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2016 Post-San Clemente Dam Removal Morphological Monitoring of the Carmel River Channel in Monterey County, California

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Executive Summary

San Clemente Dam was removed from the Carmel River in fall 2015. Channel cross sections and substrate measurements from before-and-after dam removal will assess geomorphic impacts of dam removal. In 2013 several sites were selected for monitoring, both downstream of the dam (impact sites) and upstream of the dam (control sites). Subsets of the study sites were established by CSUMB and collaborating partners with the USGS and NOAA. This report presents the resurveys that capture the first year impacts following dam removal. The 2016 data set also serves as the "before impact" data set for potential impacts of the 2016 Soberanes Fire.

The time-series cross section plots show excellent between-survey precision. There has been virtually no geomorphic change between 2013 and 2016, perhaps because there have been few significant runoff events during the study. Pebble count distributions in the study reaches generally show a lower frequency of sand fraction particles following dam removal. This change probably arose from higher flows in the 2016 Water Year compared to previous years, rather than from dam removal impacts. No observations from this study can be unambiguously ascribed to dam removal impacts. Sediment transported past the previous dam site did not reach further than 3.5 km (CSUMB 2016), far upstream of the sites surveyed in this study.

Acknowledgements

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1 Introduction

The 32 m tall San Clemente Dam, located in the northern Santa Lucia Mountains of Central California, was removed from the Carmel River in fall of 2015 (Fig. 1). The dam was decommissioned because the 1,425 acre feet reservoir was more than 95% filled with sediment, the dam was located near a seismically active fault zone, and there was uncertainty about the dam's ability to withstand a major flood (Boughton et al. 2016; CCOWS 2012).

Unlike all previous dam removal projects, this project was designed to minimize downstream impacts to fish habitat and flood frequency by sequestering all the stored sediment on site (SCDRP 2015). Sediment transport modeling of the dam removal project indicated that the river would not be significantly altered by the project (Mussetter 2005). CSUMB (2016) mapped the extent and magnitude of a small sediment wave present near the dam removal site in Fall 2016, following the first winter runoff. Newly-deposited sand and fine pebbles were found as pool-filling deposits that extended a maximum 3.5 km downstream from the dam site (CSUMB 2016).

In collaboration with the U.S. Geological Survey and NOAA Fisheries Service, we established several study reaches in 2013 to monitor unintended downstream impacts of the dam removal project (Fig. 1; Leiker et al. 2014). The study reaches include "impact" reaches located downstream of the dam, and "control" reaches located upstream of the dam. At each study reach surveyed in 2013, Leiker et al. (2014), or collaborators, surveyed benchmarked channel cross sections and performed particle counts to establish a baseline for documenting changes related to the dam removal. Chow (2016) resurveyed the Leiker et al. (2014) sites to assess natural variability before the dam was removed, and extended the study by adding two new sites. The current study resurveyed all the sites surveyed by Chow et al. (2016) to document the geomorphological changes resulting from one post-dam runoff season. The Soberanes Fire of 2016 burned a significant region of the Carmel watershed, so our fall 2016 survey also serves as the baseline from which to assess the geomorphic effects of the Sobranes Fire.

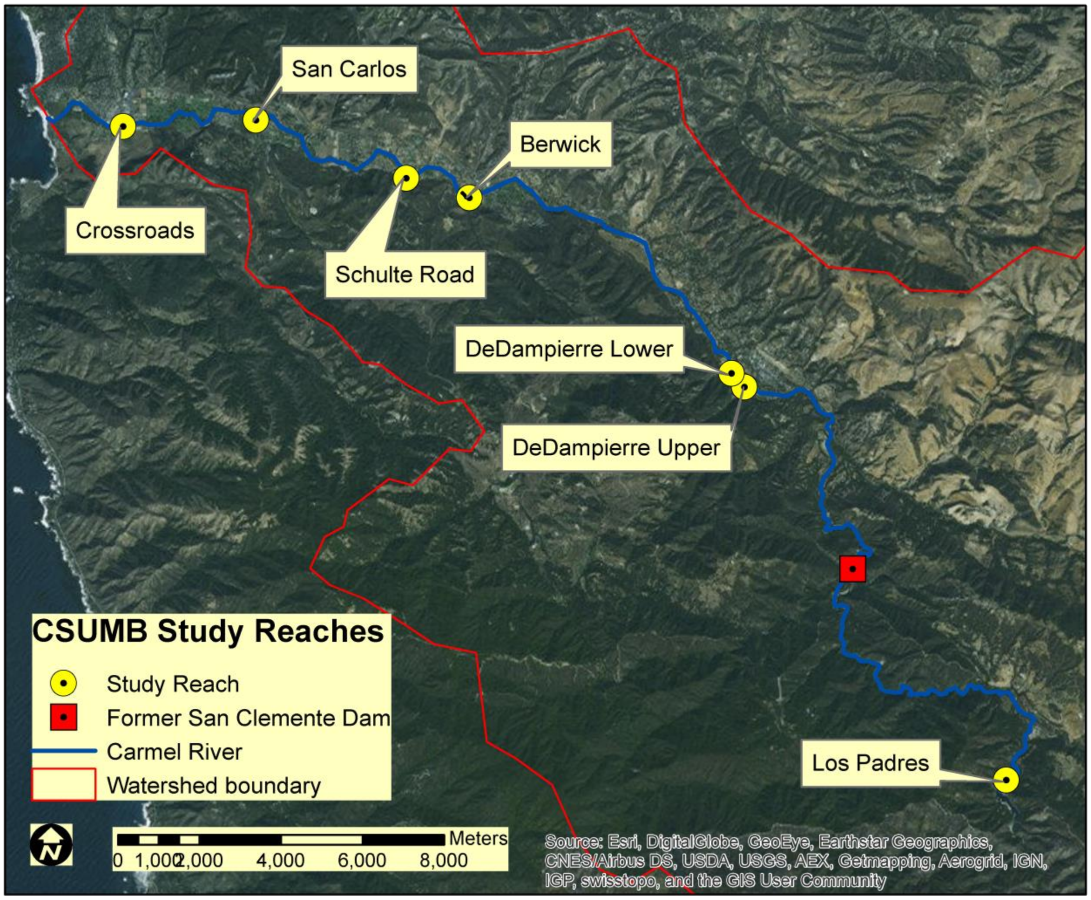


Figure 1. Location of study reaches upstream and downstream of the San Clemente Dam on the Carmel River.

2 Methods

Following the methods of the initial 2013 study (Leiker et al. 2014), we conducted geomorphic measurements of the Carmel River before the San Clemente Dam removal at seven diverse and representative reaches of the river that could change character following dam removal (Fig. 1). The cross sections were surveyed and pebble counts were performed at each site in the dry season when low flows provided easy access to the channel. Data were collected in the fall of 2016. Each study reach is described below:

- **Los Padres (LP)**: Located directly downstream from the Los Padres Dam, this reach is the most upstream reach established in 2015. This site spans a spawning gravel injection operation run by the Monterey Peninsula Water management District.
- **DeDampierre Upper (DDU)**: Located in the upper portion DeDampierre Park, the reach extends from the footbridge past the baseball fields. This reach contains several pieces of large wood installed for a restoration project by the Monterey Peninsula Water Management district.
- **DeDampierre Lower (DDL)**: This reach begins at the lower end of DeDampierre park and extends to the Carmel Valley Trail and Saddle Club downstream of the park.
- **Berwick (BW)**: Established in 2015, this reach is located on California American Water property.
- **Schulte Road (SR)**: Located upstream of the Schulte Road Bridge. This reach begins in land owned by the Big Sur Land Trust and extends to 100m upstream of the Schulte Bridge.
- **San Carlos (SC)**: Located just downstream of the San Carlos Road Bridge. The reach extends from the bridge to the California American Water San Carlos production well.

- **Crossroads (CR)**: Located adjacent to the Crossroads Shopping Center at the mouth of Carmel Valley. This is the most downstream reach included in this study.

Each reach was approximately 300 m in length and contained four to six benchmarked cross sections, approximately spaced at 60 m intervals. Cross sections were set in a variety of hydraulic settings, but mainly in riffles and pools. Using the previous benchmarks established in 2013 or 2015, we resurveyed each cross section using an autolevel, leveling rod, and 30-meter tape (Harrelson et al. 1994). At each cross section, a taut tape was set between the left and right benchmarks. Points along each transect were shot at one meter increments with additional shots to record breaks in slope. Surveys were opened and closed on the left benchmark. Cross section data were plotted and visually compared with the previous surveys.

Pebble counts were performed along each cross section to determine average particle size distribution. Pebble counts included only particles within the active channel as indicated by recent substrate activity. We employed the sampling technique from Bunte and Abt (2001) that uses a 60 x 60 cm sampling quadrat. This method reduces serial correlation by adjusting the spacing between intersections on the frame to equal the dominant large particle size (≈D95). The 60 x 60 cm square sampling frame was constructed from 1" PVC pipe with notches every 10 cm. Elastic bands were then attached to notches according to the dominant large particle size of each transect.

The sampling grid was moved repeatedly across the estimated low flow channel at fixed intervals to achieve a sample size of ≥ 100. A gravelometer was used to measure particle sizes for pebble counts. Particle size percentiles were estimated by eye from "cumulative % finer" plots. Leiker et al. (2014 and Chow et al. (2016) calculated the percentiles in a software routine that did not interpolate as well as the traditional eye method. The percentiles from those studies are re-estimated in this report. Particle size histograms and cumulative frequency graphs were generated for each cross section, and were then averaged for each reach. The 2016 data were then compared to the previous data sets.

3 Results

3.1 Los Padres Reach

The Los Padres reach is located directly downstream of the Los Padres Dam (Fig. 1). This reach is upstream of the San Clemente Dam reroute site and serves as a control reach to be compared with the downstream reaches (Fig. 2). This reach also serves as the location for sporadic spawning gravel augmentation. The most recent augmentation occurred in late calendar year 2014, approximately 10 months before the first surveys were accomplished. The subsequent runoff from water year 2015 was the lowest in a decade, with only one brief peak capable of transporting gravel on the Carmel River (e.g., Figure 8 of MacCarter et al. 2017). Therefore, the initial pebble count survey of this report (fall 2015) no doubt included spawning gravel that was present in the interstices of the native large cobble to boulder substrate, rather than the naturally sorted substrate that would be present after average runoff years.

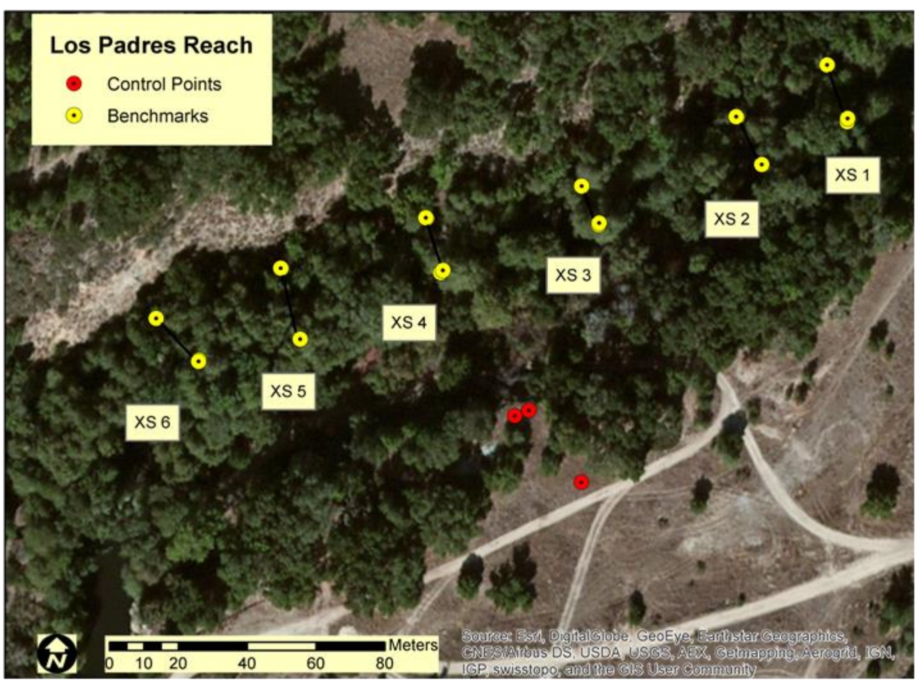


Figure 2. Location of georeferenced control points and cross sections within the Los Padres Reach.

The median grain size of this reach (D50) jumped from 90 mm to 175 mm. This shift reflects a relatively uniform increase in the 180 mm to 300 mm bin (Fig. 3). While there is minimal change in the reach average, the individual cross section changes were large and non-uniform (Table 1; Appendix B), perhaps reflecting the ability of each transect to sort the injected spawning gravel during the average runoff of the 2016 water year. The range of grain sizes still remained predominantly coarse pebbles to boulders (22.6 – 300 mm) among transects (Table 1). Cross sections located in pools tended to have smaller particle sizes while riffles tended to have larger particle sizes.

The width of cross sections in this reach covered the active channel and potions of floodplain when possible. Cross section widths ranged from 12 – 22 m and the average active channel observed in the field was between 10 – 12 m. The channel geometry and pebble count distribution of each surveyed cross section are in Appendix A and B, respectively. There was very little change in cross section geometry between 2015 and 2016.

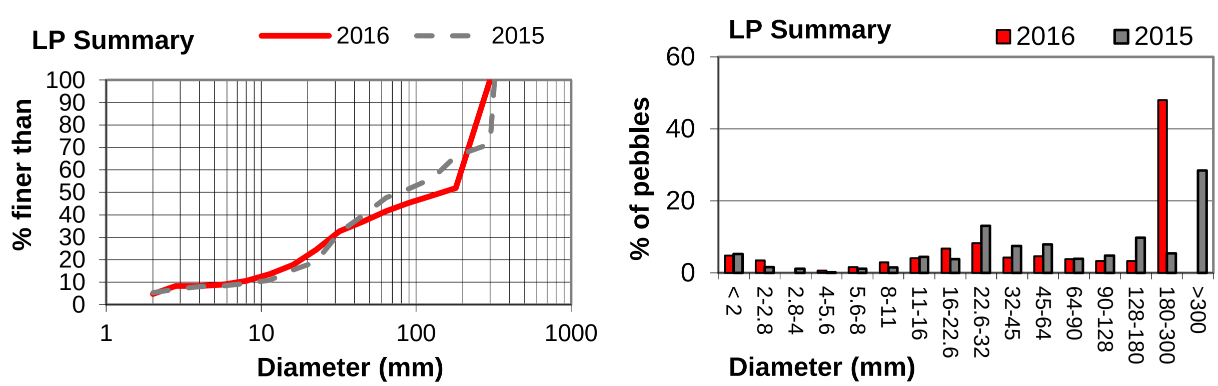


Figure 3. Summary pebble count distribution (LP 1 – LP 6) for the Los Padres reach displayed as cumulative percentiles (left) and individual bins (right) for 2015 to 2016.

Table 1. Grain size distribution among cross-sectional transects within the Los Padres Reach for 2015 & 2016. Runs like LP6 tended to have smaller particles.

	Quantile	2013	2015	2016
LP Summary	D_{16}		17	15
	D_{50}		90	175
	D_{84}		> 300	240
	D_{100}		> 300	300
LP 1	D_{16}		17	28
	D_{50}		83	185
	D_{84}		> 300	260
	D_{100}		> 300	300
LP 2	D_{16}		24	9
	D_{50}		48	34
	D_{84}		> 300	220
	D_{100}		> 300	300
LP 3	D_{16}		15	190
	D_{50}		110	220
	D_{84}		> 300	260
	D_{100}		> 300	300
LP 4	D_{16}		70	13
	D_{50}		300	90
	D_{84}		> 300	240
	D_{100}		> 300	300
LP 5	D_{16}		13	2.5
	D_{50}		130	200
	D_{84}		> 300	250
	D_{100}		> 300	300
LP 6	D_{16}		2.5	< 2
	D_{50}		25	27
	D_{84}		46	65
	D_{100}		300	300

3.2 DeDampierre Upper Reach

The DeDampierre Upper Reach (Fig. 4) is the most upstream reach monitored by CSUMB that will see impacts of the San Clemente Dam removal. This reach included four large wood installments constructed by MPWMD. The large wood installments have created large, deep scour pools.

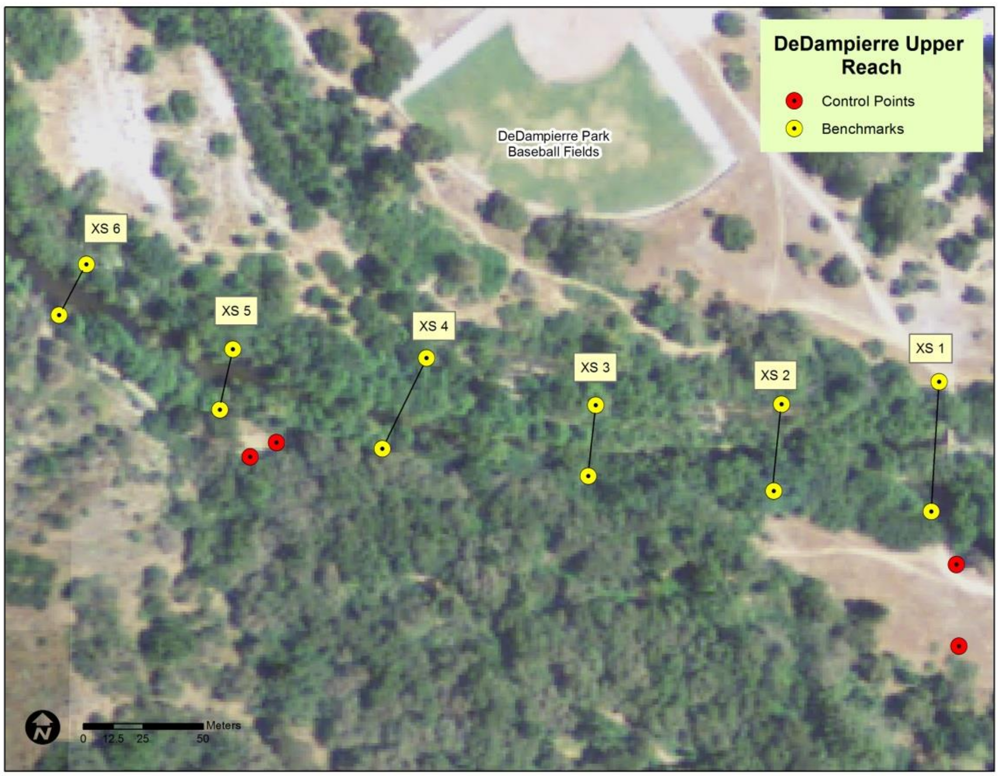


Figure 4. Location of georeferenced control points and cross sections within the DeDampierre Upper Reach.

The D50 of this reach decreased from 37 mm to 14 mm following the 2016 water year. The histogram indicates a shift from coarse pebble and cobbles to finer pebbles (Fig. 5; Table 2). Sand present in 2013 washed out before the 2015 survey (Fig. 5; Table 2). The D85 and D90 included a range of particle sizes from medium gravel and to small boulders (Table 2). Cross sections located in pools tended to have smaller particle sizes while riffles tended to have larger particle sizes. The pools formed by the large wood installments in this reach had much smaller particle sizes than other sections of the reach.

The width of cross sections in this reach covered the active channel and portions of floodplain when possible. Two of the six cross sections (DDU2 & DDU3) were extended in 2015 by approximately 10 m. There are no noteworthy changes in channel shape at this reach (Appendix A).

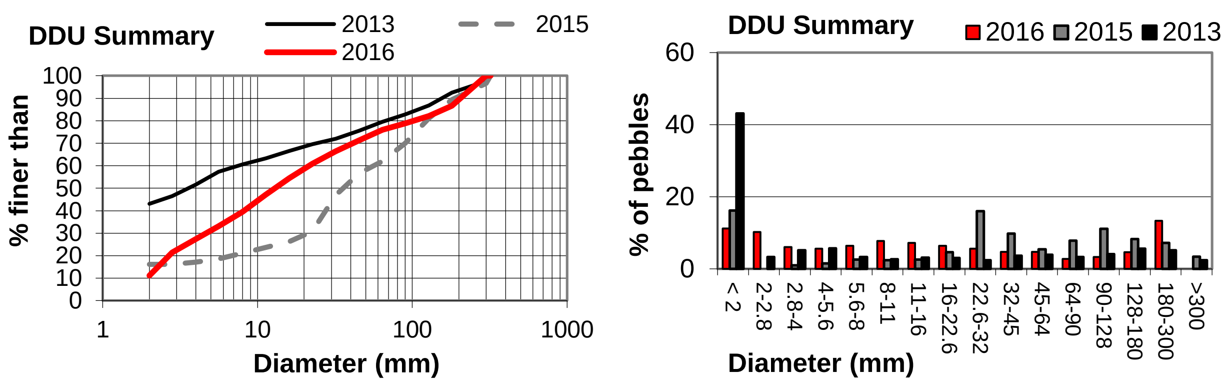


Figure 5. Summary pebble count distribution (DDU 1 – DDU 6) for the DeDampierre Upper reach displayed as cumulative percentiles (left) and individual bins (right) for 2016 and 2013.

Table 2. Grain size distribution and cumulative finer than graph among cross-sectional transects within the DeDampierre Upper Reach. Riffles such as DDU 3, tended to have larger particles than pools, such as DDU 1.

	Quantile	2013	2015	2016
DDU Summary	D_{16}	< 2	< 2	2.3
	D_{50}	3.8	37	14
	D_{84}	93	160	170
	D_{100}	> 300	> 300	300
DDU 1	D_{16}	< 2	< 2	2.2
	D_{50}	< 2	8	8
	D_{84}	16	23	29
	D_{100}	90	90	128
DDU 2	D_{16}	< 2	< 2	2.4
	D_{50}	< 2	44	8.5
	D_{84}	61	175	46
	D_{100}	> 300	300	300
DDU 3	D_{16}	< 2	24	2.6
	D_{50}	8	105	28
	D_{84}	140	270	128
	D_{100}	> 300	> 300	300
DDU 4	D_{16}	< 2	27	4.8
	D_{50}	20	90	18
	D_{84}	180	170	220
	D_{100}	> 300	> 300	300
DDU 5	D_{16}	< 2	2.2	< 2
	D_{50}	3	28	9.8
	D_{84}	120	46	140
	D_{100}	> 300	300	300
DDU 6	D_{16}	< 2	6	< 2
	D_{50}	4	83	17
	D_{84}	31	160	230
	D_{100}	290	> 300	300

3.3 DeDampierre Lower Reach

This reach is located directly downstream of the DeDampierre Upper Reach. The upstream portion of the reach is a wide and open channel with a pool and long run. The reach narrows after cross section 3 (XS 3 of Fig. 6) and has a steeper gradient than Upper DeDampierre.

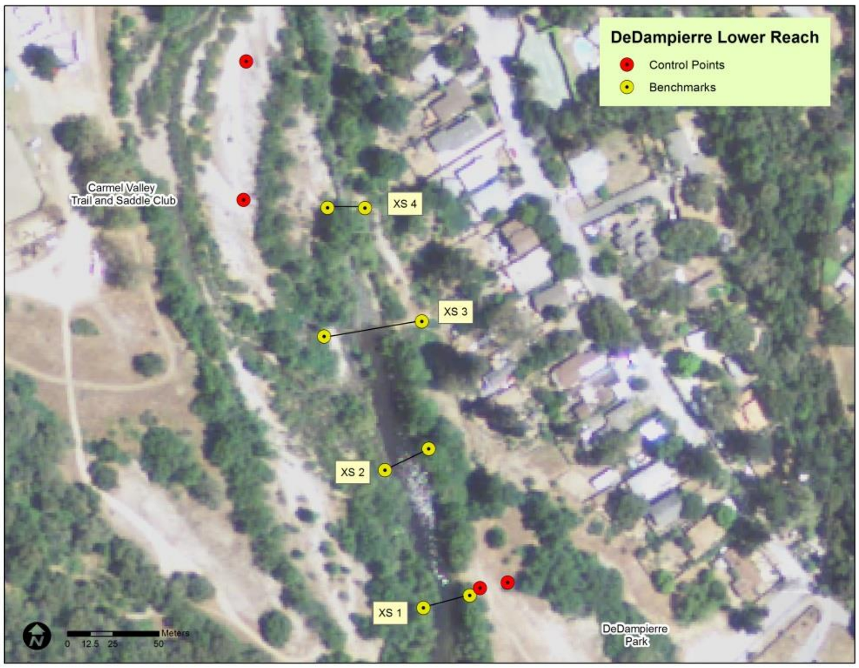
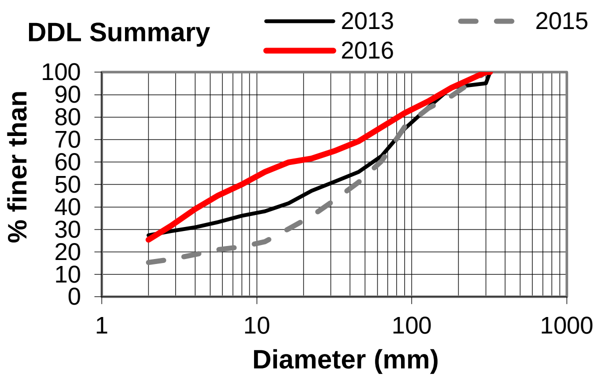


Figure 6. Location of georeferenced control points and cross sections within the DeDampierre Lower Reach.

The D50 for the Lower DeDampierre Reach shifted from 30 mm in 2015 to 8 mm in 2016. This change reflects a significant influx of sand and small gravel in DDL 4. Particle size ranged from granules to very coarse-pebbles (2 – 45 mm) among transects (Table 3). The D84 and D90 contained only cobbles for all transects other than DDL 4, which contained fine to medium pebbles.

The width of cross sections in this reach covered the active channel and portions of floodplain when possible. Cross section widths ranged from 16 – 44 m and the active channel observed in the field was between 10 – 20 m. There has been no major topographic change over all cross sections within this reach, but the lower cross sections appear to have an aggrading floodplain (Appendix A).



