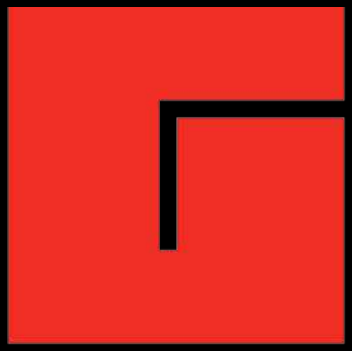

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ENGINEERS
ARCHITECTS
CONSULTANTS

REALIZE THE DIFFERENCE

ENID WATER SUPPLY STUDY

City Council Study Session

August 2013

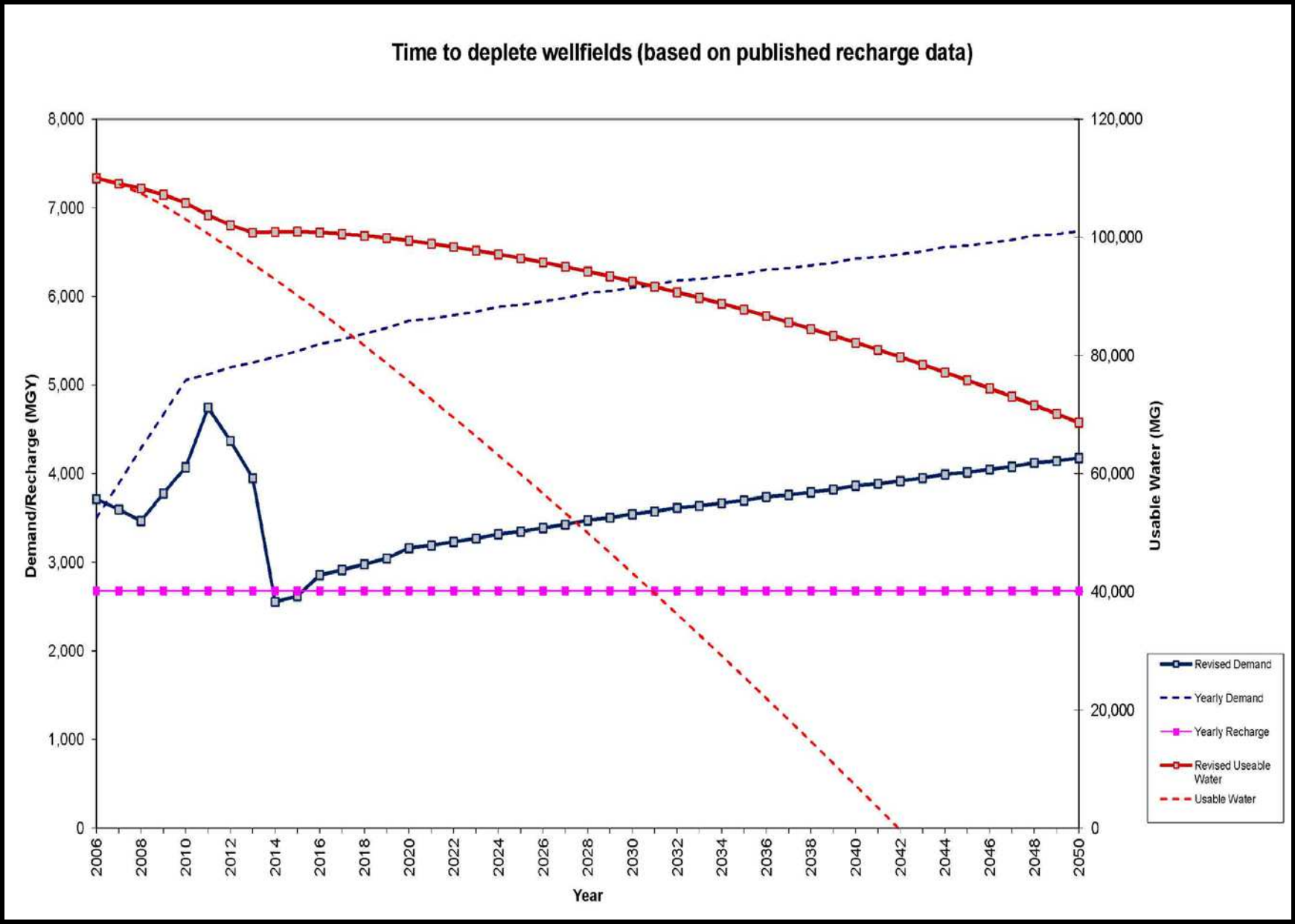
Agenda

- Usage
- Surface Water Alternatives
  - Existing Lake
  - Location, Characteristics, Cost Estimates
  - Vance AFB Flight Patterns
- Groundwater Alternatives
  - Geophysical Testing
  - Location, Characteristics, Cost Estimates
  - Immediate and Long Term Options
- Weighted Matrix
  - Approach
  - Results
- Kaw Pipeline
- Discussion

Usage

Water Usage

- Conservation measures have reduced the annual water usage
- Removal of Koch Nitrogen Plant from the demand by 1461 MGY (4 MGD) in 2014 - resuming reuse
- Addition of Canola Plant to the demand of 163 MGY (0.45 MGD) in 2016 and an increase of 42 MGY (0.11 MGD) in 2020
- Continue to expect a gradual increase in demand in future years
- Well field life based on published recharge rates
  - Well depletion was expected to occur near 2042
  - Well depletion is projected to 2084

