

TG/14 Sept. 1986 (revised 23 Jan. 1987)

WATERPOCKET ECOLOGY PROJECT  
TINAJA FIELD SAMPLING PROCEDURES

Tinajas should be sampled between 1000 and 1400 if possible, or at least before 1600. Try to sample each tinaja at about the same time of day each sample period. If you sample both Cottonwood and Willow in one day, you should try to be at Cottonwood 1 by 0930 or 0945 to finish with Willow 4 by 1600. Winter sampling may require sampling these two systems on separate days.

Sampling order:

The tinaja drainages are usually sampled in the following order: Fountain, Miaheyan, Cottonwood, Willow. Fountain and Miaheyan are sampled during one trip, Cottonwood and Willow are sampled during a separate trip. If Miaheyan were sampled first, the coliform samples would sit for over 36 hours before being cultured, without refrigeration. If Fountain is sampled first, coliform samples for both drainages can be collected the second day, and cultured that evening. Cottonwood and Willow can be sampled in either order, and they can be sampled on different days or both in one day, depending on the weather, other distractions (e.g., difficulties getting out of headquarters in the morning), and the dedication of the crew (that's you!). See below for more discussion on that.

For the Fountain/Miaheyan trip, try to leave headquarters by 0800 at the latest. This would put you at the trailhead of the airstrip route by 1000 or 1030, and at Fountain 5 by 1130. Once there, unload your camping gear, and head up to #1, checking the lower rain gauge (see below), and picking up the zooplankton sampling apparatus along the way. Check the upper rain gauge and do all sampling at #1, then do D.O. at #2 and #3 from the same spot (see tinaja diagrams). This eliminates one calibration wait. One can set up the D.O. meter at #4 and have the probe stabilizing while the other is setting up the pump at #2. Once finished with #4, go down and sample #5. You should be able to get all 5 tinajas sampled in 2.5-3 hours, finishing by 1400. Do not take coliform samples from Fountain tinajas when you do the rest of the sampling of these tinajas. Now it's time for lunch, and a nap, or explorations for the rest of the day.

The next day, hike down to the Miaheyan drainage. Take the pump, and short pvc pipe with elbow, but leave the rest of the pumping apparatus at Fountain. Pickup the pvc pipes for pumping at the stash near Miaheyan 3, and head up to #1 to sample (don't forget the upper rain gauge). Sample all 5 tinajas, including taking coliform samples, and eat lunch after doing #5. Leave the pvc at the stash but take pump and

short pvc with elbow back to Fountain. At Fountain, one of you should take the coliform samples at #5 (3 water, and 2 sediment) and begin packing up. The other take the pump and pvc pipes back to the stash, and collect the 5 coliform samples at #1. Pack up and hike out to the Beast, drive back to the GRI, where water samples are stored in refrigerator (add conc. H<sub>2</sub>SO<sub>4</sub> to NH<sub>3</sub> samples first--see below), and coliform samples are filtered and put in the incubator (see coliform procedures write-up for sample collection, filtration, and culturing instructions).

The next day, drive back to the Post, and sample Cottonwood and Willow. We've been sampling Cottonwood 1-5 in that order, then Willow 5, then hiking up to Willow 1, where we eat lunch while waiting for the D.O. probe to stabilize. It is possible to pick up the pumping apparatus, and hike up to Willow 1 and sample, then sample Willow 2-4, and then hike up and over to Cottonwood 1. Sample there and then down to 2-5, and sample Willow 5 on the way back. there are some advantages to this--climbing up to Cottonwood 1 from Willow 4 is probably less work than climbing up to Cottonwood 1 and then down to Cottonwood 5, and Willow 5, and back up to Willow 1. Willow 5 would be sampled last, so the foul smell would not be around at lunch time. This should not be attempted without scouting the route, since a lot of time could be wasted if you miss the Cottonwood 1 drainage. It also separates the sampling of Willow 1-4 from Willow 5 by more time which may or may not be significant.

