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August 14, 2000

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Ms. Muldoon and Mr. Rosenlieb:

The purpose of this letter is to provide you with the results of the Level 1 Water-Quality Inventory and Monitoring (WAQIM) Program conducted at San Juan Island National Historical Park, Washington. The primary objective of this program was to inventory and collect water-quality data from freshwater bodies (ground water, ponds, and streams) in San Juan Island National Historical Park and to document these results in a data management system consistent with the National Park Service (NPS) management needs. The following includes a brief description of the study area, a discussion of the sampling plan, protocols used, and resulting data. The U.S. Geological Survey (USGS), Water Resources Division, Tacoma, Washington, was the principal investigator of the WAQIM. Also enclosed is a 3.5" diskette containing the four files, QWDATA.XLS, PARAMETER.DOC, STATIONS.XLS, and README.DOC, documenting the water-quality inventory results in the format requested by the National Park Service.

Description of Study area

San Juan Island National Historical Park is located on San Juan Island in northern Puget Sound, about eighty miles northwest of Seattle, Washington. There are two park units; American Camp, located at the southeastern end of San Juan Island, and English Camp, located at the northwestern end of the island (Fig. 1). The total area of the park is 1,752 acres, or approximately 5 percent of the total area of the island. The park was established to interpret and preserve the historic American and English encampment sites, and to commemorate the events that occurred at these camps from 1859 to 1872 in conjunction with the resolution of an international boundary dispute between the United States and Great Britain.

The freshwater bodies in the park include ground water (accessed through wells and a spring), a perennial pond, intermittent ponds or wetlands, and an intermittent stream. Ground-water wells provide the source of drinking water for American and English Camps. The spring at American Camp is currently not used for domestic purposes, but in the past was the source of drinking water for the American Camp soldiers. The perennial pond and intermittent ponds are the primary sources of freshwater that provide habitat to wildlife populations such as migratory birds and amphibians. The ponds are important parts of the hydrologic system in the park An intermittent stream in English Camp drains several pond and wetland areas and thus integrates the water quality of those surface-water bodies.

Residential developments and agricultural activities bordering both American and English Camps could affect the water quality in the park. The residential developments adjacent to American Camp utilize the same ground-water system as the park. Ground water withdrawals for residential use could potentially lower ground-water levels, resulting in seawater intrusion. Recharge from nearby residential areas that utilize septic systems could further affect the quality of ground water and surface water (ponds) in both American Camp and English Camp with bacteriological or nutrient contamination. Fertilizers used in the residential areas might also be a source of nutrient contamination. The main agricultural activity near the park is grazing of sheep and cattle. The resulting animal waste could cause nutrient or bacteriological contamination of the ground water and ponds.

Sampling Plan

The original WAQIM sampling plan for the park called for collecting water samples from a total of seven sites from spring 1999 to winter 2000. Three ground-water wells were to be sampled, including a drinking water well and a capped well at American Camp and a drinking water well at English Camp. Four surface water sites were to be sampled, including a perennial and intermittent pond at American Camp, and an intermittent pond and intermittent stream at English Camp.

The ground water samples were to be collected in the spring and fall to determine differences in constituent concentrations from high water levels (spring) and low water levels (fall). Water samples were to be collected three times from the ponds and intermittent stream to determine seasonal differences in constituent concentrations. If the water levels in the ponds and streams were high enough in the summer, samples were to be collected in the spring, summer, and fall. If water levels were too low in the summer, samples were to be collected in the winter, instead of summer.

During the first reconnaissance trip to the park, in April 1999, the capped well at American camp and the intermittent ponds at American and English Camps were found to be dry. Based on information from Bill Gleason, an officer with San Juan Island National Historical Park, it was decided to drop these three sites because they would most likely be dry during the majority of the sampling rounds. A new sampling site added to the sampling plan was a spring located in the South Beach area of American Camp.

The revised sampling plan required the collection of water samples from five sites (table 1). Ground-water samples were collected from the drinking-water wells in American and English Camps and from the spring at American Camp. Surface-water samples were collected from the perennial pond at American Camp and from the intermittent stream at English Camp. Samples were collected from all sites possible in spring (May), fall (September), and winter (February). Samples were not collected in summer, due to very low water levels. During the fall, the stream at English Camp was not sampled because it was dry, and during the winter, the English Camp well was not sampled because the pump had been removed from the well.

