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SPATIAL AND TEMPORAL CRIME ANALYSIS TECHNIQUES

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TECHNICAL MEMORANDUM

Submitted by
Vancouver Police Department

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NOTE: Further information about this report can be obtained by calling the CPRC information number (613) 998-6343

EXECUTIVE SUMMARY

The Vancouver Police Department has developed Geographic Information Systems which go beyond the more traditional methods of statistical analysis to interpret crime data for the desktop computer user. Dispatch and offence records are extracted from the mainframe computer, converted to xBASE-compatible fields, then appended to tables on CAU workstations. Data is coded for geographical location to enable spatial and temporal analysis.

SOMMAIRE

Le service de police de Vancouver a conçu un système d'information geographique qui permet à l'utilisateur d'un ordinateur de bureau de pousser l'interprétation des données criminelles au-delà de ce que lui permettaient les méthodes traditionnelles d'analyse statistique. Les fiches de repartition et les fiches d'infractions sont extraites de l'ordinateur central, converties en zones xBASE compatibles, puis annexées aux tables des postes de travail du service des analyses des crimes. Les données sont codées selon des rep&es géographiques pour en permettre l'analyse spatiale et temporelle.

Spatial and Temporal Crime Analysis Techniques

Cst. Murray R. Rayment
VPD Crime Analysis Unit Coordinator

In common with most North American police departments, the Vancouver Police Department has undergone a shift in emphasis from record collection and storage, to analysis and interpretation of crime data. Adoption of community-based and problem-oriented policing concepts underscore the need to derive real, purposeful meaning from the body of data maintained by the records section.

Advances in technology have made powerful desktop microcomputers commonly available tools in most departments. The mainframe computer, once considered an 'end of the line' storage system, can become a way-point, serving as the hub of record distribution within police departments. Geographic Information Systems, (GIS), once firmly the domain of the mainframe computer, along with truly powerful relational database management systems, are now a reality for the desktop computer user.

These technological tools allow analysts to extend beyond the more traditional methods of statistical analysis. It is now possible to construct an accurate and timely model of criminal activity, including areal concentrations of crime. Patrol officers, as well as management, can now be provided with the high quality, current information.

Increasing capabilities and new techniques in crime analysis can point to previously unforeseen shortcomings in departmental data. This is extremely valuable, leading to improvements in types of information being collected.

The VPD Crime Analysis Unit works with existing departmental records. Analysts do not perform any data entry.

Analysts extract dispatch and offence records, from the mainframe computer. Initial processing of the extract converts the mainframe ASCII data to xBASE-compatible fields, later appended to tables on the CAU workstations.

The data records are geocoded, (assigned longitudinal and latitudinal coordinates based on street address), through MapInfo© a commercially available GIS program.

The xBASE tabies are now ready for spatial' and temporal analysis, to answer such questions as:

1. What types of events are occurring?
2. Where are they occurring?
3. To what degree are they occurring?
4. When are they occurring?

Crime events, occur in both space and time. ***Spatial analysis*** refers to the examination of the geographic aspects of events, through analytic mapping of the geographic database. ***Temporal analysis*** refers to examination of the time components of events, through construction of histograms or graphs to show distributions by weekday, hour, etc.

Analvtic Mapping

The GIS program allows analytic mapping of crime data and is the primary tool for spatial analysis. The GIS program allows placement of layers of data over the base map of regions or streets. For example, crime data can be layered on the base map, with another layer showing the rapid transit route and stations. Proximity analysis can then be performed between the location of events in one layer, and the locations of transit stations in another. The GIS program produces several styles of map, each serving a different purpose.

The pin map is the simplest form of distribution map. Symbols are overlaid on a base map, to show locations of events. This is the mapping style most familiar to police departments, and has been used for decades. There are, however, obvious shortcomings to the common pin map. The pin map displays the geographic locations of events, with perhaps different colored pins showing one more dimension of data, (e.g., premises type). Pin maps do not adequately reflect volume of events at common locations, or any of the vital temporal attributes of the events. A variation on the pin map, the graduated symbol map, uses symbols of varying size, depending on the volume of incidents at common locations, and may, in some cases, be able to dispiay another dimension of data through coloration. Again, vital temporal information is lacking.

'Hot spot' mapping plots the ellipse containing the maximum number of events, based on a user-specified radius. This form of mapping shows the greatest area concentration of crime activity, however provides no information as to the level of crime immediately surrounding the designated 'hot spot'. It is important to know whether the concentration exists as an anomaly, or whether it is just the peak of a surrounding area of slightly lower event occurrence.

