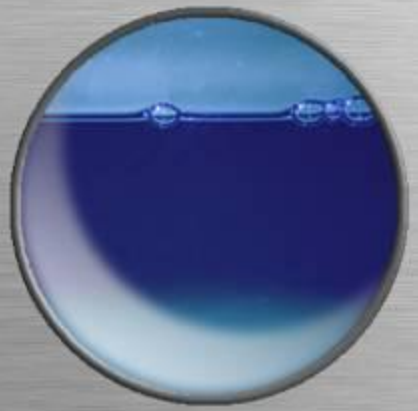
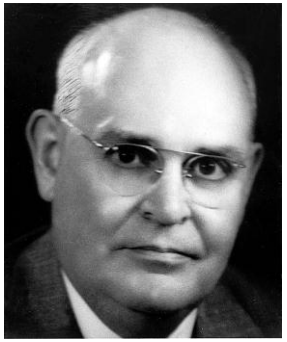
William A. McEllhiney Distinguished Lecturer Series Well Technology

Made possible by a grant from Franklin Electric Company to the National Ground Water Research and Educational Foundation



NGWREF McEllhiney Lecture Series



To foster professional excellence in water well technology, the National Ground Water Research and Educational Foundation has established the William A. McEllhiney Distinguished Lecture Series in Water Well Technology.

Initiated in 2000, the lecture series honors William A. McEllhiney, who was the founding president of the National Ground Water Association in 1948, and a ground water contractor and civil engineer from Brookfield, Illinois.

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NGWREF McEllhiney Lecture Series

"McEllhiney and the other founders of the Association saw several primary functions for the new national group," explains Foundation Executive Director Kevin McCray, "including serving as a clearinghouse for information and its dissemination, serving as an intermediary in coordinating advances occurring in different parts of the country, and serving as a place to bring contractors together so that they might have a working knowledge of contracting from all parts of the nation. NGWREF's McEllhiney Lecture series promotes and perpetuates those original aims."

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national ground water research and educational foundation

NGWREF McEllhiney Lecture Series

Annually, a panel of ground water contractors invites an outstanding ground water contracting professional to share his or her work with the industry. Individuals may nominate themselves or others they believe to be qualified to serve as the NGWA McEllhiney distinguished lecturer.

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national ground water research and educational foundation

NGWREF McEllhiney Lecture Series

Effective May 2005, Franklin Electric Co., the world's largest manufacturer of submersible electric motors, has agreed to underwrite the next three years of this lecture series for presentations to organized groups of contractors and other qualified and interested parties. Meetings and conventions of state and regional associations are eligible. Foreign associations of ground water contractors, academic institutions teaching water well technology, gatherings of water well regulators, and other bodies with a direct and identifiable interest in water well design and construction are eligible as well.

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NGWREF McEllhiney Lecture Series

2008 Lecturer

F. Michael Krautkramer, LHG, RG

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How Much Is Enough?
Making Decisions in the Water Well Industry

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Decisions Carry Consequences

A drilling project can be looked at as a series of decisions.

Unfortunately, most of our decisions get locked in place as steel and cement.

OURS ARE CRITICAL PATH PROJECTS

Knowing and doing the right things in the right order.

Your mom taught you critical path thinking when you were very young.

Socks then shoes!

THE DRILLING PROJECT VERSION: MUCH MORE COMPLICATED

You need to know things.

You need to think through the whole project.

In the example, Δs is 1.3 ft (0.4 m), which is the change in drawdown between 10 minutes and 100 minutes after the start of the pumping test, and Q equals 500 gpm (2,730 m³/day); so:

$$T = \frac{264 \cdot 500}{1.3} = 102{,}000 \text{ gpd/ft} \qquad T = \frac{0.183 \cdot 2{,}730}{0.4} = 1{,}250 \text{ m}^2\text{/day}$$

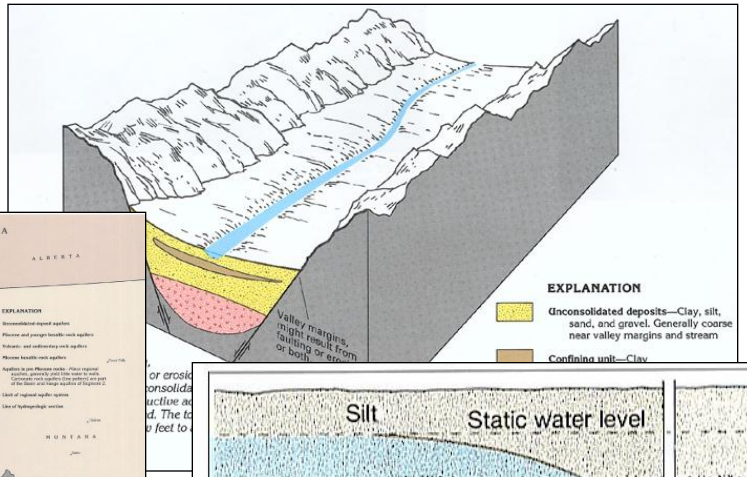
Table 9.1. Drawdown Measurements in an Observation Well 400 ft (122 m) from Pumped Well

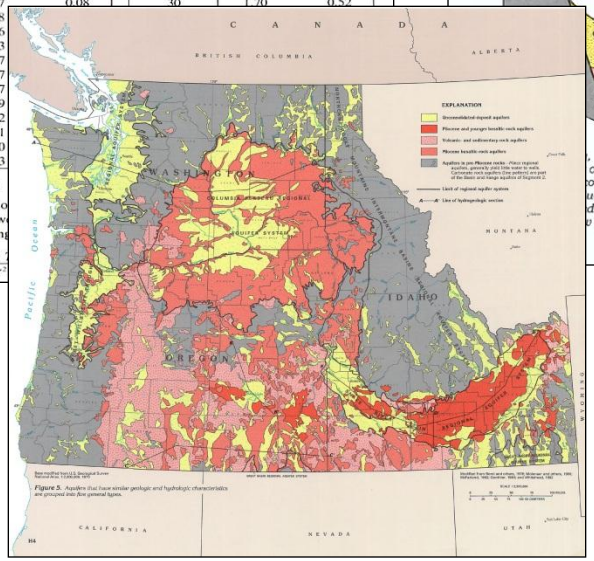
Time since pump started, in min	Drawdown, s ft	Drawdown, s m	Time since pump started, in min	Drawdown, s ft	Drawdown, s m
1	0.16	0.05	24	1.58	0.48
1.5	0.27	0.08	30	1.70	0.52
2	0.38				
2.5	0.46				
3	0.53				
4	0.67				
5	0.77				
6	0.87				
8	0.99				
10	1.12				
12	1.21				
14	1.30				
18	1.43				

Coefficient of Storage

The coefficient of sto
by using the zero-draw
equation. The following

$$S = \frac{0.3}{r^2}$$





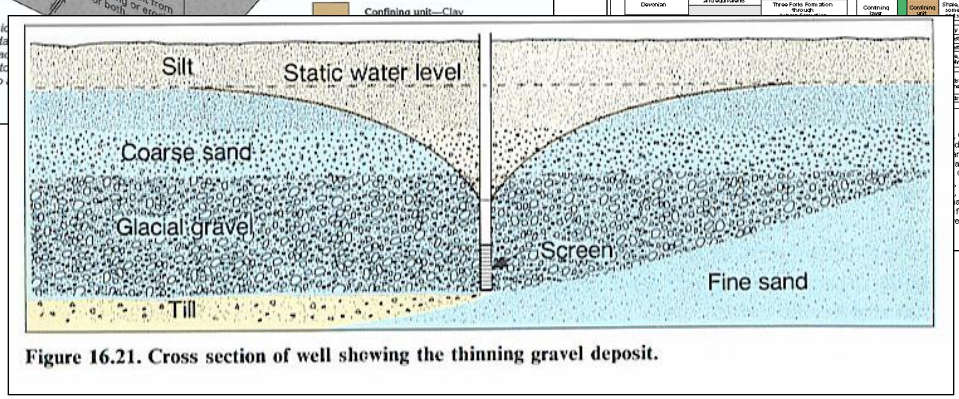
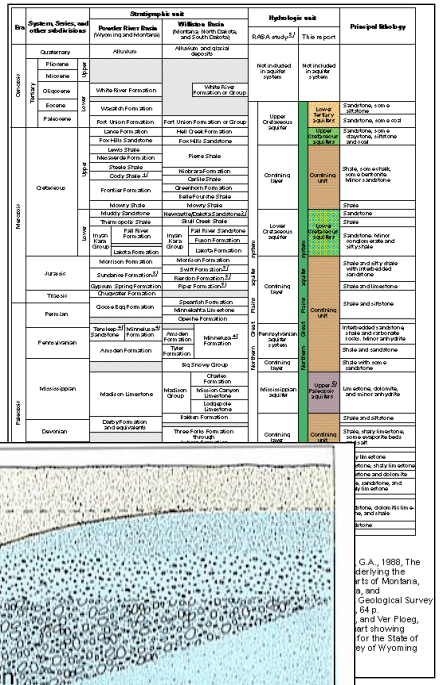
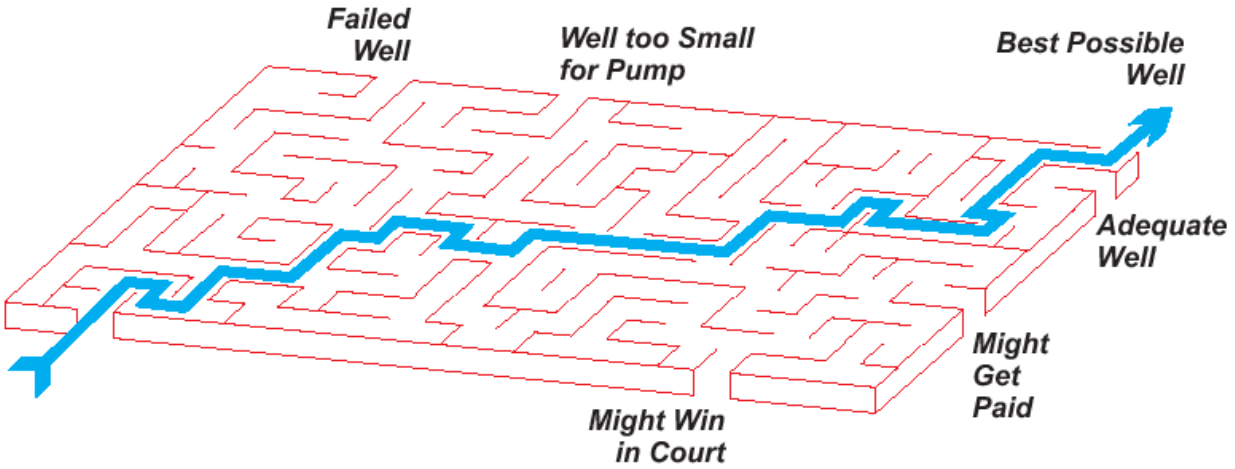


Figure 16.21. Cross section of well showing the thinning gravel deposit.



