Terrane Resources Co.

P.O. Box 173 Stafford, KS 67578 620-546-3616

KANSAS GROUND WATER: STRAIGHT UP FROM THE ROCKS!

CITY OF ANTHONY, KS:
ISSUES AND CONCERNS RE: ADDITIONAL WATER FOR THE GOLF COURSE; 29 OCTOBER, 2024

This evaluation is written to explore options for additional water to supplement the irrigation water demand at the current Anthony Golf Course.

The Golf Course(GC) is currently being supplied irrigation water by the surface diversion from the City Lake and 3 ground water wells located near the SE corner of the Golf Course.

The data we have reviewed to date indicates additional water may be available from the current GC water wells and / or the Harper Well Fields.

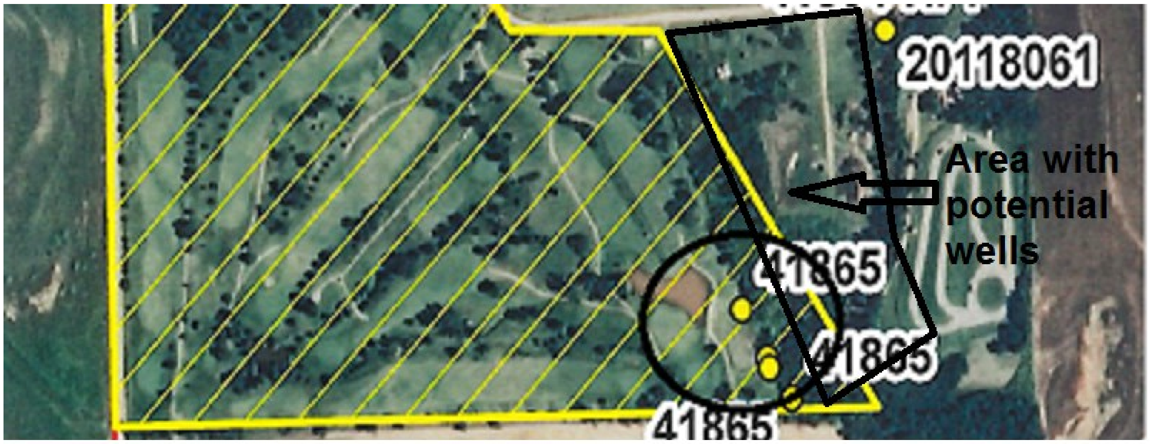
Both options have limitations that need to be further explored.

Additional water from the existing GC supply wells may be an option and will depend on proper well and storage evaluation.

Additional water from the Harper Well Fields is also an option but is limited by the facilities on site.

Golf Course(GC) Well Field:

The GC is being irrigated by a battery of 3 wells near the SE corner and by withdrawals of surface water from the City Lake.



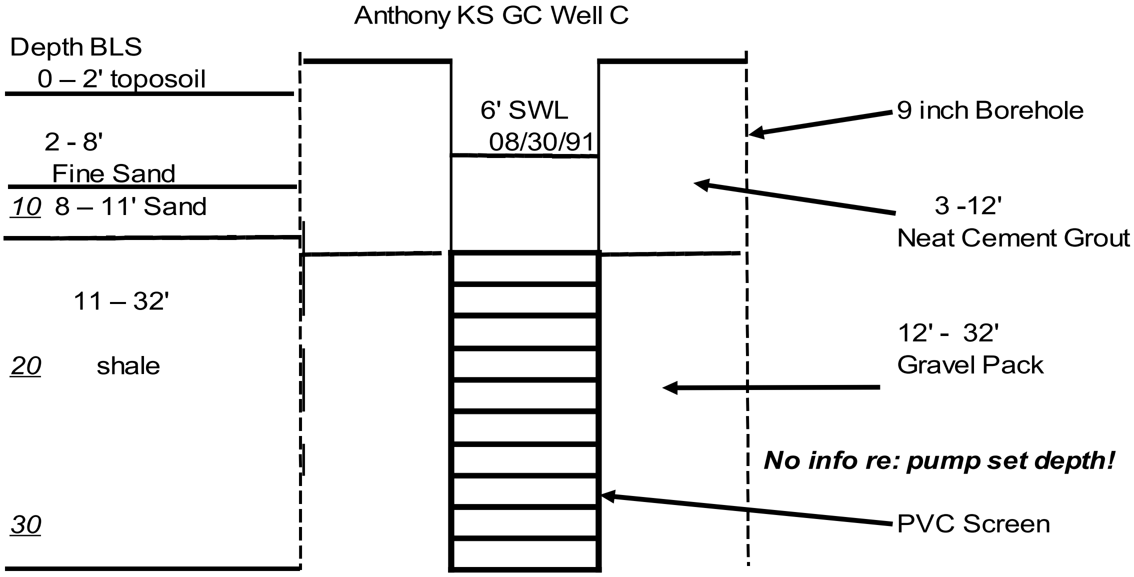
The map above shows the 3 wells, their geographical center and a 600 foot diameter circle around the geo-center. A battery of wells can be up to 4 wells all within a 600 foot diameter circle.

Spreading the wells apart, and or adding an additional well may be an option. Making those changes would better utilize the 600 foot spacing allowed. Which, should minimize any drawdown interference between wells.

The GC wells apear to be slightly artesian from the shale formation, based on data from the well record.

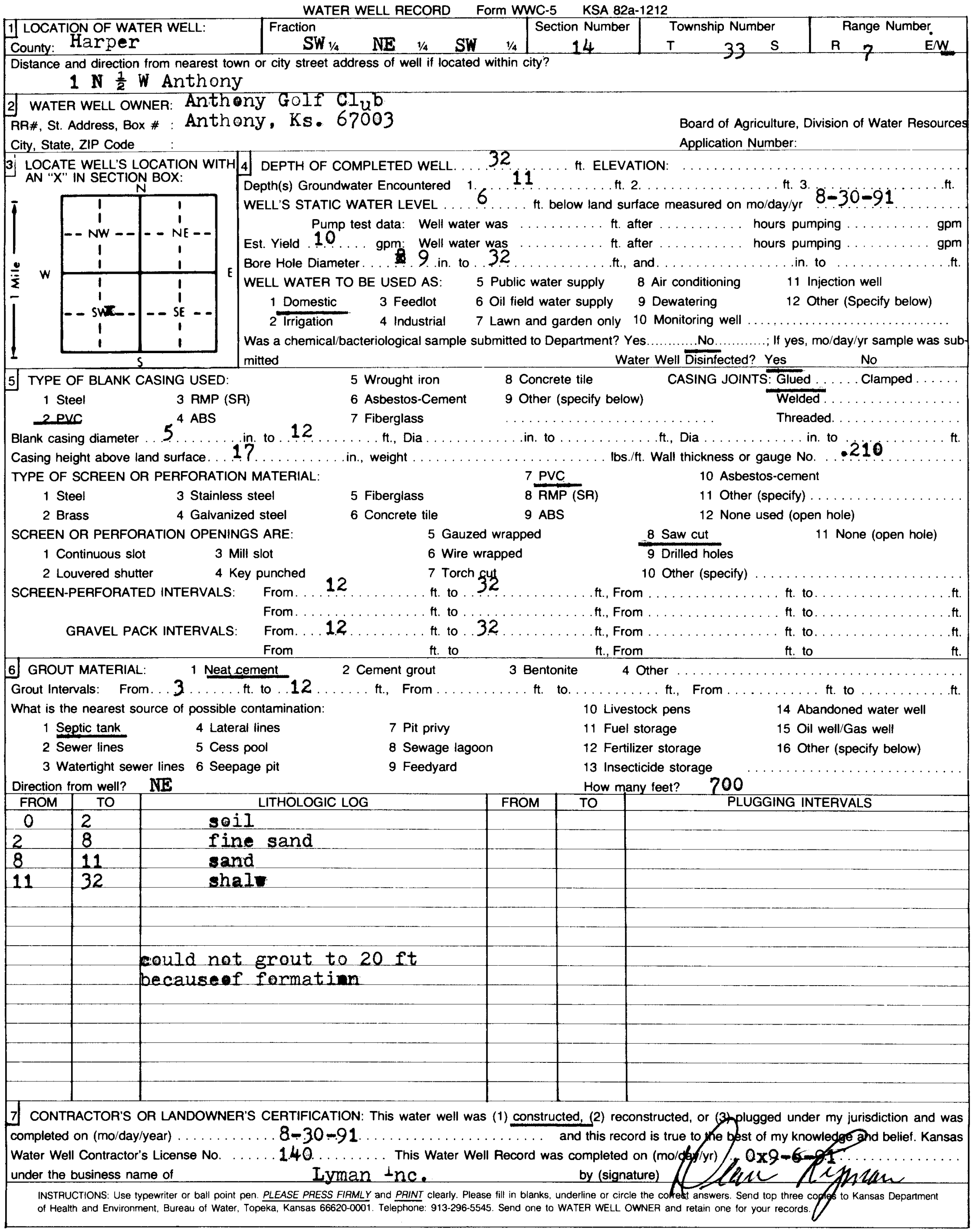
Open hole completion may increase production. Most shale formation wells yield water from the secondary porosity such as fractures and cracks. Gravel packing the screen interval with filter pack may actually plug them up and minimize the specific yield potential of the formation.

