# PERFORMANCE MEASURE INFORMATION SHEET #6

## KINBASKET RESERVOIR: DUST

| Objective / Location | Performance Measure | Units | Description |
|---|---|---|---|
| Dust Control/Kinbasket Reservoir | Dust potential days | Sq-km days | Reports on the total monthly sq-km days that each 1-m elevation band is exposed and therefore has potential to emit fugitive dust |

## Description

The operational regime of Kinbasket Reservoir is such that large areas ("beaches") of the drawdown zone in Canoe Reach are sparsely vegetated or are denuded of vegetation altogether. Those areas have the potential to emit dust, which may potentially be carried by winds to and beyond the town of Valemount, located at the northern end of Canoe Reach.

To examine the relative dust generation risk associated with each of the four NTS scenarios, a modeling exercise was undertaken based on duration and area of reservoir-bed exposure (Demarchi and Hawkes 2010). Using a GIS, the 2010 digital elevation model for Kinbasket Reservoir (712–758 m) was used to compute Elevation Band Polygons (EBPs) in Canoe Reach. Each polygon had a uniform elevation and the elevation interval between polygons was set at 1m.

The simulated month-end reservoir elevations from the HYSIM (1940-2000) were used to determine the proportion of land exposed (i.e., not submerged) and therefore able to emit dust at some point in time from April to October under each of the four scenarios. The total area exposed was used to rank the potential of each scenario to contribute to the emission of dust from the drawdown zone within Canoe Reach. In this analysis, it was postulated that the risk of a dust-storm event is related to duration and area of reservoir-bed exposure. First, a longer duration of exposure increases the probability that local meteorological conditions will be sufficient to initiate an event. Second, larger areas have greater potential for larger net volumes of dust emissions.

Other important attributes influencing the risk of dust generation (substrate particle size, vegetation cover, meteorology (i.e., wind speed, direction, precipitation)) were not factored into this analysis, because there are key data gaps that would have introduced significant error into the modeling. An earlier investigation into dust generation risk within Canoe Reach of Kinbasket Reservoir was conducted by LGL (Hawkes and Ferreira 2010), in which a series of high-level overview maps delineating the distribution of potential dust polygons in Canoe Reach were developed. Each polygon was assigned a dust contribution rating based on the hypothesized interaction of reservoir elevation (as a proxy for polygon exposure), substrate particle size, and per cent of vegetation cover. However, as the particle size[1] make-up of substrates in the drawdown zone is unknown for 41 per cent of the area covered by the dust polygons and vegetation cover[2] is known for only 15 per cent of the dust polygons, modelling of these

[1] Areas with smaller particle sizes are more likely to generate fugitive dust emissions than areas with larger particle sizes.
[2] Vegetation cover can serve to reduce dust emissions by binding the substrate.

attributes would have required a large number of assumptions regarding elevation specific dust-emission rates, and uniformity of substrate type and per cent cover.

While historic meteorological conditions allow us to predict the extent to which future conditions might be conducive to dust storm events, future meteorological conditions are independent of reservoir operations and would apply equally to all four scenarios. As this information would not inform a *relative comparison* of the risks of dust emission under the four scenarios, these data were not considered in the model.

## Performance Measure

A comparison was undertaken to test possible differences in performance of the NTS scenarios using (i) all of Canoe Reach that was mapped by the DEM, and (ii) only those DEM elevation bands that were within the dust polygons delineated by Hawkes and Ferreira (2010). Overall, the performance of the scenarios was very similar, with duration/area of exposure aligning closely. The main difference is that the entire DEM area resulted in greater exposure because of the greater area of land included in that coverage as compared to the dust polygons. Therefore, only the results of the EBPs are provided here. [The reader is referred to the Demarchi and Hawkes (2010) for a more detailed description of the modeling results].

## Calculations

1. For each month of each scenario and year, the area of exposed land was summed for those elevations of the Canoe Reach drawdown zone that are covered by the DEM.
2. Daily reservoir elevation was determined from a linear interpolation between successive monthly values by taking the difference between months, dividing by the number of days in a month, then adding the daily increment to each day of the month in a cumulative fashion, starting with the previous month-end amount.
3. For each scenario, year and month, the number of “square-kilometre-days” (sq-km-days) was calculated. These were summed and the total monthly sq-km days were used as a basis for comparing the four scenarios. These units are represented by the sum of the area of land that is above a given reservoir elevation (i.e., it is exposed) during the days of the month.

