EVALUATION OF WATER TABLE CONDITIONS WITHIN A GROVE OF *PICEA SITCHENSIS*, HOH RIVER VISITOR CENTER, OLYMPIC NATIONAL PARK, WASHINGTON

Richard Inglis

Technical Report NPS/NRWRD/NRTR-90/06

WATER RESOURCES DIVISION

National Park Service • Department of Interior
Fort Collins • Denver • Washington

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Water Resources Division • 301 S. Howes Street • Fort Collins, Colorado 80521

LIST OF FIGURES

ACKNOWLEDGEMENTS

I wish to thank the staff of Olympic National Park for their assistance and encouragement. This project would not have been completed without their help. Thanks to John Aho for his direction and guidance. In particular, Bill Rohde, Sub-District Ranger, and Janet Kailin should be mentioned for their excellent cooperation and data collection efforts during those *long* rainy sessions at the Hoh.

PURPOSE

The Water Resources Division has recently conducted a study of the effects of water level changes within an adjacent pond on water table elevations beneath a grove of old-growth Sitka Spruce (*Picea sitchensis*). This study is a part of an ongoing program to evaluate water table conditions in the subject grove, specifically to determine if ground water conditions are affecting the trees. These large trees have been exhibiting stress since a road, constructed during the 1960s, impounded drainage and formed a pond adjacent to the grove. It is hypothesized that the pond has altered ground water levels beneath the trees, increasing root zone saturation and thus contributing to the poor condition of the trees. Data analysis of a local ground water monitoring program, established 3 years ago, has not conclusively indicated that water table changes in the subject grove are caused by changes in pond water levels, or are different than those beneath trees showing less stress (Inglis, 1989).

The recent study involved artificially inducing changes in pond water levels and recording the effects on water tables within the grove of stressed trees. The objective is to determine if groundwater levels under the subject grove respond to changes in the stage of the pond. This study contributes to the overall description of hydrologic conditions in the subject grove, assisting the final analysis of the causes of the reduced growth vigor. Several pond management alternatives are also presented.

ISSUE

In the vicinity of the Hoh River Visitor Center, an impoundment on Taft Creek (created by road construction during the 1960s) inundates an area near old growth Sitka Spruce (Figure 1). Since that time the spruce trees in the vicinity of the pond have exhibited unhealthy tops, thin foliage and reduced growth rings. The trees presently do not contain much rot, but premature loss of the trees is expected if their stressed condition continues (Ed Schreiner, personal communication). It has been hypothesized that "wet feet" or excessively high ground water around the roots of the trees is causing the growth stress.

The Hoh Indian Nation and State biologists have identified the pond as coho salmon rearing habitat. These entities have informed the park that attempts to drain the pond would be detrimental to the fisheries resource.

The primary issues confronting park management are 1) the cause of tree growth stress and the relationship, if any, to water conditions, 2) the influence on ground water conditions from the Taft Creek impoundment, and 3) available options for correcting any perceived threats to the trees.

BACKGROUND

Park staff, with the assistance of the Water Resources Division, initiated a groundwater monitoring study in 1987 (Inglis, 1989). The monitoring objective was to characterize groundwater conditions in the subject grove of trees and to determine the seasonal and spacial relationship between ground water levels under the grove as related to both the stage of the pond and Taft Creek.

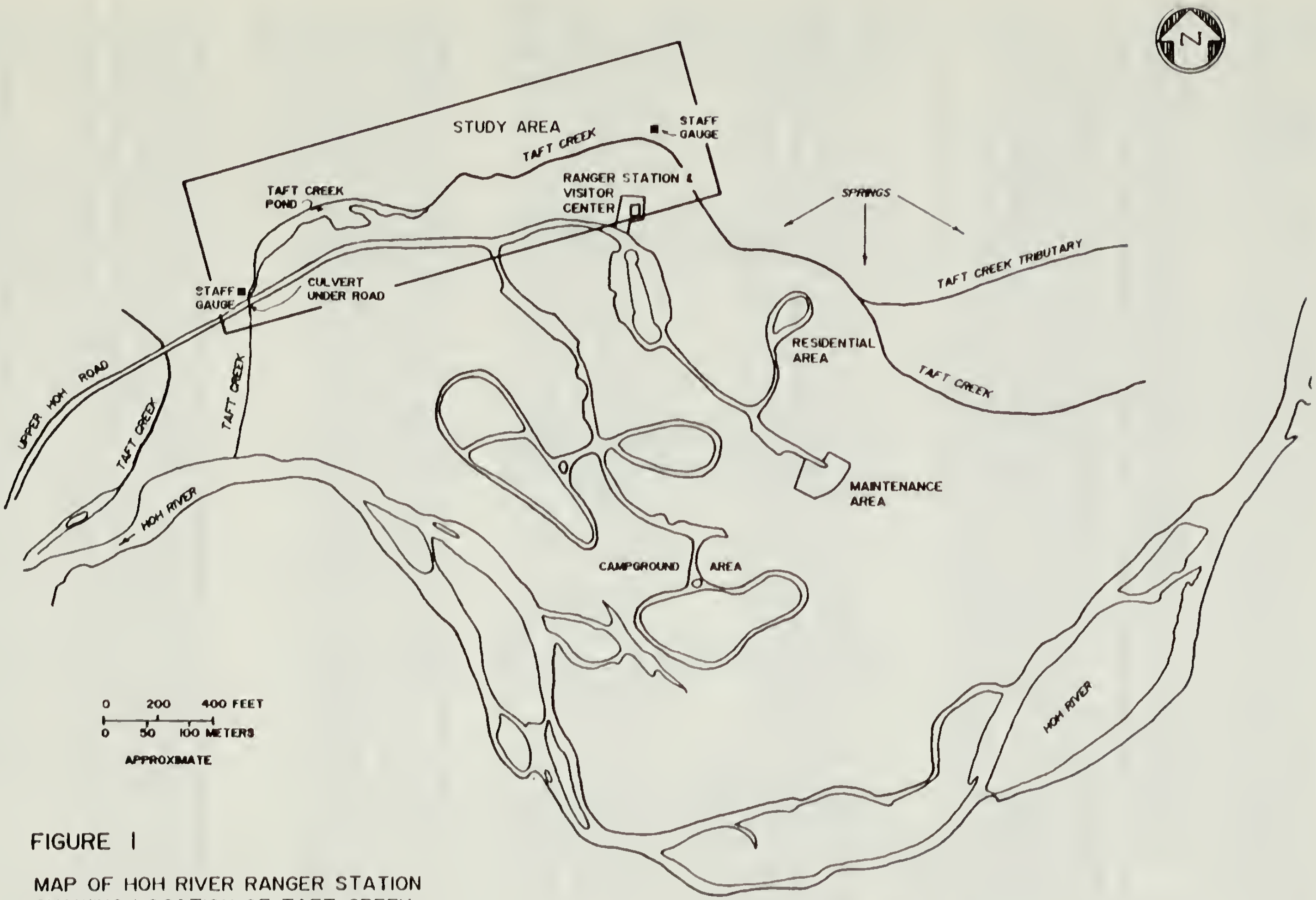


FIGURE 1

MAP OF HOH RIVER RANGER STATION
SHOWING LOCATION OF TAFT CREEK,
POND AND STAFF GAUGES

MAP COMPILED AND DRAFTED BY
JACQUELINE V. NOLAN
JUNE 1989
NATIONAL PARK SERVICE - WRD
WATER OPERATIONS BRANCH

The Taft Creek watershed, located at the west central area of the Olympic Peninsula, is predominantly located on the flood plain of the Hoh River. The springs that feed Taft Creek are located in several alluvial terraces adjacent to a large meander of the Hoh River. The study area is located on these alluvial deposits in what appears to be an old river channel.