EARLY DECISIONS ARE IMPORTANT

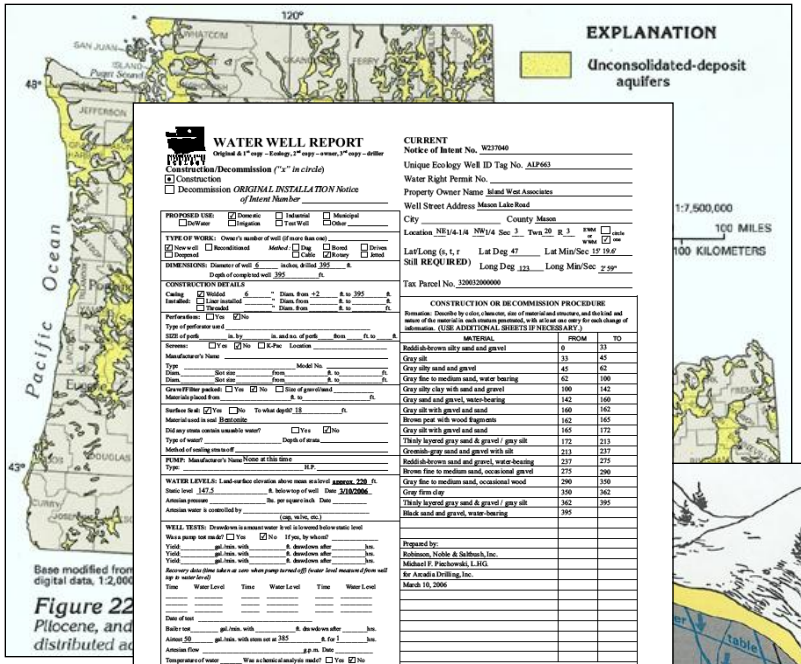


A drilling project is much like the maze puzzles you did as a child.

IMPLICATIONS TO PROJECT SUCCESS AND BUSINESS SUCCESS

Good decisions for *projects*:	Good decisions for *business:*
Ability to reach depth	People pay the invoice
Provide best completion	You do not end up in court
Install appropriate pump	Reputation gets customers
Higher production, efficient wells	Explain what you did and why
Clean & clear water production	Good decisions save time and $

DO RESEARCH AND MAKE DECISIONS BASED ON FACTS



WATER WELL REPORT
Original & 1st copy – Ecology, 2nd copy – owner, 3rd copy – driller

Construction/Decommission ("x" in circle)
(•) Construction
( ) Decommission ORIGINAL INSTALLATION Notice of Intent Number _____

PROPOSED USE: (•) Domestic ( ) Industrial ( ) Municipal ( ) Irrigation ( ) Test Well ( ) Other _____

TYPE OF WORK: Owner's number of well (if more than one) _____
(•) New well ( ) Reconditioned Method: ( ) Dug ( ) Bored ( ) Driven ( ) Deepened ( ) Cable (•) Rotary ( ) Jetted

DIMENSIONS: Diameter of well 6 inches, drilled 395 ft.
Depth of completed well 395 ft.

CONSTRUCTION DETAILS
Casing: (•) Welded 6 " Diam. from +2 ft. to 395 ft.
Installed: ( ) Liner installed _____ " Diam. from _____ ft. to _____ ft.
( ) Threaded _____ " Diam. from _____ ft. to _____ ft.
Perforations: ( ) Yes (•) No
Type of perforator used _____
SIZE of perfs _____ in. by _____ in. and no. of perfs _____ from _____ ft. to _____ ft.
Screens: ( ) Yes (•) No ( ) K-Pac Location _____
Manufacturer's Name _____
Type _____ Model No. _____
Diam. _____ Slot size _____ from _____ ft. to _____ ft.
Diam. _____ Slot size _____ from _____ ft. to _____ ft.
Gravel/Filter packed: ( ) Yes (•) No ( ) Size of gravel/sand _____
Materials placed from _____ ft. to _____ ft.

Surface Seal: (•) Yes ( ) No To what depth? 18 ft.
Material used in seal Bentonite
Did any strata contain unusable water? ( ) Yes (•) No
Type of water? _____ Depth of strata _____
Method of sealing strata off _____
PUMP: Manufacturer's Name None at this time
Type: _____ H.P. _____

WATER LEVELS: Land-surface elevation above mean sea level approx. 220 ft.
Static level 147.5 ft. below top of well Date 3/10/2006
Artesian pressure _____ lbs. per square inch Date _____
Artesian water is controlled by _____ (cap, valve, etc.)

WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? ( ) Yes (•) No If yes, by whom? _____
Yield: _____ gal./min. with _____ ft. drawdown after _____ hrs.
Yield: _____ gal./min. with _____ ft. drawdown after _____ hrs.
Yield: _____ gal./min. with _____ ft. drawdown after _____ hrs.
Recovery data (time taken as zero when pump turned off (water level measured from well top to water level))

Time	Water Level	Time	Water Level	Time	Water Level

Date of test _____
Bailer test _____ gal./min. with _____ ft. drawdown after _____ hrs.
Airlift 50 gal./min. with stem set at 385 ft. for 1 hrs.
Artesian flow _____ g.p.m. Date _____
Temperature of water _____ Was a chemical analysis made? ( ) Yes (•) No

CURRENT
Notice of Intent No. W237040
Unique Ecology Well ID Tag No. ALP663
Water Right Permit No. _____
Property Owner Name Island West Associates
Well Street Address Mason Lake Road
City _____ County Mason
Location NE1/4-1/4 NW1/4 Sec 3 Twn 20 R 3 (•) E ( ) W
Lat/Long (s, t, r Still REQUIRED) Lat Deg 47 Lat Min/Sec 15' 19.6" Long Deg 123 Long Min/Sec 2' 59"
Tax Parcel No. 320032000000

CONSTRUCTION OR DECOMMISSION PROCEDURE
Remarks: Describe by color, character, size of material and structure, and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of information. (USE ADDITIONAL SHEETS IF NECESSARY.)

MATERIAL	FROM	TO
Reddish-brown silty sand and gravel	0	33
Gray silt	33	45
Gray silty sand and gravel	45	62
Gray fine to medium sand, water bearing	62	100
Gray silty clay with sand and gravel	100	142
Gray sand and gravel, water-bearing	142	160
Gray silt with gravel and sand	160	162
Brown peat with wood fragments	162	165
Gray silt with gravel and sand	165	172
Thinly layered gray sand & gravel / gray silt	172	213
Greenish-gray sand and gravel with silt	213	237
Reddish-brown sand and gravel, water-bearing	237	275
Brown fine to medium sand, occasional gravel	275	290
Gray fine to medium sand, occasional wood	290	350
Gray firm clay	350	362
Thinly layered gray sand & gravel / gray silt	362	395
Black sand and gravel, water-bearing	395	

Prepared by:
Robinson, Noble & Saltbush, Inc.
Michael F. Piechowski, L.HG.
for Arcadia Drilling, Inc.
March 10, 2006

Start Date March 2, 2006 Completed Date March 8, 2006

WELL CONSTRUCTION CERTIFICATION: I constructed and/or accept responsibility for construction of this well, and its compliance with all Washington well construction standards. Materials used and the information reported above are true to my best knowledge and belief.
(•) Driller ( ) Engineer ( ) Trainee Name (Print) Ed Nelson
Driller/Engineer/Trainee Signature _____
Driller or trainee License No. 1886
TRAINEE.
Driller's License # No. _____
Driller's Signature _____
Drilling Company Arcadia Drilling, Inc.
Address P.O. Box 1790
City, State, Zip Shelton, WA 98584
Contractor's Registration No. ARCADI099BK1 Date 3/10/2006

ECY 050-1-20 (Rev 3/03) Ecology is an Equal Opportunity Employer.

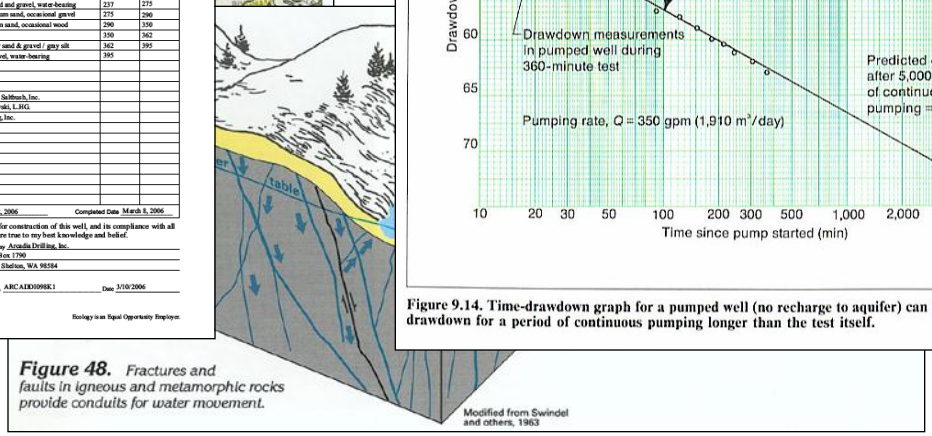


Figure 48. *Fractures and faults in igneous and metamorphic rocks provide conduits for water movement.*
Modified from Swindel and others, 1963

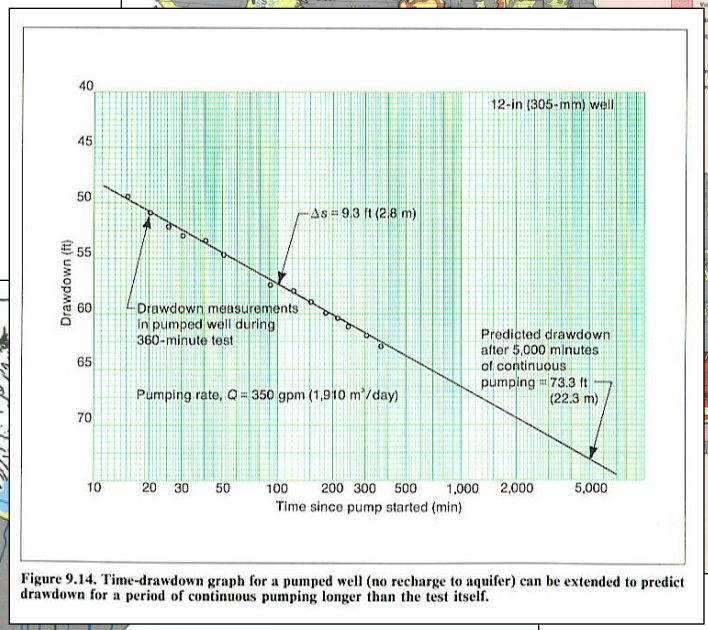


Figure 9.14. Time-drawdown graph for a pumped well (no recharge to aquifer) can be extended to predict drawdown for a period of continuous pumping longer than the test itself.

KNOW WHAT YOU NEED TO KNOW: CREATE A CHECK LIST

Ask the customer

Inspect the site

Research the area

Formally plan the work

PRE-QUOTE CHECKLIST
Questions to be answered before submitting a quote

- ☐ Where is the site?
- ☐ Can I get my equipment on the site? Will site preparation be needed?
- ☐ Does the site meet regulatory requirements? (setbacks from septic etc.)
- ☐ What is the intended use of the water?
- ☐ What production rate is needed? Does the customer desire or expect more?
- ☐ Are there specific water quality requirements?
- ☐ Which aquifers in the area are likely to meet the need?
- ☐ How deep is the well likely to have to be drilled to get the desired water?
- ☐ What is the likely static water level? Pumping water level?
- ☐ What casing or hole diameter is needed for the appropriate pump?
- ☐ Is a water right needed? Does the customer have one?
- ☐ Are there known groundwater problems in the area?
- ☐ Are there known regulatory problems in the area?