If Cottonwood and Willow must be sampled on different days, it is possible to stay at the Peek-a-boo trailer in between. Don't collect coliform samples from the system sampled the first day, and then collect all samples on the second day and analyze both sets when you return to the GRI. If you do sample on 2 days, Cottonwood would probably be the better drainage to sample on the first day, since it would be less work to get back up to Cottonwood 2 than to Willow 2 on the second day for coliform samples.

## Sampling Procedures:

The tinaja data sheet lists the parameters to be measured, and other information to be collected at each tinaja during each sampling period. Many of the items are self-explanatory, but some require clarification. The procedures are listed in the preferred order of collection.

### Rain gauges

There are 2 rain gauges in each drainage--one near the uppermost tinaja studied, and one near the lowest tinaja studied. Each sampling period, record the rainfall indicated (in mm) by each gauge, and record on the system data sheets. Then dump the water and oil out of the gauge, and pour about 30mLs of mineral (baby) oil into the gauge--about up to the 1mm mark on the gauge. Put the gauge back in place, making sure that it is vertical.

### Dissolved Oxygen

- a. Turn the meter on. Readings cannot be made for 15 minutes after first turning on the meter. Do not turn the meter off between tinajas of a system. Leave the D.O. meter on between Cottonwood and Willow drainages if sampling both in one day.

The D.O. probe temperature must be stabilized before calibration can take place. Take bottomless bottle off probe and rinse both bottle and probe in tinaja for a minute to cool them down to near tinaja water temperature. Shake probe to dry membrane, and check to be sure there are no bubbles under the membrane. If there is a bubble, see attached instructions on how to change membrane. If not, put bottle back on probe and put the probe (with bottle in place) into the tinaja. Note probe temperature, and adjust O2 solubility factor dial to that temperature (for reference). Wait at least 5 minutes (15 min. if first tinaja of the day), then check probe T. If it has changed, readjust O2 sol. factor dial, and wait another 5 min. If it hasn't changed, the probe is probably equilibrated, and you can proceed with calibration.
- b. While waiting for probe T to stabilize, and the meter to repolarize, fill out data sheets as much as possible, count invertebrates, and get pump ready to filter for zooplankton.
- c. Once probe T is stable, turn O-2 solubility factor knob to indicate probe T, using the freshwater end of the scale.
- d. Turn dial to "Calib. 0-2". Adjust calib. knob until needle indicates local altitude, 4300' for Fountain, 4200' for Miaheyan, and 4800' for Cottonwood and Willow

The meter is now ready to use

- a. Remove the bottomless bottle.
- b. Record the time the D.O. readings were begun, and the % of the tank in direct sunlight during readings.

- c. Turn dial to "Read Temp".
- d. Using the official O-2 probe suspension tool (the 1" pvc pipe), lower probe into the pool. The first reading is at the surface--the probe should be held such that the pressure compensation hole is just below the surface. Agitate (up and down about 1cm each way) rapidly (about 2 cycles/sec.) for 30-60 sec. Be careful that you do not stir up the water too much, if you create bubbles, you may be mixing extra oxygen into the water, which will change your reading.
- e. Read T, adjust "O-2 solubility factor" to that T.
- f. switch dial to "Read O-2" and read dissolved O-2 (in mg/l) from meter, and record.
- g. Repeat process at 0.25m intervals (marked on cable), and at the bottom. Record the bottom depth on the data sheet.  
Remember: read T first and adjust O-2 solubility factor if necessary before reading O-2 at each depth.

WHILE THE O-2 METER IS EQUILIBRATING, DO:

Invertebrate counts--

- a. Count all invertebrates within the 1m X 1m plot established at each tinaja. Include all organisms attached to the rock wall, those in and on the water, those on the bottom. Also include any that fly through the air over the pool.
- b. Count them as best you can, estimate if too numerous to count (note estimations).

Tadpole counts--

Count as many tadpoles as you can during a 60 sec. interval. Note stage(s) of development when possible (e.g., most without legs, most with just hind legs, etc.)