The VPD Crime Analysis Unit has created a program that produces an isopleth or contour map of crime activity. Contour lines join areas of equal levels of crime activity. A legend shows a color key to the contour levels. The contour map shows high concentration areas by level, and the occurrence level of all surrounding areas, providing a more complete model of crime activity. We believe this mapping technique is the most effective method of areal analysis of geographic crime data. Contour layer images can be generated over fixed periods of time and 'played back' using the slide-show functions in several software programs, (e.g., most spreadsheet or presentation graphics programs), to animate the movement of area crime level contours. This effectively adds the fourth dimension of time to contour mapping analysis,

Temporal Analysis

Any mapping style requires the support information provided by temporal data analysis. The required techniques of temporal analysis vary, depending on the crime type under examination.

All crimes occur at a specific date and time, however such definite temporal information is only available when victims or witnesses are present, alarms are triggered, etc., at the time of occurrence. This specific temporal data is most often collected in crimes against persons. In these cases, cross-tabulations or histogram6 of weekday and hour by count will suffice.

The great majority of reported events are crimes against property. In these cases, there are seldom victims or witnesses present. These events present the analyst with 'ranged' temporal data, that is, an event reported as occurring over a range of hours or even days.

In the case of ranged temporal data, analysis is possible through use of equal chance or probability methods. If an event was reported as having occurred from Monday to Tuesday, in the absence of evidence to the contrary, it is assumed the event had an equal chance or probability of occurring on each of the two days, or .5 (%50). In the same manner, if an event was reported as having occurred over a 10 hour span there is a 10% chance the event occurred during any one of the hours. This technique requires a reasonable number of events in the data set to be effective. The resulting probabilities are totaled in each category and graphed or cross-tabulated. This produces a comparison of relative frequency, by weekday or hour.

Some caveats apply to temporal analysis, however they are largely common sense. If a map indicates two distinct areas of concentration, for example, a separate temporal analysis is required for each identified area.

Examples

The attached examples display several mapping styles and temporal anaiysis.

Sample Data Set: District 1 Theft From Auto, April 1995 (927 events, 489 locations\

The Pin Map plots the 489 distinct ***locations*** of the 927. This mapping style, used in police departments for decades, is the least suitable for interpretation or analysis. The pin map gives a false sense of crime concentrations. At first glance, it appears the maximum area concentration is in the area of Burrard Street, between Davie and Smithe Street, with a secondary major concentration on Homby Street: between Dunsmuir and Powell Streets..

The Graduated Symbol Map plots the 489 distinct locations where the 927 events occurred. Relative symbol sizes range from a minimum size, (1 event), to a maximum size, (15 events). This map shows the distribution of events, by ***location*** and ***volume.*** This map gives an improved view of crime concentrations.

The major areas now appear to be:

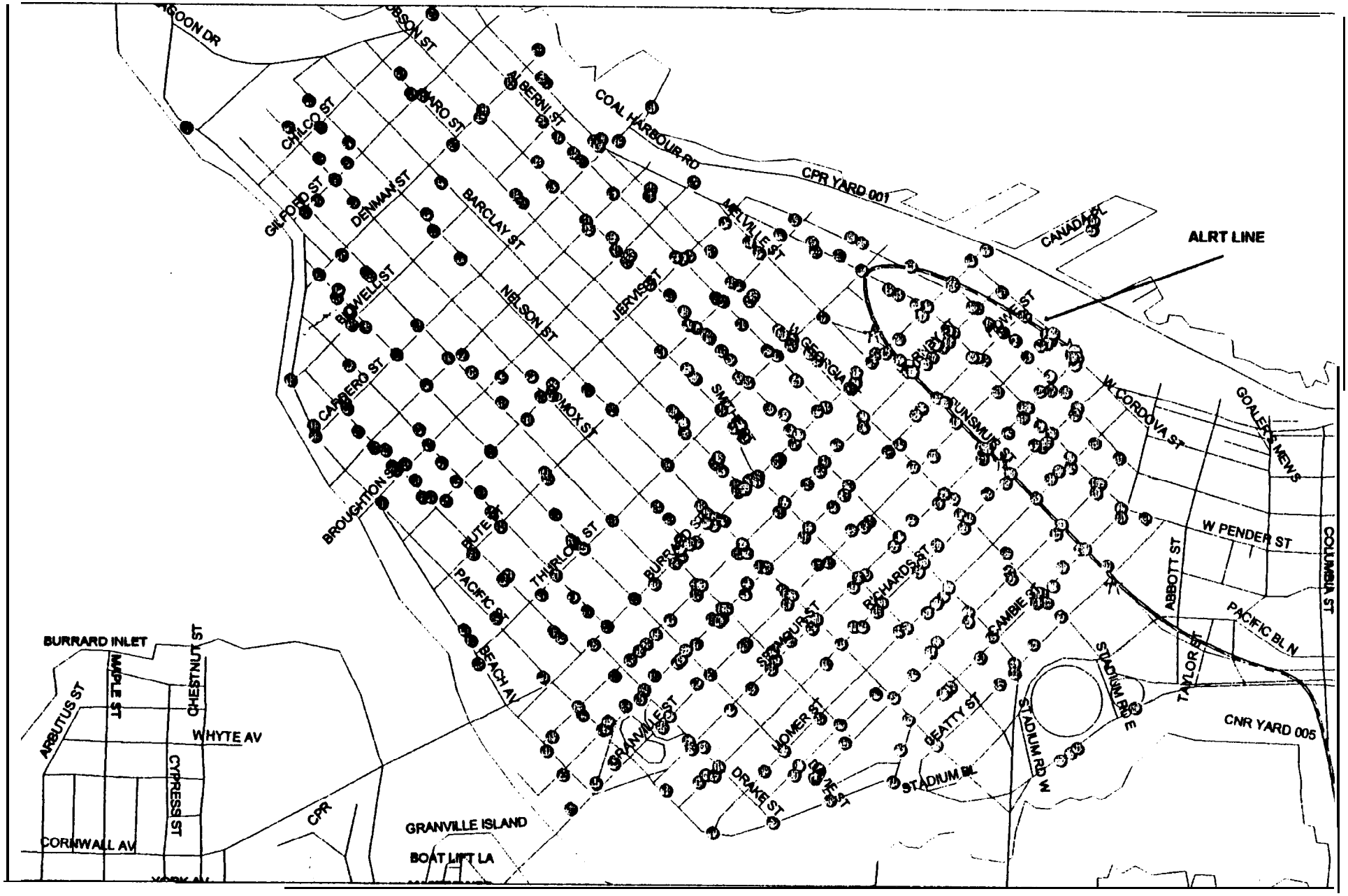
a) Robson Street, between Broughton Street and Burrard Street
b) Burrard Street, between Robson Street and Nelson Street
c) Nelson Street, between Burrard Street and Seymour Street

The Contour Map presents the entire model of the crime data, indicating several 'hot' areas of crime concentration, and all surrounding levels. This map is interpreted in the same fashion as a topographical map, and shows the distribution of events by ***area*** and ***relative volume.*** Line spacing offers an important level of detail to the analyst. Lines spaced closely together indicate a rapid change in the crime level; lines more widely spaced indicate a more gradual change in the crime level.

The follow-up to the contour map shows two areas, (A and B), selected for temporal analysis. The weekday distribution of events in area A shows a peak building to and culminating on Sunday. Peak times are from 19:00 to 20:59 hrs, shown in the middle of the three graphs. The weekday distribution of events in area B shows a slight peak on Monday, but little real variance throughout the week. Peak hours are again between 19:00 and 20:59 hrs. Note that the event frequency does not drop off nearly as sharply after 21:00 hrs as it does in area A. The bottom graph shows hours combined into two-hour blocks, rather than single hours. This has the effect of smoothing the data somewhat, and is useful when a lesser number of records are available.