The springs supplying Taft Creek are probably recharged from direct infiltration of rainfall on the flood plain and from the alluvial aquifer of the Hoh River (Kresch, 1987). Average annual precipitation at the Hoh Ranger Station is about 3000 mm. The area commonly is known as a temperate rain forest.

An old meander or flood-bypass channel of the Hoh River lies to the north of the Visitor Center. The upstream portion of this channel contains the small spring-fed branch of Taft Creek, and the downstream portion is inundated by a shallow pond fed, in part, by small hillside tributaries. The pond is bounded on the north by steep valley walls and on the south by an elevated portion of Upper Hoh Road, built on fill material. An outlet culvert under the road at the west end of the pond conveys Taft Creek flow under the road, to a narrow channel across the Hoh River flood plain and into the river. The impoundment of water in the study area was created by the Upper Hoh Road; 1959 highway construction drawings do not show the pond.

METHODS

The specific goal of this investigation is to quantify changes, if any, in groundwater levels in the subject grove of trees when water levels in the adjacent pond are increased artificially, simulating the effects of a rainstorm on pond levels, and to determine the areal extent of the pond's influence on the groundwater in the grove. Groundwater levels were measured in a series of nine observation wells installed previously in the grove (Inglis, 1989).

Digital recorders equipped with pressure transducers were installed in the wells and in Taft Creek upstream from the pond (both are identified as stations in this report) to record water level changes. Water level data were collected at five additional stations using direct measurement techniques. Most stations were surveyed for precise elevation of a reference point on the well cap or zero mark on the staff gages (see Plate No. 1). Vertical distances from the reference point to land surface datum and total depth of the wells are from 1987 field notes.

During the pre-impoundment period, static water levels in the wells, upper and lower Taft Creek were recorded at 30-minute intervals for eighteen hours starting at 4:00 pm 12/20/89. After blocking the pond's outlet culvert at 10:00 am 12/21/89, pond water levels increased rapidly for approximately 11 hours. Post-impoundment water levels were recorded for an additional 12 hours while the pond level reached equilibrium. No precipitation occurred during the study.

RESULTS

Groundwater levels in the wells, with the exception of Wells #19 and #20, began responding to changes in water levels in the pond from 30 minutes to as late as 5 hours after blocking the culvert. Groundwater levels reached approximate equilibrium with raised pond levels between 8 and 12 hours after the initial period of increase. The greatest groundwater level increases were in wells of lowest elevation. Water levels at the Upper Taft Creek in-stream station remained constant during the test.

The reason that water levels in Wells #19 and #20 did not respond is not known, but may be due to possible differences in well construction. These two stations are not used in the analysis. The discrepancy in water levels of observation wells #19 and #20 may also be due to variations in the sediments of the large terrace. The terrace was formed by the deposition of Hoh River sediments over an extended period of time involving many floods and long periods of flow at moderate rates. Although the entire terrace is composed of loose alluvial material, non-homogenetic sorting of transported materials which exhibit different aquifer characteristics are to be expected.

Table 1 presents physical characteristics of each station (measurement site) used for this study. Linear distances from the culvert to each site and the shortest (perpendicular) distance from each site to the main channel of Taft Creek are provided in Table 1 and are shown on Plate No. 2. These distances indicate the proximity of each monitoring site to surface water at pre test conditions. However, many side channels and depressions closer to many stations were inundated as the study progressed.

TABLE NO. 1 - CHARACTERISTICS OF WATER LEVEL STATIONS

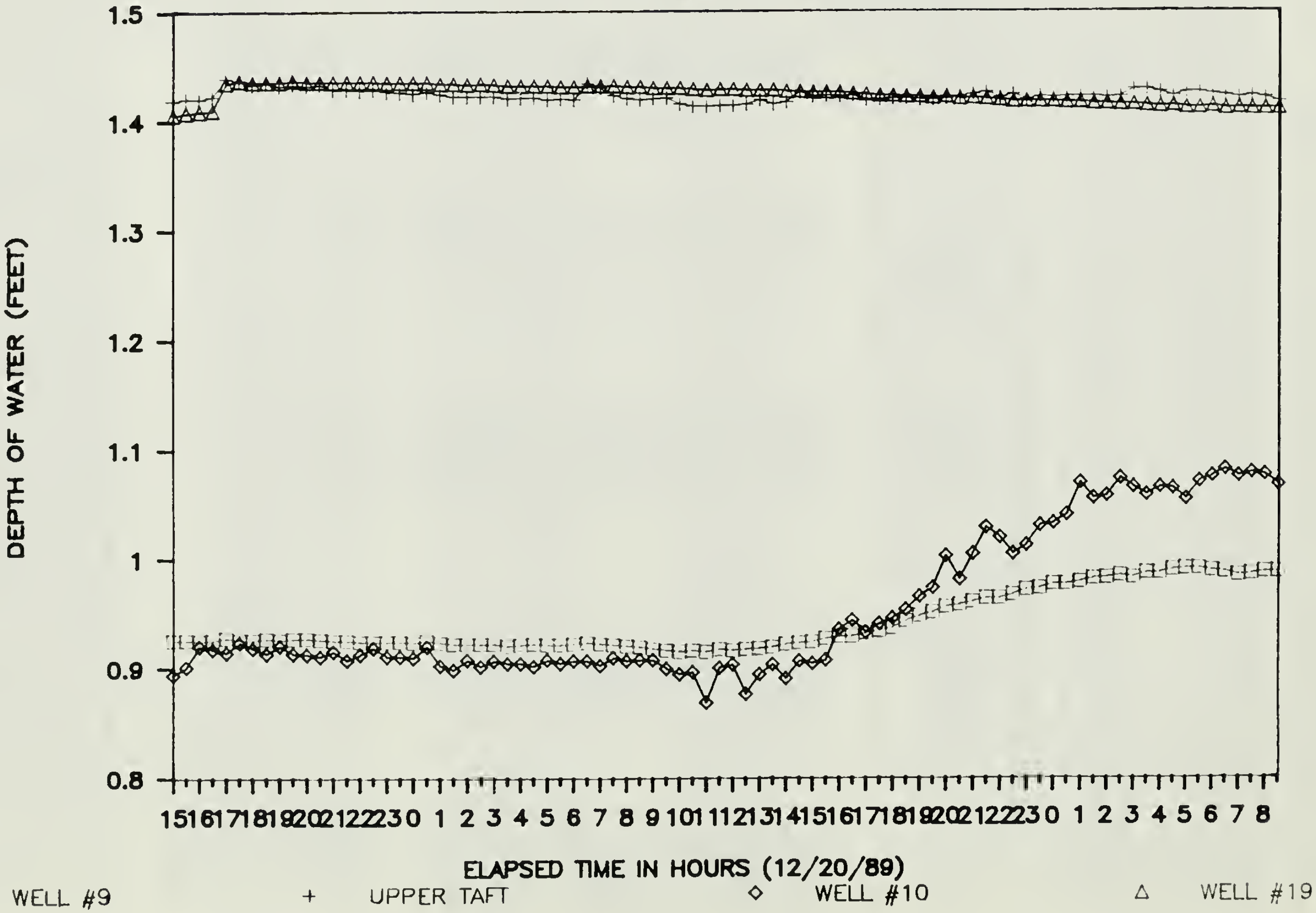
Station I.D.	Measuring Pt. Elev.	Elev. SWL or LSD*	Linear Dist. f/Culvert	Perpendicular Dist. f/Creek
Well #1	175.833	174.33	426	131.0
Well #2	175.456	174.72	353	3.7
Well #3	175.456	174.96	382	13.1
Well #4	175.702	174.85	412	16.8
Well #5	175.568	175.03	441	16.8
Well #6	175.638	175.13	472	24.4
Well #9	176.257	176.01	554	12.8
Well #10	176.041	176.04	518	53.3
Well #11	175.587	175.59	471	57.0
Well #17	ND**	175.36	486	47.8
Well #19	ND	175.60	562	9.7
Well #20	ND	175.24	483	9.4
Upper Taft	174.874	175.41	570	0.0
Lower Taft	ND	174.23	466	0.0
Culvert	173.622	174.12	0	0.0

*Static **W**ater **L**evel of Taft Creek before change or **L**and **S**urface **D**atum at each groundwater well.
****ND** No data available.

