North Fork Kings
Groundwater Sustainability Agency

Groundwater Sustainability Plan (GSP) Status Report

Kevin Johansen
Provost & Pritchard Consulting Group

BOARD OF DIRECTORS MEETING

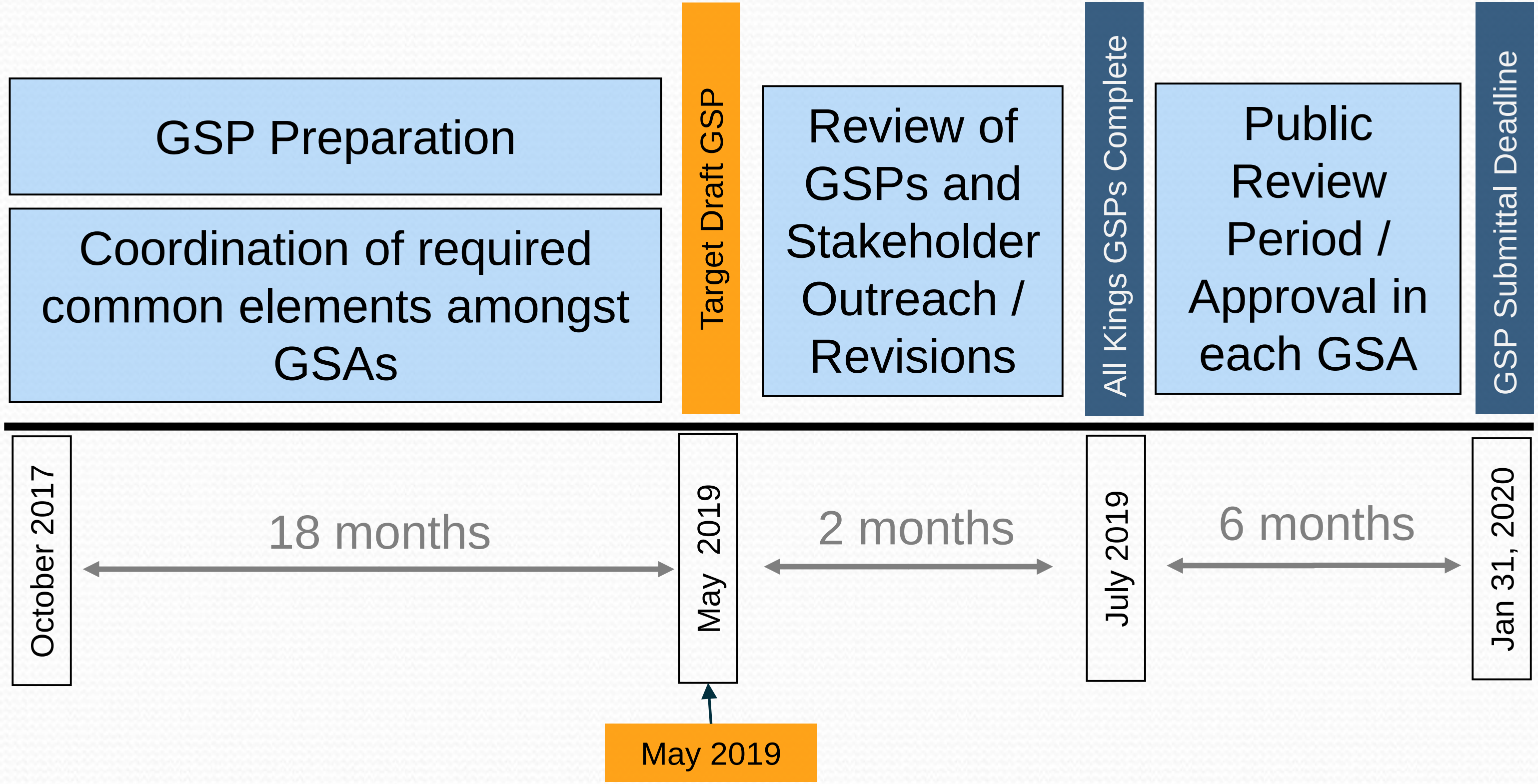
May 22, 2019

RIVERDALE COMMUNITY EDUCATION CENTER

Presentation Overview

1. Schedule
2. Kings Subbasin Coordination
3. GSP Development Update
4. Water Budgets
5. Sustainable Management Criteria

EST. 1968
PROVOST & PRITCHARD
CONSULTING GROUP
An Employee Owned Company



GSP Preparation and Coordination Timeline

Draft GSP Review Schedule

North Fork Kings GSA
GSP Development
Proposed Schedule

DRAFT
5-22-19

Admin Draft of GSP to Technical Advisory Group		end of May 2019
Admin Draft of complete GSP to Board		6/21/19
Overview Presentation of GSP to Board	Board Meeting	6/26/19
NFKGSA Stakeholder Review		
Coordination with other Kings GSAs		
Coordination with adjacent subbasins		
Public Review		
Authorize Notice of Public Hearing (90-days)	Board Meeting	7/24/19
Public review period		
Public Hearing, receive comments on GSP	Board Meeting	10/23/19
Finalize GSP		
Consider comments		
Board Adopt Final GSP	Board Meeting	11/27/19
Submit GSP to DWR - coordinated with other Kings GSAs	Prior to	1/31/20

Kings Subbasin Coordination

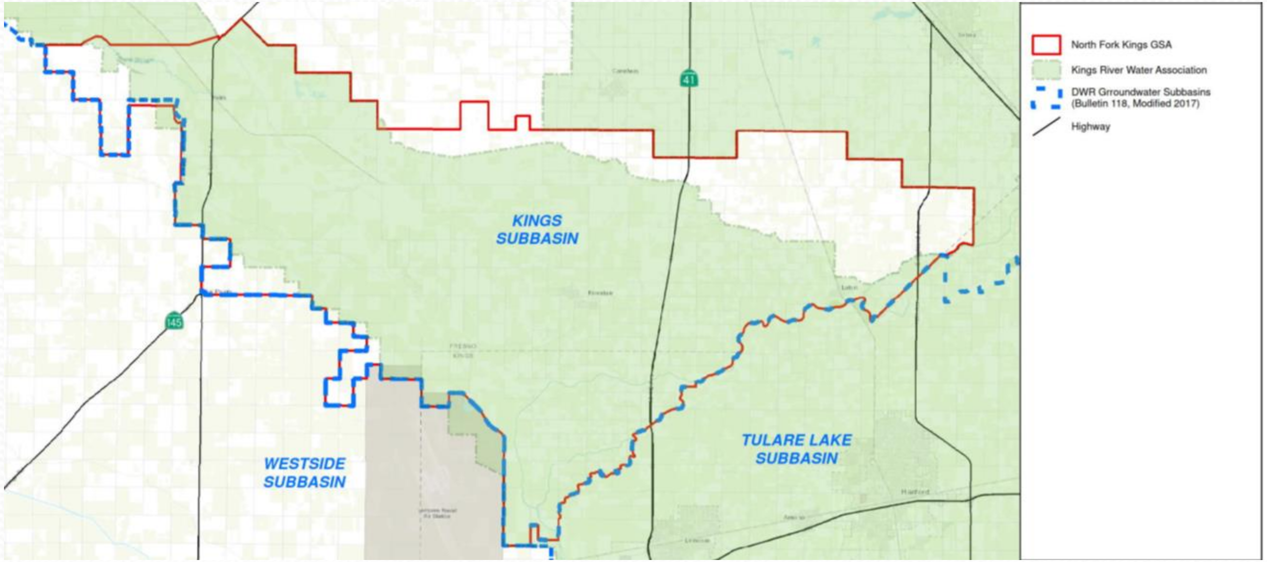
- All GSAs within Kings Subbasin working together to coordinate activities
- Work continues on coordinated plan sections regarding Kings Subbasin:
    - Water Budget
    - Sustainable Management Criteria
- Work continues on developing Coordination Agreement

GSP Development Update

GSP Section	Current Status	Future Work
1 – Introduction	In Progress	Complete Draft, submit to TAG in May
2 – Plan Area	Draft Complete – comments incorporated	Draft Provided to Board of Directors
3.1 – Hydrogeologic Conceptual Model	Draft Complete – submitted to Technical Advisory Group (TAG)	Incorporate TAG review comments
3.2 – Historical GW Conditions	Draft Complete – submitted to TAG	Incorporate TAG review comments
3.3 – Water Budget	Draft Complete – being submitted to TAG	Incorporate TAG review comments
4 – Sustainable Management Criteria	In Progress – developing criteria for water levels as key component for determining sustainability	Develop criteria, define undesirable results, set measurable objectives and minimum thresholds. Submit Draft to TAG in May.
5 – Monitoring Network	Draft Complete – submitted to TAG	Incorporate TAG review comments
6 – Projects and Management Actions	In Progress – identifying potential projects and management actions	Complete Draft, submit to TAG in May
7 – Plan Implementation	In Progress – identifying implementation costs and schedule	Complete Draft, submit to TAG in May

Water Budgets

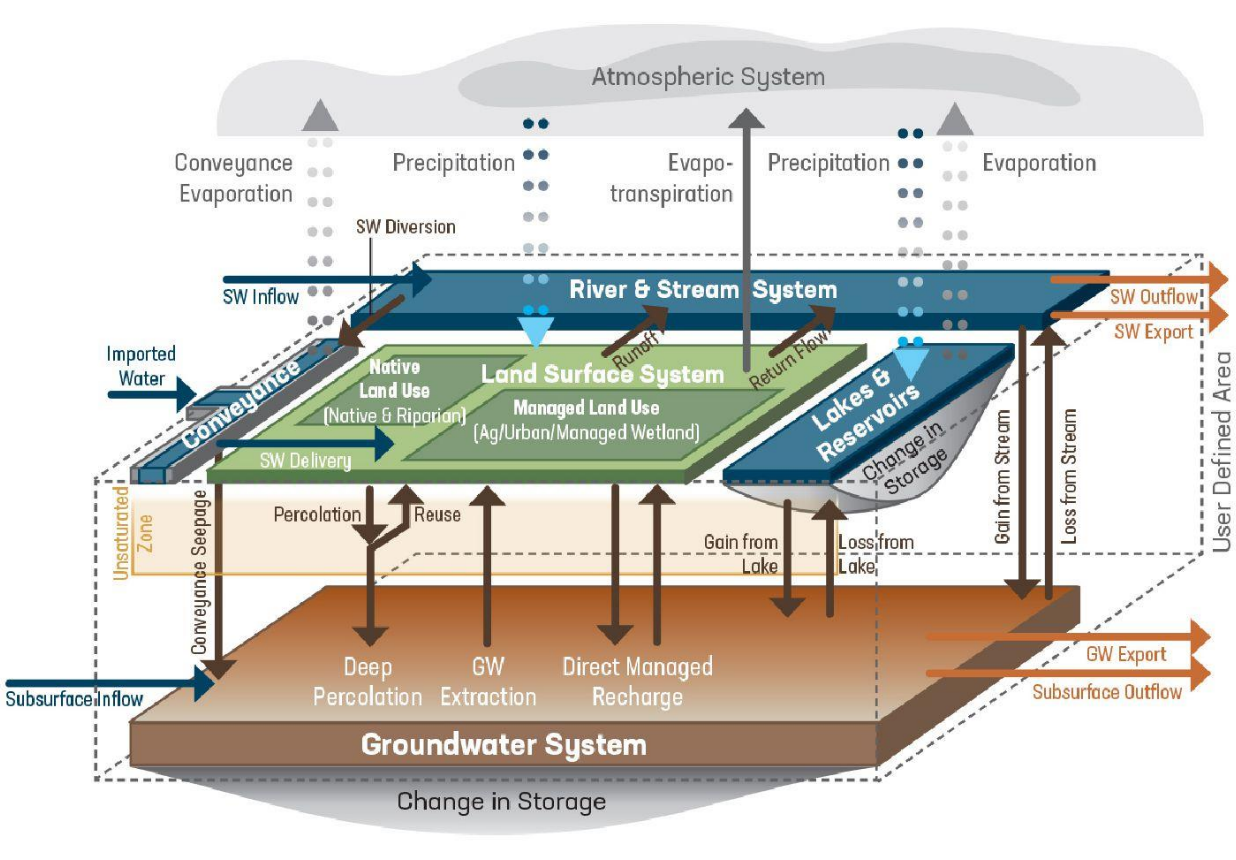
- Historical, Current and Future Water Budgets are required by SGMA as part of GSP
- Water demand not met by surface water or precipitation is met by groundwater pumping
- Surface water supply within NFKGSA almost exclusively Kings River
- Approximately 22% of NFKGSA area is outside Kings River service area



