Great River Hydro

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May 22, 2018

VIA ELECTRONIC FILING

Honorable Kimberly D. Bose, Secretary
Federal Energy Regulatory Commission
888 First Street, NE
Washington, D.C. 20426

Re: Great River Hydro, LLC; FERC Project Nos. 1855-045, 1892-026, and 1904-073 July 12, 2017 through February 9, 2018 Study Report Addenda – Response to Comments, Disagreements and Requests to Amend Study Plans

Dear Secretary Bose:

Great River Hydro, LLC (Great River Hydro) is the owner and licensee of the Wilder Hydroelectric Project (FERC No. 1892), the Bellows Falls Hydroelectric Project (FERC No. 1855), and the Vernon Hydroelectric Project (FERC No. 1904). The current licenses for these projects each expire on April 30, 2019. On October 31, 2012, TransCanada (the previous licensee) initiated the Integrated Licensing Process by filing with the Federal Energy Regulatory Commission ("FERC" or "Commission") its Notice of Intent to seek new licenses for each project, along with a separate Pre-Application Document for each project.

As required by 18 C.F.R. §5.15(f) and in accordance with the Revised Process Plan and Schedule issued February 15, 2018 by the Commission, Great River Hydro submitted four study report addenda for the three projects between July 12, 2017 and February 9, 2018. A study report meeting was held on March 8, 2018 and a meeting summary was filed March 23, 2018. With this filing, Great River Hydro submits responses to comments and specifically to Disagreements and Requests to Amend Study Plans regarding the study report addenda filed between July 12, 2017 and February 9, 2018 for the three projects, as required by 18 C.F.R. §5.15(c)(5). Comments, Disagreements, and Requests to Amend Study Plans on the study report addenda were filed by the following parties:

Name of Individual or Organization	**Acronym Used in Comment / Response Table**
Mr. Larry Scott, Connecticut River Watershed Farmers Alliance, river abutter, farmer	Scott
Mr. Tom Beaudry, certified crop advisor, resident	Beaudry
Mr. John Bruno, former river abutter	Bruno
Mr. O. Ross McIntyre, river abutter	McIntyre
Mr. John Mudge, river abutter	Mudge
Connecticut River Conservancy	CRC
Connecticut River Joint Commissions	CRJC
Upper Valley Local River Subcommittee of CRJC	UVLRS
New Hampshire Department of Environmental Services	NHDES
New Hampshire Fish & Game Department	NHFGD
Vermont Department of Environmental Conservation	VTDEC
United States Fish and Wildlife Service	FWS

Our responses are indicated in the attached table entitled *Response to Comments, Study Reports filed July 12, 2017 - February 8, 2018*. Study report addenda filed during that period are:

- Studies 2 and 3 – Riverbank Transect and Riverbank Erosion Study Supplement to Final Study Report, filed November 15, 2017
- Study 18 – American Eel Upstream Passage Assessment Report Supplement #2 to Final Study Report, filed February 8, 2018
- Study 21 – American Shad Telemetry Study Supplement to Final Report, filed February 8, 2018
- Study 25 – Dragonfly and Damselfly Inventory and Assessment Supplement to Final Report, filed July 12, 2017

No comments, and no Disagreements or Requests to Amend Study Plans were received on Study 25 – Dragonfly and Damselfly Inventory and Assessment Supplement to Final Report.

A progress report on the status of three remaining studies was filed on May 15, 2018, in accordance with the Revised Process Plan and Schedule issued February 15, 2018. The three studies are: Study 9 – Instream Flow Study, Study 24 – Dwarf Wedgemussel and Co-occurring Mussel Study, and Study 33 – Cultural Resources (specifically, the Traditional Cultural Properties report and Historic Properties Management Plan).

If there are any questions regarding the information provided in this filing or the process, please contact John Ragonese at 603-498-2851 or by emailing jragonese@greatriverhydro.com.

Sincerely,

John L. Ragonese
FERC License Manager

Attachments:

Response to Comments, Study Report Addenda filed July 12, 2017-February 8, 2018. (PDF)

Enclosures:

1. Erosion ADCP XSEC Velocities WC (Excel) – three ADCP sites associated with erosion monitoring sites
2. Erosion Monitoring Site Operating Elevations Soil Sampling Guide (Excel) – HEC-RAS model results for 21 nodes corresponding to erosion monitoring sites – array of WSE's at sites across combinations of Flow and WSE at dam conditions.
3. HECRAS Plots (PDF) – HEC-RAS 2D model channel cross-sections plots of velocity and shear stress
4. Sediment Entrainment Threshold Analysis (PDF) – Table similar to Table in Supplemental Report but includes analysis of D15 and D85 representative sediments.

cc: Interested Parties List (distribution through email notification of availability and download from Great River Hydro's relicensing web site www.greatriverhydro-relicensing.com).

Study 2/3 – Riverbank Transect and Riverbank Erosion

Comment #	Source	Comment	Response
1	NHDES-1a CRC/PH	The HEC-RAS model was run at a single manning's "n" (an indication of channel roughness), with no differentiation between in-channel and floodplain, which could, therefore, produce erroneous results that do not adequately represent ambient conditions. *NHDES requests that this concern be addressed.*	The flows for the model runs remained in the channel and therefore did not require refining overbank Manning's n-value. Inputting a Manning's n-value at the overbanks where there is no flow would not change the results.
2	NHDES-1b CRC/PH	The HEC-RAS model was run at a steady flow which is atypical and therefore doesn't account for the effects of sub-daily water surface elevation fluctuations due to project operation, which is a key concern. *NHDES requests that this concern be addressed.*	We disagree, our application of the model is not atypical. The model was run at steady flows to derive the corresponding velocity. The model can certainly be run for an inflow hydrograph or variable flows but that was unnecessary to estimate water surface elevations (WSE) at the monitoring sites as well as estimate near bank velocities and shear stress. Running the model in either steady or unsteady flow would produce the same results as each would report out a similar velocity and shear stress at a given moment representing a specific WSE at the dam and flow condition at the site.
3	NHDES-1c CRC/PH	The near-bank velocities associated with multiple water surface elevations, as measured at the six sites with ADCPs has not been provided. *NHDES requests that this information be provided.*	ADCP was performed at only **three** erosion monitoring sites only. We are including the results with this comment response; however it should be noted that the ADCP measurement were not taken at multiple WSE's as is suggested in the comment. The other remaining ADCP sites corresponded with Study 9 Instream Flow transects. The three erosion monitoring site ADCP results cannot be directly compared to HEC-RAS model unless WSE at the dam and flow at the site are similar. ADCP at W09 monitor site (Mudge) was performed during a similar roughly 5,000 cfs flow a relatively similar WSE at the dam and they compare well. ADCP measurements taken at W07 (Tullando) during conditions that were in a similar range to HEC-RAS modeling conditions and also compare reasonably well. ADCP measurements at W03 (Bellavance) were recorded during flows above Wilder minimum flow but less than 5000 cfs mid-flow modeled using HEC-RAS and the WSE at the dam differed by at least one foot. However, they are within the range the HEC-RAS results present and therefore similarly appear to compare well. The ADCP data supports the same conclusions as our HEC-RAS 2D derived velocity estimates. The comments and concerns fail to acknowledge that GRH chose to implement a better approach uniformly across the 21 monitoring sites. GRH could not use the ADCP data to examine conditions other than the "snapshot" conditions that were present when the measurement were

Comment #	Source	Comment	Response
			made. FERC was asking GRH to examine multiple conditions. Furthermore, ADCP velocity data can be quite variable due to changes in flow angles and potential upwelling from obstructions such as woody debris and vegetation, particularly along the banks. The ADCP software accounts for all this when calculating discharge. In addition, in a wide impoundment there is often surge or eddies associated with edge measurements – the reason for occasional negative velocities that can be viewed in the results.
4	NHDES-1c CRC	At the March 8, 2018 meeting, NHDES requested ADCP measurements of velocity across the river at various flows be compared with modeled velocities at the 21 monitoring stations. This information has not been provided and is needed to help determine how well the model is calibrated especially with regards to near-shore velocities. *NHDES requests that this information be provided.* As mentioned above, the validation of the model using surface water elevations at the 6 ADCP sites was not included in the supplement. We request that this information be provided, and that it include maximum historic operational surface water elevation changes at the dam and resulting surface water elevation changes at the transect sites for various flows.	As noted above, there are several reasons why we did not rely on ADCP data to develop the information requested by the FERC. NHDES is correct we did not provide ADCP data and are doing so now but only the three locations corresponding to the erosion monitoring sites. As stated in several previous discussions on calibration of the HEC-RAS model, one does not and should not use ADCP to calibrate a HEC-RAS model nor determine if the model is calibrated. We have stated in the previous comment that although the conditions under which the ADCP measurements were made can only represent those present at the time of measurement, they were somewhat similar or within proximity to conditions, requested by the FERC and modeled in HEC-RAS. They compare well and do not change the results or conclusions of the Study. Riverine ADCP sites have more than one flow condition as they were used for Instream Flow Habitat Assessment Study purposes and do not correspond with erosion monitoring sites. The calibrated 1-dimensional model was used as the foundation for creating the 2-dimensional models at each of the 21 erosion monitoring sites. As part of Study 4, the 1-D calibrated model was compared with the ADCP velocities and during this analysis the computed velocity data compared very well with the observed ADCP velocity data. During the 2D modeling, the flows and water surface elevations were compared with the 1D model to ensure that the 2D model was representing the values at the upstream and downstream boundaries that were expected from the calibrated 1D model.
5	NHDES-1d	HEC-RAS model input and output should be made available to stakeholders to facilitate their review. *NHDES requests that this information be provided.*	In the July 21, 2017 Study Determination Letter, FERC required GRH to provide model input data to parties that make a request to GRH. Since that time, the CRC has been the only party to file such a request and GRH

Comment #	Source	Comment	Response
			has distributed the HEC-RAS model files to them. If NHDES or any party is requesting it for review purposes, we respectfully ask that they make a request outside of the comments on the Supplemental Study Report and we will provide a data to them. The data set is far too large to email or distribute online.
6	NHDES-1e CRC/PH	To facilitate review, plotted cross-sections for each site are requested with the following information shown on the same figure for each of the 21 monitoring sites: • annotations of erosional features (as depicted in the February 4, 2017 Final Report Appendix A), • water surface elevation fluctuations as measured by the water level loggers, and • the locations of the three sediment samples analyzed at each site in the Supplemental Report. *NHDES requests that this information be provided.*	GRH believes the requested information has already been presented and because the various charts use a similar vertical height scale they can viewed easily as is. If all the information in this request was combined on the same figure, it would become far too "busy" with WSE logger details that the resulting figures will be difficult to interpret. It was for this reason that erosion features and water surface elevation fluctuations were presented on separate graphs in Appendix A of the February 4, 2017 Final Report. The elevations on all graphs are the same, so interested parties should be able to align individual features of interest and soil sample elevations with materials already made available in the Final Report and supplementary report without creating an unreadable graph. The effort to modify each graph to accommodate this request and make it readable would require a very significant effort that we believe is unjustified.
7	NHDES-1f CRC-8	The analysis was conducted using the median particle size (D50). According to the March 8, 2018 meeting summary, and recognizing that particles smaller than D50 may be entrained, GRH stated that 8 they will "attempt" to provide critical velocity and shear stress values for the other representative grain sizes. *NHDES requests that this information be provided.*	An analysis of entrainment was completed for fine (D15) and coarse (D85) particles in the sediment samples and is provided on the accompanying 21 tables, representing all of the monitoring sites. Grain sizes representing D15 and D85 are described and corresponding critical threshold velocity and shear stress values are compared to HEC-RAS 2D model near bank velocities and shear stress estimates. Only 4 monitoring sites suggest entrainment of the finer D15 particle sizes are possible under operational conditions where entrainment was not found to be possible during the original analysis of the D50 particle size, including one site, WR05, where the original analysis suggested no entrainment was possible under any operational condition (although the velocity threshold of 2.0 is barely crossed by the 2.088 modeled velocity for this site). Entrainment of the D15 particle sizes is possible during only 22 out of a possible 189 operational scenarios (12%). While this represents more than twice the number of conditions where entrainment is possible compared to that for D50 particle sizes, the total still represents only a small fraction of the full range of operational conditions. When considering only bank sediments, only 5 operational scenarios (3%) show entrainment of D15 particle sizes compared to 8

Comment #	Source	Comment	Response
			conditions for the D50 particle size (4%). This indicates that the D15 particle sizes of the bank sediments are more difficult to entrain than the coarser D50 particle sizes, a reflection of the impact of cohesiveness of the finer silt and clay particles in the samples. The additional analysis, therefore, while showing some increase in the number of operational scenarios where sediment entrainment is possible does not materially change the findings of the original analysis, especially when considering the conservative nature of the analysis that would suggest actual entrainment is unlikely even where predicted (see also response to Comment #10 below).
8	NHDES-1g CRC	To guide sampling station location, the HEC-RAS model was used and the mid-range operating elevation at the dam was primarily used in the model to determine soil sample collection locations for the three flows. NHDES requests that a table be provided that compares the elevations used to determine soil sample locations and shear stress in the Supplemental Report to the elevations representing typical operational fluctuations provided in the February 4, 2017 Final Study Report. If different, NHDES requests an explanation as to why the elevations in the February 4, 2017 Study Report, which are reported to be representative of typical operational fluctuations, were not used in the velocity and shear stress analysis.	NHDES is correct in stating that the HEC-RAS model was used to identify soil sample elevations. However, the model estimated WSE's throughout the normal operating range and all flows within or just exceeding station capacity and developed an array of corresponding WSE's for each erosion monitoring site. This array was used as a guide for the field work to ensure distinct soils were sampled within the overall range. In many cases however, the lowest operating range was submerged particularly in the case of Wilder's where the overall five-foot range is below normal (non-spill) operations. Crews collecting soil samples did not experience conditions where spill was occurring at the dam and river profile operation was in effect. A spreadsheet with the WSE at the erosion monitoring sites is provided with this responsiveness summary. In some cases, similar WSE's at erosion monitoring sites correspond with various combinations of flow and WSE at the dam. Similarly, soil types were often observed to be the same among various resulting WSE's. The field collection protocol was to only use one sample if the same soil was present at the anticipated WSE under one or more of the FERC requested conditions. GRH further requested that although potentially outside the limits of the HEC-RAS derived normal operations range of WSE's at the erosion monitoring sites, if normal operations aligned with beach material feature at the lower flow conditions or if a unique soil type or could potentially be affected by spill or high water flow conditions based upon the guidance spreadsheet, an additional soil sample was collected.
9	NHDES-1h	The Supplemental Report references "VANR, 2004" for some of the critical shear stresses used in the analysis. However, a citation was not provided in section 5 (Literature Cited). *NHDES requests that*	GRH apologizes for the confusion but the requested citation is already provided in Section 5.0 of the supplementary report (p. 14 or p. 18 of

Comment #	Source	Comment	Response
		this information be provided.	electronic pdf file) under Vermont Agency of Natural Resources (VANR). For convenience, the full citation is also provided here: Vermont Agency of Natural Resources (VANR). 2004. Particle Entrainment and Transport. Vermont Stream Geomorphic Assessment, Appendix O, 6 p.
10	NHDES-1i	The Supplemental Report states that that the critical stress analysis is conservative because it does not account for cohesion, compaction and other forces resisting entrainment. However, the February 4, 2017 Final Study Report (p. 124) states the following which indicates that the analysis may not be as conservative as suggested in the Supplemental Report: "The bank sediments at the monitoring sites, representative of the study area as a whole, are nearly ubiquitously comprised of fine-grained and unconsolidated floodplain or glaciogenic sediments that are particularly prone to erosion..."	The comments on both reports are accurate and not contradictory. At a general level, the bank sediments are particularly prone to erosion UNDER CERTAIN CONDITIONS where the critical velocity/shear stress threshold is crossed – such as at high flows above the operational conditions of the projects. While at the general level the sediments can be characterized as unconsolidated, when looking more specifically at threshold conditions a more detailed consideration of the character of the sediments - such as cohesion and compaction - should be accounted for. However, since such detailed analysis of sediment characteristics falls beyond the scope of the study, a conservative approach was taken where the sediment was considered to be loose and non-cohesive. All conclusions are based on this conservative assumption and we are merely pointing out that it is a conservative approach and that actual conditions would have tended to give results that would be less likely to show sediment entrainment at operational levels.
11	NHDES-1j CRC/PH	The Supplemental Report (p.11) states that "...only 8 out of 21 sites show any potential for sediment entrainment." This represents 38% of the surveyed sites, which is not insignificant. If the single site that had been armored is added, the percentage increases to 43% (9/21). If site V02 is added because the difference between the predicted shear stress and the estimated critical shear stress is so small (see the table below) and likely within the margin of error for the analysis, the percentage increases to 48% (10/21).	The potential for sediment entrainment was identified at 8 of 21 sites using the analysis provided. At most sites this entrainment occurs at the upper end of operational conditions, but the projects operate at these levels at only a small fraction of time. Furthermore, the threshold at these 8 sites is barely crossed and given that the literature strongly indicates that such critical thresholds are greatly underestimated. While we have fairly presented the results determined with the methods and procedures used, one must remember the results are conservative in nature. Rather than suggesting sites that just fall below the critical threshold and thus should be considered in the number of sites showing entrainment, the conservative approach used suggests that it is far more likely that fewer than 8 of 21 sites experience entrainment under operational conditions as opposed to 10 of 21 sites as proffered in the comment. Most of the predicted entrainment results were not from bank sediments but are almost exclusively of beach/bar sediments more likely deposited under higher flow conditions. The study showed bank sediment entrainment occurred during only 8 out of 189 operational scenarios representing only 4% of the conditions, strongly indicating

Comment #	Source	Comment	Response
			operational conditions are not responsible for excessive erosion in the project area.
12	NHDES-2a McIntyre Mudge VTDEC CRC-1	Because GRH has not adequately acknowledge the significant impact that project related WSE fluctuations likely have on bank instability (and ultimately erosion), they have not fully characterized the process of erosion or adequately addressed it as a likely cause of erosion and, therefore, have not satisfactorily addressed FERCs' study goals.	GRH respectfully disagrees with this statement and its statement of WSE fluctuations as a likely cause of erosion as a foregone conclusion. In its Final Study Reports under Study 1 we characterized the process of erosion and in the Final Study 2/3 Report issued in Feb 4, 2017, GRH adequately analyzed whether or not the effect on WSE fluctuations had a material effect on bank instability (and ultimately erosion). We acknowledged WSE's correspond with observed notching; in some cases, at normal operation conditions and others at higher flow conditions. Similar comments were presented and responded to prior to FERC issuing its July 21, 2017 Study Plan Determination. In the July 21 Determination Letter, FERC specifically asked GRH for additional analysis to address our characterization of soils, site specific near-bank velocity and shear stress estimates and soil-specific threshold velocities and shear stress; all of which has been presented in the supplemental report (including additional materials requested in Study Report meeting and subsequent comments). The fact that none of that data examines WSE fluctuations is not material to the report. The analysis and report were intended to examine whether project operations sustain the erosion cycle. Notching and bank failure absent removal of the material at the base of the bank inherently leads to bank stabilization. The analysis and report indicate that project operational flows cannot remove the material in the majority of locations and conditions but further points out that higher flows have a much higher potential for doing such and there fore continues to support our position that in this system, high flows are the likely cause and primary driver for sustained erosion.
13	NHDES-2b CRC/PH (regarding first bullet)	Visual observations strongly suggest that daily WSE fluctuations associated with project operations impact stream bank stability, and erosion potential. Examples include the following: • Beaches were noted at 18 (86%) of the 21 sites. Beaches do not typically occur on a free flowing riverine system. Rather, the presence of beaches is more indicative of a system with repeated changes in water surface elevations that inhibit the establishment	Refer to Final Study 2/3 Report issued in Feb 4, 2017 for a more systematic assessment of observations and the presence of active erosion. Based on that report, GRH disagrees with the conclusion in the comment that observations suggest WSE fluctuations impact bank stability. Nor does GRH agree with the statement on the presence of beaches, association with repeated WSE fluctuations or vegetation inhibition. Each of these statements represent conjecture used to

Comment #	Source	Comment	Response
		of vegetation. Without daily fluctuations, the beach would likely re-vegetate and provide greater bank stability. • WSEs related to normal project operations under no-spill conditions were found to be consistent with notching and overhangs observed at the bases of 8 of the 21 (38%) of the monitored banks at some point during the two-year monitoring period (p. 138 and 139 of February 4, 2017 Final Study Report). • Approximately 37% (93 miles) of the 250 miles of banks that were studied were observed with notching at the base (p. 81 of February 4, 2017 Final Study Report). Although the exact elevation of the notching along the 93 miles of banks with notching could not be determined, given that the observations occurred during no spill conditions and recorded all notches/overhangs at the base of the bank – and largely near the water level – it can be assumed that most, if not all, of the mapped notching occurs within the range of elevations associated with normal project WSE fluctuations (10/31/16 TC (now GRH) Response to Comments, comment 12, p. 6 and 7).	support the underlying unsupported statement regarding WSE fluctuation. Beaches in a reservoir setting are an indication that the bank behind the beach is stabilizing – the height of the beach will be roughly equivalent to the height of the water level fluctuation. The fact that the beaches are not revegetating and providing more stability is more a consequence of the riverine character of the system and not a reflection of project operations. If the projects were operating in a still-water reservoir, the banks would stabilize with beaches fronting all of the banks. Since the project area is in a riverine setting and we examined project operational flow capabilities in the supplemental study, we were able to indicate that high flow unrelated to project operations align with bank material and beach and bar sediments, and have the necessary near-bank velocity and shear stress potential to erode the banks, remove colluvial material accumulating at the base of the bank, and sustaining the erosion process that would have otherwise reached a stable equilibrium condition if project related WSE fluctuations were the only controlling factor. The higher velocities and shear stresses during flood flows are not only removing colluvium accumulating at base of bank but also inhibiting the growth of stabilizing vegetation on the beaches or submergent vegetation observed throughout the projects in locations subject to fluctuation but absent high flows. Regardless of whether the beaches are vegetated, if the water surface fluctuations were fully contained on the beaches – as might be the case in the absence of fluctuating riverine inflows – then flow would not reach the base of the banks and the banks would stabilize over time even if the beaches remained unvegetated. We do not disagree that notching aligns with normal WSE in some of the monitoring sites, but we re-state what has been stated in the Final Study 2/3 Report issued in Feb 4, 2017 and in many previous responses to comments, which is that the project operational range of WSE is generally distinct, consistent, limited and relatively narrow. Therefore, flows capable of removing sediment, ice scour, waves, boat traffic and WSE fluctuation can and do contribute to the formation of notching at the specific consistent normal operational WSE elevation. That does not suggest that project operation is responsible for and causes the Connecticut River erosion in the project area, downstream or upstream.

Comment #	Source	Comment	Response
14	NHDES-2c CRC-8	The Supplemental Report examined entrainment of particles that have already eroded. It’s quite possible that the D50 values used in the analysis are high because the finer material has been removed from the banks due to WSE fluctuations. No analysis was done to account for changes in cohesion due to repeated wetting and drying of the banks (and the subsequent loss of the finer material) as a result of project related WSE fluctuations.	First, a distinction needs to be made between bank sediments and beach/bar sediments that were sampled. Focusing only on bank sediments, the samples were taken at a specific time and place. While finer sediments may have been removed previously from the sample locations, we can only examine what was present on the day of sampling. While some fine sediment may have been previously removed, the coarser lag left behind becomes increasingly difficult to entrain and that is what the sample would accurately reflect. Suggesting the analysis is slanted in a particular direction because we were unable to sample a condition from a previous time fails to recognize all possible conditions that may have existed previously. Again, we can only sample and analyze conditions that existed at the time of sampling and can only report on and base conclusions on that sampling. Finally, the presence of considerable fines in the samples belies the contention that fines are preferentially being removed from the monitoring sites and leaving coarser sediment behind. As for cohesion, we took a conservative approach in that all samples – other than those with significant amounts of clay – were considered to be loose and cohesionless. As for the wetting and drying preferentially carrying away fines, the statements above are repeated in that we could only sample what was available to sample and that we cannot only assume that the sample reflects coarser conditions than once existed, but one must also realize the sample may have also been finer than in situ bank sediments
15	NHDES-2d	The analysis did not account for velocity changes due to sub-daily WSE elevations which could exceed the critical velocities.	GRH respectfully disagrees. As stated in our responses to Comments 2 and 8, soil samples from banks, beaches or bars were collected based upon the full range of WSE elevations experienced in the combination of elevations at the dam and flow conditions. Near-bank velocity and shear stress estimates using the 2D model are essentially snapshots of various conditions within the overall project range regardless of modeling steady flow or unsteady flow; velocities would be the same and there is no significant velocity response to WSE changes at the rates in which these occur under normal operations (generally 0.15 ft./hr. and no more than 0.3 ft./hr.). Given that soil samples represent soils exposed to project operations and near-bank estimates of velocity and shear stress are associated with the normal operating range; it is reasonable to state that we have adequately analyzed velocities and differences corresponding both varying WSE and Flow elevations. Analyzing velocities and shear

Comment #	Source	Comment	Response
			stresses at various stages between the conditions examined, is unlikely to materially alter the results of the supplementary study report as the intervening combinations of flow and WSE were considered in soil sample selection and are likely to experience shear stresses and velocities that fall in between the values determined for the 3 operational levels analyzed. This is a comprehensive perspective not a single situational approach.
16	CRC/PH	Critical shear stress is not as conservative a measure as claimed in the Supplement because it does not account for cohesion, compaction, and other forces resisting entrainment.	GRH respectfully disagrees. The critical shear stress values used in the analysis were largely based on values for loose uncompacted sediment reported in the literature whereas sediment cohesion and compaction may have been present in the samples analyzed.
17	CRC/PH CRC-12	The Supplemental Study and the Revised Study do not address the role played by operational water surface fluctuations in perpetuating the bank erosion cycle. Water surface fluctuations directly contribute to bank failure resulting in sediment deposits at the toe of the bank. Without addressing the effect of water surface elevation changes at the transect sites, the Supplement does not prove that project operations are not contributing to bank erosion. CRC contends that the focus on instream velocity and entrainment only addresses part of what is going on. The Final and Supplemental reports for Studies 2 and 3 have still not addressed pool level fluctuations and the resulting effects of upper bank erosion. Focusing on the entrainment and movement of already eroded and non-cohesive sediment is not proof that project operations do not contribute to the overall erosion cycle.	The supplementary analysis responded to the FERC Determination request for more information. The Supplemental analysis and report supports and bolsters the previously stated conclusion that project operations is not responsible for the sustained erosion that occurs along the Connecticut River, in areas subject to project operations or otherwise. Rather it is high flow conditions that are responsible continued this cycle of erosion that has been going on prior to the development of the Wilder Project (Study 1) and continues today. As stated in our responses to comments 2, 12, 13 and 15, GRH disagrees with the comment that the Supplemental Report and the Final Study 2/3 Report issued in Feb 4, 2017 fail to address the role played by operational water surface fluctuations in perpetuating the bank erosion cycle.
18	CRC-2	The Study Plan Determination dated September 13, 2013 states "…A stated objective of the study is to ascertain the likely causes of erosion [emphasis added] at various locations. Project operations would be a likely cause of erosion where visible signs of erosion closely track project-caused water level fluctuations…" [emphasis added]. Additionally, the Study Plan Determination states, "As a result, we recommend modifying study 3 to correlate visible indicators of erosion with project-caused water level fluctuations [emphasis added] at the 20 transect locations…" Project caused water fluctuations include daily surface water elevation changes at the dam. The Revised Final Study Report and Supplement have failed to adhere to the Study Plan Determination.	GRH respectfully disagrees that the Final and Supplemental Study Reports failed to adhere to the September 13, 2013 Study Plan Determination. We would refer to the information found within those reports, additional information provided with these comments and responses to comments 2, 12, 13 and 15.

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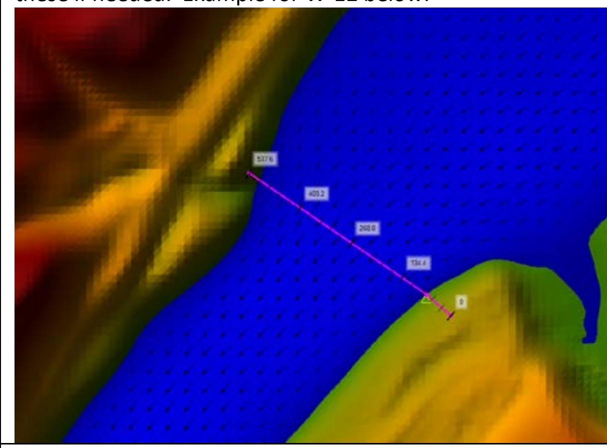
19	CRC-3	Not only did the analysis for the supplemental report not involve river fluctuations, but the dam elevations used to run the velocity and sheer stress analysis do not correspond with dam operation elevations typically used for those flows. Figures in the Pre-Application Documents (PADs) dated October 2012, for example Figure 2.5-1 in the Wilder PAD, provide "normal generation ranges" for each impoundment, and it also shows the reservoir profile operation for elevation at each dam. The table below [not replicated here] summarizes the dam elevations used in the supplemental report for the "minimum," "average operational," and "capacity" flows vs. the flows those elevations correspond to under normal operations according to the PAD. The dam elevation used for most of the Vernon Dam analysis is particularly odd, since it lies outside of the normal operational range. According to the PAD, each dam is held at higher elevations for flows within the facility's operational control, and for higher flows, each dam's elevation is lowered. That is the opposite of what was done for the analysis in this Supplement. Therefore, the dam elevations used for the analysis do not appear to reflect typical operation elevations for those flows, potentially calling the entire analysis into question.	GRH respectfully disagrees with the comment and conclusion that the dam elevations used for the analysis do not appear to reflect typical operation elevations for those flows, potentially calling the entire analysis into question as pointed out in our responses to Comments 8 and 15 and as shown in the additional materials provided with this responsiveness summary. The HEC-RAS model was used to identify soil sample elevations by estimating WSE's throughout the normal operating range and all flows within or just exceeding station capacity and developed an array of corresponding WSE's for each erosion monitoring site. This array was used as a guide for the field work to ensure distinct soils were sampled within the overall range. In many cases however, the lowest operating range was submerged particularly in the case of Wilder's where the overall five-foot range is below normal (non-spill) operations. Crews collecting soil samples did not experience conditions where spill was occurring at the dam and river profile operation was in effect. A spreadsheet with the WSE at the erosion monitoring sites is provided with this responsiveness summary. In some cases, similar WSE's at erosion monitoring sites correspond with various combinations of flow and WSE at the dam. Similarly, soil types were often observed to be the same among various resulting WSE's. The field collection protocol was to only use one sample if the same soil was present at the anticipated WSE under one or more of the FERC requested conditions. GRH further requested that although potentially outside the limits of the HEC-RAS derived normal operations range of WSE's at the erosion monitoring sites, if normal operations aligned with beach material feature at the lower flow conditions or if a unique soil type or could potentially be affected by spill or high water flow conditions based upon the guidance spreadsheet, an additional soil sample was collected. Near-bank velocity and shear stress estimates using the 2D model are essentially snapshots of various conditions within the overall project range regardless of modeling steady flow or unsteady flow; velocities would be the same and there is no significant velocity response to WSE changes at the rates in which these occur under normal operations (generally 0.15 ft./hr. and no more than 0.3 ft./hr.). Given that soil samples represent soils exposed to project operations and near-bank

Comment #	Source	Comment	Response
			estimates of velocity and shear stress are associated with the normal operating range; it is reasonable to state that we have adequately analyzed velocities and differences corresponding both varying WSE and Flow elevations. Analyzing velocities and shear stresses at various stages between the conditions examined, is unlikely to materially alter the results of the supplementary study report as the intervening combinations of flow and WSE were considered in soil sample selection and are likely to experience shear stresses and velocities that fall in between the values determined for the 3 operational levels analyzed. This is a comprehensive perspective not a single situational approach. Lastly, we would suggest that the comment somewhat mis-interprets Vernon project materials in the PAD and did not refer to the FERC application or misunderstands the Supplemental analysis. The WSE's and flows considered used in the HEC-RAS model (soil sample guidance) and HEC-RAS 2D modeling (near bank velocity and shear stress) do correspond with project operations. The Figure in the 2012 Vernon PAD was a general operational schematic and generally characterized Vernon typical operation in NGVD29. Similarly, the Vernon license application differs slightly in characterizing the typical operation as from 218.3 feet (NGVD29) upwards to the top of the operating limit 221.1 (NGVD29). If the commenter is suggesting that the WSE at the Dam used in the HEC-RAS 2D model of 217.6 ft. (NAVD88), which is .3 tenths of a foot below is cause for calling the entire analysis into question; that is an extreme overstatement. As the Vernon normal operating range is very narrow, we chose to present a reasonable operating parameter within our current operational range which align itself with the WSE conditions that soil samples were collected across varying flow levels. Analyzing velocities and shear stresses at various stages between the conditions examined, is unlikely to materially alter the results.
20	CRC-4	The data presented in Table 5.8-1 [of the Revised Final Study Report] therefore suggests that periodic operation drawdowns, in preparation for high flows, could regularly mobilize sediment at the toe of the streambank at 9 of the 13 monitored impoundment cross sections." We had hoped that because of FERC's request for additional analysis, the Supplement would shed some more light on this observation, but Great River Hydro instead set up their model runs for the supplemental analysis to completely avoid this issue altogether. They held the impoundment at the same elevation, and	GRH disagrees with the comment and interpretation of the data. The data in the table does not suggest periodic drawdowns for flood control purposes increases sediment mobilization. The Final Study Report filed on February 4, 2017 indicates the rate of drawdown is no greater then .3 tenths per hour and that generally the rate is in the .1-.15 feet per hour range particularly under increasing inflow conditions its almost impossible to drawdown faster. The presumption that this rate of drawdown could "regularly mobilize" sediment at the toe of the stream

Comment #	Source	Comment	Response
		for the sites closest to the dam, the model used a higher impoundment level to run the "max" elevations, which is directly contrary to their practice, according to the PAD, of lowering the impoundment elevations for higher flows.	bank is simply in accurate. The rate of drawdown will not materially affect velocity and shear stress and it is neither "regularly" occurring. It should be noted that the flood management operation, by reducing bank height, reduces bank exposure to higher velocity and shear stress conditions associated with flood flows and therefore would reduce the bank sediment removal that the Supplemental Study Report indicates would or could exceed critical shear stress and critical velocities associated with the material. GRH believes the comment mis-represents what the high water "profile operation" is. The model used higher impoundment levels in some cases to illustrate the maximum NORMAL operating range at the maximum flow BEFORE it would be drawn down (Abnormal operation). When inflow at the top of the reservoir exceed certain metrics the WSE at the dam is dropped in stages based upon the flow. Flood management or profile operation dictate operating at the low limit at Wilder when flows are twice station capacity or higher; at the low limit at Bellows Falls when flows are five times higher and the low limit of 212.1 at Vernon is never reached under flood management operation until flows exceed 105,000 cfs when all stanchions and flashboards have to be removed and flows recede to a point where the boards can be restored. The model runs are consistent and reasonably characterize the range of project operation.
21	CRC-5	By maintaining the WSE at the dam at the same elevation they are not actually modeling the operations of the dam. Both variables, SWE fluctuations and velocity of water, need to be considered.	GRH respectfully disagrees with this comment. See previously stated responses to comments 2, 12, 13, 15, 19 and 20.
22	CRC-6	CRC is concerned that many of the transect sediment samples were taken at elevations that do not correspond to where the surface water elevations would actually fall on the bank. Slide 28 presented during the Updated Study Report meeting clearly gives the impression that the sediment station at the upper part of the bank corresponds to the "maximum flow," the mid part of the bank corresponds to the "medium" flow, and the lower part of the bank corresponds to the "minimum" flow. This does not seem to be how it was actually done, though. For instance, the Supplement states, "Similarly, at some sites, especially impoundment sites just upstream of a dam (e.g., W12), the WSE for the 3 operational	GRH respectfully disagrees with the comment. As stated in our response to Comment 8: The HEC-RAS model was used to identify soil sample elevations. However, the model estimated WSE's throughout the normal operating range and all flows within or just exceeding station capacity and developed an array of corresponding WSE's for each erosion monitoring site. This array was used as a guide for the field work to ensure distinct soils were sampled within the overall range. In many cases however, the lowest operating range was submerged particularly in the case of Wilder's where the overall five-foot range is below normal (non-spill)

Comment #	Source	Comment	Response
		conditions were essentially at the same elevation since the nearby dam WSE remained unchanged for all operational flows considered." Additionally, the sediment sample elevations for many of the sites either fall completely outside of the median WSE fluctuation or only one sampling site falls within that area of the bank. As far as we can tell, the soil samples have no particular connection with the river flows and dam elevations used in the model, and moreover, some don't include samples within typical operational ranges. [includes graphs showing CRC interpretation of soil sample locations] We have also plotted the logger data for W10 as an example of where the sediment samples fall in relation to daily fluctuations – we note for this figure that the Supplement Appendix A lists the "max" elevation of 383.4 as "dry" for the 700 and 5,000 cfs model runs, therefore giving no velocity readings, but according to the logger graph included here, listing the max elevation as dry at 5,000 cfs does not appear to be accurate.	operations. Crews collecting soil samples did not experience conditions where spill was occurring at the dam and river profile operation was in effect. A spreadsheet with the WSE at the erosion monitoring sites is provided with this responsiveness summary. In some cases, similar WSE's at erosion monitoring sites correspond with various combinations of flow and WSE at the dam. Similarly, soil types were often observed to be the same among various resulting WSE's. The field collection protocol was to only use one sample if the same soil was present at the anticipated WSE under one or more of the FERC requested conditions. GRH further requested that although potentially outside the limits of the HEC-RAS derived normal operations range of WSE's at the erosion monitoring sites, if normal operations aligned with beach material feature at the lower flow conditions or if a unique soil type or could potentially be affected by spill or high water flow Soil samples taken to represent all soils that would be exposed to the full range of elevations at the dam and operational flows. As stated in the report, in most cases this full range corresponded with one soil type, in other case more than one sample was collected. Just because the WSE elevation for the HEC-Ras 2D model was consistent, the guideline for sediment sampling was the full range of operational elevation and flows as stated in the report. This was based on the original 1D HEC-RAS model reported on in Study 4
23	CRC-7	Also of concern is the fact that we have no way to know actual or average surface water elevation fluctuations for December to May of most years since actual SWE for those months was not provided due to the difficulty of logger placement in winter. As mentioned above, the validation of the model using surface water elevations at the 6 ADCP sites was not included in the supplement. We request that this information be provided, and it include maximum historic operational surface water elevation changes at the dam and resulting surface water elevation changes at the transect sites for various flows.	GRH has stated repeatedly and provided operational data which clearly shows there is no operational difference in how any of these projects operate between December-May and other times when loggers were deployed. The only significant difference is non-operational – the sustained high water spring runoff period. As stated in our response to Comment 4: ADCP was performed at only **three** erosion monitoring sites only. We are including the results with this comment response; however it should be noted that the ADCP measurement were not taken at multiple WSE's as is suggested in the comment. The other remaining ADCP sites corresponded with Study 9 Instream Flow riverine habitat transects. The three erosion monitoring site ADCP results cannot be directly compared to HEC-RAS model unless WSE at the dam and flow at the site are similar. ADCP at W09 monitor site (Mudge) was performed during a similar roughly 5,000 cfs flow a relatively similar WSE at the dam and they

Comment #	Source	Comment	Response
			compare well. ADCP measurements taken at W07 (Tullando) during conditions that were in a similar range to HEC-RAS modeling conditions and also compare reasonably well. ADCP measurements at W03 (Bellavance) were recorded during flows above Wilder minimum flow but less than 5000 cfs mid-flow modeled using HEC-RAS and the WSE at the dam differed by at least one foot. However, they are within the range the HEC-RAS results present and therefore similarly appear to compare well. The ADCP data supports the same conclusions as our HEC-RAS 2D derived velocity estimates. Although the conditions under which the ADCP measurements were made can only represent those present at the time of measurement, they were somewhat similar or within proximity to conditions, requested by the FERC and modeled in HEC-RAS. They compare well and do not change the results or conclusions of the Study. The calibrated 1-dimensional model was used as the foundation for creating the 2-dimensional models at each of the 21 erosion monitoring sites. As part of Study 4, the 1-D calibrated model was compared with the ADCP velocities and during this analysis the computed velocity data compared very well with the observed ADCP velocity data. During the 2D modeling, the flows and water surface elevations were compared with the 1D model to ensure that the 2D model was representing the values at the upstream and downstream boundaries that were expected from the calibrated 1D model.
24	CRC-9	During the study plan meeting on March 8, 2018, Lissa Robinson (GEI Consultants) stated that, "Sub-critical flow - in the riverine flow you would have downstream flow. Sub-critical flow is in the pools where flow might go upstream; for each 10 feet by 10 feet cell in the HEC-RAS model you would have velocity that could flow in multiple directions. It could pick up and model an eddy if it did exist." While GRH provided tables for each transect site, it is not clear if the velocity listed is "near-bank" or average velocity. Additionally, based on Lissa Robinson's comment it is not clear the direction of the flow of velocity. Is it downstream, based on an eddy, or upstream?	This comment is mis-quoted. The flow in the Connecticut river is generally characterized as subcritical with supercritical flow occurring across relatively short reaches where the flow is shallow and fast, and the Froude number is greater than 1 (i.e., some riverine sections). Critical and supercritical flows are generally considered rare in natural river channels. Often, sub-and supercritical flow is described as: If a pebble is thrown into a supercritical flow, then the ripples will all move down stream whereas in a subcritical flow some of the ripples would travel up stream and some would travel downstream. By selecting a "mixed flow regime" we enabled the 2D model to handle supercritical and subcritical flow as well as flow transitions from