Vertebrate use--

- a. Record the number of each species of amphibian seen around each tinaja.
- b. Note use by any other vertebrates--look for tracks, scat, garbage, etc. Record any birds that flew away as you approached the tinaja, or that fly into the basin while you are sampling. Record any lizards that are near the tinaja, especially if they are in the vicinity every time you sample. Try to identify all vertebrates observed to species.
- c. Record whether there are any bare human footprints near, or in the tinaja, indicating that perhaps someone was swimming (helpful for our bacteriological data).

### Tinaja sketches--

Each tinaja has been sketched, showing maximum pool outline, and nearby trees, boulders, and other landmarks. You should have copies of these sketches with you during every sampling period. Sketch in the outline of the tinaja for the date sampled, noting any significant changes in sampling locations, pool and shore characteristics (e.g., additional sediment deposition due to a flash flood through the drainage), and any concentrations of invertebrates on/in the pool.

AFTER D.O. READINGS HAVE BEEN MADE, DO:

### Zooplankton sample--

Zooplankton samples are collected from at least 2 tinajas in each system (see Table 1). Winter samples will be taken only from the tinajas listed in Table 1. Check with Norm to see whether additional tinajas will be sampled during the summer.

- a. Pump 50-100 litres of water through plankton net set in PVC pipe. When zooplankton are very numerous, pump less water. The 12L level is marked on the pipe (38mm from top of pipe). The total volume pumped depends on the density of zooplankton in the tinaja. For dense communities, pump 60L (5 fillings), otherwise, pump 100L (8.3 fillings). Use your judgement on very dense samples--we have pumped as little as 12L. When pumping 100L, pump 7 pipe-fulls, then pump 5 strokes (4L), then pump the eighth pipe-full. This way there is a full pipe to wash the organisms down into the bottom of the net.
- b. Record on the data sheet the number of litres pumped.
- c. Clean off the inside of the net with water by swishing it back and forth as you pull it up out of the pipe.
- d. Open clamp at bottom of net and empty sample into a 125mL wide-mouthed jar. Rinse the net again, and rinse plastic bottle and lid into sample bottle.
- e. Add 5mL FAA to sample, close TIGHTLY. Make sure it is labelled. Hopefully, we will be using EtOH after October, so the leaky bottles won't be such a health hazard. As of January 1987, We should be receiving some EtOH to preserve zooplankton and benthos samples.

### Water sample--

At every tinaja, 250mL of water is collected to determine pH, conductivity and turbidity at the GRI. Samples from 2 tinajas from each system (Table 1) are sent to Ft. Collins for analysis of dissolved organic carbon after you have measured the above parameters. From each of these same 2 tinajas, another 250mL of water is collected for ammonia determination. During the summer, an additional 500mL may be collected from each tinaja in Willow and Cottonwood for chlorophyll

analysis. Check with Norm to see whether chlorophyll samples are needed. At tinajas where zooplankton samples are taken, take all water samples from the pvc pipe after the last 12L is pumped. At all other tinajas, take samples from as far out in the pool as you can reach, near where the D.O. measurements were taken. Mark on the tinaja sketches where water samples were taken from.

Table 1. Tinajas being studied in the coliform bacteria monitoring program at Capitol Reef National Park

| Drainage   | impacted<br><u>tinaja</u> | unaffected<br><u>tinaja</u> |
|------------|---------------------------|-----------------------------|
| Willow     | W5                        | W2                          |
| Cottonwood | C4,C5                     | C2                          |
| Fountain   | F5                        | F1                          |
| Miaheyan   | --                        | M1,M5                       |

#### Benthic invertebrate sample--

This sample should be taken monthly during the summer. No benthic samples are taken during the winter.

- a. Sample tinajas with easily accessible bottoms only.
- b. Place benthic invertebrate sampling frame 5cm into sediment.
- c. Scoop out top 5cm of sediment within frame and put in sieve, and wash.
- d. Put any organisms retained by sieve into a labelled sample bottle.
- e. Repeat in two more locations.
- f. Put 5mL EtOH in sample, and close TIGHTLY.