Figures 2 and 3 show water levels recorded from pressure transducers in seven wells and two stations on Taft Creek. In Figure 2, water levels of Wells #9 and #10 at the upper area are stable until about 3:00 pm on 12/21/89 and increase until about 3:00 am on 12/22/89. Water levels of upper Taft Creek and Well #19 do not indicate change during the study period. In Figure 3, water levels of lower Taft Creek are stable until 11:00 am on 12/21/89 and then increase rapidly until about 9:00 pm the same day. After 9:00 pm lower Taft Creek levels increase slowly and seem to stabilize at about 2:00 pm on 12/22/89. Water levels of Wells #6, #11, and #17 are also stable until about 1:00 pm on 12/21/89 and increase less rapidly until about 2:00 am on 12/22/89.

OLYM – TAFT CR. GROUNDWATER STUDY

FIGURE 2. **WATER LEVELS AT UPPER AREA**



OLYM — TAFT CR. GROUNDWATER STUDY

FIGURE 3. **WATER LEVELS LOWER AREA**

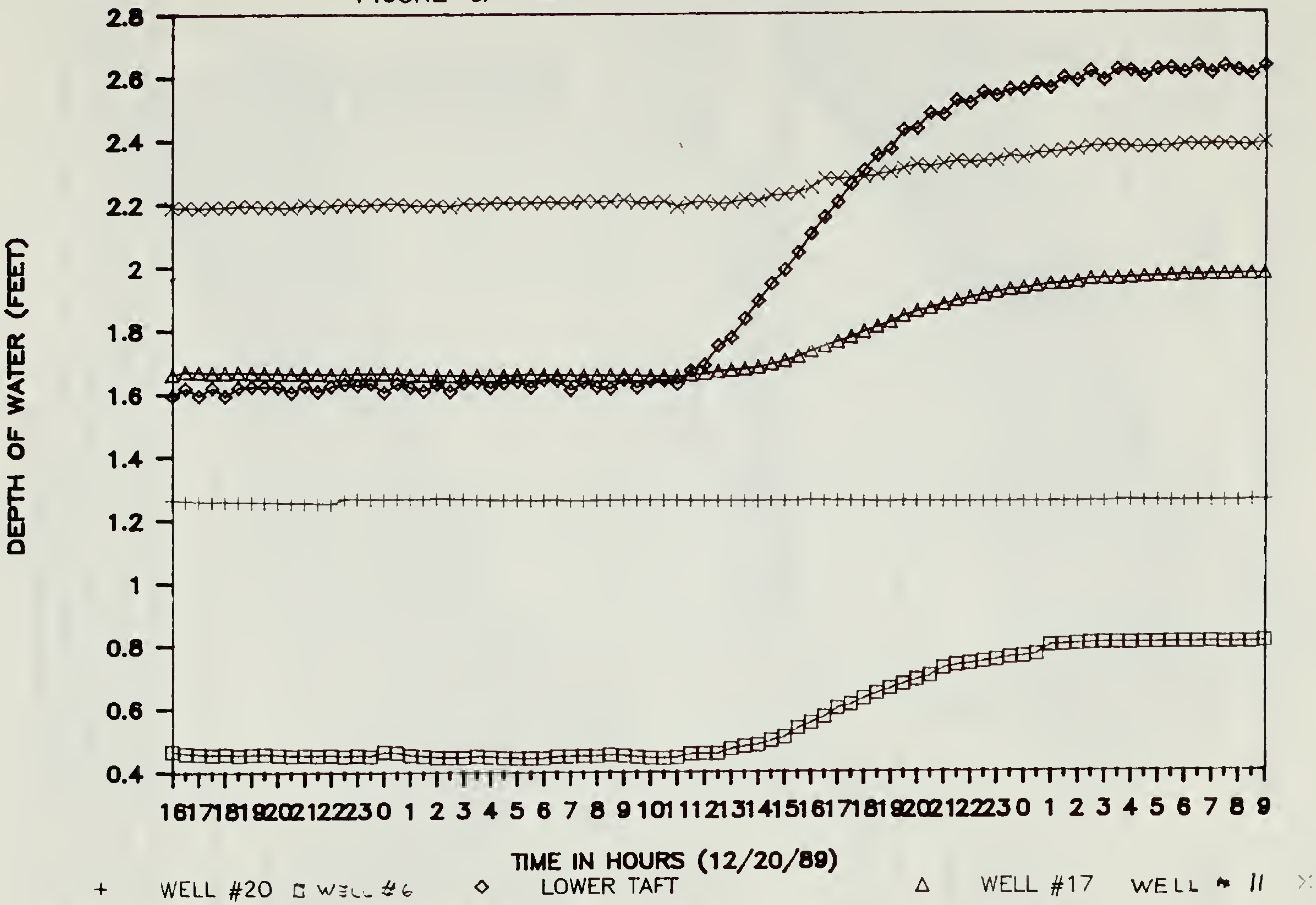


Table 2 presents direct water level measurements taken from four other wells and the pond level approximately three meters upstream from the culvert. Table 3 ranks the stations from the greatest to least according to the amount of water level change caused by blocking the culvert. Table 3 also includes ground surface elevation for these stations.

TABLE NO. 2 - DIRECT OBSERVATIONS OF SELECT STATIONS

Station I.D.	12/21/89 10:00 am	12/21/89 4:15 pm	12/21/89 6:00 pm	12/22/89 8:30 am
Well #2	.362	.429	.481	ND
Well #3	.329	.396	.442	ND
Well #4	.372	.402	.426	ND
Well #5	.521	.539	.551	ND
Culvert	.500	1.020	1.070	1.200

ND - No Data

TABLE NO. 3 - QUANTIFICATION OF WATER LEVEL CHANGES 22 HOURS AFTER BLOCKING CULVERT

Station I.D.	Change in Water Level	Elevation of SWL or LSD
Culvert	.70	173.62
Well #2	.39	174.72
Well #3	.37	174.96
Well #6	.34	175.13
Well #17	.31	175.36
Well #11	.20	175.59
Well #4	.18	174.85
Well #10	.17	176.04
Well #5	.10	175.03
Well #9	.06	176.01
Well #1	.00	174.33

Figure 4 displays a three dimensional shape of the groundwater table before and after increasing the level of the pond. The largest amount of change is seen in the northwest region of the study area, however some changes in water levels occurred in most regions excepting the south central region. The amount of change in water levels is show in the three dimensional shape in Figure 5.