DO NOT PRESUME YOU KNOW THE SITE

Don’t skip the basics

- Make a site visit every time

Don’t miss the obvious

Due diligence saves you from surprises

- (Soft ground, for instance)

KNOW WHAT THE CLIENT NEEDS AND EXPECTS

Interview the customer

Ask questions about what is needed / wanted

Communicate the options and their implications

Get as much in writing as possible

DECIDE ON A SPECIFIC SITE

Define setback issues

Define access issues

Where will the spoils go?

What do the regulations require?

What is convenient for the owner? (piping, power, ease of use)

DEVELOPING YOUR QUOTE

Clearly state your units

Research prices

Keep written records

Produce a written quote

Communicate the detail

Item	Description	Units	Price Per Unit	Estimated Cost
1	Mobilization and demobilization	One	Lump Sum	
2	Place and complete flow-protection seal (drill temporary 24-inch, place & cement 20-inch casing)	30 feet	$_____/ft	
3	16-inch drive shoe	One	Each	
4	Drill hole for 16-inch casing	170 feet	$_____/ft	
5a	Provide and install 16-inch casing	205 feet	$_____/ft	
5b	Provide and install 12-inch casing (casing cost only, installation part of Item 9)	137 feet	$_____/ft	
6	16-inch shoe cut	One	Each	
7	Provide well screen and fittings (Estimating 70 feet of 12-inch).	70 feet	$_____/ft	
8	Extra materials. Cost plus 15%.	Grouped estimate	lump sum	
9	Hourly rig work	100 hours	$_____/hr	
10	Stand-by/shop time	15 hours	$_____/hr	
11	Provide, install & remove test pump; pump for four hours,	One	Lump Sum	
12	Operate pump	24 hours	$_____/hr	
13	Salvage Credit for 16-inch casing	80 feet	($_____/ft)	( )
		Base Bid Total		$

ONCE YOU HAVE QUOTED THE JOB, YOU HAVE ALREADY MADE DECISIONS

At the very least, be aware they are made and make sure the customer knows these decisions have consequences to the job

Drilling rig

Casing size

Maximum depth you can reach

Possible types of completion

Maximum production

Pumping equipment that can be used

Testing that can be done

THE RIG IS ON SITE - NOW WHAT?

The decisions keep coming

When should I stop drilling?

How thorough a completion is appropriate?

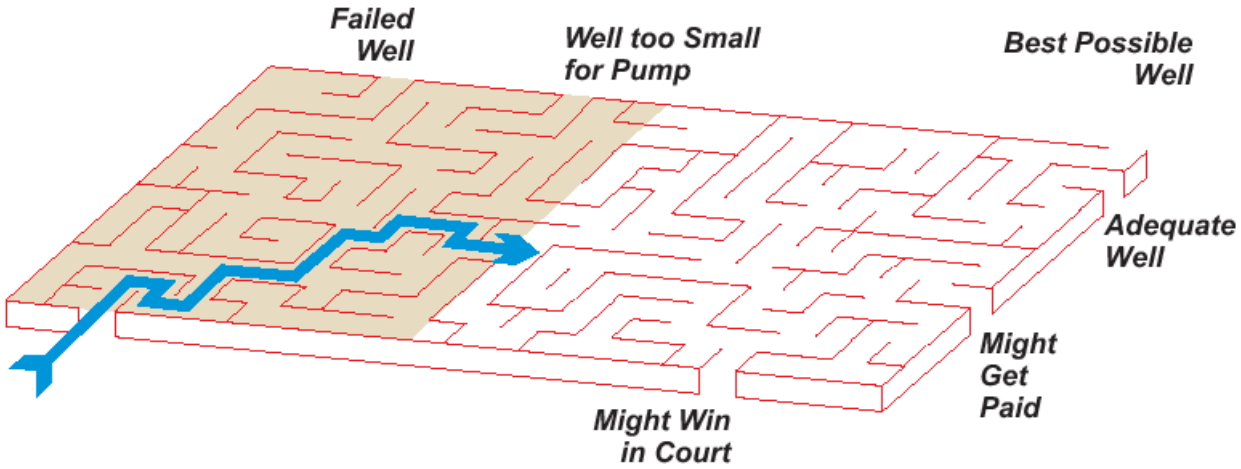
How much development should I employ?

What is the necessary testing?

How much water should I tell the customer they have?

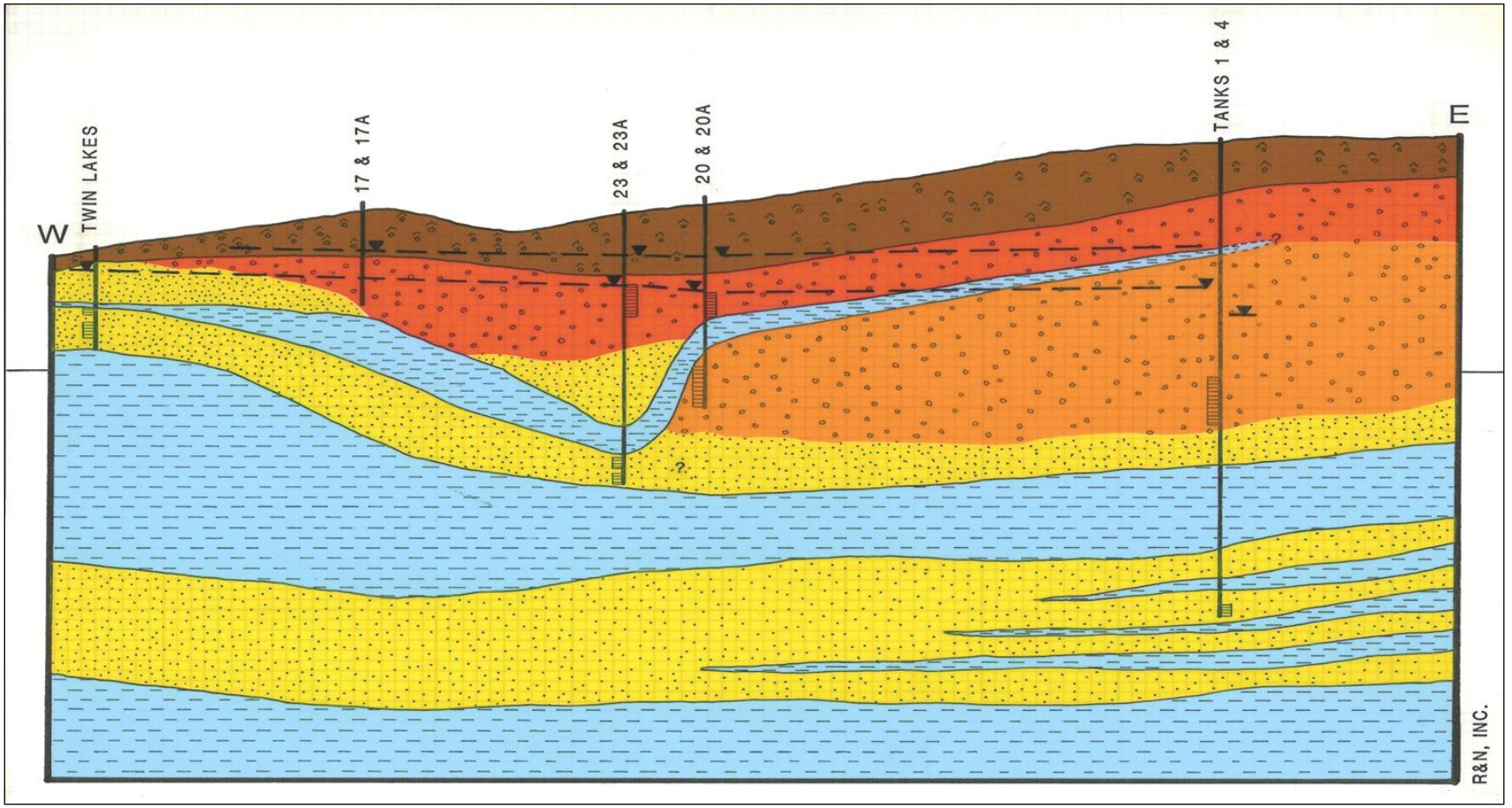
What information should I give the customer?

ON SITE – HOW DEEP DO YOU DRILL?



You have avoided some of the bad decisions

IT IS A COMPLICATED WORLD IN WHICH WE WORK



DECISIONS IN THE FIELD

How deep is deep enough?

Watch the water levels during drilling

Get the drawdown you need – then use it wisely

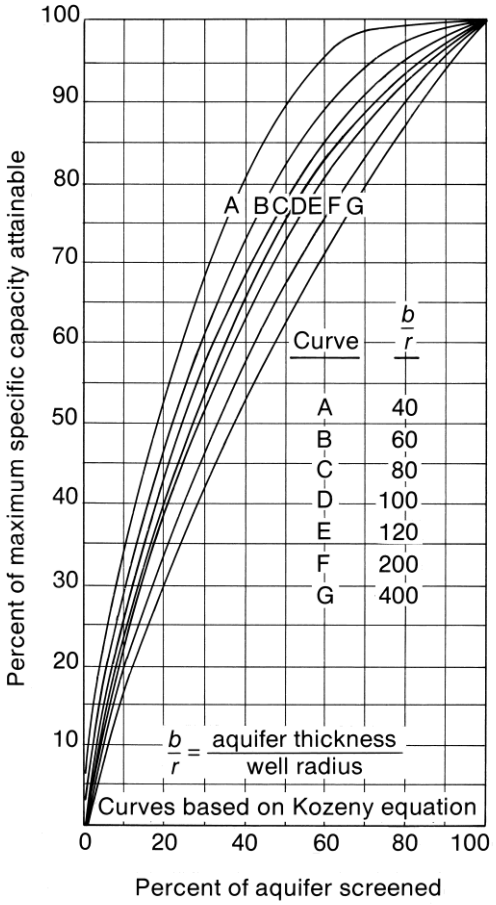
Never drill just enough to get by – things change

Drill all of the aquifer zone (unless only very little water is needed)

Part of the aquifer is not as productive as all of the aquifer

THE MATH OF ONLY TAKING "SOME OF IT"

- Lower specific capacity
- More susceptible to loss of efficiency
- You cannot screen what you do not drill



Graph courtesy of Johnson Screen

WHY THE WELL CARES ABOUT "ALL OF IT"