Keep samples as cool as possible in the field. We used a burlap sack to store them in a pool while sampling. This is fine except it could introduce foreign matter into the pools being sampled. Either store them in a pool we aren't studying, or find some shade to keep them in.

#### BACK AT GRI:

Upon arrival, unpack all water samples. Keep the coliform samples out to filter in a few minutes. Put the water samples for pH, conductivity, turbidity, and organic carbon in the refrigerator. VERY CAREFULLY add 2mL concentrated  $H_2SO_4$  to the  $NH_3$  samples. Use goggles, rubber gloves, and apron to avoid serious burns, and/or damage to clothes. Use one of the rubber aspirator bulbs to pipette, using one of the 2 pipettes with few graduations left on them (labelled "acid pipettes" in the cupboard labelled "acid straws"). Be very careful when aspirating acid not to suck any acid into the bulb. After pipetting acid into all the  $NH_3$  samples, rinse the pipette very thoroughly. Spread  $NaHCO_3$  on any spilled acid, and then flush with plenty of water. If you get any acid on you or your clothes, flush with water, and make a paste of  $NaHCO_3$  and water and spread it on the affected area for a few minutes, rubbing it into contaminated clothing (which should be removed immediately after spilling the acid).

Allow the samples to warm to 20-28 C before analyzing for conductivity, pH, and turbidity, since both conductivity and pH are temperature dependent, and the outside of the vial fogs up, affecting turbidity readings if samples are cold.

WATERPOCKET ECOLOGY PROJECT  
WATER ANALYSIS LABORATORY PROCEDURES

Take samples out of refrigerator and allow to warm to room temperature, preferably near the temperatures the water was when taken from the tinajas (20-30 C in spring/summer, 5-15 C in fall/winter). Because both pH and conductivity are temperature dependent, these parameters should be measured at temperatures as near sampling temperatures as possible. Nephelometer readings should be made on fairly warm samples (>9 C as measured by pH meter in winter) to prevent fogging of the vial. Temperatures may need to be higher in summer as the humidity is higher with the swamp cooler on.

While waiting for samples to warm up, fill squeeze bottles with distilled water, rinse 5 100mL beakers, and 1 250mL beaker, and the nephelometer sample vial with distilled water. Pour 70mL distilled water into 1 of the 100mL beakers. Turn the nephelometer on, wipe the standard vial with a kimwipe, and put it in the chamber.

Conductivity--

Read the instruction manual, especially pp.4-6!

Keep the probe in the bottle submersed in distilled water at all times when not in use.

Check the meter zero position--when the meter is off, the needle should rest on 0. If it does not, adjust the needle with the screw below the meter face.

Turn the MODE control dial to "REDLINE," and adjust Redline knob until needle lines up with the redline on the meter face. If this can't be done, replace batteries.

Calibration: Before measuring any samples, calibrate the meter and probe to the lab standard. The exact reading will depend on temperature of the solution, and can be calculated using the equations on the enclosed sheets from the YSI standard handout. The lab standard should be about 247 mhos cm at 25 C. You can approximate what the reading should be at any temperature by using the formula at the bottom of page 2 of the conductivity calibration standard handout (pp. 2-3 are included in this write-up). Check this calibration each sample period. Check the probe and meter every 6 months with the YSI 1000 mho cm standard. See pp. 2-3 of the YSI standard handout to determine whether the measured conductivity is correct for that solution temperature.

Record the lab standard reading (and YSI standard reading if measured) on the system data sheet of the 1st system analyzed.

Rinse probe in distilled water and put in 100mL beaker of distilled water.