ANALYSIS

Data collected during this investigation indicates quick response of water levels in most wells to changes in pond levels. The effect of blocking the culvert was observed as early as one hour in increased water levels in wells within the grove. In general, this

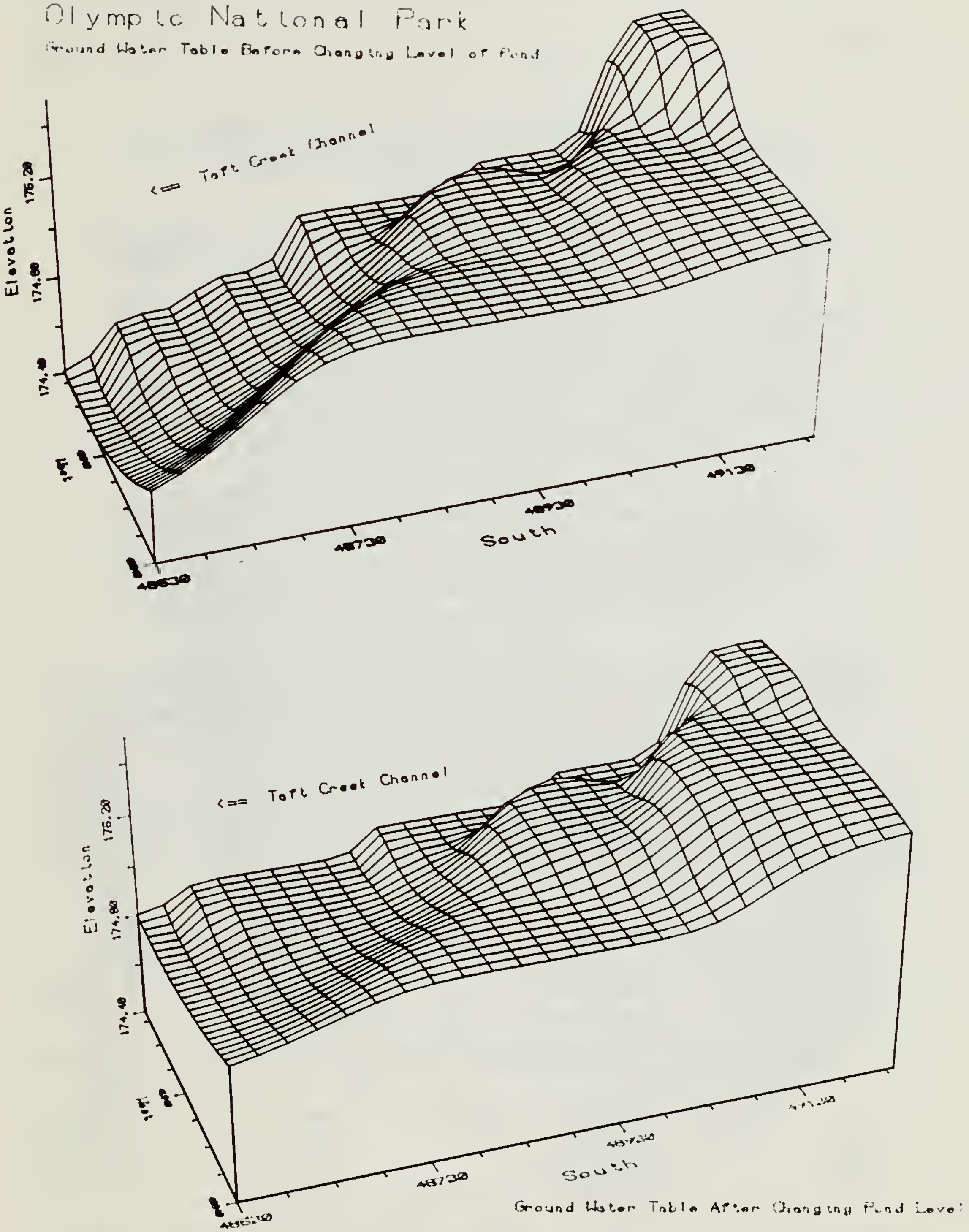


FIGURE 4. THREE DIMENSIONAL PLOT DEPICTING THE GROUND WATER TABLE BEFORE AND AFTER CHANGING THE POND LEVEL

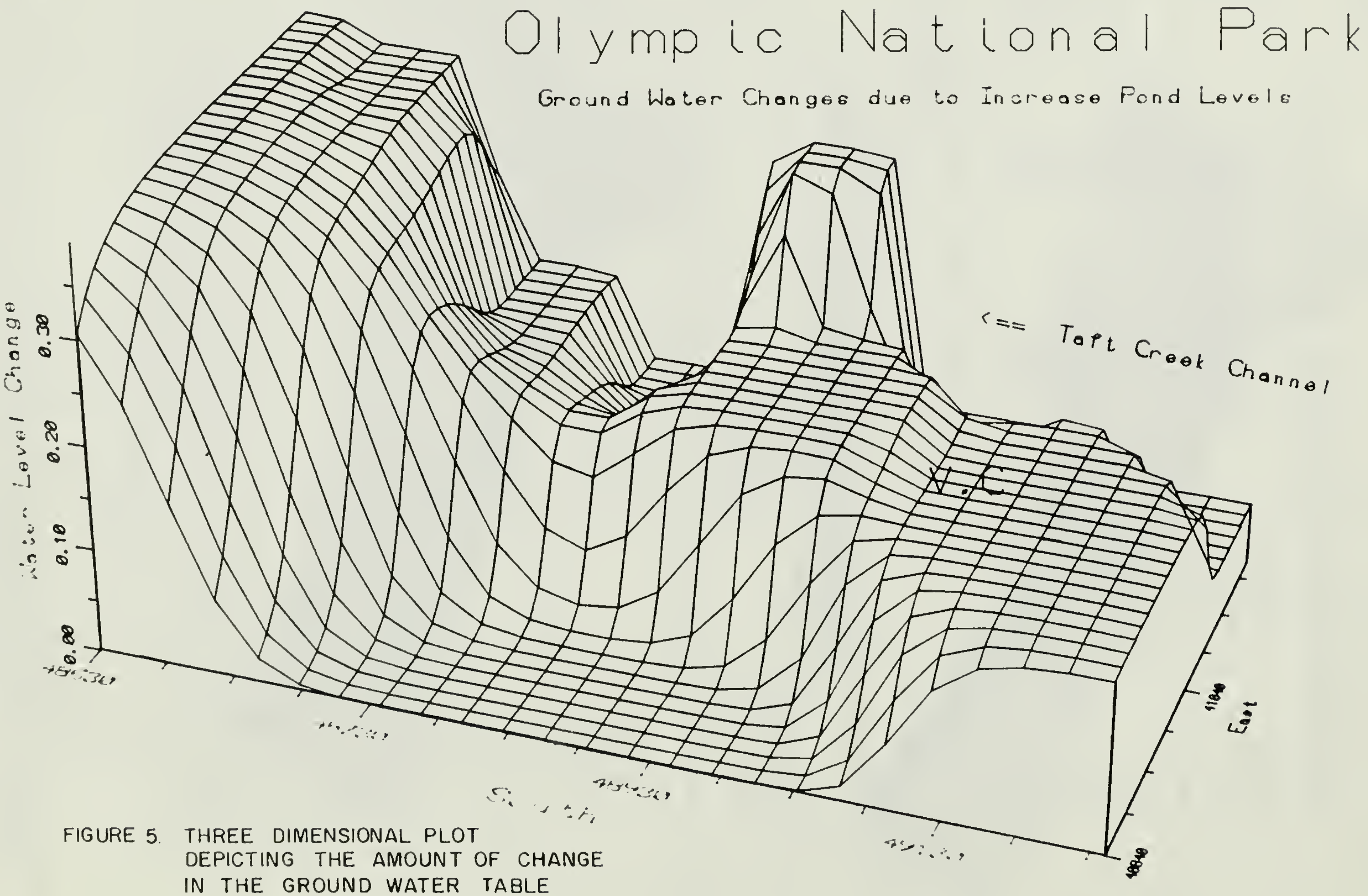


FIGURE 5. THREE DIMENSIONAL PLOT DEPICTING THE AMOUNT OF CHANGE IN THE GROUND WATER TABLE

study shows that increasing the water levels of the impoundment at the culvert by 0.70m to an elevation of 174.32m affected groundwater levels to a distance of 550m upstream (Well #9) and a up to an elevation of approximately 175.0m (574.5 ft) in the area of the subject grove (see Plate No. 1).

Several hydraulic principals affect water levels under ponded conditions are discussed below:

1) The relationship between pond water levels and discharge is controlled by the geometry of both the pond and the outlet culvert. Whenever discharge is less than inflow, pond water levels will increase.