The secondary porosity plugging would be similar to filling a tank with bricks and then filling in around them with gravel pack which would restrict the fracture flow. The bricks themselves will not store or transmit water and therefore have no primary porosity. The secondary porosity would be the spaces and gaps between the bricks. Such as fractures and solution channels in the shale. So, filling the borehole with gravel pack tends to bridge off the fracture flow and limits formation development.



Below is a WWC-5 water well record for one of the GC wells: Well C. All of the GC wells have similar consruction.

GC Well C:



WATER WELL RECORD Form WWC-5 KSA 82a-1212

1 LOCATION OF WATER WELL: County: Harper

Fraction	Section Number	Township Number	Range Number
SW ¼ NE ¼ SW ¼	14	T 33 S	R 7 [✓ E]/W

Distance and direction from nearest town or city street address of well if located within city? 1 N ½ W Anthony

2 WATER WELL OWNER: Anthony Golf Club
RR#, St. Address, Box # : Anthony, Ks. 67003
City, State, ZIP Code :
Board of Agriculture, Division of Water Resources
Application Number:

3 LOCATE WELL'S LOCATION WITH AN "X" IN SECTION BOX: N, S, E, W; NW, NE, SW (X), SE; 1 Mile

4 DEPTH OF COMPLETED WELL 32 ft. ELEVATION:
Depth(s) Groundwater Encountered 1. 11 ft. 2. ft. 3. ft.
WELL'S STATIC WATER LEVEL 6 ft. below land surface measured on mo/day/yr 8-30-91
Pump test data: Well water was ft. after hours pumping gpm
Est. Yield 10 gpm: Well water was ft. after hours pumping gpm
Bore Hole Diameter 8 9 in. to 32 ft., and in. to ft.
WELL WATER TO BE USED AS: [✓ 1 Domestic] 2 Irrigation 3 Feedlot 4 Industrial 5 Public water supply 6 Oil field water supply 7 Lawn and garden only 8 Air conditioning 9 Dewatering 10 Monitoring well 11 Injection well 12 Other (Specify below)
Was a chemical/bacteriological sample submitted to Department? Yes [✓ No]; If yes, mo/day/yr sample was submitted
Water Well Disinfected? [✓ Yes] No

5 TYPE OF BLANK CASING USED: 1 Steel [✓ 2 PVC] 3 RMP (SR) 4 ABS 5 Wrought iron 6 Asbestos-Cement 7 Fiberglass 8 Concrete tile 9 Other (specify below)
CASING JOINTS: [✓ Glued] Clamped Welded Threaded
Blank casing diameter 5 in. to 12 ft., Dia in. to ft., Dia in. to ft.
Casing height above land surface 17 in., weight lbs./ft. Wall thickness or gauge No. .210
TYPE OF SCREEN OR PERFORATION MATERIAL: 1 Steel 2 Brass 3 Stainless steel 4 Galvanized steel 5 Fiberglass 6 Concrete tile [✓ 7 PVC] 8 RMP (SR) 9 ABS 10 Asbestos-cement 11 Other (specify) 12 None used (open hole)
SCREEN OR PERFORATION OPENINGS ARE: 1 Continuous slot 2 Louvered shutter 3 Mill slot 4 Key punched 5 Gauzed wrapped 6 Wire wrapped 7 Torch cut [✓ 8 Saw cut] 9 Drilled holes 10 Other (specify) 11 None (open hole)
SCREEN-PERFORATED INTERVALS: From 12 ft. to 32 ft., From ft. to ft.
From ft. to ft., From ft. to ft.
GRAVEL PACK INTERVALS: From 12 ft. to 32 ft., From ft. to ft.
From ft. to ft., From ft. to ft.

6 GROUT MATERIAL: [✓ 1 Neat cement] 2 Cement grout 3 Bentonite 4 Other
Grout Intervals: From 3 ft. to 12 ft., From ft. to ft., From ft. to ft.
What is the nearest source of possible contamination: [✓ 1 Septic tank] 2 Sewer lines 3 Watertight sewer lines 4 Lateral lines 5 Cess pool 6 Seepage pit 7 Pit privy 8 Sewage lagoon 9 Feedyard 10 Livestock pens 11 Fuel storage 12 Fertilizer storage 13 Insecticide storage 14 Abandoned water well 15 Oil well/Gas well 16 Other (specify below)
Direction from well? NE How many feet? 700

FROM	TO	LITHOLOGIC LOG	FROM	TO	PLUGGING INTERVALS
0	2	soil			
2	8	fine sand			
8	11	sand			
11	32	shalw			
		could not grout to 20 ft becauseof formatimn			

7 CONTRACTOR'S OR LANDOWNER'S CERTIFICATION: This water well was [✓ (1) constructed,] (2) reconstructed, or (3) plugged under my jurisdiction and was completed on (mo/day/year) 8-30-91 and this record is true to the best of my knowledge and belief. Kansas Water Well Contractor's License No. 140 This Water Well Record was completed on (mo/day/yr) 0x9-6-91 under the business name of Lyman Inc. by (signature)

INSTRUCTIONS: Use typewriter or ball point pen. *PLEASE PRESS FIRMLY* and *PRINT* clearly. Please fill in blanks, underline or circle the correct answers. Send top three copies to Kansas Department of Health and Environment, Bureau of Water, Topeka, Kansas 66620-0001. Telephone: 913-296-5545. Send one to WATER WELL OWNER and retain one for your records.

OFFICE USE ONLY T R E/W SEC. ¼ ¼ ¼

The limited water level info, for this well indicates the shale formation has enough pressure to push ground water up inside the well casing. Water rising above the formation, it is produced from, indicates this is a non-flowing artesian well.

Due to the minimal grouting of 3 – 12' the grout extends only 1 foot into the shale. A minimum of 5 feet into the shale is what is required.

This type of construction creates more questions than answers.

Is the shale formation truly artesian?

If a well was constructed only in the sand aquifer would it have 5 feet of saturated thickness?

Could the upper sand formation actually yield better quantities than the shale?

How much have the water levels changed due to drought?

Can the wells achieve a combined pumping rate of 45 gpm?

A 10 – 20% increase in pumping rate would be a considerable amount of water during a 12 hour period.

Mitch Hall, with H2O Drilling, indicated there was some very limited data sent with the invoice when he worked on the GC wells. I have not seen that data. Aquifer tests and measurements could be made to verify areas of influence for each of the wells and as a combined pumping system.