Water Budget Components

- Summarize hydrologic interactions
  - Groundwater interactions: Groundwater pumping, deep percolation, intentional recharge, river/canal seepage
  - Atmosphere Interactions: Precipitation, evaporation, crop ET
- Summarize all water sources (inputs) and water uses (outputs)
  - Inputs: Surface water, precipitation, groundwater pumping (estimate), groundwater inflow
  - Outputs: Irrigation, municipal, residential, industrial, groundwater outflow
- Calculate change in groundwater storage = Inputs – Outputs
  - Water into groundwater system minus water out of groundwater system

Water Budget Diagram



Water Budget Components
Historical and Current Water Budgets

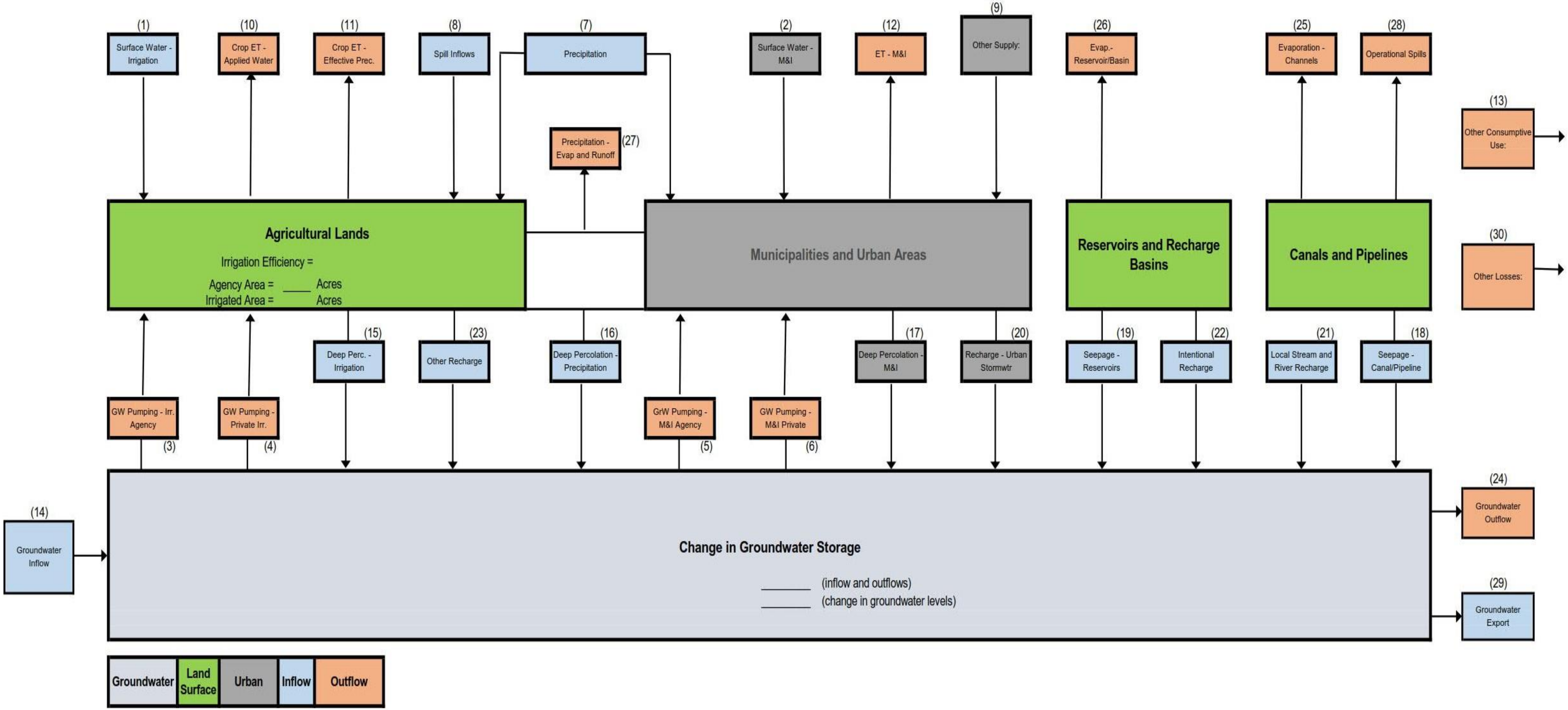
Description	
Supply	
1)	Surface Water for Irrigation and Recharge
2)	Surface Water for M&I and Recharge
3)	Groundwater Pumping for Irrigation (Agency Wells)
4)	Groundwater Pumping for Irrigation (Private Wells, unknown)
	Groundwater Pumping for Dairies
5)	Groundwater Pumping for M&I (Agency Wells)
6)	Groundwater Pumping for M&I (Private Wells)
7)	Precipitation
8)	Spill Inflows
9)	Other Supply - Kings River seepage
	Total Supply
Demand	
Consumptive Use	
10)	Evapotranspiration met by Applied Water
11)	Evapotranspiration met by Effective Precipitation
12)	Evapotranspiration of M&I
13)	Other Consumptive Use - dairy
	Other Consumptive Use - riparian vegetation
	Consumptive Subtotal

Description	
Groundwater Recharge	
14)	Groundwater Inflow
15)	Deep Percolation of Irrigation Water
16)	Deep Percolation of Precipitation
17)	Deep Percolation of M&I Water
18)	Seepage of Channels & Pipelines
19)	Seepage - Reservoirs
20)	Urban Stormwater - Recharge
21)	Local Streams/Rivers - Recharge
22)	Groundwater - Intentional Recharge
23)	Other Recharge
	GW Recharge Subtotal
Nonrecoverable Losses	
24)	Groundwater - Outflow
25)	Evaporation - Channels
26)	Evaporation - Reservoirs & Recharge Basins
27)	Precipitation - Evaporation and Runoff
28)	Operational Spills
29)	Groundwater - Export
30)	Other Losses
	Nonrecoverable Subtotal

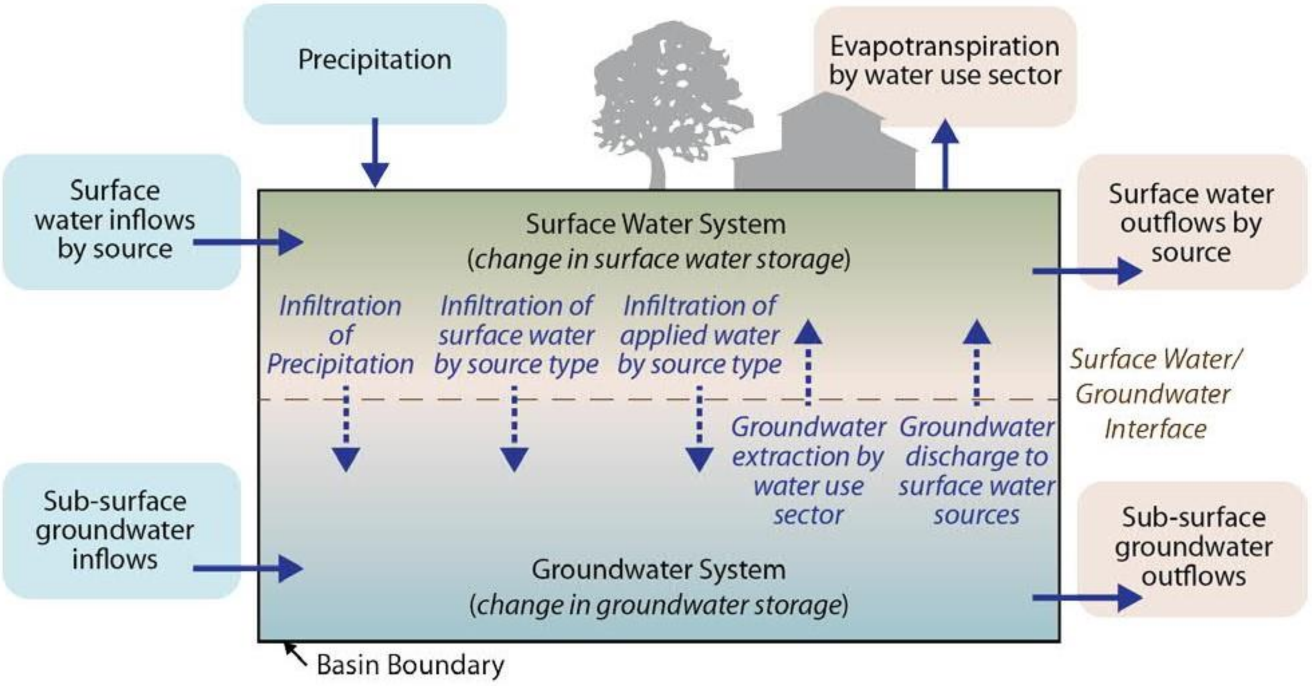
NORTH FORK KINGS GSA

WATER BUDGET DIAGRAM

PERIOD OF RECORD = 1997 - 2011



Simplified Basin Water Budget Diagram



DRAFT

Draft Historical Water Budget (Oct 1996 – Sept 2011) simplified version referred to as Basin Water Budget

