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REGIONAL GEOCHEMICAL SURVEYS: RIVERINA PILOT PROJECT

METHODOLOGY AND PRELIMINARY RESULTS

Patrice de Caritat, Subhash Jaireth, Megan Lech, John Pyke

CRC LEME OPEN FILE REPORT 160

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CRC LEME is an unincorporated joint venture between CSIRO-Exploration & Mining, and Land & Water, The Australian National University, Curtin University of Technology, University of Adelaide, Geoscience Australia, Primary Industries and Resources SA, NSW Department of Mineral Resources and Minerals Council of Australia, established and supported under the Australian Government's Cooperative Research Centres Program.

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ABSTRACT

During financial year 2003-04, we carried out fieldwork and preliminary analyses for a collaborative project between CRC LEME and Geoscience Australia aimed at testing methodologies and strategies for regional geochemical surveys in Australia. The Riverina bioregion, in southern New South Wales and northern Victoria, was selected for this pilot project. Overbank sediments were chosen as sampling media, with a near-surface sample (TOP: O horizon, from 0-10 cm below the humus layer) and a bottom sample (BOT: B-C horizon, ~10 cm interval between approximately 70-90 cm below the humus layer) being collected. River Red Gum (*Eucalyptus camaldulensis*) leaves were also collected at a small number of locations. The sample sites were selected to be near outlets or spill points of large catchments, so that overbank sediments there could reasonably be assumed to represent well-mixed, fine-grained composite samples of all major rock and soil types present in the catchment. Three field trips visited 143 sites in the Riverina. This report documents the methodologies used in this survey and presents results to date.

Sediment samples were subjected to a detailed description and the determination of bulk parameters in the field (texture, moist and dry colour, field pH). In the laboratory, the samples were analysed for moisture content, EC 1:5, pH 1:5; some were also subjected to laser particle size analysis. Bulk (<180 µm) composition was determined by X-Ray Fluorescence (XRF), Inductively Coupled Plasma Mass Spectrometry (ICP-MS) and Instrumental Neutron Activation Analysis (INAA), and the samples were also analysed by sequential digestion and prepared for heavy mineral separation. At the time of writing, bulk composition of the samples from the first fieldtrip (eastern Riverina) only was available. All together the concentrations of 62 elements were determined, and maps are presented showing the spatial and statistical distributions in the TOP and BOT samples and of the TOP/BOT ratios. These results will be the basis for further interpretative work and the backbone of a forthcoming geochemical atlas of the Riverina.

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1. INTRODUCTION

Geochemical baselines provide information on the natural concentration of chemical elements and compounds in the regolith, which is the blanket of soils, sediments and weathered rocks common in Australian landscapes. These natural concentrations vary greatly in different areas, due to geology, biological processes and other factors (Reimann and Caritat, 1998). It is important to know the natural concentration and distribution of elements so that:

1. A baseline can be established against which **future changes** can be measured; and
2. Localised **anomalies** or **contaminations** can be identified and better understood.

This knowledge will thus assist in environmental management and mineral exploration.

Regional geochemical surveys targeting 'normal' (background) sampling sites, as opposed to mineralised or polluted sites, are needed to generate baseline geochemical maps. These are fundamental data layers to develop environmentally appropriate and responsible land-use policies or, in mineral exploration, to aid discovery of ore bodies and promote the potential of certain regions.

Recent low-density geochemical surveys in China (Hangxin et al., 1997) suggest that wide-spaced geochemical sampling can provide good knowledge of broad geochemical patterns across a nation. To illustrate the potential of such studies, Xie and Ren (1993) reported *"… the discovery of several hundreds of new mineral occurrences, including 400 new gold occurrences, many of which are being developed into workable mines"*. The Chinese study has prompted Geoscience Australia and CRC LEME to propose collaborative pilot studies which will determine whether low-density sampling can be applied with similar success in Australia. The present study in the Murray-Darling Basin is the first pilot project in what is hoped will become a widespread series of pilot studies and, eventually, a national geochemical baseline study. The rationale for low-density geochemical surveys has been discussed by Bølviken et al. (1992), among others, and proven to be effective (e.g., Fauth et al., 1985; Reimann et al., 1997, 2003; Li and Wu, 1999; Ruitenbeek, 2000; Gustavsson et al., 2001). This kind of work is likely to generate interest in a range of organisations in Australia (universities, government agencies concerned with land, water, agriculture, salinity, health, industry, research organisations, etc.) and add to the development of a global geochemical baseline (Darnley et al., 1995).

Given the potential environmental problems faced by present and future governments in this country, it is timely to provide them with a truly representative, nation-wide tool describing baseline conditions at the beginning of this decade. A regional geochemical survey at the national scale would provide this information. Australia is one of the last developed nations to *not* have regional geochemical information at the disposal of decision-makers. A geochemical survey and ensuing geochemical atlas of Australia would be a tremendously useful tool to address national priority issues that are important in terms of

- **Economy**: mineral discoveries through cover, new commodities, new provinces
- **Environment**: land-use appropriate for natural conditions, natural resources management

- **Society**: health and welfare of population, health of stock and safety of crops

The Murray-Darling Basin (MDB) (Figure 1) has been selected as the focus for this initial research proposal, being a vital region in terms of social, agricultural and mineral importance. The MDB

- Covers 1.06 M km^2 or 14% of the country's total area
- Contains 45% of the Australian crop area and 43% of the total number of farms
- Is Australia's most important agricultural region, accounting for 41% of the nation's gross value of agricultural production
- Is an important provider of resources such as wheat (34% of national production), cotton (96%), dairy, rice and viticulture
- Is home to nearly 2 M people, or 11% of the total Australian population (1996 census)

More specifically, we have undertaken a first geochemical survey in the Riverina bioregion (southern New South Wales and northern Victoria) (Figure 1).

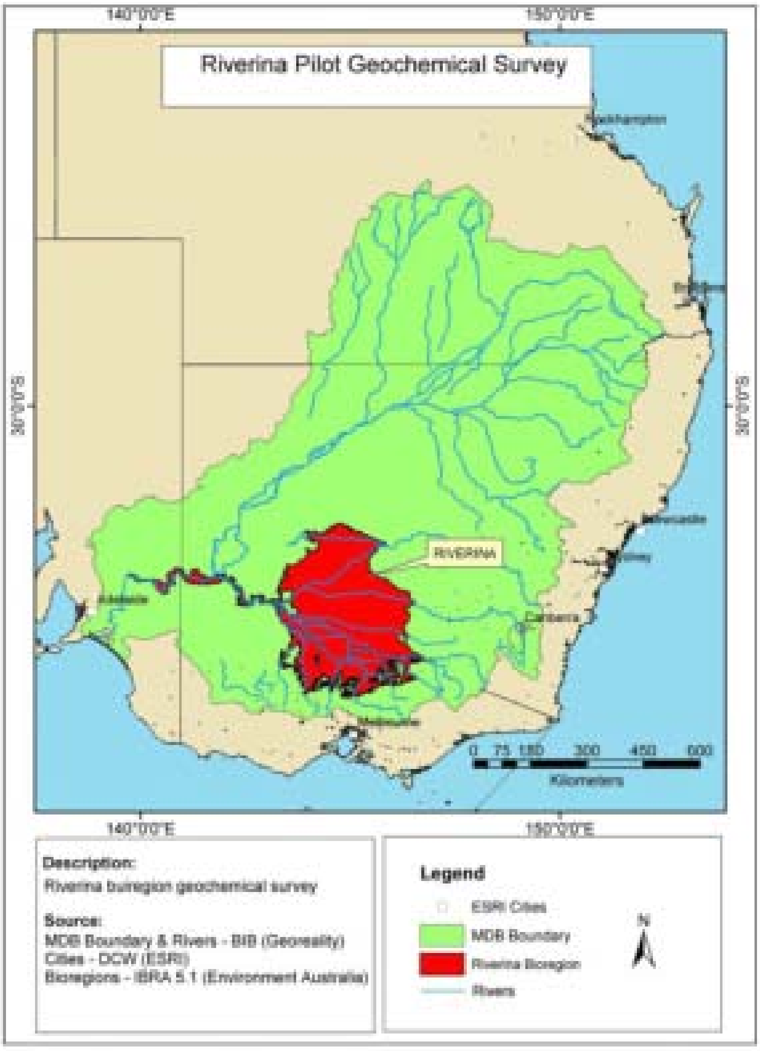

Figure 1: The Murray-Darling Basin with the Riverina pilot study area

Overbank sediment samples were collected for the pilot studies, as it is believed that this sampling medium can be used across the entire basin and beyond, providing comparable datasets between this and future pilot surveys. The merits of overbank sediments for low-density baseline geochemical surveys in Australia are borne out by previous studies (Ottesen et al., 1989; Murrell, 1991; Edén and Björklund, 1994, 1996; Ridgway et al., 1995; Volden et al., 1997; Xie and Cheng, 1997).

Top (0-10 cm) and bottom (~70-90 cm) samples have been taken at each site to detect the residence and mobility of chemical elements in natural environments and any impact of pollutants and land-use changes since European settlement. Data from the Riverina pilot study will be examined at a number of scales to ascertain suitability of low density sampling in the rest of the MDB.

2. AIMS

The aims of the project are (1) to provide internally consistent background geochemical data in the Riverina pilot region, and (2) to help develop a suitable geochemical sampling methodology for the whole MDB. This dataset will assist decisions in land-use management, geohealth and mineral exploration.

The aims of this report are to provide a detailed record of what was done during financial year 2003-04 in the Regional Geochemical Surveys project and, more importantly, to document the methods used for future reference.

3. ACHIEVEMENTS TO DATE

This pilot project started on 1 July 2003, and had a duration of 12 months. In this period, the following work was carried out:

- overbank sediment sampling in the whole Riverina area (3 fieldtrips)
- vegetation sampling at selected sites in the western and northern Riverina area (2 of the above fieldtrips)
- groundwater sampling in the eastern Riverina area (1 separate fieldtrip) (not discussed here)
- sample preparation, field and laboratory measurements (field pH, texture, wet and dry colour, pH 1:5, EC 1:5, moisture content) of all eastern Riverina overbank sediments
- total (bulk) sediment (<180 µm) analysis by X-Ray Fluorescence (majors and traces) of all eastern Riverina overbank sediments
- total (bulk) sediment (<180 µm) analysis by Inductively Coupled Plasma Mass Spectrometry (traces) of all eastern Riverina overbank sediments
- total (bulk) sediment (<180 µm) analysis by Instrumental Neutron Activation Analysis (majors and traces) of all eastern Riverina overbank sediments
- laser grainsize analysis of 20 selected eastern Riverina overbank sediment samples
- sequential digestion of all eastern Riverina overbank sediments
- analysis of sequential digest by Inductively Coupled Plasma Mass Spectrometry (traces) of all eastern Riverina overbank sediments (not discussed here)
- presentations given at the 17th Australian Geological Congress in Hobart, February 2004 (Caritat et al.., 2004) and at Geoscience Australia (15/9/03 by Patrice de Caritat, 4/2/04 by Patrice de Caritat, 7/6/04 by Megan Lech)
- preparation of a report detailing methods and showing results to date (this Report)

Outcomes achieved against the project proposal are given below.

Outcomes (proposal - 1 July 2003)	Outcomes (achieved - 30 June 2004)
Geochemical database	Database populated with results to date - Sites for the eastern Riverina entered in RTMAP (to be migrated to DEVIANT) - Chemistry results sent from laboratory to Database Group (to be entered in OZCHEM)
Geochemical maps of sediments, plants and groundwater	Maps prepared for bulk (<180 µm) sediments (this Report). Geochemistry of plants and groundwater not yet available
Implications for land-use decisions, mineral exploration and geohealth	Interpretations started, but requires further work and availability of whole dataset
Dissemination of results to stakeholders	Presentations given locally and nationally, web release of this Report
Recommendations for geochemical survey of MDB	Started, but requires further work and availability of whole dataset

4. METHODS

4.1. Site selection

The area, the Riverina bioregion, was chosen as the focus for this first pilot project because of the recent geophysical data acquisition carried out by the New South Wales Department of Mines here. Because of the nature of the main sampling medium selected, overbank sediments, the landscape units of interest here are hydrologic catchments. Thus, a coverage of Australian catchments was obtained from the Centre for Resource and Environmental Studies (CRES) at the Australian National University. The lowest points around each catchment's boundary were determined using ArcHydro, as detailed in Appendix 1. These points were the theoretical sampling sites.

All theoretical sampling sites were carefully checked with topographic, drainage and road coverages to see if the locations were reasonable and likely to generate the information sought. Where necessary, the sampling sites were moved from the software-generated ('theoretical') position to manually selected locations before going in the field. In the field, of course, the final site locations were decided by considering local landscape, likely anthropogenic interferences, and pragmatic considerations (e.g., access), and the actual site locations were recorded by GPS, after allowing for averaging, and recorded in the field log sheets (Appendix 2) and entered in the database.

4.2. Field methods

The fieldwork for the Riverina geochemical survey took place in three phases:

- eastern Riverina: 20 September to 1 October 2003 (PdC, SJ, JP, ML)
- western Riverina: 14 to 22 April 2004 (PdC, Matthew Lenahan, Benjamin Ackerman)
- northern Riverina: 12 to 19 May 2004 (SJ, ML, Peter Taylor)

The main sampling medium targeted during this survey was overbank sediments. The rationale behind this sample selection is that the majority of Australia is covered by regolith, much of it transported. Thus by avoiding *in-situ* regolith or bedrock, the sampling medium would be most likely to be found in many environments around the country (but not all!). Further, overbank sediments, by their very nature, represent well-mixed composite samples of major rock and soil types present in the catchment, and are thus a particularly appropriate choice for low-density geochemical surveys, which aim to represent large tracts of land, as accurately as possible, with as few samples as necessary. An additional advantage of these sediments is that, by virtue of being deposited at times of flooding in low-energy environments, they are fine-grained and thus are more likely to be characterised by high signal-to-noise ratios for many chemical elements.

At each site, the sampling log sheet was filled to record, among others, date, GPS location, width and flow of the stream or river (if applicable), landscape position, vegetation, etc. The main sampling media targeted was overbank sediments, with two 10-cm intervals sampled: one in the O horizon from 0 to 10 cm below the humus layer (TOP), and another in the B-C horizon at depths generally ranging from 70 to 90 cm

(BOT). For each interval, two bags of ca 1-2 kg of material were collected, one being for all geochemical and mineral analyses, the other for heavy mineral separation. The samples were numbered according to the Geoscience Australia code:

2003 751 X 601 to **2003 751 X 665**, for instance for the eastern Riverina, with ‘2003’ being the year, ‘75’ the project number, ‘1’ the geologist or team, ‘X’ the layer/bag (with ‘X’ = ‘1’ for TOP geochemistry, ‘2’ for TOP heavy minerals, ‘3’ for BOT geochemistry, ‘4’ for BOT heavy minerals) and ‘601’ the sample number (incrementally increasing for each different site). Samples for geochemistry and for heavy minerals were collected in exactly the same fashion, thus samples with ‘X’ = ‘1’ and ‘2’ are essentially field duplicates, as are those with ‘X’ = ‘3’ and ‘4’.

Similarly, the western Riverina sample numbers are **2004 751 X 001** to **2004 751 X 043**, and the northern Riverina sample numbers are **2004 751 X 100** to **2004 751 X 134**. Thus, 65, 43 and 35 sites were visited and sampled during the eastern, western and northern Riverina fieldtrips, respectively, for a total 143 sites for the Riverina geochemical survey.

During the western and northern Riverina fieldtrip, River Red Gum (*Eucalyptus camaldulensis*) leaves were collected at several sites, and for these ‘X’ = ‘5’. The reasoning behind this is that we hope to gain some insight into the biological uptake of chemical elements in this widespread plant.

During the northern Riverina fieldtrip, two sites, 111 and 133, were selected for detailed soils profile sampling; for each of these sites eight 10-cm depth interval samples, labelled ‘0-10’, ‘10-20’, ‘20-30’, ‘30-40’, ‘40-50’, ‘50-60’, ‘60-70’ and ‘70-80’, were collected in addition to the four normal samples (‘X’ = ‘1’ to ‘4’). These profiles were taken to test the representativity of the TOP and BOT samples in the context of continuous soil profiles.

The TOP sample was collected with a white plastic scoop after removal of any organic litter, humus and roots, over an area of ca 30 x 60 cm in size. For many sites, given the protracted drought during the last several months, the overbank sediments were extremely dry and hard. Thus, it was necessary at many sites to break up the material with a steel crowbar before scooping it up. It is possible that some samples have experienced minor contamination from (blue) paint flakes coming off the tools when first used, but this is not considered to be either a significant or a pervasive effect (the paint was analysed and shown to mostly consist of Ti). The BOT sample was collected after augering or digging down to the required depth, and collecting the disaggregated material either with the auger or with gloved hands. Where a trench had to be dug to reach the BOT sample, it was preferably collected using the white plastic scoop. Where augering was possible, three to six holes were generally drilled and the BOT sample was a composite of material from each hole; where digging was necessary, the BOT sample was collected from the bottom of the trench over a larger area. Up to four different hand augers (of different lengths and widths, 3 and 4 inch diameter) and a mechanical auger (posthole digger; 7 inch diameter) made of steel, a shovel and crowbar were used during fieldwork.

The TOP and BOT samples were collected in clear plastic bags (ca 30 x 40 cm), which were rolled and stapled closed, and placed in pairs in calico (cotton) bags with string closing. The sample numbers were written on both the plastic and calico bags to minimise the risk of being rubbed off during transport (which did not occur).

For the western and northern Riverina fieldtrips, the texture, pH and Munsell™ colour were determined in the field according to standard protocols (Northcote, 1971; Munsell Color Company, 1975). Soil pH test kits from Inoculo™ Laboratories were used for pH determination. For the eastern Riverina samples, these parameters were determined in the laboratory within a few weeks of collection, together with other parameters (see below). The purpose of these field determinations is as follows.

Texture: provides context as to how and why elements may be concentrated or depleted in the soil, and can be a potential indicator of material origin. Clays can adsorb and exchange several elements. This is important where multiple material sources (which may influence element dispersion) need to be discriminated (e.g. alluvium vs aeolian material). It may also provide insights into the hydrology of the material, which in turn influences the geochemistry.

Colour: is important as it gives information as to whether it is an oxidising or reducing environment. Red soils are more oxidised and contain more iron oxides whereas the more yellow soils contain more goethite. Iron oxides may absorb or adsorb metals of interest including As and Au.

pH: provides information that can be related to element mobility and stability within the regolith materials. It can be correlated with various chemical and environmental factors that influence soils and plants. It must be recognised, however, that pH can vary markedly within a few metres of the sample site.

4.3. Sample preparation methods

The various sample preparation methods used are described in detail below and summarised in Table 1.

Table 1: Summary of sample preparation methods used for the Riverina geochemical survey

Method	Analysis location	Sample 1 (TOP)	Sample 2 (TOP)	Sample 3 (BOT)	Sample 4 (BOT)
Field pH	GA/field	Raw		Raw	
Texture	GA/field	Raw W		Raw W	
Colour (Dry)	GA/field	Raw		Raw	
Colour (Moist)	GA/field	Raw W		Raw W	
EC 1:5	GA		D45 U		D45 U
pH 1:5	GA		D45 U		D45 U
Moisture Content	GA		D105 U		D105 U
XRF	GA	D40 S180		D40 S180	
ICP-MS	GA	XRF bead		XRF bead	
Neutron Activation		D40 S180		D40 S180	
Sequential leach	GA	D40 S180		D40 S180	
Laser Particle size analysis*	GA		Raw		Raw
Heavy Mineral Fraction	GA		Raw		Raw

Key:		
	Dx	Dried to x °C (see text for duration)
	W	Wet
	Sx	Sieved to x μm
	U	Unsieved
	Raw	As found under field conditions

*The analysis was done on 2 and 4 but they are labelled as 1 and 3 (eastern Riverina only)

4.3.1. Drying and sieving for geochemical analysis

- For geochemical analysis, one TOP and one BOT samples ('X' = '1' and '3', respectively) were selected for each site (for instance 2003 751 1601 and 2003 751 3601 for the first sample site from the eastern Riverina)
- The last four digits of each sample number (e.g., 1601 and 3601) were engraved into the floor of a 250 x 380 x 50 mm aluminium baking dish
- Each sample was then spread evenly in its dish and dried in an oven at 40 ^{o}C for 48 hours
- The sample was disaggregated by placing it in a 250 x 350 mm sample bag, rolling the top closed and then pounding it with a large ceramic pestle. This process was repeated until sufficient sample was obtained, replacing the sample bag as required. The sample was then sieved using 180 μm nylon cloth until approx 80 g of <180 μm material was obtained
- No further grinding of the sample was required. The samples were blended by shaking

4.3.2. Fusion of glass beads for X-ray fluorescence (XRF) analysis

- Accurately weighing approx 0.27 g of sample and 1.73 g of 57:43 (lithium tetraborate:metaborate) flux into a Pt crucible
- Adding 0.5 mL of a 20% $LiNO_3$ solution to the crucible
- Sintering the mixture in a furnace set at 400 ^{o}C for 10 minutes to oxidise any sulphides present
- Transferring the crucible to the Bradway™ rocking furnace and heat at 1100 ^{o}C for a further 10 minutes

- Adding a few crystals of NH_4I anti-wetting agent to the melt after 8 minutes
- Removing the melt after 10 minutes and quickly quench press on a preheated graphite disc using an aluminium press
- After pressing, annealing the disc on a hotplate at 180 ^{o}C for 20-30 minutes

4.3.3. Heavy mineral separation

The sample bags collected for heavy mineral analysis (‘X’ = ‘2’ and ‘4’ for TOP and BOT samples, respectively) were emptied one by one in plastic basins and immersed in water overnight to disaggregate the sediments. The resulting slurry was subsequently poured into a black plastic panning pan with ridges on one side. The fines were washed off until only coarse and dense material was left over. This residue was then washed and dried in an oven at 40 °C overnight. It is intended to further separate heavy minerals using dense liquids and carry out X-ray diffraction (XRD), Scanning Electron Microscopy (SEM, including trials on the AutoGeoSEM at CSIRO, Perth) and/or optical determination of the dominating heavy mineral phases. Geochemical analysis of these is envisaged for selected samples, as is potentially SHRIMP analysis of zircons.

4.4. Laboratory methods

4.4.1. X-ray fluorescence spectrometry (XRF) of regolith and sediment samples

XRF analysis was carried out in the Minerals Division Laboratory at Geoscience Australia. The laboratory’s XRF is a Philips PW2404 4kW sequential spectrometer using a Rh tube. It is used to determine the major elements present in samples presented to the laboratory and a range of the routinely more abundant trace elements to complement those analysed on the ICP-MS.

The instrument is calibrated using a range of USGS and SARM (South African Reference Material) and other international standards. Synthetically prepared standards and some Australian Soil and Plant Analysis Council (ASPAC) standards were also used. The ‘Classic Model’ as outlined in the ‘Philips SuperQ/Quantitative Users Guide’ was used to calculate alpha coefficients and line overlap factors.

Reference monitor standard Si3 is used.

The routinely determined major elements are SiO_2, TiO_2, Al_2O_3, Fe_2O_3, MnO, MgO, CaO, Na_2O, K_2O, P_2O_5 and SO_3 (Table 2).

This program uses 57:43 X-Ray flux (57% Li tetraborate 43% Li metaborate) because of its ability to fuse a wide range of sample types. It is used for all regolith samples and any samples that may contain significant NaCl. The trace elements Sc, V, Cr, Ni, Cu, Zn, Ba, Cl and F are determined on these fusions because NaCl and other soluble salts migrate to the surface of powder pellets as the binder dries causing gross errors. Generally speaking, the longer the wavelength of the element being measured the worse the error. ICP-MS results are used for all other trace elements.

Appendix 3 shows the detection limits of the XRF method.

4.4.2. Inductively Coupled Plasma Mass Spectrometry (ICP-MS)

ICP-MS analysis was carried out in the Minerals Division Laboratory at Geoscience Australia. The laboratory's ICP-MS is a Perkin Elmer Elan 6000. It is used to determine a range of trace elements to complement those analysed on the XRF.

The instrument is calibrated using synthetic standards. The calibrations obtained are verified against a range of USGS, SARM (South African Reference Material) and other international standards. Australian Soil and Plant Analysis Council (ASPAC) standards are used to verify calibrations for vegetable material.

The samples for ICP-MS analysis were prepared from the glass bead previously used for XRF analysis. After breaking up the bead, approximately 100 mg are weighted accurately and transferred to a Teflon™ container, to 1 mL distilled 40% HF, 5 mL distilled concentrated HNO_3 and 1 mL internal multi-element standard (see below) are added. The container is sealed and heated to 140 °C overnight. After cooling, the solution is transferred to a volumetric flask, made up to 200 mL with distilled water and run in the ICP-MS against prepared standards.

Samples are introduced to the ICP-MS as a mildly acidic aqueous solution containing approximately 100 ppm dissolved solids by way of a nebuliser that aspirates the sample with high velocity argon, forming a fine aerosol or mist. The aerosol then passes into a spray chamber where larger drops are removed via a drain. This process is necessary to produce droplets small enough to be vaporised in the plasma torch. Typically, only 2% of the original mist passes through the spray chamber.

Trace elements routinely determined by the ICP-MS are Be, V, Cr, Ni, Cu, Zn, Ga, Ge, As, Rb, Sr, Y, Zr, Nb, Mo, Ag, Cd, Sn, Sb, Cs, Ba, La, Ce, Pr, Nd, Sm, Eu, Tb, Gd, Dy, Ho, Er, Yb, Lu, Hf, Ta, Pb, Bi, Th and U (Table 2).

The analytical method used divides the analytes above into four groups. The count rate obtained for each analyte is ratioed against one of four isotopes introduced to the solution as internal standards, one for each of the analyte groups. Ni-61, Sm-147, Tm-169 and Tl-205 are the internal standard commonly used.

Inter-element interference factors are determined using a range of single element solutions. Likely inter-element interferences were selected from a Perkin Elmer compilation of theoretical interferences.

Appendix 3 shows the detection limits of the ICP-MS method.

4.4.3. Instrumental neutron activation analysis (INAA)

Neutron activation analysis was performed at Becquerel Laboratories, Sydney. For the determination of most elements samples of about 1 to 30 g are weighed and heat sealed in polypropylene vials. A flux monitor is attached to each sample and up to 200 samples and their monitors are activated for 10-30 minutes in a thermal neutron flux of 2-4 x 10^{12} n cm^{-2} s^{-1}. The gamma spectrum for each radioactive sample and monitor is measured simultaneously after seven days decay. Each sample is tested for the amount of activity to adjust sample-detector geometries so no dead time corrections are necessary. Samples are then mounted on automatic sample changer tables and counted for 10-30 minutes. The gamma ray spectra are measured using hyperpure Ge coaxial detectors linked to multichannel analysers as part of an integrated counting control and data handling system. Spectral data are analysed using in-house programs developed by Becquerel Laboratories.

4.4.4. Sequential digestions

The sequential digestion method of Gray et al. (1999) was used to specifically extract weakly bound chemical elements, which may be indicative of more recently migrated and adsorbed or incorporated species (e.g., Cameron et al., 2004). The extraction sequence is:

1. Ammonium acetate at pH 5, targeting carbonates and surface adsorbed metals
2. 0.1 M hydroxylamine hydrochloride, targeting Mn oxides
3. 0.25 M hydroxylamine hydrochloride, targeting Fe oxides

After the sequential digestions, the samples are presented to the ICP-MS as described elsewhere. Results of these analyses are not available at the time of writing.

4.4.5. Laser particle size analysis

Twenty raw (bulk) overbank sediment samples from TOP and BOT layers were delivered to the Sedimentology Laboratory at Geoscience Australia to be analysed with the laser particle size analyser. The equipment used is a Malvern™ Mastersizer 2000 coupled to a Hydro 2000 MU pump unit, which allows dispersion of large volume samples using standard laboratory beakers as the sample container. The basic principles of particle size analysis are summarised by Rawle (undated).

4.4.6. pH 1:5

The following method is from the Bureau of Rural Sciences (A. Plazinska, pers. comm., 2003). Transfer 30-40 g of unsieved (raw) sample into a labelled aluminium tray. Put sample in oven at 45 °C for a minimum of eight hours, then place in desiccators to allow to return to room temperature. Accurately weight 10 g (± 0.02 g) of sample into a plastic vial. Add 50 mL of distilled water, close vial and shake by hand to ensure thorough mixing of sample. Place sample vial in plastic bowls and place bowls in New Brunswick shaker for one hour at 160 rpm and 25 °C. Measured pH using calibrated bench top pH meter with pH probe and temperature probe. Probes are rinsed with distilled water and dried with lab tissues between samples.

4.4.7. EC 1:5

Same method as above, except EC is measured with calibrated EC meter and probe.

4.4.8. Moisture content

The following method is from the Bureau of Rural Sciences (A. Plazinska, pers. comm., 2003). Accurately weight 100-120 g of unsieved (raw) sample and transfer into a labelled, pre-weighted aluminium tray. Put the sample in oven at 105 °C for a minimum of eight hours, then place in desiccator to allow to return to room temperature. Accurately record weight of dry sample, subtract weight of aluminium tray and calculate moisture content (%).

4.5. Data analysis methods

Data generated by this project was delivered to Geoscience Australia's database group to be stored on Geoscience Australia's corporate databases Deviant and Ozchem. Data analysis is performed using ArcMap® (Minami, 2000) for basic spatial representation (e.g., Figures 2-11), and DAS® (Dutter et al., 1995) for more advanced statistical treatment (boxplots, cumulative frequency distributions, histograms) and geochemical mapping (Appendix 4). For statistical analysis, results below the detection limit (DL) were replaced by ½ DL values, to still enable mathematical treatment (such as ratios or log-transformation).

Table 2: Summary of methods used, elements analysed and detection limits obtained for the bulk (<180 µm) overbank sediments of the eastern Riverina

XRF and ICP-MS-GA Labs			INAA-Becquerel Labs		
ELEMENTS	**UNITS**	**DL***	**ELEMENTS**	**UNITS**	**DL***
Ag ICP-MS	ppm	0.01	**Ag**	ppm	5
Al2O3 XRF	%	0.001			
As ICP-MS	ppm	0.5	**As**	ppm	1
			Au	**ppb**	5
Ba ICP-MS	ppm	2	**Ba**	ppm	100
Be ICP-MS	ppm	0.05			
Bi ICP-MS	ppm	0.01			
			Br	ppm	1
CaO XRF	%	0.002	**Ca**	%	1
Cd ICP-MS	ppm	0.1	**Cd**	ppm	20
Ce ICP-MS	ppm	0.02	**Ce**	ppm	2
Cl XRF	ppm	5			
			Co	ppm	1
Cr XRF	ppm	4	**Cr**	ppm	5
Cs ICP-MS	ppm	0.01	**Cs**	ppm	1
Cu XRF	ppm	2			
Dy ICP-MS	ppm	0.01			
Er ICP-MS	ppm	0.01			
Eu ICP-MS	**ppb**	0.5	**Eu**	ppm	0.5
F XRF	ppm	50			
Fe2O3T XRF	%	0.002	**Fe**	%	0.02
Ga ICP-MS	ppm	0.1			
Gd ICP-MS	ppm	0.01			
Ge ICP-MS	ppm	0.02			
Hf ICP-MS	ppm	0.01	**Hf**	ppm	0.5
Ho ICP-MS	ppm	0.01			
			Hg	ppm	5
			Ir	**ppb**	20
K2O XRF	%	0.002	**K**	%	0.2
La ICP-MS	ppm	0.02	**La**	ppm	0.5
Lu ICP-MS	ppm	0.01	**Lu**	ppm	0.2
MgO XRF	%	0.004			
MLOI Calculate	%	0.001			
MnO XRF	%	0.001			
Mo ICP-MS	ppm	0.01	**Mo**	ppm	5
Na2O XRF	%	0.004	**Na**	%	0.01
Nb ICP-MS	ppm	0.04			
Nd ICP-MS	ppm	0.01			
Ni XRF	ppm	2			
P2O5 XRF	%	0.001			
Pb ICP-MS	ppm	0.5			
Pr ICP-MS	ppm	0.01			
Rb ICP-MS	ppm	1	**Rb**	ppm	20
Sb ICP-MS	ppm	0.01	**Sb**	ppm	0.2
Sc XRF	ppm	10	**Sc**	ppm	0.1
			Se	ppm	5
SiO2 XRF	%	0.006			

Table 2. Continued

XRF and ICP-MS-GA Labs			INAA-Becquerel Labs		
ELEMENTS	**UNITS**	**DL***	**ELEMENTS**	**UNITS**	**DL***
Sm ICP-MS	ppm	0.01	**Sm**	ppm	0.2
Sn ICP-MS	ppm	0.01	**Sn**	ppm	500
SO3 XRF	%	0.001			
Sr ICP-MS	ppm	1			
Ta ICP-MS	ppm	0.06	**Ta**	ppm	1
Tb ICP-MS	ppm	0.01			
			Te	ppm	5
Th ICP-MS	ppm	0.01	**Th**	ppm	0.5
TiO2 XRF	%	0.002			
U ICP-MS	ppm	0.07	**U**	ppm	2
V XRF	ppm	6			
			W	ppm	2
Y ICP-MS	ppm	0.22			
Yb ICP-MS	ppm	0.01	**Yb**	ppm	0.5
Zn XRF	ppm	2	**Zn**	ppm	100
Zr ICP-MS	ppm	1	**Zr**	ppm	500

* Detection Limit as provided by lab, unless different value reported with results from lab (eg, -0.01 ppm)

5. RESULTS

The actual location of sampling sites in the Riverina is shown in Figure 2. Geochemical results of the bulk analyses for the eastern Riverina region are illustrated for selected elements as ‘growing-dots’ geochemical maps (Figures 3-11) and as a complete series of diagrams (for all elements with at least one result above detection limit [DL]) combining statistical plots and Exploratory Data Analysis (EDA)-based maps (Appendix 4). Table 3 summarises the results of the bulk geochemical analyses carried out on the eastern Riverina overbank sediment samples. Where elements were analysed by more than one method, the preferred method is indicated in the Table, and the resulting maps are shown in Appendix 4.

Generally, ICP-MS and XRF are favoured over INAA because of the lower detection limits attained, the in-house analytical capability, and the internal consistency with the sequential digestion work. Only for two elements analysed in both laboratories is INAA preferred: Sb (because of erratic contamination risk by the Pt crucibles used in XRF bead preparation) and Sc (because of detection limits and potential overlap with Ca on XRF). Other elements analysed only by INAA are: Au, Br, Co, *Hg*, *Ir*, *Se*, *Te*, W (elements in italics had all results <DL in this study to date).

All elements analysed for are represented as EDA-based geochemical maps and statistical diagrams in Appendix 4 (except Hg, Ir, Se and Te, which had all results below detection limits), whilst a selection of parameters are shown as ‘growing-dots’ maps in Figures 3-11. Those maps illustrate how the distribution of various soil properties can be derived, for instance:

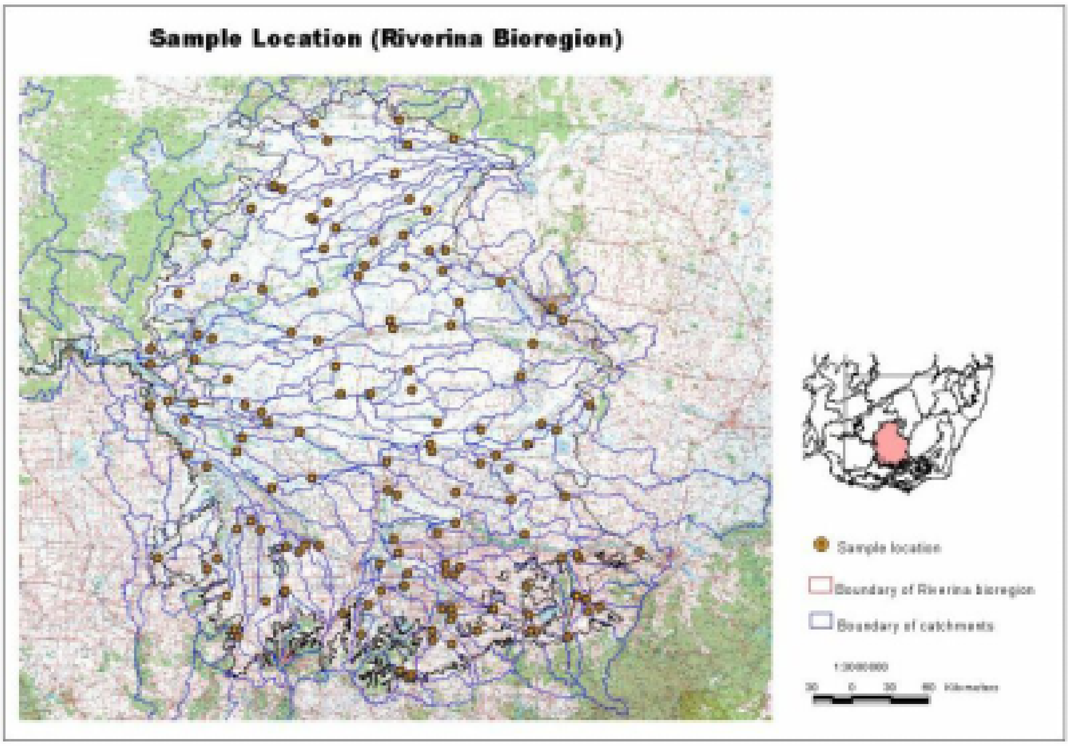

Figure 2: Location of factual sampling sites for the Riverina pilot geochemical survey (northern, eastern and western sub-regions).

- clay content (using Al_2O_3 concentrations as a proxy, Figure 3)
- nutrient status (K_2O concentrations, Figure 4)
- “sodicity risk” (Na_2O concentrations, Figure 5)
- “acidity risk” (pH, Figure 6)
- “salinity risk” (EC, Figure 7; Cl concentrations, Figure 9)
- exploration pathfinders for Au mineralisation (As concentrations, Figure 8; Sb concentrations, Figure 11)
- exploration pathfinders for Cu or Cu-Au mineralisation (Cu concentrations, Figure 10)

The results of macroscopic properties are shown in Appendices 6 and 7. The quantitative results are summarised in Table 4.

Particle size analysis results are summarised in Figure 12 and detailed in Appendix 5. On average, 91% of the material has a grain size <180 µm for these 20 samples. This suggests that the geochemical analyses performed on the <180 µm fractions are likely to be representative of the bulk sample chemistry in these overwhelmingly fine-grained sediments. This is an important observation as many environmental geochemistry reports analyse the <2 mm fractions. Our results should thus be reasonably comparable with such studies.

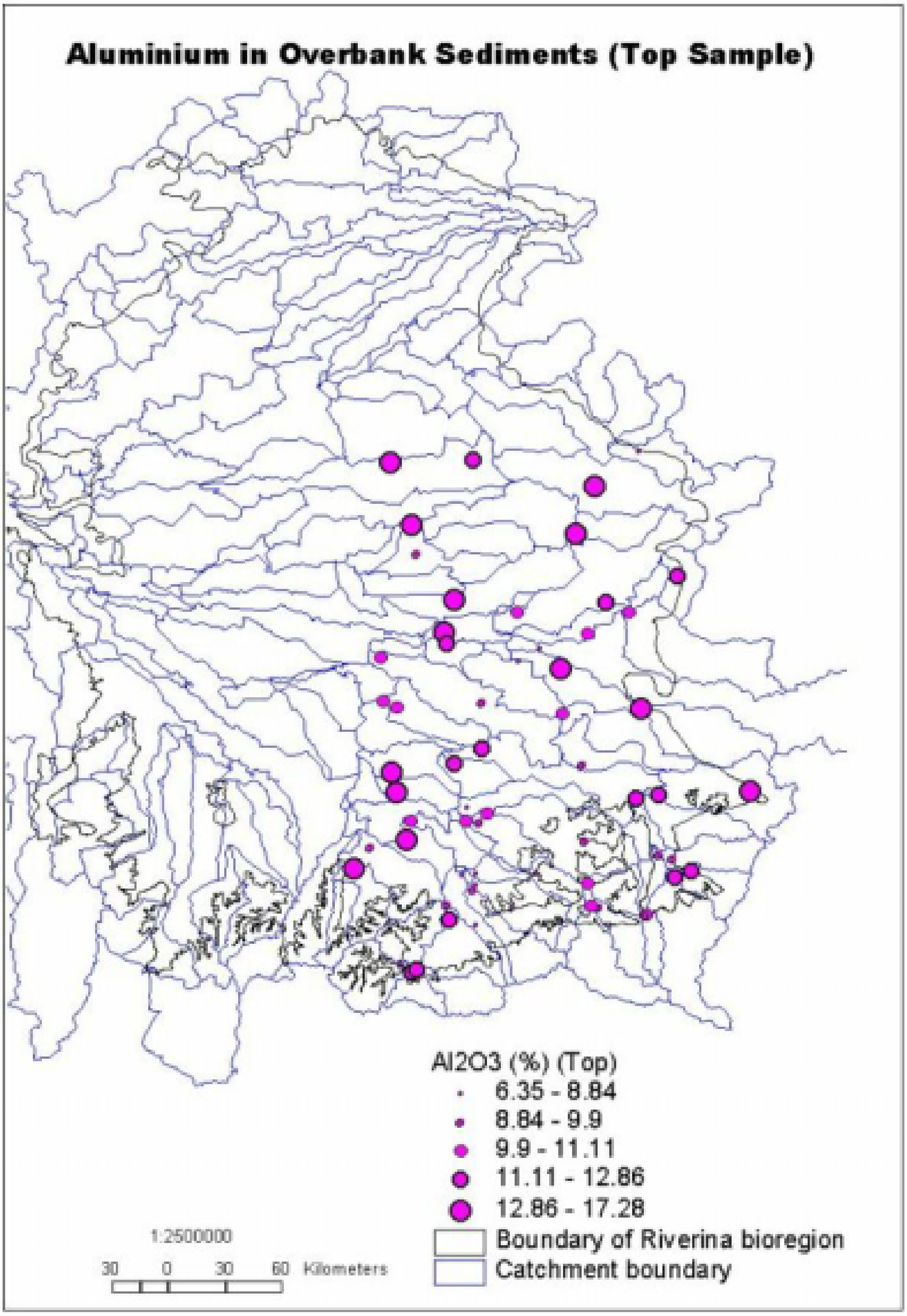

Figure 3a. Distribution of Al_2O_3 (%, by XRF) in TOP overbank sediments of the eastern Riverina study area. Each of the five classes represents 20 % of the dataset.

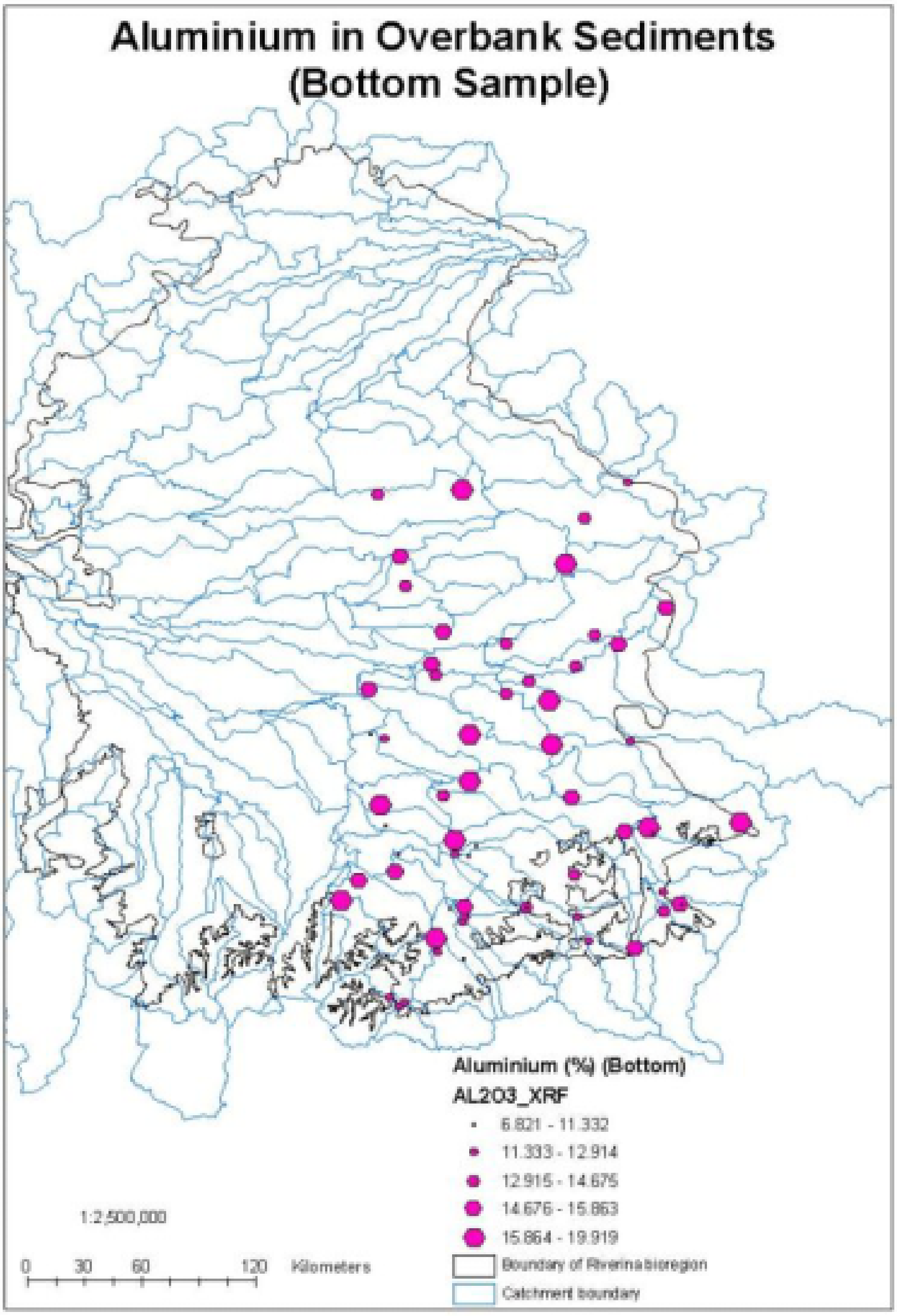

Figure 3b. Distribution of Al2O3 (%, by XRF) in BOT overbank sediments of the eastern Riverina study area. Each of the five classes represents 20 % of the dataset.

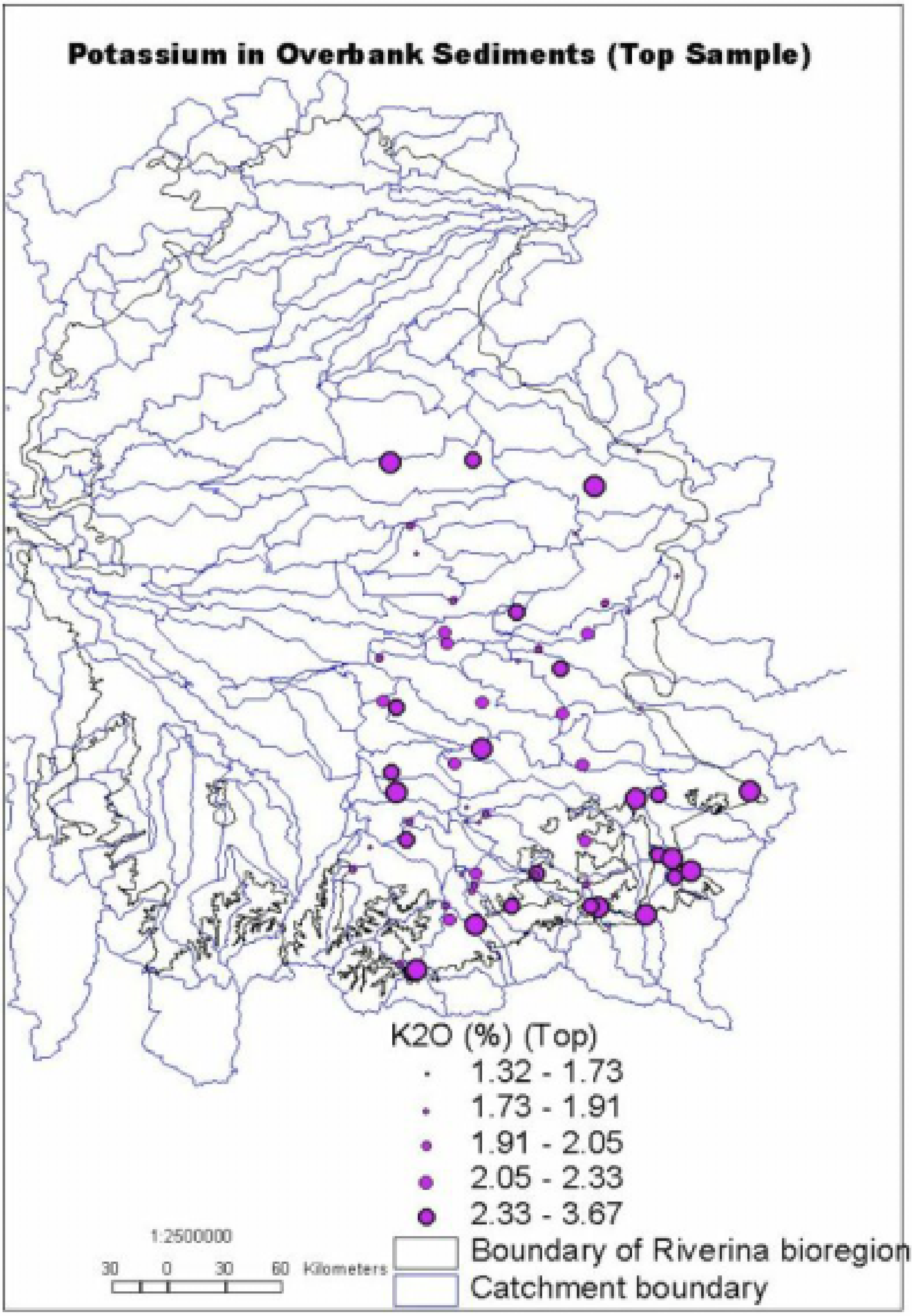

Figure 4a. Distribution of K_2O (%, by XRF) in TOP overbank sediments of the eastern Riverina study area. Each of the five classes represents 20 % of the dataset.

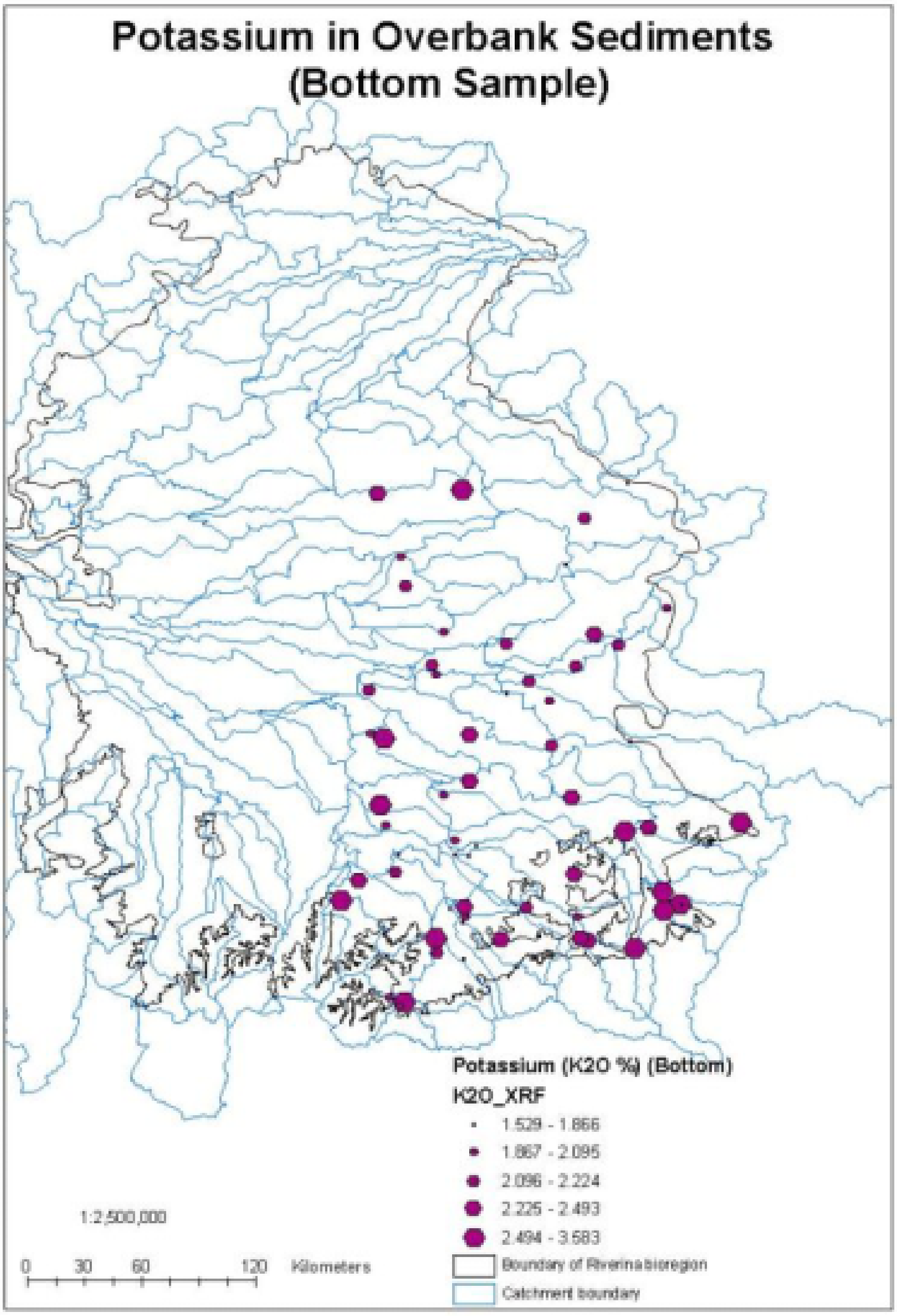

Figure 4b. Distribution of K_2O (%, by XRF) in BOT overbank sediments of the eastern Riverina study area. Each of the five classes represents 20 % of the dataset.

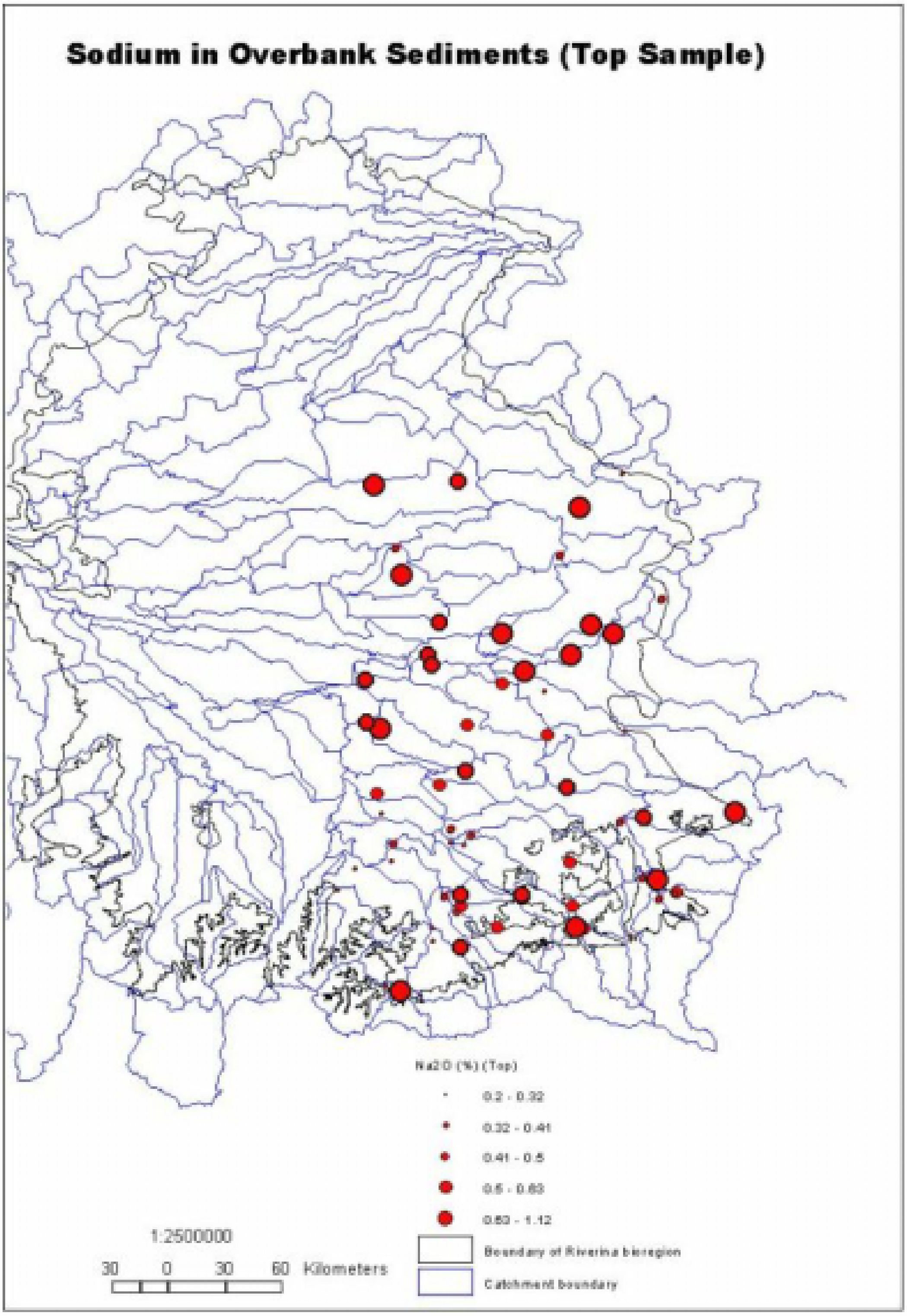

Figure 5a. Distribution of Na_2O (%, by XRF) in TOP overbank sediments of the eastern Riverina study area. Each of the five classes represents 20 % of the dataset.

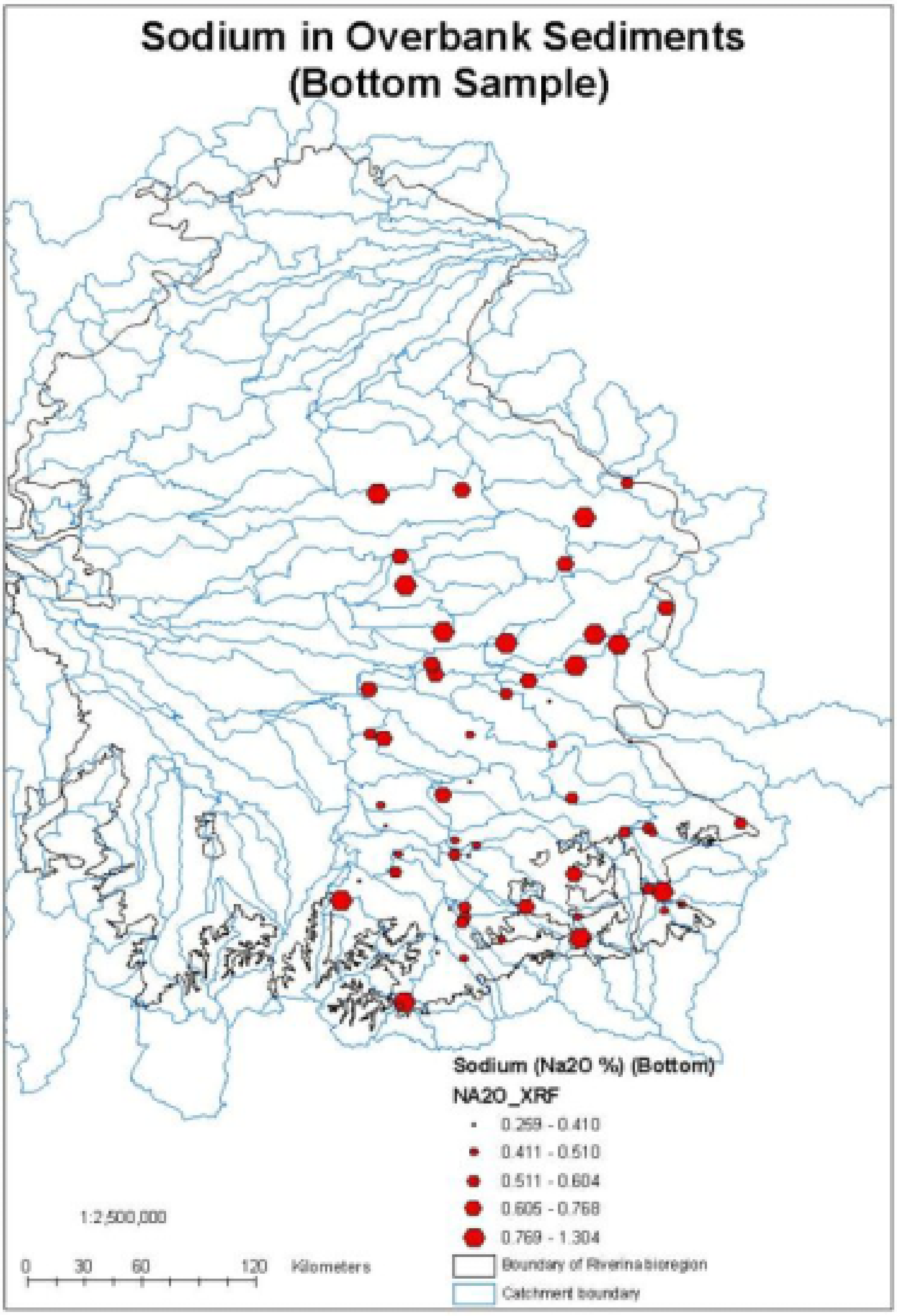

Figure 5b. Distribution of Na_2O (%, by XRF) in BOT overbank sediments of the eastern Riverina study area. Each of the five classes represents 20 % of the dataset.

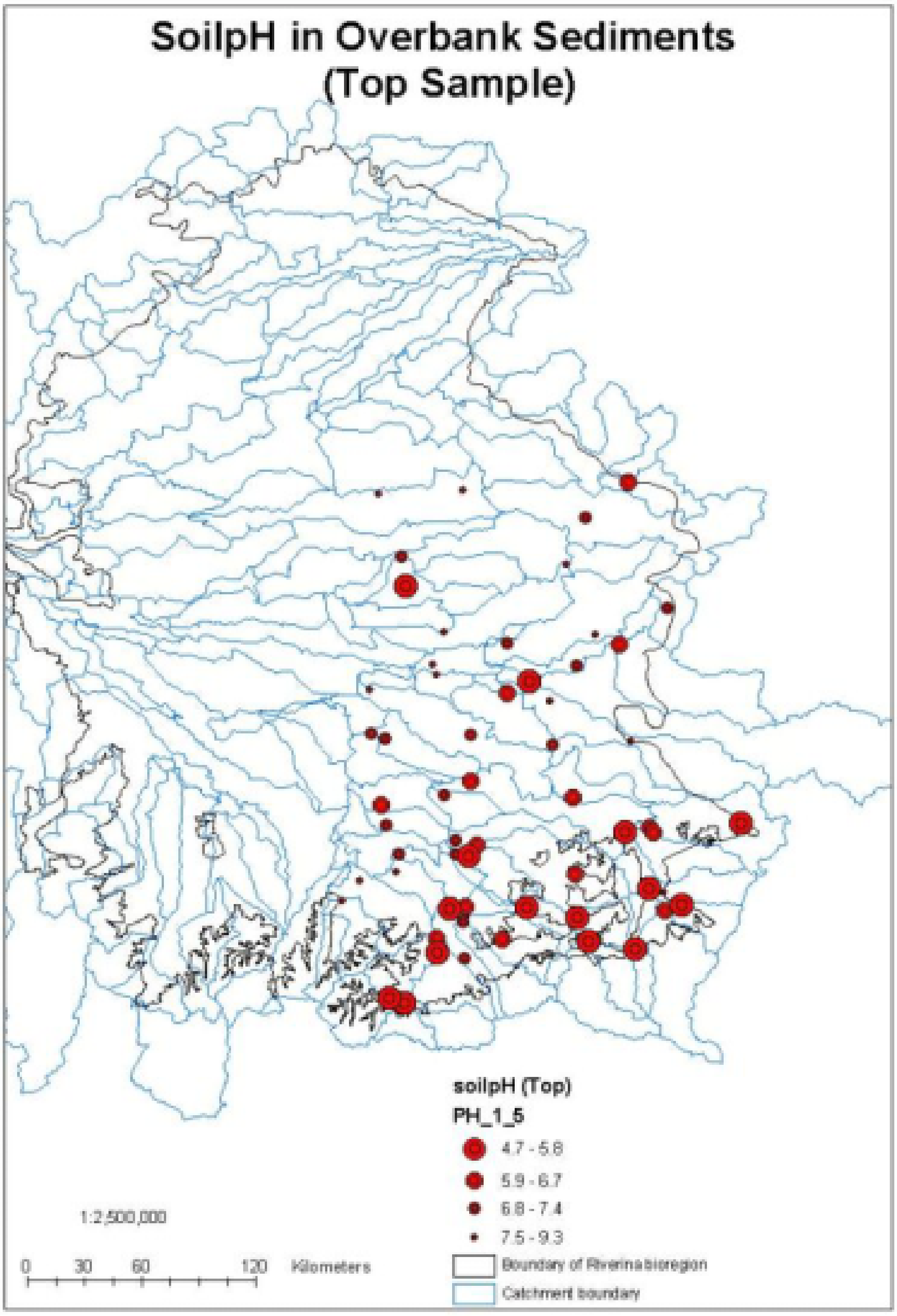

Figure 6a. Distribution of pH 1:5 in TOP overbank sediments of the eastern Riverina study area. Each of the five classes represents 20 % of the dataset.

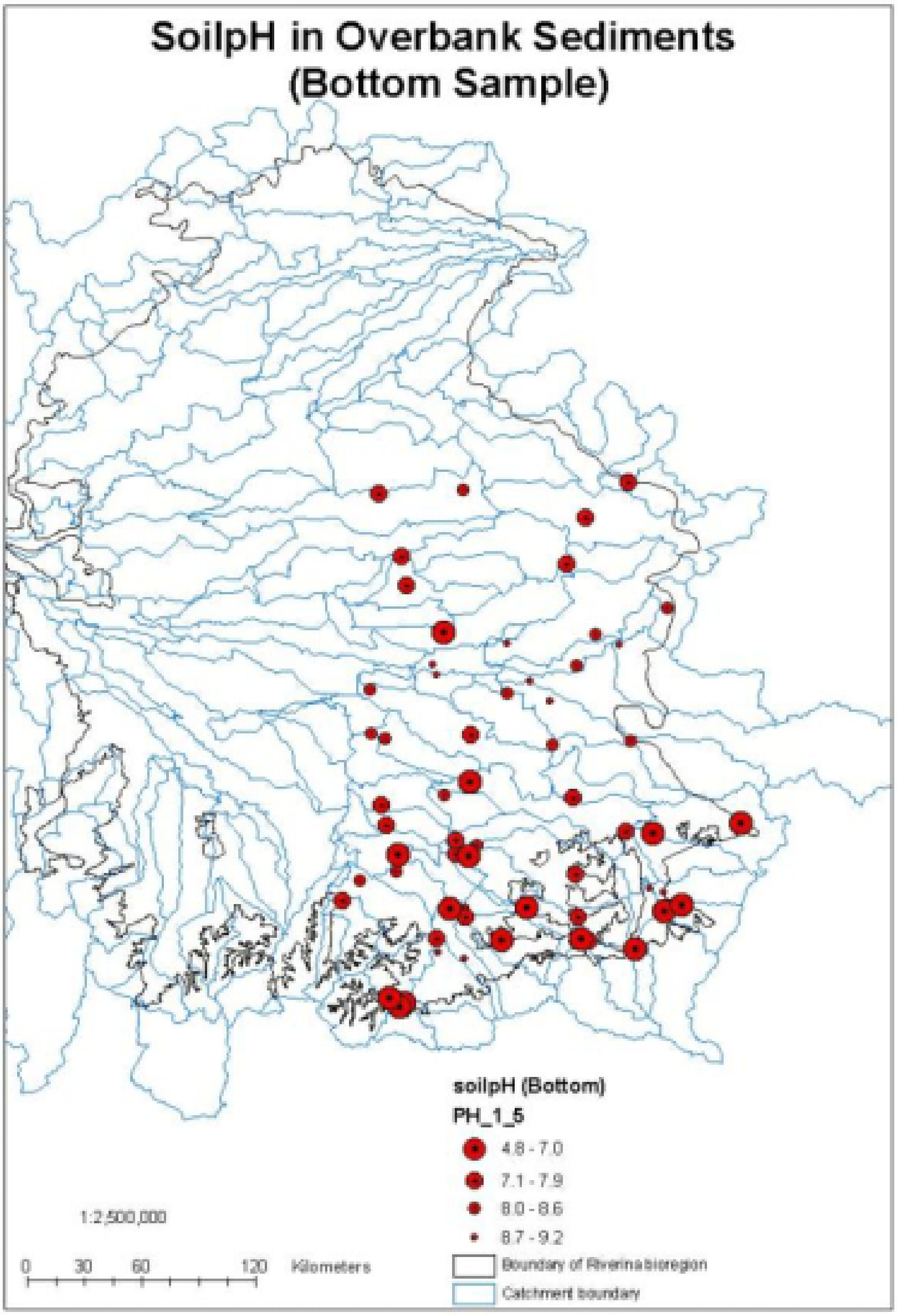

Figure 6b. Distribution of pH 1:5 in BOT overbank sediments of the eastern Riverina study area. Each of the five classes represents 20 % of the dataset.