2) Observations of the Taft Creek channel near the culvert reveal that upstream channel widths are about three times greater than the culvert width and twice the culvert width downstream. By assuming similar slope and roughness, the narrowness of the culvert compared to the natural channel means that increased flow depths over those which exist in the natural channel are required to convey the same amount of water. Therefore, the culvert functions as a partial barrier to higher flows, causing water levels at the culvert to be higher than those which would otherwise occur. These water level increases, in turn, are translated upstream in Taft Creek.

3) The minimum water level of the pond is determined, not by the capacity of the outflow, but by the elevation of the upstream invert (bottom lip) of the culvert. However, the range of fluctuation of pond water levels is determined by the flow capacity of the culvert (as related to diameter, shape, culvert slope, roughness and inlet and outlet conditions) and not by the elevation of the invert of the culvert.

Discharge though the culvert can be related to inlet stage (Bodhaine, 1968), that is, a stage-discharge rating curve or table can be developed by use of the appropriate equation determined by physical characteristics of the channel and culvert. At Taft Creek, a Type 2 flow equation is appropriate for the range of flows encountered (Bodhaine, 1968). The culvert is a 6-foot corrugated metal pipe, 64 feet long and has non-submerged outflow conditions with critical depth at the outlet. Flow calculations for four stages were determined (Table 4). The selected stages were the minimum and the maximum measured since November 1987, the artificial test water level achieved during the present investigation (Test Q), and the flow of Taft Creek during the study (Study Q).

TABLE NO. 4 - CALCULATED DISCHARGES OF TAFT CREEK AT CULVERT

Stage	Water Level (meters)	Discharge (cu. m/sec.)	Discharge (cfs)
Minimum	0.380	0.398	13
Maximum	0.820	1.386	49
Test Q	1.20	2.829	100
Study Q	0.50	1.018	36

Cummans and others (1975) used peak-discharge data to develop flood-frequency equations for 12 regions in Washington. Data of two Hoh River gaging stations were included in their analysis. The drainage area of Taft Creek lies entirely within the area they defined as Region II. These equations were used for estimating flood discharges for Taft Creek. For a one square mile watershed with mean annual precipitation of 180 inches, the recurrence intervals of 10, 50 and 100 years, peak discharges calculate to 470, 680, and 790 cfs respectively. These calculated values are presented as rough estimates only because the Taft Creek characteristics deviate from these studies by Cummans in that: 1) Taft Creek watershed is small compared to those used to develop the equations, 2) the area of the Taft Creek watershed is estimated and not measured, 3) Taft Creek flows are predominantly spring fed, and 4) Kresch (1987) reported that in 1980 high water in the Hoh River over topped its banks and flowed into the Taft Creek watershed.

CONCLUSIONS

Groundwater levels under the grove of trees is controlled, in part, by the pond stage which in turn is controlled by the culvert. Any seepage from Taft Creek into deeper aquifers, lateral movement into adjacent hillsides or under the road embankment is assumed to occur at a steady rate for the purpose of this study. The modification of groundwater levels under the trees during flooding conditions and to a lesser degree for low flows, can be accomplished by altering the size and elevation of the culvert. What, if any affect such ground water modification will have upon the trees is unknown. It has not been determined whether the trees will respond to less water-related stress.

With respect to the fishery resource, the impounded area is also controlled by the culvert. A map of bottom contours and inundated area above the culvert (see Plate No. 2) describes habitat for juvenile stages in the life cycle of the Coho salmon of the Hoh River system (John Aho, personal communication).

The pond and Taft Creek appear to be rare aquatic features in the upper Hoh River basin and therefore may be critical for managing the fishery resource. Because Taft Creek 1) is located on a large meander in the valley bottom, 2) originates from numerous clear-water springs, and 3) possesses a low gradient compared to other tributary streams flowing off the steep valley side slopes and/or across alluvial fans, it provides fish habitat not commonly found in the Hoh River basin.

Study results indicate that groundwater levels under the trees respond almost immediately to changes in pond water levels, thus, signifying a cause and effect relationship between the two. A pivotal concluding responsibility is to establish that differences exist in water table depths between stressed and unstressed Sitka Spruce groves in similar physiographic settings. This study remains to be done.

ALTERNATIVES

This section briefly presents five alternatives for managing the pond at the Hoh River Visitor Center. Alternative No. 5, which involves lowering the pond and enhance habitat is the recommended approach.

> 1) **Continue with present monitoring and establish new program at new, similar site**: This alternative involves continued monitoring of groundwater levels and growth vigor of trees in the subject grove. In addition, a new monitoring program initiated at a healthy grove in a similar physiologic setting and determining water table depths in the healthy grove. Differences in groundwater levels between the two study

areas may indicate a higher water level at the subject grove, thus providing indirect evidence that shallow groundwater is the source of stress for Sitka Spruce. No action would be taken until one year of monitoring both sites. Risk of mortality of weakened trees at the Hoh Visitor Center would continue. (No change in present action except that a healthy "control" grove would be added to the groundwater monitoring program).

2) **Lower pond water levels**: Action would be taken to install at a lower elevation a larger capacity culvert to lower pond water levels during low flow and to reduce the size and stage of the pond formed during floods. The response of both tree and fishery resources to this action would have to be monitored. Elevated groundwater and the hypothesized water related stress to the subject grove would be eliminated, but fishery habitat is expected to suffer.

3) **Stabilize pond water levels**: Install a new, large culvert near the existing culvert but at a slightly higher elevation to maintain the present pond size under low flow conditions but to allow lower pond elevations during flooding events. Flood water would be conveyed by both the old and new culverts; reducing back water conditions. High pond levels and related high ground water levels in the subject grove associated with high stream flows would be reduced but the pond water level would remain as during the non-rainy season. The effect of this action on tree condition is unknown.

4) **Manipulate pond water levels**: Replace existing culvert with large box culvert with adjustable gates designed for fish passage to allow control of pond levels. This would allow alteration of the pond size, permitting periods when the pond would be reduced, and creation of a pond at selected times to provide for fishery habitat. This option includes the advantage of alternative 3 in that the size and stage of the pond would be reduced from the present condition during flooding. The affects of the added measure of pond reduction, and thus perhaps a reduction in ground water elevations under the trees, is unknown.

5) **Lower pond and enhance fish habitat**: Install a new culvert below grade and enhance fish habitat within the present pond area with a few deep holes and some root wads for cover. This alternative would lower water tables in the subject grove, but would provide mitigation for lost fishery habitat resulting from reducing the existing pond. The effect upon the trees is unknown.

Before action is taken, consultation with the U.S. Fish and Wildlife Service will be needed to determine impacts on wetlands. Other compliance procedures may be required including Section 404 (Clean Water Act) by applying for a dredge and fill permit from the U.S. Army Corps of Engineers. The NPS Floodplain Management and Wetland Protection Guidelines provide additional information on procedures which may be required.

