Summary Report

Investigation of Irrigation Water Source for Soccer Complex

City of Rapid City Project 13-2098, CIP #50963

Prepared for

City of Rapid City
300 6th Street
Rapid City, SD 57701

August 26, 2013

Prepared by

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The City of Rapid City is planning to construct a sports complex in northeast Rapid City which will initially consist of twelve soccer fields on approximately 40 acres. About 81 percent of the site will be natural grass turf requiring irrigation. Total annual irrigation needs are expected to average over 3 million gallons per year, with peak daily usage of about 200,000 gallons per day.

The City municipal water system has adequate capacity to provide all irrigation needs to the sports complex, but treated drinking water is not required for turf irrigation. Untreated water from other sources would be acceptable as an irrigation supply, and could potentially reduce costs and demands on the City drinking water system. This study and report presents evaluation of technical and economic feasibility of potential alternate irrigation supply sources for the soccer complex.

Due to the absence of a reliable stream source in the vicinity, surface water was ruled out as a possible irrigation supply. Four groundwater supply sources were identified and investigated as potential sources.

<u>Potential Groundwater Sources</u>

Box Elder Creek Alluvium
Inyan Kara Sandstone
Minnelusa Sandstone
Madison Limestone

The Box Elder Creek Alluvium is shallow groundwater stored in subsurface gravel deposits in the Box Elder Creek floodplain. The other three potential sources are deep bedrock aquifers located from 1,600 feet to 4,300 feet below the ground surface. The bedrock aquifers are under artesian pressure which brings the water to 200 feet to 300 feet below the ground surface, thus making utilization of the water feasible using submersible well pumps. The deep aquifers are widely used in the Black Hills region for drinking water, and water quality is typically satisfactory for irrigation uses as well. Water quality in the shallow creek alluvium is typically not as good as the deep aquifers, and the quality may present soil salinity hazards with long term usage.

Schematic designs were completed for each groundwater alternative to provide a basis for cost comparison. Capital costs and operating costs were estimated for each alternative and converted to a present worth value for comparative purposes. Following is a summary of present worth costs of each alternative using a 20-year period and an interest rate of 3 percent.

<u>Summary of Present Worth Costs</u>

Source	Cost (Present Worth, 20 yrs.)
Box Elder Creek Alluvium	$ 2,963,000
Inyan Kara Sandstone	$ 2,176,000
Minnelusa Sandstone	$ 2,492,000
Madison Limestone	$ 2,768,000

For comparison, the value of an equivalent amount of municipal drinking water based on 2013 City rates for commercial irrigation over the same 20-year period is as follows:

City Water Value: $2,093,000

The analysis does not show an economic advantage for using an alternative supply source in lieu of municipal drinking water. Non-tangible items such as reducing water capacity and fire protection for long-term growth were not considered.

In addition to the higher cost of alternative supplies, there are a number of technical issues with the alternatives which are of concern. These issues include possible low yielding wells, poorer quality water, interference with existing water rights and others. It is considered likely that municipal drinking water would need to be used as a back-up supply source, or as a supplemental supply source for all of the alternatives. If the proposed soccer complex is expanded to use the full 80-acre site, then the groundwater alternatives are likely to have insufficient capacity for the expansion.

It is concluded that there is no identifiable alternate irrigation supply source in this area of the City which compares favorably with the City municipal supply option in terms of cost, reliability and capacity for expansion.

1. Introduction

1.1 Background

The City of Rapid City is planning to construct a sports complex in northeast Rapid City which will initially consist of twelve soccer fields plus support facilities, including parking and utility infrastructure. The proposed project is located on an 80-acre site on the west side of Elk Vale Road, approximately 1.5 miles north of Interstate 90, Exit 61. Refer to the vicinity map in Figure 1.

The initial 12-field project will develop the east 40 acres of the site. There is no firm site plan for the westerly 40 acres, but it is anticipated that it will be developed into soccer or similar athletic field uses. There is no firm timetable for the second phase expansion, but it is expected to be at least 10 or more years before expansion is feasible or warranted. The site development plan for the initial 40-acre development phase is shown in Figure 2.

The initial development plan shows about 81 percent of the 40-acre site (32.4 acres) as being natural grass turf or similar landscape cover, with the balance being primarily roof and pavement surface. It is proposed to provide automatic sprinkler irrigation facilities for all turf and landscape areas as a part of site development. It is proposed to irrigate on an as-needed basis for the entire growing season (May through October) to maintain a healthy dense grass cover for athletic field areas. Irrigation timing and application rates will be managed for water conservation under the control of the City Parks and Recreation Department.

The current plan is to utilize the Rapid City municipal potable water supply system as the supply source for irrigation. The planned irrigation system would connect directly to the City distribution system and use normal City water main pressure to operate the sprinkler equipment without supplemental pumping. The proposed City supply would be metered and would include the necessary backflow prevention equipment required by plumbing codes. As described in more detail later in this report, the total annual water use for irrigation for the initial development is anticipated to be in the range of 15 to 30 million gallons per year.

1.2 Scope

The City of Rapid City has authorized this investigative study to explore and evaluate the technical and economic feasibility of an alternate non-potable irrigation supply source for the sports complex. Alternate water supply sources could include wells or surface water supplies. Technical feasibility analysis includes quantity, water quality, and water rights issues which may apply to alternate sources. The economic feasibility includes cost comparison of capital and operating costs of an alternate supply source as compared with the value of City potable water to be used for irrigation.

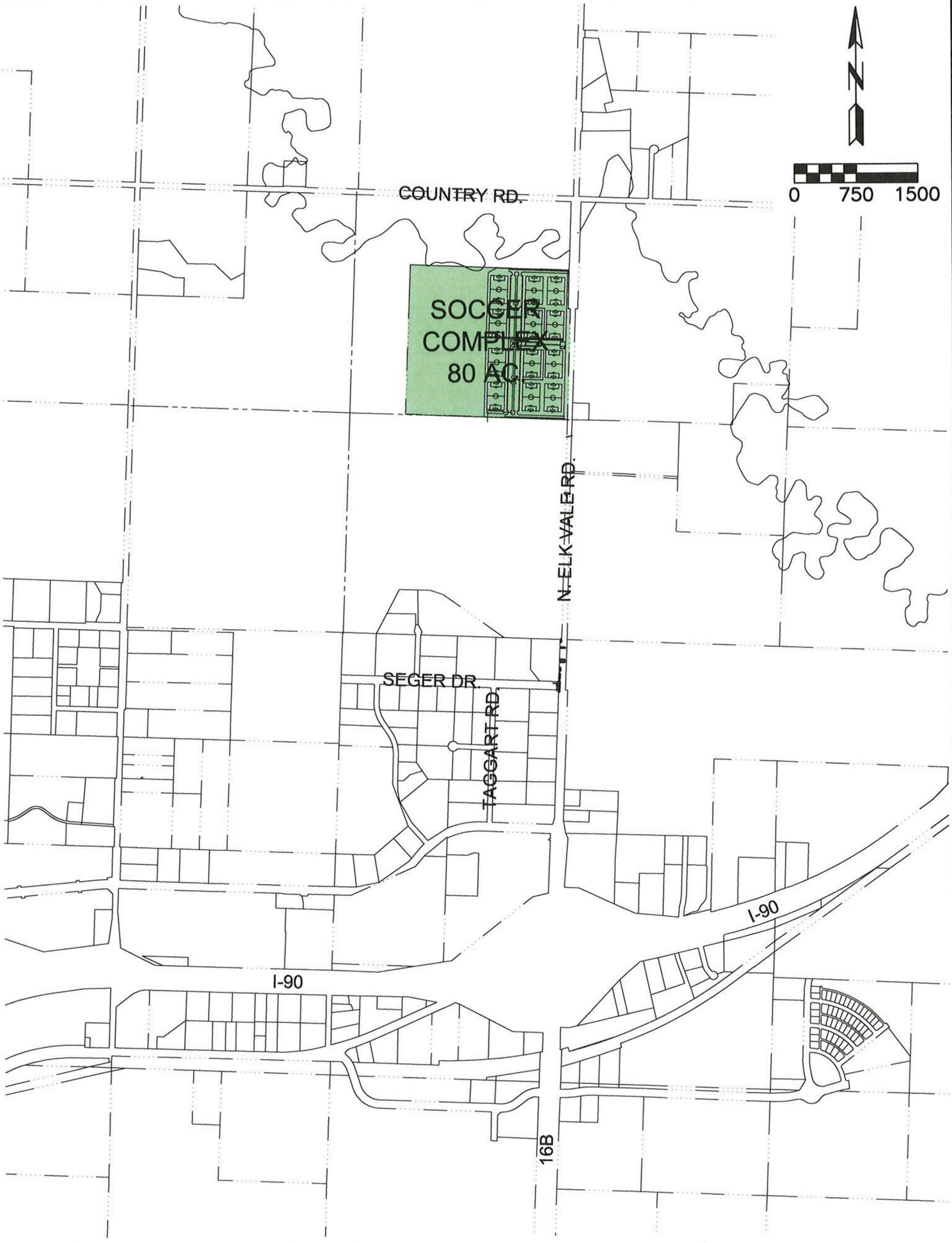

FIGURE 1
VICINITY MAP

cetec

August 06, 2013 6:18:49 a.m.
Drawing: FIGURE 1.DWG (FOX) (\\MAIN-DATA\CETEC\PROJECTS & PROPOSALS\13126.00 RC SOCCER COMPLEX IRRIGATION SUPPLY STUDY\DRAWINGS\FIGURES\)

FIGURE 2
SITE DEVELOPMENT PLAN

cetec

August 06, 2013 6:23:50 a.m. Drawing: FIGURE 2.DWG (FOX) (\\MAIN-DATA\CETEC\PROJECTS & PROPOSALS\13126.00 RC SOCCER COMPLEX IRRIGATION SUPPLY STUDY\DRAWINGS\FIGURES\)

2. Irrigation System Criteria

2.1 Irrigated Land Area

The anticipated total irrigated land area for Phase 1 of the sports complex is approximately 32.4 acres. This area is primarily natural grass turf, but includes a small percentage of other peripheral landscape area. There is no land use plan for the remaining 40 acres of the site. For purposes of this investigation, it has been assumed that the second phase of the complex will have a similar composition, and that an additional 32.4 acres will be irrigated at a future time. Total land irrigation used in this study is as follows:

Irrigated Area

Phase	Area	% Irrigated	Irrigated Area
1	40 ac.	81%	32.4 ac.
2	40 ac.	81%	32.4 ac.
Total	**80 ac.**	**81%**	**64.8 ac.**

2.2 Agronomic Water Needs

The City of Rapid City Public Works Department and Parks and Recreation Department have evaluated irrigation water requirements for turfed parklands and athletic fields. A consultant for the City performed a comprehensive study of irrigation demands for turf grass in 2012 which evaluated total water requirements, seasonal rainfall variations, growing season and application efficiency of irrigation equipment[1]. The results of this study have been used to forecast irrigation demands at the proposed sports complex and are summarized in the following table.

Irrigation Requirements for Turf

Month	Dry Year in. / mo.	Dry Year in. / day	Average Year in. / mo.	Average Year in. / day	Wet Year in. mo.	Wet Year in. / day
May	4.67	0.15	2.47	0.08	0.00	0.00
June	6.95	0.23	4.01	0.13	1.62	0.05
July	9.41	0.30	6.76	0.22	5.41	0.17
August	6.38	0.21	5.96	0.19	5.94	0.19
September	3.93	0.13	3.81	0.13	1.90	0.06
October	3.40	0.11	2.75	0.09	2.59	0.08
Total (in. / yr.)	**34.74**		**25.76**		**17.46**	

The tabulation is based upon total irrigation water applied and an average 80-percent efficiency for spray irrigation equipment[2].

[1] 42nd Street Design Studio, FMG Engineering, Inc. *Memorial Park and Civic Center Irrigation Improvements,* April 16, 2012.
[2] Ibid, Page 4.

2.3 Irrigation System Design Concept

Preliminary plans and specifications for the sports complex have been completed at the time of this investigative study, thus the conceptual design and sizing of Phase 1 system components are known. Following is a design summary of anticipated equipment capacity, design flows and water application schedule.

Irrigation System Design Summary (Phase 1)

Irrigated Area:..32.4 ac.

Irrigation Heads:..................................turf rotors (30 – 35 gpm)

Supply Pressure: ....100 psi

Distribution Headers:.. 4" PVC

Zone Laterals:.. 3" PVC

Number Heads per Zone:..3

Design Flow per Zone: ....110 – 115 gpm

Total Number of Zones: 74

Number Zones Irrigated Simultaneously:.........................3 or 4

Peak Instantaneous Irrigation Flow: ....450 gpm

Irrigation Days per Week: 6

Irrigation Time of Day:......................... 9 PM to 9 AM (12 hrs.)

The projected monthly and annual irrigation volume needed for the initial 32.4 acres is summarized in the following table and is shown graphically in Figure 3.

Irrigation Volume Required

Month	Irrigation Volume / Month (Cubic Feet) Dry Year	Average Year	Wet Year
May	549,200	290,500	0
June	817,400	471,600	190,500
July	1,106,700	795,000	636,300
August	750,400	701,000	698,600
September	462,200	448,100	223,500
October	409,300	323,400	304,600
Annual Total (cubic feet)	4,095,200 cf	3,029,600 cf	2,053,500 cf
Annual Total (100 c.f. units)	40,952 units	30,296 units	20,535 units
Annual Total (gallons)	30,634,000 gal.	22,663,000 gal.	15,361,000 gal.

The proposed system is planned to operate on a 6-day week whereby the total irrigation need is provided in 6 operating days out of every 7. The peak-day use is thereby increased by a factor of 7/6 over the average day. The maximum daily demand for dry year and average year conditions using a 6-day operating week is as follows.

Figure 3 Forecast of Irrigation Usage

	May	June	July	August	September	October	Annual Total (c.f.)
Dry	549,200	817,400	1,106,700	750,400	462,200	409,300	4,095,200 cf
Average	290,500	471,600	795,000	701,000	448,100	323,400	3,029,600 cf
Wet	0	190,500	636,300	698,600	223,500	304,600	2,053,500 cf

Peak-Day Irrigation Use

Peak Month	Monthly Use	Days	Avg. Day Peak Month	Peak Daily Use in 6-Day Week
July (Avg. Year)	795,100 cf	31	25,648 cf/day	29,930 cf/day (224,000 gal./day)
July (Dry Year)	1,106,700 cf	31	35,700 cf/day	41,650 cf/day (312,000 gal./day)

An alternate irrigation supply meeting the Phase 1 demands must be capable of supplying up to 312,000 gallons per day on a sustained basis during a dry year period, and 224,000 gallons per day in an average year.

For a 12-hour operating period, the peak delivery rate of irrigation water for the Phase 1 project during July dry year conditions is as follows.

Peak Irrigation Rate

Peak Day Use	Peak Delivery Rate (12 hrs.)
312,000 gal./day	433 gpm

2.4 Alternate Supply Criteria

The City municipal water system is capable of providing the total irrigation volume needed, and the peak delivery rate required, without supplemental water storage or pumping. There is ample storage and hydraulic capacity in the distribution system to meet all irrigation needs.

An alternate irrigation water supply may require supplemental storage and pumping to operate the irrigation system on a reliable basis. For example, a low yielding well could be pumped on a 24 hour/day basis as long as a storage facility is provided to capture water produced during non-irrigation periods. Water stored in ponds or tanks would require a separate pumping system to deliver irrigation water at the required flow rate and pressure. It is considered feasible to use a combination of municipal supply and a non-potable alternative supply. If the non-potable alternative supply is inadequate to meet the overall irrigation needs, then the City system could serve as a back-up supply. As a back-up supply, the City system could supply shortfalls during peak use periods, or handle all supply in the event of equipment failure or other interruption in the alternate supply system. It may be possible to provide a high degree of reliability with an alternate supply by incorporating redundancy and emergency power equipment into the design. However, the cost of providing a failsafe supply would be much higher. City water will be available at the site for domestic needs regardless of the irrigation source used, and it is considered feasible and prudent to utilize the City water supply to provide back-up to any alternative non-potable irrigation supply source.

For purposes of this study, the following criteria for an alternate irrigation supply source have been selected.

<u>Alternate Irrigation Supply Evaluation Criteria (Phase 1, 12 Fields)</u>

- Design alternate supply for "average year" supply needs (224,000-gpd peak)
- City system can provide supplemental supply for dry year demands.
- Redundant sources not required for alternate supply (i.e. no stand-by wells).
- Emergency power supply not required for alternate supply (i.e. discontinue irrigation during power supply interruption).
- Redundant pumps are to be provided for pumped irrigation system to maintain service in the event of pump failure.
- Pumping equipment shall be designed to meet the peak dry-year application rate (450 gpm).

3. Irrigation Supply Alternatives

3.1 Alternative Sources Considered

Surface water (lakes, flowing streams) is not present in the sports complex vicinity. Box Elder Creek flows through the northwest corner of the 80-acre site, but flows are intermittent and highly variable. There are a few irrigation permits in place for Box Elder Creek surface water east of the sports complex, but most permits have been abandoned due to unreliable flow. Surface water is not considered to be a viable source and has not been considered in this study.

There are two classifications of groundwater present in the vicinity of the sports complex: shallow alluvial groundwater and deep bedrock artesian aquifers.

Shallow alluvial groundwater is present within the Box Elder Creek floodplain at depths of about 10 feet to 30 feet depending on location and variable seasonal and climatic conditions. Water is stored within coarse and fine gravel perched over impervious shale bedrock. The water-bearing gravel is typically about 5 to 10 feet thickness and is overlain by fine grained silt and clay materials of variable thickness ranging from 5 to 20 feet or more. The alluvium is recharged by surface precipitation and intermittent streamflow in the Box Elder Creek watershed. There are a number of domestic wells constructed in the alluvium with depths ranging typically from 30 to 50 feet and with yields in the 5 to 15-gpm range. Wells are typically bored to about 2 feet diameter and cased about 12 to 18 inches.

Deep bedrock aquifers present include the following:

Inyan Kara Sandstone	-	1,600 to 1,900 feet depth below surface
Minnelusa Sandstone	-	3,100 to 3,600 feet depth below surface
Madison Limestone	-	3,800 to 4,300 feet depth below surface

These aquifers are under artesian pressure which brings the water relatively close to the ground surface (200 to 300 feet below the surface). Recharge is from precipitation over the exposed outcrops in the Black Hills. Wells are typically cased from 5 to 12 inches in diameter and equipped with submersible pumps and motors set at 200 or 300 feet below the artesian water surface.

These aquifers are the principal source of drinking water for the foothills and plains east of the Black Hills, including municipal supplies, sanitary districts and individual homes. Figure 4 shows the geologic profile and anticipated depths for the potential groundwater sources.

The shallow alluvial water and the deep aquifers are the only identified potential alternate irrigation sources for the sports complex. Description and analysis of these potential sources is presented in the following sections.

3.2 Water Quality Considerations

Groundwater supplies are highly variable in terms of water quality. Groundwater leaches minerals from the host rock over time and may become unsuitable as an irrigation source if highly mineralized. The groundwater from the bedrock aquifer becomes older with distance from the recharge zone and the potential for leaching minerals increase with age.

The principal water quality parameters which may affect suitability for irrigation include the following:

Salinity (as measured by electrical conductivity)
Sodium Absorption Ratio (SAR)
pH
Chloride

A discussion of the specific hazards associated with these parameters is beyond the scope of this report. Hazard limits are highly dependent upon crop and soil types. For grass turf irrigation in fine grained soils (silt loam) such as those present at the sports complex, recommended maximum limits are shown in the following table. The table also shows the anticipated value or concentration associated with each of the four alternative groundwater sources considered in this study.

Irrigation Water Quality Hazard

Parameter	Recommended Maximum or Range	Box Elder Alluvium	Inyan Kara	Minnelusa	Madison
Electrical Conductivity (micromhos/cm)	1900	2000 - 2400	700 - 800	*	500 - 600
SAR (units)	< 6	3 to 6	< 3	*	< 3
pH (units)	6.5 - 8.4	7 to 7.5	7.5 - 8	*	7.5 - 8
Chloride (units)	70	60 to 80	< 10	*	< 10

* No data available from nearby wells.

The table shows that the Box Elder Creek alluvial source may have salinity and chloride hazard above recommended limits. The data available on nearby Inyan Kara and Madison wells does not indicate any significant water quality limitations. There is no comparable data available for the Minnelusa aquifer.