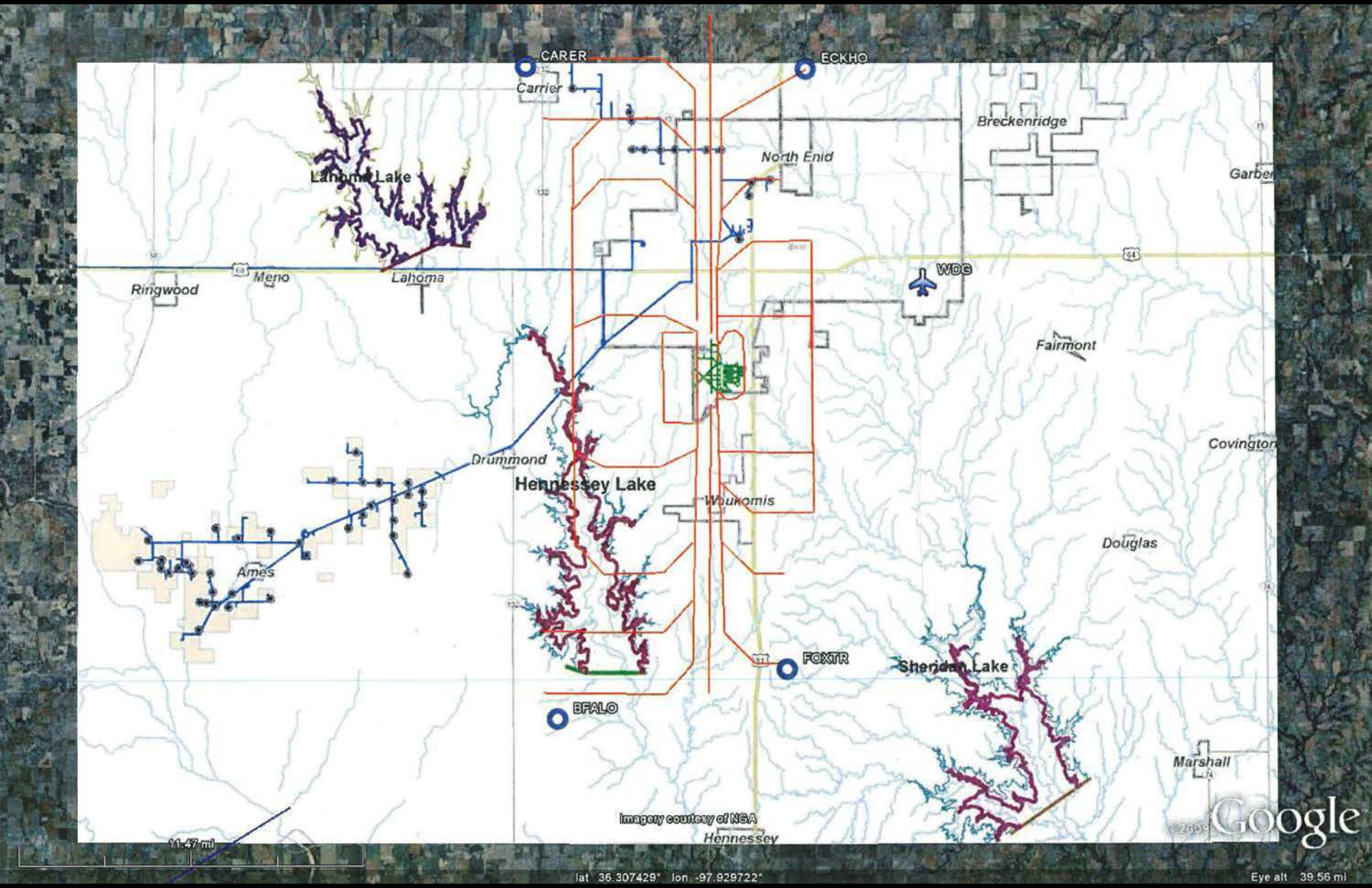

Time to deplete wellfields (based on published recharge data)
Demand/Recharge (MGY)
Usable Water (MG)
Year
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
120,000
100,000
80,000
60,000
40,000
20,000
0
2006
2008
2010
2012
2014
2016
2018
2020
2022
2024
2026
2028
2030
2032
2034
2036
2038
2040
2042
2044
2046
2048
2050
Revised Demand
Yearly Demand
Yearly Recharge
Revised Useable Water
Usable Water

Surface Water Alternatives

Hennessey Lake
Sheridan Lake
Lahoma Lake

Reservoir Elevations

Reservoir	Streambed (Ft)	Inactive Pool (Ft)	Conservation Pool (Ft)	Surcharge Pool (Ft)	Maximum Pool (Ft)
Hennessey	1,095	1,147	1,166.7	1,170.0	1,180.0
Lahoma	1,214	1,247	1,263.0	1,265.0	1,275.0
Sheridan	966	994	1,008.2	1,016.7	1,029.7


CARER
Carrier
ECKHO
Breckenridge
North Enid
Garber
Lahoma Lake
Ringwood
Meno
Lahoma
WDG
Fairmont
Covington
Drummond
Hennessey Lake
Waukomis
Douglas
Ames
FOXTR
Sheridan Lake
BFALO
Marshall
Hennessey
Imagery courtesy of NGA
Google
11.47 mi
lat 36.307429° lon -97.929722°
Eye alt 39.56 mi