Rock and sediments are usually layered

Kh is much larger than kv - water prefers to move horizontally

If you make it move vertically - it makes you pay for the right

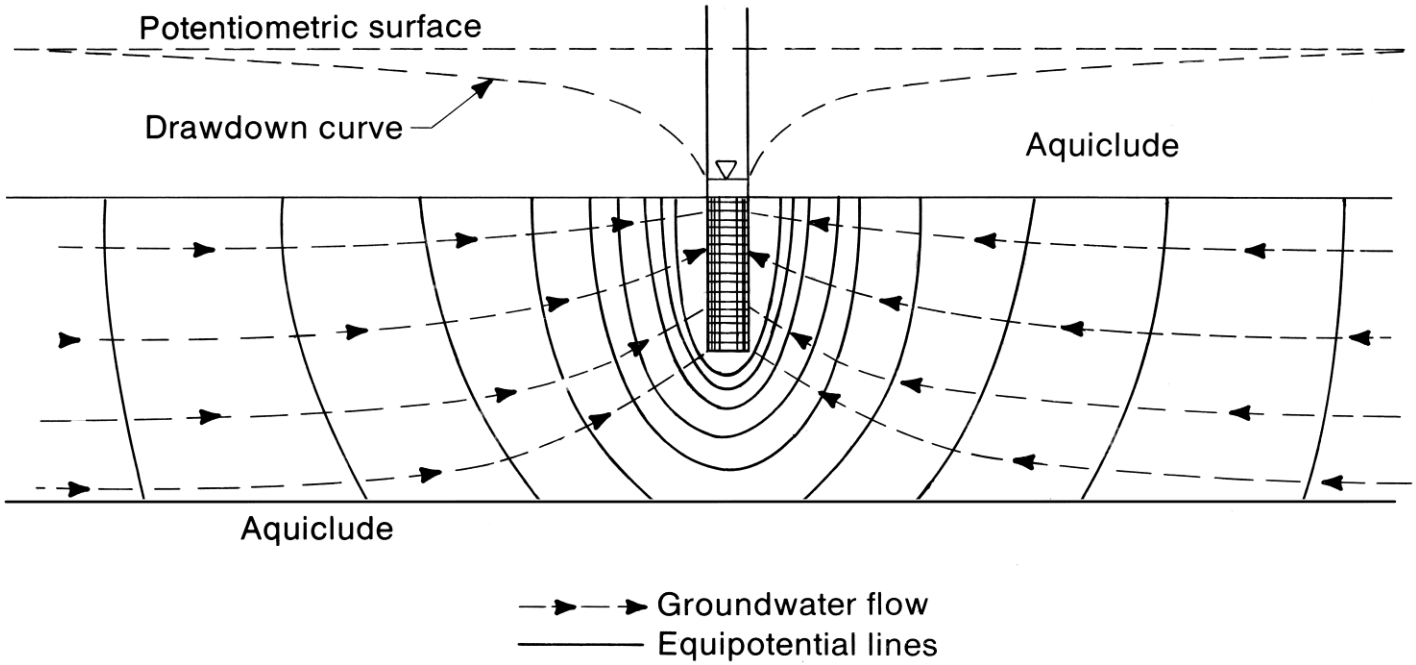
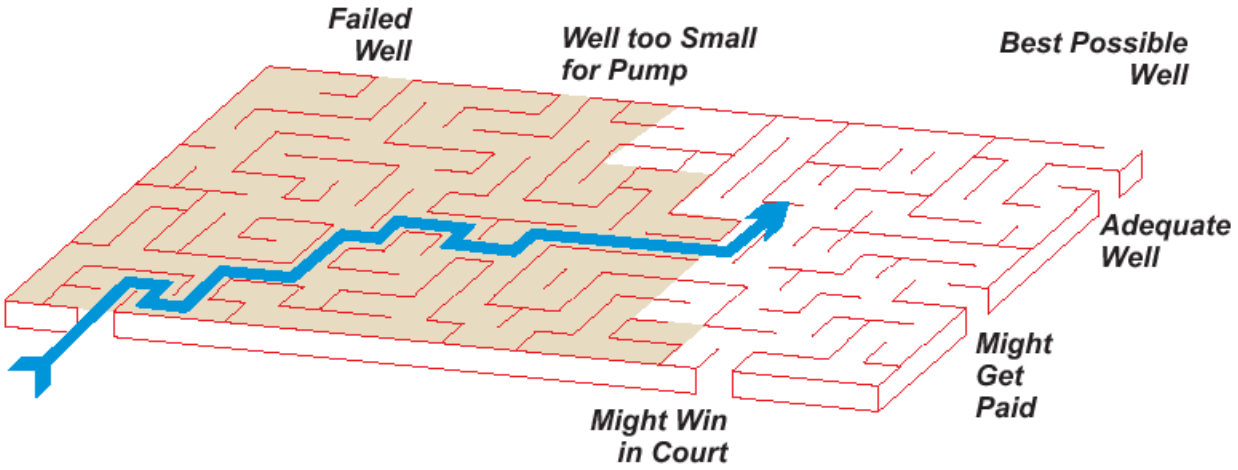


Figure courtesy of Johnson Screen

CONCEPTS IN WELL EFFICIENCY



You have drilled the hole.

Now you have to get the water out.

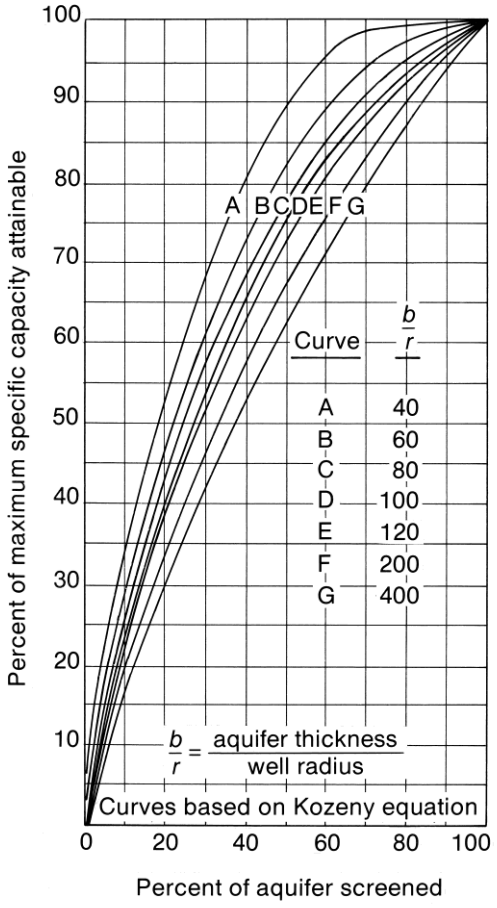
LIMITED AQUIFER EXPOSURE

Same arguments as not drilling it all

If you need all you can get, screen all that you have

2/3 of total thickness in unconfined aquifers

The less aquifer you use, the more drawdown you get



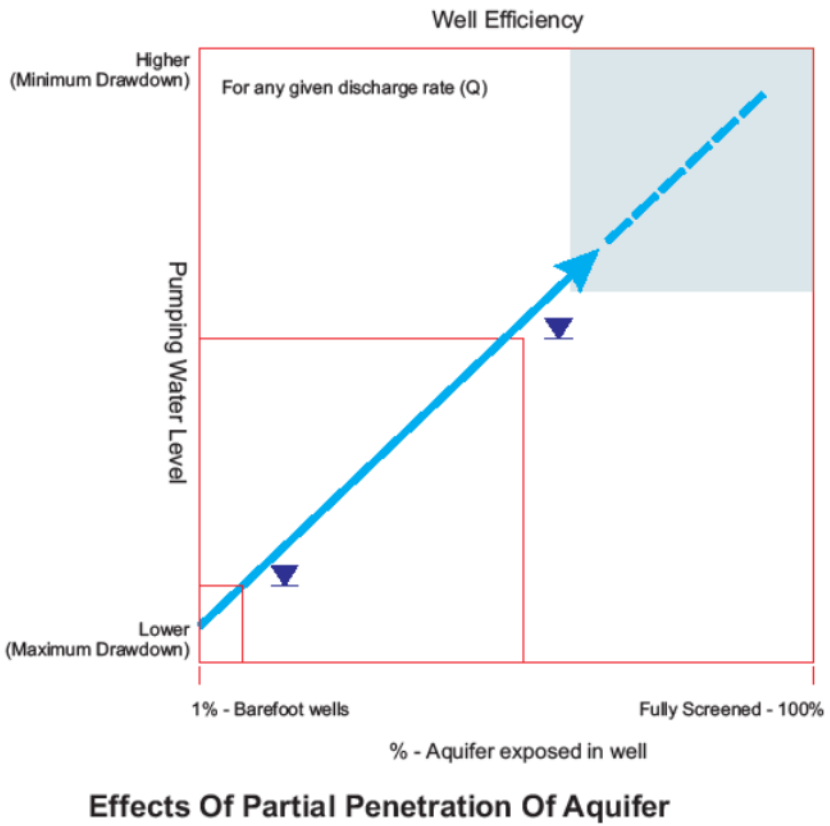
MEEK DESIGNS MAKE INEFFICIENT WELLS

Design it to be efficient

Less efficiency means more drawdown

More drawdown is a greater stress on the well

More drawdown encourages chemical and biological problems



Effects Of Partial Penetration Of Aquifer

POOR DESIGN COSTS MONEY - FOREVER

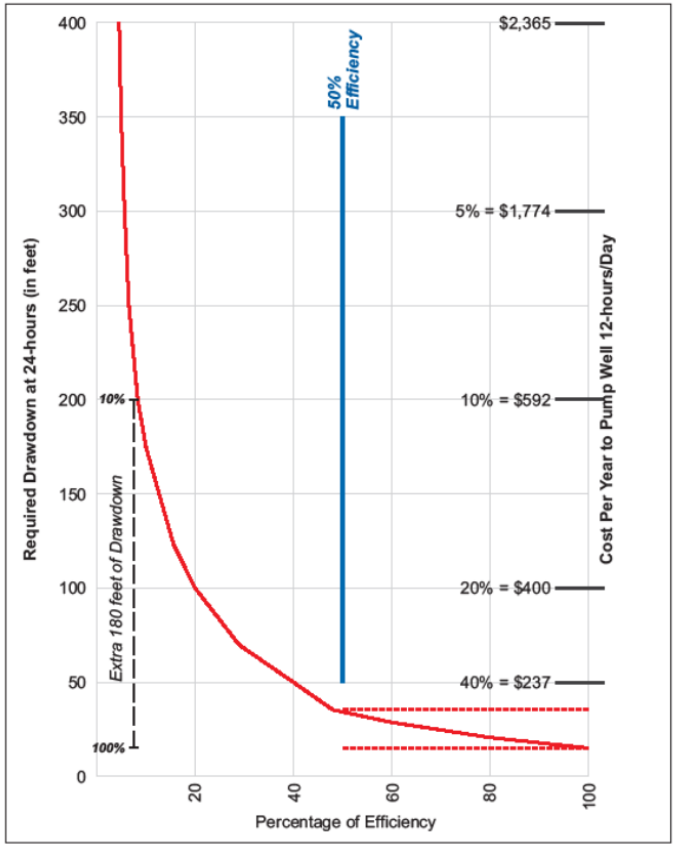
Partial penetration = greater inefficiency

Inefficiency = more drawdown

More drawdown = higher pumping costs

More drawdown = higher maintenance costs

Spend the money on the well



Well Producing 100 gpm in Aquifer with Transmissivity of 10,000 gpd/ft.

WELL COMPLETION
SO MANY QUESTIONS, SO LITTLE TIME

Should I use a liner?

Should I use a screen?