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APPENDIX

LOCATION: OLYM-HOH-A
OPERATOR: R.INGLIS
REPORT: 1

SCAN INTERVAL: 30 MINUTES
REPORT INTERVAL: 30 MINUTES
START WHEN?:
STOP WHEN?:

	WELL #6 FEET INST	WELL #20 FEET INST	LOWER TAFT-CR FEET INST	WELL #17 FEET INST	WELL #11 FEET INST
12/20 16:00	0.466	1.265	1.593	1.664	2.190
12/20 16:30	0.459	1.262	1.617	1.672	2.192
12/20 17:00	0.456	1.259	1.593	1.670	2.188
12/20 17:30	0.454	1.259	1.619	1.668	2.192
12/20 18:00	0.456	1.259	1.592	1.667	2.190
12/20 18:30	0.453	1.258	1.619	1.669	2.194
12/20 19:00	0.455	1.257	1.621	1.668	2.194
12/20 19:30	0.457	1.256	1.621	1.666	2.191
12/20 20:00	0.454	1.255	1.620	1.665	2.191
12/20 20:30	0.451	1.253	1.603	1.664	2.188
12/20 21:00	0.453	1.253	1.623	1.665	2.198
12/20 21:30	0.451	1.252	1.606	1.663	2.190
12/20 22:00	0.452	1.251	1.622	1.662	2.195
12/20 22:30	0.450	1.267	1.628	1.662	2.200
12/20 23:00	0.452	1.267	1.624	1.665	2.194
12/20 23:30	0.450	1.266	1.629	1.664	2.197
12/21 00:00	0.463	1.265	1.602	1.663	2.200
12/21 00:30	0.461	1.266	1.630	1.663	2.200
12/21 01:00	0.452	1.265	1.618	1.660	2.194
12/21 01:30	0.450	1.266	1.605	1.659	2.193
12/21 02:00	0.446	1.268	1.628	1.658	2.196
12/21 02:30	0.446	1.266	1.604	1.657	2.191
12/21 03:00	0.446	1.265	1.631	1.657	2.200
12/21 03:30	0.450	1.264	1.635	1.657	2.199
12/21 04:00	0.447	1.262	1.616	1.657	2.202
12/21 04:30	0.444	1.262	1.631	1.656	2.202
12/21 05:00	0.443	1.261	1.635	1.659	2.202
12/21 05:30	0.443	1.260	1.616	1.659	2.202
12/21 06:00	0.443	1.261	1.640	1.659	2.204
12/21 06:30	0.448	1.261	1.638	1.658	2.201
12/21 07:00	0.448	1.259	1.608	1.658	2.202
12/21 07:30	0.450	1.259	1.632	1.657	2.208
12/21 08:00	0.448	1.261	1.616	1.657	2.204
12/21 08:30	0.454	1.260	1.612	1.656	2.204
12/21 09:00	0.450	1.262	1.640	1.658	2.210
12/21 09:30	0.446	1.261	1.615	1.656	2.200
12/21 10:00	0.443	1.261	1.637	1.654	2.201
12/21 10:30	0.442	1.260	1.638	1.654	2.205
12/21 11:00	0.445	1.260	1.625	1.652	2.188
12/21 11:30	0.455	1.259	1.668	1.657	2.200
12/21 12:00	0.456	1.257	1.685	1.661	2.206
12/21 12:30	0.456	1.258	1.745	1.667	2.195
12/21 13:00	0.471	1.257	1.771	1.671	2.202
12/21 13:30	0.479	1.257	1.832	1.676	2.211
12/21 14:00	0.484	1.256	1.887	1.681	2.206

LOCATION: OLYM-HOH-A
OPERATOR: R.INGLIS
REPORT: 1

SCAN INTERVAL: 30 MINUTES
REPORT INTERVAL: 30 MINUTES
START WHEN?:
STOP WHEN?:

	WELL #6 FEET INST	WELL #20 FEET INST	LOWER TAFT-CR FEET INST	WELL #17 FEET INST	WELL #11 FEET INST
12/21 14:30	0.497	1.259	1.941	1.690	2.223
12/21 15:00	0.508	1.258	1.985	1.701	2.226
12/21 15:30	0.536	1.259	2.040	1.715	2.232
12/21 16:00	0.552	1.260	2.099	1.732	2.249
12/21 16:30	0.571	1.259	2.151	1.747	2.276
12/21 17:00	0.599	1.258	2.199	1.761	2.273
12/21 17:30	0.611	1.257	2.255	1.775	2.278
12/21 18:00	0.629	1.256	2.299	1.791	2.280
12/21 18:30	0.645	1.255	2.347	1.807	2.287
12/21 19:00	0.660	1.254	2.366	1.823	2.294
12/21 19:30	0.675	1.256	2.426	1.841	2.306
12/21 20:00	0.689	1.255	2.431	1.856	2.319
12/21 20:30	0.701	1.255	2.479	1.865	2.310
12/21 21:00	0.725	1.254	2.474	1.878	2.321
12/21 21:30	0.735	1.254	2.520	1.890	2.331
12/21 22:00	0.739	1.253	2.510	1.897	2.325
12/21 22:30	0.745	1.253	2.545	1.907	2.330
12/21 23:00	0.750	1.254	2.535	1.915	2.332
12/21 23:30	0.759	1.255	2.555	1.923	2.346
12/22 00:00	0.761	1.254	2.554	1.928	2.339
12/22 00:30	0.768	1.254	2.571	1.935	2.354
12/22 01:00	0.796	1.253	2.558	1.941	2.356
12/22 01:30	0.798	1.253	2.591	1.943	2.362
12/22 02:00	0.800	1.254	2.581	1.948	2.366
12/22 02:30	0.803	1.255	2.611	1.957	2.374
12/22 03:00	0.804	1.254	2.583	1.958	2.376
12/22 03:30	0.804	1.258	2.616	1.959	2.376
12/22 04:00	0.803	1.257	2.613	1.962	2.372
12/22 04:30	0.805	1.256	2.595	1.964	2.371
12/22 05:00	0.805	1.256	2.616	1.965	2.372
12/22 05:30	0.806	1.255	2.620	1.967	2.374
12/22 06:00	0.806	1.255	2.606	1.970	2.382
12/22 06:30	0.806	1.256	2.627	1.970	2.380
12/22 07:00	0.807	1.255	2.605	1.971	2.381
12/22 07:30	0.804	1.255	2.626	1.971	2.382
12/22 08:00	0.806	1.255	2.613	1.972	2.379
12/22 08:30	0.804	1.257	2.601	1.972	2.378
12/22 09:00	0.809	1.258	2.628	1.974	2.387

LOCATION: OLYM-HOH-B
OPERATOR: R.INGLIS
REPORT: 1

SCAN INTERVAL: 30 MINUTES
REPORT INTERVAL: 30 MINUTES
START WHEN?:
STOP WHEN?:

	WELL #9 FEET INST	UPPER TAFT-CR FEET INST	WELL #10 FEET INST	WELL #19 FEET INST	RAIN GAGE INCHES SUM
12/20 15:00	0.926	1.419	0.894	1.406	0.00
12/20 15:30	0.926	1.421	0.901	1.408	0.00
12/20 16:00	0.925	1.420	0.920	1.409	0.00
12/20 16:30	0.926	1.423	0.917	1.410	0.00
12/20 17:00	0.928	1.439	0.914	1.435	0.00
12/20 17:30	0.926	1.437	0.923	1.437	0.00
12/20 18:00	0.926	1.433	0.918	1.436	0.00
12/20 18:30	0.927	1.435	0.913	1.436	0.00
12/20 19:00	0.926	1.432	0.920	1.436	0.00
12/20 19:30	0.927	1.433	0.913	1.437	0.00
12/20 20:00	0.927	1.432	0.912	1.436	0.00
12/20 20:30	0.926	1.433	0.910	1.436	0.00
12/20 21:00	0.925	1.429	0.915	1.436	0.00
12/20 21:30	0.925	1.429	0.907	1.436	0.00
12/20 22:00	0.924	1.428	0.912	1.436	0.00
12/20 22:30	0.924	1.429	0.918	1.436	0.00
12/20 23:00	0.924	1.427	0.910	1.435	0.00
12/20 23:30	0.924	1.426	0.910	1.435	0.00
12/21 00:00	0.923	1.425	0.909	1.435	0.00
12/21 00:30	0.925	1.427	0.919	1.435	0.00
12/21 01:00	0.923	1.424	0.902	1.434	0.00
12/21 01:30	0.922	1.422	0.898	1.434	0.00
12/21 02:00	0.922	1.422	0.907	1.433	0.00
12/21 02:30	0.922	1.422	0.901	1.434	0.00
12/21 03:00	0.922	1.422	0.906	1.433	0.00
12/21 03:30	0.920	1.420	0.904	1.432	0.00
12/21 04:00	0.921	1.421	0.904	1.432	0.00
12/21 04:30	0.922	1.421	0.901	1.432	0.00
12/21 05:00	0.921	1.419	0.907	1.432	0.00
12/21 05:30	0.921	1.420	0.904	1.431	0.00
12/21 06:00	0.922	1.419	0.906	1.431	0.00
12/21 06:30	0.923	1.434	0.906	1.432	0.00
12/21 07:00	0.922	1.430	0.902	1.432	0.00
12/21 07:30	0.921	1.423	0.909	1.432	0.00
12/21 08:00	0.920	1.420	0.906	1.431	0.00
12/21 08:30	0.919	1.419	0.907	1.431	0.00
12/21 09:00	0.917	1.420	0.907	1.430	0.00
12/21 09:30	0.916	1.421	0.899	1.430	0.00
12/21 10:00	0.915	1.415	0.894	1.430	0.00
12/21 10:30	0.916	1.413	0.896	1.429	0.00
12/21 11:00	0.915	1.413	0.868	1.428	0.00
12/21 11:30	0.917	1.414	0.900	1.429	0.00
12/21 12:00	0.916	1.414	0.903	1.429	0.00
12/21 12:30	0.917	1.415	0.876	1.428	0.00
12/21 13:00	0.918	1.419	0.894	1.428	0.00