Comment #	Source	Comment	Response
			subcritical to supercritical and supercritical to subcritical in the event there were short reaches with supercritical flow. It is expected that flow is in the downstream direction. The model allows vectors to be displayed showing the direction of flow. We can print these if needed. Example for W-12 below: 
25	CRC-10	The Supplemental Report states, "Colluvial material derived from erosion higher on the bank still covered the stratigraphy at the base of the banks at many of the monitoring sites as was the case during the two years of monitoring from 2013 to 2015." The question is not why the colluvial material hasn't moved (and erroneously, thus erosion is not taking place). It is instead, "why is there colluvial material at the toe of the bank?" If the study had answered that question it might have "ascertained the likely causes of erosion" as required as a goal of the study.	GRH disagrees with comment. Through the Final Study Report filed February 6, 2017 and this Supplemental report, we believe we have met the goal the study. Except that the bank failure was not caused by project operation, we have no way of determining why there is colluvial material at the base other than to characterize the process. We have examined the correlation between eroding banks and project fluctuations and they have shown not to correlate. We have shown the range on the bank where project operations correspond with and these failures are above that range. Only high flows at corresponding WSE's can directly remove sediment from the upper bank above the elevation operational flows can ever reach. The action of high flows and other mechanisms such as waves, boat wakes, ice scour and operations changes in flow or WSE, may contribute to notching at the base of the bank, which ultimately oversteepen the bank profile, cause the upper bank to fail, and create colluvial material to accumulate at the base. The supplementary study

Comment #	Source	Comment	Response
			we have completed shows that operational flows cannot (except for minor exceptions) remove this colluvium, reemphasizing the conclusion of original report that only high flows can sustain the erosion.
26	CRC-11	The Revised Final Study Report also states, "The comparison between flow velocity and documented change at the monitoring sites shows no strong relationship and indicates that other factors [emphasis added]… may also exert some control on the location of bank changes." Those other factors may well be the loss of fines and clays from repeated water surface elevation fluctuations. The Supplement and Revised Final Study Report did not address this.	GRH is providing additional soil sediment data with the responsiveness summary on critical shear stress and velocity that includes both finer and coarser materials present as D15 and D85 level. While the winnowing of fines from a heterogeneous body of sediment is certainly possible, the impact of such a process on the entrainment of a large body of sediment is not considered significant and is unlikely to materially alter the findings of the supplementary study. First, the winnowing of fines near the surface of the sediment body would leave behind a coarser lag deposit that would armor the surface of the sediment such that a higher threshold velocity/shear stress would be needed to entrain the armored surface and mobilize the finer sediments beneath the surface armor. Second, the sediment entrainment of all particle sizes within a heterogeneous sediment body can occur simultaneously as coarser particles may protect finer particles from early movement by shielding the finer sediment from higher shear stresses/velocities. Third, finer particles, especially the clay fraction, are sometimes more difficult to entrain than coarser particles because of the cohesive nature of clay. Fourth, an analysis of sediment entrainment based on the finer fractions (D15) of the sediment samples taken at the 21 monitoring sites and discussed in Comment #7 above actually shows fewer operational conditions that initiate sediment transport of bank sediment compared with analysis based on D50 sediment size. For all of these reasons, we believe our use of the D50 (median) particle size in our analysis fairly represents the likelihood of the sediment being entrained at the 21 monitoring sites.
27	CRC-13	The system no longer operates as a free-flowing alluvial channel. Its energy gradient and the velocity have been reduced except for those reaches above the influence of the pools." Additionally, the Revised Final Study states, "NRCS' (2007) publication on thresholds for small channel design recommends a maximum permissible velocity of 1.5 feet per second (ft/s) for fine sand in clear water without any detritus but 2.5 ft/s in water carrying colloidal silts as higher velocities are needed to transport silt and clay, because of their cohesiveness, than fine sand." Hence, basing the velocity	As indicated in the supplementary report, the entrainment thresholds used in the document created for designing channels has a factor of safety built into them such that entrainment is considered to occur at velocities lower than may actually be required to initiate sediment transport. Consequently, the results derived using this document should be considered conservative in nature even given that the document is intended for channels smaller than the Connecticut River. Each published value of sediment entrainment thresholds consulted is not a perfect representation of conditions found on the Connecticut River but after completing a literature review we selected what we believed to be

Comment #	Source	Comment	Response
		threshold on the NRCS thresholds for small channel design may not be appropriate.	the most appropriate values for the Connecticut River, erring on the side of being conservative where multiple approaches/values seemed appropriate.
28	CRC	Provide graphs that show velocity across the span of the river at transect sites as shown in Slide 27 in the Study Report meeting presentation.	GRH is providing this with the comment responsiveness summary
29	Bruno	Although the intent of the studies was to determine the causes of bank erosion in the study area and the studies do identify the potential causes, there is no technical data prepared or analyzed to provide any conclusions as to the degree of erosion as it is related to the potential causes, particularly, dam operations, thereby not meeting the study objectives.	See various comment responses above. Final Study Reports for Study 1 and Study 2-3 and Supplemental Report meets the study objectives, follows the study plan and responds to FERC's request for additional information.
30	Bruno	The Supplemental Study studied near bank entrainment of soil particles. By the study near bank was 20 feet from the shoreline and the HEC-RAS model shows zero velocity at the shoreline. The zero velocity at the shoreline as the model states does not represent reality as I have observed velocities at the shoreline along my former property.	We chose 20 foot from the bank as a proxy for near-bank as requested and stated the reasons why that was appropriate in the report. The selection of a point 20 ft from the bank ensures zero values for shear stress and velocity were not used for near-bank conditions, thus ensuring a conservative approach to the analysis. Furthermore, conditions such as bank shape, presence of vegetation and wood, etc that would lead to lower velocities and shear stresses in the near-bank area were also not considered in the analysis. Refer to the channel cross-sectional velocity graphs referred to in our response to Comment 28 that are included with these comment responses.
31	Bruno	John Field's Supplemental Study relies on an entrainment analysis as the basis for his conclusion that project operations cannot be responsible for bank erosion. This is a conclusion without basis since the studies required to make that conclusion have not been undertaken. As defined entrainment and river bank erosion are two separate areas that need to be studied separately.	GRH respectfully disagrees. Sediment accumulating at the base of the bank from upslope erosion, or the in situ bank material itself at the base of the bank, must be entrained and removed before over steepening of the bank face and upslope erosion are possible. Our data suggests that the removal of this material is largely if not completely a function of high flow velocity and shear stress acting on the material.
32	Bruno	To fully determine the effects of water level fluctuations and meet the study objectives to determine the likely causes of erosion, conduct geotechnical, hydrogeological and/or modeling studies as supported by the Princeton Hydro peer reviews.	GRH respectfully disagrees for the reasons stated above, stated in previous responses to comments and based on the information presented in the Final Study Reports for Study 1, 2/3 and the Supplemental Report.
33	CRJC	The supplemental study conducted by GRH only addresses whether operational flows are sufficient to entrain the average-sized sediment particle.	We believe the analysis presented in the supplemental study was responsive to FERC's requests for further analysis of the 21 erosion monitoring sites. We have provided additional information on the D15 and D85 fractional components of the soil samples in addition to the previously report D50 characteristics. We have updated the tables previously presented in the Supplemental Report to include this

Comment #	Source	Comment	Response
			additional information and providing them with this responsiveness summary. See additional responses to Comments 7, 14 and 26
34	CRJC	The supplemental study only analyzes tractive forces generated by normal project operations. It is our opinion that using entrainment as a surrogate for erosion is problematic and only correlating the entrainment of average-sized sediment particles to operational velocities is insufficient to conclude project operations do not cause bank erosion. Also, it is not clear if the study actually correlates operational flows with erosion (or entrainment) that creates the "notching" on the banks or merely correlates operational flows with entrainment of sediment that accumulates at the toe of slope after bank failures.	The supplementary study was focused on the 21 monitoring sites. To the extent notching was present at those sites, the entrainment analysis did correlate with the presence of notching.
35	CRJC	The methodology utilized to arrive at this conclusion overlooks the fact that other aspects of normal project operations may contribute to erosion such as releases for power generation, which cause fluctuating water levels2, that even at low velocities inhibit the establishment of vegetation and cause winnowing of fine sediments, collapse of the sediment matrix, and movement of median-sized particles by gravity alone. This process likely results in wide spread bank failures and the creation of "beaches," which are usually inundated.	The analysis completed was responsive to FERC requests. The winnowing of fines is likely restricted to the sediments at the surface but does not likely apply to an entire body of sediment as winnowing of fines at the surface will lead to armoring of the surface with coarser sediments thus making it harder to entrain sediment.
36	CRJC	Also, the accuracy of velocity data estimated from HEC-RAS-modelled flows 20 feet from shore is problematic. Abutters have noted that onsite observations may be more reliable than the HEC-RAS model in determining 1) flow velocities and elevations, and 2) the effect of operational flows on particle movement and bank erosion. Significantly, direct observations by abutters of erosion (bank collapse) during low flows directly contradict the study's conclusion.	As velocities and shear stress typically decrease as one approaches the edge of the channel, the decision was made to use velocity data taken 20 ft from shore as the near-bank velocity to ensure the values used were not reduced by near-bank conditions. Consequently, the values used are conservative in that the actual values experienced at the bank are likely less than the modeled velocities used. We have presented material in Study 4, as well as Responses to Comments above that suggest the near-bank velocity and shear stress estimates derived from the model are likely to be more reliable and accurate than observational estimates cited in the comment.
37	CRJC	GRH did an exemplary inventory of existing bank erosion within the study area. However, its conclusion that project operations cannot be responsible for bank erosion is not supported by the evidence. This is particularly troublesome in light of the fact that GRH's consultant previously observed that fluctuating water levels from normal project operations align with the location of notching at the base of the banks that initiates the cycle of erosion.	The fact that water fluctuations align with the notching is not evidence in and of itself that the water fluctuations are a cause of the notching. While the final Study 2/3 report acknowledges that water level fluctuations may, in part, be a cause of the notching, several other processes may also be responsible for the notching including waves, boat wakes, ice scour, groundwater seeps, and tractive forces generated during flood flows. Regardless of the cause of notching (the initial phase

Comment #	Source	Comment	Response
			of the erosion cycle), the erosion will not continue if sediment accumulating at the base of the bank (after upper bank failure) is not removed by high flows.
38	McIntyre	I inquire why an average (or median) grain size was used in the calculation of whether entrainment was possible. Although the collected specimens varied considerably in composition it is clear that fine particles, perhaps up to almost half the weight of the total sample, could be susceptible to entrainment but the sample particle at the average weight was too heavy to be entrained. To conclude that project-induced water velocity changes had not caused an effect under conditions in which a fraction of the sample, in fact, was carried away is a serious error. Were the grain size distribution of bank soils the same distribution found in the toe? If not the same, then the toe was likely comprised of particle sizes large and heavy enough to have escaped entrainment at project related flows while smaller particles had already been lost from the toe. The size/weight distribution of the particles in each sample should have been determined. The analysis should have presented the fraction, if any, susceptible to entrainment at project related flow velocities. If as little as .01% of the particles in a sample can be mobilized (entrained) by project related flow rates each day for 365 days per year times 60 years we are discussing a lot of material.	We believe the analysis presented in the supplemental study was responsive to FERC's requests for further analysis of the 21 erosion monitoring sites. We have provided additional information on the D15 and D85 fractional components of the soil samples in addition to the previously report D50 characteristics. We have updated the tables previously presented in the Supplemental Report to include this additional information and providing them with this responsiveness summary. See additional responses to Comments 7, 14 and 26
39	McIntyre	In the Supplementary study as well as in the original study report modeled data was used to determine flow rates at the study sites. In addition, despite each site having WSE measured by pressure transducer gauges, WSE levels were modeled for the sites. Why? I don't trust models for information in turbulent systems.	WSE from pressure transducers aligned well with model WSE as stated in Study Report 4. Using the water level data was not possible as such data provided river stage information but not velocities and shear stress values required to fulfill FERC requests for additional study. For the model calibration, we have the model simulate WSE for given flows and downstream boundary conditions to make sure the model was representing the observed data and therefore could be used to model other scenarios. Yes, hydraulics engineers do create physical models to validate analytical solutions. The Army Corps of Engineers has data on this to support use of their HEC-RAS model and reports that the HEC-RAS 2D model did exceptionally well in matching laboratory data. We can provide Verification and Validation information upon request. FERC approved use of the HEC RAS model in Study 4.

Comment #	Source	Comment	Response
40	McIntyre	Project operation, in contrast to changes in WSE resulting from seasonal flow in a natural river, produces daily fluctuations sufficient to prevent the establishment of seedling vegetation in the berm area. The lack of rooted plants is likely to increase the susceptibility of the berm to entrainment by even modest high water events.	The supplemental report identified soil types on the banks and in some cases, beach material and calculated the critical shear stress and velocities need to mobilize the material. It was shown that project operations in most cases is insufficient to mobilize these soil particles whereas high flows are capable. There are many locations within the projects that submerged and emergent wetlands exist despite fluctuating water levels. There is no basis for the statements that lack of vegetation is a result of WSE fluctuations, rather GRH would suggest that shear forces and scour under high flow conditions seasonally act as a hindrance to the establishment of vegetation .
41	Mudge	Therefore, I believe that it should be concluded that the Erosion Study #3, and its Supplement, dated August 1, 2016, and November 5, 2017, respectively, have not ascertained the likely causes of erosion— a very specific and clearly stated objective in FERC's July 8, 2013, Updated Proposed Study Plan.	GRH respectfully disagrees.
42	UVLRS	The Supplement theorized river current velocities at points 20 feet into the river. The Supplement makes the assumption that, since there is zero theoretical current velocity at the water's edge, then no erosion can occur under normal project operations. The Supplement tested only sediments in the river that had already eroded from the bank.	The Supplemental Report does no presume the velocity a the water's edge is zero and therefore no erosion is possible. Conversely, it uses a modeled velocity at 20 feet from bank as a proxy for near-bank conditions as requested by the FERC. As velocities and shear stress typically decrease as one approaches the edge of the channel, the decision was made to use velocity data taken 20 ft from shore as the near-bank velocity to ensure the values used were not reduced by near-bank conditions. Consequently, the values used are conservative in that the actual values experienced at the bank are likely less than the modeled velocities used. The soil samples collected were both from beach and bar features as well as bank material as indicated in the Supplemental Report. We sampled sediment at the water surface elevation for 3 operational levels as specified by FERC. In many cases, this level was on a beach, bar, or bench which may, in some cases, be sediment eroded from the bank but may also be sediment derived from much further upstream on the mainstem or tributaries outside the project area. In other cases, the water surface elevation for a given operating condition fell on the bank material, which was collected.

Comment #	Source	Comment	Response
43	UVLRS	The FERC determination requested an analysis of shear stress and near bank velocities. The Supplement describes in detail the "near bank" velocities (i.e. 20 feet away from the bank and up to 5 feet deep), but does not discuss velocities at the water's edge, except to say that they are predicted to be zero. FERC also requested a description of "notable bank features". The Supplement does not adequately describe notable bank features, which are clearly eroding in the photos submitted.	See response to similar comments above. GRH respectfully disagrees with the comment regarding adequacy of describing bank features, as several bank features are noted for each monitoring site in Appendix A of the supplementary report including notes on vegetation, seeps, erosion features, and other characteristics. The supplementary report notes that the underlying stratigraphy at most sites was obscured by colluvium derived from upslope erosion, so a correlation between project operations and stratigraphy was not possible at most locations. Where the in situ bank stratigraphy was observed, notes were provided on relationships between the stratigraphy, seeps, and erosion features. Erosion features were noted in Appendix A of the supplementary report.
44	UVLRS	Appendix B of the July 21, 2017 Study Plan Determination issued by FERC stated: "…staff recommends that Great River Hydro include in the November 15, 2017 addendum, an analysis of the stratigraphy at the 21 monitoring sites, including, at a minimum, a discussion of any potential correlation between erosive features (e.g. notches, undercutting) and soils present within normal project operating ranges." The Supplement fails to discuss any correlation between erosive features and normal project operations.	The supplementary report notes that the underlying stratigraphy at most sites was obscured by colluvium derived from upslope erosion, so a correlation between project operations and stratigraphy was not possible at most locations. Where the in situ bank stratigraphy was observed, notes were provided on relationships between the stratigraphy, seeps, and erosion features. Erosion features were noted in Appendix A of the supplementary report.
45	UVLRS	Site selection: The Supplement states that " sediment entrainment is highly unlikely at over 75 percent of the sites", and that while "entrainment of bank sediments is considered possible at 5 of the 21 sites based on the analysis, actual entrainment is considered unlikely…" (Executive Summary). None of the 5 sites are in the Wilder Impoundment, which is in our jurisdiction, and where bank erosion is rampant.	The 21 monitoring sites were selected in consultation with stakeholders and specified in the FERC approved Study Plan. The fact that no monitoring sites in Wilder impoundment experience entrainment of bank sediment during project operations, while such entrainment is possible during high flows, suggests project operations are not a cause of excessive erosion in the impoundment..
46	UVLRS	Sediment Entrainment vs. Bank Erosion: The Supplement only analyzes entrainment, which is defined by USGS as the removal and transport of soil particles (particularly larger sizes such as sand) from the bed of the river channel. There is no supplemental analysis	GRH respectfully disagrees as we believe we have been responsive to FERC's request for additional studies at the monitoring sites.

Comment #	Source	Comment	Response
		of bank erosion, which is defined as the removal of soil particles (particularly smaller particles such as silts and clays) from the bank of the river due to shear stresses from any of the five forces (waves, water level fluctuation, overland flow, groundwater seepage, and river flow) described in the Final Study 2 and 3 Report.	
47	UVLRS	Near-bank vs. edge of bank: The Supplement describes in detail the "near bank" velocities (i.e. 20 feet away from the bank and 5 feet deep) and claims "shear stress and velocity would be close to zero at the water's edge" due to "natural edge effects" (p. 9). Upper Valley LRS members are unanimous in their observations that the edge of bank velocities can be considerable (even under normal project operations) and, in some cases, accelerated by flow over or around natural edge features such as logs, rocks and eddies. In fact, a riverbank stabilization project that we have been monitoring for several years has had damage to large logs and rocks used for stabilization, caused by increased velocities at an outside bend of the river, where the current is always faster.	See response to similar comments above. While velocities may be accelerated around bends such variations would be embodied in the 2D modeling. Local increases in velocity due to flow around logs, rocks, etc. would not be the result of project operations, so accounting for them in the supplementary report was beyond the scope of additional studies. Furthermore, not accounting for them ensures the analysis was more focused on the potential impacts of project operations and not other factors.
48	UVLRS	The Supplement studied only the coarser sediments on the beach and in the channel. There appears to be no data presented on soils in the bank itself.	The sediment entrainment analysis ensured at least one sampling site was of bank sediments if project operations under any condition reached the base of the bank, so, in fact, nearly all of the 21 sites analyzed bank sediments. During sediment sampling, turbid water at the monitoring sites was observed only when waves created by passing boats impinged on the banks.
49	VTDEC	In FERC's Determination on Requests for Study Modifications and New Studies for the River Transect and Riverbank Erosion Study dated July 21, 2017, FERC staff recommended "that Great River Hydro include, in the November 15, 2017 addendum, near-bank velocities associated with multiple water surface elevations (e.g., minimum flow, average project operating range, maximum project hydraulic capacity), as measured at the six sites with ADCPs." This information was not included in the supplemental report.	FERC suggested the analysis could be completed using the ADCP results or with values of shear stress and velocity derived from hydraulic modeling. Given that the ADCP results covered only 3 sites associated with erosion monitoring locations, did not include shear stress values, and were collected at only a single water surface elevation at the given flow at the moment of data collection, Great River Hydro decided the most prudent approach was to used values derived from the hydraulic values as all sites at all requested water surface elevations could be analyzed. ADCP data associated with the three erosion monitoring sites is included with this responsiveness summary. Data from ADCP generally aligns itself well with the HEC-RAS 2D model velocities. Similarly, noting in the ADCP data suggests anything contrary HEC-RAS data, further comparison with soil threshold velocity, or overall study conclusions.

Comment #	Source	Comment	Response
50	VTDEC	A number of the features were described as being a wide or narrow "beach fronts bank where the water surface at the minimum and average operating flow rest" in Appendix A – Sediment Entrainment Summary. This statement indicates that water level fluctuation from project operations continual water and dewater the beach type feature at these sites. Daily water level fluctuation has been found to prohibit the growth of natural vegetation. The continual effect of daily water level fluctuations from project operations on beach features is expected to prevent the re-establishment of vegetation on the bank which would provide greater stability and resistance of the river bank to erosional forces. Therefore, in is likely, in part, that operations of the projects play a role in sustaining the erosional cycle in the project affected areas.	See response to similar comments above. The presumption that beach material is either deposited or remains in a suspended state of succession due to project operational WSE fluctuations is without basis. As stated above there are numerous locations where vegetation is clearly established where normal project operational WSE fluctuation occurs. What is absent is high velocity and shear stress conditions, enough to prevent establishment or suspend plant succession. Yes, vegetation could improve material resistance to erosion, but to suggest project operations as the cause for lack of vegetation when high flows with much higher shear stresses and velocities prevent vegetation from becoming established. In some cases, suspended habitat due to high flows, ice scour can maintain valuable habitat for such species as Jesup's Mik Vetch or Cobblestone tiger Beetle.

Great River Hydro Response to Comments, Study Report Addenda filed July 12, 2017-February 8, 2018

Study 18 – American Eel Upstream Passage

Comment #	Source	Comment	Response
1	NHFGD	The NHFGD supports the proposed effort to modify the fishway to improve eel passage and the reliability of count data. Although the majority of eels observed in the study were associated with the fishway, it is still not clear whether the fishway is effectively passing eels of all sizes during normal operating conditions.	GRH agrees that eels have been observed in these studies in the fish ladder. Determining an accurate fish count and seasonality is the first stage in determining whether use of the fish ladder for upstream eel passage is reasonable and effective.
2	NHFGD	Evaluating the effectiveness of fishway modifications intended to improve eel passage in the fishway will likely require a mark/recapture study. If the fish ladder proves to be a velocity barrier for certain size classes of eels, and the issue cannot be solved by modifying the fishway under normal operating conditions, then GRH should consider alternative means of passage for the range of eel sizes that are impeded by the fishway. This may involve relocating a temporary eel trap to one of the other locations where eels have been observed along the dam.	GRH agrees in general that more study or analysis of operational changes for the fish ladder are necessary to determine effectiveness of the fish ladder. GRH proposes to continue to observe the areas below the dam in 2018 for the presence of upstream migrating eels in addition to operating the fish ladder with the aim of improving the count accuracy and determining the seasonal use by migrating eels. At this point there is not strong evidence that suggests additional ramps are needed or likely to improve passage of eels.
3	NHFGD	GRH should consider monitoring the fishway at a variety of flows to determine whether there is an optimal flow for attracting and passing eels through the fishway. Experimenting with fishway flows may provide more insight into the appropriate balance between attraction flow and passage conditions within the ladder. Experiments with fishway modifications and flows may prove more effective than the temporary eel ramp, which can only provide a limited amount of attraction flow.	GRH agrees and is consulting with resource agencies relative to 2018 operations.
4	FWS	…at the March 8, 2018 USR meeting, GRH described proposed modifications it intended to make prior to the fish ladder opening in 2018 to enhance eel passage and count reliability, including installing a mesh floor at the counting window and diffuser outlet and testing substrate (eel tiles) at the exit weir orifice and other locations within the ladder. We support these measures and recommend that dedicated monitoring take place to validate their effectiveness.	Currently, dedicated monitoring of the fishway is part of the VTFWD fishway monitoring program. Our modifications were designed to improve the system they employ to better identify passing eels as well as improve the count accuracy.
5	FWS	In addition, GRH indicated at the March 8, 2018 meeting that it would reach out to the fishery agencies to consult on the value of continuing eel monitoring either below the Vernon Dam or within the fish ladder during the upcoming 2018 season, as well as how the ladder operation should be specified to adequately capture and monitor eel passage or use during the 2018 migration season. We agree that additional consultation would be beneficial and recommend that GRH convene a meeting in May.	We have initiated consultation and continue to develop a mutually acceptable plan for 2018.

6	VTDEC	The standard operating window for the Vernon fish ladder is April 15 – July 15. However, during the 2017 supplemental effort the fish ladder remained open until August 7, well into the course of the study. This is problematic given that a primary goal of the study was to determine how well a temporary eel pass might work when the ladder is not operational (i.e., usually after July 15). During this unplanned, extended operating period eels continued to use the fish ladder, with an additional 194 eels passing via the ladder from July 15-27, for a season total of 581 eels (Note: ladder counts beyond July 27 are uncertain due to poor viewing conditions). In summary, results are confounded by the fact that the ladder was open three weeks beyond the normal operating period.	We do not believe the additional 3 weeks of operating the fish ladder reduced the assessment of whether or not the eel ramp functioned when the fish ladder was not operating. The eel ramp was installed and operated beginning June 1. The results of eel ramp collections and fish ladder counts demonstrated that more eels used the fish ladder between July 15 and at least July 27, however, after fish ladder shut down, the eel ramp clearly functioned to collect eels in numbers of similar magnitude.
7	VTDEC	During the March 8, 2018 updated study report meeting, GRH proposed modifications it intended to make to the fish ladder prior to operations in 2018. The Agency supports these measures and recommends that dedicated monitoring take place to validate their effectiveness.	See response to Study 18 Comment #5
8	VTDEC	If eel passage objectives will be most efficiently met using the ladder, as data collected to date suggest may be the case, additional information will still be needed to maximize the effectiveness of this structure for conveying eels. For example, understanding how fish of varying sizes move through the ladder, levels of fallback, etc., before and after eel-focused ladder modifications are made will help ensure that such fixes are beneficial. Thus, we recommend the following: (a) GRH should develop a clear plan to describe proposed fish ladder modifications (with intended benefits), fish ladder operating dates, and how these modifications will be evaluated in terms of effectiveness. Ideally GRH would implement a PIT tag study in concert with these efforts so that bottlenecks/problem areas can be efficiently identified and resolved; and (b) to eliminate confounding results, we recommend that the eel ramp be suspended during 2018 eel passage investigation and that the ladder be operated beyond the normal closing date of July 15 to capture the full eel migration period.	GRH agrees in part with the comment. However, there is no reliable baseline to compare as the comment suggest is important. Modifications GRH made voluntarily to the fish ladder to improve the counting accuracy for eels and identify seasonal use patterns relying on the VTFWD fish counting system will hopefully create the baseline. Concurrently eel observations at the base of the Vernon dam will continue as in past years. In future years, based on the date from 2018, recommendations for fish ladder operations and modifications, and potentially implementing various alternatives, can be examined to determine whether modifications are necessary or beneficial. GRH also contends that until improvements or effectiveness maximization occurs at downstream dams, we will not truly be able to identify what the passage metrics should be for eel passage at the Vernon dam.
9	VTDEC	The report postulates that larger eels use the fish ladder more than some other monitoring sites potential due to their relative ability to navigate the (higher) velocities. Comment: The data in Table 4.3-3 indicates that over 30 percent of the eels observed in the fish ladder were in the size class of 6 to 12 inches. Although the size class distribution is skewed towards larger eels in the ladder, the observations of smaller eels in the ladder	GRH agrees.

		appear indicate the smaller size classes are capable of entering and passing (or attempting to pass) via the ladder.	
10	CRC	We appreciate the ongoing support and enhancements that Great River Hydro is making to provide eel passage. As upgrades are made to the ladder, pit tag studies should be conducted to evaluate the efficacy of changes made. Additionally, the ladder should be open to allow for the full seasonal upstream and downstream migration.	GRH disagrees that PIT-tag studies should be conducted. PIT-tag studies are pre-mature for the reasons stated above in several comments. 2018 fish ladder operation and observations are intended to identify and capture the seasonal migration patterns and characteristics of the eels presently below Vernon.

Study 21 – American Shad Telemetry

Comment #	Source	Comment	Response
1	NHFGD	…an inflatable tag mortality study should be conducted to assess mortality rates for each route of passage. Mortality rates combined with an analysis of probable route selection under varying flow conditions could be used to estimate an annual total project mortality rate. This rate could be compared to an agreed upon target for total project mortality. Targets for total project mortality should be set based on the Connecticut River Shad population model which is currently under development.	The Study 23 desktop survival assessment and supplement included a review for adult shad passing the Vernon project. GRH believes the results of that assessment and those reported for Study 21 (i.e., the final report filed February 28, 2017, supplement to the final report filed February 15, 2018, and additional information provided with this filing) provide information necessary for assessing project effects. GRH will review the Connecticut River Shad population model when it is made available.
2	FWS	…on a number of occasions when shad were detected passing the Project, flows were within the station's hydraulic capacity, yet one or more spill gates were open. For example, on June 21,2017 at 08:01 hours, the combined flow through all structures was 14,943 cfs, including 2,348 cfs from Tainter Gate 2. Similarly, on June 25, 2017 at 15:09 hours, the combined flow through all structures was 15,316 cfs, including over 1,000 cfs released from Tainter Gate 2. This mode of operation appears to deviate from the protocol described in Table 2.5-3 of the PAD, whereby the spill gates are used only when flows exceed 17,000 cfs. We would appreciate GRH providing an explanation for why spill gates were used during those periods, as well as clarifying if these were unusual or typical occurrences.	During the course of a year, it's not unusual for a unit to be out of service for maintenance. While we made a concerted effort to have all units available and operational for the duration of the shad study, a forced outage was required on Unit 8 from June 9 – June 21 for maintenance repairs. This accounted for most of the occasions identified. As discussed in the FLA filed May 1, 2016, the maximum station discharge with all ten units operating is approximately 15,400 cfs, however 98 percent of the time maximum flows are less than 14,500 cfs. As flow increases toward station capacity spill may occur to bring the forebay elevation down to run profile operations (see Vernon FLA, Exhibit B). It's to GRH's advantage to put available water through the units rather than spill, however it's not always possible.
3	FWS	Along with the tabular data provided in the report and its appendices, it would be helpful if individual plots showing the movements for each of the 61 shad identified as returning to Vernon (i.e., all fish detected at receiver MS-26) were included. Plots should show time on the x-axis, river kilometer (rkm) on the y-axis, and include any detections on receiver MS-01. These plots are	The additional figures requested are provided in the attached Additional Information document under Study 21, Comment 3.

		important to understanding each fish's complete history of movement within the project area.	
4	FWS	Also, we recommend supplementing the results of the forebay residency analysis with a data plot of tagged fish by the total period of time from first detection at MS-26 until passage (by any route) on the y-axis (see Figure 1, below). This figure will help better illustrate the range of observations.	The additional information requested is provided in the attached Additional Information document under Study 21, Comment 4.
5	FWS	In addition, we request that GRH provide a table that summarizes the number of movements and overall residence time for fish that ultimately passed the Project versus those that never passed.	The additional information requested is provided in the attached Additional Information document under Study 21, Comment 5.
6	FWS	While GRH did complete a desktop impingement, entrainment and survival analysis that included turbine survival estimates for adult shad-sized fish, that analysis does not (and cannot) provide survival estimates for non-turbine routes of passage. One way to fill this information gap would be for GRH to undertake a balloon tag study for adult shad (similar to ones it undertook for juvenile shad and adult eels), assessing all potential passage routes.	See response to Study 21, Comment 1.
7	VTDEC	a key purpose of Study 21 was to evaluate downstream passage routing and route-specific survival. Whereas the 2017 study improved the understanding of shad's use of different passage routes, and an opportunity to link route use with operating conditions (below), it provides no information about the latter component (survival). Yet, this information is essential to determining how to optimize overall downstream passage success (a function of route, and route-specific survival). In the absence of additional field studies, the Agency would appreciate a proposal from GRH on how it plans to fill this important information gap.	See response to Study 21, Comment 1.
8	VTDEC	…more could have been done to quantify the probability that fish pass via specific routes in relation to operational or flow conditions. Without this information (and the survival info noted above), it will not be possible inform operational scenarios that optimize downstream passage success. We suggest that GRH consider doing such an analysis using the 2017 data and (possibly) 2015 results (for observations of fish with known passage routing).	The Probability of passage per approach during periods of non-spill was analyzed for generation flow and operations, as provided in the attached Additional Information document under Study 21, Comments 8 and 9.

9	VTDEC	Similar to concerns about the 2015 study, flows during the 2017 downstream migration period were consistently above long-term average levels. In the absence of an analysis that narrows the focus (or accounts for analytically) to passage events occurring under more 'typical' conditions, study findings cannot fully inform an understanding of how normal operating conditions impact downstream passage success. Although an additional year of field study may not be necessary, treatment of this issue, at least analytically, is justified.	The Probability of passage per approach during periods of non-spill was analyzed for generation flow and operations, as provided in the attached Additional Information document under Study 21, Comments 8 and 9.
10	VTDEC	More information and analysis about the operational conditions coinciding with individual passage attempts is needed. For example, while the (instantaneous) conditions coinciding with successful downstream passage events are presented, the time that fish spend in the forebay before passing (if successful at all) varies widely. It seems that there is insight to be gained from broadening the temporal view of operations coinciding with successful passage to something wider (e.g., averaged over the period that a fish spent in the forebay area before passing downstream or leaving and returning upstream). This information may help to distinguish flow or operational conditions leading to rapid passage, passage with extensive forebay delay, or failed passage (i.e., fish approaching the dam and then returning upstream to never be seen again).	See response to Study 21 Comments 4, 5, 8 and 9,
11	CRC	A goal of Study 21 was to evaluate downstream passage routes and survival. It would be helpful to have analysis that shows routes specific to project operation states, and associated survival. For example, what are common routes and survival rates when there is spill vs. when there is not spill? Similarly, what are routes and survival rates when there are certain turbines operating vs. not operating? Without this information there is not enough data to inform operational scenarios that support the success of downstream migration.	See response to Study 21 Comments 1, 8 and 9.

Study 21, Comment #3 Additional Information (set of 61 plots): Detection and location history of 61 radio-transmitter tagged adult American Shad that returned to the study area at Vernon Dam in 2017.

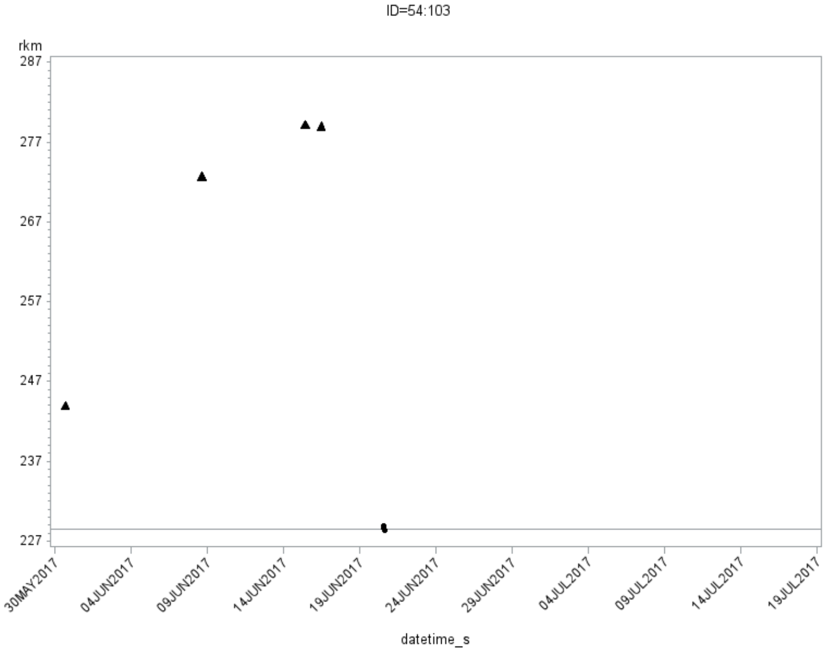
Two plots are presented for each fish, one plot (left panel) includes both detections in the fixed station receiver array (dots) and manual tracking locations (triangles) and one plot (right panel) includes detections only. The locations of fixed-station receivers on Vernon Dam were assigned arbitrary distances (river kilometers, rkm) according to the following key in order to provide separation on the vertical axis. Manual locations were assigned approximate distance upstream in river kilometers (rkm). A horizontal reference line is included to indicate Vernon Dam.

Key to distances (river kilometers, rkm) used for plotting of detections/locations.