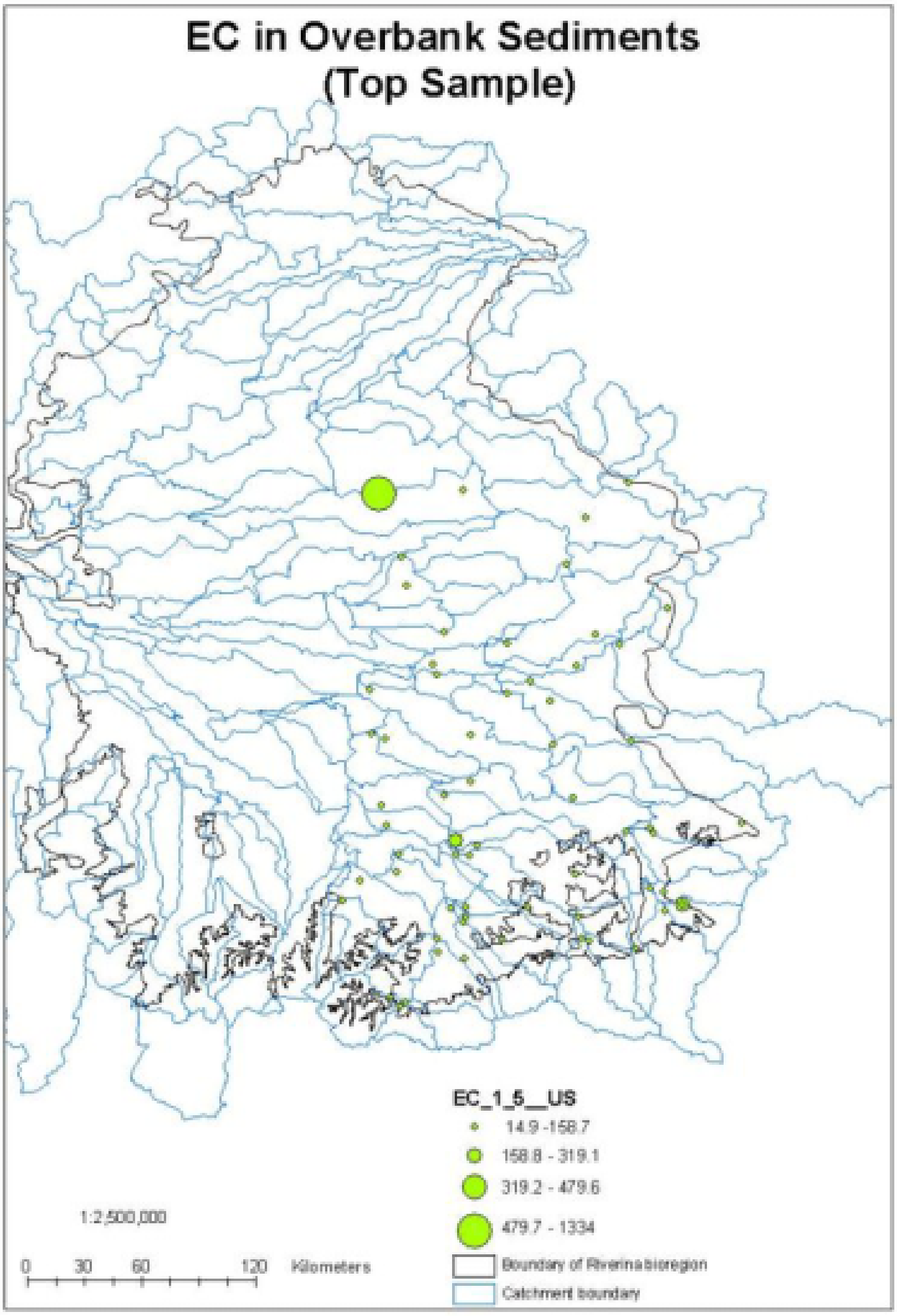

Figure 7a. Distribution of EC 1:5 in TOP overbank sediments of the eastern Riverina study area. Each of the five classes represents 20 % of the dataset.

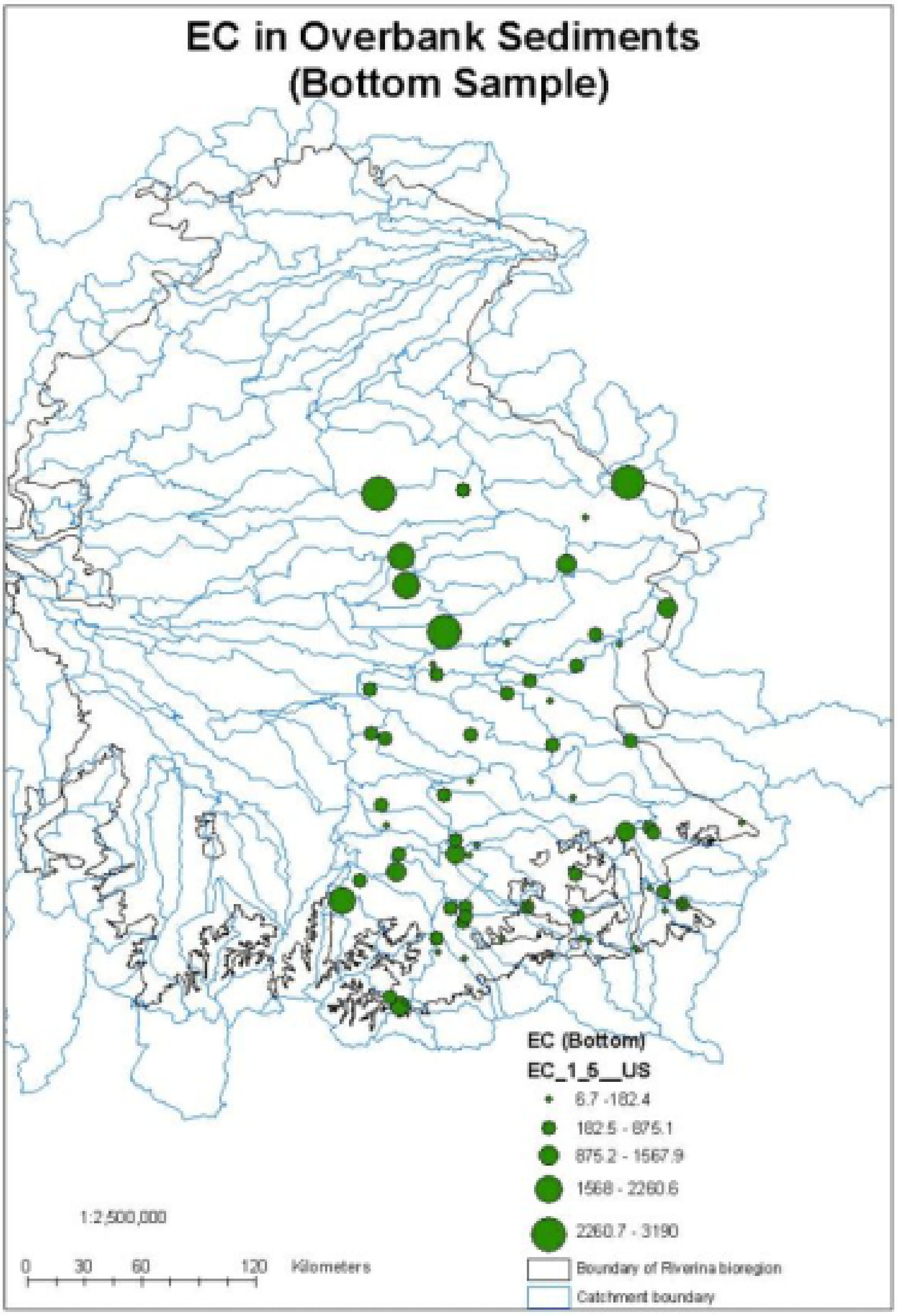

Figure 7b. Distribution of EC 1:5 in BOT overbank sediments of the eastern Riverina study area. Each of the five classes represents 20 % of the dataset.

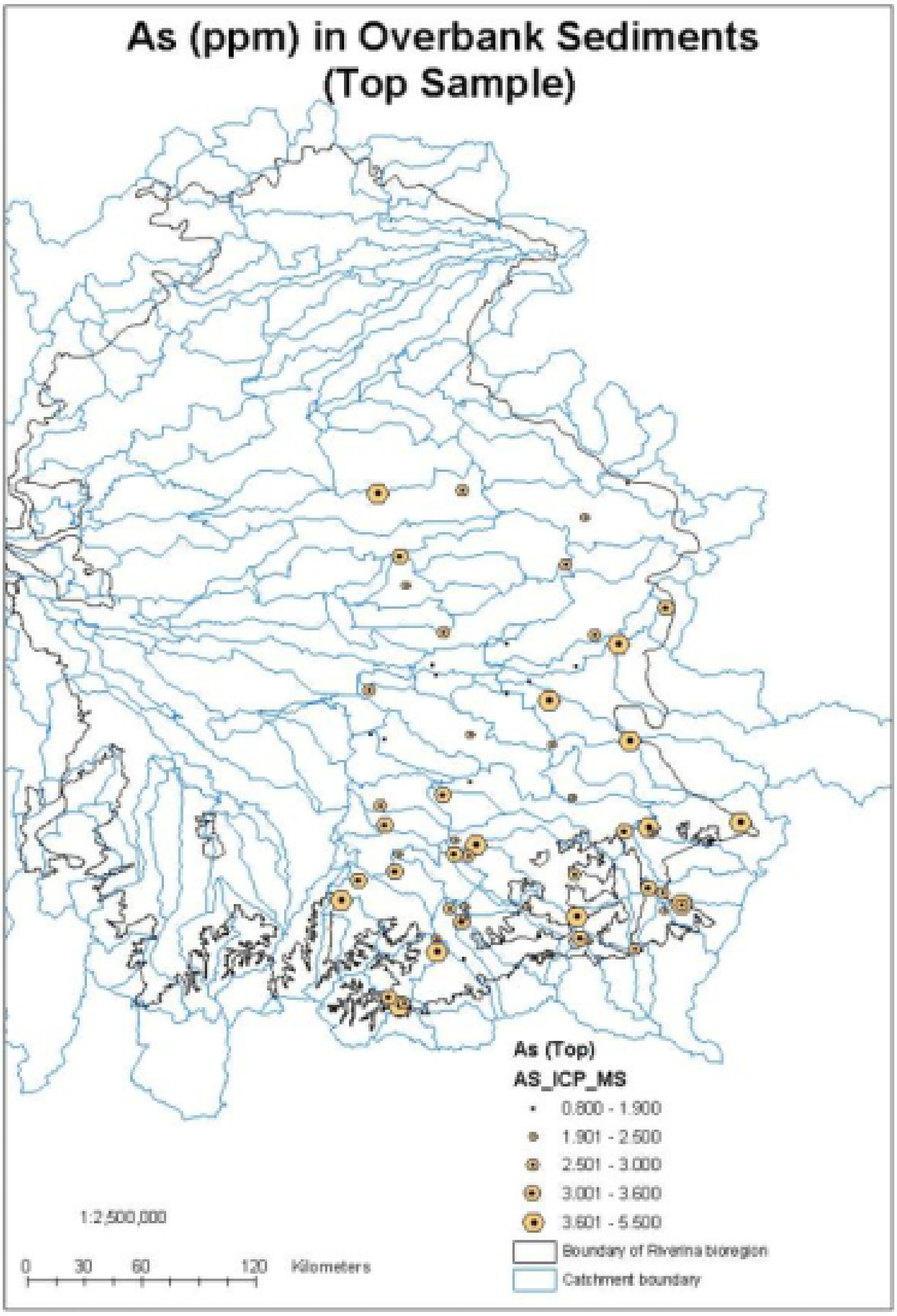

Figure 8a. Distribution of arsenic (ppm, by ICP-MS) in TOP overbank sediments of the eastern Riverina study area. Each of the five classes represents 20 % of the dataset.

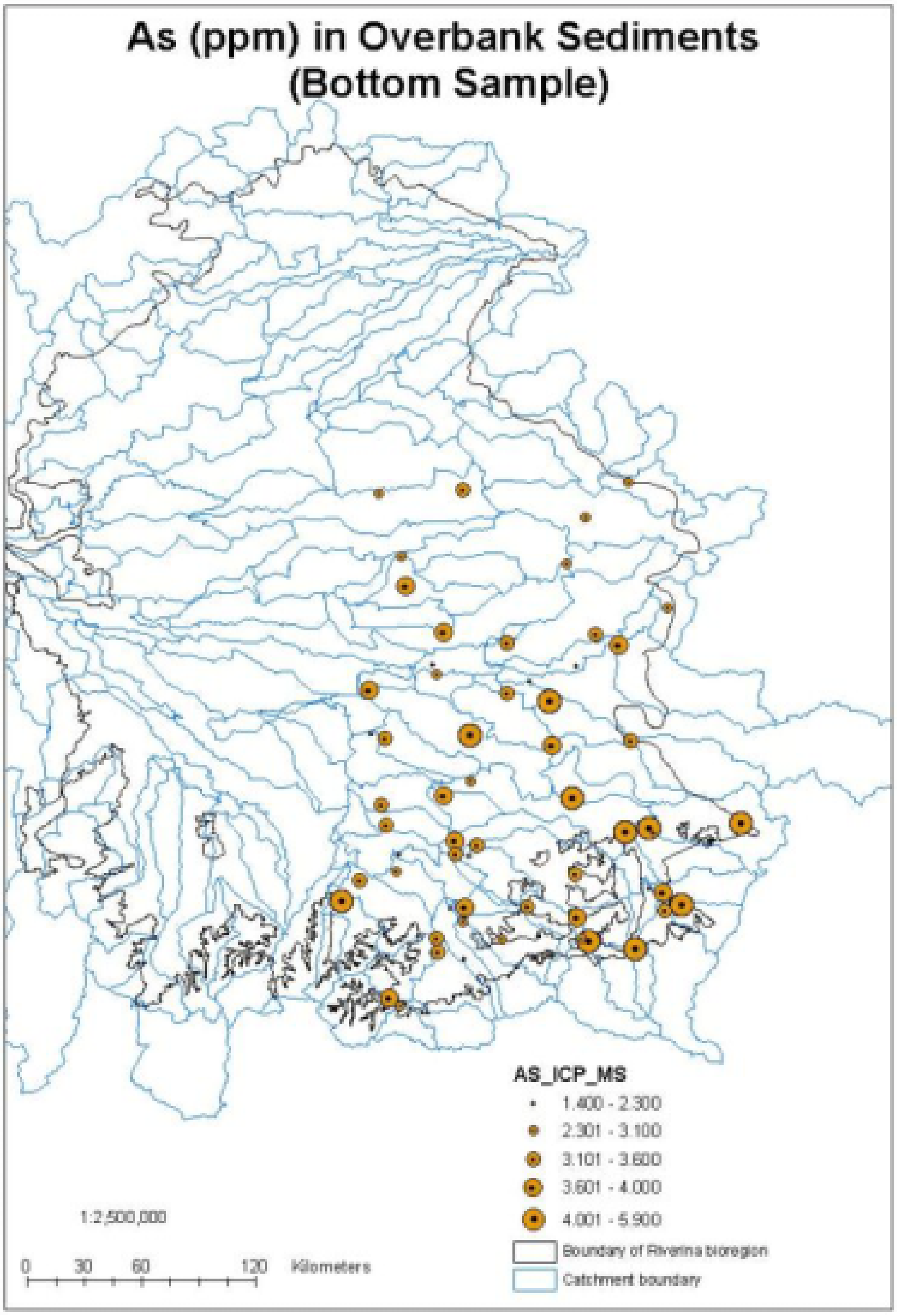

Figure 8b. Distribution of arsenic (ppm, by ICP-MS) in BOT overbank sediments of the eastern Riverina study area. Each of the five classes represents 20 % of the dataset.

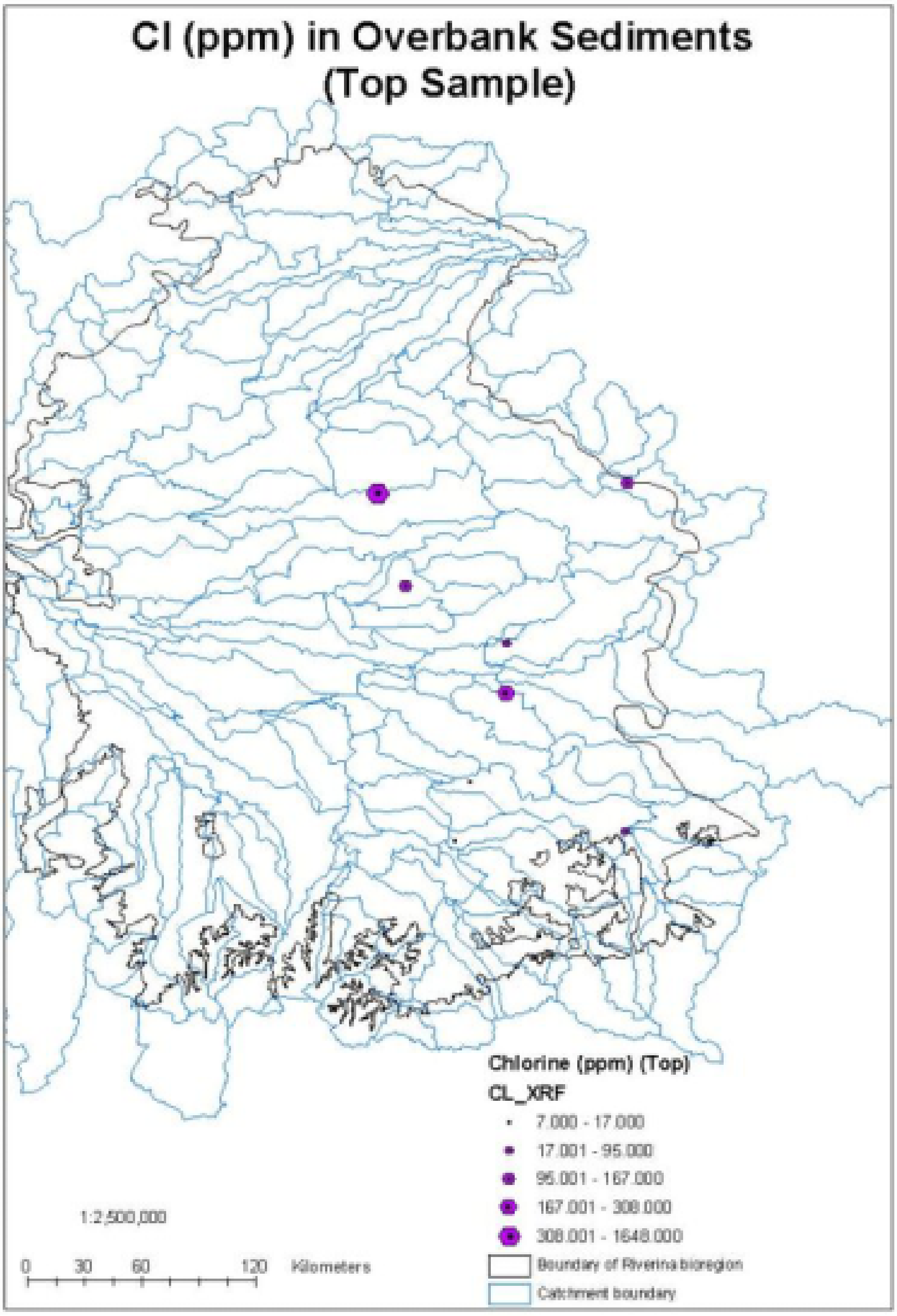

Figure 9a. Distribution of chloride (ppm, by XRF) in TOP overbank sediments of the eastern Riverina study area. Each of the five classes represents 20 % of the dataset. (Several values <DL not shown)

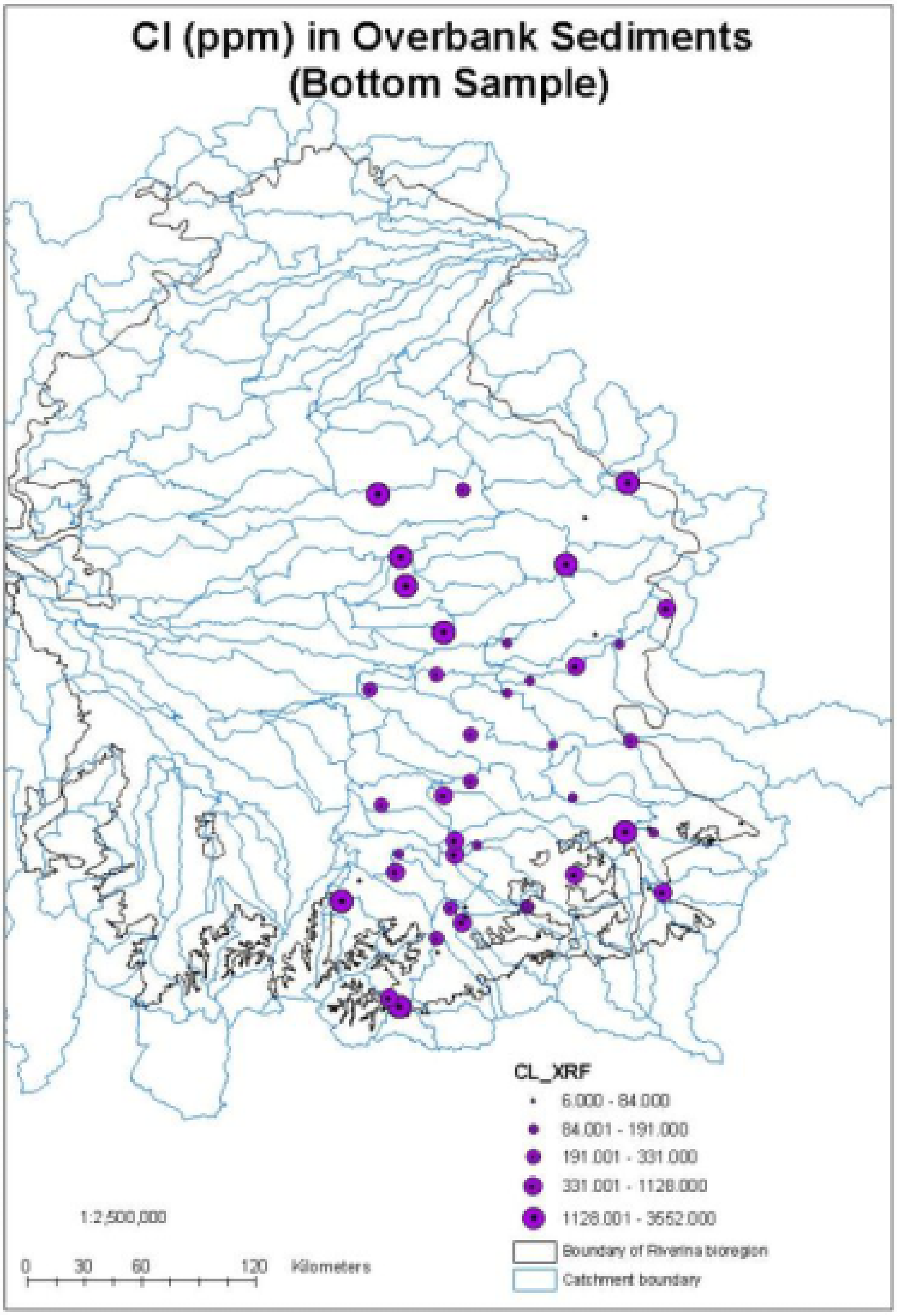

Figure 9b. Distribution of chloride (ppm, by XRF) in BOT overbank sediments of the eastern Riverina study area. Each of the five classes represents 20 % of the dataset. (Several values <DL not shown)

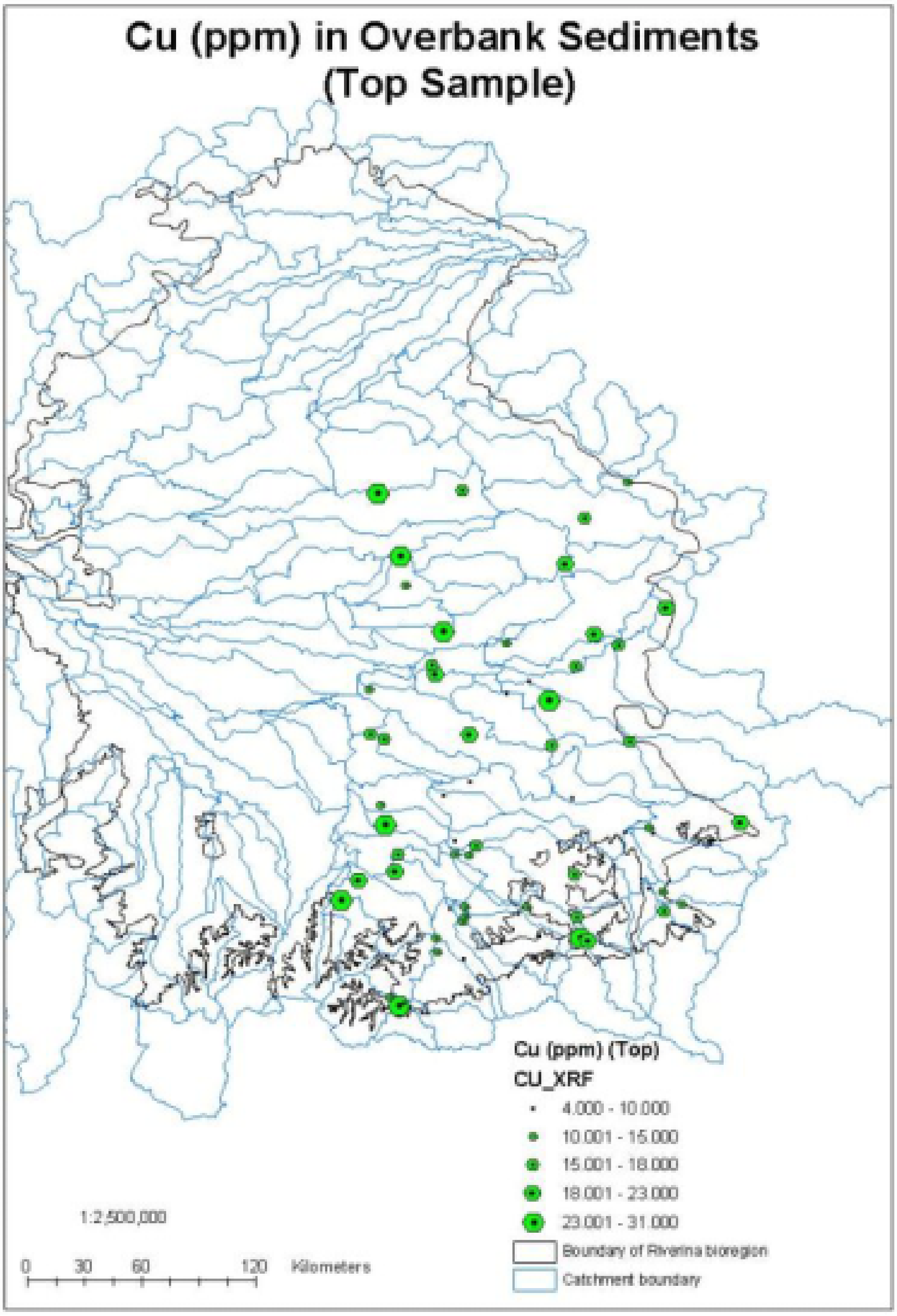

Figure 10a. Distribution of copper (ppm, by XRF) in TOP overbank sediments of the eastern Riverina study area. Each of the five classes represents 20 % of the dataset.

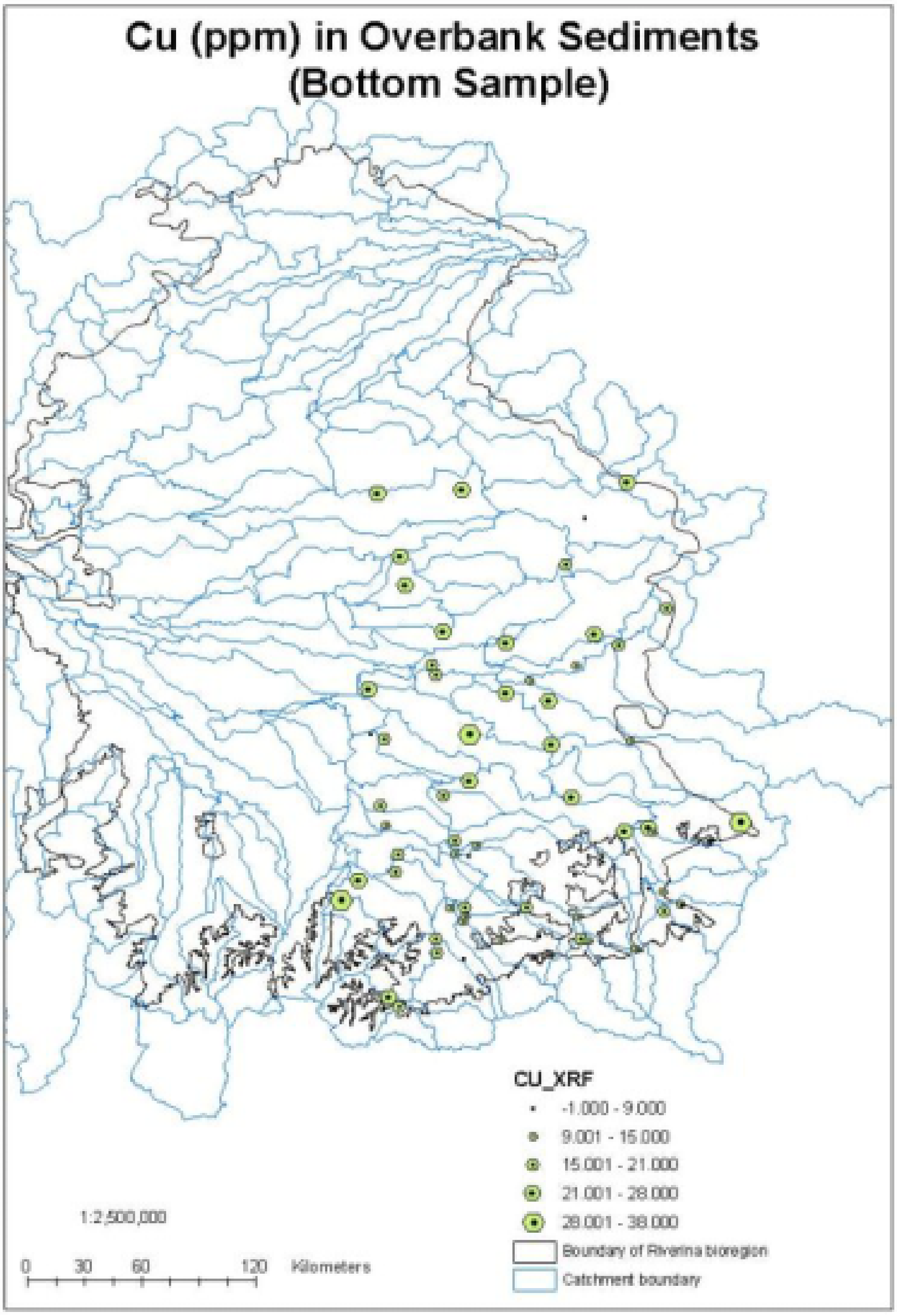

Figure 10b. Distribution of copper (ppm, by XRF) in BOT overbank sediments of the eastern Riverina study area. Each of the five classes represents 20 % of the dataset.

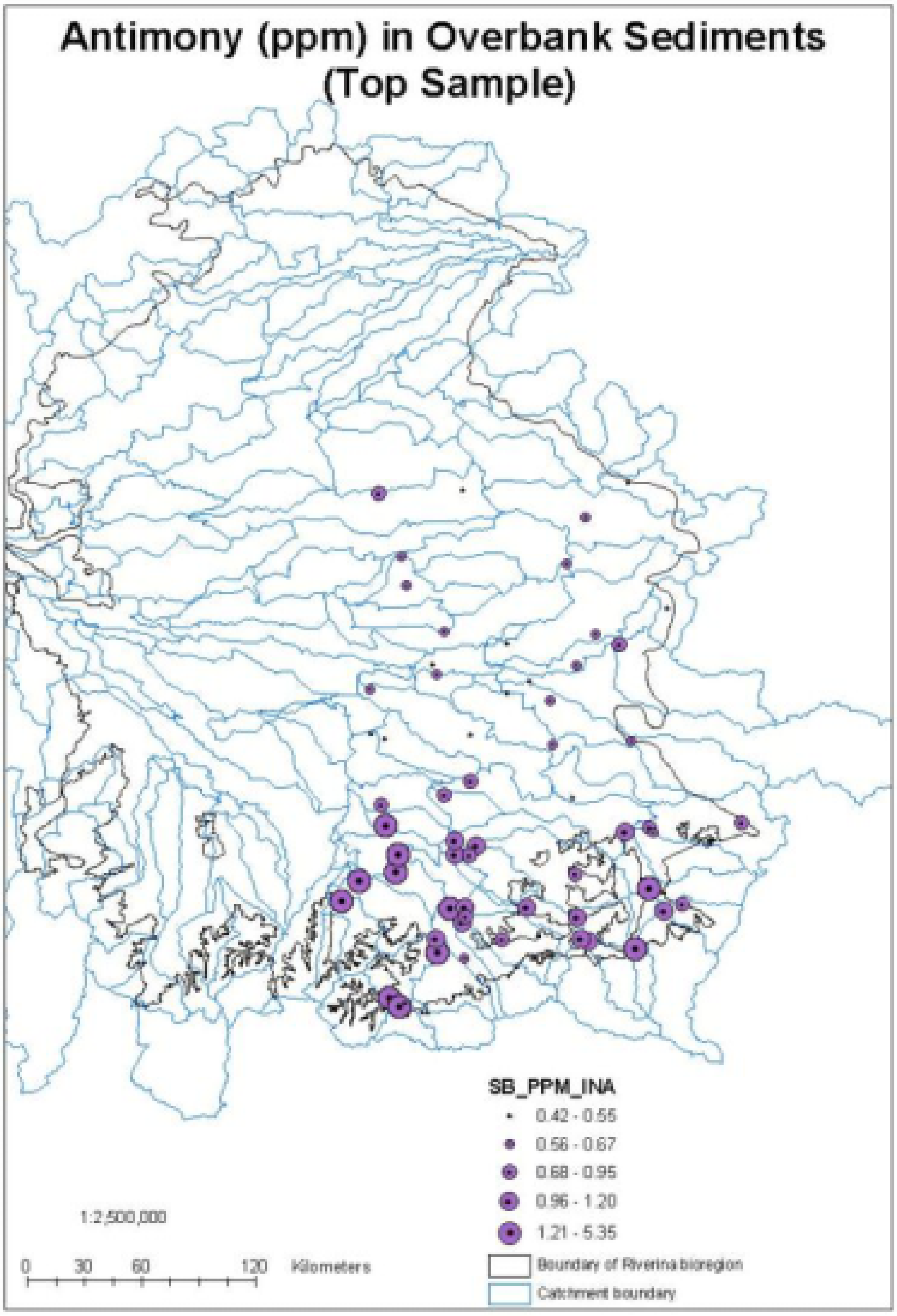

Figure 11a. Distribution of antimony (ppm, by INAA) in TOP overbank sediments of the eastern Riverina study area. Each of the five classes represents 20 % of the dataset.

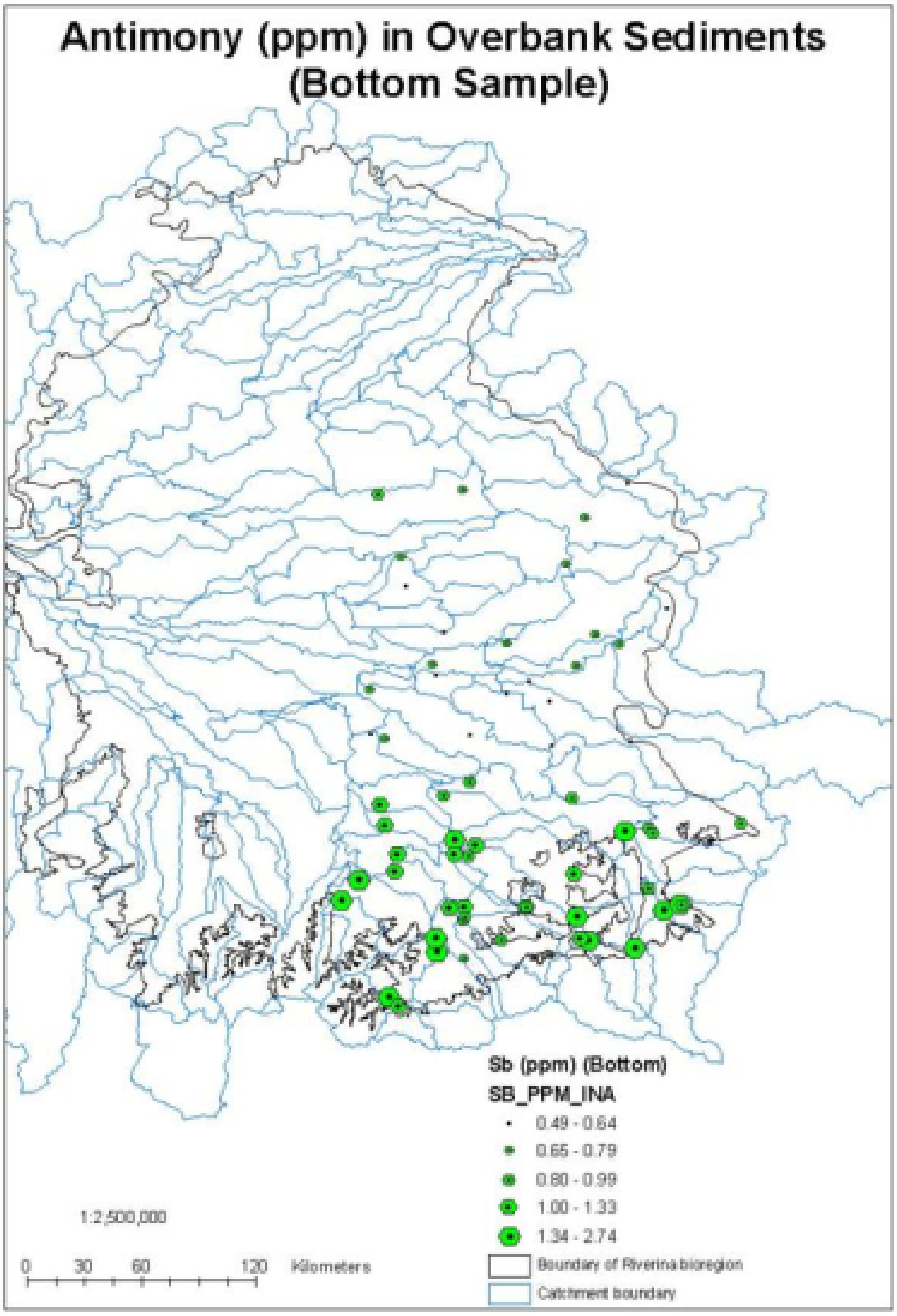

Figure 11b. Distribution of antimony (ppm, by INAA) in BOT overbank sediments of the eastern Riverina study area. Each of the five classes represents 20 % of the dataset.

Table 3. Summary of geochemical composition of overbank sediments from the eastern Riverina

El_unit_method	N	DL	Min	Med	Max	Units	% >DL	Preferred method?
Ag_ppm_ICPMS	129	0.01	0.01	0.07	0.13	ppm	100%	Y
Ag_ppm_INAA	129	5	<5	<5	<5	ppm	0%	
Al2O3_%_XRF	129	0.001	6.351	12.227	19.919	%	100%	Y
As_ppm_ICPMS	129	0.5	0.8	3	5.9	ppm	100%	Y
As_ppm_INAA	129	1	1.91	6.01	14.3	ppm	100%	
Au_ppb_INAA	129	5	<5	<5	50.7	**ppb**	9%	Y
Ba_ppm_ICPMS	129	2	249	476	1263	ppm	100%	Y
Ba_ppm_INAA	129	100	234	460	1220	ppm	100%	
Be_ppm_ICPMS	129	0.05	0.8	2.6	6.4	ppm	100%	Y
Bi_ppm_ICPMS	129	0.01	0.2	0.4	2.2	ppm	100%	Y
Br_ppm_INAA	129	1	<1	6.97	36	ppm	99%	Y
Ca_%_INAA	129	1	<1	<1	2.11	%	4%	
CaO_%_XRF	129	0.002	0.064	0.33	2.706	%	100%	Y
Cd_ppm_ICPMS	129	0.1	<0.1	<0.1	2.33	ppm	6%	Y
Cd_ppm_INAA	129	20	<20	<20	<20	ppm	0%	
Ce_ppm_ICPMS	129	0.02	56.86	86.12	170.4	ppm	100%	Y
Ce_ppm_INAA	129	2	58.8	88.4	163	ppm	100%	
Cl_ppm_XRF	129	5	<5	<5	3552	ppm	44%	Y
Co_ppm_INAA	129	1	2.96	11.1	34.2	ppm	100%	Y
Cr_ppm_INAA	129	5	27.1	69.3	182	ppm	100%	
Cr_ppm_XRF	129	4	14	56	150	ppm	100%	Y
Cs_ppm_ICPMS	129	0.01	2.57	6.96	16.08	ppm	100%	Y
Cs_ppm_INAA	129	1	2.21	7.32	17.7	ppm	100%	
Cu_ppm_XRF	129	2	<2	17	38	ppm	99%	Y
Dy_ppm_ICPMS	129	0.01	4.44	6.72	14.68	ppm	100%	Y
Er_ppm_ICPMS	129	0.01	2.64	3.94	8.39	ppm	100%	Y
Eu_ppb_ICPMS	129	0.5	734	1424	3704	**ppb**	100%	Y
Eu_ppm_INAA	129	0.5	0.71	1.39	3.65	ppm	100%	
F_ppm_XRF	129	50	<50	277	668	ppm	91%	Y
Fe_%_INAA	129	0.02	0.82	2.77	5.67	%	100%	
Fe2O3T_%_XRF	129	0.002	1.214	3.915	7.758	%	100%	Y
Ga_ppm_ICPMS	129	0.1	6.7	15.4	26.1	ppm	100%	Y
Gd_ppm_ICPMS	129	0.01	4.69	7.14	15.31	ppm	100%	Y
Ge_ppm_ICPMS	129	0.02	0.6	0.9	1.2	ppm	100%	Y
Hf_ppm_ICPMS	129	0.01	4.5	9.9	22.2	ppm	100%	Y
Hf_ppm_INAA	129	0.5	4.26	10.6	23.2	ppm	100%	
Hg_ppm_INAA	129	5	<5	<5	<5	ppm	0%	Y
Ho_ppm_ICPMS	129	0.01	0.98	1.47	3.03	ppm	100%	Y
Ir_ppb_INAA	129	20	<20	<20	<20	**ppb**	0%	Y
K_%_INAA	129	0.2	0.81	1.69	3.28	%	100%	
K2O_%_XRF	129	0.002	1.318	2.07	3.667	%	100%	Y
La_ppm_ICPMS	129	0.02	27.34	43.19	84.37	ppm	100%	Y
La_ppm_INAA	129	0.5	29.5	45.5	81.6	ppm	100%	
Lu_ppm_ICPMS	129	0.01	0.49	0.62	1.32	ppm	100%	Y
Lu_ppm_INAA	129	0.2	0.39	0.51	1.12	ppm	100%	
MgO_%_XRF	129	0.004	0.144	0.7	1.761	%	100%	Y
MLOI_%_Calculate	129	0.001	1.01	6.618	12.199	%	100%	Y
MnO_%_XRF	129	0.001	0.016	0.063	0.308	%	100%	Y

Table 3. Continued

El_unit_method	N	DL	Min	Med	Max	Units	% >DL	Preferred method?
Mo_ppm_ICPMS	129	0.01	0.5	0.9	1.9	ppm	100%	Y
Mo_ppm_INAA	129	5	<5	<5	5.1	ppm	1%	
Na_%_INAA	129	0.01	0.169	0.421	0.996	%	100%	
Na2O_%_XRF	129	0.004	0.199	0.51	1.304	%	100%	Y
Nb_ppm_ICPMS	129	0.04	10.5	17	30	ppm	100%	Y
Nd_ppm_ICPMS	129	0.01	26.07	40.63	85.45	ppm	100%	Y
Ni_ppm_XRF	129	2	<2	20	81	ppm	98%	Y
P2O5_%_XRF	129	0.001	0.036	0.073	0.186	%	100%	Y
Pb_ppm_ICPMS	129	0.5	14.1	21.8	33.8	ppm	100%	Y
Pr_ppm_ICPMS	129	0.01	7.26	11.16	23.19	ppm	100%	Y
Rb_ppm_ICPMS	129	1	65.3	123.3	216.8	ppm	100%	Y
Rb_ppm_INAA	129	20	58	136	236	ppm	100%	
Sb_ppm_ICPMS	129	0.01	0.5	2.9	11	ppm	100%	
Sb_ppm_INAA	129	0.2	0.42	0.82	5.35	ppm	100%	Y
Sc_ppm_INAA	129	0.1	5.22	12.2	22.9	ppm	100%	Y
Sc_ppm_XRF	129	10	<10	13	23	ppm	78%	
Se_ppm_INAA	129	5	<5	<5	<5	ppm	0%	Y
SiO2_%_XRF	129	0.006	54.524	72.593	87.273	%	100%	Y
Sm_ppm_ICPMS	129	0.01	5.62	8.27	16.6	ppm	100%	Y
Sm_ppm_INAA	129	0.2	5.1	7.79	15.7	ppm	100%	
Sn_ppm_ICPMS	129	0.01	2	4.2	15.6	ppm	100%	Y
Sn_ppm_INAA	129	500	<500	<500	<500	ppm	0%	
SO3_%_XRF	129	0.001	0.022	0.049	1.102	%	100%	Y
Sr_ppm_ICPMS	129	1	28.4	68.3	142.2	ppm	100%	Y
Ta_ppm_ICPMS	129	0.06	1	1.5	3.4	ppm	100%	Y
Ta_ppm_INAA	129	1	<1	1.37	2.91	ppm	91%	
Tb_ppm_ICPMS	129	0.01	0.79	1.2	2.59	ppm	100%	Y
Te_ppm_INAA	129	5	<5	<5	<5	ppm	0%	Y
Th_ppm_ICPMS	129	0.01	11.9	17.5	37.3	ppm	100%	Y
Th_ppm_INAA	129	0.5	12.2	18.4	34.7	ppm	100%	
TiO2_%_XRF	129	0.002	0.541	0.793	0.972	%	100%	Y
U_ppm_ICPMS	129	0.07	1.52	3.55	8.49	ppm	100%	Y
U_ppm_INAA	129	2	<2	3.23	7.3	ppm	88%	
V_ppm_XRF	129	6	31	78	145	ppm	100%	Y
W_ppm_INAA	129	2	<2	<2	5.13	ppm	47%	Y
Y_ppm_ICPMS	129	0.22	27.2	41.8	91	ppm	100%	Y
Yb_ppm_ICPMS	129	0.01	2.86	4.01	8.6	ppm	100%	Y
Yb_ppm_INAA	129	0.5	2.75	3.76	8.09	ppm	100%	
Zn_ppm_INAA	129	100	<100	<100	103	ppm	2%	
Zn_ppm_XRF	129	2	14	54	104	ppm	100%	Y
Zr_ppm_ICPMS	129	1	156.3	386	868.3	ppm	100%	Y
Zr_ppm_INAA	129	500	<500	<500	840	ppm	40%	

Table 4. Summary of quantitative macroscopic properties of overbank sediments from the eastern Riverina (laboratory parameters)

Parameter	N	Min	Med	Max	Units
Moisture	129	4.37	17.88	36.1	%
pH (field)	129	4	7	9	pH units
pH 1:5	129	5	7	9	pH units
EC 1:5	129	7	84	3190	μS/cm

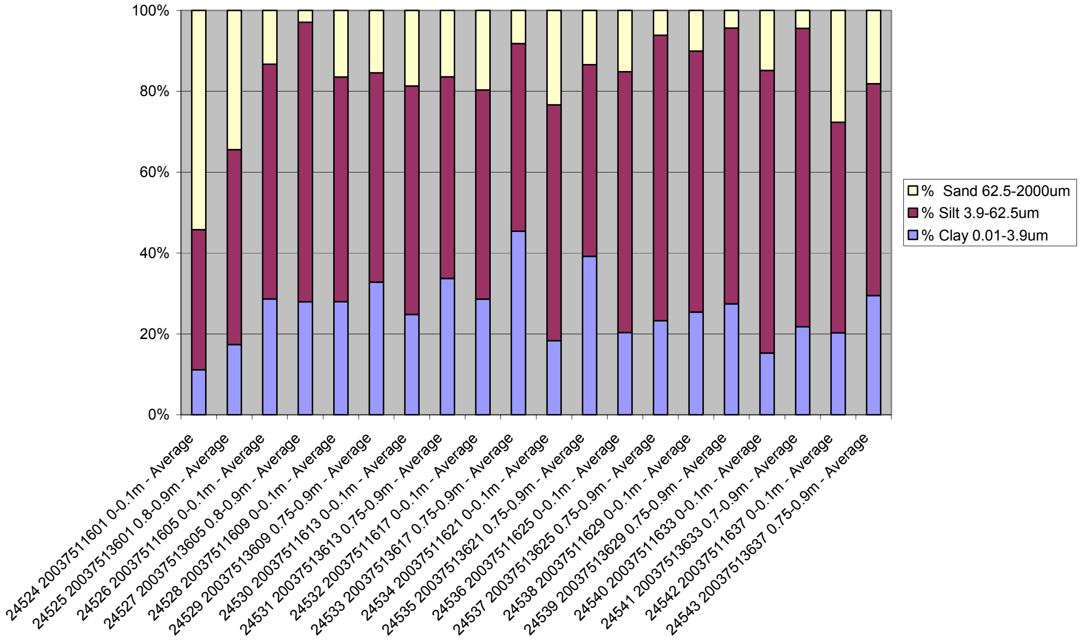

Figure 12. Summary diagram of particle size analysis results.

6. FUTURE WORK

Future work in the Riverina will include:

- Completion of lab bulk parameters (moisture content, EC 1:5, pH 1:5) of TOP and BOT samples from western and northern Riverina
- Completion of sediment laser particle size analysis, as deemed necessary
- Bulk analyses (XRF, ICP-MS, ?INAA) of TOP and BOT samples from western and northern Riverina
- Selective digestion of all Riverina samples
- Heavy mineral separation and analysis (by X-Ray Diffraction, Scanning Electron Microscopy and/or AutoGeoSEM) for all Riverina samples
- Presentation of results at conferences, workshops and in publications/reports, including a web-based ‘atlas’ product

Beyond the Riverina pilot project, we are scoping a similar study in the Gawler region of South Australia, a collaboration between CRC LEME, PIRSA and Geoscience Australia. This study has started in 2004-05. Other possible areas being considered for further testing are in the wheat belt of Western Australia, the Tanami and perhaps the lower Balonne or Fitzroy-Burdekin catchments.

As an offshoot of the Riverina study, a collaborative PhD research project with University of Sydney began earlier this year in the southeastern Highlands and Australian Alps bioregions (New South Wales and Victoria). This area borders the Riverina, giving a greater coverage for the combined surveys, and will test the methodology and strategy in vastly different geomorphic environments.

7. CONCLUSIONS

A pilot low-density geochemical baseline survey was carried out in the Riverina bioregion during 2003-04, as a collaborative project between CRC LEME and Geoscience Australia. The pilot project aimed at testing methodologies and strategies for further regional geochemical surveys in Australia. The selected region was subdivided into large catchments whose drainage points were targeted as sampling locations. 143 locations were sampled in three field trips. At each sampling location, a near-surface (TOP: O horizon, 0-10 cm) and a deeper (BOT: B-C horizon, ~70-90 cm) overbank sediment sample was collected. Leaves of River Red Gum (*Eucalyptus camaldulensis*) trees were also collected at a small number of locations.

The methodologies used to collect, prepare and analyse the samples are detailed in this report, and preliminary results (pertaining to the first field trip in the eastern Riverina) are presented. The analyses carried out on the samples to date are:

- texture
- Munsell™ colour (moist and dry)
- field pH
- moisture content
- EC 1:5
- pH 1:5
- laser particle size analysis (selected samples)
- X-Ray Fluorescence (XRF) of bulk, sieved (<180 µm) samples
- Inductively Coupled Plasma Mass Spectrometry (ICP-MS) of same
- Instrumental Neutron Activation Analysis (INAA) of same
- preparation for sequential digestion
- preparation for heavy mineral separation

Thus, the sediments are quantitatively characterised in terms of

- pH (field and 1:5), EC 1:5, moisture content
- grain size distribution (selected samples)
- Loss On Ignition (LOI)
- Bulk (<180 µm) composition for 62 elements/oxides (Ag, Al_2O_3, As, Au, Ba, Be, Bi, Br, CaO, Cd, Ce, Cl, Co, Cr, Cs, Cu, Dy, Er, Eu, F, Fe_2O_3, Ga, Gd, Ge, Hf, Hg, Ho, Ir, K_2O, La, Lu, MgO, MnO, Mo, Na_2O, Nb, Nd, Ni, P_2O_5, Pb, Pr, Rb, Sb, Sc, Se, SiO_2, Sm, Sn, SO_3, Sr, Ta, Tb, Te, Th, TiO_2, U, V, W, Y, Yb, Zn, Zr)

Preliminary statistical treatment was carried out and geochemical maps prepared for all parameters (except Hg, Ir, Se and Te, which had all results below detection limits), and presented in Appendix 4. Those maps illustrate how the distribution of various soil properties can be derived and what the results can be used for, e.g., determine clay content, nutrient status, “sodicity risk”, “acidity risk”, “salinity risk”, exploration pathfinders for Au, Cu or Cu-Au mineralisation. These results will be the basis for further interpretative work and the backbone of a forthcoming geochemical atlas of the Riverina.

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APPENDICES

Appendix 1: ArcHydro modelling

Methodology for selecting sample points using the Arc Hydro 1.1 Beta 2 extension in ArcGIS

Datasets used: Version 2 of the national 9 second Digital Elevation Model (DEM), Australian Nested Catchments and Sub-Catchments at 500 km^2 scale.

The national DEM was used to ensure that future geochemical surveys are fully comparable. NB: The DEM was not reconditioned as it is corrected using topographic information including drainage lines and point elevation data, and consequently is a robust dataset. This step may be useful for DEM's captured in airborne geophysical surveys. National Nested Catchments (500 km^2 scale) from the Centre for Resource and Environmental Studies (CRES) at the Australian National University were used instead of defining our own catchments with ArcHydro. This ensures that the dataset is fully comparable across the whole of Australia.

Installation of the ArcHydro Extension

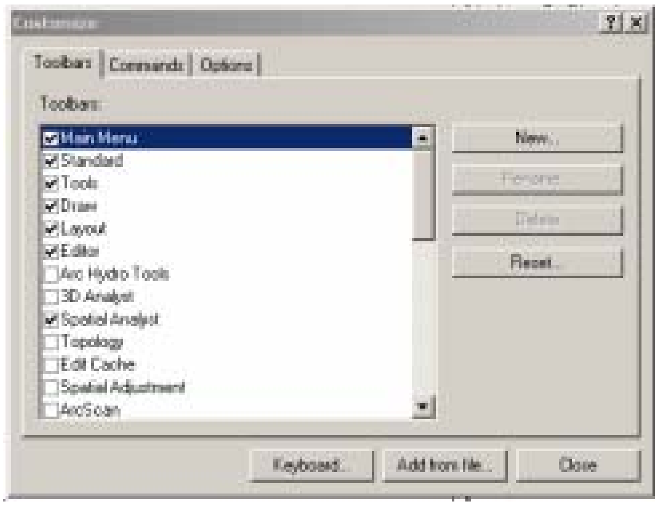
To be able to use the ArcHydro extension, the ArcInfo licence of the ArcGIS software is a requirement. The ArcHydro 1.1 Beta 2 extension was downloaded from http://www.crwr.utexas.edu/gis/gishydro03/ArcHydroTools/ArcHydroTools.html

To install the toolbar:

1. Run the ArcHydro tools setup. After double-clicking the setup, browse to the desired installation location (use default location). The necessary files will be installed in the bin directory under the destination folder.

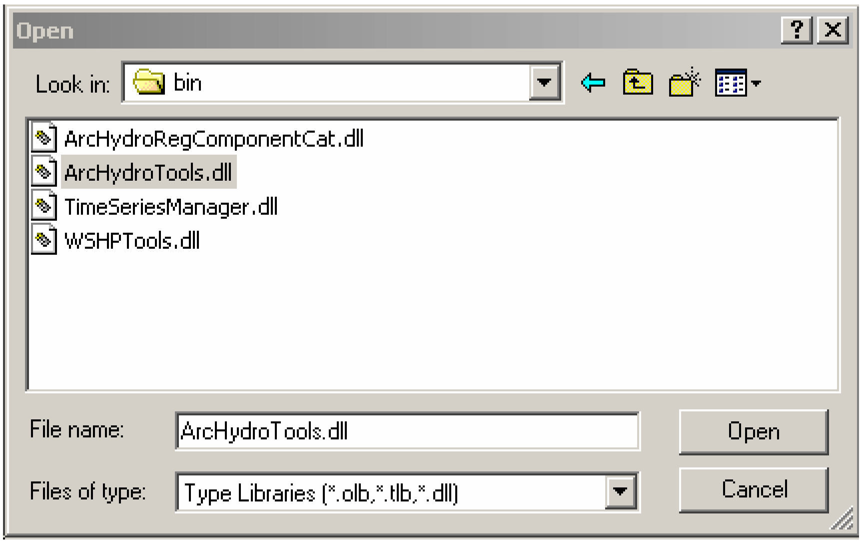
2. Open ArcMap. Right mouse click on the menu bar and scroll to "Customize."

3. Click “add from file” when the Customize dialog box appears.



4. Browse to the location of ArcHydroTools.dll. In this case, the .dll was located at: C:\Program Files\ESRI\ArcHydro

5. Select ArcHydroTools.dll and click Open to add to the Toolbar

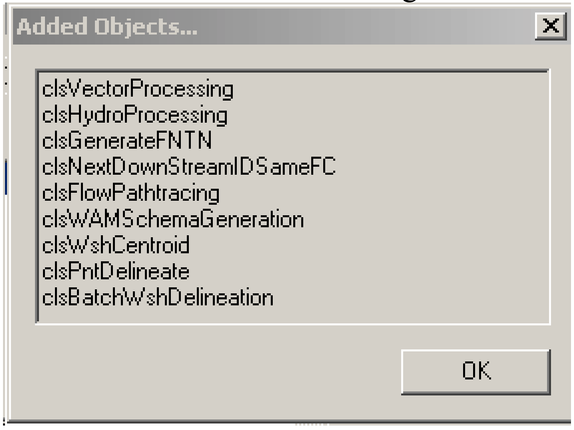


ArcHydroRegComponentCat.dll
ArcHydroTools.dll
TimeSeriesManager.dll
WSHPTools.dll

File name: ArcHydroTools.dll

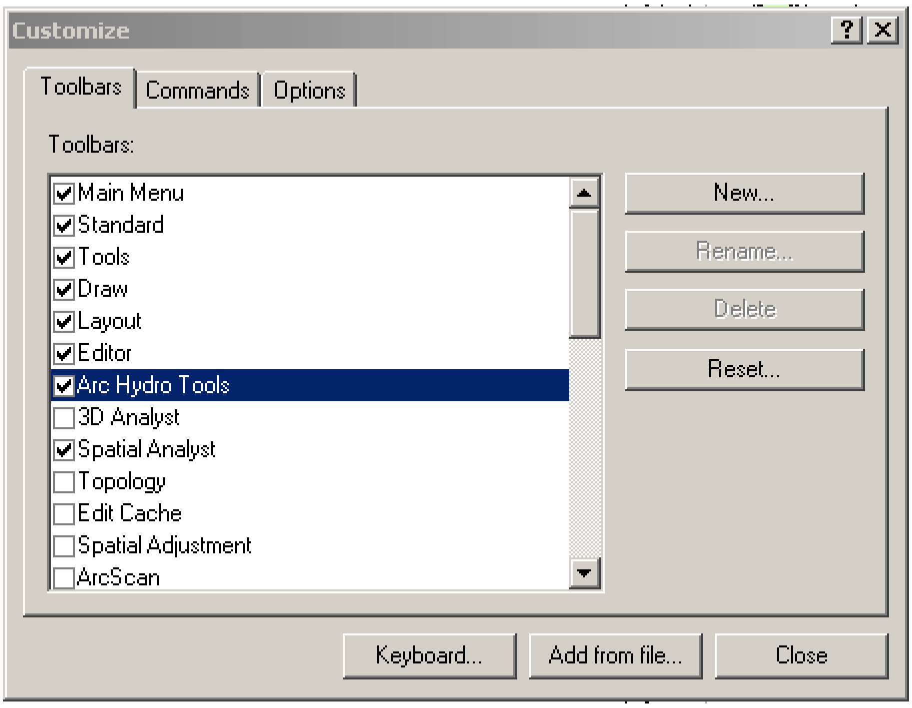
Files of type: Type Libraries (*.olb,*.tlb,*.dll)

6. Click OK to acknowledge the additions of the new objects

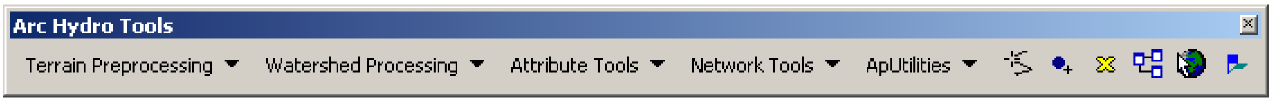


clsVectorProcessing
clsHydroProcessing
clsGenerateFNTN
clsNextDownStreamIDSameFC
clsFlowPathtracing
clsWAMSchemaGeneration
clsWshCentroid
clsPntDelineate
clsBatchWshDelineation

7. The ArcHydro toolbox should now appear as a toolbar



8. The ArcHydro Toolbar should now appear.



9. The Spatial Analyst Extension needs to be activated, by clicking Tools>Extensions…, and checking the box next to Spatial Analyst

Derivation of the Sampling Points

To get the sample points, follow the steps below:

1. **Fill the sinks**: Terrain Processing>Fill Sinks. (rivdemv2_fil). This function fills the holes in the grid. If a cell is surrounded by higher elevation cells water flows in but cannot flow out. By filling the sinks, the elevation is raised to prevent this problem from occurring.
2. **Flow direction**: Terrain Processing>Flow Direction. (fdir_rivdem2) Insert the relevant DEM and name the output file. The values in the cells of the flow direction grid indicate the steepest decent from that cell – hence the flow direction.
3. **Flow Accumulation:** Terrain Processing>Flow Accumulation. (fac-rivdem2). ArcHydro takes the flow direction grid and determines the flow accumulation grid.
4. **Drainage Point Processing**: Before this can be done, the nested catchments layer from CRES (CAT500) needs to be converted to a grid using the spatial analyst extension: Spatial Analyst>Convert>Features to Raster. The field needs to be ID, and the output cell size is 0.0025[1]. To obtain the drainage points: Terrain Processing>Drainage Point Processing. Insert the DEM and the catchment grid. The resultant points should be that the outlet points for each of the catchments. Check to ensure that there are not points in the middle of the catchments etc.

The first lot of drainage points were selected by following the whole process from start to finish. These points were then regenerated only redoing step 4. It was noted that the drainage points that were created were slightly different than the first lot of points generated. It is hypothesised that by creating the drainage points, the flow accumulation grid is modified slightly. This needs to be tested to ensure that when the process is repeated from start to finish that the same result can be achieved more than once.

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[1] This cell size was used as the 9 second grid spacing is in longitude and latitude approximates to 250 metres.

Culling sample points for the Murray Riverina Low Density Survey

This methodology was used to cull points for the low density survey for the Riverina bioregion. Present at the meeting on 19th August were PdC, JP, SJ, ML. By documenting these procedures, it is hoped that there can be consistency in any other low density geochemical survey carried out within Australia.

As the survey is low density and has a define budget it was decided that approximately 120 points would be selected for the whole Riverina bioregion. This equates to around 60 points being selected for the area covering the east of the bioregion. These will be sampled in September 2003 field excursion.

The catchments (CRES National Nested Catchments with a threshold of 500km^2) were sorted by perimeter[2]. These were classified into quantiles with 10 classes and were rounded to have no decimal places. The catchments were clipped to include those within the Riverina bioregion. It is now recognised that they should have been clipped to include those wholly or party within the bioregion. This was decided because the study boundary is arbitrary, and if the geochemical survey is to continue, picking up the samples close to those within the Riverina bioregion will save time in the long term. Those catchments that were party within the bioregion were added after the meeting and any sample points that were within these extra catchments were included into the sampling strategy.

Upon inspection, it was discovered that there were many errors[3] in the data which resulted in small "dangle" catchments in which sample points were assigned. It was essential to remove these erroneous points and this was done in a number of steps as described below:

1. Points within the bottom 10th percentile (i.e., 25 catchments with a perimeter of 947-965 m) were selected. These were randomly checked to determine that they were erroneous "dangle" catchments. The sample points minus the erroneous sample points (19 points) was named drnpts_1sel.shp
2. This second pass cleanup looked at all the points from the 10th - 20th percentiles (i.e., 53 points with a perimeter of 965-1013 m). This catchment selection was exported as a theme and converted to a shapefile called cat_perlt1013.shp. This enabled a more thorough check to determine whether they were errors. There were 26 erroneous drainage sample points within the "dangle" catchments between 965-1013 m. The new file, minus the erroneous sample points, was named drnpts_2sel. Catchments up to this size were determined to be erroneous with absolute certainty.

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[2] Alternatively the catchments could be sorted by area but were not in this case as the area statistics were not calculated at the time of the meeting.

[3] These errors can result when the raster dataset is converted to a polygon. They can also be a result of small depressions in the DEM that don't drain into a stream e.g. clay pans. In this case they are not errors as such, but have such a small area that they are not worth worrying about.

3. The perimeters ≥1013 and ≤5000 m (9 catchment polygons) were selected[4]. These 201 “real” catchments were saved as cat_pergt5000.shp. After 5000 m perimeter there looked to be a big jump in the perimeter length. Perimeters ≥5000 and ≤7000 m were selected and viewed. Some of these shapes looked more like catchments. These catchments were viewed to visually check their validity, but it was decided that they were still errors. All points between 1013 and 5000 were selected and deleted with the remaining points (158 drainage points) saved as drnpts_3sel.shp.
4. From here on in, the smallest remaining catchments were scrutinised from the shapefile cat_pergt5000.shp. The percentiles redefined for the perimeter with 10 quantile classes. The values were rounded to have no decimal places. These catchments had a mix of erroneous and “real” catchments. The points within the lower 10th percentile of the catchments were removed (140 drainage points left) and saved as drnpts_4sel.shp.
5. Lastly, those points that were contained within catchments that were partly within the bioregion polygon were added to the coverage of drainage points.
6. The final step in selection of sampling sites consisted in a detailed inspection of each catchment and its computer-derived drainage point compared to topographic maps using GIS. This resulted in deleting still a few point and moving some others to be at more pragmatic locations (closer to tracks, outside swamps or reserves).

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[4] It was suggested at this stage that it may be worth cleaning up the nested catchments shapefile to that all those catchments with a perimeter of less than 5000m as these can be confidently assigned as erroneous catchments.