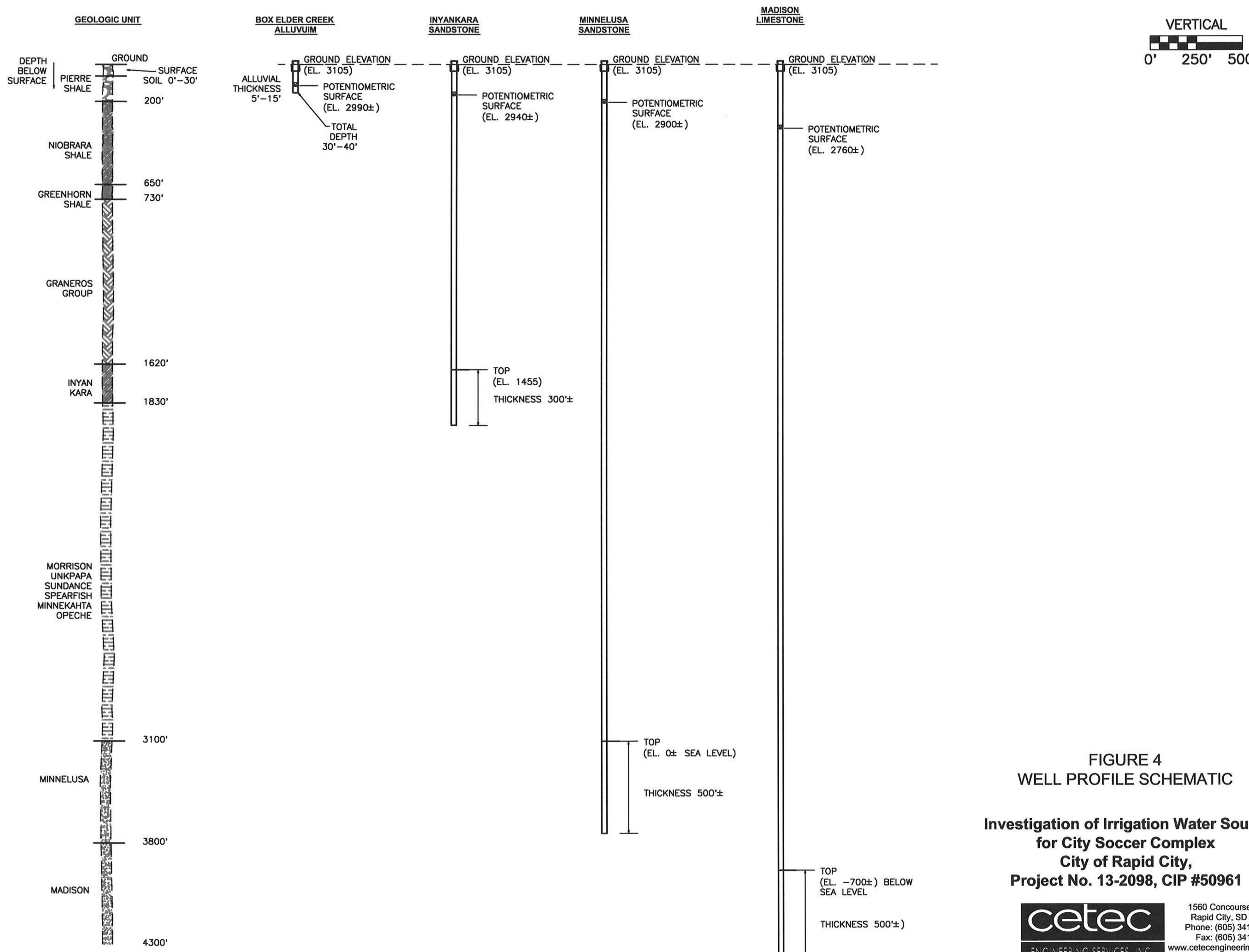

FIGURE 4
WELL PROFILE SCHEMATIC

Investigation of Irrigation Water Source for City Soccer Complex
City of Rapid City,
Project No. 13-2098, CIP #50961

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3.3 Groundwater Source Evaluation

3.3.1 Box Elder Creek Alluvium

- General Description

  There is no known technical study of the Box Elder Creek alluvium which addresses storage, recharge, water quality, well yield, or seasonal or annual variations in water levels. What is known is from construction records of a limited number of domestic wells constructed in the vicinity. USGS performed some Direct Current Resistivity measurements at the sports complex site recently using remote sensing equipment (no explorative digging). A summary of well constructions records and the resistivity data provided by the ISGS site study are included in Appendix A. The USGS data show that shale bedrock at the site is approximately 25 feet below the surface and that the granular alluvium is in the range of 10 to 15 feet thickness with water level about 10 feet below the surface. The USGS data is consistent with the limited amount of well data.

- Yield

  Reported well yields for domestic wells of 5 to 12 gpm (7,000 to 17,000 gpd) appear to be inadequate to provide the 200,000 (+) gallons per day needed for irrigation. A system of 30 or more wells spread over the complex appears to be unwieldy, impractical and possibly not sustainable. A "collection lake" constructed by excavating through the water-bearing alluvium to shale bedrock (similar to a gravel pit) could be a practical way of collecting and storing a large volume of water. However, the lack of technical information on the alluvial storage, recharge and transmissivity renders this concept to be of questionable feasibility. Further study of a shallow groundwater supply could be performed at the site using a series of bored observation and sampling wells. A long term pumping and draw down test protocol along with monitoring of seasonal water levels could provide data needed to forecast reliability. It is anticipated that reliable results may require several years to confirm seasonal and climate impacts and costs in the $100,000 to $200, 000 range would be anticipated for well construction and long term monitoring.

- Water Quality

  There is no known water quality data for the alluvial water in the complex vicinity. There is a mobile home park (Plainsview Manor) located about 2 miles east of the sports complex which utilizes the Box Elder Creek groundwater for drinking water, and water quality data is public record via the DENR public drinking water system database. Available data is included in Appendix A. The data shows that the alluvial water has a very high level of electrical conductivity (up to 2,400 micromhos/cm) which indicates high concentration of dissolved minerals. The high level of mineralization indicates that the water may be unsuited to irrigation due to long term salinity hazard in the fine grained soil at the site. It would be prudent to collect actual water quality data from the site using test wells. This could be done in conjunction with an aquifer yield study as described previously. If water quality is unsuitable then long term study of the yield would be pointless.

- Water Rights

  DENR has jurisdiction over water right permits needed for intensive irrigation use such as that proposed for the sports complex. In addition to demonstrating that sufficient water is available, it would be necessary to show that existing rights would not be impaired. There are existing permits for irrigation water for Box Elder Creek surface water downstream from the soccer complex. Affected permit holders could argue that their surface supplies could be adversely affected due to the "principal of conjunctive use" where groundwater withdrawal in the upper watershed can affect and deplete downstream flows (i.e. groundwater removed from the stream system can result in lost or reduced surface streamflow).

- Risk

  The Box Elder Creek alluvium has a number of risk factors which would, as a minimum, reduce the viability as an irrigation supply source. The principal risk is that storage volume and recharge could be inadequate to sustain irrigation withdrawals over a long time period. Further technical study including test wells and long term yield monitoring would be absolutely required to resolve unknowns. A comprehensive study would likely take several years to provide a definitive answer to all questions.

3.3.2 Inyan Kara Aquifer

- General Description

  The Inyan Kara sandstone aquifer is the shallowest of the bedrock aquifers and is recharged in outcrop areas at the periphery of the Black Hills. This formation is commonly used for drinking water, especially for small systems and municipalities east of the Black Hills. There are several Inyan Kara wells within about 2 miles of the soccer complex, and the characteristics are fairly well known and documented by USGS publications, including "Hydrology of the Black Hills Area, South Dakota", USGS Water Resources Investigations Report 02-4094 and "Atlas of Water Resources in the Black Hills Area, South Dakota", Hydrologic Investigations Atlas HA-747.

- Yield

  Most Inyan Kara wells have been developed to produce from 50 to 150 gpm, which translates to maximum daily production of from 70,000 to 210,000 gallons per day. This yield range is less than the required 224,000 gpd for the sports complex irrigation supply, thus it is likely that a single Inyan Kara well will not provide all required supply and that City water would be needed to augment the well supply. There are known methods to enhance well production, such as hydraulic fracturing, which could be employed to maximize the yield of an Inyan Kara well. Costs for well enhancement are high, but could be worthwhile. There is no documentation showing an Inyan Kara well with a yield above about 250 gpm, so the chances of a single high production well meeting all Phase 1 irrigation needs are not good.

- Water Quality

  Water quality is documented in other Inyan Kara wells used for public water supplies in the vicinity of the sports complex. Water quality parameters which would be of concern for irrigation uses (electrical conductivity, sodium, sodium absorption ratio) are well below threshold limits for irrigation suitability, thus it is anticipated that Inyan Kara water would be acceptable. See Section 3.2.

- Water Rights

  There are a number of existing Inyan Kara wells within about 2 miles of the sports complex. The nearest Inyan Kara wells supply the Flying J Truck Stop to the south, Croell Redi-Mix to the east and D&J Mobile Home Park east on Country Road. The closest wells are more than a mile from the site. Known Inyan Kara wells in the vicinity and characteristics are included in Appendix B. An irrigation permit application to DENR would be reviewed to assure that there is adequate supply, the use is suitable and of a beneficial nature, and that other prior rights are not adversely affected. There is ample storage in the Inyan Kara and spacing of existing wells is sufficient to prevent adverse impact on existing wells. It is anticipated that an Inyan Kara well would meet the requirements for a water right permit.

- Risk

  Well drilling and yield forecasting are inexact sciences, and there is always the risk of substantial failure of a well, with a yield significantly less than anticipated. In the case of an Inyan Kara well, a yield lower than 50 gpm would be considered to be a failure.

3.3.3 Minnelusa Sandstone Aquifer

- General Description

  The Minnelusa formation is about 1,300 feet below the Inyan Kara aquifer separated by shale and other impervious materials. The Minnelusa is also widely used for drinking water, primarily in the foothills area of the Black Hills. Water quality deteriorates with distance east of the foothills area. Sulfate levels, in particular, increase rapidly to the east of the foothills making this source unsuitable for drinking water.

- Water Quality

  Water quality in the Minnelusa aquifer is not documented in the vicinity of the sports complex. The site is about 1.5 miles east of any existing documented Minnelusa well. There is the possibility that overall mineralization is high and could result in unfavorable salinity levels for irrigation.

- Yield

  Typical well yields for the Minnelusa aquifer are in the 50 to 150-gpm range, similar to the Inyan Kara, although there is a potential for relatively high yields of 500 gpm or more. The lack of comparable wells in the sports complex vicinity results in uncertainty about yield potential.

- Water Rights

There are no Minnelusa well permits in the sports complex vicinity, thus there would be no adverse effect on prior water rights. The Minnelusa aquifer has a large storage and recharge capacity, and subject to water quality concerns would likely have no opposition to issuance of an irrigation permit.

- Risk

Risk factors include both water quality and yield concerns. The greater drilling depth to the Minnelusa increases well construction costs significantly which will increase the risk of unfavorable results.

3.3.4 Madison Limestone Aquifer

- General Description

The Madison formation is below the Minnelusa and is located about 3,800 feet below the surface in the soccer complex vicinity. The Madison is an important drinking water supply of the Black Hills foothills and for a limited distance east of the Black Hills. It is the primary supply of drinking water for Rapid City, Box Elder, and most of the other municipal systems at the edge for the Black Hills. Water quality, in terms of overall mineralization, deteriorates to some degree east of the foothills. There are areas of interaction between the Madison and the Minnelusa where it is theorized that there is upward flow from the Madison into the Minnelusa resulting in nearly the same potentiometric water surface. A Minnelusa-Madison connection in the sports complex vicinity is not documented.

- Water Quality

Water quality in the Madison is very good near the foothills, and deteriorates with distance to the east. Madison wells in Box Elder have higher levels of overall mineralization and higher temperatures (70 to 80 degrees F), but overall are satisfactory for drinking water. There are no water quality parameters identified which would preclude use for irrigation.

- Yield

Madison well yields typically are above 100 gpm and yields up to 1,500 to 2,000 gpm are possible due to fracturing and voids in the rock from dissolution. The nearest Madison well to the soccer complex is a City of Box Elder well about 2.25 miles to the southeast which yields about 400 gpm. City of Rapid City Well No. 6 is about 3 miles to the west and yields more than 600 gpm. The Madison aquifer provides the best chance for a high yielding well capable of meeting all Phase 1 irrigation needs as well as future needs.

- Water Rights

There are no existing Madison wells located within 2 miles of the site. The closest is Box Elder Well No. 6, 2.25 miles to the east. Rapid City's Well No. 6 is located 3 miles to the west on the east slope of the hogback. The City of Box Elder has applied for and received a future water right permit from the State Water Management Board for a new Madison well to be located adjacent to Elk Vale Road, about 0.6 miles south of the sports complex. This well has not been drilled, but water rights have been reserved for the City of Box Elder municipal system. Typically, DENR Water Rights professionals recommend spacing of high production Madison wells at a minimum of one mile, thus a permit for Madison irrigation use at the sports complex would probably be opposed by Box Elder and would likely not be supported by DENR.

- Risk

As with the other groundwater sources, there is risk of a low yielding Madison well, but risk of unsatisfactory yield is considered to be lower than the other bedrock aquifers. The Madison responds well to acid treatment to increase production, thus risk can be further mitigated, but at an increase in construction cost.

3.4 Schematic Design

This section presents schematic designs and budgetary cost estimates for the four groundwater source alternatives described in Section 3.2. The designs are based upon assumptions made regarding well yield and similar variables. Designs for alternative sources are based upon meeting "normal year" demands for Phase 1 only. Methodology for meeting peak dry year demands is included in the project description.

Issues with water rights and water quality for the various groundwater alternatives are assumed to be able to be resolved for purposes of developing schematic level project scope and costs. Risk factors are evaluated further in Section 4.2. The viability of using an alternative irrigation source is dependent upon cost as well as other factors, including risk, water rights, water quality, financing methodology and others. Section 4.4 of this report provides an overall assessment of the viability of the groundwater source alternatives and specific caveats associated with each option.

3.4.1 Box Elder Creek Alluvium

The schematic design for utilizing shallow groundwater from the Box Elder alluvium is illustrated in Figures 5 and 6. The collection system consists of a constructed pond at the southwest portion of the 80-acre site which would serve as a groundwater collection basin as well as a surface reservoir for storage and equalization. Irrigation water would be withdrawn from the reservoir via intake screen and gravity pipe flow to a pumping station designed to provide the required peak irrigation rate of flow and pressure. The pond system would be constructed through the alluvial gravel into shale bedrock. The pond water level would equalize at the potentiometric surface of the shallow aquifer. Pumping would lower the water surface and create a hydraulic gradient in the aquifer to recharge the pond.

This alternative includes a pipe connection from the City water system to the pump station wet well as an emergency supply source. No emergency power supply is included.

The principal schematic design features are summarized following.

Box Elder Alluvium System

Pond System

Surface Area:	3 acres
Depth:	30' (5' into shale)
Surface Elevation:	3105±
Bottom Elevation:	3075±
High Water Elevation	3098 (est.)
Low Water Elevation:	3088
Effective Depth	10'
Effective Storage:	1,100,000 c.f. (8.2 million gallons)
Side Slope:	3:1
Slope treatment:	Riprap

It should be noted that this schematic design will utilize a portion of the site (up to about 6 acres) which will significantly reduce the land area available for future Phase 2 expansion.

Pump Station

Type:..Wet Well, 30' depth with superstructure above grade
Pumps:..Vertical turbine (3)
Pump Capacity:.............................2 ea. 500 gpm @ 280' (40 HP)
....1 ea. 50 gpm @ 260' (7.5 HP)
Control:..VFD, constant pressure
Discharge Pipe:.............................8" dia.

Intake

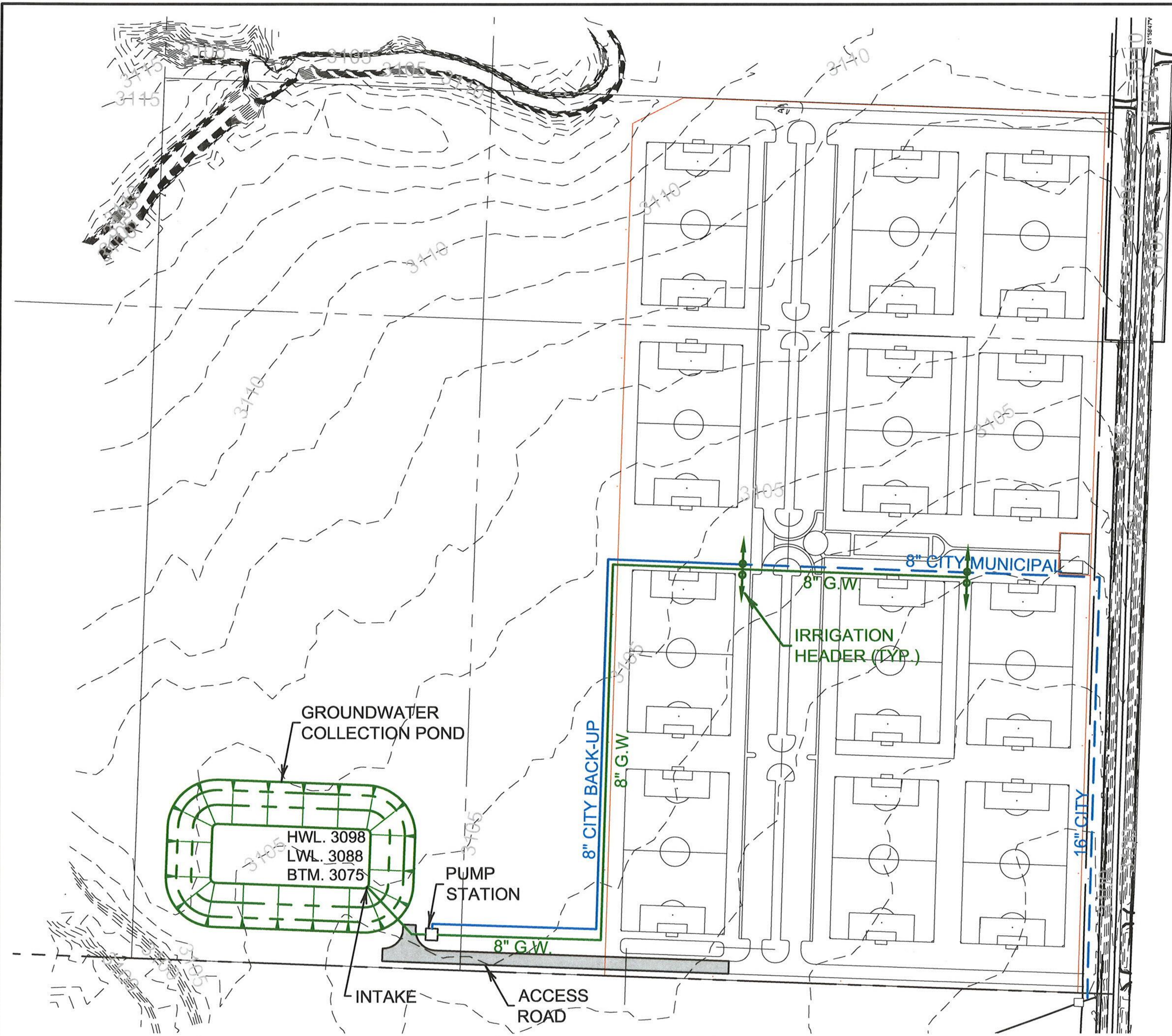
Pipe:...16" with Valve
Screen:...Stainless Steel, 1/8" slot
Cleaning System:..........................Air Purge

Treatment – None

Emergency Power – None

City Interconnection

Peak flow:....................................900 gpm
Pipe size:......................................8"
Flow Control:................................Motorized valve
Flow measurement:.......................Mag meter
Protection method:.......................air gap



LEGEND

CITY WATER MAIN INCLUDED IN PHASE 1

CITY MAIN FOR BACKUP TO ALT. SUPPLY

ALTERNATIVE IRRIGATION SUPPLY MAIN (GROUNDWATER)

FIGURE 5
SCHEMATIC DESIGN
BOX ELDER CREEK ALLUVIUM

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August 06, 2013 5:50:36 a.m. Drawing: FIGURES 5-7-8.DWG (FOX) (\\MAIN-DATA\CETEC\PROJECTS & PROPOSALS\13128.00 RC SOCCER COMPLEX IRRIGATION SUPPLY STUDY\DRAWINGS\FIGURES\)

