STEAD GOLF COURSE

WATER WELL EVALUATION

PREPARED FOR:

WASHOE COUNTY DEPARTMENT OF PUBLIC WORKS
1205 MILL STREET
RENO, NV 89502

APRIL, 1980
Mr. Floyd Vice, P.E., Director
Washoe County Department of Public Works
1205 Mill Street
Reno, NV 89502

Subject: Stead Golf Course - Well Investigations

Dear Floyd:

In accordance with our proposal dated September 20, 1979, we are submitting our report of the result of our investigation of the referenced facility. Included herein are recommendations concerning this important source of water supply for the Stead Golf Course, as well as discussing alternatives for additional source of supply development.

WATERESOURCE appreciates this opportunity to be of service to the County. Should you have any questions concerning this report, we would be happy to review them with you at your convenience.

Sincerely,

WATERESOURCE CONSULTING ENGINEERS, INC.

George W. Ball, Jr., P.E.
President

GWB/dmo

Enclosures

c: Gene Sullivan, Superintendent
\[ T = \frac{264 \times (500 \text{ gpm})}{158 - 108} = 2640 \text{ gpd} / \text{ft}^4 \]
DIVISION OF WATER RESOURCES

WELL DRILLERS REPORT

1. OWNER
Washoe County
Stead Golf Course

2. LOCATION
14 EX 14 Sec 31
T 21 N/S R 1 E
Washoe County

3. TYPE OF WORK
New Well ☑
Recondition ☐
Deepen ☐
Other ☐

4. PROPOSED USE
Domestic ☐
Irrigation ☐
Test ☐
Municipal ☑
Industrial ☐
Stock ☐
Other ☐

5. TYPE WELL
Cable ☐
Rotary ☑

6. LITHOLOGIC LOG

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8. 28' - 50' WELL CONSTRUCTION
Diameter hole 24" - 1000 inches
Total depth 1000 feet

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Depth of seal: feet

Gravel packed from: 0 feet to: 1000 feet

7. WELL TEST DATA

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Flow: G.P.M.

Perforations:

Type perforation: Lauer
Size perforation: 5/32" x 3" 8 rows

From 350 feet to 410 = 20 feet
From 550 feet to 610 = 60 feet
From 740 feet to 810 = 70 feet
From 890 feet to 960 = 70 feet

9. WATER LEVEL
Static water level: 45 feet below land surface
Flow: 145
Water temperature: ° F. Quality:

10. DRILLERS CERTIFICATION
This well was drilled under my supervision and the report is true to the best of my knowledge.

Name: PATRICK H. THOMPSON
Address: 3215 Cinder Lane Las Vegas, Nev
Nevada contractor's license number: 4286
Nevada driller's license number: 581

Date: July 10, 1970

Signature: [Signature]
PLAN VIEW

GRANULAR PACK
GROUT

STATIC WATER LEVEL
24" CASING
GROUT SEAL

12" BLANK CASING (TYP)

SECTIONAL VIEW

VERTICAL SCALE 1" = 100'
HORIZONTAL SCALE 1" = 2'-0"

MATCH LINE

WASHOE COUNTY
STEAD GOLF COURSE
WATER WELL
EVALUATION 4/1/80
#7927

PLATE I
SECTION 6

WATER QUALITY

Although not outlined in the scope of work, analyses of the quality of water as varies with pumping time were performed. Since the water is utilized for turf management, the analyses were performed with emphasis on the water's suitability as a source for irrigation. The results are as follows:

\[
\text{Me}^{1+} = \frac{w_1 - 0.82}{1 - 0.82} = 1 \text{ mg/L}
\]

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<th>6 PM</th>
<th>10 PM</th>
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</table>

1- pH level at which water is calcium carbonate saturated.