Theft From Auto - Dlstrlct One
927 Incidents

April 1995

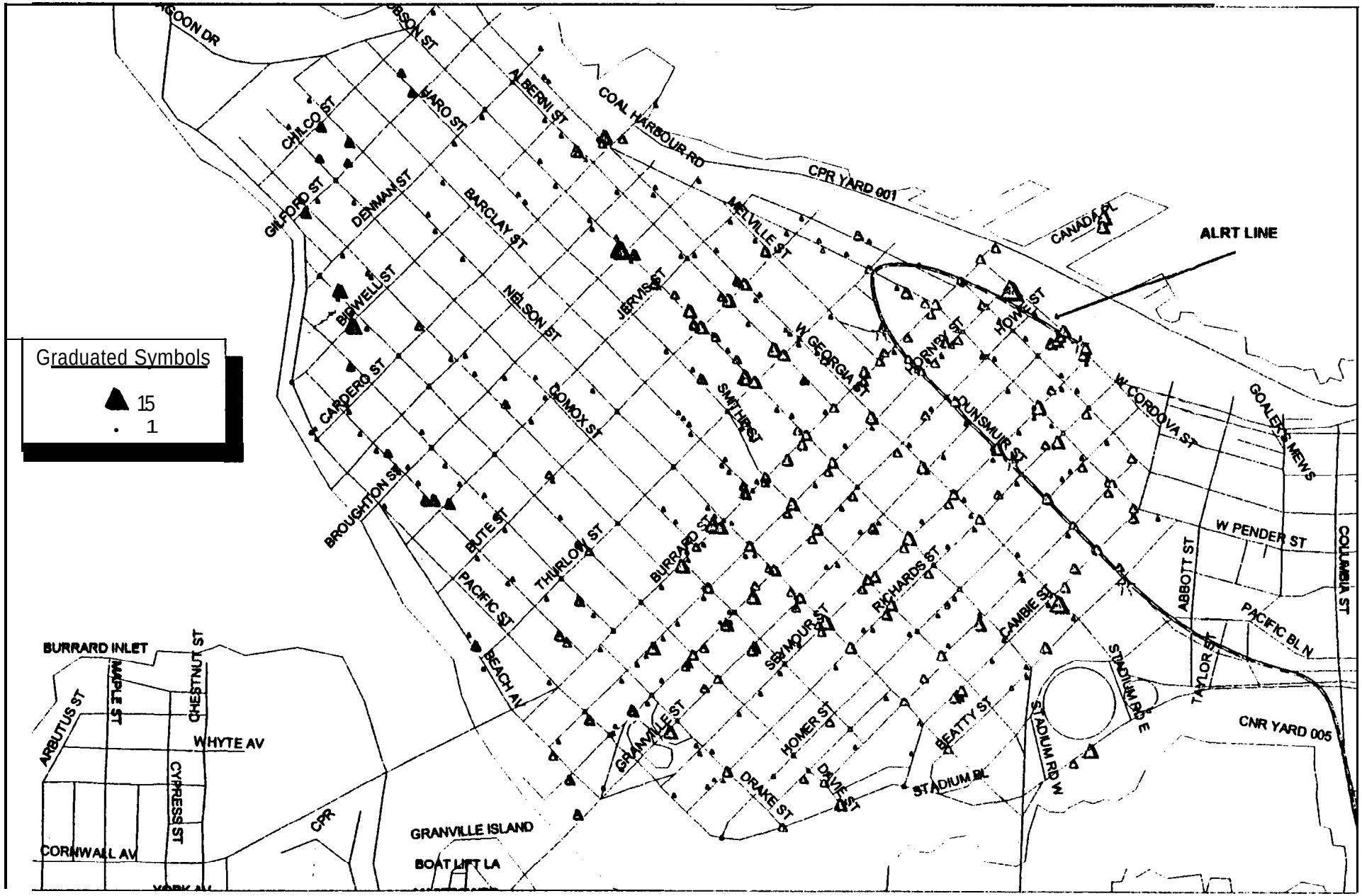


Pin Map

Vancouver Police Deportment
Crime Analysis Unit

Theft From Auto - District One
927 Incidents / 489 Locations

April **1995**

