Hood Canal is a 100km length thin bay. Left side is Olympia National Park. The only one exit is at north.
- There are round-bay roads and hinterlands in banks. Many villas and hotels along the bay.



Itinerary-7

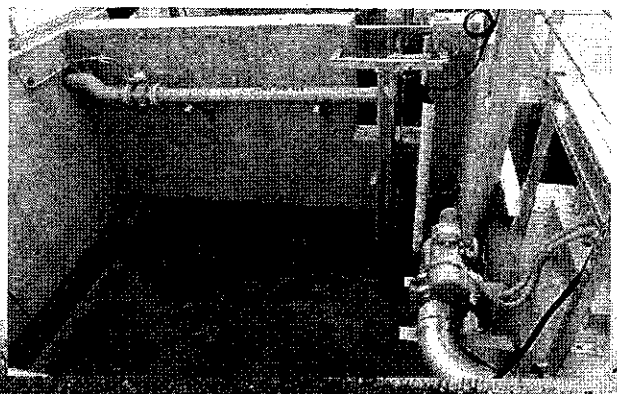
- Hood Canal bay is a famous place of fishery especially for oysters and clams.
- These year, the concentration of dissolved oxygen turns to low. It causes the death of marine life ,such as basses, octopuses, and trepang, 02’ ~03’ .
- U.S.EPA already executes the water monitoring and pollution control.

Itinerary-8

- The domestic wastewater is collected and pump to the small treatment plant. The effluent use for woodland irrigation.
- Storm water is collected by the storage system under the parking lot along the bank roads. The gravel and grass buffer zone have been used to reduce the first flush.
- The license apply of new house and house repair are under strict control in this area.

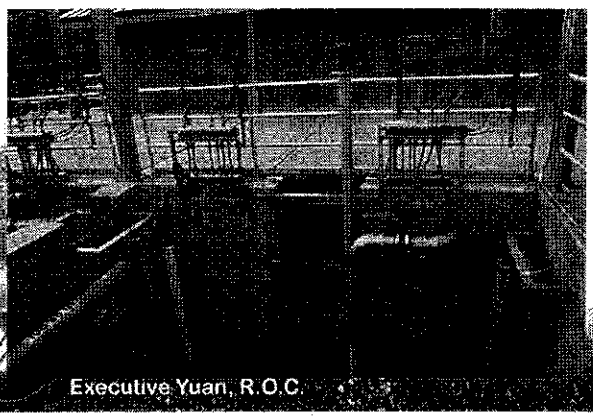
Itinerary-9

- 2008/12/10 morning, visit Boise City, Idaho
- Visit the wastewater treatment plant of new community with 700 residence, which using Submerged Membrane Bioreactors（MBR）
- The advantage of MBR is low space demand and better treatment performance. The quality of effluent can meet the recycle water standard. BOD and SS < 10 mg/L



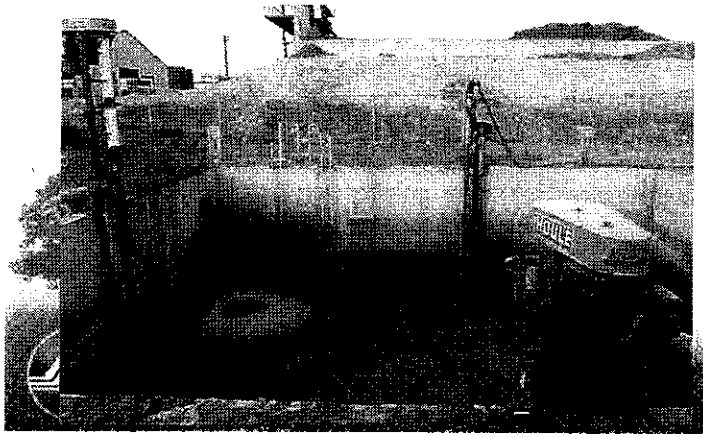
Itinerary-10

- The sludge age of MBR is longer(10-30 days). Hence, the microorganism can reproduce and block most of pathogenic microorganism. The usage of disinfectant can also be reduced, but the early cost of MBR is higher.
- The wastewater of the community are total recycled. Only small amount taken to irrigate plant, rest taken to recharge ground water after pass 60 foot coarse sand.



Itinerary-11

- 2008/12/11, afternoon, visit Idaho farm dairy.
- It's a 1300acres area, 5000 dairies farm.
- The treatment facility of the farm waste have to pass the evaluation of ministry of agriculture if use the soil treatment.
- The ratio of dairies and irrigating is under control to prevent over irrigation or soil organic content.



Conclusion

- To river which is over loading, we can establish the total amount control to limit waste discharge. Develop the discharge trading method or alternatives in large development program or industrial zone.
- Using high permeability road, house rain water collection system, grass swale, grass buffer zone and detention pond to reduce the impact of non-point source pollution for ecology sensitive zone is a good example for watershed management in Taiwan.

Conclusion-2

- Compare to Taiwan, the State try to build the WWTP on the hill of reservoir and lake watershed and reuse the treated effluent for irrigation. It can minimize the pollutant come to the water body.
- We can adapt the Hood Canal experience by using the grass swale and gravel trench at the parking lot to reduce the oil and pollutant which comes from first flush.

Conclusion-3

- We can use MBR to treat the domestic wastewater in the watershed of reservoir and the gathering ground of drinking water.