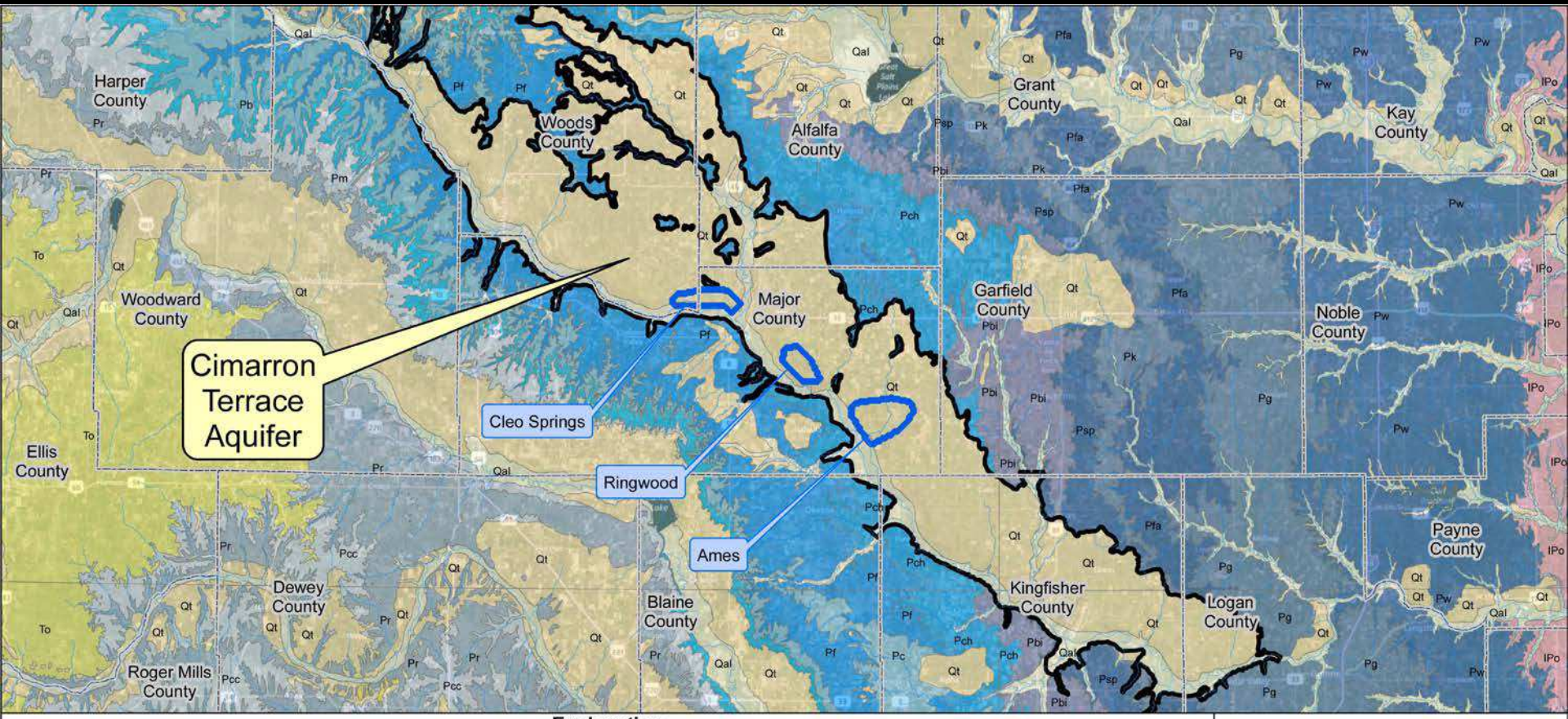
Characteristic	Lahoma	Hennessey	Sheridan
Drainage Basin (mi^2)	124	312	290
Dependable Yield (MGD)	12.6 (Still Need Wellfields)	22.9	25.0
Surface Area (Conservation Pool, ac)	3,871	6,665	4,510
Average Depth (Conservation Pool, ft)	14.6	17.5	13.4
Water Quality (will need further analysis) Desirable TDS Max. = 500	High TDS @ 820, Fe, Mn	High TDS @ 980, Fe, Mn	High TDS @ 960, Fe, Mn (potentially high As and Nitrate)
Water Treatment Needs	Reverse Osmosis for TDS removal	Reverse Osmosis for TDS removal	Reverse Osmosis for TDS removal
Oil & Gas Activities	88 wells on or within one-half mile	275 wells on or within one-half mile	365 wells on or within one-half mile
Highways/ Railroads	No	Railroad	No
Transmission Lines	No	No	Yes
Proximity to Enid center (road miles to dam)	11	18	29
Construction Cost	$218MM	$279MM	$335MM
Present Value (Includes O & M for 50 Years)	$317MM	$399MM	$477MM

Ground Water Alternatives

Geophysical Testing

Option 1: Expand Well Field with Significant Infrastructure Renovation & Expansion

Option 2: Expand Existing Well Field without Significant Infrastructure First, then Expand Well Field Requiring Significant Infrastructure in the Future



Explanation

Quaternary (Q)
- Qal — Alluvium
- Qds — Dune Sands
- Qt — Terrace Deposits

Tertiary (T)
- To — Ogallala Formation

Cretaceous (K)
- Kk — Kiowa Formation

Permian (P)
- Pdy — Doxey Formation
- Pcc — Cloud Chief Formation
- Pr — Rush Springs Formation
- Pm — Marlow Formation
- Pmd — Doe Creek Lentil of Marlow Formation
- Pdc — Dog Creek Shale
- Pb — Blaine Formation
- Pch — Cedar Hills Sandstone
- Pf — Flowerpot Shale
- Pc — Chickasha Formation
- Pd — Duncan Sandstone
- Pbi — Bison Formation
- Psp — Salt Plains Formation
- Pk — Kingman Formation
- Pfa — Fairmont Shale
- Pg — Garber Sandstone
- Pw — Wellington Formation