Description	Distance for Plots (rkm)	Comment
MS-01	**227.0**	Downstream of dam
MS-13, 33	**228.2**	Spillway receivers
MS-10, 12	**228.3**	Tailrace receivers
Vernon Dam	**228.4**	
MS-16, 17, 18, 19, 21, 22	**228.6**	Intakes and designated fish passage
MS-15	**228.7**	Forebay approach
MS-09, 39	**228.8**	Sluice, deep gate
MS-14, 34	**228.9**	Impoundment – approach to spill gates
MS-26	**229.7**	Approach to study area (VY)
Manual Location Reference Landmarks		
	240.4	West River
	244.9	Old Ferry, release point
	257.8	Partridge Brook
	270.2	Dunshee Island
	279.5	Bellows Falls dam tailrace

Comments:

Many shad that passed did so in a single approach, however, many made multiple approaches from MS-26 or points upstream as determined by manual tracking locations. It is not clear that all approaches represented attempts to pass downstream. For example, many fish that entered the study area were later located at points upstream as far as Bellows Falls. Some fish later returned to Vernon and passed downstream (e.g., 58:154, 58:189), and others returned upstream without returning to Vernon (e.g., 54:120, 58:192). The locations and distances traveled upstream suggest spawning movements so initial arrival at Vernon may have represented behaviors other than searching for downstream passage.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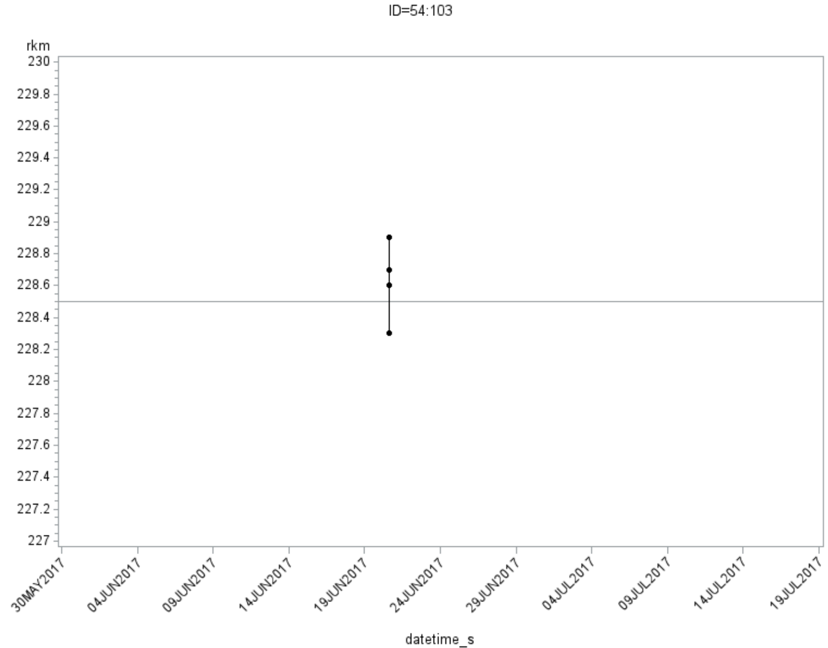
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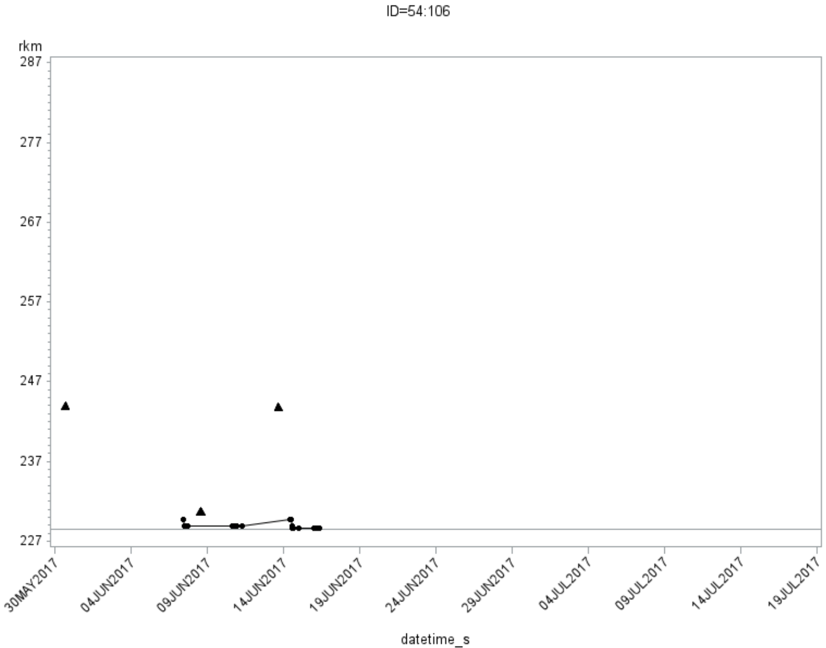
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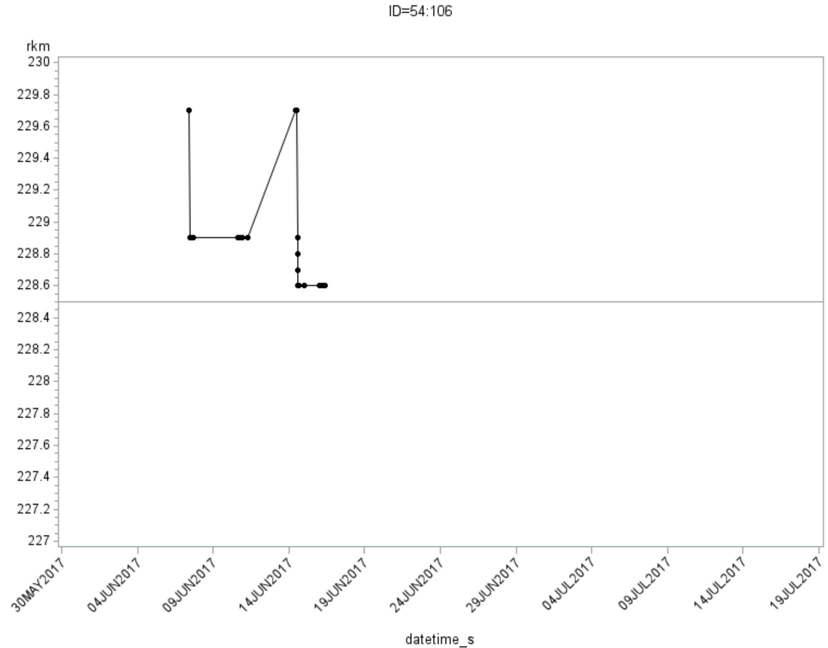
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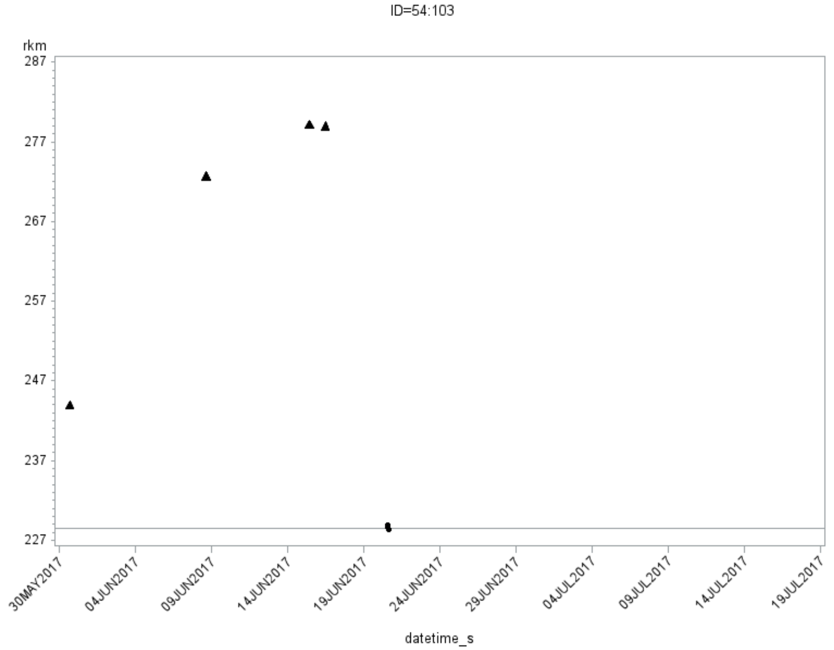
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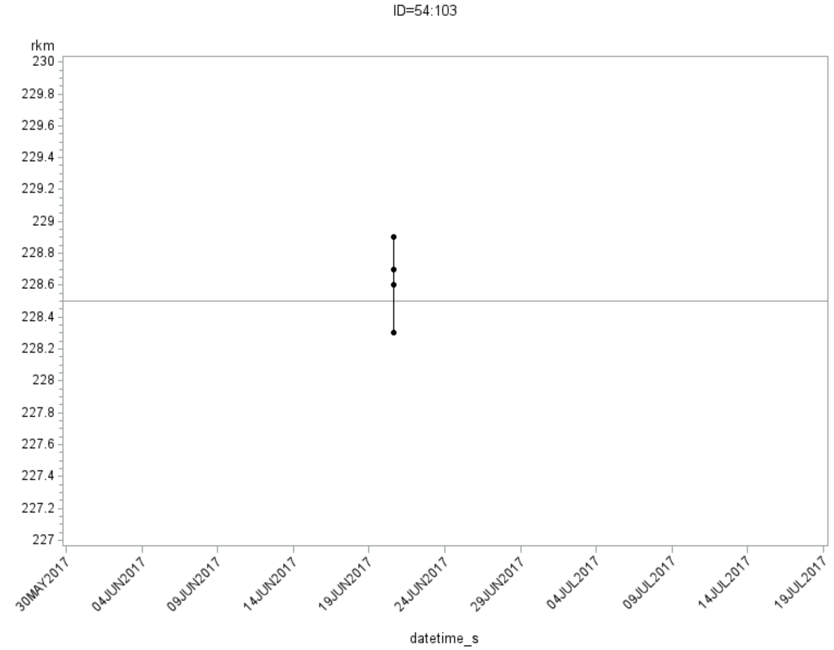
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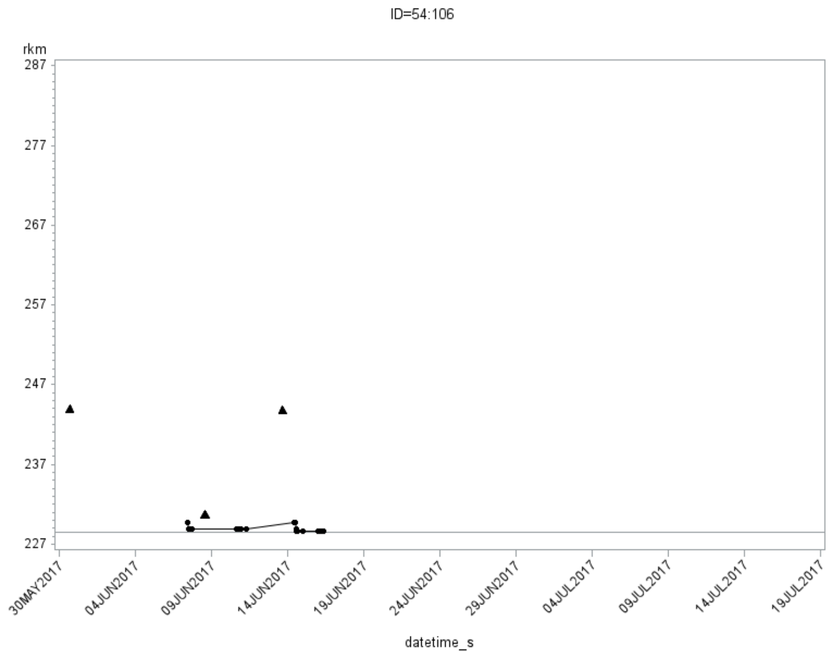
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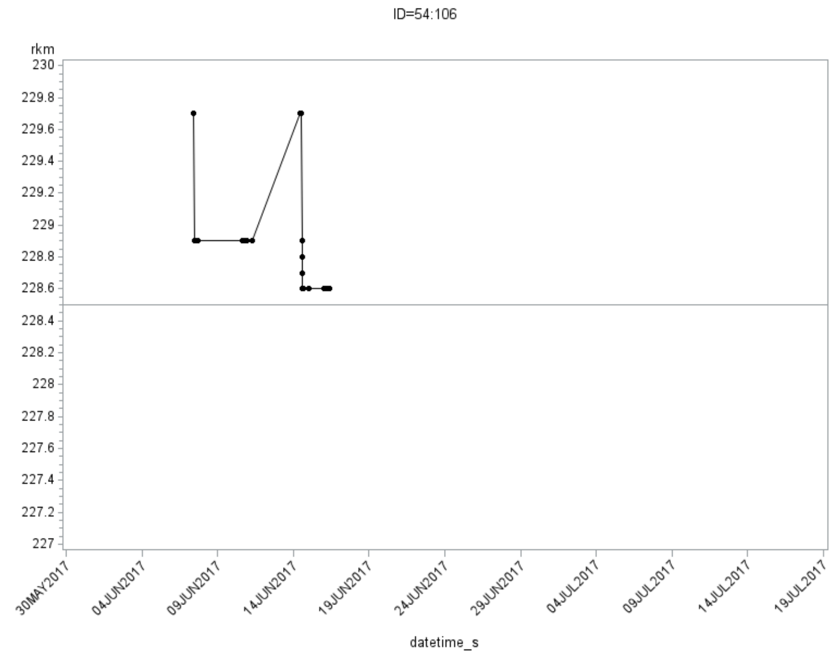
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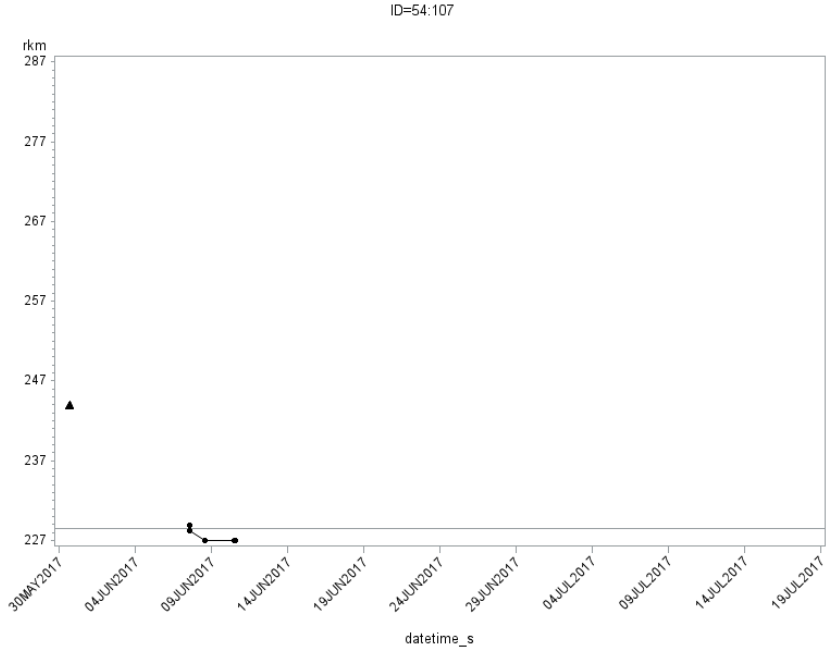
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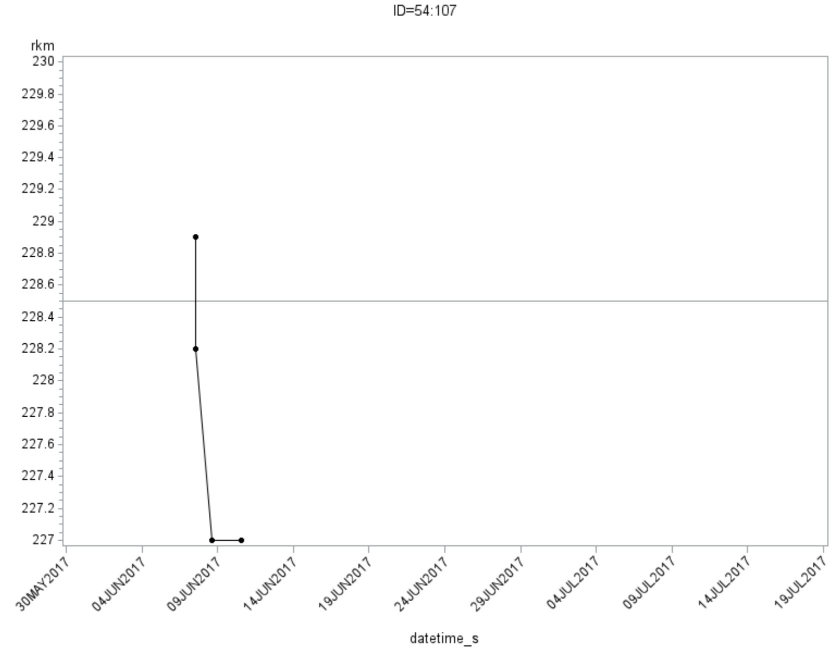
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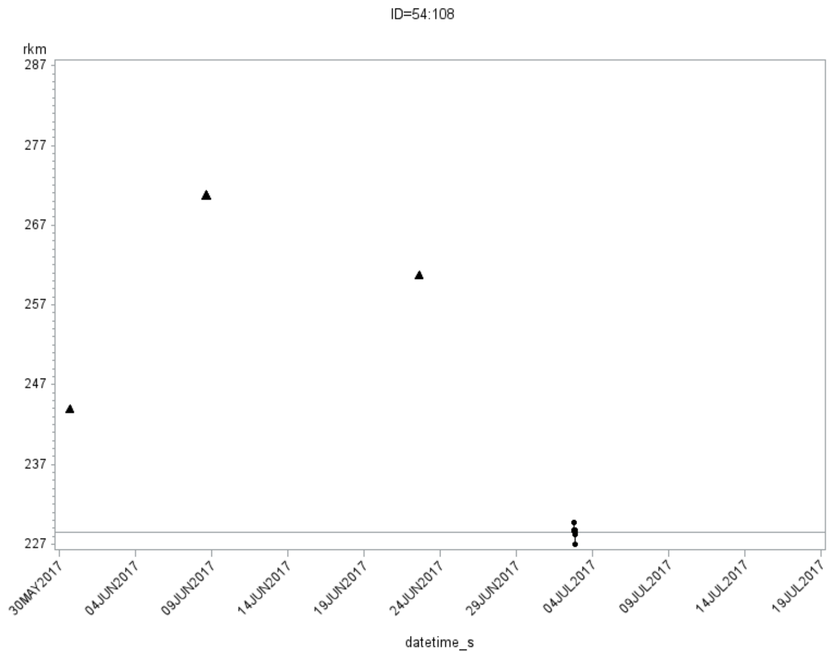
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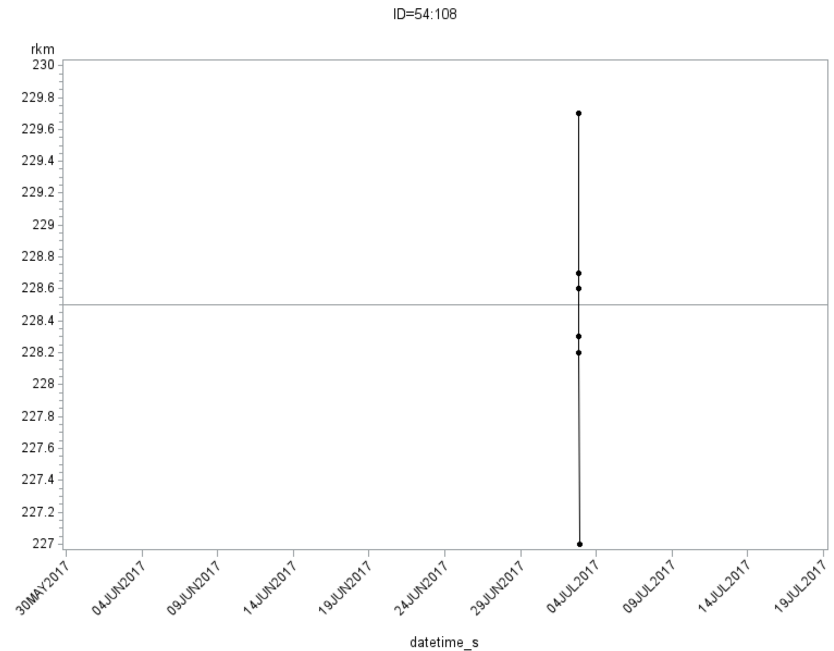
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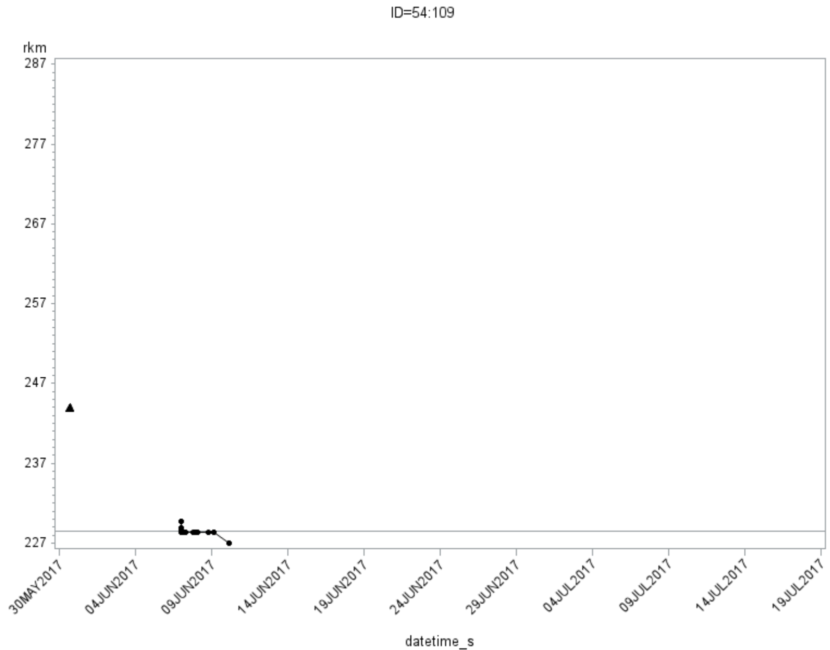
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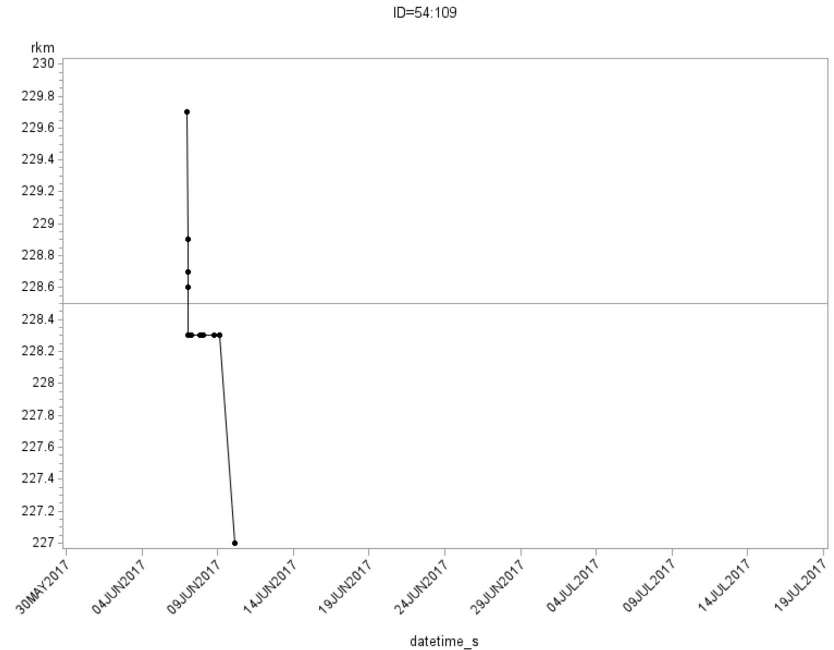
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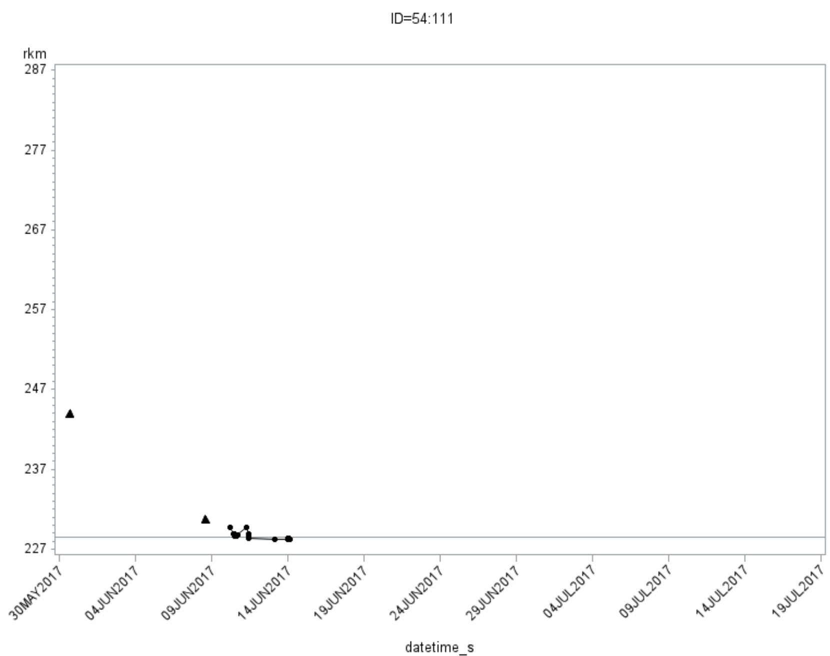
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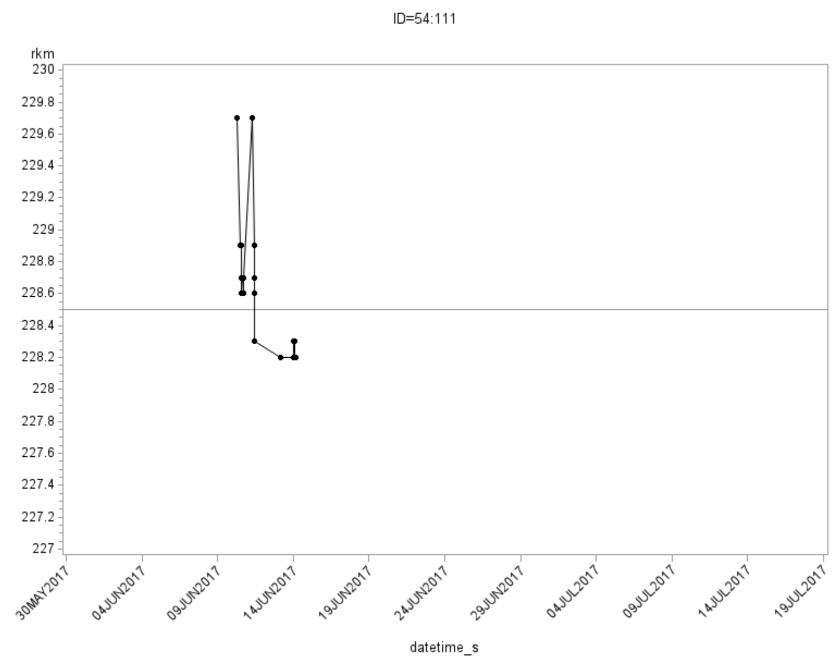
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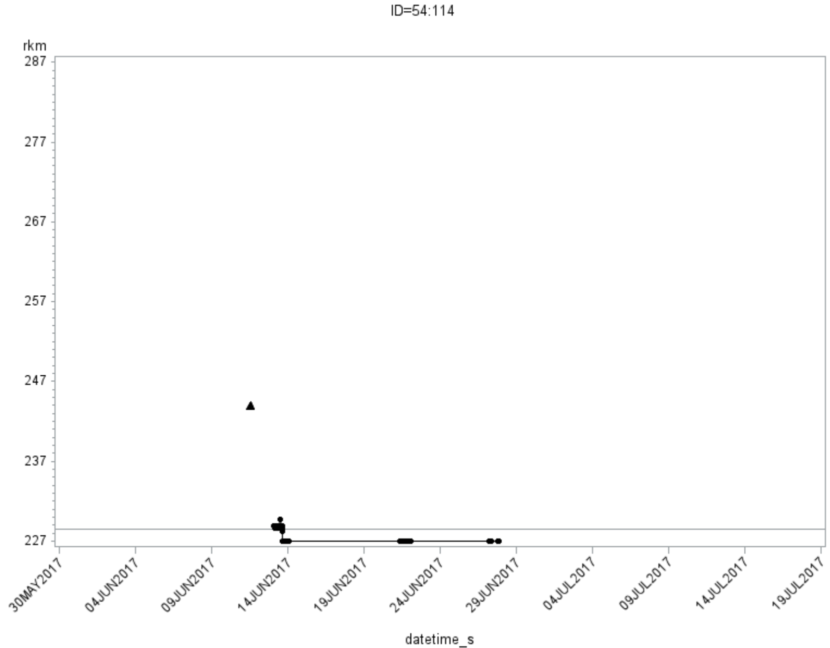
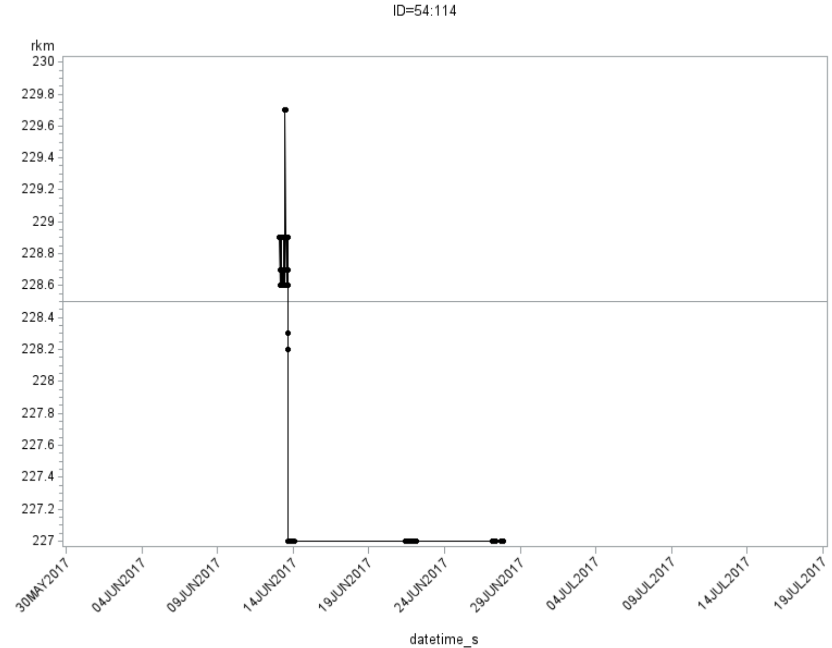
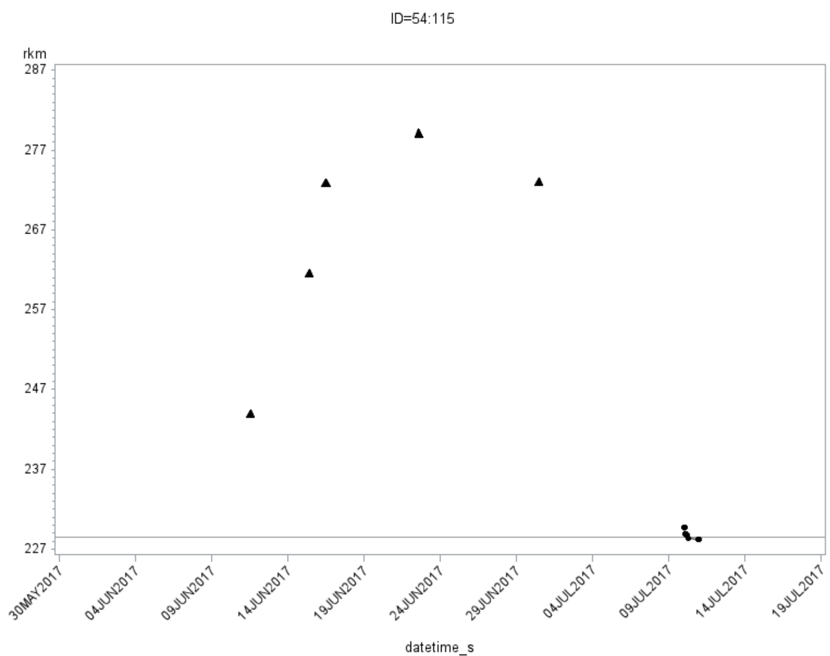
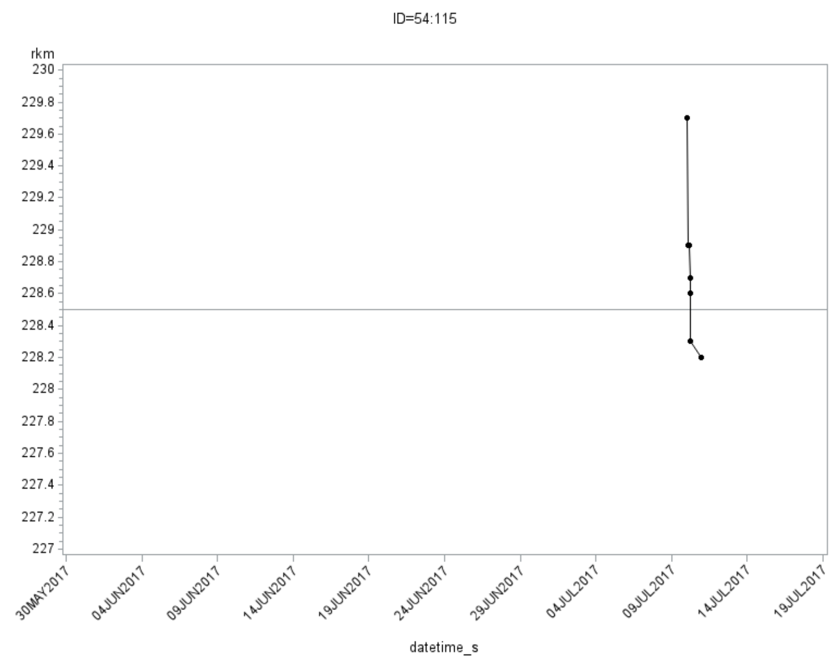
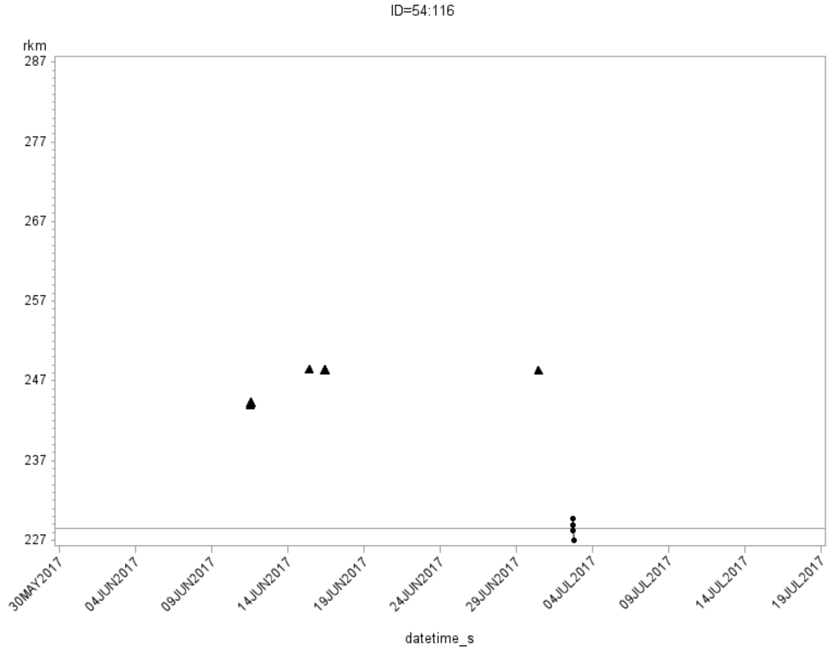
Great River Hydro Response to Comments, Study Report Addenda filed July 12, 2017-February 8, 2018