2- RSC - Residual Sodium Carbonate

3- EEESP - Expected Equilibrium Exchangeable Sodium Percentage. A soil irrigated with this water is expected to have an Exchangeable Sodium Percentage of this value.
STEAD GOLF COURSE

WATER WELL EVALUATION

Prepared for

Washoe County Department of Public Works
1205 Mill Street
Reno, Nevada 89502

April, 1980

Prepared by
WATERRESOURCE CONSULTING ENGINEERS, INC.
28 Vine Street
Reno, Nevada 89503
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SECTION 1

INTRODUCTION

In September of 1979, WATERESOURCE entered into contract with Washoe County Department of Public Works to evaluate the Stead Golf Course water well. The contract included preliminary investigations, pump test, data analyses, and report and recommendations (see Scope of Work letter in Appendix).

Portions of this report will cover:

1. Water rights permits.
2. Existing facility.
3. Test pump procedure and analyses.

The purpose of this report is to define existing conditions and offer recommendations where required. As stated in the final section of this report, no expedient, inexpensive solution is available. This report should be used as a guide in arriving at what course of action to pursue in the future.
SECTION 2
WATER RIGHTS

In 1975, Proof of Beneficial Use applications were filed for permits No. 25884 and No. 25885. As the 6-inch meter on the pipeline was not functioning at the time, records of water use for the previous year were not filed. Therefore, the Division of Water Resources did not issue the certificated rights. Since 1975, no further action was taken nor were any statements of water use filed with the DWR.

On January 21, 1980, WATERES0URCE filed an amendment to the 1975 applications showing record uses of 3.95 acre-feet per acre (see Appendix). The permitted allocation from the State is 4.0 A.F./acre. The DWR is now processing this information and will then issue the certificated water rights. It is recommended that the County follow through with the DWR to see that everything is in order and the certificates are issued.
SECTION 3
EXISTING FACILITIES

The existing water supply source, developed in 1972, consists of a well (No. 2) and vertical line-shaft turbine pump. The well was drilled to a depth of 1,000 feet at a diameter of 24 inches. The open hole was cased with 1,000 feet of 12-inch casing, including 280 feet of 12-inch "Valley Louvre" perforated casing. The cased well was then gravel-packed and sealed with 100 feet of 24-inch casing and cement grout (see Plate I, Well Construction Diagram, Page 4). The well is of excellent construction and capable of delivering significantly more water than the aquifers will yield.

The existing pump is a Johnston line-shaft turbine. The pump bowl is a 12-stage "10 cc" impeller assembly capable of delivering 600 gpm at a total dynamic head of 456 feet when new (see Plate III, Pump Field Curve, Page 8). The pump is equipped with a 100 hp electric motor, 8-inch discharge pipe, and a 6-inch meter. The meter was vandalized and repaired in 1975, but its accuracy is suspect. Removal and inspection of the meter is recommended.

The original Army Air Base well (No. 1) construction detail is unknown. It is equipped with a vertical line-shaft turbine pump; however, WATERESOURCE understands that the pump is wedged in the well and cannot be removed. Because of the age of the well, the pumping equipment problems, and its close proximity to well No. 2, it is of limited value as a water
source to the golf course. For these reasons, this well and its pumping equipment were not examined or tested during this investigation.
SECTION 4
TEST PUMPING PROCEDURE

The test pumping was accomplished in two phases--a step test, and a 30-hour test. To accomplish these tests, the existing pump was utilized. This served a dual purpose, that of determining pump wear, i.e., existing capability, and an aquifer yield capability estimate. The existing piping in the pump house was modified to allow free discharge out the pump house door and installation of an orifice plate to accurately measure the flow rate.

Step testing was performed at flow rates of 500, 600, and 700 gpm for two-hour durations each (see Plate II, Page 7). The total head produced at each step was plotted on the pump curve and a field performance curve was generated (see Plate III, Field Pump Curve, Page 8). The field pump curve thus developed indicates some wear in the bowls. This wear could be due to excessive pumping in the past when the pump broke suction, i.e., water level drawdown to pump intake, creating air around the impellers, causing accelerated pump wear (cavitation). If the existing pump is lowered, it is recommended that the pump be pulled and visually inspected and repaired if necessary.