Pumping the wells to a pond for GC usage is not uncommon. Several GC's use this technique to store water for large capacity pumping to the irrigation system.

This method allows the wells to pump at a constant head pressure.

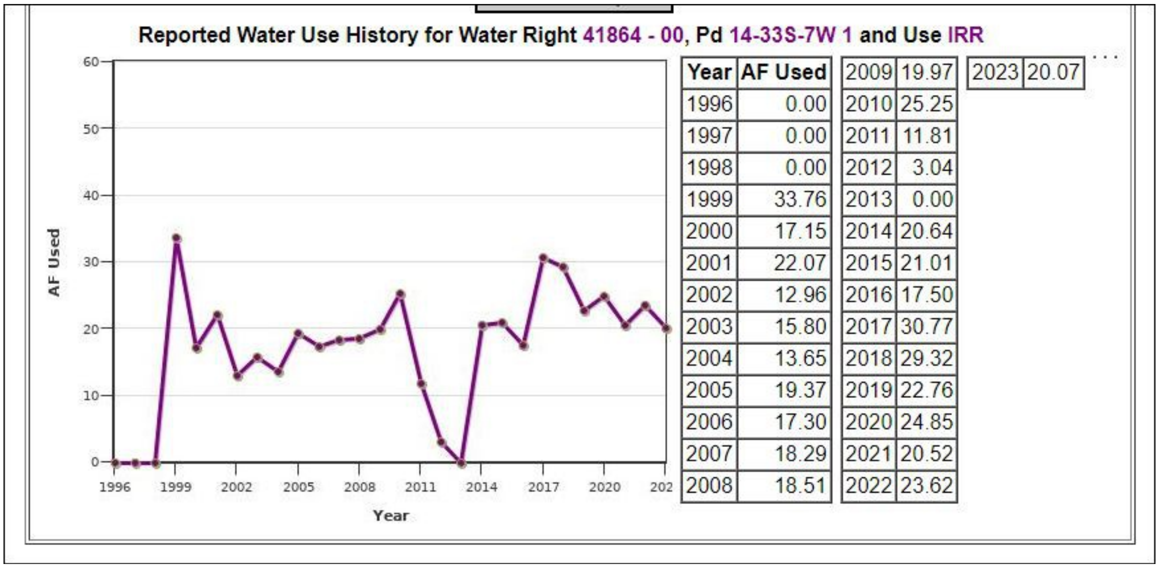
Constant head presure on wells makes for consistent pumping volumes. Pumping rates will change in relationship to the volume of the tank if all the water enters from the bottom, thus changing the head pressure on the pump.

One of the nearby ponds could possibly be used for storage to feed the pump to the irrigation system or the system storage tanks. This would allow the wells to be pumped overnight and potentialy increase the produced water quantity. If the produced water is sent to the tank via a pipe that enters the top of the tank then head pressure is kept consistent.

During our site visit, it appeared there are wells on City property on the West side of the Creek and East of the GC. These wells seemed to be associated with steel storage tanks that are no longer used.

If true they should be evaluated and possibly permitted and piped to the GC system.

The chart below is from the DWR water right database. It shows the amount of Acre Feet(AF) used. This water right for the wells at 9.5 AF and the one for the surface water right are combined and limited to 23 AF per year at 45 gm. The data indicates there are numerous years the usage was less than what is allowed.



Reported Water Use History for Water Right 41864 - 00, Pd 14-33S-7W 1 and Use IRR

Year	AF Used
1996	0.00
1997	0.00
1998	0.00
1999	33.76
2000	17.15
2001	22.07
2002	12.96
2003	15.80
2004	13.65
2005	19.37
2006	17.30
2007	18.29
2008	18.51
2009	19.97
2010	25.25
2011	11.81
2012	3.04
2013	0.00
2014	20.64
2015	21.01
2016	17.50
2017	30.77
2018	29.32
2019	22.76
2020	24.85
2021	20.52
2022	23.62
2023	20.07

To increase the amount of water using the existing sources or adding new ones will have to be justified to DWR as a reasonable request. “Just because we want extra water” may not be a valid reason.

Especially, when the GC study indicates the current supplies are sufficient.

Harper Well Fields and Plant Site.

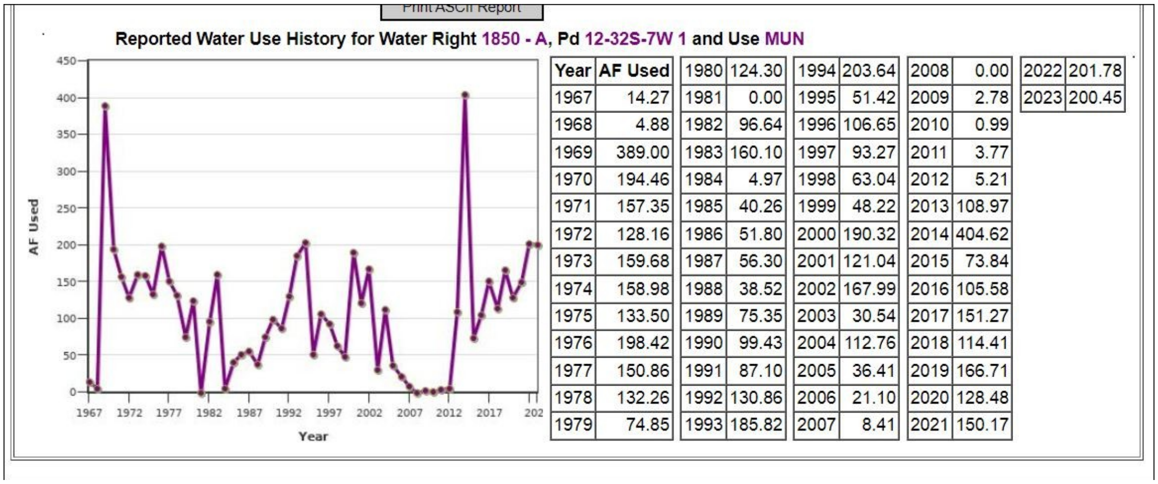
The Harper Well Fields consists of PWS Wells #1, #2 and #3 at the plant / lagoon site and PWS Wells #4 and #5 are situated approximately ½ to1 mile to WSW.

The City has good data with regards to well construction and some aquifer test data. There is limited pump placement and setting data for Wells 1 – 3. The pump data for Wells 4 & 5 is informative with regards to potential impacts on the aquifer.

Actual individual water quality data for the wells is minimal and lacking. The lack of individual water quality data for the wells is indicative of the less than ideal usage of a Point of Entry (POE) for sample collection. We see very little diagnostic benefit to POE samples unless very detailed individual well pumping records are kept.

The KDHE is slowly recognizing the limits of POE samples and are evaluating(again, slowly) the changing back to individual well sampling protocols.

The question of whether the Harper Well Field will have sufficient water to send to the GC can be answered with with a yes, a no and a maybe. Though the data is limited we will explore each option.



Reported Water Use History for Water Right 1850 - A, Pd 12-32S-7W 1 and Use MUN

Year	AF Used
1967	14.27
1968	4.88
1969	389.00
1970	194.46
1971	157.35
1972	128.16
1973	159.68
1974	158.98
1975	133.50
1976	198.42
1977	150.86
1978	132.26
1979	74.85
1980	124.30
1981	0.00
1982	96.64
1983	160.10
1984	4.97
1985	40.26
1986	51.80
1987	56.30
1988	38.52
1989	75.35
1990	99.43
1991	87.10
1992	130.86
1993	185.82
1994	203.64
1995	51.42
1996	106.65
1997	93.27
1998	63.04
1999	48.22
2000	190.32
2001	121.04
2002	167.99
2003	30.54
2004	112.76
2005	36.41
2006	21.10
2007	8.41
2008	0.00
2009	2.78
2010	0.99
2011	3.77
2012	5.21
2013	108.97
2014	404.62
2015	73.84
2016	105.58
2017	151.27
2018	114.41
2019	166.71
2020	128.48
2021	150.17
2022	201.78
2023	200.45

The DWR data above shows the water usage for the water right that covers all 5 wells. It shows the City has 400 AF of water rights. Historically the City uses 200 AF or less per year.

