Washington State Department of Health

WUE

Critical Role of Water Level and Pumping Data

for Water Planning and Resource Management

Presented by
Jon Turk, LHG

Aspect CONSULTING

earth + water

Agenda

- Concepts - Water resource planning and management is ***data driven***
- Regulatory Monitoring and Performance Monitoring
- The role of water level and pumping data in regional water supply planning
- Local and regional water level data analyses for management of declining aquifers
- Q&A

Requirements for Groundwater Level Monitoring

- **Group B Rule**
  - Group B systems regulated under Chapter 246-291 WAC, generally exempt from routine ongoing monitoring.
  - System performance monitoring or reactive management approach.
  - Ecology and Health may both establish case-by-case requirements (contamination, water availability)
- **Group A**
  - Reporting requirements for water system planning (246-290-100, and 246-290-105 for small water system management program)
  - 246-290-415 (10): All purveyors utilizing groundwater wells shall monitor water levels from ground level to the static water level on a seasonal basis, including low demand and high demand periods, to document the continuing availability of the source to meet projected long-term demands.

Requirements for Groundwater Level Monitoring

- Applies to Group A and some Group B systems
- Seasonal measurements of static and pumping water levels
- Generally reported within Water System Plans
- Potential for standardized reporting requirements to provide input to statewide water level database

Common reasons *(excuses)* for not monitoring:

- Well is not configured for monitoring
  - No monitoring ports
  - No sounding tubes (or broken tubes)
  - Insufficient space in casing for measurement device
- Need training on best practices or SOPs
- “We have all the infrastructure, but can’t get the devices to communicate, and no one understands our SCADA system.”

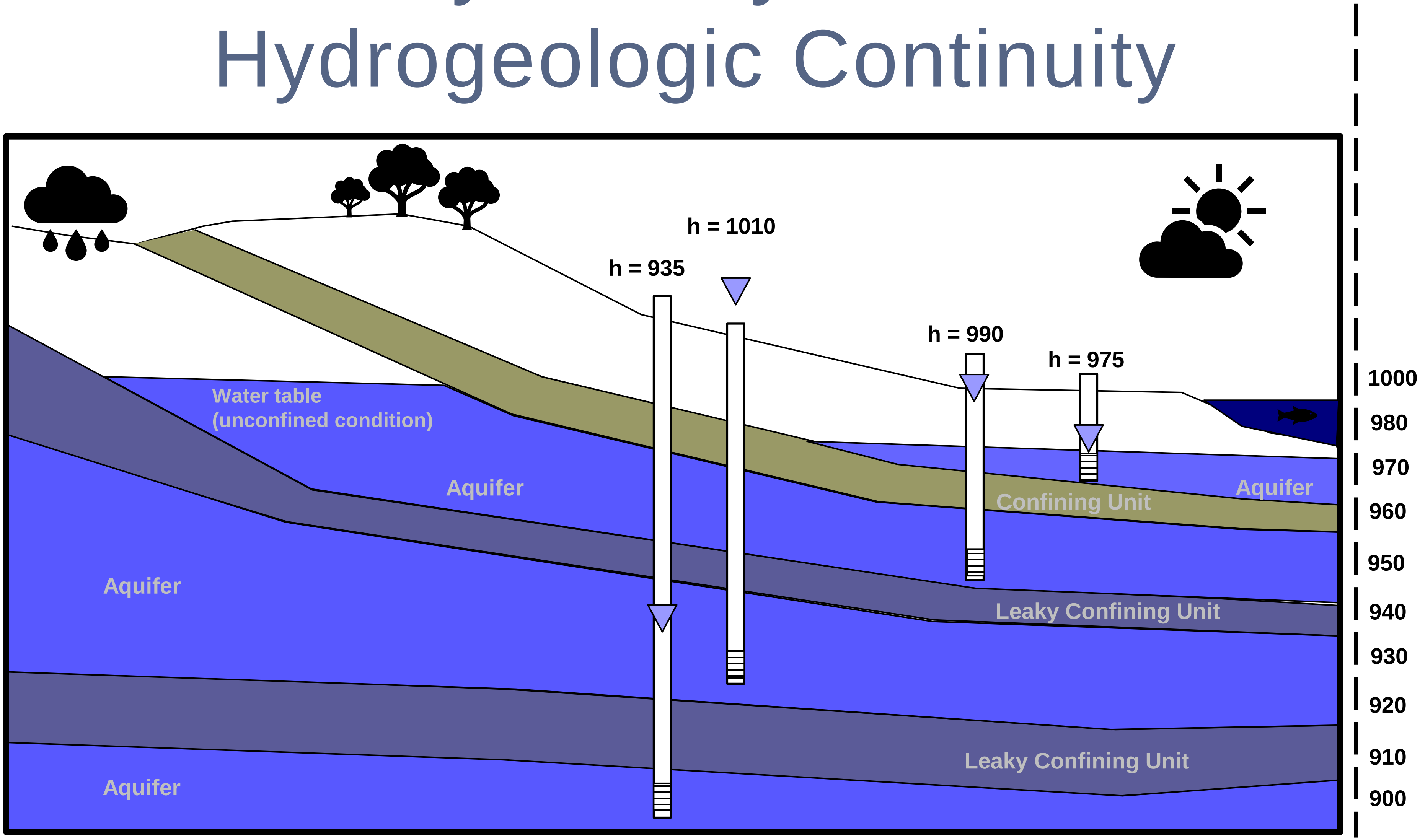
Water Levels - Defined

- **Water level**
  - Depth below (or above) measuring point (can be converted to elevation)
  - Static water level and Pumping water level
  - Drawdown
- **Head**
  - Feet of water above reference point (sometimes as PSI)
  - Elevation head
  - Pressure head (confined aquifers)
  - Total dynamic head (pumping systems)

