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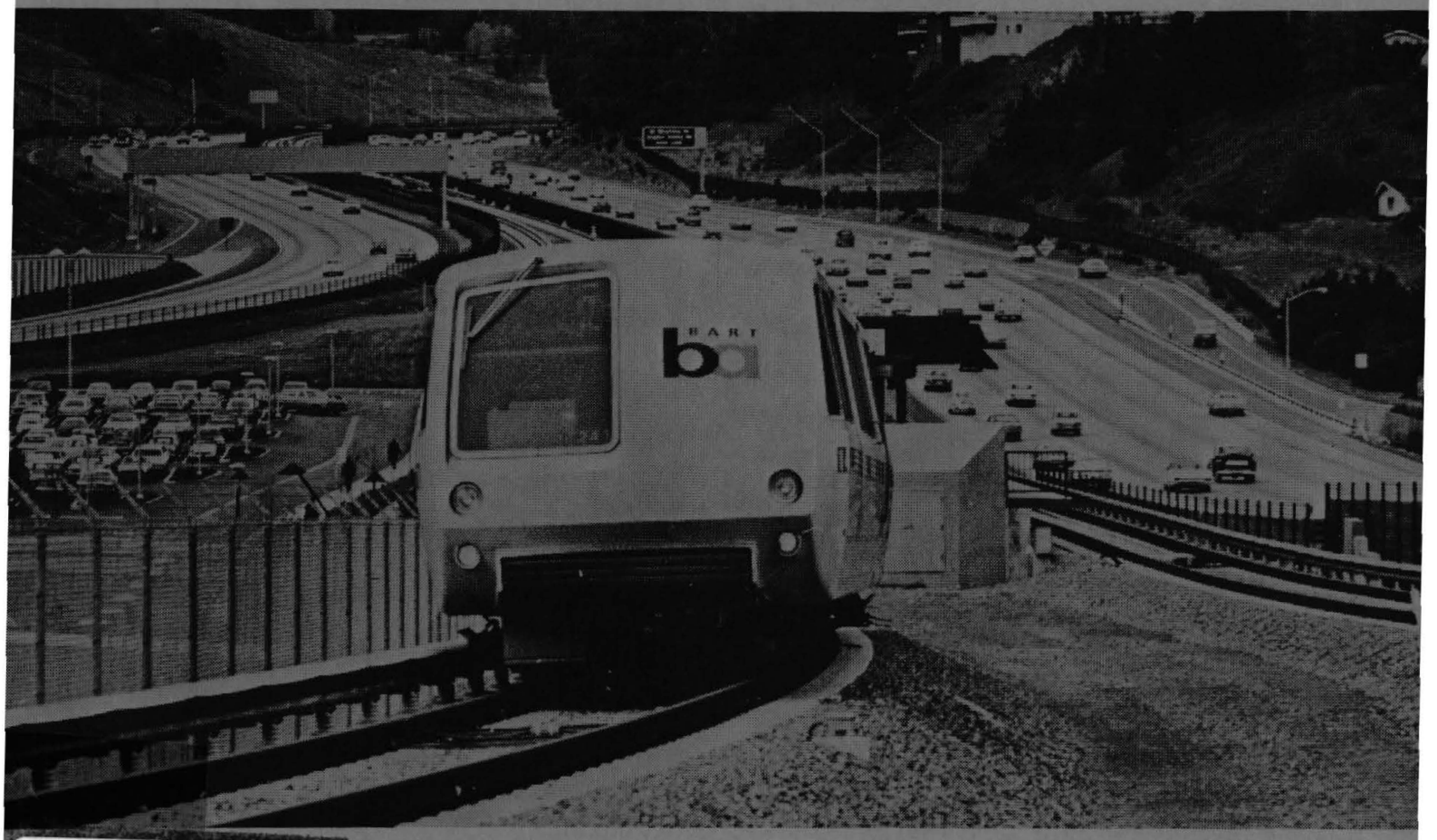
Bart
Impact
Program

THE ENVIRONMENTAL IMPACTS OF BART

Interpretive Summary



SEPTEMBER 1979

Jeff Carpenter

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The Metropolitan Transportation Commission is the prime contractor for the BART Impact Program. Gruen Associates, Inc. is the subcontractor responsible for the Environment Project.

16. Abstract

This report is a summary of the results and accomplishments of the Environment Project of the BART Impact Program. The study consisted of a detailed assessment of BART's current environmental impacts, including direct (i.e., wayside) impacts as well as indirect impacts (resulting from development in BART station areas) and effects on the system's patrons. Assessment was made using both technical impact evaluations (e.g., noise measurements) and surveys of the responses of those affected. In addition, indications of BART's construction impacts and future impacts associated with the system's full-service level of operations are described and evaluated.

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SPONSOR'S NOTE

The BART Impact Program was a comprehensive, policy-oriented study and evaluation of the impacts of the San Francisco Bay Area's new rapid transit system (BART). The program began in 1972, and was completed in 1978. Financing for the Program was provided by the U.S. Department of Transportation, the U.S. Department of Housing and Urban Development, and the California Department of Transportation. Management of the Federally-funded portion of the Program was vested in the U.S. Department of Transportation (DOT). The Metropolitan Transportation Commission (MTC), a nine-county regional agency established by California law in 1970, administered the Program as prime contractor to DOT; the research was performed by competitively selected subcontractors to MTC.

The BART Impact Program studied the broadest feasible range of potential rapid transit impacts, including impacts on traffic flow, travel behavior, land use and urban development, the environment, the regional economy, social institutions and life styles, and public policy. The incidence of these impacts on population groups, local areas, and economic sectors was measured and analyzed.

The results of the BART Impact Program have been synthesized in BART in the Bay Area, the BART Impact Program Final Report (PFR). That report was prepared by MTC and presents MTC's conclusions from and interpretation of the Program's findings. In addition to the PFR, final reports for each of the individual projects in the Program were prepared by the consultants who conducted the research. The reports are listed at the end of this Note. The final reports are supported by numerous technical memoranda and working papers. The conclusions in those documents reflect the viewpoints of the respective consultants based on their research.

Readers of BART Impact Program reports should be aware of the circumstances and the setting in which BART was planned and built and the conditions under which the Program was conducted. An understanding of these factors is critical for interpreting the Program's findings and attempting to apply them to other areas.

First, it is important to note that the San Francisco Bay Area has a sound economy, a good system of highways and public transportation, and distinctive land use and development patterns shaped by the Bay and the hills around it. BART was approved and built during a period of vigorous growth in the Bay Area. The economy was expanding, suburban development was burgeoning, and major increments of highway capacity were being added. Also, the Bay Area already had extensive public transportation services. There were public carriers operating dense networks of local transit services on both sides of the Bay, and there was frequent transbay bus service from many parts of the East Bay to San Francisco. In 1972 before BART opened, approximately 10% of the total daily trips in the three BART counties were made on transit. All of these factors made it difficult in the study to isolate BART's effects from other influences that were affecting such things as travel behavior and urban development.

A second important point is that BART was planned and designed primarily to facilitate travel from outlying suburbs to downtown areas. Multiple stops are provided in the major central business districts, but in other respects BART is

more like a commuter rail system (with long lines and widely-spaced stations) than a New York or Chicago-style subway system of interlocking crosstown lines and frequent stops. The BART system was intended to rival the automobile in comfort, speed, and convenience. Contemporary issues like energy conservation, air quality and service for the transportation disadvantaged were not widely recognized and publicized concerns during the period of BART's design.

The institutional setting in the Bay Area was a third important influence on BART's development. BART was developed as a separate institution without full coordination among existing transportation and regional development planning agencies. BART's planners had to make assumptions about policies and development, many of which turned out to be contrary to policies ultimately adopted by municipalities in the BART District.

A critical element in the study design of the BART Impact Program was the definition of the No-BART Alternative (NBA), the regional transportation facilities and travel patterns judged most likely to have evolved by 1976 if BART had not been built. The definition of an NBA was essential since the Program defined an impact as the difference between what actually occurred with BART and what would have resulted without BART. One cannot be certain about what the region would have been like had BART not been built. But based on an analysis of the political and economic decision history of the Bay Area and the professional judgment of those involved in the Program, it was determined that no significant changes to the area's freeway and bridge systems as they actually were in 1976 would have occurred without BART. It was concluded further that the public transit network and services would have been very similar to what they were just before the start of BART transbay service. One consequence of this assumption is that the NBA provides lower levels of service and less capacity than the with-BART system, and attracts fewer riders. The NBA does not extrapolate beyond 1976 and does not consider how much additional capacity in the transportation system might eventually have been required because of increasing travel demand and congestion.

An important factor affecting the findings was that BART was not operating at its full service level during the period of study by the BART Impact Program. The frequency of trains, their operating speeds, the reliability of their operations, and the capacities provided in peak periods of travel by BART were considerably lower than those originally planned. Trains were running on 12-minute headways instead of the 4.5 minutes originally planned for each of the four lines (90 seconds where three lines converged). BART did not initiate service on all lines simultaneously in 1972 but instead phased in service. The most critical link, the Transbay Tube, was not opened until late 1974. Night service did not start until the end of 1975, and Saturday service started in 1977. Direct Richmond to Daly City service still is not operating, and it now appears that "full service levels," when they are attained, will not achieve the headways and average speeds announced in the original plans.

The final point is that BART had only been operating for a relatively short period of time when its impacts were studied. The impact assessment largely depends on data collected in the first four years of BART's operations. It is likely that some of its impacts, particularly those relating to urban development, will require more time to mature.

Final Reports

These documents are available to the public through the National Technical Information Service, Springfield, VA 22151:

Metropolitan Transportation Commission, "BART in the Bay Area. The Final Report of the BART Impact Program," MTC, 1979.

Gruen Associates, Inc. and DeLeuw, Cather & Company, "Environmental Impacts of BART," MTC, 1979.

Peat, Marwick, Mitchell & Co., "BART's First Five Years: Transportation and Travel Impacts," MTC, 1979.

Jefferson Associates, Inc., "Impacts of BART on Bay Area Institutions and Life Styles," MTC, 1979.

McDonald & Grefe, Inc., "The Economic and Financial Impacts of BART," MTC, 1979.

John Blayney Associates/David M. Dornbusch & Co., Inc., "Land Use and Urban Development Impacts of BART," MTC, 1979.

Booz, Allen & Hamilton Inc., "The Impact of BART on Public Policy," MTC, 1979.

Urban Dynamics Associates, "Implications of BART's Impacts for the Transportation Disadvantaged," MTC, 1978.

Alan M. Voorhees & Associates, Inc., "Federal Policy Implications of BART," DOT, 1979.

