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DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY

MANUAL FOR LEVELING AT GAGING STATIONS IN NORTH CAROLINA

By N. O. Thomas and N. M. Jackson, Jr.

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Metric Conversion Factors

The inch-pound system of units is used in this report. For readers who prefer the International System of Units (SI), the conversion factors for the terms in this report are listed below:

Multiply inch-pound unit	By	To obtain SI unit
	Length	
inches (in)	25.4	millimeters (mm)
feet (ft)	0.3048	meters (m)
miles (mi)	1.609	kilometers (km)

National Geodetic Vertical Datum of 1929 is a geodetic datum derived from the average sea level over a period of many years at 26 tide stations along the Atlantic, Gulf of Mexico, and Pacific Coasts and as such does not necessarily represent local mean sea level at any particular place. To establish a more precise nomenclature, the terms "NGVD" or "NGVD of 1929" are used in place of "Sea Level Datum of 1929" or "mean sea level."

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N. O. Thomas and N. M. Jackson, Jr.

ABSTRACT

This manual was prepared to serve several purposes in the North Carolina District. It sets forth District policy as to frequency of levels, accuracy criteria, procedures for checking the datum and setting of the various types of gages, general rules to follow in establishing the original datum of a gage, and contains sample notes to be used as guides in level notekeeping. The manual also serves as a training tool in that the reasoning behind District policy is explained and reasons are given for following the recommended techniques to assist in a better understanding of the purpose of levels and maintaining gage datum.

INTRODUCTION

This manual establishes the criteria and the procedures for running levels in the North Carolina District. Many of the procedures and instructions were taken from training programs conducted in Raleigh, which have been expanded based on Water-Supply Paper 888 and practices used in many WRD Districts.

A new front sheet has been especially designed for summarizing level results and is to be used on all level notes. Sample sets of level notes are included as illustrations to these instructions.

Engineers and technicians supervising or performing leveling work should review and/or check levels to assure that the proper procedures were followed and that notes are clear, complete, concise, and generally conform with the illustrations in this manual.

In order for this manual to meet training needs and lead to a better understanding of levels and maintaining gage datum, various sections were expanded and reasons given for following certain techniques. The sections on Establishment of Original Gage Datum, Reference Gage, Checking the Settings of Wire-weight Gages and Digital Recorders, and Tying Gage into National Geodetic Vertical Datum particularly fall in this category.

PURPOSE OF LEVELS

Levels are run for a number of purposes. Among these are: (1) establishment of original gage datum, (2) check reference marks (RM's) and gage settings, (3) tie in physical features, (4) determine elevation of gage zero above National Geodetic Vertical Datum of 1929 (NGVD), (5) tie in high-water marks and run lines for flood profiles, (6) run cross-sections, and (7) levels for indirect measurements.

Depending on purpose, levels are run using differential-leveling or transit-stadia procedures. Differential leveling is used for establishing or checking gages and datum. Transit-stadia surveying combines differential leveling with mapping and is normally used in level work associated with indirect measurements. This manual is directed mainly to differential leveling for purposes 1-5 above. Instructions for surveying for indirect measurements are found in Techniques of Water Resources Investigations, and though they differ in some respects, the principles specified herein should generally be followed.

ESTABLISHMENT OF ORIGINAL GAGE DATUM

The original setting of the gage datum when a station is established is thought of as "arbitrary", but there are some rules to be followed.

The original gage datum ("0" plane above which gage heights are referenced) is usually set and maintained so that (1) the gage-height record will be historically compatible, (2) the datum will not have to be changed, and (3) negative readings will not occur. To meet these requirements something must be known about the flow at the time gage datum is established and the probable lowest level of future flows. Ideally a gage would read "0" at zero flow, but since this might result in negative readings if the channel degrades, the gage must be set to read greater than "0" at zero flow.

Levels may be required to determine the point of zero flow, or if the low-water control is close to the gage, a determination of the point of zero flow by depth measurements at the control will suffice. Gages are usually set to read about 1.5 ft at the point of zero flow. A greater figure should be used if there is a chance that the stream will degrade or be channelized. A smaller figure, say 1.0 ft, can be used if there is a stable, structurally-sound artificial control or if the control consists of ledge rock extending across the stream.

In actual practice, after installing a low-water staff or wire-weight (WW) gage to read according to the above criteria and establishing three independent reference marks (RM's), levels are run from a selected foot-mark of the staff or from the wire-weight checkbar (CB) to tie in the RM's and to complete the setting of other gages and staff sections. The "origin" and close-out of this first set of levels is the selected foot-mark or CB, and is the only time such origins are used. Thereafter the most stable RM is used as the origin.

An alternate practice on this first set is to establish an RM (or good mark at a low elevation), and establish its elevation using the water surface's (WS's) elevation as the origin (for example, use 2.5 ft for the water surface if the point of zero flow was determined to be 1.5 ft). This RM then becomes the origin for the full circuit of levels tying in other RM's and setting all gages to the proper datum. This RM is not necessarily the best, most stable RM for use as the origin in future levels. The reason for not using the water surface as the origin for the full circuit is that it is difficult to obtain accurate shots on it--difficult to line up the bottom of the rod with the water's surface.

The above rules should be applied when establishing the "arbitrary" gage datum and reference point (RP) elevation at water-quality monitoring or partial-record stations. Stage-discharge rating curves developed for these sites will then be compatible with and in accordance with standard practice.

If another agency such as the National Weather Service or Corps of Engineers has been collecting stage records at the station, the USGS gage(s) should be set to the same gage datum used by that agency. Use the best RM of the other agency and its gage datum elevation as the origin in setting USGS gages. Establish and tie in new RM's so that a minimum of three independent ones are available. Also, check by levels the settings of the other agency's gage(s). If the gages are "off" and if we have occasion to use readings of those gages later, we will apply the indicated correction to the readings.

FREQUENCY OF LEVELS

District policy is to run levels and check gages according to the following criteria:

1. Newly-established continuous-record (regular) stations.--Run levels when the gage is established and then annually until three sets of levels have been obtained. If the three sets show the gages to be stable, then levels will be run at three-year intervals. If the gage RM is not found to be stable, yearly or more frequent levels will be run. Corrective action: establishment of new RM's to replace damaged or settling ones and improving the supports of staff gage, etc., as needed should be taken promptly when discovered.

2. Established regular stations.--If RM's and gages are known to be stable, levels should be run at three-year intervals.

3. Crest-stage gages.--Levels should be run at two-year intervals. Levels are needed more frequently since these gages (pipes) are not as stable as regular gages and there is basically no visual check (except slippage in the brackets) or comparison of readings usually available at a regular station to detect movements of pipe and supports.

4. Exceptions.--If conditions warrant, levels should be run more frequently than indicated above. These conditions include:

   a. Known instability.

   b. Construction nearby.

   c. Unexplained differences in gage readings.

   d. Vandalism or other damage that requires replacing gages.

   e. Before discontinuing, relocating, or resetting a gage.

   f. Any other reason that casts doubt on the reliability of gage settings or the gage datum.

PREPARATION FOR LEVELS

Condition and Care of Rod and Leveling Instrument

Before running levels, the condition of the rod and level should be checked. Space is provided on the front sheet of the level notes to record the tape readings used to check the rod's scales and length.