Confidence intervals (error %) indicate relative uncertainty of components

Description	Symbol	Volume (AF)	Source	Prelim Confidence Interval % +/-	Prelim Confidence Interval Volume (AF)
Inputs (Supply + Groundwater Inflow)					
1) Surface Water for Irrigation and Recharge	Qirr	175,300	Measured	5%	8,800
2) Surface Water for M&I and Recharge	Qmi	0	Measured	5%	0
7) Precipitation	P	116,600	Measured	15%	17,500
8) Spill Inflows	Si	0	Calculated	50%	0
9) Other Supply - Kings River seepage	Os	47,000	Calculated	25%	11,800
14) Groundwater Inflow - unconfined	GWi	16,300	Calculated	30%	4,900
Groundwater Inflow - confined	GWi	15,000	Estimated	30%	4,500
Total Inputs		**370,200**			**47,500**
Outputs (Demand + Non-Recoverable Losses)					
10) Evapotranspiration met by Applied Water	ETc	326,700	Calculated	15%	49,000
11) Evapotranspiration met by Effective Precipitation	ETp	60,200	Calculated	15%	9,000
12) Evapotranspiration of M&I	ETmi	2,300	Calculated	15%	300
13) Other Consumptive Use - dairy	Od	7,200	Calculated	25%	1,800
Other Consumptive Use - riparian vegetation	Orv	2,700	Calculated	25%	700
24) Groundwater Outflow - unconfined	GWo	0	Estimated	30%	0
Groundwater Outflow - confined	GWo	13,000	Estimated	30%	3,900
25) Evaporation - Channels	Ech	1,200	Calculated	30%	400
26) Evaporation - Reservoirs & Recharge Basins	Er	200	Calculated	30%	100
27) Precipitation - Evaporation and Runoff	Ep	47,900	Residual	15%	7,200
28) Operational Spills	S	0	Measured	30%	0
29) Groundwater - Export	GE	0	Measured	5%	0
30) Other Losses	Ol	0			
Total Outputs		**461,400**			**72,400**
Method 1					
Estimated Annual Change in Groundwater Storage		**(91,200)**	Calculated		
Inputs	370,200				
Outputs	(461,400)				
Method 2					
Calculated Annual Change in Groundwater Storage		**(59,000)**		20%	(11,800)
Unconfined Aquifer	(49,000)		Measured		
Confined Aquifer (Subsidence)	(10,000)		Estimated		
Difference (AF)		**(32,200)**			

Difference in groundwater storage change is within confidence interval, therefore water budget closes within acceptable limit

Summary Comparison of

Draft Historical Water Budget

and

Draft Current Water Budget

DRAFT

Description	Historical Avg (AF)	Current Avg (AF)
Supply		
Total Supply	**616,500**	**621,600**
Demand		
Consumptive Use Subtotal	**399,100**	**403,200**
Groundwater Recharge		
GW Recharge Subtotal	**199,400**	**200,400**
Nonrecoverable Losses		
Nonrecoverable Subtotal	**62,300**	**62,300**
Method 1		
Estimated Annual Change in Groundwater Storage	**(91,200)**	**(63,100)**
Water Budget Correction		32,200
GW Recharge - #14 thru #23	199,400	200,400
GW Pumping - #3 thru #6	(277,600)	(282,700)
GW Outflow - #24 and #29	(13,000)	(13,000)
Method 2		
Calculated Annual Change in Groundwater Storage	**(59,000)**	
Difference	**32,200**	

Water Budget Components
Projected Future Water Budgets

	Description
Supply	
1)	Surface Water for Irrigation and Recharge
1a)	SGMA Supply Projects
2)	Surface Water for M&I and Recharge
3)	Groundwater Pumping for Irrigation (Agency Wells)
4)	Groundwater Pumping for Irrigation (Private Wells, unknown)
	Groundwater Pumping for Dairies
5)	Groundwater Pumping for M&I (Agency Wells)
6)	Groundwater Pumping for M&I (Private Wells)
7)	Precipitation
8)	Spill Inflows
9)	Other Supply - Kings River seepage
	Total Supply
Demand	
Consumptive Use	
10)	Evapotranspiration met by Applied Water
10a)	SGMA Management Actions - ET Reduction
11)	Evapotranspiration met by Effective Precipitation
12)	Evapotranspiration of M&I
13)	Other Consumptive Use - dairy
	Other Consumptive Use - riparian vegetation
	Consumptive Subtotal

	Description
Groundwater Recharge	
14)	Groundwater Inflow
15)	Deep Percolation of Irrigation Water
16)	Deep Percolation of Precipitation
17)	Deep Percolation of M&I Water
18)	Seepage of Channels & Pipelines
19)	Seepage - Reservoirs
20)	Urban Stormwater - Recharge
21)	Local Streams/Rivers - Recharge
22)	Groundwater - Intentional Recharge
22a)	SGMA Supply Projects - Intentional Recharge
23)	Other Recharge
	GW Recharge Subtotal
Nonrecoverable Losses	
24)	Groundwater - Outflow
25)	Evaporation - Channels
26)	Evaporation - Reservoirs & Recharge Basins
27)	Precipitation - Evaporation and Runoff
28)	Operational Spills
29)	Groundwater - Export
30)	Other Losses
	Nonrecoverable Subtotal

Summary Comparison of

Draft Early Future Water Budget

and

Draft Late Future Water Budget

DRAFT

Description	Early Future 2030 Avg (AF)	Late Future 2070 Avg (AF)
Supply		
1a) SGMA Supply Projects	24,000	56,500
Total Supply	**650,100**	**669,900**
Demand		
10a) SGMA Management Action - ET Reduction	(2,000)	(19,500)
Consumptive Use Subtotal	**406,800**	**396,600**
Groundwater Recharge		
22a) SGMA Intentional Recharge	24,000	56,500
GW Recharge Subtotal	**225,300**	**255,300**
Nonrecoverable Losses		
Nonrecoverable Subtotal	**62,300**	**62,300**
Estimated Annual Change in Groundwater Storage	**(42,700)**	**0**
Water Budget Correction	32,200	32,200
GW Recharge - #14 thru #23	225,300	255,300
GW Pumping - #3 thru #6	(287,200)	(274,500)
GW Outflow - #24 and #29	(13,000)	(13,000)

Sustainable Management Criteria

- Sustainability indicators

- Significant & Unreasonable – defined using the following:

Likely addressed in this order

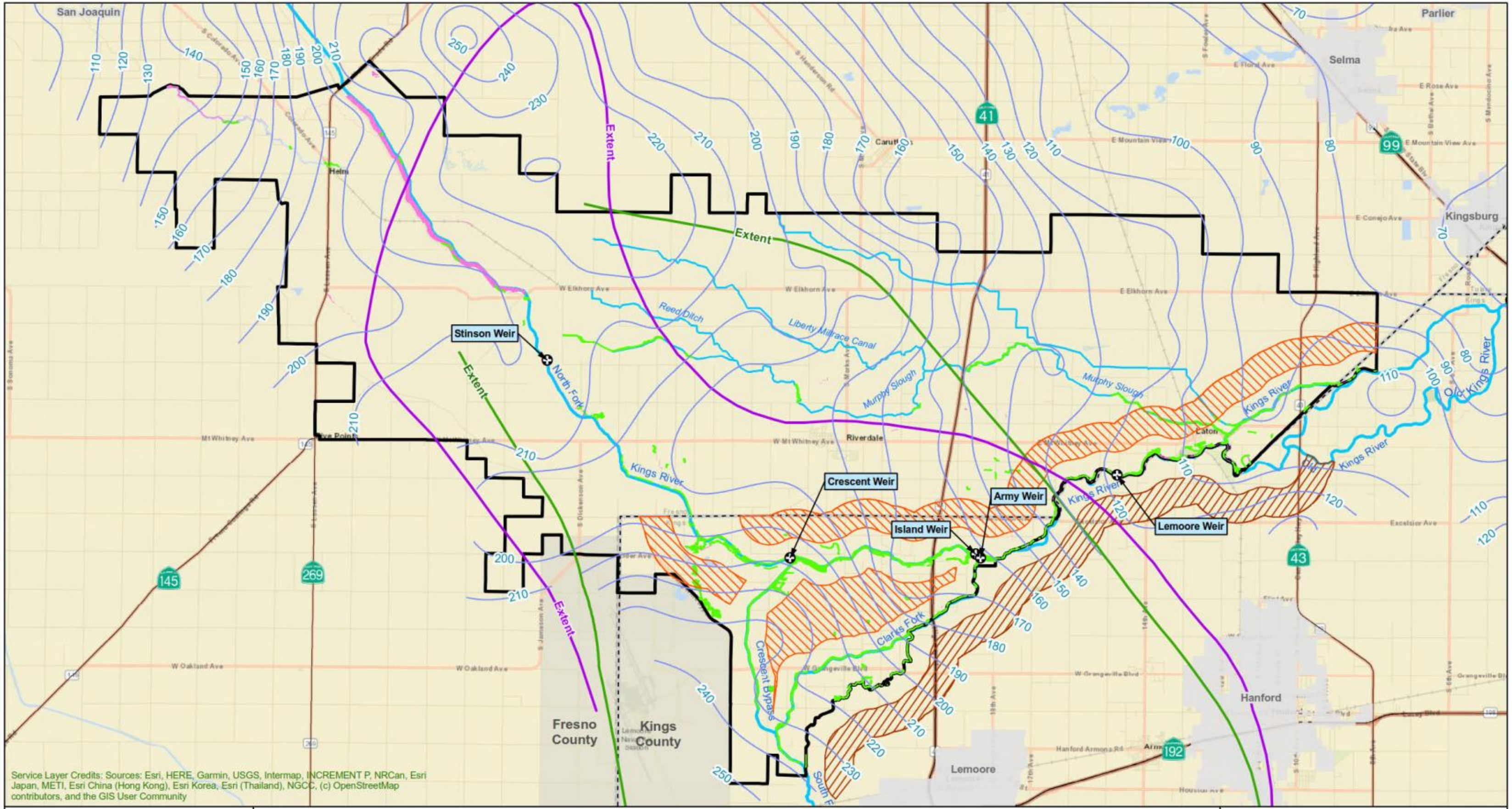
- Undesirable Results
- Minimum Thresholds
- Measurable Objectives
- Sustainability Goal