Pennsylvanian (IP)
- IPo — Oscar Group

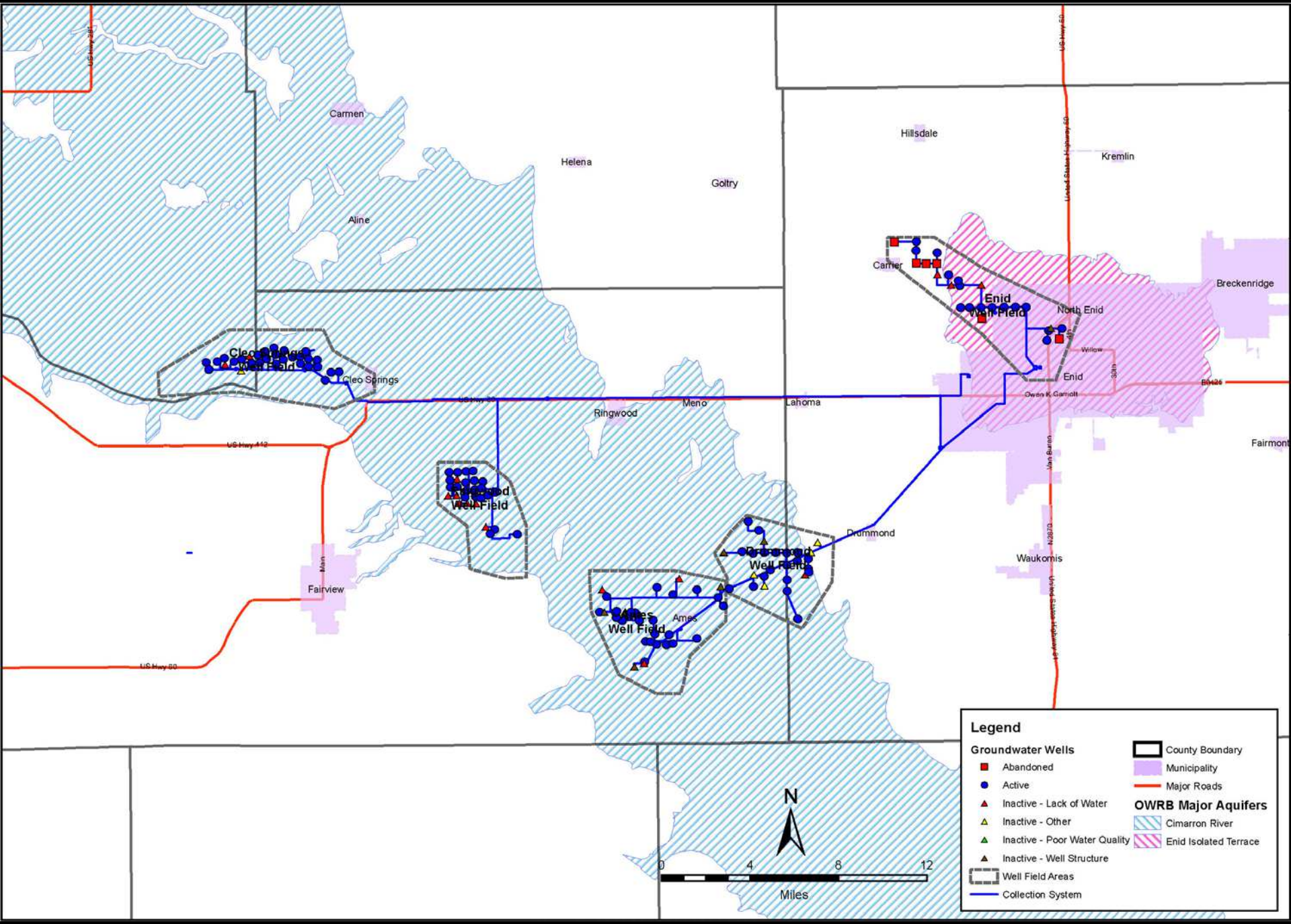
N

0 10 20
Miles

City of Enid

Figure1.
Location Map

THORNHILL GROUP, INC.
Professional Hydrogeologists • Water Resources Specialists


Carmen
Helena
Goltry
Aline
Hillsdale
Kremlin
Carrier
Enid
Well Field
North Enid
Breckenridge
Willow
Enid
Owen K. Garriott
Fairmont
Cleo Springs
Ringwood
Meno
Lahoma
Drummond
Waukomis
Fairview
Ames
US Hwy 412
US Hwy 60
Legend
Groundwater Wells
Abandoned
Active
Inactive - Lack of Water
Inactive - Other
Inactive - Poor Water Quality
Inactive - Well Structure
Well Field Areas
Collection System
County Boundary
Municipality
Major Roads
OWRB Major Aquifers
Cimarron River
Enid Isolated Terrace
N
0
4
8
12
Miles

