PHASE I

HYDROGEOCHEMICAL INVESTIGATION OF GROUNDWATERS

WARM SPRINGS VALLEY, NEVADA

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September 13, 1973

TIC Corporation
P. O. Box 10075
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Subject: Phase I, Hydrogeochemical Investigation
Ground Water in Warm Springs Valley

Dear Sirs:

Following is a report of the first phase of the hydrogeochemical investigation requested by you. The details of a phased program of investigations, analyses and report presentations are described, which will lead to development of conclusions as to source and extent of nitrate in groundwaters in Warm Springs Valley.

In this first phase we have also presented a preliminary analysis of possible origins of nitrate buildup in groundwaters taken from Irrigation Wells No. 1 and 2. Preliminary conclusions as to possible origin of nitrate buildup and possibility of future buildup in the groundwater basin have also been developed.

The analyses and research which support this first phase report have been primarily the work of Dr. Jerold Behnke, hydrogeologist, and Dr. John V. A. Sharp, hydrogeochemist. We have also made extensive use of materials prepared by R. J. Glenn, geologist. It is anticipated that Dr. Behnke, Dr. Sharp and Mr. Glenn will continue to be actively involved in subsequent phases of this investigation.

We intend that this report may be used to indicate to appropriate public health authorities, the nature and extent of investigations and analyses which will be undertaken in order to verify the acceptability of quality of Warm Springs Valley groundwater for domestic use.

Yours truly,

SHARP, KRATER, ENGSTROM & ASSOCIATES, INC.

Milton L. Sharp

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SECTION 1 INTRODUCTION AND OBJECTIVES

1.1 Introduction and Background

During the past several years the groundwater system of Warm Springs Valley has been the subject of several reports which have indicated availability of water supply for the Palomino Valley community which will be developed by McCulloch Properties Inc. The analyses, investigations and report preparation have been directed by Sharp, Krater, Engstrom and Associates, Inc. in association with several qualified, specialized consultants including R. J. Glenn, geologist; Dr. Jerold Behnke, hydrogeologist and others.

Previous investigations have been concerned with water quality, and results of chemical analyses of water samples were included in the reports. Possible effects of development on water quality were analyzed; and, although some isolated quality problems were identified, it was concluded that water generally met public health standards and that urban development would not seriously affect water quality.

Following approval of the Palomino Valley project by the Washoe County Commissioners in June 1973, some additional chemical analyses were performed on samples taken from the existing Irrigations Wells No. 1 and No. 2. Unexpectedly, these tests indicated an increase in nitrate from about 16 to 20 parts per million (ppm) to about 75 to 80 ppm. U.S. Public Health Standards for a potable water supply limit nitrate content to 45 ppm. Locations of Irrigation Wells No. 1 and No. 2 are indicated on Figure No. 1 along with the locations of other wells and location of other pertinent features. (Figure No. 1 is contained in the envelope bound at the end of the report)

Upon discovery of the nitrate buildup, McCulloch Properties, Inc., as well as public health officials, become concerned about the suitability of the Warm Springs Valley groundwater basin as a source for municipal water supply. There was concern that the nitrogen buildup in the two wells might indicate general nitrogen buildup throughout substantial portions of the groundwater basin and that high nitrate water might migrate underground to locations of water supply wells in other parts of the valley.

In August 1973, Glenn analyzed the nitrate buildup and hypothesized that the nitrate may have originated from liquid rocket fuel spillage in Axe Handle Canyon resulting from rocket engine testing by North American Rockwell Company from 1962 to 1968. Subsequently, McCulloch Properties, Inc. determined that a more extensive evaluation, including the examination of other possible sources of the nitrate buildup and consideration of more intensive field investigations.

In order to conduct the more detailed analysis, the consultants responsible for preparation of the previous groundwater reports were retained by TIC Corporation, engineers for McCulloch Propperties, Inc., to develop a program of investigation and analysis, to conduct necessary field and laboratory investigation and studies, to report as conclusively as possible on the current and possible future extent of nitrate in the Warm Springs Valley groundwater basin and to establish the suitability of the groundwater in other locations for municipal water supply. Dr. John Sharp, hydrogeochemist, has also been associated as a consultant.

1.2 Scope and Objectives

The consultants have developed a program which involves several phases which will lead ultimately to a presentation of conclusions. The phased program has been developed in order to attain certain specific objectives:

1. The determination of the origin of nitrate buildup in Irrigation Wells No. 1 and No. 2.

2. The evaluation of the extent of nitrate contamination in the groundwater basin.

3. The determination of potential for nitrate buildup in other parts of the groundwater basin or for migration of existing high nitrate water to other supply wells.

4. The determination of general suitability of the Warm Springs Valley groundwater system as a municipal water supply.

Because of the complexities of the groundwater system, the consultants recognize that all of the objectives may not be attainable without some qualification. The program should, in any case, lead to definite determination as to suitability of the groundwater system as a water supply.

The phased program is defined as follows:

Phase 1 - Program Development
The available data will be collected and evaluated. Possible sources of nitrate buildup will be hypothesized and evaluated. A program of field exploration and further studies will be planned and preliminary conclusions will be developed. Phase 1 is covered essentially by this report.

Phase 2 - Field Exploration and Evaluation
The programs of field exploration and evaluation will be initiated and concluded. Data will be gathered and evaluated.

Phase 3 - Final Report and Conclusions
New data will be evaluated with respect to stated objectives, and conclusions for all of the stated objectives will be developed as definitively as possible.

SECTION 2 OCCURRENCE OF NITROGEN COMPOUNDS IN GROUNDWATER

2.1 Nitrogen Cycle and Nitrogen Compounds in Groundwater

Nitrogen compounds in naturally occurring surface and groundwaters are numerous and complex as demonstrated by Figure 2.