Pour a few mLs of sample into the 250mL beaker, swish to rinse beaker, and discard. Pour 200mL of sample into beaker. With MODE dial on Temperature, remove probe from distilled water, blot briefly on paper towel, and place in sample. The temperature probe is the metal rod sticking out of the top of the probe. This must be immersed to read temperature. It is all right for the probe to sit on bottom of beaker when reading temperature. read temperature on bottom scale of meter face, and record on data sheet. Turn MODE dial to Conductivity X1. To read conductivity, probe must be at least 1cm from bottom and sides of beaker, and be agitated up and down for at least a minute. It is all right for the temperature probe to be out of water when reading conductivity, but not the top of the conductivity probe. Agitation does not have to be very rapid, but it must be continuous during a reading. Read conductivity directly on upper meter dial. Record conductivity on data sheet. Pour the sample back into sample bottle, and rinse beaker with distilled water in preparation for the next sample.

This meter does not compensate for temperature automatically so be sure to record the temperature for each sample. Conductivity is generally reported at 25 C; each reading will have to be converted to the corresponding conductivity at 25 C before comparisons can be made.

pH--

Read the instruction manual!

The pH meter automatically adjusts pH values to the temperature of the solution as long as the temperature probe is also in the solution. Significant errors will result if readings are taken without the temperature probe, or if the temperature probe is not in the solution.

To calibrate the meter, pour 50mL of pH 4 buffer into a 100mL beaker, 50mL pH 7 buffer into another, and 50mL pH 10 buffer into a third. Remove the cap from the pH probe tip, and rinse both temperature and pH probes with distilled water and blot dry. Put both probes into the pH 4 buffer, and press the "Clr" button to turn the meter on. then press the " " (the "standard" key), and wait for the meter and probe to

equilibrate at the correct pH. When the " " symbol appears, and the display stops flashing, the electrode has stabilized. Record the pH and temperature for pH 4 buffer on the system sheet of the 1st system measured. See the instruction manual to determine whether the measured pH is accurate for the measured temperature for this buffer (p.40). If it is not, try using fresh buffer. If this is not the problem, make sure there is enough fluid in the pH probe to cover the reference probe. This should be checked periodically anyway. To fill, take tape off probe, remove cap, and fill with "pH electrode filling solution" (of course). The cap does not stay on very well, nor does it make a good seal, so tape it back up after filling. If the probe still does not give an accurate reading, call Beckson.

Rinse the probes with distilled water, blot dry, and put into the pH 10 buffer. Press the " " button again, and wait for the probe to stabilize. Again check with tabulated pH values at varying temperatures for accuracy. Record the values of temperature and pH for pH 10 buffer on the system data sheet:

"pH calibration:

| pH 4 buffer | pH 10 buffer |
|-------------|--------------|
| T: 25.00    | 25.00        |
| cond: 4.00  | 10.01"       |

Rinse probes and blot dry, and prepare the first sample: rinse the empty 100mL beaker with a few mLs of the sample, and discard. Pour 40-60mL of sample into the beaker, and put both probes in the solution. Press the "pH" key, and wait for the probe to equilibrate. When the " " symbol appears, record both pH and temperature on the data sheet, rinse the probes, and blot dry. Pour the sample back into the bottle and recap. Rinse the beaker with distilled water. Repeat the pH determination process with each sample (calibration is required only at the beginning of the day). Check the pH meter in pH 7 buffer before analyzing samples from the next drainage. Put the rinsed, dried probes into the pH 7 buffer, and push the "pH" button. Record this check on the system data sheet.

The pH meter seems to take a while to stabilize for the first 10-20 samples, but becomes very rapid later on.

Nephelometer--

Read the instruction manual!

This instrument takes a while to warm up, so plug it in and turn it on before getting any other equipment ready. Put the scale switch on "X10." Wipe the standard 20

NTU vial surface with a kimwipe, put the vial in the cell chamber and place the cover over it. Both standard and sample vials tend to catch on a shelf in the chamber, so be sure they drop all the way to the bottom of the chamber. Adjust the calibration dial until the readout is 20.0. As you set up the rest of the equipment, check the reading occasionally to be sure it's steady. Adjust it back to 20.0 when necessary.

