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August 27, 2010

OFFICE OF SURFACE WATER TECHNICAL MEMORANDUM NO. 2010.08

SUBJECT: Processing and Publication of Discharge and Stage Data Collected in Tidally-Influenced Areas

## **Executive Summary**

This memorandum provides policy and general guidance for processing, publishing (including National Water Information System [NWIS] Web display), and archival of stage and discharge data collected in tidally-influenced areas. The policies contained herein should be implemented beginning with records published for the 2010 water year.

The expansion of coastal data-collection activities coupled with the lack of a comprehensive policy to guide the handling of data subject to tidal influences is a growing concern. The primary/motivational issue being addressed is a phenomenon called tidal aliasing. The solar day computation interval (24 hours) used by Automated Data Processing System (ADAPS) is less than a lunar day (24.84 hours) resulting in an apparent oscillation within the computed daily value time series that is unrelated to physical conditions or runoff events in the upstream basin. The application of a low-pass digital filter is one way to eliminate the effects of tidal aliasing in affected time series data effectively.

Other processing and publication issues unique to tidal data collection sites have also been considered. Most of the significant policy requirements described in the memorandum are summarized below:

1. The required processing and publication of tidal data will depend on the appropriate classification of the data-collection site. Sound hydrologic judgment will be needed to classify sites as (a) affected significantly by tides, (b) not affected significantly by tides, or (c) indeterminate. A decision tree diagram and a program that produces statistics and graphical plots are provided (in Appendix C) to help make that decision, which is relevant to the policies outlined herein.
2. The publication of 24-hour means for discharge at sites influenced significantly by tidal dynamics will no longer be allowed unless the data are first filtered to remove tide signals.
3. A Godin low-pass filtering program is provided to remove tidal signals from discharge records. The program does not filter stage data. The Godin filter is a good general-purpose filter, but any documented filter may be used to remove tidal signals from the discharge or stage data if the process and software are documented and archived properly, respectively.

4. The minimum product at continuous discharge sites affected by tides will be as follows:
  - a. Where tidal filtering is *not* done, the minimum product shall be an annual data report (ADR) site data sheet with descriptive paragraphs and a remarks section describing the availability of unfiltered unit-value data from the Water Science Center (WSC), upon request. In addition to a site data sheet manuscript, the discharge data may be released from the Instantaneous Data Archive (IDA). As stated above, daily means shall *not* be published for non-filtered data.
  - b. Where tidal filtering *is* done, the minimum product for discharge for tidally-influenced sites will be a daily-mean discharge table derived from filtered unit-value data.
5. The minimum publication product for unfiltered data from tidally-influenced stage-only sites is also a site data sheet containing informational paragraphs and a remarks paragraph informing the user that unit value data are available through the U. S. Geological Survey (USGS) WSC by request. (IDA is undergoing enhancements to enable release of other types of unit-values, such as stage and filtered discharge data, but these capabilities are not yet available.)
6. Suggested additional products for tidally-influenced stage-only sites having unfiltered data include (1) a tidal statistics table populated with tidal extremes generated from ADAPS statistic codes 00021 (higher high water) and 00024 (lower low water), (2) a table of daily mean, maximum, and minimums accompanied by an appropriate qualifier statement at sites meeting certain criteria (3.E.4.b.ii), or (3) entry of the data into IDA, when that capability is implemented.
7. Discharge records must not be processed piecemeal with some periods having filtered data and others having unfiltered data. Procedures and tools outlined in this memorandum can be used to determine whether or not data for a particular site are subject to significant tidal influences and will need to be filtered to produce daily means. At new stations, the decision to filter can be delayed for three years, but data for that site should not be published until that determination is made. Once new or old sites have been evaluated and determined to be tidally-influenced, ALL data for that site must be filtered from that point forward if the WSC publishes daily mean discharge. Where unit values are available, previously published historic data at tidally-influenced sites should be filtered and daily values revised where necessary.
8. Real-time current sites and those with historic daily value data from NWISWeb for sites or periods where unit values are not available for re-processing need to be flagged to alert the user to the aliasing problem. Until an automated flagging system is implemented, a standard qualifier-disclaimer statement should accompany the NWISWeb site page of each individual streamgage that is deemed to be affected significantly by tides. The disclaimer text should be inserted following any cooperator acknowledgements at the top of the real-time station web page.
9. In accordance with WRD Memorandum 92.59, this policy re-emphasizes that all routine data collected, including unfiltered unit value stage, velocity, and total tidal discharge data, must be entered into ADAPS with the proper parameter and site-type codes. All current and historical sites must be examined to be sure they contain the appropriate "site type" code that will be necessary to trigger future (planned) warning

messages needed to alert the user to the possibility of aliased data. Currently (2010), a different data descriptor must be used to designate each filter used.

10. Unfiltered, monthly mean discharge or stage may continue to be published, but the unfiltered daily values used in that computation process must not be available for retrieval from NWISWeb as explained in section 3.E.5.a.ii and 3.E.5.b.ii of this memorandum.
11. Annual maximum flows (minimum flows, optionally) must be documented and properly qualified in the “Extremes for Current Year” paragraph of the Site Data Sheet. Instantaneous unfiltered flows should be listed and must match the entries in the peak flow file. Extremes and peak-flow values represent the highest instantaneous seaward flow within a channel (not negative storm surges, or unconfined flows spanning several miles of shoreline).
12. As with discharge, instantaneous annual maximum and minimum stage values may be documented in the “Extremes for Current Year” paragraph. Peak gage heights at stage-only sites may be entered into the peak flow file if entered in the annual peak *gage height (ag\_gage\_ht)* field and not the *gage height (gage\_ht)* field associated with a peak streamflow value.
13. Surface water quality-assurance and quality-control plans for each WSC must describe data processing and archival procedures for data collected in tidally-influenced environments.

## 1. Introduction

This memorandum provides policy and general guidance for processing, publishing (including NWISWeb display), and archival of stage and discharge data collected in tidally-influenced areas. Specific guidance is offered concerning computation of net freshwater (filtered) discharge. No guidance is provided for velocity, groundwater, or water-quality data.

Due to the length of this memorandum, the following outline is offered to provide a guide to its overall organization:

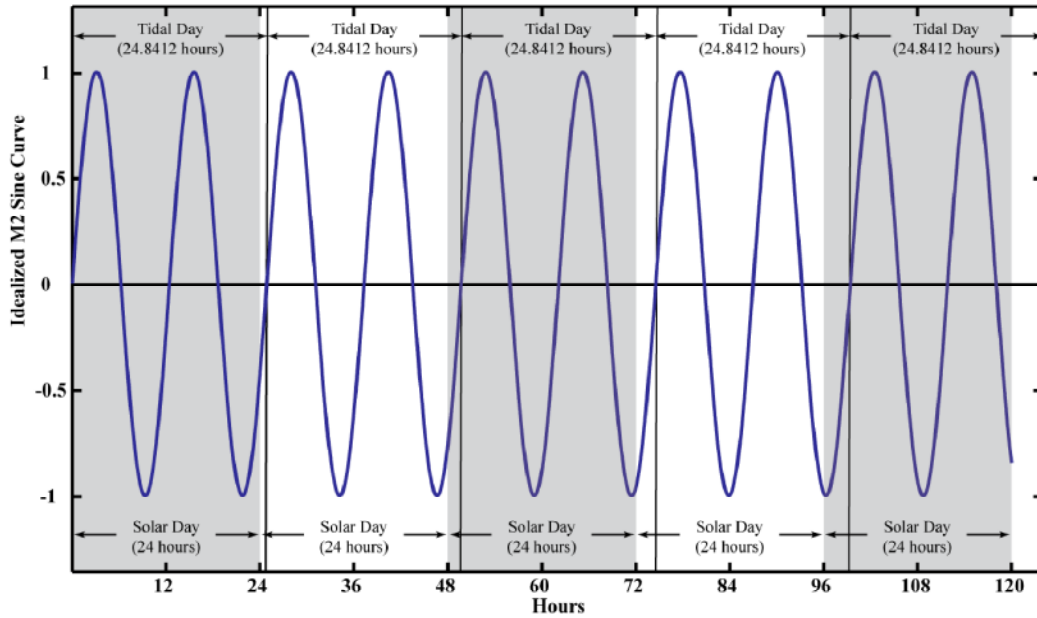
1. Introduction
2. Background
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  - Appendix C – Determination of tidally-influenced sites: classification criteria and decision tree
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## 2. Background

Advances in instrumentation technology (particularly in hydroacoustics) have permitted a rapid expansion of USGS data-collection and interpretative studies into tidally-influenced waters. The resulting unit data are valued highly for many hydrologic, oceanographic, or environmental applications and are presented easily and accurately as instantaneous observations. However, the standard publication statistic for Site Data Sheets, the daily mean value, attenuates but does not eliminate tidal effects. Indeed, the averaging process may impose on the daily-value record a spurious cyclic pattern that is misleading and that may invalidate other hydrologic statistics (such as n-day frequencies) often derived from daily values.

The principal influence on tides is the moon. The summarization problem arises as a result of publishing a solar or 24-hour [daily] mean in the presence of a strong lunar influence that repeats every 24.8412 hours. The 24-hour window incorporates into each daily average a different portion of the lunar tidal cycle with each consecutive 24-hour computation (figure 1).

**Sine Curve**  
**Amplitude = 1**  
**Period = 12.4206 hours (Lunar cycle)**



**Figure 1: Idealized M2 sine curve showing the difference between the solar day (24 hours) and the tidal day (24.8412 hours).**

Put another way, because the ADAPS computational-averaging period and tidal period are not equal, they can never be “in sync” and a low-frequency daily-value oscillation results (figure 2). This phenomenon, which is unrelated to basin hydrology, is well known in time-series analysis and is called tidal aliasing (Godin, 1972). Placed in a hydrologic context, aliasing could produce daily-flow records indicating basin outflow, when no runoff or groundwater flows to the stream are occurring or could mask such contributions depending on the relative magnitude of the tide and hydrologic flows.

