



Chapman
Engineering

Thank you, Corpus Christi! (5/19/15)

**External Corrosion Control:
Publicly Available Soils Data
And Geology Info
to Consider
(Especially About Chlorides!)**

Cal Chapman, P. E.

Model Law Engineer #35248 through
National Council of Examiners for Engineering & Surveying;
NACE-Certified Cathodic Protection Specialist #23357
cal@chapmanengr.com
P. E. in Texas, New Mexico, Oklahoma, North Dakota

Outline

- External Corrosion Control Overview
- Soil Properties That Affect External Corrosion
- Good Sources for Soil Data
- Units of measure for resistivity/conductivity
- Shallow Geology research
 - Statewide surface geology mapping
 - Water well reports available through web databases
 - Other regional/local geology reports to review
 - Developing geology understanding/cross-sections
- Practical applications of these tools
 - Design of deep anode beds
 - Estimates of current “reach” for long structures
 - Chloride – why is it so bad?

What We Don't Want:

- You see a "60 Minutes" team waiting at your office when you pull up;
- You turn on the news and they are displaying emergency routes out of the city;
- Your twin sister forgets your birthday;
- You want to put on the clothes you wore home from the party, and there aren't any;
- Your horn goes off accidentally and remains stuck, as you follow a group of Hell's Angels on the freeway . . .



Corrosion Engineering – Basic DC Electricity

- **Ohm's Law (ALWAYS true for DC):**
- **Voltage = Current x Resistance**
- **or $V = I \times R$**

If we can measure voltage and current, we can determine resistance of a circuit by “doing the math.”

Or measure voltage and resistance – then you determine the current flowing.



Corrosion Engineering – Basic DC Electricity

- Voltage in volts (V); current measured in amperes (amps or A); resistance measured in ohms (Ω).
- If one amp of DC current flows through and off of a steel or ductile iron (DI) structure **for one year**, how much metal loss occurs in that year?
 - A) 21 ounces
 - B) 21 grams
 - C) 21 pounds
- What's your pick? Keep in mind that one amp is equal to the flow of 6.24151×10^{18} electrons in every second!



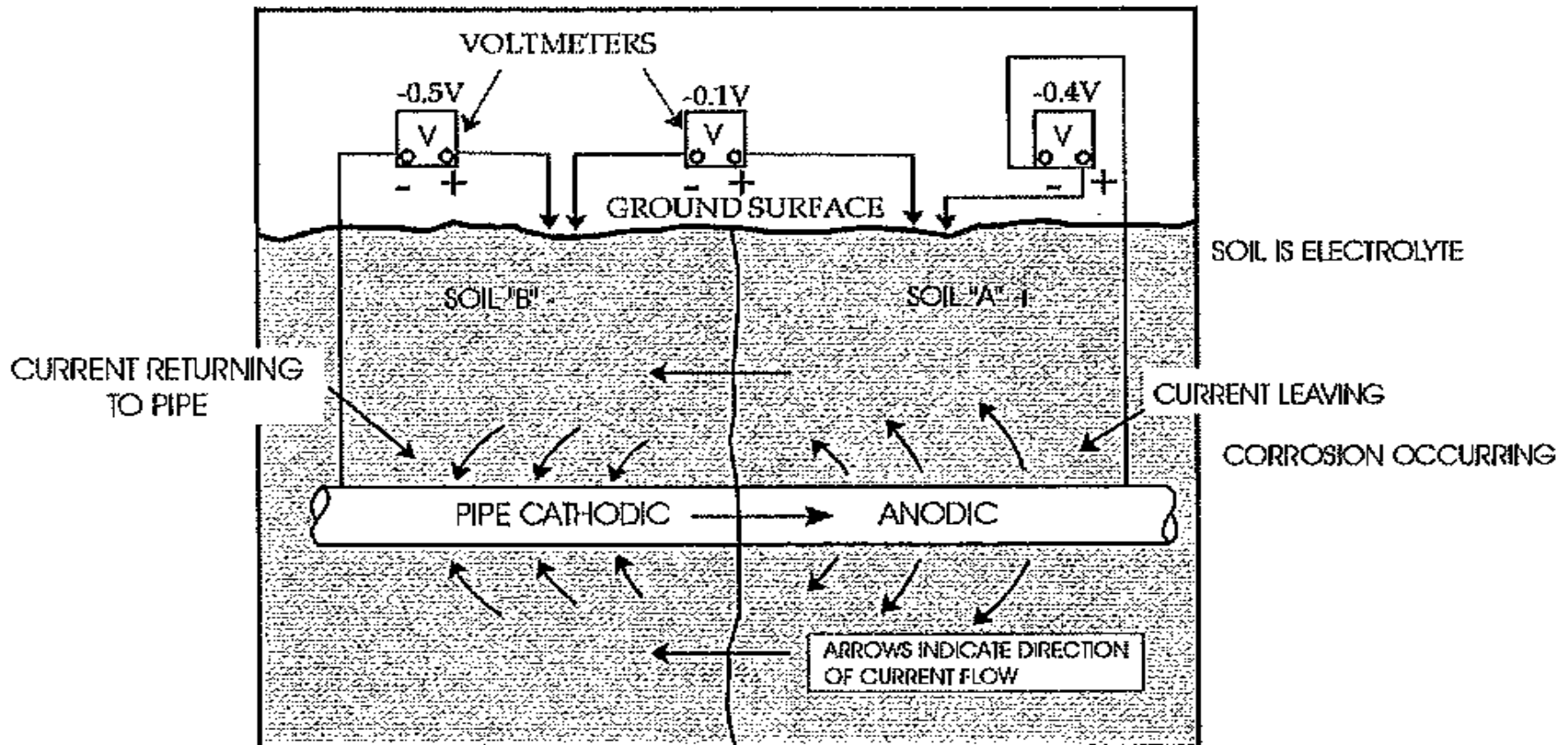
Chapman
Engineering

Corrosion Cell Defined

Corrosion of a metal **WILL OCCUR** if you have four elements present:

- Cathode
- Anode
- Metallic Path Connecting the Cathode and the Anode
- Electrolyte Contacting Both Cathode and Anode (completing the electrical circuit)

Pipe in a Soil Electrolyte – A Complete Corrosion Cell by itself



From Control of Pipeline Corrosion, Peabody, pg. 6, Figure 2-2

Driving voltage? (Steel to soil Δ often about 0.5 V.)



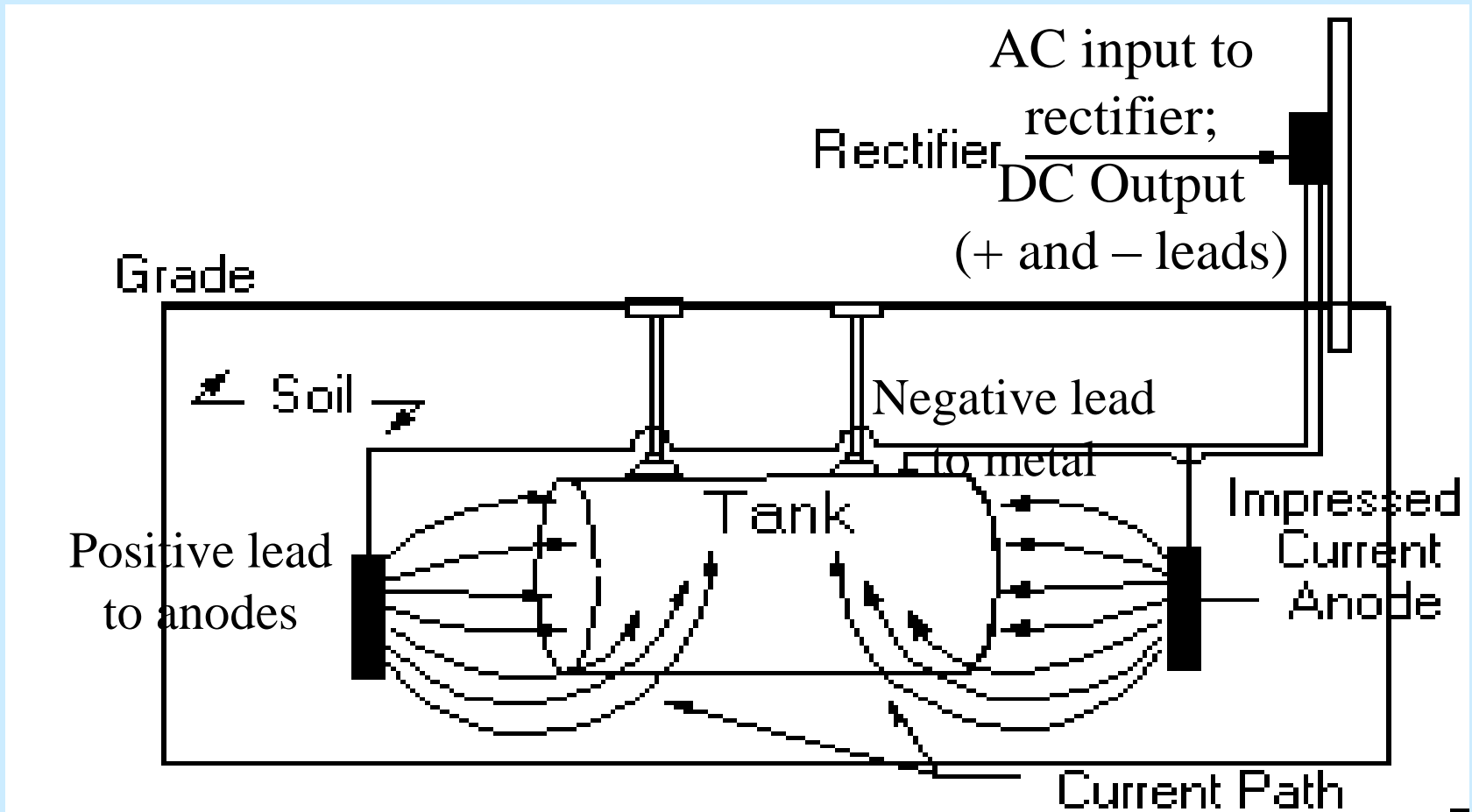
Chapman
Engineering

Corrosion Protection – Two Elements

-
- **First level of corrosion protection is Coatings** – DON'T expose metal surface to electrolyte – really, to the environment.
 - **Second level of corrosion protection is Cathodic Protection** – using ANODES to produce protective current that is applied to the metal you want to save!



Impressed-Current System for CP



Soil Properties & External Corrosion Control – Data?

- ❑ Thanks to subsurface environmental assessment work over time, we amassed and used a collection of county-based soil survey books.
- ❑ Books were produced by U. S. Dept. of Agriculture, Soil Conservation Service (later called Natural Resource Conservation Service [NRCS]).
- ❑ Original purpose of books was mainly agriculture: what could you grow in these soils? Were they good in other uses? (Septic systems, fill material, building foundation, for instance?)