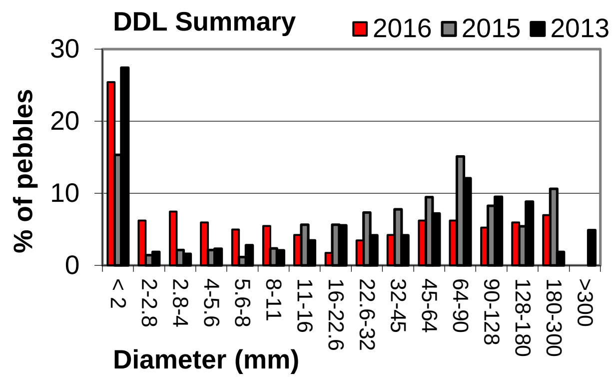


Figure 7. Summary pebble count distribution (DDL 1 – DDL 4) for the DeDampierre Lower reach displayed as cumulative percentiles (left) and individual bins (right) for 2016 and 2013.

Table 3. Grain size distribution and cumulative finer than graph among cross-sectional transects within the DeDampierre Lower Reach. DDL 4 has the largest pool (Appendix) and the largest decrease in grain size between 2013 and 2015.

	Quantile	2013	2015	2016
DDL Summary	D_{16}	< 2	2	< 2
	D_{50}	29	44	8
	D_{84}	110	120	93
	D_{100}	> 300	300	> 300
DDL 1	D_{16}	< 2	< 2	< 2
	D_{50}	9	17	53
	D_{84}	130	100	130
	D_{100}	> 300	> 300	185
DDL 2	D_{16}	< 2	10	< 2
	D_{50}	45	55	14
	D_{84}	120	105	88
	D_{100}	> 300	180	180
DDL 3	D_{16}	< 2	9	4.6
	D_{50}	21	31	15
	D_{84}	105	85	210
	D_{100}	> 300	180	300
DDL 4	D_{16}	< 2	< 2	< 2
	D_{50}	50	80	2.2
	D_{84}	170	230	5.3
	D_{100}	> 300	300	32

3.4 Berwick Reach

The Berwick reach was established in 2015 (Figs. 8 and 9).

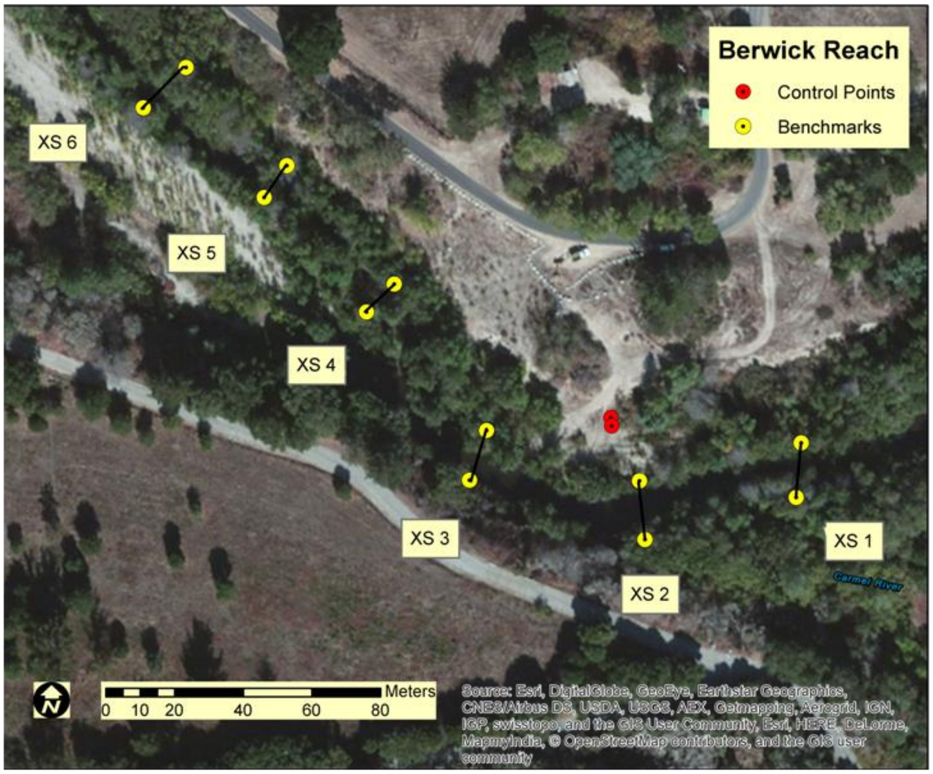


Figure 8. Location of georeferenced control points and cross sections within the Berwick Reach.

The sediment distribution shifted a little between 2015 and 2016 as sand present in 2015 was washed downstream (Fig. 9; Table 4). The reach averaged D50 was near 30 mm in both years, The D84 and D90 ranged from very coarse pebbles to boulders.

The cross sections in this reach continue the trend of pools having a smaller particle size, such as BW 4 & BW 5. Cross section widths ranged from 11 to 16 m and the typical active channel widths fell between 5-15 m. There is evidence for minor aggradation at two pool cross sections in this reach (Appendix A).

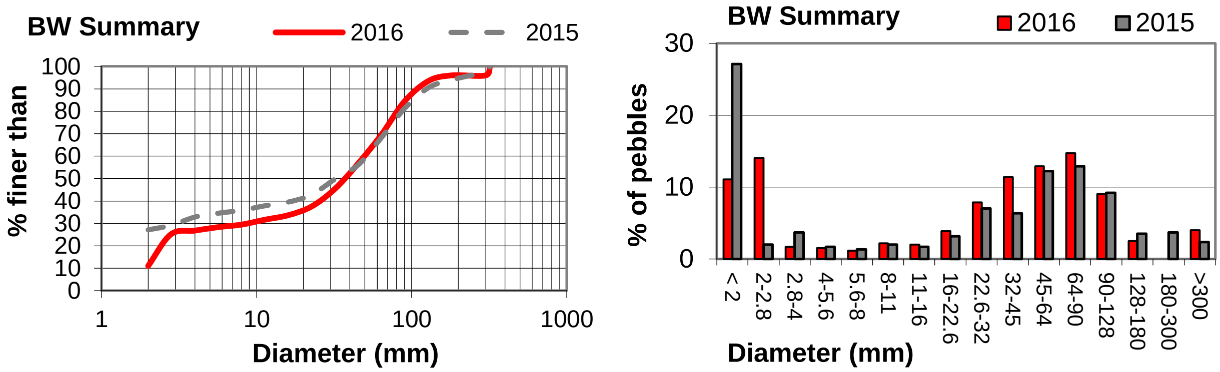


Figure 9. Summary pebble count distribution (BW 1 – BW 6) for the Berwick reach displayed as cumulative percentiles (left) and individual bins (right) for 2016 to 2015.

Table 4. Grain size distribution and cumulative finer than graph among cross sectional transects within the Berwick Reach.

	Quantile	2013	2015	2016
BW Summary	D_{16}		< 2	2.3
	D_{50}		30	37
	D_{84}		100	90
	D_{100}		> 300	> 300
BW 1	D_{16}		17	2.3
	D_{50}		65	28
	D_{84}		130	120
	D_{100}		> 300	> 300
BW 2	D_{16}		> 2	2.7
	D_{50}		78	65
	D_{84}		280	160
	D_{100}		> 300	> 300
BW 3	D_{16}		2.6	2.5
	D_{50}		23	45
	D_{84}		90	80
	D_{100}		180	128
BW 4	D_{16}		< 2	12
	D_{50}		< 2	39
	D_{84}		32	65
	D_{100}		128	90
BW 5	D_{16}		< 2	< 2
	D_{50}		24	2.8
	D_{84}		65	70
	D_{100}		> 300	128
BW 6	D_{16}		< 2	2.2
	D_{50}		29	40
	D_{84}		90	105
	D_{100}		300	> 300

3.5 Schulte Reach

The Schulte reach is located approximately 200 m upstream of the Schulte Bridge and extends above the 'Steinbeck Pool' which is located between cross sections 2 and 3 (Fig. 10).

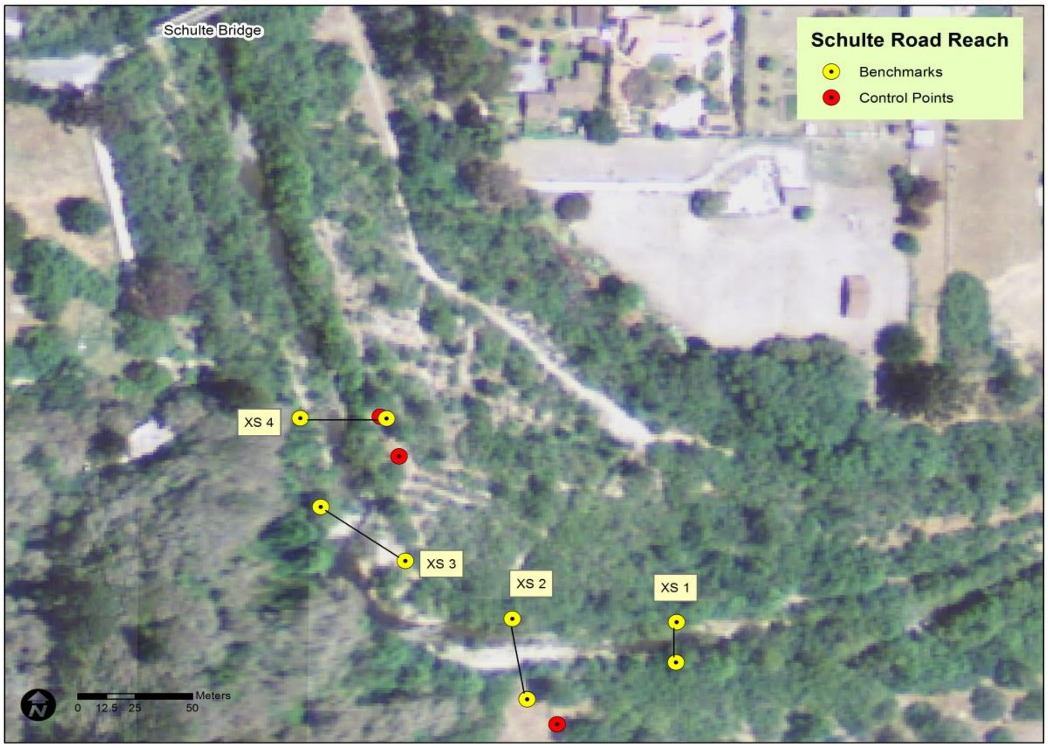


Figure 10. Locations of georeferenced control points and cross sections within the Schulte Road Reach.

The D50 in 2016 was 36 mm, coarser than in previous years because sand had been winnowed away (Fig. 11; Table 5). The shape of the histogram is similar to the previous years except for the paucity of sand (Fig. 11). The D84 and D90 contained very coarse pebbles to cobbles. The variability of sand and granules to cobbles and boulders is highest in pools, evident by cross section 1 (D16= < 2 mm, D84= 64 mm).

The channel width of cross sections in this reach covered the active channel and portions of floodplain when possible. Cross section widths ranged from 15-35 m and the active channel was between 10-15 m. There has been no change in channel morphology (Appendix A).

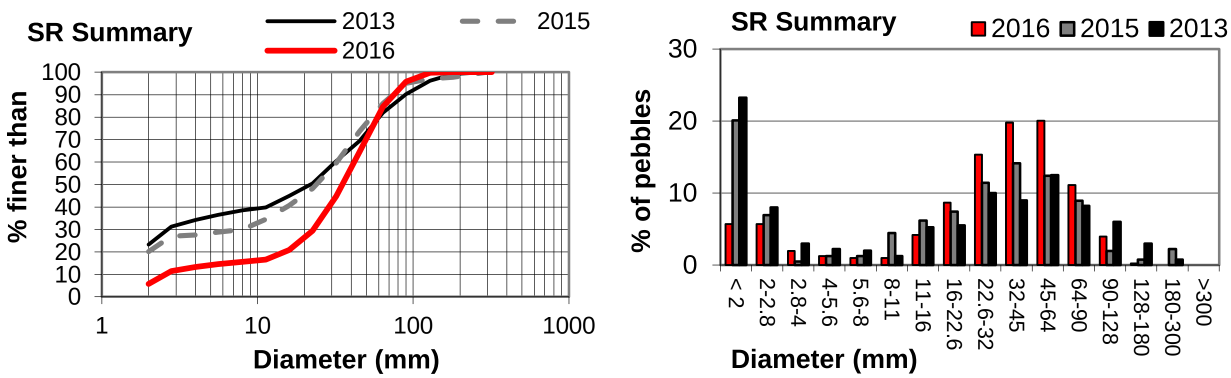


Figure 11. Summary pebble count distribution (SR 1 - SR 4) for the Schulte Road reach displayed as cumulative percentiles (left) and individual bins (right) for 2016 and 2013.

Table 5. Grain size distribution and cumulative finer than graph among cross-sectional transects within the Schulte Road Reach. SR1 has the deepest pool and smallest grain size.

	Quantile	2013	2015	2016
SR Summary	D_{16}	< 2	< 2	6
	D_{50}	22	23	36
	D_{84}	75	65	65
	D_{100}	300	300	128
SR 1	D_{16}	< 2	< 2	< 2
	D_{50}	2	2	20
	D_{84}	52	52	52
	D_{100}	300	300	128
SR 2	D_{16}	2.3	9	19
	D_{50}	24	23	39
	D_{84}	85	55	80
	D_{100}	180	128	180
SR 3	D_{16}	5.6	8.8	25
	D_{50}	38	35	41
	D_{84}	80	60	64
	D_{100}	180	90	128
SR 4	D_{16}	< 2	< 2	6
	D_{50}	23	32	37
	D_{84}	58	61	58
	D_{100}	128	128	90

3.6 San Carlos Reach

The San Carlos Reach is located downstream of the Rancho San Carlos Bridge (Fig. 12).

Figure 12. Locations of georeferenced control points and cross sections within the San Carlos Reach.

The D50 ranged from very coarse sand to coarse pebbles (1.5-32 mm; Table 6). The D84 and D90 ranged from coarse pebbles to cobbles. The overall grain size distribution has remained stable since 2013, with the exception of a reduction in sand in 2016 (Fig. 13).

The channel width of cross sections in this reach covered the active channel and potions of floodplain when possible. Cross section widths ranged from 19-47 m and the active channel was between 10-15 m. This reach has been slightly adjusting since 2013, and there appears to be a benchmark shift following the 2013 survey of SC 4 (Appendix A).

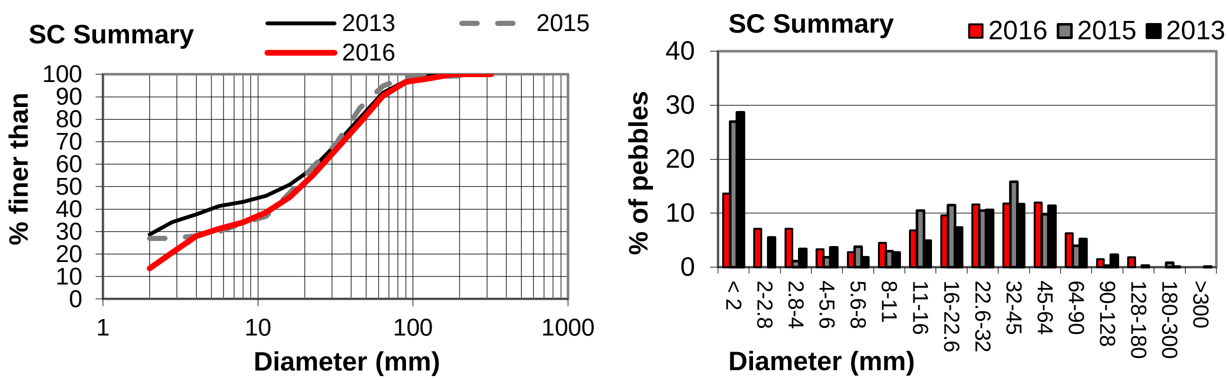


Figure 13. Summary pebble count distribution (SC 1 – SC 6) for the San Carlos reach displayed as cumulative percentiles (left) and individual bins (right) for 2016 and 2013.

Table 6. Grain size distribution and cumulative finer than graph among cross-sectional transects within the San Carlos Reach.

	Quantile	2013	2015	2016
SC Summary	D_{16}	< 2	< 2	2.3
	D_{50}	18	19	20
	D_{84}	54	45	55
	D_{100}	> 300	300	180
SC 1	D_{16}	4.5	10	5
	D_{50}	44	22.6	22.6
	D_{84}	80	62	63
	D_{100}	> 300	300	180
SC 2	D_{16}	8.5	15	20
	D_{50}	32	35	39
	D_{84}	60	58	60
	D_{100}	128	128	128
SC 3	D_{16}	< 2	< 2	3
	D_{50}	< 2	15	8.9
	D_{84}	23	39	26
	D_{100}	90	128	64
SC 4	D_{16}	< 2	< 2	< 2
	D_{50}	2	2	2
	D_{84}	46	46	59
	D_{100}	90	90	180
SC 5	D_{16}	< 2	< 2	3.2
	D_{50}	23	15	31
	D_{84}	48	38	70
	D_{100}	90	90	180
SC 6	D_{16}	< 2	< 2	< 2
	D_{50}	2.7	2	7.5
	D_{84}	28	38	31
	D_{100}	128	90	64

3.7 Crossroads Reach

Crossroads is the lowermost reach monitored, and is located adjacent to the Crossroads shopping center near the mouth of Carmel Valley (Fig. 14).

Figure 14. Locations of georeferenced control points and cross sections within the Crossroads Reach.

The D50 consisted of coarse pebbles (16-32 mm) among transects (Table 7). The D84 and D90 contained very coarse pebbles. Particle size distributions among cross sections and between years were very consistent, with the exception of the loss of sand in 2016 (Fig. 15).

The channel width of cross sections in this reach covered the active channel and potions of floodplain when possible. Cross section widths ranged from approximately

16 – 25 m and the active channel was between 10 – 15 m. Overall, the channel has slightly aggraded since 2013 (Appendix A).

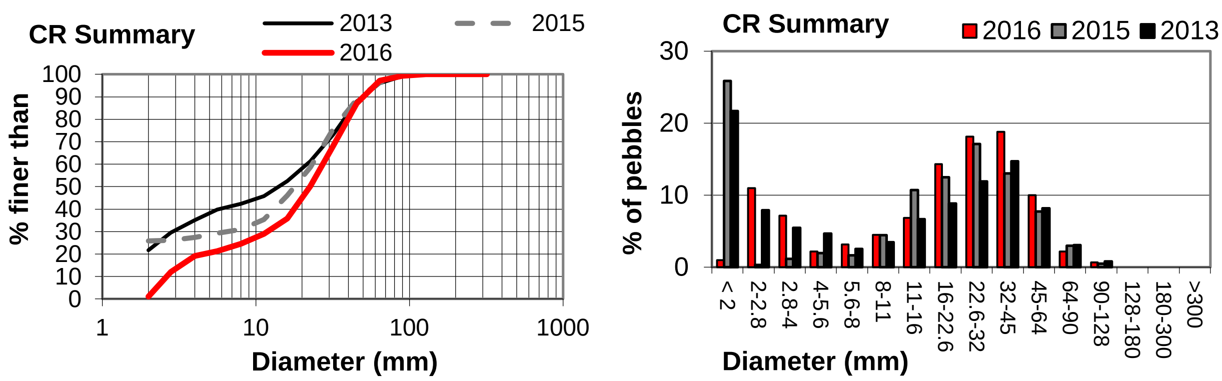


Figure 15. Summary pebble count distribution (CR 1 – CR 6) for the Crossroads reach displayed as cumulative percentiles (left) and individual bins (right) for 2016 and 2013.

Table 7. Grain size distribution and cumulative finer than graph among cross-sectional transects within the Crossroads Reach. This reach is dominated by sand. It is the furthest downstream and has the smallest average grain size.

	Quantile	2013	2015	2016
CR Summary	D_{16}	< 2	< 2	3
	D_{50}	17	18	21
	D_{84}	50	50	55
	D_{100}	128	128	128
CR 1	D_{16}	3	9	16
	D_{50}	29	21	31
	D_{84}	50	50	55
	D_{100}	128	90	90
CR 2	D_{16}	< 2	< 2	3
	D_{50}	11	12	20
	D_{84}	38	38	45
	D_{100}	128	128	128
CR 3	D_{16}	< 2	< 2	3
	D_{50}	3.5	12	18
	D_{84}	40	40	40
	D_{100}	128	90	128
CR 4	D_{16}	< 2	< 2	2.5
	D_{50}	15	17	21
	D_{84}	42	42	42
	D_{100}	90	128	90
CR 5	D_{16}	2	7	2.8
	D_{50}	22	22	17
	D_{84}	50	44	38
	D_{100}	128	90	128
CR 6	D_{16}	< 2	2	10
	D_{50}	8	15	26
	D_{84}	42	42	42
	D_{100}	128	90	64

4 Discussion

This report is part of a multi-year effort to identify unintentional geomorphic changes in the Carmel River following the removal of San Clemente dam in 2015. Two studies before the dam was removed captured pre-removal variability by surveying the sites in 2013 and 2015 (Leiker et al. 2014; Chow et al. 2016). Inconsequential cross section adjustment was reported in the pre-dam removal period of the study, but those studies occurred during drought years, when significant, channel altering, flows were absent from the watershed. Pebble counts from the pre-dam removal period showed variability, but chiefly in the amount of sand and fine pebbles in the channel rather than because of significant changes in larger channel framework grains (Appendix B).

The 2016 data in this report are the first post-dam data set of the long-term study, following one year of runoff in water year 2016. Water year 2016 produced average rainfall and runoff conditions, with just two main runoff peaks (approximately 800 cfs and 1900 cfs). No significant changes occurred in cross section geometry (Appendix A). A more detailed study that tracked the precise limit of sediment movement from the dam-removal site indicated that sediment impacts were limited to within 3.5 km of the dam site (ENVS 660 2016), which is far upstream of the study reaches surveyed in this report. In general, there was less sand in the cross sections in 2016, perhaps because sand deposited during the drought year low flows was winnowed by the elevated flows of 2016. In summary, no observations in the 2016 surveys can be ascribed to dam-removal impact. Following the first year of dam removal, there are no unintended consequences to report.

Figure 16 shows the downstream and temporal patterns in grain size from the three years of observation. Anticipated downstream fining in the D50 fraction is evident in all percentile categories. In 2016, the downstream reduction in D50 is interrupted by fining of the D50 in the two closely spaced sites at deDampierre.

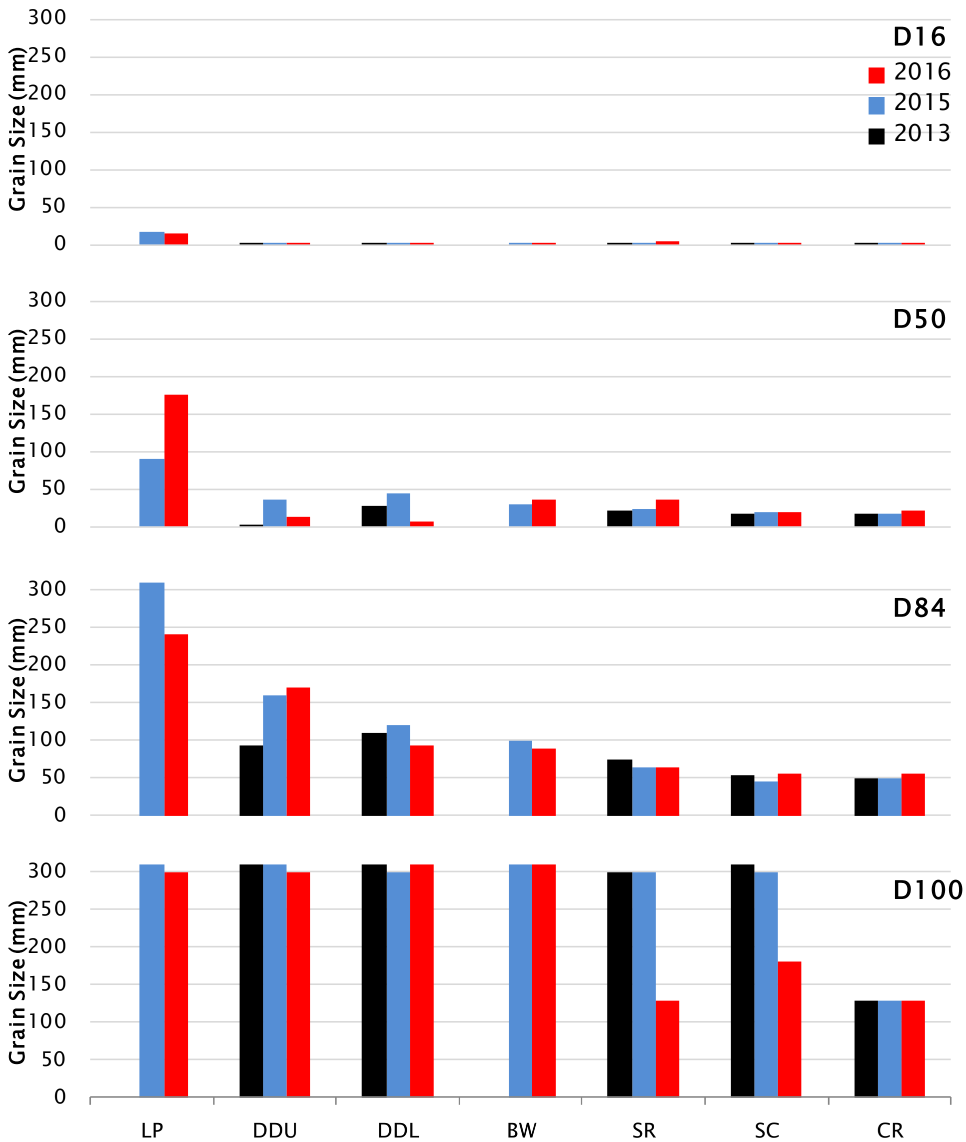


Figure 16. Particle size percentiles averaged within reaches and arranged by year from upstream (LP) to downstream (CR). Symbols are Los Padres (LP), upper DeDampierre (DDU), lower DeDampierre (DDL), San Carlos Road (SC), and Crossroads (CR). 2013 data from Leiker et al. (2014). Locations in Figure 1.