Must be agreed to, and be consistent in the GSPs of all GSAs within basin

North Fork Kings GSA - Sustainable Management Criteria Summary

DRAFT 5/15/2019

Sustainability Criteria	Groundwater (GW) Level UNCONFINED AQUIFER	Change in Groundwater Storage	Water Quality (WQ)	Land Subsidence	Interconnected Surface Water (ISW)
Sustainability Goal	The sustainability goal of the Kings Basin and this GSA is to ensure that by 2040 the basin is being managed in a sustainable manner which maintains a reliable water supply for current and future beneficial uses without experiencing undesirable results. This goal will be met by balancing water demand with available water supply and stabilizing the long term trend of declining groundwater levels without significantly or unreasonably impacting groundwater storage, water quality, land subsidence or interconnected surface water.				
Definition of Undesirable Results (UR)	Significant and unreasonable chronic lowering of water levels that does not provide operational flexibility to sustain a 5-year drought and negatively impacts groundwater storage, water quality, land subsidence or interconnected surface water.	Significant and unreasonable chronic decrease in groundwater storage that has an impact on the beneficial uses of groundwater	Significant and unreasonable degradation of groundwater quality that has an impact on the beneficial uses and users of groundwater.	Changes in ground surface elevation that cause damage to critical infrastructure that would cause significant and unreasonable reductions of conveyance capacity, damage to personal property, impacts to natural resources or create conditions that threaten public health and safety.	Depletions of interconnected surface water that have significant and unreasonable adverse impacts on the beneficial uses of surface water
Metric	Groundwater elevation (GWE) of representative monitoring wells and corresponding GWE surface contours	Volume withdrawn from primary aquifer calculated by GWE of representative monitoring wells and corresponding GWE surface contours.	WQ sample data from representative monitoring wells.	Rate and extent of land subsidence from representative monitoring points.	Rate or volume of surface water depletion from representative monitoring points.
Minimum Threshold (MT)	• Determine operational flexibility from maximum deviation from historic trend line • Groundwater levels sufficient to meet operational flexibility as well as 5-year drought buffer storage	Water level as proxy to calculate GW storage change.	When WQ is below MCL, MT will be the MCL. When WQ is above MCL, MT will be the highest recorded value at each monitoring site.	Annual Rate = 1.5x MO for operational flexibility. Maximum Cumulative = 1.5x MO for operational flexibility.	Not applicable since Kings River system is not continously wet within NKFGSA.
Measurable Objective (MO)	Historic trend line of available data 1985 to present, extend trendline to 2020, apply phased mitigation to reduce rate of decline every 5 years (10%, 20%, 30%, 40%).	Water level as proxy to calculate GW storage change.	When WQ is below MCL, MO will be 10% below the MCL. When WQ is above MCL, MO will be the highest recorded value at each monitoring site.	Annual Rate = Based upon maximum rate from KRCD 2013-2016 data. Maximum Cumulative = Based upon minimum rate from KRCD 2013-2016 data over 20 years.	Not applicable since Kings River system is not continously wet within NKFGSA.
5-Year Interim Goals	• Year 5: 10% reduction of historical rate of decline • Year 10: 20% additional reduction (30% total) • Year 15: 30% additional reduction (60% total) • Year 20: 40% additional reduction (100% total)	Water level as proxy to calculate GW storage change.	When WQ is below MCL, milestones will match MO. When WQ is above MCL, milestones will match MO.	Annual Rate milestone will match MO. Maximum Cumulative milestone will be linear trend from 2020 to MO.	Not applicable since Kings River system is not continously wet within NKFGSA.
Notes	ISW - Per GSP Reg. 354.28.E: ... not required if existing groundwater levels indicate that surface water is not hydraulically connected at any point in the GSA area by a continuous saturated zone to the underlying aquifer, and overlying surface water is completely depleted at times during the year. Need to document that a continuous saturated zone to the underlying groundwater aquifer is not present.				



PROVOST & PRITCHARD CONSULTING GROUP
EST. 1968
An Employee Owned Company

N
0 1 2
Miles

- Measurement Location
- Highway
- Vegetation (Nature Conservancy iGDE)
- Wetlands (Nature Conservancy iGDE)
- North Fork Kings GSA
- County Boundaries
- City
- Proposed Shallow Monitoring Well Area
- Proposed Shallow Monitoring Well Area Outside GSA
- A-Clay Extent (1999-H)
- C-Clay Extent (1999-H)

Depth To Water, Kings Basin Coordinated Effort

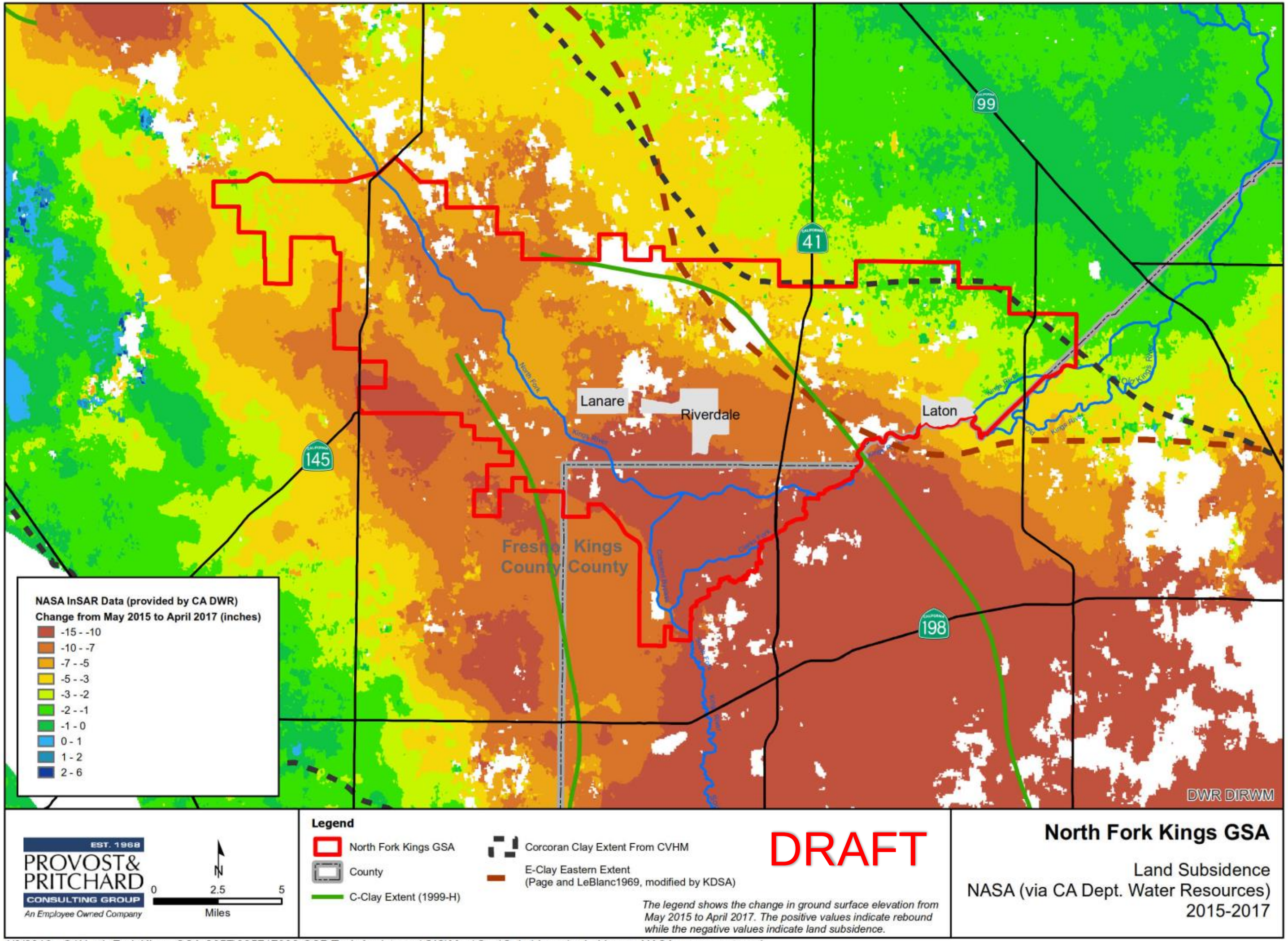
- Line of Equal Depth (feet), Spring 2016