Appendix 2: Field log sheet

Method of digging hole:

REGIONAL GEOCHEMICAL SURVEY
OVERBANK SEDIMENT SAMPLING

SAMPLE ID **2004 75 1 ☐* __ __ __**

Date ____/____/__________ (dd/mm/yyyy)
Sampler/Team ________________________

LOCATION
REGION: NRBR_______
STREAM NAME __________________
SHIRE __________________
MAPSHEET __________________
NEAREST TOWN __________________
PROPERTY __________________

Zone ______________	Latitude ______________	Longitude ______________
Datum ______________	Way Pt. ______________	Altitude ____________ m

DESCRIPTION OF CATCHMENT BASIN
Approx size of catchment ______________ (hectares / km^2) Catchment ID __________ (ANU catch500)
Predominant bedrock lithology within catchment basin _____________________

SITE DESCRIPTION
Landscape/topography _________________________________
Land use
☐ Agriculture, specify crop _____________
☐ Pasture, grassland, fallow field
☐ Forest ☐ Native __________ ☐ Plantation ________ ☐ Other __________
☐ Wetland
☐ Not-cultivated
☐ Urban
☐ Other, specify ______________

River width ______________m depth______________m
Channel Characteristics ☐ Natural ☐ reinforced
☐ Man-made (ditch, irrigation channel)
Time since last rainfall ____ days ____ hours
Stream flow ☐ Dry ☐ Flowing ☐ Flooding
Bedrock lithology ______________________________
Outcrops ☐ Yes, specify ______________
☐ No
Grain size ______% silt-clay ______% sand-silt ______% clasts > 2 mm
Depth of observed groundwater table (cm) ______

* Sampling interval from surface	☐ 0-10 cm (**1**)	Geochem	Sieved? < _______	microns
For heavy minerals:	☐ 0-10 cm (**2**)	Heavy Min	Sieved? < _______	microns
	☐ 90-100 cm (**3**)	Geochem	Sieved? < _______	microns
	☐ 90-100 cm (**4**)	Heavy Min	Sieved? < _______	microns
	☐ other, specify: ( )	________	Sieved? < _______	microns

Possible sources of contamination, specify ____

OTHER	Field pH	Top ____	Munsell Colour	- Dry	Top	___________
		Bottom ____			Bottom	___________
	Texture	Top _________		- Moist	Top	___________
		Bottom _________			Bottom	___________

NUMBER OF SAMPLE BAGS **PHOTOS**

COMMENTS

Modified from Salminen, R. et al,. 1998. FOREGS geochemical mapping field manual. Geologian tutkimuskeskus, Opas 47, Geological Survey of Finland, Guide 47. Espoo. Appendix.

Appendix 3: Practical detection limits for XRF and ICP-MS, Minerals Division Laboratory, Geoscience Australia

ANALYTES WITH DETECTION LIMITS (as reported)
FOR SAMPLES LIKELY TO CONTAIN NaCl

XRF MAJOR ELEMENTS		
Al_2O_3	0.001	%
CaO	0.002	%
Fe_2O_3	0.002	%
K_2O	0.002	%
MgO	0.004	%
MLOI	0.001	%
MnO	0.001	%
Na_2O	0.004	%
P_2O_5	0.001	%
SiO_2	0.006	%
SO_3	0.001	%
TiO_2	0.002	%
XRF TRACE ELEMENTS		
(determined on fused disc)		
Cl	5	ppm
Cr	3	ppm
Cu	2	ppm
F	50	ppm
Ni	2	ppm
Sc	2	ppm
V	4	ppm
Zn	2	ppm

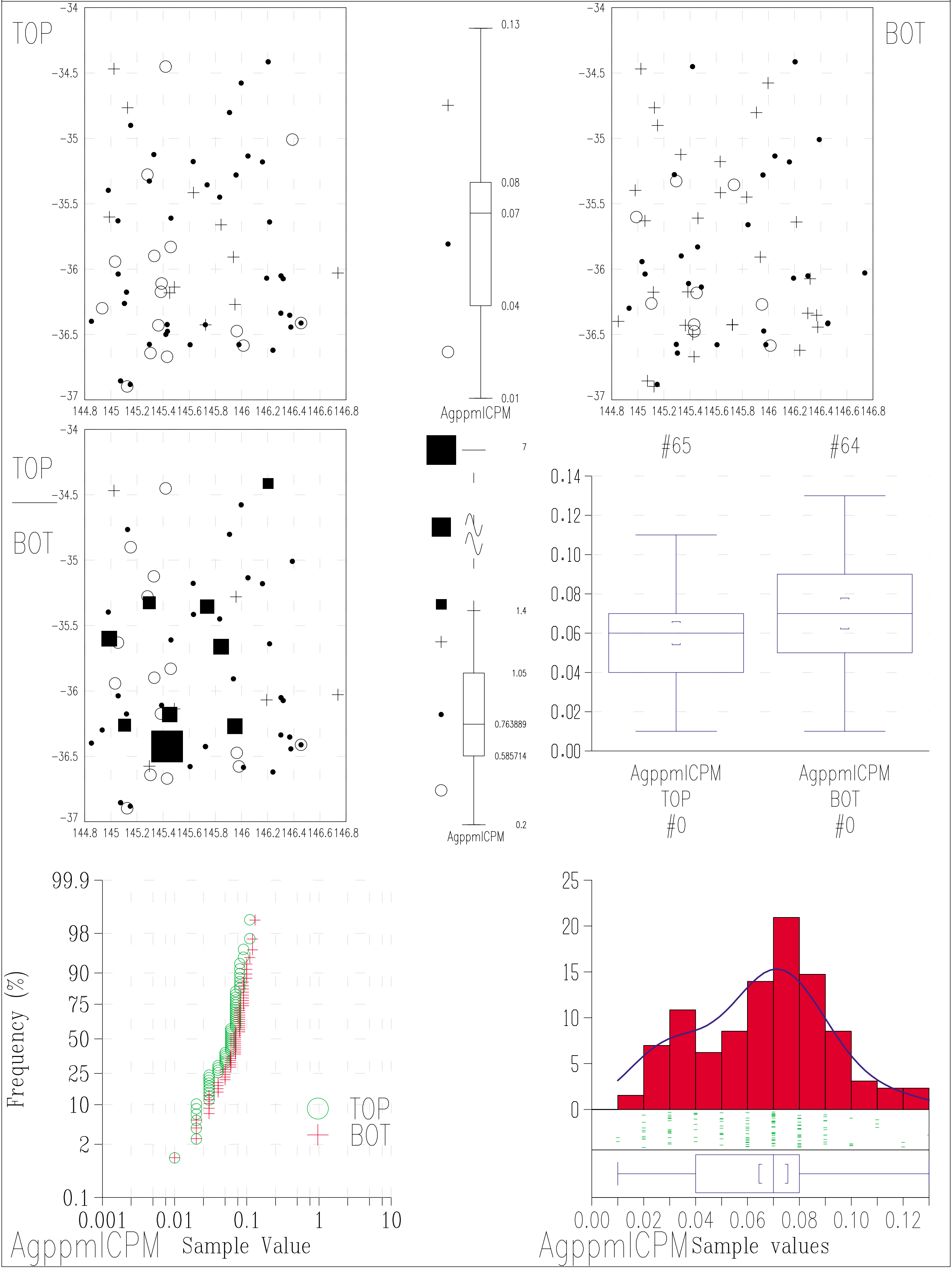
ICP-MS TRACE ELEMENTS		
Ag	0.01	ppm
As	0.5	ppm
Ba	2	ppm
Be	0.05	ppm
Bi	0.01	ppm
Cd	0.05	ppm
Ce	0.02	ppm
Cs	0.01	ppm
Dy	0.01	ppm
Er	0.01	ppm
Eu	0.50	ppb
Ga	0.1	ppm
Gd	0.01	ppm
Ge	0.02	ppm
Hf	0.01	ppm
Ho	0.01	ppm
La	0.02	ppm
Lu	0.01	ppm
Mo	0.01	ppm
Nb	0.04	ppm
Nd	0.01	ppm
Pb	0.5	ppm
Pr	0.01	ppm
Rb	1.0	ppm
Sb	0.01	ppm
Sm	0.01	ppm
Sn	0.01	ppm
Sr	1.0	ppm
Ta	0.06	ppm
Tb	0.01	ppm
Th	0.01	ppm
Tl	0.01	ppm
Tm	0.01	ppm
U	0.07	ppm
Y	0.22	ppm
Yb	0.01	ppm
Zr	1.0	ppm

Appendix 4: Statistical and geochemical distributions of bulk (<180 µm) overbank sediments from the eastern Riverina area. Where more than one method was used for a particular element, the preferred method results only are shown here. All values <DL (detection limit) were set to 1/2 DL before statistical manipulation.

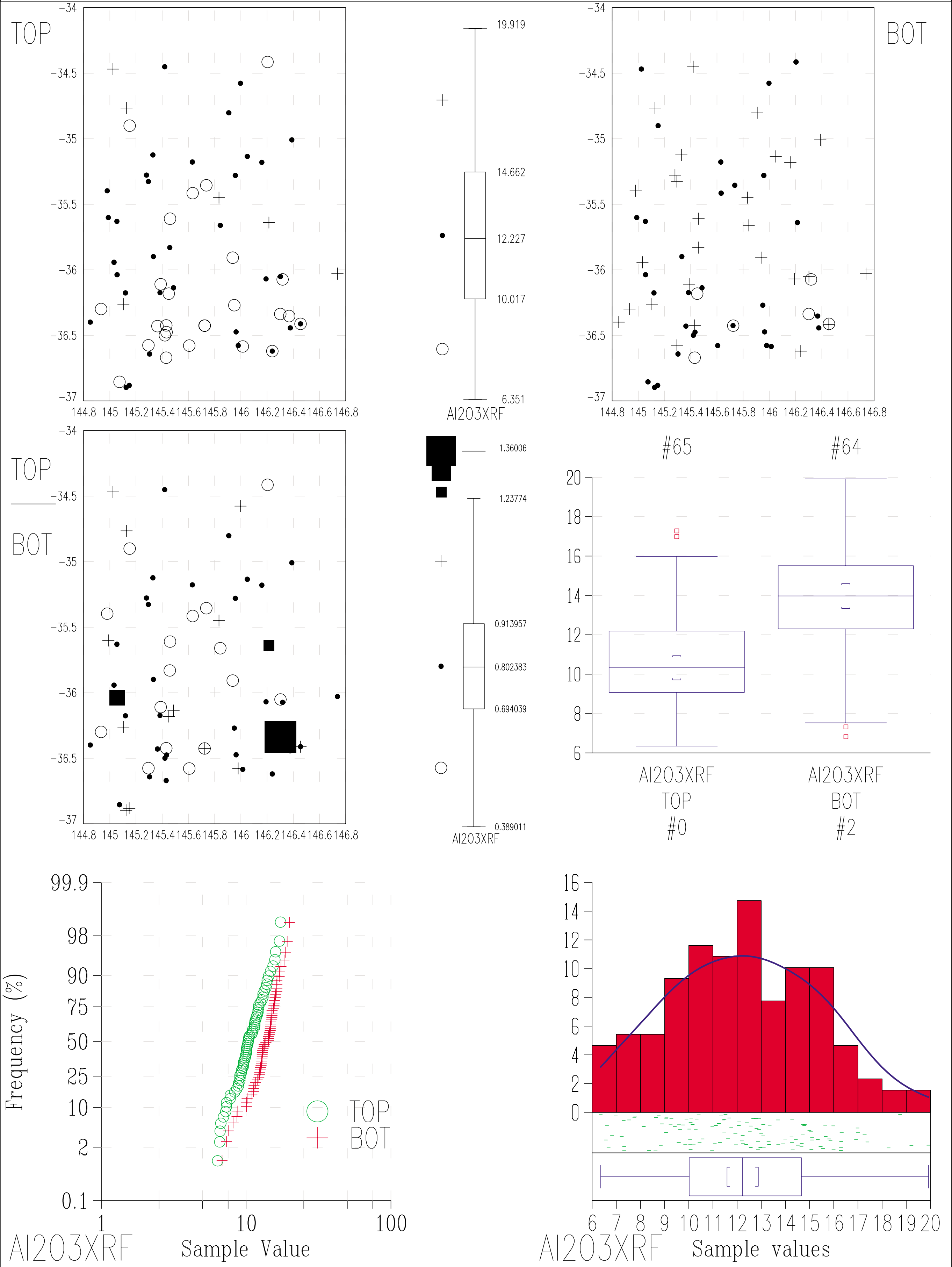
Diagrams shown are:

1. **Distribution map of element concentration in TOP overbank sediment, using boxplot classification of both TOP and BOT values**
2. **Distribution map of element concentration in BOT overbank sediment, using same boxplot classification**
3. **Distribution map of TOP/BOT ratio in overbank sediment**
4. **Boxplot distribution of TOP and BOT overbank sediments**
5. **Cumulative frequency diagrams of TOP and BOT overbank sediments**
6. **Histogram, density curve, scatter and boxplot of element concentration in TOP and BOT overbank sediment**

REGIONAL GEOCHEMICAL SURVEY: EASTERN RIVERINA



REGIONAL GEOCHEMICAL SURVEY: EASTERN RIVERINA



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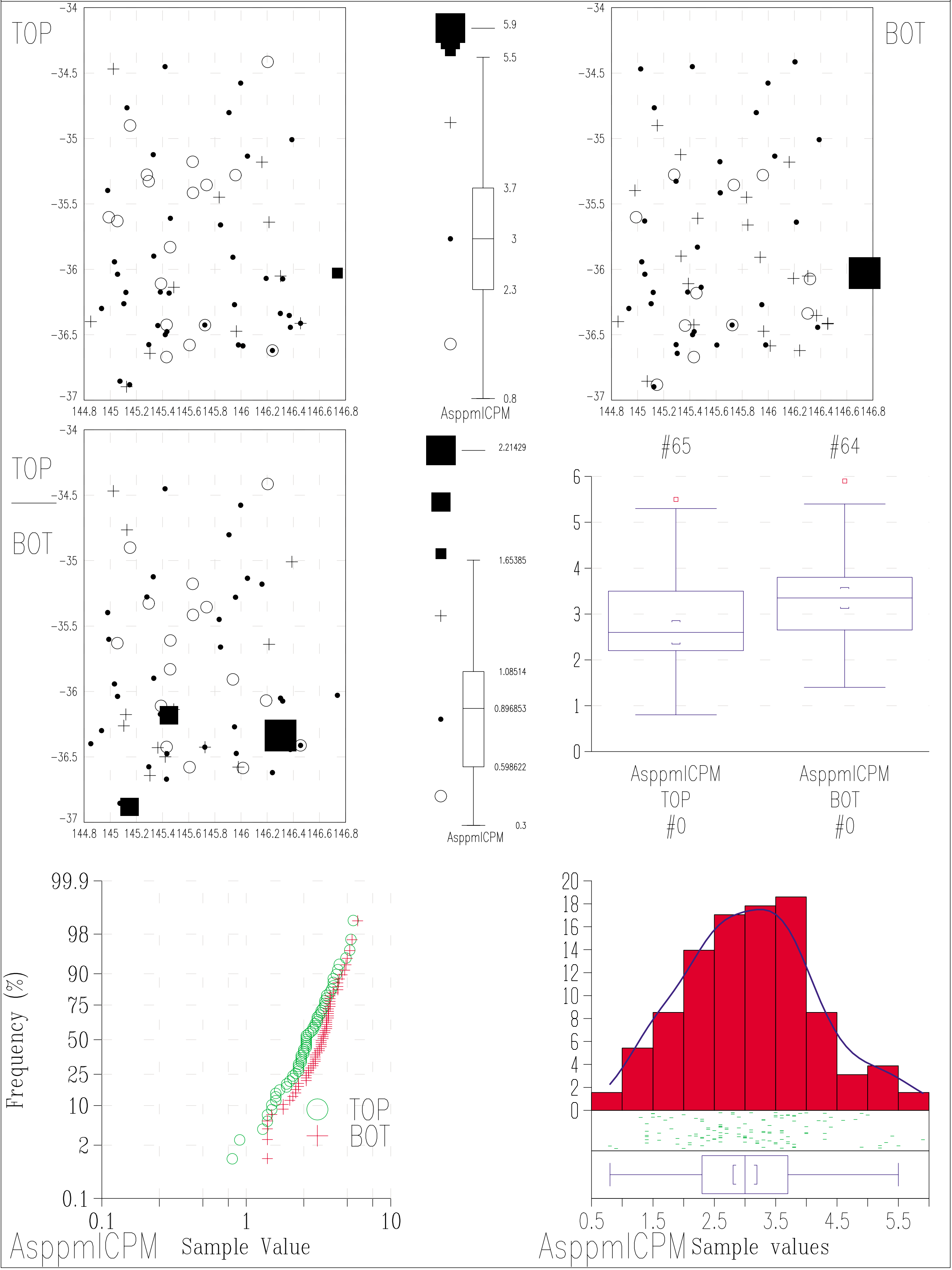

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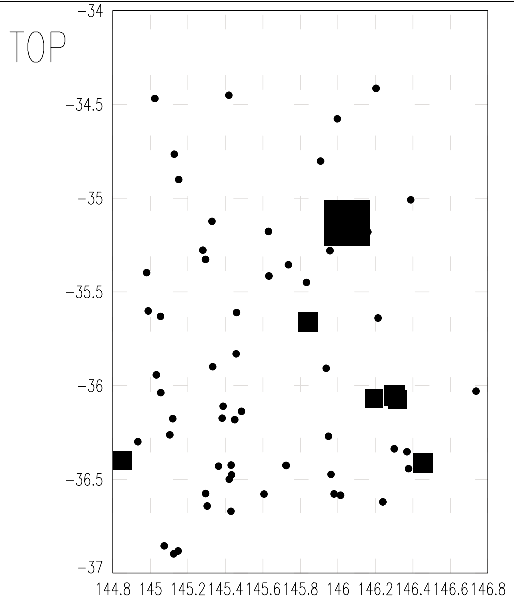

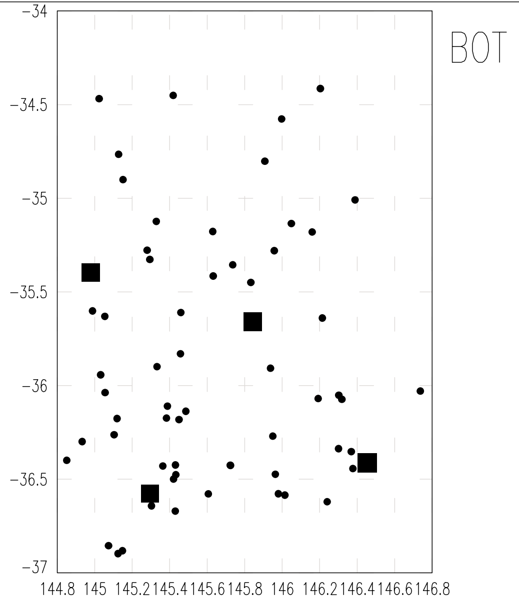

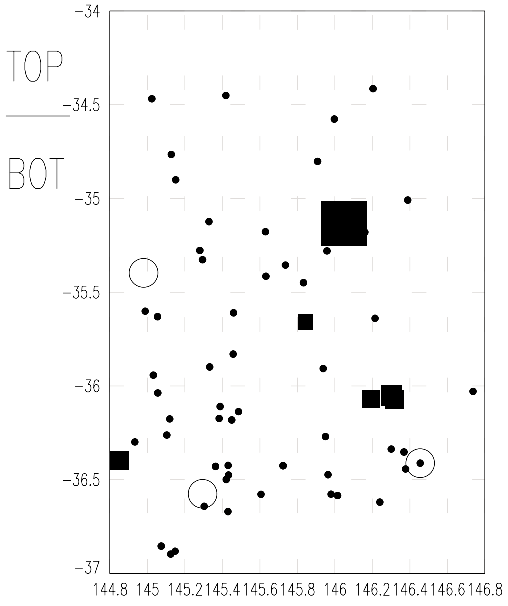

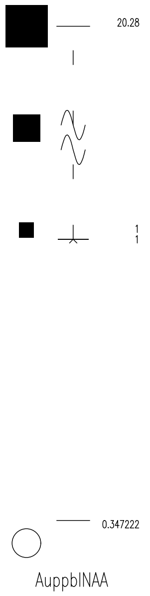

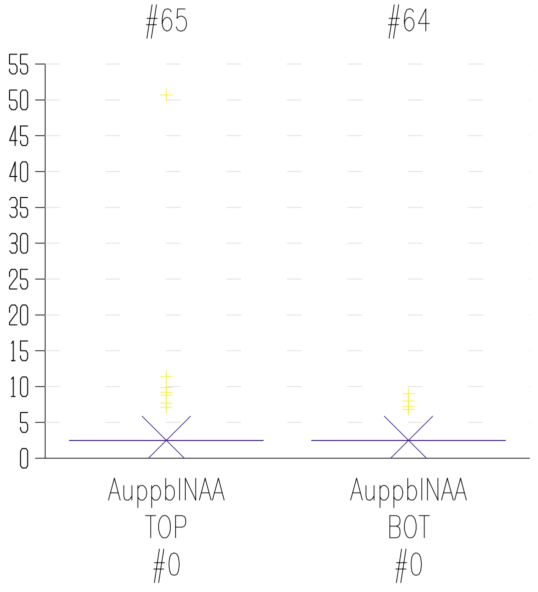

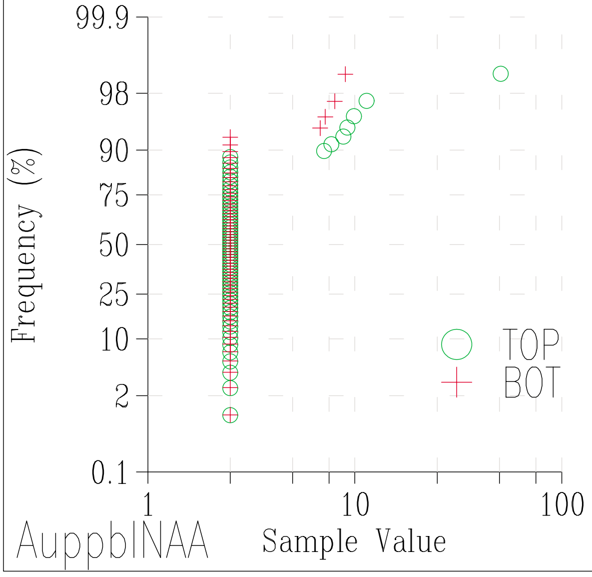

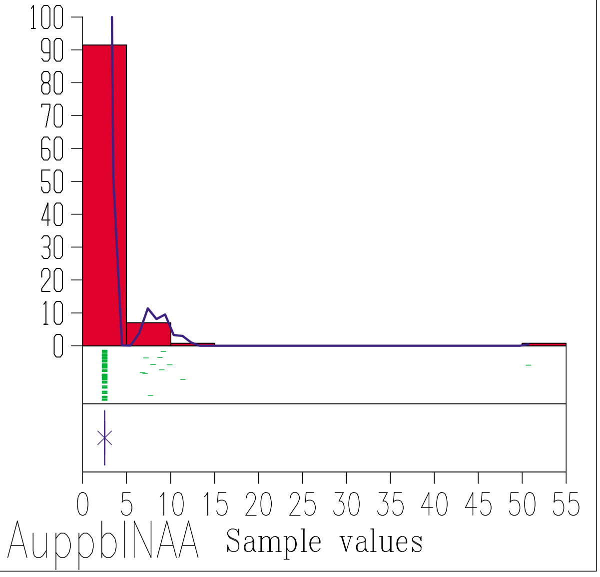

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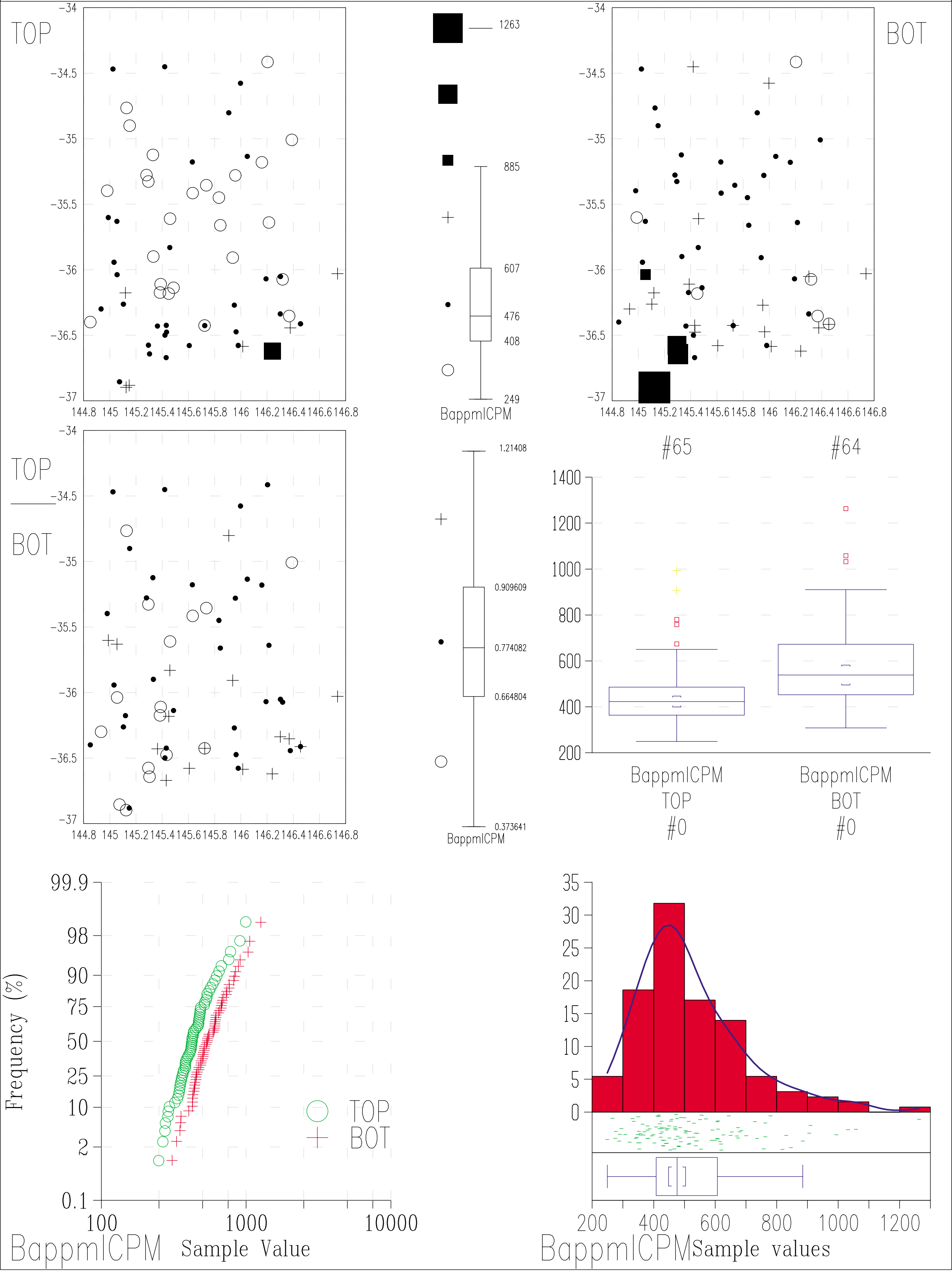

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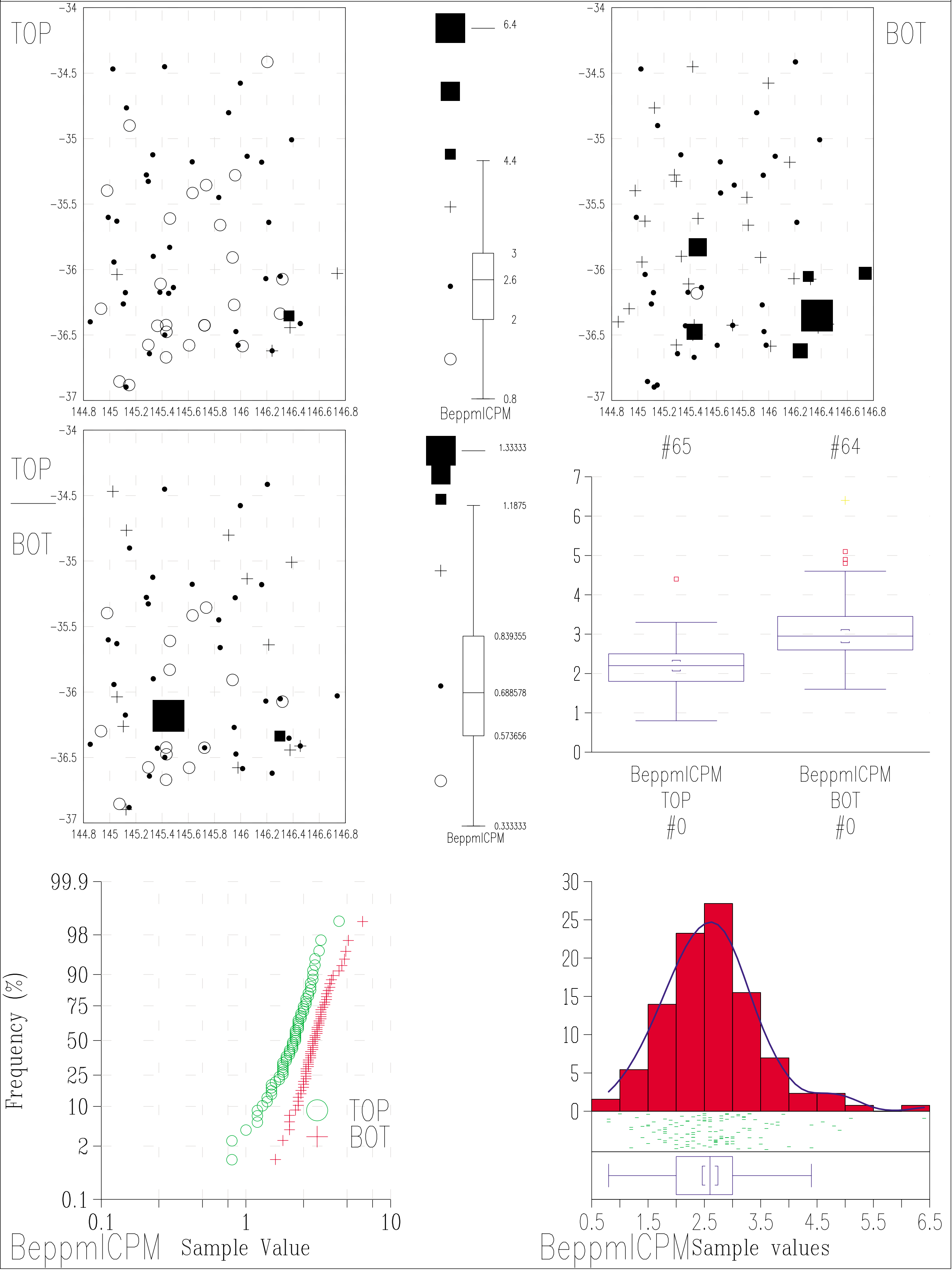

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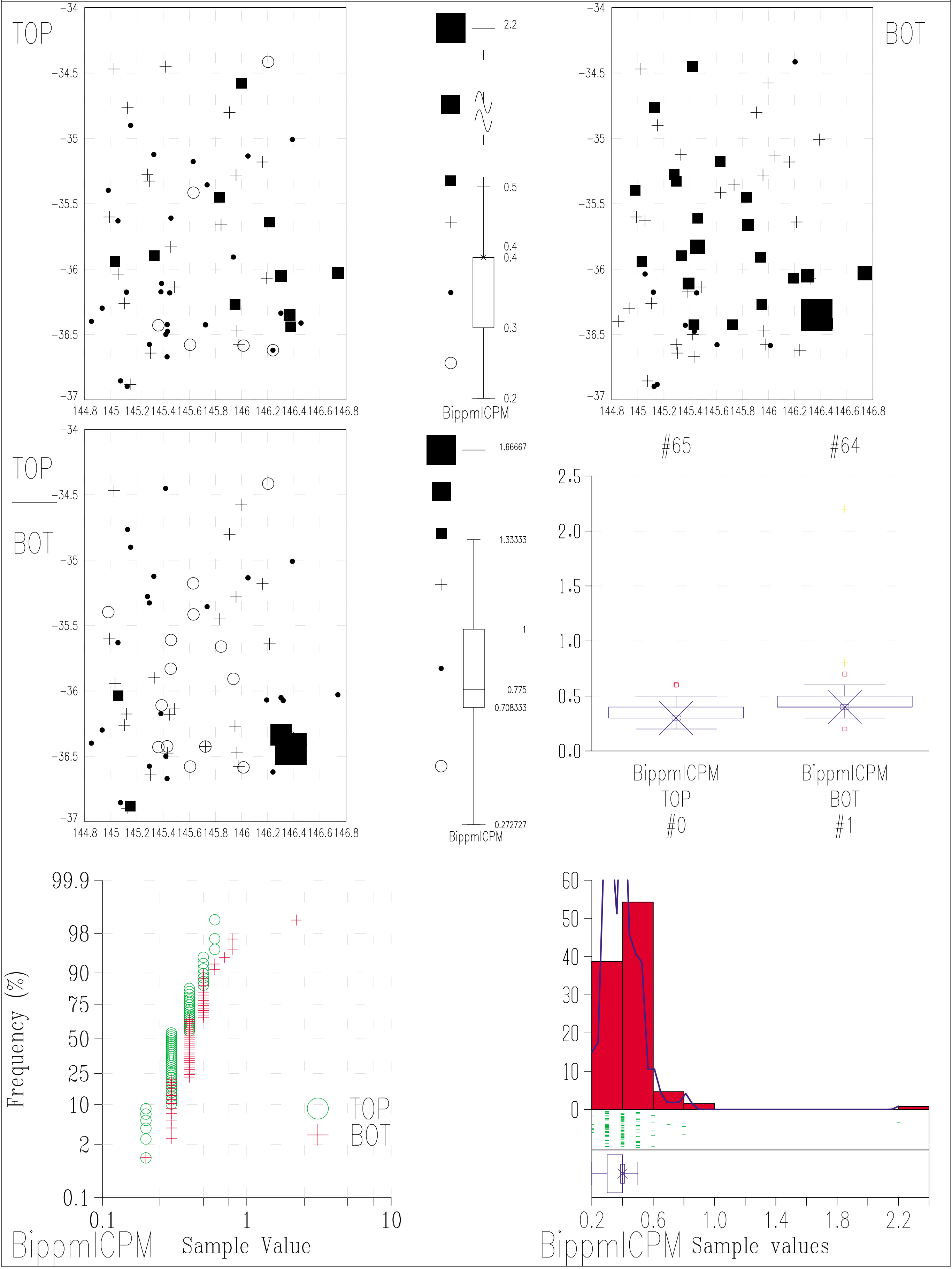
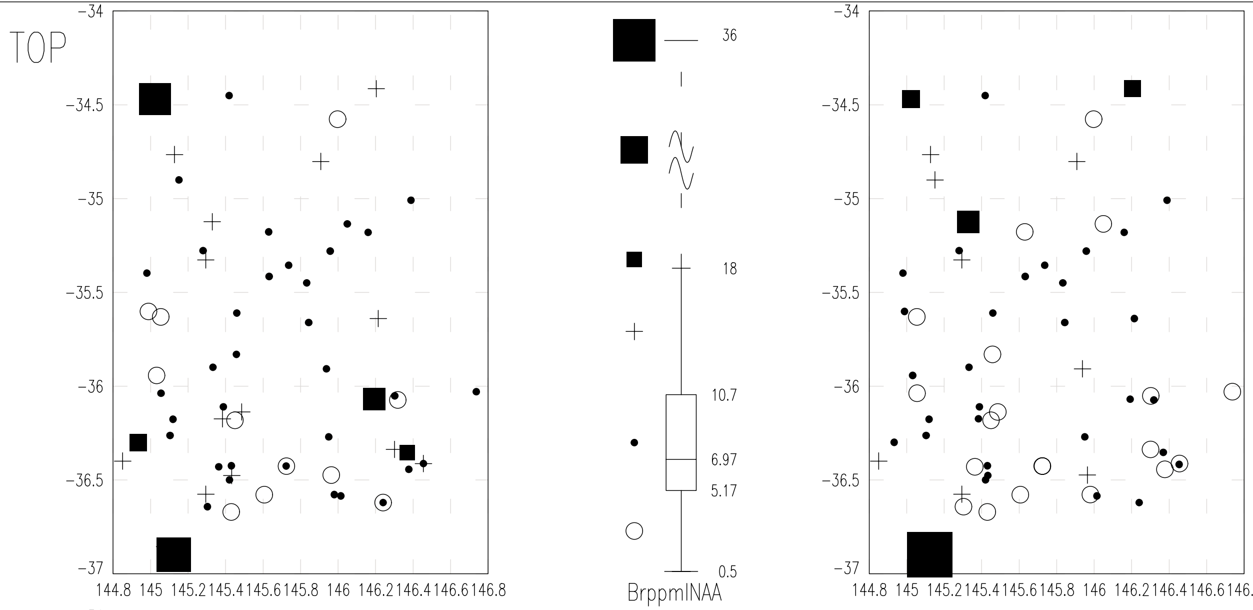
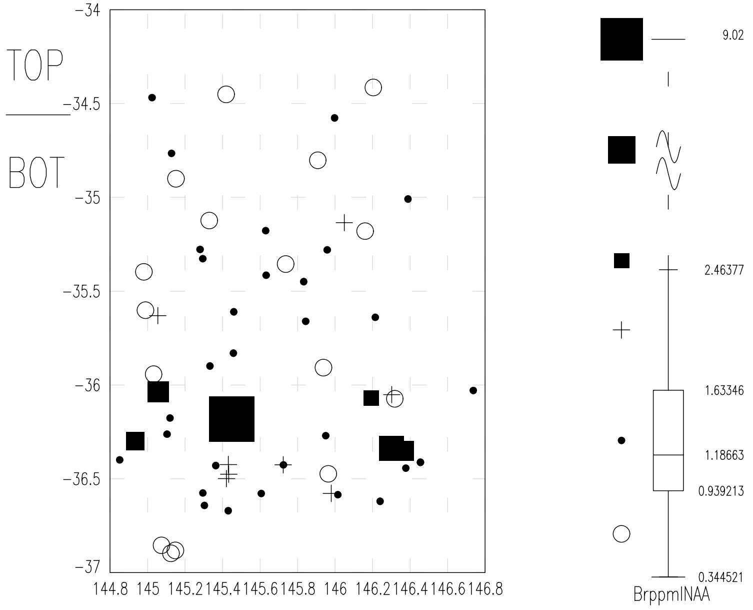
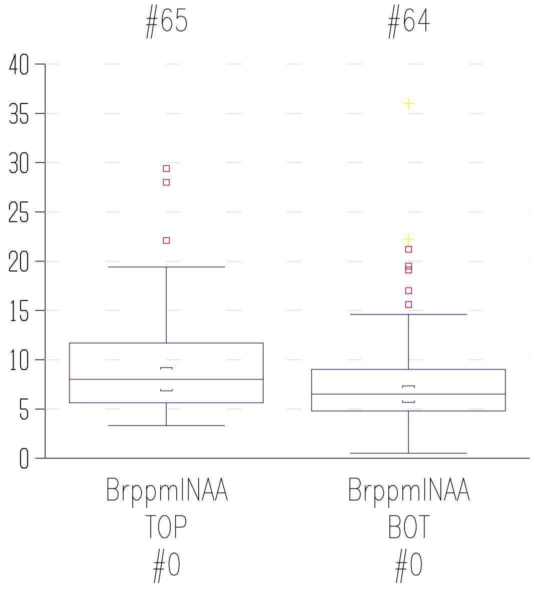
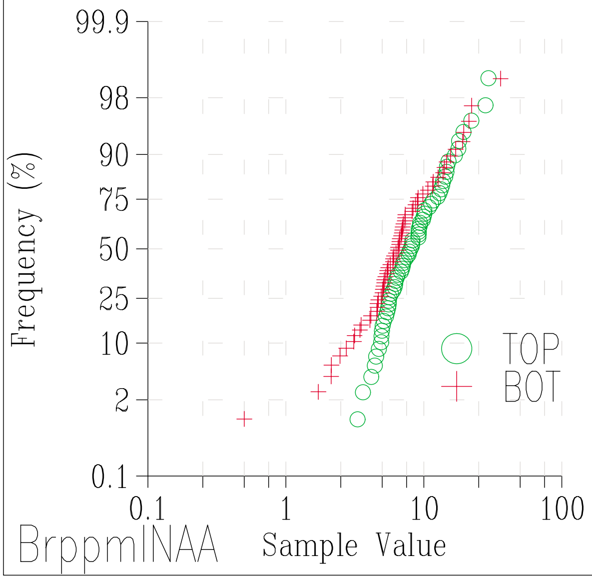


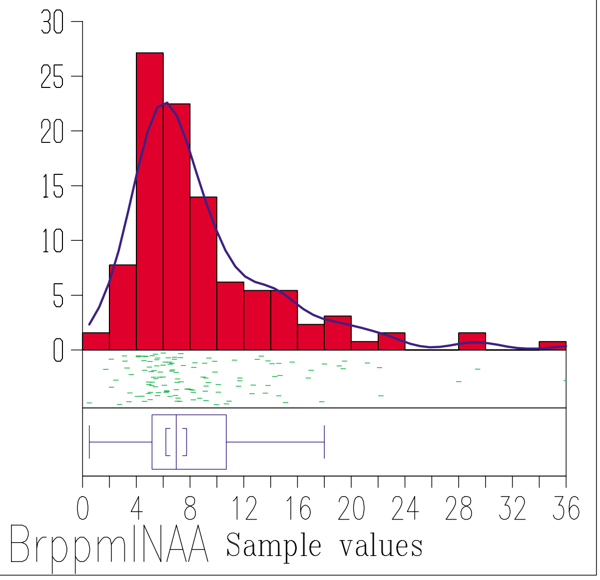
REGIONAL GEOCHEMICAL SURVEY: EASTERN RIVERINA











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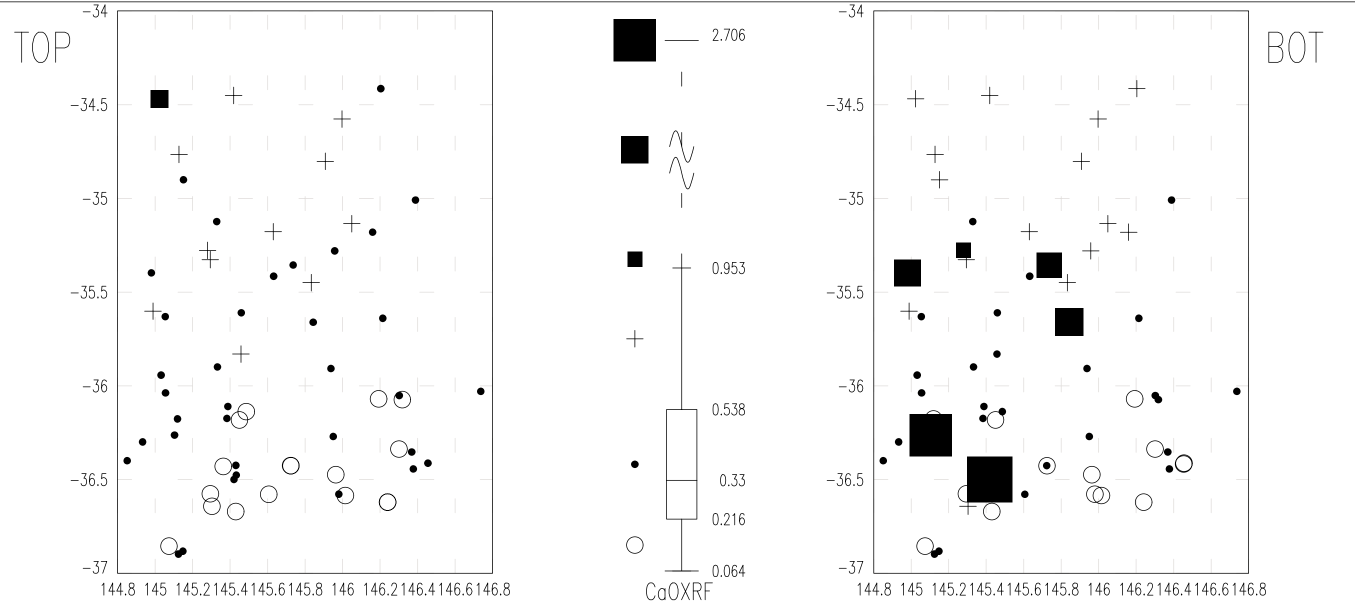

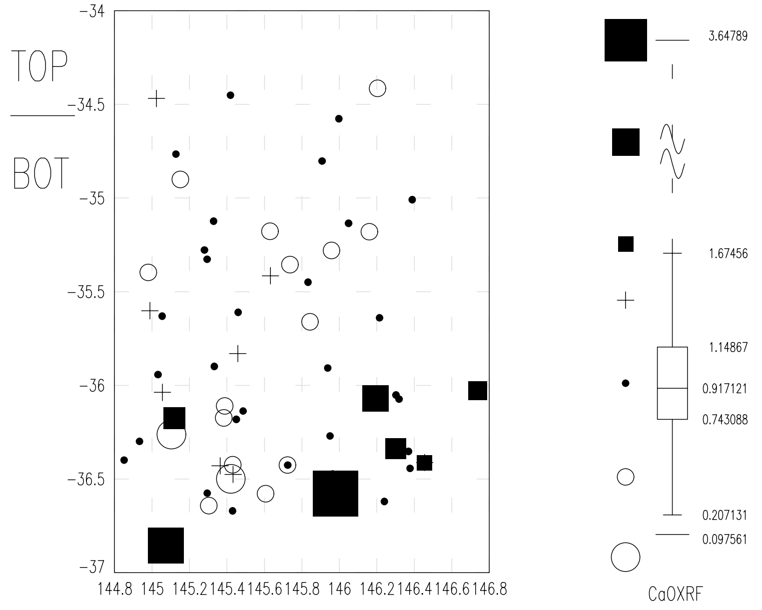

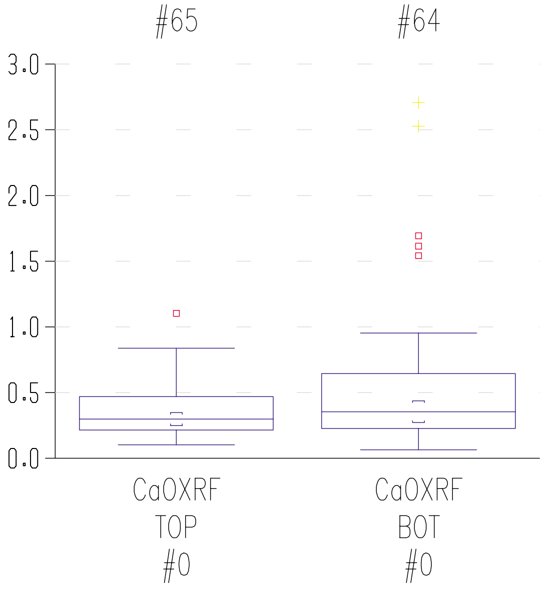

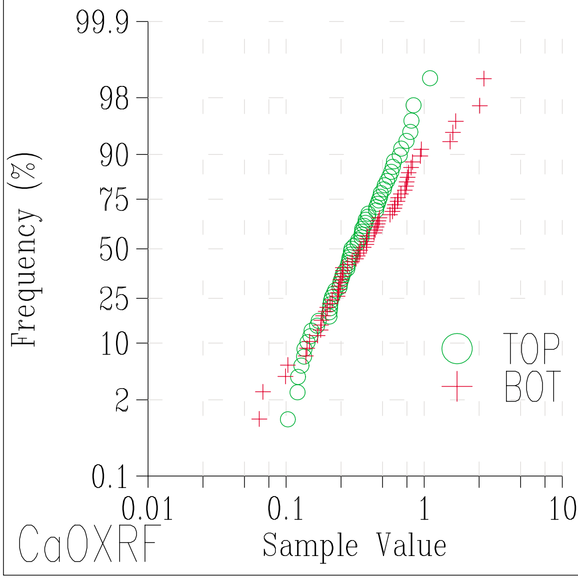

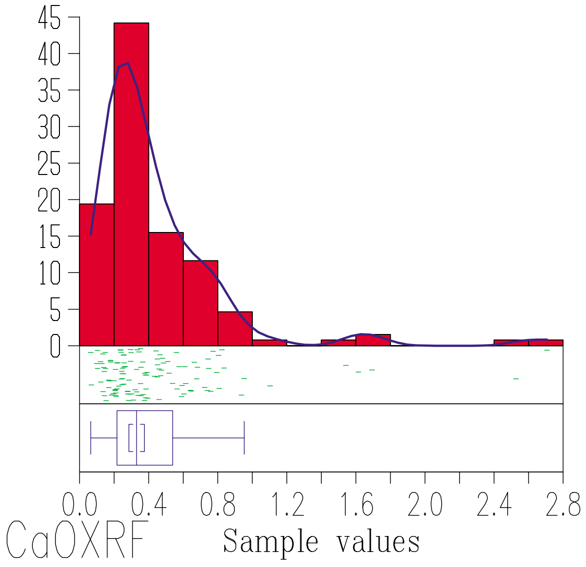

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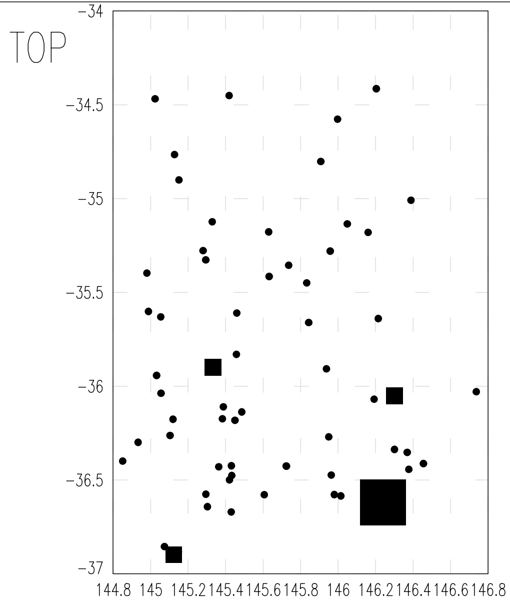

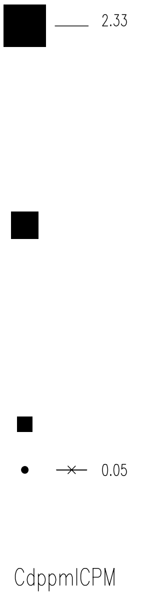

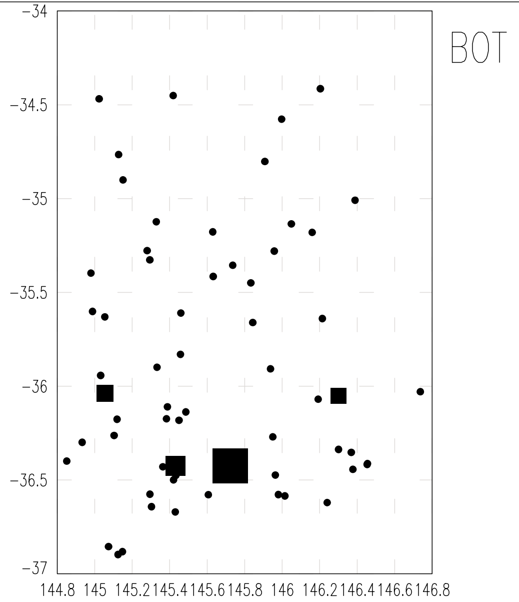

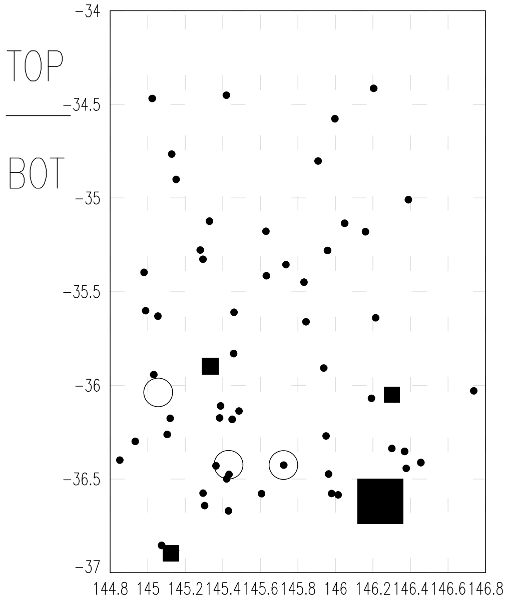

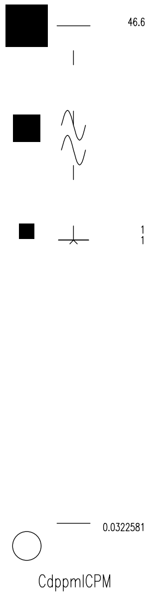

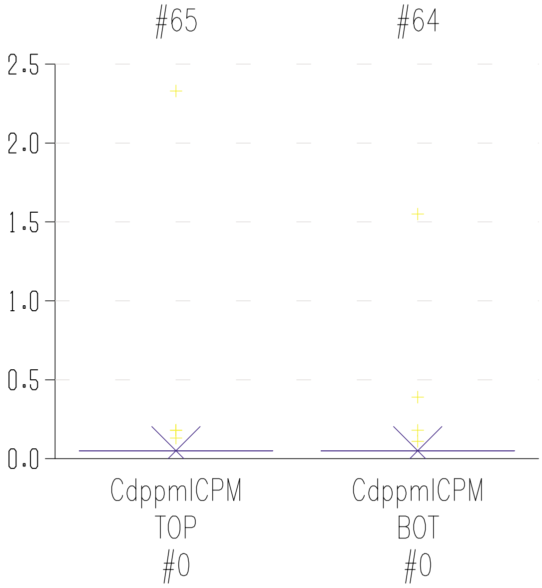

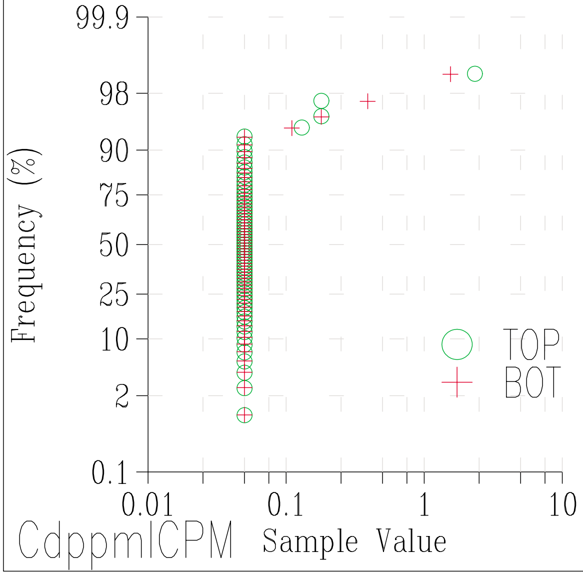

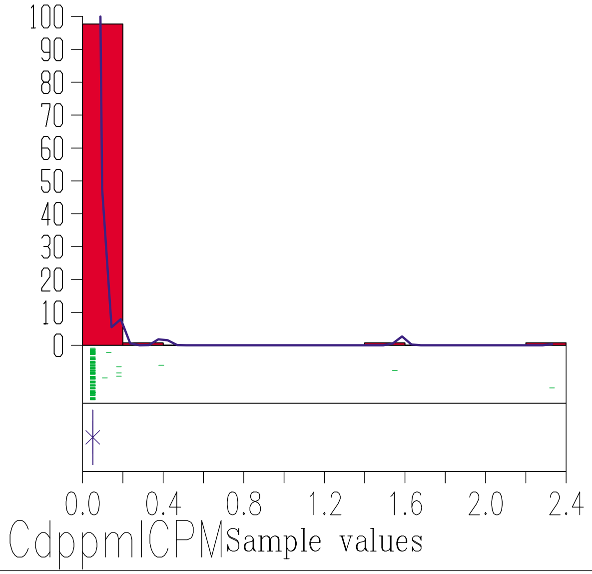

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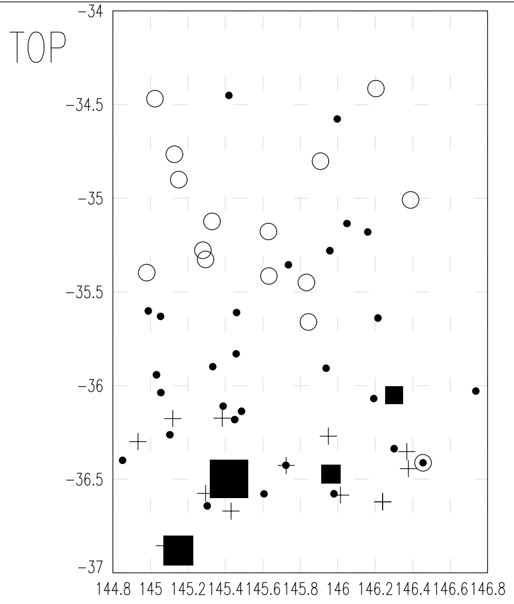

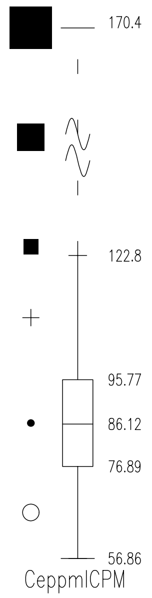

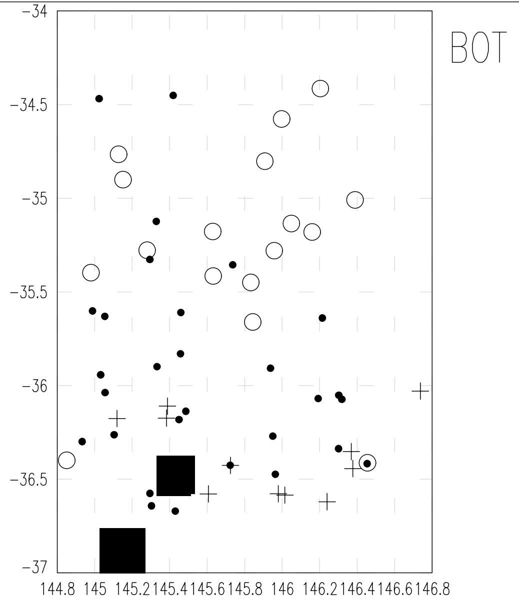

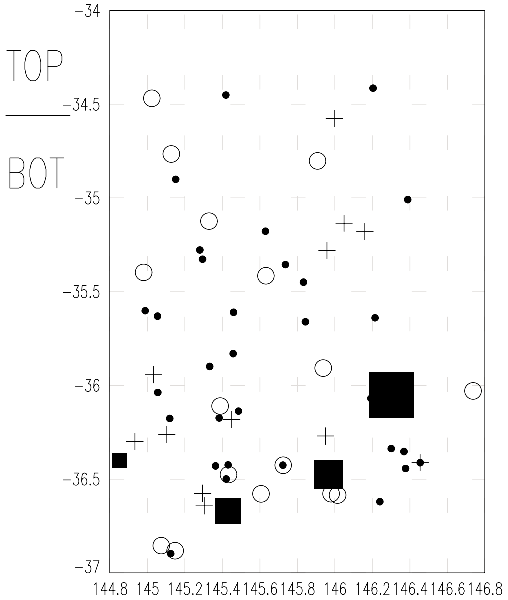

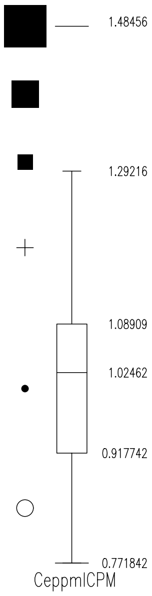

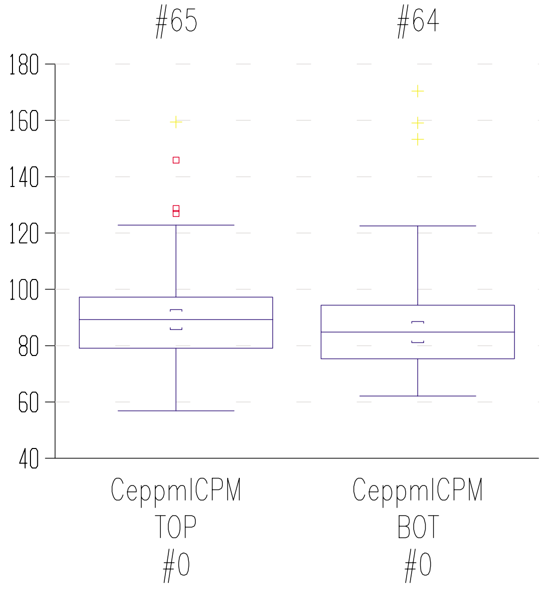

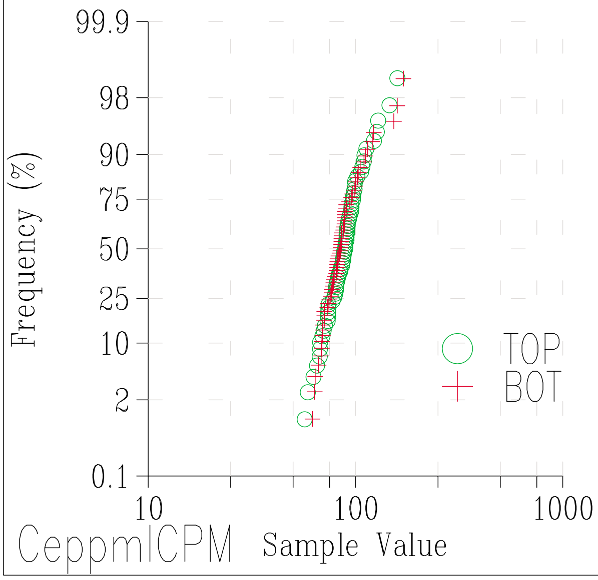

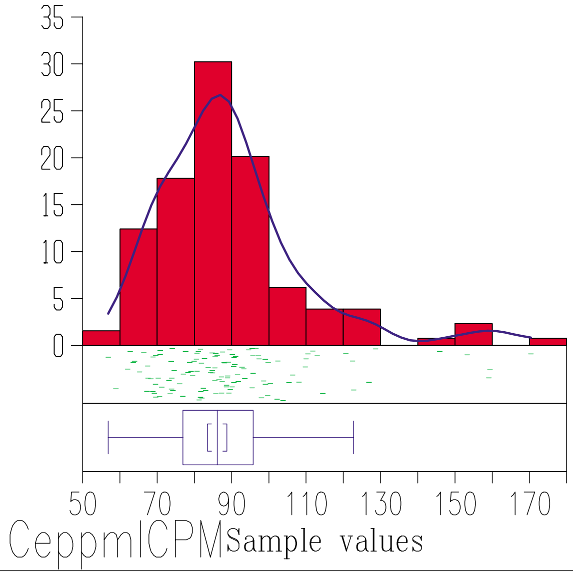

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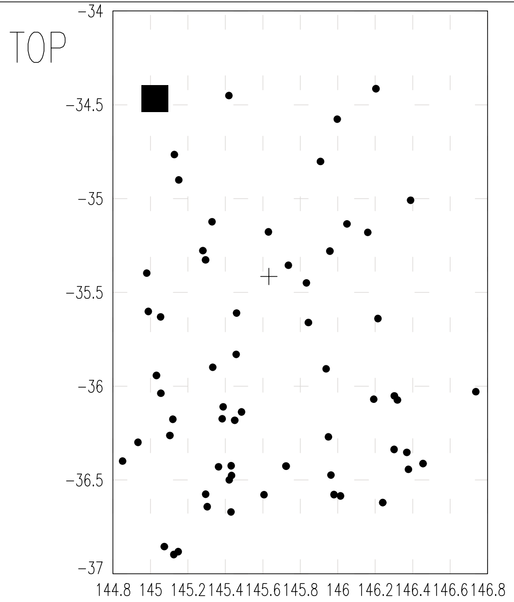

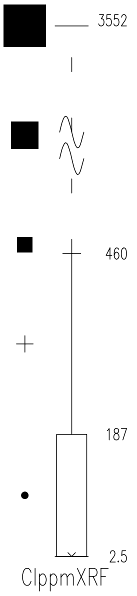

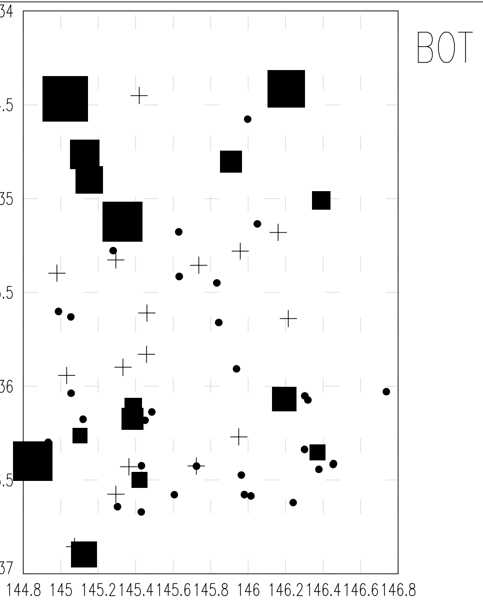

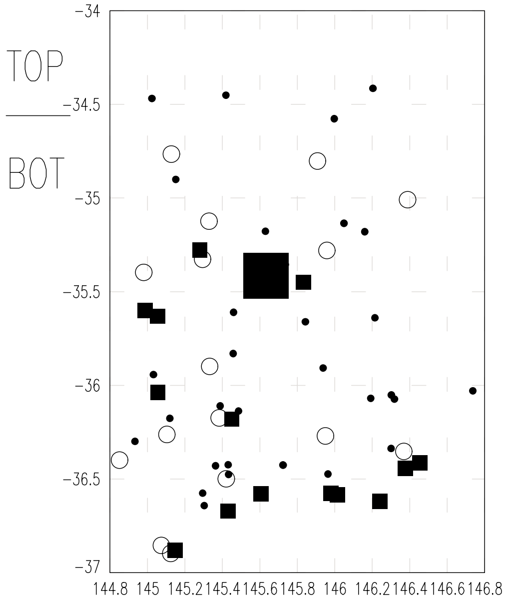

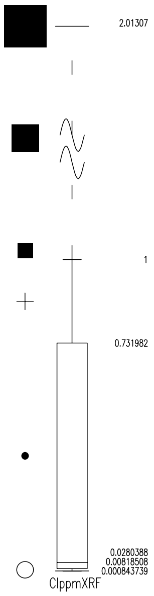

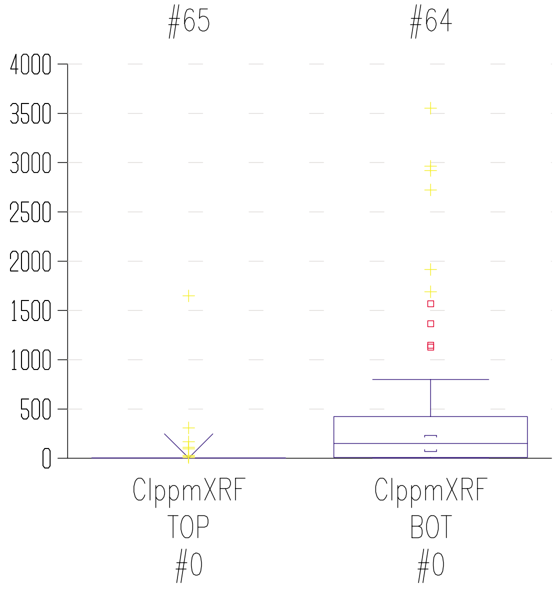

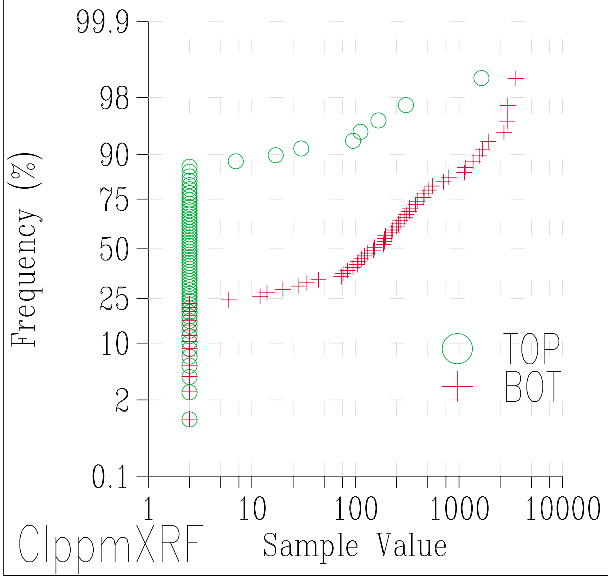

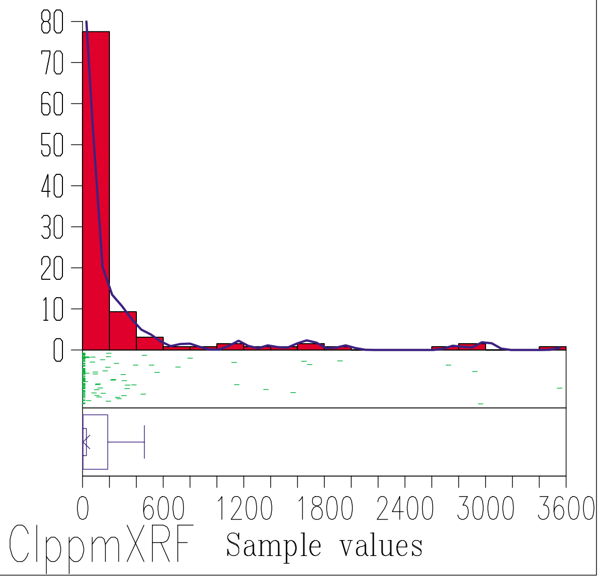

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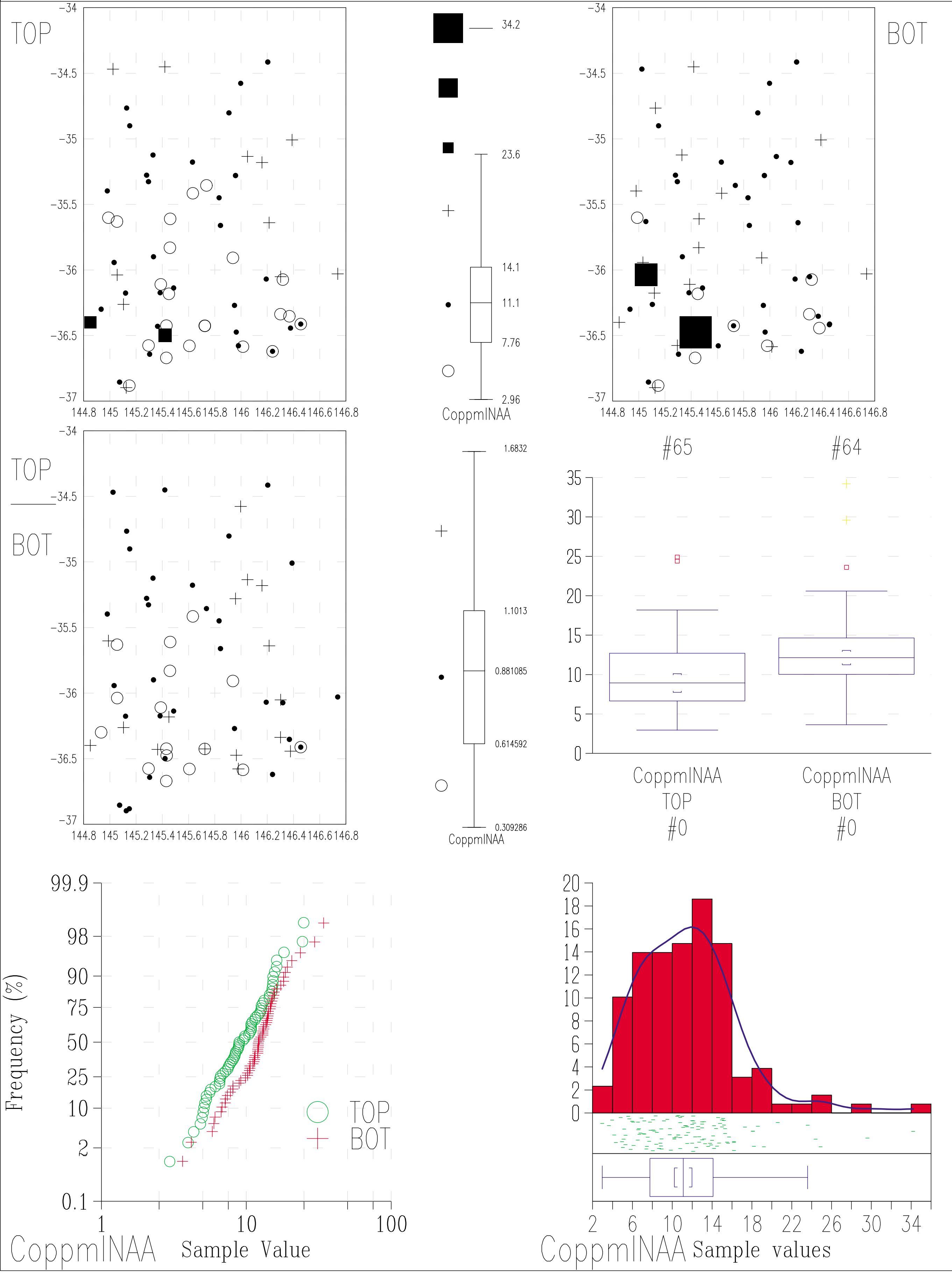