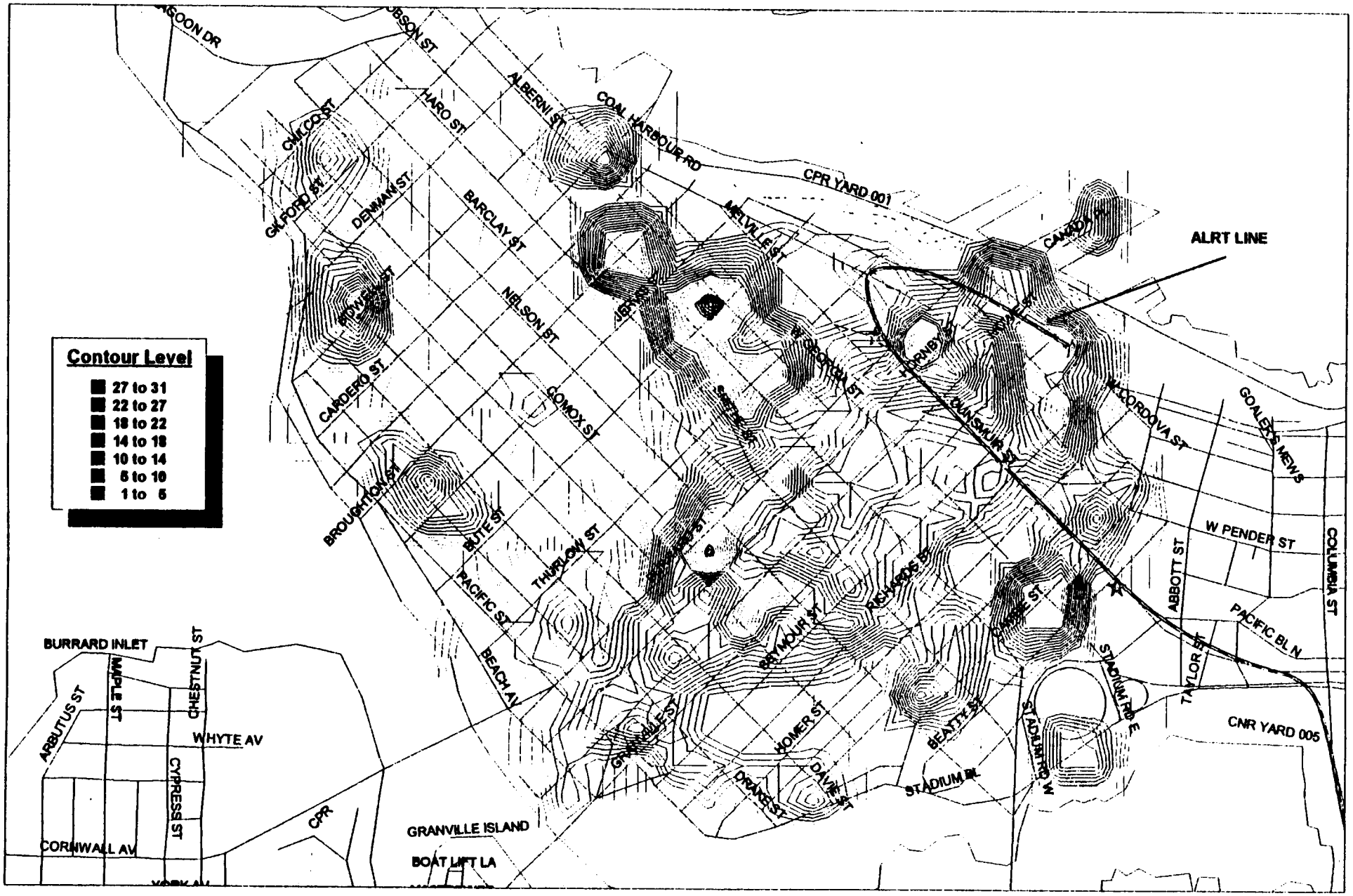


Graduated Symbol Map

Vancouver Police Department
Crime Analysis Unit

Theft From Auto - District One
927 Incidents

April 1995

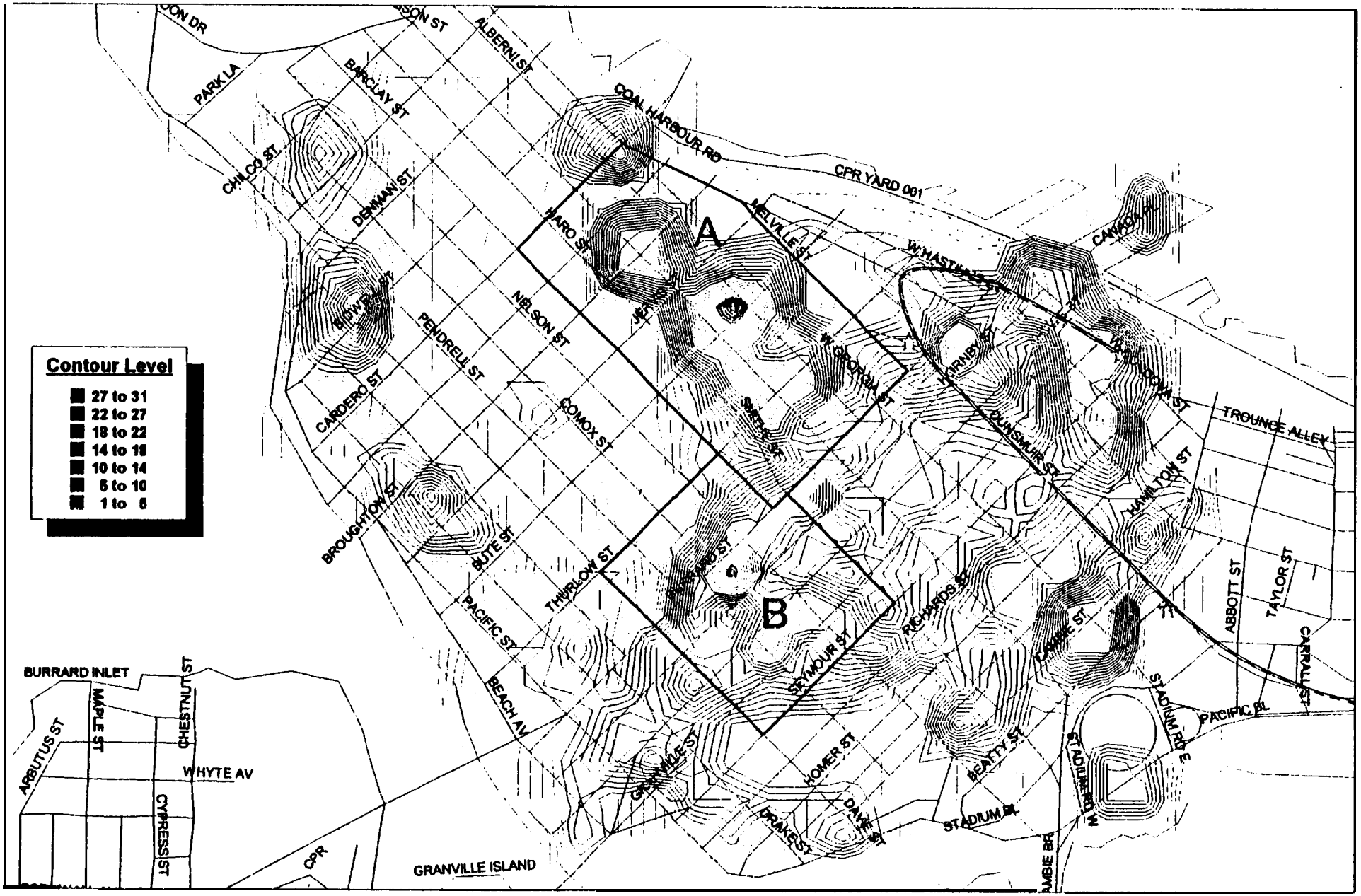


Contour Map