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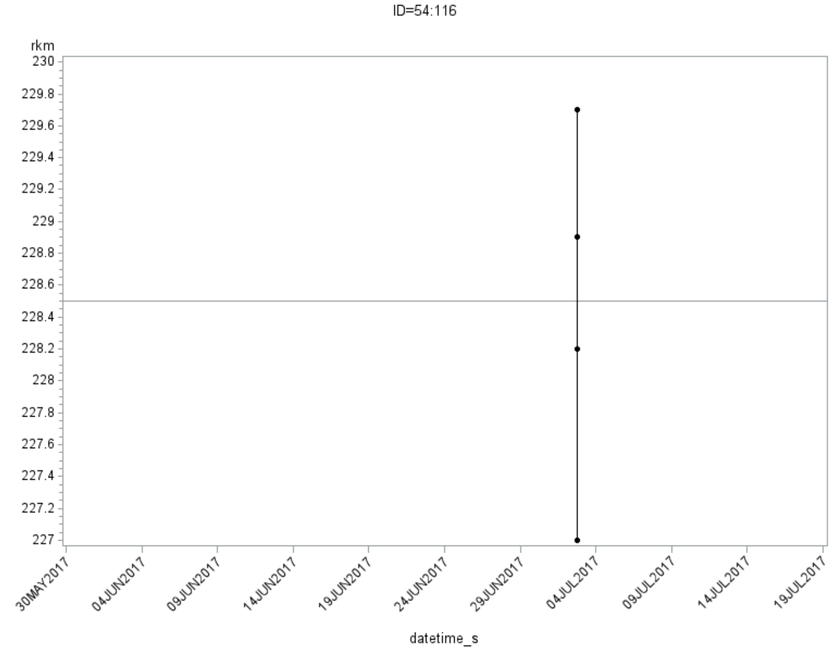
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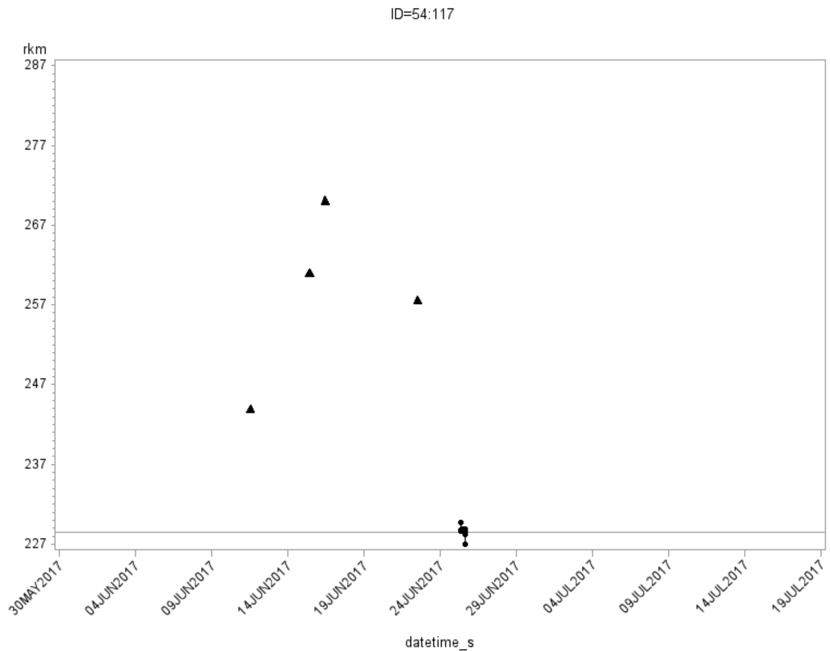
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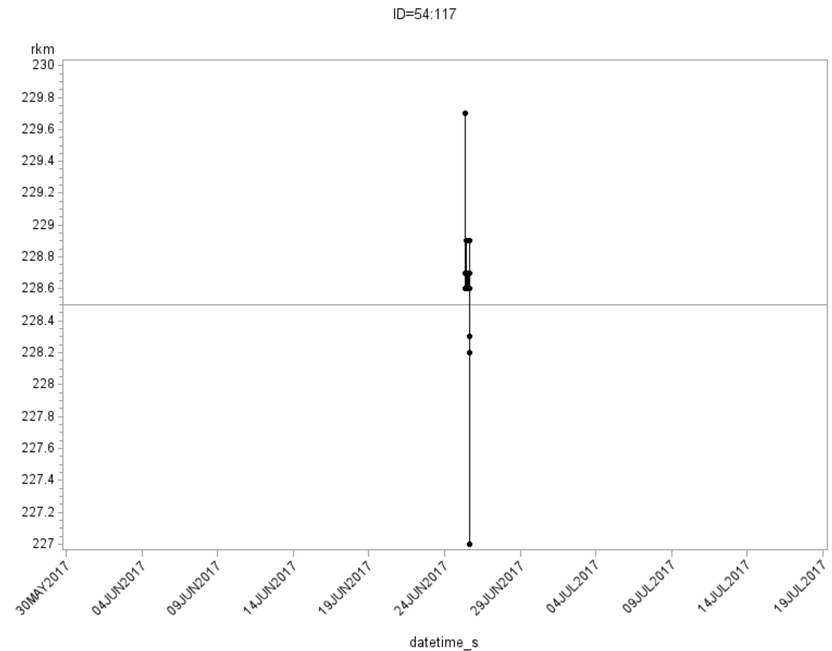
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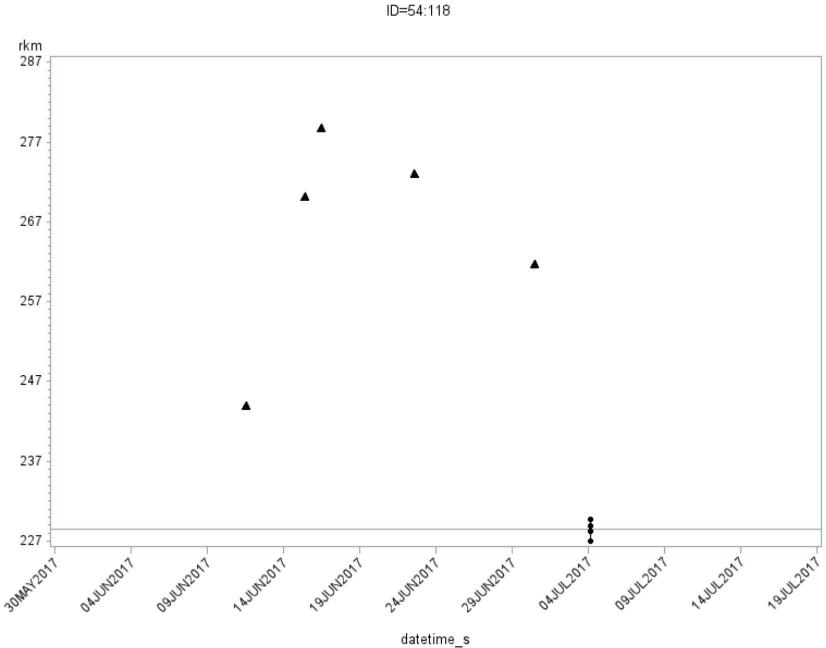
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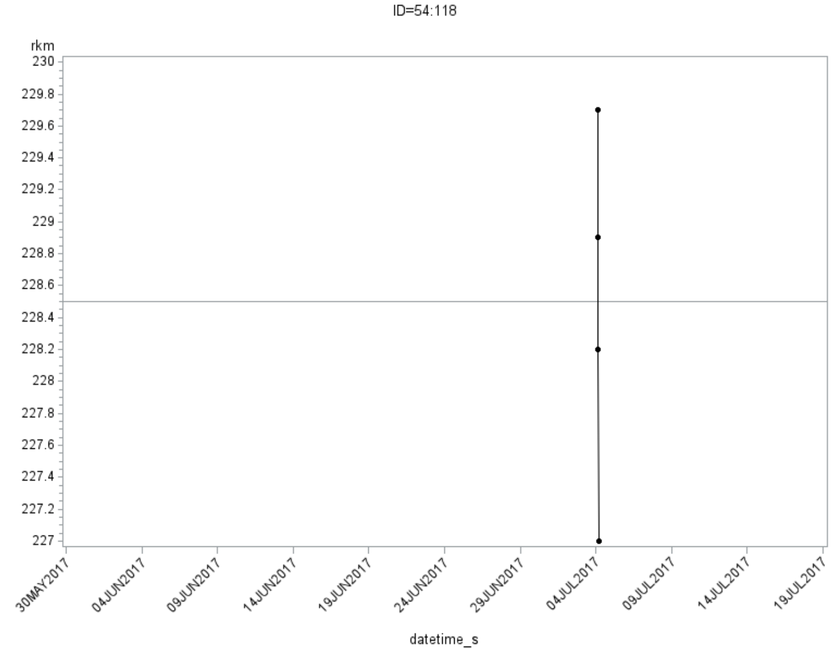
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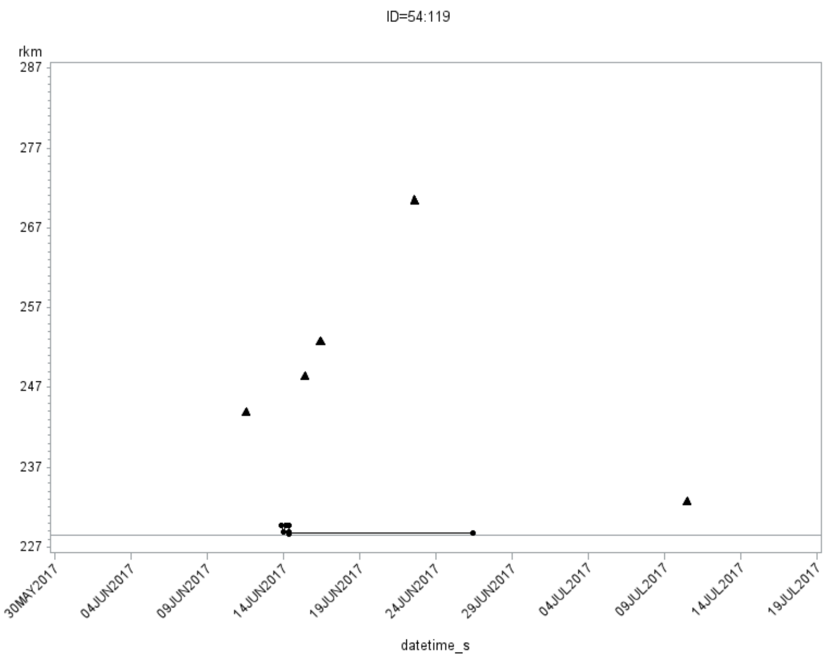
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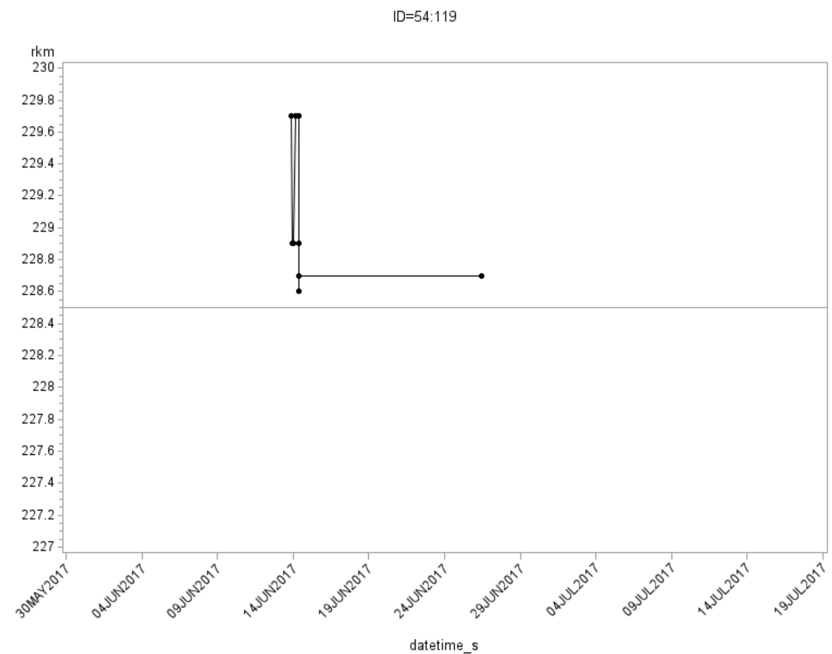
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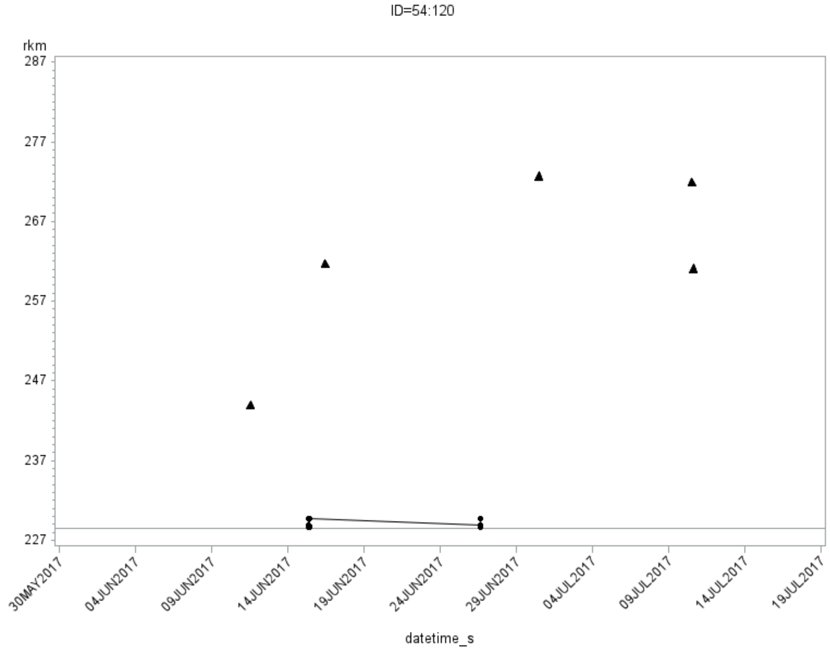
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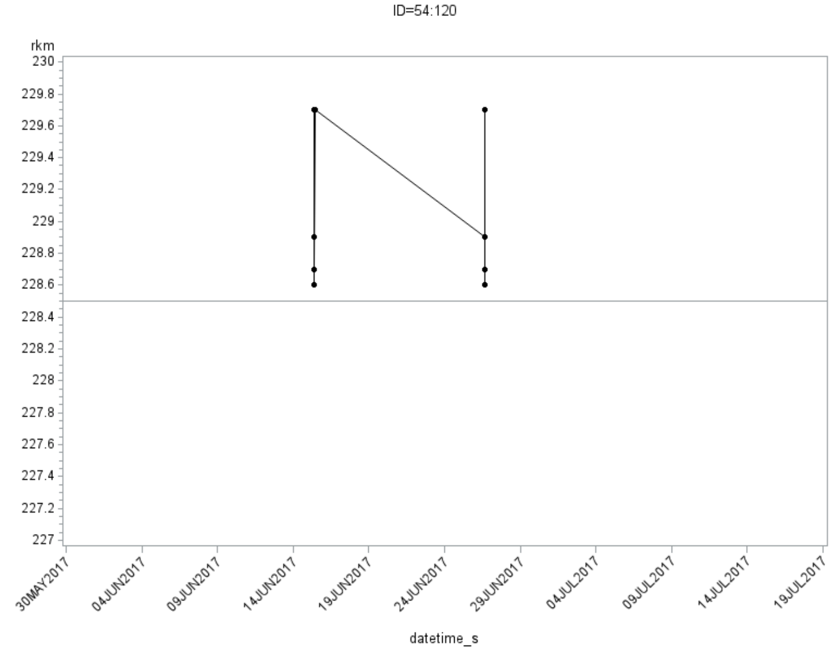
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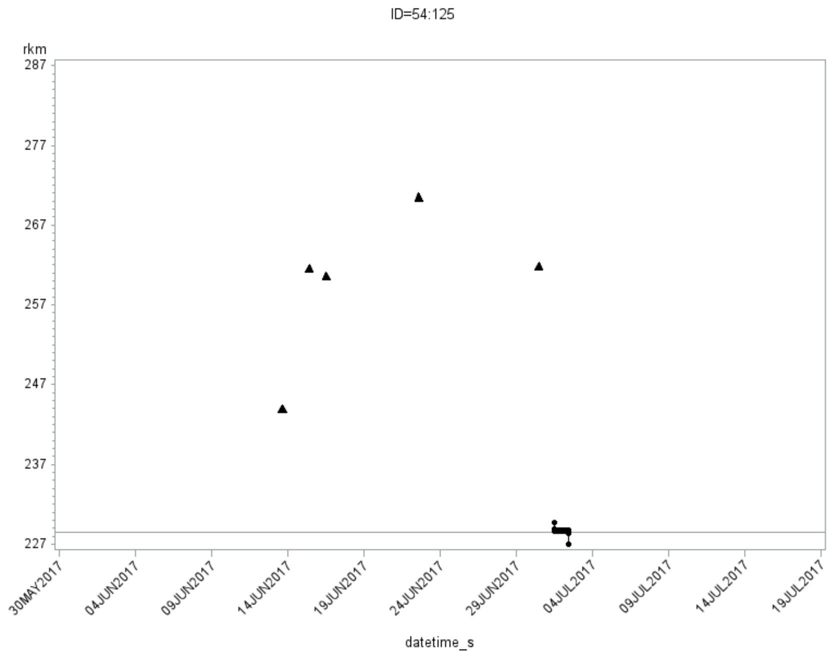
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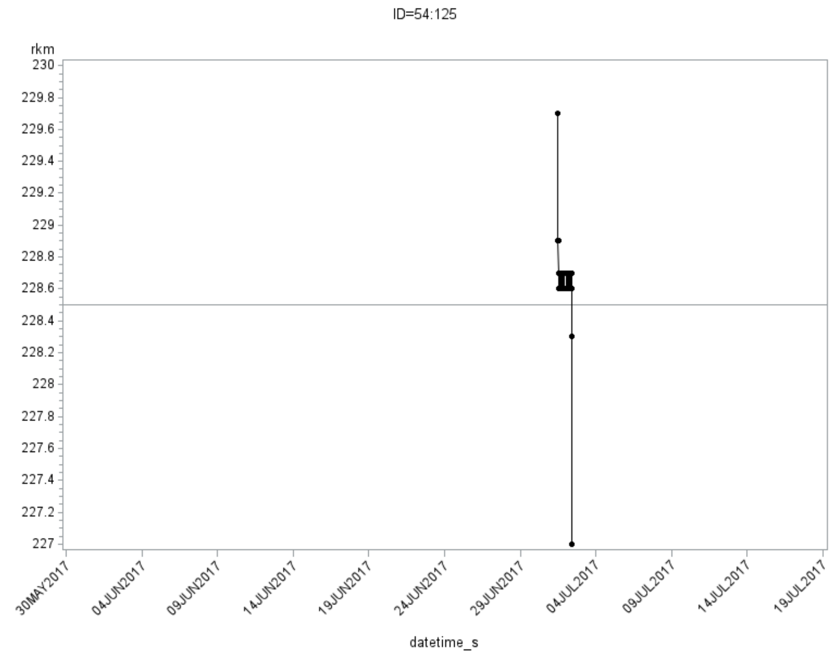
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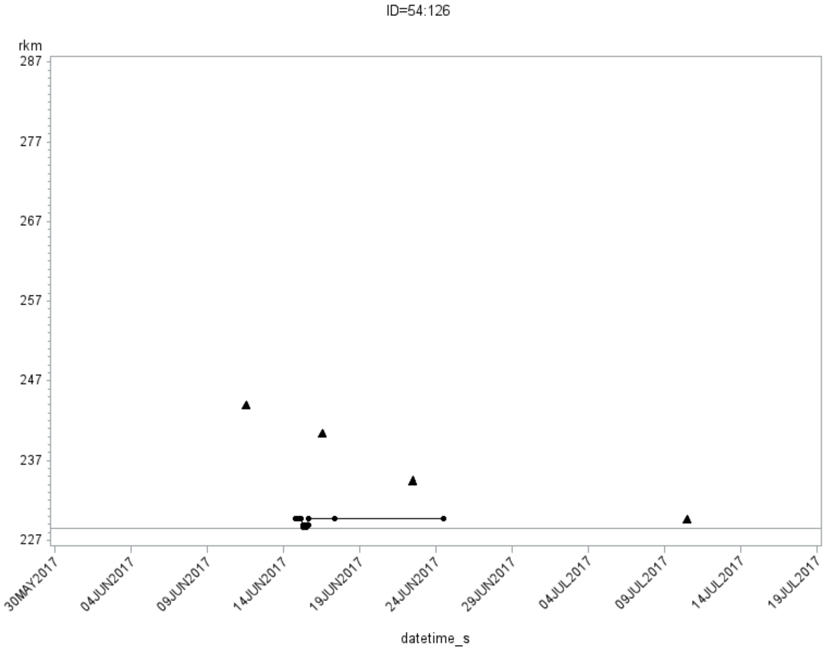
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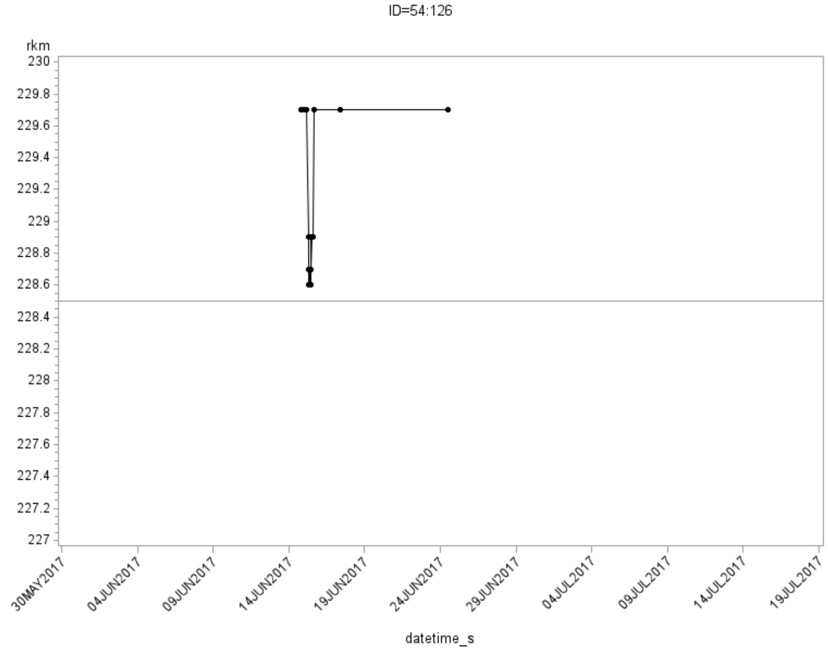
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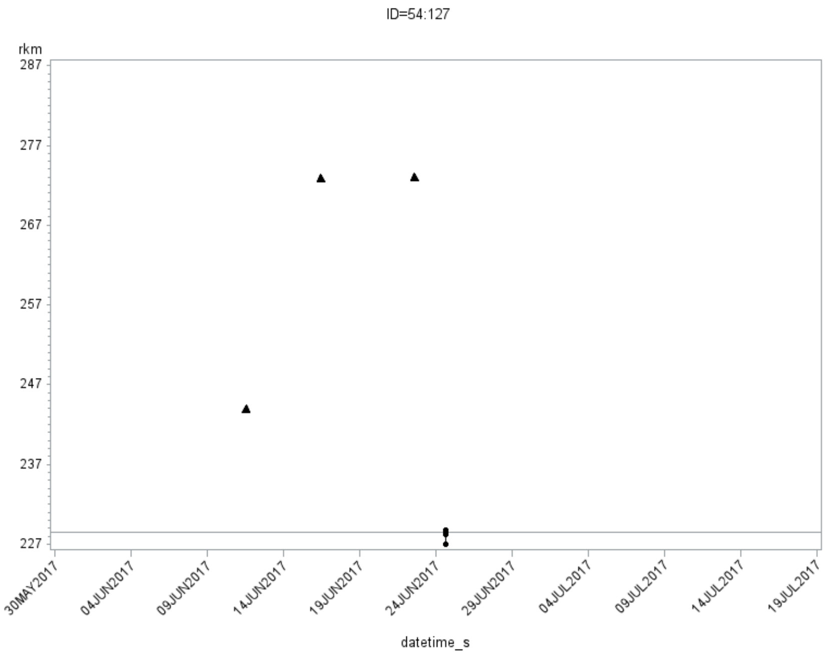
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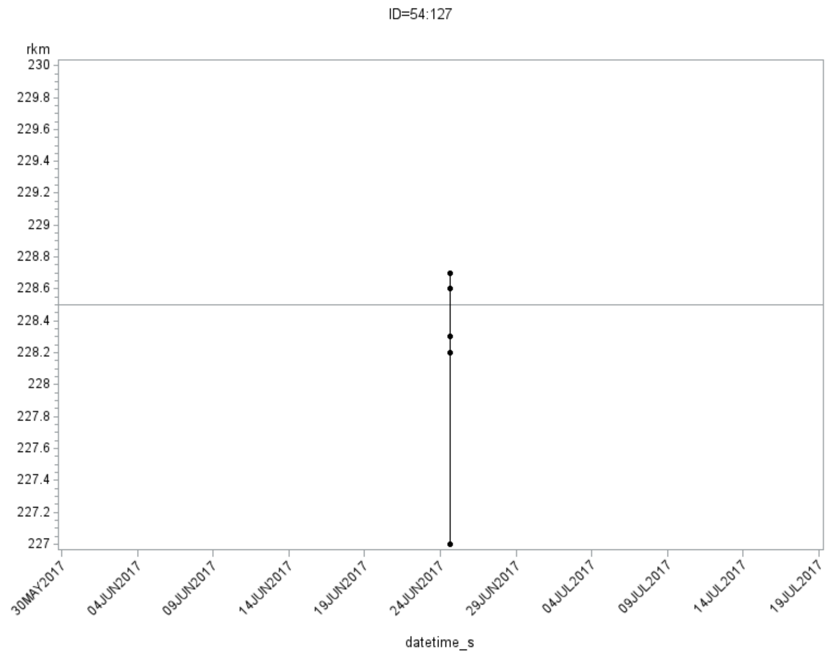
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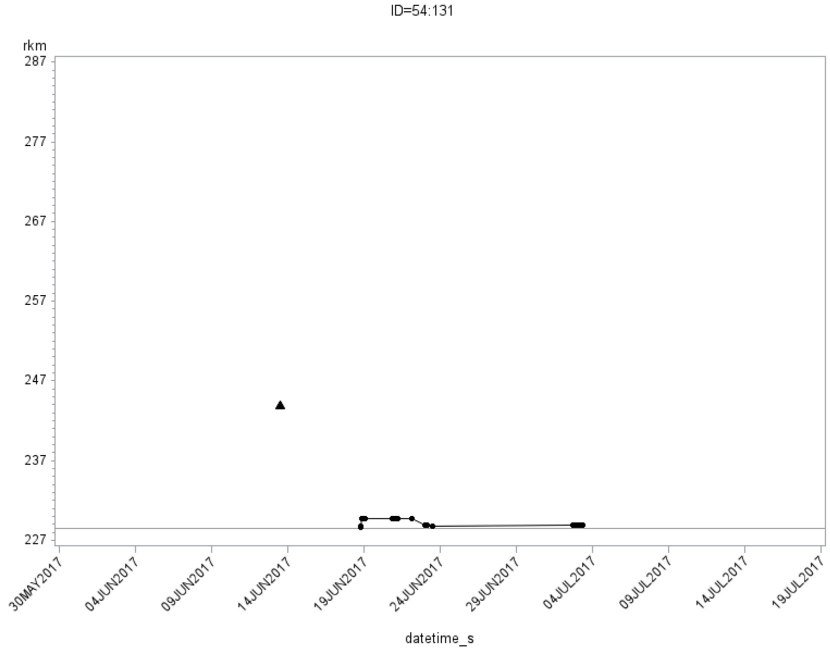
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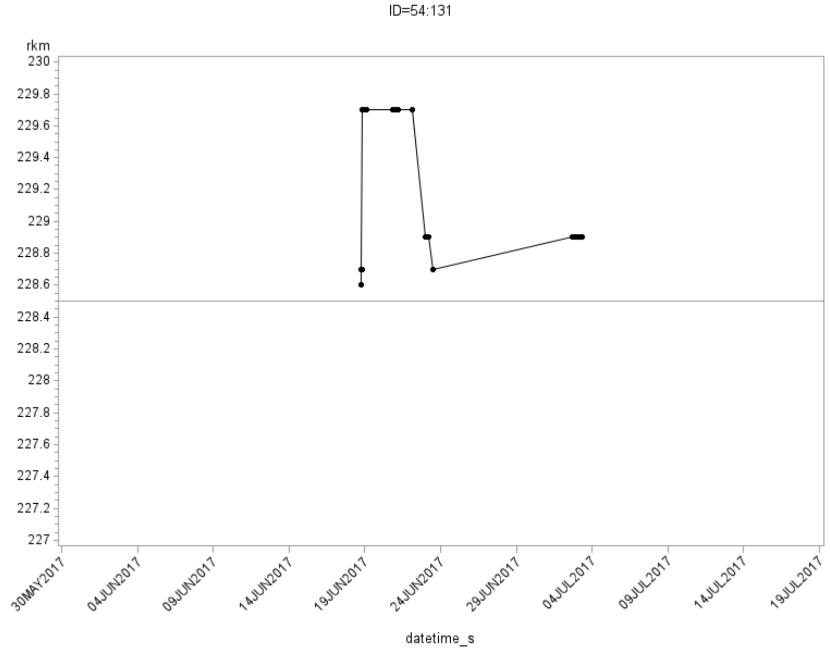
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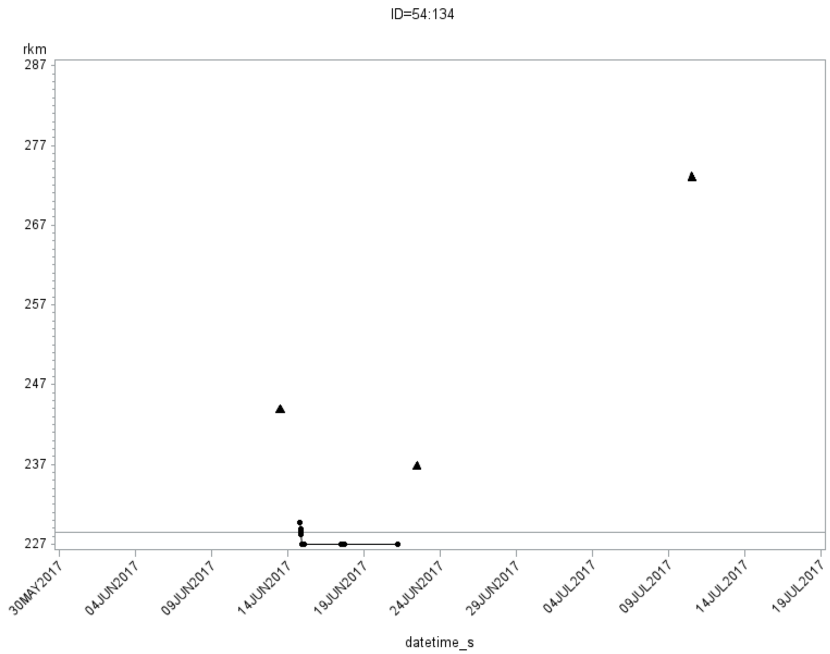
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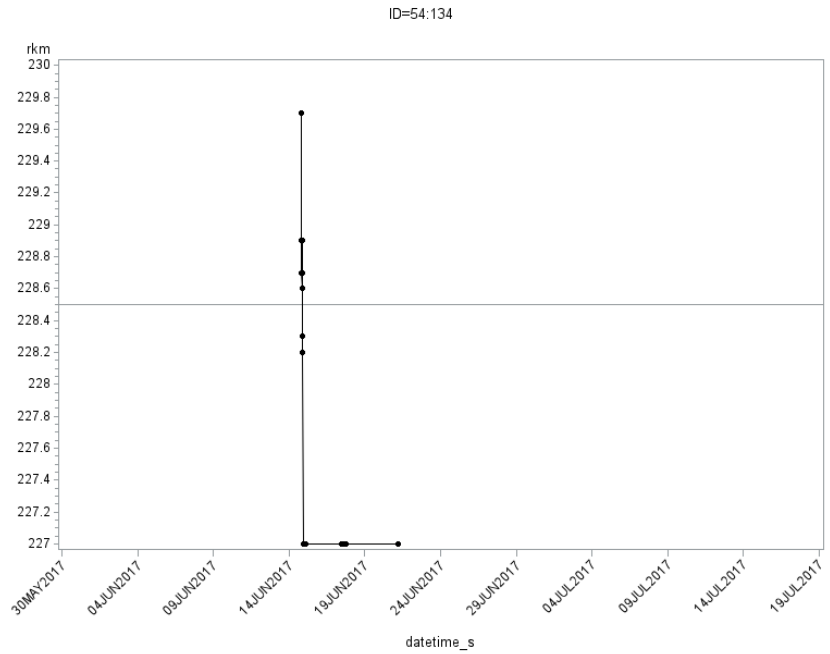
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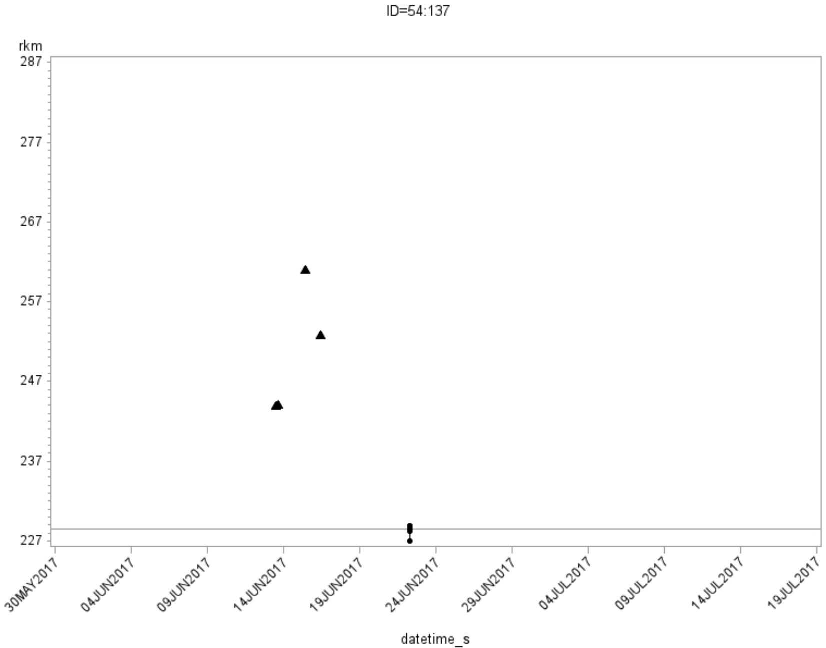
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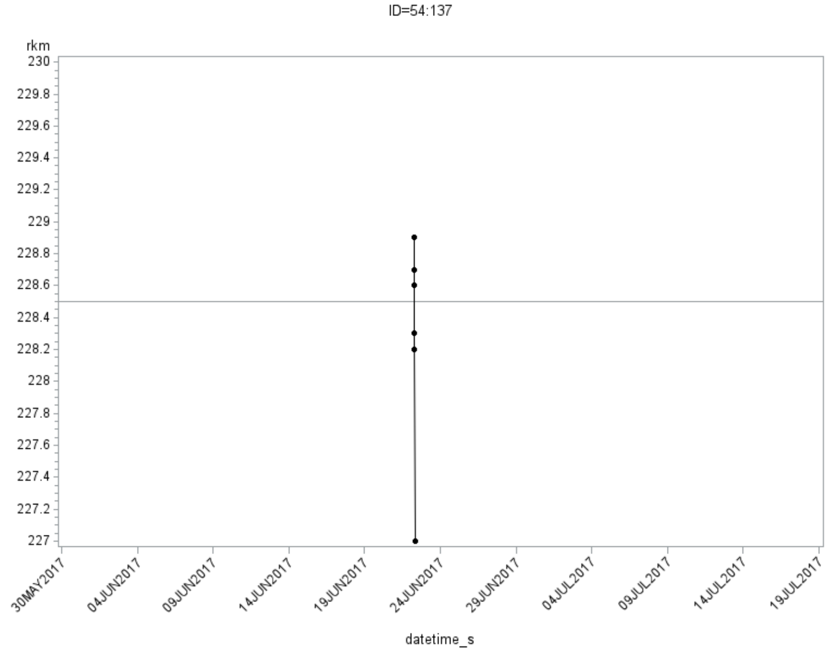
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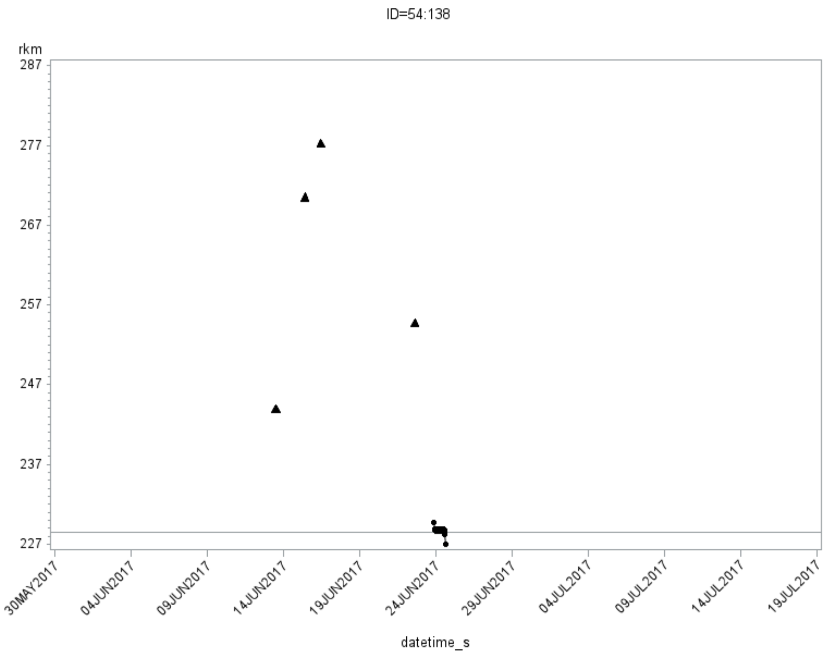
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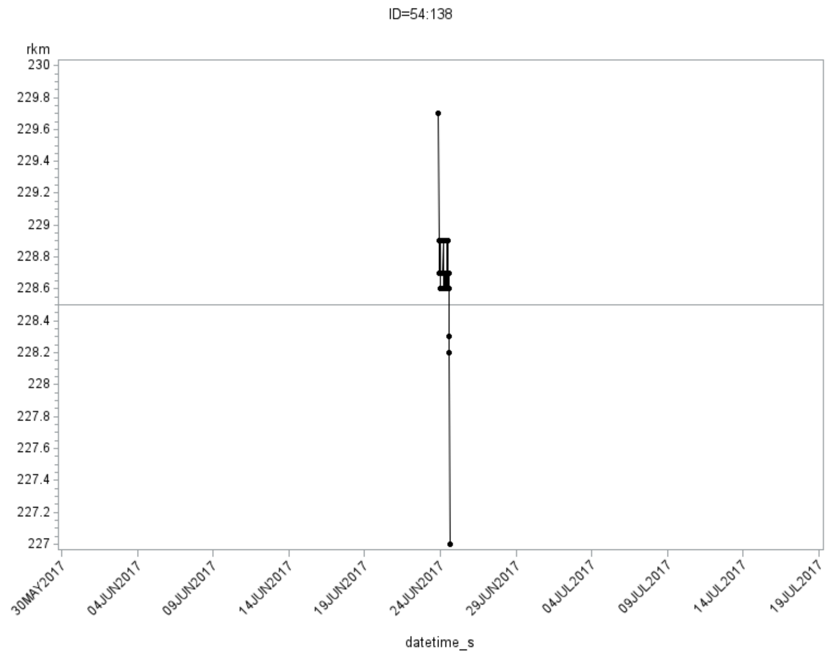
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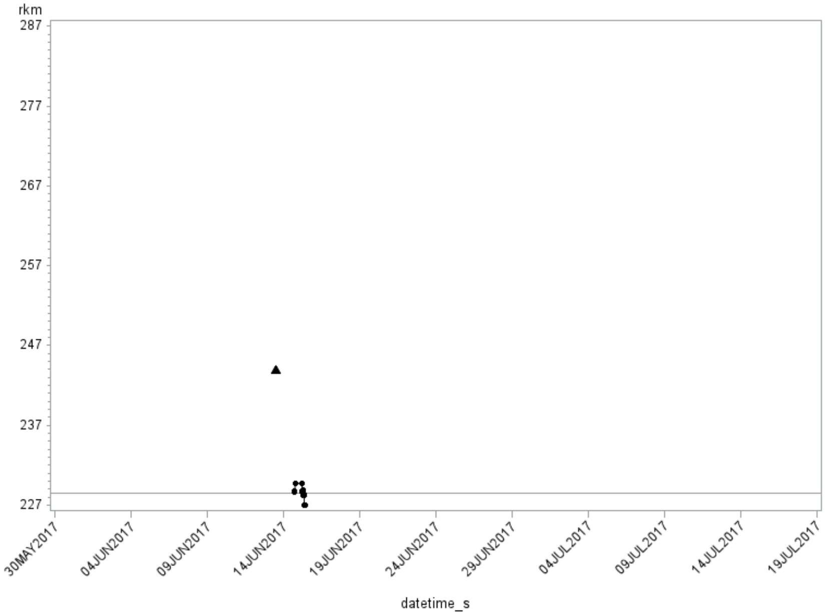

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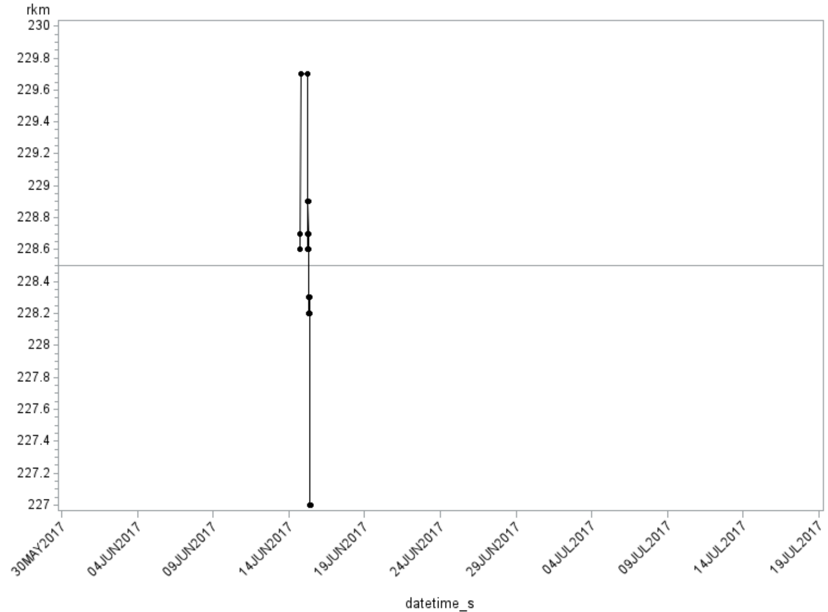

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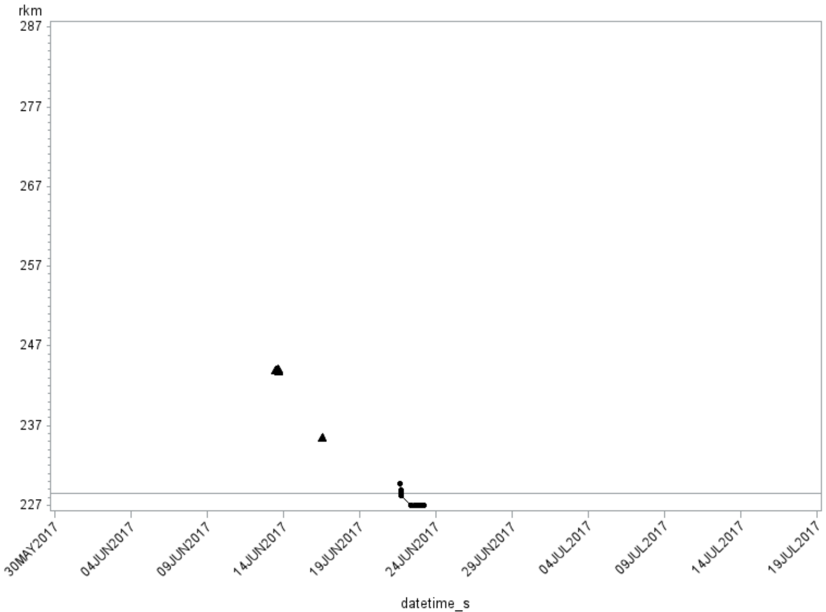

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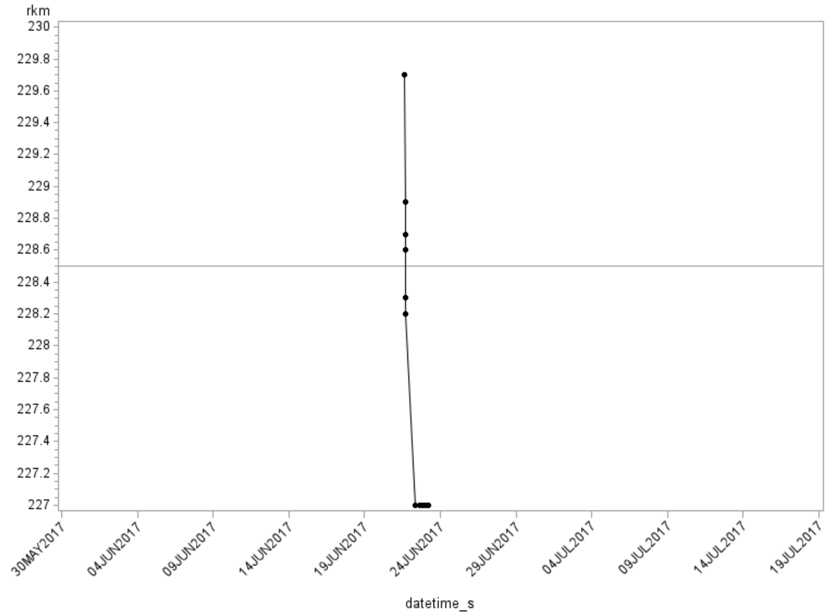