A 30-hour pump test was initiated with a constant well discharge rate of 700 gpm. However, strong winds, rain, and a power failure forced cancellation of the test during the thirteenth hour. Examination of the
STEP TEST - DRAWDOWN CURVE

- Drawdown in Feet
- Time in Minutes
- Plate

Q = 500
Q = 600
Q = 700

Water Resource Consulting Engineers

Washoe County
Stead Golf Course
Water Well Evaluation
4/1/80 #7927
test data indicated the pumping rate was too high for the aquifer yield capability and a lower rate of 500 gpm was selected for the second test. The data generated by the 30-hour test is contained in Tables 1 and 2, Pages 10 and 11. The data for well No. 2 (pumped well) is plotted on Plate IV, Page 12.
TABLE 1
WELL NO. 2 - PUMPED WELL
30-HOUR TEST

Well size--12-inch
Pump setting--240 feet
Static water surface--31 feet
Pumping rate--500 gpm

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1 t - time since pumping started in minutes
2 ws - depth to water surface in feet

April 1980
TABLE 2

WELL NO. 1 - OBSERVATION WELL
30-HOUR TEST

Well size--12-inch
Distance to pumped well--105 feet
Static water surface--33.73 feet

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</table>

1 t - time since pumping started in minutes
2 ws - depth to water surface in feet
SECTION 5

PUMPING DATA ANALYSIS

The data from Tables 1 and 2 was analyzed to establish groundwater characteristics and aquifer yield. The analysis of the test pumping data was complicated by the fact that the aquifer response to pumping did not conform to generally accepted groundwater analysis techniques. The reason for this unconformity is not totally understood, nor is it computationally defineable with the data that could be developed from the pump test (it is noted that the complexity and resulting cost of a test to ascertain in detail the groundwater response to pumping is significantly beyond the scope of work for the project).

WATERRESOURCE has preliminarily theorized that the aquifer response to pumping could be related to overpumping the well, i.e., pump capacity is greater than yield of aquifer penetrated by the well and possible encountering of groundwater barriers by the cone of influence of the pumped well, i.e., the area of the aquifer influenced by pumping intersects a barrier which prevents the expansion of the area of influence, thereby reducing water available to the well from storage.

The previous notwithstanding, it is emphasized that methods exist with which the principal groundwater aquifer coefficients can be estimated within a sufficient degree of accuracy to allow interpretations of aquifer pumping response, i.e., yield and relateable pumping level. Several methods
for evaluation of this data were analyzed. The results of these analyses yield approximate values for the groundwater coefficients of transmissibility (T) and storage (S). The coefficient of transmissibility (T) indicates the rate at which an aquifer will transmit water under a certain pressure release and has units of gallons/day/foot, whereas the coefficient of storage (S) characterizes the ability of the aquifer to release water from storage as the head (pressure) in the aquifer declines and is a dimensionless number.

From these analyses, the estimated value of transmissibility (T) is approximately 3,000 gpm/day/foot, and the coefficient of storage is approximately $5 \times 10^{-5}$. Using these approximate values, the specific capacity of the well at a pumping rate of 500 gpm is 1.2 gpm/foot drawdown. In other words, for every foot of water surface drawdown at a pumping rate of 500 gpm, 1.2 gallons per minute can be pumped. With the present pump setting at 240 feet, with a nonpumping water level at 31 feet, and allowing for five feet of water over the top of the pump bowls, the available drawdown is 240 - 31 - 5 = 204 feet. The estimated maximum allowable pump rate is approximately $(1.2 \text{ gpm/ft.})(204 \text{ ft.}) = 245 \text{ gpm}$. To increase the maximum allowable pumping rate, the pump could be lowered, thereby increasing the allowable drawdown. Since it is not recommended to set the pump in or below the perforated casing, the maximum depth of pump setting is 360 feet (see Plate I, Well Construction Diagram, Page 4). Again, considering the nonpumping water surface elevation and minimum pump submergence, the available drawdown is 360 - 31 - 5 = 324 feet, and the recommended maximum well production is $(324)(1.2) = 390 \text{ gpm}$.