What Soil Properties Matter?

What soil properties are “in play” for external corrosion of pipelines, bulk storage tank bottoms, other metal?

- Resistivity (or inverse, conductivity)
- Ion content (especially chloride, sodium, sulfate)
- Moisture content – Water’s EVERYWHERE!

From Corrosion & Corrosion Control, Uhlig & Revie, pg. 178, “soil conditions for iron and steel [are like] submerged conditions.”

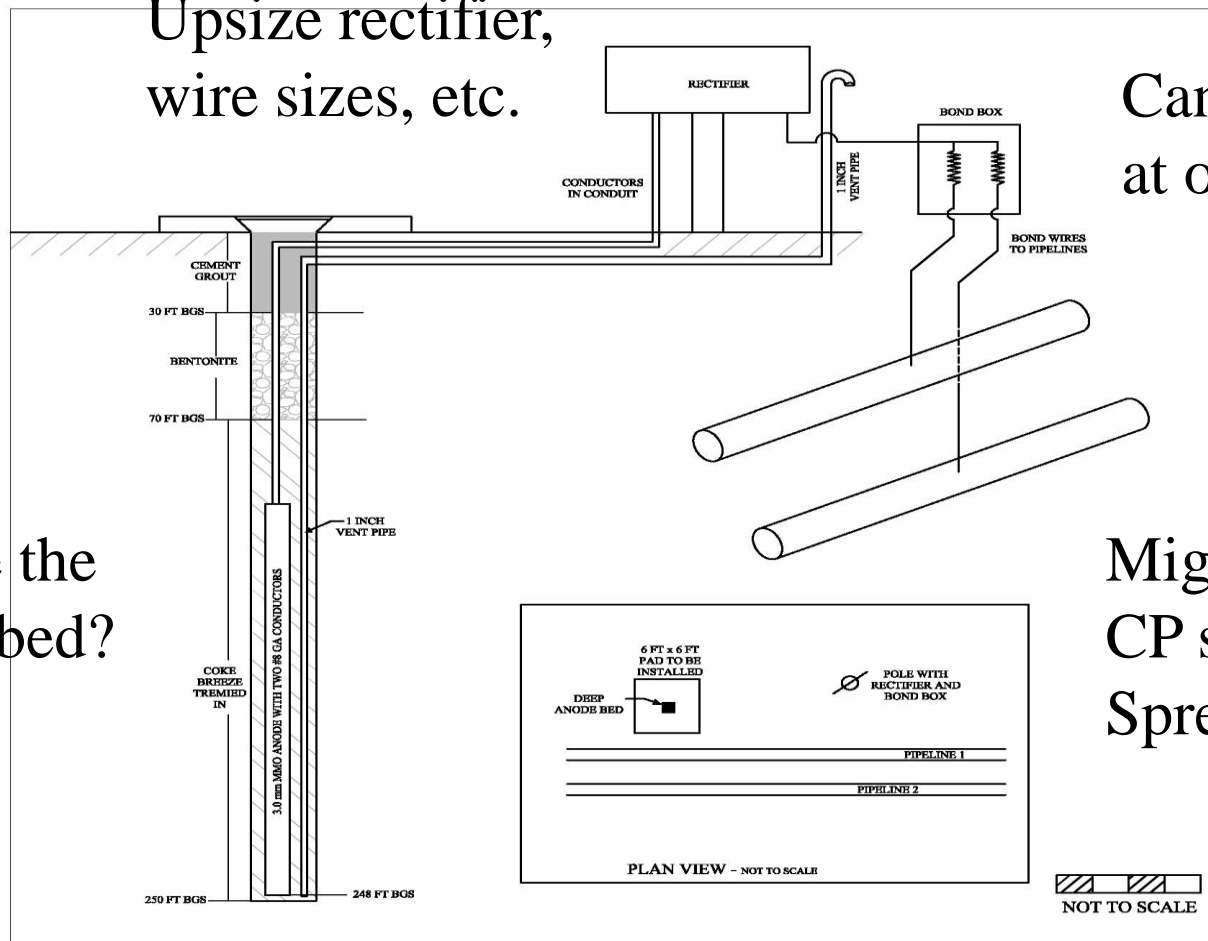
➤ Also SAR, pH, particle sizes, organic carbon/matter, permeability for water, soil type transitions . . .

CP System for Pipelines – what is Current Demand?

- Typical soils might require 20-amp system;
- High-chloride, low-resistivity soils might need 60!

Upsize rectifier,
wire sizes, etc.

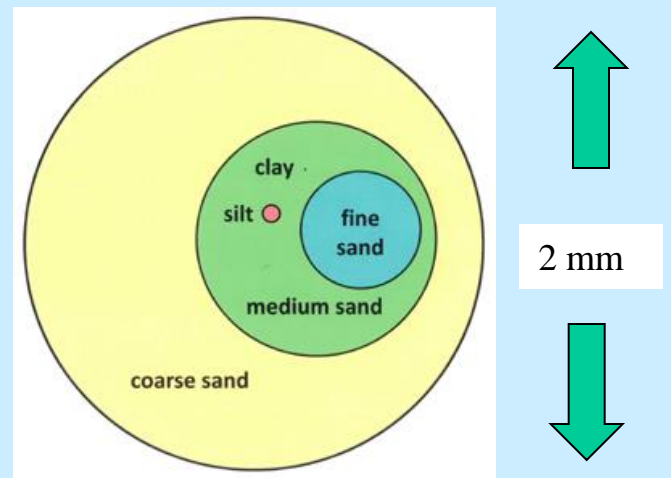
Can you bond
at one point?



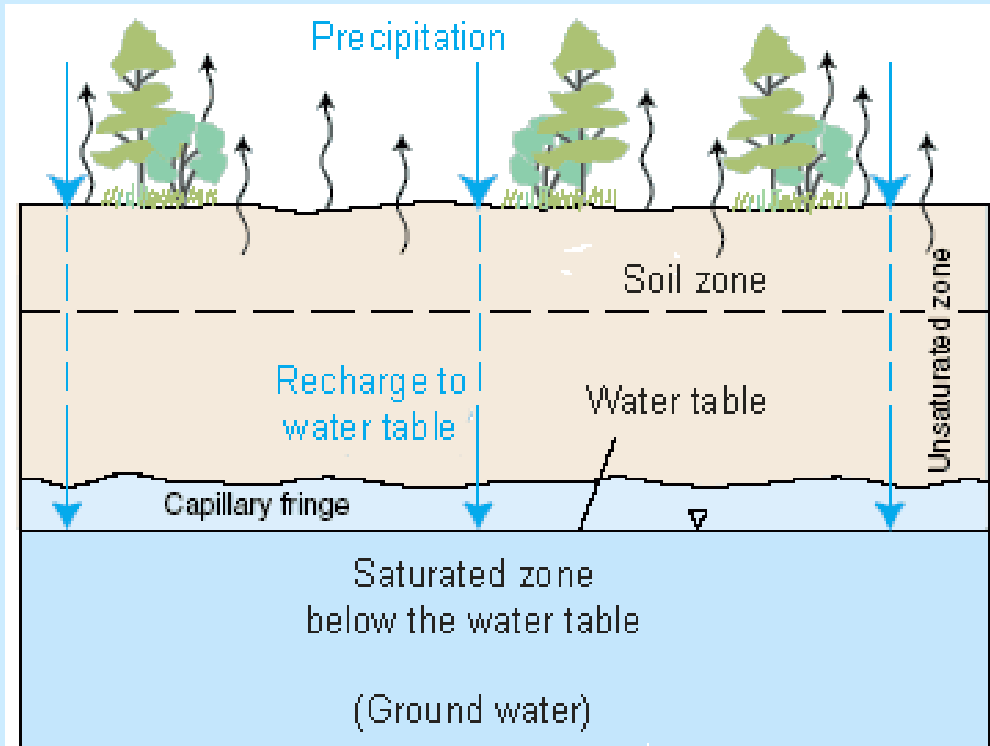
Upsize the
anode bed?

Might need more
CP systems!
Spread them out!

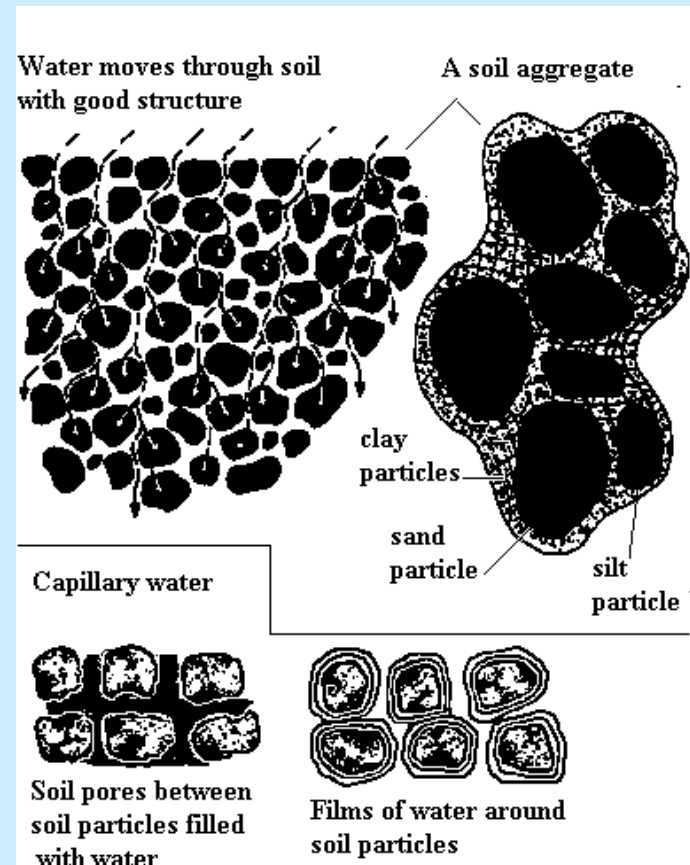
Soil as the Electrolyte – What's the make-up?



<http://www.ext.colostate.edu/mg/gardennotes/213.html>



<http://water.usgs.gov/edu/watercyclegwstorage.html>



http://www.uq.edu.au/_School_Science_Lessons/Soils.html

Electrolyte in the Environment – Always Water with Soil! And What Else?

- **Soil and moisture make the electrolyte touching pipelines, tank bottoms, other metallic structures below grade;**
- **How good an electrical conductor is the soil?
Depends on ion contents, grain sizes and particle “mixes,” plus organic contents;**
- **Electrical resistivity is a broad measure of soil character, relating resistance to current flow.**

USDA Web Soil Survey & Older County- by-County Books

U. S. Department of Agriculture has given us an incredible suite of info regarding soils;

One fantastic program is comprehensive “soil science” studies across the U. S., from the 1950’s through the ‘80’s. Done mainly for better agricultural management and increasing food production . . .