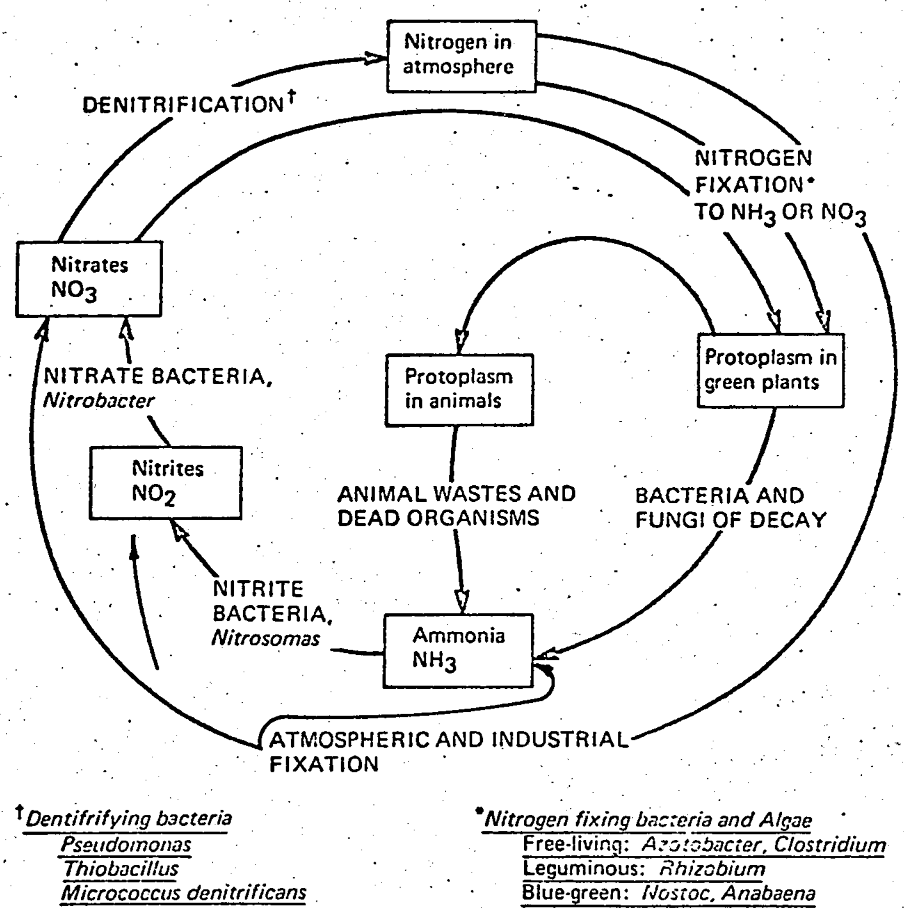


Figure No. 2 - Nitrogen Cycle

In groundwaters, nitrogen compounds occur primarily as a gas, ammonia (NH_3), and in the three ionic forms ammonium (NH_4^+), nitrite (NH_2^-) and nitrate (NO_3^-). Microorganisms transform gaseous atmospheric nitrogen into fixed forms such as ammonia and nitrate. Other microorganisms are able to denitrify fixed nitrogen back into gaseous forms such as nitrous oxide (N_2O) and free nitrogen (N_2).

As Figure No. 2 suggests, the type of nitrogen compound encountered in underground waters is related primarily to the type of microorganisms present and the amount of oxygen available in the soil water matrix. Temperature, solubility and pH also play important roles in determining which nitrogen compound will be locally abundant. In nature, the dynamics of nitrogen transformations are further modified by other variables including rainfall, temperature, evaporation and percolation rates, the type of plant cover and the amount of dissolved oxygen in the soil-water system.

Nitrate (NO_3^-) and nitrite (NO_2^-) anions are not adsorbed by soils or porous aquifer materials because these particles possess a negative surface charge which repels the two negative ionic species. However, the ammonium ion (NH_4^+) possesses a positive charge and will be adsorbed on the surface of negatively charged soil and aquifer particles. Ammonium ions bound to negatively charged particles may be oxidized via the action of microorganisms (see Figure No. 2), the resulting negatively charged nitrite or nitrate ions are no longer attracted to the negatively charged solid particles, and migrate freely in soil or groundwaters.

Nitrate reported in water analyses would include nitrate originally present in the water but, also, could include oxidized ammonia, ammonium, and nitrite originally present. Ammonium in some cases occurs in thermal waters and, unless proper sampling/analysis techniques are used, will tend to oxidize to nitrate and be reported as such (Roberson and Whitehead, 1961).

High nitrate values have been encountered in groundwaters having direct or indirect hydraulic continuity with decaying plant or animal material, agricultural fertilizers, domestic sewage, areas of high density of animal confinement and other materials containing soluble nitrogen compounds. Stout et. al. (1965) compared groundwater nitrate accumulations beneath a domestic sewage treatment plant, cropped areas and areas having a native vegetative cover. Schroepfer and Preul (1964) described the travel of nitrogen compounds in laboratory soil columns and beneath waste stabilization ponds in the field. Schmidt (1972) and Behnke and Haskell (1968) discuss nitrate buildups in groundwaters beneath subdivisions served by septic tanks and sewage treatment plant oxidation ponds.

Nightengale (1970) compares the rates of nitrate groundwater buildup in urban and agricultural areas in Fresno County, California. Hem (1959) describes high nitrate concentrations in deep desert basin wells, and he attributes the nitrate to the possible leaching of nitrate fixed in the soil by desert plants or the progressive leaching of old organic-rich, buried soil horizons. Glenn (1973) ascribes the nitrate buildups in Irrigation Wells 1 and 2 in Palomino Valley to the infiltration and down-gradient migration of nitrogen rich, rocket fuels originally discharged in Axe Handle Canyon.

The occurrence of nitrate in groundwater of Warm Springs Valley may be related to any of the sources described in the technical literature or to a combination of such sources.

2.2 Occurrence of Nitrate in Warm Springs Valley

Previous reports (Sharp, Krater, Engstrom and Associates, Inc. 1972 and 1973 and Glenn) have indicated that groundwaters in Warm Springs Valley did not contain excessive nitrate concentration. Nitrate concentrations of 16 to 20 ppm were noted in Irrigation Wells No. 1 and 2 but the relatively low concentration compared to health standards (45 ppm) indicated that the water was acceptable for domestic use. Behnke (1973) in the Sharp, Krater, Engstrom report concluded that nitrate would not present a serious threat to the acceptability of the Warm Springs Valley groundwater basin as a municipal supply. The nitrate buildup in Irrigation Wells No. 1 and 2 was noted only after completion of the 1973 Sharp, Krater, Engstrom report.