Pumping 400 AF would require all 5 wellls to pump 100 gpm each for 12 hrs for a year.

So Yes! The Harper Well Fields appear to have the capacity to handle additional usage at the GC.

However, under the current equipment configuration the Harper Well Fields can not handle the additional usage at the GC.

The main reason for the 'No' is the lagoons at the plant site can not handle the additional process waters from the plant.

The City is routinely out of compliance with regards to freeboard at the lagoons.

Additionally, the City supplies at the plant site are under threat from leaks at the plant and the lagoons.

There are fundamentals to Source Water Protection that should never be ignored. Unfortunately, many were when the lagoons and plant were installed.

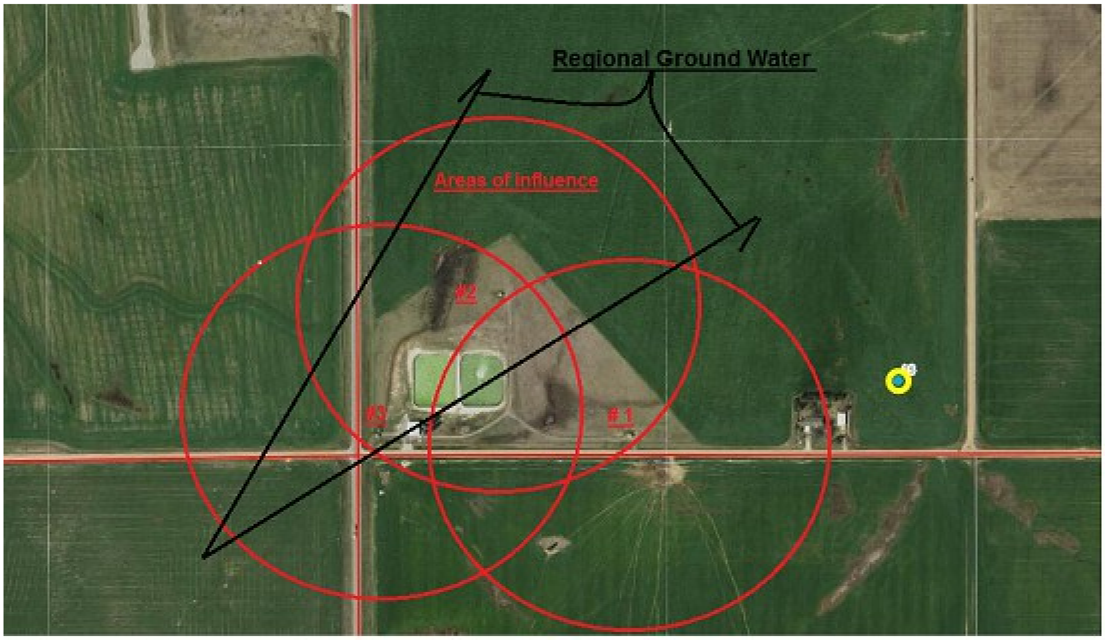
The essence of the removal plant is to remove a somewhat troublesome contaminant and in the process creates a contaminant that is very expensive to handle, dispose of and is difficult to minimize environmental damage. It is my opinion that salt contamination is 10 to 100 times worse than nitrate.

There are only 2 types of storage / containment, those that leak and those that have not been built!!!!! Much like pipelines, unfortunately, a current issue the City is dealing with.

This is a fundamental concept that has proven true over the many years of investigating and cleaning up contamination sites. Many being caused by leaking lagoons or storage containments. Ignoring this fundamental concept has lead to some very expensive cleanups.

The City has already seen containment failue that ponded saltwater around Well #3. The pictures below show the saltwater that escaped from the plant which ran downhill to and around PWS #3. The “down hill” reference will be discussed later in this report. The spillage actually left the compound area and entered the ditch. The spill was caused by an equipment failure which caused a salt tank to be overflowed. A portion of the spill went down the floor drain in the plant and ended up in a lagoon. A significant portion escaped the building and ran towards and ponded around PWS #3. This spill site is also up-gradient of PWS #2 and could enter the capture area for PWS #1.

The aerial picture below shows the location of the PWS Wells, the plant site and the salt water lagoons. The cirlces around each of the wells show the area of influence for each well. These circles are based on the pump test data collected and are part of the Layne Western reports.



These lagoons represent a direct threat to the water security and the aquifer quality stability for the City of Anthony and down gradient neighbors.

The KDHE and the ground water industry failed the City by not protecting the aquifer for Wells #1 - #3. Therefore, adding new or replacement wells at the plant site may be problematic due to KDHE design criteria and spacing requrements.

There is no argument that can be made to justify the placement of the plant and lagoons within the areas of influence / rechage areas / capture zones for Wells #1, #2 and #3.

The area of influence / recharge area / capture zone for these wells should be classified as the Inner Sanctum, the Holiest of Holy's. These areas were designed to be protected when the EPA Well Head Protection Area program was developed in the "80's"

Below is a listing of some of the criteria that would have to be met to install new wells. And, protect existing wells

KDHE Design Criteria: These regs are in place to protect existing and future ground water supplies.

CHAPTER IV

SOURCE DEVELOPMENT

D. GROUNDWATER – RESOURCE FACILITIES AND OTHER REQUIREMENTS

Groundwater sources include water from drilled, bored, or driven wells and infiltration lines, not under the direct influence of surface water. Drilled wells are preferred. Springs are considered surface water sources (Section C). Sources most likely to be under the direct influence of surface water (GWUI) include infiltration lines, horizontal collector wells, and shallow wells with screen openings less than 50 ft. (15 m) deep and located within 200 ft. (61 m) of surface water. Under the SWTR, all GWUI must be treated like surface water (Chapter V, Section M on Disinfection).

All water obtained from wells shall be disinfected and filtration employed where needed (Chapter V, Section M on Disinfection). The extent of water treatment required will be determined on the basis of geological data, well construction features, nearby sources of contamination, laboratory analyses, and MCLs. When a well draws water from creviced limestone strata and it is evident that the limestone supply is contaminated, the use of that supply cannot be considered appropriate unless the water is properly treated, in part by clarification and filtration, to eliminate harmful contaminants.

The criteria above establishes some of the items to consider when developing a new well field. However the fundamental concepts would apply to existing systems to protect the source of supply,

Most of the criteria listed were not adhered to when the contamination sources were installed. Some appear to have been completely ignored.

1. <u>SANITARY SURVEYS</u> – By means of a sanitary survey, the PWSS evaluates the potential threats to a proposed well presented by nearby sources of contamination. This allows the PWSS to estimate costs to reduce or contain threats to the proposed well by contaminant sources identified in the survey. Sanitary surveys made for selection of locations for wells should consider the following items:

   a. Character of local geology, size and topography of catchment area, and slope of ground surface, as such factors relate to the potential transport of contaminants toward the well.

Locating new wells would require starting with this criteria. Protecting exisiting sources would need to follow the same criteria.

Apparently this was not done.

b. Nature of soil and underlying porous strata whether clay, sand, gravel, or rock (especially porous limestone); and coarseness of sand or gravel, thickness of water bearing stratum, depth to water table, and location and log of wells in the vicinity that are in use and/or abandoned, as such factors relate to the potential transport of contaminants towards the well. Geologic data should be obtained for new wells at 5 ft. (1.5 m) intervals and at each pronounced change in formation along with other pertinent well drilling information. KGS maintains a Well Sample Library in Wichita.

c. Slope of water table, as determined from observation wells, preferably, or from studies of wells in the area.

d. Extent of drainage area likely to contribute water and potential contaminants to the supply, population of drainage area, and waste disposal methods employed in the drainage area.

e. Susceptibility of the proposed well location to flooding from nearby surface waters as indicated by the boundaries of flood plain delineations or historical high water elevations.

f. Nature, distance, and direction of potential local sources of pollution such as animal feedlot operations, sanitary landfills, seepage pits, cesspools, septic tank lateral fields, privies, sink holes, salt or brine supplies, test holes, abandoned wells, borings, and chemical manufacturing, handling, and storage facilities, including underground storage tanks, pipelines for industrial products, and industrial lagoons.