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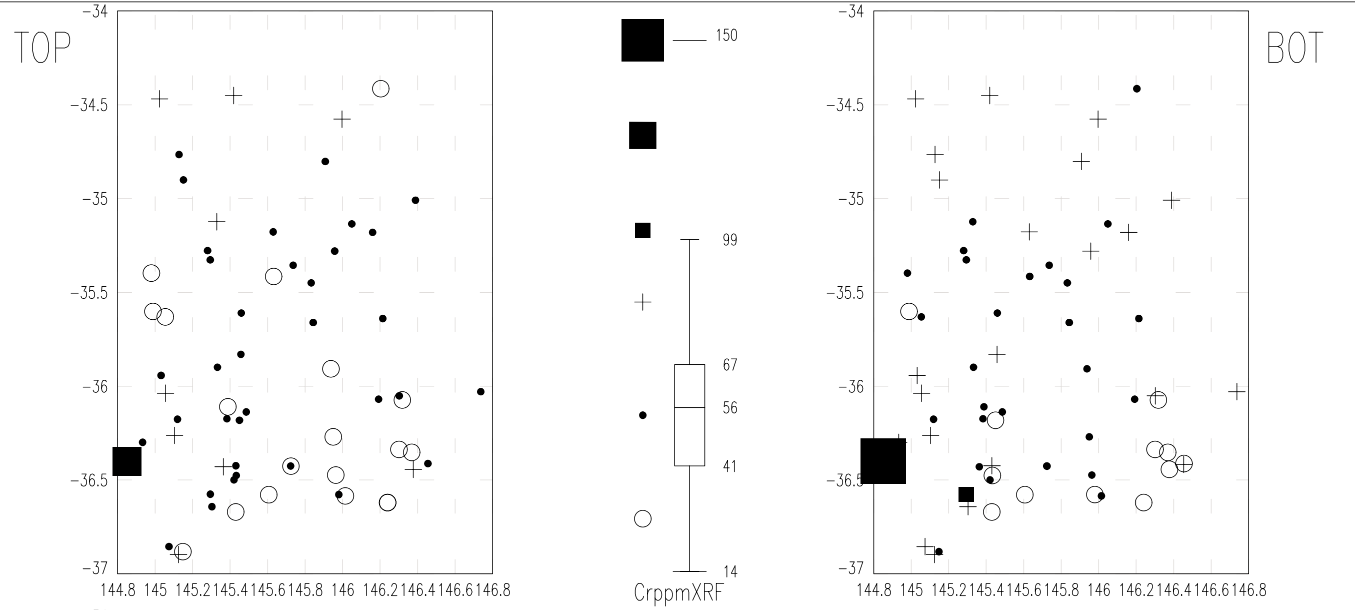

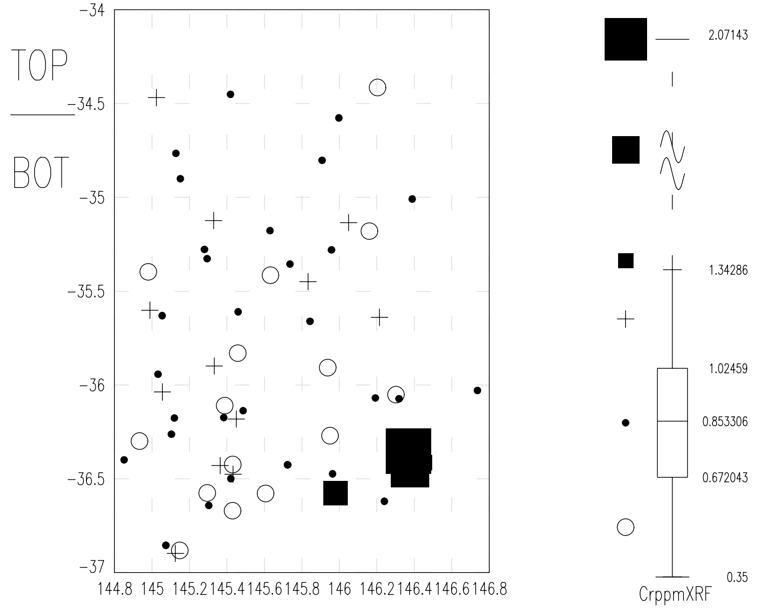

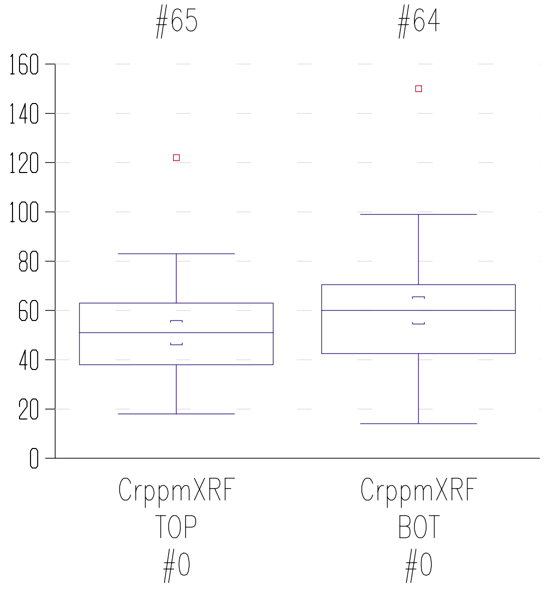

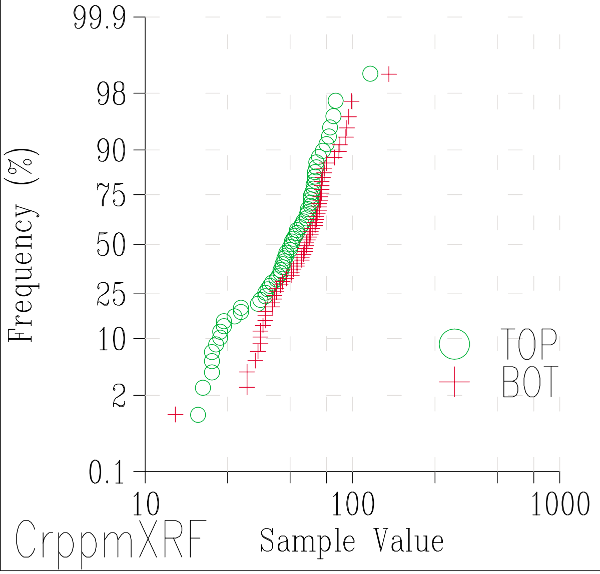

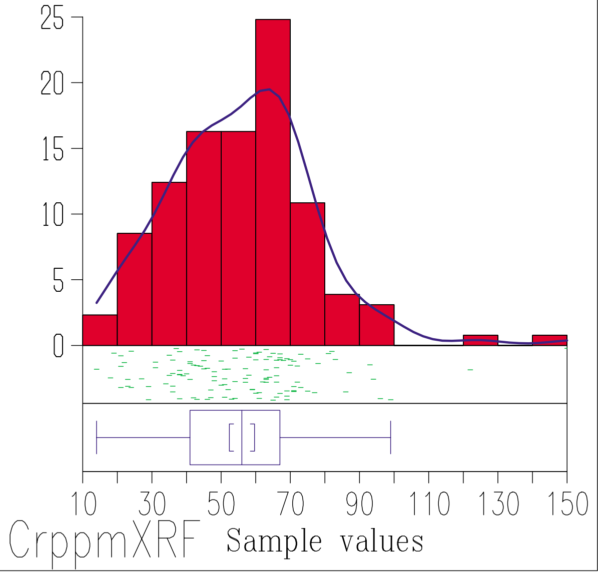

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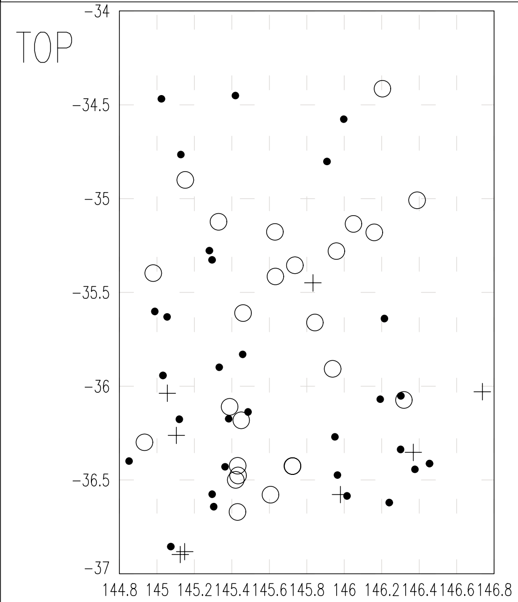

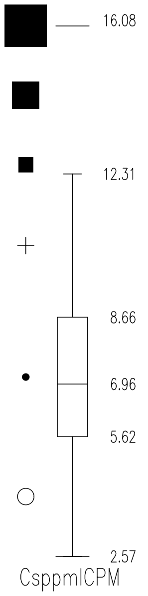

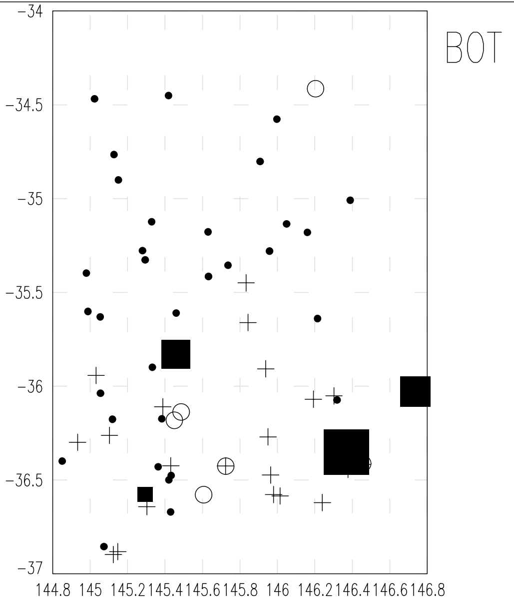

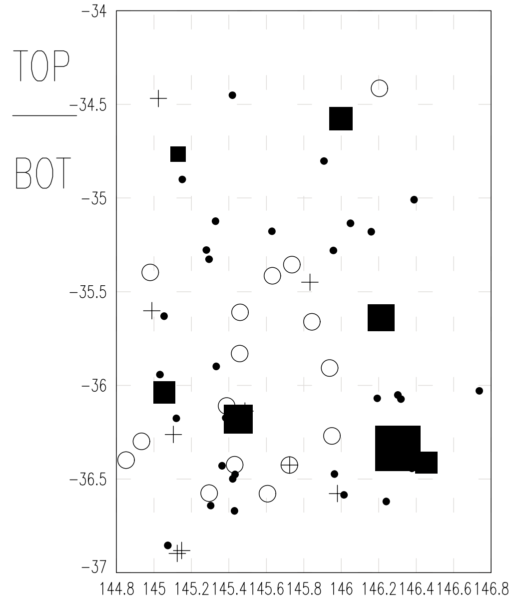

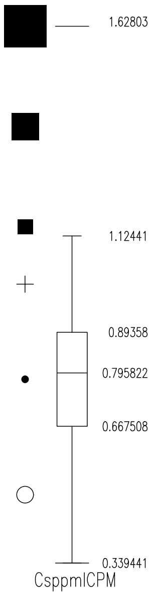

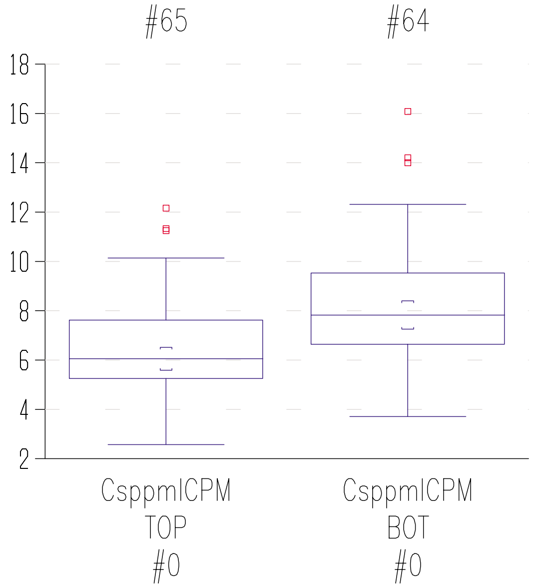

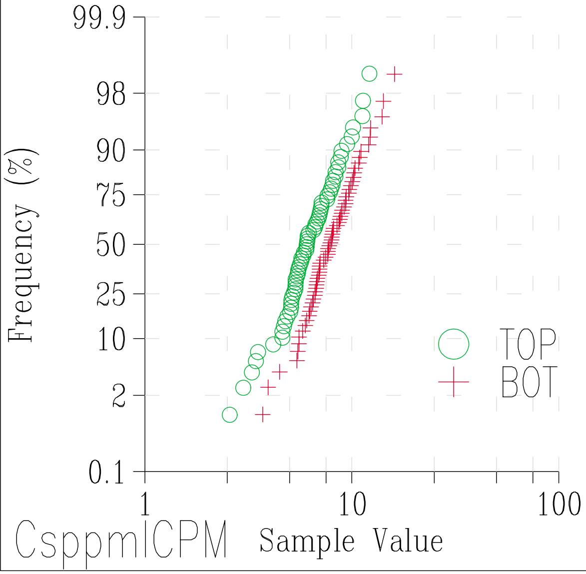

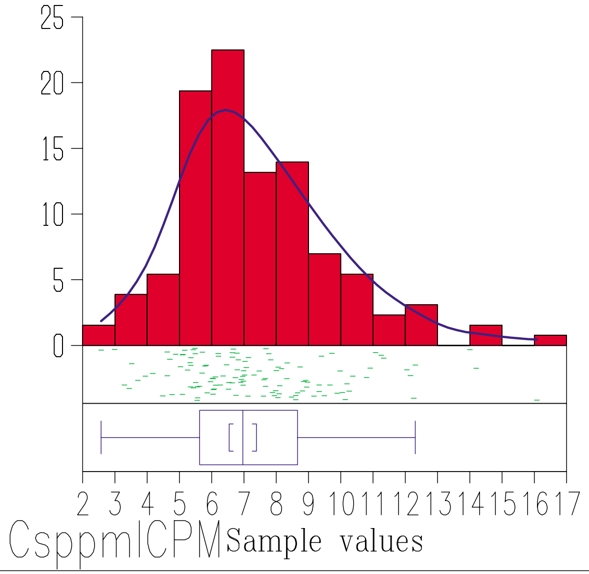

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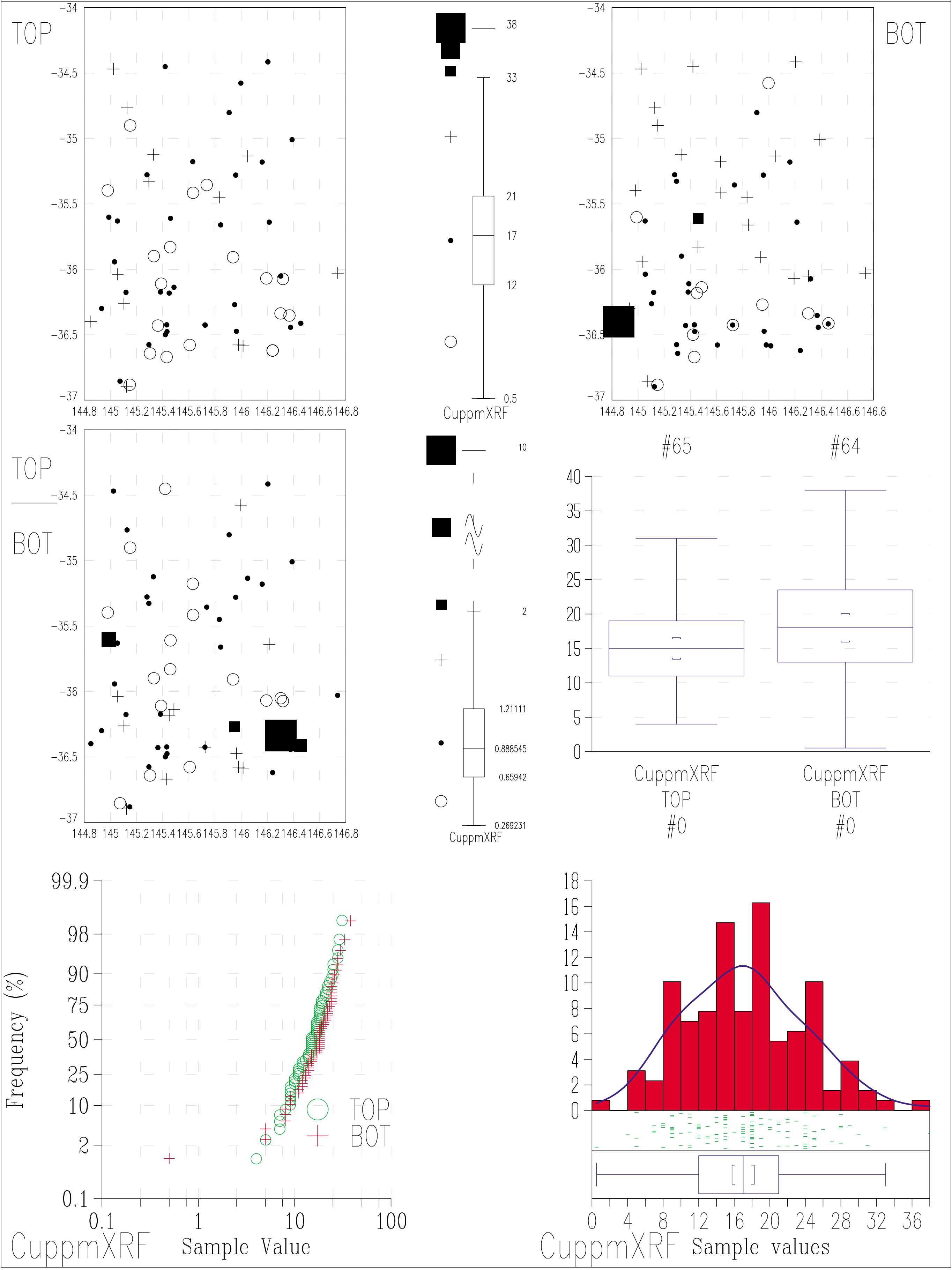

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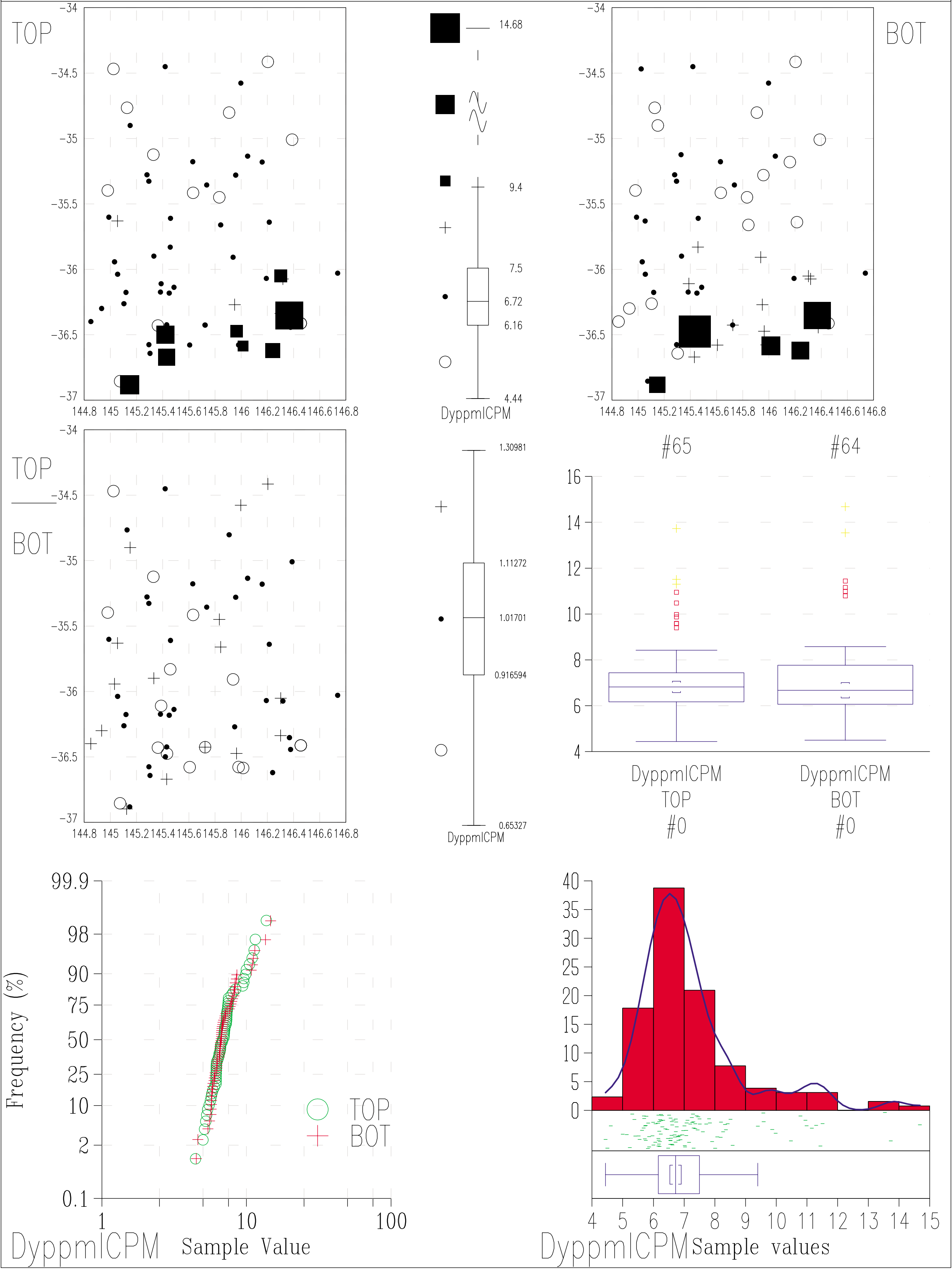

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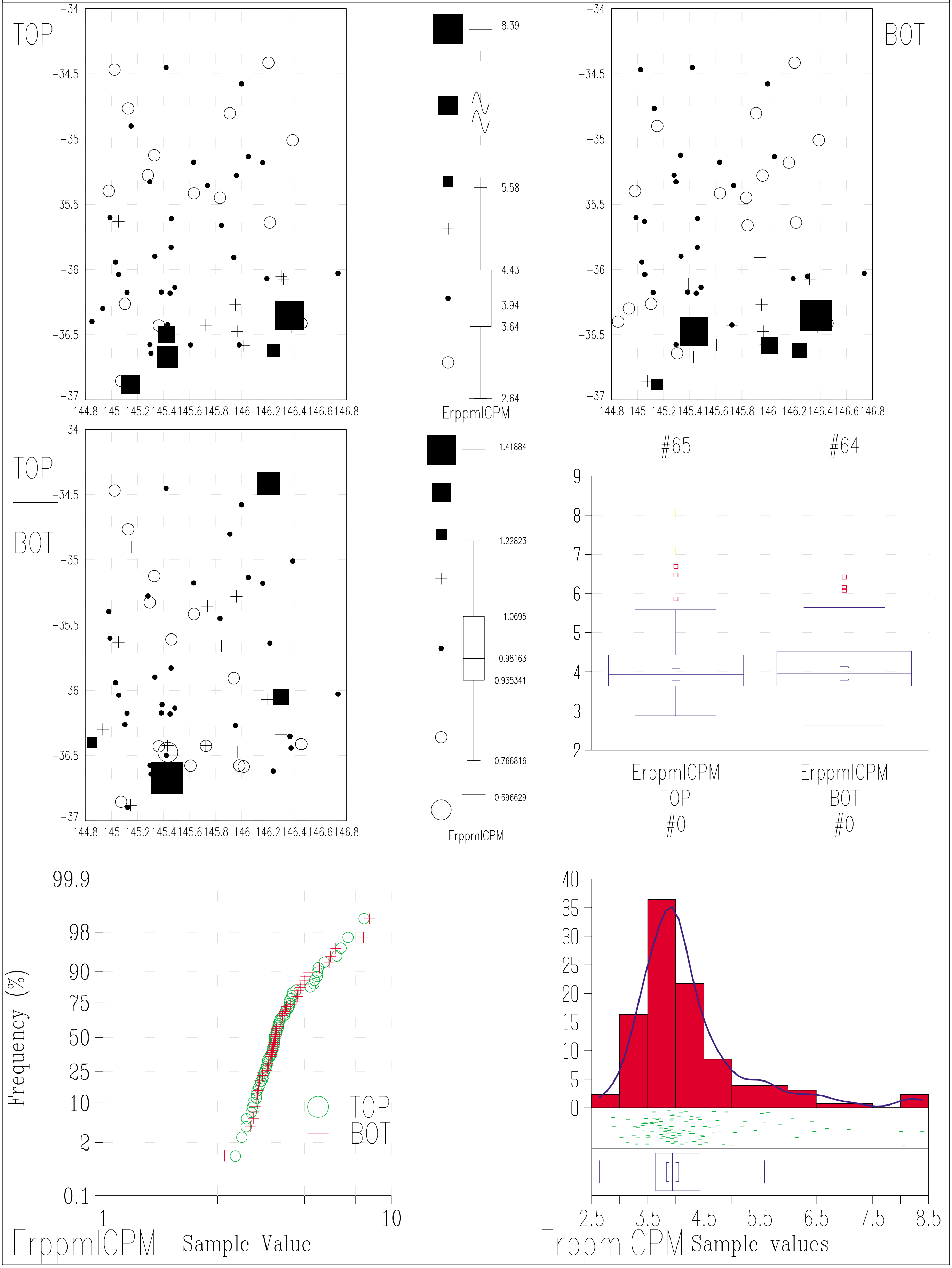

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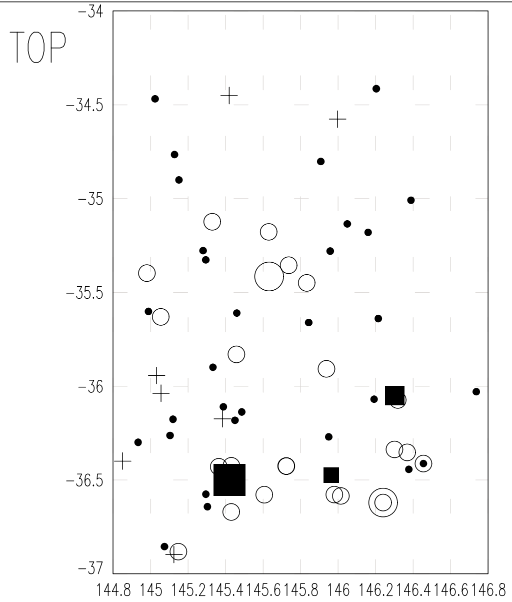

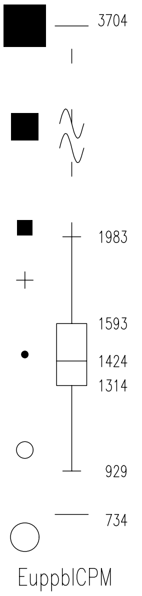

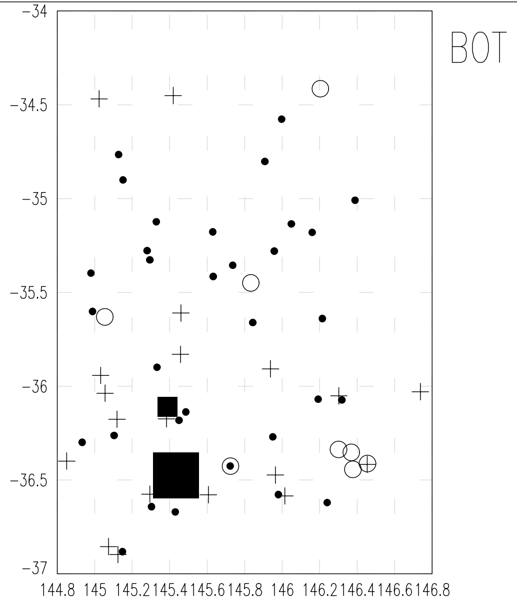

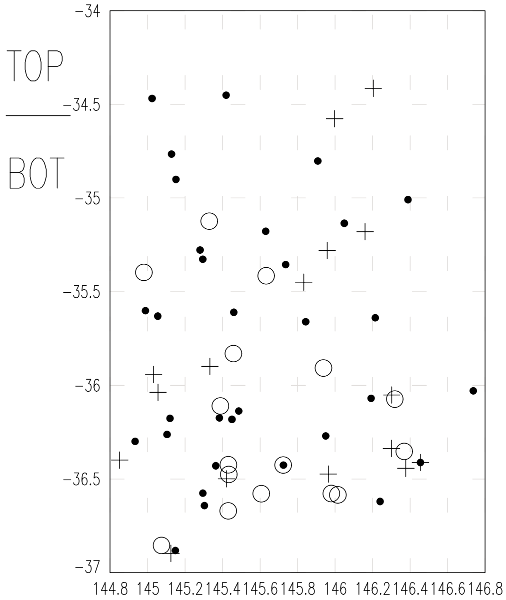

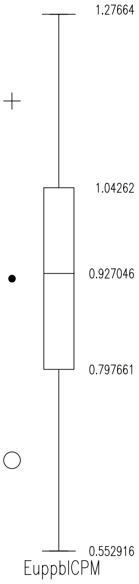

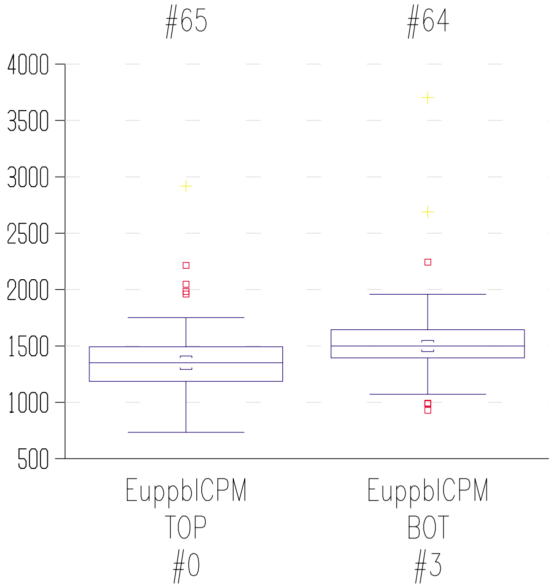

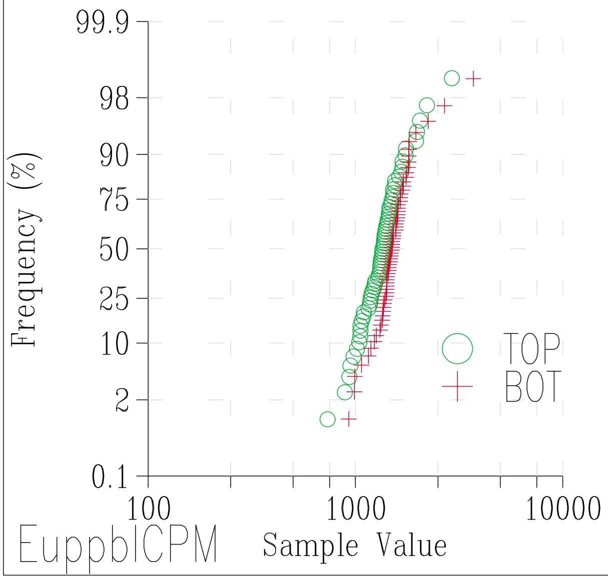

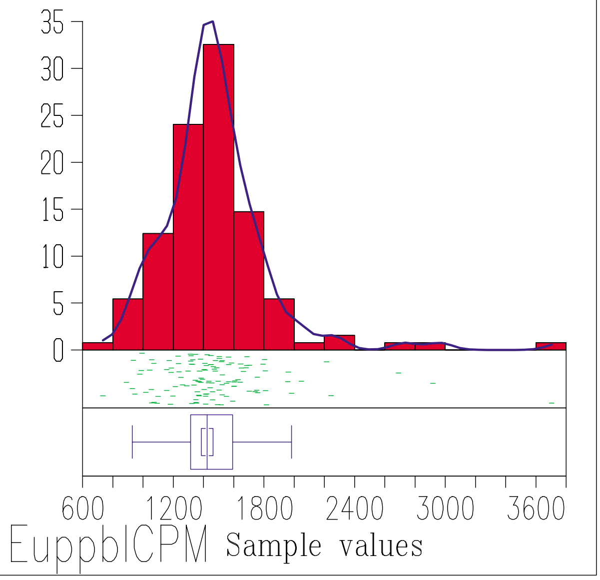

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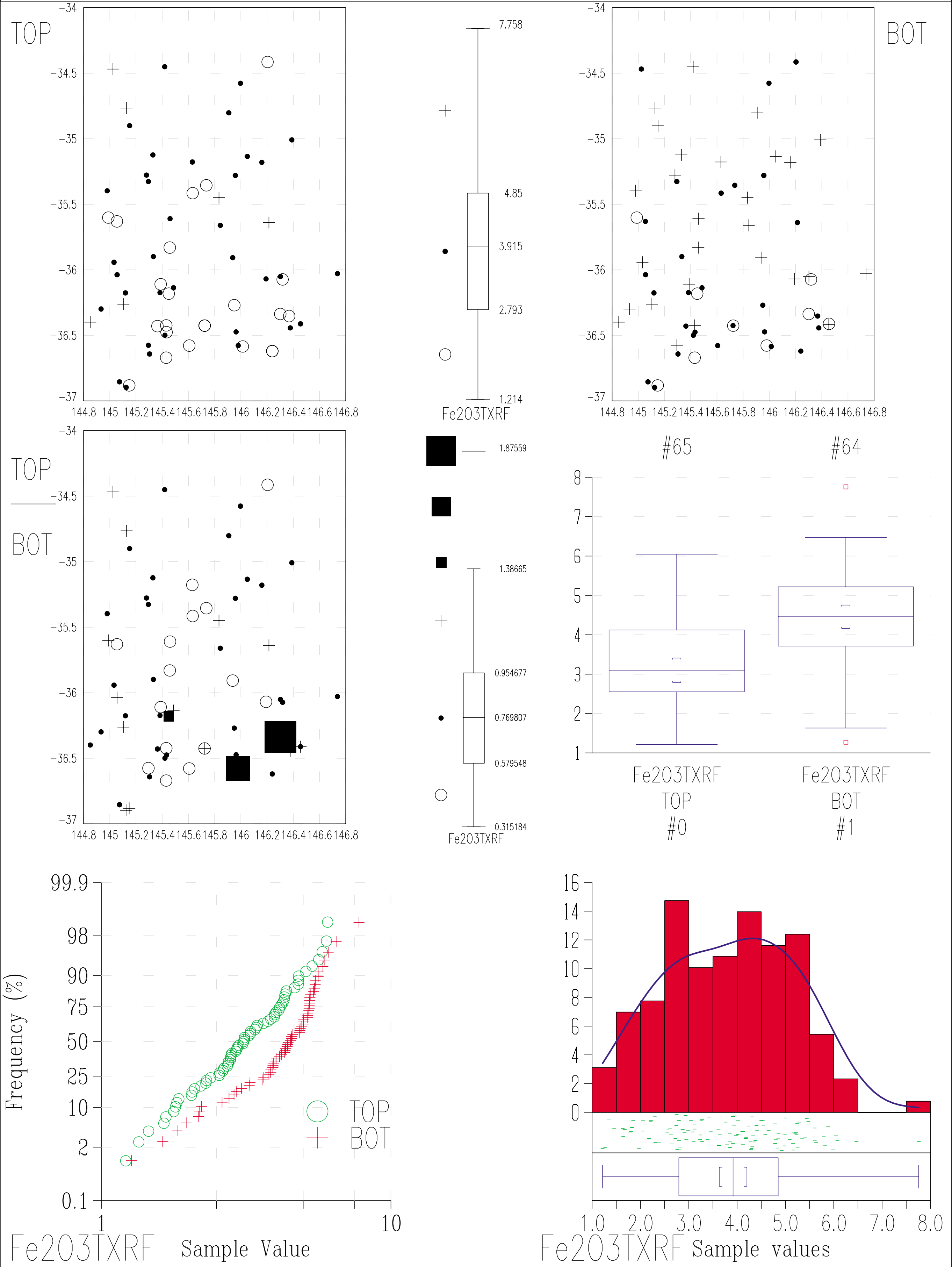

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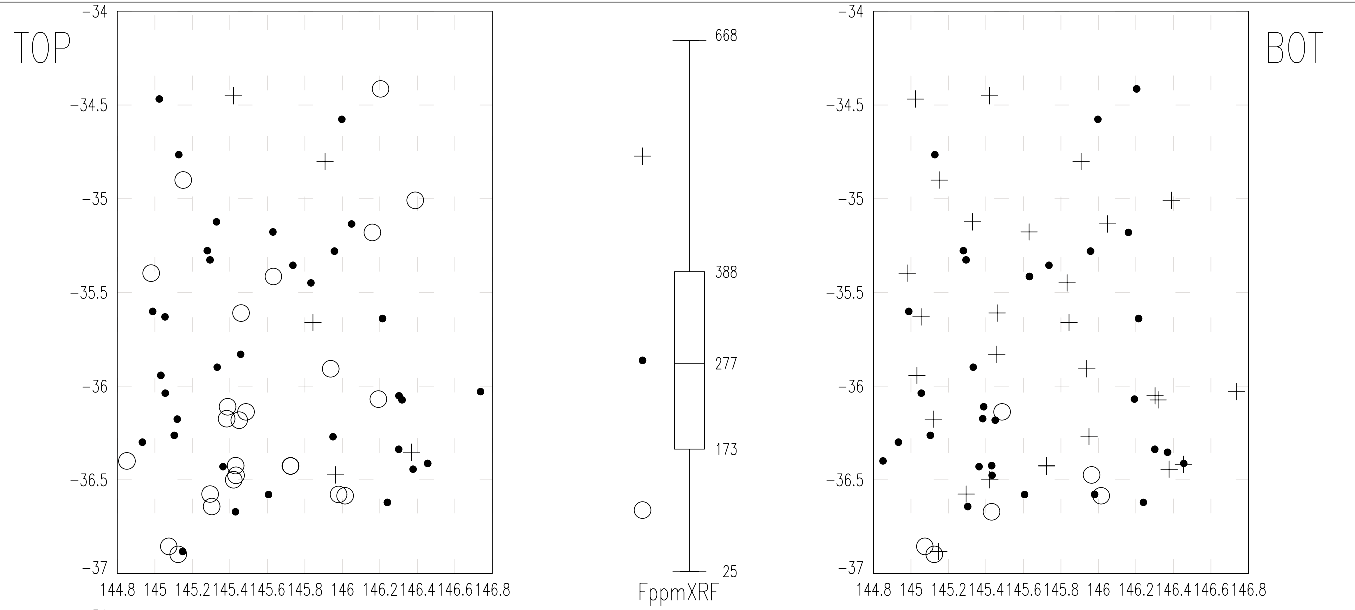

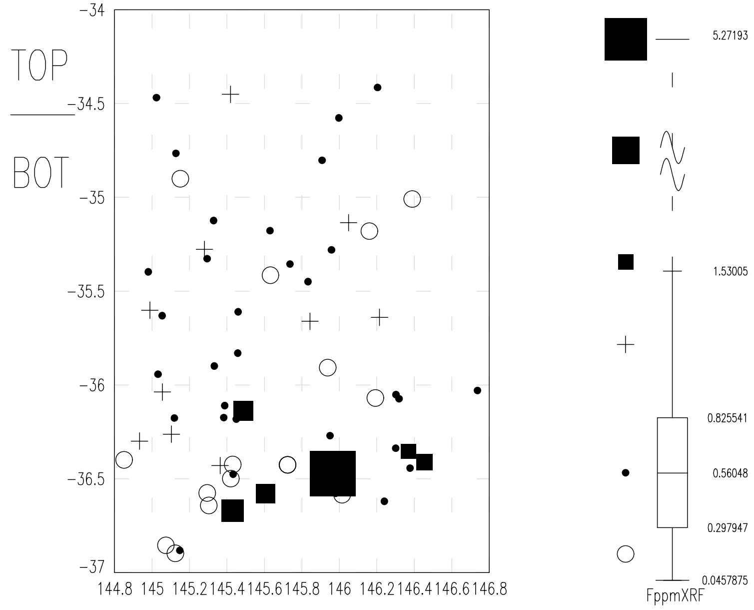

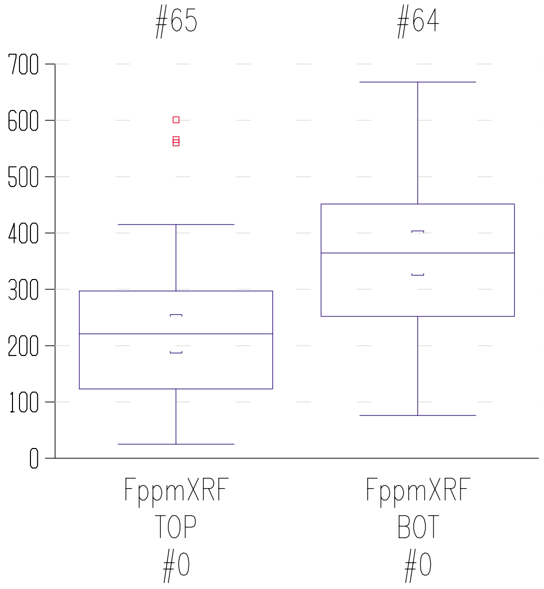

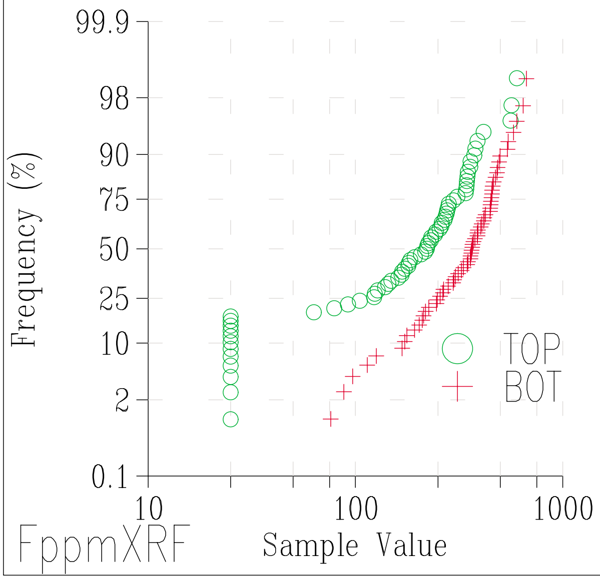

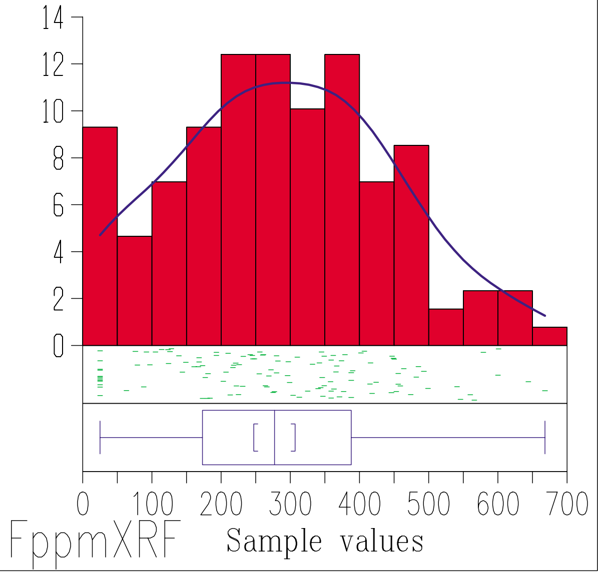

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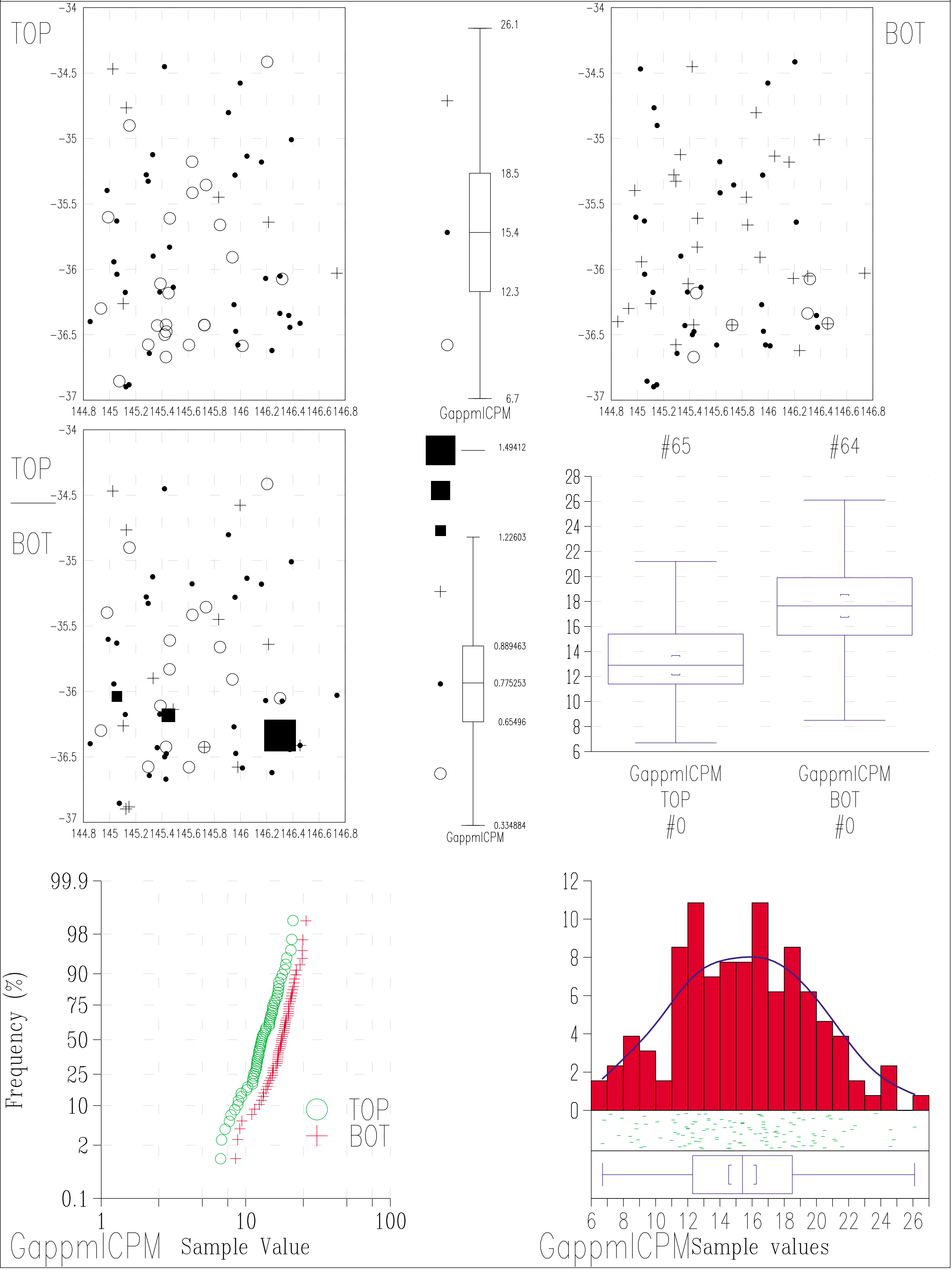

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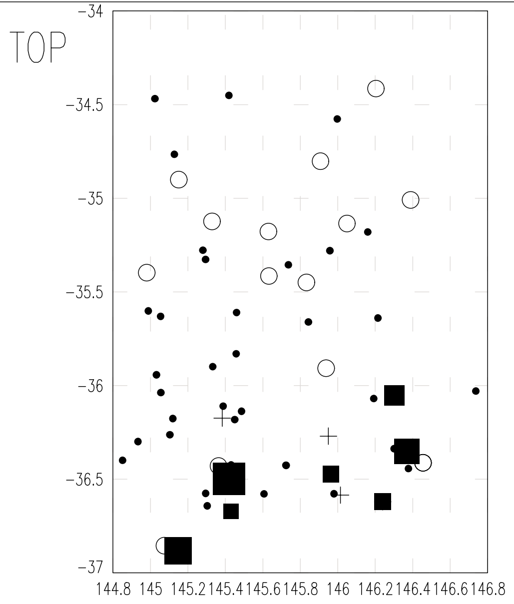

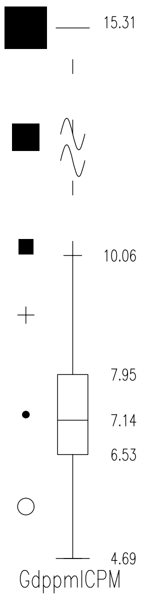

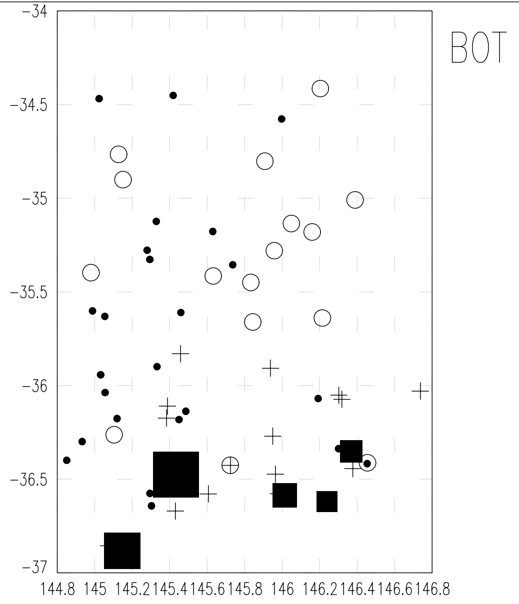

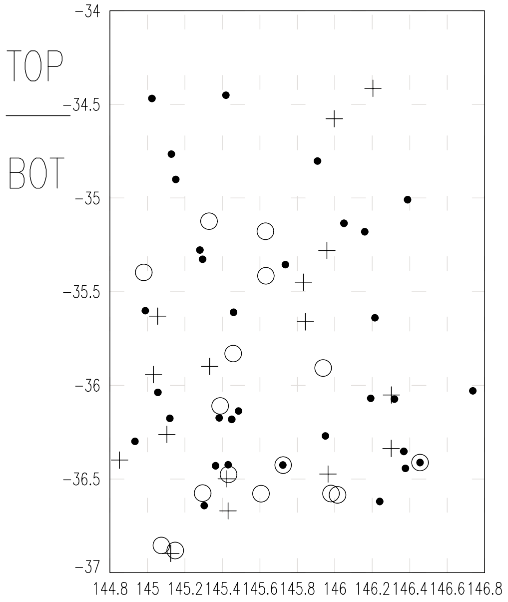

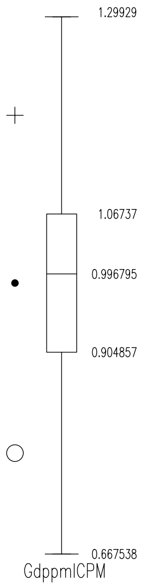

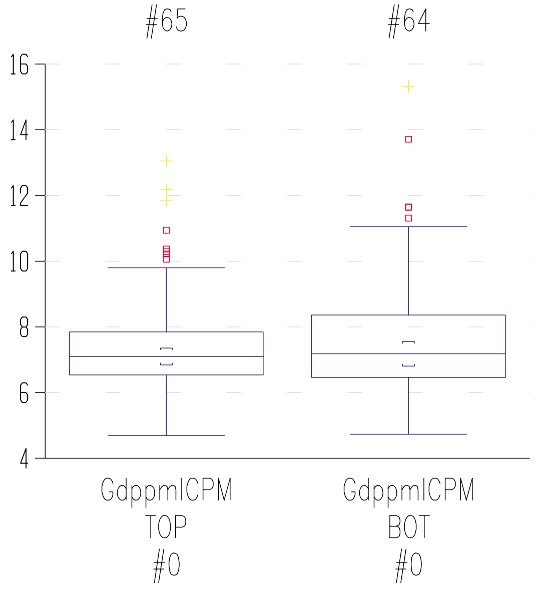

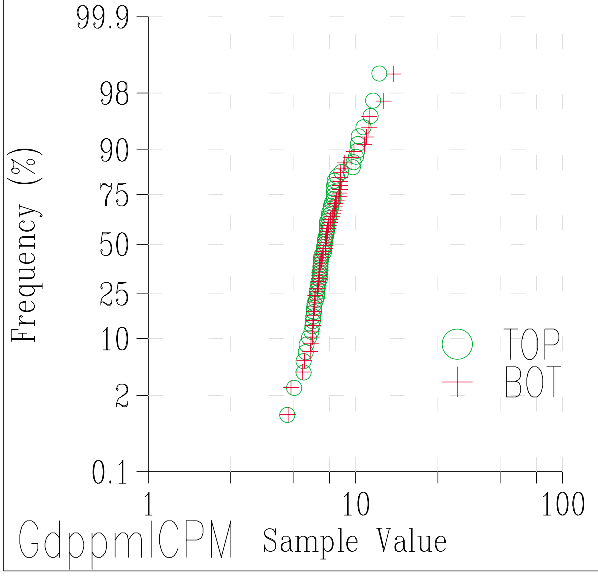

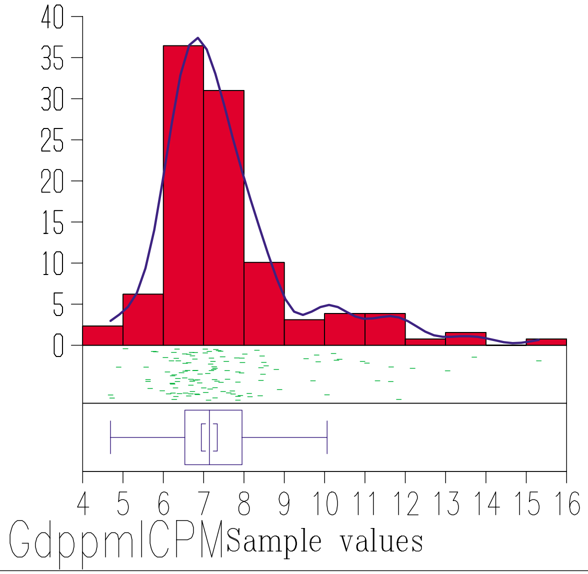

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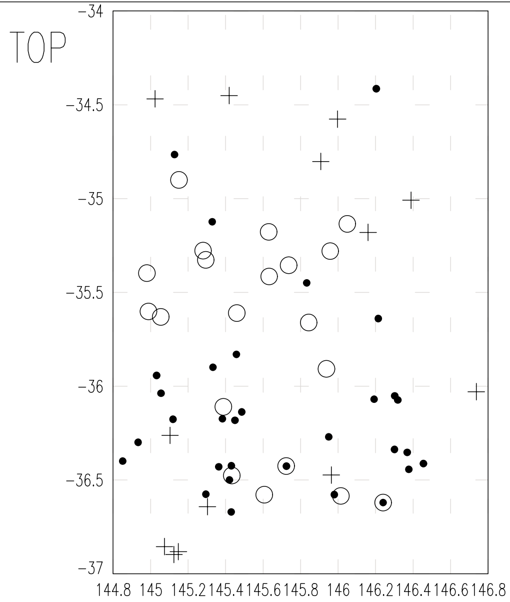

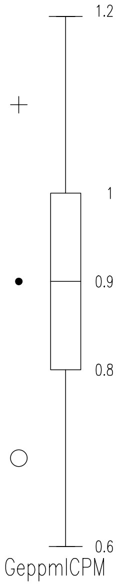

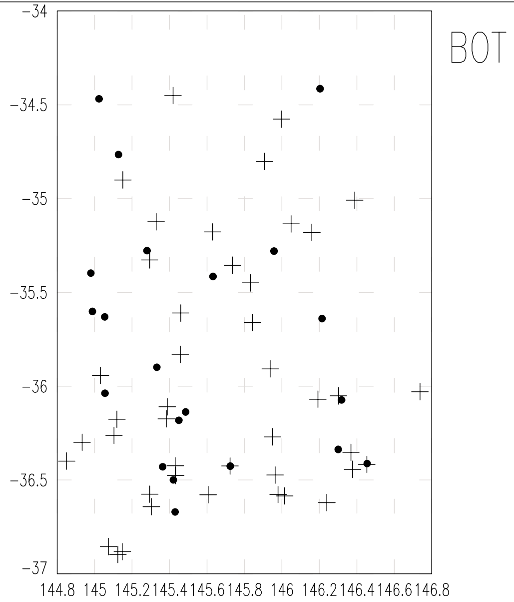

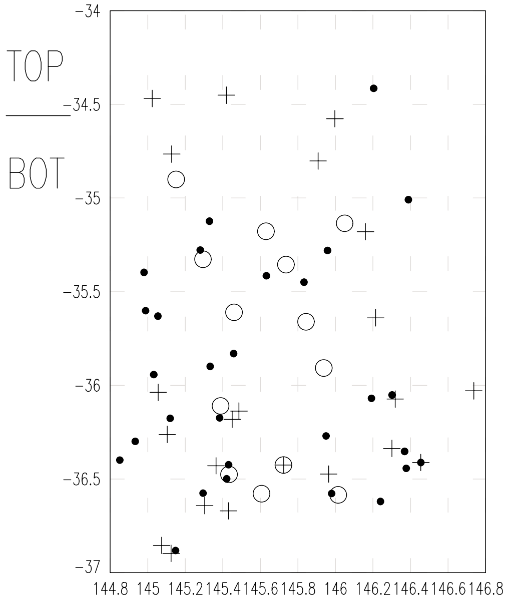

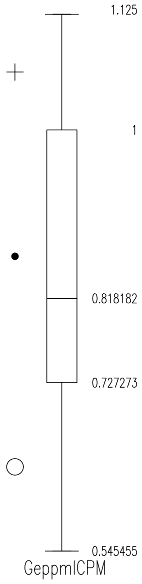

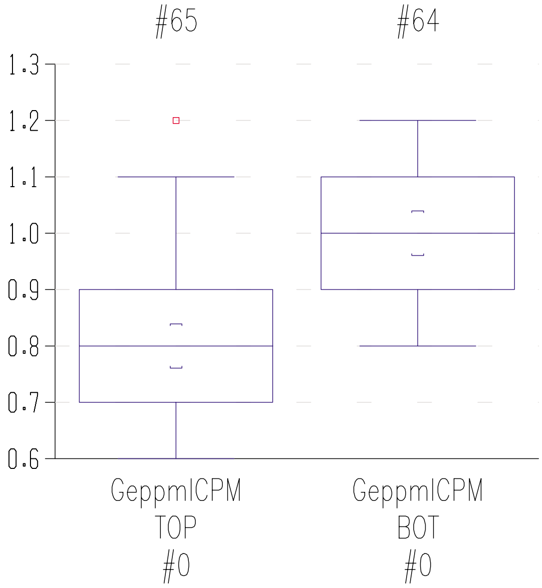

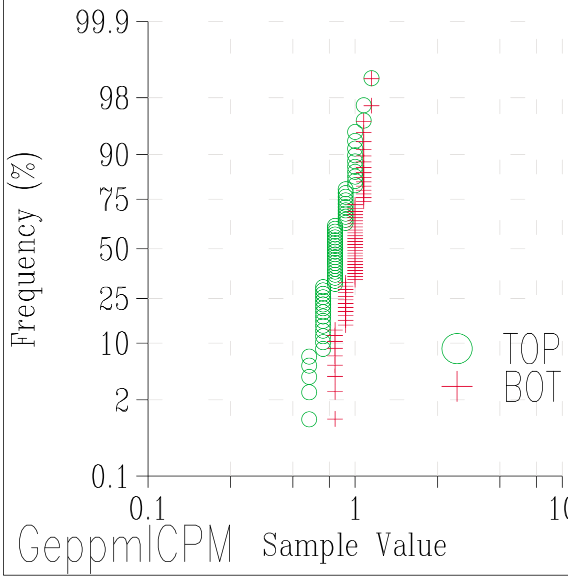

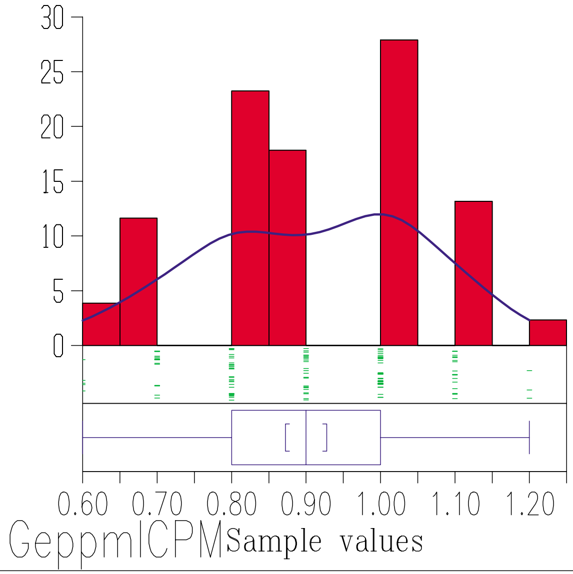

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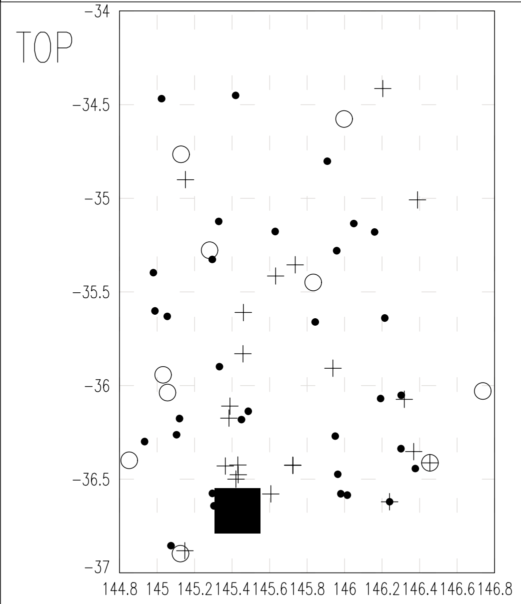