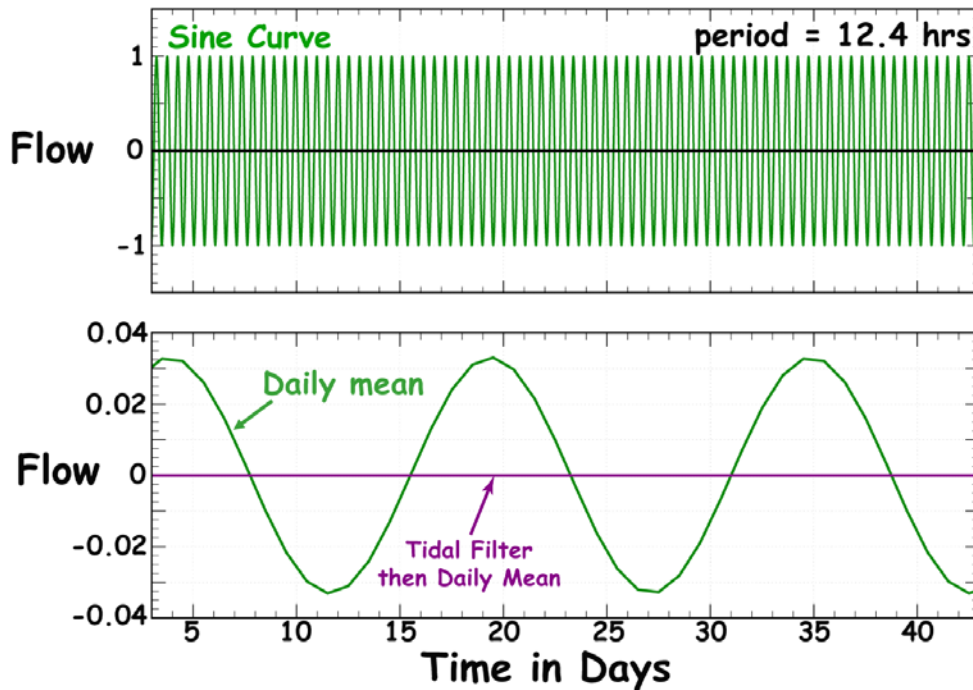


Figure 2: A) Approximately 40-days of an idealized tidal cycle with a period of 12.42 hours. B) Comparison of daily value computations through the standard daily mean (green curve) and through the use of a tidal filter then computing a daily mean (purple line).

Often the quantity of real interest to a user or cooperator is net (or seaward) freshwater discharge or basin yield, and WSCs are asked often to present this quantity in data and interpretive publications. Net discharge cannot be determined from the maximum and minimum statistics nor, for reasons related to the aliasing issues described above, can it be inferred or determined from daily (24-hour) averaging. Thus, other approaches must be utilized. One way to obtain net flows is to remove the effects of tidal components through the application of a low-pass filter to the unit-value time series.

Currently, there are no specific guidelines in the WRD Data Reports Preparation Guide (Novak, 1985) or as official technical memoranda that address the complexities associated with the publication of gage height or discharge data collected in tidal areas. As a result, WSCs have evolved practices and policies independently; data presentations are inconsistent geographically and temporally and, in some cases, misleading. General guidelines to promote appropriate and consistent use are provided by this memorandum.

### 3. Policy and Guidelines

Recognizing that situations vary and that judgment at the WSC level will need to be applied, the following policies and guidelines should be followed beginning with data collected and published for the 2010 water year.

A. Classification of Data-Collection Sites

- 1) **Classification of discharge sites:** The handling of data as outlined in this memorandum is dependent upon classification of the site for which data are collected. Appendix C of this memorandum contains a decision tree to assist WSCs in that classification. As additional criteria or tools become available, they will be posted to the Office of Surface Water (OSW) scripts website.

A minimum of one year of data (preferably a year with below-average flow or stage) for the site in question is needed to evaluate the presence of a significant tidal influence. The *tidal filter* program (see Appendix B) has an option to generate a 5-panel plot with pertinent statistics which is useful for classifying sites with respect to tidal influences. Using those plots along with the objective criteria outlined in Appendix C, **discharge sites** will fall into one of three categories as noted below. If daily values (DVs) are to be published, the unit data may need to be filtered accordingly:

CLASSIFICATION	STATISTICAL ANALYSIS	ACTION REQUIRED FOR PUBLICATION OF DV's
non-tidal	conclusive	do not filter the data
indeterminate	inconclusive	filtering is recommended, but not required
tidal	conclusive	filter the data

Sites not affected significantly by tides should be classified as non-tidal and treated as “standard” stage-discharge, index-velocity, or stage-only sites and their data processed as outlined under existing policy memoranda. However, classification should not be subject to change; it would be undesirable to store data from one site under two different parameter codes for alternating years or periods within a year. Therefore, sites that fall into the indeterminate region must be managed consistently as either affected or not affected at the discretion and judgment of the WSC. If historic data for sites not in operation currently are evaluated and re-classified as tidally-influenced, the published record may be revised, if desired and necessary, according to OSW Technical Memorandum 2006.05 guidelines

(<http://water.usgs.gov/admin/memo/SW/sw06.05.html>) if unit values are available.

Sites being operated currently, but established prior to this policy, should be evaluated and, if classified as significantly tidally-influenced, that portion of the record for which unit values are available electronically should be re-processed and revised as time permits. Current site data sheet manuscripts should be revised properly to alert the user to past, uncorrected aliasing problems as indicated in section 3.E.2.a of this memorandum. If a newly established site is not classified initially as tidally-influenced but later examination indicates it should have been, then the entire daily-value record must be re-processed and revisions published as necessary.

At inactive historical sites where only daily values are available (no unit values exist for re-processing) and for current sites, NWIS is planning software that will trigger a flag to accompany unfiltered, and thus potentially aliased, daily values. Until an automated flagging system is implemented, a standard qualifier-disclaimer statement must accompany the NWISWeb real-time or historical retrieval display of each individual site that is determined to be affected significantly by tides. The disclaimer text should be inserted following any cooperator acknowledgements at the top of the NWISWeb site page.

In addition, if at any time a decision is made to filter the data, it must be treated as such in perpetuity. To avoid future revisions, WSCs are encouraged strongly to treat sites that fall into the indeterminate classification as though they were affected significantly by tides unless filtering can be shown to introduce error or mask a non-lunar signal or phenomenon that is important to the ultimate purpose of the data. For example, a strong diurnal regulation pattern may result in cycles that are indistinguishable from a tide signal and filtering of the data could remove both the tide and regulatory signals erroneously.

Only a few criteria are outlined in Appendix C and it is possible that tests developed in the future may not corroborate one another. For example, one test may result in a decision to not filter while the other test may indicate the site lies in the indeterminate area. When in doubt, prudent action would dictate that data from that site should probably be filtered prior to publishing the daily values. WSCs are encouraged to develop/defend their own criteria to help mediate an indeterminate classification so long as an Appendix C decision to filter is not overturned.

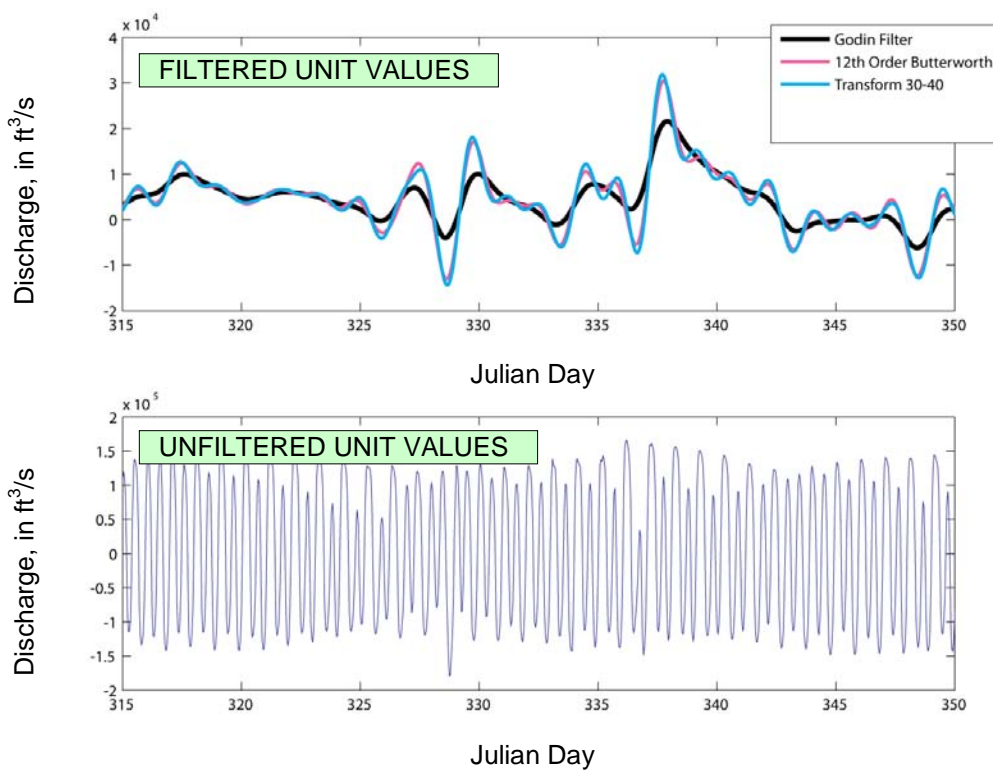
- 2) **Classification of stage or stage-only sites:** If a site is considered to be tidally-influenced for discharge, the stage record is also considered tidally-influenced. For stage-only sites, if a cyclic signal is evident in a hydrograph corresponding to low stages then the data should probably be considered to be tidally-influenced. A power spectrum analysis might also help reveal the presence of a significant tidal signal.

#### B. Selection of Low-Pass Filter

Once a decision to filter the data has been made, the data analyst must select an appropriate filter. A filter is a mathematical process that extracts or emphasizes data residing within a specified range or frequency of a record. Common digital filters apply a system of weights to exclude, include, or emphasize data, often through a process that combines sequential members of a time series within a computational window. A moving average, for example, could be considered a filter, smoothing out extremes and outputting adjusted records more closely representing a mean tendency. Filters are often used in oceanographic applications to remove background sea-level fluctuations from the effects of tsunamis and storm surges. The term, “detided” refers to records from which tide components have been removed. In essence, detiding is the process focus of this technical memorandum.

Characteristics and performance of filters vary in terms of attenuation of tidal and non-tidal components (figure 3), and loss of data at the extremities of a record (not shown). No filter will work equally well for all situations and each will have its own set of advantages and disadvantages. Commonly used digital filters include the Lanczos-window, Butterworth, and Godin filters.

Ample literature exists to guide individuals in selecting and implementing filters based on tidal amplitudes, data constraints, and project objectives. Information on the use of low-pass filters is contained in Walters and Heston (1982), Godin (1972), Roberts and Roberts (1978), Thompson (1983), and Emery and Thompson (1997). Emery and Thompson, in particular, consider the design and refining of detiding filters.