It represents an incredible tool box!!!

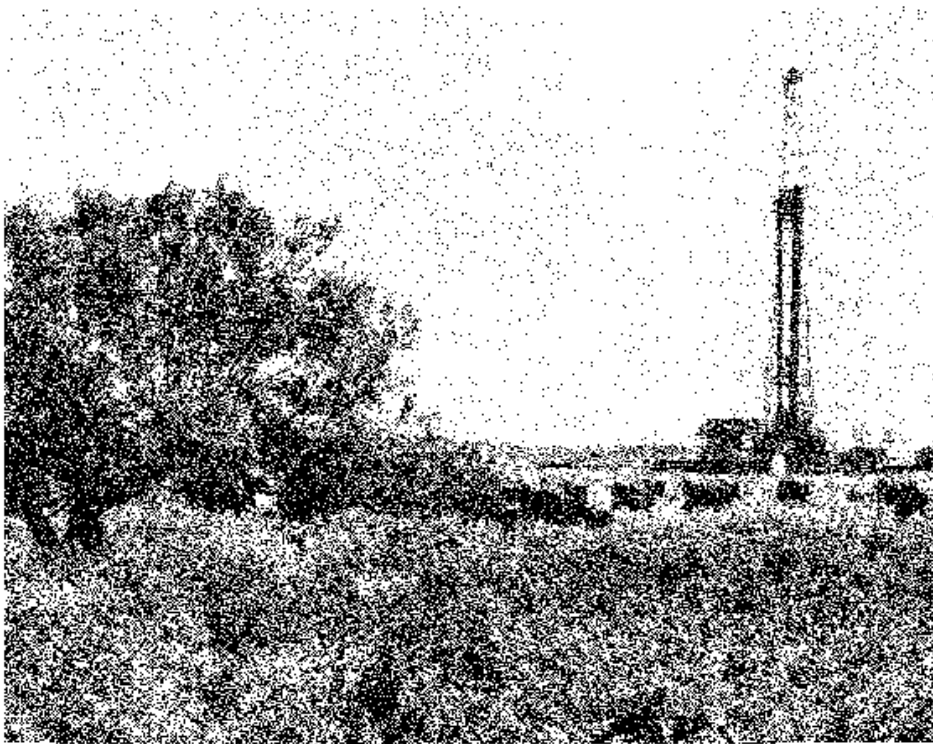


United States
Department of
Agriculture

Soil
Conservation
Service

In cooperation with
Texas Agricultural
Experiment Station

Soil Survey of Webb County, Texas



Soil Survey Book Example

(published in 1984
for the Laredo, Texas
area)



United States
Department of
Agriculture

Soil
Conservation
Service

In cooperation with
North Dakota Agricultural
Experiment Station, North
Dakota Cooperative
Extension Service, North
Dakota State Soil
Conservation Committee,
and United States
Department of the
Interior, Bureau of Indian
Affairs

Soil Survey of Mountrail County, North Dakota

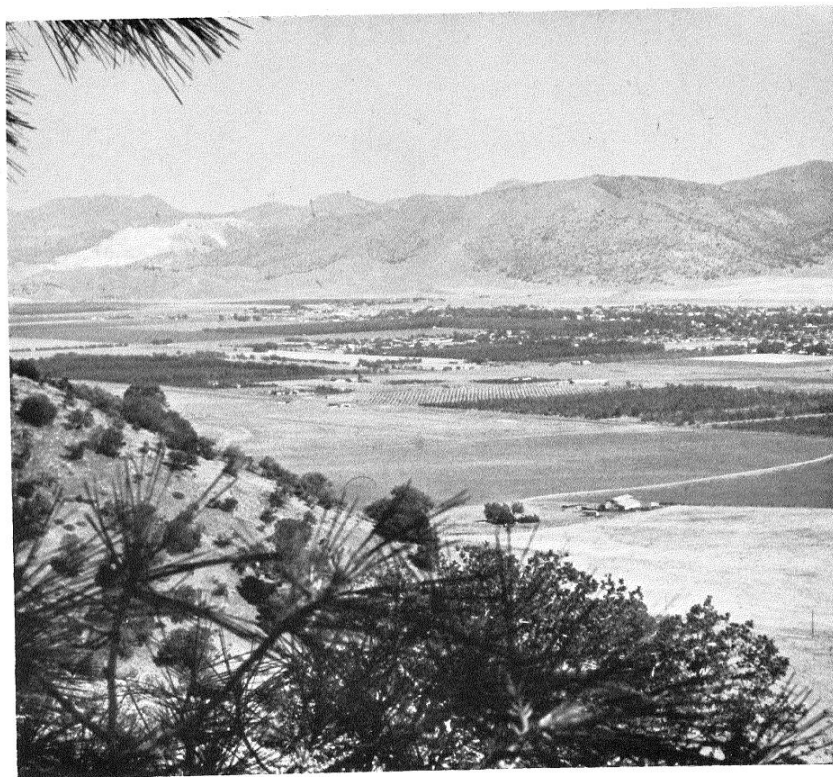


Another Soil Survey Book Example

(issued June 1991 for
the Stanley, North
Dakota area – northeast
quadrant of the Bakken
Fields in ND)

Soil Survey of

**KERN COUNTY
CALIFORNIA
SOUTHEASTERN PART**



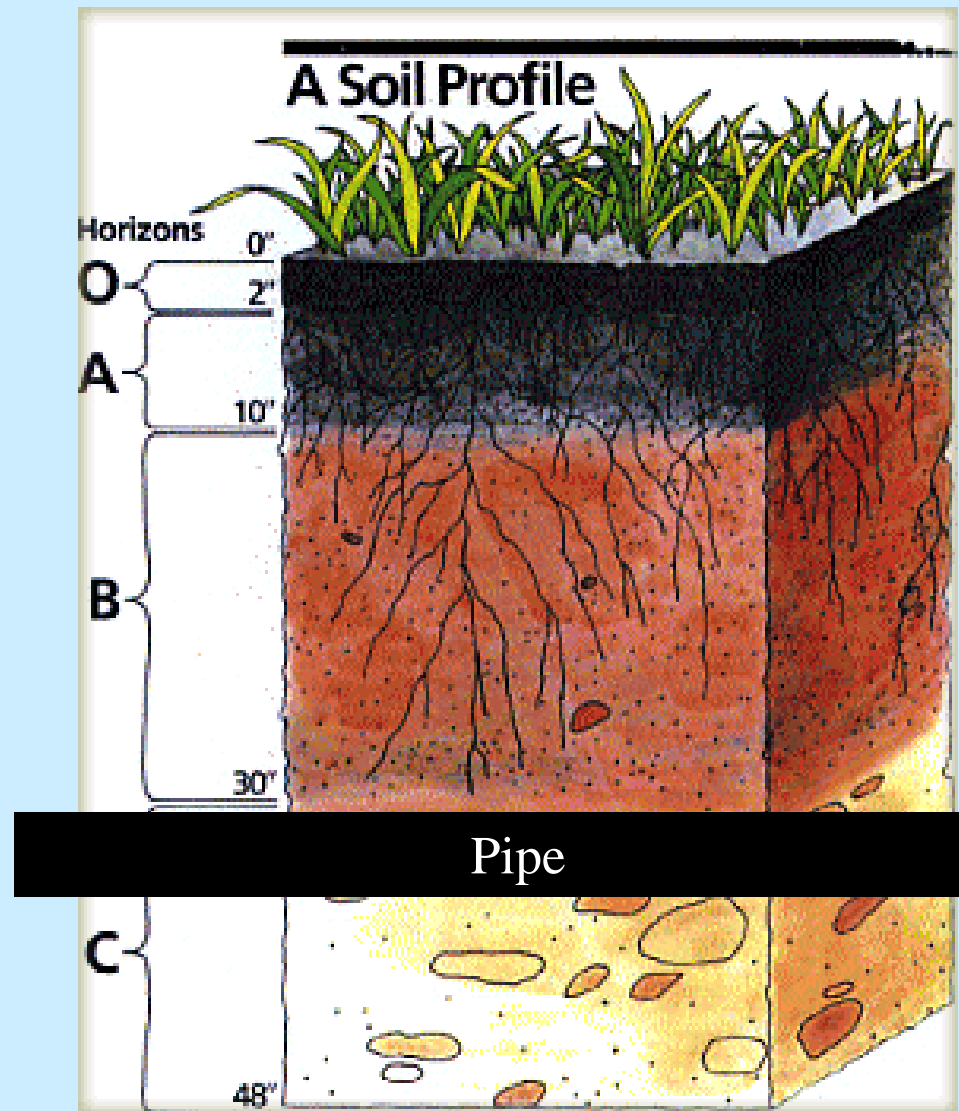
United States Department of Agriculture, Soil Conservation Service,
in cooperation with University of California, Agricultural Experiment Station

**And One
More**

(one of four parts for
Kern County,
California, issued in
September 1981 –
Bakersfield general
area)

Soil “Horizons” Change With Depth

- “O” horizon rich in organisms, roots, vegetative debris (“top soil” with A);
- “A” horizon rich in roots and organic material;
- “B” horizon has less roots, less air recharge, more CO₂, some methane (CH₄);
- “C” horizon more like geology below, very little organic activity, low oxygen.