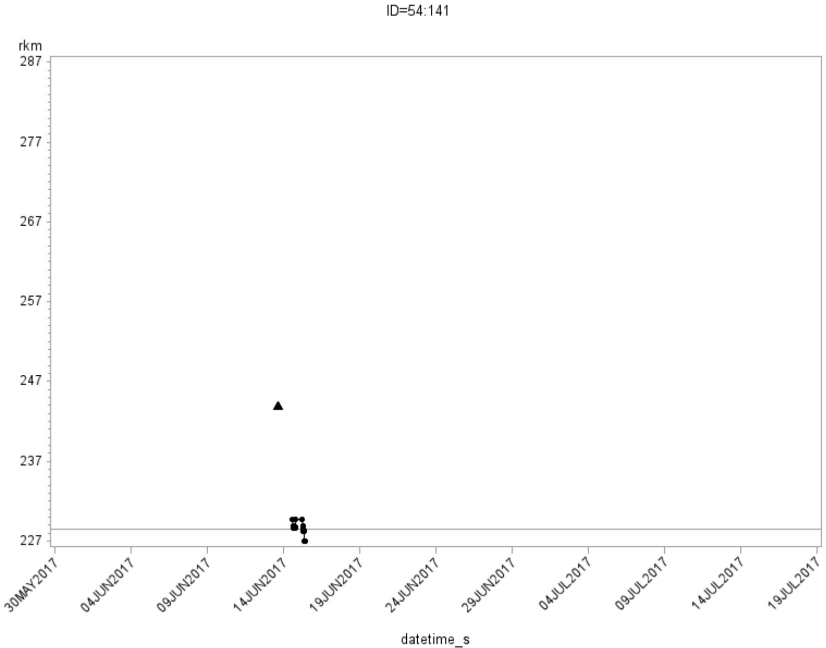
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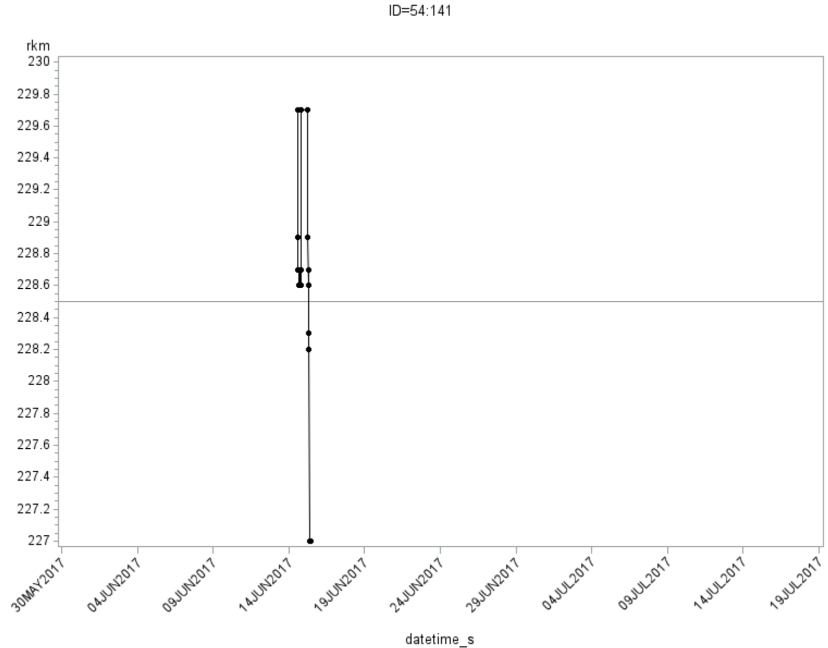
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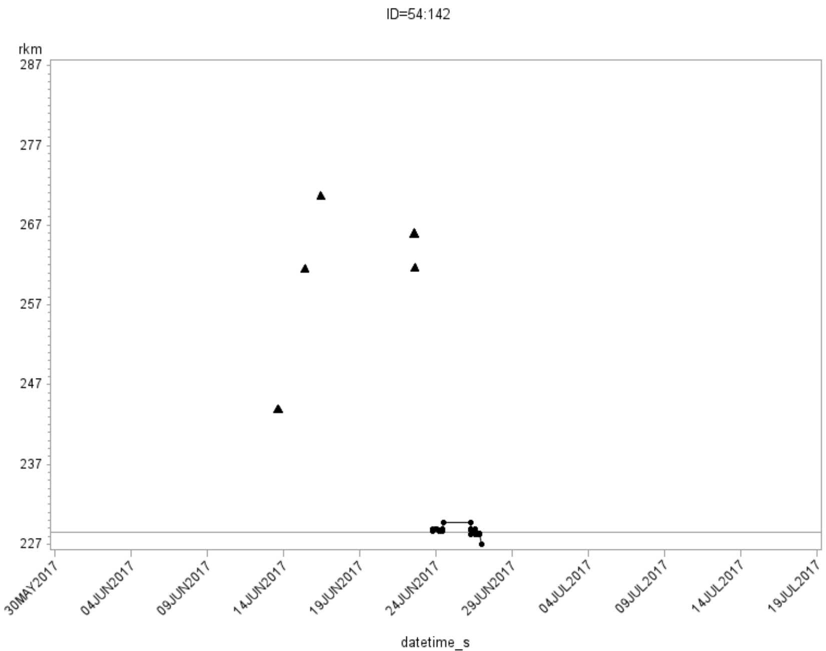
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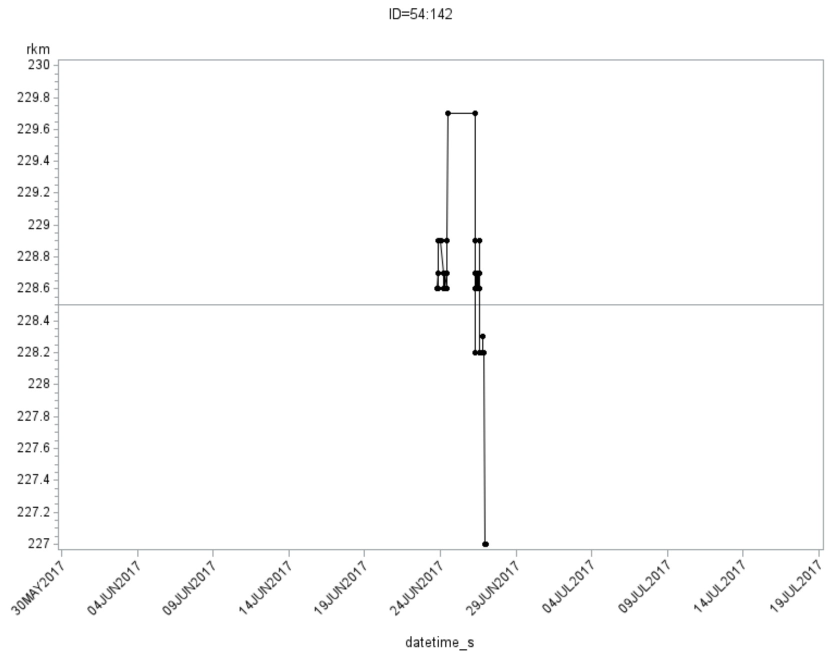
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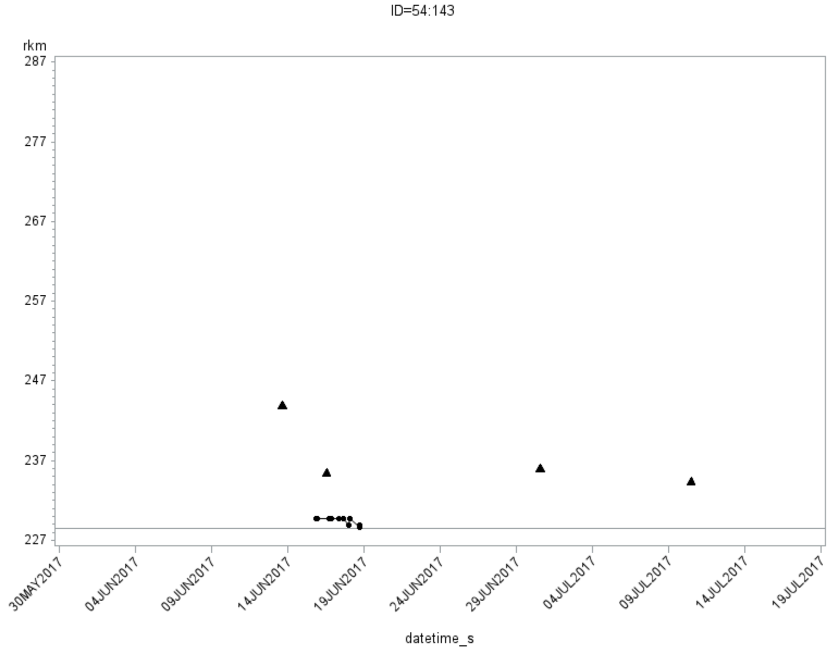
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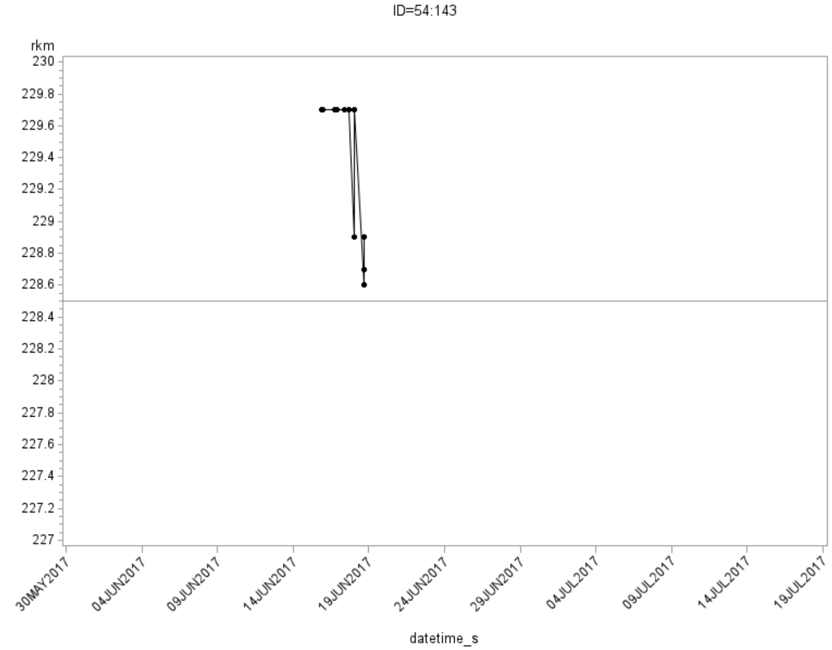
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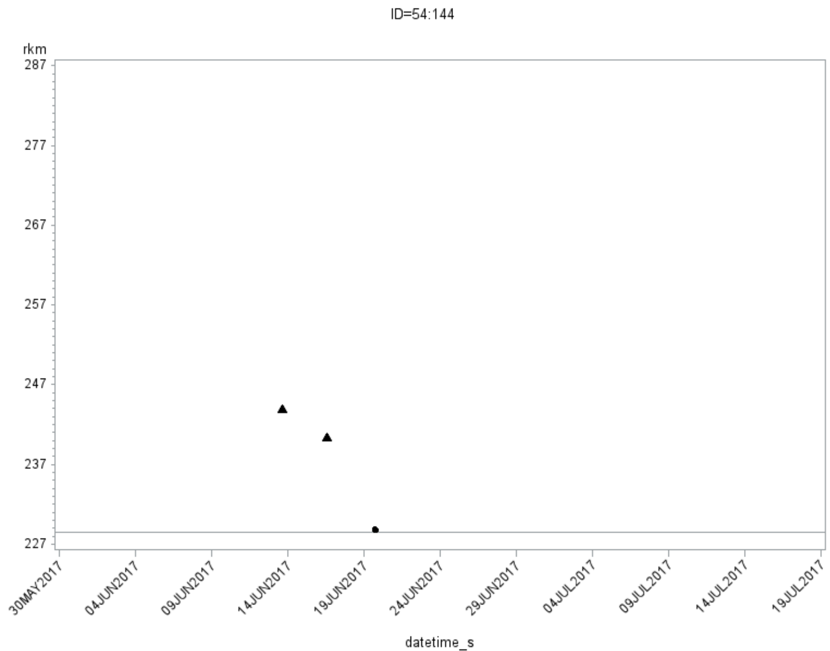
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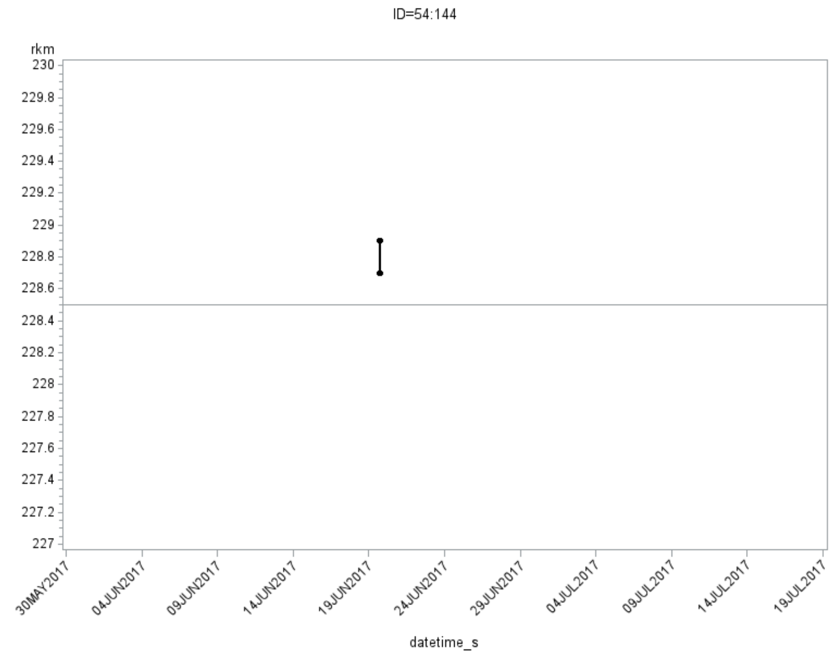
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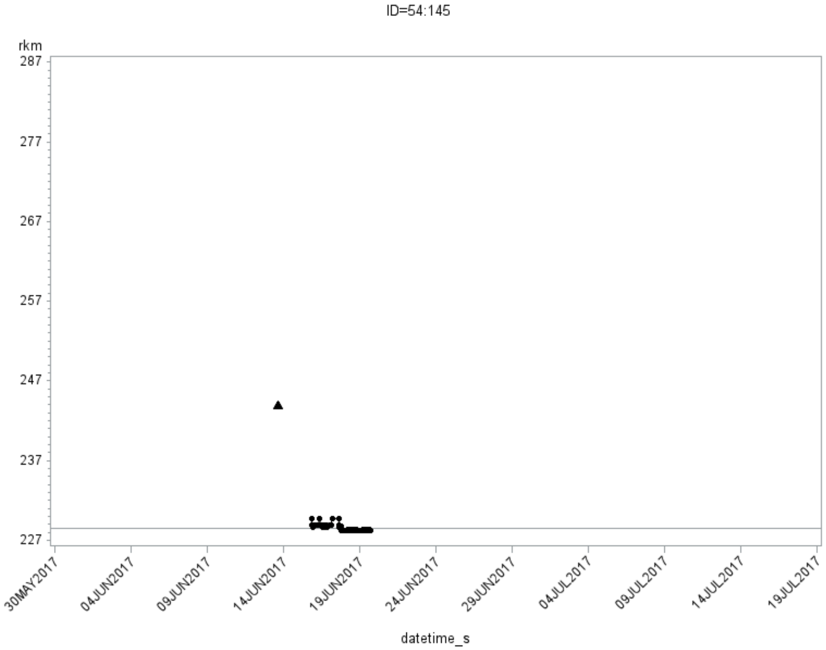
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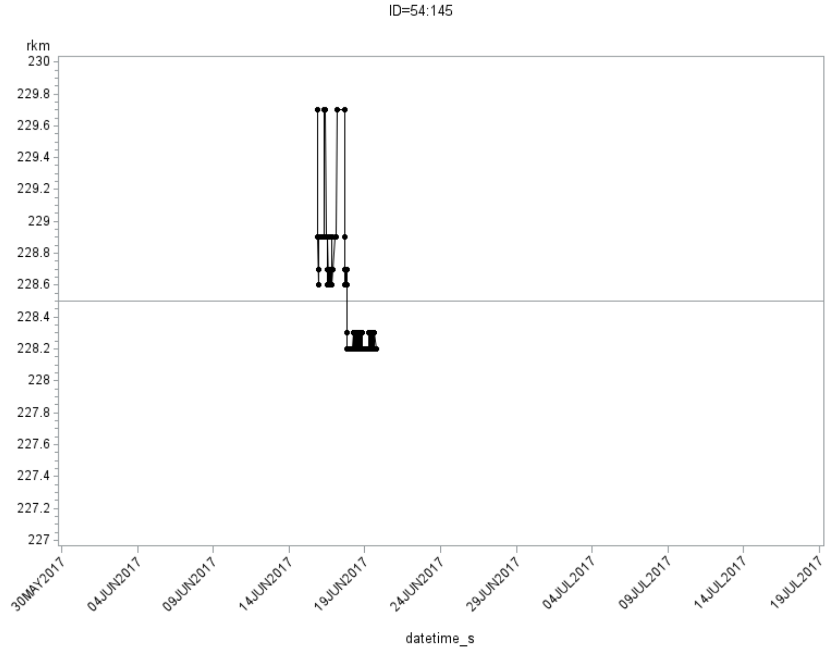
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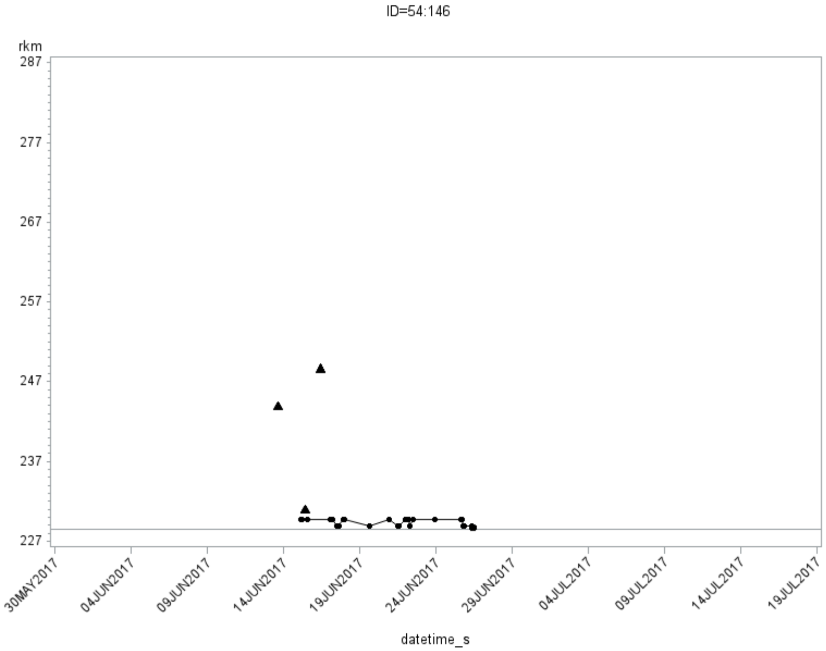
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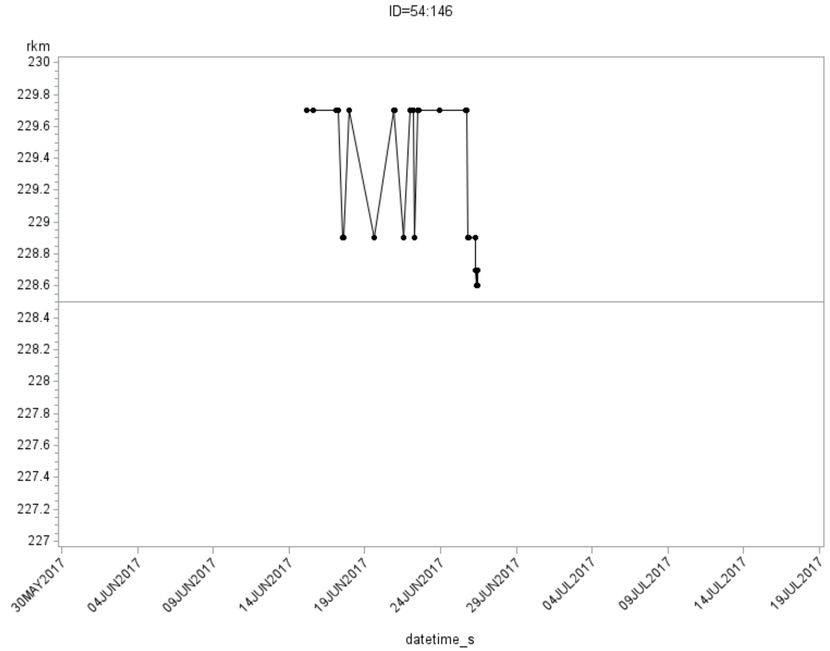
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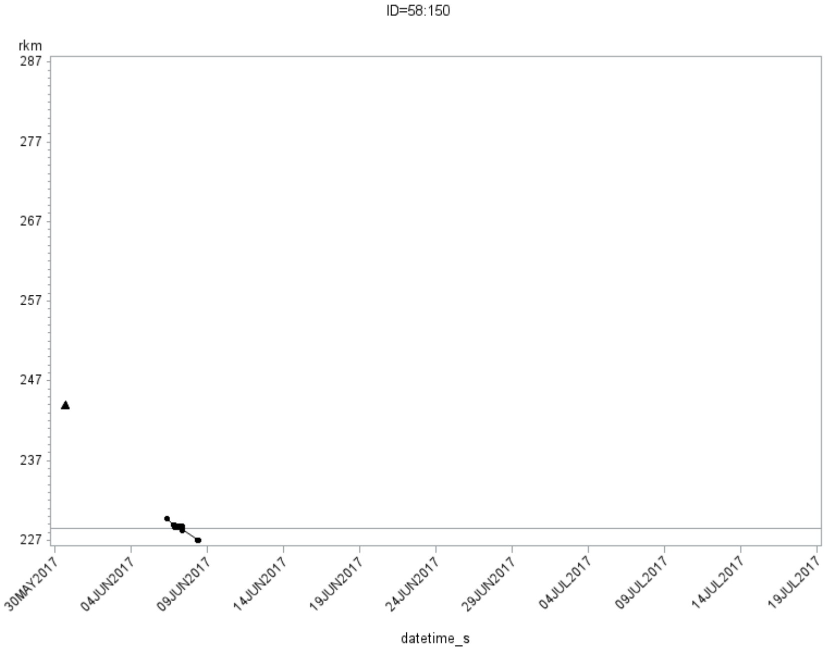
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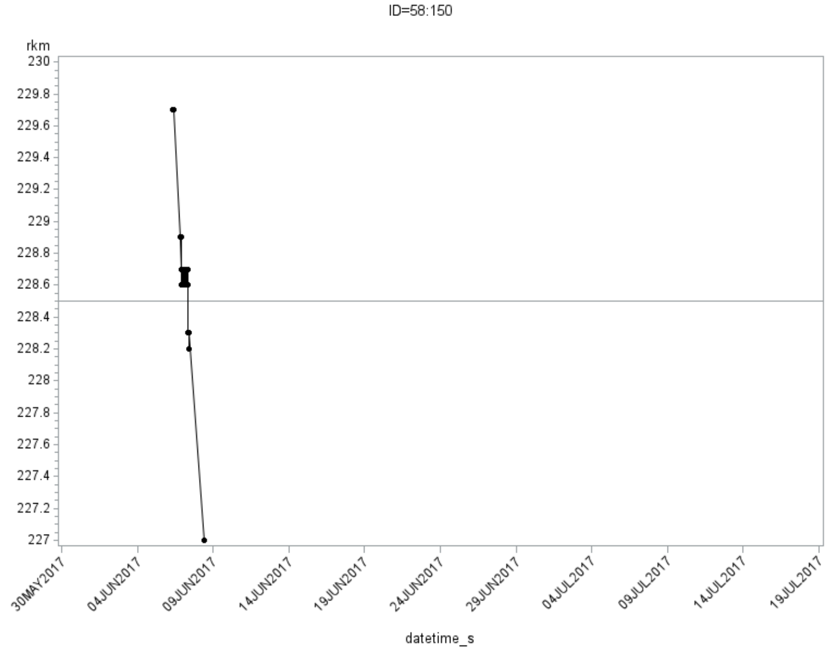
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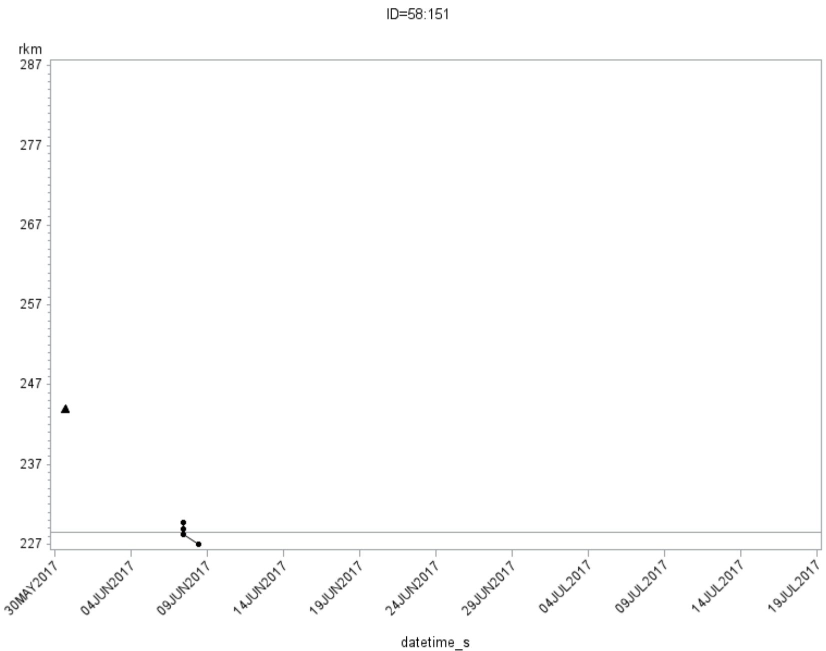
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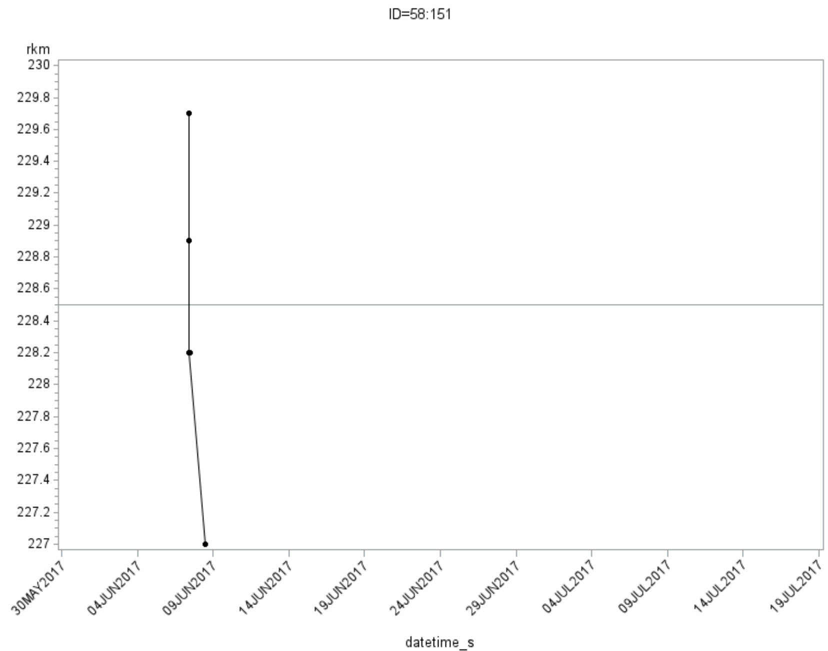
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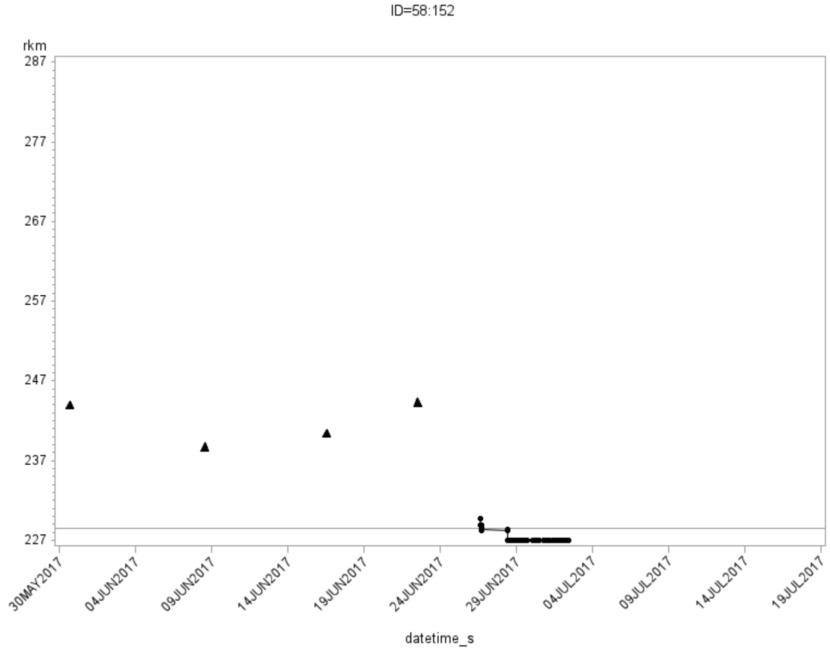
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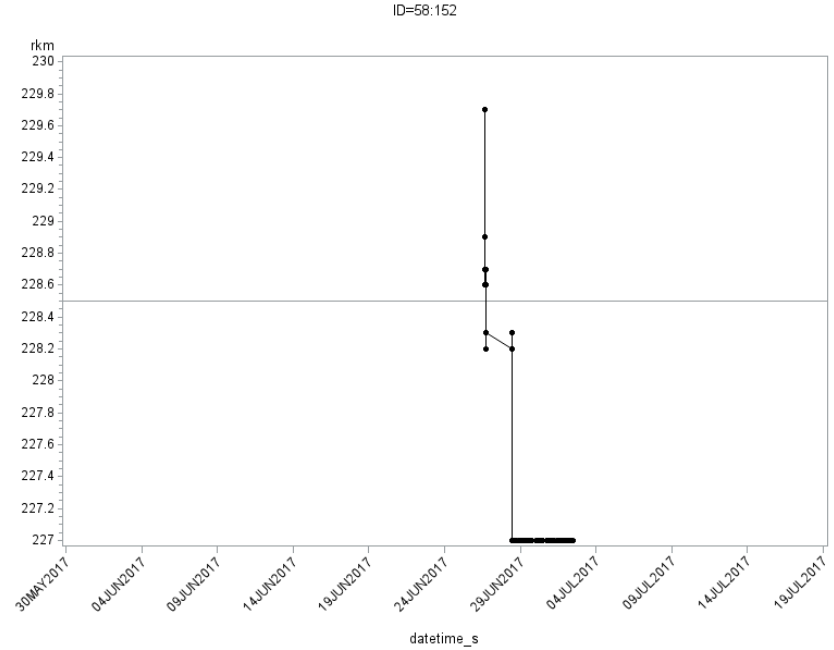
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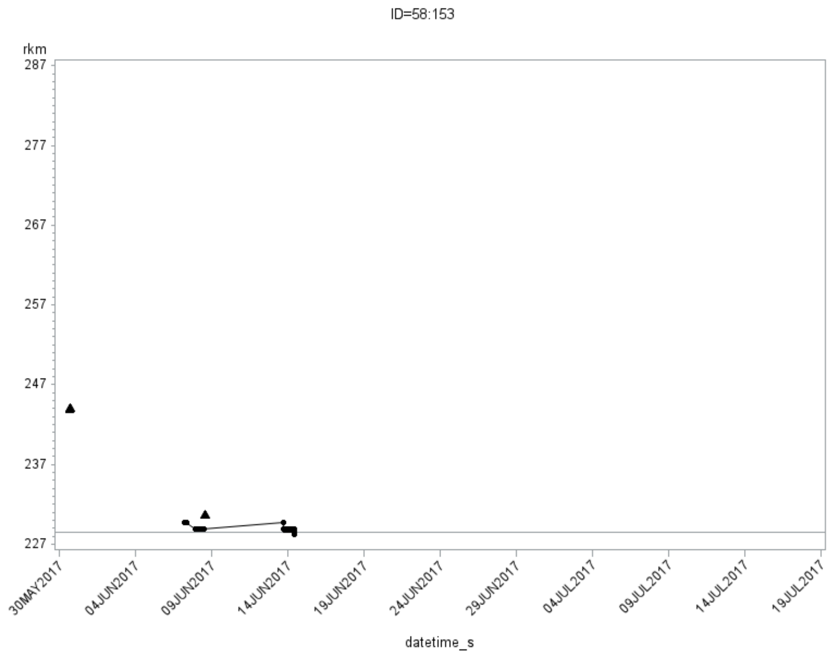
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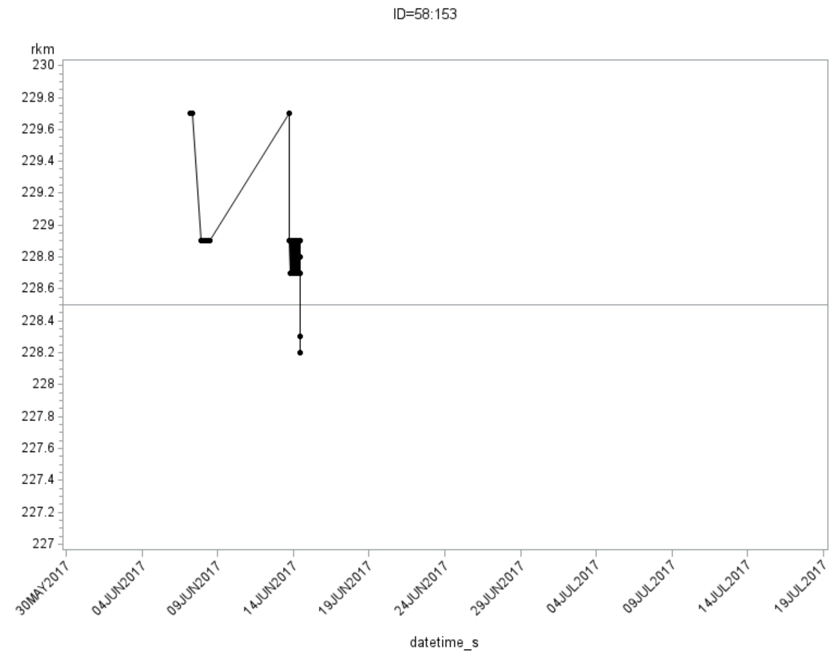
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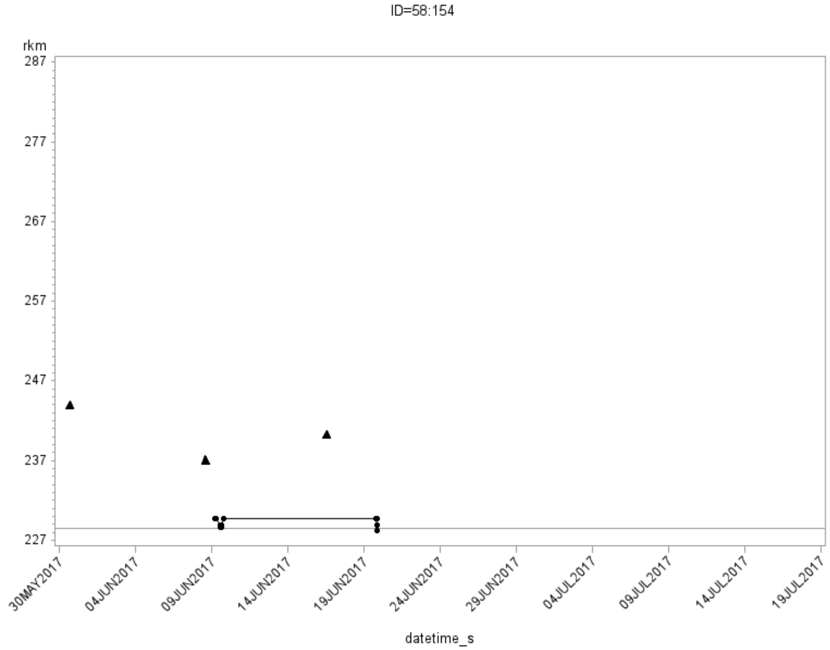
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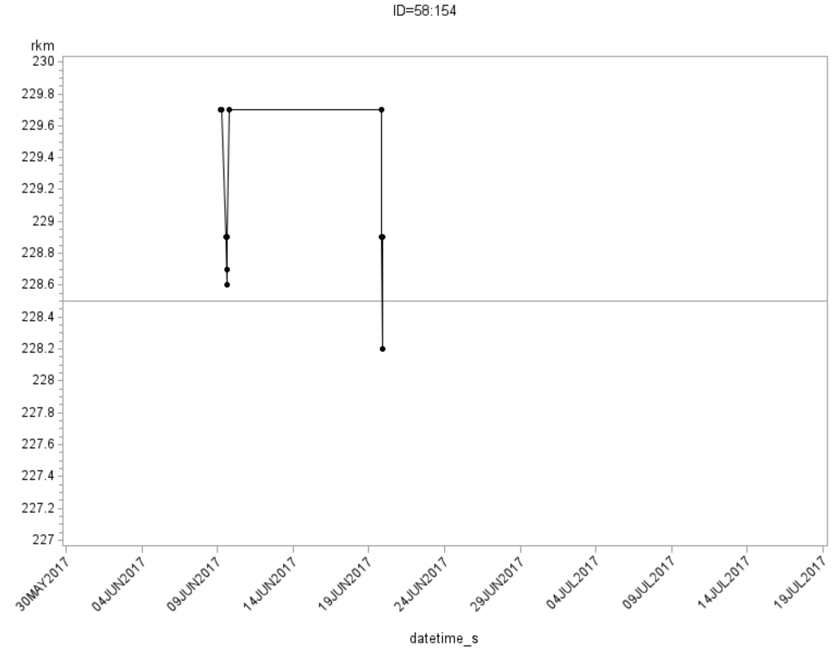
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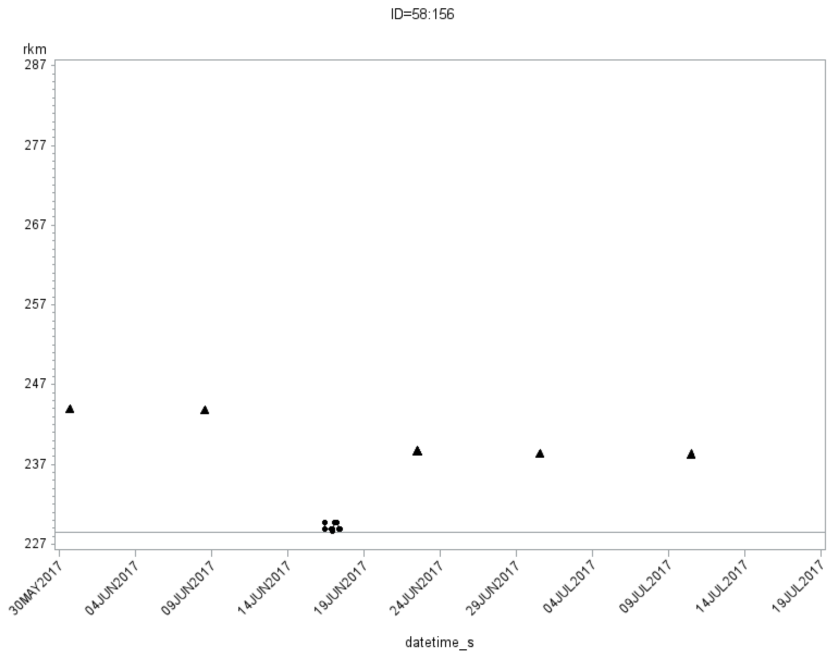
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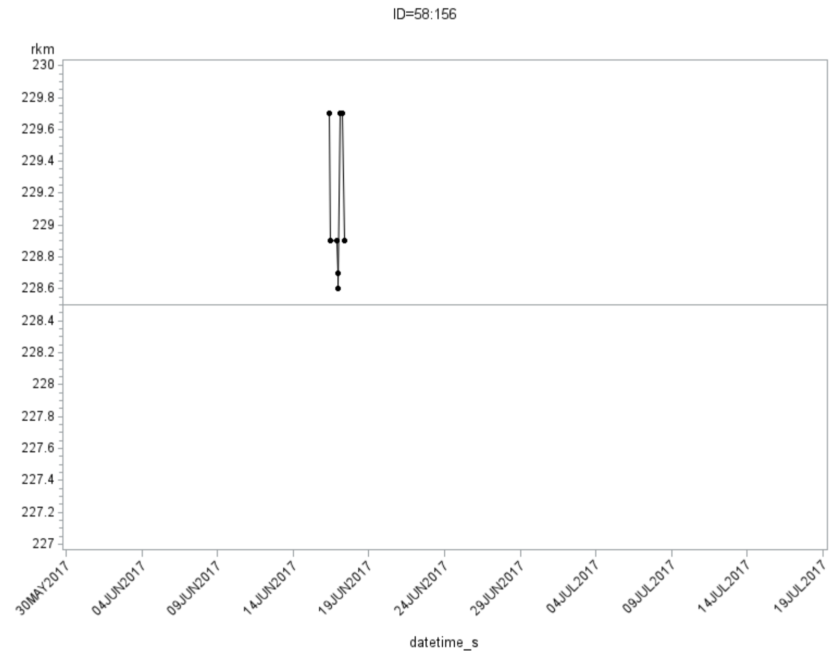
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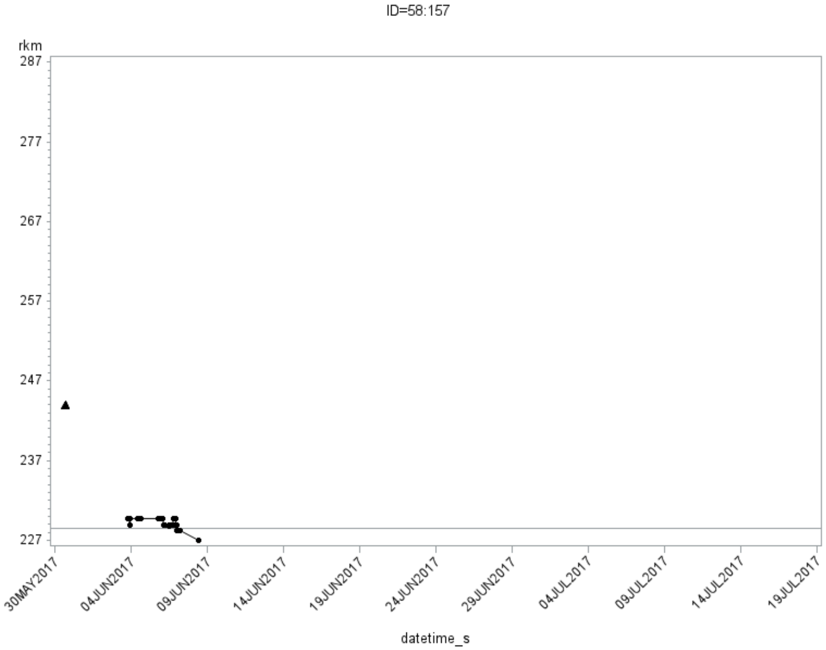
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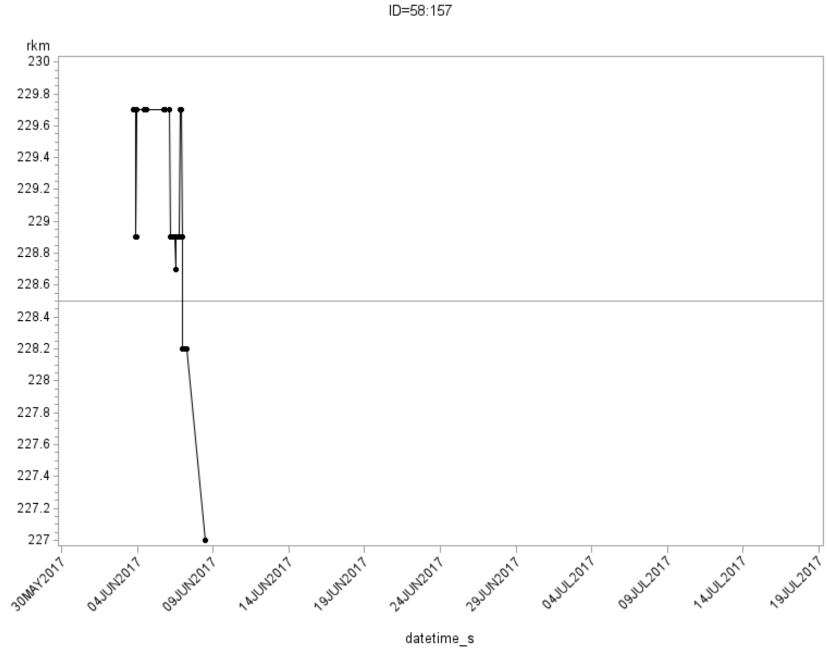
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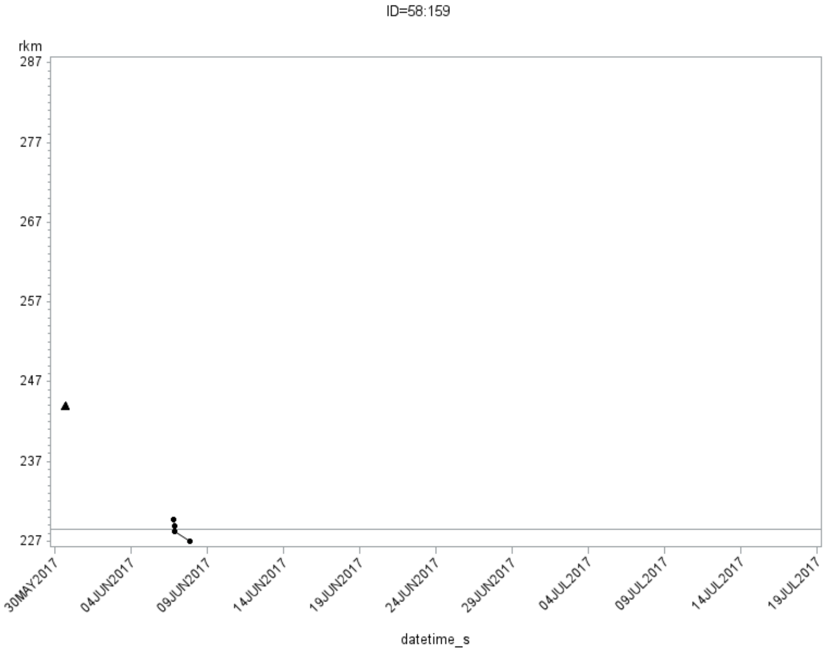
