DESIGN REPORT

WATER SUPPLY AND STORAGE PROJECT

KONGIGANAK VSW FACILITY

KONGIGANAK, ALASKA

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INTRODUCTION

In May of 1981, QUADRA Engineering was retained by the Village Safe Water (VSW) program, a division of the Alaska Department of Environmental Conservation, to design improvements for the previously constructed public laundry facility in Kongiganak, Alaska. The improvements desired included: 1) selection of a surface water source appropriate for operation of the facility, 2) selection of a preferred routing for a VSW designed raw water transmission line from the selected water source, 3) design of a foundation and structural deck system for a VSW selected 572,000 gallon water storage tank, 4) design of modifications to the existing water treatment system to accomplish treatment of raw water from the selected water source, and 5) design of miscellaneous electrical and mechanical modifications within the existing laundry facility to facilitate ease of operation.

The intent of the proposed project was to mitigate water supply and treatment difficulties which had continually plagued the facility since it was opened for public use in late 1978. The original water supply and treatment design utilized a well, located several hundred feet from the facility. The raw water from this well was high in several objectionable contaminants, notably total dissolved solids, and elaborate, sophisticated treatment was required to produce potable water.

In July of 1977, the barge carrying project construction materials from Anchorage to Kongiganak encountered rough weather in Bristol

Bay, and ultimately sank with the loss of all project materials. At this point further consideration was given to the intended water source and treatment, with the ultimate decision to abandon the well, and instead utilize water from the river fronting the village. The water treatment design was modified to accomplish treatment of the river water, but was never completely successful in actual operation. While excellent quality water could be produced during certain times of the year, high total dissolved solids and/or suspended organic loading rendered the treatment system ineffective at other times of the year.

With the recognition that neither the well nor the river was a long term acceptable water source, VSW secured an appropriation of $480,000 during the 1981 Alaska legislative session. This appropriation was the funding available for the water supply improvement project herein described. Early in the design process, QUADRA Engineering realized that the appropriation secured was insufficient to construct the project within the parameters established by VSW, and VSW was so advised in August of 1981.

With the foundation design complete, and the remainder of the design essentially complete, the majority of required construction materials were purchased in August of 1981 and delivered to Bethel on the last barge of the surface transportation season. Upon arrival in Bethel, project materials were offloaded and reloaded onto a local barge which was chartered from Bethel to Kongiganak. As of this writing all materials are located on the river bank, to be moved to the construction site after complete freezeup, at which time the pile foundation will be drilled in place. QUADRA Engineering has been retained to provide construction management for installation of the pile foundation, erection of the structural deck, and installation of the raw water transmission line. The work which remains thereafter may be managed by QUADRA or internally by VSW, depending on the severity of budget limitations. The decision on future required project management activities has not been made as of this writing.

SITE SOILS AND THERMAL CONDITIONS

The investigations done for the existing VSW Facility and State school show that the area considered for the water storage tank is composed of fine grained delta deposits. These soils are typically peats, organic silts, silts, fine sands, and clayey silts. The VSW Facility, which is the closest to the proposed tank location, has the following soil profile:

0- 4 feet	Peat, 50% visible ice	(pt)
4- 8 feet	Organic silt, 30% visible ice	(ol)
8-12 feet	Silt with some organic, 20% visible ice	(ml)
12-20 feet	Grey green silt with some clay, no visible ice, 40% w/c	(cl-ml)
20 feet	Brown silt with some clay trace organic, no visible ice, 35% w/c	(ml)

Permafrost appears to be continuous in the vicinty of the village. All borings in the area encountered frozen ground at a depth of up to three-feet in late fall. All of the piling installed for the VSW Facility had ABS tubes embedded so that temperature readings could be obtained using thermistor strings. Several readings were taken in 1976 and 1977. This data is shown on the As-Built drawing for the VSW facility, Sheet S-1, a copy of which is included in the Appendix. In May of 1981, additional readings were taken to determine if the existence of the facility had modified the ground temperatures to any significant extent. This data is also included in the Appendix, and is plotted on Figure 1.

Analysis of the data shows that the mean annual soil surface temperature, as indicated by readings below 20-feet, was 29 degrees Fahrenheit in 1976-1977. Readings taken in May of 1981 show an average of 29.7 degrees Fahrenheit.

PRELIMINARY FOUNDATION DESIGN

DESIGN PARAMETERS

Based on an analysis of the data available, the following conditions were established for design:

Soil Profile

Similar to that shown at the VSW Facility. See Site Soils And Thermal Conditions.

Thermal Profile

Assume three foot active layer, temperature decreases from 32 degrees Fahrenheit at three feet, to 30.5 degrees Fahrenheit at 23 feet. See Figure 1.

Design Loads

Tank - 55 feet diameter x 33 feet 3 inches high

Tank Weight - 93,000 lbs.