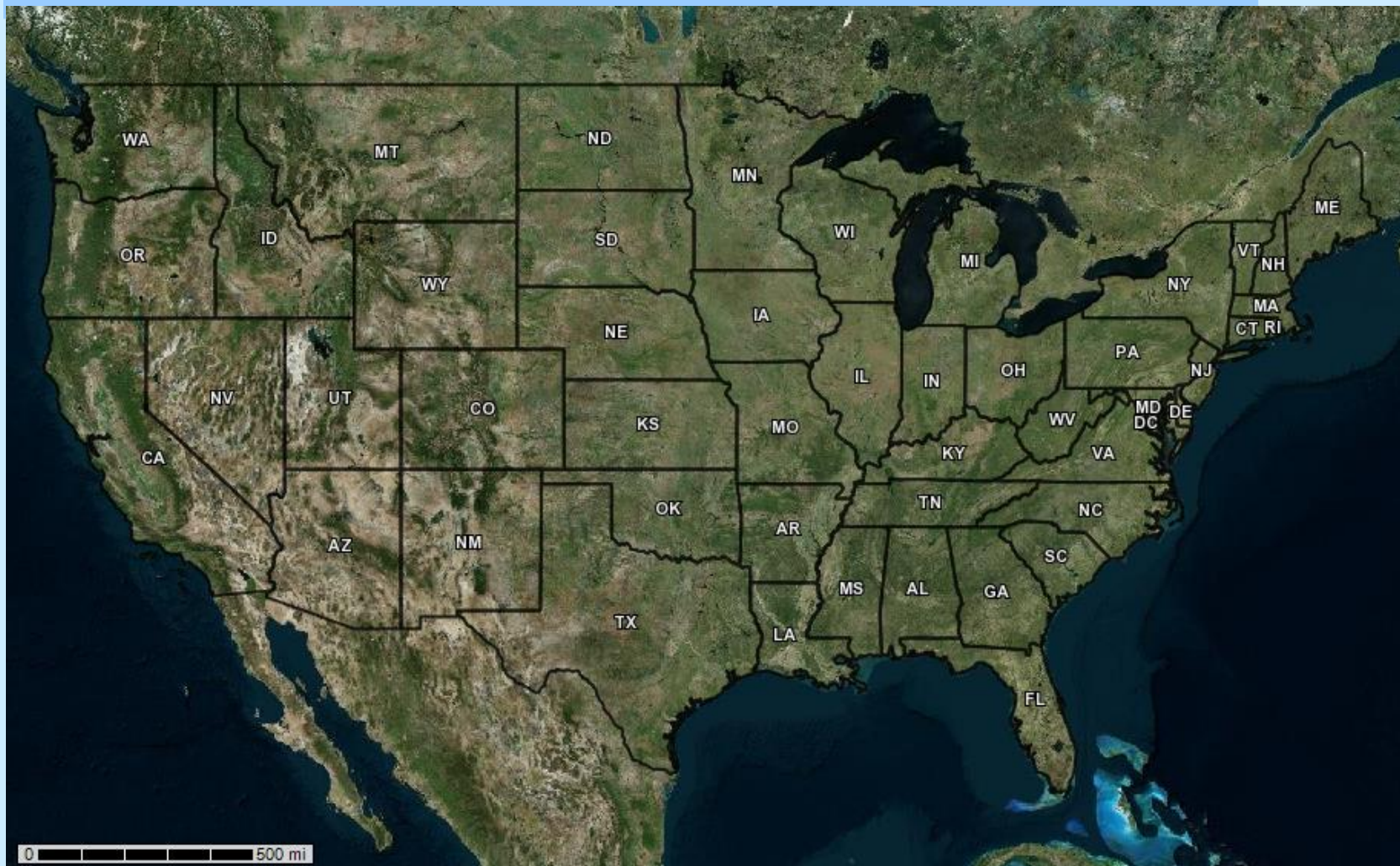


<http://www.terrapsych.com/ecology.html>

They change with other factors, too.

Web Soil Survey

<http://websoilsurvey.sc.egov.usda.gov/App/WebSoilSurvey.aspx>



U. S. Web Soil Survey

- **Look up your geography of interest – yes, Alaska and Hawaii are included.**
- **It's good to start with a broader area, and then “hone in” on smaller sections. Then look at individual soil types, one at a time, and check some of the specific properties.**
- **Must set the “area of interest” to less than 100,000 acres at a time.**
- **We always want general soil description – fractions of gravel, sand, silt, clay, rock shards. How thick is soil column, for what was measured? Often goes to 60 inches, may go to 84 or 96 inches. That covers a lot of pipeline burial horizons!**

Web Soil Survey Search Example



[Contact Us](#) |
 [Subscribe](#) |
 [Archived Soil Surveys](#) |
 [Soil Survey Status](#) |
 [Glossary](#) |
 [Preferences](#) |
 [Link](#) |
 [Logout](#) |
 [Help](#)

A A A

[Area of Interest \(AOI\)](#) |
 [Soil Map](#) |
 [Soil Data Explorer](#) |
 [Download Soils Data](#) |
 [Shopping Cart \(Free\)](#)

[Printable Version](#) |
 [Add to Shopping Cart](#)

Search

Map Unit Legend

Kern County, California, Northwestern Part (CA666)

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
196	Milham sandy loam, 0 to 2 percent slopes MLRA 17	647.2	35.0%
211	Panoche clay loam, 0 to 2 percent slopes	1,197.8	64.7%
257	Water	4.9	0.3%
Totals for Area of Interest		1,849.9	100.0%

Soil Map



Kern County, California, Northwestern Part

196—Milham sandy loam, 0 to 2 percent slopes MLRA 17

Map Unit Setting

Elevation: 200 to 1,200 feet

Mean annual precipitation: 5 to 8 inches

Mean annual air temperature: 63 to 65 degrees F

Frost-free period: 250 to 300 days

Map Unit Composition

Milham and similar soils: 85 percent

Minor components: 15 percent

Description of Milham

Setting

Landform: Fan remnants, plains, terraces, alluvial fans

Landform position (three-dimensional): Tread, rise

Down-slope shape: Linear

Across-slope shape: Linear

Parent material: Alluvium derived from igneous and sedimentary rock

Typical profile

Ap - 0 to 4 inches: sandy loam

Bk - 4 to 10 inches: sandy loam

Btk1 - 10 to 22 inches: loam

Btk2 - 22 to 49 inches: clay loam

2Ck - 49 to 60 inches: sandy loam

Properties and qualities

Slope: 0 to 2 percent

Depth to restrictive feature: More than 80 inches

Natural drainage class: Well drained

Capacity of the most limiting layer to transmit water (Ksat):

Moderately high (0.20 to 0.60 in/hr)

Depth to water table: More than 80 inches

Frequency of flooding: Rare

Frequency of ponding: None

Calcium carbonate, maximum in profile: 10 percent

Gypsum, maximum in profile: 1 percent

Salinity, maximum in profile: Nonsaline to slightly saline (0.0 to 8.0 mmhos/cm)

Sodium adsorption ratio, maximum in profile: 25.0

Available water storage in profile: High (about 9.1 inches)

Interpretive groups

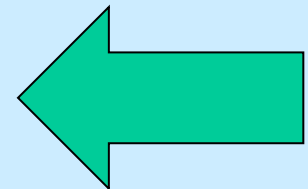
Farmland classification: Prime farmland if irrigated

Land capability classification (irrigated): 1

Land capability classification (nonirrigated): 7c

Hydrologic Soil Group: C

Soil of
Interest
(represents
about 35% of
study area)

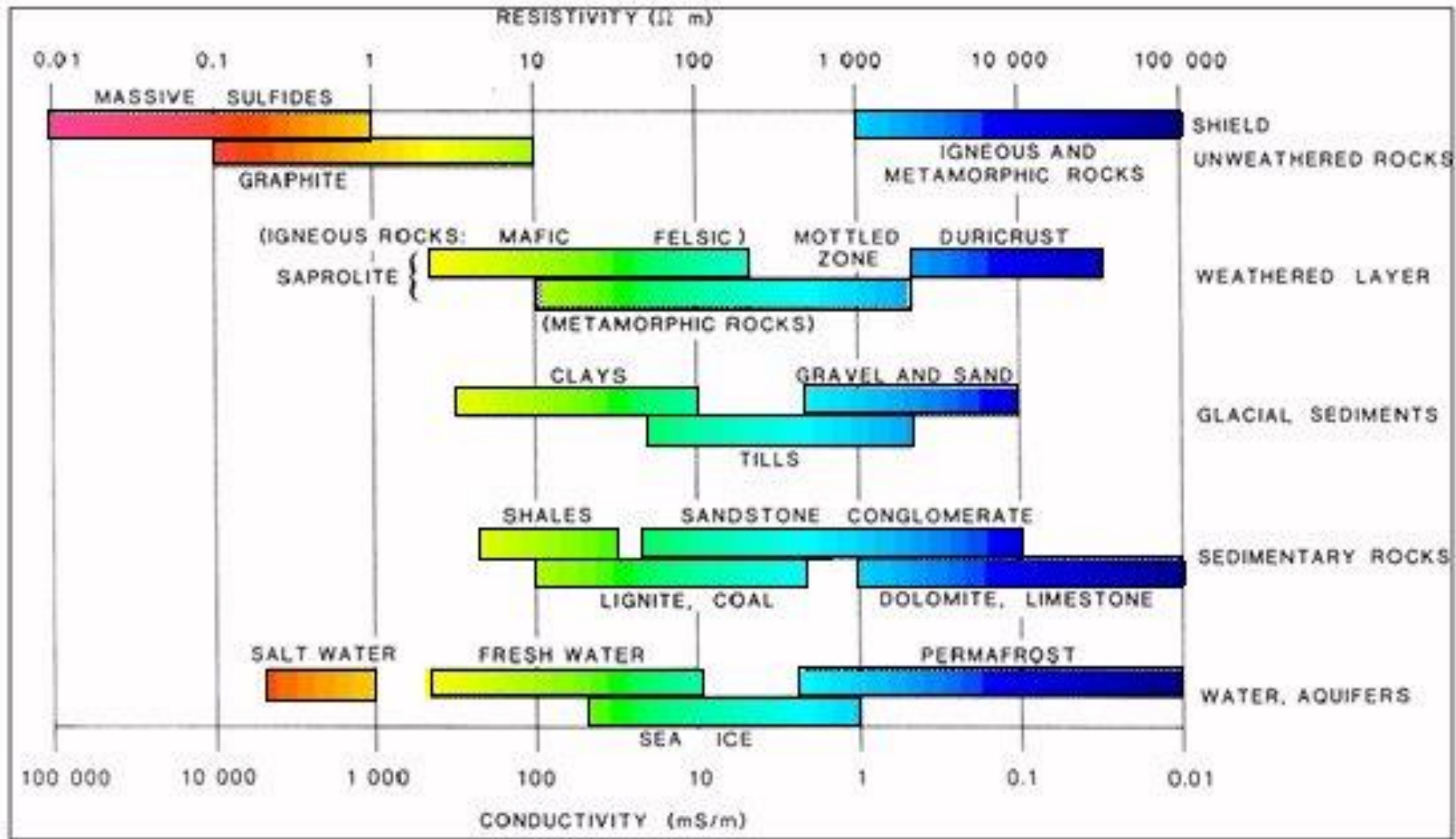


Units for Conductivity

On Web Soil Survey – Electrical conductivity described in either “milli-mhos per centimeter” (mmho/cm), or “deci-Siemens per meter” (dS/m).

- One Siemen (S) is equal to 1/ohm (or Ω^{-1}).
- One millimho is equal to 1,000 ohms.
- It turns out that one dS/m is the same as one mmho/cm – they are equivalent.

Soil Resistivity ($\Omega\text{-m}$) and Conductivity (mS/m)



Soil Electrical Conductivity

On WSS – often, a soil conductivity is given as 4 to 32 mmho/cm, a wide range. Simple conversion: Divide 1,000 ohm-cm by the conductivity number in dS/m or mmho/cm:

- Soil with 4 mmho/cm: $1,000/4 = 250$ ohm-cm – very low.
- Soil with 32 mmho/cm is 67 ohm-cm for ρ – bad news!
(Sea water is 20 to 35 ohm-cm resistivity.)

From San Diego State University write-up accompanying chart on slide above this:

“Water is the most important variable in hydrologic resistivity studies because the solid rock matrix or soil grains are comparatively very good insulators. Consequently, the ions dissolved in water are the electric charge carriers responsible for the bulk material’s ability to conduct electricity. This is true for both "clean" (clay-free) and "shaly" (clay-rich) formations . . .”

