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EXECUTIVE SUMMARY
HOT SPRINGS STATE PARK MASTER PLAN
LEVEL I

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HOT SPRINGS STATE PARK MASTER PLAN
LEVEL I

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EXECUTIVE SUMMARY

Authorization and Purpose

Hot Springs State Park (HSSP) via the Wyoming Division of State Parks and Cultural Sites submitted an application to the Wyoming Water Development Commission (WWDC) to fund a Level I study for the development of a Master Plan for HSSP. On June 19, 2002, Lidstone and Associates, Inc. (LA) entered into contract with the WWDC to provide professional services related to the Level I Hot Springs State Park Master Plan, Level I. LA was assisted by three subcontractors: (1) BRS, inc, (2) Summit GeoScience, and (3) Tetra Tech. The purpose of the project was to:

- Determine if there has been a decline in flow from the Big Spring;
- Assess the existing operation of the hot water transmission and distribution system;
- Evaluate the condition of the various components of the water system;
- Evaluate the existing user agreements as documented in the leases with the State of Wyoming;
- Develop alternatives to improve flow over the terraces; and,
- Develop a Master Water Supply Plan to improve the existing conditions.

Project Location and Summary of Existing Conditions

HSSP is located in Hot Springs County, along the Big Horn River at the northeast edge of the Town of Thermopolis. The HSSP site was conveyed to the United States in 1896 by treaty with the Shoshone and Arapaho tribes and ceded by the United States to the State of Wyoming the following year. HSSP's major attraction is the Big Spring that supplies water to five facilities (users) for bathing, swimming, and soaking and the "rainbow colored" travertine terrace at the edge of the Big Horn River. The Big Spring has an adjudicated water right for approximately 3,200 gpm and the appropriator is the Board of Charities and Reform.

Recently many life-long patrons of HSSP have indicated that it was their belief that flows from the Big Spring have declined. Scientific data to support this assertion have never been collected, rather the belief appears to be based on personal observation and verbal reminiscence. Patrons remember the times when water almost covered the entire terrace and long icicles could be seen during the winter hanging from the terrace wall overlooking the Big Horn River. Because of this perception, Simons Li Associates (SLA) was hired to perform a study of the Big Spring in 1983. The goal of this study was, to determine if there had been a decline in spring flow and to develop alternatives for improving spring flow over the terraces.
Subsequent to the findings of the SLA, 1983 study, HSSP personnel have lined several terrace ponds in an attempt to increase water supply and decrease seepage loss. Beyond lining of several ponds, the overall layout and system operation is somewhat different today in comparison to when SLA completed their study. The south canal has been removed and all water conveyed to the Star Plunge by the South Canal is by pipe. HSSP staff now utilizes sand bags to divert water to different areas of the terraces in an attempt to maintain growth of the bacteria and algae, which provide the various colors observed across the terraces.

Basic user operation of the various mineral baths and pools has remained constant with time. There are no treatment facilities for water used in the various mineral baths, spas, and tubs. Users operate with a flow-through system whereby a given volume of water is passed through the system to maintain pool temperature and control bacterial growth. The temperature of Big Spring water remains relatively constant within the system at an average of 127 degrees Fahrenheit. For use in the mineral baths and pools the water is cooled by routing some of the Big Spring flow through a series of cooling ponds and combining it with hot water piped directly from the Big Spring. Cooling water is supplied to the Star Plunge, Tepee Spa and the State Bath House using this method. There is insufficient volume of cooling water available for the Tepee Spa, State Bath House and travertine terraces.

**Overview of the Level I Field Investigation and Results**

Quantifying user demand is difficult given the nature of the distribution system. User water supply pipes are unmetered and often inaccessible. Given these limitations, LA gaged flow at each user outfall and reasonably approximated the maintenance inflows to each facility. LA gaged the flow at the Big Spring as open channel flow and balanced inflow and outflow estimates with system losses.

Gaging results indicated that there was little change in user demand relative to the SLA, 1983 study. The primary differences were the result of the elimination of various demands on the system, including the Gottshe Center, the Pioneer Home, and heating of the bathroom adjacent to the Tepee Fountain. LA measured the Big Spring discharge at 2,328 gpm. LA compared this measurement to the historical data and concluded there was no evidence to support the assertion that there has been a decline in Big Spring flow with time. A statistical analysis of historical flow measurements from the Big Spring indicates a mean flow of 2,415 gpm and a standard deviation of 250 gpm. Big Spring flow measured by LA is within one standard deviation of the estimated mean spring discharge.

Evaporative losses from the system were estimated using lake evaporation rates described in Lewis, 1978. Average monthly evaporation rates were calculated using data from US Bureau of Reclamation and the Wyoming Climatic Atlas. Traditional evaporation rates from the hot pools for each pool and pond were calculated by measuring the surface area and multiplying it by the estimated monthly evaporation
rate. Evaporation rate estimates actually underestimate true evaporation rates because of the high temperatures associated with each open body of water.