Occurrence of nitrate in Warm Springs Valley wells is summarized in Table A. Figure No. 3 depicts graphically the buildup of nitrate in Irrigation Wells No. 1 and 2.

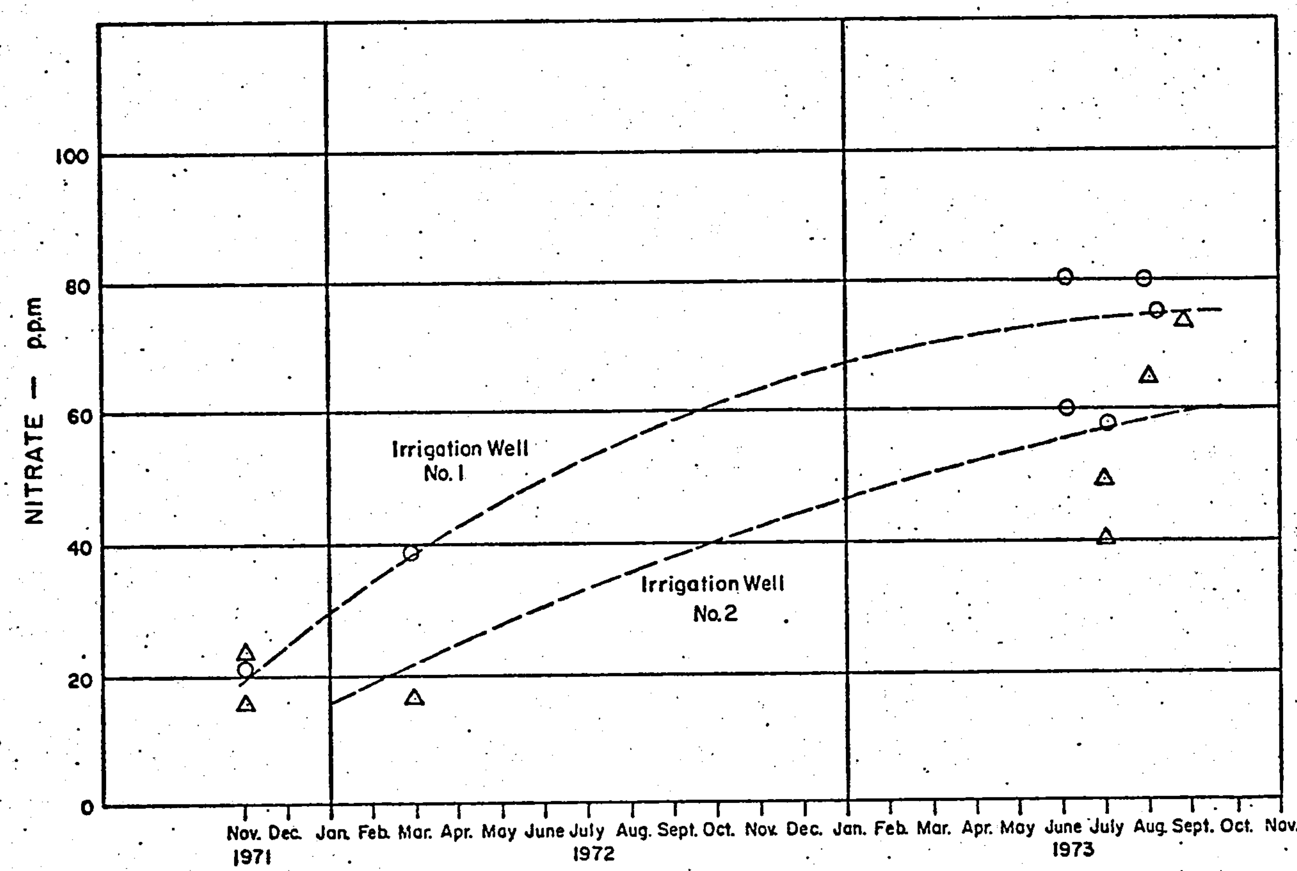


FIGURE NO. 3
NITRATE BUILDUP, WELLS NO. 1 AND NO. 2

TABLE A

NITRATES IN GROUNDWATER
WARM SPRINGS VALLEY

WELL	DATE OF TEST	NITRATES, PPM
Larue	11-71	2.0
	7-73	4.0
	8-73 (5 tests)	3.0 to 4.0
T-1	10-64	0
	7-73	4.0 to 5.0
	8-73 (5 tests)	4.0 to 5.0
T-3	10-64	0
	7-73	1.0
T-4	10-64	1.4
	7 and 8-73 (6 tests)	3.0 to 5.0
T-8	8-73	6.0
Sharrock	10-64	Trace
	7 and 8-73 (7 tests)	3.0 to 4.0
Industrial Well	11-71	16 to 18
Hot Well	11-71	0
Irrigation Well #1	11-71	16
	11-71	21
	3-72	39
	6-73	86
	7 and 8-73	75 to 80
Irrigation Well #2	11-71	16 to 22
	3-72	23
	7-73	40 to 50
	8-73	65-77

All of the wells indicate some nitrate increase from 1964 to 1971. This should not be taken as evidence of general nitrate buildup because the test results could be influenced by modifications in testing procedures, handling of samples or by techniques of a particular laboratory technician.