Checking the rod

The rod should be checked in the field prior to running levels. The best procedure is to match 2.000 ft of a steel tape with the 1.000-ft mark of the rod; holding that match, read the tape at the bottom of the rod and at the 2.000, 3.000, and up to the 12.000 or 13.000-ft marks of the rod. Indicate where the rod's scales change from one section to another. For example, this might be at the 6.64-ft mark on a 2-piece Philadelphia-type rod. For a 3-piece pointed rod (2 telescoping joints) the breaks between scales might be at 4.28 ft and 8.54 ft. This type of rod is a little over 12 ft long when assembled.

If the bottom of the rod is off, it will make no difference as long as all sights (shots) are taken using the rod. However, if the electric-tape (ET) gage, wire-weight gage, and staff-gage plates are checked by direct-shot readings (rod not used) at height of instrument (HI), the bottom of the rod should not be off by more than 0.002 ft. Preferably, rods with an error of more than 0.002 ft on the bottom should not be used. However, if used, all

direct shots should be corrected for rod error. For example, if the bottom of the rod is 0.005 ft instead of 0.000 ft, readings on the rod will be 0.005 ft too high and the HI and any direct shots are also 0.005 ft too high. In this example, all elevations determined by direct shots should be corrected by subtracting 0.005 ft.

On many 2-piece Philadelphia rods there is a vernier adjustment on the "stop" when the rod is fully extended, which allows the high scale to be matched with the low scale of the rod and eliminating an error or correction change between sections. The rod may still be "off" at the 0.000-ft mark. After adjusting the vernier or stop, the 1.000-ft mark and other points on the rod should check within 0.002 ft.

Philadelphia leveling rods have a scale painted on steel strips which ride in narrow slots in the wooden rod. This makes the scale resistant to wear, highly visible, more accurate, and replaceable. Scales in poor condition or with inaccuracies should be replaced with new metal scales to the above standards. Never use a 25-ft fiberglass telescoping rod for gaging station levels.

Rods should be carefully stored when transporting them in a vehicle and not be abused through use as a "prop" in wading or taking cross-sections in the stream.

Checking the level

The level's condition is also important. Two-peg tests should be made periodically, but continual small adjustments of dumpy and wye levels should be avoided. The adjustment procedures for dumpy and wye levels are different. The wye level requires more steps, can be tedious and difficult, varies with the type of construction, and must be adjusted by an experienced person. Avoid experimenting, over-adjusting, and twisting cross-hair frames so that the horizontal cross-hairs are not horizontal. Select a clear day and a good location. Use the longest shots (about 100 ft$\pm$ between pegs) that can be read to thousandths.

Zeiss levels, particularly, are delicate instruments and their internal construction is such that they are easily damaged by rough handling. The self-leveling prisms are supported by wires.

Freedom of the internal prism assembly to rotate can be easily checked on any setup by turning the level screw under the telescope slightly in both directions to see whether the assembly promptly returns to the same rod reading. It should not be necessary to tap the side of the telescope.

The only adjustment that should be undertaken locally is to eliminate leveling errors (prisms free, but line of sight not horizontal), but it is not recommended that this be done often although the instruction book covers it. The small internal capstan (inside telescope) is very sensitive and over-adjustment can result. If, on a peg test the instrument is not "off" by more than about 0.005 ft (equivalent 1-way shot of about 80 ft), do not adjust--instead, plan on balancing sights as closely as practicable when running the levels and the small error will be substantially eliminated.

Levels are delicate instruments and should be handled, stored, transported, and used with care. Care of the Zeiss level is emphasized because repairs require that it be shipped to a dealer or repair shop. Repair costs average about one-third of the original cost.

Review of earlier levels

The level summary sheet showing the results of earlier levels or at least the most recent complete set of level notes at the station should be reviewed before leaving the office. "Given elevations" (see new front sheet, Form WRD RAL-4-74) for all RM's, RP's, and other points to check should be determined and the RM to be used as the origin or starting point of the level circuit selected. Remember, the origin RM should be the mark that has proved to be the most stable over the years. Do <u>not</u> average the HI's from shots on two or more RM's and run the levels to an average.

If the review indicates an RM has not been stable or has been disturbed, plan to establish a new one. Also plan to determine the elevation of any physical features needed to complete the field station description. Among these are: bottom of stilling well, intakes (both ends), cleanout door sill, floor of gage house, recorder shelf, top of house, tops of A-frame foundations, elevation at which water starts to flow against bottom chord of bridge beams, and lowest elevation that water starts to flow over approach roadway.

Establishment of new reference marks

New RM's should be established before the level circuit is begun. The new RM should be set where it has the best chance of being stable and completely independent of the other RM's at the station. Independent in this case means, for example, not on the same bridge; the bridge may be destroyed or replaced.

Assign the next highest number to the new RM and describe it fully in the notes. If there are three RM's at the station, one of which is to be abandoned due to instability, the new RM is RM_4. Indicate in the notes the RM to be abandoned and make one last datum check to confirm its unreliability.

If in the rare case all RM's are found to be unreliable or have been destroyed, the reference gage, as found, may have to be accepted as correct and used as the starting point to establish three new RM's.

Reference marks must be stable and permanent. Rock outcrops, poured concrete posts, large permanent existing structures are all desirable locations for markers. Large trees may be used but extensive timber cutting will continue to diminish permanency. At swift rivers, one of the RM's should be located on high ground well above any known or possible floods. This will assure datum recovery should catastrophic flooding occur.

PROCEDURES FOR CHECKING REFERENCE MARKS AND GAGE SETTINGS

Levels at the Gaging Station

Just before starting the actual levels in the field, measure the rod's length and enter rod measurements on front sheet--see the above instructions for checking the rod, and establish and describe any new RM's needed.

The procedures to be followed in running the levels are outlined in the steps below. The objectives are: to determine elevations of RM's, electric tape gage index, check bar of wire-weight gage, and RP's; determine gage settings found; and show basis for resetting gages if reset. Use level notes Form 9-276, miscellaneous field notes Form 9-275d, and the new front sheet, Form WRD RAL-4-74, to cover and summarize the set of levels. Notes should be clear and concise. Sample level notes shown in the illustrations serve as guides.

1. Enter on note sheets the WR number and condition of level. A complete reading of all gages and digital recorder (ADR) dial with the time, and other information (party, etc.).

2. Start the circuit with a backsight on the origin RM; then run the circuit so that all RM's, RP's, ET Index, CB, and gages are tied in by either: (a) two side-sights (foresights) or (b) if RM's and RP's are used as turning points (TP's), the usual foresight (FS) and backsight (BS) will be adequate. Read all shots to thousandths. Close out on the origin RM.

3. Do not change any gage settings until the level circuit is closed and adjusted, and elevations averaged where two foresights were made on a mark. "Mark" includes: an RM, ET index, CB, and RP or special TP set for checking staff and other gages. It also includes nails driven into staff gage backings and used (after adjusting the circuit) for checking and resetting staff gages, and a firm temporary reference mark set at a low elevation to check the wire-weight gage. These marks should be set as the level circuit is run.