Before lowering the pump, its capability must be reviewed. The pump head
(or discharge pressure) is based on the total dynamic head (TDH) required to lift the water to the place of use. The friction loss plus the elevation difference from the pump to the irrigation storage pond, based on replacement and realignment of a portion of the existing pipeline (see Plate V, Site Plan, Page 16), is approximately 271.5 feet. This energy (pressure) requirement when added to the drawdown in the well during pumping is the TDH required. At the present setting, the TDH is $204 + 271.5 = 475.5$ feet and the theoretical pump capacity is 555 gpm (from Plate III, Page 8, $475.5 \div 12$ stages is approximately 40 feet of TDH per stage) much greater than the allowable aquifer yield of 245 gpm. Lowering the pump to 360 feet, the TDH is $324 + 271.5 = 595.5$ feet and the flow rate is 200 gpm (from Plate III, Page 8, $595.5 \div 12$ stages is approximately 50 feet of TDH per stage), less than the existing well's recommended maximum yield of 390 gpm. Plotting the two curves on the same flow rate vs. drawdown graph, an optimum setting and flow rate (for the existing pumping equipment) of 330 feet and 350 gpm is attained (see Plate VI, Well Yield, Page 17).

In summary, therefore, the existing pumping equipment can optimally pump from well No. 2 approximately 350 gpm without overpumping the aquifer. The estimated maximum recommended pumping rate for this well and aquifer is 390 gpm.
WASHOE COUNTY
STEAD GOLF COURSE
WATER WELL EVALUATION
4/1/80 #7927

S = 293
Q = 351.6 \text{(TIS)}

TDH = 564.5 \text{(PUMP CURVE)}
\eta < 70\%

WELL YIELD

--- BASED ON TIS

--- BASED ON PUMP FIELD CURVE
SECTION 6

WATER QUALITY

Although not outlined in the scope of work, analyses of the quality of water as varies with pumping time were performed. Since the water is utilized for turf management, the analyses were performed with emphasis on the water’s suitability as a source for irrigation. The results are as follows:

\[ \frac{Me_{L}}{L} = \frac{mg}{L} \]

\[ \frac{Me_{L}}{L} = \frac{mg}{L} \]

\[ \frac{Me_{L}}{L} = \frac{mg}{L} \]

\[ \frac{Me_{L}}{L} = \frac{mg}{L} \]

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<th>10 PM</th>
<th>2 AM</th>
<th>6 AM</th>
<th>10 AM</th>
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<td>C2-S1</td>
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<td>21.00</td>
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</table>

\(^1\)- pH level at which water is calcium carbonate saturated.

\(^2\)- RSC - Residual Sodium Carbonate

\(^3\)- EEESP - Expected Equilibrium Exchangeable Sodium Percentage. A soil irrigated with this water is expected to have an Exchangeable Sodium Percentage of this value.
For the key to the classifications, see "Interpretation of Irrigation Waters for Salinity and Sodium Hazards" in the Appendix. The water quality is generally alkaline in nature. Without moderate amounts of leaching (applied water in excess of the turf evapotranspiration needs), a salt toxicity and sodium hazard are expected to stress and may even kill the golf course grasses. The golf course soils are assumed to be fine textured, i.e., silts and clays, and have a high cation-exchange-capacity. Therefore, gypsum could be added to the turf to reduce injury as a result of sodium accumulation in plant tissues. Additional water applications would be desirable to effect salt leaching. Instituting winter irrigation, if the water is available, in conjunction with natural precipitation, may enhance salt leaching (the flushing of salt through the turf root zone to keep salinity concentrations beneath those toxic to the plant). Without development of substantial additional quantities of water for growing season irrigation, other special practices for salinity control should be investigated.