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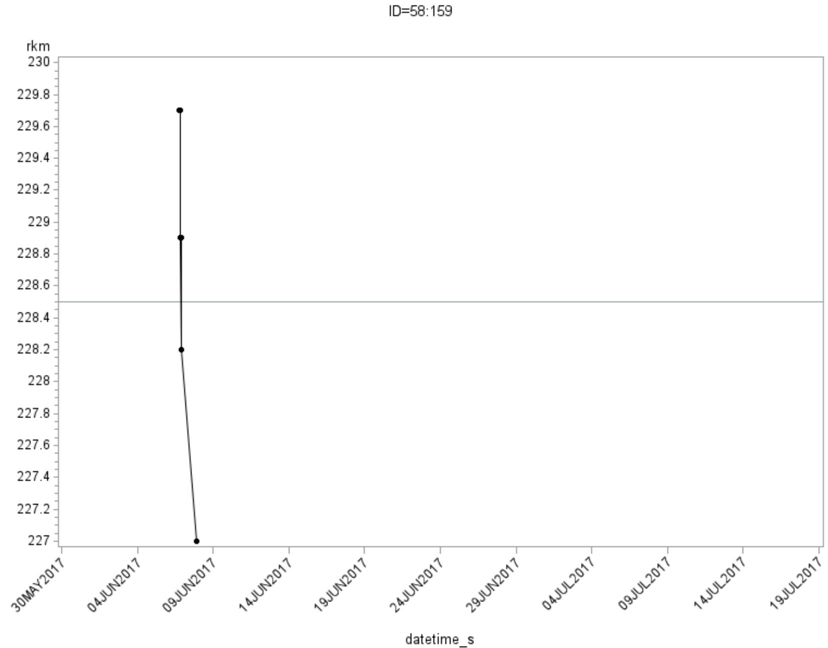
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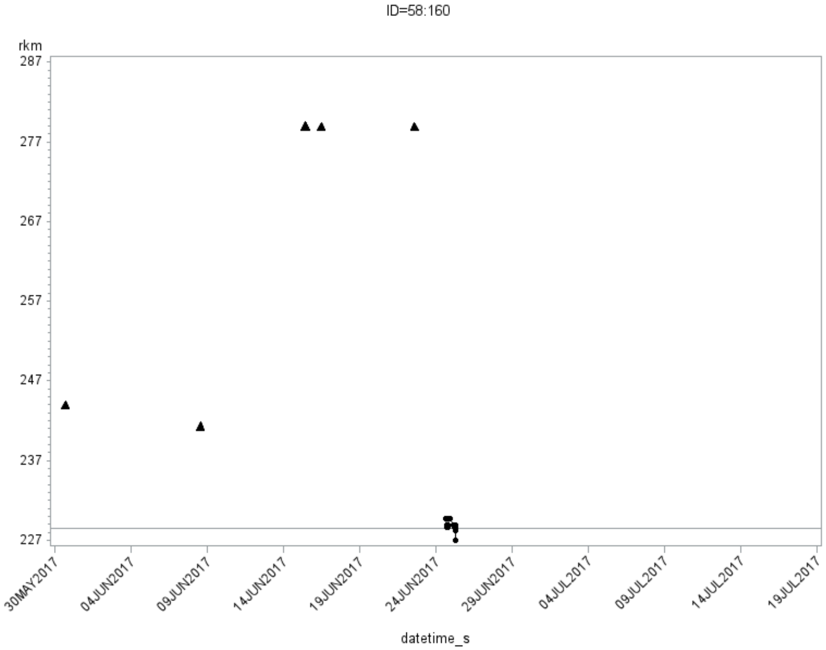
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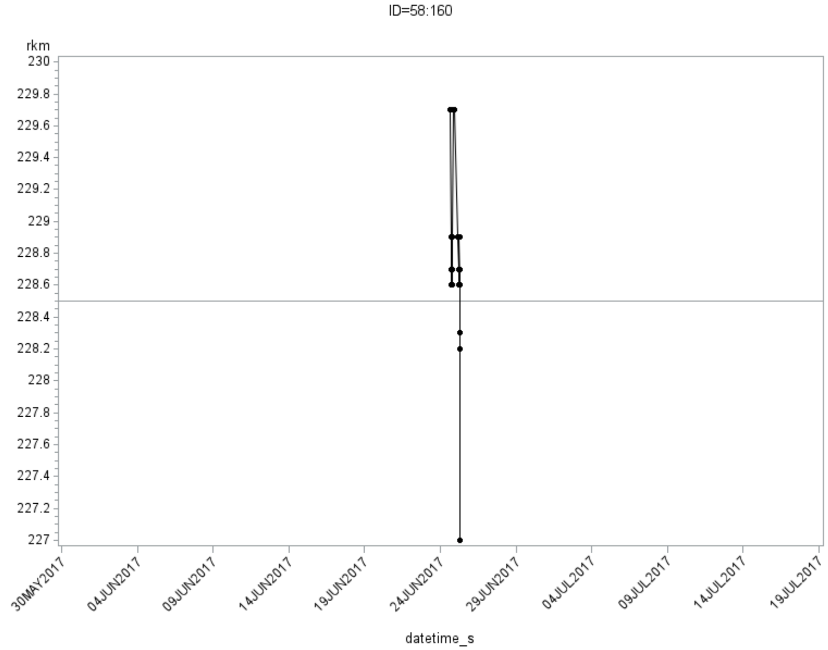
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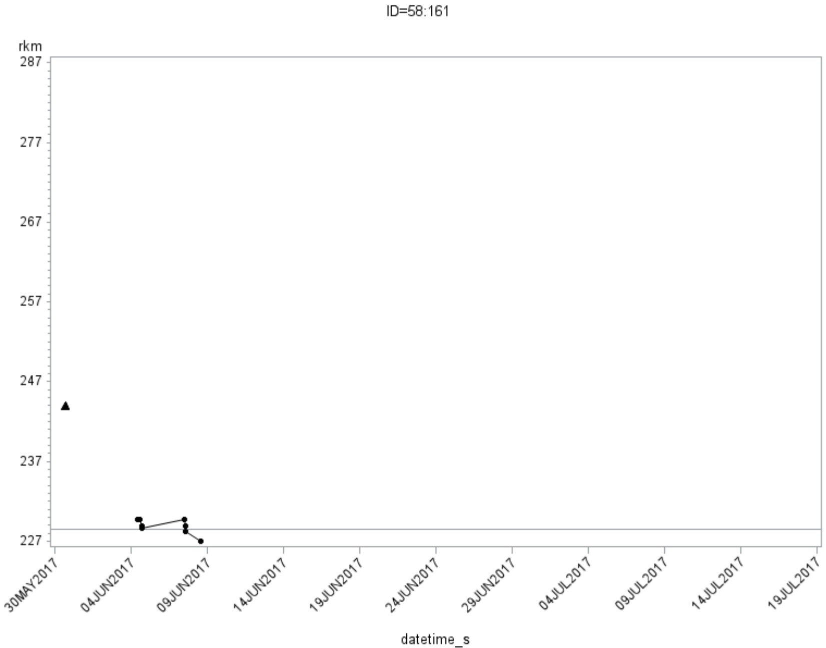
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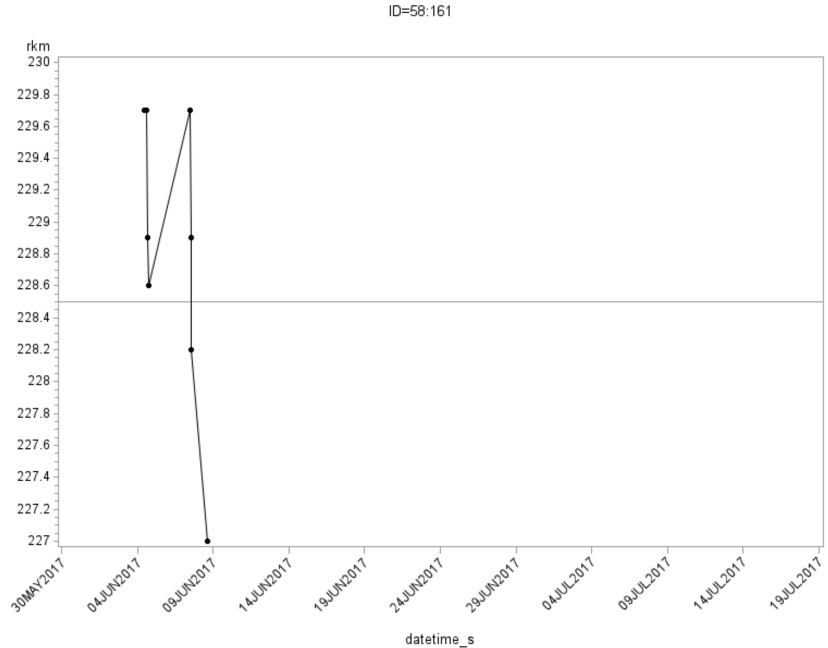
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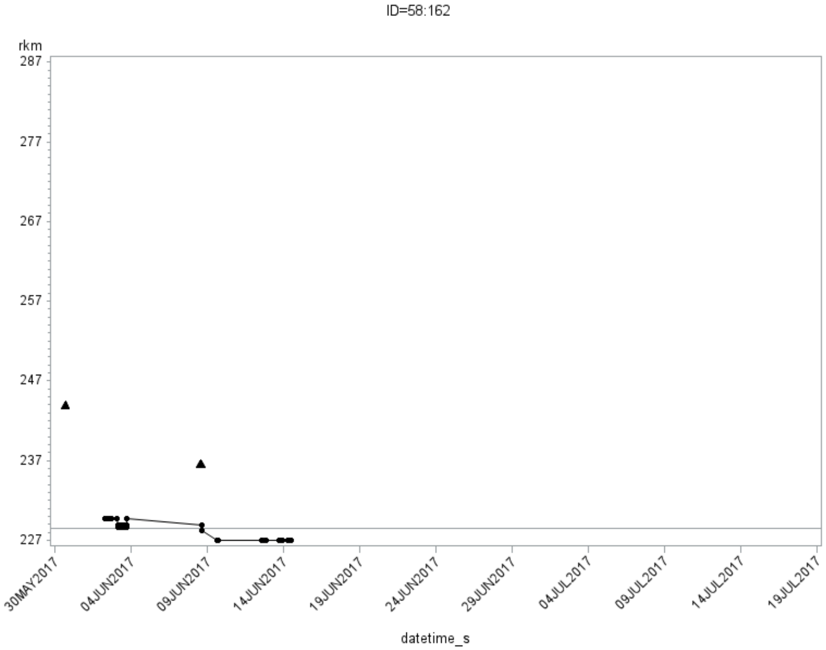
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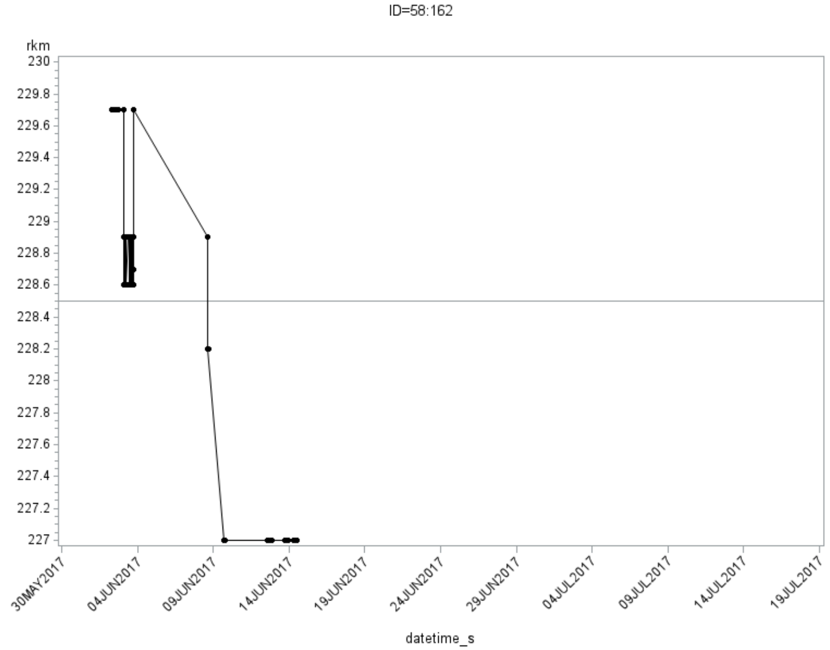
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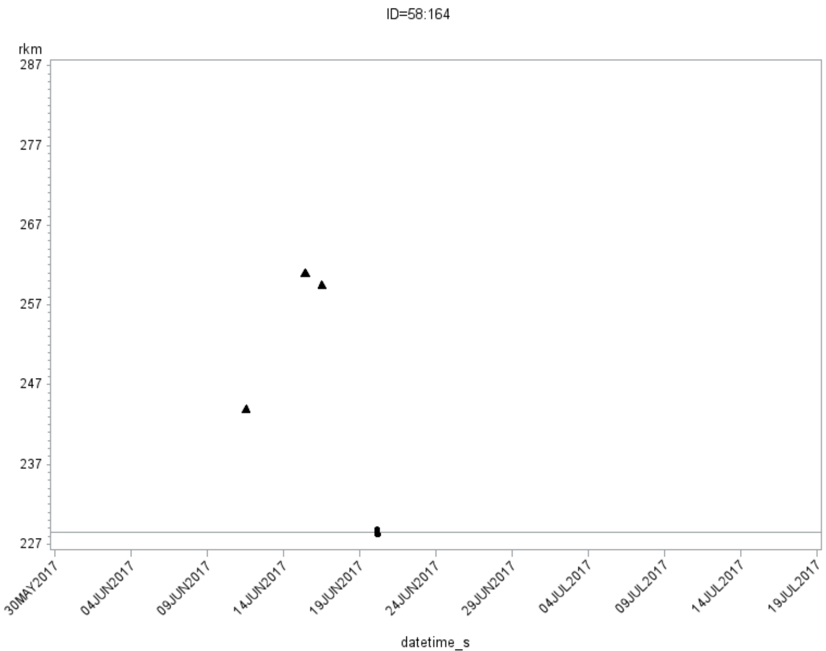
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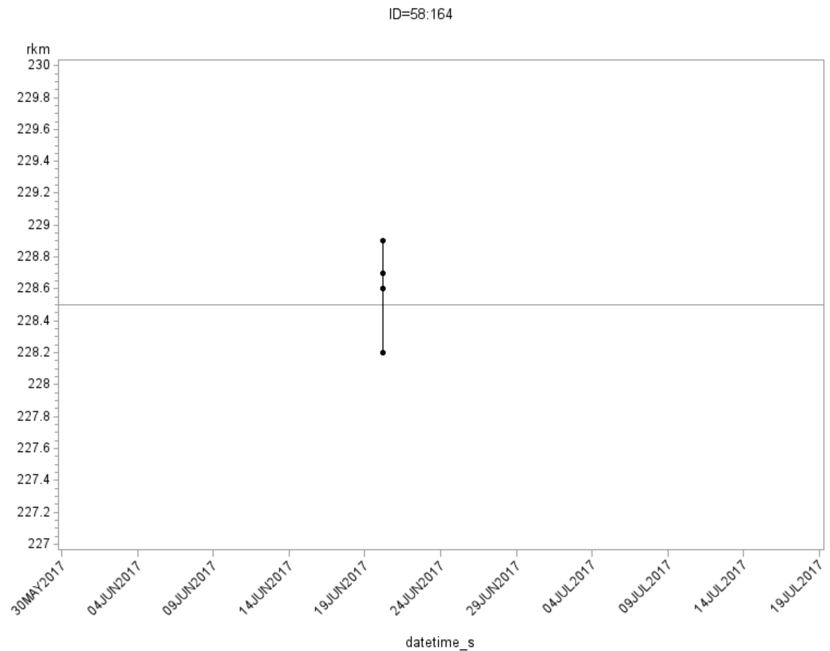
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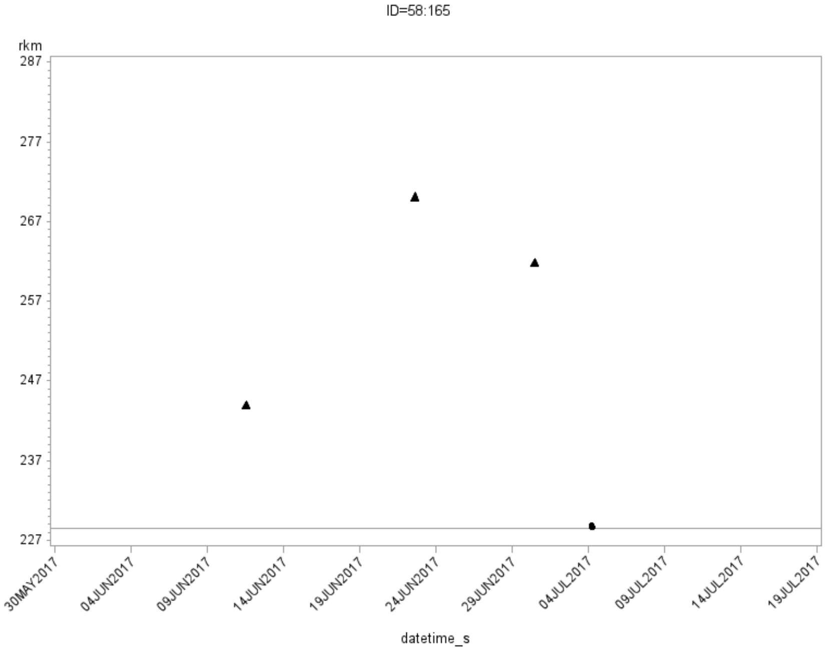
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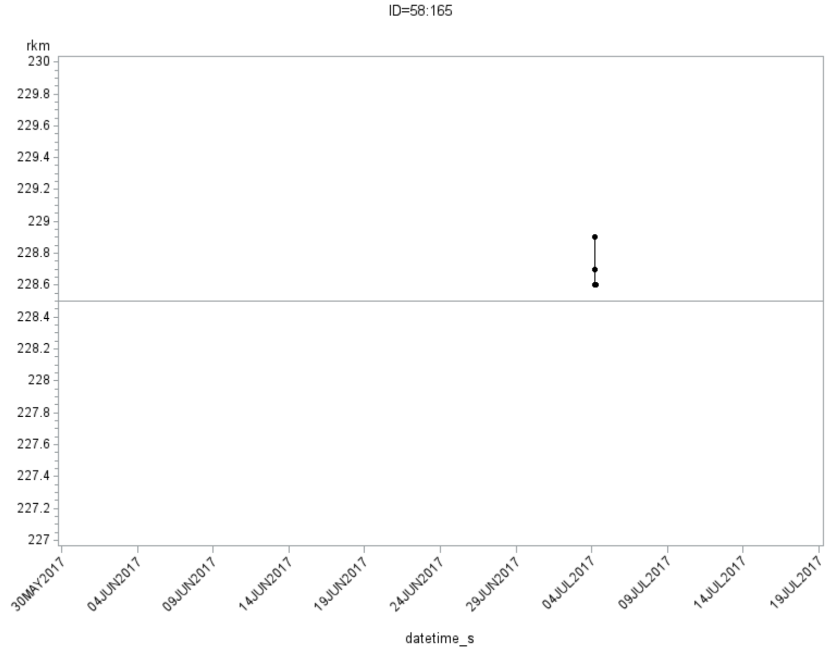
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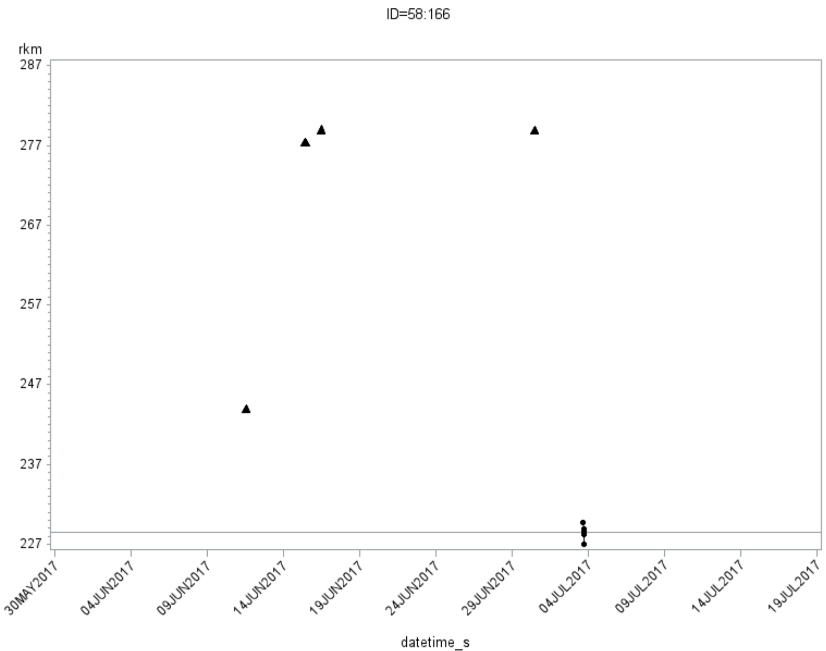
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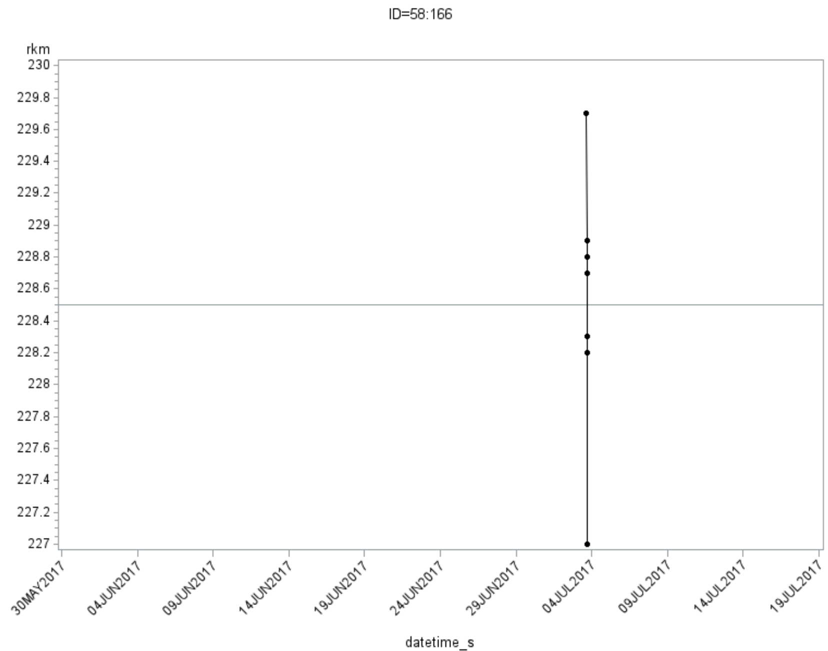
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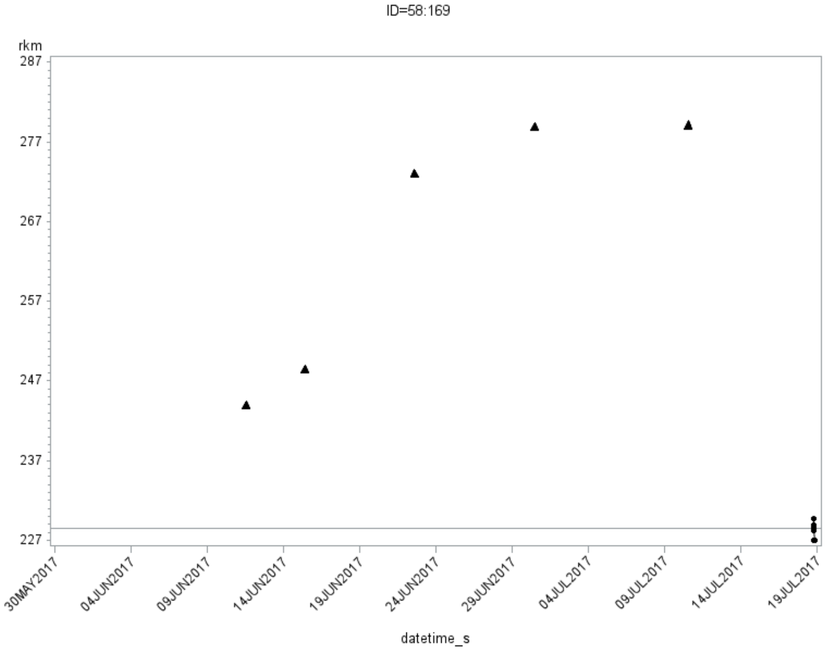
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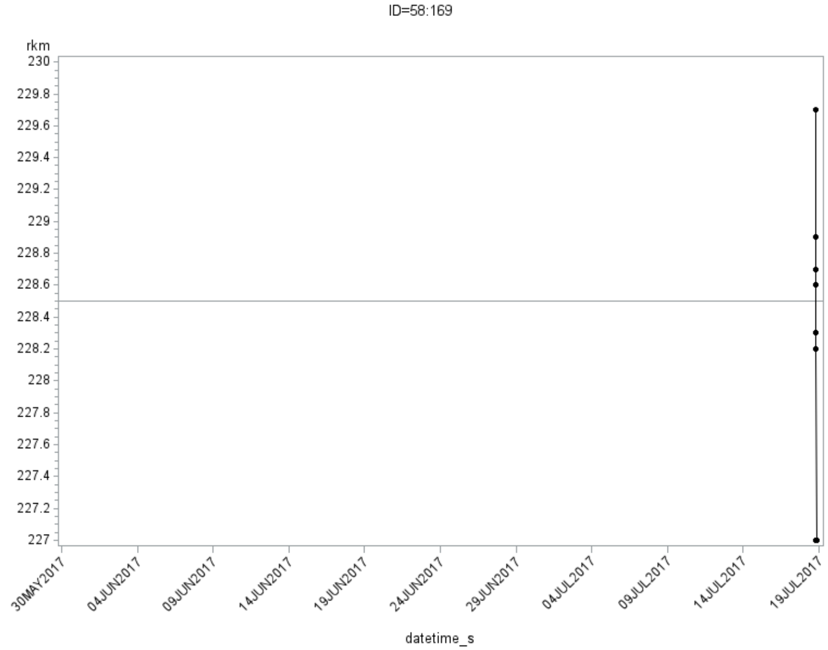
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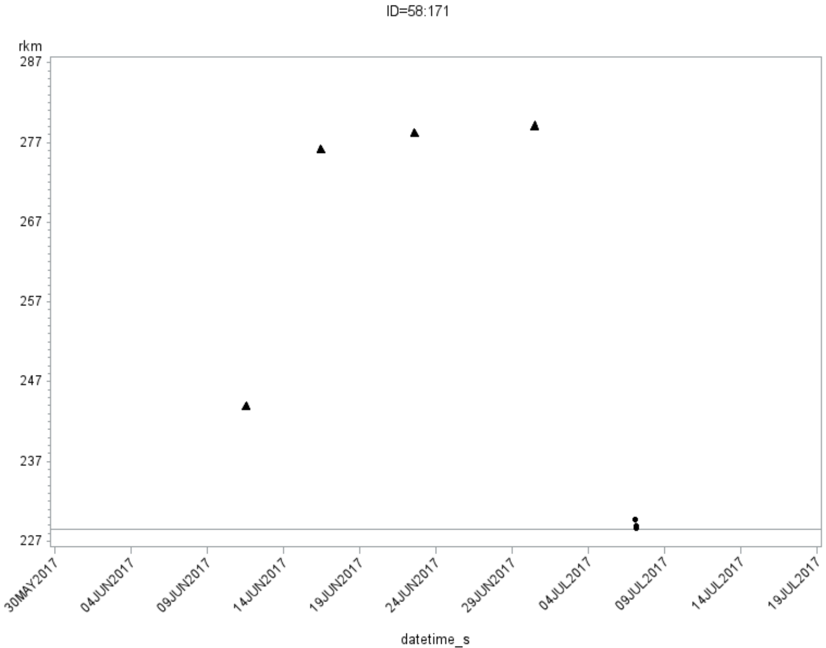
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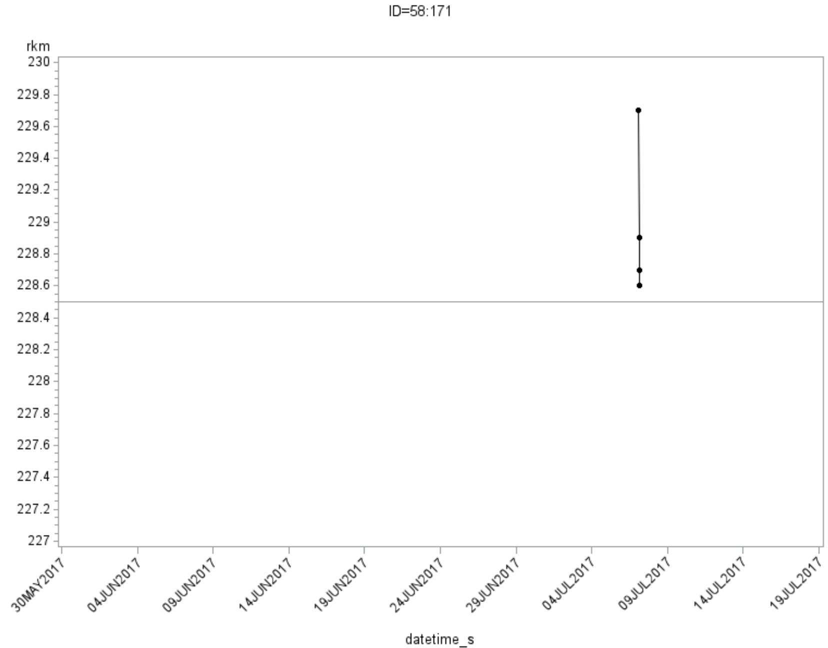
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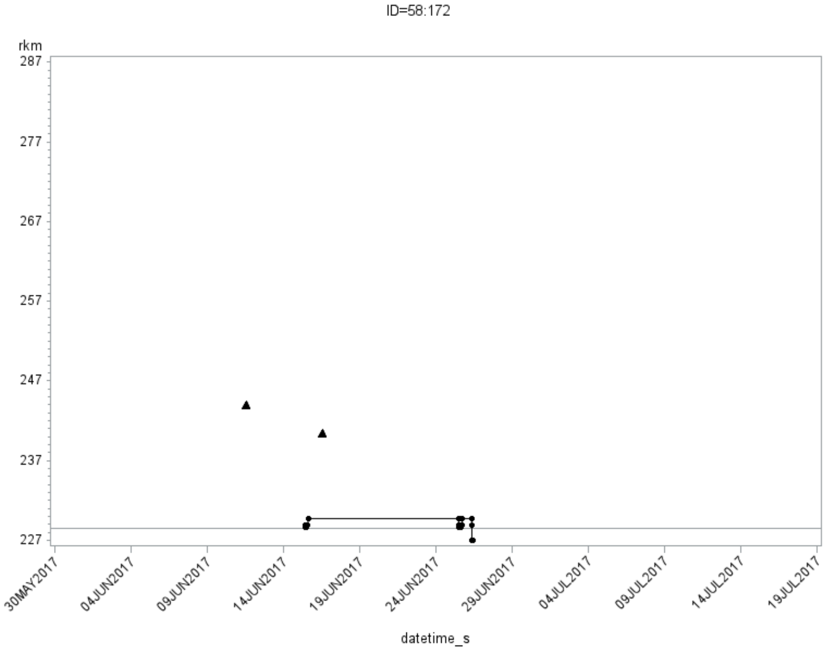
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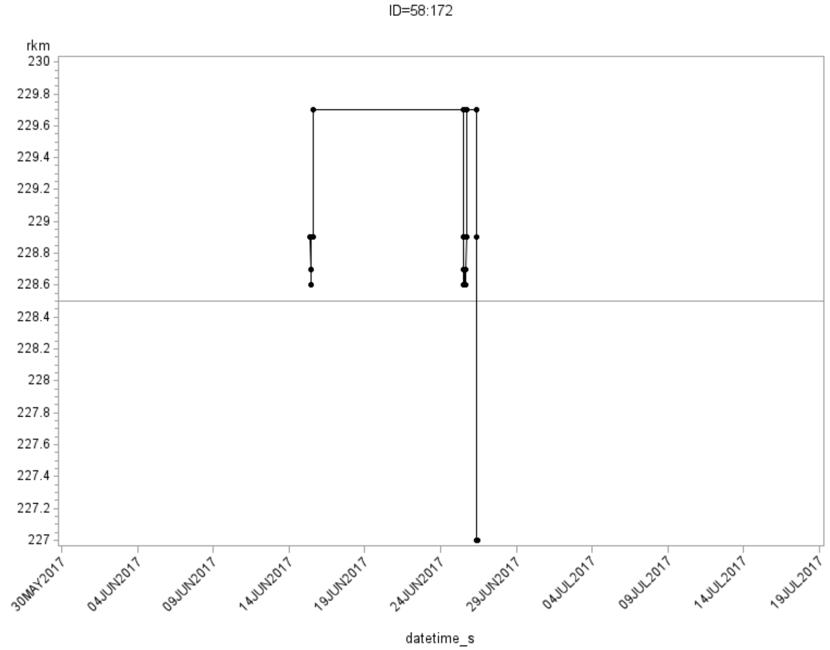
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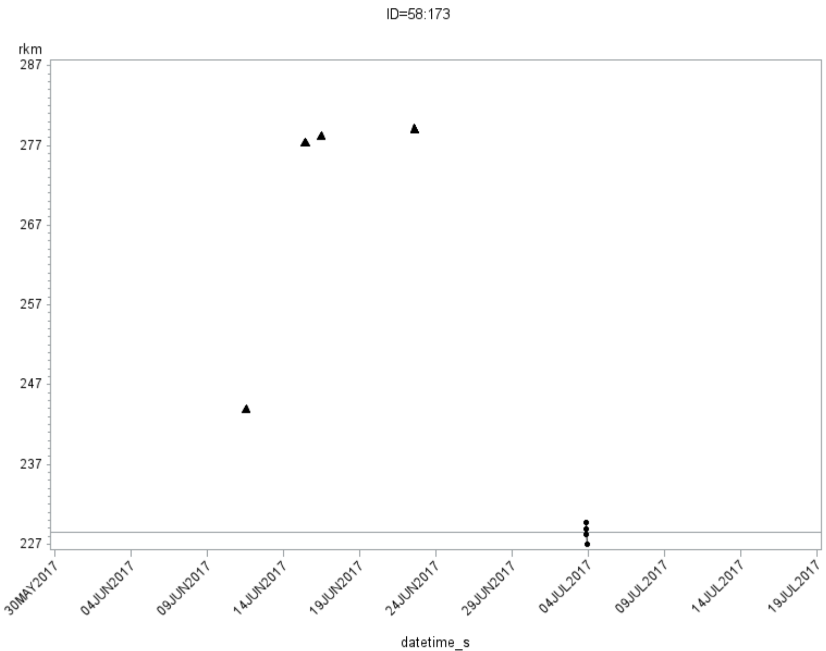
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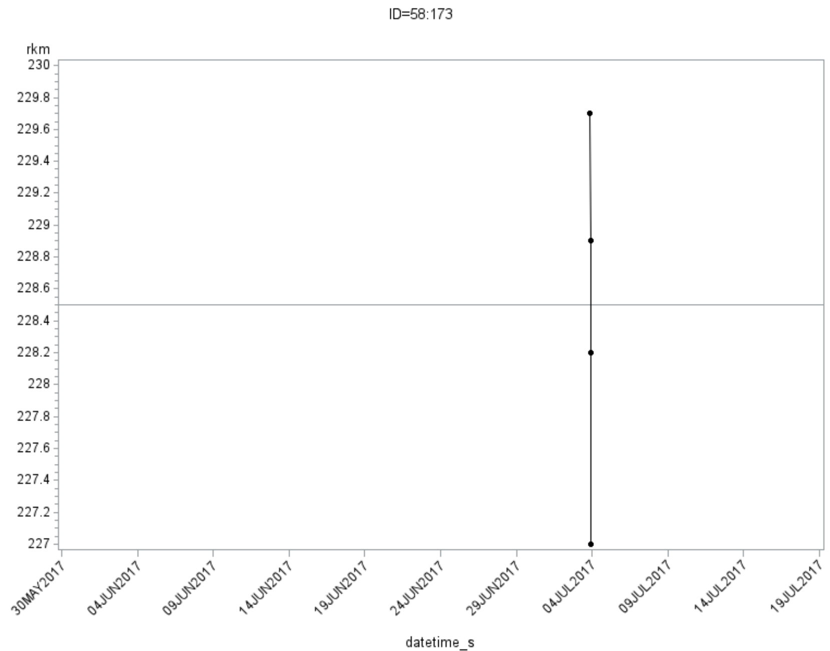
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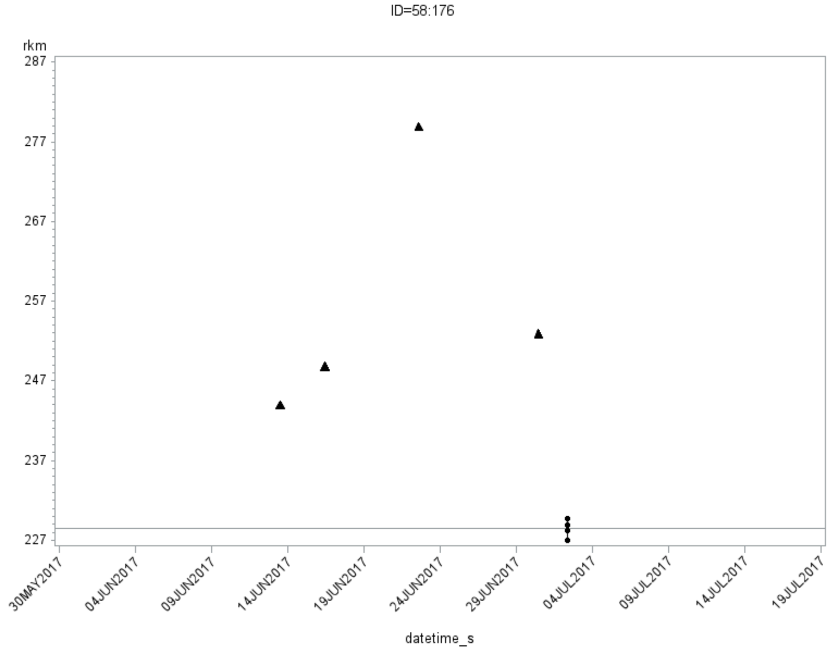
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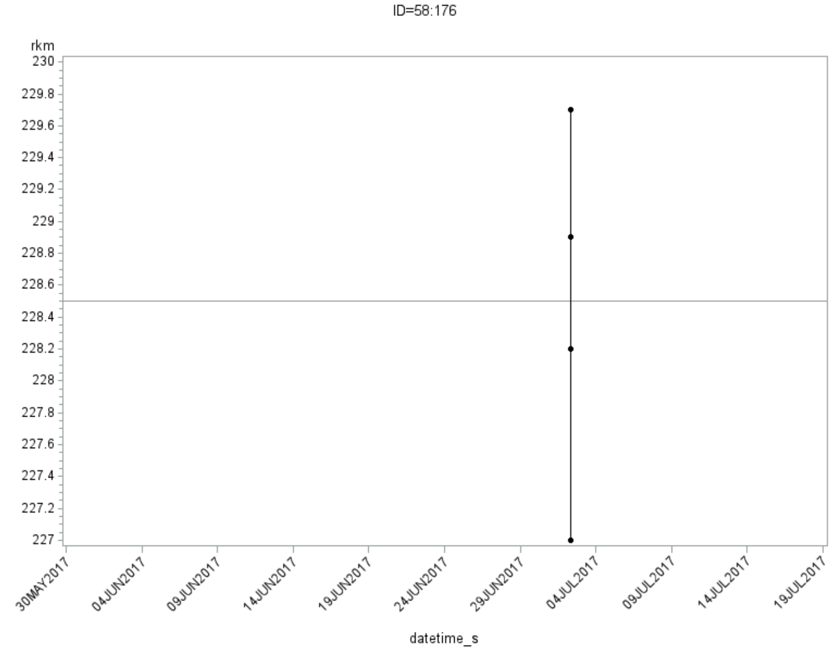
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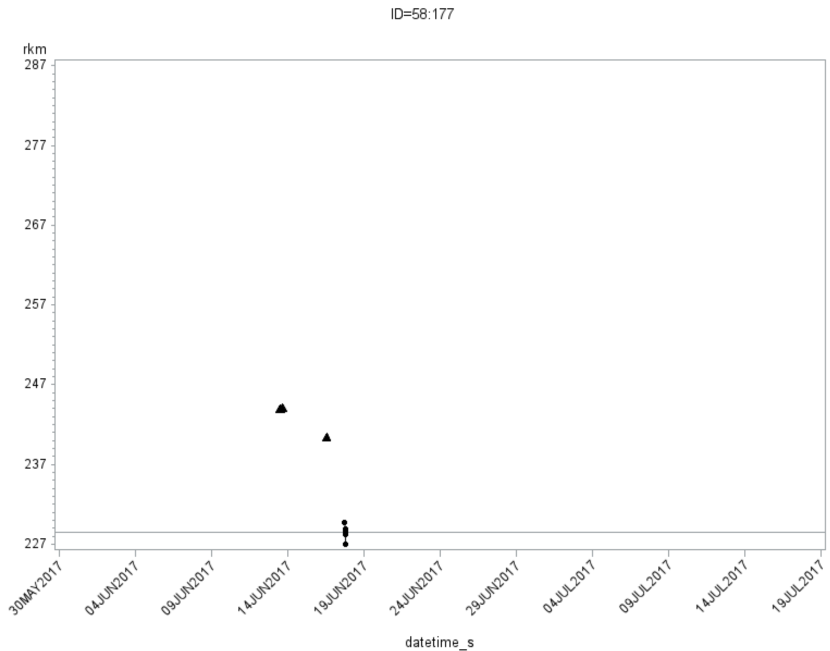
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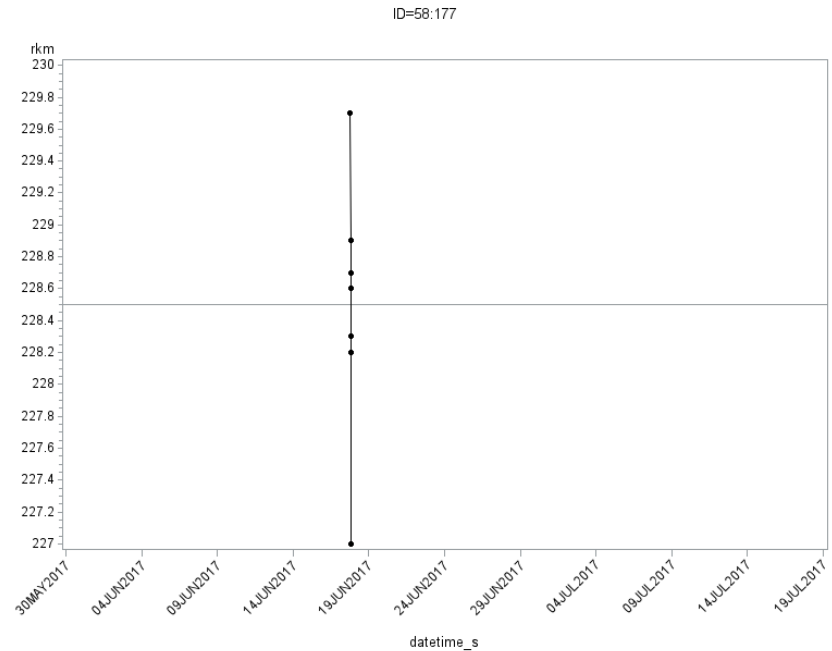
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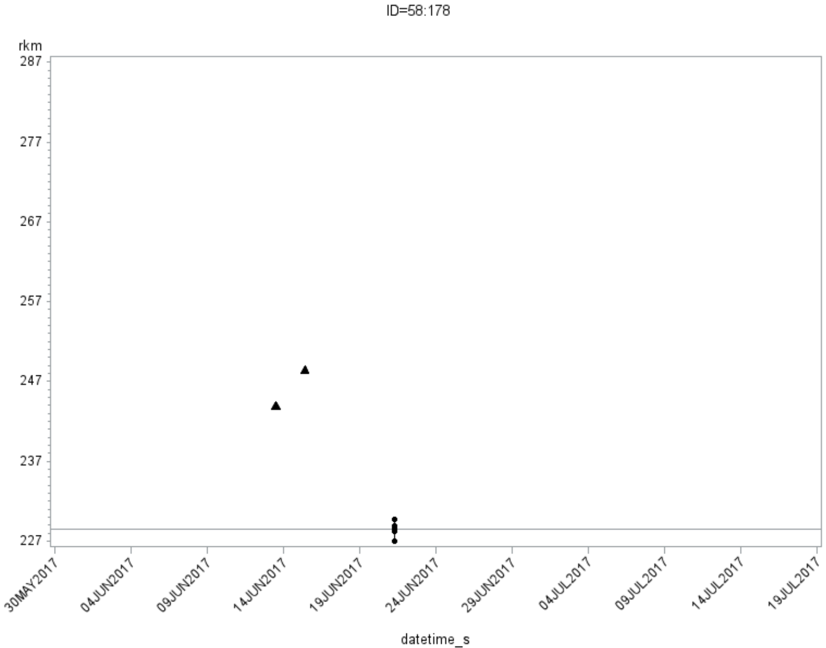
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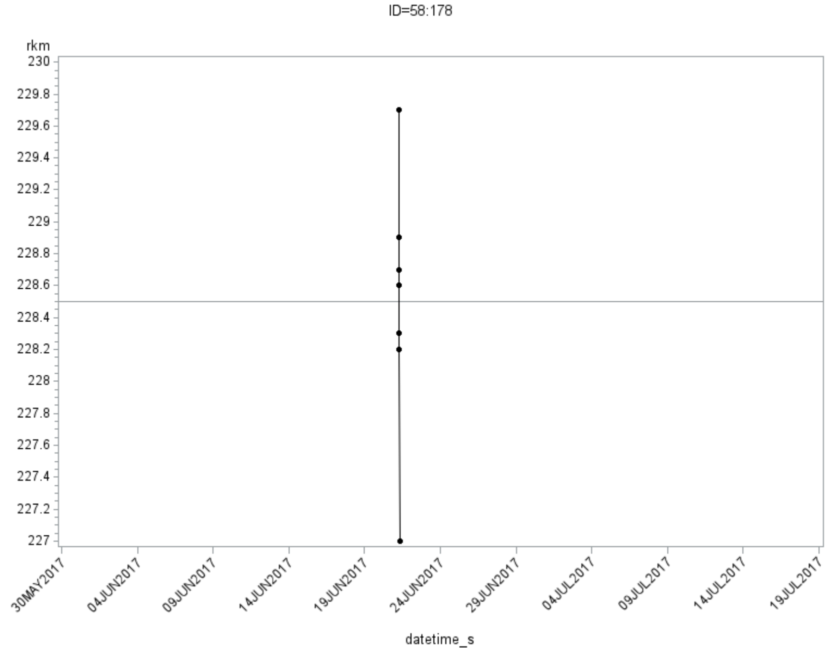
