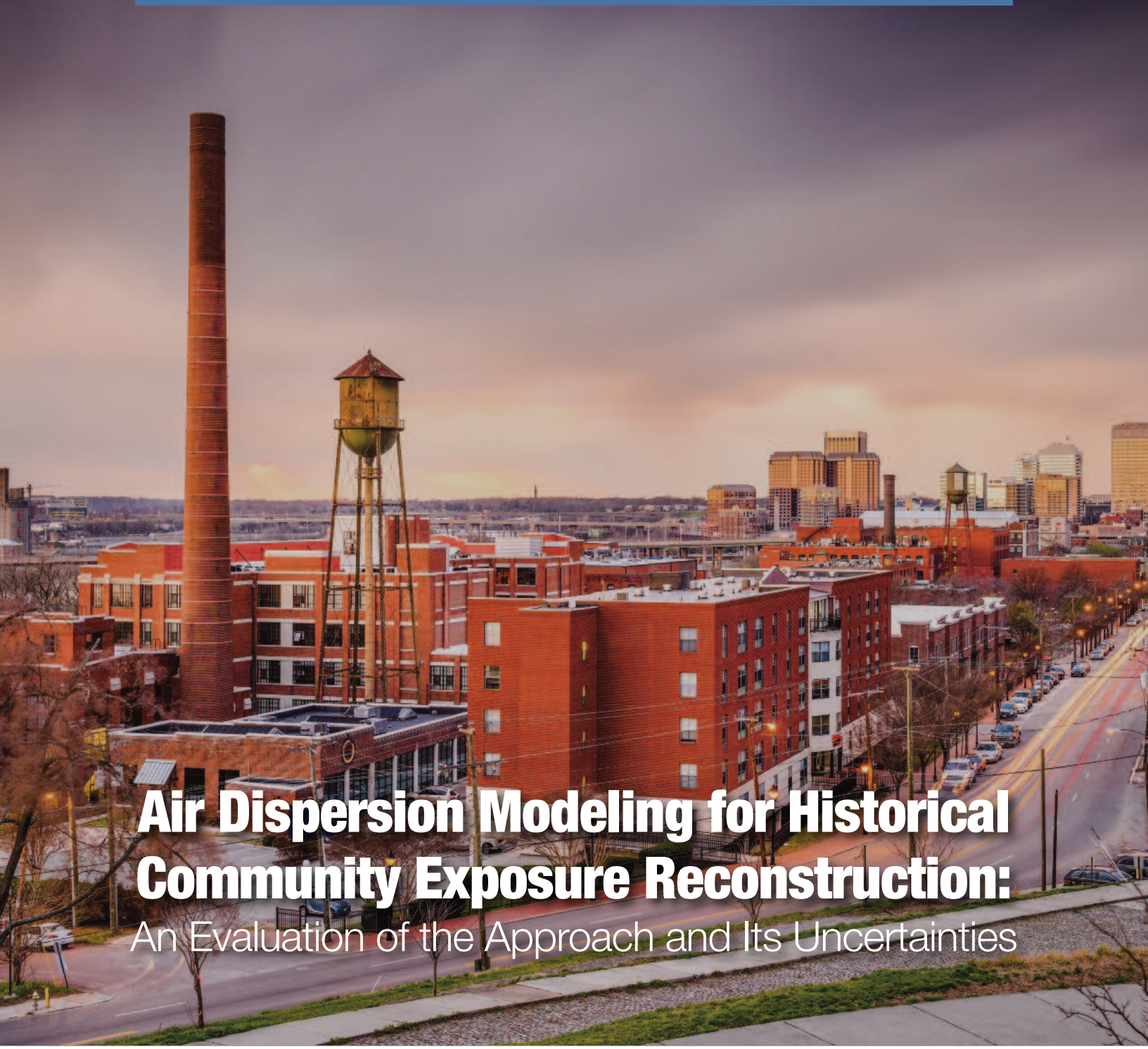

Air Dispersion Modeling for Historical Community Exposure Reconstruction:

An Evaluation of the Approach and Its Uncertainties

by Paul K. Scott, Matthew M. Abramson, Jennifer L. Bare, and Christy A. Barlow

A case study evaluation using the AERMOD model to estimate air concentrations for a historical exposure reconstruction of community exposures to a hypothetical manufacturer of brakes containing asbestos.