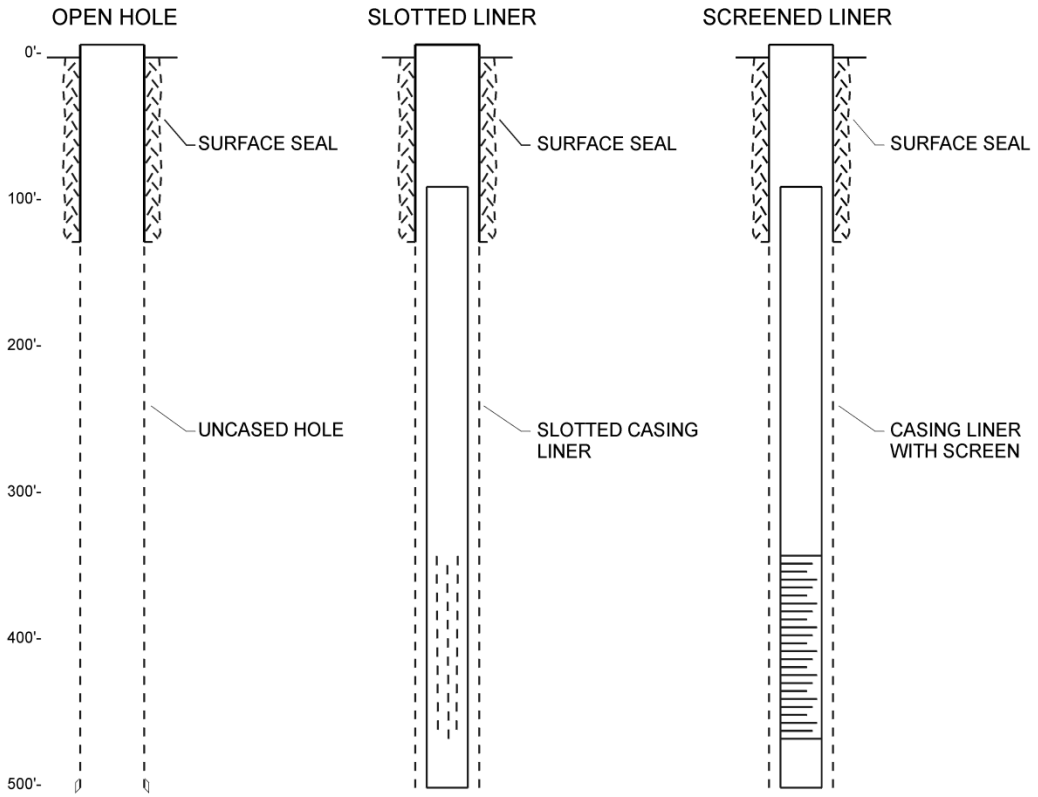
What about gravel packing?

How much screen?

What type of screen?

What cost is justified?

CONSOLIDATED ROCK WELLS



Liners add security, stability, and reliability.

CASED WELLS: THE BAREFOOT WELL

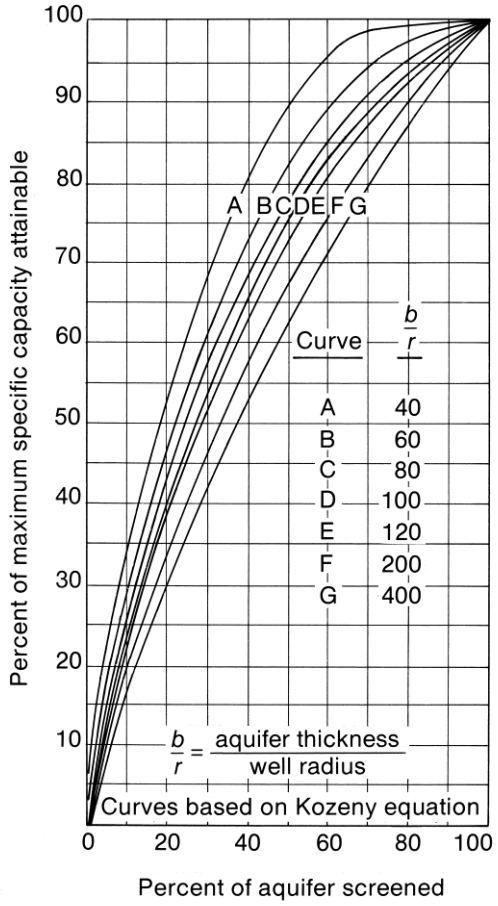
" Everything should be made as simple as possible

– but no simpler"

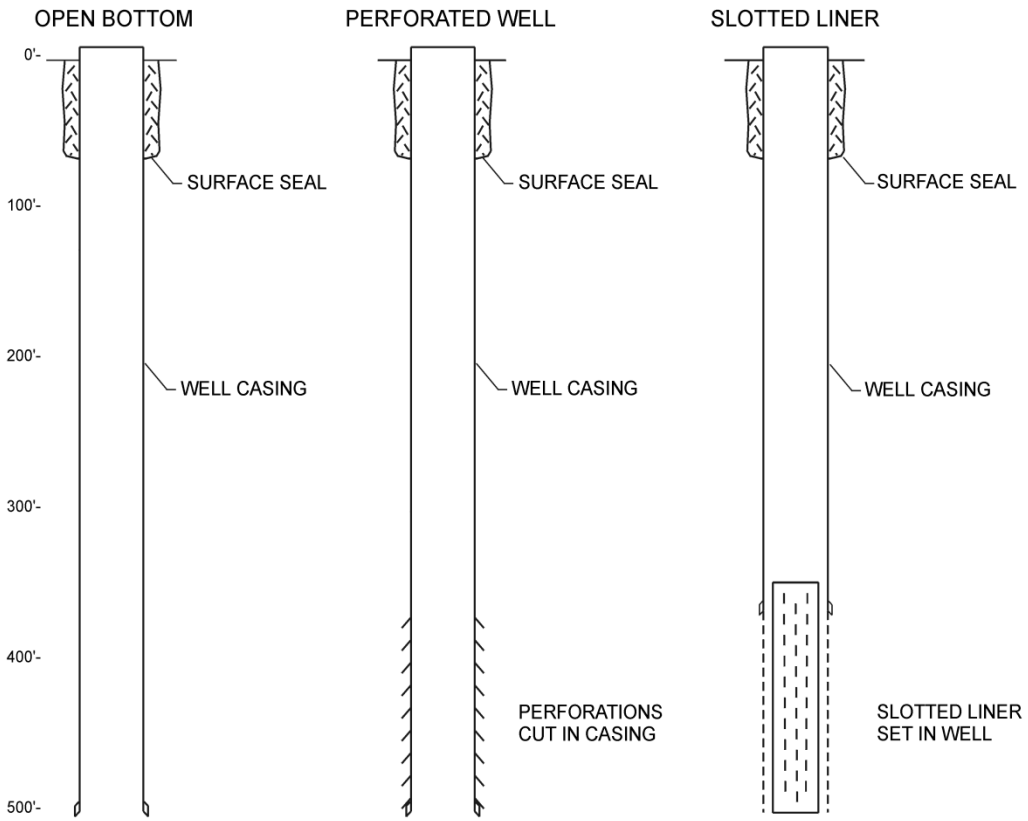
--Albert Einstein

The Barefoot well may be the " but no simpler" part

CHEAP CAN BE EXPENSIVE



PERFORATIONS AND LINERS



They are cheaper but at what cost?

WELL SCREENS ADD VALUE

Screens = open area

= lower entrance velocity

= better production

= lower operational cost

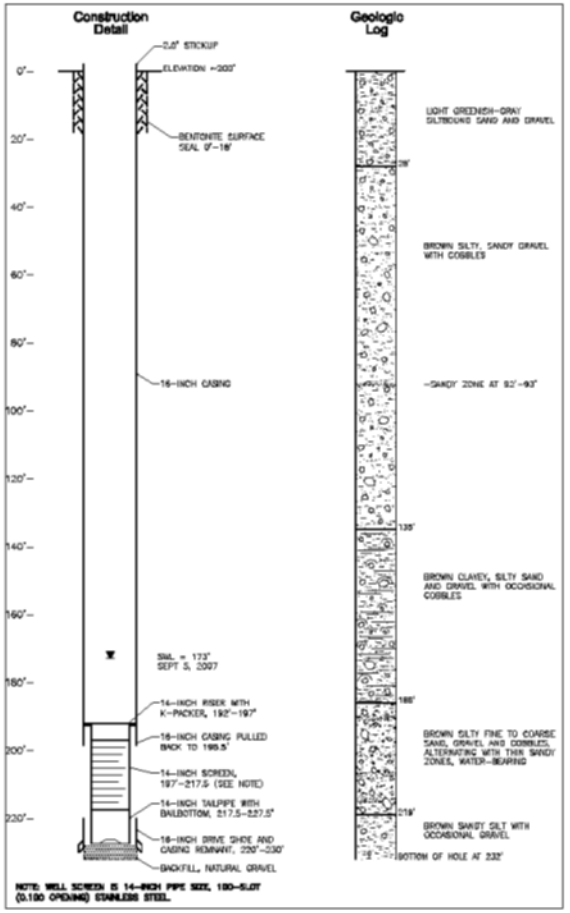
DIRECT SCREEN METHOD

Use your samples and your head

Don’t get reckless – more length is usually better than a larger slot size

Risers, tail pipe & packers

Put it in the right place (and leave it there)



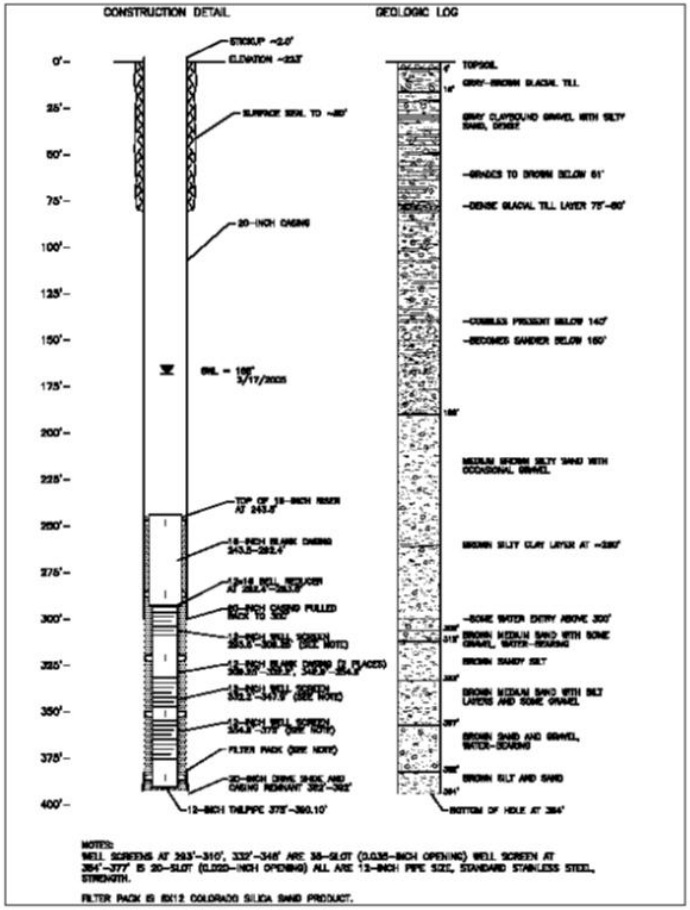
GRAVEL-PACKED SCREENS

Traditional filter-pack design
- Careful design (use enough riser)
- Careful construction
- Careful development