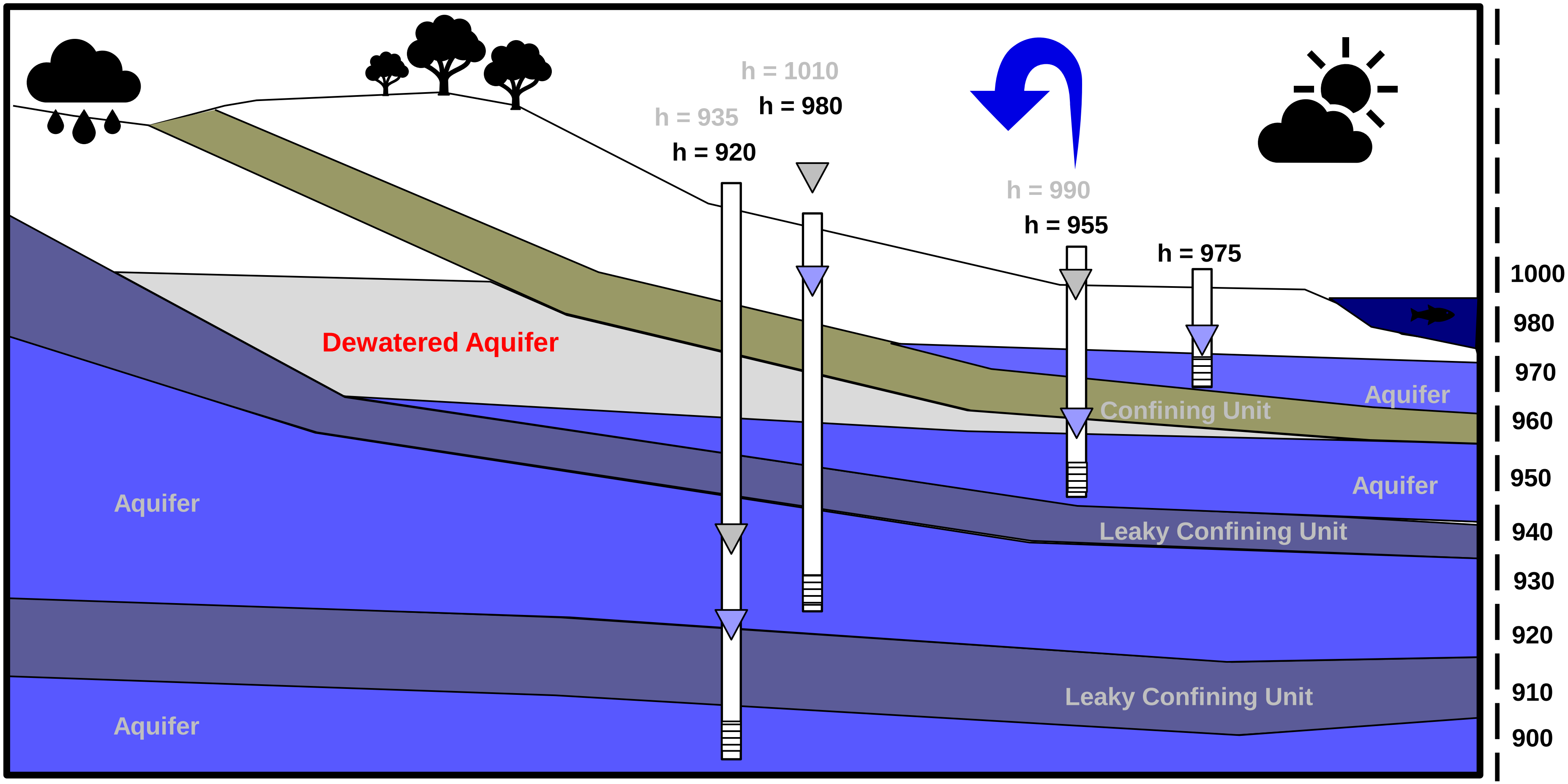
Aquifer Types

- **Unconfined Aquifers** are generally shallow; the water table functions as the upper boundary.
  - **Perched Aquifers** are unconfined, but form as lenses on top of lower permeability deposits, laterally discontinuous.
- **Confined Aquifers** are bounded by low-permeability deposits, occur at depths, water levels are usually above the upper confining unit.
  - **Artesian Aquifers** are confined aquifers where the aquifer pressure produces head in excess of the ground surface

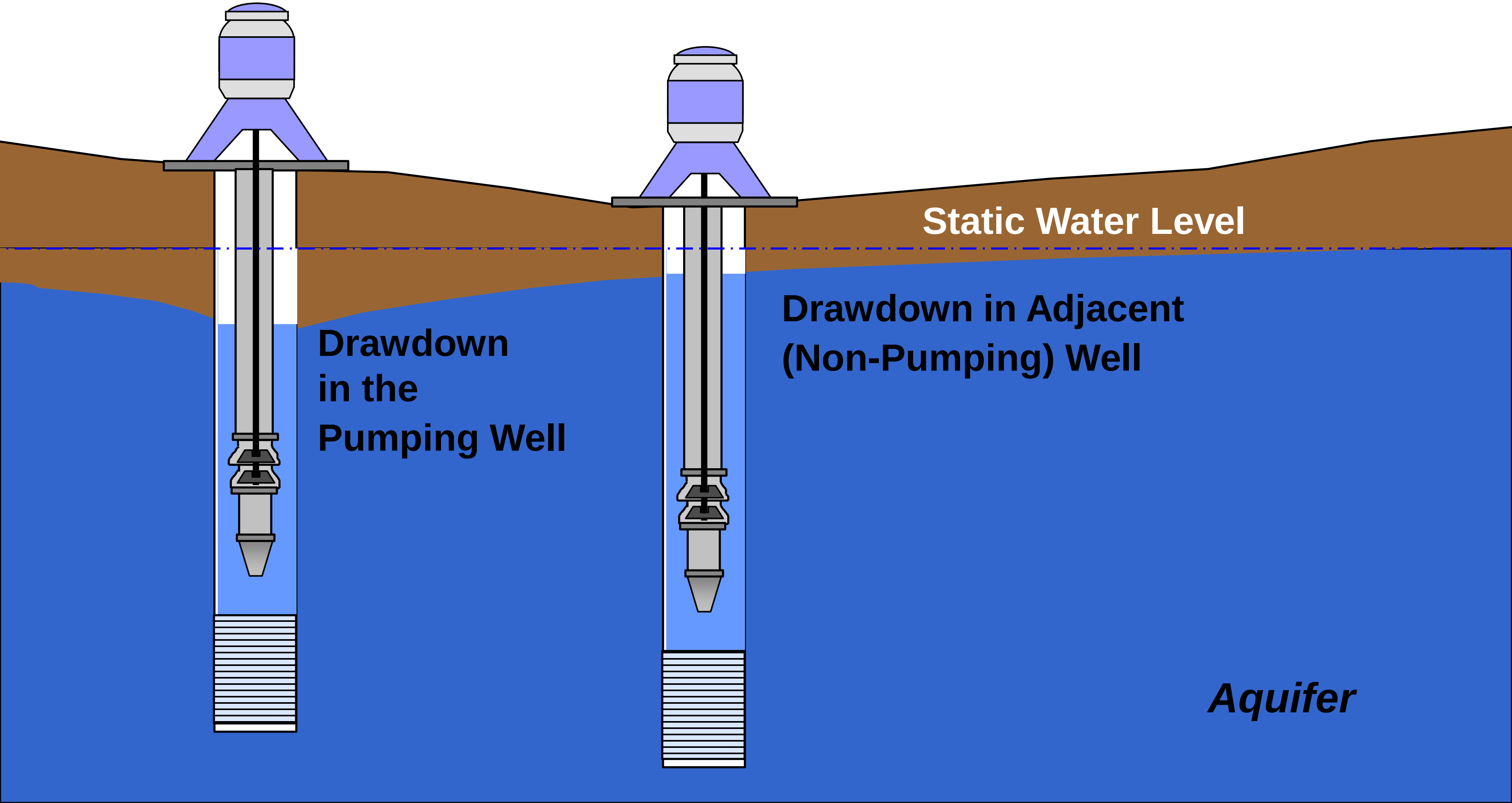
Multilayered Systems and Hydrogeologic Continuity