Interconnected Surface Water Review

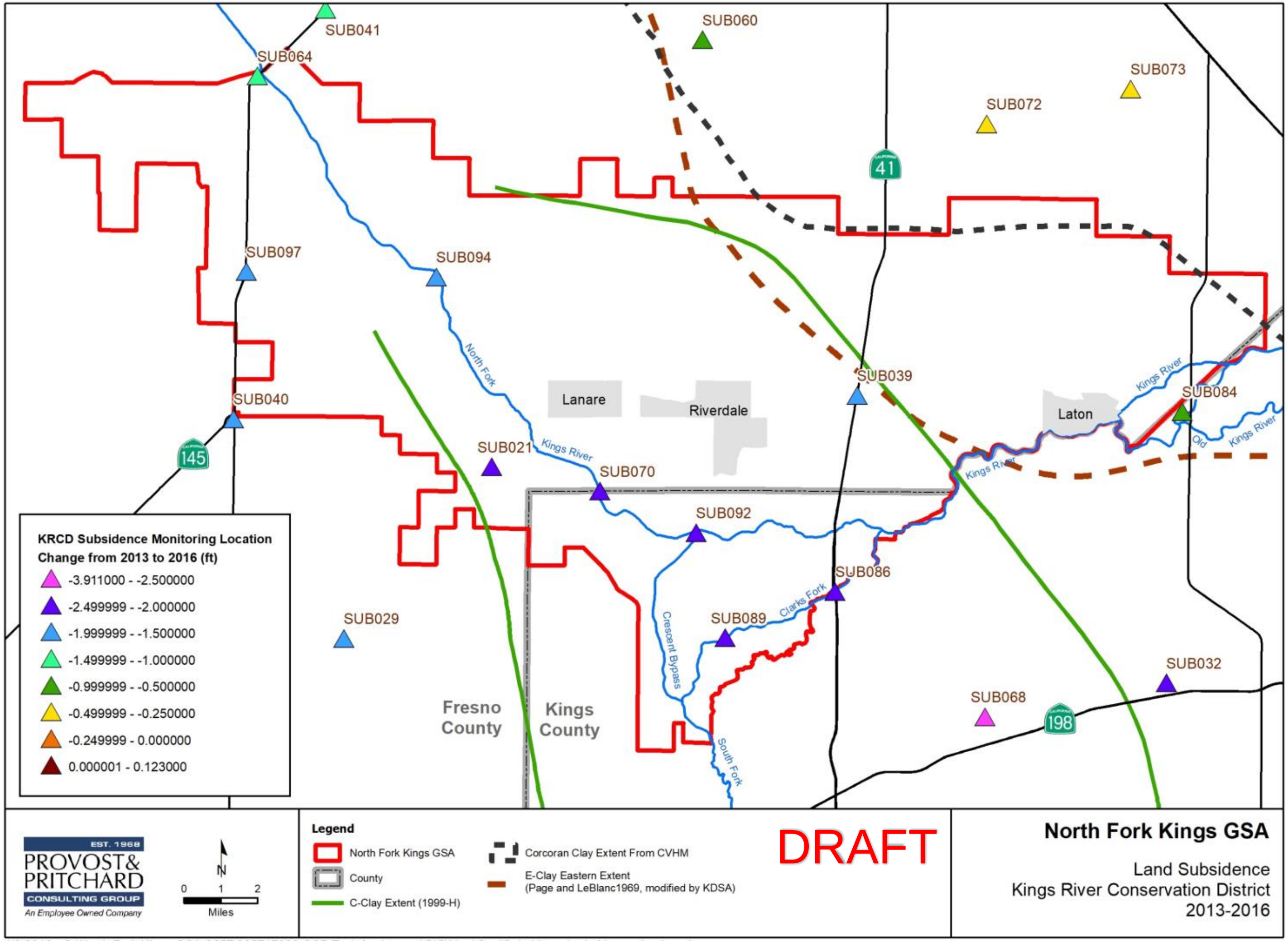
North Fork Kings GSA

DRAFT

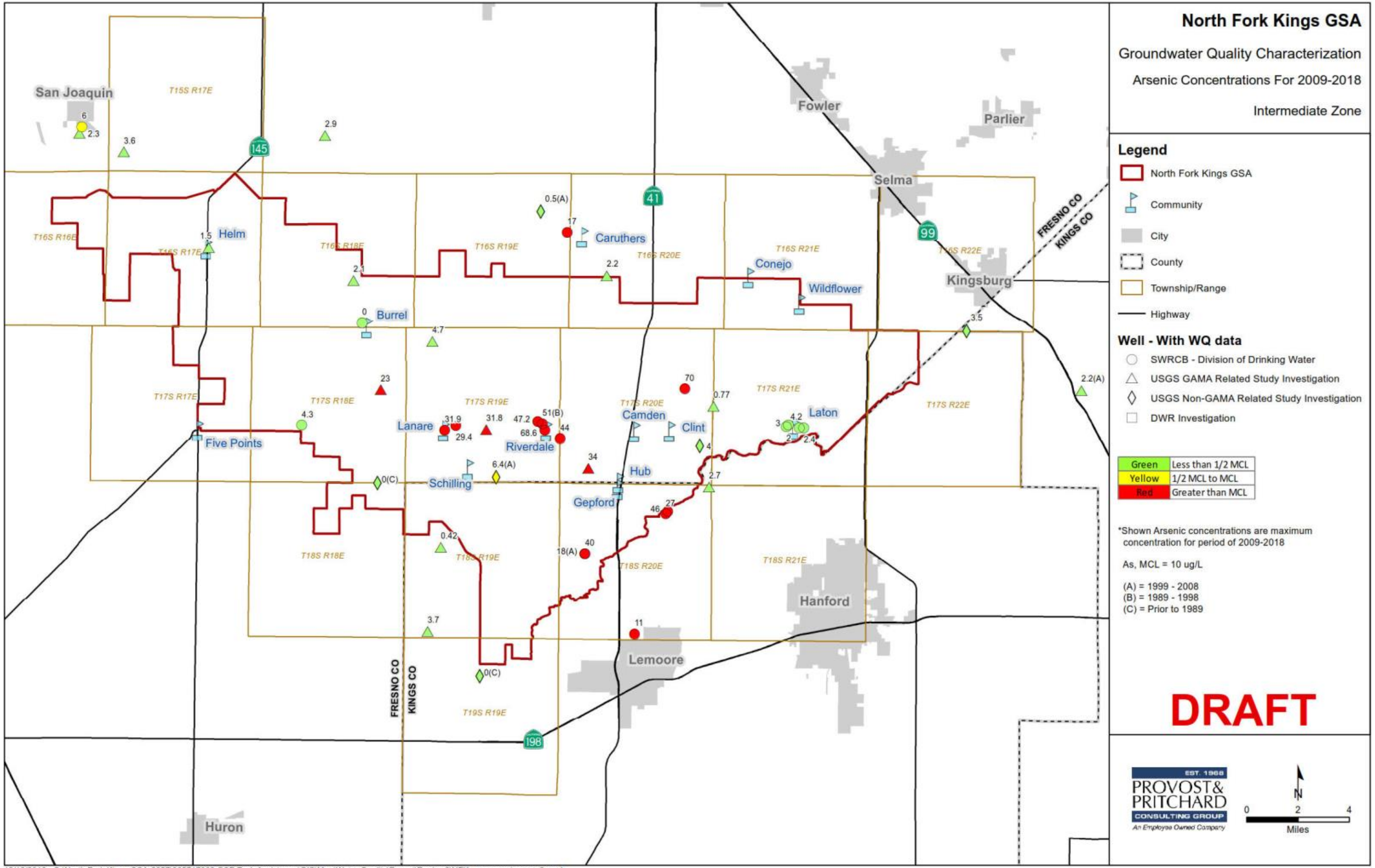
5/20/2019 : G:\North Fork Kings GSA-2657\265717002 GSP Tech Assistance\GIS\Map\GDE\NFK_wetlands_veg v2.mxd



4/9/2019 : G:\North Fork Kings GSA-2657\265717002 GSP Tech Assistance\GIS\Map\Gen\Subsidence\subsidence_NASA_zoom_out.mxd

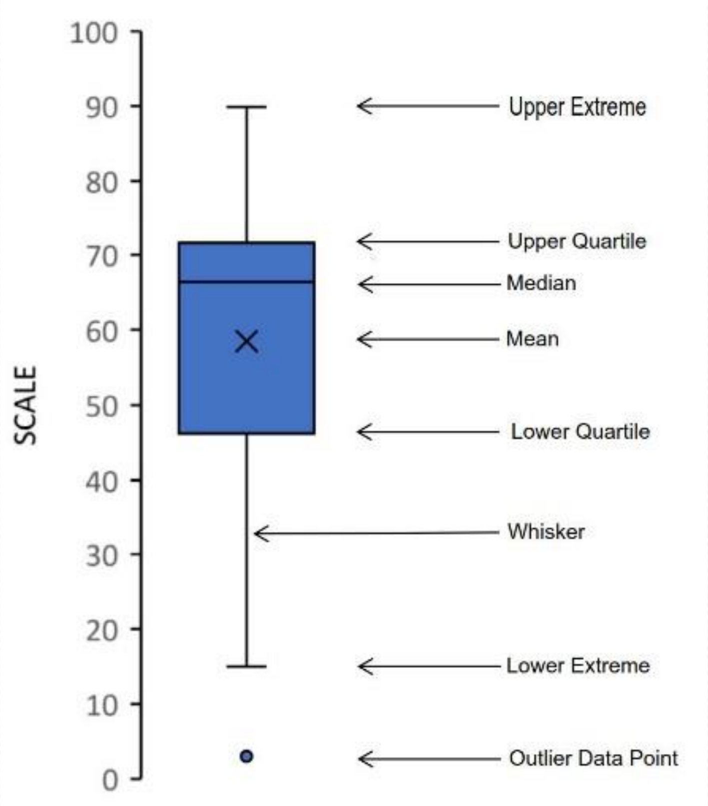


4/9/2019 : G:\North Fork Kings GSA-2657\265717002 GSP Tech Assistance\GIS\Map\Gen\Subsidence\subsidence_krcd.mxd

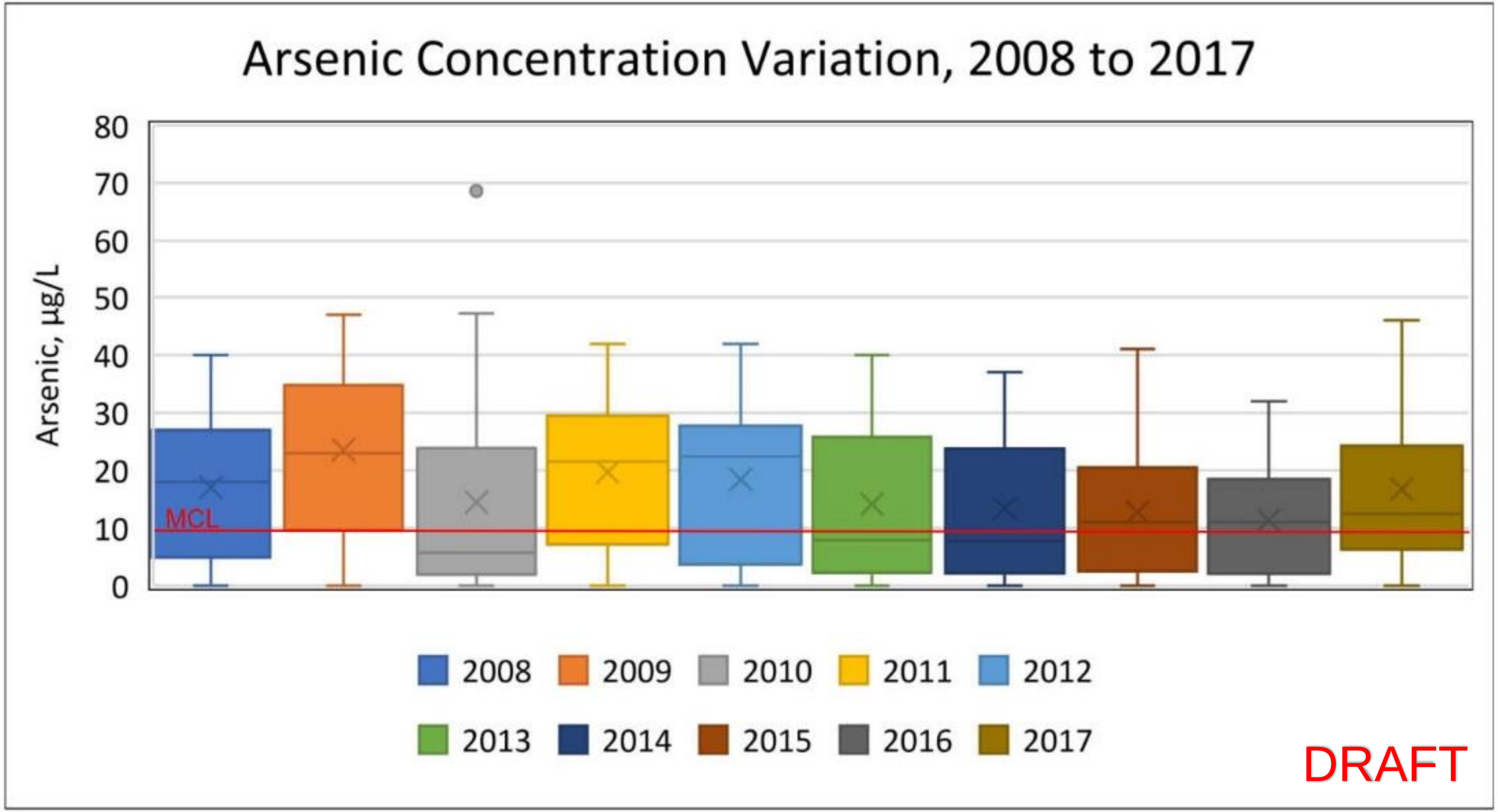


12/16/2018 : G:\North Fork Kings GSA-2657\265717002 GSP Tech Assistance\GIS\Map\Water Quality\Report\Review2\NFK_wq_arsenic_zone2.mxd