LOCATION: OLYM-HOH-B
OPERATOR: R.INGLIS
REPORT: 1

SCAN INTERVAL: 30 MINUTES
REPORT INTERVAL: 30 MINUTES
START WHEN?:
STOP WHEN?:

	WELL #9 FEET INST	UPPER TAFT-CR FEET INST	WELL #10 FEET INST	WELL #19 FEET INST	RAIN GAGE INCHES SUM
12/21 13:30	0.919	1.415	0.903	1.428	0.00
12/21 14:00	0.922	1.417	0.890	1.427	0.00
12/21 14:30	0.923	1.426	0.906	1.427	0.00
12/21 15:00	0.924	1.422	0.904	1.426	0.00
12/21 15:30	0.927	1.423	0.907	1.426	0.00
12/21 16:00	0.929	1.422	0.935	1.426	0.00
12/21 16:30	0.929	1.423	0.943	1.425	0.00
12/21 17:00	0.932	1.419	0.932	1.424	0.00
12/21 17:30	0.934	1.419	0.940	1.423	0.00
12/21 18:00	0.937	1.420	0.945	1.423	0.00
12/21 18:30	0.943	1.420	0.953	1.422	0.00
12/21 19:00	0.948	1.419	0.965	1.422	0.00
12/21 19:30	0.951	1.419	0.973	1.421	0.00
12/21 20:00	0.956	1.420	1.002	1.422	0.00
12/21 20:30	0.958	1.422	0.981	1.420	0.00
12/21 21:00	0.961	1.424	1.004	1.421	0.00
12/21 21:30	0.964	1.426	1.028	1.420	0.00
12/21 22:00	0.964	1.421	1.019	1.419	0.00
12/21 22:30	0.967	1.424	1.004	1.418	0.00
12/21 23:00	0.972	1.419	1.012	1.418	0.00
12/21 23:30	0.973	1.422	1.030	1.418	0.00
12/22 00:00	0.977	1.421	1.032	1.418	0.00
12/22 00:30	0.977	1.422	1.040	1.417	0.00
12/22 01:00	0.979	1.422	1.069	1.417	0.00
12/22 01:30	0.982	1.422	1.055	1.416	0.00
12/22 02:00	0.983	1.421	1.057	1.416	0.00
12/22 02:30	0.985	1.422	1.073	1.415	0.00
12/22 03:00	0.983	1.429	1.065	1.415	0.00
12/22 03:30	0.987	1.429	1.058	1.414	0.00
12/22 04:00	0.987	1.426	1.065	1.413	0.00
12/22 04:30	0.990	1.422	1.064	1.414	0.00
12/22 05:00	0.991	1.426	1.054	1.412	0.00
12/22 05:30	0.991	1.426	1.070	1.412	0.00
12/22 06:00	0.989	1.424	1.075	1.413	0.00
12/22 06:30	0.988	1.423	1.081	1.411	0.00
12/22 07:00	0.985	1.421	1.075	1.412	0.00
12/22 07:30	0.986	1.423	1.078	1.411	0.00
12/22 08:00	0.988	1.421	1.076	1.411	0.00
12/22 08:30	0.988	1.417	1.067	1.411	0.00

[PLATES 1 AND 2 IN BACK POCKET]