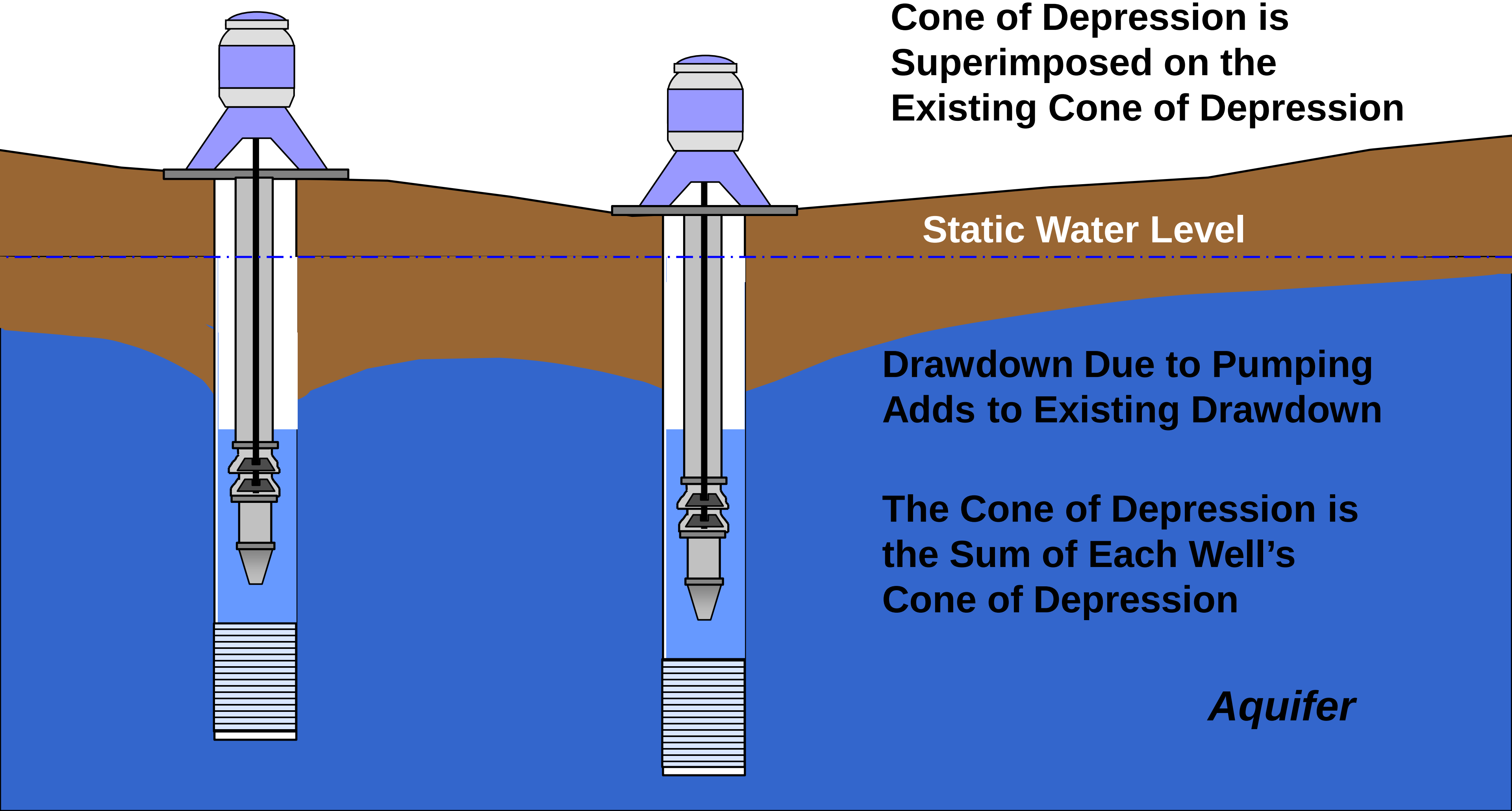
Pumping can Change Aquifer Conditions



Well Interference and Water Level Measurements



Well Interference and Water Level Measurements



Static Water Level ≈ Non-Pumping Water Level

- Pump cycling: Some pumps run more frequently than others. Aquifer water level recovery not always fully achieved.
  - **Recommendation**: Record static water level at a point just prior to turning on the pump.
  - Consider other nearby wells and pumping influence.
- Recovery of water levels from pumping can take hours to weeks before a true “static level” or new equilibrium is achieved from non-pumping conditions.
- Generally (but not always), 24-hours of non-pumping results in substantial recovery.

Dynamic or Pumping Water Level

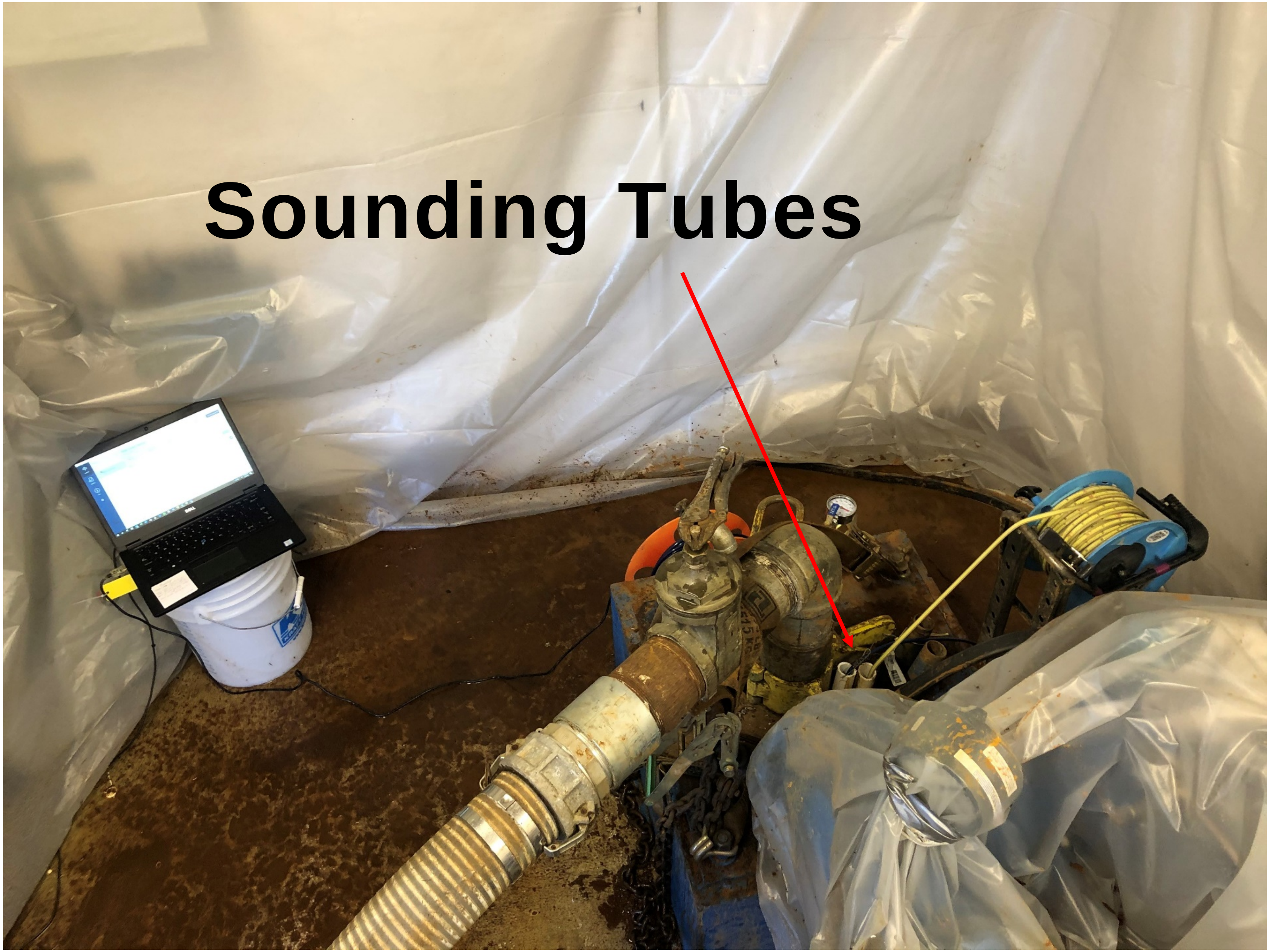
- Measure of the maximum amount of drawdown induced from pumping.
- Collected just prior to pump shut down.
- Seasonal water level fluctuations – generally the late summer to fall season exhibits seasonal low water levels.