4. Leave space in the left part of the Remarks column for entering adjusted elevations. Use two lines or more if needed to describe features of any mark, foresight, or gage.

The procedures for adjusting the circuit and checking various gages are given in subsequent sections of this manual.

Adjusting the level circuit

The circuit should be adjusted if the error of closure exceeds 0.015 ft. More consistent and compatible elevations and gage settings will result if the circuit is adjusted. If the error of closure exceeds 0.025 ft, it may be prudent to consider rerunning the levels. Good work with good instruments makes it fairly easy to keep the error within 0.015 ft.

Adjust the elevations on the basis of the number of turning points in the circuit. For example, if there are 9 HI's and -0.019 ft error of closure, add progressively to the unadjusted elevations as follows:

Elevations determined by foresights from:	Add		
1st HI	0.002'	(0.019 ÷ 9)	
2nd HI	.004'	do	times 2
3rd HI	.006'	do	times 3
4th HI	.008'	do	times 4
5th HI	.011'	do	times 5
- - -	- - -	- - -	- - -
9th HI (last)	.019'	do	times 9

Show the adjusted elevations in the Remarks column of the level notes, Form 9-276. After the adjustment there will be two adjusted elevations for most points. List the two elevations in two columns on a miscellaneous notes form; and then average the two, putting the average in a third column labeled Final Average Balanced. The sample notes show the procedure. These final elevations are carried to the Front Sheet in the Elevation Found column.

Electric-tape gage

Since the ET gage usually serves as the reference gage (see section on Reference Gage), its setting should be carefully checked. Checking consists of three steps: (1) determining the elevation of the ET index by levels, (2) measuring the tape's length, and (3) comparing the two. If the tape is long as compared with the index elevation, the ET gage is reading too high and minus correction is applicable to readings. If the tape length is short, a plus correction is applicable.

Reset the ET tape if it is found reading off more than 0.015 ft. In resetting, follow the examples given in the illustrated level notes. Reset to make the ET tape length equal the elevation of the index.

The ET tape length is the distance from the "0" of the tape to the bottom of the weight. The distance, however, should be determined by measuring from the 1st or 2nd foot mark of the tape nearest the weight to the bottom of the weight and adding this distance to the foot mark used. Be sure that the tape hangs without twists or kinks. Replace the tape if found in poor condition.

In the sample notes the elevation of the ET index was determined by: (1) rod shots on the index through the house or shelter door; and (2) by direct shots on the lowered tape taken at HI through the cleanout door.

Other techniques for determining the elevation of the ET index, where the installation is a half-shelter or a pipe well (no cleanout door) and it is difficult to take shots, are as follows:

1. Set up if possible where a direct shot can be taken at HI on the ET tape through the float access door. This is the small door near the top of pipe wells. Notes should be similar to those for a direct shot through the cleanout door.

2. Use a short steel tape graduated to hundredths of a foot and hold vertical by a spirit level; with "0" on the index. Take a direct shot on this tape through the shelter door. A special instrument set-up on the walkway may be required. Notes to be included in the level line should be as follows:

Station	BS	HT. Inst.	FS	Elev.	Remarks
ET Index		31.483	1.211	30.272	Steel tape

   Measurement of the ET tape length is a separate phase after adjustment of the level line. Examples are shown in the illustrations.

3. Set up if possible where the HI is only a tenth or two above the ET index and in a position so that a direct shot can be taken on the ET tape through the shelter door. Notes should be similar to those for a direct shot on the ET tape through the cleanout door.

4. Determine the elevation of an RP set as closely as possible to the ET gage and level across to the ET index using a spirit level. Keep appropriate notes on the leveling using the spirit level. There is no example in the illustrations.

It should be remembered that rod error, particularly at the bottom of the rod (rod did not measure 1.000 ft from 1.000-ft mark to bottom), which can be large, will result in a corresponding error in the ET index elevation. This applies to any direct shot on staff gages, on lowered ET tape, and on the

bottom of the wire-weight gage weight. The problem has been discussed in more detail under "Checking the rod". A limit of 0.002 ft error was set for the bottom of the rod and if the error exceeds this limit, direct shots should be corrected accordingly.

Staff gages

There are three ways to check staff gages:

1. Drive a nail in the gage backing at the scale edge of each staff section, take shots on the nail, and compare the final elevation of the nail with the gage reading of the staff. A good horizontal heavy pencil mark can be substituted for the nail.

2. Same as 1, but there are two or more staff-plate sections on the same backing and only one nail or mark was set and tied in: Measure vertically from nail or mark, using a tape, to selected gage-reading marks of other plates. Compare the true elevation of the marks with the gage reading.

3. By direct foresight on the gage plate (0.000 ft FS) and compare adjusted HI with gage reading.

The three methods are shown in the sample notes. The third method is affected by rod errors, particularly the error at the bottom of the rod. However, the method must be used where the rod cannot be matched with a nail or mark or a staff plate cannot be measured to by tape from a nail or mark because the section is too high above the ground (as on the side of a gage well).

Depending on the installation arrangement of staff gages, several nails or marks on the wood backing may be required under the first two methods. The front sheet is designed especially for these two methods as well as to avoid confusion in the determination and direction of corrections to be applied. The results are listed on the front sheet.

If there is an inside staff (IG, with ranges shown) in addition to an outside staff (OG, with ranges shown), use a continuation front sheet for the IG. Indicate whether OG or IG in column headed "Staff section".

Outside staff gage sections should be reset if found reading more than 0.015 ft off. This is critical where the outside staff is being used as the reference gage for a bubble gage. The lowest section is more critical than others because (1) more accurate readings to correct datum should be made and are needed at low water, (2) small gage-height errors at low water usually cause large percentage errors in discharge, and (3) it is desirable that all gages read closely together at low water. If an inside staff is being used as a reference gage for graphic or digital recorder (there is no ET or other inside reference gage), the same critical factors apply.

For higher staff gage sections the criteria for resetting is relaxed to 0.020 ft. If the higher sections are found reading off by more than 0.020 ft, they should be reset. The logic of the relaxed criteria is based on inaccuracies in reading staff gages at higher stages where drawdown, pileup and other factors affect readings.

One advantage of the nails driven into the backing of the staff plates is that they serve as a check on the stability of the gage support and can be used year after year. Also, they eliminate the need for setting up the level again to reset the plates. Staff plates should not be reset until the line is closed out, adjusted, and final elevations of the nails determined.

The stability of the staff backing and its support are a factor in resetting staff gage plates. If they are not stable, the supports and bracing should be improved before resetting. If the backing is disturbed or moved, additional level setups will be required because the elevations of the nails are no longer known. It is recommended that more permanent RP's or TP's be set as references as levels are run, and left in place so that the entire circuit will not need to be run again to reset the staff gages after they have been improved.

If the level rod errors are 0.002 ft or less, direct shots can be used to check the staff gage setting without correction. If used, the staff should read the same as the HI.

To avoid confusion on staff gage settings it is better to think in terms of gage readings and the datum correction to be applied. The following statements explain:

1. If a staff gage is reading too high, the datum correction is minus; the gage section has settled or is physically too low as compared with the gage datum.