**Figure 3: Example showing the effects of three different filtering algorithms**

This memorandum does not restrict the use of any published filter so long as the WSC documents the computation process and archives the filtering program(s) properly. WSCs are encouraged to explore the advantages and disadvantages of alternative filters as they apply to their particular situation.

NWIS ADAPS does not include algorithms for computing averages at other than 24-hour intervals, nor does it contain filters needed to remove tidal effects at present. Thus, WSCs that wish to compute net discharge or detided data must export unit-value data from ADAPS, filter those data using external software, and then reload the computed unit values back into

ADAPS under a different parameter code (such as 72137 – discharge, tidally-filtered) and a different data descriptor. The filtered discharge unit values can be the final product or they can be further averaged within ADAPS to provide a daily (24-hour) discharge.

OSW has implemented the Godin filter (Godin, 1972) as a script that interacts with ADAPS to facilitate the filtering of tidally-influenced discharge data only. The Godin filter results are very predictable and consistent. The Godin filter drops exactly 35 hourly data points from the beginning and end of the input series as well as adjacent to any gap in the unit-value data. Moreover, unlike some other low-pass filters, appending new data points either to the beginning or end of the input series will not cause a change in filtered values calculated previously. It is well suited for use in the computation of daily values, since higher frequency variations are not preserved. Unlike filters that work in the frequency domain (such as the Butterworth or Transform filters) the Godin filter does not have a discreet range over which it transitions from removing frequencies to passing frequencies. Therefore, the Godin filter will partially attenuate the hydrologic/hydraulic response to non-lunar driving forces (such as wind and other atmospheric phenomena) that have signal periods up to 60 hours or more. If signals with periods in the 40-hour to 60-hour range are critical for interpretation/analysis, a different filter should be considered.

A description of the *tidal\_filter* program and a README file (see Appendix B) to facilitate installation and use is available at the OSW Script site:

<http://water.usgs.gov/usgs/osw/adaps/scripts.html>. A description of necessary database preparation and processing procedures using program *tidal\_filter* also are found in Appendix B. Note that the filter only works for discharge data. OSW plans to program the capability to filter other parameters, such as stage. In the meantime, WSCs that wish to filter stage data will have to procure or develop their own filtering program.

### C. Database Issues

- 1. Externally processed data:** Regardless of which low-pass filter is used, the resulting tidally-filtered unit values must be stored in ADAPS and subsequently used to compute daily values. As stated in WRD Memorandum 92.59 (and detailed in Open-File Report 92-56), WSCs that process data outside of ADAPS are still required to enter all raw or computed unfiltered stage and total tidal discharge data into the NWIS database.
- 2. Parameter Codes:** A list of available parameter codes used within the NWIS can be found at <http://nwis.waterdata.usgs.gov/usa/nwis/pmcodes>. Over the years, a large number of these 5-digit parameter codes have been created in ADAPS for nuances of discharge and gage height (water surface elevation), some of which may be redundant except for location, units of measure, datum, and so forth. As a result, entry of similar data within or among WSCs has not always been consistent over time and space. These variations of (“prefixes” to) discharge and gage height may reflect the location or the dominant processes at a monitoring site, but could be inappropriate and misleading under certain conditions or in certain settings. For

example, the word “TIDE” in front of some parameter names creates the impression that the dominant signal in the record is the astronomical tide. In reality, an estuarine or coastal system may be more affected by meteorological forcing. Similarly, the records of tidal streams are probably even less representative of the astronomical tides.

WSCs should consider carefully the parameter code assignment by focusing on the physical measurement. First (and most importantly), the site type code (section 3, below) assignment should be made carefully. Then, when selecting the proper parameter code, consider if the site is affected significantly by tides (see Appendix C). If affected, use one of the “tide” codes shown in *italics* below. If you are monitoring at a site that is dominated mostly by riverine characteristics, then use a stream or gage height parameter code. Of course, the other valid selection criteria are (1) units of measure, and (2) the datum; local or national.

a. Discharge:

- i. 00060 Discharge, cubic feet per second [NOTE: should be used for unfiltered unit values (representing total flow excursion past a point) and historical unfiltered daily values that are potentially aliased].
- ii. *72137 Discharge, tidally-filtered, cubic feet per second* [NOTE: must be used for filtered daily or unit values (72138 for cubic meters per second or 72139 for gallons per minute)].
- iii. 30208, Discharge, cubic meters per second

b. Stage:

- i. 00065 gage height, feet [NOTE: may be used for unfiltered unit values and unfiltered daily values that are potentially aliased].
- ii. *72170 Stage, tidally-filtered, above datum, feet* [NOTE: must be used for filtered daily or unit values (72171 for meters)].
- iii. Other parameter codes that may be considered include:
  - 00072 Stream stage, meters
  - 62623 *Tide stage, above datum, feet*
  - 62624 *Tide stage, above datum, meters*
  - 30207 Gage height, above datum, meters
  - 62619 *Tide elevation above NGVD 1929, feet*
  - 62620 *Tide elevation above NAVD 1988, feet*
  - 62621 *Tide elevation above NGVD 1929, meters*
  - 62622 *Tide elevation above NAVD 1988, meters*
  - 63158 Stream water level elevation above NGVD 1929, in feet
  - 63159 Stream water level elevation above NGVD 1929, in meters
  - 63160 Stream water level elevation above NAVD 1988, in feet
  - 63161 Stream water level elevation above NAVD 1988, in meters

- 3) **Site Type Codes:** All current and historical sites must be examined to be sure they contain the appropriate “site type” code that future versions of NWIS may use to trigger warning messages needed to alert the user to the possibility of aliased data. Currently, the site type does not allow for a change of status over time if, for example, a low-head dam is installed which eliminated tidal effects at an upstream gage. Until this shortcoming can be corrected in ADAPS, the recommended work-around is to use a different DD when conditions change. Detailed descriptions of the available “site type” categories can be found at [http://nwis.usgs.gov/nwisdocs4\\_8/gw/gwcoding\\_Sect2-1.pdf](http://nwis.usgs.gov/nwisdocs4_8/gw/gwcoding_Sect2-1.pdf) (see section 1.9). The “site types” that are applicable to tidally-influenced areas are: “Estuary”, “Ocean – Coastal”, and “Stream – Tidal”.
- 4) **Method Codes:** Currently, appropriate method codes (similar to those used by QWDATA to identify field and laboratory methods) are unavailable in NWIS. Until method codes become available, WSC’s should make use of the optional DD description field within ADAPS to identify the filtering method. It is recognized that this will not allow method-based retrievals but does, at least, store the method within the database. When/if a different filter is used, a new DD must be created to hold the new filtered data. When method codes become available, a unique code will be assigned that will indicate (1) that the time series data have been filtered, and (2) what type of filter was used.

#### D. Data Processing

The Godin filter is applied to unit-value data sequentially, essentially as a moving window, performing a cascading series of moving averages, each centered on the unit value and extending backward and forward in time. However, the filter always omits the 35 hourly data points from the beginning and end of the input series as well as adjacent to any gap in the unit-value data. Hence, real-time processing (with data current through the present date and time) is not possible. Instead, a “cron-job” should be established to process data on a continuous basis, but lagging 35 hours behind the current time. For batch data, the frequency of filtering is not important. Processing will yield the same result for any given point in time regardless of the starting or ending times input for processing.

#### E. Publication

A conventional manuscript entry in a site data sheet is required for all discharge and stage-only stations. Although filtered data are not considered to be interpretive, the data must not be provided to users apart from our Site Data Sheets or the NWISWeb system without documenting the filter used and the reference. The station analysis must also describe the recording interval of the data and any site-specific values used to control processing within the filtering program.

- 1) **Disallowed product:** *ELIMINATION OF DAILY MEAN DISCHARGE AS A PRODUCT* -- Daily (24-hour) mean values of discharge (from unfiltered data) in streams or estuaries affected significantly by tides as determined by the classification

system established in Appendix C MUST NOT BE PUBLISHED. A daily mean discharge table may be published if the site is classified as indeterminate, but it would still be prudent to warn the user of the possibility that low-flow periods may contain aliased data.

2) **Site Data Sheet qualifiers and NWISWeb retrieval warnings:**

- a. *Documenting past records in site data sheets where tidal aliasing needs to be identified:* Station manuscripts for discharge or stage sites affected significantly by tides where 24-hour means were previously published heretofore must contain a disclaimer in the remarks section. An example disclaimer is: “*Astronomical tides cause significant cycles of approximately 24.84 hours at this site. Because a different portion of the 24.84 hour tidal cycle is averaged in successive daily (24-hour) computations, a systematic secondary oscillation, unrelated to basin hydrology and having a period of about two weeks may be apparent in daily data published from XdateX to YdateY.*”
- b. *NWISWeb display/retrieval of unfiltered data:* Until an automated flagging system is implemented, a standard qualifier-disclaimer statement must accompany the NWISWeb display of each individual gaging station (current or historical) that is deemed to be affected significantly by tides. The disclaimer text should be inserted following any cooperators acknowledgements at the top of the NWISWeb site page and should be similar to the qualifier immediately above (except that dates are not given). Instructions on how to insert the standard disclaimer are available from the NWISWeb Manual – Frequently Asked Questions web pages at URL:  
[http://waterdata.usgs.gov/nwis/news?nwisweb\\_manual\\_faq#site\\_text](http://waterdata.usgs.gov/nwis/news?nwisweb_manual_faq#site_text)

The following standard disclaimer in HTML format can be cut-and-pasted directly into your site-text file as per the instructions in the NWISWeb FAQ:

```
<table border="1" cellpadding="5" width="576">
<tr>
<td><b>Data are tidally affected --</b> Astronomical tides
cause significant cycles of approximately 24.84 hours at this
site. Because a different portion of the 24.84-hour tidal cycle
is averaged in successive daily (24-hour) computations, a
systematic secondary oscillation, unrelated to basin hydrology
and having a period of about two weeks may be apparent in
daily data. </td>
</tr>
</table>
```

3) **Minimum product**

- a. *Discharge Sites:*
  - i. Unfiltered Unit-Value Data: The minimum product for tidally-influenced discharge sites is a site data sheet containing appropriate informational paragraphs (location, period-of-record, etc.), a warning that the data are tidally-influenced (see item iii below), and a remarks