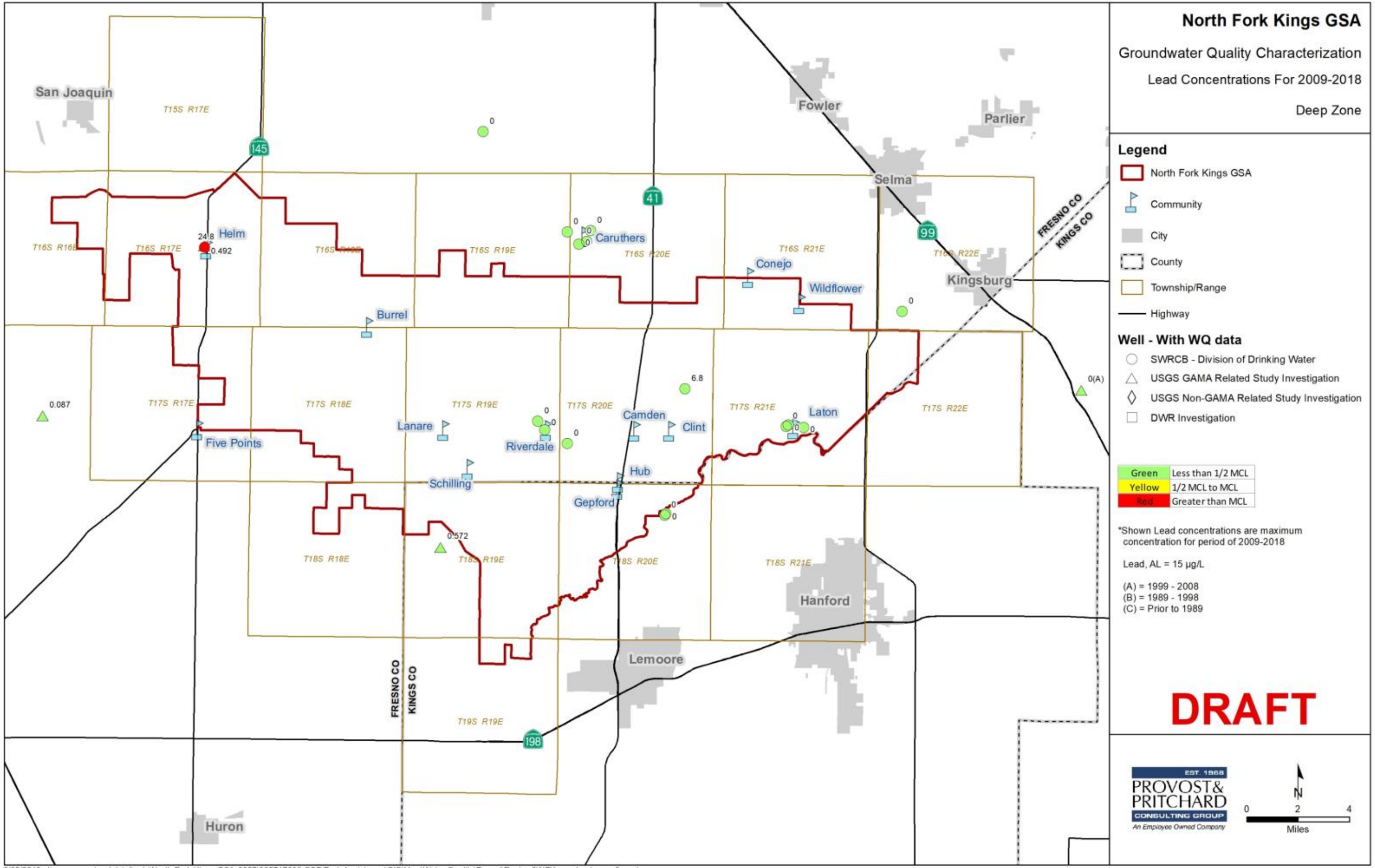
Box and Whisker Plots



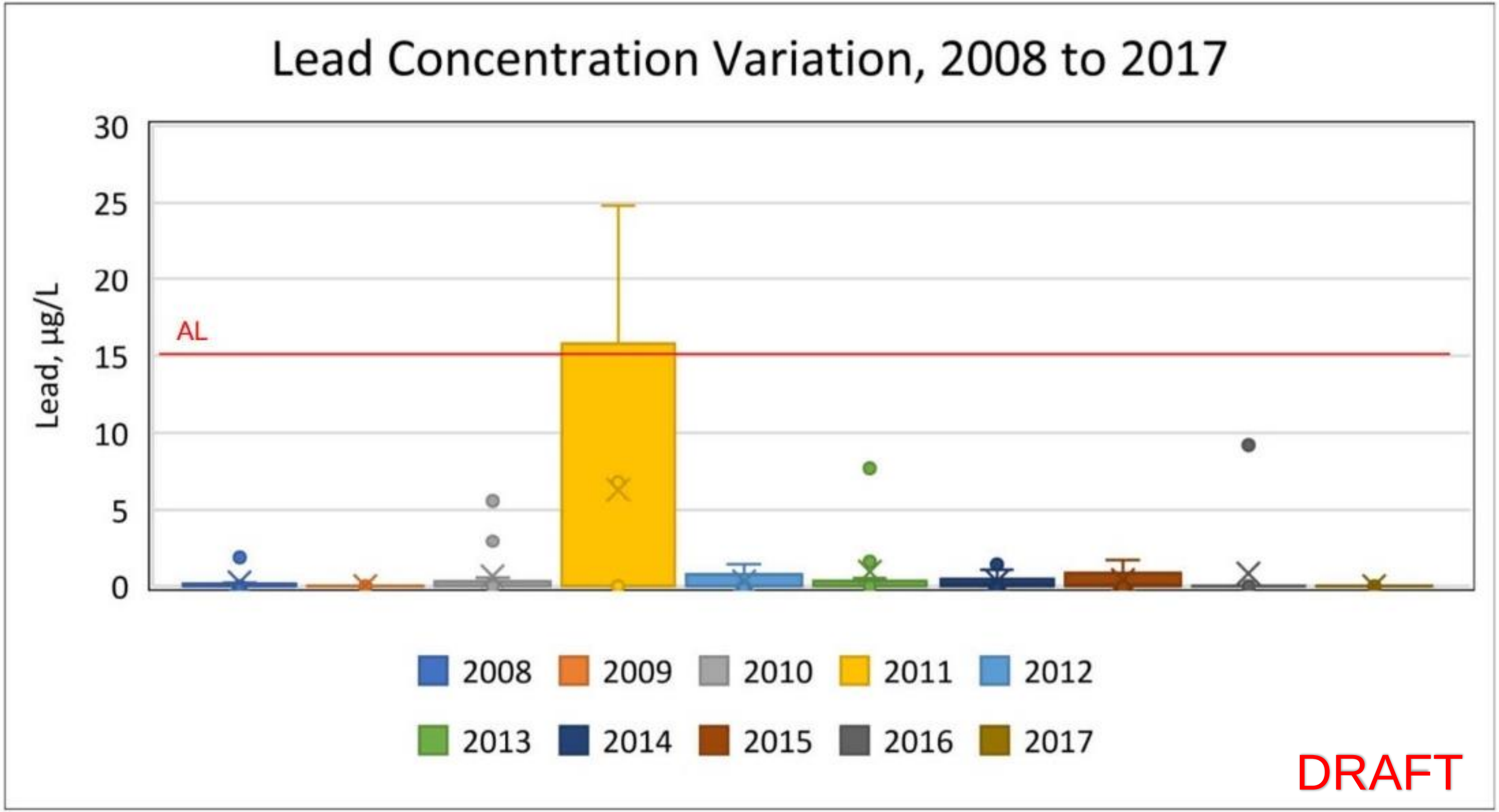
- The box portion of the plot shows the upper and lower quartiles and represent the likely variation of the data set. The difference between the upper and lower quartile values is known as the inter-quartile range. The mean value of a data set is the sum of all the data point values divided by the number of data points in the set. This value is shown as an "X' in the plot. The median value is the value of the data point in the middle of a data set that has been sorted sequentially from smallest to largest. The upper extreme and the lower extreme are called the whiskers.



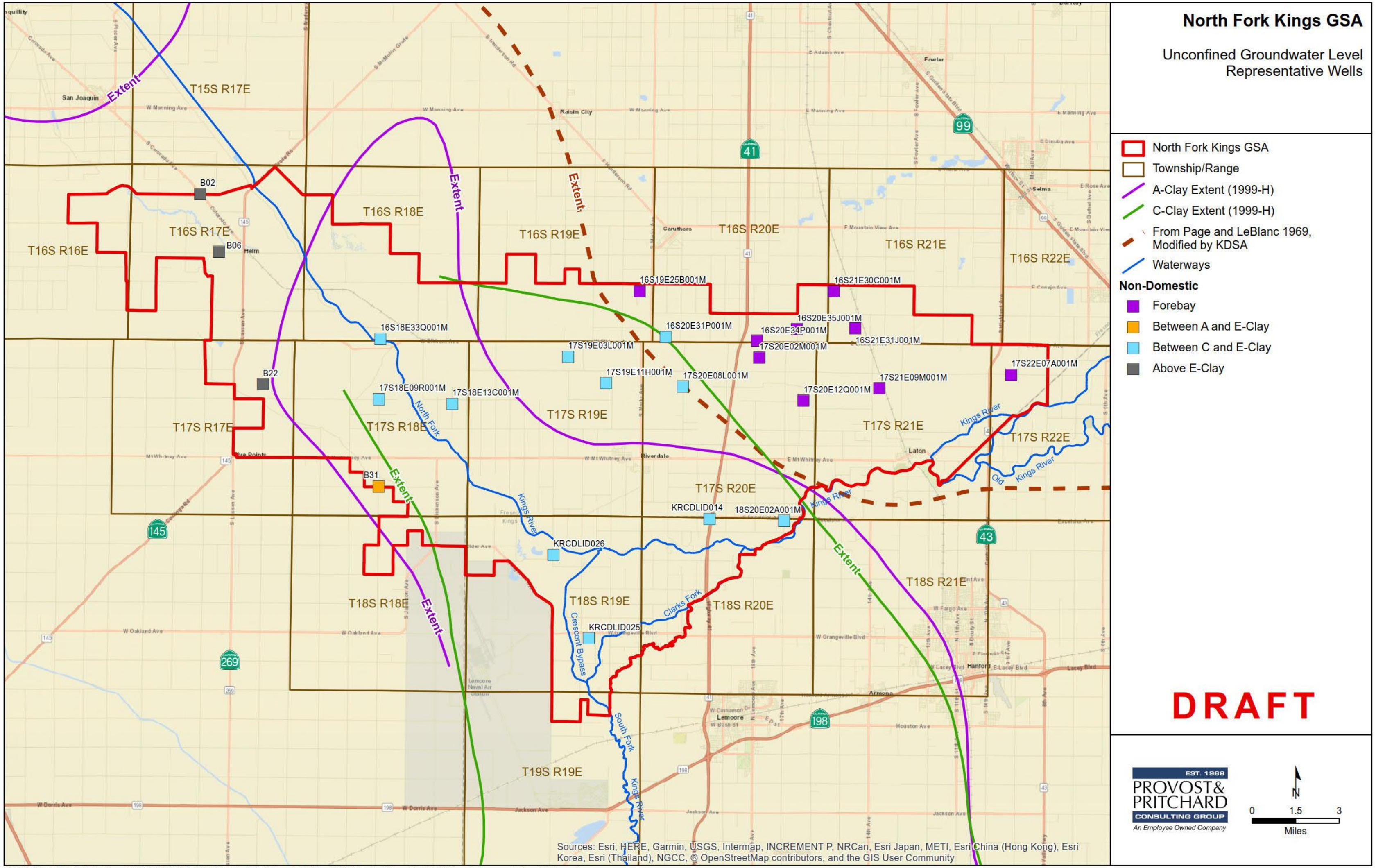
This may suggest lowering of groundwater levels may not impart a significant change in arsenic levels but may give cause for elevated concern if water within the areas of lower concentrations is withdrawn.