Field measurements were made at every site for temperature, pH, specific conductance, dissolved oxygen, alkalinity, and fecal-indicator bacteria (total coliform, fecal coliform, and *Escherichia coli* (*E. coli*)). Water samples were collected and sent to the USGS National Water Quality Laboratory to be analyzed for concentrations of nutrients, chloride, major ions, and arsenic. Nutrients included nitrite, nitrite plus nitrate, ammonia, ammonia plus organic nitrogen, orthophosphate, and dissolved phosphorus. Major ions included calcium, magnesium, sodium, potassium, sulfate, fluoride, iron, and manganese. The constituents and frequency of sampling at each site are shown in table 1.

The purpose of this water-quality study was to collect water samples and analyze for constituents that describe the general water chemistry and for constituents that could indicate possible contamination. Temperature, pH, specific conductance, and concentrations of dissolved oxygen, alkalinity and major ions describe the general water chemistry in the park. Elevated bacteria and nutrient concentrations could indicate that residential septic systems, fertilizers, or animal manure have affected the surface- or ground-water quality of the park. Chloride concentrations in ground water can indicate the presence of seawater intrusion. Arsenic has been detected in ground water in other areas of San Juan Island (Vicki Heater, San Juan County Department of Health, oral commun. 1999) and elevated concentrations of arsenic are a health concern.

Table1. Analyzed constituents and frequency of sampling for selected sites in San Juan Island National Historical Park

[F, field measurements; N, nutrients; CL, chloride; MI, major ions including chloride; A, arsenic; --, not sampled]

Site	Spring (May)	Fall (September)	Winter (February)
American Camp			
Drinking-water well	F, N,CL	F,N,MI,A	F,N,MI
Pond	F,N,CL	F,N,MI,A	F, N
South Beach spring	F,N,CL	F,N,MI,A	F,N,MI
English Camp			
Drinking-water well	F,N,CL	F,N,MI,A	--
Intermittent stream	F,N,CL	--	F,N,MI

Sampling Protocols

Samples from wells were collected from a point ahead of filtration and treatment, before entering a holding tank, and as close to the wellhead as possible. In a mobile water-quality laboratory, the samples were collected and prepared using USGS protocols. Sample water flowed from a hose bib through Teflon tubing to a flow-directing stainless-steel manifold that allowed the sample water to flow into either a flow chamber, raw-water line, or filtration unit. Temperature, pH, specific conductance, and dissolved-oxygen concentrations were monitored continuously at the flow chamber. Once the constituent readings stabilized, filtered and unfiltered samples were collected from the appropriate manifold outlet. Stabilization criteria for recording field measurements and collecting samples are outlined in the USGS National Field Manual (U.S. Geological Survey, 1998) and by Koterba and others (1995). Samples for the analysis of bacteria were collected in a sterilized 1-liter bottle.

Water-quality samples from the intermittent stream, pond, and spring were collected as depth-integrated or point (grab) samples, depending on the depth of the water. The water was composited into a 3-liter bottle, cleaned to the specifications of the USGS National Field Manual (U.S. Geological Survey, 1998) and Horowitz and others (1994). The composite sample was taken to a mobile laboratory where pH, specific conductance, and alkalinity were measured. Dissolved oxygen and temperature readings were made on site. Filtered and unfiltered samples were collected from the composite sample. Samples for the analysis of bacteria were collected at the stream, pond, and spring sites in a sterilized 1-liter bottle. Discharge was measured using a 3-inch Parshall flume (U.S. Geological Survey, 1983) at the stream and spring sites during sampling.

Temperature, pH, specific conductance, alkalinity, and dissolved oxygen were measured on site with meters using methods outlined by Horowitz and others (1994), Koterba and others (1995), and U.S. Geological Survey (1998). Samples for bacteria were analyzed for concentrations of total coliform, fecal coliform and *E. coli* using membrane filtration methods described by U.S. Geological Survey (1998). Total coliform bacteria were analyzed using the m-Endo agar media, fecal coliform were analyzed using m-FC agar media, and *E. coli* were analyzed using m-TEC agar media as described by the U.S. Environmental Protection Agency (1985). With the exception of the bacteria analyses, all other constituents (nutrients, chloride, major ions and arsenic) were conducted by the USGS National Water Quality Laboratory in Denver, Colorado. Analytical procedures used at the National Water Quality Laboratory are described by Fishman and Friedman (1989), Fishman (1993), Jones and Garbarino (1998), and Patton and Truitt (1992).