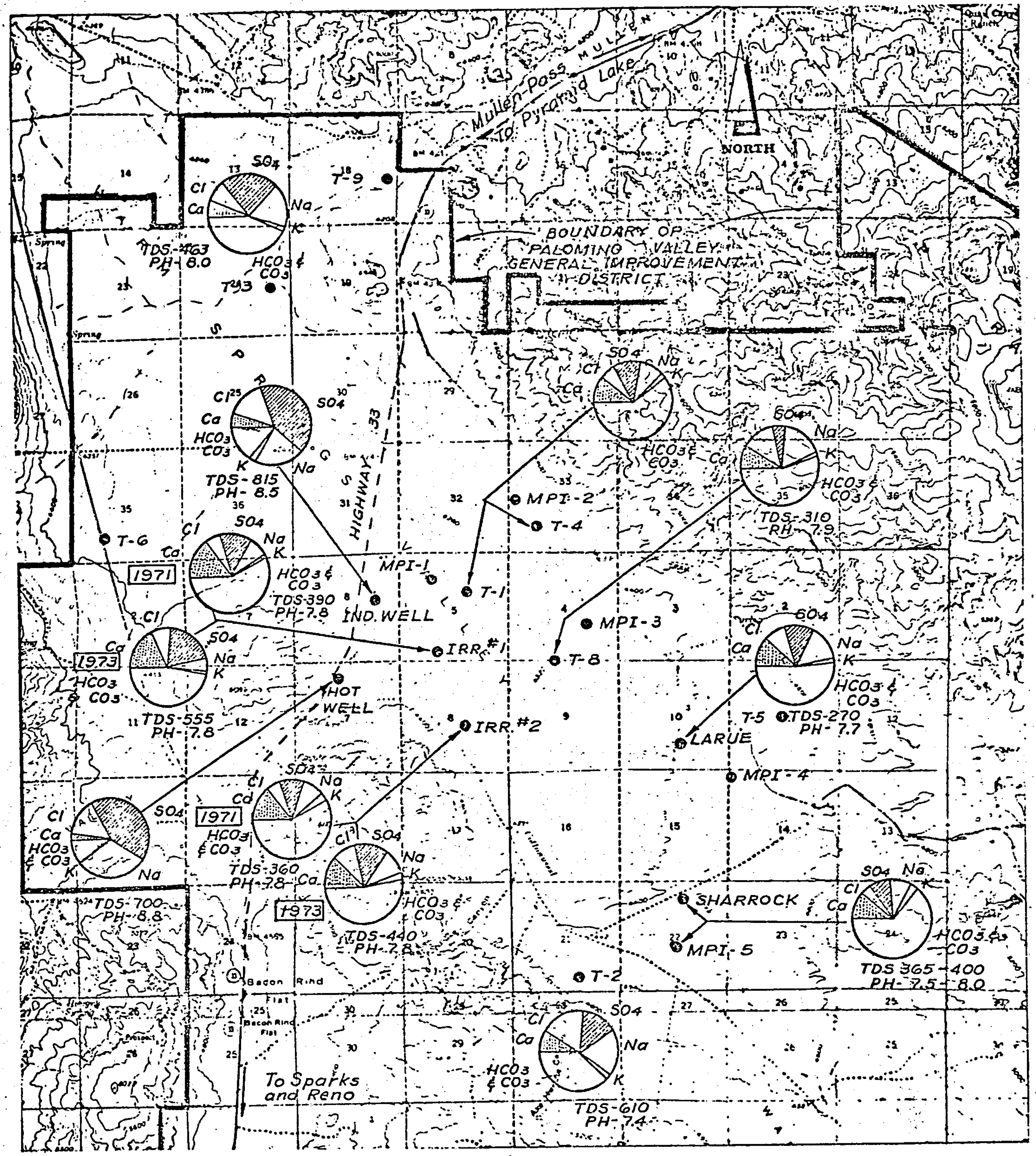
2.3 Water Quality in Warm Springs Valley

Results of water quality tests have been reported in the SKEA reports (1972 and 1973) and in reports prepared by Glenn for North American Rockwell Corporation. Additional chemical analyses have been obtained more recently.

Results of chemical analyses of well waters are presented graphically in Figure No. 4. Relative proportions of six of the major chemical constituents are indicated, in circular diagrams in order to permit generalized comparison among water samples.

Figure No. 4 does not show quantitive values for chemical composition but only relative proportions of calcium (Ca), chloride (Cl), sulfate (SO_4), sodium (Na), potassium (K), and alkalinity as bicarbonate (HCO_3) or carbonate (CO_3). Examination of Figure No. 4 indicates that relative proportions of chemical constituents are similar throughout the groundwater basin except for the "Hot Well" located in Section 7, T22N, R21E and the "Industrial Well" located in Section 6, T22N, R21E.

The Hot Well and the Industrial Well show higher proportion of sulfate and sodium compared to most of the groundwater in the basin and lower proportions of bicarbonate and carbonate. Figure No. 4 also indicates temporal changes in chemical constituents of samples taken from Irrigation Wells No. 1 and 2 in 1971 compared to samples taken in 1973. In both wells; calcium, sulfate and chloride proportions have increased while bicarbonate and carbonate proportions have decreased. Total dissolved solids have also increased in both wells. The chemical changes of water taken from Irrigation Wells No. 1 and 2 have been accompanied by an increase of nitrate content.



Legend:

- Well Location - ●
- Cl - chloride
- Ca - calcium
- SO_4 - sulfate
- Na - sodium
- HCO_3 - bicarbonate
- CO_3 - carbonate
- TDS - Total Disolved Solids

Figure No. 4

Chemical Constituents of Groundwater

Warm Springs Valley

SECTION 3 ANALYSIS OF POSSIBLE ORIGIN OF NITRATE IN IRRIGATION WELLS NO. 1 AND 2

3.1 General Discussion

After reviewing the hydrogeologic conditions in Warm Springs Valley and the literature concerning nitrate sources in groundwaters, four probable sources of nitrate enrichment have been identified for additional, more detailed analysis. Probable sources include:

1. Vertical downward leaching from irrigated lands.
2. Upwelling of thermal water associated with a major fault system.
3. Expulsion of nitrogen laden waters from organic rich, clay layers in response to reduced pressures resulting from extensive pumping.
4. Infiltration and down gradient migration of liquid rocket fuels.

Other possible sources exist such as nitrate salts, mammals and wastes, which could be suggested by results of additional field investigations. In this preliminary report the four identifiable, most likely sources are discussed in detail.