Why Monitor?

- System data informs management decisions
- Data assists with asset management and budgeting
- Prolongs asset life cycle
- Establishes routine maintenance requirements
- Predicts and plans for repairs and replacements
- Knowing when and why maintenance is needed

Water Levels - Measurement

- **Transducer** – Preferred option, high resolution data, digital records
- **Air line** – Low-cost option, analog measurements
- **E-tape** – The old faithful method
- **Sonic** – Quick, and works when too deep for an e-tape, or risk to down-hole equipment is high


Sounding Tubes

Transducers

- Vented/non-vented cables and barometric influence
- Data storage and transfer, manual download from internal memory, or integrated with SCADA system
- Calibration and maintenance
- Permanent versus temporary deployment

Transducers

Airlines

- Lower cost than transducer, unless you need to buy a compressor
- Much easier than extra-long e-tapes
- Analog/manual measurements for deep water levels
- Life cycle, breakage, maintenance

E-tapes

- Reliable
- Common and versatile
- Simple to use
- Can be challenging for deep water levels
- Manual/analog measurements

Sonic Meters

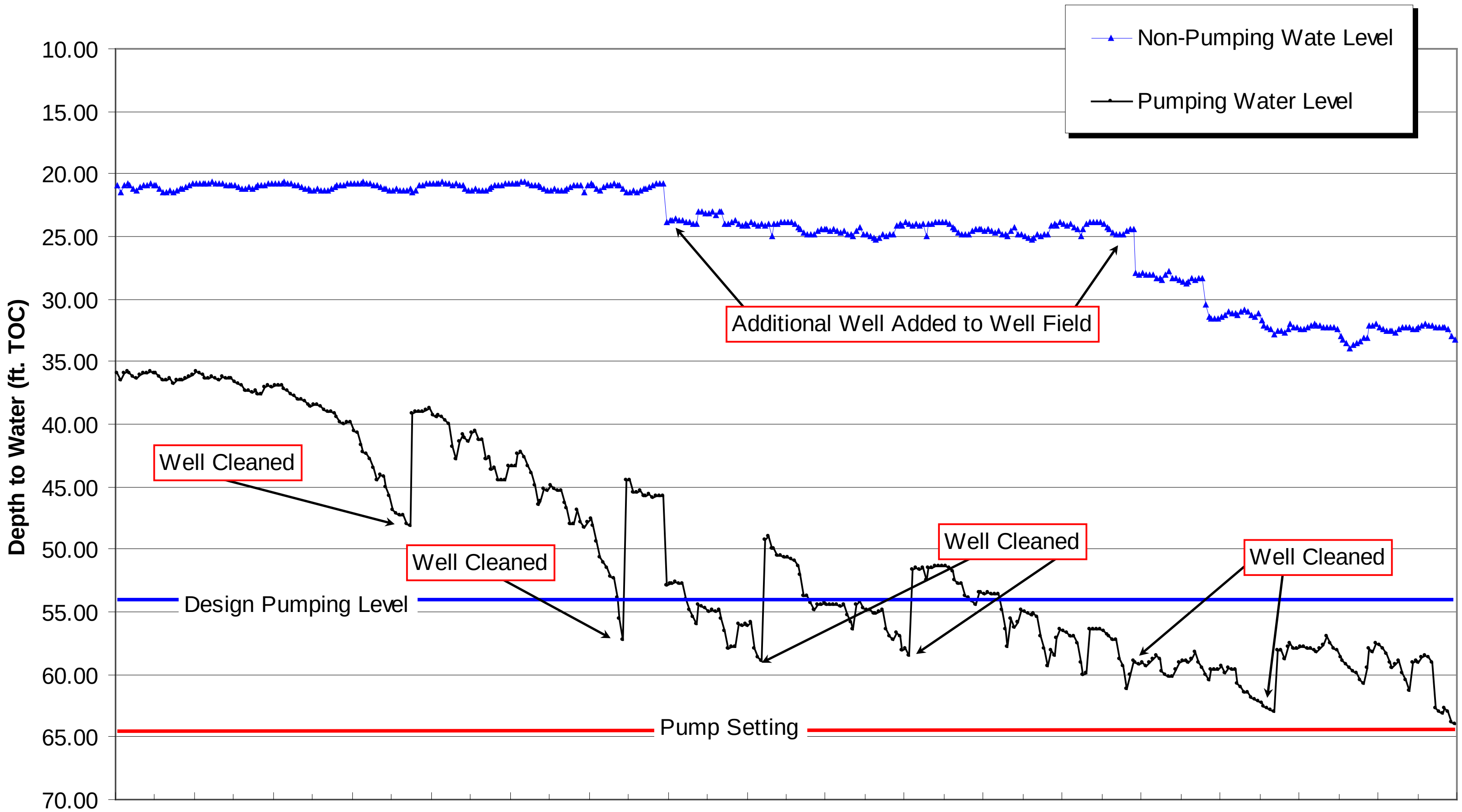
- Quick and easy
- Deep, >1000 ft measurement capability in seconds
- Nothing but sound goes down the hole
- Manual/analog spot measurements
- Temperature sensitive
- Interference issues

Monitoring during performance testing

Water Level Measurement References

- Manual Well Depth and Depth to Water Measurements, Standard Operating Procedure EAP052, Version 1.2 (2018)
- Use of Submersible Pressure Transducers During Groundwater Studies, Standard Operating Procedure EAP074, Version 1.2 (2019)
- Measuring Water Levels by use of an Air Line, USGS GWPD 13, Groundwater Technical Procedures of the U.S. Geological Survey (2010)
- AWWA Standard for Water Wells A100-84