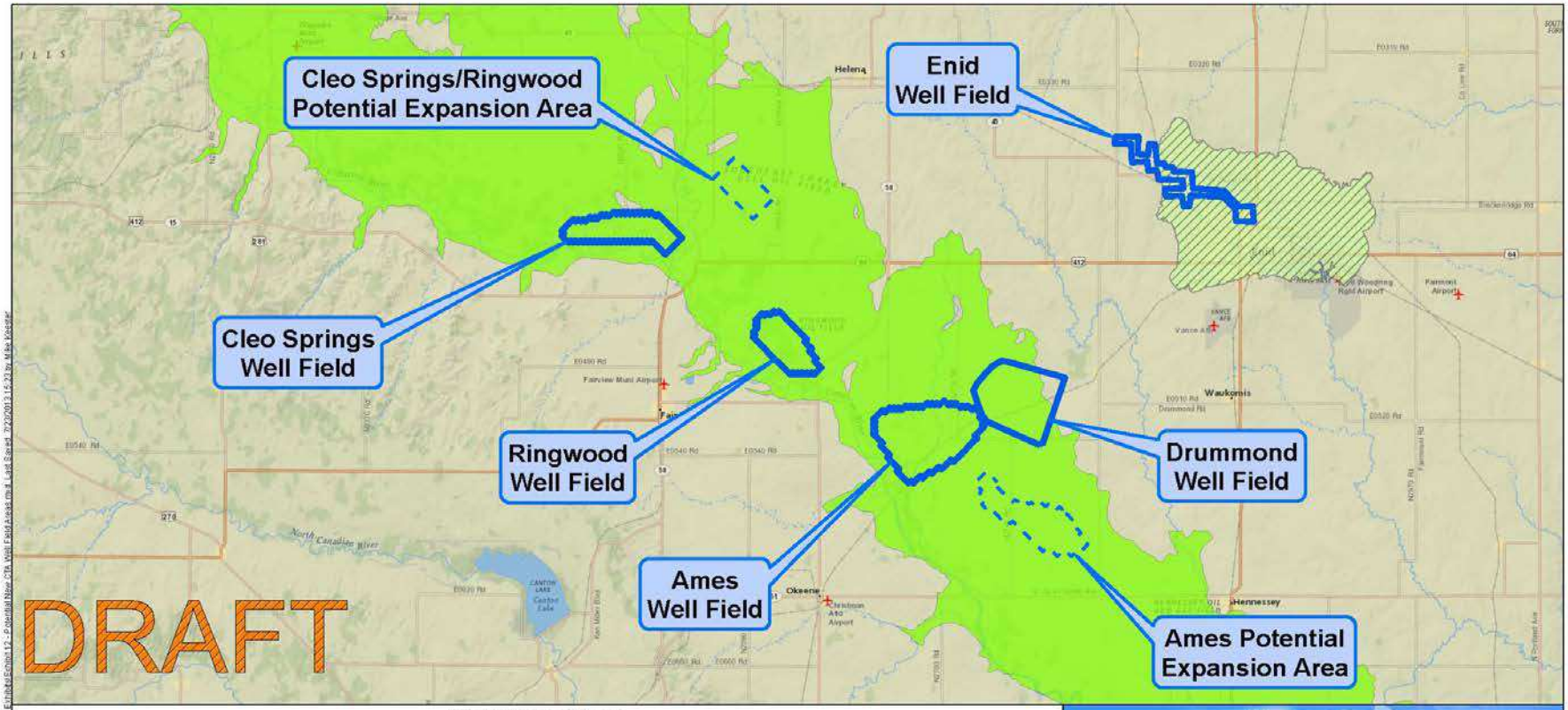
Geophysical Testing

Proposed New Well Fields

- Used geophysical testing to provide additional data for the Cimarron River Terrace Aquifer
- Updated an older aquifer model with the results of the testing
- Determined several promising locations for expansion of the south well fields
- Will require significant expansion and renovation of the City's well field collection system to bring water into the City's system
- Will require test wells to confirm hydraulic characteristics
- Will require acquisition of additional water rights

Proposed Groundwater Alternatives

Southeast of Ames Well Field
Northeast of the Cleo Springs Well Field



CITY of Enid Oklahoma

Exhibit 12.
Potential CTA Well Fields

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Characteristic	Southeast of Ames	Northeast of Cleo Springs
Aquifer Characteristics	Best saturated thickness in Cimarron Terrace Aquifer	Expand in areas similar to Cleo Springs & Ringwood Wellfields, then develop best saturated thickness in Cimarron Terrace Aquifer
Phasing	New pipeline and plant required before utilizing "first drop" of water from aquifer	Can connect to Cleo Springs pipeline with limited cost
Water Treatment	Treat 7.35 MGD for Nitrate Removal	Treat 7.35 MGD for Nitrate Removal
Pumping Plant(s)	One pumping station with 1.0 MG ground storage tank	Two pumping stations, each with 1.0 MG ground storage tanks
Number of Wells	40	52
Construction Cost	$83MM	$86MM
Present Value (Includes O & M for 50 Years)	$136MM	$141MM
Average Production	4 MGD for more than 60 years	2.87 MGD for 60 years
Anticipated Acres needed for Expansion	5,000	3,400