2/25/2019 : \\ppeng.com\pzdata\clients\North Fork Kings GSA-2657\265717002 GSP Tech Assistance\GIS\Map\Water Quality\Report\Review2\NFK_wq_lead_zone3.mxd

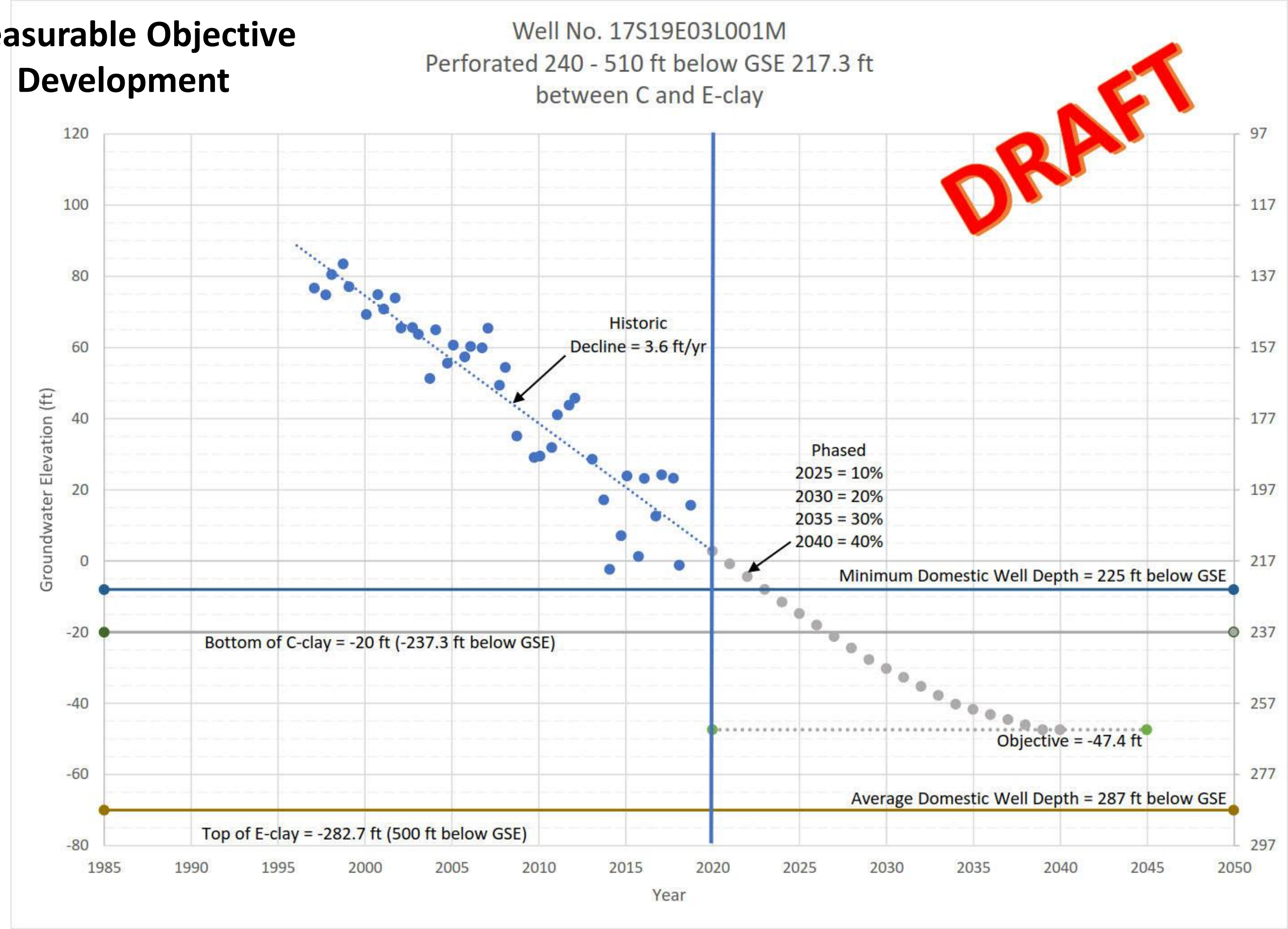


The 2011 spike in concentration is attributed to a single elevated data point which is not considered reliable as subsequent samples did not have detections of lead for this particular well. Change in concentrations relative to time show slight variation, and overall shows the Plan Area is well below the AL for Lead

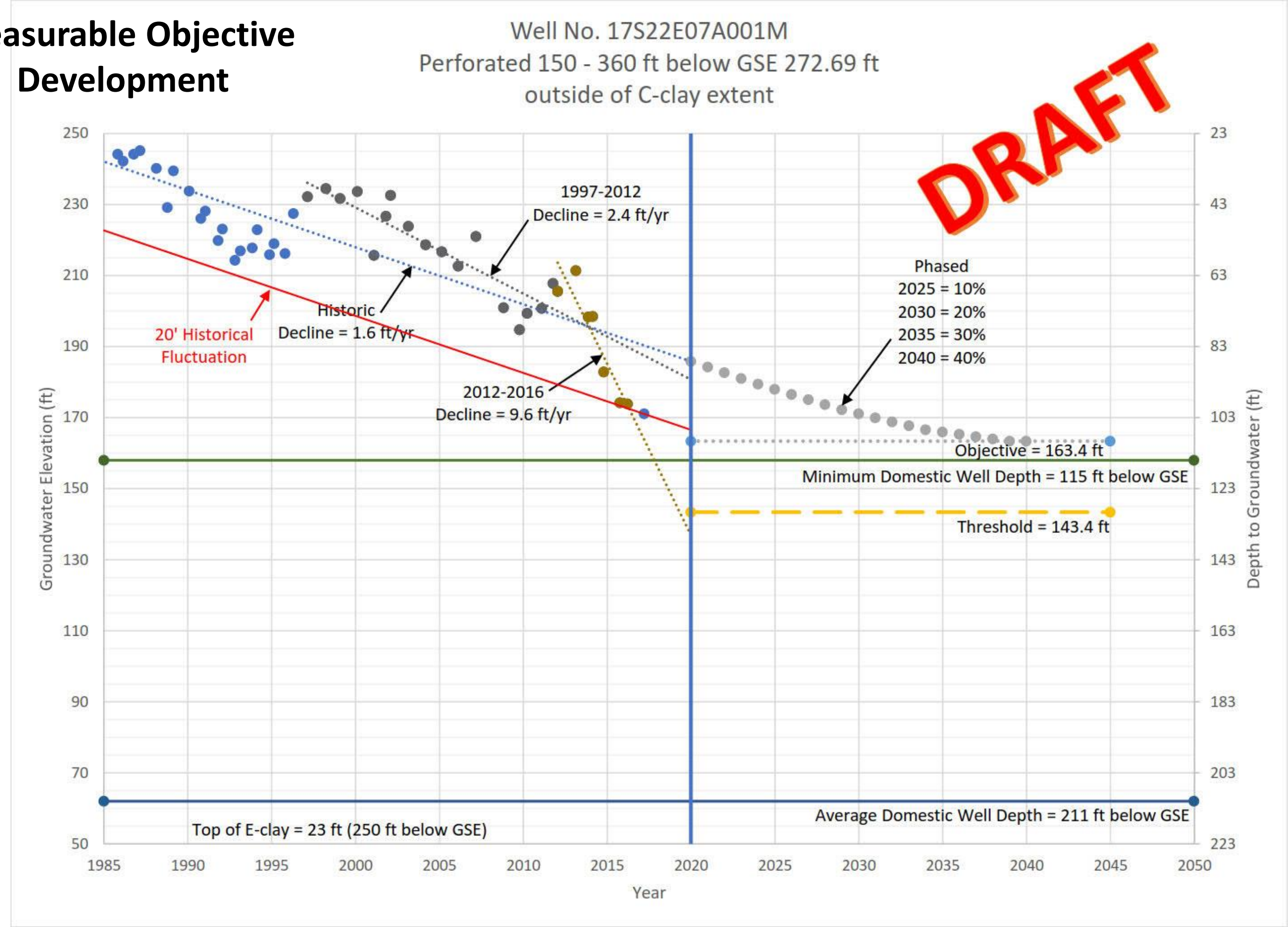


5/22/2019 : G:\North Fork Kings GSA-2657\265717002 GSP Tech Assistance\GIS\Map\Wells\Monitor\Unconfined_GW_Level_Representative_Wells.mxd