Resistivity/Conductivity Factors in Soils

- **High Chloride (or other ion) concentrations in shallow soils** – Used to be “ocean-front” property or shallow sea-bed. “Native” salt leads to free Cl^- (and Na^+) ions, which greatly accelerate steel corrosion rates. Other minerals? May be gypsum (hydrated CaSO_4), epsomite (epsom salts or MgSO_4), and calcium carbonate (CaCO_3).
- ρ for sandy loams is often 1,500-5,000 ohm-cm. In South and West Texas, parts of California, and much of American Southwest, we commonly find 100 to 300 ohm-cm clayey, salty soils. Low electrical resistivity (ρ) means high electrical conductivity.

What happens to current requirement?

On WSS & in soil books – Lowest conductivity often stated as “< 2 mmho/cm” – call that a soil resistivity of “>500 ohm-cm.”

What if driving voltage is 0.5 V? For ρ of 1,000 ohm-cm, assign a current demand of 1 mA/sq ft of exposed steel (some say 2.5 mA/sf) for typical CP design.

But if ρ goes to 250 ohm-cm (4 dS/m conductivity), what happens to I demand? **Goes to 4 mA/sq ft, not 1! (Or to 10 mA/sf, from the 2.5!)**

There are soils with conductivity of 32 mmho/cm!

Multiply again by EIGHT!

Another concern: Sodium Ion and “Sodium Adsorption Ratio” (SAR)

When chloride counts are high, sodium ion is, too. Naturally occurring salt –

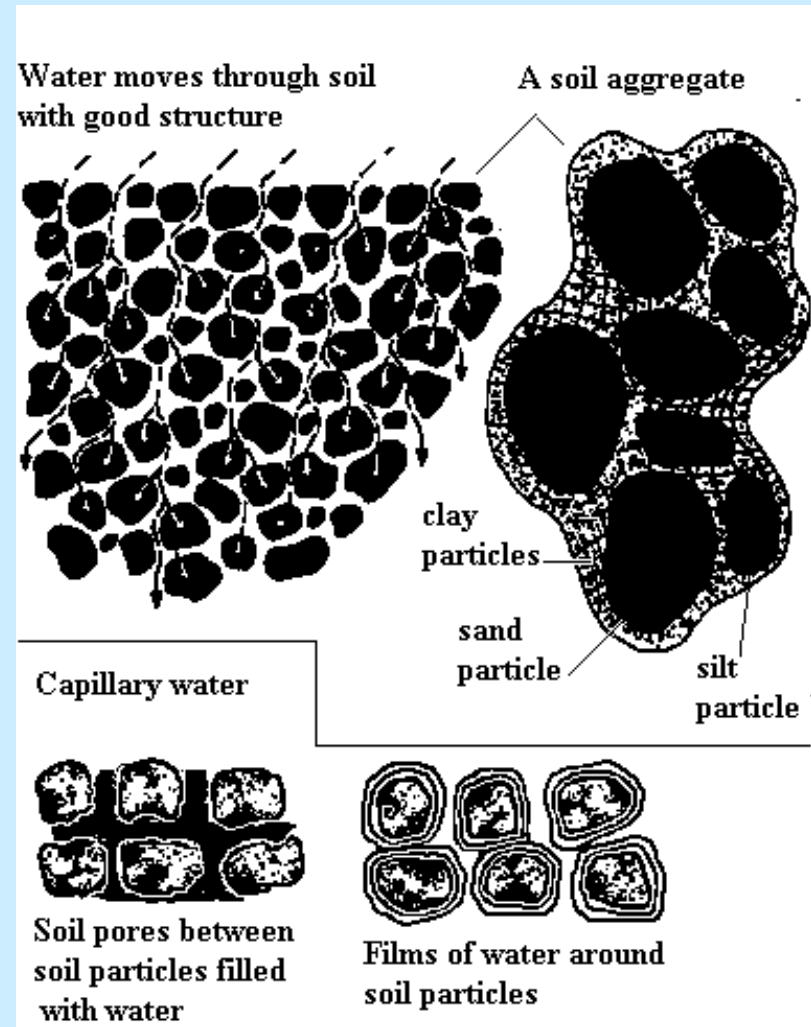
Sodium ion breaks down soil particles, making them much finer. Soils then compact and “plug up.” Rainfall does not percolate in; soil “health” is badly compromised.

When you check soil parameters, check for “sodium adsorption ratio” (SAR) above 9. If it is, you have very compacted surface soils (due to sodium’s compacting mechanism).

This may lead you to think resistivities are very high – but they’re not. Instead, soil moisture may be very low in shallow zone. Surface is crusted, dry and hard to break through.

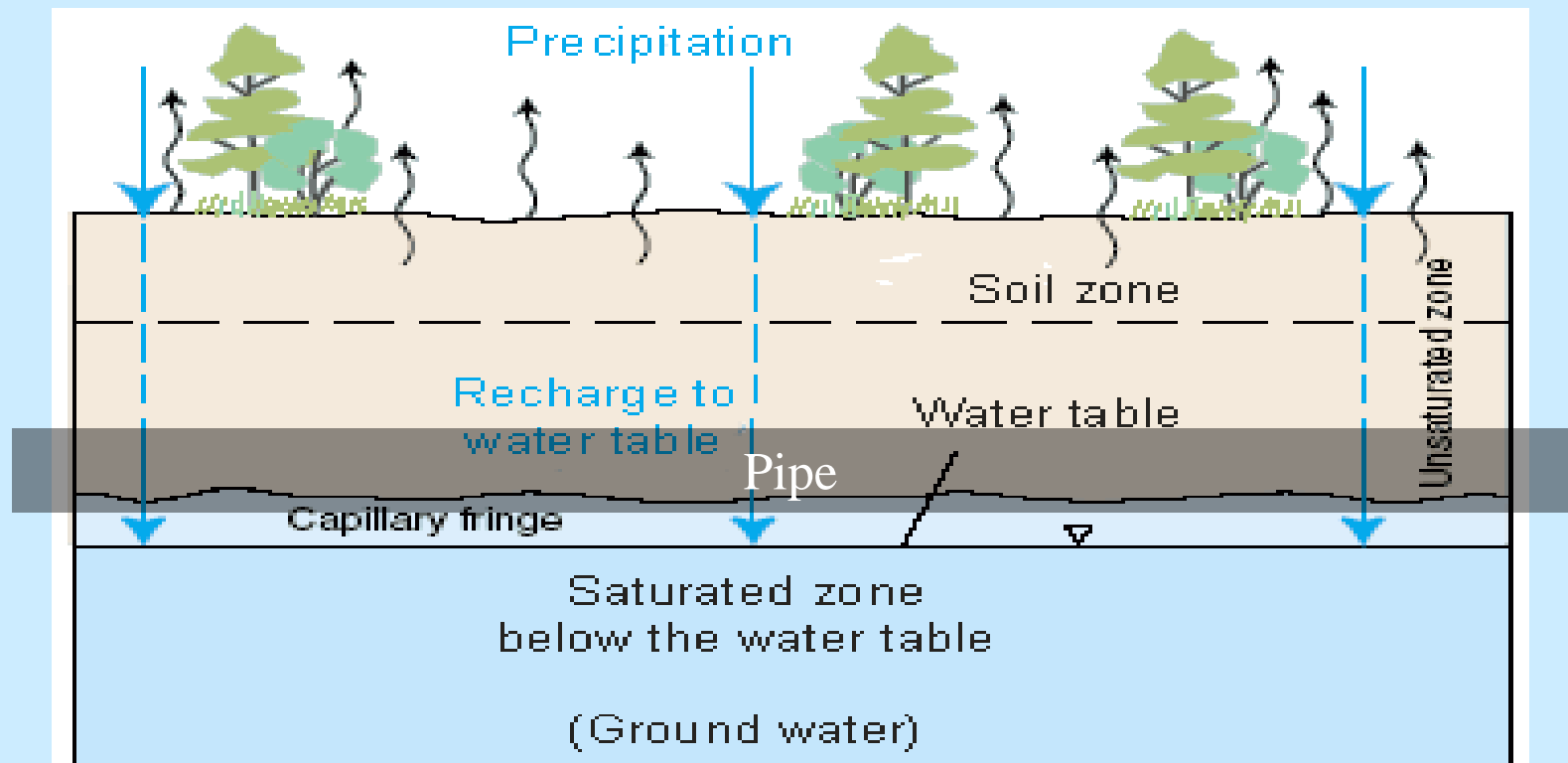
Soil as the Electrolyte – Look at Water Content!

- **Dry soils often still have 10 to 20 percent moisture by weight!**
- **Say one cubic yard of dirt weighs 2,800 pounds, in place. 20-percent moisture means 560 pounds of water! Every soil particle is “wetted” by that water – so the “continuous” water path, WITH IONS IN SOLUTION, is the current flow path.**
- **Some of this water is tied up in chemisorbed bonds; some is free.**



Soil Properties – Look at Microbes, O₂, CO₂

- **If soils appear good for agriculture, they probably host a lot of aerobic microbes. Great Plains root zones may go to 15 feet!**
- **If soils appear compacted, and plants have a hard time growing, then there is little root zone activity. May be anaerobic conditions present around the pipeline.**





Chapman
Engineering

Costs of Corrosion Protection



Shallow Geology Info Available?