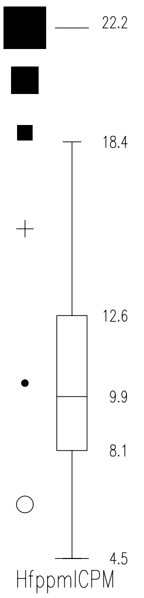

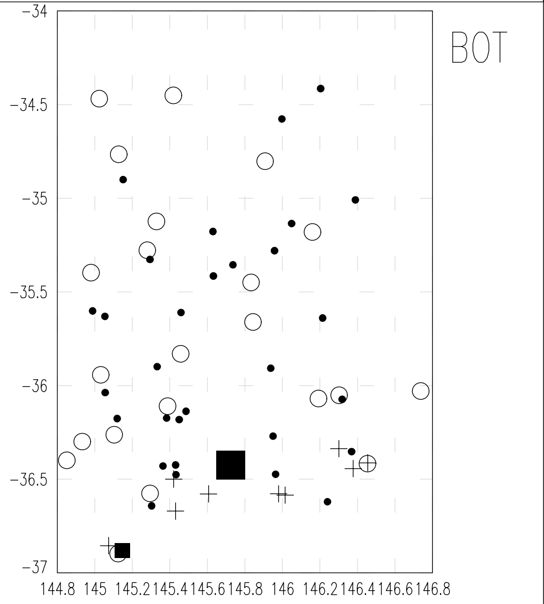

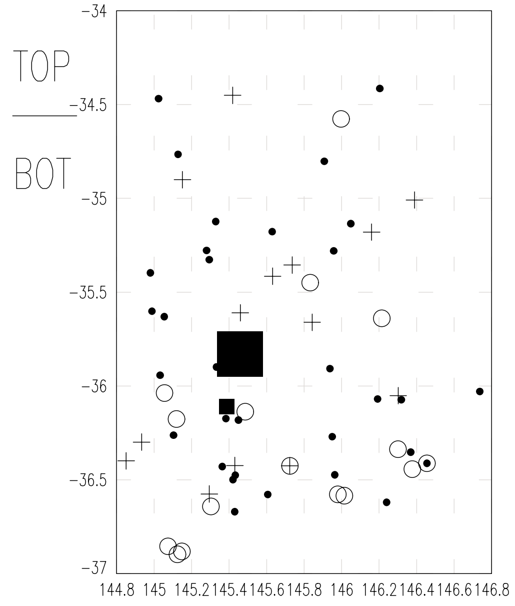

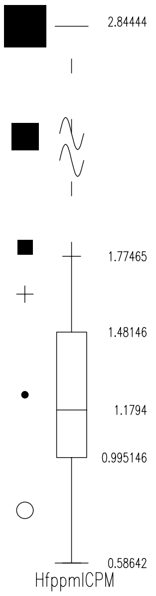

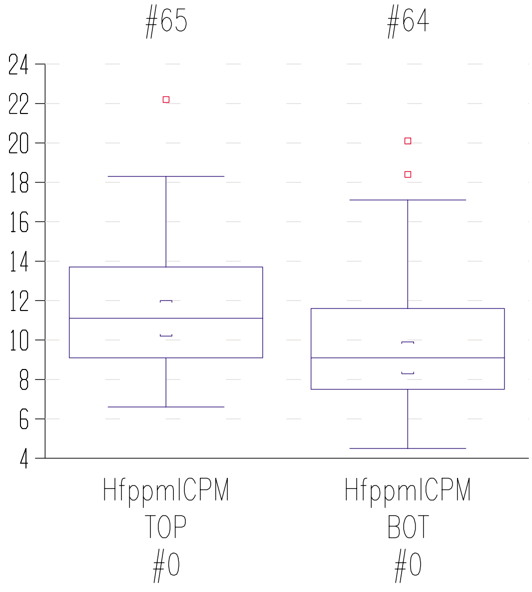

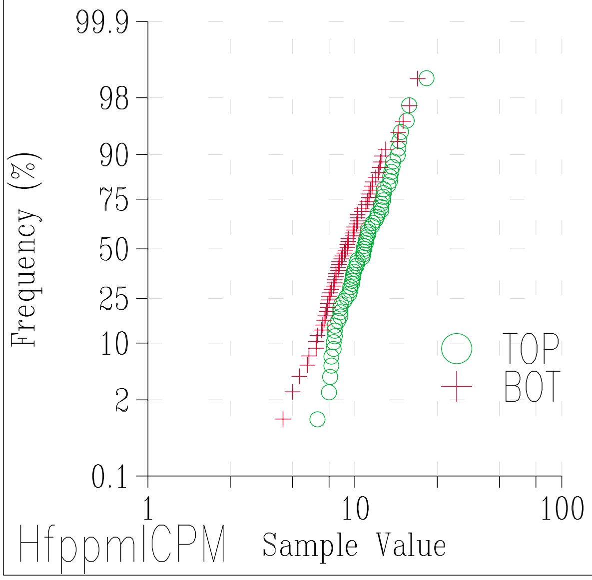

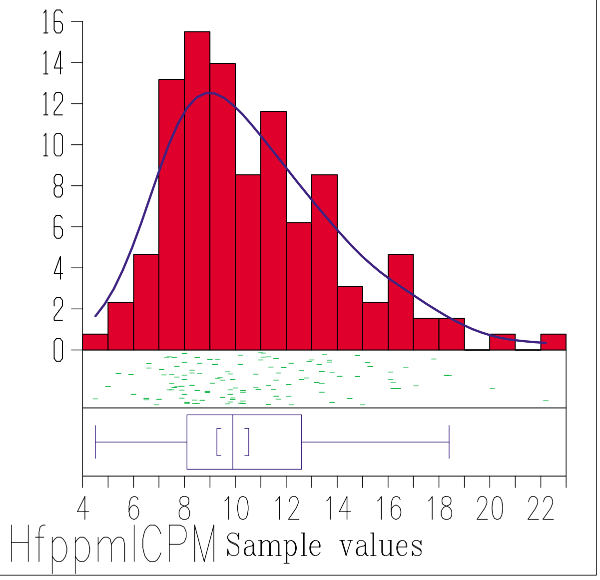

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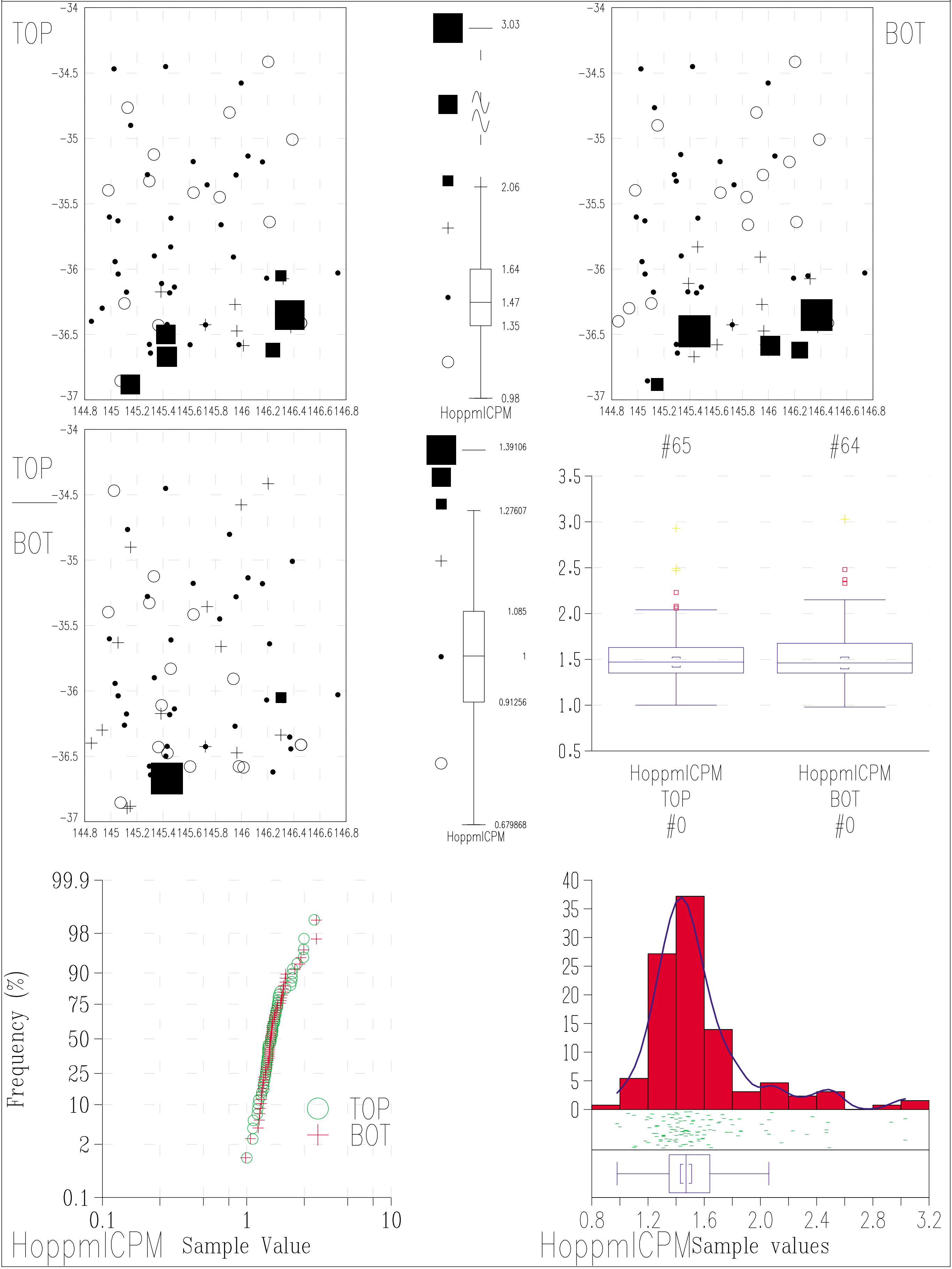

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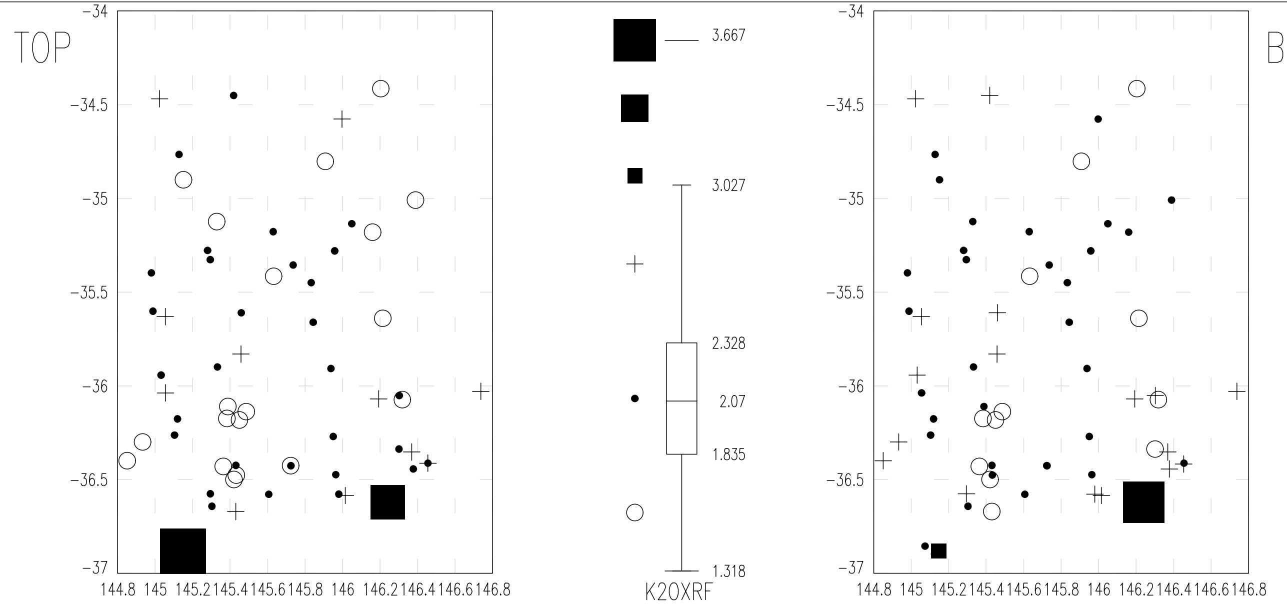

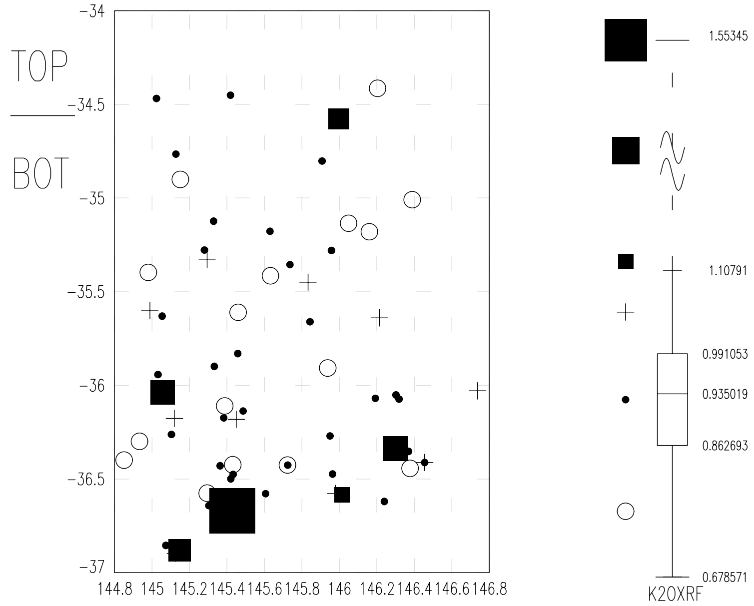

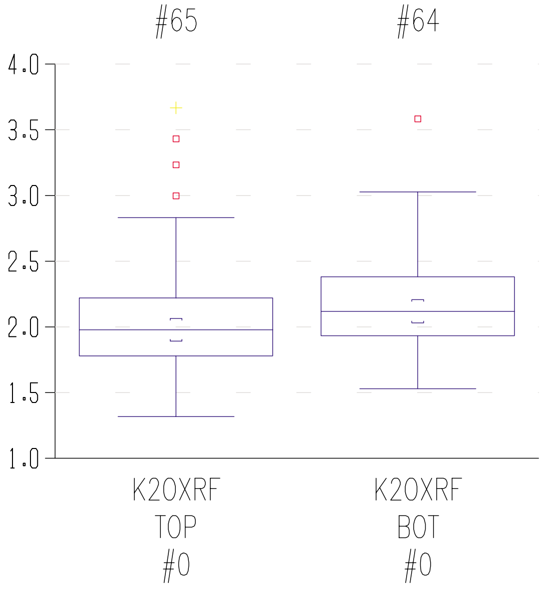

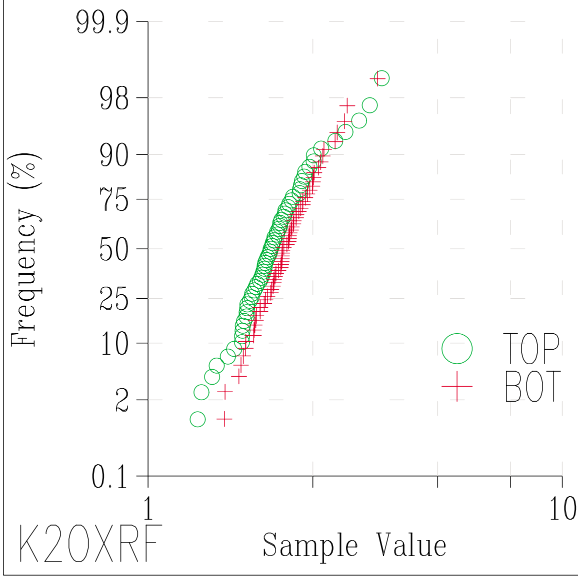

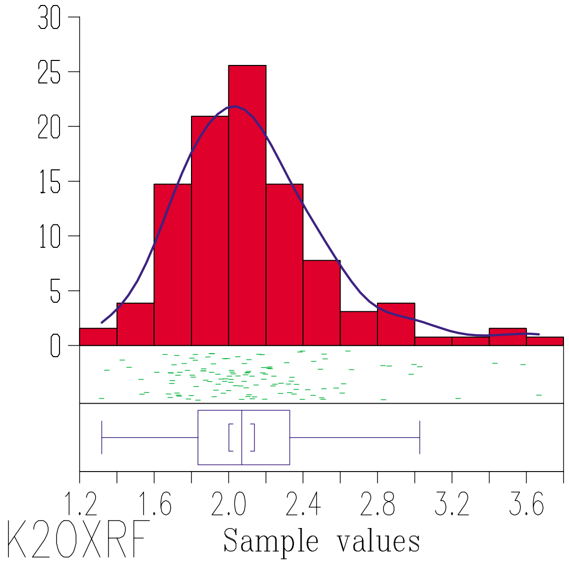

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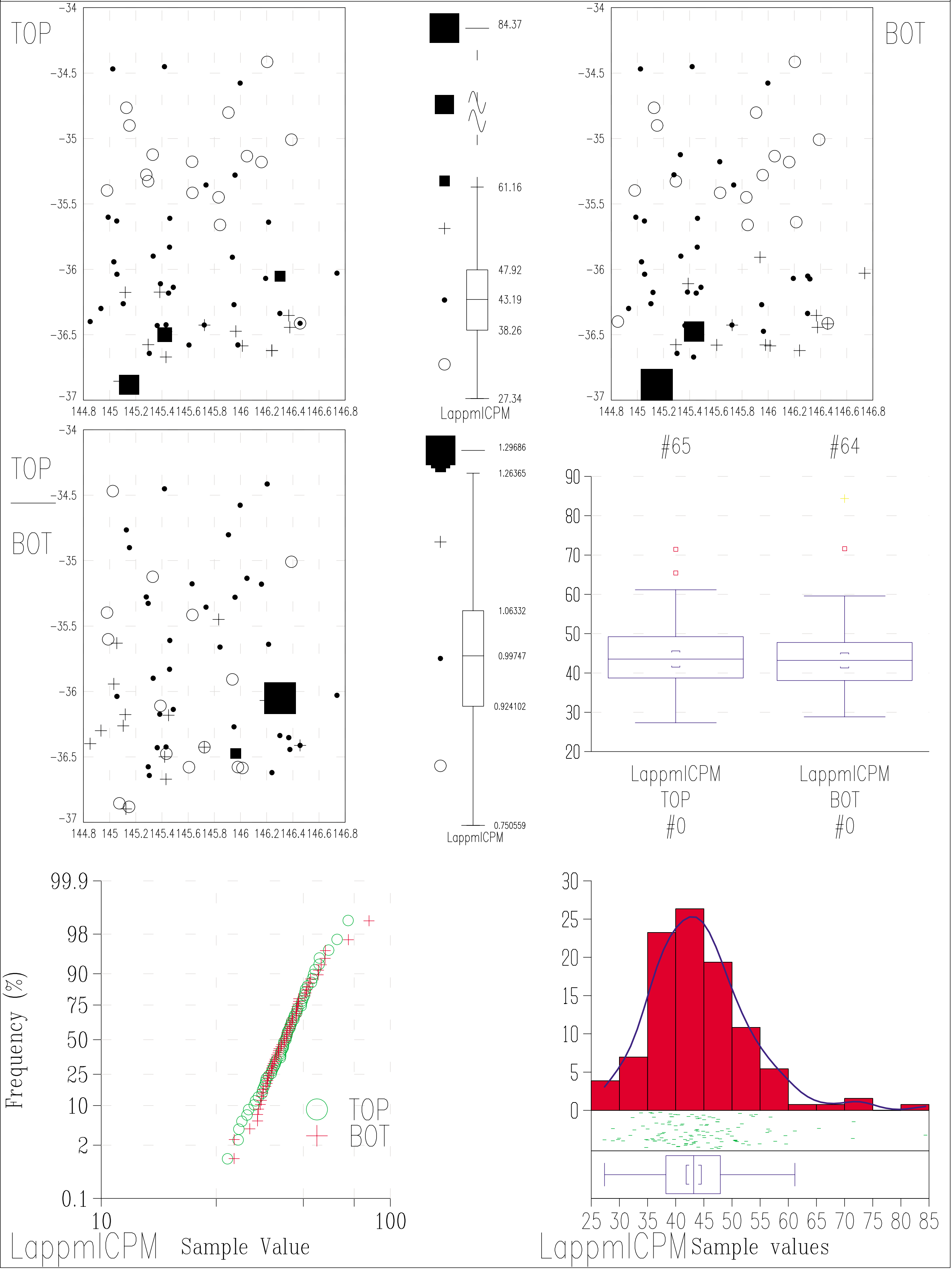

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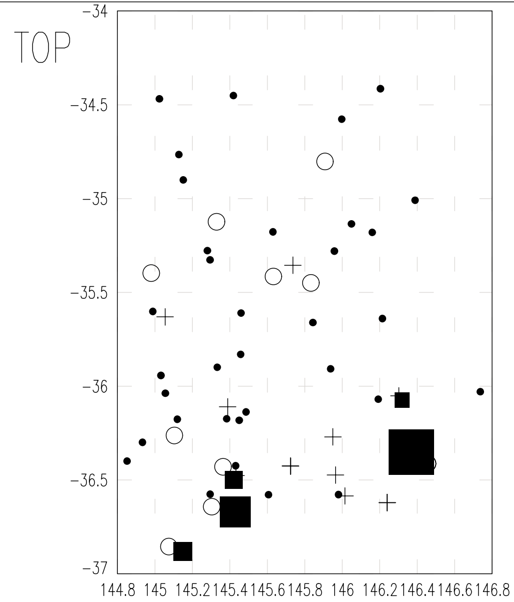

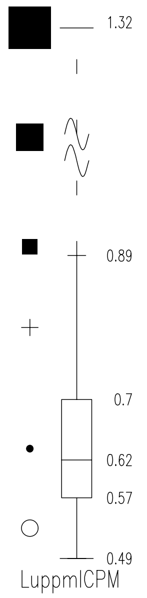

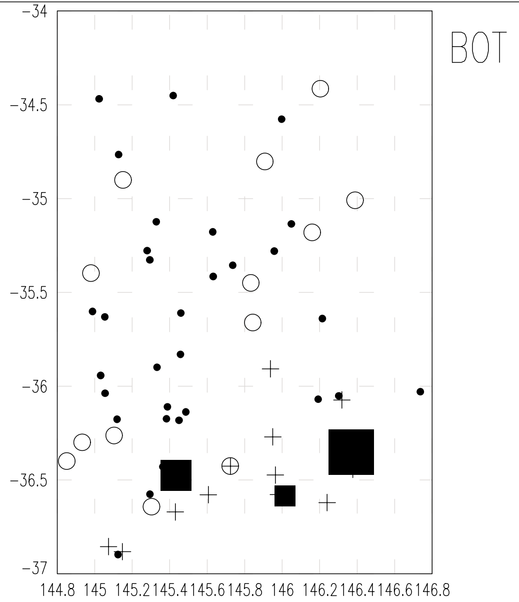

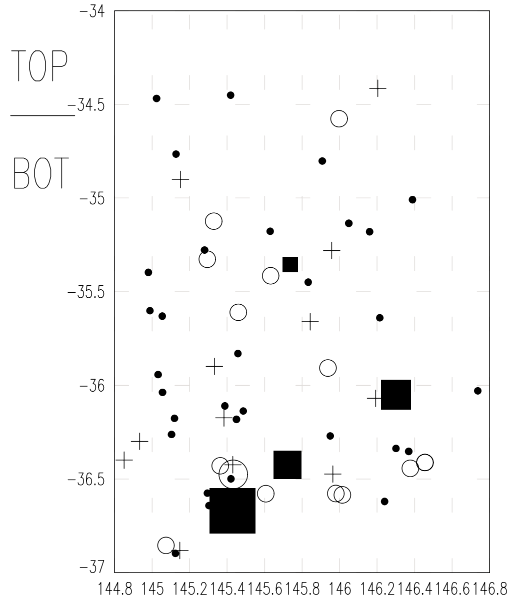

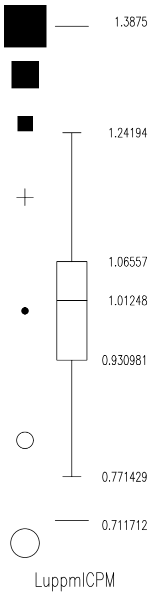

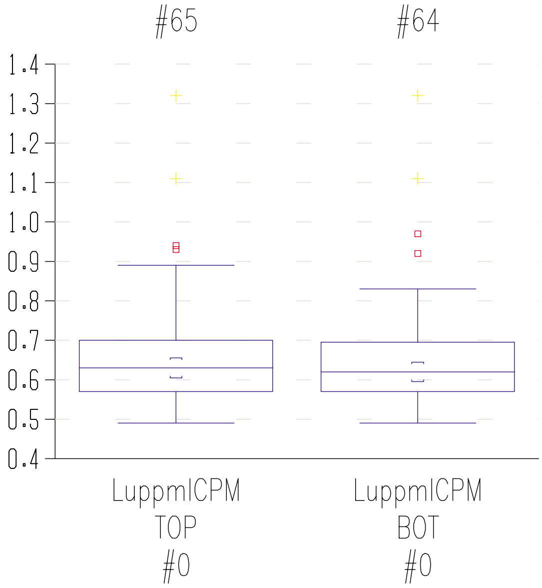

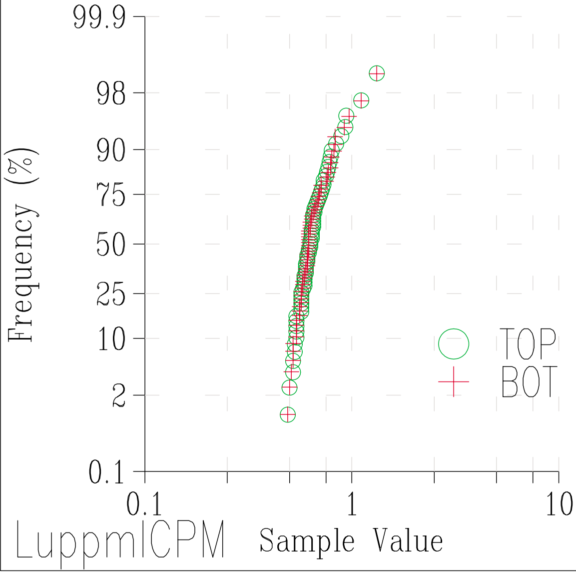

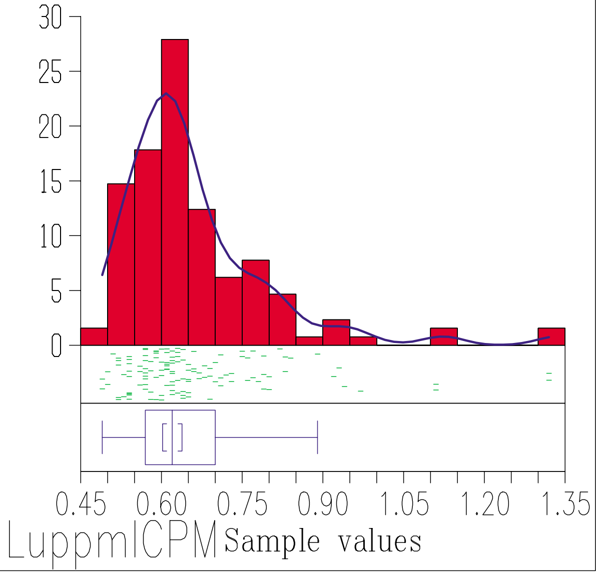

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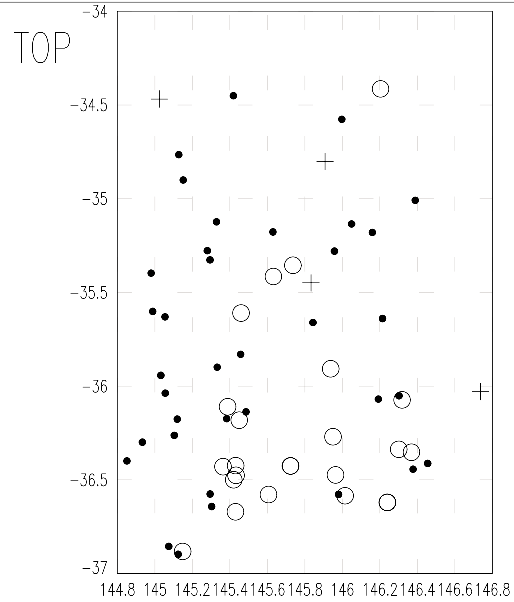

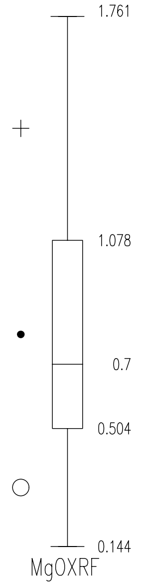

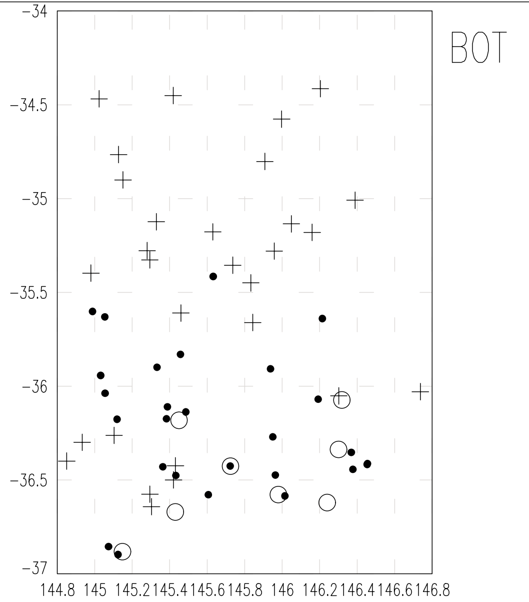

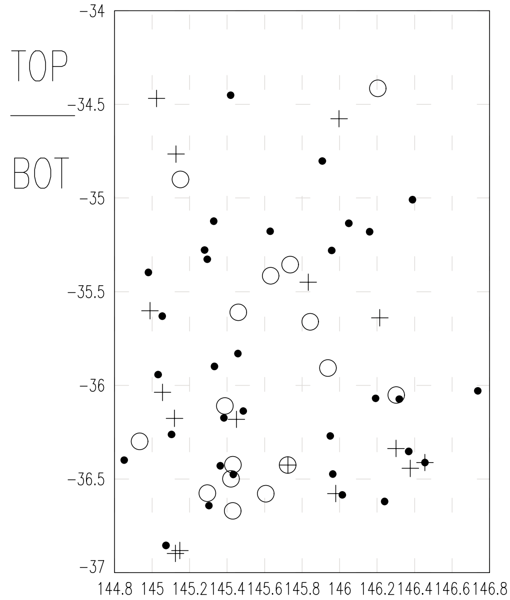

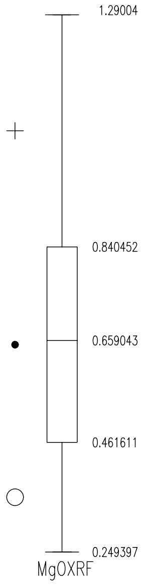

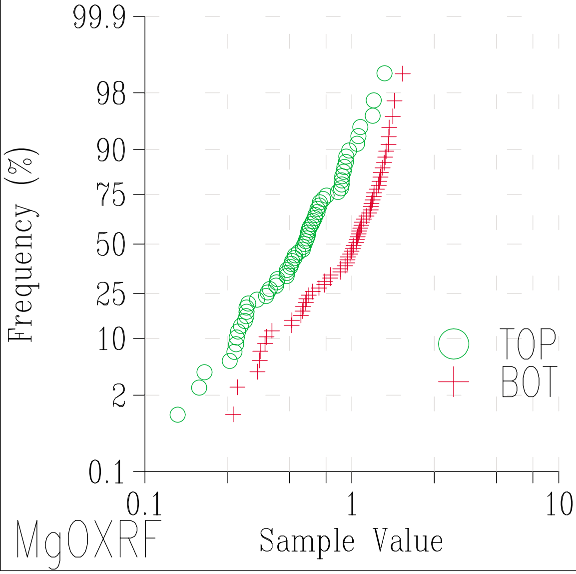

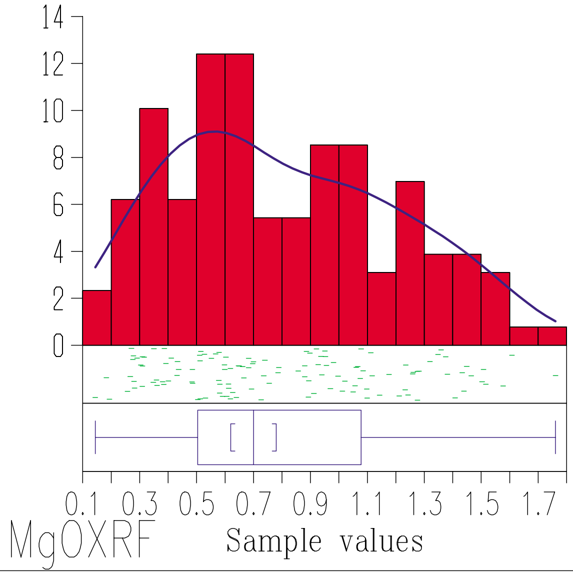

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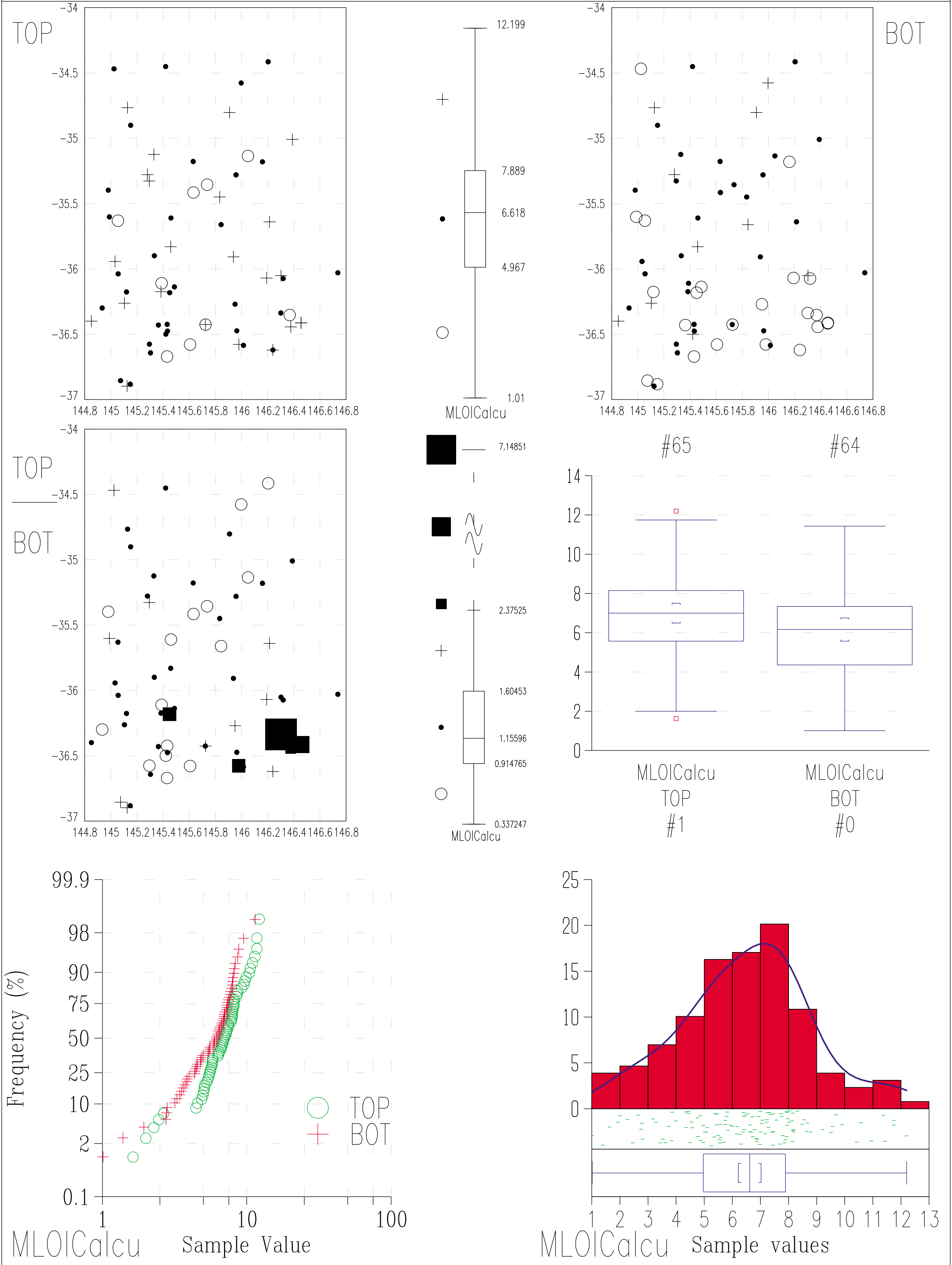

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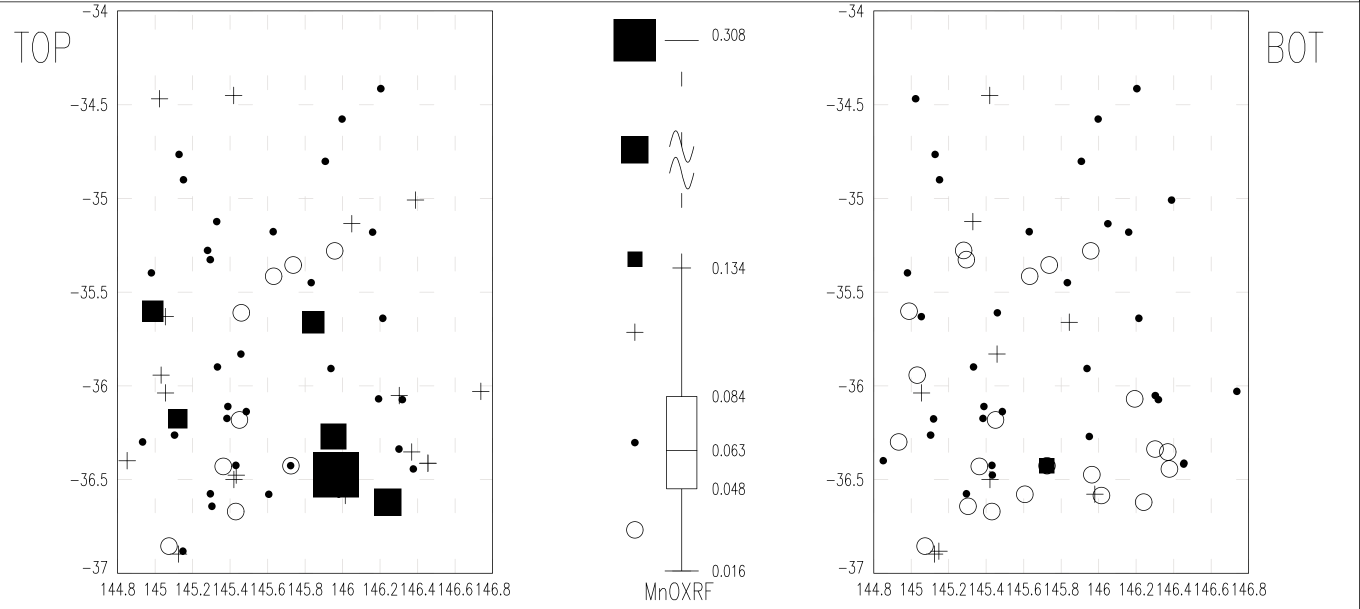

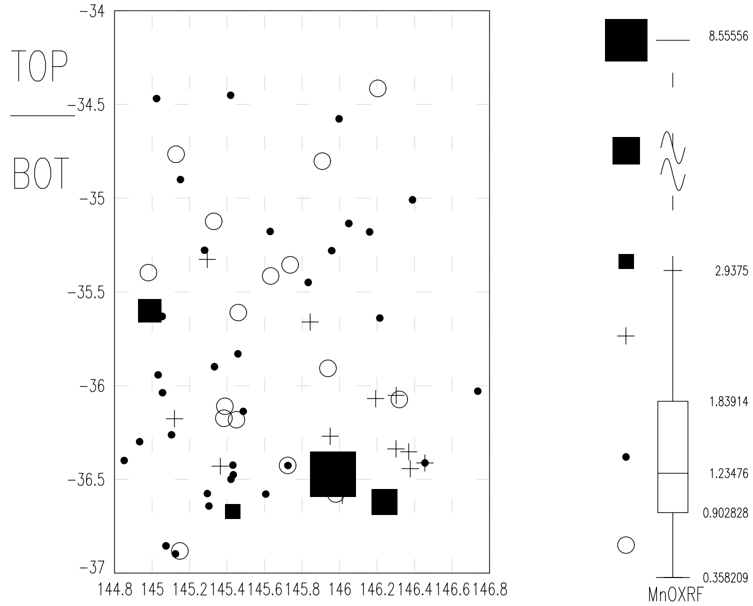

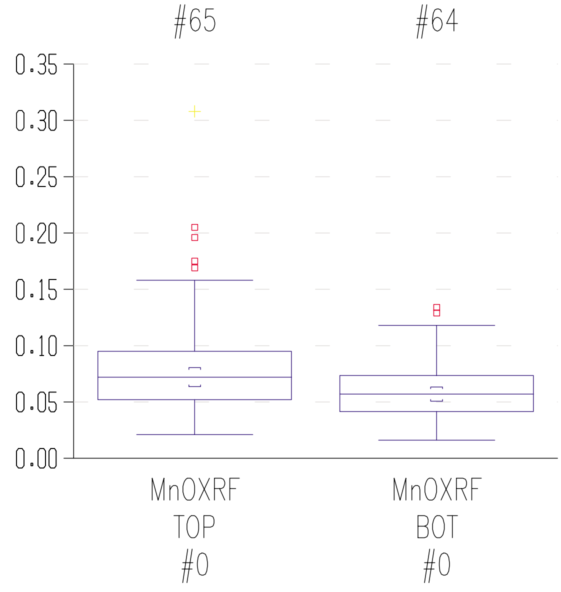

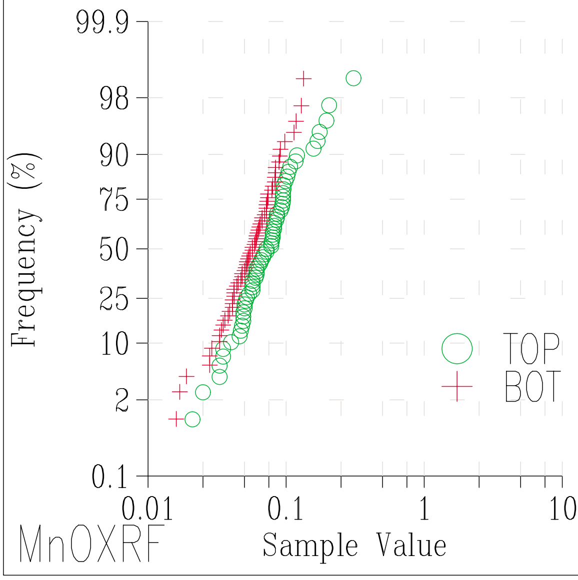

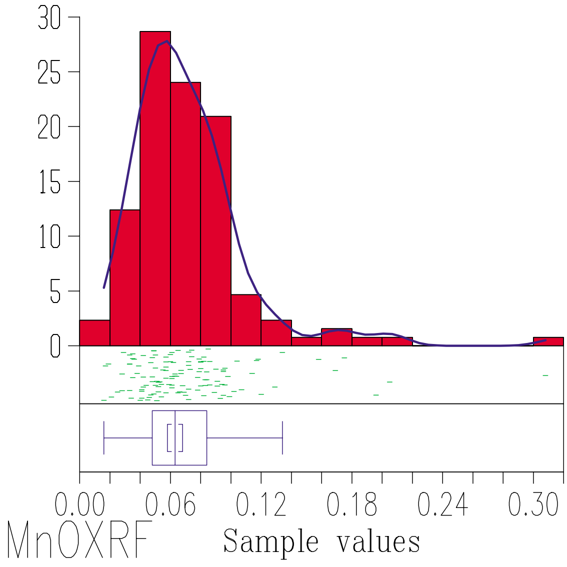

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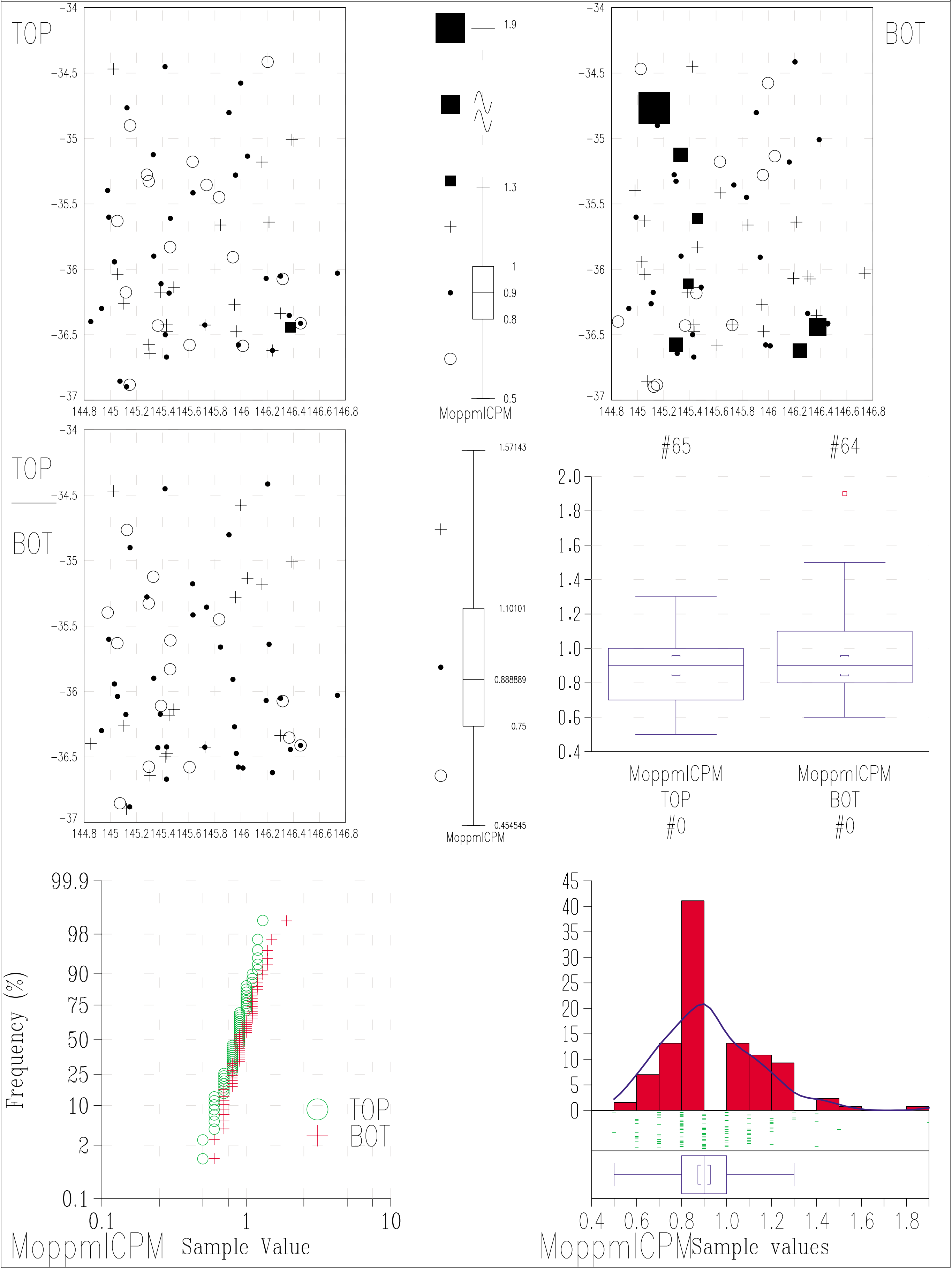

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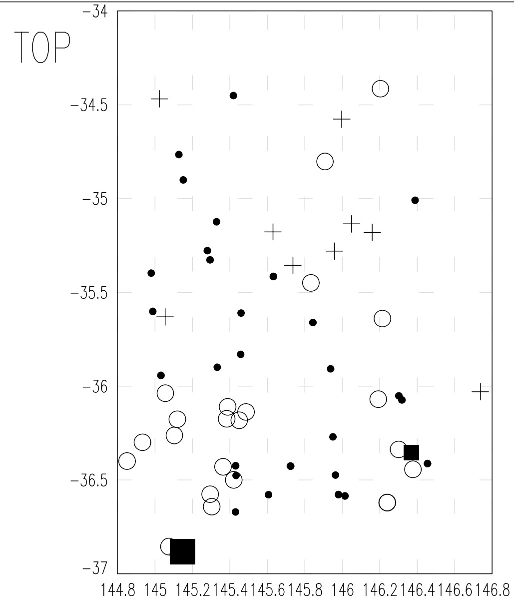

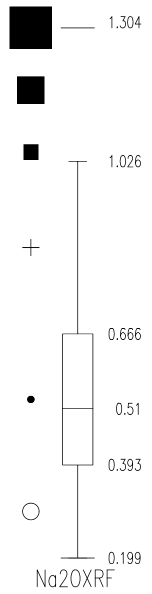

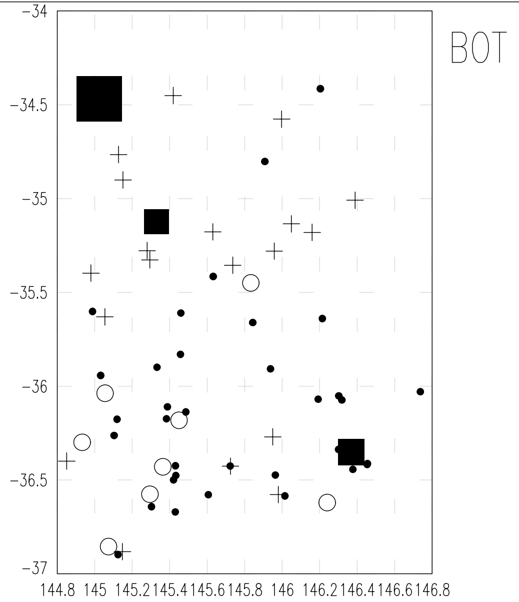

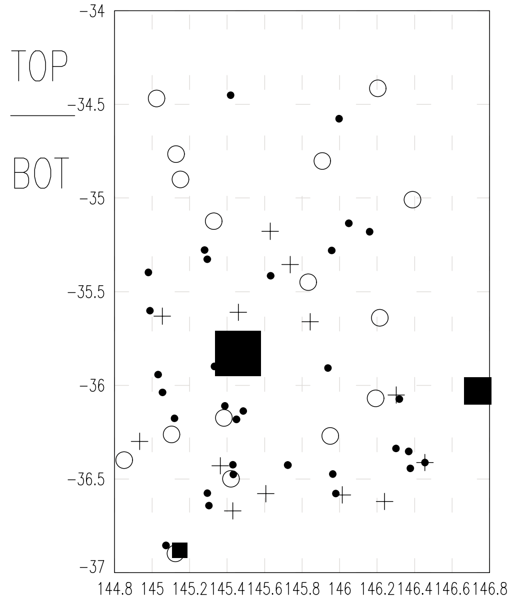

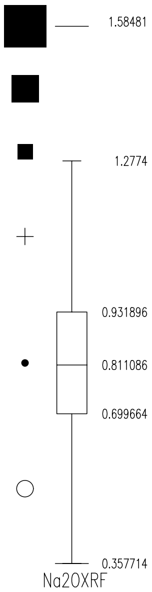

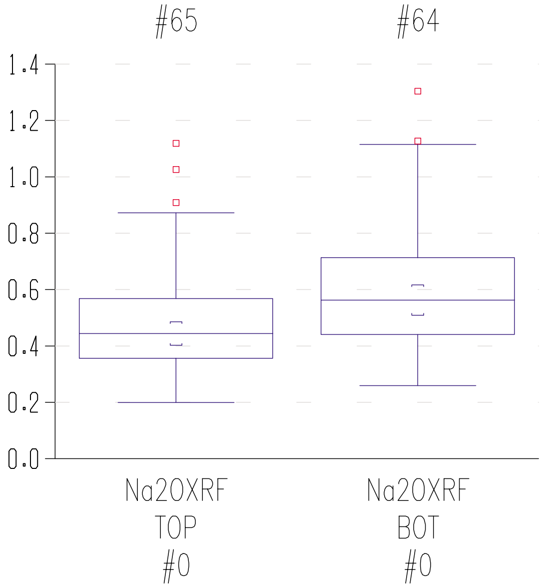

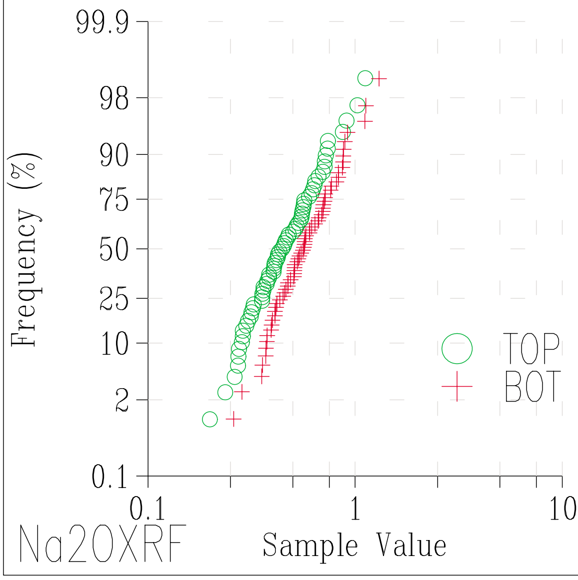

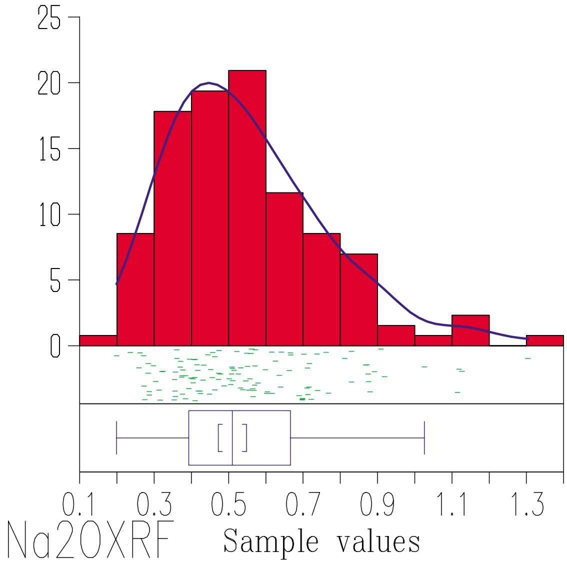

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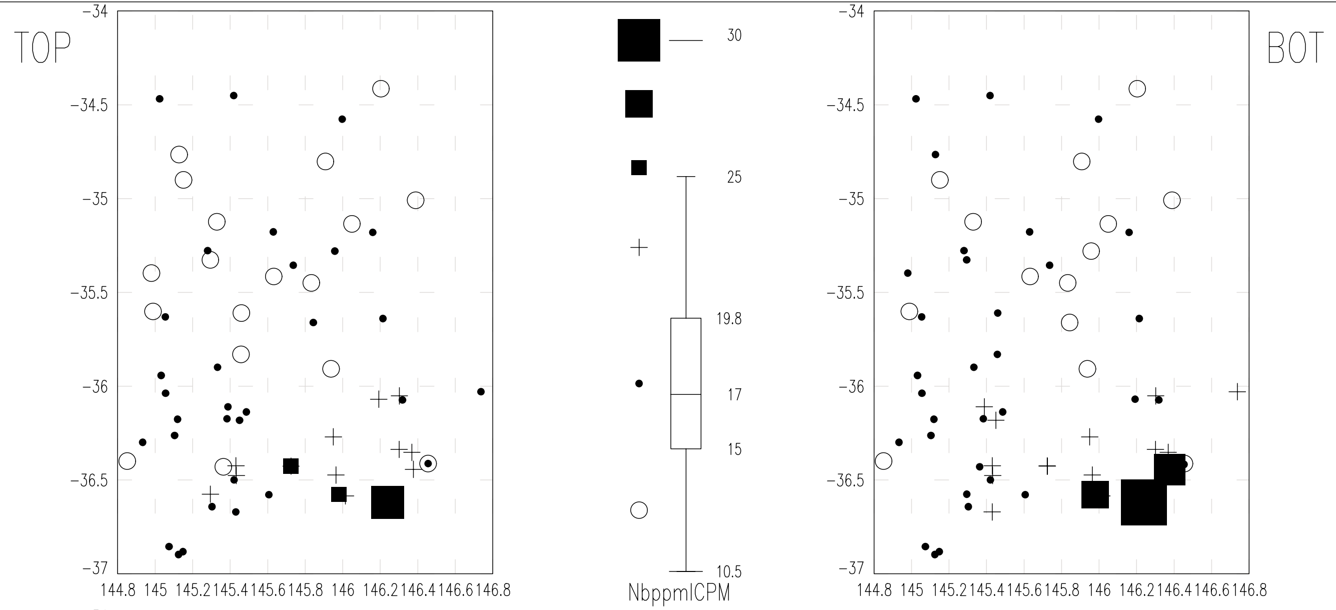

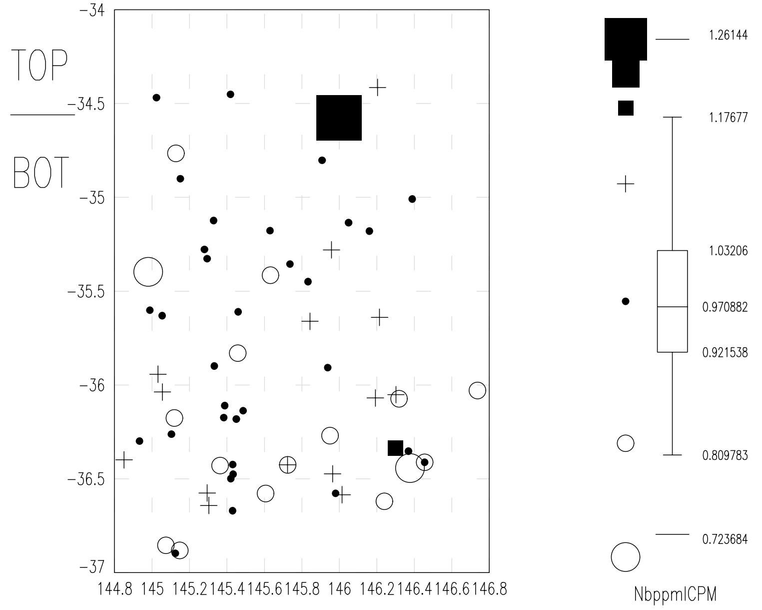

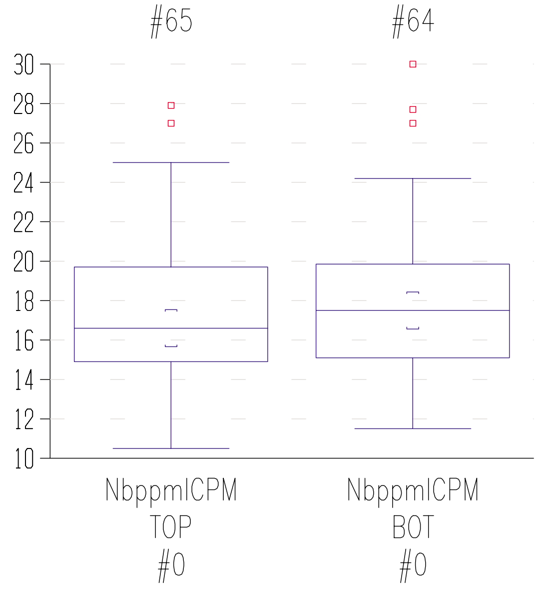

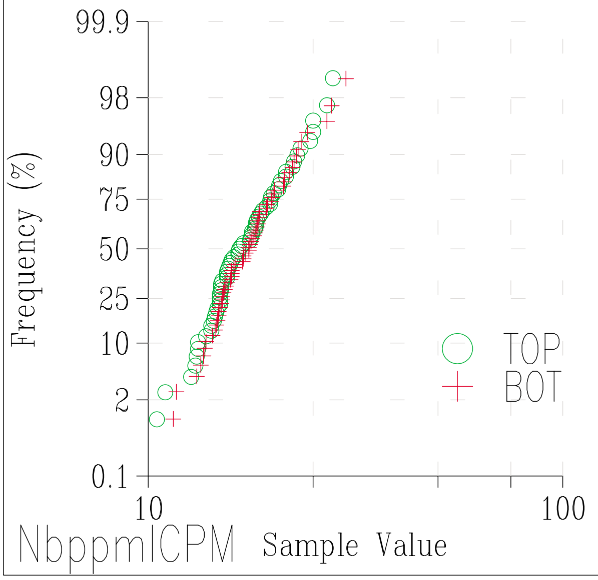

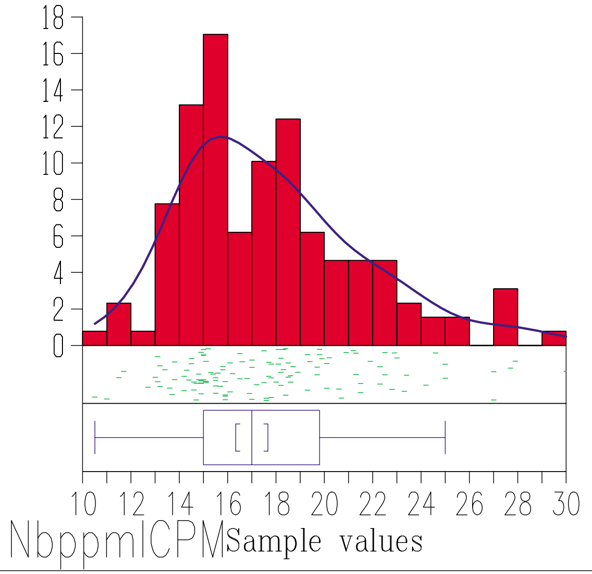

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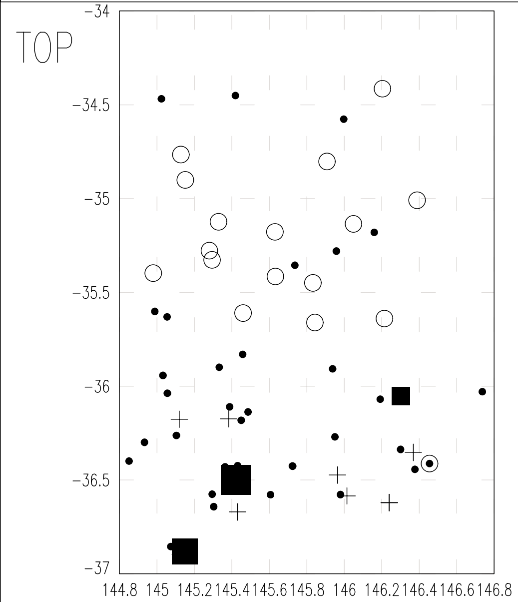

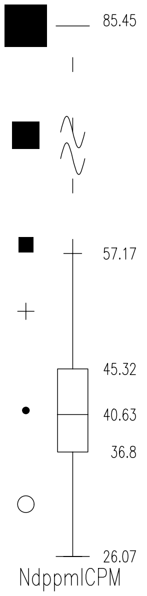

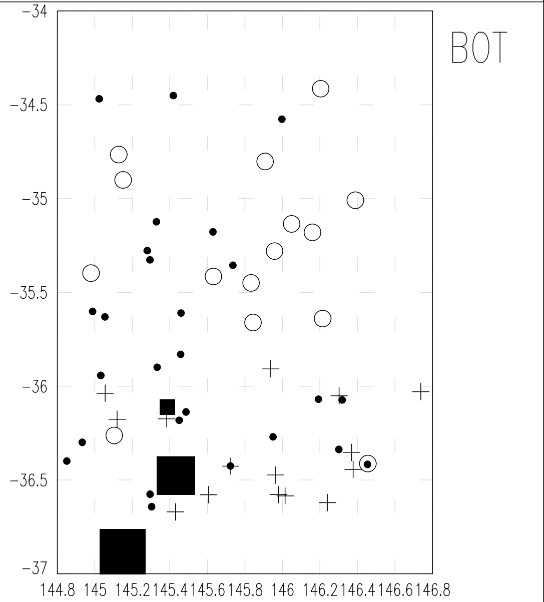

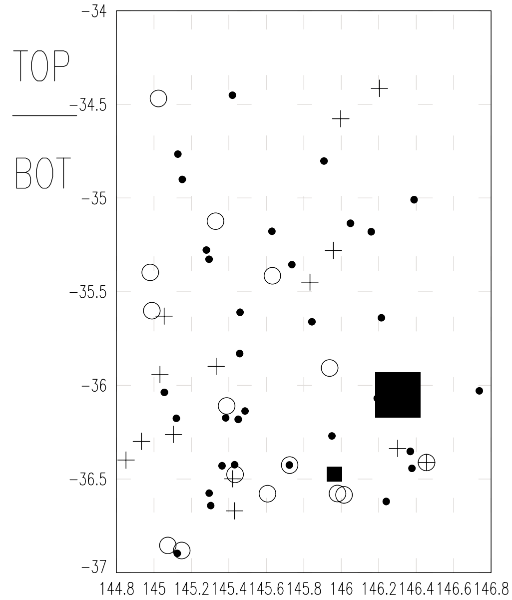

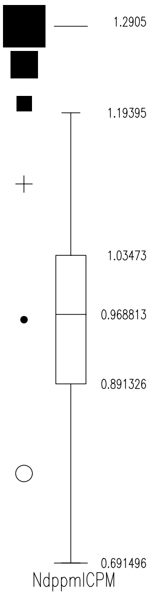

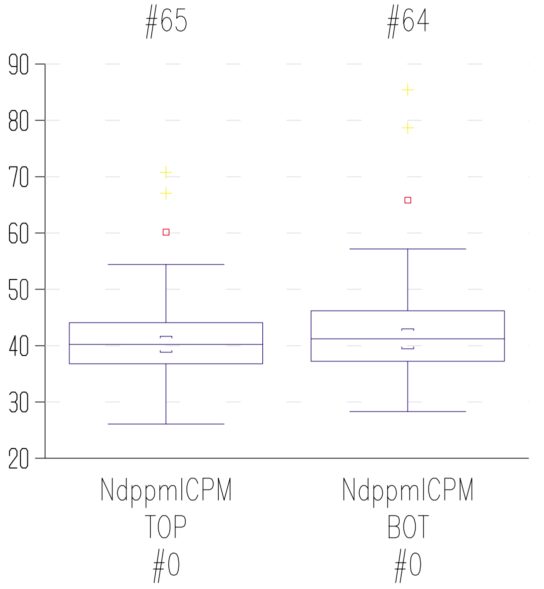

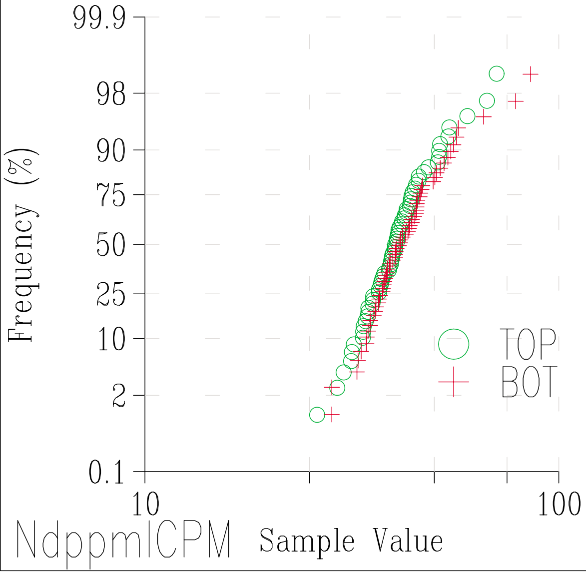

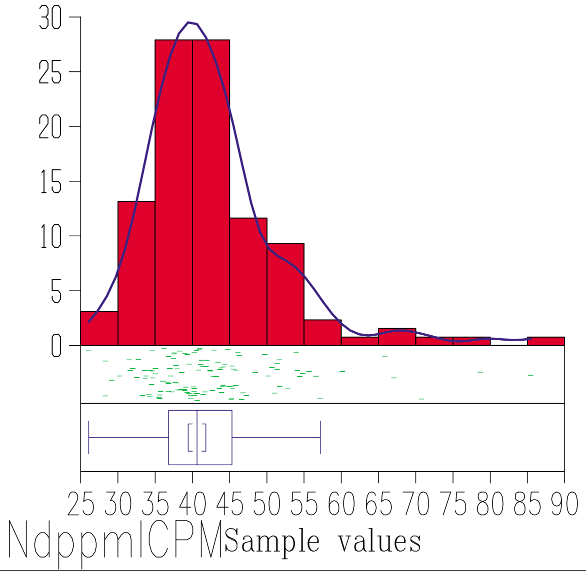

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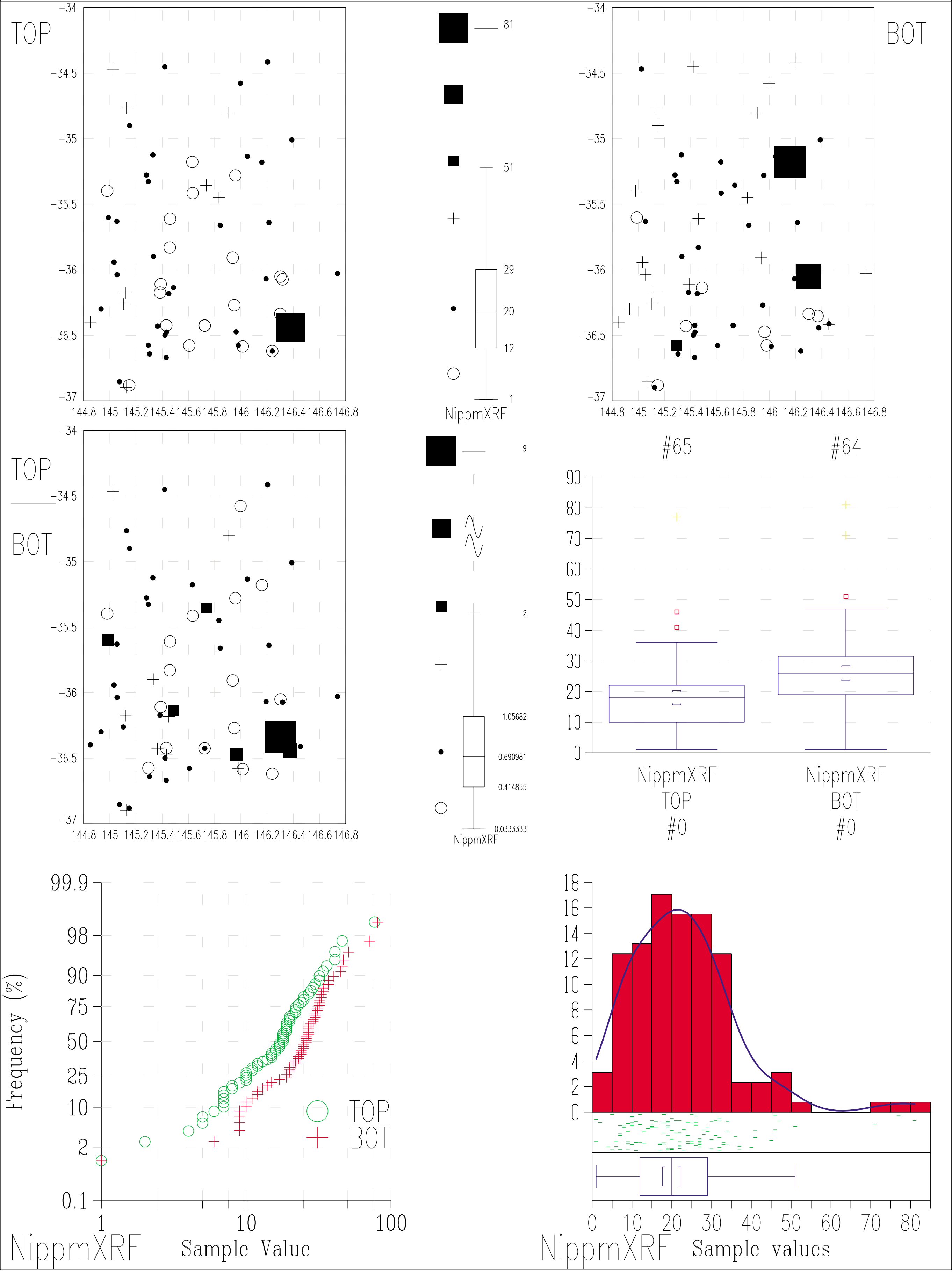