Widespread industrial asbestos use began in the early 1900s resulting in asbestos being incorporated into thousands of commercial and consumer products.[1] Historical manufacturing of these asbestos-containing products have resulted in intermittent environmental release of asbestos into surrounding communities. While some facilities may have historical industrial hygiene measurements available, in the absence of these data, estimation of airborne concentrations may be necessary using facility information on the consumption of asbestos, types of emissions, and presence of air pollution control devices. While these estimates will be limited by the availability of historical information, this type of historical exposure reconstruction can produce bounding estimates of community exposure over time that are better than those based on limited or no measured air sampling data. AERMOD, the U.S. Environmental Protection Agency's (EPA) preferred model for a wide range of regulatory applications in all types of terrain, is often used for this purpose.

This article describes a case study using the AERMOD model to estimate air concentrations for a historical exposure reconstruction of community exposures to a hypothetical asbestos-containing friction product manufacturer (e.g., a brake manufacturer). To better understand how uncertainties in the selection of model parameters may affect the results, a sensitivity analysis was performed that included varying the modeled asbestos particle size, changing the fugitive emission model type, using different methods to calculate the emission rate from asbestos handling, and evaluating the impact of control technologies. A similar approach could also be adapted for other chemicals and facility types in order to estimate historical air concentrations in the absence of an adequate historical air sampling database.

Baseline Modeling

AERMOD was used to estimate historical ambient airborne asbestos concentrations resulting from a hypothetical manufacturer of asbestos-containing friction products that operated between 1965 and 1989 (see Figure 1). The technical details for this evaluation, including the hypothetical facility description, are presented in Abramson et al.[2] Although this hypothetical manufacturer does not have a defined location, in accordance with EPA guidance for particulate matter, five years of meteorological data from the early sixties collected in Hartford, CT, were used because these data were available and historically there have been many facilities in the state that manufactured asbestos-containing products.

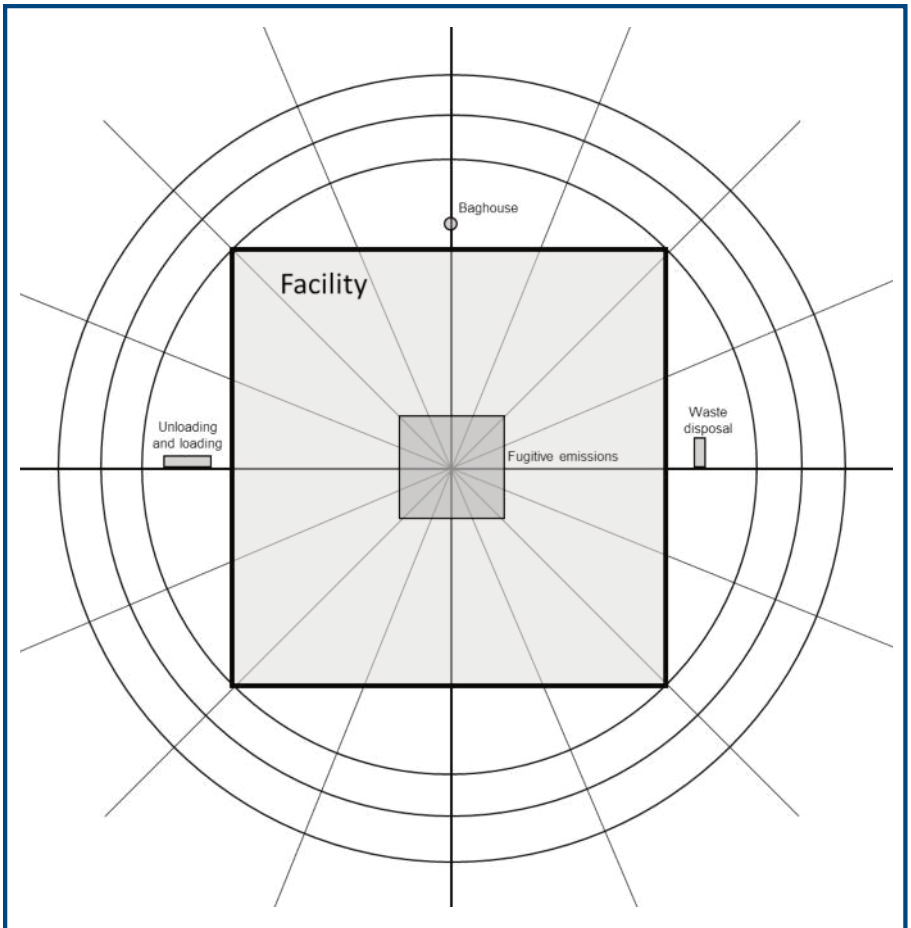

Figure 1. Emission sources and building plan for the hypothetical facility.