Wellfield Performance Monitoring



~30-year life cycle of well

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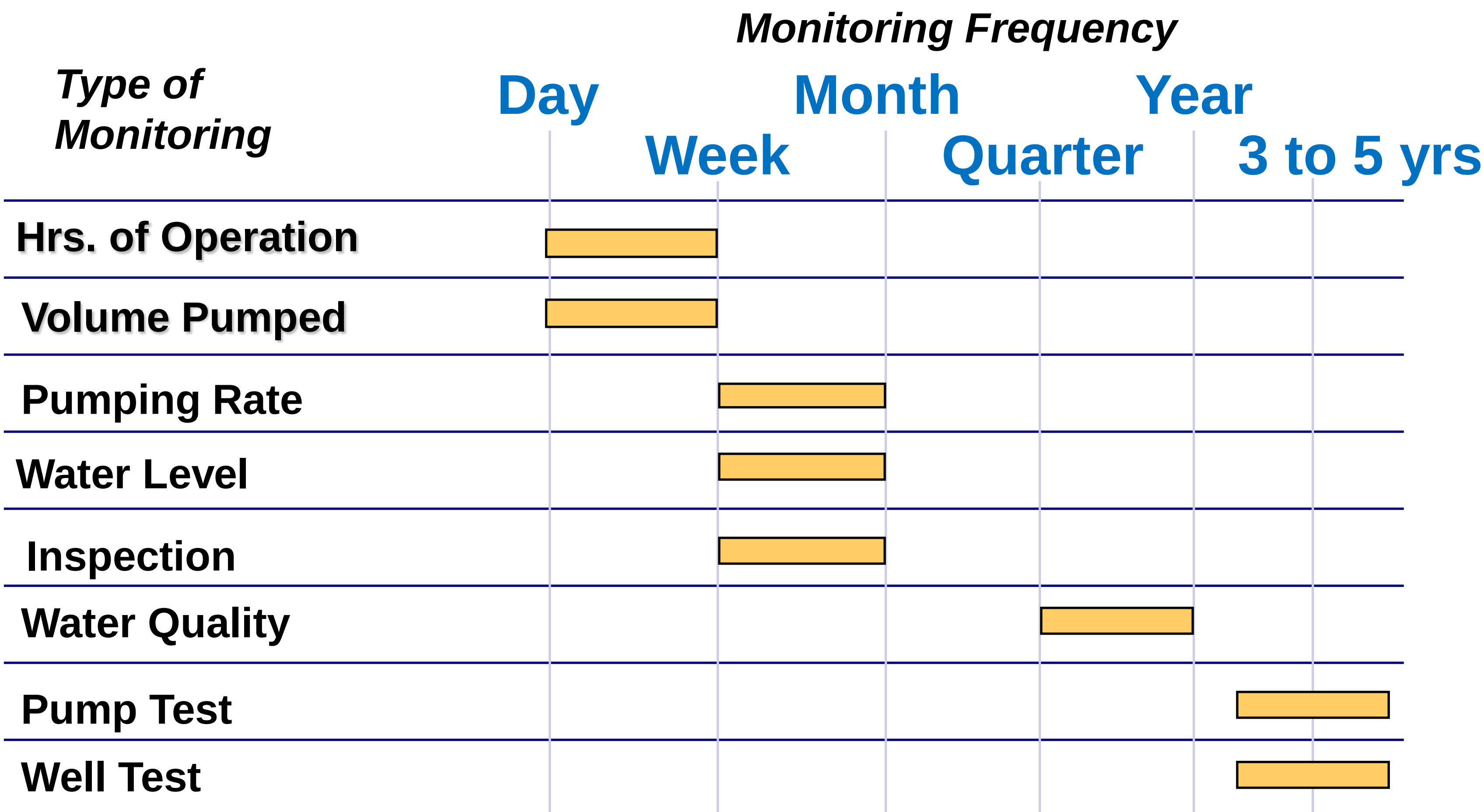
System Performance Monitoring and Testing

High Frequency

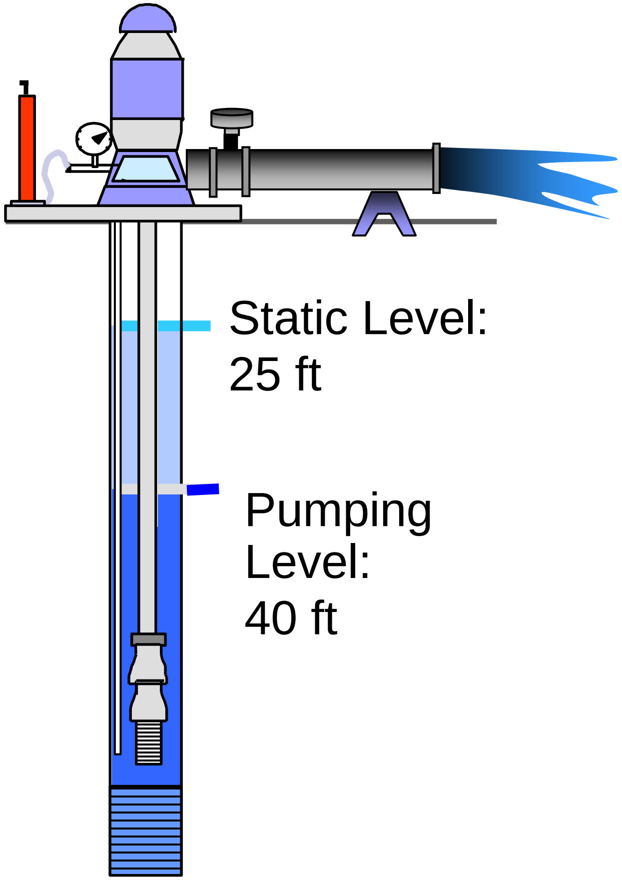
Low Frequency

- Water Level Collection and Flow Metering
- Water Quality testing
- Specific capacity testing/monitoring
- Pump test/wire-to-water
- Constant rate testing

Developing a Wellfield Performance Monitoring Program



Wellfield Performance Testing



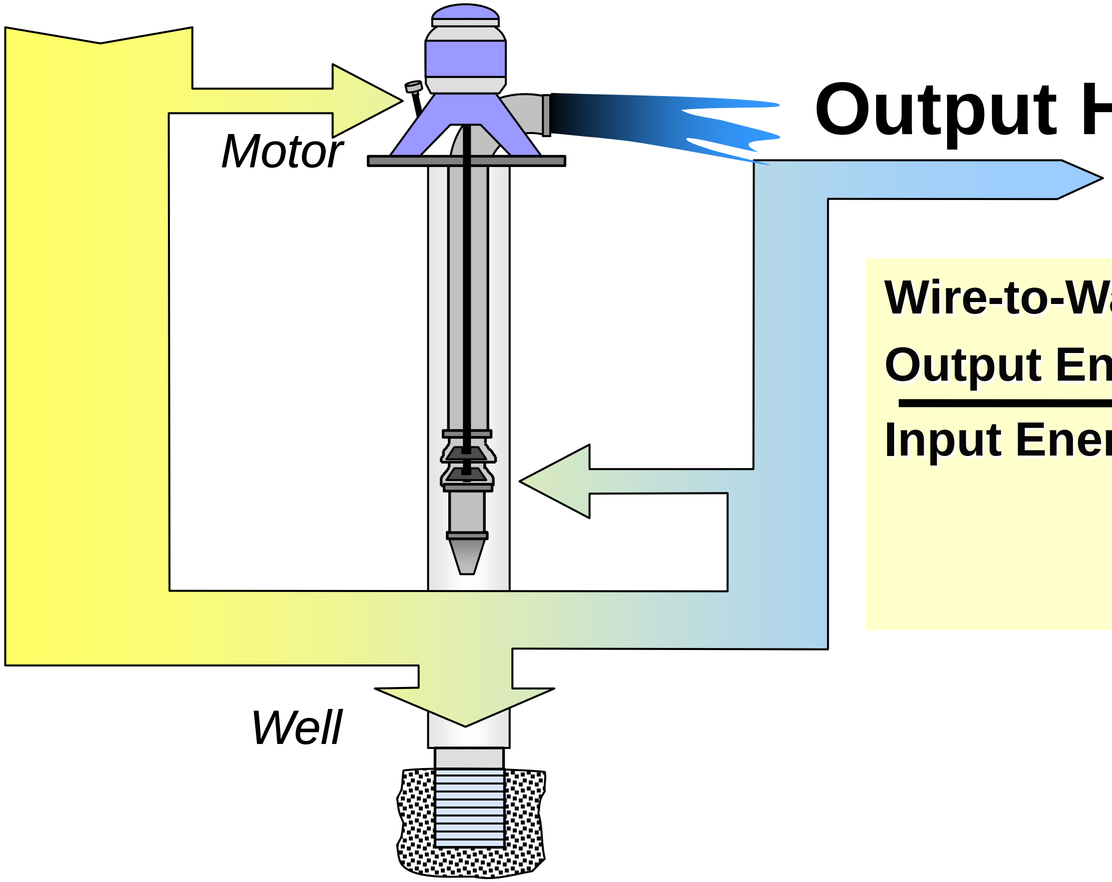
Drawdown (s) = Pumping level (40') – Static Level (25') = 15 feet