2. If a staff gage is reading too low, the datum correction is plus; the gage section has risen or is physically too high as compared with the gage datum.

Wire-weight gage

Due to drum or wire-diameter errors a wire-weight gage may not read to the correct datum at low water if it is set to the check bar elevation. Errors in low-water readings can amount to several hundredths when the CB is set to read the same as the CB elevation.

The correct CB reading is to be determined as follows (see sample notes):

1. In addition to tying in the CB (be sure that the bar is in the "out" position under the weight) when running the level circuit, also set a firm turning point or temporary RM or other point with two side shots at the lowest elevation possible.

2. After closing out and adjusting the line and TP or other point, set up the instrument again at or near the TP (or between it and the wire-weight gage). Set up at the lowest elevation practicable.

3. Read the CB making sure bar is in the "out" position under the weight. Lower the weight and take a direct sight (FS = 0.000) on the bottom of the weight. Compare the actual WW gage reading with the HI.

4. Adjust the CB reading by the amount needed to make the gage read correctly. For example, if the gage reads 0.035 ft too high or 0.035 ft greater than the HI, crank up the weight and reduce the CB reading by 0.035 ft. An example would be; change the CB reading from 31.09 ft to 31.055 ft. Show in the notes all the CB readings and the WW gage readings at HI before and after changing the CB; make check shots also, and show, to assure that the final setting of the CB is the correct CB reading. Write the correct CB reading and date inside the WW gage.

5. On CB readings and settings, the acceptable refinement is the nearest half hundredth (0.005 ft). But do not first round the HI elevation to this lowered accuracy.

Do not loosen the two clamp screws on the drum end of the WW gage with the weight in the lowered position. Make all adjustments on basis of the CB reading. This can be handled easily by one man and will result in more accurate settings. Trials of CB changes and sights on bottom of weight with gage readings will be necessary.

If the wire needs straightening on the drum, do this after checking the "as-found" situation (CB reading and first shot(s) on the bottom of the weight). In determining the correct CB reading, as reset and left, the normals of properly-wound wire, and so forth, will apply. As a last item, adjust the foot counter (Veeder) on the gage so that it starts to turn over to the next higher foot at about 0.95 or 0.96.

As in the case of staff gages, it is more important that the WW gage read correctly at low water; hence the adjustment procedure outlined above.

One technique that may be used to check the WW gage at a low elevation follows.

Establish an RP, a bolt set in outer guardrail over land, near low-water's edge. Place the ring of an inverted tape over the bolt, and take two rod foresights on the end of the ring (this is 0 of tape). Later, when the level circuit at high elevations is adjusted, set up instrument at low elevation take a 0.000 ft BS, read tape at HI, compute HI by subtracting the inverted tape reading at HI from the elevation of 0 of the tape. Then take shots on the bottom of the WW gage weight and adjust the CB reading as described above. This can save a number of setups in turning down. The tape case serves to keep the inverted tape plumb.

Digital recorder

A digital recorder dial is not a reference gage in the sense that an ET, a graduated tape on the recorder, a float gage, and a staff gage are. If the digital recorder is equipped with a graduated steel tape and index pointer, the tape could serve as a reference gage if it is set by levels.

However, since few if any digital recorders have graduated steel tapes, the solution is to set the dial to read the same as the reference gage. (See section on Reference gage). Generally, the best reference gage is the electric-tape gage. A special effort has been made to equip all continuous-record stations with ET's.

Before running levels, all gages and the ADR dial should be read (complete inspection). After running the levels, adjusting the line, and resetting the inside gages (all except the ADR and graduated tape), read all inside gages and the ADR dial.

If the ADR has a graduated tape and index, reset the index or slip the tape through the float connector to make the tape read the same as the ET. Then set the dial to read the same as the ADR's graduated float tape.

If there is no graduated float tape on the ADR, simply set the dial to read the same as the ET.

If there is no ET and some other type of gage is being used as the inside reference gage, set the dial to read the same as the other gage. Other types of gages being used at a few locations as reference gages include: inside staff and float tape gage (a separate float-tape, or a tape over the recorder float wheel).

Bubble gage

Keeping bubble gages "on datum" is a matter of checking and resetting the outside staff gage by levels. In this case the outside staff is the reference gage. After checking the staff gage, the procedure is to read the bubble gage's counter, record it in notes (compare with staff), and set the counter to read the same as the staff gage. After setting the counter to the staff, set the ADR dial and/or the graphic recorder pen to read the same as the counter. Cross-check ADR dial versus staff reading. Instructions for checking staff gages are given above. In some cases, WW gages may serve as the reference gage.

The successful setting of the counter presumes that the manometer is operating properly, has stabilized at the correct position, and has been adjusted to minimize lag due to float-switch gap. The delay should be turned off, so that the "seeking" range can be observed.

Since the outside staff is the reference gage in this case and is more subject to support damage, bank slippage, and so forth, it should be checked by levels annually, or more often if conditions warrant. Crest-stage gages used to verify recorded peaks should also be checked during annual levels.

Float-tape gages

These are commonly referred to as FT (separate float-tape gage) and RT (tape runs over recorder float wheel). As discussed here, the tapes are graduated and have indexes for reading.

If there is an ET, set the FT or RT to read the same as the ET at the water's surface. Trials and cleaning the bottom of the ET between trials will be needed.

If there is no ET, the FT or RT should be checked by measuring from an established RP to the water surface. The RP can be the inside edge of the cleanout door sill, a bolt projecting from inside wall below the sill, a nail in inside staff gage backing, or similar mark. This RP should be established, identified and tied in as the level circuit is run. After adjusting the circuit, the notes for checking the FT or RT should read as follows (use a steel tape and weight to measure from the RP to the water surface):

"Check of RT: Dist. from RPX to WS. Tape reads 12.950 at RP
" " 1.444 at WS
Dist. to WS = 11.506

Elev. RP = 15.218
Dist. to WS = 11.506
Elev. WS = 3.712
RT found reading 3.691, or 0.021 too low, at 3:15 p.m.
(Check distance to WS and computations)
RT reset to read 3.711 at 3:20 p.m.; read correctly-ok."
(Include check measurements, RP to WS, after resetting)

If the gage height is changing, rereading of the RT should be made as checks before and after the change in setting was made.

A steel tape and weight using chalk on the tape where it will intercept the water surface is preferred in measuring the distance to the WS.

The best way to reset an RT is to mark or read the tape where it enters or leaves the connector on the float, then loosen the connector screws and slip the tape as needed. In the above note-keeping example, the tape would have been slipped out (up, or toward the recorder) by 0.021 ft. This makes the RT read higher. It was found reading too low.

Crest-stage gages

Most crest-stage gages (CSG) have been established with the top of the pipe (cap off) as the key reference elevation. A mark on the stick matches the top of the pipe.

In checking by levels, start at the selected origin RM and tie in other RM's and the top of the pipe. Run levels to thousandths. At least two set ups are required, since two side shots are needed on the top of the pipe.

At most CSG's the elevation of the top of the pipe was assumed and originally an even foot or even tenth-of-a-foot was selected. Because of slippage of the pipe in the brackets and repairs or changes over a period of years, few remain at the elevation originally assumed. However, the RM's originally-established elevations remain the same and datum is maintained. CSG's are not reset to their original elevation.