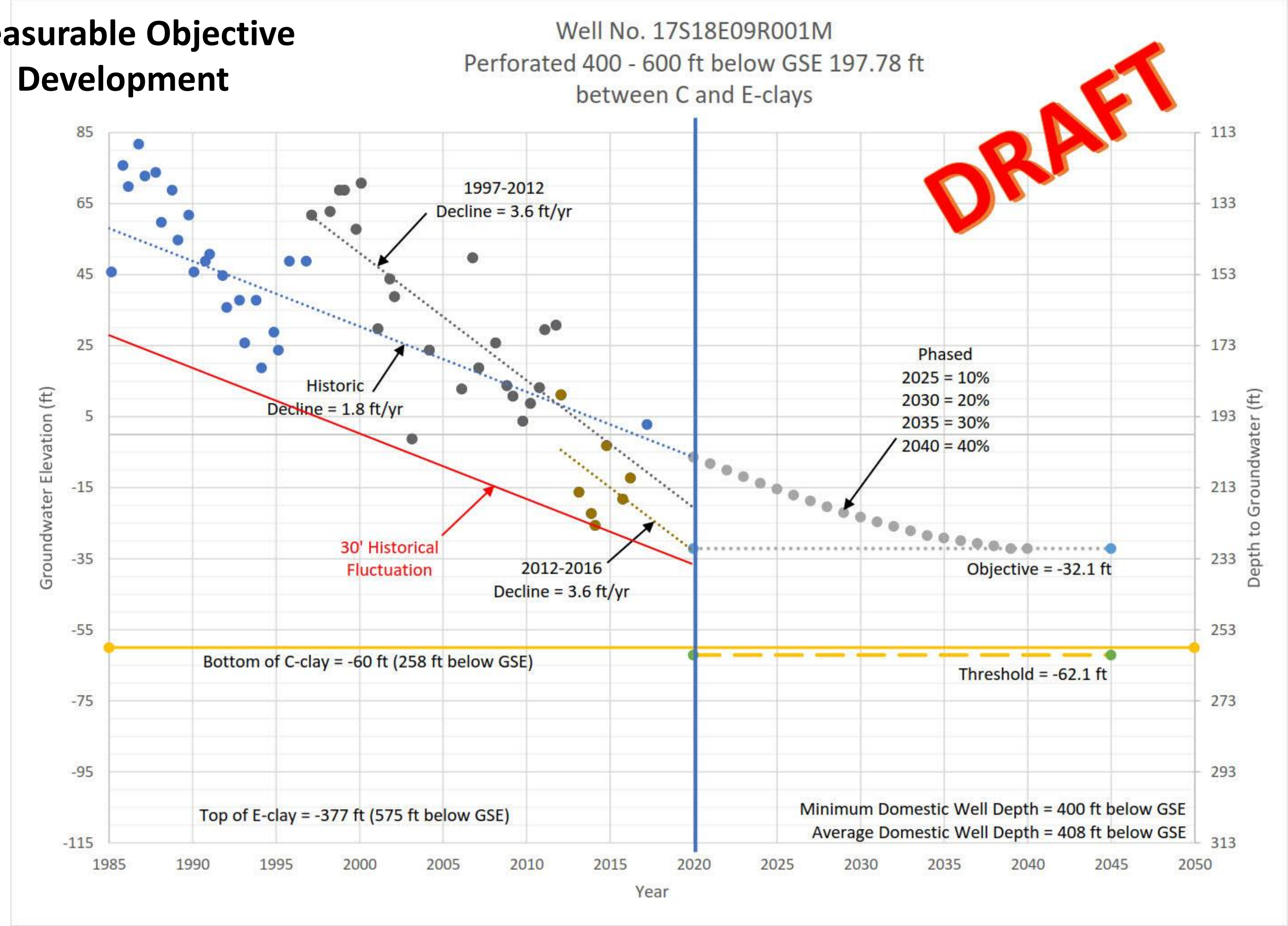
Measurable Objective Development

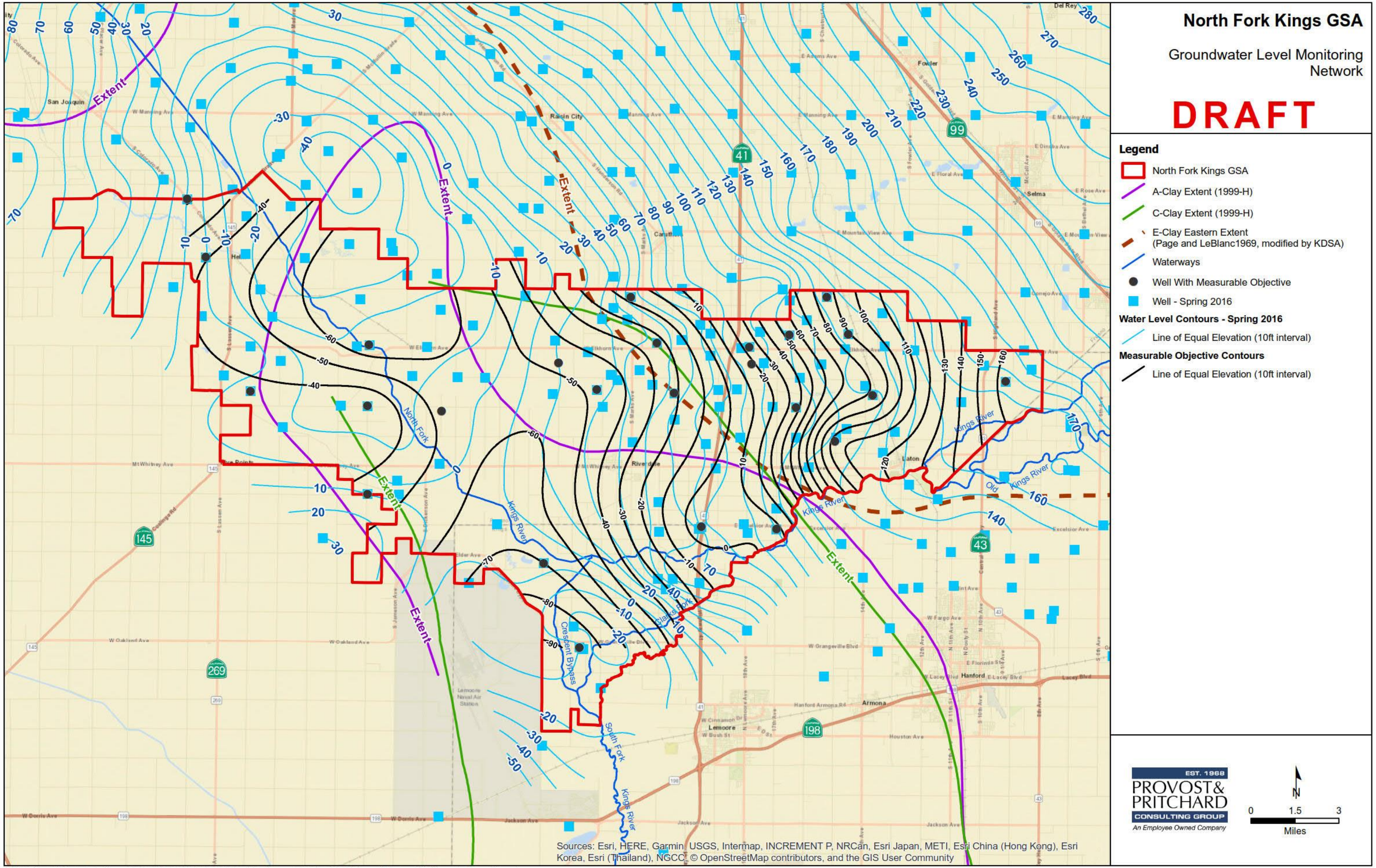


Measurable Objective Development

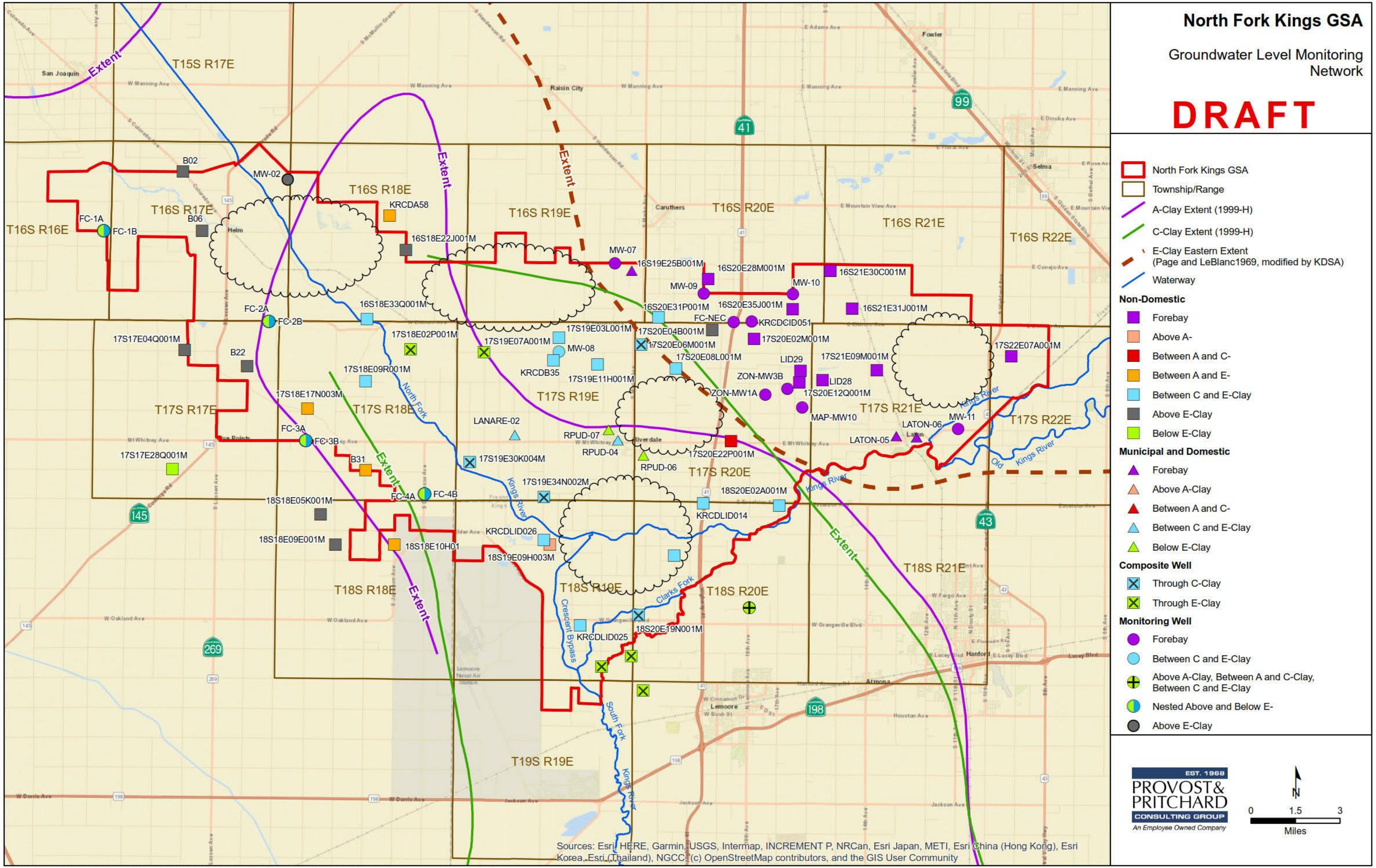


Measurable Objective Development





4/12/2019 : G:\North Fork Kings GSA-2657\265717002 GSP Tech Assistance\GIS\Map\Wells\MeasObjNetwork\NFK_wells_MeasObj.mxd



5/22/2019 : G:\North Fork Kings GSA-2657\265717002 GSP Tech Assistance\GIS\Map\Wells\Monitor\NFK_wells_aquifer_v6_11x17.mxd

Achieving Sustainability

- There are basically only two ways to achieve sustainability and eliminate overdraft:
  - Increase water supply – primarily through project development
  - Reduce water demand – primarily through management actions
- Increasing water supply will be the emphasis, but there are hurdle to overcome
- Preliminary project list continues to be updated and contains recharge projects that would yield an estimated annual average of approx. 50,000 AF/yr based on historic floodwater availability
- The amount of overdraft that can't be overcome with increasing the water supply will need to be overcome with management actions that reduce water demand
- Demand reduction through management actions will likely need to be initiated within 5 - 10 years if project development is not progressing as needed

Continuing efforts after GSP adoption Jan. 2020

1. Improving monitoring networks and filling data gaps
2. Exploration of primary clay layer extents and thickness
3. Method for determining pumping volumes from various aquifers
4. Data management system development
5. Funding mechanisms for project development & implementation
6. Discussion and possible adoption of potential management actions

EST. 1968
PROVOST& PRITCHARD
CONSULTING GROUP
An Employee Owned Company

Questions?