Vancouver Police Department
Crime Analysis Unit

Selected Areas For Temporal Analysis

April 1995



Vancouver Police Department
Crime Analysis Unit

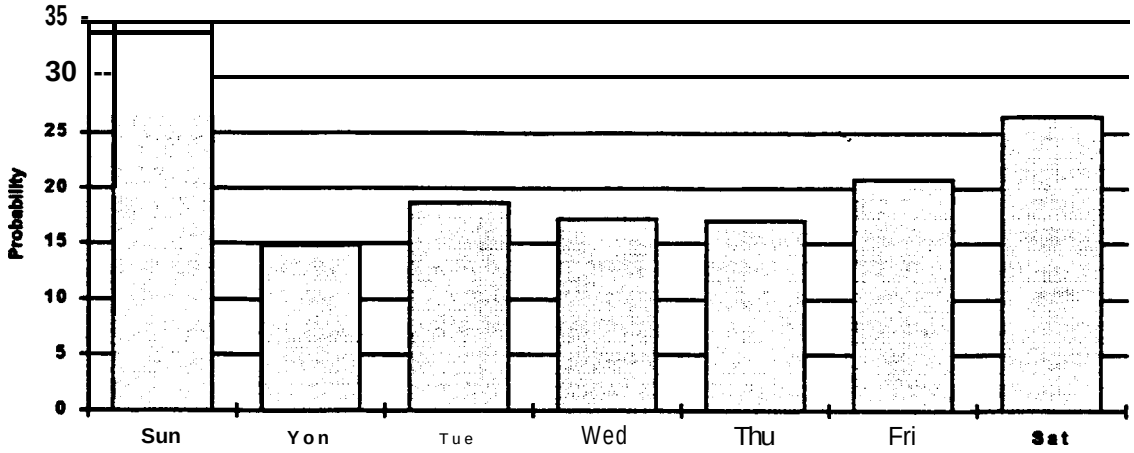
Vancouver Police Department
Crime Analysis Unit