- paragraph informing the user that unfiltered unit-value discharge data (parameter code 00060) are available through the USGS WSC on a request basis or through the IDA located at URL: <http://ida.water.usgs.gov>. Selected portions of the unit-values record may also be tabulated on the data sheet.
- ii. Filtered Daily-Value Data: The alternative minimum product for discharge sites influenced significantly by tides is a daily mean discharge table derived from filtered unit values. Note that a Summary Statistics Table for filtered daily values (parameter code 72137) is a new feature in NWIS beginning with WY2010 records (ADAPS version 4.10).
  - iii. Qualifier Statement: The ADR manuscript entry for tidally-influenced sites must contain a qualifier stating that data collected at the site is tidally-influenced. If the data have been filtered, the qualifier must have a second sentence to indicate that fact and state the type of filter used. For example, “*Streamflow at this site is affected significantly by astronomical tides. Daily mean discharge was computed using the Godin low-pass filter to remove tidal effects from instantaneous values.*”
  - iv. Specification of direction of flow: The REMARKS section of the manuscript must describe direction of flow (as it relates to positive and negative values) individually for each site (as opposed to something general in the annual data report’s Definition of Terms section). Use of the terms positive/negative, ebb/flood, and seaward/landward (to name a few) may not be meaningful particularly in all situations, especially where flow is being measured from one part of a braided estuary to another. Some examples of appropriate descriptions of flow direction follow:
    1. Sites where landward or seaward flow direction is obvious:  
*By convention, the U.S. Geological Survey has established ebb (seaward) flows as positive flows and flood (landward) flows as negative flows.*
    2. Sites where landward or seaward flow direction is **not** obvious:  
*Positive and negative flows at this site are defined by direction and are specified to be parallel to the channel at the gage location. The positive flow direction is XXX degrees based on the compass rose with 0 degrees being true north, 90 degrees being east, 180 degrees being south, and 270 degrees being west.*
- b. Stage Sites:
- i. Filtered or Unfiltered Unit-Value Data: The minimum product for tide-affected stage sites is a site data sheet containing appropriate informational paragraphs (location, period-of-record, etc.) and a remarks paragraph informing the user that unit-value data are available through the USGS WSC on a request basis. Once the capability to handle non-discharge parameters has been added to IDA, selected

portions of the unit-values record may also be tabulated on the site data sheet.

#### 4) Suggested additional products

##### a. Discharge Sites:

- i. Filtered Unit-Value Data: Computed unit values of tidally-filtered flow (parameter code 72137) cannot be entered currently into IDA, but are suggested products and may be added to IDA when that capability becomes available.

##### b. Stage Sites:

- i. Unfiltered Unit-Value Data: A Tidal Statistics Table of tidal extremes generated using ADAPS tidal statistic codes 00021 & 00024 (higher high water and lower low water, respectively). Tables containing the other tidal statistic codes 00022 and 00023 (low-high and high-low, respectively) may be included also to further characterize tidal stage, but are not required to accompany the other two statistic codes. Because inexperienced users may be confused by the difference between daily extremes and tidal extremes, the following qualifier statement is recommended in the station manuscript: *“This site is affected by astronomical tides. The **higher high water** and **lower low water** values shown represent the extremes of the tidal cycle at this station, but do not necessarily represent the maximum and minimum values recorded for that day.”*
- ii. Unfiltered Unit-Value Data: Unfiltered daily maximum, minimum, and mean tables (RESTRICTED TO CERTAIN CONDITIONS): In order to avoid exclusion of possibly valid but unforeseen data uses or in those situations that would require excessive editing of ADAPS tidal statistics, it is permissible to publish unfiltered DAILY maximum/minimum/mean statistics under the following conditions:
  1. Oftentimes stage gages are operated in tandem with water-quality monitors and it is possible that someone might want to pair the daily maximum, mean, or minimum values from a water-quality monitor (particularly parameters with a solar day cycle, such as DO, chlorophyll, temperature, etc.) with daily maximum, mean, or minimum stage values. For coastal or estuarine gage records that are inherently tidal (open ocean) and not affected by inland runoff WSCs may publish DAILY (24-hour) statistics of unfiltered data if required to satisfy an operational or interpretive need.
  2. For smaller, flashy urban stream sites or sites of indeterminate classification, where the stage is often affected significantly by either upland runoff events or meteorological forcings (such as wind), the use of ADAPS tidal statistics is discouraged because (1) extensive editing and judgment are required to provide meaningful *higher high water* and *lower low water* values, and (2) blind reliance on the algorithms in ADAPS sometimes

results in assigning values to tidal statistics that have little or no association with true high or low tides. The daily maximum and minimum values may be published only when accompanied by a qualifier statement in the REMARKS paragraph of the ADR: *“This site is affected by astronomical tides. The daily maximum and minimum values shown are not comparable to tidal statistics for **higher high water** or **lower low water**. Consecutive daily maximums or minimums may be from the same tidal cycle and are not independent highs or lows necessarily.”*

- iii. Filtered or Unfiltered Unit-Value Data: As with filtered discharge, unit values of either computed stage (parameter code 00065) or tidally-filtered stage (parameter code 72170) cannot be entered currently into IDA, but will be acceptable and suggested products if/when that capability becomes available. Because tidal sites are hydraulically complex sites subject to both meteorological and astronomical influences, filtered stage values must never be applied to a stage-discharge rating curve to compute net discharge.

## 5) Other allowable products

### a. Discharge Sites:

- i. Unfiltered Unit-Value Data: For sites classified as indeterminate, it is permissible to publish DAILY statistics (mean or maximum-minimum values) with an appropriate qualifier statement in the REMARKS paragraph of the Site Data Sheet. The qualifier should inform the user that although flood flows are not tidally-influenced typically, intervening low-flow periods may contain aliased data.
- ii. Monthly mean discharge table: Monthly mean discharge values (derived from unfiltered daily mean values) for sites influenced significantly by tides may be published as they address the aliasing issue. Currently, it is recognized that ADAPS does not have the capability to store monthly statistics independently of daily values. This capability may be forthcoming in a future version of ADAPS. In the interim, if a WSC chooses to provide monthly mean values of discharge that were generated in ADAPS, they must ensure that the provisional (aliased) daily-mean values based on unfiltered data remain unpublished and unavailable for NWISWeb retrieval. As such, they must be deleted or flagged as erroneous once the monthly values are tabulated.

### b. Stage Sites:

- i. Filtered Daily Stage Table: Tidally-filtered stage may be useful for detection of long-term trends in sea level rise at a site. Therefore, filtered (non-tidal) unit value stage record (parameter code 72170) may be further processed to provide a daily mean stage table.
- ii. Monthly mean stage table: Values of unfiltered monthly mean stage in streams affected by tides may be published, as they address the aliasing

issue. The guidelines for discharge (see section 3.E.5.a.ii) apply generally to stage as well.

**6) Statistics table and extremes**

- a. *Period of record documentation:* No guidance is offered for the optional manuscript paragraphs addressing “EXTREMES FOR THE PERIOD OF RECORD” or “EXTREMES OUTSIDE THE PERIOD OF RECORD” for discharge or stage-only stations.
- b. *Discharge documentation for current year.* The terms “Maximum discharge” and “Minimum discharge” shall be used to document extreme instantaneous flow values.
  - i. Maximum discharge – It will continue to be mandatory to document the current year’s maximum instantaneous discharge in either the SUMMARY STATISTICS table or the EXTREMES FOR CURRENT YEAR paragraph of the site data sheet manuscript. As with non-tidal stations, manual entry of instantaneous values into the Summary Statistics table will likely be necessary especially because the largest filtered unit value will likely be different from the unfiltered unit value, which is the appropriate number to input. The maximum unfiltered instantaneous discharge must match the value entered into the peak flow file (see section 3.E.7) unless the current year peak occurred during a recession that began in the previous water year. Documenting extremes in the “EXTREMES FOR CURRENT YEAR” paragraph of the manuscript has the advantage of qualifying the value easily. Therefore, instantaneous unfiltered flow values with a parameter code of 00060 must be listed in this table or paragraph, even if a table of filtered daily values is provided. Flow values provided should reflect only flows confined to a channel (storm surge flows characterized by miles of unbroken water surface should not be documented).
  - ii. Minimum discharge – The minimum (largest negative or smallest positive) flow values may also be described/documented, but only in addition to providing the maximum discharge.
- c. *Stage documentation for current year.* The terms “Maximum gage height,” and “Minimum gage height” shall be used to document extreme stage values.
  - i. WSCs must document the current year’s maximum gage height/elevation in the Summary Statistics Table or the “EXTREMES FOR CURRENT YEAR” paragraph of the manuscript and qualify those values as necessary (for example, if they are due to storm surge). Unlike streamflow, where documentation refers to situations in which flows are confined to a channel, all stages (including storm surge peak elevations) may be documented under stage. The minimum stage also may be documented, but is optional.

**7) Peak flow files:**

- a. *Discharge site documentation:* The peak flow file database was designed to document annual maximum instantaneous flows, other peaks above base, and associated stage values for flood frequency studies AND higher stage values

(if/when they occur) resulting from backwater conditions or other rating curve anomalies. It is appropriate to enter only the highest instantaneous seaward streamflow under the present database format. If the landward storm surge during a hurricane produces a higher water surface elevation than that associated with the peak seaward flow, then that gage height/water surface elevation and date must be coded in the peak gage height field just as one would do if the peak gage height for the year did not correspond to the peak flow. Streamflow values must match those values presented and explained in the EXTREMES paragraph of the annual data report unless the peak occurred during a recession that began during the previous water year, and should refer to confined channel flows as described previously. An explanation in the ADR would be useful if the stage values listed in this paragraph are storm-surge related. If the flow is hurricane-related, a discharge qualification code of “9” (discharge due to snowmelt, hurricane, ice jam, or debris dam breakup) should also be entered.

- b. *Stage documentation*: In addition to other publication requirements, it is suggested that the maximum stage be entered in the peak flow file *ag\_gage\_ht* field (not the *gage\_ht* field associated with a peak streamflow value). Peak gage heights may also be documented in the EXTREMES paragraph of the annual data report, but, as with discharge, the value must match the peak flow file if both documentation outlets are used.

#### **4. Archival of non-NWIS computations**

External processing of tidal data will negate automated NWIS procedures for records control and edit tracking. Thus, WSCs that employ the *tidal\_filter* or other non-NWIS computational algorithms must ensure that both the raw and edited data are also stored in NWIS and that the computational process is well-documented. An executable copy of any alternative software or macros used in the editing and filtering process must be stored in an archive. The raw data and those values resulting from the editing and filtering process must be entered into the ADAPS database so that those same flows will be available to all interested parties.