Seepage rates were not directly measured. The majority of the terrace pools have been lined since the 1983 SLA investigation. LA’s field investigation also indicates that the North Canal has also been lined. The poor condition of the liner in the Star Plunge cooling ponds indicates there is a significant potential for elevated seepage losses at this location. LA calculated the cooling pond inflow rate through indirect methods and measured the outflow rate using a Pygmy meter. Based on these measurements, LA estimated that approximately 90 gpm was being lost to seepage through these ponds.

Summit GeoScience (SGS) at LA’s request performed a geochemical analysis of the system. Water samples were collected and analyzed from different locations within the system and the Big Horn River. The purpose of this analysis was to determine how water chemistry changed with travel distance and to evaluate potential impacts to water chemistry under different water management scenarios. Analysis results indicate that when the mineral water is exposed to the atmosphere, the farther it travels from the spring the greater the pH and lower the concentration of calcium. This change in chemistry indicates that as the water is exposed to the atmosphere, calcium carbonate precipitates out and is deposited on the terraces, pools, baths, and tubs.

Initial biochemical modeling indicates that there should be virtually no change in water chemistry provided that any change in water management solely utilizes water from the Big Spring. One alternative considered to increase the amount of cooling water available is to use water from the Big Horn River to mix with the hot Big Spring water. This was deemed acceptable, provided that the water is only utilized for cooling and is not discharged to the terraces. If the water was applied to the terraces, there could be a significant change in the algal and bacterial composition of the terraces. This change would not only impact the appearance of the terraces, but potentially their infiltration characteristics as well.

Water quality sample results from this study were compared to previous analyses of the mineral water from the Big Spring. An analysis of the historical data indicates that there has been a decline in the concentration of several constituents and commensurately a decline in total dissolved solids. The reduction in mineral content has resulted in a decline in travertine formation, which also affects bacteria and algal formation. Bacteria and algae play a significant role in sealing the terraces and preventing seepage loss. Based on the results of this study, LA believes that the perceived decline in Big Springs flow is actually a function of increased seepage rates along the terrace rather than a significant decline in spring flow.

**User Agreements**

LA reviewed each of the long-term leases between the various users of the Big Spring water and the State of Wyoming. None of the leases provide a quantitative description of how much water they are allowed to use. Three out of the four leases describe the
quantity in terms of “that which is necessary and proper” for their operation. In attempting to develop an agreement between all users, LA utilized the principles outlined in the treaty with the Shoshone and Arapaho tribes. Based on this treaty, water to supply the terraces and the State Bath House were ranked as priority 1 and 2, respectively. To define the quantity of water which was “necessary and proper” for all other users, LA suggested that the forthcoming results from the microbiological study by the Wyoming Department of Agriculture (WyDOA) be incorporated into minimum flow requirements for each user such that each user can maintain an acceptable pool temperature and meet WyDOA standards for flow-through pools.

Recommendations

LA developed several recommendations concerning upgrades to the existing system, including replacement of the two shutoff valves on the Star Plunge supply lines. Because of the complications associated with these two valves, LA was only able to obtain one Big Spring discharge measurement during the study. LA would recommend that additional measurements be obtained. Four quarters of measurements could serve to address the seasonality (if any) of Big Spring flows. Based on the data collected and the known variability in discharge associated with barometric pressure, etc., LA concluded that there has not been a significant decline in Big Spring flow. To validate study results, LA suggested that HSSP install meters on the major transmission lines.

To increase flows across the terraces, LA developed four potential alternatives. These alternatives include:

- Line the Star Plunge cooling ponds and utilize the reduction in seepage loss to supply cooling water for the State Bath House and Tepee Spa. The existing channel along the east edge that supplies cooling water to the State Bath House and Tepee Spa could be eliminated, allowing more flow across the terraces.

- Pump “wastewater” from the Star Plunge outfall to a point near where the North Canal opens on to the terrace. Care would need to be exercised to minimize the potential of this wastewater being used as cooling water for the State Bath House and Tepee Spa.

- Utilize Big Horn River water to supply all or part of the cooling water for the Star Plunge, State Bath House, and Tepee Spa.

- Install a heat exchanger to lower the temperature of the Big Spring to the desired user temperature.

The positive and negative aspects of each option are discussed in the report, including estimated costs for the implementation of each option. The preferred option is lining the Star Plunge cooling ponds and using the increased flow to supply cooling water to the Tepee Spa and State Bath House. This option is recommended because there should be no impacts to the system in terms of water quantity and quality. The other options
do present viable alternatives, especially using a Heat Exchanger to cool the water if a study by the Wyoming Department of Agriculture indicates that there is a potential threat to human health. Once this study is completed, additional flow measurements, and more extensive geochemical modeling is recommended. The final and composite data analysis will be used to select an ultimate course of action.

Two sets of costs were presented. The first included system upgrades for an estimated total materials cost of $27,000.00. This estimate included: (1) the replacement of two transmission line valves; (2) installation of meters on the transmission lines; (3) installation of meters on the distribution lines: and (4) the installation of 2 staff gages. The second set of costs correspond to the four alternatives developed to increase terrace flows and improve cooling water supply. The estimated 2002 construction costs for implementation of each alternative is described below. Option 1 is the preferred option.

- Option 1: $120,820.00
- Option 2: $89,960.00
- Option 3: $203,780.00
- Option 4: $303,000.00