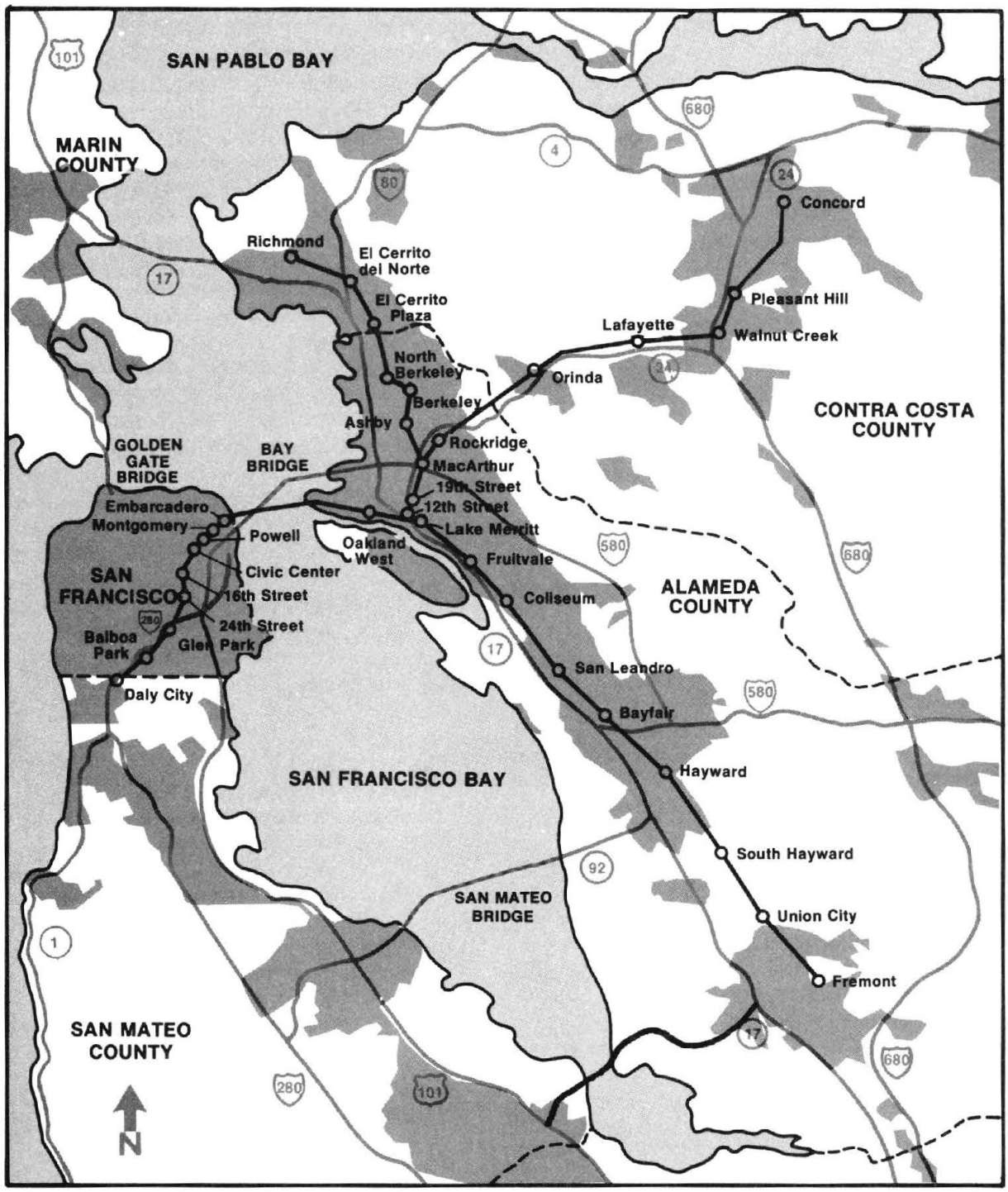
Introduction

BART—The Bay Area Rapid Transit System—is a commuter-oriented rail system that serves three counties on San Francisco Bay. It began operating in September 1972. BART's weekday patronage now is about 146,000 one-way trips a day, and the BART staff expects it to reach 180,000 trips by 1981.

In 1972, the Metropolitan Transportation Commission began a BART Impact Program—a study of BART's effects on the people, the communities and the region that it serves. The program will be completed at the end of this year. A major element in the program was the Environment Project, which analyzed BART's impact on the Bay Area's physical and social environment. The results of this analysis, it is hoped, will help planners and public officials make informed decisions about transportation systems in the Bay Area and elsewhere.

This report summarizes the Environment Project's findings. It has been written for public officials and other readers who have a general interest in transportation systems and their effects. Detailed information about the Environment Project appears in the technical reports that are listed in Section 9.

Contents


SAN PABLO BAY
MARIN COUNTY
Richmond
El Cerrito del Norte
El Cerrito Plaza
North Berkeley
Berkeley
Ashby
Rockridge
MacArthur
19th Street
12th Street
Lake Merritt
Fruitvale
Coliseum
Oakland West
GOLDEN GATE BRIDGE
BAY BRIDGE
Embarcadero
Montgomery
Powell
Civic Center
16th Street
24th Street
Glen Park
Balboa Park
Daly City
SAN FRANCISCO
SAN FRANCISCO BAY
SAN MATEO BRIDGE
SAN MATEO COUNTY
Concord
Pleasant Hill
Walnut Creek
Lafayette
Orinda
CONTRA COSTA COUNTY
ALAMEDA COUNTY
San Leandro
Bayfair
Hayward
South Hayward
Union City
Fremont
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101
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urbanized area
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BART
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1 The BART System

BART lies within three Bay Area counties—San Francisco, Alameda and Contra Costa—whose combined population was 2.4 million in 1970. The system traverses municipalities and several unincorporated areas. About 1 million people live within 1 mile of BART trackways.

BART's four lines radiate from the downtown centers of San Francisco, Oakland and Berkeley. The lines are named for their termini: the Richmond line, the Concord line, the Fremont line and the Daly City line. All of the lines pass through older, medium-density residential and industrial areas; the Concord and Fremont lines extend into newer, low-density suburbs.

In the commercial centers of San Francisco and Oakland, BART provides local subway service. Its stations there are 0.3 to 0.5 miles apart.

In the suburbs, BART serves as a commuter railway. Its suburban tracks extend through a broad area, and its suburban stations are 2 to 4 miles apart. Carrying commuters is one of BART's major functions, as BART's planners intended it to be. About 65% of BART's passengers are traveling between their homes and their jobs. The average length of a trip on BART is 13 miles.

Cost

The capital cost of building and equipping BART was about $1.6 billion. Some 10% of this was the cost of the MUNI-Metro project in San Francisco, which is described under **Coordinated Development,** later in this section.

About half of BART's capital was raised through the sale of bonds. The bonds are serviced by the revenue from a property tax levied in the three BART counties. Sources for the rest of BART's capital spending include bridge tolls, a sales tax and a Federal capital grant.

Configuration

The combined length of BART rights-of-way is 71 miles. Of this, about 20 miles are underground: 13 miles in subway tunnels built by boring or by cut-and-cover work; 3 miles in a hard-rock tunnel on the Concord line; and 4 miles in the Transbay Tube beneath San Francisco Bay. The remaining 51 miles of BART trackways are at grade, or on earth embankments, or on aerial structures.

About 85% of BART's trackways lie within, beside or below the rights-of-way of other transportation routes—arterial streets, highways or other railroads.

Stations

BART has 34 stations, of which 14 are below ground. Parking lots are included in 23 of the stations. Their capacity ranges from 240 to 1,600 cars. The combined capacity of the 23 lots is about 20,000 cars.

Coordinated Development

While BART was being built, several cities carried out municipal-improvement projects that were coordinated with work on BART. These improvements included the development of plazas and pedestrian malls, and the refurbishing of important downtown streets. The redevelopment of Market Street in San Francisco is a noteworthy example. Other examples can be found in Berkeley and Oakland.

The building of BART also coincided with the MUNI-Metro Project in San Francisco — a $160-million modernization of streetcar lines operated by the San Francisco Municipal Railway (MUNI). The project, which is scheduled for completion next year, has included the construction of underground stations and tunnels (3.2 miles long) beneath Market Street. Four of the MUNI-Metro stations will share common concourses with BART's Embarcadero, Montgomery Street, Powell Street and Civic Center stations. The 1.7-mile MUNI-Metro tunnel that connects these four stations is immediately above the corresponding BART tunnel.

Train Operations

BART began service between Oakland and Fremont in September 1972; between Richmond and Fremont in January 1973; between Concord and Oakland in May 1973; and between Daly City and downtown San Francisco in November 1973.

Trains began running through the Transbay Tube in September 1974—between Concord and Daly City, and between Fremont and Daly City.

Initial service over all of these routes was confined to weekdays, between 6:00 AM and 8:00 PM. BART began nighttime service in November 1975, with trains running until midnight. Saturday service began in November 1977, and Sunday service in July 1978.

BART plans to expand its service significantly during the next two years by starting service between Richmond and Daly City, and by increasing the frequency of trains on all lines during peak travel periods.

BART's Patrons

As a whole, BART riders are somewhat younger and better educated than the general population of the Bay Area. Their income distribution is about the same as that of the general population.

Riders through the Transbay Tube have somewhat higher incomes than do Bay Area residents as a whole, because many transbay riders are commuters who have white-collar jobs in San Francisco.

BART was the United States' first public-transit system designed to accommodate handicapped travelers, including travelers in wheelchairs. Nonetheless, the percentage of handicapped persons among BART's patrons is much smaller than their percentage in the general population.

Handicapped persons interviewed during the BART Impact Program have suggested that BART's trains and stations still don't provide some of the special features that the handicapped need. But two other factors seem to be more important in deterring the handicapped from using BART. First, they have difficulty in reaching BART stations by bus or by auto. Second, they generally don't perceive themselves as being mobile; as a result, they do less traveling—by any mode—than other persons do.

The representation of blacks and Asians among BART's patrons is about equal to their representation in the general population. Hispanics constitute about 12% of the people in the BART counties, but only 6% of BART's riders. This might be true because the largest concentration of Hispanics lies in San Francisco's Mission District, which enjoys excellent bus and trolley-car service.

BART Fares

BART's fares range from $0.25 to $1.45. The chief determinant of a fare is the distance travelled. Fares from downtown San Francisco to some of the destinations shown on the map on page 2 are:

$0.55 to Daly City	$1.20 to Lafayette
0.75 to Oakland	1.35 to Concord
1.00 to Richmond	1.40 to Fremont

Tickets and Ticket-Processing

Passengers can buy tickets in denominations from $0.25 to $20.000. The value left in a ticket after a trip can be applied to later trips.

Tickets are sold from machines, and are processed by automatic faregates at both the origin and destination of each trip. At the origin station, the passenger inserts his ticket into a faregate that marks it magnetically with an origin code and returns it to the passenger. At his destination, a second faregate reads the origin code, devalues the ticket by the appropriate fee, and again returns the ticket to him.