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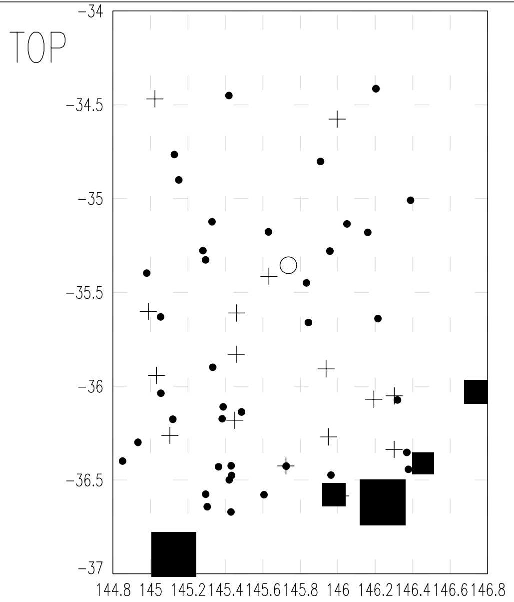

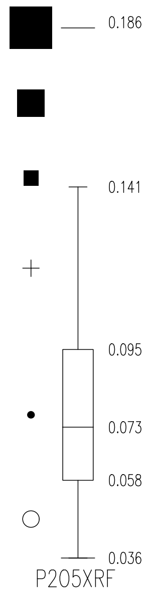

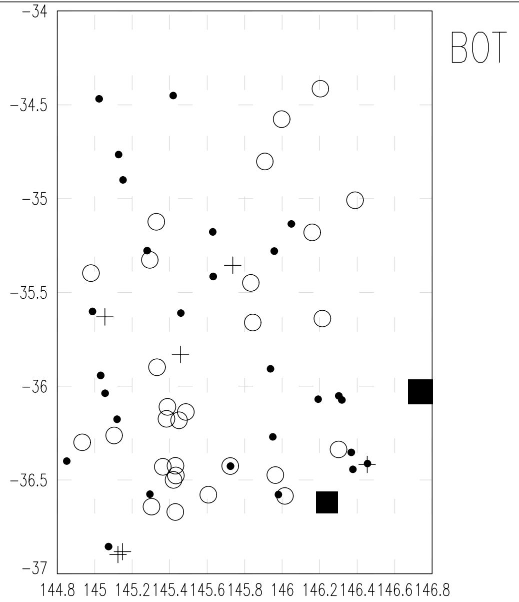

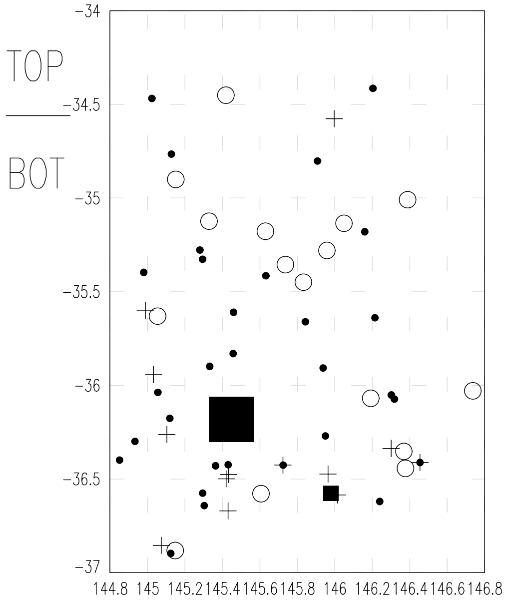

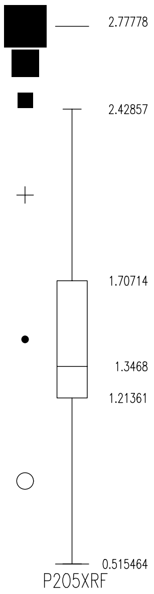

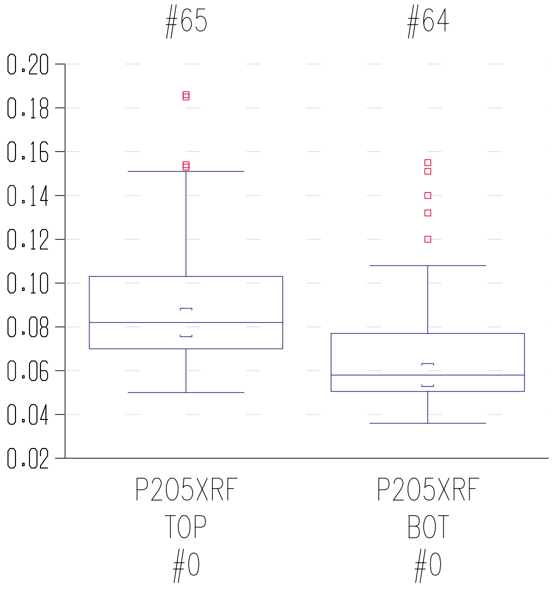

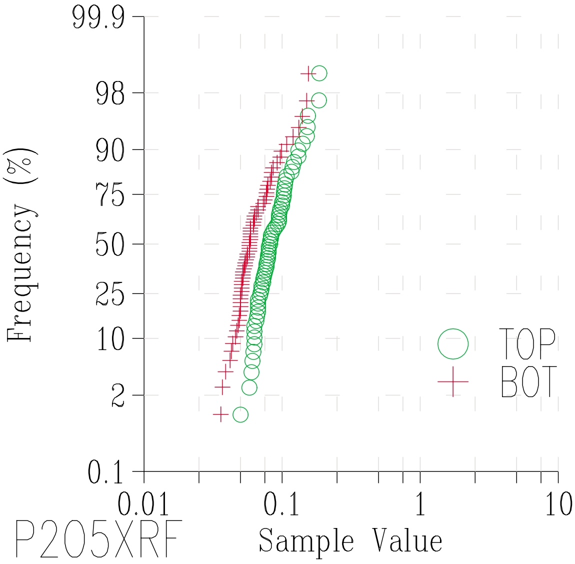

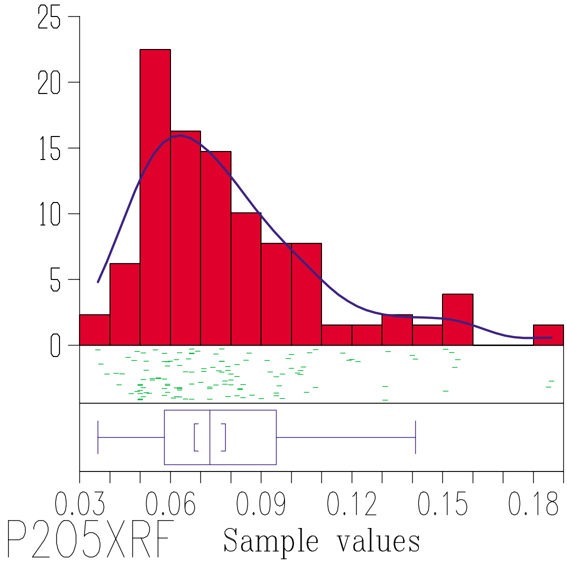

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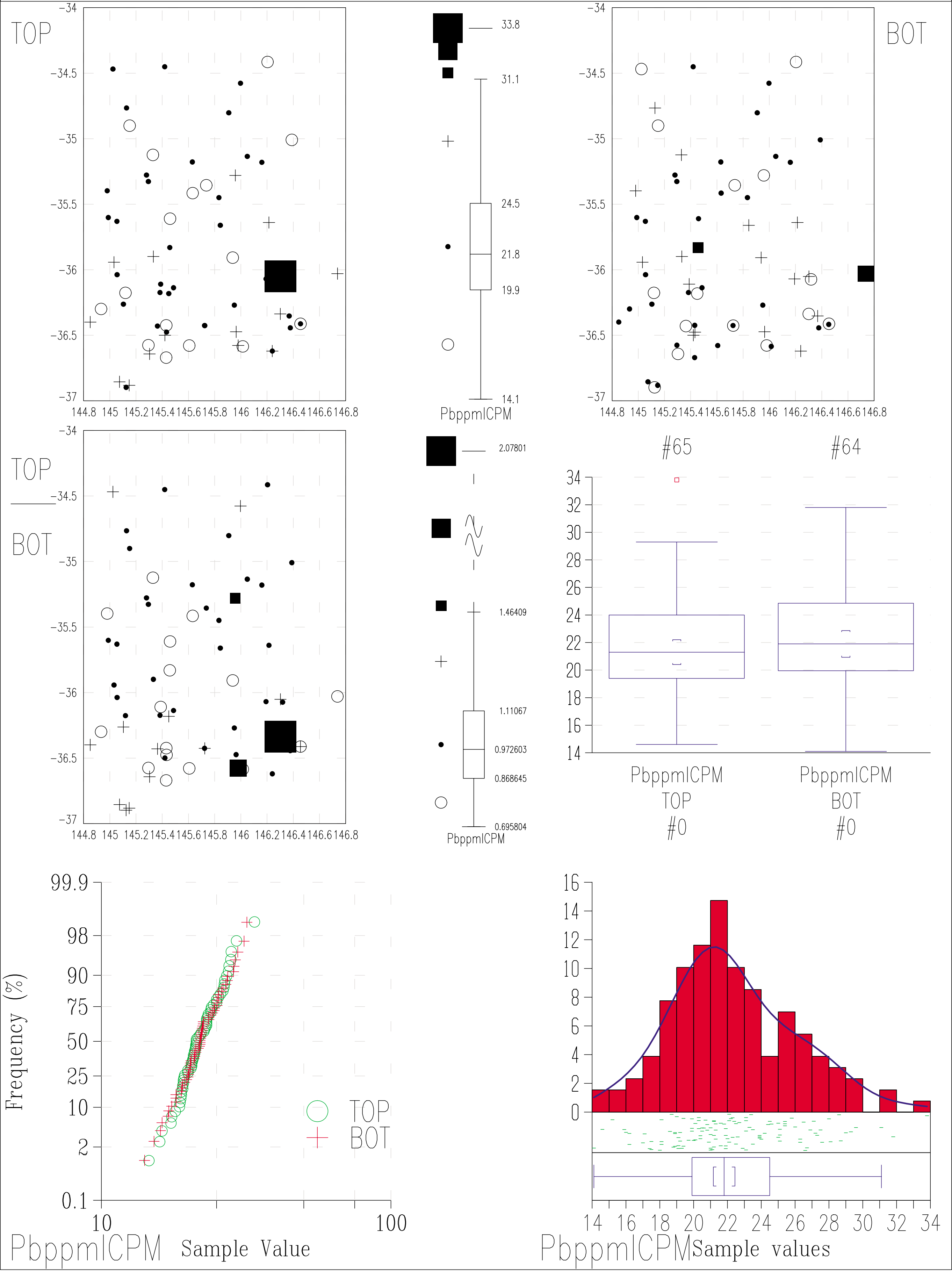

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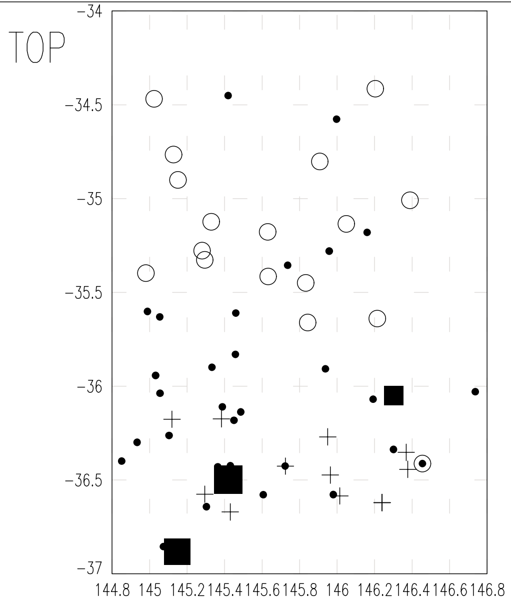

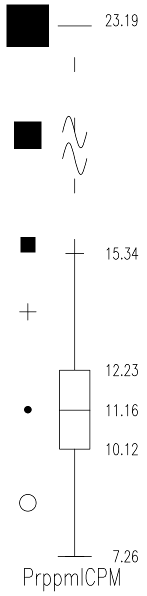

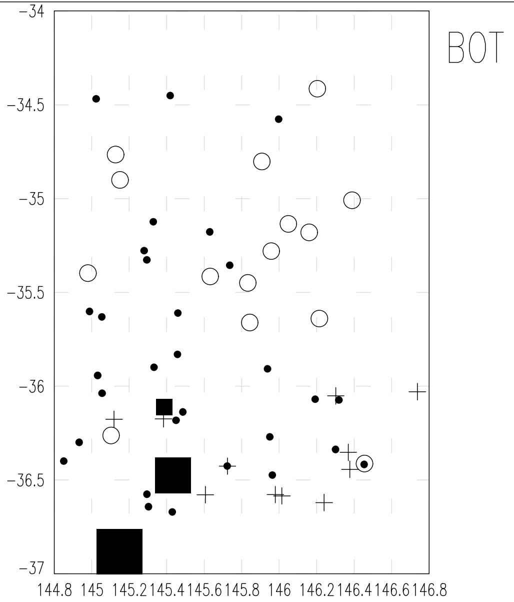

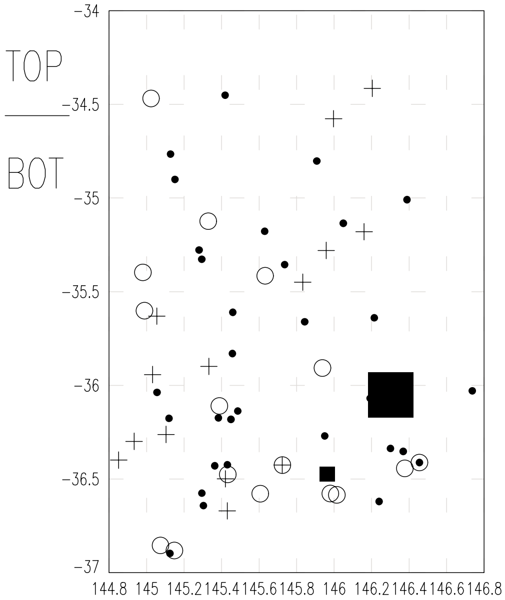

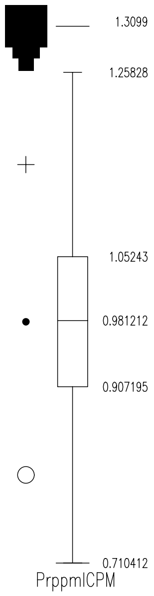

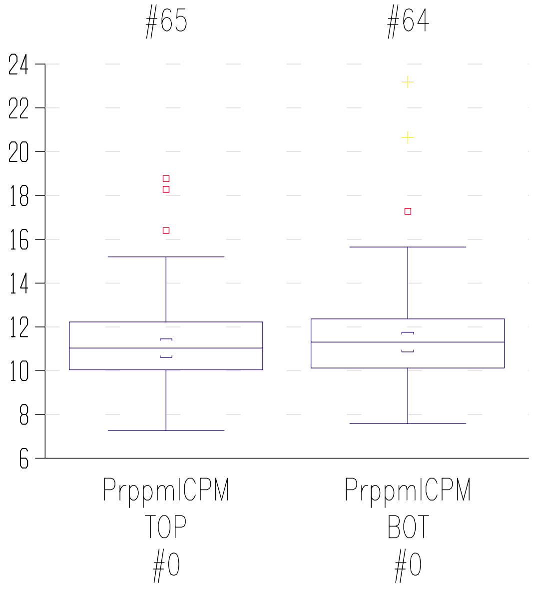

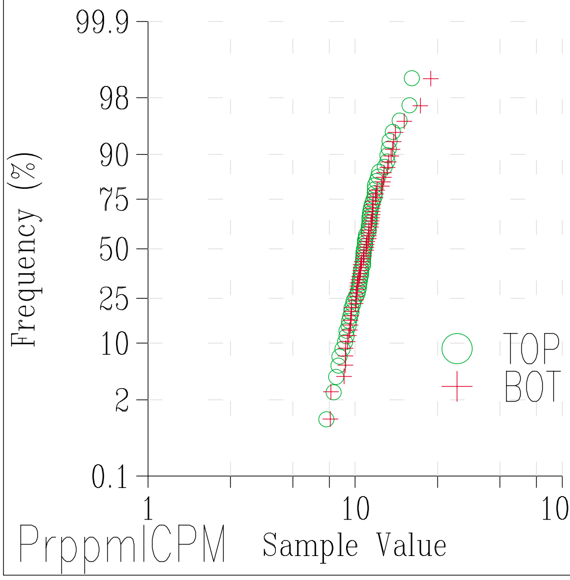

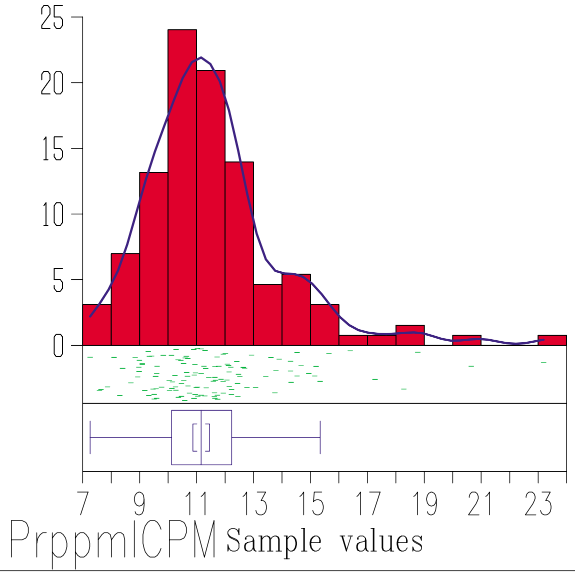

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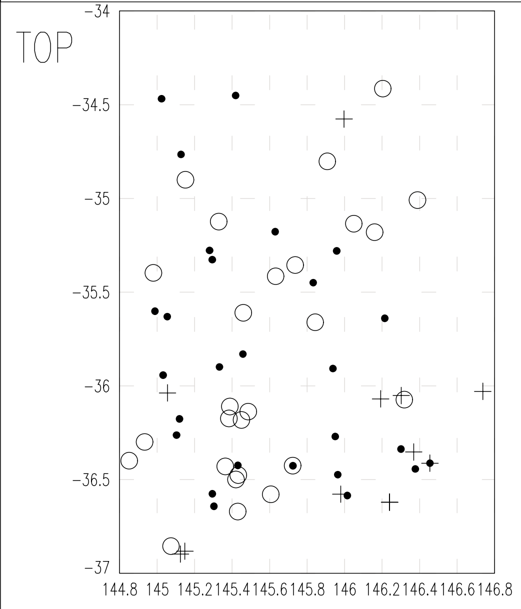

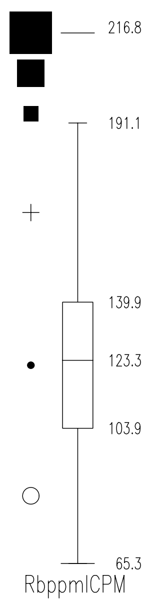

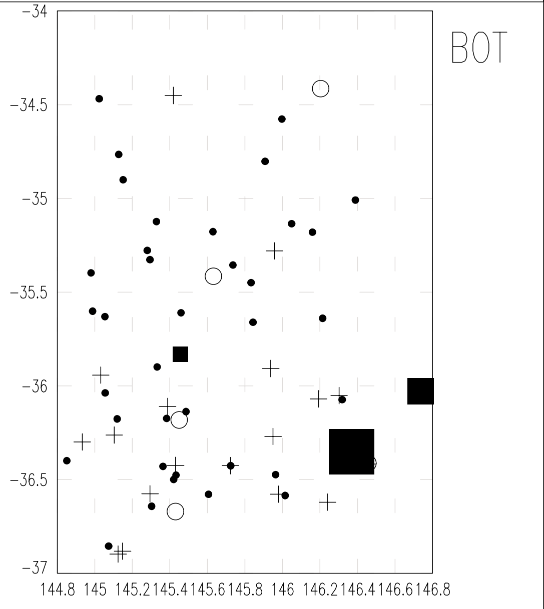

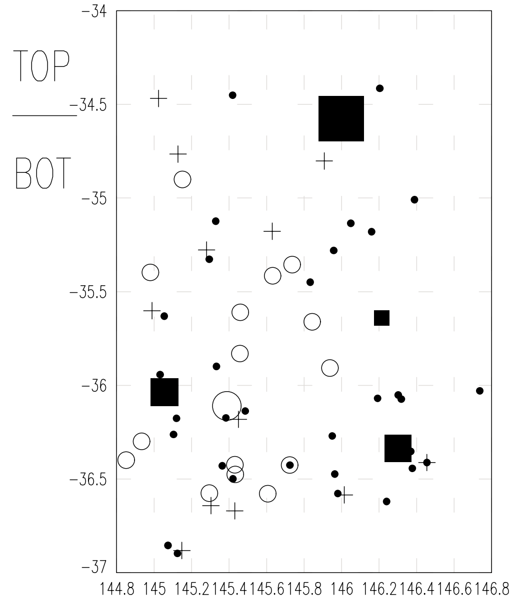

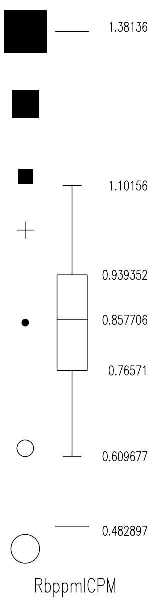

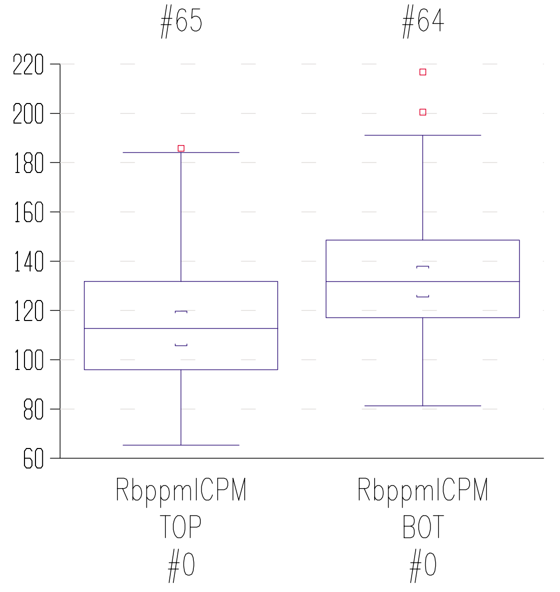

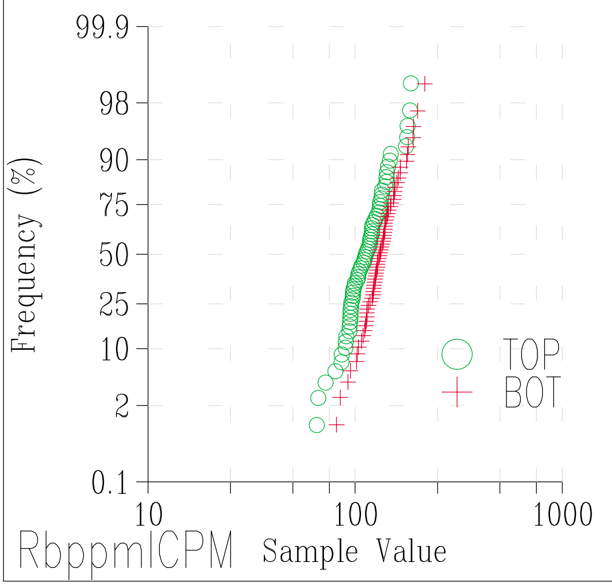

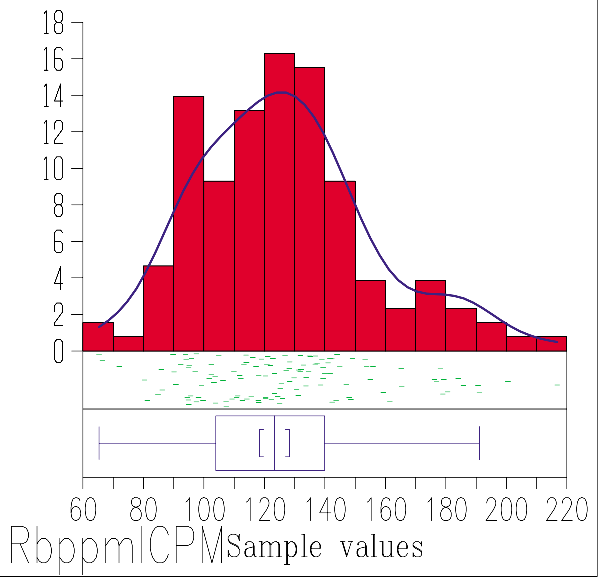

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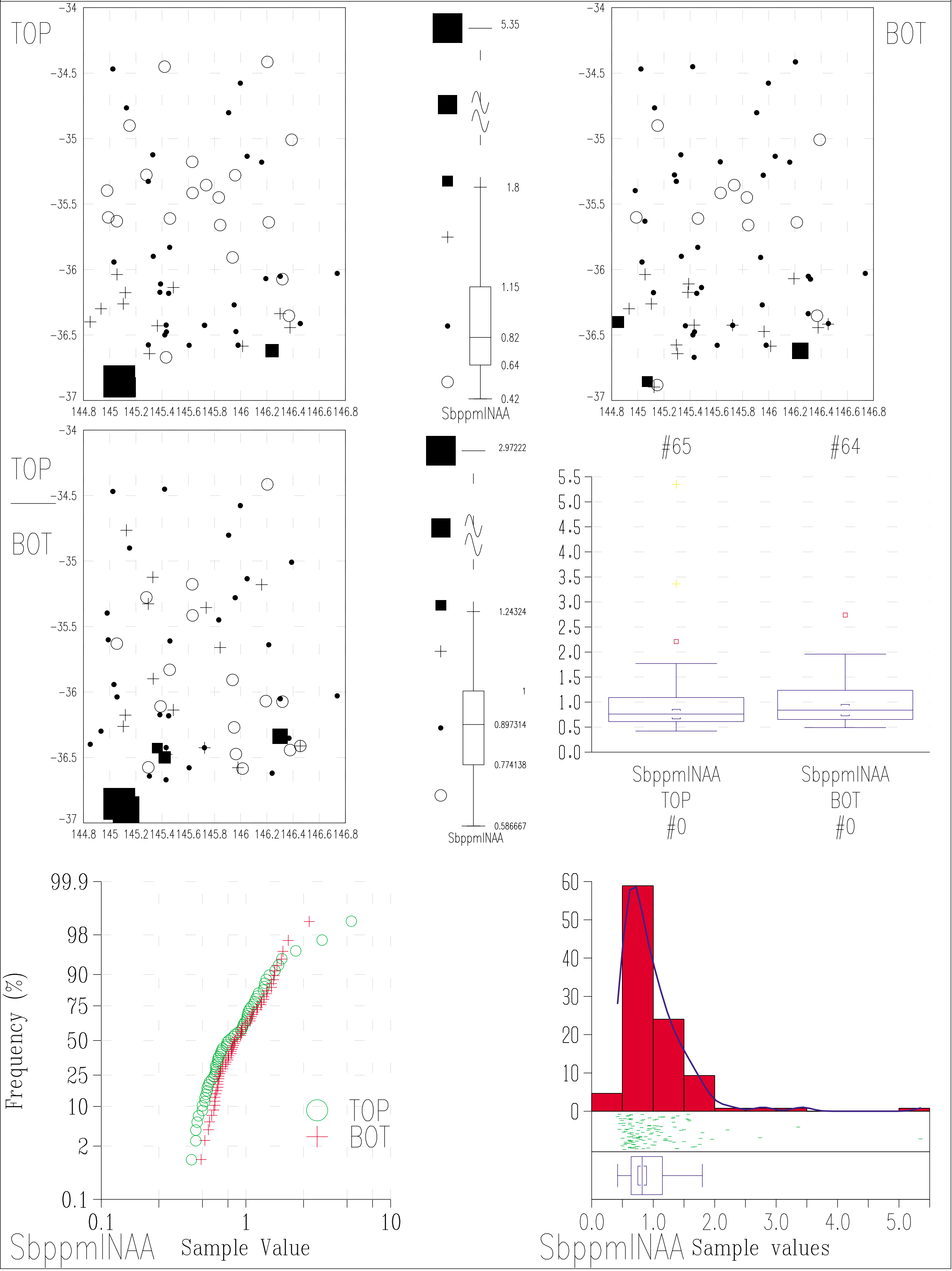

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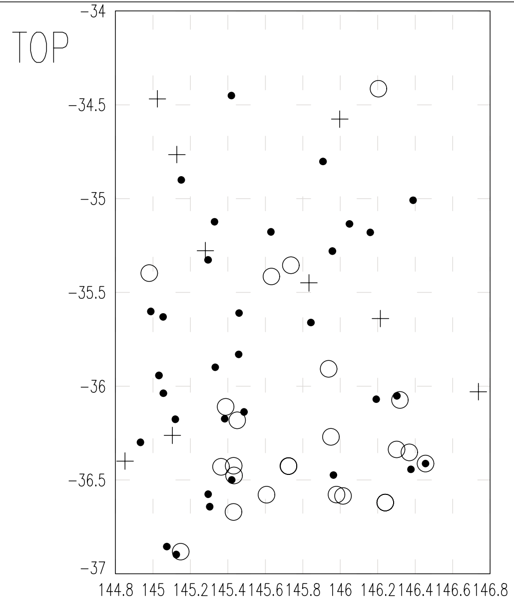

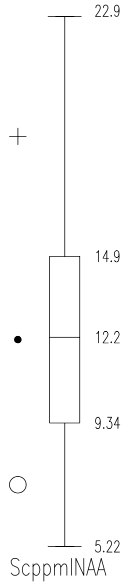

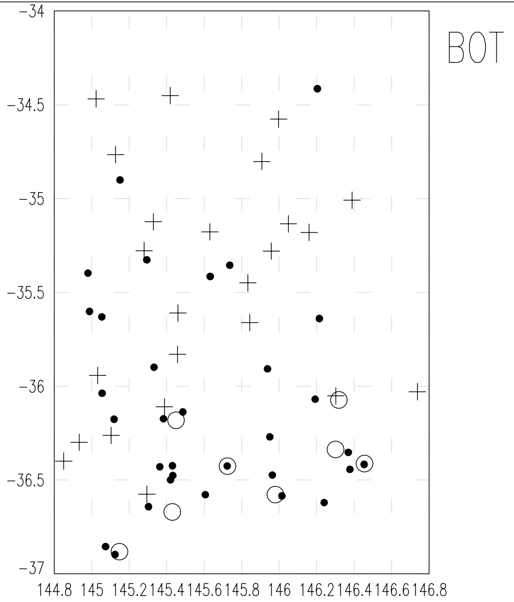

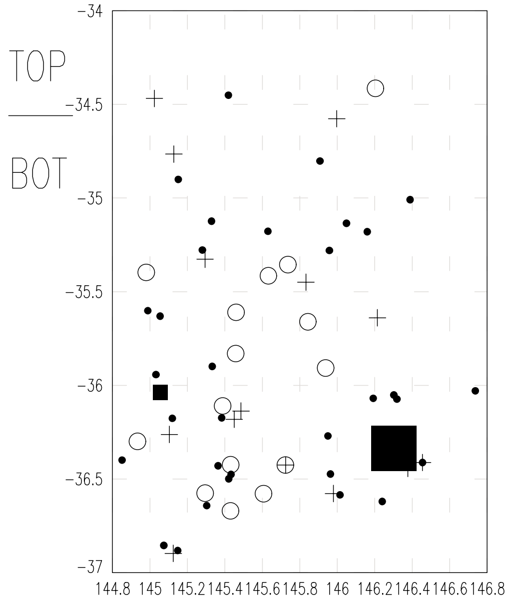

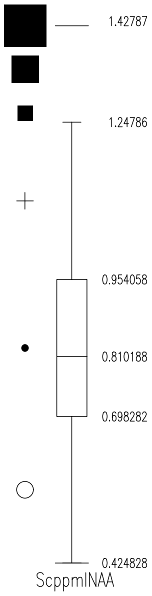

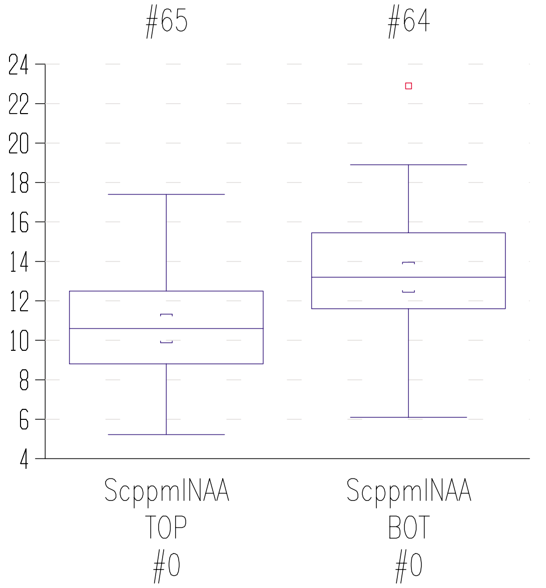

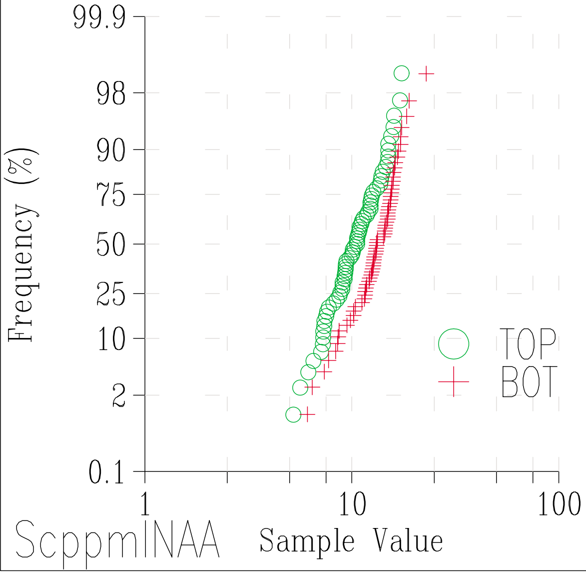

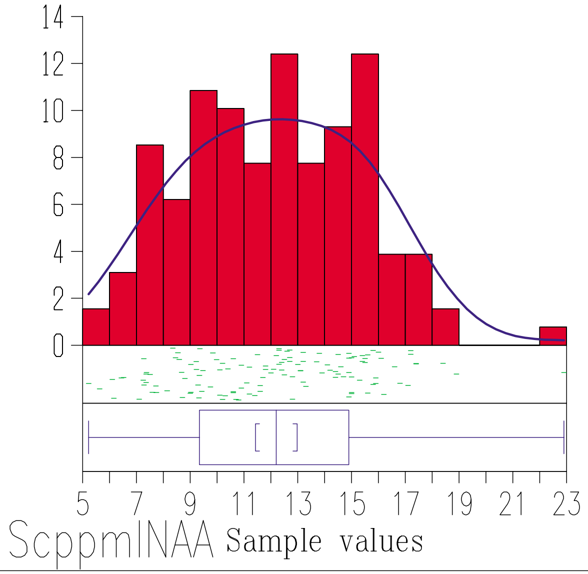

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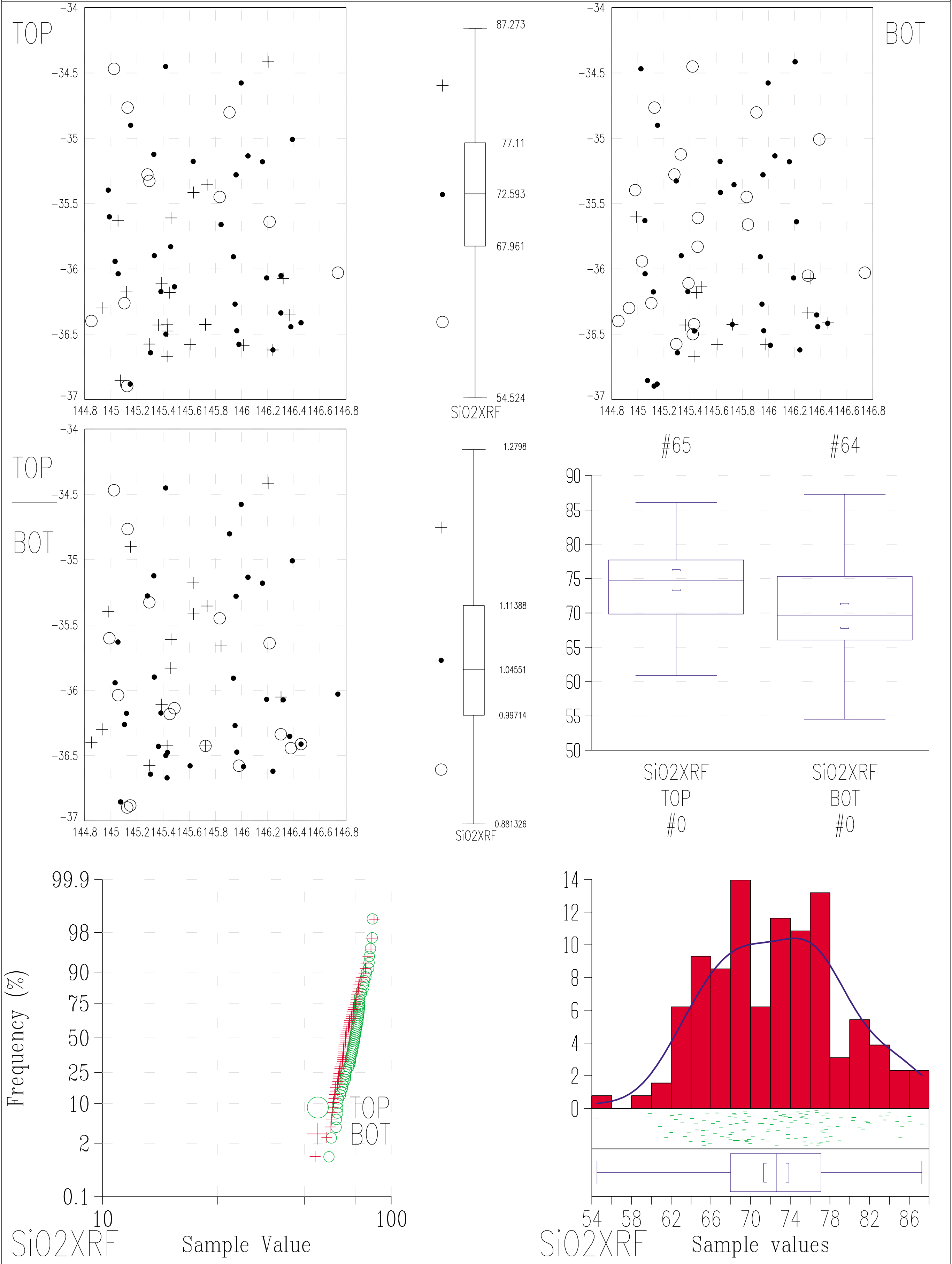

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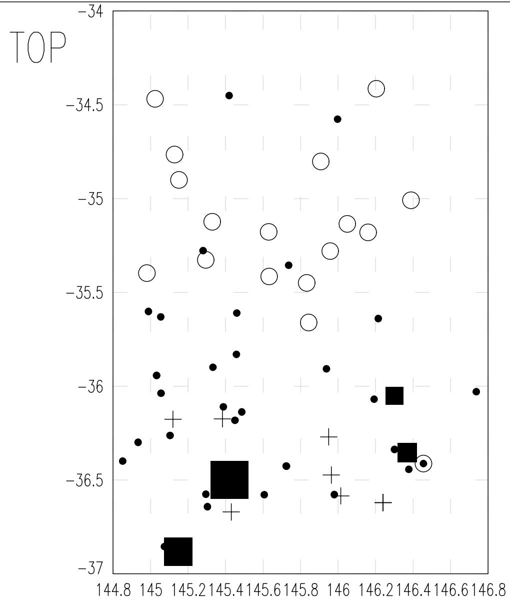

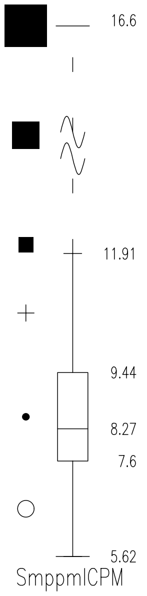

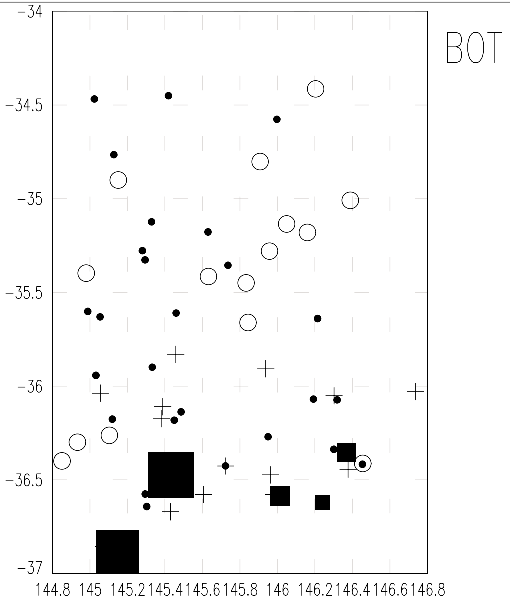

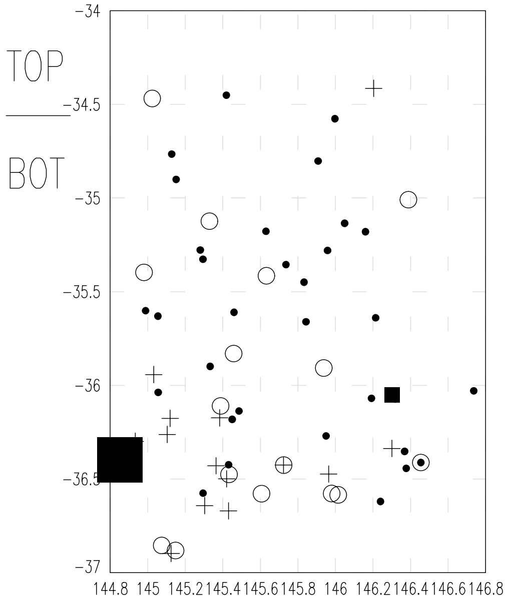

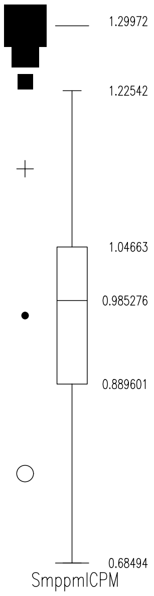

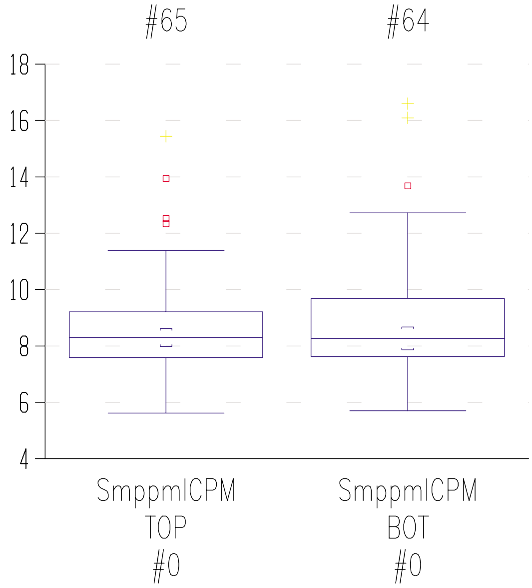

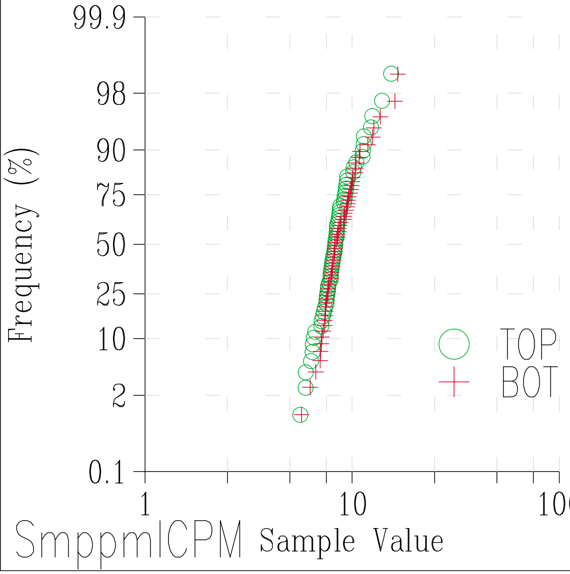

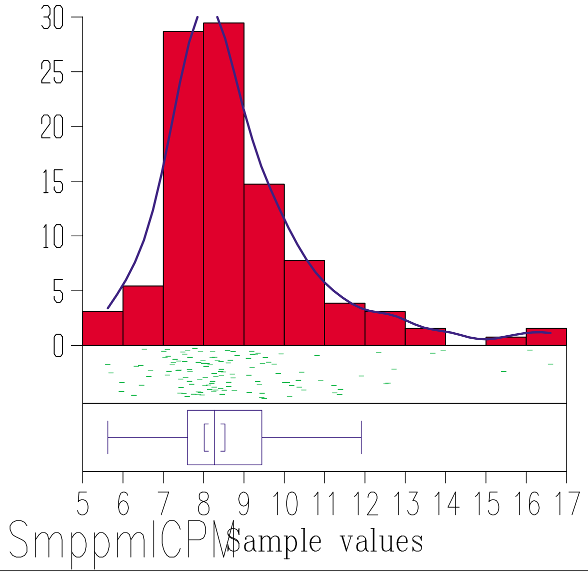

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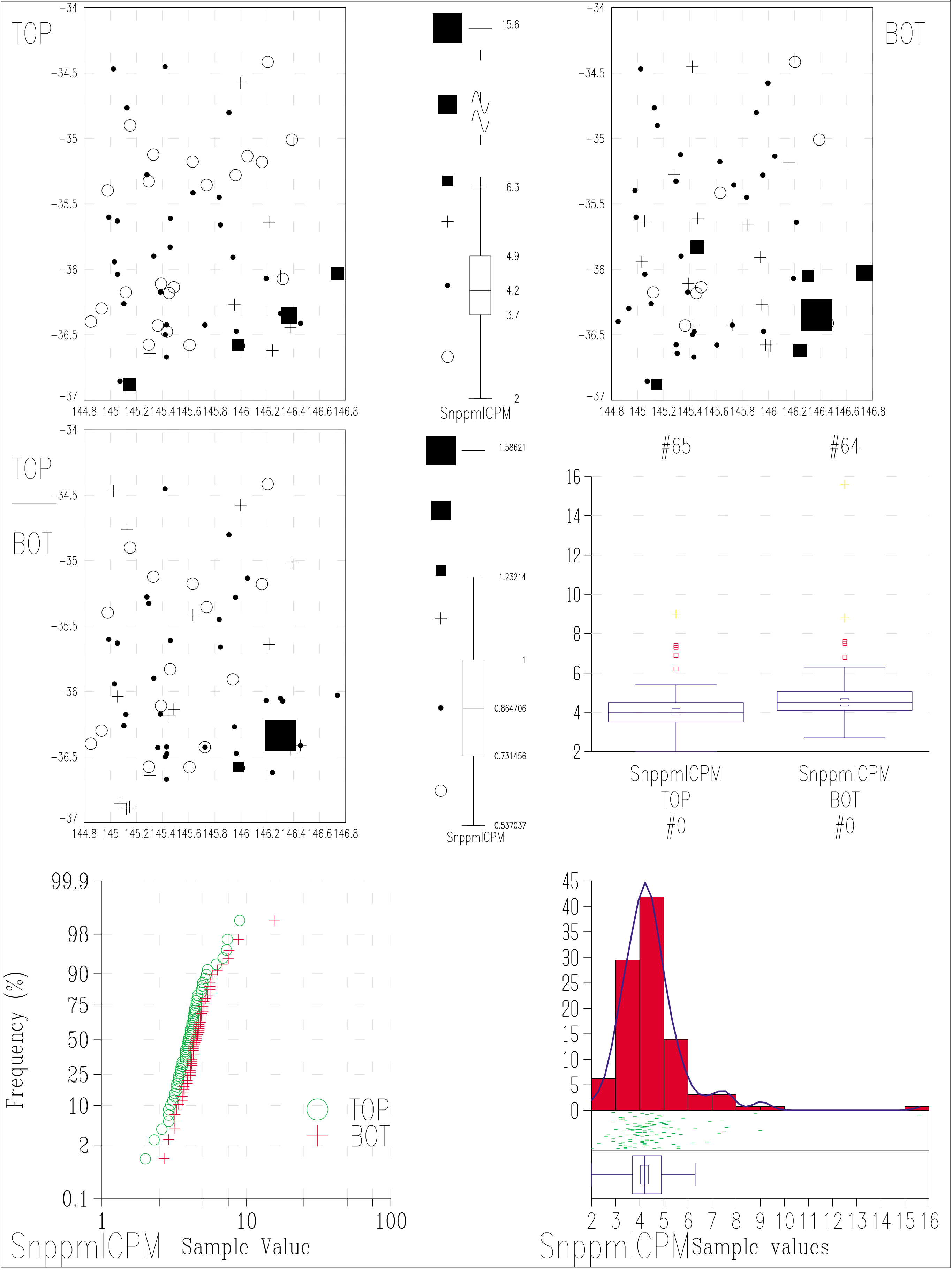

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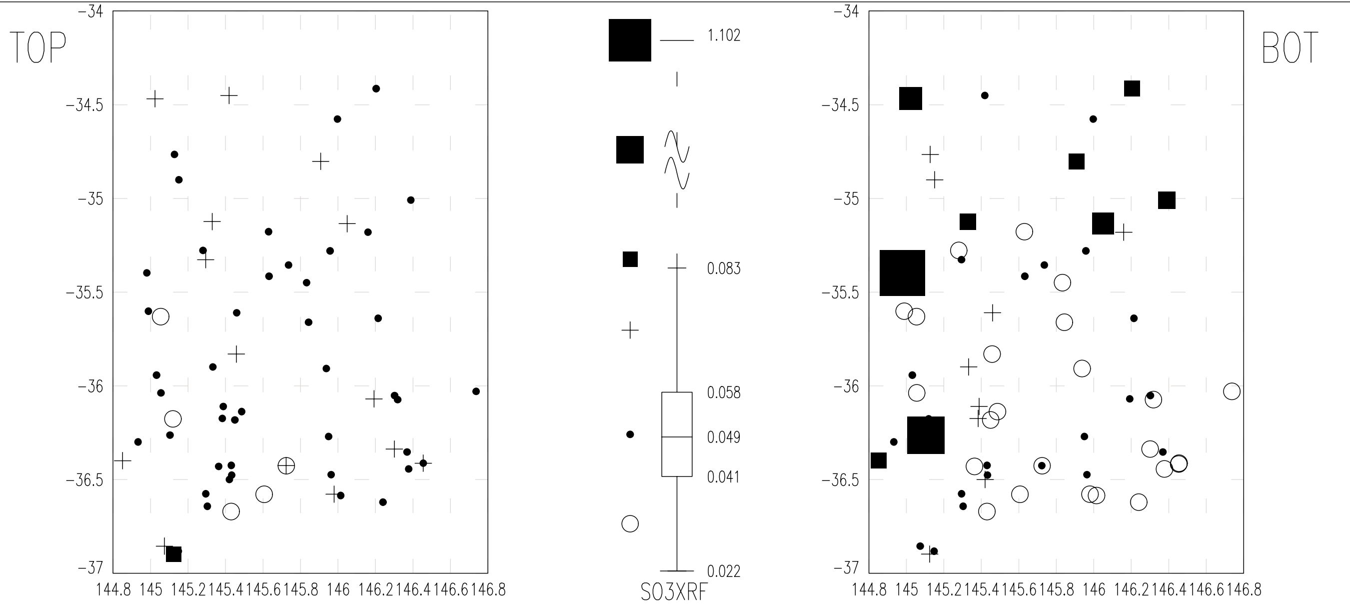

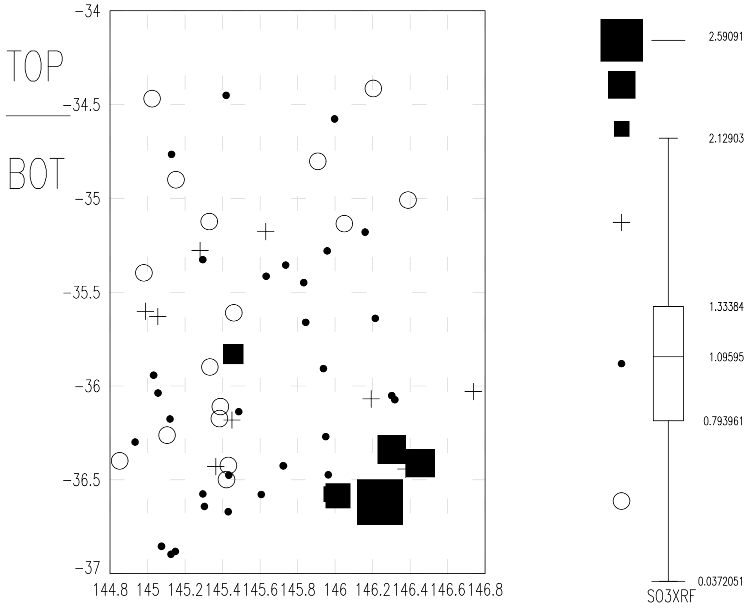

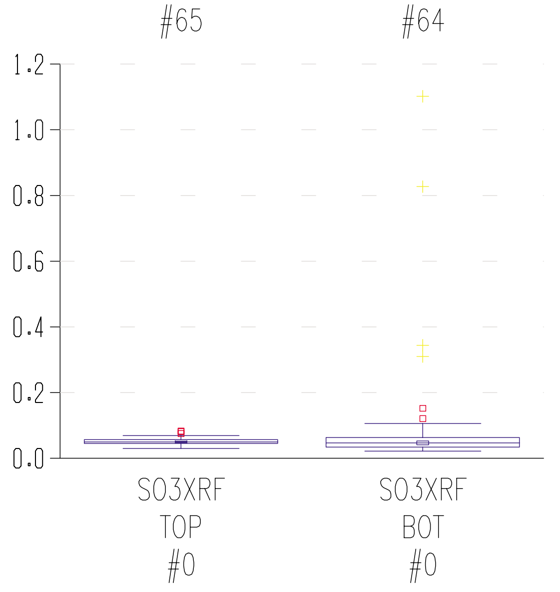

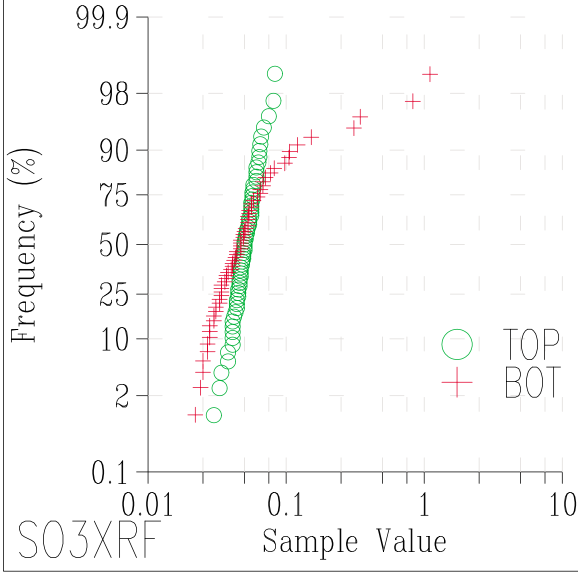

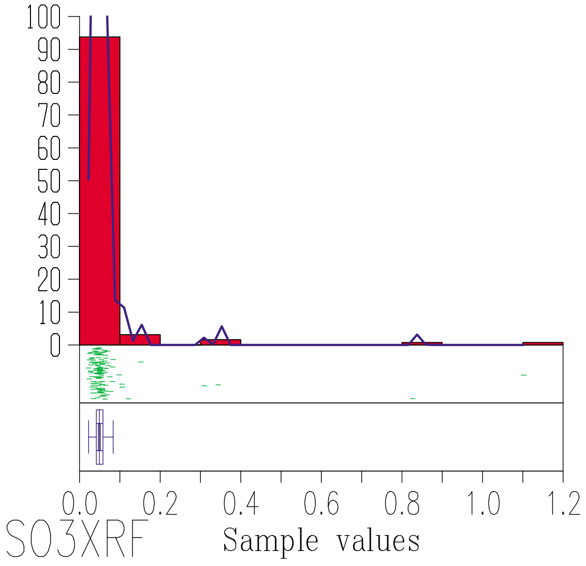

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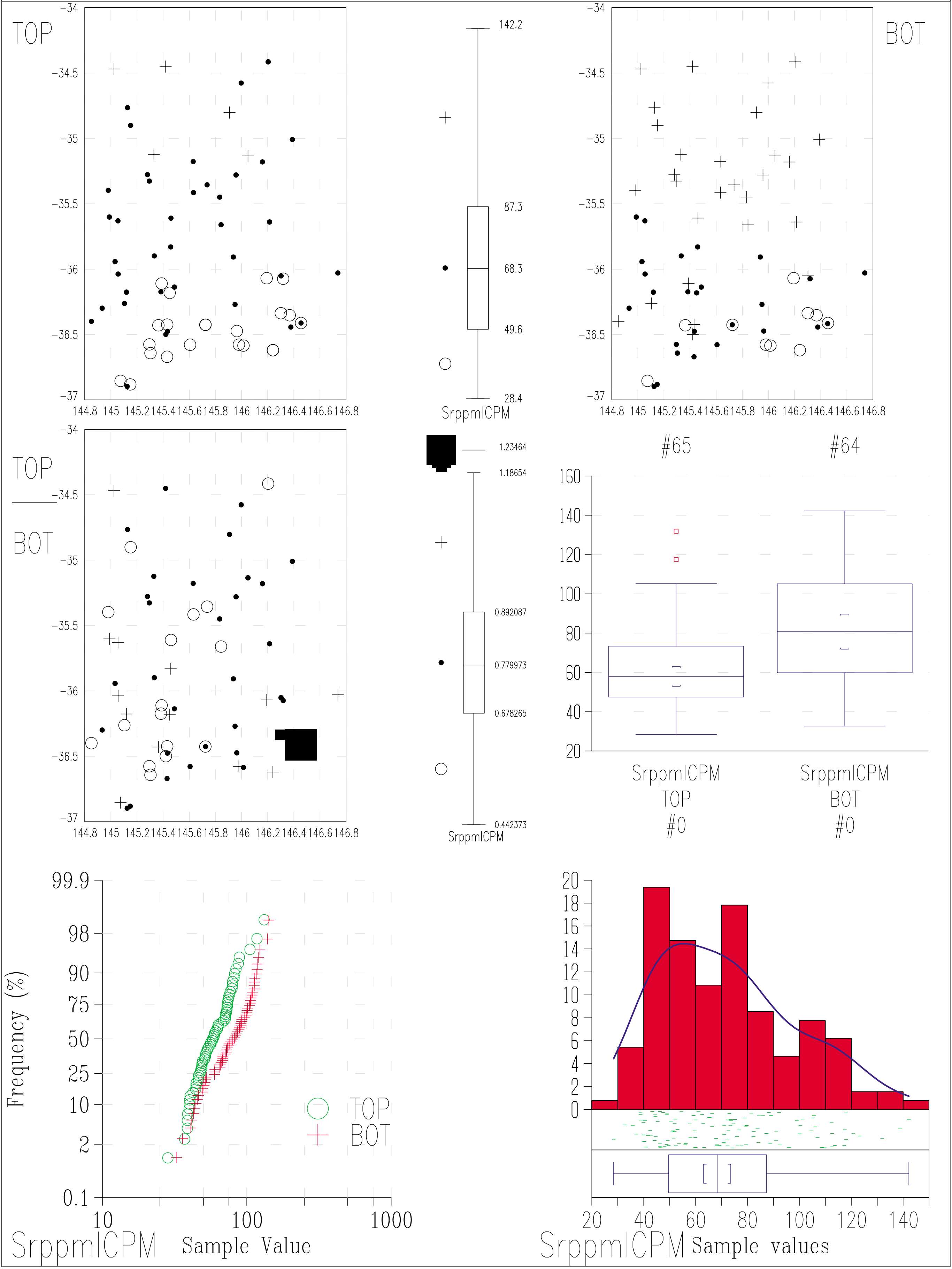

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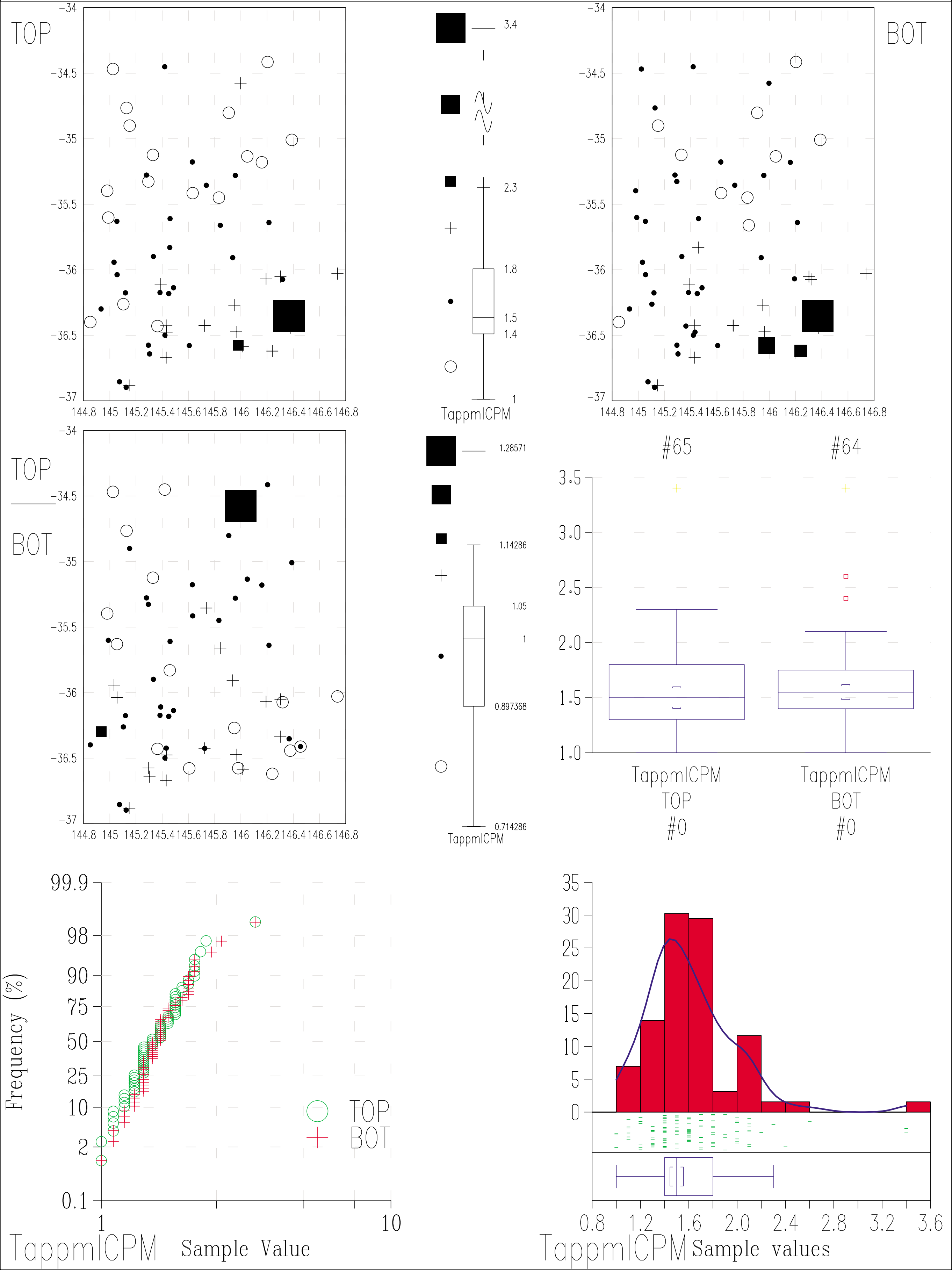

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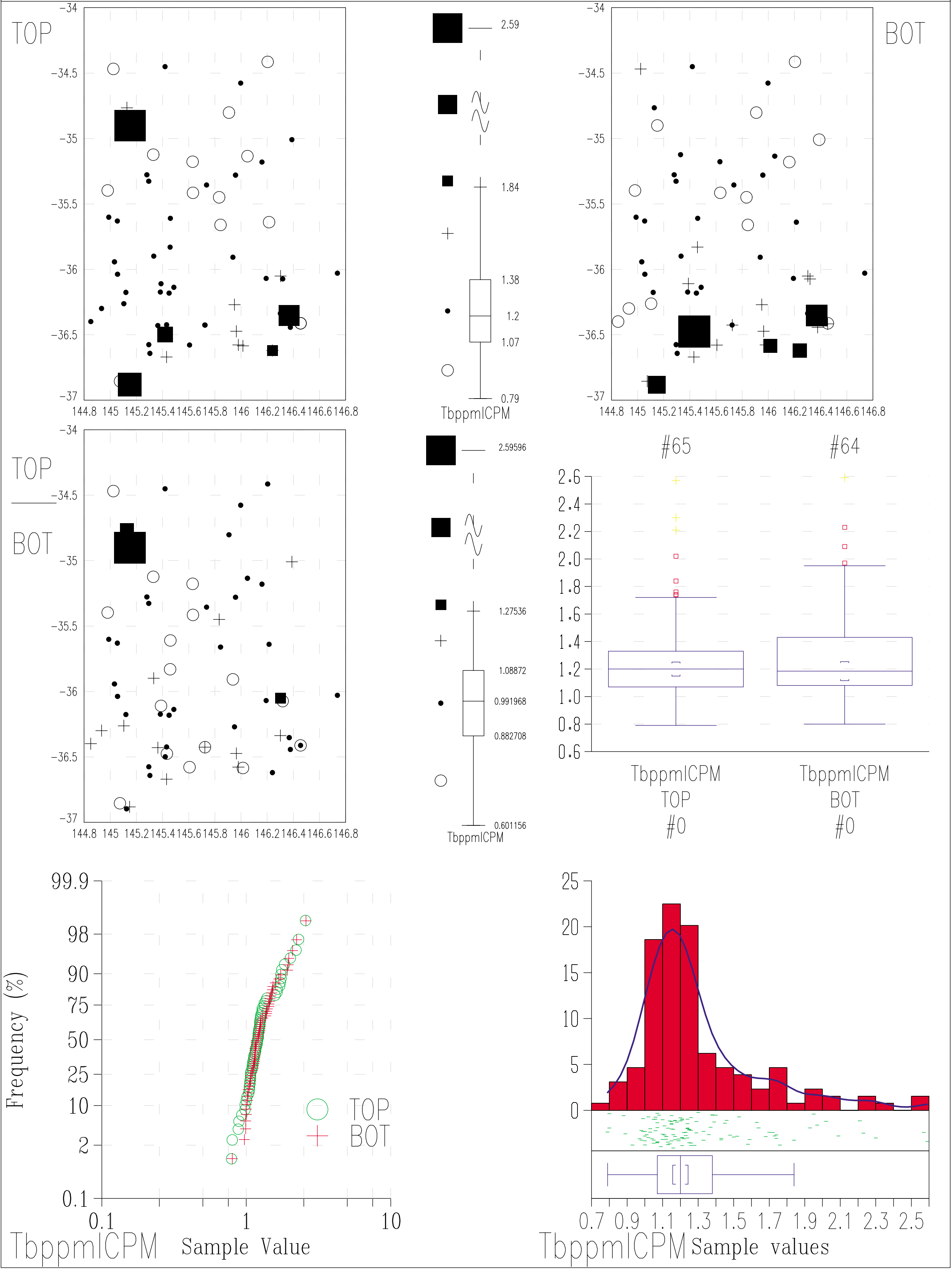