For more information on the interpretation of the test results, or on special salinity control practices, contact the Soil and Water Testing Laboratory in the Plant, Soil, and Water Science Department of the College of Agriculture at the University of Nevada-Reno.
SECTION 7

RECOMMENDATIONS

It is WATERESOURCE's understanding that 500 gpm is needed to properly maintain the golf course. As was discussed in the Pumping Data Analysis section, a maximum of approximately 390 gpm is available in the well. WATERESOURCE envisions three possible alternatives available to the County:

1. Lower existing pump.
2. Drill a new well.
3. Construct a storage reservoir, i.e., pond.

All three alternatives will require accurate measurement of well discharge for determining the discharge rate of Well No. 2 and thereby to ascertain how much of the permitted water right is available (or required) to be transferred to another point of diversion, should this alternative be pursued.

For this reason, the 6-inch meter currently installed in the well field discharge main should be removed for an accuracy check, repair, and/or replacement immediately. It is imperative that the County followup with the DWR to assure that the water rights certificates for these sources are issued.

The first alternative of lowering the existing pump would involve pulling the pump for visual inspection and repair, if needed; purchasing 80 feet of pipe column, oil tube, and shafting; and reinstalling the pump to a depth of 320 feet. This would cost approximately $3,600 in 1980 dollars for additional piping plus whatever labor and materials might be needed for
repair of the bowl assembly. At this depth, the pump will deliver approximately 350 gpm. The additional 150 gpm needed for golf course irrigation would have to be developed through other alternatives.

A variation of this alternative would be to purchase a new bowl assembly that would be capable of delivering the maximum allowable well yield of approximately 390 gpm from a depth of 360 feet. The additional expense for this would be approximately $5,000 for the bowl assembly, and $5,500 for pipe column and shafting, plus the labor to remove the existing pump and install the new pump. A properly sized bowl assembly would not require additional horsepower, thereby utilizing the existing motor. The additional 110 gpm required would again need to be developed through other alternatives.

The second alternative involves drilling a new well. This well should be located approximately 4,000 to 6,000 feet north of the wells No. 1 and No. 2 sites. Based on depths of other wells in that vicinity, a 1,000 foot well is anticipated. The well capacity should be such that, together with the existing pump, 500 gpm can be delivered. The cost of such a well would be between $35,000 and $50,000, depending on the size selected. An additional $10,000 to $15,000 would be needed for pumping equipment, plus cost of a transmission line, right-of-way, land acquisition, etc. This alternative also requires a change of point of diversion of a portion of the water rights from the DWR. Such a change may be difficult to obtain considering the close proximity of the Silverlake Water Distribution Company wells. Although this alternative appears costly and problematic, WATERESOURE recommends serious consideration of this alternative as a possible long-term solution.
The third alternative contemplates the construction of a storage pond (reservoir) capable of holding and releasing enough water that, when mixed with the well water, a 500 gpm delivery rate to the golf course irrigation system can be maintained. Assuming a maximum pumping capability of the existing pumping equipment for well No. 2 of 350 gpm and an irrigation season of 150 days, the reservoir would have to be sized to store in the order of 110 A.F. This could be an 11-acre pond with an average depth of ten feet. It appears to WATERRESOURCE that sufficient land area in or around the golf course is not available for this use.

Other concerns regarding a storage reservoir are the design and water transmission requirements. A storage reservoir located in a significant natural drainage area could come under the requirements of the "Laws and Regulations Pertaining to Dams" of the State of Nevada. In this situation, extensive hydrology studies, spillway designs, and other significant design cost considerations are required. In addition, the construction costs would also be significant since extensive dam structure and spillway would be required to pass maximum hydrological precipitation flood flows. Once the reservoir is constructed, the water must be delivered to the irrigation reservoir. If the storage reservoir is located above the irrigation pond, gravity feed is possible. However, a larger pump is required in the well to fill the storage reservoir during the off season. A storage reservoir below the irrigation pond does not require a larger pump to fill it, but does require a second pump to transfer the water. In either case, more equipment is needed and power costs increase due to year around pumping.