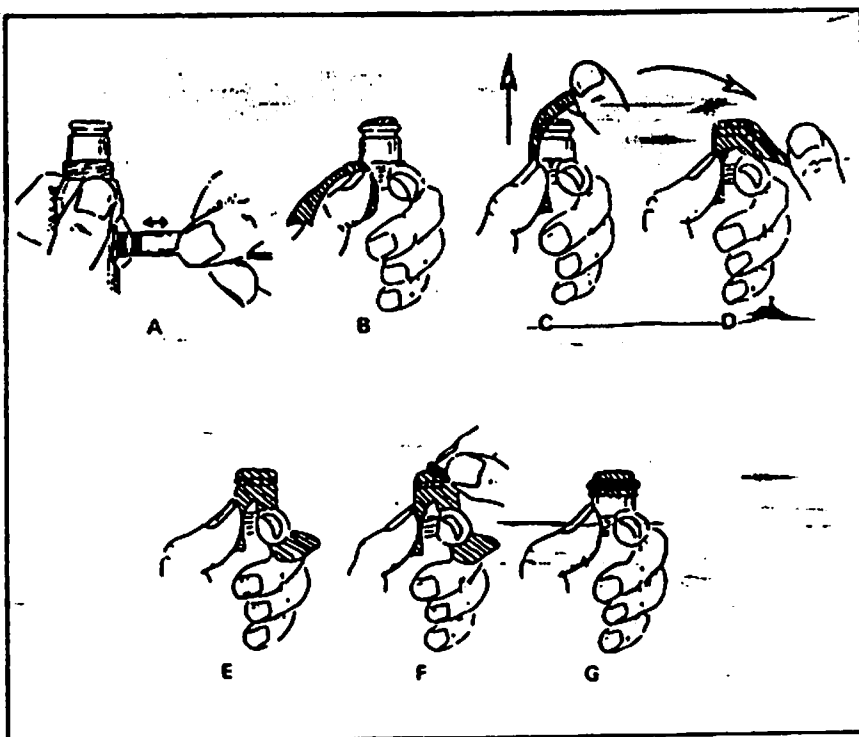
Rinse the sample vial with a few mLs of sample and discard. Fill the vial to the shoulder below the threads on the vial. Cap tightly. Small bubbles may cling to the sides of the vial, affecting the turbidity reading, and fingerprints, water drops, and dust on the outside may also affect the reading. To remedy both problems, after capping, tilt the vial onto its side, and rotate it slowly while wiping the outside with a kimwipe. Be sure the kimwipe stays fairly dry, otherwise the water droplets will be spread over the surface even more.

Remove the standard vial, and replace it with the sample vial, cover it and wait for the reading to stabilize (read conductivity and/or pH during this time). If the sample has a lot of sediment, be sure it is shaken up, since it was suspended at the time of collection, and thus should be suspended for the reading. Readings will not stabilize for turbid samples, and for these I would watch the meter, and try to record the highest value reached. If the sample is very turbid, the readout will flash about 2.4, or some other number. This meter only reads to 99.9 NTU's, so if the readout is flashing, the sample has a turbidity > 99.9--record that on the data sheet. After recording the turbidity reading, put the standard back into the chamber, and pour the sample back into the sample bottle. Rinse the sample vial with distilled water in preparation for the next sample.

### Changing membrane and solution in D.O. probe:

Fill the probe with electrolyte as follows:

- A. Grasp the probe in your left hand. When preparing the YSI 5739 probe the pressure compensating vent should be to the right. Successively fill the sensor body with electrolyte while pumping the diaphragm with the eraser end of a pencil or similar soft, blunt tool. Continue filling and pumping until no more air bubbles appear. (With practice you can hold the probe and pump with one hand while filling with the other.) When preparing the YSI 5720A and 5750 probes, simply fill the sensor body until no more air bubbles appear.
- B. Secure a membrane under your left thumb. Add more electrolyte to the probe until a large meniscus completely covers the gold cathode. **NOTE:** Handle membrane material with care, keeping it clean and dust free, touching it only at the ends.
- C. With the thumb and forefinger of your other hand, grasp the free end of the membrane.
- D. Using a continuous motion *stretch* the membrane *UP, OVER,* and *DOWN* the other side of the sensor. Stretching forms the membrane to the contour of the probe.
- E. Secure the end of the membrane under the forefinger of the hand holding the probe.
- F. Roll the "O" ring over the end of the probe. There should be no wrinkles in the membrane or trapped air bubbles. Some wrinkles may be removed by lightly tugging on the edges of the membrane beyond the "O" ring.
- G. Trim off excess membrane with scissors or sharp knife. Check that the stainless steel temperature sensor is not covered by excess membrane.