Provides good efficiency

Provides good reliability

Screens pre-packed by manufacturer
- Expensive, but at times a good alternative



THE COST OF AN INEFFICIENT WELL

If the well is short on available drawdown –

It costs you production

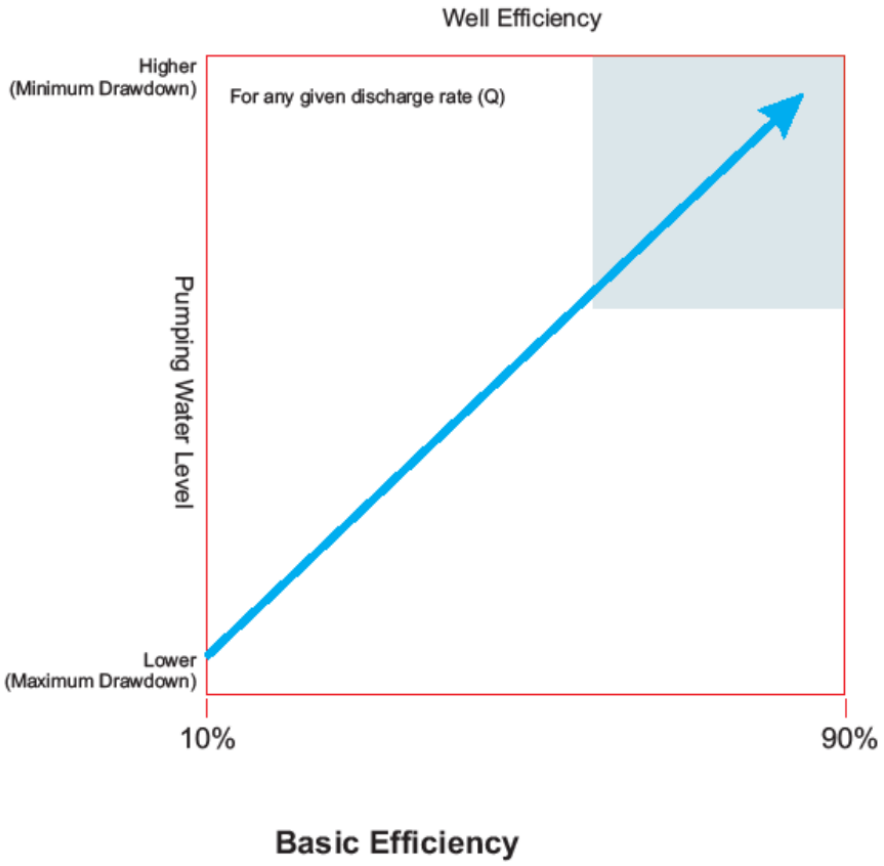
(100 gpm becomes 50 gpm)

If the well uses excessive drawdown –

It costs the customer money

Higher pumping costs

Higher maintenance costs



COMPLETION DECISIONS MATTER

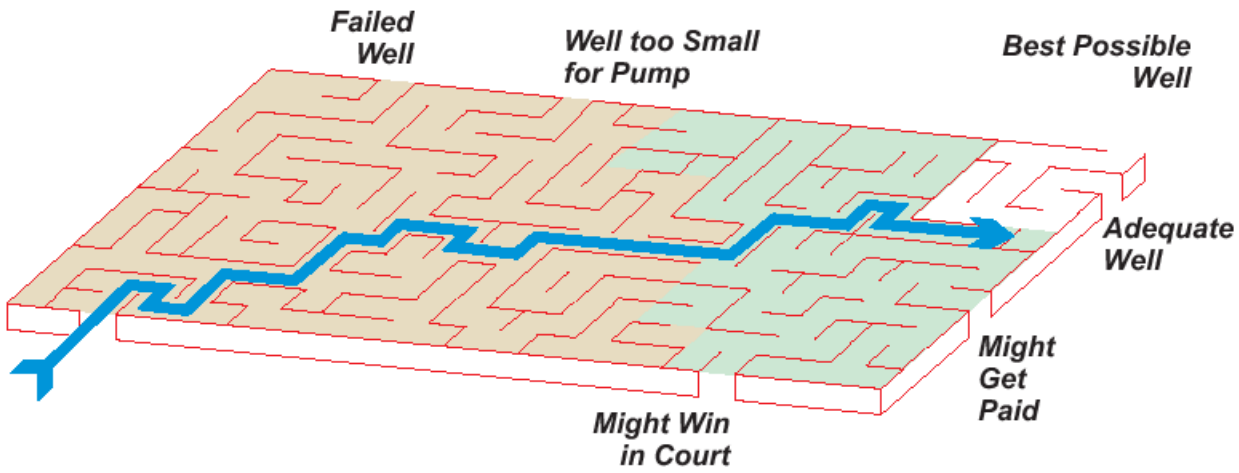
Try to achieve both efficiency and reliability.

Your design should provide:

- Optimal efficiency and reliability
- Protection of the well and the pump
- Cost effective service throughout the operational life of the well

The cost of screens is generally a bargain.

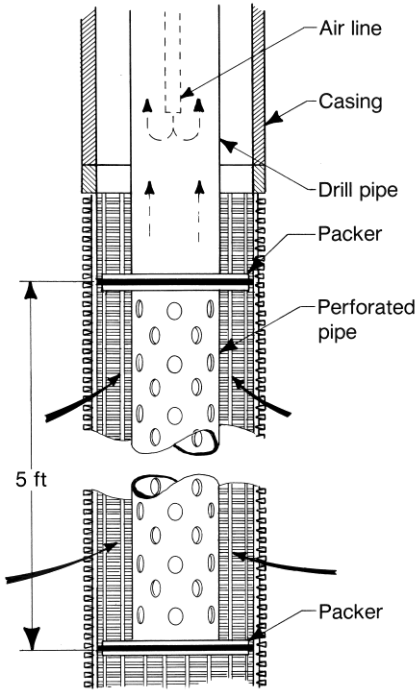
WELL DEVELOPMENT DECISIONS



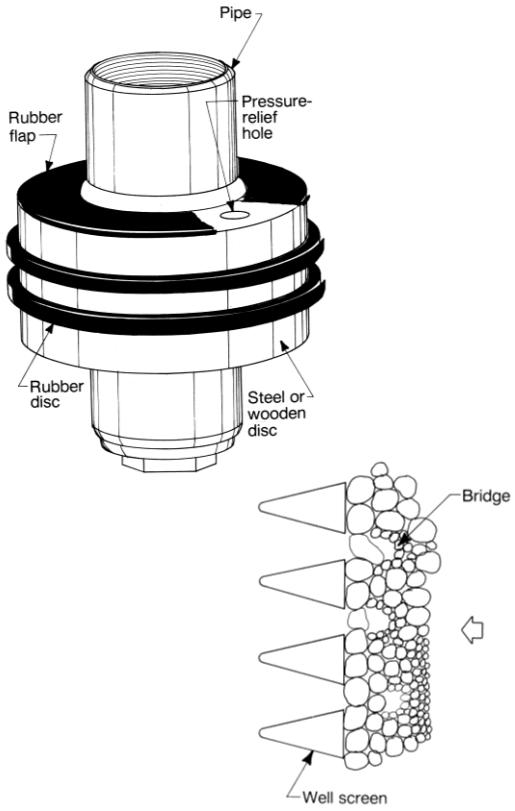
At what point am I wasting my time and their money?

METHODS OF DEVELOPMENT

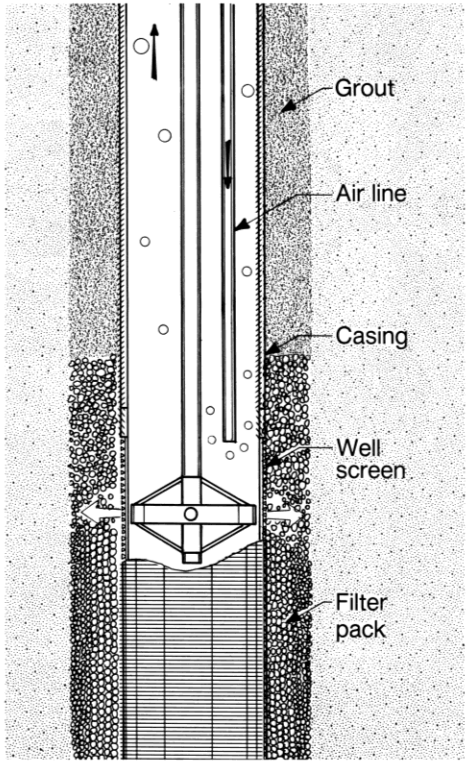
AIR LIFT



SURGE & BAIL



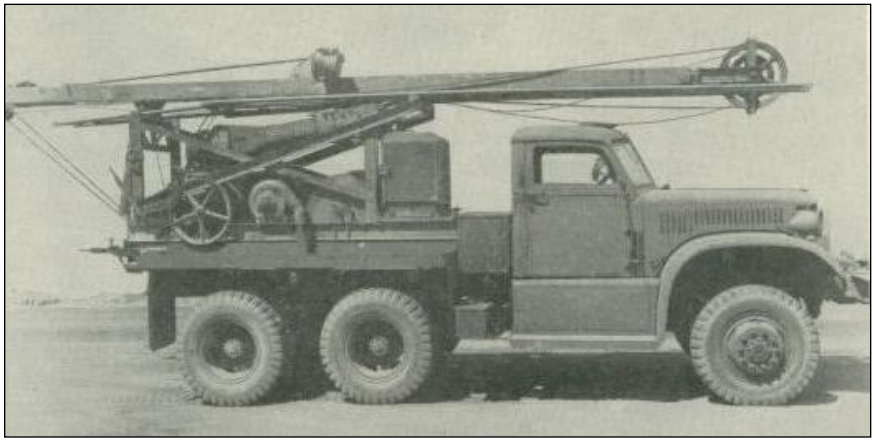
JETTING



DURATION OF DEVELOPMENT

Earlier in my career:

- Two weeks of surge development was common



Nowadays:

- A few hours of blowing with air and it's good to go

Or is it?

HOW CAN YOU TELL WHEN YOU'RE DONE?

Comparative bailer or pumping tests

- Does the same discharge have a higher pumping water level than last time?
- If so, you are not done!

Compare the development spoils – are they more " mature" ?

Has the well response stopped improving?

- Surge runs no easier, air lift not producing any more water

BENEFITS OF PROPER DEVELOPMENT

Well efficiency

Well stability

Stability during testing
(More accurate well rating)

Long-term reliability

Fewer problems with encrustation and biofouling?

WELL TESTING
Where the big answer comes from

Well testing is not about water;
it is about ***information***.

You must be able to project the long-term well performance.

Only proper procedures and accurate data can do that.