Many CSG pipes have been marked by hack-saw cuts or other methods at tenth-of-a-foot intervals from the top of the pipe, where the pipes were inaccessible at high water. This enables a visual reading at a distance.

If there are other gages such as staffs, they should be checked by levels. If there are any recent high-water marks in the vicinity of the gage which may possibly have been missed on inspections, they should be tied in also. Tying in such marks (extreme high water) on both sides of the bridge (or culvert) may permit an indirect measurement computation and improvement of the rating.

REFERENCE GAGE

When regular stations are established, a "reference gage" should be designated. This is the gage to which measurements will usually be plotted and it must be a gage that can be checked by levels and for which datum corrections can be clearly determined. It is usually a gage inside the well: an electric tape gage, a float-tape gage on the recorder (graphic or ADR), or an inside staff. If the designated "reference gage" is out of operation for some reason and another gage is used temporarily, readings from the latter should be converted to the reference gage. The basis for converting is by applying a datum correction if applicable by comparative readings, or a combination of the two.

The best reference gage is the electric tape. It has a fixed index and the only possible source of reading errors or datum changes are: errors in reading the WS, and settling (or movement) of the house or shelf.

By comparison other gages have the following undesirable characteristics:

FT and RT.--Subject to tape slippage at connectors, connectors rusting or failing, float rusting and sinking, easy adjustment and movement of the index or pointer, line shift, and settling of house or shelf.

Staff gage.--Support of staffs is often a problem. Supports may not be stable and wood rots out, thus gages are difficult to maintain at the correct datum. Often the scales enamelled on staff plates are not correct. Some plates have been found to be off by 0.03 ft over their range. Gage plates corrode and are difficult to read at the water surface. Readings are affected by drawdown, build-up.

The concept of the reference gage is that one reliable reference is needed as a basis for gage heights and discharge. In practice, however, it is not possible to use the reference gage directly for determination of gage record and discharge. But the recorder should be set to read as closely as possibly with the reference gage. The difference should be minimal, or 0.005 ft or less. This is not too strict when consideration is given to what can happen. Suppose that the ET is found reading 0.015 ft too high and not reset, and the ADR dial is found reading 0.015 ft higher than the ET. In this example, the station's gage heights are 0.030 ft off as compared with the correct gage datum.

The objective is for all gages to be set and read to the correct datum. It is especially desirable that they read the same at low water. However, due to water-surface slope and other factors, the outside gage, WW or staff, may read as much as several hundredths off on the comparison. If the outside gage is used directly for gage height and discharge, the readings from it should be adjusted to the inside reference gage. If the difference is more than about 0.03 ft this should be done, otherwise both gage height and discharge error can be quite large: 0.03 ft at low water can result in 20 percent plus errors in discharge.

TYING GAGE INTO NATIONAL GEODETIC VERTICAL DATUM OF 1929

The following procedure is specified for levels to determine the elevation of the gage zero above NGVD (formerly mean sea level):

1. First identify the nearest bench mark (BM) to the gaging station by searching the bench mark file and lists in the office. Contact other agencies as necessary. Include a full description of the BM in your level notes showing the agency (USGS, USC&GS, Corps of Engineers, NC Highway Commission or NC Geodetic Survey) that established and determined its NGVD elevation; and describe the datum used. The datum, for example, might be "sea level datum of 1929, supplementary (or general) adjustment of 1936" if USGS or USC&GS. Lists are often issued where elevations are unadjusted (that is the level line(s) by the USGS or NC Geodetic Survey has not been adjusted). Later, the lines in an area are adjusted and final lists are issued. The terms unadjusted or adjusted are different from supplementary or general adjustments. The latter are wide-area adjustments made by USC&GS or perhaps by USGS from a rerunning and general adjustment of primary and first order lines. Second-order lines are then adjusted generally to conform.

2. Start at the "origin" RM at the gaging station, using its gage datum elevation. Run a loop to the BM and close out on the RM at the gaging station. Do not intermix these levels with those to check RM's and gages.

3. Rod shots may be taken to the nearest 0.005 ft, since longer sights are usually involved. Also, there usually will be more shots and more opportunity overall to average the roundings, up and down, to nearest 0.005 ft. Attempt to reasonably balance the length of the backsight with that of the foresight at each instrument set up. Do not run a double-rodded line.

4. Set a more-permanent TP or temporary bench mark (TBM) every five instrument set-ups or so on the outbound part of the loop, and tie these in on the return to the gaging-station RM. This will localize error due to misreading of rod, and only five setups are needed in rerunning that portion to eliminate the error. The new run can be substituted for the portion in which there was an apparent erroneous rod reading. Errors of 0.10 ft or 1.00 ft in reading the rod on longer lines are not uncommon.

5. After eliminating errors (see item 4 preceding), adjust the line as described under "Adjustment of levels". Adjust the BM elevation (it is to gage datum, or course) and the permanent TP's.

6. After determining the adjusted elevation of the BM to gage datum, subtract that elevation from the stated NGVD elevation of the BM. The result is the datum of the zero of the gage above NGVD.

7. The BM's description and elevation above NGVD should be included in the Field Station Description. After the elevation NGVD, include: "Elev. to gage datum, xx.xx ft, by levels of _____ (date)".

There are several reasons for specifying that levels start at the origin RM and be run to gage datum: (1) WRD does not normally undertake to run long level lines across county to NGVD datum, (2) level computations are easier because smaller figures of "elevation" are used, and (3) confusion usually results when a later, better elevation above NGVD becomes available for the BM, and levels have been run from the BM using NGVD datum. The subtraction in step 6 is merely performed again after substituting the new NGVD elevation of the BM.

Levels to determine land surface datum (LSD) at observation wells usually start at the BM--contrary to the above procedure--and is covered by a manual on ground water.

LEVEL SUMMARY SHEET

A sheet summarizing all levels at gaging stations should be maintained in the station file. Levels should be added as run. The sheet enables a review of all levels at a station. It assists in identifying unstable RM's, RP's, and gage supports, and enables a quick comparison of gage settings and errors applied over a long period of time. See section on Review of earlier levels.

Various forms have been used. However, Form 9-230a, headed up to fit the particular station probably is best because it provides a larger number of columns. Two examples of level summary sheets are attached.

It has been the custom for many years to show gage errors in terms of the gage "reads high" or "reads low". The custom may be continued if desired, but it requires an adaptation from the new front sheet. Note also that an "H" or "L" must be placed on the level summary sheet by each correction. H means reading high and a minus correction is applicable to gage reading, while L means reading low and a plus correction is applicable. This is demonstrated on the first example.

The second example conforms with the manner of showing gage corrections on the new front sheet and is recommended for any new level summary sheet prepared. It directly answers the question: How much is the correction and what direction is it applied to adjust actual gage readings to true datum?

For staff gages, the corrections are copied directly from the level front sheet.

ILLUSTRATIONS

Form WRD
RAL-4-74

LEVEL NOTES
FRONT SHEET

Sta. No. 02999500 Date May 10, 1974

Sta. Name Water Creek at Spring, N.C.