## YSI STANDARD Handout

**FILL CELLS:** Fill and empty the cell at least three times with the Conductivity Calibrator Solution. When the cell temperature is stable (allow at least two minutes), record the cell temperature and record or adjust the conductance meter reading.

When calibration is complete, rinse and store the cell in distilled water, or a dilute solution of HCl or KCl. The Conductivity Calibrator Solution is now contaminated to some extent and must not be returned to the original container.

**CALCULATIONS:** If the calibration was performed at 25.00°C or is ostensibly corrected to 25.00°C, the meter reading for calibrator solution should have been the nominal 25.00°C value of 1000, 10,000 or 100,000  $\mu\text{mho/cm}$ . Adjustable meters can be trimmed to agree exactly with the nominal value of the calibrator solution. If the meter is not adjustable, or is to be used with several different probes, calculate a cell constant or a correction factor as follows:

$$\text{Cell Constant} = \frac{\text{Actual Calibrator Solution Conductivity}}{\text{Conductance Meter Reading}}$$

Conductivity readings on unknown solutions with this cell and meter may then be taken according to:

$$\text{Solution Conductivity} = (\text{Conductance Meter Reading}) \times (\text{Cell Constant})$$

For meters which presume a cell constant (not necessarily a round number) and give a reading in conductivity, it is more practical to calculate a correction factor:

$$\text{Correction Factor} = F = \frac{\text{Actual Calibrator Solution Conductivity}}{\text{Conductivity Meter Reading}}$$

Unknown solution readings are then corrected by:

$$\text{Correct Conductivity} = F \times (\text{Meter Reading})$$

Note that meter calibration is a factor in all these readings--unless the meters are accurately calibrated, different "cell constants" or correction factors will be obtained from the same cell and solution with different meters, or even on different ranges of the same meter. For independent calibration of conductance meters, use the YSI #3166 Conductance and Resistance Calibrator Set. If the meter or meters are not independently calibrated, the cell constant or correction factor calculated above will apply only to the very cell, meter, range and mode (for meters which read both in ohms and mhos) used in calibration. Calibrate each cell in each range and each mode for best results.

When calibrating at other than 25.00°C, without temperature compensation, use the Calibrator Solution Conductivity at the temperature of calibration (not the 25.00°C value) in the equations above. Refer to the section on Temperature Effects, which follows.

Apart from errors due to conductance meter calibration, cell constants may vary slightly with conductivity and with cell history. Calibration should therefore be undertaken with a Calibrator Solution as near as possible to that of the unknown solutions to be measured. For unknowns of very low conductivity, use the 1000  $\mu\text{mho/cm}$  Calibrator Solutions, because lower calibrator values are less stable and less well documented. Recalibrate at six-month intervals, or following any visible change in cell condition. Cell fouling, cleaning or replatinization may have a substantial effect on cell constant, as will any mechanical bending or displacement of the electrodes.

### TEMPERATURE EFFECTS

Over the range 20°C to 30°C, conductivity of the Calibrator Solutions may be calculated from the following equation:

$$\text{Conductivity} = (\text{Conductivity at } 25.00^\circ\text{C}) \times (A + BT + CT^2)$$

where T = temperature in degrees Celsius, IPTS 68. Use these coefficients:

Cell constant for our meter as measured 24 January 1987:  
825.5/810 = 1.02285

| SOLUTION          | 25.00° CONDUCTIVITY        | A      | B      | C        |
|-------------------|----------------------------|--------|--------|----------|
| YSI #3160 & #3161 | 1000 $\mu\text{mho/cm}$    | 0.5407 | 0.0173 | 0.000043 |
| YSI #3162 & #3163 | 10,000 $\mu\text{mho/cm}$  | 0.5538 | 0.0168 | 0.000042 |
| YSI #3164 & #3165 | 100,000 $\mu\text{mho/cm}$ | 0.5825 | 0.0157 | 0.000040 |

Nominal values are tabulated below by whole degrees. Interpolate linearly.

| TEMPERATURE | YSI #3160 & #3161      | YSI #3162 & #3163        | YSI #3164 & #3165         |
|-------------|------------------------|--------------------------|---------------------------|
| 20°C        | 904 $\mu\text{mho/cm}$ | 9,066 $\mu\text{mho/cm}$ | 91,260 $\mu\text{mho/cm}$ |
| 21          | 923                    | 9,251                    | 92,980                    |
| 22          | 942                    | 9,437                    | 94,730                    |
| 23          | 961                    | 9,624                    | 96,480                    |
| 24          | 981                    | 9,812                    | 98,230                    |
| 25          | 1000                   | 10,000                   | 100,000                   |
| 26          | 1020                   | 10,190                   | 101,770                   |
| 27          | 1039                   | 10,380                   | 103,560                   |
| 28          | 1059                   | 10,571                   | 105,350                   |
| 29          | 1079                   | 10,763                   | 107,140                   |
| 30          | 1098                   | 10,956                   | 108,950                   |

The following tolerances apply, whichever method is used to find conductivity:

| TEMPERATURE RANGE | YSI #3160-3161 | YSI #3162-3165 |
|-------------------|----------------|----------------|
| 24.5 to 25.5°C    | $\pm 0.50\%$   | $\pm 0.25\%$   |
| 22.5 to 27.5      | $\pm 0.55\%$   | $\pm 0.30\%$   |
| 19.5 to 30.5      | $\pm 0.60\%$   | $\pm 0.35\%$   |

#### NUMERICAL EXAMPLE

It is desired to measure the conductivity of groundwater which is expected to be in the range 3000 to 8000  $\mu\text{mho/cm}$  at 25°C. YSI #3162 is selected as an appropriate calibrator because it is 10,000  $\mu\text{mho/cm}$  at 25.00°C. About 900 ml of YSI #3162 Calibrator Solution is poured into a clean and dry 1000 ml Erlenmeyer flask. The flask is equilibrated to room temperature. A dip cell is connected to a conductance meter. The cell is rinsed with a little bit of Calibrator Solution which is then discarded. The cell is immersed in the Calibrator Solution. After two minutes of stirring, the solution temperature is measured with a 0.1°C thermometer and found to be 22.1°C. From the equation, the conductivity of the Calibrator Solution is then calculated:

$$\text{Conductivity} = (10,000)[0.5538 + (0.0168)(22.1) + (0.000042)(22.1)^2] = 9456 \mu\text{mho/cm}$$

The tolerance of the Calibrator Solution at this temperature is  $\pm 0.35\%$ . The conductance meter reading is 9200  $\mu\text{mho}$ . Therefore, the cell constant is calculated to be:

$$\text{Cell Constant} = (9456 \mu\text{mho/cm}) / (9200 \mu\text{mho}) = 1.028/\text{cm}$$

When a groundwater specimen gives a meter reading of 4000  $\mu\text{mho}$ , the actual conductivity is

$$\text{Solution Conductivity} = (4000 \mu\text{mho})(1.028/\text{cm}) = 4112 \mu\text{mho/cm}$$

#### STORAGE

Store below 25°C (77°F) to minimize the likelihood of error due to bottle wall leaching or to microbial growth. Do not freeze, as the bottle may break! If a container does freeze, thaw completely and mix contents before removing any solution. Discard if expiration date is past, or if color, turbidity or visible microbial growth develops. Since the iodine used for initial disinfection of these solutions will lose potency on standing, solutions which have been opened are not secure against microbial invasion and must be discarded within one month of opening.