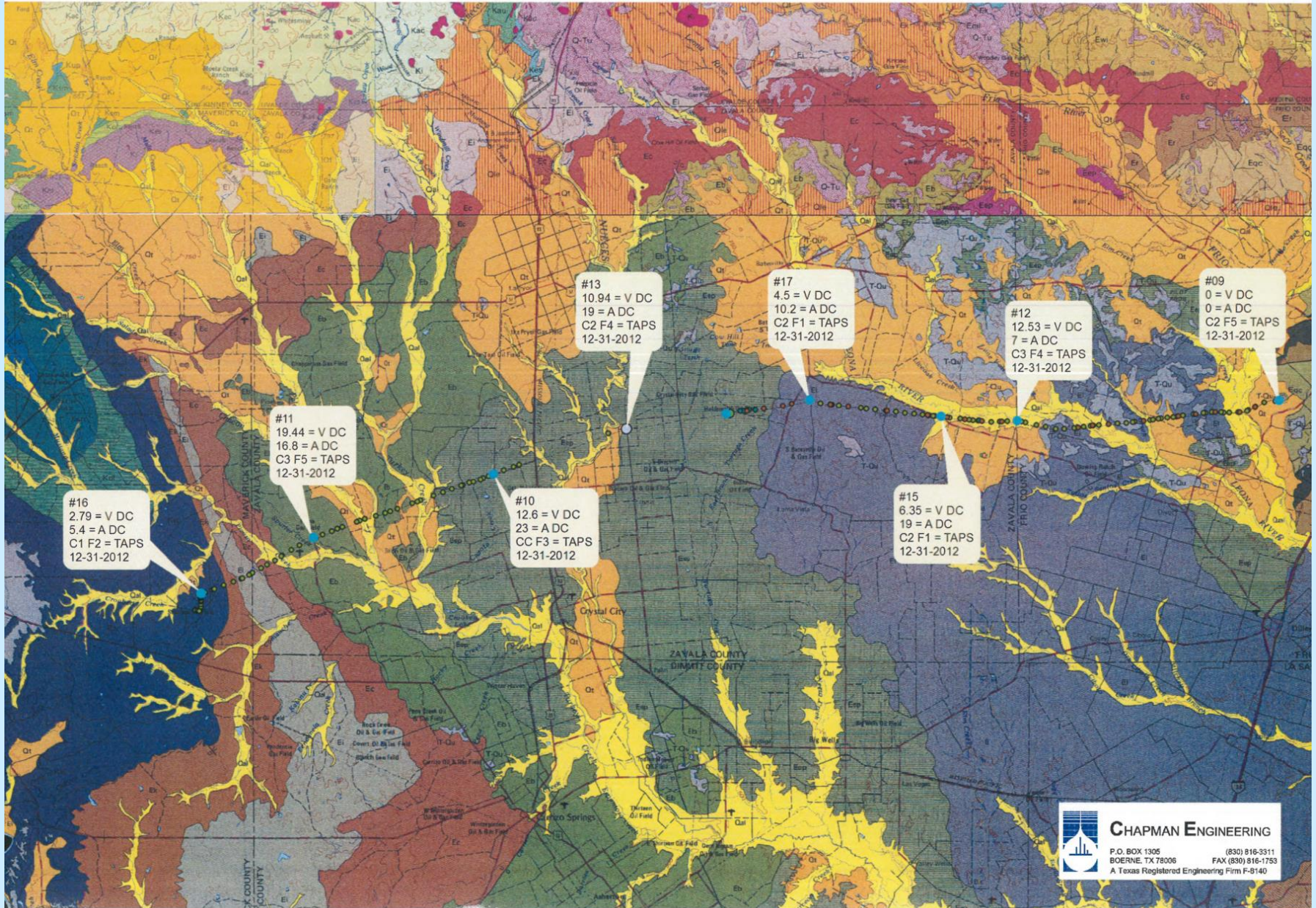
One can use geologic maps of surface and shallow geology, when available. Texas, Oklahoma, North Dakota are mapped this way, as are many other states and Canadian provinces.

Partly, this helps confirm what surface soil characteristics look like, from Web Soil Survey.

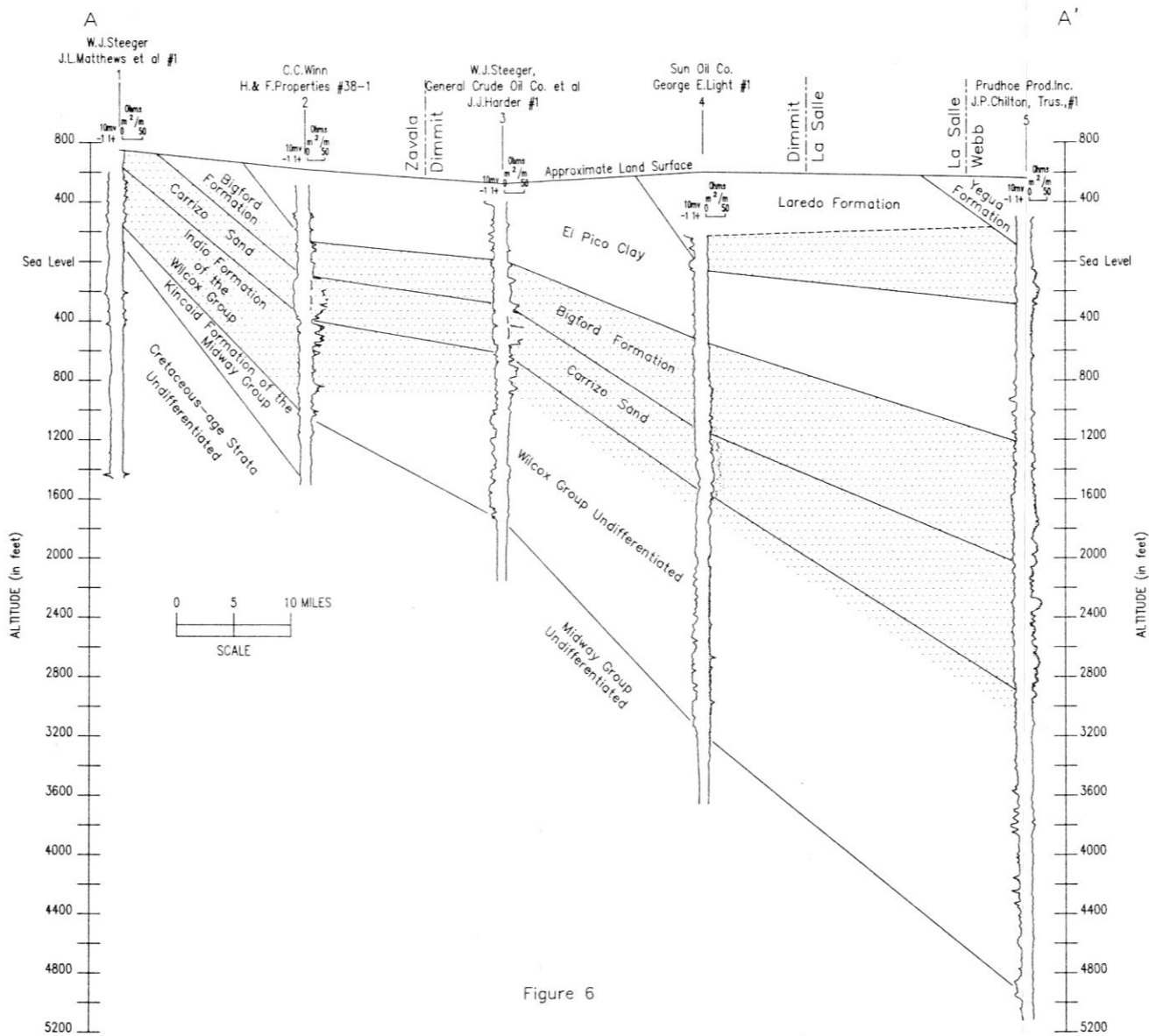
Geologic calls also help one figure out what a deep anode bed design should look like, how to drill it, and whether protective current will or won't flow "deep" for longer reaches.

Many states have databases of water well installation reports. These sometimes include good geology info. Water wells and deep anode beds are similar to each other.

Geologic Atlas Map in Texas with project info overlay

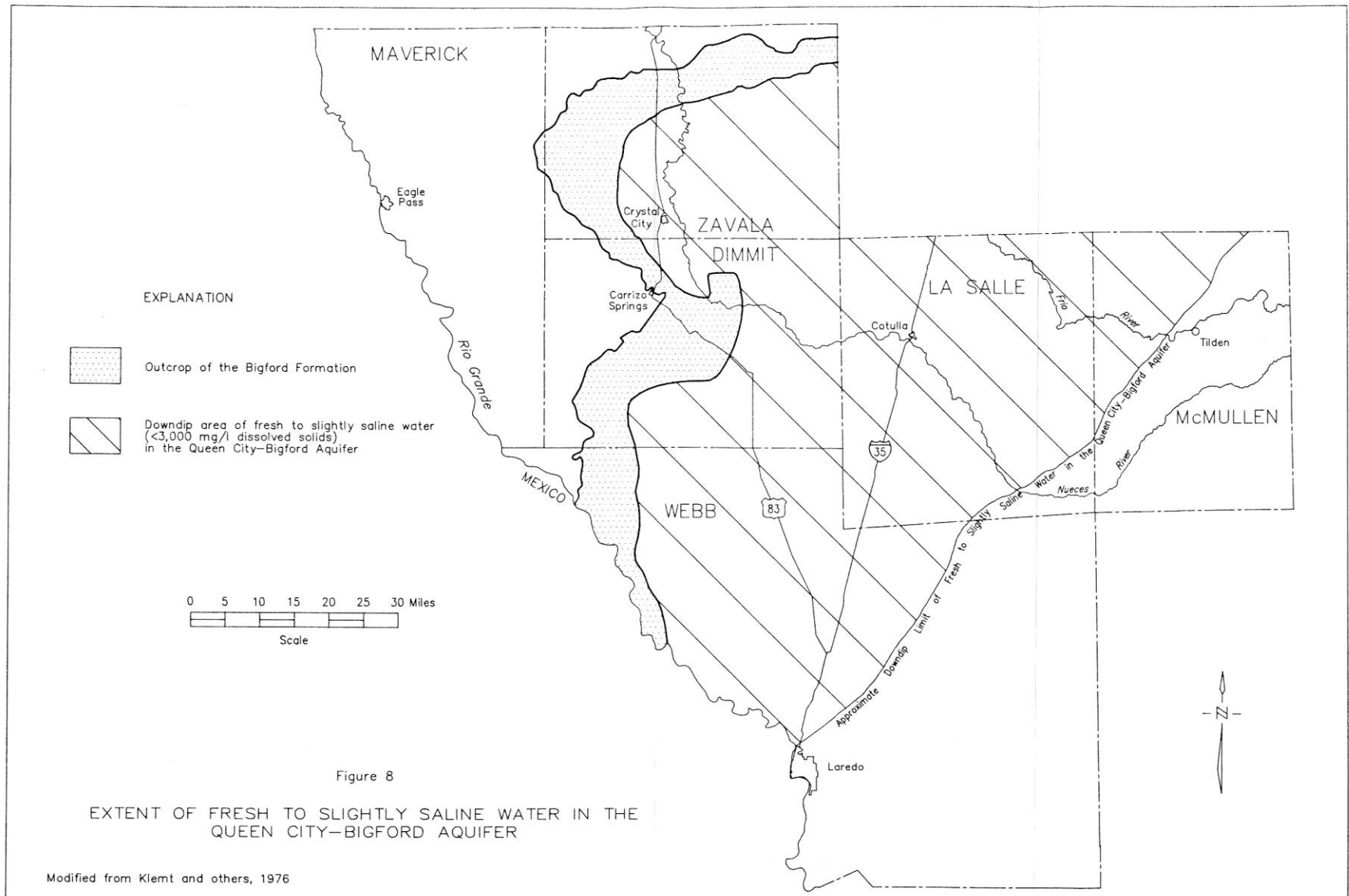


Geologic Cross-Section, Same Area



HYDROGEOLOGIC CROSS-SECTION A-A'

Regional Geology Publications Can Be Studied



Please fill in spaces which checked and mail back to me.