Party: A.B. Smith ⊼ ; J.S. Doe ϕ Level WR # 251691

Rod type and No. — 2pc. Phila Rod level used? Yes

Rod length by steel tape: Rod Bot. 1.000 2.000 3.000
Tape 1.002 2.000 2.999 3.998

4.000 5.000 6.000 7.000 8.000 9.000 10.000
4.998 5.999 6.999 8.003 9.002 10.003 11.002

Starting Mark RM No. 2 Elev. 22.405 Closure -.028 ft.

*Marks tested	Given elev.	Elev. found(balanced)	Remarks
RM 2	22.405	22.405	Origin
RM 3	23.015	23.018	
RM 1	7.351	7.327	May be settling
RP 1	9.990	9.986	
ET Index	21.083	21.080	
Ck Bar	25.492	25.497	

*Include RM's, C.B., E.T.Index, and permanent RP's.

OG Staff Section	Holding rod on	Elevation found	Corr. to staff reading Found	Left
0-3.3	See Sheet 7 Mk.	—	+.05	0 Reset
3.3-6.7	5.00 'Mk.	5.060	+.06	0 Reset
6.7-10.1	8.50 'Mk.	8.516	+.016	+.016
10.1-13.3	12.00 'Mk.	11.968	-.032	0 Reset
13.3-16.7	15.00 'Mk.	14.964	-.036	0 Reset
	'Mk.			

E.T. Length: Found 21.066 ; Left 21.066 ; Time 11:55 a.m.

C.B. Setting: Found 25.525 ; Left 25.560 ; Time 1:15 p.m.

If the correct C.B. setting was determined at low H.I. near water surface enter correct C.B. 25.560 and H.I. 7.644.

When a gage is reset, so state, and show tests both before and after.

Prepared by A.B.S. Checked by J.S.D.

Sheet 1 of 7 sheets. Date 5-11-74

Level notes, example 1

9-276
(Rev. 7-67)

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
WATER RESOURCES DIVISION

Station Number
02999500

LEVEL NOTES

Stream Water Cr at Spring, N.C.

~~Locality~~ To check RM's and gages

Party A.B. Smith π, J.S. Doe ϕ Date May 10, 1974

STATION	B. S.	HT. INST.	F. S.	ELEVATION	REMARKS
Level	WR	25169	Zeiss		
Rod:	2-pc.	Phila.			
Rod	level	used			
WW = 2.25, CB = 25.525, OG = 2.33, ET = 2.27,					
ADR dial = 2.27 at 9:40 a.m.					
					Adj Elev
RM 2	6.033	28.438		22.405	Origin
RM 3			5.422	23.016	23.020 Given 23.015
Ck Bar			2.943	25.495	25.499 Given 25.492
ET Index			7.362	21.076	21.080 Given 21.083
TP	1.777	18.790	9.425	17.013	
Nail 15.00' Mk			3.830	14.960	14.968 OG 13.3-16.7
Nail 12.00' Mk			6.825	11.965	11.973 OG 10.1-13.3
Nail 8.50' Mk			10.279	8.511	8.519 OG 6.7-10.1
RM 1			11.467	7.323	7.331 Given 7.351
TP	.926	11.183	8.533	10.257	
Nail 5.00' Mk			6.131	5.052	5.064 OG 3.3-6.7
					(OG 0-3.3 on same backing)
Point A			3.973	7.210	7.222 Stake-set to check WW.
RP 1			1.210	9.973	9.986 Given 9.990 Ins.edge C-O door
TP	4.635	11.412	4.406	6.777	

No. 2 of 7 sheets Comp. by Chk. by

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895-172

Level notes, example 1--Con.

9-276
(Rev. 7-67)

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
WATER RESOURCES DIVISION

Station Number
02999500

LEVEL NOTES

Stream Water Cr at Spring, N.C

~~Locality~~

Party A.B.S. and J.S.D. Date May 10, 1974

STATION	B.S.	HT. INST.	F.S.	ELEVATION	Adj. Elev.	REMARKS
		11.412				
RP1			1.442	9.970	9.986	
Point A			4.210	7.202	7.218	
Nails: 5.00'Mk.			6.371	5.041	5.057	OG
RM1			4.105	7.307	7.323	
Nail: 8.50'Mk.			2.915	8.497	8.513	OG
TP	8.847	19.086	1.173	10.239	10.255	
Nails: 12.00'Mk			7.142	11.944	11.964	OG
15.00'Mk			4.146	14.940	14.960	OG
TP	9.007	25.997	2.096	16.990	17.010	
ET Index			4.942	21.055	21.079	
Ck Bar			.526	25.471	25.495	
TP	1.749	26.267	1.479	24.518	24.542	
RM3			3.278	22.989	23.117	
RM2			3.890	22.377	22.405	Closure -.028 11:20 a.m.

Adjusted line by $\frac{.028}{7}$, or +.004' rate per setup (H.I.)

Add to elev. determined from:

1st	H.I.	+.004		5th H.I	+.020
2nd	"	+.008		6th "	+.024
~~3rd H.I.~~		~~+.012~~			
4th	"	+.016		7th "	+.028

See next sheet for Final adjusted balanced elev's to use

No. 3 of 7 sheets Comp. by Chk. by

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89.5-172

Level notes, example 1--Con.

9-275d
(Feb. 1964)

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
WATER RESOURCES DIVISION

Date May 10, 1974 LEVEL

02999500 ~~MISCELLANEOUS FIELD~~ NOTES

Water Cr at Spring, N.C.

	Adjusted		Final (avg.)
	1st Elev	2nd Elev	Balanced (Use)
RM 3	23.020	23.017	23.018
Ck. Bar	25.499	25.495	25.497
ET Index	21.080	21.079	21.080
15.00' Mk, OG	14.968	14.960	14.964
12.00' Mk, OG	11.973	11.964	11.968
8.50' Mk, OG	8.519	8.513	8.516
RM 1	7.331	7.323	7.327
5.00' Mk, OG	5.064	5.057	5.060
Point A	7.222	7.218	7.220
RP 1	9.985	9.986	9.986

RM 1 may be settling

No. 4 of 7 sheets

GPO 869-125

Level notes, example 1--Con.

9-275d
(Feb. 1964)

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
WATER RESOURCES DIVISION

Date May 10, 1974 LEVEL

02999500 ~~MISCELLANEOUS FIELD~~ NOTES

Water Cr at Spring, N.C.

Check of ET gage:

Measured 2.066' from 19.000' Mk to bott. of Wt.

19.000
+ 2.066

ET length = 21.066 11:55 a.m.

From levels, ET Index Elev = 21.080

∴ ET gage found reading 0.014' too low. Not reset (Corr'n = +.014)

Check of ADR dial. No graduated tape on ADR

Readings of water surface: ET = 2.265'

ADR dial = 2.255'

or ADR found reading .010' too low

Reset ADR dial to read 2.265 at 12:10 p.m.

Re-check: ET = 2.265'

ADR dial = 2.265'

No. 5 of 7 sheets

GPO 869-123

Level notes, example 1--Con.