The air concentration estimates for all emission sources were modeled to account for particle deposition and depletion. The default particle size parameters associated with asbestos were used, which include the mass mean aerodynamic particle diameter of 0.3 microns and the assumption that 85 percent of the asbestos fibers were considered fine.[2] Annual average airborne concentrations were estimated for a receptor grid extending 2,000 m from the center of the manufacturing building with 1.8-m flagpole heights. Annual average concentrations were reported by geographical quadrants (NE, SE, SW, and NW) and by distance bands (<500 m; 500 – <1,000 m; and 1,000 – <2,000 m).

Emission rates for each source and year were estimated by applying an emission factor, as detailed below, to the amount of asbestos assumed to be used

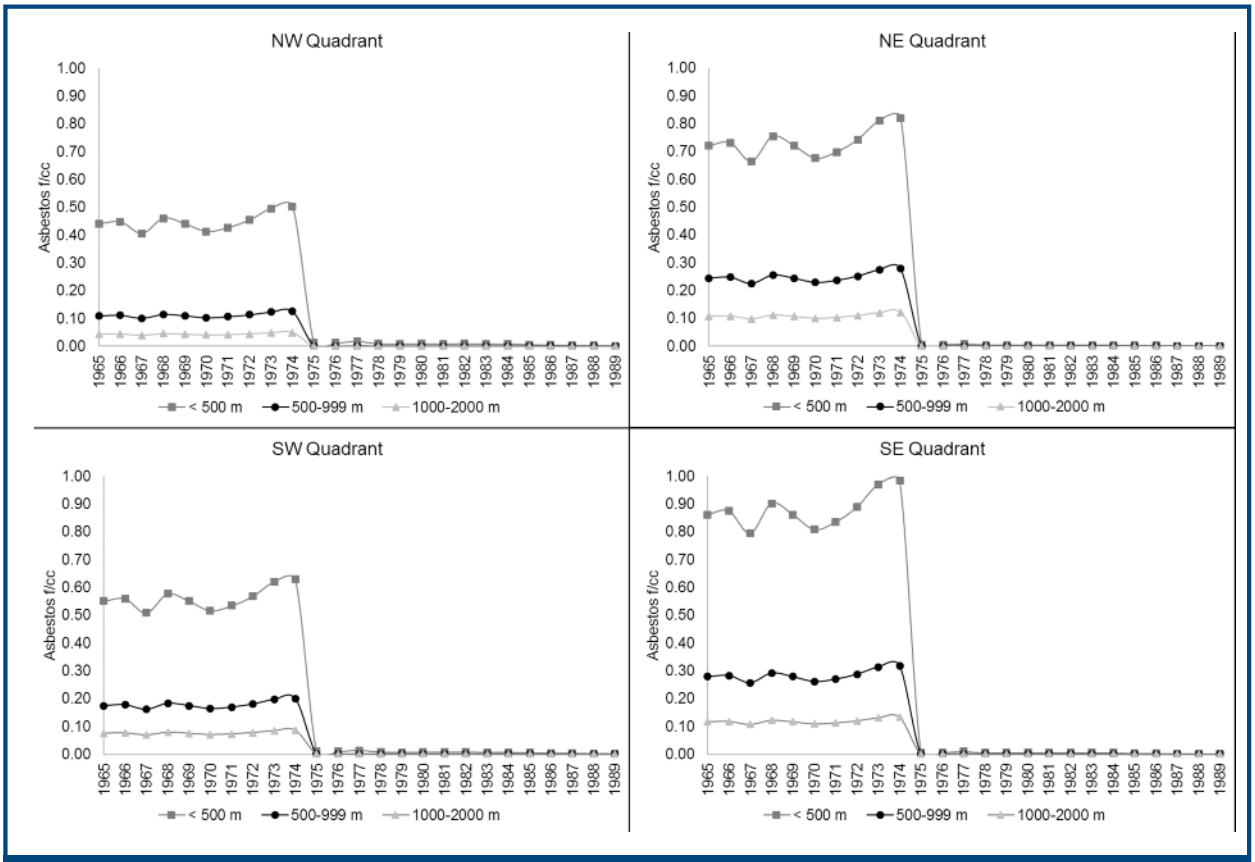

Figure 2. Annual average air concentration by distance and direction.

