**Eklutna 206 Groundwater Quality Study**

**U.S. Army Corps of Engineers**

**Environmental Resources Section**

In October 2006, the Corps installed five groundwater monitoring wells in areas thought to be promising for the construction of overwintering ponds adjacent to Reach 2. The wells were intended to provide information on the behavior of the groundwater that would be depended upon to fill and recharge any future engineered ponds, especially during the winter months. Of particular interest were:

* the degree of seasonal fluctuation of the groundwater levels;
* the degree of tidal influence, if any, on groundwater levels;
* the degree of saltwater intrusion, if any, in the groundwater;
* the concentration and seasonal fluctuation of dissolved oxygen in the groundwater.

Water-level data-loggers (In-Situ, Inc., Level TROLL® 500) were installed in MW-1 and MW-4 (Figure B-1), to provide a continuous record of groundwater levels, and the remaining three wells were designated for monthly water quality measurements.

The winter groundwater study was limited by the fact that groundwater within all the wells had frozen by 22 November 2006. This unexpected event was at first attributed to an unusual, prolonged period of very cold weather in early November 2006, combined with minimal snow cover and high groundwater levels caused by an unusually rainy autumn. However, in 2007 the wells also began to freeze by early December, despite relatively mild temperatures, suggesting that the freezing of shallow groundwater may be a typical phenomenon in the area. Soils and Geology (CEPOA-EN-ES-SG) personnel thawed several wells in late 2006 using forced hot air, and attempted to insulate the thawed wells and the surrounding ground surface with fiberglass batting and foam board. However, the thawed wells soon refroze. The wells were thawed again in April 2007 using circulated warm water. This tactic was successful and the wells remained open, but the wells were probably thawing naturally at that time of year.

**Water Quality Measurements**

Corps Environmental Resources personnel (primarily Chris Floyd) conducted water quality measurements at MW-2, MW-3, and MW-5, during approximately monthly visits spanning April through December 2007. They were assisted by several NVE employees, including Bobby Chilligan, Max Alex, Floyd Hamrick, and NVE Land & Environment Coordinator Heidi Shepherd.

The monitoring wells were sampled using “low flow” purging techniques consistent with U.S. EPA and U.S. Army Corps of Engineers guidelines. A direct-current electric submersible pump (a Proactive® Mini-Typhoon) was set approximately one foot from the bottom of the well screen, and operated at the lowest sustainable flow rate (generally 0.75 to 1.0 liter/min). Polyethylene tubing carried the purge water from the pump to a flow-through cell containing the water quality meter probes, thus creating a closed system in which the purged groundwater was not exposed to air prior to analysis. A YSI® model 556 barometrically-compensating water quality meter was used to measure a wide range of parameters, including dissolved oxygen, conductivity, and temperature. The instrument automatically calculated salinity using conductivity and temperature measurements. Table 1 presents selected data pertinent to salinity and dissolved oxygen.

A chemical field test was used to corroborate and spot-test the readings from the YSI® dissolved oxygen meter, after several months of unexpectedly high dissolved oxygen readings at MW-2. The HACH® test kit (model OX-2P) is a modified Winkler drop-titration method, which provided results that were generally highly comparable to those of the YSI meter. The only exception proved to be in December, when cold ambient temperatures may have affected the performance of the test kit reagents.

On the May and June 2007 sampling dates, a water quality measurement was collected at each well twice each day, in an attempt to detect differences between low and high tides. This strategy was discontinued when preliminary results from the autologgers suggested only a minor tidal influence (less than 6 inches) at MW-4, and no discernable tidal influence at MW-1 (figures 1a and 1b).

**Figure 1a – Water levels within MW-1, as recorded by autologger**



**Figure 1b – Water levels within MW-4, as recorded by autologger**



 **Conclusions**

 **Dissolved Oxygen**

 The minimum concentration range of dissolved oxygen required for the survival of over-wintering juvenile salmon is roughly 3-5 mg/l. The groundwater in the study area contained at least that concentration during the April to December time period in which groundwater samples could be collected. Unfortunately, no sampling was possible during the critical mid-winter period, during which groundwater would be the primary source of oxygen in the proposed over-wintering ponds.

 The measured concentrations of dissolved oxygen in the groundwater differed greatly between the three wells. The concentrations were highest (9.51 – 13.49 mg/l) at MW-2, presumably due to that wells proximity to the oxygen-saturated flow of the Eklutna River. The well next closest to the river, MW-3, had the lowest concentrations of the three (3.77 – 8.21 mg/l). Figure 2 plots the oxygen concentrations by well over the course of the study period. The graph shows, very generally, relatively higher concentrations in the spring and early summer, which begin to trend downward in the autumn.