9-276
(Rev. 7-67)

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
WATER RESOURCES DIVISION

Station Number 02999500

LEVEL NOTES

Stream Water Cr at Spring, N.C.

~~Locality~~

Party A.B.S. and J.S.D. Date May 10, 1974

STATION	B. S.	HT. INST.	F. S.	ELEVATION	REMARKS
Levels to check WW gage: —					1:00 p.m.
Point A	.424	7.644		7.220	stake from levels today
Bott. Wt.			0.000	7.644	WW reads 7.608, or .036' too low. CB changed from 25.525 to 25.560 at 1:10 p.m.
WW Bott. Wt			0.000	7.644	WW reads 7.642
Point A			.422	7.222	Closure +.002' OK
Use correct CB reading = 25.560' at H.I. 7.644'					
[Include check sights ✓✓ on bottom of Wt and check WW readings. Straighten and re-lay wire on drum as CB setting is changed. Adjust Veeder counter so that it starts to turn to next higher foot at about 0.96 on circular scale]					

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Level notes, example 1--Con.

9-275d
(Feb. 1954)

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
WATER RESOURCES DIVISION

Date May 10, 1974 LEVEL

02999500 ~~MISCELLANEOUS FIELD~~ NOTES

Water Cr at Spring, N.C.

Check of OG staff sect. 0-3.34:
Measured 2.50' down (by tape) from nail in OG 3.34-6.14, and marked with pencil:
Elev. nail at 5.00' Mk = 5.060
- 2.500
Elev of pencil mark = 2.560
OG 0-3.34 reads 2.51' at pencil mark. Thus sect reads 0.06' too low. Corr'n to readings = +.06 1:30 p.m.

Reset of OG staffs. In resetting:

Sect	Reset to read	At mark and Elev.	Corr'n as left
0-3.3	2.51	Pencil Mk, 2.51	0
3.3-6.7	5.06	Nail, 5.06	0
6.7-10.1	Not reset		+.016
10.1-13.3	11.968	Nail, 11.968	0
13.3-16.7	14.964	Nail, 14.964	0

2:00 p.m.

WW=2.28, CB=25.560, OG=2.28, ET=2.27, ADR dial = 2.27 at 2:05 p.m.

No. 7 of 7 sheets

GPO 889-125

Level notes, example 1--Con.

Form WRD
RAL-4-74

LEVEL NOTES
FRONT SHEET

Sta. No. 02107500 Date May 5, 1976

Sta. Name Any Creek near Any Place, N.C.

Party: N.M. Jackson ⊼ ; H.C. Gunter ϕ Level WR # 421

Rod type and No. — 2-pc. Phila Rod level used? Yes

Rod length by steel tape: Rod Bot. 1.000 2.000 3.000
Tape .999 2.000 3.002 4.002

4.000 5.000 6.000 7.000 8.000 9.000 10.000
5.001 6.000 7.001 8.002 9.001 10.002 11.003

Starting Mark RM No. 1 Elev. 10.000 Closure −.002 ft.

*Marks tested	Given elev.	Elev. found(balanced)	Remarks
RM 1	10.000	10.000	Origin
RM 2	11.187	11.138	Found loose-abandon
RM 3	4.998	5.000	
RM 4	—	11.053	Set today
ET Index	22.463	22.462	
Ck Bar	13.646	13.649	

*Include RM's, C.B., E.T. Index, and permanent RP's.

Staff Section	Holding rod on	Elevation found	Corr. to staff reading Found	Left
OG 0-3.3	1.48 'Mk.	1.47	−.005	−.005
OG 3.3-6.7	5.48 'Mk.	5.486	+.006	+.006
OG 6.7-10.1	Direct F.S. 'Mk.	—	−.004	−.004
IG 0-3.3	By tape 'Mk.	—	−.005	−.005
IG 3.3-6.7	from RP 1 'Mk.	—	−.010	−.010
IG 6.7-10.1	'Mk.	—	−.010	−.010

E.T. Length: Found 22.473 ; Left 22.473 ; Time 9:50 a.m.

C.B. Setting: Found 13.670 ; Left 13.625 ; Time 10:35 a.m.

If the correct C.B. setting was determined at low H.I. near water surface enter correct C.B. 13.625 and H.I. 4.590.

When a gage is reset, so state, and show tests both before and after.

Prepared by N.M.J. Checked by N.O.T.

Sheet 1 of 5 sheets. Date 5-5-76

Level notes, example 2

9-276
(Rev. 7-67)

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
WATER RESOURCES DIVISION

Station Number
02107500

LEVEL NOTES

Stream Any Creek nr Any Place, N.C.
~~Locality~~ To check RM's and gages
Party N.M.J. T, H.C.G ϕ Date May 5, 1976

STATION	B. S.	HT. INST.	F. S.	ELEVATION	REMARKS
Level WR # 421 Dumpy					
Rod: 2 pc. Phila.					
Rod level used					
WW = 0.63, CB = 13.670, OG = 0.61, IG = 0.60, ET = 0.60,					
ADR dial = 0.60 at 8:15 a.m.					
					Adj Elev
RM 1	4.760	14.760		10.000	Given-Origin
RM 2			3.621	11.139	Given 11.187
Ck Bar			1.110	13.650	" 13.646
TP 1	1.109	10.106	5.763	8.997	
RP 1			.872	9.234	Nail on inside staff
OG: 3.34-6.74			4.620	5.486	Rod on 5.48' Mk.
0-3.34			8.632	1.474	Rod on 1.48' Mk.
6.74-10.14			0.000	10.106	Plate reads
(Direct shot)					10.111, or .005 too high
ET tape			0.000	10.106	ET at H.I. = 20.990
				ET at Index reads -	8.633
				Dist., Index above H.I. =	12.357
				H.I. Elev =	10.106
				Elev ET Index =	22.463
TBM	9.248	10.222	9.132	0.974	Set to check WW

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Level notes, example 2--Con.

9-276
(Rev. 7-67)

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
WATER RESOURCES DIVISION

Station Number
02107500

LEVEL NOTES

Stream Any Creek nr Any Place, N.C.

~~Locality~~

Party N.M.J. T, H.C.G. Φ Date May 5, 1976

STATION	B. S.	HT. INST.	F. S.	ELEVATION	REMARKS
TBM		10.222			
RM 3	4.611	9.611	5.222	5.000	Given 4.998
RP 1			.373	9.238	
OG: 0-3.34			8.135	1.476	Rod on 1.48' Mk
3.34-6.74			4.126	5.485	" " 5.48' "
6.74-10.14			0.000	9.611	Plate reads 9.614, or .003' too high.
ET tape			0.000	9.611	ET at H.I. = 21.483
			ET at Index reads		- 8.633
			Dist. Index above H.I. =		12.850
				H.I. Elev =	9.611
				Elev. ET Index =	22.461
TP 2	8.609	14.793	3.427	6.184	
RM 2			3.655	11.138	
Ck Bar			1.145	13.648	
RM 1			4.795	9.998	Closure = .002'
					9:45 a.m.

Check of ET tape: Dist from 21.00' Mk on tape to bottom of Wt. = 1.473'. ET length = 21.000 + 1.473 = 22.473

From levels, ET Index Elev. = 22.462

Tape 0.011 too long. ET found reading 0.011' too high.