The BART Travel Experience

Stations BART stations display high standards of design and construction. They signify an important assumption by BART's planners: that a pleasant environment for traveling would attract motorists out of automobiles and into trains.

Each station has two levels: the concourse and the platform. Patrons enter and leave through the concourse, which houses a station agent, ticket-selling machines, lavatories, telephones and vending machines, and displays maps and other information about the BART system. Patrons board their trains on the platform, which is connected to the concourse by stairs, escalators and elevators.

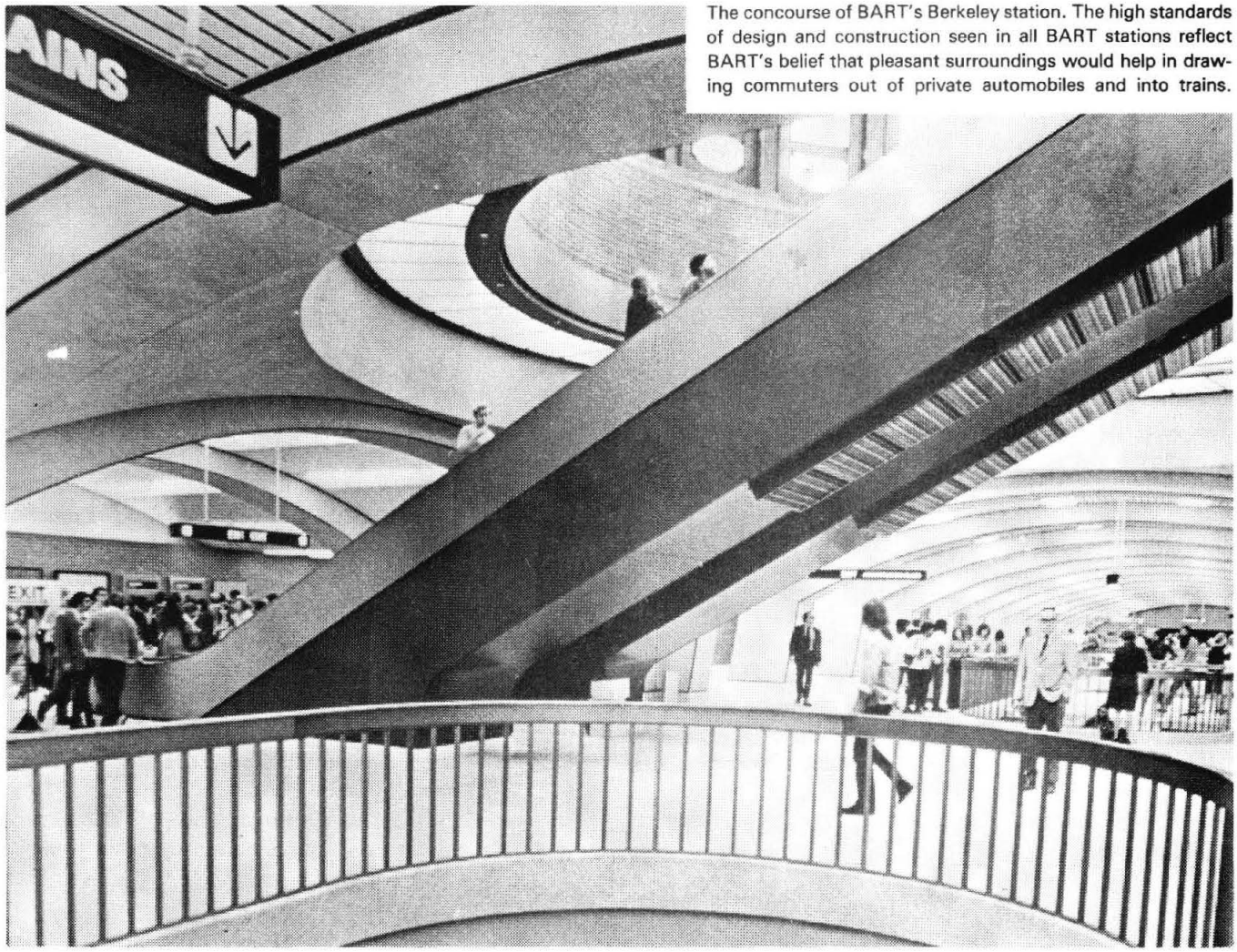
The stations were designed by 15 different architectural firms. BART established engineering standards for the stations, but it imposed few restrictions on style, appointments, finishing materials or other architectural features. As a result, station concourses differ in size and layout, and their individuality is enhanced by the use of distinctive materials and works of art.

BART stations are notably quiet. The noise levels generated as BART's trains enter and leave the stations generally are lower than the levels permitted by the Institute of Rapid Transit's current design goals. Details appear in the table below.

BART stations are pleasingly free of graffiti and other marks of vandalism. This can be ascribed to several factors: the extensive use of ceramic tile

source of sound	design maxima: dB(A)	observed values: dB(A)
train entering or leaving an above-ground station	75	70 to 94
train entering or leaving a subway station	80	75 to 86
stationary train in a subway station	67	62 to 68
ventilation system of a subway station	55	52 to 57

Sound levels in BART stations. *The design maxima are the highest values given in the Institute of Rapid Transit's current design standards. The observed values are sound levels measured on the platforms of BART stations. Both the maxima and the observed values are expressed in decibels, abbreviated as dB. The notation dB(A) means that the sound was measured in a way that gives special emphasis to sound that falls within range of normal hearing. The design maxima in this table were taken from* Guidelines and Principles for Design of Rapid Transit Facilities, *published in 1973 by the Institute of Rapid Transit (headquarters in Washington, D.C.).*



The concourse of BART's Berkeley station. The high standards of design and construction seen in all BART stations reflect BART's belief that pleasant surroundings would help in drawing commuters out of private automobiles and into trains.

(and other unreceptive materials) in many stations; the spacious, open design of most station interiors, which facilitates continual surveillance by BART personnel and by closed-circuit television cameras; and diligent attention to the cleaning and maintenance of station property.

BART Trains The passenger compartment of a BART car is 70 feet long, and the car can carry 72 seated passengers. BART's designers expected its trains to run so frequently that all of its patrons would ride seated, so they provided seat handles but no grab rails for standing passengers. In practice, the peak-period trains on some BART lines carry as many passengers standing as seated, and BART has installed grab rails in all of its cars.

The cars are unusually attractive and comfortable. Their interior features include air-conditioning, carpeting, tinted window glass, upholstered seats and a public address system for announcement of stations and transfers. These appointments reflect again BART's hope that pleasing surroundings would attract passengers.

Train length varies between 3 and 10 cars. The trains can reach 80 miles an hour, but their maximum speed in ordinary service is 70. The average speed of all trains on all four lines—computed to include running time and station stops—is 38 miles an hour. The comfort of a BART ride is outstanding. The trains run with very little vibration or sway, for several reasons: Each car is supported by 8 pneumatic cushions that are more effective than springs in absorbing vibration; BART tracks are broad-gauged and continuous; and the tracks are well maintained.

Sound levels inside BART trains are higher than those in stations, but few patrons find the sound objectionable. Riders hear much less noise than they would be in the cars of most other systems.

Access to BART During morning rush periods, about 60% of BART's patrons ride from their homes to their stations in private automobiles. About half of the rest use buses, and about half walk. In downtown areas, 75% of BART's riders walk to their stations. Most of the rest use buses.

2 Studying BART's Impacts

MTC's BART Impact Program is a policy-oriented effort. It seeks information that will be useful to policy-makers in the Bay Area and throughout the country, helping them make decisions about transportation systems, urban development and environmental management. The program includes studies of BART's effects on transportation and travel within the Bay Area; on land use and urban development; on the regional economy; on social institutions and life styles; on public policy; and on the environment.

The Environment Project

The Environment Project, whose results are described in his report, wasn't a conventional environmental impact study, for two important reasons. First, the Project analyzed the actual effects of an existing system, rather than the predicted effects of a proposed system. Second, the Project adopted a broad definition of "environment." This definition embraced common environmental parameters (such as air quality and noise levels) along with some aesthetic, social and psychological factors that usually aren't considered in environmental studies.

The Project was executed in two phases:

Phase I, completed in August 1975, focused on effects that were attributable directly to BART's structures and the operation of BART trains. These effects included: noise and vibration; effects on the natural environment; effects on safety, security, traffic flow and air quality near BART stations; and the visual impact of BART stations and trackways. Various methods were used in assessing these effects: direct observation, aerial photography, interviews with local officials and BART personnel, and instrumental measurements of environmental parameters.

Phase I also included the statistical analysis of data from two surveys that MTC had sponsored before the Environmental Project began. One of these was the 1972 Systemwide Survey, in which researchers interviewed about 2,500 persons who lived within 1 mile of BART trackways. This study sought to learn how these residents perceived the impacts of BART construction and the operation of BART trains, and to find out what effects they expected from BART in the future. The other survey was the 1972 Special Sites Survey, which sought the same information from about 600 persons who lived within 2 blocks of a BART station or trackway. Results from these two surveys will be described in later sections of his report.

Phase II of the Environment Project, finished in July 1977, had four major elements:

- further objective measurements of BART's direct effects;
- an appraisal of BART's indirect environmental impacts—i.e., the impacts of new development and new land-use policies that were induced by the building of BART;
- an evaluation of BART from the patron's point of view, considering BART's safety, comfort, visual attractiveness and other factors that invite or deter patronage;
- the 1976 Wayside Survey, in which 700 residents near BART stations and tracks were questioned about the effects of BART construction and the operation of BART trains, and reported their reactions to the effects that they cited.

An important objective of the Wayside Survey was to learn whether the subjective perception of BART's impacts by local residents agreed with the objective measurements that had been made during Phase I. Another was to learn whether reactions to BART were influenced by a person's race, age, social group or economic status.

Both phases of the Environment Project were conducted for MTC by Gruen Associates, Inc., and DeLeuw, Cather & Co. The Project was supported by the U.S. Department of Transportation and the U.S. Department of Housing and Urban Development.

Using the Project's Findings

BART has some distinctive and important features. As Section 2 pointed out, it combines the functions of an urban subway with those of a commuter railway. It also serves a region that is topographically unusual: San Francisco Bay divides the region into eastern and western parts, widely separated. The city of San Francisco occupies the northern tip of a peninsula in the western part. In the eastern part, a range of hills parallel to the Bay constrains urban development to a coastal plain west of the hills and a series of suburbs east of them.

Can an analysis of BART be useful in the planning of systems that serve other purposes in other regions?

Yes, it can. Here is why.

First: The Environment Project's findings reflect the consequences of decisions that must be made during the planning of almost every rail rapid-tran-

sit system, regardless of its purpose or locale. When should trackways be placed near existing highways and railroads and when should they follow wholly new routes? What effects can be expected if tracks are placed on elevated structures, instead of in subways or at grade? What can local government do to mitigate the personal and economic disruptions that will accompany the construction of the system?