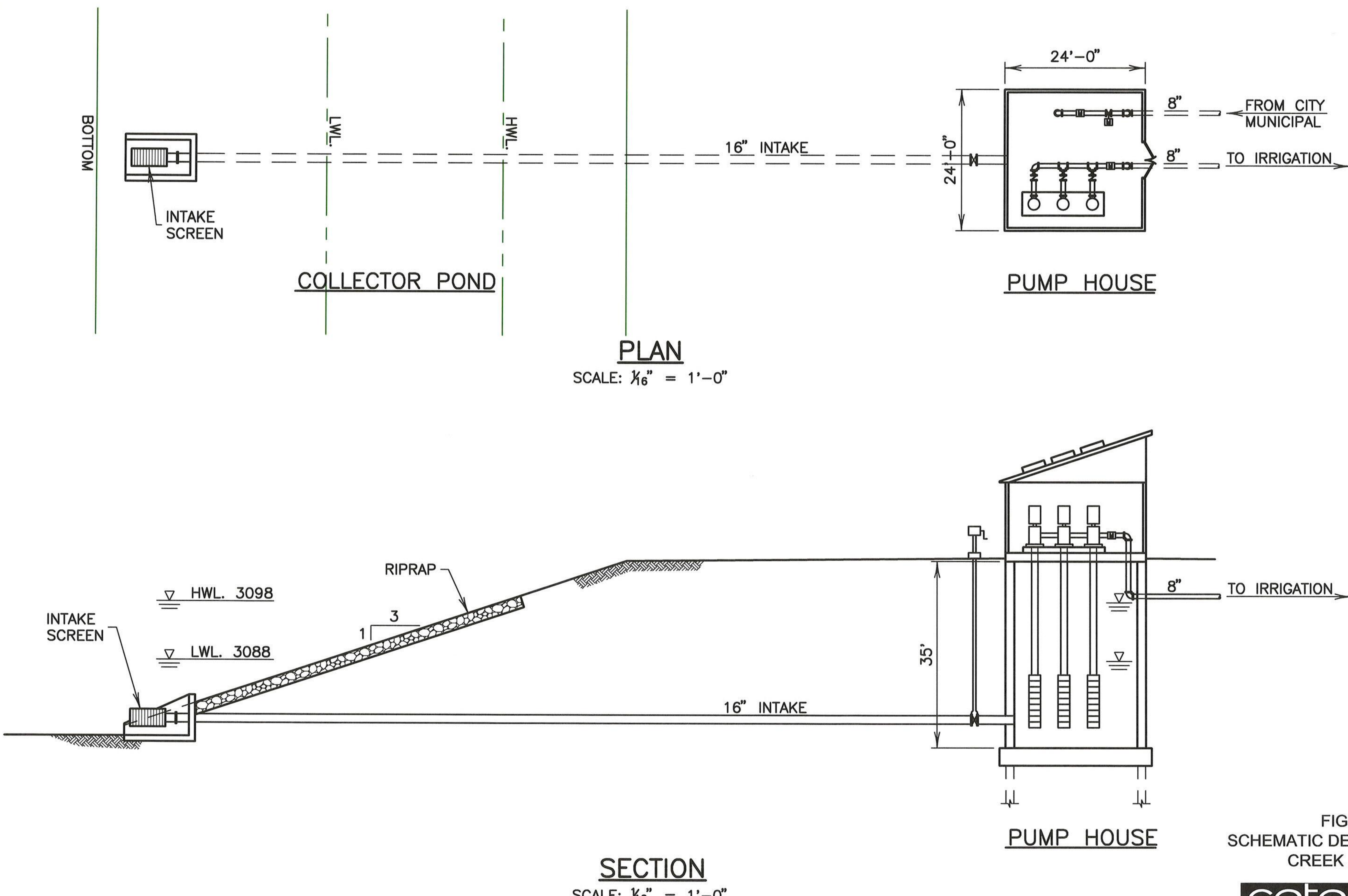

FIGURE 6
SCHEMATIC DESIGN BOX ELDER CREEK ALLUVIUM

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Table 1 Budgetary Cost Estimate – Box Elder Creek Alluvium Source

Capital Costs

Item	Quantity	Unit Cost	Total
Collection Pond			
Contractor Mobilization	1 LS	$ 50,000	$ 50,000
Construction Dewatering	1 LS	$ 30,000	$ 30,000
Topsoil (Stripping / Stockpile)	4,500 CY	$ 4	$ 18,000
Unclassified Excavation	100,000 CY	$ 4	$ 400,000
Hauling to Waste	100,000 CY	$ 2	$ 200,000
Geotextile	10,000 SY	$ 4	$ 40,000
Riprap	7,500 Tons	$ 56	$ 420,000
Intake Screen	1 LS	$ 5,000	$ 5,000
16" D.I. Gravity Pipe	125 LF	$ 100	$ 12,500
16" Gate Valve and Box	1 Ea.	$ 8,000	$ 8,000
		Collection Pond Subtotal	$ 1,183,500
Pump Station			
Structure Excavation	4,000 CY	$ 15	$ 60,000
Select Structural Backfill	3,000 CY	$ 10	$ 30,000
Steel Piling	120 LF	$ 100	$ 12,000
Concrete Wet Well (24 x 24 x 35)	260 CY	$ 300	$ 78,000
Pump Station Structure	580 SF	$ 200	$ 116,000
Pumping System and Controls	1 LS	$ 110,000	$ 110,000
Process Pipe and Valves	1 LS	$ 24,000	$ 24,000
6" Mag Meters	2 Ea.	$ 5,000	$ 10,000
Intake Screen Purge System	1 LS	$ 10,000	$ 10,000
Wet Well Level Controls	1 LS	$ 15,000	$ 15,000
Well House Electrical System	1 LS	$ 30,000	$ 30,000
Electric Service	1,300 LF	$ 20	$ 26,000
		Pump Station Subtotal	$ 521,000
Sitework and Piping			
8" PVC City Connection Main	1,400 LF	$ 40	$ 56,000
8" PVC Station Discharge / Header	1,800 LF	$ 40	$ 72,000
Access Roadway, 16' wide	700 LF	$ 60	$ 42,000
Site Restoration / Seeding	3 Ac.	$ 2,000	$ 6,000
Erosion Controls	1 LS	$ 7,000	$ 7,000
		Sitework and Piping Subtotal	$ 183,000
		Total	$ 1,888,000
		Construction Contingencies 15%	$ 283,000
		Total Construction	$ 2,171,000
		Design and Construction Engineering (12%)	$ 260,000
		Total Capital Cost	**$ 2,431,000**

Annual O&M Costs

Item	Cost / Year	
Electrical Demand (90 HP @ $16.75)[3]	$	1,500
Electrical Energy (25,500 kwh @ $.09)	$	2,300
Operator Labor (26 weeks @ 10 hrs. x $25/hr.)	$	6,500
Equipment Depreciation		
Pumps (20 yrs., $100,000)	$	5,000
Structure / Piping (60 yrs., $270,000)	$	4,500
Groundwater Cost	$	0
City Water Cost	$	0
Annual O&M	$	19,800/YR.

3.4.2 Inyan Kara Aquifer

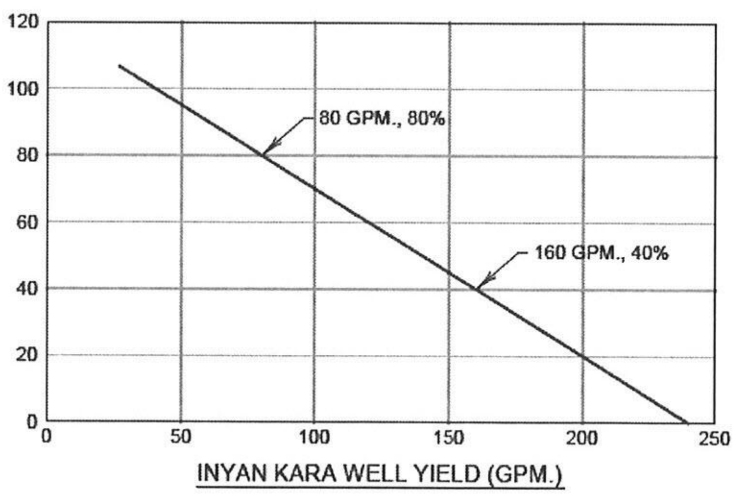
The schematic design for utilizing the Inyan Kara aquifer consists of a well and submersible pump, ground level steel storage reservoir and a multi-pump pressure booster station to supply the irrigation system. The design is illustrated in Figures 7 and 8.

The Inyan Kara aquifer typically will not provide well yields at a rate needed to meet peak irrigation demands (up to 450 gpm for Phase 1). The necessary well yield can be reduced by providing on-site storage which would allow for the well to pump continuously over a 24-hour period versus the 12-hour-per-day irrigation period. Based upon a projected maximum daily irrigation use rate of 224,000 gpd (average year), the required well yield for 24 hours of continuous pumping is as follows:

Required Well Yield

$$224{,}000 \text{ gpd} \div 24 \div 60 = 160 \text{ gpm}$$

The required yield is significantly more than can normally be expected form an Inyan Kara well. The following graphic illustrates the approximate range and probability of well yields from the Inyan Kara.



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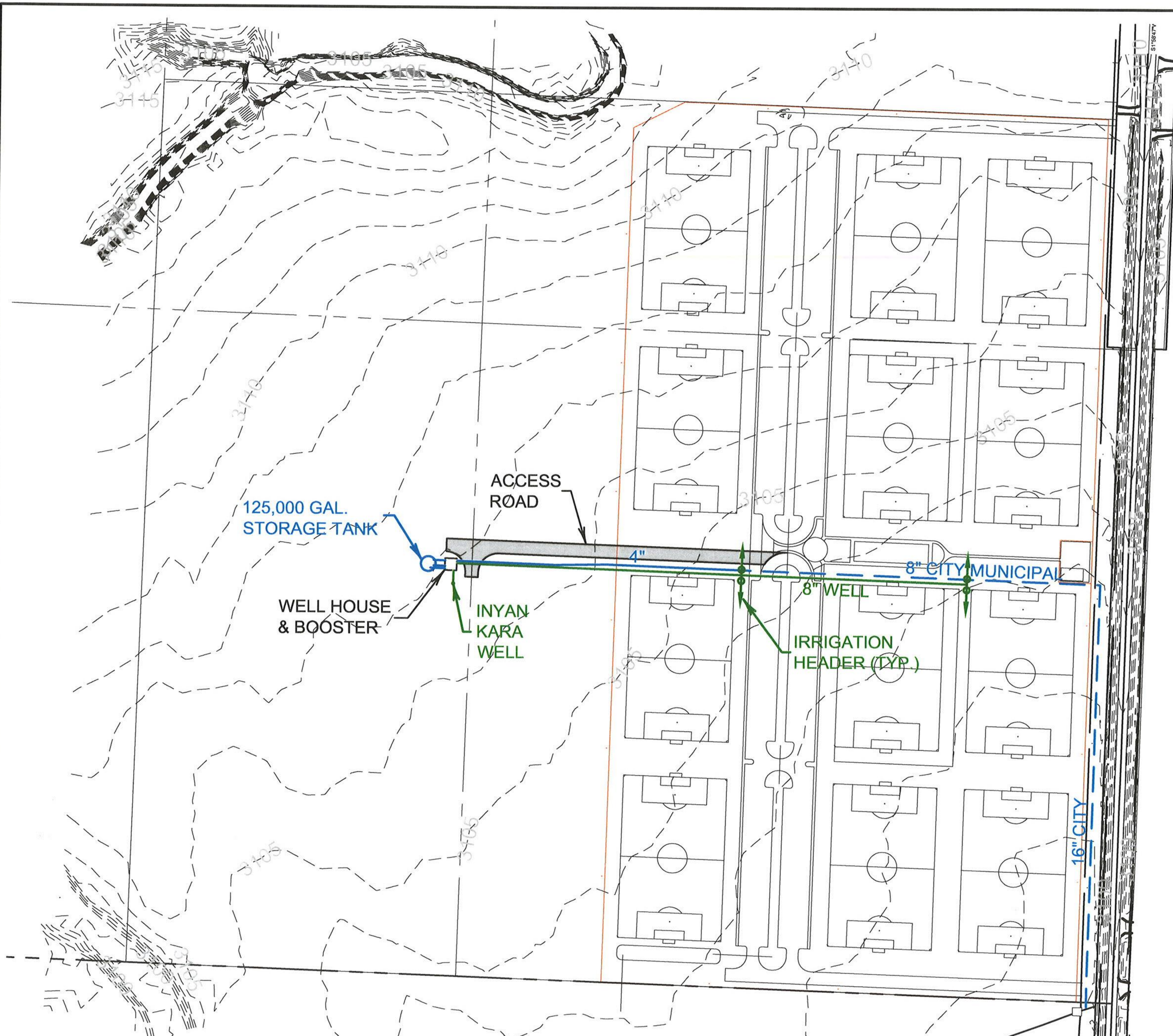
[3] West River Electrical Association Rates, Class of Services: Irrigation Rate No. 30 and 31. Demand charge is $16.75 per horsepower per season. Energy change approximately $0.09/kwh.



LEGEND

CITY WATER MAIN INCLUDED IN PHASE 1

CITY MAIN FOR BACKUP TO WELL SUPPLY

WELL SUPPLY IRRIGATION HEADER

FIGURE 7
SCHEMATIC DESIGN
INYAN KARA WELL

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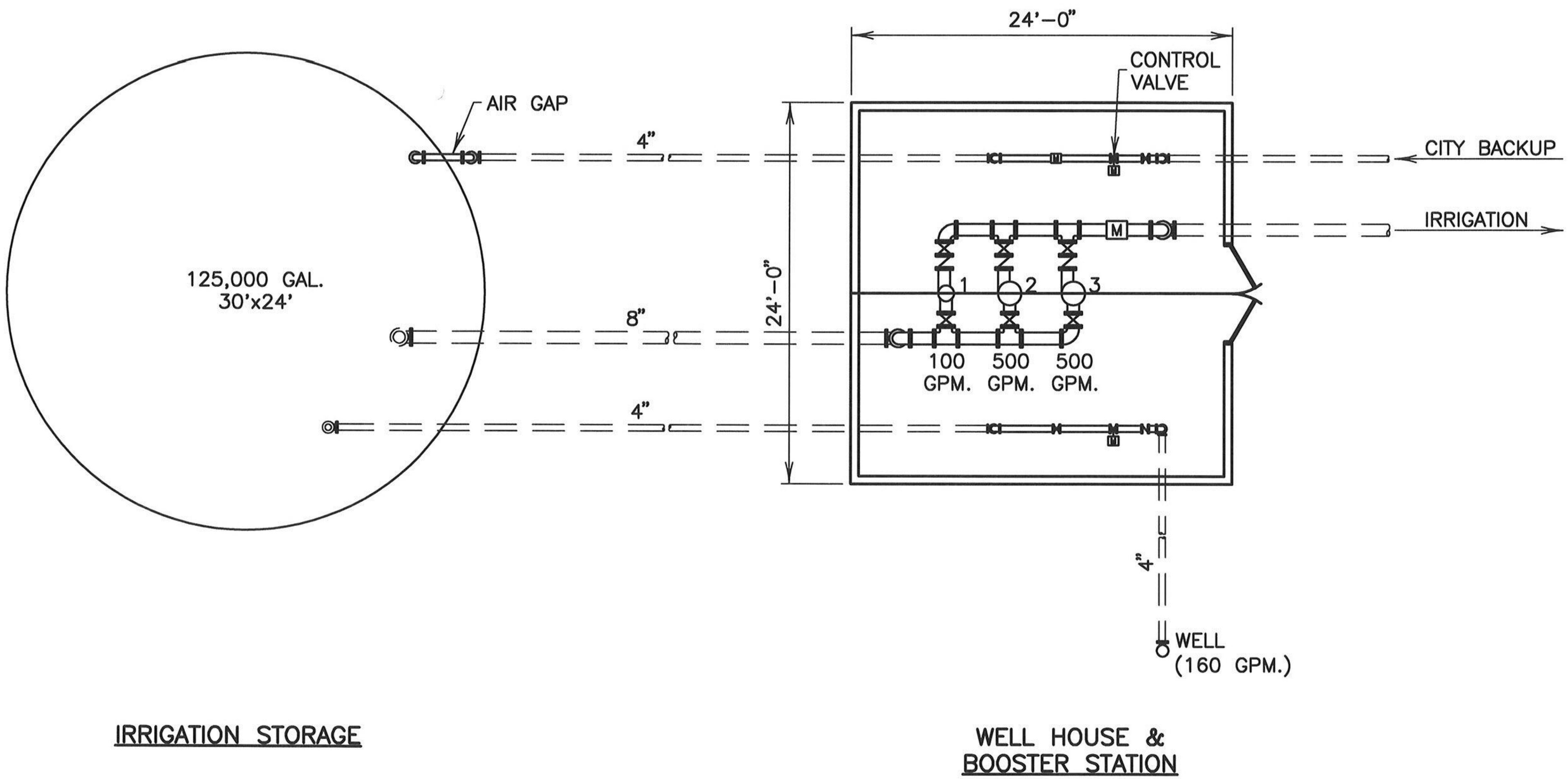
Drawing: FIGURES 5-7-9.DWG (FOX) (\\MAIN-DATA\CETEC\PROJECTS & PROPOSALS\13128.00 RC SOCCER COMPLEX IRRIGATION SUPPLY STUDY\DRAWINGS\FIGURES\)



PLAN

SCALE: ⅛" = 1'–0"

FIGURE 8
SCHEMATIC DESIGN
INYAN KARA WELL

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It is estimated that there is approximately an 80 percent chance of a well yield of 80 gpm or more, but only 40 percent chance for 160 gpm.

The on-site storage needed to allow continuous pumping at up to 160 gpm is as follows:

Storage Need

160 gpm x 12 hrs. x 60 min. = 115,000 gal.

A well yield of 160 gpm or more would meet the average year irrigation demand with continuous pumping, provided that storage is provided to allow well pumping during the 12-hour non-irrigation period. Actual storage needs are variable depending upon well yield, but for purposes of this study, a 125,000-gallon storage reservoir has been selected for cost estimating purposes.

This alternative includes a pipe connection to the City municipal supply to provide emergency back-up to the well supply and to provide supplemental water to the storage tank to meet peak dry year demands or compensate for a well yield less than 160 gpm.

The principal schematic design features for this alternative are as follows:

Inyan Kara System

Well

Design Capacity:.. 160 gpm
Drilling Depth:.. 2,000 feet
Casing Size: .... 8" i.d.
Casing Intake: .... stainless steel screen / gravel pack
Column Pipe: .... 4"
Submersible Pump:............................ 160 gpm @ 400' (20 HP)

Storage Tank

Construction: .... bolted steel, epoxy coated
Capacity:...................................... 125,000 gal.
Size: .... 30' dia. x 24' high
Level Control:.............................. electronic transducer

Booster Pump System

Well House .... 24' x 24' masonry
Pump Type: .... vertical turbine
Pump Size:................................... 2 ea. 500 gpm @ 280' (40 HP)
1 ea. 50 gpm @ 240' (5 HP)
Pump Control:.............................. VFD, constant pressure
Discharge Header: .... 8"

City Interconnection

Peak Flow: .... 200 gpm
Pipe Size: .... 4"
Flow Control:............................... motorized valve

Flow Measurement: ....magnetic flow meter
Protection Method: ....air gap

Treatment - None

Emergency Power - None

Estimated capital costs and operating costs are presented in Table 2. See Section 4.2 of this report for discussion and analysis of cost impacts of risk and cost related to well yield below 160 gpm.