TEST PROCEDURES

Step tests

tell you about the well

Constant-rate tests

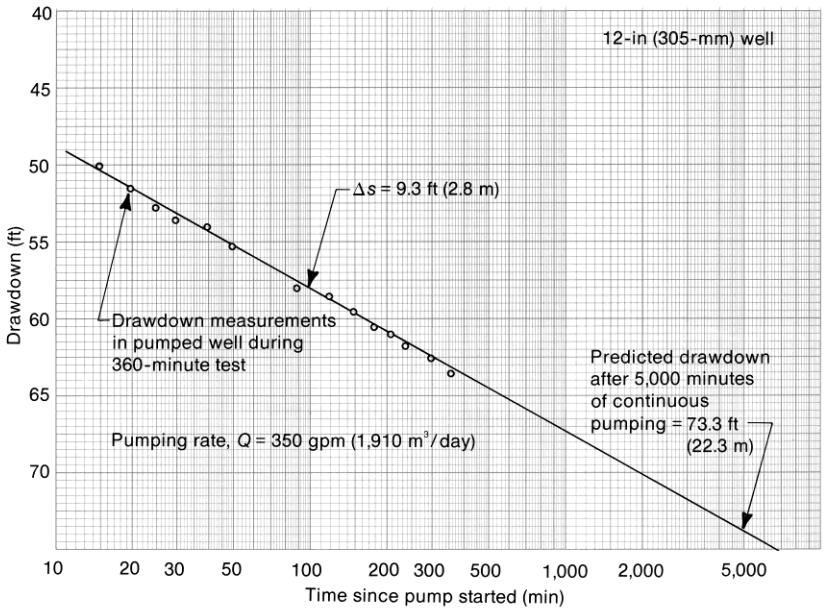
tell you about the aquifer

Observation wells

tell you more about both

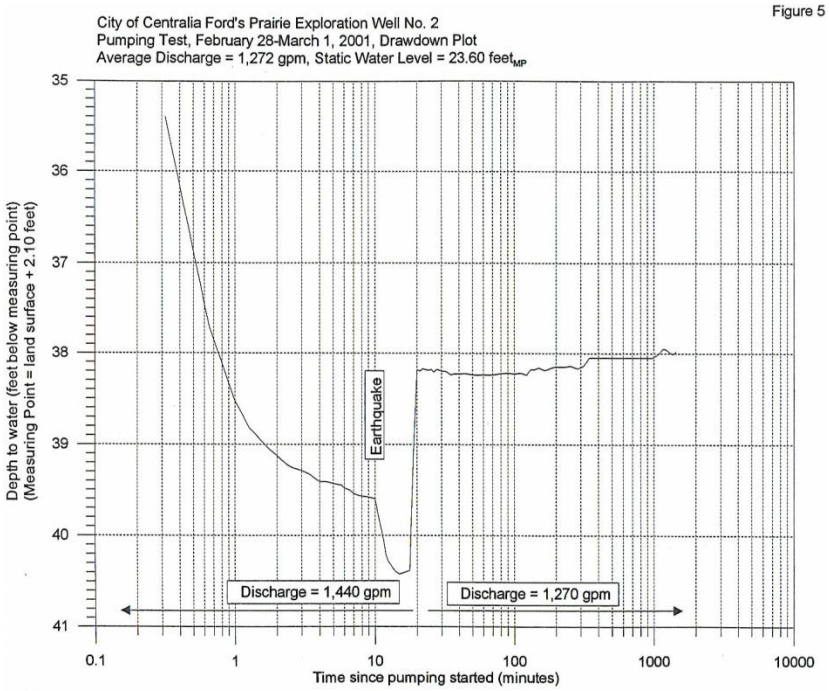
The more you know, the more accurately you rate the well

TEST DATA TELL THE TALE



Typical drawdown plot

Figure 5



Earthquake during test

You never know what is going to happen, so keep good data.

WATER LEVEL RECOVERY DATA

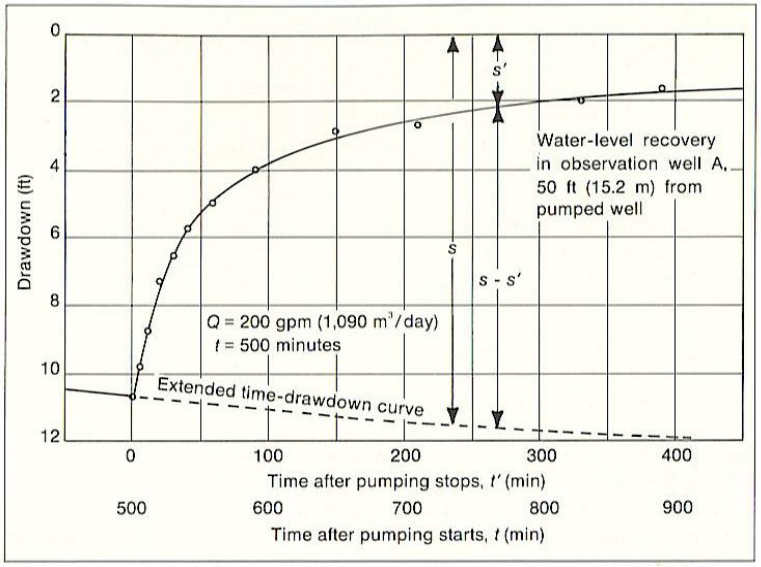


Figure 9.39. Residual-drawdown curve from observation well, with extended time-drawdown curve (on arithmetic scales) showing how calculated recovery is determined at any instant during the recovery period. Producing well pumped 200 gpm (1,090 m³/day) for 500 minutes.

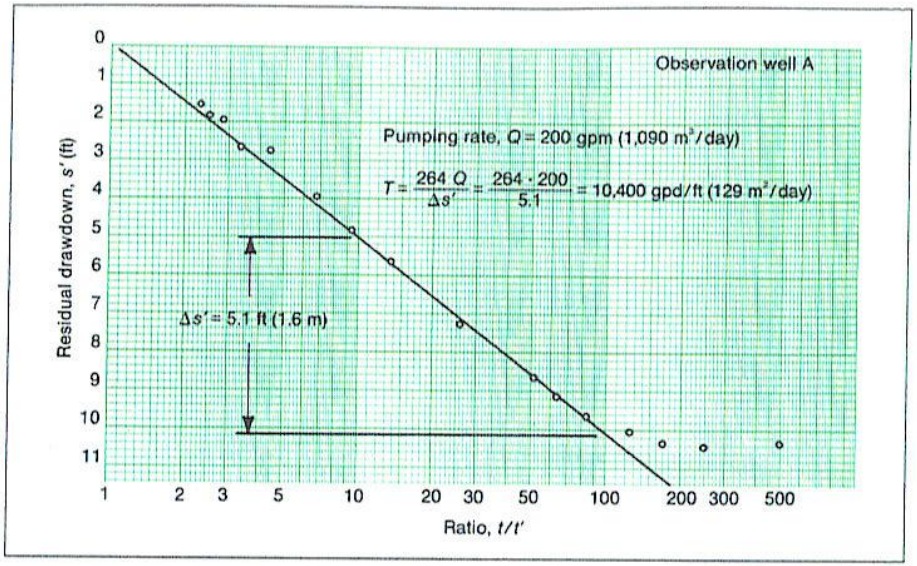


Figure 9.41. Residual drawdown plotted against the ratio t/t' becomes a straight line on semilog graph and permits calculation of transmissivity as shown. Time during recovery period increases toward the left in this diagram.

Linear recovery plot

t/t' recovery plot

RATING THE WELL

Does the drawdown hold its pattern?

Is the drawdown less than would be expected? (Indication of positive boundary)

Is drawdown more than expected?

(Negative boundary)

Was recovery complete? Was it timely?

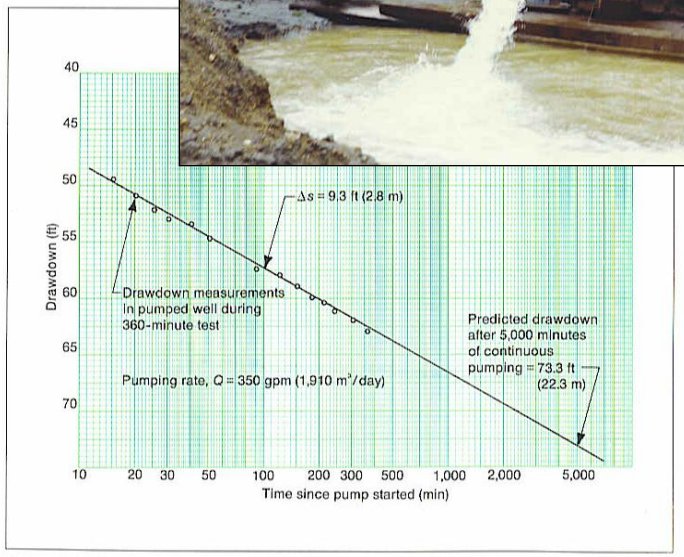


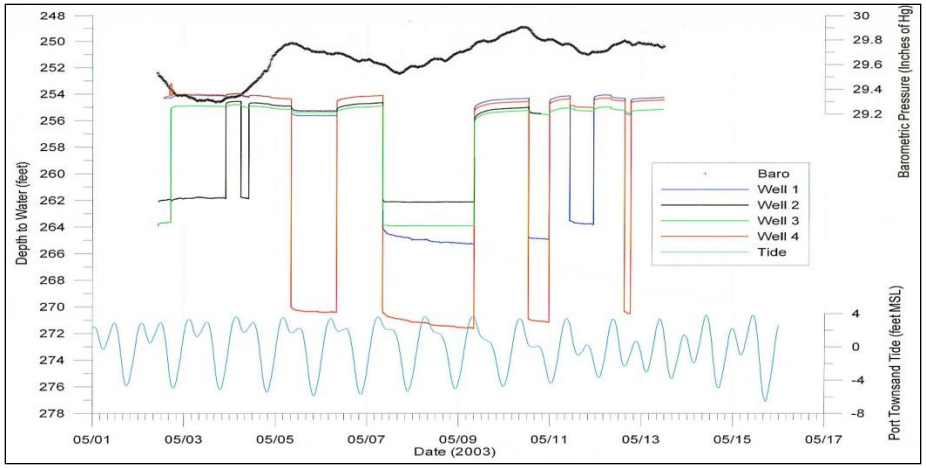
Figure 9.14. Time-drawdown graph for a pumped well (no recharge to aquifer) can be extended to predict drawdown for a period of continuous pumping longer than the test itself.

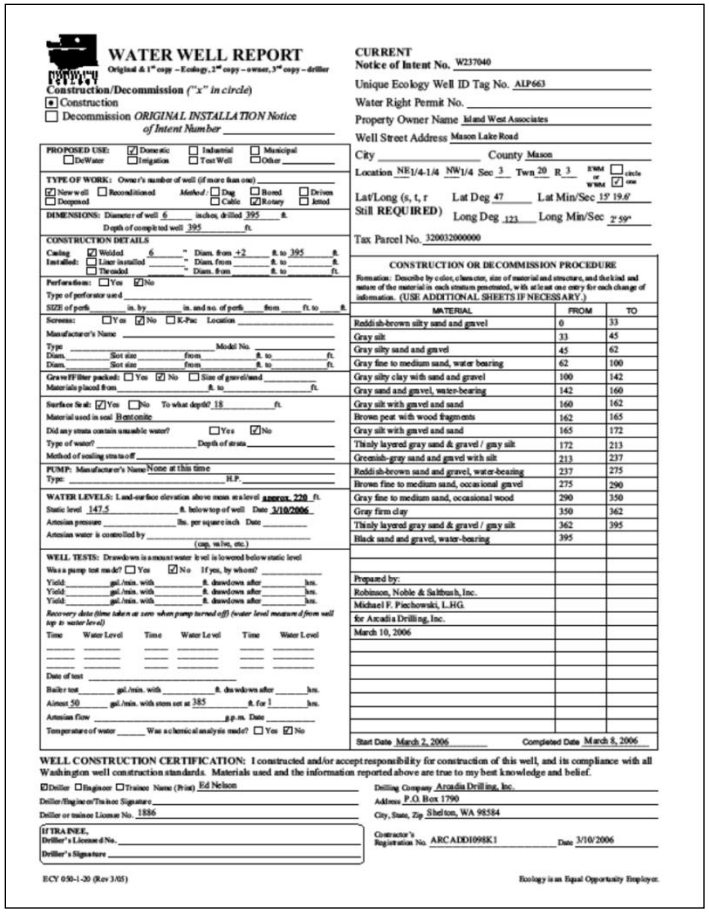
HOW MUCH INFORMATION SHOULD I DELIVER?