Weighted Matrix

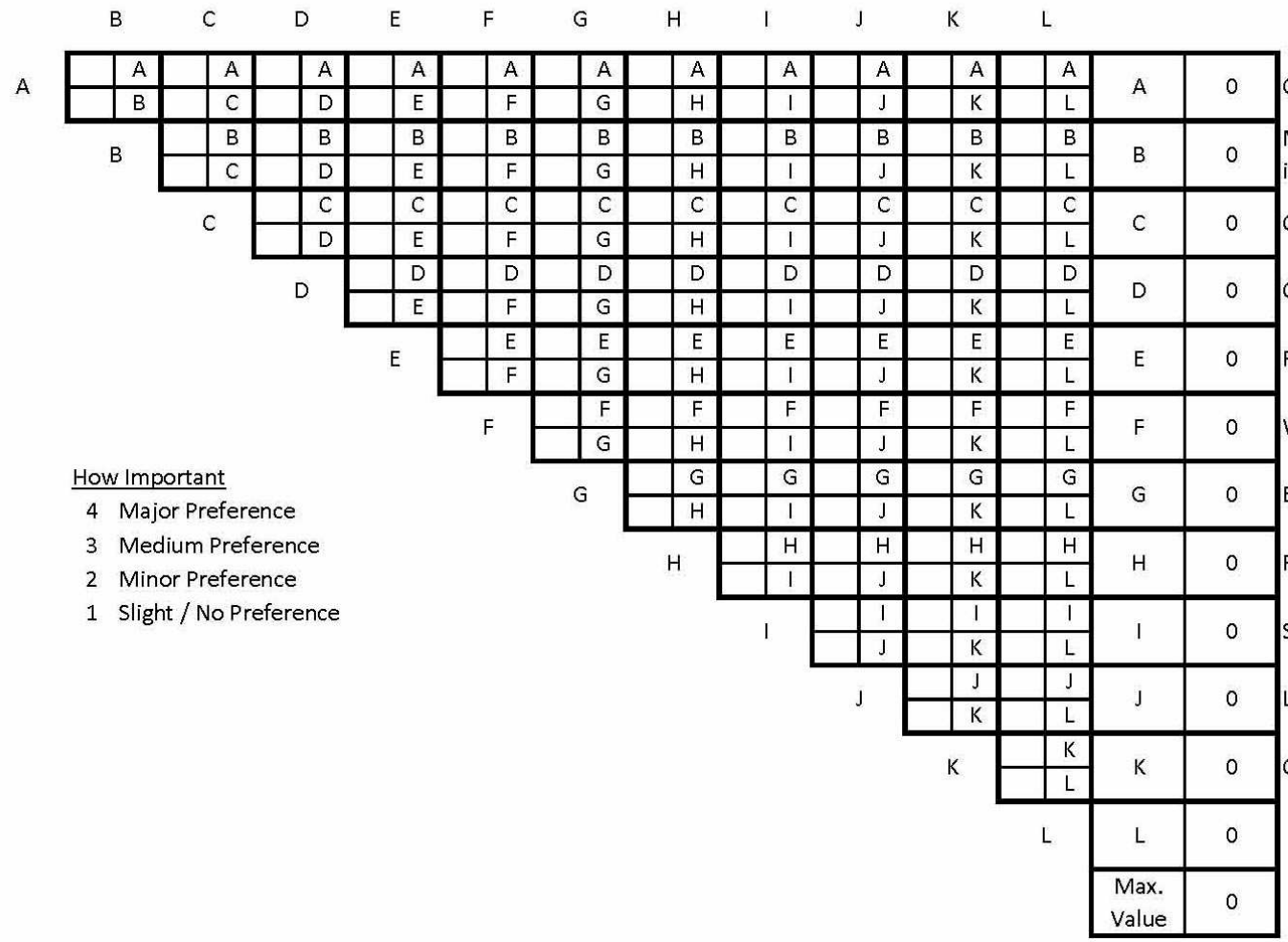
Approach
Results

Enid Water Supply Factors

1. Capital Costs
2. Mitigatable Environmental/Cultural Issues (If not mitigatable = fatal flaw)
3. Operations & Maintenance (O&M) Costs
4. Quality of Life Impacts
5. Reliability/Security
6. Water Quality
7. Ease of Implementation
8. Financial Impact (Phasing)
9. Socioeconomic
10. Land Acquisition
11. Oil/Gas Impacts

Blank Weighted Matrix

Water Supply Feasibility Analysis
Criteria Weighting Process



A	0	Capital Costs
B	0	Mitigatable environmental/cultural issues
C	0	O&M Costs
D	0	Quality of life impact
E	0	Reliability/Security
F	0	Water quality
G	0	Ease of implementation
H	0	Financial Impact (Phasing)
I	0	Socioeconomic
J	0	Land Acquisition
K	0	Oil/Gas Impacts
L	0	
Max. Value	0	

Weighted Value

Capital Costs	0.0
Mitigatable environmental/cultural issues	0.0
O&M Costs	0.0
Quality of life impact	0.0
Reliability/Security	0.0
Water quality	0.0
Ease of implementation	0.0
Financial Impact (Phasing)	0.0
Socioeconomic	0.0
Land Acquisition	0.0
Oil/Gas Impacts	0.0

How Important

4 Major Preference
3 Medium Preference
2 Minor Preference
1 Slight / No Preference

Evaluated Weighted Matrix

Water Supply Feasibility Analysis
Criteria Weighting Process

	B	C	D	E	F	G	H	I	J	K	L
A	4 A	A	A	A	4 A	3 A	3 A	2 A	3 A	2 A	A
	B	2 C	D	3 E	F	G	H	I	J	K	L
B		B	B	B	1 B	2 B	B	B	B	B	B
	4 C	4 D	4 E	1 F		G	4 H	4 I	3 J	4 K	L
C		3 C	C	1 C	2 C	3 C	1 C	2 C	3 C	C	C
		D	3 E	1 F		G	H	1 I	J	K	L
D			D	1 D	3 D	2 D	1 D	2 D	3 D	D	D
		3 E	1 F		G	H	1 I	J	K	L	
E			4 E	3 E	3 E	2 E	3 E	3 E	E	E	
			F	G	H	I	J	K	L		
F				F	F	F	F	F	F	F	
			2 G	3 H	3 I	2 J	2 K	L			
G				G	G	G	G	G	G		
				3 H	3 I	2 J	3 K	L			
H					1 H	1 H	3 H	H			
					1 I	1 J	K	L			
I						3 I	2 I	I			
						J	K	L			
J							J	J			
							3 K	L			
K								K			
								L			
L											

		Weighted Value
A	24	7.7
B	3	1.0
C	21	6.8
D	16	5.2
E	31	10.0
F	3	1.0
G	2	0.6
H	15	4.8
I	18	5.8
J	8	2.6
K	12	3.9
L	0	
Max. Value	31	

A	Capital Costs
B	Mitigatable environmental/cultural issues
C	O&M Costs
D	Quality of life impact
E	Reliability/Security
F	Water quality
G	Ease of implementation
H	Financial Impact (Phasing)
I	Socioeconomic
J	Land Acquisition
K	Oil/Gas Impacts