in product manufacturing. All emissions were assumed to be continuous for this evaluation (i.e., 24 hours per day, 7 days per week). In lieu of site-specific information, the hypothetical facility was assumed to use an amount of asbestos per year equal to the total amount of asbestos processed each year in the U.S. friction industry divided by the number of facilities known to manufacture asbestos for that year for 1965 through 2003.[1] Three types of sources were evaluated:

1 **Unloading and loading of asbestos.**
Emissions from the unloading and loading of asbestos from a 26-foot box truck onsite were modeled.[2] The annual emission rates were estimated using EPA's AP-42 emission factor from Section 11.28 for vermiculite transferring of 0.013 kg of $PM_{2.5}$ emitted per Mg processed.[2]

2. **Waste disposal dumpster.**
Asbestos waste from the facility was assumed to be disposed of in a 20-cubic yard dumpster that was emptied for offsite disposal on a regular basis. The percentage of scrap asbestos that was disposed of in the dumpster was set equal to around 3 percent of the total amount used per year.[2] The AP-42 emission factor from Section 13.2.4 for aggregate handling and storage piles[2] was used to estimate emissions.

3. **Facility emission source.**
Fugitive emissions from the building prior to the installation of a baghouse in 1975 were modeled as a volume source with a release height equal to the building height. These fugitive emissions were assumed to be from manufacturing activities and to be emitted from windows, doors, and other openings prior to the installation of local exhaust ventilation that would have been emitted from a common stack. Based on an asbestos sources and emissions inventory from 1968 for various industries, controlled asbestos emissions for friction product manufacturing were 6 lb/ton processed, assuming 95 percent particulate controls.[2,3] Assuming this control efficiency, uncontrolled emissions were estimated to be 120 lb/ton processed. Assuming the friction manufacturer installed a baghouse as a control measure in 1975, baghouse emissions were modeled as a point source with asbestos emissions of 0.019 lb emitted per ton used assuming a control efficiency of 99.99 percent of 0.019 lb emitted per ton was used.[4,5]

Modeling Results

As shown in Figure 2, the annual average airborne concentrations for the receptor band closest to the facility (<500 m from the sources) were higher than the concentrations at distances further away from the building. Variability in concentrations between quadrants was attributed to the

redominant wind direction in the meteorological data set being from the northwest. Figure 3 shows that estimated annual airborne concentrations prior to 1975 were dominated by the fugitive emissions from the facility, while after 1975, the estimated concentrations were the result of the unloading and loading emissions with the contributions associated with baghouse facility emissions and the dumpster being nearly negligible.

As seen in both Figures 2 and 3, the introduction of the baghouse in 1975 decreased overall asbestos emissions associated with facility operations and therefore the exposure potential of the community related to the hypothetical manufacturer decreased substantially. As such, the emissions associated with the unloading and loading of asbestos become the main contributor to the estimate air concentrations after baghouse installation.

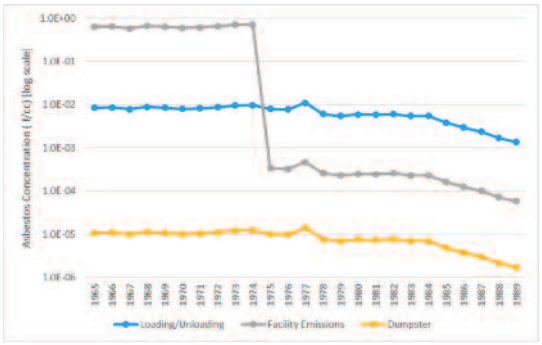

Figure 3. Annual average air concentration by source for receptors <500 m.