TEMPORAL ANALYSIS

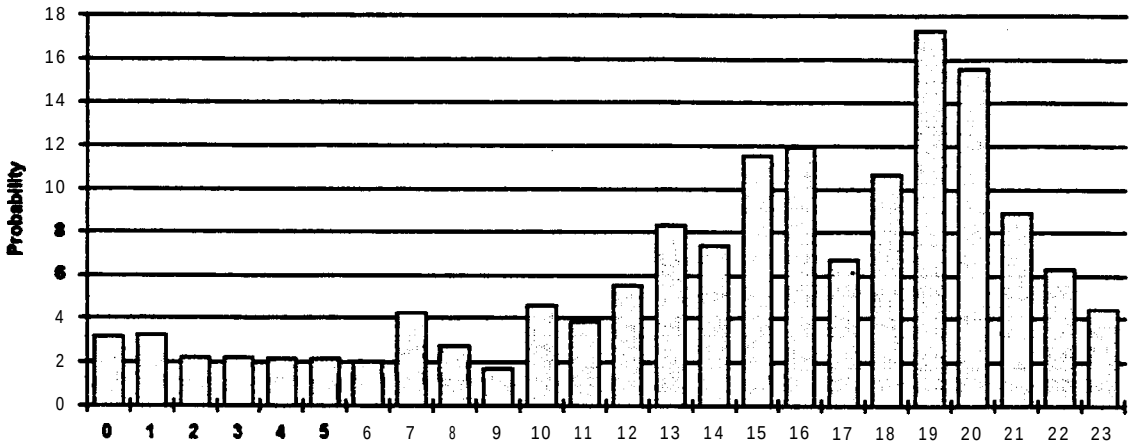
Theft From Auto - Area "A"

149 Observations from 95/04/01 to 95/04/30

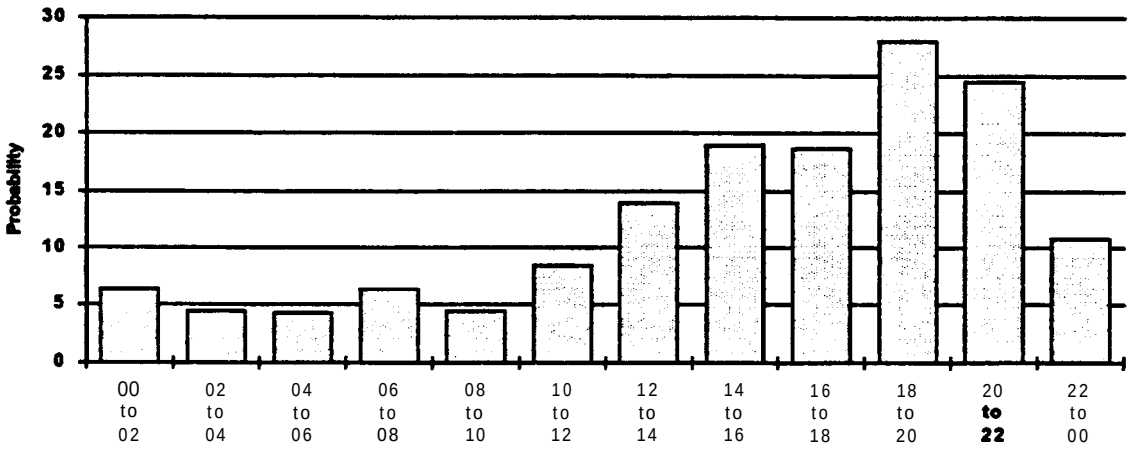
Weekday Distribution (35+ Observations)



Hourly Distribution (120+ 0 bservations)



Two-Hour Block Distribution (60+ Observations)



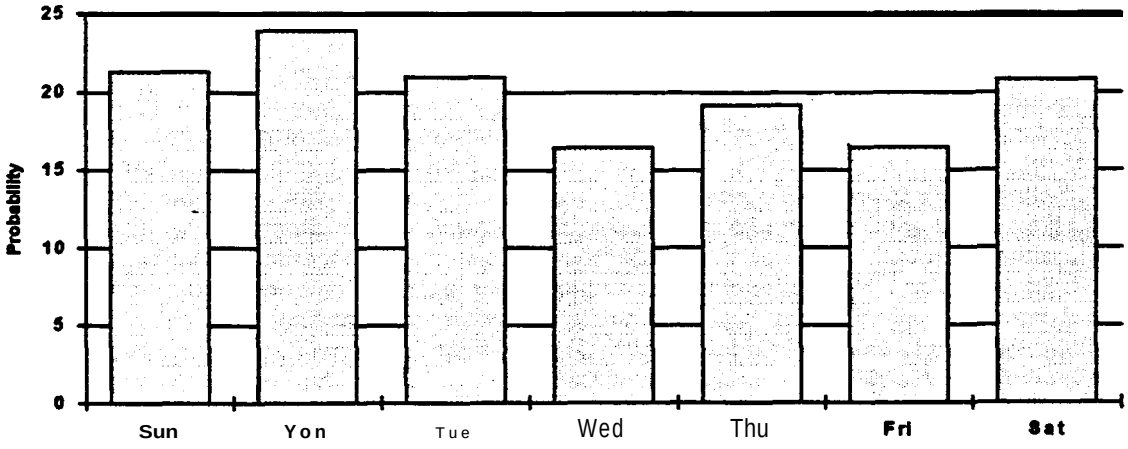
Vancouver Poke Department
Crime Analysis Unit