3.2 Leaching of Irrigated Lands

Stout, et.al. (1964) stated that it is not unusual for legume plant covers to fix 880 lbs. of nitrate per acre per annum. Feth (1966) indicates that legumes may fix from 150 to 780 lbs. of equivalent nitrate per acre per annum. Since alfalfa is grown in Warm Springs Valley, it may be possible to fix as much as 880 lbs. of nitrate per acre per year beneath this type of plant cover. For a consumptive use of water of 3 acre feet per year with an assumed 50% leaching requirement, an estimate of the ppm nitrates in the soil profile below the root zone can be calculated as follows:

$$\text{ppm } NO_3^- = \frac{8.80 \times 10^8}{4.36 \times 10^4\ (1.5)\ 62.4} = \frac{8.8 \times 10^8}{40.8 \times 10^5} = \frac{8.8 \times 10^8}{4.08 \times 10^6} = 2.15 \times 10^2$$

$\underline{\underline{215}}$ ppm NO_3^-.

Stout, et.al. (1964) estimates that the average concentration of nitrate arriving at the water table is approximately 1/4 of the amount found in the central portions of the soil profile. If 215 ppm nitrate is representative of nitrate concentrations in the central portions of the vertical profile near Irrigation Wells 1 and 2, then approximately 54 ppm nitrate might be arriving at the water table in annual waves. The concentrations of the annual nitrate waves depend upon such variables as irrigation amounts, annual precipitation, soil textures, and annual evapotranspiration. The 54 ppm nitrate estimate is interesting, because added to the 1971 background nitrate level of 21.5 ppm a total of 75.5 ppm nitrate is indicated, which is exactly the current nitrate concentration found in the wells.

An examination of the driller's logs for Irrigation Wells 1 and 2 does indicate that there probably is a relatively open profile to the water table. At least there are no thick, impermeable layers between the ground surface and the water table. Figure 5 shows the driller's logs for the two irrigation wells.

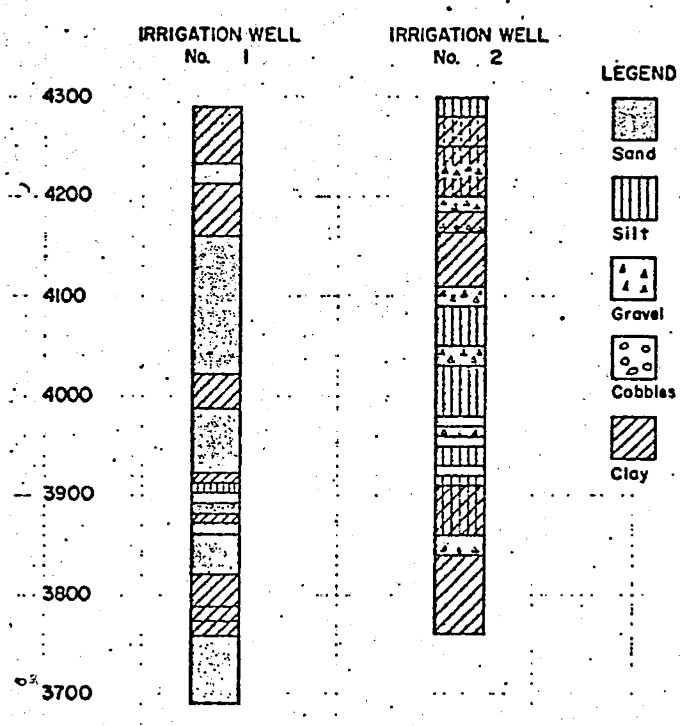


FIGURE NO.5

DRILLERS LOGS FOR IRRIGATION WELLS NO.1 AND NO.2

If leaching of nitrogen from legumes is the source of nitrate buildup in Irrigation Wells No. 1 and 2, the presence of nitrogen in the form of nitrate, nitrite and ammonium should be detectable in the soil mantle. The nitrate concentration should also be higher in the upper levels of the water table acquifers. These conditions must be verified by additional testing.

3.3 Deep Upwelling, Thermal Waters

The analysis of chemical composition of groundwaters as presented in Figure No. 4 indicates that waters from the Hot Well and the Industrial Well are geochemically different from the waters in other parts of the basin. Basically, sulfate and sodium are dominant chemical constituents in water samples taken from these two wells. Calcium is a relatively minor constituent and chloride is relatively more important than in most of the basin's groundwaters. Bicarbonate and carbonate are relatively minor constituents of water taken from the Hot Well and the Industrial Well and total dissolved solids are high.

The comparision of water quality changes in samples taken from Irrigation Wells No. 1 and 2 in 1971 with samples taken in 1973 indicate that the waters in Irrigation Wells No. 1 and 2 are assuming quality characteristics similar to waters in the Hot Well and the Industrial Well (see Figure No. 4).

This geochemical evidence suggests the possibility that waters containing nitrogen compounds and high sulfate and sodium concentrations, may have a common deep, thermal origin not representative of the remaining, shallower groundwaters of the Warm Springs Valley water basin. Geologic data taken from a Masters Thesis by Glenn (1968) and the geophysical study conducted by Gimlett (1967) show a northwest-southeast trending normal fault along the southwest margin of the basin. The depth to bedrock, suggested by Gimlett's geophysical work, indicates that the west side of Warm Springs Valley was tectonically the most active. Also, the presence of thermal water from the Hot

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Gordon Freudig
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Mineral

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Jack Cardinalli
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Palomino Valley

Ernie Gregory
Dave Mendelsw
Gene Clark
Jerry Brownfield

Dr Dick Cooley
Gil Cochran

Gene Rush - USGS
others

State & County Health Depts are to advise planning commission staff when they are satisfied that there is sufficient quantity & quality for development. Then processing of 4 subdivisions will start.

Report will probably be completed in 60-90 days.

well may indicate the upwelling of deeper, hotter waters associated with this fault system.

The combination of geologic, geochemical and geophysical evidence indicates possible upwelling of deep, thermal waters associated with a fault system. The continued pumping of water from Irrigation Wells No. 1 and 2 could possibly be inducing local upwelling of deeper waters containing nitrogen compounds, sulfate and sodium similar to waters already apparent in the Hot Well and the Industrial Well.