Corr'n. to ET readings = -.011'. Not reset. 9:50 a.m.

No. 3 of 5 sheets Comp. by Chk. by

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895 • 172

Level notes, example 2--Con.

9-275d
(Feb. 1964)

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
WATER RESOURCES DIVISION

Date May 5, 1976 LEVEL

02107500 ~~MISCELLANEOUS FIELD NOTES~~

Any Creek nr Any Place, N.C.

Check of Inside staffs from RP 1 (Elev. 9.236 avg.).

9.236' on tape held at RP 1 10:00 a.m

Section	Reading on tape	Reading on staff	Corr'n to readings
0-3.34	3.26	3.265	-.005
3.34-6.74	3.98	3.990	-.010
6.74-10.14	7.75	7.760	-.010

None reset 10:15 a.m.

Review of Outside staff checks:

Section	Mark	Elev.	Corr'n. to readings
0-3.34	1.48' Mk	1.475	-.005
3.34-6.74	5.48' Mk	5.486	+.006
6.74-10.14	—		-.004 (Avg. of Direct shots)

No. 4 of 5 sheets

GPO 889-12

Level notes, example 2--Con.

9-276
(Rev. 7-67)

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
WATER RESOURCES DIVISION

Station Number
02107500

LEVEL NOTES

Stream Any Creek nr Any Place, N.C.

~~Locality~~

Party N.M.J. T, H.C.G. Φ Date May 5, 1976

STATION	B. S.	HT. INST.	F. S.	ELEVATION	REMARKS
Check of WW gage:					
TBM	3.616	4.590		0.974	From levels today.
Bott. Wt.			0.000	4.590	CB reads 13.670 WW reads 4.635, or 0.045' too high
					CB reset to read 13.625' @ 10:35 am.
WW Bott. Wt.			0.000	4.590	WW reads 4.592' OK
TBM			3.617	0.973	Closure -.001' OK
∴ Correct CB reading = 13.625 @ H.I. of 4.590'					
Tie in of RM 4, established today. RM 2 found loose and to be abandoned:					
RM 1	5.545	15.545		10.000	Given
RM 4	6.121	17.174	4.492	11.053	
RM 1			7.173	10.001	Closure +.001
Description: RM 4.--A chiseled square in rock ledge on right bank 30 ft upstream from gage and 18 ft from edge of low-water channel. Painted yellow. Elev 11.053'.					

No. 5 of 5 sheets Comp. by Chk. by

*U.S. GOVERNMENT PRINTING OFFICE: 1971-720-060

895-172

Level notes, example 2--Con.

(October 1967)

COMPUTATION FORM—DOUBLE

UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

File 02999597

02999597 John Creek near Doe, N.C.

LEVEL SUMMARY

EXAMPLE 1

Date of levels	Elevations RM 1	RM 2	RM 3	RM 4		EPI (C-O dec)		ET gage Elev. index	ET length	Reading	WW gage Elev. C.B.	Correct C.B. rdg.	C.B. setting	Reading	Reading errors of OG staffs	0-3.3	3.3-6.7	6.7-10.1	10.1-13.3	13.3-16.7	Remarks
5/1/70	25.120 (orig)	24.166	23.721			7.737		26.191	26.166	.025 L	27.150	27.115	27.150	.035 H	Found:	.008 H	.025 H	.029 H	.014 L	.015 L	OG plates 3.3-10.1 reset.
								Left: 26.191		0		Left:	27.115	0	Left:	do	0	0	do	do	
7/2/72	25.120 (Orig.)	24.111	23.720	16.157		7.738		26.188	26.191	.003 L	27.152	27.113	27.120	.007 H	Found:	.005 H	.004 H	.002 L	.011 L	.018 L	RM2 found settling. Estd RM 4.
												Left:	27.120	.007 H	Left:	do	do	do	do	do	CB setting not changed.
6/16/75	25.120 (Orig.)	—	23.723	16.160		7.735		26.193	26.191	.002 L	27.149	27.116	27.132	.016 H	Found:	.009 H	.001 H	.005 H	.008 H	.002 H	OG 10.1-16.7 may be settling.
												Left:	27.115	.001 L	Left:	do	do	do	do	do	
5/31/76	25.120 (orig.)	—	23.719	16.156		7.736		26.189	26.192	.003 H	27.151	27.114	27.090	.024 L	Found:	.010 H	.003 H	.003 H	.035 H	.030 H	OG 10.1-16.7 supports rebuilt and
												Left:	27.114	0	Left	do	do	do	0	0	plates reset.
6/27/78	25.120 (Orig.)	—	23.722	16.158		Not tied		Not checked			Found 27.103 Left 27.121	Found 26.065 Left 27.140	Found 27.113 Left 27.140	Found .048 H 0	Found: Left	Not checked					WW gage found damaged; checked and new one installed. Partial levels.

N.O.T 6/28/74

(October 1967)

COMPUTATION FORM—DOUBLE

UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

02999602 Wet Creek at Dry, N.C.

File 02999602

LEVEL SUMMARY

EXAMPLE 2

Date of levels	Elevations					ET gage			WW gage				Corr'ns. to OG staff readings						Remarks
	RM 1	RM 2	RM 3	RM 4	RP 1 (Cadmar)	Elev. index	ET length	Corr. to reading	Elev. C.B	Correct C.B rdg.	C.B. setting	Corr'n. to rdgs.		0-3.3	3.3-6.7	6.7-10.1	10.1-13.3	13.3-16.7	
5/1/70	25.120 (orig.)	24.166	23.721		7.737	26.191	26.166	+.025	27.150	27.115	27.150	-.035	Found:	-.008	-.025	-.029	+.014	+.015	OG plates 3.3-10.1 reset.
						Left:	26.191	0		Left:	27.115	0	Left:	do	0	0	do	do	
7/2/70	25.120 (orig.)	24.111	23.720	16.167	7.738	26.188	26.191	-.003	27.152	27.113	27.120	-.007	Found:	-.005	-.004	+.002	+.011	+.018	RM2 found setting. Est'd RM 4.
										Left:	27.120	-.007	Left:	do	do	do	do	do	CB setting not changed.
6/16/72	25.120 (orig.)	—	23.723	16.160	7.735	26.193	26.191	+.002	27.149	27.116	27.132	-.016	Found:	-.009	-.001	-.005	-.008	-.002	OG 10.1-16.7 may be settling.
										Left:	27.115	+.001	Left:	do	do	do	do	do	
5/31/73	25.120 (orig.)	—	23.719	16.156	7.736	26.189	26.192	-.003	27.151	27.114	27.090	+.024	Found:	-.010	-.003	-.003	-.035	-.030	OG 10.1-16.7 supports rebuilt and
										Left:	27.114	0	Left:	do	do	do	0	0	plates reset.
6/27/74	25.120 (orig.)	—	23.722	16.168	Not tied	Not checked			Found 27.103 Now 27.121	Found 26.065 Now 27.140	Found 27.113 Left 27.140	Found -.048 Left 0		Not checked					WW gage found damaged, checked and new one installed. Partial levels.

N.O.T. 6/28/74