Table 2 Budgetary Cost Estimate – Inyan Kara Source

Capital Costs

Item	Quantity	Unit Cost	Total
Well Construction			
Contractor Mobilization	1 LS	$ 30,000	$ 30,000
Borehole, 12¼"	2,000 LF	$ 60	$ 120,000
Logging	1 LS	$ 15,000	$ 15,000
Casing, 8"	1,900 LF	$ 50	$ 95,000
Well Screen / Gravel	100 LF	$ 200	$ 20,000
Grouting	800 CF	$ 40	$ 32,000
Hydrofracture	1 LS	$ 50,000	$ 50,000
Development and Testing	1 LS	$ 30,000	$ 30,000
	Well Construction Subtotal		$ 392,000
Well House and Pumps			
Contractor Mobilization	1 LS	$ 20,000	$ 20,000
Well Pump and Cable (20 HP)	1 LS	$ 20,000	$ 20,000
Column Pipe, 4"	400 LF	$ 20	$ 8,000
Check Valve	2 EA.	$ 500	$ 1,000
Pitless Unit	1 EA.	$ 8,000	$ 8,000
24' x 24' Structure	580 SF	$ 250	$ 145,000
4" City Pipe, Meter Valves	1 LS	$ 25,000	$ 25,000
4" Well Pipe, Meter Valves	1 LS	$ 20,000	$ 20,000
8" Booster Pipe, Meter Valves	1 LS	$ 30,000	$ 30,000
Booster Pump System	1 LS	$ 110,000	$ 110,000
Electrical and Control	1 LS	$ 50,000	$ 50,000
Electrical Service to Building	1,000 LF	$ 20	$ 20,000
Sitework	1 LS	$ 20,000	$ 20,000
	Well House and Pumps Subtotal		$ 477,000
Storage Tank			
Contractor Mobilization	1 LS	$ 20,000	$ 20,000
125,000-Gallon Tank and Foundation	125,000 Gal.	$ 1.40	$ 175,000
Tank Piping	1 LS	$ 20,000	$ 20,000
	Storage Tank Subtotal		$ 215,000
Sitework and Piping			
4" PVC City Supply / Fittings	300 LF	$ 35	$ 10,500
4" Gate Valve	1 EA.	$ 1,000	$ 1,000
4" Well Pipe / Fittings - Exterior	50 LF	$ 100	$ 5,000
8" PVC Discharge Header	750 LF	$ 50	$ 37,500
Concrete Access Driveway (16' wide)	350 LF	$ 60	$ 21,000
Site Restoration / Seeding	3,000 SY	$ 2	$ 6,000
	Sitework and Piping Subtotal		$ 81,000
	Construction Subtotal		$ 1,165,000
	Construction Contingencies 15%		$ 175,000
	Total Construction		$ 1,340,000
	Design and Construction Engineering (12%)		$ 161,000
	Total Capital Cost		**$ 1,501,000**

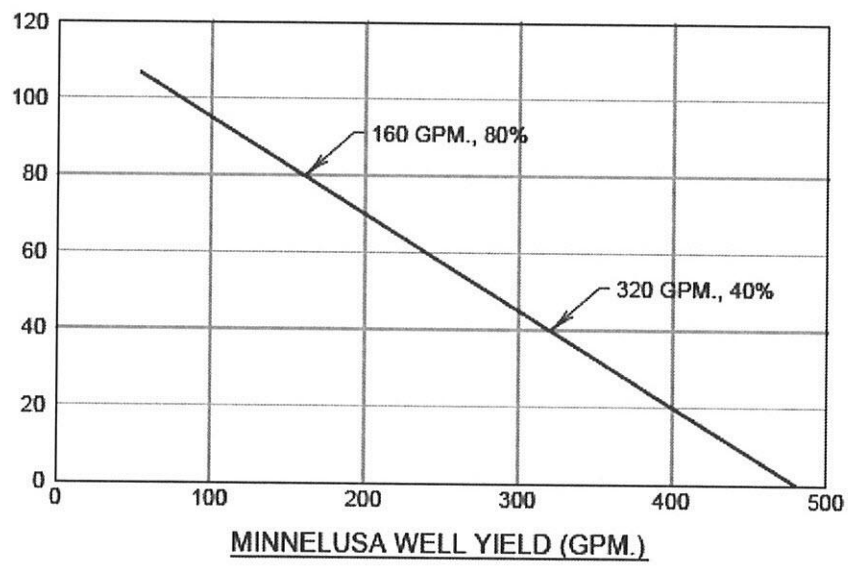
Annual O&M Costs

Item	Cost / Year
Electrical Demand (100 HP @ $16.75)	$ 1,700
Electrical Power (Well Pump)	
(2,300 Hrs. @ 20 hp @ $.09/KW)	$ 3,100
Electrical Power (Booster Pump) - 450 gpm	
(840 Hrs. @ 40 HP (22.0 KW) 22,000 KWH $.09 KW	$ 2,300
Operator Labor (26 weeks @ 10 hrs. x $25/hr.)	$ 6,500
Equipment Depreciation (Straight Line)	
Pumps (20 yrs., $120,000)	$ 6,000
Structures / Piping / Tank (60 yrs., $600,000)	$ 10,000
Well Water (Free)	$ 0
City Water Purchase	$ 0
Annual O&M	$ 29,600/YR.

3.4.3 Minnelusa Aquifer

The schematic design for utilizing the Minnelusa aquifer is similar to the Inyan Kara option presented in Section 3.3.2. The principal difference is the additional drilling depth and higher construction cost for a Minnelusa formation well. Figures 7 and 8 are representative of the schematic design for a Minnelusa well.

The Minnelusa aquifer typically has a higher yield potential than the Inyan Kara, although information on comparable nearby wells is lacking in the public record. The following graphic illustrates the approximate range and probability of well yield from the Minnelusa.



There is an estimated 80 percent chance of a 160-gpm well which would be capable of supplying all Phase 1 irrigation needs in the "average year" design conditions. There is a possibility that a higher yielding well could handle dry year demands and possibly have some capacity available for Phase 2 of the sports complex.

For purposes of this report, the Minnelusa supply alternative includes a 125,000-gallon storage tank, with the sizing rationale being the same as for the Inyan Kara option. A 160-gpm well will need about 115,000 gallons of storage to allow continuous pumping during the 12-hour period between irrigation cycles.

The other components of the system, including pumping system and back-up connection to the City system are the same as for the Inyan Kara option.

The principal schematic design features for this alternative are as follows:

Minnelusa System

Well

Design Capacity:.. 160 gpm
Drilling Depth:.. 3,600 feet
Casing Size: .... 8" i.d.
Casing Intake: .... s.s. screen / gravel pack
Column Pipe: .... 4"
Submersible Pump:............................ 160 gpm @ 400' (20 HP)

Storage Tank

Construction: ....bolted steel, epoxy coated
Capacity:......................................125,000 gal.
Size: ....30' dia. x 24' high
Level Control:..............................transducer

Booster Pump System

Well House..................................24' x 24' masonry
Pump Type: ....vertical turbine
Pump Size:...................................2 ea. 500 gpm @ 280' (40 HP)
....1 ea. 50 gpm @ 240' (5 HP)
Pump Control:..............................VFD, constant pressure
Discharge Header: ....8"

City Interconnection

Peak Flow:...................................200 gpm
Pipe Size: ....4"
Flow Control:...............................motorized valve
Flow Measurement: ....mag meter
Protection Method: ....air gap

Treatment - None

Emergency Power - None

Estimated capital costs and operating costs are presented in Table 3. See Section 4.2 of this report for discussion and analysis of risk factors.

Table 3 Budgetary Cost Estimate – Minnelusa Well Supply

Capital Costs

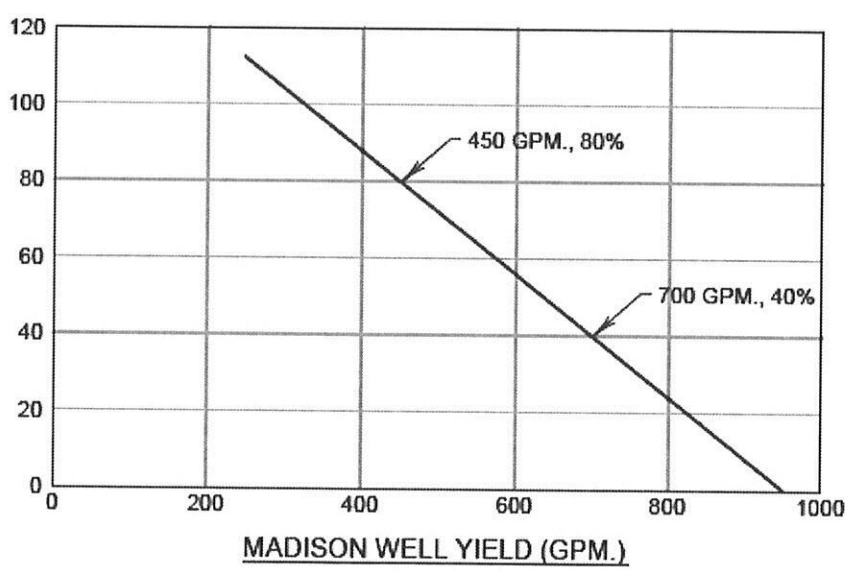
Item	Quantity	Unit Cost	Total
Well Construction			
Contractor Mobilization	1 LS	$ 35,000	$ 35,000
Borehole, 12¼"	3,600 LF	$ 80	$ 288,000
Logging	1 LS	$ 25,000	$ 25,000
Casing, 8"	3,500 LF	$ 50	$ 175,000
Well Screen / Gravel	100 LF	$ 200	$ 20,000
Grouting	1,500 CF	$ 40	$ 60,000
Hydrofracture	1 LS	$ 50,000	$ 50,000
Development and Testing	1 LS	$ 35,000	$ 35,000
		Well Construction Subtotal	$ 688,000
Well House and Pumps			
Contractor Mobilization	1 LS	$ 20,000	$ 20,000
Pump and Cable (20 HP)	1 LS	$ 20,000	$ 20,000
Column Pipe, 4"	400 LF	$ 20	$ 8,000
Check Valve	2 EA.	$ 500	$ 1,000
Pitless Unit	1 EA.	$ 8,000	$ 8,000
24' x 24' Structure	580 SF	$ 250	$ 145,000
4" City Pipe, Meter Valves	1 LS	$ 25,000	$ 25,000
4" Well Pipe, Meter Valves	1 LS	$ 20,000	$ 20,000
8" Booster Pipe, Meter Valves	1 LS	$ 30,000	$ 30,000
Package Booster Pump System	1 LS	$ 110,000	$ 110,000
Electrical and Control	1 LS	$ 50,000	$ 50,000
Electrical Service to Building	1,000 LF	$ 20	$ 20,000
Sitework	1 LS	$ 20,000	$ 20,000
		Well House and Pumps Subtotal	$ 477,000
Storage Tank			
Contractor Mobilization	1 LS	$ 20,000	$ 20,000
125,000-Gallon Tank and Foundation	125,000 Gal.	$ 1.40	$ 175,000
Tank Piping and overflow	1 LS	$ 20,000	$ 20,000
		Storage Tank Subtotal	$ 215,000
Sitework and Piping			
4" PVC City Supply / Fittings	300 LF	$ 35	$ 10,500
4" Gate Valve	1 EA.	$ 1,000	$ 1,000
4" Well Pipe / Fittings - Exterior	50 LF	$ 100	$ 5,000
8" Booster Pipe - Fittings	750 LF	$ 50	$ 37,500
Access Driveway	350 SY	$ 60	$ 21,000
Site Restoration / Seeding	3,000 SY	$ 2	$ 6,000
		Sitework and Piping Subtotal	$ 81,000
		Construction Subtotal	$ 1,461,000
		Construction Contingencies 15%	$ 219,000
		Total Construction	$ 1,680,000
		Design and Construction Engineering (12%)	$ 202,000
		Total Capital Cost	**$ 1,882,000**

Annual O&M Costs

Item	Cost / Year	
Electrical Demand (105 HP @ $16.75)	$	1,800
Electrical Power (Well Pump)		
(2,300 Hrs. @ 20 hp @ $.09/KW)	$	3,100
Electrical Power (Booster Pump) - 450 gpm		
(840 Hrs. @ 40 HP (22.0 KW) 22,000 KWH $.09 KW	$	2,300
Operator Labor (26 weeks @ 10 hrs. x $25/hr.)	$	6,500
Equipment Depreciation (Straight Line)		
Pumps (20 yrs., $140,000)	$	7,000
Structures / Piping (60 yrs., $660,000)	$	11,000
Well Water (Free)	$	0
City Water Purchase	$	0
Annual O&M	$	31,700

3.4.4 Madison Aquifer

The Madison aquifer has the highest potential yield of the three bedrock aquifers. A high yield well could allow for reducing or eliminating storage needs and irrigating directly from a submersible pump system. Well yields from the Madison of more than 500 gpm are common, but not guaranteed. A yield of at least 450 gpm is required to meet peak instantaneous irrigation demands for Phase 1 without supplemental storage and booster pumping. The following graphic illustrates approximate yield potential for the Madison. The Madison limestone responds well to acid treatment to enhance production, so there is a reasonable chance to be able to develop a well which meets the instantaneous 450-gpm production requirement.



The schematic design for utilizing the Madison aquifer consists of a single well and submersible pump with variable speed drive to allow pumping over a wide range of flow from 100 gpm or less up to 450 gpm. The well system would include a well house structure for above-ground piping and flow metering / flow control. This system would also include a separate irrigation supply connection to the City municipal system to back up the irrigation well and allow continuous service in the event of an equipment failure.

The principal schematic design features for a Madison well supply are illustrated in Figures 9 and 10 and described following.

Madison System

Well

Design Capacity:..450 gpm
Drilling Depth:..4,300 feet
Casing Size: .... 12" i.d.
Casing Intake: .... none (open hole)
Column Pipe: .... 6"
Submersible Pump:............................ 450 gpm @ 850' (125 hp)
Well House: .... 14' x 20', masonry
Pump Control:.. VFD, constant pressure
Discharge Header.. 8"
Flow Meter: .... 8" mag meter

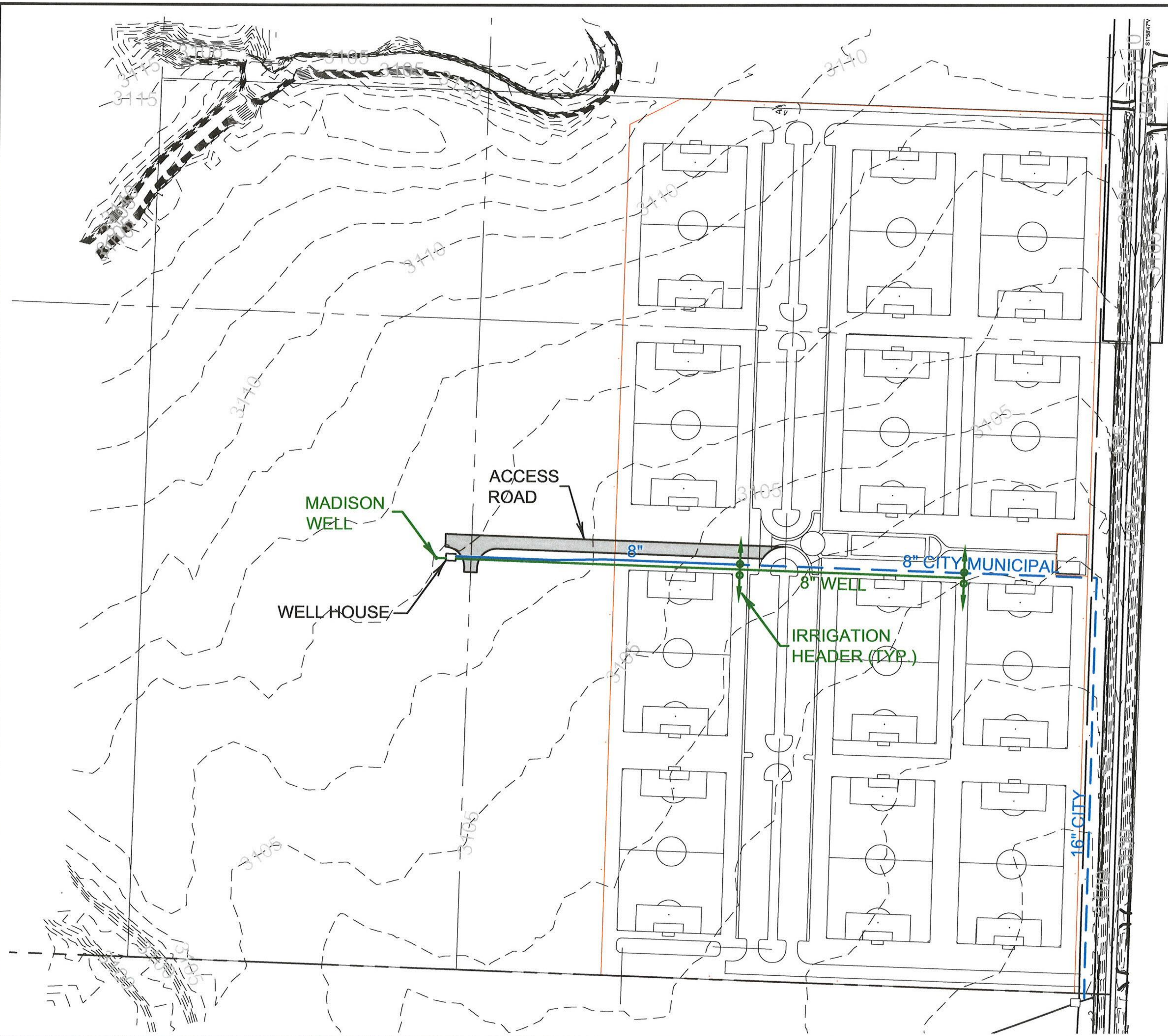
City Interconnection

Peak Flow: ....450 gpm
Pipe Size: .... 8"
Flow Meter: .... 8" mag meter
Protection Method: .... reduced pressure zone backflow preventer*

Treatment - None

Emergency Power – None

* Backflow preventer is used in this schematic design because there is no gravity storage system which would allow the use of an air gap protection device. A backflow preventer allows use of City water at normal system pressure without re-pumping.



LEGEND

- CITY WATER MAIN INCLUDED IN PHASE 1
- CITY MAIN FOR BACKUP SUPPLY TO WELL
- WELL SUPPLY IRRIGATION HEADER

FIGURE 9
SCHEMATIC DESIGN
MADISON WELL

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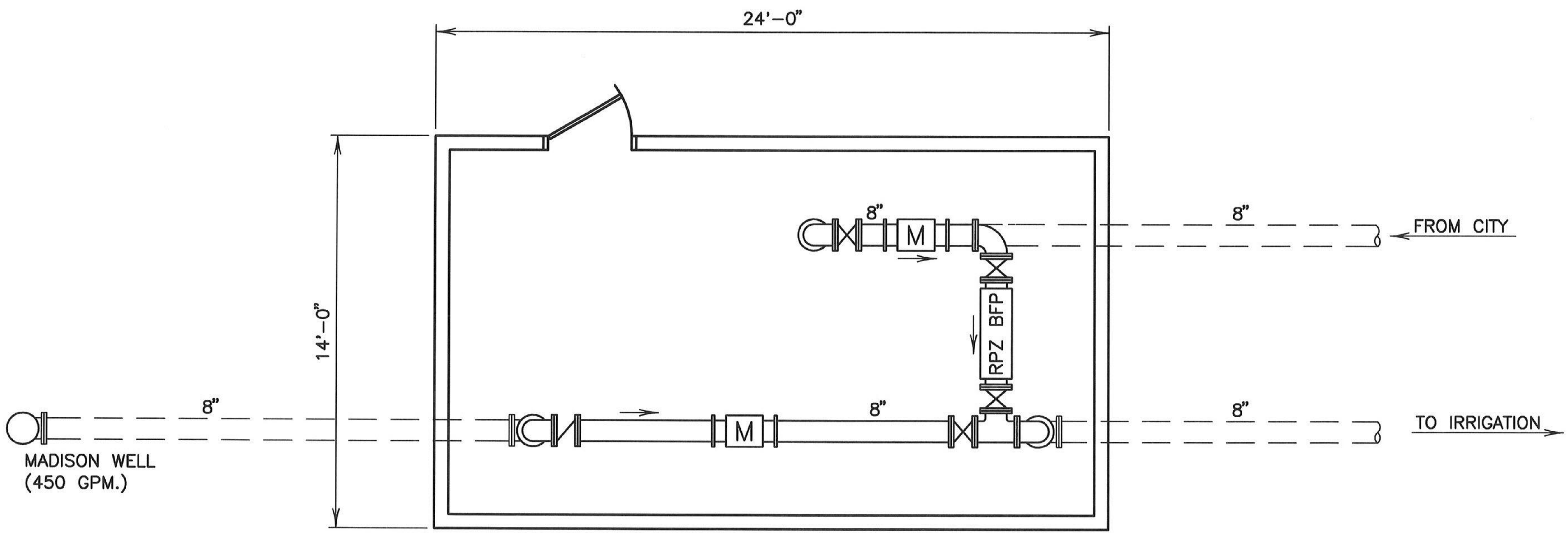

MADISON WELL
(450 GPM.)

WELL HOUSE

PLAN

SCALE: ¼" = 1'–0"

FIGURE 10
SCHEMATIC DESIGN
MADISON WELL

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Drawing: FIGURE 6.DWG (FOX) (\\MAIN-DATA\CETEC\PROJECTS & PROPOSALS\13126.00 RC SOCCER COMPLEX IRRIGATION SUPPLY STUDY\DRAWINGS\FIGURES\)

Estimated capital cost and operating costs are presented in Table 4. Section 4.2 of this report presents further discussion and analysis of risk factors.

Table 4 Budgetary Cost Estimate – Madison Well Supply

Capital Costs

Item	Quantity	Unit Cost	Total
Well Construction			
Contractor Mobilization	1 LS	$ 50,000	$ 50,000
Borehole, 17½"	3,800 LF	$ 200	$ 760,000
Borehole, 12¼"	500 LF	$ 120	$ 60,000
Logging	1 LS	$ 30,000	$ 30,000
Casing, 12" I.D.	3,800 LF	$ 70	$ 266,000
Grouting	2,000 CF	$ 40	$ 80,000
Acid Treatment	1 LS	$ 50,000	$ 50,000
Development and Testing	1 LS	$ 50,000	$ 50,000
		Well Construction Subtotal	$ 1,346,000
Well House and Pump			
Contractor Mobilization	1 LS	$ 20,000	$ 20,000
Pump and Cable	1 LS	$ 45,000	$ 45,000
Column Pipe, 6"	700 LF	$ 30	$ 21,000
Check Valves	2 EA.	$ 1,000	$ 2,000
Pitless Unit	1 LS	$ 20,000	$ 20,000
Well House Structure (14 x 20)	280 SF	$ 250	$ 70,000
Well House Piping / Valves	1 LS	$ 20,000	$ 20,000
8" Mag Meters	2 EA.	$ 7,500	$ 15,000
Backflow Preventer	1 EA.	$ 6,000	$ 6,000
Well House Electrical / Control	1 LS	$ 40,000	$ 40,000
Electrical Service to Building	1,000 LF	$ 20	$ 20,000
		Well House and Pump Subtotal	$ 279,000
Sitework and Piping			
8" PVC Header	750 LF	$ 50	$ 37,500
8" PVC Well Discharge	50 LF	$ 50	$ 2,500
8" PVC City Connection	800 LF	$ 50	$ 40,000
Site Restoration / Seeding	3 Ac.	$ 2,000	$ 6,000
		Sitework and Piping Subtotal	$ 86,000
		Construction Total	$ 1,711,000
		Construction Contingencies 15%	$ 257,000
		Total Construction	$ 1,968,000
		Design and Construction Engineering (12%)	$ 236,000
		Total Capital Cost	**$ 2,204,000**

Annual O&M Costs

Item	Cost / Year	
Electrical Demand Charges (125 HP @ $16.75)	$	2,100
Electrical Energy (78,000 kwh @ $.09)	$	7,000
Operator Labor (26 weeks @ 5 hrs. x $25/hr.)	$	3,300
Equipment Depreciation		
Structure and Piping (60 YRS, 120,000)	$	1,900
Well Pump / VFD (20 YRS, 110,000)	$	5,500
Well Water Cost	$	0
City Water Cost	$	0
Annual O&M	$	19,800

4. Cost Evaluation and Comparison of Alternatives

4.1 City Municipal Supply

Preliminary designs for the sports complex are based upon using the Rapid City municipal water system as the irrigation system supply source. The project includes extending a new 16" main north in Elk Vale Road from Seger Drive to the sports complex. The municipal system will operate at a pressure above 100 psi and will have ample capacity to supply the proposed sports complex irrigation system without pumping or supplemental storage. The planned main extension to the sports complex is a component of the City's long-range water master plan, thus it will be constructed in the proposed location and size regardless of whether or not the City potable water supply is used for the irrigation system supply.