How Important

4 Major Preference
3 Medium Preference
2 Minor Preference
1 Slight / No Preference

Blank Evaluation Form

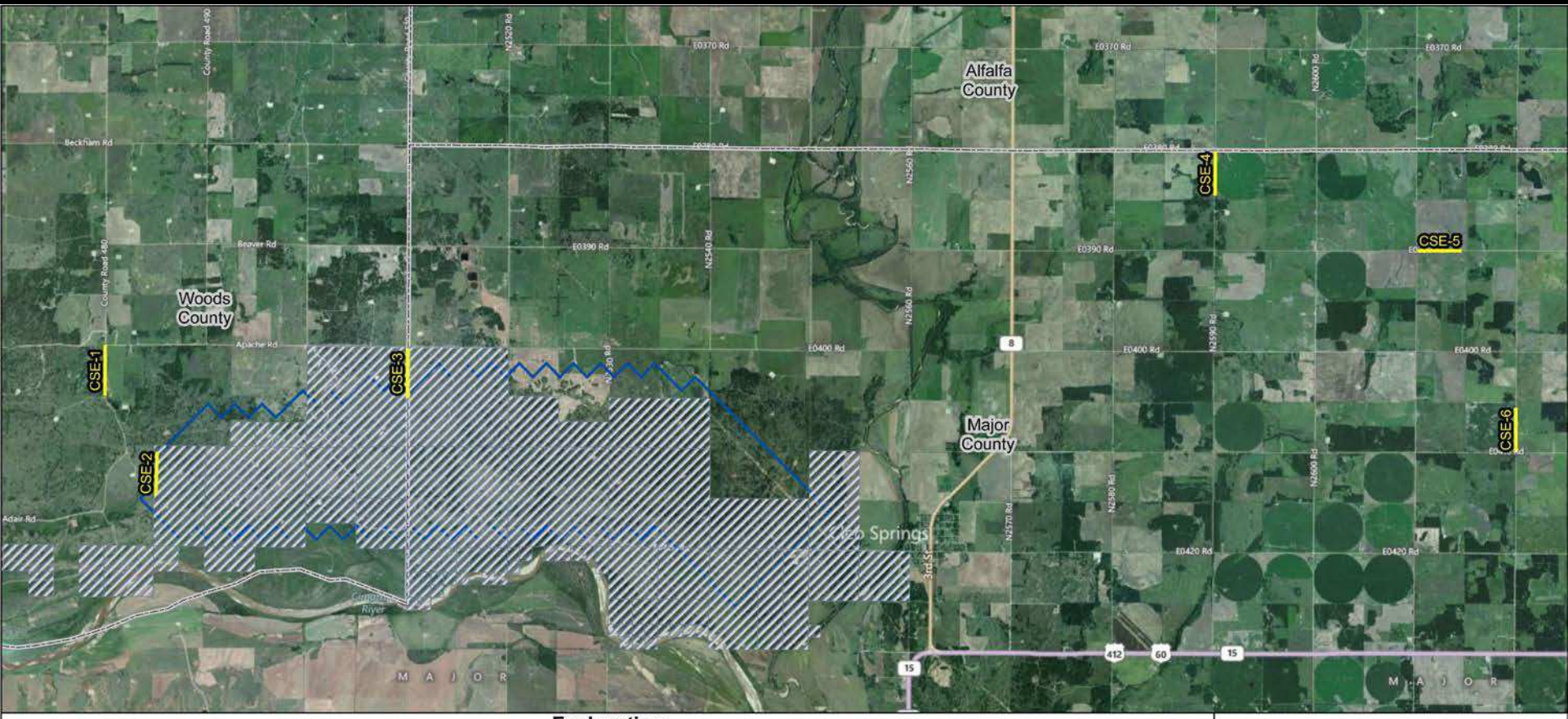
ENID ALTERNATIVES EVALUATION													
ALTERNATIVES	Ranking/Score	Capital Cost	Migatable Env & Cultural	O&M Costs	Q of L Impact	Reliability & Security	Water Quality	Ease of Implementation	Financial Impact & Phasing	Socio-Economic Impact	Land Acquisition	Oil & Gas Impacts	Total Score
		7.7	1	6.8	5.2	10	1	0.6	4.8	5.8	2.6	3.9	
1. Hennessey Lake	Ranking												0
	Score	0	0	0	0	0	0	0	0	0	0	0	
2. Sheridan Lake	Ranking												0
	Score	0	0	0	0	0	0	0	0	0	0	0	
3. Lahoma Lake	Ranking												0
	Score	0	0	0	0	0	0	0	0	0	0	0	
4. Wellfield Option 1	Ranking												0
	Score	0	0	0	0	0	0	0	0	0	0	0	
5. Wellfield Option 2	Ranking												0
	Score	0	0	0	0	0	0	0	0	0	0	0	
	Ranking												0
	Score	0	0	0	0	0	0	0	0	0	0	0	
Ranking: Excellent = 5, Very Good = 4, Good = 3, Fair = 2, Poor = 1													

Alternatives Evaluation

ENID ALTERNATIVES EVALUATION													
ALTERNATIVES	Ranking/Score	Capital Cost	Migatable Env & Cultural	O&M Costs	Q of L Impact	Reliability & Security	Water Quality	Ease of Implementation	Financial Impact & Phasing	Socio-Economic Impact	Land Acquisition	Oil & Gas Impacts	Total Score
		7.7	1	6.8	5.2	10	1	0.6	4.8	5.8	2.6	3.9	
1. Hennessey Lake	Ranking	4	4	5	5	5	5	3	2	3	3	4	202
	Score	30.8	4	34	26	50	5	1.8	9.6	17.4	7.8	15.6	
2. Sheridan Lake	Ranking	3	4	4	2	4	3	4	2	4	4	3	165
	Score	23.1	4	27.2	10.4	40	3	2.4	9.6	23.2	10.4	11.7	
3. Lahoma Lake	Ranking	5	5	2	3	3	4	5	5	3	5	5	183.6
	Score	38.5	5	13.6	15.6	30	4	3	24	17.4	13	19.5	
4. Wellfield Option 1	Ranking	5	5	5	3	5	4	4	3	3	5	5	213.8
	Score	38.5	5	34	15.6	50	4	2.4	14.4	17.4	13	19.5	
5. Wellfield Option 2	Ranking	5	5	3	3	3	4	3	5	3	4	5	186.6
	Score	38.5	5	20.4	15.6	30	4	1.8	24	17.4	10.4	19.5	
	Ranking												0
	Score	0	0	0	0	0	0	0	0	0	0	0	
Ranking: Excellent = 5, Very Good = 4, Good = 3, Fair = 2, Poor = 1													