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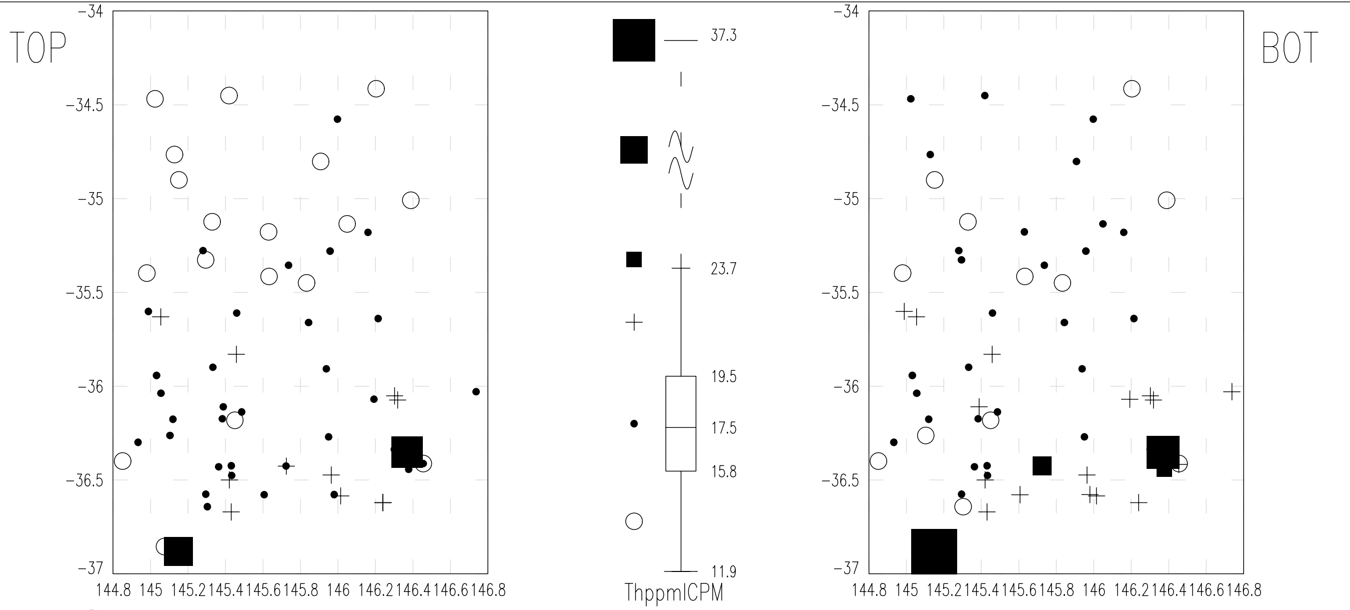

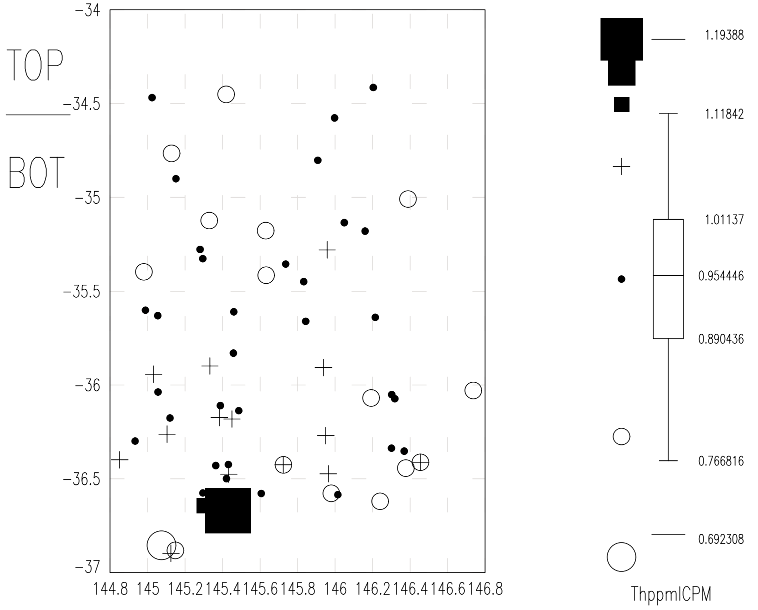

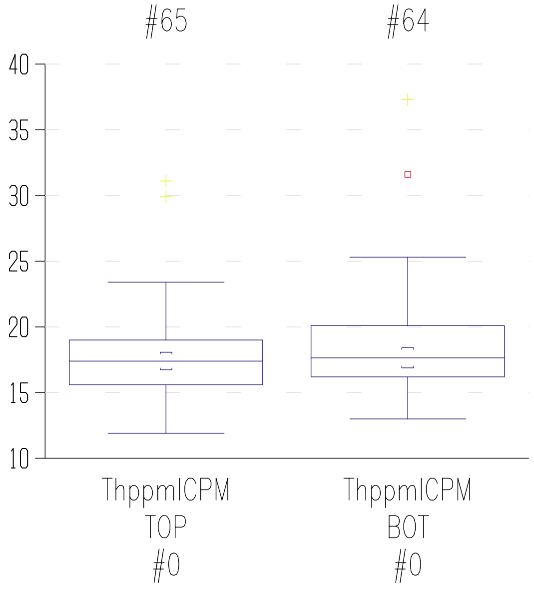

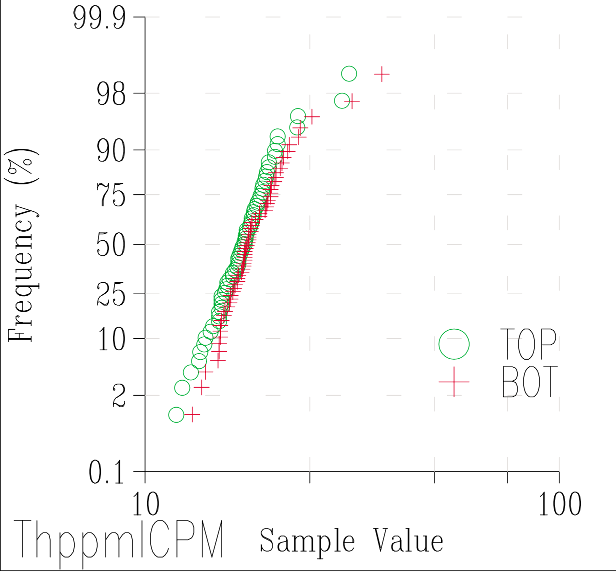

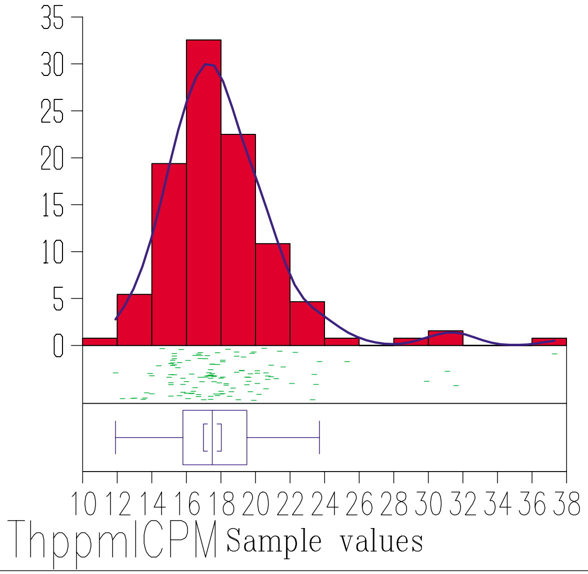

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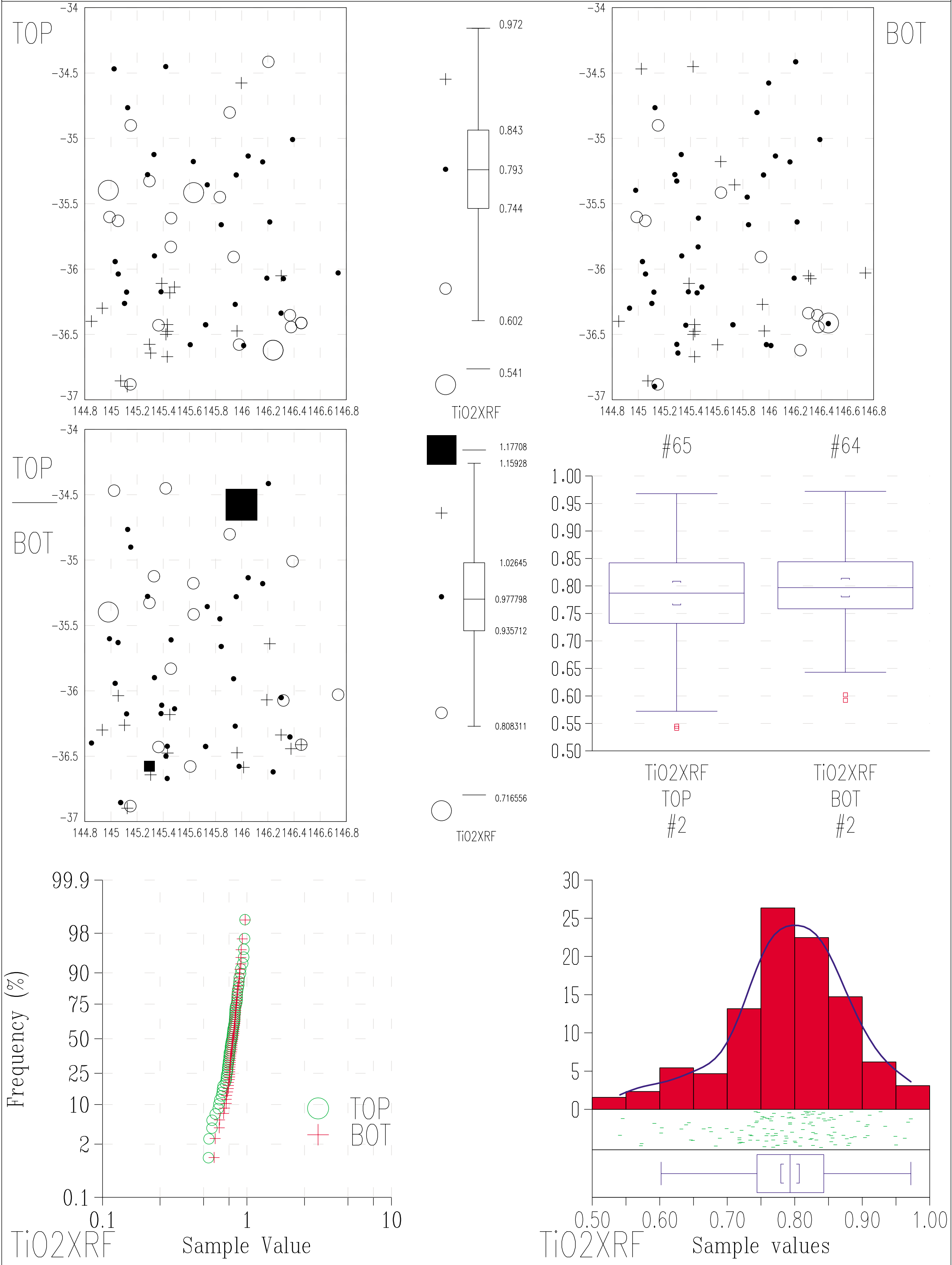

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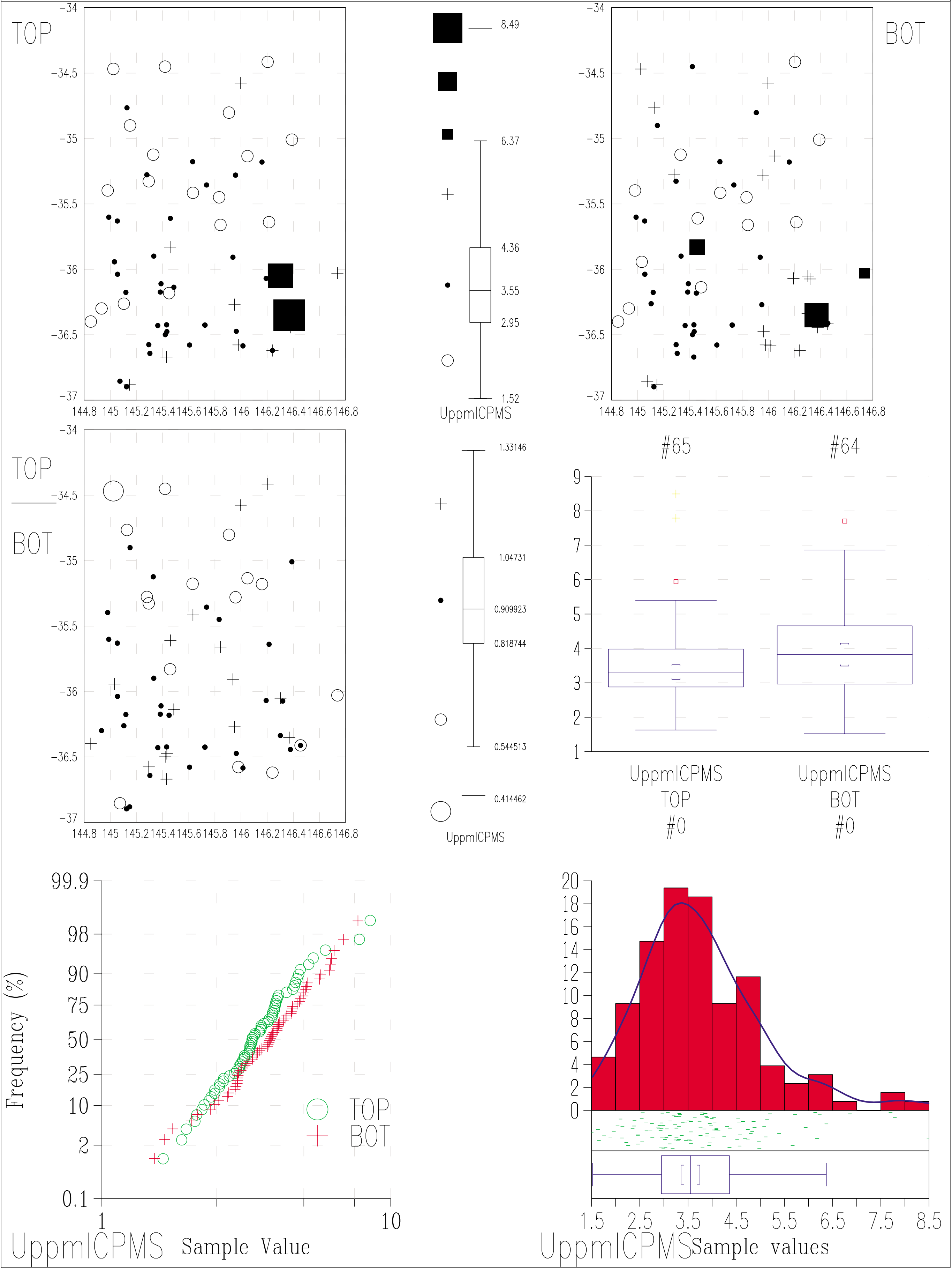

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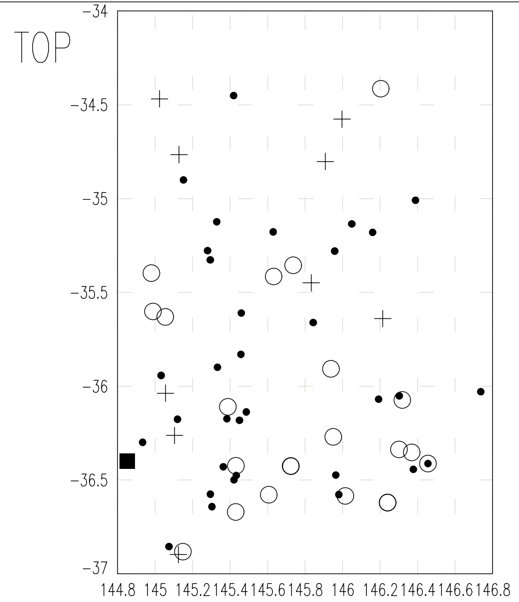

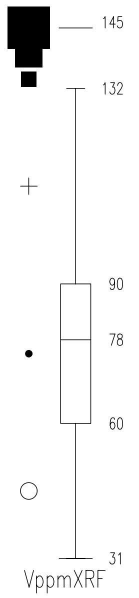

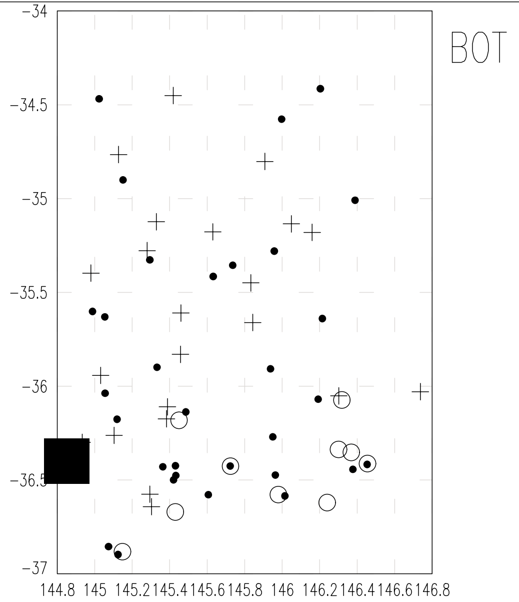

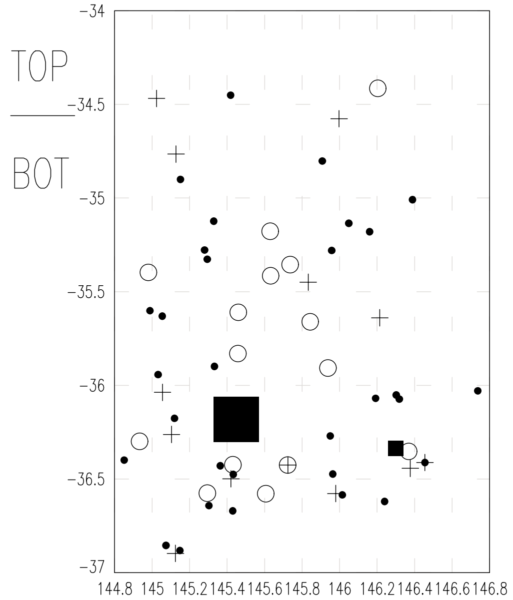

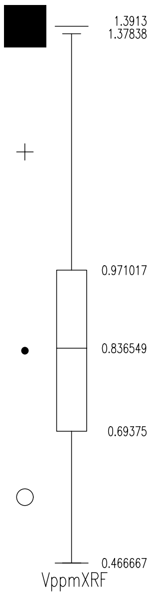

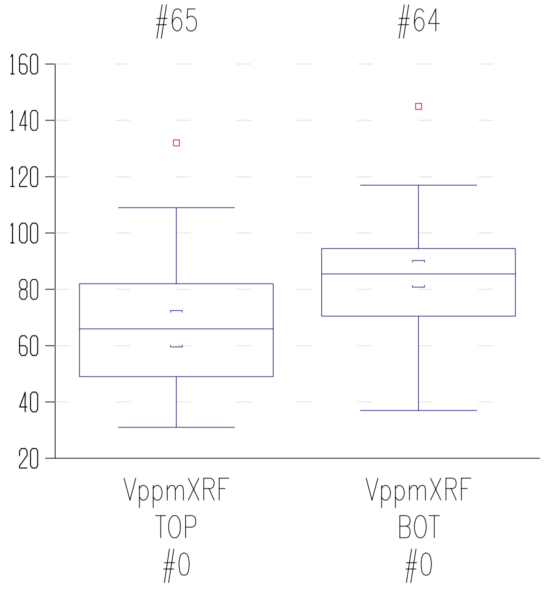

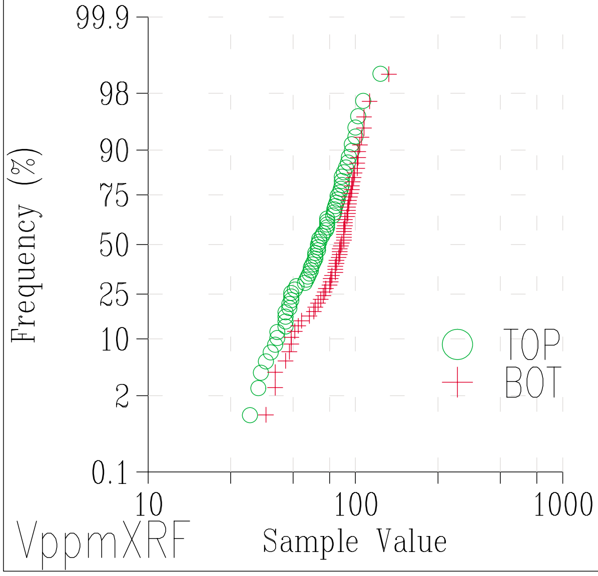

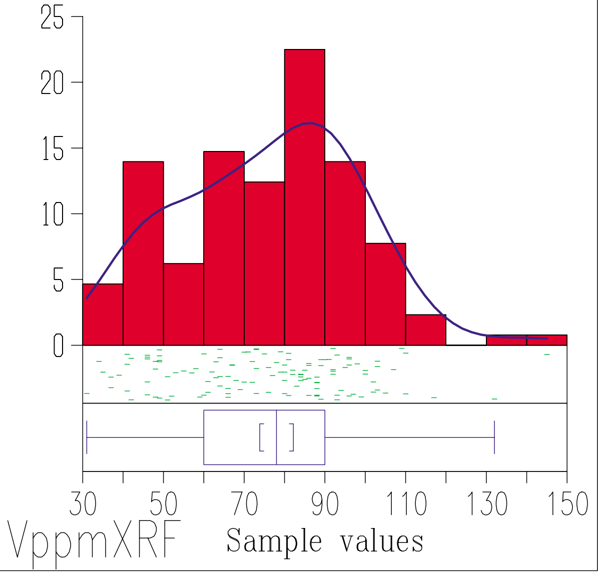

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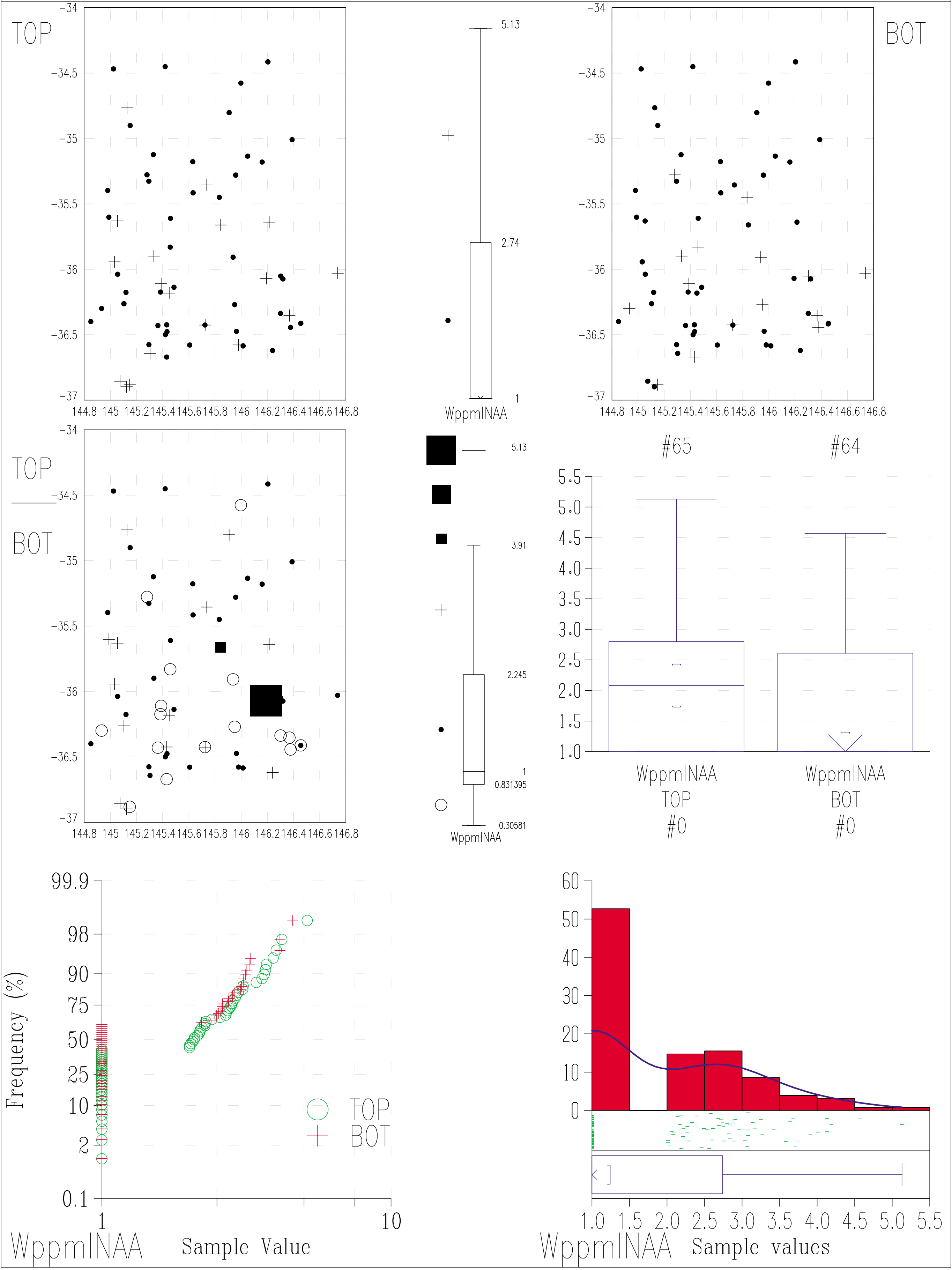

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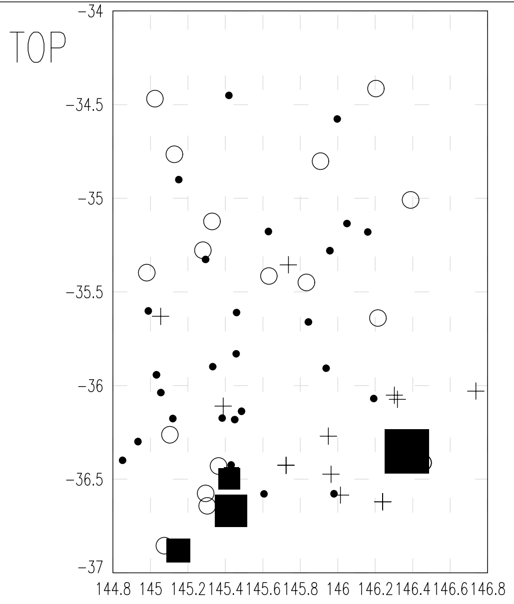
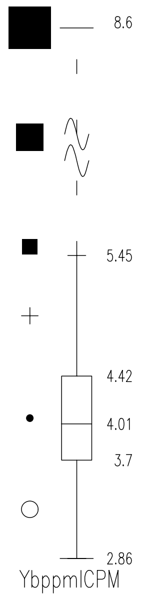
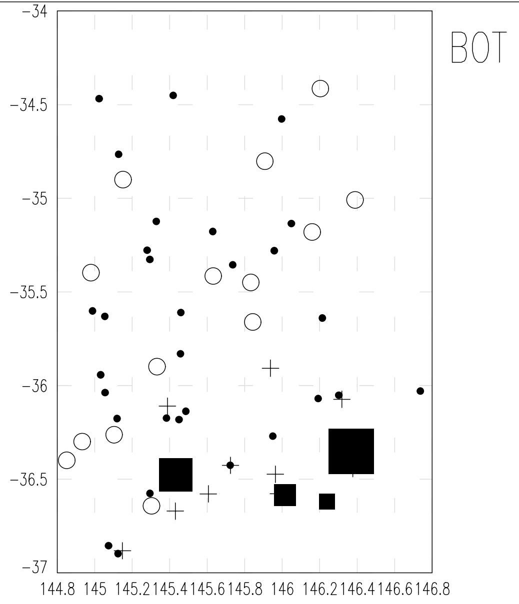
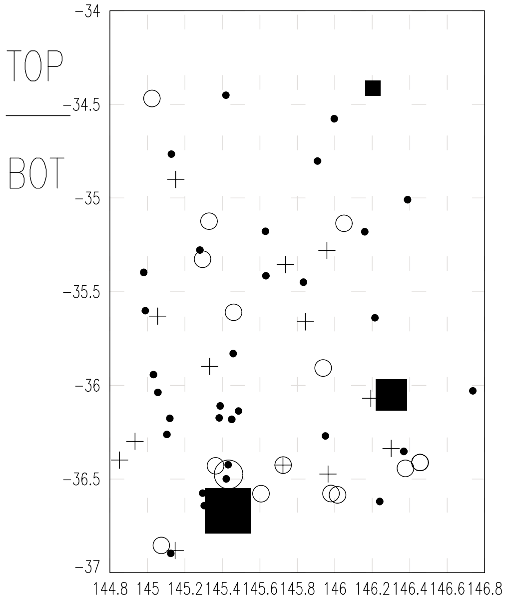
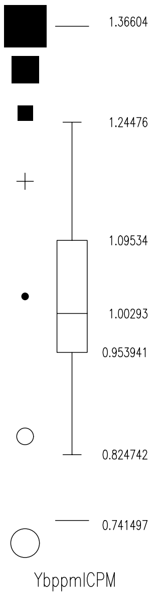
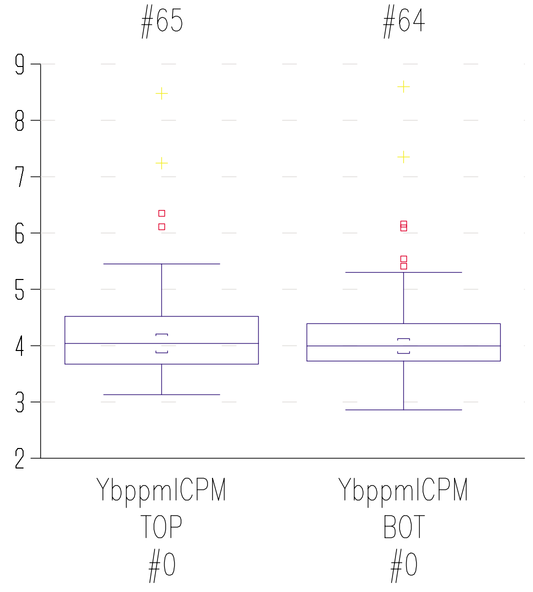


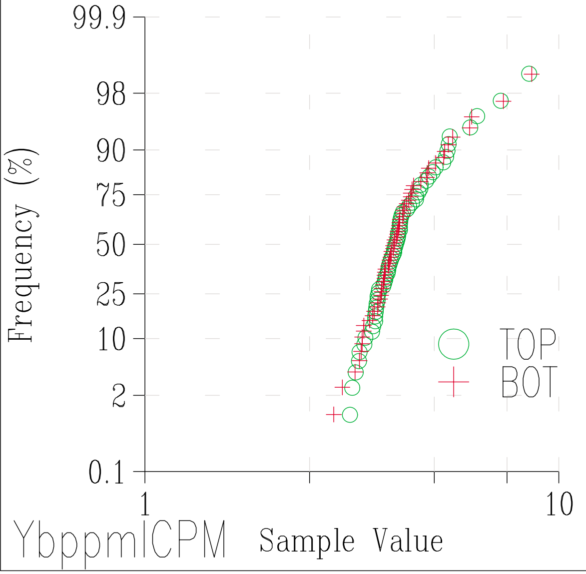


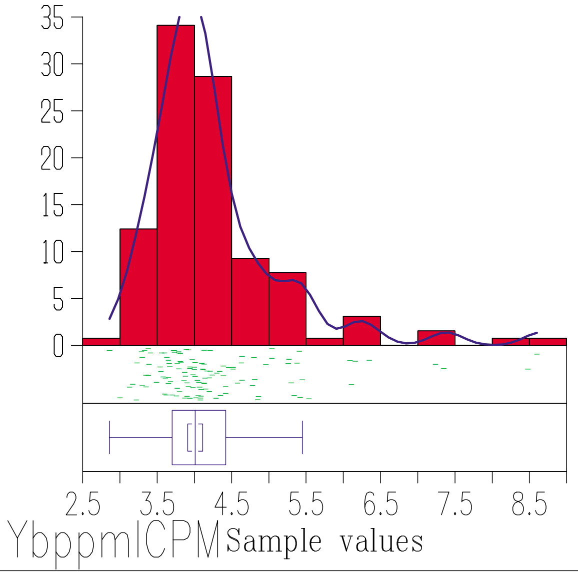




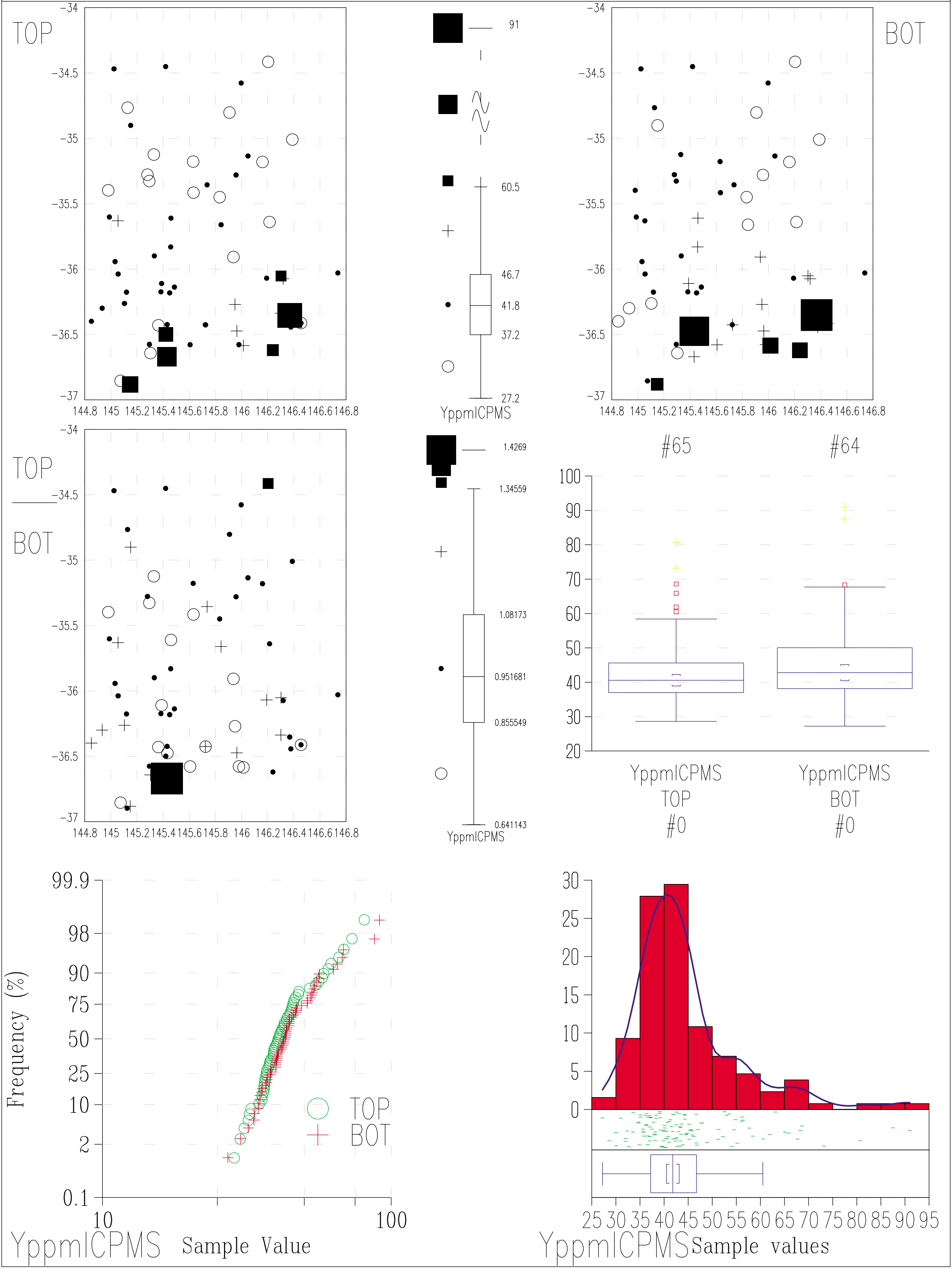




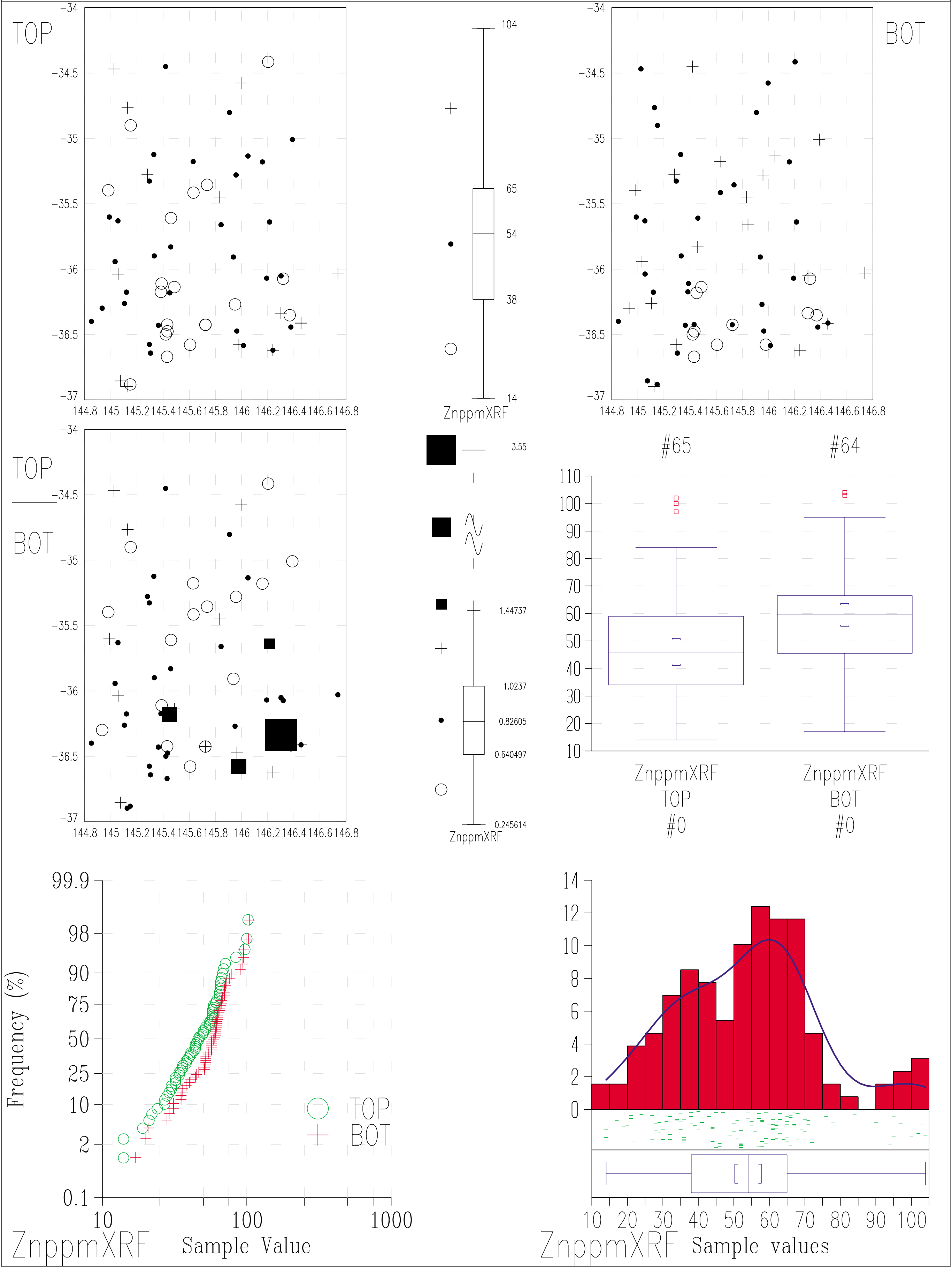




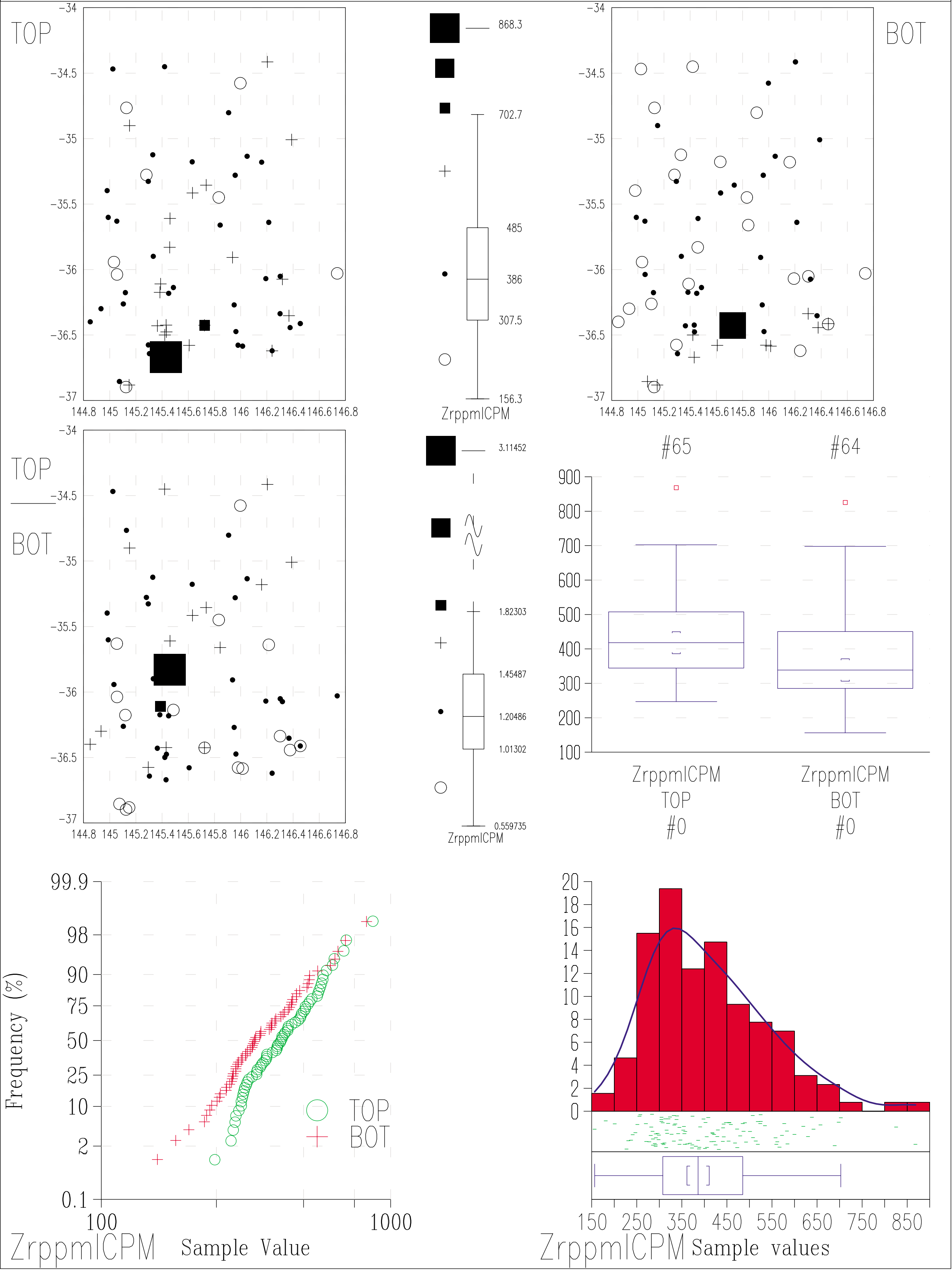
REGIONAL GEOCHEMICAL SURVEY: EASTERN RIVERINA



REGIONAL GEOCHEMICAL SURVEY: EASTERN RIVERINA



REGIONAL GEOCHEMICAL SURVEY: EASTERN RIVERINA



Appendix 5: Results of laser particle size analysis of 20 samples from the eastern Riverina region (bulk samples), Sedimentology Laboratory, Geoscience Australia

Laser Grainsize Analysis

Sample Name : 24524 20037511601 0-0.1m - Average

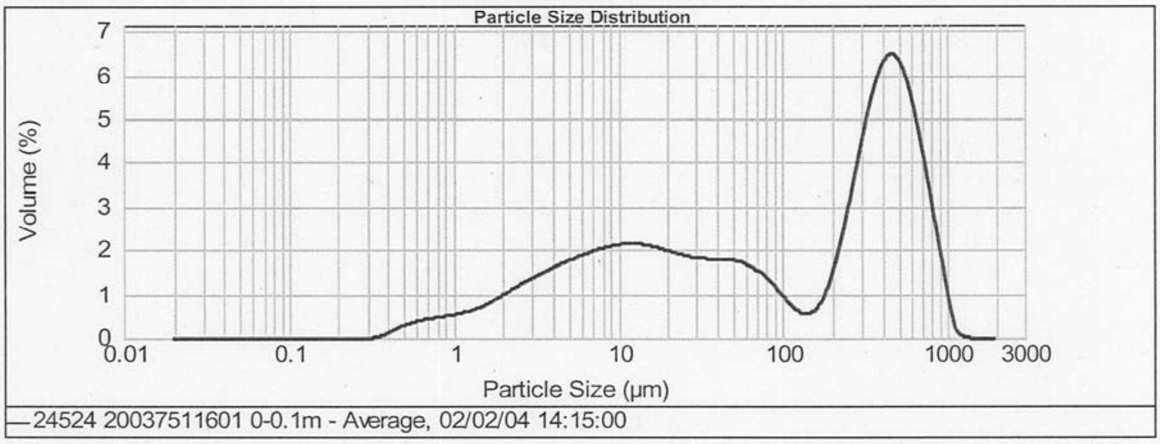
Record No.: 4

Operator Notes :

SOP Name: Silicious (Regolith)		**Analysed:** 02/02/04 14:15:01		**Result Type:** Averaged	
Measured: 02/02/04 14:15:00	**Measured by:** mclachlan alex	**Project Code 29302**		**Job No.:** Job Sheet No 2003/04-104	

Particle Name: Silica 0.0001		**Accessory Name:**	Hydro 2000MU (A)	**Obscuration:**	13.79%
Particle RI: 1.544	**Absorption:** 0.1	**Analysis model:**	General purpose	**Weighted Residual:**	1.271 %
Dispersant Name: Water		**Dispersant RI:**	1.330	**Size range:**	0.020 to 2000.0... um

Concentration:	0.0199 %Vol	**Vol. Weighted Mean D[4,3]:**	242.540 um	**Specific Surface Area:**	0.647 m²/g
d(0.1):	3.499 um	**d(0.5): 101.421**	**um**	d(0.9):	631.755 um



	Mean	Stand. Dev.	Skewness	Kurtosis
Volume:	242.54	264.125	0.874	-0.251

Distribution Modal Sizes

Mode 1: 455.634 um, Mode 2: 12.044 um,

Volume Under %

Size (μm)	Vol Under %	Size (μm)	Vol Under %	Size (μm)	Vol Under %	Size (μm)	Vol Under %
0.060	0.00	31.000	37.63	149.000	51.62	710.000	93.60
0.120	0.00	37.000	39.72	177.000	52.43	840.000	97.39
0.240	0.00	44.000	41.75	210.000	53.94	1000.000	99.53
0.490	0.29	53.000	43.91	250.000	56.68	1190.000	99.98
0.980	2.14	62.500	45.76	300.000	61.21	1410.000	100.00
2.000	5.41	74.000	47.51	350.000	66.37	1680.000	100.00
3.900	11.09	88.000	49.03	420.000	73.63	2000.000	100.00
7.800	19.32	105.000	50.20	500.000	81.01		
15.600	28.90	125.000	50.99	590.000	87.58		

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Laser Grainsize Analysis

Sample Name : 24525 20037513601 0.8-0.9m - Average

Record No.: 8

Operator Notes :

SOP Name: Silicious (Regolith) **Analysed:** 02/02/04 14:24:01 **Result Type:** Averaged

Measured: 02/02/04 14:24:00 **Measured by:** mclachlan alex **Project Code 29302** **Job No.:** Job Sheet No 2003/04-104

Particle Name: Silica 0.0001 **Accessory Name:** Hydro 2000MU (A) **Obscuration:** 28.48 %

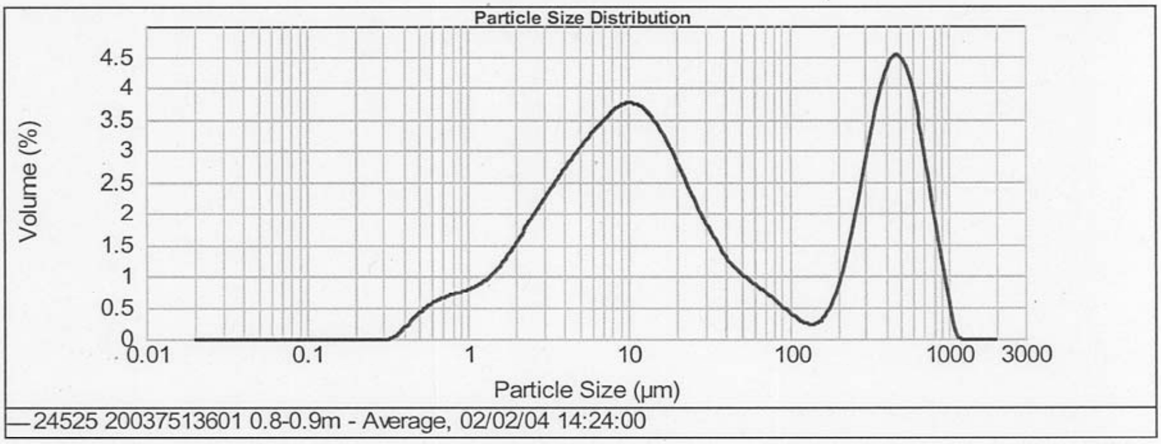
Particle RI: 1.544 **Absorption:** 0.1 **Analysis model:** General purpose **Weighted Residual:** 1.147 %

Dispersant Name: Water **Dispersant RI:** 1.330 **Size range:** 0.020 to 2000.0... um

---

Concentration: 0.0291 %Vol **Vol. Weighted Mean D[4,3]:** 164.109 um **Specific Surface Area:** 1 m²/g

d(0.1): 2.358 um d(0.5): 16.904 um d(0.9): 557.199 um



	Mean	Stand. Dev.	Skewness	Kurtosis
Volume:	164.109	243.314	1.406	0.864

Distribution Modal Sizes

Mode 1: 471.404 um, Mode 2: 10.409 um,

Volume Under %

Size (μm)	Vol Under %	Size (μm)	Vol Under %	Size (μm)	Vol Under %	Size (μm)	Vol Under %
0.060	0.00	31.000	59.91	149.000	68.25	710.000	95.81
0.120	0.00	37.000	61.77	177.000	68.61	840.000	98.40
0.240	0.00	44.000	63.27	210.000	69.35	1000.000	99.78
0.490	0.46	53.000	64.60	250.000	70.85	1190.000	100.00
0.980	3.24	62.500	65.59	300.000	73.56	1410.000	100.00
2.000	8.20	74.000	66.44	350.000	76.86	1680.000	100.00
3.900	17.35	88.000	67.14	420.000	81.74	2000.000	100.00
7.800	31.67	105.000	67.66	500.000	86.88		
15.600	48.26	125.000	67.99	590.000	91.55		

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Laser Grainsize Analysis

Sample Name : 24526 20037511605 0-0.1m - Average

Record No.: 12

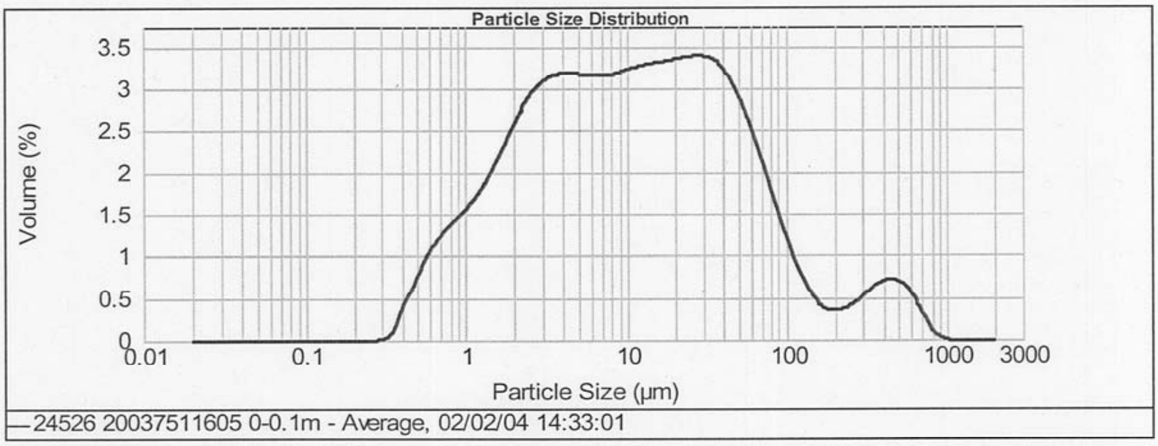
Operator Notes :

SOP Name: Silicious (Regolith)
Analysed: 02/02/04 14:33:02
Result Type: Averaged
Measured: 02/02/04 14:33:01 **Measured by:** mclachlan alex **Project Code 29302**
Job No.: Job Sheet No 2003/04-104

Particle Name: Silica 0.0001
Accessory Name: Hydro 2000MU (A)
Obscuration: 34.25 %
Particle RI: 1.544 **Absorption:** 0.1
Analysis model: General purpose
Weighted Residual: 1.000 %
Dispersant Name: Water
Dispersant RI: 1.330
Size range: 0.020 to 2000.0... um

Concentration: 0.0237 %Vol
Vol. Weighted Mean D[4,3]: 41.377 um
Specific Surface Area: 1.58 m²/g

d(0.1): 1.358 um
d(0.5): 10.918 um
d(0.9): 78.801 um



	Mean	Stand. Dev.	Skewness	Kurtosis
Volume:	41.377	97.842	4.549	22.869

Distribution Modal Sizes

Mode 1: 28.288 um, Mode 2: 4.258 um, Mode 3: 448.352 um,

Volume Under %

Size (μm)	Vol Under %	Size (μm)	Vol Under %	Size (μm)	Vol Under %	Size (μm)	Vol Under %
0.060	0.00	31.000	72.69	149.000	94.50	710.000	99.76
0.120	0.00	37.000	76.57	177.000	94.97	840.000	99.96
0.240	0.00	44.000	80.23	210.000	95.36	1000.000	100.00
0.490	0.98	53.000	83.87	250.000	95.78	1190.000	100.00
0.980	6.36	62.500	86.73	300.000	96.32	1410.000	100.00
2.000	15.67	74.000	89.20	350.000	96.90	1680.000	100.00
3.900	28.65	88.000	91.23	420.000	97.70	2000.000	100.00
7.800	42.98	105.000	92.76	500.000	98.52		
15.600	57.63	125.000	93.80	590.000	99.21		

Laser Grainsize Analysis

Sample Name : 24527 20037513605 0.8-0.9m - Average

Record No.: 16

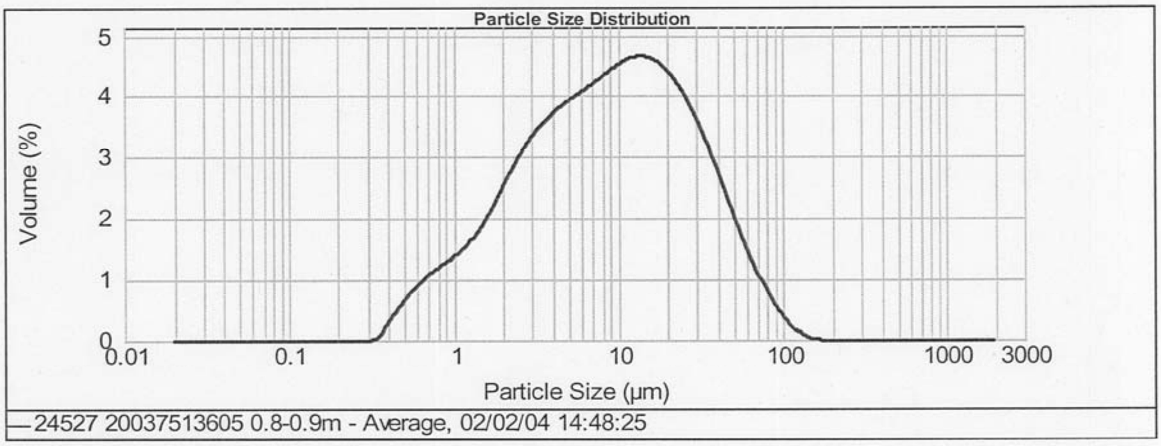
Operator Notes :

SOP Name: Silicious (Regolith) **Analysed:** 02/02/04 14:48:26 **Result Type:** Averaged
Measured: 02/02/04 14:48:25 **Measured by:** mclachlan alex **Project Code 29302** **Job No.:** Job Sheet No 2003/04-104

Particle Name: Silica 0.0001 **Accessory Name:** Hydro 2000MU (A) **Obscuration:** 26.84 %
Particle RI: 1.544 **Absorption:** 0.1 **Analysis model:** General purpose **Weighted Residual:** 1.096 %
Dispersant Name: Water **Dispersant RI:** 1.330 **Size range:** 0.020 to 2000.0... um

Concentration: 0.0176 %Vol **Vol. Weighted Mean D[4,3]:** 15.372 um **Specific Surface Area:** 1.54 m²/g

d(0.1): 1.528 um d(0.5): 8.953 um d(0.9): 38.016 um



	Mean	Stand. Dev.	Skewness	Kurtosis
Volume:	15.372	17.664	2.249	6.549

Distribution Modal Sizes

Mode 1: 13.837 um,

Volume Under %

Size (µm)	Vol Under %	Size (µm)	Vol Under %	Size (µm)	Vol Under %	Size (µm)	Vol Under %
0.060	0.00	31.000	85.65	149.000	100.00	710.000	100.00
0.120	0.00	37.000	89.47	177.000	100.00	840.000	100.00
0.240	0.00	44.000	92.61	210.000	100.00	1000.000	100.00
0.490	0.71	53.000	95.29	250.000	100.00	1190.000	100.00
0.980	5.34	62.500	97.07	300.000	100.00	1410.000	100.00
2.000	13.96	74.000	98.37	350.000	100.00	1680.000	100.00
3.900	27.93	88.000	99.22	420.000	100.00	2000.000	100.00
7.800	46.07	105.000	99.72	500.000	100.00		
15.600	66.68	125.000	99.93	590.000	100.00		

Laser Grainsize Analysis

Sample Name : 24528 20037511609 0-0.1m - Average

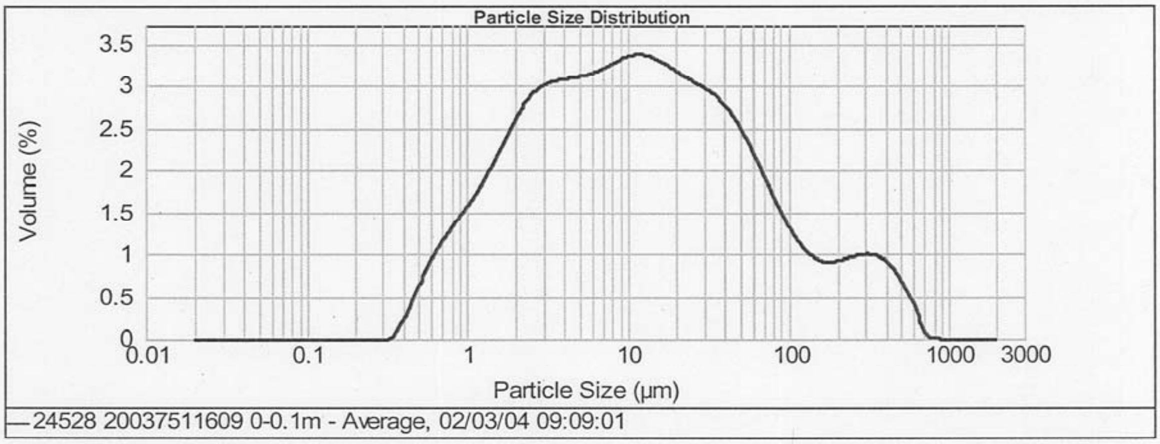
Record No.: 20

Operator Notes :

SOP Name:	Silicious (Regolith)	**Analysed:**	02/03/04 09:09:02	**Result Type:**	Averaged
Measured:	02/03/04 09:09:01	**Measured by:**	mclachlan alex	**Job No.:**	Job Sheet No 2003/04-104
		Project Code 29302			

Particle Name:	Silica 0.0001	**Accessory Name:**	Hydro 2000MU (A)	**Obscuration:**	23.91 %
Particle RI:	1.544 **Absorption:** 0.1	**Analysis model:**	General purpose	**Weighted Residual:**	1.092 %
Dispersant Name:	Water	**Dispersant RI:**	1.330	**Size range:**	0.020 to 2000.0... um

Concentration:	0.0159 %Vol	**Vol. Weighted Mean D[4,3]:**	45.558 um	**Specific Surface Area:**	1.5 m²/g
d(0.1):	1.425 um	d(0.5):	11.168 um	d(0.9):	114.963 um



	Mean	Stand. Dev.	Skewness	Kurtosis
Volume:	45.558	94.023	3.558	13.862

Distribution Modal Sizes

Mode 1: 11.918 um, Mode 2: 308.924 um,

Volume Under %

Size (μm)	Vol Under %	Size (μm)	Vol Under %	Size (μm)	Vol Under %	Size (μm)	Vol Under %
0.060	0.00	31.000	71.41	149.000	91.74	710.000	99.98
0.120	0.00	37.000	74.78	177.000	92.77	840.000	100.00
0.240	0.00	44.000	77.93	210.000	93.79	1000.000	100.00
0.490	0.65	53.000	81.07	250.000	94.87	1190.000	100.00
0.980	5.65	62.500	83.56	300.000	96.05	1410.000	100.00
2.000	15.19	74.000	85.77	350.000	97.06	1680.000	100.00
3.900	27.97	88.000	87.69	420.000	98.18	2000.000	100.00
7.800	42.21	105.000	89.29	500.000	99.08		
15.600	57.33	125.000	90.60	590.000	99.68		

Laser Grainsize Analysis

Sample Name : 24529 20037513609 0.75-0.9m - Average

Record No.: 24

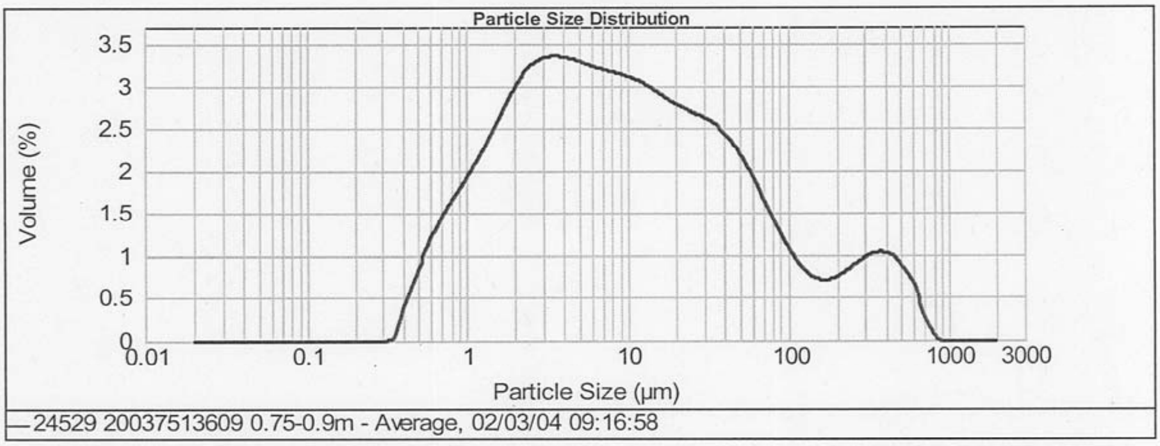
Operator Notes :

SOP Name: Silicious (Regolith)
Analysed: 02/03/04 09:16:59
Result Type: Averaged
Measured: 02/03/04 09:16:58
Measured by: mclachlan alex
Project Code 29302
Job No.: Job Sheet No 2003/04-104

Particle Name: Silica 0.0001
Accessory Name: Hydro 2000MU (A)
Obscuration: 24.30 %
Particle RI: 1.544
Absorption: 0.1
Analysis model: General purpose
Weighted Residual: 1.259 %
Dispersant Name: Water
Dispersant RI: 1.330
Size range: 0.020 to 2000.0... um

Concentration: 0.0141 %Vol
Vol. Weighted Mean D[4,3]: 47.452 um
Specific Surface Area: 1.75 m^2/g

d(0.1): 1.205 um
d(0.5): 8.768 um
d(0.9): 114.322 um



	Mean	Stand. Dev.	Skewness	Kurtosis
Volume:	47.452	107.213	3.601	13.72

Distribution Modal Sizes

Mode 1: 3.529 um, Mode 2: 374.65 um,

Volume Under %

Size (μm)	Vol Under %	Size (μm)	Vol Under %	Size (μm)	Vol Under %	Size (μm)	Vol Under %
0.060	0.00	31.000	73.88	149.000	91.40	710.000	99.85
0.120	0.00	37.000	76.85	177.000	92.20	840.000	100.00
0.240	0.00	44.000	79.63	210.000	93.02	1000.000	100.00
0.490	0.95	53.000	82.39	250.000	93.95	1190.000	100.00
0.980	7.26	62.500	84.57	300.000	95.06	1410.000	100.00
2.000	18.57	74.000	86.49	350.000	96.08	1680.000	100.00
3.900	32.79	88.000	88.13	420.000	97.31	2000.000	100.00
7.800	47.58	105.000	89.46	500.000	98.42		
15.600	61.51	125.000	90.51	590.000	99.27		

Laser Grainsize Analysis

Sample Name : 24530 20037511613 0-0.1m - Average

Record No.: 28

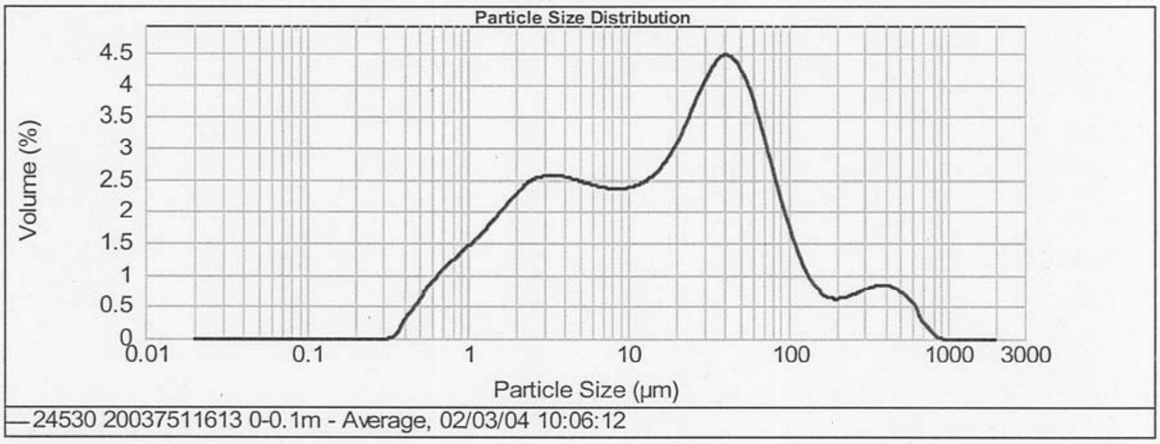
Operator Notes :