5 References

Boughton DA, East A, Hampston L, Kiernan J, Leiker, S, Mantua N, Nicol C, Smith D, Urquhart K, Williams T, Harrison L. 2016. Removing a dam and re-routing a river: Will expected benefits for Steelhead materalize in Carmel River, California? NOAA Technical Memorandum, NOAA-TM-NMFS-SWFSC-553. US Department of Commerce. Southwest Fisheries Science Center, Santa Cruz, CA. 89 pp.

Bunte K., Abt S. 2001. Sampling Frame for Improving Pebble Count Accuracy in Coarse Gravel-bed Streams. Journal of the American Water Resources Association. Vol. 37, No. 4:1001-1014.

[CCOWS] Central Coast Watershed Studies. 2012. San Clemente Dam Removal and Carmel River Reroute Monitoring Plan: Carmel, CA. The Watershed Institute, Seaside, CA. Available from: http://ccows.csumb.edu/pubs/proj_pubs/2012/ENVS660_Carmel_Monitoring/CSUMB_ENVS660_ClassReport_DamRemovalMonitoring_121024.pdf

Chow K., Luna L., Delforge A. and Smith D. 2016. 2015 Pre-San Clemente Dam Removal Morphological Monitoring of the Carmel River Channel in Monterey County, California. The Watershed Institute, California State University Monterey Bay, Publication No. WI-2016-01, 50 pp.

[CSUMB] Class ENVS 660: Chow K, Fields J, Flores S, Hart K, Kleven A, Luna L, MacCarter L, and Smith D. 2016. San Clemente Dam Removal Sediment Impacts: Year One Report. Watershed Institute, California State University Monterey Bay, Publication No. WI-2016-10, 38 pp.

Harrelson C. Rawlins C. Potyondy J. 1994. Stream channel reference sites: an illustrated guide to field technique. Gem Tech. Per. RM-245. Fort Collins, CA: U.S.

Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station, 61 pp.

Leiker S. Delforge A. Geisler E. Smith D. 2014. Pre-San Clemente Dam Removal Morphological Monitoring of the Carmel River Channel in Monterey County, California. The Watershed Institute, California State University Monterey Bay, Publication No. WI-2014-07, 32 pp.

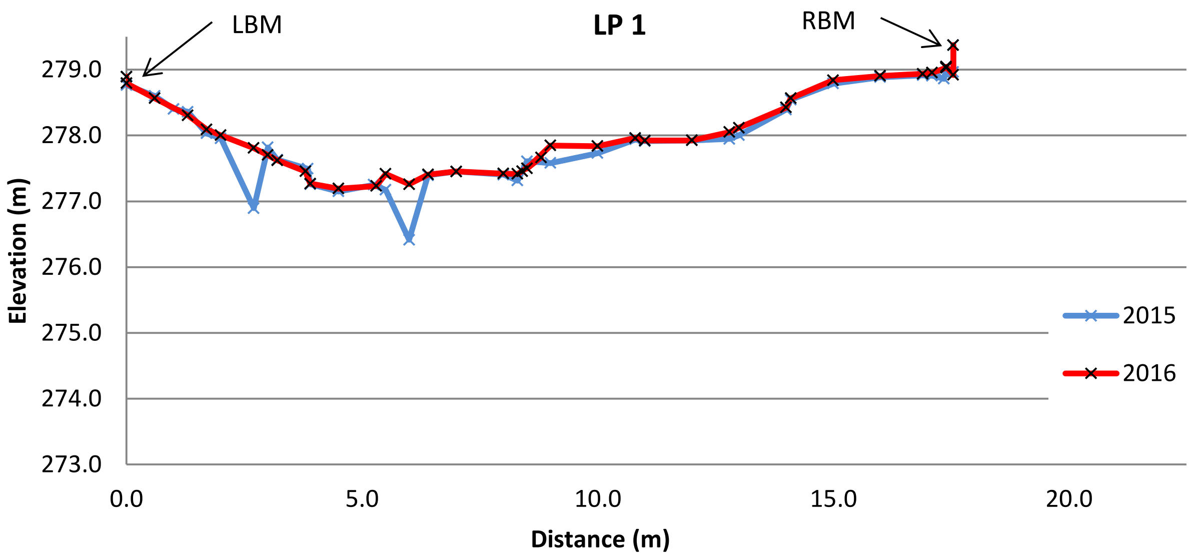
Mussetter Engineering, Inc., 2005. Hydraulic and Sediment-transport Analysis of the Carmel River Bypass Option, California. Prepared for California American Water. April 25, 2005. 74pp.

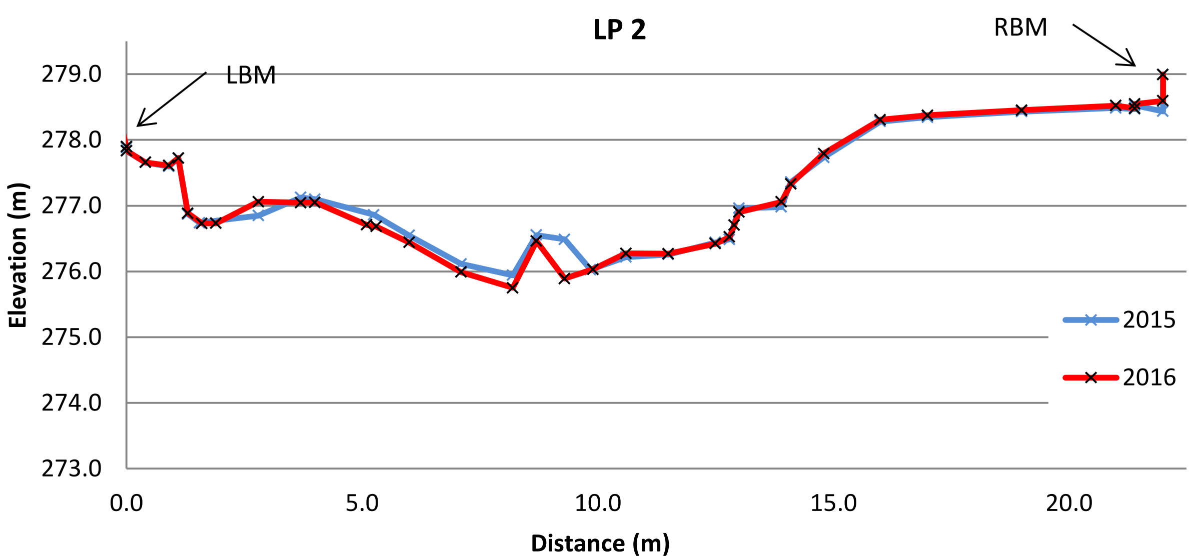
[NOAA] National Oceanic and Atmospheric Administration. Fisheries Staff and Collaborators. Nov 2012. DRAFT Conceptual Model of the Carmel River System. SW Fisheries Science Center, Santa Cruz, CA.

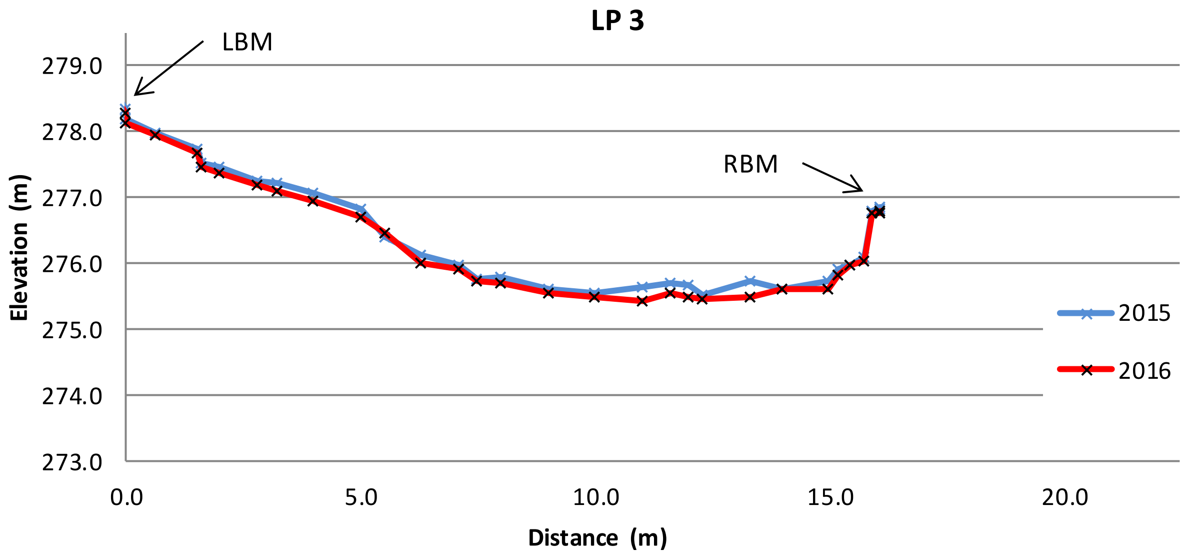
[SCDRP] San Clemente Dam Removal Project. 2014. Project Overview. Available from: http://www.sanclementedamremoval.org/

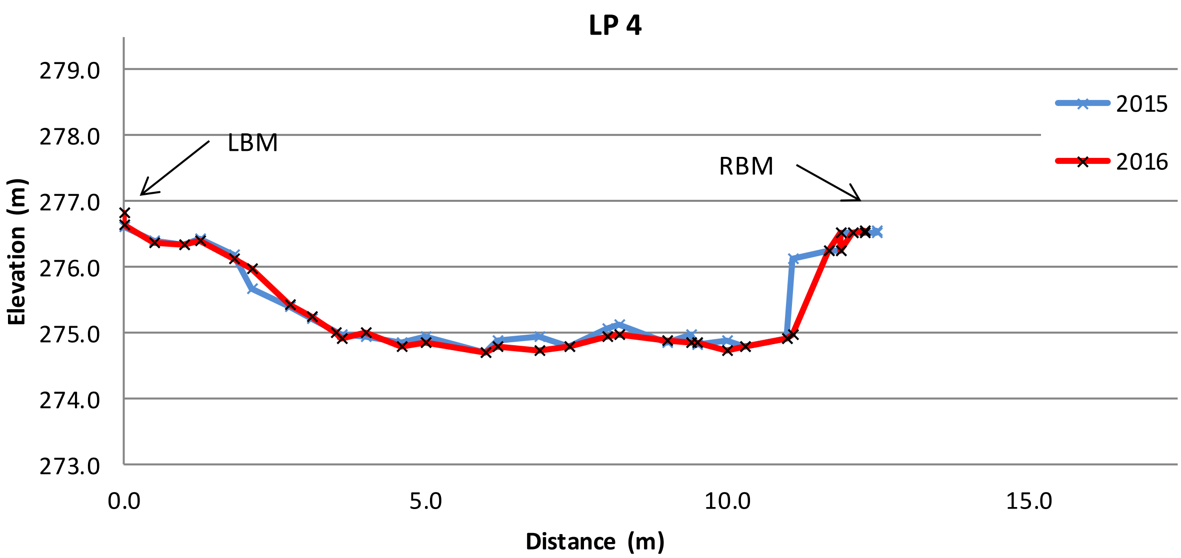
6 Appendix A: Cross Sections

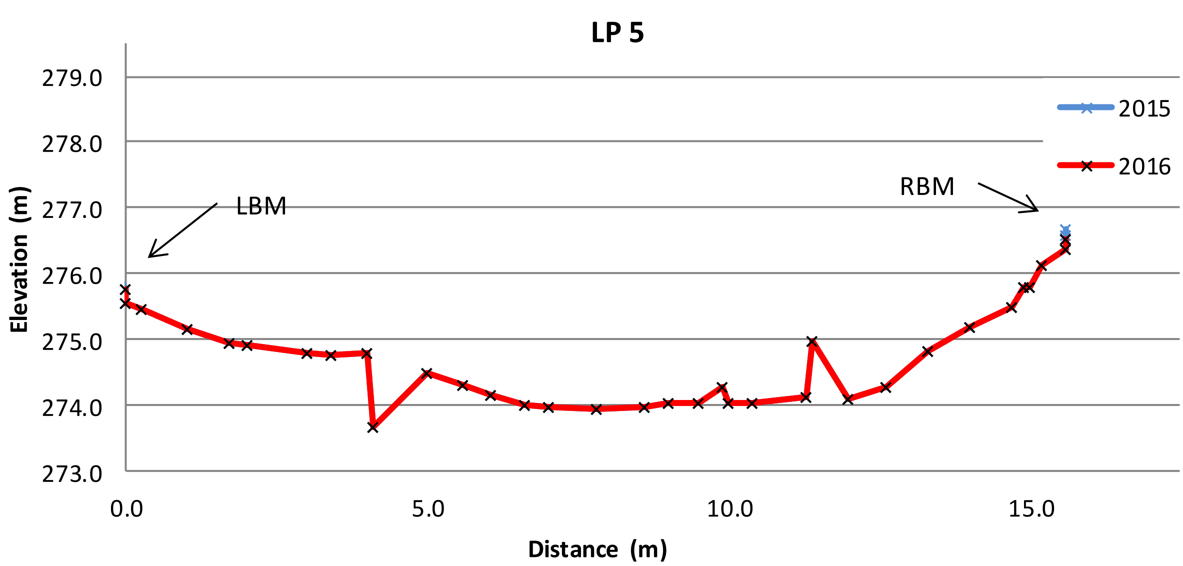
Channel geometry for each cross section surveyed within each reach. Cross sections are denoted by their reach abbreviation (LP, DDU, DDL, BW, SR, SC, and CR) and transect number descending from upstream to downstream (1 to 4 or 6). An asterisk (*) next to the left or right benchmark (LBM or RMB) indicates a different benchmark than the original (2013 or 2015) survey.

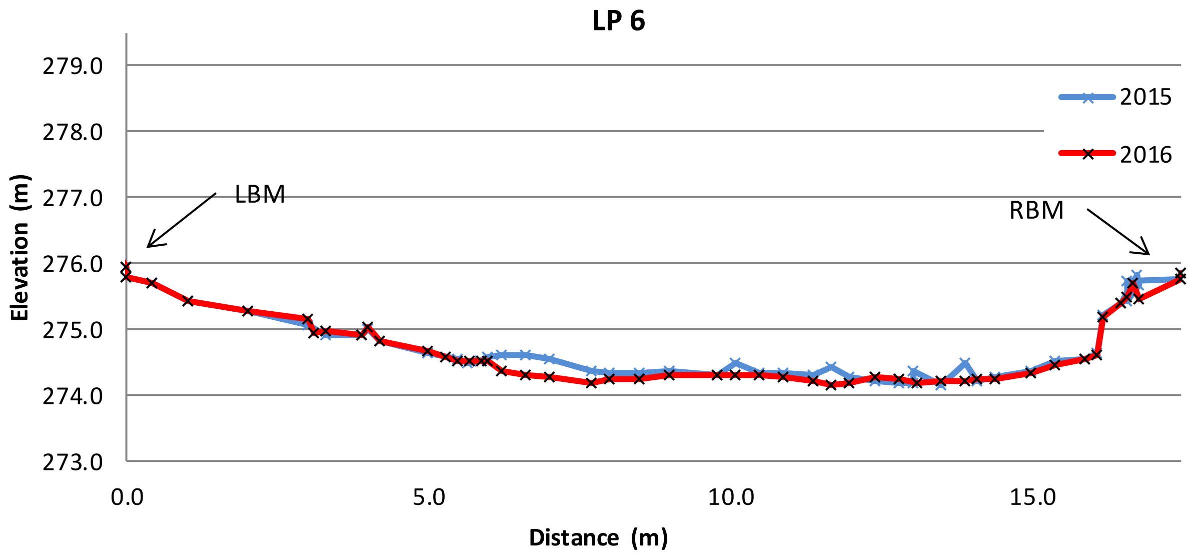


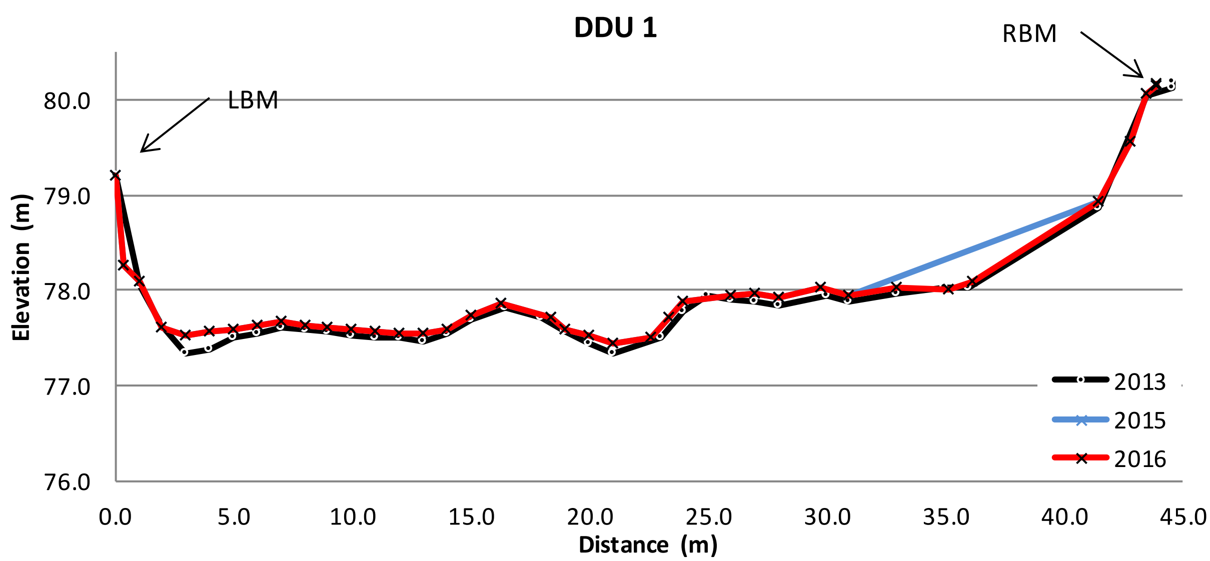


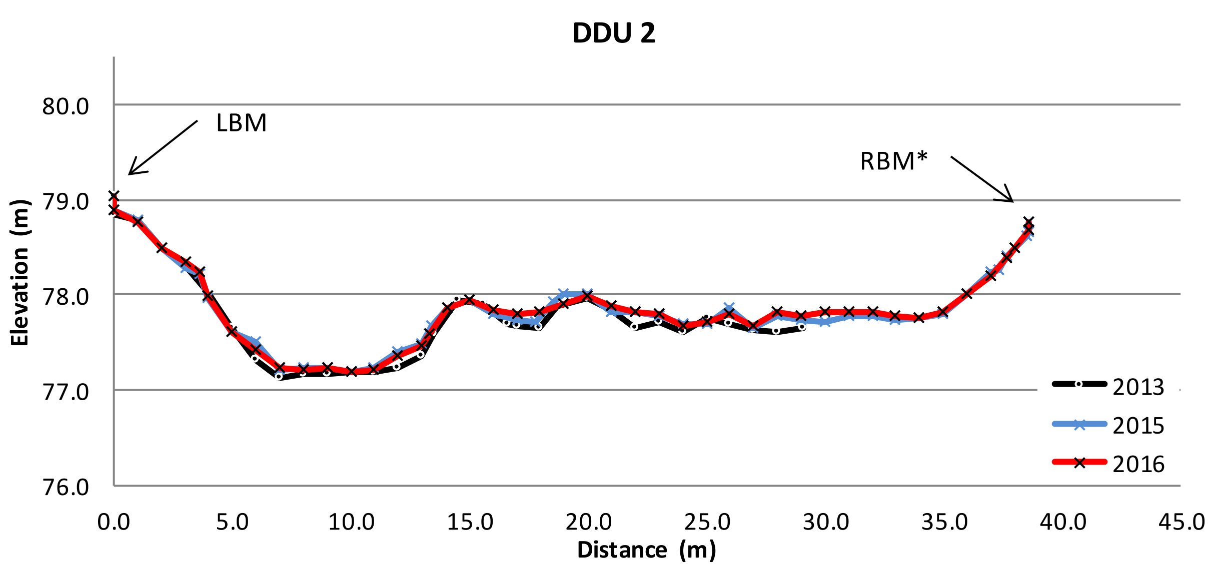

LP 3
LBM
RBM
Elevation (m)
Distance (m)
279.0
278.0
277.0
276.0
275.0
274.0
273.0
0.0
5.0
10.0
15.0
20.0
2015
2016

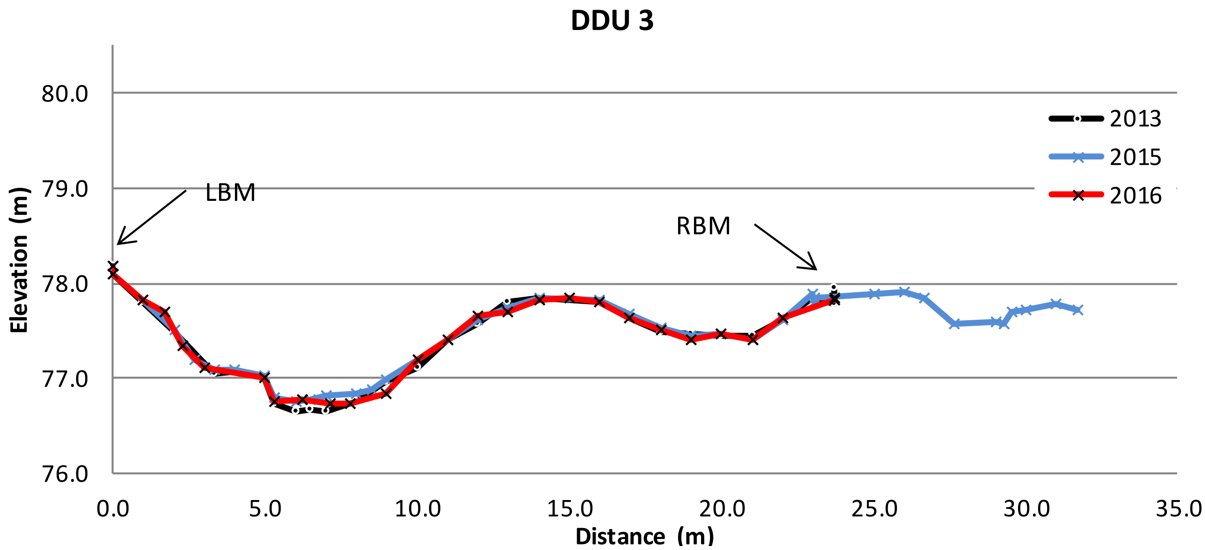

LP 4
LBM
RBM
Elevation (m)
Distance (m)
279.0
278.0
277.0
276.0
275.0
274.0
273.0
0.0
5.0
10.0
15.0
2015
2016

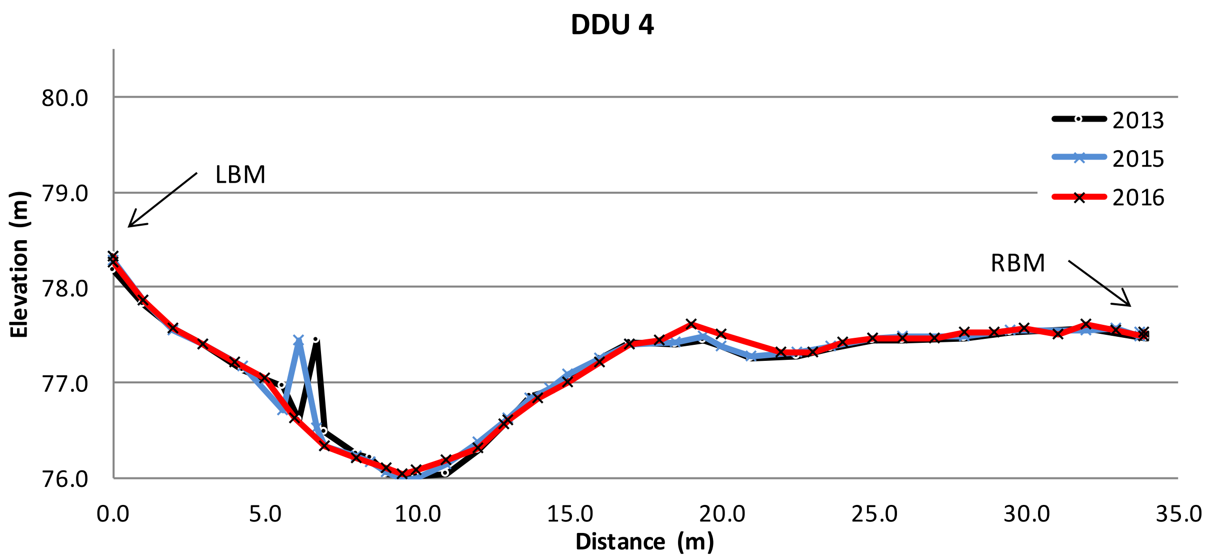

LP 5
LBM
RBM
Elevation (m)
Distance (m)
279.0
278.0
277.0
276.0
275.0
274.0
273.0
0.0
5.0
10.0
15.0
2015
2016