Pumping Rate (Q) = 450 gpm

Specific Capacity (S_c) = Q/s = 450 gpm / 15 feet = 30 gpm / ft

Wellfield Performance Testing

Input Electrical Energy

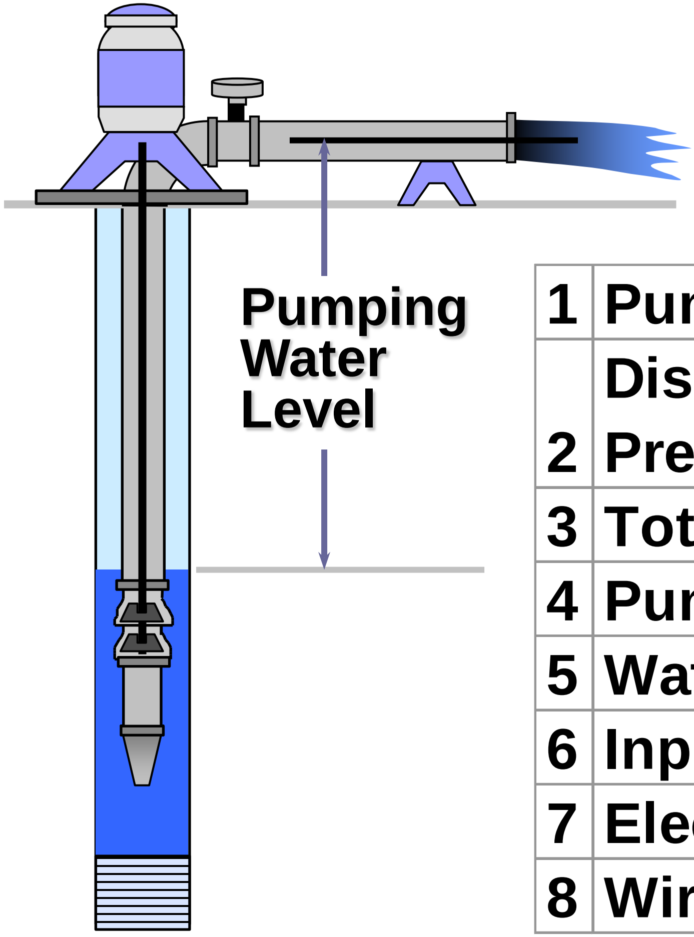


Output Hydraulic Energy

Wire-to-Water Efficiency(%) =

$$\frac{\text{Output Energy (Hp)}}{\text{Input Energy (Hp)}} \times 100$$

Wellfield Performance Testing



1	Pumping Water Level (feet)	65.7
2	Discharge Head, Discharge Pressure x 2.31 (feet)	127
3	Total Head, (feet) [1 + 2]	192.7
4	Pumping Rate (gpm)	1685
5	Water HP [3 x 4 / 3960]	82.0
6	Input to Motor (kiloWatts)	97.9
7	Electrical HP [6 / 0.746]	131.2
8	Wire-to-Water Efficiency [5 /7]	62.5%

Data Management

Amps

Well Construction

Water Level Trends

Head

Pumping Level

Horse Power

Water Quality

Non-Pumping Level

Specific Capacity

Discharge Rate

Aquifer Testing

Water Level and Pumping Data Inform Long-Range Planning and Water Rights

- Consumptive Uses
  - How do we quantify the effects of consumptive use?
- In-Stream Flows
  - Over appropriated?
  - Seasonal supplies available?
- Aquifer Storage Properties (Storage)