As part of the study's quality-assurance program, pH and specific conductance meters were calibrated daily with known standards, and sampling equipment was cleaned before the collection of each sample. Dissolved-oxygen meters were also calibrated daily using the water-saturated air technique (U.S. Geological Survey, 1998).

In accordance with the project's quality-assurance plan, field blanks and duplicate samples were collected at some sampling sites. Duplicate samples for analysis of nutrients were collected once

every sampling event. One duplicate sample was collected for major ions. Field blank samples of deionized water were analyzed for nutrients for each well and surface-water site for every sampling event. One field blank was collected and analyzed for arsenic.

The results of the quality assurance samples are shown in table 2. The concentrations of most of the field blanks are negligible. However, during the first sampling event in May 1999, there were detections of nutrients (American Camp well, and American camp pond) at or near the concentrations of environmental samples. For subsequent trips, sampling equipment was assured to be properly cleaned, and the resulting field blank concentrations were negligible. The duplicate data were good, ranging from 0 to 7.5 percent as measured by relative percent difference.

Water-Quality Results

The water-quality results are presented in table 3. The overall quality of ground water and surface water in the study area is generally good; however, there are some items to note.

The well at American camp had elevated specific conductance (1280-1440 microsiemens per centimeter (µS/cm)) and chloride concentrations (250-260 miligrams per liter (mg/L)), indicating seawater intrusion. Also the lack of nitrate (nitrite plus nitrate) and the presence of ammonia and organic nitrogen are due to the low dissolved oxygen concentrations. In the absence of oxygen, reduced nitrogen compounds like ammonia are not converted to nitrate, which is an indication of seawater intrusion. The manganese concentrations at this site are high, exceeding the U.S. Environmental Protections Agency's secondary maximum contaminant level of 0.05 mg/L for public water systems. The high manganese concentrations can be attributed to low dissolved oxygen concentrations. Manganese is more soluble when little or no oxygen is present. In contrast the quality of water from the well at English camp is better, water from this well has much lower concentrations of chloride, ammonia, and manganese. Concentrations of bacteria were not found in either well.

Samples from all surface water sites (American Camps' pond and spring, and English Camp stream), had concentrations of bacteria, and *E. coli* was found in samples from water at American camp spring and English camp stream. The presence of *E. coli* in water is direct evidence of fecal contamination from warm-blooded animals and could indicate sewage contamination. One would expect more detections in surface water environments than in a ground water environment because pathways for bacteria to enter the water are shorter and more conductive than those to ground water. Nitrate (nitrite plus nitrate) concentrations in the spring and stream were also elevated. American Camp spring concentrations ranged from 2.4 to 2.8 mg/L. and concentrations at English Camp stream ranged from 0.46 to 1.1 mg/L. High nitrate levels can be an indication of sewage or organic waste pollution. Although English Camp stream and American Camp spring are not used as a drinking-water source or for recreational use, it must be noted that land-use activity might be affecting the quality of the water at these sites.

Arsenic concentrations were not detected at any site with the exception of American Camp well, which had a concentration of 3 micrograms per liter (µg/L). This concentration is below the U.S. Environmental Protection Agency's maximum contaminant level of 50 µg/L; however, the

proposed new standard of 5 µg/L will be in effect January 1, 2001. Arsenic is implicated in causing several types of a cancer, a concern not recognized when the previous standard was set.

In conclusion, this letter summarizes the objectives, sampling plan, and protocols utilized by the USGS in conducting the Level 1 Water-Quality Inventory and Monitoring Program. The resulting water-quality data indicate that the ground and surface water at San Juan Island National Historical Park is of generally good quality, and does not pose a health risk. However, land-use activities might be affecting the quality of water at the park. If questions should arise about the Water-Quality Inventory and Monitoring conducted at San Juan Island National Historical Park, please feel free to contact the principal investigator and author of this report, Raegan Huffman, at (253) 428-3600, ext. 2651 or Sue Kahle, Supervisory Hydrologist, at ext. 2616.

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