SOP Name: Silicious (Regolith) **Analysed:** 02/03/04 10:06:13 **Result Type:** Averaged
Measured: 02/03/04 10:06:12 **Measured by:** mclachlan alex **Project Code 29302** **Job No.:** Job Sheet No 2003/04-104

Particle Name: Silica 0.0001 **Accessory Name:** Hydro 2000MU (A) **Obscuration:** 23.01 %
Particle RI: 1.544 **Absorption:** 0.1 **Analysis model:** General purpose **Weighted Residual:** 0.945 %
Dispersant Name: Water **Dispersant RI:** 1.330 **Size range:** 0.020 to 2000.0... um

Concentration: 0.0170 %Vol **Vol. Weighted Mean D[4,3]:** 50.215 um **Specific Surface Area:** 1.36 m²/g

d(0.1): 1.502 um d(0.5): 18.507 um d(0.9): 102.574 um



	Mean	Stand. Dev.	Skewness	Kurtosis
Volume:	50.215	98.593	3.915	17.247

Distribution Modal Sizes

Mode 1: 41.515 um, Mode 2: 3.364 um, Mode 3: 388.524 um,

Volume Under %

Size (µm)	Vol Under %	Size (µm)	Vol Under %	Size (µm)	Vol Under %	Size (µm)	Vol Under %
0.060	0.00	31.000	61.75	149.000	92.86	710.000	99.84
0.120	0.00	37.000	66.71	177.000	93.65	840.000	100.00
0.240	0.00	44.000	71.77	210.000	94.35	1000.000	100.00
0.490	0.69	53.000	77.06	250.000	95.08	1190.000	100.00
0.980	5.39	62.500	81.32	300.000	95.94	1410.000	100.00
2.000	13.94	74.000	85.02	350.000	96.74	1680.000	100.00
3.900	24.83	88.000	88.02	420.000	97.74	2000.000	100.00
7.800	35.93	105.000	90.25	500.000	98.65		
15.600	46.92	125.000	91.79	590.000	99.35		

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Laser Grainsize Analysis

Sample Name : 24531 20037513613 0.75-0.9m - Average

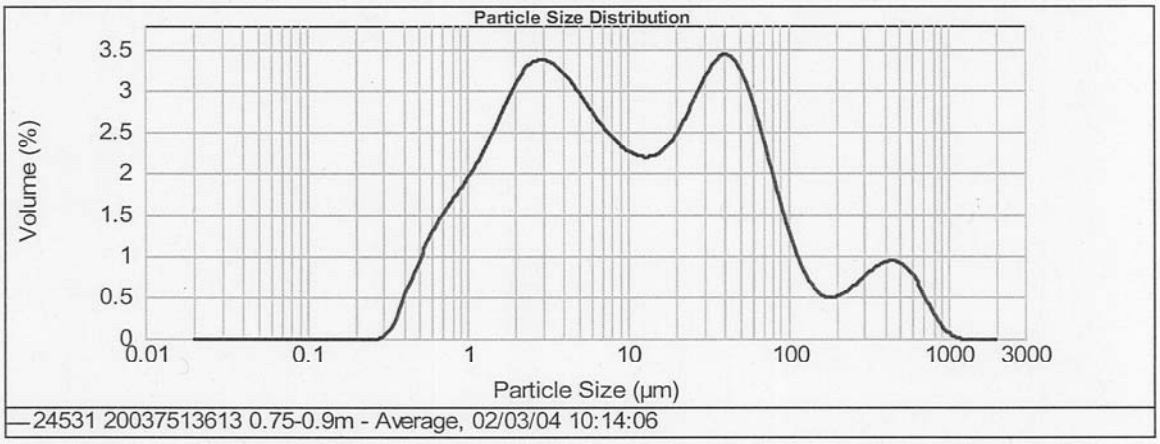
Record No.: 32

Operator Notes :

SOP Name:	Silicious (Regolith)	**Analysed:**	02/03/04 10:14:07	**Result Type:**	Averaged
Measured:	02/03/04 10:14:06	**Measured by:**	mclachlan alex	**Project Code** 29302	**Job No.:** Job Sheet No 2003/04-104

Particle Name:	Silica 0.0001	**Accessory Name:**	Hydro 2000MU (A)	**Obscuration:**	23.34 %
Particle RI:	1.544 **Absorption:** 0.1	**Analysis model:**	General purpose	**Weighted Residual:**	1.130 %
Dispersant Name:	Water	**Dispersant RI:**	1.330	**Size range:**	0.020 to 2000.0... um

Concentration:	0.0134	%Vol	**Vol. Weighted Mean D[4,3]:**	52.023	um	**Specific Surface Area:**	1.81 m²/g
d(0.1):	1.151	um	d(0.5):	9.732	um	d(0.9):	101.534 um



	Mean	Stand. Dev.	Skewness	Kurtosis
Volume:	52.023	121.234	3.993	17.503

Distribution Modal Sizes

Mode 1: 41.047 um, Mode 2: 2.943 um, Mode 3: 444.941 um,

Volume Under %

Size (μm)	Vol Under %	Size (μm)	Vol Under %	Size (μm)	Vol Under %	Size (μm)	Vol Under %
0.060	0.00	31.000	68.62	149.000	92.16	710.000	99.38
0.120	0.00	37.000	72.44	177.000	92.74	840.000	99.80
0.240	0.00	44.000	76.32	210.000	93.29	1000.000	99.96
0.490	1.33	53.000	80.36	250.000	93.91	1190.000	100.00
0.980	7.89	62.500	83.59	300.000	94.71	1410.000	100.00
2.000	19.34	74.000	86.38	350.000	95.52	1680.000	100.00
3.900	33.71	88.000	88.62	420.000	96.59	2000.000	100.00
7.800	46.59	105.000	90.27	500.000	97.65		
15.600	56.82	125.000	91.39	590.000	98.58		

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Laser Grainsize Analysis

Sample Name : 24532 20037511617 0-0.1m - Average

Record No.: 36

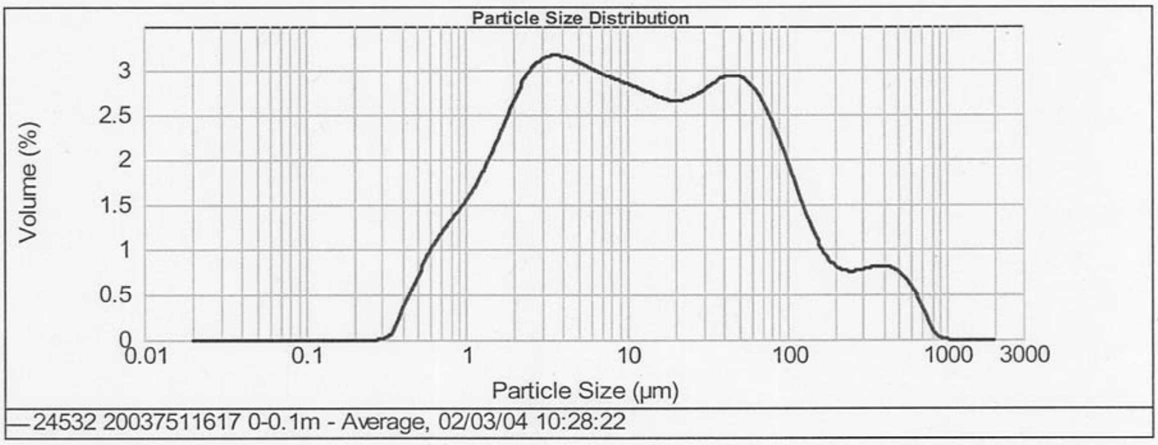
Operator Notes :

SOP Name: Silicious (Regolith)
Analysed: 02/03/04 10:28:23
Result Type: Averaged
Measured: 02/03/04 10:28:22 **Measured by:** mclachlan alex
Project Code 29302
Job No.: Job Sheet No 2003/04-104

Particle Name: Silica 0.0001
Accessory Name: Hydro 2000MU (A)
Obscuration: 28.57 %
Particle RI: 1.544 **Absorption:** 0.1
Analysis model: General purpose
Weighted Residual: 0.978 %
Dispersant Name: Water
Dispersant RI: 1.330
Size range: 0.020 to 2000.0... um

Concentration: 0.0195 %Vol
Vol. Weighted Mean D[4,3]: 50.579 um
Specific Surface Area: 1.53 m²/g

d(0.1): 1.397 um
d(0.5): 11.740 um
d(0.9): 120.722 um



	Mean	Stand. Dev.	Skewness	Kurtosis
Volume:	50.579	104.875	3.819	16.539

Distribution Modal Sizes

Mode 1: 3.67 um, Mode 2: 46.671 um, Mode 3: 395.539 um,

Volume Under %

Size (µm)	Vol Under %	Size (µm)	Vol Under %	Size (µm)	Vol Under %	Size (µm)	Vol Under %
0.060	0.00	31.000	67.11	149.000	91.86	710.000	99.75
0.120	0.00	37.000	70.38	177.000	93.02	840.000	99.97
0.240	0.00	44.000	73.67	210.000	93.98	1000.000	100.00
0.490	0.88	53.000	77.23	250.000	94.85	1190.000	100.00
0.980	5.99	62.500	80.32	300.000	95.76	1410.000	100.00
2.000	15.46	74.000	83.29	350.000	96.55	1680.000	100.00
3.900	28.60	88.000	86.04	420.000	97.52	2000.000	100.00
7.800	42.38	105.000	88.43	500.000	98.42		
15.600	55.10	125.000	90.35	590.000	99.16		

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Laser Grainsize Analysis

Sample Name : 24533 20037513617 0.75-0.9m - Average

Record No.: 40

Operator Notes :

SOP Name: Silicious (Regolith)
Analysed: 02/03/04 10:37:12
Result Type: Averaged

Measured: 02/03/04 10:37:11
Measured by: mclachlan alex
Project Code 29302
Job No.: Job Sheet No 2003/04-104

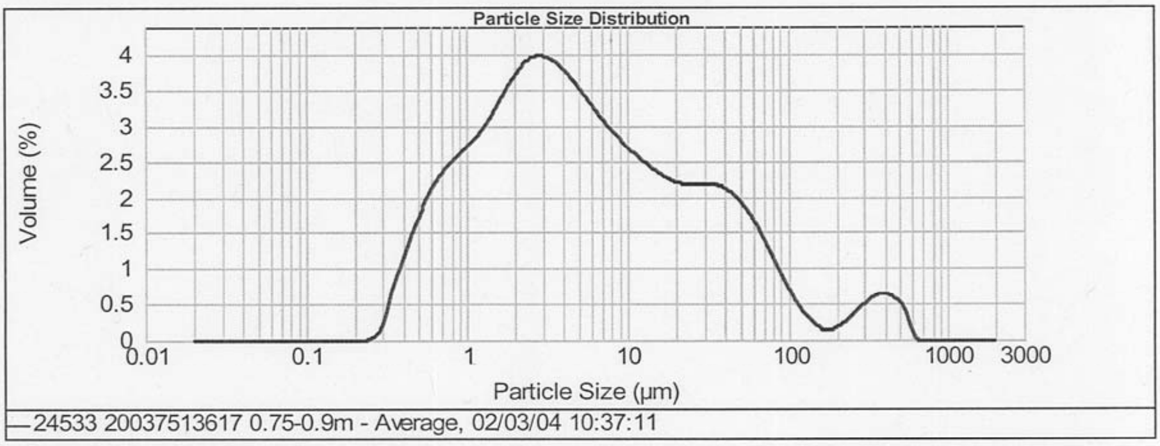
Particle Name: Silica 0.0001
Accessory Name: Hydro 2000MU (A)
Obscuration: 33.59 %

Particle RI: 1.544
Absorption: 0.1
Analysis model: General purpose
Weighted Residual: 1.325 %

Dispersant Name: Water
Dispersant RI: 1.330
Size range: 0.020 to 2000.0... um

Concentration: 0.0152 %Vol
Vol. Weighted Mean D[4,3]: 25.939 um
Specific Surface Area: 2.67 m²/g

d(0.1): 0.792 um
d(0.5): 4.722 um
d(0.9): 53.405 um



	Mean	Stand. Dev.	Skewness	Kurtosis
Volume:	25.939	69.987	5.012	27.048

Distribution Modal Sizes

Mode 1: 2.881 um, Mode 2: 31.009 um, Mode 3: 394.464 um,

Volume Under %

Size (µm)	Vol Under %	Size (µm)	Vol Under %	Size (µm)	Vol Under %	Size (µm)	Vol Under %
0.060	0.00	31.000	82.57	149.000	96.48	710.000	100.00
0.120	0.00	37.000	85.08	177.000	96.65	840.000	100.00
0.240	0.00	44.000	87.49	210.000	96.82	1000.000	100.00
0.490	3.31	53.000	89.91	250.000	97.11	1190.000	100.00
0.980	13.59	62.500	91.81	300.000	97.60	1410.000	100.00
2.000	28.28	74.000	93.43	350.000	98.16	1680.000	100.00
3.900	45.35	88.000	94.72	420.000	98.93	2000.000	100.00
7.800	60.73	105.000	95.63	500.000	99.60		
15.600	72.64	125.000	96.18	590.000	99.99		

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Laser Grainsize Analysis

Sample Name : 24534 20037511621 0-0.1m - Average

Record No.: 44

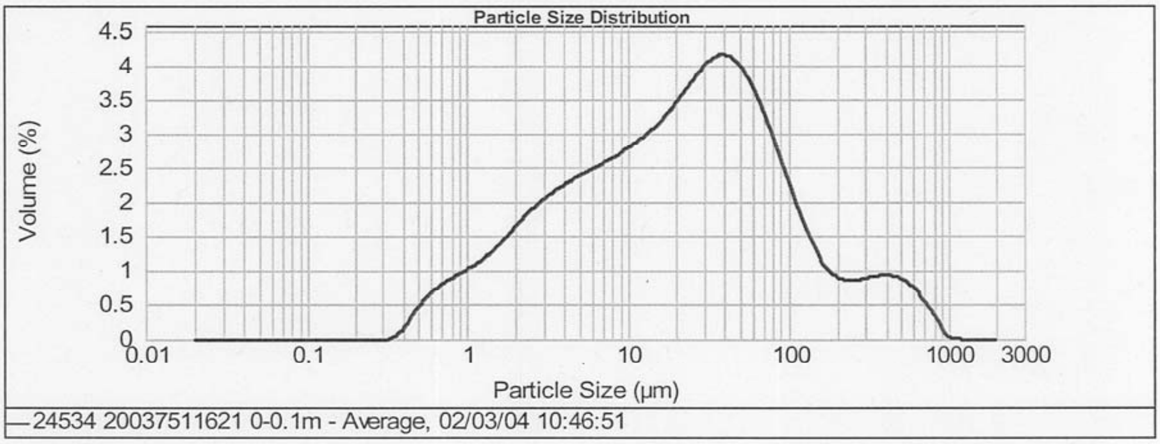
Operator Notes :

SOP Name: Silicious (Regolith)
Analysed: 02/03/04 10:46:52
Result Type: Averaged
Measured: 02/03/04 10:46:51
Measured by: mclachlan alex
Project Code 29302
Job No.: Job Sheet No 2003/04-104

Particle Name: Silica 0.0001
Accessory Name: Hydro 2000MU (A)
Obscuration: 26.30 %
Particle RI: 1.544
Absorption: 0.1
Analysis model: General purpose
Weighted Residual: 0.838 %
Dispersant Name: Water
Dispersant RI: 1.330
Size range: 0.020 to 2000.0... um

Concentration: 0.0252 %Vol
Vol. Weighted Mean D[4,3]: 62.980 um
Specific Surface Area: 1.06 m²/g

d(0.1): 2.035 um
d(0.5): 22.262 um
d(0.9): 142.984 um



	Mean	Stand. Dev.	Skewness	Kurtosis
Volume:	62.98	120.868	3.696	15.385

Distribution Modal Sizes

Mode 1: 39.829 um, Mode 2: 397.21 um,

Volume Under %

Size (μm)	Vol Under %	Size (μm)	Vol Under %	Size (μm)	Vol Under %	Size (μm)	Vol Under %
0.060	0.00	31.000	58.24	149.000	90.35	710.000	99.36
0.120	0.00	37.000	62.96	177.000	91.61	840.000	99.83
0.240	0.00	44.000	67.66	210.000	92.65	1000.000	99.99
0.490	0.46	53.000	72.58	250.000	93.63	1190.000	100.00
0.980	3.87	62.500	76.66	300.000	94.66	1410.000	100.00
2.000	9.81	74.000	80.43	350.000	95.56	1680.000	100.00
3.900	18.35	88.000	83.76	420.000	96.66	2000.000	100.00
7.800	29.33	105.000	86.54	500.000	97.69		
15.600	42.23	125.000	88.69	590.000	98.57		

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SEDIMENTOLOGY LABORATORY

Laser Grainsize Analysis

Sample Name : 24535 20037513621 0.75-0.9m - Average

Record No.: 48

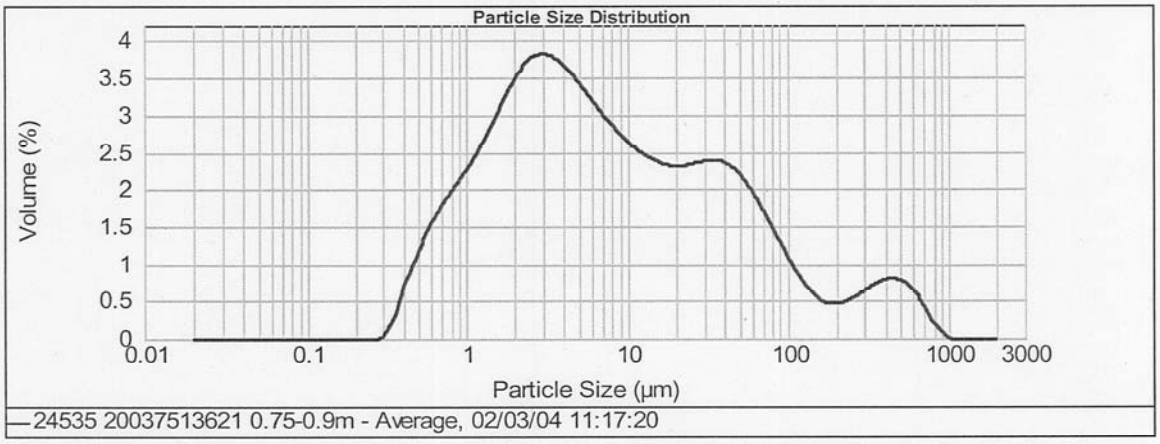
Operator Notes :

SOP Name: Silicious (Regolith)
Analysed: 02/03/04 11:17:21
Result Type: Averaged
Measured: 02/03/04 11:17:20
Measured by: mclachlan alex
Project Code 29302
Job No.: Job Sheet No 2003/04-104

Particle Name: Silica 0.0001
Accessory Name: Hydro 2000MU (A)
Obscuration: 30.44 %
Particle RI: 1.544
Absorption: 0.1
Analysis model: General purpose
Weighted Residual: 1.219 %
Dispersant Name: Water
Dispersant RI: 1.330
Size range: 0.020 to 2000.0... um

Concentration: 0.0158 %Vol
Vol. Weighted Mean D[4,3]: 42.542 um
Specific Surface Area: 2.13 m²/g

d(0.1): 1.005 um
d(0.5): 6.325 um
d(0.9): 85.715 um



	Mean	Stand. Dev.	Skewness	Kurtosis
Volume:	42.542	108.339	4.251	19.654

Distribution Modal Sizes

Mode 1: 2.989 um, Mode 2: 34.446 um, Mode 3: 443.199 um,

Volume Under %

Size (μm)	Vol Under %	Size (μm)	Vol Under %	Size (μm)	Vol Under %	Size (μm)	Vol Under %
0.060	0.00	31.000	76.25	149.000	93.31	710.000	99.62
0.120	0.00	37.000	79.01	177.000	93.88	840.000	99.91
0.240	0.00	44.000	81.68	210.000	94.40	1000.000	100.00
0.490	1.78	53.000	84.40	250.000	94.96	1190.000	100.00
0.980	9.62	62.500	86.60	300.000	95.65	1410.000	100.00
2.000	22.85	74.000	88.56	350.000	96.34	1680.000	100.00
3.900	39.17	88.000	90.23	420.000	97.26	2000.000	100.00
7.800	54.10	105.000	91.57	500.000	98.17		
15.600	65.79	125.000	92.56	590.000	98.96		

Laser Grainsize Analysis

Sample Name : 24536 20037511625 0-0.1m - Average

Record No.: 52

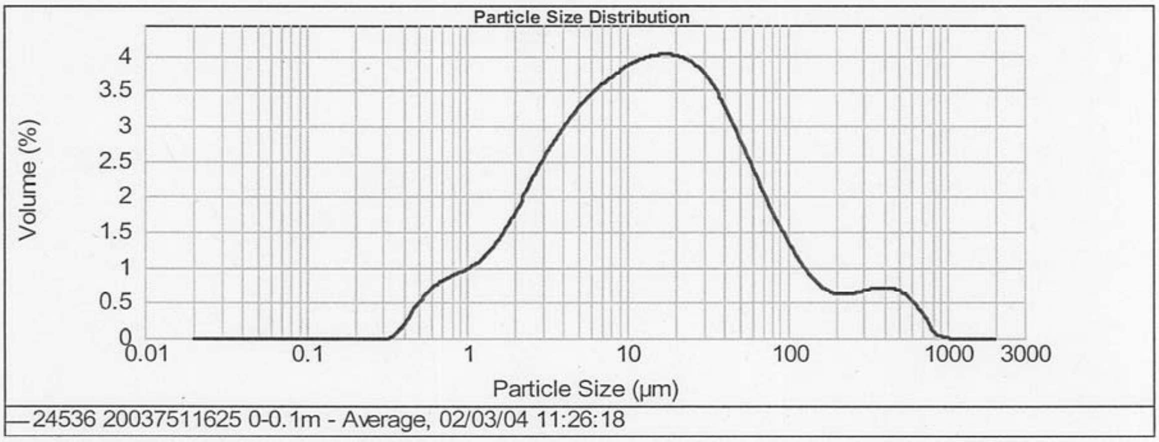
Operator Notes :

SOP Name: Silicious (Regolith) **Analysed:** 02/03/04 11:26:19 **Result Type:** Averaged
Measured: 02/03/04 11:26:18 **Measured by:** mclachlan alex **Project Code 29302** **Job No.:** Job Sheet No 2003/04-104

Particle Name: Silica 0.0001 **Accessory Name:** Hydro 2000MU (A) **Obscuration:** 25.27 %
Particle RI: 1.544 **Absorption:** 0.1 **Analysis model:** General purpose **Weighted Residual:** 0.904 %
Dispersant Name: Water **Dispersant RI:** 1.330 **Size range:** 0.020 to 2000.0... um

Concentration: 0.0215 %Vol **Vol. Weighted Mean D[4,3]:** 45.644 um **Specific Surface Area:** 1.18 m²/g

d(0.1): 2.001 um d(0.5): 13.919 um d(0.9): 94.897 um



	Mean	Stand. Dev.	Skewness	Kurtosis
Volume:	45.644	99.24	4.264	20.449

Distribution Modal Sizes

Mode 1: 17.455 um, Mode 2: 401.134 um,

Volume Under %

Size (μm)	Vol Under %
0.060	0.00
0.120	0.00
0.240	0.00
0.490	0.55
0.980	4.03
2.000	9.99
3.900	20.32
7.800	35.43
15.600	52.98

Size (μm)	Vol Under %
31.000	70.66
37.000	74.81
44.000	78.55
53.000	82.11
62.500	84.84
74.000	87.22
88.000	89.24
105.000	90.91
125.000	92.21

Size (μm)	Vol Under %
149.000	93.24
177.000	94.06
210.000	94.77
250.000	95.47
300.000	96.23
350.000	96.92
420.000	97.76
500.000	98.55
590.000	99.21

Size (μm)	Vol Under %
710.000	99.75
840.000	99.97
1000.000	100.00
1190.000	100.00
1410.000	100.00
1680.000	100.00
2000.000	100.00

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Laser Grainsize Analysis

Sample Name : 24537 20037513625 0.75-0.9m - Average

Record No.: 56

Operator Notes :

SOP Name: Silicious (Regolith) **Analysed:** 02/03/04 11:34:57 **Result Type:** Averaged

Measured: 02/03/04 11:34:56 **Measured by:** mclachlan alex **Project Code 29302** **Job No.:** Job Sheet No 2003/04-104

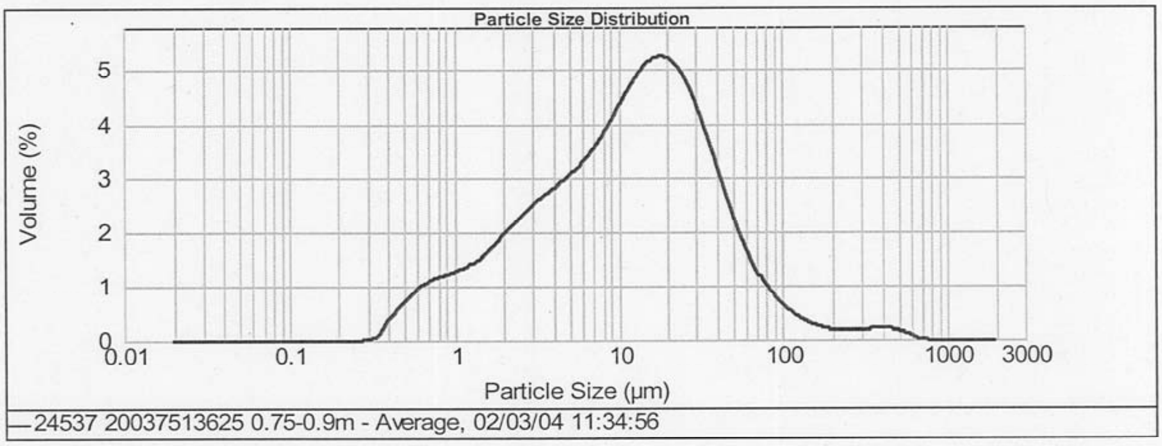
Particle Name: Silica 0.0001 **Accessory Name:** Hydro 2000MU (A) **Obscuration:** 23.35 %

Particle RI: 1.544 **Absorption:** 0.1 **Analysis model:** General purpose **Weighted Residual:** 1.043 %

Dispersant Name: Water **Dispersant RI:** 1.330 **Size range:** 0.020 to 2000.0... um

Concentration: 0.0170 %Vol **Vol. Weighted Mean D[4,3]:** 23.727 um **Specific Surface Area:** 1.41 m²/g

d(0.1): 1.588 um d(0.5): 12.117 um d(0.9): 46.961 um



	Mean	Stand. Dev.	Skewness	Kurtosis
Volume:	23.727	47.978	6.901	60.23

Distribution Modal Sizes

Mode 1: 18.332 um,

Volume Under %

Size (μm)	Vol Under %	Size (μm)	Vol Under %	Size (μm)	Vol Under %	Size (μm)	Vol Under %
0.060	0.00	31.000	80.65	149.000	98.22	710.000	100.00
0.120	0.00	37.000	85.19	177.000	98.51	840.000	100.00
0.240	0.00	44.000	88.84	210.000	98.73	1000.000	100.00
0.490	0.90	53.000	91.86	250.000	98.92	1190.000	100.00
0.980	5.56	62.500	93.85	300.000	99.13	1410.000	100.00
2.000	12.73	74.000	95.35	350.000	99.33	1680.000	100.00
3.900	23.27	88.000	96.45	420.000	99.58	2000.000	100.00
7.800	37.76	105.000	97.26	500.000	99.80		
15.600	58.24	125.000	97.82	590.000	99.95		

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SEDIMENTOLOGY LABORATORY

Laser Grainsize Analysis

Sample Name : 24538 20037511629 0-0.1m - Average

Record No.: 60

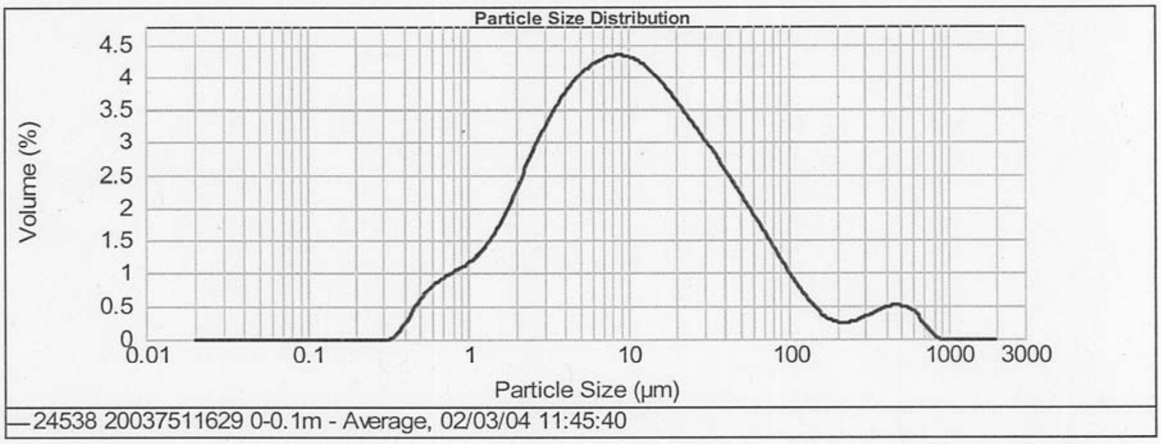
Operator Notes :

SOP Name: Silicious (Regolith)
Analysed: 02/03/04 11:45:41
Result Type: Averaged
Measured: 02/03/04 11:45:40
Measured by: mclachlan alex
Project Code 29302
Job No.: Job Sheet No 2003/04-104

Particle Name: Silica 0.0001
Accessory Name: Hydro 2000MU (A)
Obscuration: 29.82 %
Particle RI: 1.544
Absorption: 0.1
Analysis model: General purpose
Weighted Residual: 1.041 %
Dispersant Name: Water
Dispersant RI: 1.330
Size range: 0.020 to 2000.0... um

Concentration: 0.0219 %Vol
Vol. Weighted Mean D[4,3]: 32.602 um
Specific Surface Area: 1.4 m^2/g

d(0.1): 1.715 um
d(0.5): 9.686 um
d(0.9): 62.903 um



	Mean	Stand. Dev.	Skewness	Kurtosis
Volume:	32.602	81.449	5.374	32.326

Distribution Modal Sizes

Mode 1: 8.827 um,
Mode 2: 464.971 um,

Volume Under %

Size (μm)	Vol Under %	Size (μm)	Vol Under %	Size (μm)	Vol Under %	Size (μm)	Vol Under %
0.060	0.00	31.000	78.72	149.000	96.19	710.000	99.88
0.120	0.00	37.000	82.03	177.000	96.60	840.000	100.00
0.240	0.00	44.000	84.97	210.000	96.89	1000.000	100.00
0.490	0.63	53.000	87.76	250.000	97.16	1190.000	100.00
0.980	4.66	62.500	89.92	300.000	97.50	1410.000	100.00
2.000	12.12	74.000	91.81	350.000	97.87	1680.000	100.00
3.900	25.39	88.000	93.39	420.000	98.41	2000.000	100.00
7.800	43.88	105.000	94.65	500.000	98.98		
15.600	63.04	125.000	95.56	590.000	99.48		

Laser Grainsize Analysis

Sample Name : 24539 20037513629 0.75-0.9m - Average

Record No.: 64

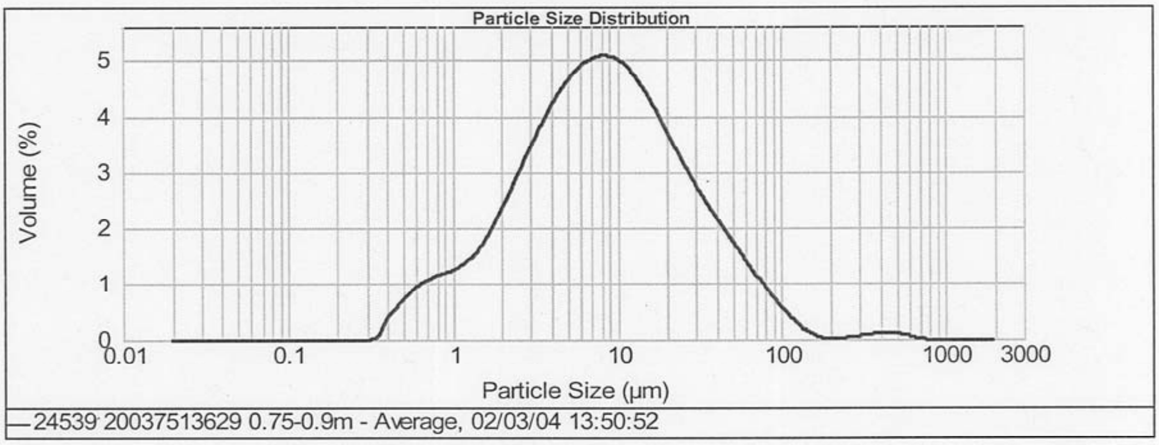
Operator Notes :

SOP Name: Silicious (Regolith) **Analysed:** 02/03/04 13:50:53 **Result Type:** Averaged
Measured: 02/03/04 13:50:52 **Measured by:** mclachlan alex **Project Code 29302** **Job No.:** Job Sheet No 2003/04-104

Particle Name: Silica 0.0001 **Accessory Name:** Hydro 2000MU (A) **Obscuration:** 33.51 %
Particle RI: 1.544 **Absorption:** 0.1 **Analysis model:** General purpose **Weighted Residual:** 1.150 %
Dispersant Name: Water **Dispersant RI:** 1.330 **Size range:** 0.020 to 2000.0... um

Concentration: 0.0231 %Vol **Vol. Weighted Mean D[4,3]:** 17.309 um **Specific Surface Area:** 1.56 m²/g

d(0.1): 1.590 um d(0.5): 8.086 um d(0.9): 38.634 um



	Mean	Stand. Dev.	Skewness	Kurtosis
Volume:	17.309	36.97	9.38	116.777

Distribution Modal Sizes

Mode 1: 8.332 um,

Volume Under %

Size (μm)	Vol Under %	Size (μm)	Vol Under %	Size (μm)	Vol Under %	Size (μm)	Vol Under %
0.060	0.00	31.000	86.43	149.000	99.35	710.000	100.00
0.120	0.00	37.000	89.35	177.000	99.43	840.000	100.00
0.240	0.00	44.000	91.82	210.000	99.44	1000.000	100.00
0.490	0.85	53.000	94.06	250.000	99.47	1190.000	100.00
0.980	5.44	62.500	95.68	300.000	99.52	1410.000	100.00
2.000	13.11	74.000	97.01	350.000	99.60	1680.000	100.00
3.900	27.40	88.000	98.03	420.000	99.73	2000.000	100.00
7.800	48.80	105.000	98.73	500.000	99.86		
15.600	70.76	125.000	99.15	590.000	99.96		

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Laser Grainsize Analysis

Sample Name : 24540 20037511633 0-0.1m - Average

Record No.: 68

Operator Notes :

SOP Name: Silicious (Regolith) **Analysed:** 02/03/04 14:05:12 **Result Type:** Averaged

Measured: 02/03/04 14:05:11 **Measured by:** mclachlan alex **Project Code 29302** **Job No.:** Job Sheet No 2003/04-104

Particle Name: Silica 0.0001 **Accessory Name:** Hydro 2000MU (A) **Obscuration:** 21.08 %

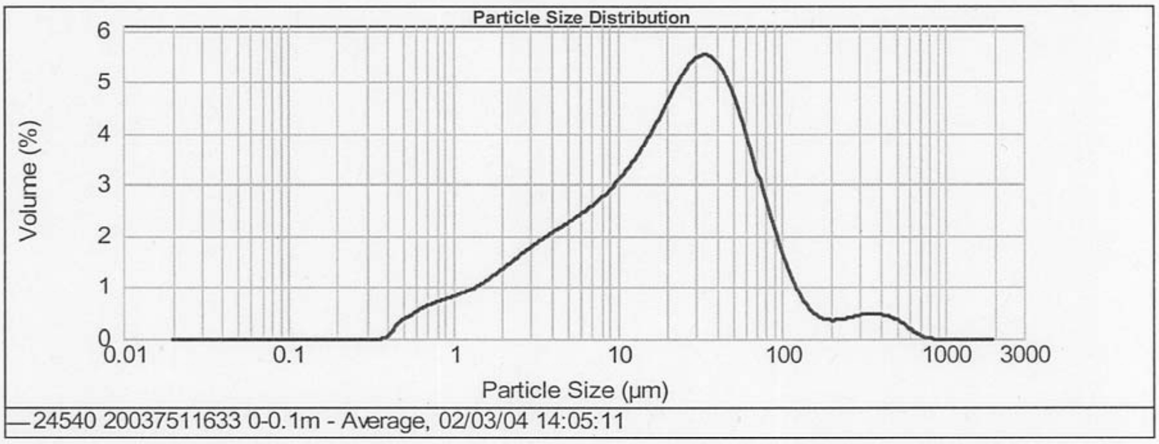
Particle RI: 1.544 **Absorption:** 0.1 **Analysis model:** General purpose **Weighted Residual:** 0.802 %

Dispersant Name: Water **Dispersant RI:** 1.330 **Size range:** 0.020 to 2000.0... um

---

Concentration: 0.0220 %Vol **Vol. Weighted Mean D[4,3]:** 39.933 um **Specific Surface Area:** 0.923 m²/g

d(0.1): 2.509 um d(0.5): 21.748 um d(0.9): 77.960 um



	Mean	Stand. Dev.	Skewness	Kurtosis
Volume:	39.933	69.095	4.888	29.241

Distribution Modal Sizes

Mode 1: 34.446 um, Mode 2: 362.504 um,

Volume Under %

Size (µm)	Vol Under %
0.060	0.00
0.120	0.00
0.240	0.00
0.490	0.25
0.980	2.96
2.000	7.81
3.900	15.23
7.800	25.87
15.600	40.56
31.000	62.03
37.000	68.42
44.000	74.54
53.000	80.58
62.500	85.18
74.000	89.01
88.000	91.97
105.000	94.06
125.000	95.38
149.000	96.18
177.000	96.69
210.000	97.08
250.000	97.50
300.000	98.00
350.000	98.47
420.000	99.03
500.000	99.50
590.000	99.83
710.000	99.99
840.000	100.00
1000.000	100.00
1190.000	100.00
1410.000	100.00
1680.000	100.00
2000.000	100.00

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3633

Laser Grainsize Analysis

Sample Name : 24541 20037510.7-0.9m - Average

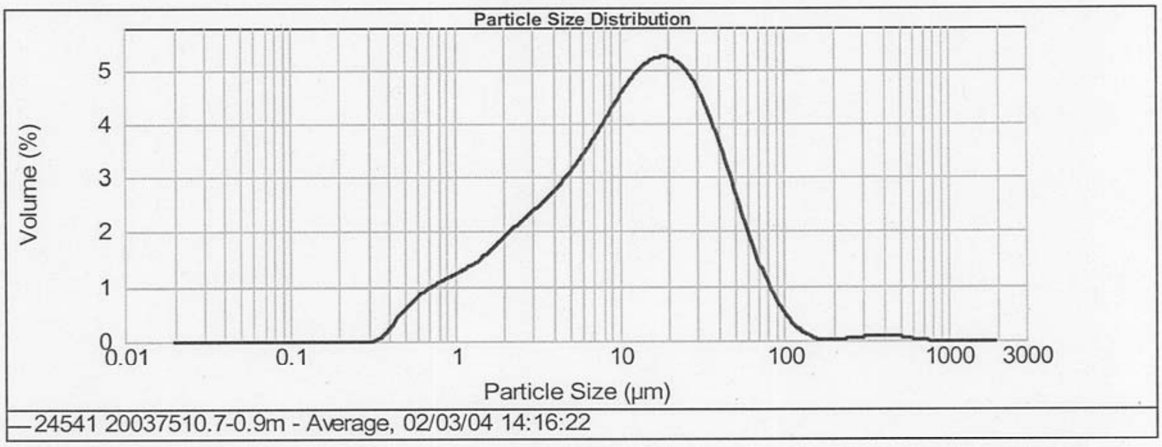
Record No.: 72

Operator Notes :

SOP Name:	Silicious (Regolith)	**Analysed:**	02/03/04 14:16:23	**Result Type:**	Averaged
Measured:	02/03/04 14:16:22	**Measured by:**	mclachlan alex	**Project Code 29302**	**Job No.:** Job Sheet No 2003/04-104

Particle Name:	Silica 0.0001	**Accessory Name:**	Hydro 2000MU (A)	**Obscuration:**	26.57 %
Particle RI:	1.544 **Absorption:** 0.1	**Analysis model:**	General purpose	**Weighted Residual:**	1.013 %
Dispersant Name:	Water	**Dispersant RI:**	1.330	**Size range:**	0.020 to 2000.0... um

Concentration:	0.0207 %Vol	**Vol. Weighted Mean D[4,3]:**	20.315 um	**Specific Surface Area:**	1.31 m²/g
d(0.1):	1.729 um	**d(0.5): 12.380**	**um**	d(0.9):	44.913 um



	Mean	Stand. Dev.	Skewness	Kurtosis
Volume:	20.315	32.654	8.864	117.238

Distribution Modal Sizes

Mode 1: 18.831 um,

Volume Under %

Size (μm)	Vol Under %	Size (μm)	Vol Under %	Size (μm)	Vol Under %	Size (μm)	Vol Under %
0.060	0.00	31.000	80.35	149.000	99.52	710.000	100.00
0.120	0.00	37.000	85.35	177.000	99.54	840.000	100.00
0.240	0.00	44.000	89.55	210.000	99.55	1000.000	100.00
0.490	0.59	53.000	93.17	250.000	99.58	1190.000	100.00
0.980	4.73	62.500	95.57	300.000	99.65	1410.000	100.00
2.000	11.72	74.000	97.30	350.000	99.72	1680.000	100.00
3.900	21.79	88.000	98.44	420.000	99.82	2000.000	100.00
7.800	36.63	105.000	99.09	500.000	99.92		
15.600	57.60	125.000	99.40	590.000	99.98		

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SEDIMENTOLOGY LABORATORY

Laser Grainsize Analysis

Sample Name : 24542 20037511637 0-0.1m - Average

Record No.: 76

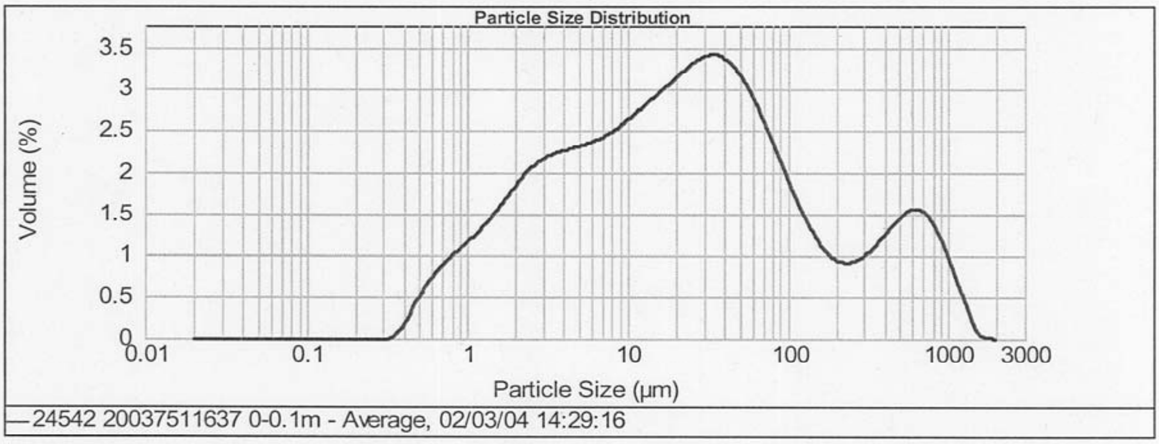
Operator Notes :

SOP Name: Silicious (Regolith)
Analysed: 02/03/04 14:29:17
Result Type: Averaged
Measured: 02/03/04 14:29:16
Measured by: mclachlan alex
Project Code 29302
Job No.: Job Sheet No 2003/04-104

Particle Name: Silica 0.0001
Accessory Name: Hydro 2000MU (A)
Obscuration: 19.89 %
Particle RI: 1.544
Absorption: 0.1
Analysis model: General purpose
Weighted Residual: 1.008 %
Dispersant Name: Water
Dispersant RI: 1.330
Size range: 0.020 to 2000.0... um

Concentration: 0.0172 %Vol
Vol. Weighted Mean D[4,3]: 110.556 um
Specific Surface Area: 1.13 m²/g

d(0.1): 1.819 um
d(0.5): 22.037 um
d(0.9): 390.432 um



	Mean	Stand. Dev.	Skewness	Kurtosis
Volume:	110.556	226.121	2.975	9.043

Distribution Modal Sizes

Mode 1: 34.566 um, Mode 2: 632.442 um,

Volume Under %

Size (μm)	Vol Under %
0.060	0.00
0.120	0.00
0.240	0.00
0.490	0.50
0.980	4.30
2.000	11.11
3.900	20.24
7.800	30.85
15.600	43.06
31.000	57.40
37.000	61.36
44.000	65.18
53.000	69.12
62.500	72.35
74.000	75.32
88.000	77.99
105.000	80.28
125.000	82.14
149.000	83.67
177.000	84.91
210.000	85.99
250.000	87.02
300.000	88.14
350.000	89.18
420.000	90.59
500.000	92.15
590.000	93.78
710.000	95.65
840.000	97.24
1000.000	98.58
1190.000	99.47
1410.000	99.92
1680.000	100.00
2000.000	100.00

Laser Grainsize Analysis

Sample Name : 24543 20037513637 0.75-0.9m - Average

Record No.: 80

Operator Notes :

SOP Name: Silicious (Regolith) **Analysed:** 02/03/04 14:46:34 **Result Type:** Averaged
Measured: 02/03/04 14:46:33 **Measured by:** mclachlan alex **Project Code 29302** **Job No.:** Job Sheet No 2003/04-104

Particle Name: Silica 0.0001 **Accessory Name:** Hydro 2000MU (A) **Obscuration:** 24.84 %
Particle RI: 1.544 **Absorption:** 0.1 **Analysis model:** General purpose **Weighted Residual:** 1.184 %
Dispersant Name: Water **Dispersant RI:** 1.330 **Size range:** 0.020 to 2000.0... um

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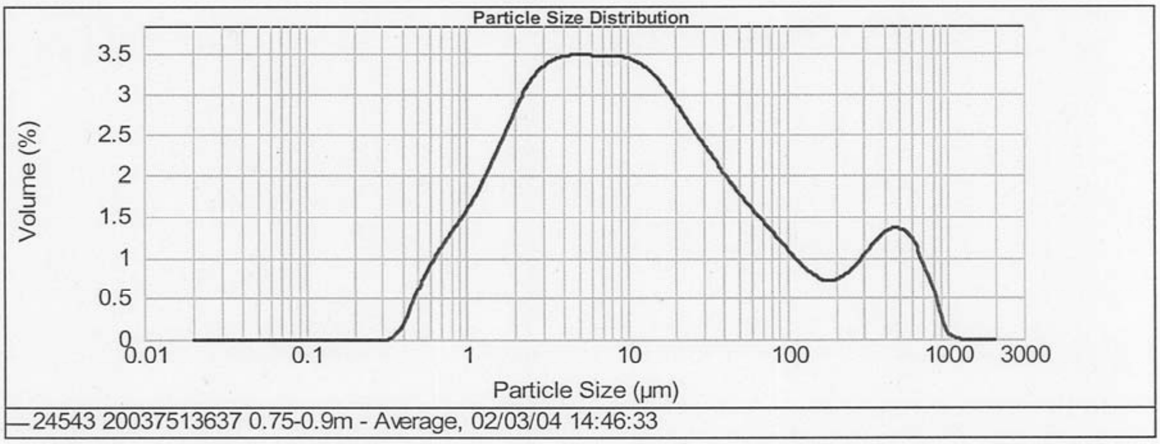
Concentration: 0.0161 %Vol **Vol. Weighted Mean D[4,3]:** 65.714 um **Specific Surface Area:** 1.52 m²/g

d(0.1): 1.437 um **d(0.5): 9.644 um** d(0.9): 209.461 um



	Mean	Stand. Dev.	Skewness	Kurtosis
Volume:	65.714	149.182	3.213	10.408

Distribution Modal Sizes

Mode 1: 4.978 um, Mode 2: 473.878 um,

Volume Under %

Size (μm)	Vol Under %
0.060	0.00
0.120	0.00
0.240	0.00
0.490	0.56
0.980	5.42
2.000	15.38
3.900	29.45
7.800	45.19
15.600	60.54
31.000	72.99
37.000	75.58
44.000	77.88
53.000	80.12
62.500	81.91
74.000	83.55
88.000	85.03
105.000	86.34
125.000	87.44
149.000	88.38
177.000	89.21
210.000	90.01
250.000	90.90
300.000	92.00
350.000	93.11
420.000	94.60
500.000	96.13
590.000	97.54
710.000	98.86
840.000	99.67
1000.000	99.97
1190.000	100.00
1410.000	100.00
1680.000	100.00
2000.000	100.00

Appendix 6: Macroscopic properties of overbank sediments form the eastern Riverina (field parameters)

SampleID	Texture	pH (field)	Colour (dry)	Colour (dry)	Colour (wet)	Colour (wet)
20037512601	S	6	10YR6/6	Brownish Yellow	10YR4/3	Brown
20037514601	SCL	6.5	10YR7/6	Yellow	10YR4/4	Dark Yellowish Brown
20037512602	SC	6	10YR5/3	Brown	10YR3/3	Dark Brown
20037514602	LMC	6.5	10YR6/3	Pale Brown	7.5Y4/3	Brown
20037512603	CL	6	10YR5/2	Greyish Brown	10YR4/2	Dark Greyish Brown
20037514603	SiCL	5.5	10YR5/3	Brown	10YR3/2	Very Dark Greyish Brown
20037512604	LS	6	10YR5/3	Brown	10YR3/2	Very Dark Greyish Brown
20037514604	FSL	6	10YR4/2	Dark Greyish Brown	10YR2/2	Very Dark Brown
20037512605	FSCL	6	10YR7/6	Yellow	10YR5/4	Yellowish Brown
20037514605	LC	7.5	10YR6/4	Light Yellowish Brown	10YR5/4	Yellowish Brown
20037512606	Lfsy	6.5	10YR6/4	Light Yellowish Brown	10YR4/3	Brown
20037514606	M	7	10YR7/4	Very Pale Brown	10YR4/4	Dark Yellowish Brown
20037512607	Lfsy	6	10YR5/4	Yellowish Brown	10YR4/4	Dark Yellowish Brown
20037514607	CL	6.5	2.5Y7/4	Pale Yellow	2.5Y5/3	Light Olive Brown
20037512608	CLS	6	2.5Y6/2	Light Brownish Grey	2.5Y4/2	Dark Greyish Brown
20037514608	HC	7	2.5Y7/2	Light Grey	2.5Y5/2	Greyish Brown
20037512609	CL	6	10YR5/4	Yellowish Brown	7.5YR3/3	Dark Brown
20037514609	LC	7.5	2.5Y6/4	Light Yellowish Brown	2.5Y5/3	Light Olive Brown
20037512610	CL	6.5	2.5Y7/2	Light Grey	2.5Y6/2	Light Brownish Grey
20037514610	MC	7	2.5Y5/2	Greyish Brown	7.5YR4/2	Brown
20037512611	LMC	6.5	10YR4/3	Brown	10YR3/3	Dark Brown
20037514611	LMC	8	2.5Y6/3	Light Yellowish Brown	2.5Y5/3	Light Olive Brown
20037512612	SiCL	6.5	10YR6/3	Pale Brown	10YR4/3	Brown
20037514612	MHC	7	10YR6/3	Pale Brown	10YR4/3	Brown
20037512613	CL	7	10YR5/3	Brown	10YR3/3	Dark Brown
20037514613	HC	9	10YR5/4	Yellowish Brown	10YR4/4	Dark Yellowish Brown
20037512614	Lfsy	7	10YR7/2	Light Grey	10YR6/3	Pale Brown
20037514614	CL	8	10YR7/3	Very Pale Brown	10YR6/3	Pale Brown
20037512615	LMC	6.5	10YR4/2	Dark Greyish Brown	10YR3/1	Very Dark Grey
20037514615	MC	8	2.5Y5/2	Greyish Brown	10YR4/2	Dark Greyish Brown
20037512616	CL	7	10YR5/4	Yellowish Brown	10YR3/4	Dark Yellowish Brown
20037514616	HC	8.5	2.5Y6/3	Light Yellowish Brown	2.5Y5/3	Light Olive Brown
20037512617	MC	7	10YR5/4	Yellowish Brown	10YR4/3	Brown
20037514617	HC	8.5	7.5YR5/4	Brown	7.5YR4/4	Brown
20037512618	SiL	6.5	10YR5/3	Brown	10YR3/3	Dark Brown
20037514618	CL	5.5	10YR6/4	Light Yellowish Brown	10YR5/4	Yellowish Brown
20037512619	L	5.5	10YR5/3	Brown	10YR3/3	Dark Brown
20037514619	Lfsy	8.5	10YR6/4	Light Yellowish Brown	10YR5/4	Yellowish Brown
20037512620	Lfsy	5.5	10YR7/4	Very Pale Brown	10YR5/4	Yellowish Brown
20037514620	CL	7	10YR7/3	Very Pale Brown	10YR5/4	Yellowish Brown

SampleID	Texture	pH (field)	Colour (dry)	Colour (dry)	Colour (wet)	Colour (wet)
20037512621	L	5	10YR6/3	Pale Brown	10YR3/3	Dark Brown
20037514621	MC	5	10YR6/3	Pale Brown	10YR4/3	Brown
20037512622	Lfsy	7	10YR6/4	Light Yellowish Brown	10YR5/4	Yellowish Brown
20037514622	SC	7	10YR6/4	Light Yellowish Brown	10YR4/4	Dark Yellowish Brown
20037512623	L	4	10YR6/3	Pale Brown	10YR3/3	Dark Brown
20037514623	MC	7	2.5Y7/4	Pale Yellow	10YR4/6	Dark Yellowish Brown
20037512624	Lfsy	7	10YR5/3	Brown	10YR3/3	Dark Brown
20037514624	SCL	5.5	10YR7/2	Light Grey	10YR5/3	Brown
20037512625	SiL	5.5	10YR5/4	Yellowish Brown	10YR 3/3	Dark Brown
20037514625	SiCL	6.5	10YR6/6	Brownish Yellow	10YR4/6	Strong Brown
20037512626	SiL	5.5	10YR5/3	Brown	10YR3/3	Dark Brown
20037512627	LC	6.5	2.5Y7/4	Pale Yellow	2.5Y5/4	Light Olive Brown
20037514627	SC	6	2.5Y7/4	Pale Yellow	10YR5/4	Yellowish Brown
20037512628	SiL	5.5	10YR5/3	Brown	10YR3/2	Very Dark Greyish Brown
20037514628	S	5.5	10YR5/4	Yellowish Brown	10YR4/4	Dark Yellowish Brown
20037512629	SiCL	5.5	10YR6/3	Pale Brown	10YR4/2	Dark Greyish Brown
20037514629	SC	6	2.5Y7/4	Pale Yellow	10YR5/6	Yellowish Brown
20037512630	CL	5	10YR5/3	Brown	10YR3/2	Very Dark Greyish Brown
20037514630	SC	8	2.5Y7/2	Light Grey	2.5Y5/2	Greyish Brown
20037512631	L	5	10YR6/3	Pale Brown	10YR3/3	Dark Brown
20037514631	S	9	2.5Y7/3	Pale Yellow	2.5Y6/4	Light Yellowish Brown
20037512632	SL	9	10YR6/3	Pale Brown	10YR4/3	Brown
20037514632	LC	8.5	2.5Y7/4	Pale Yellow	2.5Y6/4	Light Yellowish Brown
20037512633	SiL	5.5	10YR6/3	Pale Brown	10YR4/3	Brown
20037514633	SiCL	6	2.5Y6/2	Light Brownish Grey	10YR3/2	Very Dark Greyish Brown
20037512634	LC	6	2.5Y6/3	Light Yellowish Brown	2.5Y4/2	Dark Greyish Brown
20037514634	SC	8.5	2.5Y6/3	Light Yellowish Brown	2.5Y5/3	Light Olive Brown
20037512635	L	5.5	10YR7/3	Very Pale Brown	10YR4/3	Brown
20037514635	LC	8	10YR6/6	Brownish Yellow	10YR4/6	Dark Yellowish Brown
20037512636	L	6.5	10YR4/4	Dark Yellowish Brown	7.5YR3/3	Dark Brown
20037514636	HC	7	7.5YR4/6	Strong Brown	7.5YR3/4	Dark Brown
20037512637	SiL	6	10YR5/3	Brown	10YR3/2	Very Dark Greyish Brown
20037514637	SC	8	10YR6/2	Light Brownish Grey	10YR5/3	Brown
20037512638	SiCL	7	10YR5/4	Yellowish Brown	10YR4/4	Dark Yellowish Brown
20037514638	LC	7.5	10YR6/4	Light Yellowish Brown	10YR5/4	Yellowish Brown
20037512639	SiC	6	10YR5/2	Greyish Brown	10YR3/2	Very Dark Greyish Brown
20037514639	LC	7	10YR5/2	Greyish Brown	10YR4/2	Dark Greyish Brown
20037512640	CL	6.5	10YR5/4	Yellowish Brown	10YR4/3	Brown
20037514640	LC	8.5	10YR5/4	Yellowish Brown	10YR4/4	Dark Yellowish Brown

SampleID	Texture	pH (field)	Colour (dry)	Colour (dry)	Colour (wet)	Colour (wet)
20037512641	SL	6.5	10YR6/2	Light Brownish Grey	10YR3/2	Very Dark Greyish Brown
20037514641	SC	6	10YR6/2	Light Brownish Grey	10YR4/2	Dark Greyish Brown
20037512642	LS	7	7.5YR4/6	Strong Brown	7.5YR3/3	Dark Brown
20037514642	MC	8	7.5YR4/6	Strong Brown	7.5YR3/4	Dark Brown
20037512643	FSL	6.5	10YR5/2	Greyish Brown	10YR3/2	Very Dark Greyish Brown
20037514643	SC	8.5	2.5Y6/4	Light Yellowish Brown	10YR5/4	Yellowish Brown
20037512644	SL	7.5	10YR5/2	Greyish Brown	10YR3/2	Very Dark Greyish Brown
20037514644	SC	8	10YR6/3	Pale Brown	10YR5/2	Greyish Brown
20037512645	FSL	7	10YR6/6	Dark Yellowish Brown	10YR3/4	Dark Yellowish Brown
20037514645	HC	8.5	10YR6/3	Pale Brown	2.5Y6/3	Light Yellowish Brown
20037512646	HC	7	2.5Y4/1	Dark Grey	2.5Y2.5/1	Black
20037514646	MC	8.5	2.5Y5/1	Grey	2.5Y4/1	Dark Grey
20037512647	CL	7.5	2.5Y5/1	Grey	2.5Y3/1	Very Dark Grey
20037514647	SiC	8	2.5Y6/2	Light Brownish Grey	2.5Y5/3	Light Olive Brown
20037512648	S	6	10YR4/3	Brown	7.5YR3/3	Dark Brown
20037514648	Lfsy	8.5	10YR4/4	Dark Yellowish Brown	10YR3/6	Dark Yellowish Brown
20037512649	SiCL	8	2.5Y5/1	Grey	2.5Y4/1	Dark Grey
20037514649	HC	9	2.5Y5/2	Greyish Brown	10YR4/2	Dark Greyish Brown
20037512650	L	7	10YR5/4	Yellowish Brown	10YR3/3	Dark Brown
20037514650	SiC	8.5	7.5YR5/6	Strong Brown	7.5YR4/6	Strong Brown
20037512651	MC	7	10YR5/2	Greyish Brown	10YR4/2	Dark Greyish Brown
20037514651	SCL	8	10YR5/4	Yellowish Brown	10YR4/3	Brown
20037512652	L	7	7.5YR4/4	Brown	10YR3/4	Dark Brown
20037514652	SiL	7.5	10YR6/4	Light Yellowish Brown	10YR4/4	Dark Yellowish Brown
20037512653	L	7	10YR5/3	Brown	10YR5/3	Brown
20037514653	LC	8.5	10YR6/4	Light Yellowish Brown	10YR4/6	Dark Yellowish Brown
20037512654	CL	7.5	10YR5/3	Brown	10YR4/3	Brown
20037514654	LC	8	10YR6/4	Light Yellowish Brown	10YR5/4	Yellowish Brown
20037512655	L	6.5	10YR5/2	Greyish Brown	10YR3/1	Very Dark Grey
20037514655	CL	8.5	2.5Y6/3	Light Yellowish Brown	2.5Y5/3	Light Olive Brown
20037512656	LS	5	2.5Y6/2	Light Brownish Grey	2.5Y4/2	Dark Greyish Brown
20037514656	SiCL	8.5	2.5Y5/2	Greyish Brown	2.5Y4/2	Dark Greyish Brown
20037512657	CL	6.5	10YR6/2	Light Brownish Grey	10YR4/2	Dark Greyish Brown
20037514657	SiC	8.5	2.5Y6/2	Light Brownish Grey	2.5Y5/2	Greyish Brown
20037512658	LC	8.5	7.5YR4/4	Brown	7.5YR3/4	Dark Brown
20037514658	MC	8.5	10YR6/4	Light Yellowish Brown	10YR5/4	Yellowish Brown
20037512659	LC	6.5	10YR5/3	Brown	10YR3/3	Dark Brown
20037514659	CL	8.5	10YR5/4	Yellowish Brown	10YR4/3	Brown

SampleID	Texture	pH (field)	Colour (dry)	Colour (dry)	Colour (wet)	Colour (wet)
20037512660	L	7	10YR5/3	Brown	10YR3/2	Very Dark Greyish Brown
20037514660	SiL	8.5	2.5Y6/3	Light Yellowish Brown	2.5Y5/3	Light Olive Brown
20037512661	MC	8	10YR4/2	Dark Greyish Brown	10YR3/2	Very Dark Greyish Brown
20037514661	CL	8	10YR5/3	Brown	10YR4/4	Dark Yellowish Brown
20037512662	L	6.5	2.5Y7/1	Light Grey	2.5Y4/2	Dark Greyish Brown
20037514662	LC	8	2.5Y6/3	Light Yellowish Brown	2.5Y5/3	Light Olive Brown
20037512663	Lfsy	6	2.5Y5/2	Greyish Brown	2.5Y3/2	Very Dark Greyish Brown
20037514663	CL	8.5	10YR6/3	Pale Brown	10YR5/3	Brown
20037512664	CL	7	2.5Y5/2	Greyish Brown	2.5Y3/2	Very Dark Greyish Brown
20037514664	LMC	8.5	10YR5/3	Brown	10YR4/3	Brown
20037512665	CL	8.5	7.5YR4/6	Strong Brown	7.5YR3/4	Dark Brown
20037514665	L	8.5	2.5Y6/4	Light Yellowish Brown	2.5Y4/4	Olive Brown

Appendix 7: Macroscopic properties of overbank sediments form the eastern Riverina (laboratory parameters)

SampleID	Moisture (%)	pH 1:5	EC 1:5 (µS/cm)
20037512601	11.50	5.7	28.3
20037514601	14.77	6.3	53
20037512602	20.24	5.3	79.7
20037514602	15.48	4.8	581
20037512603	24.38	6	99.1
20037514603	21.04	5.3	1528
20037512604	15.01	5.6	61.1
20037514604	22.48	6.2	39.8
20037512605	23.30	5.5	76.7
20037514605	14.22	8.9	169.8
20037512606	22.35	6.5	22.2
20037514606	22.10	7.8	403
20037512607	15.99	5.6	23.7
20037514607	12.91	5.1	252
20037512608	24.47	5.3	60.3
20037514608	15.54	7	29.6
20037512609	15.13	6.7	29.9
20037514609	14.89	8.3	170
20037512610	8.14	6.8	164.5
20037514610	20.18	7.1	575
20037512611	22.35	7.2	47.7
20037514611	19.20	7.8	1013
20037512612	16.36	7.7	38.8
20037514612	21.71	7.9	223
20037512613	16.80	6.9	37.7
20037514613	21.58	9.2	340
20037512614	20.87	7.3	26.7
20037514614	9.15	8.8	76
20037512615	22.34	7.5	44.8
20037514615	33.81	7.9	1628
20037512616	15.57	7.6	45.5
20037514616	23.46	8.6	216
20037512617	19.62	7.6	52.5
20037514617	22.99	8.3	1068
20037512618	20.75	7.3	46
20037514618	13.47	6.8	250
20037512619	10.23	6.5	34
20037514619	15.58	8.7	240
20037512620	12.20	5.4	39.4
20037514620	14.35	7.2	309
20037512621	11.71	5.5	55.6
20037514621	18.87	5	39.7
20037512622	16.14	6.7	14.9
20037514622	19.12	7	14.2
20037512623	23.65	4.7	49.4
20037514623	20.04	7.1	19.6
20037512624	19.86	6.8	52.7
20037514624	19.20	6.2	16.1
20037512625	31.42	6	26.5
20037514625	21.60	6.7	7.2
20037512626	22.78	5.8	23.1
20037512627	20.94	6.2	22.1
20037514627	19.40	6.5	8.2
20037512628	18.22	5.4	159.5
20037514628	20.09	5	187.8
20037512629	32.31	5.7	80.9
20037514629	24.20	6.9	6.7
20037512630	21.20	5.8	26.7
20037514630	19.18	7.6	226
20037512631	27.17	5.3	93.9
20037514631	14.07	9.1	121.4
20037512632	19.16	9.3	130.1
20037514632	24.17	8.7	515
20037512633	9.34	6.4	42
20037514633	20.06	6	198.5
20037512634	30.59	6.5	44.9
20037514634	27.13	8.6	288
20037512635	24.40	5.8	121.4
20037514635	20.29	7.3	884
20037512636	14.32	6.7	61.9
20037514636	19.21	7.4	101.4
20037512637	10.61	6.4	32.9
20037514637	15.97	7.6	463
20037512638	16.64	7	21.1
20037514638	15.23	7.9	25.6
20037512639	16.16	6.6	34.5
20037514639	20.85	7.1	291
20037512640	14.68	7	37.2
20037514640	14.34	8.2	668
20037512641	16.73	6.2	94
20037514641	18.59	6.4	104.9
20037512642	5.52	7.2	83
20037514642	16.86	7.9	393
20037512643	7.04	7	33
20037514643	7.77	8.6	216
20037512644	6.64	7.4	66.2
20037514644	11.79	8.4	245
20037512645	10.68	7.6	53.3
20037514645	20.92	8.4	733
20037512646	18.75	7.6	25.4
20037514646	18.28	8.8	123.7
20037512647	17.56	7.9	78.6
20037514647	17.89	8.7	317
20037512648	4.37	6.7	36.5
20037514648	18.09	8.6	382
20037512649	36.10	8.1	83.7
20037514649	31.41	9.2	136.4
20037512650	7.45	7.4	48.3
20037514650	21.13	8.5	463
20037512651	20.83	7.5	39.8
20037514651	13.34	8.1	240
20037512652	16.52	7.4	100.7
20037514652	17.88	7.1	2190
20037512653	8.26	5.6	89.3
20037514653	12.65	7.8	1734

SampleID	Moisture (%)	pH 1:5	EC 1:5 (µS/cm)	SampleID	Moisture (%)	pH 1:5	EC 1:5 (µS/cm)
20037512654	15.06	7.8	64.8	20037512660	11.10	7.4	63.4
20037514654	18.38	6.9	2890	20037514660	17.17	8.1	1251
20037512655	13.59	7.2	35.7	20037512661	19.81	8.3	97.7
20037514655	12.95	8.8	116.6	20037514661	21.52	7.8	1155
20037512656	4.99	4.7	59.6	20037512662	10.81	7.1	37.5
20037514656	16.69	8.9	391	20037514662	14.26	7.9	160.9
20037512657	11.65	7	47.2	20037512663	5.75	6.1	141.8
20037514657	18.76	8.4	320	20037514663	22.93	7.9	2520
20037512658	9.78	8.5	83.8	20037512664	10.95	7.5	76.9
20037514658	16.85	8.5	805	20037514664	15.76	8.6	349
20037512659	19.98	6.6	35.6	20037512665	11.79	8	1334
20037514659	19.98	8.7	169.9	20037514665	14.61	7.7	3190