#### **5. Quality assurance and quality control plans**

WSC procedures for exporting unit value data from ADAPS, filtering those data, and importing any filtered data back into ADAPS must be described in WSC surface-water quality-assurance plans, an addendum to it, or in a similar quality-assurance plan governing surface-water activities for tidally-influenced areas. Software developed for these purposes must be described in the quality-assurance plans or another USGS-approved report. The quality-assurance plan must be submitted to OSW for approval.

Stephen F. Blanchard  
Chief, Office of Surface Water

**Attachments:**

- Memorandum Appendix A – Glossary of terms
- Memorandum Appendix B – Processing procedures for streamflow using *tidal\_filter*
- Memorandum Appendix C – Determination of tide-affected sites; classification criteria and decision tree
- Memorandum Appendix D – Summary table of publication guidelines and policies

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## Appendix A: Glossary of Terms

**Aliasing.** -- A phenomenon encountered when sampling a continuous time series to produce values at discrete points. If the sampling frequency is not high enough to resolve the highest frequency signal present in the continuous function, the high frequency information above the sampling frequency will appear as a false enhancement of (or, equivalently, be aliased onto) a related lower frequency in the computed power spectrum.

**Astronomical tide.** -- The tidal levels and character which would result from the change in magnitude and direction of gravity as caused by the Earth, Sun and Moon, without any atmospheric/meteorological influences (see also meteorological tides).

**Coastal** (USGS site type code). -- An oceanic site that is located off-shore beyond the tidal mixing zone (estuary) but close enough to the shore that the investigator considers the presence of the coast to be important. Coastal sites are typically within three nautical miles of the shore (modified from NWIS).

**Direction of current or flow.** -- Direction *toward* which the current is flowing. At sites where landward or seaward flow direction is obvious, the U.S. Geological Survey (USGS) has established ebb (seaward) flows as positive flows and flood (landward) flows as negative flows. At sites where landward or seaward flow direction is **not** obvious, positive and negative flows are specified to be parallel to the channel direction at the location that the gage is installed. The “positive” flow direction is defined in degrees based on the compass rose with 0 degrees being true north, 90 degrees being east, 180 degrees being south, and 270 degrees being west.

**Diurnal.** -- This term describes a situation when only one high water and one low water occur during a tidal day, and the tidal current is said to be diurnal when there is a single flood and a single ebb period of a reversing current in the tidal day.

**Ebb current.** -- The tidal flow or current existing during any time the height of the tide is decreasing. These flow generally in a seaward direction and have been called ebb tides erroneously. In the semidiurnal type of reversing current, the terms greater ebb and lesser ebb are applied respectively to the ebb currents of greater and lesser velocity of each day. The terms maximum ebb and minimum ebb are applied to the maximum and minimum velocities of an ebb current running continuously, the velocity alternately increasing and decreasing without coming to a slack or reversing current. The expression maximum ebb is applicable also to any ebb current at the time of greatest velocity.

**Ebb tide.** -- That interval of the tidal cycle between high water and the following low water, also known as falling tide.

**Estuary** (USGS site type code). -- A coastal inlet of the sea or ocean; especially the mouth of a river, where tide water mixes normally with stream water. Salinity in estuaries typically ranges from 1 to 25 Practical Salinity Units (psu), as compared to oceanic values of around 35 psu.

**Flood current.** -- The movement of a tidal current towards the shore or up a tidal stream. In the semidiurnal type of reversing current, the terms greater flood and lesser flood are applied respectively to the flood currents of greater and lesser velocity each day. The terms maximum flood and minimum flood are applied to the maximum and minimum velocities of a flood current the velocity of which increases and decreases alternately without coming to slack or reversing. The expression maximum flood is also applicable to any flood current at the time of greatest velocity.

**Flood tide.** -- A non-technical term used for rising tide or flood current. In technical language flood refers to current and the portion of the tidal cycle between low water and the following high water.

**High water (HW).** -- Maximum height reached by a rising tide. The height may be due solely to the periodic tidal forces, or it may have the effects of prevailing meteorological conditions superimposed upon it. Non-technically, called the high tide also. For tidal datum computational purposes, the maximum height is not considered a high water unless it contains a tidal high water

**Higher high water (HHW).** -- The highest of the two high waters (for semi-diurnal tidal sites) or single high water (for diurnal tidal sites) of any specified tidal day due to the declinational effects of the Moon and Sun.

**Higher low water (HLW).** -- The higher of the two low waters of any tidal day. The highest of the low waters of any specified tidal day due to the declinational effects of the Moon and Sun.

**Low pass filter.** -- In data or signal analysis, a filter that passes frequencies below some cutoff frequency while attenuating higher frequencies.

**Low water (LW).** -- The minimum height reached by each falling tide. The low water is due to the periodic tidal forces and the effects of meteorological, hydrologic, and/or oceanographic conditions. Non-technically, called low tide also. For tidal datum computational purposes, the minimum height is not considered a low water unless it contains a tidal low water.

**Lower high water (LHW).** -- The lower of the two high waters of any tidal day. The lowest of the high waters of any specified tidal day due to the declinational effects of the Moon and Sun.

**Lower low water (LLW).** -- The lower of the two low waters (for semi-diurnal tidal sites) or single low water (for diurnal tidal sites) of any specified tidal day due to the declinational effects of the Moon and Sun.

**Meteorological tides.** -- Rises or falls in coastal water levels that are caused by meteorological conditions such as seasonal, persistent or storm-related winds.

**Net freshwater discharge.** -- The gravity-induced seaward flow of fresh water originating from the drainage basin of a river that would occur in the absence of tidal influences. In a tidally-influenced environment, the freshwater flow of a river is increased and decreased alternately by seawater as a result of astronomical tidal dynamics.

**Ocean** (USGS site type code). -- Site in open ocean, gulf, or sea.

**Parameter code.** -- A 5-digit number used in the USGS computerized data system, National Water Information System (NWIS), to identify an unique specific constituent or property.

**Power spectrum.** -- The presentation of the square of the amplitudes of the harmonics of a time series as a function of the frequency of the harmonics.

**Range of tide.** -- The difference in height between consecutive high and low waters.

**Storm surge.** -- A phenomena wherein sea level rises above the normal tide level when hurricanes or tropical storms move from the ocean along or across a coastal region. Technically, this is defined as the difference between the actual sea (tide) level under the influence of a meteorological disturbance (storm tide) and the level which would have been reached in the absence of the meteorological disturbance. This sea level rise can consist of three components, the first of which results from low barometric pressure, or the inverse barometer effect, where lower atmospheric pressure on the surface of the water

allows it to rise. The second component is wind set-up where the winds drag surface water to the shore where it piles up. The third component of the rise is due to coupled long waves where the peak of the wave coincides with the shoreline. A storm surge is most severe when it occurs in conjunction with a high tide.

**Stream.** -- A body of running water moving under gravity flow in a defined channel. The channel may be entirely natural, or altered by engineering practices through straightening, dredging, and (or) lining.

**Tidal cycle.** -- The periodic changes in the intensity of tides caused primarily by the varying relations between the Earth, Moon, and Sun. Usually indicates a complete set of tidal conditions occurring over a tidal day, but may refer to periods of a lunar month, or a Metonic cycle (the 19-year cycle corresponding to the 235 lunar months, over which phases of the moon almost land on the same dates of the year also).

**Tide filter.** -- A linear algebraic process by which a sequence or window of input data are combined by application of a series of weights to remove or de-emphasize a tidal signal. Common tide filters include the Godin, Lanczos-window, and Butterworth filters.

**Tidal stream** (USGS site type code). -- A *stream* reach where the flow is influenced by the tide, but where the water chemistry is not influenced normally. A site where ocean water mixes typically with stream water should be coded as an *estuary* (see also criteria outlined in Appendix C of this memorandum).

**Tide.** -- The periodic rising and falling of the water that results from gravitational attraction of the Moon and Sun acting upon the rotating earth. Although the accompanying horizontal movement of the water resulting from the same cause is called the tide sometimes, it is preferable to designate the latter as tidal current, reserving the name tide for the vertical movement.

**Tides, types of.** -- Tides are sometimes classified as *diurnal*, *semidiurnal*, and *mixed*, but there are no defined limits sharply separating the groups. The tide is said to be diurnal when the diurnal wave predominated and only a single high and single low water occur each day during the greater part of the month. The tide is semidiurnal when the semidiurnal wave predominates and two high and two low waters occur each tidal day with a relatively small inequality in the high and low water heights. In the mixed type of tide, the diurnal and semidiurnal waves are both important factors and the tide is characterized by large inequality in the high or low water heights or in both. There will usually be two high and two low waters each day, but occasionally the tide will become diurnal.

## Appendix B: Processing Procedures for Streamflow Using *tidal\_filter*

### INTRODUCTION

The purpose of this appendix is to document the procedures for utilizing the *tidal\_filter* script. *tidal\_filter* provides an interface with ADAPS and another program (*grfilt*) that contains the processing algorithms that remove tidal signals from time series data using the Godin filter (Godin, 1972, and Emery and Thompson, 1997). The user interfaces only with *tidal\_filter*; program *grfilt* is essentially a subroutine called by *tidal\_filter* that is “invisible” to the user. Currently (2010) program *tidal\_filter* only serves to filter flow data (filtering of stage data must be done using another external program).

### INSTALLATION

Both the *grfilt* and *tidal\_filter* scripts need to be installed for the process to function properly. Details on the installation and initial configuration can be found on the OSW Scripts page in the “README.doc” documentation URL: [http://water.usgs.gov/usgs/osw/adaps/tide\\_README.doc](http://water.usgs.gov/usgs/osw/adaps/tide_README.doc) *tidal\_filter* Also, the script can be configured to run as an automated “cron job” processing a list of sites. Instructions for this process are in the README.doc also.

### USING *tidal\_filter*

Several preparatory tasks must be completed prior to invoking the *tidal\_filter* interface script.