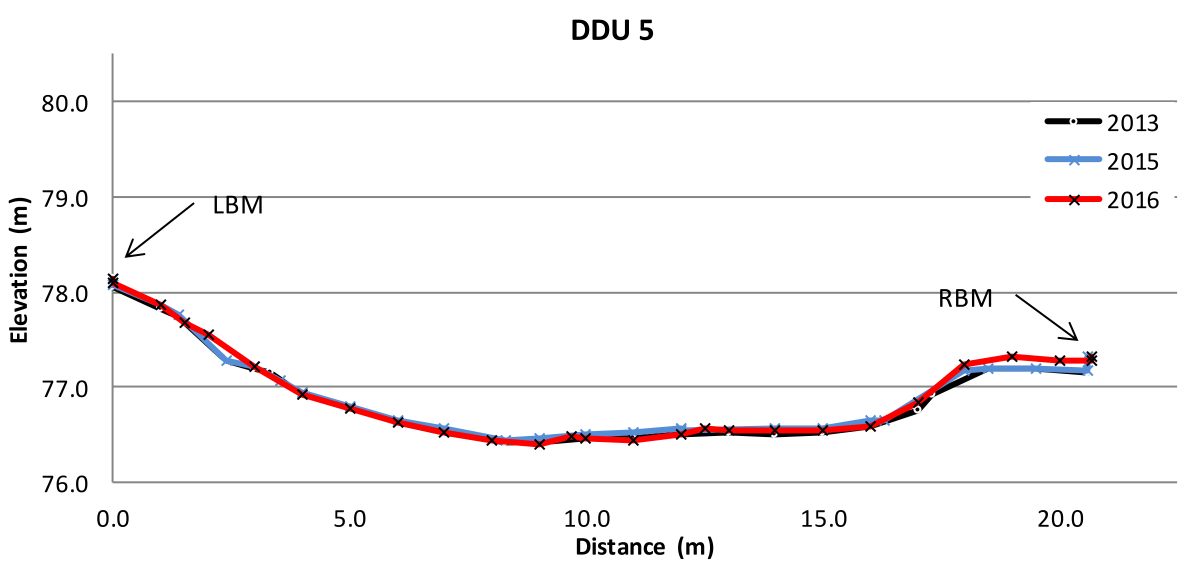

LP 6
Elevation (m)
Distance (m)
2015
2016
LBM
RBM
279.0
278.0
277.0
276.0
275.0
274.0
273.0
0.0
5.0
10.0
15.0


DDU 1
Elevation (m)
Distance (m)
2013
2015
2016
LBM
RBM
80.0
79.0
78.0
77.0
76.0
0.0
5.0
10.0
15.0
20.0
25.0
30.0
35.0
40.0
45.0


DDU 2
Elevation (m)
Distance (m)
2013
2015
2016
LBM
RBM*
80.0
79.0
78.0
77.0
76.0
0.0
5.0
10.0
15.0
20.0
25.0
30.0
35.0
40.0
45.0


DDU 3
LBM
RBM
2013
2015
2016
Elevation (m)
Distance (m)
80.0
79.0
78.0
77.0
76.0
0.0
5.0
10.0
15.0
20.0
25.0
30.0
35.0


DDU 4
LBM
RBM
2013
2015
2016
Elevation (m)
Distance (m)
80.0
79.0
78.0
77.0
76.0
0.0
5.0
10.0
15.0
20.0
25.0
30.0
35.0


DDU 5
LBM
RBM
2013
2015
2016
Elevation (m)
Distance (m)
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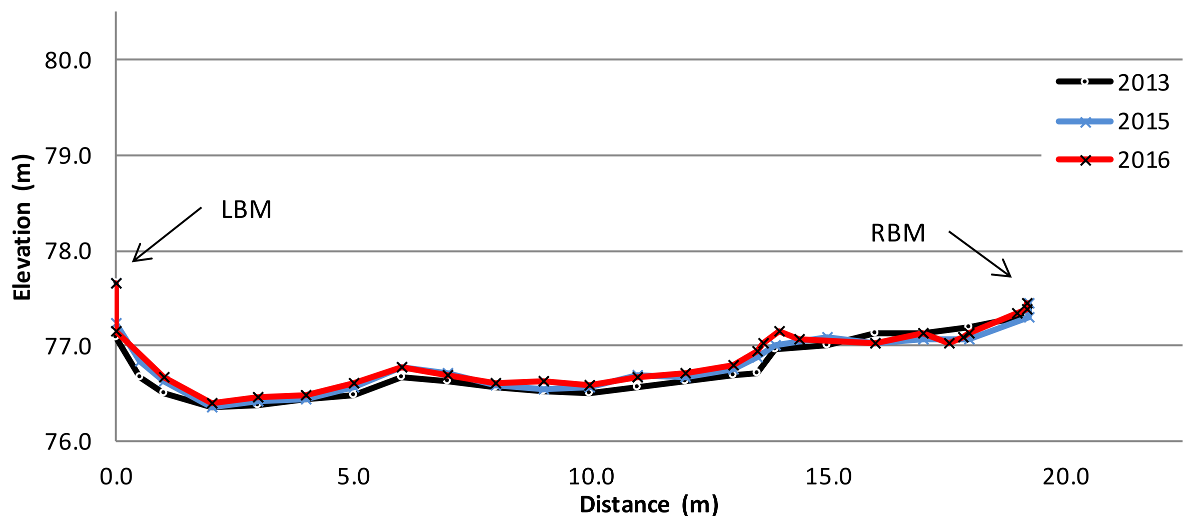
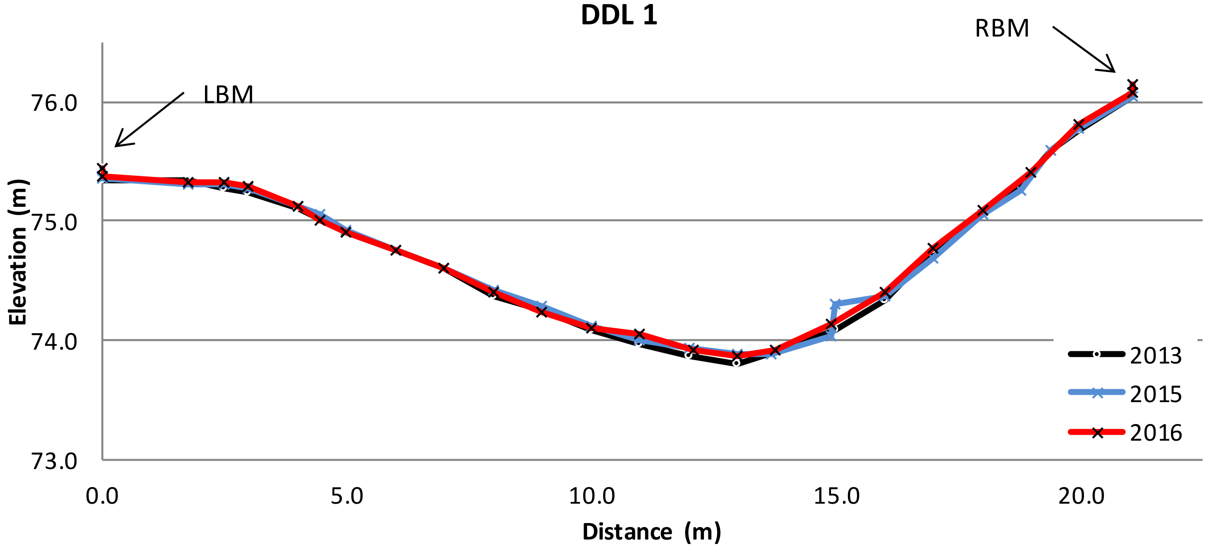
79.0
78.0
77.0
76.0
0.0
5.0
10.0
15.0
20.0

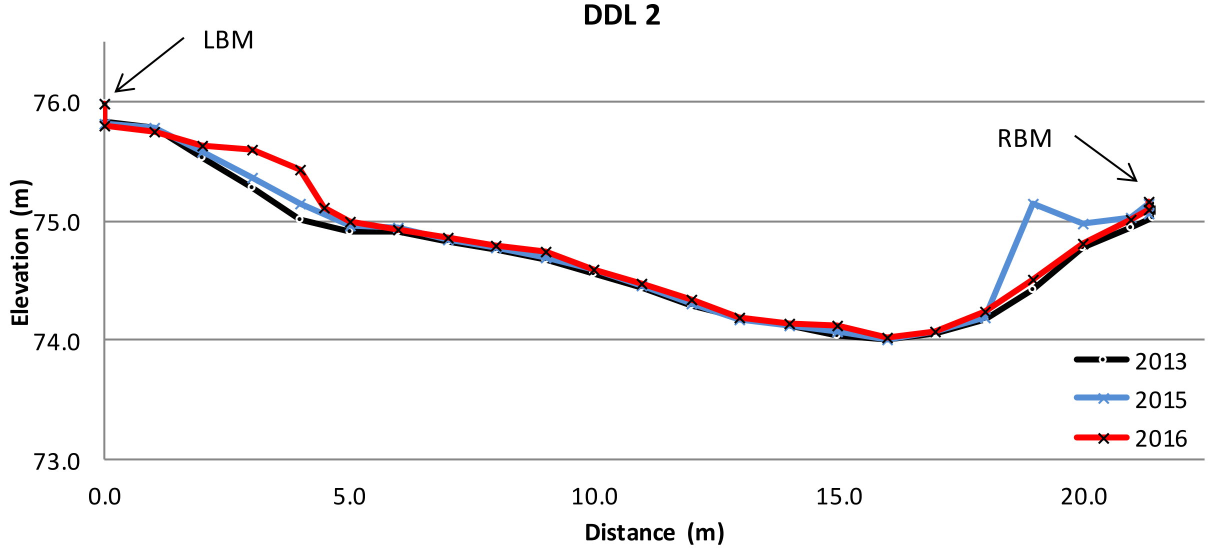
DDU 6

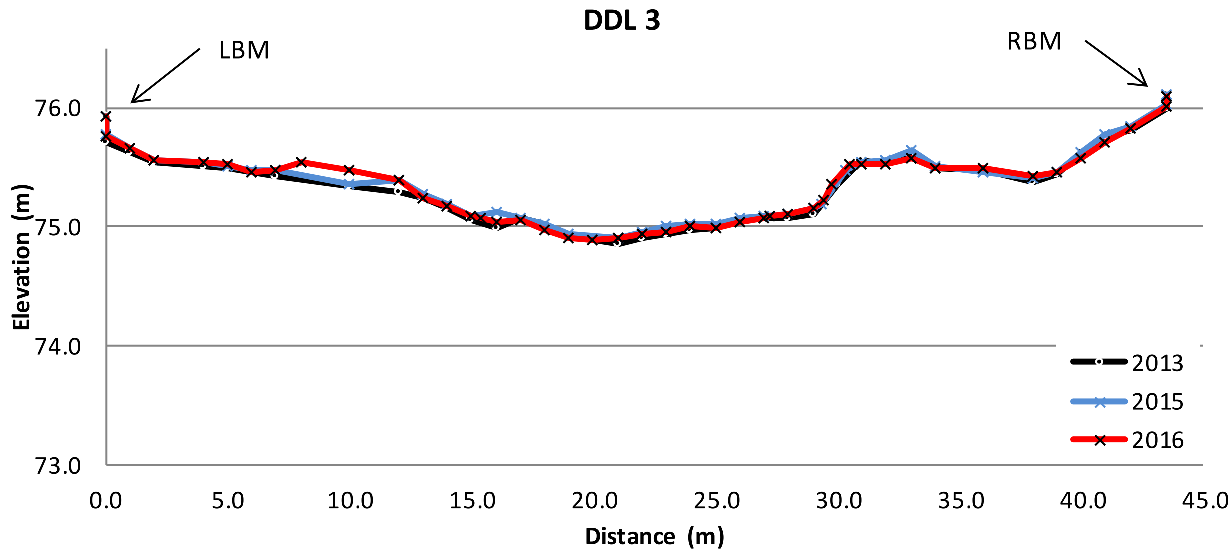


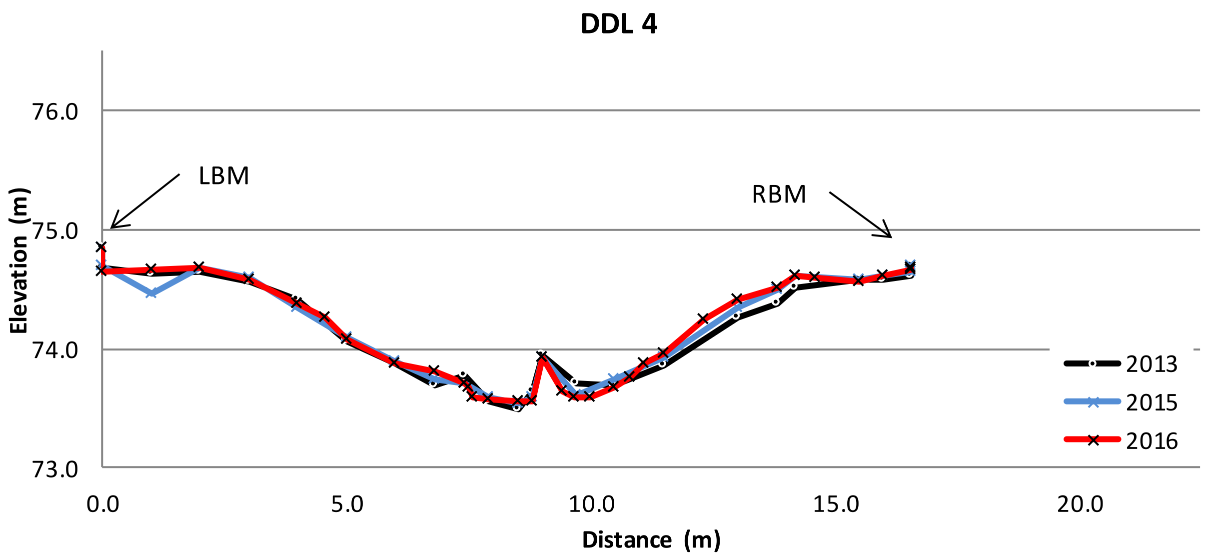
DDL 1

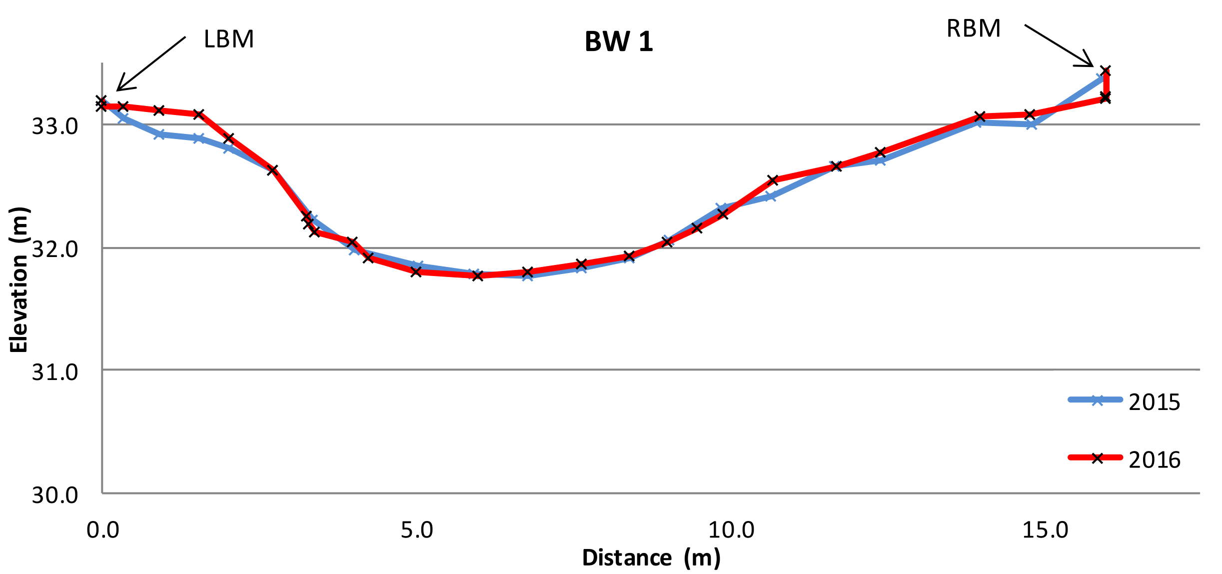


DDL 2




DDL 3
LBM
RBM
76.0
75.0
74.0
73.0
Elevation (m)
0.0
5.0
10.0
15.0
20.0
25.0
30.0
35.0
40.0
45.0
Distance (m)
2013
2015
2016


DDL 4
LBM
RBM
76.0
75.0
74.0
73.0
Elevation (m)
0.0
5.0
10.0
15.0
20.0
Distance (m)
2013
2015
2016


BW 1
LBM
RBM
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30.0
Elevation (m)
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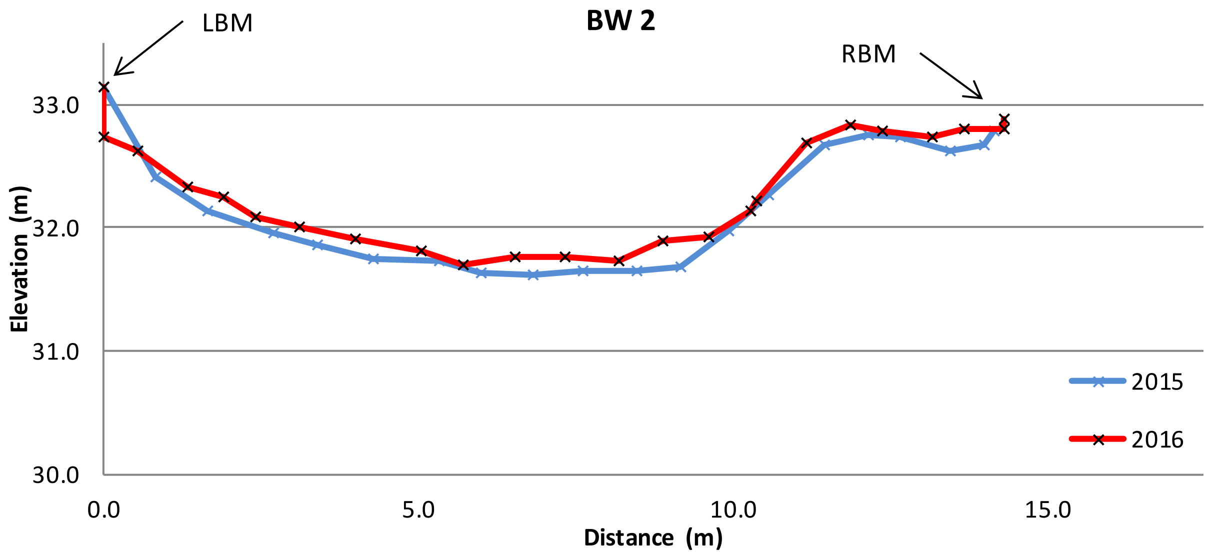
5.0
10.0
15.0
Distance (m)
2015
2016


BW 2
LBM
RBM
Elevation (m)
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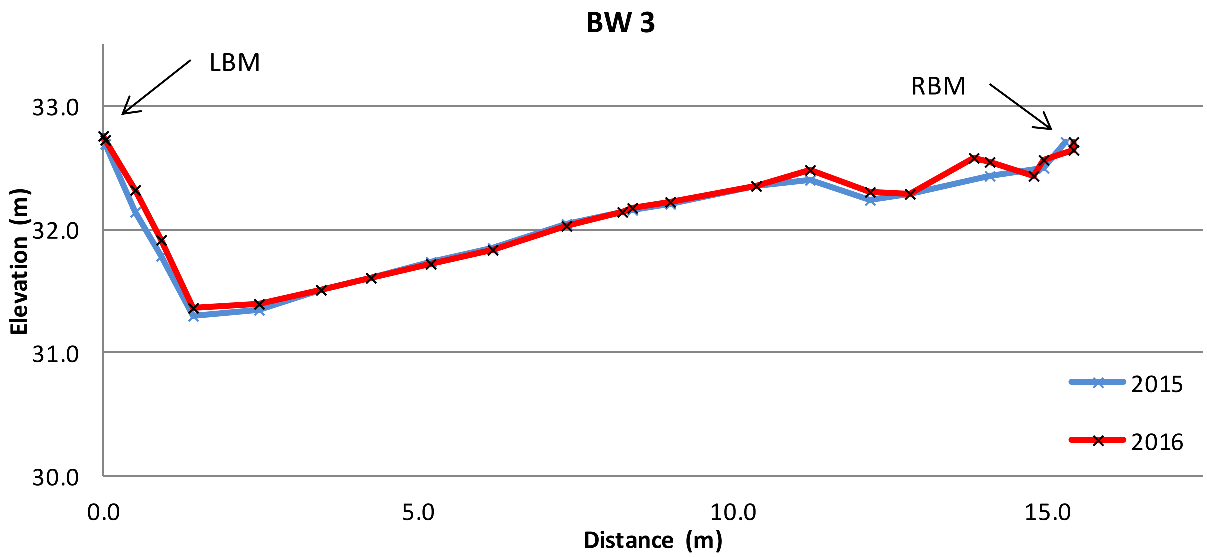
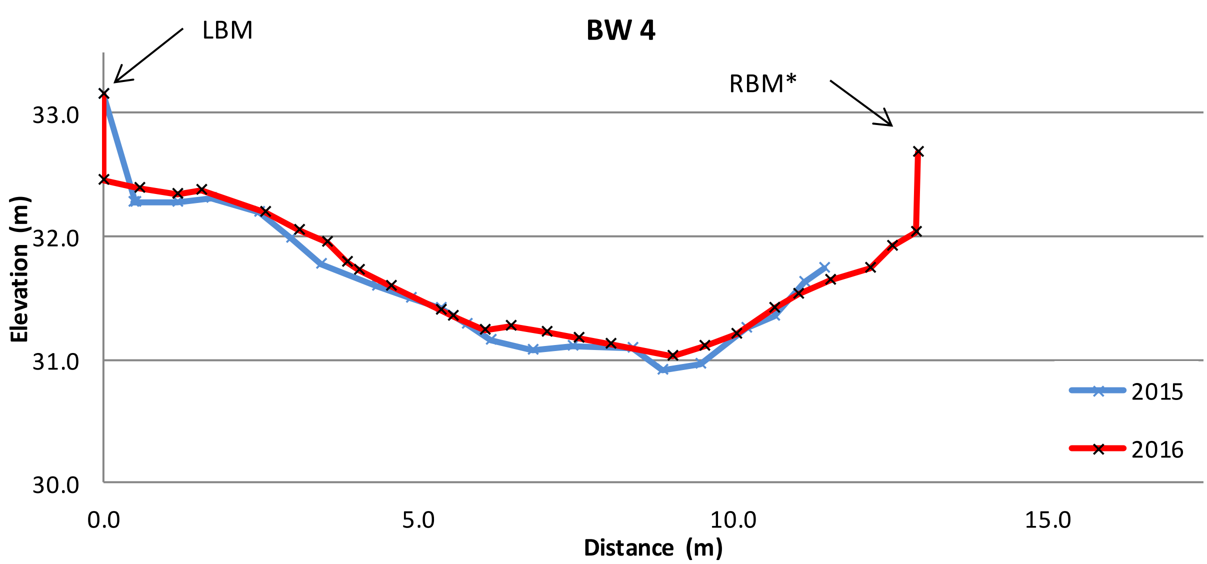
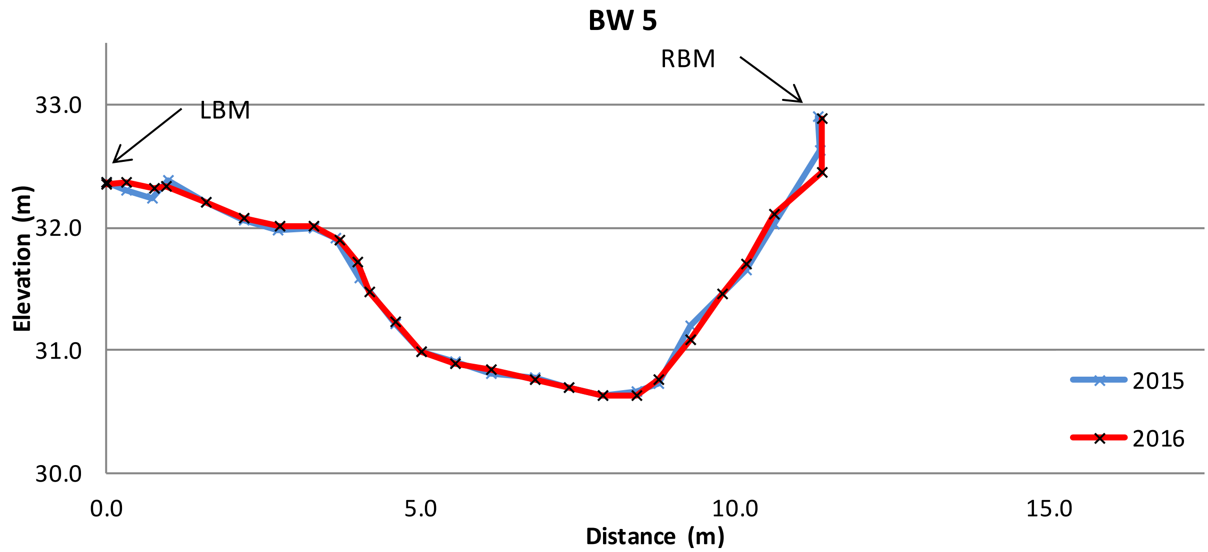
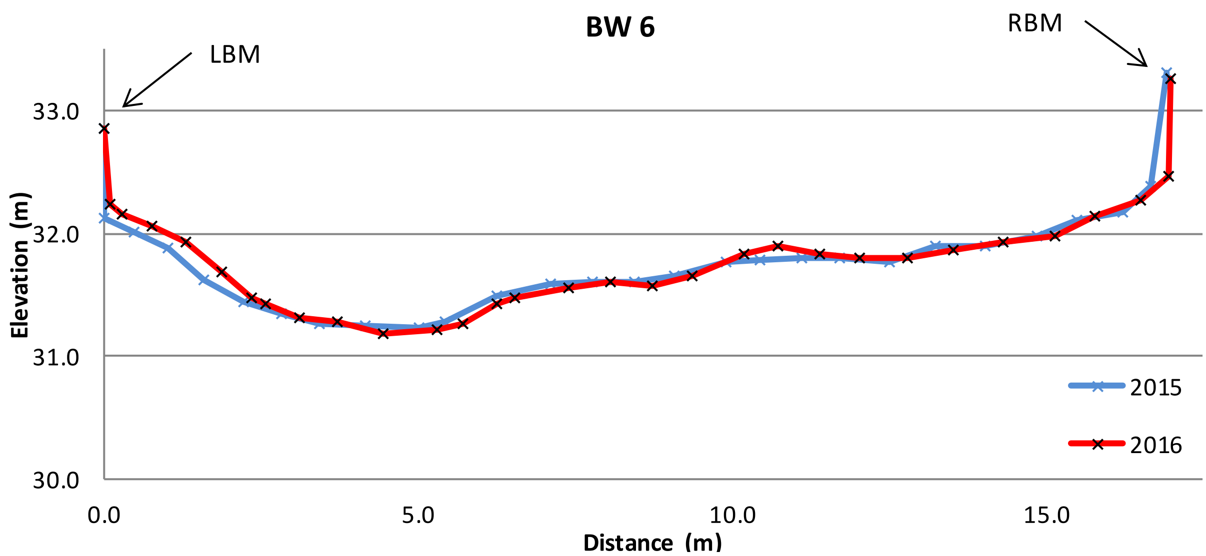
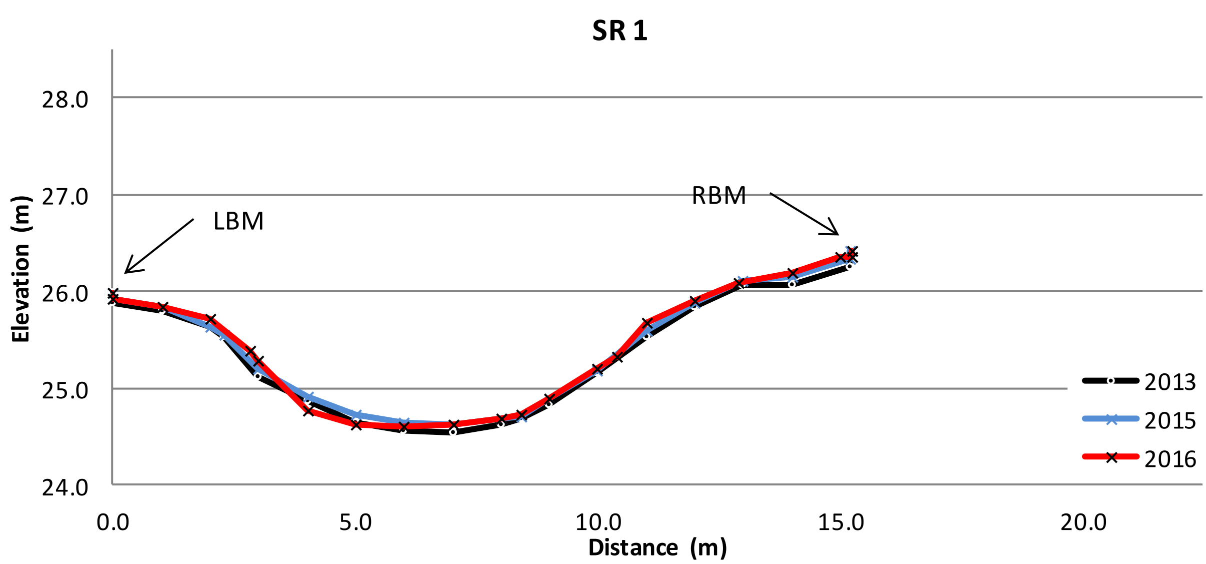
32.0
31.0
30.0
0.0
5.0
10.0
15.0
Distance (m)
2015
2016