Criteria “b. thru e.” appear to have not been adhered to. The Plant site drains contaminated water towards PWS #3. These criteria are important for new wellls and the protection of existing wells.

It is readily apparent criteria “f.” was completely ignored. Both salt or brine supplies, handling and storage facilites were installed as lagoons and as salt storage containment in the building.

g. Special care should be taken to determine nitrate sources in the proposed well's recharge area and to evaluate fully the nitrate concentration in the aquifer in which the well will be completed. In addition to nitrate sampling of test holes in the immediate vicinity of the proposed public water supply well, other sources of information that should be considered include data from irrigation wells or other water supply wells in the general vicinity, KGS bulletins assessing the geology and hydrology of the region, and data from the KDHE Groundwater Quality Monitoring Network. The nitrate level in the aquifer in which the well will be completed should be significantly less than the current nitrate MCL unless blending with other low nitrate water or treatment for nitrate removal will be provided.

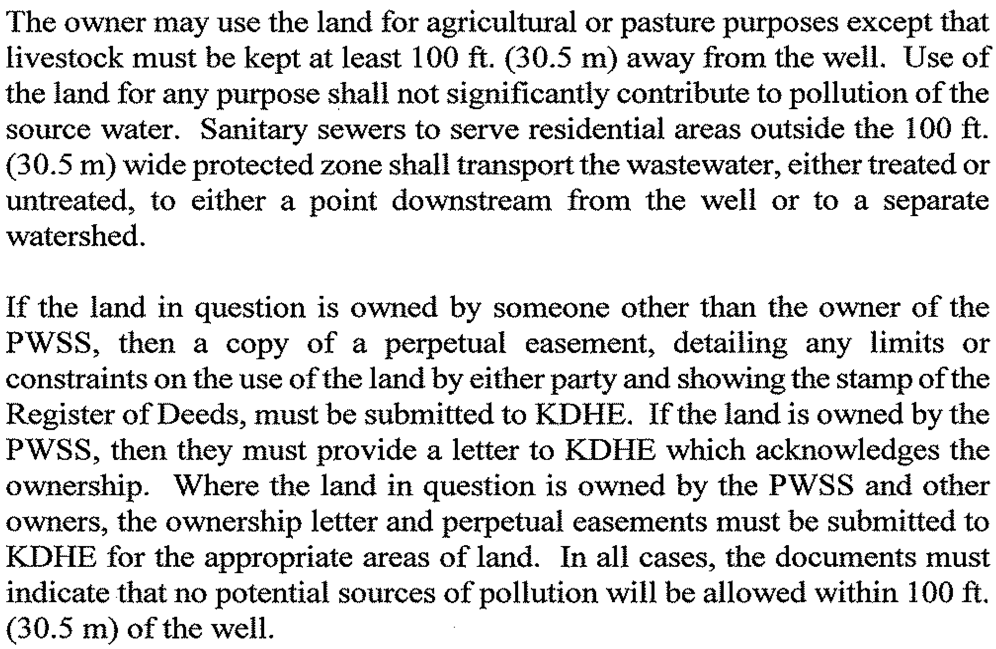
h. The SWA conducted for the PWSS under SWAP shall be reviewed as part of the sanitary survey when determining the sources of real or potential contamination. The SWA shall be updated as is necessary based on the findings of the sanitary survey.

Criteria “g.” appears to have been completely ignored with regards to the nitrate sources. It appears the KDHE allowed the center pivot and ag to contaminate the existing wells. And subsequently ignored “Special care” when the nitrate contamination is being replaced by salt contaminants. These sources are not non-point sources

Criteria “h.” appears to have been ingnored and the Sanitary Surveys were not performed to delineate the Source Water Areas around the wells. It appears site specific Source Water Area Protection delineations were not developed for the existing wells.

2. <u>LOCATION AND PROTECTION OF WELLS</u> – Groundwater sources shall be located, constructed, and maintained in a manner which will assure minimal possibility of contamination and be so situated and developed as to prevent surface water from entering the well. During the installation of the well, the contractor shall provide protection to prevent tampering or accidental entrance of foreign materials. The following are specific siting limitations for new wells.

a. There must be an absence of pollution sources within 100 ft. (30.5 m) of the well. Documentation must be provided to confirm the absence of such sources. Either ownership or a perpetual easement must be obtained by the owner of the well for the land within 100 ft. (30.5 m) measured horizontally outward from the well center. In either case, positive assurance is to be provided that no septic tanks, wastewater facilities, sanitary sewers, force mains, or tile absorption fields will be allowed within that area.

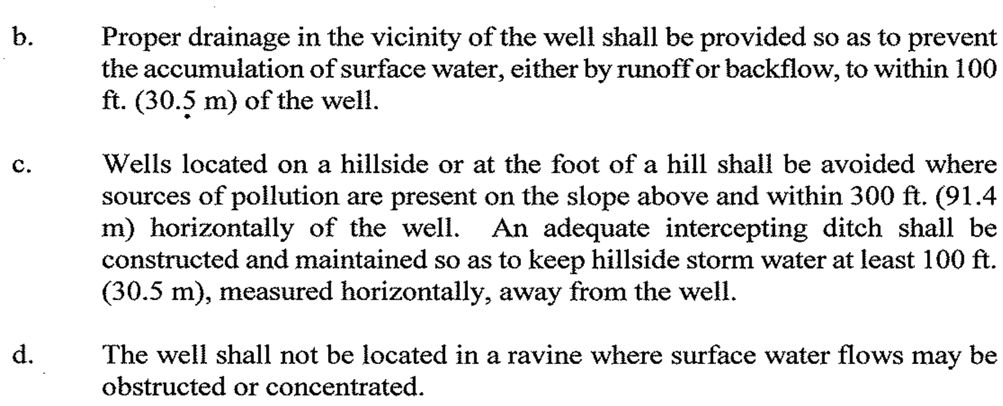


> The owner may use the land for agricultural or pasture purposes except that livestock must be kept at least 100 ft. (30.5 m) away from the well. Use of the land for any purpose shall not significantly contribute to pollution of the source water. Sanitary sewers to serve residential areas outside the 100 ft. (30.5 m) wide protected zone shall transport the wastewater, either treated or untreated, to either a point downstream from the well or to a separate watershed.
>
> If the land in question is owned by someone other than the owner of the PWSS, then a copy of a perpetual easement, detailing any limits or constraints on the use of the land by either party and showing the stamp of the Register of Deeds, must be submitted to KDHE. If the land is owned by the PWSS, then they must provide a letter to KDHE which acknowledges the ownership. Where the land in question is owned by the PWSS and other owners, the ownership letter and perpetual easements must be submitted to KDHE for the appropriate areas of land. In all cases, the documents must indicate that no potential sources of pollution will be allowed within 100 ft. (30.5 m) of the well.

Criteria “2.” and “a.” pertain mostly to new well construction and location. However, the fundamentals of protecting new sources can be applied to existing sources.

Contamination sources were placed within the areas of influence for the existing wells.

Installed contamination sources have contributed surface runoff contamination at a minimum.