- computed unit values of discharge must be available for the time period selected
- a data descriptor for parameter code 72137 (tidally-filtered discharge) must be available to store the filtered product data

Filtering data requires the user to run the script *tidal\_filter*, which executes four steps: (1) retrieves data, (2) filters data, (3) runs decodes, and (4) loads the results back into ADAPS. Processing times vary with the length of the time period, but one year of data can generally be filtered and loaded back into ADAPS in less than two minutes with approximately 70% of the time required to load the ADAPS Standard Input file back into the database and run primary computations. If run manually (interactively), messages requesting user input and messages describing computational progress are displayed on the user’s terminal. The step-by-step process is summarized below followed by example sessions for filtering flow data (EXAMPLE 1) and for generating tidal influence diagnostics (EXAMPLE 2):

- 1) **Retrieve Data:** Data is retrieved from ADAPS using *nwts2rdb* based on the following user defined criteria:
  - a. **Invoke program:** Type “*tidal\_filter*” at the Unix command prompt.
  - b. **Station number:** Type the station number at the prompt.
    - i. Valid station number: the program will list all of the available data descriptors at the station

- ii. Invalid or no station number input: the program will generate an error message and return to the “Enter station number:” prompt.
    - c. **Data descriptor identification number:** Type the data descriptor number associated with the data requiring tidal filtering (usually the number for the primary discharge DD).
      - i. Valid data descriptor: the program will prompt the user for the date range for filtering.
      - ii. If the parameter code for the chosen data descriptor is not 00060, the program will generate an error message and return to the “Enter station number:” prompt.
    - d. **Start and end dates:** Type the date range.
      - i. The required input format for the start and end dates is YYYYMMDD. Simple error checking on the date ranges are made at this time. For example, dates in the future are flagged and the user is asked to enter a valid date.
      - ii. There is a message reminding the user that the filter will cause 1.5 days to be trimmed from the beginning and end of the data set selected so a longer date range is necessary to compute tidally-filtered values for a specific period.
- 2) **Filter data:** *tidal\_filter* calls *grfilt* and the Godin filter is applied to the data. Several messages may be displayed to the user screen as follows:
- a. **Gap in input data:** if there is a gap in the input data, a message will be displayed showing the date and time of the beginning and end of the gap in the input series. It will also display the dates and times of the longer gap in the output series that will result. For example:
 

```
Gap in input series from 2006/06/25 08:00 to 2006/06/26 22:15 will cause
Gap in output series from 2006/06/23 21:00 to 2006/06/28 10:00 (4 days, 13
hours)
```
  - b. **Input data insufficient in length:** if there is a segment of data that is less than 71 hours in length, the Godin filter cannot generate a result. This is because a total of 35 hours is removed from the beginning and end of any time series. For example:
 

```
Cannot filter segment of less than 71 hours between 2006/07/25 00:00 and
2006/07/26 00:00
```
- 3) **Run DECODES:** DECODES program *cvtstd* is run automatically and is currently programmed to use GRFILTF-USGSGR-001 only.
- 4) **Load results into ADAPS.**
- a. The names of the \*.sum and \*.std files that were generated are displayed on the screen and the user is reminded to review the \*.sum file.
  - b. The user has the opportunity to automatically load the data into ADAPS by typing “Y”. The default is “N”, in which case the user would like to review the DECODES summary file and load the \*.std file manually.

## EXAMPLE 1 – flow filtering session

Below is an edited screen capture of the process. The text in black is displayed on the user's terminal and the text in red is information that the user must provide.

```
placer[101]% tidal_filter
```

```
At any prompt you may enter EX (or ex) to exit the program...
```

```
>>> Enter station number: 11311300
```

```
>>>> SELECT DISCHARGE DD CONTAINING THE DATA YOU WISH TO FILTER <<<<
```

```
AVAILABLE PARAMETERS FOR  
11311300 TURNER CUT NR HOLT CA
```

```
DD  PARM  
ID  CODE          DESCRIPTION  
  
*   1 00060 Discharge (15 minute ave) (cfs)  
*   2 72137 Discharge,tide fltrd (cfs)  
*  11 00065 Gage height (15 minute ave) (ft)  
*  12 00055 Stream velocity (15 minute ave) (ft/sec)
```

```
Enter the number of the parameter desired: 1
```

```
Enter Dates to filter. These dates specify what to retrieve from ADAPS.  
Remember that the filtering process will leave at least 1.5 days on  
both ends of the requested period blank, so you may wish to pad  
your begin and end dates by 2 days in order to compensate.  
See the grfilt readme file for more information.
```

```
Enter Begin Date (YYYYMMDD): 20091201  
Enter Ending Date (YYYYMMDD): 20100120
```

```
>>>> RUNNING NWTS2RDB DATA RETRIEVAL <<<<
```

```
nwts2rdb retrieval completed for station 11311300 and DD 1
```

```
>>>> RUNNING TIDAL FILTER: OUTPUT FILE tdf_11311300.grfilt <<<<
```

```
Reading RDB input...
```

```
Identifying gaps...
```

```
-- gap in input from 2010/01/19 20:15 to 2010/01/19 21:30 will cause  
   gap in output from 2010/01/18 09:00 to 2010/01/21 09:00 (3 days)
```

```
Cannot filter segment of less than 71 hours between 2010/01/19 21:30 and 2010/01/20  
23:30
```

```
Running Godin Filter...
```

```
Writing output...
```

```
Complete.
```

```
>>>> TIDAL FILTER COMPLETED. <<<<
```

```
>>>> RUNNING DECODES CVTSTD. OUTPUT DATAFILE: tdf_11311300.grfilt.std <<<<
```

```
>>>> CHECK ABOVE FOR DECODES PROCESSING ERRORS
```

```
***** BE SURE TO REVIEW YOUR SUMMARY FILE tdf_11311300.grfilt.sum
***** BEFORE LOADING DATA INTO ADAPS.
```

```
>>> DO YOU WISH TO LOAD DATA INTO ADAPS (Y/N)? N
EXITING..
```

```
placer[102]% ls -tl
tdf_11311300.grfilt.std
tdf_11311300.grfilt.sum
tdf_11311300.grfilt
placer[103]%
```

## EXAMPLE 2 – tidal influence diagnostics mode

If the user would like to assess a data set to determine if it is necessary to use a tidal filter, the option “-a” will compute statistics, generate a postscript plot which can be viewed, and provide an initial assessment based on OSW guidelines. This is the only command line option. Below is a slightly edited screen capture of the process using the “-a” option. The text in black is displayed on the user’s terminal. The text in red is information that the user must provide. Important diagnostic messages are shown in blue text.

```
placer[103]% tidal_filter -a
```

```
*** tidal_filter running with options: -a
```

```
At any prompt you may enter EX (or ex) to exit the program...
```

```
>>> Enter station number: 11311300
```

```
>>>> SELECT DISCHARGE DD CONTAINING THE DATA YOU WISH TO FILTER <<<<
```

```
AVAILABLE PARAMETERS FOR
11311300 TURNER CUT NR HOLT CA
```

DD	PARM	
ID	CODE	DESCRIPTION
*	1 00060	Discharge (15 minute ave) (cfs)
*	2 72137	Discharge,tide fltrd (cfs)
*	11 00065	Gage height (15 minute ave) (ft)
*	12 00055	Stream velocity (15 minute ave) (ft/sec)

```
Enter the number of the parameter desired: 1
```

```
Enter Dates to filter. These dates specify what to retrieve from ADAPS.
Remember that the filtering process will leave at least 1.5 days on
both ends of the requested period blank, so you may wish to pad
your begin and end dates by 2 days in order to compensate.
See the grfilt readme file for more information.
```

```
Enter Begin Date (YYYYMMDD): 20080101
Enter Ending Date (YYYYMMDD): 20100120
```

```
>>>> RUNNING NWTS2RDB DATA RETRIEVAL <<<<

nwts2rdb retrieval completed for station 11311300 and DD 1

>>>> RUNNING TIDAL FILTER: OUTPUT FILE tdf_11311300.grfilt <<<<

Reading RDB input...
Analyzing tidal data series...

Ratio of "Filtered Discharge / Tidal Range" calculated.
If above 3, do not filter. If below 1, filter.
744 Points Analyzed.
0 (0%) above 3.
0 (0%) between 1 and 3.
744 (100%) below 1.

Recommendation: Filter
Confidence: High

Writing analysis graphs to PostScript file...

Identifying gaps...
-- gap in input from 2009/06/18 15:15 to 2009/06/18 21:30 will cause
   gap in output from 2009/06/17 04:00 to 2009/06/20 09:00 (3 days, 5 hours)

-- gap in input from 2010/01/19 20:15 to 2010/01/19 21:30 will cause
   gap in output from 2010/01/18 09:00 to 2010/01/21 09:00 (3 days)

Cannot filter segment of less than 71 hours between 2010/01/19 21:30 and 2010/01/20
23:30
Writing output...
Complete.

>>>> TIDAL FILTER COMPLETED. <<<<

> Diagnostics only option selected. Program halting.

> Filtered data output file: tdf_11311300.grfilt
> Postscript diagnostics file: tdf_11311300.ps

placer[104]% ls -tl
tdf_11311300.grfilt
tdf_11311300.ps
placer[105]%
```

## Appendix C: Determination of Tide-Affected Sites; Classification Criteria and Decision Tree

Every streamgauge should be evaluated to determine the significance of tidal influences on the resulting data. In the case of strong tidal effects or no tidal effects, the answer is likely to be obvious and the data analyst can classify the data without utilizing any tools or complex criteria. The tide-filter decision tree (figure C-1) and *tidal\_filter* assessment tools (figure C-2) target streamgauges for which classification may not be so clear.

Each streamgauge can be categorized into one of the following classifications. Depending on the classification, different actions will need to be taken if daily values are to be published. If daily values are not going to be published, filtering is not required.

CLASSIFICATION	STATISTICAL ANALYSIS	ACTION REQUIRED FOR PUBLICATION OF DVs
non-tidal	conclusive	do not filter the data
indeterminate	inconclusive	filtering is recommended, but not required
tidal	conclusive	filter the data

In the event that a station is classified as “indeterminate” the decision whether or not to use a tidal filter can be delayed up to three years. Though WSC’s are encouraged to populate IDA with unfiltered UV discharge data as soon as possible, until a decision to filter/not filter is made, daily-value data for the site should not be published in order to reduce the number of revisions that future classification may require. Obviously, daily-value data for existing sites with historical unit values that are tested and show significant tidal effects will have to be re-processed and revised records may need to be published.