## Key Limitations

- Wave action is not considered in the model. Although higher winds can be expected to be capable of causing higher emission rates, net emission could be offset to the extent that wind-waves cause wetting of surface materials above the standard reservoir elevation.
- Emission rates within and among different substrate types have not been calculated or ranked. It is expected that lower elevations will have higher emission rates due to: (i) greater proportion of finer particles, (ii) less vegetation cover, and (iii) less woody debris cover. As such, elevation-specific emission rates could increase with decreasing elevation. This compounds (as opposed to mitigate) dust emissions at lower water levels.
- The distribution of vegetation, which serves to mitigate dust emissions, has not been mapped throughout the entire drawdown zone of Canoe Reach.

## Key Assumptions

- Assumes daily changes in water elevation between month-end monthly estimates occur in a linear fashion.
- Assumes that the water level (elevation) in Canoe Reach equals that in the Mica Dam forebay.
- Assumes emission rates are constant over time and space (e.g., a lack of submergence in Year 1 does not affect emission rates in years 1 + n). It is possible that emission rates in Year n are not independent of water levels in previous years; flooded beaches can receive silt deposits that are then available to become dust when that area is next exposed. Thus, consecutive low-water years could serve to mitigate dust potential due to (i) reduced siltation deposits, (ii) increased vegetation growth, and (iii) increased losses to aeolean processes.
- Exposed areas within the drawdown zone have potential for fugitive dust emissions, regardless of substrate type; submerged areas have no such potential.

## Results

Figure 1 shows how the total number of square-kilometre days varies over the simulated timeframe for each of the four scenarios for the elevation based polygons (EBPs). Of the four scenarios, Scenario D has the lowest dust-risk potential for the greatest proportion of time. The “with NTS” scenarios all performed similarly in terms of dust-risk potential.

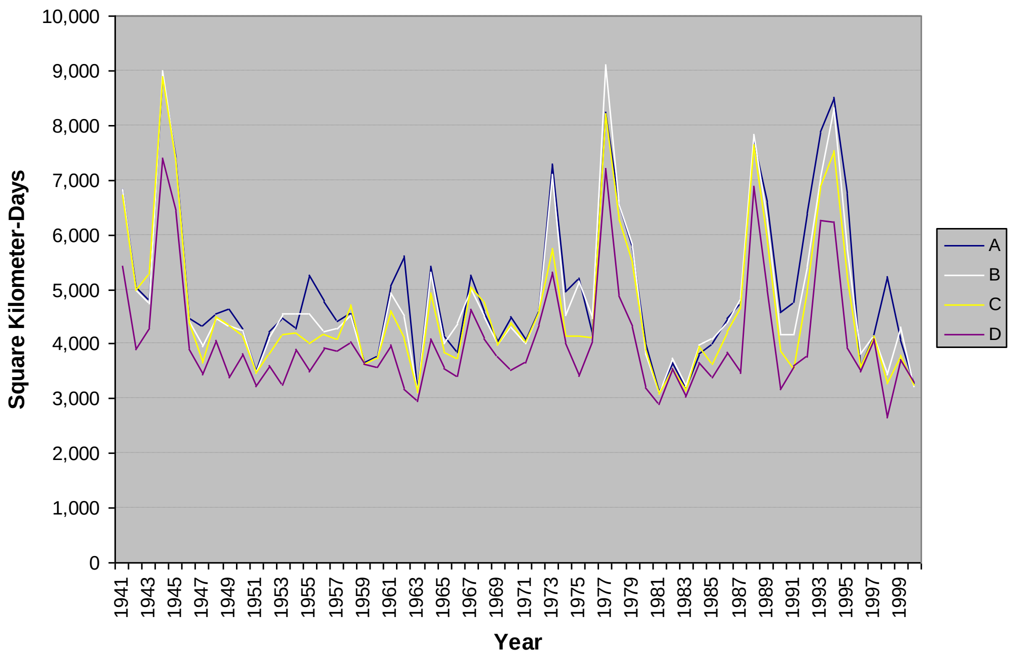



**Figure 1. Plot of Square-kilometre Says from April to October from 1940 to 2000 for Scenarios A–D. Data are Elevation Based Polygons (EBPs) derived from the DEM Overlay.** One square-kilometre day equals one square kilometre of land exposed for one day.

Figure 2 depicts how the number of square-kilometre days changes during each month (all years combined) for each of the four scenarios. In all scenarios, dust risk is highest in April, after which it diminishes rapidly until August, and then levels out as reservoir levels peak. The four scenarios track each other closely, with Scenario D exhibiting the lowest dust-risk potential. Risks associated with scenarios A and B are nearly identical, with Scenario C being modestly lower than both A and B.