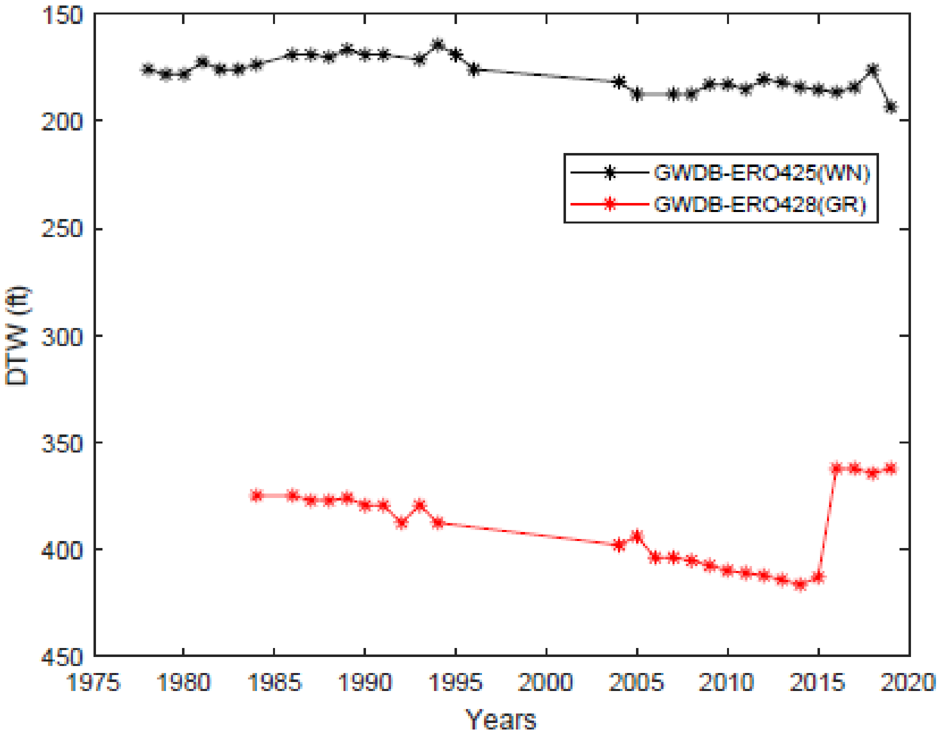
Declining Aquifer Levels

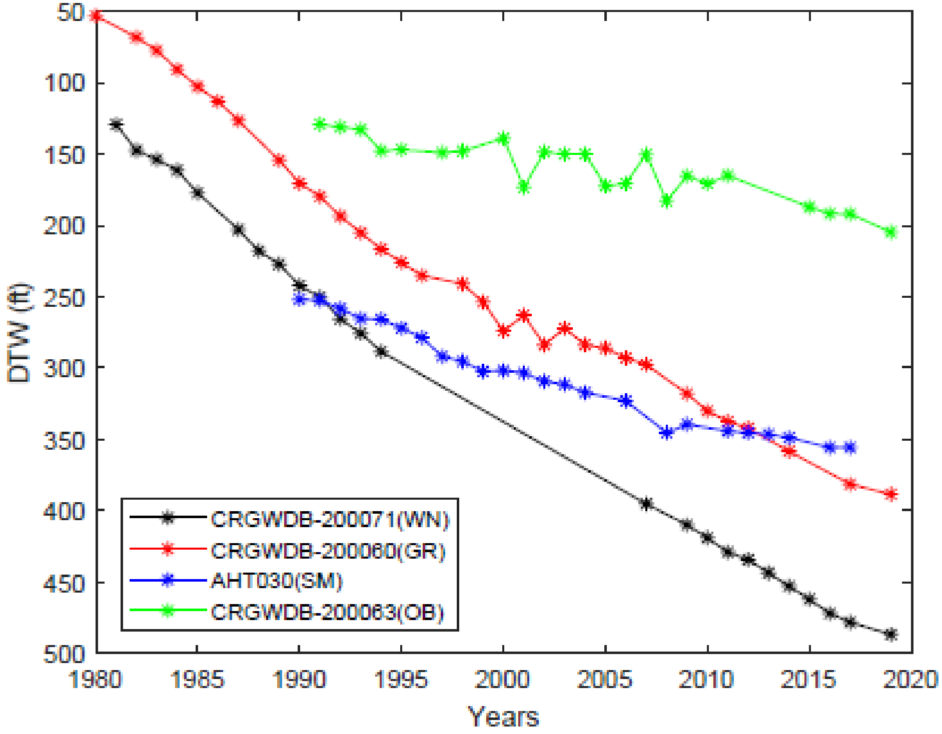
- Groundwater mining – groundwater pumping outpaces aquifer recharge
- Diversions from recharge zones
- Geologic change

- NOT increased drawdown in a deteriorating pumping well (decrease in well efficiency)
- NOT incremental drawdown as new points of withdrawal come online (drawdown interference)

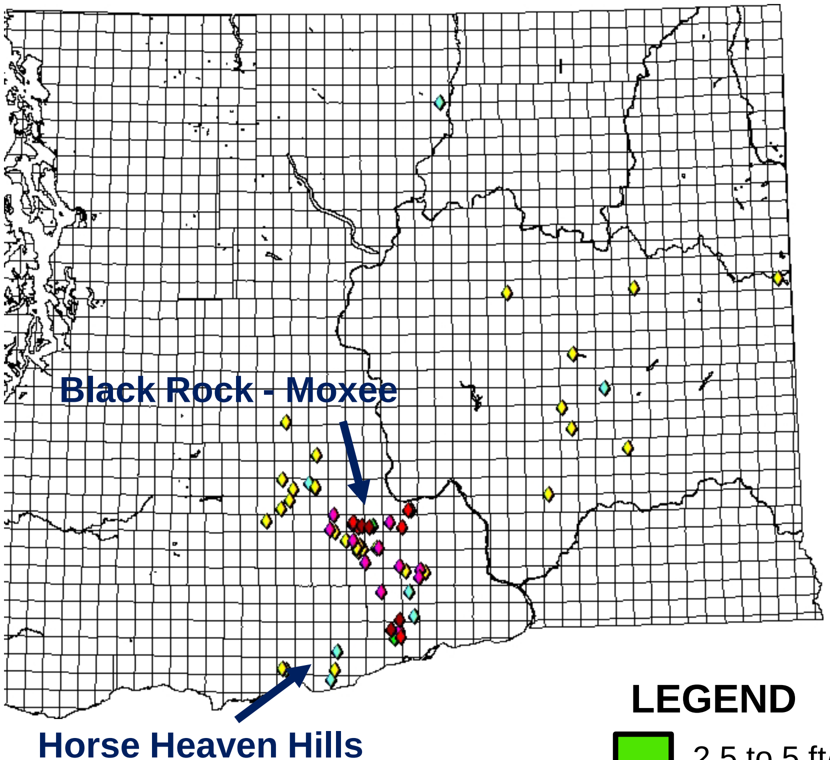
- More that a dozen aquifers in Washington have documented declining water levels from overdraft conditions
- May result in up-coning of lower quality water, or saltwater intrusion
- Basin subsidence

Assessing Aquifer Interactions and Trends

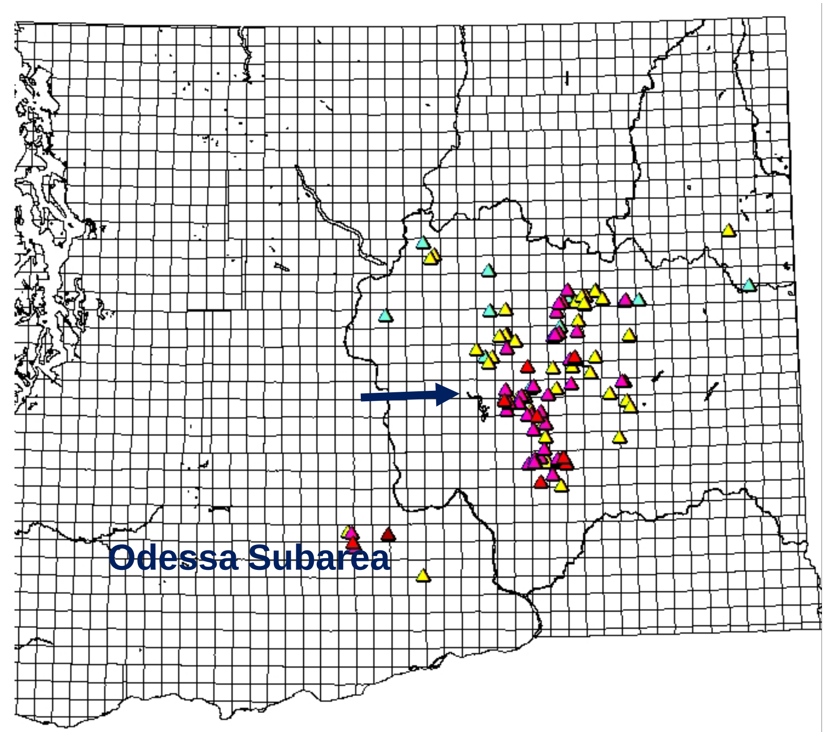




WANAPUM



GRAND RONDE



LEGEND

- 2.5 to 5 ft/yr
- 0 to 2.5 ft/yr
- -2.5 to 0 ft/yr
- -5 to -2.5 ft/yr
- -7.5 to -5 ft/yr
- townships