To evaluate the presence of a significant tidal influence, a minimum of one year of data (preferably a dry one) is needed from the site in question. The three tidal tests described in figure C-1 are referenced to statistical and graphical assessments that are reflected in figure C-2 as 5-panel plots. The plots are generated by using the *tidal\_filter* script with the “-a” option. This optional sub-routine is discussed in detail in Appendix B: Processing Procedures using the OSW script *tidal\_filter*. This sub-routine will generate the 5-panel plot which includes summary statistics and a filter usage recommendation. The file is created as a PDF in the user’s home area. A short description of each subplot in the panel follows:

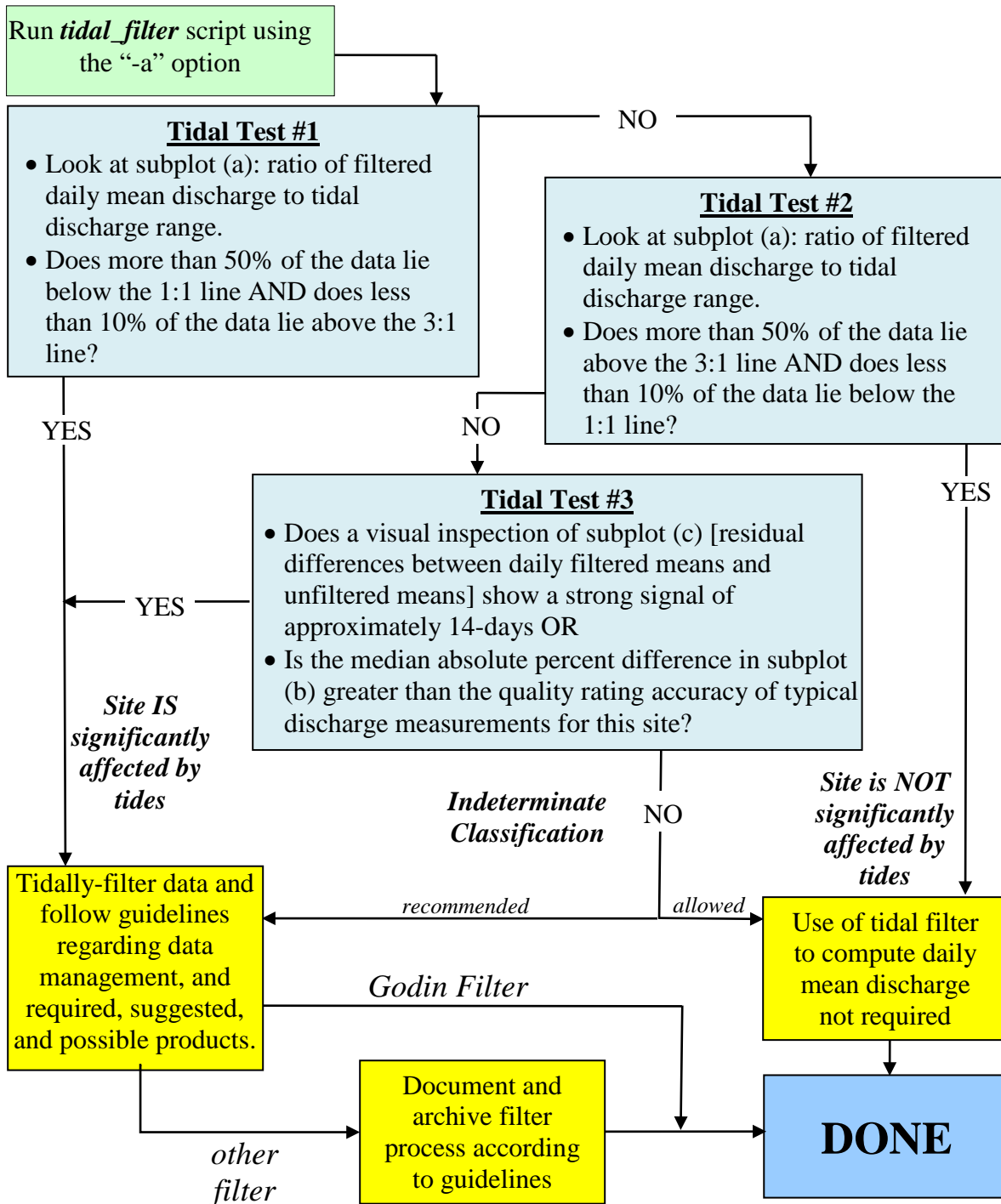


Figure C-1 -- Discharge station classification decision tree.

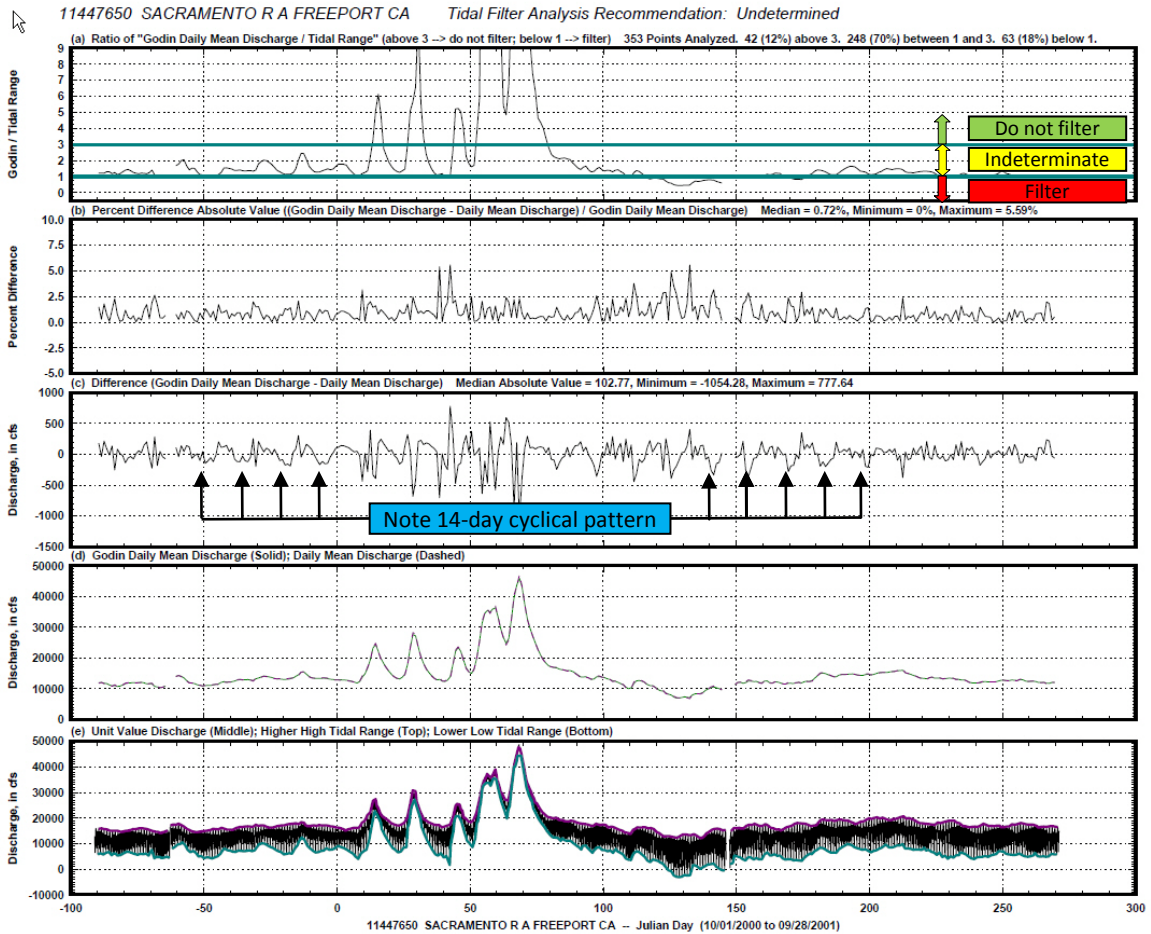


Figure C-2. 5-panel plot from program *tidal\_filter*. [a -- ratio of filtered daily-value average versus tidal range; b -- percent difference between filtered and unfiltered daily-value data; c -- difference between the filtered and unfiltered data; d -- filtered unit and daily-value data; e -- unit value discharge and tidal envelope discharge (high and low)].

**Subplot (a)** shows the ratio of tidal envelope discharge to filtered discharge, the decision-criteria thresholds, and provides some general statistics about where data points fall with regard to these thresholds. Plotting positions were computed as follows (see figure C-3 below):

- i. determine the high-high discharge and low-low discharge for each tidal cycle,
- ii. compute the difference between the high-high discharge and low-low discharge (that is, the "envelope discharge" for the tidal range,
- iii. use Godin filter to tidally-filter the original data, and
- iv. for each day, compute the value for the ratio of filtered discharge/envelope discharge.

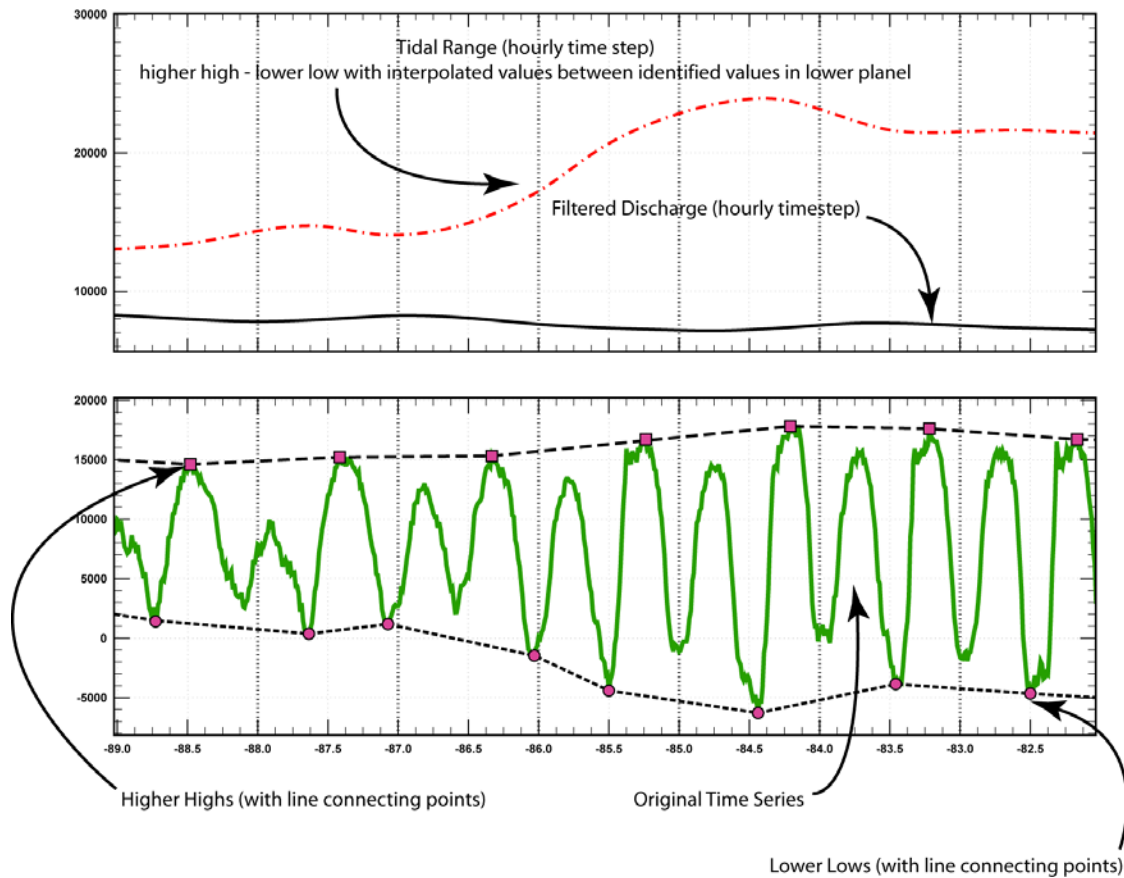


Figure C-3. -- Schematic illustrating computation of ratio of tidal envelope discharge to filtered discharge.