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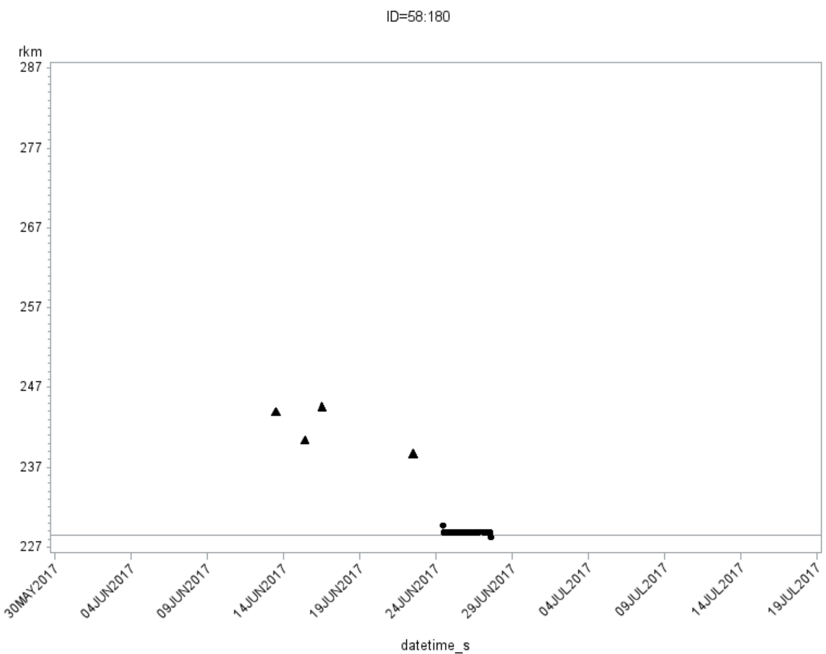
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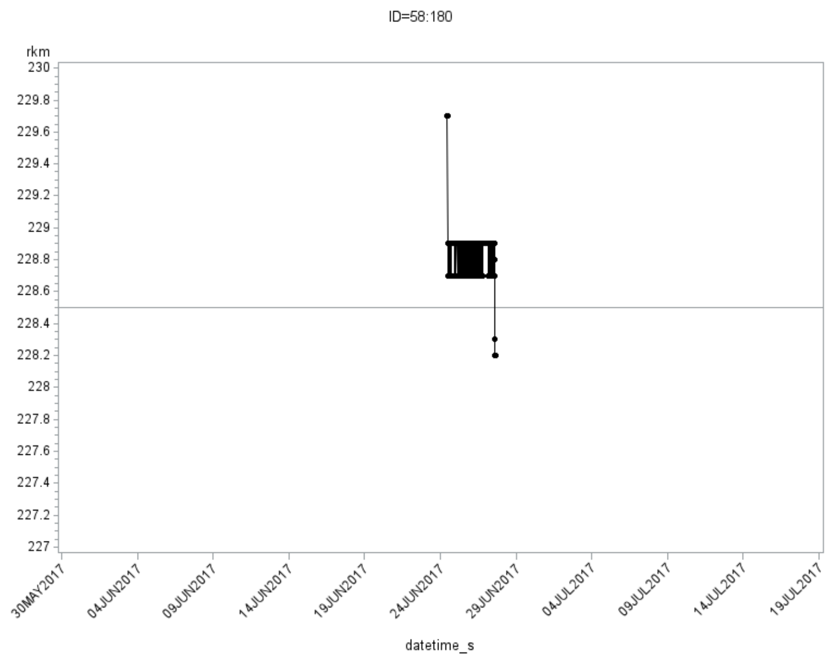
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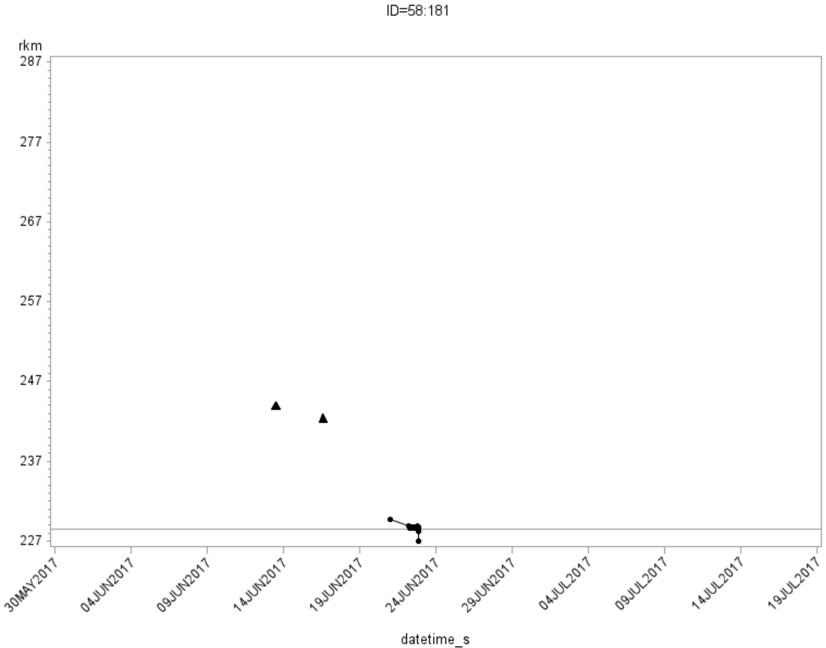
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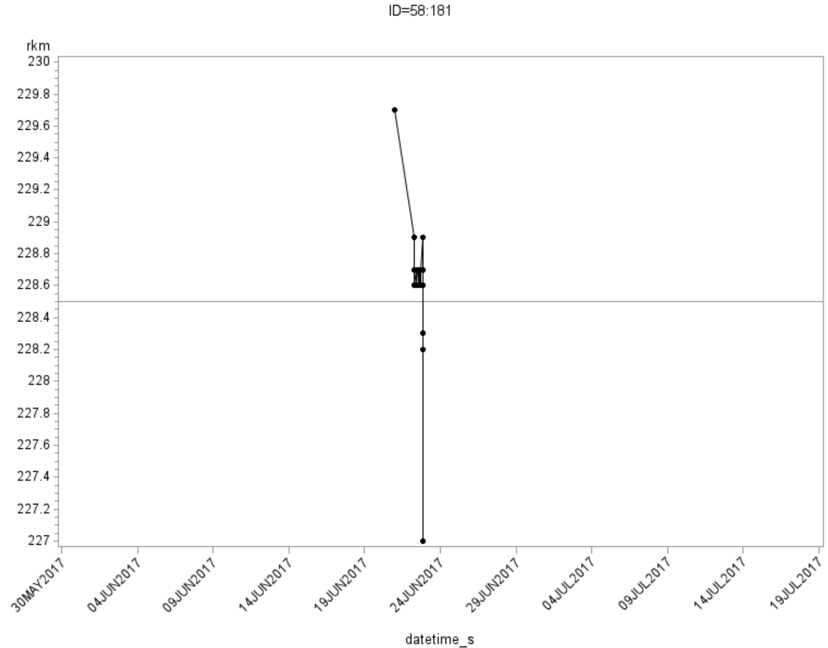
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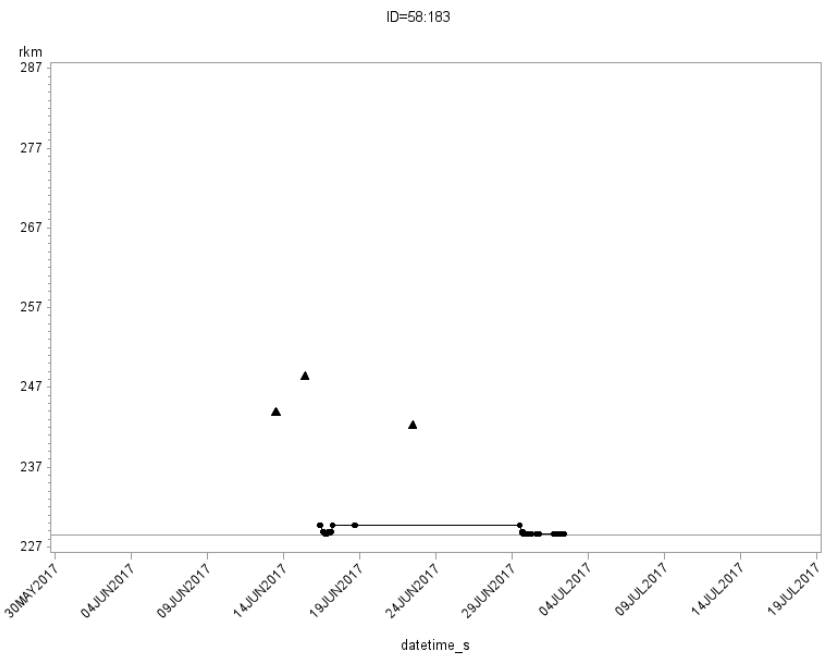
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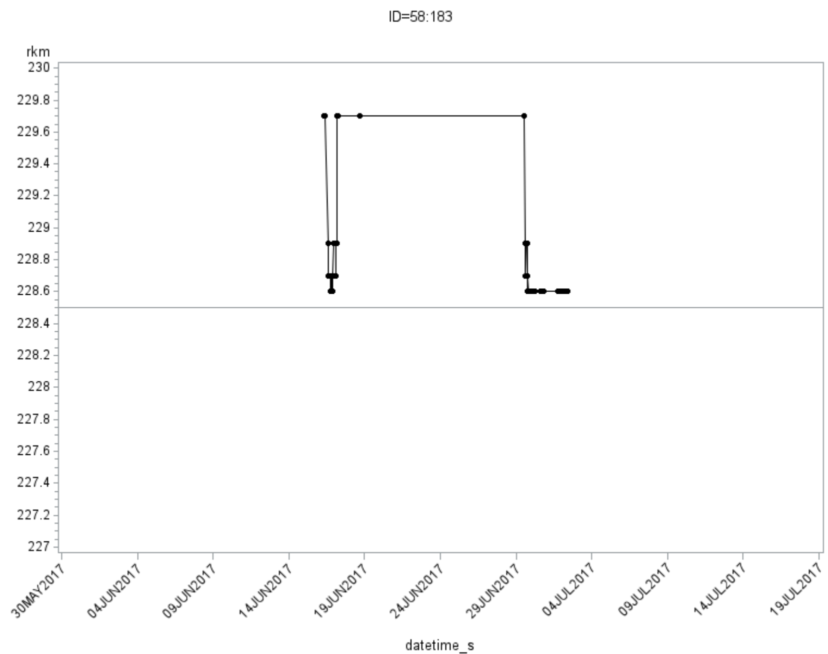
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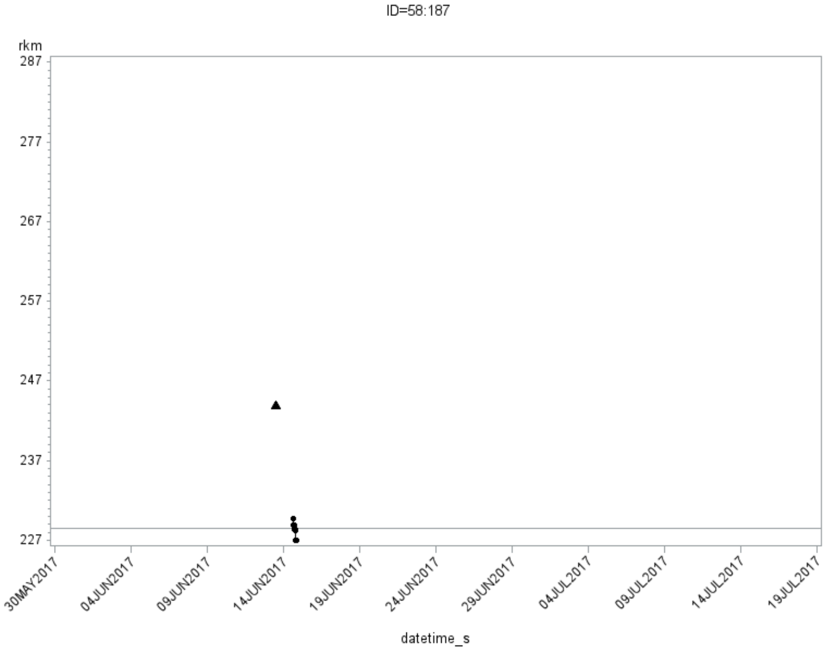
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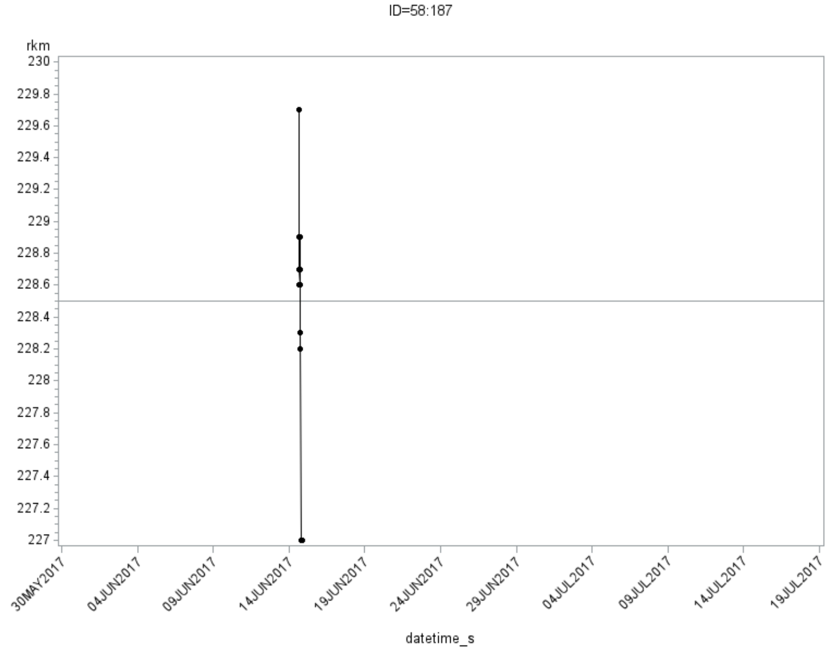
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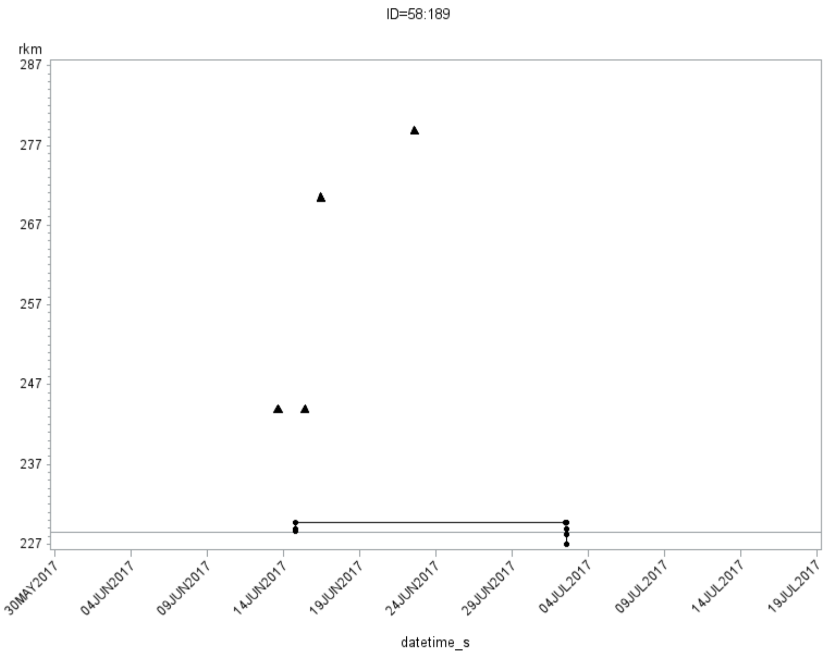
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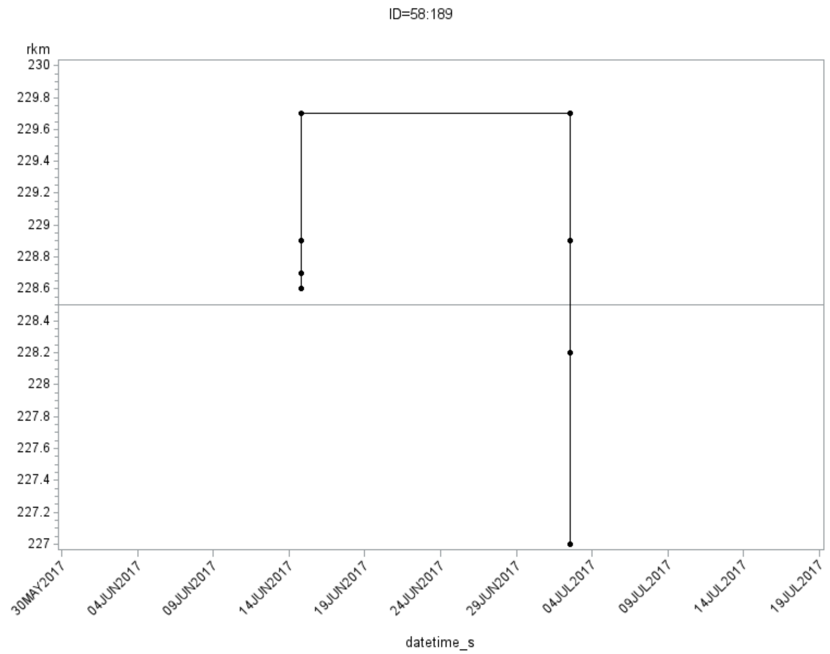
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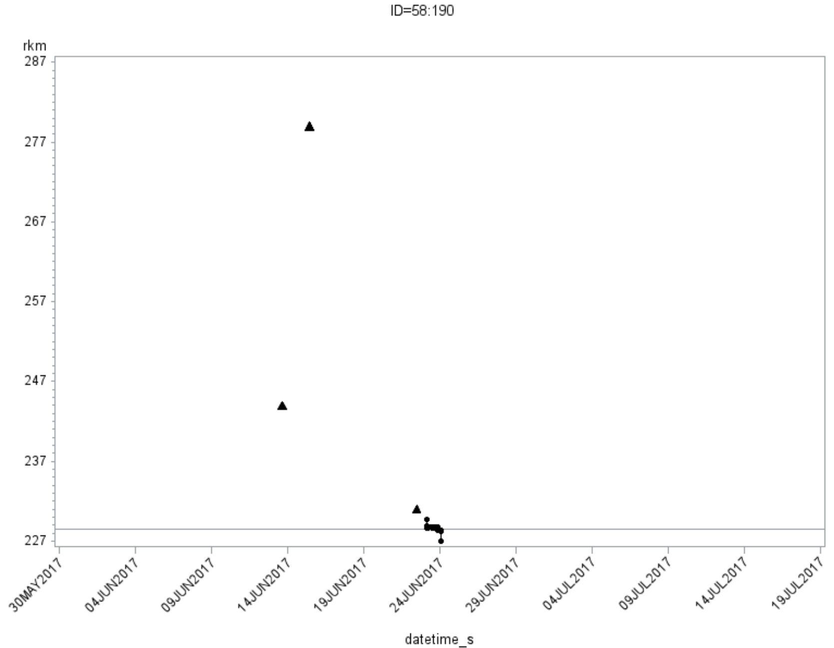
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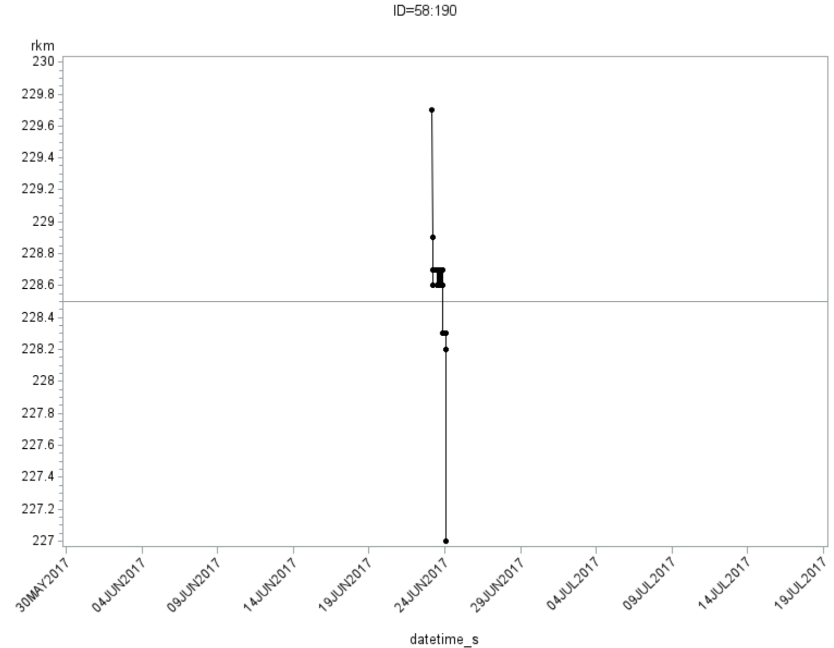
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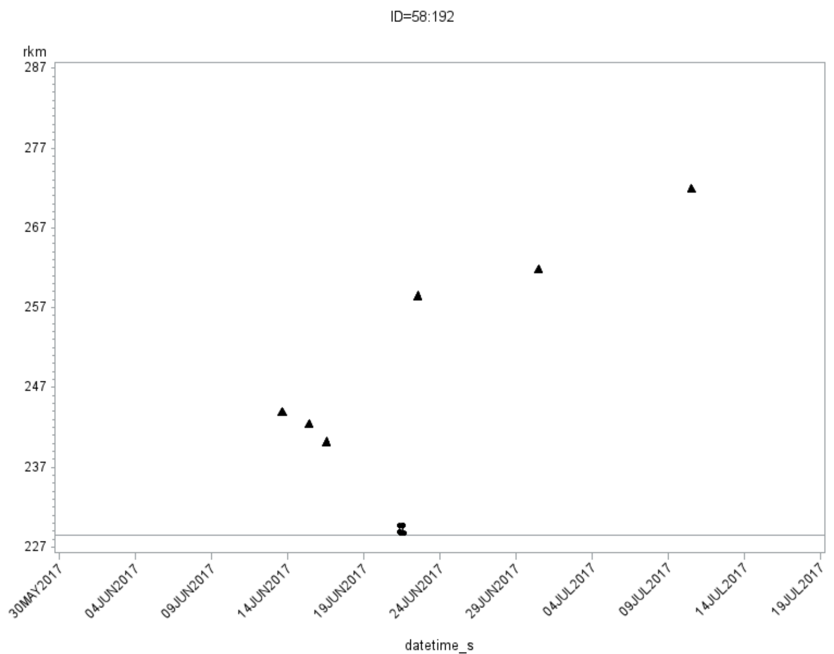
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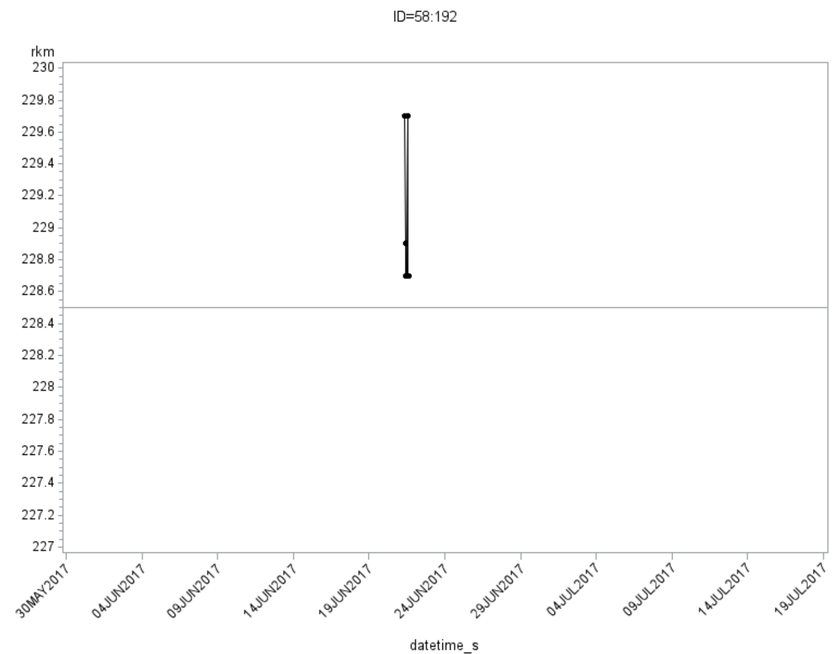
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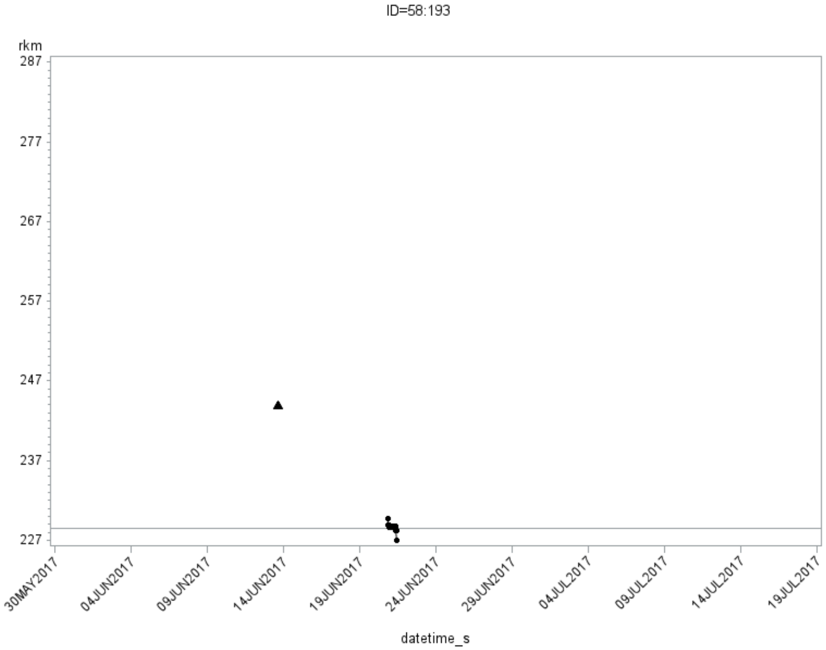
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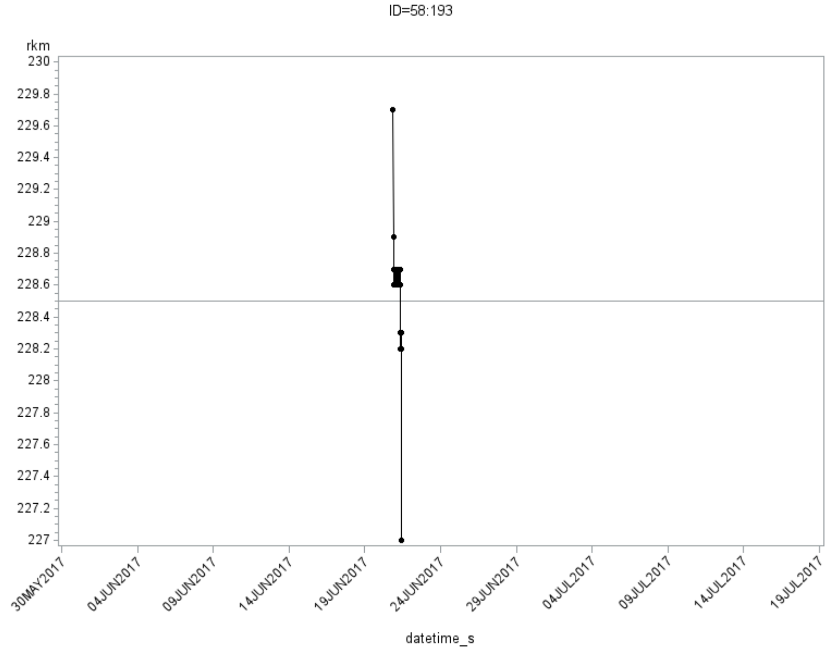
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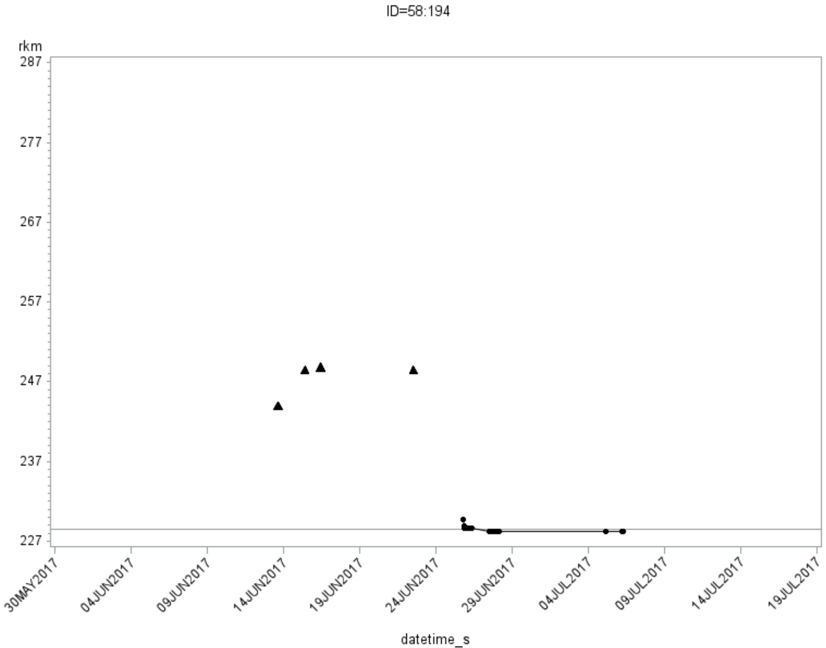
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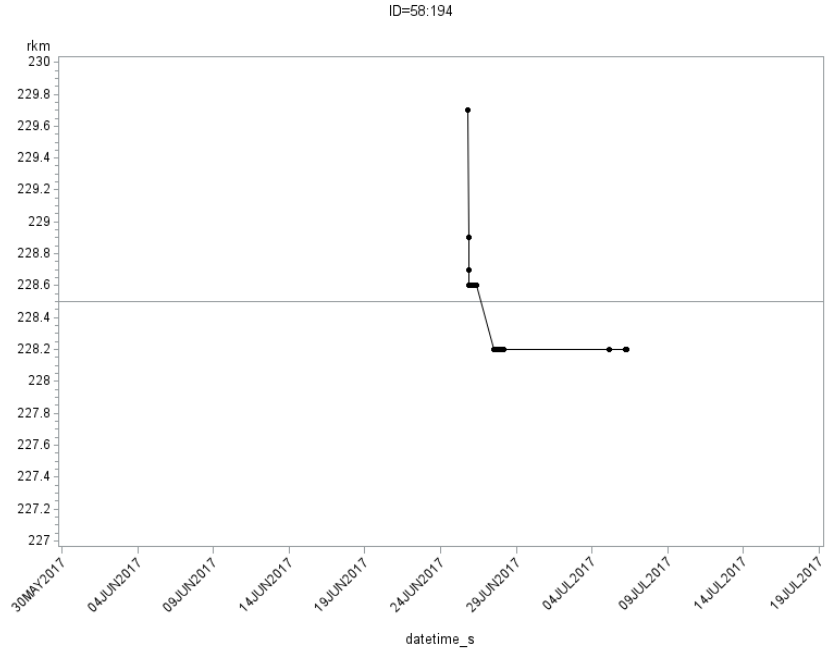
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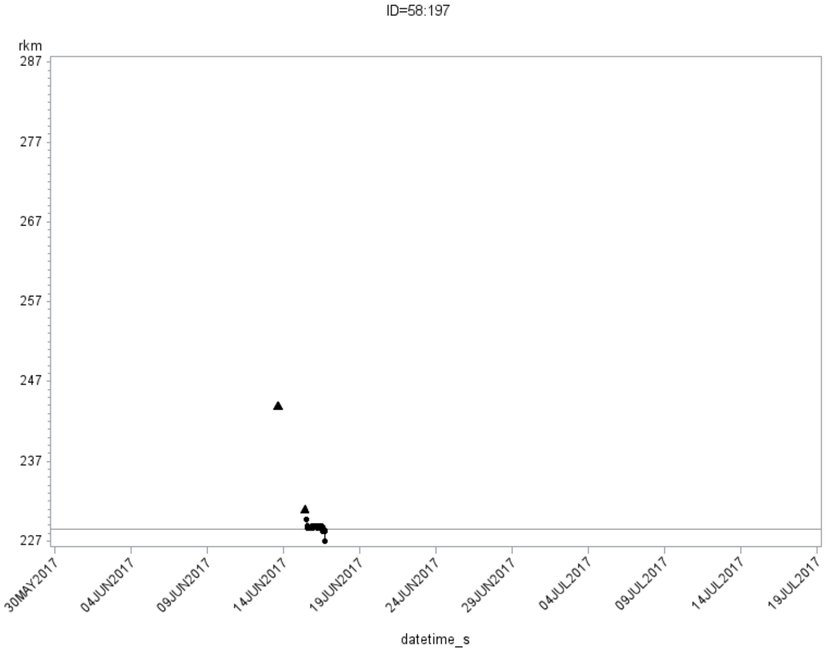
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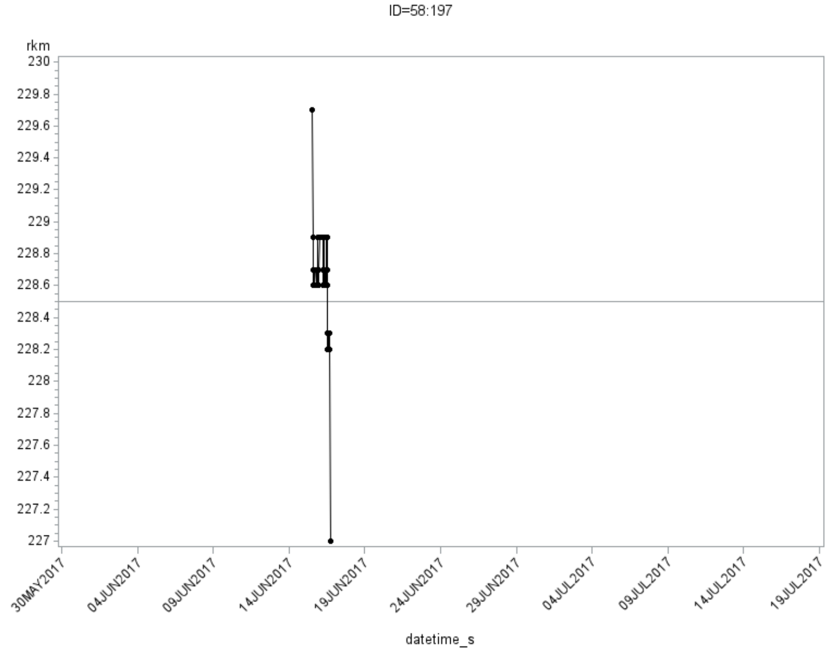
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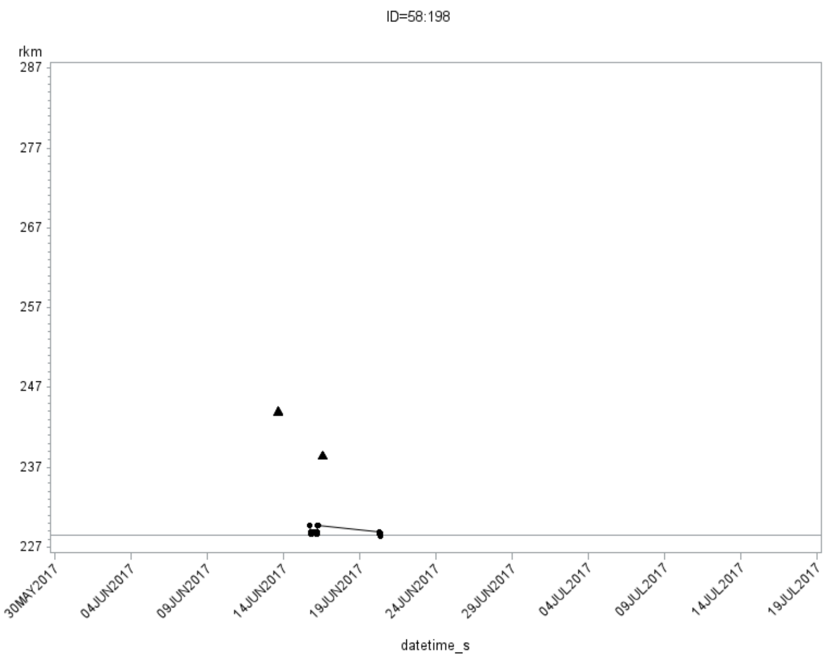
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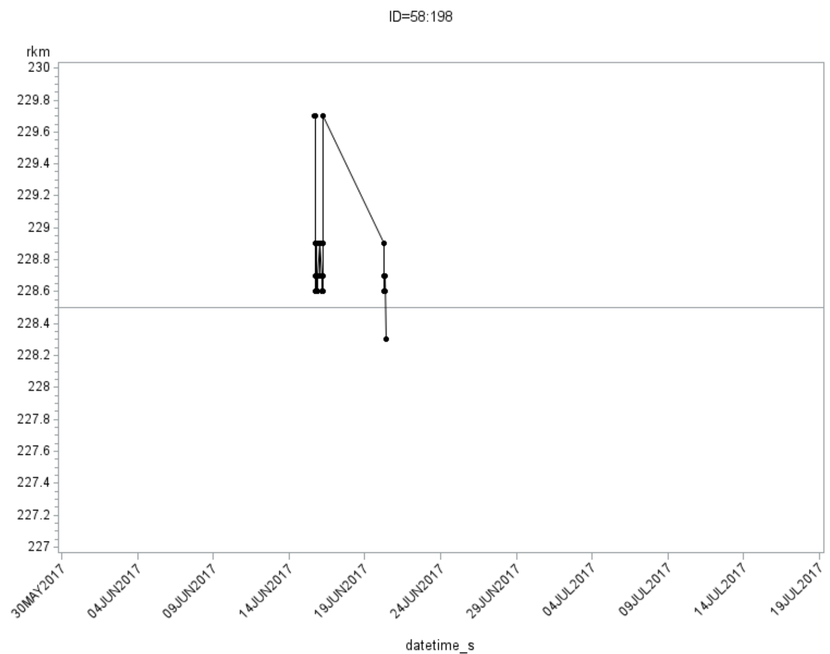
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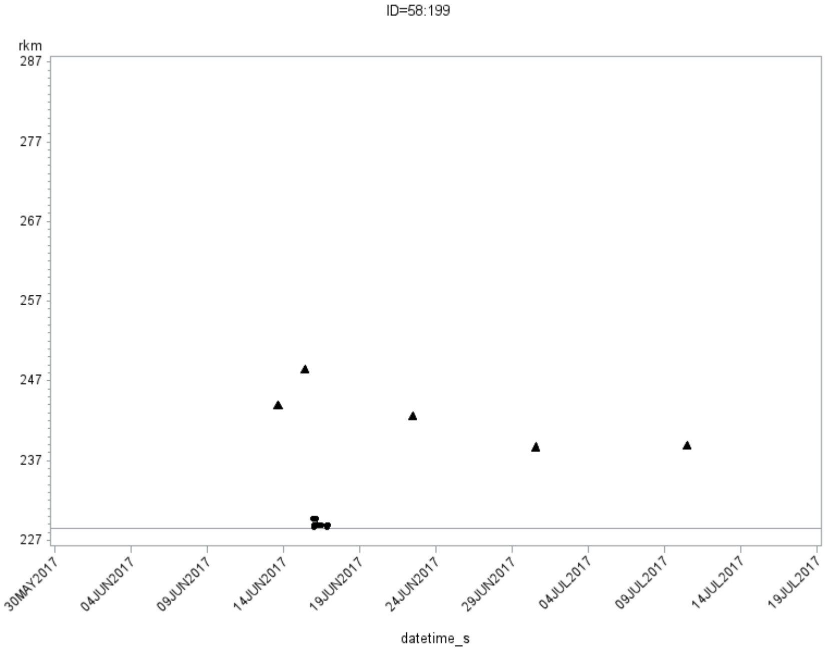
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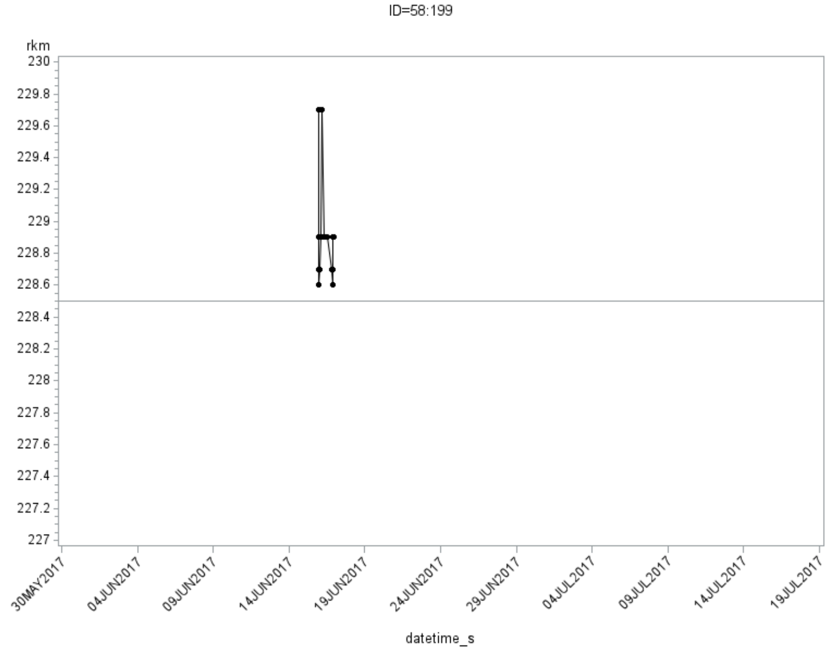
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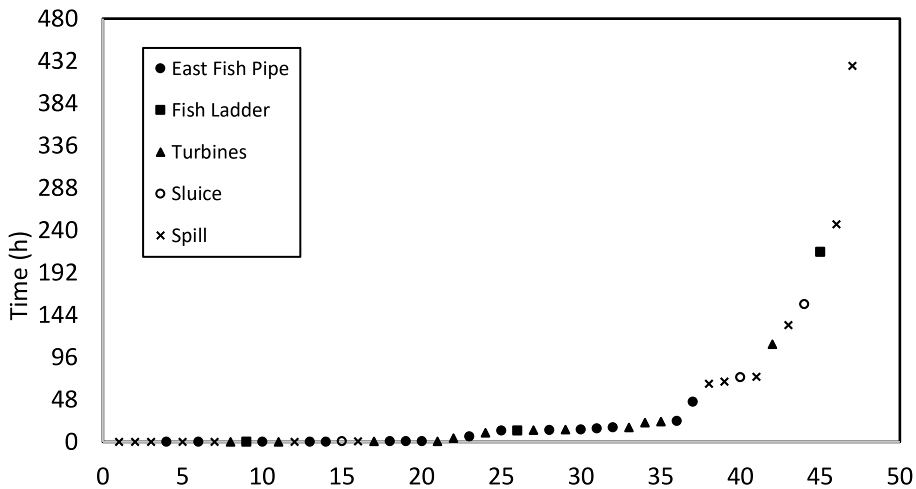
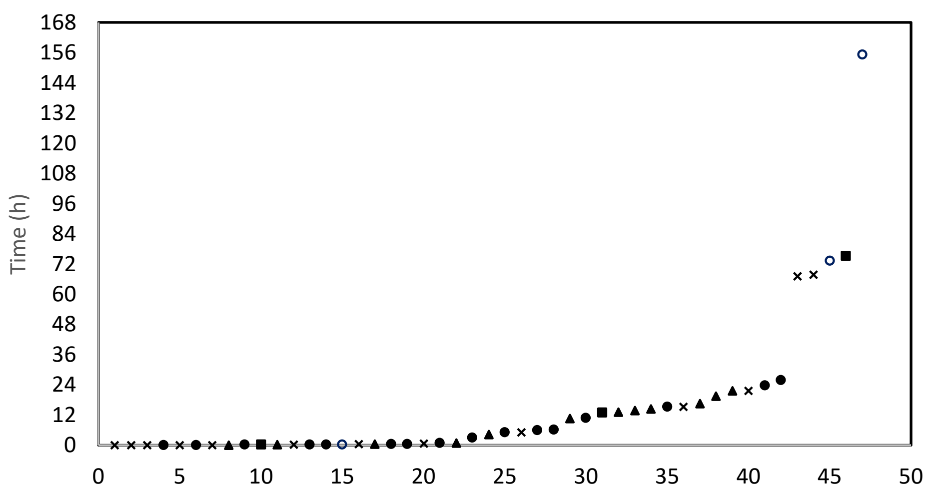
Study 21, Comment #4 Additional Information: The plots show unadjusted (A) and adjusted (B) residency durations by route of passage for each fish.