Chemical analysis of waters from the Hot Well does not indicate nitrate, but more thorough chemical investigation may reveal nitrogen in other forms such as ammonium, ammonia or nitrite. Analysis of water from the Industrial Well does indicate higher nitrate content than from most of the basin. If deep upwelling is the source of nitrate, it may be possible to detect higher nitrate concentrations from water taken at greater depths than from waters nearer the surface.

3.4 Expulsion of Nitrate from Organic Clays

Figure No. 6 shows the relative amounts of sand, silt and clay in the basin as estimated from driller's logs. The lack of thick sequences of organic-rich, argillaceous material in the basin tends to rule out the possibility of expulsion from clay. However, according to the driller's log, a blue-clay layer was encountered in the Industrial Well located in Section 6, T22N, R21E, and shown in Figure No. 6 which could possibly be a local source of nitrogen enrichment. The clay was encounterd at a depth of 365 feet and the layer was never fully penetrated at 500 feet, so a known thickness of 135 feet of blue-clay exists at that location. The blue-clay was not encountered in Irrigation Wells 1 and 2 although drilling reached elevations well below the elevations at which blue-clay was encountered in the Industrial Well. Blue-clay may exist at an elevation below the depth of drilling of Irrigation Wells No. 1 and 2 or below the depth of drilling of other wells.

3.5 Infiltration and Migration of Liquid Rocket Fuel Spillage

The possibility of nitrate contamination of water at Irrigation Wells No. 1 and No. 2 by rocket fuel spillage has been discussed in detail by Glenn (1973). Subsequent evaluation and investigation has indicated that this source is only one of several which might have induced the nitrate buildup in Irrigation Wells No. 1 and 2.

The details of evaluation of possible rocket fuel contamination need not be repeated here, but future programs of investigation and analysis will review and evaluate this possibility.

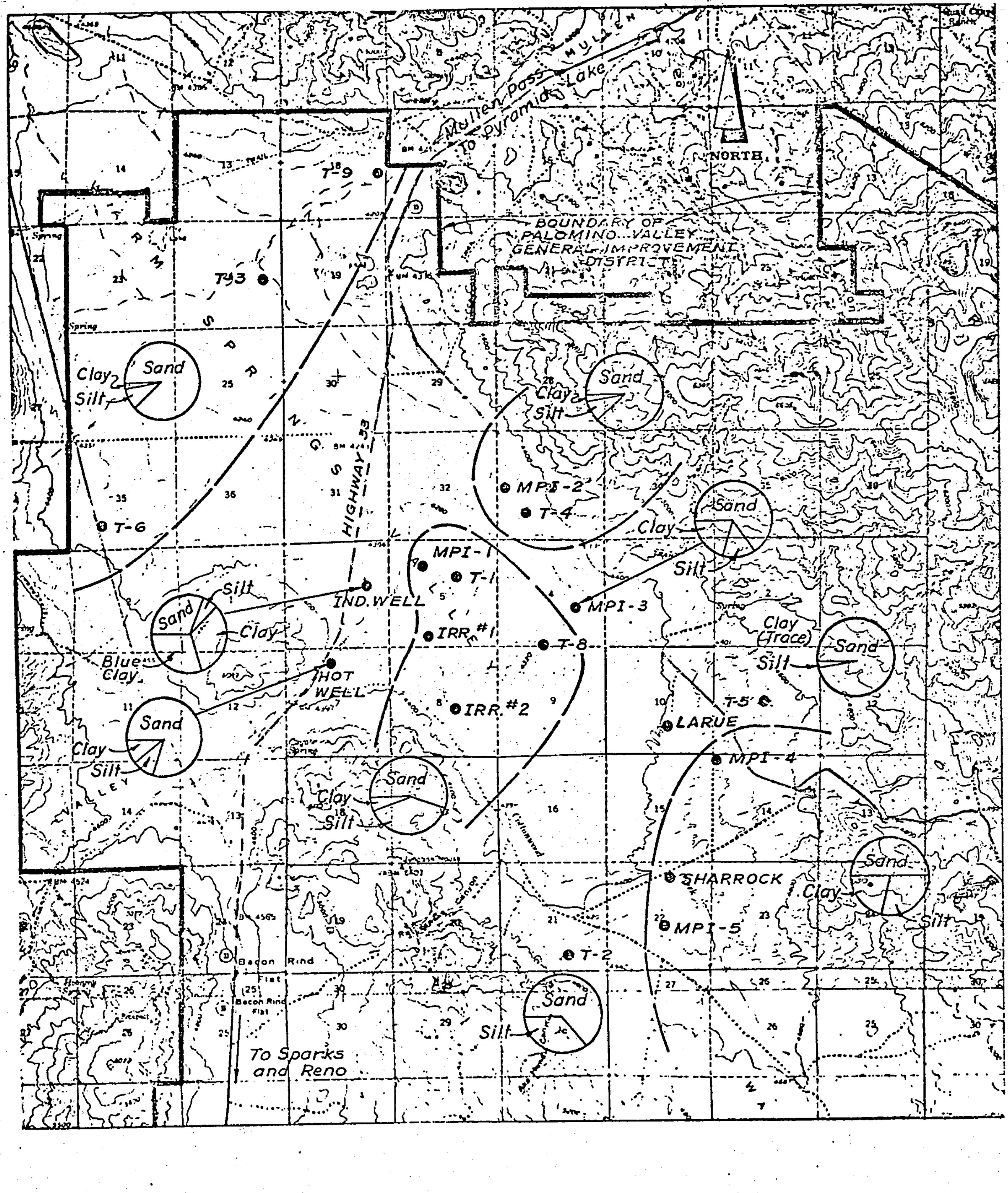

Figure No. 6

Generalized Driller's Logs

SECTION 4 ANALYSIS OF POSSIBLE EXPANSION OF NITRATE CONTAMINATION

4.1 Relationship Between Origin of Nitrate and Possible Expansion of Contamination

If it is possible to determine the origin of nitrate buildup in Irrigation Wells No. 1 and 2, it will be possible to evaluate the potential for occurrence of similar buildup in groundwaters in other parts of the basin. Even if the origin cannot be precisely determined, it should be possible to evaluate the possibility of similar nitrate buildup in other parts of the basin with a reasonable degree of certainty.