Second: Although the Bay Area's striking geography creates important constraints, many other metropolitan areas have a similar urban form: a major commercial center, medium-density urban housing, lower-density suburbs, and travel corridors constrained by water crossings and other geographical barriers. To the extent that another region shares this pattern, the environmental lessons provided by the building and operation of BART will apply.

The Environment Project's findings will remain valid even as BART's service and patronage increase. No new kinds of environmental impacts are expected to arise simply because BART expands its service. The sites and intensities of some existing impacts will change as BART begins operating more trains, but the changes will be marginal. These predictions are explained in Section 8 of this report.

3 Impacts During Construction

Sources of Information

Major sources of information about the environmental effects of BART's construction were: BART's records of comments and complaints received during construction; aerial photographs of construction sites; news articles; interviews with BART personnel, construction superintendents and local officials; and Environment Project surveys—especially the 1976 Wayside Survey.

Impact on the Natural Environment

The building of BART had no significant effects on components of the natural environments, such as soil, drainage and water systems, and living things. Here are the chief reasons for this:

First: Most of BART lies in areas that already were urbanized when the system was built. The few non-urbanized places traversed by BART were not ecologically sensitive, and the impact of BART on these areas often was mitigated by combining the BART right-of-way with an existing highway or railroad.

Second: BART and its contractors strove to minimize changes to the natural environment. For example:

- In designing and locating parking lots, contractors made certain that runoff from the lots wouldn't overload local storm drains. In some cases, BART paid for the enlargement of a drainage channel to accommodate runoff from a BART station itself and from private projects that might be attracted into the neighborhood by the station.
- When the construction of a trackway required the cutting of a hillside, the resulting slopes were stabilized to limit erosion.
- After the construction of the Fremont station and its parking lot obliterated part of a natural marsh that was a habitat for waterfowl, BART extended the remaining portion of the marsh into a new area.

Impacts on Residents

BART's construction operations had noticeable effects on nearby residents, and these effects depended on the kind of structure being built—downtown subway, suburban station or aboveground tracks.

Downtown Subways BART's most important subway sections lie beneath the downtown areas of San Francisco, Oakland and Berkeley. The subways were built by boring and by cut-and-cover work.

The environmental effects of boring were negligible, but cut-and-cover work disrupted traffic flow and reduced parking space. Cut-and-cover construction in downtown areas lasted from about two years (in Berkeley) to five years (in San Francisco). Construction in San Francisco was complicated by the redevelopment of Market Street and by related work.

Little information exists to show how local businesses were affected by BART's downtown construction work. Newspaper articles and other anecdotal sources suggest that some retail stores lost revenues, because construction operations interfered with the movement of pedestrians and with the parking of automobiles on local streets in in commercial districts.

Sales-tax data from stores near BART construction sites support these suggestions.

Among merchants who were interviewed after construction had been completed, about half reported that their sales had declined during the construction period; and about half of those attributed the decline to the BART work.

Efforts to Minimize Impacts BART and its contractors used three tactics to reduce the negative effects of subway construction:

- working with local governments in managing and facilitating the flow of traffic near construction sites.
- adopting construction methods that minimized dirt, disruption and noise. Examples: installing timbers over excavations, so that traffic could pass over the site while work continued; and using sonic piledrivers, which make considerably less noise than conventional piledrivers do.
- operating a community-relations program that informed local residents and businessmen of impending construction activity wherever possible, and provided mechanisms for responding to complaints. In some cases, engineers visited complainants to observe and measure troublesome effects, such as noise and vibration.

Suburban Stations The major environmental effects of building suburban stations arose during the clearing of land for parking lots.

Dislocation of Housing The construction of BART required the demolition of about 3,000 housing units. Some of these were removed to create space for above-ground trackways, but most were condemned for the building of parking lots. A large lot—say, one providing 1,400 parking spaces—covers four blocks or more.

The values of condemned buildings, and the compensation paid by BART to their owners, were established by independent appraisers.

BART made no substantial effort at relocating the building's residents, and this sometimes created hardship for people who could not easily search for new housing. Houses were pulled down quickly after they were condemned, even while some neighboring buildings were occupied.

Other Effects Respondents to the 1972 Special-Sites Survey and the 1976 Wayside Survey recalled dirt, dust, noise and the disruption of traffic as other adverse effects of station-building. Traffic was disrupted, they said, by the digging-up of local streets, and by the flow of trucks to and from construction sites. These effects typically last for 6 to 12 months.

Above-Ground Tracks BART's above-ground tracks are on aerial structures, on earth embankments or at grade.

The disruptions caused by the construction of a track section on an embankment or at grade lasted for only a few weeks. The construction created no significant environmental impacts.

The building of an aerial track section took about two months. Residents questioned in the 1976 Wayside Survey recalled that the most troublesome effects of the construction were noise, dirt and dust, and barriers to local travel.

Discussion

Experience during the construction of BART suggests several methods and policies that planners should use for mitigating the local effects of subway construction:

They should provide alternative means of transportation through areas where construction has impeded traffic.

They should establish a system for responding rapidly to complaints from local residents. These complaints probably will cite a variety of provocations, including noise, dirt, the severing of underground utility lines, and danger (real or imagined) to historically significant buildings. BART had a program for replying to complaints about such things, and it proved to be valuable.

They should establish an authority to hear complaints from local businessmen, and to minimize the negative effects of construction work on local businesses.

They should make sure that the demolition of houses imposes minimal hardship on local residents, and that persons who are displaced from condemned dwellings get help—if they need it—in finding new housing.

They should use the most rapid construction methods practicable, such as round-the-clock excavation, to minimize the duration of disruptions to local traffic and businesses.

They should make sure that local residents are informed about the nature and schedule of work to be done. If residents know when work will be done and how long it will take, they can plan their activities accordingly.

Most of these measures are well known and are practiced during large, urban construction projects. Some of them now are mandated by law. Since 1970, for example, the federal Uniform Relocation Assistance and Land Acquisition Policies Act has required that help in finding new dwellings must be available to persons displaced by projects that receive federal money.

4 Impacts of BART Structures

This section considers some effects of BART trackways and stations as structures that have been placed in the community—effects that would be perceived even if no BART trains were running.

The most important of these effects are the visual impacts of BART stations and trackways on local neighborhoods.

Visual Impacts

Regional Effects BART presents prominent and familiar sights to residents of the Bay Area: above-ground stations and tracks, moving trains, and highway signs that direct travelers to BART. Inside BART stations and BART cars, patrons encounter large, colorful maps that show the entire BART system, its track routes and the names of its stations.

Data from the 1976 Wayside Survey indicate that persons who travel outside of their accustomed neighborhoods are generally aware of BART structures as features of the landscape. Between 80% and 95% of the persons interviewed at various survey sites liked the appearance of BART structures, and about 20% said that BART had made them more aware of the Bay Area's overall geography.

Local Effects The local visual impact of a BART station or trackway is determined by its scale, its mass, its color and other architectural features, its attendant landscaping and its overall harmony or disharmony with its immediate surroundings.

The Environment Project evaluated the entire BART system according to visual quality criteria adapted from the San Francisco Urban Design Plan.* This evaluation showed that:

- Along approximately half of BART's length, its structures have produced little or no visual impact.

  Several factors explain this finding. Along one-third of its length BART is underground. Many of BART's above-ground trackways are near roads or other railroads. Many of BART's stations were built near existing large structures, such as shopping centers. And about a third of BART's stations have no parking lots. Parking lots are a major source of visual impact, as later paragraphs will explain.

- Along a quarter of its length, BART has created adverse visual effects—especially in residential areas.

  These adverse effects arise from highways that have been widened to accommodate BART tracks, from neglected vacant land above a five-block segment of BART subway in Berkeley, and from conspicuous stations and aerial trackways in residential areas.

- Along the remainder of its length, BART has created positive visual effects, directly or indirectly.

  Direct visual improvements arose from the screening of unattractive local features, and from BART's easing the transition between different modes of land use—e.g., residential and industrial.

  Indirect visual improvements arose from various municipal improvements that were induced by the building of BART. Example: the refurbishing of Market Street in San Francisco, noted on page 3 of this report.

Visual Impact of Stations The Environment Project evaluated BART's stations to determine whether each station's mass, scale, architectural style and general appearance were consonant with local surroundings.

In commercial and industrial districts, BART stations generally are appropriate and visually unobtrusive. But in residential neighborhoods, BART stations often create strong, adverse visual effects. The stations themselves contrast sharply with adjacent houses, and their large barren parking lots clash with the tree-lined streets that surround them.

Generally, the least obtrusive stations in residential areas have these characteristics: They were deliberately designed and located to be inconspicuous. They are relatively small. They use adjacent back-yard fences (rather than streets) as parking lot boundaries. They are served by several small parking lots, rather than one large lot. And they show judicious use of landscaping, which can reduce significantly the adverse impact of parking lots.

Although many stations in residential areas seem obtrusive when judged by professional standards, local residents generally find the stations pleasing or visually neutral. The 1976 Wayside Survey showed this clearly. About 40% of the respondents who lived near the Daly City station

*San Francisco Department of City Planning. 1971. *The Comprehensive Plan, Urban Design.*