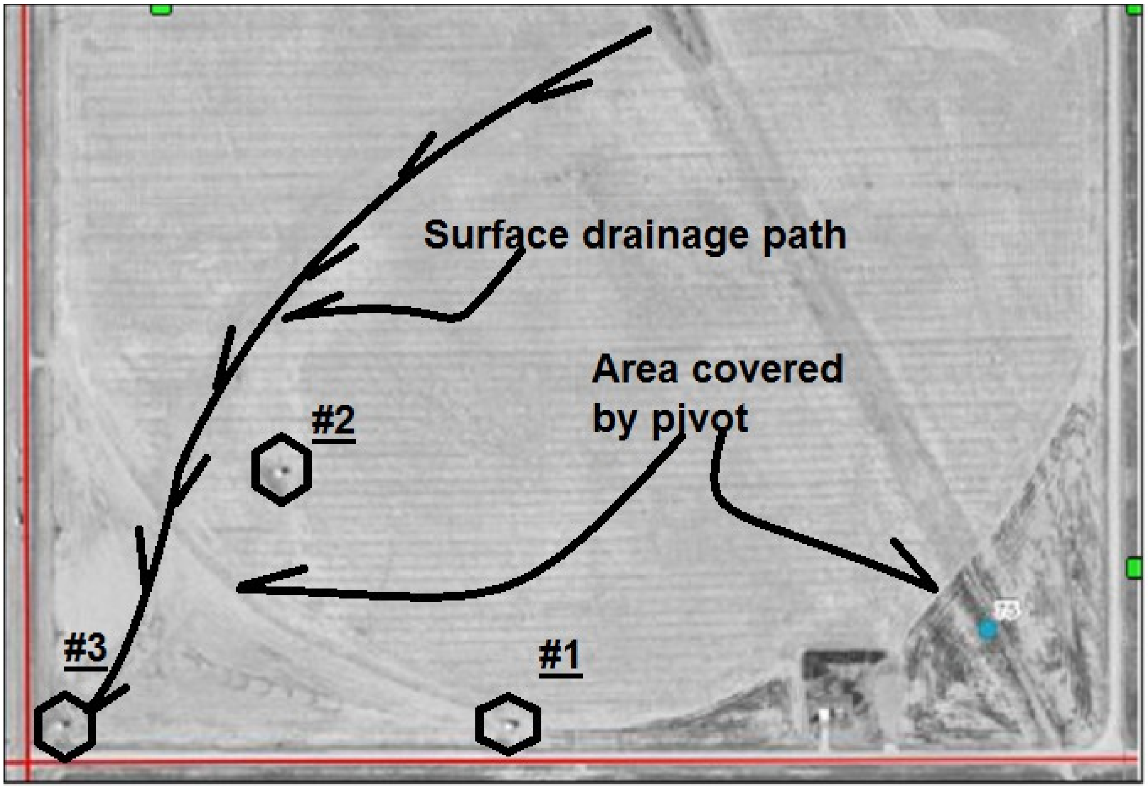


> b. Proper drainage in the vicinity of the well shall be provided so as to prevent the accumulation of surface water, either by runoff or backflow, to within 100 ft. (30.5 m) of the well.
>
> c. Wells located on a hillside or at the foot of a hill shall be avoided where sources of pollution are present on the slope above and within 300 ft. (91.4 m) horizontally of the well. An adequate intercepting ditch shall be constructed and maintained so as to keep hillside storm water at least 100 ft. (30.5 m), measured horizontally, away from the well.
>
> d. The well shall not be located in a ravine where surface water flows may be obstructed or concentrated.

Criteria “b.,c.and d.” appear to have been ignored. Contamination sources were installed upgradient of the wells and within the minimum 300 ft horizontal criteria.

It appears no surface controls were constructed.

The wells have been subject to this criteria from the time they were installed. As shown by the aerial photo below showing some of the surface drainage, wells and the original relevant area covered by the center pivot.



Subsequently, additional sources of contamination have been added to the areas that will have potential impact on the wells.

> g. A wellhead protection plan for continued protection of the wellhead from potential sources of contamination shall be provided as determined by KDHE. The PWSS's sanitary survey and SWA should be reviewed as part of developing a wellhead protection plan.

Critera "g." appears to have not been considered. Even the generic SWPA plans prepared for the systems, that did not have site specific plans prepared, would not have allowed the contamination sources as installed.

If we are not protecting the Aquifer we are not protecting the System.

Again, there is no argument that can be made that would allow the additional contamination sources to placed within the areas of influence and capture zones for the PWS Wells at the plant site.

The ground water and regulatory industries appear to have failed the City by approving the placement of lagoons and plant in the well field.

Because of the new contamination sources we may not be able to install a new / replacement well at the plant site.

An oilfield saltwater storage lagoon would not be allowed. A dead cat / dog or livestock hide procesing facility would not be allowed to put a saltwater lagoon in this location. (yes a bit over the top but then so is the actual approval of these facilities). A saltwater storage lagoon for underground salt dissolution would not be allowed etc....

Some of the new / replacement lagoons at some salt mining / storage facilities are using 3 liners per lagoon.

Disposing of the lagoon waste will be expensive. The last saltwater project we consulted on required disposal at Cavern Storage, South of South Hutchison. Based on recent conversation with the storage staff getting rid of the saltwater may be a significant challenge as they have converted over to carbon sequestration.

There are numerous regs the KDHE appears to have ingnored or did not apply, subsequently allowing the threat to manifest. It is absolutely puzzling why the KDHE would allow the pivot to travel over one well and barely bypass the other.

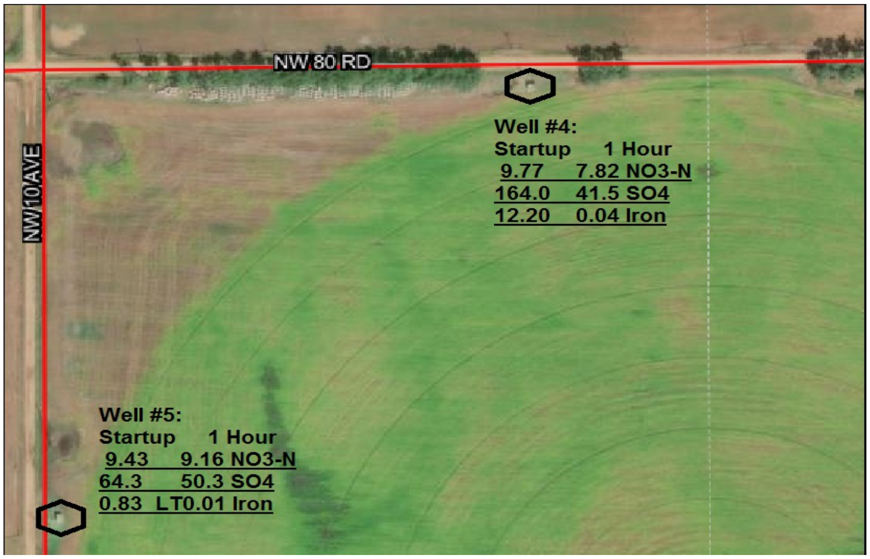
One option to consider in order to send additional water to the GC is to truck out the excess saltwater from the lagoons and make room for more effluent brine. At this time, it is not clear where that waste would go or the cost of disposal. Based on previous projects it is estimated each foot of water in the lagoon will cost 50 to 75 thousand dollars to dispose of. If a close disposal facility can be found.

Currently, Class 1 non-hazarous disposal wells are running 1 - 2 million dollars each to install. They would have to be tested at least yearly if not every 6 months

The aerial photo below shows PWS #4 and #5 with their respective water quality data.

The lab data shows PWS #4 has less NO3-N present in the well after an hour of pumping. We have seen this phenomenon before and attribute it to lack of proper grouting in annular space of the well. The annular space is between the casing and the borehole. The Nitrate values for both of the wells is under 10. Based on this data a 50:50 blend of the water from both wells would have a Nitrate value of 8.49 mg/L.