TEMPORAL ANALYSIS

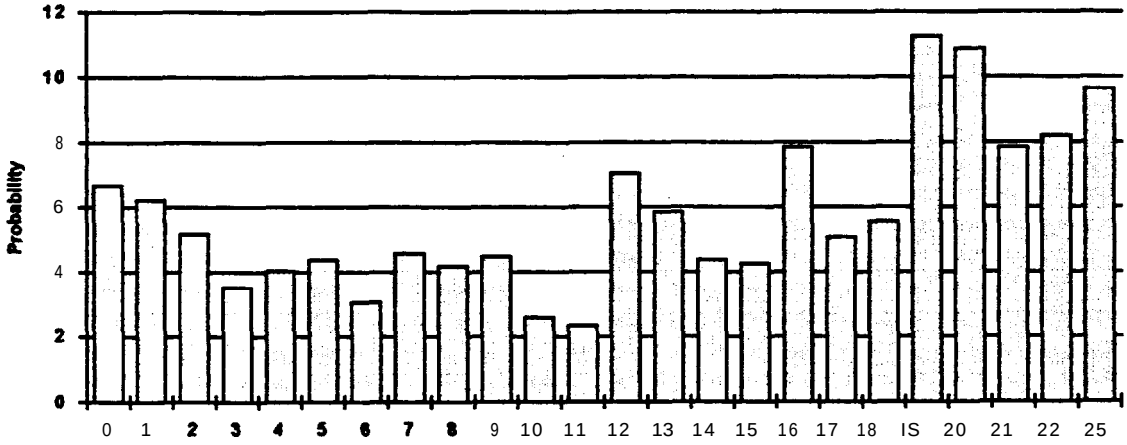
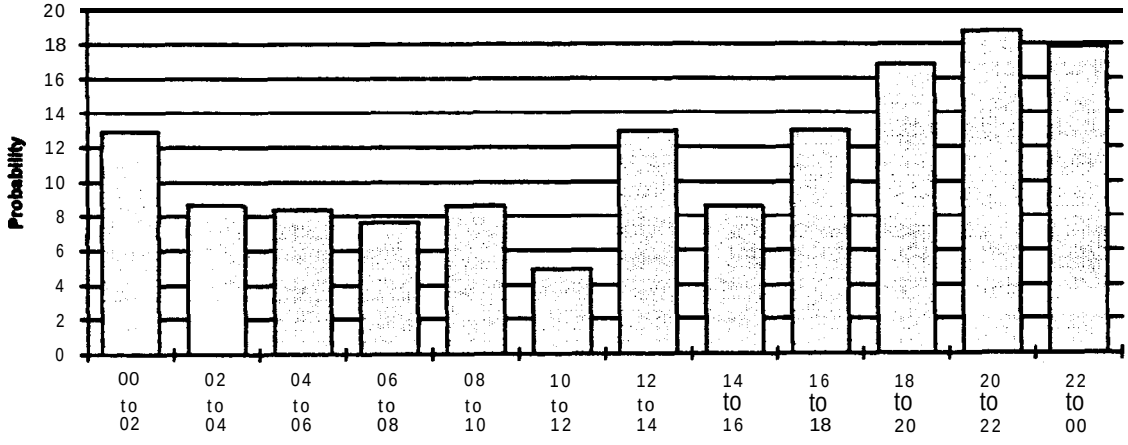
Theft From Auto - Area "B"

139 Observations from 95/04/01 to 95104430

Weekday Distribution (35+ 0 bservations)



Hourly Distribution (120+ Observations)



Two-Hour Block Distribution (60+ 0bservations)