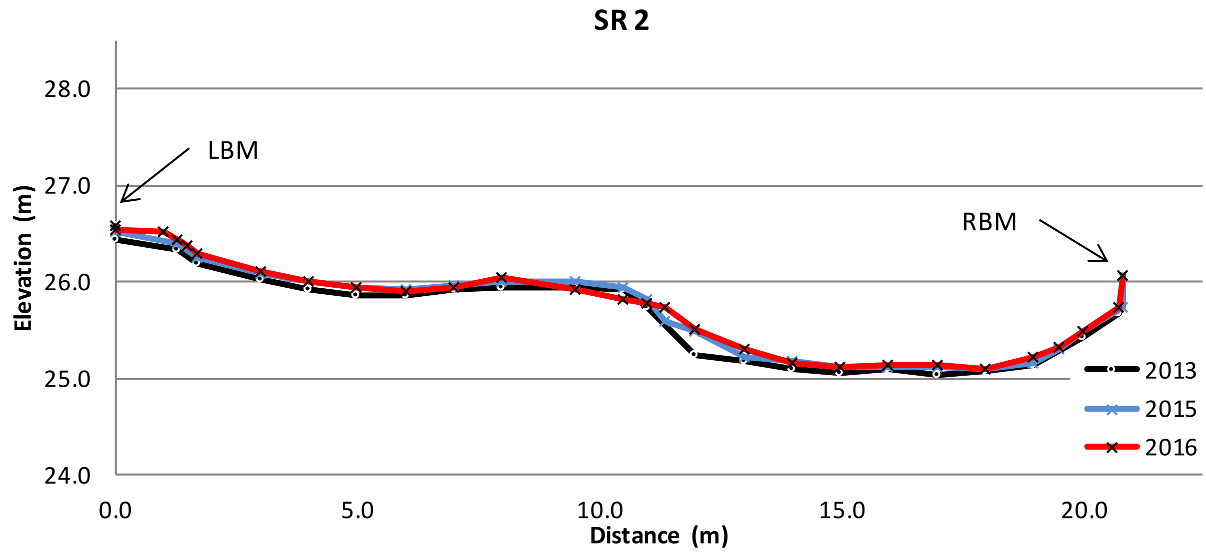

BW 3
LBM
RBM
Elevation (m)
33.0
32.0
31.0
30.0
0.0
5.0
10.0
15.0
Distance (m)
2015
2016


BW 4
LBM
RBM*
Elevation (m)
33.0
32.0
31.0
30.0
0.0
5.0
10.0
15.0
Distance (m)
2015
2016


BW 5
RBM
LBM
33.0
32.0
31.0
30.0
Elevation (m)
0.0
5.0
10.0
15.0
Distance (m)
2015
2016


BW 6
LBM
RBM
33.0
32.0
31.0
30.0
Elevation (m)
0.0
5.0
10.0
15.0
Distance (m)
2015
2016


SR 1
28.0
27.0
26.0
25.0
24.0
Elevation (m)
LBM
RBM
0.0
5.0
10.0
15.0
20.0
Distance (m)
2013
2015
2016


SR 2
LBM
RBM
Elevation (m)
Distance (m)
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26.0
25.0
24.0
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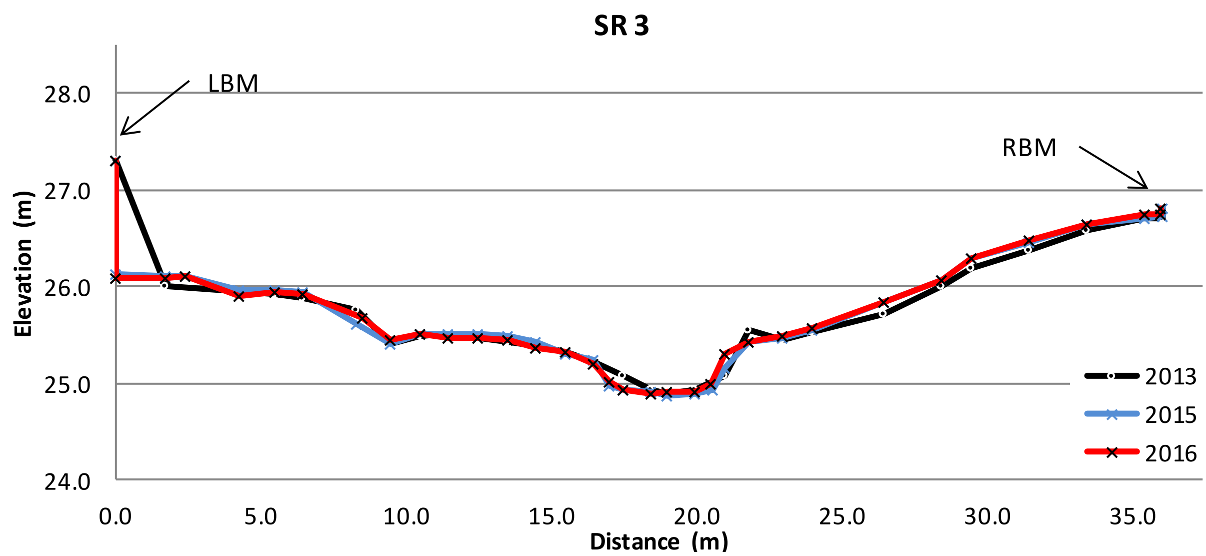
5.0
10.0
15.0
20.0
2013
2015
2016


SR 3
LBM
RBM
Elevation (m)
Distance (m)
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27.0
26.0
25.0
24.0
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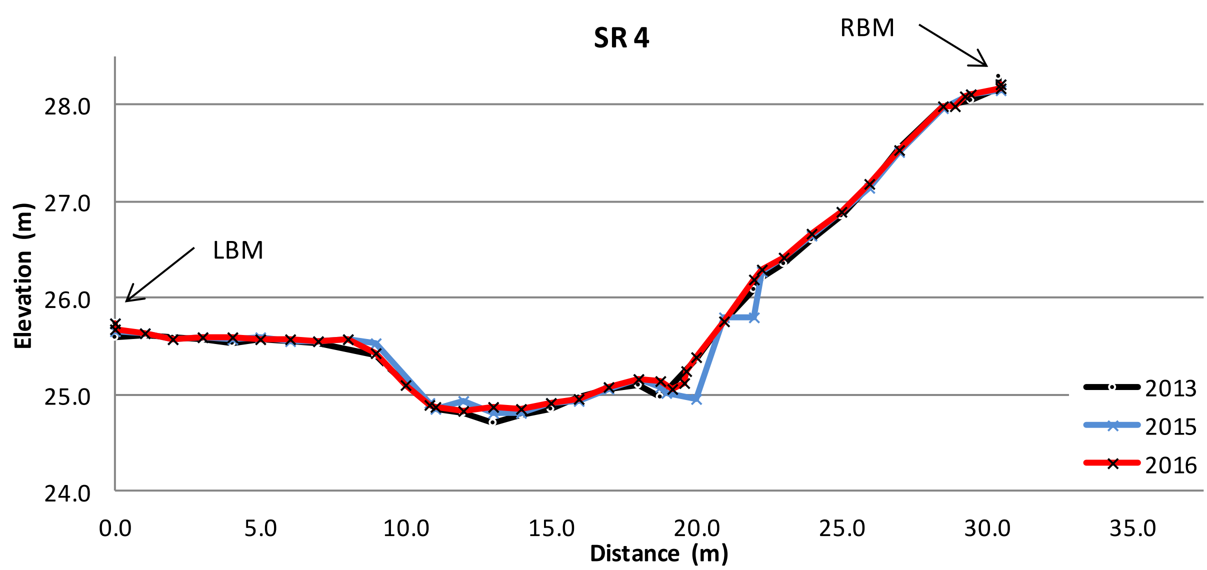
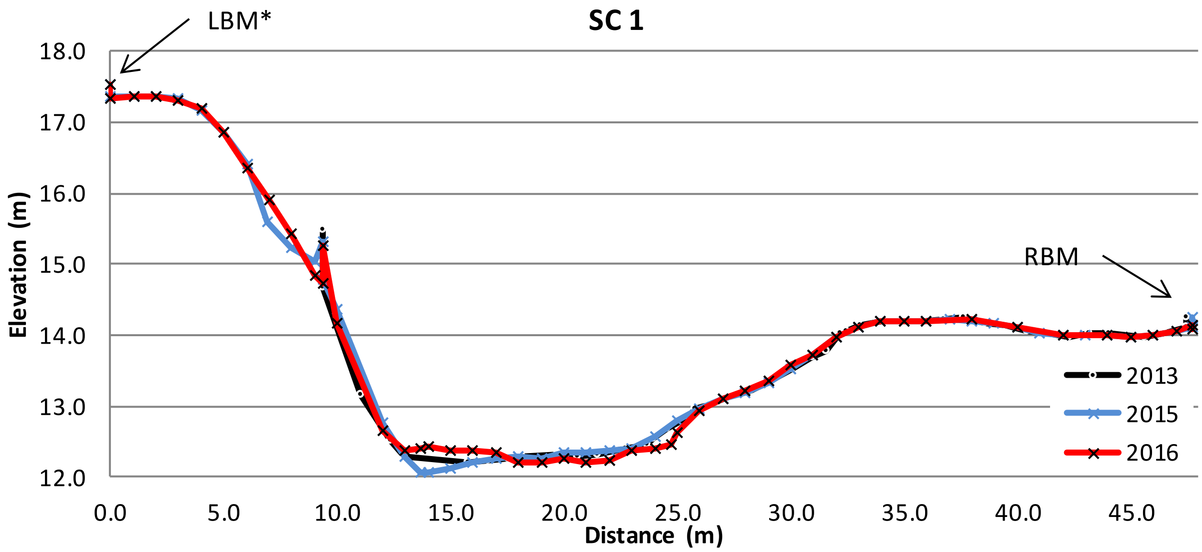
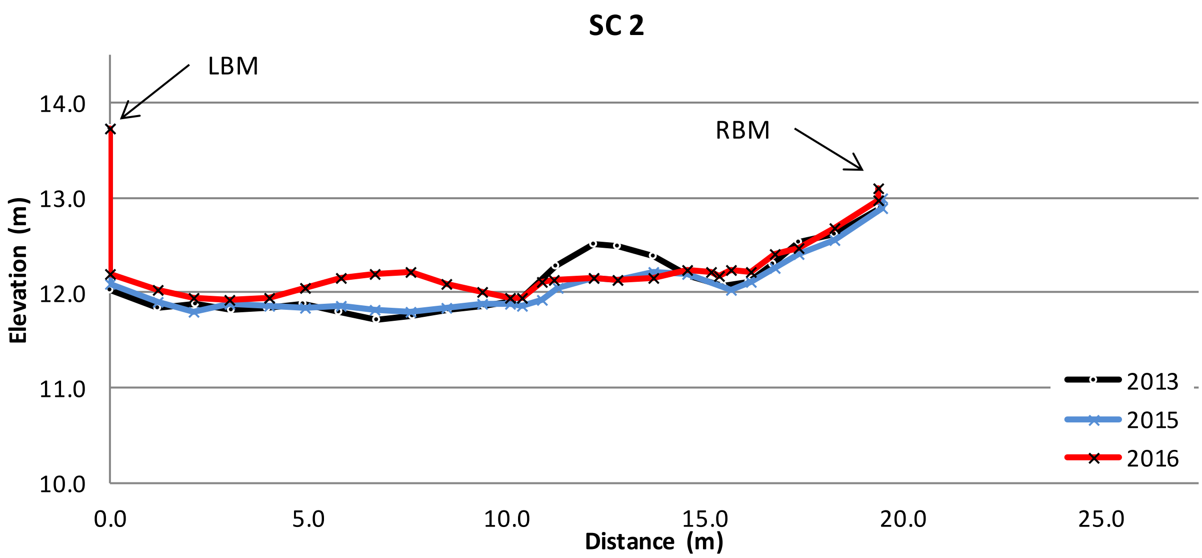
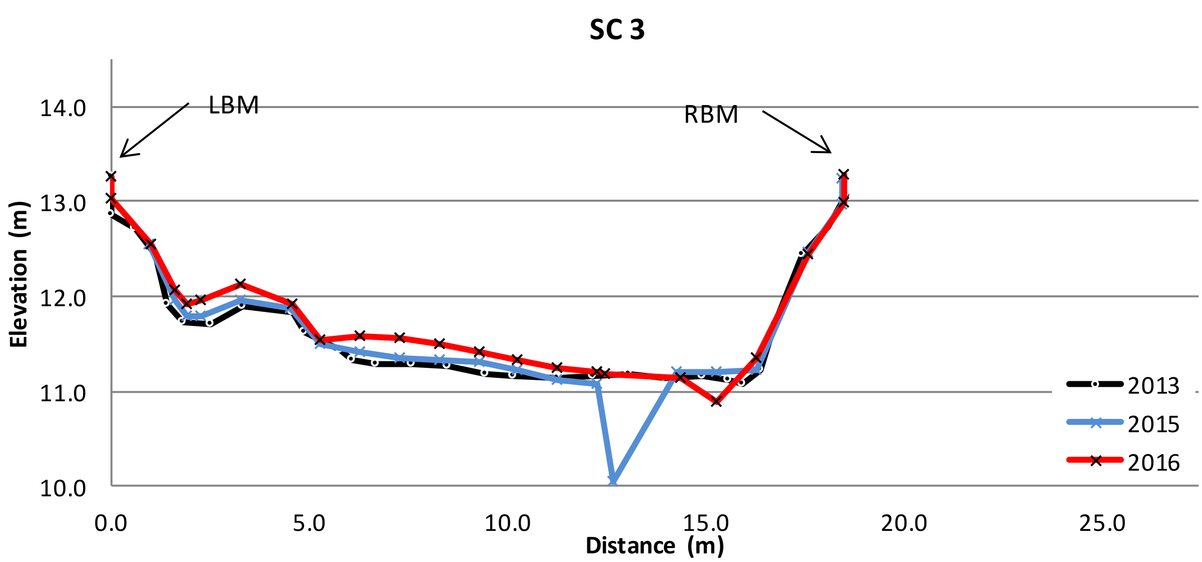
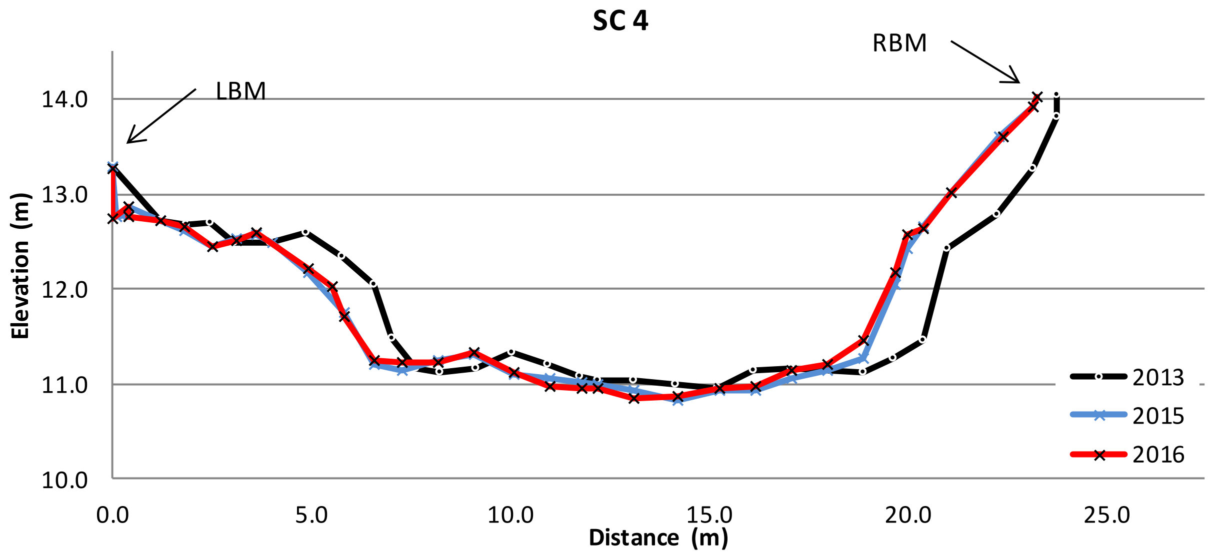
5.0
10.0
15.0
20.0
25.0
30.0
35.0
2013
2015
2016

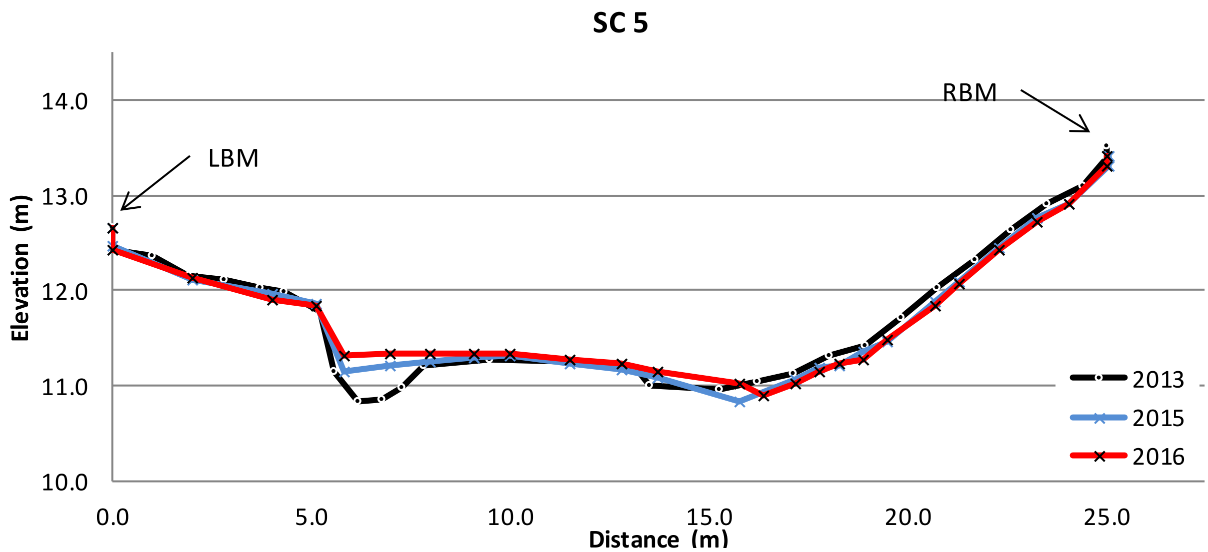

SR 4
RBM
LBM
Elevation (m)
Distance (m)
28.0
27.0
26.0
25.0
24.0
0.0
5.0
10.0
15.0
20.0
25.0
30.0
35.0
2013
2015
2016

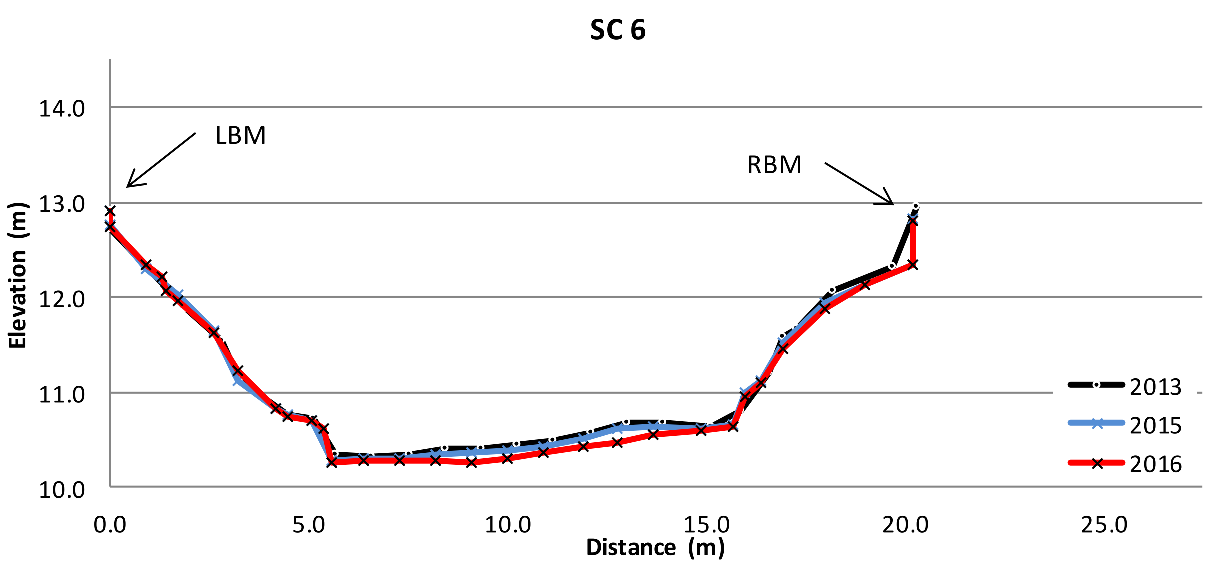

SC 1
LBM*
RBM
Elevation (m)
18.0
17.0
16.0
15.0
14.0
13.0
12.0
0.0
5.0
10.0
15.0
20.0
25.0
30.0
35.0
40.0
45.0
Distance (m)
2013
2015
2016

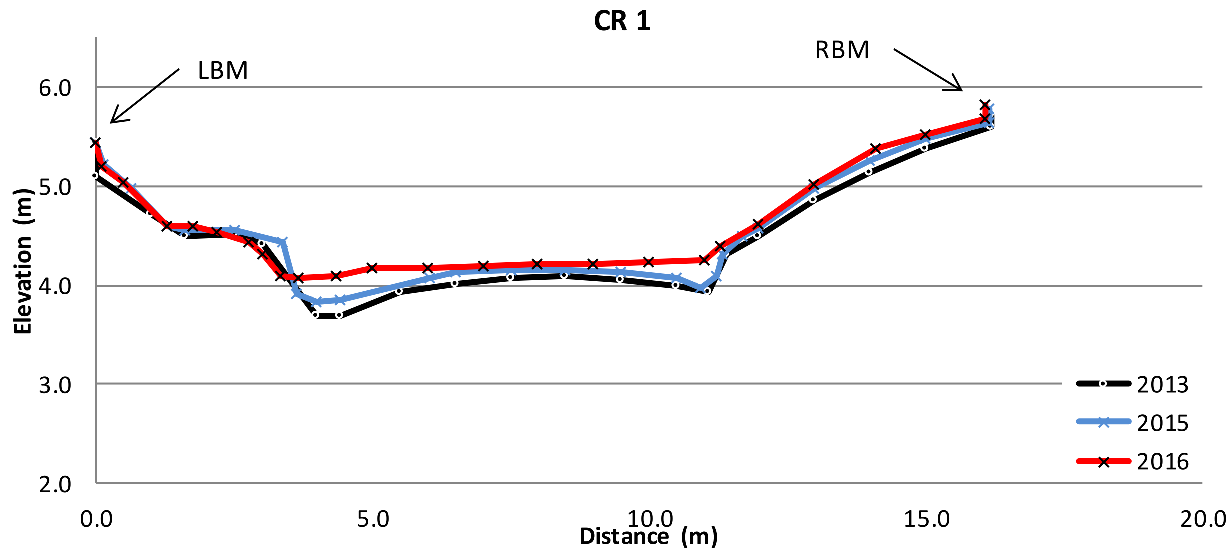

SC 2
LBM
RBM
Elevation (m)
14.0
13.0
12.0
11.0
10.0
0.0
5.0
10.0
15.0
20.0
25.0
Distance (m)
2013
2015
2016