Concern has also been expressed that nitrogen bearing water from the vicinity of the irrigation wells might migrate to other parts of the groundwater basin due to changing hydraulic gradient caused by drawdown at other locations. Water movement can be predicted fairly well if adequate data are available, and such movement can be controlled by proper management of drawdown and draft on wells throughout the basin.

The four possible sources of nitrate buildup can be analyzed as localized conditions and the remainder of the groundwater basin can be examined for conditions which might indicate similar nitrate sources. Additional field investigations and analyses will provide data to make such an evaluation possible. Similarly, migration of water from one part of the basin to another will be analyzed by using more detailed field data and investigations.

4.2 Effect of Developmental Conditions on Nitrate Levels

The possible buildup of nitrate due to development conditions has been discussed in previous groundwater studies (Sharp, Krater, Engstrom 1972 and 1973). It was concluded that, with the low background level of nitrate in the groundwater basin and the low density and dispersed nature of development, there would be no significant buildup of nitrate. The earlier conclusions can be reconsidered and verified using additional data derived from more extensive field exploration.

SECTION 5 RECOMMENDED ADDITIONAL INVESTIGATIONS

In order to test the various hypotheses advanced as to possible origin of nitrate in Irrigation Wells No. 1 and 2, a program of additional field exploration is recommended as Phase II of this investigation. Data gathered may apply to one or more of the hypotheses and could even indicate other potential sources of nitrate which would be examined.

5.1 Soil Profile Analysis

Soil cores will be obtained at selected vertical intervals beneath cropped areas, under areas of flood and sprinkler irrigation, beneath adjacent uncropped areas, under native vegetative cover, and beneath the areas of past releases of rocket fuel in the Axe Handle Canyon. The cores will be sealed and frozen in the field and conveyed to a laboratory where soil moisture will be extracted and chemical analysis for nitrogen species will be performed. These data will provide information concerning the vertical distribution of nitrogen species between the soil surface and the water table.

5.2 Static Well Water Analyses

After the two irrigationwells have been shutdown for the winter season, and after the water levels have fully recovered, water samples will be taken at selected time intervals at various vertical depths. These waters will be subsequently analyzed for nitrate, nitrite, ammonium and nitrogen. If the vertical downward leaching theory is predominate, then the static groundwater should display a cap of high nitrogen waters in the upper portions of the aquifer near the water table. If a deep upwelling is the source, there could be a uniform nitrogen concentration or an increased concentration with depth. If a single strata in the aquifer system is responsible for most of the nitrogen, this should be indicated by a high concentration band at a particular depth.

In addition to sampling and testing of the irrigation wells, waters from the Hot Well and Industrial Well will be analyzed for the various nitrogen species. All water samples will be acidified to pH near 4.0 and mercuric chloride added to 40 ppm, Hg^+ to preserve the various nitrogen species. This will forestall oxidation of ammonia, ammonium and nitrite to nitrate.

By testing samples from the Hot Well and Industrial Well, geochemical comparisons may be made with water in the irrigation wells and with water in other locations. From the geochemistry comparisons, conclusions as to similarity of waters and possible origin of waters may be developed.

5.3 Well Pumping Tests

The only wells in Warm Springs Valley which have been extensively and continuously pumped are the two irrigation wells. At present, several additional wells are under construction or will be constructed. These new wells are identified by "MPI" on Figure No. 1.

When Well MPI 5 is completed, pumping tests will be conducted involving continuous pumping for at least 30 days. Samples will be taken and analyzed chemically on a continuous basis. Temperature of water will also be recorded continuously. As other wells are completed, similar pumping tests will be undertaken.

The pumping tests will be used in an effort to determine if extensive pumping will cause a change in water quality similar to changes identified in the irrigation wells.

5.4 Examination and Comparison with Conditions in Similar Groundwater Basins

Using available hydrologic, geologic and geochemical data, comparisons will be attempted between Warm Springs Valley and other similar intermountain basins in Nevada in which buildup of nitrogen species from legumenous and thermal sources might be expected.

If similar nitrogen buildup in other groundwater basins can be identified and the cause of the buildup identified, the comparison may lead to conclusion as to probable origin and future course of nitrogen buildup in the two irrigation wells and throughout Warm Springs Valley.

5.5 Trace Elements and Stable Isotopes

Groundwaters associated with thermal sources commonly show elevated temperatures; high arsenic, fluoride and boron concentration (Sharp, 1969); and characteristic ratios of certain ions. Appropriate temperature and chemical measurements will be made of groundwaters and results evaluated in terms of these guidelines which indicate influence of thermal water.

The stable isotope of nitrogen, N^{15}, has been of some use in determining source of nitrate in surface waters (Kohl, et.al., 1971). This possibility will be investigated for Warm Springs Valley.

5.6 Nitrogen Balances

Using the information developed in the above studies and from literature sources, a nitrogen (nitrate) balance will be attempted for the area of interest and other areas which are found to be in trial. This will provide a possible basis for understanding controlling or managing nitrate occurrences and buildups.

SECTION 6 PRELIMINARY CONCLUSIONS

Although definite conclusions as to origin and extent of nitrate contamination cannot be developed until more data are obtained, some preliminary conclusions can be derived on the basis of available data and preliminary evaluation.

1. The high nitrate concentration in the two irrigation wells appears to be a localized phenonemon possibly associated with downward leaching of irrigated lands or the vertical upwelling of deep, nitrogen-laden thermal waters associated with fault complexes along the west side of the valley.
2. Through proper management, groundwater hydraulic gradients can be maintained within the Warm Springs Valley groundwater basin to preclude the transfer of the nitrogen-rich waters of local origin to other portions of the basin.
3. For the initial phase of development, McCulloch Properties, Inc. is contemplating use of a new domestic water supply well in the south end of the basin, (MPI-5. See Figure No. 1). An existing well, the Sharrock Well, located about one-half mile north of the MPI-5 Well has been sampled and tested. Results of nitrate determinations in the Sharrock Well are summarized in Table B.