The majority of total (unadjusted) residency durations were less than 24 hours. Eleven fish had unadjusted residencies of 24 hours to 247 hours. Those passed by all routes, but most (6) passed by spill. The adjusted residency durations removed periods of time when a fish was not present in the study area as determined by sequential detection upstream at MS-26. All but five fish had adjusted residency durations of less than 26 hours. The remaining five had substantially longer durations of 67 hours to 155 hours. Two of those passed via sluice and were noted in the report as potentially dead before passage. Two passed via spill and one passed via the fish ladder.

A.



B.



Study 21, Comment #5 Additional Information: Summary table of residency durations (hours) in study area by route of passage.

ID	Approach	Duration	Adjusted Duration	Disposition
54:114	2	12.72	10.98	passed via east fish pipe
54:117	1	6.10	6.10	
54:127	1	0.63	0.63	
54:134	1	0.58	0.58	
54:137	1	0.13	0.13	
54:138	1	15.37	15.37	
54:139	2	14.08	3.16	
54:140	1	0.36	0.36	
54:141	2	16.26	5.11	
54:145	3	45.38	31.71	
58:160	2	13.64	6.22	
58:164	1	0.10	0.10	
58:177	1	0.33	0.33	
58:178	1	0.28	0.28	
58:187	1	0.90	0.90	
58:197	1	23.72	23.72	
Median (range)		3.5 (0.10-45.38)	2.03 (0.10-31.71)	
Mean (SD)		9.41 (12.00)	6.60 (9.00)	
54:109	1	0.28	0.28	passed via fish ladder
54:146	5	215.33	75.23	
58:150	1	13.06	13.06	
Median (range)		13.06 (0.28-215.33)	13.06 (0.28-75.23)	
Mean (SD)		76.22 (99.00)	29.52 (33.00)	
58:181	1	13.96	13.96	passed via Units 1-4
58:194	1	13.30	13.30	
54:111	2	23.01	19.53	passed via Units 5-8
58:169	1	0.21	0.21	
58:190	1	16.57	16.57	
58:193	1	10.67	10.67	
58:198	2	110.59	14.43	
54:103	1	0.48	0.48	passed via Units 9-10
54:108	1	0.30	0.30	
54:115	1	4.32	4.32	
54:125	1	21.65	21.65	
58:152	1	0.94	0.94	
Median (range)		11.98 (0.21-110.59)	11.98 (0.21-21.65)	
Mean (SD)		18.00 (29.00)	9.69 (8.00)	Passed via units (combined)

ID	Approach	Duration	Adjusted Duration	Disposition
58:153	2	156.30	155.33	
58:166	1	0.41	0.41	
58:180	1	73.35	73.35	passed via sluice
Median (range)		73.35 (0.41-156.30)	73.35 (0.41-155.33)	
Mean (SD)		76.68 (64.00)	76.36 (63.00)	
54:107	1	0.43	0.43	
54:116	1	0.01	0.01	
54:118	1	0.12	0.12	
54:142	2	65.84	21.73	
58:151	1	0.05	0.05	
58:154	2	246.83	5.25	
58:157	3	74.00	15.90	
58:159	1	0.31	0.31	passed via spill
58:161	2	68.71	67.28	
58:162	2	132.73	15.41	
58:173	1	0.18	0.18	
58:176	1	0.06	0.06	
58:189	2	426.30	0.75	
Median (range)		0.43 (0.01-426.30)	0.43 (0.01-67.28)	
Mean (SD)		78.12 (123.00)	9.80 (18.00)	
54:106	3	91.26	95.27	Third approach, stationary on MS-16
54:119	3	0.42	4.44	Returned upstream
54:120	2	270.79	1.79	Returned upstream
54:126	1	9.71	9.71	Returned upstream
54:131	3	350.69	12.43	Last detected MS-14
54:143	2	17.01	1.65	Returned upstream
54:144	1	1023.42	1023.42	Stationary on MS-15
58:156	2	22.71	15.19	Returned upstream
58:165	1	159.25	159.25	Stationary on MS-16
58:171	1	636.19	636.19	Stationary on MS-16
58:183	2	380.23	82.28	Second approach, Stationary on MS-16
58:192	2	6.59	5.80	Returned upstream
58:199	2	23.43	19.51	Returned upstream
Median (range)		91.34 (0.42-1023.42)	13.81 (1.65-1023.42)	
Mean (SD)		241.7 (305.00)	164.3 (311.00)	

Study 21, Comment #'s 8 and 9 Additional Information: Additional analysis of operational conditions during approaches (periods of residency within the project area).

Individual periods of residency for each approach by each fish that entered the study area, whether resulting in 'passage' or 'failure to pass', were delineated, except that approaches that resulted in immobility upstream of the dam were omitted. Those events suggested mortality, either before or after arrival, and resulted in long periods that were not representative of live fish behavior. Total project discharge, spill discharge, and turbine unit discharge were summarized for each individual period of residency (Table 1). Of 87 approaches: 43 (49%) occurred during non-spill conditions. Of all approaches, 47 (54%) resulted in passage by known route. Overall, 34 passage events were by non-spill gate routes and 18 of those (53%) occurred during non-spill periods.

The probability of passage during non-spill periods was further investigated by compiling contingency tables of successful and failed passage attempts[1] by mean operational condition during the period of residency and calculating predicted probabilities (Proc CATMOD, SAS V9.4). Passage probabilities were calculated for all routes combined (units, sluice, east fish pipe, fish ladder) and for the east fish pipe alone, by classified total generation and turbine unit type operations (at least one unit of type on during any time during period or off during entire period). The Analyses were limited because there were too few observations in many categorical cells. The probability of passage per approach was greater during high generation (58%) than mid-level generation (35%). The probability of passage when units 1-4 were off but units 4-8 and units 9-10 were operating (50%) appeared slightly higher than when all three unit types were operating (40%), though with a high standard error driven by small sample size. The probability of passage via the east fish pipe was greater during high generation (42%) than during mid-level generation (22%, Table 2).

[1] Note that some periods of residency were followed by migration upstream to likely spawning habitat. It is not clear that all approaches to the study area represented passage attempts.

Table 1. Range and mean (with standard deviation, SD) discharge (cfs) for individual periods of residency (approach).

			Total Discharge		Spill		Total Generation		Units 1-4		Units 5-8		Units 9-10	
Fish ID	Approach	Route/Disposition (0=end Approach)	Range	Mean (SD)	Range	Mean (SD)	Range	Mean (SD)	Range	Mean (SD)	Range	Mean (SD)	Range	Mean (SD)
54:103	1	passed Units 9-10	16813-18451	17632 (1158)	3193-4877	4035 (1191)	12442-12490	12466 (34)	3917-3939	3928 (16)	5241-5241	5241 (0)	3262-3333	3297 (50)
54:107	1	passed spill	38494-38507	38500 (9)	27854-27928	27891 (53)	9411-9476	9443 (46)	2377-2477	2427 (71)	4093-4093	4093 (0)	2905-2941	2923 (25)
54:108	1	passed Units 9-10	57047-57047	57047 (.)	47340-47340	47340 (.)	7753-7753	7753 (.)	2324-2324	2324 (.)	3113-3113	3113 (.)	2316-2316	2316 (.)
54:109	1	passed fish ladder	40830-40830	40830 (.)	28236-28236	28236 (.)	11402-11402	11402 (.)	3357-3357	3357 (.)	5026-5026	5026 (.)	3019-3019	3019 (.)
54:111	1	0	4412-18217	12931 (3685)	0-5200	1073 (1841)	3212-12056	10682 (2783)	739-4013	3513 (1021)	1174-4689	3999 (1117)	1183-3587	3169 (733)
54:111	2	passed Units 5-8	12798-12816	12807 (13)	0	0	11628-11644	11636 (11)	3898-3918	3908 (14)	4862-4862	4862 (0)	2865-2868	2866 (3)
54:114	1	0	1204-12778	8145 (2311)	0	0	23-11611	6942 (2319)	8-3983	2291 (1158)	12-5129	3310 (1603)	3-3036	1342 (476)
54:114	2	passed east fish pipe	12583-12716	12661 (45)	0	0	11484-11601	11546 (42)	4027-4257	4126 (70)	4339-4512	4452 (55)	2946-3010	2968 (22)
54:115	1	passed Units 9-10	8139-9248	8248 (258)	0	0	6908-8023	7002 (263)	0	0	5392-6510	5477 (266)	1514-1542	1526 (8)
54:116	1	passed spill	56135-56135	56135 (.)	46399-46399	46399 (.)	7780-7780	7780 (.)	2214-2214	2214 (.)	3364-3364	3364 (.)	1514-1542	1526 (8)
54:117	1	passed east fish pipe	14025-15534	14801 (637)	0-1224	574 (587)	12830-13146	13035 (71)	3567-3861	3743 (68)	6219-6290	6245 (23)	3025-3089	3047 (17)
54:118	1	passed spill	36346-36346	36346 (.)	23367-23367	23367 (.)	10845-10845	10845 (.)	3428-3428	3428 (.)	4396-4396	4396 (.)	3021-3021	3021 (.)
54:125	1	passed Units 9-10	23439-51485	32746 (6993)	9957-39956	19869 (7748)	9551-12606	11753 (828)	2662-3712	3397 (246)	4169-5851	5353 (523)	2720-3136	3003 (88)
54:127	1	passed east fish pipe	13714-13792	13763 (43)	0	0	12563-12649	12617 (47)	3716-3777	3754 (33)	6255-6276	6262 (12)	2591-2606	2601 (8)
54:134	1	passed east fish pipe	6222-6253	6234 (17)	0	0	5093-5126	5104 (19)	0	0	3591-3625	3602 (19)	1502-1502	1502 (0)
54:137	1	passed east fish pipe	14440-14440	14440 (.)	0	0	13287-13287	13287 (.)	3863-3863	3863 (.)	6181-6181	6181 (.)	3243-3243	3243 (.)
54:138	1	passed east fish pipe	6169-13871	9590 (2396)	0	0	4955-12691	8403 (2419)	95-3858	2214 (1470)	2607-6624	4423 (1235)	1146-3062	1766 (388)
54:139	1	0	9399-9444	9415 (19)	0	0	8282-8330	8300 (20)	2084-2108	2101 (11)	4767-4776	4772 (5)	1408-1456	1427 (20)
54:139	2	passed east fish pipe	6460-6488	6477 (9)	0	0	5251-5283	5272 (12)	1357-1428	1380 (26)	2571-2621	2599 (17)	1267-1314	1292 (15)
54:140	1	passed east fish pipe	16074-16074	16074 (.)	1219-1219	1219 (.)	13699-13699	13699 (.)	3920-3920	3920 (.)	6575-6575	6575 (.)	3204-3204	3204 (.)
54:141	1	0	6281-9444	9221 (734)	0	0	5162-8330	8098 (733)	0-2128	1985 (496)	3699-4802	4691 (249)	1395-1463	1423 (18)
54:141	2	passed east fish pipe	6479-6483	6481 (2)	0	0	5277-5283	5280 (4)	1357-1370	1363 (9)	2612-2612	2612 (0)	1294-1314	1304 (14)
54:142	1	0	6169-13871	9415 (2225)	0	0	4955-12691	8235 (2249)	95-3858	1779 (1340)	2607-6627	4796 (1474)	1146-3062	1660 (388)
54:142	2	passed spill	15710-18027	17012 (1030)	1226-3574	2560 (1074)	13091-13333	13250 (59)	3666-3843	3807 (46)	6355-6403	6371 (14)	3050-3095	3072 (12)
54:145	1	0	2415-12899	5884 (4473)	0	0	1219-11769	4683 (4517)	0-3965	1187 (1705)	441-4611	1952 (1864)	757-3216	1544 (1010)
54:145	2	0	2145-11988	7070 (4744)	0	0	963-10835	5889 (4759)	0-4083	1990 (1962)	0-4627	1855 (1804)	508-3260	2044 (1075)

			Total Discharge		Spill		Total Generation		Units 1-4		Units 5-8		Units 9-10	
Fish ID	Approach	Route/Disposition (0=end Approach)	Range	Mean (SD)	Range	Mean (SD)	Range	Mean (SD)	Range	Mean (SD)	Range	Mean (SD)	Range	Mean (SD)
54:145	3	passed east fish pipe	12403-12676	12548 (89)	0	0	11273-11546	11418 (89)	3693-3952	3825 (85)	4313-4326	4320 (4)	3263-3289	3272 (9)
54:146	1	0	12401-12676	12570 (67)	0	0	11269-11546	11440 (67)	3693-3952	3840 (64)	4312-4338	4325 (7)	3247-3295	3276 (11)
54:146	2	0	13421-28740	19358 (4097)	0-15983	6268 (4366)	7982-13019	11908 (986)	0-4307	3549 (847)	1991-5334	5062 (436)	3027-3468	3297 (92)
54:146	3	0	11407-16369	15712 (758)	912-1226	1113 (109)	8978-13948	13442 (770)	1019-4179	3813 (462)	4623-6623	6404 (407)	3177-3336	3224 (27)
54:146	4	0	9165-14440	10828 (2125)	0	0	7979-13287	9642 (2144)	969-3881	1780 (1224)	5311-6196	5810 (335)	1635-3268	2052 (694)
54:146	5	passed fish ladder	15271-18027	16241 (1116)	1020-3577	1868 (1145)	12936-13307	13170 (85)	3529-3891	3776 (87)	6300-6392	6339 (21)	3018-3089	3055 (17)
58:150	1	passed fish ladder	27928-45124	39689 (4417)	14170-32864	27234 (5048)	10081-12550	11263 (689)	3061-3847	3340 (226)	4126-5501	4898 (388)	2880-3225	3025 (94)
58:151	1	passed spill	41533-41533	41533 (.)	30764-30764	30764 (.)	9608-9608	9608 (.)	2983-2983	2983 (.)	3687-3687	3687 (.)	2938-2938	2938 (.)
58:152	1	passed Units 9-10	16959-17051	17007 (38)	2754-2757	2755 (1)	13011-13088	13053 (32)	3649-3738	3699 (37)	6306-6320	6310 (6)	3042-3047	3044 (2)
58:153	1	0	1204-37938	16559 (7973)	0-26908	4713 (7563)	23-13642	10667 (2161)	0-4266	3496 (870)	12-6129	4430 (866)	3-3587	2741 (852)
58:153	2	passed sluice	5903-10604	7126 (1152)	0	0	4689-9571	5963 (1161)	0-3371	939 (883)	2595-4794	4335 (617)	277-1512	689 (351)
58:154	1	0	14474-16868	15426 (1038)	1120-2136	1511 (417)	12084-13642	12741 (695)	3928-4097	4039 (48)	4572-6129	5227 (755)	3391-3525	3475 (36)
58:154	2	passed spill	27111-27111	27111 (.)	13985-13985	13985 (.)	11898-11898	11898 (.)	3590-3590	3590 (.)	5160-5160	5160 (.)	3148-3148	3148 (.)
58:157	1	0	11324-11341	11333 (12)	0	0	10197-10214	10206 (12)	1999-2022	2011 (17)	6524-6524	6524 (0)	1668-1675	1672 (5)
58:157	2	0	14315-25876	18166 (3333)	0-12025	3799 (3577)	12645-13631	13158 (298)	3656-4222	3946 (185)	5547-5862	5776 (99)	3231-3565	3435 (94)
58:157	3	passed spill	38675-38675	38675 (.)	25810-25810	25810 (.)	11664-11664	11664 (.)	3421-3421	3421 (.)	5174-5174	5174 (.)	3069-3069	3069 (.)
58:159	1	passed spill	31444-31444	31444 (.)	17930-17930	17930 (.)	12315-12315	12315 (.)	3665-3665	3665 (.)	5424-5424	5424 (.)	3225-3225	3225 (.)
58:160	1	0	13629-13801	13736 (44)	0	0	12505-12689	12633 (49)	3550-3742	3633 (51)	6366-6446	6386 (21)	2562-2648	2613 (25)
58:160	2	passed east fish pipe	9254-9313	9283 (19)	0	0	8068-8178	8122 (32)	432-455	451 (7)	5315-5394	5346 (23)	2292-2352	2326 (16)
58:161	1	0	2984-45124	20103 (12501)	0-32864	7870 (12145)	1762-14049	11039 (3169)	0-4222	3272 (1161)	1494-6720	5217 (1322)	0-3565	2551 (1049)
58:161	2	passed spill	38507-38507	38507 (.)	27928-27928	27928 (.)	9411-9411	9411 (.)	2377-2377	2377 (.)	4093-4093	4093 (.)	2941-2941	2941 (.)
58:162	1	0	4724-15804	14791 (1445)	0-1021	467 (463)	2498-13792	13180 (1531)	550-4181	3848 (646)	1369-6802	6385 (807)	578-3495	2947 (398)
58:162	2	passed spill	28751-28751	28751 (.)	15993-15993	15993 (.)	11558-11558	11558 (.)	3567-3567	3567 (.)	4806-4806	4806 (.)	3185-3185	3185 (.)
58:164	1	passed east fish pipe	18883-18883	18883 (.)	6312-6312	6312 (.)	11417-11417	11417 (.)	3103-3103	3103 (.)	5025-5025	5025 (.)	3289-3289	3289 (.)
58:166	1	passed sluice	35660-36419	36039 (537)	25309-25380	25345 (50)	8401-9086	8744 (484)	3005-3005	3005 (0)	2502-3147	2824 (456)	2895-2935	2915 (28)
58:169	1	passed Units 5-8	12828-12828	12828 (.)	0	0	11760-11760	11760 (.)	3534-3534	3534 (.)	6700-6700	6700 (.)	1526-1526	1526 (.)
58:173	1	passed spill	36631-36631	36631 (.)	23647-23647	23647 (.)	10866-10866	10866 (.)	3241-3241	3241 (.)	4678-4678	4678 (.)	2947-2947	2947 (.)

			Total Discharge		Spill		Total Generation		Units 1-4		Units 5-8		Units 9-10	
Fish ID	Approach	Route/Disposition (0=end Approach)	Range	Mean (SD)	Range	Mean (SD)	Range	Mean (SD)	Range	Mean (SD)	Range	Mean (SD)	Range	Mean (SD)
58:176	1	passed spill	44554-44554	44554 (.)	33008-33008	33008 (.)	10424-10424	10424 (.)	2975-2975	2975 (.)	4498-4498	4498 (.)	2952-2952	2952 (.)
58:177	1	passed east fish pipe	12642-12642	12642 (.)	0	0	11512-11512	11512 (.)	3925-3925	3925 (.)	4318-4318	4318 (.)	3269-3269	3269 (.)
58:178	1	passed east fish pipe	15265-15265	15265 (.)	2348-2348	2348 (.)	11712-11712	11712 (.)	3896-3896	3896 (.)	4542-4542	4542 (.)	3274-3274	3274 (.)
58:180	1	passed sluice	9241-18027	14099 (2568)	0-3577	880 (1098)	8033-13757	12054 (1875)	0-4135	3136 (1251)	3869-6657	5988 (735)	1961-3319	2929 (281)
58:181	1	passed Units 1-4	9165-14440	10898 (1527)	0	0	7979-13287	9701 (1541)	969-3920	1939 (879)	5311-6196	5882 (229)	1624-3268	1879 (550)
58:187	1	passed east fish pipe	9359-9392	9375 (14)	0	0	8232-8270	8250 (16)	2069-2110	2095 (20)	4727-4767	4741 (19)	1395-1435	1414 (16)
58:189	1	0	6241-6281	6267 (23)	0	0	5116-5162	5146 (26)	0	0	3625-3699	3664 (37)	1463-1492	1482 (16)
58:189	2	passed spill	56191-56191	56191 (.)	46528-46528	46528 (.)	7715-7715	7715 (.)	2433-2433	2433 (.)	4061-4061	4061 (.)	1221-1221	1221 (.)
58:190	1	passed Units 5-8	9157-11182	9733 (737)	0	0	8000-9990	8577 (728)	988-2038	1235 (368)	5665-6548	5976 (336)	1241-1682	1366 (146)
58:193	1	passed Units 5-8	14812-25624	17531 (2024)	2346-12237	4215 (2117)	2696-12722	12112 (1525)	220-4068	3831 (615)	2243-5238	5019 (492)	232-3474	3262 (477)
58:194	1	passed Units 1-4	15271-18027	16182 (1098)	1020-3577	1821 (1141)	12936-13307	13157 (90)	3529-3890	3761 (90)	6304-6365	6339 (17)	3022-3088	3057 (15)
58:197	1	passed east fish pipe	2145-12899	7568 (4672)	0	0	976-11769	6389 (4705)	0-4328	1814 (1735)	0-4627	2679 (2067)	757-3216	1895 (1056)
58:198	1	0	2415-12899	7865 (5097)	0	0	1219-11769	6685 (5146)	0-3965	1973 (1953)	441-4617	2651 (2019)	757-3216	2061 (1175)
58:198	2	passed Units 5-8	15639-19552	17734 (1581)	6342-6533	6401 (68)	7982-11993	10166 (1638)	0-4047	2029 (1675)	4575-4896	4765 (126)	3322-3456	3371 (48)
54:106	1	0	37765-42644	39712 (1693)	26101-31907	28631 (1852)	8913-10731	9919 (609)	2377-3139	2987 (216)	2884-4752	4048 (592)	2804-2996	2884 (56)
54:106	2	Third approach, stationary on MS-16	4412-15136	11700 (3060)	0-2135	102 (403)	3212-12056	10421 (2995)	739-4013	3447 (1112)	1174-4852	3905 (1210)	1183-3587	3069 (791)
54:119	1	0	5903-7788	6363 (663)	0	0	4689-6635	5168 (681)	0-1821	341 (689)	4171-4372	4272 (59)	437-704	555 (118)
54:119	2	0	6246-9388	8341 (1814)	0	0	5065-8215	7165 (1818)	1114-2141	1799 (593)	2621-4783	4062 (1248)	1289-1331	1304 (24)
54:119	3	Returned upstream	18011-18011	18011 (.)	3571-3571	3571 (.)	13243-13243	13243 (.)	3819-3819	3819 (.)	6362-6362	6362 (.)	3062-3062	3062 (.)
54:120	1	0	6789-6826	6808 (26)	0	0	5627-5662	5645 (25)	1617-1631	1624 (10)	2695-2695	2695 (0)	1315-1336	1325 (15)
54:120	2	Returned upstream	15705-17138	16270 (766)	1226-2759	1839 (839)	13111-13271	13216 (74)	3738-3815	3778 (35)	6308-6384	6361 (31)	3065-3089	3077 (12)
54:126	1	Returned upstream	2168-12346	5539 (3312)	0	0	976-11179	4356 (3318)	0-4328	1176 (1244)	0-4566	1760 (1548)	976-3185	1419 (685)
54:131	1	0	12550-12749	12651 (72)	0	0	11396-11598	11498 (73)	3672-3823	3758 (56)	4606-4616	4609 (5)	3111-3169	3131 (19)
54:131	2	0	9197-11221	10421 (930)	0	0	8000-10046	9230 (933)	988-2038	1636 (454)	5665-6413	6077 (297)	1270-1688	1517 (186)
54:131	3	Last detected MS-14	44561-57696	51389 (3837)	35294-47965	41559 (3961)	7335-8868	7912 (335)	2056-2636	2400 (150)	2218-4334	3083 (276)	2159-2755	2428 (164)
54:143	1	0	2224-2256	2240 (13)	0	0	1016-1051	1039 (16)	0	0	0	0	1016-1051	1039 (16)
54:143	2	Returned upstream	12586-12595	12592 (5)	0	0	11430-11439	11436 (5)	3756-3763	3761 (4)	4572-4576	4573 (2)	3094-3107	3102 (7)

			Total Discharge		Spill		Total Generation		Units 1-4		Units 5-8		Units 9-10	
Fish ID	Approach	Route/Disposition (0=end Approach)	Range	Mean (SD)	Range	Mean (SD)	Range	Mean (SD)	Range	Mean (SD)	Range	Mean (SD)	Range	Mean (SD)
58:156	1	0	2145-11988	7845 (4758)	0	0	963-10835	6667 (4769)	0-4083	2353 (1972)	0-3554	2056 (1718)	508-3260	2258 (1084)
58:156	2	Returned upstream	5781-5781	5781 (.)	0	0	4570-4570	4570 (.)	0	0	3063-3063	3063 (.)	1507-1507	1507 (.)
58:183	1	Second approach, Stationary on MS-16	2186-11988	7842 (4760)	0	0	963-10835	6657 (4780)	0-4083	2346 (1980)	0-3554	2045 (1730)	508-3260	2266 (1075)
58:192	1	0	11407-15319	14233 (871)	1123-2451	1660 (572)	8978-11709	11367 (673)	1019-3924	3562 (710)	4492-4648	4529 (53)	3232-3336	3276 (24)
58:192	2	Returned upstream	15828-16293	16020 (157)	1119-1223	1197 (47)	13431-13899	13644 (183)	3575-4057	3809 (196)	6583-6623	6610 (14)	3194-3233	3225 (13)
58:199	1	0	2415-12834	4523 (4109)	0	0	1219-11710	3316 (4150)	0-3912	726 (1561)	441-4602	1325 (1628)	757-3216	1265 (964)
58:199	2	Returned upstream	2145-11939	8558 (4074)	0	0	963-10779	7383 (4082)	0-4083	2457 (1690)	0-4627	2777 (1756)	508-3212	2150 (1012)

Table 2. Probabilities of passage per approach during periods of non-spill by A. total generation class and, B. turbine unit type operation.

A.

	All Passage Routes		East Fish Pipe	
	N (Pass, Fail)	P (SE)	N (Pass, Fail)	P (SE)
Low (<4250 cfs)	0, 2	NA	0, 2	NA
Mid (4250-11000 cfs)	11, 20	0.35 (0.08)	7, 24	0.22 (0.08)
High (>11000 cfs)	7, 5	0.58 (0.14)	5, 7	0.42 (0.14)

B.

			All Passage Routes		East Fish Pipe	
U1-4	U5-8	U9-10	N (Pass, Fail)	P (SE)	N (Pass, Fail)	P (SE)
Off	Off	Off	0, 0	NA	0, 0	NA
On	Off	Off	0, 0	NA	0, 0	NA
Off	On	Off	0, 0	NA	0, 0	NA
Off	Off	On	0,1	NA	0, 1	NA
On	On	Off	0, 0	NA	0, 0	NA
On	Off	On	0, 0	NA	0, 0	NA
Off	On	On	2, 2	0.50 (0.25)	1, 3	0.25 (0.22)
On	On	On	16, 24	0.40 (0.08)	11, 29	0.28 (0.07)