Storage - 572,000 gallons @ 8.35 lb/gal = 4,776,000 lbs.

Snow Load = 40 PSF

Wind Load = 8 PSF

DESIGN OPTIONS

A timber mat foundation was considered, but rejected, due to the considerable settlement which would occur as the warm tank melted the permafrost. A refrigerated mat foundation was also considered, but rejected also, since it would require some maintenance and would use considerable high cost energy. A pile foundation was selected as being able to provide the stability required, at a cost which appeared to be realistic, given funding limitations.

PRELIMINARY FOUNDATION LAYOUT

The basic pre-layout was dictated primarily by the maximum pile capacity which could be obtained. Equipment which is available in the area could only drill to approximately 28 feet. Using this limit and the design procedure recommended by F.J. Sanger in "Foundations of Structures in Cold Regions", CRREL monograph 111-C4, a maximum pile capacity of 60 kips was used. This design required that a clean sand/water slurry be used to backfill the annular space between the pile and the hole. This lead to a grid of 5 feet by 6 feet for the piles, since the total deck load was 2 KSF. Based on a 56 foot square deck, 119 piles would be required.

A cost estimate of this design was done and it was determined that it could not be built within the project budget. A major cost would be involved in shipping 215,000 lbs. of sand from Bethel to Kongiganak, since there is not a source available locally. This had been done for the VSW Facility, as well as for the school. A cost was obtained from Erv Long, of Arctic Foundations, for supplying thermal piles which would give higher capacities without sand. However, the cost of obtaining these was also prohibitive.

An analysis was done using local silt as backfill material. The ultimate capacity of this type pile would be 75 kips, for a safety factor of 1.25. This was judged too low for a structure of this cost and importance to the community.

FINAL FOUNDATION DESIGN

MODIFICATION OF DESIGN CRITERIA

The preliminary design showed that a foundation could not be constructed at this location, within budget limits, with the criteria used, i.e. that the tank have essentially no settlement over its 30 year life. This is the presumptive inherent in the Sanger analysis. The pre-capacity was analyzed using two other design procedures, both of which are based on the assumption that some long term creep (settlement) of the piles will occur. These procedures are documented in the following papers.

"A Design Approach for Pile Foundations in Permafrost", J.F. Nixon and E.C. Mc Roberts, Canadian Geotechnical Journal, Volume 13, 1976.

"The Behavior of Friction Piles in Ice and Ice-Rich Soils", N.R. Morgansteinn, et.al., Canadian Geotechnical Journal, Volume 17, 1980.

Prior to using these methods, a meeting was held with Ed Jacobsen of Village Safe Water to establish if a design based on allowing some movement would be acceptable. Since the structure could not otherwise be constructed, it was decided to allow a maximum of one-half inch per year settlement.

Using this figure, a maximum capacity of 56 kips per pile was calculated. Since this was still somewhat low, it was decided to place 17-inch diameter end bearing plates on the piles, which would increase the capacity to 63 kips.

FINAL FOUNDATION LAYOUT

Since the design assumes that the platform will settle one-half inch per year, the pile grid was recalculated assuming that all piles were evenly loaded. The resulting layout gave a smaller deck and reduced the number of piles to 88. Some edge piles have reduced embedment to equalize pile stress. The glulam beams spanning the piles were deepened, so that in the event one pile begins to settle more than those adjacent, the load will be redistributed and settlement equalized. The final pile layout is depicted on Sheet 3 of the project construction drawings, to be forwarded under seperate cover.

VSW also requested that QUADRA conduct a site survey sufficient to describe the parcel of land upon which the entire project, the existing facility as well as the new water storage tank, is to be located. This survey was conducted in June of 1981 by a land surveyor registered in Alaska. The resultant legal description is included in the Appendix, as well as on the project construction drawings.

PRELIMINARY WATER SOURCE INVESTIGATION

Prior to initiating the investigation to locate an acceptable surface water source within reasonable proximity of the village, VSW established several parameters which were to be given consideration prior to final source selection. These parameters included: 1) distance from the existing facility, 2) estimated quantity of water available considering recharge potential, 3) water quality improvement or degradation over a period of time based on analytical laboratory results, 4) acceptability of the water source to local consumers, and 5) history of salt water encroachment if available. The contaminants which were to be considered of major significance included color, turbidity, iron, manganese and total dissolved solids. It was also considered advisable to conduct analytical tests sufficient to detect gross amounts of heavy metals.

During the late spring and early summer of 1981, four potential surface sources were selected for consideration. Three of these lakes, designated as Lake 1, Lake 2 and Lake 3 were selected relatively independently by QUADRA Engineering, based on the estimated quantity of water available and proximity to the facility. Village residents and VSW personnel later requested a lake known as Contractor's Lake also be considered, as it had previously been used as a water source by contractors working in the village. This lake was also seen to be advantageous in that it was far enough removed from the village to avoid significant contamination by local residents. The location of these four lakes relative to the facility is shown on an aerial photograph (approximate scale 1 inch = 600 feet) included in the Appendix.