Aquifer Water Budget: Inflow - Outflow = Change in Storage

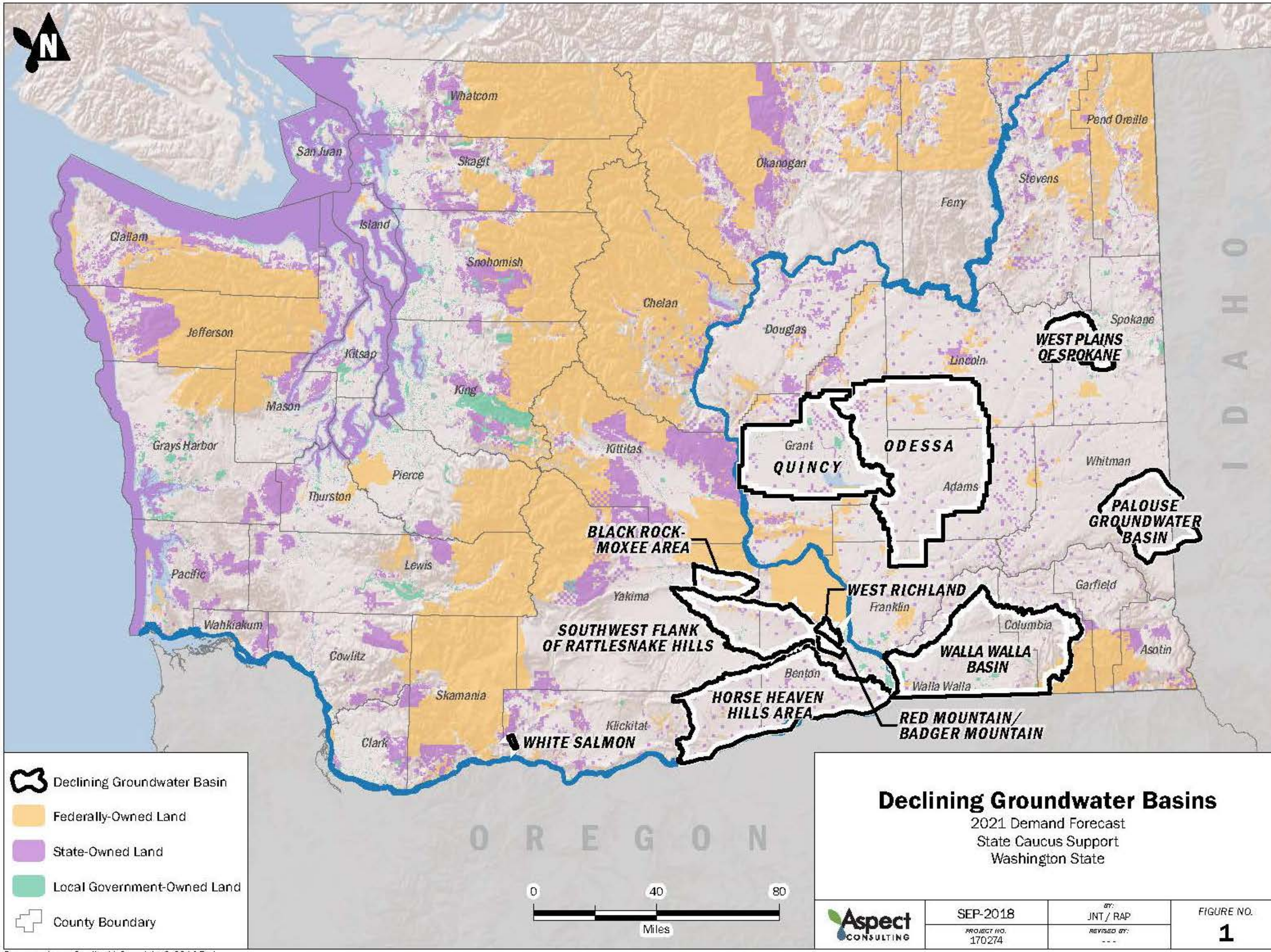
- **Inflows**
  - Deep percolation of precipitation (Recharge)
  - Seepage from surface waterbodies (Seepage)
  - Leakage from adjacent aquifers (Leakage)
- **Outflows**
  - Seepage to surface waterbodies (Seepage)
  - Leakage to adjacent aquifers (Leakage)
  - Pumping (Pumping)
- Aquifer Storage properties (Storage)

Aquifer Water Budget for Declining Groundwater Basins

- Hydrogeologic boundary conditions that impede surface water-groundwater interactions.
- Bedrock valley walls, glacial deposit margins, igneous dikes or other boundaries limit the areal extent of the aquifer.
- Interference between pumping systems.
- **Pumping outpaces increasing inflows and decreasing discharge.** Discharge primarily derived from stored water.

Predicting Groundwater Declines – Systems Analyses

- Watershed and hydrogeologic characterization – establishing a water budget framework
- Modeling change
  - Data driven
  - Simplistic water balance approach
  - Drawdown calculations for pumping wells
  - Numerical modeling


Declining Groundwater Basins
2021 Demand Forecast
State Caucus Support
Washington State
Declining Groundwater Basin
Federally-Owned Land
State-Owned Land
Local Government-Owned Land
County Boundary
0
40
80
Miles
SEP-2018
PROJECT NO.
170274
BY:
JNT / RAP
REVISED BY:
- - -
FIGURE NO.
1
Aspect
CONSULTING
OREGON
IDAHO
Whatcom
San Juan
Skagit
Okanogan
Ferry
Stevens
Pend Oreille
Island
Clallam
Snohomish
Chelan
Jefferson
Douglas
Spokane
WEST PLAINS OF SPOKANE
Lincoln
Kitsap
King
Mason
Grays Harbor
Grant
QUINCY
ODESSA
Kittitas
Whitman
Adams
Pierce
Thurston
PALOUSE GROUNDWATER BASIN
BLACK ROCK-MOXEE AREA
Lewis
Pacific
Garfield
WEST RICHLAND
Yakima
Franklin
Wahkiakum
SOUTHWEST FLANK OF RATTLESNAKE HILLS
Columbia
WALLA WALLA BASIN
Asotin
Cowlitz
Benton
Walla Walla
Skamania
HORSE HEAVEN HILLS AREA
RED MOUNTAIN/ BADGER MOUNTAIN
Klickitat
Clark
WHITE SALMON

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Understanding the Basic Data Needs for Prediction

- Regulatory reporting requirements
  - The bare minimum
- Performance monitoring
  - System status
- Performance testing
  - System capabilities

Developing a Wellfield Performance Monitoring Program

- Determine the well's drawdown/recovery characteristics
- Determine time interval for measurements
- Measure water levels the same way every time
- Calibrate air line, water level meter, transducer, etc.
- Record levels, pumping rate, date and time, and document other wells that are operating

Planning for Declining Groundwater

Planning:

- Begin with a conceptual understanding of the hydrogeologic system.
- Collect data and monitor trends.
- Establish thresholds and triggers for changes in water use/ management.
- Assess mitigation opportunities.
- Assess alternative water supplies.

Managing:

- Incorporate trends and triggers into planning.
- Understand the value of water - $/kgal for each source.
- Develop business case for mitigation or alternative water supply projects.

Questions?

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