Information has value.

Organize what you deliver

3-ring binders work well





WATER WELL REPORT
Original & 1st copy – Ecology, 2nd copy – owner, 3rd copy – driller

CURRENT
Notice of Intent No. W237040
Unique Ecology Well ID Tag No. ALP663
Water Right Permit No.
Property Owner Name Island West Associates
Well Street Address Mason Lake Road
City County Mason
Location NE1/4-1/4 NW1/4 Sec 3 Twn 20 R 3 EWM or WWM (circle one)
Lat/Long (s, t, r Still REQUIRED) Lat Deg 47 Lat Min/Sec 15' 19.6" Long Deg 123 Long Min/Sec 2' 59"
Tax Parcel No. 320032000000

Construction/Decommission ("x" in circle)
(•) Construction
( ) Decommission ORIGINAL INSTALLATION Notice of Intent Number

PROPOSED USE: (•) Domestic ( ) Industrial ( ) Municipal ( ) Dewater ( ) Irrigation ( ) Test Well ( ) Other
TYPE OF WORK: Owner's number of well (if more than one)
(•) New well ( ) Reconditioned Method: ( ) Dug ( ) Bored ( ) Driven ( ) Deepened ( ) Cable (•) Rotary ( ) Jetted
DIMENSIONS: Diameter of well 6 inches, drilled 395 ft. Depth of completed well 395 ft.
CONSTRUCTION DETAILS
Casing: (•) Welded 6" Diam. from +2 ft. to 395 ft.
Installed: ( ) Liner installed " Diam. from ft. to ft.
( ) Threaded " Diam. from ft. to ft.
Perforations: ( ) Yes (•) No
Type of perforator used
SIZE of perfs in. by in. and no. of perfs from ft. to ft.
Screens: ( ) Yes (•) No ( ) K-Pac Location
Manufacturer's Name
Type Model No.
Diam. Slot size from ft. to ft.
Diam. Slot size from ft. to ft.
Gravel/Filter packed: ( ) Yes (•) No Size of gravel/sand
Materials placed from ft. to ft.
Surface Seal: (•) Yes ( ) No To what depth? 18 ft.
Material used in seal Bentonite
Did any strata contain unusable water? ( ) Yes (•) No
Type of water? Depth of strata
Method of sealing strata off
PUMP: Manufacturer's Name None at this time
Type: H.P.
WATER LEVELS: Land-surface elevation above mean sea level approx. 220 ft.
Static level 147.5 ft. below top of well Date 3/10/2006
Artesian pressure lbs. per square inch Date
Artesian water is controlled by (cap, valve, etc.)
WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? ( ) Yes (•) No If yes, by whom?
Yield: gal./min. with ft. drawdown after hrs.
Yield: gal./min. with ft. drawdown after hrs.
Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test
Bailer test gal./min. with ft. drawdown after hrs.
Airest 50 gal./min. with steam set at 385 ft. for 1 hrs.
Artesian flow g.p.m. Date
Temperature of water Was a chemical analysis made? ( ) Yes (•) No

CONSTRUCTION OR DECOMMISSION PROCEDURE
Formation: Describe by color, character, size of material and structure, and thickness and nature of the material in each stratum penetrated, with at least one entry for each change of information. (USE ADDITIONAL SHEETS IF NECESSARY.)

MATERIAL	FROM	TO
Reddish-brown silty sand and gravel	0	33
Gray silt	33	45
Gray silty sand and gravel	45	62
Gray fine to medium sand, water bearing	62	100
Gray silty clay with sand and gravel	100	142
Gray sand and gravel, water-bearing	142	160
Gray silt with gravel and sand	160	162
Brown peat with wood fragments	162	165
Gray silt with gravel and sand	165	172
Thinly layered gray sand & gravel / gray silt	172	213
Greenish-gray sand and gravel with silt	213	237
Reddish-brown sand and gravel, water-bearing	237	275
Brown fine to medium sand, occasional gravel	275	290
Gray fine to medium sand, occasional wood	290	350
Gray firm clay	350	362
Thinly layered gray sand & gravel / gray silt	362	395
Black sand and gravel, water-bearing	395	

Prepared by:
Robinson, Noble & Saltbush, Inc.
Michael F. Piechowski, L.HG.
for Arcadia Drilling, Inc.
March 10, 2006

Start Date March 2, 2006 Completed Date March 8, 2006

WELL CONSTRUCTION CERTIFICATION: I constructed and/or accept responsibility for construction of this well, and its compliance with all Washington well construction standards. Materials used and the information reported above are true to my best knowledge and belief.
(•) Driller ( ) Engineer ( ) Trainee Name (Print) Ed Nelson
Driller/Engineer/Trainee Signature
Driller or trainee License No. 1886
Drilling Company Arcadia Drilling, Inc.
Address P.O. Box 1790
City, State, Zip Shelton, WA 98584
IF TRAINEE, Driller's License No. Driller's Signature
Contractor's Registration No. ARCADDI098K1 Date 3/10/2006

ECY 050-1-20 (Rev 3/05) Ecology is an Equal Opportunity Employer

CLIENTS OPERATION OF THE WELL

SECTIONS OF THE INFO PACKAGE

Well Operations section

Well construction report, screen info, development records, testing data, use recommendations

Pump Information section

Pump recommendations or description of equipment installed, electrical info, max allowable drawdown, probes & settings

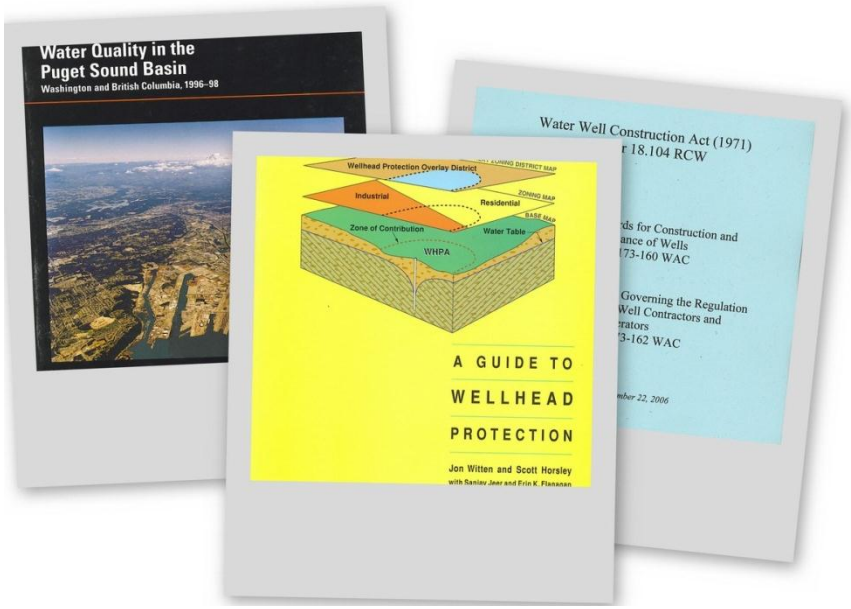
Water level info and directions for measurement

Info for regulatory agencies

CLIENTS REGULATORY NEEDS & DEFINITION OF PROPERTY

Provide information needed to:

- Demonstrate siting compliance
- Meet regulatory submittal needs
- Support wellhead protection planning
- Meet health department requirements



SUMMARY

Before you quote the job, do the whole job in your head.

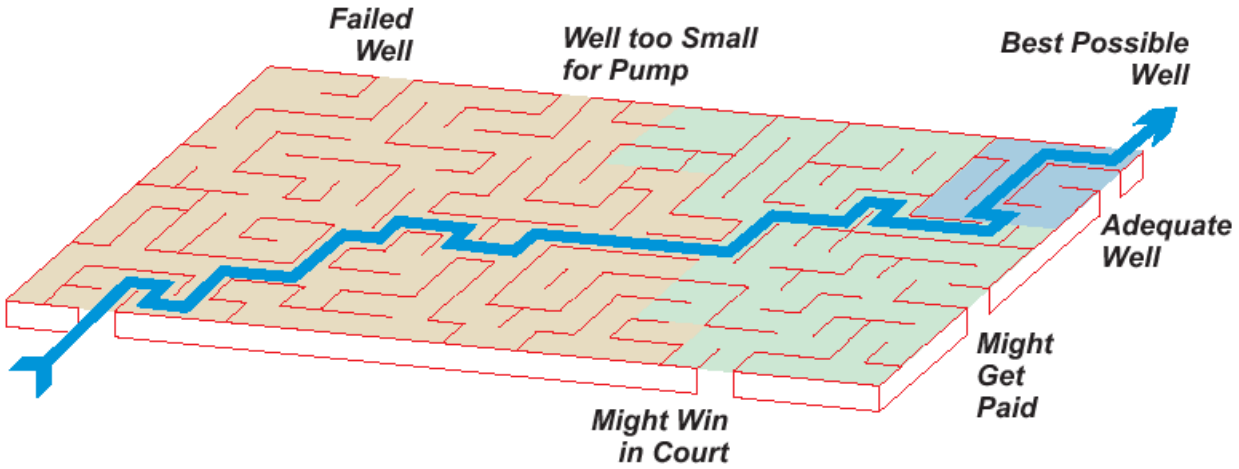
Drill as much of the aquifer as is practical.

Design the well for maximum efficiency.

Develop the well until it is done.

Test the well sufficiently and report it all in writing

GOOD DECISIONS MAKE GOOD WELLS
THE WORLD IS WET - LIFE IS SWEET



Best possible well

Happiest possible customer

Strongest possible business

Contact Information

Thank you for the opportunity and the honor
of addressing you as the
2008 McEllhiney Distinguished Lecturer

Mike Krautkramer

mkrautkramer@robinson-noble.com

National Ground Water Research and Educational Foundation

Your vital and integral resource for ground water's future

Established in 1994, the National Ground Water Research and Educational Foundation is operated by the National Ground Water Association as a 501(c)(3) public foundation and is focused on conducting educational, research, and other charitable activities related to a broader public understanding of ground water.

The Foundation is an arm of NGWA that is focused on activities related to a broader understanding of ground water.

National Ground Water Research and Educational Foundation

For more information visit us on the web at www.ngwa.org or write us at the below address.

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