Although a dust storm could happen at any time of year under the right conditions, the probability is greatest during the period of April through October when local weather conditions are conducive to dust mobilization and transport. Furthermore, within that period, the months of April–June present the greatest overall risk of dust storms according to the extent of the area of the drawdown zone that is exposed.

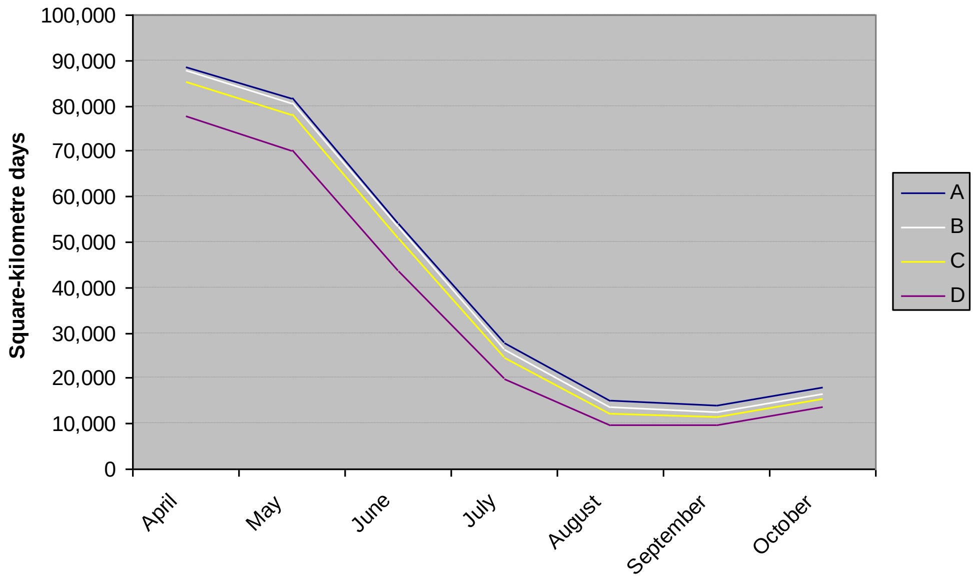
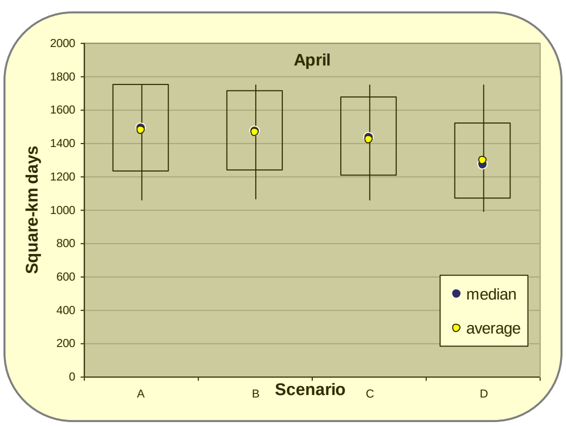
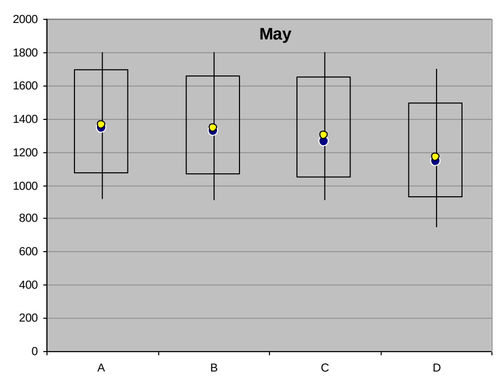



**Figure 2. Monthly Sum of Square-kilometre Days for Scenarios A–D.** Data are for all areas mapped by the DEM (EBPs). One square-kilometre day equals one square kilometre of land exposed for one day.