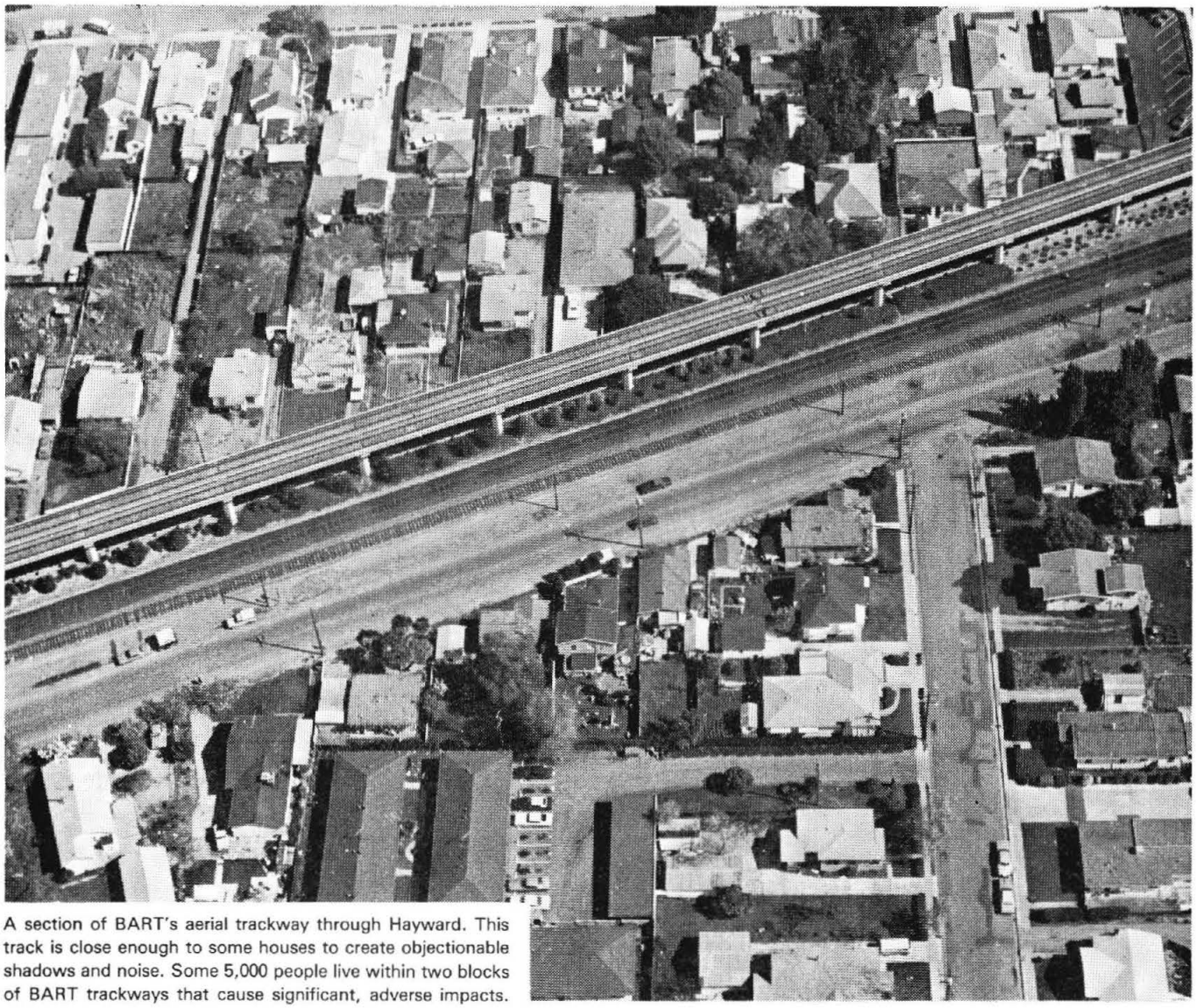
thought that the station had improved the appearance of their neighborhood. Most of the other respondents said that the station had no significant visual impact. Similar results were obtained from residents near the El Cerrito Plaza station, which lies between houses and a shopping center.

At Concord, about 25% of the survey respondents said that the BART station had a negative visual effect on their area. But more than 60% perceived no effect at all, and the rest were pleased with the visual effect.

Visual Impact of Aerial Trackways About a quarter of BART's tracks are on aerial structures that pass through residential districts. To minimize noise from these trackways, and to keep them from casting shadows on nearby houses, BART's designers tried to locate them on rights-of-way that were at least 100 feet wide; in some places, however, this wasn't possible. In the 1976 Wayside Survey, 25% to 50% of the residents at sites near aerial tracks said that the trackways cast unwelcome shadows or were blocking desirable views.

In Albany and El Cerrito, the adverse visual impacts of an aerial trackway in a residential area are partially offset by the beneficial effect of a *linear park.* This is a landscaped, planted area under the trackway. It is 2.7 miles long, and is open to the public.

The impact of BART structures on the local movement of pedestrians and vehicles was determined from maps and aerial photographs. BART's ground-level trackways have created very few barriers to movement. In some places, BART has built new pedestrian bridges and has widened existing vehicular underpasses, so that the flow of traffic has been improved.



A section of BART's aerial trackway through Hayward. This track is close enough to some houses to create objectionable shadows and noise. Some 5,000 people live within two blocks of BART trackways that cause significant, adverse impacts.

5 Impacts of BART Operations

Regional Impact

On the regional scale, the operation of BART has worked only one effect on the environment: a small reduction in the emission of air pollutants from automobiles.

BART's present weekday patronage is 146,000 trips a day. If patronage grows to 180,000 by 1981 (as BART's staff predicts it will), BART then will be handling 3% of all the trips that Bay Area residents will be making on weekdays. While this percentage is small, BART will have a measurable effect on the generation of reactive hydrocarbons (and other automotive pollutants), because it will carry trips that otherwise would be made by auto.

The attainment of existing air-quality goals in the Bay Area will require a large reduction in emissions of reactive hydrocarbons. Approximately 90% of this reduction will be sought through controls on stationary sources of pollution and through control devices on automobiles. About one-third of the remaining 10% could be achieved through the diversion of trips from autos to BART.

BART itself generates a minuscule amount of air pollution: BART consumes electrical energy, and the power plants that produce that energy also produce pollutants. But the incremental pollution due to the making of electricity for BART is negligible, as the table below shows.

Local Impacts

Impacts at Stations The environmental effects of BART's operations are negligible at downtown stations, which don't have parking lots. Stations with parking lots — whether in the suburbs or in urban residential districts — create strong effects. The most important impacts are traffic congestion and parking problems; they are most severe at line termini.

	1972 emissions, tons/day	reduction by BART, tons/day	emissions due to BART, pounds/day
CO	1073	32	13
RHC	168	5	96
NO_x	141	4	2000

BART's impact on air quality in the BART counties. *The first column shows the average daily emissions of automotive air-pollutants in 1972, before BART began operating. The middle column shows the maximum reductions that BART could create by reducing weekday automobile traffic. The last column shows the emissions associated with the production of electric power for BART. Notice that numbers in the first two columns represent tons/day, while the last column shows pounds/day. Abbreviations: CO is carbon monoxide, RHC means reactive hydrocarbons, and NO_x means oxides of nitrogen. CO is a toxic gas. RHC and NO_x are very important in the generation of photochemical smog.*

Traffic Congestion The Daly City station has adversely affected traffic safety, traffic flow and the availability of parking on nearby streets. BART recently replaced part of the station's parking lot with a three-story parking garage, to increase parking capacity at the station from 800 to 1600 cars.

Similar problems occur at Fremont and Concord, and they might arise at El Cerrito del Norte when transbay service begins on the Richmond line. Interstate 80 meets the Richmond line at El Cerrito del Norte, bringing auto and bus travelers from the north.

Strategies for controlling automobile traffic on streets near BART stations have varied greatly among local jurdisdictions. Some jurisdictions planned traffic-control before a station was built; some acted only after the station was operating; and some have done nothing. Most of the existing traffic-control problems near stations could have been avoided by planning and cooperation between BART and the local government.

During the 1976 Wayside Survey, about two-thirds of the respondents who lived near the Daly City and Concord Stations said that they were displeased by BART-induced traffic, and about half of them said that this traffic had increased the danger of accidents.

Except at Daly City, police records do not show an increase in the frequency of accidents near BART stations since BART began operations. At Daly City, accidents involving *parked* cars have become much more common.

Parking Problems The use of automobiles to travel to and from BART stations is vital in low-density suburbs, which usually cannot support concentrated local bus services.

When BART's designers chose a system whose patrons would have to use automobiles extensively, they recognized the corresponding need for abundant parking capacity at suburban stations. Plans proposed in 1962, for example, contemplated a total of 36,000 spaces in BART parking lots. That number was reduced to 24,000 after a new estimate of parking demand was made in 1963; and it later was reduced to 18,000 to cut BART's construction costs. Under present cir-

cumstances—i.e., sparse bus service to many of the suburban stations—BART's parking capacity at some stations is inadequate.

At 7 stations—5 that have parking lots and 2 that don't—substantial numbers of BART patrons park their cars on nearby streets. Residents near the Daly City and Concord stations assert that this "overflow" parking is BART's worst local effect. They say that the cars of BART patrons occupy spaces that otherwise would be available to local residents and their guests, and impede the flow of traffic through local streets.

Overflow parking near the Daly City station affects streets in both Daly City and San Francisco. Both cities have adopted regulations that give local residents special parking privileges near the station. These new rules have mitigated the effects of overflow parking on residents, while a new parking structure and improved feeder-bus service have relieved somewhat the parking problem for commuters. Nonetheless, access to the station still presents problems that await solution.

Crime The most frequent crimes near BART stations are thefts: thefts of bicycles, thefts of automobiles and thefts from automobiles in BART parking lots and on nearby streets. The presence of BART stations hasn't induced local increases in crimes against persons.

Crime within BART stations and BART trains themselves isn't an important problem. It consists chiefly of petty thefts, vandalism and fare-evasion. About 15 such incidents occur each day in the entire system; the rate of crimes against persons is less than one a day.

Some public officials thought that crime near BART stations would increase when BART began nighttime service, in November 1975. In general, this hasn't happened. Arrests have increased near some urban stations, but most of the incremental arrests involved drunkenness—not crimes against persons or property.

Impact of Station Lights The parking lots at most BART stations are illuminated by unshaded, high-intensity lights. To save electrical energy, about half of the lights at most parking lots have been turned off, but illumination in the lots is adequate nonetheless.

Generally, residents near BART stations haven't been annoyed by the glare from parking-lot lights. The 1976 Wayside Survey showed that most respondents were indifferent to the light from BART stations, and some thought that the light could discourage crime and reduce the frequency of pedestrian accidents. (Police reports don't confirm these notions.)

Noise There is no loud train noise at stations. A BART train decelerates gradually and gently, over a distance of 2,000 feet or so, as it enters a station. Its disk brakes are virtually silent: They don't make the squealing and grinding sounds produced by the brakes on older rapid-transit trains. Automotive traffic near BART stations during the morning and evening rush periods generates some noise. But the noise from traffic unrelated to BART is so loud that the increment due to BART-induced traffic is not significant.

Impact on Air Quality The effect of BART stations on local air quality was evaluated by measuring the concentration of carbon monoxide (CO) in the air near typical stations. At each of these stations, both the total CO concentration and the portion due to BART-related traffic were innocuously low.

An exception to this generalization might exist at the Daly City station, which is near a major freeway. There, 25% of the residents who were interviewed during the 1976 Wayside Survey said that BART-related traffic had degraded local air quality. (Daly City was not one of the stations at which CO was measured, so these opinions have not been confirmed independently.) The negative response here was notably higher than in other communities. At Concord, for example, only 8% of the survey's respondents thought that the local BART stations had affected air quality adversely. At El Cerrito, 5% thought so.

Impact on Demography There is no evidence that BART stations have induced changes in the demographic features of residential neighborhoods, such as age structure, household composition or income structure. This finding is based wholly on the 1976 Wayside Survey, since appropriate census information wasn't available.

Impact on Choice of Residence The presence of a BART station seems to influence some people's decisions about where to live.

During the 1976 Wayside Survey, 15% of the respondents at the Concord and Daly City stations said that easy access to BART had affected their choice of residence. About 25% of the respondents from El Cerrito made similar comments.