For cost comparison purposes, the value of treated City water expected to be used for irrigation at the sports complex is taken to be the retail cost per standard City water rates. City Ordinance 13.08.430 establishes the following rates for commercial and industrial irrigation accounts for the year 2013 (meter size 3"):

City Irrigation User Rates

Unit Tier	Rate per Unit
1	$ 3.32
2	$ 3.77
3	$ 4.31

Where:

Unit = 100 cubic feet (748 gallons).
Tier 1 = 0 - 50 units / month.
Tier 2 = 51 - 100 units / month.
Tier 3 = >100 units / month.

In addition to the above described use rates, irrigation user accounts are charged a monthly meter fee which varies with meter size. The planned irrigation system for Phase 1 will utilize three separate 3-inch size meters. The monthly charge for a 3-inch size meter is as follows:

Meter Charge (3" Meter): $583.36 / month.

It is typical to activate irrigation meters only for the irrigation season and to de-activate during non-irrigation months so as to avoid meter charges when no water is being used. There is an annual activation charge of $30 per meter.

Table 5 presents a projected annual cost of City water for irrigation use at the sports complex using "average year" conditions. The projected monthly water use is from Section 2.2 of this report. The costs of water presented in Table 5 represent the annual cost of irrigation water to a private user. For purposes of this study the complex is anticipated to pay for water at the rates established by Ordinance 13.08.430.

Table 5 Annual Cost of City Water for Irrigation

Average Year Conditions

Month	Monthly Irrigation Demand Units (100 cf)	Billing Amount (2013 Rates) Tier 1 ($3.32/unit) Units	Tier 1 Amount	Tier 2 ($3.77/unit) Units	Tier 2 Amount	Tier 3 ($4.31/unit) Units	Tier 3 Amount	Meter Charges* (3 - 3")	Total for Month
May	2,905	50	$ 166	50	$ 189	2,805	$ 12,090	$ 1,840*	$ 14,284
June	4,716	50	$ 166	50	$ 189	4,616	$ 19,895	$ 1,750	$ 21,999
July	7,951	50	$ 166	50	$ 189	7,851	$ 33,838	$ 1,750	$ 35,942
August	7,010	50	$ 166	50	$ 189	6,910	$ 29,782	$ 1,750	$ 31,886
September	4,481	50	$ 166	50	$ 189	4,381	$ 18,882	$ 1,750	$ 20,986
October	3,234	50	$ 166	50	$ 189	3,134	$ 13,508	$ 1,750	$ 15,612
								Annual Total	$ 140,708

* Includes $30/meter activity charge

4.2 Cost of Risk

None of the four alternative irrigation supply sources considered in this study is guaranteed to provide a reliable source of supply at the production rates used for the schematic designs. Water well drilling carries an inherent risk of failure in the sense that underground geohydrology can vary significantly at any particular location. Past well yields for each aquifer do not necessarily predict future results at different locations. There is always the chance of a "dry hole", defined as a well yield significantly less than predicted or necessary to function as planned.

Alternatives 3 and 4 (Minnelusa and Madison aquifers) are based upon a predicted well yield with an estimated 80 percent probability of success. Alternative 2 (Inyan Kara) is based upon a design yield (160 gpm) with only a 40 percent probability of success. The probability of producing water from the Box Elder Creek alluvium is considered to be 100 percent, but it is uncertain if the projected withdrawals for irrigation can be sustained during prolonged drought conditions. Water levels in the alluvium are known to fluctuate with seasonal and annual precipitation, but technical studies of aquifer storage and recharge are not available.

Quantitative analysis of risk can take many forms, but the simplest and most widely accepted methodology for calculating a monetary value of risk is as follows[4]:

Cost of Risk = Probability of Loss (%) x Expected Loss ($)

For the drilled deep well alternatives, the cost of risk can be estimated by applying the probability of loss (100% minus success probability) to the well construction cost. The risk of loss for well drilling is typically only in well construction, not including well pump, well house and related surface improvements. For purposes of this report, the probability of success for the Box Elder collector system outlined in Section 3.2 has been assigned a value of 80 percent to acknowledge that there are unknowns and long-term risk with this option that may not be immediately apparent. It should be noted that portions of the cost of an Inyan Kara or Minnelusa well which does not produce sufficient water could potentially be offset by frilling the failed well deeper to the next aquifer below. However, this possible "salvage value" has not been considered in this analysis.

The estimated cost of risk associated with each of the four groundwater source alternatives is presented following.

Cost of Risk

Alternative Source	Probability of Loss	Potential Loss	Cost of Risk
Box Elder Alluvium	20%	$ 1,840,000	$ 237,000
Inyan Kara	60%	$ 392,000	$ 235,000
Minnelusa	20%	$ 688,000	$ 138,000
Madison	20%	$ 1,346,000	$ 269,000

The risk amounts summarized above will be discussed further in the following Section, 4.3.

4 ISO 31000, Risk Management – Principles and Guidelines, 2009.

4.3 Present Worth Analysis

This section presents an economic analysis of the four alternative sources of irrigation and the treated City municipal supply. Each alternative has differing capital costs, operation and maintenance costs, and different levels of risk. A "Present Worth" analysis is used to provide a method to compare total costs of alternative projects which have differing annual costs. The analysis converts a series of future expenditures, such as operation and maintenance costs, to a single equivalent present value. The conversion takes into account the interest rate, sometimes referred to as the "time value of money". A present worth can also include consideration of a series of non-uniform expenditures such as may be the case when inflation increases annual expenditures. The present worth analysis must include a defined time period or service life for the future costs.

The following criteria have been selected for present worth analysis of the alternate irrigation sourced alternatives, including the City of Rapid City municipal supply option:

Present Worth Criteria

Interest Rate:................................3%
Time Period: ....20 yrs and 40 yrs.
Inflation Rate:...............................0% and 2%

The criteria presented above use two alternate time periods and two alternate inflation rates. This provides information on the sensitivity of costs to the time period and inflation costs. A project with low operating costs will have an advantage with a longer time period and higher inflation rate as compared with a project with high annual operating costs. The 3 percent interest rate corresponds with the current State Revolving Fund (SRF) Rate from the South Dakota Department of Environment and Natural Resources (DENR) for public water and sewer projects within the State, and is representative of the cost of money. The two alternative time periods are arbitrary, but are typical loan terms for SRF as well as federally-funded water projects via USDA Rural Development. The two time periods are useful to help define the short and long-term costs associated with annual operation and maintenance. The inflation rates selected for analysis are arbitrary, but considered to be representative of current economic conditions.

Table 6 presents a present worth analysis of irrigation system costs for City municipal water versus the groundwater supply alternatives. The capital cost of the City supply is taken to be zero for this analysis on the basis that the basic connection to the City system and the individual irrigation zone metering stations will be installed regardless of the source of supply. The City operation and maintenance cost is taken to be the cost of water at commercial rates per Section 4.1. The cost of the groundwater alternatives are, therefore, the added capital cost, over and above the basic City-supplied system. The table also illustrates the cost impact of risk by adding the cost of risk to the total project cost as described in Section 4.2.

Table 6 Present Worth Analysis

(Rate of Inflation, 0%)

	City Water Enterprise	Alternative Source: Box Elder Alluvium	Inyan Kara	Minnelusa	Madison
Capital Costs	$ 0	$ 2,431,000	$ 1,501,000	$ 1,882,000	$ 2,204,000
Annual O&M	$ 140,715	$ 19,800	$ 29,600	$ 31,700	$ 19,800
Present Worth of O&M					
20 yrs (i=3%, uspwf = 14.8775)	$ 2,093,000	$ 295,000	$ 440,000	$ 472,000	$ 295,000
40 yrs. (i=3% uspwf = 23.1148)	$ 3,253,000	$ 458,000	$ 684,000	$ 733,000	$ 458,000
Cost of Risk	$ 0	$ 237,000	$ 235,000	$ 138,000	$ 269,000
Net Present Worth*					
20 Yr	$ 2,093,000	$ 2,963,000	$ 2,176,000	$ 2,492,000	$ 2,768,000
40 Yr.	$ 3,253,000	$ 3,126,000	$ 2,420,000	$ 2,753,000	$ 2,931,000

(Rate of Inflation, 2%)

	City Water Enterprise	Alternative Source: Box Elder Alluvium	Inyan Kara	Minnelusa	Madison
Capital Costs	$ 0	$ 2,431,000	$ 1,501,000	$ 1,882,000	$ 2,204,000
Annual O&M	$ 140,715	$ 19,800	$ 29,600	$ 31,700	$ 19,800
Present Worth of O&M					
20 yrs (i=3%, ispwf = 17.7267)	$ 2,494,000	$ 351,000	$ 525,000	$ 562,000	$ 351,000
40 yrs. (i=3% ispwf = 32.3110)	$ 4,547,000	$ 640,000	$ 956,000	$ 1,024,000	$ 640,000
Cost of Risk	$ 0	$ 237,000	$ 235,000	$ 138,000	$ 269,000
Net Present Worth*					
20 Yr	$ 2,494,000	$ 3,019,000	$ 2,261,000	$ 2,582,000	$ 2,824,000
40 Yr.	$ 4,547,000	$ 3,308,000	$ 2,692,000	$ 3,044,000	$ 3,113,000

* Net Present Worth = Capital Cost + Present Worth of O&M + Risk

Table 6 shows that when potential inflation is ignored (0 percent) that none of the groundwater sources have a lower present worth cost than City rates over a 20-year period. All four groundwater sources have a lower present worth cost over 40 years than purchasing City water at current rates. In general, it will take longer than 20 years to recover the initial investment in an alternate groundwater source to the point where it is economically favorable as compared to City municipal rates. When an inflation rate of 2 percent is considered, the cost recovery of the groundwater source is more rapid, and one source (Inyan Kara) shows that it has a lower present worth cost than purchasing City water over a 20-year period.

4.4 Phase 2 Considerations

The analysis in Table 6 is based upon projected irrigation use for the currently proposed Phase 1 consisting of 32.4 irrigated acres. The overall site is large enough that expansion to as much as 64 irrigable acres is possible. The schematic designs presented herein include facilities sized for future expansion, where feasible, but with certain exceptions. A discussion of expansion feasibility for each supply alternative follows.

Phase 2 Expansion Capability

- City Municipal Supply

  The City system could supply the maximum projected irrigation demand without any significant alterations to Phase 1 components.

- Box Elder Alluvium

  The collection pond size and pumping system design are expected to be adequate for Phase 2 demands. The pump system design includes redundant pumps which can be operated in parallel to meet increased flow rate to 900 gpm. Loss of production capacity due to drought conditions will, however, be exacerbated with higher pumping rates. Use of the City municipal system as a back-up supply will become more likely.

- Inyan Kara Well

  The Inyan Kara well capacity will likely not be able to be improved to produce more water. Drilling a second well on site is not considered to be practical because of drawdown interference with the first well. Phase 2 demands can be met only by utilizing the City municipal system back-up piping to maintain tank storage levels. Booster pump capacity included in the Phase 1 schematic design will be sufficient for Phase 2 demands.

- Minnelusa Well

  The Minnelusa well capacity will also be unlikely to be able to be increased for Phase 2. As in the case of Inyan Kara, Phase 2 demands will need to be obtained from the City municipal system.

- Madison Well

  The schematic design includes a well which is expected to be able to meet peak Phase 2 demands (450 gpm) without storage. The likelihood of developing a 900-gpm well to handle both Phases 1 and 2 is considered remote. For this alternative to handle Phase 2, it will probably be necessary to construct an on-site storage reservoir and booster pumping station, or alternatively to modify designs so that the City municipal supply handles the Phase 2 expansion with the Madison well dedicated to Phase 1 only.

4.5 Summary and Conclusions

There is no appaent alternative source of irrigation supply for the proposed sports complex which is clearly technically viable and economically justified over a 20-year period. Economic justification for developing a groundwater irrigation source improves over time after 20 years, with all options being competitive with the cost of City water over a 40-year period. If City water rates are assumed to increase for inflation or due to increased system operating costs, then the groundwater options become more viable economically.

There are, however, serious technical issues associated with all of the potential groundwater sources considered. Technical issues include risk of loss due to uncertainty, but also include water rights and water quality issues which have a significant impact on feasibility. Negative technical and economic factors to consider are summarized following.

<u>Box Elder Creek Alluvium</u>

- Possible contested water rights from downstream irrigation permit holders.
- Water quality is anticipated to be significantly poorer than other sources. Overall high levels of mineralization may present a long-term salinity hazard to soils.
- Long-term aquifer performance in terms of storage and recharge may result in unreliable yield.
- Initial construction costs are higher than other options.

<u>Inyan Kara Well</u>

- Well yield likely to be too low to provide all required irrigation.
- Probable significant reliance on City water to supplement.
- No possibility of supplying Phase 2 irrigation needs.

<u>Minnelusa Well</u>

- Uncertain water quality; may be less desirable than other sources and may have salinity levels which would preclude use for irrigation.
- Relatively high construction cost.

- Uncertain yield; may require supplemental supply from City to meet Phase 1 irrigation needs.

- Unlikely to be able to meet Phase 2 irrigation needs.

- Possible contested water rights permit by City of Box Elder if DENR considers interconnection of Minnelusa and Madison.

<u>Madison Well</u>

- Unlikely that a well at this site will be able to obtain water rights permit due to prior rights reserved by City of Box Elder.

- Relatively high construction cost results in very long payback period relative to City rates.

References

42[nd] Street Design Studio ,FMG Engineering, Inc., *Memorial Park and Civic Center Irrigation Improvements,* April 16, 2012.

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Carter,J., Driscoll, D. and Williamson, J., *Atlas of Water Resources in the Black Hills Area, South Dakota* U.S. Geological Survey, Hydrologic Investigations Atlas HA-747, 2005.

Carter, J., Driscoll, D., Foster Sawyer, J., *Ground-Water Resources in the Black Hills Area, South Dakota.* Water-Resources Investigation Report: 03-4049, 2003.

Ensz, E., *Soil Survey of Custer and Pennington Counties, Black Hills Parts, South Dakota*, 1990.

Bauder, T., Waskom, R., Sutherland, P., & Davis, J., 2013. *Irrigation Water Quality Criteria. no. 0.506* [online]. Colorado State University. Available: http://www.ext.colostate.edu/pubs/Crops/00506.html.

ISO 31000: 2009, *Principles and Guidelines of Risk Management.*

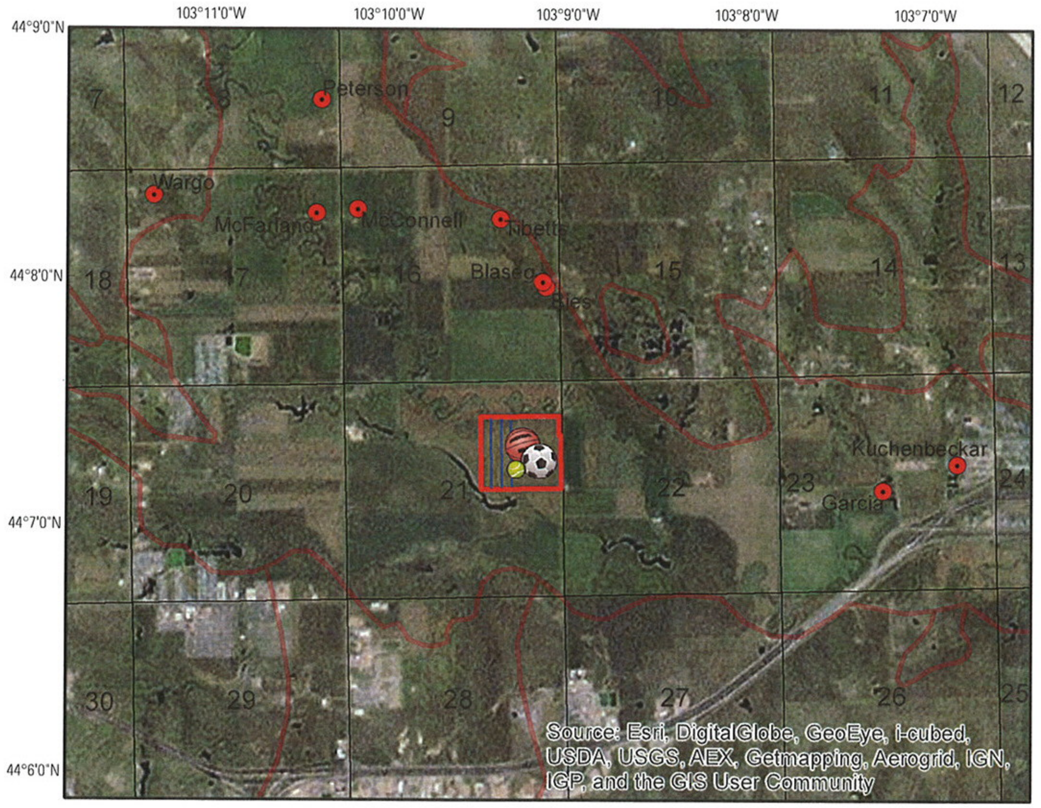
Driscoll, Dan, USFS Senior Hydrologist – Discussion regarding well yields in shallow and deep aquifers.

Buhler, Ken, DENR National Resources Engineer – Discussion regarding well yield and water rights.