Reservoir versus Wellfield Evaluation

ENID ALTERNATIVES EVALUATION													
ALTERNATIVES	Ranking/Score	Capital Cost	Migatable Env & Cultural	O&M Costs	Q of L Impact	Reliability & Security	Water Quality	Ease of Implementation	Financial Impact & Phasing	Socio-Economic Impact	Land Acquisition	Oil & Gas Impacts	Total Score
		7.7	1	6.8	5.2	10	1	0.6	4.8	5.8	2.6	3.9	
1. Hennessey Lake	Ranking	2	2	4	5	3	2	1	2	3	2	1	139.3
	Score	15.4	2	27.2	26	30	2	0.6	9.6	17.4	5.2	3.9	
4. Wellfield Option 1	Ranking	5	5	5	2	3	4	5	4	2	4	4	181.7
	Score	38.5	5	34	10.4	30	4	3	19.2	11.6	10.4	15.6	
	Ranking												0
	Score	0	0	0	0	0	0	0	0	0	0	0	
Ranking: Excellent = 5, Very Good = 4, Good = 3, Fair = 2, Poor = 1													



Explanation

- Survey Lines
- Enid Municipal Authority Water Rights
- Cleo Springs Well Field
- County

DRAFT

0 1 2
Miles

N

City of Enid

Figure 2.
Survey Line Locations

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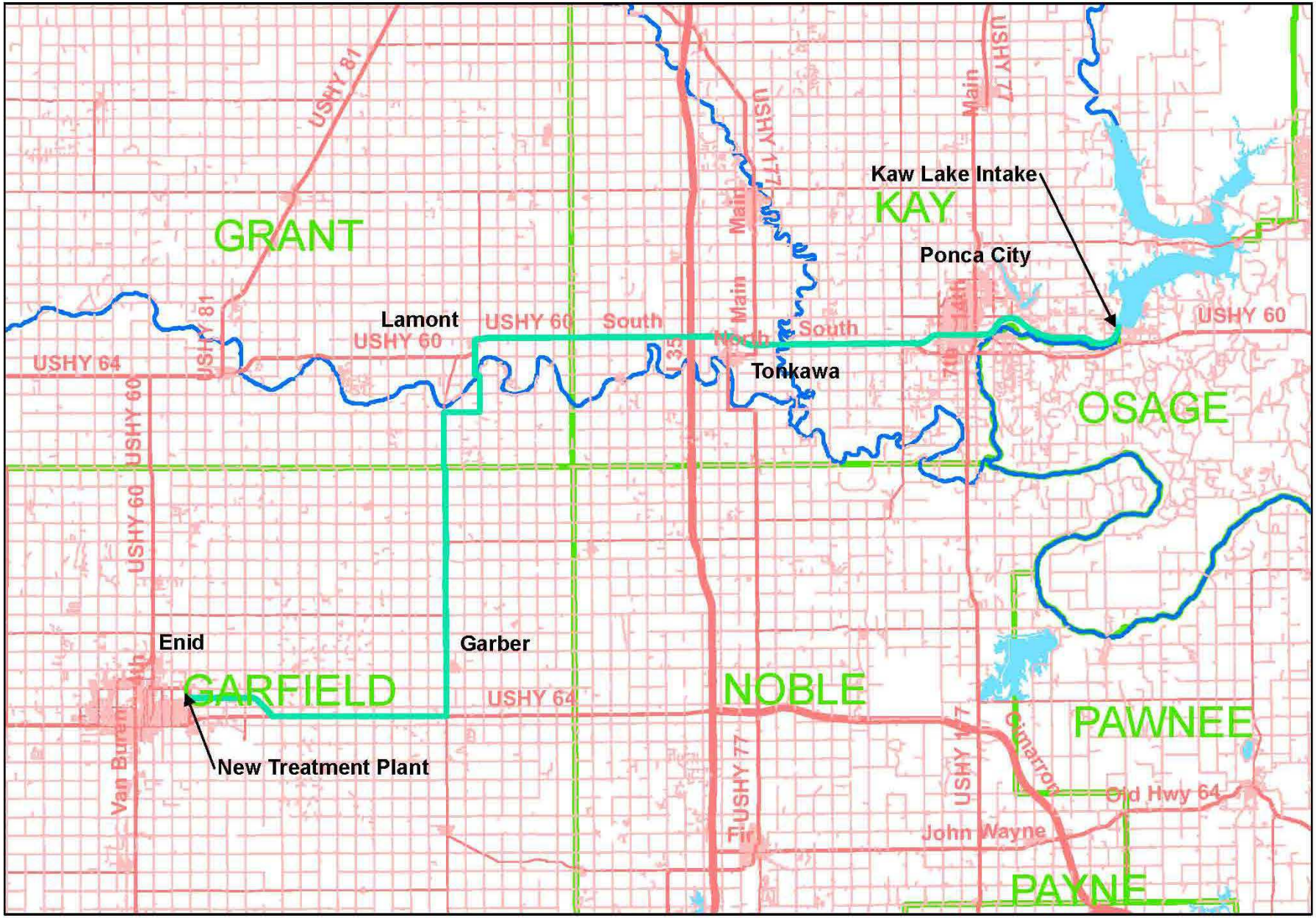
Water rights based on OWRB datafile published 11/1/2012.

Kaw Pipeline



Kaw Pipeline Route

Characteristic	24” Pipeline	36” Pipeline	48” Pipeline
Peak Flow	15.5 MGD 6,665 MGY	20 MGD 7,320 MGY	24 MGD 8,770 MGY
Average Plant Production	7.75MGD 2,826 MGY	10 MGD 3,648 MGY	12 MGD 4,373 MGY
Construction Cost	$105MM	$148MM	$205MM
Energy Use	7,750,000 KWH per yr	10,000,000 KWH per yr	12,000,000 KWH per yr
Present Value (Includes O & M for 50 Years)	$182MM	$251MM	$336MM

Discussion

July 2012