BART stations also might induce some emigration. At Concord, 40% of the persons interviewed said that they had considered moving away, and half of these mentioned BART as one reason why they would like to do so. At Daly City and El Cerrito Plaza, fewer respondents said that they would like to move away, and very few cited BART as a reason for emigrating.

Impacts of Trackways The most important environmental effect of BART trackways is the noise of BART trains. Information from residents and real-estate agents suggests that trackways might induce some people to move away, and that they discourage the building of new houses on adjacent undeveloped land.

Noise The Environment Project measured sound levels with instruments aboard BART trains and near BART tracks. In general, the sound of a BART train—measured at trackside—is comparable to the sound of a passing delivery truck.

The instruments showed that train noise is loudest where trains reach high speeds, where they run along aerial trackways, and where they encounter switches, tunnel openings or overpasses.

To local residents, train noise is most noticeable along the 7 miles of aerial trackways that pass through neighborhoods where ambient noise levels are low. Noise is perceived most strongly in dwellings that stand within 250 feet of the track centerline, and that aren't shielded by other buildings.

The maintenance of tracks also affects sound levels. Where tracks are smoothed by grinding them once a year, sound levels are noticeably lower than they are where tracks have not been ground for three years or more.

Vibration The vibration produced in nearby structures by BART trains on aerial trackways and in subway tunnels was measured directly by instruments. As with sound, the vibration is comparable to that caused by passing trucks.

Impact on Privacy Along approximately 15 miles of BART's trackways, BART passengers can look into areas that formerly were hidden from view—e.g., the interiors and back yards of houses. In the 1976 Wayside Survey, about half of the persons who lived near these trackways said that the resulting loss of privacy was an adverse effect of BART. But few of these residents have erected screens or other devices to mitigate this effect.

Interference With Television The movement of BART trains on aerial trackways can interfere with television reception in nearby houses. This effect apparently isn't important to local residents: Few persons have complained to BART about it, and few have tried to circumvent it by installing taller antennae, or by other means.

Electrolytic Effects BART's tracks were designed to minimize the leakage of electrical current into the earth. The present leakage, however, is higher than had been expected. It could cause corrosion of buried metal structures, such as water pipes. BART now is improving the electrical insulation of its tracks.

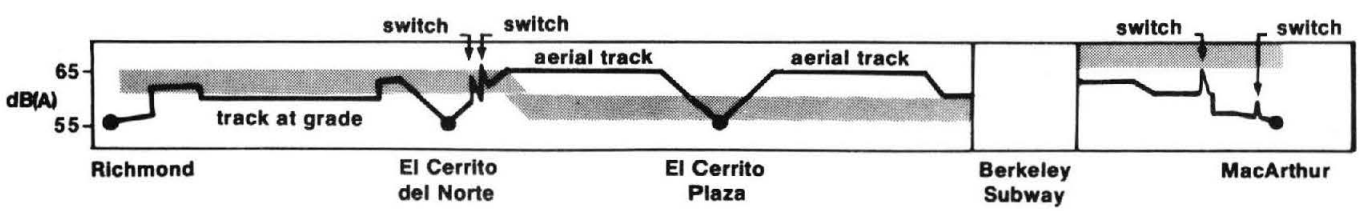
Impact on Demography BART's trackways have had no noticeable effect on the demographic characteristics of residential neighborhoods, but they might be influencing emigration. In the 1976 Wayside Survey, about a third of the respondents who lived near aerial trackways said they had considered moving. Of these, about 40% declared that the nearby BART line was one of their reasons.

Discussion

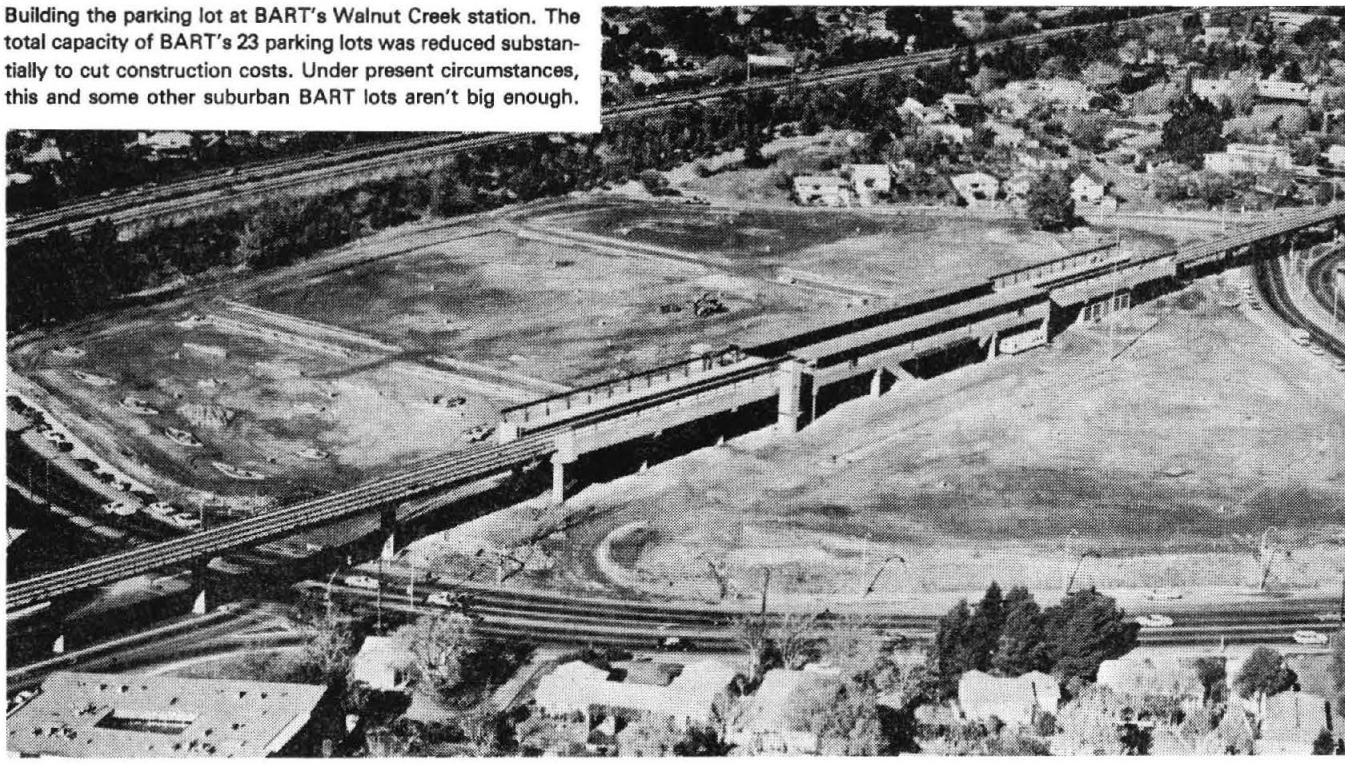
Comparing BART with Highways On the regional scale, BART has produced one beneficial environment effect (a very small improvement in air quality) and no adverse effects. This finding has great significance, because BART is a long system with 51 miles of tracks and 27 stations above ground. Nonetheless, the system has been built and started up with no regional environmental disruption.

This finding underscores an inherent property of a rapid-transit railway: If it is designed and built with proper care, it creates much milder environmental effects than would the highways and automobiles required to move the same number of people to the same destinations.

A rail system can use relatively narrow rights-of-way, so its construction entails less environmental damage than does the building of a major high-



Trackside train noise (solid line) compared with ambient sound levels (shaded bar), both in dB(A). Notice that train noise is significantly louder than ambient sound in residential areas adjacent to the El Cerrito Plaza station.



Building the parking lot at BART's Walnut Creek station. The total capacity of BART's 23 parking lots was reduced substantially to cut construction costs. Under present circumstances, this and some other suburban BART lots aren't big enough.

way. Tracks and stations can be placed underground in population centers, so their effects on local residents will be small. Trackways can be designed so that they create less visual impact than highways would. And rapid-transit trains generate much less air pollution than cars do.

Comparing BART with Bus Fleets New highways and more automobiles, however, aren't the only alternatives to a rapid-transit railway. Instead of building BART, planners in the Bay Area could have relied on existing local and express buses, which were providing their highest historical level of service in 1973—the year before BART began transbay service. A study of economic and political decisions in the Bay Area suggests that the transit system that would have evolved if BART hadn't been built would have been very similar to the system that actually existed in 1973. This system would have provided less service and less capacity than the present with-BART system, and it would have attracted fewer patrons.

The continuation of bus service alone would have caused none of the environmental effects or the disruption that accompanied the building of BART. And the buses wouldn't have created permanent visual impacts, as BART's above-ground structures have done.

But if BART hadn't been built, bus fleets and bus travel in the Bay Area probably would have expanded beyond their 1973 levels; and this expansion might have required the construction of new bus terminals and the creation of express-bus lanes on highways. These measures, along with the increased bus traffic on local streets, would have produced new and substantial environmental impacts.

BART's Impact on Air Quality The Environment Project found that BART's impact on regional air quality has been minor. The fundamental reason for this is that BART's patronage is minor, when it is compared with total travel in BART's service area.

A recent survey indicates that BART is handling 2.4% of the weekday trips that are made by residents of the three BART counties. Even if BART were operating at full capacity, it could handle only about 5% of the trips made. Hence, the maximum *theoretical* effect that BART could have on the emission of air pollutants would be a reduction by 5%. The actual reduction in emissions, if BART were running at full capacity, would be 3%—not 5%—for these reasons: Not all BART trips would be trips that formerly were made by auto; and some BART patrons would use autos in travelling to and from BART stations. Most of the pollutants generated during a local auto trip are created when the auto's engine is started and stopped. The length of the trip has a relatively small effect on pollutant emissions, so substituting an automobile-and-BART trip for an automobile trip doesn't have much impact on pollution.

If pollutant emissions alone are considered, local buses provide the best way for patrons to reach rapid-transit stations. But bus systems in low-density suburbs are costly, and some travellers find them too inconvenient to use.

Impact of Stations The design and placement of stations entails some important compromises. Patrons must be able to reach a station quickly and conveniently, but local residents will suffer inconvenience if the station draws too much traffic into their neighborhood.

The greatest potential for disruption of neighborhoods arises at stations that draw commuters from unusually large areas—for example, a station at a line terminus, or at a place where the rapid-transit line intersects a major highway. If such a station is built in an established residential neighborhood, it can create safety problems, traffic congestion and overflow parking. These problems can be mitigated by good feeder-bus service to the station.

Experience with BART has shown that persons who live near rapid-transit stations won't accept overflow-parking problems passively. In Daly City and San Francisco, residents have acquired by law the power to restrict non-resident parking. They are exercising this power without regard to the possible success of other measures that have been designed to relieve parking problems and to improve access to stations.