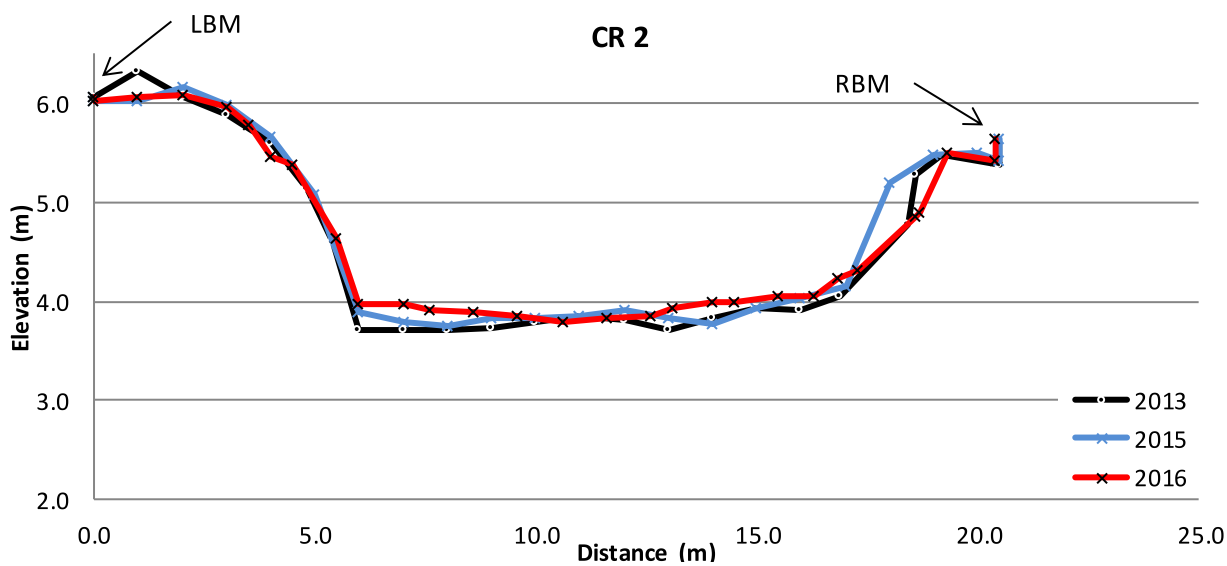

SC 3
LBM
RBM
Elevation (m)
14.0
13.0
12.0
11.0
10.0
0.0
5.0
10.0
15.0
20.0
25.0
Distance (m)
2013
2015
2016

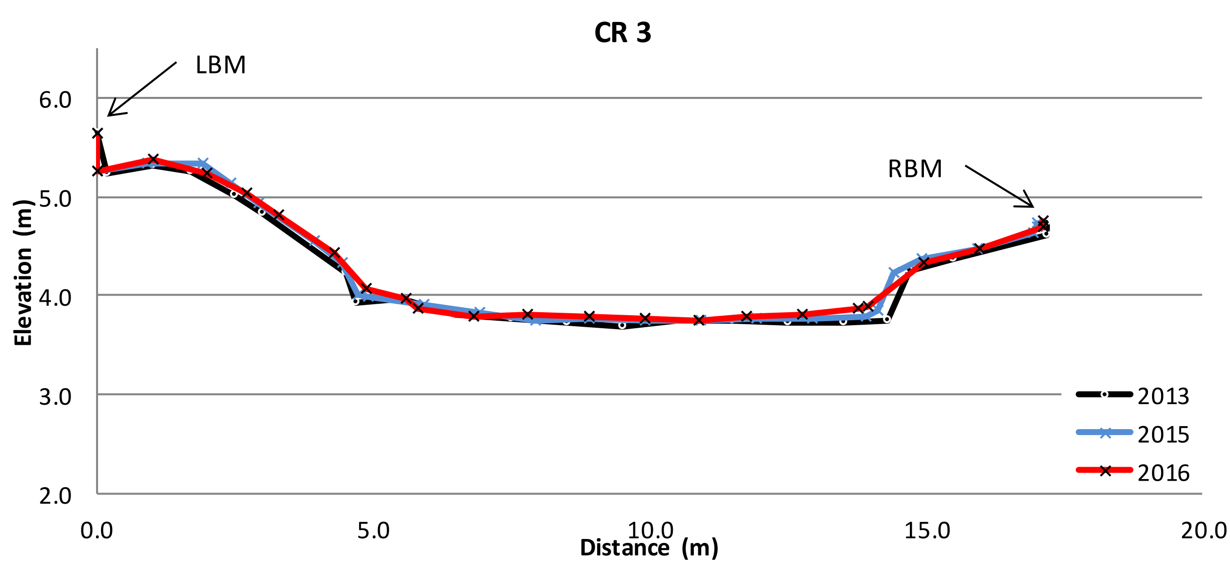

SC 4
RBM
LBM
14.0
13.0
12.0
11.0
10.0
Elevation (m)
0.0
5.0
10.0
15.0
20.0
25.0
Distance (m)
2013
2015
2016

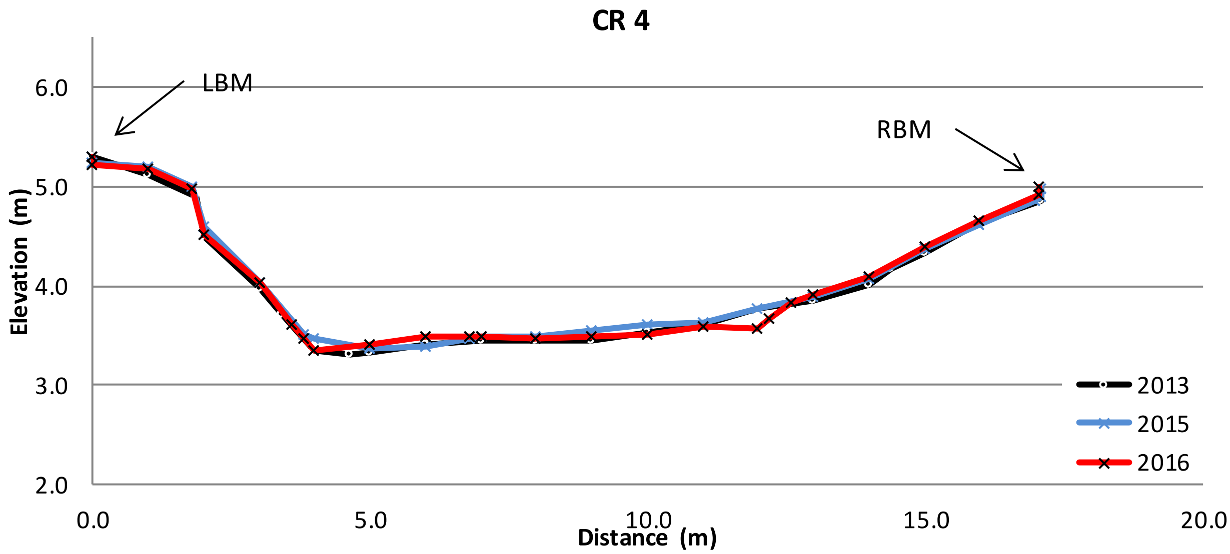

SC 5
RBM
LBM
14.0
13.0
12.0
11.0
10.0
Elevation (m)
0.0
5.0
10.0
15.0
20.0
25.0
Distance (m)
2013
2015
2016

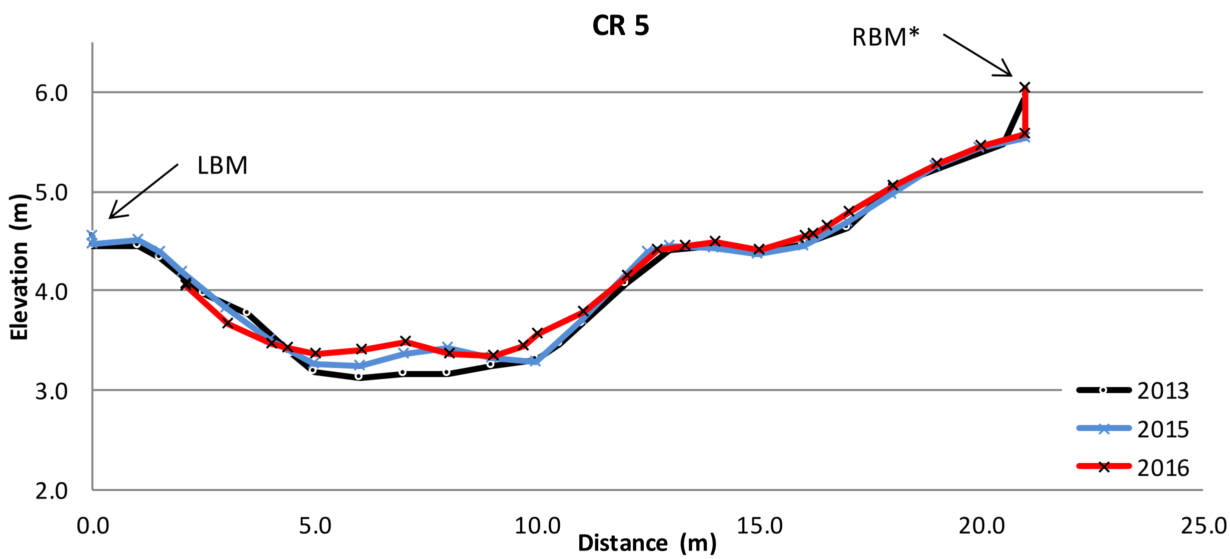

SC 6
LBM
RBM
14.0
13.0
12.0
11.0
10.0
Elevation (m)
0.0
5.0
10.0
15.0
20.0
25.0
Distance (m)
2013
2015
2016

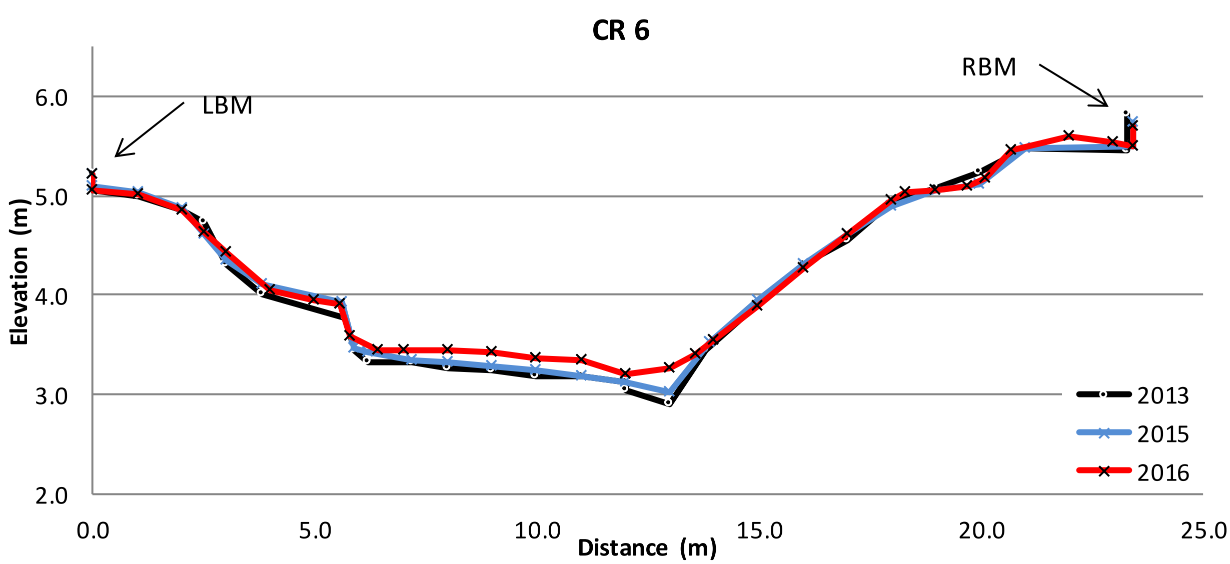

CR 1
LBM
RBM
6.0
5.0
4.0
3.0
2.0
Elevation (m)
0.0
5.0
10.0
15.0
20.0
Distance (m)
2013
2015
2016


CR 2
LBM
RBM
6.0
5.0
4.0
3.0
2.0
Elevation (m)
0.0
5.0
10.0
15.0
20.0
25.0
Distance (m)
2013
2015
2016


CR 3
LBM
RBM
6.0
5.0
4.0
3.0
2.0
Elevation (m)
0.0
5.0
10.0
15.0
20.0
Distance (m)
2013
2015
2016

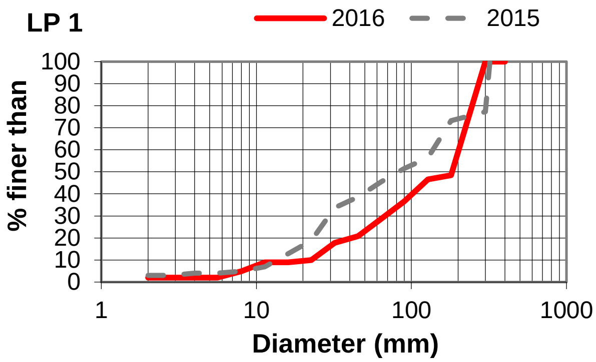

CR 4
LBM
RBM
Elevation (m)
Distance (m)
6.0
5.0
4.0
3.0
2.0
0.0
5.0
10.0
15.0
20.0
2013
2015
2016

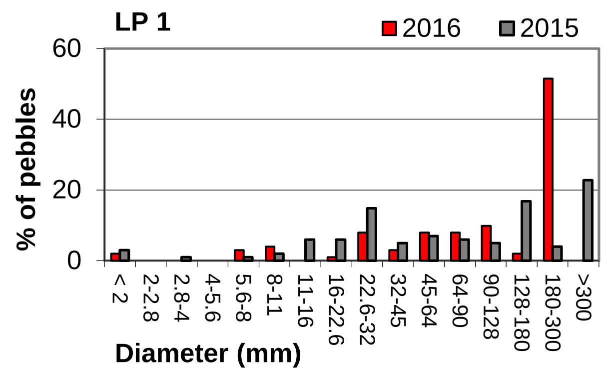

CR 5
RBM*
LBM
Elevation (m)
Distance (m)
6.0
5.0
4.0
3.0
2.0
0.0
5.0
10.0
15.0
20.0
25.0
2013
2015
2016

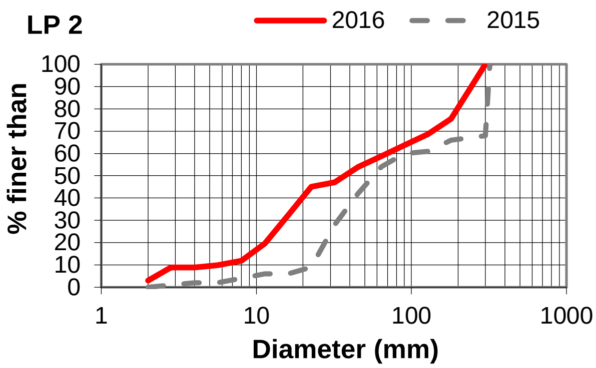

CR 6
RBM
LBM
Elevation (m)
Distance (m)
6.0
5.0
4.0
3.0
2.0
0.0
5.0
10.0
15.0
20.0
25.0
2013
2015
2016

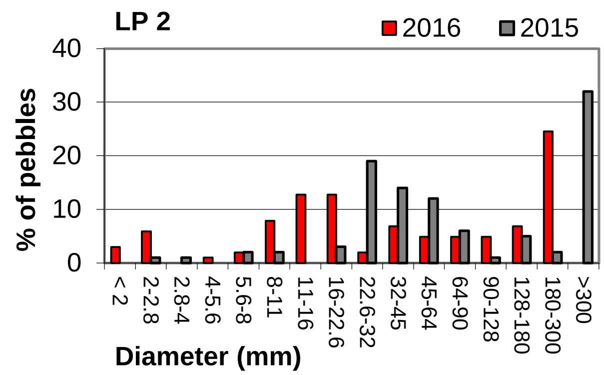
7 Appendix B: Pebble Count Plots

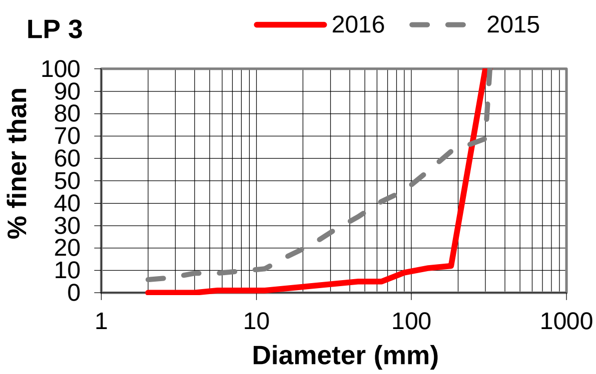
Channel pebble counts for each cross section within each reach. Reaches are denoted by their reach abbreviation (LP, DDU, DDL, BW, SR, SC, and CR) and transect number descending from upstream to downstream (1 to 4 or 6).

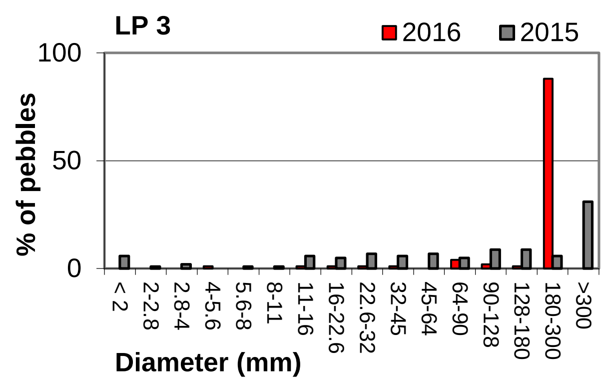

LP 1
2016
2015
% finer than
100 90 80 70 60 50 40 30 20 10 0
1 10 100 1000
Diameter (mm)

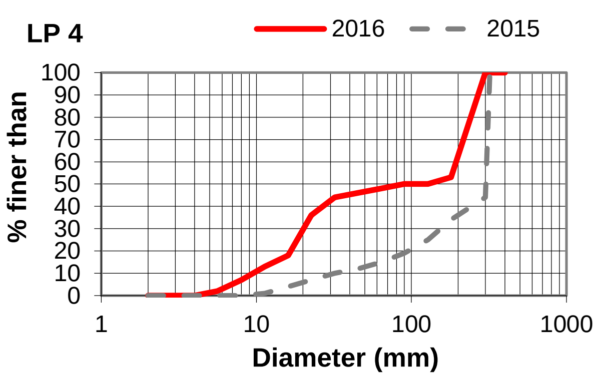

LP 1
2016
2015
% of pebbles
60 40 20 0
< 2 2-2.8 2.8-4 4-5.6 5.6-8 8-11 11-16 16-22.6 22.6-32 32-45 45-64 64-90 90-128 128-180 180-300 >300
Diameter (mm)

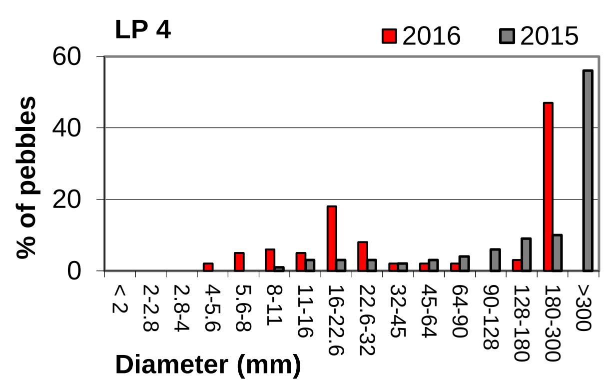

LP 2
2016
2015
% finer than
100 90 80 70 60 50 40 30 20 10 0
1 10 100 1000
Diameter (mm)

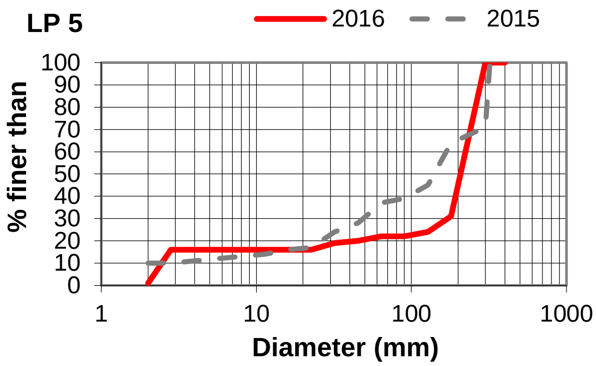

LP 2
2016
2015
% of pebbles
40 30 20 10 0
< 2 2-2.8 2.8-4 4-5.6 5.6-8 8-11 11-16 16-22.6 22.6-32 32-45 45-64 64-90 90-128 128-180 180-300 >300
Diameter (mm)

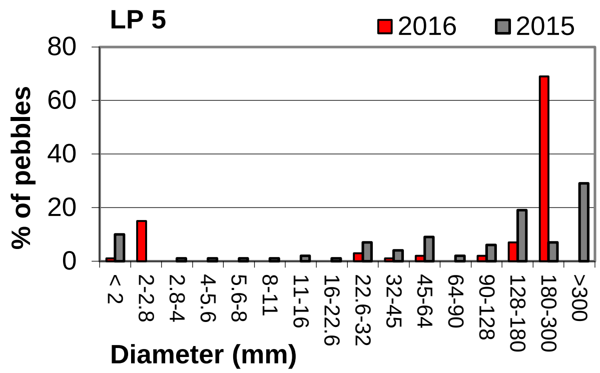

LP 3
2016
2015
% finer than
100 90 80 70 60 50 40 30 20 10 0
1 10 100 1000
Diameter (mm)

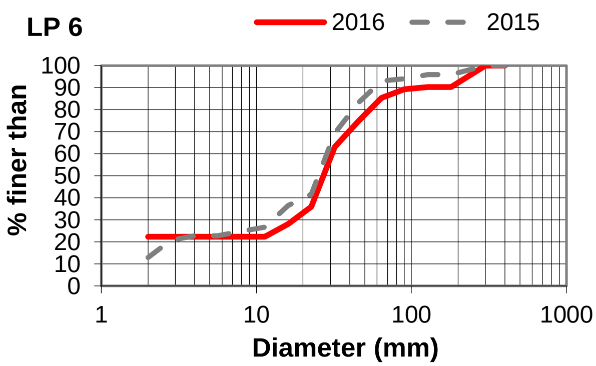

LP 3
2016
2015
% of pebbles
100 50 0
< 2 2-2.8 2.8-4 4-5.6 5.6-8 8-11 11-16 16-22.6 22.6-32 32-45 45-64 64-90 90-128 128-180 180-300 >300
Diameter (mm)

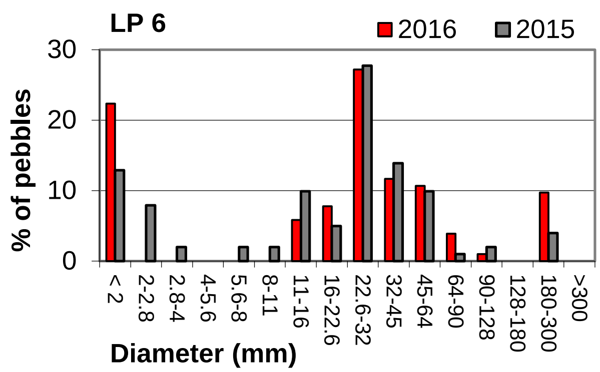

LP 4
2016
2015
% finer than
100 90 80 70 60 50 40 30 20 10 0
1 10 100 1000
Diameter (mm)

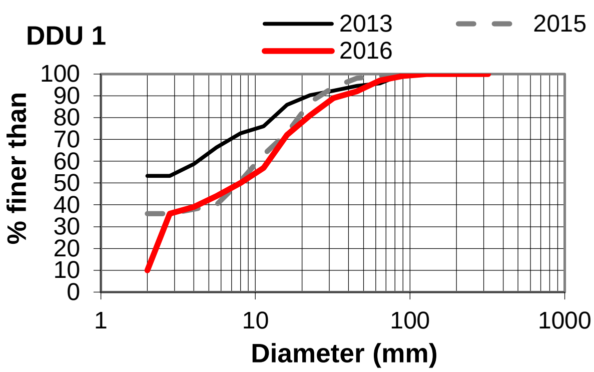

LP 4
2016
2015
% of pebbles
60 40 20 0
< 2 2-2.8 2.8-4 4-5.6 5.6-8 8-11 11-16 16-22.6 22.6-32 32-45 45-64 64-90 90-128 128-180 180-300 >300
Diameter (mm)

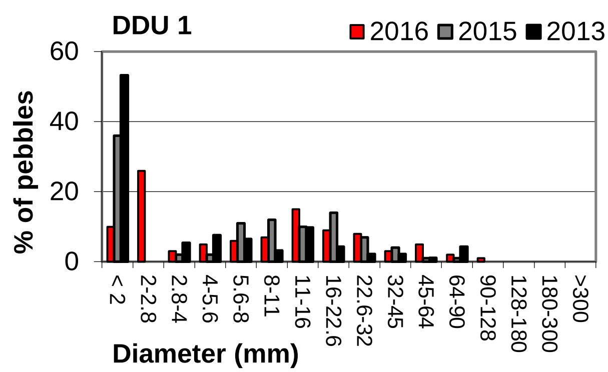

LP 5
2016
2015
% finer than
100
90
80
70
60
50
40
30
20
10
0
1
10
100
1000
Diameter (mm)