Water samples were collected from each of the four lakes in June, July and October of 1981 and analyzed by Chemical & Geological Laboratories of Alaska. Additional samples were collected from Lake 1, Lake 2 and Lake 3 in May of 1981 and also analyzed. All water quality analysis reports are included in the Appendix.

LAKE 1

The body of water designated as Lake 1 is approximately 27.5

acres in size and lies immediately east of the Kongiganak airstrip. The most probable and acceptable transmission line routing would follow the boardwalk from the VSW facility to the airstrip, continue past the south end of the airstrip and follow the bluff to the south edge of the lake, with a total length of about 2300 feet.

The color, turbidity and total dissolved solids of the water from Lake 1 generally increase from spring to late fall. Total dissolved solids decreased from July to October, but this may be a rare occurence because of the lack of fall storms during the fall of 1981. Usually the Kongiganak area is beset by strong onshore winds during the fall, with resultant high wind blown tides. The northeast edge of Lake 1 is in an area likely to be flooded. This lake is well drained, however, and would in all probability be usable again by the following spring. With the exception of moderately high TDS, the remaining objectionable contaminants can be successfully removed with the existing F-86 fed multimedia filters.

The volume of water available from Lake 1 is estimated to be between 55 acre-feet (17.9 million gallons) and 68.8 acre-feet (22.4 million gallons). Based on the hydrology of the area, total annual recharge of the lake can be expected with a normal amount of precipitation.

LAKE 2

The lake designated as Lake 2 is approximately 3.4 acres in size and lies to the southeast of the airstrip, approximately 1000 feet south of Lake 1. The most acceptable transmission line routing would be generally as described for Lake 1, except veer to the southeast after passing the airstrip and intercept the north edge of the lake, with a total length of about 2750 feet.

The water quality of Lake 2 is similar to that of Lake 1, although generally having a slightly higher color and lower turbidity. The total dissolved solids, however is much higher and does not meet preferable drinking water limits. From July through October the TDS concentration exceeds 1000 mg/l. For this reason, Lake 2 should not be considered an acceptable source for this project. With the exception of TDS, the water can be treated with existing equipment.

The volume of water available from Lake 2 is estimated to be between 6.8 acre-feet (2.2 million gallons) and 8.5 acre-feet (2.8 million gallons). This lake is not likely to be annually recharged and will not effectively drain in the event of gross contaminant intrusion.

LAKE 3

The lake designated as Lake 3 is approximately 1.4 acres in size and lies west of the north end of the airstrip. The most probable transmission line routing would be from the VSW facility past the south end of the airstrip, then along the east side of the airstrip as far as the north end, and then west to the east edge of the lake, with a total length of approximately 4100 feet.

The water quality of Lake 3 is much like that of Lake 2, although TDS concentrations are slightly lower. The TDS concentration exceeded 1000 mg/l in the July analysis and is in an area subject to tidal flooding. Lake 3 should not be considered an acceptable water source for this project.

The volume of water available from Lake 3 is estimated to be between 2.8 acre-feet (0.9 million gallons) and 3.5 acre-feet (1.1 million gallons). While the lake is moderately well drained, high tidal action will result in long lingering impacts on the water quality.

CONTRACTOR'S LAKE

Contractor's Lake is located approximately 5500 feet northeast of the north end of the airstrip, and is approximately 5.2 acres in size. The most practical transmission line route would be similar to that for Lake 3 until the north end of the airstrip is reached, at which point the line would veer to the northeast and follow a ridge line for about 2600 feet, cross a seasonally tidal influenced area for approximately 1600 feet, and cross another bluff to intercept the south edge of the lake. The total transmission line would be approximately 8700 feet long.

The water quality of Contractor's Lake is excellent relative to the other lakes considered. The June water quality analysis showed the water to meet Alaska Drinking Water Standards. From July through October the water quality deteriorates slightly with color and iron concentrations increasing above preferred limits.

Even in late fall the water is of sufficiently high quality to allow economical and effective treatment with existing equipment. Total dissolved solids are extremely low, and the lake's relatively high elevation will preclude tidal encroachment in the normal course of events.

The volume of water available from Contractor's Lake is estimated to be between 13 acre-feet (4.2 million gallons) and 15.6 acre-feet (5.1 million gallons). The area of recharge is considered sufficient to allow nearly total annual recharge with normal precipitation.