The planning of access and parking at a station is easier if the station is in an undeveloped area where more space is available. If a line can either be ended in a developed area or be extended into a less developed one, the latter choice has clear advantages—provided that the cost of the additional trackway can be borne, and that the less developed site is compatible with development objectives.

Impact of Trackways The Environment Project has shown that aerial trackways create strong visual and acoustic effects. These effects will present potential problems wherever rail rapid-transit systems are built.

In residential neighborhoods or other quiet areas, designers should consider alternative routes for aerial lines, the avoidance of narrow rights-of-way, the construction of sound shields, and the use of tracks in below-grade channels or in subway tunnels, rather than on aerial structures. All of these measures—especially the use of subway tunnels—can increase the system's cost.

The residents of Berkeley chose to have all of BART's tracks there placed in tunnels, although BART's original plans called for aerial trackways through some parts of the city. The suppression of noise and the avoidance of visual and social barriers were among the reasons why Berkeley voters favored a subway, even though they had to pay for their choice through higher local taxes.

6 The People Affected by BART

Along BART trackways, most of BART's environmental effects fall on strips of land a few hundred feet wide. In residential areas, these strips embrace one or two rows of houses on each side of the track.

Most of the environmental effects at stations don't reach far beyond the stations' boundaries. The important exception is overflow parking, which can extend for several blocks in all available directions.

The 1970 census showed that about 2.4 million people lived in the three BART counties. About 1 million (42%) of these live within 1 mile of a BART line. About 180,000 (less than 8%) live within a quarter-mile of a BART station with a parking lot, or within two blocks of a BART track. Of these 180,000, about 134,000 live in blocks where BART has generated no important adverse effects. The remaining 46,000 comprise: 5,000 who live near trackways that produce significant noise or other adverse effects; 8,000 who are affected by traffic congestion and overflow parking caused by BART stations; and 33,000 who live near areas adversely affected by impacts during construction (these include the 5,000 who now endure noise and other adverse impacts.)

Most of the impacts of BART structures and BART operations are borne by middle-income persons who live near suburban stations and aboveground tracks. There is no evidence that poor people, old people or members of any ethnic minority bear an inordinate share of these effects.

A different distribution of impacts prevailed when BART was being built. The adverse effects of construction work were strongest near the sites of urban subway stations. About 55% of the residents near such sites were poor people or members of ethnic minorities.

7 Indirect Impacts

New development projects and new land-use policies that were induced or promoted by the building of BART have produced environmental effects of their own.

Studying these effects was difficult, because researchers rarely could be certain that a particular project or policy wouldn't have arisen if BART hadn't been built. Therefore, the Environment Project surveyed *all* of the local changes that accompanied or followed the building of a BART station and the environmental effects of these changes, without judging whether the changes were induced by BART.

What follows, then, is an overstatement of BART's indirect effects—a description of a maximal case, rather than an actual one. But even in this maximal case, the indirect environmental impacts of BART stations appear to be very small.

Classification of Affected Areas

In studying the indirect effects of BART stations, the Environment Project divided the station sites into three classes:

- *developed areas,* which were fully or intensively developed before the BART station was built. Examples: the areas around stations in downtown San Francisco, Oakland and Berkeley.
- *partly developed areas,* which had some local development before the BART station was built, and which showed significant new development or land-use changes after the station was built. Example: the site of the Walnut Creek station.
- *undeveloped areas,* which had no significant development or local population before the BART station was built, and which experienced some growth after the station was erected. Examples: the areas around the Fremont and Union City stations.

Changes in Land-Use Policy

Changes in zoning and land-use plans—identified by interviewing local officials—have occurred near 26 of BART's 34 stations.

In most cases, the changes favored less restrictive regulations—as when the maximum permissible height of buildings was increased, or when commercial zoning replaced residential zoning in the area near a station. The table at the top of the next column relates the direction and frequency of policy changes to local conditions before the BART stations were built.

	number of areas that adopted	
before BART, the area was	less restrictive policies	more restrictive policies
developed	13	8
partly developed	3	0
undeveloped	2	0
totals	18	8

Changes in land-use policy near BART stations. *Areas near stations were classified by their condition before the stations were built. The classes are explained on this page.*

Induced Development

Distribution New development has arisen near 12 BART stations. Most of these are downtown stations, in areas that were fully developed before the stations were built. There has been very little new development in areas that were undeveloped before BART materialized.

New development occurred most often at sites where less restrictive land-use policies had been adopted. The table below shows this clearly.

All of the new development near BART stations occurred in commercial or mixed (commercial-and-residential) settings, or on vacant land. No new development took place in strictly residential neighborhoods near BART stations.

In several suburbs, land adjoining BART stations was zoned for high-density residential development, but no significant building occurred. This result probably reflects continuing suburban preference for automobile travel and single-family dwellings.

All of these observations are consistent with experience in other places. These include Toronto, where a 32-mile rapid-transit system was constructed, in six increments, between 1954 and 1974; and a group of suburban "bedroom" com-

	number of stations showing	
new policy	new development	no development
less restrictive	9	7
more restrictive	1	7
similar or unchanged	2	8

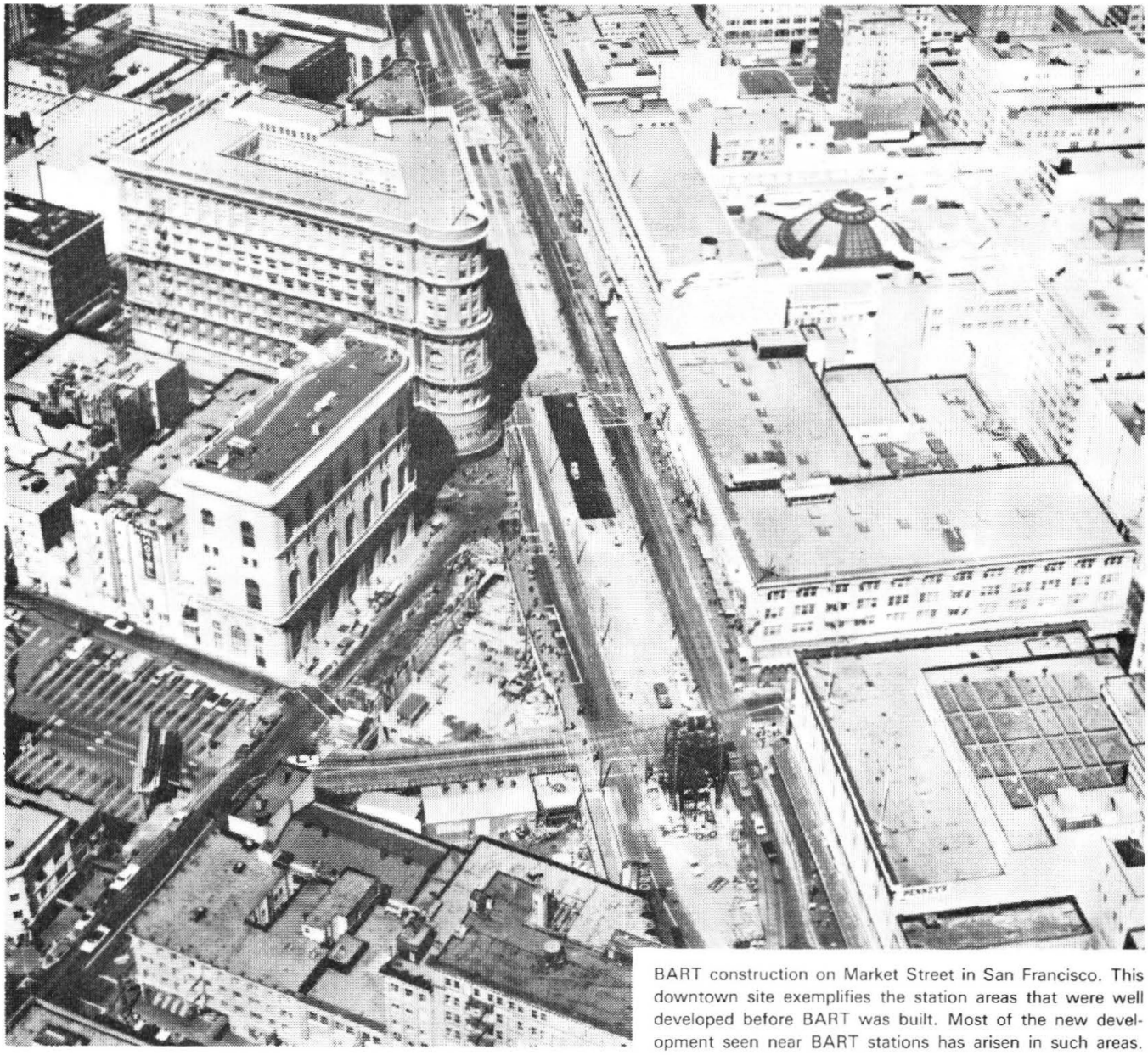
Distribution of new development. *This table relates new development to the changes in land-use policy that accompanied or followed the building of a BART station. New development occurred most often in areas where less restrictive land-use policies or zoning had been adopted.*

munities near Philadelphia, served by the Lindenwold rapid-transit line. Studies in those places showed that a rapid-transit system—by itself—doesn't have a strong impact on local development. New development can occur only if the transit system is coupled to many other factors, such as the availability of attractive sites for construction, strong zoning incentives and a vigorous demand for residential and commercial space in the system's service area.*

Environmental Impacts New development near BART stations consists chiefly of new commercial or public buildings. The most noticeable environmental effect of this development is traffic congestion, and this effect is small—small when compared with BART's direct environmental impacts, and small when compared with the impacts of the structures, transportation resources and population that existed at these sites before the BART stations were built.

This finding isn't surprising. It reflects the fact, noted above, that most new development near BART stations has occurred in areas that already were developed. BART might induce or influence more new development in the future than it has thus far. But even if it does so, the resulting indirect effects on the environment will be smaller than the direct effects of BART itself. This prediction is derived from the third projection of patronage and development in Section 8 of this report.

*R.L. Knight and L.L. Trygg. 1977. *Land Use Impacts of Rapid Transit: Implications of Recent Experience.* DOT-TPI-10-77-29, U.S. Department of Transportation, Washington, D.C.



BART construction on Market Street in San Francisco. This downtown site exemplifies the station areas that were well developed before BART was built. Most of the new development seen near BART stations has arisen in such areas.

8 Future Impacts

Patronage and Development Projections

To predict how BART's effects might change during the next 5 to 15 years, the Environment Project considered three alternative projections of patronage and development—three sets of events that might occur and produce predictable effects.