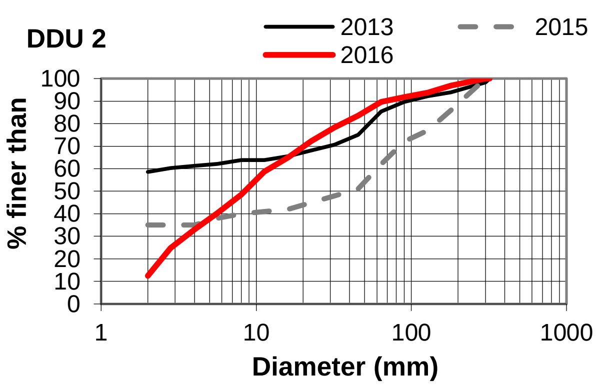

LP 5
2016
2015
% of pebbles
80
60
40
20
0
< 2
2-2.8
2.8-4
4-5.6
5.6-8
8-11
11-16
16-22.6
22.6-32
32-45
45-64
64-90
90-128
128-180
180-300
>300
Diameter (mm)

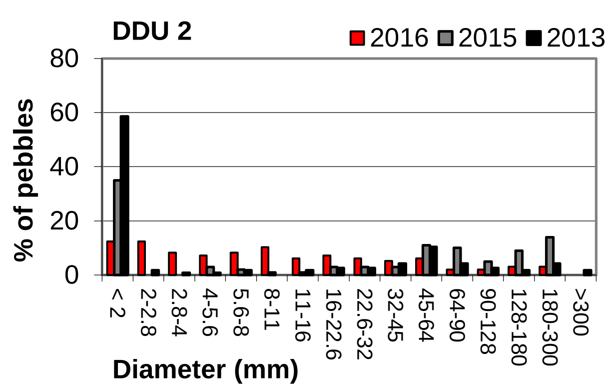

LP 6
2016
2015
% finer than
100
90
80
70
60
50
40
30
20
10
0
1
10
100
1000
Diameter (mm)

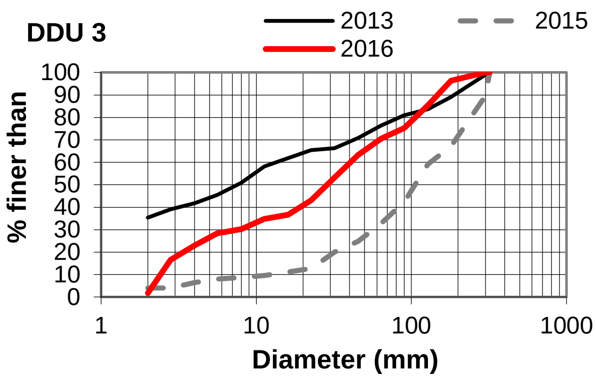

LP 6
2016
2015
% of pebbles
30
20
10
0
< 2
2-2.8
2.8-4
4-5.6
5.6-8
8-11
11-16
16-22.6
22.6-32
32-45
45-64
64-90
90-128
128-180
180-300
>300
Diameter (mm)

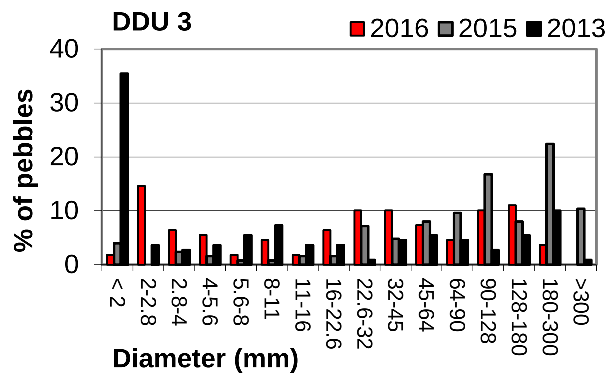

DDU 1
2013
2016
2015
% finer than
100
90
80
70
60
50
40
30
20
10
0
1
10
100
1000
Diameter (mm)

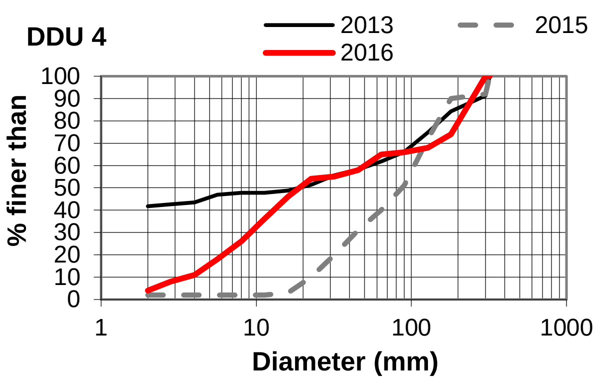

DDU 1
2016
2015
2013
% of pebbles
60
40
20
0
< 2
2-2.8
2.8-4
4-5.6
5.6-8
8-11
11-16
16-22.6
22.6-32
32-45
45-64
64-90
90-128
128-180
180-300
>300
Diameter (mm)

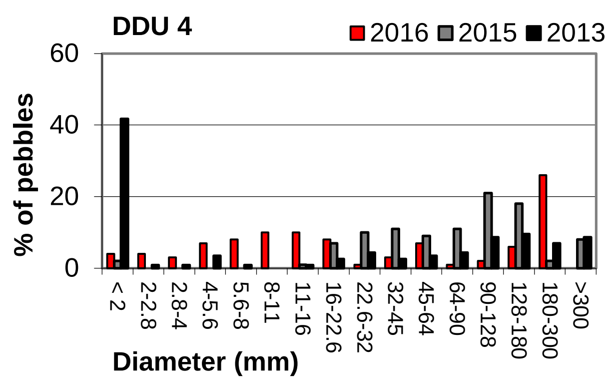

DDU 2
2013
2016
2015
% finer than
100
90
80
70
60
50
40
30
20
10
0
1
10
100
1000
Diameter (mm)

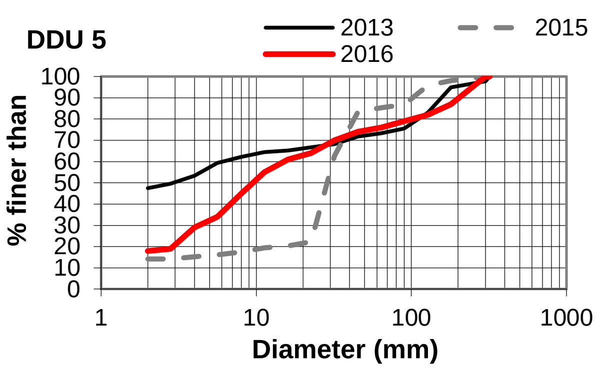

DDU 2
2016
2015
2013
% of pebbles
80
60
40
20
0
< 2
2-2.8
2.8-4
4-5.6
5.6-8
8-11
11-16
16-22.6
22.6-32
32-45
45-64
64-90
90-128
128-180
180-300
>300
Diameter (mm)

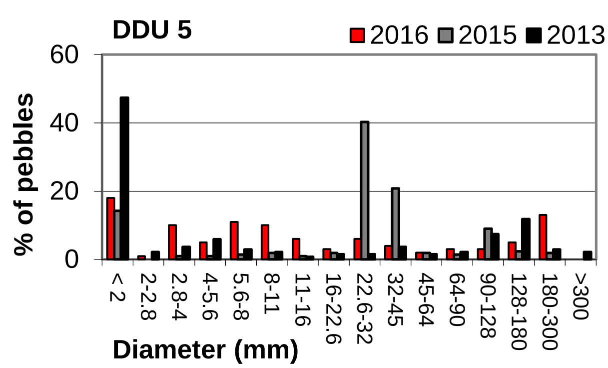

DDU 3
2013
2015
2016
% finer than
Diameter (mm)

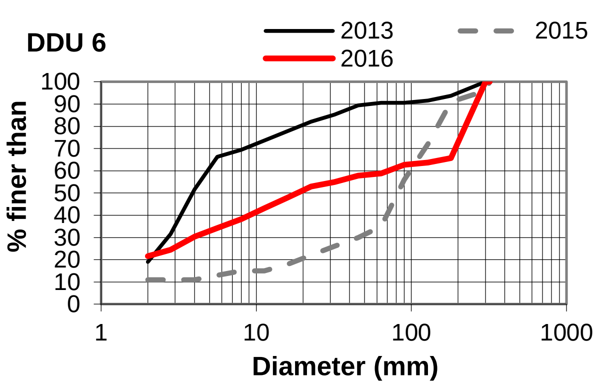

DDU 3
2016 2015 2013
% of pebbles
Diameter (mm)

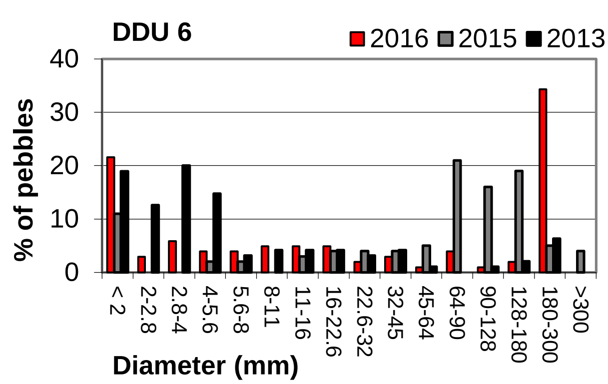

DDU 4
2013
2015
2016
% finer than
Diameter (mm)

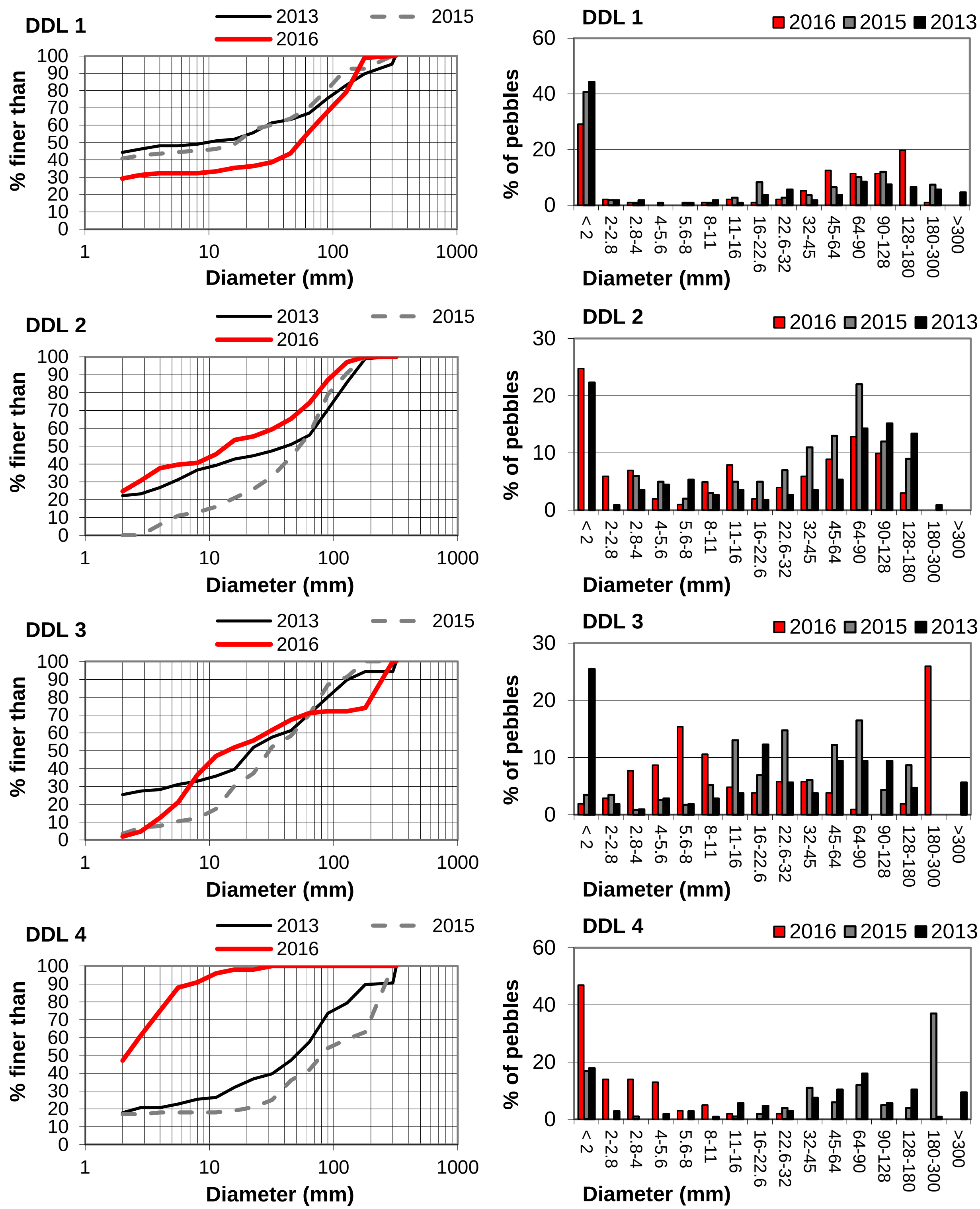

DDU 4
2016 2015 2013
% of pebbles
Diameter (mm)

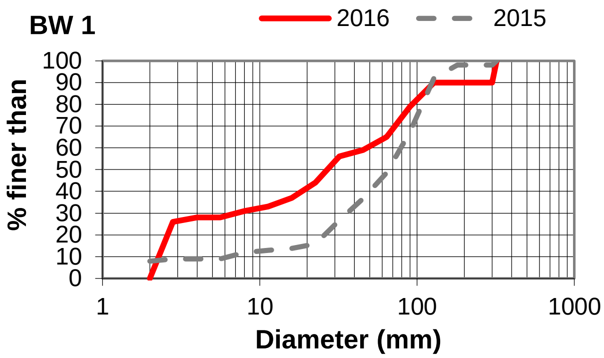

DDU 5
2013
2015
2016
% finer than
Diameter (mm)

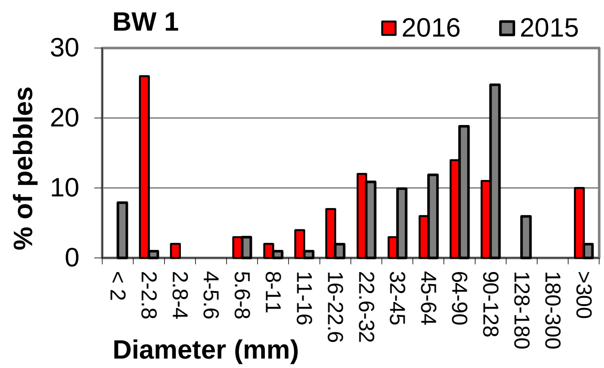

DDU 5
2016 2015 2013
% of pebbles
Diameter (mm)

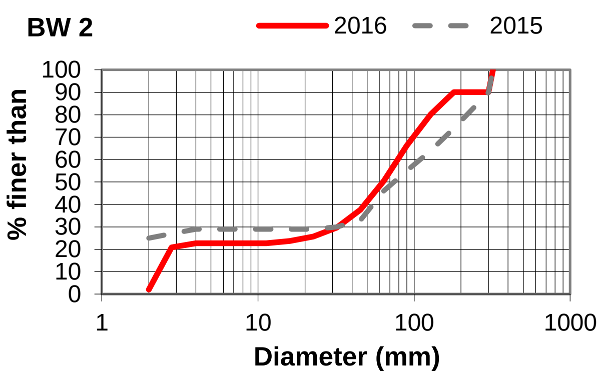

DDU 6
2013
2015
2016
% finer than
Diameter (mm)

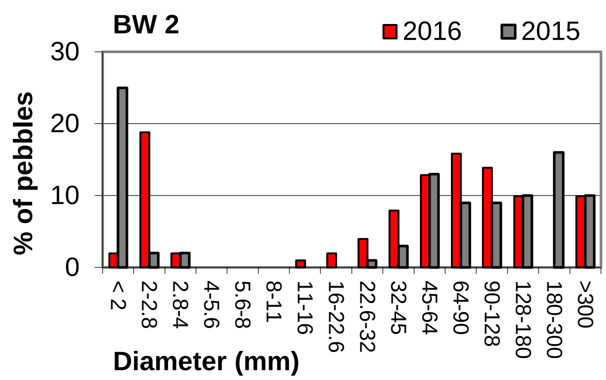

DDU 6
2016 2015 2013
% of pebbles
Diameter (mm)

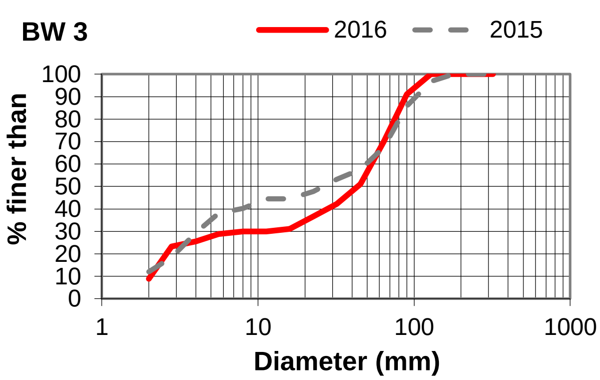

DDL 1
2013
2015
2016
% finer than
Diameter (mm)
DDL 1
2016 2015 2013
% of pebbles
Diameter (mm)
DDL 2
2013
2015
2016
% finer than
Diameter (mm)
DDL 2
2016 2015 2013
% of pebbles
Diameter (mm)
DDL 3
2013
2015
2016
% finer than
Diameter (mm)
DDL 3
2016 2015 2013
% of pebbles
Diameter (mm)
DDL 4
2013
2015
2016
% finer than
Diameter (mm)
DDL 4
2016 2015 2013
% of pebbles
Diameter (mm)
< 2
2-2.8
2.8-4
4-5.6
5.6-8
8-11
11-16
16-22.6
22.6-32
32-45
45-64
64-90
90-128
128-180
180-300
>300

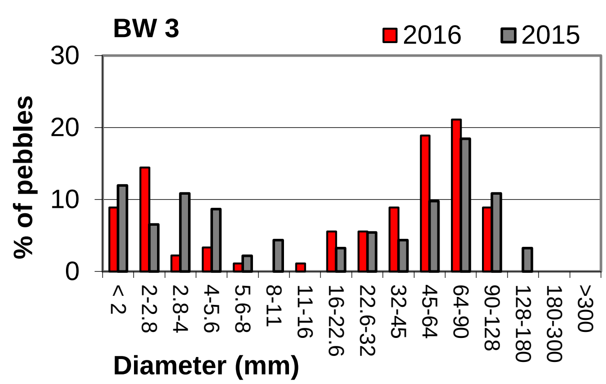

BW 1
2016
2015
% finer than
100 90 80 70 60 50 40 30 20 10 0
1 10 100 1000
Diameter (mm)

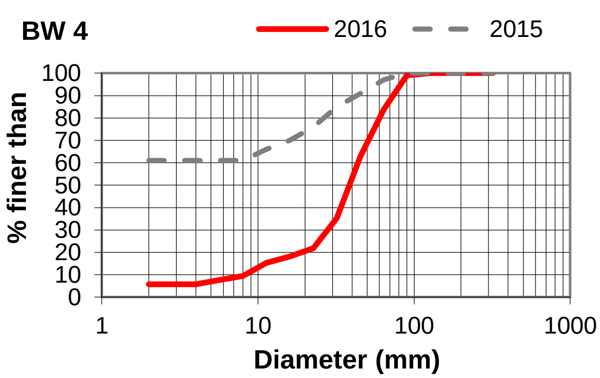

BW 1
2016
2015
% of pebbles
30 20 10 0
< 2 2-2.8 2.8-4 4-5.6 5.6-8 8-11 11-16 16-22.6 22.6-32 32-45 45-64 64-90 90-128 128-180 180-300 >300
Diameter (mm)

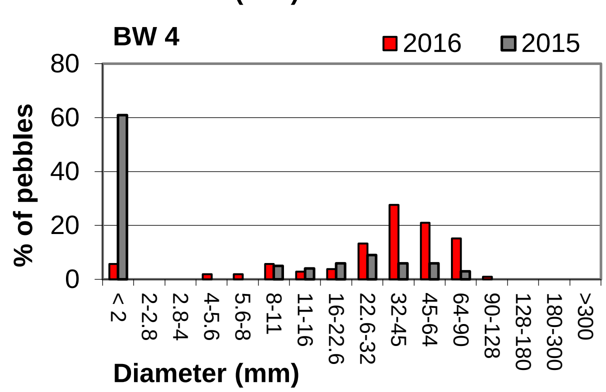

BW 2
2016
2015
% finer than
100 90 80 70 60 50 40 30 20 10 0
1 10 100 1000
Diameter (mm)

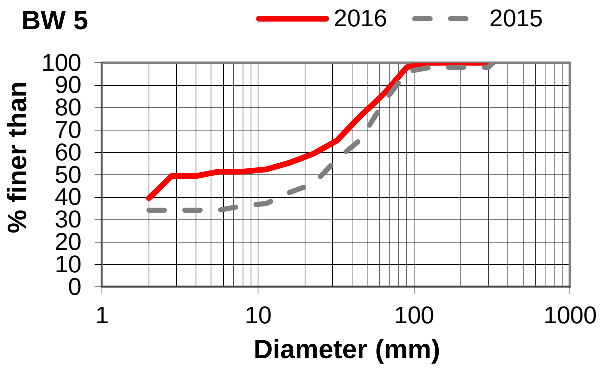

BW 2
2016
2015
% of pebbles
30 20 10 0
< 2 2-2.8 2.8-4 4-5.6 5.6-8 8-11 11-16 16-22.6 22.6-32 32-45 45-64 64-90 90-128 128-180 180-300 >300
Diameter (mm)

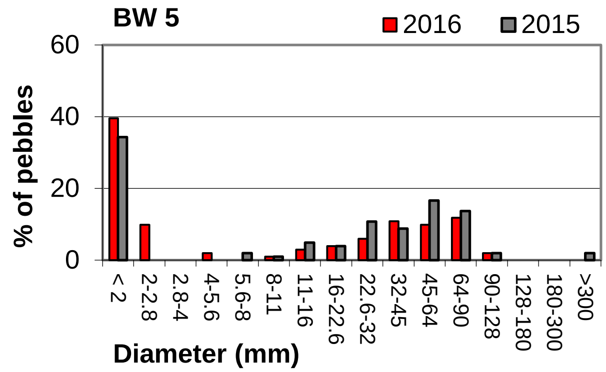

BW 3
2016
2015
% finer than
100 90 80 70 60 50 40 30 20 10 0
1 10 100 1000
Diameter (mm)

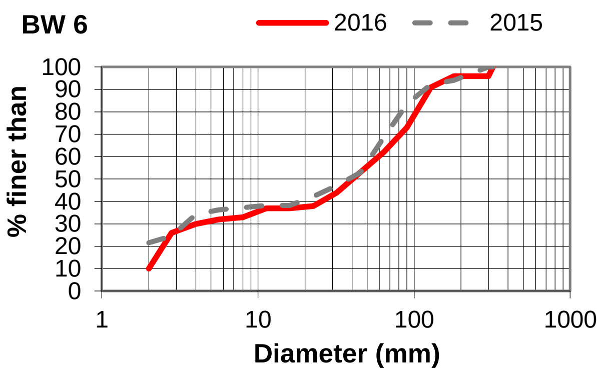

BW 3
2016
2015
% of pebbles
30 20 10 0
< 2 2-2.8 2.8-4 4-5.6 5.6-8 8-11 11-16 16-22.6 22.6-32 32-45 45-64 64-90 90-128 128-180 180-300 >300
Diameter (mm)

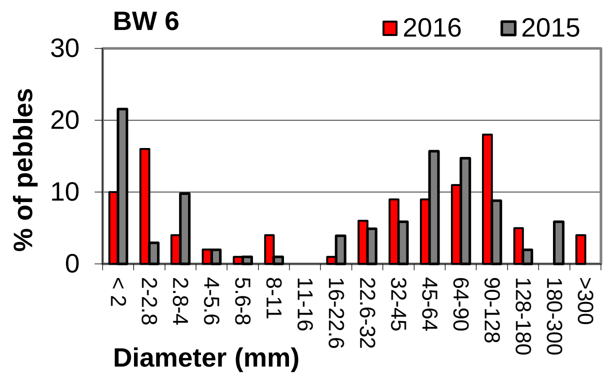

BW 4
2016
2015
% finer than
100 90 80 70 60 50 40 30 20 10 0
1 10 100 1000
Diameter (mm)

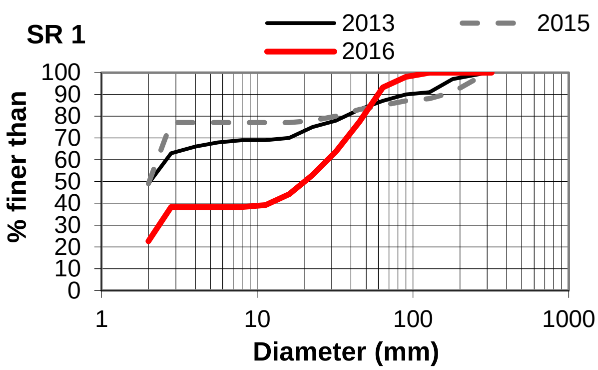

BW 4
2016
2015
% of pebbles
80 60 40 20 0
< 2 2-2.8 2.8-4 4-5.6 5.6-8 8-11 11-16 16-22.6 22.6-32 32-45 45-64 64-90 90-128 128-180 180-300 >300
Diameter (mm)

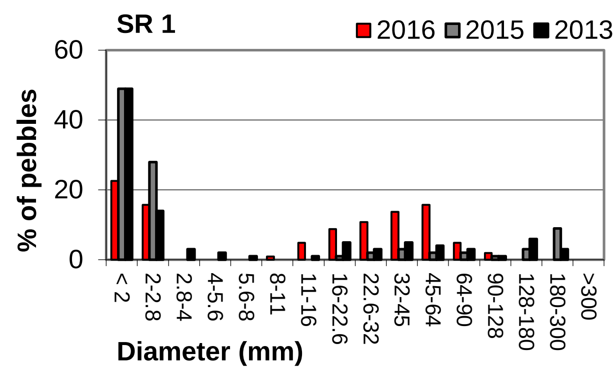

BW 5
2016
2015
% finer than
100
90
80
70
60
50
40
30
20
10
0
1
10
100
1000
Diameter (mm)