Of the three alternatives, the first is obviously the least expensive and
should be implemented as soon as practical. The second and third alternati-
tives are solutions for obtaining the additional 100 to 150 gpm required
for golf course irrigation purposes. Obviously, an engineering economic
analysis between the latter two alternatives should be performed before
a decision is made. This analysis should include not only quantity con-
siderations, as was done in these recommendations, but also quality
aspects of the water. It is obvious that any long-term solution will
be complicated, involved, and costly.
APPENDIX

September 20, 1979 letter to Washoe County regarding scope of work.
January 21, 1980 letter to DWR regarding Proof of Beneficial Use.
Interpretation of Irrigation Water for Salinity and Sodium Hazard.
Mr. Floyd Vice, P.E., Director
Washoe County Public Works Department
1205 Mill Street
Reno, NV 89502

Subject: Stead Golf Course--Well Investigation

Dear Floyd:

In accordance with our letter of August 2, 1979, and the County's recent verbal approval to proceed with a portion of the scope of work defined in the August 2, 1979 letter, this letter sets forth WATERESOURCE's understanding of our work tasks, engineering costs, and a preliminary time schedule.

The scope of work, as understood by WATERESOURCE, involves the preliminary investigation of the existing principal water well for the Stead golf course; retain a contractor to pull the existing pump, install a suitable test pumping unit and perform a comprehensive pump test, remove the test pump and reinstall the existing well pumping unit at the conclusion of the test pumping; analyze the test pump data; and submit a brief letter report to the County outlining the results of the test along with a recommendation for a pumping unit and related pump performance specification. It is noted that the securing of the necessary pump contractor to pull the existing pump and install a test pump and perform and supervise the pump testing, pump reinstallation, etc., will be coordinated by WATERESOURCE through this contract with Washoe County.

The estimated maximum engineering and pump contractor cost to be incurred in this project is approximately $7,500. However, it is noted that the pump contractor's cost associated with the project are preliminary at this time due to the unknown conditions which could be encountered in pulling the existing pump. Should conditions become apparent which will adversely affect this estimated cost, WATERESOURCE will notify the County of the circumstances involved. WATERESOURCE would propose to accomplish this work on a time and expense basis in accordance with the attached fee schedule.

Due to the fact that this project cannot proceed until golf course irrigation ceases, it is proposed to initiate the work on this project around the middle of November. It is anticipated that the work would be completed and a brief
September 20, 1979

letter report submitted to the County in January, 1980. We realize that
the time required to accomplish this work does not dictate this extended
time schedule; however, the coordination and scheduling of pump removal
and the pump testing operation could involve time delays that cannot be
totally anticipated. Therefore, we have provided what we believe to be
a conservative margin for this time estimate. We will coordinate our
efforts not only with your office but also with Gene Sullivan, Director
of Parks and Recreation.

Receipt of written authorization to proceed in accordance with this letter
and our August 2, 1979 letter will be sufficient to constitute an engineer-
contract with WATERESOURCE. Should you have any questions concerning
this letter, please do not hesitate to call.

Sincerely,

WATERESOURCE CONSULTING ENGINEERS, INC.

George W. Ball, Jr., P.E.
President

GWB/dmo
Enclosure
c:  Gene Sullivan
    George Fugi
Office of the State Engineer
Division of Water Resources
201 South Fall Street
Carson City, NV 89701

Subject: Applications No. 25884 and No. 25884

Gentlemen:

On May 22, 1975, the Proofs of Beneficial Use concerning the above-referenced permits were filed. It was stated after question 10 that the meter on the eight-inch line was destroyed by vandalism and the record of pumping would be sent by letter after the meter was repaired.

The following is a record of water use developed by WATERESouce from golf course pumping records:

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</tr>
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<td>07/05/79</td>
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</tr>
<tr>
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<td></td>
</tr>
<tr>
<td>10/29/79</td>
<td>937118</td>
<td></td>
</tr>
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</table>

Start pumping season
End pumping season

The total amount pumped during the 1979 irrigation season year was 109,316,100 gallons or 335.5 acre feet. The water was applied to 85 acres for a total annual duty of 3.95 A.F./acre which is within the permit allocation of 4.00 A.F./acre.
Office of the State Engineer -2- January 21, 1980

This amount is for the waters of both permits as they are comingled upstream of the meter. We assume this is sufficient to allow you to complete action on the Proofs of Beneficial Use and issue certificates for these rights.