Box 714
Wassell

77-09-2A

Send original copy by certified mail to the Texas Water Development Board P. O. Box 13087 Austin, Texas 78711		State of Texas WATER WELL REPORT	For TWDB use only Well No. <u>77-09-2A</u> Located on map <u>4P2</u> Received: <u>74</u> <u>28</u>
1) OWNER: Person having well drilled <u>A Jack WARE</u> (Name) ✓ Address <u>Rt 1 Box 42A Carrizo Spgs. Tex</u> (Street or RFD) (City) (State)		Landowner <u>SAME</u> (Name) ✓ Address (Street or RFD) (City) (State)	
2) LOCATION OF WELL: County <u>Zavala</u> ✓ <u>21</u> miles in <u>WNW</u> direction from <u>Crystal City</u> (N.E., S.W., etc.) (Town)		Locate by sketch map showing landmarks, roads, creeks, highway number, etc.* North ↑ (Use reverse side if necessary)	
3) TYPE OF WORK (Check): <input checked="" type="checkbox"/> New Well <input type="checkbox"/> Deepening <input type="checkbox"/> Reconditioning <input type="checkbox"/> Plugging		4) PROPOSED USE (Check): <input checked="" type="checkbox"/> Domestic <input type="checkbox"/> Industrial <input type="checkbox"/> Municipal <input type="checkbox"/> Irrigation <input type="checkbox"/> Test Well <input type="checkbox"/> Other	
		5) TYPE OF WELL (Check): <input checked="" type="checkbox"/> Rotary <input type="checkbox"/> Driven <input type="checkbox"/> Dug <input type="checkbox"/> Cable <input type="checkbox"/> Jetted <input type="checkbox"/> Bored	
6) WELL LOG: Diameter of hole <u>8 1/2</u> in. Depth drilled <u>212</u> ft. Depth of completed well <u>212</u> ft. Date drilled <u>April 14-74</u> All measurements made from _____ ft. above ground level.			
From (ft.) To (ft.) Description and color of formation material		9) CASING: Type: <input checked="" type="radio"/> Old <input checked="" type="radio"/> New <input type="radio"/> Steel <input type="radio"/> Plastic <input type="radio"/> Other Cemented from <u>710</u> ft. to _____ ft.	
<u>0-6 sand</u> <u>6-20 = caliche</u> <u>20-60 clay</u> <u>60-120 - gray shal.</u> <u>120-194 - hardy shal</u> <u>194-212 - Carrizo sand</u>		Diameter (inches) Setting From (ft.) To (ft.) Gage <u>7" OD.</u>	
		10) SCREEN: Type Perforated Slotted ✓ Diameter (inches) Setting From (ft.) To (ft.) Slot Size <u>1/4"</u> <u>190-212 ft</u>	
7) COMPLETION (Check): <input type="checkbox"/> Straight wall <input type="checkbox"/> Gravel packed <input type="checkbox"/> Other <input type="checkbox"/> Under reamed <input type="checkbox"/> Open Hole		11) WELL TESTS: Was a pump test made? Yes No If yes, by whom? Yield: _____ gpm with _____ ft. drawdown after _____ hrs. Bailer test <u>20</u> gpm with <u>710</u> ft. drawdown after _____ hrs. Artesian flow _____ gpm Temperature of water _____	
8) WATER LEVEL: Static level <u>150</u> ft. below land surface Date <u>4-14-74</u> Artesian pressure _____ lbs. per square inch Date _____ Depth to pump bowls, cylinder, jet, etc., _____ ft. below land surface.		12) WATER QUALITY: Was a chemical analysis made? Yes No Did any strata contain undesirable water? Yes No Type of water <u>fresh</u> depth of strata <u>14'</u>	
I hereby certify that this well was drilled by me (or under my supervision) and that each and all of the statements herein are true to the best of my knowledge and belief.			
NAME <u>J.A. Letsinger</u> (Type or Print) ADDRESS <u>P.O. Box 714</u> (Street or RFD) <u>Wassell</u> (City) <u>Texas</u> (State) <u>78801</u>		Water Well Drillers Registration No. <u>696</u>	
(Signed) <u>J.A. Letsinger</u> (Water Well Driller)		<u>Sonora Drilling Co.</u> (Company Name)	
Please attach electric log, chemical analysis, and other pertinent information, if available.			

Water Well Report, older format in Texas. Note geology calls by driller.

STATE OF TEXAS WELL REPORT for Tracking #269102

Owner:	Billy Jack Deen	Owner Well #:	1
Address:	28450 SH 64 Canton, TX 75103	Grid #:	34-25-5
Well Location:	28450 SH 64 Canton, TX 75103	Latitude:	32° 32' 56" N
Well County:	Van Zandt	Longitude:	095° 56' 07" W
Elevation:	No Data	GPS Brand Used:	Not Given
Type of Work:	New Well	Proposed Use:	Domestic

Drilling Date: Started: 9/21/2010
Completed: 9/22/2010

Diameter of Hole: Diameter: 8 in From Surface To 330 ft
Diameter: 5 in From 330 ft To 400 ft

Drilling Method: Mud Rotary

Borehole Completion: Gravel Packed From: 330 ft to 400 ft
Gravel Pack Size:

Annular Seal Data: 1st Interval: From 0 ft to 330 ft with 66 (#sacks and material)
2nd Interval: No Data
3rd Interval: No Data
Method Used: Pressure
Cemented By: C & P
Distance to Septic Field or other Concentrated Contamination: n/a ft
Distance to Property Line: 1500 ft
Method of Verification: Owner
Approved by Variance: No Data

Surface Completion: Alternative Procedure Used

Water Level: Static level: 143 ft. below land surface on 9/22/2010
Artesian flow: No Data

Packers: No Data

Plugging Info: Casing or Cement/Bentonite left in well: No Data

Type Of Pump: Submersible
Depth to pump bowl: 294 ft

Well Tests: Jetted
Yield: 18 GPM with 236 ft drawdown after 1 hour

Water Quality: Type of Water: No Data
Depth of Strata: No Data
Chemical Analysis Made: No
Did the driller knowingly penetrate any strata which contained undesirable constituents: No

Water Well Report, Newer Texas Format (pg 1)

Certification Data: The driller certified that the driller drilled this well (or the well was drilled under the driller's direct supervision) and that each and all of the statements herein are true and correct. The driller understood that failure to complete the required items will result in the log(s) being returned for completion and resubmittal.

Company Information: **Chambers & Phillips Inc.**
701 E Hwy. 243
Canton , TX 75103

Driller License Number: 55067

Licensed Well Driller Signature: **Brian Butcher**

Registered Driller Apprentice Signature: **No Data**

Apprentice Registration Number: **No Data**

Comments: ^EAD

IMPORTANT NOTICE FOR PERSONS HAVING WELLS DRILLED CONCERNING CONFIDENTIALITY

TEX. OCC. CODE Title 12, Chapter 1901.251, authorizes the owner (owner or the person for whom the well was drilled) to keep information in Well Reports confidential. The Department shall hold the contents of the well log confidential and not a matter of public record if it receives, by certified mail, a written request to do so from the owner.

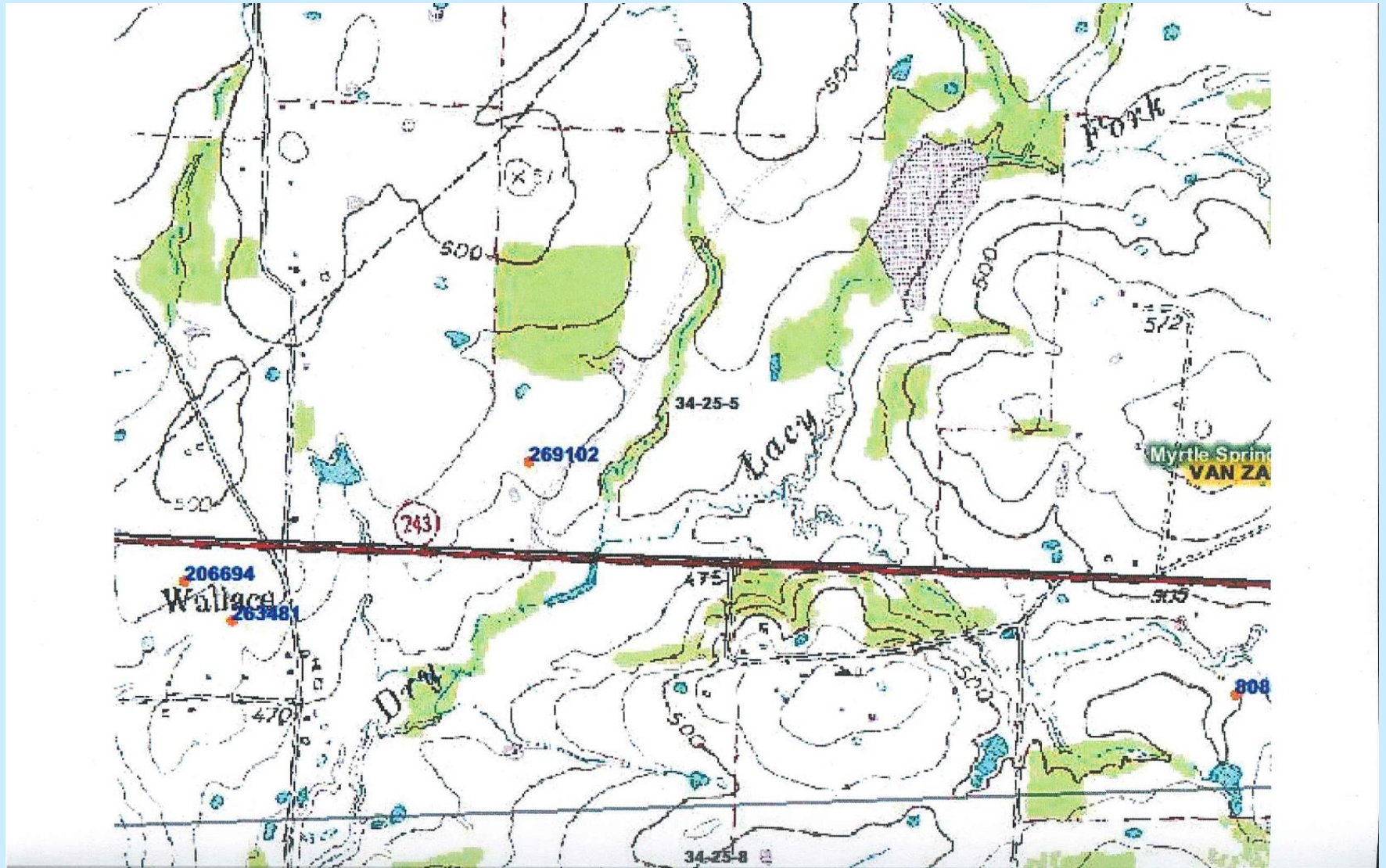
Please include the report's Tracking number (Tracking #269102) on your written request.