FINAL WATER SOURCE SELECTION

Based on the analysis of water from the four lakes under consideration and discussions with VSW personnel and village residents, Contractor's Lake was selected as the water source for this project. The transmission line route will be as previously described and as shown on the construction drawings. The existing raw water pump building, which houses the electrical controls for the existing raw water pump, will be relocated to the south edge of Contractor's Lake in early spring of 1982. It is envisioned that the existing building can be relocated using local snow machines. At such time as the building is relocated it will be necessary to terminate service at the VSW facility or arrange for a temporary river pumping facility. While relocation of the existing structure may result in closure of the facility for a period of time, it will also result in saving money in a strained budgetary situation.

Because the transmission line will cross an area subject to tidal influence on a seasonal basis, it is necessary to attach extra weight to the transmission pipeline in this area. Based on a worst case of an empty pipe and four feet of water, additional weight of approximately 3.5 pounds per lineal foot of pipe is required to prevent floating of the empty transmission line and potential damage. This additional weight will be supplied by securing concrete weights to the pipe at appropriate intervals.

Although Contractor's Lake is the best water source for this project, it is advisable that Lake 1 not be completely disregarded as a potential future water source. The transmission line route to Contractor's Lake was selected based on using Lake 1 as a contingency water source in the event that Contractor's Lake is unavailable at some point in the future. The conversion from the use of Contractor's Lake to the use of Lake 1 can be accomplished through relocation of the new gasoline driven water pump and a minimum amount of pipe work. Lake 1 should be viewed only as a contingency water source and used only in the early spring.

WATER TREATMENT MODIFICATIONS

The existing water treatment system consists of an F-86 fed multi-media filter, two potassium permanganate fed pressure greensand filters and two carbon filters. The existing treatment system will be extensively modified for the raw water quality which is anticipated based on water quality analysis reports for Contractor's Lake.

Past experience has shown that the F-86 fed multi-media filter is capable of the removal of significant concentrations of organic color, as well as moderate amounts of iron. As the iron concentration of the raw water is very low, the greedsand iron removal filters will be removed from service, the media removed and the filter bodies available for service at other sites, at the option of VSW personnel.

Experience has also shown that slight amounts of color and turbidity have no impact on the public service activities of the facility other than the use of the public drinking water service. Thus no additional treatment other than chlorination and fluoridation will be provided, except for drinking water dispensed to the public, and domestic water supplied to the LKSD operated high school. One of the existing carbon filters will be relocated to the downstairs mechanical area to provide carbon filtration just prior to distribution to the public (including the drinking fountain) and the school. This is considered advisable, not necessarily to provide additional water treatment, but to help "freshen" and reoxygenate the water after prolonged storage. Carbon filtration will also provide dechlorination, thus making the water more palatable for village residents.

The remaining carbon filter will be converted to a second multi-media filter, thus providing a standby filter in the event of a mechanical problem with the first filter, or to provide uninterrupted filtration when the first filter is in a backwash mode. Within the existing facility there is a flow rate controller downstream of the water treatment filters which limits the filtration flow rate to 15 gallons/minute. With improved raw water quality the acceptable filtration rate can vary between 15 gallons/minute (5 gpm/ft^2) and 30 gallons/minute (10 gpm/ft^2). It is suggested the actual filtration rate not be determined until operational experience has been obtained.

In October of 1981 jar tests were conducted on the "worst case" raw water from Contractor's Lake (Color @ ~125 PCU). Following the jar tests, vacuum filtration was conducted through filter paper. Based on these results, an F-86 feed rate of 30-40 mg/l is required to provide high quality water. However, past experience has shown that there is no well defined correlation between jar tests and actual filter operation. Also, the vast majority of the water used with the new storage tank will not require this chemical concentration for effective treatment. It is advised that the F-86 chemical solution be prepared to allow the chemical feed pump to inject between 10 and 30 mg/l, with the actual feed rate based on operational experience.

The existing chemical solution tank and feed pump operation will also be modified for the proposed water treatment scenario. Two of the solution tanks and chemical feed pumps will be removed from service and should be left onsite for spare parts. The remaining four pumps will be used for F-86 solution (10-30 mg/l), backwash chlorine solution for the multi-media filter (20-30 mg/l), domestic water chlorination (0.5 mg/l) and domestic water fluoridation (1.2 mg/l).

MISCELLANEOUS FACILITY MODIFICATIONS

Several other facility modifications will be completed under this project. Some of these modifications are required for compatibility with the new water source and supply, while others are desirable to simplify the operational characteristics of the facility. The major items of work to be accomplished are as follows.

1) Installation of a foundation and structural deck, erection of a water storage tank, installation of a raw water transmission line and appurtenances, and modifications to the water treatment system, all as previously described.
2) Erection of a small insulated enclosure on the new structural deck adjacent to the water storage tank.
3) Insulation of and provisions for heating the newly erected water storage tank.
4) Removal and/or abandonment in place of the existing raw water transmission system, including the pump, transmission utilidor, buffer tank and related piping and controls.