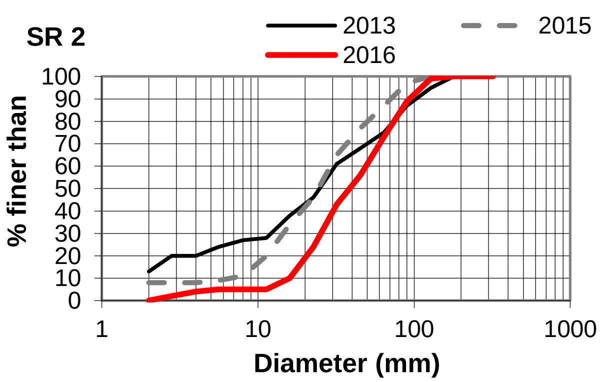

BW 5
2016
2015
% of pebbles
60
40
20
0
< 2
2-2.8
2.8-4
4-5.6
5.6-8
8-11
11-16
16-22.6
22.6-32
32-45
45-64
64-90
90-128
128-180
180-300
>300
Diameter (mm)

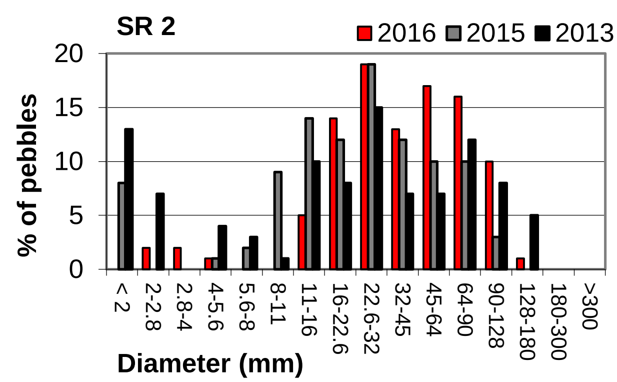

BW 6
2016
2015
% finer than
100
90
80
70
60
50
40
30
20
10
0
1
10
100
1000
Diameter (mm)

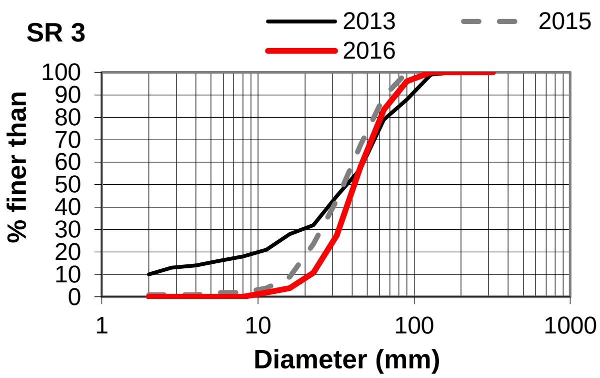

BW 6
2016
2015
% of pebbles
30
20
10
0
< 2
2-2.8
2.8-4
4-5.6
5.6-8
8-11
11-16
16-22.6
22.6-32
32-45
45-64
64-90
90-128
128-180
180-300
>300
Diameter (mm)

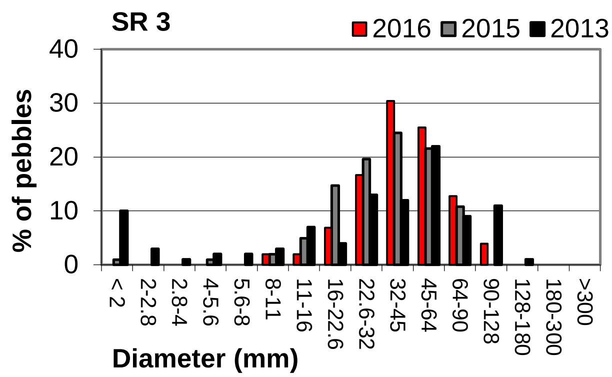

SR 1
2013
2015
2016
% finer than
100
90
80
70
60
50
40
30
20
10
0
1
10
100
1000
Diameter (mm)

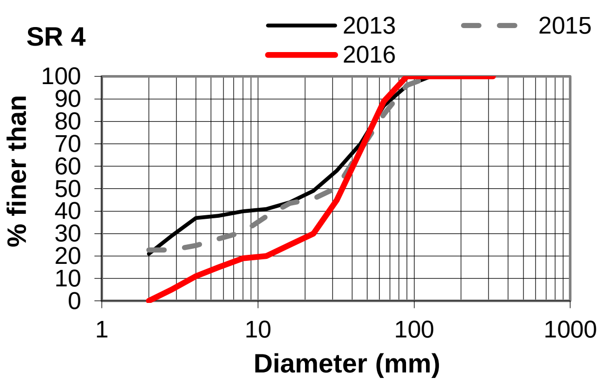

SR 1
2016
2015
2013
% of pebbles
60
40
20
0
< 2
2-2.8
2.8-4
4-5.6
5.6-8
8-11
11-16
16-22.6
22.6-32
32-45
45-64
64-90
90-128
128-180
180-300
>300
Diameter (mm)

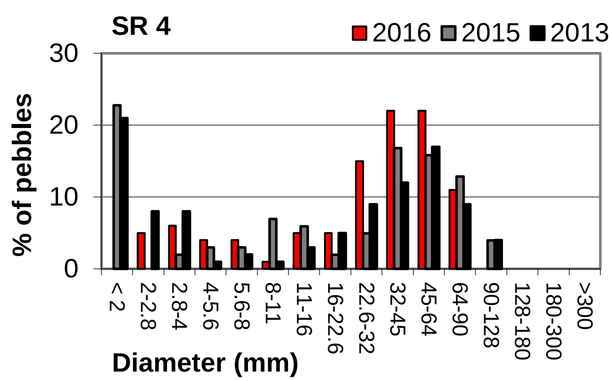

SR 2
2013
2015
2016
% finer than
100
90
80
70
60
50
40
30
20
10
0
1
10
100
1000
Diameter (mm)

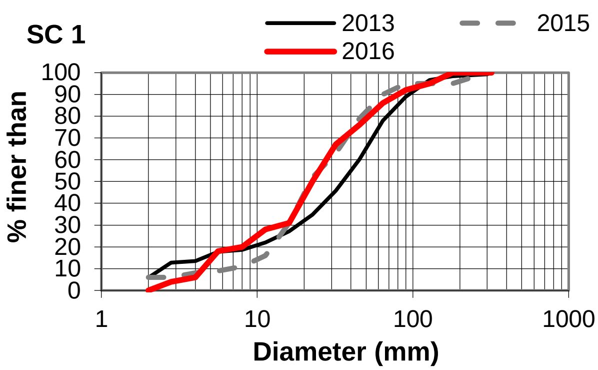

SR 2
2016
2015
2013
% of pebbles
20
15
10
5
0
< 2
2-2.8
2.8-4
4-5.6
5.6-8
8-11
11-16
16-22.6
22.6-32
32-45
45-64
64-90
90-128
128-180
180-300
>300
Diameter (mm)

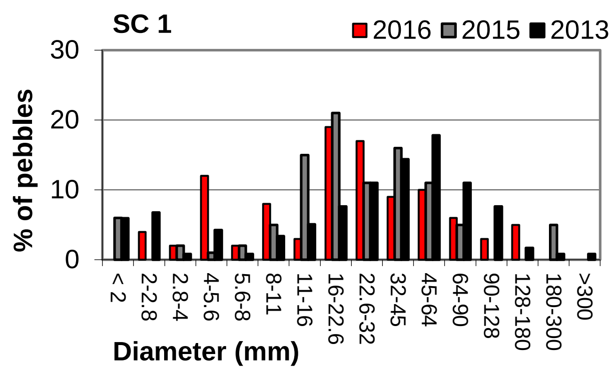

SR 3
2013
2015
2016
% finer than
100
90
80
70
60
50
40
30
20
10
0
1
10
100
1000
Diameter (mm)

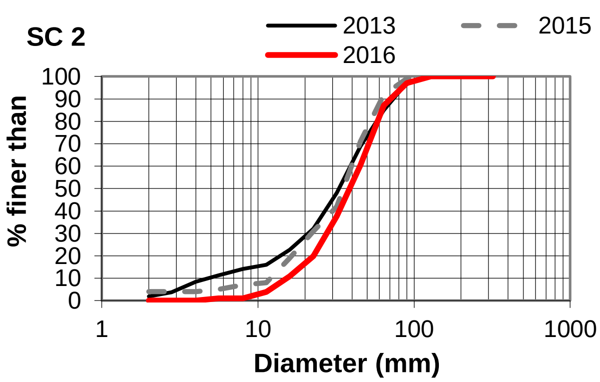

SR 3
2016
2015
2013
% of pebbles
40
30
20
10
0
< 2
2-2.8
2.8-4
4-5.6
5.6-8
8-11
11-16
16-22.6
22.6-32
32-45
45-64
64-90
90-128
128-180
180-300
>300
Diameter (mm)


SR 4
2013
2015
2016
% finer than
100
90
80
70
60
50
40
30
20
10
0
1
10
100
1000
Diameter (mm)


SR 4
2016
2015
2013
% of pebbles
30
20
10
0
< 2
2-2.8
2.8-4
4-5.6
5.6-8
8-11
11-16
16-22.6
22.6-32
32-45
45-64
64-90
90-128
128-180
180-300
>300
Diameter (mm)


SC 1
2013
2015
2016
% finer than
100
90
80
70
60
50
40
30
20
10
0
1
10
100
1000
Diameter (mm)


SC 1
2016
2015
2013
% of pebbles
30
20
10
0
< 2
2-2.8
2.8-4
4-5.6
5.6-8
8-11
11-16
16-22.6
22.6-32
32-45
45-64
64-90
90-128
128-180
180-300
>300
Diameter (mm)


SC 2
2013
2015
2016
% finer than
100
90
80
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60
50
40
30
20
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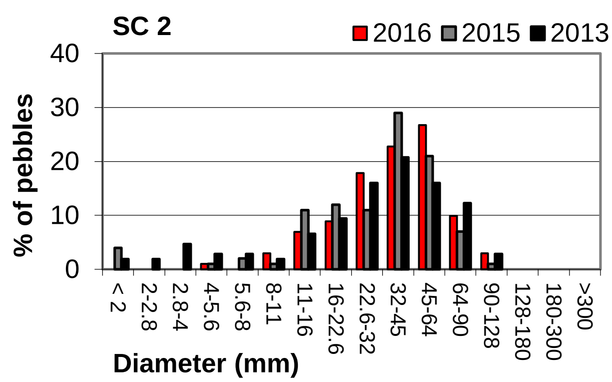
0
1
10
100
1000
Diameter (mm)


SC 2
2016
2015
2013
% of pebbles
40
30
20
10
0
< 2
2-2.8
2.8-4
4-5.6
5.6-8
8-11
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16-22.6
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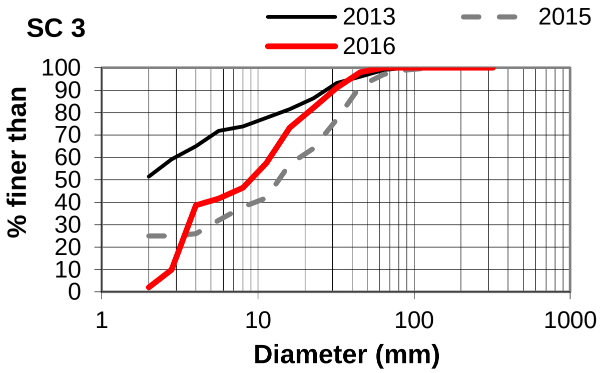
32-45
45-64
64-90
90-128
128-180
180-300
>300
Diameter (mm)


SC 3
2013
2016
2015
% finer than
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90
80
70
60
50
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30
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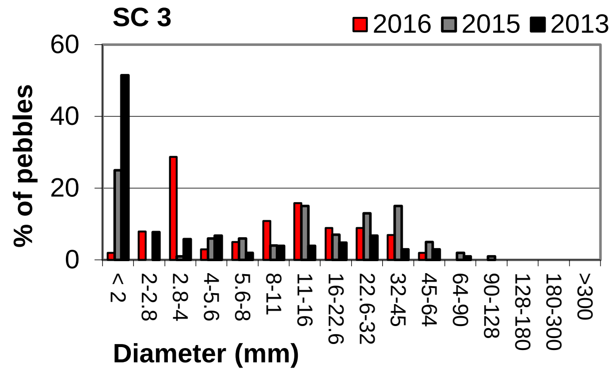
0
1
10
100
1000
Diameter (mm)


SC 3
2016
2015
2013
% of pebbles
60
40
20
0
< 2
2-2.8
2.8-4
4-5.6
5.6-8
8-11
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16-22.6
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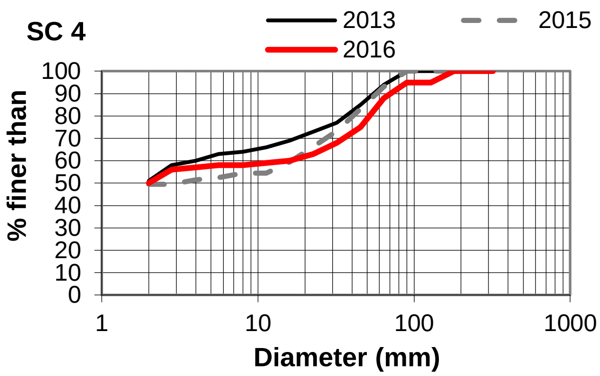
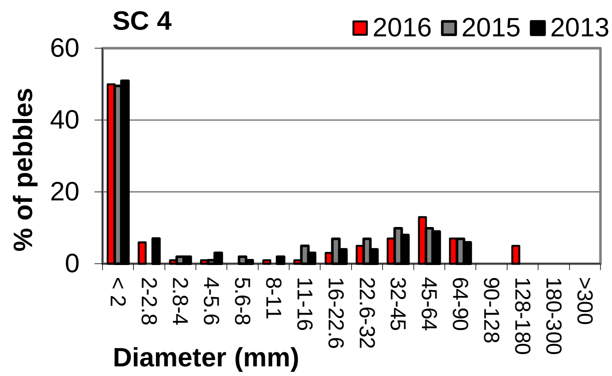
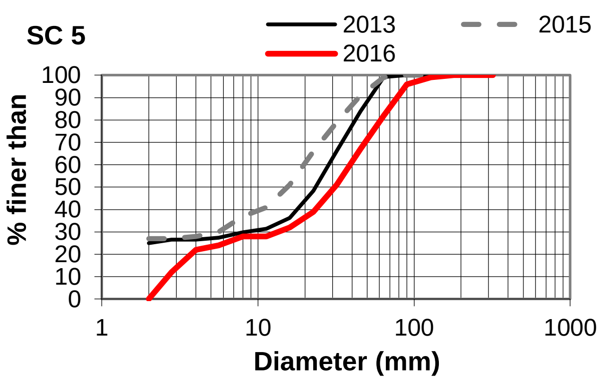
45-64
64-90
90-128
128-180
180-300
>300
Diameter (mm)


SC 4
2013
2016
2015
% finer than
100
90
80
70
60
50
40
30
20
10
0
1
10
100
1000
Diameter (mm)


SC 4
2016
2015
2013
% of pebbles
60
40
20
0
< 2
2-2.8
2.8-4
4-5.6
5.6-8
8-11
11-16
16-22.6
22.6-32
32-45
45-64
64-90
90-128
128-180
180-300
>300
Diameter (mm)


SC 5
2013
2016
2015
% finer than
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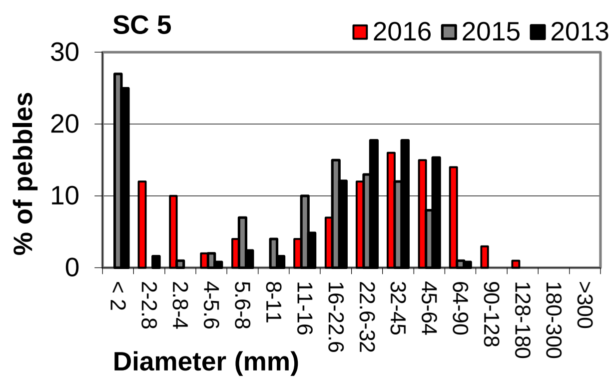
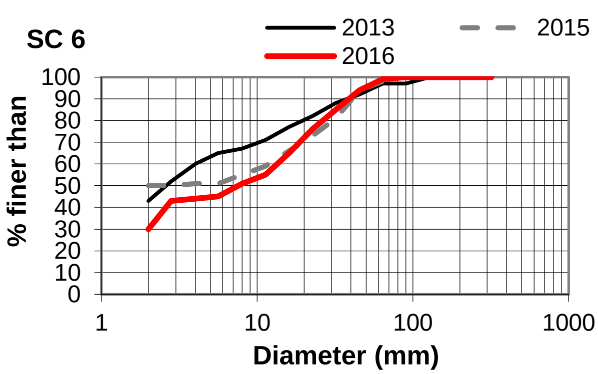
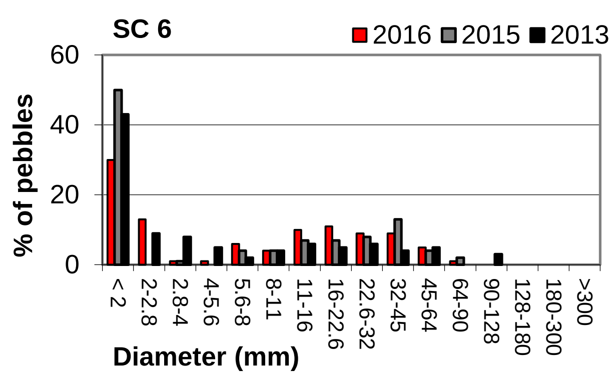
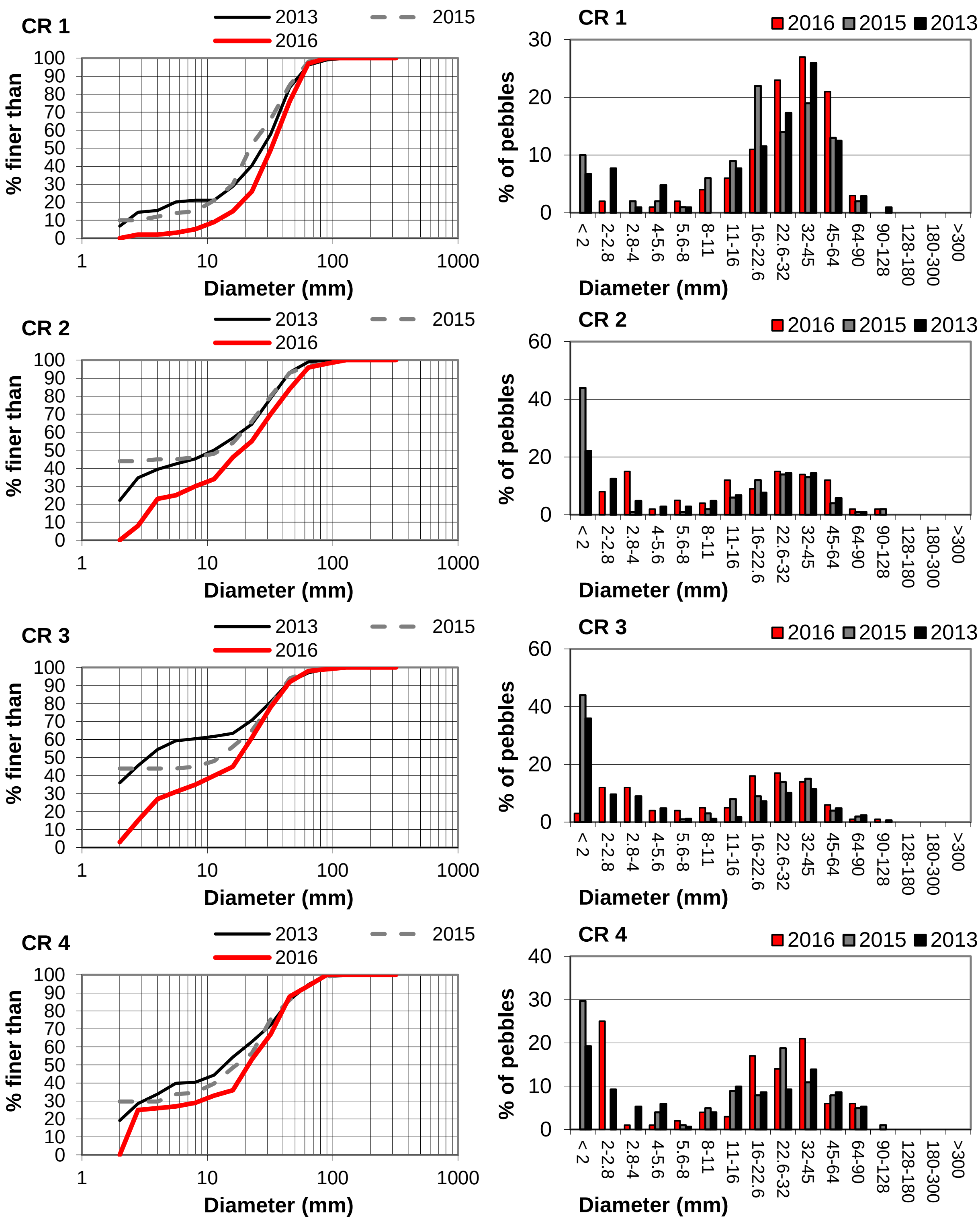
90
80
70
60
50
40
30
20
10
0
1
10
100
1000
Diameter (mm)


SC 5
2016
2015
2013
% of pebbles
30
20
10
0
< 2
2-2.8
2.8-4
4-5.6
5.6-8
8-11
11-16
16-22.6
22.6-32
32-45
45-64
64-90
90-128
128-180
180-300
>300
Diameter (mm)


SC 6
2013
2016
2015
% finer than
100
90
80
70
60
50
40
30
20
10
0
1
10
100
1000
Diameter (mm)


SC 6
2016
2015
2013
% of pebbles
60
40
20
0
< 2
2-2.8
2.8-4
4-5.6
5.6-8
8-11
11-16
16-22.6
22.6-32
32-45
45-64
64-90
90-128
128-180
180-300
>300
Diameter (mm)


CR 1
2013
2015
2016
% finer than
Diameter (mm)
% of pebbles
2016 2015 2013
CR 2
2013
2015
2016
% finer than
Diameter (mm)
% of pebbles
2016 2015 2013
CR 3
2013
2015
2016
% finer than
Diameter (mm)
% of pebbles
2016 2015 2013
CR 4
2013
2015
2016
% finer than
Diameter (mm)
% of pebbles
2016 2015 2013
< 2
2-2.8
2.8-4
4-5.6
5.6-8
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11-16
16-22.6
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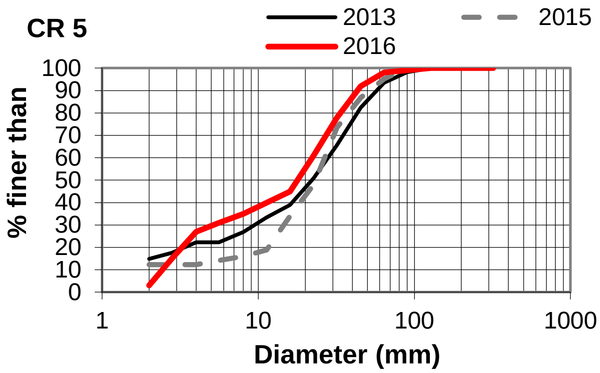
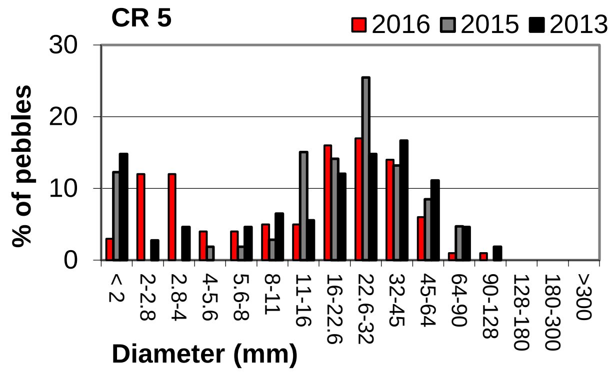

CR 5
2013
2015
2016
% finer than
Diameter (mm)


CR 5
2016 2015 2013
% of pebbles
< 2
2-2.8
2.8-4
4-5.6
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16-22.6
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45-64
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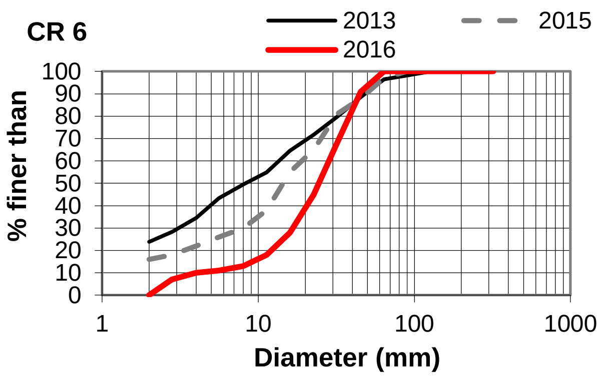
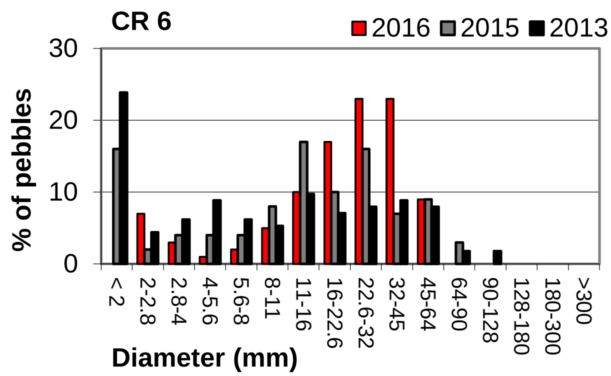
128-180
180-300
>300
Diameter (mm)


CR 6
2013
2015
2016
% finer than
Diameter (mm)


CR 6
2016 2015 2013
% of pebbles
< 2
2-2.8
2.8-4
4-5.6
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8-11
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45-64
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90-128
128-180
180-300
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Diameter (mm)