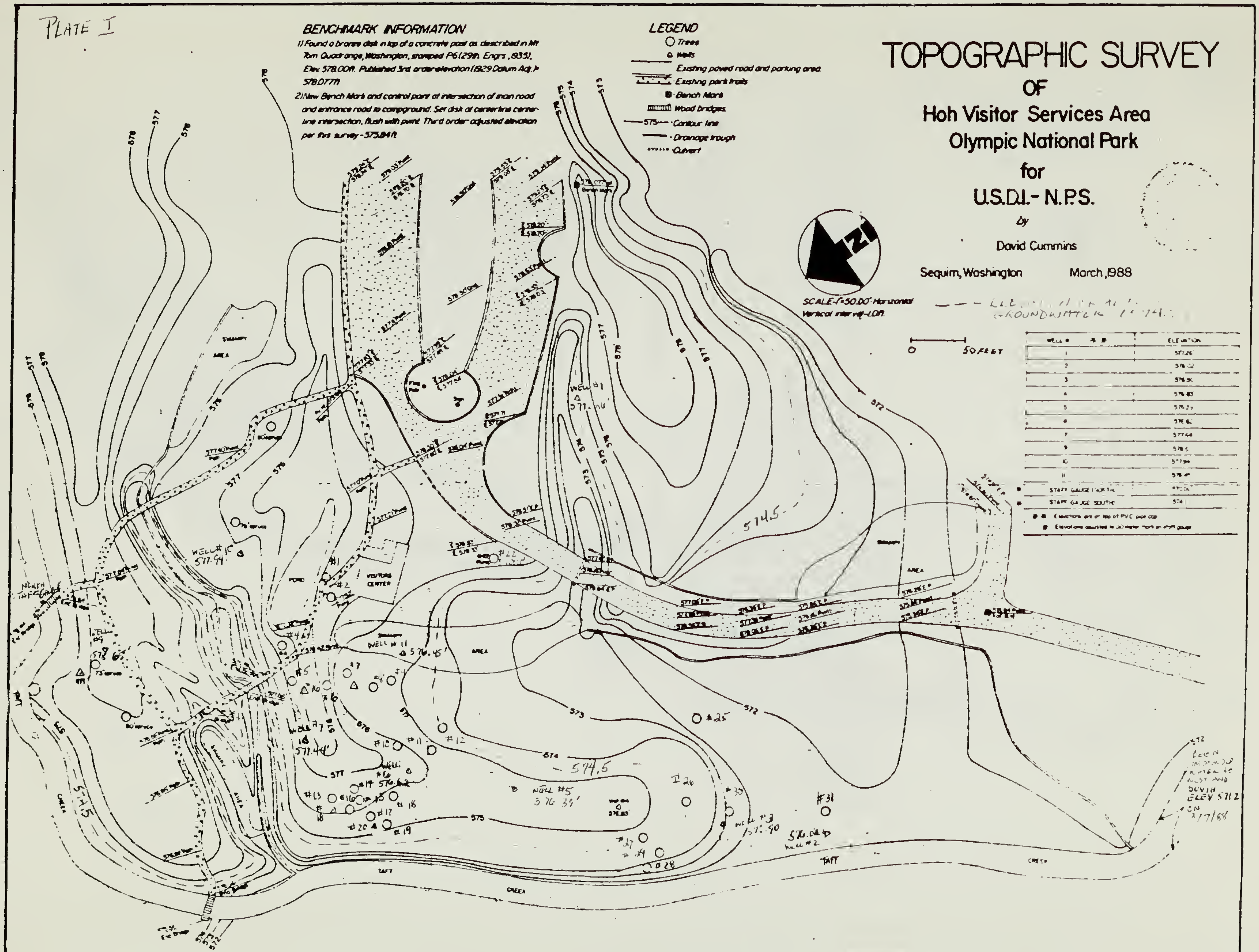
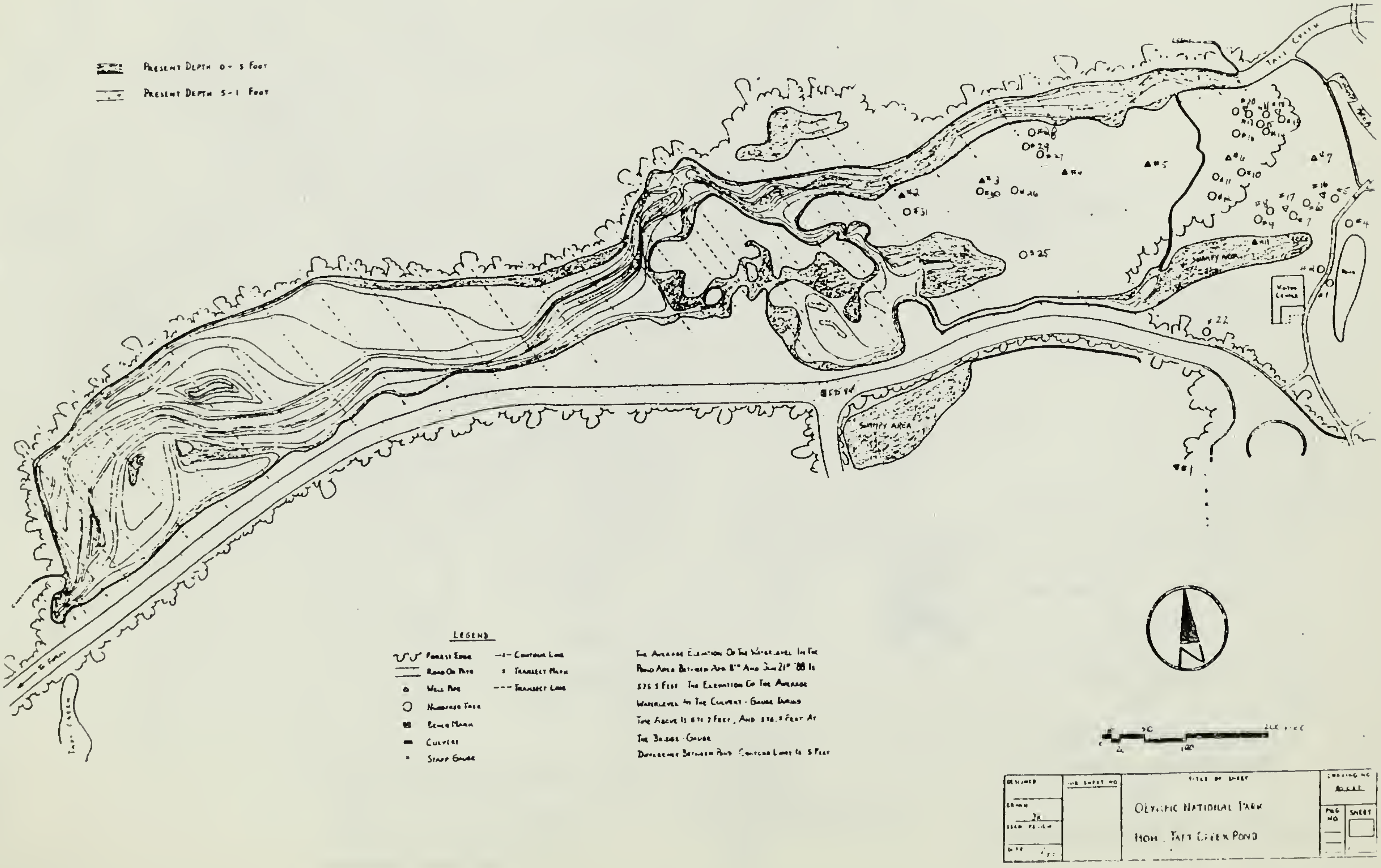


PLATE I
TOPOGRAPHIC SURVEY
OF
Hoh Visitor Services Area
Olympic National Park
for
U.S.D.I.- N.P.S.
by
David Cummins
Sequim, Washington
March, 1988
SCALE-1"=50.00' Horizontal
Vertical interval-1.0ft.
0
50 FEET
BENCHMARK INFORMATION
1) Found a bronze disk in top of a concrete post as described in Mt Tom Quadrangle, Washington, stamped P6 (29th Engrs, 1935). Elev 578.00ft. Published 3rd order elevation (1929 Datum Adj.) = 578.077ft
2) New Bench Mark and control point at intersection of main road and entrance road to campground. Set disk at centerline center-line intersection, flush with pavmt. Third order adjusted elevation per this survey - 575.84ft
LEGEND
Trees
Wells
Existing paved road and parking area
Existing park trails
Bench Mark
Wood bridges
575 Contour line
Drainage trough
Culvert
VISITORS CENTER
POND
SWAMPY AREA
TAFT CREEK
NORTH TAFT CREEK

PLATE II



PRESENT DEPTH 0 - .5 FOOT
PRESENT DEPTH .5 - 1 FOOT
TAFT CREEK
SWAMPY AREA
VISITOR CENTER
LEGEND
FOREST EDGE
ROAD OR PATH
WELL PIPE
NUMBERED TREE
BENCH MARK
CULVERT
STAFF GAUGE
CONTOUR LINE
TRANSECT MARK
TRANSECT LINE
THE AVERAGE ELEVATION OF THE WATERLEVEL IN THE
POND AREA BETWEEN APR 8TH AND JUN 21ST '88 IS
575.5 FEET. THE ELEVATION OF THE AVERAGE
WATERLEVEL AT THE CULVERT - GAUGE DURING
THE BRIDGE - GAUGE
DIFFERENCE BETWEEN POND CONTOUR LINES IS .5 FEET
OLYMPIC NATIONAL PARK
HOH . TAFT CREEK POND

The National Park Service Water Resources Division is responsible for providing water resources management policy and guidelines, planning, technical assistance, applied research, training and operational support to units of the National Park Service. Program areas include water rights, water resources planning, regulatory guidance and review, hydrology, water quality, watershed management, watershed studies and aquatic ecology.

Copies of this report are available from the following:

Computer Assistant (303) 221-8330
National Park Service
Water Resources Division
301 S. Howes Street
Fort Collins, CO 80521

Technical Information Center (303) 969-2130
Denver Service Center
P.O. Box 25287
Denver, CO 80225-0287

As the nation's principal conservation agency, the Department of the Interior has the responsibility for most of our nationally owned public lands and natural and cultural resources. This includes fostering wise use of our land and water resources, protecting our fish and wildlife, preserving the environmental and cultural values of our national parks and historical places, and providing for enjoyment of life through outdoor recreation. The department assesses our energy and mineral resources and works to ensure that their development is in the best interests of all our people. The department also promotes the goals of the Take Pride in America campaign by encouraging stewardship and citizen responsibility for the public lands and promoting citizen participation in their care. The department also has a major responsibility for American Indian reservation communities and for people who live in island territories under U.S. administration.

The mission of the Water Resources Division is to preserve and protect National Park Service water resources and water dependent environments. This mission is accomplished through a watershed management program based on needs at the park, Region, and National levels.

NPS D-184 October 1990