**Subplot (b)** shows the percent difference (absolute value) between the daily mean filtered and unfiltered discharges so hydrographers can get a feel for the percent difference that results from application of the tidal filter.

**Subplot (c)** shows the magnitude of the differences between the daily mean filtered discharge and the daily mean discharge. (As can be seen in the example dataset of figure C-2, this site did NOT need filtering based on the first and second tier tests, but the fairly prominent 14-day signal illustrated in this example indicates that filtering the data might be warranted.)

**Subplot (d)** shows the filtered and unfiltered daily mean discharges. In figure C-2, the differences over time are so small they can only be seen if the plot is magnified significantly and subplot (c) may be more effective in evaluating differences.

**Subplot (e)** displays the original unit value time series data. It also shows the higher high and lower low values that are used to determine the tidal range.

### Example Data Classification:

To provide further direction to data analysts, station 11447650, Sacramento River at Freeport, water year 2001 will be used as an example of this process. This station is located on a large river at the northern boundary of the Sacramento – San Joaquin Delta and WY2001 was classified as a “dry year.” During low and moderate flow conditions, tidal oscillations are obvious, and during extreme low flow conditions there are short periods of reverse flow. Basin hydrology, however, is a strong forcing mechanism at this site. This station has been operated since 1978 and measurements are rated GOOD typically. The site has been treated traditionally as a “standard discharge station” and daily values have been computed without using a tidal filter.

Run the *tidal\_filter* script using the “-a” option. The basic statistics as illustrated in figure 2 show:

```
Ratio of "Filtered Discharge / Tidal Range" calculated.  
If above 3, do not filter.  If below 1, filter.  
353 Points Analyzed.  
42 (12%) above 3.  
248 (70%) between 1 and 3.  
63 (18%) below 1.
```

Recommendation: Undetermined

The program offers a recommendation based on Tidal Test #1 and Tidal Test #2, which are described below:

Step 1: Assess data using Tidal Test #1:

- Look at *tidal\_filter* subplot (a): Ratio of “Godin Daily Mean Discharge / Tidal Range”. Do more than 50% of the data lie below 1 AND do less than 10% of the data lie above 3?
  - **NO:** Only 18% of the data lie below 1 (FILTER zone) and 12% lie above 3 (DO NOT FILTER zone). Both tests fail, so we must continue our analysis.

Step 2: Assess data using Tidal Test #2:

- Look at *tidal\_filter* subplot (a): Ratio of “Godin Daily Mean Discharge / Tidal Range”. Do more than 50% of the data lie above 3 AND do less than 10% of the data lie below 1?
  - **NO:** Over 10% of the data are in the FILTER zone (below 1). Because we do not meet both of the criteria in Tidal Test #2, we must proceed to Tidal Test #3.

Step 3: Assess data using Tidal Test #3:

- Look at *tidal\_filter* subplot(b): Percent Difference: Absolute Value((Godin Daily Mean Discharge – Daily Mean Discharge)/Godin Daily Mean

Discharge) and subplot(c): Difference: (Godin Daily Mean Discharge – Daily Mean Discharge). Is the median absolute percent difference in subplot (b) greater than the quality rating for typical discharge measurements made at the site OR does an inspection of subplot(c) indicate a strong 14.7-day signal?

- **YES:** Although the median value from subplot(b) is quite low (0.72% < 5%) subplot(c) reveals an obvious approximately 14.8-day pattern particularly during low flow conditions in the fall and spring. Thus, a “YES” result indicates the data should be filtered.

## Appendix D: Summary table of publication guidelines and policies

This appendix provides a broad summary of the publication guidelines presented in this memorandum. It does not cover all guidelines (processing, archival, and so forth) addressed in this memorandum, but serves as a quick reference to highlight important publication policies.

### Summary table of publication guidelines for parameters at tidally-influenced sites<sup>1</sup> [memorandum reference section bracketed]

Data type and presentation media or database	Minimum Product(s) <sup>2</sup> (required)	Suggested Additional Product(s) <sup>2</sup>	Other Allowable Product(s) <sup>2,3</sup>	Disallowed Products
<b>DISCHARGE SITES</b>				
Time series tables/statistics, Site Data Sheet	<p><i>Unfiltered data:</i> Site data-sheet with appropriate paragraphs (including location, period of record, etc.) and a remarks section that tells the user how to retrieve unfiltered data. [3.E.3.a.i]</p> <p><i>Filtered data:</i> Daily discharge table derived from tidally-filtered discharge (parameter code 72137) unit values. [3.E.3.a.ii]</p> <p><i>Filtered or Unfiltered data:</i></p>	<p><i>Filtered data:</i> Unit value discharge (parameter code 72137) may be entered into IDA when that option becomes available. [3.E.4.a.i]</p>	<p><i>Unfiltered data:</i> Daily mean/max/min statistics for indeterminate sites with a qualifier statement. [3.E.5.a.i]</p> <p><i>Unfiltered data:</i> Table of monthly mean discharge based on daily discharge (parameter code 00060) values. Daily values (parameter code 00060) must <b><i>NOT</i></b> be accessible through NWIS Web. [3.E.5.a.ii]</p>	<p><i>Unfiltered data:</i> Daily mean discharge table (parameter code 00060). [3.E.1]</p>

Data type and presentation media or database	Minimum Product(s) <sup>2</sup> (required)	Suggested Additional Product(s) <sup>2</sup>	Other Allowable Product(s) <sup>2,3</sup>	Disallowed Products
	<p>A qualifier statement is required that indicates the data is tidally-influenced. [3.E.3.a.iii]</p> <p>Filtered or unfiltered data: The manuscript must describe the direction of flow. [3.E.3.a.iv]</p>			
Extremes, Site Data Sheet	<p>MAXIMUM DISCHARGE – Document maximum instantaneous unfiltered (parameter code 00060) discharge in either the Summary Statistics Table or the "Extremes for the Current Year" paragraph. [3.E.6.b.i]</p>	<p>MINIMUM DISCHARGE – Document minimum instantaneous unfiltered (parameter code 00060) discharge (largest negative or smallest positive) in the Summary Statistics Table or the "Extremes for the Current Year" paragraph. [3.E.6.b.ii]</p>	<p>Gage height extremes at discharge sites also may also be documented in "Extremes for the Current Year" part of the manuscript as the MAXIMUM GAGE HEIGHT or MINIMUM GAGE HEIGHT. [3.E.6.c.i]</p>	
Extremes, Peak Flow File	<p>Enter highest instantaneous seaward flow and associated GH. If storm surge GH is higher than the GH corresponding to the peak discharge, enter the peak associated with the</p>			

Data type and presentation media or database	Minimum Product(s) <sup>2</sup> (required)	Suggested Additional Product(s) <sup>2</sup>	Other Allowable Product(s) <sup>2,3</sup>	Disallowed Products
	discharge in the <i>gage_ht</i> field and the largest GH into the <i>ag_gage_ht</i> field as you would at any standard site where the peak GH and peak discharge do not coincide. [3.E.7.a]			
<b>STAGE-ONLY SITES</b>				
Time series tables/statistics, Site Data Sheet	<p><i>Filtered or unfiltered data:</i> Site data-sheet with appropriate paragraphs (including location, period of record, etc.) and a remarks section that <u>tells</u> the user how to retrieve the data.            [3.E.3.b.i]</p>	<p><i>Unfiltered data:</i> Tidal statistics table based on existing ADAPS statistic codes 00021 &amp; 00024 (codes 00022 &amp; 00023 are also encouraged).            [3.E.4.b.i]</p> <p><i>Unfiltered data:</i> Daily mean, maximum, minimum tables are allowed under certain circumstances:</p> <ul style="list-style-type: none"> <li>• Open ocean sites not affected by inland runoff</li> <li>• Flashy urban streams dominated frequently by basin runoff or other meteorological forcings.            [3.E.4.b.ii]</li> </ul>	<p><i>Filtered data:</i> Table of daily mean stage.            [3.E.5.b.i]</p> <p><i>Unfiltered data:</i> Table of monthly mean stage based on daily stage (parameter code 00065) values. Daily values (parameter code 00065) must <b>NOT</b> be accessible through NWISWeb.            [3.E.5.b.ii]</p>	

Data type and presentation media or database	Minimum Product(s) <sup>2</sup> (required)	Suggested Additional Product(s) <sup>2</sup>	Other Allowable Product(s) <sup>2,3</sup>	Disallowed Products
		<p><i>Filtered or unfiltered data:</i> Unit value stage (parameter codes 00065 or 72137) may be entered into IDA when that option becomes available. [3.E.4.b.iii]</p>		
Extremes, Site Data Sheet			<p>Gage height extremes may also be documented in "Extremes for the Current Year" part of the manuscript as the MAXIMUM GAGE HEIGHT or MINIMUM GAGE HEIGHT. [3.E.6.c.i]</p>	
Extremes, Peak Flow File		<p>Maximum instantaneous stage may be entered into the <i>ag_gage_ht</i> field (all discharge-related fields left blank). [3.E.7.b]</p>		

<sup>1</sup> Sites not influenced significantly by tides as dictated by the guidelines in this memorandum are still subject to previous OSW policy guidelines

<sup>2</sup> One of the minimum products is always required (discharge or stage-only sites) along with appropriate qualifiers and flow direction (discharge sites). Additional suggested products and allowable products may be provided in addition to the minimum.

<sup>3</sup> Other products may be allowed but should be approved by OSW prior to publication.