It s interesting to note the Sulfate(SO4) concentration drops considerably with pumping from Well #4. Recent publications indicate increased Sulfate in the feed water to the plant can actually strip Nitrates off the media and send it out to the system.



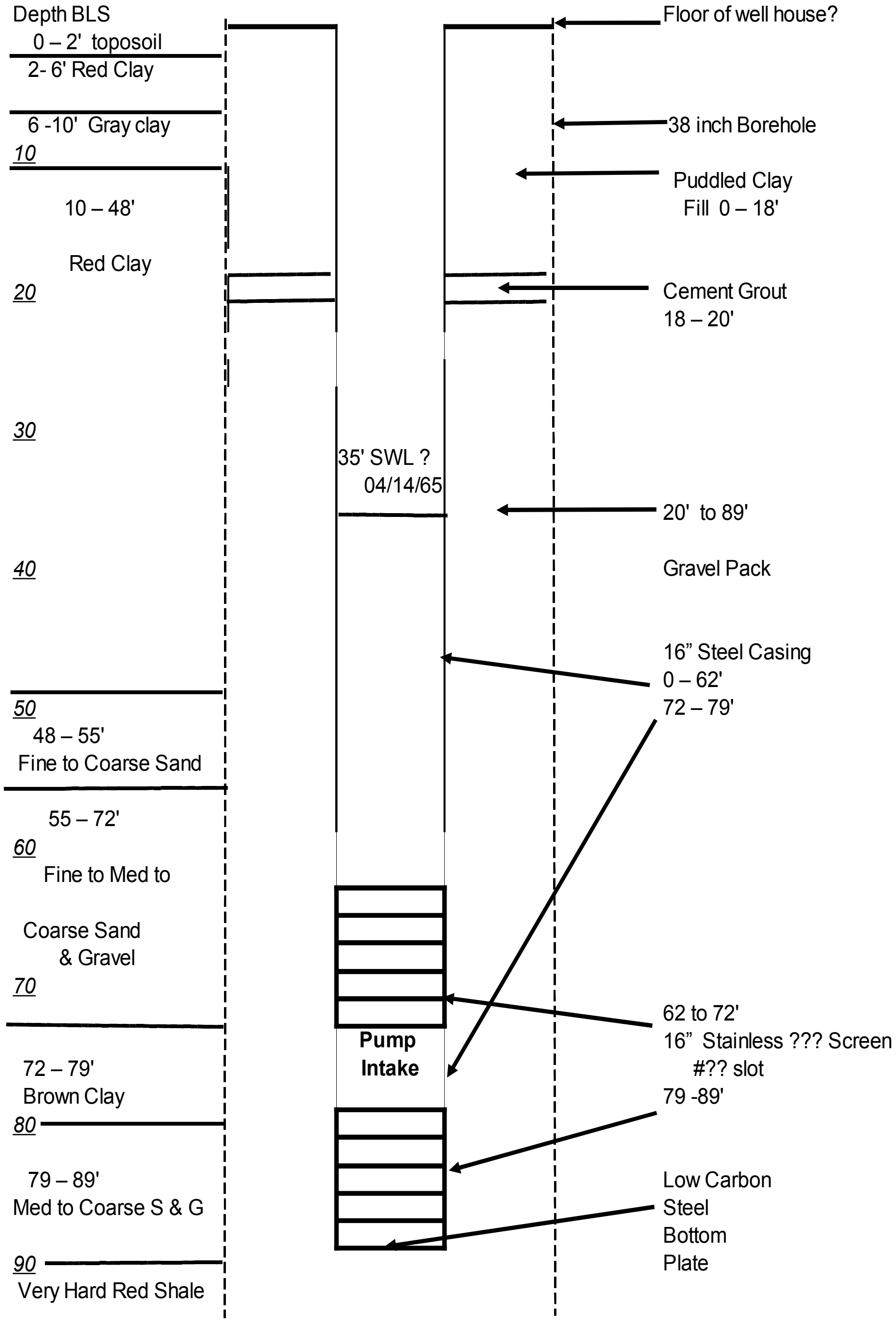
The increased Iron content in the startup samples indicates the presence of Iron bacteria and / or galvanic corrosion of the low carbon steel(LSC) casing. The corrosion process would provide Iron as a food source for the bacteria.   In addition, the bacteria themselves will attack and feed off the LCS   Ultimately, these processes can cause casing and some times screen failure in the well.

There is some concern re: the amount of iron being pushed through pipelines to the treatment vessels which may be impacting the effectiveness of the ion exchange media. There is Iron buildup within the plant as evidenced by the small plastic tubing used in the plant. This tubing is being coated on the inside with an iron based deposit. Those iron based deposits may be impacting the media, monitoring equip, valves and check valves,etc. Tyically, there is bag filter placed upstream of the vessels. As we have seen in other plants this filter catches the big iron deposits but bypasses the dissolved or small fraction material.

The well graphic below shows the litholgic formation material, casing and screen types and placement, well bore diameter, filter pack, grout intervals and the approximate location of the pump intake.

The grout interval and type are common for wells of this age. Unfotunately, they were built for production not water quality. We do recognize when all the wells were installed commercial fertilizer were either just beginning use or had been available for only for a few years.

Anthony KS PWS #4



“.... A deep well is no safer than a shallow one, unless the upper part of the deep well is properly consructed to seal out all shallow water and surface drainage...”

From Water-Well Supplies, Eng. Bull. No. 22, 1947, Univ. of Kansas, published by Kansas State Board of Health, Sanitation Division

The above fundamental concept regarding well construction, was published in 1947, it is still applicable today and actually more relevant.

As with most wells of the age of the City's, few adhered to that concept. Sometimes we can upgrade the wells and minimize contaminant inflows. Additionally, we have been succesful with lowering the pump intakes and slowing the production rate down.

Ground water flow within the sands and gravels tend to be horizontal as that is the orientation the formation was deposited. That is until we drill a hole into them and create an artificial contaminant pathway with the filter pack. The new pathway allows for contaminant transport to now run vertical, both up and down the borehole.

The current wells are designed and built to commingle the shallow portion of the aquifer with the deeper portion.