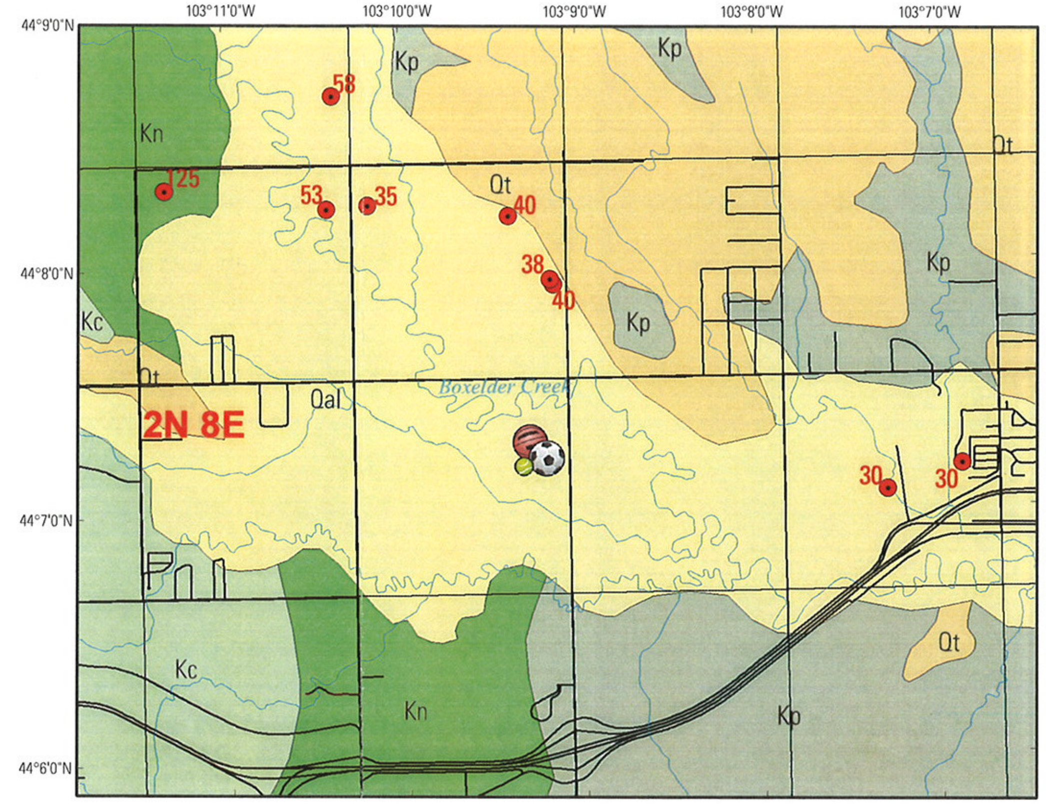
Appendix A

Box Elder Creek Alluvium Background Data

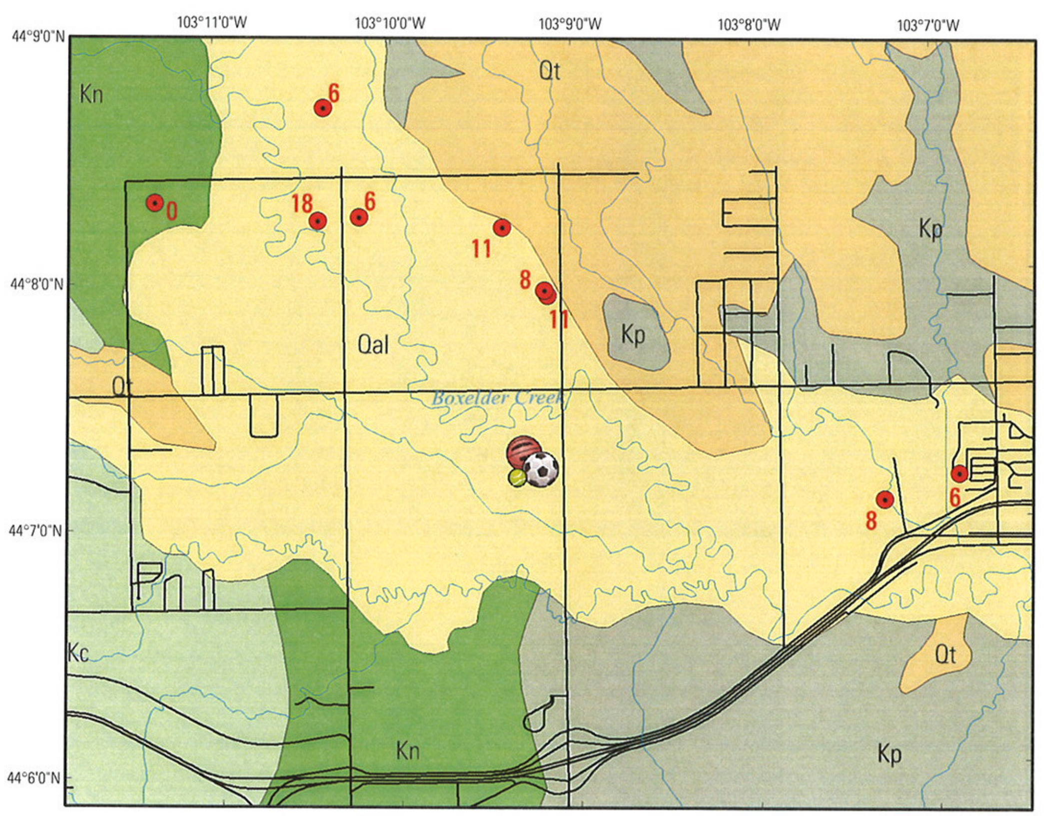
Shallow wells near proposed soccer field-well



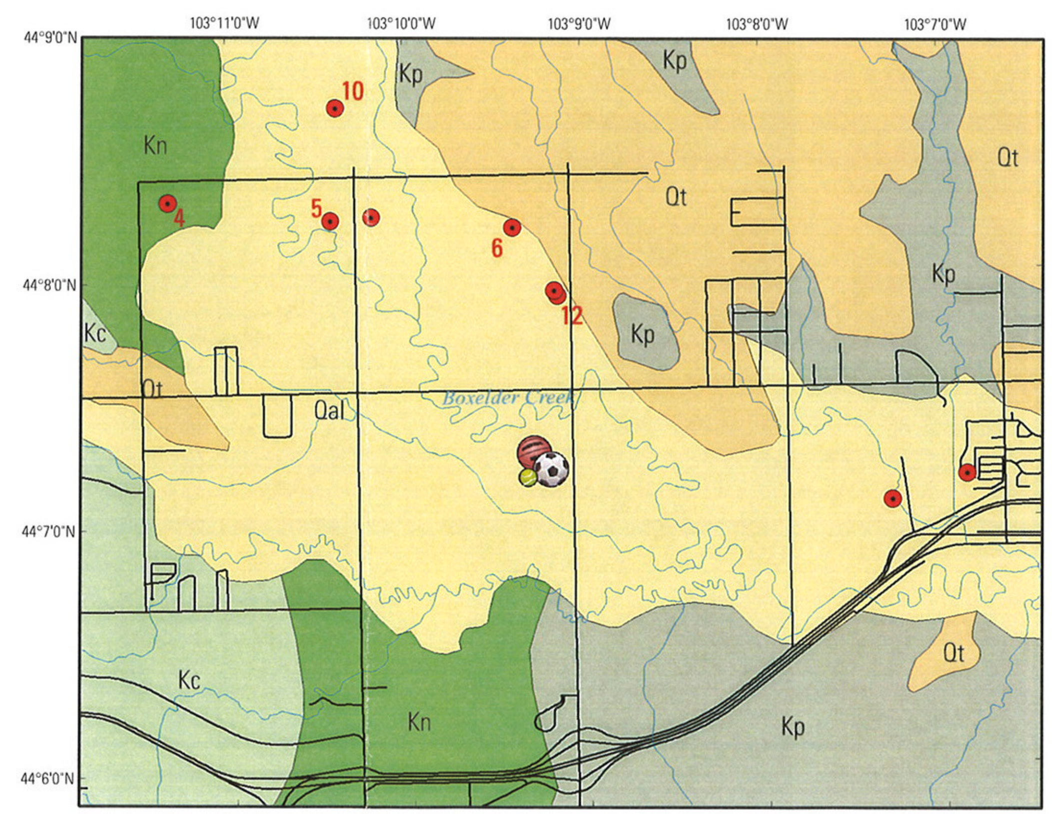
Detailed view- outline of geology overlain on aerial imagery (NAIP)



Well depth (in feet)



Thickness of alluvium/gravels and depth to bedrock (in feet)



Well production rate (in gallons per minute)

Explanation

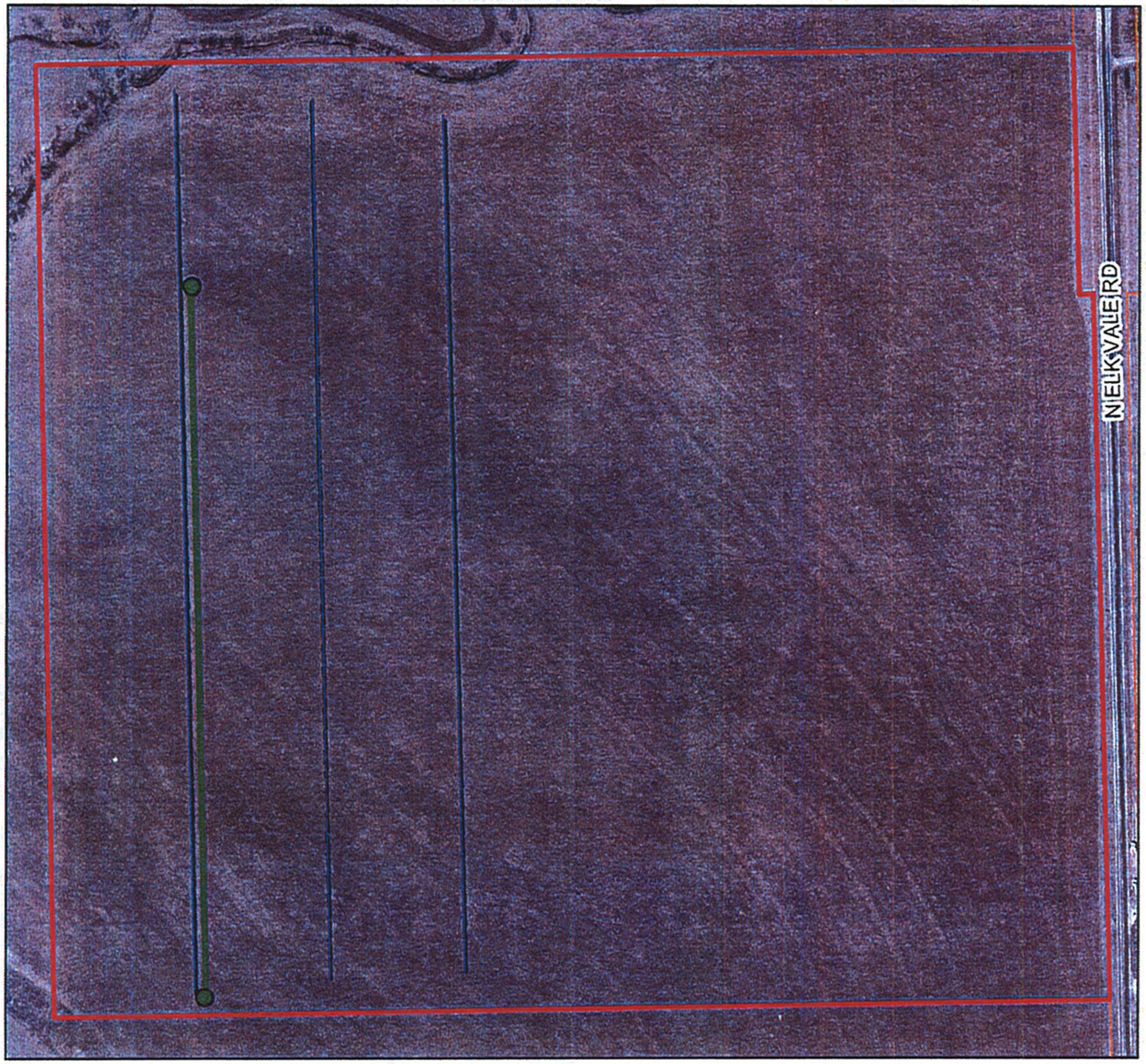
- Qt- Terrace gravels
- Qal- Alluvium
- Kp- Pierre Shale
- Kn- Niobrara Formation
- Kc- Carlile Shale
- Soccer field
- Wells with labels
- Streams with labels
- Roads

0 0.5 1 2 Miles

0 0.5 1 2 Kilometers

Jonathan McKaskey, 10/2012

Direct Current Resistivity Profiles



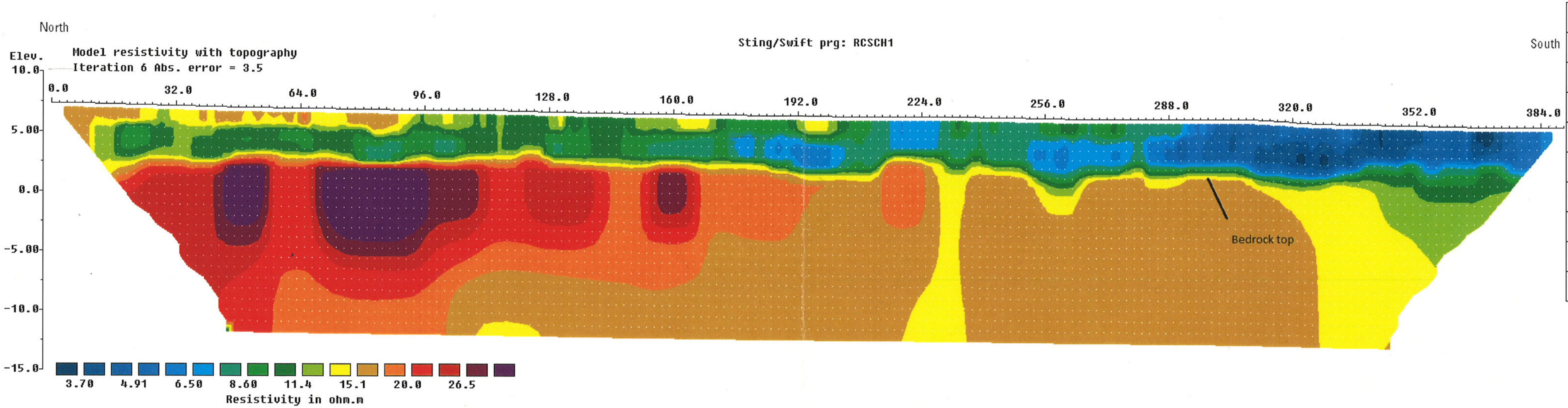
Explanation

DC Resisitvity Transect

0 0.03 0.06 0.12 Miles

0 0.06 0.12 Kilometers

Detailed view- aerial imagery (NAIP)



Horizontal scale is 9.11 pixels per unit spacing
Vertical exaggeration in model section display = 3.07
First electrode is located at 0.0 m.
Last electrode is located at 390.0 m.

Unit Electrode Spacing = 2.00 m.

EPA ID#: 0259 System Name: Plainsview Mobile Manor

Common Ion Data

(All chemical data are reported in milligrams per liter (mg/l) except pH and Langlier Index)

Source	Type	Date	TDS	Conductance	pH	Alk-M	Alk-P	Na	K	Ca	Mg	Fe	Mn	Cl	SO4	HCO4	CO3	Hardness	Langlier	NO3	F
01	Raw	01/23/86	1480	1840	7.34	386	0	140	12.0	195.0	97.0	0.13	0.03	30.0	716	471	0	400	+0.19	3.0	0.39
02	Raw	05/17/90	1269	2060	7.31	344	0	160	7.2	224.0	104.0	0.16	0.02	65.7	793	420	0	987	+0.33	2.0	0.35
02	Raw	06/18/96	2015	2332	7.30	365	0	182	5.9	239.0	120.0	0.06	0.10	71.0	967	445	0	1090	+0.51	0.0	0.34
02	Raw	05/10/05	1936	2430	7.47	366	0	178	7.1	232.0	113.0	0.04	0.02	74.0	969	447	0	1040	+0.67	2.8	0.45
Averages			1675	2166	7.36	365	0	165	8.1	222.5	108.5	0.10	0.04	60.2	861	446	0	879		2.0	0.38

Source	Type	Date	TDS	Conductance	pH	Alk-M	Alk-P	Na	K	Ca	Mg	Fe	Mn	Cl	SO4	HCO4	CO3	Hardness	Langlier	NO3	F
01	Treated	09/14/93	1900	2500	7.28	365	0	161	7.0	298.0	120.0	0.04	0.03	78.0	923	445	0	1240	+0.11	2.3	0.34
02	Treated	11/09/98	1700	2500	7.82	360	0	180	11.0	260.0	46.0	0.05	0.02	54.0	930	440	0	1100	+1.29	2.5	0.40
02	Treated	04/29/02	1829	2320	7.51	367	0	153	5.2	231.0	111.0	0.06	0.05	60.0	968	448	0	1034	+0.94	1.8	0.35
02	Treated	12/04/07	1760	2370	7.42	369	0	162	7.8	225.0	104.0	0.40	0.01	85.0	919	450	0	990	+0.84	3.9	0.35
02	Treated	05/19/11	1680	2310	8.00	362	0	170	5.7	237.0	101.0	0.47	0.01	64.5	912	442	0	1010	+1.43	4.7	0.34
Averages			1774	2400	7.61	365	0	165	7.3	250.2	96.4	0.20	0.02	68.3	930	445	0	1075		3.0	0.36

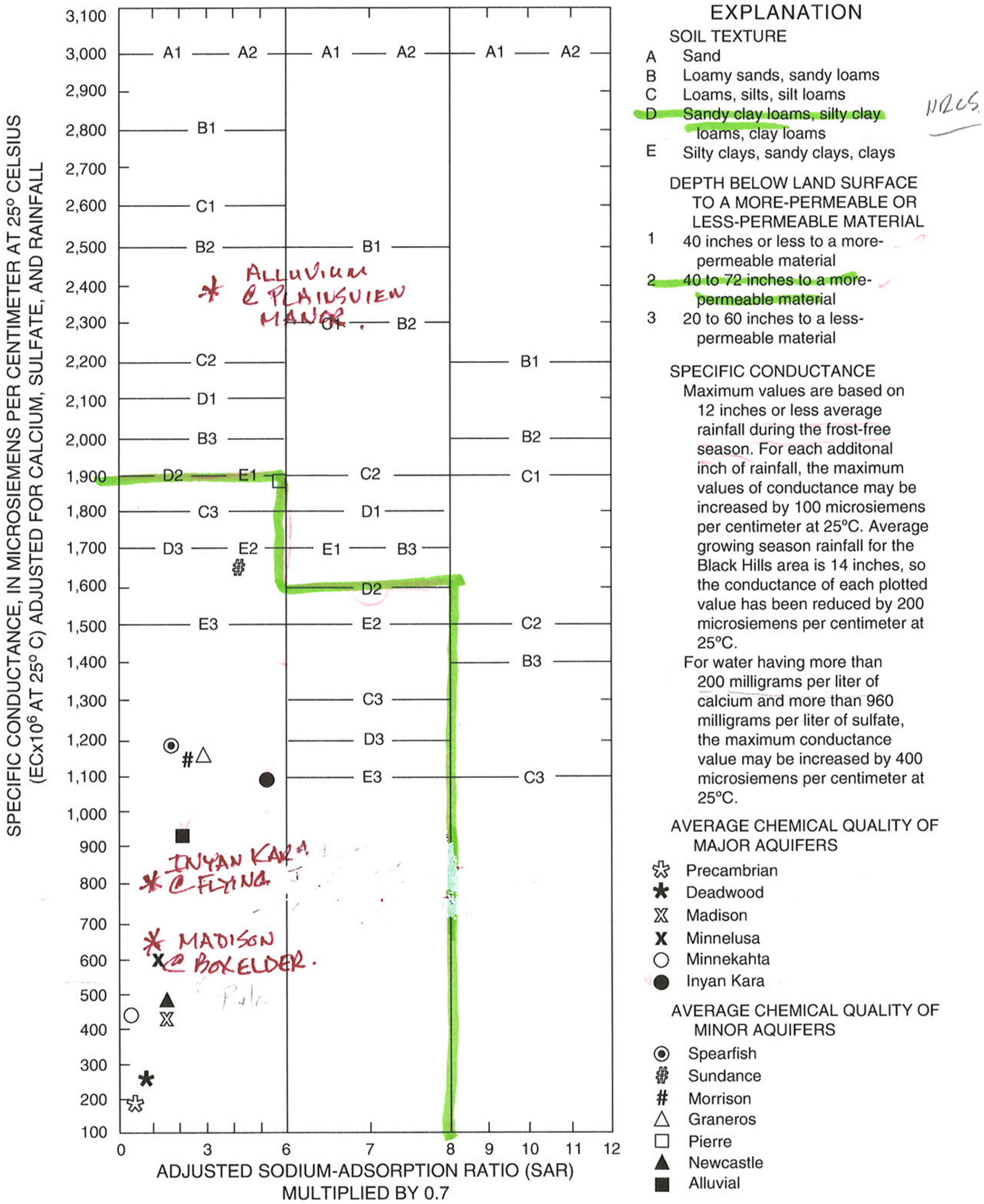


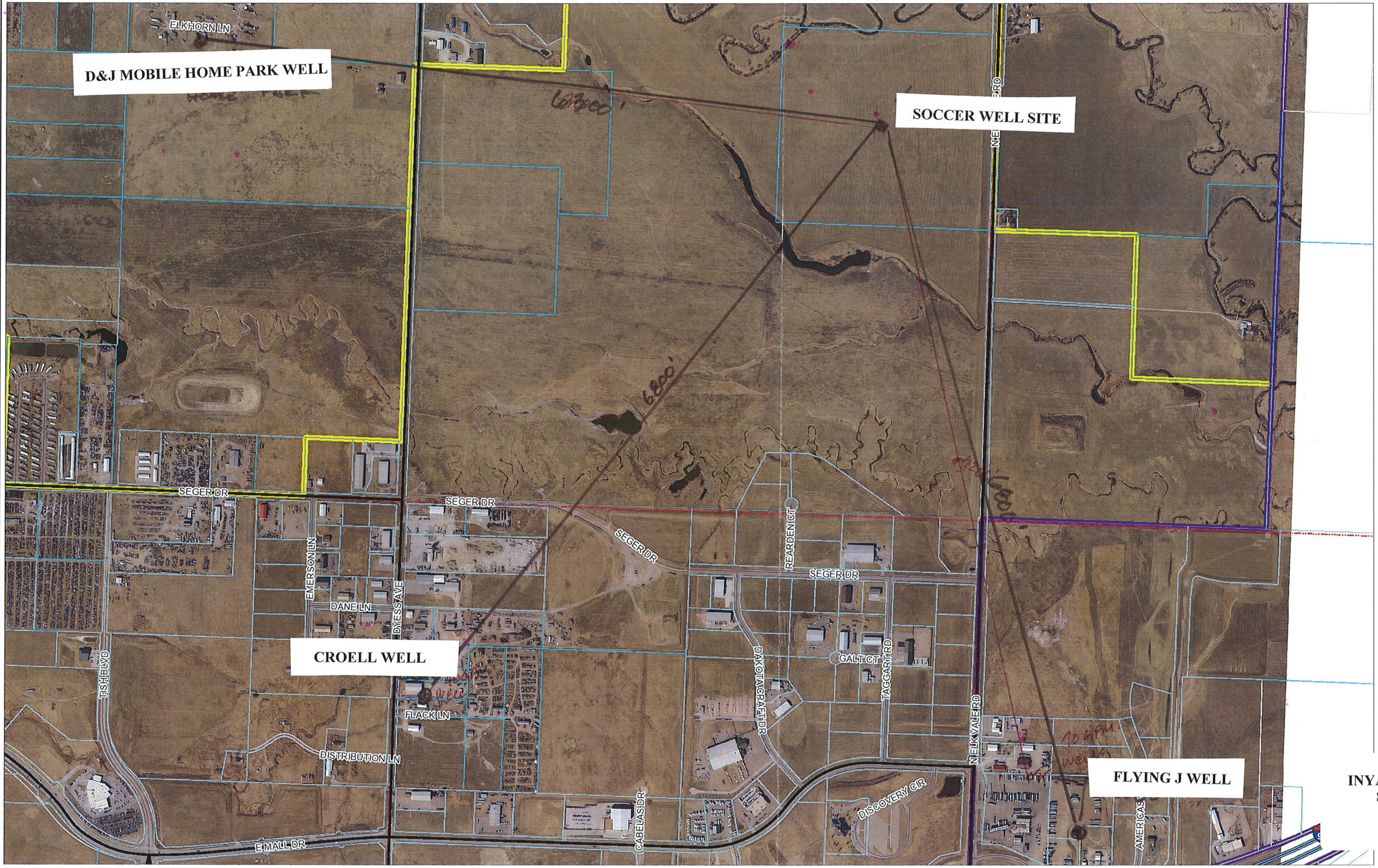
Figure 39. South Dakota irrigation-water classification diagram for selected aquifers (from Williamson and Carter, 2001). This diagram is based on South Dakota standards (revised Jan. 7, 1982) for maximum allowable specific conductance and adjusted sodium-adsorption-ratio values for which an irrigation permit can be issued for applying water under various soil-texture conditions. Water can be applied under all conditions at or above the plotted point, but not below it, provided other conditions as defined by the State Conservation Commission are met (from Koch, 1983).