TABLE B

NITRATE VALUES FOR THE SHARROCK WELL

Sample Date	Nitrates ppm
July 23, 1973	4.0
July 30, 1973	3.0
Aug. 5, 1973	4.0
Aug. 8, 1973	4.0
Aug. 13, 1973	3.0
Aug. 18, 1973	3.0

* Analysis preformed by Edward S. Babcock and Sons Laboratory Riverside, California

The results of testing of the Sharrock Well indicate that nitrates should not be a problem in MPI-5. This conclusion will be verified during test pumping. Furthermore, as described by Glenn (1973), water from the new well is derived from an artesian system characterized by the fact that water was first encountered at a depth of 280 feet below ground surface and after completion of the well the static water level rose 120 feet to within 160 feet of the land surface. The artesian condition indicates that contamination of groundwater by leaching due to vertical, downward movement of surface waters will be difficult. Also, the presence of confining soil layers should preclude the possibility of surface waters of lower quality from mixing with the deeper artesian water contemplated for domestic supply.

All of these conditions lead to a conclusion, subject to verification by test pumping, that MPI-5 can be used as a source of water without fear of nitrate buildup or without fear of inward migration of nitrogen-bearing water sources.

4. The two irrigation wells cannot be used as a part of the municipal water supply, but they can be used for irrigation of agricultural land and ornamental features without fear of contamination of other water supplies or migration of contaminated supply to other parts of the basin. Water from the irrigation wells might be used in the municipal supply if mixed with low nitrate waters from other sources.
5. The preliminary conclusions can be verified by the additional investigations. It should then be possible to draw final conclusions as to the localized extent of nitrate buildup and the acceptability of the remainder of the groundwater basin as a source for water supply to Palomino Valley.

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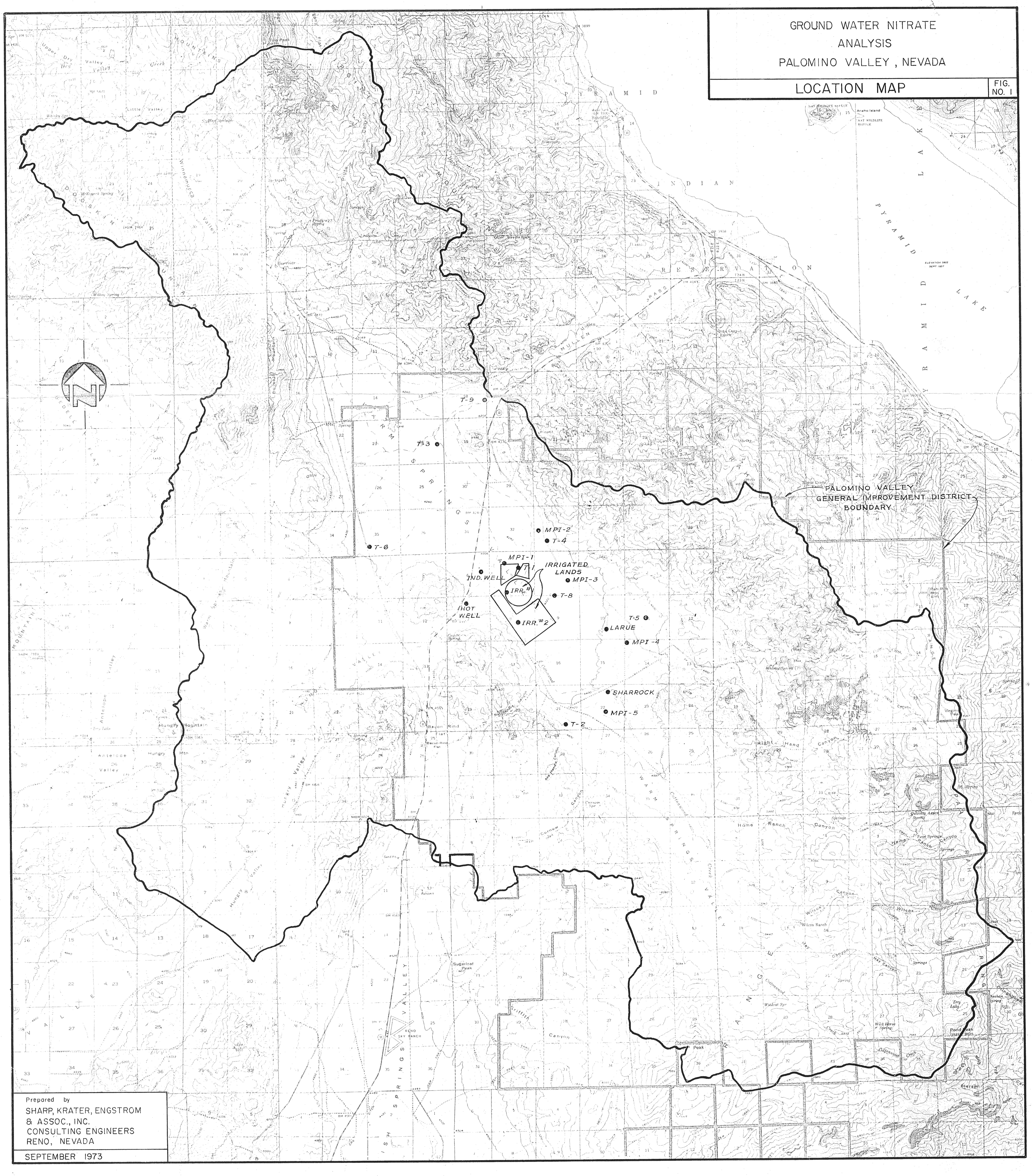
GROUND WATER NITRATE
ANALYSIS
PALOMINO VALLEY, NEVADA
LOCATION MAP
FIG. NO. 1
PALOMINO VALLEY
GENERAL IMPROVEMENT DISTRICT
BOUNDARY
T-9
T-3
T-6
MPI-2
T-4
MPI-1
T-1
IND. WELL
IRRIGATED
LANDS
MPI-3
IRR. #1
T-8
HOT
WELL
T-5
IRR. #2
LARUE
MPI-4
SHARROCK
MPI-5
T-2
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