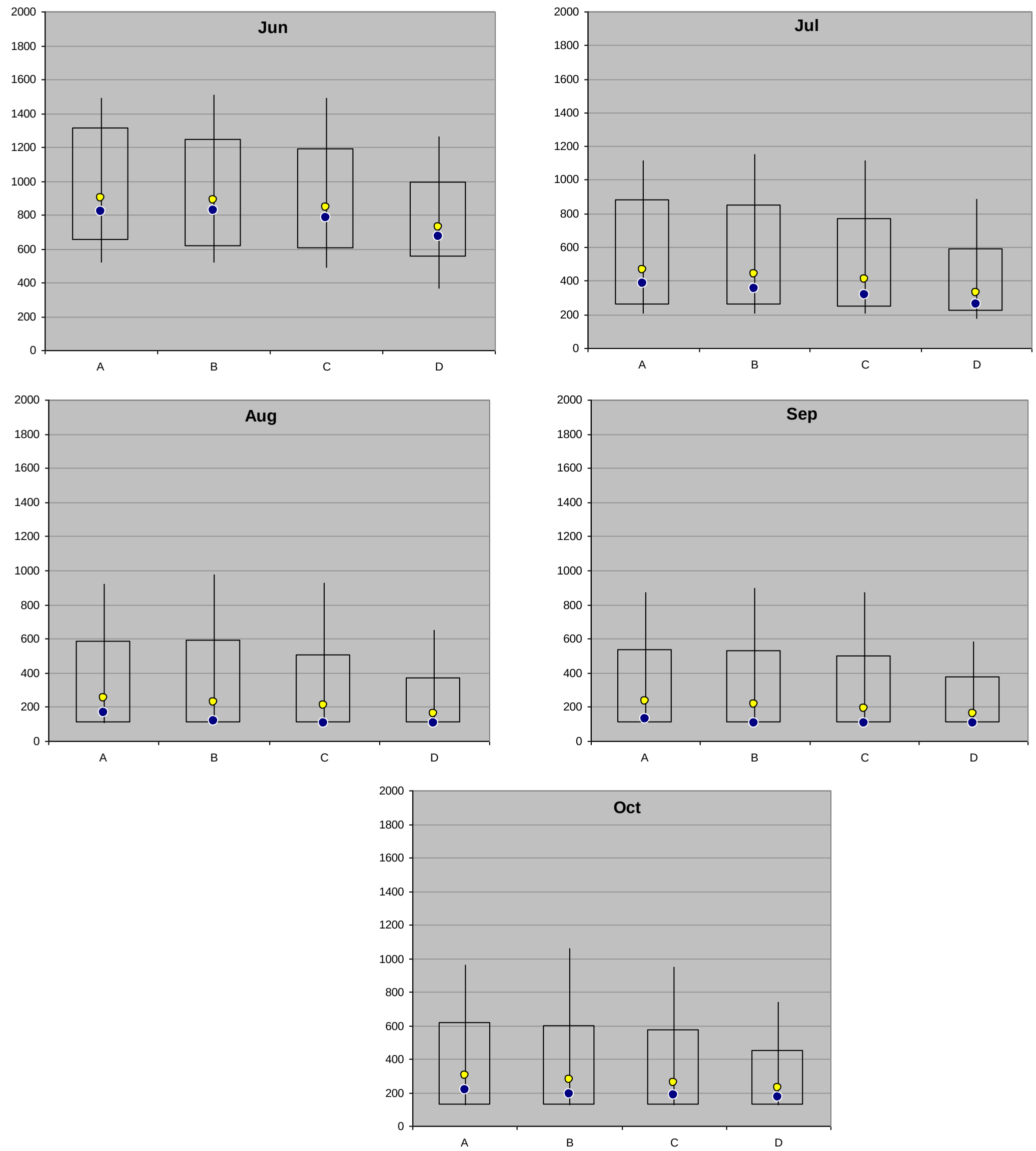



**Figure 3. Summary of Square-kilometre Days for each Scenario (A–D) during the Months of April through October for HYSIM Data spanning years 1940-2000.** Data are for all areas mapped by the DEM (EBPs). Plots show the mean, median, 10% and 90% percentiles (lower and upper limits of boxes), and minimum and maximum values (lower and upper limits of vertical lines). April (Yellow-shaded) results carried forward to Consequence Table.

## References

Demarchi, M. and V. Hawkes. 2010. Kinbasket Reservoir, Comparison of Dust Emission Risks in Canoe Reach among four NTS scenarios. LGL Report EA3211 prepared for BC Hydro Generation Resource Management by LGL Limited environmental research associates. 17pp. plus appendix.

Hawkes, V. anad L. Ferria. 2010 Kinbasket Reservoir. Valemount/Canoe Reach Dust Source Assessment. LGL Report EA3211 prepared for BC Hydro Generation Resource Management by LGL Limited environmental research associates. 15pp. plus appendices.