Appendix B

Inyan Kara Background Data

RapidMap
Rapid City-Pennington County GIS
www.RapidMap.org

Rapid City-Pennington County GIS



Legend

Roads
- Interstate
- US highway
- SD highway
- County highway
- Main road
- Minor arterial
- Collector
- Ramp
- Paved road
- Unpaved road
- Unimproved road
- Trail
- FS Highway
- Airport Runway
- Not yet coded

Lot Lines
- <Null>
- Lot Line
- Parcel Line

Township/Section Lines
- 0
- 7

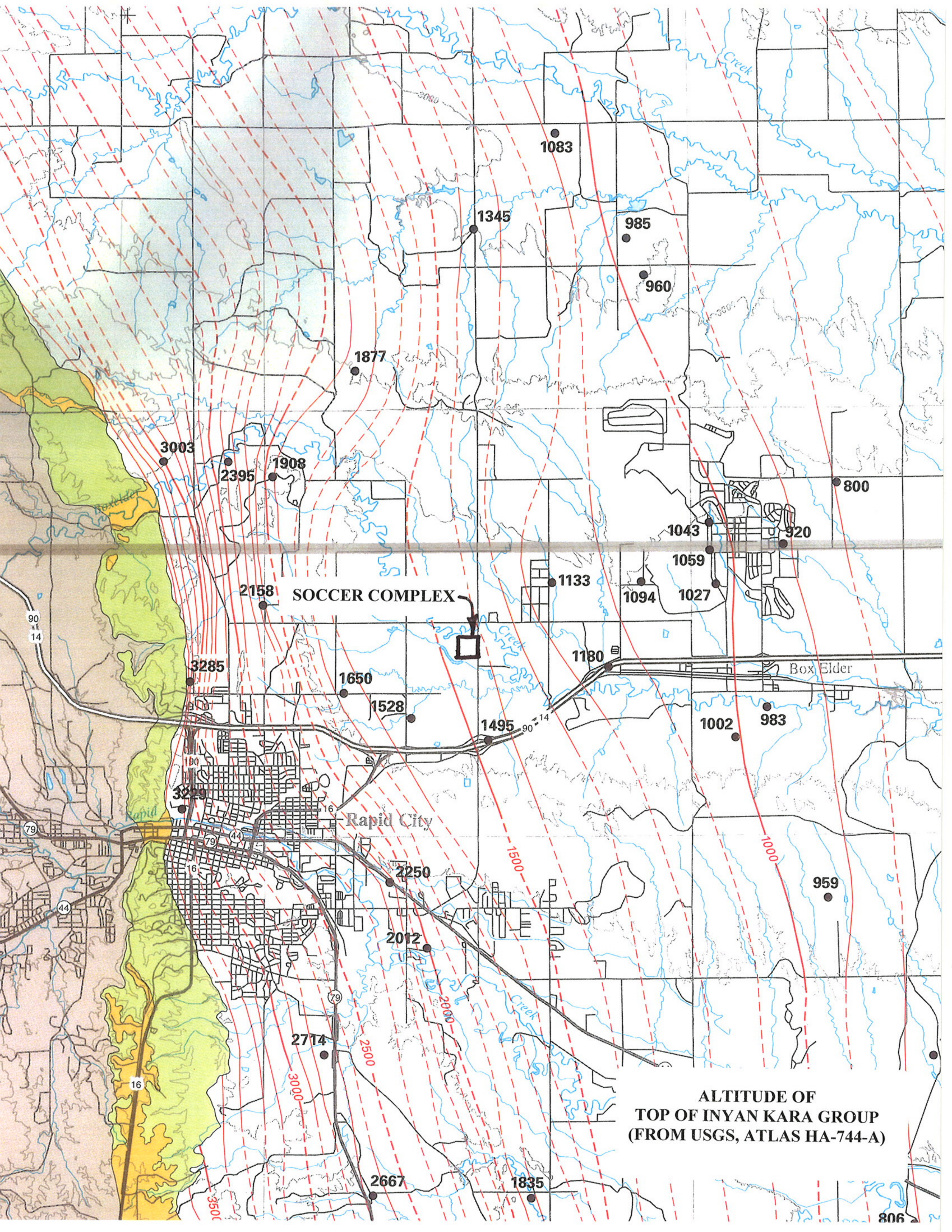
County Line

1,740.3 0 870.17 1,740.3 Feet

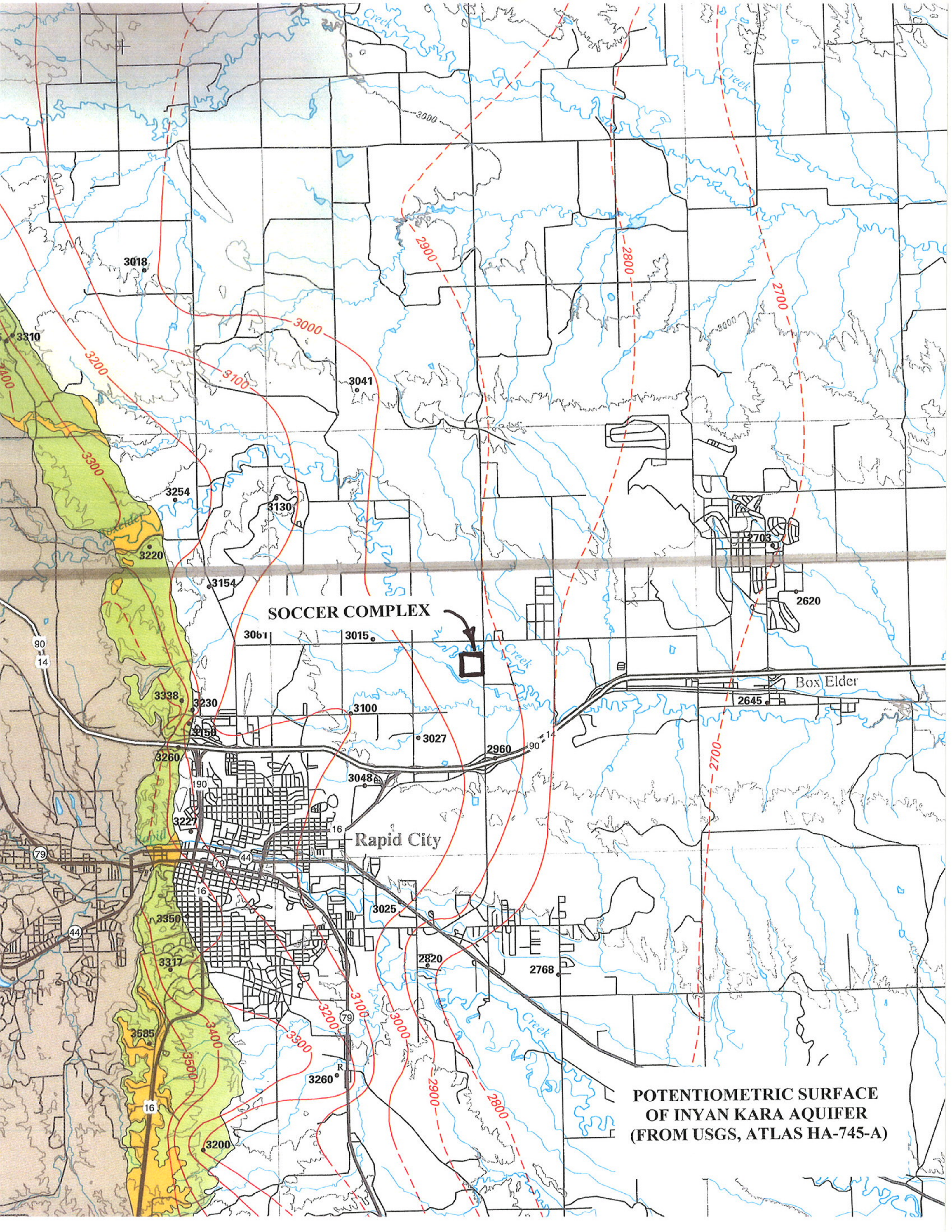
1" = 906'

Map Notes:

DISCLAIMER: This map is provided 'as is' without warranty of any representation to accuracy, timeliness, or completeness. The burden for determining accuracy, completeness, timeliness, merchantability, and fitness for or the appropriateness for use rests solely on the user. Rapid City and Pennington County make no warranties, express or implied, as to the use of the map. There are no implied warranties of merchantability or fitness for a particular purpose. The user acknowledges and accepts the limitations of the map, including the fact that the data used to create the map is dynamic and is in the constant state of maintenance, correction, and update. This documents does not represent a legal survey of the land. There are no restrictions on the distribution of printed Rapid City/Pennington County maps, other than the City of Rapid City copyright/credit notice must be legible on the print. The user agrees to recognize and honor in perpetuity the copyrights and other proprietary claims for the map(s) established or produced by the City of Rapid City or the vendors furnishing said items to the City of Rapid City.



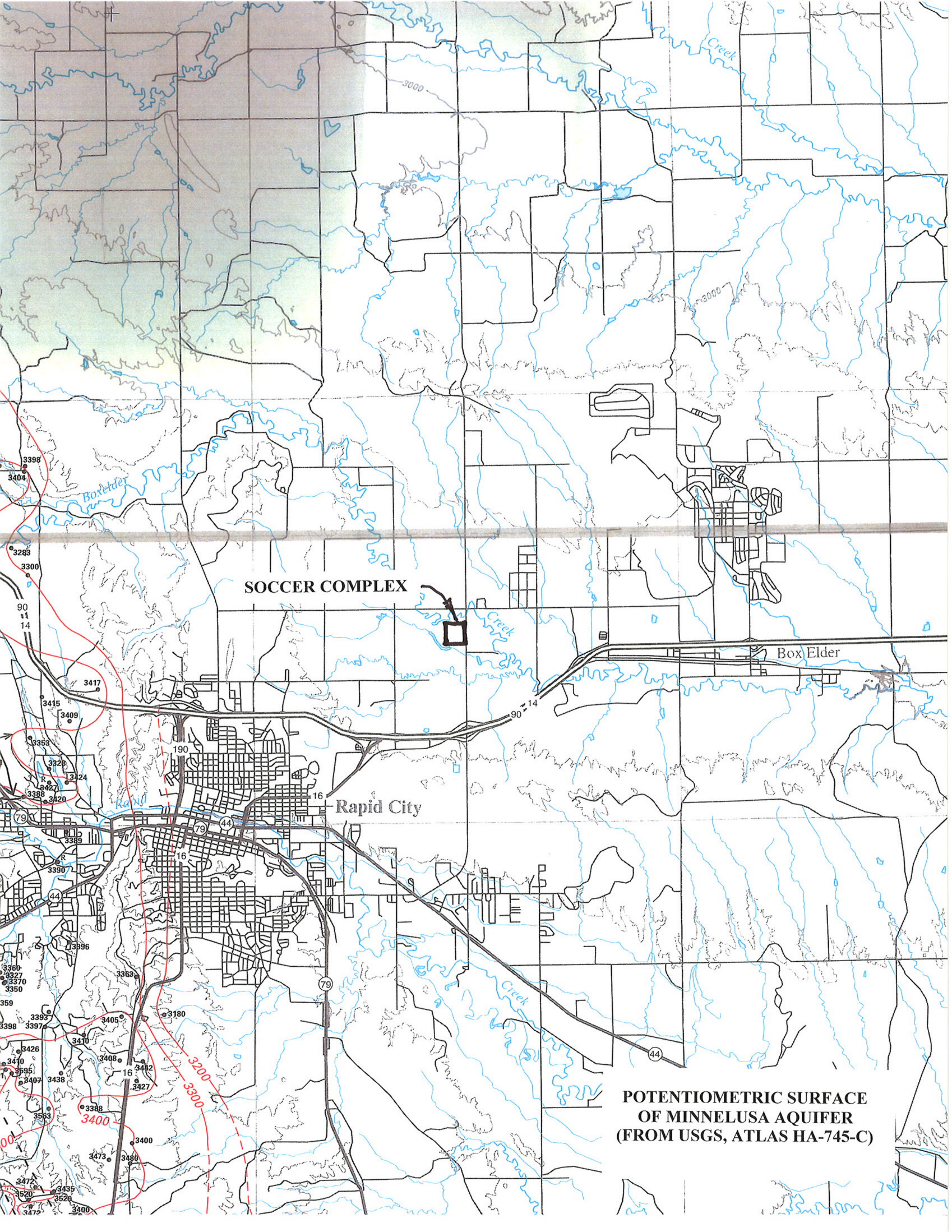
1083
1345
985
960
1877
3003
2395
1908
800
1043
920
1059
1133
2158
SOCCER COMPLEX
1094
1027
1180
3285
1650
Box Elder
1528
983
1495
1002
3229
Rapid City
1500
1000
2250
959
2012
2000
2714
2500
3000
2667
1835
806
ALTITUDE OF
TOP OF INYAN KARA GROUP
(FROM USGS, ATLAS HA-744-A)



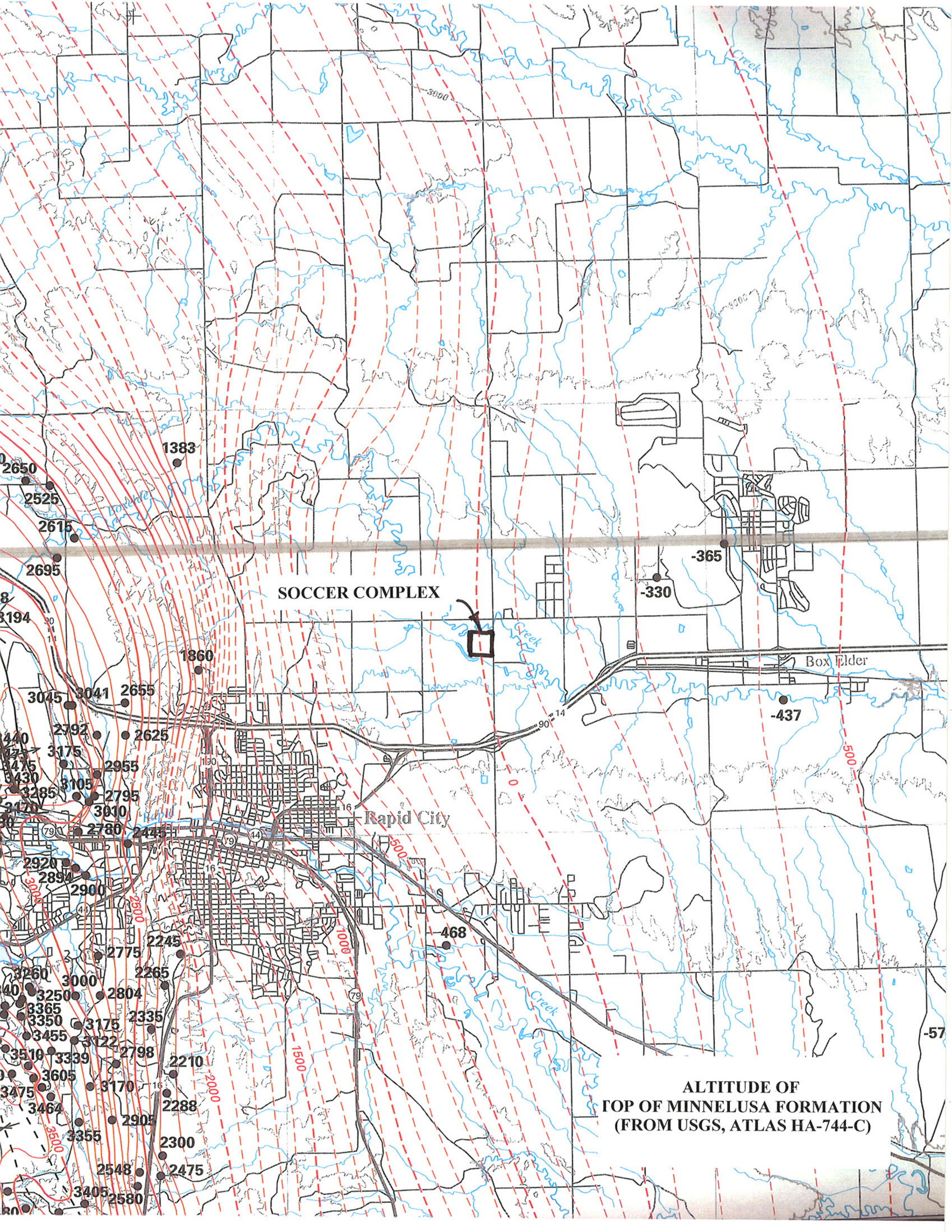
POTENTIOMETRIC SURFACE
OF INYAN KARA AQUIFER
(FROM USGS, ATLAS HA-745-A)

Appendix C

Minnelusa
Background Data



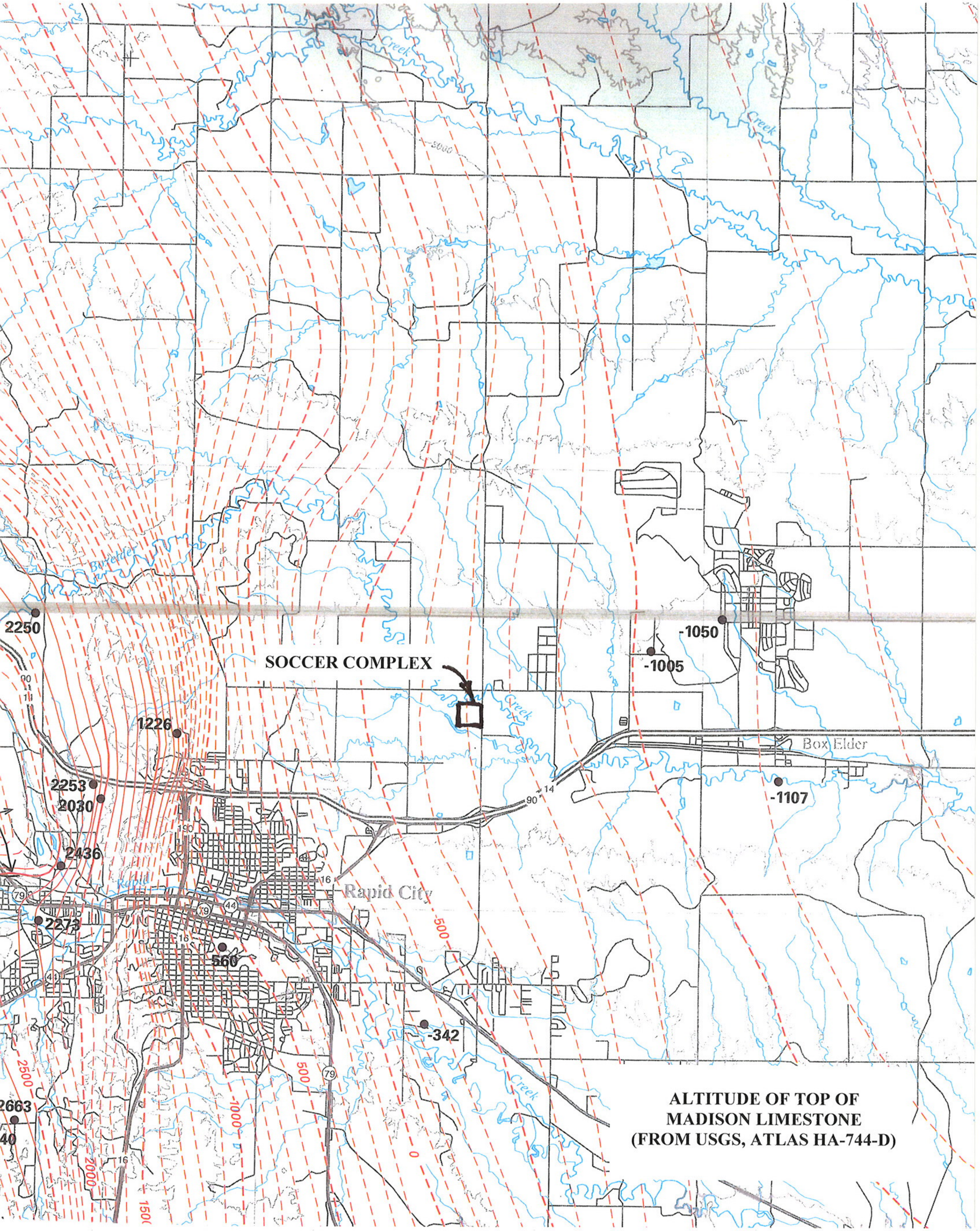
POTENTIOMETRIC SURFACE OF MINNELUSA AQUIFER (FROM USGS, ATLAS HA-745-C)