If you have any questions regarding these measurements, please contact us.

Sincerely,

WATERRESOURCE CONSULTING ENGINEERS, INC.

George W. Ball, Jr., P.E.
State Water Rights Surveyor No. 409

GWB/dmo

c:  Floyd Vice
    Gene Sullivan
    George Fujii
CLASSIFICATION I

Low-Salinity Water (C1) can be used for irrigation with most crops on most soils with little likelihood that soil salinity will develop. Some leaching is required, but this occurs under normal irrigation practices except in soils of extremely low permeability.

Medium-Salinity Water (C2) can be used if a moderate amount of leaching occurs. Plants with moderate salt tolerance can be grown in most cases without special practices for salinity control.

High-Salinity Water (C3) cannot be used on soils with restricted drainage. Even with adequate drainage, special management for salinity control may be required and plants with good salt tolerance should be selected.

Very High-Salinity Water (C4) is not suitable for irrigation under ordinary conditions, but may be used occasionally under very special circumstances. The soils must be permeable, drainage must be adequate, irrigation water must be applied in excess to provide considerable leaching, and very salt-tolerant crops should be selected.

Sodium

The classification of irrigation waters with respect to SAR is based primarily on the effect of exchangeable sodium on the physical condition of the soil. Sodium-sensitive plants may, however, suffer injury as a result of sodium accumulation in plant tissues when exchangeable sodium values are lower than those effective in causing deterioration of the physical condition of the soil.

Low-Sodium Water (S1) can be used for irrigation on almost all soils with little danger of the development of harmful levels of exchangeable sodium. However, sodium-sensitive crops such as stone-fruit trees and avocados may accumulate injurious concentrations of sodium.

Medium-Sodium Water (S2) will present an appreciable sodium hazard in fine-textured soils having high cation-exchange capacity, especially under low-leaching conditions, unless gypsum is present in the soil. This water may be used on coarse-textured or organic soils with good permeability.

High-Sodium Water (S3) may produce harmful levels of exchangeable sodium in most soils and will require special soil management—good drainage, high leaching, and organic matter additions. Gypsumous soils may not develop harmful levels of exchangeable sodium from such waters. Chemical amendments may be required for replacement of exchangeable sodium, except that amendments may not be feasible with waters of very high salinity.

Very High-Sodium Water (S4) is generally unsatisfactory for irrigation purposes except at low and perhaps medium salinity, where the solution of calcium from the soil or use of gypsum or other amendments may make the use of these waters feasible.

Sometimes the irrigation water may dissolve sufficient calcium from calcareous soils to decrease the sodium hazard appreciably, and this should be taken into account in the use of C1-S3 and C1-S4 waters. For calcareous soils with high pH values or for non-calcareous soils, the sodium status of waters in classes C1-S3, C1-S4 and C2-S4 may be improved by the addition of gypsum to the water. Similarly, it may be beneficial to add gypsum to the soil periodically when C2-S3 and C3-S2 waters are used.

CLASSIFICATION II* - Residual Sodium Carbonate
(Used only for waters containing more carbonate + bicarbonate than calcium + magnesium)

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<td>1.25 - 2.50</td>
<td>Marginal</td>
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<td>over 2.50</td>
<td>Not suitable for irrigation</td>
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CLASSIFICATION III* - Expected Equilibrium Exchangeable Sodium Percentage
(Used only for water containing more carbonate + bicarbonate than calcium + magnesium)

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<td>Usually safe for use on all soils</td>
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<td>11 - 18</td>
<td>Marginal (especially on fine-textured soils)</td>
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<tr>
<td>19 or more</td>
<td>Adverse soil physical conditions expected. If used, amendments probably will be required (see discussion on Sodium under Classification I above).</td>
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*If Interpretations by Classifications I, II and III differ, it is recommended that you be guided by Classification III.