- First Projection: During the next 5 years, BART's patronage grows according to BART's current forecasts. Weekday patronage (which now is 146,000 patrons a day) reaches 180,000 by 1981. Weekend patronage (now 96,000 for Saturday and Sunday combined) reaches 135,000.
- Second Projection: BART's patronage increases substantially beyond 180,000 patrons a day. The increase could occur gradually, impelled by commercial development near BART stations. Or it might occur rapidly, if economic forces or government policies cause large numbers of commuters to stop using their automobiles.
- Third Projection: BART induces major changes in urban form—i.e., changes in zoning, land-use and rates of development—and thus creates further indirect impacts on its environment.

The three projections aren't mutually exclusive. BART's patronage could grow at predicted rates during the next five years (First Projection) and then increase sharply at some later time (Second Projection). Similarly, BART could induce major changes in urban form (Third Projection) with or without a sudden increase in patronage.

Analyses of Projections

First Projection As BART's patronage increases gradually to about 180,000 trips a day, there will be some changes in the system's operation and configuration. The average length of trains will increase slightly, and the typical rush-hour train will have 10 cars. BART already has built a siding for disabled trains at Daly City and is planning a third track through the BART tunnel* under central Oakland, to facilitate the flow of trains through these parts of the system. The intervals between rush-hour trains will decrease on all four lines. On the Daly City line, for example, the time between rush-hour trains now is 6 minutes; it will decrease to 3 minutes. On the Richmond line, the headway during rush hours now is 12 minutes; it will decrease to 6 minutes.

*Space was left for this track when the tunnel was built.

And there will be an increase in the number of feeder buses that carry patrons to and from BART stations. Feeder-bus patronage will double, more or less.

The maximum noise levels along BART trackways won't change, but the noise will be heard more frequently, because BART will be running more trains. BART's noise will be more noticeable against ambient sound levels in more residential neighborhoods. As a result, the number of houses exposed to significant BART noise will increase by about one-third. Persons living near aerial trackways will find vibration more noticeable, and BART will receive more complaints about it. But the vibration probably won't cause significant structural damage.

The number of automobiles arriving at BART stations will increase by about 30%. The traffic and parking problems associated with BART stations will worsen, and overflow parking will appear at some stations whose lots now are ample.

Second Projection BART's weekday patronage might be driven above 180,000 by a severe, long-term energy shortage, or by substantial increases in the costs of owning and using an automobile. These increases might arise from a shortage of petroleum, or from public policies, adopted by various levels of government, intended to restrict automobile travel. (Instituting such policies probably won't be politically feasible in the near future.)

A relatively small transfer of passengers from automobiles to BART would produce a large increase in BART patronage. Section 6 of this report pointed out that BART now handles about 3% of the weekday trips made by residents of BART's service area. If this percentage rose to only 5%, BART's weekday patronage would increase to 229,000.

An increase to 5% certainly is conceivable. During a survey (in May, 1975) of residents throughout the BART service area, respondents said that 9% of the trips that they made on weekdays *could have been made* by using BART.

The major environmental effects of a sharp increase in patronage will arise from traffic and overflow parking at stations. New feeder buses will carry some of the additional patrons to the stations, but feeder-bus service can't expand indefinitely. Ultimately, the growth of patronage will be limited by line capacity and by the difficulties of moving people to and within BART stations.

Third Projection In predicting how BART might influence urban form and development, the Environment Project reviewed experience in Toronto. During the 26 years since that city began building its rapid-transit system, the system has had major effects on development. About 15 of its 49 stations are surrounded by new high-rise residential and office buildings, in areas that formerly had low population densities. (The effects of the Toronto system were guided by the Metropolitan Toronto Planning Board, which was given considerable power to coordinate development with the building of the transit network.)

If BART induces similar development in the Bay Area, high-rise buildings will be erected near 10 BART stations. If the average population density in these buildings is comparable to the average density observed in Toronto, the new structures will provide about 15,000 residential units. Most of these new units will be within 1,000 feet of a BART-station boundary.

The difficulty of achieving such development mustn't be underestimated. It will require substantial changes in local ordinances, the assembly of sizable tracts of land, and the displacement of many existing buildings. In recent decades, only the Toronto system has catalyzed development on so large a scale.

The chief environmental effect of this new residential construction will be the preservation of open space at other sites. Some recent forecasts by the Association of Bay Area Governments* indicate that about 100,000 acres of land now vacant will be developed in BART's service area by the year 2000. Shifting 15,000 new residential units from low-density to high-density projects would spare about 5,000 of those acres, or about 8 square miles.

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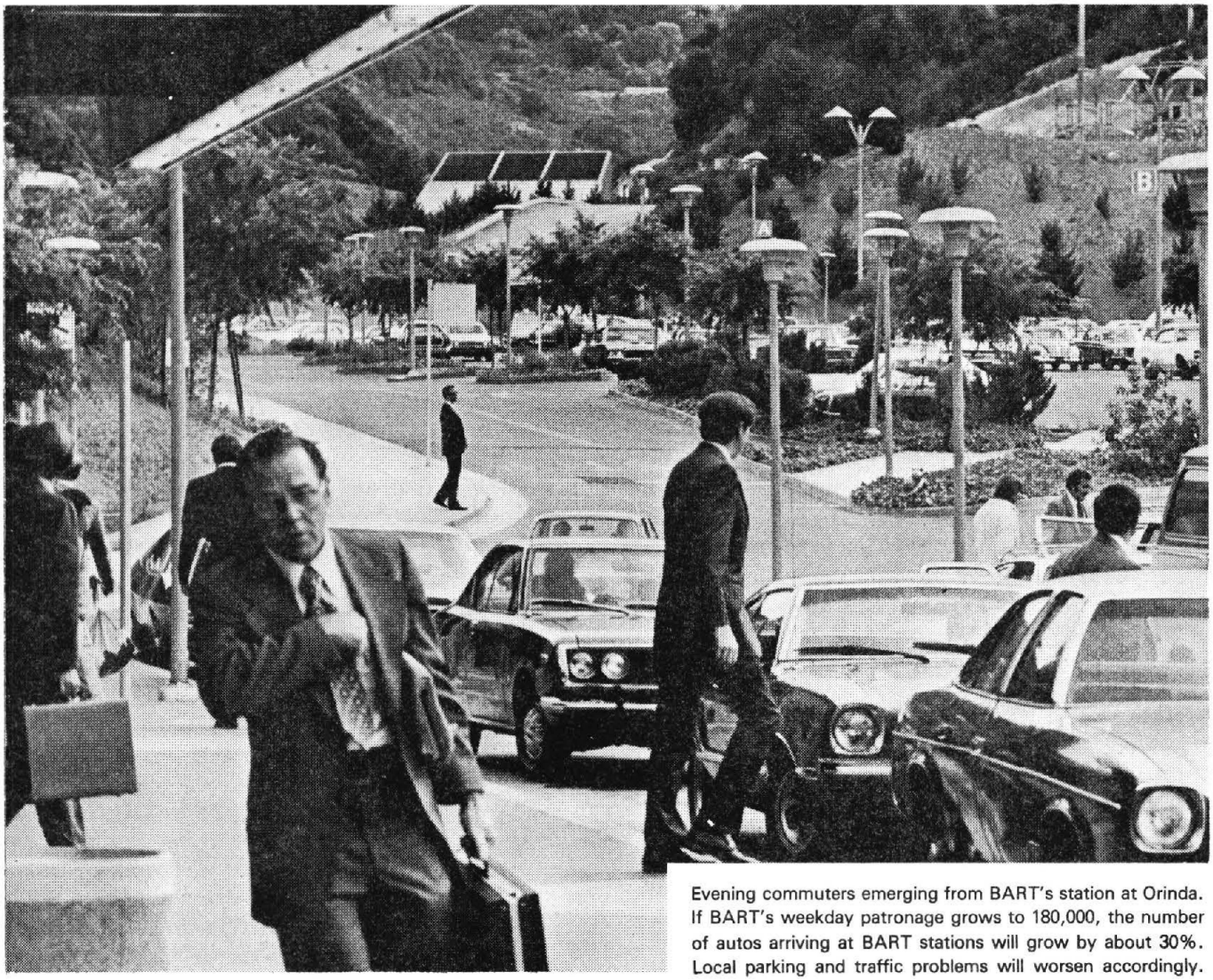
*Association of Bay Area Governments (Berkeley, Calif.). 1977. *Series 3 Projections: Population, Housing, Employment and Land Uses, San Francisco Bay Region.*



Evening commuters emerging from BART's station at Orinda. If BART's weekday patronage grows to 180,000, the number of autos arriving at BART stations will grow by about 30%. Local parking and traffic problems will worsen accordingly.

9 Technical Literature

These MTC publications provide further information about the BART Impact Program and the Environment Project. All of them are available from the National Technical Information Service (Springfield, Va.).

Reports by the Environment Project

Environmental Impacts of BART: Final Report
Report No. DOT-BIP-FR 7-4-77. 137 pp.

This is the final report of the Environment Project.

Analysis of Pre-BART Urban Residential Environment Survey
Report No. DOT-BIP-WP 24-4-76. 51 pp.

This report presents data and findings from the 1972 Systemwide Survey and the 1972 Special-Sites Survey.

Responses of Nearby Residents to BART's Environmental Impacts
Report No. DOT-BIP-TM 25-4-77. 164 pp.

This report describes the 1976 Wayside Survey and its findings.

Environmental Impacts of BART: Interim Service Findings
Report No. DOT-BIP-FR 2-4-75. 112 pp.

Environmental Impacts of BART: The User's Experience
Report No. DOT-BIP-TM 23-4-77. 149 pp.

Impacts of BART on the Social Environment: Interim Service Findings
Report No. DOT-BIP-TM 19-4-76. 124 pp.

Impacts of BART on Visual Quality: Interim Service Findings
Report No. DOT-BIP-TM 18-4-76. 42 pp.

Impacts of BART on the Natural Environment: Interim Service Findings
Report No. DOT-BIP-TM 17-4-76. 86 pp.

Acoustic Impacts of BART: Interim Service Findings
Report No. DOT-BIP-TM 16-4-76. 69 pp.

Impacts of BART on Air Quality: Interim Service Findings
Report No. DOT-BIP-WP 20-4-76. 97 pp.

Other Reports by the Bart Impact Program

BART's First Five Years: Transportation and Travel Impacts
Report No. DOT-BIP-FR 11-3-78

Impacts of Bart on Bay Area Institutions and Life Styles: Final Report
Report No. DOT-BIP-FR 10-6-77

The Impact of BART on Public Policy: Final Report
Report No. DOT-BIP-FR 13-8-78

The Economic and Financial Impacts of BART: Final Report
Report No. DOT-BIP-FR 8-7-77

The Impact of BART on Land Use and Urban Development: Final Report
Report No. DOT-BIP-FR 14-5-78

BART in the Bay Area
Report No. DOT-BIP-FR 9-201-78

This is the final report of the BART Impact Program. It summarizes and integrates the findings of the program's several projects.

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