**Figure 2 – Dissolved oxygen concentrations**



 **Salinity**

 The salinity and conductivity measurements show no indication of saltwater influence in the groundwater, at least in the near-surface portion of the aquifer in which the monitoring wells were screened. On those days where high-tide and low-tide measurements were collected, no significant difference in salinity or conductivity was apparent between the different readings. The salinity measurements range from 0.20 to 0.43 ppt, with the great majority falling around 0.21 ppt (the slightly elevated readings from 15 June may be anomalous). Water begins to be considered brackish at a salinity of around 0.5 ppt, while seawater has an average salinity of 35 ppt. The more precise conductivity measurements range from 230 to 449 µS/cm. By comparison, the conductivity of drinking water typically ranges between 50 and 1,500 µS/cm, whereas the conductivity of seawater is, on average, around 50,000 µS/cm.

**Table 1. Selected Water Quality Measurements from Groundwater Monitoring Wells**

MW-2

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | 30 Apr | 18 Maya.m. | 18 Mayp.m. | 15 Juna.m. | 15 Junp.m. | 31 Jul | 30 Aug | 25 Sep | 26 Oct | 7 Dec |
| GW depth (ft below ground surface)  | 9.66 | 9.50 | 9.46 | 9.46 | 9.44 | 9.33 | 9.52 | 9.85 | 10.02 | 4.28 |
| T (ºC) | 2.39 | 1.99 | 4.01 | 2.81 | 3.12 | 2.70 | 3.16 | 3.75 | 3.37 | 1.79 |
| Diss Oxygen (% sat) | -- | 96.0 | 92.3 | 86.6 | 91.7 | 99.5 | 86.1 | 72.2 | 75.2 | 68.9 |
| Diss Oxygen (mg/l) | 13.28 | 13.41 | 12.07 | 11.96 | 11.95 | 13.49 | 11.51 | 9.51 | 10.00 | 9.56 |
| Diss Oxygen (mg/l)by HACH test kit | -- | -- | -- | -- | -- | -- | 11 | 9 | 9-10 | 7-8 |
| Salinity (ppt) | -- | 0.21 | 0.21 | 0.398 | 0.400 | 0.21 | 0.20 | 0.22 | 0.21 | 0.21 |
| Conductivity (µS/cm) | 249 | 248 | 264 | 230 | 236 | 249 | 248 | 269 | 258 | 449 |

MW-3

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | 30 Apr | 18 Maya.m. | 18 Mayp.m. | 15 Juna.m. | 15 Junp.m. | 31 Jul | 30 Aug | 25 Sep | 26 Oct | 7 Dec |
| GW depth (ft below ground surface) 2.5 | 1.25 | 0.83 | 1.08 | 1.03 | 1.23 | 0.89 | 1.02 | 1.14 | 1.12 | *frozen* |
| T (ºC) | 1.86 | 2.49 | 2.70 | 3.66 | 3.55 | 5.28 | 7.74 | 7.15 | 5.57 | *frozen* |
| Diss Oxygen (% sat) | -- | 58.8 | 51.9 | 48.1 | 48.7 | 65.0 | 53.4 | 37.3 | 42.9 | *frozen* |
| Diss Oxygen (mg/l) | 3.77 | 8.00 | 7.03 | 6.24 | 6.46 | 8.21 | 6.36 | 4.73 | 5.39 | *frozen* |
| Diss Oxygen (mg/l)by HACH test kit | -- | -- | -- | -- | -- | -- | 6-7 | 4-5 | -- | *frozen* |
| Salinity (ppt) | -- | 0.20 | 0.21 | 0.386 | 0.389 | 0.21 | 0.20 | 0.21 | 0.20 | *frozen* |
| Conductivity (µS/cm) | 299 | 244 | 249 | 230 | 230 | 268 | 278 | 291 | 267 | *frozen* |

MW-5

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | 30 Apr | 18 Maya.m. | 18 Mayp.m. | 15 Juna.m. | 15 Junp.m. | 31 Jul | 30 Aug | 25 Sep | 26 Oct | 7 Dec |
| GW depth (ft below ground surface) 2.2 | 1.66 | 1.60 | 0.90 | 1.54 | -- | 1.32 | 1.20 | 1.79 | 1.58 | *frozen* |
| T (ºC) | 3.18 | 2.80 | 2.85 | 5.48 | -- | 6.92 | 6.66 | 7.03 | 4.71 | *frozen* |
| Diss Oxygen (% sat) | -- | 65.3 | 62.6 | 56.5 | -- | 75.8 | 68.0 | 49.5 | 46.0 | *frozen* |
| Diss Oxygen (mg/l) | 8.89 | 8.81 | 8.44 | 7.02 | -- | 9.21 | 8.32 | 6.00 | 5.92 | *frozen* |
| Diss Oxygen (mg/l)by HACH test kit | -- | -- | -- | -- | -- | -- | 8 | -- | -- | *frozen* |
| Salinity (ppt) | -- | 0.22 | 0.21 | 0.428 | -- | 0.22 | 0.21 | 0.22 | 0.21 | *frozen* |
| Conductivity (µS/cm) | 259 | 259 | 279 | 269 | -- | 294 | 281 | 301 | 267 | *frozen* |



**Figure 3 – Monitoring Well Locations**