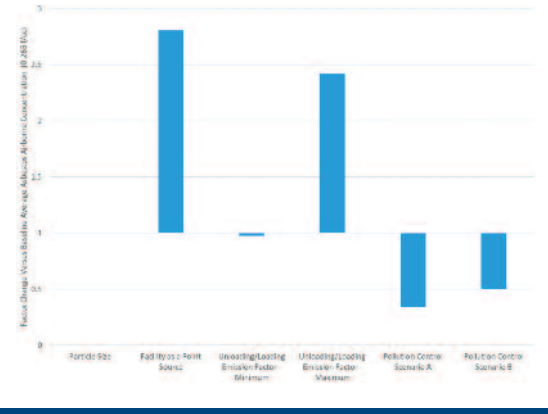

Figure 4. Factor change versus the baseline average air concentrations 1965–1989 for the sensitivity scenarios for receptors <500 m. Average baseline air concentration is 0.265 f/cc.

Sensitivity Analysis

To compare the results for each of the sensitivity scenarios with the baseline results, the average air concentration from 1965 to 1989 was calculated for each direction and each receptor band. Figure 4 presents the factor change in average airborne concentrations from 1965 to 1989 for receptors located <500 m across all directions for each parameter changed in the sensitivity analysis. While not presented here, in general, the trends seen for the receptors for each direction and each distance category were similar.

Particle Size

The particle size characteristics of asbestos fibers suggest that the aerodynamic diameter may be 2.5 to 5 times larger than the actual diameter and that there is a weak dependence on length. Therefore, for the sensitivity analysis, the particle distribution was varied to have a mass mean aerodynamic particle diameter of 0.75 microns with 78 percent of particles considered fine based on a 2.5 times increase in mean diameter. While it was expected that the increase in particle size would substantially change the air concentration with distance from the facility, the adjustment did not result in substantial changes in the concentrations (Figure 4).

Fugitive Building Emission Type

While the fugitive building source was modeled as a volume source for the baseline scenario to simulate emissions of material from windows and other openings, these uncontrolled emissions could be modeled as a point source.[2] Therefore, in the sensitivity analysis, the fugitive building source was modeled as a point source located at the center of the facility with the same emission rate as the baseline scenario. This change in source type increased the average air concentration by almost a factor of 3.

Unloading and Loading Emission Factor

The emission factor used in the baseline model scenario for unloading and loading was selected from the AP-42 documentation on vermiculite processing. Although vermiculite is qualitatively similar to asbestos, other AP-42 documents provide estimates for the mass of particulate released during loading and unloading activities.[2] In this sensitivity analysis, the maximum and minimum emission rates were used.

Decreasing the emission factor for the unloading and loading scenario to the minimum emission factor value decreased the average air concentration by only a small amount (0.265 f/cc to 0.258 f/cc), as seen in Figure 4. However, increasing the unloading and loading emission factor to the maximum caused a substantial increase in the average air concentration (0.265 f/cc to 0.640 f/cc). The cause for this difference is that the percent contribution to the average air concentration due to unloading/loading emissions increases substantially from baseline with the use of the maximum emission factor, from 3 percent to 60 percent.

Pollution Control Scenario

The baseline model scenario assumed that the hypothetical facility installed a baghouse in 1975 with uncontrolled emissions prior to this date. However, baghouses may have been installed at earlier dates and it is likely that emissions were controlled to some degree prior to the installation of the baghouse. Therefore, in the deterministic sensitivity analysis, two scenarios were considered: (A) emission control processes were implemented in 1968 that controlled emissions by 95 percent until 1975, when the baghouse was installed; and (B) the baghouse was installed in 1970, but no emission control processes were implemented prior to the installation.

Due to these emission rate reductions, the average air concentration from 1965 to 1989 was decreased by approximately three-fold and two-fold for scenario A and scenario B, respectively (Figure 4). Facilities that were able to implement pollution controls earlier may have been able to significantly reduce the potential exposure of the community compared to those that did not implement such controls. In general, the model assumptions that had the largest impact on the results in order of effect were the choice of source type for facility emissions, the choice for the unloading/loading emission factor, and the assumption related to the timing and effectiveness of pollution controls at the facility. The change in particle size assumption had no apparent impact on the estimate air concentration.

Conclusion

The use of air dispersion modeling to estimate historical community exposures to asbestos can be a valuable tool in the absence of historical sampling data and for extended exposure periods of interest. The sensitivity analysis presented here demonstrates the importance of site-specific emission information to characterize potential emission sources. Any implementation of this methodology should use the best available site-specific information, particularly when pollution control methods were implemented. **em**

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