Texas Department of Licensing & Regulation
P.O. Box 12157
Austin, TX 78711
(512) 463-7880

DESC. & COLOR OF FORMATION MATERIAL		CASING, BLANK PIPE & WELL SCREEN DATA			
From (ft)	To (ft) Description	Dia.	New/Used	Type	Setting From/To
0-20	surface	4"	N	PVC	0'-330'
20-60	sand	2"	N	PVC Slotted	330'-400' .013
60-140	sand sandy shale				
140-210	shale				
210-290	sand				
290-340	sand fine				
340-390	shale				
390-400	shale				

**Water Well
Report,
Newer Texas
Format
(pg 2) – Note
geology “calls”
by driller**

On-Line Water Well Location Info (from Texas Water Development Board) w/Topo



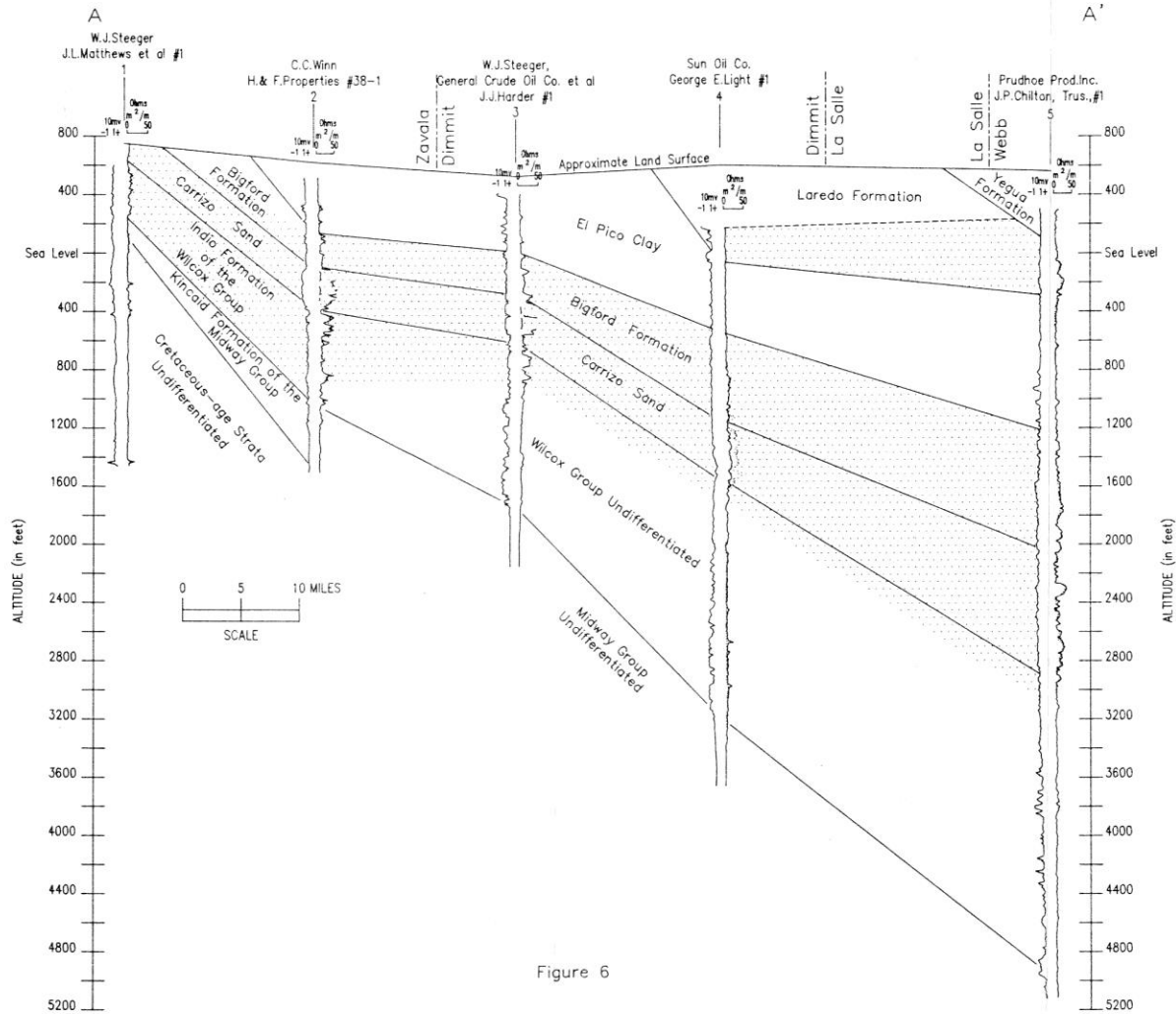
Geologic Cross-Sections and Local Drilling History/Knowledge

We had an anode bed to install in South Texas, to 350 feet of depth. Called two area drillers, and the pipeline operator, to ask them about local conditions.

Design was someone else's – we just wanted to do our research before mob-ing out.

Operator said, “If I was you, I'd stop at 300. We had a gas pocket blow out an anode hole we were drilling about 20 years ago, just a mile west. Coal seam.” We looked at geologic section info from water well drilling, and saw the lignite bed to avoid. Drillers had similar stories, but they had to complete through it to get to good water.

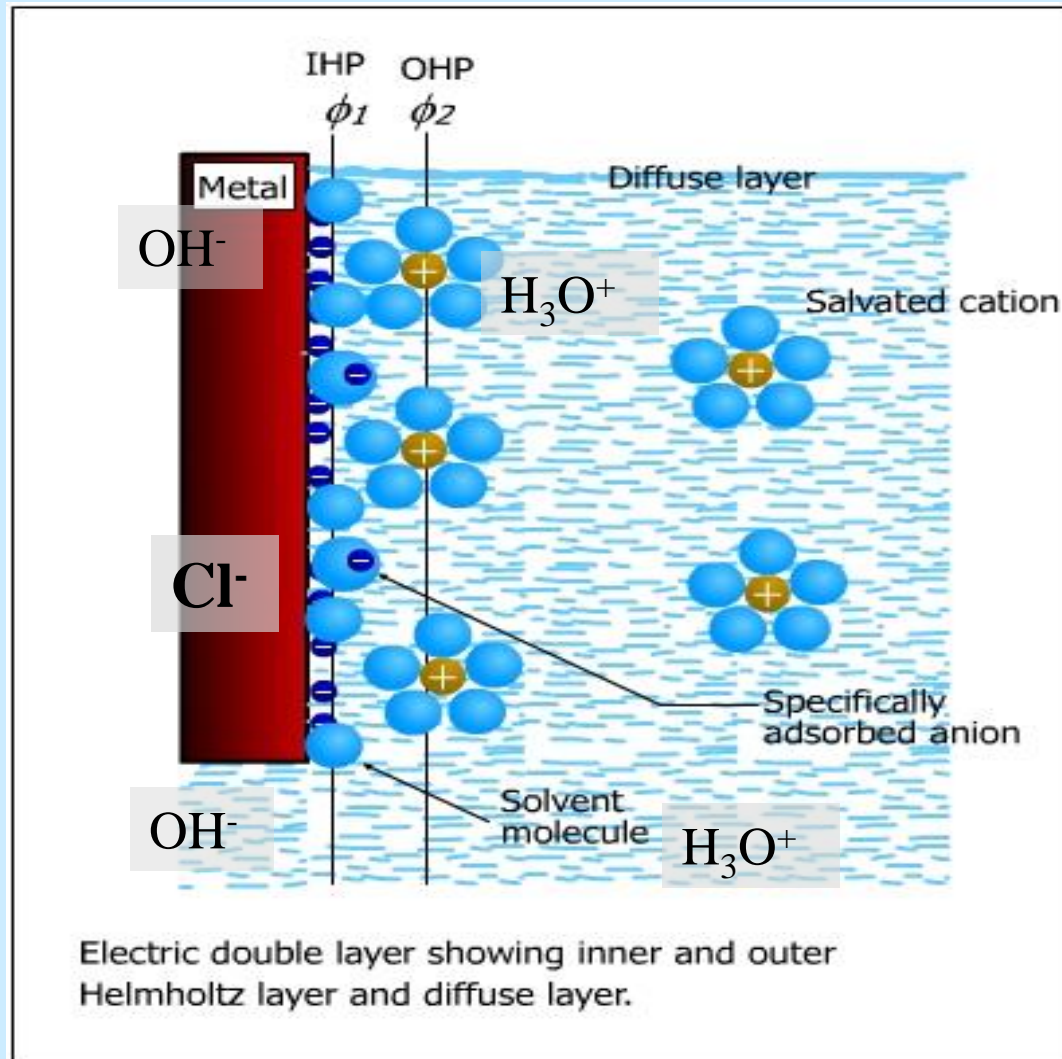
You Can Study Geologic Cross Section to Assure Deep Anodes Will Work



Why are Chlorides So Bad?

- ❑ Chloride ions drive resistivity way down; chloride is also VERY electronegative.
- ❑ **With chlorides prevalent, individual chloride ions attach to exposed steel surface, and then never leave. This depolarizes steel around each chloride, making that area a very small anode (Remember the “small anode/large cathode” bad combo?).**
- ❑ **With low resistance, “local-action” corrosion cells are way more active. Pit formation starts, pH in pit decreases rapidly. And chlorides stay there!**
- ❑ **Chloride enhances Fe^{+2} ion going into solution.**

Helmholtz layers at steel surface: a chloride ion “lodges” and the process starts . . .



This is caused by atmospheric conditions,
with wind-driven chloride, dust, dewfalls,
and three years exposure.

Above-grade Load
Line into a 400-
bbl API 12 oil
tank.

Coat the metal!
Pipe was wetted
by dewfalls.



Galvanized Skirt

Southwest Kansas produced-water containment (six months old). Galvanizing being lost rapidly. Gypsum locally, with moisture.



Coatings Damaged in Field

One-inch dry gas line – FBE got smacked!

Dissimilar-metal contact nearby, chlorides in soil, and no external CP for two years. Wall T about 250 mils originally.



Produced Water Facility

Barnett Shale site – chloride and atmospheric damage over 5 years



Particular Challenges

- Modeling some older pipeline ROWs for soil types and resistivities, chlorides, coating quality. Owner thought 2-3 amps per mile was adequate, but had failures. Pipe may need far more current! High chlorides and other ions, low ρ .
- Need test stations and CP-interrupted survey to understand what is really happening.
- Learn the soil column and whether rainfall recharge is happening or not. Look at soil/geology variability.
- Review historical data and watch CP systems age. Look at cycles of wetting and drying in soils, anode beds, etc. Talk with local drillers.
- Tank farms are bathtubs; water stays under tanks.

Glad to be of service!

Questions?

And remember, the only bad question is the one
not asked . . .

Cal Chapman, P. E.
cal@chapmanengr.com

or

cchapman@chapman.engineering
www.chapman.engineering