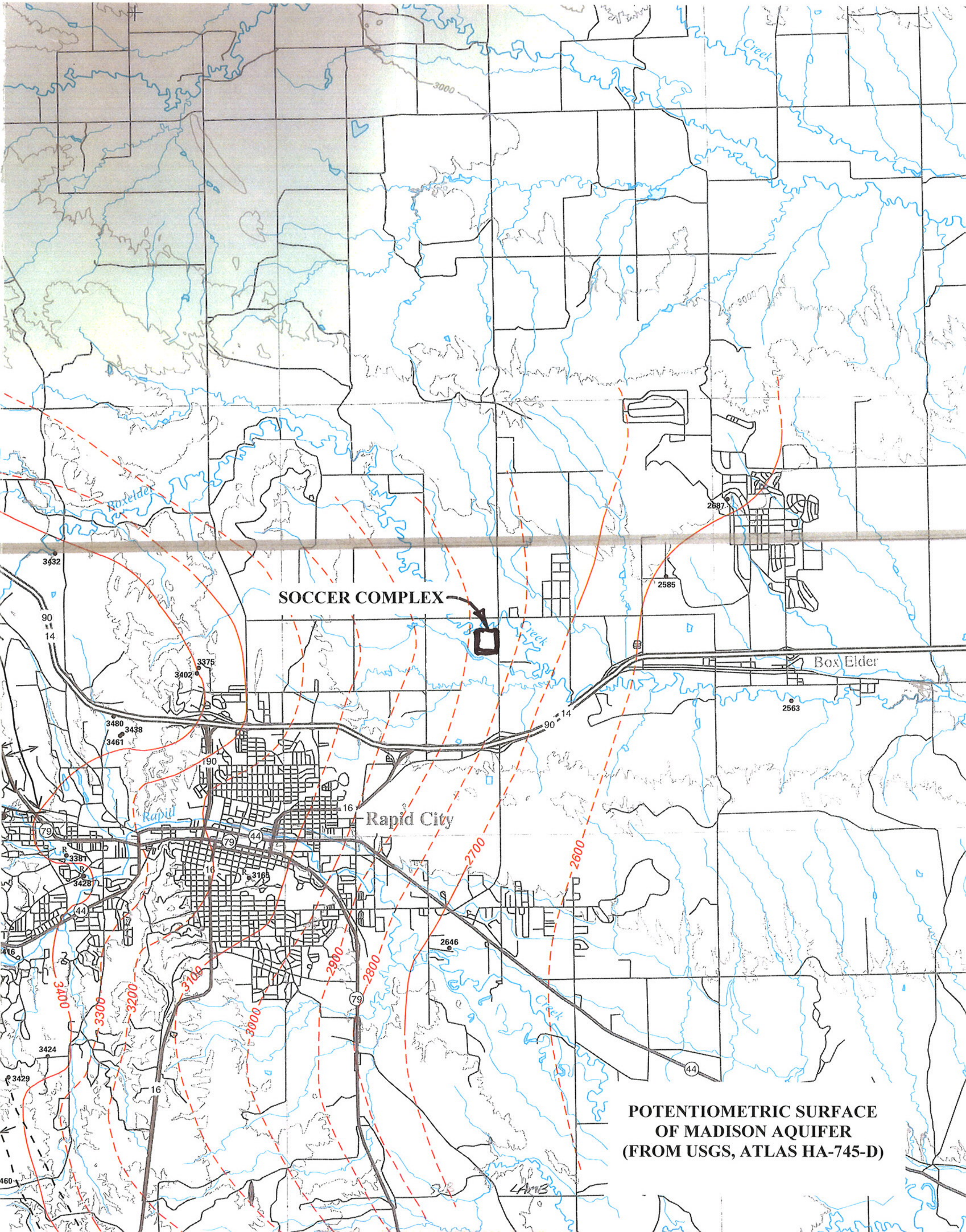
ALTITUDE OF
TOP OF MINNELUSA FORMATION
(FROM USGS, ATLAS HA-744-C)

Appendix D

Madison
Background Data



SOCCER COMPLEX
2250
-1050
-1005
1226
Box Elder
-1107
2253
2030
2436
Rapid City
2273
560
-500
-342
500
2500
-1000
2663
2000
0
ALTITUDE OF TOP OF
MADISON LIMESTONE
(FROM USGS, ATLAS HA-744-D)



POTENTIOMETRIC SURFACE OF MADISON AQUIFER (FROM USGS, ATLAS HA-745-D)

WATER PERMIT NO. 2632-2

Name of Applicant: **City of Box Elder**

Address: **520 N Ellsworth Rd, Suite 9C, Box Elder SD** Phone: **605 923-1408**

Amount of Water Claimed: **1.0 cfs (~~725~~ 435 AF)** Total Acres: **NA**

Source of Water Supply: **groundwater (one well)**

Water to be used for: **municipal** County: **Pennington and Meade**

Type of Waste Disposal System:

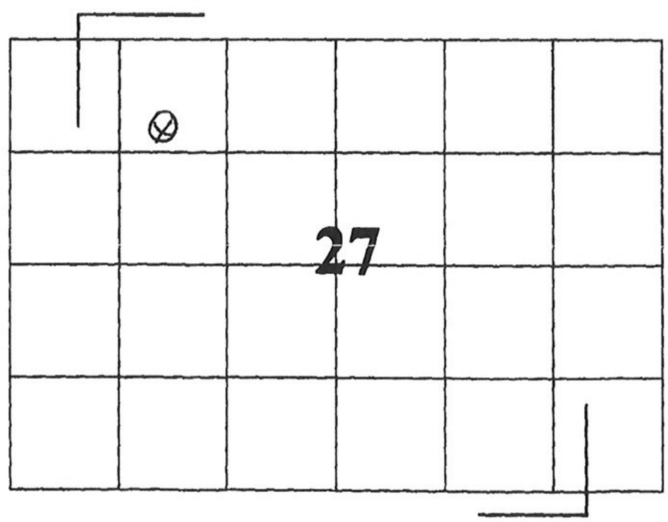
Location: **north of Box Elder**

PRIORITY Date Received: **4-16-08** Application/License Fee: **$375**

Corrected Application Received: **5-23-08** Period of Annual Use: **January 1 – December 31**

Remarks:

Diversion Point: **NW ¼ NW ¼ Sec 27-T2N-R8E**



Land to be Irrigated: **NA**

Depth of Well: **4,244 feet deep well**

Well Driller:

Remarks:

Type of Map: **aerial**

Prepared by: **Raymond T Bettmeng, PE**

Reviewed and the Number Assigned on: **5-27-08** By: **Karen Schlaak**

Notice of Hearing - date to intervene: ______________________________

D EForm - 1585 V2
ORM 2, Application for uses other than irrigation
(type or print)

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WATER RIGHTS PROGRAM
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Mail to: Water Rights Program, Joe Foss Building, 523 E. Capitol, Pierre, SD 57501-3181, (605) 773-3352	No. 2632-2 (office use only) Hydrologic Unit 10120111 Basin Upper Cheyenne Newspaper Rapid City Journal PO BOX 450 605-394-8300 57709 Meade County Times PO Box 69 Sturgis 57785 605-347-2503

Application For Permit To Appropriate Water Within The State Of South Dakota

Well 10

Check use(s) of water:

- [X] Municipal
- [ ] Rural Water System
- [ ] Domestic (over 18 gpm)
- [ ] Suburban Housing
- [ ] Commercial
- [ ] Industrial
- [ ] Recreational
- [ ] Fish & Wildlife
- [ ] Other ______
- [ ] Institutional
- [ ] Geothermal Heat

Type of Application: (check one)

- [X] **New**
- [ ] **Vested Right** (Use predates Mar 2, 1955)
- [ ] **Future Use Reservation**
- [ ] **Place to Beneficial Use Water Reserved by Future Use Permit No.** ______
- [ ] **Amendment/Correction to Permit No.** ______

Description of amendment/correction: (i.e. change diversion point(s), add diversion point(s), change use, etc.)

1. Name of Applicant CITY OF BOX ELDER, SOUTH DAKOTA Phone 605 923-1408
   (check one) [X] Owner [ ] Tenant/lessee
   Mailing Address 520 N. ELLSWORTH RD STE 9C BOX ELDER (Street, RR, or Box and City) State SD 57719 (Zip Code)
2. Amount of water claimed 1.0 *CFS or 450 **GPM ~~[illegible]~~ 435 ***AF
   (*Cubic Feet per Second) (**Gallons per Minute) (***Acre Feet - storage capacity of dam/dugout or annual use if applicable)
3. Source of water supply MADISON AQUIFER
4. Location of point of diversion (example - 3 wells in SW1/4 NE1/4 section 12-T104N-R53W) County PENNINGTON
   1 WELL IN NW 1/4 of NW 1/4, SECTION 21-T2NR8E BHM
5. County or counties where water will be used PENNINGTON, MEADE
6. Annual period during which water is to be used JANUARY 1 THROUGH DECEMBER 31
7. Give a description of the project. When available include any preliminary engineering report or other reports or information that will help explain the project. (Attach sheet if more space is needed)
   THE PROJECT CONSISTS OF CONSTRUCTING AN APPROXIMATELY 4500 FOOT DEEP WELL AND PUMPHOUSE WITH ELECTRICAL CONTROLS AND CHEMICAL FEED SYSTEM TO TIE INTO THE MUNICIPAL WATER OF CITY OF BOX ELDER

STATE OF SOUTH DAKOTA)
County of PENNINGTON) SS

Attachments: Attach Form 2A if diversion is from a well or dugout, or if storage of water is proposed. Attach map and any other technical information. (see instructions)

I, AL TODD, the applicant, certify that I have read this application, have examined the attached map and that the matters stated are true and that I intend, and am able to complete the necessary construction.

Applicant's signature Al Todd

Subscribed and sworn to before me this 11th day of April 2008

MYSTEE L ROTH
NOTARY PUBLIC
SEAL
SOUTH DAKOTA

Mystee L Roth
Notary Public signature

2-2007

SOUTH DAKOTA
WATER PERMIT NO. 2632-2

Date of first receipt of application April 16, 2008.
Date of return to applicant for corrections, amendments or changes April 16, 2008.
Date of receipt of corrected application May 23, 2008.

The Chief Engineer, on behalf of the Water Management Board, issues Water Permit No. 2632-2 to the City of Box Elder, 520 N Ellsworth Rd, Ste 9C, Box Elder SD 57719 authorizing the construction of the water use system and the placing of water to beneficial use subject to the following limitations, conditions and qualifications:

1. Water Permit No. 2632-2 appropriates 435 acre feet of water annually at a maximum diversion rate of 1.0 cubic feet of water per second (cfs) from one well to be completed into the Madison Aquifer (approximately 4,244 feet deep) located in the NW 1/4 NW 1/4 Section 27-T2N-R8E.

2. The water appropriated shall be used for the purpose of municipal use and may not exceed the amount of water needed for beneficial use.

3. The water is to be used during the following described annual period: January 1 – December 31.

4. The date of approval of Permit No. 2632-2 is August 25, 2008.

5. The date from which applicant may claim right is April 16, 2008.

6. One-fifth of the construction is to be completed on or before February 25, 2010.

7. All construction is to be completed on or before August 25, 2013.

8. Water is to be put to beneficial use on or before August 25, 2017.

9. Water rights obtained in compliance with the laws of the State of South Dakota may not be unlawfully impaired by this appropriation.

QUALIFICATIONS

1. In accordance with SDCL 46-1-14 and 46-2A-20, Permit No. 2632-2 is issued for a 20-year term. Pursuant to SDCL 46-2A-21, the 20-year term may be deleted at any time during the 20-year period or following its expiration. If the 20–year term is not deleted at the end of the term, the permit may either be cancelled or amended with a new term limitation of up to twenty years. Permit No. 2632-2 may also be cancelled for nonconstruction, forfeiture, abandonment, or three permit violations pursuant to SDCL 46-1-12, 46-5-37, 46-5-37.1 and ARSD 74:02:01:37.

2. The well approved under this Permit will be located near domestic wells and other wells which may obtain water from the same aquifer. The well owner under this Permit shall control his withdrawals so there is not a reduction of needed water supplies in adequate domestic wells or in adequate wells having prior water rights.

3. The City of Box Elder shall report to the Chief Engineer annually the amount of water withdrawn from the Madison Aquifer.

WATER MANAGEMENT BOARD

By: Garland Erbele — OCT 30 2008

Garland Erbele, Chief Engineer — date
Water Rights Program
Department of Environment and Natural Resources

STATE OF SOUTH DAKOTA GREAT SEAL 1889

Form 2A **SUPPLEMENTAL INFORMATION**
(Complete applicable portions only)

(type or print in ink)

1. Well Information – Proposed Construction

a) Drill Hole Diameter 20", 14-3/4", 9-1/2", 6-1/4" Depth 40', 1340', 3844', 4244'

b) Casing Type Steel Diameter 16", 10-3/4", 7" Thickness 62.6 lb/ft, 41.9 lb/ft, 23 lb/ft

c) Screen Type None Diameter ____ Thickness ____

d) Gravel Pack None Length of Gravel Pack ____

e) Depth to Top of Water Bearing Material Approximately 3,819 feet

f) Depth to Water (ground surface to water level) Madison Aquifer, approximately 303 feet

g) Distance to nearest existing domestic well:

On applicants property 2.0 miles Lakota Formation On property owned by others 1.5 miles Lakota Formation

2. Wastewater Disposal System Information

a) Type of System (i.e. septic tank, drain field) None

b) System Capacity (gallons) ____ Year Constructed ____

c) Connected to the City of ____ Sanitary System ____

3. Dugout Information

a) Surface Dimensions ____ Depth ____

b) Depth to water (Ground surface to water level) ____

4. Water Storage Dams

If the proposed water use system contains one or more storage dams, please furnish the information requested below for each dam. The locations of the dams need to be shown on the map submitted with the application.

a) If a private engineering firm or government agency was involved in the design of this dam, please give their name and address:

b) Freeboard ____

c) Crest Width ____

Crest Height ____

d) Height ____

e) Primary Outlet Capacity ____

If pipe, diameter ____

f) Secondary Spillway Capacity ____

Spillway Width ____

g) X & Y Slope ____

Upstream ____

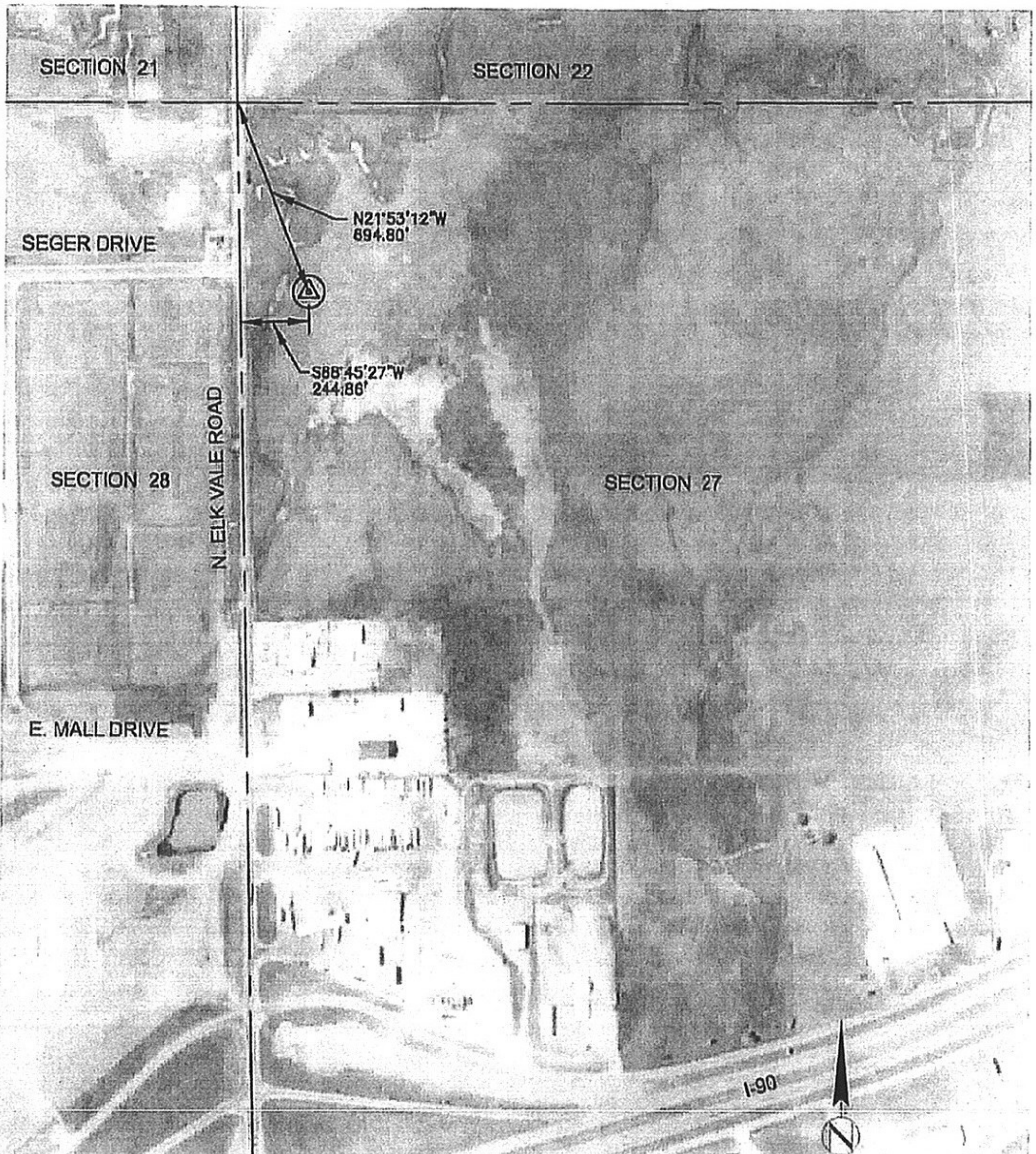
Downstream ____

h) Surface Area of Impoundment ____

i) Storage ____ Acre Feet

j) Drainage Area Above Dam ____ Acre

EXHIBIT A



(△) = PROPOSED WELL LOCATION

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500 250 0 500

HORIZ. SCALE: 1"=500'

THE ABOVE AERIAL PHOTO DEPICTS THE APPROXIMATE PROPOSED WELL LOCATION AS PRESUMED PER THE CITY OF BOX ELDER. THE SECTION LINES HERE HAVE BEEN ADDED TO THE ABOVE MAP IN THEIR APPROXIMATE LOCATIONS.

REGISTERED PROFESSIONAL ENGINEER
REG. NO. 8307
RAYMOND T. BETTMENG
SOUTH DAKOTA

5/9/08

RAYMOND T. BETTMENG DATE

FRONT
ARCHITECTURE ENGINEERING

PROPOSED MADISON WELL #10 BOX ELDER, SOUTH DAKOTA LOCATED IN THE NW 1/4 NW 1/4 SECTION 27 T2N, R8E, B.H.M JOB NUMBER 08.1425.001 PENNINGTON COUNTY, SD DATE 05/07/08	SHEET TITLE: EXHIBIT A WELL LOCATION	SHEET 1 OF 1

FILE NAME: 1425-S01-EXHIBIT02.DGN DRAWN BY: RJD