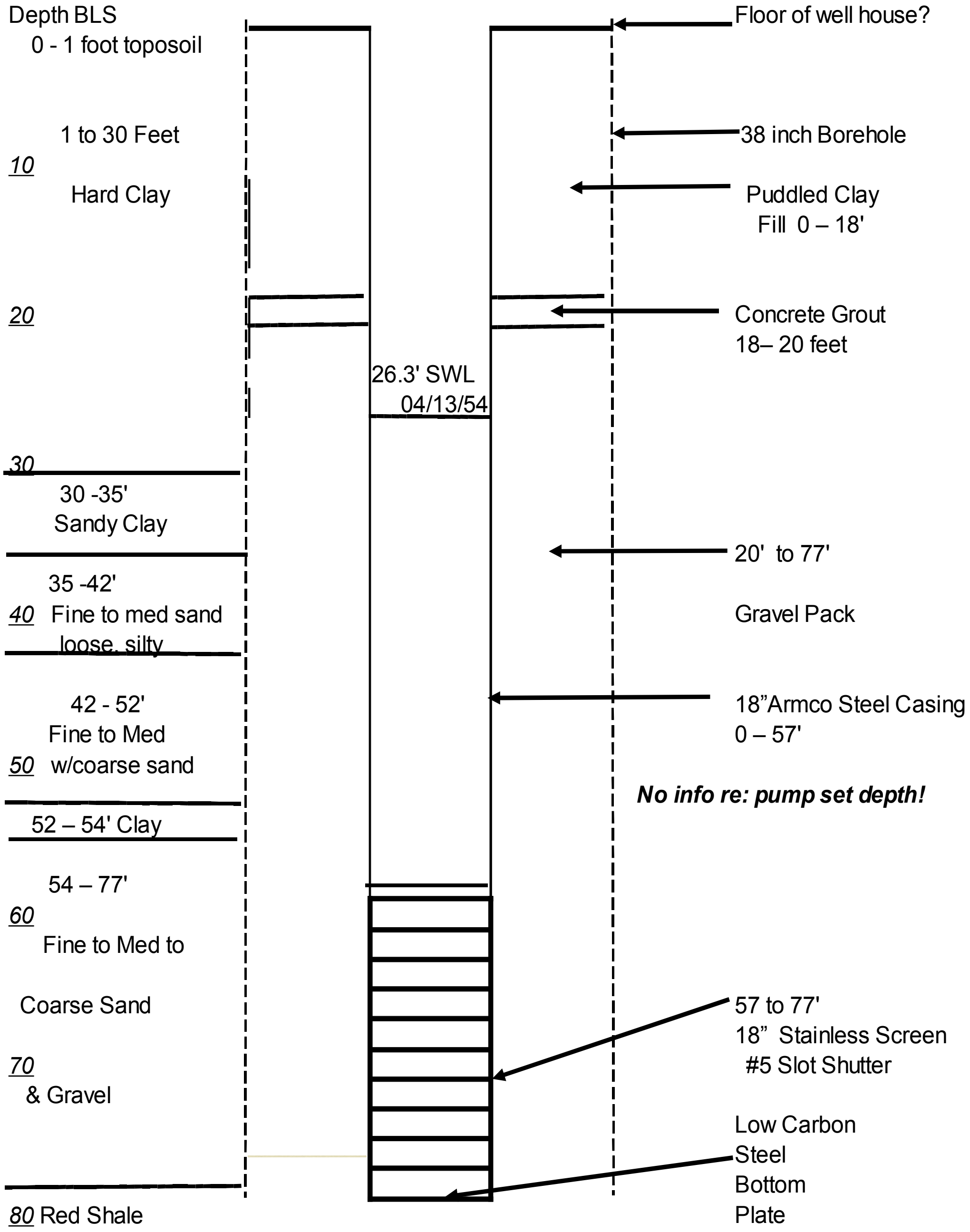
Lowering the pumps? And reducing the pumping rate may minimize the infiltration of Nitrates into the wells.

Wells #4 and #5 might be repaired or modified but do not have sufficient sanitary easements to facilitate replacement at the current sites.

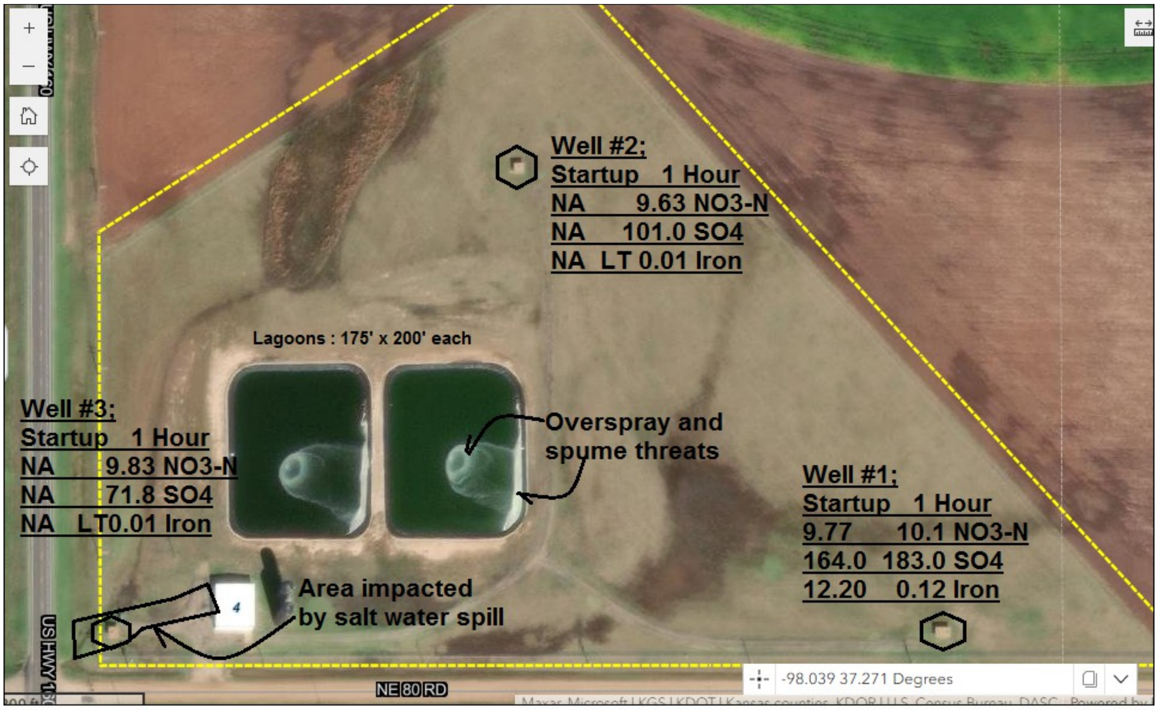
Properly placed and designed monitoring wells would help identify the water quality of each zone at the well sites.

The graphic for PWS #1 below shows some of the same isues as Well #4. minimal grouting and we have no information about the pump setting. Wells #2 and #3 are constructed in the same manner.

Anthony KS PWS #1



The aerial below shows the locaion of the wells, the water quality from the sampling event, the salt spill area, potential surface contamination from the lagoon aeration equip and runoff areas impacted by the nearby irrigation field.



The lab data for these wells indicate Nitrates hover around the 10 mg/L value. The sulfates increase with pumping in Well #1 and are significantly higher than Wells #2 and #3. Again, this increase in Sulfates may impact plant efficiencies.

The plant removes nitrates and stores it on the media until recharged by saltwater. The data we are reviewing indicates some of the wells have elevated Sulfates SO4. There is some published data which indicates the media would rather strip out Sulfates then Nitrates. When elevated Sulfate water is sent to the vessels the media might shed Nitrates into the water going to the City's storage.

Having to rely on Point OF Entry(POE) water quality from the plant puts the City in a bind and blind with regards to managing the water quality to the plant. The more consistent the water quality blend to the plant the more efficient the plant is. Conversely, when the POE samples go out of compliance you are back to sampling individual wells to try and find the offending contaminant.

Wells #2 and #3 appear to be in current or old drainage from the irrigated field. This situation may cause quality issues due to the minimal grout in the boreholes.

Sending well field water to the GC increases the plant usage and will further challenge the saltwater storage capacity capabilities of the lagoons.

The Nitrate removal plant is for Nitrates only, It is important to understand various contaminants can affect the efficiency of the plant. Iron, Manganese, Sulfates and bacteria are just a few of those contaminants.

It appears the overspray from the fountains and the spume blowing out of the lagoons is impacting the surface soils around the lagoons (salt scaring) Soil samples would verify that condition.

The limited pump setting information reviewed indicates the pumps are not set to maximize the water produced from the bottom of the aquifer. The bottom is where we typically find lower Nitrate water. Along with minimal well grouting it appears the wells are set up to produce from the upper part of the aquifer.

When the application of fertilizers is stopped or significantly reduced in the recharge area / the area of Influence / the capture zone, water quality typically Improves with time!

5 wells at reduced pumping rates of 100 gpm would operate 12 hrs per day for a year. Using combined pumping rates and pumping everyday should allow for better well field management. Especially if well specific sampling increases.

The data from the wells indicates the City might be able to blend the waters from specific wells and eliminate the need for the plant. This will not be an easy process, the KDHE has only a couple of staff members that would even understand the process or be willing to allow the City to manage their own well field. As evident by them even approving this facility location to begin with.

It appears the well fields were never truly evaluated. It is possible the high Nitrate water in the upper portion of the aquifer can be pumped out, utilized and cause a significant reduction in the Nitrates affecting the wells.

As always, if you have any questions let me know.

Respectfully Submitted,

Ned Marks

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